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Project 1592

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WOLVERINE TUBE DIVISION
DETROIT, MICHIGAN

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ABSTRACT

This report contains a summary of the operations of the research group and work completed during the year 1959. The status of the work of the project is reviewed and discussed.

INTRODUCTION

The Wolverine Tube heat transfer project at The University of Michigan Research Institute is in its twentieth year of operation. During the past year the project normally employed five to six men on a part-time basis. Part-time secretarial help was also employed. In January it became necessary to vacate the East Engineering Building research laboratories. The project research equipment was moved to the North Campus Fluids Building, Figure 1. The installation of the equipment in the new laboratories was completed in March. The move to the North Campus interferred with the normal operation of the project during the first three months of the year.

As usual, there were many more prospective investigations than could be handled simultaneously. The investigations undertaken were in accordance with the current priority status set as a result of conferences held with the Technical Managers of New Products Division and Operations Division of Wolverine Tube.

In January 1959, the prospective projects in order of priority were:

1. Influence of thermal cycling on bond resistance

2. Heat transfer and pressure drop characteristics of internally finned tubes

3. Performance of finned tube banks in a wind tunnel

4. Revision of the Williams-Katz report

5. Heat transfer and pressure drop characteristics of corrugated tubes

6. Determination of bond resistances for Type L/C Trufin over a wide range of temperatures

7. A revision of Dr. Dennis J. Ward's paper, "Heat Transfer and Pressure Drop of Air in Forced Convection Across Triangular Pitched Banks of Finned Tubes", including data on bond resistance.

