WADC TECHNICAL REPORT 56-180

BIBLIOGRAPHY OF THE MATERIAL DAMPING FIELD

(With Abstracts and Punched Card Codings)

COMPILED BY

L. J. DEMER

UNIVERSITY OF MINNESOTA

JUNE 1956

MATERIALS LABORATORY

CONTRACT No. AF 33(616)-2803

PROJECT No. 7360

WRIGHT AIR DEVELOPMENT CENTER

AIR RESEARCH AND DEVELOPMENT COMMAND

UNITED STATES AIR FORCE

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.

400 - September 1956

FOREWORD

This report was prepared by the University of Minnesota, under USAF Contract No. AF33(616)-2803 and covers work during the period from May 1954 through December 1955 The USAF contract was initiated under Project No 7360, "Materials Analysis and Evaluation Techniques", Task No. 73604, "Fatigue Studies." The contract was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. W. J. Trapp acting as Project Engineer.

A compilation of this nature is necessarily the combined result of the endeavors of a group of individuals and scarcely the sole product of the one under whose name the collection appears. Appreciation is due Dr. B. J. Lazan for assistance in the formation of the adopted indexing system for the Processes and Property Index and for his continued support throughout the project. Mr. C. H. Ma made a great contribution to the bibliography in reference collecting, card notching, and checking. Mr. C. A. Lysdale aided in the card notching, checking, and in preparing the Materials and Author indexes. The manuscript preparation was by Y. Erickson with assistance from D. Schultz, B. Gulbrandson, H. Thomas, and J. Davis.

There is no claim made for originality in this work. The punched card system used is that which the ASM-SLA committee has set up for metallurgical literature classification with a change only in the Processes and Property Index. The manual prepared by them for use with their system was followed in preparing the explanation accompanying this collection. However, any misapplication of their aims and methods in the use of this system, any limitations of the adopted index for Processes and Properties, and all inaccuracies in the notch codings listed are the responsibility of the compiler.

An attempt has been made throughout the collection to acknowledge the source of the abstracts. The compiler must be held accountable for the accuracy of those abstracts not bearing credit lines.

ABSTRACT

This bibliography was compiled as an aid in furthering current and future research in the field of the damping of materials and structures. Consisting of almost 900 entries, it is believed to be the most extensive such collection presently available. An abstract of each reference is included in all but a few cases. A detailed classification system for the Damping Field is described which differs from the ASM-SLA Metallurgical Literature Classification only in the Processes and Property Index. Directions for use of the Damping Field classification system and ASM-SLA punched filing cards in conjunction with the present bibliography are given. Punched card codings are included with each reference in the bibliography so that the entries in this report copy may be used in constructing a personal punched card filing system of the damping field for the individual user.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

M. R. WHITMORE
Technical Director
Materials Laboratory
Directorate of Research

1.3 Form of Presentation

The entries in this collection are presented in chronological order by year of publication. Within each year they are in alphabetical order according to author. An abstract, where available, is included for each entry. The bibliographic portion of the report is printed on one side of the page only so that these references and abstracts may be cut out and pasted to suitable ASM-SLA filing cards to be discussed later.

At the end of each abstract is a group of symbols for use with the punched card filing system to be described in the next section. A subject outline for the punched card classification headings and an alphabetical listing of the headings to aid in indexing are included in this report. Finally, a complete author index for reference entries in the bibliography completes the collection.

1.4 Sources

The references were obtained chiefly from the following sources:

Bibliographies and comprehensive review papers

Metals Review of the American Society for Metals

Applied Mechanics Review

Aeronautical Engineering Review

Engineering Index

Chemical Abstracts

Metal Abstracts of the Institute of Metals

Abstracts from the Journal of the Iron and Steel Institute

Science Abstracts

Chemisches Zentralblatt

Office of Naval Research Technical Information Pilot

Armed Services Technical Information Agency Title Announcement Bulletin

The abstracts for the articles were obtained from the following sources:

Abstract, summary, or synopsis accompanying the paper in published form

Abstract accompanying reference in the various review and abstract publications cited above

The summaries accompanying the printed reports

Condensations made by the compiler from original articles when no abstract was available.

In the case of certain references there are no abstracts presented. These were often from very early papers where difficulty was encountered in finding the publication, or from references in foreign languages where no abstract in English was available and time did not permit translating the article and writing an accurate abstract.

It will be noted that the abstracts of certain papers are much longer than those of others. The length of the abstract is no indication of the value of the paper. The authors' abstracts when available were usually reproduced in their entirety.

SECTION II. PUNCHED CARD FILING SYSTEM

2.1 Choice of Punched Cards

The number of published reports or articles on damping investigations was known to be in the range of 500 - 1000. A plain card bibliographic file for such a large number of entries would be difficult to use. Thus it was decided to adopt a punched type of card to afford the many advantages associated with such a useful technique[1/]. For example, in most bibliographic files the emphasis is on the manner in which data are to be put into the file; but the basis of the punched card system is facility in getting data out of the file. Plain card files are arranged usually either by dates, authors, sources, or by subjects. With the punched card systems it is not necessary to choose any such categories as those named for the arrangement of references. When desired, one can arrange or segregate the cards according to any of those categories, and include other classes as desired, still using only one card for each reference. But there is no necessity for maintaining the file in any sequential order, for the desired reference can be selected no matter how the cards are shuffled.

2.2 Hand-Sorted Cards

It was recognized that this bibliography might find a greater use by individuals or small groups of researchers than by the research departments of large activities. Thus, due to the relative scarcity of equipment for coding and sorting machine-sorted cards, a hand-sorted type was adopted for this collection.

2.3 The ASM-SLA Card

In recent years a new scheme was adopted for coding and classifying metal literature. Design and development of this system was undertaken jointly by the American Society for Metals and the Special Libraries

---

1/ Casey, R. S. and Perry, J. W., Punched Cards, Their Applications to Science and Industry. Reinhold Publishing Corp., New York, N. Y., 506 pp., 1951

Association. The classification system was developed to provide a complete breakdown of the metallurgical field. Provision was made on the card, therefore, for four types of indexes as well as for numerous first and second order subdivisions (and third and fourth order subdivisions in one of the indexes). This provides ample opportunity for the specialist to expand his own particular field of interest to any desired degree. A booklet[1] published by the ASM-SLA committee on the classification project contains a detailed explanation of the punched card system and a complete subject outline.

The ASM-SLA punched filing card was adopted for use with the damping bibliography for several reasons among which are the following:

It has been carefully designed

It provides space for a large amount of stored information

It is large enough (5" x 8") to allow ample area for typed abstracts and other information

The supply of cards is adequate

Punches and sorting equipment are readily available

2.4 Use of the Punched Card System

A reproduction of an ASM-SLA card is shown in Fig. 1. It is seen that a double row of holes has been punched on all four outer edges of the card. Each of these holes, or combinations thereof, has a distinctive meaning in the indexes of the classification system.

To index a card the appropriate hole is clipped or notched so as to open the portion of the card between hole and margin. A simple hand punch may be used for this purpose. When a sorting needle, resembling a crocheting needle, is inserted into a given hole on a group of cards and is lifted, the cards on which that particular hole has been notched then drop out and all the others remain suspended on the needle. In this way the desired cards are separated from the group.

It is noted in Fig. 1 that the lower right corner of the card is cut off diagonally as an aid in keeping the cards right-side up when needling. If the cards become turned, needling through the three large corner holes in succession will bring them back into order.

Equipment for setting up a punched-card literature indexing system for use with the ASM-SLA cards consists of the cards, a punch (notcher), needles, and sorting trays (if desired). These are available from Lee F. Kollie, Inc., Chicago, Ill. The proper use of this equipment is explained in the ASM-SLA pamphlet [1] on pages 13, 14.

---

[1] ASM-SLA Joint Committee: ASM-SLA Metallurgical Literature Classification. American Society For Metals, Cleveland, Ohio, 49 pp., 1950.

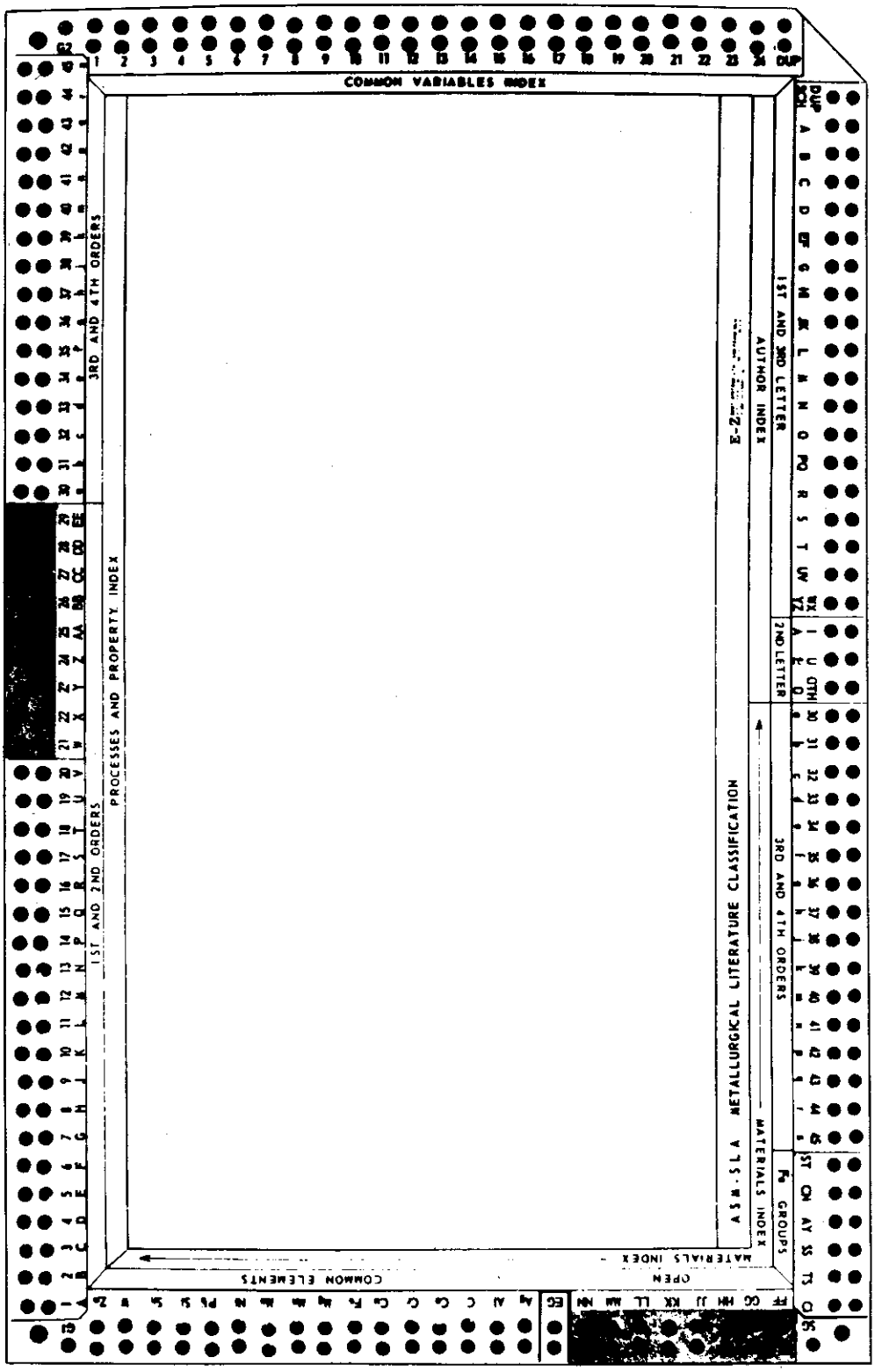

Fig. 1 ASM-SLA-Designed Punched Card Adopted For Use With Damping Field Classification System

SECTION III. PUNCHED CARD INFORMATION

3.1 Description of Classification System

3.1.1 General. The ASM-SLA classification system encompasses the entire metallurgical field whereas the subjects Damping Capacity and Internal Friction comprise only 2nd order subdivisions in that classification. It was decided, therefore, to alter the ASM-SLA classification system to some extent and devise a system for the damping field alone which would, however, make use of the ASM-SLA card.

A reproduction of the ASM-SLA file card is shown in Fig. 1. Provision is made on this card for four main indexes:

Author Index

Common Variables Index (Including Date)

Materials Index

Processes and Property Index

These four indexes have been retained in the classification of damping literature adopted here.

For an understanding of the Damping Field classification system it is recommended that the reader first become familiar with the pamphlet describing the ASM-SLA system referred to previously. In the limited space available here only a very short description of the Damping Field classification system can be given.

3.1.2 Author Index. The Author Index is accomodated on the bottom right edge of the card, as shown in Fig. 2. Its use is described on pages 11 and 12 of the ASM-SLA pamphlet. The index provides for entering the first three

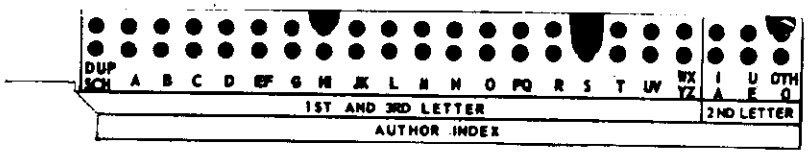

Fig. 2

letters of the author's last name. The first letter is notched deep, the second in the appropriate hole, and the third, shallow. This method of notching is shown in the diagram for the name SMITH. In the case of the name SCHMIDT,

and for any other names starting with SCH, the first three letters are taken as a group and the notching is made in the hole marked SCH while M is notched as the second letter, and I as the third. For a name such as SESSLER where the third letter is identical with the first the hole DUP for duplicate is notched for the third letter.

When a paper is jointly authored by two investigators, the first three letters of each name may be entered in the index, that is, notched on the card. It has been found that this does not produce too much trouble from unwanted cards. It is not recommended, however, that more than two names be entered.

3.1.3 Common Variables Index (Including Date). The Damping Field classification system makes use of the versatility of the Common Variables Index of the ASM-SLA system to accomodate several factors which refer to the physical characteristics of the publication. These are the years of publication, the language, and the type of literature.

As shown in Fig. 3, the first ten holes of the Common Variables section on the right edge of the card are used for the date index, with provision for recording the year and decade of a literature reference. For example, the year 1938 would be notched deep in 3 and shallow in 8, as shown. If the year and decade were the same, as in 1955, the card would be notched deep

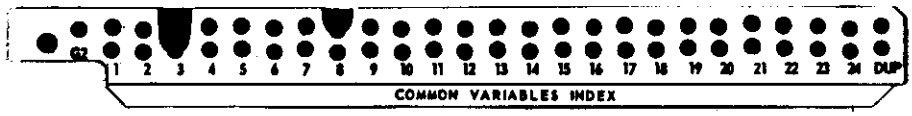

Fig. 3

in 5 and the hole for DUP (following 24) would be notched shallow. Of course, if there are entries in more than one century some unwanted cards may be selected in the recovery process, but these would probably be so few that they could be easily sorted. If a century entry is desired, some of the unused holes in this index may be employed for the purpose.

The Language (other than English) of the publication is entered by notching in the holes 11, 12, or 13, as indicated later, with provision for German, French, Russian, other language, or for a translation.

The type of literature, that is, whether an original experimental work, original theoretical work, bibliography, review, or a book, may be recorded in the holes for numbers 14 through 18 as indicated later. This leaves unused the holes 19 through 24.

3.1.4 Materials Index. The Materials Index of the ASM-SLA classification with additions in the section for Open Codings was adopted for the Damping Field system. The index is described fully in the ASM-SLA pamphlet. It consists of four main sections -- an element index, a section for element groups, a section for special groups, and one for ferrous groups.

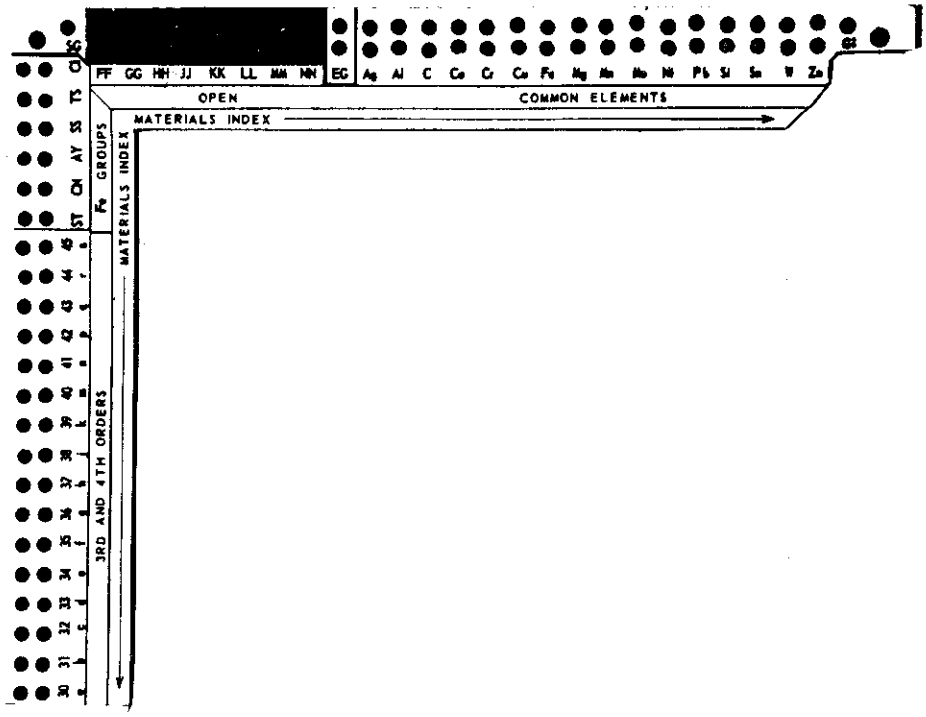

Fig. 4

As shown on the portion of a card in Fig. 4, the element index is accomodated on the punched card by the row of double holes at the upper left entitled "Common Elements" plus the double hole immediately following the common elements and designated EG for the element groups. In the case of the common elements and alloys, indexing may be done by composition according to chemical symbol. Base metal is indicated by notching the deep hole, and an alloying addition by notching the shallow hole. With the less common elements for which no hole is provided an indirect index is obtained by which all of these other elements are reached by notching the hole designated EG (deep for a base metal, shallow for an alloying addition). The individual element desired is then obtained by notching the appropriate combination of lower case letter and numeral in the third and fourth order section of the materials index located at the bottom of the card. The appropriate notchings for these may be obtained from the list of codings in Section 3.4 of this report or from the much more detailed Materials Index for the AMS-SLA system pamphlet, pages 23-27 of that publication.

The Special Groups (SG hole) Index is used to accommodate materials listed by special properties and application. This is also subdivided in the

third and fourth orders coded "a" through "s" and "30" through "45" in Fig. 4. Additional special groups for the Damping Field have been accommodated in the open spaces FF through NN as indicated in the listing on page 12 of this report.

Accomodation for the Ferrous Group is made in the six double holes at the bottom left edge of the card. Since these are all base metals, the shallow holes in this section have no intrinsic value in the classification system used for the damping field. The most important classification codings are given in Section 3.4 of this report. More detailed codings are to be found in the ASM-SLA pamphlet.

3.1.5 Processes and Property Index. The material filed under the Processes and Property Index for the Damping Field represents the only major deviation from the ASM-SLA Metallurgical Literature Classification. This change was made so as to provide a very detailed breakdown of the damping field alone. In the special damping classification, the holes in the shaded section at the top center of the card, as shown in Fig. 5, are used to designate the

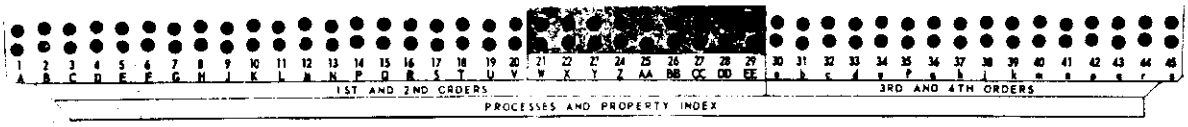

Fig. 5

principal type of damping considered, that is, whether internal, external, or system damping. The main divisions adopted are:

Material Damping

Structural Damping

Fluid Damping

Eddy Current, Magnetic, and Related Damping Systems

Energy Transfer and Isolation Systems

For the first three of these divisions there are appropriate subdivisions for which holes 23 through 29 are used.

It is appropriate to reemphasize here that, although this classification method provides for five main divisions in the damping field, the bibliographic data compiled refer chiefly to the first division, material damping. However, numerous articles concerned with the other divisions are also included.

In the same section of the card with the above five main divisions, that is, in holes W, X, and Y, is provided accommodation for coding references according to the following divisions:

Service Experience Indicating Engineering Importance of Damping

Studies Involving Dynamic Modulus of Elasticity

Vibration Analysis of Systems with Damping

The remainder of the Processes and Property Index at the top of the card is used for the following coding divisions:

Significance of Damping Data

Methods of Measuring Damping

Units for Specifying Damping

Mode of Applied Stress

Effect of Test Variables

Studies of the Mechanism of Damping

Effect of Metallurgical and Surface Treatment Factors

Relationship of Damping to Other Properties

The holes for these divisions and their corresponding subdivisions are located on the card above the sections entitled "1st and 2nd orders" and "3rd and 4th orders". However, these orders have no particular significance in this classification since only one order of subdivisions is used in each case.

It may be noted later that there are undesignated holes left in this index for further codings if a user wishes to adopt them. These are holes Z, 21, 22, and 45. The complete codings for the Processes and Property Index are given in Section 3.2 of this report.

3.2 Damping Field Classification

The detailed listing of the codings for the Damping Field classification is shown on the following pages. At the top of each section is given the type of index considered. Below are listed the headings and sub-headings. Under the column titled "Hole" are given the hole designations for entering the given information on the cards. Information is placed into the cards by notching the appropriate holes. The order of needling the holes in a stack of cards in order to recover the cards containing any desired information will be obvious when some familiarity with the system has been obtained.

The only codings shown here for the Materials Index are those added to the ASM-SLA index of the elaborate form for which the codings are given on pages 23-27 of the ASM-SLA pamphlet. For the other three indexes a list of codings is given here.

It should be mentioned that in the system employed here, the term "internal friction" is not used. Articles involved with this subject are classified under "Material Damping", code AA, in the subdivision "Low Stress", code 27, as indicated on the next page.

* *

AUTHOR INDEX

Coding is done, in general, according to the first three letters of the last name. The exceptions involving "Sch" and duplication in the first and third letters were explained previously.

* *

COMMON VARIABLES INDEX

Publication DATE is coded according to the decade and year of the article.

LANGUAGE	Hole	TYPE OF LITERATURE	Hole
German	13	Original Experimental Work	14
French	13'	Review	15
Russian	12	Book (or part of)	16
Other	12'	Original Theoretical Work	17
Translation	11'	Bibliography	18

Note: The prime (') adjacent to a hole number indicates that the shallow hole is to be notched. Otherwise, the deep hole should be notched.

* *

*

MATERIALS INDEX

For coding in general divisions of this index, see the alphabetical listing in Section 3.4 of this report. Detailed coding may be done according to the ASM-SLA classification, pages 23-27 of their pamphlet, with the following additions to unassigned holes:

	Hole		
Plastics	FF		Prime (')
Thermoplastics		GG'	indicates
Thermosetting Plastics		HH'	shallow
Plastic Laminates		JJ'	punch.
Rubber and Rubber-Like Materials	GG		
Wood and Timber, Paper	HH		
Textile Fibers and Filamentous Materials	JJ		
Glass, Ceramics, Cermets, Ceramals, Porcelain	KK		
Salts, Quartz, Mica Crystals	LL		
Cement, Concrete	MM		
Water, Oil, Ether, Glycerine, etc.	NN		

*

PROCESSES AND PROPERTY INDEX
(1st and 2nd orders)

In this classification the orders indicate only the section of the card where the holes are to be found. There is no significance as to sub-divisions.

	Hole	
MATERIAL DAMPING	AA	
Low stress, < 500 psi or 0.1 of fatigue limit		27
Medium stress, 500 psi or 0.1 F.L. to 15,000 psi or 0.5 F.L.		28
High stress, >15,000 psi or 0.5 F.L.		29
STRUCTURAL DAMPING	BB	
Slip		23
Impact		24
FLUID DAMPING	CC	
Aerodynamic effects		25
Viscous (or semi-) fluids		26
EDDY CURRENT, MAGNETIC, AND RELATED SYSTEMS	DD	
ENERGY TRANSFER AND ISOLATION SYSTEMS	EE	
SERVICE EXPERIENCE INDICATING ENGINEERING IMPORTANCE OF DAMPING	W	
STUDIES INVOLVING DYNAMIC MODULUS OF ELASTICITY	X	
VIBRATION ANALYSIS OF SYSTEMS WITH DAMPING	Y	

(continued)

	Hole
SIGNIFICANCE OF DAMPING DATA	--
Use as a resonance limiter	A
Use as a metallurgical tool	B
Use in nondestructive testing	2
Other engineering uses	1
METHODS OF MEASURING DAMPING, General	3 or C *
Decay	D
Rotating beam	4
Resonant and near-resonant vibration	E
Loop area measurement	5
Thermal methods	F
Pulse and reflection methods	6
UNITS FOR SPECIFYING DAMPING	--
Absolute energy units	--
Total or average damping energy	7
Specific damping energy	G
Energy ratio units	--
Resonance Amplification Factor, A_r, Q, Q^{-1}	8
Logarithmic decrement	9
Specific damping capacity, %	J
Miscellaneous units, including complex notation	10
Study of relationship among units and methods of calculation of energy and energy ratios	11
Effect of specimen size and shape	L
MODE OF APPLIED STRESS	--
Axial tension-compression	M
Flexure	12
Rotating bending	N
Torsion or shear	13
Combined stress	14
Comparison between different modes	P
EFFECT OF TEST VARIABLES	16 or R *
Amplitude of stress or strain	S
Effect of static mean stress	17
History effects (including rest) at constant amplitude	T
History effects under variable amplitude, or fatigue damage in service	18
Temperature	U
Frequency	19
Magnetic field, magnetization	V
Specimen shape and dimensions	20

* see note on next page.

(continued)

(Processes and Property Index, Cont'd.)
(3rd and 4th orders)

Again, the orders indicate only the section of the card where the holes are to be found. There is no significance as to subdivisions.

	Hole
STUDIES OF MECHANISM OF DAMPING	30 or a*
Micro- and macro-effects, relaxation, diffusion, etc.	31
Plastic effects	b
Dislocations	32
Magneto-mechanical effects	c
Defects, faults, and cracks	33
Viscoelasticity	d
Mechanical and mathematical models	34
EFFECT OF METALLURGICAL AND SURFACE TREATMENT FACTORS	36 or g*
Composition	37
Heat treatment	h
Single crystals	j
Grain size	38
Deformation, cold or hot working, residual stresses, etc.	k
Plating, case hardening, shot peening, corrosion, etc.	39
Inhomogeneity, imperfections, voids	m
Preferred orientation, ordering	40
Phase and Magnetic transformations, aging	n
Recrystallization	41
RELATIONSHIP OF DAMPING TO OTHER PROPERTIES	42 or p*
Elasticity	q
Creep	43
Fatigue	r
Notch sensitivity	44
Other properties	s

* Note: These alternate punchings have been used to distinguish between a coding calling for a deep notch in a given column of subdivision holes and codings calling for both deep and shallow notchings in the same column. The alternate or star-marked punch is used in the case where both deep and shallow punches are to be made in a given column. For example, 36 and h would be notched to indicate the effect of heat treatment; 36 and 37 would indicate the effect of composition; but g and h should be notched to indicate a study dealing with the effects of both composition and heat treatment. Similar application should be made to the alternate punchings in the other divisions indicated.

* *

3.3 Codings for Individual Entries

The codings for notching information into the punched cards are given for each entry in the bibliography in the letters and figures following the abstract. Codings are given for the Processes and Property Index (PP), the Common Variables Index (CV), and the Materials Index (MI). Codings are not given, however, for the authors' names nor for the date of publication. Such obvious information can readily be punched into the card by the user directly from the reference entry.

It should be noted that the codings, with main and subdivisions, which are given are only as complete as was the material available to those preparing the codings. In some cases the original paper was obtainable and the codings were prepared directly from that. Often, only an abstract was available for preparing the codings. In other instances where no abstract was available only a few major codings are indicated. These were obtained from the title of the paper. The user of this system may, however, complete the coding information on a given reference when he is able to secure a copy of the paper.

The Material Damping division is subdivided into Low, Medium, and High Stress divisions to separate the many studies dealing with very low stress damping or internal friction from those concerned with the behavior at engineering stress levels and those in which the damping was measured at fatigue stress levels. In cases where the stress level of the damping tests was unknown, no subdivision coding is indicated. Of course, these also can be added later for completeness.

References to some unclassified government reports are included in this bibliography. For these entries either the TIP number (U-----) or the AD number (AD-----) is given to assist in obtaining report copies.

3.4 Alphabetical Index Giving Codings for the Damping Field Classification System

Note: A dash between two codings means to notch both holes; a comma between two codings indicates that only one of the two holes is to be notched depending upon the subdivision intended. The prime (') indicates that the shallow hole is to be notched where there is a choice; otherwise, the deep hole should be notched.

D

E

F

G

H

R

S

T

U

V

W

X

Y

Z

For a more complete list of codings for Materials see the ASM-SLA pamphlet, pages 31-49.

1887

Tomlinson, H.

The Permanent and Temporary Effects on Some of the Physical Properties of Iron, Produced by Raising the Temperature to 100°C.

Phil. Mag., Ser. 5, Vol. 23, pp. 245-252, 1887

Observations were carried out in which an annealed wire of iron was subjected to torsional oscillation after which it was repeatedly heated to 100 C and slowly cooled. The logarithmic decrement then amounted only to 1/8th of the original value. Sections discuss the internal friction of iron in a detailed manner, the longitudinal and torsional elasticity of iron and the velocity of sound in iron.

PP: 3 D 6 9 13 16 S T U AA 30 31 36 h CV: 14 MI: Fe a

1889

Ewing, J. A.

On Hysteresis in the Relation of Strain to Stress

Brit. Assoc. Report, Sec. G, p. 502, 1889

In describing some experiments on steel wires in tension the author gives an account of a type of hysteresis other than the hereditary one and arising from a specific departure from Hooke's law at stresses within the so-called proportional limit of bodies; that is, even though the hereditary function of a body may be zero, the body may still exhibit hysteresis in a closed cycle. The author studied the straining of long wires of iron, steel, brass, and copper subjected to direct tension. He came to the conclusion that perfect elasticity did not exist with the materials used, definite hysteresis loops always being obtained.

PP: 3 5 M AA 28 CV: 14 MI: CN Cu Fe Zn' a n

1890

Barus, C.

On the Change of the Order of Absolute Viscosity Encountered on Passing From Fluid to Solid

Phil. Mag., Series 5, Vol. 29, pp. 337-355, 1890

This paper submits two methods for the coordination of the viscous behavior of solids and of liquids. It contains a discussion of the viscosity of solids in general. A detailed description is then given of the torsion apparatus for solids. Values are given for the coefficient of viscosity of ether, H_2, air, O_2, water, glycerine, Maine glue, paraffine, hard steel, and soft steel.

PP: 3 13 AA CC 30 d CV: 14 MI: CN NN EG n q

Niven, W. D.

Scientific Papers of James Clerk Maxwell

Cambridge University Press, London, England, Vol. 2, pp. 26, 1890

No abstract available.

CV: 14

1892

Voigt, K.

(In German)

Abh. der Königl. Gesell. der Wiss. zu Göttingen, Vol. 38, p. 189, 1892

It was found that the logarithmic decrement varies approximately as the square of the amplitude. Voigt's conclusion was that in some cases the preponderant factor in damping is internal friction, whereas, in other cases, it is the after-effect.

PP: 3 D 9 16 S AA CV: 13 14

Voigt, K.

On the Internal Friction of Solid Bodies, Particularly of Metals. (In German)

Annalen der Physik, Vol. 47, pp. 671-693, 1892

Experimenting with a large number of rods of different metals, Voigt finds that the self-damping of the oscillations of small amplitude, whether produced by bending or torsion, and their dependence on frequency cannot be explained satisfactorily by internal friction. When the strains are increased beyond a critical value, the losses increase more rapidly than as the square of the strains.

PP: 3 D 9 10 12 13 16 19 AA 27 CV: 13 14
MI: CI EG Ag Al Cu Mg Ni Sn Zn a 34 35 n s

1895

Cantone, M.

(In Italian)

Nuovo Cimento (4) 1, March and April, 1895

Self damping of torsional oscillations made by iron wires is attributed exclusively to hysteresis. Statical measurements show this to be independent of time.

PP: 3 4 5 13 16 T AA 30 34 CV: 12' 14 MI: Fe

1896

Strutt, J. W. (Lord Rayleigh)

The Theory of Sound. Vol. II (Book)

Macmillan and Co., N. Y., 1896

Chapter XXII on Vibrations of Solid Bodies, pp. 415-431, deals with the following topics: General equations. Plane waves, dilatational and distortional. Stationary waves. Initial disturbance limited to a finite region Theory of Poisson and Stokes. Waves from a single center. Secondary waves dispersed from a small obstacle. Linear source. Comparison with Stokes and Hertz. Reflection of plane waves at perpendicular incidence. Principle of dynamical similarity to elastic plates.

In Chapter XXIII, Helmholtz's theory of audition and the degree of damping of vibrators internal to the ear are discussed.

PP: 3 6 Y 30 34 CV: 16

1898

Brillouin, M.

Deformation of Metals. (In French)

Comptes Rendus, Vol. 126, pp. 328-330, 1898. Also Annal. Chim. Phys., Vol. 14, pp. 311-331; Vol. 15, pp. 447-469, 1898

This is a note on a theoretical investigation of the properties of commercial metals, which will appear shortly in the "Journal de Physique". The author considers the commercial metals as heterogeneous structures built up of elastic crystals to which the laws of electricity apply, and between the crystals a viscous cement of metal which obeys the laws of viscosity. Considering the effect of stress on such a mass, he is able to explain all the phenomena connected with stresses in metals, such as time lag, hysteresis, permanent set, etc. (Sci. Abs., Vol. 1, p. 126, 1898).

PP: AA 30 d 34 CV: 13 17

1899

Thompson, J. O.

Period and Logarithmic Decrement of a Continuously Vibrating Wire

Physical Review, Vol. 8, pp. 141-151, 1899

Experiments performed at Glasgow in 1864-5 made it appear probable that a wire kept for a long time in constant torsional vibration exhibited an increased period and an increased logarithmic decrement. The present paper describes elaborate experiments undertaken to test this conclusion. The torsional pendulum was arranged in a basement chamber whose temperature suffered a change of only about 1/2° in 24 hours. The amplitude was maintained constant by an automatic electromagnetic arrangement when testing the constancy of the period. The wire was of copper, 37.7 cm long, and 0.081 cm in diameter. The arc was 180°. The figures for the period incline the author to the belief that the period changes with the temperature, not instantly, but in a somewhat sluggish manner.

Other experiments showed that, by suitably modifying the antecedent amplitude of vibration, any decrement within wide limits, and any period within narrow limits might be obtained. The author concludes that in any vibrating wire not unduly loaded, when temperature and amplitude of vibration are constant both the period and logarithmic decrement are constant quantities. (Sci. Abs., Vol. 2, 1118, 1899).

PP: 3 D 13 16 T 19 AA 28 29 CV: 14 MI: Cu a

References for 1900-1909

1902

Hartmann-Kempf, R.

(In German)

Dissertation, Wurzburg, 195 pp., 1902

It is considered that a decrease in damping generally involves an increase in the elastic modulus and conversely. See entry under 1903.

PP: X AA 42 q CV: 13 14

1903

Hartmann-Kempf, R.

Influence of Amplitude Upon the Pitch and Decrement of Tuning-Forks and Steel Strips. (In German)

Ann. d. Physik, Vol. 13, No. 1, pp. 124-162, December 29, 1903; Vol. 13, No. 2, pp. 271-288, January 26, 1904

This is a description of the work reported in the author's Würzburg dissertation. In a tuning fork the effect of amplitude a on frequency n follows the form $n = n_0 - (p + \Delta a)\, a$; the logarithmic decrement is $\lambda = p_1 a$. In steel strips the pitch is affected not only by damping but much more by the shortening of the moment of inertia by deformations, especially at wide amplitudes. Thinness of section affects the internal friction by reducing the amount of stretching and compression; and the resistance of the air alters the pitch n and the decrement far more than it does in tuning forks. Theoretical and experimental development of the subject is given. Included also is a study of the lag ($\frac{1}{4}$) of maximum resonance under forced vibrations, under which the resonance vibration may differ in frequency and phase from the exciting pulsation. (Sci. Abs., A, Vol. 7, 1111, 1904)

PP: 3 D E L 12 16 S AA 27 28 CV: 13 14 MI: ST CN

Sella, A.

Sensibility of Iron to Electric Waves in Magneto-Elastic Hysteresis. (In Italian)

Acca. Lincei, Atti, Vol. 12, pp. 340-341, May 3, 1903

The action discovered by Rutherford, Phil. Trans., p. 189, 1897, that thin wires magnetized to saturation are partially demagnetized by electric waves, and that by Marconi that electric waves passed through a solenoid always produce abrupt variations in the magnetic energy of an iron wire core undergoing a magnetic hysteretic cycle, are found to be general. The same effects are observed when the magnetic hysteresis is due to an elastic deformation by twisting or traction. The author's experiments are also more fully described by C. Corpini in Elettricista, Rome, Vol. 13, p. 17, January 5, 1904; as also A. Banti's; the latter has obtained similar results with nickel. (Sci. Abs., A. Vol. 7, 1134, 1904)

PP: 16 V AA 30 c CV: 12′ 14 MI: SG Fe p

1904

Grimaldi, G. and Accolla, G.

Effect of Electric Waves and of Magnetism on the Elastic Hysteresis of Iron. (In Italian)

Accad. Gionenia Boll., Fasc. 80, pp. 34-38, February 1904

A vertical iron wire surrounded by a solenoid was cyclically loaded and unloaded, the alteration in length being observed by means of a specially constructed extensometer which is described (Ibid. pp. 32, 34). The area enclosed by the curve obtained from these readings was found to be diminished when electric waves were passed through the solenoid, sometimes up to 20%. A magnetic field, produced by another solenoid external to and concentric with the first, produced a similar diminution of the elastic hysteresis, but smaller in amount. (Sci. Abs. A, 927, 1905)

PP: 3 5 M 16 V AA 28 CV: 12′ 14 MI: SG Fe p

1906

Berlinèr, S.

Behavior of Cast Iron Under Slowly-Alternating Stresses. (In German)

Ann. d. Physik, Vol. 20, No. 3, pp. 527-562, June 26, 1906

This is an extract from the author's dissertation, Göttingen, 1906. The strain after successive tension and compression loadings to stress ± p' is, at any stress p, approximately

$$f = \int_{p}^{p'} adp + \frac{c}{4}(p-p')^3 + \text{const}$$

a is a function of p and c is nearly constant. The equation of the "traverse curve" joining the peaks of the loops obtained by loadings and unloadings of successively diminishing range is

$$\lambda = \int_{p_1}^{p} adp + c\,(p-p_1)^3 + \text{const}$$

λ being the strain, p, the lower limit of stress. For the virgin material --

$$\lambda = \int_{o}^{p} adp + cp^3$$

With fair approximation, the following may be respectively used in place of the above---

$$f = a\,(p-p') + \frac{c}{4}(p-p')^3 + \text{const}$$

$$\lambda = a\,(p-p_1) + c\,(p-p_1)^3 + \text{const}$$

$$\lambda = ap + cp^3$$

The elastic time-effect which can be developed in conjunction with these strains is of practically equal amount at corresponding points on each of the curves. The experiments also extended to the corresponding questions in torsion. (Sci. Abs., Vol. 9, No. 1528, 1906)

PP: M 13 16 S AA CV: 13 14 MI: CI Fe

1908

Bouasse, H. and Carriere, Z.

Decay of Oscillations

Annal. Chem. Phys., Vol. 14, pp. 190-224, June 1908

Working upon a sample of iron, it is established that permanent deformation results in a sub-permanent increase of "internal friction," and a permanent effect which may be either an increase or a decrease according to circumstances. The amount of the decrement immediately after tensile straining increases with the elongation, but decreases more rapidly the greater this elongation. A wire annealed at a high temperature and tested at an atmospheric temperature after a long rest, has 20 percent less decrement than after heating up to 100 C and again testing at the ordinary temperature. This effect is opposite to that of overstrain. In experiments with less than 4 percent elongation, heating to 100° decreased it. The decrements for wires in the normal condition and some which had been equally elongated in tension were greater at atmospheric temperature than at 100°. Wire as drawn has a lower decrement than the same wire after annealing, being nearly half for the same amplitude. As drawn the decrement is greater for the wire at 100° than at 15°.

PP: 3 D 13 16 S T U AA 36 h k CV: 13′ 14 MI: Fe

Gulliver, G. H.

Internal Friction in Cases of Compound Stress

Proc. Roy. Soc. Edinburgh, Vol. 29, pp. 427-431, 1908/09

The values of the coefficient of internal friction (μ) for steel deduced from Guest's and Hancock's results range from -0.242 to +0.380 and thus do not allow of assigning a definite value. (Sci. Abs., A., Vol. 12, 1695, 1909)

PP: 14 AA CV: 17 MI: ST CN

Guthe, K. E.

Properties of Platinum-Iridium Wires

Proc. Iowa Ac. Sci., Vol. 15, p. 147, 1908. Also Physical Review, Vol. 26, p. 201, 1908

Investigations show that platinum-iridium wires deviate from ordinary wires in elastic behavior when used for experiments on the decay of torsional vibrations. They show a decided decrease of decrement as well as of period with decreasing amplitude. The decrease in amplitude is nearly proportional to the square of the amplitude.

PP: 3 D 9 10 13 16 S AA 30 31 36 37 CV: 14 MI: EG c 40 43

Guye, C. E. and Mintz, S.

Study of the Viscosity of Some Metals as a Function of Temperature

Arch. Sci. Phys. Nat., Vol. 26, pp. 136-166 and 263-278, 1908

The decreasing amplitude of the torsional vibration of metal wires is due to air friction, to support losses, and to the internal friction or viscosity of the metal itself. Use of a vacuum eliminates the first cause, the second is negligible with good mechanical construction, and consequently the loss of amplitude may be used to measure the viscosity of the metal of the wire. The logarithm of the ratio of two successive amplitudes, called the logarithmic decrement, is proportional to the coefficient of viscosity, f; and measurements of the decrease of amplitude thus give a direct measure of the viscosity.

The article gives a historical summary of previous investigations on the subject, a detailed description of the apparatus used, with an accurate drawing; and the preliminary measurements of f made by this method for Pt, Au, Ag, Cu, and steel.

PP: 3 D 9 13 14 16 17 T U AA CV: 13′ 14 15
MI: ST CN EG Ag Cu a c 36 43

Searle, G. F. C.

Experimental Elasticity. (Book)

Cambridge University Press, London, 187 pp., 1908

One portion of the book discusses an experiment dealing with the measurement of the energy dissipated through torsional hysteresis. The method of calculating the energy dissipated per cycle is given and a practical example is computed from observations made on a test of copper wire.

PP: 3 5 7 13 AA 28 CV: 16 17

1909

Grimaldi, G. and Accolla, G.

Influence of Oscillatory Discharge and Magnetization Upon the Elastic Hysteresis for Extension of Iron. (In Italian)

Elettricista, Rome, Vol. 8, pp. 329-331, December 15, 1909. Also N. Cimento, Vol. 18, pp. 446-477, November-December 1909

The methods of suspending the thin iron wire, of loading it, and of measuring the extension are described. Two loads are put on the wire and the hysteresis is determined from the difference in the reading when loading and unloading. It is found that when an oscillatory discharge passes through a solenoid surrounding the wire, the hysteresis is diminished 26 to 36 percent. With a magnetizing field of 9.7 cgs units the hysteresis is diminished 24 to 30 percent. (Sci. Abs., 276, 1910)

PP: 3 5 M V AA CV: 12′ 14 MI: Fe

Guillet, A.

Intervention of Damping into the Study of Irons. (In French)

Rev. Metall, Memoires, p. 885, 1909

While studying vibrations in metals he shows that the internal damping varies with the period over which the repeated stresses have been applied. He suggests that measurement of this internal damping might play a part in the study of the elastic properties of metals, and especially in the study of fatigue.

PP: 3 16 S T AA 42 q r CV: 13′ 14 MI: ST Fe

Gulliver, J.

Internal Friction in Loaded Materials

Int. Assoc. Test. Mat., 5th Congress, Art. VIII, 1909

No abstract available.

PP: AA CV: 14

Guye, C. E. and Fréedericksz, V.

Internal Friction of Metals at Low Temperatures. (In French)

Compte Rendus, 149, pp. 1,066-69, December 6, 1909

Previous investigations by Guye and Mintz had shown that the damping of torsional oscillations in several metals increased rapidly with temperature, the law suggesting that of the increase of vapor pressures. This raised the question whether the phenomenon was due to the motion of "free molecules," as with gaseous or fluid friction. The course of the phenomenon, as absolute zero is approached, is thus of great interest and was investigated as far as liquid air temperature. A great decrease was found, 274 times in aluminum from +100° to -196°. Fe and Ag also decreased, Ag twice as fast. Au and Mg increased again from -80° to -196° and quartz was very irregular. The damping was proportional to the amplitude. The elastic modulus increased at lower temperatures for the metals but decreased (about 3%) for quartz.

PP: 3 D 9 13 16 S U X AA 30 34 CV: 13′14
MI: LL EG Ag Al Fe Mg a 36

Le Chatelier, H.

On the Study of Metals by the Decay of Free Vibrations. (In French)

Revue de Metallurgie, Vol. 6, (Memoirs), pp. 887-889, 1909

No abstract available.
PP: B 3 D 9 AA CV: 13′14

References for 1910-1914

1910

Bairstow, L.

The Elastic Limits of Iron and Steel Under Cyclical Variations of Stress

Roy. Soc. Phil. Trans., Ser. A, Vol. 210, pp. 35-55, 1910

The plan of research has been to carry out observations of the length of the specimen under the conditions of fatigue testing. By plotting extensions as ordinates against stresses as abscissae throughout the cycle, "hysteresis loops" are obtained. The maximum width of the loop measured parallel to the extension axis gives the cyclical permanent set." For equal stresses no permanent extension occurs and the hysteresis loop is quite closed, any change in the specimen being shown by the production of cyclical permanent set- an increase in the extension during each cycle. With unequal stresses the loop is not quite closed and the cyclical permanent set is accompanied by a very small change of length. When the maximum stress is high, the hysteresis loop becomes very small and the superior elastic limit is raised by extension. The hysteresis loop retains the same general character for all ratios of maximum and minimum stress. The results show, that after a sufficient number of repetitions, iron or steel is capable of adjusting itself to cyclic variations of stress, after which adjustment the specimen becomes perfectly elastic throughout the cycle and the fatigue does not occur. This adjustment becomes possible because of the raising and lowering of the elastic limits under the action of repeated stresses. During the adjustment to a given cycle of stress, a change of length occurs, even when the maximum stress in the cycle is less than the static yield-stress. This change of length corresponds to the extension in an ordinary tensile test on exceeding the yield-stress, and the increase of elastic limit is greatest in specimens showing the greatest extension during adjustment.
PP: 3 5 M 16 S 18 AA 28 29 42 q r CV: 14 MI: ST CN CI Fe

Boudouard, O.

Tests of Metals by the Abatement of Vibrating Movements. (In French)

Bull. soc. encour. Ind. Nat., Vol. 114, Pt. II, pp. 545-574, 1910;
Vol. 115, pp. 235-237, 1911
Comptes Rendus, Vol. 150, p. 696- , March 14, 1910
Vol. 152, , January 3, 1911

A metal is not perfectly elastic and when the stress which has produced a deformation is removed, the piece returns toward its original dimensions by virtue of successive phenomena of elasticity and viscosity, but a permanent deformation always remains which, although very small, is never rigorously nil. These residual deformations are of an absolutely negligible magnitude compared with the elastic deformations, but their repetition by summation of these parasitic effects, can bring about a profound alteration in the metal, even to the point of fracture. The viscosity of a metal is manifested by the damping of vibration, the measurement of which may allow the alteration of the metal to be detected before fracture results. For annealed steels the author found damping varied conversely as the carbon content, and for hard steels that the number of vibrations before rupture was diminished by quenching and increased by tempering. However, he found that the periodic time of oscillations remained the same as at the commencement of the vibration test even up to a few moments before the occurence of fracture.
PP: AA 29 30 d g h 42 q r CV: 13′14 MI: ST CN

Guthe, K. E. and Sieg. L. P.

The Elastic Properties of Platinum-Iridium Wires

Physical Review, Vol. 30, No. 4, pp. 610-633, May 1910

The results of the investigation show that (1) platinum-iridium wires containing over 30 percent iridium show striking peculiarities in their elastic behavior, which become more marked the higher the percentage of iridium, (2) for small amplitudes the period of torsional vibration is nearly proportional to the amplitude, but for larger amplitudes the rate of increase of the period becomes smaller, and for very large amplitudes the period tends toward a constant value, (3) the logarithmic decrement increases with the amplitude, reaches a maximum, after which it again decreases, and probably reaches a minimum for very large amplitudes. The maximum is the more pronounced the larger the original distortion, (4) if the wire has been allowed to rest before the torsional vibrations are produced the total number of vibrations necessary to bring the system to rest is the smaller the larger the initial amplitude, and (5) when tested by the static method the wires closely obey Hooke's law, but there was a slight hysteresis effect. The torsional moment calculated from the static experiment is larger than the largest torsional moment found by the dynamic method.
PP: 3 D 5 9 L 13 R S T U X AA 29 36 37 k CV: 14 MI: EG c 40 43

Guye, C. E.

Viscosity of Metals as a Function of the Temperature. (In French)

Arch. Sci. Phys. Nat., 29, 474; through Chem. Zentr., II, 432, 1910

In the previously published work of Guye and Mintz the so-called logarithmic decrements are expressed in common logarithms, the oscillation times correspond to whole periods of oscillations, and the pressures are given in mm. Hg. Other details in the former article are explained.
PP: 3 D 9 16 U AA 30 d CV: 13′14

Guye, C. E. and Fréedericksz, V.

The Internal Friction of Metals at Low Temperatures. (In French)

Arch. Sci. Phys. Nat., Vol. 29, pp. 157-174, 261-289, 1910

For abstract see reference under 1909.
PP: 3 D 13 16 U X AA 30 34 CV: 13′14 MI: LL EG Fe Mg a 36

Guye, C. E. and Schapper, H.

Internal Friction of Metals at Low Temperatures. (In French)

Arch. des Sci. Phys. Nat., Vol. 30, pp. 133-51, 1910. Also Compt. Rendu., Vol. 150, pp. 962-64, 1910

The authors have determined the internal friction of several metals at the temperatures 100°, 50°, 0°, -80°, and -195°. The damping of the torsional vibration of wires was measured by means of the arrangement previously used by Guye and Freedericksz. The viscosity of Cu and Zn decreases with the temperature; that of Au increases again at -195°. The damping coefficient of Ni, Pt, and Pd are so small that no definite conclusions can be drawn regarding the effect of temperature on the internal friction; but the viscosity of Pt is greater at 0° and -80° than at 100° and -195°. Temperatures in °C.
PP: 3 D 10 13 16 U AA 27 CV: 13′14 MI: EG Cu Ni Zn a c 36 42 43

Ritchie, J. B.

Dissipation of Energy in Torsionally Oscillating Wires; Effects Produced by Changes in Temperature

Proc. Roy. Soc. Edinburgh, Vol. 31, pp. 424-439, 1910-11

Deals with the effect of temperature on the constants of the equation $y^n (x+a) = b$, which represents the law of decrease of torsional oscillations of an iron wire. Wires of nine different metals were tested: brass, Cu, Al, Sn, Zn, Ag, German silver, Pt, and Ni; of these, brass, Sn, Zn, Ag, German silver, and Ni were found at the ordinary temperatures to give close agreement, over a very large range of oscillations, to the general law. With the remaining metals no one value of a could be fixed. (Sci. Abs. A, Vol. 14, 1310, 1911)
PP: 3 D 9 13 16 U AA 28 CV: 14 MI: EG Ag Al Cu Ni Sn Zn c n 43

Robin, F.

Report on the Wear of Steels and on Their Resistance to Crushing

Iron and Steel Inst., C.S.M., Vol. II., p. 260, 1910

The author correlates the work of Guye on the damping of vibrations of steel at different temperatures with the results of his own investigation on the damping down of the intensity of sound. At a certain temperature a low carbon steel completely loses the sonorousness which it possessed; the intensity of the sound becomes progressively damped down. It reappears little by little at a higher temperature; the steel recovers its sonorousness, only to lose it again the second time with the advent of red heat.
PP: 3 D 6 10 16 U AA CV: 14 MI: ST CN j

Sieg, L. P.

Elastic Properties of Platinum-Iridium Wires

Physical Review, Vol. 31, pp. 421-462, October 1910

Tests were made on a 40 percent platinum-iridium wire. The wire was first annealed at red heat and then tested for its period-amplitude characteristics with varying initial displacements; (a) when these initial

amplitudes were gradually increased, (b) when they were similarly diminished. The series (a) showed that, for increasing initial amplitudes the range of period became greater; for any one amplitude the period increased, and the number of vibrations necessary for damping to 5° diminished. The logarithmic decrements, as functions of the amplitudes, increased with the amplitudes to a maximum. In the series (b) where the order of experiment was reversed, the period-amplitude curves in passing over common ground agreed much more closely, the logarithmic decrement curves were very nearly in agreement with each other, and the number of vibrations necessary for damping to 5° now diminished with the initial amplitude. Wire was annealed to a red heat and then vibrated through a large amplitude, and subjected to electric currents which, as they were increased, exerted increasing restoring effects on the wire. This restoring power was greatly accelerated when the wire was heated to 275°C.

PP: 3 D 9 13 15 S AA CV: 14 MI: EG c 40 43

1911

Brown, W. and Smith, J.

Torsional Oscillations in Nickel-Wires in Alternating Magnetic Fields

Proc. Roy. Dublin Soc., Vol. 14, pp. 215-223, February 1911

The results show clearly the effect of an alternating magnetic field in decreasing the damping of torsional oscillations in a soft nickel-wire. In a hard wire the damping due to an alternating magnetic field is greater than that due to an equivalent direct magnetic field, while in the soft wire the damping due to the alternating field is less than that due to the equivalent direct field. Moreover, the damping due to a direct field is much greater in a soft nickel-wire than in a hard one; while the damping due to an alternating field is greater in a hard nickel-wire than in a soft one.

PP: 3 D 13 16 V AA CV: 14 MI: SG Ni n p

Robin, F.

The Variation in the Acoustic Properties of Steel with Changes of Temperature

Iron and Steel Inst., Carnegie Schol. Mem., Vol. 3, pp. 125-215, 1911

In this study the effect of elevated temperatures on the duration of sound caused by striking iron and steel bars 15 mm in diameter and 200 mm long was investigated. The behaviors of hardened steel and a quenched and tempered eutectoid steel are given. The annealed specimens were "dead" at about 120°C but became resonant again at higher temperatures while the hardened steel showed a curve of the same general slope only after tempering at 550°C. A standard impulse was used to set the bars vibrating and the duration of the note was timed by a stop watch.

PP: 3 6 16 U AA 36 h CV: 14 MI: ST CN CI Fe

1912

Boudouard, O.

Breakdown Tests of Metals

Inter. Assoc. Test. Mat., VIth Congress, Paper V3, 1912

Rectangular bars were subjected to alternating bending stresses by electromagnetically vibrating them at the natural frequency (1000 cps). Deflections were measured optically. It was found that the rate of damping did not increase abruptly at the endurance limit. The damping increased rapidly only near fracture.

PP: 3 E 12 16 T AA 29 42 r CV: 14

Guye, C. E.

Internal Damping of Solids; Variation with Temperature. (In French)

Jour. d. Physique, 2nd Ser., Vol. 620, pp. 621-645, 1912.
Sci. Abs., A., No. 1793, 1912

The section titles of this paper include the definition of internal damping of solids, difficulties of experimental research in this field, the variation of internal damping as a function of both elevated and depressed temperatures, and hypotheses on the nature of the internal damping of solids. The experimental results were obtained by the decay of free torsional oscillations of wires in vacuo. The wires tested were copper, gold, steel, aluminum, and silver. The decrements were obtained as a function of temperature and under various loads.

PP: 3 D 9 13 16 S U AA CV: 13 14 MI: ST CN EG Ag Al Cu a 36

Harris, J. E.

Elastic Properties of Bismuth Wires

Physical Review, Vol. 35, pp. 95-119, August 1912

Bismuth wires were found to exhibit some of the peculiar properties possessed by the platinum-iridium wires examined by Guthe and Sieg. When the wires were vibrated torsionally a great decrease in the period of vibration and the logarithmic decrement was observed when the amplitude decreased. The curves for the bismuth wires were found to differ in some respects from those of the platinum-iridium wires, but the amplitudes in the latter were greater in some cases than in bismuth wires, because of the low elastic limit of bismuth. In two experiments in which the mass of the vibrating system was kept constant but the moment of inertia varied, the period-amplitude curves in the two cases could be made to coincide by applying a reduction factor to the periods in one set of observations. This reduction factor was found to be equal to the ratio of the square roots of the moments of inertia used in the two experiments, thus indicating that the mathematical relation between the period and amplitude does not depend upon the rapidity of motion of the system.

PP: 3 D 9 10 L 13 16 S 19 X AA CV: 14 MI: EG a 34

Hopkinson, B. and Williams, G. T.

The Elastic Hysteresis of Steel

Proc. Roy. Soc. London, Ser. A, Vol. 87, pp. 502-511, 1912. Also Scientific Papers of Bertram Hopkinson, Cambridge University Press, London, 1921, pp. 99-107. Disc., Engineering, Vol. 94, pp. 827-828, December 13, 1912

This paper contains an account of experiments made with the alternating stress machine of Hopkinson, with the object of measuring the energy dissipated by elastic hysteresis when steel undergoes cyclical variations of stress within the elastic limit. The method used was to measure the fall of temperature between the center and ends of the test piece when it is undergoing continuous alternating stress through a constant range. Steel used was an 0.18% C steel with 0.7% manganese. The energy dissipated in hysteresis increases about as the fourth power of the stress range according to the results. Energy loss was measured both statically and at 120 cycles per second. It seems probable that the hysteresis in cycles performed 120 times per second is (if anything) less than that found in static tests, but it is unlikely that the difference is more than 30 percent.

PP: 3 5 F G 10 M 16 S 19 AA 29 CV: 14 MI: Cn j

Sieg, L. P.

Note on the Elastic Peculiarities of Platinum-Iridium Wires

Physical Review, Vol. 35, pp. 347-358, 1912

A study of the elastic nature of Pt-Ir wires shows that:
(a) Hooke's law holds both statically and kinetically,
(b) the torsional vibration of the wires is practically angular harmonic,
(c) the elastic properties are profoundly modified by prolonged rest under load,
(d) the elastic properties of the wires vary with the speed of vibration, or at any rate with the period of vibration, and
(e) the elastic properties are much modified by drawing the wires.

It seems probable that all these phenomena are related to the crystal structure although attempts to prove this by micrographic studies have thus far been unsuccessful.

PP: 3 D 9 10 L 13 16 S T 19 X AA 28 29 36 k CV: 14
MI: EG c 40 43

1913

Popplewell, W. C.

The Connection Between the Elastic Phenomena Exhibited During Slow Reversals of Stress and the Ultimate Endurance of Steel

Proc. Inst. Civ. Eng., Pt. III, p. 264, 1913-14

The author performed a series of tests to determine the effects of slow reversals of stress upon the elastic limits of iron and steel. From the results of the tests he came to the conclusion that the limits of elasticity attained were not accidental, but obeyed very definite laws. The behavior of these limits was then suggested as a means for determining the fatigue limit of a material in a rapid fashion.

PP: AA 42 q r CV: 14 MI: ST CN CI Fe

Rowett, F. E.

Elastic Hysteresis in Steel

Proc. Roy. Soc. London, Ser. A, Vol. 89, pp. 528-543, 1913-14

This paper describes experiments made in amplification of the work by Hopkinson and Williams. In order to secure higher accuracy in the measurement of the static hysteresis, thin-walled tubes were used in torsion. The high-speed cycles were observed by the method of torsional oscillations. From the rate of decay, after correcting for air-friction, the hysteresis loss was calculated. These experiments show that the hysteresis is, probably within 5%, the same at high speeds as at low speeds. Furthermore, the shape of the hysteresis loop, which was left uncertain by Hopkinson and Trevor-Williams' work, has been determined. If the constant giving the area of the loop from its principal dimensions, which has been determined here for torsional cycles, be substituted for the conjectural constant used by them, the result is to bring the hysteresis of their static cycles into almost exact agreement with that which they found at high speeds. It also appears that in a hard drawn steel tube, the hysteresis is for all stress-ranges only about one-eighth of the hysteresis in the same tube after it has been softened by annealing. In the annealed tube the loss per cc per cycle varies approximately as the cube of the stress-range. In an unannealed steel bar Hopkinson and Trevor-Williams found at higher stresses that the loss in their experiments varied as the fourth power of the stress-range.

PP: 3 D 5 F G 10 11 13 16 S T 19 AA 29 36 h CV: 14 MI: ST CN

1914

Grammel, R.

Recent Experiments on Elastic Hysteresis. (In German)

Zeit. Ver. Deut. Ing., Vol. 58, p. 1600, November 28, 1914
Also Jour. Am. Soc. Mech. Eng., pp. 115-116, February 1915

The phenomenon of elastic hysteresis in solid bodies is discussed. The author claims that by the application of especially delicate methods of observation it has been found that the proportionality between deformation and force applied, as expressed by the Hooke law, does not hold good exactly, and one can not strictly speak of the reversibility of the process. It may be explained that the deformation lags behind the force so that if the point of reversal be suitably selected, a closed curve process can be produced. The author presents the data on elastic hysteresis obtained by Professors Hopkinson, Trevor-Williams, and F. E. Rowett in their tests in the Engineering Laboratory which were published in the Proceedings of the Royal Society of London, Ser. A., Vol. 87, p. 502 and Vol. 89, p. 528.

PP: AA CV: 13 15 17

Lindsay, G. A.

A Study of the Longitudinal Vibration of Wires

Physical Review, Vol. 3, pp. 397-438, 1914

Sections: Introduction II. Elongation of the Wires. Apparatus. Instantaneous Recovery. Lever Systems for Measuring Recovery. Instantaneous Recovery Independent of Period of Deformation. Temperature Change Due to Loading and Unloading. Variation of Instantaneous Recovery with Temperature. Rapidity with Which the Wire Regains Normal Temperature. Results for Elongation. III. Determination of Frequency of the Vibrations. Apparatus. Measuring the Free Period. Relation of Frequency to Amplitude. Free and Forced Vibrations. Variation of Frequency with Mass. IV. Derivation of the Period. Solution of the Equation. Computation of Constants. Computation of Frequency for Wires

Obeying Hooke's Law. Comparison of E from Static and Dynamic Observations. V. Discussion of Results. Possible After-Effect in All the Wires. Influence of the After-Effect on the Period. VI. The Damping of Longitudinal Vibrations. Apparatus. Variation of the Logarithmic Decrement. Cause of Damping. Correction for Air Damping. The Platinum-Iridium Wire. Variation of Period with Amplitude. VII. Summary.

PP: C D E 9 M 16 S 19 X Y AA 30 CV: 14 15 17
MI: ST CN EG Cu c 40 43 s

Guye, C. E. and Vassileff, S.

Variation with Temperature of Internal Friction of Glass. (In French)

Arch. Sci. Phys. Nat., Vol. 37, pp. 214-215, March; pp. 301-323, April; 1914

This paper describes the experimental determination of the coefficient of internal friction of glass by decrement observations on oscillations performed by a torsion pendulum vibrating in a partial vacuum and maintained by electrical means at various constant temperatures lying between 18° and 360°C. Experiments were made with ordinary, Jena, and lead glasses, the threads being of drawn glass in each case and examined for anisotropy both before and after the experiments by a polarisation microscope. The oscillations were recorded photographically. From an examination of the photographic records of the oscillations an approximate determination of the coefficient of damping could be determined. The coefficients of friction thus deduced were: for Jena and lead glasses, both at 360°C, it was 7.6108 and 13.4028 respectively; for ordinary glass at 310°C, it was 7.2375. The variation of decrements with temperature and for a small range of frequencies was examined.

PP: 3 D 9 13 R U AA 27 CV: 13 14 MI: KK

Stromeyer, C. E.

The Determination of Fatigue Limits Under Alternating Stress Conditions

Proc. Roy. Soc. London, Ser. A, Vol. 90, pp. 411-425, 1914

Tests were made on tool steel, Mn steel, Cr-Ni steel, cast iron, rolled Ni, Cu, phosphor-bronze, and rolled Al. Results are shown. Stromeyer studied the character of the heat evolved by a specimen of metal subjected to alternating stresses in order to develop a calorimetric method of determining the fatigue limit. It was found that up to a certain range of stress, no evolution of heat from the specimen was observed, but when a certain stress had been exceeded a definite evolution of heat became perceptible. If the stress range was still further increased, the rate of heat was taken as the fatigue limit.

PP: 3 F G 10 13 16 S AA 29 42 r CV: 14
MI: ST AY TS CI Al Cu Ni c p r s

References for 1915-1919

1915

Jordan, H.

Disturbance of Elastic After-Effect by Elastic Hysteresis. (In German)

Berichte der Deutsch. Phys. Gesell., Verh. 17, Nr. 23, pp. 423-436, December 15, 1915

The results of other workers are reviewed and elastic after-effects are proposed as being the cause of self-damping of oscillations. Aluminum, iron and zinc were examined, the least complex behavior being exhibited by aluminum and the most by zinc. While data given by aluminum were in accordance with theory, iron gave simple after-effects which, while proportional to the logarithms of the time, were also dependent on other factors. The divergence for iron was much greater than for aluminum. This disturbance was found to be due to hysteresis.

PP: AA 30 b 42 q CV: 13 15 MI: Al Fe Zn a

Koch, K. R. and Dannecker, C.

Variation with Temperature of the Elasticity of Metals and Alloys from 20°C to Near Their Melting Points. (In German)

Annale d. Physique, Vol. 47, pp. 197-226, 1915

Differences were manifest in investigations on the influence of temperature on the elastic properties. Here, as with tenacity and notch-sensitivity, maxima and minima were found when curves of damping and frequency of resonance were plotted on a temperature base.

PP: 3 E 8 10 13 16 U X AA 42 q 44 s CV: 13 14
MI: EG Ag Al Cu Fe Mn Ni Pb Sn Zn a c 35 36 42 43 s

Smith, J. H. and Wedgwood, G. A.

Stress-Strain Loops for Steel in the Cyclic State

Jour. Iron and Steel Inst., Vol. 91, pp. 365-397, 1915

Experimental work on the fatigue of steel has been continued by subjecting test-pieces to a given alternating stress range and simultaneously applied mean stresses which were varied between certain limits. Under these conditions it has been found that the mean strain is proportional to the mean stress up to a certain point, just as in the ordinary static tests. Beyond this point there is a distinct yield, and the ranges determined in this manner are spoken of as the "yield ranges." It has already been suggested in an earlier paper that these yield ranges are identical with the Wöhler limiting ranges, and the method therefore provides a rapid way of determining values which can only be determined otherwise by a prolonged series of experiments. A material is said to be in the cyclic state when its yield stress in tension and compression are equal. The results of a large number of experiments carried out on very mild steels indicate that the effect of yield is to lower the Bauschinger range. During a period of rest the Bauschinger range gradually recovers; the material always returns to the primitive state. In the primitive state this range is always unstable. If a material be subjected to alternating stresses whose mean value is other than zero and yield does not occur, then the alternating stress range is an elastic one but if a yield range is the maximum possible elastic range for that mean stress. (Sci. Abs., A. No. 1169, 1915)

PP: 3 5 14 R S T X AA 28 42 r CV: 14 MI: ST CN g j

Warburg, E. and Hense, W.

Elastic "After-Effect" and Hysteresis. (In German)

Deutsch. Phys. Gesell., Verh., Vol. 17, Nos. 11 and 12, pp. 206-213, June 30, 1915. Communication from Physikal-Techn. Reichsanstalt

Experiments were made by loading plates of steel, German silver and ebonite, and taking these round a cycle of loads at two widely different speeds. In German silver with a half-period of 160 minutes, the true hysteresis effect is much greater than that due to the "after-effect", while in ebonite this is not so. The effects in steel are too small for any conclusion to be drawn.

PP: 3 5 16 19 AA 42 q CV: 13 14 MI: ST CN KK Ag

1916

Guye, C. E. and Einhorn-Bodzechowski, M.

Internal Friction of Quartz Filaments at Low Temperatures. (In French)

Arch. Sci. Phys. Nat., Vol. 41, pp. 376-400, pp. 457-468, 1916

A mirror was suspended on a quartz fiber surrounded by a case immersed in a thermostat. Determinations were made of the logarithmic decrement of the fiber, and of the influence of temperatures of 17°, 0°, -79°, and -194° on this decrement. Further work, and an interpretation of the results are given in the second portion of the paper.

The experiments deal with the influence of temperature and amplitude on the logarithmic decrement of the vibrating filament. Cooling to -194° produces a permanent modification of the physical or chemical structure of the quartz filament which shows itself by a permanent increase in the logarithmic decrement. After this change has once been produced, the value remains constant between 20° and -194°, the whole temperature range covered. The decrement diminishes rapidly with falling temperature down to -79° after which there is little change. The 2nd modulus of elasticity of quartz decreases 2 to 3.5% when the temperature is lowered from 0 to -194°. Only a feeble influence is exerted by changing amplitude. When glass filaments are cooled to -194° and brought back to 20° they regain the original value of the decrement, and show no change with time for any temperature. At 20° and 0° the decrement is large and independent of the period of vibration; at low temperatures it is smaller and changes with the period. The 2nd modulus of elasticity of glass increases about 3% at -194°.

PP: 3 D 9 16 S U AA 42 q CV: 13 14 MI: LL

Mason, W.

Stress Distribution in Engineering Materials

Engineering, Vol. 102, pp. 268-270, September 15, 1916

The results show that when the range of cyclic strain in alternating torsion tests is not entirely elastic, the range of nonelastic strain varies with change of cyclic frequency to a very large extent. After rest the elasticity is apparently recovered.

PP: 13 16 S T 19 AA 28 42 q CV: 14

1917

Guest, J. J. and Lea, F. C.

Torsional Hysteresis of Mild Steel

Proc. Roy. Soc., Ser. A, Vol. 93, pp. 313-332, 1917

The general failure to establish clearly the existence of a hysteresis loop for mild steel stressed alternately in tension and compression, and the difficulty of reversing stresses readily from tension to compression, suggested the desirability of making an accurate and sensitive torsion machine, in which a specimen could be subjected to pure torsion in either a clockwise or anti-clockwise direction, and in connection with which angular strains could be measured with very great precision. Such a machine is described in this paper. Spec. 7/8 in. dia. and 16 in. long have been used in this research on 0.15% C steel.

From a considerable number of tests typical examples have been selected illustrative of the various points investigated in the course of the experiments: (1) the existence of hysteresis loops at low loads; (2) their relation to those loads over a wider (but elastic) range and to small loops at high average stress; (3) the effect of plastic overstrains, of rest, and of mild heat treatment.

The particulars given in this paper are but a commencement of the researches it is proposed to carry out, but they clearly demonstrate the existence of a hysteresis loop at stresses considerably below the generally accepted elastic limits for mild steel, and they further show the beneficial effect of rest and of mild heat treatment.

PP: 3 13 16 S T AA 28 36 h k CV: 14 MI: CN g j

Mason, W.

Alternating Stress Experiments

Engineering, Vol. 103, pp. 187-190, 1917. Also Jour. Inst. Mech. Eng., Vol. 4, pp. 121-159, disc. 159-196, February 1917

The main feature of these experiments is the systematic measurement of cyclic strains during complete alternating stress tests. The tests were on mild steel in alternating torsion and in alternating bending.
PP: 3 12 13 AA CV: 14 MI: CN j

1918

Schlink, F. J.

Study of Mechanical Hysteresis Will Advance Our Knowledge of Materials

Eng. News-Record, Vol. 80, pp. 1035-1037, May 30, 1918

Hysteresis is defined as the lag of strain behind the stress in cyclic loading. It appears that failure under repeated stress may be related to the loss of energy in stress. Hysteresis as a source of error in measuring instruments is discussed and some effects of mechanical hysteresis appear analogous to this type of action. The need for high hysteresis in airplane shock absorbers and the need for dashpot action as a desirable quality are dealt with. The author ventures the opinion that in the field of mechanical hysteresis and elastic after-effect there is much of striking interest and value to the engineer that can be gained by moderate expenditure in research.
PP: W AA 29 42 q CV: 15 17

1919

Ishimoto, M.

Investigation of Metals with Regard to Their Internal Friction

Proc. Math. Phys. Soc. Japan, Ser. 3, Vol. I, pp. 267-276, 1919

Using tuning forks and torsion pendulums the variations of the internal friction of metals with temperature were investigated and the results are given in the form of curves and tables. The characteristic curve of pure iron has a minimum at 65° and a maximum at 183° (heating) or at 170° (cooling). At about 260° the abnormal change ceases and above this point up to 500° the curve is represented by a straight line with a downward slope as the temperature increases. These maximums and minimums have never been observed before. The form of the curve is altered by the presence of carbon, especially in the vicinity of the maximum. The minimum point is not influenced by the presence of carbon. Quenching had little effect on the form of the curve. The curves of Brinell hardness are practically parallel to those of internal friction. The curves for Ni, Ag, Al, and Cu were also determined and nothing unusual was found.
PP: 3 12 13 16 U AA 27 g h 42 s CV: 12 14 MI: Ag Al Cu Fe Ni a

1920

Dalby, W. E.

Researches on the Elastic Properties and the Plastic Extension of Metals

Philosophical Trans., Roy. Soc. London, Ser. A., Vol. 221, pp. 117-138, 1920

This is a continuation of the author's previous work with special reference to the load-extension and loop diagrams. Hysteresis loops have been recorded for metals under the conditions of repeated tensile loading. In the case of aluminum it was recorded that no loops were obtained for an aluminum alloy, even when the limit of proportionality had been greatly exceeded. When iron or mild steel is overstrained it returns to the perfectly elastic state with remarkable rapidity by mere boiling in water. High carbon and alloy steels do not recover either by resting for many months or boiling. Reheating to 550°C caused the entire recovery of elastic properties of an overstrained 3% Ni steel. The interruption of the tensile test with the removal of the load results, if the metal has been stressed beyond the limits of proportionality, in an unproportional shrinkage rather greater than the previous elastic extension. When the load is reapplied, extension is no longer proportional to the load, and a loop is formed in the stress-strain curve. If this process is continued, each successive loop is slightly greater than the preceding one. This applied to mild, high carbon, and alloy steels. In the case of zinc, copper, and tin, there is no true elastic limit, and on the removal of the load shrinkage proceeds for some time under no load. The relatively slow rate of increase of the area of the loop in the case of copper is noteworthy. An aluminum alloy is of special interest in that the diagrams show no looping. It appears as though the metal continuously anneals itself as the plastic stretching proceeds at ordinary temperatures. The area of the loop appears to tend towards a maximum value for each material. In iron and mild steels the time factor is of great importance, but the harder steels are comparatively little affected. Even here, however, there appears to be a slight change proceeding during the first few moments after the removal of the load, after which further change is negligible. When stressed under a constant load about the elastic limit a series of loops can be produced which decreases at first and tend towards a constant minimum value. That the limiting fatigue stress has for its positive value the stress equal to the limit of proportionality, is shown in the case of iron. The average value of the limiting fatigue stress for 24 million revs. is 11.75 tons per sq. in., while the limit of proportionality was 11.45 tons per sq in. (Sci. Abs. A, 1520, 1920).
PP: 3 5 M AA 28 g h 42 q CV: 14
MI: ST CN AY Al Cu Fe Sn Zn j g

Iokibe, K. and Sakai, S.

The Change of Rigidity and Logarithmic Decrement of Different Metals by Heating

Proc. Phys. Math. Soc. Japan. Ser. 3, Vol. 2, p. 93, 1920

It is concluded that (1) the rigidity decreases with a rise of temperature at first slowly and then rapidly, tending to become zero at the melting point. (2) The logarithmic decrement of fusible metals increases rapidly with a rise of temperature. For metals having a high melting point it decreases slightly at first, and after passing through a minimum, begins to increase, its rate becoming always greater with the rise of temperature. (3) For ferromagnetic metals having transformation points, logarithmic decrement temperature curves show a correspondingly abnormality.
PP: 9 16 U X AA 42 q CV: 12 14
MI: SG n p

Whitby, G. S.

Plantation Rubber and the Testing of Rubber. (Book)

London, 1920

This book gives an excellent summary on the subjects of relaxation, hysteresis, and elastic after-effect in rubber.
PP: AA 42 q CV: 15 16
MI: GG

1921

Hersey, M. D.

Theory of Irreversible Time Effects

Washington Acad. Sci., J., Vol. 11, pp. 149-155, April 4, 1921

The study of irreversible phenomena has never been carried far in comparison with other aspects of physics. This paper aims to formulate the problem of time effects -- meaning transient or recoverable effects as distinguished from permanent changes -- and to develop methods of analysis for use in subsequent research. Among the irreversible time effects discussed are the elastic after-effect with torsion and magnetic hysteresis.
PP: 13 AA 30 d 42 q CV: 17

Honda, K. and Konno, S.

On the Determination of the Coefficient of Normal Viscosity of Metals

Phil. Mag., Vol. 42, pp. 115-123, 1921

The following values (x 10-8) are obtained: -aluminum rolled, 0.822; aluminum annealed at 400°C., 1.25; zinc rolled, 27.4; zinc annealed at 200°C., 9.27; silver annealed at 400°C., 2.24; magnesium, hammered, 1.61; magnesium annealed at 400°C., 0.722; nickel rolled, 3.05; brass, 59: 39.5 rolled, 1.55. The large value of the coefficient of viscosity in the case of zinc is to be expected from its low melting point, since the viscosity increases rapidly on approaching the melting point. Annealing diminishes the viscosity. In carbon steels, the coefficient of viscosity increases with the carbon content. The coefficients of normal and tangential viscosity are of the same order of magnitude.
PP: 3 D 9 10 11 12 16 S AA 36 h CV: 14
MI: CN Ag Al Cu Mg Ni Zn a n

Iokibe, K. and Sakai, S.

The Effect of Temperature on the Modulus of Rigidity and on the Viscosity of Solid Metals

Phil. Mag., Ser. 6, Vol. 42, No. 249, pp. 397-418, September 1921

For thirteen different metals, both rigidity and logarithmic decrement at ordinary and high temperatures were measured. As the temperature rises, the rigidity of these metals decreases according to a parabolic law. In the case of metals having low melting-points, this diminution of rigidity is very rapid, tending to zero at their melting-points. For metals having high melting-points the initial diminution of rigidity is small, but as the temperature becomes higher, the diminution is more and more rapid. The logarithmic decrement increases with the amplitude of oscillation; this increase is greater as the temperature becomes higher. The variation is partly due to the amplitude of oscillation being not sufficiently small, and partly to the loss of energy through the point of suspension. The logarithmic decrement rapidly decreases with the suspended weight. The logarithmic decrement of different metals increases with the rise of temperature, except in the case of metals having a high melting-point. In the case of the latter it decreases at first, reaches a minimum, and afterwards increases rapidly. In ferromagnetic substances the logarithmic decrement, and also the rigidity in a somewhat less degree, are affected by the magnetic transformation, in the sense that they are decreased by that transformation. (From authors' conclusions)
PP: 3 D 9 10 11 13 14 16 S U X AA 30 d 36 37 n CV: 14
MI: CN EG Ag Al Cu Fe Ni Zn a c 36 q 44 s

1922

Gough, H. J.

Elastic Limits of Copper Under Cyclical Stress Variations

Engineering, Vol. 114, pp. 291-293, September 8, 1922

In these tests reversed bending stresses were used and the results are in agreement with Bairstow's work on steel. A very definite value of the fatigue range of ±5.5 tons/inch^2, was first determined by the usual endurance tests. The elasticity of the material under repetitions of a range of ±4.7 ton/inch^2 is shown in graphical form. Large hysteresis loops are first obtained. With the applications of cycles of stress these loops diminish rapidly, and after 406,900 reversals the material has become sensibly elastic, as consistent with elastic hysteresis, the readings taken after 2,812,200 reversals showing that this condition persists.
PP: 3 5 12 16 T X AA 29 42 r CV: 14
MI: Cu a

Gumbel, L.

Torsional Vibration and Its Damping. (In German)

Z. d. V.D.I., pp. 252-256, 281-283, 1922

Initially the problem of determining vibrational amplitude and phase of any elastic specimen with outside and internal damping forces under the influence of periodic forces is solved in general. The solution is applied to the calculation of the effect of different damping arrangements, and it is illustrated with a number of examples.
PP: 13 Y AA CV: 13 17

Lees, S.

On a Simple Model to Illustrate Elastic Hysteresis

Phil. Mag., Vol. 44, pp. 511-537, September 1922

The author has here described a simple model which would seem in many ways to bring out, at least qualitatively, many of the general effects observed in connection with elastic hysteresis. The ultimate standpoint is that such effects are due to something analogous to the ordinary solid friction of everyday life. The model enables some simple deductions to be drawn of a mathematical character, but no attempt is made to push these deductions unduly, since (involving one dimension of displacement) it can only roughly represent what is essentially a question of statistics, involving slippings in all conceivable directions. The paper is largely mathematical and contains a number of diagrams showing the model or the displacements in question. (Sci. Abs., A, 2, 1923).
PP: AA 30 34 CV: 17

Ludwik, P. and Scheu, R.

The Variability of Materials Damping. (In German)

Zeit. des Vereins Deutscher Ingenieure, Vol. 76, pp. 683-685, 1922

In tests on various steels the authors measured the area of the hysteresis loops after intervals of applied stress cycles, and noted the behavior obtained.
PP: 3 5 16 T AA CV: 13 14
MI: ST

Dalby, W. E.

Further Researches on the Strength of Materials

Phil. Trans., Roy. Soc. London, Ser. A, Vol. 103, pp. 8-25, 1923

This paper describes a modification of the testing machine (previously described) and the elastic recorder, so that records can be taken of alternate loading between tensile and compressive limits. The outstanding features of the diagrams outlined are, that during the removal of a load after overstrain, the material responds in an elastic manner although the elasticity is imperfect; that during the increase of load of opposite sign to that of the load removed, although at first the response of the material is approximately elastic, plastic extension is combined with it and the plastic extension readily increases until a yield load is reached, after which the extension is almost wholly plastic at a constant or slightly increasing load. A new instrument, the elastic twist recorder, is also described and is used for recording the torque and the elastic twist which it produces on a suitably formed test piece. Comparing the records obtained by the elastic twist recorder with push-and-pull records, there is a striking similarity of form. Both show: an elastic line and a limit of proportionality; a definite yield of the material followed by plastic flow; an imperfect elasticity as torque is reversed in sign.

PP: 3 5 M 13 P AA 29 30 b 42 q CV: 14
MI: ST CN j

Föppl, O.

Rotating Bending Fatigue Strength and Damping Capacity. (In German)

Werkstoff Berichte No. 36, Verein Deutscher Eisenhüttenwesen, 1923

Abstract not available.

PP: AA 29 42 r CV: 13

Gough, H. J. and Hanson, D.

The Behaviour of Metals Subjected to Repeated Stresses

Proc. Roy. Soc., A., Vol. 104, pp. 538-565, 1923

The authors investigated the elasticity of Armco iron subjected to reversed bending stresses; it was found that, under a range of stress less than the limiting range, the hysteresis loop quickly attained a steady value which persisted unchanged for thirty million reversals. This seems to be the greatest number of reversals during which observations of hysteresis effects have been made, and may be taken as sufficient evidence that elastic hysteresis is a state of imperfect elasticity consistent with indefinitely large endurance. Other specimens endured one hundred million reversals of the same range of stress without fracture.

PP: 3 5 12 16 T AA 29 30 42 q CV: 14
MI: Fe a

Haigh, B. P.

Energy-Theory of Mechanical Fatigue and Hysteresis in Metals

Report to Aeronautical Research Committee; Report Brit. Assoc., 1923

No abstract available.

PP: AA 42 r CV: 17

Hort, W.

Fatigue Strength by High Frequency Stressing. (In German)

Maschinenbau, Heft 27, Vol. 13. 11. 24. /3. Jahrg. 1923/24

Investigates fatigue strength at high loading frequencies. The results of damping tests on turbine blades are shown. The special apparatus employed is explained. Actual blades were vibrated by electrical means. Decay curves were recorded photographically at the end of the forced vibration period.

PP: 3 D 9 12 16 S 19 AA 42 r CV: 13 14 MI: AY q

Kimball, A. L.

Internal Friction Theory of Shaft Whirling

Physical Review, Vol. 21 (second series) p. 703, June 1923

It is shown on theoretical grounds that an internal friction action, due to progressive bending in a rotating shaft, may cause the shaft to whirl at any speed above the resonant or first critical speed. The equations of motion of the shaft are derived for an ideal case taking account of internal friction, and solutions are obtained giving the motion of the shaft in the final state. No assumption is made as to the cause of internal friction. It may be due to a molecular friction producing a damping action in the shaft itself, or to a friction at its surface due to a working of the shaft in rings or other parts of the rotor which may be shrunk on to the shaft. Substantiation of the theory was obtained from experiments with a model shaft so built up as to have a large capacity for internal friction.

