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NATIONAL BUREAU OF STANDARDS REPORT

7760

CAPACITY TESTS OF FIVE REMOTE AIR-COOLED
REFRIGERANT CONDENSERS

Manufactured by
Dunham-Bush, Inc.
West Hartford, Connecticut

by

R. J. Dockery and C. W. Phillips

to

Mechanical Engineering Division
Quartermaster Research and Engineering Command
Natick, Massachusetts

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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1003-20-10435	November 30, 1962	7760

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1.0 INTRODUCTION

This report presents results of tests of five remote air-cooled refrigerant condensers, of three sizes and four classes listed in, "Purchase Description, Condensers, Air-Cooled, for use with Dichlorodifluoromethane (F-12)," dated March 22, 1957. All five were manufactured by Dunham-Bush, Inc., West Hartford, Connecticut. All were constructed with tubes containing the Company's patented "Inner-Fin."

The five condensers were:

Specimen No. 1. Size B Class 4 Steel Tubes, Steel Fins NBS Test No. 170-58
Specimen No. 2. Size B Class 3 Aluminum Tubes, Aluminum Fins NBS Test No. 166-58
Specimen No. 3. Size B Class 2 Copper Tubes, Copper Fins NBS Test No. 159-58
Specimen No. 4. Size C Class 1 Copper Tubes, Aluminum Fins NBS Test No. 140-57
Specimen No. 5. Size A Class 1 Copper Tubes, Aluminum Fins NBS Test No. 138-57

1.1 BACKGROUND

The performance evaluations of condensers discussed in this report represent a resumption in July 1961 of a study started in 1957 and interrupted for fiscal reasons in 1959. Apparatus designed and constructed specifically for this work was originally patterned after a proposed ASRE Standard PS-2.4. During the time the project was inactive, the proposed ASRE Standard PS-2.4 was modified and adopted as ASHRAE Standard 20-60, "Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled and Evaporative Condensers." It should be noted that ASRE (American Society of Refrigerating Engineers) and ASHAE (American Society of Heating and Air Conditioning Engineers) merged in 1959 to form ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers). The primary change between ASRE PS-2.4 and ASHRAE Standard 20-60 affecting this test series was the substitution of a low side refrigerant calorimeter for the air-side psychrometric measurement of heat rejection. In reactivating the project, the air-side psychrometric measurement was retained, and the original test system evaporator was modified to function as a low-side refrigerant calorimeter. For some tests a separate low-side refrigerant calorimeter was used. The use of a turbine-type electric flowmeter for determination of the electronic rate of liquid refrigerant flow was retained.

Neither ASRE PS-2.4 or ASHRAE Standard 20-60 established requirements for minimum or maximum subcooling of the liquid refrigerant leaving the condenser. Failure to control the degree of subcooling to as low a positive value as possible, and certainly failure to condense completely will result in unsuitable comparisons of different test condensers. All tests in both the prior and present series were made with condensation of all of the refrigerant (indicated by a sight glass at the condenser outlet) and with subcooling less than five degrees F in most cases and less than 10.5°F in all cases.

ASRE PS-2.4 included Standard Rating Conditions, ASHRAE Standard 20-60 does not. QMR&E Purchase Description dated 22 March 1957 entitled "Condensers, Air-Cooled for Use with Dichlorodifluoromethane (F-12)" set forth the following capacity requirements, at an entering refrigerant saturation temperature of 135°F and 25°F temperature

difference between the entering air (110°F) and entering saturation refrigerant temperature (135°F) for the four series of condensers:

Size A	22,300	Btu/hr (Min.)
Size B	35,600	Btu/hr (Min.)
Size C	46,000	Btu/hr (Min.)
Size D	57,000	Btu/hr (Min.)

Capacities have also been determined at the following conditions as suggested in ASRE PS-2.4.

	High Rate	Low Rate
Dry bulb temperature of air entering unit	95°F	95°F
Wet bulb temperature of air entering unit	75°F ±5°F	75°F ±5°F
Dry bulb temperature of ambient air	95°F	95°F
Saturation temperature of dry vapor entering condenser	130°F	105°F
Actual temperature of dry refrigerant vapor entering condenser	195°F ±10°F	170°F ±10°F

Other relevant document changes occurring since the original implementation of these tests include Military Specification MIL-C-23122, "Military Specifications for Condensers, Air Cooled, Refrigerant-12" adopted December 27, 1961, and proposed Military Standard "Condensers, Air Cooled, Refrigerant." (FSC 4130)

2.0 TEST APPARATUS AND PROCEDURES

The test apparatus and procedures used were similar to those used for tests previously reported in NBS Reports 6378, 6401, 6420, and 6670, except as modified to conform generally to ASHRAE Standard 20-60, "Standard Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled or Evaporative Condensers."

Tests were run in general conformance with requirements of ASHRAE Standard 20-60. A few points of non-conformance are discussed.

1. The requirement in Section 4-2 of ±0.1°F accuracy of of absolute temperature measurements is unrealistic for normal laboratory-quality measuring systems. ±0.2°F is more realistic and test results reported were based on measurements approaching this degree of accuracy.

2. ASHRAE Standard 20-60 requires two simultaneous measurements of refrigerant flow rate as the means for determining performance. Tests reported here compare a psychrometric "air-side" measurement with a simultaneous refrigerant flow measurement. On each run at least these two independent determinations of capacity were made. On some of the runs, the evaporator in the test circuit was adapted and instrumented to serve as a low-side refrigerant calorimeter to provide a third measurement, and a direct comparison with the turbine-type liquid refrigerant flowmeter determination was made in all runs.

3. ASHRAE Standard 20-60 does not establish requirements for maximum or minimum subcooling of the liquid refrigerant leaving the test condenser. In fact only by inference does it require that all refrigerant vapor entering the condenser must be condensed. Tests reported were all run with minimum positive subcooling. The desired subcooling was controlled by means of an adjustable flow valve at the receiver inlet.

The three independent measuring systems can be described briefly.

1. Air-side or Psychrometric. The test condenser was mounted in one end of an insulated air duct apparatus installed in a test room with ambient temperature and humidity controlled at the specified condenser entering air conditions. The air was drawn through the condenser by a selected fan discharging at atmospheric pressure in a chamber large enough to simulate free discharge. The air was drawn out of this chamber through a long radius nozzle by means of an auxiliary blower which discharged into the surrounding room temperature and humidity controlling apparatus. Condenser heat rejection capacity was determined by measuring air quantity and enthalpy change and correcting for fan motor energy input.

2. Liquid Refrigerant Flowmeter. The subcooled condensed liquid refrigerant was metered by means of a totalizing (integrating) turbine-type flowmeter and heat rejection capacities were determined from refrigerant mass flow and enthalpy change.

3. Low-side calorimeter. Liquid refrigerant flow was determined by means of measurement of the enthalpy change in the refrigerant and the energy (heat) required to evaporate the refrigerant in an insulated, metered, electrically heated evaporator using one or the other of two low-side calorimeters. The first was the original tube-type evaporator equipped with immersion electric heaters, modified to operate as a dry system primary calorimeter by installing electric energy meters, thermocouples, and better insulation. Although this calorimeter was generally satisfactory for the larger size condensers producing liquid refrigerant flow rates greater than about 8.0 lbs/min. its overall accuracy was not considered suitable for useful comparison. For smaller flow rates a secondary refirgerant calorimeter constructed for a previous study was used, and results are given for the one Size A condenser included in this report.

Figures 1 through 8 show certain features of the test apparatus and instrumentation.

Figure 1. Schematic drawing of complete measuring apparatus.

Figure 2. Inclined gauges and manometers for air pressure measurements, totalizing counter for refrigerant liquid flowmeter, barometer, hot and cold temperature reference baths. Switch box (lower left) controlled position of auxiliary blower inlet damper.

Figure 3. Wet and dry-bulb thermocouple grid at test condenser air inlet.

Figure 4. Auxiliary blower (left) and inlet damper control motor. Blower is at exit end of air duct apparatus.

Figure 5. Condensed refrigerant liquid line leaving test condenser (right). Pressure tap (right), sight glass (center) and thermocouple well (left) and part of measuring system for determining temperature and degree of subcooling of leaving refrigerant liquid.

Figure 6. Test system refrigerant pressure gauges and precision galvanometer type potentiometer.

Figure 7. Instruments for measurement of electric energy, current and voltage, and relative humidity.

Figure 8. Components of condenser test circuit including compressor, vertical liquid receiver, primary dry system calorimeter evaporator (in plywood enclosure, top), and various accessories for controlling and measuring refrigerant temperatures, pressures and flow. Two pressure gauges (center) indicate pressure drop across liquid line flowmeter(s) directly above gauges.

Figure 9. Secondary refrigerant calorimeter.

The vertical liquid receiver shown in Figure 8 was located near an outside door and during cold weather was influenced by frequent and excessive changes in ambient temperatures not experienced during earlier tests. These temperature changes interfered with control of subcooling A water coil was formed around the receiver, with water flow controlled by receiver refrigerant pressure and the entire assembly insulated as shown in Figure 8, eliminating the effect of ambient temperature changes. Water-cooling the receiver also facilitated pump down of the refrigerant when changing test condensers.

Additional details concerning apparatus will be found under "Data and Results."

3.0 DATA AND RESULTS

Each condenser coil was studied at three different sets of standard conditions as previously described. Each test required control of refrigerant inlet temperature and pressure, air inlet temperature and pressure, air outlet pressure and refrigerant subcooling. Although each condenser was supplied with its own fan, and fan motor, tests were made using a selected military standard fan, and fan motor conforming to the fan air delivery vs. static pressure requirements of the purchase description. Figure 10 shows the three fan types and two motors used for the series.

Figure 11 shows the typical construction of the tube, "Inner-Fin," and fin assembly used in all of the condensers covered by this report. Refrigerant passage is through the spirally-wound accordian-pleated "Inner-Fin." The center tube is closed to refrigerant flow. Materials and dimensions vary as reported. Note the cut raised sections in the external fins.

Figure 12 is a pressure-enthalpy diagram for dichlorodifluoromethane on which the three sets of rating conditions are shown. Symbols used in the tables of test results are identified on this diagram.

Photographs and drawings of the five specimen condensers are shown in Figures 13 to 24. Dimensional and material data and test results are summarized in Tables 1 to 10.

In each table of test results, Items 1 through 6 are specified test conditions and the corresponding observed conditions, Items 7 and 8 are performance observations based on air-side measurements, Items 13 through 23 are ratings derived from both sets of measurements. Two additional ratings, Items 24 and 25 are given separately for further comparison. They are:

Item 24 Btu per (sq.ft.) (°F) (Hour)

Item 25 Btu per (sq.ft.) (°F) (CFM) (Hour

where:

sq.ft. = total surface area of the condenser

°F = log mean temperature difference, refrigerant to air

CFM = air flow rate

Items 1 through 12, 17, and 18 are observed test results, corrected for gauge calibration, etc. Items 13 through 16 and 19 through 25 are values which have been converted from observed test conditions to standard conditions. Item 14 "Condensing Heat Rejection" includes desuperheating of the inlet refrigerant. Where a zero appears in Item 15, the adjusted average value for total capacity was the same or slightly smaller than condensing heat rejection as determined from refrigerant flow rate.

Specimen #1, a Size B Class 4 condenser, NBS No. 170-58 was the first unit tested following reactivation of the test apparatus. Figure 13 is a view of this condenser which had steel tubes and fins, and the tubes contained the patented "Inner-Fin" made of aluminum. Figure 14 and Table 1 give the dimensional data, and Table 2 gives the test results for this condenser. In Figure 14, the black tube connections on the right side view designated tubes which connect into headers, the clear tube connections are return bends and do not connect to the headers.

During the collection of these data, a difference in the degree of liquid refrigerant subcooling between the outlet conditions as observed at the sight glass and as shown by the pressure temperature relationship was noted. Bubles appeared in the sight glass where the instruments indicated a degree or two of subcooling. The instruments were checked and the temperature measuring station was relocated with relation to the sight glass as it was thought that this might be causing some disturbance. The difference persisted but because it was slight, nothing more was done at this time. Later in this test series, the discrepancy was found to be caused by lack of adequate mixing of the vapor and liquid leaving the different parallel circuits.

Specimen #2, was a Size B Class 3 all-aluminum condenser. It was equipped with an aluminum patented "Inner-Fin." Figure 15 is a view of this specimen, NBS No. 166-58, with shroud removed. Coil has been cut at lower left for tube and fin examination.

The fin bond on this coil seemed to be poor compared with others in the series.

Figure 16 and Table 3 give dimensional data for Specimen #2, and Table 4 presents the test results.

Specimen #3 was a Size B Class 2 condenser with copper fins and copper tubes. It is equipped with a copper "Inner-Fin." Figure 17 is a view of this condenser, NBS No. 159-58.

Figure 18 and Table 5 present dimensional characteristics, and Table 6 gives the test results for Specimen #3.

Specimen #4 was a Size C Class 1 condenser, NBS No. 140-57, with aluminum fins and copper tubes with aluminum "Inner-Fin" construction. Figure 19 is a view of this condenser. Figure 20 shows the condenser in place in the rack designed to position it in the test apparatus, and Figure 21 shows the entering air face of the coil.

Figure 22 and Table 7 shows the dimensions and Table 8 gives test results of Specimen #4. It will be noted in the table that two separate tests, on different dates, were made at the ASRE High Saturation Temperature, both with free air discharge. Ability of the test apparatus to repeat is shown by the 2.9 percent agreement for the two air side determinations, 1.6 percent for the refrigerant side determination, and 0.14 percent agreement between the two total heat rejection ratings. Other similarities can be seen in Table 8.

Specimen #5 was a Size A Class 1 condenser, NBS No. 138-57 with copper tubes, aluminum fins, and an aluminum "Inner-Fin" in the tubes. Figure 23 shows this specimen.

Figure 24 and Table 9 give dimensional data and Table 10 presents the test results for Specimen #5. These test results were affected by partial restriction at the condenser inlet. See later discussion.

In Table 10 two values are shown for Items 9 and 12 for each of the three tests reported. The numbers to the left of each main column represent the refrigerant flow rate and total heat rejection capacity for Items 9 and 12 respectively, as determined by the low side secondary refrigerant calorimeter shown in Figure 9. Items 9 and 12 in the main column for each test were derived from the refrigerant liquid turbine-type flowmeter. The agreements obtained between flow rates determined by the two methods were 2.0, 2.0, and 0.5 per cent for the three tests. Specimen #5 was the only condenser of the five in this report for which the secondary refrigerant calorimeter values were obtained. The liquid refrigerant flowmeter was used for all tests here reported.

Examination of the condenser following the completion of the test series showed that the two inlet tubes were partially restricted by foreign material at the inlet face of the inner fin. Consequently, these test results should not be considered representative of those for a similar condenser with no such restriction.