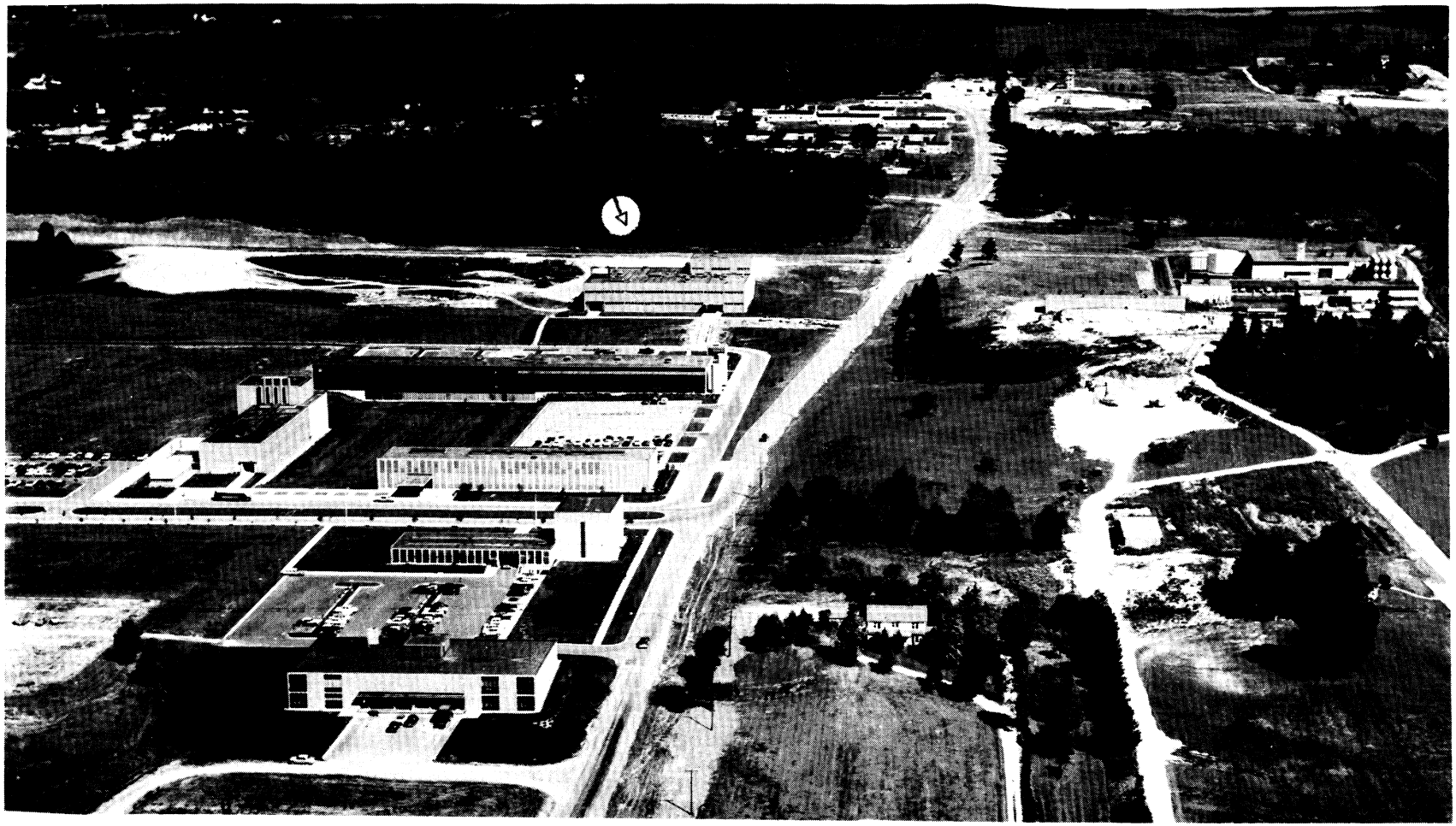

Figure 1. View of the North Campus of The University of Michigan. The Fluids Building is Indicated by an Arrow. The Aeronautical Laboratory, Phoenix Laboratory with the Ford Nuclear Reactor and the Automotive Laboratory are also Shown.

8. Heat transfer and pressure-drop characteristics of Type S/T Trufin in shell and tube exchangers in (a) gas cooling (b) with shell side liquids in longitudinal unbaffled flow

9. Internal finned tube data on Trufin Type I/L tubes in various heat transfer applications.

PERSONNEL

At the beginning of the year the following personnel were employed on the project on a part-time basis:

1. Dale E. Briggs
2. Henry C. Lim
3. J. David Hellums
4. William H. McCarty
5. Thad D. Epps
6. Ardis R. Vukas (typist)

All the employed except the typist were graduate students in Chemical Engineering. Several personnel changes were made during the year. In February, Mr. Thad D. Epps completed his work on a master's degree in Chemical Engineering and left the project to accept a position with Union Carbide and Carbon Corporation, Whiting, Indiana. On February 3, 1959, Michael J. Humenick began work on the project and on February 9, 1959, John S. Cornell began work on the project. Both men were working toward a master's degree in Chemical Engineering. Mr. Henry Lim obtained his degree and left the project in May to accept a position with Charles Pfizer and Company, Inc., Groton, Connecticut. Mr. Lim had been on the project since September 1957. On June 15, 1959, Mr. J. S. Cornell obtained his master's degree, left the project, and accepted a position with Union Carbide and Chemical Company, Charleston, West Virginia. Mr. John G. Lavin began work on the project in August 1959. He is working towards a doctor's degree in Chemical Engineering. Mr. J. David Hellums accepted the Bendix Fellowship and Mr. William H. McCarty accepted the Shell Oil Company Fellowship and they left the project on September 18, 1959. Mr. Raymond E. Pecsar was added to the project on September 22, 1959. Mr. Pecsar is working toward a master's degree in Chemical Engineering. In December, Mrs. Angela Chu was added to the project to make heat transfer calculations. She is a chemical engineer, working toward a doctor's degree in Chemistry.

At the end of 1959, the following persons were employed by the project:

1. Dale E. Briggs
2. Michael J. Humenick
3. John G. Lavin

4. Raymond E. Pecsar
5. Angela Chu
6. Ardis R. Vukas (typist)

BOND RESISTANCE STUDIES

The cycling investigation of bimetallic finned tubes was continued during January. In January, it became necessary to vacate the East Engineering Laboratory and move to the Fluids Building. The bond resistance measuring device and the cycling equipment were moved at that time. Two admiralty liner bimetal tubes had been cycled in excess of 23,000 times in the steam cycling apparatus. Several steel liner bimetal tubes had been cycled 140 times in the hot oil cycling apparatus. The hot oil cycling equipment is shown in Figure 2.

