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FERCLEVE CORPORATION

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TECHNICAL DIVISION

2369

AEC RESEARCH AND DEVELOPMENT REPORT

FINAL REPORT

September 25, 1945

UNCLASSIFIED

VOLUME II OF II VOLUMES

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This document consists of 166 pages
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FERCIEVE CORPORATION

TECHNICAL DIVISION

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FINAL REPORT

SEPTEMBER 25, 1945

Volume II of II Volumes

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Reported by: O. E. Dwyer
Assistant Technical Director

Casper A. Todaro
Director, Process Development
Group No. 2

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Tab 24

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 24

FREEZE-OFF STUDIES

By: R. Van Winkle
W. W. Binger

W W Binger
R Van Winkle

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FREEZE-OFF STUDIES

Object

The object of this project was to study various types of freeze-off coils in an effort to design the most effective coil.

Progress During Month

During the past few weeks several of the newly designed coils have been broken during unfreezing. It has been thought that the trouble was caused by live steam entering the coil directly and thus not allowing the coil to heat up uniformly. It was thought that parts of the coil thawed faster than others and that at those points the material pressure would increase until the coil burst.

To prevent this rapid heating, a new coil was designed. A four foot link line was coiled on a 1/4" rod and then inserted into a 3/4" water pipe 10" long. A 1-1/4" water pipe was used for the steam jacket. The coil was welded together as shown in Figure I. With this type of coil only water was allowed to be in contact with the material line. When the coil is unfrozen the material is thawed gradually by the steam which heats the water around the coil.

The coil was tested in Transfer Room No. 11 by connecting it directly to a storage chamber (1500 psi) and using a 75 pound pot as a receiver. The coil was frozen and thawed about two dozen times and seemed to function very well, taking about 30 seconds or less to thaw.

Conclusions

It appears that this type of coil will work very well and that the steam jacket construction will prevent the coil from breaking when the steam is turned on.

Several of these coils were to be made up but due to the termination of the S-50 operations the order was cancelled and the project concluded.

Future Work

It would be well to have several of these coils made up and put in service and run for a period of time to determine their effectiveness.

W. W. Binger
R. Van Winkle

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Freeze-off Coil

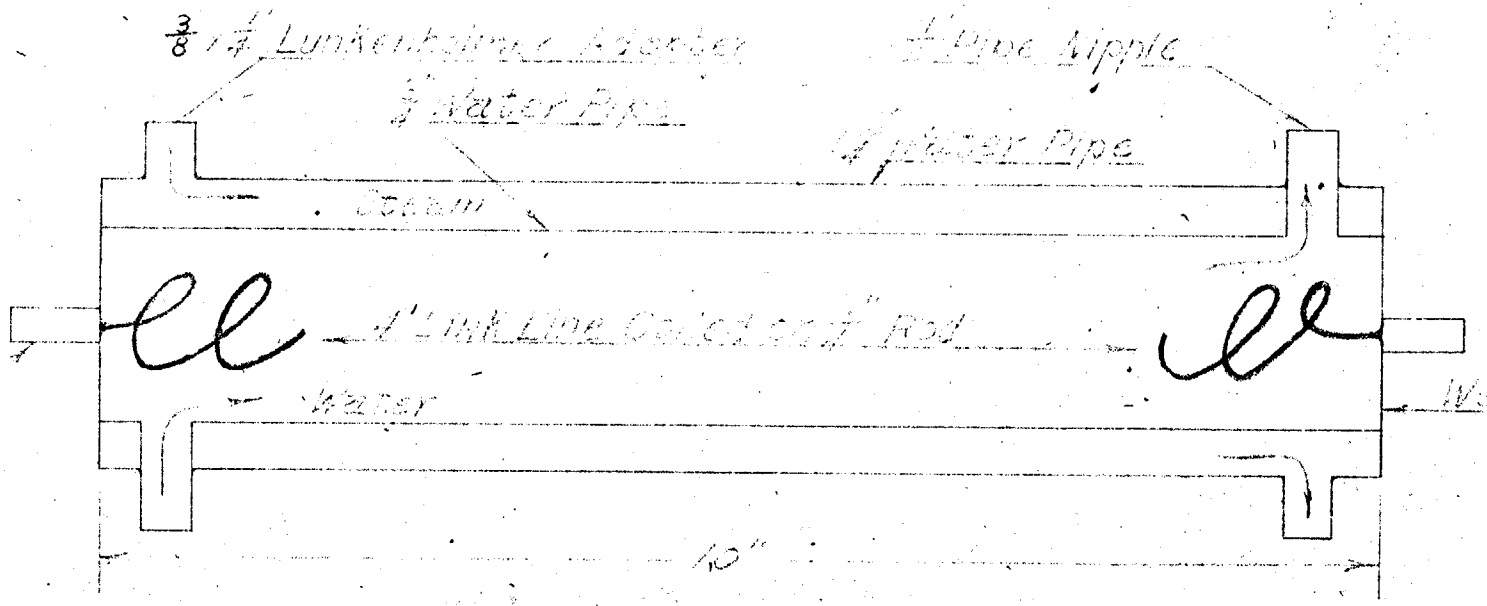

Fig. 1

Project 24
Aug. 31, 1945

WAVE

Tab 27

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MONTHLY REPORT FOR PERIOD ENDING

AUGUST 31, 1945

UNCLASSIFIED

PROJECT NO. 27

IDENTIFICATION AND REMOVAL OF PLUG-FORMING MATERIALS IN PROCESS FLUID

Reported by: Bernard Selikson

Bernard Selikson

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IDENTIFICATION AND REMOVAL OF PLUG-FORMING MATERIALS IN PROCESS FLUID

Object

It was the original objective of this project to identify the plug-forming materials found in the plant circulation systems, to seek means of preventing their formation, and to devise a satisfactory method for their removal.

Progress During Month

Fabrication of twelve sediment traps has been completed. (See drawing Z-635 attached). Several of these traps have been installed in poorly circulating systems at the exit and entrance of the storage chambers for the purpose of removing sediment in order to improve circulation:

Circuit 3 Rack 5
Circuit 5 Rack 5
Circuit 6 Rack 6
Circuit 2 Rack 14

The trap installed at the bottom of Circuit No. 2 Rack No. 14 has been removed after four and a half days use in an attempt to locate a plug which had stopped circulation. No marked change or improvement in circulation has thus far been observed.

One new type "quantitative" sediment trap has just been fabricated at Fercleve (See drawing FC-A-622 attached), but plant operation was suspended before it could be put to use.

Summary of the Project

As the formation of plugs by cooling with consequent solidification of C-616 is outside the scope of this project, we merely shall consider the formation of plugs due to sediment.

The source of sediment is apparently twofold:

(1) Chips of copper formed by the gouging of the spacers into the tube walls when the columns were first put together;

(2) Reaction products of C-616 with water, organic matter and column metal.

Both types of sediment are best dealt with by preventive means. Thus, if the columns and storage chambers were properly conditioned, then the chips and particles as well as organic matter should be removed, the walls should have a sufficient protective film to prevent further reaction with C-616, and the elimination of water should prevent the formation of TF_2O_2.

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The opinion of all people connected with the problem of plug-formation is that the best answer is careful and complete conditioning of the storage chambers, columns, and connecting lines before installation, for once sediment is formed, it is not easily removed. In fact, in certain instances it has been found that sluggish systems have had to be washed out and reconditioned before they would circulate properly.

Sediment traps and filter cones have been used in the plant in an attempt to remove sediment. A sintered bronze filter cone was found to be quite unsatisfactory. After an hour of use, the cone was examined because the material flow was considered too slow. The cone had blackened and crumbled into several pieces. Sediment traps were installed at the inlet to the storage chamber on several circuits. The traps were removed after various lengths of service to determine their effectiveness. Approximately one pound of C-616 was contained in a trap and after the C-616 had been distilled out, and the trap cleared of C-616 with passage of N_2, varying amounts of sediment ranging from 0.1 gm to 0.5 gm were obtained. (Refer to June Monthly Report for procedure).

For control purposes, it was decided to compare the amount of sediment found in "snap" samples of process fluid taken from the circulating system and that found in sediment traps operating for extended periods of time. "Snap" samples from the top of the racks showed no copper chips but did contain what appeared to be TF_4 (approximately 0.2 gm. per pound of C-616) indicating that a considerable amount of sediment was carried in suspension. "Snap" samples from the bottom apparently contained copper chips, some nickel filings and, in general, somewhat more sediment (mostly TF_4) than the top.

In order to be able to remove all the sediment thoroughly and obtain reliable quantitative data, it was necessary to have a trap with a removable top. Such a trap has been fabricated but was not put to use because of suspension of plant operation.

Conclusions

The following conclusions can be drawn:

(1) Sediment collected from the plant circulation systems apparently contain minor amounts of copper and other metallic chips, considerable TF_4, possibly some TF_2O_2, and slight traces of metallic fluorides.

(2) Sediment plugs will often occur at those places in the system which have been exposed to atmospheric moisture, due to formation of solid TF_2O_2.

(3) Sediment (mostly TF_4) is suspended throughout the material fluid in concentrations of approximately 0.2 gm. per pound.

Recommendations

(1) Removal of sediment by traps has been found to be less effective in improving circulation than complete reconditioning of the circuit. However, the use of traps should be continued with occasional emptying because they do remove a certain amount of sediment.

(2) Before starting up a new circuit, it is very strongly recommended that the entire circuit, i.e., storage chamber, columns, and connecting lines, be carefully and thoroughly conditioned.

(3) Opened connections in the material circuit should be exposed for an absolute minimum period of time.

Recommendations for Future Work

The new type "quantitative" trap should be used to (a) compare the amount of sediment in different systems, and correlate this data with fluid flow rates of those systems, (b) determine the most effective location for traps in a system, (c) determine the effectiveness of traps in removing sediment over periods of time.

7-6

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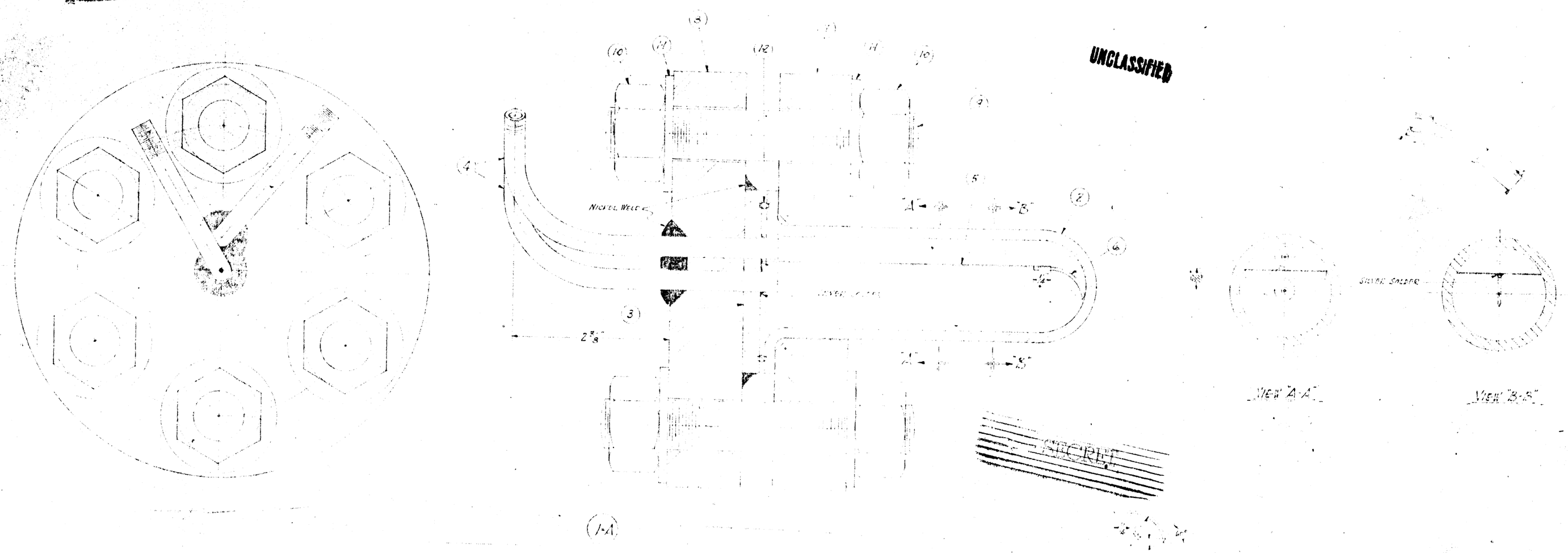
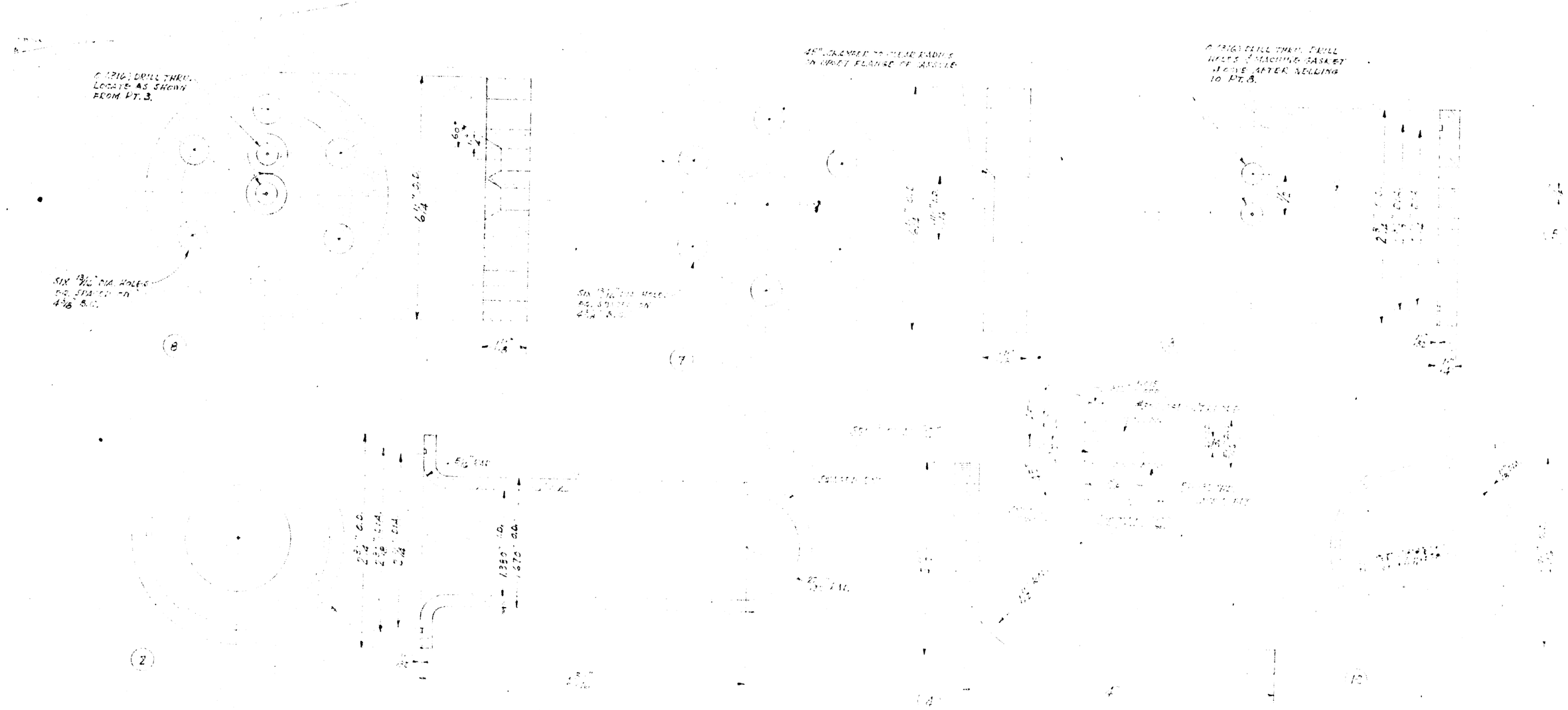
REVISIONS	
Issue No. 1	8-3-45





PART NO.	ASSEM NO.	NAME OF PART	MATERIAL	STOCK SIZE	QUANT.
12		GASKET	HARD SOFTER	2 3/8" O.D. X 1/8 DIA.	1
11		WASHER	STEEL	1 3/4" O.D. X 19/32" I.D. X 1/8" THK.	12
10		HEX NUT	ALLOY STEEL	3/4-10	12
9		STUD BOLT	ALLOY STEEL	3/4-10 X 4 3/4" LG.	6
8		END FLANGE	STEEL	6 1/2" DIA. X 1 1/8" THK.	1
7		CUP FLANGE	STEEL	6 1/2" DIA. X 1 1/8" THK.	1
6		WIRE	NICKEL	.050 DIA. X 15/16" LG.	1
5		SHEETS	NICKEL	1 3/8" WIDE X 4 1/2" LG. X .015" THK.	1
4		TUBE	NICKEL	5/16" O.D. X 3/16" I.D. X 5 7/8" LG.	2
3		DISC	NICKEL	3" O.D. X 1/2" THK.	1
2		CATHODE	NICKEL	1.670" O.D. X 1.380" I.D. X 5 3/4" LG.	1
1-A		ASSEMBLY			1

DRAWN BY	H.S. Ham 8-3-45
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SCALE	Half Full

FERCLEVE CORPORATION
P.O. BOX 1265 OAK RIDGE, TENN.

PROJECT S-50

FERCLEVE SERVICE TEAM

CONTRACT NO. W7409-Eng-100

SHEET NO. FC-A-622

#2369

Tab 28

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

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PROJECT NO. 28

EXAMINATION OF BROKEN COLUMNS

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By: Roy W. Greenlee

Roy W. Greenlee

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EXAMINATION OF BROKEN COLUMNS

Object:

Columns which had leaks, internal failures, or were simply poor producers were removed from the S-50 plant as new replacements became available. It was desirable to know the causes of these undesirable features in order that their causes might be eliminated in the construction of new columns.

Discussion of Results:

All broken columns were sent to the Continental Gin Company of Birmingham, Alabama for dismantling and examination.

It was found, very early, that no failures in the nickel tube of a column ever occurred. Quite often, the nickel tube surface of a dismantled column was found to be badly scratched and dented, and/or the buttons torn off and piled up together at some spot in the annulus. However, these phenomena relate more to poor column performance than to column failure (See monthly report for August, Project No. 41).

A careful examination was made of copper tubes from columns rejected for failure, and it was found that in a very large number of cases, the wall was bulged near several, or, in some columns, all of the silver-soldered sleeve joints.

A summary of outside diameter measurements made at the Continental Gin Company (in connection with Project No. 41) on a random group of 28 faulty columns is given in Table No. 1. From the results obtained, it is seen that the annulus must have increased by several fold in some cases. In other cases, it was certainly possible for the annulus to be nearly closed off at the end of bloated areas.

In contrast with this, outside diameter measurements taken every 2" over the entire length of several columns showed an average deviation of less than .0005", except for the critical areas around the sleeves.

This pointed directly to the probability that the copper tube was annealed during the silver soldering process. Application of excessive heat over a short period of time in the torch silver-soldering step could account for very critical softening and weakening of the copper tube in the area where the defects were observed.

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Lt. Col. M. C. Fox submitted pieces of copper tubes considered possibly annealed to the Pittsburgh Testing Laboratory for Rockwell "F" hardness tests. Four samples of (A) the center joint (B) an end joint (C) a piece of copper tube, all from used columns, and one of each from an unused column, were tested.

The results were reported to H. K. Ferguson Company on February 9, 1945. They are tabulated in Figure I (photostat of H.K.F blueprint X-107), and plotted in terms of approximate yield strength in Figure II (photostat of H.K.F. blueprint X-113).

The average yield strength for both used and unused copper tube was approximately 50,000 psi., which is very close to the value found along the copper tube 2" beyond the sleeve. Closer than 2", however, the strength drops very sharply to less than 10,000 psi. 1/4" inside the sleeve area itself.

This comprises adequate proof of the annealed condition of the copper near and in the joints, and provides data by which failure at these areas could have been predicted.

Conclusions:

The conclusion that annealing of the copper tube (as a result of gas torch silver soldering) occurs all along and for 2" out side the sleeves is inescapable. The observation that the majority of column failures occur in the especially weak zone 1/2 to 1-1/2" from the edge of the sleeves is completely explained by this study of the change in hardness of the copper tube, not as a result of use, but as a necessary outcome of such heating during fabrication.

Recommendations for Future Work:

The conclusions above make clear that a new type of column construction must be adopted to avoid the annealing effects on the copper tube of the silver soldered joint. It would be advisable to keep in mind this physical property of copper in deciding upon a new design, and the effect of fabrication methods upon the hardness of the drawn copper tube should be carefully observed.

It is to be noted that these recommendations were kept in mind during the progress of Project No. 41, "Column Construction", in which a new column design was evolved.

