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FOREWORD

This report was prepared by the American Cyanamid Company, Organic Chemicals Division, Bound Brook, New Jersey, under Air Force Contract AF 33(616)-8056, Project No. 6301, "Aerospace System Personnel Protection," and Task No. 630103, "Vision Enhancement and Protection in Aerospace Environments." Dr. R.E. Horn, Vision Section, Protection Branch, Life Support Systems Laboratory, 6570th Aerospace Medical Research Laboratories, was project monitor. This review started April 1961 and ended October 1961.

This literature search is limited, for the most part, to articles referenced in Chemical Abstracts from 1916 to 1959, in Science Abstracts, Section A, Physics Abstracts from 1922 to 1959 and in the Journal of the Optical Society of America from 1917 to 1960. A few text books concerned with electromagnetic radiation, several brochures of commercially available optical filters, and some recent publications, not as yet indexed in the journals of abstracts, were also included in the review.

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ABSTRACT

The purpose of this review was to investigate the literature for near infrared absorbing or attenuating systems with an emphasis on those that allow transmission of visible wavelengths. The spectral range of interest, therefore, lies between 0.4 to 5.0 microns. The types of infrared attenuating systems investigated include inorganic and organic compounds and other optical methods; such as, the interference filters and Christiansen filters.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

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INTRODUCTION

The purpose of this review is to investigate the literature for near infrared absorbing or attenuating systems with an emphasis on those which allow transmission of visible wavelengths. The spectral range of interest, therefore, lies between 0.4 to 5.0 microns.

No such previous review was found to exist in the literature. However, there are reviews on optical filters (44),* (48), (78), (82), (83), (92), (101) which include some infrared absorbing filters.

In order to provide a background about infrared absorbers, some statistics on the amounts and the ranges of infrared energy of sources commonly encountered will first be presented.

The radiant energy from the sun (63) (70), our most fundamental source of light, can be divided into three regions; the near ultraviolet, the visible and the near infrared (Tables I and II). The heat from the sun is essentially due to this near infrared radiant energy. The radiant energy from tungsten filaments and fluorescent lamps (128) has about the same range as sunlight (Table II). The upper limit being due to the absorption of longer wavelengths by the glass bulb (Table III).

For the purposes of this study, the near infrared spectrum is defined as falling between 0.7 and 5.0 microns, as this is the area where the common sources of infrared emit substantially all of their I.R. energy. It should be noted that over half of the total radiant energy emitted by the sun or electric lamps (128) lies in the near infrared region (Tables IV and V). Also, Table VI indicates that the radiation from a 20 kiloton nuclear blast (45) peaks at 1.3 microns after 0.015 second and again after 2.0 seconds.

Within the near infrared region, it seems that the greatest amount of infrared energy is radiated close to the visible spectrum; i.e. 0.7 to 2.0 microns (Table IV). For sunlight, two thirds of the infrared energy comes from between 0.7 and 1.3 microns.

The region between 0.7 to 2.0 microns lies between the usual electronic spectra (U.V. and V.S.) and the rotational-vibrational spectra (I.R.). Because electronic absorption spectra not only have broader bands but are stronger than the rotational-vibrational lines or bands, it is probable that the most efficient near infrared absorbing chemicals will be of the electronic absorption type. However, the particular vibrational absorptions in this area should not be overlooked, as they may at least give added absorption capacity to some compounds; e.g. the N-H, O-H, and C-H stretching vibrations absorb around 3 microns, so that their second harmonic, although weak, would appear at about 1.0 micron (129), (124), (125). One major application of infrared absorbers will probably be in plastics. Many plastics themselves absorb large amounts of light above 2.5 or 3.0 microns (80), (87), (115), (129). Water, which may be considered as essentially undiluted O-H vibration, is the one known colorless compound that absorbs all the light above 1.4 microns (127) (97).

* Numbers in parentheses denote references.