PP: 3 4 N Y AA 30 34 CV: 15 17

Mason, W.

The Mechanics of the Wöhler Rotating Bar Fatigue Test

Engineering, pp. 698-699, June 1, 1923. Also, Aeronautical Research Committee, Reports & Memo. No. 838, 1923

The relation between later deflection and deflection in the plane of bending of a Wöhler rotating bar is briefly discussed, and an attempt is made to ascertain if there is a constant ratio between lateral deflection and width of the hysteresis loop. It is concluded that this ratio is determinate for specimens of steel affected only by elastic hysteresis; but for partially elastic or non-elastic conditions the ratio appears to depend on the shape of the hysteresis loop. The work done on the bar per cycle is shown to be equal to $2\pi G\phi$ where G is the couple imposed on the chuck which holds the rotating bar, and ϕ is the inclination of the plane of this couple to the axis of the chuck. The work done on the bar during the whole, or during any stage of the test may be found if ϕ is continuously measured. (From author's summary)

PP: 3 4 G 11 N AA 29 CV: 17

Stanton, T. E.

Friction. (Book)

First Edition, Longmans, Green and Co., New York, 1923

This book gives a complete discussion of the various types of damping forces.

PP: 23 AA BB CC CV: 16

Bennewitz, K.

On Elastic After-Effect, Elastic Hysteresis, and Internal Friction. (In German)

Physikalische Zeitschrift, Vol. 25, pp. 417-431, 1924

Taking the effect of a force varying with time according to the law G(t), acting upon an ideal "afterworking" substance as given by $\beta' \int \frac{G(t)dt}{t_a - t+r}$ at time t_a, the elastic properties of the substance are found to depend upon two constants, β' and $\gamma = -\log_{10}$.

The effects of V and sine wave form for G are worked out in detail and formulas connecting β and γ with measurable quantities are thus obtained. In particular, it is found that the ratio of the energy lost per cycle in a vibrating elastic body, due to hysteresis, is a definite fraction of the average values of the energy, and the γ can be found from this ratio, which can itself be found from the logarithmic decrement of the vibration.

PP: G Y AA 42 q CV: 13 17

Busemann, A.

The Damping Capacity of Iron and Steel Specimens Under Torsional Vibration. (In German)

Dissertation, Braunschweig, 1924; Bericht n. 60 des Werkstoffausschusses des Vereins deutscher Eisenhüttenleute, e anche a Düsseldorf

No abstract available.

PP: 13 AA CV: 13 14
MI: ST CN CI

Föppl, O.

Torsional Fatigue Strength and Damping Capacity of Engineering Materials. (In German)

Schweizerische Bauzeitung, Vol. 83, No. 2, pp. 17-20, 1924

The torsion method of determining damping is illustrated. The damping capacity of construction material is discussed in general. Eleven criteria for running torsional vibration investigations are offered. Criticism is made on different processes employed in vibration investigations. The results of the present study are presented in tabular form.

PP: 3 4 13 AA 42 r CV: 13 14 15

Föppl, O.

The Torsion Machine, a New Testing Machine for Determining the Properties of Materials. (In German)

Zeitschrift Vereines Deutscher Ingenieure, Vol. 68, No. 9, pp. 203-205, March 1924

There is a new property of materials called damping capacity, which is displayed during torsional vibrations. By means of the proper diagrams the dependence of damping on shear stress may be shown. Such curves indicate the practical usefulness of the material.

PP: 3 5 G 9 13 16 S AA CV: 13 14 MI: CN AY d j r

Gough, H. J.

The Fatigue of Metals. (Book)

D. Van Nostrand Co., Inc., New York, 304 pp., 1924

This includes a discussion of the damping tests of Sir. W. Thompson (p. 4), those of Hopkinson, Williams, and Rowett (pp. 130-131), and Boudouard and Dalby (pp. 207-208). The works of Bairstow and the author on obtaining hysteresis loops are described (pp. 123-129) along with other experiments in the chapter dealing with various theories of fatigue failure and associated phenomena (pp. 175-203). The relation of damping to fatigue is covered.

PP: AA 42 r CV: 15 16

Gough, H. J., Hanson, D. and Wright, S. J.

The Behavior of Single Crystals of Aluminum Under Static and Repeated Stresses. Parts 1, 2, 3

Aeronautical Res. Com., Rep. & Memo, No. 995, 1924; Phil. Trans. Roy. Soc. A, Vol. 226, pp. 1-30, 1926

Metals as ordinarily used in practice are in the form of "crystalline aggregates" made up of large numbers of small crystals separated by boundaries. Little or nothing is known of the influence of these boundaries on the observed fatigue phenomena. This report deals with the results so far obtained from tests on test pieces cut from single crystal bars of aluminum.

The report deals with the changes in microstructure and the deformation and fracture of single crystals of aluminum subjected to (1) rapid reversals of direct stresses; (2) reversals of torsional stresses; (3) slow cyclic repetitions of tensile stresses and (4) single blow impact-tensile tests.

Mechanical, microscopical and X-ray methods have been employed and the results of all three methods of investigation have been correlated.

PP: 3 5 M 16 T AA 28 36 j 42 r CV: 14
MI: Al a

Kimball, Jr., A. L.

Internal Friction Theory of Shaft Whirling

General Electric Review, Vol. 27, No. 4, pp. 244-251, April 1924

The idea of forces, viscous in nature, resisting the change of elastic distortions, is applied to explain the phenomena in whirling shafts. It is shown that the internal friction due to bending may cause a shaft to whirl when rotating at any speed above the first critical speed.

PP: 3 4 N Y CV: 17

Lesch, P.

The Influence of Internal Damping on Impact Strength. (In German)

Zeit. f. angewandte Math. und Mech., Vol. 4, pp. 124-142, 1924

This is a mathematical analysis on the influence of internal damping upon the strength of material with regard to transverse thrust. The article deals with the energy equation, motion equation, calculation of thrust effect, determination of dissipation coefficient, etc. The situations of both simple beams and cantilever beams were considered. Also treated is a beam with a slight deflection.

PP: 3 7 12 16 S Y AA 30 34 42 s CV: 13 17

Newkirk, B. L.

Shaft Whipping

General Electric Review, Vol. 27, pp. 169-178, 1924

A form of vibration which has proved troublesome in the operation of blast furnace compressors was analyzed and found to resemble the motion of a shaft as given by a well known solution of the differential equations of undamped shaft motion. The dominant motion in this case corresponds to the terms in the solution which are independent of the unbalance, which motion is assumed to disappear rapidly due to damping. A stimulus producing this motion was found to arise from a cramping of the shaft by sleeves or hubs which grip the shaft. It was found that in some cases this whirling would build up of its own accord and that in others a shock was necessary to start it. It was found that the cause mentioned above would not build up a whirl or "whip" when the rotor was running below its critical speed, but that with sufficient cramping the whipping would build up with a rotor running at any speed above the critical. It was found that the damping resistance to the vibration applied at any point along the shaft would suppress the whip; also that flexibility in the bearing supports with no more than the unavoidable damping incident to the flexibility of support would prevent whipping. (From author's summary)

PP: N W Y CV: 14 17

Prescott, J.

Applied Elasticity. (Book)

Longsman, Green and Co., N. Y., pp. 42-46, 1924

The empirical basis of elasticity is discussed. Hooke's law and the yield point are treated. The property of a solid which causes the damping of a vibrating body is viewed as being due to the viscosity of the solid which is assumed similar to the viscosity of a fluid. Elastic fatigue of solids due to alternating loads is discussed. The theories of elastic failure are briefly mentioned.

PP: AA 30 d 42 r CV: 16

Wydler, H.

Torsional Vibration in Reciprocating Engines and the Law of Their Compensation. (In German)

Springer, Berlin, 1924

Author assumes that the damping forces are proportional to the frequency or the rate of oscillation and on this basis calculates certain damping coefficients.

PP: 13 16 19 Y CV: 13 16 17

1925

Becker, R.

Elastic After-Effect and Plasticity. (In German)

Zeit. f. Physik, Vol. 23, pp. 185-213, 1925

The subject is treated in four sections: (1) the Boltzmann theory; (2) plastic inhomogeneity as cause of the after-effect; (3) quantitative investigation of von Wartenburg theory; (4) consideration of the actual plastic properties of metals. It would appear from the theoretical formula that the damping decreased at increasing frequencies as the formula was

$$\delta = \beta \cdot \frac{\pi 2}{2} \cdot \left(1 - \frac{2}{\pi} - \text{Tang } \frac{V}{R}\right)$$

Where β denoted the after-working constant (< 1), $1/R$ the time of relaxation (i.e. decrease of loading with lapse of time) and $V = 2\pi f$ (where f was the frequency.)

PP: AA 30 d 42 q CV: 13 17

Chevenard, P. and Portevin, A.

Elasticity of Alloys. Variation with Chemical Composition. (In French)

Comptes Rendus Acad., Vol 181, pp 780-782, 1925

Curves are given which exhibit the changes in the elastic modulus μ, its temperature coefficient $(\delta N / \delta \theta)/\mu$ and decrement, for binary metallic alloys at ordinary temperature. The cases are distinguished in which the alloys are constituted of aggregates of two phases and those of solid solution or one phase of variable concentration. It is concluded that the elastic modulus of an alloy varies as an almost linear function of chemical composition and it is affected only in a secondary way by the structure of the alloy. It is considered that the value of the modulus cannot be increased to the same extent as the tenacity or hardness by alloying or other treatment. Variation of the decrement with composition deviates from linear law especially in solid solutions which approximate to pure metals. (Sci. Abs. A, 879, 1926)

PP: 3 D 9 16 U X AA 36 37 42 q CV: 13 14

Föppl, O.

Determination of the Properties of Special Engineering Steels by Means of the Torsional Vibration Machine. (In German)

Maschinenbau, Vol. 4, No. 11, pp. 515-521, 1925

The damping capacity of construction materials is a very important property which requires careful determination. Data are given here in curve form as a function of stress for different constructional steels. The criteria for the establishing of induced decay under the application of damping are given, which may be more important in practical use than fracture strength. (Author's abstract)

PP: 3 D 13 16 S AA 42 s CV: 13 14
MI: ST CN AY

Föppl, O.

The Technical Meaning of the Damping Capacity of a Structural Material. (In German)

Schweizerische Bauzeitung, Vol. 86, pp. 281-285, 1925

No abstract available.

PP: W AA CV: 13 17

Howard, J. V. and Smith, S. L.

Recent Developments in Tensile Testing

Proc. Roy. Soc. London, Ser. A, Vol. 107, pp. 113-125, 1925

The researches described here were undertaken to investigate the factors influencing the formation of direct stress-strain loops resulting from the application removal and reapplication of a tensile load, at such a maximum stress as to result in the condition of non-proportional elasticity. The effects of variations in composition on the looping properties is also studied with special reference to tests on steel. The paper is in the nature of a summary of much experimental work. Topics discussed are: recoverable slip dependent only on stress, mean loop as a measure of recoverable slip, looping at constant load, effect on the quality factor of variations in the composition and heat treatment of steel, and overstrain followed by rest.

PP: 3 5 M 16 T 36 37 CV: 14
MI: ST CN

Kimball, Jr., A. L.

Internal Friction as a Cause of Shaft Whirling

Phil. Mag., Ser. 6, Vol. 49, No. 292, pp. 724-727, 1925

Many articles have been written upon causes of the whirling of shafts, but, so far as the writer is aware, it is only within the last year that the internal friction within the shaft, or within the rotor itself has been suggested as a cause of whirling.

In this paper it is shown that under the right conditions internal friction will sustain a whirl rather than damp it out. No assumptions are made as to what laws the internal force obeys, as they are not well understood. The important fact is that this disturbing force must exist if internal friction is present, and that the force may produce whirling. (Author's abstract)

PP: 3 4 N W Y CV: 17

Lehr, E.

Short Time Testing Methods for Determining the Fatigue Strength of Materials

Dissertation, Darmstadt, 1925

It is concluded that, at its fatigue limit, a given material can only develop a certain characteristic hysteresis loss per unit volume per cycle without eventually breaking.

PP: 3 5 G AA 29 42 r CV: 13 14

Lewis, F. M.

Torsional Vibration in the Diesel Engine

Trans. Soc. Naval Arch. & Mar. Eng., America, Vol. 33, pp. 104-105, 1925

The method developed for assessing the severity of the conditions at the several critical speeds depends upon the fact that at resonance the vibrational energy given to the shaft by the periodic forces is absorbed by the damping forces alone. The relative value of the input energy for a particular vibration form can be estimated with fair accuracy for each critical speed.

PP: 3 E 13 AA BB CC CV: 17

Polanyi, M. and Sachs, G.

Elastic Hysteresis and Internal Stresses in Bent Rock-Salt Crystals. (In German)

Zeit. f. Physik, Vol. 33, Vol. 9, pp. 692-705, 1925

Variations of the limits of elasticity of rock-salt under normal temperature conditions and when heated to 600° C are found to be 500 grs. and 200 grs. per sq. mm. respectively. With plastic deformation elastic hysteresis effects occur, and the resulting variations are not proportional to the stress. In plastic strained crystal movements of the surface layers occur, demonstrating the existence of internal stresses.

PP: 16 U AA 30 b CV: 13 14
MI: LL

Quimby, S. L.

On the Experimental Determination of the Viscosity of Vibrating Solids

Physical Review, Vol. 25, pp. 558-573, April 1925

Specimen bars are excited to longitudinal vibration by means of a high-frequency electrical field impressed on a piece of piezo-electric quartz cemented to one end of the bar. The experimental curves for hard-drawn copper, aluminum and glass are in good agreement with those deduced from theory. The values found for the viscosities of these are aluminum 545, copper 2,880 and plate glass 2,440 c.g.s. units.

PP: 3 E 10 M 13 16 S AA 30 d 36 k CV: 14 MI: KK Al Cu

Subrahmaniam, G. and Gunnaiya, D.

Variation of Logarithmic Decrement with Amplitude and Viscosities of Certain Metals

Phil. Mag., Ser. 6, Vol 49, No 292, pp. 711-724, 1925

With a view to determine the absolute coefficients of viscosity of certain liquids by oscillating a wire of "easy" shape, the authors have used a fine copper wire as suspension and have noticed remarkable variation of logarithmic decrement with amplitude. The results are not quite in agreement with those obtained previously by others, and could not therefore be

represented by any one of the empirical formulae proposed. They have instituted a series of experiments to study, at some length, the nature of variation of logarithmic decrement with amplitude and, if possible, to correlate it with other elastic properties of the material. Results of their experiments are set forth in the first instance for copper, brass, and steel wires. They concluded that: (1) the logarithmic decrement is not constant for different amplitudes, but is found to vary appreciably; (2) in the case of copper and brass wires the decrement remains constant over a certain range depending on the material, its length, and cross-section and then varies linearly; (3) the behavior of steel wires is quite different. The decrement does not show any constant value but falls off steadily with decreasing amplitudes.

PP: 3 D L 13 16 S AA CC 36 37 42 q CV: 14 MI: ST CN Cu Zn n

1926

Föppl, O.

The Damping Capacity of Structural Steels Under Alternating Stress. (In German)

Zeitschrift des Vereines Deutscher Ingenieure, Vol. 70, No. 39, pp. 1291-1295, 1926

Ten specimens of structural steel were investigated for the dependence of damping on deformation or strain by the torsional vibration method. When a critical stress is reached during the vibration, a characteristic change occurs in the material. The critical point for the steel under investigation lies somewhat below the endurance strength and the change is not regarded as the forerunner of fracture. The problem of avoiding the plastic deformation into the groove or notch was also studied.

PP: 3 5 G 13 16 S AA 28 29 42 q CV: 13 14 MI: CN m

Keulegan, G. H

Statical Hysteresis in the Flexure of Bars

U. S. Bureau of Standards, Technologic Paper No. 332, pp. 145-162, November 4, 1926

Boltzmann's theory of elastic time effects does not always account for the hysteresis observed in the deformation of an elastic body during a closed load cycle. In fact, there are materials for which the component of hysteresis which is due to the time effects constitutes only a small portion of the observed hysteresis. Thus other supplementary theories are required to account for that portion of the hysteresis which Boltzmann's theory does not explain. In this paper is presented an additional theory of hysteresis on the assumption that the stress-strain relation of elastic bodies in a cyclic state for stress cycle s_1 to s_1+s_m and back to s_1, instead of being given by a straight line, is given by a symmetrical loop when the time effects are negligible. Hysteresis arising from this source is called statical hysteresis. The theory is developed to show how the statical hysteresis of a rectangular bar, one end of which is clamped and the other end loaded, depends on the length of the bar and on the load. (Author's abstract)

PP: 3 5.10 L 12 16 S Y 30 b 42 q CV: 17 MI: Fe a

Kimball, A. L. and Lovell, D. E.

Internal Friction in Solids

Trans., Am. Soc. Mech. Eng., Vol. 48, pp. 479-500, 1926
Also Physical Review, Vol. 30, pp. 948-959 for second series, December 1927

It is shown from tests on eighteen different solids including several metals, glass, celluloid, rubber and maple wood, that the internal friction for strains below the elastic limit does not obey the liquid viscosity law, as is usually assumed, according to which the frictional force depends upon the velocity of strain, but that the internal friction is entirely independent of velocity, so far as can be observed. It was found to depend upon the amplitude of strain during the strain cycles and approximately to obey the law: Energy loss per cycle per unit volume equals ϵf_m^2. In this expression f_m is the maximum value of the stress during the stress and ϵ a proportionality factor, which may be called the internal friction constant.

PP: 3 4 G 10 11 N 16 S 19 AA 28 29 CV: 14
MI: CN AY CI FF GG HH KK Al Cu Fe Mo Ni Sn W Zn a c d j n q

Odone, V.

Transverse Vibrations of a Bar Excited by Periodic Movements of one End. Influence of Friction. (In Italian)

Atti della R. Accademia delle Scienze di Torino, Vol. 61, pp. 187-202, 1925-1926

No abstract available.

PP: 12 AA CV: 12 14

Subrahmaniam, G

Variation of Logarithmic Decrement in Metals

Phil. Mag., Vol 1, pp 1074-1081, 1926

The decrement-amplitude curves for tungsten, silver, platinoid and phosphor bronze wires run parallel to the x-axis until a limiting twist is reached and thereafter increase more or less linearly with the amplitude. Curves for platinum, nickel, and gold rise proportionately with the amplitude With regard to lead and tin wires no detailed investigation was practicable. The twist given was about 5°, except in the case of gold, lead, and tin when it was smaller. (Sci Abs. A, 1990, 1926)

PP: 3 D 9 13 16 S AA 27 CV: 14
MI: EG Ag Cu Ni Pb Sn W a c 36 43 s

1927

Chevenard, P.

Anomalous Internal Friction of Ferro-Nickel (In French)

Comptes Rendus, Vol. 184, pp. 378-380, February, 1927

A study of the internal friction of ferro-nickel and its variation with temperature and content of nickel was made. The temperatures ranged from 0° to 400° C., and it was found that the decrement of tenacity reached a maximum at 38% Nickel. The abnormal behavior is explained by the existence of the alpha and beta phases, which are subject to reversible transformations and are stable at different temperatures. (Sci. Abs., No. 1922, 1927)

PP: 3 D 13 16 U AA 30 31 36 37 n CV: 13 14 MI: SG Fe Ni n p

Föppl, O.

The Damping Which Occurs in Metals Under Vibrational Stresses in Relation to the Rate of Deformation. (In German)

Proc., Second International Congress Applied Mechanics, Zurich, pp. 328-331, 1927

No abstract available.

PP: 3 5 G 13 16 S T 19 AA 30 34 42 q CV: 13 14 MI: ST

Föppl, O., Becker, E., von Heydekampf, G., and Pertz, E.

Special Publication of Contributions to the Vibration Conference of the V. D. I. in Braunschweig. (In German)

Verein Deutscher Ingenieure, Verlag, Berlin, March 1927

No further information available.

PP: AA CV: 13

Inglis, N. P.

Hysteresis and Fatigue of Wöhler Rotating Cantilever Specimen

The Metallurgist, pp. 23-27, February 1927

Hysteresis effects are detected during an endurance test by measuring the deflection of the end of the cantilever in a plane perpendicular to that of the imposed bending moment.

PP: 3 4 N 16 T AA 29 30 31 42 q r CV: 15 17

Inglis, N. P.

Hysteresis in Metals Under Alternating Stresses

The Metallurgist, pp. 138-140, September 1927. Also Supplement to The Engineer, pp. 138-140, September 30, 1927

A short review of published work.

PP: AA CV: 15

Kimball, A. L. and Lovell, D. E.

Internal Friction in Solids

Mechanical Engineering, Vol. 49, pp. 440-442; Disc., pp. 442-444, May 1927. Also Physical Review, Vol. 30, pp. 948-959, December 1927

It is shown from tests on eighteen different solids, including several metals, glass, celluloid, rubber and maple wood, that the internal friction for strains below the elastic limit does not obey the liquid viscosity law, as is usually assumed, according to which the frictional force depends upon the velocity of strain, but that the internal friction is entirely independent of the strain velocity, so far as can be observed. It was found to depend upon the amplitude of strain during the strain cycles and approximately to obey the law: Energy loss per cycle per unit volume equals ξf_m^2. In this expression f_m is the maximum value of the stress during the stress cycle and ξ a proportionality factor, which may be called the internal friction constant. The method used was to measure the transverse deflections of the end of a rod, about a meter long, of the material being studied, which transverse deflections were produced during rotation of the rod when its end was deflected downwards by suitable loads on it. The experiments differ from most previous work in that relatively large masses of material were employed, tending to reduce surface effects, which are likely to enter in the case of vibration decrement experiments on wires and on thin strips. A table of the internal friction constants is given, and also a table of similar internal friction constants calculated from data of previous investigators. A reasonable agreement is found. (Authors' abstract)

PP: 3 4 G 10 11 N 16 S 19 AA 28 29 30 34 CV: 14
MI: CN AY CI FF GG HH KK Al Cu Fe Mo Ni Sn W Zn a c d j n q

Lehr, E.

Fatigue Strength, Its Importance in Practice, and Its Short-Time Determination by Means of New Type Testing Machines. (In German)

Glasers Annalen, Vol. 127, pp. 109-114, 117-122, 177-180, 1926; pp. 33-39, 1927

Reference is made to changes in damping, but no further information is available.

PP: AA 42 r CV: 13 14

Mason, W. and Inglis, N. P.

The Distribution of Stress and Strain in the Wöhler Rotating Cantilever Fatigue Test

Aero. Res. Comm., R. & M., No. 1126 (M52), October 1927

A certain relation between maximum cyclic strain and applied bending moment has been found. The importance of this strain as a determining factor in relation to the endurance has been shown. The actual skin stress in thin-walled hollow specimens has been calculated, and estimate made of this stress for solid bars.

PP: X AA 42 r CV: 14 17

Moore, H. F. and Kommers, J. B.

The Fatigue of Metals. (Book)

McGraw-Hill Book Co., Inc., New York, 1927

In the historical survey, the experiments of Bairstow are discussed. In the section on Slip, Overstrain, and Hysteresis, the experiments of Bairstow, Smith and Wedgewood, and Mason are described and evaluated. A short section deals with elastic hysteresis.
PP: AA 42 r CV: 14 15 16

Nádai, A.

The Plastic State of Materials. (In German) (Book)

Julius Springer, Berlin, 171 pp., 1927

Dr. Nádai describes the behavior of structural materials in the plastic state, in the light of his own researches at Göttingen, as well as those of other investigators. He brings together the information at present available for developing laws upon which the behavior of metals under stress may be predicted, and on the phenomena attending the plastic flow of solids. (Mech. Eng'g., Vol. 50, p. 261, 1928)
PP: AA 30 b CV: 13 14 15 16

Späth, W.

Computation and Measurement of Internal Losses in Periodically Loaded Bodies (In German)

Zeit. f. angewandte Math. u. Mech., Vol. 7, pp. 360-365, 1927

The general phenomenon of internal damping is explained by two theories. One of these is the theory of viscosity or internal friction of solid material which was developed principally by W. Voigt. In this theory the logarithmic decrement is dependent on the vibration time. The other theory is proposed by Maxwell and Boltzmann, which considers the relaxation or elastic after-effect. According to this theory, the damping is independent of vibration time. The purpose of this article is to arrive at simple formulas regarding periodically stressed material and to describe the accurate behavior of the material. The friction loss of vibration, which is dependent of vibration period, and the stress loss which is dependent only on the stress are included in the mathematical considerations.
PP: 9 16 S 19 Y AA 30 b CV: 13 17

Subrahmaniam, G.

Variation of Logarithmic Decrement with Amplitude and Viscosity of Certain Metals. Part IV

Phil. Mag., Vol. 3, Suppl. pp. 854-863, 1927

This is the fourth and concluding member of the series. In it a study is made of the behavior of wires of magnesium, zinc, and cadmium. The experimental arrangements are similar to those already described in previous papers. The results are given both in graphical and tabular form. (Sci. Abs. A, 1618, 1927)
PP: 3 D 9 13 16 S AA 27 CV: 14 MI: EG Mg Zn a 35

Welter, G.

A Contribution to a Contest of the Scientific Society for Aeronautics. (In German)

Zeit. f. Flugtechnik und Motorluftschiffahrt, pp. 418-438, 1927

This paper pertains to the damping capacity of materials.
PP: AA CV: 13 14

1928

Becker, E. and Föppl, O.

Fatigue Tests for the Determination of Elastic Properties. Relation Between Elastic Hysteresis and Speed of Deformation. (In German)

Forschungshefte des Vereines deutscher Ingenieure, No. 304, Pt. 2, pp. 8-28, 1928

This is a detailed report of experimental research at the testing laboratory of Brunswick Institute of Technology. It includes a general discussion of fatigue testing, a study of the elastic hysteresis of steel and copper by three dynamical methods using speeds up to 2600 rpm, and a study of the thermal effect of stresses. The material damping of iron and copper was determined for several strain levels and these were compared with the results of dynamic methods. From the results it may be concluded that the damping of a solid material at alternating strain within certain limits is independent of the rate of deformation.
PP: 3 5 F 7 9 L 13 16 S 19 AA 28 42 r CV: 13 14 MI: ST CN Cu Fe

Canfield, R. H.

Internal Friction in Metals

Physical Review, 2nd Series, Vol. 32, No. 3, pp. 520-530, September 1928

A tubular specimen of the metal is made the elastic control of a heavy pendulum bar. The system can be set into forced vibrations, either bending or twisting the specimen, by a measured periodic magnetic force-couple. The resonance amplitude and frequency, with the moment of the impressed force-couple, yield the ratio of the energy dissipated in one cycle to the energy of vibration. The tubular form of the specimen enables the relation between dissipation and stress-amplitude to be studied in detail, at least for torsion. For normal (unfatigued) metal, the internal friction appears to be entirely associated with shear. This is not borne out in certain specimens of fatigued or overstrained metal; but these exceptions are easily accounted for. If the energy dissipated per cc per cycle of stress-amplitude is represented by F, the relation of friction to stress-amplitude is given by the formula $F = 8 \phi W (1-f_0/f)$ where W is the total strain energy, ϕ is the coefficient of internal friction, and f_0 is a "threshold" stress-level which is zero initially, but takes on larger values as the vibration history becomes longer. If $f_{02} = 0$, this formula is the same as that proposed by Kimball, viz. $F = \xi f^2$. The coefficient ϕ here introduced is independent of systems of units and to a certain extent independent of the vibration history. If f is less than f_0 the dissipation is negligible; if f is greater than another much higher level f_1, F increases faster than any power of f. Repeated cycles of high amplitudes cause all the constants gradually to change; f_0 decreases again, ϕ increases many fold, the upper limit itself may change. These progressive changes are probably associated with the progress of fatigue. (Author's abstract)
PP: 3 E G 10 11 12 13 16 S T AA 28 36 k 42 r CV: 14
MI: ST CN Al Cu Fe Ni Zn' a c d j n s

Deutsch, W. and Fiek, G.

Fatigue Testing Machines. (In German)

V. D. I. Z., Vol. 72, No. 48, pp. 1760-1764, 1928

This article contains descriptive notes on the Losenhausen, Schenk, Amsler, and other special machines exhibited at the Berlin Engineering Materials Exhibition of 1927, some of which have provision for the determination and recording of mechanical hysteresis loops. (Eng'g. Index, p. 1881, 1928)
PP: 3 5 AA 29 42 r CV: 13 14

Föppl, O.

Determination of the Damping of Metals by Means of the Torsional Vibration Decay Machine. (In German)

Zeit. Ver. D. Ing., Vol. 72, pp. 1293-1296, 1928. Also Zeit. f. Metallkunde, Vol. 20, No. 4, pp. 142-144, 1928

Description of theory and operation of the machine is given. By use of this machine oscillating and mechanical hysteresis resistance can be determined. Article points out value of these determinations for the evaluation of technical material.
PP: 3 D 9 13 W AA CV: 13 14

Gough, H. J.

Note on Some Fatigue Phenomena with Special Relation to Cohesion Problems

Jour. Faraday Soc., Vol. 24, pp. 137-148, 1928

Theories of fatigue based on experiments which ignore any of the essential factors (stress system applied, temp, and nature of surrounding medium) are likely to be incomplete. Some experimental results from the National Phys. Lab. are summarized: (1) In cyclical stress-strain relations the typical phenomena are accounted for by plastic deformation and elastic hysteresis separately or together. (2) Fatigue phenomena in single crystals and aggregates are compared. (3) The intercrystalline boundaries in aggregates are probably occupied by a large number of very small crystallites.
PP: AA 30 b 42 r CV: 14 17

Haigh, B. P.

Hysteresis in Relation to Cohesion and Fatigue

Trans., Faraday Society, Vol. 24, pp. 125-137, 1928. Condensation in The Metal Industry, pp. 584-585, 1927

This paper reviews some of the previous work and describes experiments by Hopkinson and Trevor on thermal hysteresis. The changes in hysteresis are discussed in relation to fatigue. A graph typical of the results obtained with ductile metals reveals three characteristic stages of the fatigue test. A discussion of each is presented. Topics covered are work during cyclic loading, hardening due to repetition of stress, development of a crack, elastic hysteresis as distinct from plastic flow, the action under corrosive influences, and the limiting conditions of fatigue. According to the view taken, elastic hysteresis should no longer be regarded as an incidental imperfection of a more ideal state of elasticity represented by Hooke's law, but rather as an inherent characteristic of the state of elasticity that can be acquired by metals; and that state of elasticity should be attributed to the influence of the grain boundaries and surfaces of slip within the grains, rather than to the crystalline metal. Elastic hysteresis is regarded as a process that is thermodynamically irreversible even when it occurs in a manner that is perfectly cyclic; and of a nature totally distinct from plastic flow or slip. It is regarded as the action that leads to fatigue when it occurs in a manner that is only imperfectly cyclic; and fatigue fracture is attributed to the action of triple-tensile stress then induced by local contractions of volume.
PP: 3 5 G 16 T AA 29 30 31 d 42 q r CV: 14 15 17

Herold, W.

Fatigue Stressing, Structure, and Damping. (In German)

Stahl und Eisen, Vol. 48, No. 31, pp. 1051-1052, 1928. Also Archiv. für das Eisenhüttenwesen, Vol. 2, No. 1, pp. 23-39, 1928

This study gives the results of prolonged tests on annealed pearlitic and hardened martensitic and austenitic steels. The endurance strength and damping characteristics of the materials were determined. An investigation was also made into the characteristics of artifical and natural fractures. (Eng'g. Index, p. 1799, 1928)
PP: AA 36 h CV: 13 14 MI: ST CN

Holzer, H.

Flexural Vibrations with Consideration of Specimen Mass and External and Internal Damping. (In German)

Zeit. f. angewandte Mathematik und Mechanik, Vol. 8, pp. 272-283, 1928

This is a mathematical presentation of the problem of transverse vibration with consideration of mass of the specimen and external and internal damping. The article deals with the following topics: Vibration in General; Excited Vibration; Numerical Examples; Characteristic Vibration; The Action of Exciting Force and the Resistance Work of Damping.
PP: 3 E 7 12 Y CV: 13 17

Keulegan, G. H.

Statical Hysteresis in Cycles of Equal Load Range

U. S. Bur. of St'ds: Tech. Paper, No. 365, pp. 379-387, 1928

This paper deals with an investigation made for the purpose of ascertaining the influence of the extreme loads on the energy loss in the cycles of equal load range during the flexure of an Armco iron bar. The flexure of the bar is considered for the case where one end of the bar is clamped and the other end loaded. Since in Armco iron the hereditary hysteresis is negligible in comparison with the statical hysteresis, the results of the experiment apply mainly to statical hysteresis. Cycles of small extreme loads only are considered, and the conclusion derived from the result of the experiments is to the effect that the energy loss due to statical hysteresis in cycles of equal load range is independent of the extreme loads. (Author's abstract)
PP: 3 5 10 11 16 S AA CV: 14 MI: Fe a

Kuntze, W.

Effect of Pretreatment on the Young's Modulus of Copper. (In German)

Zeit. f. Metallkunde, 20. Jahrgang, Heft 4, 1928

For abstract see translation entry under 1950.
PP: 3 5 10 AA 27 36 h k CV: 13 14 MI: Cu a

Lehr, E.

Surface Susceptibility and Internal Work Absorption of Materials with Vibrating Load. (In German)

A paper in Fatigue Failure Symposium held by the Deutsche Gesellschaft für Metallkunde. Zeit. f. Metallkunde, Vol. 20, pp. 78-85, 1928

Fatigue is indicated by the absorption of work in the specimens tested, caused by deformation in the crystals. Fatigue characteristics in general and slip hysteresis curves are discussed. The character of the surface is of considerable influence in determining fatigue strength. A polished specimen shows in general better fatigue strength than a smoothed specimen. C steels low in Si and the Ni and Cr-Ni steels are characterized by considerable work absorption which C steels high in Si show little work absorption.

PP: AA 30 b 36 37 42 r CV: 13 14 MI: CN AY e q r

Ludwik, P.

Failure (of Materials) and Materials Testing. (In German)

Schweizerischer Verband fuer die Materialpruefung der Technik. Diskussionsber, No. 13, Zurich, 1928

The author studied the effect of stress history upon damping capacity in the higher range of stresses. He observed first an increase and then a decrease in damping with number of cycles for a Cr-Ni steel subjected to fatigue stressing at constant stress amplitude. He employed a method in which the temperature rise in the specimen was measured. For a carbon steel at the higher stresses he observed a continuous increase in the temperature rise to fracture.

PP: 3 F 16 T AA 28 29 42 r CV: 13 14 MI: CN SS

Pertz, E.

Damping Determination by Free Torsional Vibration Decay. (In German)

Sammlung Vieweg, Heft 91, Braunschweig, 1928

Discussion of theory and description of method.

PP: 3 D 9 13 AA CV: 13 14 17

Prandtl, L.

A Hypothetical Model for the Kinetic Theory of Solid Bodies. (In German)

Zeit. Mathematik und Mechanik, Vol. 8, No. 2, pp. 85-106, 1928

A model is described for the representation of form change so that hysteresis, elastic after-effect, and the dependence of flow stress on flow velocity are in good agreement with observation; regularities are given for the temperature dependence which enable the entire transition from solid body to the liquid state to be followed; phenomenological expressions are derived and the application of formulas is made to the case of sliding friction. It is suggested that the internal damping of metals of plastic origin might arise from the motion of a crystalline imperfection.

PP: R U AA BB CC 30 31 34 CV: 13 17

Quimby, S. L.

An Experimental Determination of the Relation Between Viscosity and Frequency in Vibrating Solids

The Physical Review, Vol. 31, Ser. 2, p. 1113, 1928

A bar of the material under examination with small iron armature attached to each end is suspended by light silk fishline. Opposite one armature is placed the magnet of a telephone receiver and opposite the other an electromagnet which is connected to a source of variable frequency alternating current. The bar is excited to resonance at one of its harmonics and while in this condition the excitation is suddenly removed. The amplitude of vibration diminishes exponentially at a rate which depends upon the frequency and the viscosity of the material. The emf induced in the telephone receiver, which is proportional to the amplitude, is rectified, amplified, and photographed on an oscillograph giving a record from which the decrement of the vibrations and the viscosity may be obtained. Experiments are made over a frequency range of 500 to 3000 cycles. The results are in agreement with those obtained by Kimball below 200 cycles and permit the generalization of his conclusion that in solid media the fractional loss of energy per cycle due to internal friction is a constant of the material independent of the speed of performance of the cycle. (Entire article)

PP: 3 D 9 M 16 19 AA CV: 14

Timoshenko, S.

Vibration Problems in Engineering, (Book)

D. Van Nostrand and Co., 1928, 2nd edition, 1937

Discussion of Whirling of a Rotating Shaft Caused by Hysteresis (pp. 222-229); Coulomb Damping (p. 30); Energy Absorption Due to Damping (p. 45); Damping Proportional to Velocity (p. 32); and in Torsional Vibration (p. 271).

PP: N 16 19 Y CV: 16

Voigt, E.

A New Method for the Determination of Damping Capacity of Materials Under Dynamic Loads. (In German)

Doctor's Thesis, Jena, and Zeit. f. Technische Physik, No. 9, pp. 321-337, 1928

The particular object of the experiments is to examine the decay in the amplitude of the vibrations after forcing ceases, the logarithmic decrement being closely related to the internal energy loss. The method of correcting for that part of the energy loss due to air disturbance is indicated, and the final results show the decrement plotted against the amplitude. Iron and steel, copper, brass, glass and porcelain have been examined after various initial treatments.

PP: 3 D 9 L 16 S T U AA 30 b d 42 q CV: 13 14
MI: ST CN CI KK Cu Fe Zn' n

Voigt, E.

Measurement of Internal Energy Loss Due to Elastic Hysteresis. (In German)

Zeit. f. technische Physik, Vol. 9, No. 9, pp. 321-337, 1928

The specimen in the form of a rod is fixed at its upper end to a massive block of metal and at its lower end to a smaller, but appreciable mass. By means of an alternating current device (frequency 500 cyps) the lower mass and the rod are thrown into forced longitudinal vibration. The vibrations are recorded on a moving photographic film by optical arrangements which are described. The particular object of this experiment is to examine the decay being closely related to the internal energy loss. The method of correcting for that part of the energy loss due to air disturbance is indicated, and the final results show the decrement plotted against the amplitude. Iron and steel, copper, brass, glass, and porcelain have been examined after various initial treatment (fatigue, temp. etc.). From the results a dynamic value for Young's modulus may also be found. (Sci. Abs., A. p. 368, 1929)

PP: 3 D 9 M 16 S X AA CV: 13 14 MI: ST CN CI KK Cu Fe Zn' n

1929

Föppl, O.

The Importance of Damping Capacity in the Valuation of Materials of Construction. (In German)

Metallwirtschaft, Vol. 18, pp. 419-422, May 1929

The importance of the knowledge of the capacity for damping in the valuation of a material is emphasized, and it is shown that this property also permits conclusions to be drawn as to the surface sensitivity of the material.

PP: A W AA 42 44 CV: 13 15

Föppl, O.

Determination of the Damping of Porcelain with the Torsional Vibration Machine. (In German)

V. D. I. Z., Vol. 73, pp. 766-767, 1929

A short discussion of the determination of the relative damping of porcelain by means of the torsional vibration machine. The dependence of damping on strain was established. A table and diagram are included.

PP: 3 D 9 13 16 S AA CV: 13 MI: KK

Föppl, O., Becker, E., and Heydekampf, G. V.

The Fatigue Testing of Materials in Regard to Their Alternating Strength and Damping Ability

Translated from Book published by Julius Springer, Berlin, pp. 48-124, 1929

Translation available, J. Crerar Library, Chicago, SLA list of translations.

PP: A W AA 42 r CV: 13 14

Gerdien, H.

On a New Apparatus for the Investigation of Bending Vibration Fatigue. (In German)

Zeit. f. Techn. Physik, Vol. 10, pp. 389-392, 1929

No abstract available.

PP: 3 12 AA CV: 13

Kimball, A. L.

Vibration Damping, Including the Case of Solid Friction

Trans., Am. Soc. Mech. Eng., Vol. 51, pp. 227-236, 1929

The idea of logarithmic decrement of vibration is reviewed briefly. Several ways of finding it and expressing it are given. The simplest case of a vibrating reed is treated with three kinds of damping being considered: (1) an external liquid damping, (2) a liquid viscosity damping within the spring, and (3) solid damping within the spring whereby the dissipation per cycle is independent of frequency but depends upon the amplitude squared. These cases are discussed both for free vibrations and sustained vibrations.

A method is given for analyzing solid damping vibration problems which is of general application to all cases of vibration that can be treated on the assumption of an ideal viscosity damping. The discussion of vibration damping given presents methods used by the author for several years past in vibration work.

PP: 3 D G 9 11 16 S 19 Y CV: 15 17

Ludwik, P.

Fatigue Testing of Construction Materials. (In German)

V. D. I. Z., Vol. 73, No. 51, pp. 1801-1810, 1929

This is a summary of recent research on fatigue testing with constant and variable loads. Subjects considered are the flow of solids, the reversal of stresses, internal stresses, hysteresis, fatigue failure, short methods of fatigue testing, the relation between vibration resistance and other properties, the effect of the nature of the surface, notches and heat treatment, and impact fatigue testing. (Eng'g. Index, p. 1095, 1930)

PP: AA 29 36 h k 42 r CV: 13 15

Ludwik, P. and Scheu, R.

Endurance Testing of Metals. (In German)

Metallwirtschaft, 8[a] annata, Heft 1, 1929

This paper describes some fatigue tests on metals and includes also data on damping.

PP: AA 29 42 r CV: 13 14

Rayleigh, Lord

Theory of Sound. (Book)

The Macmillan Company, London, 1929, Vol. 1, pp. 285, Dover Publications, N. Y., 1945

The author concluded that the frequency of any dynamical system found by assuming the displacement to be of a special type, cannot be less than the frequency of the gravest mode of vibration of the system. For a rod clamped at one end and free at the other he shows that a good approximation to the frequency may be made by assuming the displacement of the rod to be of the same type as if it were deflected statically by a transverse load, concentrated at a distance from the free and equal to one quarter of the length.
PP: Y CV: 16 17

Reissner, H.

On the Influence of Internal Friction on the Stability of Rotating Shafts. (In German)

Z. M. M., Vol. 9, pp. 483-485, 1929

No abstract available.
PP: N Y CV: 13

Späth, W.

Dynamic Testing of Engineering Systems. (In German)

Z. V. D. I., Vol. 73, No. 27, pp. 963-965, July 1929

This article is a description of the author's instruments for the measurement and analysis of vibrations, which may be used in the testing and inspection of bridges and buildings, for the determination of periods of vibrations, the damping of oscillations, etc. The precision of dynamical testing, the determination of spring constants, and the evaluation of resonance curves are discussed. (Eng'g. Index, p. 1911, 1929)
PP: 3 D E 9 11 M AA BB CV: 13 14

Stieler, G. and Heydekampf, G. V.

A Flexural Fatigue Testing Machine Employing an Oscillating Specimen with a Uniformly Stressed Gage Length. (In German)

Dissertation, Braunschweig, Library of Nem, Berlin, 1929

No abstract available.
PP: 12 AA 29 CV: 13 14

1930

Canfield, R. H.

Internal Friction as a Physical Test of Materials

Proc. of Third International Congress For Applied Mechanics, Stockholm, Vol. 2, pp. 311-322, 1930

After a general mathematical introduction to the subject the experimental procedure used in these tests was described. It consists of exciting an elastically controlled pendulum into forced vibrations by means of a periodic impulse couple of the proper frequency. Theory of the method is given and the experimental results obtained are discussed in terms of general reliability, influence of the chemical nature of the material and of grain size, cold work, age-hardening, and repeated stress cycles. Regarding the influence of repeated stress cycles it was found that for all materials tested, there exists a stress S, such that repeated cyclic stress of smaller amplitude than S, produces no change in the internal friction curve, whereas repeated cyclic stress of higher amplitude than S always produces a change. It is concluded that measurements of internal friction, apart from their purely scientific interest, have a technological importance from three different standpoints. (1) They provide an additional strictly definable property of materials (strictly definable as contrasted with hardness, impact resistance, etc. which are defined in terms of a particular apparatus). Moreover, this property is one that is very sensitive to physical changes not always easily detectable by other means; and the specimen survives the experiment. (2) Results of internal friction tests yield a certain stress-amplitude which is certainly not higher than the endurance limit, and therefore a conservative estimate for the latter quantity. (3) Internal friction is a criterion of safety from critical vibrations.
PP: B 3 E 10 L 13 16 S T W AA 28 29 36 h 38 k 42 r CV: 14
MI: ST CN Al Cu Fe Zn a h j 40 n q

Colonnetti, G. and Pugno, G. M.

On Elastic Hysteresis of Aluminum and Its Alloys. (In Italian)

Memorie della Pontificia Accademia delle Scienze, Vol. 14, pp. 435-488, 1930

The elastic properties of the alloys of Al do not depend only on the chemical composition of the alloy but also, and perhaps more, on the thermal or mechanical treatment that the material has undergone. The following three properties which were noted in alloys of copper were found also in aluminum alloys: (1) The irreversibility of the phenomenon of deformation. If a specimen is gradually subjected to a load increasing from zero to an arbitrary value and then the load is gradually decreased the deformations observed on the original process are in general different from those in the reverse process. (2) The adjustment of the cycles. If the operation of loading and unloading is repeated a second time the deformation curve is different in the latter case from that in the first. (3) The modulus of elasticity assumes for each material a value practically constant immediately after inversion of the sense of variation of the load. In some respects the characteristics of the alloys of Al differ from those of Cu. While in the case of Cu alloys examined the modulus of elasticity always assumed after every regression was a maximum value, with numerous specimens of Al alloys the characteristic value of the modulus immediately after a regression was minimum. Attention is called to the asymmetry of the bilateral cycles, that is, the diversity of the values that, other circumstances being equal, the modulus of elasticity can assume according as the experiment is with tension or compression.
PP: 16 T X AA 36 h k 42 q CV: 12' 14 MI: Al Cu b

Den Hartog, J. P.

Forced Vibrations with Combined Viscous and Coulomb Damping

Phil. Mag., Vol. 9, pp. 801-817, April 1930

This is a theoretical analysis and discussion of the subject. Divisions of the paper are: Introduction, Coulomb Damping Only, Validity of Solution, Combined Viscous and Coulomb Damping, and Other Problems to Which the Solution Applies.
PP: Y 30 34 CV: 17

Esau, A. and Voigt, E.

On the Occurrence of Inharmonic Vibrations in Dynamic Testing of Materials Under Alternating Stresses. (In German)

Zeit. f. Tech. Physik, Vol. 11, No. 4, pp. 113-114, 1930

The conditions under which inharmonic vibrations occur in the magnetic alternating stress machine are investigated. With hardened steels the inharmonic vibrations occur at smaller amplitudes than in soft steels.
PP: 3 E M 13 16 S X AA CV: 13 14 MI: CN j

Föppl, O.

Damping of Materials Under Alternating Normal Stresses and Under Alternating Shearing Stresses. (In German)

Zeitschrift des Vereines Deutscher Ingenieure, Vol. 74, pp. 1391-1394, 1930

High damping of a material prevents the amplitude of the self-vibration of a construction from becoming too great and inducing a dangerous internal stress. Small damping signifies a high sensitivity to surface imperfections or damage. In copper, brass, and steel, the damping values in torsion tests and bending tests are similar, but great deviation is met with Elektron metal.
PP: A 3 D M 13 AA 28 42 44 CV: 13 14
MI: ST CN AY Cl FF GG HH Al Cu Mg Zn' c n

Föppl, O.

Dependence of the Damping (of Metals) on the Rate of Deformation. (In German)

Arch. Eisenhüttenwesen, Vol. 4, pp. 607-608, 1930-31

Under alternating stresses below the yield point the damping is independent of the rate of deformation. If the vibration strength of the metal is a little above the yield point, it is to be expected that the damping under alternating stress nearly equal to the vibration strength will decrease with increasing frequency of the vibrations. On the other hand, under alternating stress sufficient to cause plastic deformation the energy consumption and the frequency will naturally increase. (Abstract J. I. & S. I.)
PP: 16 S 19 AA 29 42 r CV: 13

Föppl, O.

Vibration Damper for Crankshafts. (In German)

Ing. Arch., Vol. I, pp. 223-231, 1930. Also Forschung auf dem Gebiet des Ingenieurwesens, Vol. 2, No. 4, pp. 124-128, 1931

The effect of a damper on a shaft is analysed. A calculation is given for the best damping coefficient of friction for the damper. Finally the results are applied to rubber dampers. (Eng'g. Index, p. 356, 1931)
PP: Y BB CV: 13 17 MI: GG

Föppl, O.

Dependence of the Duration of Oscillations in a Damped Vibration Upon the Magnitude of Damping. (In German)

Z. M. M., p. 92, 1930

No abstract available.
PP: 3 D 16 T AA CV: 13 14

Föppl, O. and Schaaf, G.

Material Damping Under Torsional and Bending Vibration Stresses. (In German)

Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Heft 335, Berlin, 1930

In tests at the Wöhler Institute of Braunschweig Institute of Technology, hysteresis values were obtained with bending stress and torsional stress. The values are compared. As a result a deep insight is obtained into the behavior of materials under alternating stresses. The hysteresis is found to be quite different for light metals than for the other metals investigated. (Eng'g. Index, p. 873, 1931)
PP: 3 12 13 P AA CV: 13 14

Jacobson, L. S.

Steady Forced Vibration as Influenced by Damping

Trans., Am. Soc. Mech. Eng., Vol. 52, Paper APM-52-15, pp. 169-181, 1930

The author presents a general method of obtaining approximate solutions of the steady forced vibration of a damped system of one degree of freedom for the case of sinusoidally varying disturbing forces. The approximation consists in expressing all the damping terms of the original differential equation by a single equivalent damping term, proportional to the first power of the velocity of motion. In the case of a system influenced by a centrifugal disturbing force and damped by constant friction and by friction proportional to the first power of the velocity of motion. In the case of a system influenced by a centrifugal disturbing force and damped by constant friction and by friction proportional to the first power of the velocity, experimental evidence is in good agreement with the approximate solution. While this paper deals solely with a system of one degree of freedom, there is no reason aside from complexity why the approximate solution cannot be applied to systems of several degrees of freedom. (Author's abstract)
PP: Y 30 34 CV: 17

Kimball, A. L.

The Damping Factor in Vibrations

Product Engineering, Vol. 1, 11. 499-501, November 1930

Noise, critical speeds, resonance, vibrational stresses, and damping are problems of basic importance in meeting the insistent demands for high-speed machines and silent operation. This paper describes the damping factor as the fundamental element in the solution of such problems. Values of logarithmic decrement are given for some fifteen materials. Equations are derived for logarithmic decrement, the total vibrational energy and the energy loss per cycle.

PP: A 3 D 9 11 12 N W AA 36 h k CV: 15 17
MI: ST CN AY CI FF GG HH KK Al Cu Fe Mo Ni Sn W Zn a c d j n q

Knackstedt, W.

Material Damping Under Torsional Vibration Determined for Constant Amplitude and For Vibration Decay Conditions. (In German)

Dissertation, Braunschweig, 1930, Library of NEM, Berlin, 1930. Mitteilungen des Wöhler Instituts, Heft 4, 1930. V. D. I. Zeit., Vol. 74, No. 34, pp. 1182-1184, 1930

This is a report on hysteresis observed in fatigue testing of specimens of brass, chromium-copper steel, standard steel, etc., subjected to torsional vibration and to rotational repeated vibrations by two types of machines. The effect of high temperatures is considered. (Eng'g. Index, p. 1085, 1930)

PP: 3 4 N P 16 U AA 29 42 r CV: 13 14 MI: ST CN AY Cu Zn' 31 h n

Knackstedt, W.

The Measurement of Damping Effect in Metallic Materials by Torsional Vibration. (In German)

Berlin, N. E. M. -Verlag G. m. b. H., 60 pp., 1930

By means of specially designed torsional-vibration machines the damping effect in both metallic and non-metallic materials was investigated at temperatures not exceeding 30° C., and with the same amplitude of vibration. These machines gave values for the damping of oscillations that agreed with those measured with a constant amplitude of vibration. Tension is applied to the test-piece by means of a fine-thread screw.

PP: 3 13 14 AA CV: 13 14

Kommers, J. B.

Mechanical Hysteresis and Fatigue -- a Chapter in the Report of Research Committee on Fatigue of Metals

Proc. Am. Soc. Test. Mat., Vol. 30, pp. 287-288, 1930

This is a review of the present day knowledge of the subject. The results of past investigators dealing with the relation of mechanical hysteresis are considered. It is concluded that the phenomenon of mechanical hysteresis seems to be associated with plastic action. Fatigue cracks may be caused by repeated stress causing plastic action, but plastic action does not always start fatigue. Whether fatigue cracks can be started without any previous development of hysteresis is as yet a matter of uncertainty, the author concludes.

PP: AA 28 29 30 b 42 r CV: 15

Kortum, H.

A Method for the Determination of the Damping of the Apparatus in the Testing of Materials by the Vibration Method. (In German)

Z. Tech. Physik, Vol. 11, pp. 24-26, 1930

It is pointed out that in testing the fatigue of metals, the damping capacity measured is the sum of that of the test-piece and that of the machine. Both can be determined separately by testing consecutively two rods of different dimensions but of the same material. The necessary mathematical formulae for calculating the results have been worked out.

PP: 3 D J 11 M 16 S AA BB CV: 13 17

Kortum, H.

On Material Testing by Means of Fatigue Stressing in Torsional Vibration. (In German)

Technische Mechanik und Thermodynamik, pp. 297-307, 1930

No abstract available.

PP: AA 29 42 r CV: 13 14

Lehr, E.

Mechanical Vibrations. Vol. 1. Principles of Natural Vibrations of Simple Systems. (In German)

Book. J. Springer, Berlin, 295 pp., 1930

First volume of a series designed to discuss the question of vibrations from the view point of the practical engineer and machine builder, without the use of higher mathematics. This volume is devoted to general principles and simple cases. Eng. Soc. Lib., N. Y. (Eng'g. Index, p. 1844, 1930)

PP: Y CV: 13 15 16 17

Muto, K.

Flexural Vibrations with Consideration of the Specimen Mass and External and Internal Damping. (In German)

Z. A. M. M., pp. 346-353, 1930

This is a theoretical mathematical discussion of the Holzer theory. The principles of free and constrained vibrations and their bearing on earthquake phenomena are discussed. Numerical examples are presented. (Eng'g. Index, p. 1844, 1930).

PP: L Y CV: 13 17

Ono, A.

On the Theory of Fatigue Strength. (In German)

Verhandlungen der 3 Inter. Kongr. für techn. Mechanik, Stockholm, pp. 305-310, 1930

No abstract available.

PP: AA 42 r CV: 13 17

Sayre, M. F.

Elastic and Inelastic Behavior in Spring Materials

Trans., Am. Soc. Mech. Eng., Vol. 52, No. 15, Paper APM-52-9, pp. 105-109, 1930

This is progress report No. 5 of the ASME special research committee on mechanical springs. In a previous report mention was made of a discrepancy in the law of variation of internal friction, or elastic hysteresis, between tension and bending specimens. Later tests have shown that this discrepancy resulted from a sharp break in the law of hysteresis in tension which occurs at about the yield point. This point has been investigated further. For stresses below 160,000 psi (0.68% C steel), the actual width of the hysteresis loop increased in these tests as some power of the maximum load varying between 2.5 and 3. The energy loss in hysteresis would vary as the maximum load raised to the 3.5 or 4 power. Above 160,000 psi., (midway between elastic limit and yield point) and up to 180,000 psi the hysteresis varies more nearly as the eighteenth power of the maximum stress. In specimens in bending, the outside fibers reach the yield point only one by one as the load is increased, and consequently no such sharp change in the law of hysteresis will be evident. The fact that permanent or quasi-permanent changes in both modulus of elasticity and hysteresis begin at about the same unit stress indicates that the two are tied together. Data obtained as to the actual shape and character of the hysteresis loop are not yet complete.

PP: 3 5 10 M P 16 S AA 29 42 q CV: 14 MI: CN r

Thomas, S.

Vibrations Damped by Solid Friction

Phil. Mag., 7th Ser., Vol. 9, No. 57, pp. 329-345, March 1930

A variation on the solid friction problem is the case where the two bodies between which friction may exist have on the average, a relative velocity. It is shown here analytically and experimentally, that vibrations, initiated in any manner, tend to persist within a certain maximum amplitude without any impressed disturbing force other than that provided by the relative motion of the bodies. The necessary conditions are frequently met in practice, and it appears permissible that the continued vibrations maintained may be responsible in some measure, for the production of sound by bodies in rubbing contact. The subject is treated analytically for the case of solid friction only and for the case of combined solid and fluid friction. The experimental part of the work deals with solid friction only.

PP: Y BB CV: 14 17

Tomlinson, G. A.

A Molecular Theory of Elastic Hysteresis

Phil. Mag., 7th Ser., Vol. 9, pp. 913-935, May 1930

The loss of energy during a stress-strain cycle is discussed on the basis that elastic hysteresis is caused by internal solid friction in a restricted sense -- i.e. it is not supposed that any gross tangential forces operate on planes of slip within the solid in the manner than friction ordinarily manifests itself to the senses, but that the process whereby individual atoms dissipate energy is identical in solid friction and elastic hysteresis.

PP: AA 30 31 34 CV: 17

Townsend, J. R.

Correlation of Endurance Limit with Other Physical Properties

Am. Soc. Test. Mat., Proc., Vol. 30, No. I, pp. 270-272, 1930

The author attempts to correlate the endurance limit of metals to other physical properties such as tensile strength, elastic limit, yield point, modulus of elasticity, elastic hysteresis, etc. As to the elastic hysteresis, he makes the following short statement: "Elastic hysteresis can only be regarded as a symptom of action which may or may not lead to fatigue." No experiments were made to confirm the author's view.

PP: AA 42 r CV: 17

1931

Anonymous

Damping Tester for the Determination of Internal Friction of Materials

Metals and Alloys, Vol. 2, No. 2, p. 28, February 1931

A description is given of the Foppl-Pertz damping machine sold by Southwark Foundry & Machine Company, Philadelphia, Pa. Sample records are included.

PP: 3 D 9 13 AA CV: 14

Barron, H. and Cotton, F. H.

Trans. Inst. Rubber Ind., Vol. 7, pp. 209- , 1931

This article describes a study of the influence of fillers on the properties of rubber and shows that if the work required to extend vulcanized rubber is increased by fillers, the hysteresis losses will increase relatively as the number of stress cycles increases.

PP: 16 T AA 36 37 CV: 14 MI: GG

Chevenard, P.

Mechanical Properties of Metals at Elevated Temperatures

Am. Soc. Test. Mat., Vol. 31, pp. 245-268, 1931

Internal friction is one of the properties discussed. Subjects included are the experimental methods of study, the influence of the amplitude of torsion and of frequency, effect of temperature, the measurement of the coulomb modulus and its thermic coefficient, the influence of the initial state of the metal, influence of composition. Isothermic viscosity is then discussed, and viscosity at increasing temperatures, internal friction and viscosity, and applications.

PP: 3 D 9 13 R S U AA 30 b d 36 h CV: 14 15
MI: AY SG EG Cr' Cu' Mn' Ni Si' W' Zn' a f 36 h r

Colonnetti, G.

Elastic Hysteresis and the Fatigue of Metals. (In Italian)

Memorie della Pontificia Accademia delle Scienze, Vol. 15, pp. 345-362, April 15, 1931

A description is given of the Amsler testing machine for direct tension-compression and the results of tests performed for the determination of cyclic hysteresis and the variations provided by various metals.

PP: 3 5 M AA 42 r CV: 12' 14

Den Hartog, J. P.

Forced Vibrations with Combined Viscous and Coulomb Damping

Proceedings of the 3rd International Congress for Technical Mechanics, Vol. III, pp. 181-189, Stockholm, 1931

This is a mathematical discussion presenting the exact solution of problems involving steady-state vibrations of mechanical systems damped by a combination of dry and viscous damping. (Eng'g. Index, p. 1503, 1931)
PP: Y CV: 17

Esau, A.

The Relaxation of Some Materials Under Dynamic Strain. (In German)

Zeit. f. Techn. Phys., Vol. 12, pp. 492-495, 1931

In the region of frequency of 50 to 110 per second, no change in damping with frequency change was detected for Cu, wrought Fe, or steel plate. The relaxation time is very small for pure or nearly pure metals. Brass, duraluminium and elektron metal show the frequency dependability of damping required by theory. (Chem. Abs., Vol. 26, p. 677, 1932)
PP: 3 16 19 AA CV: 13 14 MI: ST CN Al Cu Fe Mg Zn' h m n

Esau, A. and Kortum, H.

The Influence of Direct Current Magnetization on Material Damping in Torsional Vibrations, (In German)

Forschung, Vol. 2, pp. 429-434, 1931

No abstract available.
PP: 13 V AA CV: 13 14

Föppl, O.

Vibration Damper for Crankshafts. (In German)

Forschung auf dem Geibete des Ingenieurwesens, Vol. 2, No. 4, pp. 124-128, 1931

This paper discusses the effect of a damper on the motion of a shaft. A calculation of the best damping coefficient for a frictional damper is presented. The results are applied to a rubber damper. (Eng'g. Index, p. 356, 1931)
PP: A 13 Y CV: 13 14 MI: GG

Föppl, O.

Principles of the Engineering Mechanics of Vibrations. (In German)

Book, edited by Julius Springer, 2nd edition, Berlin, 1931

From pages 164-168 the section "Die Dämpfungsfähigkeit" is presented. A photo of a ship wall cracked due to vibration is shown. The loop area method for calculating damping is illustrated. Values of damping for about a dozen materials such as copper, brass, rubber, steels, etc., are shown by curves. Curves show the variations of the logarithmic decrement.
PP: 3 D 5 9 16 S W AA CV: 13 14 16 MI: ST CN GG Cu Zn' n

Föppl, O., Becker, E., and Von Heydekampf, G.

The Fatigue Testing of Materials. (Book) (In German)

Berlin, 1931

The fatigue testing of materials is considered. References are made to the damping properties of materials.
PP: AA 42 r CV: 13 16

Giebe, E. and Blechschmidt, E.

On the Influence of Magnetisation on the Elastic Modulus Under Longitudinal Vibration of Ferromagnetic Specimens. (In German)

Annalen der Physik, Vol. 11, pp. 905-936, 1931

The logarithmic decrement was measured for a ferromagnetic material in longitudinal vibrations with a frequency of 70,000 cyps under variable magnetization. Generally the losses increased with the intensity of the magnetization but in one case there was a slight decrease.
PP: 3 D 9 M 16 V X AA 30 c CV: 13 14 MI: SG n p

Hempel, M.

Behavior of Some Materials Under Dynamic Bending Stress. (In German)

Forschungen auf dem Gebiet des Ingenieurwesens, Vol. 2, No. 9, pp. 327-334, September 1931

Preliminary tests are described with particular attention to the determination of external losses. Results of damping measurements are given. Other topics dealt with are vibration rupture and the change in frequency with increasing load. The damping of different metals, including iron, steel, brass, and aluminum, is determined in relation to amplitude and fatigue stress (load fluctuation coefficient).
PP: 12 16 S AA 29 42 r CV: 13 14 MI: ST CN Cl Al Cu Fe Zn' a

Howland, R. C. J.

The Vibrations of Revolving Shafts

Phil. Mag., 7th Ser., Vol. 12, pp. 287-319, 1931

This paper considers the problem of instability in a shaft rotating at certain critical speeds and the problem of vibration at speeds other than the critical. In this work the effects of internal friction are considered on the basis of certain not improbable assumptions. The results do not support Kimball's theory that the instability has its origin in the internal friction of the shaft. Alternative explanations are suggested but no final conclusion is reached. A much more elaborate analysis appears to be needed especially at the higher speeds.
PP: N W Y AA CV: 17

Keulegan, G. H.

On the Vibration of U Bars

Jour. of Research, Nat'l. Bur. of St'ds., Vol. 6, pp. 553-592, 1931

A theoretical study has been made of elongated and short U bars with special reference to their use as vibrators in investigations of elastic hysteresis. First, an expression for the frequency of the fundamental mode of vibration of the elongated U bar is derived by solving the differential equations of motion of the yoke and of the prongs through the use of an approximation, the physical basis of which is the fact that the bar vibrates with a pitch differing slightly from that of the clamped free bar of half the length. Secondly, Ritz's method of approximation is developed for initially curved bars, the development being based on the principle of least action. In this connection a new proof is given of Rayleigh's method for determining the fundamental mode of vibration. As an illustration of Ritz's method, the example of the free-free bar is treated, and the results of the calculations are compared with the known solution of the problem. Next the method is used to determine the fundamental mode of vibration of the short U bar, the latter being defined as one wherein the length of the curved portion, or the yoke, is equal to the sum of the lengths of the two parallel prongs. Finally, Raleigh's method is used to determine the static deformation of the short U bar by the application of a single load so applied that the deformation is most nearly that present in the fundamental mode of vibration.
(Author's abstract)
PP: Y CV: 17

Kidani, Y.

The Crystallographic Investigation of Some Mechanical Properties of Metals. (In English)

Jour. of Eng., Univ. of Tokyo, Vol. 19, No. 7, pp. 177-190, February 1931

The paper is a study of fatigue of metals under alternating torsion. Tests results are given for the internal friction of fatigue specimens. The structure of steel and copper specimens is investigated. (Eng'g. Index, p. 881, 1931)
PP: 3 13 AA 36 42 r CV: 14 MI: ST CN Cu a

Kimball, A. L.

Analysis of Vibration with Solid Friction Damping

Proc. of the 3rd International Congress for Appl. Mech., Stockholm, Vol. III, pp. 190-198, 1931

This paper contains two principal or pivotal ideas. The first is a demonstration of how the amplitude-frequency relation for sustained vibrations of systems containing solid friction damping can be found for any case which can be solved for viscous camping. The second is the setting forth of the great value of the energy formula for logarithmic decrement $\delta = \Delta W / 2W$ in work on vibration damping and vibration prevention.
(Author's summary)
PP: 16 Y CV: 17

Moore, H. F.

Crackless Plasticity - A New Property of Metals

Iron Age, pp. 674-678, September 10, 1931

The author says "There seems to be a property of metals which is neither strength nor ductility as revealed by a tension test and appears to be important, namely the ability to resist fairly large numbers of loads which cause very slight plastic action, without starting a crack." He offers the term "crackless plasticity" to denote the property. Suggested methods of experimental study of this property include fatigue tests following a period of overstress notched bar impact tests and tests of the damping of vibrations in the metal.
PP: 3 D 5 13 AA 30 b CV: 15 17 MI: ST CN

Nadai, A.

Plasticity. (Book)

McGraw-Hill Book Co., Inc., New York, pp. 10-11, 1931

A general discussion of the viscosity of liquids is given which can be considered as internal friction. The viscosity is greatly affected by pressure. In general the effect of pressure on viscosity is greater than on any other physical property. The relation between pressure and viscosity appears to be an exponential function. Temperature also affects the viscosity.
PP: N 16 U 26 CC CV: 16 MI: NN

Pugno, G. M.

On a Possible Relation Between Surface Roughness and the Phenomenon of Elastic Hysteresis. Experimental report of some considerations presented by Professor G. Colonnetti of the Conference on "Elastic Hysteresis and the Fatigue of Metals" held on the occasion of the Academic Week, dated 15 April 1931.

Memorie della Pontificia Accademia delle Scienze, pp. 291-304, April 19, 1931

Determination of the cyclic hysteresis in wires of various metals stressed in tension is described. Investigation of the effect of final treatment on the form of the hysteresis is made.
PP: 3 5 M AA 36 CV: 12' 14

Quimby, S. L.

Some New Experimental Methods in Ferromagnetism

Symposium on Ferromagnetism, Am. Physical Society, December 1931

A description is given of methods for observation of magneto-elastic, mechanical and thermal properties of single crystals of nickel, as well as polycrystalline samples of the same metal. The preparation of pure nickel for test purposes is detailed, and experimental work thereon is described, including thermal elastic and magnetic characteristics. A piezoelectric method is employed. The paper is an efficient summary of the properties of single crystals of nickel. (Sci. Abs., p. 2130, 1932)
PP: 3 D E 9 M X AA 30 32 CV: 14 MI: SG Ni a n p

Sayre, M. F.

Elastic and Inelastic Behavior in Spring Materials

Trans. Am. Soc. Mech. Eng., Vol. 53, Paper APM-53-8, pp. 99-105, 1931

This is a progress report of the ASME special research committee on mechanical springs. The report describes the results obtained to date in connection with the more fundamental studies of the elastic behavior of spring materials. In addition to other studies, mechanical hysteresis values for unidirectional stress in tension have been obtained for several additional samples of various materials. Enough data have been obtained to serve as a basis of comparison in further studies of the relative suitability of various materials and of the effect of various types of cold work or heat treatments. A possible correlation between hysteresis values and fatigue strength deserves investigation. Materials studied were oil-tempered steel, 17SRT aluminum alloy, brass, and phosphor-bronze wires. It was noted that the mechanical hysteresis energy loss increases sharply with stress, at a higher power than the square. It was noted earlier that for the heat-treat steel samples tested, a sharp rise in hysteresis occurred on approaching the yield point of the metal. No such sharp rise has been noticed in the non-ferrous materials. This is a result of the nature of the materials, but may be partly connected also to the relative amount of cold drawing following heat treatment in the two cases. Further discussion is given concerning the shape of the hysteresis loops obtained.

PP: 3 5 G M 16 S AA 36 h k 42 r CV: 14
MI: ST CN al Cu Zn' c h 40 n

Schenk, D.

Measurements of the Damping (Of Oscillations) in Vibrating Steel Rods. (In German)

Zeit. f. Physik, Vol. 72, pp. 54-67, 1931

A method for the investigation of fatigue in steel rods is described. The technique is dependent on the measurement of the decrement of longitudinal oscillations excited in the rods by means of a Piezo-electric quartz oscillator. The damping coefficient is found to depend on the amplitude of the oscillations, and changes of the coefficient are attributed to structural changes in the rods, which is confined to X-ray analysis. After long use both the rods experimented with lost their oscillating property. (Abstract, Institute of Metals)

PP: 3 D M 16 S T AA CV: 13 14 MI: ST CN

Schmidt, J.

Damping Capacity of Iron and Nonferrous Metals Under Torsional and Bending Fatigue Stress. (In German)

Veröffentlichungen des Wöhler Instituts, Braunschweig, No. 9, 52 pp., with 39 illustrations, 1931

Many investigations have been made into the damping effect in plastically deformed materials. These investigations showed the dependence of the damping on a particular state of stress -- in torsional alternating stress on the shear stresses, and in bending fatigue on normal stresses. The object of this study is to complete the elucidation of these relationships in the case of ferrous and non-ferrous metals and alloys in the cast, pressed, and rolled conditions. The methods and technique adopted are fully described. It is shown that the ratio between the shear and normal stresses with equal damping, amounts to 0.5 to 0.6 for ferrous and non-ferrous metals. The damping is essentially dependent on the shear stress. The limiting damping in torsion is in most materials greater than that in bending. (Abstract, Journal of Metals)

PP: 12 13 P AA 29 36 k CV: 13 14 15 MI: Fe b

von Heydekampf, G. S.

Damping Capacity of Materials

Proc. Am. Soc. Test. Mat., Vol. 31, Part 2, pp. 157-171, 1931

The damping capacity of materials is defined, and shown to be identical with the "mechanical hysteresis effect" or "internal friction of solids." Different methods of determining the damping capacity are described. Results are given of damping tests obtained in torsion and flexure at the Wohler Institut, Braunschweig. The significance of this property is explained. In the author's opinion, the damping capacity is not only important in cases of direct application, such as resonance vibrations, but deserves attention as a novel method of investigating the elastic behavior in the range of low stresses. Recent tests by Föppl indicate that the damping capacity is a measure of "dynamic ductility" which should be coordinated with the fatigue limit in the same way that tensile strength and elongation are considered together. (Author's abstract)

PP: A 3 D E F G J 12 13 16 S W AA 27 29 p q r CV: 15 18 MI: ST AY

1932

Bankwitz, E.

Dependence of the Damping of Materials Upon the Magnitude and Speed of Deformation. (In German)

Mitteilungen des Wöhler-Instituts, Braunschweig, Heft 11, 53 pp., 1932
Also Metallwirtschaft, Vol. 12, No. 3, p. 33, 1933

Torsional damping tests, which included rise of temperature determinations, were made on three low and medium carbon steels, copper, cast brass, commercial aluminum alloys, and elektron. The three main objects of the research are summarized as: (1) to determine the extent of the damping effects with small changes of form; in the case of the light metals and other good conductors the difficulties in making these determinations are great; (2) to determine the influence of the rate of change and form on the magnitude of the damping phenomena, and (3) to investigate to what extent the static properties of materials are affected by alternating stresses. It was found that on the curves showing the damping characteristics of materials with low yield points such as the light metals, copper, etc., the null point and the first portion of the curves cannot be satisfactorily determined; but by means of new diagrams showing the number of alternations in the tests and their relationship to the damping effects the null point has been fairly accurately determined. Thermal measurements have confirmed these results. The latter part of the report deals with the raising of the yield point by the application of alternating stresses. (Metal Abstracts)

PP: 3 F L 13 16 S 19 20 AA 36 k CV: 13 14
MI: CN Al Cu Mg Zn' r

Back, G.

Vibration Damping by Means of Material Damping. (In German)

Z. M. M., Vol. 12, pp. 261-274, 1932

A vibration absorber is considered in which the forced torsional oscillations of a rod are damped by internal friction in the material. This system and that formed by adding the absorber to another system are analyzed mathematically. (Sci. Abs. p. 58, 1933)

PP: 3 E 13 Y EE CV: 13 17

Brophy, G. R.

Damping Capacity of Steels and Correlation with Other Properties

Iron Age, Vol. 130, November 24, pp. 800-802, December 29, p. 989, advertising section, pp. 10, 12, 1932

Damping capacity is a comparatively new term as applied to the properties of steel. Other names for it are "mechanical hysteresis" and "crackless plasticity." The influence of various fundamental metallurgical factors on this interesting property are discussed as well as any possible correlation between it and other commonly determined physical properties. Methods of measuring the damping capacity and the effect of heat treatment are taken up. In the concluding portion of the article the relation of damping capacity to cold work, composition, creep, fatigue, and Charpy values are discussed. The experiments, performed on a Föppl-Pertz machine, show that there is probably no general correlation with other properties with the exception of creep. The relation between damping effect and creep appears logical since both are a measure of plasticity at very low stresses. (From author's abstract)

PP: 3 D J 13 14 16 S U AA 29 g h k 42 43 r s CV: 14 15
MI: ST CN AY j p q r s

Canfield, R. H.

Internal Friction in Iron and Iron Alloys

Trans., Am. Soc. Steel Treat., Vol. 20, pp. 549-576, December 1932

The author describes a method of measuring the dissipation of energy in a tubular specimen of metal when carried through cycles of alternating torsional stress. A method of plotting results is used, where the half width of the hysteresis loop is plotted against the stress amplitude. This curve is "friction stress" plotted against "elastic stress" and its slope is a coefficient of internal friction. In alpha iron the curve shows four critical points, at each of which new mechanical phenomena manifest themselves. The author advances a partial explanation of these facts, based on intracrystalline slippages of the order of atom diameters. Data are given covering the internal friction behavior of the purest iron, of iron and mild steel after plastic deformation and of a few alloy steels. A few numerical values of internal coefficients are included. (Author's abstract).

PP: 3 5 10 11 13 16 S T AA 28 30 31 36 h 38 k 42 r CV: 14
MI: ST CN AY CI Fe a j

Dorey, S. F.

Elastic Hysteresis in Crank Shaft Steels

Proc. Inst. Mech. Eng., Vol. 123, pp. 479-510, Disc. 511-535, 1932

As the result of his investigation the author drew the following conclusions: (1) All the steels tested exhibited a quasi-critical point above which the hysteresis increases at a much greater rate than for lower stress ranges. (2) The mid-width loop factor for any particular stress range depended on the quasi-critical stress. Generally for values below this quasi-critical stress the width factor was of the order of 0.55, whereas above this stress the value increased to about 0.62. (3) The rate of dissipation of energy per cycle varied approximately as the third power of the stress range below the quasi-critical stress, as about the tenth power above the critical range when primarily loaded and as about the sixth power of the stress range for secondary loading. (4) The energy dissipated per cycle by hysteresis for any range of alternating stress depends upon the previous history of the material. Its value at any particular range varies with the excess of stress above the critical range to which the material has been subjected previously. (5) The high elastic steels showed low damping capacity. (6) Above the critical stress range the width of the hysteresis loop was hardly affected by a period of rest. (7) The hysteresis effect can be almost entirely removed in the case of low carbon steels by heating in boiling water for one hour.

PP: 3 5 G 11 13 16 S T AA 28 29 36 h 42 q CV: 14 MI: ST CN AY

Esau, A. and Kortum, H.

Concerning an Effect Exhibited by Ferromagnetic Materials Subjected to an Alternating Electromagnetic Field. (In German)

Zeit. f. Physik, Vol. 73, No. 9-10, pp. 602-619, 1932

A discussion of an effect exhibited between the mechanical characteristics of a material and its ferromagnetic properties when subjected to alternating magnetisation. The vibration power is exhibited mechanically when the elasticity of the material is affected by an alternating longitudinal magnetisation, by means of the torsional vibrations of the material. The apparatus is fully described. The amplitude of the torsional vibrations is only related to the frequency of the exciting field within wide limits, but when the frequency of the exciting field and the natural frequency of the mechanical vibrating system coincide, a maximum is reached, after which a slow drop is noted with further increase of frequency. The effect is examined for a variety of conditions and previous treatments. (Sci. Abs., p. 2557, 1932)

PP: 3 M 13 16 19 AA 30 c CV: 13 14 17 MI: SG n p

Field, G. S.

Vibrations in Solid Rods

Nature, Vol. 130, pp. 130-131, July 23, 1932

In connection with the study of vibrating metal rods a method of investigation has been devised which promises to lead to a number of new and interesting results. The experiment consists in tapping a rod at one end with a small hammer, and then making visible the train of waves which occur as a result of the impact. A piezo-electric crystal is used for a pickup. After amplification the voltage is impressed on a cathode ray oscillope. Upon synchronizing the time axis, the record may be recorded by photographing. In most cases the waves are quite complex, being combinations of longitudinal, flexural, and possible other modes of vibration. It is possible to pick out vibrations of different types by selecting the voltage output by means of tuned circuits. Curves are given for aluminum rods. Coefficients of viscosity were calculated from measured logarithmic decrements. The longitudinal vibration decrement for a certain aluminum rod was found to be 0.016, giving a value for the coefficient of solid viscosity of 4.6×10^4.

PP: 3 D 9 M AA 27 CV: 14 MI: Al a

Föppl, O. and Ludwik, P.

Methods of Material Testing for a True Strength Determination. (In German)

V. D. I. Z., Vol. 76, pp. 345-346, 1932

No abstract available.

PP: 3 D AA CV: 13

Götzelt, R.

The Damping Capacity of Copper, Zinc, and Its Alloys Under Dynamic Tension Compression Stresses. (In German)

Forschung, Zeitschrift Technische Mechanik und Thermodynamik, Vol. 3, pp. 241-246, September-October 1932

At equal loads, special copper shows a considerably higher damping than commercial copper. Damping of Cu-Zn alloys is appreciably smaller than that of its two main components. Slight surface imperfections do not affect the damping properties of brass. Measuring of damping capacity of plastic metals such as copper and its alloys requires special precautions as regards specimen dimensions and grips.

PP: 3 D G 9 L M 16 S 18 U X AA 28 36 39 CV: 13 14 MI: Cu Zn n

Henry, P. S. H.

Energy Exchanges Between Molecules

Proc. Camb. Phil. Soc., Vol. 28, pp. 249-255, 1932

In a study of the internal friction of gases, sound waves were found to be damped most strongly in bands whose periods are comparable to the relaxation times of the gas. For example, sound waves in N_2 are damped most strongly for those periods of vibration which are comparable to the time required for the temperature equilibrium to be established between the vibrational and translational degrees of freedom of the N_2 molecules.

PP: 3 6 CC CV: 14 MI: EG p

Keulegan, G. H.

Investigation of the Method of Determining the Relation of Statical Hysteresis and Flexural Stress by Measurement of the Decrement of a Freely Vibrating U Bar

Jour. of Research, U.S. Bur. of St'ds., Vol. 8, pp. 635-656, 1932

This investigation was undertaken to determine whether measurements of the decrement of a vibrating U bar could be used to measure with sufficient accuracy the statical hysteresis of the material. The statical hysteresis of a U bar of Armco iron was first measured under cyclic static loading, and then the decrement of the vibrations of the same bar were measured. The results of the experiments showed that within the limits of accuracy of the approximate theory used, both methods gave equivalent results. For stresses above a certain small threshold value, it was found that in Armco iron the energy lost by statical hysteresis varied approximately as the cube of the amplitude of the maximum stress. (Author's abstract)

PP: 3 D 5 16 S AA 28 CV: 14 MI: Fe a

Kimball, A. L.

Measurement of Damping Constants of Solid Materials

"Vibration Prevention in Engineering", John Wiley & Sons, Inc. N. Y., Chap. XIV, pp. 130-133, 1932

Two articles cover the revolving rod method of measuring internal friction and present damping constants for some eighteen various solids.

PP: 3 4 9 10 11 N 16 S W AA 28 CV: 16
MI: ST CN AY CI FF GG HH KK Al Cu Fe Mo Ni Sn W Zn a c d j n q

Kimball, A. L. n q

Measurements by Electrical Means of Vibration Damping in a Steel Bar. (In French)

Congrès International d'Electricité -- Compte Rendus, Vol. 13, Sec. 12, pp. 133-144, 1932

The methods used by the author in a study of internal friction and damping are described. Bars 37 in. in length and 1.25 cm in diameter were employed, however, use of larger samples is suggested.

PP: AA 27 28 CV: 13' 14 MI: ST CN

Ludwik, P. and Scheu, R.

Variability of the Damping Materials. (In German)

Zeitschrift des Vereines deutscher Ingenieure, Vol. 76, pp. 683-685, 1932

The damping capacity of several steels, electrolytic copper, and several aluminum and magnesium base alloys was investigated, and it was indicated that damping is greatly dependent on frequency and temperature. The change of the damping of the material with the number of alternations was examined by means of continuous optical measurements of the hysteresis loops during fatigue tests. Comparative fatigue tests with and without cooling demonstrated the very great influence of the temperature on the damping. An explanation of the observed phenomena is put forward.

PP: 3 5 R T U AA 29 30 CV: 13 14 MI: ST CH Al Cu Mg a b

Quimby, S. L.

Some New Experimental Methods in Ferromagnetism

Physical Review, Second Series, Vol. 39, pp. 345-353, January 15, 1932

This is a summary of the properties of single crystals of nickel. The discussion is limited to a brief description of certain methods which have been devised for observing the magneto-elastic, mechanical, and thermal properties of single crystals of nickel, as well as polycrystalline specimens of the same substance. Attention is directed to the refining of nickel, the growth of single crystals, measurement of the coefficient of thermal expansion with temperature, magnetostrictive changes in length, variation with temperature through the Curie Point of Young's modulus, measurement of the coefficient of rigidity, and the measurement of coefficient of internal friction by direct determination of the decrement of longitudinal vibration in freely suspended rods. The rods were excited to resonance at one of its harmonics by piezoelectrical means. The variation of internal friction with magnetic field intensity is discussed and experimental results are shown.

PP: 3 D 9 M 16 V X AA 30 c 36 j CV: 14 MI: SG Ni a n p

Robertson, D.

The Vibrations of Revolving Shafts

Phil. Mag., 7th Ser., Vol. 13, pp. 862-865, 1932

In discussing the paper by R. C. J. Howland in Phil. Mag. for August 1931, this article suggests that certain assumptions employed there were not valid and the conclusions drawn from the resulting analysis are incorrect. This author concludes that the explanation of the phenomena of shaft whirling put forth by Kimball and Newkirk, namely, as being due to elastic hysteresis and cramping fits, is essentially correct.

PP: N Y

Sayre, M. F.

Elastic After-Effect in Metals

J. of Rheology, Vol. 3, pp. 206-211, 1932

A discussion is given of a group of phenomena lying on the border line between plastic and elastic action in metals and in other solids. This group results from the so-called elastic after-effect. Typical measurements for spring steels, hard copper wire and aluminum alloy wire are given. The causes for this effect are examined. The presence of an elastic after-effect due to thermal causes implies the existence also of a mechanical hysteresis loop due to the same causes. Based on experimental data given for after-effect and on some theoretical studies of heat transfer rates, the computed probable area of such a loop was found to be not far different in magnitude from the experimental results obtained. However, here again it is highly probable that both this thermal effect and also some form of inelastic action combine in most cases if not in all to produce the final loop.

PP: 3 5 AA 30 b d CV: 17 MI: CN Al Cu s

Sezawa, K.

The Effect of End Pressure on the Flexural Vibration of a Specimen with Internal Damping. (In German)

Zeit. f. angewandte Math. u. Mechanik, pp. 275-279, October 1932

A bar of a material having internal friction executes transverse oscillations while under the action of thrusts at the ends. The problem is stated mathematically and solved. The end pressures have a profound effect on the frequency of oscillation, in extreme cases reducing it to zero and under conditions here determined, sometimes producing a labile state in the bar. (Sci. Abs., p. 59, 1933)

PP: 3 12 14 Y CV: 13 17

Sezawa, K. and Kubo, K.

Measurements of Solid Viscosities of Metals Through Flexural Vibrations of a Bar. (In English)

Rep. Aero. Res. Inst., Tokyo Imperial Univ., Vol. 7, No. 89, pp. 195-231, December 1932

This describes the experimental determination of coefficients of solid viscosities of aluminum, duraluminum, copper, and brass, by means of flexural vibrations of a bar. The resistance of a solid body due to damping was assumed to be proportional to the velocity of deformation. The coefficient of solid viscosity was found to be as amsll as 10^6 in c.g.s. units.