The foreign material was probably introduced into this condenser when it was being used at the outset of the test series to check the performance of the test system. Burnout of an electric immersion heater in the system evaporator contaminated the system. The condenser was removed and the system cleaned at that time and the condenser was not tested until the second part of the test series. The restriction at the inlet tube was not discovered until the test apparatus was being dismantled, which prevented running comparative tests of another specimen of the same type and size.

The effect of the restriction on the capacity is not known. A previous experience in this test series involving two Size B condensers also manufactured by Dunham-Bush, Inc., one partially restricted, the other clean, was reported earlier in NBS Report 6378. The difference in capacity at the QMR&E High Ambient Temperature Conditions for those two condensers was about 7 per cent.

For the Size A condenser in the current test series, the condenser coil internal pressure drop, Item 10, for the QMR&E High Ambient Temperature Test was 7.7 psi as shown in Table 10. There is, of course, some pressure drop for any condenser, but if it is assumed ideally that all or most of this observed pressure drop occurred at the inlet restriction, the refrigerant saturation temperature in the coil would have been 132°F instead of the 135°F design test conditions. With air entering the condenser at 110°F assuming that neither tube was completely blocked, the probable capacity reductions can be approximated by the relationship:

$$1 - \left(\frac{132 - 110}{135 - 110}\right) = 0.13 \text{ or } 13\%$$

If one of the two tubes was completely blocked, the capacity reduction was probably more than this amount and less than 50 per cent. It did not appear that either tube was completely blocked but the first row (in direction of air flow) contained more foreign material than the second. In considering these assumptions it must be remembered that the subcooling of the refrigerant liquid leaving the condenser was controlled at a minimum value as a part of the test conditions.

COMPARISON OF SEVEN DUNHAM BUSH-CONDENSERS

Table 11 shows the total heat rejection capacity for seven Dunham-Bush condensers (including two Size B condensers previously reported in NBS Report 6378. Also shown is the percent of QMR&E requirement (22,300, 35,600, and 46,000 BTUH for Sizes A, B, and C respectively) for the QMR&E High Ambient Temperature Test.

TABLE 11

TOTAL HEAT REJECTION OF SEVEN DUNHAM-BUSH CONDENSERS

Condenser NBS No.	Class	Size	TOTAL HEAT REJECTION, BTUH			
			ASRE High Sat'n Temp.	ASRE Low Sat'n Temp.	QMR&E High Amb.	% QMR&E Req'mnt
138-57[a]	1	A	21480	6190	16120	72
139-57[a,b]	1	B	39400	10600	30100	85
155-58[b]	1	B	45000	--	32100	90
159-58	2	B	41010	8430	29890	84
166-58	3	B	47940	7170	32810	92
170-58	4	B	38990	8730	27830	78
140-57	1	C	55490	9665	37950	83

a. Foreign material in condenser inlet during tests
b. Previously reported in NBS Report 6378.

Table 12 lists the Heat Transmission Coefficient, BTUH per Ft^2 (°F log mean temperature difference), (Item 24 in Tables of Test Results), for the seven Dunham-Bush condensers.

TABLE 12

HEAT TRANSMISSION COEFFICIENT OF SEVEN DUNHAM-BUSH CONDENSERS

Condenser NBS No.	Class	Size	ASRE High Sat'n Temp.		ASRE Low Sat'n Temp.		QMR&E High Ambient	
			Trans. Coeff. BTUH/ ft^2(°F)	Air Face Vel. FPM[c]	Trans. Coeff. BTUH/ ft^2(°F)	Air Face Vel. FPM[c]	Trans. Coeff. BTUH/ ft^2(°F)	Air Face Vel. FPM[c]
138-57[a]	1	A	5.03	540	5.32	555	5.30	585
139-57[a,b]	1	B	5.01	660	4.67	655	5.42	655
155-58[a]	1	B	5.84	660	--	--	6.00	655
159-58	2	B	5.54	720	4.67	710	5.84	720
166-58	3	B	6.87	675	3.22	685	6.54	690
170-58	4	B	5.18	695	4.15	690	5.46	665
140-57	1	C	4.62	545	3.05	545	4.35	535

a. Foreign material in condenser inlet during tests.
b. Previously reported in NBS Report 6378
c. Based on CFM at Test Conditions (Item 7, Tables of Test Results)

Table 13 gives the Heat Transmission Coefficient, BTUH per Ft^2 (°F log mean temperature difference) (CFM), (Item 25 in Tables of Test Results) for the seven Dunham-Bush condensers

TABLE 13

HEAT TRANSMISSION COEFFICIENT OF SEVEN DUNHAM-BUSH CONDENSERS

Condenser NBS No.	Class	Size	Coefficient, BTUH Per Ft^2 (°F log Mtd)(CFM[c])		
			ASRE High Sat'n Temp.	ASRE Low Sat'n Temp.	QMR&E High Amb.
138-57[a]	1	A	0.00302	0.00312	0.00313
139-57[a,b]	1	B	.00146	.00135	.00162
155-58[b]	1	B	.00170	--	.00183
159-58	2	B	.00149	.00125	.00163
166-58	3	B	.00192	.00088	.00187
170-58	4	B	.00145	.00114	.00162
140-57	1	C	.00127	.00083	.00122

a. Foreign material in condenser inlet during tests.
b. Previously reported in NBS Report 6378
c. Based on standard air, (Item 16 in Tables of Test Results)

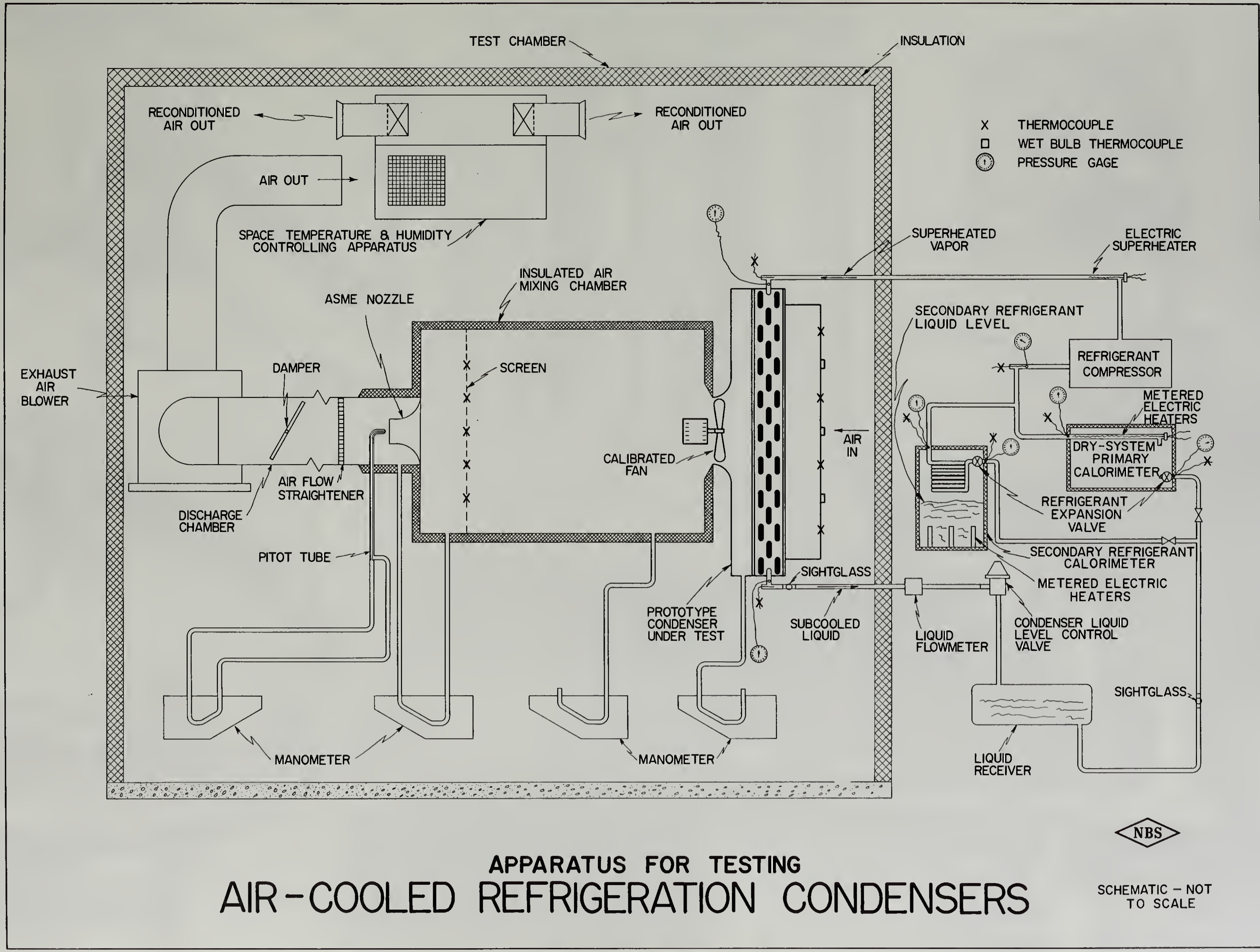
Table 14 presents the Heat Transmission Coefficient, BTUH per Ft^2 (°F log mean temperature difference) (FPM entering air face velocity).

TABLE 14

HEAT TRANSMISSION COEFFICIENT OF SEVEN DUNHAM-BUSH CONDENSERS

Condenser NBS No.	Class	Size	Coefficient, BTUH Per Ft^2 (°F log Mtd)(FPM[c])		
			ASRE High Sat'n Temp.	ASRE Low Sat'n Temp.	QMR&E High Amb.
138-57[a]	1	A	0.00932	0.00959	0.00906
139-57[a,b]	1	B	.00759	.00713	.00828
155-58[b]	1	B	.00885	--	.00916
159-58	2	B	.00770	.00658	.00811
166-58	3	B	.0102	.00470	.00948
170-58	4	B	.00746	.00602	.00821
140-57	1	C	.00848	.00560	.00813

a. Foreign material in condenser inlet during tests
b. Previously reported in NBS Report 6378
c. Based on FPM entering air face velocity at test conditions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INSULATION
RECONDITIONED AIR OUT
RECONDITIONED AIR OUT
X THERMOCOUPLE
WET BULB THERMOCOUPLE
PRESSURE GAGE
AIR OUT
SPACE TEMPERATURE & HUMIDITY CONTROLLING APPARATUS
SUPERHEATED VAPOR
ELECTRIC SUPERHEATER
INSULATED AIR MIXING CHAMBER
ASME NOZZLE
SECONDARY REFRIGERANT LIQUID LEVEL
REFRIGERANT COMPRESSOR
EXHAUST AIR BLOWER
DAMPER
SCREEN
METERED ELECTRIC HEATERS
DRY-SYSTEM PRIMARY CALORIMETER
AIR IN
CALIBRATED FAN
AIR FLOW STRAIGHTENER
DISCHARGE CHAMBER
REFRIGERANT EXPANSION VALVE
PITOT TUBE
SECONDARY REFRIGERANT CALORIMETER
SIGHTGLASS
METERED ELECTRIC HEATERS
PROTOTYPE CONDENSER UNDER TEST
SUBCOOLED LIQUID
LIQUID FLOWMETER
CONDENSER LIQUID LEVEL CONTROL VALVE
SIGHTGLASS
MANOMETER
MANOMETER
LIQUID RECEIVER
NBS
APPARATUS FOR TESTING
AIR-COOLED REFRIGERATION CONDENSERS
SCHEMATIC - NOT TO SCALE