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TABLE I

Important Spectral Regions

<u>Region</u>	<u>Range (Microns)</u>
Near ultraviolet (U.V.)	.300 - .400
Visible Spectrum (V.S.)	.400 - .700
Near infrared (N.I.R.)	.700 - 5.000
Far infrared (I.R.)	5.000 - 100.000

TABLE II

Spectral Range of Several Energy Sources

	<u>Range (Microns)</u>	<u>Wavelength of Maximum (Microns)</u>
Sunlight	.290 to 4.0	.500
Tungsten light (500 W)	.320 to 5.0	.970
Fluorescent light 40 W	.280 to 5.0	.580
Carbon arcs	.200 to 5.0	.390
Carbon filament heater lamp	.450 to 6.0	1.40
Non-luminous heater	1.000 up	3.00
Boiling water	2.500 up	--

TABLE III

Transmission Regions of Common Substances

	<u>Wavelengths (Microns)</u>
Water	.2 - 1.4
Human cheek	.6 - 1.4
Glass	.3 - 5.0
Common Plastics	.3 - 2.5

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TABLE IV

Approximate Distribution of Radiant Energy from Several Energy Sources

	Per Cent of Total Radiant Energy Emitted			
	<u>.3-.4 micron</u>	<u>.4-.7 micron</u>	<u>.6-1.6 micron</u>	<u>>.7 micron</u>
Sunlight (reaching earth)	5.	42	54	53
Tungsten lamp - 500 W	.1	10	53	90
Carbon Filament heater	---	1.	28	71
Fluorescent (40 W)	~ 5	~ 35	~ 28	~ 60
Non-luminous heater	0	1.5	1.3	97
Boiling water	0	0	0	100

TABLE V

Approximate Distribution of Radiant Energy of Sunlight

<u>Region (Microns)</u>	<u>Per Cent of Total</u>	<u>Per Cent of Infrared</u>
.3-.4	5	--
.4-.7	42	--
.7-1.0	23	43.5
1.0-1.3	12	22.5
1.3-1.6	4.5	8.5
1.6-1.9	4.5	8.5
1.9-2.7	5	9.5
2.7-up	4	7.5
	<u>100.</u>	<u>100.0</u>

TABLE VI

Wavelength of Maximum Radiation of 20 Kiloton Nuclear Bomb

<u>Elapsed Time After Detonation (Seconds)</u>	<u>Wavelength of Maximum (Microns)</u>	<u>Temperature (°K)</u>
0.0001	0.240	15,000
0.0015	0.500	5,000
0.0150	1.30	2,000
0.06	0.500	5,000
0.15	0.400	8,000
1.0	0.500	5,000
2.0	1.3	2,000

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The scope of the search, for the most part, entailed investigating the journals under the subject headings as follows:

1) Chemical Abstracts (1916-1959)

Absorption, rays and waves
Coatings
Films
Heat, radiant
Light, infrared
Light, filters
Plastic Materials
Reflection
Spectra

2) Science Abstracts - Section A Physics Abstracts (1922-1959)

Absorption, light
Films
Filters, optical
Heat
Light
Optical Films
Radiation
Reflection
Spectra

3) Journal of the Optical Society of America (1917-1960)

Dyes
Films
Filters
Glass
Light
Radiation (Radiant Energy)
Reflectance
Reflection

Also, some brochures on commercial filters were included in the search.

The types of infrared attenuating systems can be classified as follows:

- 1.) inorganic compounds
 - a.) glass compositions
 - b.) compositions other than glass
- 2.) organic compounds
- 3.) optical methods
 - a.) interference filters
 - b.) Christiansen filters
- 4.) commercial filters

LISTING OF NEAR INFRARED ATTENUATING SYSTEMS

A. Inorganic Compounds

For heat absorbing glasses, the best and usual additive has been found to be ferrous oxide, the ferric state not being as good as the ferrous (33). However, the ferric compounds being somewhat yellow, probably absorb considerable ultraviolet light. Copper, nickel and cobalt salts have also been mentioned as absorbing the radiant heat rays. Other compounds mentioned are tin oxides, chromium oxides, manganese dioxide, cadmium oxide, antimony oxide and arsenic oxide. One heat absorbing glass was described as transmitting 61.3 per cent V.S. and 27.4 per cent heat (28). An important use for these glasses is in the construction of projection apparatus, where excessive heat will damage the film.