PP: 3 10 12 16 19 AA 36 k CV: 14 MI: Al Cu Zn' a h 40 n

Voigt, E. and Christensen, K. H.

Damping Capacity and Fatigue Strength of Steels. (In German)

Mitteilungen aus dem Kaiser-Wilhelm Institut für Eisenforschung, Vol. 14, pp. 151-167, 1932

Comparisons were made of the damping capacities of a number of steels in a special form of an electrically operated machine, which measured damping in torsional fatigue at very low stresses. The general conclusion was drawn that, for torsional stress cycles at rates between 200 and 2500 cycles per minute, the elastic and plastic behavior was independent of the rate of strain.

PP: 3 13 16 19 AA 27 42 r CV: 13 14 MI: ST CN

1933

Auwers, O. von

On the Dependence of the Elastic Moduli and Damping of Ferromagnetic Material on the Intensity of Magnetization. (In German)

Annalen der Physik, Vol. 17, Ser. 5a, pp. 83-106, 1933

The materials investigated in this study were nickel rod (hard and annealed), nickel tube (soft), Permalloy, soft iron, and hard steel. It was found that the change in modulus of elasticity is greater the softer the material and the greater the magnetostriction. Longitudinal tension practically obscured the effect. (I. of Met., Met. Abs., Vol. 1, p. 165, 1934).

PP: 14 16 V AA 30 c 42 s CV: 13 14 MI: ST CN SG Fe Ni a 35 h n p

Bankwitz, E.

The Dependence of Material Damping on the Magnitude and Speed of Deformation. (In German)

Metallwirtshaft, Vol. 12, No. 3, pp. 33-35, January 20, 1933

The relation of damping or the elastic hysteresis of materials to the magnitude and speed of deformation is considered. Several methods of determining elastic hysteresis are enumerated. A new method is described with which the damping can be determined at zero deformation, at which point, it is claimed, all other methods fail. The dependence of the resonance vibration frequency on the magnitude of the torsion angle has been measured in a torsion vibration machine. The frequency is constant for small twists, but decreases linearly above a definite limiting value which must be considered as the beginning of the damping action, and is about half as great as the twist value at which heating of the material becomes measurable. This procedure therefore provides a sensitive method for determining the beginning of damping. The behavior is the same for vibration frequencies between 200 and 2500 cyps. The different frequencies were obtained by altering the oscillating mass. The damping behavior is thus independent of the rate of deformation. The static yield point rises appreciably after some millions of alternations under torsion vibration loading; this effect is particularly marked with aluminum and an aluminum alloy the rise being between 40-50% compared with 15-30% for other metals.

PP: C D E F 13 16 S T 19 AA 27 28 CV: 13 14 15 MI: Al a

Esau, A. and Kortum, H.

The Variability of Material Damping (In German)

V.D.I.Z., Vol. 77, No. 42, pp. 1133-1135, 1933

Tests have shown that for the determination of the damping properties of materials it is not sufficient to make only a short-time test, but that the variability of the damping during prolonged stressing and also the damping range both must be determined. For these tests, machines in which, besides the endurance stressing, the damping can be measured by oscillation methods, are particularly well suited. (Abstract J. I. & S. I.).

PP: 3 16 T AA 29 42 r CV: 13 14 MI: ST CN CI Fe Ni

Filliâtre, L. and Vernotte, P.

The Elastic Defects of Metals. (In French)

Comptes Rendus hébdomadaires de Séances de l'Academie des Sciences de Paris, Vol. 196, pp. 1374-1376, 1933

On deviations from elasticity in metals.
PP: AA 42 q CV: 13'

Frankenberg, H.

The Influence of Torsional Vibration on the Strength and Damping Capacity of Metals with Special Reference to Aluminum Alloys. (In German)

Mitteilungen des Wohler-Instituts, Heft 16, Braunschweig, 1933
Berlin: NEM Verlag, G. m. b. H., Schöneberger Ufer 34

This work described in this publication is based on that undertaken by Bankwitz and published in Heft 11 of the Wohler Institute Journals. There are four sections, of which the first serves as an introduction and a review of previous work, and the last is a summary of the conclusions. The second section is devoted to standard static calibration curves of various ferrous and non-ferrous materials, the third to "Werkstoffdampfung" (defined as "that work per unit volume which in every change of loading is converted into heat") and rate of oscillation, and the fourth to the mechanical properties of the materials under test. The object of the research is to supply answers to the following questions:
(1) What is the course of the "Dämpfung" curve when alternations between o and 200 per minute are employed?
(2) Does the "Dämpfung" of a material vary when the latter is maintained under constant stress for a lengthy period?
(3) What influence have impurities in aluminum on the form of the alternating stress diagram?
(4) Is there a reliable relationship between an alteration in the rate of alternations and the "Dämpfung"?
(5) Is a greater or lesser number of small changes of form more potent in raising the elastic limit?
(6) What is the effect of continued application of stress on the plastic limit?
(7) What relationships exist between the "Dämpfung," rate of alternations, and the fatigue strength? (Inst. of Metals, Met. Abs., Vol. 1, p. 404, 1934
PP: 3 7 13 16 T 19 AA 36 37 k 42 r CV: 13 14 15 MI: Al b)

Hempel, M.

The Behavior of Material Damping Under Vibrational Stress. (In German)

Z. f. Tech. Physik, Vol. 14, pp. 232-235, 1933

This is a brief account of experiments investigating a possible relation between the strength of steel under alternating loads and the damping of free oscillations in the material. The damping increases with the number of alternations of the load previously imposed on the specimen. No certain relation is found, however, by which the strength could be found from the damping. (Sci. Abs., p. 3322, 1933)
PP: 3 D 9 16 T AA 42 r CV: 13 14 MI: ST CN

Homann, E. and Bernhard, R. K.

Mechanical Vibration of Bridges. (In German)

Verkehrstechnische Lehrmittelgesellschaft, Berlin, 1933

No abstract available.
PP: 3 E W BB CV: 13

Parzich, G.

The Damping Properties of Non-Metals. (In German)

Forschung, Vol. 4, No. 1, pp. 8-10, 1933

Results of damping and fatigue tests of the following non-metallic materials are given: Novotext, hard rubber, vulcanized fiber, and Trolit. A comparison of edge damping in cases of bending and torsion is given. Endurance strength is treated.
PP: 12 13 AA 28 42 r CV: 13 14 MI: GG

Pohl, W. M.

Vibrations of Structures and Materials

Product Engineering, Vol. 4, pp. 91-94, 1933

This is a general article discussing the importance of damping in the vibrations of structures and materials from the viewpoint of the designer. The effect of different methods of fabrication on vibration response is considered with special reference to the effect of joints.
PP: A W 23 AA BB CV: 15 MI: CN CI Al a

Polotowsky, L.

Electromagnetic Measurement of Internal Friction. (In German)

Physikalische Zeitschrift der Sowjetunion, Vol. 3, p. 555, 1933

Abstract not available.
PP: 3 AA CV: 13 14

Pomp, A. and Zapp, B.

Acoustic Materials -- Testing of Steel Bars, Especially for Chimes. (In German)

Mitt. Kaiser - Wilhelm - Inst. Eisenforschung, Vol. 15, pp. 21-35, 1933

The authors studied the acoustic properties of a series of quenched and tempered carbon-steel rods. They also determined the damping properties on a few specimens and correlated damping with acoustic properties. It was found that the steels with the highest damping capacity made the poorest gongs. The sonorousness and the damping were found to be related to the metallographic structure and the internal stresses present.
PP: 3 6 12 W AA 36 h 42 s CV: 13 14 MI: ST CN

Popoff, W.

A Resonance Torsional Vibration Damper with Material Damping for the Crankshafts of Diesel Engines. (In German)

V. D. I. Z., Vol. 77, pp. 19-23, 1933

This is a theoretical and experimental investigation of the efficiency of a torsional vibration damper using rubber. The results of tests on a 500 hp. stationary and an 80 hp. automotive Diesel engine are given. Reductions of amplitude by 50% at the critical speeds are effected.
PP: 3 E 13 W Y AA CV: 13 14 17 MI: GG

Schrader, J.

On the Damping Behavior of Flat Leaf Spring Vibrations. (In German)

Dissertation, Braunschweig, 1933

No abstract available.
PP: 12 Y AA CV: 13 14

Smith, D. M.

The Motion of a Rotor Carried by a Flexible Shaft in Flexible Bearings

Proc. Roy. Soc. Ser. A, Vol. 142, pp. 92-118, 1933

This paper discusses the transverse motion of a rotor carried by a flexible shaft rotating in flexibly-supported bearings. The rotor is assumed to consist of one or more rigid bodies mounted on a shaft which is weighless and torsionally rigid. The rotor and shaft are in rotation; in the first place, it is taken that the speed of rotation is maintained constant, driving torques being applied if necessary about the shaft axis. Unsymmetrical flexibility of the bearing supports and unsymmetrical transverse flexibility of the shaft are taken into account, and the effect of damping which resists change of strain of the flexible members of the system is also considered. The work is mainly analytical, but reference is also made to experiments which have been carried out. (Author's introduction)
PP: N Y CV: 14 17

Waller, M. D.

Vibrating Properties of Metals at Different Temperatures

Physical Soc , Proc., Vol. 46, pp. 124-126; Disc., pp. 126-7, Jan. 1, 1933

A simple acoustical method of studying the vibrating properties of metals at different temperatures is described. Since the damping of the vibrations, which is mainly due to internal friction or solid viscosity, is greatly altered either by previous heat or mechanical treatment and by impurities, i.e. is not constant at any given temperature, such a method capable of giving numerous comparative data over wide ranges of temperature should be of value. Furthermore, there is promise that on account of the large variations of the vibrating properties with temperature it will be possible to obtain, by observations of irregularities in these variations, much interesting information regarding the state of metals and alloys at different temperatures. (Author's abstract)
PP: B 3 6 10 12 16 U AA 27 36 h CV: 14

Weckmar, W.

On the Influence of Notch Sensitivity and Cold Work on the Damping Capacity and Vibration Fatigue Strength of Cut and Rolled Threads by Dynamic Tension-Compression Loading. (In German)

Dissertation, Jena, pp. 1-35, 1933

No abstract available
PP: M AA 36 k 42 44 CV: 13 14

1934

Becker, R. and Kornetzki, M.

Some Magneto-Elastic Torsion Experiments. (In German)

Zeit. f. Physik, Vol. 88, Nos. 9-10, pp. 634-646, 1934

It is observed that when wires are twisted and released a residual twist is obtained, which increases at first with the initial twist applied, but finally approaches a saturation value. It can be removed by applying a longitudinal magnetic field or an alternating current demagnetization. With a still larger initial twist a genuine plastic residual twist occurs which cannot be similarly removed. (2) The maximum residual twist agrees closely with that produced by a spiral magnetic field (Wiedemann effect). (3) Curves connecting applied torque with resulting twist show marked hysteresis, which is almost entirely suppressed by applying a longitudinal field of 100 Oersteds. (4) The damping of torsional oscillations in the wires is reduced to about a tenth by applying a similar field. These effects on the purely mechanical properties of the materials are explained by the change of direction of the spontaneous magnetisation produced by external mechanical forces.
PP: 3 D 10 13 16 S V AA 30 c CV: 13 14 MI: Fe Ni a

Cooke, W. T.

Dependence of Internal Friction on Magnetisation in Iron

The Physical Review, Vol. 45, Ser. 2, p. 742, 1934

Experiments are described in which the specimen used in the form of a rod 28 cm. by 5 mm. in dia. forms part of a composite piezoelectric oscillator. The decrement in vacuo of the mechanical system is obtained by measuring the equivalent resistance and inductance of the oscillator with an alternating current bridge. Approximately uniform magnetization is obtained by the use of special coils. The decrement increases with magnetization, reaches a maximum near the knee of the magnetization curve, and then decreases. The largest value is about four times that when demagnetized.
PP: 3 D M 16 V BB 27 30 c CV: 14 MI: SG Fe p

Cremer, L.

Resonance Curves for Vibrating Rods. (In German)

Preuss Akad. Wiss., Berlin, Ber. 1, pp. 2-24, 1934

An electrical analogy is employed in calculating the particle velocities in the longitudinal and flexural oscillations of a rod by the four pole method. Forced oscillations and resonance are chiefly considered. (Sci. Abs., p. 3512, 1934).

PP: 3 E M Y CV: 13 17

Esau, A. and Kortum, H.

Damping Measurements as the Basis of a Method for the Determination of Vibration Fatigue Strength. (In German)

Messtechnick, Vol. 10, pp. 21-23, 1934

No abstract available.

PP: 1 3 AA 42 r CV: 13

Föppl, O.

Appraisal of Materials by Their Damping Properties. (In German)

Mitteilungen des Wöhler-Instituts, Braunschweig, Vol. 18, 8 pp., 1934

Föppl complains that his arguments in favor of making crankshafts for internal combustion engines from materials with high damping power have not received the attention they deserve. Purely elastic materials are free from damping, and local stresses cannot be readily relieved by local flow. Notches and other stress-raisers are, therefore, more harmful in materials of low damping capacity.

PP: 1 W AA 42 44 CV: 13 15

Föppl, O. and Buchmann, W.

The Notch Sensitivity of Materials. (In German)

Forschung, Vol. 5, pp. 192-194, 1934

The notch sensitivity of materials is discussed and the relation of damping capacity to this property is considered.

PP: AA 42 44 CV: 13 17

Frankenberg, H.

The Influence of Torsional Vibration on the Strength and Damping Capacity of Aluminum Alloys. (In German)

Metallwirtschaft, No. 11, pp. 187-191, 1934

The fatigue tests were made on rolled bars of 99.5% and 98% pure Al, 98-2, 96-4, and 94-6 Al-Cu, 95-5, 87-13 Al-Si, and 98-2 Al-Mg alloys. The Cu and Mg alloys were heat treated, the others hot rolled. The test bars were calibrated before and after each fatigue test. The results of the fatigue tests are shown in graphs. The elastic limit of all the materials except the Al-Mg alloy was increased by repeated stresses near the endurance limit. The increase in elastic limit is not changed by interruptions in stressing. The damping ability at 20-1500 cycles/min is not affected by the rate of deformation. In the Cu alloys the damping ability increases with the total cycles of deformation; in the 98% Al it decreases; and in the others it is unchanged. (Chem. Abs., Vol. 28, pp. 4354-4, 1934)

PP: 13 16 T 19 AA 36 37 42 q r CV: 13 14 MI: Al Cu' Mg' Si' a

Geiger, J.

The Damping Under Torsional Vibration of Internal Combustion Engines. (In German)

Mitteilungen aus den Forschungstalten -- GHH -- Konzern, Vol. 3, No. 6, pp. 147-165, December 1934

This deals with the damping of torsional oscillations in internal combustion engines. It is shown that use of a mean damping factor for internal combustion engines leads to incorrect analytical results. An investigation is made of different apparent and actual damping processes, the most important of which is claimed to be hysteresis. It is indicated that when passing through a critical speed, 60-65% of the total energy of torsional oscillation is converted into heat by the internal damping of the crankshaft steel, and that only the remaining 40-35% is accounted for by external damping.

PP: 3 13 W Y AA BB CV: 13 14 17 MI: ST

Geiger, J.

Damping During a Rotational Vibration of an engine. (In German)

Zeitschrift des Vereines deutscher Ingenieure, Vol. 78, pp 1353-1355, 1934

Damping which takes place during the rotational vibration of an engine consists of a series of different increments following a certain law. This is investigated on the basis of thirty different cases.

PP: 3 4 J 13 15 S AA BB CC CV: 13 14 15 MI: ST CN AY CI

Griffith, T. R.

A Mathematical Treatment of a Theory of Rubber Structure

Canadian Jour. of Research, Vol. 10, pp. 486- , 1934

This includes an explanation of the cause of hysteresis in rubber through the action of Van Der Waals forces.

PP: AA 30 31 CV: 17 MI: GG

Kersten, M.

On the Explanation of the Mechanical Damping of Ferromagnetic Materials Due to Magnetization. (In German)

Z. Tech. Phys., Vol. 15, No. 11, pp. 463-467, 1934

The mechanical damping of a ferromagnetic body is greatly affected if the body is magnetized to a degree below the saturation value. It is shown that the damping is due to eddy currents which arise in the oscillating body through variations in magnetization and which are coupled with the mechanical oscillations.

PP: 3 D 9 11 M 16 S 19 V AA 30 c CV: 13 17 MI: SG Ni 35 h n p

Klein, W.

The Measurement of the Damping of Structural Materials by Means of the Recording of Resonance Curves

Ing. Arch., Vol. 5, No. 1, pp. 1-6, 1934

No abstract available.

PP: 3 E AA CV: 13

Mansa, J. L.

The Determination of the Damping of Torsional Vibrations of an Aircraft Engine Crankshaft. (In German)

Thesis published by Messrs. Levin and Munksgaard of Copenhagen. Review in Engineering, Vol. 137, p. 529, 1934

The study comprises a theoretical and experimental analysis of the torsional vibrations of an aero-engine crank-shaft, with special reference to the influence of damping on the form of the oscillations and to the relative importance of the different factors which normally contribute to the damping of torsional vibrations in a typical combination of propeller and piston driven engine. The author's work provides an indication of the direction in which the restriction of torsional vibrations, leading to power losses and possible fatigue failure, may most profitably be taken.

PP: A 3 13 Y AA CV: 13 14 17

McAdam, D. J. Jr. and Clyne, R. W.

Influence of Chemically and Mechanically Formed Notches on Fatigue of Metals

Nat. Bur. Standards, Jour. of Research, Vol. 13, pp. 527-572, 1934

Section IV of this paper considers the relationship between notch sensitivity (as measured by percentage damage) and other properties of metals. The properties considered are: Hysteresis, ductility, and work-hardening capacity. Evidence is presented that scatter of individual results in a composite graph, of the type used, is due largely to differences in work-hardening capacity. Evidence is also presented that notch sensitivity, while depending somewhat on elastic hysteresis, depends largely on work-hardening capacity. (From authors' abstract)

PP: 16 T AA 29 42 44 CV: 14 15 MI: ST Al

Orowan, E.

Damping of Vibrations in Mica. (In German)

Zeit. f. Physik, Vol. 87, No. 11-12, pp. 749-752, 1934

In a piece of mica as ordinarily cut, vibrations appear strongly damped and the note emitted resembles that from a piece of paper. If, however, the specimen is cut with a diamond saw, so as to leave no frayed edges, the note is metallic and undamped. The damping has therefore no connection with the internal structure of mica. (Sci. Abs. A, p. 1661, 1934).

PP: 3 6 AA 30 CV: 13 14 MI: LL

Orowan, E.

Plasticity of Crystals. (In German)

Zeit. f. Physik, Vol. 89, No. 9-10, pp. 605-659, June 26, 1934

In Part I, Becker's formula for the rate of slip in a crystal deformed beyond its elastic limit is shown to yield the following equation for the variation of the yield stress with temperature, viz., $\sigma = \sigma_0 - \beta\sqrt{T}$, where σ_0 and β are constants. In Part II the significance of the relation between shear stress and the rate of slip is considered in greater detail. In Part III are described experiments to elucidate the mechanism of slip, and the conclusion reached is that in a crystal both the "static" process originated by microscopic faults and the "dynamic" process due to thermal fluctuations are operative.

PP: AA a b CV: 13 17

Robertson, D.

The Whirling of Shafts

The Engineer, Vol. 158, pp. 216, 228, 1934

This is a detailed discussion of the problem. Sections deal with a lengthy introduction, causes of whirling, the Coriolis acceleration, the principles of suppression, the trochoidal family of curves, whirl induced by a rotating force, locus diagrams for point of equilibrium, equilibrium circles, stability above the critical speed, and unbalance whirl. Frictional and hysteretic forces are considered.

PP: N Y CV: 17

Rouchet, M.

A Contribution to the Study of Dynamic Fatigue Phenomena. (In French)

Bulletin de l'Association téchnique Maritime et Aéronautique, No. 38, pp. 463-514, 1934

This paper is a contribution to the study of the phenomena of dynamic fatigue. It gives the results of tests and theoretical and practical conclusions. The tests were made with the Losenhausen torsion machine. The results of static torsion tests and dynamic tests are included. (Eng'g Index, p. 1045, 1935)

PP: 3 5 13 AA 42 r CV: 13 14

Späth, W.

Characterization and Measurement of the Internal Energy Absorption of Materials. (In German)

Z. f. Techn. Phys., Vol. 15, pp. 477-4781, 1934

This paper defines attenuation in vibrating systems and describes the various methods of measurement. The advantage of defining symbols for theoretical and practical consideration of electric and mechanical vibrating systems is discussed. Attention is confined to systems which are subjected to a periodically varying torsional deformation.

PP: 3 13 Y AA 36 CV: 13 14

Waller, M. D.

Note on the Vibrating Properties of Metals at Different Temperatures

Proc., Phys. Soc., Vol 46, pp. 124-126, 1934

A simple acoustical method of studying the vibrating properties of metals at different temperatures is described. Since the damping of the vibrations, which is mainly due to internal friction or solid viscosity is greatly altered either by previous heat or mechanical treatment and by impurities, i.e. is not constant at any given temperature, such a method of giving numerous comparative data over wide ranges of temperature should be of value. Furthermore, there is promise that on account of the large variations of the vibrating properties with temperature it will be possible to obtain, by observations of irregularities in these variation, much interesting information regarding the state of metals and alloys at different temperatures. The method used consists of suspending a bar of square or circular cross section, of side or diameter 0.5 cm. and length 15 cm. from two nodes so that it may vibrate transversely as a free-free bar, heating it to known temperatures, striking it a smart blow with a hammer held in the hand, and determining by means of a stop-watch the number of seconds which the resulting note remains audible to the observer listening near the bar with the same ear.

PP: B 3 6 12 16 U AA 27 CV: 14

Appenrodt, A.

The Damping Capacity of Crankshaft Steels in the Cold and Hot Conditions As Supplied and in Continuous Service. (In German)

Mitteilungen des Wöhler-Instituts, Braunschweig, No. 24, 98 pp., 1935
Abstract: Stahl and Eisen, Vol. 55, No. 2, pp. 964-965, 1935

A series of C, Ni, Ni-Cr, Ni-Mo, Ni-W, Ni-Cr-Mo, and Ni-Cr-W steel specimens, many of them cut from large crankshafts, and ranging from 70,000 to 200,000 psi tensile strength, was studied as to torsional damping properties. The damping properties were studied as received, and after 1/20, 1/4, 1-1/4, 6-1/2, and 31-1/4 million cycles of repeated stress both at 20° C and at 120° C. The change in damping between the original condition and 50,000 cycles is usually noticeable. In general, the damping capacity increases with service in the very hard steels, and decreases in the soft ones. Low-tensile steels show high damping capacity, and the high tensile steels, low damping capacity.

PP: 13 16 T U AA 36 k 42 s CV: 13 14
MI: ST CN AY C' Fe Mo' Ni' W' 37 q r s

Eccles, J. C. and Thompson, J. H. C.

An Investigation of the Visco-Elastic Properties of Rubber

Proc. Roy. Soc. London, Vol. 148, pp. 171-185, 1935

An account is given of an investigation of the visco-elastic properties of rubber by means of observations on the damping of forced longitudinal vibrations. An attempt is made to determine the visco-elastic limits for rubber, as well as the normal visco-elastic constant T and the coefficient of normal viscosity E'. The analysis of the experiment predicts the forms of the photographic record of the damped vibrations, and gives an expression for T in terms of the period of vibration and the logarithmic decrement of the amplitude per vibration. Two series of experiments are described in detail.

In the first series, where catapult elastic was used, the experimental results are susceptible of detailed analysis. They agree with those predicted by the theory of viscous-elasticity when the rate of strain does not exceed 0.1 per sec. This is the upper visco-elastic limit. The lower visco-elastic limit for the rate of strain was not reached, so it must be less than 0.017 per sec. The value obtained for T is 28.7×10^{-4} sec, and the corresponding value of E' is 3.42×10^{4} in cgs units.

In the second series of experiments pure black rubber was used, and a wider range of frequency of vibration and rate of strain was obtained. Also experiments were carried out at different mean tensions. The experimental results show signs of some unknown disturbance and are difficult to analyze. They suggest 6×10^{-4} sec as a probable value for T, and 0.78×10^{4} for E', for pure black rubber, with a rate of strain 0.1 sec as a probable upper visco-elastic limit (at a mean tension of 150 gm weight). The value of T at 300 gm mean tension does not differ significantly from that at 150 gm. (Authors' summary)

PP: 3 D 9 M 14 16 19 Y AA 30 d CV: 14 MI: GG

Hempel, M. and Plock, C. H.

Endurance Strength and Damping Capacity of Unalloyed Steels as Dependent on Chemical Composition and Heat Treatment (In German)

Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Vol. 17, pppp. 19-31, 1935

Tensile, endurance, and damping tests were made on a series of carbon steels. The damping was determined by varying the amplitude and plotting this, expressed in percentage, against the logarithmic decrement. No definite relation between carbon content and logarithmic decrement was found. To determine the effect of structure, two steels containing 0.39 and 0.77% carbon were used. These were treated so that various structures were obtained, including completely troostitic, sorbitic, and lamellar pearlitic structures. In general it was found that the specimens having structures corresponding to high strength also had high endurance (alternate tension-compression) and low damping capacity. Troostite had the lowest damping capacity; furthermore the damping of a steel which is wholly troostitic changes but slightly as the amplitude increases. The superiority of the pearlitic structure in damping out vibration becomes more clearly apparent as the amplitude increases.

PP: 3 E 9 M 16 S 19 AA 28 g h 42 q r CV: 13 14
MI: ST CN AY Fe Mn' Si' 32 h p r

Holtschmidt, O.

A New Vibration and Damping Testing Machine of MAN. (In German)

Mitteilungen aus den Forschungenanstalten des G. H. H. Konzerns, Vol. 3, pp. 279-284, 1935

This is a description of a machine for testing under alternating stresses in torsion or bending. The damping is shown by automatically registering the curve for the decay of free oscillations.

PP: 3 D 12 13 AA CV: 13 14

Kersten, M.

The Characteristic Behavior of the Elasticity Modulus of Ferromagnetic Materials. (In German)

Zeit. f. Metallkunde, Vol. 27, pp. 97-101, 1935

The theory of magnetic domains, as developed by Weiss and Heisenberg, is described simply, especially with regard to magnetostriction. It is shown that the deviations from Hooke's Law which occur in ferromagnetic materials even in the absence of an external magnetic field, may be explained.

PP: AA 30 c CV: 13 17 MI: SG n p

Körber, F. and Hempel, M.

Influence of Straining and Aging Upon Behavior of Steel Under Alternating Stresses

1935 Mitt. a. d. Kaiser-Wilhelm Institut für Eisenforschung, Vol. 17, No. 22, pp. 247-257, 1935. Abstract: Trans. available from Henry Brutcher, Altadena, Calif., No. 372

The effect of the mechanical and thermal aging of cold worked steels on the static properties, the bending and tension-compression fatigue strength, the changes in the damping capacity of the material and metallographic and X-ray tests are described. In the damping measurements, the dependence of the damping on the amplitude, time and deformation was determined. For both materials the stable damping of the 5% cold worked and thermally aged specimens was less than that of those aged mechanically; after 10% cold-work the condition was reversed.

PP: 3 E 9 M 16 ST AA 28 36 h k CV: 11' 13 14 MI: ST CN g p

Kostitzin, V. A.

On Hereditary Elastic Phenomena. (In French)

Bulletin de Sciences Mathématiques, Ser. II, pp. 204-224, 227-237, 1935

This paper treats the theory of a series of cases of retarded elasticity and of secondary hysteresis somewhat analogous to that of Boltzmann and of Wiechert.

PP: AA 30 34 42 q CV: 13' 17

Odone, V.

Transvers Vibrations of a Bar in a Resisting Medium, Caused by Oscillations of One End. (In Italian)

Atti Accademia delle Scienze di Torino, Vol. 70, pp. 276-283, 1935

No abstract available.

PP: 12 Y CC CV: 12' 17

Orowan, E.

Plasticity of Crystals. Part IV. Further Foundation for the Dynamic Plasticity Law. (In German)

Zeit. f. Physik, Vol. 97, pp. 573-595, 1935

The dynamical view of slip, put forward in a previous paper, is considered in greater detail. The plastic limit is not noticeably affected by the recovery of the crystal during the experiment. Hence its dependence on temperature and flow velocity cannot be interpreted as a recovery effect in a statical theory. In particular, its velocity dependence is directly connected with a dynamic plasticity law. Confirmation is derived from curves of flow of Zn crystals. (Chem. Abs., pp. 1278-9, 1936)

PP: AA 30 b CV: 13 17 MI: Zn a

Orowan, E.

Plasticity of Crystals. Part V. Completion of the Slip-Velocity Formula. (In German)

Zeit. f. Physik, Vol. 98, pp. 382-387, 1935

A new term is added to the formula so that it gives zero slip velocity for zero shearing stress; this term is practically negligible for metals but may be of importance in organic crystals. (Eng'g. Index, p. 2071, 1936)

PP: AA 30 b CV: 13 17

Robertson, D.

Transient Whirling of a Rotor

Phil. Mag., 7th Series, Vol. 20, pp. 793-825, 1935

This is a lengthy study of the problem which considers transient whirls, initial magnitude of transient, form of transient motion, examples of transient whirls, transient with shaft running at the critical speed, experimental observation of the transient, observed behavior of transient, repeated transient due to striking, experimental observations of repeated transient, and historical notes on the results of previous investigations.

PP: N Y CV: 14 15 17

Robertson, D.

Hysteresis Influence on Whirling of Rotors

Proc., Inst. Mech. Eng., Vol. 131, pp. 513-537, December 1935

After a short summary of the known facts concerning elastic hysteresis, an explanation is given of the way in which it can produce whirling when the shaft is running above its critical speed. Elastic hysteresis causes a deflexion of a revolving shaft subject to a transverse load, and a summary is given of the laws of elastic hysteresis found by Kimball, and Kimball and Lovell, from tests which made use of this phenomenon.

Clamping fits, couplings, and the endwise friction in the bearings, can act in a similar manner, and attention is drawn to several important points which should be borne in mind when designing a high-speed rotor. The effects of hysteretic forces on the stability of the shaft are discussed, with an approximate quantitative theory, and a simple method of experimentally observing the sustained transient is described. Paper concludes with a bibliography.

PP: 1 3 D N Y AA CV: 15 17

Shannon, J. F.

Damping Influences in Torsional Oscillation

Proc., Inst. Mech. Eng., Vol. 131, pp. 387-492, 1935

An investigation of the damping influences occurring in multicrank engines when in a state of torsional oscillation is described. The major part of the experimental work was carried out on a four-cylinder petrol engine, and a Geiger torsiograph was used to examine conditions of resonance. Extreme methods of lubrication are adopted, and the outstanding influence of lubrication in the control of amplitude at resonance is demonstrated. For the engine dealt with, the principal source of damping is traced to the main bearing. The dissipation of energy in an oil film, due to journal vibration, is examined analytically and expressed in terms of journal displacement. From an investigation of the journal displacements caused by crankshaft oscillation, it is found that practically all the input energy of vibration could be accounted for in this manner, thus confirming the experimental observations. The results are finally reduced to an overall non-dimensional factor which is practically constant for the range of frequencies investigated. Results from a number of multicrank engines on which further experiments had been carried out were available and these, together with other published data, are also reduced to this simple non-dimensional form. The value of the factor is not constant for the different engine systems, but appears to be correlated to the elastic curve form at the engine, and an average curve taken on this basis is presented as a guide in design. (Author's abstract)

PP: 3 E G 10 11 13 16 S 19 AA BB CC 36 h k CV: 14 17 MI: ST

Späth, W.

Model to Demonstrate the Phenomena in Loaded Materials. (In German)

Archiv. f. d. Eisenh., Vol. 8, pp. 405-416, March 1935

By means of a model the author explains the experimentally determined relationships between the load and the deformation under static and dynamic loading. Under load, transverse slip must take place, on which the elastic limit, the yield point and limit of proportionality depend very largely.

PP: 3 D 8 9 10 11 M 16 S T 19 AA BB 28 29 30 34 36 k 42 CV: 13 17

Van Dyke, K. S.

A Determination on Some of the Properties of Piezoelectric Quartz Resonators

Proc., Inst. Radio Eng., Vol. 23, pp. 386-392, 1935

The logarithmic decrement of X-cut quartz rods was determined from the oscillographic records of the decay of free vibrations of the rods and the results were in agreement with those obtained by the resonance curve method.

PP: 3 D E 8 9 M 16 U AA 28 36 39 CV: 14 MI: LL

Von Schlippe, B.

On Internal Damping. (In German)

Ing. Arch., Vol. VI, pp. 127-133, 1935

PP: AA CV: 13

Wegel, R. L. and Walther, H.

Internal Dissipation in Solids for Small Cyclic Strains

Physics, Vol. 6, No. 1, pp. 141-157, April 1935

This paper presents the results of investigations of dissipation of energy in vibrating solids, mostly metals, by means of longitudinal and torsional vibrations of cylindrical rods. The amplitudes of strain used have been kept between 10^{-5} cm/cm and 10^{-8} cm/cm, in which range the dissipation of energy is proportional to the square of the strain. The specific dissipative property of a material is expressed in three different ways: (1) equivalent viscosity or the ratio of stress to dissipative component of strain rate; (2) hysteretic constant defined as the area in ergs of the cyclic stress-strain diagram; and (3) elastic phase constant defined as the ratio of specific elastic reactance to equivalent viscosity. Within a range of frequencies

PP: 3 D E G 8 10 11 M 13 P 16 S 19 W AA 27 30 31 d 36 h 38 42 q s
CV: 14 MI: ST AY GG KK Ag Al Cu Mg Ni Pb Zn' n

1936

Anonymous

Damping Capacity of Metals

The Engineer, p. 388, October 9, 1936

This is a report of the discussion at a meeting of the Iron and Steel Institute following the reading of the paper: Damping Capacity of Metals, by O. Föppl.

PP: 3 D L 13 W AA 36 h 38 k 42 q 44 CV: 15 MI: ST

Bacon, F.

A Note on the Terminology of Damping and Fatigue

Iron and Steel Institute, Jour., No. 2, p. 418, 1936

The translation into English of O. Föppl's paper presented certain difficulties because English versions of some of the chief technical terms are either non-existent, not exact equivalents, or in an unfortunate state of confusion. In these notes, arranged alphabetically under the German symbols, it is hoped that readers will obtain assistance not only in reading Professor Föppl's paper but other work from German sources. (Author's note)

PP: AA CV: 11' 18

Bennewitz, K. and Rötger, H.

On the Internal Friction of Solid Bodies: Absorption Frequencies of Metals in the Acoustic Range. (In German)

Physikalische Zeitschrift, Vol. 37, pp. 578-588, 1936

The damping of free vibrations of acoustic frequency was determined in aluminum, copper, silver, steel, and brass. A theory of internal friction is proposed in which the time of relaxation and the existence of faults are used to deduce the absorption frequencies.

PP: 3 6 AA 27 30 32 34 CV: 13 17 MI: ST CN Ag Al Cu Zn'

Brophy, G. R.

Damping Capacity, A Factor in Fatigue

Trans., Am. Soc. Metals, Vol. 24, pp. 154-174, 1936

The damping characteristics and endurance properties of several steels in several conditions of heat treatment have been determined and an attempt made to correlate these properties. Damping capacity seems to be related to the damage resulting to steel from overstress and notches. High damping steels are resistant to sharp notches, but not to overstress, while low damping steels are resistant to overstress, but sensitive to notches, is recognized. Below this limit, extreme notch sensitivity occurs. Several factors influencing these properties have been studied and among the most important are grain-size and structure. (Author's abstract)

PP: 3 D J 11 13 16 S AA 29 36 h 38 p r CV: 14
MI: ST CN AY TS Cl Fe g q r

Brophy, G. R. and Parker, E. R.

Damping Capacity -- Its Variation and Relation to Physical Properties

Trans., Am. Soc. Metals, Vol. 24, pp. 919-931, 1936

Damping capacity (plasticity) of steel is greatly influenced by such factors as stress, chemical composition, structure, heat treatment, mechanical work, and temperature. These factors are dealt with briefly, and in addition the relation of damping capacity to fatigue and creep performance is shown. Damping capacity is particularly important in determining the differences in behavior of steel, when repeatedly stressed, to the effects of overstress, stress concentration and speed. The order of creep resistance of a series of steels at elevated temperatures may be predicted by determining the damping capacities at the desired temperatures, provided there are no structural changes other than grain size. (Authors' abstract)

PP: 3 D J 13 16 S AA 29 g h 38 k 42 q r CV: 14
MI: ST CN AY Cr' W' 34 h p r

Cooke, W. T. and Brown, W. F.

Variation of Internal Friction and Elastic Constants with Magnetisation in Iron

Physical Review, Parts I and II, Vol. 50, pp. 1158-1172, Dec. 15, 1936

The experimental method described is applied to measure the variation of the rigidity modulus and torsional decrement with magnetisation in unannealed Armco iron. Formulae are derived which evaluate the contributions to the moduli and decrements arising from eddy currents induced in the vibrating specimen by the change in magnetisation produced by the varying stress. These formulae contain the magnetostriction and Wiedemann effect coefficients, which are discussed in the light of recent ferromagnetic theory.

PP: 3 E 9 L M 13 16 V X AA 27 30 31 c 36 h CV: 14 15
MI: SG Fe a p

Cornelius, H. and Bollenrath, F.

Cast Camshafts and Crankshafts. (In German)

Giesserei, Vol. 23, No. 10, pp. 229-236, May 8, 1936

Cast camshafts and crankshafts are discussed. The reasons which have led to the replacement of forgings by castings for these auto parts are given. The damping property is considered. A review of experience with cast shafts is presented. Parts drawings are included.

PP: W AA CV: 13

Elsner, H.

Influence of Heat Treatment on the Material Damping and Fatigue Strength of Chrome-Nickel Steel. (In German)

Dissertation, pp. 1-39 and 33 fig., Jena, 1936

This is a study of the effect of cold working, the number of cycles, and the amplitude of deformation on the tangential damping, determining the logarithmic decrement by the decay of free oscillations.

PP: 3 D 9 13 16 S T AA 36 h k CV: 13 14 MI: AY r

Föppl, O.

The Practical Importance of the Damping Capacity of Metals, Especially Steels

Iron and Steel Institute, Jour., Vol. 134, No. 2, pp. 393-423, 1936. Abstracts, Engineer, Vol. 162, p. 388, 1936. Foundry Trade Journal, Vol. 55, p. 270, 1936. Metals and Alloys, Vol. 8, p. 374, June 1937

Under cyclic stresses well within the fatigue limits, many steels exhibit appreciable plastic strains. The "damping capacity" depends on the ratio of the plastic to the elastic strain, and is best defined by the non-dimensional ratio ψ obtained by dividing the area of the hysteresis loop by the strain energy stored in the extreme positions of the cycle. Damping does not foretell impending fatigue failure, nor does it tend to disappear under prolonged cyclic stressing. On the contrary, it is capable of dissipating an unlimited amount of energy in heat without damage to the material. Ultimate damping, i.e., the steady value attained after some millions of cycles, is often considerably greater than initial damping. Unlike most other mechanical properties, the value of ψ is not affected by weak spots and is independent of the form of the specimen. The value of ψ is of great importance as a criterion of suitability, (1) because a high value of ψ confers notch-toughness in fatigue, and (2) because it controls the amplitude of undesired and often dangerous vibrations at critical speeds.

The paper mentions five different methods of measuring ψ in use at the Wöhler Institute, and between which good agreement has been obtained. The method of free torsional vibrations receives preferential treatment, and the Föppl-Pertz apparatus is described in some detail. Damping curves are given for different materials, including a range of crankshaft steels. Damping in torsion is compared with damping in flexure. The limits within which damping is independent of frequency are also discussed. The great and increasing importance of the damping capacity of materials in many different fields of engineering is illustrated by reference to aerial cables, aeroplane wings and propellers, crankshafts of internal combustion engines, steam turbine blades, and welded versus riveted construction. Finally, attention is focused on the need for finding a ductile steel which will give high damping at low stresses. (Author's abstract)

PP: A 3 D 5 F 7 J L M 13 P 16 S 19 W AA 28 30 b CV: 14 15 18
MI: ST CN AY Cl GG HH Cu Fe Mg W' Zn' 31 34 h n p q r

Föppl, O.

Excitation and Damping of Vibrations. (Book). Vol. 2. Principles of the Engineering Mechanics of Vibrations. (In German)

Springer, Berlin, 121 pp., 1936

This book, which forms volume two of the author's Grundlagen der technischen Schwingungslehre, discusses a number of questions which have acquired technical importance in recent years, such as the balancing of crankshafts, artificial damping of vibrations, the prevention of resonance, and the vibration of ships. (Eng'g. Index, p. 1179, 1936)

PP: A W AA CV: 13 16 17

Giordano, G.

Connecting Rods for High Speed (Engines). (In Italian)

Il Politecnico, Vol. 34, pp. 182-192, Milano, 1936

Consideration of internal damping and of its possible beneficial effects on the resistance of high speed engines.

PP: A AA CV: 12' 17

Holtschmidt, O.

A New Fatigue and Damping Testing Machine. (In German)

Montanistische Rundschau, Vol. 28, Stahlbau-Technik, p. 103, Aug. 16, 1936

A new machine, built by the M. R. N. concern, for testing the fatigue strength and damping capacity of metals is described and illustrated.
PP: 3 AA 29 CV: 13 14

Kahnt, H.

Dissertation, Jena, 1936

See abstract under the year 1937.
PP: 13 16 T AA 29 CV: 13 14 MI: ST CN AY r

Katz, A. and Puckov, S.

On Coefficients of Internal Friction of Metals. (In Russian)

Pubblicazioni dell'Istituto di Sismologia dell'Accademia delle Scienze dell'U. R. S. S., No. 75, pp. 1-37, 1936

In Russian with abstract in English. No abstract was available, however.
PP: AA CV: 12 14

Kidani, Y.

Fatigue of Metals and Internal Friction

Sci. Rep. Tohoku Imp. Univ., 1st Ser. K. Honda Anniversary Vol., pp. 1050-5, 1936

Annealed specimens of 0.6, 0.3, 0.1% C steels and Cu were tested under constant alternating torque up to the plastic range. A curve shows that hardening and fatigue effects occur in succession. The rate of damping of the vibration gives significant information as to the degree of fatigue. The microscope shows that fatigue in Cu is due to growth of twinning and slip bands in certain grains which appear in the axial or peripheral direction according to the crystallographic direction of the grains. (Chem. Abs., p. 3844, 1937)
PP: 3 D 13 16 S T AA 28 29 36 37 42 r CV: 14 MI: CN Cu a j p r

Körber, F. and Hempel, M.

Fatigue Strength of Steel as Function of Frequency of Load Reversals

Abstract Translation - Mitteilungen Kaiser-Wilhelm Institut Eisenforschung, Vol. 18, No. 1, pp. 15-19, 1936

This paper gives results of tension-compression fatigue tests on various steels carried out at two different frequencies of load reversals 450 rpm and 450 rps in order to throw light on the influence of the frequency of load alternations upon the fatigue strength values. Steels used in study: Carbon steels containing 0.11 to 0.64% carbon; spring steel; Ni-Cr steels.
Data on damping capacity of above steels are given. (H. Brutcher Translation, Altadena, California, No. 2145)
PP: 3 D 9 M 16 S 19 AA 42 r CV: 11' 13 14 MI: CN AY b r

Lohr, A.

Changes in Endurance and Damping as a Result of Hydraulic Pressure. (In German)

Mitteilungen des Wöhler-Instituts, Vol. 29, pp. 1-55, 1936

Fatigue tests on copper and zinc by a short-cut method of progressively raised stress, which admittedly strengthens by understressing, showed no consistent effect from having been subjected to high hydraulic pressure. No effect on damping capacity from pressure was observed for copper, zinc, and duralumin. Lead showed a decrease in damping on specimens subjected to pressure, without changes in modulus.
PP: 16 17 AA CV: 13 14 MI: Al Cu Pb Zn h 40

Neugebauer, F.

The Material Damping of Shafts of Light Engines. (In German)

Luftfahrtforschung, Vol. 13, pp. 57-60, 1936

Theoretical mathematical analysis of relationship between damping capacity of structural material and torsional vibration stresses which may cause fracturing of transmission shafts of driving gear between airplane engine and propeller. Bibliography. (Eng'g. Index, p. 45, 1936)
PP: 16 S Y AA CV: 13 17

Ono, A.

The Energy Dissipation and Heat Development of a Vibrating Steel Specimen. (In German)

Zeit. f. Angewandte Mathematik u. Mechanik, Vol. 16, No. 1, pp. 23-32, February 1936

This is an experimental and theoretical study of the consumption of energy and production of heat in a vibrating steel bar. It is shown that a stationary state of motion, when energy employed equals heat produced, is reached only after a considerable number of vibrations. (Eng'g. Index, p. 1180, 1936)
PP: 3 F Y AA CV: 13 14 17 MI: ST CN

Siegel, S. and Quimby, S. L.

Variation of Young's Modulus with Magnetisation and Temperature in Nickel

Physical Review, Vol. 49, pp. 663-670, May 1, 1936

The relation between Young's modulus, magnetization, and temperature in annealed polycrystalline nickel, 99.7% pure, is determined for values of J between zero and saturation, and for values of T between 23.5° C and 400° C. The percent increase in Young's modulus is proportional to J^2 between zero and about 0.4 saturation, at all temperatures below 311° C. The total increase in the modulus from the demagnetized to the saturated state is 6.7% at 23°, reaches a maximum of 18.7% at 185°, and decreases to zero at the Curie point. The results indicate that the theory of this phenomenon offered by Akulov is probably essentially correct but requires modification. The method employed for the measurement of Young's modulus yields at the same time a measure of the coefficient of internal friction of the material. The internal friction decreases with increasing magnetization at all temperatures below the Curie point. In the demagnetized material it reaches a maximum value at the same temperature as does the change in elastic modulus. Its value at magnetic saturation is the same order of magnitude as that of a nonferromagnetic substance. (Authors' abstract)
PP: 16 U V X AA 30 c CV: 14 MI: SG Ni a n p

Sonnemann, H.

The Fatigue Strength and Damping Capacity of Commercial Steels and Copper and the Influence of Cold Riveting. (In German)

Mitteilungen des Wöehler-Instituts Braunschweig, No. 28, pp. 5-87, 1936

Describes investigations at Woehler Institut of fatigue resistance and damping capacity of commercial steels, armco iron, and influence of cold riveting on these properties.
Bars of a standard steel were procured with a view to comparing the damping curves obtained in reversed bending and alternating torsion. It was assumed that both bars being of ostensibly the same material and giving the same tensile strength and percentage elongation, would have something like the same damping capacity. But it was found that the two damping curves exhibited discrepancies which could not possibly be attributed entirely to the fact that one bar was tested in torsion and the other in bending.
PP: 3 12 13 P AA 36 k 42 r CV: 13114 MI: ST CN Fe a

Waller, M. D.

Acoustic Studies of Some Non-Transforming and Transforming Special Steels at Low Temperatures

Proc. Roy. Soc. London, Ser. A, Vol. 156, pp. 383-393, 1936

An acoustic method used for determining the persistence of vibration and vibration frequency of transversely vibrating bars at different temperatures, is described. Some Hadfield special steels have been examined by the method between -183°C and room temperature. During the transformation from austenitic, gamma to martensitic, alpha nickel steel, the internal damping is greatly increased and Young's modulus of elasticity is considerably decreased. The modulus of alpha nickel steel is permanently less than that of nickel gamma steel. Hadfield steel (12.69% Mn, 1.27% C) has a maximum found for carbon, and which is not present when the carbon content of this steel is low. (Author's summary)
PP: 3 6 10 12 16 U X AA 27 36 h n CV: 14 MI: AY p q

1937

Anonymous

Recording Apparatus for Torsional Damping

Engineering, p. 652, December 10, 1937

This article describes a recording apparatus for torsional damping constructed by the Cambridge Instrument Co., Ltd., London
PP: 3 D 9 13 AA 28 29 MI: AY CI

Bernhard, R. K.

Dynamic Tests By Means of Induced Vibrations

Trans. Am. Soc. Test. Mat., Vol. 37, No. II, pp. 634-645, 1937

This paper gives a short report of a method of dynamic research in the engineering field. Various applications of this method are described. Tests have been carried out since 1928, the system being used for various types of investigation, from small laboratory specimens to heavy ships. Different materials and all types of construction have been examined and compared by fatigue and aging tests. A few of the results, particularly various damping and all types of construction have been examined and compared by fatigue and aging tests. A few of the results, particularly various damping and amplifying factors of standard engineering systems are considered. Advantages and difficulties of this method are summarized.
In the method here discussed, vibration is induced by centrifugal forces resulting from revolving eccentric disks. As soon as the natural period of the structure coincides with the revolution of the disks, the amplitude of vibration of the system and the power input to drive the revolving disks reaches a maximum. Plotting the power input against the revolutions of the disks, characteristic curves can be obtained, which indicate first of all the natural frequency of the vibrating system which is to be investigated. Any coincidence between natural frequency and dynamic load, such as a locomotive with unbalanced masses passing over a bridge with critical speed, is to be avoided. Vibrating a structure with this type of oscillator for a long period has in many cases a similar effect as an annealing process; internal stresses remaining from the rolling process or due to welding are in some measure dissipated over the complete structure. A change in the natural frequency may indicate some failure or plastic flow; this forms a means to check from time to time the behavior of the structure, even after erection.
The determination of the natural frequency of soil and the propagation speed of these induced vibrations can sometimes replace seismic investigations or borings. (Author's synopsis)
PP: 2 3 E 8 9 10 11 M 13 16 T AA 28 CV: 17 18

Caldwell, F. W.

The Vibration Problem on Propeller Designing

Trans., SAE, Vol. 41, No. 2, pp. 373-379, 1937

The paper represents an effort on the part of the propeller designer to look at some phases of the vibration problem as it affects him. A very brief description of some of the work being done in vibration is given. The subject is treated from the aspect of experimentation and the physical phenomena without any effort to introduce the mathematical phase of the subject. Examples are given of the measurements of the vibratory stress in propeller blades by a new method introduced during the last year. Damping is considered from the points of view of internal damping of materials and the damping from aerodynamic forces.
PP: 1 W AA CC CV: 15 17

Champion, F. C. and Davy, N.

Properties of Matter. (Book)

Prentice Hall, Inc., N. Y., 1937

The vibrations of stretched bodies are discussed (pp. 64-65). The subjects treated are (a) transverse vibrations of a loaded bar, and (b) vertical oscillations of a loaded spring. The simple pendulum with friction is explained on pp. 12-13. The differential equation and its general solution with a damping factor are given. The damping due to viscosity is dealt with on pp. 29, 250, 256-257.
PP: 12 13 Y AA BB CV: 16

Föppl, O.

Results, Discussion, and Additional Remarks on Damping Capacity. (In German)

Mitteilungen des Wöhler-Instituts, Heft 30, pp. 34-44, 1937

No abstract available.
PP: A W AA CV: 13

Föppl, O.

Damping Capacity of Materials; Shot-Peening; Resonance Vibration Damper for Crankshafts. (In German)

Mitteilungen des Wöhler-Instituts, No. 30, 58 pp., 1937

See Föppl, 1936.
PP: A AA CV: 13 14

Föppl, O.

Vibration Damper for the Crankshafts of Automotive Engines. (In German)

Mitteilungen des Wöhler-Instituts, Heft 30, pp. 49-58, 1937

A vibration damper for automobile crankshafts is described.
PP: A AA CV: 13

Förster, F.

A New Method of Measurement for Determining Modulus of Elasticity and Damping. (In German)

Zeit. f. Metallkunde, Vol. 29, pp. 109-115, 1937

With this method a suspended test piece is excited by a transmitter operating electrodynamically to produce mechanical oscillations. With a suitably designed receiver, the resonance curve is determined from which curve the natural frequency and damping values can be obtained.
PP: 3 E X AA CV: 13 14

Förster, F. and Köster, W.

Effect of the Condition of the Material on its Modulus of Elasticity and Damping. (In German)

Zeit. f. Metallkunde, Vol. 29, pp. 116-123, 1937

Tests carried out by the vibration method, referred to in the previous paper showed that the modulus of elasticity decreases with rising temperature at a gradually increasing rate, while the damping increases with temperature in a similar manner so long as the slip process is unchanged. When new slip planes come into action, e.g. with aluminum between 300° and 400°C, the damping increases very rapidly. When a phase change, or a change from the ordered to the disordered atomic arrangement takes place, the elastic modulus changes at the transition point corresponding to the change from one state to the other, while the damping is increased only during the transition period. Metals in the ferromagnetic state have high damping, which decreases as the temperature is raised to the point at which the magnetism is lost, and then increases again. The elastic modulus of soft nickel is greater in the ferromagnetic than in the paramagnetic state. Modulus and damping decrease with alloy additions both for the homogeneous copper-zinc alloy and the heterogeneous iron-carbon alloy. The damping of annealed metals increases with grain size. In all the above examples, the damping increases with decreasing resistance to deformation. Damping increases with hardening due to precipitation hardening or to the transformation to the ordered atomic arrangement of crystals.
PP: 3 D E 9 11 12 16 S U X AA 27 30 31 c g h 38 k 40 n 42 q CV: 13 14
MI: ST AY EG Al Co Cu a 36

Förster, F. and Köster, W.

On the Dependence of the Elastic Modulus and Damping, of Transverse Vibration Metal Specimens, on the Amplitude. (In German)

Naturwissenschaften, Vol. 25, pp. 436-439, 1937

It was found that for paramagnetic metals and alloys, the elastic modulus and damping are nearly independent of the amplitude, if the measurements are carried out sufficiently far below the melting point. For ferromagnetic metals and alloys, these constants are largely dependent on the values of the amplitude. The change is shown to follow parallel to magnetostriction values.
PP: 12 16 S X AA 30 c 36 37 42 s CV: 13 14 MI: AY SG Fe Ni n p

Gemant, A. and Jackson, W.

The Measurement of Internal Friction in Some Solid Di-Electric Materials

Phil. Mag., Series 7, Vol. 23, pp. 960-983, 1937

The methods of free torsional and free lateral vibrations have been employed to study the internal damping of several solid dielectric materials ebonite, Trolitul, quartz, glass and wood over the frequency range 0.3 to 10. The assumption that the friction is of a viscous character is found to be an erroneous one. The "viscosity constant" of this classic analysis is found to vary inversely as the frequency to a first approximation. This corresponds to a constant energy loss per cycle. This behavior is in agreement with certain observations of A. C. Kimball, and is probably to be explained in terms of solid friction. An alternative explanation based on the conception of a complex viscosity is also considered. The dependence of the elasticity modulus and the damping on temperature has been studied between 20 and 180°C. The general tendency is for the former quantity to decrease and the latter to increase with temperature, although the damping-temperature curve for two glass samples exhibits a low-temperature maximum preceding this normal behavior. (From authors' summary).
PP: 3 D G 10 11 12 13 14 R U X AA 27 30 b d CV: 14 15
MI: ST CN HH KK LL Cu

Giovannozzi, R.

The Influence of Internal Friction on the Longitudinal Vibration of Prismatic Bars. (In Italian)

L'Aerotecnica, Vol. 17, pp. 935-954, 1937

A theoretical study on the longitudinal vibrations of prismatic bars with internal damping, the variations with frequency and exciting force, and a determination of the approximate modes with a variation in internal damping and the amplitude of the strain. Numerical application of the results is shown using the results of the experiments of Sezawa and Kubo.
PP: M 16 S 19 Y CV: 12' 17

Giovannozzi, R.

The Flexural Vibration of Prismatic Bars with Internal Damping. (In Italian)

L'Aerotecnica, Vol. 17, pp. 1047-1066, 1937

This is a theoretical study on the flexural vibrations of prismatic bars with internal damping, the variations with frequency and exciting force, and a determination of the approximate modes with a variation in internal damping and amplitude of the strain. Numerical application of the results is shown using the results of the experiments of Sezawa and Kubo.
PP: 12 16 S 19 Y CV: 12' 17

Higuchi, S.

Problems of Frictional Vibration. (In English)

Science Reports, Tohoku Imperial University, 1st Series, Vol. 25, pp. 1121-1135, 1937

In this paper, the problems of the oscillatory motion of a system consisting of an elastic rod or spring and its attached load in which the usual type of solid friction as well as the elastic force are called into action, are solved by using either the method of complex integration or that deduced from Green's theorem, according to the nature of the individual problem. From the result obtained here, the main characteristic properties of the motion in question, such as the decrease of damping ratio or the logarithmic decrement, are fully discussed. (Sci. Abs., A, p. 2958, 1937).
PP: Y CV: 17

Higuchi, S.

A Study of the Damping Characteristics of an Elastic Vibration. (In English)

Science Reports, Tohoku Imperial University, 1st Series, Vol. 26, No. 2, pp. 236-242, September 1937

By introducing the internal resistance of a solid having the usual type of a solid friction, the solution of the longitudinal oscillation of an elastic rod is obtained and the effects of this resistance upon the decay of elastic vibration, such as decrease of damping ratio or logarithmic decrement, are examined.
PP: M Y CV: 17

Hirschfeld, C. F. and Piron, E. H.

Rubber Cushioning Devices

Trans., Am. Soc. Mech. Eng., Vol. 59, pp. 471-491, 1937

This paper describes briefly the production of compounded rubber which is the material commonly used by engineers and others under the name of rubber. The wide range of physical properties obtainable by different compounding and curing is indicated. Springs of steel and springs of rubber are compared with respect to certain important characteristics and the conclusion drawn that neither can completely replace the other for springing purposes. There are applications in which one or the other gives the better or the only solution and there are other cases in which neither may be used. Various types and forms of rubber springs are described and illustrated and methods available for calculation and design are given. Finally certain applications of rubber to the springing of rail vehicles are described and their results are illustrated. (Authors' summary)
PP: A L AA 36 37 CV: 15 MI: GG

Hort, H.

New Methods for Damping Ship Movements in High Seas. (In German)

Werft Reederei Hafen, Vol. 18, No. 16 and 17, pp. 251-253 and pp. 262-265, 1937

Modern methods for damping of ship movements; notes on stabilizing tanks of various types; stabilizing of pitching motion. Bibliography. (Eng'g Index, p. 1052, 1937)
PP: CC EE CV: 13 15 18

Jack, W. and Parkinson, J. S.

A Method for Evaluating Compliant Materials in Terms of Their Ability to Isolate Vibrations

Jour. Acoust. Soc. of Am., Vol. 9, pp. 141-145, 1937

The theory and general factors involved in vibration isolation are first discussed. A compliance machine is described which is a device for evaluating the stiffness and the resistance factor c. The latter, defined as the force per unit velocity developed in opposition to motion, is probably related to viscosity, and is certainly a measure of internal work. Evaluation is obtained from the damping of free vibrations. Service tests are described and data and curves are given for a steel spring and for rubber. The limitations of the theoretical treatment are finally discussed.
PP: A 3 D 10 Y AA CV: 17 MI: CN GG s

Jacquesson, R.

Variation of the Internal Friction of Solids Under the Influence of Thermal and Mechanical Treatment. Effect of a Tensile Force. (In French)

Comptes Rendus Hébdomadaires des Séances de l'Académie des Sciences de Paris, Vol. 205, pp. 357-360, 1937

Experiments concerned with the damping of free torsional oscillations of wires of iron, aluminum, and copper, subjected to various tensile forces.
PP: 3 D 13 14 AA 36 h k CV: 13' 14 MI: Al Cu Fe a

Kahnt, H.

Notch Sensitivity, Strain Hardening and Damping of Steels Subjected to Alternating Torsional Stressing. (In German)

Zeit. f. Technische Physik, Vol. 18, pp. 230-237, August 1937

Ten different steels variously heat treated were subjected to alternating torsional stressing at constant deformation according to the method of A. Esau and H. Kortum (Metal and Alloys, Vol. 5, p. MA 148, April 1934), and then alternating torsion fatigue limit, notch sensitivity, strainability, and damping capacity were determined.

PP: 3 D 9 13 16 S AA 28 36 k 42 44 CV: 13 14 18 MI: ST CN AY r

Kukanov, L. I.

Damping of Metals. (In Russian)

Savodskaja Laboratorja Moskau, Vol. 6, pp. 722-733, 1937

A review.

PP: AA CV: 12 15

Robertson, S. L.

Metallic Damping

Metal Treatment, Vol. 3, pp. 138-142, 150, Autumn, 1937

Review of German work on significance and measurements of damping capacity. Points out that since notch sensitivity involves local strains much greater than those in damping measurements, it is not necessarily associated with low damping capacity. Importance of damping capacity in relation to flaws reviewed.

PP: B 3 D E 10 11 W X AA 30 33 36 h 40 42 44 CV: 15
MI: SS EG Al Cu Fe Mg Mo Ni Pb Sn Zn a 34 35

Schneider, A. and Förster, F.

The Measurement of Damping and Characteristic Frequency as Aids in Corrosion Research. (In German)

Zeit. f. Metallkunde, Vol. 29, pp. 287-292, 1937

The relationship between heat treatment and the corrosion properties of an aluminum-magnesium alloy with 11% Mg is investigated. The corrosion progress is observed by following the time change of damping and the characteristic frequency. When intercrystalline corrosion occurs, the value of damping rises strongly while on surface-corroded samples the values of damping remain constant. The results of short time laboratory measurements concerning the corrosion properties of Al-Mg alloy agree with previous results of a long time investigation. The studies showed that to investigate corrosion progress the measurement of time change of damping and characteristic frequency is suitable. It is probably possible not only to show qualitatively the beginning and progress of intercrystalline corrosion but also to show the quantitative results as to the velocity of corrosion progress from the change of characteristic frequency. This may be applied to surface corrosion as well as intercrystalline corrosion.
(Author's summary)

PP: B 3 X AA 36 39 42 s CV: 13 MI: Al Mg'

Sisco, F. T.

Miscellaneous Engineering Properties of Commercial Iron-Carbon Alloys

"Alloys of Iron and Carbon", McGraw-Hill, Vol. 2, Chap. XVII, Damping Properties, pp. 637-646, 1937

A general discussion of damping and its engineering application is followed by a treatment of the acoustic properties of carbon steels, the relation of damping to structure and the relation of damping to other properties.

PP: 3 6 W AA 36 h 42 s CV: 15 MI: CN

Späth, W.

A Measuring Instrument for the Determination of Internal Damping of Periodically Loaded Specimens. (In German)

Messtechnik, Vol. 13, pp. 125-128, 1937

Gives the description of the apparatus and method of using a machine for testing in alternating torsion. It permits the measurement of tensile forces and of the deformation, from which may be determined the damping.

PP: 13 AA CV: 13 14

Steinborn, B.

Damping as a Quality Criterion for Rubber. (In German)

Mitteilung des Wöhler-Instituts, Vol. 31, pp. 1-76, 1937

Damping is discussed as a standard of quality for rubber. Investigations were carried out to demonstrate that the measurement of damping capacity is necessary for satisfactory appraisal of elastic materials, especially rubber. Test methods and results are presented. A bibliography is included. The paper includes a brief contribution by O. Föppl on theoretical considerations of the elastic properties of materials, especially rubber. (Eng'g. Index, p. 1061, 1938)

PP: 1 3 AA CV: 13 14 18 MI: GG

Walls, F. J.

Cast Camshafts and Crankshafts Possess Many Advantages

Soc. Auto. Engrs., Trans., Vol. 41, No. 1, pp. 284-290, February 1937

From the data at present available it can be assumed that a crankshaft made of material of high damping capacity with moderate strength may have greater effective strength and life-expectancy than one made from a material with a much higher strength having a low damping capacity.

PP: 3 D 13 W AA 27 42 r CV: 14 15 MI: ST CN Cl Cu' Fe Mo' Ni' f

Zener, C.

Internal Friction in Solids - I Theory of Internal Friction in Reeds

Physical Review, Vol. 52, pp. 230-235, August 1, 1937

In a vibrating reed opposite sides have dilations of opposite signs. Thus when one side is heated the other is cooled. At low frequencies the vibrations are isothermal. At high frequencies they are adiabatic. At intermediate frequencies they are of a hybrid type accompanied by internal friction. In this paper this internal friction is calculated solely from thermo-dynamical considerations. It is predicted that the internal friction associated with this hybrid type of vibration is of a larger order of magnitude than that due to all other causes. (Author's abstract)

PP: 8 12 16 19 AA 30 31 34 CV: 17

Bennewitz, K. and Rotger, H.

Internal Friction in Solids, Part II

Zeit. f. tech. Phys., Vol. 19, pp. 521-526, 1938

This is a continuation of an earlier paper (Sci. Abs. p. 5030, 1936). The authors give a general mathematical theory of thermal damping in torsional vibrations. On the basis of this theory the variation of the decrement (due to internal friction) with periodic time of the vibrating system is calculated and compared with experimentally obtained values in the case of german silver wires of various diameters. It is considered that the theoretical results are confirmed, and in particular it is concluded that the decrement depends on the dimensions of the specimen. (Sci. Abs. p. 1023, 1939)

PP: 9 L 13 16 20 AA 30 31 34 CV: 13 17 MI: Ag

Bergman, L.

Ultrasonics. (Book)

John Wiley & Sons, New York, 1938

Chapter I, entitled "The Generation of Ultrasonics" presents information on mechanical, thermal, magnetostriction, and piezoelectric generators. These are used in apparatus for the determination of the damping of materials in some instances. The determination of the logarithmic decrement of quartz by the piezoelectric resonance method is given. The magnetostriction effect and piezoelectric effects are discussed in detail.

PP: 3 D E 9 AA CV: 15 16

Brauer, H.

The Damping of Wires

Metallwirtschaft, Vol. 18, pp. 503-505, June 16, 1938

A brief description is given of a machine for measuring the damping capacities of wires. An example is given of the variation of damping capacity in a given lot of material. The percentage variation is considerable for materials of low damping capacities. The damping capacities of cold drawn and annealed steel are compared, the cold drawn wire having a higher damping capacity at low deformations. Pure aluminum has practically the same damping characteristics as electrolytic copper.

PP: 3 13 AA 27 36 h k CV: 13 14 MI: CN Al Cu a

Case, S. L.

Damping Capacity and Aging of Steel

Metal Progress, Vol. 33, pp. 54-59, 1938

Changes in damping capacity, after cold work, give a precise method for evaluating aging characteristics and are preferable to Izod impact data. The combination of damping capacity and work brittleness tests show close correlation for measuring the aging behavior of over-strained steel. Results of tests on seven steels show that the damping capacity of steel is strongly influenced by cold work.

PP: 3 D J 13 16 S AA 28 36 h 38 k 42 s CV: 14 MI: ST CN

Denison, A. C.

High-Strength Grey Iron

Mechanical Engineering, Vol. 60, pp. 945-946, December 1938

This paper discusses the advantages that modern high-strength grey irons have to offer the engineer. Some of the properties that are of inherent engineering importance are discussed in a general way. Among these are the good damping properties with its accompanying advantages. A comparison with the damping of steel illustrates the advantages of high strength grey iron in many applications.

PP: A W AA CV: 15 MI: Cl c

Flinn, R. A. Jr. and Norton, J. T.

Measurements of Internal Friction in Age-Hardening Alloys with a Modified Torsion Pendulum Apparatus

Metals Technology, Vol. 5, Tech. Publ. No. 914, 10 pp., 6 ref., 1938

A modified torsion pendulum apparatus is described for measuring the "damping capacity" of alloys, and the requirements of apparatus for this purpose are discussed. Curves are reproduced showing the relation between specific damping capacity and stress for ternary and quaternary alloys of copper and beryllium with other metals. In age-hardening alloys the damping capacity is sensitive to the structural changes taking place, and the method may be used for the study of the age-hardening process.

PP: B 3 D J 11 13 16 S AA 28 29 36 h n CV: 14 18
MI: CN EG' Co' Cu a b 33 p

Förster, F.

Sound as an Aid to Research. (In German)

Umschau, Vol. 42, pp. 1025-1029, 1938

This is an up-to-date review. The damping of sound in a specimen is strongly influenced by flaws in the material. Different materials have different damping characteristics. There is a simple relationship between the natural frequency and the modulus of elasticity of a material. Both damping and the modulus of elasticity can be determined by means of sound. Curves of resonance, i.e., amplitude against frequency, are plotted. A wide curve corresponds to strong damping, and vice versa. The specimen can be mounted in a furnace or in a cooling tank during the test. Almost all metallographic changes (transformation change in distribution, recyrstallization, grain growth, change in plastic behavior, magnetic changes, etc.) show up in the sound characteristics. Internal stresses are even more evident in the sound properties than are transformations.

PP: 3 E 6 AA 30 33 36 38 n CV: 13 15

Förster, F. and Breitfeld, H.

An Apparatus for the Direct Indication of Damping Capacity. (In German)

Zeit. f. Metallkunde, Vol. 30, No. 9, pp. 343-345, 1938

A self-exciting vacuum-tube circuit is described by means of which damping capacities can be determined at 4-second intervals. Applications of this equipment during stress and recovery of an aluminum rod, during the cooling of a stressed steel rod, and during the accelerated elongation of an aluminum rod are described briefly. (Chem. Abs., pp. 1248-9, 1939).

PP: 3 E J 12 16 S 18 U AA 27 30 31 CV: 13 14 MI: ST CN Al a

Förster, F. and Köster, W.

Elasticity and Damping in Relation to the State of Material

Engineer, Vol. 166, pp. 626-628, 1938

A sonic method of measurement of damping and modulus of elasticity is presented. The effects of temperature, polymorphous transformation, ordered and disordered conditions, magnetic transformations, alloy additions, grain size, precipitation hardening, deformation and recrystallization, internal stresses, local defects, and intergranular corrosion on the damping and modulus of elasticity of metals and alloys were studied. Graphs of the various effects are presented.

PP: 3 E 9 11 12 16 S U X AA 27 30 c 33 g h 38 k m 42 q CV: 14
MI: CN EG Al Cu Fe Mg Mo Ni Pb Sn Zn a 34 35 41 s

Francis, J. L.

Cast Iron in Engineering Construction

Iron and Steel Industry, Vol. 11, pp. 607-613, September 1938; Vol. 12, pp. 17-22, October 1938

This is a continuation of a series of articles. In Part IV of this series, the author summarizes the physical properties of cast iron which he has discussed in previous articles, with particular reference to its damping capacity, which he states is approximately 20 times as great as that of carbon steel.

PP: W AA 28 CV: 15 MI: CI

Gemant, A.

Role of Solid Friction in Synthetic Dielectrics

Jour. Appl. Physics, Vol. 9, pp. 730-734, November 1938

New synthetic dielectric materials, both of the ceramic and resinous type, exhibit, among other features, a high grade of homogeneity. This will not only affect the mechanical properties, the electrical breakdown strength and the dielectric losses due to layer mechanism favorably, but will reduce also losses due to dipole rotation. In case, namely, dipolar constituents rotate at all in the solid state, dissipation of energy will be caused by the solid friction, which has to be overcome. This latter, on the other hand, can be shown to be related directly to the imperfections of the material, thus indicating the beneficial effect on the dielectric low angle of a homogeneous nature. (Author's abstract)

PP: 3 D 5 N AA 30 31 36 m CV: 17 MI: FF HH' KK

Giovannozzi, R.

Theory and Experiments on the Internal Damping of Metals. (In Italian)

L'Aerotecnica, Vol. 18, pp. 1095-1133, October, 1938

This is a critical review of the principal researchs concerned with internal damping.

PP: 3 AA 30 CV: 12' 15

Körnetski, M.

On the Interpretation of the Relation Between Elastic Modulus and Damping in Ferromagnetic Materials. (In German)

Wissenschaftliche Veroeffentlichungen aus den Siemens-Werken, Vol. 17, No. 4, pp. 48-62, 1938

The author shows that the relationship of the elongation to the stress in a ferromagnetic material is similar to that of the magnetisation to the strength of the magnetic field. Basing his investigations on J. W. Raleigh's law for magnetisation in weak fields, he studies the elongation under small alternating stresses and arrives at the following conclusions: (1) at low stresses the modulus of elasticity decreases directly as the stress increases; (2) the logarithm of the damping decrement increases directly with increase in stress; and (3) a mathematical relationship exists between the decrease in the modulus of elasticity and the increase in the damping. The author found that the results he obtained experimentally were in agreement with those obtained by calculation. (Abs. J. I. & S. Inst.)

PP: 9 16 S X AA 30 34 42 q CV: 13 17 MI: SG n p

Köster, W. and Rosenthal, K.

Change in Elastic Modulus and Damping of Brass During Deformation and Recrystallization. (In German)

Zeit. f. Metallkunde, Vol. 30, pp. 345-348, 5 ref., 1938

Deformation considerably increases the damping due to increase in the internal stress, but on keeping the cold-worked metal at room temperature, the increased damping rapidly disappears; gentle heating accelerates this effect and increases it. During recrystallization, damping increases due to increases in the plasticity of the metal. Work-hardening alone does not appreciably affect damping.

PP: 3 E 9 12 16 U X AA 27 30 31 36 h k 41 CV: 13 14 MI: Cu Zn' b n

Kruger, F. and Rohloff, E.

Internal Friction of Wood

Zeit. f Physik, Vol. 110, No. 1-2, pp 58-68, 1938

The logarithmic decrements of transverse oscillations of frequencies 10-700 cycles per second and of longitudinal oscillations of frequencies 2000-10000 cycles per second are determined for pine, maple, Scotch pine and oak.

PP: 3 D E 9 11 M 16 S 19 AA 27 CV: 13 14 MI: HH

Luntz, E.

The Damping of Torsional Oscillations. (In Russian)

Matematica e Meccanica applicata, New Ser., Vol. 1, pp. 331-369, 1938

This article is in Russian with a short abstract in English. The abstract was not available

PP: 13 AA CV: 12 14

Mason, C. C.

Recording Apparatus for Torsional Damping

Engineering, p. 119, February 4, 1938

It is interesting to note from the results of the author's experiments that whereas in the chrome ball steel the percentage damping increases as the temperature is raised, in the case of mild steel it decreases. The paper includes a discussion of above results and a description of method for adapting the Cambridge torsional vibration testing machine to damping measurements at elevated temperatures.

PP: 3 D J 13 16 S U AA 28 29 CV: 14 MI: CN AY c j

Ockleston, A. J.

The Damping of Lateral Vibration of a Mild Steel Bar

Phil. Mag., Ser. 7, Vol. 26, No. 177, pp. 705-712, November 1938

An investigation was made of the vibration of a steel frame. Logarithmic decrements of normal modes of free vibration were determined. The values obtained could not be satisfactorily explained by either a viscous damping theory or that of Kimball and Loveil. Experiments were carried out to investigate the value of damping for lateral vibrations of small amplitude. A bibliography is included.

PP: 3 D 9 10 12 P 16 S 19 AA 27 28 CV: 14 18 MI: CN j

Ravilly, E.

Contribution to the Study of Rupture of Metal Wires Under Alternating Torsion. (In French)

Publications Scientifiques et Techniques du Ministère de l'Air, No. 120, 1938

No abstract available.

PP: 13 AA 29 CV: 13' 14

Read, T. A.

The Internal Friction of Metallic Crystals

Physical Review, Vol. 54, p. 389, 1938

Some results are reported of tests made on single crystals of copper, lead, and tin. They show that the internal friction of a single metal crystal is substantially less than that of the polycrystalline material. The effect of internal strain on the internal friction of crystalline copper is noteworthy. The decrement of a crystal, on removal from the furnace in which it is grown, is of the same order as that of the polycrystalline material. After vacuum annealing the crystal its internal friction is markedly lower. Lead and tin crystals, on the other hand, remain unaffected by annealing.

PP: 3 D M 16 S AA 27 36 h j CV: 14 MI: Cu Pb Sn a

Scheil E. and Thiele, W.

Change of Elasticity Modulus and Damping of an Iron-Nickel Alloy at the Gamma-Alpha Transformation. (In German)

Arch. Eisenhüttenwesen, Vol. 12, No. 2, pp. 103-105, August 1938

A wire of an Fe-Ni alloy with 22% Ni was subject to torsional oscillations. In the gamma-alpha range the center of the oscillations and damping changed with temperature. The changes were only partly due to the transformation; the change in the oscillation center had to be ascribed to an asymmetry of the little flywheel arranged to maintain oscillations. (Chem. Abs., pp. 5344-9, 1939)

PP: 3 D 9 13 16 U X AA 27 30 31 36 h n CV: 13 14 MI: Fe Ni'

Snoek, J. L.

Time Effects in Magnetization

Physica, Vol. 5, pp. 663-668, 1938

A theory is given of the phenomenon of magnetic viscosity and of the reversible aging of magnets. A bibliography is included.

PP: AA 30 c CV: 17 18 MI: SG n

Späth, W.

Damping and Strength Values of Materials. (In German)

Archiv. fur das. Eisenhüttenwesen, Vol. 11, No. 10, pp. 503-507, April 1938

A close relationship exists between damping, creep, and the static characteristics such as limits of elasticity and proportionality and the yield point. It is considered that damping may replace the customary precision measurements with optical apparatus.

PP: 1 3 5 9 10 11 16 S AA 27 p q CV: 13 14 MI: ST

Stern, N. S.

Crankshaft Damping

Auto. Engr., Vol. 28, No. 376, pp. 360-362, October 1938

The article gives an illustrated description of the "Metalastik" device for the absorption of torsional vibration energy.

PP: A AA

Van Der Wyk, A. J. A. and Meyer, K. H.

The Internal Friction of Vulcanized Rubber

From Proceedings of the Rubber Technology Conference, G. Heffer & Sons, Ltd., Cambridge, Eng. Preprint No. 66, 2 pp. 1938

Formulas for determining the internal friction or viscosity and the shearing modulus from torsional oscillation tests of cylinders of vulcanized rubber are given. An experimental method for this test is described and the results are summarized. Internal friction increases much less. Extrapolation to zero amplitude of oscillation shows that the internal friction is of the order of several million cgs units; it is affected only slightly by vulcanization. The elastic modulus decreases with increase in the degree of vulcanization, contrary to the behavior at greater deformations or stresses. The viscosity of vulcanized rubber is nearly independent of temperature between 12° and 45°, and thus resembles vitreous quartz. (Chemical Abstract, p. 8212, 1938)

PP: 3 D 13 X AA 30 34 36 h CV: 14 MI: GG

Waller, M. D.

Magneto-Damping in Nickel

Proc. Phys. Soc., Vol. 50, pp. 144-146, 1938

A demonstration resulting from some acoustic studies previously made on metals and special alloy steels in order to determine how the internal damping is affected by various physical conditions is described. A pure hard nickel rod was suspended horizontally at the two nodes by means of fine threads and struck with a hammer. The emitted note remained audible for some seconds. This procedure was repeated after the specimen had been placed in a magnetizing field of about 100 gauss, when it was found that the note died out 3 or 4 times more rapidly. A typical set of observations made with the ear in a standard position and using a stop watch is shown. Similar observations have been made with a more highly damped annealed pure nickel rod and with rods made of commercial nickel, iron, cobalt, and a number of Hadfield's special alloy steels. The effect is greatest with nickel and greater with cobalt than with iron. The effect is too small to be detected in some of the magnetic alloys investigated. The increase in damping in the case of nickel is comparable with that which can be produced by suitable mechanical and heat treatment.

PP: 3 6 12 16 V AA 30 c 36 CV: 14 MI: AY Co Fe Ni a p

Zener, C.

Internal Friction in Solids - II. General Theory of Thermoelastic Internal Frictions

Physical Review, Vol. 53, pp. 90-99, 1938

Stress inhomogeneities in a vibrating body give rise to fluctuations in temperature, and hence to local heat currents. These heat currents increase the entropy of the vibrating solid, and hence are a source of internal friction. The general of this internal friction is here developed. The simplest example of stress inhomogeneity is that occurring in the transverse vibrations of reeds and wires. Explicit formulae are obtained for reeds and wires, and the effect is calculated of crystal orientation in single crystal specimens. Microscopic stress inhomogeneities arise from imperfections, such as cavities, and from the elastic anisotropy of the individual crystallites. The internal friction due to spherical cavities is calculated. The internal friction due to elastic anisotropy is investigated for cubic metals, and is found to be greatest for lead, least for aluminum and tungsten. (Author's abstract)

PP: 3 D 8 L 12 P AA 27 28 30 31 d 34 36 j m CV: 17
MI: SG Ag Al Cu Fe Mg Ni Pb Sn W Zn a 31 c 34 35 36 42 43 r

Zener, C., Otis, W., and Nuckolls, R.

Internal Friction in Solids - III. Experimental Demonstration of Thermoelastic Internal Friction

Physical Review, Vol. 53, pp. 100-101, January 1, 1938

In order to demonstrate the presence of thermoelastic internal friction, the authors measured the internal friction of a copper reed over a wide frequency range (50 to 4000 cycles/sec). They obtained a maximum precisely at the predicted frequency. The observed variation of internal friction with frequency proves that, over a wide frequency range, the internal friction due to the flow of heat back and forth across a reed is of a larger order of magnitude than that due to all other causes. Independent experiments of Bennewitz and Rötger on wires of silver, aluminum, brass, steel, and glass are shown to furnish an equally striking demonstration of thermoelastic internal friction. (Authors' abstract)

PP: 3 E 8 16 19 AA 27 28 30 31 34 CV: 14
MI: ST CN KK Ag Al Cu Zn' a n

Zener, C.

Inter Friction in Solids.- IV. Relation Between Cold Work and Internal Friction

Physical Review, Vol. 53, pp. 582-586, April 1, 1938

Previous investigators have found that cold working of metals has a marked effect upon internal friction, increasing it, in certain cases, by a factor of more than ten. In the present paper it is assumed that the effect of cold work upon internal friction is due to the internal stresses which it produces. During vibration these residual stresses give rise to fluctuations in temperature, and thus to local heat currents, which are inevitably associated with a rise in entropy, i.e. with internal friction. A formula is obtained for this internal friction in terms of the energy associated with the residual stresses, and the temperature variation of the modulus of rigidity. It gives the observed order of magnitude. According to the theory developed in this paper, the measurement of internal friction of a cold worked specimen over a wide frequency range and for various types of vibration will give not only the mean square of the residual stresses, but also their preferred axes, if any, and the mean linear dimensions of their inhomogeneities. (Author's abstract)

PP: AA 30 31 34 36 k CV: 17

Zener, C.

Internal Friction in Solids - V. General Theory of Macroscopic Eddy Currents

Physical Review, Vol. 53, pp. 1010-1013, June 15, 1938

Internal friction is calculated for all frequencies for both longitudinal and transverse vibrations. The theory of internal friction due to macroscopic eddy currents is shown to be formally identical with the theory of internal friction due to macroscopic thermal currents. The methods developed by the author for the study of thermo-elastic internal friction are thus directly applicable to the study of the macroscopic electric eddy currents. (Author's abstract)

PP: 3 8 11 M P 16 19 AA 27 30 31 34 CV: 17

1939

Barron, S. L.

Torsional Damping Capacity

Aircraft Engineering, Issue II, Vol. 130, pp. 445-447, 461, December 1939

The introduction and recent development of instruments for the accurate measurement of torsional damping capacity have provided for the metallurgist an accurate indication of this property, while structural changes due to processing can be observed and much valuable information gained. In this paper are described some of the latest methods of recording that are available. Accessories for the pre-stressing of specimens and examination of records are also considered. A final reference is made to the method of calculation from record measurements.

PP: 3 D J 11 13 AA 27 28 29 36 k CV: 15 18

Carpenter, H. and Robertson, J. M.

Metals (Book, 2 Vol.)

Oxford University Press, New York, 1447 pp., 1939

General discussion of damping capacity (pp. 496-497); damping capacities of typical metals and the relation of damping to fatigue (pp. 1212-1214).

PP: AA 42 r CV: 16

Endo, S.

Fundamental Equation of Vibration with Internal Friction. (In Japanese)

Soc. Mech. Engrs. Japan, Trans., Vol. 5, pp. 1-16, 18, August 1939

This is a derivation of the equation of vibration with internal friction in which energy dissipation per stress cycle is independent of frequency and logarithmic decrement of amplitude of natural vibration is dependent on or independent of amplitude; this formula can unify theoretically phenomena of natural vibrations, elastic hysteresis, and resonances of forced vibrations. (In Japanese with brief English abstract). (Eng'g. Index 1273, 1940)

PP: Y AA 30 34 CV: 12' 17

Förster, F. and Köster, W.

Modulus of Elasticity and Damping in Relation to the State of the Material

Jour. Inst. Elec. Eng., Vol. 84, pp. 558-564, 1939

In the space available, it is possible only to review a few of the researches which have been carried out. The choice is made to show that the method of measurement described provides an important aid to the determination of the state of materials. It is important to note that the damping and the modulus of elasticity are quantities which, in contrast to many other technical values, possess an exact physical meaning. Topics discussed are: Introduction, Method of Measurement, Pure Metals, Dependence on Temperature, Modulus of Elasticity and Damping of Some Pure Metals, Polymorphous Transformation, Ordered and Disordered Conditions, Magnetic Transformation, Influence of Alloy Additions, Grain Size, Precipitation Hardening, Deformation and Recrystallization, Internal Stresses, Local Defects, Intercrystalline Corrosion, Technical Investigations, Conclusion.

PP: 3 E 11 12 16 S U X AA 27 30 33 g h 38 k 40 n 42 q CV: 11' 14 15
MI: AY SG EG Al Cu Fe Mg Mo Ni Pb Sn Zn a 34 35 n p q

Geiger, J.