During March, the design of a high temperature bond resistance measuring device was completed. The equipment was designed to use high temperature heat transfer oil which would make possible the measurement of bond resistances up to a bond temperature of approximately 550 °F. Actual construction of the unit began in March and was completed in October. The completed unit is shown in Figure 3. Figure 4 shows part of the instrumentation system.

Data were taken on a brazed applied-fin tube in the high temperature bond resistance tester. The data were analyzed to determine the inside and outside heat transfer coefficients for the applied-fin tube geometry.

Several minor modifications were made to the test apparatus as a result of operating experience. These modifications improved heat balances and operational control.

Mr. Dale E. Briggs visited the Wolverine Tube Division, Decatur, Alabama, plant twice during the year to participate in conferences and to conduct seminars on the operation and use of the bond resistance equipment at this plant. The first visit was from January 26 to February 4, and the second from December 28 to December 30. During the year, experiments were conducted on the Decatur and The University of Michigan bond resistance equipment using the same bimetal tubes to determine if bond resistance measurements were in agreement.

Bond resistance measurements were also made on two experimental applied steel fin tubes. These measurements were conducted on the low temperature bond resistance measuring device using hot water and cold water. The equipment is shown in Figure 5.

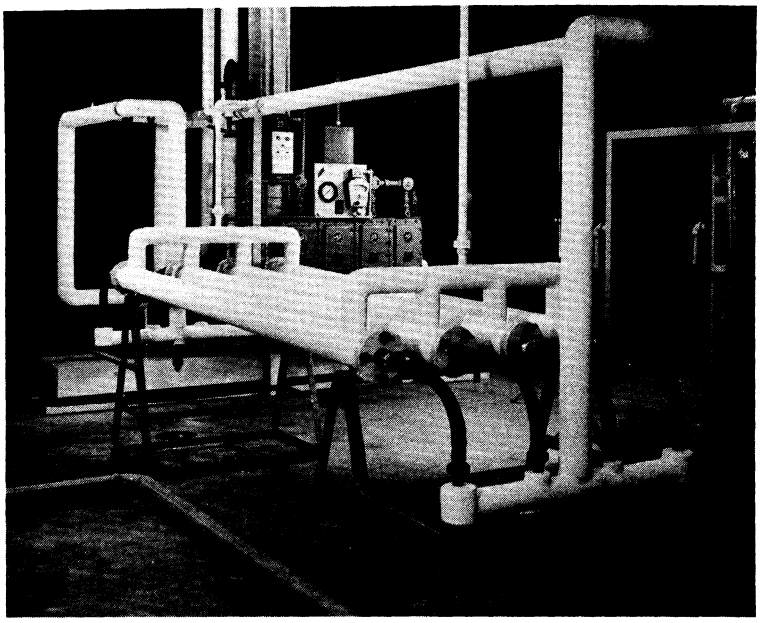

Figure 2. View of the 600 °F Hot Oil Cycling Apparatus with the 48 k.w. Electric Heater in the Background.

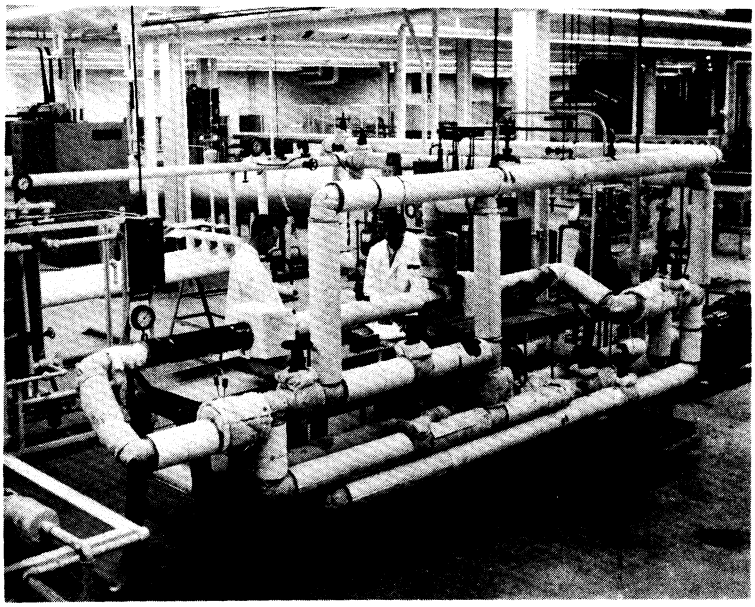

Figure 3. A View of the High Temperature Bond Resistance Equipment with Mr. J. G. Lavin on the Left and Mr. D. E. Briggs Taking Heat Transfer Data.