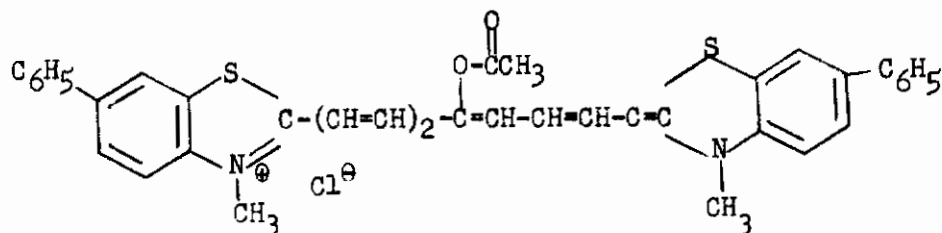
In Table VII is shown a list of near infrared absorbing glasses with their compositions if made available in the corresponding references cited.

Table VIII contains a list of inorganic substances in media other than glass. Here, one finds, besides salts of the metals mentioned above, compounds of columbium, molybdenum, ruthenium, rhodium, palladium, tungsten, iridium, platinum, uranium, strontium, indium, vanadium, vanadyl ion ($\sqrt{VO^{++}}$), and rhenium. Again the ferrous and the cupric salts excel in near-infrared absorption. The ferrous salts, in general, e.g. $Fe(NH_4)_2(SO_4)_2$ in water solutions (94), give very good transmission throughout the visible wavelengths.

B. Organic Near Infrared Absorbers

For an organic compound to be an effective and desirable infrared absorber it should be colorless, stable and absorb strongly in the near infrared. Or, if one considers changing available compounds, then a green dye that has its absorption shifted bathochromically (to longer wavelengths) would be suitable if other absorptions did not appear in the visible spectrum. However, it is quite difficult to shift the absorption of most green dyes any further into the infrared region.

Although several organic compounds have been mentioned as absorbing above 0.6 micron (Table IX), such as 1,4,5,8-tetraaminoanthraquinones $\sqrt{Allen et al (3)}$, how strong and how broad the absorptions were is not made clear. Also, several of the substances were colored. In the German patent 699,205 (1933) $\sqrt{Koenig and Alt (62)}$ the compound below and other similar ones are described as having the chief



absorption maximum between 0.900 and 1.000 micron and acting as infrared filter dyes. Barker and Barker (8) have shown that the fluorene analogs of malachite green, of the unsymmetrically substituted derivative of malachite green, and of crystal violet have strong absorption bands in the near infrared. These, however, have strong bands in the visible region also. Another compound of interest, recently reported by

TABLE VII

Near Infrared Absorbing Glass Compositions

<u>Glass Type</u>	<u>N.I.R. Absorbing Species</u>	<u>Reference</u>
Boric Oxide	Co ⁺⁺ as $\sqrt{CoO_4}^{-2}$	(1)
-	MnO ₂ , TiO ₂ , "nickel oxide," biotite	(2)
P ₂ O ₅ -Boric acid	0.2% FeO	(12)
Reduced Mg-K-Zn meta-phosphate glass	"Fe containing"	(16)
Boric oxide	Fe ₂ O ₃	(18)
-	Mn, Cr ₂ O ₃ , CoN ₃ , CuO, Se	(19)
"Dethermaline"	FeO	(28)
-	Fe ⁺⁺ ions	(29)
-	Co and Fe oxides (Fe ₂ O ₃) under reducing conditions	(30)
-	FeO	(33)
-	"Vibrating groups": CO ₂ , OH, CO ₃ , NO ₃ , SiO	(34)
-	Oxides of Fe, Cu, Co, Ni, Nd, Pr, and U	(36)
Optical Glass (Quartz, Na ₂ CO ₃ , CaO and Fluorite)	Fe ⁺⁺ + Carbon soot and Sb as reducers	(38)
Aluminum-phosphate	FeO (Analyzed as 1.67% Fe ₂ O ₃)	(46)
Glasses	FeO better than Fe ₂ O ₃	(49)
-	Oxidized Compounds of Metals of At. Wts. 51 to 65 (Especially: Cu, Fe, V)	(67)
Soda-Lime-Silica	Fe ₂ O ₃ + NaCl and/or CaF ₂	(85)
-	0.35% FeO (3-4 mm thickness glass)	(89)
Cobalt Glass	Fe ₂ O ₃ (1.39%), FeSO ₄ (2.98%), CoO (1.86%), NiO (0.59%)	(109)
Cobalt Glass	FeSO ₄ and NiO	(110)
-	Fe ⁺⁺ , Sb oxide and metallic Al reducing agent	(112)