Figure 1

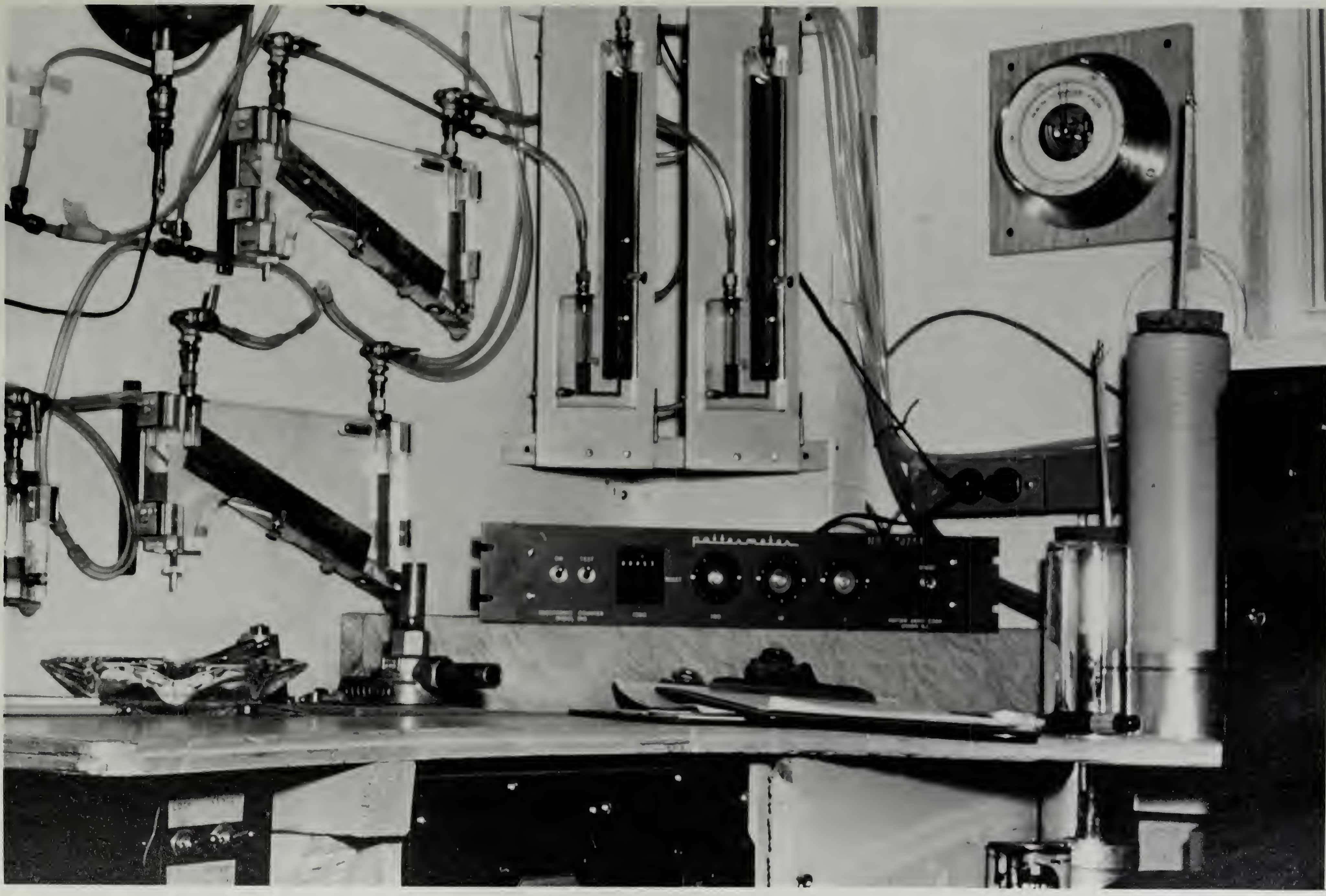


Figure 2

Figure 3

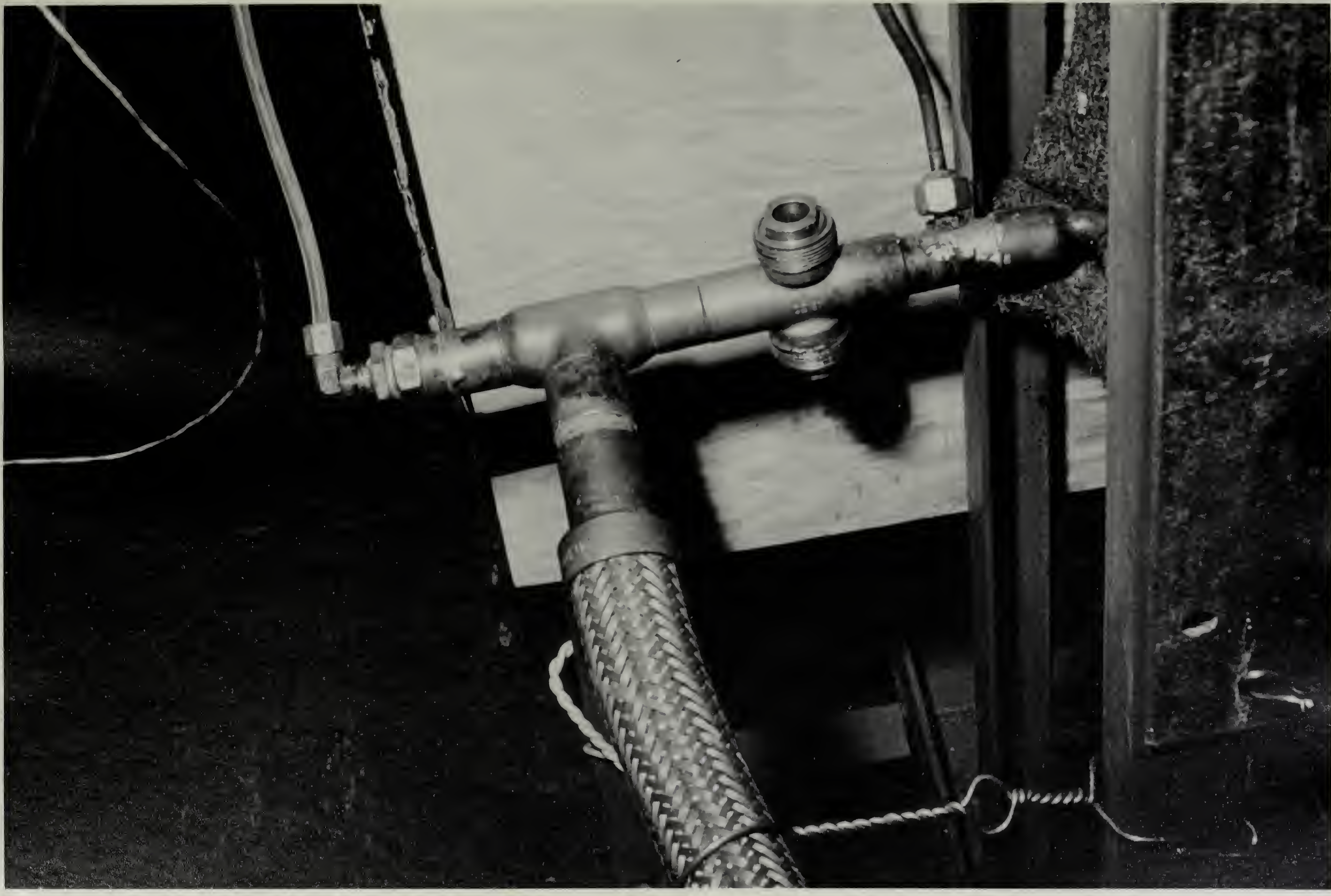


Figure 5

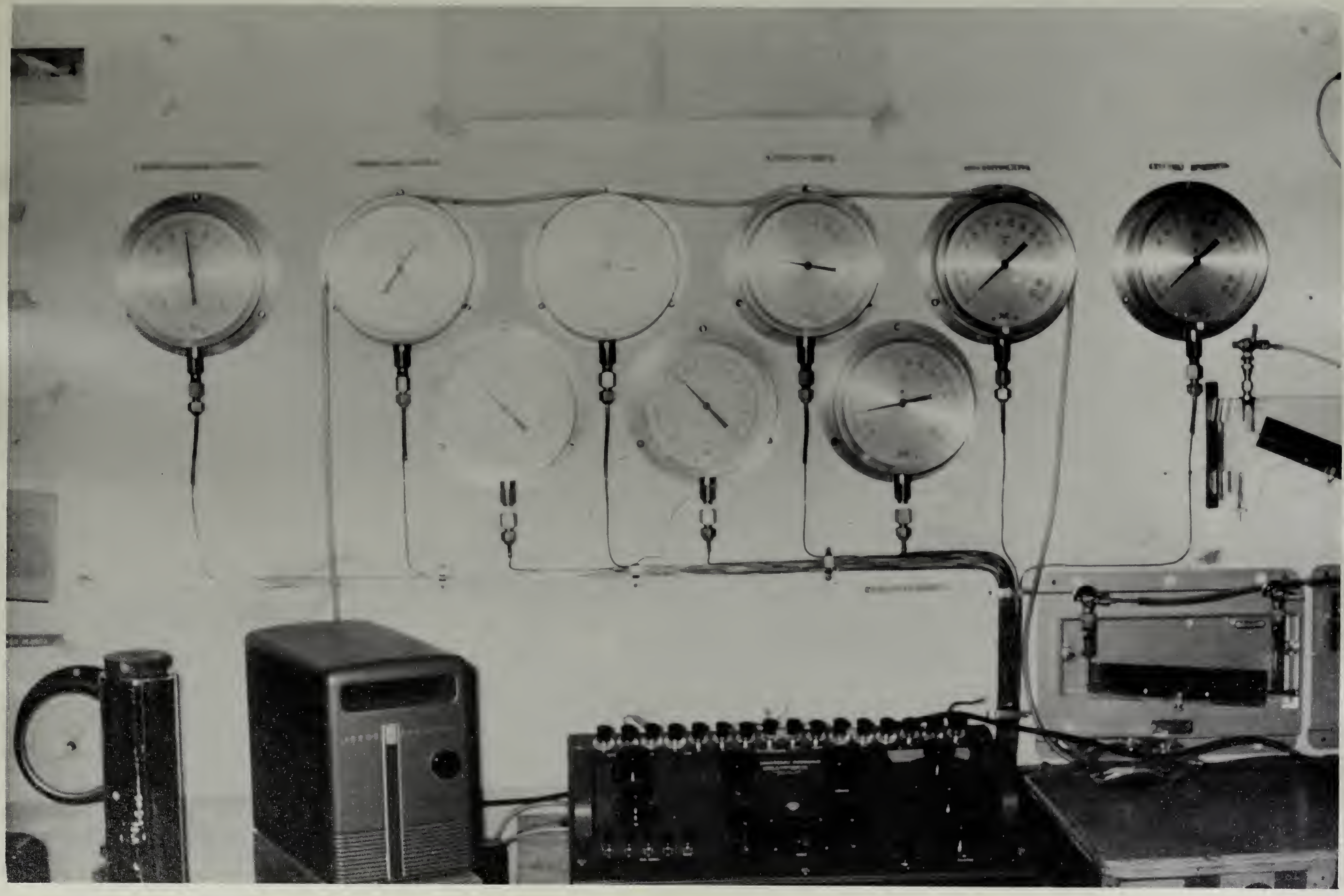


Figure 6

Figure 7

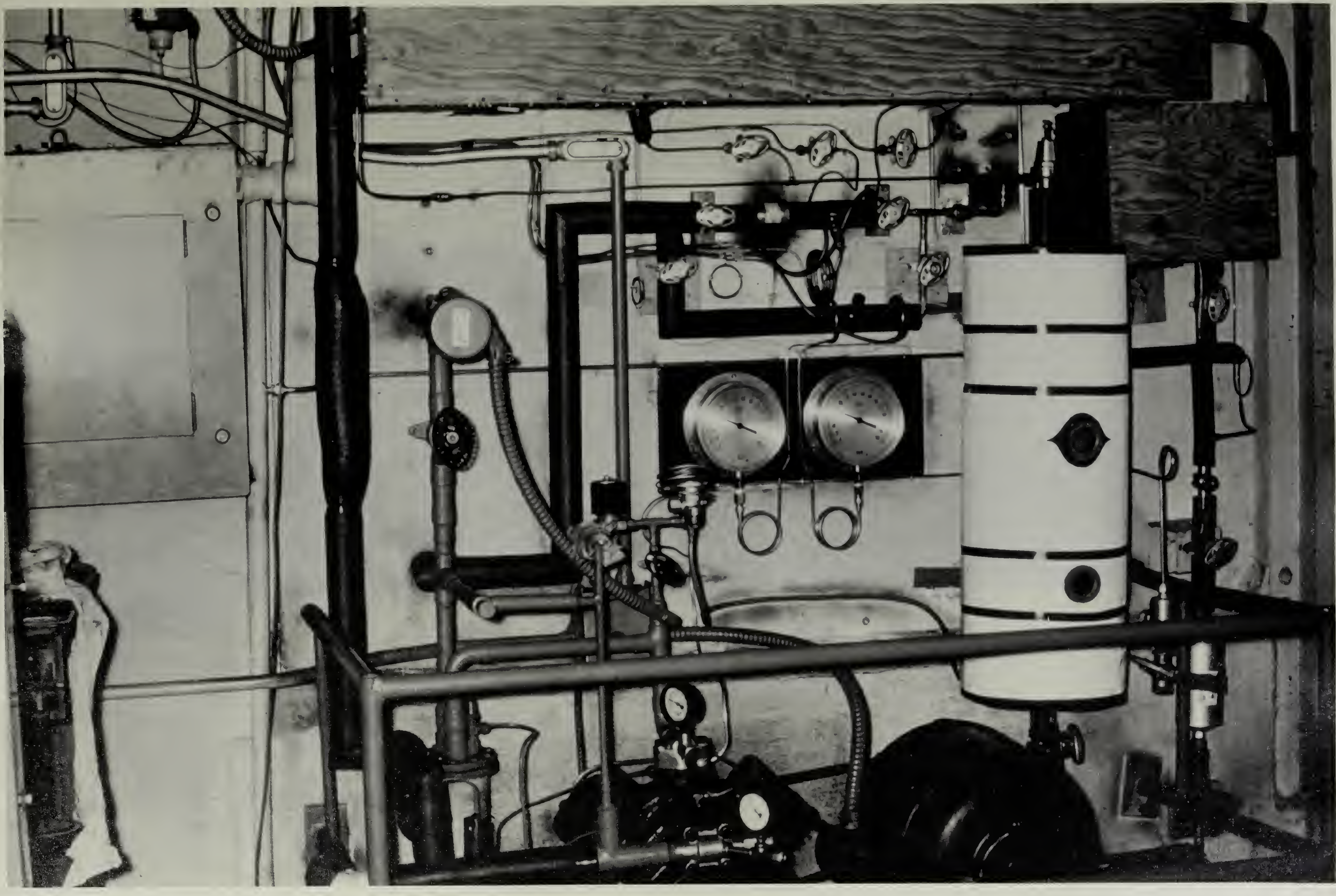


Figure 8

Figure 9

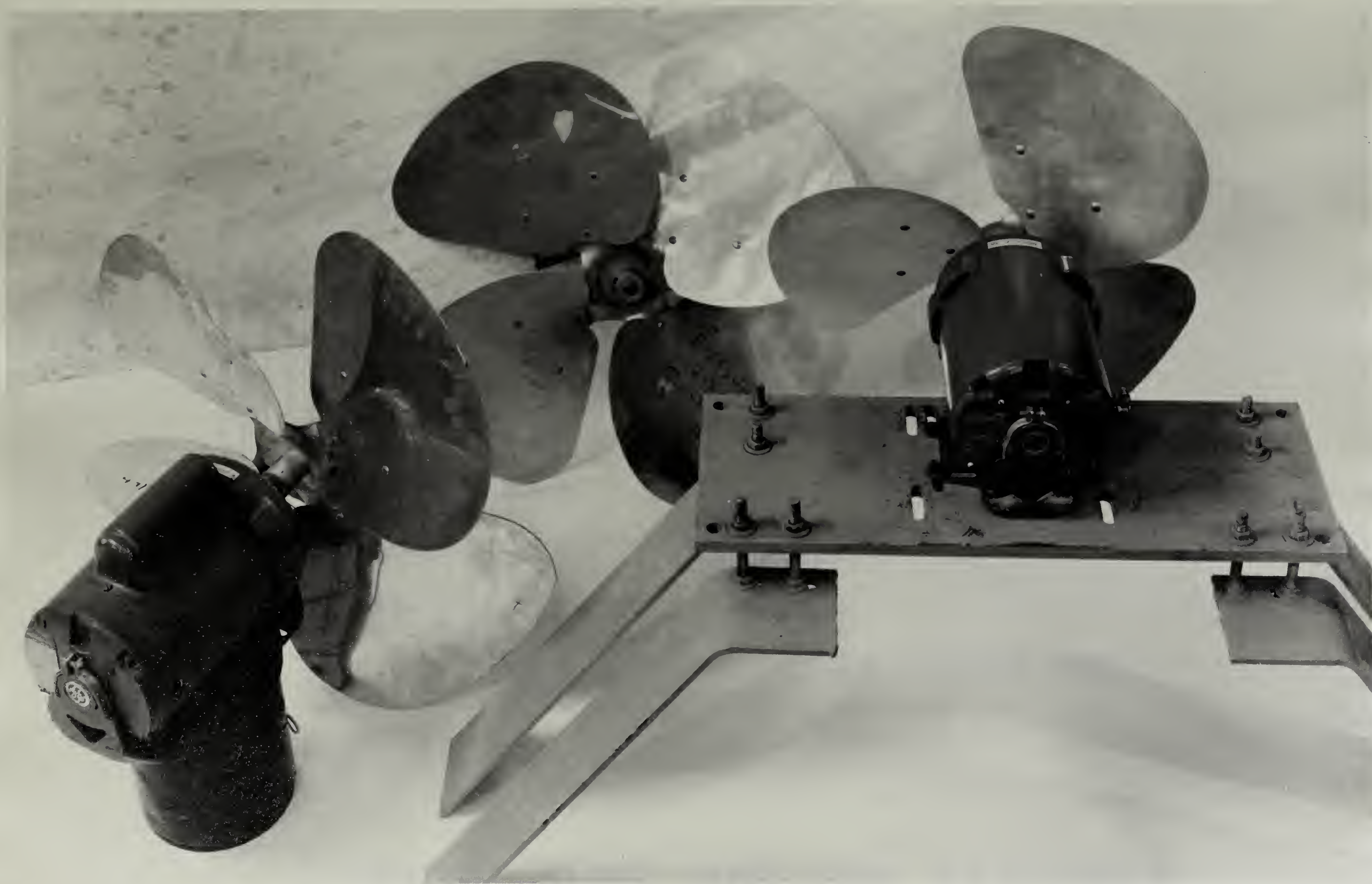


Figure 10

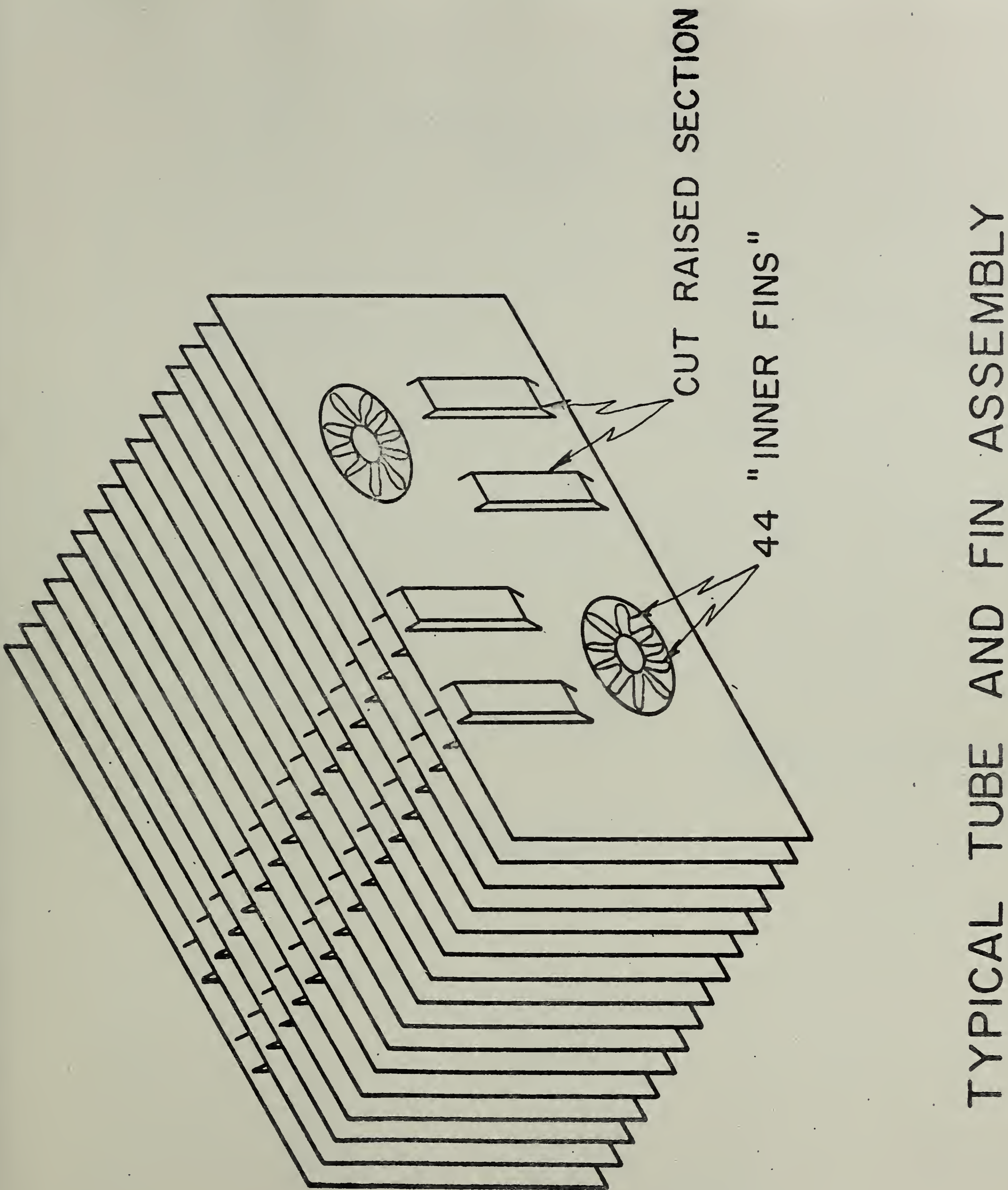
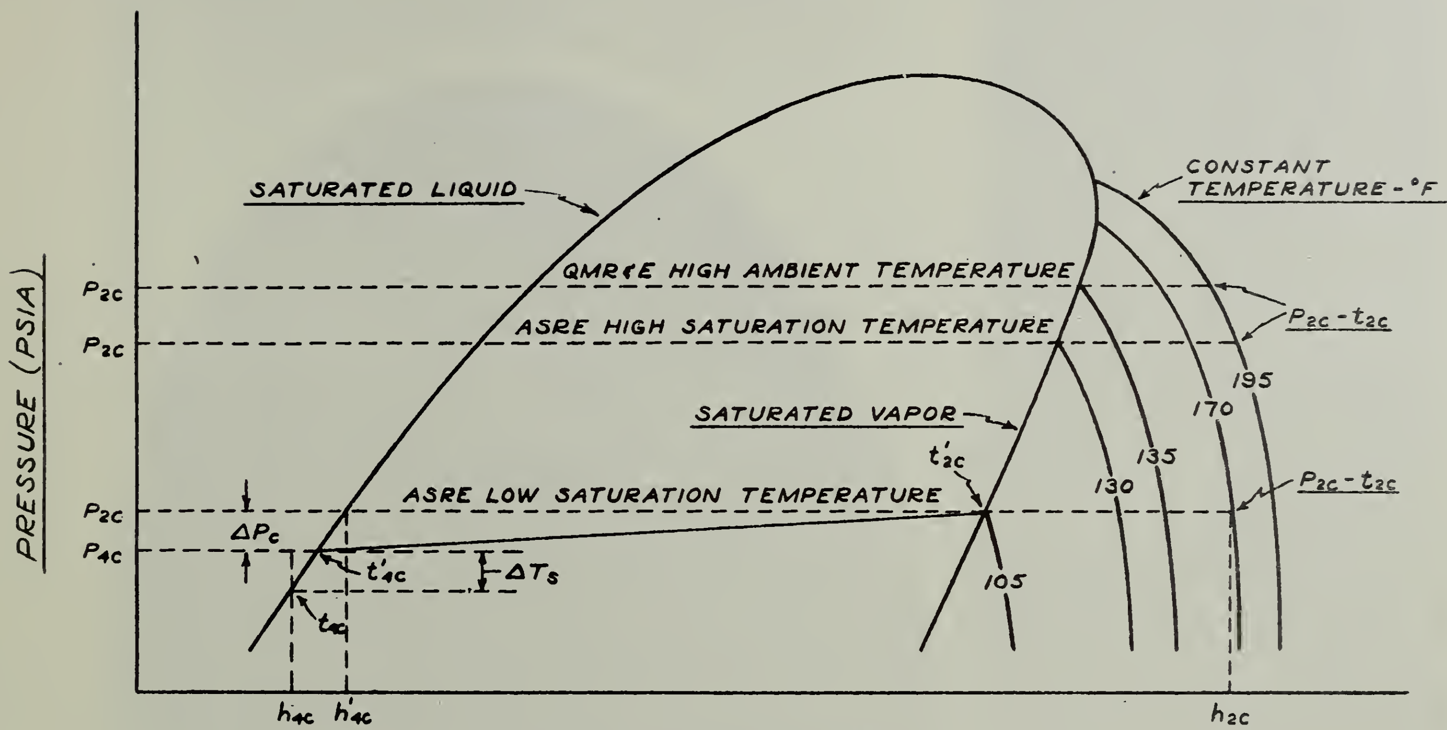

CUT RAISED SECTION
44 "INNER FINS"
TYPICAL TUBE AND FIN ASSEMBLY

Figure 11

PRESSURE - ENTHALPY DIAGRAM

NO SCALE



NOTE:
LABELED IN ACCORDANCE WITH ASRE PS 2.4

CONDENSER SPECIMEN DIAGRAM

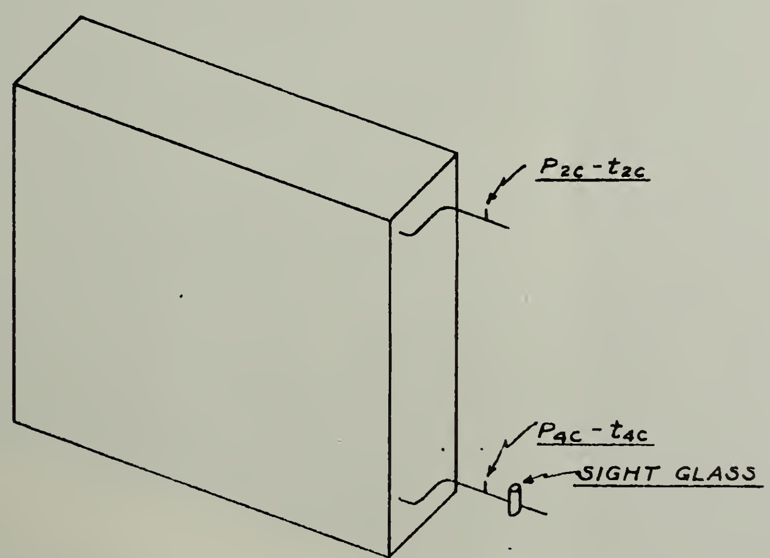


Figure 12

Figure 13

CONDENSER SPECIMEN #1

MFR. Dunham-Bush | **NBS NO.** 170-58 | **SIZE** B | **CLASS** 4

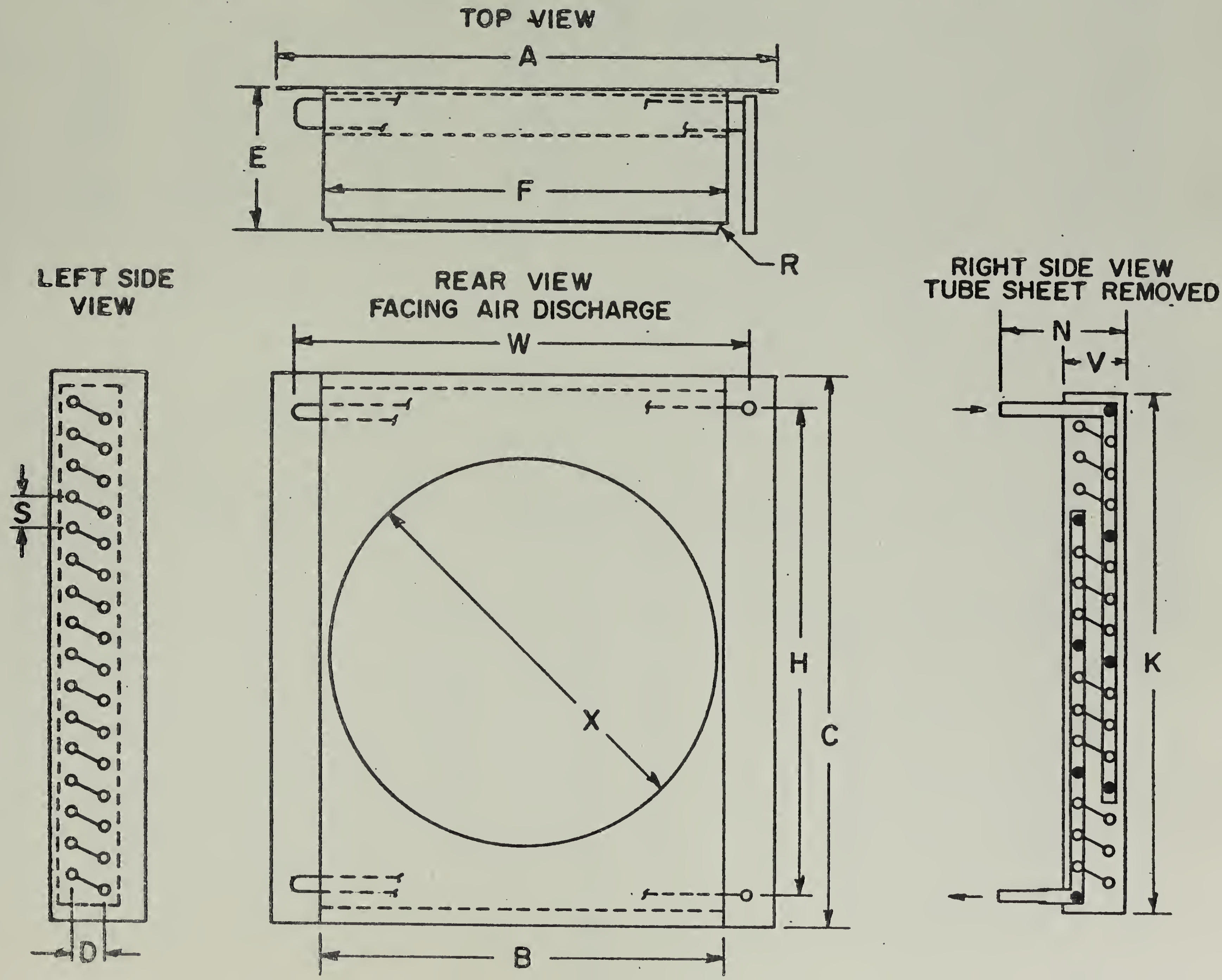


Figure 14

CONDENSER SPECIMEN #1

MFR. Dunham-Bush	SIZE - B
NBS NO. 170-58	CLASS - 4

ITEM		PROPERTY	REMARKS
COIL TUBE CHARACTERISTICS			
1 MATERIAL		Steel	
2 NUMBER OF ROWS DEEP		2	
3 NUMBER OF TUBES HIGH		16	
4 NUMBER OF CIRCUITS IN PARALLEL		4	