On the Damping of Cast Iron with Special Reference to Cast Crankshafts. (In German)

Automobiltechnische Zeit., Vol. 42, No. 24, pp. 634-644, 1939. Also Giesserei, Vol. 27, No. 1, pp. 1-9, January 12, 1940; No. 2, pp. 30-32, January 26, 1940

The author discusses various methods of determining the damping properties of cast iron and describes a testing machine developed by himself for measuring and recording the damping capacity of cast iron test pieces. With this machine he undertook an investigation with the object of determining the relationship between the structure of cast iron and its damping capacity as well as the composition of an iron with good casting properties, high strength, low notch-sensitivity and high damping capacity. The data he obtained led to the following conclusions: (1) The damping capacity of an unused specimen is much greater than that of a specimen which has been previously subjected to stress reversals, and a final and constant value is approached after about 200,000 reversals. (2) In comparing the damping capacities of different qualities of cast iron it was found that, as a rule, the lower the strength and the shear modulus the higher was the damping capacity. (3) The damping capacity of a cast iron crankshaft was from 80% to 150% greater than that of a steel one, the increase depending upon the quality of the iron used. (Abstract J. I. & S. I., 1940)

PP:

Giovannozzi, R.

Some Recent Studies on Internal Damping of Materials. (In Italian)

L'Aerotechnica, Vol. 19, pp. 245-272, 1939

This is a summary of recent studies in the field. Some 120 references are given with short abstracts of each.

PP: 3 9 M 16 V AA CV: 12' 15 18

Houwink, R.

Elasticity, Plasticity and Structure of Matter. (Book)

Cambridge University Press, London, 1939

Short definition of elastic hysteresis (p. 8); reference to the work on the hysteresis of rubber by Bouasse and Carriere (p. 192); Griffith's theory in regard to an explanation of hysteresis in rubber (p. 216).

PP: AA 30 CV: 16 MI: GG

Leaderman, H.

Creep, Elastic Hysteresis, and Damping in Bakelite Under Torsion

Trans., Am. Soc. Mech. Eng., Vol. 61, pp. A-79-85, 1939

The creep in torsion of various forms of bakelite under constant load and the creep recovery on removal of load is found to follow closely the superposition principle or "memory law" of Boltzmann, if the previous maximum strain in a test is not exceeded. If the previous maximum strain is exceeded, an additional plastic flow takes place which is not, at any rate immediately, recoverable. A function of the elapsed time called the "equivalent time" is introduced in order to analyze the creep and creep recovery when the loading history is complex. A method is developed for calculating the stress-strain loop due to creep for step-by-step cyclic loading. Results of cyclic-loading tests reveal the presence of a true elastic-hysteresis loop in addition to the loop due to creep. The specific damping capacity in torsion at a given stress, calculated from the measured creep and elastic-hysteresis loop, is shown to agree fairly well with the damping measured directly. (Author's abstract)

PP: 3 D 5 J 11 13 16 S AA 28 30 d 42 43 CV: 14 17 MI: FF GG'

Luttgerding, H.

Damping of Wires. (In German)

Mitteilungen des Wöhler-Instituts, Vol. 35, pp. 7-55, 1939

The Föppl-Pertz torsional damping tester has been redesigned to take wire specimens of 0.2-mm. diameter. Damping data and curves for piano wire and a variety of high-carbon steel wires, wires of duralumin of various compositions, Aldrey, aluminum with 3-1/2% copper, commercial aluminum and commercial copper, some in annealed as well as cold-drawn condition, are given. Hard-drawn wires usually gave S curves with generally good agreement among duplicates; annealed wires gave parabolic curves, with greater variation. The results for duralumin were prone to give irregular curves, with poor agreement among duplicates. (Translation available through Henry Brutcher, Altadena, California, No. 840)

PP: 3 D J 13 16 S AA 27 28 36 h CV: 11' 13 14 MI: ST CN Al Cu a h

MacKenzie, J. T.

Damping Capacity

Pig Iron Rough Notes, pp. 9-12, Summer, 1939

No abstract available.

PP: AA CV: 15 MI: Fe p

Norton, J. T.

Torsion Pendulum Instrument for Measuring Internal Friction (of metals)

Rev. Sci. Inst., Vol. 10, pp. 77-8, March 1939

A torsion pendulum instrument developed along the lines of the Foppl-Pertz instrument is described. The method of obtaining data and making calculations is indicated. Typical results on cast iron, armco iron, annealed 0.40% C steel, beryllium copper, and SAE 1112 are given.

PP: 3 D J 11 13 16 S AA 36 h CV: 14
MI: ST CN CI EG' Cu Fe a 33 g q

Ormondroyd, J.

Vibration Problems. Part II

Trans., Am. Soc. Mech. Eng., Vol. 61, pp. A127-A130, 1939

The major part of any vibration analysis lies in the calculation of the dynamic specifications of the simplified system which represents the machine or structure being studied. The dynamic specifications of a system are the numerical values of the masses, moments of inertia, spring constants, and damping constants which determine its dynamic behavior. These quantities are the coefficients which appear in the differential equations of motion of the system. After a general discussion of dynamic specifications, attention is given to damping constants, Coulomb Friction, Internal friction in solids, viscous friction, and impactive damping. No experimental data are given. 37 ref.

PP: Y 24 AA BB CV: 15

Otpushchennikov, N.

Absorption of Supersonic Waves in Solid and Liquid Media. (In Russian)

Jour. of Exp. and Theor. Physics, U.S.S.R., Vol. 9, No. 2, pp. 229-232, 1939

Preliminary measurements on the absorption of supersonic waves in various media are reported. The absorption coefficients in liquids seem to be much greater than those calculated from the Stokes' formula assuming the absorption to be due to internal friction. The absorption in metals is shown to be sensitive to their physical and chemical state. (Sci. Abs. p. 3733, 1939)

PP: 3 6 AA CC 36 CV: 12 14 MI: NN

Randall, R. H., Rose, F. C., and Zener, C.

Intercrystalline Thermal Currents as a Source of Internal Friction

Physical Review, Vol. 56, pp. 343-348, 1939

An experiment has been designed to detect the contribution of intercrystalline thermal currents to the internal friction of polycrystalline metals. In accordance with a theory developed by Zener, the internal friction is a maximum when the vibration is partly isothermal and partly adiabatic with respect to adjacent grains. By passing in small steps from the nearly isothermal case of very small grain size through maximum internal friction to the nearly adiabatic case of large grain size, one can detect the relative importance of the intercrystalline thermal currents. Such an experiment has been performed on single phase 69-31 brass, with mean grain size ranging in small steps from 0.0006 cm. to 0.4 cm. and with frequencies of 6000, 12000, and 36000 cycles per second. Not only has a maximum obtained with the anticipated grain size, but the maximum is of a larger order of magnitude than the background upon which it is superimposed. The internal friction in the extreme isothermal case (Q > 300,000) was lower than has ever been observed for metals; in the extreme adiabatic case it approached the low values obtained for single crystals. This experiment indicates that in annealed nonferromagnetic metals at room temperature, intercrystalline thermal currents are the dominant cause of inter friction measured at small strains, aside from possible macroscopic thermal currents. (Authors' abstract)

PP: 3 D E 8 11 M 16 19 AA 27 30 31 36 38 CV: 14 MI: Cu Zn' b n

Snoek, J.

Mechanical After Effect and Chemical Constitution

Physica, Vol. 6, No. 7, pp. 591-92, 1939

The experiment was conducted to prove that small amounts of carbon or nitrogen when introduced into a sample of iron which is otherwise very pure, will produce a mechanical after effect just as the same treatment is capable of producing a strong magnetic after effect. Damping measurements were taken over the range -50° C to +100° C in pure iron and in a sample into which about 0.02% of nitrogen was introduced. The nitrogen caused a maximum in the damping curve at +9° C that was not observed with the pure iron. Further experiments after heat treatment proved that really only the nitrogen present in solid solution is active in causing the after effect observed.

PP: 3 D 9 13116 U AA 27 28 36 h 42 s CV: 13 14 MI: EG' C' Fe p

Spaeth, W.

The Physics of Mechanical Materials Testing. (In German) (Book)

Springer, Berlin, p. 164, 1939

In a summary of previous work, the author indicates that both ferrous and non-ferrous materials exhibit the following behavior: when damping energy is plotted as a function of stress, the initial portion of the curve shows a relatively constant or slowly increasing damping but beyond a given stress value there is a rapid rise in the damping.

PP: 16 S AA 28 CV: 13 16 18

Tsien, W. H.

Internal Damping in Crankshafts

Massachusetts Institute of Technology, Master's Thesis, June 1939

In this investigation the damping capacity of crankshafts were compared with that of a straight uniform shaft of the same material and physical properties, and under the same testing conditions. The five specimens tested were of SAE 1045 steel; one was a straight uniform shaft, the second a shaft with enlarged diameter collars, and the remainder were two-throw crankshafts with varying crank throw web thicknesses. The specimens were all small -- approximately 1/4 in. in diameter x 3 in. long. These specimens were subjected both to static torsional deflection and to free torsional vibration tests. The internal damping of crankshafts was concluded to be much higher than a similar uniform straight shaft, the ratio depending on the applied-surface shear stress and the relative crank web thickness.

PP: 3 D 16 20 AA CV: 14 MI: CN q

1940

Allen, R. C.

Steam Turbine Blading

Trans., Am. Soc. Mech. Eng., Vol. 62, pp. 689-709. 1940

This paper reviews the blading-design practice associated with modern high temperature steam turbines. The design problems encountered in the development of partial-admission impulse blading for topping units are described as well as the current engineering practice employed in the manufacture of such blading. The stress analysis used in the construction of full-admission blading is reviewed. Materials for turbine blading are considered as well as the metallurgical problems associated with fabrication and welding of alloy steels. Damping is one of the properties of materials which is considered.

PP: A W Y AA CV: 15 MI: SG h

Anonymous

A New Method of Determining Damping Coefficients

Automotive Industries, Vol. 82, pp. 252-255, 263, March 1, 1940

This article reviews previous methods of measuring damping and then describes the method outlined by Dr. J. Geiger of the MAN firm in his article in Automobiltechnische Zeitschrift for December 25, 1939.

PP: C D E F AA CV: 15

Barnes, A. H., and Zener, C.

Internal Friction at High Temperatures

Physical Review, Ser. 2, Vol. 58, No. 1, p. 87, July 1940

Internal friction in metals is known to increase rapidly at high temperatures. If associated with thermal currents flowing back and forth between stress inhomogeneities it would vary comparatively slowly with temperature. Thur a new type of internal friction is apparently introduced at high temperatures. This paper reports the results of experiments conducted to determine the dependence of this internal friction upon temperature and grain size. Tests were made on samples of zinc. The grain size range investigated was between 0.04 mm. and 0.4 mm. To within experimental error, the temperature-dependent part of the internal friction varies inversely with grain size. Since the area of the grain boundaries per unit volume is also inversely proportional to grain size, this experiment indicates that the source of this high temperature internal friction lies on the grain boundaries, rather than in the interior of the grains. (Authors' abstract)

PP: 16 U AA 27 30 31 36 38 CV: 14 MI: Zn

Contractor, G. P. and Thompson, F. C

The Damping Capacity of Steel and Its Measurement

J. Iron and Steel Institute, Vol. 141, Pt. 1, pp. 157-218, 1940

The Föppl-Pertz apparatus for the measurement of "damping capacity" was found to yield unduly high values, mainly as the result of frictional losses between the stylus and the recording medium. To eliminate these, the instrument was modified so as to employ an optical recording device. Particular attention has been paid to a consideration of the effect on damping capacity of factors such as the initial stress, bending, size and shape of the specimen, etc. An account is given of experiments to study the influence of moderate temperatures on the damping capacity of a series of typical steels. This work, which is of an exploratory nature, covers only an account of the experimental results and no attempt is made to deal with them theoretically. (Authors' abstract)

PP: 3 D J L 13 16 S U 20 AA 28 36 h k CV: 14 18 MI: ST CN Fe a

Gebhardt, E. and Kőster, W.

The Platinum-Cobalt System With Special Regard to the Cobalt-Platinum Phase. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 253-261, 1940

This discusses the cobalt system, with special regard to the CoPt phase. The experiments show that platinum forms a perfect mixed crystal series with surface centered modification of cobalt at high temperatures; with lower temperatures, cobalt-rich alloys are transformed into hexagonal modification of cobalt. The results of X-ray and microscopic examinations are presented. The influence of heat treatment is examined. (Eng'g. Index, 258, 1941)

PP: B 3 5 AA 36 h CV: 13 14 MI: EG Co c 43

Gemant, A.

The Measurement of Solid Friction in Plastics

Jour. Appl. Physics, Vol. 11, pp. 647-653, October 1940

In view of the increasing importance of synthetic plastic materials, a method is developed to measure their vibrational damping in a wide range of temperature up to fairly high plasticity. The experimental method is a variation of that developed by Förster, utilizing forced flexural vibrations of cylindrical bars with free ends, suspended at nodal points. After explanation of the principle and theory of the method, the apparatus is described, and then measurements are presented from tests on glass, polystyrene, and paraffin wax. . The first two were investigated at room temperature and the purpose of obtaining these data was chiefly to check the efficiency of the method. Data on paraffin wax were obtained both at room and elevated temperatures up to the softening range. The general trend of the temperature curves is in agreement with theoretical expectations.

PP: 3 E J 10 11 12 16 U AA 27 28 CV: 14 MI: SG FF GG' KK

Hague, F. T.

Superposed Turbine Blade Research

Mechanical Engineering, Vol. 62, pp. 275-277, 1940

A description is given of research initiated to develop a better understanding of the conditions affecting the operation of impulse blades in superposed turbines. An ingenious optical method is described for actually photographing the blades' movements under actual operating conditions to give adequate and accurate records of the stresses imposed on these blades. A description is given of studies made with its use. The phenomena of resonance and damping are discussed. Important relationships in regard to damping show that: 1. Damping is not constant but increases with blade stress and is extremely low at low stress. 2. The damping characteristics of different steels vary widely. The widely used 12% chrome steel has more damping in its usable application range than any other material yet investigated. The materials of the chrome-nickel class that excel in high strength at high temperatures have about 1/10 as much damping as 12% chrome steel. 3. Damping becomes less as the frequency of vibration increases. This means that the increased stiffness of heavier blades does not result in much lower blade stresses. 4. Damping decreases rapidly at higher operating temperatures, particularly beyond 750°F. At 100°F the damping is only 1/3 as much as at room temperature and is decreasing precipitously. A discussion of the possibilities of applying some sort of separate dampers to the blades is included.

PP: A 3 E R S U W AA EE CV: 15 17 MI: AY SG h

Hibi, T.

The Change of the Damping Coefficient Due to Magnetization of Some Ferromagnetic Substances. (In English)

Sci. Repts., Tohoku Imperial University, pp. 450-457, March 1940

The author found that the damping coefficient in a magnetic field of constant intensity depends upon the amplitude of the oscillations, and it appears that there are two or three ranges of amplitude in which the damping coefficient is of a nearly constant value.

PP: 3 16 S V AA 30 c CV: 14 MI: SG n p

Köster, W.

Elastic Modulus and Damping of Aluminum and Aluminum Alloys. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 282-287, 1940

A thorough study has been made of the effect of cold work and subsequent annealing upon Young's modulus (E) and the damping capacity of aluminum. Two grades were used, 99.99% and 99.5%. Before elongation, the damping capacity was nearly independent of degree of purity, and also of grain size. The damping capacity rose rapidly with elongation up to 20% elongation, then slowly to the final elongation of 80%.

PP: 3 D E 9 11 12 16 U X AA 27 36 h 38 k 42 q CV: 13 14 MI: Al a

Köster, W.

Modulus of Elasticity and Damping of Iron and Iron Alloys. (In German)

Archiv. Eisenhüttenwesen, Vol. 14, pp. 271-278, 1940

Description is given of an acoustic method used for measuring the modulus of elasticity and damping properties. Materials studied are Armco-iron, steels with 0.1 to 1.7% C; cast iron, iron-nickel alloys, and iron-chromium-cobalt alloys. The influence of temperature, grain size, deformation, recovery, recrystallization, (hot) precipitation hardening, and atomic arrangement upon damping and modulus of elasticity were studied. The effect of graphitization in cast iron was investigated. Damping measurements for determining hardening range and effect of multiple hardening are given. Damping measurements as a suitable nondestructive test method for defects, e.g. microquenching cracks and especially intergranular corrosion, is discussed. Superiority is found for damping mea measurements in the latter case over all mechanical tests. Quantitative data are given on the process of (surface and intergranular) corrosion obtainable from measurements of damping combined with measurements of resonant frequency. (Translation available from Henry Brutcher, Altadena, Calif., No. 1310)

PP: 2 3 6 16 U W X 36 37 38 k m 42 q CV: 11' 13 14
MI: ST CN CI Co' Cr' Fe Ni' a

Köster, W.

The Elastic Moduli and Damping Capacities of the Ordered Phases, of Copper-Zinc, Gold-Copper, Palladium-Copper, and Platinum-Coppen (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 145-150, 1940

This is a discussion of the influence of temperature on modulus of elasticity and internal friction (damping capacity); the influence of time on the modulus of elasticity at the change from ordered to disordered condition; the influence of annealing on quenched alloys; and the range of stability in the Au-Cu II phase. For the cubic body-centered alloy CuZn and for the cubic face-centered alloys $AuCu_3$, $PdCu_3$, and $PtCu_3$, the modulus of elasticity is greater in the oriented than in the random condition. With decreasing temperature below the transition point, the modulus of elasticity increases at first rapidly, later slowly. The random atom distribution is established after quenching $AuCu_3$, $PdCu_3$, and $PtCu_3$. Upon heating they reach the modulus of elasticity value corresponding to the ordered condition in two steps. The atom arrangement has a marked effect on the modulus of elasticity. For AuCu alloys (cubic, face-centered) which transform into a tetragonal lattice upon orientation, the modulus of elasticity is higher in the later condition. There is a maximum between 385° and 405° for heating, and between 380° and 355° for cooling. Between the diagram sections of the tetragonal phases AuCu I, and the random cubic face-centered solid solution there is a third condition assumed to be rhombic AuCu II. During the transition from the quenched (disordered) solid solution to the ordered tetragonal condition, an intermediate condition occurs which is characterized by great hardness and high modulus of elasticity. The condition AuCu II is likewise distinguished by high modulus of elasticity; upon annealing the decrease in these values indicates the transformation into AuCu I. The damping capacity of the alloys increases slightly at first and from 300-500° very rapidly. (Chemical Abstracts, p. 3581, 1941)

PP: 3 E 9 11 12 16 U X AA 27 30 31 36 h 40 42 q CV: 13 14
MI: EG Cu Zn a c 36 42 43

Köster, W.

The Elastic Moduli and Damping Capacities of the Intermediary Phases in the Systems Copper-Zinc, Silver-Zinc, Gold-Zinc, and Silver-Cadmium. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 151-156, 1940

The temperature dependence of the modulus of elasticity and internal friction (damping capacity) and the influence of annealing on the modulus of elasticity of quenched alloys were studied. In the alloy Ag-Zn the transformation from the delta to the beta phase causes a sharp drop in the modulus of elasticity. By quenching the ordered B' condition is obtained; upon transformation into the delta condition, damping capacity goes through a maximum value. Transformations of the phase Au_3Zn are noticeable by changes in the course of the temperature-modulus of elasticity curve; they correspond with observations made by conduction tests. The same is true for $AuZn_3$. Alloy Au_3Zn, if quenched from above 420°, shows face-centered cubic superstructure. Transformations in AgCd alloys can be followed closely by measurements of modulus of elasticity. The polymorphous character of the B' to psi and psi to B transformations can be seen by the sudden change in the value of the modulus of elasticity. There are indications pointing to the existence of superstructure transformation of the gamma phase of the Cu-Zn and Ag-Cd systems. Generally, the internal friction rises slowly at first and then more rapidly with increased temperature. (Chemical Abstracts, p. 6552, 1941)

PP: 3 E 9 11 12 16 U X AA 27 36 h n 42 q CV: 13 14
MI: EG Ag Cu Zn a 35 36

Köster, W.

On the Concentration and Temperature Dependence of the Elastic Moduli of Alloys of Copper, Silver, and Gold with Zinc and Cadmium, Also of Copper with Gold, Palladium, and Platinum. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 160-162, 1940

In the Cu-Zn system, the initial addition of Zn increases the modulus of elasticity above that of Cu; it then decreases through the alpha plus beta range to the value for beta brass (approximately 1,024,000 lb/in^2); it drops further through the beta field. Upon further addition of zinc the modulus rises to the value for the gamma phase (approximately 2,062,500 psi), then drops to the point characteristic for the epsilon phase (1,500,000), and finally to the value for Zn. In the alloys of Ag and Au with Zn and Cd the influence of concentration runs in the same manner as in the Cu-Zn system. A comparison between the corresponding phases shows that the modulus of elasticity for beta, epsilon, and gamma in the Ag alloy is lower for Cu, and in Au still lower; for the epsilon it drops slightly in the same direction. The values for corresponding phases are always lower in the Cd than in the Zn systems. In phases which are stable at elevated temperatures, the modulus of elasticity changes linearly with temperature. In low temperature phases the drop with temperature proceeds at an accelerated rate. Transformation from one crystal into another is not always accompanied by a jump in the modulus curve. A certain curved course can be observed in intermediary phases and solid solutions. (Chemical Abstracts, pp. 3581-2, 1940)

PP: 16 U X 36 37 n 42 q CV: 13 14 MI: EG Ag Cu Zn a c 35 36 42 43

Köster, W. and Rosenthal, K.

The Variations of Elastic Modulus in the Systems of Magnesium with Zinc, Aluminum, Tin, Lead, Antimony, and Bismuth. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 163-164, 1940

The modulus of elasticity of Mg is lowered by the formation of a solid solution in the systems investigated. In the intermediate phases it may be higher or lower than in the pure metals. The compounds Mg_2Sn and Mg_2Pb have modulus of elasticity much higher than those of the component metals and Mg_3Sb_2 and Mg_3Bi_2 much lower. (Chemical Abstracts, p. 3582, 1941)

PP: 16 U X 36 37 CV: 13 14 MI: EG al Mg Pb Sn Zn a 31 34

Köster, W. and Schneider, A.

The Elastic Moduli and Damping Capacities of the Intermediary Phases in the Gold-Cadmium System. (In German)

Zeit. f. Metallkunde, Vol. 32, pp. 156-159, 1940

The alloy (1) AuCd changes at 475° from α to α_1, and again at 415° to α_1'. At the first step only the temperature coefficient of the modulus of elasticity change; at the second the curve of modulus of elasticity versus temperature indicates the formation of an ordered arrangement. The phases α and α_1 (disordered) can be obtained at room temperature by quenching. Upon annealing α changes to α' (ordered) between 75 and 150°, and α_1 to α_1' between 225° and 325°. At 410° to 440° α transforms suddenly to α_1'. According to X-ray patterns α_1 seems to have a slightly distorted tetragonal face-centered lattice; the superstructure lines of α_1' are shown. The alloy (2) CuCd shows polymorphous transformation at 30° evident by a marked decrease in modulus of elasticity and increase in volume. The X-ray pattern seems to show a tetragonal body-centered lattice with superstructure. Above 30° the modulus of elasticity rises slowly, and drops again above 275°. According to modulus of elasticity, the ϵ to ϵ' transformation of the CuCd phase can be interpreted as an ordering of the atom arrangement. (Chemical Abstracts, p. 3582, 1941)

PP: 3 E 9 11 12 16 U X AA 27 36 h 40 n 42 q CV: 13 14
MI: EG a 35 36

Kroon, R. P.

Turbine Blade Fatigue Testing

Mechanical Engineering, Vol. 62, pp. 531-535, July 1940

In this paper attention is placed on the strength of turbine blades. Fatigue fractures due to vibratory loading, the selection of lashing wires for maximum blade strength, a method of making fatigue tests by use of an electromagnetic vibrator, and other devices used to fatigue turbine blades are considered. Principally this is a description of fatigue testing technique and its use in obtaining blade structures of optimum strength. Damping is considered in estimating the maximum oscillating load which a blade can carry at resonance. Formulae to determine this are presented.

PP: 3 E W Y AA CV: 15 MI: SG h

Kroon, R. P.

Turbine-Blade Vibration Due to Partial Admission

Trans., Am. Soc. Mech. Eng., Vol. 62, pp. 531-535, July 1940

This paper deals with stresses in steam-turbine blades set up during partial admission, that is, when the steam loading on the blades is intermittent. By making simplifying assumptions about the character of the loading, it is possible to develop simple relations showing how the blade stress depends on frequency, running speed, and damping. Apparatus to determine experimentally the damping of blade steels and optical equipment to investigate the exact nature of the steam forces acting on the blades in actual operation are described. Data on the damping of blade materials are reported as functions of stress, frequency, and temperature. 12% Cr and CrNi steels were investigated.

PP: A 3 D 9 12 R S U W AA 29 CV: 17 MI: AY SG c h r

Lawson, A. W.

The Variation of the Adiabatic and Isothermal Elastic Moduli and Coefficient of Thermal Expansion with Temperature Through the λ-Point Transition in Ammonium Chloride

Physical Review, Vol. 57, pp. 417-426, 1940

Measurements of the temperature variation of the adiabatic and isothermal Young's and rigidity moduli and of the coefficient of thermal expansion of pressed specimens of ammonium chloride in the neighborhood of the λ-point transition at 242-8°K are reported. Some data are given on the way in which the internal friction associated with longitudinal vibration of a specimen of polycrystalline ammonium chloride in cylindrical form varies with temperature. The variation of the torsional internal friction, determined previously, has similar characteristics.

PP: 3 D 10 M P 16 U X AA 27 30 b 36 n CV: 14

Lennard-Jones, J. E.

Some Theoretical Problems Concerning the Solid State

Proc. Phys. Soc. London, Vol. 52, pp. 38-53, 1940

This paper contains a discussion of some of the unsolved theoretical problems connected with the solid state of matter. One of these is the occurrence of small crystallites even in the most perfect crystals. Reasons are given for attributing such imperfections in crystals to the conditions of growth from the melt. It is pointed out that a study of the conditions prevailing at the boundaries between crystallites might throw light on slip and on the appearance of slip bands--properties of crystals which have not yet been adequately explained. The nature of melting and the converse process of solidification require further study. Local melting may occur in crystals owing to slip and be a factor in producing strain hardening. A method is given of evaluating the relation between stress and strain outside the usual elastic limits and at temperatures approaching the melting temperature. (Author's abstract)

PP: 3 16 U AA 30 31 32 CV: 15 17

Locati, L.

Determination of the Damping Capacity of Materials as a Method of Investigating Their Structure. (In Italian)

Metallurgia Italiana, Vol. 32, pp. 219-235, 1940. The same abstract. Jour. Institute of Metals, Vol. 11, p. 95, 1944

A survey is presented of the significance of damping as a property of the material, the investigations carried out hitherto, and the machines used. A new testing machine is described in which a metallic mirror, attached to the test-piece, registers oscillograms on a drum. Examples of measurements are given, showing the effect of the thermal treatment of steels on their damping curves, and the difference in the behavior of cast iron and steel, and of zinc and a eutectic zinc-cadmium alloy.

PP: B 3 AA 36 h CV: 12' 15 MI: ST CN CI EG' Zn a 35

Lorig, C. H. and Schnee, V. H.

The Damping Capacity, Endurance, Electric, and Thermal Conductivities of Some Gray Irons

Trans., American Foundrymen's Association, Vol. 48, pp. 425-446, 1940

In this paper, the authors record data accumulated during an investigation of the effect of copper on cast irons. They made a series of low, medium, and high carbon cast irons with additions of copper varying from 0 to 3.0% and studied the effect of that element on the properties indicated in the title of the paper. From their results, they determined that copper may benefit damping capacity at working stresses; that, as copper increases up to 3%, there is a slight decrease in the endurance ratio; that it has little, if any, effect on the thermal conductivity within the percentages of copper investigated; and that the effect of copper on the electrical conductivity, again within the percentage additions investigated, was insignificant. For the records, the authors given an appendix to their paper which shows the method for computing percentage damping capacity. (Authors' abstract)

PP: 3 D J 11 13 16 S W AA 28 36 37 CV: 14 18 MI: CI Cu' Fe n

Norton, J. T.

Changes in Damping Capacity During Annealing of Alpha Brass

Am. Inst. Min. and Met. Eng., Technical Publication No. 1168, Vol. 137, pp. 49-61, 1940

The present experiments confirm the fact that when metals are tested at comparatively low frequencies, the principal cause of energy dissipation is local or general plastic deformation. In cold-worked metals, the internal stress system is an important factor in the production of localized plastic flow. The relief of internal stresses by annealing reduces the damping to a low value, and the value is low over a considerable range of applied stress. At the recrystallization temperature, the damping capacity shows little change, provided the applied stress is well within the so-called elastic range of the material. Considered from the point of view of a metallurgical tool, the damping capacity is a sensitive indicator of internal stresses, but is relatively insensitive to change in grain size. 4 ref. (Author's summary)

PP: B 3 D J 13 16 S U AA 28 30 b 36 h 38 k 41 CV: 14 MI: Cu Zn' n

Parker, E. R.

The Influence of Magnetic Fields on Damping Capacity

Trans., Am. Soc. Metals, Vol. 28, pp. 661-667, 1940

Damping tests were made on a 0.40% carbon steel and a 5.0% chromium, 0.5% molybdenum steel in steady and alternating magnetic fields. The energy loss when a steady field was present was less than half the value for zero field. An alternating field reduced the energy loss still further, to about half the value obtained in a steady field. A maximum in the damping-stress curve for high Cr-Fe alloys was due to the magnetic component of damping. The importance of measuring damping at different stresses is demonstrated by the results for the Cr-Mo steel where the effect of magnetic fields on damping varies with different stresses. The endurance of fatigue specimens having stress concentrations was found to be reduced by the presence of a magnetic field. (Chem. Abs., pp. 7234-5, 1940)

PP: 3 D J 13 16 S V AA 29 30 c CV: 14 MI: ST CN AY c s

Poritsky, H. and Robinson, S. L.

Torsional Vibration in Geared Turbine Propulsion Equipment

Jour. Appl. Mech., Trans., Am. Soc. Mech. Eng., Vol. 62, pp. A117-A124, 1940

Two alternative methods are presented by the authors for the determination of torques in the propelling machinery of ships when friction is taken into account. One is called the "direct method," while the other is called the "method of normal coordinates." The latter is described at length, showing the great saving of numerical work possibly by its use when compared to the direct method. The paper points out that at critical propeller speeds oscillatory torques are limited only by damping. Two types of damping are taken into account: One is damping of the propeller in water; the other is friction in the driving mechanism, introduced as solid friction in the shafts similar to damping in the metal. (Authors' abstract)

PP: A 10 11 W AA BB CC CV: 17

Randall, R. H. and Zener, C.

Internal Friction of Aluminum

Physical Review, Vol. 58, pp. 472-473, September 1, 1940

It has previously been pointed out that the nearly elastic isotropy of aluminum necessitates a very small internal friction. By making measurements over a range of grain sizes and of frequency it is established that the internal friction of aluminum is less than 1/10 of that of alpha-brass under corresponding conditions. (Authors' summary)

PP: 16 19 AA 27 36 38 42 q CV: 14 MI: Al Cu Zn' a

Read, T. A.

Internal Friction of Single Metal Crystals

Physical Review, Vol. 58, pp. 371-380, August 15, 1940

The internal friction of crystalline copper, tin, lead, and zinc has been measured by the composite piezoelectric oscillator method. It is found that the decrement of an unannealed crystal may be as that of the polycrystalline material, that annealing reduces the decrement to a value of the order 10^{-4} to 10^{-5}, and that both Young's modulus and the decrement vary with the vibrational strain amplitude at strain amplitudes as low as 10^{-6}. In the case of zinc crystals, a detailed study has been made of the way in which the elastic modulus and internal friction depend on the previous history of the specimen, on the vibration frequency and amplitude, and on the orientation of the vibration axis with respect to the crystal slip planes. The results suggest that the mechanism involved is a propagated "dislocation" of the sort proposed by Taylor, Polanyi and Orowan to account for macroscopic plastic flow, and that the application of a stress is accompanied by a plastic strain, together with an associated strain hardening in consequence of which the stress-strain relation on removal of the applied stress is nearly elastic. (Author's abstract)

PP: 3 D E 9 M 16 S T 19 X AA 30 b 32 36 h j 40 CV: 14 18
MI: Cu Pb Sn Zn a

Taylor, H. D.

Critical Speed Behavior of Unsymmetrical Shafts

Trans., Am. Soc. Mech. Eng., Vol. 62, pp. A-71 - A-79, 1940

The development of large two-pole turbine generators with rotors running above the critical speed and having long core bodies slotted for field coils, makes desirable a working familiarity with the vibrational characteristics of unsymmetrical shafts. It is the purpose of this paper to describe these characteristics which are distinctly peculiar. This problem has received some attention from previous writers, who have pointed out an unstable range of operation due to dissymmetry of the shaft and some of whom made small-scale tests for demonstration. In the present investigation, experimental work on a special rotor of 10-1/2 ft span and weighing over 5000 lb was carried out to test in some detail the indications of a thorough analysis of the problem by the late V. Petrovsky of the Lynn Works of the General Electric Co. This analysis is given in outline in an appendix. The first part of the paper deals briefly with the static characteristics of unsymmetrical shaft as a basis for defining the degree of dissymmetry. The critical speed behavior of ordinary round shafts is reviewed and the theoretical differences due to dissymmetry are described. These are (a) with moderate dissymmetry compared with the degree of damping a marked increase in the critical speed amplitude, and a pronounced variation with the angular position of the unbalance of the rotor; (b) with greater dissymmetry beyond a limiting value, an infinite critical speed amplitude; or rather, two infinite peaks, with unstable operation between them; (c) considerable distortion of the phase-angle curves, such that, in general the phase angle may be much larger or smaller than 90 degrees at the critical speed; (d) double-frequency vibration, if the shaft is horizontal, with an auxiliary peak, or subcritical at half the main critical speed. Tests on the 500 lb rotor are described which give general confirmation of these characteristics. (Author's summary)

PP: A Y AA CV: 17

Zener, C.

Internal Friction in Solids

Proc. Phys. Soc. London, Vol. 52, Part 1, No. 289, pp. 152-166, 1940. Also Physical Review, Vol. 58, pp. 152-165, 1940

The various causes of internal friction in solids are discussed. Internal friction depends in general on thermal currents which occur owing both to the inhomogeneous strains set up by the vibrations in the solid, and to the variations in the elastic constants from point to point in polycrystalline materials. The variations of internal friction with amplitude of vibration, temperature of measurement, annealing temperature, with frequency, with grain size, and with residual stresses, are discussed. Graphs are shown and data are presented for a variety of materials. Lattice dislocations and ferromagnetism as sources of internal friction are considered.

PP: 3 D E 8 11 M 13 R S U AA a 31 c 36 h 38 k m CV: 17 18
MI: ST AY SG KK Ag Al Cu Mg n

Zener, C. and Randall, R. H.

Variation of Internal Friction with Grain Size

Trans., Am. Inst. Mech. Eng., Institute of Metals Div., Vol. 137, pp. 41-47. Paper No. 1146, 1940

The internal friction arising from intercrystalline thermal currents is examined from a theoretical standpoint. It is found that in the extreme isothermal case of small grain size d this internal friction varies as d^2, while in the extreme adiabatic case of large grain size it varies as 1/d. These predictions may be tested by examining a single specimen over a range of frequencies of vibration. Experimental data are presented which are in complete agreement with these theoretical predictions. It is found possible to estimate the part of the internal friction that does not arise from thermal currents. This residual internal friction is very small in the specimens examined. The relative grain sizes of specimens may be from internal friction measurements with an accuracy comparable with that obtained from grain counts. (Authors' summary)

PP: 3 D 8 11 M 16 19 AA 30 31 36 h 38 CV: 14 17 MI: Cu Zn a

1941

Anonymous

The Damping Capacity of Metals

Engineer, Vol. 171, p. 384, 1941

This consists of a discussion of damping capacity in assessing the "trustworthiness" of metals; a discussion of the damping properties of metals in general; and the significance of damping and its results.

PP: A AA CV: 15

Battelle Memorial Institute Staff

Prevention of the Failure of Metals Under Repeated Stress. (Book)

John Wiley & Sons, Inc. New York, Appendix 23, pp. 210-211, 1941

This is a general discussion of damping. It points out that damping measurements average the behavior of the piece and do not pick out the properties of a specific location as is the case with most types of fatigue tests. The amount of internal friction is dependent upon the applied stress, so there is no one figure for the damping capacity of a material, and, in comparing different materials, especially materials of widely different strengths, it is difficult to decide at what stress to make the measurement... The damping measurement is therefore an integration of damping capacities at a range of stresses, usually. It has often been suggested that the damping properties are somehow related to the endurance strength of a metal, and it was once hoped that a measurement of damping might determine the endurance limit. But this is not true.

.... There does not seem to be either any relationship between the damping and notch sensitivity of a material.

Before anything of the nature of a reasonable correlation can be shown to exist or not to exist, it will be necessary to follow out the suggestion of Hoyt and compare damping capacities at the endurance limits of different alloys, with the notch sensitivity of those alloys. This one figure of damping alone is not likely to show a very good correlation, but in conjunction with other factors, it may play a part in determining whether an alloy will or will not have the desired "crackless plasticity."

No matter how limited the applicability of damping capacity of a metal may be to the fatigue resistance of a metal part itself, the ability of a complete structure to damp out vibrations of high intensity is very important. (Excerpts)

PP: 16 S AA 29 42 r CV: 15

Bernhard, R. K.

Testing Material in the Resonance Range

Proc., ASTM, Vol. 41, pp. 747-757, 1941

The effect of the amplification factor at or near resonance can be used advantageously in testing materials. The fundamental principle governing the investigations at or near resonance are discussed. An oscillator driven endurance test machine based on the resonance principle is described more in detail including control units and calibration. The main purpose of this machine is to test larger specimens and riveted or welded structural units; static and dynamic load conditions, alone or superimposed, can be produced at high frequencies, requiring a rather small power input for the driving motor. A few test data are presented. The determination of damping is discussed. (Author's abstract)

PP: 3 E 8 14 16 T AA 29 CV: 14 MI: CN j

Brick, R. M, and Phillips, A.

Fatigue and Damping Studies of Aircraft Sheet Materials: Duralumin Alloy 24ST, Alclad 24ST, and Several 18/8 Type Stainless Steels.

Trans., Am. Soc. Metals, Vol. 29, pp. 435-469, 1941

The strong wrought aluminum alloys, 24ST and Alclad 24ST, and nine 18-8 type commercial grades of stainless steels of low and moderate carbon contents, and in the annealed, cold-rolled, stabilized and aged conditions were fatigue tested under constant deflection conditions. The S-N data so obtained indicate the probable endurance limits but are incomplete because of lack of time for aluminum alloys and the scatter of results for many of the stainless steels. The ratio of endurance limit to tensile strength of the stainless steels was found to be relatively constant for one type of surface condition but to change a maximum of 30 to 70% with different commercial finishes. Errors considered were mechanical or inherent in the test method; i.e. increases of stress at constant deflection near the endurance limit accompanied by plastic behavior resulted from work hardening or decreases in apparent stress from crack formation and propagation, particularly in Alclad. The effects of the two opposing factors, work hardening and cracking, were studied by means of damping and mechanical hysteresis (load-bending) tests on actual fatigue specimens at various intervals during stressing above and near the endurance limit. Very considerable changes took place in Alclad specimens but changes in the stainless steels were relatively slight although considerable differences were found among the various types studied. (Authors' abstract)

PP: 3 D 5 J 10 12 16 S T AA 28 29 36 h k n 42 r CV: 14 18
MI: SS Al Cr' Ni' h

Dean, R. S., Anderson, C. T., and Potter, E. V.

The Alloys of Manganese and Copper: Vibration Damping Capacity

Trans., Am. Soc. Metals, Vol. 29, pp. 402-414, 1941

Preliminary measurements showed that certain manganese-copper alloys possessing a remarkable deadness or lack of metallic ring also have remarkably high vibration damping capacity at low stresses. An instrument for the determination of this property is described, and the results obtained with it using manganese-copper alloys are discussed. The results indicate that the high values obtained by certain heat treatments are due to the formation of ordered anti-phase nuclei in the mass of the alloy. The vibration damping capacity appears to reach a maximum with some critical distribution of these anti-phase nuclei and decrease as a state of equilibrium order is approached. The effect of cold work is to decrease the vibration damping capacity of the alloys as would be expected from its disordering effect. The unusually high vibration damping capacity of the quenched alloys drops with time, and it is suggested that it is due to their failure to come to an equilibrium volume when quenched. There would thus seem to be a similarity in structure with regard to its effect on vibration damping capacity between an alloy in a supercooled state and an alloy in a partly ordered state. In both instances, some of the atoms of the metal are not in the equilibrium positions required by the temperature. High vibration damping capacity appears to be an attribute of such metastable systems. (Authors' abstract)

PP: 3 E J M 16 S T AA 27 30 31 g h k m CV: 14 MI: Cu Mn

Fry, A., Kessner, A., and Oettel, R.

Significance of Yield Point for the Fatigue Strength

Translated from Archiv Eisenhuttenwesen, Vol. 14, pp. 571-576, 1941

Investigation of six Cr-Mo and Ni-Cr structural steels (Heat treating types) for yield point, tensile strength, bending fatigue limit, damping, and impact fatigue limit. Composition of steels studied: .12-.42C, .22-.33Si, .46-.53 Mn, .3-2.1 CR, 0-3.5 Ni, 0-.33 Mo. Interrelations amoung these properties. Derivation of a new formula for computing the bending fatigue limit from the yield point and the tensile strength to same time and work. Advantages of new formula over known formulae. Influence of damping upon yield point is discussed. Correctness of new formula in the light of 42 samples. (Cr, Cu, Ni-Cu, Si-Mn, Cr-Mo-Ni, Cr-Mo-Ni-V, Cr stainless, and Cr-Ni Stainless steels). Important practical conclusions to be drawn from the present study as to materials suitable for crank shafts, piston rods and other machine parts exposed to resonance vibrations. (Translation by Henry Brutcher, No. 1194, Altadena, Calif.)

PP: A 3 5 G N 14 16 S AA 28 29 42 44 CV: 11' 13 14 MI: ST AY SS s

Harris, C. O.

Some Properties (Dynamic) of Rubber

Jour. Appl. Mechanics, Vol. 63, pp. A-129-A-135, December 1941

The purpose of the investigation described in this paper was to obtain information concerning the dynamic properties of rubber bonded to metal. Two properties of rubber were measured (a) the internal damping and (b) the dynamic modulus of elasticity. Two types of specimens were tested (a) rubber cylinders bonded to steel cylinders at the ends and stressed in compression and (b) specimens of rubber bonded to steel and stressed in shear. For the tested specimens it was found that for cylinders in compression and specimens in shear, the damping can be expressed in terms of a velocity coefficient. The damping decreases with increase of frequency; it increases with increase of static strain. The dynamic modulus of elasticity is slightly larger than the static modulus and is not affected by change of frequency. It increases with increase of static strain for the cylinders and decreases for the shear specimens. For cylinders in compression, both damping and modulus of elasticity are dependent upon the ratio of diameter to length.

PP: 3 D 10 L M 13 14 16 17 19 20 X AA 27 CV: 14 MI: GG

Hempel, W.

Fatigue Characteristics of Ordinary and Malleable Cast Iron, (In German)

Zeitschrift des Vereines Deutscher Ingenieure, Vol. 85, pp. 290-292, 1941. (British Min. Aircraft Prod.; R. T. P. Trans. No. 1214, 1941)

The results of fatigue tests of previous investigations by Pomp and Hempel on round, flat, screw, and wire specimens of different steels at different stress levels is reviewed. In further pursuit of this work, cast iron and malleable iron, which have been in increasing use for vibration application in recent years, were studied. The damping of these materials was determined.

PP: 16 S AA 42 r CV: 13 14 15 MI: CI s

Higuchi, S.

On the Internal Resistance of Solid Bodies

J. Franklin Inst., Vol. 231, No. 5, pp. 421-445, May 1941

The damping characteristics of seven different metals, i.e. brass, copper, aluminum, Duralumin, mild steel, silver and zinc were investigated. Based on these experiments the laws of internal resistance of solids are examined and it is concluded that the law of viscous resistance is valid, especially in the state of small stresses.

PP: 3 D 9 12 16 S AA 27 30 d 34 CV: 14 MI: CN Ag Al Cu Zn h j n

Kimball, A. L.

Vibration Problems. Part IV. Friction and Damping in Vibrations

Trans., Am. Soc. Mech. Eng., Vol. 63, pp. A-37 - A-41, 1941

The following items are discussed: classification of vibration phenomena, cyclical energy dissipation, logarithmic decrement and formulas therefor, decaying vibrations with damping, sustained vibrations with damping, vibration decrement magnitudes, and solid friction. It is an article dealing with general vibrations with special emphasis on damping.

PP: 3 D E 9 AA 30 34 CV: 15 17

Kimball, A. L.

Vibration Problems. Part V. Friction and Damping in Vibrations

Trans., Am. Soc. Mech. Eng., Vol. 63, pp. A-135 - A-140, 1941

The following items are discussed: factors controlling internal friction constants, logarithmic decrement curves, thermoelastic effects on vibration damping, other effects, and engineering applications. The results of numerous previous investigators are summarized in curves and tables.

PP: A 3 D 9 L M N 14 16 S U AA 28 29 30 31 c 36 h 38 CV: 15 17
MI: ST CN FF GG HH KK LL Al Cu Fe Mo Ni Sn W Zn c d

Kochendorfer, A.

Plastic Properties of Crystals and Metallic Materials, (In German)

Book, J. Springer, Berlin, 294 pp., 1941

The book deals with the following subjects: Homogeneous deformation of single crystals. Alternate homogeneous deformation of single crystals. Inhomogeneous deformation of single crystals. Deformation of metallic materials. Alternate deformation of metallic materials. Mathematical principles.

PP: AA 36 j CV: 13 16 17

Lawson, A. W.

The Effect of Stress on Internal Friction in Polycrystalline Copper

Physical Review, Vol. 60, pp. 330-335, August 15, 1941

The internal friction of polycrystalline specimens of oxygen-free copper, subjected to compressive stress, increases and then decreases with continuously increasing stress. A complementary behavior of Young's modulus is found. Thus, while the internal friction increases 100%, Young's modulus decreases about 6% for a stress of 90 kg/cm^2. An increase of stress to 160 kg/cm^2 leaves a remnant increase of only 40% in the internal friction and a remnant decrease in Young's modulus of 4%. This effect is nearly independent of the temperature at which the stress is applied. Although the Taylor dislocation of plasticity is capable of explaining qualitatively the data obtained at any one temperature, no simple explaination of the temperature independence of the effect is available at the present time. (Author's abstract)

PP: 14 16 S U X AA 30 32 CV: 14 MI: Cu a

Maier, K.

Damping of Torsional Vibrations by Means of Electrically Coupled Masses with Non-Linear Spring Constants

Luftfahrt-Forsch., No. 1, pp. 18-23, February 28, 1941. Also Roy. Aero. Soc. Jour., p. 111, May, 1941

It has been observed in practice that dampers with non-linear elastic constants do not experience an increase in temperature comparable with the vibrational energy destroyed. Therefore, the explanation that such fittings work mainly by internal fraction has to be discarded. The author showed that the damping effect is mainly a question of tuning. The best results are obtained if both mass and elastic constant of damper are chosen so as to produce maximum changes in the natural frequencies of the whole system with change in "equivalent" stiffness due to deflection of damper. If the tuning is, however, such that an increase in the "equivalent" stiffness produces only a slight increase in the natural frequency of the system, the damper works mainly by internal friction of the spring system.

PP: 3 13 W Y AA EE CV: 11' 13 17

Read, T. A.

Internal Friction of Single Crystals of Copper and Zinc

Trans. Am. Inst. Mining and Metal. Eng., Vol. 143, pp. 30-44, 1941

In this paper the results of the only study to date on the damping of mechanical vibrations in single crystals of metals are presented. The method of measurement use is that of the composite piezoelectric oscillator. Measurements of the internal friction of single-crystal rods of copper and zinc have been made for longitudinal oscillations at frequencies of 33.5 and 39.0 kc., respectively. The measurements on zinc were also made at 78.0 kc. By careful annealing, the decrements of the single-crystal rods may be made as low as 1 x 10^{-5}. The internal friction of single crystals of copper and xinc is increased by even very small amounts of cold-work. The decrements of all crystals vary markedly with the amplitude in the range of "small strains." The damping properties of copper crystals do not change with time at room temperature, and are not affected by vibrations of the amplitude employed. The zinc crystals exhibit the phenomenon of recovery at room temperature. Their internal friction is increased by all but the smallest oscillating stresses. The internal friction of zinc crystals depends in such a manner on the angle between the rod axis and the hexagonal axis as to indicate that the rate at which the energy of vibration is dissipated is determined primarily by the resolved shear stress on the slip plane. The resonant frequencies of the crystal rods change as the vibration amplitude is increased in a way that can be correlated with the decrement changes. The internal friction of zinc single crystals is approximately inversely proportional to the frequency. The behavior of these crystals can be explained in terms of the dislocation theory of slip. (Author's summary)

PP: 3 E 9 M 16 S T 19 AA 27 28 30 32 36 h j k 40 42 q CV: 14
MI: Cu Zn a

Rinehart, J. S.

Temperature Dependence of Young's Modulus and Internal Friction of Lucite and Karolith

Jour. Appl. Physics, Vol. 12, pp. 811-816, November 1941

The Young's modulus and specific energy loss of Lucite and Karolith were measured at different frequencies in the neighborhood of 50 kc/sec. as a function of temperature. The temperature range for Lucite was from -55°C to 65°C and for Karolith, 25°C to 110°C. It was found that the reciprocal of Young's modulus versus temperature curves showed positive curvatures at higher temperatures for both materials. At room temperature the Young's moduli of Lucite and Karolith were 4.72 and 6.14 x 10^{10} dynes/cm^2, respectively. The specific loss was found to vary with frequency for both materials and varied in a linear fashion for Lucite at room temperature. Absorbed water seemed to have a pronounced effect on the Young's modulus of Karolith. (Author's abstract)

PP: 3 E J 10 L 16 U X AA 27 30 b CV: 14 MI: FF GG'

Seitz, F., and Read, T. A.

The Theory of the Plastic Properties of Solids. IV.

Jour. Appl. Physics, Vol. 12, pp. 538-554, July 1941

The properties of polycrystals are influenced by two separate factors--first by the intrinsic properties of the single crystal constituents or grains, and second by the restrictions neighboring grains exert on one another. Many properties of polycrystals, such as shear strength and internal friction, are affected by the discontinuities in structure that occur in a way that cannot be explained simply by treating the system as a set of disoriented isolated single crystals. This additional factor is referred to as grain boundary influence and it is attempted to unify present knowledge of this factor in this paper. By grain boundary influence is meant not only the effect arising from the atoms in the transition region between two grains, but also the effect that neighboring grains exert on one another. Only in a few cases is it possible to draw conclusions from available experiments on single crystals. One section is devoted to the subject internal friction.

PP: AA 30 34 g j CV: 17

Snoek, J. L.

Internal Damping of Ferromagnetic Materials

Nederland. Tydschr. Natuurkunde, Vol. 8, pp. 177-179, 1941. See also Chem. Abs., Vol. 35, p. 7776, 1941; Inst. Metals, Met. Abs., Vol. 9, p. 68, 1942

Torsional oscillations of iron or nickel are strongly damped because of magnetic effects and ferromagnetic hysteresis. No external changes in magnetostriction are observed. The hysteresis damping is proportional to the amplitude of the oscillation. Large variations in induction can be obtained for large magnetostriction, annealing of the material, or application of an external magnetic field. Fe and alloys containing small amounts of C or N in solid solution show in addition an "after effect" damping without hysteresis depending on the temperature. Its characteristic frequency of maximum damping is found from $V = V_o e^{-Q/KT}$ with Q of the order of 20,000 cal/mol. It is attributed to a diffusion of the admixtures in the iron lattice. Cold-working of the metal causes a shift in the characteristics of this type of damping.

PP: 13 16 S U V AA 30 31 c 36 h k CV: 12' 14 MI: SG Fe Ni n p

Späth, W.

Plasticity Modulus -- Hardness -- Damping

Zeit. f. Metallkunde, Vol. 33, No. 6, pp. 221-224, 1941. Also Met. Abstracts, Jour. Institute of Metals, p. 258, September 1942

The author suggests that in any mechanical test which involves measuring a load and a deformation, the results should be expressed as a relation between the load and the deformation produced, e.g., the hardness should be expressed by load (kg./mm^2 divided by the depth of impression, and softness by the reciprocal of this number. If H is this new hardness number, d the damping, and E the elastic modulus, then it can be shown that H = E/d. The total resistance (P) to deformation is made up of the resultant of the elastic (e) and plastic (p) resistances, from which it follows that e+p/P = E(1+d), which is proportional to H. Various objections to these suggestions were raised in the discussions, and some modifications were proposed, e.g., that the hardness would be better expressed by H = t/D where t is the depth and D, the diameter of the impression. (Chemical Abstracts, 1942, p. 258)

PP: AA 36 k 42 s CV: 13 17

St. Clair, H. M.

Electromagnetic Sound Generator for Producing Intense High Frequency Sound

Review of Scientific Instruments, Vol. 12, pp. 250-256, 1941

A new type of high frequency sound generator is described in detail. It is necessary that the vibrator should be made of a metal having both low resistivity and low internal friction or vibration-damping capacity This matter is given considerable attention in the discussion.

PP: 1 2 3 6 9 AA CV: 14

Wache, X., and Chevenard, P.

Causes of the Dispersion of Results in the Study of the Phenomena of Fatigue. (In French)

Le Genie Civil, Vol. CXX, No. 18, p. 210, 1941

A report is made on experiments investigating the effect of thermal treatment and residual stresses due to machining on the variation of log decrement with maximum shearing stress. Specimens were tested in alternating torsion in a Chevenard micro testing machine. Variation in decrement as a function of the number of cycles for specimens subjected to different thermal and machining treatments is shown. Material was a nickel-chrome-molybdenum steel.

PP: 3 5 9 13 16 S T AA 28 29 36 h k 42 r CV: 13'14 MI: AY f

Williams, H. J., Bozorth, R. M., and Christensen, H.

The Magnetostriction, Young's Modulus and Damping of 68 Permalloy as Dependent on Magnetization and Heat Treatment

Physical Review, Vol. 59, pp. 1005-1012, June 15, 1941

This paper describes measurements of the changes in certain physical properties of 68 Permalloy that result from different thermal and mechanical treatments and considers them in relation to the domain theory. The magnetostriction varied with heat treatment from 2.5 x 10^{-6}. The

change in Young's modulus with magnetization to saturation varied from 0.09 to 10.5%. The damping of mechanical vibrations was also measured as dependent on magnetization and heat treatment. Young's modulus and the damping constant were determined by measuring the natural frequency of vibration and the width of the resonance curve of a hollow rectangle magnetized parallel to its sides so that the magnetic circuit was complete without air gaps or end effects. (Authors' abstract)

PP: 3 E 16 V X AA 30 c 36 h k CV: 14 MI: SG Ni 35 h n p

Zener, C.

Theory of Internal Friction Introduced by Cold Working

Physical Review, Vol. 60, pp. 455-457, September 15, 1941

Experiments indicate that those changes in a cold worked metal which give rise to internal friction are distinct from those changes which give rise to hardening and to the broadening of X-ray lines. It is suggested that this internal friction is due to the inability of certain areas on slip planes to maintain shearing stresses. The theoretical consequences of this suggestion are carried out, and are found to be in agreement with present experimental data. (Author's abstract)

PP: 8 AA 27 30 b 36 k CV: 17

1942

Gehman, S. D.

Rubber in Vibration

Jour. Appl. Physics, Vol. 13, pp. 402-413, June 1942

A machine is described which has been used for determining the vibration properties of various types of rubber mountings used for the isolation of mechanical vibrations. The vibrations are excited by oppositely rotating eccentric weights and are recorded on a tape. It was found that resonance curves for various types of rubber vibrations such as shear, torsion, and compression are, except for some minor deviations, adequately accounted for by the equation which contains a damping term proportional to the velocity and inversely proportional to the frequency. The apparent static modulus of rubber in compression depends upon the shape of the piece, more explicitly on the ratio of load area to the free area. The same is true for the dynamic modulus. It was found that pieces of similar shape have identical values for the dynamic modulus and also for the internal friction. Some curves are given showing the dependence of dynamic modulus and internal friction on the shape factor. The dynamic stiffness shows the largest deviation from the static values at high shape factors. The internal friction has a linear relationship to the dynamic modulus when the shape factor is varied. This results in damping which is practically independent of the shape. The effect of temperature on the vibration properties of mounting stocks for a range -10°F to 160°F was studied and curves are included showing the temperature dependence in this range. (Author's abstract)

PP: 1 3 E 10 L M 13 R S U 20 X AA 27 28 42 q CV: 14 MI: GG

Hatfield, W. H., Stanfield, G., and Rotherham, L.

The Damping Capacity of Engineering Materials

Trans., Northeast Coast Engineers and Shipbuilders, Vol. 58, pp. 273-332, 1942. The Same, secondary reference. Engineer, Vol. 173, pp. 477-480, 1942. The Same, Abstracts. Metallurgia, Vol. 26, pp. 57-58, 1942. Bulletin, British Non-Ferrous Metals Research Association, No. 157, pp. 220, 292, 1942.

This presents discussion and examples of damping capacity, forms of expression of damping properties, influence of speed, influence of temperature, methods of determination of characteristics of materials. The truly austenitic alloys show relatively low values of damping, while the stainless materials of the 14% Cr type give particularly high values. Low-carbon steel shows an intermediate value. Nickel has exceptionally high damping at room temperatures.

PP: C D E F J 11 13 R U AA 28 CV: 14 15
MI: CN AY SS CI SG FF GG' KK Al C Co Cr' Cu Mg Ni b h j m n r

Kutsay, A. U.

On the Torsional Damping Capacity of Three Magnesium Alloys

Thesis for Master of Science Degree, University of Michigan, p. 44, April 1942

Test results of experiments on the damping capacities of three magnesium alloys, J, M. and O, are given. Solid cylindrical specimens of each were subjected to torsional oscillations of fixed frequency, induced by a synchronous mechanical oscillator, producing a sinusoidal torque. The natural frequency of the system was changed by altering the moment of inertia of the oscillator assembly, thus making it possible to operate at any point of the resonance curve. Three resonance curves were obtained at different values of applied torque for each alloy. The above data were used to calculate the maximum shear stress, the dynamic modulus of rigidity, the energy dissipated per cycle per cubic inch, the relative damping, and the logarithmic decrement. Curves are shown for these values as a function of maximum shear stress. The alloys tested indicated that, for magnesium, the energy dissipated per cycle per cubic inch is proportional to the 2.8th power of the maximum shear stress. Of practical significance is a figure showing the variation of maximum shear stress at resonance with applied torque. This curve is an experimental demonstration of Föppl's statement, "damping is, so to speak, a guarantee against the occurrence of unusually high stresses due to vibration." (Author's synopsis)

PP: 3 E G 8 J 10 11 13 15 16 S X AA 28 CV: 14 18 MI: Mg b

Lazan, B. J.

Behavior of Plastics Under Vibrations

Modern Plastics, pp. 83-142, November 1942

A new oscillatory-type testing machine was developed for determining the mechanical properties of material under alternating torsional stress. The damping capacity and dynamic modulus of rigidity of both plastics and metals were evaluated. A similar dynamic testing machine was built for applying alternating direct stress, and parallel studies were made under axial-loading conditions. The mechanical properties of selected materials in static tension, compression and torsion were also determined. Experimental data on the damping capacities, dynamic moduli of elasticity, and some static mechanical properties are presented for mild steel, duralumin, and laminated paper phenolic (grade X), laminated canvas phenolic, phenolic, and ploymethyl methacrylate plastics. The resonance-amplification factor for the plastics tested was about 1/10 that of the metals.

PP: 3 E 8 M 13 X AA CV: 14 MI: CN FF GG' HH' JJ' Al h j 40

Lichtenberg, H.

Damping Curves from Accurate Tensile Measurements on Duralumin Test Bars. Damping as a Criterion of Corrosion. (In German)

Korrosion und Metallschutz, Vol. 18, pp. 325-329, 1942

Damping curves of test bars of heat treated and corroded alloys of the type Al-Cu-Mg under stress have been plotted by a simple method using measurement of their elastic and plastic deformations. The damping curves of surface-treated test specimens may be considered as a perfect criterion of the progress of corrosive attack of corrosive agents on the metal surface.

PP: 3 5 M AA 30 b 36 39 42 q CV: 13 14 MI: Al Cu' Mg' h 40

Malkin, I.

On a Generalization of Kirchhoff's Theory of Transverse Plate Vibrations in the Vibration Problem of Steam Turbine Disks

Journal of Franklin Institute, Vol. 234, pp. 355-369, 1942

The author's outline of the paper is as follows: a. The vibration problem in its actual aspects in steam turbine design. b. The fundamental conception of the solution used in steam turbine practice as derived from the Rayleigh Ritz method substituted for the original Kirchhoff theory. c. Illustration of the actual problem by an example taken from the one dimensional theory of vibrations. d. The "wheel vibrations" of the disk. e. The blade vibrations with the disk proper entirely at rest. f. Asymptotical representation of the actual (Disk Blade) vibrations of the disk. g. Simplifications used in the procedure of frequency computation. h. The disk with heavy rim.

PP: I Y CV: 17

Stambaugh, R. B.

Vibration Properties of Rubber-Like Materials. Dependence on Temperature.

Ind. Eng. Chem., Vol. 34, No. 11, pp. 1358-1365, November 1942

An electrical vibrator for determining dynamic properties of rubber-like materials is described. Dynamic modulus, internal friction, and dynamic resilience are measured, from 30 to 100 cyc. per sec. and -30° to +120°C for rubber, butadiene-acrylonitrile and butadiene-styrene copolymers, Thiokol, neoprene, and gum rubber. Dynamic modulus and resilience for these materials are independent of frequency, internal friction is approximately inversely proportional to frequency. Modulus decreases as temperature increases. Some synthetic stocks which are hard and nonresilient at room temperature behave at high temperatures much like rubber at room temperature.

The dependence of internal friction on temperature follows the same exponential law as the viscosity of liquids. At certain critical temperatures sudden changes apparently occur in the inter-molecular forces which cause a transition from one curve to another. Resilience rises linearly with temperature and shows the same transition points. There is a wide variation in the properties of stocks made from different polymers. The effect of amplitude of vibration on modulus and friction is discussed. Modulus and internal friction are affected by temperature in the same way. Thus both properties are dependent on some fundamental characteristic of molecular structure. (Author's abstract)

PP: 3 E F 10 L M R S U X AA 27 28 30 31 CV: 14 18 MI: GG

Tarnopol, L. and Morgan, J. R.

Effect of Machining and Aging on the Damping Capacity of Steel

Jour. Appl. Physics, Vol. 13, pp. 343-344, 1942

Machining causes an increase in the damping capacity which is decreased by aging or low-temperature annealing, as revealed by experiments on SAE 1020 and 2320 steels.

PP: 3 D J AA 27 28 30 b c 36 h k CV: 14 MI: CN AY j 41 q

Thum, A. and Petersen, C.

The Processes in Metal Structure Subjected to Tensile and Alternating Loading - Part II. Consideration of Damping Capacity

Zeit. f. Metallkunde, Vol. 24, No. 2, pp. 39-46, February 1942. Also Bulletin of British Non-Ferrous Metals Research Association, p. 358, November 1942

A survey: damping at very small alternating amplitudes; damping at large alternating amplitudes; change in the damping at larger alternating amplitudes as a result of tensile and alternating deformation; damping and fatigue strength.

PP: 3 D 9 M 16 S T AA 27 28 30 b 36 k 42 r CV: 13 14 15 18

Zener, C., Clarke, H., and Smith, C. S.

Effect of Cold-Work and Annealing Upon Internal Friction of Alpha Brass

Trans., Am. Inst. Min. Met. Engrs., Vol. 147, pp. 90-95, 1942

It has previously been shown that the internal friction introduced by cold-work is removed by annealing at comparatively low temperatures. In this paper the following additional factors are investigated: (1) frequency of measurement, (2) amount of cold-work, (3) temperature of measurement. Special care was taken to minimize the internal friction due to causes other than cold-work. It was found that the internal friction introduced by cold-working is independent of the frequency of measurement. When the cold-work is introduced by stretching, the increase of internal friction is initially proportional to the elongation. An optimum percentage of elongation exists, beyond which the internal friction decreases. Annealing below the recrystallization temperature removes the internal friction introduced by cold-work. The internal friction introduced by cold-work decreases with increasing temperature of measurement. (Authors' abstract)

PP 3 D 8 12 R U AA 27 36 h k CV: 14 MI: Cu Zn' n

Zener, C., Winkle, D. van, and Nielsen, H.

High-Temperature Internal Friction of Alpha Brass

Trans., Am. Inst. Min. and Met. Eng., Vol. 147, pp. 98-102, 1942

An investigation of the internal friction of 70-30 alpha brass at high temperatures has yielded the following results: 1. At high temperature this internal friction is larger, the smaller the grain size. The literature contains instances in which recrystallization and grain growth were manifested in the internal friction measured during the annealing treatment. 2. This internal friction depends upon temperature as if it were associated with a distribution of heats of activation, the maximum being about 20,000 cal/mol. Comparison of this heat of activation with that for diffusion shows that this internal friction is in no way connected with atomic diffusion. 3. The observed dependence upon grain size indicates that this internal friction is due to internal surfaces. The present experiments cannot distinguish between the effects of a slip at the grain boundaries and of a movement of the twin faces. 4. This high-temperature internal friction, whatever its source, constitutes a large part of the total I. F. at room temperature in specimens having very small grain size. (Authors' summary)

PP 3 E 16 U AA 27 30 34 36 h 38 CV: 14 MI: Cu Zn' n

Geiger, J.

Investigation of Various Types of Malleable Iron. (In German)

Stahl u. Eisen, Vol. 63, No. 21, pp. 429-430, 1943
Abs. Giesserei, Vol. 30, pp. 85-92, 1943

This describes investigations of different varieties of malleable iron castings to determine their torsional strength under repeated tests on notched and unnotched specimens, and their damping properties; the results show remarkably good damping properties and torsional strength of black heart malleable as compared with gray cast iron. (Eng'g Index, 631, 1943)

PP: 3 AA CV: 13 14 MI: CI n s

Gemant, A.

Frictional Phenomena. Chapter XIII. Internal Friction in Solids

Jour. Appl. Physics, Vol. 14, pp. 204-216, 1943

This chapter deals with the following topics: (1) The quantitative definition of losses, usually characterized as internal friction losses, that occur in vibrating solids. (2) Experimental methods for the determination of the losses and some of the results obtained on different materials; also a few empirical rules obtainable from the experimental results. (3) The chief mechanisms that lead to internal friction, namely, thermal processes and plastic processes; also the physical basis for the experimentally observed behavior of losses when measured as a function of the frequency of vibrations. (Author's abstract)

PP: C D E 9 11 M N R S U AA 27 28 30 b 34 36 38 m CV: 15 16
MI: ST CN AY CI SG FF GG HH KK LL Al Cu Fe Ni Sn' d

Gemant, A.

Frictional Phenomena. Chapter XIV. Technical Applications of the Internal Friction of Solids

Jour. Appl. Physics, Vol. 14, pp. 258-270, 1943

In this chapter technical applications of the solid friction concept in four different fields are discussed. These are: (1) mechanical engineering, (a) damping of unwanted vibrations in machinery-- for instance, crank-shaft vibrations, (b) vibrations excited by internal friction-- for instance, whirl of rotating shafts; (2) metallurgy in which damping measurement promises to be a useful tool; (3) rubber technology, as applied to automobile tires with regard to the heat generated therein; and (4) electrical engineering, specifically dielectric losses in electrical insulating materials. (Author's abstract)

PP: A B W AA CV: 14' 15

Henry, O. H., Feitl, R. R., and Falcon, J. A.

The Determination of the Effect of Various Types of Weld Metals on the Internal Damping Characteristics of Steel Specimens

Welding Journal, Vol. 22, pp. 266s-269s, 1943

Damping stress curves made on specimens of hot-rolled mild C steel (60,000 lb/sq in tensile strength) with 60° V-groove welds of Ni, monel, bronze and an "alloy steel" show little difference from the damping stress curves obtained on the base metal. It was concluded that, although welds made with the scarf angle and the weld metals used here have little effect on the damping characteristics of steel specimens, both the weld materials and the type of joint have an effect on the damping characteristics.

PP: 3 D J 11 13 16 S 23 AA 27 28 CV: 14 MI: CN AY Cu Ni Sn' d j

Köster, W.

On the Damping of Nickel and Iron-Nickel Alloys. (In German)

Zeit. f. Metallkunde, Vol. 35, pp. 246-249, 1943

The paper deals with the temperature dependence of the damping of nickel on different heat treatments; the proportionality between damping and the ΔE effect; theoretical calculations; the damping of Fe-Ni alloys; its amplitude dependence; the effect of deformation; recrystallization and transition; and the dependence of damping on the magnetic field. (From author's outline)

PP: 3 16 S U V AA DD 30 c 36 h k n 42 s CV: 13 14 17 MI: Fe Ni a

Kutsay, A. U., and Yorgiadis, A. J.

On the Torsional Damping Capacity of Solid Magnesium-Alloy Rods as Affected by Cold-Working

Jour. Aero. Sciences, Vol. 10, No. 8, pp. 303-310, 1943

the necessity of associating the damping capacity of magnesium in torsion, with both the shearing stress amplitude and the cold-work history of the material, is discussed. Consideration is given to the relative merits of the "freely decaying vibrations" method, and the "sustained resonant vibrations" method for the dynamic testing of magnesium. Test results on the torsional damping capacities and dynamic moduli of rigidity are given for two extruded magnesium alloys, O and J, tested under sustained resonant vibrations. The vibrations were induced to solid cylindric magnesium specimens by a mechanical oscillator driven by a synchronous motor. The effect of various degrees of cold-work on the dynamic properties was investigated and found to be of the utmost significance in that cold-working decreased the damping capacity considerably, thus showing the danger in neglecting the effect of cold-work on the induced stress in a member vibrating at resonance. (Authors' summary)

PP: 3 E G J 11 13 16 S T X AA 27 28 36 k CV: 14 15' MI: Mg b

Lazan, B. J.

Some Mechanical Properties of Plastics and Metal Under Sustained Vibrations (Including Damping Capacity of Duralumin)

Trans., Am. Soc. Mech. Eng., Vol. 65, pp. 87-104, 1943

A new oscillatory-type testing machine was developed for determining the mechanical properties of materials under alternating torsional stress. The damping capacity and dynamic modulus of rigidity of both plastics and metals were evaluated by the use of this machine and studies are reported of how these properties are affected by sustained cyclic stress below the endurance limit and also at impending fatigue failure. A similar dynamic testing machine was built for applying alternating direct stress, and parallel studies were made under axial loading conditions. The mechanical properties of selected materials in static tension, compression, and torsion were also determined to supplement the dynamic tests. The wide deviations observed between the static and dynamic moduli of elasticity for plastics are analyzed and are associated with the damping capacity of the material. The significance of these deviations, as related to the repeated constant-deflection type of fatigue test on plastics, is discussed. Experimental data on the damping capacities, dynamic moduli of elasticity, and some static mechanical properties are presented for mild steel, Duralumin, grade X laminated bakelite, laminated-canvas phenolic, and methyl-methacrylate plastic. An appendix deals with equations associated with the dynamic testing machine employed, namely: equations of natural frequency of vibration, and equations of stress, dynamic moduli of elasticity, vibration-amplification factor, and damping capacities. (Author's abstract)

PP: 3 E 8 11 M 13 16 S T W X AA 27 42 q CV: 14 17 18
MI: CN FF Al h j 40

Seitz, F.

Internal Friction

The Physics of Metals, McGraw-Hill Book Co., Inc. N.Y., Chapter X, pp. 152-163; see also 301-302, 1943

Internal friction of both single crystals and polycrystals is discussed with special emphasis on the two important sources of internal friction in solids that are not ferromagnetic, namely, plastic flow and intergranular thermal currents. The factors affecting these modes of energy dissipation are discussed. In ferromagnetic metals, such as iron, cobalt, and nickel, an additional type of internal damping is exhibited which originates in their ferromagnetism; this is briefly discussed.

PP: J 16 S T AA DD a b c 36 h j k CV: 15 16 17 MI: SG Cu Zn n p

Stanton, L. R., and Thompson, F. C.

A Note on the "Damping" Characteristics of Some Magnesium and Aluminum Alloys

Jour. Institute of Metals, Vol. 69, Part 1, pp. 29-43, 1943

The damping capacities of 3 magnesium alloys and 2 aluminum alloys were determined over the range of -50° to 280°C. The magnesium alloys have a higher damping capacity than the aluminum alloys and, for equal fiber stresses, have much greater values than steel. Both the magnesium and aluminum alloys show a minimum value just below room temperature. Except for the magnesium alloy Elektron AZ855, properties of which are normal in this respect, the damping capacity of the alloys decreases as fiber stress is reduced. A Föppl torsional decay machine was used in the damping measurements.

PP: 3 D J 13 16 S U AA 28 CV: 14 MI: Al Mg b h 40

Swinden, T.

Leaded Manganese-Molybdenum Steel

Iron and Steel Institute, Jour., Vol. 148, No. 2, pp. 450-451, 1943

This describes measurements of the damping capacity on a Cambridge torsional damping machine on specimens machined from bars heat treated to approximately 53 and 65 tons per square inch to insure that the stress applied in the damping tests did not exceed the limit of proportionality in torsion; determinations were also made of the limit of proportionality in torsion. Results are given.

PP: 3 D J 13 16 S AA 28 29 36 h CV: 14 MI: AY Mg' Mo' Pb'

Thum, A., and Petersen, C.

Changes Taking Place in the Crystal Structure of Metals Under Tensile and Alternating Stresses. (In German)

Metallwirtschaft, Vol. 22, pp. 547-51, 1943

An attempt is presented at untangling factors producing damage in fatigue by correlation with damping behavior at different loads and in different stages of fatigue. General speculation is given rather than experimental evidence.

PP: 3 D 9 16 S T AA 30 b 33 36 k 42 r CV: 13 15 17

Zener, C.

Internal Friction of an Alpha-Brass Crystal

Trans. Am. Inst. Mech. Eng., PR 142, pp. 122-126, 1943

The internal friction of nonferrous metals vibrating at low stress amplitudes has so far always been successfully interpreted in terms of inhomogeneities of one sort or another. The present investigation was undertaken to determine whether the internal friction of single crystals may likewise be attributed to inhomogeneities. The investigation of the internal friction of an alpha-brass crystal at high temperatures has yielded the following results: 1. As the crystal slowly cools from a high temperature, its internal friction rises rapidly from 550°C to about 420°C then falls equally rapidly upon further cooling. 2. The observed internal friction follows a simple relaxation formula containing only a single parameter. This dimensionless parameter is a function of both the frequency and the temperature of measurement and contains as an unknown constant only a heat of activiation. 3. The observations may be interpreted as evidence of inhomogeneities of some unknown type, which give rise to a stress relaxation. 4. The heat of activation for the relaxation of stress is about 33,000 cal. per gram mol. (Author's summary)

PP: 3 D 8 11 M 16 U AA 27 30 31 36 j CV: 14 15' MI: Cu Zn'

Burpo, Jr., R. S.

The Damping Capacity of Engineering Materials

Engineering File Facts, No. 50, Metals and Alloys, pp.1435-1437, June 1944

The practical items of importance to design engineers are abstracted as an "Engineering File Facts Page." The British units and terminology have been converted to those more commonly used in this country and the tabulations of research data have been reduced to include only the more practical items of direct value to designers and builders of machinery and machine tools. It gives damping capacities as a function of stress for lead solder, plate glass, various Bakelites, carbon steels, nickel steels, Ni-Cr steels, Ni-Cr-Mo steels, stainless irons, stainless steels, cast irons, sintered carbides, magnesium alloys, aluminum alloys, copper-tin alloys, and copper-zinc alloys.

PP: 3 D J 16 S 19 AA 27 28 36 k CV: 14 15
MI: CN AY SS CI FP GG' KK Al C Cu Mg Pb Sn Zn b c d f g n q r

Frommer, L., and Murray, A.

Damping Capacity at Low Stresses in Light Alloys and Carbon Steel, With Some Examples of Non-Destructive Testing

Jour. Institute of Metals, Vol. 70, pp 1-50, 1944. Also, Iron and Steel, pp 367-370, May, 1944; pp.494-497, June 1944.

This work was undertaken to establish: (1) a reliable and accurate method for measuring the damping capacity of materials, particularly metals; (2) the significance of the damping capacity as a physical property of the material in terms of other known characteristics; (3) the influence exerted by structural defects, such as cracks and porosity, upon the measured damping, and thus to afford means for non-destructive testing; and (4) the practicability of employing damping measurements as a means of quality control and inspection of raw material and finished components. By careful design, and as the result of experiment, it has been found possible to separate excessive external damping losses from the intrinsic damping which it was desired to measure. It has been established that at room temperature the damping capacity of the principal aluminum alloys is of the order of 10^{-5} as expressed by the logarithmic decrement. The measured damping is a constant up to a maximum shear stress of 30 lb/sq in. The damping of aluminum alloys appears to depend upon the degree of precipitation present, being highest for maximum solid solution and lowest in the annealed state. The damping is markedly increased by small cracks or such porosity as would not normally occasion the rejection of a cast ingot. In some instances localized defects modify the damping at the various harmonics, so that the position of the defect can be estimated. This latter feature depends upon the experimentally determined fact that the torsional damping does not vary over the available frequency range.

The damping of a 0.6% carbon steel has been studied up to a maximum stress of 90 lb/sq in. and has been found to be 0.5×10^{-4} for the tempered condition and 0.7×10^{-4} for the oil-quenched condition, these values being closely reproduced through successive cycles of heat treatment. Whilst the damping values found by this technique are comparable with those obtained by other workers employing a somewhat similar technique, they are many times smaller than those found at stresses a few times higher by the Föppl-Pertz technique. (Authors' abstract)

PP: 1 2 3 D F 9 11 13 AA 27 36 h 39 m CV: 14 MI: CN Al b q

Gemant, A.

The Problem of Reduction of Vibrations by Use of Materials of High Damping Capacity

Jour. Appl. Physics, Vol. 15, pp.33-42, 1944

This deals with considerations concerning the reduction in amplitude of unwanted vibrations of machinery parts through the use of materials of high damping capacity. Two ways are suggested for reconciling the requirement for high damping with that for high mechanical quality (strength, fatigue resistance, etc.): (1) the use of a material whose decrement generally is low but rises rapidly as the stress increases; (2) the use of a material whose damping capacity is low but rises to high peaks in certain frequency ranges. It is shown by numerical computation in two instances, namely turbine blade vibrations and crankshaft oscillations in engines, how the suggested methods would work out in practice.

PP: A 9 16 S 19 W Y AA 30 CV: 17 MI: AY

Hatfield, W. H., Rotherham, L., and Harvey, E. M.

Damping Capacity of Metals

Iron and Steel, Vol. 17, pp.613-618, 1944

Damping capacity has aroused considerable interest among workers in search of a new non-destructive method of testing. In this paper, the authors describe work done on several matters which were raised in the discussion on their earlier paper. The various sections deal with the effect of air resistance, length of service, temperature changes, reproducibility of tests, variation in alloy content, and mechanical treatment. Values are given for a variety of metallic alloys.

PP: 2 3 D J 11 13 16 S T U AA 27 28 36 37 k CV: 14
MI: ST CN AY SS CI FG' Cr Fe Ni W' 30 31 d 34 j q r

Hatfield, W. H., and Rotherham, L., and Harvey, E. M.

Further Experiments on the Damping Capacity of Metals

Trans., North East Coast Institute of Engineers and Shipbuilders, Vol. 60, pp 227-268, 1944. The same, abstract. Metallurgia, Vol. 29, pp.295-298, 1944

After considering forms of expression of damping properties the apparatus used in the present work is described. Experiments are discussed in detail dealing with the effects on damping capacity of air resistance, long period of service, small temperature changes, variation of carbon content, variation of chromium content, variation in nickel content, miscellaneous tests investigated the reprocibility of test results, the influence of defects and of added sulphur, the effect of cold work, and the effect of surface finish. Most of the work was done on a variety of steels but tests were also performed on a high strength cast iron and also on two grades of Stellite.

PP: 3 D J 11 13 16 S T U AA 27 28 36 37 k m CV: 14
MI: ST CN AY SS CI FG' Co Cr Fe Ni W 30 31 c d 34 j m p q r

Karius, A., Gerold, E., and Schulz, E. H.

Changes in Materials During Endurance Testing.(In German)

Archiv. f. d. Eisenh., Vol. 18, pp.113-124, 1944

This deals with the measurement of damping and of modulus of elasticity of materials by use of F. Forster's vibration apparatus. The influence of vibration stress on the damping and modulus of elasticity with notched and unnotched specimens was determined. Supplementary investigations for the explanation of processes of the material at fatigue stress were carried out. The subjects studied were the time change of damping and modulus of elasticity in a previously statically stretched and a previously vibration stressed specimen; the change of damping and of modulus of elasticity on the stretched or dynamically prestressed steel St37 upon bending alternating stress; structure study; and the relation between damping and surface cracks. (From authors' outline)

PP: 3 F 12 16 S 20 X AA 27 29 36 k m 42 44 CV: 13 14 MI: ST CN

Lazan, B. J., and Yorgiadis, A.

The Behavior of Plastics under Repeated Stress

Symposium on Plastics, Am. Soc. Test. Mats., Philadelphia, Pa. pp.67-84, 1944

A brief discussion is given of the inelastic behavior of materials and the basic dynamic properties of materials. Damping capacity is discussed in terms of the expressions used for measuring it, and its engineering significance in regard to the limitation of stresses due to near-resonance vibrations, reduction of noise, possible indication of low notch-sensitivity. The harmful effects of high damping capacity are explained in the production of internal heat which raises the temperature of a part, the production of lag and distortions in measuring and indicating instruments, and an increase in shaft whirling. The six major methods of measuring damping capacity are summarized. A figure is presented giving the damping capacity of several plastic materials plotted as a function of stress. The limited data available indicate that the torsional damping capacity is considerably higher than that under the same direct stress. The unfilled bakelite resin has the smallest damping capacity of the group with a resonance amplification factor exceeding 100 at low stresses. However, most of the structural laminated plastics have an R. A. factor of from 7 to 18 at stresses near the fatigue limit which is roughly one tenth of that of most steels and aluminum alloys.

The remainder of the paper discusses dynamic modulus of elasticity and fatigue properties, discussing the engineering significance and presenting methods of measurement and factors affecting these properties. Data on these are presented for a variety of plastics and a few metals.

PP: A 3 D F 8 11 M N 16 S W X AA 27 28 42 r CV: 14 15 MI: FT

Päsler, M.

On a Theory of Thermal Damping in Solid Bodies.(In German)

Z. Phys., Vol. 122, pp.357-386, 1944

In this article a theory of internal damping is developed. The damping is calculated using this theory for bodies of different forms, such as spheres, cylinders, and plates.

PP: Y AA 30 CV: 13 17

Pochapsky, T. E., and Mase, W. J.

Damping Capacity of Heat-Resisting Metals for Gas Turbine Parts

O. S. R. D. Report No. 3549, April 15, 1944

Damping capacities up to 1500° F were determined for 18 heat-resistiug alloys, including among them some of the strongest alloys recently developed for gas turbine service. The damping decrements were measured using the tuning-fork vibration decay method. The damping capacities were found to be very low for most of the alloys, and were lowest for the strongest materials. The minimum values were indicated to occur at about 900° F, rising with increasing temperature above 900° F, but the damping capacities rarely exceed 0.01 at 1500° F.

PP: 3 D 9 12 16 U AA CV: 14 MI: AY SG Al h

Sachs, G., and Van Horn, K. R.

Practical Metallurgy. (Book)

Am. Soc. Metals, Cleveland, Ohio, p. 257, 1944

In Chapter IX on the mechanical properties of casting the authors claim that damping capacity is distantly related to fatigue. Cast alloys and especially cast irons are considered superior to wrought materials in damping capacity. The advantage of using high damping material for absorbing vibration by shock and the resulting resonant vibration is discussed briefly.

PP: A AA 42 r CV: 16 MI: Cl

Schabtach, C., and Fehr, R. O.

Measurement of the Damping of Engineering Materials During Flexural Vibrations at Elevated Temperatures

Jour. Appl. Mechanics, Vol. 11, No. 2, pp.A85-A92, 1944

The method and equipment developed and used by the authors for measuring the damping of materials are described. A tuning-fork specimen is set into vibration by jerking a spreader from the gap between the ends of the tines. The damping is expressed in terms of the logarithmic decrement of the decaying vibration, which is measured and recorded by means of a magnetic oscillograph, amplifiers, and a resistance-type electric strain gage cemented to the specimen. The results include (1) the damping of a number of materials during flexural vibration at approximately 1000 cycles per sec, at maximum bending stresses up to 40,000 psi, and at temperatures up to 1400 F; (2) the variation in modulus of elasticity with temperature, as determined from the specimen vibration frequencies (Authors' abstract)

PP: 3 D 9 12 16 S U X AA 28 29 CV: 14 MI: ST CN AY Co Cr Fe

Scheil, E., and Reinacher, G.

The Elastic Modulus and Damping Capacity of Irreversible Iron-Nickel Alloys. (In German)

Zeit. f. Metallkunde, Vol. 36, pp.63-69, 1944

An investigation of the γ - α transformation in some irreversible iron-nickel alloys containing 10-29% of nickel was carried out by making simultaneous measurements of the elastic modulus, which is dependent on the microstructure, and of the damping capacity, which is not dependent on the microstructure.