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TABLE VII (cont'd)

<u>Glass Type</u>	<u>N.I.R. Absorbing Species</u>	<u>Reference</u>
-	$\text{Fe}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$ (1-10%)	(122)
-	$\text{Fe}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$	(123)
-	FeO better than Co, Ni, Cu ions (Nd, Pr, U oxides were weak absorbers)	(134)
"Signal Green Glass"	CuO (4.5%) + As_2O_3 (0.8-0.29%)	(135)
$\text{P}_2\text{O}_5\text{-Al}_2\text{O}_3\text{-SiO}_2$	FeO + Fe_2O_3	(95)
Borosilicate	FeO, Cd, and SnO or SnO_2	(104)
"KS-9"	Red Selenium Glass - Transparent beyond 0.8μ (Like 9% alcoholic I_2)	(107) (35)
Glass	-	(42) (91)
Glasses	Rare earths: e.g. 10% Pr as Pr_6O_{11} 10% Nd as Nd_2O_3 10% Sm_2O_3 10% Er_2O_3	(118)
Glass	Oxides or Silicates of Fe and Cu associated with compounds of Ni, Co, Cr, or V	(68)

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TABLE VIII

Near Infrared Attenuating Inorganic Compositions Other than Glass

<u>Medium</u>	<u>N.I.R. Absorbing Species</u>	<u>Reference</u>
"in solution"	Cupric ion, pyridine salicylate ion (Cu^{++} sal ⁻⁻ py ₂)	(4)
Propyl alcohol	CoCl_4^{--} , CoBr_4^{--} , CoI_4^{--}	(10)
"in solution"	Bivalent ions of Cu, Fe, Ni, and Co	(13)
-	Copper Salts	(14)
Water	CuSO_4 and NiSO_4	(20)
Water	FeSO_4 , CuSO_4	(26)
Water	Fe, Mn, Cr, V, Ti salts	(32)
-	VO^{++} ion	(39)
Methyl methacrylate polymer	Copper Oleate	(40)
Water	Ammonium Vanadyl Oxalate $(\text{NH}_4)_2 \text{VO}(\text{oxalate})_2$	(51)
Synthetic Atmospheres:	CO_2 gas and H_2O vapors	(57)
-	Complex Cr salts	(60)
Plastics	Metal particles; size > longest λ (Neutral Filter for UV, Visible, and I.R.)	(59)
Water	Ti, UO_2 , Cr, Mn, Fe, Co, Ni, Cu, Cb, Mo, Ru, Rh, Pd, WO_3 , Ir, Pt, U compounds at lower than maximum valencies	(61)
Water	CuCl_2	(65)
Gelatin	$\text{Cu}(\text{OAc})_2$ and $\text{Ni}(\text{OAc})_2$ (ethanolamine as stabilizer)	(69)
"solution"	Strontium oxide	(71)
Transparent Plastics	CuCl_2 + diethoxyaniline in ethyl alcohol	(72)
Polyvinyl-acetaldehyde	3-8% Cupric halide or Cupric nitrate	(74)
"solution"	Cu, Fe, Co salts	(77)
Nujol mull	"inorganic ions"	(79)

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TABLE VIII (cont'd)