5 NUMBER OF TUBES PER CIRCUIT		8	
6 TUBE DIAMETER, O.D., IN.		5/8	With aluminum "Inner Fin"
7 TUBE WALL THICKNESS, IN.		--	
8 TUBE RETURN BEND DIAMETER, O.D., IN.		1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.		3/4	
10 LIQUID OUTLET CONN. DIAMETER, O.D, IN.		5/8	
11 VERTICAL TUBE SPACING, IN.	S	2	
12 PRIMARY SURFACE AREA, SQ. FT.		10.75	
COIL FIN CHARACTERISTICS			
1 MATERIAL		Steel	
2 TYPE OF FIN		Plate	Flat with cut raised sections
3 FIN SPACING, PER INCH		8	
4 FIN THICKNESS, IN.		0.02	
5 SECONDARY SURFACE AREA, SQ. FT.		249.6	
COIL DIMENSIONS			
1 FINNED HEIGHT, IN.	K	32	
2 FINNED WIDTH, IN.	F	25 1/2	
3 FINNED DEPTH, IN.	V	3	
4 COIL HEIGHT, IN.	H	31	
5 COIL WIDTH, IN.	W	29	
6 COIL DEPTH, IN.	D	1 1/2	
7 COIL DEPTH, OVERALL, IN.	N	---	
8 FACE AREA, SQ. FT.		5.67	
9 TOTAL SURFACE AREA, SQ. FT.		260.4	
OVERALL CONDENSER DIMENSIONS			
1 WIDTH, OVERALL, IN.	A	32 3/8	
2 WIDTH, SHROUD, IN.	B	25 3/4	
3 HEIGHT, IN.	C	34 1/8	
4 DEPTH, IN.	E	11	
5 BELLMOUTH ORIFICE DIAMETER, IN.	X	24 1/2	
6 BELLMOUTH RADIUS, IN.	R	0.406	Approx.