PP: X AA 30 31 36 n CV: 13 14 MI: Fe Ni'

Siegel, S.

A Review of Supersonic Methods for Measuring Elastic and Dissipative Properties of Solids

Jour. Acoustical Soc. of America, Vol. 16, pp.26-30, 1944

Several of the commonly used dynamical methods for measuring the elasticity and damping of solids from resonance frequency and width of the resonance curve, are reviewed. Examples of their application are: (1) investigation of the variation of the elastic and damping properties of single and polycrystalline samples of nickel with intensity of magnetization and temperature, (2) variation with temperature of the principal elastic moduli of Cu_3Au, (3) study of the variation of internal friction of polycrystalline brass with grain-size and frequency, and (4) the elastic moduli of NaCl near its melting point (904° C). (Metal Abstract 227, 1945)

PP: 3 E R U V X AA g j CV: 15 MI: LL EG Cu Ni Zn' a 32 e 36 k 40

Thompson, F. C.

Damping Capacity: A General Survey of Existing Information

British Non-Ferrous Metals Research Association Report R r. A. 657, 37p., August 1944

An intelligent correlation of present knowledge from both the engineering and the theoretical points of view is presented. Damping behavior is more sensitive to minor changes in metallurgical history of a specimen than any other measurable property. It cannot be predicted by any other test and conversely it cannot be used to predict anything else, such as fatigue behavior. Qualitatively a high damping capacity is useful to the engineer as a means of helping to avoid build-up of resonant stresses. Quantitative measurements are intriguing, but the author doesn't indicate that they have much practical application. Avenues through which more useful data might perhaps be found are pointed out.

PP: A 3 D F F G 8 J 11 M N 16 S T U W AA 27 28 29 30 b 36 h 38 k m CV: 15 18

Yorgiadis, A. J., and Robertson, J. M.

Plywood Characteristics Disclosed by Vibration Tests

Aero Digest, Vol. 45, No. 1, pp.76-77, 80-81, 196, 198, 201-202, 204, April 1, 1944

The importance of dynamic property tests of fatigue strength, dynamic modulus, and damping capacity for the intelligent use of plywood in aircraft structures is discussed. A testing method is described in detail and the equations for determining damping and modulus values from resulting data is presented for the conditions of direct tension-compression stresses. Damping capacity and dynamic modulus properties are reported for a variety of plywoods and comparison is made with several other materials. The damping capacities of plywoods are such that plywood structures are more resistant to vibration. It is shown that as the dynamic moduli of elasticity of plywoods and wood differ greatly from their static moduli, computations of resonant frequencies must be based on the dynamic moduli. The damping capacity of plywood is greater than that of structural metals but less than that of plastics. A correlation was found between the damping capacity and dynamic moduli of plastics, plywoods and wood, such that the larger the modulus of a material, the lower is its damping. For the plywoods, the dynamic moduli increase with specific weight. The damping capacity of plywoods does not vary greatly (not by more than a factor or two) in the range of ply thicknesses and molding pressures covered. Nor does the damping vary greatly between the woods tested, or with a doubling of the resin film. (Authors' abstract)

PP: 3 E 10 L M 16 S W X AA 27 28 42 43 CV: 14 MI: AY FF GG' HH Al' Mg 36 s

1945

Alfrey, T. and Dory, P.

The Methods of Specifying the Properties of Viscoelastic Materials

Jour. Appl. Physics, Vol. 16, pp.700-713, 1945

Seven methods (Voigt model, Maxwell model, operator equation, mechanical impedance function, creep curve, relaxation curve, and dynamic modulus function) of specifying viscoelastic behavior are discussed. A number of exact relations between these methods of specification are worked out in detail. The majority of these relations are simple enough to be of practical value although a few are too cumbersome. Approximate relationships between the creep curve, the relaxation curve, Maxwell model, and Voigt model are discussed and numerical examples show the magnitude of errors introduced by the approximation to be small even in quite unfavorable cases. A consideration of the practical utility and physical meaning of the various methods of specification distinguishes between (1) those of general descriptive value and those of direct experimental value, (2) those useful in a phenomenological study of mechanical behavior and those more suited in a formulation of molecular theory. A summary of the present molecular theories is presented together with their interpretation in terms of the Voigt and Maxwell specifications. (Authors' abstract)

PP: Y AA 30 d 34 CV: 15 17

Erickson, J. L.

Fatigue in Light Metals

Light Metal Age, Vol. 3, pp.17-20, 31, 44, October 1945

This paper considers the phenomena of fatigue failure of metals, with special reference to aluminum and magnesium alloys. It discusses such aspects as the range of stress, method of performing fatigue tests, the effect of surface conditions temperature, recrystallization, and elastic hysteresis.

PP: AA 42 r CV: 14 MI: Al Mg b

Found, G. H.

Internal Friction of Single Crystals of Brass, Copper, and Aluminum

Trans., Am, Inst. Min. Met. Engrs., Vol. 161, pp.120-139, 1945

The internal friction of single crystals of brass, copper, and aluminum, and of brass specimens consisting of two and three large grains in each specimen was measured at low vibratory stress amplitudes after various stressing and annealing treatments. A dependence of the internal friction upon crystallographic orientation was found in the single srystals of brass. The increase in the internal friction associated with cold-working in single crystals of brass was found to be of a transient nature that declines with time at room temperature to the value of original unstrained specimens. In polycrystalline brass definite stable values can be associated with the amount of plastic straining in the structure. The stressing of brass and aluminum crystals in tension below their respective yield points effected no increase in their internal-friction values. In fact, the values in many cases decreased as a result of this stressing to others that were lower than those obtained by annealing treatments. This effect is magnified in bicrystalline and tricrystalline specimens of brass. The stressing of brass single crystals in compression results in the same effects on the damping as does tensile loading. There is an increase in the internal friction of copper crystals, which accompanies stressing at loads considerably below the yield point. This value declines with time. Loading above the yield point results in unmeasurably high values. The results can be interpreted in terms of a localized relaxation mechanism based on localized residual stresses associated with inhomogeneities, rather than on areas of inherently low shearing strength, as hypothesized by previous investigators. The existence of these localized residual stresses permits an explanation of the recovery-hardening effect. (Author's summary)

PP: B 3 D 8 11 M 16 17 T 19 AA 27 30 31 36 h j k CV: 14 MI: Al Cu Zn' n

Frommer, L., and Murray, A.

The Influence of the Heat Treatment of Steel on the Damping Capacity at Low Stresses

Jour., Iron and Steel Institute, Vol. 61, pp.45-53, 1945. Also, The Iron Age, p 69, August 16, 1945

An electromagnetic method of inducing torsional oscillations in freely-suspended cylindrical steel bars was used for measurements of the damping capacity up to a maximum stress of 1000 lb per sq in. There were six specimens, each 3 in. in diameter and 3 ft long, all from the same melt, with a composition normal to a 0.6% carbon steel. Measurements were made in the normalized, 830° C -oil-quenched and the fully-tempered conditions; by successive heat treatment these conditions were repeated. The measurements showed that the damping value was a characteristic property which varied for each condition and was reproduced through two heat-treatment cycles. Within the experimental accuracy the torsional damping capacity is independent of oscillation frequency up to 7000 cycles per sec and of stresses up to 100 lb per sq in. The damping values as expressed by the logarithmic decrement are 0.5×10^{-4} for the tempered condition, and 0.7×10^{-4} for the oil-quenched condition. The Brinell hardness values showed changes similar to these, and it is suggested that this correspondence is due to the state of aggregation of the carbide, resulting from the heat treatment given. (Authors' abstract)

PP: 3 D E 9 13 16 S 19 AA 27 36 h 42 s CV: 14 MI: CN q

Geiger, J.

Determination of Crankshaft Stresses in Critical Regions With Damping

Automotive Industries, Vol. 92, pp.28-32, April 1, 1945

In determining the incremental stresses in the critical regions, the point of application of the exciting force is very important as well as damping force. With high effective damping, when the amplification is less than three times the static deflection, a corresponding correction must be made in the incremental stresses determined from torsiograms taken at the free end of the shaft. (Translated from Automobiltechnische Zeitschrift)

PP: Y AA CV: 11' 17

Gemant, A.

Dependence on Stress of Damping Capacity of Alloys

Mechanical Engineering, Vol. 67, pp.33-38, January, 1945

This describes studies on steels, copper, aluminum, magnesium, and lead alloys. Stress dependence of the damping capacity is shown. It is found that alloys having damping characteristics of pronounced stress dependence do exist, and that such a characteristic is particularly promoted by additions of silicon and nickel. The purpose of this paper is to promote additional and more systematic experimental research. It is believed that an analysis approached by way of the flow resistance is particularly suited for the purpose. It is mentioned that, on the basis of the correlation between creep and damping characteristics, a method of finding the former by means of the latter might be devised. The correlation between creep and damping by means of the two components of the flow resistance can be applied not only in the field of alloys but also in the field of plastics.

PP: 3 D 10 11 16 S AA 28 29 30 34 36 37 42 43 CV: 14 17 MI: CN AY Al Cu Mg Ni' Pb Si' b

Kleiner, A.

Dynamic Damping of Vibrations

Sulzer Tech. Rev. No. 1, pp.115-126, 1945

This paper describes the theory and methods of vibration damping and notes application to high speed Diesel design; properties of simple vibrating system; dynamic vibration dampers with varying and unvarying natural frequency; and the application of damper to crankshaft and torsional vibrations.

PP: A 3 Y AA 30 CV: 13 15 17

Monypenny, J. H. G.

Special Practice Required for Maximum Damping Capacity

Metal Progress, Vol. 47, pp.280-281, February, 1945

Prior cold work reduces very considerably the damping capacity of steel as shown by tests on mild steel before and after normalizing followed by various amounts of cold drawing.

PP: J AA 28 36 h k CV: 14 15 MI: SS C' Cr' Fe j

Russenberger, M.

A Dynamic Tension-Compression Testing Machine For Determining Endurance Strength and Material Damping. (In German)

Schweizer Archiv., Vol. 11, No. 2, pp.33-42, February 1945

The paper presents a description of a dynamic tension-compression test machine for determination of fatigue strength and damping capacity of materials. The operation of a new high frequency pulsator operating on the resonance principle is given. An increase in alternating strength by means of surface pressure is indicated. A method of quantitative determination of the damping capacity of materials is developed. (Eng'g Index 652, 1945)

PP: 3 F M AA CV: 13 14

Shannon, J. F.

Vibration Problems in Gas Turbines, Centrifugal and Axial Flow Compressors

Aeronautical Research Council (Great Britain) R & M No. 2226, March 1945

Failures have occurred in the blading, impeller vanes and combustion chambers of gas turbines, due to vibration. The scope of the problems involved in explaining these failures is illustrated, and the importance of the higher modes of vibration is emphasized. Stalling flutter in axial compressors is considered and a simple rule to avoid this phenomenon is given. The importance of investigating vibration problems in gas turbines by experiment is well established, and the technique developed is fully examined. The damping characteristics of duralumin compressor blades and steel turbine blades have been investigated and the results indicate that in the former aerodynamic damping is 60 percent, whilst material and blade root provide about 20 percent each; in the latter the blade root provides about 70 percent and the remainder shared by aerodynamic and material damping. Heat resisting alloys suitable for 650° C and above have low damping capacity. Experimental methods have been devised for fatiguing blades at resonance and have shown up weaknesses in blade and root design. (Author's summary)

PP: 3 D F 9 16 S W 23 AA BB CV: 14 MI: AY SG Al h 40

1946

Anonymous

Damping Properties of Nickel Alloy Steels

International Nickel Company, Inc., New York, Dev. and Res. Div., Nickel Alloy Steels, Section 6, Data Sheet C, 4 p., 1946

A short article deals with the general characteristics of the damping capacity of metals. Considerations presented in this data sheet are of value in indicating qualitatively the general effect of such factors as stress magnitude, heat-treatment, temperature, and aging on the damping properties of several metals.

PP: G 16 S U AA 28 36 h n CV: 14 15 MI: ST AY CI Al Cu Fe Ni

Cooper, D. H. D.

A suggested Method of Increasing the Damping of Aircraft Structures

Aeronautical Research Council (Great Britain) Tech. Rept. No. 2398, 13 p., August 1946

The object of this work was to find means of increasing damping in the joints of a structure, similar to a riveted structure, by the use of plastic inserts in the joints. Information on the effect of pressure-cabin sealing and the adoption of spot-welded or Redux welding construction is also given. This report discusses the operation of an insert and the properties called for in service, and recommends four suitable materials for further tests. The apparatus used to compare the damping of inserts made from a number of different materials is described. The effect of thickness of insert on damping has been investigated, and the variation of damping with temperature has been obtained between -25° and +25° C. for the material Poly-iso-butelene. These investigations show how, by means of an insert of Poly-iso-butelene, it is possible to increase the damping of a riveted structure. For vibration at a frequency of 36 cycles per second the damping is increased 200 percent for a maximum dynamic stress in the test specimen of 70 lb/sq in. For stresses higher than this but within the elastic range of the structure a larger increase in damping may reasonably be expected. (Author's synopsis)

PP: 16 S U 23 BB 28 CV: 14 MI: FF GG'

Cross, H. C.

Bibliography on the Damping of Metals

National Defense Research Committee, OSRD, War Metallurgy Division, OSRD No. 6603, Serial No. M-659, February 20, 1946

This is a selected bibliography listing available articles which present data on the damping properties of metals, both ferrous and non-ferrous. No attempt was made to include those articles which discuss only the theoretical aspects of damping testing or those articles describing various types of testing equipment. It includes a short abstract indicating the contents of each article. There are 65 entries from the years 1927 to 1946.

PP: AA CV: 18

Glickman, L. A., and Grinberg, M. I.

Zhur. Tekhn. Fiziki, Vol. 16, p. 985 1946.
Engineers' Digest, Vol. 8, p. 266, 1946

Stainless steel turbine blades were found to have decreased in damping as a result of long service.

PP: 16 18 AA 28 CV: 11' 13 14 MI: SS

Guillet, Jr., L.

Influence of Chemical Composition and Structure of Certain Metallic Alloys on Their Damping Capacity. (In French)

Revue de Métallurgie, Vol. 43, pp.265-267, 1946

Experiments conducted with a micropendulum are reported. Equimol. Au-Cu alloys were quenched from 650° C in water to obtain a solid solution in a disordered state and cooled at 30°/hr to room temperature. Then they were reheated 100 hours at 380° to produce an ordered solid solution in which Au and Cu atoms are arranged along tetragonal planes. Damping capacity of the annealed alloy was 0.022 and of the quenched one 0.0005. For $Cu_{31}Sn_8$ in the gamma phase this capacity is 0.0004 and CuZn in the beta phase it is 0.0011. Irregularity in the structure and disordered space lattice result in a lower internal friction than in well oriented bodies, so that plastic deformation leading to a greater damping capacity is more pronounced in the latter. Damping capacity appears to be parallel to the electric resistance of the metal. (Chem. Abs. 1947, 686le)

PP: 3 D 9 13 AA 30 b 36 37 40 42 s CV: 13' 14 MI: EG Cu Sn' Zn' a 36

Hanstock, R. F.

Damping Capacity and the Fatigue of Metals

Engineering, Vol. 161, pp.358-360, April 12, 1946

Research was undertaken to develop a method of fatigue testing which would allow determinations to be made of the damping capacity of the specimen during the course of the test. As a result of this work, it has been possible to investigate fatigue and damping capacity simultaneously for some aluminum alloys. There is a reasonable expectation that eventually the method may be applied to a wide variety of materials. (ASM Rev., p. 209, 1946)

PP: 3 16 T AA 29 42 r CV: 14 MI: Al b

Hanstock, R. F. and Murray, A.

Relation between Damping Capacity and Fatigue of Aluminum Alloys. (In French)

Revue de Métallurgie, Vol. 43, pp.58-62, 1946

A brief description is given of a new method of determining damping capacity concurrently with the development of fatigue at mechanical resonance frequencies of the order of one kilocycle per second. The application of the method is illustrated by referring to studies of some well-known aluminum alloys.

PP: 3 D F J L 13 16 S AA 29 30 b 33 36 h k 42 r CV: 11' 13' 14
MI: Al Cu Mg a 33 42 r

Hanstock, R. F. and Murray, A.

Damping Capacity and the Fatigue of Metals

Jour. Institute of Metals, Vol. 72, Pt. 2, pp 97-132, 1946

Fatigue phenomena in aluminum alloys have been investigated by observing changes in the damping capacity of the material during continuous vibration at surface shear stresses up to 10 tons/sq in. A high frequency of stress alternation -- of the order of 1500 cycles/sec--is employed, the specimen being freely suspended and vibrated torsionally at the resonance frequency. The alternating torque is applied electromagnetically, and the maximum surface shear stress developed depends on the damping capacity of the specimen. Changes in damping capacity of the specimen during vibration at a stress above a critical value are associated with strain-hardening and fatigue, the former being indicated by a gradual decrease, and the latter by a gradual increase, in the damping capacity. Increase in damping occurs as a result of the formation of fatigue cracks, and at a given vibrational stress it appears that the time rate of this increase may be indicative of the endurance of the material. Examination of selected materials, including a 0.6% carbon steel, shows that the relation between damping capacity and magnitude of the vibrational stress depends very sensitively on composition and metallurgical state. (Authors' synopsis)

PP: 3 D F J L 13 16 S T AA 28 29 30 b 33 36 h k 42 r CV: 14
MI: CN Al Cu Mg 32 42 q r

Pochapsky, T. E. and Mase, W. J.

A Photoelectric Method of Measuring Damping in Metal Forks at Elevated Temperatures

Trans., Am. Soc. Mech. Eng., Vol. 68, pp. A157-A161, 1946

Engineering measurements of internal friction in metals have been obtained from the decay characteristics of tuning forks of metals of interest. A damping program at Battelle Memorial Institute, conducted for the Office of Scientific Research and Development, called for such measurements at temperatures up to 1500° F, and it was necessary to develop suitable apparatus for obtaining accurate results at those elevated temperatures. A photoelectric method of measuring time amplitude decay, using shutters on a vibrating fork to modulate light directed at a photocell was developed. It proved to give very satisfactory results and had none of the mechanical difficulties in operation and uncertainties in results that were encountered at high temperatures when platinum-wire Sauereisen-cemented strain gages w were used. It was necessary to reduce energy losses from the fork to its support by using a compliant coupling. This suspension worked so well that the lower limit of decrement measurements was probably determined by acoustic losses. It is believed that such losses added less than 0.00004 to the decrements of steel forks. This report includes details of construction of the equipment and reviews tests performed to establish its accuracy. (Authors' abstract)

PP: 3 D 9 12 16 S U AA 28 29 CV: 14 MI: AY SG h

Portevin, A. and Guillet, L.

Internal Friction of Metallic Alloys. (In French)

Comptes Rendus, Acad. Sci., Vol. 223, No. 6, pp. 19-21, 1946

This is a discussion of the internal friction of alloys. A description of the Chevenard microtesting machine employed in the experimental work is given. The method used gives the decrement as a function of oscillation amplitude. Results obtained with different alloys are presented. (Eng'g Index 719, 1947)

PP: 3 D 9 13 16 S AA CV: 13' 14

Read, T. A. and Tyndall, E. P. T.

Internal Friction and Plastic Extension of Zinc Single Crystals

Jour. Appl. Physics, Vol. 17, No. 9, pp.713-720, September 1946

Data on the internal friction of four single crystals of zinc while oscillating longitudinally, and a description of various slow speed tension tests on a fifth crystal within and beyond the elastic limit are presented. In the first named measurements the behavior of the crystals bears little resemblance to that of zinc of greater purity prepared by another method, which has previously been reported. The most outstanding feature is that the decrement, although higher at the lowest stress amplitude than for the previous ones, shows very little rise with increasing stress amplitude, even up to stresses far beyond the statically determined elastic limit. The difference in behavior seems to be caused by the difference in purity of the zincs. An optically mosaic structure, such as that described by Schilling, does not appear to be responsible. In the slow speed tension tests the zinc crystal, after a period of self-annealing at room temperature, has a Hooke's law region up to about 70 g/mm^2 (R.S.S. 28.6 g/mm^2) and at greater stress shows transient and steady creep. Under some circumstances the creep is in two parts, a slow starting creep followed by much more rapid creep. The crystal when measured following a permanent strain, shows creep at loads well below the elastic limit and has a large amount of hysteresis. Self-annealing occurs during rest periods and the initial elastic limit is gradually regained while the hysteresis disappears. (Authors' abstract)

PP: 3 D 9 M 16 S T AA 27 28 29 36 37 j CV: 14 MI: Zn a

Robertson, J. M. and Yorgiadis, A. J.

Internal Friction in Engineering Materials

Jour. Appl. Mechanics, Vol. 13, pp.A173-A182, September 1946

This paper is a report on some experiments conducted on the subject of internal friction or damping in solid engineering materials, with apparatus and technique comparatively new to the field. The use of this equipment and technique enabled the measurement of internal friction in a more direct way than most if not all of the methods used by previous investigators. In the light of the results reported, empirical relations are presented for the variation of internal friction with stress amplitude in the range of engineering stresses. These relations are compared with the findings of others. (Authors' abstract)

PP: 3 F G J 11 M 13 16 S 19 X AA 28 29 36 h CV: 14 15
MI: ST CN AY FF HH LL Mg

Rotherham, L.

Damping Capacity

Metal Treatment, Vol. 12, pp.215-222, 232, Winter 1946

The engineering and physical aspects of damping are considered in this article, and experimental methods for its determination are described. The effect of carbon and chromium content upon damping is discussed, and also the effect of cold work and magnetic properties. Although investigation was held up by the war, the author considers that now is the time for it to be continued if it appears important to engineering, if it will give further information on the internal structure of metals, or if it will assist in other metallurgical studies. (Author's abstract)

PP: B 3 D 13 16 S U AA 30 c g h k CV: 14 MI: SG C Cr Fe Ni n p

Zener, C.

Anelasticity of Metals

Trans. Am. Inst. Min. and Met. Eng., Vol. 167, Iron and Steel Division, pp 155-189, disc. pp.189-191, 1946. Also Metals Technology, Vol. 13, T. P. 1992, 35 p., August 1946

Anelasticity is defined as that property of solids in virtue of which stress and strain are not uniquely related in the elastic range. Examples of anelastic effects are: elastic after-effects, internal friction, and the frequency variation of the elastic moduli. A review is given of the mathematical formulation of anelasticity according to the fundamental ideas of Boltzman as interpreted in terms of stress relaxation by Thomson and Wiechert.

A review is given of the various physical origins of anelasticity; i.e., of stress relaxation. One common source of anelasticity is diffusion: thermal diffusion, atomic diffusion, magnetic diffusion. Several heretofore unexplained types of anelasticity are herein interpreted in terms of atomic diffusion. As examples: the existence of a temperature band around 400° C within which the internal friction of alpha brass is anomalously high implies that in alpha the zinc concentration suffers a periodic fluctuation; the existence of a temperature band around 100° C within which the internal friction of mild steel is anomalously high implies that an applied stress causes a preferential distribution of dissolved carbon or nitrogen atoms among the various types of tetragonal interstitial positions. Through such anelastic studies information may be obtained regarding atomic distributions, which can be obtained in no other manner.

Another common source of anelasticity lies in the relaxation of shear stress across localized regions that behave in a viscous manner with respect to shear stresses, and that are surrounded by an elastic matrix. Grain boundaries and freshly formed slip bands are examples of such regions. The most direct approach to a study of shear stress relaxation along grain boundaries by viscous flow is through anelasticity. A discussion is given of the practical importance of such stress relaxation. It is shown that such stress relaxation plays a dominant role in stress relief, in primary creep, and in small dimensional changes at room temperature. More important, such stress relaxation is intimately related to fracture. Stress relaxation within slip bands at room temperature leads to the initiation of microcracks, which ultimately lead to macroscopic fracture. Relaxation of shear stress across grain boundary under creep condition likewise leads to the initiation of microcracks, which ultimately cause macroscopic fracture. (Author's summary)

PP: B 16 U X AA 27 30 31 d CV: 15 17 18 MI: CN Cu Zr' j

1947

Bordoni, P. G.

Study of the Elastic Properties of Aluminum by an Electro-Acoustic Method. (In Italian)

Alluminio, Vol. 16, pp.495-502, November-December 1947

A method of measurement is described whereby the elastic parameters of solids and their internal friction may be determined accurately at various ambient temperatures. Data obtained in a preliminary research on the effects of impurities on the elastic properties of aluminum are given.

PP: 3 6 16 U X AA 27 36 37 CV: 12' 14 MI: Al a

Boulanger, C.

Internal Friction of Ferromagnetic Metals and Alloys. (In French)

Comptes Rendus, Vol. 224, pp.1286-1288, 1947

Magnetization of metals and alloys decreases their internal friction. A field of 100 oersteds, sufficient to saturate ferronickel contraining 46% Ni decreased the internal friction 35 times; for pure nickel it was decreased 100 times.

PP: 16 V AA 27 CV: 13' 14 MI: SG Fe Ni a n p

Boulanger, C.

Progress in Determination of Internal Friction of Metals and Alloys Using Coulomb's Micro-Pendulum Testing Machine. (In French)

Comptes Rendus, Vol. 225, pp 624-626, 1947

Modifications in the machine made during research on the internal friction of metals and alloys are described. These made it possible to determine decrements of less than 0.0001.

PP: 3 D 9 13 AA 27 CV: 13' 14

Brandenberger, H.

Numerical Calculation of Improvement in Tensile Strength During Cold Drawing and Cold Working. (In German)

Schweizer Archiv., Vol. 13, Nos. 8 and 9. pp.232-238, 1947

Subjects considered are: the computation of stress hardening due to cold strain and cold compression; clarification of conditions which cause flow; yield point with 2% elongation increased by 54%; the Bauschinger effect (strain hardening occurs with all ductile materials, such as steel, brass, aluminum; it disappears when internal stresses are eliminated by slight heating). (Engg. Index, 776, 1948)

PP: AA 36 h k CV: 13 17 MI: CN Al Cu Zn' n

Brandenberger, H.

New Results in the Field of Materials Research. (In German)

Schweiz. Bauzeitung, Vol. 65, No. 37, pp 509-515, 1947

New results of material research; with aid of author's theory of spatial and grid stresses, various problems are clarified, particularly, the cause of fracture of ductile materials, which is attributed to the natural resistivity of the material; study of creep, yield point, fatigue, and hysteresis. A bibliography is included. (Eng'g. Index. 727, 1947)

PP: AA CV: 13 17

Brandenberger, H.

New Principles of Materials Testing and of Strength of Materials. (In German)

Sonderdruck aus der schweiz Bauzeitung, 65, Jahrgang, Nr. 49 and 50, 1947

New principles of material testing and of strength of materials. References are made to the damping of materials.

PP: AA CV: 13 17

Den Hartog, J. P.

Mechanical Vibrations. (Book)

McGraw-Hill Book Company, Inc., New York, 3rd Edition, 1947

Included in the text are references made to the following types of damping: dry friction (pp.355, 438); hysteresis (pp.265-362); negative (p. 347); nonlinear (p. 440); propeller (p. 262); and viscous (p. 51).

PP: AA BB CC CV: 16

Desch, C. H., Sproule, D. O., and Dawson, W. J.

The Detection of Cracks in Steel by Means of Supersonic Waves

Welding Res. Supplement, Vol. 12, No. 1, pp 1-3, January 1947

This article discusses developments in the use of sound waves to detect defects in metallic alloys and also to measure damping characteristics. The older method of detecting flaws by the change in "note" after striking the object with a hammer is limited, due to the wave length being large in comparison with the defect. To overcome these limitations the new technique uses "supersonic" or "ultrasonic" wave lengths of 1.6 cm to 0.6 x 10^{-6} cm. In steel these wave lengths become 5.1 mm for a 20,000 cycle frequency and 0.01 mm for a 5 x 10^4 cycle frequency. Wave lengths between these values are generally used.

The early German patents are cited together with the later developments in the USSR. The work in England in collaboration with the Hair Line Cracks Subcommittee of the Iron and Steel Institute, and the possibilities of the Sperry Supersonic Reflectoscope are mentioned. Frommer's method of measuring damping capacity, using torsional methods, is also discussed.

The author concludes that the method does not seem to be of general application in the detection of material defects in steel because of its sensitiveness to variations in the structural condition. It may, however, form a valuable means of investigating changes brought about by heat-treatment. Application of the method to the examination of light alloys may be more successful since in these cases the structure is less dependent on the thermal treatment than in the case of steel.

PP: 2 3 6 8 16 S W AA 28 36 h m CV: 15 MI: ST CN

Dijkstra, L. J.

Elastic Relaxation and Some Other Properties of Solid Solutions of Carbon and Nitrogen in Iron

Phillips Res. Reports, Vol. 2, No. 5, pp.357-381, 1947

The theory of elastic relaxation in alpha iron caused by carbon and nitrogen in solid solution predicts strong anisotropy for various crystal directions. This theoretical conclusion has been confirmed in a series of experiments carried out on prepared single crystals of iron in (100) and (111) directions. (Eng'g Index, 654, 1948)

PP: AA 30 31 34 36 j CV: 14 17 MI: EG' C' Fe p

Draminsky, P.

Damping in Crankshaft Vibrations. Book. (In Swedish)

Nytnordisk forlag Arnold Busck, Copenhagen, 166 p., 38 figs, 1947

In this book the author gives an extension of the theory of Shannon, that the damping is mainly due to small transverse movements of the shaft in the bearings. It is shown that this theory is in accord with hydrodynamical theory for cylindrical bearings. Experiments were carried out with Diesel engines and shafts to confirm the theory, and the transverse movements in the bearings were measured and photographed with an oscillograph, thus removing any doubt about their nature.

In order to isolate the main-bearing damping, the shaft was run without connecting rods, being driven by an electric motor, with vibration impulses supplied from outside by a special pulsator. As a by-product of the experiments it was shown that very short bearings have a greater load capacity than indicated by the common hydrodynamical theory, because the oil temperature is low due to the increased oil flow through such bearings.

For a shaft of mild steel the hysteresis damping factor was found to be absolutely constant for torsional stresses up to the fatigue limit, after which the damping rose sharply. It would seem that hysteresis measurements would be helpful for determining exact fatigue limits.

The author shows that the apparent damping in engine crankshaft systems is not as great as was supposed by Ker Wilson. Some attention is given to external damping in connected machines expecially hydraulic couplings, for which a well-composed theory using vector diagrams is given.

PP: 13 16 S Y AA CC 29 30 34 42 r (Appl. Mech. Rev.)
CV: 12' 14 16 17 MI: CN j

Gemant, A.

Internal Friction in Engineering Materials

Jour. Appl. Mechanics, Vol. 14, Transactions ASME, Vol. 69, p. A164, June 1947

Discussion of paper by I. M. Robertson and A. J. Yorgiadis, published in September 1946 issue and author's reply.

PP: 16 S AA 28 29 30 b 34 36 k MI: CN Mg

Glikman, L. A. and Grinberg, M. I.

Variation of the Damping Decrement of Turbine Blades in Service

Engineers' Digest (American Edition), Vol. 4, pp.364-366, August 1947

Failures of turbine blades of the ninth stage in a powerful steam turbine, which were obviously due to fatigue, led to investigations into the vibrations of these blades. The object was to determine the natural frequency of the blade groups or "packets," and to ascertain the possibilities of tuning the blades. (Translated and condensed from Jour. Tech. Physics, Vol. 16, No. 9, pp 985-992, 1946)

PP: 16 18 W X AA EF CV: 14 MI: AY

Guillet, L.

Influence of Structure and Composition on the Elastic Properties of Metallic Alloys

Engineers' Digest (American Edition), Vol. 4, pp.429-432, September 1947

Described are two pieces of test equipment for measuring elastic properties of metals: LeRolland-Sorin's apparatus for measurement of elastic moduli and Chevenard's micropendulum for torsion tests. Relative influence of metallographic factors on the elastic constant of metals. Elastic modulus is only slightly affected by composition or structure, but damping capacity (internal friction) is very sensitive to these changes. Therefore alloying heat treatment, or cold work can be used to avoid dangerous resonance vibration stresses. (Translated from Le Genie Civil, Vol. 124, pp 45-50, February 1, 1947)

PP: A 3 13 X AA g h k CV: 11' 14

Hanstock, R. F.

Damping Capacity, Strain Hardening and Fatigue

Proc., Physical Society, Vol. 59, pp 275-287, 1947

An electromagnetic method of exciting torsional resonance vibrations is described. For some alloys of aluminum, notably binary alloys containing 5% and 11% of magnesium, vibrational strains of sufficient magnitude to cause fatigue cracks can be developed by this method at frequencies of the order of one kilocycle per second. During vibration, measurements are made of the damping capacity of the specimens to provide information concerning strain hardening and energy conversion within the specimens up to the time when failure occurs by fatigue. Fatigue failure of the two binary alloys containing magnesium is shown to be preceded by strain hardening. The endurance of individual specimens is related to the amount of irreversible strain imposed per cycle, failure occurring when the cumulative internal strain approached a limiting value. (Author's abstract)

PP: 3 E 13 16 S T AA 28 29 30 b 42 q r CV: 14 MI: Al Mg'

Huntington, H. B.

Ultrasonic Measurements on Single Crystals

Physical Review, Vol. 72, No. 4, pp.321-331, August 15, 1947

A pulse technique at 10 Mc/sec. has been used to measure acoustic velocity and attenuation of several alkali halides and Rochelle salt. Values for the elastic moduli of LiF, NaCl, BRr, and KI have been determined. The attenuation of the ultrasonic beam in these media is small. Corresponding measurements on the elastic moduli of Rochelle salt are reported. Under the assumption of plane wave transmission many of these moduli automatically correspond to those measured on foiled crystals by other methods. Attenuation is considerable in Rochelle salt, and appears to be excessively high for transmission involving the temperature-dependent c_{44} (foiled case). Where this modulus is involved marked effects have been observed from electric bias and mechanical pressure. A complete set of elastic moduli has been obtained and used to calculate the corresponding values for the moduli of compliance. (Author's abstract)

PP: 3 6 X AA 36 j CV: 14 MI: LL FG 31 32 33 e 37 38 k 40

Kê, T. S.

Experimental Evidence of the Viscous Behavior of Grain Boundaries in Metals

Physical Review, Vol. 71, No. 8, pp.533-546, April 15, 1947

The mechanical behavior of grain boundaries in metals has been a subject of constant controversy. The present research is designed to examine thoroughly the mechanical behavior of grain boundaries in metals in a quantitative manner. A simple torsional apparatus has been devised for measuring four types of anelastic effects at very low stress levels, namely: internal friction at low frequencies; variation of dynamic rigidity with temperature; creep under constant stress; and stress relaxation at constant strain. All four types of anelastic effects have been studied in 99.991% polycrystalline aluminum as well as in single crystal aluminum. The four types of anelastic effects observed in polycrystalline aluminum are completely recoverable and are linear with respect to the applied stress and prior strain. They satisfy the interrelations derived by Zener from Boltzmann's superposition principle within experimental error. These are consistent with the viewpoint that the grain boundaries behave in a viscous manner. The maximum amount of shear stress relaxation in polycrystalline aluminum determined by the four types of anelastic measurements is about 33 percent. This is in good agreement with the theoretical value of 36% calculated by assuming the grain boundary to be viscous. The heat of activation associated with the viscous slip along the grain boundaries has been found to be 34,500 calories per mole. The coefficient of viscosity of the grain boundaries in aluminum estimated using this heat of activation, is consistent with that of molten aluminum at the same temperature. Similar anelastic effects have been also observed in polycrystalline magnesium, indicating that the viscous behavior is common to all metals. (Author's abstract)

PP: B 3 D 8 13 R S U X AA 27 30 31 d 36 38 CV: 14 17 MI: Al Mg a

Kê, T. S.

Stress Relaxation Across Grain Boundaries in Metals

Physical Review, Vol. 72, No. 1, pp.41-46, July 1, 1947

In order to elucidate further the concept of relaxation of shear stress across grain boundaries in metals, the temperature dependence of internal friction and rigidity modulus of 99.991% aluminum have been measured as a function of frequency of torsional vibration and as a function of grain size of frequency of vibration shifts the internal friction curve and the rigidity relaxation curve to higher temperatures; and when the frequency of vibration is kept constant, a change in grain size of the specimen has the same effect as a change of the frequency of vibration. The observed internal friction and rigidity relaxation can be expressed as functions of the parameter (G. S.) Xf Xexp (H/RT), where (G. S.) is the grain size or average grain diameter of the specimen, j is the frequency of vibration, and H is the heat of activation. It is shown that all these observed phenomena are necessary manifestations of the stress relaxation across grain boundaries arising from the viscous behavior of the grain boundaries in metals, which behavior has been demonstrated by previous anelastic-effect measurements. (Author's abstract)

PP: B 3 D 8 13 R U X AA 27 30 d 36 38 CV: 14 MI: Al a

Locati, L. and Di Carlo, R.

Concerning the Vibration-Damping Capacity of Certain Copper Alloys. (In Italian)

La Metallurgia Italiana, Vol. 39, pp.201-205, September-October 1947

The damping capacity of copper alloys containing various amounts of Zn, Ni, and Mn. Relationships between damping, microstructure, and other physical and mechanical properties. (Metals Review)

PP: AA 36 37 42 s CV: 12' 14 MI: Cu Mn' Ni' Zn'

Marin, J. and Stulen, F. B.

New Fatigue Strength-Damping Criterion for Design of Resonant Members

Jour. Appl. Mechanica, Vol. 14, No. 3, pp.A209-A212, September 1947

In the selection of materials for machine and structural parts subjected to vibrations it is common practice to cinsider the fatigue strength of materials. In come cases the damping constant of the material may be considered in a qualitative manner. A theoretical analysis is given in this paper to show that the load resistance of resonant members is a function not only of the fatigue strength but also of the damping constant and modulus of elasticity of the material. Test data on various materials are presented to show that the load resistance of a vibrating member may be appreciably changed by a correct selection of the material when this new design criterion is used. Fatigue-strength-damping design criteria are presented in this paper for vibrating beams and plates subjected to both concentrated and distributed resonant forces. Results are given for both external and internal damping. The theory developed may be extended for other members where the possible condition of resonant vibrations may occur. Turbine blades, airplane propeller blades, and shafts of various kinds are applications where the design criteria presented herein may be found useful. (Authors' abstract)

PP: A 3 E 10 12 Y AA CC 28 29 42 q r s CV: 14' 17
MI: CN AY FF GG' HH Al' Mg Mn' Ni Zn' d 36 j s

Mason, W. P.

Measurement of the Viscosity and Shear Elasticity of Liquids by Means of a Torsionally Vibrating Crystal

Trans. ASME, Vol. 69, pp.359-370, May 1947

This paper describes a method of measuring viscosities of liquids at high frequencies by means of oscillating cylinders, in which a torsionally vibrating crystal generates a viscous wave in the medium to be measured. Both a reactance and a resistance loading occur in the crystal which lowers its frequency and raises the measured resistance at resonance. The viscosity may then be determined by measuring the changes in the properties of the crystal. By varying the voltage on the crystal, the shearing displacement can be varied and hence the viscosity can be measured as a function of shearing stress. Measurements on light oils over a viscosity range from 0.01 poise to 10 poises check within a few percent when made with rough temperature-control conditions. (Author's abstract)

PP: 3 13 16 S 26 CC CV: 14

Mason, W. P., and McSkimin, H. J.

Attenuation and Scattering of High Frequency Sound Waves in Metals and Glasses

J. Acoust. Soc. Amer. Vol. 19, No. 3, pp. 464-473, May 1947

By using a pulse method, attenuation and velocity measurements have been made for aluminum and glass rods in the frequency range from 2 to 15 megacycles. The sound pulses are generated by crystals waxed to the surface of the rod. This wax joint limits the band width of the transmitted pulse and measurements are made using long pulses which approach steady state conditions. The reflected pulses show evidence of several normal modes which can be minimized by using specially shaped electrodes. Longitudinal waves showed delayed pulses of smaller magnitude that are caused by the longitudinal wave breaking up into reflected longitudinal and shear waves at the boundary. The effect is small if the diameter of the rod is 20 wave-lengths or more. The measured losses for aluminum rods show a component proportional to the frequency and another proportional to the fourth power of the frequency. The first component is the hysteresis loss found for most solid materials. The component proportional to the fourth power of the frequency is caused by Rayleigh scattering losses which is the result of differences in the elastic constants between adjacent grains caused by changes in orientation. Calculated scattering losses agree quite well with the measured values. The fourth power scattering law holds quite well until the grain size is equal to one-third of the wave length. For higher frequencies the scattering loss increases more nearly with the square of the frequency. Glasses and fused quartz have a loss directly proportional to the frequency showing that any irregularities must be of very small size. (Authors' abstract)

PP: 3 6 16 19 AA 27 30 31 36 38 CV: 14 MI: KK LL Al a

Michener, J. W. and Handloser, J. S.

Apparatus for Measuring Young's Modulus and Decrement of Graphite and Metals

U. S. Atomic Energy Commission, MDDC-1428, 12 p., November 5, 1947

Instrument is essentially an impedance bridge for measuring the a. c. resistance between two electrodes of a quartz crystal which are part of a composite oscillator. The oscillator is a quartz bar, to which is glued a specimen of the material under test.

PP: 3 E M X AA 27 CV: 14

Sack, H. S., Motz, J., Raub, H. L., and Work, R. N.

Elastic Losses in Some High Polymers as a Function of Frequency and Temperature

Jour. Appl. Physics, Vol. 18, pp.450-456, 1947

The frequency and temperature dependence of the elastic losses of polyvinylchlorides (0° to 80° C, 60 to 1400 cps) and of natural rubber and butadienestyrene copolymers (GRS) of different relative concentration (-50° to 35° C, 20 to 3500 cps) was studied by 3 methods, in which the motion of a reed in free or forced vibration is observed. Natural rubber at temperatures above 20° C and polyvinyl chloride exhibit frequency independent losses, the mechanism of which is not yet clear. The results for rubber below 20° and for GRS can be explained by a relaxation theory. The behavior of the elastic losses also reflects the existence of a second-order transition, below which rotation of chain segments is hampered. (Authors' abstract)

PP: 3 D E M R U AA 27 30 31 34 CV: 14 MI: FF GG

Swift, I. H. and Richardson, J. F.

Internal Friction of Zinc Single Crystals

Jour. Appl. Physics, Vol. 18, pp.417-425, April 1947

Measurements were made of the internal friction of single crystal rods when vibrating longitudinally at 45 kilocycles per sec. The decrement, or ratio of energy dissipated per cycle to twice the total vibrational energy, was used as a measure of the internal friction. At strain amplitudes below about 10^{-5} or 10^{-6} the decrement was independent of strain amplitude. The value of the constant decrement at low amplitudes, and the changes which occurred as the amplitude was increased, were both greatly dependent on the history of the specimen. The constant decrement for different crystal ranged from 7×10^{-5} to values higher than could be measured (about 200×10^{-5}). For some of the initially high-decrement crystals, values decreased with time (room temperature anneal). In general, for annealed crystals the decrement, measured as a function of increasing strain amplitude, remained almost constant up to and beyond the static elastic limit and then rose rapidly. It returned to the initial value when the strain amplitude was again reduced. On a second run, however, the rise in decrement occurred at much lower amplitude than on the initial one. It is concluded that the decrement is the result of two separate processes. The changing decrement at high strain amplitudes is qualitatively explained with the use of dislocation theory. (Authors' abstract)

PP: 3 D 9 M R S T AA 30 32 36 h j CV: 14 MI: Zn a

Vanick, J. S.

Some Unusual Tests of Cast Iron

Foundry, Vol. 75, Nos. 1 and 2, Jan., pp.66-71; Feb., pp 78-83, 1947

Paper contains a brief review of testing methods for cast iron on bending, compression, tensile, elasticity and deformation, torsion, fatigue, impact, corrosion, heat resistance, wear, and damping. No data on damping are given.

PP: 1 3 D 9 AA CV: 15 MI: CI

Worrell, F.

The Structure of Mn-Rich Alloys of Copper and Mn

Physics Review, Vol. 72, p. 533, 1947

Manganese-copper alloys containing more than 82% manganese have, when appropriately heat treated, a face-centered tetragonal structure with an axial ratio varying from 0.937 for pure manganese to 1.00 (i.e., face-centered cubic) at 82% manganese. Alloys in this range often have high internal friction. The results of metallographic examination of the alloy 88% manganese indicate characteristics not in complete agreement with the suggestion of Zener in regard to the cause of this high damping. Results are confirmed by X-ray studies. (Author's abstract)

PP: AA 30 34 36 37 CV: 14 MI: Cu' Mn

Zener, C.

Mechanical Behavior of High Damping Metals

Jour. Appl. Physics, Vol. 18, pp.1022-1025, November 1947

The relation between the two measures of internal friction most commonly used, logarithmic decrement and tangent of the angle with which strain lags behind stress, is deduced for all levels of internal friction in the important case in which the dissipation of energy is due to a relaxation process having a single time of relaxation. The conditions are further derived under which a specimen of such a metal will not vibrate, but returns periodically to its equilibrium configuration. (Author's abstract)

PP: 9 10 11 AA 30 31 34 CV: 17

Zener, C.

Stress Induced Preferential Orientation of Pairs of Solute Atoms in Metallic Solid Solution

Physical Review, Vol. 71, No. 1, pp.34-38, January 1, 1947

In a non-stressed cubic crystal the axes of pairs of adjacent solute atoms are rangomly orientated along the several permissible crystallographic directions. It is shown that in the presence of a stress the equilibrium orientation is no longer random, but that certain directions become preferred, and it is further shown that the continual striving of the crystal to maintain equilibrium causes it to manifest all the characteristic anelastic effects, stress relaxation, internal friction, etc. In particular, its internal friction will be anomalously high in that temperature range where the time of relaxation for the establishment of equilibrium is comparable with the period of oscillation. The theory is developed for the dependence of anelastic effects upon temperature and upon crystallographic orientation, and it is found that in b. c. c. crystals these effects vanish for a tensile stress applied along one of the (100) axes. The magnitude of the anelastic effects associated with this stress induced preferential orientation may be very large. Thus in the alpha-brass past experiments indicate that under optimum conditions the associated internal friction is at least 20 times as large as that due to all other causes. (Author's abstract)

PP: 16 U AA 27 30 34 36 40 CV: 17 MI: Cu Zn'

1948

Anonymous

Microtesting and Micromachines. (In French)

Acieries D'Imphy (Nievre), Siege Social: 84, Rue de Lille, Paris (7e), 1948

A monograph on three very important pieces of microapparatus for the study mechanical systems designed by Chevenard for la société de Commentry-Fourchambault et Decazeville.

Sections: Introduction

Part I. - Micromachine for the study of tension, of shear, and of bending.
1. Description of the micromachine.
2. Applications of the micromachine.

Part II. - Micromachines for studying the mechanical hysteresis of metals.

Chapter I. -- Micromachine for the study of alternating torsion.
1. Description, calibration, and use of the micromachine.
2. Magnification of the cycles of couple-torsion. - Influence of amplitude on the elastic parameters. -- Influence of the frequency.
3. Approximate equation for cycles of couple-torsion. --Conjectures and experimental verification.
4. Progressive modification in the couple-torsion cycles due to repeated alternations and under constant amplitude.

Chapter II. Micropendulum of Coulomb
1. Description and use. --Calculation of the decrement.
2. Magnetoelastic phenomena of metal and ferromagnetic alloys.
3. Variation of internal friction with amplitude in a stretched region. --Relation between the results obtained by the micropendulum and by the micromachine for alternating torsion.
4. Modification of internal friction resulting from cold working.

PP: 3 D 5 9 13 16 S T V AA 28 36 k CV: 13' 14 MI: SG Al Ni n p

Bailey, G. L. J.

The Estimation of Specific Damping Capacity From Measurements of Experimental Decay Curves

Jour. Institute of Metals, Vol. 74, pp.417-424, March 1948

This article is an appendix to one on the measurement of the damping capacity of metals in torsional vibration. A method for treating experimental decay curves is proposed and explained which permits estimation of specific damping capacity at any measured amplitude within calculable limits of error.

PP: 3 D 9 11 13 AA CV: 17

Bohnenblust, H. F. and Duwez, P.

Some Properties of a Mechanical Model of Plasticity

Jour. Appl. Mechanics, Vol. 15, (Trans., Am. Soc. Mech. Engrs., Vol. 70) pp.222-225, September 1948

An analytical expression for the stress-strain curve and the hysteresis curve of a metal in the plastic range can be deducted from the model presented. Further analysis of the model leads to the computation of the change in potential energy of the metal due to work hardening.

PP: 3 5 Y AA 30 b 34 36 k CV: 17

Boulanger, C.

Influence of Homogeneous Deformation on the Internal Friction of a Solid Solution.(French)

Comptes Rendus, Acad. Sci. Paris, Vol. 226, pp.1170-1171, April 12, 1948

Experiments were performed on 80/20 Ni-Cr alloy, the internal damping and its rate of decrease immediately after deformation being measured as a function of amount of permanent elongation. The residual internal damping after ageing was also measured. The results are interpreted in terms of dislocation theory. (Sci. Abs., 3965, 1948)

PP: AA 30 32 36 k n CV: 13' 14 MI: Cr' Ni

Cabarat, R., Guillet, L., and Le Roux, R.

Influence of the Physicochemical Constitution of Copper Zinc Alloys on Elastic Properties.(In French)

Comptes Rendus (France), Vol. 227, pp 681-683, October 4, 1948

Cabarat's apparatus, first described in 1943, in which cylindrical samples are subjected to high-frequency longitudinal vibrations, thus permitting tracing of the amplitude curve of the vibrations as a function of the frequency of excitation, was used to determine Young's modulus and internal friction of the above alloys containing up to 30% Zn as a function of their composition.

PP: 3 D M 16 19 X AA 36 37 CV: 13' 14 MI: Cu Zn' n

Cottell, G. A., Entwistle, K. M., and Thompson, F. C.

The Measurement of the Damping Capacity of Metals in Torsional Vibration

Jour. Institute of Metals, Vol. 74, pp.373-417, March 1948

The cause of the discrepancy between the results of "mechanical" and "physical" methods of measuring damping capacity in torsional vibration was investigated. In a machine of the Foppl-Pertz type the energy loss in the machine itself, may, when testing a material of low damping capacity, amount to about 500 to more times the intrinsic energy dissipation of the specimen. All the major sources of loss have been isolated, and complete redesign of an existing machine has reduced the measured damping to twice the lowest values measured by the physical method. The damping capacity of duraluminum as measured with this machine was found to be in excellent agreement with the lowest determinations by physical methods. This investigation confirms the postulate that the physical and mechanical methods are in fact measuring the same property, and shows that, at any rate for aluminum alloys, results of the same order can be obtained by the two methods, provided that the apparatus is designed correctly. An appendix to the paper (by G. L. J. Bailey) proposes a method of treating experimentally-recorded decay curves which permits the estimation of the specific damping capacity at any measured amplitude, within calculable limits of error. (From authors' synopsis)

PP: 3 D J 13 16 S 19 AA 27 28 CV: 14 MI: ST Al b h 40 p

Daas, H. C.

Internal Friction in Metals. (In Dutch)

Metalen, Vol. 3, pp 73-77, December 1948

The mechanical behavior of metals under varying stresses depends for the greater part on what is called "anelasticity." This implies that there is no linear or even single valued relation between stress and strain in the elastic region. An important manifestation of anelasticity is the dissipation of vibration energy, called internal friction. In this article a review is given of the various physical origins of internal friction, as far as they are known today. In general the sources of internal friction can be divided into two parts, diffusion effects and viscosity effects. The latter are important to get insight into the mechanica properties of metals. (Author's summary)

PP: B AA 30 31 c d CV: 13 15

Dean, R. S., Potter, E. V., Huber, R. W., and Lukens, H. C.

Trans., Am. Soc. Metals, Vol. 40, pp.355-380, 1948

The unusually high damping capacities produced by certain heat treatments were previously reported. These investigations were continued to determine the effects of other heat treatments and the fundamental nature of the damping property, and its variation with heat treatment. Damping capacities and moduli at high and low stresses were determined for alloys quenched from the gamma field and slowly cooled at various rates. The variations in moduli, Poisson's ratio, and damping capacity are correlated. Relationships to the presence of varied phases and structural types are indicated. (Authors' abstract)

PP: 3 D E G J M X AA 27 29 30 31 36 h n 42 q s CV: 14 MI: Cu Mn

Eckart, C.

The Thermodynamics of Irreversible Processes. IV. The Theory of Elasticity and Anelasticity

Physical Review, Vol. 73, pp.373-382, February 15, 1948

The traditional theory of the solid state is said to rest on two false assumptions. One is the principle of a constant relaxed (or standard) state. The other is the principle of relaxability-in-large, first formulated mathematically by DeSaint-Venant. It is shown that a principle of relaxability-in-the small is sufficient for the geometry of strain--which then becomes a 3-dimensional Riemannian geometry. The kinematics of strain is next developed without introducing the principle of a constant relaxed state. A classical theory of anelasticity is established on this basis. The results are used to derive the equations for the waves of distortion and dilation in an ideal isotropic anelastic medium. (Author's abstract)

PP: AA 30 34 42 q CV: 17

Entwistle, K. M.

The Damping Capacity of Metals in Transverse Vibration

Jour. Institute of Metals, Vol. 75, pp.81-96, October 1948

The development is described of a method for the measurement of damping capacity at low stresses on specimens of uniform cross-section vibrating transversely in the "free-free" mode. The damping capacity of aluminum-rich alloys (R. R. 56, R. R. 88), and Duralumin) measured with the fully developed apparatus ranges between 0.0022 and 0.0035%. The discrepancy between these values and those published by Frommer and Murray (J. Inst. Metals, 70, 1, 1944) for specimens of similar material in torsional vibration can be explained by the existence of transverse thermal currents in the former case. The changes of damping capacity during the ageing of Duralumin and R. R. 56 at room temperatures following solution treating and quenching, were measured; in addition, it was found that a marked decrease in damping capacity resulted from precipitation at elevated temperatures in R. R. 56 and copper-beryllium which had previously been aged for over 18 months at room temperature. (Author's synopsis)

PP: 3 D E 9 12 AA 27 30 31 36 h n CV: 14 MI: EG' Al Cu a 33 h 40

Entwistle, K. M.

The Effect of Grain-Size on the Damping Capacity of α Brass

Jour. Institute of Metals, Vol. 75, pp.97-106, 1948

The effect of grain size in the damping capacity of α brass in both torsional and transversal vibration were investigated, using apparatus already described. The results are in close agreement with Zener's prediction of a contribution to damping capacity in all three kinds of vibration by intercrystalline thermal currents, which was varified experimentally in longitudinal vibration by Randall, Rose, and Zener. (Phy. Review, Vol. 56, p. 343, 1939)

PP: 3 D 9 12 13 AA 27 30 31 36 38 CV: 14 MI: Cu Zn' n

Fowler, Jr., F. H.

Theories of the Fatigue of Metals

Lessells and Associates, 916 Commonwealth Avenue, Boston 15, Mass. Dynamic Properties of Materials, Tech. Rept. No. 1, 1948

In this report is given first a brief discussion of several fatigue mechanisms proposed to explain the origination of fatigue failures. Next there is a discussion of the manner in which fatigue cracks begin to propagate and the manner in which static stresses and triaxial loading should be considered. This is followed by an analysis of the statistical aspects of the problem. Finally, the variation in elastic hysteresis predicted assuming one of the proposed mechanisms is compared with experimental data.

PP: AA 30 42 r CV: 17

Guillet, L.

Report of a Conference on Strength of Solids

The Physical Society, pp.116-119, 1948

First results of a study of internal friction begun in 1943 using Chévenard's microtorsion test apparatus. Data for the solid-solution alloys Cu-Zn, Cu-Sn, and Cu-Al; the order-disorder transformations of Au-Cu alloys; and the contrasting behavior of the gamma type, $Cu_{31}Sn_8$, and the beta type, CuZn, of intermetallic compound.

PP: 3 13 AA 36 37 40 CV: 14 MI: EG Al Cu Sn Zn a 36

Hanstock, R. F.

Damping Capacity

Metal Industry, Vol. 73, pp.383-385, Nov. 12, 1948; pp 411-413, Nov. 19, 1948

The usefulness of damping capacity measurements at both low and high stresses for the investigation of the properties and constitution of metals and alloys is discussed. It is also made clear that damping capacity measurements can be of value in estimating the probability of fatigue failures occurring under specified conditions. The various ways in which vibrational energy is dissipated are discussed in detail. Three groups of methods for the measurement of damping capacity are given. Factors affecting damping capacity such as the effects of temperature, frequency and mode of vibration, composition, defects, grain size, and stress level are examined. Finally the practical importance of damping capacity and its measurement is covered.

PP: B C D F R U W AA 27 28 29 36 37 39 42 r CV: 15

Hanstock, R. F.

The Effect of Vibration on a Precipitation-Hardening Aluminum Alloy

Jour. Institute of Metals, Vol. 74, pp.469-492, May 1948

The dynamic properties of the precipitation-hardening aluminum alloy Hiduminium R. R. 56 have been investigated by determining the relation between damping capacity and strain amplitude for various metallurgical conditions of the alloy. The form of this relation suggests that strain-dependent damping capacity is attributable to dislocations generated under the combined influence of strain and thermal fluctuations. The factors which appear to be mainly responsible for the dynamic behavior of the alloy are: an internal field of strain, probably originating from foreign atoms, in solution or dispersed in the aluminum lattice, and a strain-concentration factor depending on the degree of precipitation. Vibration at high strain amplitudes accelerates precipitation and, if sufficiently prolonged produces changes in metallurgical condition normally associated with temperature ageing and annealing. Being of a directional nature, vibration is probably selective in its action on the grains of a polycrystalline metal and consequently does not affect the average static mechanical properties to a significant extent. However, the grains affected by vibration determine the fatigue properties, and it is shown that the endurance under a given strain amplitude may be inferred from the change in damping capacity during vibration. (Author's synopsis)

PP: 3 D F 9 13 16 S T AA 28 29 30 31 32 33 36 h n 42 r CV: 14 15' MI: EG' Al Cu' Fe' Mg' Ni' Si' d 34

Ke, T. S.

Anelastic Properties of Iron

Metals Technology, Vol. 15, T. P. 2370, 27 p., June 1948

This describes a number of anelastic effects observed in alpha-iron and attempts to derive valuable information from a critical study of these effects. Then it deals with the inter-relation between various anelastic effects; the experimental methods and apparatus used; and the results with their theoretical interpretation.

PP: B 3 D 8 13 15 U AA 27 30 31 d 36 h 42 q CV: 14 17 MI: Fe a

Ke, T. S.

Viscous Slip Along Grain Boundaries and Diffusion of Zinc in Alpha-Brass

Jour. Appl. Physics, Vol. 19, pp 285-290, March 1948

The viscous behavior of the grain boundaries in 70-30 alpha-brass was demonstrated by anelastic measurements. It was shown that the grain boundaries cannot sustain permanently a shear stress and have a coefficient of viscosity decreasing with an increase of temperature. Using the same alpha-brass specimen, the activation energy associated with the stress-induced preferential orientation of pairs of zinc atoms in alpha-brass (which is a diffusion process) was determined. This activation energy was found to be identical, within experimental error, to the activation energy associated with the grain boundary slip in alpha-brass. This finding indicates that the grain boundary slip in alpha-brass is a diffusion process and the diffusion mechanism is similar to the volume diffusion in alpha brass. Internal friction measurements were employed in this work. (Author's abstract)

PP: B 3 AA 27 30 31 36 40 CV: 14 MI: Cu Zn' n

Ke, T. S.

On the Structure of Grain Boundaries in Metals

Physical Review, Vol. 73, pp.267-268, 1948

There is no method known at present of determining the structure of grain boundaries in metals. This is a brief review of past experimental evidence and a discussion of the theories of possible grain boundary structure which these data support or refute. (Author's abstract)

PP: B AA 27 30 31 CV: 15

Ke, T. S.

Internal Friction in the Interstitial Solid Solutions of Carbon and Oxygen In Tantalum

Physical Review, Vol. 74, pp 9-15, July 1, 1948

Some internal-friction measurements are presented from which it is concluded that carbon and oxygen form interstitial solutions with tantalum. This observation is the first evidence that oxygen forms an interstitial solid solution with a metal. The location of carbon and oxygen in the tantalum lattice is discussed.

PP: B 3 D 8 13 16 U AA 27 30 31 36 h CV: 14 MI: FG C' 32 d q

Ke, T. S.

Internal Friction and Precipitation From the Solid Solution of N in Tantalum

Physical Review, Ser. 2, Vol. 74, pp.914-916, October 15, 1948

The internal friction or acoustic absorption peak (vs temperature) around 350° C previously observed with a frequency of vibration of about one cycle per sec. was further analyzed. It was shown that this peak has its origin in the stress-induced interstitial diffusion of N in tantalum similar to the cases of C and O in tantalum previously reported. The precipitation of N from the solid solution was followed by internal-friction measurements. (Author's abstract)

PP: B 3 D 8 13 16 U AA 27 30 31 36 k n CV: 14 MI: FG 32 d p

King, R.

Symposium on Internal Stresses in Metals and Alloys

Institute of Metals, pp 13-23, disc. pp.375-397, 1948

Description is given of the use of measurements of magnetic properties, electrical resistivity, and internal friction to observe changes in internal stresses produced by treatments such as cold work, quenching, or annealing. Quantitative determinations were made by means of magnetic measurements on plastically stretched and cold-drawn nickel wires.
PP: B AA 36 h k CV: 15 MI: Ni

Kornetzki, M.

The Stress-Strain Curve of Ferromagnetic Materials (Magneto-Mechanical Hysteresis Curve). (In German)

Annalen der Physik, Ser. 6, Vol. 2, pp.265-269, May 8, 1948

The relationship of torsion strength to torsion stress was determined for a soft nickel tube. Stress was applied cyclically, with stepwise increases in rate of application. Results show that relations between elongation and stress are exactly like those between magnetic induction and field strength. At very low amplitudes, variations of mechanical properties of ferromagnetic materials are parallel to those of the magnetic Rayleigh curve.
PP: 13 AA 27 30 c 42 s CV: 13 14 MI: SG Ni a n p

Köster, W.

An Unusual Deviation in the Temperature Curve of the Modulus of Elasticity and Damping of the Metals Copper, Silver, Aluminum, and Magnesium. (In German)

Zeit. f. Metallkunde, Vol. 39, pp.9-12, January 1948

The above metals show an unexpected lowering of the elasticity modulus and an increase in damping over a fairly wide temperature range. The amount of deflection depends on the purity of the metals. Deoxidation or addition of deoxidizing elements eliminates these effects in copper and silver. The phenomenon is explained by the diffusion of foreign atoms in solution.
PP: 16 U X AA 27 30 31 36 37 CV: 13 14 MI: Ag Al Cu Mg

Le Rolland, P.

A New Method for Determination of Energy Dissipation by Internal Friction in Solids. (In French)

Comptes Rendus, Vol. 227, pp. 37-39, July 5, 1948

This describes a method based on determination of the capacity of the materials for absorption of artificially produced vibrations and gives the fundamentals of the method. Its advantage consists in its applicability to specimens of any shape such as wires, rods, bars, and plates.
PP: 3 E AA CV: 13' 14

Linacre, E. T.

Viscosity

Iron and Steel, Vol. 21, No. 8, pp.315-318, July 1948, pp 363-366, August 1948

This is a critical survey of the viscometry of molten iron-carbon alloys. Methods of measurement used by various workers in the measurement of the viscosity of molten white cast iron are outlined. Oscillation decrement, concentric cylinder, and torque methods are covered. Work on gray iron is described and results are presented. Consideration is given to the possibility of applying the methods to molten steels. The oscillation decrement method is concluded as preferably. (Eng'g Index 761, 1948)
PP: 3 D 9 AA 26 CC CV: 14 15 MI: CI C' Fe

Lyons, W. J. and Prettyman, I. B.

Method for the Absolute Measurement of Dynamic Properties of Linear Structures at Sonic Frequencies

Jour. Appl. Physics, Vol. 19, pp.473-480, May 1948

A full account, including the theoretical basis, is given of a method whereby the dynamic stretch modulus, coefficient of internal friction, and hysteretic energy loss of textile yarns and cords, composed of either continuous filaments or staple fibers, can be accurately determined at longitudinal vibration frequencies above 100 cycles/sec.

The method, which employs electromagnetic excitation, is applicable also to glass cords, and metallic wires and cables. Results have been obtained at frequencies extending to above 300 cycles per sec. A concise description is given of the improved stretch vibrometer. Results on a typical cotton cord show that energy absorption by this instrument is negligible, permitting the calculation of an accurate internal friction coefficient, and absolute hysteretic loss. Measurements on eight natural and synthetic textile fibers reveal that the dynamic moduli range from 6.4×10^{10} dynes/cm^2 for Velon monofil to 32×10^{10} dynes/cm^2 for a ramie cord. The dynamic moduli of Fiberglas and steel cords are found to be 54 and 106×10^{10} dynes/cm^2, respectively. The internal friction coefficients are found to vary hyperbolically with frequency; in a 11/4/2 cotton cord, for example, from 16 to 3×10^6 poises between frequencies of 60 and 320 cycles/sec. (Authors' abstract)
PP: 3 E 10 M 16 19 X AA CV: 14 17 MI: JJ

Potter, E. V.

Damping Capacity of Metals

Bureau of Mines, Report of Investigations, No. 4194, 48 p., March 1948

This report presents work which has been done as described in the literature. It described various test methods, their theory and accuracy; fundamental mechanisms contributing to energy losses and their relative magnitudes; and the relation between damping capacity and other properties of materials. It also discusses the various units for expressing damping capacity; the choice of testing methods; the importance of damping capacity in engineering; and practical applications of damping capacity measurements. Forty-nine references are included.
PP: A B C D E F G 8 J 11 M N R S T U W AA 27 28 29 a b c d g h 38 k m 42 q r MI: AY FG Al Cu Mo Ni a 36 n q CV: 15 17

Reinacher, G. and Scheil, E.

Modulus of Elasticity and Damping of Zinc Monocrystals. (In German)

Zeit. f. Metallkunde, Vol. 39, pp.231-232, August 1948

The temperature dependence was determined for five differently oriented monocrystals.
PP: 3 6 16 U X AA 27 36 j CV: 13 14 MI: Zn a

Salceanu, C.

New Method for Determination of the Viscosity of Metals. (In French)

Comptes Rendus, Vol. 226, pp. 1798-1800, May 31, 1948

This presents a modification of a previously described method, based on the determination of the logarithmic decrement of the oscillations of a torsional pendulum. Comparative data for Al, Fe, steel, Pb, Ag, Ni, Cu, Pt, and W are given. Of these only the values for Fe, Al, and Pb are in general agreement with previous work. The influence of temperature on viscosity was shown by carrying out the determinations with an electric current passing through the wires. The general increase of viscosity with temperature is contrary to the behavior of liquids.
PP: 3 D 9 13 16 U AA CV: 13' 14 MI: CN EG Ag Al Cu Fe Ni Pb W c 43

Tarnapol, L. and Morgan, J. R.

Damping Capacities of S. A. E. 1020 and 2320 Steels. (In English)

Trans., Indian Institute of Metals, Vol. 1, pp. 55-69, June 1948

Damping capacities were studied as a function of maximum fiber stress after various anneals and case carburization. It was found that machining increases the damping while subsequent aging or annealing decreases damping. Changes in damping capacity observed at high stress could be accounted for by assuming that plastic slip was an important factor.
PP: 3 D 9 13 16 S AA 28 29 30 b 33 g h k n CV: 14
MI: CN AY j 41 q

Zener, C.

Elasticity and Anelasticity of Metals. (Book)

University of Chicago Press, Chicago, Illinois, 167 p., 1948

Contents: Part One. Elasticity of Metals. I. Formal Relations between Stress and Strain. II. Low-Temperature Elastic Constants in Cubic Metals. III. Temperature Dependence of Elastic Constants. IV. Microelasticity. Part Two. Anelasticity of Metals. V. Formal Theory of Anelasticity. VI. Measurement of Relaxation Spectrum. VII. Physical Interpretation of Anelasticity.
PP: B C D E F 8 10 P R S T U X AA 27 a b c g 37 j 40 n
CV: 16 17 18 MI: CN Ag Al Cu

1949

Anonymous

Crankshaft Damping

Engineering, Vol. 167, No. 4336, pp 205-206, March 4, 1949

A discussion of some of the experiments of P. Draminsky and J. L. Mansa.
PP: AA CV: 15

Apert, C. and Cabarat, R.

Influence of Magnetic Field on the Internal Friction of Reversible Ferro-nickels. (In French)

Comptes Rendus, Vol. 228, pp 490-492, February 7, 1949

Investigation was performed on test specimens with 30-90% nickel content, and annealed at 800° C for 7 hours at atmospheric pressure. The internal friction was found to increase rapidly for low values of magnetic field, reach a maximum, then decrease to practically a constant value at 300 oersteds. The influence of nickel content is shown.
PP: 3 16 V AA 36 37 CV: 13' 14 MI: SG Fe Ni n

Boulanger, C.

Internal Friction Caused by Ferromagnetism. (In French)

Physica, Vol. 15, pp.266-271, April 1949

The above was investigated for Armco iron, nickel, ferromagnetic metals, Ni-Cr-Mo steel, and a hypereutectoid steel. Method of investigation and results are given.
PP: 3 16 V AA 30 c CV: 13' MI: CN AY SG Cr' Fe Mo' Ni n p

Boulanger, C.

Contribution to the Study of Internal Friction. (In French)

Revue de Metallurgie, Vol. 46, pp 255-265, April 1949, pp.321-342, May 1949

Extensive descriptive review of the literature, including experimental methods and apparatus and reproduction of the more important experimental results. 156 ref. (Metals Review)
PP: 3 16 AA 36 CV: 13' 14 15 18

Brown, R. S.

Plastic Strain and Hysteresis in Drawn Steel Wire

Jour. Iron and Steel Institute, Vol. 162, pp 189-200, 1949. Disc., Vol. 166, pp.319-320, 1950. Also, Iron and Steel, Vol. 22, pp 629-632, 1949

Forms of test applicable to wire are briefly reviewed and it is suggested that none of the tests normally applied can be used to assess the properties of wire required to withstand dynamic stresses. Considerable importance is attached to stress-strain characteristics at loads up to 75% of the ultimate tensile strength, and curves involving high magnification of strain are shown, in which important changes in plastic properties exhibited by drawn wire when subjected to static and cyclic loads and after passing round pulleys, are discussed in relation to the behavior of colliery winding ropes. The effect of temperature during wire-drawing is examined and some comments are made relating to the behavior of heat-treated wires when subjected to combined bending and dynamic stresses.

Stress/strain diagrams are shown for cyclic tension-tension loading for various steel wires. They show a stress history effect on damping. Conclusions:

(1) Wire as-drawn possesses no elastic properties and therefore has no elastic limit. (2) The unique ability of drawn wire to withstand the repeated application of combined bending and tensile stresses is shown to be due to its capacity for plastic creep associated with hysteresis behavior of a high order. Wires of high tensile strength produced by hardening and tempering are shown to possess negligible creep characteristics and greatly reduce hysteresis. Such wires have proved to be unsuitable for use under conditions involving dynamic stresses.

Other conclusions are drawn in regard to the proper treatment of wire for dynamic applications.

From the investigation the inference is drawn that:

(1) High plastic and hysteresis properties are essential for a durable drawing, future progress of the art must be along lines of complete suppression of temperature rise in the wire immediately as it leaves the drawing die.

PP: 1 3 M 14 16 T AA 28 29 36 h CV: 14 MI: ST CN

Cabarat, R.

A New Dynamic Method for the Measurement of Elastic Constants. (In French)

Revue de Metallurgie, Vol. 46, No. 9, pp.617-621, September 1949

Description is given of a new dynamic method for the measurement of elastic constants. The method uses the classical relation between the speed of propagation of a longitudinal wave in a specimen, the modulus of elasticity, and the density. An electrostatic method is used to produce vibrations in the specimen and an oscilloscope is used in the detection of the waves. Testing may be done at various temperatures. The method also permits a determination of the internal friction of the specimen through the decay of free vibrations. Determination of the logarithmic decrement is described.

PP: 3 D E 9 M 16 U X AA CV: 13' 14

Cabarat, R., Guillet, L., and Le Roux, R.

Internal Friction and the Elastic Anisotropy of Metals and Alloys. (In French)

Comptes Rendus, Vol. 228, pp.570-572, February 14, 1949

A method is described using the specially developed apparatus of Cabarat. Results of determinations for Mg, Al, Fe, Pt, Cd, and Zn are given. It is believed that this method can also be applied to various alloys.

PP: 3 E 9 M 16 X AA 36 37 CV: 13' 14
MI: EG Al Fe Mg Zn a c 35 43

Cabarat, R., Guillet, L., and Le Roux, R.

Internal Friction in Metallic Alloys. (In French)

Revue de Metallurgie, Vol. 46, pp.622-626, September 1949

The specially developed apparatus of Cabarat is used in this study to determine the effect of physicochemical constitution of a full range of Cu-Zn and Cu-Sn alloys on their modulus of elasticity and internal friction. Curves showing E and δ as a function of percent of alloy are presented.

PP: B 3 E 9 X AA 36 37 CV: 13' 14 MI: Cu Sn Zn

Cottrell, A. H., and Bilby, B. A.

Dislocation Theory of Yielding and Strain Ageing of Iron

Proc. Phys. Soc. London, Vol. 62, pp 49-62, 1949

A theory of yielding and strain ageing of iron, based on the segregation of carbon atoms to form atmospheres round dislocations, is developed. The form of an atmosphere is discussed and the force needed to release a dislocation from its atmosphere is roughly estimated and found to be reasonable. The dependence on temperature of the yield point is explained on the assumption that thermal fluctuations enable small dislocation loops to break away; these loops subsequently extend and cause yielding to develop catastrophically by helping other dislocations to break away. The predicted form of the relation between yield point and temperature agrees closely with experiment. Strain ageing is interpreted as the migration of carbon atoms of free dislocations. The rate of ageing depends upon the concentration of carbon in solution and the estimated initial rate agrees with experiment on the assumption that about 0.003% by weight of carbon is present in solution. Application of the theory to a discussion of several mechanical and physical effects is made. In particular, an explanation of certain anelastic effects is made. (From authors' abstract)

PP: AA 30 32 CV: 17 MI: CI C' Fe

Denkhaus, G.

On Materials Damping Under Bending Vibrations. (In German)

Ingenieur Archiv, Vol. 17, pp.300-307, 1949

No Abstract available.

Diepschlag, E. and Müller, H.

The Damping Characteristics of Carbon Steels for Strains Within the Range of Elastic Deformation. (In German)

Arch. Metallkunde, Vol. 3, pp.400-406, November 1, 1949. See also: Chem. Zentr. Vol. I, p. 1776, 1950

Damping tests are reported on unalloyed steels containing 0.02 - 0.93 carbon. Tests were run on the steels as received and with and without fine-grain and coarse-grain annealing. The influence of such factors as carbon content, fine structure, the presence of flaws, etc.; on the damping curves is discussed. It is shown that it is necessary to distinguish damping phenomena in the plastic deformation range from those in the elastic range. The damping was found to increase with grain size.

PP: 3 AA 28 g h 38 m CV: 13 14 MI: CN g j m p q r s

Dijkstra, L. J.

Jour. Metals, Vol. 3, No. 3, pp 252-260, 1949

"Precipitation Phenomena in the Solid Solutions of Nitrogen and Carbon in Alpha Iron below the Eutectoid Temperature"

The precipitation of carbon and of nitrogen from solid solution in alpha-iron has been studied at different tempering temperatures by internal friction measurements. In the case of nitrogen these measurements suggested the presence of two successive stages in precipitation which were then verified by metallographic examinations. The observed rate of precipitation follows the general behavior to be anticipated from the standard theory of diffusion and nucleation. Plastic deformation (studied only in the case of N) was found not only to increase the rate of precipitation, but also to lower the final solution concentration presumably in equilibrium with the precipitate. It appeared therefore, as if the precipitate induced by plastic deformation was not identical to that which forms in annealed material. This viewpoint was confirmed by metallographic examination which failed to reveal visible precipitates even after the final equilibrium solute concentration had been attained. (From author's summary)

PP: B 3 D 8 13 16 U AA 27 36 h n CV: 14 MI: EG' C' Fe p

Eshelby, J. D.

Dislocations as a Cause of Mechanical Damping in Metals

Proceedings of the Royal Society, Ser. A, Vol. 197, pp.396-416, June 22, 1949

Zener has shown how thermoelastic effects give rise to damping of the mechanical vibrations of a solid. For example in a vibrating reed opposite sides are alternately compressed and extended. This gives rise to an alternating temperature difference across the width of the reed, and the resulting flow of heat leads to dissipation of mechanical energy. In a vibrating single crystal of a metal an additional energy loss is observed which is usually attributed to the motion of dislocations. In this paper the following mechanism is proposed. Dislocations are trapped in 'potential troughs' at the minima of the internalstress in the crystal. When the crystal vibrates the dislocations oscillate in their potential troughs and the moving stress system associated with them produces a fluctuating temperature distribution in the material; this leads to damping as in Zener's case. The rate of loss of energy produced by a dislocation oscillating with a given amplitude is calculated and the effect of a collection of them is discussed. An actual estimate of the damping in a vibrating crystal requires (1) a knowledge of the relation between the amplitude of oscillation of a dislocation and the vibrational stress causing it to move, and (2) a knowledge of the density of dislocations in the material. A tentative discussion of (1) is given. The quantity of (2) is known; however, it is shown that the damping depends only on the ratio of the number of dislocations per unit area to the number of potential troughs per unit area. If this ratio is calculated from the theoretical result and the observed damping in copper single crystals it is found to be of the order of unity. The present theory predicts that the damping should increase with frequency. This is in agreement with the limited data available. Two subsidiary effects are also investigated, the thermoelastic damping arising from the interaction between the vibrational stresses and the stresses surrounding stationary dislocations, and the damping due to theemission of elastic waves from an oscillating dislocation. Both of these effects are shown to be small compared with the thermoelastic damping caused by moving dislocations. (Author's abstract)

PP: 12 16 19 AA 27 30 31 32 j CV: 17

Glickman, L. A., Zhuravlev, V. A., and Snezhkova, T. N.

The Variation of the Damping at Cyclic Stressing Below and Above the Fatigue Limit (Contribution to the problem of the physical nature of the fatigue process). (Russian)

Jour. Tech. Physics, U. S. S. R., Vol. 19, pp.448-464, April 1949

The specimens were tested on a specially designed fatigue testing machine for alternating stressing and the decrement of damping of the specimens was measured at various stages of the cycle. For 3 steels (2 carbon and 1 high-chrome stainless) the variation of the damping was studied in cycles of varied amplitude, above and below the fatigue limit, this including the investigation of the influence of intermediate ageing and tempering in the cyclic treatment on the variation of the damping. The results of the investigation are a further contribution to the physical character of the ageing process. (Metals Review)

PP: 3 D 9 16 S T AA 28 29 36 h n 42 r CV: 12 14 MI: CN SS

Kamel, R.

Measurement of the Internal Friction of Solids

Physical Review, Ser. 2, Vol. 75, p. 1606, May 15, 1949

Internal friction of a number of metallic solids and glass was determined from transverse vibrations. Two methods were employed: decay of free lateral vibrations and width of resonance.

PP: 3 D E 8 10 12 16 19 AA 27 CV: 14
MI: CN SG KK EG Cu Ni Pb Sn Zn a c 42 43

Ke, T. S.

A Grain Boundary Model and the Mechanism of Viscous Intercrystalline Slip

Jour. Appl. Physics, Vol. 20, pp.274-280, 1949

A study of the activation energy associated with the viscous intercrystalline slip shows that the conventional theories of grain boundary, e. g. the intercrystalline amorphous cement theory and the abrupt transitional theory, are both untenable. A grain boundary model is described in which the transition region at the boundary is considered as consisting of numerous disordered groups of atoms or diffused holes. The intercrystalline slip occurs through the atomic rearrangement by thermal agitation within each "disordered group" by a shear process involving as units of flow only a few atoms. This grain boundary model and slip mechanism are consistent with experimental facts and furnish, furthermore, a unified viewpoint as to the mechanism of the viscous intercrystalline slip, the volume diffusion in metals, and the constant rate creep of metal crystals under small stress. Further experiments are described concerning the influence of previous deformation and impurities on grain boundary viscosity. It has been found that the grain boundary viscosity is lower in a specimen subjected to a heavier deformation prior to its recrystallization. A very small amount of impurities was found to be able to block partially or completely the grain boundary slip in aluminum, iron, and copper. These observations are readily understood on the basis of the proposed grain boundary model and slip mechanism. Internal friction data are used as supporting evidence of the theories. (Author's abstract)

PP: B AA 27 30 d 34 CV: 14 17 MI: Al Cu Fe a

Kê, T. S.

Grain Boundary Relaxation and the Mechanism of Embrittlement of Copper by Bismuth

Jour. of Appl. Physics, Vol. 20, pp.1226-1231, 1949

Voce and Hallomes proposed that the agent responsible for embrittlement is bismuth in the form of thin films at the grain boundaries. Internal friction and elastic modulus measurements were made on copper specimens free from and containing bismuth up to 0.01% with a frequency of transverse vibration of about 1000 cycles per sec. from -50° C. The effects of cold work, heat treatment, and the rate of cooling were also studied. The results support the theory of Voce and Hallomes.

PP: B 3 12 16 U X AA 27 36 37 k CV: 14 MI: EG' Cu a 34

Kê T. S. and Ross, M.

An Apparatus for Measurement of Extremely High Internal Friction

Review of Scientific Instruments, Vol. 20, pp.795-799, November 1949

This is an improved form of torsion apparatus in which internal friction is measured by determining angle by which strain lags behind stress in forced cyclic vibration. A periodic voltage of sawtooth wave form is applied to a moving coil galvanometer, in which the test specimen constitutes the suspension; deflection of this galvanometer is a measure of shear strain. As the experiments are conducted at low stress levels, current is a measure of shear stress and is indicated by a second galvanometer. Projection of both galvanometer images on a special scale, and reading of double the distance between stress and strain defections at position of zero strain, allow determination of time separation and hence, phase difference. Apparatus has the advantage that measurements can be made at a constant stress amplitude and frequency. Results of measurements on internal friction appear to compare favorably with torsion pendulum measurements using free decay method. The feature that measurements can be made while the zero point is changing renders the apparatus useful in the study of internal friction of freshly cold worked metals. (Authors' abstract)

PP: 3 E 10 13 16 S 19 AA 27 36 k CV: 14

Kepes, A.

A New Apparatus for Measuring of the Modulus of Elasticity and Internal Friction of Solids. (In French)

Instrument Measurement Conf., Stockholm, Trans., pp.136-138, 1949

A simple dynamic method for measuring moduli in the range from 0 to 2000 rpm is presented. A cylindrical sample is used, the base of which is rotated in a rigid holder. A perpendicular force is applied at the other end of the cylinder so that the elements of the cylinder are subjected to sinusoidal stress variations. Curves of internal friction coefficient vs frequency are given for three materials: ebonite, saran, and polyvinyl chloride. Method has the advantage that the frequency is continuously variable, unlike resonance methods, but requires fairly precise observations.

PP: 3 4 10 13 14 16 19 X AA CV: 13' 14 MI: FF GG' KK

King, R. and Chalmers, B.

Crystal Boundaries

Book: Progress in Metal Physics I. Interscience Publishers, London, pp.127-162, 1949

Knowledge about the regions separating or joining the crystals of metals has until recently been obtained mainly as a by-product of experiments made for quite different reasons. There are still many aspects of the subject that are not understood, but recent work, both experimental and theoretical, has led to a clearer understanding of the part which the crystal boundaries play in the resistance of metals to deformation. The purpose of this chapter is to review the most recent experimental and theoretical work on the behaviour of crystal boundaries. It is necessary to examine the new results in terms of the ideas and experiments of the past in order to see whether the older facts as well as the newer ones are accounted for. Attention is focused in turn on the following aspects of the subject. The first problem is the origin of the boundaries themselves, after which the mechanical properties and effects of the boundaries are discussed, and a short account is given of the work which has been done on the melting of crystal boundaries. Crystal boundaries may for many purposes be regarded as surfaces, and they possess surface energy which may manifest itself as a surface tension. After considering the consequences of this, the chemical behaviour of the boundaries is described. The subject of intercrystalline corrosion has been excluded, as it throws little if any light on the main problem, the structure of the boundary. A final section summarizes the conclusion which may be drawn from the available facts. (Authors' abstract)

PP: AA 27 30 31 CV: 15 16

Koehler, J. S.

The Influence of Dislocations and Impurities on the Damping and the Elastic Constants of Metal Single Crystals

Carnegie Institute of Technology, Tech. Rept. No. 4, Contract No. N6onr-47, 19 p., November 1949

A Theoretical interpretation is presented of the dependence of damping of sound waves in metal single crystals on dislocations tied down at various points along their length by impurity atoms. The dislocations were produced by a rapidly oscillating external shearing stress applied to the solvent-crystal lattice. The influences of the motion of a dislocation and the energy levels of the atoms on the decrease of the effective Young's modulus are described. Fractional density change, dependent on the relative interatomic-distance increase in expanded regions and the lattice-parameter decrease in compressed regions, was negligible between cold-worked and annealed samples. No decrease was observed for cold-worked metals until double slip appeared. The magnitude of elastic-constant change depended on the ability of dislocations to move under stress rather than on the presence of the dislocations. The decrement calculated for a single copper crystal increased with an increase in strain amplitude and a decrease in the dissipation factor. Damping increased to a maximum with a subsequent decrease for large amounts of cold working. Reversible changes were obtained for small strain amplitudes; the limited motion of a dislocation with respect to neighboring dislocations was more important at large strains than the rigidity produced by impurities.