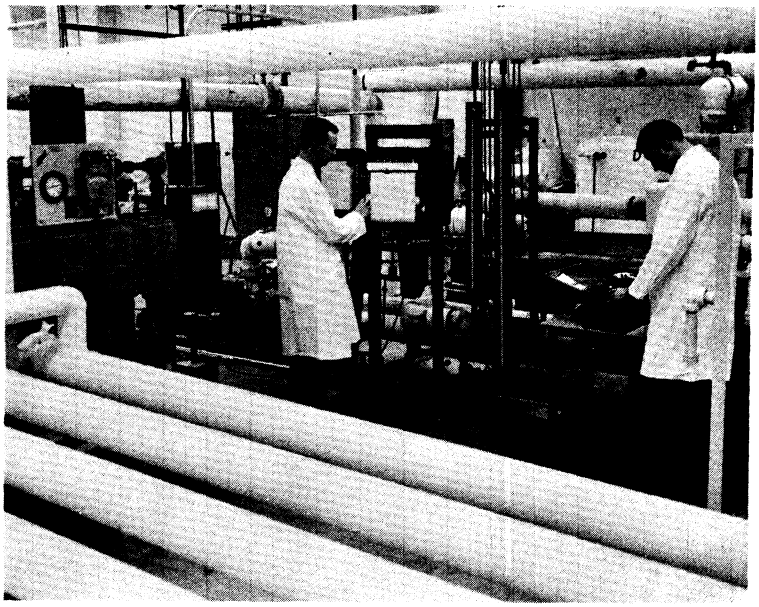

Figure 4. Project Personnel Operating the High Temperature Bond Resistance Equipment. Mr. J. G. Lavin is Shown Adjusting the Temperature Recording Potentiometer and Mr. D. E. Briggs Measuring Temperatures with a Precision Potentiometer.

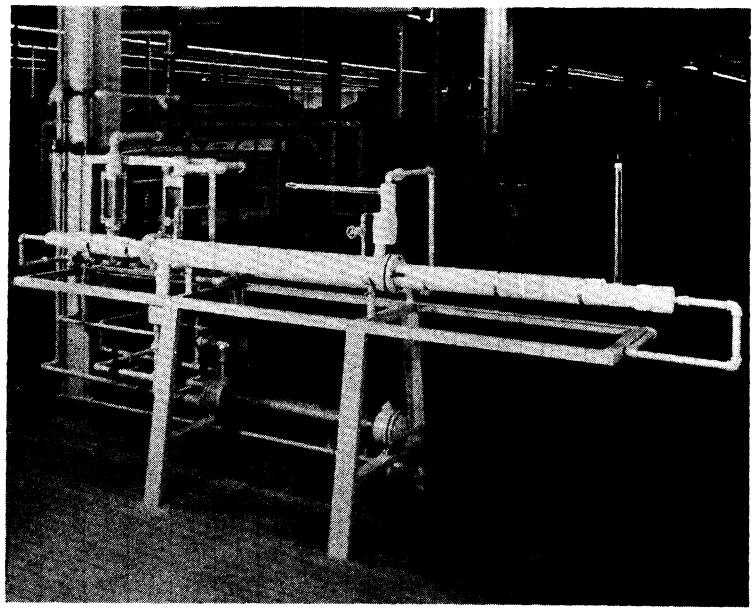

Figure 5. Low Temperature Bond Resistance Measuring Equipment Located in the Fluids Building.

TRANSFORMER OIL COOLERS

An investigation was undertaken to determine heat transfer and pressure drop data for typical tubes used in transformer oil cooling. Two tube banks were fabricated and studied using the wind tunnel to determine pressure drop as a function of air velocity. The tubes were 1.573-in. O.D., 3/4-in. root diameter, and 11 fins per inch. The pressure drop was determined for tube pitches of 1-3/4 in. and 2 in. using the wind tunnel shown in Figure 6. The concentric pipe heat exchanger was modified to permit use of transformer oil on the tube side of the equipment. This equipment can be seen in Figure 7. Data were then taken to determine the inside heat transfer coefficients for various tubes with and without turbulators. With the pressure drop and heat transfer results, typical transformer oil coolers were designed.