Table 1

CONDENSER SPECIMEN #1

MFR. Dunham-Bush NBS NO. 170-58 SIZE - B CLASS - 4

AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED:
FAN MFR. Torrington
FAN SERIAL NO. E-2420-4
FAN SPEED 1140
MOTOR HP RATING 0.5
REFRIGERANT 12

ITEM			ASRE HIGH SATURATION TEMPERATURE: STANDARD CONDITION	ASRE HIGH SATURATION TEMPERATURE: OBSERVED CONDITION, AIR FLOW RATE CFM, FREE DISCH.	ASRE LOW SATURATION TEMPERATURE: STANDARD CONDITION	ASRE LOW SATURATION TEMPERATURE: OBSERVED CONDITION, AIR FLOW RATE CFM, FREE DISCHARGE	QMR&E HIGH AMBIENT TEMPERATURE: STANDARD CONDITION	QMR&E HIGH AMBIENT TEMPERATURE: OBSERVED CONDITION, AIR FLOW RATE CFM, FREE DISCHARGE
1. BAROMETRIC PRESSURE	P_{ab}	"Hg	29.921	29.90	29.921	29.72	29.921	29.41
2. DRY BULB TEMPERATURE OF AIR ENTERING COIL	t_{ae}	°F	95	95.4	95	95.0	110	110.0
3. WET BULB TEMPERATURE OF AIR ENTERING COIL	t'_{ae}	°F	75±5	78.5	75±5	78.3		72.8
4. DRY BULB TEMPERATURE OF AMBIENT AIR	t_{ae}	°F	95	95.4	95	95.0	110	110.0
5. SATURATION TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t'_{2c}	°F	130	130.4	105	104.3	135	135.0
6. SUPERHEAT TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t_{2c}	°F	195±10	189.7	170±10	169.6		194.0
			AIR FLOW METHOD		AIR FLOW METHOD			
7. NOZZLE AIR AND WATER VAPOR MIXTURE FLOW RATE	Q_{ad}	CFM		3929		3917		3759
8. TOTAL HEAT REJECTION CAPACITY	q_{tc}	BTUH		38890		8094		28130
			REFRIGERANT FLOW METHOD		REFRIGERANT FLOW METHOD			
9. REFRIGERANT FLOW RATE	W_r	lb/min		10.01		1.98		7.38
10. CONDENSER COIL INTERNAL PRESSURE DROP	ΔP_c	PSI		7.7		1.1		5.0
11. SUBCOOLING OF LEAVING REFRIGERANT LIQUID	ΔT_s	°F	10° MAX.	7.7	5° MAX.	5.1		1.1
12. TOTAL HEAT REJECTION CAPACITY	q_{tr}	BTUH		39090		8076		27530
			RATINGS		RATINGS			
13. TOTAL HEAT REJECTION	q_{tR}	BTUH		38990		8732		27830
14. CONDENSING HEAT REJECTION	q_{cR}	BTUH		37860		8561		27180
15. SUBCOOLING HEAT REJECTION	q_{sR}	BTUH		1123		171		647
16. AIR FLOW RATE	Q_R	CFM		3578		3647		3364
17. CONDENSER COIL EXTERNAL RESISTANCE	P_{as}	"H_2O		0.25		0.25		0.22
18. FAN MOTOR POWER	P_{fm}	WATTS		480		475		462
19. FAN BRAKE HORSEPOWER	P	BHP		---		--		---
20. HEAT REJECTION PER UNIT PRIMARY SURFACE AREA	BTUH/SF			3610		866.3		2577
21. HEAT REJECTION PER UNIT SECONDARY SURFACE AREA	BTUH/SF			156.2		34.98		111.4
22. HEAT REJECTION PER UNIT TOTAL SURFACE AREA	BTUH/SF			149.7		33.53		106.9
23. HEAT REJECTION PER CFM	BTUH			10.90		2.39		8.27
24. " " , BTUH/SF(°F)				5.18		4.15		5.46
25. " " , BTUH/SF(°F)(CFM)				0.00145		0.00114		0.00162

Table 2

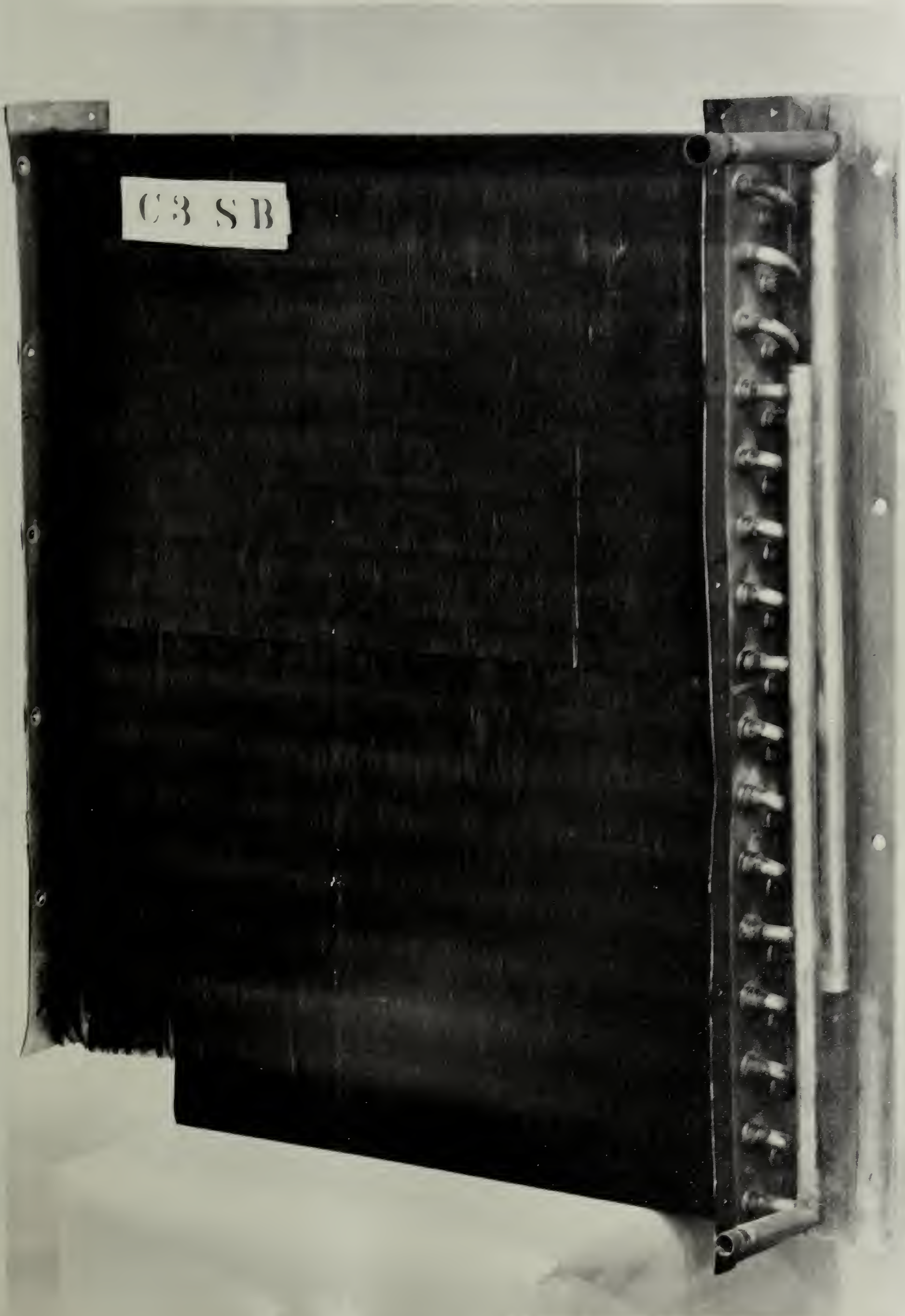


Figure 15

CONDENSER SPECIMEN #2

MFR. Dunham-Bush | NBS NO. 166-58 | SIZE B | CLASS 3

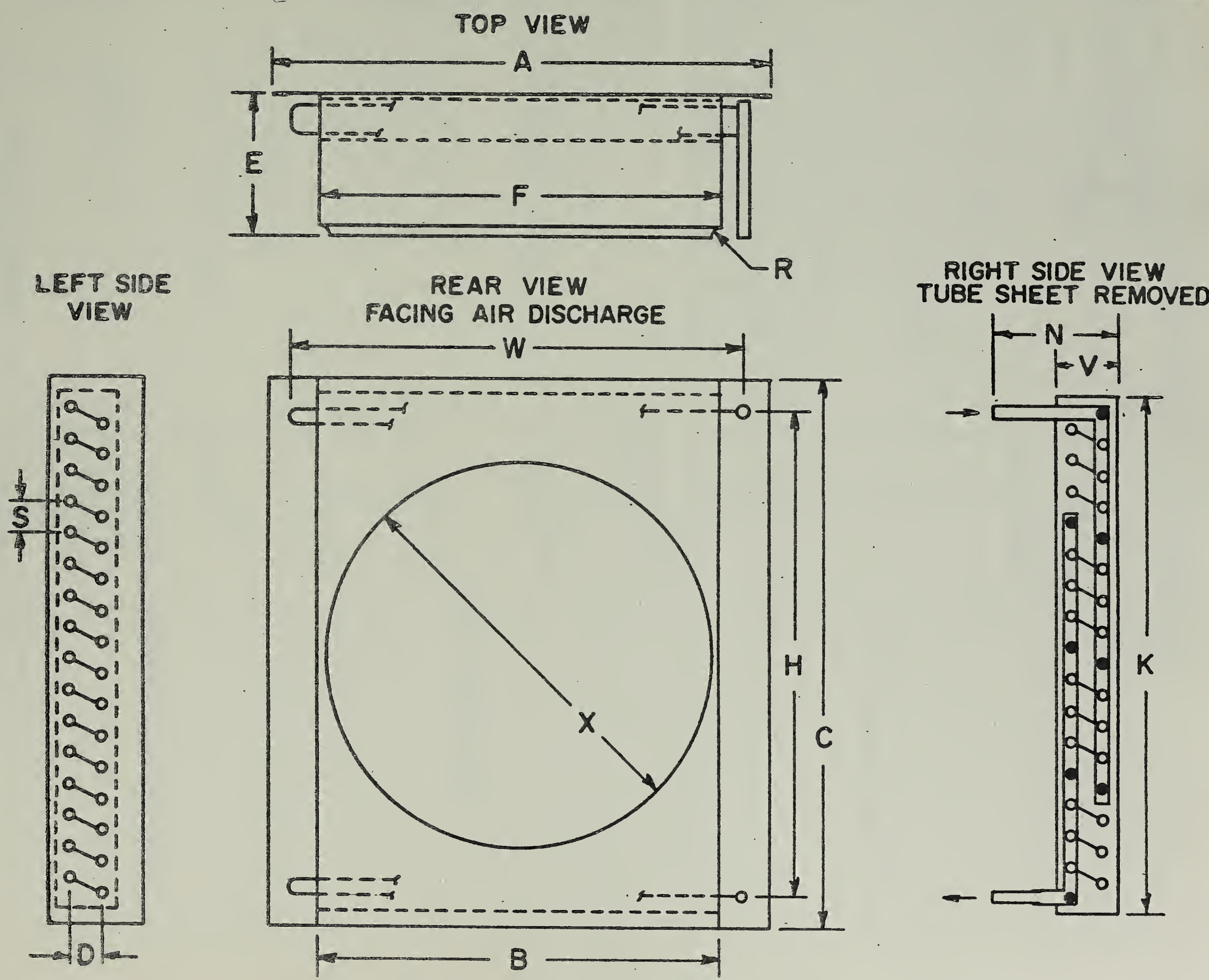


Figure 16

CONDENSER SPECIMEN #2

MFR. Dunham-Bush		SIZE - B
NBS NO. 166-58		CLASS - 3
ITEM	PROPERTY	REMARKS
COIL TUBE CHARACTERISTICS		
1 MATERIAL	Aluminum	
2 NUMBER OF ROWS DEEP	2	
3 NUMBER OF TUBES HIGH	16	
4 NUMBER OF CIRCUITS IN PARALLEL	4	
5 NUMBER OF TUBES PER CIRCUIT	8	
6 TUBE DIAMETER, O.D., IN.	5/8	With aluminum "Inner Fin"
7 TUBE WALL THICKNESS, IN.	—	
8 TUBE RETURN BEND DIAMETER, O.D., IN.	1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.	7/8	
10 LIQUID OUTLET CONN. DIAMETER, O.D, IN.	5/8	
11 VERTICAL TUBE SPACING, IN. S	2	
12 PRIMARY SURFACE AREA, SQ. FT.	10.50	
COIL FIN CHARACTERISTICS		
1 MATERIAL	Aluminum	
2 TYPE OF FIN	Plate	Flat with cut raised sections
3 FIN SPACING, PER INCH	8	
4 FIN THICKNESS, IN.	0.011	
5 SECONDARY SURFACE AREA, SQ. FT.	244.3	
COIL DIMENSIONS		
1 FINNED HEIGHT, IN. K	32 1/4	
2 FINNED WIDTH, IN. F	25 1/2	
3 FINNED DEPTH, IN. V	3	
4 COIL HEIGHT, IN. H	31	
5 COIL WIDTH, IN. W	28 3/4	
6 COIL DEPTH, IN. D	1 1/2	
7 COIL DEPTH, OVERALL, IN. N	----	
8 FACE AREA, SQ. FT.	5.74	
9 TOTAL SURFACE AREA, SQ. FT.	254.8	
OVERALL CONDENSER DIMENSIONS		
1 WIDTH, OVERALL, IN. A	32 1/2	
2 WIDTH, SHROUD, IN. B	25 3/4	
3 HEIGHT, IN. C	34 1/8	
4 DEPTH, IN. E	11	
5 BELLMOUTH ORIFICE DIAMETER, IN. X	24 1/2	
6 BELLMOUTH RADIUS, IN. R	0.406	Approx.