PP: 16 S U X AA 27 30 32 36 37 j k CV: 17 MI: Cu a

Lloyd, D. H.

Metallic Noise

Metal Industry, Vol. 75 Oct. 28, pp.371-375; Nov. 4, pp.391-393; Nov. 11, pp.419-421; Nov. 18, pp.436-438, 444; Nov. 25, pp.455-457, 461; Dec. 2, pp.479-481, 1949

The fundamental principles responsible for the production of noise by metallic objects and structures are outlined. The principles of damping are described which, it is said, may be applied to the design of noise-free metallic products such as car bodies, cabinets, sinks, refrigerators, washing machines, ash-trays, utensils, etc. The methods of application of coatings having damping properties are given. The various sections deal with the nature of noise, noise and the human ear, the mechanism of vibration, origin and control of noise, mechanism of damping, dry friction, viscous damping, application of bitumen compounds, location and quantity of compound, domestic applications, mechanical advantages of damping.

PP: A W AA BB CC 36 39 CV: 15 17

Manson, S. S.

Stress Investigation in Gas Turbine Disks and Blades

Soc. Autom. Engrs., Quart. Trans., Vol. 3, No. 2, pp.229-239, April 1949

Results of an investigation to measure the operating temperatures in a disc of a typical gas turbine are presented here. These temperature data were used to determine operating stresses and their implications on disc bursting, rim cracking, and inner-region cooling.

In turbine blades the major unknowns are reported to be temperatures and vibrational stresses during operation. Results are shown of investigations to measure temperature distributions and vibrational stresses in a typical gas-turbine engine. The temperatures and centrifugal stresses were such as to allow little vibratory stress. Measurements showed that appreciable vibration was present, however, excited mainly by the nozzle vanes and the combustion chambers. Rim cracking in discs with welded blades is probably attributable to plastic flow. Several remedies suggest themselves but the acceptability of the welded-blade construction is limited by considerations of damping and replacement in the field.

PP: A W AA 28 29 CV: 14 17

Manson, S. S., Meyer, A. J., Calvert, H. F., and Hanson, M. P.

Factors Affecting Vibration of Axial Flow Compressor Blades

Proc. Soc. Exp. Stress Analysis, Vol. 7, No. 2, pp.1-15, 1949

Measurements by means of wire-resistance strain gages of blade vibrations in an experimental 10-stage axial-flow compressor during engine operation are used to present information relating to: (1) the effect of centrifugal force on natural frequency of blades; (2) the common modes of vibration present and orders of excitation producing them; (3) the effect of disturbances in the air flow originating in the inlet passage on vibration in each of the 10 stages; (4) the use of loosely mounted blades as a means of vibration suppression (a supplementary laboratory investigation on a rotating wheel was conducted in conjunction with the engine tests); (5) the importance of aerodynamic damping in limiting vibration. Test methods and techniques for testing full-scale compressors under engine operation are described in detail. (Authors' summary)

PP: A W 23 AA BB CC 28 29 36 37 CV: 14 17

Morduchow, M.

On Internal Damping of Rotating Beams

NACA TN 1996, December 1949

For a beam rotating about a transverse axis and harmonically vibrating in a direction normal to its plane of rotation, it is assumed that an internal damping force exists inversely proportional to the vibration frequency and directly proportional to the time rate of change of the elastic load. It is shown that, with such a force, the internal logarithmic decrement of the beam increases asymptotically with the principal mode of vibration to the value πg, which it would have in any mode if the same beam were not rotating. The term g in this value is a dimensionless internal-damping coefficient depending on the beam material. If the beam performs vibrations in the plane of rotation, then the internal logarithmic decrement in the fundamental mode will be either equal to, or slightly less than, πg, but will decrease in the second mode and will then increase asymptotically with the higher modes to the value πg. Thus, rotation of a beam in general diminishes the internal logarithmic decrements.

PP: 3 4 9 10 12 16 19 Y AA 28 CV: 14' 17

Pardue, T. E., Melchor, J. L., and Good, W. B.

Energy Losses and Fracture of Some Metals Resulting From A Small Number of Cycles of Strain

Soc. Exp. Stress Anal. Vol. 7, No. 2, pp.27-39, 1949

Observations are made on behavior of materials when subjected to repeated stresses which exceed their yield strength. Standard specimens of seven different material specifications were tested in an R. R. Moore fatigue machine (operating at 72rpm) at loads which would produce failure in range below 10,000 stress reversals. Energy dissipated during life of each specimen is evaluated and correlated with nominal stress. For the several materials investigated, it is found that energy dissipated increases as applied load is decreased. These tests also indicate that relative ability of materials to absorb energy at equal loads is not always a measure of their ability to withstand repeated cycles of strain at that load. Tests were performed on cold rolled mild steel, commercial copper, stainless steel and 2S aluminum which had been cold worked prior to test, and for hot rolled mild steel, annealed mild steel, cast iron, 24ST aluminum, and annealed copper which had received no cold working prior to test.

Observations were made on the deflections in the vertical plane and in the horizontal plane of the specimens tested in R. R. Moore rotating beam machines and of the changes of these deflections with number of cycles as the tests went on. (1) The hysteresis in the material was observed to produce a curvature of the specimen in the horizontal plane. This has been observed by previous observers for loads in the region of the endurance limit. (2) The curvature in the horizontal plane, and that in the plane of loading was found to vary with number of cycles of strain. (3) Both deflections were found to continually increase, in the case of materials that had received cold work prior to the present test. (4) For cast iron, both deflections continually increased, but at a much slower rate than that for the cold worked materials. (5) The deflections, for three materials which had received no prior cold work, reached a maximum as the applied load reached its full value. Both deflections then decreased rapidly to a value which remained approximately constant for most of the life of the specimen. Just prior to fracture both deflections increased rapidly. (6) The deflections for 24ST were found to continually decrease with the number of strain cycles. This is in contrast to the other materials.

PP: 3 4 7 16 S T AA 29 30 b 36 k CV: 14
MI: ST CN SS Cl Al Cu a h j 42

Peterson, C.

Measurement of Mechanical Damping of Metals. (In German)

Arch. Tech. Messen., No. 164, Vol. 9115-6, pp. T74-T76, September 1949

This paper presents a general discussion of damping and its causes. Factors of which it is often a function are mentioned. Six measuring procedures are reviewed, from static measurement of the damping loop to heat gain methods. Specific machines are described including the optical loop recording machine of Lehr. The presentation is well supported by an extensive bibliography.
PP: C D E F 9 16 AA 30 36 CV: 13 15 18

Pian, T. H. H. and Siddall, J. N.

The Prediction of Stresses in a Structure Under an Arbitrary Dynamic Loading

Mass. Inst. of Tech., Tech. Rept. for Contract N5ori-07833, Dept. of Aero. Engr. 31p., July 15, 1949

An experimental method of predicting the stress at any point in a complex elastic structure under an arbitrary dynamic loading is described. It is shown theoretically that the stress response to a harmonically oscillating force at a given point on the structure may be used to predict the response to any arbitrary force at the same point. Tests are described in which a model wing was shaken by an electro-magnetic shaker at resonant frequencies and the stress response recorded on an oscillograph. Structural damping constants are required and methods for their determination are described. Data on damping from resonance curves and from decay curves are presented. The stress response to a step load was recorded and comparison is made with predicted values. (Authors' abstract)
PP: 3 D E 8 11 12 16 S Y 24 AA BB 28 CV: 14 17 MI: Al

Ruble, E. J.

Tests of a Railroad Bridge With a Mechanical Oscillator

Proceedings of the Soc. for Exp. Stress Analysis, Vol. 7, No. 1, pp.31-44, 1949

Tests were conducted on a truss span in order to determine the separate effect of unbalanced forces in locomotive driving wheels and to study the damping of the structure. The design and construction of the oscillator used to excite the motion is discussed.
PP: 3 E AA BB 28 CV: 14

Sato, H.

On the Internal Stress and the Internal Friction of Metals. I. On the Mechanism of Fatigue. II. The Change of the Internal Friction of Ni_3Fe during the Formation of Superlattice. (In English)

Science Reports of the Research Institues, Tohoku University, Ser. A, Vol. 1, pp.203-211, October 1949

I. The internal friction of a sample was determined as a function of the number of cycles during a fatigue test. The values increased rapidly during the initial stages of fatigue, achieved an equilibrium value, and then increased abruptly just prior to fracture. There was a large decrease in internal friction during the first 25 hours following removal from the testing machine and then it decreased more slowly. II. The internal friction of Ni_3Fe was measured after various periods of annealing at 490°. It decreased during the early stages of superlattice formation but changed very slightly thereafter. The initial decrease occurred more rapidly than the square of the permeability. Inferences were made concerning the internal stress distribution. (From Chem. Abstract, 1951, 5587)
PP: 3 16 T AA 27 30 31 33 36 h 40 42 r CV: 14 MI: CN Al Fe Ni a

Sauer, J. A., Marin, J., and Hsiao, C. C.

Creep and Damping Properties of Polystyrene

Jour. Appl. Physics, Vol. 20, No. 6, pp.507-517, June 1949

The anelastic behavior of polystyrene has been studied by means of creep tests under long-time load application and by means of damping capacity tests under rapidly varying repeated loading. Tensile creep data taken at various stress amplitudes reveal that the log of the creep rate (at 1000 hrs) varies linearly with the log of the stress amplitude. A similar type of variation is obtained when damping capacity or energy absorbed per cycle is plotted against stress amplitude. From these two sets of data, the creep rate is found to be proportional to the square of the damping capacity. It would thus appear possible, for polystyrene at least, to predict 1000-hour creep rates from short-time measurements of absorbed energy under dynamic loading conditions. The data obtained from the creep and damping tests, together with additional data from short-time tension and compression tests, seem to be consistent with an internal structure in which the linear polymer chains and groups of chains are in ordered or partially extended positions, but in which, in the absence of stress, no preference is shown for any particular direction. Under the action of stress--particularly if the stress is maintained for a long period of time--a tendency exists for the ordered regions to orient in the direction of the applied stress. The so-called "crazing" condition which has been observed to occur in the creep specimens is probably a manifestation of this orientation. X-ray evidence appears to support this point of view. (Authors' abstract)
PP: 3 E 7 M 16 S T X AA 27 28 36 40 42 43 CV: 14 17 MI: FF GG'

Sauer, J. A. and Oliphant, W. J.

Damping and Load Carrying Capacities of Polystyrene and Other High Polymers

Proc., ASTM, Vol. 49, pp.119-132, 1949

The investigation is concerned with the experimental determination of the relation between damping capacity and stress for specimens of polystyrene and some other thermoplastic and thermosetting materials. The damping capacities of these materials are determined by a resonant vibration method and found to increase with stress amplitude approximately to the 2.3 power. Among the thermoplastic materials tested, cellulose acetate butyrate is found to have the highest damping capacity and polystyrene the lowest. Various grades of phenolic laminates show still lower energy absorptions under dynamic tension-compression loading. An attempt is made to evaluate the design importance of both damping capacity and fatigue strength by setting up an analysis for the determination of the relative load-carrying capacities of a simple member subject to dynamic loads oscillating at resonant frequency. Despite some rather drastic assumptions, comparative rating of the different plastic materials based on resonant load factors would appear to be more significant than comparative ratings based solely on endurance strength or solely on damping capacity. Among the thermoplastics, methyl methacrylate exhibits the highest resonant load values and is about comparable in this respect to the paper-base phenolic laminates.

For polystyrene, it is observed that damping capacity varies with stress amplitude in the same manner as experimental creep rate values vary with applied tensile stress. Comparison of the data show that the creep rate increases approximately as the square of the damping capacity. (Authors' synopsis)
PP: A 3 E 7 M 16 S X Y AA 27 28 29 42 43 r CV: 14 17 MI: FF GG' HH'

Shepler, P. R. and Nicholson, W. E.

Design, Construction, and Partial Proof Testing of High-Frequency Direct-Stress Fatigue-Damping Machine

Lessells and Associates, Inc., Boston, Mass., Tech. Rept. No. 4 on Dynamic Properties of Materials, O.N.R. Contract N7onr-468-Task Order 1, NR-035-153, 77 p. plus tables and Figures, December 30, 1949.

The report covers the design, construction, and partial proof testing of a high-frequency direct-stress fatigue-damping machine. There is described a three-degree-of-freedom machine and a slight modification denoted as a two-degree-of-freedom machine. The dynamics of the seismic system of the former are covered in the previous report, No. 3. In addition there is described the preliminary design, construction, and testing of a single-degree-of-freedom machine that was done by the contractor at its expense. The three-or two-degree-of-freedom machine has been carried to about 90% completion and is capable of producing direct stress in a 0.44 in. diameter steel specimen of ± 40,000 psi at 950 cps.; the hysteresis measuring equipment is not completely perfected. The single-degree-of-freedom machine is only about 20% complete but shows much promise because of simplicity and versatility. Contractor feels no further work should be done on the large three- or two-degree-of-freedom machine and recommends that full efforts be given in future to research on the single-degree-of-freedom machine. (From contractor's abstract)
PP: 3 E G 11 M Y AA 29 CV: 14 15 17

Shimozuru, D.

Study on the Coefficient of Internal Friction of Materials used in Civil Engineering and Architectural Structures

Bull. Earthq. Res. Inst. Tokyo University. Vol. 27, parts 1-4, pp 85-89, January-December 1949

Damping in solid cylindrical specimens of steel, aluminum, ebonite, and wood was measured by decay of free torsional oscillations. Vibrations were initiated by an electromagnet. Specimen, with a disk fixed at each end, was suspended by a fine wire in a vacuum to reduce external losses. Relative motion of the end of specimen was optically recorded. Curves given of logarithmic decrement vs air pressure do not have numerical ordinates, so that effectiveness of the design in reducing external losses cannot be judged. No information as to stresses, physical properties, and condition of the specimens are given, so that results cannot be compared with other work.
PP: 3 D 9 13 16 19 AA 27 28 CV: 12' 14 MI: CN HH KK Al

Skudrzyk, E.

Internal Friction and Material Losses of Solid Bodies. I. General Theory. (In German)

Öst. Ing.-Arch. Vol. 3, No. 4, pp.356-373, 1949

This paper attempts to treat elastic aftereffects by the common expedient of superposing ordinary elastic and viscous effects (cf., e.g., Weissenberg, Abh. Preuss. Akad. Wiss. Phys.-Math. Lk. 1931, No. 2). Author's theory is tacitly limited to infinitesimal displacement gradients, since he does not distinguish between Eulerian and Lagrangian coordinates and since he employs local rather than material time derivatives. He notes that the response of the material may be characterized by four real functions of frequency. He discusses the definition of elastic moduli and damping coefficients appropriate to various special cases in terms of these functions. A second part is to follow.
PP: Y AA 27 30 d 34 CV: 13 17

Stockel, I. H.

Analysis of a Three Degree of Freedom Seismic System and its Application to a High-Frequency Fatigue Machine

Lessells and Associates, Inc., Boston, Mass., Dynamic Properties of Materials, Tech. Rept. No. 3, O.N.R. Contract N7onr-468-Task Order I, NR-035-153, 37 p. plus figures, December 30, 1949

The analysis carried out in this report was performed to shed light on the mechanics and properties of the seismic system of the three-degree-of-freedom high-frequency direct-stress fatigue-damping machine of Contract N7onr-468. Subjects dealt with were first, seismic analogy in general, then seismic analogy of the three-degree-of-freedom machine, and lastly, certain considerations as to hysteresis gage design. (Contractor's abstract)
PP: 3 5 G 11 Y AA 28 29 CV: 14 17

Wert, C. A.

The Internal Friction of Zinc Single Crystals

Jour. Appl. Physics, Vol. 20, pp.29-37, 943, January 1949

The measurements of decrement were made at frequencies of 41 kc. and 57 kc. For one crystal the decrement showed little rise from its initial value of 2×10^{-5} at very low stress amplitudes up to stress amplitudes nearly three times the static elastic limit. Considerable similarity of behavior of the decrement as a function of stress amplitude resolved into the basal plane has been found for a number of crystals with a wide range or orientation. The obtaining of these consistent results depend on the use of appropriate annealing and etching techniques. The decrement of a well annealed crystal increased with rising temperature at all stress amplitudes throughout the temperature range -75° C to 150° C.

The prior application of static stress far below the static elastic limit has been found to increase the decrement at high stress amplitudes without affecting that at very low stress amplitudes. This increase was a function of the stress amplitude at which the decrement was measured, and of the prior static stress, L. The observations fitted a relation of the form $\log \Delta = C_1 + C_2 L$, where C_1 depended on the amplitude of measurement and C_2 was approximately constant. (Author's abstract)
PP: 3 D 9 M 16 S U AA 27 28 29 36 h j k 40 CV: 14 MI: Zn a

Wilkes, Jr., G. B.

Changes in Internal Damping of Gas Turbine Materials Due to Continuous Vibration

Trans. ASME, Vol. 71, pp 631-634, disc. 634, August 1949.
Am. Soc. Mech. Eng., Paper No. 48-A-95, 1948

A pneumatically driven elevated-temperature fatigue machine and its control. Use of this machine to qualitatively determine initial damping as well as changes in damping of the test specimen during vibration. Variation in high-stress initial damping vs temperature was qualitatively determined for four high-temperature alloys. (Metals Review)
PP: 3 E 10 12 16 S T U AA 29 CV: 14
MI: SG EG' Co Cr Fe Mo Ni W' 30 d e h

Anonymous

Sound-Damping in Business Machines With Magnesium Die Castings

Die Castings, Vol. 8, pp.28-30, February 1950

The use of die-cast magnesium alloys in the LaSalle Stenotype machine is described. (Metals Review)
PP: A 3 6 AA 28 CV: 14 MI: Mg q

Barducci, I.

The Zener Effect in Metals. (In Italian)

Alluminio, Vol. 19, No. 4, pp.324-333, 1950

Theoretical discussion of the thermoelastic (Zener) effect. Internal dissipation of energy by vibration and bending: characteristics of the Zener effect importance of the thermoelastic effect; the magneto-elastic effect. 15 ref. (Metals Review)
PP: AA 27 30 31 c CV: 12' 17

Davies, R. M.

Internal Friction of Solids

"Some Recent Developments in Rheology," London, United Trade Press, pp.27-37, June 1950

Several methods of measurement are discussed. The more interesting and newer methods are those involving wave and pulse attenuation, the first being more suitable for high friction materials. Possible wave distortion is an objection to the second method. The Voigt and Boltzmann models for solids having internal friction are compared with actual observations. Friction of materials stressed at low levels is discussed in terms of relaxation frequencies. (Appl. Mech. Reviews)
PP: 3 D F 6 AA 27 28 30 31 34 CV: 15

Dubs, W.

Recent Investigation of Steam Turbine Blade Vibrations

Escher Wyss News, 23/23, 61-68, 1950/1951

No abstract available

PP: W AA 28 29 CV: 13 14 MI: AY

Duce, A. G.

A Study of Some Fatigue Phenomena in Pure Metals and Alloys

PhD Thesis, Univ. of Cambridge, England, 225 p., 1950

This is an extensive work investigating the mechanism of fatigue in metals and the accompanying phenomena. It is clear that the most important single factor in fatigue is the process of plastic deformation under the influence of cyclic stress or strain. This process was studied for the pure face centered cubic metals, nickel, copper, and aluminum, and to a somewhat lesser extent for the hexagonal metal magnesium. The Chevanard Micro-machine for fatigue testing in alternating torsion, was employed with very small specimens. This machine provides for direct recording of the couple-twist diagram. Readings made from these hysteresis loops were Δ E, the area, and tan β, the slope of the line joining the two ends of the loop with respect to the axis of strain. This slope is directly proportional to an 'apparent' or 'secant' modulus of elasticity. Values of Δ E and tan β were obtained at regular intervals throughout the fatigue tests of specimens of the various materials. Graphs are presented showing the changes in these quantities for specimens tested at various stress levels. These changes indicate three definite stages in the fatigue action. The characteristic changes of each stage are discussed in detail for the different materials. A careful microscopic study was made for the various metals studied in which both the light microscope and the electron microscope were employed. Excellent photomicrographs show the changes in surface structure characteristic of the different stages of the fatigue process in the different materials. In addition to the materials mentioned above, less exhaustive tests were run on ingot iron and a free-cutting sulphur bearing steel to investigate the effect of inclusions on the fatigue process.
PP: 3 5 7 13 16 S T X AA 28 29 42 q r CV: 14
MI: CN Al Cu Fe Mg Ni a k p

Evans, T. F.

The Evaluation of Warp Sizing, Dynamic Resilience and Weaving Tests

Textile Research Inst., Inc. Tech. Rept. No. 8, Contracts N7onr-374, Nonr-09001, 134 pp, 1950 (U 17799)

The resilient properties of coated and uncoated viscose and nylon yards were investigated by the method of forced resonance vibration, using a linear variable differential transformer. Fibers and yarns exhibited nonlinearity in their dynamic behavior as evidenced by the dependence of modulus and internal friction on amplitude of vibration, static testing tension, and time after application of the testing tension. Measurements on coated and uncoated yarns, dried under a tension sufficient to prevent crimp, indicated that the differences in modulus and internal friction can largely be attributed to the change in cross-sectional area due to coating, and that these properties would be of no value in characterizing sized yarns for this efficiency in weaving. A statistical analysis of weaving operations showed that warp stops and total loom stops, even within a single weaver's set, do not follow a Poisson distribution. The variances were represented by px, where p is a constant between 1.0 and 3.0 and x is the average breaking rate. The residual variance, after the removal of regression of loom stops on total picks woven, was different for individual weavers (or set) but was not correlated with the average number of stops of the average time required for repairing a stop. The duration of a test required to establish a significant difference between 2 sizing processes by counting warp breaks, total stops, or total picks woven was estimated to have a ratio of about 1:2:7. (Contractor's abstract)
PP: 1 3 E G M 14 16 S T X AA 27 30 34 36 39 42 43 CV: 14 15' MI: JJ

Findley, W. N.

Comments on Creep and Damping Properties of Polystyrene

Jour. Appl. Physics, Vol. 21, No. 3, pp.258-260, March 1950

This is a letter to the editor commenting on the article written in 1949 by Sauer, Marin, and Hsiao on creep and damping properties of polystyrene. There is presented a different interpretation of the data on creep and damping, and the correlation of damping capacity and creep rate than the views advanced by Sauer, Marin, and Hsiao.
PP: AA 28 29 30 34 42 43 CV: 17 MI: FF GG'

Fine, M. E.

A Simple Torsion Pendulum for Measuring Internal Friction

Jour. Institute of Metals, Am. Inst. Min. and Met. Eng., Trans., Vol. 188, p. 1322, 1950

This paper is a brief technical note presenting design of a torsional pendulum for measuring internal friction. This particular design, a modification of the pendulum of Ke, is aimed at reducing parasitic or background energy loss to a minimum. Data are given for several nonferrous alloy wires.
PP: 2 3 D 8 13 AA 27 CV: 14 MI: EG' Co Cu Fe Mn Ni Zn' a 33 g

Finkelshtein, B. N. and Fastov, N. S

Contribution to the Theory of Relaxation Phenomena in Solids. (In Russian)

Dokalady Akademi Nauk S. S. S. R., New ser., Vol. 71, pp.875-878, April 11, 1950

The paper attempts to formulate a new theory of relaxation on the basis of general thermodynamic considerations. Basis mathematical formulas for this theory are interpreted for different values of the variables.
PP: AA 27 30 31 34 CV: 12 17

Freudenthal, A. M.

The Inelastic Behavior of Engineering Materials and Structures (Book)

John Wiley & Sons, Inc., New York, 587 pp., 1950

Chapter 10 deals with the inelastic behavior of materials under dynamic condition. A general treatment of the subject of damping capacity is given followed by a discussion of the theory of anelastic effects, (pp. 326-349).
PP: A B C D E 7 8 J 11 R S T U AA 27 28 29 a 31 32 g 38 CV: 16

Fukada, E.

The Vibrational Properties of Wood

Jour. Phys. Soc. Japan, Vol. 5, No. 5, pp.321-327, Sept.-Oct., 1950

Logarithmic decrements are recorded on the basis of electric charges applied, and Young's moduli are measured on the basis of resonant frequency of lateral longitudinal vibration of 30 x 2 x 0.5-cm specimens representing 18 softwood and 10 hardwood species. The experimental data were obtained for the frequency range of 100 to 5000 cps at 10 C and 15% moisture content of the samples. While Young's modulus shows hardly any variation with change in frequency of vibration, the decrement varies considerably. Thus, the decrement increases gradually with frequency of softwood specimens and decreases with a maximum value within the test range of hardwood specimens. This definite variation of the logarithmic decrement is considered to be a characteristic behavior of the two basic wood types.

According to a few additional exploratory tests, the modulus of elasticity perpendicular to the grain is about one tenth, and the logarithmic decrement is approximately three times that for wood parallel to grain. The influences of both moisture content and temperature of wood on the vibrational properties will be reported on in a second paper. (Appl. Mech. Reviews)
PP: 3 E 9 M 16 19 X AA 36 40 CV: 12' 14 MI: HH

Fusfeld, H. I.

Apparatus for Rapid Measurment of Internal Friction

Review of Scientific Instruments, Vol. 21, No. 7, pp.612-616, July 1950

This paper describes apparatus for measuring internal friction which satisfies the conditions (a) low induced stress amplitude to preclude any plastic flow of the specimen; (b) ability to install specimen within a few minutes after treatment; (c) rapidity of measurement, at a rate of 10 to 20 per min.; and (d) accuracy of at least one percent.

Longitudinal vibrations are induced by an eddy-current drive, similar to one previously described in the literature, satisfying (a) and (b). Conditions (c) and (d) are obtained by measuring the decay time of free vibrations using vacuum-tube trigger circuits and a counter chronograph. Satisfactory measurements can be made with push-button rapidity and simplicity. (Author's summary)
PP: 3 D E M AA 27 CV: 14

Fusfeld, H. I. and Gilbert, J. T.

Some Physical Properties of Titanium

The Physical Review, Vol. 77, pp.302-303, 1950

On specimens cut from three titanium rods obtained from a commercial facility tests were made of internal friction and velocity of sound, using apparatus previously described (Phys. Rev., Vol. 75, p. 1626, 1949). Measurments were made at less than 0.1mm. Hg. Results are given in tabular form.
PP: 3 D 9 M X AA 27 CV: 14 MI: FG d 34

Geiger, P. H.

Vibration Damping

Engineering Research Inst., U. of Michigan (N6onr-23211), 44 p., October 1, 1950 (ATI 114970)

Materials and structures which are capable of reducing vibration in solids are discussed. An economical method for damping a vibrating panel consists of covering small areas of the panel at the antinodes with damping material. An instrument (nodagraph) which was devised to plot the vibration pattern on an automobile door and may be of use in general vibration studies determines the nodal lines by the phase shift which occurs at a nodal line. A miniature velocity microphone is used as the pickup device thus permitting measurements to be made without making contact with the vibrating body. A method for measuring the rate of decay of vibrations is described. The characteristics of several forms of damping materials and their suitabilities for various applications are discussed. A vibration damping structure being developed offers effective damping at all frequencies and is extremely effective at a selected frequency. Small circular portions are embossed in a sheet material possessing damping properties, and a mass is placed at the center of each circle. The structure is cemented to the panel be to damped. (Contractor's abstract)
PP: A 3 D W AA BB EE 36 39 CV: 14 17 MI: GG JJ

Gemant, A.

Frictional Phenomena (Book)

Chemical Publishing Co., Brooklyn, N. Y., 497 pp., 1950

Part A deals with Frictional Processes in General; Part B, with Frictional Processes in Gases; Part C, with Frictional Processes in Liquids; Part D, with Frictional Processes in Solids; and Part E, with Problems. Part D has chapters dealing with: The Plastic Flow of Solids, Correlation between Elastic Moduli and Viscosity of Liquids and Plastics; Engineering Applications of the Plastic Flow of Solids, Internal Friction in Solids, Engineering Applications of the Internal Friction in Solids, Reduction of Vibrations by use of Materials of High Damping Capacity, Stress-dependent Plastic Resistance and Damping Capacity of Solids, and Engineering Applications of External Friction.

PP: A Y AA BB CC 28 CV: 15 16 18

Gerold, E. and Karius, A.

Rapid Method for Determining Fatigue Strength. (In German)

Archiv. Für das Eisenhüttenwesen, Vol. 21, pp.191-195, May-June, 1950

New method which measures change in natural frequency and damping power of the metal under alternating stresses increased in steps. Tests were made on seven carbon and six alloy steels, also three nonferrous metals. Results show that the test is only partly valid for tempered Cr steels and nonferrous alloys, and wholly useless for notched specimens. (Metals Review)

PP: 3 D 9 12 16 S X AA 29 42 r CV: 13 14 15
MI: ST CN AY Al Cu Fe Zn' n

Good, W. B., Melchor, J. L., and Pardue, T. E.

Energy Losses and Fracture of Some Metals Resulting from a Small Number of Cycles of Strain

Proceedings, Soc. Exp. Stress Analysis, Vol. 7, pp.27-29, 1950

Observations are made on the behavior of materials when subjected to repeated stresses which exceed their yield strength. Standard specimens of seven different material specifications were tested in an R. R. Moore fatigue machine (operating at 72 rpm) at loads which would produce failure in range below 10,000 stress reversals. Energy dissipated during life of each specimen is evaluated and correlated with nominal stress. For the several materials investigated, it is found that energy dissipated increases as applied load is decreased. These tests also indicate that the relative ability of materials to absorb energy at equal loads is not always a measure of their ability to withstand repeated cycles of strain at that load.

PP: 7 N 16 S AA 29 42 r CV: 14

Hermes, R. M. and Yen, C. S.

Dynamic Modeling for Stress Similitude

U. of Santa Clara, Santa Clara, Calif., Dept. of Appl. Mech., Tech. Rept. No. 2, ONR Contract N8onr-523, 43 p., July 1950

Modeling methods for dynamic stress analysis and the concept of engineering accuracy are briefly discussed. The results of the analytical work on dynamic modeling of beams presented previously by the senior author are then summarized. In order to verify the results of this previous analysis, three series of tests of cantilever beams, namely, (1) free vibration tests, (2) impulse or drop tests, and (3) forced vibration tests below and at resonance speed were made. The test procedure is described and the results discussed. A dimensionless unit of time is introduced and the effect of damping is considered. It is indicated that the tests conducted verify within the limits of engineering accuracy the conclusions of the previous analysis, namely: for those applications where damping can be neglected, modeling for stress similitude can be attained if the dimensionless radius of gyration is the same for prototype and model; and for those applications where internal damping is of importance, geometric similarity between prototype and model is necessary. (Authors' abstract)

PP: 3 D F 10 12 Y AA 28 30 34 CV: 14 17 MI: CN Al Cu Zn' n

Kammerer, A.

Internal Friction of Solids and Viscosity. (In French)

Comptes Rendus Acad. Science Paris, Vol. 231, No. 23, pp.1285-1286, December 1950

Damping of solid materials increases with temperature. It would therefore seem that this effect cannot be considered as a viscosity since viscosity decreases with increasing temperature. This contradiction is only apparent and can be explained by a decrease in elastic modulus larger than a decrease in viscosity. (From author's summary)

PP: 16 U X AA 30 d CV: 13' 15

Kawai, H. and Tokita, N.

On the Young's Moduli and Internal Friction of Papers

Jour. Phys. Soc. Japan, Vol. 5, No. 5, pp.365-369, 1950

The dynamic properties of paper such as modulus of elasticity and internal friction were investigated. These properties depend on moisture content of paper and properties of fiber of the paper. In region of audio frequencies, they are almost independent of frequency. Above 100 KC damping capacity increased linearly with frequency. Below 100 KC the internal friction shifts from this straight line relationship.

PP: 3 16 19 X AA 27 36 40 CV: 12' 14 MI: HH

Kê, T. S.

Internal Friction of Cold-Worked Metals at Various Temperatures

Trans. AIME, Vol. 188, pp.575-580, 1950

Low stress internal friction measurements in torsion were made on severely cold-worked 99.991% aluminum where it was annealed at successively higher temperatures until it had completely recrystallized. Measurements were over a temperature range from room temperature up to the temperature for complete recrystallization. Internal friction Q^{-1} is reported as $1/\pi$ times the logarithmic decrement. Factors affecting the internal friction such as temperature of prior anneal, the temperature of measurement, the amount of cold-working, the annealing time, and the presence of impurities, were examined. Experiments were carried out at a low stress level and at a strain amplitude which makes the Q^{-1} measurements independent of the strain amplitude. Observations indicate that Q^{-1} exhibited by the specimen consists of two parts, that introduced by cold-worked, and that which is "residual" and not influenced by annealing even above recrystallization temperature. Q^{-1} due to cold-work is observed to depend on many factors. It increases with temperature at which it is measured, and is highest just below recrystallization temperature. At higher temperatures it is higher than the residual Q^{-1}. It increases with amount of cold-work, and decreases with aging at a high temperature. The presence of impurities reduces both the cold-work and residual Q^{-1}, and, in addition, produces an anomalous effect similar to that produced in iron by the presence of carbon or nitrogen. The cause or causes of the Q^{-1} due to cold-working are not completely isolated; however, it is suggested that it may have its origin in a discontinuous viscous phase such as slip bands, grain or crystallite boundaries, or with the stress-induced motion of dislocations inside the grain boundary. (Author's abstract)

PP: B 3 D 8 13 16 U AA 27 30 31 32 36 h k n CV: 14
MI: Al a

Kê, T. S.

A Study of Recrystallization and Grain Growth by Measurments of Internal Friction

Jour. of Metals: Am. Inst. Min. and Met. Eng., Trans, Vol. 188, pp.581-585, March 1950

It is shown that a study of the change of internal friction during recrystallization and grain growth furnishes a new method of approach toward the understanding of recrystallization and grain growth in terms of elementary atomic process. Each metal has a definite temperature at which the internal friction of a cold-worked specimen drops abruptly with an increase of temperature of anneal and of measurement. This can be defined as the complete recrystallization temperature. It is higher than the conventional recrystallization temperature. It is displaced toward a higher temperature for a small amount of prior cold-work, but seems to be relatively insensitive to the amount of prior cold-work, but seems to be relatively insensitive to the variation of the rate of heating and of the impurity content although the magnitude of internal friction is considerably reduced by slow heating or the presence of impurities. I. F. measurements on a slightly cold-worked specimen indicate that the recrystallization process is heterogeneous under these conditions. The I. F. curve is composed of an apparent peak and a continuous rising branch at high temperatures. The former is associated with the stress relaxation across the boundaries of the recrystallization grains and the latter has its origin in the unrecrystallized grains. The conditions favoring grain growth or grain boundary migration are shown to correspond to conditions for a lower coefficient of viscosity at the grain boundary. It is suggested that the grain boundary viscosity is lowered by the accumulation of diffused holes at the grain boundaries. The viewpoint indicates that the effect of holes is a reverse of that of impurity atoms. (From author's summary)

PP: B 3 D 8 13 16 U AA 27 30 31 32 34 36 k 41 CV: 14
MI: Al Cu Fe a

Kê., T. S.

A New Internal Friction Peak and Experimental Evidence of the Existence of Dislocations in Metals

Sci. Rec. Peking, Vol. 3, No. 1, pp.61-65, October 1950

Internal damping measurements have been employed often in recent years to study relaxation-time effects. In particular, if a graph of internal dissipation as a function of frequency (or temperature) shows a peak, then this peak is supposedly connected with a relaxation time of the material under study. Present paper reports such a study in which it is believed the observed peak in dissipation is associated with the phenomenon of capture of dislocations by a solute atom. The material studied was pure aluminum with 0.5% of electrolytic copper added. It was annealed at 500 C and cold-worked by drawing through a 0.033-in. dia, after which it was annealed for one hour at 300 C. The grains in this material were still imperfect.

It was found that the internal damping at any given frequency and temperature was a function of the amplitude of vibration and was a maximum at a specific amplitude. Likewise, the damping as a function of temperature at a fixed amplitude of vibration also showed a maximum. No peaks were found with high-purity aluminum which was copper-free or with the alloy after complete recrystallization had been effected by annealing at 400 C for two hours. Author interprets these results as substantiating the notion that dislocations and solute atoms tend to bind together. (Appl. Mech. Reviews)

PP: 3 D 8 13 16 S U AA 27 30 32 CV: 14 MI: Al Cu' a

Kê, T. S.

Internal Friction of Metals at Very High Temperatures

Jour. Appl. Physics, Vol. 21, pp.414-419, May 1950

In connection with a study of internal friction peak (versus temperature) associated with viscous behavior of grain boundaries in metals, some other effects were observed at higher temperatures causing additional internal friction in superposition with the high-temperature branch of this internal friction peak. This additional internal friction was found to have its origins in some effects of cold working introduced into the interior of the grains which remains even after complete recrystallization. This friction was found to be very high in aged specimens of high-purity aluminum. Observations are consistent with the viewpoint that this internal friction is caused by the presence of dislocations in the interior of the specimen.

PP: B 3 D 8 13 16 U AA 27 30 32 36 37 k CV: 14 MI: Al Cu Mg a

Kê, T. S.

Anomalous Internal Friction Associated With the Precipitation of Copper in Cold-Worked Al-Cu Alloys

Physical Review, Ser. 2, Vol. 78, pp.420-423, May 15, 1950

Anomalous internal friction at very small stress levels observed in cold-work aluminum containing high-purity Al, can be eliminated by annealing at high temperatures so that the specimen completely recrystallizes. This anomalous behavior is shown to be associated with an early stage "precipitation" of Cu from the solid solution with Al. Observed phenomena are consistent with the concept that atmospheres of foreign atoms are formed around the dislocations created in the specimen by cold working. (Metals Review)

PP: B 3 D 8 13 16 S U AA 27 30 32 36 h n CV: 14 MI: Al Cu' a

Kê, T. S. and Zener, C.

Structure of Cold-Worked Metals as Deduced From Anelastic Measurements

"A Symposium on the Plastic Deformation of Crystalline Solids." Office of Technical Services, U. S. Dept. of Commerce, pp.185-191, 191-192, 1950

No progress has been made to date in a quantitative correlation of the internal friction with the structure of cold-worked metals. This lack of quantitative correlation is due primarily to lack of knowledge of the structure of cold-worked metals. The authors have therefore abandoned attempts to interpret the observed anelastic phenomena associated with cold-working in terms of structure and have attempted the converse, namely, to interpret the structure of cold-worked metals in terms of the associated anelastic behavior. Results are reported in this paper. Internal friction measurements, and creep and creep recovery measurements were employed in the interpretation. (Authors' abstract)

PP: B 3 D AA 27 30 31 36 k 42 43 CV: 14

Koehler, J. S.

The Influence of Dislocations and Impurities on Damping and the Elastic Constants of Metal Single Crystals

Carnegie Institute of Technology, Tech. Rept. No. 5, Contract N6onr-47, 21 p., August 1950 (U12987)

The notion of edge type dislocations which are "pinned down" by impurity atoms is treated for the case of a periodic external stress. An expression for the distribution of free lengths of dislocation is obtained. The zero amplitude decrement and plastic contribution to the elastic constants are calculated. The amplitude dependence is discussed by supposing that some of the dislocations break away from the impurities. The results obtained are in agreement with experiment if the damping force on a dislocation is about a hundred times previously suggested values. (Author's abstract)

PP: 3 6 9 16 S U X AA 27 30 32 36 37 j k CV: 14 17 MI: Cu

Koehler, J. S.

The Influence of Dislocations and Impurities on the Damping and the Elastic Constants of Metal Single Crystals (Enlarged Version Including Strain Amplitude)

Final Rept. 7p. 18 refs. Carnegie Inst. of Tech. (N6oni-47, Task Order 1) September 1950. (U 13163)

Measurements of Δ and Y made on 99.999% pure Cu and Pb crystals in the kc. range indicate (1) an increase in Δ with strain amplitude, small amounts of cold working, temperature, and frequency from 37 to 111 kc. (2) a decrease in Δ with impurities and large amounts of cold working, (3) and increase in Y with impurities and decrease with strain amplitude, (4) a permanent increase in Δ with strain amplitude above 10^{-6} and decrease with annealing, and (5) a maximum Δ with a strain of 10^{-3} to 10^{-4}. The residual electrical resistance of initially ordered single $AuCu_3$ crystals increased linearly with extension and suddenly at definite strains. Creep data for 99.999% Cu and Pb were obtained at 90° to 0°C for Pb. The Cu yield stress was independent of temperature in the T range. Steady-state creep increased rapidly with temperature and stress. Kink bands of 99.9999% pure Zn crystals were produced by the application of 10^9 ergs for 0.04 sec. The dislocation theory gave a general expression for the force on a line element of a dislocation; the force was proportional to the shearing stress component acting on the slip plane. (Contractor's abstract)

PP: 3 6 9 16 S U X AA 27 30 32 36 37 j k CV: 14 17
MI: EG Cu Pb Zn a 36

Kuntze, W.

Dependence of the Elastic Strain Coefficient of Copper on the Pre-treatment

National Advisory Committee for Aeronautics, Tech. Memo., p.1287, 1950

Original article appeared in Zeit. f. Metallkunde, 20. Jahrgang, Heft 4, 1928. "Abhängigkeit der elastischen Dehnungszahl α des Kupfers von der Vorbehandlung"

The effect of various pretreatments on the elastic strain coefficient α (defined as the reciprocal of the modulus of elasticity E) and on the mechanical hysteresis of copper has been investigated. Variables comprising the pre-treatments were prestraining by stretching a tensile testing machine and by drawing through a die, ageing at room temperature and elevated temperatures, and annealing. The variation of the elastic strain coefficient with test stress was also investigated.

PP: 3 5 10 X AA 27 36 h k n CV: 11' 13 14 MI: Cu a

Lazan, B. J.

A Study With New Equipment of the Effects of Fatigue Stress on the Damping Capacity and Elasticity of Mild Steel

Trans., Am. Soc. Metals, Vol. 42, pp.449-549, 1950

Initial work on a research program for correlating fatigue, damping, and elasticity behavior of materials and structures under sustained cyclic stress indicated the inadequacy of existing testing equipment, particularly for damping measurements at high stress levels. One of two new dynamic testing machines developed for this work, a rotating cantilever beam machine, is described. Test data are presented to indicate the changes in damping capacity and dynamic modulus of elasticity of hot-rolled mild steel during a fatigue test. In general, cyclic stress below 80% of the fatigue limit has little effect on damping and elasticity, whereas stress applied between this cyclic stress sensitivity limit and the fatigue limit increases damping as much as 2500% and reduces modulus as much as 11%. Cyclic stress above the fatigue limit has even more pronounced effects. Consistent and significant patterns and trends under sustained cyclic stress are presented to show relationship of damping and elasticity to fatigue. An analysis and correlation of changes in damping capacity with the changes in dynamic modulus is given. Two newly introduced terms, cyclic stress sensitivity and ultimate cyclic stress sensitivity, are used in the analysis of dynamic ductility or notch concepts and fatigue specimen form factors. Exploratory tests on variable stress histories, overloading, underloading, rest, speed, and other variables are presented. (Author's abstract)

PP: 3 4 7 L N 16 S T 19 X AA 28 29 42 43 r CV: 14 MI: CN j

LeRolland, M.

Use of the Pendulum for the Study of Elastic Properties of Solids

Non-Destructive Testing, pp.16-19, Spring Number, 1950

Discusses the use of the pendulum for the study of the mechanical properties of solids, especially the modulus of elasticity and internal friction. The method involves the use of sympathetic pendulums. The principle, simplicity, convenience, and accuracy of the method are discussed.

PP: B 3 D J 13 X AA 27 CV: 17

Lethersich, W.

Apparatus for the Study of Creep of Dielectric Polymers and Their Dynamic Rheological Properties

Instrument, Vol. 27, No. 11, pp.303-306, November 1950

Apparatus is decribed for applying a shear stress rapidly to solid materials and for measuring the strain a few milliseconds afterwards. Apparatus can also be used for measuring the dynamic modulus and internal friction coefficient over a range of frequency from 30 to 1000 c/s; a modified form enables the frequency range to be extended down to 10^{-4} c/s. (From author's summary)

PP: 3 10 13 16 19 X AA 28 d CV: 17

Lethersich, W. and Pelzer, H.

The Measurement of the Coefficient of Internal Friction of Solid Rods by a Resonance Method.

British Jour. Appl. Physics, Vol. 1, pp.18-22, January 1950

A theory is given and an expression derived relating amplitude of vibration with frequency for a rod subjected to alternating mechanical stress. The coefficient of internal friction of the material can be deduced providing the internal friction is small as for example with metals. With plastics the internal friction is larger, so that a correction must be applied. The form of the expression is given for this correction. The physical basis from which the fundamental equations are derived is discussed and the relation between longitudinal and tangential viscosity is deduced. An expression has also been derived which enables the volume viscosity to be determined should experiments show the existence of volume viscosity. (Authors' abstract)

PP: 3 F 10 M P 16 19 X Y AA 30 d 34 CV: 17

Linacre, E.

Damping Capacity. Part I. Introduction and Technique of Measurement.

Iron and Steel, Vol. 23, pp.153-156, May 1950

This review of the literature on the property of a material which damps out vibrations, shows that past work has been carried out by two groups of workers. The first were engineers interested in measurements at the high stress amplitude of practical importance, and the second group were physicists who made measurements at much lower stresses in order to examine metallic structure. In this survey the methods of measurement are considered, and then the results obtained by alteration of any of the factors involved in either the method of measurement or the condition of the specimen. Theories (notably by Zener) are briefly introduced to explain the results, and the correlation of damping capacity with other physical properties is considered. (Author's summary)

PP: 3 D F F 8 J 10 M N P 16 20 AA 27 28 29 CV: 15 18

Linacre, E.

Damping Capacity. Part II. Effect of Conditions of Measurement.

Iron and Steel, Vol. 23, pp.285-288, June 1950

This part deals with the results of past measurements, in particular considering the effect of the conditions of the measuring procedure, on the damping capacity. The factors discussed are the effects of vibration amplitude, mode, and frequency, as well as temperature and duration of testing.

PP: 16 S T U AA 27 28 29 CV: 15 18 MI: ST KK Ag Al Cu Zn' n

Linacre, E.

Damping Capacity. Part III. Effect of the Specimen. Part IV. Correlations and Conclusions

Iron and Steel, Vol. 23, pp.344-348, August 1950

Part III discusses the effect of specimen condition on damping capacity. The effects of composition and grain size, heat treatment, cold work, imperfections, and ferromagnetism are dealt with. Part IV deals with the connection of damping capacity with other physical properties of a specimen, namely plasticity and strength and elasticity. Finally a few conclusions are drawn from this review of the present situation in this field of research.

PP: J 16 V AA 27 28 29 30 b c g h j k m 42 q CV: 15 18
MI: CN Al Cu Fe Pb Zn

Lyons, W. J.

Some Theoretical Considerations of Dynamic-Property Data on Textile Specimens

Jour. Appl. Physics, Vol. 21, No. 6, pp.520-522, June 1950

Early stretch-vibrometer data, of quite extensive character, on the frequency dependence of the internal friction μ of a Nylon monofil, has been found to conform to a relation which was deduced independently by Tobolsky and Eyring from considerations of molecular structure. Among other constants evaluated was the relaxation time for the secondary-bond network, which was found to have the value 9.3 sec. By more sensitive graphing methods than had been used heretofore, it was confirmed by the Nylon data that the hyperbolic relationship between resonant frequency and the internal friction holds equally as well as the equation referred to above. The two relationships are shown to be nearly equivalent in the present experimental range. Using the same graphical method with a set of data on 11/4/2 cotton cord a relation between resonant frequency and internal friction was also established. (From author's abstract)

PP: 3 E 10 M 16 19 X AA 27 42 q CV: 17 MI: FF GG' JJ

Marx, J. and Koehler, J. S.

Decrement and Young's Modulus Measurements on Single Crystals of Copper and Lead

"A Symposium on the Plastic Deformation of Crystalline Solids" Office of Tech. Services, U. S. Dept. of Commerce, pp.171-183; disc. pp.183-184, 1950

It is felt that the damping and the elastic constant measurements provide useful information on the internal imperfections present in well-annealed metal single crystals. They also provide information concerning the internal changes which occur for very small stresses which are, however, already capable of producing a small amount of plastic deformation. The present paper gives a survey of information obtained recently on single crystals of 99.999% pure copper and lead. The tests were made by the method of longitudinal waves established in specimens by cementing them to piezoelectric quartz crystals.

PP: B 3 6 M 16 S 19 X AA 27 30 b 33 36 h j k m CV: 14 MI: Cu Pb a

Masing, G.

Physics and Metallurgy

Metall. Vol. 4, Nos. 9/10, pp.171-178, May 1950

This paper is a discussion of the important role played by modern physics in the interpretation of (1) the crystal structure of intermetallic compounds--Hume-Rothery phases, Laues phases, etc., (2) the properties of solid solutions, (3) the nature of plastic deformation--the dislocation theory, and (4) the nature of damping. 17 references. (Institute of Metals, Met. Abs. Vol. 18, P. 466, 1950)

PP: AA 30 31 34 CV: 13 15

Mitsuhashi, T. and Tsuya, K.

On the Fatigue Strength and Damping Capacity of Time-Piece Springs. (In Japanese)

Jour. Mech. Lab. Tokyo, Vol. 4, No. 5, pp.180-185, September 1950

Authors examined the relation between the damping capacity and fatigue strength of time-piece springs. Results obtained are as follows: (1) Damping capacity of those springs which are oil quenched and tempered is the lowest at the tempering temperature 300-400 C, when the structure of the spring is most stable and strongest for repeated stress. This low damping capacity and high fatigue strength are due to the fine tempering structure (2) When spring is tempered at constant temperature, damping capacity decreases rapidly and then increases slowly as the tempering time. This coordinates the relaxation of internal stress and the decomposition of residual austempering, the experimental results are so irregular that no conclusion is drawn. (From authors' summary)

PP: AA 36 h 42 r CV: 12' 14 MI: ST CN AY

Mooney, M. and Black, A. S.

Elongation Hysteresis of Hevea and Synthetic Elastomers

Canad. Jour. Res. Sec. F., Vol. 28, No. 4, pp.83-100, April 1950

Using an ingenious instrument termed a "spider hysterometer" (U. S. Patent, 1,595,318, Shields, 1926) direct measurements were made of the energy loss per cycle of elongation in certain commercial elastomers. Six samples positioned like spokes of a wheel are stretched to various mean initial elongations between a small disk (hub) and a large disk (rim). The rim is motor-driven and the hub, mounted in a ball bearing, is displaced eccentrically with respect to the rim. In the straining cycle which each sample undergoes from some minimum arbitrary extension to some maximum arbitrary extension, the hysteresis gives rise to average force on the hub which is proportional to the energy loss per cycle of rim rotation. A level and balance system using special low-friction air bearings makes it possible to measure the hysteresis force while the rim is turning. Measurements were made on T-50 specimens, die cut from 1/10-in. sheet Hevea, GR-S, Butyl, Hycar, Perbunan and Neoprene gum sticks. Absolute hysteresis coefficient, defined as the ratio of energy loss per cycle to the product of specimen volume, and the square amplitude of strain cycle were obtained as a function of mean initial elongation of the six specimens. These data indicated for all stocks that the absolute hysteresis decreased as function of mean initial elongation except the crystalline stock, which initially decreased, then increased with larger strains. The hysteresis decreased slightly as a function of strain amplitude for all stocks, increased with frequency between 2 and 60 cps, and decreased as a function of temperature. A simple theory for the measurement of a "differential modulus" by means of the instrument is given and measurements presented which have dependencies on mean initial strain which first decrease then increase as the strain increases. This modulus decreases as the strain amplitude increases; is comparatively unaffected by frequency changes between 2 and 60 cps, and decreases with temperature except in Hycar and Perbunan at low initial extensions and Hevea at low strain amplitudes. The "relative Hysteresis" (proportional to the log dec.) is defined as the ratio of "absolute" hysteresis to the differential modulus. The dependency of the relative hysteresis on the independent variables on the study is similar to that given above for the absolute hysteresis. All the data suggest that the absolute hysteresis increases as temperature of the test approaches the second-order transition temperature of the various stocks used; and roughly follows a common trend when plotted as a function of temperature of test minus the second-order transition temperature for the respective stocks. This suggests to authors that the mechanisms leading to this tensile hysteresis in the stocks studied are related to those which develop "brittleness" as the temperature is reduced to the second-order transition temperature. Certain departures from this observation were noted for Hevea and Butyl stocks. (Appl. Mech. Reviews)

PP: 3 5 7 10 M R S U X AA 28 CV: 14 MI: GG

Nielsen, L. E.

Some Instruments For Measuring the Dynamic Mechanical Properties of Plastic Materials

Bul. Am. Soc. Test. Mat., No. 165, pp.48-52, April 1950

Author describes apparatus and experimental technique for determining the dynamic elastic moduli and damping or energy dissipation factors for vibrating specimens of plastic material. Two types of test are described. One uses the cylindrical specimen as the elastic element of a torsion pendulum. From observations of the freee oscillations of the system, the shear modulus and logarithmic decrement are calculated. Frequencies in the range 1/50 to 2 cycles have been used. The other test utilizes a specimen in form of a reed or strip forced to vibrate as a cantilever by the motion of the base, which is driven by a loudspeaker coil at frequencies of about 10 to several hundred cycles per sec. Observations of the amplitude through the resonance range enable Young's modulus and the damping coefficient to be determined. Author discusses applications of these test methods to study properties of plastic materials, such as polystyrene and polyvinyl chloride. (Appl. Mech. Reviews)

PP: 3 D E J 10 L 12 13 16 U X AA CV: 14 MI: FF GG'

Nowick, A. S.

A Study of Amplitude-Dependent Internal Friction Arising from the Motion of Dislocations in Single Crystals of Copper

"A Symposium on the Plastic Deformation of Crystalline Solids," Office of Technical Services, U. S. Dept. of Commerce, pp.155-167; pp.167-170, 1950. Abs. Physical Review, Vol. 80, No. 2, p. 249, October 15, 1950

The behavior, under stress, of individual dislocations of various types, and the interaction of pairs of dislocations, have been studied theoretically. In order to understand the plastic behavior of real crystals, however, one must know the properties of the complex array of dislocations that occurs within the crystal lattice, i.e., how this array is affected by stress, temperature, and the presence of impurity atoms. The arrangement or array of dislocations will be said to determine the condition of the lattice.

In this paper measurements of internal friction, which reflect the condition of the lattice are described. It is shown that (1) the measurements correspond to a relatively simple behavior of dislocations, viz., their oscillation about an equilibrium position under alternating stress, and (2) the measurements do not in themselves produce a change in the condition of the lattice, so that each observation may be regarded as a measure of that condition. Because (2) applies it is possible to carry out external treatments on the specimen using the measurements under discussion to describe its conditions at each stage of the treatments. Such an application will be discussed in the last section of this paper

The method of measurement of internal friction used is that of the composite piezoelectric oscillator. In this method the resonant frequency and decrement of the specimen are obtained by measuring the equivalent electrical circuit of an X-cut quartz crystal cemented to the specimen so that the two vibrate together in forced longitudinal vibration. Measurements are made at 39 and 78 kc/sec/ and are carried out so that external dissipation is practically eliminated. (Metals Review)

PP: B 3 E 9 M 16 S U X AA 27 30 32 36 j CV: 14 17 MI: Cu a

Nowick, A. S.

Variation of Amplitude-Dependent Internal Friction in Single Crystals of Copper With Frequency and Temperature

Physical Review, Ser. 2, Vol. 80, pp.249-257, October 15, 1950

The amplitude-dependent internal friction which originates in the motion of dislocations in single crystals of copper is studied as a function of frequency and temperature. Quantities are introduced which express the dependence of internal friction and of Young's modulus on strain amplitude and it is shown that these quantities are significant measures of the properties of a crystal. Measurements made between -60°C and +33°C show that the observed internal friction can be expressed as the product of a function of temperature and a function of amplitude alone. The data also indicate that the internal friction and elastic modulus are frequency independent when the structure sensitivity of the material is taken into account. The results are considered in terms of two viewpoints: a mechanism of relaxation by which dissipation is controlled through a rate process, and simple hysteresis, by which the stress-strain loop is independent of the rate of traversal. It is shown that the latter mechanism gives much better agreement with the experimental facts. Finally, simple hysteresis is interpreted in terms of the dislocation theory. (Author's abstract)

PP: 3 E J 10 L M R U X AA 27 28 30 31 32 34 36 j CV: 14 MI: Cu a

Pian, T. H. H. and Hallowell Jr., F. C.

Investigation of Structural Damping in Simple Built-Up Beams

Massachusetts Institute of Technology, Tech. Rept. (Contract N5ori-07833) 56 p. incl. illus. diagrs. February 2, 1950 (U 18145)

A theoretical study was made of the bending of a simple built-up beam with either spliced joints or thin reinforcing spar caps. The analysis is based on the assumptions that the spar caps and beam are held together by pressures which depend upon the tightness of the screw joints and that the clearances of the screws in the holes are large enough to allow sliding motion between the 2 surfaces. The theoretical results indicate that the nonlinear component of the load-deflection curve contains mainly a second power term, and that the energy loss per cycle varies as the third power of the amplitude of vibration and is in inverse proportional to the tightness of the screw joints. Results of experimental investigations of the damping of a simple cantilever beam with a spliced joint checked favorably with analytical solutions. The main source of damping was the slippage of the joints, the internal friction of the material contributing very little. The methods of determining the damping in a structure from its rate of decay are also analyzed. (Contractor's abstract)

PP: 3 D 5 7 12 16 S Y AA BB CV: 14 17

Portevin, A., Cabarat, R., and Guillet, L.

Influence of the Form of Graphite on Internal Friction in Cast Irons. (In French)

Comptes Rendus (France), Vol. 230, pp.891-892, March 6, 1950

Investigated for four different cast irons, using the apparatus developed by Cabarat. The form of the graphite is the principal factor, while the nature of the matrix (ferritic, pearlitic, or mixed) has little effect on internal friction.

PP: 3 AA 30 31 36 37 CV: 13' 14 MI: CI C' Fe

Rocca, R. and Bever, M. B.

The Thermo-Elastic Effect in Iron and Nickel as a Function of Temperature

Jour. of Metals; Am. Inst. Min. and Met. Eng., Trans., Vol. 188, pp.327-333, February 1950

Adiabatic thermo-elastic temperature change was determined as a function of the temperature and stress in nickel and Armco iron. Results are in agreement with an equation first derived by Lord Kelvin. Near the Curie temperature, the thermo-elastic effect changes appreciably. Calculations confirm that the thermal expansion coefficient of iron decreases in the vicinity of the Curie temperature as predicted by the theory of ferromagnetism. Tensile stresses of various magnitudes were employed No mention of damping or internal friction is made. May be important in that thermo-elastic effects are a method of energy dissipation in material damping.

PP: 16 U AA 30 31 34 MI: Fe Ni a q

Rossmassler, S. A., Christensen, C. J., and Eyring, H.

Utah U. (N7onr-45101) Tech. Rept. No. 15., 23p. incl. illus. diagrs. 16 refs. October 15, 1950. (U 13539)

The energy loss per simple harmonic cycle in forced vibrations was theoretically derived, using a simple type of Maxwell flow unit which was extended to include different types of units in parallel. A simple distribution of 5 flow units shows a total energy loss which is constant to ± 5% over a frequency range of $\omega = 0.6$ to $\omega = 300$ sec.$^{-1}$ An apparatus was designed to measure energy loss of fibers under a sinusoidal elongation at variable frequencies superimposed upon an initial elongation of such magnitude that the fiber is intension throughout the cycle; frequency and amplitude of vibration can be accurately controlled. The loss of energy of nylon 610 monofilament was measured over a ten-fold increase in frequency. The importance of reaching a steady-state condition before taking measurements is discussed; non-steady-state behavior was tentatively attributed to thixotropy and the decrease in viscosity resulting from the reorientation of bonds. ΔF for the flow process was calculated on the basis of the viscosity theory. The model used in the development of the equations required that the relationship between stress and strain is linear except for a phase angle; the actual relationship was shown to be nonlinear. Theoretical and experimental energy losses are compared. (Contractor's abstract)

PP: 3 5 7 M 16 17 19 AA 27 30 d 34 CV: 14 17 MI: FF GG'

Russell, P. A.

Where is Cast Iron Going to?

Foundry Trade Journal, Vol. 89, pp.7-10; disc. pp.11-13, July 6, 1950

Article discusses the damping capacity of nodular irons and its future prospects. Then it deals with the possibility of solving the problems of phosphorus content, porosity, and shrinkage, and marketing problems.
PP: A AA CV: 15 MI: CI r

Skudrzyk, E.

Application of Ultrasonics in Material Testing.(In German)

Ost. Ing.-Arch., Vol. 4, No. 5, pp 408-424, November 1950

This review of German work, both recent and during the war, stresses the application of transmission, reflection, and absorption techniques. Means of producing sound images of defects in workpieces under test are described and include acoustoptical scattering and diffraction; the Pohlmann screen; and scanning with a microphone tracked by an ink-writer similar to that used in wire photos. A valuable section is devoted to the mechanism of internal friction and frequency effects. Paper closes with suggestion that destructive testing for corrosion, cavitation, and fatigue are possible with high-intensity ultrasonic excitation. (Applied Mechanics Reviews)
PP: 2 3 6 10 16 19 AA 27 30 31 CV: 13 14 15 MI: KK Al Fe

Suzuki, T., and Yamamoto, M.

Anelasticity of Ferromagnetics: Magneto-Elastic Relaxation in Nickel. (In English)

Science Reports of the Research Institutes, Tohoku University, Ser. A, Vol. 2, pp.68-80, February 1950

Concerned with the relation between Bloch walls and structural imperfections in ferromagnetics, both of which are movable under an applied stress. Experimental results are discussed somewhat quantitatively from the point of view of the recent theory of the boundary layer model of mosaic structure in metals in connection with ferromagnetic domain structures. (Metals Review)
PP: AA 30 31 c 34 CV: 14 17 MI: SG Ni n p

Thorne, C. J.

On Plastic Flow and Vibrations

Jour. Appl. Mechanics, Vol. 17, No. 1, pp.84-90, March 1950

Solutions are presented for a mechanical model comprising a mass supported by a spring in parallel with a spring-dashpot combination, the mass being acted on by a force F(t) where t = time. Formulas are worked out in detail for the following cases: (1) constant force $F_0 \cos \omega t$; and (2) force increased at constant rate $F = F_0 t$. Such a model has been utilized by Eyring and others in analyzing stress-strain diagrams of organic plastics and textiles. However, in discussion of paper (title source, 17, p. 343, Sept. 1950) it is pointed out that model cannot represent plastic flow with large permanent strains in such a material as medium carbon steel (cited as an example in paper).
PP: Y AA 27 28 30 b 34 CV: 17

Volterra, E.

Vibrations of Elastic Systems Having Hereditary Characteristics

Jour. Appl. Mechanics, Trans., ASME, Vol. 72, pp.363-371, 1950

The results of experiments carried out on plastics and rubberlike materials at high rates of straining are given. It is shown that the dynamic stress-strain (σ, ϵ) relationship for those materials can be expressed by the formula

$$\sigma = f(\epsilon) + \int_0^t \phi(t-\tau) \frac{d\epsilon(\tau)}{d\tau} d\tau$$

The first term represents the static stress-strain relationship while the second depends on the rate of straining $d\epsilon/dt$. As a first approximation it is supposed that the materials follow Hooke's law when statically stressed. Equation (1) then becomes

$$\sigma = E\epsilon + \int_0^t \phi(t-\tau) \frac{d\epsilon(\tau)}{d\tau} d\tau$$

Materials which follow the second equation are called materials with "hereditary characteristics." Vibrations of single-degree-of-freedom systems having hereditary characteristics are considered. Methods of finding the hereditary function $\phi(t)$ from forced vibrations are given. Free and forced vibrations of simply supported beams having hereditary characteristics are studied. (Author's abstract)
PP: Y AA 30 34 CV: 17 MI: FF GG

Wert, C. A.

Measurements on the Diffusion of Interstitial Atoms in B. C. C. Lattices

Jour. Appl. Physics, Vol. 21, pp.1196-1197, November 1950

The alloys of interstitial dissolved atoms in the b.c.c. lattices offer the possibility that one can make extremely accurate measurements of the rate of diffusion of the solute atoms. This is so because the high temperature bulk diffusion measured by standard metallurgical methods can be extended to lower temperatures by measurements made on an atomistic scale by use of relaxation measurements. The diffusion of C in alpha-iron offers an example of this technique. Stanley measured the rate of diffusion in the range of 500°C to 700° C. The author measured in the range -35°C to +200° C. Together the data extend knowledge of the diffusion coefficient over some 14 cycles. This range is somewhat higher than has been done for any other system. In an effort to extend this type of measurement to other systems the author has made measurements of diffusion of C in Ta and Cb and of N in alpha-iron. These measurements were made by two manifestations of the anelastic relaxation effects; the internal friction and the elastic aftereffect. The methods used have been described earlier.
PP: 3 16 U AA 30 31 CV: 14 MI: AY EG C' Fe 30 32 d p

Wert, C. A.

Solid Solubility of Cementite in Alpha-Iron

Jour. of Metals, Trans., AIME, Vol. 188, pp.1242-1244, 1950

By the use of the internal friction of carbon in alpha-iron the solubility of cementite in alpha-iron has been measured down to a temperature of 150° C. The yield strength of ingot iron containing small amounts of cementite has also been determined as a function of carbon concentration. (Author's abstract)
PP: B 3 16 U AA 27 36 37 CV: 14 MI: CI C' Fe p

Wu, T.

A Theoretical Study of the Fatigue and Related Problems including a Damping Capacity Hypothesis

Institute of Industrial Research, Syracuse U., 29p. incl. diagrs. 51 refs. (Part II of its Tech. Rept. No. 50-1, Feb. 1, 1949 - Feb. 1, 1950, TIP U15964). 1950 (U 15966)

The relation between mechanical hysteresis and fatigue of metals is discussed. Fatigue failure in a common b.c.c. and f.c.c. metallic specimen appears to be associated with the slip mechanism. The mechanism which Orowan considers to cause the continuous increase in local peak stresses in a fatigue specimen explains qualitatively many phenomena associated with fatigue test. The application of Orowan's theory showed that the fatigue life of a specimen is determined by 2 separate processes: (1) the formation of microcracks which are caused by the increase in local peak stress in excess to the theoretical fracture strength; and (2) the propagation of these microcracks which is intimately related to the macrostrain distribution inside the specimen. The effects of room temperature recovery on damping and elasticity of mild steel were investigated. A theoretical analysis of a possible mechanism of precipitation is presented. Data indicate that the activation energy of recovery on damping in steel would be about the same as that for C diffusion in α-Fe; measurements on several specimens at 33,000 psi from 50° to 400° C are planned. (Contractor's abstract)
PP: 3 4 16 T AA 28 29 30 b 32 36 41 42 r CV: 17 18
MI: CN C' Fe

1951

Alder, M. F. and Eyring, H.

Forced Vibrations of Polyamide Monofils

Utah U., 58 p. incl. illus. diagrs. 12 refs. (Tech. Rept. No. 21) (Contract N70nr-45101) April 15, 1951 (U 18483)

A theoretical and experimental study was made of the net cyclical energy-absorption characteristics of certain polyamide monofils which were subjected to sinusoidal loading. The net absorptions resulting from the application of varying strain to highly crystalline monofilaments of polyhexamethyleneadipamide, polyhexamethylensebacamide, and poly (2-methyl hexamethyleneadipamide) varies from 0.8 to 9.0 x 10^4 ergs/c. A 2% average strain bias with a superimposed sinusoidal strain having an amplitude of 1% was employed in these determinations. A theory based on the absolute reaction-rate treatment of viscous flow was developed which relates the net cyclical energy absorption to the frequency of vibration. The average values of the net absorbed energy were exponential functions of the reciprocal absolute temperature. The temperature dependence on the apparent elastic constant is discussed in terms of both pure entropy elasticity and elasticity involving changes of both potential energy and entropy. The observed nonlinear spring characteristics of the net energy absorption loops are theoretically treated and correlated. (Contractor's abstract)
PP: 3 5 G M 14 R U AA 27 30 34 CV: 14 17 MI: FF

Allard, M.

French Contribution to the Progress of Technique and Instruments for Metallographic Investigation

The World Metallurgical Congress, Detroit, October 1951

The author listed the apparatus which are not well known in the U. S. A. They are as follows:

1. Differential dilatometer with mechanical or photographic recording.
2. Machines for micro-mechanical tests-traction, torsion, shearing.
3. Thermo-magnetometers giving magnstization-temperature curves.
4. Micro-machines for torsion fatigue test.
5. Micro torsion-balance of Coulomb (Damping)
6. Creep-test machines
7. Hysteresimetric torsion-balance IRSID

Short descriptions of some of these are given.
PP: 3 5 13 AA 28

Anderson, O. L. and Poncelet, E. F.

Physical Constituents of Stress and Strain With Applications to Anelasticity

Utah U. 36 p. incl. illus. diagrs. 33 refs. (Tech. Rept. No. 24) (Contract N7onr-45101) May 30, 1951 (U 18338)

The decomposition of stress and strain into independent dilation and distortion constituents is described. These constituents are applied to: (1) Elastic-strain energies and wave velocities, (2) fracture propagation and (3) flow. Major stress and transverse waves affected the phenomenon of fracture; the distorting stress and longitudinal waves were involved in flow phenomena. Viscous and elastic flow are discussed. Elastic flow appeared to induce a reversal of the distorting constituent of the applied stress. Experimental evidence is presented which established the reality of this induced stress. (Contractor's abstract)
PP: Y AA 30 d CV: 14 17

Bastien, P. and Azou, P.

Effect of Cold Working on the Internal Friction of Iron and Steel, With or Without a Hydrogen Charge.(In French)

Comptes Rendus hebdomadaires des Seances del'Academie des Sciences, Vol. 232, pp.1845-1348, May 16, 1951

Study of 0.08% C steel showed that charging with H_2 by immersion in a solution of HCℓ and Na2S has little effect on internal friction unless the steel is first plastically deformed. (Metals Review)
PP: AA 30 b g k CV: 13' 14 MI: CN EG' Fe g n

Blizard, R. B.

Visco-elasticity of Rubber

Jour. Appl. Physics, Vol. 22, No. 6, pp.730-735, June 1951

A theory for the frequency dependence of the dynamic modulus and internal friction coefficient in rubber is developed on the basis of a simple physical model. The basis of the model is that usually employed in the kinetic theory of rubberlike elasticity, but for each rubber chain the internal friction is introduced by postulating viscous couplings between the chain and the average surrounding medium. The complex modulus for such chains with either free or cross-linked ends is calculated by employing an electrical analog. The complex modulus of the rubber is then obtained from those of the individual chains and the distribution function for chain length and type of termination. The results of the theory are compared with experimental results for various rubbers. However, the basis on which the comparison is made is not sufficiently clear to allow any assessment of the significance of the agreement obtained. (Appl. Mech. Rev.)
PP: 3 10 13 16 19 X AA 30 d 34 CV: 14 17 MI: GG

Boulanger, C.

Pendulum Hysteresis Meter of Torsion Pendulum With Double Elastic Device for Measuring Internal Friction and Elastic Modulus of Metals in an Extensive Range From Very Low Temperatures up to 1300°. (In French).

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences Vol. 233, pp.732-733, Oct. 1, 1951

Describes tests and reports results obtained with the above instrument.

PP: 3 5 13 16 U X AA CV: 13' 14

Boulanger, C., Delabart, G., and Ravery, M.

Relation Between Internal Friction and Resistance to Creep of Steel as a Function of Microstructure. (In French)

Internal friction and modulus of elasticity were measured at different temperatures between 300° and 700° for Cr-Mo steel of four different microstructures: (1) ferrite-pearlite, (2) martensite, (3) fine-grained bainite, and (4) coarse-grained bainite. The curves for the four structures appeared in the same order as those obtained for creep tests. The results show that viscous flow takes place at the grain boundaries. (Chem. Abs. 2980h, 1952)

PP: B 16 U X AA 30 b 42 43 CV: 13' 14 MI: AY 36 s

Bozorth, R. M.

Ferromagnetism

Book. D. Van Nostrand Company, Inc. New York, pp.685-712, 1951

The effects of magnetization on dynamic Young's modulus and internal damping of metals are described. Experimental data are presented and analyzed. A theory of magnetomechanical damping is presented. The 'magnetic' losses are divided into three parts: 1. macro eddy currents, micro eddy currents, and hysteresis. Each of these is discussed in considerable detail and their dependence on frequency and amplitude of stress is examined. Methods of measuring dynamic modulus and internal friction are also presented.

PP: 3 D E 8 9 10 11 13 16 S U AA 27 30 31 c 36 h CV: 15 16 17
MI: SG Fe Ni 35 h n p

Bozorth, R. M., Mason, W. P., and McSkimin, H. J.

Frequency Dependence of Elastic Constants and Losses in Nickel

Bell System Technical Journal, Vol. 30, pt. 1, pp.970-989, October 1951

The elastic constants of nickel crystals, and their variation with magnetic field, the Δ E effect, were measured by a 10-mc. ultrasonic pulsing method. The constants of three crystals agree well with one another when the crystals are magnetically saturated, but vary with domain distribution when demagnetized. By measuring the ΔE effect and the decrement of polycrystalline rods at low frequencies, it is shown that the small effect observed at 10 mc. is due to a relaxation in the domain wall motion due to micro eddy-current damping. 13 ref. (Metals Review)

PP: 3 6 16 V X AA 27 30 31 c 36 j CV: 14 MI: SG Ni n p

Cabarat, R.

Internal Friction in Small Amplitude Vibrations

Mém. Soc. Ing. Civ. Fr., Vol. 104, No's. 5/6, pp.167-183, 1951

A brief review is given of apparatus used by others for measuring damping of sound vibrations in metals. A new test unit at testing laboratories of C. N. A. M. permits testing in partial vacuum (0.1 mm Hg) at temperatures up to 800 C.

Longitudinal sound waves are electrically generated in a rod sample; electrostatic pickup measures amplitude. Internal friction in rod is measured in two ways: (a) by resonance curves over a range of frequencies; (b) by damping of free vibrations after generator is cut off. In (b), logarithmic recorder gives linear amplitude-time curve, slope of which indicates damping.

Some selected data illustrate applications of test. Phase changes with temperature in a Cu-Al alloy are followed in detail. Graphite in cast iron has little effect on friction when in nodular form, but increases friction markedly when in lamellar form. (Appl. Mech. Review)

PP: B 3 D E 6 7 9 16 S AA 27 36 n CV: 13' 14 MI: CI Al' Cu r

Chalmers, B.

The Structure and Mechanical Properties of Metals, Vol. 2. (Book)

Monograph on Metallic Materials published by authority of Royal Aeronautical Society.

Chapman & Hall, Ltd., pp.80, 122-123, 1951

Damping capacity is listed and described under the classification of mechanical tests. The definition of damping capacity is given. Its relation to metal structure is suggested. However, the author cautions that any attempt to generalize on the relationship between damping and structure would be premature.

PP: AA 42 s CV: 16

Darling, A. S.

Internal Friction Measurement

Metal Industry, Mar. 23, 1951, pp.223-5; April 6, pp.271-3; April 13, pp.291-2; 1951

This is a correlative review of the damping literature. The theory of damping and effects of structural conditions of metals on damping are treated in detail. The effect of stress on damping of metals is described. Application of damping measurements to the study of the structural changes in metals is suggested. The author is of the opinion that the use of internal friction measurements for investigating changes in the structure of metals may well prove to be a field of metallurgical research comparable to that now occuppies by X-ray diffraction methods. Main topics are kinetics of change in microstructure, thermo-elastic coupling, microscopic stress variations, plastic deformation, effects on alpha brass, effect of amplitude on internal friction, grain boundaries, polycrystalline material, equalibrium diagrams, preferential distribution, twin interface movement, and stress and damping capacity.

PP: B 16 S T 19 AA 27 30 b 34 36 38 40 CV: 15 17 18 MI: Cu Zn'

Dunell, B. A. and Dillon, J. H.

The Measurement of Dynamic Modulus and Energy Losses in Single Textile Filaments Subjected to Forced Longitudinal Vibrations

Text. Res. Jour., Vol. 21, No. 6, pp 393-403, June 1951

Apparatus and techniques for measuring the cynamic properties of single fibers in the frequency range 1-100 cps at 70° F and 65% R. H. are described. For the viscose rayon, acetate rayon, nylon, feather keratin, silk, and polyethylene fibers studied, it is found that the quantities $\eta\omega$ and E are approximately independent of frequency in this range, where η is the internal friction, ω the radian frequency, and E, the dynamic modulus. Measured values of the energy dissipated per cycle are found to be proportional to the square of the amplitude, in accordance with the prediction of the simple differential equation of vibration assumed (viscous damping and Hookean elastic reaction). Stress relaxation data were obtained with the same fibers and the results are given. Theoretical interpretation of the results is given in another paper. (See Tabolsky, Dunell, and Dillon, 1951) (Authors' summary)

PP: 3 7 M 16 S 19 20 X AA 27 CV: 14 MI: FF GG' JJ

Edmondson, B.

The Internal Friction of Metals, Its Measurement and Its Applications to the Problems of Physical Metallurgy

Jour. of the Birmingham Metallurgical Society, Vol. 31, pp.75-104, June 1951

A non-mathematical description of the causes of the phenomenon. Methods of measurement of internal friction, and effects of experimental variables on the values obtained. 23 ref. (Metals Review)

PP: B 3 16 AA 27 30 CV: 15

Fast, J. D. and Dijkstra, L. J.

Philips Tech. Rev., Vol. 13, No. 6, pp.172-179, December 1951

A mathematical expression for torsional damping is derived and the general technique of measuring low-stress internal friction at frequencies of the order of one cycle per sec is reviewed with great clarity. Damping caused by interstitially dissolved atoms is discussed. Damping experiments, at different temperatures, with a torsion-wire pendulum made of iron or steel containing a little carbon or nitrogen in solution (with or without the admixture of Mn) were made. The results throw some light on the extent to which the dissolved atoms precipitate after quenching of the metal. How the internal friction resulting from the solute atoms jumping from one interstice in the crystal lattice to another causes the amplitude of the torsional oscillations to decay exponentially was explained. Results of the damping experiments make it possible to give a new explanation of the phenomenon of "magnetic aging." (Metals Review)

PP: B 3 D 9 13 16 U AA 27 30 31 c 36 h CV: 14 17
MI: CN EG' C' Fe Mn' p

Fearnow, D. O.

Investigation of the Structural Damping of a Full Scale Airplane Wing

NACA Res. Memo. No. L51A04, 13 p., March 9, 1951

An investigation to determine the structural damping characteristics of a full-scale airplane wing was conducted by the shock-excitation method wherein the wing was loaded to a predetermined deflection and the load suddenly released. The test specimen vibrated at its fundamental bending frequency of 1.69 cycles per second. Only the first 2 or 3 cycles showed any indication of a higher frequency being superimposed upon the fundamental bending frequency. The damping was found to increase from about 0.002 of critical at an amplitude of vibration of +0.05 inch to approximately 0.006 of critical at an amplitude of +5 inches. (NACA abstract)

PP: 3 D 12 16 S AA BB 28 CV: 14

Ferro, A. and Montalenti, G.

Internal Friction of Ferromagnetic Materials

Jour. Appl. Physics, Vol. 22, pp.565-568, May 1951

It is common knowledge that in cyclically stressed ferromagnetic materials and energy loss due to internal friction is observed; this part of loss disappears when the material is brought to saturation or above the Curie temperature. It is also known that a stress applied to a ferromagnetic material, produces a motion of Weiss domains from their rest position.

The scope of this paper is to verify experimentally the following hypothesis: in cyclically stressed ferromagnetic materials, energy loss because of magneto-elastic internal friction is induced by a domain motion due to the applied stress itself.

The ratio I_r/I_s (where I_r = residual induction, and I_s = saturation intrinsic induction) has been chosen as an index of the domain position; its measure has been carried out by normal ballistic method on a permeameter rigged with a torsion applying device.

Energy loss was measured by means of a torsion pendulum; a coil allowed the saturation of specimen in order to separate magneto-elastic from purely mechanical losses. Plotting curves of I_r/I_s and of magneto-elastic losses as a function of applied stress and comparing them for each tested material, it has been found that they, besides having the same shape, show abrupt slope variations at practically the identical value of stress. It has further been observed that a specimen presenting only a low percent variation of I_r/I_s showed also moderate magneto-elastic losses. These results appear to confirm assumptions made about the magneto-elastic internal friction in ferromagnetic materials. The reason why motion of domains takes place in an essentially irreversible way still remains unknown.

Materials tested: pure nickel, plain carbon, and nickel-chromium steels. (Authors' abstract)

PP: 16 S AA 28 30 c CV: 14 17 MI: CN AY SG Ni a n p q r

Freudenthal, A. M.

Theories of Mechanical Behavior of Materials

Applied Mechanics Reviews, Vol. 4, No. 7, pp.394-396, July 1951

This short review deals with the various aspects of the study of the mechanical behavior in crystalline and "amorphous" materials from three levels of investigation, namely, atomic and molecular, microscopic, and mascroscopic (phenomenological). An extensive bibliography is included.

PP: AA CV: 15 18

Gebhardt, E. and Becker, M.

Viscosity of Liquid Gold-Silver Alloys. (In German)

Zeit. f. Metallkunde, Vol. 42, pp.111-117, 1951

A torsion-type viscometer for the determination of viscosity of molten alloys at temperatures of 1000-1300° is described and viscosity data (± 3% accuracy) are reported in this range for (Wt.%) 100 Ag, 80 Ag: 20 Au, 60 Ag: 40 Au, 40 Ag: 60 Au, 20 Ag: 80 Au, and 100 Au. The logarithmic decrement of damping, λ, is determined experimentally from which the viscosity, η, is calculated. The value of η are shown as functions of temperature and concentration; η decreases exponentially with temperature. The isotherms increase with increasing Au content but temperature coefficients are nearly the same in all systems. Au shows a considerably higher viscosity coefficient than Ag. Dissolved O has no influence on η. (From Chem. Abs. Vol. 45, 6141g, 1951)

PP: 3 D 9 10 13 16 U AA 26 CC 36 37 CV: 13 14 MI: EG Ag a 36

Gebhardt, E. and Wörwag, G.

Intrinsic Viscosity of Liquid Gold-Copper and Silver-Copper Alloys

Zeit. f. Metallkunde, Vol. 42, pp.358-361, 1951

The intrinsic viscosity, η, of molten alloys was determined from the logarithmic decrement of damping (λ) with a torsion wire, according to

$$(\lambda_1 - \lambda_2) = \delta t / \delta t_s = K\sqrt{\eta \delta t}$$

where λ_1 is the experimental decrement, corrected for the gaseous friction decrement of the wire λ_2, K an apparatus constant., δt the sp. gr. of the melt and t_s of the system at the m.p. The isotherms of η for the systems Ag-Cu and Au-Cu are shown for the temperature range 900-1300°. The curves so obtained are steeper (higher η) at lower temperatures. Higher values are found for Cu-rich alloys in the Ag-Cu system, for Au-rich alloys in the Au-Cu system. No evidence for structural processes in the liquid state is found. (Chem. Abs. Vol. 46, 2466e, 1952)

PP: 3 D 9 13 16 U AA CC 36 37 CV: 13 14 MI: EG Ag Cu a 36

Grant, J. W.

Comprehensive Mechanical Tests of Two Pearlitic Gray Irons

British Cast Iron Research Association, Jour. of Research and Development, Vol. 3, pp.861-875, 1951

Reports tests on cast irons with nominal tensile strengths of 18 and 22 tons per sq in. respectively. The tests include transverse, tensile, hardness, impact, shear, torsion, damping capacity, compression, fatigue, electric resistivity, density, and coefficient of expansion. (Metals Review)

PP: 3 D AA 28 CV: 14 MI: CI n

Grummann, H. R. and Newton, R. E.

Structural Damping With Complex Stiffness

Aero Digest, Vol. 63, No. 1, pp 22, 70, 74-76, 78, 80, 84, July 1951

Attention is confined to one degree of freedom systems with sinusoidal excitation. The classical case of such a system with viscous damping is reviewed. A differential equation with real coefficients for a system with restoring force (1 + ig) kx is obtained in such a form that solutions for it may be written down at once from the corresponding results for the classical case.

PP: Y AA CV: 17

Hanstock, R. F.

The Non-destructive Testing of Metals

Book. British Institute of Metals, 1951

Three chapters are devoted to damping capacity. It deals with definitions and methods of measurement, dependence on metallurgical conditions and theoretical aspects of damping.

PP: 2 3 D E F 9 M N 16 S U AA 36 h CV: 15 16 17

Harper, S.

Precipitating of Carbon and Nitrogen in Cold-Worked Alpha-Iron

Physical Review, Vol. 83, No. 4, pp.709-712, August 15, 1951

The strain-induced precipitation of carbon and nitrogen from supersaturated solution in alpha-iron is shown to be in agreement with a dislocation mechanism and estimates of the dislocation density required to produce the observed precipitation rates are in agreement with dislocation theory. The activation energies involved in the process are found to be 20,000 cal/mole for carbon and 17,200 for nitrogen in agreement with published data for the activation energies of diffusion of the two solutes. In the experimental work the internal friction of the specimen was measured directly by means of a torsion pendulum, which was set oscillating and the friction measured by the decay of the free vibrations. The frequency corresponding to the internal friction peak at the temperature of aging was used in each case. The method was that used by Kê. (Author's abstract)

PP: 3 D 9 13 AA 27 30 31 32 CV: 14 17 MI: EG' C' Fe p

Hasiguti, R. R. and Hirai, T.