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TABLE I

Outside Diameter Measurements on
Copper Tube From Dissembled Faulty Columns

MAXIMUM WITHIN 2" OF SLEEVES

Column	Top of Bottom Sleeve	Bottom of Center Sleeve	Top of Center Sleeve	Bottom of Top Sleeve
MM-222	2.006	2.011	1.999	2.013
MM-492	2.079	2.085	2.090	2.083
G-978	2.010	2.002	2.001	2.006
G-97	2.031	2.043	2.004	2.028
MM-520	2.102	2.060	2.113	2.212
MM-781	2.005	2.019	2.010	2.018
MM-783	2.004	2.010	2.007	2.017
MM-838	2.073	2.204	2.128	2.241
G-1261	2.028	2.011	2.003	2.025
G-765	1.997	2.004	2.000	2.029
MM-964	2.010	2.016	2.016	2.011
MM-493	2.008	2.014	2.010	2.040
MM-524	2.007	2.015	2.018	2.022
G-59	2.024	2.026	2.001	2.020
G-127-A	2.018	2.017	2.012	2.024
MM-832	1.995	2.014	2.031	2.510
MM-804	2.011	2.016	2.010	2.018
MM-829	2.011	2.020	2.001	1.999
MM-807	2.001	2.015	2.020	2.200
MM-500	2.084	2.061	2.095	2.081
MM-503	2.003	2.012	2.012	2.027
G-1035	2.014	2.004	2.003	2.016
MM-276	2.000	2.024	2.004	2.008
MM-954	2.019	2.017	2.019	2.020
G-980	2.006	2.005	2.002	2.018
MM-827	1.999	2.020	2.075	2.083
G-901	2.018	2.018	1.996	2.027
G-970	2.054	2.170	2.182	2.653

From Inter-department letter, G. F. Nellett to B. F. Dodge,
August 29, 1945

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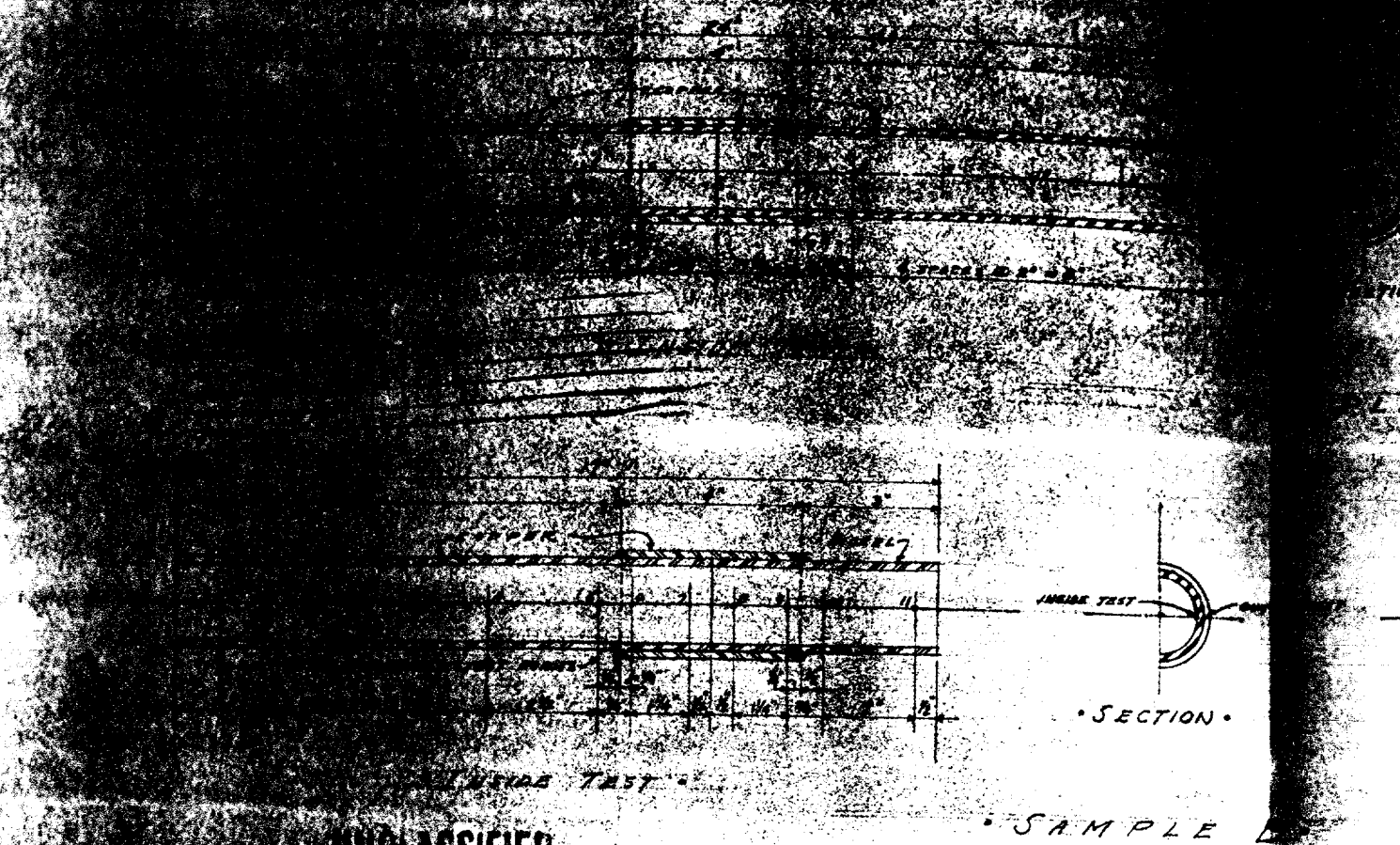

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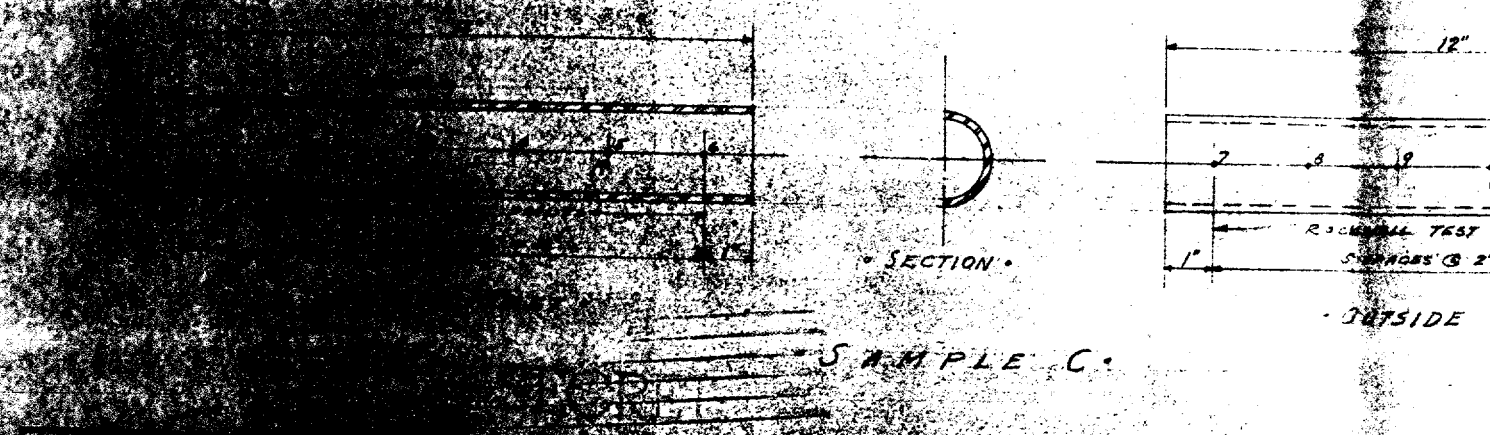

ROCKWELL "F" HARDNESS.

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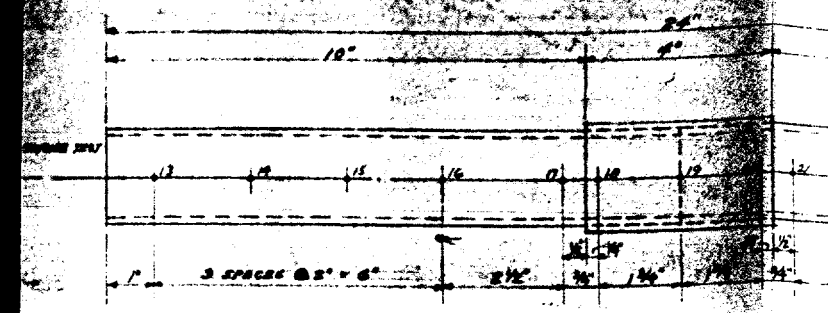
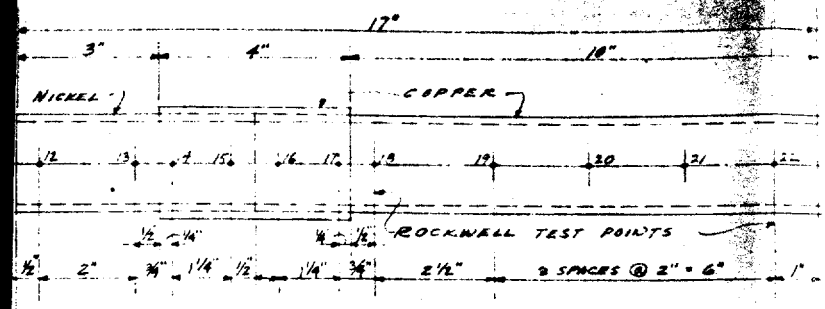


• OUTSIDE TEST •

"A"



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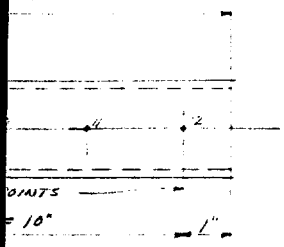

EST •

NOTE –

SAMPLES TO BE SAWED FROM TUBES AFTER SEVERAL ALTERNATE HEATING & COOLING CYCLES IN OPERATION. SAMPLES SHOULD NOT BE BURNED, CHISELED, OR OTHERWISE HEATED OR COLD WORKED WHICH WOULD AFFECT THE PHYSICAL PROPERTIES.

SAMPLES TO BE TESTED FOR ROCKWELL HARDNESS "B" OR "F" ACCORDING TO STANDARD METHODS OF TEST, A.S.T.M. - E 18-42.

RESULTS SHOULD BE RECORDED ACCORDING TO POINT NUMBERS AS SHOWN ON THIS DWG. (SKETCH X-107)

FOR ANALYSIS OF TEST DATA SEE DWG X-113.

	16	17	18	19	20	21	22	23	24	25	REMARKS.
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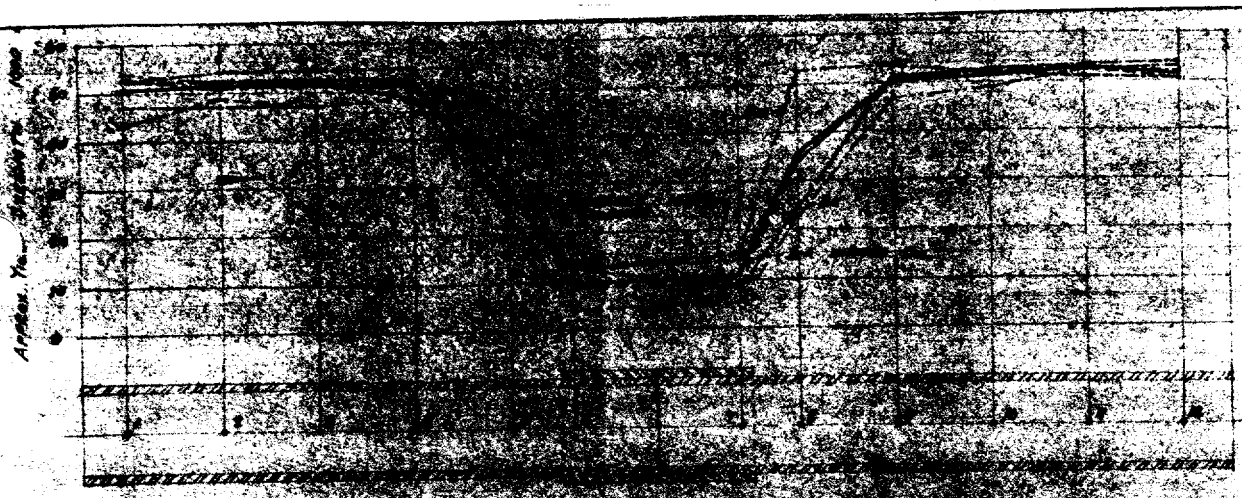
.0	90.5	74.0	47.0	51.5	74.5	91.5	92.0	92.5	92.5	91.0	
.0	91.5	70.5	53.0	58.0	75.0	93.0	92.5	91.0	92.0	92.0	
.5	51.5	52.0	67.0	85.0	86.0	86.0	84.5				
.5	56.0	50.0	69.0	83.5	86.0	82.5	86.0				
.0	53.5	50.0	74.0	92.0	92.0	90.0	91.5				
.0	54.0	55.0	66.0	92.0	92.0	90.0	91.0				
3.0	88.5	71.0	48.5	49.0	68.0	88.0	82.0	86.0	88.0	90.0	
3.0	52.0	54.0	58.5	85.0	85.0	85.5	85.0				

RESTRICTED

DRAWN BY	Big Business Builds The Ferguson Way
12-14-44	The H. K. Ferguson Company
TRACED BY	ENGINEERS
	HANNA BUILDING — PHONE CHERRY 5870
	CLEVELAND, OHIO
CHECKED BY	• PROJECT S-50 •
	PROCESS BUILDING
SCALE	



SAMPLE "A"

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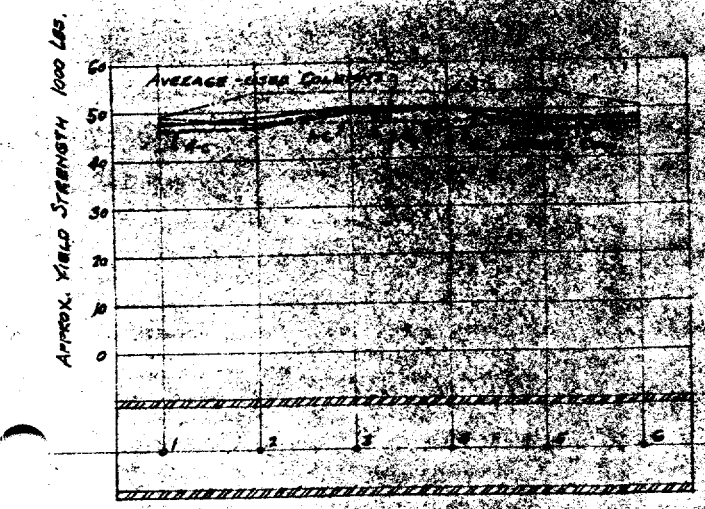
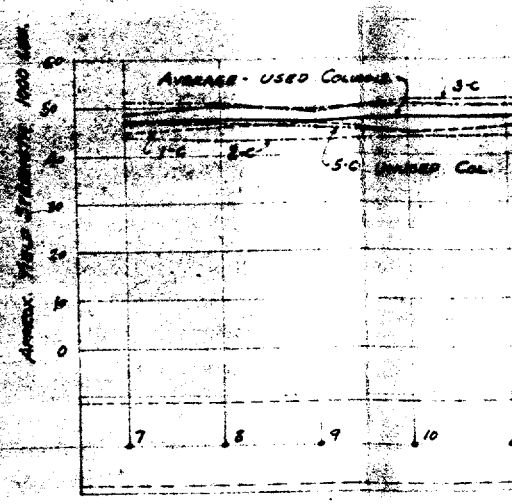
SAMPLE "B"



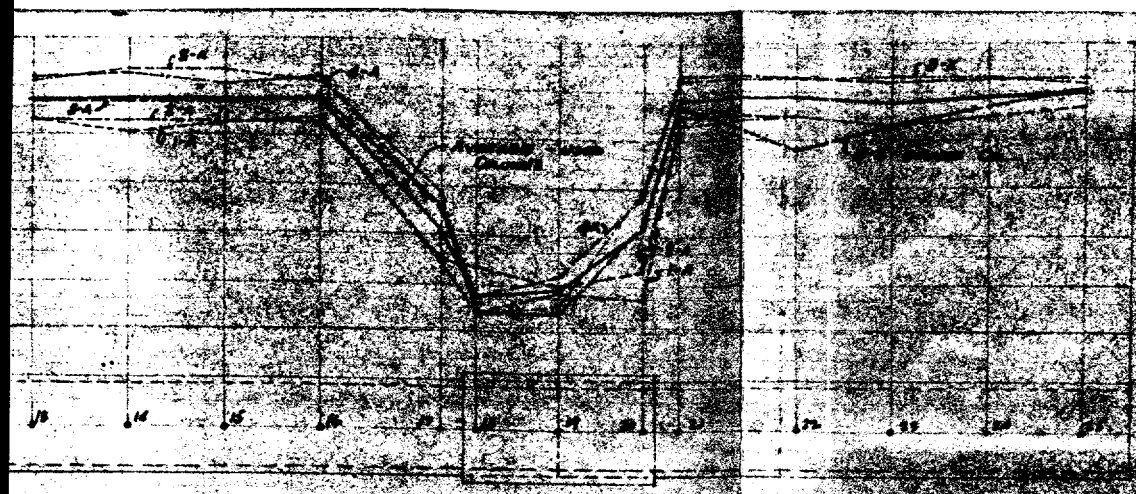
INSIDE TEST



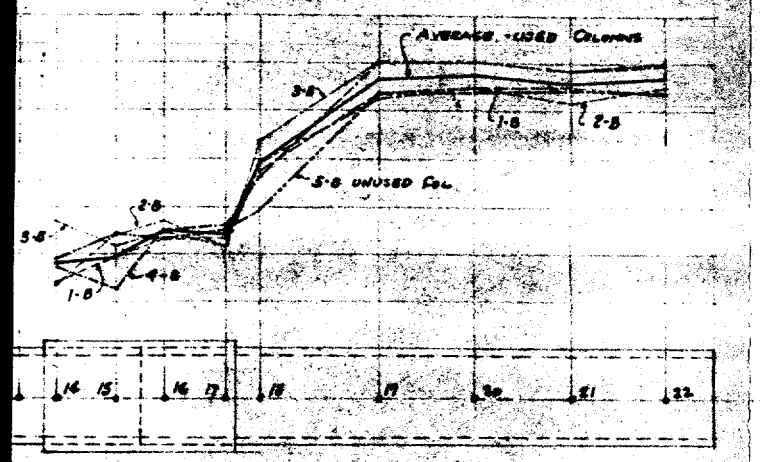
UNCLASSIFIED

OUTSIDE TEST

SAMPLE "C"



OUTSIDE TEST



OUTSIDE TEST

NOTE:
FOR RECORD OF TEST DATA SEE DWG. X-107.
YIELD STRENGTH (0.2% OFFSET) BASED ON DATA FROM "COPPER AND COPPER BASE ALLOYS" BY WILKINS & BUNN.
YIELD STRENGTH BASED ON MEAN BETWEEN .015 MM AND .040 MM GRAIN SIZE.
YIELD STRENGTH FIGURES ARE APPROXIMATE BUT CURVES INDICATE DEFINITELY ANNEALED CONDITION OF METAL AT COUPLINGS.
DATA WAS PLOTTED FOR COPPER ONLY.

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DRAWN BY J.M.M. 2-30-45	Big Business Builds The Ferguson Way **The H. K. Ferguson Company** ENGINEERS HANNA BUILDING PHONE CHERRY 5870 CLEVELAND, OHIO PROJECT S-50	CONTRACT NUMBER 1032
TRACED BY		SHEET NUMBER X-113
CHECKED BY		
SCALE		

Tab 30

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

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PROJECT NO. 30

PRODUCTION RATE VS. ASSAY ON CIRCUITS COMPOSED OF SELECTED COLUMNS

By: R. Van Winkle

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PRODUCTION RATE VS. ASSAY ON CIRCUITS COMPOSED OF SELECTED COLUMNS

INTRODUCTION AND OBJECT

The results of Project No. 19-I[1], completed in April, 1945, showed that there were large differences in the operating characteristics of columns as shown by the X and y values (See Table I). The variation from column to column was found to be independent of the location of the columns and the manufacturers. From the data on each column, the production rate at various product assays can be calculated. It was the purpose of this project to determine to what extent plant output, on a column basis, can be increased by using selected columns.

RESULTS OF PROJECT NO. 19-I

The data obtained on Project No. 19 for Circuit 2, Rack 21 were worked up by Drs. Abelson and Rosen[2], who calculated values of X and y for the columns, These are given in Table 1. In reporting the values, they divided the columns into two groups, of "better" and "poorer" columns, respectively. The columns were arbitrarily divided into exactly these same groups, the criterion being whether or not a column reached par assay in 72 hours of operation. At the time, it was believed that an "average" column should reach par in 3 days.

There were 22 columns in Circuit 2, Rack 21, for which X and y values were determined by Project No. 19-I. Of these, nine were assigned to the "good" group, and thirteen to the "bad" group. It so happened that columns with X values below 80 days and y values above 0.25 were put in the good group, while columns which had X values above 80 days or y values below 0.25 were put in the bad group.

EXPERIMENTAL WORK

1. The complete Circuit 2, consisting of 22 columns, was milked at the rate of 89 g.c.d. The product assays were found to be exactly at par. Total circulation time at this time was about 8 hours per day.

2. At the beginning of May, the circuit was divided into two top circuits -- 2A and 2B, as indicated in Table 1. Observation of the column numbers shows that these circuits were "intertwined" It was, therefore, necessary to use about 20 link lines to connect the columns at the top of the circuit. These link lines were wired to the existing intercolumn connector system so that they would be frozen when the top of the circuit was supposed to be frozen.

---

1. Report M2356 "Test of Uniformity of Columns in a Circuit" by L. Davidson and Ens. Chad Raseman, U.S.N.R., April 28, 1945.

2. Letter to Dr. Barnett F. Dodge from Dr. P. H. Abelson, April 30, 1945.

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However, some of the lines in Circuit 2B were not in good contact with the copper freeze water line, which resulted in some intercolumn circulation. Despite many efforts to remedy this condition, it persisted until the "split-pipe" intercolumn connector system was installed in June. (See report on Project No. 16).

3. The bottoms of all 22 columns remained connected as one circuit, and consequently both 2A and 2B had identical circulation rate, time and bottom assay. Circuits 2A and 2B were each milked automatically, using a No. 9 metering capsule on each, because of the small number of columns per circuit. Separate No. 120 capsules were used. This system was used from May 7 to May 24, During this time, Circuit 2B accidentally filled its No. 120 capsule on four occasions when the No. 2 coil failed to freeze-off. As a result, no satisfactory data were collected from Circuit 2B during this period.

Circuit 2A produced at a rate varying from 40 to 80 g.c.d. averaging about 60 g.c.d., with assays close to +2. Circulation was very poor during this period, averaging about 5 hours per day. On the whole, the data being collected were not too useful.

On May 25, the I.C.C.'s were equipped with steam purging, and the circulation time increased to about 20 hours per day. At this time, the automatic milkers were abandoned, and manual milking was instituted. The circuits were milked into No. 9 capsules, which were dumped into separate No. 120 capsules for each circuit in the transfer room. One or two of the No. 9 capsules from each circuit were sampled daily, and the No. 120 capsules were changed and sampled each day.

Circuit 2A produced at about 98 g.c.d. at a +3 assay, under this system, but Circuit 2B was only able to produce about 67 g.c.d. at a very low assay, about -8 to -11. This poor performance was, in part, caused by intercolumn circulation between several pairs of columns in Circuit 2B. Many attempts to remedy this situation were made, but because of the "intertwining" of the circuits, there was too great a tangle of link lines. Circuit 2B continued to have intercolumn circulation until the split-pipe intercolumn connector system was installed on June 25. Intercolumn circulation was immediately eliminated, and the assay of product from Circuit 2B rose to about -2. No signs of intercolumn circulation have since been observed.

Data obtained from June 25 to July 17 show that Circuit 2A produced about 100 g.c.d. at about +3 and that Circuit 2B produced about 67 g.c.d. at about -2. Substituting these data in Rosen's equation for S vs ν (See Appendix), and using the appropriate average y values for the circuits, it can be calculated that Circuit 2A would produce about 170 g.c.d. at par, while 2B would only be capable of producing about 10 g.c.d. at par.