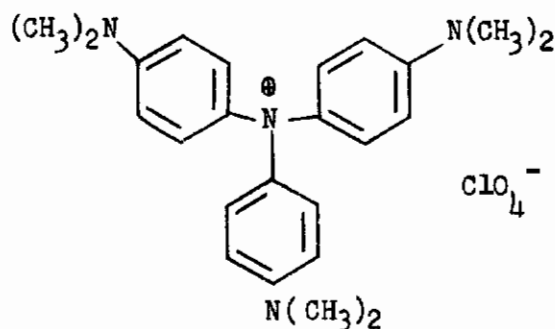
<u>Medium</u>	<u>N.I.R. Absorbing Species</u>	<u>Reference</u>
Iridized Coatings on Glass	Oxides of Sn, In, Cd, Sn + Sb, Sb + In, In + Cd and up to 20% Cu, Zn, V, Cr, Mn, and Co oxides	(81)
Water	30% FeSO ₄ solution	(86)
Water	Fe(NH ₄) ₂ (SO ₄) ₂ -opaque beyond 0.8μ CuSO ₄ -opaque beyond 0.8-1.1μ I ₂ -transparent beyond 0.8μ VOSO ₄ transparent beyond 0.9-1.2μ Opaque beyond 1.4μ	(83), (94)
-	Films of Te, Bi, Sb and MgO opaque in visible; cut off at 1-3μ	(96)
Water	Ni(II) and Co(II) complex ions Ni(En) ₃ ⁺⁺ and Ni(o-phen) ₃ ⁺⁺ with absorption max. at 0.895 and 0.790μ	(105)
-	UBr ₄ , UCl ₃ , UCl ₄ , UO ₂ Cl ₂ , UO ₂ (NO ₂) ₃ have bands at 0.82 and 1.06μ	(106)
-	K alum, KCl, FeSO ₄ , NH ₄ SO ₄ , NiSO ₄ , CuSO ₄	(111)
Polar organic Solvents	K ₂ Co(CNS) ₄	(126)
Water	Cobalt complex salts	(133)
-	TiO ₂ films (selective reflectors) 30-40% Reflectance at 1.10μ only 8% Reflectance at 0.550μ	(120)
Conc. HNO ₃	$\sqrt{\text{Co(Dip)}_2}^+$ Dip = α, α'-dipyridyl $\sqrt{\text{Rh(Dip)}_2}^+$ $\sqrt{\text{Cu(Dip)}_3}^+$ $\sqrt{\text{Ni(Dip)}_3}^+$ $\sqrt{\text{Ni(Phen)}_2}^+$ Phen = o-phenanthroline	(27)
Water	10N KOH and NaOH; 5N LiOH	(47)
Plastics	Rhenium Oxide	(76)
Synthetic Polymers	Tungstate of Sodium	(5)
Transparent Vitreous Plate	Metal Powder	(132)
-	Powders spread over speculum metal	(93)
-	Chlorophyll, Green Inorganic Salts, Green Dyes	(103)
-	Colored Cations of Transition Elements	(108)
-	A ^{III} B ^V semi-conductors	(90)

TABLE IX
Organic Electronic Near Infrared Absorbers

<u>Compound</u>	<u>N.I.R. Absorption (λ_{max}) (Microns)</u>	<u>Reference</u>
1,4,5,8-Tetra(substituted amino) anthraquinone	N.I.R.	(3)
3,6-Bis(dimethylamino)-9-phenyl-9-fluorenol (In acetic acid)	.850 and .955	(8), (17), (25)
3-Dimethylamino-9-p-dimethylaminophenyl-9-fluorenol (In acetic acid)	.728 and .788	(8), (17), (25)
3,6-Bis(dimethylamino)-9-p-dimethylaminophenyl-9-fluorenol (In acetic acid)	.850	(8), (17), (25)
Complexes of p,p'-Dihalogen-or p,p'-dialkoxy-tri-phenylcarbinol with phenylenediamine	.620 to .720	(23)
Benzthio-penta-carbocyanine	.840 extinction limit	(31)
Naphthothio-hepto-carbocyanine	.920 extinction limit	(31)
Mn(II) Complexes of Nitrosophenols ex. Mn(II) complex of 2-nitroso-5-dimethylamino-phenol	.842	(24)
Sulfur Dyes	N.I.R.	(37)
Co, Rh, Cu, and Ni complexes of Dipyriddy and Phenanthroline in conc. HNO ₃		
$\sqrt{\text{Co(Dip)2}}^+$	1.280	(27)
$\sqrt{\text{Rh(Dip)2}}^+$	1.070	(27)
$\sqrt{\text{Cu(Dip)3}}^{2+}$.970	(27)
$\sqrt{\text{Ni(Dip)3}}^{2+}$.840	(27)
$\sqrt{\text{Ni(Phen)2}}^{2+}$.950	(27)
Diphenylmethane Dyes ex. $\sqrt{\text{Cl(COOH)C}_6\text{H}_3\text{NH}_2} \sqrt{\text{C(C}_5\text{H}_4\text{N)Cl}}$ (in methanol)	.720	(43)
Ni(II) Complex of N-phenyl-N'-2-methoxyphenyl-C-phenyl formazan	.840	(54)
Ni(II) Complex of N-phenyl-N'-(2-methoxy-5-chlorophenyl)-C-(2-chlorophenyl)-formazan	.805	(54)
General Formula: $\sqrt{p-R^1R^2N:C_6H_4:CR^3CH(:CHCH)n}$ $CR^4C_6H_4NR^5R^6P^{\oplus}X^{\ominus}$ R's = organic radicals, n=0,1,2,3; x=anion	N.I.R.	(58), (76)