Internal Friction of Cold-Worked Single Crystals of Copper

Jour. Appl. Physics, Vol. 22, pp.1084-1085, August, 1951

The internal friction of single crystals of copper was measured as a function of degree of cold working, and these measurements were compared with stress-strain curves. Specimens of single crystals were made from electrolytic copper. Tests of internal friction were performed by a modified Zener apparatus which has as a detector a condenser formed between a plate and a flat end of the rod specimen vibrating longitudinal The frequencies of vibration used were from 20 to 100 kilocycles per second

Results are shown in graphs of Q^{-1} vs. shear strain. The degree of cold working is expressed in terms of resolved shear strain calculated in the slip direction in the slip plane.

The internal friction of crystals annealed at 800° C for two days was from 2×10^{-5} to 2×10^{-4}. It increases rapidly with increasing degree of cold working, making respective maxima at the shear strains between 0.05 and 0.2 which correspond to the elongations of 1 to 10%. These maximum values of internal friction spread between 3×10^{-3} and 10^{-2} according to individual specimens. After the maxima it decreases rapidly as the strain increases, until it comes to a fairly constant value, which is well below the maxima, but above the initial values. No relation has been found until now between the formation of maxima and the directions of crystals with respect to specimen axes. It was confirmed that the occurrence of double slip has nothing to do with these maxima.

Although the amount of resolved shear strain, at which the maximum of internal friction occurs, differs in each specimen, it is always within a narrow range of strain, where the tangent of stress-strain curve increases considerably, as is seen in Fig. 2. In other words, the internal friction begins to decrease when the rate of hardening begins to increase.

The internal friction decreases considerably when the specimen is left at room temperatures and almost resumes its original low value when the crystal is annealed at comparatively low temperatures, say below 150° C, where no recrystallization takes place. And this is true, whatever the degree of cold working before annealing may be.

Remainder of paper discusses the relation between internal friction and dislocations.

PP : 3 E 8 M 16 S 18 19 AA 27 30 32 36 h j k n CV: 14 MI: Cu a

Horio, M. and Onogi, S.

Forced Vibration of Reed as a Method of Determining Viscoelasticity

Jour. Appl. Physics, pp.977-981, July 1951

The motion of a clamp-free reed excited by a sinusoidal displacement of the clamped end was analyzed by rigorously solving the fundamental equation for vibration. The real and imaginary parts of the modulus are given in terms of resonant frequency and band width of the frequency curves. The results are compared with those of Nolle which were obtained in an approximate manner by introducing an equivalent electric circuit. As long as the mechanical loss tangent is smaller than 10^{-1}, as is the case in most high polymers, the practical error caused by the approximation is estimated to be insignificant. Nolle's network was interpreted from a purely mechanical standpoint by means of the fundamental equation for vibration. (Authors' abstract)

PP: 3 E 8 10 11 12 X AA 30 d 42 q CV: 17

Jaquerod, A.

Is Hooke's Law a Limiting Law? (In French)

Revue de Metallurgie, Vol. 48, pp.85-90, February 1951

Experimental investigation indicates that flexion oscillations of metals and alloys are never isochronous even at an amplitude as low as 0.5°. Similar deviations from Hooke's law were previously observed in a series of experiments based on torsion oscillations. (Metals Review)

PP: 3 5 12 AA CV: 13' 14

Klotter, K.

Technical Vibration Theory. (In German)

Book. Springer-Verlag, Berling, Germany, 1951. Sect. 71 and 72, The Damping of Materials, pp.237-250

A theoretical discussion of the damping of materials in general is presented. Mathematical analyses are then presented for relating element damping, nominal damping, and total damping energy. The interrelationships among these and procedures and formulae for determining the element damping from tests performed in tension-compression oscillators, torsion oscillators, and bending oscillators are derived. The effects of variation in form of cross section and type of loading are considered in detail.

PP: 3 5 G L M 13 16 S Y AA 30 b CV: 11' 13 15 17

Kneser, H. O.

On the Damping of Oscillating Cylindrical Bars by the Surrounding Medium. (In German)

Zeits. f. Angew. Physik, Vol. 3, No. 3/4, pp.113-117, 1951

The damping capacity with the presence of air as an enclosed medium is investigated for various metals. The author classified damping into three kinds: internal damping which largely is due to the plasticity of the material; friction damping which is due to contact of the material surface with the medium; and finally radiation damping which is due to the absorption of sound waves. Various factors affecting the value of damping, such as frequency, pressure of air, etc., are also investigated. The apparatus and methods of investigation are described.

PP: 3 E 16 19 AA CC CV: 13 14 MI: ST CN Al h

Köster, W. and Bangert, L.

Effect of Load on Modulus of Elasticity and Damping Properties of Copper, Silver, Ordinary Brass, and Red Brass. (In German)

Zeit. f. Metallkunde, Vol. 42, pp.391-394, December 1951

The effects of lead content and temperature on the damping and modulus of elasticity of copper, silver, ordinary brass, and red brass are investigated. Data are charted, tabulated, and discussed.

PP: 3 E 9 12 16 U X AA 36 37 CV: 13 14 MI: Ag Cu Pb' Zn' a 35 n

Küsten, C. W. and Bronkhorst, J. A. J.

Vibration Dampers

Tech. Wet. Tijdschr. Vol. 20, No. 2, pp.28-33, February 1951

Article deals with the elastic behavior of rubber, sketches theoretical research on the subject, and gives a few general results of experimental research. Actual measurements have led to the simple formulas and graphs which will help to calculate cushion foundations on rubber with a fair grade of accuracy. A nomogram has been devised for the same purpose.

Comparisons are given between dampers in rubber, cork, felt, and metal, by considering, among other things, aftereffects, internal friction of the material, and proper vibrations of the cushion. (From authors' summary)

PP: Y EE CV: 13 15 17 MI: GG

Lazan, B. J. and Demer, L. J.

Damping, Elasticity, and Fatigue Properties of Temperature-Resistant Materials

Am. Soc. Test. Mat., Proc., Vol. 51, pp.611-646, 1951

The damping, elasticity, and fatigue properties of several temperature-resistant materials (S816, type 403, Inconel X, molybdenum, and a Mo-W alloy, copper infiltrated sintered iron powder, and N-155) were investigated in rotating cantilever-beam testing equipment. The room and elevated temperature tests were designed to reveal changes in damping energy and dynamic modulus of elasticity during constant cyclic stress fatigue tests at engineering stress levels. Usual S-N fatigue curves are presented in addition to a series of new diagrams designed to show the effects of both stress magnitude and stress history on the damping and elasticity properties. Two methods for comparing the damping energies of a group of materials are offered and the merits of each discussed. Diagrams are also presented to facilitate comparison of the elasticity properties among materials tested at a given temperature. (Authors' synopsis)

PP: 3 4 G N 16 S T U X AA 28 29 42 q r CV: 14
MI: SS SG Co Cr Fe' Mo Ni W' a c e h 42

Lazan, B. J. and Wu, T.

Damping, Fatigue, and Dynamic Stress-Strain Properties of Mild Steel

Proceedings, Am. Soc. Test. Mat., Vol. 51, pp.649-678, 1951

Damping energy, dynamic modulus of elasticity, and fatigue properties of mild steel are investigated in recently developed rotating-beam testing equipment. Data on the effect of several important test variables, such as stress magnitude, history, frequency, and rest are presented. Stress magnitude and stress history data are analyzed in terms of cyclic stress sensitivity limit and stabilized damping points. These data are presented in S-N-N, S-N-D, and other new types of diagrams to indicate not only the fatigue behavior but also the damping and modulus properties. The effect of frequency of cyclic stress on damping and dynamic modulus is found to be considerable at stresses above the dynamic proportional limit. Dynamic stress-strain data are presented and analyzed to indicate the effect of stress magnitude and stress history on the dynamic proportional limit. Frequency sensitivity data are also presented in terms of strain rate and flow stress. (Authors' synopsis)

PP: 3 4 N 16 S T 19 X AA 28 29 42 q r CV: 14 MI: CN j

Lienard, P.

Method for the Measurement of Interior Friction of Plastic Coatings Subjected to Transversal Vibration. (In French)

Recherche Aeronautique (No. 20 Bimonthly); pp.11-22, Mar-April, 1951

A vibrating rod, supported at its two nodes of vibration, is a perfect and physically defined oscillator. A resonance curve may be plotted with reference to the excited rod, with and without plastic coating. On the basis of this curve, the elasticity modulus of the two materials, as well as the energy loss, can be calculated. Comparisons with the damping of free oscillation are made. The results of measurements are given. The general pattern for the calculation of energy losses reveals that the energy loss is proportional to the square of the thickness of the material used for coating, and also proportional to an amplitude power slightly greater than 2.

PP: 3 D E 12 16 S 20 AA 28 36 39 CV: 13' 14

Linacre, E.

Damping Capacity Measurements as an Aid to the Metallurgist

Research, Vol. 4, pp.540-541, December, 1951

A discussion is given of the techniques for making damping capacity measurements. The use of such measurements in the determination of diffusion coefficients, grain size, intensity of magnetization, and phase changes on transformation is treated. No experimental data are given.

PP: B AA 27 CV: 15

Marvin, R. S.

Interim Report on the Cooperative Program on Dynamic Testing

National Bureau of Standards. April 25, 1951

This is a presentation of test results on the dynamic modulus of elasticity of rubber-like materials from a group of investigators. An attempt was made to correlate the results. The investigators are listed along with descriptions of a wide variety of methods of measurement. Test data are charted. The effects of frequency and temperature on the modulus are indicated. Some of the test methods employed for determination of the modulus also provide data on damping energy.

PP: 3 E 6 16 T 19 X CV: 14 15 MI: GG

Marx, J.

Use of the Piezoelectric Gauge for Internal Friction Measurements

Rev. of Sci. Inst., Vol. 22, No. 7, pp 503-509, July 1951

The addition of an auxiliary quartz crystal to the usual composite piezoelectric resonator provides a convenient strain gauge, which simplifies the measurement procedure and permits the evaluation of amplitude dependent decrements over a wide range of strain amplitudes. A unique feature of the new procedure is that virtually instantaneous values of the decrement are obtained, thus bringing transient internal friction phenomena under observation. Mechanical resonance frequencies may be precisely determined for high as well as low decrement specimens. The numerical evaluation of terms is carried out for a recommended driver-gauge construction of 18.5° X-cut quartz bars. (Author's abstract)

PP: 3 E 9 M 16 S AA 27 CV: 14 17 MI: LL

Nabarro, F. R. N.

The Interaction of Screw Dislocations and Sound Waves

Proc. Roy. Soc., Ser. A, Vol. 209, pp.278-290, 1951

In Part I, Peierl's model of a dislocation is adapted to dynamical problems by taking account of the inertia of the matter which in a continuum would lie between the two sheets of atoms defining the glide plane. The scattering of long shear waves by a screw dislocation is examined. The scattering cross-section is nearly proportional to the wave-length. The force acting on the dislocation in the direction of propagation of the wave depends on a specific interaction between a moving dislocation and a varying displacement field. This interaction is derived formally from an electromagnetic analogy, and its meaning is discussed. By its use, the moment transfer cross-section is calculated, and shown to equal the scattering cross-section.

In Part II, the results of Part I are applied to analyze Liebfried's estimate of the resistance to the motion of a dislocation caused by its interaction with lattice vibrations. The estimate depends on a confusion of two effects. It is shown that for each effect, that the contribution of long waves to the resistance is smaller than that calculated by Leibfried, but no quantitative estimate is given for the contribution of waves near the top of the Debeye spectrum. It is concluded that Leibfried's result is correct in form and order of magnitude but numerically too high. (Author's abstract)

PP: AA 27 30 32 34 CV: 17

Narayanamurti, D. and Jain, N. C.

The Damping Capacity of Some Indian Timbers: II-Logarithmic Decrement in Flexure

Jour. Aero. Soc. India, Vol. 3, No. 3, pp.79-87, August 1951

In continuation of previous tests on the damping capacity of Indian woods in torsion, data are presented on the damping capacity and moduli of elasticity of air-dry Indian timbers in flexure parallel and perpendicular to grain, on the basis of photographic records of light beams reflected from the oscillating test specimens of 12 x 1 x 1/8 and 6 x 1 x 1/8 in. sizes, respectively.

The logarithmic decrement along the grain of the tested woods varied from 0.01008 to 0.02307. The ratio of the decrement across to that along the grain varied from 2.07 to 3.93 and 6.44, with an average of about 3.5. The logarithmic decrement in torsion was found to be about 1.5 to 4.5 times that in flexure. (Appl. Mech. Reviews).

PP: 3 D 9 12 13 P X AA 36 40 CV: 12' 14 MI: HH

Nielsen, L. E.

A Recording torsion Pendulum for the Measurement of the Dynamic Mechanical Properties of Plastic and Rubbers.

Rev. Sci. Instr., Vol. 22, No. 9, pp.690-693, September 1951

A recording instrument for measuring the dynamic shear modulus and mechanical damping of plastic and rubber-like materials using the principle of torsion pendulum has been constructed. The mechanical oscillations are converted into electrical potentials for recording by a torque measuring device which is actuated by a differential transformer. The apparatus is capable of measuring the modulus and damping of materials over an extremely wide range.

PP : 3 13 X AA CV: 14 MI: FF GG

Nowick, A. S.

Measurements of Atomic Mobility in Binary Alloys by Means of the Pair-Orientation Effect

Phys. Rev., Vol. 82, p. 340, 1951

The anelasticity associated with stress-induced reorientation of paris of solute atoms is utilized to study atomic mobility in homogeneous substitutional alloys. From the time of relaxation, τ , obtained at each temperature by measurement of elastic after-effect (for $\tau > 20$ sec) of an internal friction peak ($\tau < 1$ sec), the corresponding diffusion coefficient may be obtained. Since the time required for a measurement is of the order of the mean time for a single atomic jump, the atomic mobility may be obtained at temperatures considerably below those at which macroscopic diffusion measurements can be made. The method is applied to silver-zinc and silver-indium alloys; the heat and entropy of activation for the elementary diffusion process are obtained as a function of alloy composition. The data obtained by this method are compared with conventional diffusion data for these alloys.

PP : B AA 27 CV: 14 MI: 3G' Ag Zn' b 36

Nowick, A. S.

Anelastic Effects Arising From Precipitation in Aluminum-Zinc Alloys

Jour. Appl. Physics, Vol. 22, pp.925-933, July 1951

Torsion experiments on an Al-Zu alloy (20% Zn) show that percipitation produces large values of internal friction. After prolonged periods of aging, sufficient to produce growth of the precipitate particles, internal friction begins to decrease. Curves of internal friction vs. temperature do not show a peak but rise indefinitely with increasing temperature. This behavior cannot readily be interpreted in terms of the usual concept of a relaxation spectrum, but requires a new concept of "coupled relaxations". Metallographic examination reveals that large internal friction is correlated with discontinuous precipitation. The observed anelasticity is interpreted in terms of the fragmentation of the lattice. (Metals Review)

PP: 3 D 8 13 16 U AA 27 30 31 34 36 h n CV: 14 MI: Al Zn'

Painter, C. W.

The Measurement of the Dynamic Modulus of Elastomers by a Vector Subtraction Method

ASTM Bulletin, pp.45-47, October 1951

A description is given of a technique and apparatus for measuring the dynamic modulus and damping hysteresis of viscoelastic materials. The principle involved in the measurement is explained and the accuracy and range of the equipment are discussed. Experimental data are given on elastic shear modulus and dissipation factor as a function of dynamic strain.

PP: 3 10 12 16 S X AA 28 CV: 14

Pian, T. H. H. and Hallowell, F. C., Jr.

Investigation of Structural Damping in a Simple Built-up Beam

Paper From "Proceedings of the First U.S. National Congress of Applied Mechanics, pp.97-102, June 11-16, 1951

A slightly condensed version of Technical Report for Contract N5-ori-07833 to ONR, by the Aeroelastic and Structures Research Laboratory, Mass. Inst. of Tech., February 2, 1950.

PP : 3 D 5 7 12 16 S Y AA BB CV: 14 17

Pittenger, J. T.

Temperature Dependence of Internal Friction of Single Crystals

Physical Review, Vol. 83, p. 872, 1951

The internal friction has been measured as a function of temperature for single crystals of cu, Mg, and Al in the temperature range of 20 to 400° C and in frequency range of 4 to 30 kc and at various values of strain amplitude. Resonant rods were excited with a magnetic drive, and the decrement was measured by counting electronically the number of cycles after the drive is switched off. The Cu and Mg crystals both show a pronounced minimum in the decrement versus 1/T curve. In Mg this minimum occurs at about 60° C; in copper it is found at about 180° C and is considerably sharper. In Mg the minimum is broadened by the ability of this metal to anneal or "age" at room temperatures. In the case of the Al crystals the data indicates a rise in decrement near room temperature although the presence of a minimum in that region has not been established with certainty. The apparatus will be described and an attempt made to interpret the data. (Phys. Rev. Abs.)

PP: B 3 D 9 M 16 U AA 27 36 j CV: 14 MI: Al Cu Mg a

Pittenger, J. T.

Temperature Dependence of Internal Friction of Magnesium, Copper, and Aluminum Single Crystals

Carnegie Inst. of Tech. Submitted in partial fulfillment of the requirements for the degree of Doctor of Science. Tech. Rept. 77p. diagrs. 20 refs. (Contract N6ori-47, T. O. 1) August 10, 1951 (U 19072)

The dependence of internal friction on temperature was determined for single crystals of 99.999% Cu, and 99.99% Al, and the effect of pyramidal slip on the logarithmic decrement was investigated. The apparatus used counted the number of cycles required for the electromagnet oscillation of the specimen to decay to a factor of 1/1.5. The different amplitude intervals over which the decay was timed were separated by factors of 2.5. The slope of 1 n A(amplitude) versus time curves was used as the measure of internal friction. With Mg, a break occurred in the curve for δ (slope) versus 1/T (assolute temperature) at about 300° C ($1/T = 1.75 \times 10^{-3}$). Between 300° and 170° C, the decrement appeared to be due to a thermally activated process and was relatively independent of amplitude for small strain amplitudes. Below 170° C, the decrement passed through a minimum between 60° and 100° C and was dependent on past thermal and vibrational history. When the temperature was changed below 100° C, the decrement first increased and then decreased to a steady value. The aging process (decrease in decrement) appeared to have an activation energy of about 7000 cal. /mole. The decrement of Mg at low amplitudes was increased by brief oscillation at a larger amplitude. Orientation dependence studies indicated that a large projection of the basal plane normal to the stress or specimen axes favors large decrements. The decrement of Cu showed a minimum near 215° C and was amplitude-dependent for all temperatures. (Contractor's abstract)

PP: B 3 D 9 M 16 U AA 27 36 j CV: 14 MI: Al Cu Mg a

Ree, T., Chen, M. C., and Eyring, H.

Molecular Theory of Damping in Fibers. (I)Vibrational Study of Saran Fibers

Utah U. (Tech. Rept. No. 20) Contract N7onr-45101 46p. incl. tables, diagrs. 21 refs. (U 18482)

The structure and properties of polyvinylidene chloride (Saran) fibers were studied relative to the energy loss or internal friction accompanying their longitudinal vibration. The 225-cm.-long fibers were either dyed green (I), pigmented gray with Al, or pigmented gray with Al and exposed at 220°F for 9 sec. under tension (II). The measuring apparatus consisted of a transducer, d.c. amplifier, oscillograph, and pendulum weight. The relative energy losses per cycle b' and frequencies ν (1.75 to 31.5 cps) were measured after stretching the fiber by the weight for 5 to 100 min. Young's moduli determined by the vibrational method were larger than those determined by the static stretching method. The b' values and Young's moduli were largest for I and smallest for II. The flow unit consisted of n1 Maxwell units, n2 springs (these were Maxwell units whose dashpots were combined tightly), and n3 initially unstressed bent springs arranged in parallel. The dashpots of the mobile Maxwell units were further subdivided into dashpots 1 and 2. Formulas for b' and b=b' ν (the specific damping coefficient) were derived which agreed with experimental data. The relaxation times and the effective viscosities at 25° C for dashpots 1 and 2 were 0.030 and 0.50 sec. and 4.92×10^8 and 8.22×10^9 dyne-sec/sp. cm., respectively. The number of dashpots per unit area in the flow unit for dashpots 1 and 2 were 10.6 and 4.41×10^{13}. The changes in the b' values and Young's modulus accompanying the structural change of the fiber are discussed. A classical mechanical treatment for the longitudinal vibration showed that the phase difference between strain and stress in the damped vibration is equal to ($\pi - \delta'$) /2, where δ is the corresponding phase difference in the harmonic motion having the same energy loss as the damped free vibration. (Contractor's abstract)

PP: 3 D 9 11 M 16 T 19 X Y AA 27 30 b 34 CV: 14 17 MI: FF GG' JJ

Ree, T., Chen, M. C., and Eyring, H.

Molecular Theory of Damping in Fibers (II). The Effect of Temperature and Heat Treatment on the Energy Loss in Saran

Utah U. Tech. Rept. No. 25, Contract N7onr-45101, 22p, incl. tables, diagrs. July 20, 1951 (U 18942)

A longitudinal free-vibration method was employed in measuring the relative energy losses in Saran fibers. The pendulum, consisting of a Saran fiber and iron ball, weighed 535 g. A strain gage and electrical device described the pendulum motion. The b' values (TIP U18482) of sample I are plotted against frequency at 42.0°, 33.8°, 14.8°, 3.5°, and -1.2° C. Good agreement with theoretical curves is demonstrated. The b' value rose with decreasing temperature until 14.8° C was reached and then fell with further decrease in temperature. At 20 cps b' attained a maximum at around 10.2C showed a maximum at 13.5 cps. The Young's modulus for sample I increased with lowering temperatures, the increase being sharper in the range below 17° C. Young's moduli are tabulated for 3 samples. The b' values for II and a gray sample at 25.5° C are plotted against frequency. Activation heats, activation entropies, and dissociation heats were calculated for dashpots 1 and 2. Heat-treatment decreased the number of dashpots without changing their character. (Contractor's abstract)

PP: 3 D 9 11 M 16 T U X AA 27 30 b 34 36 h CV: 14
MI: FF GG' JJ

Rorden, H. C. and Grieco, A.

Measurment of Dynamic Internal Dissipation and Elasticity of Soft Plastics

Jour. Appl. Physics, Vol. 22, No. 6, pp.842-845, June 1951

In order to measure the mechanical properties of soft plastics over wide frequency and temperature ranges two new techniques have been devised. The first one, which operates in the frequency range of a few cycles, uses a horizontal oscillating pendulum. The shear impedance of the sample is measured by mounting a small pad of the material between the vibrating pendulum and a fixed platform and determining the change in frequency and the change in the decrement caused by the sample. From these measurements the shear mechanical resistance and reactance of the specimen can be determined. The other technique, which is applicable in the frequency range from 100 cycles to 10,000 cycles, makes use of a vibrating tuning fork. Two identical samples are mounted between a stationary weight and the moving tines, and the shear mechanical impedance is determined by determining the change in frequency and change in decrement caused by the specimen. These two techniques have been applied to measuring the shear properties of a number of soft plastics including Pyralin, Koroseal, Keldur, polyvinyl butyral, Thiokol, and gum rubber. All of these show relaxation effects. The polyvinyl butyral appears to be approaching a crystalline elastic stage at the low frequency of 1000 cycles, while gum rubber remains in a quasi-configurational stage from 2 cycles to 1000 cycles. (Authors' abstract)

PP: 3 D 9 13 R U X AA MI: FF GG

Rotherham, L., Smith, A. D. N., and Greenough, G. B.

Internal Friction and Grain-Boundary Viscosity of Tin

Jour. of the Institute of Metals, Vol. 79, pp 439-454, August 1951

Internal friction of high-purity Sn was studied between 15 and 150° C by measurements made on bars vibrating transversely at audio frequencies in the free-free mode. Both polycrystalline specimens and bars consisting of a very few crystals were examined. A peak in the curve of internal friction vs. temperature ascribed to viscous relaxation at the grain boundaries was found to exist for the former, type, but not for the latter. The activiation energy associated with the relaxation was measured, and is consistent with that for steady-state creep of single crystals, but differs greatly from the value for self-diffusion in tin. This is contrary to a theory proposed by Ke that all three values should be the same. Variation of Young's modulus with temperature was observed over the same range for both types of specimen. (Metals Review)

PP: B 3 D 9 11 12 16 U X AA 27 30 d CV: 14 MI: Sn a

Siefert, A. V. and Worrell, F. T.

The Role of Tetragonal Twins in the Internal Friction of Copper Manganese Alloys

Jour. Appl. Physics, Vol. 22, pp 1257-1259, October 1951

Internal-friction studies were made of an 88% Mn, 12% Cu alloy. This alloy when annealed at 925° C and quenched to room temperature has a tetragonal structure of axial ratio 0.97. Twins are readily formed along the (101) and (011) planes. It is verified that relaxation across these twin boundaries would account for certain observed internal friction. (Metals Review)

PP: 3 E 8 12 16 T U AA 27 30 31 36 h CV: 14 MI: Cu' Mn

Smith, A. D. N.

An Electronic Instrument for the Measurement of the Damping Capacity of Materials

Jour. of Scientific Instruments, Vol. 28, No. 4, pp 106-109, April, 1951

This is an instrument for measuring the rate of decay of any vibration that is exponential and in the frequency range of 50-10,000 cycles per sec. The vibrations are detected by an electrical pickup. A circuit that transmits two timed pulses to an electronic timing unit measures the time for the amplitude of vibration to decrease to half its value during decay. The maximum error in the measured time is + 1/2 the period of vibration. A circuit diagram gives the arrangement and values of the components.

PP: 3 D 16 19 AA 27 CV: 14

Tobolsky, A. V., Dunell, B. A., and Andrews, R. D.

Stress Relaxation and Dynamic Properties of Polymers

Test. Res. Jour., Vol. 21, No. 6, pp.404-411, June 1951

The mechanical behavior of an idealized linear polymer is discussed in terms of the Maxwell relaxation theory. When a simple rectangular distribution of relaxation times is assumed, it is shown that the dynamic properties can be related to those deduced from stress relaxation data by the equation:

$$\omega\eta_{dyn} = \frac{\pi E^\circ}{2 \log_e 10}$$

where η_{dyn} is the dynamically measured internal friction or viscosity, ω the radian frequency, and E° the negative slope of the relaxation curve plotted as reduced stress vs. $\log_{10}$ time. Application of this equation to values of $\omega\eta_{dyn}$ and stress relaxation data on rubbers obtained by Dillon, Prettyman, and Hall (5) and data on textile fibers by Dunell and Dillon (6) is made. Better than order-of-magnitude agreement was obtained between dynamically measured values of $\omega\eta_{dyn}$ and those calculated by the above equation for the series of rubber stocks and fibers considered. The theory presented has interesting implications in regard to the structures of the various polymers studied, most of which would not a priori be considered linear in the sense of the idealized model. The relationships deduced from the "box" distribution are extended to other broad distributions of relaxation times. (Authors' abstract)

PP: AA 27 28 30 31 d 34 CV: 14 17 MI: FF GG JJ

Volterra, E. G.

On Elastic Continua With Heredity Characteristics

Jour. Appl. Mechanics, Vol. 18, pp.273-279, (1951)

The classical equations of motion for elastic media extended on the basis of a general linear stress-strain law involving hereditary damping equations are applied to the case of free radial vibrations of a sphere. Furthermore, the free vibrations of strings, the free transverse vibrations of beams, and the free vibrations of rectangular and circular membranes are studied under the assumption of hereditary damping. (Author's abstract)

PP: Y AA 30 34 CV: 17

1952

Anonymous

Aircraft Gas-Turbine Research

Mechanical Engineering, Vol. 74, pp.21-24, January 1952

Includes discussion of compressor blade vibration, compressor test blade fabrication, turbine blade cooling, materials research, instrument research, fuels and combusion, and afterburner development. In the section on blade vibration it is suggested that a remedy for fatigue failure is the introduction of enough damping action in the blade mount to overcome the aerodynamic excitation of the wind stream. In the conventional method of blade mounting, when the engine is operating, the centrifugal pull on a blade is so great that it is effectively locked in the mount and it is difficult to introduce damping. If a thin film of dry lubricant is introduced between the blade and the mount, then the locking action is minimized and damping can be effectively achieved. Use of this technique, when applied to compressor blades, reduced the stress amplitude to about one third of its former magnitude. Tests referred to were conducted at the NACA Lewis Flight Propulsion Laboratory in Cleveland, Ohio.

PP: A W 23 BB CV: 14 15 MI: SG KK h

Anonymous

Amsler High-Frequency Torsional Vibrator of 2,000 Kg, Type 2,000 HFT 423

Bulletin de la Reunion des Laboratoires d'Essais et de Recherches sur les Matériaux et les Constructions. (English Ed.) pp.17-21, July 1952

The bulletin describes the principle, source of current, and uses of the machine. Special attention is devoted to static tests and combined flexure and torsion fatigue tests. A photographic drum to determine internal damping of materials is described. Machine data are supplied including a photograph and diagram.

PP: 3 5 12 13 14 AA 28 29 42 r CV: 13' 14

Artman, R. A.

Temperature Dependence of Young's Modulus and Internal Friction of Single Crystals of Beta-Brass

Jour. Appl. Physics, Vol. 23, No. 4, pp.475-482, April 1952

The temperature variation of Young's modulus of beta-brass single crystals of 55% (atomic) copper has been determined. Comparison is made with previously reported results. Internal friction has been measured at 21 and 42 kilocycles per second at room temperature and as a function of temperature to slightly above the complete disappearance of order. The room temperature decrement is for all crystals of the order of 10^{-4} and mainly independent of amplitude of oscillation. The decrement as a function of temperature shows a "relaxation peak." Zener's theory for alpha-brass is found to apply and the source of the relaxation is preferential orientation of pair axes of solute atoms in adjacent cells. The heat of activation is about 20×10^3 calories per mole. The relaxation peak is shown to be characteristic of the disordered state. There seems to be no relaxation phenomenon present in the ordered state. The effect of precipitation of the alpha-phase on Young's modulus and the internal friction has been found negligible unless a large amount of precipitation occurs. (Authors' abstract)

PP: 3 E 9 M R S U X AA 27 30 31 34 40 n CV: 14 MI: Cu Zn' n

Bonfiglioli, G., Ferro, A., and Montalenti, G.

Comparison of Magnetoelastic Energy Losses and Magnetic Hysteresis in Ferromagnetic Materials

Physical Review, Ser. 2, Vol. 86, pp.959-961, June 15, 1952

In the present work it is shown that in several samples of ferromagnetic materials, with medium coercive forces, magnetic hysteresis energy losses in a saturation loop are higher than, but of the same order as, magnetoelastic energy losses in a stress cycle described between values of stress not far from the yield point. Moreover, it is observed that the law that expresses the magnetoelastic energy loss of a stress loop as a function of the difference between maximum remanence $J_r(r)$ (measured at the maximum value of stress) and the initial value $J_r(0)$ (measured on material at rest is of the type,

$$E = K \left[\Delta J_r(r)\right]^n,$$

where E is the energy loss and n is an exponent comprised between 1.2 and 2.2. This law is very similar to the Steinmetz law, with the value of ΔJ_r substituted for the value of J (intrinsic induction at the tip of a magnetic loop). Materials dealt with are nickel, alloy steel, carbon steel, and iron. Paper contains tables and graphs. (Authors' abstract)

PP: 3 D 7 13 AA 29 30 c CV: 14 17 MI: CN AY SG Fe Ni a n p q

Fast, J. D. and Dijkstra, L. J.

Internal Friction; Influence of Carbon and Nitrogen in Iron and Steel

Iron and Steel, Vol. 25, pp.165-169, 188, May 1952

An abstract. For the original article see 1951 entry from Philips Technical Review.

PP: B 3 D 9 13 16 U AA 27 28 30 31 36 37 CV: 14
MI: ST CN CI EG' C' Fe p

Fearnow, D. O.

Investigation of the Structural Damping of a Full-Scale Airplane Wing

National advisory committee for aeronautics, 11 p.diagrams., photo., tab. (NACA TN 2594. Formerly RM L5kA04) February 1952 (U 15581)

An investigation to determine the structural damping characteristics of a full-scale airplane wing was conducted by the shock-excitation method wherein the wing was loaded to a predetermined deflection and the load suddenly released. The test specimen vibrated at its fundamental bending frequency of 1.69 cycles per second. Only the first 2 or 3 cycles showed any indication of a higher frequency being superimposed upon the fundamental bending frequency. The damping was found to increase from about 0.002 of critical at an amplitude of vibration of +0.05 inch to approximately 0.0006 of critical at an amplitude of +5 inches. (Author's summary)

PP: 3 D 10 12 16 S 23 AA BB 28 CV: 14

Gebhardt, E., Becker, M., and Schäfer, S.

Properties of Metallic Melts. V. Viscosity of Liquid Copper-Tin Alloys. (In German)

Zeit. f. Metallkunde, Vol. 43, pp.292-296, 1952

Viscosity measurements are reported for liquid Cu-Sn alloys throughout the ranges of 231-1300° for pure Sn and 1083-1300° for pure Cu. A torque method described earlier was used. The alloys contained 10, 20, 25, 32, 38, 50, 60, 65, and 70% Sn. Viscosity decreases with Sn content. Isotherms begin linearly but diverge to higher viscosity values for Sn between 25 and 65% with maxima in the 32 and 38% range corresponding to $Cu_{31}Sn_8$ and Cu_3Sn respectively. This effect is ascribed to affinity between certain atomic groups. The shape of the isotherms is further discussed and it is pointed out that the affinity decreases with increase in temperature, that the degree of short-range order of the components corresponds to an equilibrium which in turn depends on the temperature but not on the pretreatment of the melt. (Chem. Abst., Vol. 47, 8492g, 1953)

PP: 16 U CC 36 37 CV: 13 14 MI: Cu Sn b

Gebhardt, E. and Wörwag, G.

Viscosity of Liquid Silver-Copper-Gold Alloys. (In German)

Zeit. f. Metallkunde, Vol. 43, pp. 106-108, 1952

In addition to the contributing binary systems the intrisic viscosities of ternary system, starting from the binary point, 48% Ag - 52% Cu, are reported. The viscosity decreases with temperature and increases with Au content. All curves at 1000, 1100, and 1300° are continuous and nearly parallel. No evidence for any structural processes is indicated. (Chem. Abs. Vol. 46, 6575e, 1952)

PP: 3 D 9 10 13 16 U CC 36 37 CV: 13 14 MI: EG Ag Cu a b 36

Jensen, J. W.

A Torsion Pendulum of Improved Design for Measuring Damping Capacity

Review of Scientific Instruments, Vol. 23, No. 8, pp.397-401, Aug. 1952

The construction of a torsion pendulum with an improved method of alignment and minimized friction losses is described. An optical recording system is employed, using a moving film camera with film velocity variable from 1 in. per hr to 60 in. per sec to record amplitude decay of freely vibrating specimens. Simplicity of operation permits semiskilled personnel to obtain 6 to 10 records per hr of high-damping Mn-Cu specimens. Sample records demonstrate how variations from 0.002% to over 33% in damping capacity may be measured at torsional stresses ranging from several hundred to about 20,000 psi. (Author's summary)

PP: 3 D 13 AA 27 28 29 CV: 14 MI: Cu Mn b

Johnson, W. H.

Vibration and Flutter of Aircraft Aerials

Ministry of Supply, Aeronautical Research Council Current Papers London: Her Majesty's Stationery Office. Report No.: Structures 126. C.P. 146 July 1952. (Addendum Dec. 1953)

Fatigue failures of blade and whip aircraft aerials have been investigated and it is shown that stalling flutter and mechanically excited vibration have both contributed in large measure to the failures. All the aerial types involved possess considerable flexibility and very low internal damping. It is shown that the introduction of damping into the mounting of the aerials has a very beneficial effect on their behaviour as regards both flutter and mechanically excited vibration. Methods are described for preventing failure from either cause.

PP: A W 23 AA CC 28 29 CV: 14

Josefesson, A. and Kula, E.

Internal Friction Measurements on Iron Wires of Commercial Purity

Jour. of Metals, Vol. 4, Feb. 1952; Trans. Am. Inst. Min. and Met. Eng. Vol. 194,pp.161-165, 1952

The internal friction method of determining carbon and nitrogen in solid solution in alpha iron is applied to some steels of commercial purity. The presence of impurities, such as manganese and perhaps phosphorus, changed the position of the internal friction curve for nitrogen and broadened it. For carbon, the position was not changed, although the curve may be broadened somewhat. Aging curves after water quenching, normalizing, and furnace cooling are given. The fixation of nitrogen by means of aluminum is illustrated, and further the inclination of nitrogen to stay in supersaturated solid solution, even at rather slow rates of cooling, in some steels is shown. (Authors' summary)

PP: B 3 8 13 16 U AA 27 36 37 n CV: 14 MI: ST CN EG' C' Fe a p

Kawashima, S. and Kimura, H.

Measurements of the Internal Friction of Metal Wires and Metal Wire Ropes by Means of Longitudinal Vibrations. (In English)

Mem. Fac. Eng. Kyushu University, Vol. 13, No. 1, pp.119-129, 1952

The internal friction of two steel and copper wires, one stranded copper wire, and four steel wire ropes was determined by measuring the logarithmic decrement of longitudinal vibrations excited electromagnetically in the wires and ropes suspended vertically and stretched by various loads, the extension of the wire or rope, while vibrating, being amplified and determined by an electronic amplifier. The longitudinal elasticity of wire ropes, E, increases with increase of the load. The dynamic modulus of elasticity is greater than the static modulus for wire ropes. The logarithmic decrement of the longitudinal vibrations increases about proportionally to the increase of initial amplitude and decreases with increasing load in the case of the ropes, but for the metal wires the logarithmic decrement does not vary with the load. The logarithmic decrement of steel wire ropes is especially large compared with that of the wires, and increases with the number of wires in the rope, except in the case of the unpreformed type of rope. The internal friction of wire ropes is determined almost entirely by mutual friction of each wire and strand and the internal friction of the constituent wires is very small. (Met. Abs., 1952/53, p.329)

PP: 3 D 9 M R S X 23 AA BB CV: 14 MI: ST CN Cu a

Koehler, J. S.

The Influence of Dislocations and Impurities on the Damping Single Crystals

"Imperfections in Nearly Perfect Crystals" (John Wiley and Sons, New York), pp 197-212; Disc., pp.212-216, 1952

The motion of edge-type dislocations which are "pinned down" by impurity atoms is treated for the case of a periodic external stress. An expression for distribution of free lengths of dislocation is obtained. Zero-amplitude decrement and plastic contribution to the elastic constants are calculated. Amplitude dependence is discussed by supposing that some of the dislocations break away from the impurities. The results obtained are in agreement with experiment if the damping force on a dislocation is about 100 times previously suggested values. (Author's abstract)

PP: 3 D 9 16 S X A 27 30 32 36 h j k CV: 14 15 16 17

Lazan, B. J., Brown, J., Gannett, A., Kirmser, P., and Klumpp, J.

Dynamic Testing of Materials and Structures with a New Resonance Vibration Exciter and Controller

Am. Soc. Test. Mat., Proc. Vol. 52, pp 858-875, 1952

The characteristics of near-resonance vibration are discussed to clarify the relationships among resonance amplification factor, damping energy, and dynamic modulus of elasticity. A newly developed machine is described for exciting and controlling resonance or near-resonance vibrations in materials and joints under various types of stress. This machine imposes an adjustable-while-running mechanical exciting force at a controllable frequency, and by means of automatic electronic controls maintains the desired vibration phase angle and the desired magnitude of the excited force. This is done by controlling the frequency and magnitude of the exciting force, respectively. Equations are developed for determining the resonance amplification and other properties from the machine readings. The stability and accuracy of the machine are discussed. Data are presented on the damping and elasticity properties of aluminum and mild steel, and these are compared with results procured in rotating cantilever beam equipment. The resonance response, damping, and elasticity properties of a bolted joint were determined, and the effects of bolt tension and molybdenum disulfide lubrication are illustrated and partially analyzed. (Authors' abstract)

PP: A 3 E 8 11 12 16 S T X AA BB 28 29 CV: 14 MI: CN Al j

Lee, E. W.

Magnetostriction of Some Ferromagnetic Alloys

Journal of the Iron and Steel Institute, Vol. 171, pp.160-164, June 1952

A simple apparatus which comprises a double roller and mirror system is capable of giving accurate measurements of magnetostriction of ferromagnetic rods. The apparatus was used to study the magnetostriction of some alloys, including the Ni-Co system. Temperature coefficients of magnetostriction of four Ni alloys were measured. Data are given for Co, 4 Ni-Fe alloys; 2 Ni-Si alloys; Monel; Mangonic; and 8 Ni-Co alloys. Apparatus diagram and graphs are shown. (Metals Review)

PP: DD 30 c CV: 14 MI: SG Co Fe Ni Si' a d n p q

Majors, H., Jr.

Dynamic Properties of Nodular Cast Iron. Part I.

Transactions ASME, Vol. 74, pp.365-375, disc. 375-380, April, 1952

This paper presents the experimental results of an investigation on the mechanical properties of magnesium-treated nodular cast iron in the annealed and as-cast condition. The dynamic stress-concentration factors are compared with Neuber's theoretical factors for hyperbolic notches, with Peterson's results for steel, with Frocht's photoelastic results, and with Grant's data on flake case iron and cerium treated nodular iron. Fatigue results are shown for square and 45-degree. V-shaped notches at speeds of 200 and 6000 rpm, as well as for various notch depths. The trend in size effect is indicated. Static damping capacities and static damping capacities from bending are determined. (Author's abstract)

PP: 3 D 5 9 11 M 13 16 S AA 28 29 CV: 14 MI: CI r

Maringer, R. and Muehlenkamp, G. T.

Anelastic Studies of the Effects of Nitrogen in Molybdenum

Jour. of Metals, Vol. 4, p.149, February 1952

Internal-friction tests were made. Molybdenum wire, impregnated with N_2 was inserted as the suspension of a torsion pendulum and oscillated at low frequencies. A stable peak was observed in the internal friction vs. temperature curve at 1300° F. and a frequency of 1 cycle per sec.

PP: B 3 D 8 13 16 U AA 27 30 31 36 37 CV: 14 MI: EG' Mo p

Maringer, R. E., Muehlenkamp, G. T., and Schwope, A. D.

Anelasticity of Molybdenum

A chapter in the Battelle Memorial Institute, 11th Quarterly Status Rept., Nov. 1, 1951 to Feb. 29, 1952, on a Metallurgical Study of Molybdenum, Contract No. N9onr 82100, Project NR 034-402, pp.94-103, 1 Mar. 1952

Additional information is presented for the 1100 F and 1300 F peaks in the internal friction-versus-temperature curves of nitrided molybdenum. The mechanism responsible for these peaks is believed to be the stress-induced diffusion of interstitial nitrogen atoms in solid solution in Mo_2N and MoN. This work on the nitrides is not immediately pertinent to the problem of the effect of solid-solution elements on the ductility of molybdenum. However, the results are reported at this time to complete this phase of the investigation and as a possible aid in future studies on the nitrogen-molybdenum system. Discontinuities have been noted in the internal friction-versus-temperature curves of molybdenum wire at temperatures below 1000 F and are believed to be due to the stress-induced diffusion of interstitial impurities in the molybdenum lattice. An explanation is given for the variations in the temperature at which the grain boundary relaxation peak begins to appear. (Authors' abstract)

PP: 3 D 8 13 16 U AA 27 28 30 31 36 h 39 CV: 14 MI: EG' Mo p

Mima, G. and Imoto, M.

The Internal Friction of Zinc Single Crystals. (In English)

Technol. Rept. Osaka University, Vol. 2, No. 23, pp.93-100, 1952

The internal friction of zinc crystals was found to be increased very considerably after annealing and thereafter to diminish continuously during the period of 20 hours. The higher the temperature of annealing, the greater the initial increase of internal friction. Two causes operate to produce internal friction, viz, thermal agitation of atoms, molecules, etc., and scattering of elastic waves at lattice defects, e.g. dislocations. The greater increase of internal friction after annealing is attributed to the liberation of dislocations which during the subsequent period become trapped, so that the internal friction is reduced. (Met. Abs., 1952-53, p. 326)

PP: 3 16 U AA 27 30 31 32 34 36 h j n CV: 14 MI: Zn a

Morgunova, N. N.

Comparison of Damping Capacities of Some Steels and Cast Irons

Vestnik Mashinostroeniya, Vol. 32, No. 11, pp. 59-61, 1952

This consists of a determination of the relative attenuation of torsional vibrations in structural steels (plain carbon, low alloy, also some high alloy steels) and cast irons (gray iron; inoculated cast iron; high-strength cast iron). Conclusions are drawn from the results concerning the effect of changes in composition and various heat treatments upon damping capacity. Preliminary statements are made regarding the damping capacity of austenitic steels, as cast and heat treated. Translation available through H. Brutcher, P. O. Box 157, Altadena, Calif.

PP: 3 D 13 AA 28 g h CV: 14 MI: CN AY CI n r

Myklestad, N. O.

The Concept of Complex Damping

Jour. Appl. Mechanics, Vol. 19, No. 3, pp.284-286, September 1952

In this paper it is shown that if the hysteresis loop for a material has a particular shape, the damping can be considered adequately by multiplying modulus of elasticity of the material by the complex number e^{2bi} where 2 b is called the complex damping factor. For small values of b it is shown that both for free and forced vibrations of a simple spring-mass system the motion in the case of complex damping is the same as in the case of viscous damping, with $b = C/C_{cr}$, except that in the steady-state case the phase angles are slightly different. Also, it is shown how complex damping may be applied to cases of forced vibrations of uniform rods and beams. The greatest advantage of using complex damping, however, is in numerical calculations of forced vibrations of engine crankshafts, airplane wings, and other types of structures; and for such calculations it has already been extensively used. (Author's abstract)

PP: 3 5 Y AA 30 34 CV: 17

Nishihara, T., and Miki, H.

On the Change of Internal Friction Due to Repeated Stress (Japanese)

Trans., Soc. Mech. Engrs. Japan, Vol. 18, No. 71, pp.34-38, July 1952

During rotating-bending tests, the logarithmic decrements of 0.1% carbon steel (cold drawn wire rod, 3.25 mm diam) were measured by the damping method in a frequency range of from 56 to 2250 cps., and the mechanism of fatigue fracture is studied from the change of internal friction. It is concluded that the intercrystalline strain gradient induced within the material as a result of repeated stresses plays an important role, and the imperfection of the structure plays the secondary role in the fatigue failure which sets in as microscopical cracks within the crystals in the early stage of the repetition of stresses and propagates itself to cause the fracture of the whole material. (ASME. Appl. Mech. Rev. 1904, 1953)

PP: 3 4 9 N 16 S T 19 AA 27 30 31 33 42 r CV: 12' 14 MI: CN j

Nowick, A. S.

Stress Relaxation Across Interfaces

Book: Metal Interfaces, Am. Soc. for Metals, pp.248-268, 1952

A wide variety of anelastic phenomena that occur in materials containing internal interfaces may be explained under the simple assumption that an interface is unable to maintain permanently a shearing stress across it. The detailed behavior of a material depends on how the interfaces within it are distributed. Slip bands may be thought of as interfaces in the same sense as grain boundaries, since the only difference between the behavior of a cold-worked and a well-annealed polycrystalline metal can be accounted for by a difference in the distribution of interfaces rather than in the mechanism of relaxation. Grain boundary relaxation is very sensitive to the presence of impurities in minute amounts. This fact provides an interesting field of investigation which is, as yet, relatively unexplored.

The activation energy for the process of interface relaxation is a kinetic quantity which yield information about the nature of the interface and the mechanism by which slip is produced across it. Two hypotheses have been suggested in the past: Kê has proposed that the activation energy for relaxation may be the same as that for volume diffusion, implying that the unit mechanisms in the two types of experiments are the same. Mott has suggested that the unit mechanism in the relaxation process involves the simultaneous activation of a fairly large number of atoms in a process similar to melting. Both of these suggestions seem to be inconsistent with new data presented. A tentative mechanism for interface relaxation, consistent with present experimental data, is that relaxation occurs by the transfer of atoms from one edge dislocation to another. The rate-determining process may be the creation of a vacancy at the center of an edge dislocation. (Author's summary)

PP: AA 27 30 31 32 CV: 17

Oberst, H.

Damping of Bending Vibrations in Thin Sheets by Firmly Adhering Coatings (In German)

Akustische Beihefte, No. 4, pp.AB181-AB194, 1952

Bending vibrations of thin sheet metal covered on one side by an adhesive layer of a damping material are treated theoretically. Measurements confirm theoretical results. Results are of practical importance.

PP: A 12 AA 28 36 39 CV: 13 14

Osawa, M.

Internal Friction of Iron and Nickel. II. Internal Friction and Plastic Deformation of Pure Ferromagnetic Metals. (Japanese)

Nippon Kinzoku Gakkai-Si (Jour. of the Japan Institute of Metals), Vol. 16, pp.15-18, January 1952

The internal friction of pure Fe and Ni subjected to plastic deformation by tensile and simple and repeated torsion was measured by means of the resonance of longitudinal oscillations. Author found that (1) the internal friction decreases rapidly with plastic deformation at a very small degree of working and (2) there is a peak friction. It is suggested that the first effect is due to ferromagnetism and the second to dislocations. (Author's abstract)

PP: 3 E M 14 AA 27 a b c 36 k CV: 12' 14 MI: SG Fe Ni a n p q

Pässler, M.

Vibration Damping in Solids. (German)

Kolloid, Z. Vol. 129, pp.65-72, 1952

The phenomenological theory of the effect is discussed and equations previously developed by the author and others are reviewed. These include the influence of the thermoelastic effect and are obtained by a superposition of mechanical and thermal stresses and resulting deformations in the equations of motion for an elastic body. Thus the system is characterized by the elastic moduli, the thermal expansivity, sp. heats c_p and c_v, and the heat conductivity. It is pointed out that thermoelastic effects are not the only ones giving rise to internal friction. This is illustrated by experimental results on the frequency dependence of the logarithmic decrement in silver and aluminum, where more than one maximum is observed. In the most general case, then, a viscosity and diffusion coefficient must also appear in the equations. (Chem. Abs. 1953)

PP: 3 D 16 19 Y AA 30 31 d 34 CV: 13 14 17 MI: Ag Al

Perls, T. A.

A Magnetostriction Magnetometer

Office of Basic Instrumentation, Nat'l. Bur. of St'ds. 17p. incl. diagrs. 14 refs. (NBS Rept. No. 1632) May 1952 U 22266

Tests were conducted to determine the effect of external magnetic fields on the resonant amplitude of oscillation of rods made of Ni, Permalloy, 99.99% pure Fe, and cold-rolled steel. Evidence was obtained of large variations in the magnetostrictively excited vibration amplitude with changes in the externally applied steady magnetic field. These changes in amplitude could not be accounted for by independently observed changes in the resonant frequency and damping of the rod, but were related to changes in slope of the curve of magnetostriction vs. intensity of magnetization. A system is described for determining the most suitable magnetic material with regard to sensitivity to small changes in magnetic field intensity. A $BaTiO_3$ accelerometer mounted on one end of a resonant rod generates a voltage which, through a limiter-amplifier, a band-pass filter, a phase-shifting net work, and a power amplifier, excites the resonant rod magnetostrictively at constant voltage independent of the accelerometer output and at a frequency determined by the rod. Consideration was also given to investigating annealing procedures and to the use of fine-wire rather than long-rod samples.

PP: 3 E M 16 V AA 27 CV: 14 MI: CN Fe Ni a 35 h

Roderick, R. L. and Truell, R.

The Measurement of Ultrasonic Attenuation in Solids by the Pulse Technique and Some Results in Steel

Journal of Applied Physics, Vol. 23, No. 2, pp.267-279, February 1952

Pulse techniques for the measurement of attentuation in solids have been extended and refined sufficiently to obtain dependable measurements over a frequency range from 5 to 50 megacycles. Understanding of the relative importance of beam spreading, geometrical boundaries, and method of coupling has been improved. Coupling by means of a water buffer and direct mounting is discussed in detail. Attenuation measurements in the frequency range from 5 to 10 megacycles have been made on chrome molybdenum steel specimens, and these measurements have shown large differences in ultrasonic attenuation for samples of the same chemical composition but different heat treatment. The resulting differences are connected with anisotropy which appears in the photomicrographs. The attenuation and measurements are quite sensitive to heat treatment and other factors. The application of the methods to metallurgical problems and the physics of solids is suggested. (Authors' abstract)
PP: B 3 6 16 19 AA 27 36 h CV: 14 MI: AY 36 s

Rolland, P. Le

Mechanical Properties of Solids as a Function of Temperature. (Plasticity, Viscosity, and Internal Friction.) (French)

Metaux: Corrosion--Industries, Vol. 27, pp.216-232, May 1952

The properties are discussed on the basis of the literature. Treats of atomic models, the perfect crystal at absolute zero, thermal agitation, imperfect crystals and the migration of atoms, mechanical behavior of crystals, real behavior of polycrystalline materials, hardening--interpretation from the structural changes, internal stresses, the role of boundaries at high temperatures, the role of strange elements in the resistance to heating, and internal friction.
PP: 16 U AA 27 30 34 CV: 13 15 17

Russenberger, M.

Contribution to the Fatigue Strength of Notched Bodies. (German)

Schweizer Archiv., Vol. 18, No. 7, pp.220-227, July 1952

Author performed experiments relating the change of damping capacity of 0.40% C steel with repeated stressing. Both the "dynamic damping," which was measured at the stress-cycle frequency of 10,800 cpm, and "static damping," which must have taken at least several minutes to measure the hysteresis loop, were determined. At a stress slightly below the fatigue-endurance limit, both the static and dynamic damping had a low and constant value; at a stress slightly above the endurance limit they increased greatly after 6000 stress cycles. Although the cyclic stress was reduced to the lower value, the damping remained the same. After a rest period of twenty-four hours, the dynamic damping was at a lower value, but quickly returned to the high value. The static damping was not reduced by the rest and remained the same before and after subsequent stressing. The effects of cold-stretching and rest periods of 4000 hours were examined. The static damping returned to the low value for the unstressed material when heated to 200° C.
PP: 3 5 16 S T AA 28 29 36 h k 42 r CV: 13 14 15 MI: CN p

Schuette, E. H.

Plastic Flow and Work-Hardening Phenomena in Magnesium Alloys During Fixed-Deflection Fatigue Tests

Proceedings, Am. Soc. Test. Mat. Vol. 52, pp.804-812, 1952

Whenever fatigue tests are conducted in fixed-deflection machines at stresses above that for which the load-displacement relationship is essentially elastic, the possibility exists that the load on the specimen will change during the course of the test. It is possible to introduce substantial errors in this manner. The phenomena involved has been investigated for several magnesium alloys, for both axial load and repeated-flexure testing, and recommendations are made for testing procedures designed to minimize the undesirable effects. (Author's synopsis)
PP: 3 5 M AA 28 29 30 b 42 r CV: 14 MI: Mg 31 36 37 n s

Skudrzyk, E.

Internal Friction and Elastic Properties of Solid Liquid and Gaseous Bodies. (In German)

Öst. Ing.-Arch., Vol. 6, No. 3, pp.157-196, May 1952

The author continues his studies of materials defined by superposition of all orders of local time derivatives of stress and strain components (Acta Phys., Austr. 2, 148, 1948; AMR 4, Rev. 1485). For infinitesimal oscillations of frequency ω, these equations are equivalent to those obtained by supposing the ordinary moduli of elasticity to be complex and frequency dependent (see Frenkel and Obrastzov, J. Physics Acad. Sci USSR 2, 131-142, 1940). The author discusses the phenomena represented in this theory. Among these are simple and and complex relaxation effects in solids and fluids, elastic after effects, viscous and plastic damping, hysteresis, and plastic flow. There are many comparisons with experimental data, which are used to determine experimental values for the various constants for various specific materials.
PP: 3 5 G 16 U Y AA CC 30 b d 34 36 38 CV: 13 17
MI: AY Al Cu Mg Zn n

Takahashi, S.

Anelasticity of Zinc

Jour. Appl. Physics, Vol. 23, No. 8, pp.866-868, August 1952

Anelastic properties of zinc single crystal of high purity (99.996%) have been studied, using bars vibrating transversely at audio frequencies in free-free modes. Internal friction, effective elasticity, and shape of resonance curve were determined against the strain amplitude. When the driving force exceeds a critical value, the internal friction increases, its maximum-amplitude-frequency decreases, and its resonance curve becomes asymmetrical. Furthermore, under this condition, a discontinuous phenomenon, which is supposed to be closely correlated with slips occurring in the crystal, has been found. This discontinuous phenomenon was recorded under different stresses. (Author's abstract)
PP: 3 E 8 12 16 S 19 X AA 27 28 36 j CV: 14 MI: Zn a

Vreeland, T., Jr., Wood, D. S., and Clark, D. S.

Pre-yield Plastic and Anelastic Micro-Strain in Low Carbon Steel

Dynamic Properties Lab., Calif. Inst. of Tech. 28p.incl. diagrs. 15 refs. (Tech. Rept. No. 6) (Contract N6onr-24418) Sept. 1952 (U 24406)

Annealed low-C steel specimens were subjected to rapidly applied constant stresses which were less than the static upper-yield stress of 0.04 psi. A record of load and microstrain was made continuously for 3.5 sec and then at intervals for about 5 min until the microstrain reached an equilibrium value. These data provide for a quantitative evaluation of a Frank-Read dislocation generating mechanism (Phys. Rev. 79:722, 1950). The characteristic length of dislocation determined by comparison of the theory and data agreed with previous concepts of a mosaic block structure. The total microstrain produced by stresses less than yield was a function of the stress and increased from zero at a stress about 0.4 times that at yield to about 30×10^{-6} in/in. at the yield stress. Derivations and methods of correlating data are given, and other mechanism theories are discussed. (See also TIP U21498) (Contractor's abstract)
PP: AA 27 30 32 CV: 14 MI: CN j

Welch, W. P. and Cametti, B.

Hysteresis of Shaft Materials in Torsion

Trans., Am. Soc. Mech. Engrs., Vol. 74, pp.753-763, July 1952

Static determinations of hysteresis of typical shaft materials in torsion show that the values are low for high-quality materials in unidirectional loading after several cycles of loading up to a shear-stress amplitude of 24,000 psi. For reversed loading, the hysteresis becomes several times larger and may be of significance in accurate torque-weighing devices. The measured hysteresis in a tubular specimen had values 3 to 4 times that for a solid specimen. Two nonmagnetic materials displayed very low values of hysteresis. The apparatus developed for this investigation had sensitivity sufficient to measure displacement changes of 0.002% of the full-load deflection, and was designed to eliminate errors due to temperature changes, extraneous loads, and external vibration. Elastic hysteresis tests were limited to those shaft materials that could be supplied in large diameters. Materials tested were SAE 1015 and 4140, K Monel, and Inconel-X. (Authors' abstract)
PP: 1 3 5 10 13 16 20 AA 28 29 42 q r CV: 14
MI: ST CN AY Ni 32 d e 36 j s

Wert, C. and Marx, J.

Investigation and Study, Anelastic Behavior of Binary Alloys of High Melting

Illinois U., Urbana. Progress Rept. No. 4, 1 July - 30 Sept. 1952, 8 p. incl. table. (Contract DA 11-022-ORD-535). 5 Oct. 1952 (AD 19129)

A new method was developed for calculating the activation energy of a relaxation. The values of the entropy of activation of a number of alloys including N_2 and O_2 in Nb were compared with those previously calculated. The values for N_2 and O_2 in Ta were remeasured. A table showing all the known values for any alloy is appended. Practical methods of heat treatment were established to produce the desired binary alloys. The internal friction peak for O_2 and N_2 in polycrystalline Nb was calibrated by comparison with chemical analysis. The line of α-solid solubility in equilibrium with the nitride was determined, as well as some of the aging characteristics of N_2 in Nb and the effect on electrical resistance of adding small amounts of N_2 and O_2 to Nb. Internal-friction measurements were completed for single crystals of Pb, Zn, and Cu. The internal-friction spectra of Ta and Nb were examined over the range -170° to 1000° C. (Contractor's abstract)
PP: B 3 8 16 U AA 27 30 34 36 j CV: 14 15 17
MI: EG Cu Pb Zn 30 32 d p q

Wood, D. S.

On Longitudinal Plane Waves of Elastic-Plastic Strain in Solids

Trans. Am. Soc. Mech. Eng., Vol. 74, pp.521-525, 1952

A theoretical description is given for the propagation of longitudinal plane waves of large lateral extent in solids, for waves of plastic as well as elastic strain. The importance of the hydrostatic compressibility in determining the nature of the waves is brought out. The results are illustrated by a computation of the velocities of propagation of such waves in 24S-T aluminum alloy, and a computation of the propagation of a pressure pulse of short duration through a flat plate. The effects of the pressure dependence of the compressibility, the temperature changes accompanying compression and the time and rate dependence of the mechanical properties upon the propagation of such waves are discussed.
PP: Y AA 27 CV: 14 17 MI: Al

1953

Anonymous

Failure of High-Pressure Oil Pipes

Machinery Lloys (overseas Ed.), Vol. 25, pp.101-104, July 4, 1953

Types of failures, vibration frequencies, fatigue limit of pipe materials, and the damping of vibrations in pipes are discussed.
PP: W AA 26 CC 28 29 42 r CV: 14

Barber, W. J.

Determination of Damping Capacity of Typical Metals by Free Vibration Method

Kentucky University, Eng. Exp. Sta. Bul. No. 27, 32 p., March 1953

Studies made with a Cambridge Torsional Vibration Recorder are described in which the specimen performs free vibrations which are damped only by internal friction of material. Tests were made of eleven typical metals used in machines and structures including carbon steels, alloy steels, aluminum, brass, pure copper, and cast iron. Results show that a high strength material does not necessarily have high damping capacity.
PP: 3 D G 13 16 S AA 28 42 s CV: 14 MI: CN AY Cl Al Cu a n

Brennan, J. N.

Large Amplitude Vibrations of Rods and Tubes at Audio Frequencies

Jour. Acoust. Soc. of Am. Vol. 25, No. 4, pp. 610-616, July 1953

A new apparatus for investigation of sound propagation constants for large amplitude audio-frequency vibrations in metals is described. One novel feature of the apparatus is the use of tuned resonant supports that are tilted with respect to the specimen. The tilting minimizes the tendency to chatter due to the Poisson effect. Because the supports are driven at their resonant frequency, large amplitudes may be achieved without the occurrence of an energy loss due to slipping at the contact surfaces between supports and test specimen. The error caused by energy dissipation due to the internal friction of the support is, in most cases, negligible. In those cases where it is not neglibible, it can be closely estimated and corrected for. Auxiliary equipment permits determination of the resonant frequency of the specimen to better than 1/1000. The total error in the determination of the logarithmic decrement varies between 2% and 5%. (Author's abstract)

PP: 3 E 6 9 X AA 28 CV: 14

Brennan, J. N. and Sauer, J. A.

Dynamic Properties of Metals

Pennsylvania State College, Tech. Rept. No. 2, Contract DA36-061-ORD-237, 1 Mar.-31 Aug. 53, 27 p. incl. illus. 1953. (AD-17203)

A report on experimental work is divided into three sections: (1) high frequency investigation, (2) low frequency transverse vibration investigation, and (3) a low frequency direct stress study. The three phases were concerned with the determination of the same two properties: velocity of sound and internal friction, but under different conditions.

In the study of internal friction of materials in the range of 100 kc to 1 mc the test apparatus consisted of a square-wave generator, a grating circuit, a power amplifier, and HF oscillator, oscilloscope, and 2 barium titanate transducers. The attenuation constants for 61ST, 24ST, and 14ST aluminum alloys at 400 and 1100 kc were determined and tabulated. The difficulties and limitations of the experiment are discussed. Another apparatus is described which was developed for determining internal friction, either at room temperature or as a function of temperature at small amplitudes in the audio range. It consists of a -50° to 250° C temperature chamber, a transducer, a pick-up, a 400 to 2000 cy. oscillator, and an amplifier to provide driving power for the transducer. Preliminary results indicate that this transverse vibration apparatus is useful in measuring values of $1/Q = \Delta F/f_o$ between 2×10^{-4} and 0.2, where ΔF is the difference between half-power points of the resonance curve and f_o is the resonant frequency. Values were obtained for nylon, glass, pure magnesium, and copper. Modification of a low frequency-direct stress apparatus was made to permit the testing of larger specimens thus extending the frequency range downward to 1 kc. The apparatus has been used to test various metals. Results to be published later. (copies of Report available from ASTIA-DSC).

PP: 3 E 6 8 M 16 U X AA 27 30 31 34 CV: 14 18
MI: FF GG' JJ KK Al Cu Mg a h j 42 43

Brennan, J. N. and Sauer, J. A.

Dynamic Properties of Metals

Pennsylvania State College, Annual Rept. (Final), Contract DA 36-061-ORD-237, Continuation of Contract DA 36-(061)-ORD-106, 1 Sept. 52 - 31 Aug. 53, 4 p., Dated 30 Sept. 1953. (AD-21670)

This investigation differs from most previous work in being concerned with investigating the dynamic properties of materials for large strain amplitudes (ranging upward from 10^{-6}) at frequencies many times greater than used heretofore for large amplitudes. No specific details are given here but full descriptions may be found in the reports and publications listed. A summary follows: (1) Work was continued on a theoretical investigation of thermal samping. (2) An apparatus for investigation of dynamic properties in transverse vibration in the frequency range from 400 cps to 2 kc has been assembled. The internal damping and dynamic modulus of a number of materials has been determined. (3) Direct stress apparatus, in which longitudinal vibrations are studied has been modified to extend the frequency range downward to about 1 kc. Measurements of damping and elastic moduli have been made on a number of additional materials. (4) An apparatus for use in the frequency range from 100 kc to 1 mc was built and used to measure the propagation constants of 61S-T6 aluminum. (Copies of report obtainable from ASTIA-DSC).

PP: 3 E 6 M U X AA 28 29 30 31 34 CV: 14 MI: Al j 43

Cabarat, R., Gence, P., Guillet, L., and Le Roux, R.

Thermo-Elastic Analysis of Transformations in Metallic Alloys. (In French)

Reve de métallurgie, Vol. 50, No. 7, pp. 495-499, July 1953

A thermoelastic analysis of transformations in alloys is made. The effect of allotropic transformation on internal friction is studied by thermoelastic measurements. Tests results on copper and aluminum are given.

PP: B 3 AA 27 30 31 36 h n CV: 13' 14 MI: Al Cu a

Catsiff, E. and Tobolsky, A. V.

Approximate Methods for Determining the Distribution of Relaxation Times and Predicting Dynamic Properties From Stress-Relaxation Studies of Viscoelastic Materials. I. First-Approximation Methods

Frick Chemical Lab., Princeton U., N. J. (ONR Tech. Rept. RLT-5) Contract No. N6onr-27021, Project NR 330-023, 10 p., February 27, 1953 (AD 8309)

Analytical functions have previously been proposed which correspond very closely to observed stress relaxation data of amorphous polymers in the transition region and the rubbery region. In some of these cases a closed function can be found which corresponds to the distribution of relaxation times and furthermore, closed expressions can also be obtained for the dynamic modulus and dynamic viscosity. In other cases approximation methods have to be used to convert the analytical expression for relaxation modulus to the above-mentioned quantities. In this paper the validity of previous approximations is assessed, and new convenient approximation methods are given. (From authors' abstract).

PP: X Y AA 30 d CV: 17 MI: GG

Catsiff, E.

Approximate Methods for Determining the Distribution of Relaxation Times and Predicting Dynamic Properties From Stress-Relaxation Studies (of) Viscoelastic Materials. II. Second Approximation Methods

Frick Chemical Lab., Princeton U., N. J. (Tech. Rept. RLT-6). Contract No. N6ONR-27021, Project NR 330-023, 21 p. February 27, 1953. (AD 8308)

Two "second-approximation" methods for determining the distribution of relaxation times and predicting dynamic properties from stress-relaxation data of amorphous polymers are developed and their validity assessed. Prediction of dynamic properties for a GR-S gum stock is briefly discussed.

PP: X Y AA 30 d CV: 17 MI: GG

Chang, L. C. and Gensamer, M.

Internal Friction of Iron and Molybdenum at Low Temperatures

Acta Metallurgica, Vol. 1, No. 5, pp. 483-486, September 1953

An internal friction peak has been found in iron at about 100° K, and possibly in molybdenum at about 300° K. These internal friction peaks occur at temperatures corresponding to the ductile to brittle transition of these materials in slow tension tests. The possible role of hydrogen in causing the 100° K peak in iron is briefly discussed. (Authors' abstract)

PP: 3 D 12 16 T U AA 27 36 37 CV: 14 MI: Fe Mo a

Cochardt, A. W.

The Origin of Damping in High-Strength Ferromagnetic Alloys

Jour. Appl. Mech., Trans. ASME, Vol. 75, pp. 196-200, June 1953

A theoretical analysis and test data are presented which explain the damping capacity of standard high-strength alloys in terms of the magnetostrictive effect. Conditions for obtaining maximum damping are described and the results of experiments are reported which provide a firm basis for the development of high-strength high-damping alloys. (Author's abstract)

PP: 3 D 8 12 13 16 S AA 28 29 30 c 36 h CV: 14 17
MI: AY SG Co' Cr' Fe n p q

Cochardt, A. W.

A Method for Determining the Internal Damping of Machine Members

Westinghouse Research Lab., East Pittsburgh, Pa. Scientific Paper No. 1721, also ASME annual meeting paper No. 53-a-44. Jan. 29, 1953.

A method is described by which the internal damping of a machine member can be evaluated in a simple way. It is shown that the results of a conventional damping test on a simple shaped specimen of the chosen material can be combined with a newly introduced quantity, the stress-distribution function, to yield the internal damping of a particular member. The suggested method eliminates the necessity for testing expensive specimens as was often the practice. (Author's abstract)

PP: 3 8 L 16 S 20 Y AA 28 CV: 14 17 MI: AY

Demer, L. J. and Lazan, B. J.

Damping, Elasticity, and Fatigue Properties of Unnotched and Notched N-155 at Room and Elevated Temperatures

Minnesota U., Minneapolis. Final Rept., Contract AF 33(038)18903, WADC Tech. Rept. 53-70, 70 p. incl. illus. tables, 14 refs., Feb. 1953. AD 13052

Determination of the damping, elasticity, and fatigue properties of unnotched and notched specimens of N-155 was made at room temperature-1350°, and 1500° F. The properties were compared on the basis of equal stress and equal stress ratio. Curves for first-evidence-of-crack points plotted against stress were compared with S-N fracture diagrams. Effective stress concentration factors were determined from both the fracture and first-evidence-of-crack data; the latter values were nearly independent of the number of fatigue cycles. Data are presented for unnotched and notched specimens on the relationship of the dynamic proportional limit to the fatigue strength. Fatigue strength values for the unnotched specimens were 53,000, 40,000, and 29,000 psi at room temperature, 1350°, and 1500° F, respectively, at 2×10^7 cycles; the notched fatigue strengths were 2200, 1850, and 1500 psi for the respective temperatures. A comparison of the room temperature damping properties of N-155 with those of types S-816 and 403 stainless steel on the basis of equal stress ratio indicated little difference in the magnitude of specific damping at a ratio of 1. Photomicrographs showed a fatigue crack that was transgranular and of unequal depth around the notch periphery and had short branches and a forked appearance. Equations were developed for interpreting rotating cantilever-beam data in calculations of the effective length of specimen fillets, specific damping energy, and dynamic modulus of elasticity. (Authors' abstract)

PP: 3 4 G 12 16 S U 20 X Y AA 28 29 42 q r CV: 14 17
MI: SG Co' Cr' Fe Ni' h

Demer, L. J. and Lazan, B. J.

The Effect of Stress Magnitude and Stress History on the Damping, Elasticity, and Fatigue Properties of Metallic Materials

University of Minnesota, Minneapolis, Report on Contract N8-ONR-66207, Project NR-064-361, 56 p. incl illus. tables, 53 refs. September 1953. (AD 26069)

A brief review of the literature and a general treatment of the damping field are presented dealing with factors involved in the experimental determination of the damping properties of materials, particularly at engineering stress levels. The relationships among damping, elasticity, and fatigue are discussed. The research program at the University of Minnesota in this field is described, and the results of past work are reviewed. Data obtained from rotating cantilever beam tests at room temperature are presented on the damping, elasticity, and fatigue properties of a variety of metallic materials over a wide range of stresses. The damping and elasticity data were obtained at a frequency of 20 rpm.

The existence of a damping cyclic stress sensitivity limit for all materials tested is shown. Various stress history effects above the cyclic stress sensitivity limits are indicated. Slopes for the logarithmic plot of damping vs. stress are investigated throughout the range of test stresses employed. Dynamic stress-strain curves are presented and the variation of dynamic modulus of elasticity as a function of stress for the various materials is indicated. Comparisons are made among the damping and elasticity properties of the materials. An approximate relationship between damping and the fatigue and tensile strengths is shown. Problems to be studied in future investigations are mentioned. An appendix is included in which equations are developed for interpreting rotating cantilever beam data so that the effective length of specimen fillets, and specific damping energy and dynamic secant modulus of elasticity may be calculated. (Authors' abstract)

PP: 3 4 G 12 16 S T 20 X Y AA 28 29 42 q r CV: 14 15 17 18
MI: ST CN AY Al Mg b h j 42

Duke, C. E.

Analysis of Damping in Elastic Solids

Pennsylvania State College, State College. Tech. Rept. No. 1, 37 p. incl. illus. 21 refs. (Contract DA 36-061-ord-237) 1 Sept. 52 - 28 Feb. 1953. (AD 4483)

The equations of motion of a homogeneous, elastic, thermally conducting solid are developed. Within the limitations of the classical theory of elasticity of infinitesimal displacements, a single equation is obtained for the propagation of a stress distrubance. The limiting cases of vanishing thermal conductivity and infinite thermal conductivity yield the adiabatic and isothermal motions. The isothermal motion also satisfies the equations when the thermal coefficient of expansion is zero. The equations are simplified by the assumption of isotropy, and the shear waves in an isotropic medium are shown to be undamped. The medium is dispersive to longitudinal waves so that the velocity of propagation varies with the frequency, the wave form changes with time, and the amplitude is attenuated. With thermal damping, the heat-flow path varies with the frequency. The frequency effect is shown to be the same as that due to the thermal conductivity: low frequencies propagate at the adiabatic velocity and high frequencies tend toward the isothermal value. (Author's abstract)

PP: 16 19 Y AA 27 30 31 34 CV: 17

Eubanks, R. A., Muster, D., and Volterra, E. G.

An Investigation of the Dynamic Properties of Plastics and Rubber-Like Materials

Illinois Inst. of Tech., Chicago. Final Rept. 50 p. incl. illus. tables. (Contract N7ONR-32911) 30 June 1953 (AD 18614)

An improved method of analyzing the experimental data is presented, in which the characteristics of the materials tested are deduced directly through the Prony method of approximation without performing a double differentiation on the experimental results. The results of experiments performed on specimens of Geon Ployblend 503, Geon PVC, and Butyl Rubber indicated that the viscous effects were dominant. This showed that the mechanical method of representing the behavior of the material was better represented by a Voigt model than by a Boltzmann model. The stress-strain relationships had a well-marked nonlinear character. The elastic modulus and the modulus of viscosity were evidently not invariant but functions of the maximum strain. (See also AD 307) (Contractor's abstract)

PP: 16 S X AA 30 d 34 CV: 14 17 MI: FF GG

Frankl, D. R.

The Internal Friction of Rock Salt Crystals

Physical Review, Vol. 92, Nol 3, pp 573-579, November 1953

The internal friction of rock salt crystals is markedly decreased by mild x-radiation. This is interpreted as the pinning of dislocations by cation vacancies liberated from vacancy pairs or the trapping of photoelectrons. Very small applied stresses are capable of breaking down the pinning points. Under some conditions, such breakage under the vibrational stress measurement may lead to a doubly valued dependence of internal friction on strain amplitude. A variety of other phenomena occur, most of them being qualitatively explainable on the basis of damping by moving dislocations. (Author's abstract)

PP: 16 S AA 27 30 32 CV: 14 17 MI: LL

Frederick, D.

The Role of Thermodynamics in Stress Analysis

Mechanics Division Bulletin, ASEE, pp. 14-19, December 1953

In an attempt to focus attention on the role of thermodynamics in stress analysis, examples are cited in the various fields of mechanics for illustrative purposes. Reference is made to thermodynamic effects present in vibration problems in the form of a thermodynamic damping and a change in the frequency arising from a variation of the constants with temperature. The paper was motivated on the belief that the subject is not discussed adequately in the undergraduate stress analysis courses.

PP: 16 19 W AA 30 31 CV: 15

Gebhardt, E., Becker, M., and Dorner, S.

Properties of Metallic Melts. VII. Viscosity of Molten Aluminum and Its Alloys.

(Max-Planck-Inst. Metallforschung, Stuttgart, Ger.)
Zeit. f. Metallkunde, Vol. 44, No. 11, pp. 510-514 (1953)

The viscosity (η) of molten Al and alloys containing (At. %) 1.191, 3.94, 5.98, 8.04, and 12.0 Cu; 0.94 and 3.01 Mg; 0.19, 0.61, and 1.1 Fe; 0.1, 0.5, and 1.0 Ti is measured with a torsion viscometer in the temperature range 650-900°. Pure Al (99.996%) at its m.p. has η of 1.175 centipoises. Addition of Mg has a small effect on η, Cu is more pronounced while small amounts of Fe and particularly Ti increase η very markedly. (Chem. Abs., Vol. 48, 1914 f, 1954)

PP: B 3 D 9 10 13 16 U 26 CC 36 37 42 s CV: 13 14
MI: EG' Al Cu' Fe' Mg' b d 34

Gebhardt, E., Becker, M., and Trägner, E.

Properties of Metallic Melts. VI. Viscosity of Liquid Silver-Tin Alloys

(Max-Planck-Inst. Metallforschung. Stuttgart, Ger.)
Zeit. f. Metallkunde, Vol. 44, No. 8, pp. 379-382, August 1953.

Temperature and concentration dependence of Ag-Sn alloys between 600 and 1300° has been investigated. Similarly as in the case Cu-Sn, N content decreases with increasing temperature and Sn content. Binding forces are discussed which become less important at higher temperatures. For each temperature a degree of order in the melt can be stipulated. (Chem. Abs. Vol. 47, 11115f, 1953)

PP: B 16 U 26 CC 30 31 36 37 40 42 s CV: 13 14 MI: Ag Sn b

Hanson, M. P., Meyer, A. J., and Manson, S. S.

A Method of Evaluating Loose-Blade Mounting as a Means of Suppressing Turbine and Compressor Blade Vibrations

Proc. Soc. Exp. Stress Analysis, Vol. 10, No. 2, pp 103-116, 1953

A method is presented for evaluating loose-blade mounting as a means of suppressing turbine and compressor blade vibration. The method consists of measuring the total damping on a rotating blade system and subtracting from it material and aerodynamic damping. While several methods are presented for the measurement of the total damping, the one used most extensively in the investigation was based on the frequency response curve, suitable corrections being applied to take account of the variation in natural frequency resulting from the effects of centrifugal force. Material and aerodynamic damping were measured on blades machined or solidly fixed in the rotor.

The results of the investigation indicated that while considerable damping could be achieved at low rotative speeds by inserting blades loosely in their mounts, the benefit was lost under the centrifugal force of high rotating speeds. The use of a solid lubricant, such as molybdenum disulphide extended the beneficial effects of looseness to much higher rotative speeds. (Authors' abstract)

PP: A 3 D E 7 8 23 AA BB CC CV: 14

Jewell, W. R.

Apparatus for Measuring Internal Friction in Transversely Vibrating Metal Reeds

Review of Scientific Instruments, Vol. 24, No. 1, pp.5-10, Jan. 1953.

This paper described apparatus for measuring internal friction of nonferromagnetic reeds set in transverse vibration. It includes a description of a symmetrical transducer for inducing the vibrations and an optical method of observing the amplitude. Measurements can be made while the reed is temperature controlled and vibrating in a vacuum. (Author's abstract)

PP: 3 E 8 12 AA 27 CV: 14

Jones, E. R. W. and Munro, W.

The "Elastic Hysteresis" of Uranium

Jour. Mech. and Phys. of Solids, Vol. 1, pp.182-188, 1953

It is shown that the "elastic" properties of polycrystalline uranium at room temperature are very sensitive to the mechanical history of the sample. The metal exhibits "elastic hysteresis" losses that are a factor ten times greater than those found in steel and brass. The energy dissipated per stress cycle has been measured for samples of various grain size and orientation; the results show that the microstructure of the metal affects the degree of energy loss. It is concluded that the energy loss in stress cycling is due to mechanical twinning.

Damping decreases with No. of cycles; compression stress employed, zero to maximum to zero, not reversed.

PP: 3 5 7 M 16 T AA 28 29 30 b 34 36 38 k CV: 14 MI: EG h 44

Kirby, P. L.

A Method of Examining the Transverse Vibrations of Rods and Reeds

British Jour. Appl. Physics, Vol. 4, No. 9, pp 279-281, September 1953.

Apparatus is described with which the vibrations of a thin rod or reed are transformed by means of a capacitance type electromechanical transducer and a capacity-sensitive circuit into varying electrical potentials. The latter are displayed on a voltmeter and oscillograph, and techniques are described for measuring the internal friction or damping capacity at frequencies of vibration from ten to several hundred cycles per second. (Author's abstract)

PP: 3 D 9 12 AA 27 CV: 14 MI: KK

Kirby, P. L.

Internal Friction in Glass. I. Theoretical Aspects

(J. A. Jobling & Co. Ltd., Sunderland, Eng.) J. Soc. Glass. Tech. Vol. 37, 7T-26T, 1953

Relations between internal friction or damping capacity and delayed elastic effects are discussed both effects being related to a quantity denoting the relaxation ratio of an anelastic process. The connection between damping factors for oscillatory and aperiodic stress-time phenomena is considered. Suggestions are made concerning the probable relations between the relaxation ratios (and hence internal friction peaks in the acoustic spectrum) corresponding to different types of elastic deformation. The physical causes of anelasticity in glass are considered including the effects of inhomogeneity, thermal diffusivity, ionic mobility, and effective configuration temperature, the result of which is to suggest reasons for the surprisingly small difference in the time order of elastic after-effects at room temperature and those in the transformation range. (Chem. Abs., Vol. 47, 4567g, 1953)

PP: 16 S AA 27 30 b d 34 36 m CV: 17 MI: KK

Koehler, J. S.

The Influence of Damping on Slip Band Formation

Illinois U., Urbana. Tech. Rept. No. 1. 1 Feb. 52- 30 Apr. 53, on Experimental Research on Plastic Deformation. 9p. illus. 13 refs. (Contract DA 11-022-ORD-1212) 1953 (AD 11266)

The theory of Mott and of Fisher, Hart, and Pry for the production of slip bands is considered. This theory suggests that the kinetic energy of dislocations is what sustains glide on a slip band; it also asserts that the process is stopped by the back stress resulting from dislocation loops previously generated at the Frank Read source. Experimental observations giving the damping experienced by a dislocation and giving the velocity of glide are used to show that the potential energy of a dislocation is generally more than a hundred times the kinetic energy. Evidence indicates that the rate of glide decreases by a factor of about 50 during the production of a single slip band in aluminum. Data also indicate that twinning requires rapid dislocations whereas slip seems to deman slow dislocations. A method of reconciling these observations is suggested. (Contractor's abstract)

PP: AA 27 30 b 32 CV: 14 17 MI: Al a

Koehler, J. S.

The Influence of Crystal Anisotropy on Internal Friction and Elastic Constants

Illinois U., Urbana. Tech. Rept. No. 2, 1 Feb - 1 Dec. 53. (on Experimental Research on Plastic Deformation). 22p.incl. illus. tables, 11 refs. (Contract DA 11-022-ORD-1212) (AD 21610)

Experimental data on internal friction shows that the decrement and the reversible plastic contribution to the elastic constants are much larger for elastically anisotropic materials than for isotropic solids. This is regarded as evidence that in anisotropic materials some of the dislocations do not run straight from one pinning point to the next, but adopt a bent configuration. The two straight portions of such a bent dislocation lie along such crystallographic directions in the glide plane that the bent dislocation has the lowest possible energy. The large motion which results when alternating stresses are applied to such dislocations enables and explanation to be given for the differences between the internal friction and modulus changes in isotropic and in anisotropic materials. Quantitative application of the theory gives $B = 5 \times 10^{-3}$ dyne sec cm^{-2} which is about a hundred times the present theoretical values. (Contractor's abstract)
(See also AD 11266)
PP: 3 G J 12 16 S 19 X AA 27 28 30 b 32 36 j 42 q CV: 14
MI: KK Al Cu Pb Zn

Koenig, J. F.

A Relative Damping Criterion for Linear Systems

Transactions, AIEE, Vol. 72, No. 9, pp.291-294, 1953

Criteria are present which yield information on the following, concerning the characteristic equation of any linear system: 1. the sectorial regions of the complex plane in which roots are located; 2. a lower limit to the damping ratios of the roots, in order to be certain that all oscillatory, transient components disappear quickly; 3. whether the frequencies of all roots are less than any given value; 4. the number of roots with frequencies greater than any given value. A method is presented which yields the solution for any root pair of a polynomial equation with real coefficients, and in particular the pair with the smallest damping ratio. It also applies to complex polynomial equations. The method of Vazsonyi, for the determination of the number of roots within sectorial regions, was extended to yield solutions for root pairs, but it has been pointed out that the pair with the lowest frequency is necessarily the first one evaluated. (From the author's summary)
PP: Y CV: 17

Kolsky, H.

Stress Waves in Solids. (Book)

Oxford at the Clarendon Press; Chapter V, Internal Friction, 1953

Definitions; Methods of Measurement; Behavior of visco-elastic solid-(models); Superposition Principle; Propagation of stress waves in a visco-elastic solid; Mechanism of internal friction.
PP: 3 E 6 11 AA 27 30 31 d 34 CV: 15 16 17

Kunitomi, N.