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The milking rates were therefore altered to about 170 g.c.d. and 28 g.c.d. on Circuits 2A and 2B respectively, on July 17. After this change in milking rates, the assay of the product from Circuit 2A dropped steadily until a value of about -2 was reached. Circuit 2B produced par product at 28 g.c.d.

It was then calculated that Circuit 2A should product 130 g.c.d. at par, based on the data which indicated that Circuit 2A produced 170 g.c.d. at -2.

On August 16, the milking rate on Circuit 2A was changed to 128 g.c.d., and the assay finally reached +1.9. Using these values, it was calculated that Circuit 2A should produce 179 g.c.d. at par.

It should be stated that because of frequent shut-downs of Rack 21 during the last of July and all of August, neither the assay obtained at 170 g.c.d. nor the assay obtained at 128 g.c.d. could be regarded as steady or wholly reliable. However, because of the fair agreement of the data obtained at 100 and 130 g.c.d., it is thought that Circuit 2A could produce about 170 g.c.d. at par.

DATA

The data for this project are included in the monthly reports beginning with May. The data for the month of August are included in Table II.

OPERATING DETAILS

To insure proper milking, gauges were placed at the tops of each end column on each circuit, and pressure drops of about 100 psi. were observed at each milking on each gauge.

Since 2A and 2B are actually only one circuit at the bottom, the circulation rate, duration of circulation, and bottom depletion have been identical for the two circuits. Therefore, these possibly critical variables have been eliminated completely from the comparison of the two circuits.

Circulation was very poor (about eight hours per day) before May 25. Since then it has been about twenty hours per day. For this reason, the data taken before May 25 should not be compared with data taken since then. The production of the complete circuit (all 22 columns) should be redetermined, under the existing good circulation conditions, to give a valid basis for comparison of the complete circuit to the "selected" circuits.

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DISCUSSION

Calculation of H and R (See Appendix) gives much higher values for production rates then were actually obtained. However, inefficient milking might be to blame. It has been found by other investigators that top circuits with fewer columns are milked more efficiently than circuits with more columns. Circuits 2A and 2B, stretching from columns 28 to 42 and 30 to 50 respectively, must be considered "long" circuits. It is therefore highly probable that they have not been milked efficiently during the course of this experiment. Old-style restrictor coils were used, which are not as good as the new-type of coils.

Plant operating efficiency might be greatly improved by selecting matched columns to compose circuits. This would eliminate any possible degradation effects caused by the top circulation system.

The average power consumption per column with 1000# steam and 150° F. cooling water is about 10,000 BTU/min. It is not known how heat consumption varies from one column to another. If the columns are assumed to use equal amounts of heat, it is obvious that the efficiency of heat consumption would be improved by cutting out the columns which produce at below average rates. If only the nine "good" columns in Circuit 2 were used, it would be possible to produce 80.8% as much product as would be produced by all 22 columns in Circuit 2, using only 40.9% as much steam, or essentially twice as much product per lb. of steam.

This work also gives definite evidence of the harmful effect of intercolumn circulation.

CONCLUSIONS

This project has demonstrated that by:

(1) Using selected columns it is possible to greatly increase the operating efficiency of the plant. On Circuit 2 of Rack 21, nine selected "good" columns produced 1530 g. of par product per day as compared with 364 g. of par product from the remaining 13 "poor" columns. The nine "good" columns produced approximately twice as much product per pound of steam as did the original circuit of 22 columns.

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TABLE NO. I

OPERATING CHARACTERISTICS OF INDIVIDUAL COLUMNS - Rack 21

Circuit 2A

Col. No.	X	y	H	R_p
28	62	.27	107	262
29	70	.28	92	242
32	48	.26	144	310
33	48	.25	150	292
35	54	.32	104	348
38	67	.27	99	243
42	74	.27	91	223
44	79	.26	88	189
47	44	.32	128	429
Ave.	61	.28	111	254

Circuit 2B

Col. No.	X	y	H	R_p
30	88	.22	98	83.4
31	122	.22	70	59.1
34	105	.17	100	0
36	115	.25	63	120
39	185	.17	57	0
40	195	.16	58	0
41	195	.16	58	0
43	86	.21	99	0
45	68	.19	140	0
46	110	.20	82	0
48	158	.21	54	0
49	110	.17	96	0
50	275	.15	44	0
Ave.	139	.19	78	263 g.

R_p = Production Rate at Par Assay

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TABLE NO. II

Circuit 2A

Date	Production Rate g.c.d.	ASSAYS No. 120 Capsules	No. 9 Capsules	
8-17-45	128.0	-0.9	+3.9	-6.7
8-18	126.8	+3.7	+1.7	-12.1
8-19	128.7	+3.3	+3.4	+2.1
8-20	128.5	+2.6	+2.7	+2.6
8-21	128.0	+1.9	+0.6	+2.6
Ave.	128.0			

Circuit 2B

Date	Production Rate g.c.d.	ASSAYS No. 120 Capsules	No. 9 capsules	
8-16-45	23.8	+3.1	+3.0	+0.8
8-17	27.4	----	+2.0	+1.6
8-18	23.2	----	+4.9	+2.9
8-19	27.9	+2.0	+2.0	+2.0
8-20	28.0	----	+1.1	+2.0
8-21	23.0	----	+1.3	+0.0
Average	27.5	+2.5	+2	

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MONTHLY REPORT FOR PERIOD ENDING

AUGUST 31, 1945

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PROJECT NO. 31

TWO-STAGE OPERATION FOR INCREASED PRODUCTION

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Daniel Frishman

Reported by: Daniel Frishman

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TWO-STAGE OPERATION FOR INCREASED PRODUCTION

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Purpose

The original purpose of the two-stage system was to make the top circulation method of product removal more efficient. (See the letter of April 17, 1945 from D. Frishman to R. S. Lamie). Subsequently, it was thought that the two-stage system might give more production than the one-stage system. When the two-stage top circulation method showed no improvement over the one-stage top circulation method, it was decided to milk the second stage by the monorail method to see whether an increase in production would result.

The chief objectives of this project was to study and improve the two-stage system.

Discussion

The shape of the Assay vs. Production curve (see April report, Project 29, Figure 3) is such that operating two stages in series under ideal conditions would appear to give more production. The slope of the curve decreases as enhancement decreases; for example at 20% enhancement the production is 103 grams per column per day, but at 10% enhancement it is approximately 250 grams per column per day. If the two groups of columns were therefore operated in series, for example each group at 10% enhancement, an increase in production might be expected.

Performance Prior To August 1

The arrangement of the circuit is described in the May and June reports of this project. The circulation rate was high because of the many convectors in each stage and actually no circulation difficulties were encountered. The first stage had on the average 10 - 13 hours circulation per day and circulation between the two stages averaged 8 - 10 hours per day.*

The two-stage system with product removal by top circulation was tried on Rack 9, Circuit 2, with 28 Columns in the first stage and 12 Columns in the second stage. The production rate of "par" product was 90 grams per column per day; a rate very close to that obtained by the one-stage system with product removal by top circulation, (see Project 12 report). The circuit was then changed to monorail milking from the top of the second stage and 99 grams per column per day at "par" assay were produced (July); this was a 10% improvement. During July, Rack 9, Circuit 1 was changed to the two-stage system because there were several high pressure pots containing low assay material that needed enhancing. It was found that in the 12 - 20% enhancement range the two-stage system of product removal by top circulation was more efficient than the one-stage system, (see Figure 1, Project 12 and Figure 4, Project 31 in the May report). The result was that the two-stage system enhanced the low assay pots 35% more efficiently than the one-stage system (see Project 31, July report). Because we expected that steam would be available only in SP 3 we decided to try the two-stage system on Circuit 1, Rack 6. During July this circuit did the same as would be expected from a one-stage system.

* The stage fed by the storage chamber is known as the first stage.

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Production From August 1 to September 5

The production is given in the following table :

Table 1

Rack	Circuit	Number of Columns	Days of Operation	Production of Two-stage system Gr/col/day At par	Estimated production based on Project 1 data Gr/col/day at par
6	1	43	33	91	120*
9	1	37	16	131	125
9	2	41	10	100	97
			Averages	107	114

* The actual value for 1000 psi steam was 133 grams per column per day. Since 450 psi steam was known to give approximately 10% less production than 1000 psi steam and since Rack 6 was operated with 450 psi steam, the correction was made.

Comparatively few days of operation were recorded for Rack 9 because the rack was shut down until August 6 and then the individual column test was made until approximately August 19. Furthermore, the two days immediately following the individual column test were not included in the data. Interchanging the two stages for reasons mentioned below on August 30 on Rack 9, Circuit 2, further reduced the operating days that could be used in the above comparison.

The following conclusions can be made from the data in Table 1:

(1) The two stage system produced on the average 6% less than the predicted production. In Project 1 it was shown that the monorail-milking racks produced on the average 10% less than the predicted production from the individual column milking test. This indicated that both methods of operation as far as production was concerned were equivalent. However, it is felt that operational errors, especially inter-column circulation, occurred more frequently on the two-stage circuits. The system was not complicated; the difficulty was that the same men operated the usual one-stage circuits as well as the two-stage circuits. This sometimes led to confusion.

(2) In July, Rack 9, Circuit 2 had 28 columns in the first stage and 12 columns in the second stage. This was changed so that in August there were 20 columns in the first stage and 20 columns in the second stage. The production for July was 99 grams per column per day at "par" and for August, 100 grams per column per day. The ratio of columns in the stages therefore made no difference.

The Quality of Columns in the First and Second Stages:

The individual column test at 1000 psi steam at a milking rate of 100 grams per column per day gave the following average assay for the columns in the first and second stages:

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Table 2

Rack	Circuit	Number of Columns		Average Assay	
		First Stage	Second Stage	First Stage	Second Stage
6	1	28	15	+1.8	+4.4
9	1	25	12	+0.8	+5.1
9*	2	27	12	-1.9	+2.1
9**	2	20	20	-2.3	+1.4

* Arrangement of circuit before August 6.
** Arrangement of circuit after August 19; the individual column test extended from August 6 to August 18.

In every case, by chance, the columns have been so arranged that the first stage contained poorer columns than those in the second stage. This may account for the fact that the assay on the top of the first stage was not as high as it was expected to be (-11 or -12).

The following are the average assays of the interbank on the various circuits <u>after</u> a period of interbank circulation. The interbank samples were taken directly out of the lines between the first and second stages

Table 3

Rack	Circuit	Number of Columns		Interbank Assay
		First Stage	Second Stage	
6	1	28	15	-15.5
9	1	25	12	-13.5
9	2	20	20	-19.0

In one case, Rack 6, a more thorough study of the change in assay during various periods in a cycle was made.

Table 4

Assay at the bottom of the second stage after 1-1/2 hours of no interbank circulation -20

Assay at the top of the first stage after 1-1/2 hours of no interbank circulation -13

Assay at the bottom of the second stage after 1 hour of interbank circulation -15

Assay at the top of the first stage after 1 hour of interbank circulation -15

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When the bottom of the second stage reaches an assay of -20 practically all of the advantage of a two stage system is lost. On August 31, Rack 9, Circuit 2 was changed so that what was the first stage became the second stage, and vice-versa. The plant was shut down before any data could be obtained.

Conclusions

The production at "par" of the two-stage system was about the same as that of the one-stage system. Many operational errors that surely limited the production were discovered; aside from these there were probably other reasons why the system did not meet expectations. Removal of the light component by circulation from the first stage might have been inefficient; circulation hours, because they were shared between the bottom of the first stage and the interbank might have been insufficient; and the unfortunate arrangement, occurring purely by chance, of all the circuits having the poorer columns in the first stage might have contributed to the limited production. Controlled experiments to test these points are necessary.

However, even if the two-stage system only equals the production of the one-stage system, it has several operational advantages that might make a definite contribution. It is particularly well adapted to automatic control using cam timer and solenoid valves; monorail milking is simplified because it occurs only at one point on the side of a rack, rather than at 2, 3 or 4 places. The product can be milked into a high pressure pot; and finally, milking time is not critical because it takes place during the period of circulation across the bottom of the first stage.

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Tab 32

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 32

TESTING COLUMNS BY SEPARATING SYSTEMS OTHER THAN C-616

By: S. J. Green
L. Silver

Stanley J Green

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TESTING COLUMNS BY SEPARATING SYSTEMS OTHER THAN C-616

Purpose of Study

In the separation of C-616 isotopes in the S-50 plant, the considerable difference in the separative capacity of individual columns posed an important problem. This study was undertaken for the purpose of developing a method for determining the performance characteristics of different columns with separating systems other than C-616. It was planned to test individual columns with gaseous mixtures and with C-616 to ascertain if any correlation existed between the relative performances of a single column when used on the two systems. Such a test, if successful, could be employed to evaluate a column before installation and possibly at the point of manufacture.

Experimental Method

Systems Employed

Preliminary tests with air at atmospheric pressure in columns operating with 1000 lb. steam and 150° F. cooling water (Columns 1, 2, and 3 of Rack 21) were inconclusive and unsuccessful.

It then seemed desirable to employ a two-component gas mixture whose components had a greater molecular weight difference than those of air. Due to the high steam temperature the use of aqueous solutions was not considered. The use of high boiling-point organic liquids was possible but none was readily available. It seemed desirable to use CO_2 as one of the components because of the ease of analysis. Consequently, a gaseous mixture of 60% CO_2 and 40% He (by volume) was selected. Ample quantities of this mixture were available on short notice from K-25. This gaseous separation system was used in all subsequent work.

Rate-of-rise data were obtained on columns isolated top and bottom rather than on columns isolated only on the top with a large bottom reservoir, since equilibrium is approached about 3 times as fast with top-and-bottom isolation as compared with only top isolation. This method also served to conserve gas and to simplify the apparatus and experimental technique.

Columns which were selected for testing were either new ones or ones which were either "good" or "poor" columns as indicated by the results of Project No. 1. The columns which were tested are listed in Table No. 1.

New columns were conditioned for testing by purging with N_2 and moisture testing. Columns which had been in service with C-616 were conditioned by draining all material, blowing with N_2, washing with H_2O, and moisture testing.

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Each column had a calibrated pressure gauge installed on one of the bottom tits. Each gauge was accurate to within 1 lb. per sq.in. and could be read to within 0.2 lb. per sq. in.

Gas samples were taken at the top and bottom of the columns through 1/4-inch 3000 lb. Crane stainless steel valves. These valves had 5/16-inch nickel half nipples silver soldered to their bases in order to reduce dead space to a minimum. The valves were connected to a top and bottom tit by 4-inch link lines which had been pressed in a vise and constricted so that they barely permitted the flow of gas through them. With this technique the volume of the gas sample was maintained between 20 and 25 ml. measured at atmospheric pressure. The gas samples were collected in a 50 ml leveling bulb and were analyzed in a home made Orsat by absorption in 25% NaOH solution. The Orsat analysis was accurate to within 0.3% Co_2. Usual precautions were taken to avoid the dilution of the sample with air.

At the start of a run, all columns were purged with the He - Co_2 mixture until the Co_2 concentration at the top of the column was the same as the feed mixture. By the use of the valves, the columns could be filled to any predetermined gas pressure. Samples were then periodically taken for analysis every 24 hours for approximately 7 days.

Preliminary tests indicated that an initial gaseous pressure of 60 lb. per sq.in. gauge was satisfactory. Consequently, for purposes of comparison, all columns were run at this pressure. In order to determine the reproducibility of the method, duplicate tests on several columns were conducted. Since gaseous pressure was very early shown to be an important variable, individual columns were run at various pressures in order to ascertain the effect of this variable.

Calculations:

The empirical equation which appears to successfully correlate the experimental data is:

$$g = g_e \left(1 - e^{-bt}\right)$$

Where,

$$g = \ln S$$

g_e = equilibrium value of g

$$S = \left(\frac{C_t}{1 - C_t}\right)\left(\frac{1 - C_b}{C_b}\right) = \text{Separation factor}$$

C_t = Concentration of He at top of column, vol. %.

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C_b = Concentration of He at bottom of column, vol. %.

b = "Time constant", hours $^{-1}$.

t = Time, hours.

Plots of g vs. t resulted in curves which closely resemble the enhancement vs. time curves obtained on C-616.

Values of g and b can be calculated by the following method:

1. From plots of C_t and C_b vs. t, calculate S and g for various values of t.

2. Estimate g_e from a plot of g vs. t and then so select g_e that $\ln(g_e - g)$ vs. t (use a semi-log plot) gives a straight line.

3. The slope of the semi-log plot = b, since $\ln(g_e - g) = \ln g_e - bt$.

Experimental Results

The experimental data describing the tests conducted at initial gas pressures of 60 lb. per sq.in. are presented in Table No. 2, and a summary of these tests is given in Table No. 3. Duplicate runs were conducted on 5 columns and for these tests average values of g_e and b, together with percent average deviation, were calculated. These values are shown in Table No. 4. From an examination of Tables 3 and 4, it is seen that the percent average deviation of g_e ranged from 0 to 4%, and that of b from 0.4 to 12.5%. It is felt that the deviations in g_e and b are due principally to variations in the quantity of gas removed from a column during a test. The variations in quantity of gas removed from a column was the cause for the variations in rate of gas pressure drop. This drop was difficult to control and was due to variations in the amount of gas removed for sampling and undetectible leaks. Based on a precision in the CO_2 analysis of 0.5% the errors in g_e and b were calculated to be about 5 percent. This agrees substantially with the results shown in Table No. 4. Figure 1 illustrates typical rate-of-rise data and the reproducibility of duplicate runs performed on column 53 of Rack 2.

In Table No. 4 is presented the average values of g_e for 8 columns, together with the type of column. It is evident that there are significant differences in columns principally in the values of g_e. It is not meaningful to compare, for the individual columns, the values of g_e and b obtained with the He - CO_2 mixtures with the milking data obtained on C-616 from Project No. 1 as they are on a different basis.

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It was planned to obtain rate-of-rise data with C-616 and thus calculate X and y values. The X and y values could then have been compared to the b and g_e values respectively. However, the racks were shut down before it was possible to obtain this data.

Effect of Pressure

To determine the effect of gas pressure on the separative capacities of columns, runs at initial pressures of 61,51, and 31 lb. per sq.in. were conducted on Column No. 54 of Rack No. 2 (Tests 2-54-2, 2-54-3, and 2-54-4 respectively).

The experimental data are presented in Table No. 5 and a summary of the tests in Table No. 6. From the results of these tests, it is seen that an increase in initial gas pressure materially increases g_e, but that there is no observable trend in b.

Conclusions

1. The equation $g = g_e (1 - e^{-bt})$ can adequately represent the separation of He - CO_2 mixtures in S-50 columns. Values of g_e and b can be calculated on the basis of rate-of-rise data within an error of approximately 5 percent.

2. Increasing the gas pressure from 30 to 60 lb. per sq.in. gauge causes about a 2-1/2 fold increase in g_e from approximately 1.7 to 4.0. Values of b are of the order of 0.010 hrs. $^{-1}$ and essentially independent of pressure.

3. Removal of appreciable quantities of gas during a run causes significant changes in the experimental constants. This indicates the need for improved experimental technique in which the removal of appreciable amounts of gas is not necessary.

4. Significant differences in the separative capacities of individual columns with He - CO_2 mixtures are evident.

Recommendations for Future Work

1. Obtain rate-of-rise data with C-616 on the columns previously tested with He - CO_2 mixtures. These columns are listed in Table 1. Values of X and y can thus be calculated and can be compared to the g_e and b values obtained with the He - CO_2 mixture.

2. Develop an experimental and analytical technique which can eliminate the drop in gaseous pressure during a run. One possibility is the use of very small (1Ml) gas samples and a micro-orsat for gas analysis.

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Another possibility is the use of a thermal conductivity meter which permits the analysis of the gas without the consumption of the sample.

3. Conduct comparison tests with He - CO_2 mixtures on various columns at pressures other than 60 lb. in order to determine optimum operating pressure.

4. Investigate the use of other 2-component mixtures such as N_2 - CO_2, air, high-boiling point organic liquids. Smaller molecular weight differences between the components or the presence of a liquid, or a liquid and gas phase may give more significant results.

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TABLE NO. I

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COLUMNS TESTED

Rack	Column	Nature of Column	
2	1	Poor*	Class IV*
2	53	New	
2	54	New	
3	90	Good	Class A*
4	18	Good	Class A*
5	31	Poor	Class II*
8	2	New	
8	3	New	

* From Project No. 1; See August 1945 report for description of classification.