Table 3

CONDENSER SPECIMEN #2

MFR. Dunham-Bush			NBS NO. 166-58		SIZE - B		CLASS - 3	
AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED			ASRE HIGH SATURATION TEMPERATURE		ASRE LOW SATURATION TEMPERATURE		QMR&E HIGH AMBIENT TEMPERATURE	
FAN MFR. Torrington FAN SERIAL NO. E-2420-4 FAN SPEED 1140 MOTOR HP RATING 0.5 REFRIGERANT 12			STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCH.	STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCHARGE	STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCHARGE
ITEM								
1. BAROMETRIC PRESSURE	P_{ab}	"Hg	29.921	29.35	29.921	29.85	29.921	29.85
2. DRY BULB TEMPERATURE OF AIR ENTERING COIL	t_{ae}	°F	95	95.0	95	95.1	110	109.9
3. WET BULB TEMPERATURE OF AIR ENTERING COIL	t'_{ae}	°F	75 ± 5	78.4	75 ± 5	77.2		86.2
4. DRY BULB TEMPERATURE OF AMBIENT AIR	t_{ae}	°F	95	95.0	95	95.1	110	109.9
5. SATURATION TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t'_{2c}	°F	130	130.4	105	105.2	135	134.4
6. SUPERHEAT TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t_{2c}	°F	195 ± 10	202.0	170 ± 10	169.7		192.0
			AIR FLOW METHOD		AIR FLOW METHOD			
7. NOZZLE AIR AND WATER VAPOR MIXTURE FLOW RATE	Q_{ad}	CFM		3875		3920		3947
8. TOTAL HEAT REJECTION CAPACITY	q_{tc}	BTUH		49340		7225		32730
			REFRIGERANT FLOW METHOD		REFRIGERANT FLOW METHOD			
9. REFRIGERANT FLOW RATE	W_r	lb/min		11.7		1.77		8.22
10. CONDENSER COIL INTERNAL PRESSURE DROP	ΔP_c	PSI		5.5		2.7		3.7
11. SUBCOOLING OF LEAVING REFRIGERANT LIQUID	ΔT_s	°F	10° MAX.	9.8	5° MAX.	5.3		9.8
12. TOTAL HEAT REJECTION CAPACITY	q_{tr}	BTUH		47510		7260		31600
			RATINGS		RATINGS			
13. TOTAL HEAT REJECTION	q_{tR}	BTUH		47940		7171		32810
14. CONDENSING HEAT REJECTION	q_{cR}	BTUH		45260		7044		30990
15. SUBCOOLING HEAT REJECTION	q_{sR}	BTUH		2683		127		1823
16. AIR FLOW RATE	Q_R	CFM		3581		3636		3493
17. CONDENSER COIL EXTERNAL RESISTANCE	P_{as}	"H_2O		0.22		0.22		0.22
18. FAN MOTOR POWER	P_{fm}	WATTS		477		485		478
19. FAN BRAKE HORSEPOWER	P	BHP		---		--		---
20. HEAT REJECTION PER UNIT PRIMARY SURFACE AREA	BTUH/SF			4566		683.0		3125
21. HEAT REJECTION PER UNIT SECONDARY SURFACE AREA	BTUH/SF			196.2		29.35		134.3
22. HEAT REJECTION PER UNIT TOTAL SURFACE AREA	BTUH/SF			188.1		28.14		128.8
23. HEAT REJECTION PER CFM	BTUH			13.39		1.97		9.39
24. " " , BTUH/SF(°F)				6.87		3.22		6.54
25. " " , BTUH/SF(°F)(CFM)				0.00192		0.00088		0.00187

Table 4

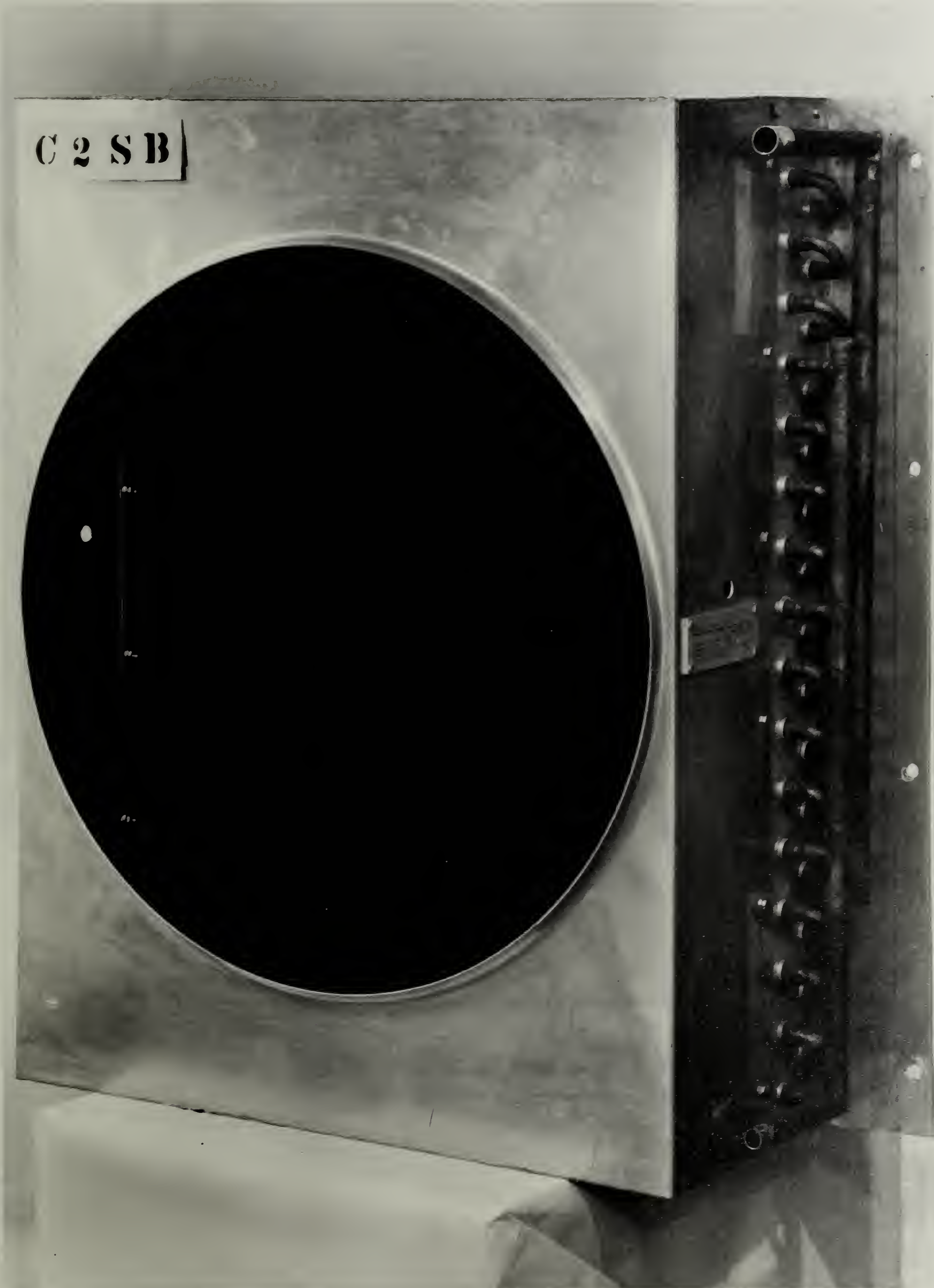
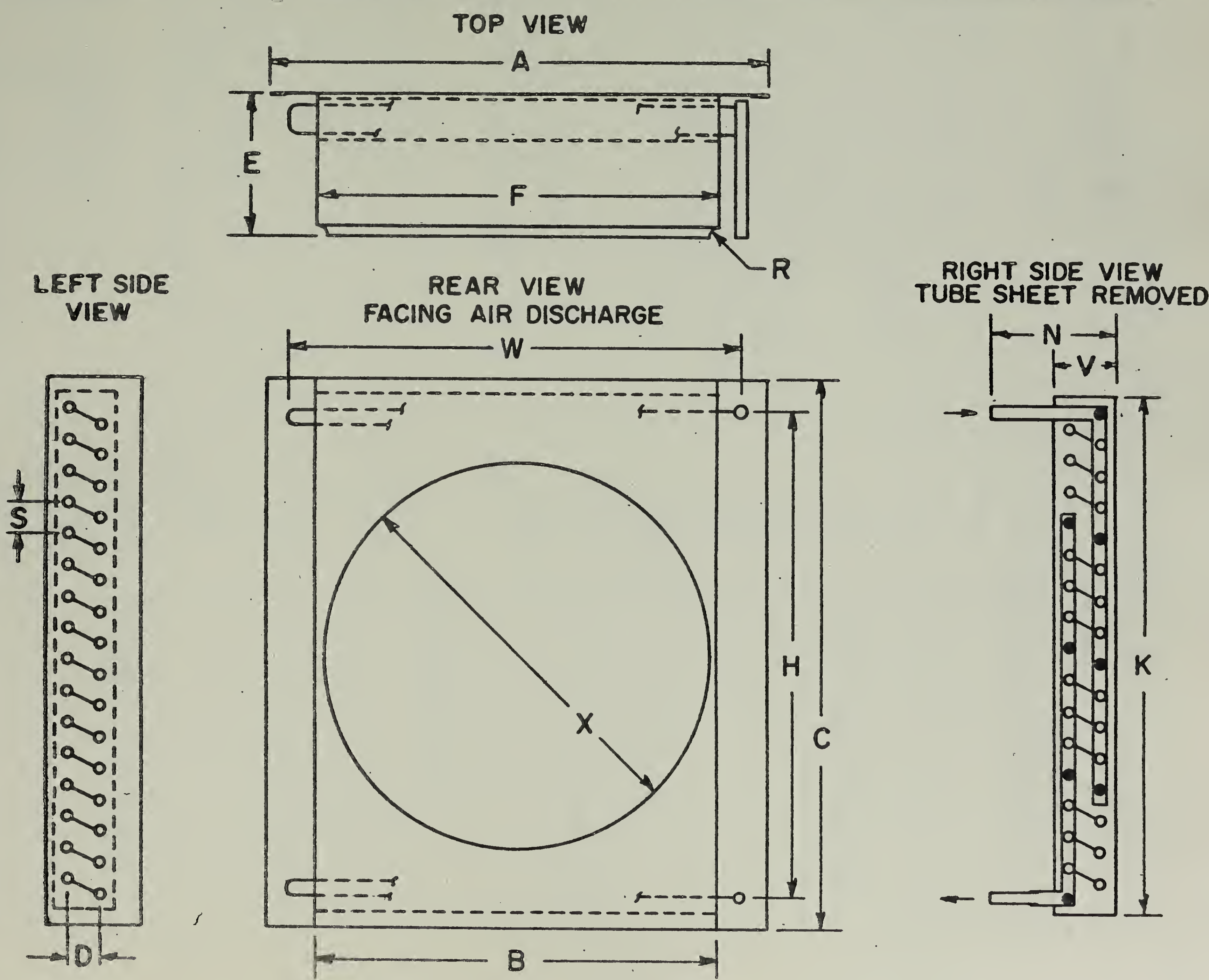


Figure 17

CONDENSER SPECIMEN #3

MFR. Dunham-Bush | **NBS NO.** 159-58 | **SIZE** B | **CLASS** 2



USCOMM-NBS-DC

Figure 18

CONDENSER SPECIMEN #3

MFR. Dunham-Bush		SIZE - B
NBS NO. 159-58		CLASS - 2
ITEM	PROPERTY	REMARKS
	COIL TUBE CHARACTERISTICS	
1 MATERIAL	Copper	
2 NUMBER OF ROWS DEEP	2	
3 NUMBER OF TUBES HIGH	16	
4 NUMBER OF CIRCUITS IN PARALLEL	4	
5 NUMBER OF TUBES PER CIRCUIT	8	
6 TUBE DIAMETER, O.D., IN.	5/8	With copper "Inner Fin"
7 TUBE WALL THICKNESS, IN.	——	
8 TUBE RETURN BEND DIAMETER, O.D., IN.	1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.	7/8	
10 LIQUID OUTLET CONN. DIAMETER, O.D., IN.	5/8	
11 VERTICAL TUBE SPACING, IN. S	2	
12 PRIMARY SURFACE AREA, SQ. FT.	10.75	
	COIL FIN CHARACTERISTICS	
1 MATERIAL	Copper	
2 TYPE OF FIN	Plate	Flat with cut raised sections
3 FIN SPACING, PER INCH	8	
4 FIN THICKNESS, IN.	0.006	
5 SECONDARY SURFACE AREA, SQ. FT.	240.0	
	COIL DIMENSIONS	
1 FINNED HEIGHT, IN. K	32	
2 FINNED WIDTH, IN. F	25 3/8	
3 FINNED DEPTH, IN. V	3	
4 COIL HEIGHT, IN. H	31	
5 COIL WIDTH, IN. W	28 7/8	
6 COIL DEPTH, IN. D	1 1/2	
7 COIL DEPTH, OVERALL, IN. N	----	
8 FACE AREA, SQ. FT.	5.64	
9 TOTAL SURFACE AREA, SQ. FT.	250.8	
	OVERALL CONDENSER DIMENSIONS	
1 WIDTH, OVERALL, IN. A	32 1/2	
2 WIDTH, SHROUD, IN. B	25 3/4	
3 HEIGHT, IN. C	34 1/8	
4 DEPTH, IN. E	11	
5 BELLMOUTH ORIFICE DIAMETER, IN. X	24 1/2	
6 BELLMOUTH RADIUS, IN. R	0.406	Approx.