On the Internal Friction of Ferromagnetic Substances

Science Reports of the Research Institutes Tohoku University, Series A, Vol. 5, No. 4, pp.287-310, 1953

Microscopic eddy currents calculated as a function of magnetization. Results compared with experimental data. Graphs, tables, diagrams, 20 ref. (Metals Review)
PP: 16 V AA 27 30 c CV: 14 MI: SG Fe n q

Kunitomi, N.

Anelastic Study on the Diffusion Coefficients of Alpha-Brass.

Science Reports of the Research Institutes, Tohoku University, Series A., Vol. 5, No. 4, pp.335-343, August 1953

Anelastic relaxation in alpha brass was measured in temperature range from about 20 to 400° C. Chemical diffusion coefficient was calculated from these results. Diagram, graphs. 19 ref. (Metals Review)
PP: 16 U AA 27 30 31 CV: 14 MI: Cu Zn' n

Lazan, B. J.

Effect of Damping Constants and Stress Distribution on the Resonance Response of Members

Journ. Appl. Mechanics, Vol. 20, pp.201-209, June 1953; Am. Soc. of Mech. Engrs., Trans, Vol. 75

The amplitude of vibration of a member at resonance, as defined by its resonance amplification factor, is analyzed in relationship to the damping properties of materials. Data are presented on damping energy to indicate the effect of stress magnitude, stress history, and temperature. Based on the mathematical relationship found to exist between damping and stress magnitude the resonance amplification factors are determined for a variety of direct stress members and beams. It is shown that the amplification in vibration caused by resonance may be considered to be the product of three basic factors, i.e., (a) the material factor, (b) the cross-sectional shape factor, and (c) the longitudinal stress-distribution factor. The first of these factors may be calculated from the damping and dynamic modulus properties of the material and the last two from the shape and loading characteristics of the member. Diagrams are presented to show these basic factors as functions of the shpae and loading characteristics of the member. Diagrams are presented to show these basic factors as functions of the damping exponent and other variables for members commonly encountered in engineering practice. Experimental data are presented to confirm the equations derived for resonance amplification factor of members having various shapes and stress distribution. (Author's abstract)
PP: A 3 E G 8 L M 16 S T U X Y AA 28 29 CV: 14 17
MI: SS SG Co Cr' Ni c e h 42

Leaderman, H. and Marvin, R. S.

Dynamic Compliance, Dynamic Modulus, and Equivalent Voigt and Maxwell Models for Polyisobutylene

Jour. Appl. Physics, Vol. 24, No. 6, pp.812-813, June 1953

Most of the data on viscoelastic properties of noncross-linked polymers in the rubberlike range published recently have been presented in terms of Maxwell distribution functions. Experimental data on dynamic modulus are compared with models of Maxwell and also Voigt. Evidence indicates the desirability of considering such properties as the real part of the dynamic modulus and the real part of the dynamic compliance in terms of a Voigt presentation. Indication is given of advantages gained from measurements of creep and recovery.
PP: X AA 30 d 34 42 43 CV: 14 MI: GG

Levy, S. and Truell, R.

Ultrasonic Attenuation in Magnetic Single Crystals

Reviews of Modern Physics, Vol. 25, pp.140-145, January 1953

This paper describes experimental work using Nickel crystals. The results are presented in the form of graphs and diagrams.
PP: 3 6 A 36 j CV: 14 MI: SG Ni a n

Levy, S., Hobbs, E. V., Kroll, W. D., and Mordfin, L.

Damping of Elastically Supported Element in a Vacuum Tube

Jour. of Research, Nat'l. Bur. of St'ds. Vol. 50, No. 2, pp.71-74, 1953 RP 2391

It is shown that it is possible to damp the motion of an element in a vacuum tube by making the tube part of a two-degree-freedom system. The equations of motion of this system are presented. The optimum valves of the parameters are determined on SEAC, the National Bureau of Standards electronic automatic computer, for a particular set of design requirements. In carrying out this computation, SEAC is used not only to compute the displacements of the system for given values of parameters, but also to choose that set of parameters for which the performance is optimum. A description is given of a tube mount built in accordance with the computations and of the degree of damping achieved. (Authors' abstract)
PP: Y EE 30 34 CV: 14 17

Lewis, F. A., Roberts, G. E., and Ubbelohde, A. R.

Electrolytic Cold-Working and Internal Friction in Palladium/Hydrogen Alloys

Proc. Roy. Soc. (London), Ser. A, Vol. 220, pp.279-289, 1953

Hydrogen electrolyzed into palladium changes the internal friction. In torsional oscillations at 0.54 and 0.22 c/s an immediate large increase of internal friction is observed after charging, or after removing some of the hydrogen by electrolysis. On ageing, the internal friction in such specimens falls to a limiting values, without appreciable loss of hydrogen. This decrease of internal friction obeys approximately a unimolecular rate law, with velocity constant markedly affected by the grain size of the metal. Decay is fastest in annealed specimens with large grain sizes, where in the limit the internal friction returns almost to the value for pure palladium, notwithstanding the presence of about 0.6 H/Pd. In fine-grained charged specimens the internal friction decays to limiting values rather larger than for the pure metal. The observations on palladium/hydrogen suggest that there is a diversity of relaxation processes in the alloy. Electrolysis produces large but temporary 'cold-working' which is accompanied by high internal friction. Rested alloys show permanent relaxation effects related to the initial grain size.
Brief discussion is given of measured effects of hydrogen on Young's modulus and the rigidity modulus of parradium, both of which are somewhat decreased on charging with hydrogen. (Authors' abstract)
PP: 3 D 8 13 X AA 27 30 31 34 36 h 38 k n CV: 14 MI: EG c n 42

Lukaesfalvi, T.

Present Status of the Testing of Iron Castings. (In Hungarian)

Ontode, Vol. 4, No. 9, pp.196-201, September 1953

Necessity and usefulness of various tests are discussed. Impact, fatigue limit, damping capacity, and non-destructive tests and outlines. Diagrams, micrographs. 13 references.
PP: W AA CV: 15 MI: Cl Fe

Maringer, R. E.

Internal Friction of Molybdenum During Tensile Deformation

Jour. of Appl. Physics, Vol. 24, p. 1525, December 1953

In order to relate more closely internal friction and plastic deformation phenomena, internal friction tests have been run during tensile deformation. At or slightly before plastic strain is observed in the stress-strain curve, the internal friction rises sharply, and then drops off suddenly just after the discontinuous yield. In the strain hardening range the internal friction increases approximately linearly with the stress. It is hoped that this method may be of value in dislocation theories.
PP: B 3 D 8 13 14 R S AA 27 29 30 b 32 36 k CV: 14 MI: Mo a

Maringer, R. E. and Schwope, A. D.

The Anelasticity of Molybdenium

Battelle Memorial Inst., Columbus, Ohio. Final Rept. 1 May 50 - 14 July 53 and Quarterly Rept. No. 16, 1 Mar - 14 July 53, 44 p. Incl. illus. tables, 17 refs. (Contract N9ONR-82101) 1950-1953 (AD 24087)

Factors affecting the mechanical properties of Mo were studied by means of internal-friction experiments, in conjunction with chemical, spectrographic, and vacuumfusion analysis, and mechanical testing. Heat-treating Mo in vacuum at 4100° F reduced the O, N, H, and Ca content. The heat-treatment of Mo in NH_3 caused discontinuous yield points in the tensile test. Various internal friction phenomena resulted from the formation of a hard, brittle nitride case. Heat-treatment under 0 pressure caused Mo oxide to form at the grain boundaries and thereby severely embrittled Mo, although the presence of 0 failed to affect the mechanical properties of single crystals. The internal-friction phenomena caused by C and N in cold-worked Mo appeared to be related to mechanical properties such as discontinuous yield point, strain aging, and blue brittleness. The use of H or of metallic impurities in the removal of internal-friction phenomena offered convenient methods of controlling C and N impurities in Mo. (See also AD 24088) (Contractor's abstract)
PP: B AA 27 36 h j 42 s CV: 14 MI: Mo a

Mash, D. R. and Hall, L. D.

Anelastic Behavior of Pure Gold Wire

Trans. Aime, Vol. 197, pp.937-942, 1953

The paper presents the results of experiments on the anelastic behavior of gold, as manifested by grain boundary relaxation. Two grain boundary internal friction peaks are found for gold of 99.9998 pct Av. It is found that the peaks are associated with primary and secondary recrystallization. However, the existence of the two discrete peaks cannot be explained on the basis of grain size and shape above. It is suggested that grain boundary stability, as determined by orientation plays a role in the observed effects. (Authors' abstract)
PP: B 3 9 13 16 S U AA 27 30 31 34 36 h j k 40 41 CV: 14
MI: EG a 36

Marx, J. W., Baker, G. S., and Sivertsen, J. M.

The Internal Friction of Tantalum and Columbium Foils at Ultrasonic Frequencies

Acta Metallurgica, Vol. 1, pp.193-201, March 1953

The internal friction and effective elastic moduli of polycrystalline Ta and Nb foils were measured at vibrational frequencies of about 37 kc and 111 kc. Relaxation effects readily identified with O and N impurities were observed and correlated with the low frequency data of other investigators. Activation energies for O and N diffusion in both Ta and Nb were observed to decrease with increasing temperature, while the internal friction peaks were shifted upward on the temperature scale when the impurity content was increased. Measurement extended over the temperature interval from about -160° C to about 1000° C. Low temperature anomalies in the internal friction of Ta were believed to be caused by hydrogen. Room temperature plastic deformation of Ta and Nb produced large but poorly defined decrement increases between 20° C and 200° C, a range which showed no anomalies for annealed specimens. (Authors' abstract)
PP: 3 D 9 16 U X AA 27 30 31 36 h k CV: 14 MI: EG 30 32 d

Marx, J. W. and Silvertsen, J. M.

Temperature Dependence of the Elastic Moduli and Internal Friction of Silica and Glass

Jour. Appl. Physics, Vol. 24, pp.81-87, 1953

The dynamic Young's moduli and the internal friction of fused quartz, Pyrex-glass, and soft glass rods were measured at a frequency of 37 kc, in longitudinal vibration within the temperature range -170° to 1000° C. The moduli of Pyrex and quartz increased with rising temperature up to the softening point of the glass, while that of soft glass decreased. All three moduli were approximately linear with respect to the temperature over most of the measurement interval. Internal friction maxima were noted at high temperatures while at the lowest measurement temperatures a significant increase in background damping occurred. A brief recapitulation of existing theory is given and employed to interpret the internal friction data. It is suggested that in microscopically inhomogeneous mediums the diffusion measurement by internal friction methods is not equivalent to the determination by other techniques. (Chem. Abs., 1953, 4055b)
PP: 3 M 16 U X AA 27 30 31 36 m CV: 14 17 MI: KK LL

Nowick, A. S.

Internal Friction in Metals

Paper from "Progress in Metal Physics" (book), Vol. IV, Interscience Publishers, Inc., pp.1-70, 1953

An attempt is made to provide a phenomenological description of general features of nonelastic deformation which is sufficiently general to include anelasticity, static hysteresis, and amplitude dependent internal friction. Paper includes graphs, diagrams, and gives 149 references.
PP: 3 16 S AA 27 30 31 34 CV: 15 16 18

Nowick, A. S. and Sladek, R. J.

Anelastic Measurement of Atomic Mobility Under Non-Equilibrium Conditions

Acta Metallurgica, Vol. 1, pp.131-140, March 1953

The anelastic method for the measurement of atomic mobility in substitutional solid solutions, which has been applied previously to the study of Ag-Zn solid solutions under equilibrium conditions, is now used to measure mobility in these same alloys after quenching-in of an excess of vacancies. From the variation of the initial relaxation time with temperature of measurement, it is possible to separate the composite "activation energy" for atomic movement into the heat of formation of vacancy and the heat of activation for the movement of vacancy. In the case of a 70-30 Ag-Zn alloy the values obtained are 11.8 kcal/mol for the heat of formation and 19.7 kcal/mol for the heat of activation associated with a vacancy. The mole fraction of vacancies that are frozen in by quenching from 400° C, calculated from the experimental results, is 5×10^{-4}; the corresponding freezing-in temperature is probably 300° C. The early part of the vacancy decay curve represents an approximately exponential time decay; in the latter part of this curve the rate of disappearance of vacancies is very much diminished. The effect of cold working is to increase the rate of vacancy decay. A lower limit is estimated for the number of jumps of a vacancy before its annihilation; this value is consistent with the concept that dislocations act as sinks for vacancies. (Authors' abstract)
PP: 3 D AA 27 30 31 32 36 k CV: 14 17
MI: Ag Zn b

Owner, F. M.

Fatigue in Engine Design

Roy. Aero. Soc. Jour., Vol. 57, pp.580-584; disc. pp 589-592. September 1953

Discussed design aspects of fatigue, assessment of conditions of loading, effect of damping diversity of parameters fatigue life, and design maxims. Author's summary on Effect of Damping:

In considering damping it is important to distinguish between (1) the effect of damping in reducing fatigue stressing by a reduction of vibration amplitude and (2) the possible relationship between damping and fatigue strength. The usefulness of high damping capacity in reducing response to vibratory forces may be limited by a reduction of fatigue strength.

In general variations of heat treatment, which improve fatigue strength tend to reduce damping capacity in most steels, but because damping coefficients vary with stress levels there is no inherent relationship between damping and fatigue strength.

A correlation is often sought between damping capacity and notch sensitivity but there does not seem to be any essential connection between the two. Some plastics, for example, have high damping capacity but are very notch-conscious and the same applies in a lesser degree to some light alloys.
PP: A 16 S AA 28 29 36 h p r CV: 15 MI: ST

Paranjape, B. V.

On the Theory of Internal Friction in Metals

Physical Soc., Proc., Vol. 66, Sec. A, pp 572-575, June 1953

The absorption and emission of vibrational quanta by the conduction electrons in metals leads to a contribution $\pi^2 \nu F\sigma/K_0(10^{-3})$ to the internal friction per cycle independent of frequency. This holds only for longitudinal vibrations whose wavelength is sufficiently small compared with the dimensions of the sample. In the above ν is the number of free electrons per atom; ν/K_0 is twice the ratio of the velocity of sound to that of the fastest electron and is of the order of 10^{-3}. F is a constant of the order unity; its exact value can be found from the temperature coefficient of the electrical resistivity at high temperatures. (Author's abstract)
PP: AA 27 30 31 34 CV: 17

Pearson, S.

Internal Friction and Grain Boundary Viscosity of Silver and of Binary Silver Solid Solutions

Royal Aircraft Establishment (Gt. Brit.) 16 p. illus. tables, 32 refs. (Rept. No. MET 71) January 1953. (AD 3501)

The variation of internal friction with temperature was measured for spectroscopically pure Ag and for a series of solid solutions of Ag with Cd, In, and Sn by means of a torsion-pendulum apparatus described by Kê (Phys. Rev. 71:533, 1947). The effect of nonmetallic impurities on the grain-boundary relaxation in Ag was also investigated. The alloying elements increased the grain-boundary viscosity and raised the activation energy for grain-boundary relaxation from 22,000 cal/mol for pure Ag to 43,000 cal/mol for the solid solutions. The same value was obtained within the limits of experimental error for all the alloying elements and the solute concentrations. Relaxation caused by stress-induced perferential orientation of solute atoms was apparent only in alloys of maximum Cd and In content. The results conformed with the general theory of grain-boundary relaxation developed by Zener (Elasticity and Anelasticity of Metals, University of Chicago Press, 1948) and Kê but did not appear consistent with mechanisms postulated to explain grain-boundary slip. (Author's abstract)
PP: B 3 D 9 13 16 U AA 27 30 31 d 35 37 40 CV: 14
MI: EG' Ag Sn' a b 35 36

Plunkett, R.

Vibration Damping

Appl. Mechanics Reviews, Vol. 6, No. 7, pp.313-315, July 1953

The author defines the term vibration damping as the reduction of the response of a mechanical system to a vibratory force. This can be done by increasing the mechanical impedance of the system by energy dissipation or by tuned attachments (vibration isolation). Author classifies energy dissipation into three kinds: vibration dampers, connection damping, and materials damping. The paper contains the following sections: (1) vibration dampers, (2) connection damping, (3) material damping, (4) vibration isolation. 56 ref.
PP: A 23 AA BB CC EE CV: 15 18

Postnikov, V. S.

Internal Friction and Shear Modulus of Pure Copper and Beryllium Bronze

National Science Foundation Translation, No. 86, 4 p, September 1953 (Original in Doklady Akademii Nauk SSSR, Vol. 91, No. 1, pp 79-82, July 1953. Available from office of Technical Services, Department of Commerce, Washington 25, D. C. $0.10

Studies of internal friction and shear modulus as depending on temperature and soaking time. Graphs, 6 ref. (Metals Review)
PP: 3 4 8 13 R U X AA 27 28 30 31 34 36 h n CV: 11' 12 14
MI: EG' Cu a 33 s

Rozin, K. M. and Finkel'shtein, E. N.

Phase Transformation by Method of Internal Friction. (In Russian)

Doklady Akademii Nauk SSSR, Vol. 91, No. 4, pp.811-812, August 1, 1953 Trans. available from H. Brutcher, Altadena, Calif., Trans. No. 3303

Advantages are shown for studying the actual kinetics and results of phase transformations in steel on the basis of the internal friction instead of on the basis of the electrical resistance. Internal friction was determined from the logarithmic decrement of torsional oscillations in wire specimens. Experimental results are given for internal friction as a function of temperature; and for the effect of tempering on austenite lattice constant and on the internal friction maxima of steel. Explanation is given for the variation in internal friction and the same is confirmed by X-ray data.
PP: B 3 D 9 13 16 U AA 27 36 h n 42 s CV: 11' 12 14 MI: ST CN m

Russenberger, M.

A New Amsler High-Speed Fatigue Testing Machine

Pamphlet publ. in Switzerland, 11 p, 1953

The paper describes a new alternating push-pull fatigue testing machine with a high testing speed (high frequency pulsator) working on the resonance principle. First the main difference in operation of resonance testing machines from others is outlined. The technical problems which were encountered, both of construction and of evolving a mode of measurement, are indicated. A method of determining quantitatively the damping capacity of materials by a decay method is also described. The relevant theory is expounded and selected experimental values are given. Furthermore, a simple and accurate method is expounded for determining the modulus of elasticity. (Author's summary)
PP: 3 D E G M 16 S 19 X Y AA 28 29 CV: 14 17 MI: AY

Sauer, J. A.

Summary of Research 1947-1951 on Penn State ONR High Polymer Project

Pennsylvania State Coll. Eng. Exp. Sta. and Dept. of Eng. Mech., Final Report, ONR Contract No. N6ONR-269, Task Order VI, Project No. NR033077, March 1953

Studies were made of the creep behavior of polystyrene and methyl methacrylate under loading conditions of tension, compression, bending, and torsion. The relaxation properties of polystyrene and plexiglas were determined; theories were developed to relate relaxation to creep. The internal frictional properties of various linear high polymers and thermosetting plastics were established; a suitable mechanics of damping was determined to predict relative performance ratings of different materials under resonant load conditions. Correlation of the creep and damping properties of polystyrene allowed the prediction of one from the other. The dependence of crazing in plastics on time, stress amplitude, and orientation was outlined. In developing a theory of crazing both the molecular structure and engineering aspects were explored. The effect of rate of straining on the stress-strain characteristics of plastics was correlated with the creep process. Analytical theories were developed for predicting creep deformation and for relating creep data under different states of stress. An analytical method was established to correlate the ultimate strength properties of plastics with their degree of orientation. The titles of eight technical reports issued during the project are presented. References are also given to 15 articles published on the results of the research. (Contractor's abstract)

PP: 3 E Y AA 28 42 43 CV: 14 15 17 MI: FF GG' HH' KK

Sizov, V. P.

An Acoustic Study of the Delta E-Effect and the Damping of the Elastic Waves in Polycrystalline Nickel

National Science Foundation Translation, No. 31, 5 p, July 1953. (Original in Doklady Akademii Nauk SSSR, Vol. 89, p.427, 1953. Available from Office of Technical Services, Department of Commerce, Washington 25, D. C. $0.10.

Results of an experimental study of effect of magnetic field and elastic stresses in polycrystalline nickel. (Metals Review)

PP: 3 6 16 S V AA 30 c CV: 11' 12 14 MI: Ni a

Sorger, G.

An Amplitude and Temperature-Dependent Hysteresis of Alpha Iron at -70° C. (In German)

Zeit. für angewandte Physik, Vol. 5, No. 11, pp.406-413, November 1953

Amplitude and temperature dependent after-effects in alpha iron at -70° C are investigated. Measurements are given of complex permeability of iron and iron-silicon alloys. The relation of the after effect occurring at -70° C and the variation of permeability with strength of magnetic field is investigated.

PP: 3 5 16 U AA 30 c CV: 13 14 MI: Fe Si' q

Sylwestrowicz, W. and Truell, R.

Ultrasonic Attenuation as a Function of Plastic Deformation in Aluminum

Metals Research Laboratory, Brown University, September 1953

Ultrasonic attenuation measurements made on 2S aluminum have shown that attenuation as a function of permanent deformation or strain behaves in a form similar to the stress-strain relation. It appears that 20 MC may be optimum. There is reason to believe that attenuation measurements may yield information about the material which is not available from stress-strain measurements. Attenuation data are expected to be useful in interpreting fatigue data and cold work data.

PP: B 3 6 AA 30 b 36 k 42 r CV: 14 MI: Al b

Tiedemann, J. B., Vigness, I., and Pardue, T. E.

Rotating Beam Deflection Studies

Naval Research Laboratory. Report 4139. 17 p.& figs., May 7, 1953

Thick-walled mild-steel cylinders, while rotating about their axes, were bent transversely by forces applied perpendicular to their lengths. The magnitudes of the loads, and of the internal energy losses per cycle, were determined as a function of angle of bend. Experiments were made, on separate specimens, at different constant rotational speeds and at different constant rates of transverse bending.

Because of the Bauschinger effect, the rotating cylinders exhibited and obvious yield at much less load than did the nonrotating specimens. This yield occurred when the maximum stress in the rotating specimen was approximately equal to the yield stress as determined by a tensile test of the material. The rigidity of a rotating specimen increased in a nearly linear manner with deflection after yield. Nonrotating specimens would continue to large deflections at nearly constant load after a small amount of plastic strain. For large plastic strains, rotating specimens were more rigid than nonrotating specimens.

When the time-rate of transverse bending was held fixed, changes of rotational speeds from 8 to 10,000 rpm had little or no effect upon the apparent yield point. When the ratio of rate of transverse bending to rotational speed was held constant, increasing the rotational speed caused the apparent yield point to increase. If this increase in apparent yield is due to a delayed yield effect, the specimen must have a memory of the number of cycles with stress above the static elastic limit that occurred prior to yielding.

The amount of work hardening, as measured by the load supported for a given deflection, reached a constant value after the first few cycles at a given deflection, and thereafter was not increased until the deflection was increased. (Authors' abstract)

PP: 3 4 7 N 16 S T 19 AA 28 42 s CV: 14 MI: CN j

Van Itterbeek, A. and Myncke, H.

Vibration of Plates Covered With a Damping Layer

Acustica, Vol. 3, No. 4, pp.207-212, 1953

A study is made of the damping of steel plates covered with a thin layer of bitumen emulsion containing schist powder or similar products. This damping is characterized by the constant τ which is the time corresponding to a decrease of the amplitude of the vibration to one half. After the description of the experimental set-up, results obtained with plates of various thicknesses and covered with different materials are given. The damping as a function of temperature, between -20° C and +80° C. is also determined. The check of the efficiency of the damping paint on a cement mill is also discussed. (Authors' summary)

PP: 3 D 10 12 16 U AA 27 36 39 CV: 14 MI: ST CN

Vitovec, F. H. and Lazan, B. J.

Review of Previous Work on Short-Time Tests for Predicting Fatigue Properties of Materials

Wright Air Development Center Technical Report No. 53-122, 59 pp. incl. figs., August, 1953

Experimental observations relating to the fatigue process and theories of fatigue are briefly reviewed. Short-time fatigue testing methods are systematically reviewed and critically discussed. The classification of the methods is based on the relationship of fatigue properties to static properties, to stress-strain characteristics under reversed stress, and to other physical properties. Other methods discussed involve assumptions regarding the shape of the S-N curve. Also tests utilizing special loading conditions are reviewed. Advantages and applicability of the different methods are discussed. A section of the report is devoted to the mechanism of damping in metals at low and high stress, the relationship of damping at high stress to fatigue properties, and to damping at low stress.

PP: 16 S AA 28 29 30 b 42 r CV: 15

Weertman, J. and Koehler, J. S.

Internal Friction and Young's Modulus of Cold-Worked Copper Single Crystals

Jour. Appl. Physics, Vol. 24, No. 5, pp.624-631, May 1953

The internal friction and Young's modulus of single crystals of copper were measured as a function of strain amplitude after they were subjected to various amounts of cold work and different annealing treatments. It was found that the position of the peak in the internal friction versus cold-work curve was dependent upon the strain amplitude of the measurement. No minimum in the Young's modulus versus cold-work curve was found as contrasted with Lawson's result for polycrystalline copper. A minimum was found in the internal friction versus annealing time curve, and a maximum was found in the corresponding Young's modulus curve. The results are semiquantitatively explained using a dislocation model. (Authors' abstract)

PP: 3 E 9 13 16 S X AA 27 28 30 32 34 36 h j k CV: 14 17 MI: Cu a

Wert, C.

Investigation and Study, Anelastic Behavior of Binary Alloys of High Melting Metals

Illinois U., Urbana, Progress Rept. No. 5, 1 Oct., 31 Dec. 1952 - 12 Jan. 1953. (Contract DA 11-0220ORD-535) (AD 19130)

The investigation is directed toward the overall goal of measuring changes produced by alloying elements in the diffusion rate of carbon, in the solid solubility of cementite or other carbides, and in the kinetics of carbide formation. This report compares carbon contents (by chemical) analysis) for several samples of various alloys with the measured internal friction values. The latter were obtained from tests at 40° C at 1 cps from tests on wires. Pure iron and Fe-Cr, Fe-Mn, Fe-V, Fe-Si, Fe-Ni, Fe-Mo, and Fe-Ni-Mo alloys were tested. Results are inconclusive and as yet incompletely understood. (Contractor's abstract)

PP: 3 E M 16 U AA 27 30 31 36 37 j CV: 14
MI: AY EG' Cr' Fe Mn' Mo' Ni' Si' a d 35

Wert, C.

The Metallurgical Use of Anelasticity

Paper from "Modern Research Techniques in Physical Metallurgy," Am. Soc. Metals, Cleveland, pp.225-250, 1953

Paper is concerned with the method of measurement and the interpretation from the measurements which are of interest to metallurgists. Sections deal with internal friction, measurement of a relaxation, torsional pendulum, Electromagnetic drive, quartz crystal drive, elastic after-effect, examples of the use of anelasticity, interstitial alloys, relaxation in substitional alloys, anelasticity of grain boundaries, internal friction associated with plasticity, and a summary of the present state of the field.

PP: B 3 D M 13 AA 27 30 b d CV: 15

1954

Bainton, G. W. Jr.

Use of the Repeated Hysteresis Loop for the Evaluation of Reinforced Plastic Materials and Structures

Amer. Soc. of Mech. Engrs. Annual Meeting, Paper, No. 54-A-269, 1954

Glass-fiber reinforced plastics possess high physical strengths only when the glass fibers assume the load. The degree to which the glass fibers assume the load depends upon a number of factors among which are: Uniform tension of the fibers, the amount of bend produced in the fiber during secondary fabrication, the size of the unit fiber bundles, and the efficiency of wetting of the fiber by the resin.

Because of one or more of these factors, plus the added effects of moisture, only a small fraction of the initial strength of a glass-fiber reinforced-polyester structure can be used as a working load. Standard strength tests have been used to determine the relative worth of resins and filler structures under various conditions of temperature and humidity and much has been learned about behavior under static load through the use of creep tests.

The purpose of this paper is to show that such data can be supplemented by a study of the hysteresis loops and flexural modulus during repeated cycling of a specimen in flexure. In particular, this paper is concerned with the differences in safe working loads as a function of differences in reinforcing structure, together with the rate and mechanism of failure encountered. (Author's abstract)

PP: 1 3 5 7 12 16 T X AA 29 42 r CV: 14 MI: FF JJ' KK

Bordoni, P. G.

Elastic and Anelastic Behavior of Some Metals at Very Low Temperature

Acoustical Soc. of America, Jour., Vol. 26, pp. 495-502, July 1954

Vibration frequency and damping have been measured as a function of temperature from 4.5 - 300°K for Pb, Cu, Al and Ag rods.

PP: 3 6 16 U X AA 27 CV: 14 MI: Ag Al Cu Pb a

Bordoni, P. G. and Nuovo, M.

The Damping of Elastic Waves in Lead at High Temperature. (In Italian)

Nuovo cimento, Vol. 11, Set. 9, No. 2, pp. 127-141, February 1, 1954

Results are given for the damping of longitudinal vibrations measured in the range from 10 to 40 kc and for temperatures between 300 and 600°K.
PP: M R U AA 27 CV: 12' 14 MI: Pb a

Boulanger, C.

Effect of Grain Boundaries in Metals and Alloys on Some of Their Mechanical Properties in the Region of Melting Point. (In French)

Revue de metallurgie, Vol. 51, No. 3, pp. 210-218, March 1954

The paper describes the use of Hysteresimeter for studying internal friction and elastic modulus of alloys.
PP: B 16 U X AA 27 36 38 CV: 13' 14 MI: Al

Brennan, J. N.

Putting Sound to the Test

Penn State Rev., pp. 3-6, Spring, 1954

This is a description of the Ultrasonics Laboratory of the Department of Engineering Mechanics at Penn State University and the general type of research being done. It is a popular treatment.
PP: 2 AA 27 CV: 14

Chatterjee, G. P.

A Simple Method of Measuring Vibration Damping Capacities of Metals and Alloys

J. Instn, Engrs., India, Vol. 35, No. 1, pp. 30-37, September 1954

Low-carbon steel specimens were subjected to a forced amplitude of vibration to known stress (about 18,000 psi) levels. Internal friction (specific damping capacity) was determined by measuring the rate of temperature rise over about one minute of time by means of thermocouples. Temperature changes of about 0.5° C were observed which had constant slope over this period of time. Equations relating the specific damping capacity to the conditions of the experiment and properties of the materials are given. (Appl. Mechanics Reviews)
PP: 3 F J AA 28 CV: 14 MI: CN j

Chen, Y. N.

Torsional Vibrations with Consideration of Mass and Damping of Elastically Stressed Parts. (In German)

Zeit. f. angewandte Math. und Physik, Vol. 5, No. 4, pp. 293-316, July 1954

No abstract available.
PP: Y AA 28 CV: 13 17

Cochardt, A. W.

A Method of Measuring Magnetostriction

Jour. Appl. Physics, Vol. 25, pp. 91-95, January 1954

Torsion tests were made on wires of various ferromagnetic materials. It was found that the relationship between shear stress and shear strain is different for magnetized and unmagnetized wires. The difference is explained in terms of wall movement and rotation of ferromagnetic domains, and magnetostriction values are derived from it. This method of determining magnetostriction has several advantages. It is simpler to carry out than most other methods, its accuracy is 4×10^{-7}, and it can be used at elevated temperatures. Its main limitation is that saturation magnetostriction values are not obtainable for alloys which have a large crystal anisotropy energy. (Author's summary)
PP: 13 16 V AA 28 30 c CV: 14 MI: SG Al' Co' Cr' Fe Ni a n p q

Cochardt, A. W.

Some New Magneto-Mechanical Torsion Experiments

Jour. Appl. Physics, Vol. 25, No. 5, pp. 670-673, May 1954

The internal damping of ferromagnetic wires was measured as a function of either a superimposed static stress or an alternating magnetic field. Similar to a static magnetic field, a static stress affects the damping considerably. For example, the logarithmic decrement of a Fe-40 percent Co wire in torsional vibration is reduced by a factor of 33 when a heavy weight is suspended on the wire. The effect of an alternating magnetic field on the damping was studied by varying the frequency of the field. It is found that the damping reaches a strong minimum at a field frequency of the order of magnitude of 20 cycles/sec. Magnetic hysteresis loss measurements were made which explain the phenomenon in terms of magneto-mechanical hysteresis. (Author's abstract)
PP: 3 D 9 10 13 14 16 17 V AA 27 28 29 30 c CV: 14
MI: SG Co' Cr' Fe a n p q

Dieter, G. E., Horne, G. T. and Mehl, R. F.

Statistical Study of Overstressing in Steel

National Advisory Committee for Aeronautics, TN 3211, 34 pp., April 1954

The effect of overstressing on the fatigue properties of SAE 4340 steel has been studied statistically. In the first part of the study the effect of microstructure on the fatigue damage produced by overstressing was investigated. Fatigue damage was measured by the percentage decrease in fatigue life at the test stress for specimens subjected to varying cycle ratios of fatigue damage at the prestress. The second part of the study was an investigation of the effect of a certain amount of overstressing on the endurance limit and its statistics. In the appendix, damping is discussed as a method of measuring fatigue damage.
PP: B G AA 29 42 r CV: 14 MI: AY 37 s

Dove, R. and Murphy, G.

Experimental Technique for Predicting the Dynamic Behavior of Rubber

Amer. Soc. Mech. Eng., Preprint No. 54-A-41, 9 pp., 1954

An experimental technique is presented for evaluating those mechanical properties of materials which permit the prediction of the stress-strain diagram associated with a given stress-strain time. Particular attention is given to the unrelaxed or dynamic modulus of elasticity and the relaxed modulus. It is shown how the energy loss for a cycle of loading and unloading depends on the rates of straining and unstraining as well as on any elapsed time between the straining and unstraining. The equipment and equations necessary to evaluate the properties and make the predictions are discussed. Several predicted stress-strain diagrams are compared with diagrams constructed from direct observations. (Authors' abstract)
PP: 7 16 T 19 X AA 30 34 CV: 14 17 MI: GG

Entwistle, K. M.

Changes of Damping Capacity in Quench-Ageing Aluminum-Rich Alloys

Institute of Metals, Jour., Vol. 82, pp. 249-263, February 1954

Changes of damping capacity recorded during the ageing of quenched Duralumin at constant temperatures up to 65°C reveal two distinct contributions to the vibrational energy loss. The second of these, which appears as a peak in the curve relating damping and ageing time, has been investigated in detail. The time to reach peak damping was found to vary with ageing temperature (T, °K) as exp (H/RT), where H is 38,000 cal/mole. Further, the damping was established to be of anelastic origin, having a temperature-dependent relaxation time governed by a heat of activation of 13,500 cal/mole.

Simpler, high-purity alloys, namely the binary alloys of aluminum with copper, manganese, or iron, and the ternary aluminum-magnesium-silicon, aluminum-copper-silicon, and aluminum-copper-magnesium alloys, showed neither of these effects, not did commercial-purity alloys of aluminum-magnesium and aluminum-magnesium-silicon. The damping of a quaternary aluminum-copper-magnesium-silicon alloy rose to a peak during ageing. This is considered to correspond to the second contribution observed in Duralumin, since the activation energies describing the temperature dependence of relaxation time (13,200 cal/mole) and the attainment of peak damping during ageing (38,000 cal/mole) are in good agreement with the corresponding values for Duralumin.

The marked difference between the two activation energies in both alloys is taken to mean that the factor governing the attainment of peak damping during ageing is different from that responsible for the vibrational energy loss, but it is not possible at this stage to identify the precise mechanism by which the damping arises. (Author's synopsis)
PP: B 3 D 9 12 13 16 U AA 27 30 31 36 h n CV: 14
MI: EG' Al Cu' Fe' Mg' Mn' Si' h 40

Frinken, H. and Kapler, E.

Elastic Hysteresis. Elastic Hysteresis and Internal Stresses. (In German)

Naturwissenschaften, Vol. 41, No. 20, pp. 472-473, October 1954

The paper deals with the correlation between elongation and stress on removing and reapplying a load on a plastically deformed bar, and with the relationship of internal stresses to the area of the statically measured elastic hysteresis curve. Nickel was the test material.
PP: 3 5 AA 28 29 36 k CV: 13 14 MI: Ni a

Gebhardt, E., Becker, M., and Dorner, S.

Properties of Metallic Melts. IX. Internal Friction of Liquid Aluminum-Zinc Alloys. (In German)

Zeit. f. Metallkunde, Vol. 45, No. 2, pp. 83-85, February 1954

The test results on the melts showed a continuous decrease of viscosity with increasing temperature. Results are given in tabular and graphical form. Aluminum and zinc were studied.
PP: 16 U 26 CC CV: 13 14 MI: Al Zn' b

Granato, A. and Lucke, K.

Internal Friction and Modulus Change Due to Dislocation Damping in Undeformed Crystals

Brown Univ., Providence, R. I., Technical Report, Contract DA 36-039-SC-52623, 61 pp., August 15, 1954 AD 62636,

It is found that the model used by Koehler of a pinned dislocation loop oscillating under the influence of an applied stress leads to two kinds of loss, one frequency dependent and the other not. The frequency dependent loss is found to have a maximum in the high megacycle range. The effect of several distributions of loop lengths is investigated, and it is found that the changes in the characteristics of the loss may be described approximately by associating an effective single loop length with the distribution. The stress dislocation-strain law is derived and found to be frequency independent over a wide frequency range which embraces the kilocycle range. This fact, used together with a derived distribution function for loop lengths as a function of strain amplitude, implies a frequency independent strain-amplitude dependent loss of the type observed in the kilocycle range. The theory provides a quantitative interpretation of this loss. (Authors' abstract)
PP: 16 S 19 X AA 27 30 32 34 CV: 17

Guillet, L. and Hocheid, B.

Internal Friction of Alpha-Iron Due to the Presence of Carbon and Nitrogen in Solution. (In French)

Comptes rendus, Vol. 238, No. 8, pp. 905-906, February 22, 1954

Variations of damping were studied as a function of temperature.
PP: 16 U AA 27 36 37 CV: 13' 14 MI: EG' C' Fe n p

Hull, T. N., Jr.

Gas-Turbine Bucket-Operating Experience and Bucket and Wheel Design Method

Amer. Soc. Mech. Eng., Preprint No. 54-A-172, 16 pp., 1954

This paper presents a report on the operating experience of the General Electric Company's gas turbine buckets, with a discussion of design considerations and preliminary bucket-and-wheel design methods. It includes a discussion of gas-turbine-bucket material selection with a listing of material properties to be considered in the material selection. Operating problems are also discussed. The material internal damping is said to determine the level of vibratory stress which can be obtained on resonance from a given stimulus. High damping is considered very desirable.
PP: A W Y AA 29 CV: 15 MI: SG h

Karpenko, G. V.

Effect of Surface-Active Substances on Decrement of Damping of Vibrations in Steel. (In Russian)

Doklady Academic Nauk SSSR, Vol. 97, No. 1, pp. 81-83, July 1, 1954

Effect of penetration of lubricating oil into microcracks.
PP: AA 36 39 CV: 12 14 MI: ST CN

Klotter, K.

The Attenuation of Damped Free Vibrations and the Derivation of the Damping Law from Recorded Data

Proceedings, 2nd U. S. Natl. Congress of Applied Mechanics, pp. 85-93, June 1954

An approximate method, known in non-linear mechanics as the "Kryloff-Bogoliuboff Method," allows describing in closed form the attenuation of free damped vibrations, for a large variety of damping laws, provided the damping forces are sufficiently weak. From the expressions for the attenuation it is possible to derive rules for finding the damping law from a set of observed data. (Author's abstract)
PP: 3 D 11 Y CV: 17

Klumpp, J. H. and Lazan, B. J.

Frictional Damping and Resonant Vibration Characteristics of an Axial Slip Lap Joint

Wright Air Development Center, Technical Report 54-64, 33 pp., March 1954

A brief summary of the various methods of damping analysis is presented. Data are procured on the frictional properties of mild steel in reciprocating sliding motion. The variation of the kinetic coefficient of friction as a function of normal load, lubrication, and number of cycles of motion is studied. The friction testing apparatus is considered as a vibrating system with Coulomb damping and its frequency response and damping energy are analysed. (Authors' abstract)
PP: 16 17 Y BB CV: 14 MI: CN j

Köster, W., Bangert, L., and Hahn, R.

The Damping Behavior of Stretched Commercial Iron. (In German)

Archiv für das Eisenhüttenwesen, Vol. 25, Nos. 11-12, pp. 569-576, disc., pp. 756-758, November-December, 1954

The study involves a determination of the damping properties of cold-worked iron between 20 and 400°C. Tables and graphs are presented and micrographs are included.
PP: 16 U AA CV: 13 14 MI: Fe a

Köster, W. and Stolte, E.

Recovery of Internal Friction in Brass Immediately After Deformation. (In German)

Zeit. f. Metallkunde, Vol. 45, No. 6, pp. 356-365, June 1954

The apparatus and technique are described. The effects of degree of deformation, temperature, and grain size on recovery rate were determined. 16 ref. (Metals Review)
PP: 3 16 U AA 27 36 38 k n CV: 13 14 MI: Cu Zn'

Krägeloh, W.

Instrument for Measuring Static and Alternating Elongation as Well as Materials Damping. (In German)

Zeitschrift des Vereines deutscher Ingenieure, Vol. 96, No. 25, pp. 864-866, September 1, 1954

The paper describes an instrument with two strain gages for the simultaneous recording of elongation, applied load, and damping properties of statically or dynamically stressed materials. Circuit diagrams are presented in addition to tables, graphs, photographs and oscillograms.
PP: 3 5 AA 28 CV: 13 14

Lazan, B. J.

Fatigue Failure Under Resonant Vibration Conditions

Second paper in the book, "Fatigue", Am. Soc. Metals, Cleveland 3, Ohio, pp. 36-76, 1954

The nature of resonant vibration and its amplification of fatigue stress are demonstrated with the aim of illustrating the significance of system damping. The latter is divided into external and internal sources. The variation of each with stress is discussed. Some basic damping elasticity and fatigue data are given for a number of materials tested at various temperatures. The existence of a cyclic stress sensitivity limit and general damping patterns are described in terms of a "log-average" damping curve. Material damping is shown more likely to offer significant contributions near or above the fatigue limit than at lower stress levels. Where internal damping is a factor, the importance of both fatigue strength and damping as joint criteria for resonant strength is demonstrated. Equations and data are presented for qualitatively evaluating resonant strength constants of materials under uniform stress distribution. The critical importance of damping is shown. The effect of non-uniform stress distribution in a part on its resonant strength is expressed in terms of a volume-stress factor, K_V. The determination of K_V and its dependence on part shape, stress distribution, and the general form of the damping-stress curve are discussed. It is shown that, for high resonant strength it may be desirable in many cases to select material or heat treatments which result in somewhat lower than the optimum fatigue strength but which have considerably higher damping capacities.
PP: A G L 16 S T Y AA BB 28 29 42 r CV: 15 17

Lücke, K.

The Physical Basis of Ultrasonic Attenuation. Part I. The Attenuation Caused by Visco-Elastic Behavior, Especially by the Thermo-Elastic Effect and by Diffusion of Atoms

Brown Univ., Providence, R. I., Metals Research Lab. WAL report No. 143/14-43, Contract DA 19-020-ORD-1579, 20 pp., January 1954

The equation for wave propagation in a linear standard visco-elastic medium is derived. The result, a 3rd order differential, is analyzed for the frequency dependence of the attenuation, the phase velocity and the group velocity of a plane wave. A survey is given of the different damping phenomena caused by the heat flow connected with the thermoelastic effect. It is shown that the heat flow between the different grains of a polycrystalline material can lead to attenuation in the lower megacycle range if the grain diameter is smaller than 10^{-3} cm. With decreasing temperature the thermoelastic effect becomes less important. A survey is given of the damping phenomena caused by the movement of atoms. At temperatures below 200°C these motions are fast enough only for very high diffusion constants to cause an attenuation in the megacycle range. It is possible that diffusion of hydrogen in iron will give considerable damping at this frequency. (Contractor's summary)
PP: 16 19 Y AA 27 30 31 d 36 38 CV: 15 17

Marsh, K. J.

Some Observations on the Anelastic Properties of Copper and Tin Bronzes

Acta Metallurgica, Vol. 2, No. 3, pp. 530-545, May 1954

Investigations have been made into the low-frequency damping of copper and certain tin bronzes, using the method suggested by Kê. Damping curves were obtained at two frequencies, and the various features of these (peak damping, peak temperature and activation energy) were compared with the results of impact-tensile tests on the same materials; but no correlation was found. A simple model is suggested to account for the damping effects in terms of the properties of the grains. The damping at amplitudes higher than those used by Kê was examined and curves showing the variation of damping with amplitude were obtained. Some measurements were made of the torsional creep of copper at low amplitudes and at various temperatures, but the results were not consistent and did not fit the equations proposed by Kê. A reduction in the torsional creep and the damping was found in materials of large grain size. (Author's abstract)
PP: 3 D 9 13 16 S U AA 27 28 30 34 36 37 38 42 43 CV: 14
MI: Cu Sn' a s

McGuigan, M. J. Jr., Bryan, D. F., and Whaley, R. E.

Fatigue Investigation of Full-Scale Transport Wings. Summary of Constant-Amplitude Tests Through 1953

Levin, M. H.

Appendix A. Notes on the Use of Bonded Wires to Detect Fatigue Cracks

National Advisory Committee for Aeronautics Technical Note 3190, 45 pp., March 1954

Results are presented of constant-amplitude fatigue tests on the wings of C-46 airplanes. Eight complete wings were tested at four alternating load levels ranging from 7-1/2 to 22 percent of the design ultimate load factor. All tests were conducted with a 1 g mean load, which is about 22 percent of the design ultimate load factor. All failures which occurred are classified in five types according to the structural stress raisers in which they originated. Effective stress-concentration factors were determined for each stress raiser where failures occurred, the rate and manner of fatigue-crack propagation was investigated, and the effect of the magnitude of load on these items was determined. The scatter in fatigue life of the wings was analyzed statistically. The load-lifetime relationship of the test structure was compared with that of several other full-scale and component structures which have been subjected to fatigue tests. An appendix by M. H. Levin presents information on the use of bonded wires to detect small fatigue cracks; another appendix deals with the use of fiber glass as a method of structural repair. The paper contains damping information in regard to wing structures. (Authors' abstract)
PP: 23 BB CV: 14

Morduchow, M.

On Application of a Quasi-Static Variational Principle to a System with Damping

Trans., Am. Soc. Mech. Eng. (J. Appl. Mech.), Vol. 21, No. 1, pp. 8-10; disc. Vol. 21, No. 3, pp. 303-304, 1954

The principal bending modes of vibration of a beam with a damping force proportional to the velocity are considered. It is shown that, in an important class of cases, the damping has exactly no effect on the mode shapes. It is further shown that the linear differential equation for the vibrating beam with damping can be transformed mathematically into a stationary condition after eliminating the time as a variable. Application of the Rayleigh method to this condition then leads to general approximate results for the logarithmic decrement, and for the effect of damping on the natural frequency, not only in the fundamental mode, but also in any higher principal mode.
PP: 9 12 Y CV: 17

Morrison, D.

Deviations From Hooke's Law Within the "Elastic Range"

Engineering, Vol. 177, pp. 141-144, January 29, 1954

A description is given of a pendulum apparatus developed for the measurement of the very small plastic strains occurring in steel at stresses within the so-called "elastic limit." Such measurements are of particular interest in the study of damping capacity or elastic hysteresis. The apparatus determines the absolute shape of the hysteresis loop and is capable of detecting departures from Hooke's law of as little as 1 lb per sq in. A few results are given for mild steel specimens. The specimen, fixed at the end, carries at its other end a heavy inverted pendulum which has a bending motion. A pneumatic system is used for load measuring and tests are made under static (in the sense of being non-cyclic) conditions. Results from plotting the unidirectional hysteresis loops obtained are analyzed to give energy loss per cycle and the damping coefficient, that is, the ratio of energy loss per cycle to strain energy at the maximum stress of the cycle. Formulae are given for converting from the damping coefficient in bending obtained from the data to the damping coefficient in pure tension.
PP: 3 D 5 7 10 L P 16 S AA 28 CV: 14 17 MI: CN j

Musikant, S.

Vibration of Glass

Product Engineering, pp. 166-169, February 1954

This paper deals with the resiliency and damping properties, shear strength, serviceable temperature range, special design factors, and future development. The damping data consist of oscillograph records of the decay curves for an equal impulse applied to glass fiber cushioning and a steel spring suspension. Glass fiber damped out the impulse in 1-1/2 cycles as compared to 30 cycles for the steel spring.
PP: A 3 D 12 AA 27 28 CV: 14 MI: ST KK

Nowick, A. S.

Internal Friction and Dynamic Modulus of Cold Worked Metals

Jour. Appl. Physics, Vol. 25, No. 9, pp. 1129-1134, September 1954

The complexities of the internal friction and dynamic modulus of metals in the cold-worked condition may be understood reasonably well by separation of the phenomena into the following three distinct effects: (1) the "nonlinear" effect, characterized by strong amplitude dependence, frequency independence, and its disappearance after severe deformation; (2) the Köster effect, which shows rapid recovery after deformation, at temperatures well below the recrystallization temperature; (3) the "viscosity" effect, characterized by strong frequency and temperature dependence. The origin of each of these effects is briefly discussed from the point of view of dislocation theory. (Author's abstract)
PP: X AA 27 30 32 d 36 k CV: 17

Nowick, A. S.

Internal Friction in Metals

Paper from "Progress in Metal Physics, Vol. IV," Interscience Publishers, Inc., pp. 1-70, 1954

This is an attempt to provide a phenomenological description of the general features of nonelastic deformation. The treatment is sufficiently general to include anelasticity, static hysteresis, and amplitude dependent internal friction. An extensive bibliography includes 149 references.
PP: 16 S AA 27 28 30 31 32 CV: 16 18

Olsson, C. O. and Orlik-Ruckemann, K.

The Dampometer

Electronic Engineering, Vol. 26, pp. 420-428, October 1954

A description is given of electronic apparatus for the automatic recording of logarithmic decrement and frequency of oscillations in the audio and sub-audio range.
PP: 3 D 10 AA 28 CV: 14

Pattison, J. R.

An Apparatus for the Accurate Measurement of Internal Friction

Review of Scientific Instruments, Vol. 25, pp. 490-496, May 1954

Electronic instrument developed for measurement of internal friction to high level of accuracy is described. The instrument is activated by an input signal consisting of a voltage time decay wave form, with the necessary condition that decay should follow an exponential law. Operation is both automatic and rapid so that the apparatus is suitable for investigating changes in damping when a given dependent parameter is being investigated.
PP: 3 AA 27 CV: 14

Pian, T. H. H.

A Study of the Structural Damping of a Simple Built-Up Beam with Riveted Joints in Bending

Mass. Inst. of Tech., Aeroelastic and Structures Laboratory, Technical Report, Contract N5Ori-07833 to ONR, 21 pp., May 1954

A theory of structural damping in the bending of a simple built-up beam with either spliced joints or thin reinforcing spar caps is extended to include bending in which the screws or rivets block the sliding motion between the cap and the beam. The analysis assumes that the spar caps and the beam are held together by rivets which are distributed continuously and by pressures which depend upon the tightness of the rivet joint. The theoretical results indicate that, for beams with very flexible rivets, the energy loss per cycle is roughly inversely proportional to the tightness of the joint and tends to vary as the third power of the amplitude of vibration, provided the amplitude is not too large. For very small amplitudes, the same relationship holds for all rivets except very stiff ones. At the opposite extreme, the theory indicates that, for beams with very stiff rivets, the energy loss per cycle is directly proportional to the tightness of the joint and to the amplitude of vibration, provided that the amplitude is not too small. For very large amplitudes, this direct proportionality holds for all rivets except those which are very flexible. Experimental measurements on a test beam provide a qualitative verification of the theory. (Contractor's abstract)
PP: 7 12 16 S Y BB CV: 14 17

Pisarevskii, M. M.

Relation Between Temperature and the Decrement of Vibrations and the Modulus of Elasticity of Some Steels. (In Russian)

Vestnik Mashinostroeniia, Vol. 34, No. 8, pp. 61-65, August 1954

Experimental data are presented for steels of various heat treatments.
PP: 9 16 U X AA 36 h CV: 12 14 MI: ST CN

Postnikov, V. S.

Temperature Dependence of Internal Friction of Aluminum and Copper (In Russian)

Zhurnal Tekhnicheskoi Fiziki, Vol. 24, No. 9, pp. 1599-1608, Sept. 1954

It is shown that the heat of activation of viscous flow at grain boundaries is the same as that for self diffusion. The mechanism of relaxation is considered. Data are given for nickel, aluminum, and copper.
PP: 16 U AA 27 30 31 d CV: 12 14 MI: Al Cu Ni a

Powers, R. W.

Internal Friction in Oxygen - Vanadium and Nitrogen-Vanadium Solid Solutions

Acta Metallurgia, Vol. 2, No. 4, pp. 604-607, July 1954

Two internal friction peaks have been identified in vanadium. One occurring at 186°C for frequencies of 1 cps is associated with the stress-induced diffusion, and the other occurring at 272°C is associated with the diffusion of nitrogen. The corresponding activation energies for these peaks were found to be 28.6 and 34.1 kcal, respectively. The skewness of the oxygen peak has been shown to be a concentration effect. This investigation was undertaken to complete a gap in our understanding of interstitial diffusion in the V B group of the periodic table. The elements of this group, vanadium, niobium (columbium) and tantalum are all body-centered cubic metals with relatively high solubilities for oxygen and nitrogen, which occupy interstitial positions when in solution. Consequently, diffusion studies in these alloys can be conveniently undertaken by means of internal friction measurements. Internal friction measurements on vanadium wires were made in a torsional pendulum similar to the one described by Ke. Phys. Rev., Vol. 71, p. 533, 1947. (Author's abstract)
PP: B 3 D 16 U AA 27 30 31 36 37 CV: 14 MI: EG d 35 p q

Pratt, J. N., Bratina, W. J., and Chalmers, B.

Internal Friction in Titanium and Titanium-Oxygen Alloys

Acta Metallurgica, Vol. 2, No. 2, pp. 203-208, March 1954

A low-frequency torsional pendulum technique has been used to study internal friction in alpha-titanium and in some titanium-oxygen alpha-solid-solutions containing up to 4.5 atomic percent oxygen. Characteristic grain-boundary relaxations peaks are exhibited by the pure titanium and by the alloys; the respective heats of activation were found to be 46,000 cal/mol and 75,000 cal/mol. The introduction of oxygen results in the appearance of additional relaxation peak at approximately 700°K; the mechanism involved is not established but the associate heat of activation is estimated as 48,000 cal/mol. (Metals Review)
PP: 3 D 10 16 U AA 27 30 31 CV: 14 MI: EG d 34 q

Richardson, E. G.

Acoustic and Ultrasonic Relaxation Processes

Applied Mechanics Review, Vol. 7, No. 9, pp. 377-378, 1954

A short article gives a general description of these processes.
PP: 3 6 16 19 AA 27 30 31 d 34 CV: 15

Seeman, H. J. and Bentz, W.

Research on the Effect of Structure on the Extinction of Ultrasound Waves in Metals. (In German)

Zeit. f. Metallkunde, Vol. 45, No. 12, pp. 663-669, December 1954

This consists of a review of the literature and experimental data on aluminum and copper to determine the influence of grain size on the loss of intensity of high-frequency elastic waves.
PP: 3 6 AA 27 36 38 CV: 13 15 MI: Al Cu a

Settles, J. C.

Application of Dynamic Vibration Absorber to Vehicles

Proceedings, 2nd U. S. Natl. Congress of Applied Mechanics, pp. 111-119, June, 1954

This paper deals with the use of dynamic vibration absorbers for simultaneous control of forced linear and rotational motions of vehicles or similar systems.

The equations for the motions of the main mass, the absorber masses, and the relative motion between the main and absorber masses are presented. The equation for the phase angle between the separately forced motions is also presented and the effects of variations in speed and load are discussed. Examples are given of the application of the equations to systems in which (1) the absorber mass remains constant, and (2) the mass ratio remains constant. (Author's abstract)
PP: Y ZE CV: 17

Shea, J. F.

An Anti-Resonant Damper for Dancing Cables

Proceedings, 2nd U. S. Natl. Congress of Applied Mechanics, pp. 127-133, June, 1954

The "dancing" or "galloping" of aerial lines has long been a problem for telephone and power companies. Dancing is a large amplitude, low frequency oscillation of the line usually in one of its first four modes. The amplitude may be as large as ten feet, and the frequency is the order of one cps. The motion is apparently caused by the aerodynamic instability of the cross section of the line in a side wind. This paper develops the theory of a simple anti-resonant damper which may be attached to the cable to prevent excessive amplitudes of motion. (Author's abstract)
PP: W Y ZE CV: 17

Tsobkallo, S. O. and Chelnokov, V. A.

New Method for the Determination of True Damping of Oscillations in Metals. (In Russian)

Zh. tekh. Fiz., Vol. 24, No. 3, pp. 499-510, March 1954

The authors describe an experimental method, in which the number of cycles N is counted by a binary electronic computer between two given values of the amplitude, x_0 and x_N, in free bending vibrations. The logarithmic decrement is then found from the formula $= (\ln x_0 - \ln x_N) / N$. The ratio x_0/x_N may be chosen comparatively close to unity without great loss of accuracy. The experimentally found damping is a mean value for the cross section. The authors show how to compute true damping, i.e., damping at a fixed stress level, from this mean value for rectangular and cylindrical specimens. The method is illustrated by experimental results for two different kinds of steel, with mean value and true damping as functions of stress. (Appl. Mech. Reviews)
PP: 3 D G 9 L 16 S AA 28 CV: 12 14 17 MI: ST

Voelz, K.

Theory of Internal Damping of Vibrating Solids. (In German)

Wissenschaftlichen Gessellschaft, Vol. 6, pp. 125-165, 1954

The theories of Maxwell, Kelvin, Prandtl, and Eyring are discussed. Also considered are damping independent of frequency and true relaxation phenomena. The discussion is accompanied by numerous graphs and diagrams.
PP: AA 27 28 30 31 34 CV: 13 15 17

Weissman, G. F., Pao, V., and Marin, J.

Prediction of Creep Under Fluctuating Stress and Damping from Creep Under Constant Stress

Proceedings, 2nd U. S. Natl. Congress of Applied Mechanics, pp. 577-583, June 1954

The first part of this paper presents a theory for predicting creep strains under dynamic fluctuating stresses from an assumed static creep strain-stress-time relation. A comparison of the theoretical dynamic creep strain values with preliminary experimental results on plastics shows good agreement between the theoretical and test results. A second part of this investigation presents a theory for predicting internal damping of materials under dynamic stress based upon short time static tension creep data. For the material considered the theoretical internal damping value agrees well with the actual damping constants obtained by tests. (Author's abstract)
PP: AA 42 43 CV: 14 17 MI: FF

Yorgiadis, A.

Damping Capacity of Materials

Product Engineering, Vol. 25, pp. 164-170, Nov. 1954

Damping capacity is important as a means of limiting the stresses and amplitudes of vibration in structures operating at resonant speeds. A practical approach is developed herein for analyzing and evaluating this phenomenon in nonuniformly stressed as well as uniformly stressed members. (Author's abstract)
PP: G 10 L M 13 16 S Y AA 28 29 CV: 15 17
MI: ST AY Cl HH JJ KK Al Cu Mg Ni

Yousef, Y. L. and Kamel, R.

Elastic Relaxation and Grain Boundary Diffusion in Cadmium

Journal of Applied Physics, Vol. 25, No. 8, p. 1064, August 1954

Internal friction and Young's modulus relaxation, in relation to intergrain diffusion, are investigated for pure cadmium in the polycrystalline and single crystal states.
PP: X AA 27 30 31 36 j CV: 14 MI: EG A 35

Ang, C., Sivertsen, J., and Wert, C.

Some Anelastic Phenomena in Alloys of Gold and Nickel

Acta Metallurgica, Vol. 3, No. 6, pp. 558-565, Nov. 1955

Two relaxation peaks are found in polycrystalline alloys of Au and Ni between room temperature and 600° C. One of these peaks has been identified as the order peak; the origin of the other is uncertain. Both peaks exist in alloys quenched from the solid solution region of the constitution diagram. Upon annealing of these quenched solid solutions both of these peaks disappear; the order peak along with the formation of the mixture phases, the other peak much earlier than this. The kinetics of the disappearance of the order peak are consistent with all measurements of the kinetics of formation of the mixture phases as determined by independent methods. The behavior of the second peak upon quenching and annealing indicates a process which has not been observed before. (Authors' abstract)

PP: 3 D 13 R U AA 27 30 31 36 38 n CV: 14 MI: EG Ni a 36

Bainton, G. W.

Use of the Repeated Hysteresis Loop for Evaluating Reinforced Plastics

Plastics Technology, pp. 290-294, June 1955

Standard strength tests have been used to determine the relative worth of resins and filler structures under various conditions of temperature and humidity, and much has been learned in the past about behavior under static load through the use of creep tests. It is the purpose of this paper to show that such data can be supplemented by the study of the hysteresis loops and flexural modulus during repeated unidirectional cycling of a specimen in flexure. The paper is concerned in particular with the variation in safe working loads as a function of differences in reinforcing structure, and with the rate and mechanism of failure encountered. Three types of glass reinforcement were used in these tests: rove cloth, fabric, and unidirectional roving. The magnitude of the resin-glass interface place in shear varies with different sample constructions and controls the behavior of the samples under repeated stress. It was found that hysteresis energy loss provides a means of measuring the effect of stress at the resin-glass interface. With repeated stress cycles, measurement of hysteresis loss provides a means of following the changes occurring at this interface. The flexural modulus indicates the degree to which the glass fibers take stress in tension and compression. With repeated stress cycles, changes in flexural modulus indicate changes in the ability of the glass to take load, i.e., broken fibers, loosened fiber bundles, etc.

PP: 1 3 5 W X AA 28 CV: 14 MI: FF JJ' KK

Berry, B. S.

Apparatus for the Measurement of the Internal Friction of Metals in Transverse Vibration

Rev. of Scientific Instruments, Vol. 26, pp. 884-887, Sept. 1955

The apparatus incorporates a specially designed piezoelectric pickup which serves in turn as an exciter and as a detector.

PP: 3 E AA 27 CV: 14

Birnbaum, H. K.

Double-Valued Internal Friction Behavior

Acta Metallurgica, Vol. 3, No. 3, pp. 297-299, May 1955

This work is an extension of the study of two types of double valued behavior of the internal friction versus strain amplitude which have been reported (by Read in zinc single crystals Type I, and by Frankl in sodium chloride single crystals Type II). The materials used in this study are sodium chloride, silver, and aluminum single crystals. The measurements were made by the composite piezoelectric oscillator method.

PP: 3 E 16 S AA 27 36 j CV: 14 MI: LL Ag Al a

Bleakney, H. H.

Internal Friction in Titanium and Titanium-Cxygen Alloys

Acta Metallurgica, Vol. 3, No. 1, pp. 103-104, January 1955

This article shows that stress relaxation across grain boundaries cannot explain the rapid drop in modulus of elasticity at elevated temperatures.

PP: AA 27 30 31 42 q CV: 17 MI: EG d 34 q

Brook, G. B. and Sully, A. H.

Some Observations on the Internal Friction of Polycrystalline Aluminum During the Early Stages of Creep

Acta Metallurgica, Vol. 3, No. 5, pp. 460-469, Sept. 1955

Measurements of internal friction at strain amplitudes of less than 10^{-5} have been made during the tensile creep at constant load of super- and commercial-purity aluminum wires at room temperature, 250° C, and 350° C. On loading, an increase in internal friction occurred and this was partially recovered during the primary creep stage in 1 to 2 hours at 350° C, 4 to 8 hours at 250° C, and about 2 to 20 hours at room temperature (the stresses used at room temperature were too small to cause creep). The component of internal friction due to deformation remained constant during the next few hours and at 350° C was proportional to the applied stress. On unloading, almost complete recovery occurred. There was also evidence of a slight decrease in grain-boundary damping during creep and this has been interpreted tentatively as resulting from a decrease in "grain-boundary roughness." The internal friction due to deformation was only partially recovered without stress. At room temperature a maximum in internal friction occurred with increasing load and appeared to be a result of the rate of recovery exceeding that of the increase in internal friction due to deformation. Commercial-purity aluminum behaved similarly at 350° C a much higher stress being required to produce the same effects. At low stresses no recovery occurred. X-ray observations suggested that the recovery of very high internal friction at high stresses was accompanied by some polygonisation. The results are discussed qualitatively in terms of the dislocation theory. (Authors' abstract)

PP: 3 D 9 16 S 18 U AA 27 30 31 32 CV: 14 MI: Al a 35 38

Cochardt, A. W.

Effect of Static Stress on the Damping of Some Engineering Alloys

Trans. Amer. Soc. for Metals, Vol. 47, pp. 440-450, 1955

Wires of alloy type AISI 403 and Refractaloy 26, with weights suspended on them, were twisted, and the decay of the free torsion vibration was measured. The static stress was varied between 910 and 51,000 psi, the vibrational torsion stress between 0 and 40,000 psi, and the temperature between 70 and 1300° F. (21 and 705° C.). It was found that the damping of alloy type 403 is considerably affected by a superimposed static stress; for example, at a temperature of 750° F (400° C) its damping decreases with static stress by a factor of 5 at lower vibrational stresses. A different effect is observed in Refractaloy 26 whose damping always increases with static stress. The data are found to be in agreement with our present concept of the mechanism of damping, from which it follows that at lower vibrational stresses the damping generally decreases with stress in ferromagnetic materials while the opposite effect occurs in non-ferromagnetic alloys. At larger vibrational stresses, the damping behavior is governed by strain hardening and recovery. (Author's abstract)

PP: 3 D 9 10 13 14 R S U AA 28 29 30 c 36 h k CV: 14
MI: AY SG Ni b h

Damask, A. C. and Nowick, A. S.

Internal Friction Peak Associated With Precipitation in an Al-Ag Alloy

Journal of Appl. Physics, Vol. 26, pp. 1165-1172, Sept. 1955

A specimen which was quenched from the solid solution region and aged at 155° C shows a peak at 140° C for a vibration frequency of 0.25 cycles per second.

PP: 16 U AA 27 CV: 14 MI: Ag' Al

Friedel, J., Boulanger, C. and Crussard, C.

Elastic Modulus and Internal Friction of Polygonized Aluminum. (In French)

Acta Metallurgica, Vol. 3, No. 4, pp. 380-391, July 1955

In polygonised coarse-grained aluminum, one can observe at elevated temperature a strong drop of Young's modulus, while the internal friction reaches high values. The drop of modulus is attributed to displacements of the dislocation walls of the polygonised structure. The fact that it spreads over a large temperature interval, as well as the complex activation energy of the phenomenon, seems to prove that it is due to the joint contribution of several relaxation mechanisms: probably microcreep and climb of dislocations. According to this explanation, the energy of jog formation on dislocations should be about 0.7 to 1 ev, in aluminum. (Authors' abstract)

PP: 9 16 U X AA 27 30 31 32 CV: 13' 14 17 MI: Al a

Gebhardt, E., Becker, M., and Sebastian, H.

Melted Metal Properties. XI. Internal Friction of Magnesium-Tin Alloys

Zeitschrift für Metallkunde, Vol. 46, No. 9, pp. 669-672, Sept. 1955

Experiments and data on relation of internal friction, temperature, concentration and activating energy of viscous flow. (Metals Review)

PP: 3 D 9 13 16 U 26 CC 36 37 CV: 13 14 MI: Mg Sn'

Gebhardt, E., Becker, M., and Trägner, E.

The Properties of Molten Metals. X. Internal Friction of Liquid Magnesium-Lead Alloys. (In German)

Zeitschrift für Metallkunde, Vol. 46, No. 2, pp. 90-94, Feb. 1955

Data are given showing the dependence of internal friction upon temperature and composition. The activation energy for viscous flow is determined.

PP: 16 U 26 CC 36 37 CV: 13 14 MI: Mg Pb' b

Goodman, L. E. and Klumpp, J. H.

Analysis of Slip Damping with Reference to Turbine Blade Vibration

Wright Air Development Center Technical Note 55-232, 30 pp., June 1955

Energy of vibration may be dissipated by microscopic slip on interfaces where machine elements are joined in a press fit. In this report slip damping is studied as an agent in reducing turbine blade resonant stresses and prolonging turbine life. A general theory of slip damping is developed and an expression for the energy loss per cycle of oscillation is found. The predictions of the theory are compared with the results of controlled experiments. It appears that the theory is in satisfactory agreement with experiment and with measurements made on turbine blades elsewhere in this country and abroad.

The implications of the general theory in the design of turbine blades are discussed. It appears that slip damping is capable of being an effective agent in reducing resonant stresses, especially in the 'stall-flutter' condition where aerodynamic damping is inadequate. The design of a slip damping joint which would achieve theoretically possible energy decrements much larger than are present in existing commercial construction is shown to depend on the maintenance of an optimum contact pressure. (Authors' abstract)

PP: A 7 23 BB CV: 14 17

Granato, A. and Lucke, K.

Internal Friction and Modulus Changes Due to Dislocation Damping in Undeformed Crystals -- Part II - Comparison of Theory With Experiment

Brown Univ., Providence, R. I., Technical Report, Contract DA-36-039-SC-52623, 79 pp., January 15, 1955 (AD 62637)

Theories so far proposed to account for sound damping measurements in terms of dislocation behavior have not been developed to the point where they apply for all the forms of damping behavior observed. Even in the ranges for which the proposed theories are supposed to apply, it has not been possible to check them quantitatively with the available data.

Here a theory, based on a model used by Koehler, is developed to a point where quantitative checks are possible. It is found that the same model leads to both the kind of loss found in the kilocycles region and that found in the megacycle region. The predicted results of the theory are compared in so far as is possible with the available data with respect to the dependence of the loss on the principal variables, and on many of the parameters. No serious contradictions are found, but because not all of the parameters in the theory are well known theoretically, it is not possible to say firmly that the theory agrees everywhere. It seems to be especially difficult to come to any conclusions about the initial loss in the kilocycle region. Where conclusions are possible, it is evident that a great deal of quantitative information about dislocation behavior in metals can be obtained from damping measurements.

A number of experiments are suggested by the theory which may permit stronger conclusions to be made. (From authors' conclusion)

PP: B 16 S 19 X AA 27 30 32 34 CV: 15 17

Kawamoto, M. and Nishioka, K.

Researches on the Fatigue Under Consideration of the Phenomenon of Elastic Hysteresis

Kyoto University, Memoirs of the Faculty of Engineering, Vol. 17, No. 1, pp. 1-29, January 1955

The study deals with the relation between stress and strain on some metallic materials subjected to reversed stress and the condition of the fatigue limit. Also considered are the effect of shape of cross section of the specimen on the fatigue limit and the relation between the form and notch factors.
PP: 16 20 AA 28 29 42 r CV: 12' 14

Köster, W., Bangert, L., and Lang, W.

Damping and Modulus of Elasticity of Deformed and Recrystallized Copper. (In German)

Zeitschrift für Metallkunde, Vol. 46, No. 2, pp. 84-89, February 1955

The paper deals with the temperature dependence of damping and modulus of elasticity; the effects of deformation and grain size; and relaxation by means of grain boundary viscosity.
PP: 16 U X AA 30 31 36 38 k CV: 13 14 MI: Cu a

Kunz, F. W.

The Segregation of Carbon in Iron Single Crystals as Studied by Torsion Pendulum Damping

Acta Metallurgica, Vol. 3, No. 2, pp. 126-129, March 1955

The effect of quenching and straining on the segregation of carbon in single crystals of alpha iron was studied by means of torsion pendulum damping. The changes in damping observed in carburized single crystals during room temperature aging were explained on the basis of the Cottrell mechanism. Some mechanism of interaction between dislocations and precipitated iron carbide particles was also required to explain the changes in damping observed in iron crystals after aging at 115° C. A correlation between damping and yielding behavior during room temperature aging was also observed. (Author's abstract)
PP: B 3 D 9 13 AA 27 30 32 36 h j k n 42 s CV: 14 MI: CI C' Fe

Kvashnina, E. I. and Prosvirin, V. I.

Internal Friction of Steel in Relation to Temper (Thermal) Brittleness. (In Russian)

Izvestiia Akademii Nauk SSSR, Otdelenie Tekhnicheskikh Nauk, No. 1, pp. 157-159, January 1955

The study deals with the effect of heating brittle steel at 500° C; the high-temperature tempering and subsequent heating at 500° C; and the effect of molybdenum on the behavior of steel.
Translation available, No. 3555, through Henry Brutcher, Altadena, Calif.
PP: AA 27 g h CV: 12 14 MI: ST Cr' Fe Mn' Mo'

Lazan, B. J.

"The Damping Properties of Materials and Their Relationship to Resonant Fatigue Strength of Parts"

General Electric Co., Report No. R55GL129, January 11, 1955

In this report the damping properties of common structural materials are discussed with a view towards applying the information to the design of machine parts. Basic terms which are used to express damping test results are defined and their uses compared. Various methods and devices for measuring damping are evaluated. The probably causes of damping at various stress levels are given with the effect on damping of stress amplitude and history, temperature, frequency, rest periods, and mean stress. The effect on non-uniform stress distribution in a part on its resonant strength is quantitatively expressed in terms of a volume-stress factor. Methods for determining this factor and its dependence on part shape, stress distribution, and the general form of damping versus stress curve are discussed.
PP: A C D E F G 8 9 L M 13 R S T U 20 W X Y AA 27 28 29 30 31 34 36 h 42 r
CV: 15 17 MI: CN AY CI FF JJ EG Al Fe Mg d 34

Phillips, E. M. and Weymouth, R. E.

Jet Engine Compressor Blades--Hard or Soft?

Preprint No. 438, 7 pp., S. A. E. Annual Meeting, Detroit, Michigan, January 1955

The paper includes a discussion of compressor failure; material used in compressor blades in the J47 engine; the effect of hardness on compressor blade properties; the three types of damping of importance in axial flow compressors; advantages attendant on the use of softer blades; the resistance to corrosion cracking, impact strength, heat treatment, machining; service experience with soft blades. There appears to have been a significant reduction in the incidence of soft blade failures. More service experience is required for conclusive evidence of the superiority of the performance of soft blades. Though much knowledge of damping and related factors is known, much more knowledge is necessary. Though the high damping of the soft blades may be the chief factor resulting in the better performance indicated, it is possible that the improvement may be due in part to other factors.
PP: A W 23 AA BB CC 42 s CV: 15 MI: SS Al Cr Fe c 42

Pippard, A. B.

Ultrasonic Attenuation in Metals

Philosophical Magazine, Vol. 46, 7th Ser. No. 381, pp. 1104-1114, Oct. 1955

This paper analyzes ultrasonic attenuation in metals in terms of a free-electron model.
PP: 3 6 AA 27 34 CV: 17

Powers, R. W.

Internal Friction in Solid Solutions of Oxygen-Tantalum

Acta Metallurgica, Vol. 3, No. 2, pp. 135-139, March 1955

The breadth of the internal friction peak arising from the diffusion of oxygen in tantalum has been found to increase monotonically with the oxygen concentration. Broadening was found to occur asymmetrically by displacement of the high-temperature branch of the damping curve. The data can be described by assuming that the experimental internal friction peak is a composite of the dilute oxygen peak found at 137° C with an activation energy of 25000 cal/mole and a second peak located near 162° C. Evidence is presented which indicated that the peak previously attributed to carbon in tantalum actually is caused by oxygen at low concentrations. In an attempt to determine the nature of the interaction giving rise to the broadening of the oxygen peak it was observed that atoms of another element, nitrogen, can also broaden it considerably. Plastic deformation apparently did not affect the peak breadth. (Author's summary)
PP: 3 D 8 16 U AA 27 30 31 36 37 k CV: 14 MI: EG 32 d q

Salceanu, C.

The Viscosity of Metallic Wires. (In French)

Comptes rendus, Vol. 241, No. 12, pp. 734-736, Sept. 1955

Apparatus for measuring, based on determination of the time necessary to reduce half the initial amplitude of the oscillations of a torsion pendulum, whose suspension wire is made of the metal to be studied. Results of tests on aluminum wire given. (Metals Review)
PP: 3 D 9 13 AA CV: 13' 14 MI: Al

Schnittger, J. R.

The Stress Problem of Vibrating Compressor Blades

Journal of Applied Mechanics, Vol. 22, No. 1, pp. 57-64, March 1955

In order to demonstrate the general nature of the actual vibrations of compressor and turbine blades, the author undertakes a simplified analysis in which a single stiff blade, with one translational and one pitching mode, is studied. It is shown that all problems of stress in vibrating compressor blades whether they arise from forced or self-sustained vibrations may be related to the magnitude of finite mechanical or aerodynamic disturbances. The discussion is a comparison of the order of magnitude of the damping in the blade holder and the internal damping with the magnitude of the damping of the aerodynamic reactions. It is seen that the structural damping for advanced designs appears to be of the order of 10 to 20 percent of the total damping.
PP: A Y AA BB CC CV: 17

Smithells, C. J.

Metals Reference Book

Interscience Publishers Inc. 2 vols., 1955

This set is a convenient and comprehensive summary of a wide range of physical, mechanical, and electrical data relating to metallurgy and metal physics. In this new edition, new values have been substituted where more recent and reliable information has become available. Several sections have been added covering elastic properties and damping capacity, physical properties of molten salts, and friction. Presentation is largely in tabular form, with brief monographs included where information could not otherwise be adequately given. In Vol. II there is a chapter dealing with Elastic Properties and Damping Capacity.
PP: J 11 M 13 16 S U AA 27 28 CV: 15 16
MI: CN AY CI EG Ag Al Co Cu Fe Mg Mo Ni Sn W Zn e k

Stanley, J. T. and Wert, C. A.

Internal Friction of Interstitial Solid Solutions of Oxygen and Nitrogen in Vanadium

Acta Metallurgica, Vol. 3, No. 1, pp. 107-108, January 1955

This paper deals with the effects of carbon, nitrogen, and oxygen on damping peaks in ductile vanadium.
PP: 8 R S U AA 27 30 31 CV: 14 MI: EG C' d 35 p q

Stevens, S.

Skis, Any Way You Want 'Em

Ski, Vol. 19, No. 5, pp. 20, 26-27, Feb. 1955

A research physicist reports the results of experiments designed to measure the torsional rigidity and damping of various types of skis. Various makes of laminated aluminum, wood, and metal top and bottom with wood core types of construction were tested. All wood skis have approximately the same damping. Some laminated woods have about twice the damping of solid woods. The metallic, made of laminated aluminum, have a damping not very different from wood, but give greater damping at larger amplitudes but smaller at the lesser amplitudes than many wood skis. The ski with the metal top and bottom enclosing a wood core has amazingly little damping. The desirable damping requirements of a good ski are as yet unknown and present a topic for future study.
PP: 3 D 12 16 S AA BB 28 CV: 14 MI: HH Al

Truell, R.

Ultrasonic Attenuation Measurements For Study of the Engineering Properties of Materials

Mechanical Engineering, Vol. 77, No. 7, pp. 585-587, July 1955

A relatively new method of studying the physical properties of materials is presented. It can be used in metallurgy, in many engineering applications of both fundamental value and of immediate practical value, including a number of quality-control applications. It is a method about which a great deal will be heard in the future. The paper includes an outline classifying the energy losses in terms of absorption and scattering. The results of typical experiments on a copper-aluminum alloy and a titanium-hydrogen alloy are presented. A curve is also presented showing the results of attenuation in the low megacycle region of chrome-nickel-moly specimens.
PP: 1 B 3 6 AA 27 CV: 14 MI: Al' Cu d 34

Vitovec, F. H. and Lazan, B. J.

Strength, Damping, and Elasticity of Materials Under Increasing Reversed Stress with Reference to Accelerated Fatigue Testing

Wright Air Development Center Technical Report 55-225, 32 pp., June 1955

The purpose of the work was to investigate the damping, stress-strain, and failure properties under uniformly increasing stress amplitude and to determine the relation of these properties to conventionally determined fatigue strength. Data are presented on SAE 1020 Steel, 24S-T4 Aluminum Alloy, SAE 4340 Steel, and RC-55 Titanium under rotating bending stress amplitudes which (a) are progressively increased during the test and (b) are held constant as in conventional fatigue tests. The Gough dynamic proportional limit method and the Lehr damping intercept under uniformly increasing stress amplitude were found to agree with the conventional fatigue strength only for certain materials and to be misleading in other cases. The failure stress at different rates of stress increase and different starting stresses was determined to evaluate the reliability of the Prot short-time fatigue testing method. For the materials tested the starting stress below the cyclic stress sensitivity limit (in the region where damping is unchanged by stress history) has practically no effect on the Prot failure stress. In general, the test results for the four materials indicates that the Prot method indicates the conventional fatigue strength with a reliability of 10 percent. The use of modified Prot methods which utilize exponents n other than 0.5 were not significantly better for indicating fatigue strength. (Authors' abstract)
PP: 3 4 G N 16 S AA 28 29 42 r CV: 14 15
MI: CN AY EG Al d 34 h j 42 s

Watari, A.

Dry Friction Damper and Its Condition of Tuning. (In English)

Report of the Institute of Industrial Science, University of Tokyo, Vol. 5, No. 2, Serial No. 36, pp. 28-36, August 1955

The performances of the Lanchester damper with dry friction are discussed in detail and the condition of tuning is analyzed and compared with that of Lanchester damper with viscous friction. There is an approximate fixed point of tuning also in the case of dry friction, and the optimum damping is

$$\frac{4}{\pi}\left\{\frac{\text{Dry friction torque (force)}}{\text{Amplitude of exciting torque (force)}}\right\}_{\text{opt.}} = \frac{2}{\sqrt{2+\text{Re}}}$$

and the most favorable resonant amplitude ratio is

$$\frac{\theta}{\theta_{st}} = 1 + \left(\frac{2}{\text{Re}}\right)$$

where R_e is the equivalent mass ratio and

$$\text{Re} = \frac{8}{\pi^2} R = \frac{8}{\pi^2}\left\{\frac{\text{Absorber mass}}{\text{Main mass}}\right\}$$

The characteristics of the Lanchester damper with dry friction can be derived from the results concerning the damper with viscous friction by substituting $4/\pi$ times the dry friction torque for the amplitude of the viscous damping torque and the equivalent mass ratio for the mass ratio. The idea of equivalent mass ratio is necessary for discussing vibration absorbers with dry friction besides the thought of equivalent viscous damping. (Author's synopsis)

PP: Y EE CV: 17

Weertman, J.

Internal Friction of Metal Single Crystals

Journal of Applied Physics, Vol. 26, No. 2, pp. 202-210, February 1955

Semiquantitative calculations were made of that portion of the internal friction of annealed and moderately cold-worked metal single crystals which is due to dislocation motion. The calculations were made on the basis of a qualitative theory of Nowick. It is shown that Nowick's theory leads to reasonable orders of magnitude of the observed internal friction and changes of the modulus of elasticity. At low temperature or at high frequencies (megacycle range) Nowick's hysteresis mechanism becomes inoperative and theories of Koehler and of Eshelby have to be considered to calculate the internal friction. (Author's abstract)

PP: 16 U AA 27 30 32 36 j CV: 17

Weertman, J. and Salkovitz, E. I.

The Internal Friction of Dilute Alloys of Lead

Acta Metallurgica, Vol. 3, No. 1, pp. 1-9, January 1955

The internal friction and Young's modulus were measured for a series of single crystals of lead containing approximately 0.01 to 1 atomic percent of either Bi, Sn, or Cd. It was discovered that the internal friction was independent of strain amplitude up to a critical strain amplitude, at which point the internal friction increased and the modulus decreased with further increase in strain amplitude. At room temperature the resolved shear stress for this critical strain amplitude is approximately equal to $0.15\ \mu\epsilon c$ where μ is the shear modulus, ϵ is the fractional difference in size between the solute and solvent atoms, and c is the fraction of the total number of atoms which are solute atoms. The data also agree well with results on the change in the critical shear stress with alloying content in copper crystals reported by Linde, Lindell, and Stade. (Authors' abstract)

PP: 13 16 S Y AA 27 30 36 37 j CV: 14 MI: EG' Pb Sn' a 31 34 35 n

Weinig, S.

High-Vacuum Torsional Pendulum for Anelastic Studies

Rev. of Scient. Inst., Vol. 26, pp. 91-92, 1955

In this paper a high vacuum internal friction apparatus is described by means of which a wire specimen may be studied without manual manipulation of the sample or reduction of vacuum in the system from a time prior to annealing until completion of the test. Results are presented for tests on two annealed high purity copper aluminum alloys with the decrement being measured at 50° C. The frequency ratio used was $f_1/f_2 = 2.85$. Within the experimental accuracy no variation in logarithmic decrement was found. A decrease of internal friction with increased solute which was observed in these tests is due to the pinning down of dislocations in the metal.

PP: 3 D 9 16 19 AA 27 30 32 36 37 CV: 14 MI: Al' Cu b

Wert, C. A.

Internal Friction of an Alloy of 16 percent Aluminum in Iron

Journal of Applied Physics, Vol. 26, pp. 640-641, May 1955

The results of measurements of the internal friction of "16 Alfenol" are presented. No damping peaks were observed which could be identified as being associated with interstitial impurities. However, some interesting damping effects of different origins were found. These are believed due to stress relaxation in the grain boundaries, to stress induced ordering, and to an effect probably magnetic in origin. A torsion pendulum was used for the measurements. A graph of damping as a function of temperature is shown.

PP: 3 D 9 13 16 U AA 27 30 31 c 36 40 CV: 14 MI: Al' Fe n

D

E

F

G

H

M

N

O

P

Q

R

S

T