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TABLE NO. II

COMPARISON OF COLUMNS, Experimental Data

Time Hours	Pressure, p.s.i.g.	Top Concn. He	Top Concn. CO_2	Mol. % He/CO_2	Bottom Concn. He	Bottom Concn. CO_2	Mol. % He/CO_2	S	g = ln S
				Test 2-1-1					
3.8	61.5	51.3	48.7	1.053	33.5	66.5	.503	2.10	0.742
21.7	59.5	65.3	34.7	1.881	20.1	79.9	.251	7.50	2.015
46.9	56.8	68.0	32.0	2.123	13.8	86.2	.160	12.59	2.53
70.9	55.8	73.4	26.6	2.76	13.2	86.8	.152	18.2	2.90
118.0	54.7	80.3	19.7	4.08	6.0	94.0	.064	64.0	4.16
141.4	52.3	81.8	18.2	4.50	5.7	94.3	.061	74.4	4.32
				Test 2-1-3					
4.5	62.0	49.3	50.7	0.973	31.4	68.6	0.457	2.13	0.755
23.5	59.7	62.5	37.5	1.669	16.6	83.4	.199	8.36	2.12
46.8	57.8	68.7	31.3	2.19	9.5	90.5	.105	20.9	3.04
118.6	55.6	80.1	19.9	4.02	4.8	95.2	.050	79.7	4.37
				Test 2-53-1					
4.4	61.0	47.7	52.3	0.0913	34.7	65.3	0.531	1.72	0.543
21.4	59.3	58.4	41.6	1.403	24.8	75.2	.330	4.25	1.446
46.5	57.0	65.9	34.1	1.933	19.5	80.5	.242	7.98	2.075
70.9	55.0	71.3	28.7	2.48	15.2	84.8	.179	13.83	2.63
93.6	53.4	74.5	25.5	2.92	14.2	85.8	.166	17.64	2.87
144.5	51.3	79.9	20.1	3.98	8.7	91.3	.095	41.8	3.73
				Test 2-53-4					
17.5	61.5	58.4	41.6	1.403	25.6	74.4	0.344	4.08	1.406
41.1	59.6	66.9	33.1	2.02	19.7	80.3	.245	8.23	2.11
65.8	57.5	72.2	27.8	2.60	16.2	83.8	.193	13.44	2.60
91.3	55.4	75.4	24.6	3.06	15.2	84.8	.179	17.08	2.84
139.2	54.6	81.0	19.0	4.26	10.4	89.6	.116	36.68	3.60
165.0	52.4	83.1	16.9	4.92	8.7	91.3	.095	51.60	3.93
				Test 3-90-1					
5.4	61.5	49.7	50.3	0.988	32.3	67.7	0.477	2.07	0.728
23.0	59.8	56.4	43.6	1.295	24.7	75.3	.328	3.95	1.373
49.2	56.5	60.4	39.6	1.526	19.2	80.8	.238	6.42	1.859
70.7	52.1	66.8	33.2	2.01	17.6	82.4	.214	9.38	2.24
96.4	50.7	71.4	28.6	2.50	16.0	84.0	.191	13.12	2.57
119.3	49.2	73.6	26.4	2.79	13.8	86.2	.160	17.42	2.86
166.9	47.8	77.5	22.5	3.45	11.3	88.7	.128	27.0	3.30

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TABLE NO. II - Continued

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COMPARISON OF COLUMNS, Experimental Data

Time Hours	Pressure, p.s.i.g.	Top Concn. He	Top Concn. CO_2	Mol. % He/CO_2	Bottom Concn. He	Bottom Concn. CO_2	Mol. % He/CO_2	S	g = ln S
				Test 4-18-3					
4.7	61.0	49.8	50.2	0.992	34.7	65.3	0.531	1.87	0.626
21.6	59.2	58.2	41.8	1.392	28.1	71.9	.391	3.56	1.27
48.2	56.8	66.4	33.6	1.976	22.0	78.0	.282	7.02	1.95
70.2	54.0	70.8	29.2	2.42	19.7	80.3	.245	9.88	2.29
94.1	51.8	72.7	27.3	2.66	16.9	83.1	.203	13.10	2.58
118.0	50.8	74.2	25.8	2.88	17.2	82.8	.208	13.84	2.63
				Test 4-18-4					
22.2	58.9	55.6	44.4	1.251	25.6	74.4	0.344	3.64	1.29
46.4	56.2	62.7	37.3	1.68	21.7	78.3	.277	6.07	1.80
70.2	54.8	65.8	34.2	1.92	17.7	82.3	.215	8.95	2.19
93.3	51.9	68.9	31.1	2.22	15.6	84.4	.185	11.98	2.48
116.3	50.3	71.7	28.3	2.54	14.1	85.9	.164	15.49	2.74
167.2	48.2	78.3	21.7	3.62	11.2	88.8	.126	28.69	3.35
188.4	47.0	77.6	22.4	3.48	11.1	88.9	.123	28.3	3.34
				Test 5-31-4					
18.3	61.0	60.4	39.6	1.53	22.9	77.1	0.297	5.14	1.64
43.9	57.5	70.1	29.9	2.34	16.2	83.8	.193	12.12	2.49
66.5	55.5	74.0	26.0	2.84	13.2	86.8	.152	19.3	2.96
92.1	54.0	77.2	22.8	3.39	10.4	89.6	.116	29.2	3.37
116.0	52.3	80.3	19.7	4.07	10.2	89.8	.114	35.8	3.58
162.9	50.8	83.9	16.1	5.21	7.2	92.8	.078	67.2	4.20
				Test 5-31-5					
4.5	61.3	51.5	48.5	1.06	31.7	68.3	0.464	2.29	0.829
25.0	59.9	64.9	35.1	1.85	21.4	78.6	.272	6.81	1.92
47.0	58.5	73.6	26.4	2.79	19.5	80.5	.242	11.53	2.44
70.6	57.2	76.9	23.1	3.33	15.3	84.7	.181	18.42	2.91
94.1	55.7	79.9	20.1	3.97	12.2	87.8	.139	28.50	3.35
117.2	53.6	81.8	18.2	4.49	12.5	87.5	.143	34.90	3.55
168.4	51.7	85.2	14.8	5.76	8.6	93.4	.071	81.6	4.40
190.5	49.8	85.7	14.3	5.99	5.5	94.5	.058	10.3	4.63

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TABLE NO. II - Continued

COMPARISON OF COLUMNS, Experimental Data

Time Hours	Pressure, p.s.i.g.	Top Concn. He	Top Concn. CO_2	Mol. % He/CO_2	Bottom Concn. He	Bottom Concn. CO_2	Mol. % He/CO_2	S	g = ln S
				Test 8-2-4					
5.0	61.0	49.2	50.8	0.968	31.2	68.8	0.453	2.13	0.756
22.2	57.5	61.1	38.9	1.57	23.3	76.5	.305	5.15	1.64
45.3	53.5	64.8	35.2	1.84	18.8	81.2	.231	7.97	2.07
69.4	51.4	71.2	28.8	2.47	16.1	83.9	.192	12.85	2.55
93.6	48.0	73.3	26.7	2.74	14.6	85.4	.171	16.02	2.77
143.7	46.0	78.9	21.1	3.74	12.0	88.0	.136	27.4	3.31
165.5	44.2	78.8	21.2	3.71	10.3	89.7	.115	32.3	3.47
				Test 8-3-4					
4.9	61.0	50.3	49.7	1.01	30.6	69.4	0.441	2.29	0.829
22.0	58.2	60.4	39.6	1.53	21.5	78.5	.274	5.57	1.72
45.9	55.7	67.5	32.5	2.08	16.8	83.2	.202	10.30	2.33
69.3	53.0	67.7	32.3	2.09	14.8	85.2	.174	12.02	2.49
94.4	49.6	71.8	28.2	2.55	13.1	86.9	.151	16.90	2.83
145.3	46.8	76.7	23.3	3.29	10.2	89.8	.114	28.9	3.36
163.9	45.0	77.7	22.3	3.48	10.2	89.8	.114	30.6	3.42

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TABLE NO. III

COMPARISON OF COLUMNS

Summary of Tests

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Test	Steam Temp. °F	H_2O Temp. °F	Initial Gas Pressure, p.s.i.g.	Final Gas Pressure, p.s.i.g.	Duration of Test, Hours	Rate of Pressure Drop p.s.i. per Hr.	g_e	b, Hours^{-1}
2-1-1	456	144	61.5	52.3	141.4	.065	5.30	0.0115
2-1-3	456	144	62.0	55.6	118.6	.054	5.40	0.0114
2-53-1	456	144	61.0	51.3	144.5	.067	4.75	0.00967
2-53-4	456	144	61.5	52.4	165.0	.055	4.75	.00916
2-54-1	456	144	61.0	46.3	167.4	.0088	3.98	.00817
2-54-2	456	144	61.5	51.4	140.9	.072	3.98	.0105
3-90-1	456	144	61.5	47.0	188.4	.074	4.10	.00840
4-18-3	456	144	61.0	50.0	118.0	.093	3.70	.00950
4-18-4	456	144	61.0	47.0	188.4	.074	4.00	.00854
5-31-4	456	144	61.0	50.8	162.9	.063	5.30	.00817
5-31-5	456	144	61.3	49.8	190.5	.060	5.70	.00670
8-2-4	553	154	61.0	44.2	165.5	.101	4.10	.00926
8-3-4	553	154	61.0	45.0	163.9	.098	4.00	.00941

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TABLE NO. IV

COMPARISON OF COLUMNS

Column	Ave. g_e	Value b	Ave. Deviation % g_e	b	Type of Column
2 - 1	5.35	.0115	0.9	0.4	Poor - Class IV**
2 - 53	4.75	.00992	.0	2.8	New
2 - 54	3.98	.0105	.0	12.5	New
3 - 90	4.10	.00934	---	----	Good - Class A*
4 - 18	3.85	.00902	3.9	5.3	Good - Class A*
5 - 31	5.50	.00743	3.6	9.8	Poor - Class II*
8 - 2	4.10	.00926	---	----	New
8 - 3	4.00	.00941	---	----	New

* Obtained from Project No. I.

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TABLE NO. V

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EFFECT OF PRESSURE, Experimental Data

Rack 2, Column 54

Time, Hours	Pressure, p.s.i.g.	Top Concn. He	Top Concn. CO_2	Mol. % He/CO_2	Bottom Concn. He	Bottom Concn. CO_2	Mol. % He/CO_2	S	ε = ln S
				Test 2-54-1					
4.8	61.0	49.8	50.2	0.933	33.7	66.3	0.508	1.95	0.671
21.9	57.5	57.4	42.6	1.350	25.8	74.2	.348	3.88	1.36
47.1	55.0	63.1	36.9	1.710	21.7	78.3	.277	6.17	1.82
71.5	53.1	67.0	33.0	2.03	17.7	82.3	.215	9.45	2.25
94.1	51.2	68.7	31.3	2.19	16.6	83.4	.199	11.01	2.40
144.4	49.0	73.9	26.1	2.83	11.7	88.3	.133	21.3	3.06
167.4	46.3	74.1	25.9	2.86	10.8	89.2	.121	23.6	3.16
				Test 2-54-2					
4.8	61.5	49.3	50.7	0.972	34.1	65.9	0.518	1.88	0.629
22.0	59.9	59.4	40.6	1.465	26.3	73.7	.357	4.11	1.41
45.8	58.0	65.6	34.4	1.905	20.2	79.8	.253	7.53	2.02
68.6	56.3	71.1	28.9	2.46	16.0	84.0	.191	12.92	2.56
118.0	53.7	75.0	25.0	3.00	12.5	87.5	.143	21.0	3.04
140.9	51.4	76.6	23.4	3.27	11.1	88.9	.125	26.1	3.26
				Test 2-54-3					
4.1	51.3	48.6	51.4	0.945	34.2	65.8	0.519	1.82	0.599
22.9	49.7	56.7	43.3	1.310	27.3	72.7	.375	3.50	1.25
47.9	48.3	61.3	38.7	1.585	22.7	77.3	.294	5.39	1.69
72.0	46.1	65.5	34.5	1.900	22.0	78.0	.282	6.73	1.91
121.2	44.5	70.2	29.8	2.359	15.2	84.8	.179	13.15	2.58
145.3	42.8	71.5	28.5	2.51	13.8	86.2	.160	15.70	2.76
166.5	41.1	72.0	28.0	2.57	13.2	86.8	.152	16.92	2.82
				Test 2-54-4					
21.0	31.3	52.7	47.3	1.113	36.7	63.3	0.589	1.892	0.639
44.1	29.1	52.9	47.1	1.125	33.5	66.5	.504	2.23	.802
117.0	27.3	60.5	39.5	1.532	28.1	71.9	.391	3.92	1.367

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TABLE NO. VI

EFFECT OF PRESSURE , Summary of Tests

Rack 2, Column 54

Test No.	Steam Temp. °F	H_2O Temp. °F	Initial Gas Pressure p.s.i.g.	Final Gas Pressure p.s.i.g.	Duration of Test, Hours	Rate of Pressure Drop psi. per hr.	g_e	b, $hour^{-1}$
2-54-1	456	144	61.0	46.3	167.4	.0088	3.98	.00817
2-54-2	456	144	61.5	51.4	140.9	0.0072	3.98	.0105
2-54-3	456	144	51.3	41.1	166.5	0.0061	3.40	.00941
2-54-4	456	144	31.3	27.3	117.0	0.0034	1.77	.0108

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Project 32

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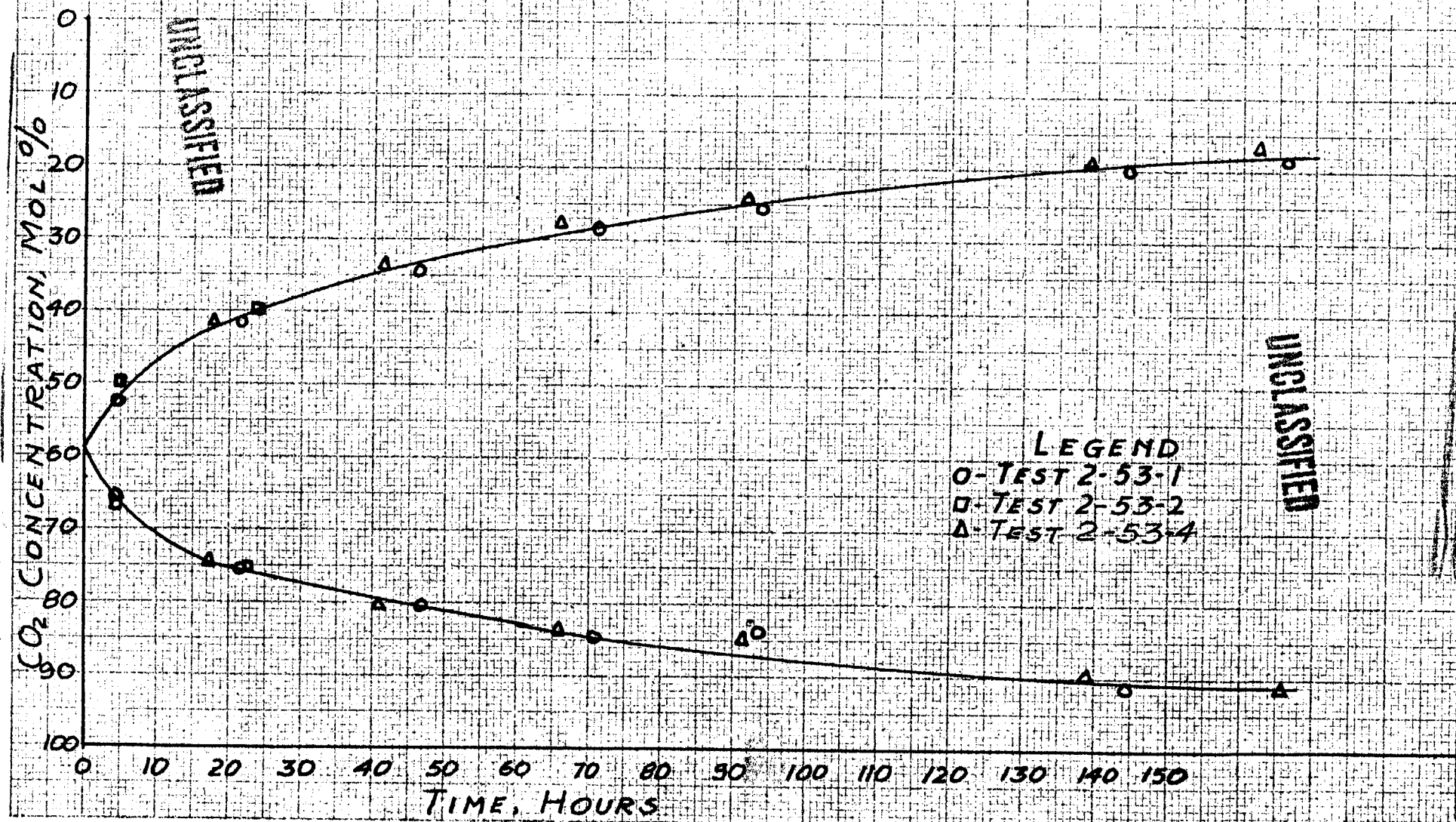
FIGURE 1
REPRODUCIBILITY OF RESULTS



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Tab 34

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MONTHLY REPORT FOR PERIOD ENDING

AUGUST 31, 1945

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PROJECT NO. 34

INVESTIGATION OF THE METHODS OF TRANSFERRING PROCESS MATERIAL

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Reported by: W. W. Binger
R. Van Winkle

W W Binger R Van Winkle

INVESTIGATION OF THE METHODS OF TRANSFERRING PROCESS MATERIAL

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Object

The object of this project was to study various methods of transferring material in an attempt to discover which factors affect the rate of transfer the most, and to find the best method of transferring material.

Progress During Month

A transfer manifold similar to the one proposed in the last monthly report was installed in Transfer Room No. 5 and tried with rather disappointing results*. At the beginning of the transferring, a rate of 5 pounds per minute was obtained, but this rate steadily decreased until a very low rate of about one pound per minute was obtained.

It was believed that the special adapter used to connect the 1/4" nickel line to the tit of the storage chamber was the cause of the poor showing of the new transfer system. This adapter was crudely constructed and poorly conditioned.

A new adapter was made which had a smooth tapered inlet and a transfer was again tried. A ferruled link line was hooked to the transfer pot and one was attached to the "A" cylinder from the tee on the conduit provided for that purpose. Heating of the transfer pot was begun before the storage chamber was frozen off.

The "A" cylinder valve was opened and the process of emptying the storage chamber progressed very smoothly. The last 40 pounds emptied at approximately 3 pounds per minute. The time for emptying was as follows:

Time	S. C. Weight
0340 (started)	374
0420 (completed)	5

The line from the conduit to the transfer pot was heated, the "A" cylinder Kerotest valve was closed and the valve on the transfer pot was opened. At the same time the high pressure steam was being taken off the storage chamber and low pressure steam applied to the jacket. When the temperature dropped sufficiently, water was substituted for steam to cool the storage chamber. The water valve was adjusted during the transfer to maintain the material temperature at 145°-150°F.

The transfer log was as follows:

Time	Lbs. Transferred
0440 (start)	0
0510	153
0540	297
0615	421

* See last month's report for details of the set-up.

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The run was started with a full pot of material. The steam pressure on the pot at the start of the transfer was 70 psi but after 30 pounds of material were transferred the pressure was increased to 100-105 psi. The entire job was performed with a minimum of effort on the operators' part and the set-up as used appeared to be very satisfactory for material transfer. The entire transfer filling required one hour and thirty five minutes.

The operations were carried out under the supervision of T/Sgt. J. F. Hunt.

Due to the termination of the S-50 operations this project is to be concluded with this report.

Future Work

It would be well to install this type of transfer system in all Transfer Rooms and carefully instruct the operators in the use of this type of system.

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 55

EFFECT OF SHORT AND LONG NON-CIRCULATION PERIODS ON CIRCUIT PERFORMANCE

By: Leonard Silver

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EFFECT OF SHORT AND LONG NON-CIRCULATION PERIODS ON CIRCUIT PERFORMANCE

OBJECT:

In the analysis of plant production data, it is necessary to have some means of properly accounting for non-circulation periods of different lengths in order to accurately compare performance of different circuits. This requires plant data on circuit performance where both long and short periods of non-circulation have been used. The purpose of this project was to obtain such data.

Progress During August:

Circuit 4, on Rack 21 was used for this project. The third run was started during this month and was operated under the following conditions:

(a) Pressure on storage chamber - - - - - - - - - - 1500 psi

(b) Steam pressure on rack - - - - - - - - - - - - - 1000 psi

(c) Inlet water temperature - - - - - - - - - - - - - 150 °F.

(d) Milking - The circuit was milked manually three times a day into a No. 31 capsule.

(e) Circulation - The bottom of the circuit was frozen off a total of six hours during and subsequent to each milking, i.e., there were three two-hour periods of circulation per day, spaced six hours apart.

(f) Samples - Bottom samples were taken simultaneously from the first and last columns in the circuit just prior to the milking on the day shift. All No. 31 capsules used for milking were weighed and sampled before dumping.

Run No. 3 was started on August 8 and continued to August 11 when Rack 21 was shutdown. The run started again on August 15, but another shut down occurred on August 22. This run recommenced on August 31 but was finally halted by the termination of all experimental work at the Fercleve Corporation on September 4.

Discussion of Results for August:

The frequency of these shutdowns made it impossible to obtain conclusive information regarding production under the operating conditions of Run No. 3.

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This would entail operation at steady conditions for a period of at least one week. Steady state conditions were apparently reached during two three-day periods, August 11 through 21 and September 1 through 4. The information obtained during these periods can be found in Table 1.

Discussion of Results for Entire Project:

Three runs were made at different length non-circulation periods during the course of this project. In all runs circuit 4 on Rack 21 was milked once every eight hours into a No. 31 capsule. In the first run, one hour of non-circulation was allowed for each milking period. In the second run, the bottom of the rack was frozen off approximately three hours out of each eight. During the third run, there were only two hours of circulation during each milking period.

The results of these runs are presented in Table 2. It can be seen that the withdrawal rates for Runs No. 1 and No. 2 are substantially the same despite the fact that the circulating time of Run No. 2 was 50% that of Run No. 1.

In order to compare the withdrawal rate of Run No. 3 with those of the other two runs, it is necessary to convert the actual withdrawal rate to that which would be obtained if the circuit were producing material of the same assay as runs 1 and 2. The chart "Separation Factor vs. ν " from "Application of Theory to S-50", by Dr. O. E. Dwyer, September 5, 1945 was used for this purpose. This chart is composed of a family of curves corresponding to the equation:

$$S = \frac{1 +}{\nu + e^{-(1 + \nu)y}}$$

Where,

$$S = \frac{C_T}{1 - C_T} \cdot \frac{1 - C_o}{C_o}$$

C_T = Concentration of desirable component at top of column.

C_o = Concentration of desirable component at bottom of column.

and

$$\nu = \frac{XyR}{M}$$

X = Time in days

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TABLE I - Project No. 35

PRODUCTION DATA ON RUN NO. 3

Date	Total wgt. Product in Grams	Average Weighted Assay of Product	Arith. Ave. Bottom Assay In	Arith. Ave. Bottom Assay Out	Total Hours Circulated	Total Hours Operated	Potentiometer Ave. Readings High	Potentiometer Ave. Readings Low	No. Of Cols.	With-Drawal Rate g/c/d	Pitching Leaks, Loss Unusual Behavior, etc.
8/19	1890	1.161	0.960	0.938	5-1/4	24	374	316	15	126	None
8/20	1886	1.162	0.985	0.950	5-3/4	24	392	326	15	126	None
8/21	1897	1.152	0.973	0.963	6	24	400	345	15	126	None
8/19-8/21 Incl.	5673	1.158	0.972	0.950	17	72	389	329	15	126	None
9/1	1895	1.169	0.988	0.964	5-1/2	24	402	348	15	126	None
9/2	1874	1.159	0.994	0.971	6	24	358	315	15	125	None
9/3	1889	1.155	0.966	0.963	6	24	383	320	15	126	None
9/4	661	1.159	-----	-----	2	8	410	340	15	132	None
9/1-9/4 Incl.	6319	1.161	0.983	0.966	19-1/2	80	386	330	15	126	None
8/19-8/21 9/1 -9/4 Total	11992	1.160	0.977	0.958	36-1/2	152	387	330	15	126	None

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y = ln S at equilibrium

R = Withdrawal rate, gms/col/day.

M = Holdup of column in grams.

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For Run No. 3,

$$S = \frac{1.160}{0.967} = 1.200$$

R = 126 gms/col/day

Assume M = 1800 gm/col. and y = 0.322.

