WADC TECHNICAL REPORT 54-576
PART 1

EFFECT OF METALS ON LUBRICANTS

Part 1. Design, Development and Instrumentation of a High Temperature Bath

VERNON A. LAUER

MATERIALS LABORATORY

FEBRUARY 1955

PROJECT No. 7331

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.
300 - 3 May 1955

FOREWORD

This report was prepared by the Lubricants Section, Organic Materials Branch. The work was initiated under Project No. 7331, "Hydraulic Fluids", Task No. 73314, "Lubricants", formerly RDO No. 613-15, "Hydraulic Fluids and Lubricants", and was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. V. A. Lauer acting as project engineer.

ABSTRACT

This report is the first of a series of reports concerning the effect of metals on the stability of lubricants at elevated temperatures. In order to accomplish this, equipment capable of attaining these temperatures was required.

This report describes the design, development and instrumentation of a high temperature bath capable of attaining and controlling temperatures up to 700°±1.0°F.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

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

TABLE OF CONTENTS

SECTION I

INTRODUCTION

Guided missiles and high speed aircraft which, due to skin friction and operating temperatures, generate extremely high temperatures during operation have been and are continuously being designed. In order to develop lubricants or fluids which will operate satisfactorily at such elevated temperatures, it is necessary to evaluate the high temperature characteristics of base materials, additives, and finished blends which may ultimately be used in such aircraft. Since flight test facilities are not yet available this can be accomplished only by laboratory procedures which may best simulate or correlate with expected operational conditions.

In order to approach this reality, high temperature laboratory equipment not available from scientific equipment manufacturers must be devised. A bath for use in high temperature regions is discussed in this report.

SECTION II

Description of and Operational Procedure for a High Temperature Bath

The bath consists of a solid cast aluminum block with holes to receive the thermoregulator and 62 mm x 500 mm test tubes described in Federal Specification VV-L-791e, Method 5308.3, "Corrosiveness and Oxidation Stability of Light Oils" (See Figures 1 and 2). The block is contained in an angle iron frame with $^{3}/_{8}$ inch plate aluminum sides and bottom as shown in Figure 1. The block is supported from the aluminum bottom by four solid aluminum feet which are bolted to the block. These aluminum feet rest on a $^{1}/_{4}$ inch transite sheet which is in contact with the aluminum bottom. The sides and bottom are insulated by means of three inches of fiberglass which is placed between the aluminum shell and the heating block. The top of the bath is made of sandwich construction with holes to correspond and align with the holes in the block. The layers are formed using sheet transite, an air space filled with fiberglass, and a sheet of aluminum. Heat is supplied to the block by means of fifteen — 200 watt chromalox strip heaters which are spaced evenly (three per side and bottom), See Figure 3, and fastened to the block with screws. These heaters are wired with seven strand No. 12 Rockbestos wire. The heat input is regulated by the switch arrangement shown in Figure 4. This switch system permits various series and parallel combinations. Using this arrangement, input ranging from 0 to 800 watts can be attained for each ring of four heaters. The center ring of heaters is intermittent, being controlled by a bimetallic thermoregulator placed in the center well of the block. With intermittent heating controlled by this thermoregulator and the proper combination of continuous heaters, a temperature of $400 \pm 2°F$ can be maintained. To insure good heat transfer by means of intimate contact with the test tubes, a low melting alloy (woodsmetal) was placed in the holes of the bath. The composition of this alloy is by weight 50% Bismuth, 25% Lead, 12.5% Tin and 12.5% Cadmium.

Discussion

After construction of the original equipment, preliminary tests indicated that some modifications were desirable.

In order to facilitate more rapid setting of the various desired operating temperatures of the bath, and to reduce temperature fluctuation, the bimetallic thermoregulator cited above has been replaced by an "Electronik" proportional, indicating controller, Model No. Y156 R16RS, manufactured by the Brown Instrument Company. This controller has a range of 0 to 1200°F, in two ranges, with one degree scale divisions. With this equipment, the control at 400°F, 550°F and 700°F is ±1.0°F, and it is anticipated that the control at 1000°F will be quite close to that at the low temperatures.

The bath was originally wired with 7 strand No. 12 Rockbestos wire; however, at the higher operating temperatures, the wire oxidized at the heater terminals and the bath became inoperative. This difficulty was eliminated by cutting approximately six inches from each lead and substituting ceramic insulated heavy gauge nichrome wire for the portion removed. This nichrome lead was then connected to the heater terminals.