Table 5

CONDENSER SPECIMEN #3

MFR. Dunham-Bush   NBS NO. 159-58   SIZE - B   CLASS - 2

ITEM			ASRE HIGH SATURATION TEMPERATURE				ASRE LOW SATURATION TEMPERATURE		QMR&E HIGH AMBIENT TEMPERATURE	
AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED FAN MFR. Torrington FAN SERIAL NO. E-2420-4 FAN SPEED 1140 MOTOR HP RATING 0.5 REFRIGERANT 12			STANDARD CONDITION	OBSERVED CONDITION — AIR FLOW RATE CFM			STANDARD CONDITION	OBSERVED CONDITION — AIR FLOW RATE CFM	STANDARD CONDITION	OBSERVED CONDITION — AIR FLOW RATE CFM
					FREE DISCH.			FREE DISCHARGE		FREE DISCHARGE
1. BAROMETRIC PRESSURE	P_{ab}	"Hg	29.921		29.81		29.921	29.65	29.921	29.87
2. DRY BULB TEMPERATURE OF AIR ENTERING COIL	t_{ae}	°F	95		95.0		95	94.9	110	110.2
3. WET BULB TEMPERATURE OF AIR ENTERING COIL	t'_{ae}	°F	75±5		78.6		75±5	77.4		88.2
4. DRY BULB TEMPERATURE OF AMBIENT AIR	t_{ae}	°F	95		95.0		95	94.9	110	110.2
5. SATURATION TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t'_{2c}	°F	130		130.0		105	105.0	135	134.6
6. SUPERHEAT TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t_{2c}	°F	195±10		194.3		170±10	175.9		191.9
			AIR FLOW METHOD				AIR FLOW METHOD			
7. NOZZLE AIR AND WATER VAPOR MIXTURE FLOW RATE	Q_{ad}	CFM			4053			4001		4061
8. TOTAL HEAT REJECTION CAPACITY	q_{tc}	BTUH			41520			8384		29850
			REFRIGERANT FLOW METHOD				REFRIGERANT FLOW METHOD			
9. REFRIGERANT FLOW RATE	W_r	lb/min			10.40			2.08		7.68
10. CONDENSER COIL INTERNAL PRESSURE DROP	ΔP_c	PSI			4.7			1.5		3.3
11. SUBCOOLING OF LEAVING REFRIGERANT LIQUID	ΔT_s	°F	10° MAX.		5.2		5° MAX.	4.2		3.8
12. TOTAL HEAT REJECTION CAPACITY	q_{tr}	BTUH			40560			8650		28760
			RATINGS				RATINGS			
13. TOTAL HEAT REJECTION	q_{tR}	BTUH			41010			8432		29890
14. CONDENSING HEAT REJECTION	q_{cR}	BTUH			39720			(8432)		28890
15. SUBCOOLING HEAT REJECTION	q_{sR}	BTUH			1294			(0)		994
16. AIR FLOW RATE	Q_R	CFM			3705			3743		3584
17. CONDENSER COIL EXTERNAL RESISTANCE	P_{as}	"H_2O			0.22			0.22		0.22
18. FAN MOTOR POWER	P_{tm}	WATTS			473			466		467
19. FAN BRAKE HORSEPOWER	P	BHP			---			--		---
20. HEAT REJECTION PER UNIT PRIMARY SURFACE AREA	BTUH/SF				3814			784.3		2780
21. HEAT REJECTION PER UNIT SECONDARY SURFACE AREA	BTUH/SF				170.9			35.13		124.5
22. HEAT REJECTION PER UNIT TOTAL SURFACE AREA	BTUH/SF				163.5			33.62		119.2
23. HEAT REJECTION PER CFM	BTUH				11.07			2.25		8.34
24. " " , BTUH/SF(°F)					5.54			4.67		5.84
25. " " , BTUH/SF(°F)(CFM)					0.00149			0.00125		0.00163

Table 6

Figure 19

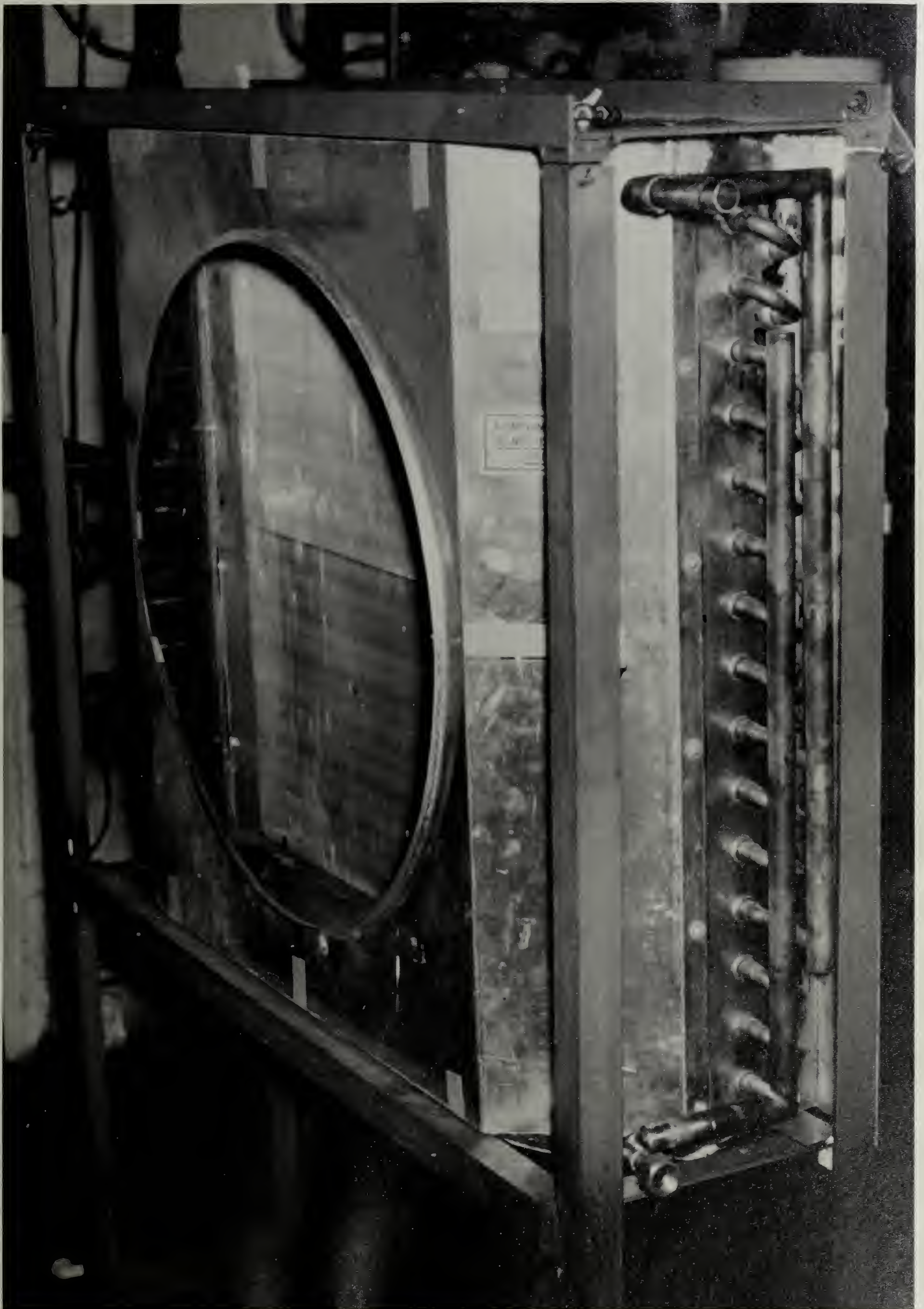


Figure 20

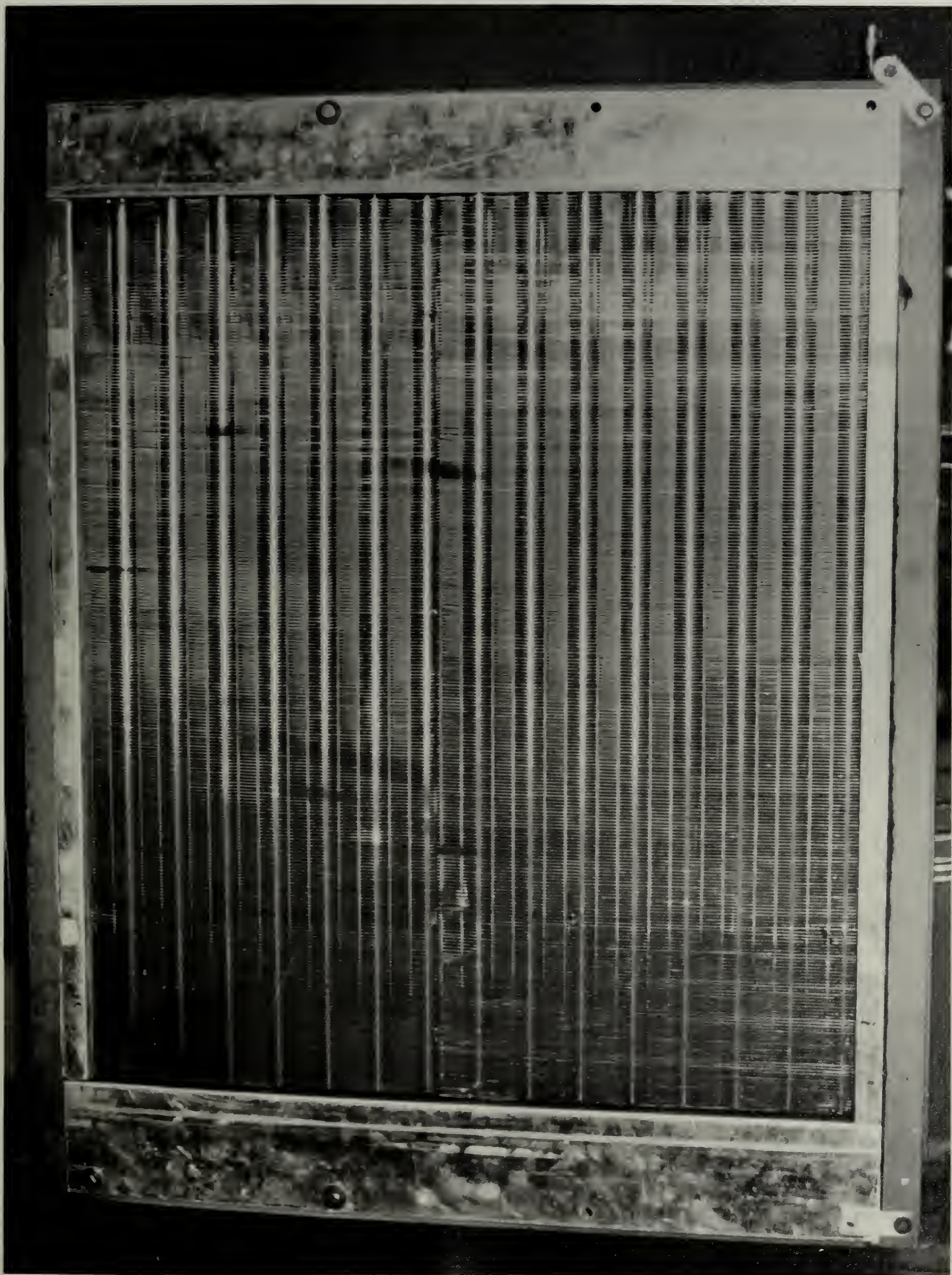


Figure 21

CONDENSER SPECIMEN #4

MFR. Dunham-Bush Inc. NBS NO. 140-57 SIZE C CLASS 1

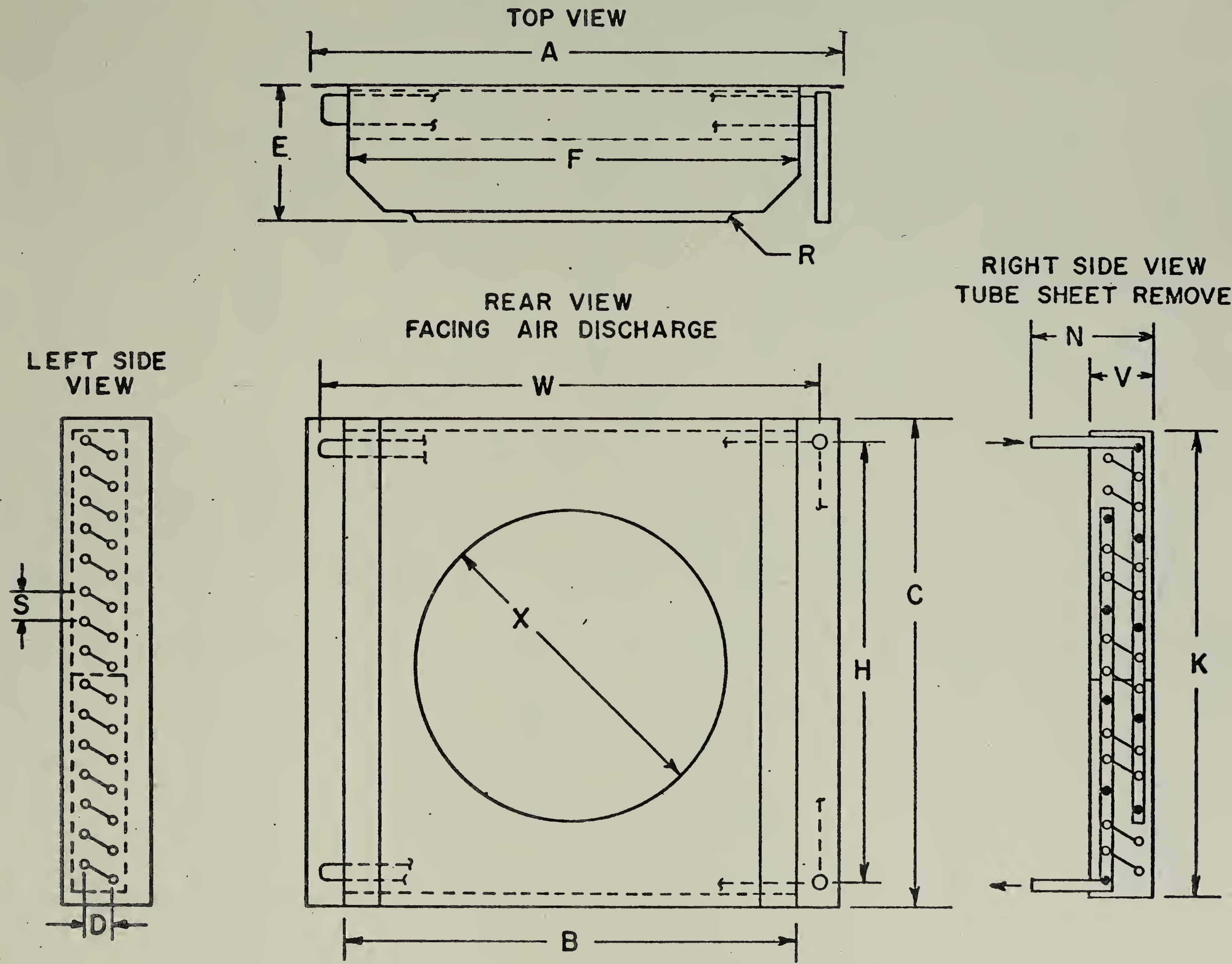


Figure 22

CONDENSER SPECIMEN #4

MFR. Dunham-Bush		SIZE - C	
NBS NO. 140-57		CLASS - 1	
ITEM		PROPERTY	REMARKS
		COIL TUBE CHARACTERISTICS	
1 MATERIAL		Copper	
2 NUMBER OF ROWS DEEP		2	
3 NUMBER OF TUBES HIGH		15	
4 NUMBER OF CIRCUITS IN PARALLEL		5	
5 NUMBER OF TUBES PER CIRCUIT		6	
6 TUBE DIAMETER, O.D., IN.		5/8	With aluminum "Inner-Fin"
7 TUBE WALL THICKNESS, IN.			
8 TUBE RETURN BEND DIAMETER, O.D., IN.		1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.		7/8	
10 LIQUID OUTLET CONN. DIAMETER, O.D, IN.		7/8	
11 VERTICAL TUBE SPACING, IN.	S	2	
12 PRIMARY SURFACE AREA, SQ. FT.		13.57	
		COIL FIN CHARACTERISTICS	
1 MATERIAL		Aluminum	
2 TYPE OF FIN		Plate	Flat with cut raised section
3 FIN SPACING, PER INCH		8	
4 FIN THICKNESS, IN.		0.010	
5 SECONDARY SURFACE AREA, SQ. FT.		422.4	
		COIL DIMENSIONS	
1 FINNED HEIGHT, IN.	K	30	
2 FINNED WIDTH, IN.	F	35 1/8	
3 FINNED DEPTH, IN.	V	4	
4 COIL HEIGHT, IN.	H	29 3/8	
5 COIL WIDTH, IN.	W	38 1/2	
6 COIL DEPTH, IN.	D	1 1/2	
7 COIL DEPTH, OVERALL, IN.	N	---	
8 FACE AREA, SQ. FT.		7.32	
9 TOTAL SURFACE AREA, SQ. FT.		436.0	
		OVERALL CONDENSER DIMENSIONS	
1 WIDTH, OVERALL, IN.	A	43 1/2	
2 WIDTH, SHROUD, IN.	B	35 1/8	
3 HEIGHT, IN.	C	32 1/8	
4 DEPTH, IN.	E	11	
5 BELLMOUTH ORIFICE DIAMETER, IN.	X	24 1/2	
6 BELLMOUTH RADIUS, IN.	R	0.406	Approx.