From chart, using S = 1.200 and y = 0.322, $\mathcal{V}$ = 3.67

Then,

$$X = \frac{M\mathcal{V}}{y\,R} = \frac{(1800)(3.67)}{(0.322)(126)} = 162.5 \text{ days}$$

For Run No. 1,

$$S = \frac{1.182}{0.956} = 1.236$$

From chart, assuming y = 0.322,

$\mathcal{V}$ = 2.58

Assuming X, y, and M to be constants of the circuit, the withdrawal rate which would have been obtained in Run No. 3, if the material had been withdrawn at the same assay as Run No. 1.

$$R' = \frac{(2.58)(1800)}{(162.5)(0.322)}$$

= 89 gms/col/day

This rate can be compared with the withdrawal rate of 117 gms/col/day obtained in Run No. 1. Hence, a decrease in production rate of 24% was indicated by a decrease in total circulating time of 71%.

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TABLE II - Project No. 35

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EFFECT OF VARIED PERIODS OF NON-CIRCULATION ON CIRCUIT PERFORMANCE

Run No.	Average Circulation per Day in Hours	Arith. Avg. Bottom Assay In	Arith. Avg. Bottom Assay Out	Potentiometer Avg. Reading High	Potentiometer Avg. Reading Low	No. of Cols.	Average Weighted Assay of Product	Withdrawal rate, g/c/d.
1	19.8	0.960	0.952	340	296	16	1.18	117
2	9.3	0.066	0.955	349	297	16	1.18	116
3	5.8	0.977	0.958	387	330	15	1.16	126
							1.18	89*

Final Conclusions:

The results of this project show that:

(1) Production is not appreciably affected by a total non-circulation time of less than fifteen hours per day where the maximum single period of non-circulation is no greater than five hours.

(2) A decrease in production rate of about 25% occurs when there are only six hours of circulation per day occuring in three two-hour periods spaced six hours apart.

Recommendations for Future Work:

On Rack 21, Circuit 4:

(1) Repeat Run No. 3, i.e., circulate two hours during each eight hour milking period.

(2) Run with a circulating time of one hour out of every eight hours.

* Calculated

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Tab 39-1

MONTHLY REPORT FOR PERIOD ENDING

AUGUST 31, 1945

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PROJECT NO. 39-I

VARYING MILKING TIME WITH DIFFERENT RESTRICTOR COILS

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Reported by: William B. Daly Jr.

William B. Daly Jr.

VARYING MILKING TIME WITH DIFFERENT RESTRICTOR COILS

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Purpose

The purpose of this investigation was to determine the effect of increased milking time (actual time required for product withdrawal) on the production of a long circuit.

Progress During August

The circuits under study, a description of the restriction and the average time required to fill the metering capsule are listed in Table I

Table I

Rack	Circuit	Description of Milking System Restrictors	Average Milking Time
14	2	2 type B* restrictor coils, each 10 ft. long, in series with and upstream from a type B freeze off coil, 8 ft. long	75 seconds
14	4	2 type B restrictor coils, each 10 ft. long, in series with and upstream from a type A freeze-off coil, 3-1/2 ft. long	75 seconds
21	1	2 type B restrictor coils, each 10 ft. long, in series with and downstream from a type B freeze-off coil, 8 ft. long	60 seconds
21	3	2 type B restrictor coils, each 8 ft. long in series with and upstream from a Type B freeze-off coil, 3-1/2 ft. long	50 seconds

* An explanation of coil types can be found in the June 1945 Report on this project.

It was possible to gather data on all four circuits during August but these data are meager and their value questionable. This is especially true in the case of Circuits 1 and 3 Rack 21 because operation was spasmodic and at no time during the course of this project did the rack have more than a week of normal operation. Rack 14 was converted to eight milking circuits August 24 at which time data for only two weeks were available.

The results appear in Table II. This table also lists the performance of these circuits with the standard No. 1 coils. No data for past performance were available for Circuits 1 and 3 Rack 21. Circuit 1 was an experimental circuit and Circuit 3 was using a different size metering capsule before they were selected for study under this project.

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Table II

Rack	Circuit	No. of Cols.	Meter Capsule	Performance With Standard Coil (Month of June 1945) Production Gms/col/day	Ave. Weighted Assay	Performance With Added Restriction Production Gms/col/day	Ave. Weighted Assay
14	2	20	23	107	1.184	106[1]	1.184
14	4	23	31	128	1.188	117[1]	1.184
21	1	22	23	No Data Available		84[2]	1.202
21	3	18	23	No Data Available		101[3]	1.188

1. Data cover period of August 9 to August 23.
2. Data cover periods of July 15 to July 21, August 7 to August 11 and August 15 to August 21.
3. Data cover periods of June 7 to June 11, June 15 to June 20, July 13 to July 21, August 7 to August 11 and August 15 to August 21.

A 50 foot coil of 0.025" I.D. nickel tubing was prepared for use in connection with this study but was not installed so its value as a restrictor coil is still unknown.

Discussion of Results

The time required to fill a metering capsule using the standard No. 1 coil (Type A) was approximately seven seconds. This led to the suspicion that, during a milking, the metering capsule was being filled from the center columns of the circuit and the circuit pressure then equalized from the end columns. Obviously this would be more noticeable in the case of long circuits (18 to 25 columns).

As a result of adding various types of restrictor coils to the circuits' milking systems the milking time was greatly increased but no appreciable difference can be seen in the circuit performance before and after the additions.

Conclusions

The data are insufficient to warrant any definite conclusions but it may be said that no appreciable change in circuit performance seems to be brought about by increasing the milking time.

Recommendations for Future Work

More conclusive data should be obtained on long circuits to permit a definite conclusion regarding the value of increased milking time.

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Tab 39 II

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 39-II

STUDY OF MILKING PROCEDURES ------ IMPROVEMENT OF TECHNIQUE

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By: John D. Hoffman
Mark D. Snyder

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John D. Hoffman

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STUDY OF MILKING PROCEDURE ------ IMPROVEMENT OF TECHNIQUE

OBJECT

The purpose of this project was to study the performance of the "automatic milkers" used for removing product from the plant circuits with a view to its operation and effectiveness.

DESCRIPTION OF AUTOMATIC MILKING APPARATUS

The automatic milker is shown in Drawing 9-17. The No. 1 and No. 2 freeze-off coils acted as valves to control the withdrawal of product. The flow of water and air through these coils* as well as through the top and bottom intercolumn connectors, was regulated by solenoid valves which were controlled by toggle switches located in the control room. When these switches were operated manually, the milking process was termed "semi-automatic". They could also be operated by an automatic timer, in which case the process was termed "full automatic". Semi-automatic was used most at S-50. The No. 23 capsule acted as a metering device limiting the amount of product withdrawn to about one pound. On very good circuits, a No. 31 capsule was used in place of the No. 23 capsule permitting the withdrawal of about a pound and a half. The metering capsule was dumped into a No. 120 capsule, which was changed after four or five milkings had accumulated.

Adherence to the following specifications for installation was essential for the proper operation of the milker.

(1) The milker should be attached to the center column of the circuit, or as near to it as possible.

(2) The No. 1 coil must be of the restrictor type. In the present set-up, the coil as shown is followed by a restrictor composed of eight feet of unjacketed, heavy-walled, one-eighth inch link line (.065 I.D.) containing an equal length of 0.054 inch diameter nickel wire. This system gives a milking time of thirty to forty-five seconds while the restrictor coil alone gives one of about five seconds. This unjacketed restrictor coil is not shown in the diagram.

(3) The metering capsule must make about a thirty-degree angle with the bottom of the duct and dump through the lower end.

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* 100 pound steam was sometimes used in place of an air purge to speed the milking operation.

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(4) The capsule must rest between the two steam lines that run along the floor of the duct.

(5) The entire system leading from the metering capsule to the No. 120 must be free from contact with the top intercolumn connectors or other potential cold spots.

(6) The No. 2 coil must be of the unrestricted type, and contain at least four feet of link line.

(7) The link line leading to the No. 120 capsule must be coiled in a manner that will have the least effect on the scale readings.

(8) The top of the No. 120 capsule must not bind where it passes through the duct floor.

(9) A gauge should be installed between the metering capsule and the No. 2 coil, to enable the operator to check on the filling and dumping of the capsule.

This is not shown in the diagram.

PROCEDURE

In order that the best milking method could be developed and applied quickly, many observations were made during the early stages of plant operation and product withdrawal. As a result, the "automatic milking apparatus" as shown in the diagram was conceived by J. D. Hoffman and J. K. Ballou on Jan. 1*, 1945 and put into initial operation January 10.

As the installations were completed on various racks, this group made frequent checks during the first days' use in order to detect mechanical flaws and acquaint the operators with the prescribed techniques. However, it became evident that occasional checks would be necessary in order to avoid carelessness on the part of the operators and maintain production at the desired level.

The observations made during the milking operation usually uncovered the reasons for low production and in some cases enabled estimates to be made of the loss in production due to improper operation. These irregularities were reported to the appropriate authorities for positive general action and the crews involved were instructed in the proper methods of operation.

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* The basis idea of using frozen material as a valve and a capsule as a metering devise was advanced by the Naval Research Laboratory.

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RESULTS

A. Defects Noted:

The following defects of milking were noted subsequent to the installation of the automatic milker and are listed in roughly descending order of occurence.

(1) Plugged monorail and equipment due to moisture from improper installation or conditioning.

(2) Cold spots along the monorail due to cold ducts, and due to water lines and freeze-off coils touching unfrozen lines; also insufficient time to unfreeze monorail. Water sometimes drips into I.C.C.'s from dead-end pipes.

(3) Absence of a restrictor coil when making a provisional milking.

(4) Reverse positions of the No. 1 (restrictor) and No. 2 freeze-off coils.

(5) Intercolumn circulation due to the separation of link lines from the copper tube carrying the freeze-off water.

(6) Improper positioning of the metering capsule.

(7) Purposely milking directly into the No. 120 capsule during the final addition to that capsule.

(8) Binding scales.

(9) Lack of proper circulation across bottom of rack due to plug or improper hook-up.

B. Recommendations made:

As these defects in milking were discovered, they were discussed with the operating personnel. If the defects were of a serious nature, such as interchanged No. 1 and No. 2 freeze-off coils or top intercolumn connectors cold at the time of product withdrawal, the facts were communicated to the proper authorities for general action. As a result of the various recommendations and general advice, milking technique gradually improved.

C. Some Typical Improvements in Production:

The results of this project were largely of an intangible and qualitative nature, and the benefits were often concerned with the immediate solution of operational difficulties. However, some actual studies of the effects upon production were made as illustrated in Table 1.

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TABLE NO. I

Comparison of Production of Circuits before and after Milking Inspections*

	Rack	Circuit	Production Before Inspection Grams per column per day	Assay	Production After Correction Grams per column per day	Assay	Defect Found
1.	20	2	73	-6	107	-2	a
2.	17	4	41	-6	98	-2	a
3.	6	2	30	-5	130	par	b
4.	6	3	30	-5	110	par	b

a. Plugged monorail near the middle of the circuit.

b. Circulation, but not through the storage tank. (improper circuit hook-up).

It is obvious from the above table that the improvement in production was enormous.

D. Recommended Milking Procedure:

1. Raise the material pressure to 1800 psi. so that pitching will not occur during milking.

2. Freeze bottom intercolumn connectors and coils. Freeze the bottom 3 min. before unfreezing the top. Every effort must be made to prevent intercolumn circulation.

3. Unfreeze top I.C.C.'s. Make certain that they are hot.

4. Unfreeze the No. 1 coil.
   a. Make certain that the top intercolumn connectors are hot before unfreezing the No. 1 coil.
   b. Make certain that the No. 2 coil is frozen before unfreezing the No. 1 coil. Important!
   c. Read gauges before and after milking. Gauge must drop about 150 psi. on both ends of the circuits simultaneously.

5. Freeze the No. 1 coil and the top I.C.C.'s.
   a. Check these steps.
   b. Make certain that no material lines touch the I.C.C.'s in such a manner that they will become frozen off unintentionally.

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* See Project 15 (June report) for original data on runs 1 and 2; runs 3 and 4 were obtained during August, 1945.

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6. Unfreeze coil No. 2 and the bottom I.C.C.'s.
   a. Check the increase in weight of the No. 120 capsule, and record.
   b. Make certain that the circuit is circulating.

It must be pointed out that milking without checking all of the steps cannot give consistently good results. The procedure should take from 30-40 minutes.

FUTURE WORK

A. It is recommended that the project be continued and expanded if possible.

B. An expanded program would involve close cooperation with the Product Control and Material Accounting Sections so that non-ideal behavior of any operating circuit could be acted upon immediately. As the various circuits lost production they could be systematically observed at least once during every shift until the operational difficulty were removed. Such a procedure would minimize the shift-to-shift carry-over of many of the irregularities given in Section above.

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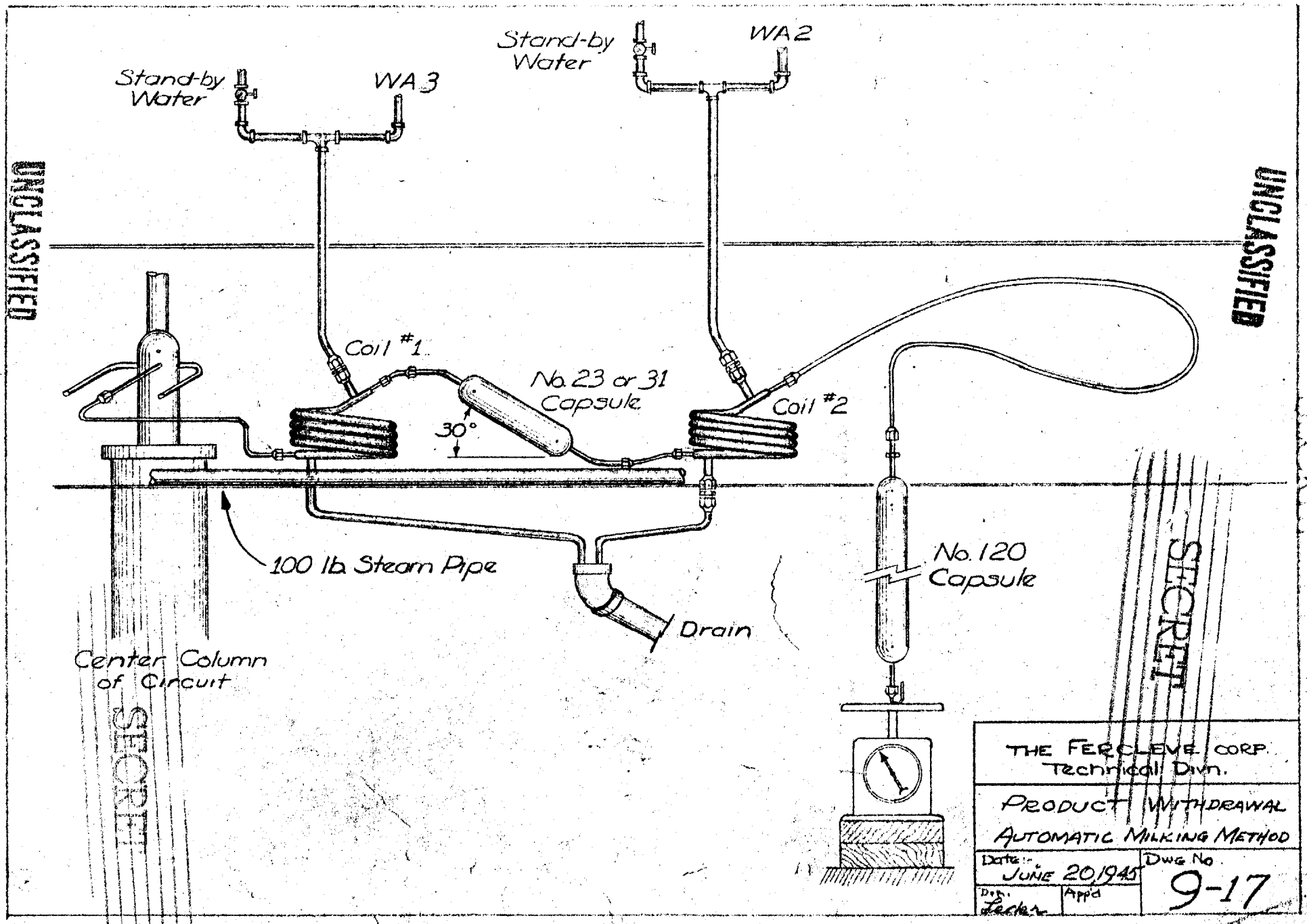

Tab 40

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 40

BEST OPERATING CONDITIONS WITH 450 POUND STEAM PRESSURE

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By: Daniel Frishman

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BEST OPERATING CONDITIONS WITH 450 POUND STEAM PRESSURE

PURPOSE:

All of our experience to June 30th, at S-50 had been with 1000 psi. steam. Although we would have liked to study the thermal diffusion process using other steam pressures and other material pressures we were too busy with other essential work. Late in June the new powerhouse which would supply 450 psi. steam to racks 1 - 7 was nearing completion and several questions arose concerning best operating conditions. A study of the literature was not very helpful; therefore we planned an experiment to start as soon as steam would be available on Rack 1, to determine as soon as possible the best material pressure, pitching pressure, expected production and all changes in operating technique that might be necessary.

METHOD:

The four circuits on Rack 1 were operated from separate storage chambers at four different material pressures -- 700, 1000, 1250 and 1500 psi. for circuits 1, 2, 3 and 4 respectively. Each circuit was milked and sampled to determine its productive capacity.

RESULTS:

Whereas with 1000 psi. steam, pitching occurs at or below 1200 of 1300 psi. material pressure, with 450 psi. steam pitching occurs at about 450 psi. material pressure. Since columns can be operated safely at 2000 psi. material pressure, a range of operating pressures from 500 - 2000 is possible. We investigated the range 700 - 1500 psi. and found that 1500 psi. material pressure gave maximum production. A minimum in production seemed to exist at 1000 psi. material pressure but this has not been verified on other circuits and therefore cannot be considered as definitely real. The report of July, 1945 gave in detail the results of the experiment.

Other proof that 1500 psi. material pressure gave better results was found in observing the results of Racks 2 - 7. When racks 2 - 7 were started with 400 psi. steam they were operated at 1000 psi. material pressure; when we learned that 1500 psi. gave better results the pressure was raised to 1500 psi. and a 30% increase in production was observed. After the milking study on Rack 1 was completed a rate-of-rise study, (Project No. 19-III) was started.

When rate-of-rise studies were completed on Rack 1 all columns not included in the test were sampled twice. No consistent difference was noticed between the first and second samples.

The following are the results obtained:

TABLE NO. I

Material Pressure	Number of Columns Sampled	Average Assay	Assay at Bottom of Col.	Separation Factor
700	15	1.229	0.950	1.294
1000	17	1.254	0.957	1.310
1250	14	1.257	0.965	1.303
1500	14	1.276	0.950	1.343

The results are compared with the average assays of the milking obtained during the individual column test with 1000 psi. steam.

TABLE NO. II

Separation Factor of Same Columns during Individual Column Test with 1000 psi. steam pressure and 1500 psi. material pressure (Project 1 data, 100 g.c.d. milking rate.)	Material Pressure Project 40, 450 psi. Steam	Average Separation Factor at Equilibrium with 400 psi. steam and designated Material Pressure.	Ratio Col. 3 to Col. 1.
1.238	700	1.294	1.045
1.282	1000	1.310	1.022
1.251	1250	1.303	1.042
1.268	1500	1.343	1.059

The last column in the above table is the ratio between the separation factor at equilibrium (specified material pressure, and 400 psi. steam) and the assays reported in Project 1. Fifteen hundred psi. material pressure shows a definite increase over the others. Equilibrium data are not a good indication of the productive capacity, but they do help to confirm our previous data.

The results of Project 19-III are in substantial agreement with the results of this project.

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PRODUCTION AND ENERGY CONSUMPTION:

The following table compares the production with 1000 psi. steam with that at 450 psi. steam. The 1000 psi. data is the average production for May and June; the 450 psi. data are the production for August 1 - 20 (1500 psi. material pressure.)

TABLE NO. III

Rack	Grams/col/day at Par 1000 psi. Steam	450 psi. Steam	Ratio - Production 450 psi. Steam to Production 1000 psi. Steam
2	123	91	.74
3	124	80	.65
4	145	100	.69
5	135	136	1.01
6	117	110	.94
7	108	108	1.00
Averages	124	104	.84

Racks 3 and 4 suffered circulation and operational difficulties because of Transfer Room repair work; neglecting their production the average production with 450 psi. steam was 92% of what it was with 1000 psi. steam.

With 1000 psi. steam 10,000 BTU's per col. per min. were consumed; with 450 psi. steam about 7,500 BTU's per col. per min. were consumed. Operating with 450 psi. steam, 1500 psi. material pressure and 140° F. circulating water temperature, the production can be 90 - 100% of the production with 1000 psi. steam, yet the energy consumption with 450 psi. steam is 75% of that with 1000 psi. steam.

CONCLUSIONS AND RECOMMENDATIONS:

This project indicates:

1. Production increases with increase in pressure.

2. For the same material pressure, production at a lower steam pressure (450 psi.) is more economical.

A thorough study of the effect of steam temperature and material pressure should be made to determine the most economical operating conditions. Rate-of-rise studies would be the most reliable study method.

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SUMMARY:

With 450 psi. steam, production increases with material pressure. There is an indication of a small minimum at 1000 or 1250 psi. material pressure but this needs further confirmation. Production at 1500 psi. material pressure and 450 psi. steam is very close (90 - 100%) to the production with 1000 psi. steam and 1500 psi. material pressure. Production with 450 psi. steam is more economical than at 1000 psi. steam. A thorough investigation of the most economical steam and material pressures should be made.

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FINAL REPORT

SEPTEMBER 25, 1945

PROJECT NO. 41

COLUMN CONSTRUCTION AT CONTINENTAL GIN COMPANY

Reported by: Roy W. Greenlee

Roy W. Greenlee

Project Supervisor:

George F. Nellett

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COLUMN CONSTRUCTION AT CONTINENTAL GIN COMPANY

I. OBJECT

The purpose of Project No. 41 was to carry out experiments in new types of column design, to evaluate the modifications individually by special tests for the purpose of achieving design, and to assist the Continental Gin Company in placing the new methods of column construction upon a production basis.

The decision to modify column design had been made as a result of the examination of broken columns, in which expansion of the copper tube at the silver soldered joints was usually observed. Attempts to work-harden the tube near the sleeve by swaging had proved ineffective. See Project No. 28.

II. PROGRESS BEFORE AUGUST

A. Dissembly:

It was hoped that new columns could be constructed from old ones by splitting open the defective copper lengthwise in order to prevent scarring the surface of the nickel tube, which would be re-used. It was immediately clear, however, that the nickel had received so much abuse during fabrication of the old column that such precautions were not justified, and it was not considered advisable to re-use the nickel tube without refinishing.