It was found that the original material used as the heat transfer media oxidized rapidly at the higher operating temperatures, necessitating frequent changes. Therefore, it was replaced with a low melting salt eutectic consisting of 7% by weight sodium nitrate, 40% by weight sodium nitrite and 53% by weight potassium nitrate.

With the incorporation of these modifications, a bath considered satisfactory for use in evaluation studies at elevated temperatures, to 1000°F if sufficient heat capacity is available to attain this temperature, is available.

SECTION III

Conclusions

The bath described in this report is satisfactory for use in evaluation studies at elevated temperatures to 700°F and probably as high as 1000°F providing sufficient heat capacity is available to attain this temperature.

Future work: Studies will be conducted on the lubricants now employed for high temperature applications and those anticipated for future high temperature use. These studies will be conducted at 400°F, 550°F and 700°F under atmospheres of nitrogen and air for 48, 96 and 168 hours while in contact with various metals, both individually and in combination, to determine the effect of metals and temperatures on these lubricants, and the effect of the lubricants on the metals.

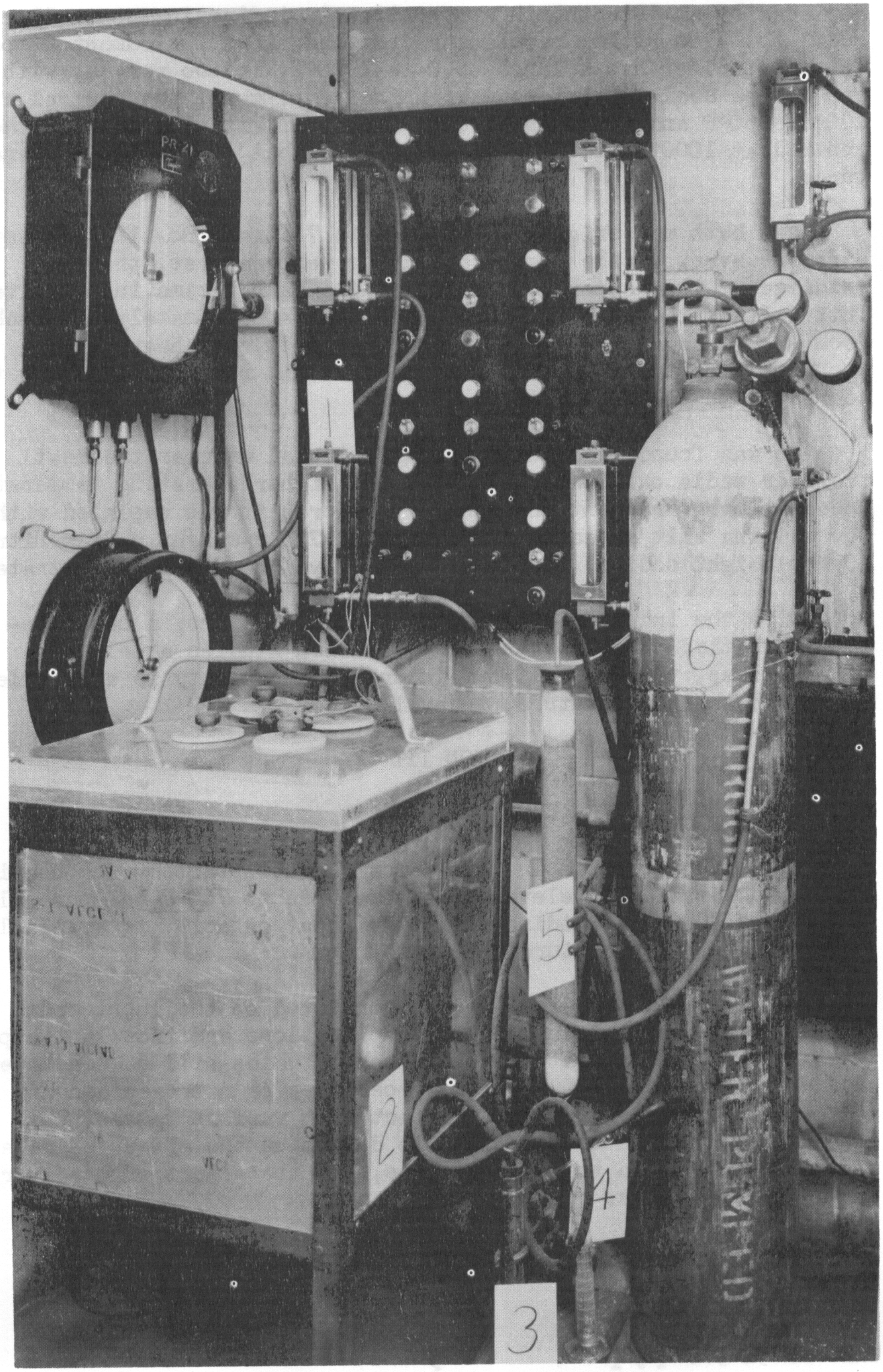

Figure 1

Assembled Bath

TABLE I

Legend for Figure 1

1. Panel board with indicator lights and switches shown in Figure 3 and Flowmeters, 0.9 to 9.0 liters per hour of air.
2. Shell containing aluminum block described in Figure 2.
3. Pressure regulators consisting of a 100 ml. graduate with 30 ml. mercury, the open end of the Y tube extends to bottom of graduate.
4. Flow indicator, consisting of graduated wash bottle with mercury as indicating fluid.
5. Column of indicating drying agent.
6. Cylinder of waterpumped nitrogen.

HIGH TEMPERATURE OXIDATION BATH (ALUMINUM BLOCK)