CORRUGATED TUBE INVESTIGATION

In February, a mathematical investigation was begun to determine the optimum geometries of corrugated tubes for use in steam condensing applications. No experimental data were taken. All the necessary information was either obtained from previous project work or from data available in the literature.

Since any optimum is fixed by the operating conditions, only the two extreme conditions normally encountered were studied. The first was at condensing pressures at or near atmospheric pressure and the second was at high vacuum conditions. Recent data on experimental corro-tubes made by Wolverine were obtained from the U. S. Naval Experiment Station. These data were at high vacuum conditions.

A letter report was submitted outlining the ranges of inside and outside dimensions which were recommended for condensing steam at both atmospheric pressures and at high vacuums.

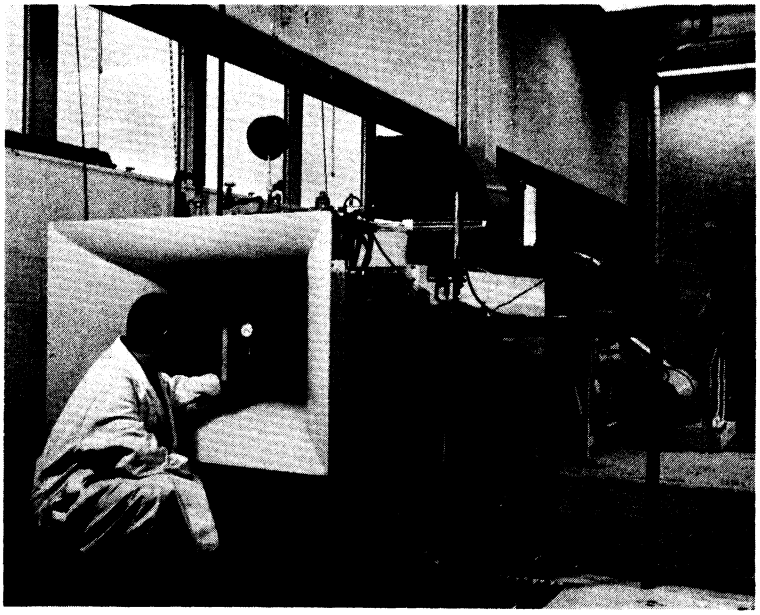

Figure 6. Mr. M. J. Humenick Locating a Vane Type Aneometer in the Entrance Section of the Wind Tunnel for Air Velocity Measurements.

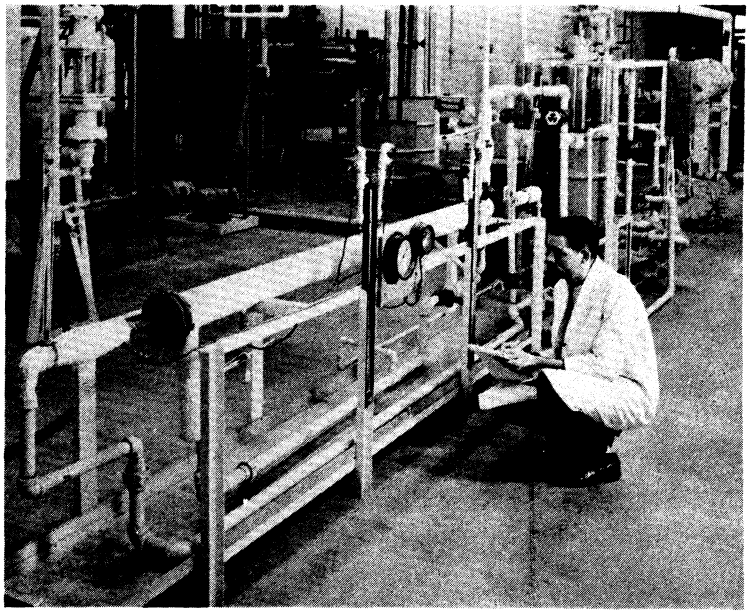

Figure 7. Mr. R. E. Pecsar Recording Pressure Drop Experimental Data Using the Concentric Pipe Heat Exchanger.