Table 7

CONDENSER SPECIMEN #4

MFR. Dunham-Bush — NBS NO. 140-57 — SIZE - C — CLASS - 1

AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED

FAN MFR. Torrington
FAN SERIAL NO. E-2420-4
FAN SPEED 1140
MOTOR HP RATING 0.5
REFRIGERANT 12

ITEM			ASRE HIGH SATURATION TEMPERATURE: STANDARD CONDITION		OBSERVED CONDITION, AIR FLOW RATE CFM: FREE DISCH.	FREE DISCH.	ASRE LOW SATURATION TEMPERATURE: STANDARD CONDITION	OBSERVED CONDITION, AIR FLOW RATE CFM: FREE DISCHARGE	QMR&E HIGH AMBIENT TEMPERATURE: STANDARD CONDITION	OBSERVED CONDITION, AIR FLOW RATE CFM: FREE DISCHARGE
1. BAROMETRIC PRESSURE	P_{ab}	"Hg	29.921		29.92	29.97	29.921	29.84	29.921	29.51
2. DRY BULB TEMPERATURE OF AIR ENTERING COIL	t_{ae}	°F	95		95.0	95.3	95	95.0	110	109.9
3. WET BULB TEMPERATURE OF AIR ENTERING COIL	t'_{ae}	°F	75±5		74.0	79.2	75±5	77.8		88.1
4. DRY BULB TEMPERATURE OF AMBIENT AIR	t_{ae}	°F	95		95.0	95.3	95	95.0	110	109.9
5. SATURATION TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t'_{2c}	°F	130		130.2	129.8	105	105.9	135	135.4
6. SUPERHEAT TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t_{2c}	°F	195±10		195.2	192.0	170±10	171.5		198.4
			AIR FLOW METHOD				AIR FLOW METHOD			
7. NOZZLE AIR AND WATER VAPOR MIXTURE FLOW RATE	Q_{ad}	CFM			3980	3971		3977		3911
8. TOTAL HEAT REJECTION CAPACITY	q_{tc}	BTUH			55940	54330		10130		39090
			REFRIGERANT FLOW METHOD				REFRIGERANT FLOW METHOD			
9. REFRIGERANT FLOW RATE	W_r	lb/min			14.25	14.22		2.66		9.87
10. CONDENSER COIL INTERNAL PRESSURE DROP	ΔP_c	PSI			5.5	5.4		1.2		2.6
11. SUBCOOLING OF LEAVING REFRIGERANT LIQUID	ΔT_s	°F	10° MAX.		7.1	4.9	5° MAX.	5.2		10.2
12. TOTAL HEAT REJECTION CAPACITY	q_{tr}	BTUH			56170	55270		10880		38360
			RATINGS				RATINGS			
13. TOTAL HEAT REJECTION	q_{tR}	BTUH			55490	55570		9665		37950
14. CONDENSING HEAT REJECTION	q_{cR}	BTUH			54050	54960		(9665)		36040
15. SUBCOOLING HEAT REJECTION	q_{sR}	BTUH			1439	606		0		1914
16. AIR FLOW RATE	Q_R	CFM			3625	3587		3682		3559
17. CONDENSER COIL EXTERNAL RESISTANCE	P_{as}	"H_2O			0.14	0.15		0.15		0.15
18. FAN MOTOR POWER	P_{fm}	WATTS			468	463		470		464
19. FAN BRAKE HORSEPOWER	P	BHP			---	---		--		---
20. HEAT REJECTION PER UNIT PRIMARY SURFACE AREA	BTUH/SF				4021	4027		700.4		2750
21. HEAT REJECTION PER UNIT SECONDARY SURFACE AREA	BTUH/SF				131.4	131.6		22.88		89.80
22. HEAT REJECTION PER UNIT TOTAL SURFACE AREA	BTUH/SF				127.3	127.5		22.16		87.04
23. HEAT REJECTION PER CFM	BTUH				15.31	15.49		2.62		10.66
24. " " , BTUH/SF(°F)					4.62			3.05		4.35
25. " " , BTUH/SF(°F)(CFM)					0.00127			0.00083		0.00122

Table 8

Figure 23

CONDENSER SPECIMEN 5

MFR. DUNHAM-BUSH NBS NO. 138-57 SIZE A CLASS 1

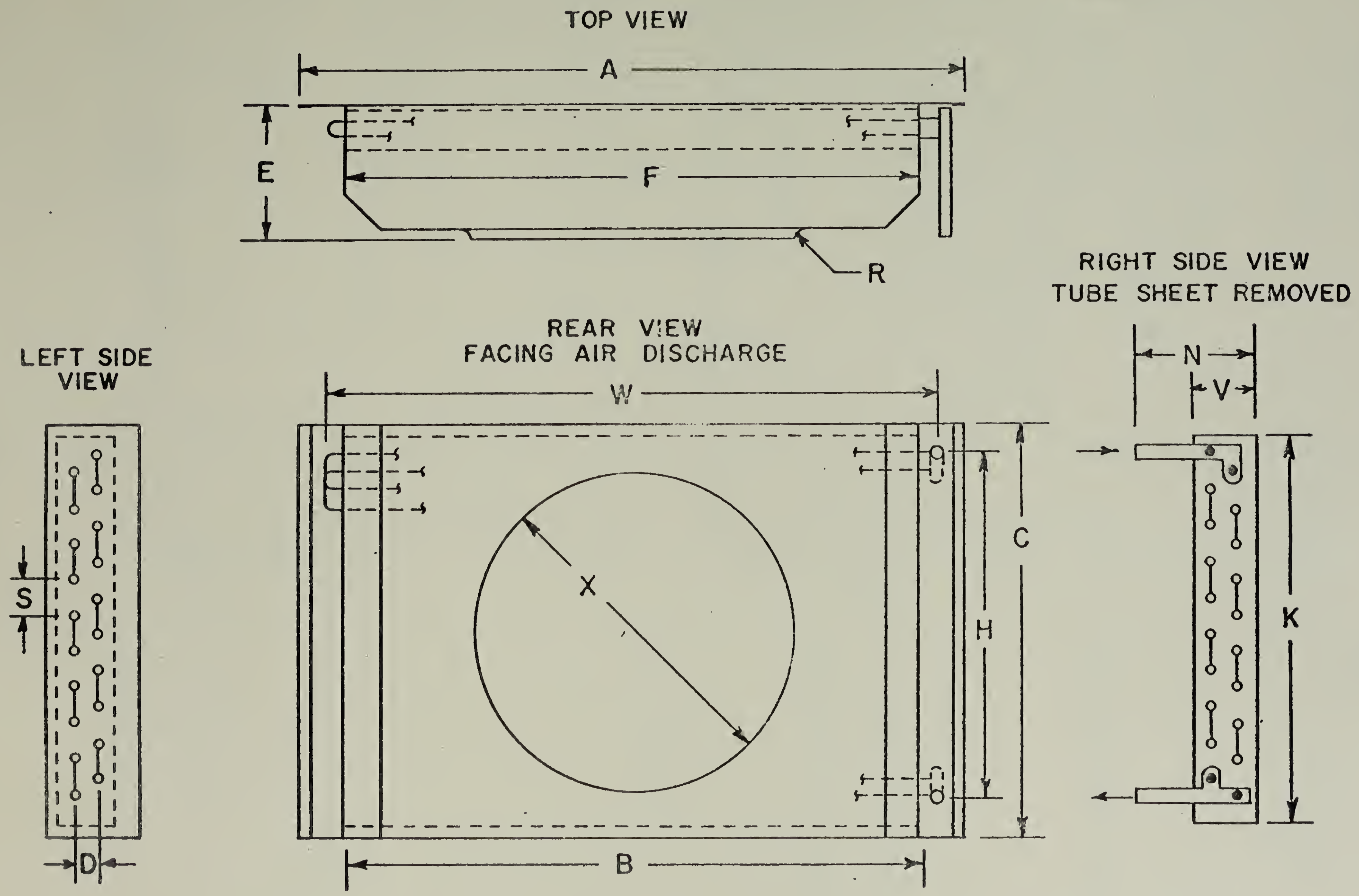


Figure 24

CONDENSER SPECIMEN #5

MFR. DUNHAM-BUSH	SIZE - A	
NBS NO. 138-57	CLASS - 1	

ITEM	PROPERTY	REMARKS
	COIL TUBE CHARACTERISTICS	
1 MATERIAL	Copper	
2 NUMBER OF ROWS DEEP	2	
3 NUMBER OF TUBES HIGH	10	
4 NUMBER OF CIRCUITS IN PARALLEL	2	
5 NUMBER OF TUBES PER CIRCUIT	10	
6 TUBE DIAMETER, O.D., IN.	5/8	With aluminum "Inner Fin"
7 TUBE WALL THICKNESS, IN.	---	
8 TUBE RETURN BEND DIAMETER, O.D., IN.	1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.	5/8	
10 LIQUID OUTLET CONN. DIAMETER, O.D, IN.	5/8	
11 VERTICAL TUBE SPACING, IN. S	2	
12 PRIMARY SURFACE AREA, SQ. FT.	6.494	
	COIL FIN CHARACTERISTICS	
1 MATERIAL	Aluminum	
2 TYPE OF FIN	Plate	Flat with cut raised sections
3 FIN SPACING, PER INCH	8	
4 FIN THICKNESS, IN.	.010	
5 SECONDARY SURFACE AREA, SQ. FT.	142.6	
	COIL DIMENSIONS	
1 FINNED HEIGHT, IN. K	20	
2 FINNED WIDTH, IN. F	24	
3 FINNED DEPTH, IN. V	3	
4 COIL HEIGHT, IN. H	19	
5 COIL WIDTH, IN. W	27 1/2	
6 COIL DEPTH, IN. D	1 1/2	
7 COIL DEPTH, OVERALL, IN. N	---	
8 FACE AREA, SQ. FT.	3.33	
9 TOTAL SURFACE AREA, SQ. FT.	149.1	
	OVERALL CONDENSER DIMENSIONS	
1 WIDTH, OVERALL, IN. A	30	
2 WIDTH, SHROUD, IN. B	24 1/8	
3 HEIGHT, IN. C	22	
4 DEPTH, IN. E	10 7/8	
5 BELLMOUTH ORIFICE DIAMETER, IN. X	18 5/8	
6 BELLMOUTH RADIUS, IN. R	---	Conical section

Table 9

CONDENSER SPECIMEN #5

MFR. DUNHAM-BUSH — NBS NO. 138-57 — SIZE - A — CLASS - 1

AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED

FAN MFR. Torrington
FAN SERIAL NO. E-1826-3
FAN SPEED 1140
MOTOR HP RATING 1/3
REFRIGERANT 12

ITEM			ASRE High Saturation Temperature: Standard Condition	ASRE High Saturation Temperature: Observed Condition, Air Flow Rate CFM	ASRE High Saturation Temperature: Observed Condition, Air Flow Rate CFM, Free Disch.	ASRE Low Saturation Temperature: Standard Condition	ASRE Low Saturation Temperature: Observed Condition, Air Flow Rate CFM, Free Discharge	QMR&E High Ambient Temperature: Standard Condition	QMR&E High Ambient Temperature: Observed Condition, Air Flow Rate CFM, Free Discharge
1. Barometric pressure	P_{ab}	"Hg	29.921		29.78	29.921	29.90	29.921	29.92
2. Dry bulb temperature of air entering coil	t_{ae}	°F	95		94.8	95	95.6	110	110.2
3. Wet bulb temperature of air entering coil	t'_{ae}	°F	75±5		77.5	75±5	78.0		90.8
4. Dry bulb temperature of ambient air	t_{ae}	°F	95		94.8	95	95.6	110	110.2
5. Saturation temperature of entering refrigerant vapor	t'_{2c}	°F	130		129.8	105	105.0	135	135.3
6. Superheat temperature of entering refrigerant vapor	t_{2c}	°F	195±10		192.2	170±10	169.3		197.2
			AIR FLOW METHOD			AIR FLOW METHOD			
7. Nozzle air and water vapor mixture flow rate	Q_{ad}	CFM			1791		1846		1944
8. Total heat rejection capacity	q_{tc}	BTUH			21040		5710		16010
			REFRIGERANT FLOW METHOD			REFRIGERANT FLOW METHOD			
9. Refrigerant flow rate	W_r	lb/min		5.43	5.54	1.49	1.46	4.25	4.27
10. Condenser coil internal pressure drop	ΔP_c	PSI			10.9		0.4		7.7
11. Subcooling of leaving refrigerant liquid	ΔT_s	°F	10° MAX.		7.2		3.1		4.4
12. Total heat rejection capacity	q_{tr}	BTUH		21410	21910	6050	5929	16280	16360
			RATINGS			RATINGS			
13. Total heat rejection	q_{tR}	BTUH			21480		6192		16120
14. Condensing heat rejection	q_{cR}	BTUH			20890		6123		15760
15. Subcooling heat rejection	q_{sR}	BTUH			589		69		357
16. Air flow rate	Q_R	CFM			1665		1705		1692
17. Condenser coil external resistance	P_{as}	"H_2O			0.16		0.17		0.17
18. Fan motor power	P_{fm}	WATTS			175		187		177
19. Fan brake horsepower	P	BHP			---		---		---
20. Heat rejection per unit primary surface area	BTUH/SF				3307		953.5		2482
21. Heat rejection per unit secondary surface area	BTUH/SF				150.6		43.42		113.0
22. Heat rejection per unit total surface area	BTUH/SF				144.0		41.53		108.1
23. Heat rejection per CFM	BTUH				12.90		3.63		9.53
24. " " , BTUH/SF(°F)					5.03		5.32		5.30
25. " " , BTUH/SF(°F)(CFM)					.00302		.00312		.00313

Inlet tubes partially restricted by foreign material during these tests. See text.

Table 10

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

NBS