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Neunhoeffler and Heitmann (88), is tris(p-dimethylaminophenyl)aminium perchlorate (structure shown below) which exhibits a strong absorption band at about 0.960 micron with no visible peak, but a weaker peak at about 0.396 micron giving solutions of only a pale yellowish-green color by transmission.



In Table IX is given a list of several organic compounds believed to absorb infrared radiations via electronic transitions. Besides those mentioned above, these include several dyes, and metal complexes in a variety of media. Although only the infrared peaks or cut off points are given in Table IX, almost without exception, these also have absorption peaks or at least some absorption in the visible.

C. Other Optical Methods for Attenuating Infrared

1. Interference Filters

Since the development by Banning (6) (7) in 1944, by Polster (98) in 1947 and by others (55) of the technique of vacuum evaporating thin multilayer dielectric coatings on glass substrates, and improved methods for computing (84), much work has been done in formulating interference filters for specific uses and extending their application to the infrared region. Table X contains some interference coatings or filters including all-dielectric and dielectric-metallic thin multilayers for use in the infrared. Both infrared reflecting and transmitting types are presented. Unfortunately, all of these are opaque to visible radiation. However, infrared attenuating and visible transmitting types are possible, and are commercially available (See Table XI - Tiffen Color Filters).

2. Christiansen Filter Effect

Christiansen filters (21), which consist of a powder suspended in a transparent medium, depend for their action upon the equality of refractive indices of powder and medium for some one wavelength of light but differing at all other wavelengths. Many examples are given by McAlister (75) of these filters for use in the visible region. Barnes and Bonner (9) and Price and Tetlow (99) give evidence of the effect to occur in the far infrared also. No work in the near infrared was found in the literature; the possibility, however, remains that Christiansen filters can be made for this spectral region.

TABLE X

Interference Filters

<u>Coating Materials</u>	<u>Spectral Properties</u>	<u>Reference</u>
Various Dielectrics (Multilayer)	Selective transmission in 1.4-4.5 micron range opaque to visible	(11)
PbS, PbSe, PbTe	Transmit long-wave I.R., reject visible and near I.R.	(15)
CeO ₂ or SiO and MgF ₂	No reflectance at 1 and 2.2 microns	(22)
Te and NaCl	I.R. Transmission Bands at 5 to 20 microns	(50)
Ge and SiO on Al	Reflectance in Visible = 2% I.R. Reflectance (0.7 to 1.2 microns) = 5 to 90%	(52)
Al-SiO-Al-SiO	Low Reflectance from 0.4 to 1.5 microns More than 90% reflectance at longer wavelengths	(52)
Ge and Cryolite	Infrared Filter	(53)
Al-Ge-SiO	Absorb visible and reflect I.R. with cut off at 0.8 micron	(116)
Bi ₂ O ₃ -Au-Bi ₂ O ₃	Green light transmittance = 73% Near infrared reflectance = 74%	(56)

D. Commercial Filters

Table XI is a summary in outline form of some commercially available near infrared attenuating filters.