The procedure decided upon for dissembly was (1) heating the nickel stub weld to the softening point, relieving the internal strain, (2) sawing through the center sleeve and the stubs at both ends, (3) forcing the nickel tube out by hydrostatic (oil) pressure. The 24' lengths of used nickel tube were now to be brought down to 1.664" O.D. by use of a centerless grinder.

B. Silver Soldering Copper Joint by Induction Heating:

The first attempt to eliminate the areas of annealed copper resulting from silver-soldering of the sleeve joint was to heat evenly by electrical induction instead of the gas torch.

The advantages of this method were expected to be:

(1) Localization of the heating, by choice of the proper coil.

(2) Further localization of the annealing by water cooling the copper tube up the sleeve.

(3) Speed and ease of operation.

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The use of high frequency current for induction heating of a copper object was apparently a new field, and it was necessary to perform several experiments with different types of induction coils in order to find the optimum conditions for silver soldering.

The joint to be soldered in each case consisted of the usual 4" sleeve, with silver wire solder in the annular grooves along the inside of the sleeve, 5/8" from the ends. A hinged disc was clamped next to the end of the sleeve, and a steady stream of cold water was directed on the tube at the base of the disc.

The following is a tabulation of the conditions for and results of operation of 7 special copper induction coils, cooled with internal circulating water, in the usual way. The current source was a Tocco generator, delivering 9.600 cycles/min.

TABLE I

Coil	Field Amps	Line Volts	Line Amps	K.W.	KVAR	Condenser Unit	Results
1. Two Single Turn 1/4" Copper Coils Operating In Parallel, spaced 2-1/4" apart.	4.0	240	100	23	-10	46	Slow, Insufficient Heating.
2. Two Turns, 3" apart, in Series, Single 1/4" Copper tube	4.8	290	90	19	-15	69	Slow, Heating Localized to a Narrow Band in Center
3. Four Turns, 7/8" apart, in Series, Single 1/4" Copper.	4.2	290	60	12	+15	46	Slow, Insufficient Heating
4. Five Turns, 5/8" apart, in Series, Single 1/4" Copper	3.3	290	100	11	+28	46	Slow, Insufficient Heating
5. One Turn Flat Copper Band 3-1/2" Wide with 1/4" x 1/2" Flat Copper Tubing Soldered to the Ring	5.0	290	190	40	+10	207	Machine Overloaded
6. Four Turns, 1/4" x 1/2" Flat Copper Tubing 7/8" apart, in Series, (1/2" from Sleeve)	4.0	240	90	10	-10	144	Slow, Insufficient Heating
7. Four Turns, Spaced Two Together at Each End, Series, 3/8" Ovaled Copper Tube.	4.4	280	50	13	+ 6	46	Heated Evenly and Fairly Rapidly, Good Operation

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Coil No. 7 is seen to be the only one suited to the purpose, although a coil similar to No. 6, but with a smaller diameter, would probably have also been satisfactory. The heating was fairly rapid and even, it being necessary to allow the sleeve to become quite red hot before the temperature of the tube inside was high enough for the solder to flow. (In attempting to silver solder a joint using a similar sleeve made of Monel, the difficulty of heating the inside was considerably greater).

The steady flow of water on the copper tube up to the special disc (next to the sleeve) was sufficient to cool the exposed copper effectively, and keep 1/2" of the outside sleeve edges below red heat.

The resulting joints appeared satisfactory except that in no case did appreciable solder appear at the edge of the sleeve. On sectioning the joints, it was found in general that soldering had not been effected in the zone between the edges and the solder grooves.

Table No. 2 shows the results of Rockwell "F" hardness tests made on the inside surface of two such joints, and calculated approximate yield strengths, based on the mean between .015 and .040 mm. grain size. For comparison the available corresponding figures for torch soldered joints, and for unsoldered copper tube, are supplied. (H.K.F. blueprints, X-107, X-113).

It can be seen from Figure 1, in which these results are plotted, that the yield strength of all copper not heated by soldering is approximately 50,000 psi. but this value drops sharply in all joints to a very small figure in the central areas, which had undergone the most heating. However, it should be observed that the fall in strength of the torch soldered joints begins 2" beyond the edge of the sleeve, while those made by induction heating in no case show appreciable decrease as close as 1/8" to the sleeve, although falling rapidly within the sleeve area itself. The cooling during silver soldering by this method was obviously effective in preventing any of the extended copper tube from being annealed.

Although adoption of this method in column construction would eliminate the four major zones of copper tube weakness near the center and end sleeves, it should be be noticed in examining the data that the entire joint is weak and a potential point of failure. When a 5000 psi. hydrostatic test was given two of the joints soldered by induction heating, failure by expansion was observed, not in the copper tube, but the joint itself.

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COMPARISON OF HARDNESS AND YIELD STRENGTH OF DRAWN COPPER TUBE, TORCH AND INDUCTION HEAT SOLDERED JOINTS

TABLE NO. II

Distance From Sleeve Center (Inches)	Joints Soldered by Induction Heating: Rockwell "F" Hardness No. 1	Rockwell "F" Hardness No. 2	Yield Str. (x1000 psi.) No. 1	Yield Str. (x1000 psi.) No. 2	Ave., 4 Gas Torch Soldered Joints: Rockwell "F" Hardness	Yield Str. (x1000 psi.)	Drawn Copper Tube: Rockwell "F" Hardness	Yield Str. (x1000 psi.)
6.00					91.0	49.5		
5.00					91.3	50		
4.00					91.5	50		
3.50	96		54					
3.25	95		53					
3.00	96	96	54	54	74.2	34		
2.75	95	96	53	54				
2.50	96	95	54	53			90.5	48.5
2.25	95	95	53	53				
2.12	94	94	52	52				
2.00	80	94 (93)	39	52 (51)				
1.75	78	84 (60)	37.5	43 (21)	55.8	17		
1.50	76	56	36	17			89.0	47.5
1.25	67	54	27	15				
1.00	48	48	10	10				
0.75	43	42	5	4				
0.50	62	39	23	1.5			91.5	50
0.25	54	32	15	0				
-0.25	37	36	0	0				
-0.50	41	37	3.5	0			87.0	46
-0.75	42	36	4	0				
-1.00	43	37	5	0				
-1.25	58	43	19	5				
-1.50	69	46	29	8			89.5	48
-1.75	78	51 (74)	37.5	12.5 (34)	56.8	18		
-2.00	79	89	38	47				
-2.12	90	91	48.5	49				
-2.25	95	92	53	50				
-2.50	95	92	53	50			88.0	47
-2.75	95	91	53	49				
-3.00	95	92	53	50	79.0	38.5		
-3.25	93		51					
-3.50	93		51					
-4.00					90.4	49		
-5.00					90.8	49		
-6.00					92.1	50.5		

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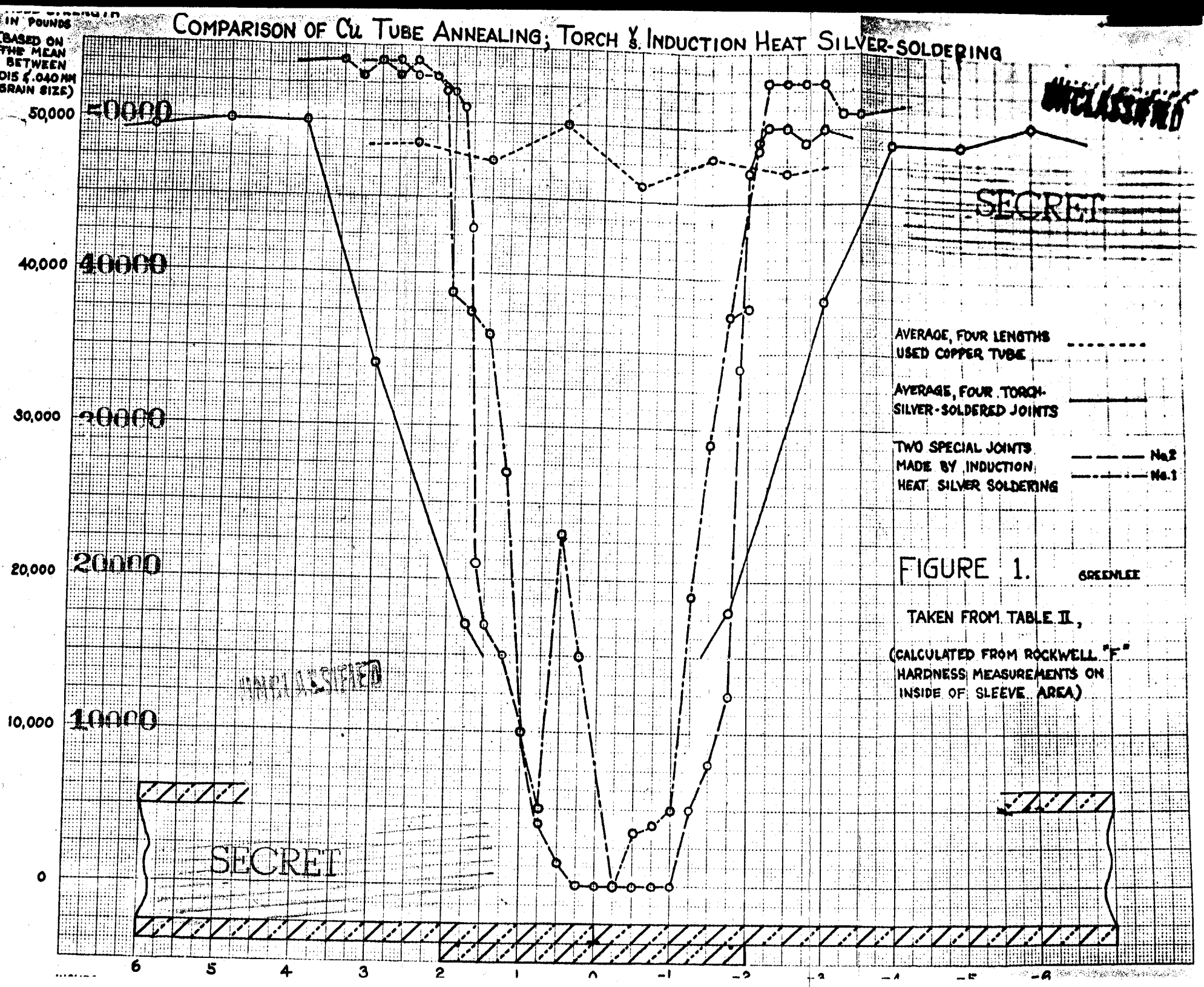
COMPARISON OF Cu TUBE ANNEALING; TORCH & INDUCTION HEAT SILVER-SOLDERING
IN POUNDS
(BASED ON THE MEAN BETWEEN .015 & .040 MM GRAIN SIZE)
50,000
40,000
30,000
20,000
10,000
0
50000
40000
30000
20000
10000
UNCLASSIFIED
SECRET
AVERAGE, FOUR LENGTHS USED COPPER TUBE
AVERAGE, FOUR TORCH-SILVER-SOLDERED JOINTS
TWO SPECIAL JOINTS MADE BY INDUCTION HEAT SILVER SOLDERING
No.2
No.1
FIGURE 1.
GREENLEE
TAKEN FROM TABLE II,
(CALCULATED FROM ROCKWELL "F" HARDNESS MEASUREMENTS ON INSIDE OF SLEEVE AREA)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
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CHICAGO

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Another objection already mentioned was the failure of the solder to flow into the 5/8" area outside of the solder grooves. This was undoubtedly due to loss of heat through conduction to the adjacent water-cooled copper tube extension. The smaller amount of annealing suffered by the copper over this distance can be estimated from Figure 1, but it was still sufficient that application of 29,000 psi. tensile caused appreciable elongation and shrinkage from the sleeve.

This fault, as well as the general annealing of the sleeve, must be accepted as a relatively minor evil inherent to application of induction heating with an exterior coil. The first successful tests on rolled joint construction diverted all attention from this problem.

C. Soldering Ferrules for Lunkenheimer Fittings by Induction Heating:

In connection with the work on the joint soldering problem, another use of induction heating silver soldering was conceived. This application was to the usually tedious soldering of the ferrules for Lunkenheimer fittings in the construction of link lines and sample tubes.

The method consisted of subjecting the assembled fittings and the necessary solder to the field produced by a coil carrying a high frequency current.

The coil used was simply a long narrow U made of bronze, square on cross section, drilled out inside to carry cooling water. Six assembled fittings were now distributed along the slot, supported by holes drilled in an underlying block of transite. Within 20 seconds after beginning the 9,600 cycle, 150 ampere current flow, soldering of the ferrule was complete and perfect.

Such an arrangement could easily be adapted to assembly line operation, the assembled fittings passing continuously through the field of a similar oblong coil.

III. PROGRESS DURING AUGUST-SEPTEMBER

A. Experimental:

1. Construction of Special Joint Testing Unit:

Preliminary tests made on a special Monel-sleeve rolled copper joint (intended to supplant the silver soldered copper joint) had been very encouraging.

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In preparing for possible adoption of such a design, it seemed advisable to arrange means for testing experimental joints by simultaneous application of several critical conditions encountered in plant column operation.

Allowing large safety factors, the conditions were (1) 25,000 lbs. tensile (29,000 psi. copper) (2) 5000 psi. hydrostatic (3) rapid variation of the temperature between 25° and 125° C.

The tensile load was exerted by grasp rod caps, V-threaded 16 TPI to the copper tube extensions of the joint. For application of the hydrostatic pressure, both grasp rods were drilled laterally, and short tits were brazed to them. The bottom tit was attached by a link line to a hand operated pump, provided with 5000 psi. pressure gauge. In order that the oil capacity of the inside of the joint should be small, a hermetically sealed thin-wall steel can, provided with spacers, was constructed to fill virtually all of the enclosed volume.

The need for rapid change of temperature dictated this last arrangement, since the heat capacity of the system could thus be materially reduced. To impose this temperature change, a special jacket was built for rapid circulation of oil (at two different temperatures) around the entire outside area of the joint. The jacket was tightly sealed along the sides of the extended copper tubes (without affecting the tensile tests) by a small stuffing box at each end, and inlet and exit 1/4" pipe elbows were welded on the side near the bottom and top, respectively.

In operation, either hot or cold oil could be supplied to the inlet through a 3/8" copper line by operating a T-valve. This valve was connected directly to (1) a 50' coil of 3/8" copper tube immersed in an oil bath maintained at 150° C. (2) a 50' coil of 3/8" copper tube immersed in a overflow tap-water bath at about 17° C. Circulation was provided down stream from the oil jacket by a small valve type pump capable of delivering about 1 gpm. (of the high grade turbine oil used) at room temperature. An overflow valve and a reservoir were provided downstream from the pump, a simple T-joint distributing the oil to the coil being circulated. The volume of each coil was about 30 cu.in., while the estimated volume of the remainder of the circulating system was 15 cu.in.

The resultant temperature of the oil contacting the jacket was either 25° or 125° C. (as indicated by thermometers in the inlet and exit jacket connections) according to which coil was circulated. The change could be effected within 30 seconds.

Five views of this special joint testing unit are given in Figures 2-6 inclusive:

Figure 2.

Rear elevated view, showing 150° C. oil and 17° C. overflow water tanks, the immersed coils, and their connection through the T-valve to the jacket around the sleeve.

Figure 3.

Side view, showing burner heated oil tank and hand operated static pressure pump.

Figure 4.

Front view of Riehle load machine, showing connection to the jacketed test joint.

Figure 5.

Oblique elevated view, showing 5000 psi. gauge reading. Note oil reservoir tank and circulating pump.

Figure 6.

Rear view, showing link line connection between hand pump and bottom of joint. Note thermometer at jacket fitting.

2. Use of Special Rolling Tools:

Construction of rolled joints involving copper and nickel tubes required the use of a specially designed rolling tool in both cases. These can be seen as applied to actual column construction in Figures 28 and 32 respectively. Each consisted of a hardened steel cylinder, with 3 beveled rollers fitting loosely in as many slots around one end.

In use, the rollers were held out against the side of the tube being rolled by a freely rotating pointed spindle. This rod was threaded into a fixed bearing, so that by loosening the set nut and making a small increase in the extension of the spindle, the rollers would operate through a slightly larger diameter.

Four to six passes through a joint being rolled were usually necessary, increases in diameter from .001" to .005" being made each pass. The resulting rolled area was found to be closely concentric with the rest of the tube, if care had been taken to align the sleeve properly with the tube being rolled.

FIGURE 2

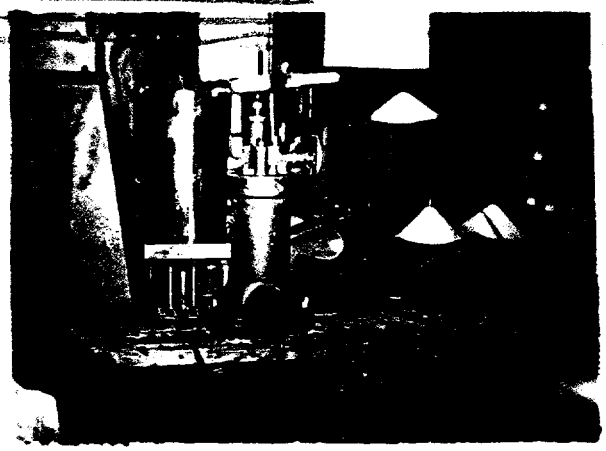

FIGURE 3

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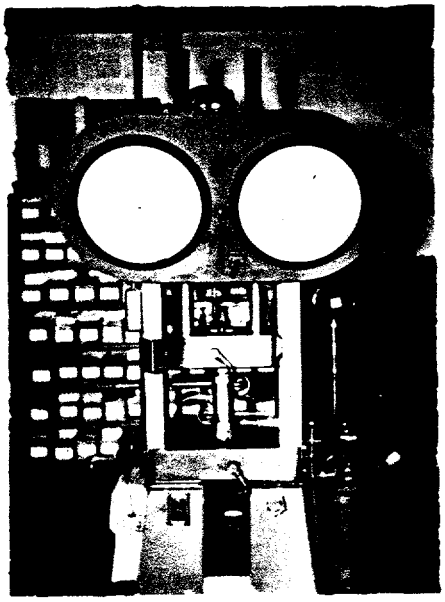

FIGURE 4

SPECIAL JOINT TESTING UNIT

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FIGURE 5

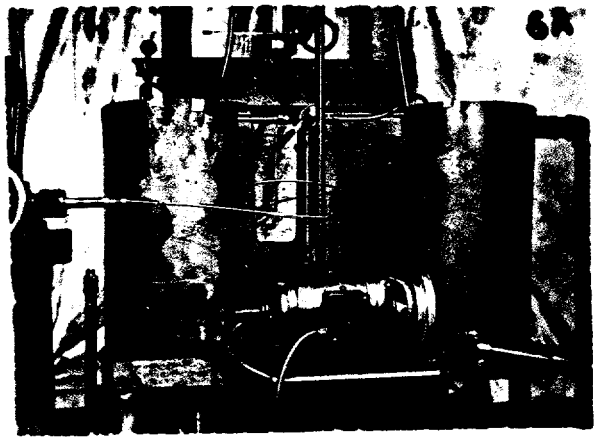

FIGURE 6

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3. Results of Rolled Center Joint Construction:

The special rolled-copper center joint first tried consisted of a 6" length of Monel or nickel tube drilled slightly smaller than the outside of the copper tube, with a series of shallow annular grooves turned into the inside area. The joint was assembled by "sweating" the sleeve on the swaged ends of the copper tubes being joined. These were now expanded to approximately their former diameter by a device similar to a boiler tube roller.

The exact procedure used for assembling a test joint of this type (with copper tube recovered from a assembled column) is described graphically in Figure 7, CB-1171-B.

(A) A 5-7/8", 2.500" O.D., 1.984" I.D. Monel sleeve was prepared, and annular grooves .030" deep, sides 60° to the lateral, .085" flat bottom, were turned 1/4" apart on the inside surface.

(B) The 2.000" O.D., 1.696" I.D. copper tubes to be joined were then swaged down .011" for 3-1/8" from the ends. These constricted ends were then inserted into the sleeve, which had previously been expanded by heating to dull redness with a torch. The joint was immediately shrunk tight by quenching with cold water, speed being required to prevent annealing the hard-drawn copper.

The "sweating" operation constricted the copper tube an additional .005", for a total of .016", the final I.D. being 1.680". In rolling the tube back to the original I.D., about 50% more copper than the calculated amount is available for filling the sleeve grooves

(C) The rolling operation was performed as described in III-A2, .003-4" being rolled out each pass at first, less with the final passes, until the I.D. of the sleeve was only .001-2" smaller than originally, the remainder to be removed by honing.

The resulting joint appeared to be tight, the two pieces of tubing having been rolled together and so intimately bonded that they were indistinguishable, even after etching. When the joint was subjected to the special testing conditions described in III-A-1 (29,000 psi. tensile, 5,000 psi hydrostatic, and temperature change from 25° to 125° C.), no failure occurred at the lower temperature over a 20 minute period.