REVISION OF REPORT ON PERFORMANCE OF FINNED TUBES IN SHELLS AND TUBE HEAT EXCHANGERS

Report No. 25, entitled "Performance of Finned Tubes in Shell and Tube Heat Exchangers" by R. B. Williams and Professor D. L. Katz, was issued in 1951. Additional work was done during the year to develop an improved correlation of the original data. The issuance of a final report is being delayed until experimental data can be obtained on 12 and 16 inch shells. A more comprehensive and more useful correlation will then be presented.

OTHER ACTIVITIES

A close liaison was maintained between the research project and the U. S. Naval Experiment Station, Annapolis, Maryland. Professor E. H. Young and Mr. Dale E. Briggs made several trips to Annapolis to hold conferences with Mr. J. A. Bauman and associates, concerning their experimental work on Wolverine corro-tubes. Several services were performed by the project in conjunction with their activities.

Professor E. H. Young was able to obtain two heat exchangers from the Aurora Gasoline Company. The exchangers have 12 and 16 inch shells and will be used in the proposed shell-and-tube investigation.

Several other minor investigations and services were performed by the research group during the year. Many of the investigations consisted of analysis of data obtained by other organizations on various types of heat transfer equipment. The wind tunnel investigation which was begun by Dr. Dennis J. Ward was continued. Data were taken on a bank containing four rows of 7/8-in. O.D. and 3/16-in. fin height copper fin tubes with 2-in. pitch.

Professor E. H. Young and other members of the group participated in a large number of meetings with representatives of Wolverine Tube for the purpose of reporting results and planning of future project activities. The participants of one of the conferences are shown in Figure 9. Professor

Figure 8. Conference with Representatives of Wolverine Tube Held at The University of Michigan on May 7, 1959. Back Row, Left to Right, J. S. Cornell, H. C. Lim, W. H. McCarty, J. D. Hellums, and D. E. Briggs. Front Row, Left to Right, D. F. Grimm of Wolverine Tube, Professor E. H. Young, and J. S. Rodgers of Wolverine Tube.

E. H. Young attended the Third National ASME-AIChE Heat Transfer Conference at the University of Connecticut, Storrs, Connecticut, on August 10 and 11. On November 30, Professor E. H. Young and Mr. D. E. Briggs attended a heat transfer symposium at the ASME Annual Meeting at Atlantic City, New Jersey. Other meetings were held with representatives of other companies concerning various aspects of heat transfer with finned tubes.

Professor Donald L. Katz, Chairman of the Department of Chemical and Metallurgical Engineering, and Professor E. H. Young are co-authoring a book entitled Heat Transfer Through Finned Tubes. The book is to be published by John Wiley and Sons of New York. The preparation of the manuscript is being supported by a grant from Wolverine Tube.

The research project received many requests for copies of the reports and technical papers which have been published as a result of the research program. These requests were fulfilled whenever possible.

CURRENT STATUS

The current priority list as established by Wolverine Tube as of January 1, 1960, was separated into two categories. One consisted of projects requiring laboratory facilities and the other consisted of study groups to make analytical analysis using information from technical literature, and that obtained from other sources.

Equipment (Laboratory) projects in order of priority are:

1. High temperature bond resistance measurements of Type L/C tubes at various tube wall temperatures and effects of cycling.

2. High temperature bond resistance measurements of steel applied finned tube at various tube wall temperatures.

3. Study of internal finned tube configurations; the effect of finned tube in boiling; and subsequent use as water chiller tubes.

4. Investigation of heat transfer and pressure drop characteristics of Type S/T tubes in shell-and-tube exchangers in both gas cooling and liquid-liquid heat transfer applications.

5. Comparative studies between the Decatur bond-resistance measuring equipment and the equipment at The University of Michigan.

Paper studies:

1. Steam condensing with corrugated tubes.

2. Study of the optimum number of fins per inch for normal Freon-12 condensing applications.

3. Heat transfer and pressure drop characteristics of internal extended surface configurations in a number of applications.

4. Wind tunnel data analysis.

5. Revision of Williams-Katz report.