Of the glass filters (group A), C.S. 1-69 (Corning Glass Works) and KG-3 (Jena Glaswerk Schott und Gen.) are of most interest. Both show good visible transmittance, approximately 85 per cent from about 0.38 micron to 0.55 micron and less than 1 per cent below 0.28 micron and above 0.90 micron.

In group B is given a list of several eye-protective glasses produced by some manufacturers for sun and welding protection. These, in general, have transmission peaks at about 0.55 micron and absorb essentially all of the ultraviolet and near infrared radiations. The maximum visible transmissions for these glasses are usually much less than 50 per cent; and, for welding purposes, are only of the order of a few per cent.

Many optical and glass concerns produce interference filters designed to give very narrow pass bands at various wavelengths from the ultraviolet to the infrared. Other firms (see Table X) have designed interference filters which are opaque to the visible but transmit the near infrared. One company (Table XI, group C), however, makes available filters which transmit almost the entire visible (80 to 90 per cent transmittance) but reflect a broad band in the near infrared. A good example is "Tiffen No. 143 (UV and IR reflector)" which shows 80 to 90 per cent transmittance between 0.42 and 0.69 micron and sharply reduces to only about 5 per cent between 0.75 and 1.2 microns, the attenuation being by reflection a more desirable and efficient mode. The transmission increases sharply again, however, beyond 1.2 microns giving a second broad pass band, this time in the infrared. These higher order pass bands are inherent in interference filters and can be attenuated only by an auxiliary filter.

In the last group of Table XI (D), are given a few plastic filters. The Ilford and the Kodak Wratten filters shown are greenish-blue filters absorbing the red and the near infrared. These have peak transmissions of about 75 per cent with dominant wavelengths at about 0.5 micron. "Infropake" plastic filters (73) are claimed to absorb all of the ultraviolet between 0.20 and 0.40 micron, transmit 84 per cent of the visible light, and transmit only about 15 per cent of the infrared between 0.75 and 1.5 microns. These have been suggested for such uses as goggle lenses, automobile windshields, and sun visors.

TABLE XI

Commercial Near Infrared Attenuating Filters

A. Glass Filters

1. Glass Color Filters - Bulletin CF-1, Corning Glass Works, Corning, New York

C.S. No.
H.R. 1-56
H.R. 1-57
H.R. 1-58
H.R. 1-59
1-69

2. Farb und Filterglas - Jenaer Glaswerk Schott und Gen., Mainz

Cat. No.
KG4
KG3
KG2
KG1
BG22
BG10

B. Eye-Protective Glasses (117) - National Bureau of Standards Circular No. 471(1948)

Filterweld - American Optical Co.
Didymium Noviweld - " " "
Thermion Glass - " " "
Aviation Glass - " " "
Calobar - " " "
Cool Ray - " " "
Antiglare - Bausch and Lomb Optical Co.
Ray-Ban - " " " " "
Cescoweld - Chicago Eye Shield Co.
Cesco Antiglare - " " " "
Corning Glass G-171 - Corning Glass Works
Contra-glare - Titmus Optical Co.
Willson Weld - Willson Products, Inc.
Willson-Weld Didymium - " " "
Willsonite Aviation Glass - Willson Products, Inc.
Kilglare - " " "
Willsonite - " " "

TABLE XI (cont'd)

C. Interference Filters - Dielectric Multilayer Coatings on Glass

Tiffen Photar Filter Glass - Tiffen Optical Co., Roslyn Heights, New York

<u>Color Tiffen No.</u>	<u>Description</u>
025	Near Infrared Reflector
025 + 025	Near Infrared Reflector
96	Infrared Reflector
143	U.V. and I.R. Reflector
800	Blue and Infrared Reflector
1400	Infrared Reflector
2600	Infrared Reflector
311800	Infrared Reflector

D. Plastic Filters

1. Ilford Colour Filters - Ilford Ltd., London

Red-Absorbing Filters Nos.

801
802
803
804

2. Kodak Wratten Filters - Eastman Kodak Co., Rochester, New York

Wratten No.

38
38A

3. Infropake - The Charles Fischer Co.

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