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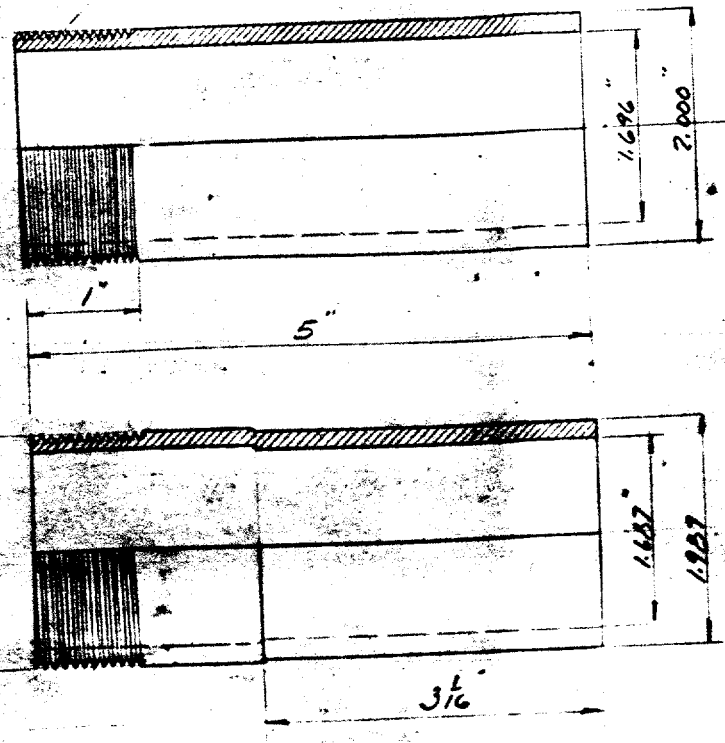

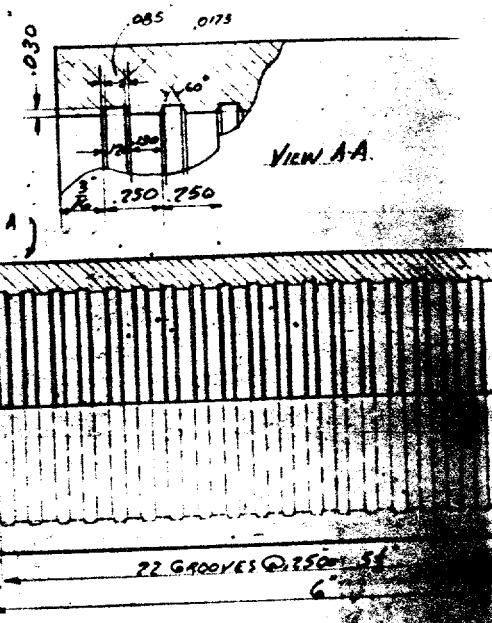

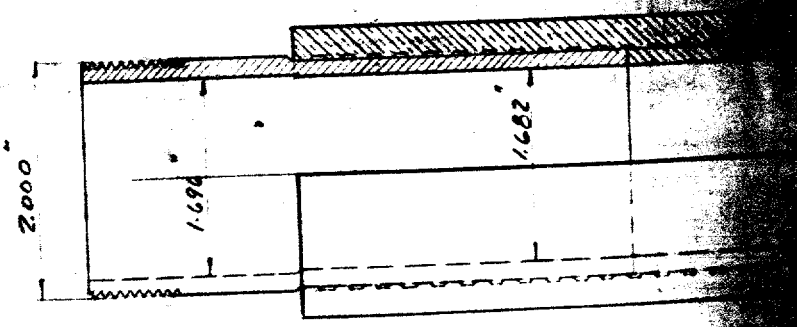

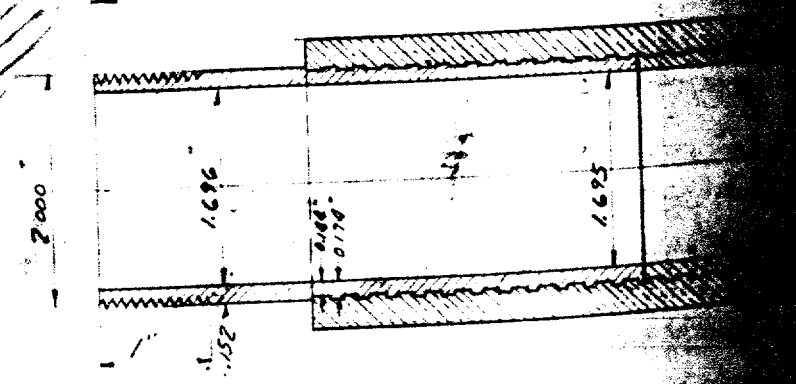

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		APPROVED			

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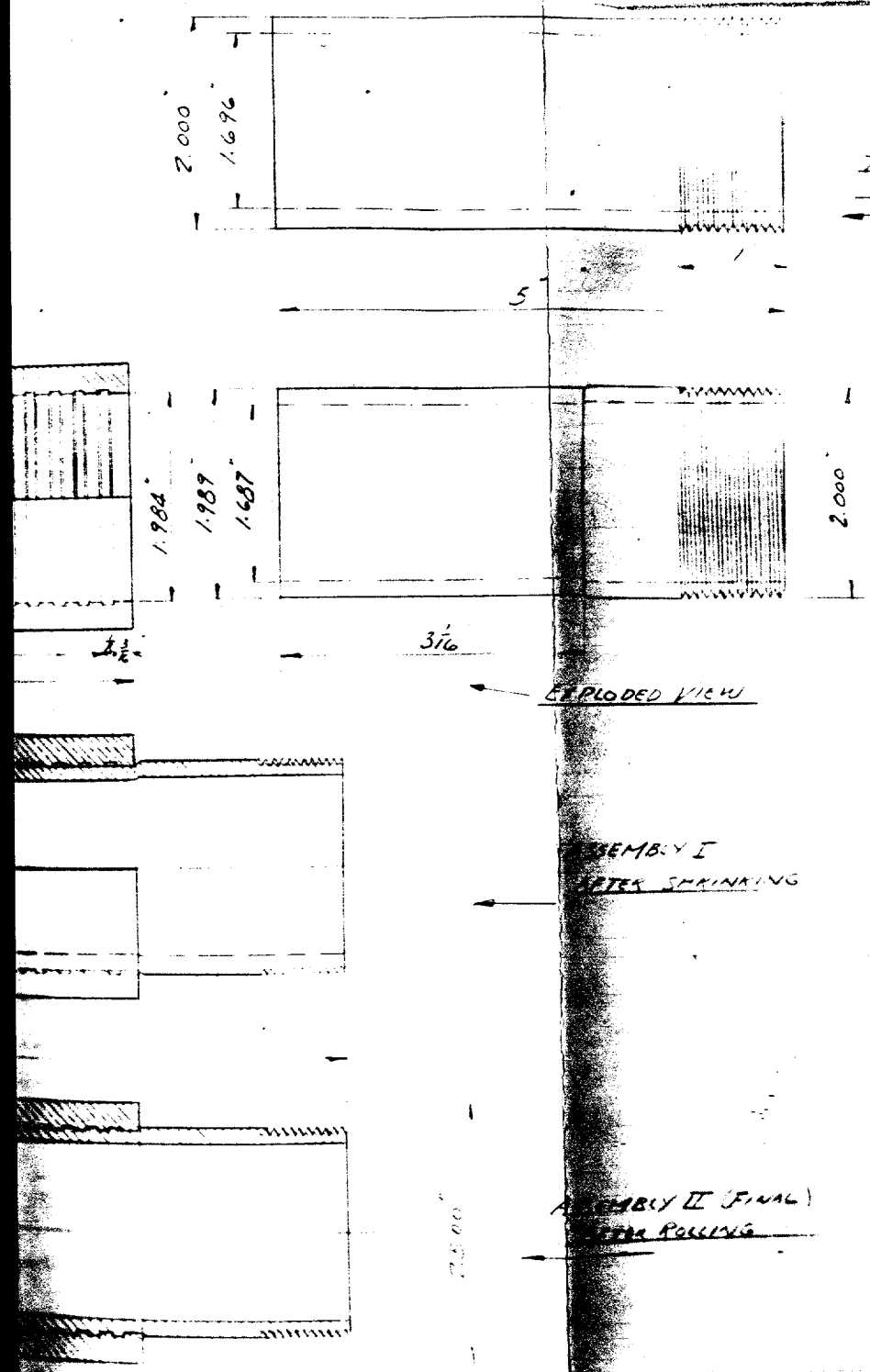
FIGURE 7



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However, 4 minutes after changing to the higher temperature, the copper tube began to yield at the threads cut to attach the grasp rod cap.

The joint itself was not disturbed and apparently would have withstood more critical conditions if they could have been applied. Sectioning the joint showed that no shrinkage or appreciable elongation had occurred, and the grooves were well filled. The fact that another joint with incompletely filled grooves also took a 29,000 psi. tensile at the lower temperature was considered evidence that a properly constructed center joint of this type would have a yield strength equalling the copper tube itself (50,000 psi.).

4. Results of Rolled End Joint Construction:

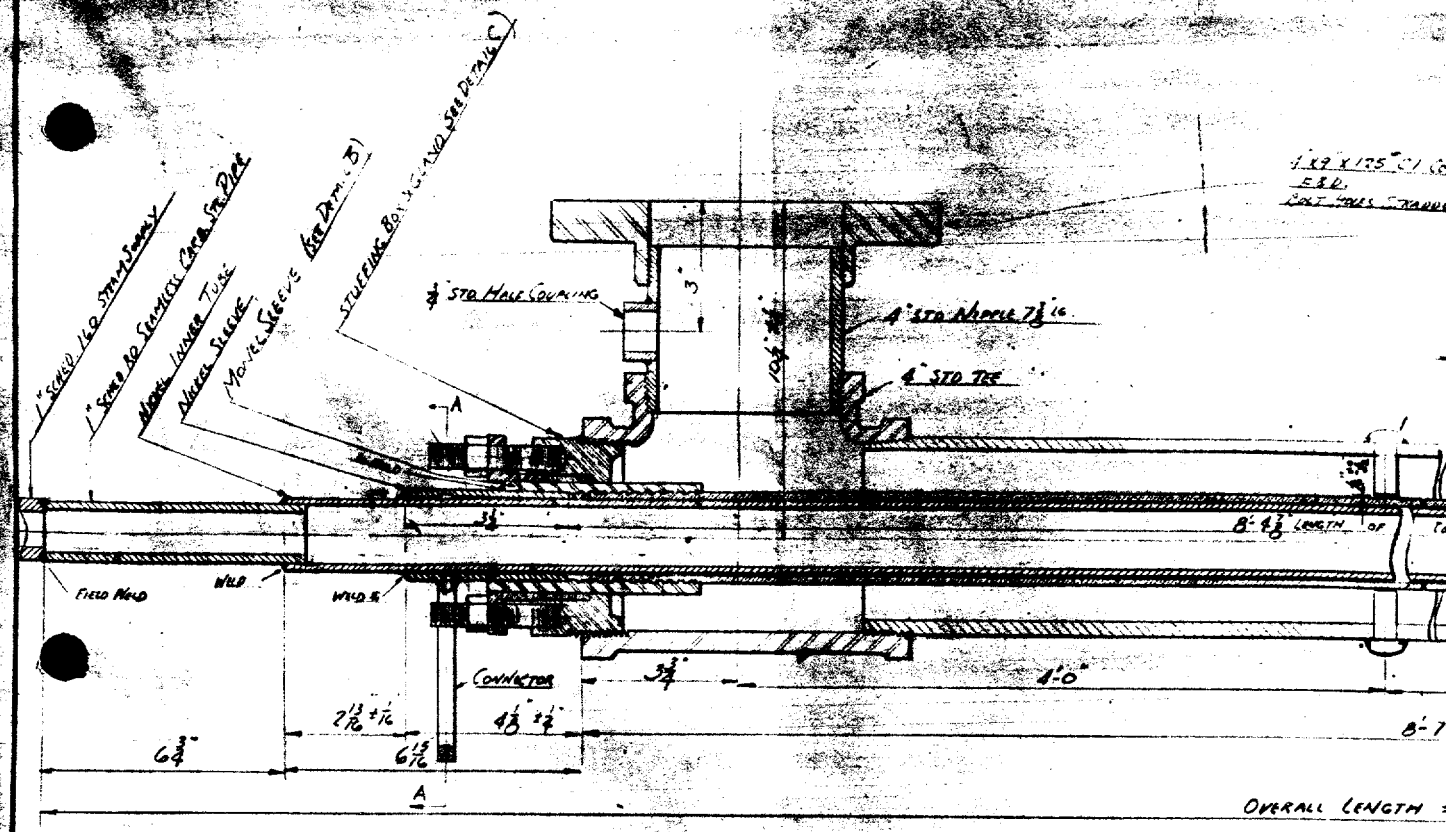
The merit of the method of bonding the copper tube to a nickel or Monel sleeve by rolling it out into a grooved surface was now established. Its application to the end joint was especially advantageous since the nickel stub could now be welded instead of silver soldered to the sleeve. Furthermore, a very short rolling tool could be employed, eschewing the 24' extension contemplated for use in constructing columns with the rolled center joint.

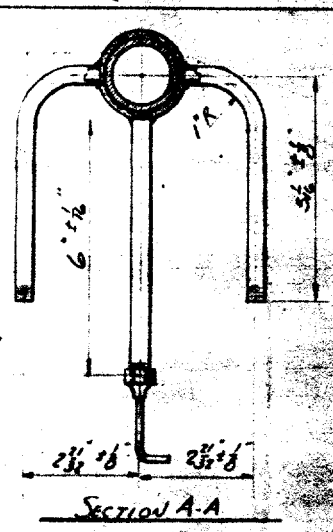
The first end joint of this type subjected to tests consisted of a 5-7/8" length of 2.500" O.D. monel tube drilled 4" to 1.984" for rolling the 2.000" O.D. copper tube. The remaining 1-7/8" was drilled for a press fit with the 2.000" O.D. nickel stub. A similar but shorter joint is detailed in Figure 8, CB-1178-A, as used in a test column.

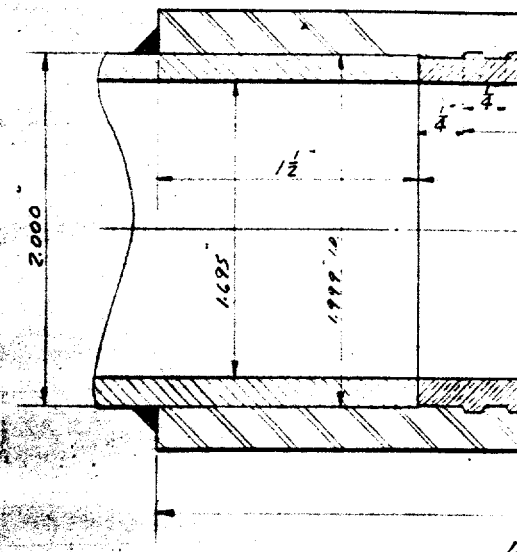
Assembly consisted of inserting the stub and arc welding with a nickel welding rod along the edge of the sleeve, followed by heating the sleeve area to dull redness to receive the swaged copper tube, and shrinking them together by quenching. The rolling operation was performed in just the way described in the preceding section.

The resulting joint was subjected to the special testing conditions applied to the rolled center joint, with essentially the same result. The 29,000 psi. tensile, 5000 psi. hydrostatic gave no failure at 25° C. over a period of 15 minutes, but when the temperature was raised to 125° C., the threads connecting the copper tube to the machine began to give way after 2 minutes.

Examination of the joint after sectioning revealed no shrinkage, elongation, or any other effect along the entire rolled area. The copper tube and nickel stub had been rolled together at their edges in an extremely intimate bond, and this was not disturbed by the special testing conditions.







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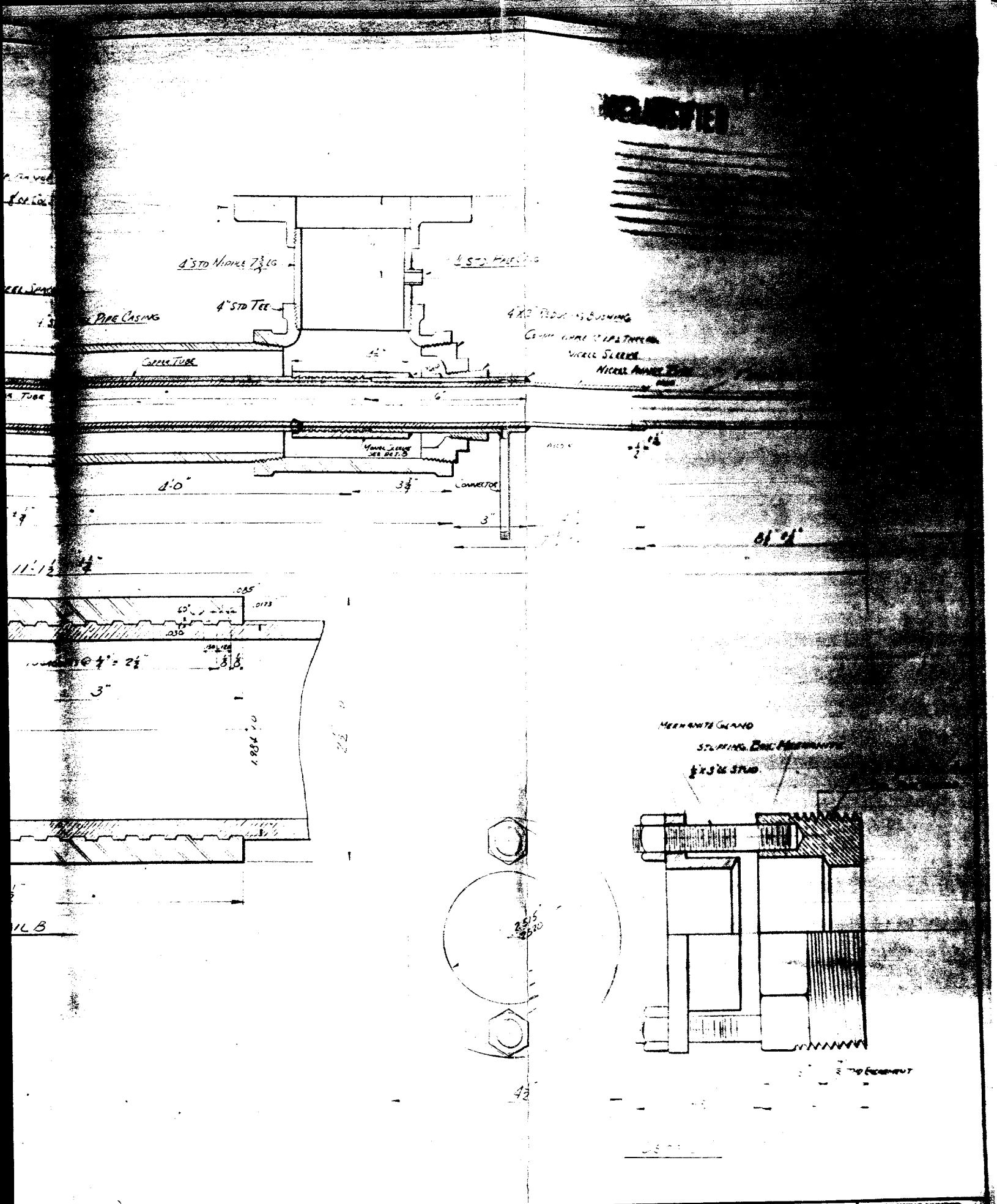

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It was concluded that the strength of this type of end joint, like that of the rolled center joint was probably equal to that of the copper tube. This, combined with the more desirable welding of the stub and the complete elimination of copper annealing, seemed sufficient to recommend the tentative adoption of both the rolled center and end joint designs. These plans were later abandoned in favor of superior arrangements.

5. Construction of 8' Test Column:

It had been planned to complete the tests on the center and end joints by incorporating them in a short column, and shipping it to the Fercleve plant to be subjected to the conditions of plant operation.

Before the column was built, however, the Wolverine Tube Co. had agreed to draw 46' lengths of copper tube, thus eliminating the need for fabricating a rolled center joint, an operation which would have required a 24' rolling tool. The test column was therefore to be built with only the 2 end joints, these of the type described in the last section. It was decided, however, to shorten the rolled area to 3", since this had proved satisfactory in center joint construction. The joint was further shortened by reducing the inserted length of the nickel stub to 1-1/2", the overall length being 4-1/2" (Figure 8). Otherwise the test column was designed to follow as nearly as possible the general form of H.K.F. drawing A-601, except for foreshortening to 8' between centers of tees, and the use of Mechanite instead of bronze for the stuffing box. Note that one set of spacers was included. No effort was made to obtain proper annulus measurements, since the column was not going to be tested for its separative ability.

The assembled column corresponded fairly closely to the design drawing, CB-1178-A, Figure 8, except for a few minor differences:

(1) A 5-1/2" nickel stub, instead of 6", was used at the bottom.

(2) Distance between center of tees was 7' 11½-3/4 instead of 8' 0".

Assembly operations consisted of:

(1) The nickel stubs (drilled for attachment of tits) were inserted in and welded to the monel sleeves.

(2) The ends of the copper tubes were swaged down .011", and the dull red hot sleeve assemblies were slipped on and quickly quenched.

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(3) The rolling operation was now performed, completing the end joints, without honing.

(4) The buttoned nickel tube was telescoped, and the assembly inserted into the casing.

(5) The stuffing box and the 4" x 2" bushing were now threaded in, the copper nipple silver soldered to the nickel stub.

(6) After tightening the nipple in the bushing, the tits were arc welded, completing the assembly.

Preliminary hydrostatic tests were performed separately on the three main compartments of the column at the Continental Gin Company:

(1) Casing. The tees were capped, and after filling with water, the casing was subjected to 40 psi. water pressure. No leaks were in evidence.

(2) Nickel tube. The nickel tube was tested with a 3 cylinder reciprocating oil pump delivering 3000 psi. fluctuating ± 300 psi. Over the course of 15 minutes no break had occurred, and there was no evidence of leakage.

(3) Annulus. The tits were made tight, one being connected to a link line to a hand pump containing water 5000 psi. was developed immediately, remaining static over 3 minutes. The pressure was now reduced to 3000 psi., and the following readings were taken.

initial	3085 psi.
15 min.	3085 psi.
30 min.	3080-5 psi.

The columns was shipped to Forclove, where it was subjected to normal operating conditions for one week. At the end of this time, a series of deliberate attempts to break the annulus at its weakest point ended in failure with the sudden application of pressures above 7,000 psi. (see Project 41-a).

A point of weakness, nevertheless, was revealed. The extreme pressure, while insufficient to cause appreciable expansion of the copper tube or failure of the rolled joint, expanded the nickel stub by more than .01". Since such failure of the stub wall had never been encountered in the plant, it was concluded that columns built with the modifications included in the test column design would probably be much superior to those of the old type.

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6. The Double Rolled End Joint:

The end joint discussed in the last two sections would undoubtedly have been entirely satisfactory as part of final column design. It seemed desirable, however, to consider means of avoiding a nickel stub weld, since annealing of the adjacent metal during this operation might contribute materially to the relative weakness of the stub wall.

The design conceived was one in which the annulus would be closed just beyond the tits by expanding the nickel tube out into grooves near the end. The tits would now be welded directly to the sleeve.

The details of such a Monel sleeve joint, suitable for both ends of the column, are shown in CB-1190-B, Figure 9. It consists of 11-1/2" of monel tube drilled to the I.D. of the copper tube, except 3" at one end, which is drilled 1.972" and grooved .030" deep for the rolled copper joint. The other end (for 3") is grooved .015" deep for the rolled nickel joint, the tit holes being drilled 4" from that end. This means that the annulus would have a Monel outside wall at both ends for a distance of 5-1/2". If this should be undesirable, there seems no reason why the sleeve could not be made of drawn nickel.

For testing the strength of the rolled nickel and copper connections simultaneously, small clearances in the load machine dictated a shortened joint. A 6" test sleeve was made to accomodate 3" of nickel tube at one end, 3" of copper at the other. Both were grooved 1/4" apart, .015" deep, like the small end of the sleeve in Figure 9. After rolling, V-threads, 16 TPI, were cut in both copper and nickel tube ends to attach grasp rod caps.

The following tests were performed:

(1) 25,500 lbs. tension gave no failure.

(2) 5000 psi. hydrostatic revealed no leakage.

(3) Continuously increasing tension caused failure of the nickel tube end threads at 33,800 lbs. or 49,000 psi. nickel tube.