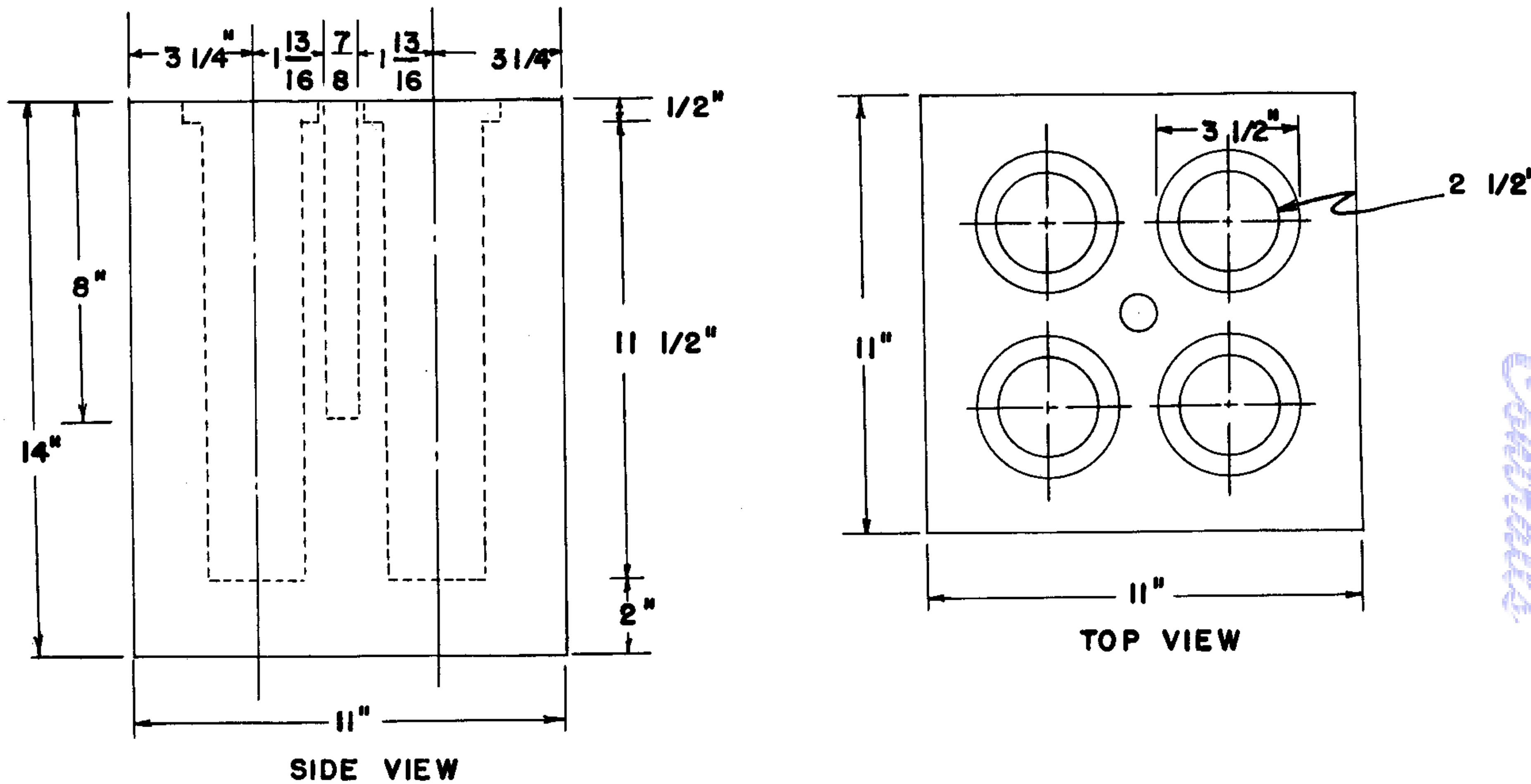

Figure 2. Drawing of Block

BATH CAST OF COMMERCIALLY PURE ALUMINUM

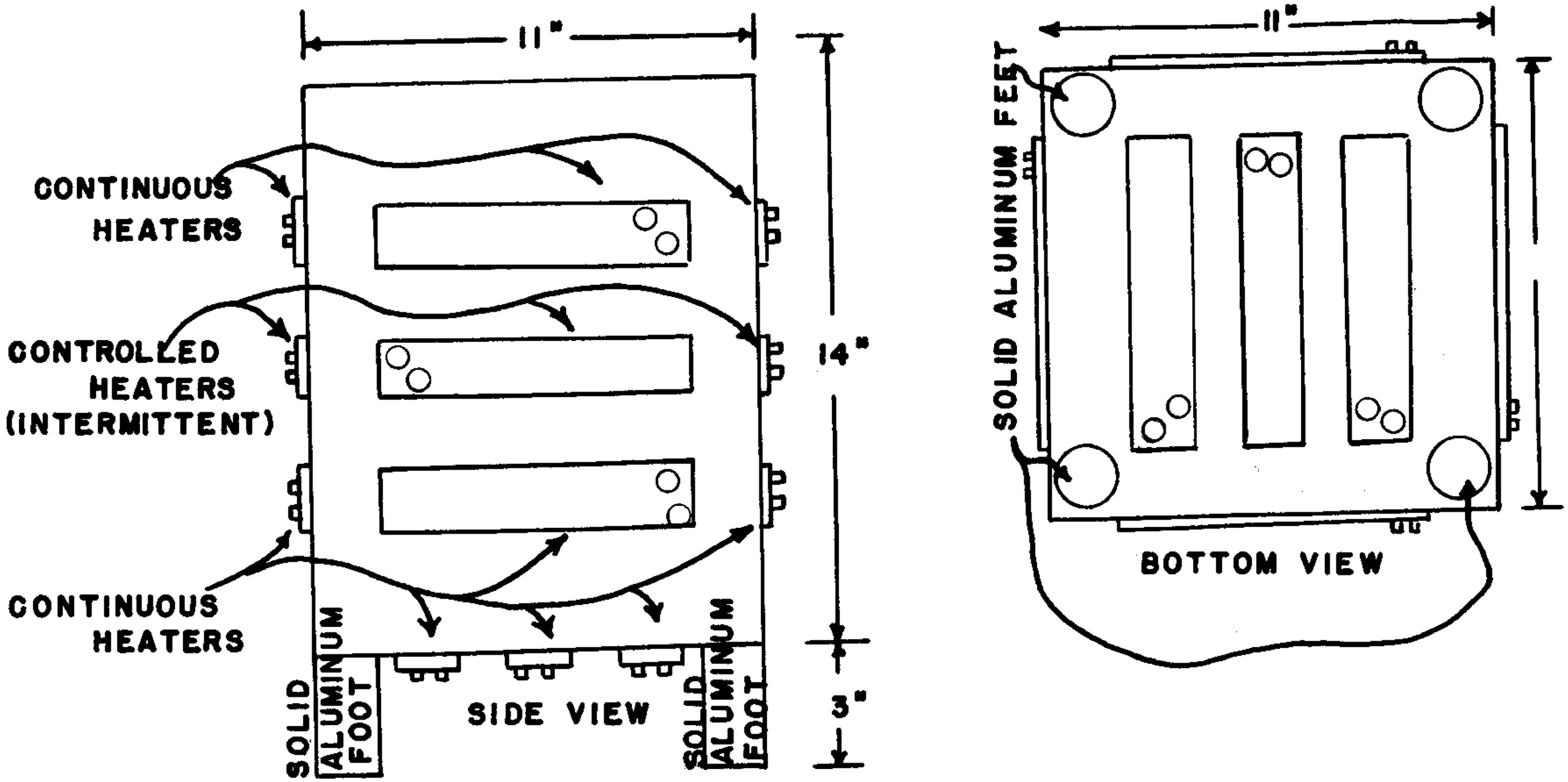

FIGURE 3. HEATER ARRANGEMENT FOR HIGH TEMPERATURE BATH

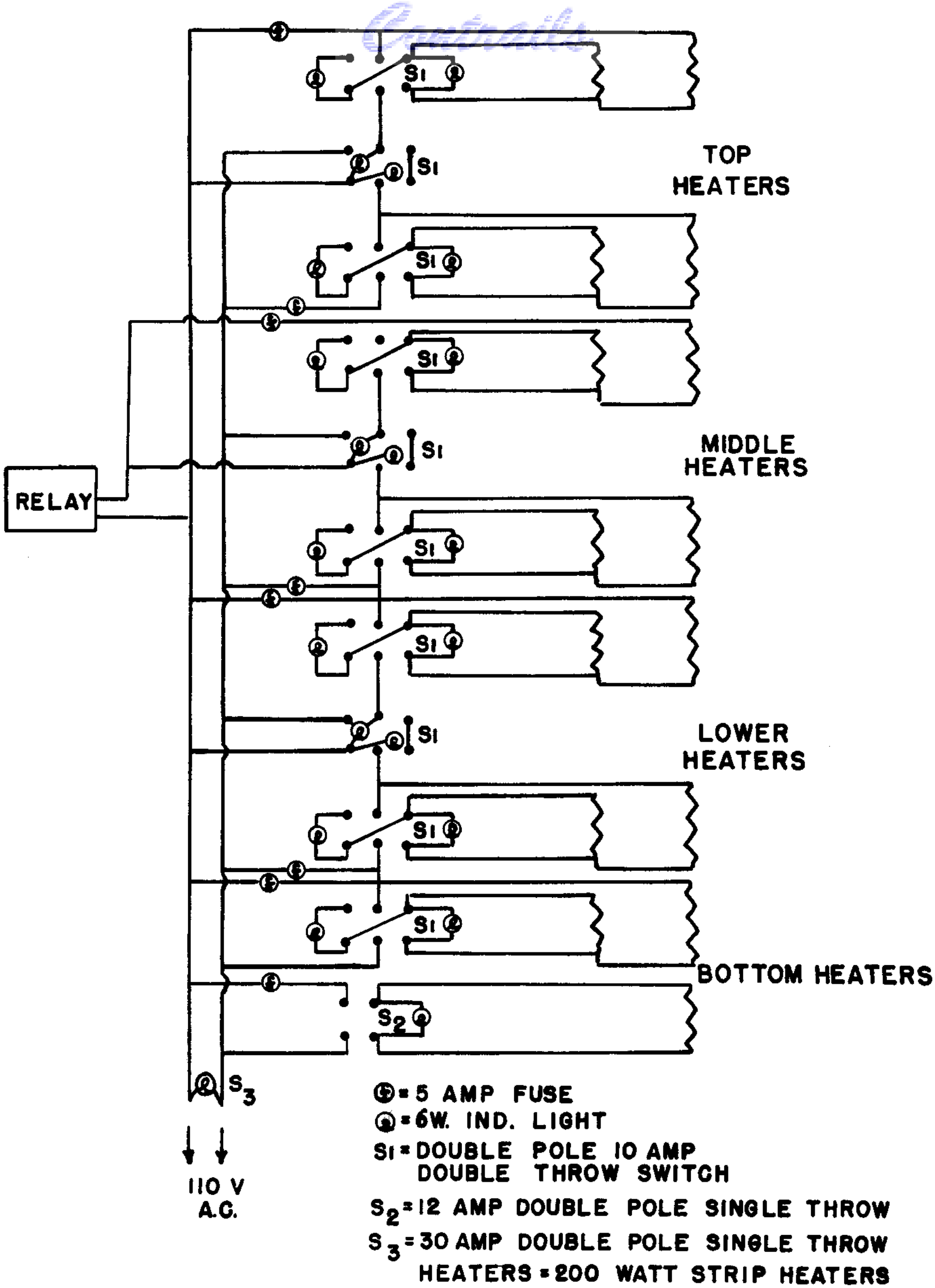

FIGURE 4 WIRING DIAGRAM

SECTION IV

Bibliography

Fenske, M. R., Fluids, Lubricants, Fuels and Related Materials, Quarterly Progress Report Number PRL 5.5 - December 1952 for Period Ending December 1952