(4) After welding the grasp rod to the nickel tube, yield occured at 35,900 lbs., or 40,880 psi. copper tube. Examination showed that only the copper joint had failed, the metal having been uncompletely rolled into grooves half the usual depth.

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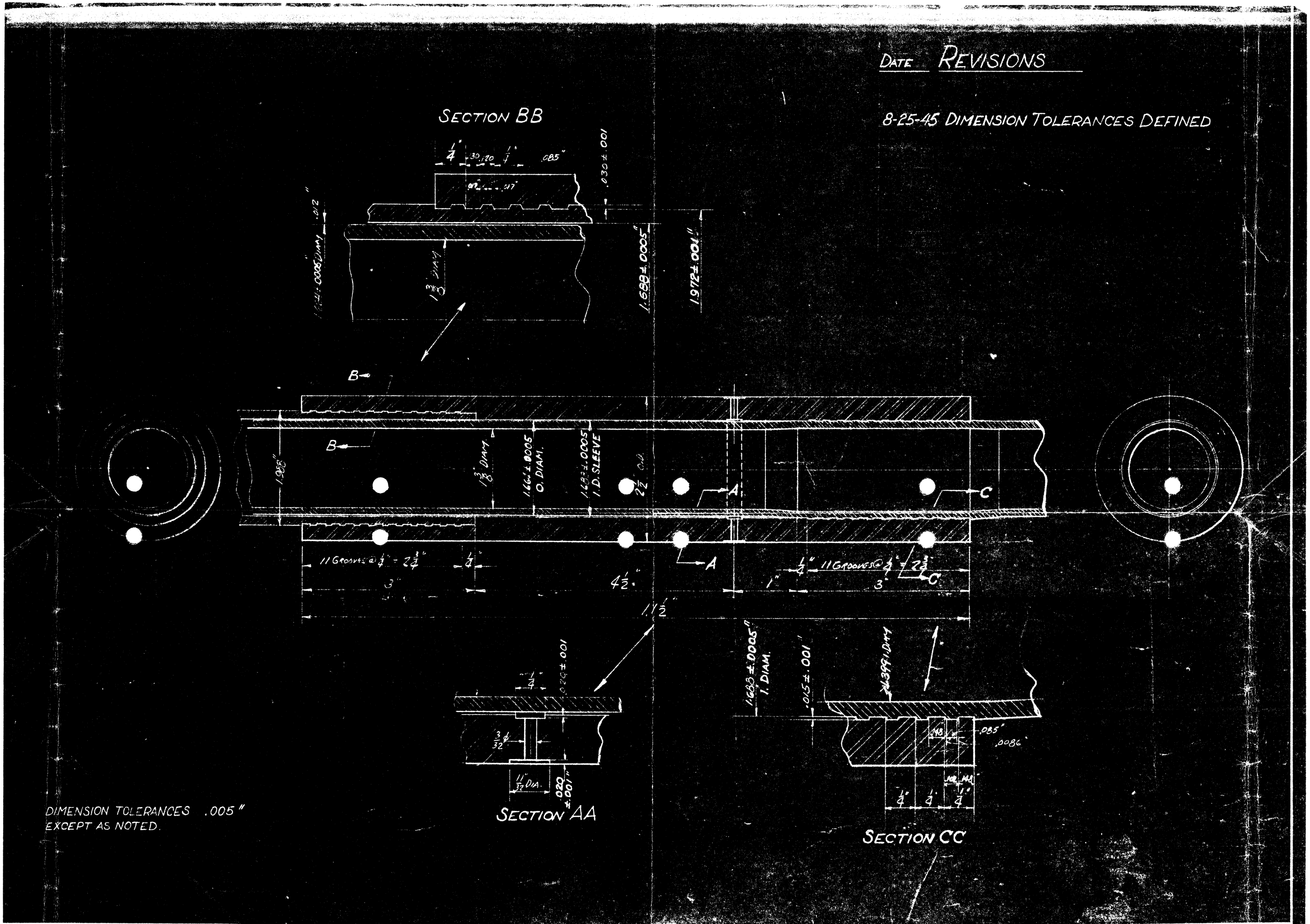

ENTAL GIN COMPANY CGC INDUSTRIAL DIVISION

EX. MEMPHIS, TENN. BIRMINGHAM, ALA. ATLANTA, GA. PRATTVILLE, ALA.

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	APPROVED [illegible]	8/25/45		

#2369

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DRAWING NUMBER CB-1190 B

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(5) Finally a grasp rod was welded to the Monel sleeve after removing the copper, and the strength of the nickel joint was tested alone. The joint itself did not yield, but at 45,200 lbs., or 65,500 psi., the nickel tube began to part, not near the rolled area, but in the annealed zone near the grasp rod weld. Sectioning showed that the nickel had filled the grooves, and there was no indication of shear of shrinkage from the sleeve.

The results are probably fair evidence of the superiority of the rolled nickel joint over the welded stub connection. The excellence of the construction and the ease of assembly effected the incorporation of the double rolled end joint in the final plans for fabrication of new columns.

B. Fabrication of New Columns:

1. Final Column Design:

The 11-1/2" long Monel sleeve for the double rolled end joint adopted for column construction had been dictated by the 46' 5-3/4" lengths of copper tube which had already been received, it being undesirable to change the overall length of the column.

The joint innovation made necessary a change in the bottom tee connection, since the 4" x 2" bushing was too small for the 2-1/2" sleeve. Instead of using a 4" x 2-1/2" bushing, it was decided to employ a stuffing box at the bottom of the column as well as the top, which necessitated attaching a steel collar to the bottom sleeve to seat against the packing box. This is shown in CB-1195-A, Figure 10, the final assembly drawing, which also includes details of the double rolled joint and the bronze stuffing box.

Other minor modifications included are the following:

(1) Stuffing box was redesigned to include a single piece bronze packing gland, also detailed in XB-11522, XB-11521, and XA-11523, Figures 34, 35, and 36 respectively.

(2) New type fillister head rivet spacer, detailed in XA-11724, Figure 37, was provided.

(3) Slightly smaller diameters of both copper and nickel tube resulted from the refinishing of the latter.

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FIGURE 10

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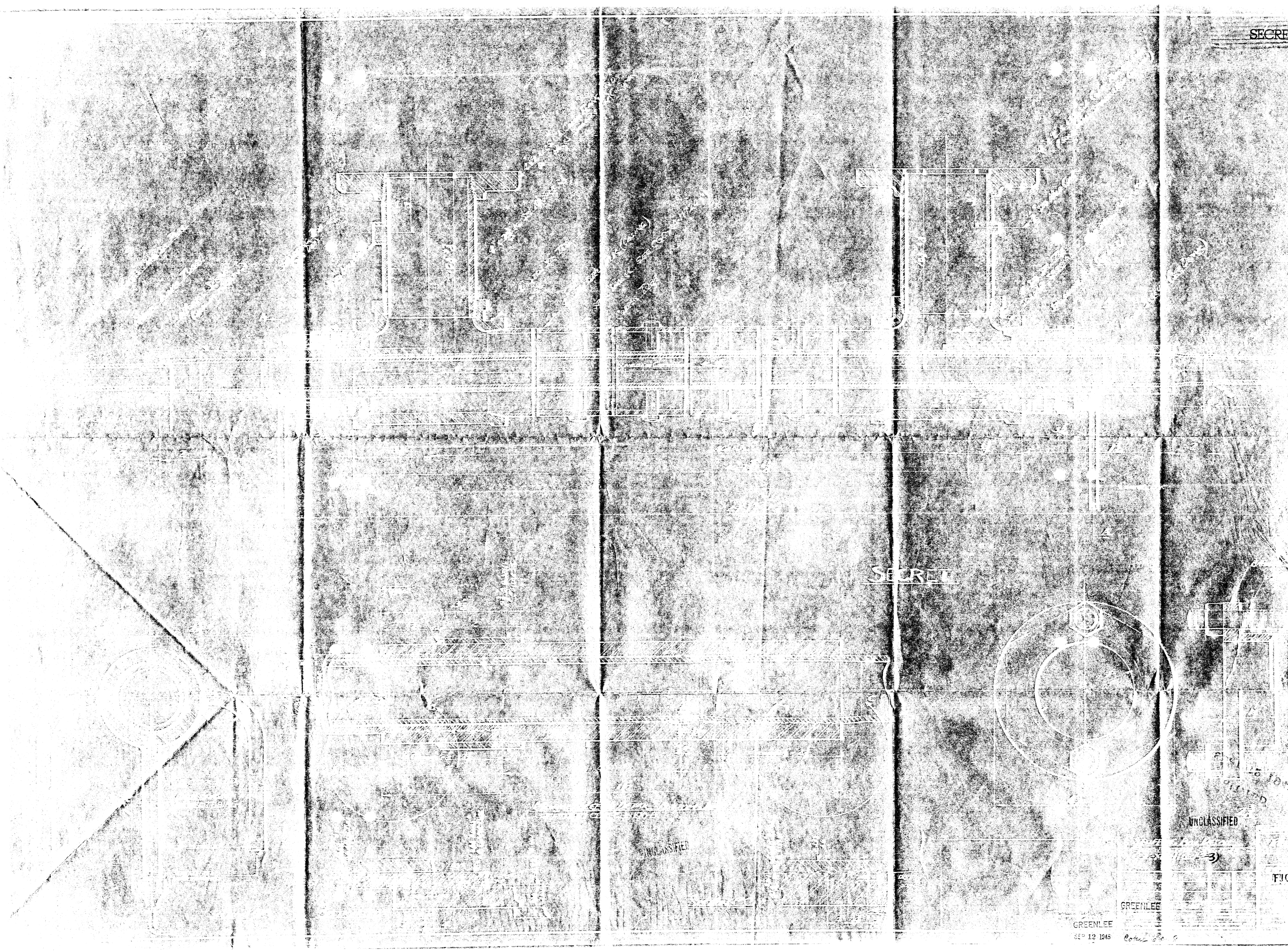

FIGURE 10

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2. Fabrication Procedure

The construction of new columns was accomplished by the following steps, given here only in brief outline (see subsequent sections).

(a) The defective columns were dissembled to recover the nickel tube and the casing for re-use, by cutting through the copper tube at the joints, and "shooting" out the nickel tube with hydrostatic pressure.

(b) The nickel tube lengths were ground to 1.664 ± .0005" by use of a centerless grinder, and brought to a high polish with a buffing machine.

(c) Nickel buttons were now spot welded at 4 places around the diameter 6" apart, and ground down to .010".

(d) Components of the 48' length of nickel tube required were now welded by acetylene torch, being careful to secure proper alignment, and subjected to a 4000 psi. hydrostatic test.

(e) The copper tube was carefully honed by use of the Barnes Honing machine to 1.6880 ± .0005" along the entire length.

(f) The ends of the copper tube were swaged down .011"; the heated sleeve slipped over it, followed by quenching. The copper tube was now rolled out, and finally honed to the exact original diameter.

(g) The nickel tube was now telescoped, either by hand or by use of hydrostatic pressure, and the nickel tube rolled out into the end of the top sleeve. After expanding the nickel tube 5/8" by steaming, the bottom joint was completed by rolling in the nickel tube.

(h) After the assembly was inserted into the casing, the steel collar was tack welded to the bottom sleeve, and the stuffing boxes tightened. The final step consisted of arc welding the tits and spacers. A 2000 psi. hydrostatic test was given the annulus, and the casing was tested with a 40 psi water line.

The route sheets, by which these operations were conducted in the Continental Gin Company plant, are attached. Details of dissembly, operation of the machinery for finishing the tubes, and of the final assembly steps are included in the following sections.

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ROUTE SHEET

(PRODUCTION ORDER)

DRY NO. A-601 REV.	PATT. OR TEMP. NO.	SUPERCEDES R. S. DATED	FEED. ORD. NO. / OR EXP. ORD. NO.
			INT-FACT. ORD. NO. / SALES ORD. NO.
			N-STOCK ORD. NO. / STOCK ORD. NO.
			UNIT / PROD. ORD. QUANTITY

DESCRIPTION OF ITEM COVERED BY ABOVE CODE NO.

NICKEL TUBE SEC. A

REWORK REFLUXER COLUMN ASSEMBLY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY

UNIT

CODE NO.

QUANTITY

UNIT

OPER. SEQ.	DEPT.	OPER. CODE	INSTRUCTIONS	DATE SCHED.	SET UP RATE	MACH. CLASS	OPER. RATE	SET UP RATE	ALT. MACH. CLASS	OPER. RATE
1	32		GRIND O.D. OF TUBE				.08E			
2	74		INSPECT & REPORT DAILY IN LINEAL FEET							

NOTICE—The FIRST piece produced on EACH operation on EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

APPROVED BY

UNCLASSIFIED

SECRET

UNCLASSIFIED

SECRET

DWG NO. A-601 [illegible]

NICKEL TUBE SEC. B

REMOVE REFLUXER COLUMN ASSEMBLY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS [illegible] WASTE FACTOR)

CUT FROM (1ST [illegible] ORDER MATERIAL REQUIREMENTS)

MATERIAL ORD. NO.	SALES ORD. NO.
MOTOR ORD. NO.	STOCK ORD. NO.
UNIT	PROD. ORD. QUANTITY

FOR COST AND SCHED-ULING PURPOSES ONLY

QUANTITY

UNIT

CODE NO.

QUANTITY

UNIT

PER. NO.	[illegible]	[illegible]	DESCRIPTION	RATE SCHED.	CUT UP RATE	[illegible]	OPER. RATE	CUT UP RATE	[illegible]	[illegible]
1	22		BUFF O.D. OF TUBE				.06E			
2	77		INSPECT & REPORT DAILY IN LINEAL FEET							

NOTE: [illegible] as [illegible] operation [illegible] day [illegible] Inspector [illegible] production.

REMARKS:

GOOD QUANTITIES

[illegible]

QUANTITY COMPLETED

[illegible]

ROUTED BY

SECRET

[illegible] BY

UNCLASSIFIED

UNCLASSIFIED

SECRET

DRG NO. A-601 REV.

DESCRIPTION OF ITEM COVERED BY WORK ORDER NO.

NICKEL TUBE SEC. C

REWORK DISTILLER COLUMN ASSEMBLY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

SUPERSEDES U.S. BUILD

INT-FACT. ORD. NO.

SALES ORD. NO.

M-STOCK ORD. NO.

STOCK ORD. NO.

UNIT

PROD. ORD. QUANTITY

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY

UNIT

CODE NO.

QUANTITY

UNIT

OPER. SEC.	[illegible]	[illegible]	INSTRUCTIONS	DATE COMPD.	SET UP RATE	[illegible]	OPER. RATE	SET UP RATE	[illegible]	[illegible]
1	32		SPOT WELD BUTTONS ON TUBE				.02E			
2	74		INSPECT & REPORT DAILY IN LINEAL FEET							

NOTICE—The FIRST piece produced on EACH operation in EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

ROUTED BY

CHANGED BY

SECRET

APPROVED BY

UNCLASSIFIED

SECRET

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DR. NO. -601 REV. | MATT. OR TEMP. NO. | SUPERSEDES U.S. DATED | INT-FACT. ORD. NO. | SALES ORD. NO.

PRODUCTION OF ITEM COVERED BY ABOVE CODE NO.

NICKEL TUBE SEC. D

REWORK REFLUXER COLUMN ASSEMBLY

X-STOCK ORD. NO. | STOCK ORD. NO.

UNIT | PROD. ORD. QUANTITY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY

UNIT

CODE NO.

QUANTITY

UNIT

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

OPER. SEQ.	EXPL.	SEQ. ORD.	INSTRUCTIONS	DATE SCHED.	SET UP RATE	MACH. CLASS	OPER. RATE	SET UP RATE	MAT. MACH. CLASS	OPER. RATE
1	22		GRIND BUTTONS TO .010				.015F			
2	74		INSPECT & REPORT DAILY IN LINEAL FEET							

NOTICE—The FIRST piece produced on EACH operation on EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

APPROVED BY

UNCLASSIFIED

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SECRET

ROUTE SHEET

(PRODUCTION ORDER)

DR. NO. A-610 REV.	PATT. OR TEMP. NO.	SUPERCEDES N. S. DATED	INT-STOCK ORD. NO.	SALES ORD. NO.
DESCRIPTION OF ITEM COVERED BY ABOVE CODE NO. NICKEL TUBE SEC. E REWORK REFLUXER COLUMN ASSEMBLY			N-STOCK ORD. NO.	STOCK ORD. NO.
			UNIT	PROD. ORD. QUANTITY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY

UNIT

CODE NO.

QUANTITY

UNIT

OPER. SEC.	DEPT.	DATE	INSTRUCTIONS	DATE SCHED.	INT. OP. RATE	MACH. CLASS	OPER. RATE	SET UP RATE	[illegible]
	32		ASSEMBLE WELD TUBES IN [illegible] 10½"				.5		
			LENGTH PIECES						
2	74		INSPECT & REPORT DAILY [illegible] COMPLETE						
			LENGTH PIECES						

NOTICE—The FIRST piece produced on [illegible] operation [illegible] EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

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ROUTE SHEET

(PRODUCTION ORDER)

CODE NO. [illegible]

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PROD. OR EXP. ORD. NO.

DR'G NO. A-601 REV.

PATT. OR TEMP. NO.

SUPERSEDES R. S. DATED

INT-FACT. ORD. NO.

SALES ORD. NO.

DESCRIPTION OF ITEM COVERED BY ABOVE CODE NO.

NICKEL TUBE SEC. F

REWORK REFLUXER COLUMN ASSEMBLIES

N-STOCK ORD. NO.

STOCK ORD. NO.

UNIT

PROD. ORD. QUANTITY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY

UNIT

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

CODE NO.

QUANTITY

UNIT

OPER. SEQ.	[illegible]	[illegible]	INSTRUCTIONS	DATE SCHED.	SET UP RATE	MACH. CLASS	OPER. RATE	SET UP RATE	[illegible]	[illegible]
1	32		GRIND NICKEL [illegible] & TEST WITH 3000 LBS.				2.0E			
			PRESSURE							
2	1A		INSPECT & REPORT DAILY BY PIECES							

NOTE: [illegible] piece produced on [illegible] operation on EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

ROUTED BY

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ROUTE SHEET
(PRODUCTION ORDER)

DRW. NO. A-601	PATT. OR TEMP. NO.	SUPERCEDES R. S. DATED	INT-FACT. ORD. NO. / PROD. OR EXP. ORD. NO. / SALES ORD. NO.
DESCRIPTION OF ITEM GOVERNED BY ABOVE CODE NO.			N-STOCK ORD. NO. / STOCK ORD. NO.
COPPER TUBES SEC. G REWORK REFLUXER COLUMN ASSEMBLIES			UNIT / PROD. ORD. QUANTITY

STANDARD PER UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

CUT FROM (TOTAL PRODUCTION ORDER MATERIAL REQUIREMENTS)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY
UNIT
CODE NO.
QUANTITY
UNIT

OPER. SEQ.	DEPT.	OPER. CODE	INSTRUCTIONS	DATE SCHED.	SET UP RATE	MACH. CLASS	OPER. RATE	SET UP RATE	ALT. MACH. CLASS	OP. R.
1	32		HONE TUBE & WASH				.5E			
2	74		INSPECT & REPORT DAILY BY PIECES							

NOTICE—The FIRST piece produced on EACH operation on EACH shift EVERY day must be approved by the inspector before proceeding with production.

REMARKS:

GOOD QUANTITIES

WHEN COMPLETED DELIVER TO

QUANTITY COMPLETED

DATE COMPLETED

ROUTED BY

CHANGED BY

APPROVED BY

SECRET

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ROUTE SHEET
(PRODUCTION ORDER)

PROD. OR REP. ORD. NO.

DWG NO. A-601 REV. | DATE OF PROD. REQ. | SUPERSEDES P. R. DATED | PR-PACK. ORD. NO. | SALES ORD. NO.

DESCRIPTION OF ITEM CONTROLLED BY ABOVE ORDER NO.
ASSEMBLY SEC. II

REVOLVING DEFLUXER COLUMN ASSEMBLIES

PR-TOOL ORD. NO. | STOCK ORD. NO.

UNIT | PROD. ORD. QUANTITY

STANDARD MAT'L UNIT MATERIAL REQUIREMENTS (PLUS % WASTE FACTOR)

CUT FROM (TOTAL REPRODUCTION ORDER MATERIAL REQUIREMENTS)

FOR COST AND SCHEDULING PURPOSES ONLY

QUANTITY
UNIT
CODE NO.
QUANTITY
UNIT

OPER. SEQ.	DEPT.	PER. CENT	INSTRUCTION	DATE SCHED.	SET UP DATE	MACH. CLASS	OPER. DATE	SET UP DATE	ALT. MACH. CLASS	O. R.
1	92		(A) ROLL SLEEVE & HONE				8.02			
			(B) TELESCOPE NICKEL TUBE INTO COPPER TUBE							
			(C) ROLL SLEEVE TO NICKEL TUBE							
			(D) TELESCOPE TUBES INTO 4" CASING & INSTALL PACKING BOXES & TITS							
			(E) ATTACH STEAM & WATER CONNECTIONS & EXPAND NICKEL TUBE 5/8"							
			(F) AFTER FLUSHING BETWEEN TUBES, MAKE FINAL NICKEL ROLL & TEST 2000#							
			(G) WELD 1/8" NICKEL MARBLES IN TOP & BOTTOM & CENTERING LUGS IN SLOT							
2	92		INSPECT & REPORT DAILY IN NUMBER OF FINISHED ASSEMBLIES (CLOCK ALL INSPECTION LABOR FOR THE ENTIRE JOB ON THIS OPERATION)							

NOTE: The MATL plans provided on ROUTE sheets on SHOP floor EVERY day must be supplied by the Inspection Dept. preceding with production.

GOOD QUANTITIES

REMARKS:

UNITS COMPLETED SATISFIED

QUANTITY SATISFIED

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3. Dissembly of Broken Columns

The dissembly of columns received from Fercleve was done for the most part according to the following procedure:

(1) The inside assembly was removed from the casing after sawing off the tits.

(2) The stub weld at the top end was heated with a torch to the softening point, the nickel tube "jumped" back into the copper, buckling the weld.

(3) The column was now cut across the centers of the three joints.

(4) The special fitting shown in Figure 11 was clamped to the sleeve, tightening the chuck by forcing the ring up the outside of the jaws. The oil pressure line was now threaded in tight, butting it against the end of the sleeve and the copper tube. Application of less than 100 psi. hydrostatic (oil) pressure was sufficient to force out the capped 24' nickel tube.

4. Grinding the Nickel Tube

Two views of the Cincinnati No. 2 centerless grinder, used for this operation, are given in Figures 12 and 13. It was necessary to modify the recommendations of Schmidt, the company representative, in many particulars, in order to get the present good quality of finished nickel tube. Mechanite substituted for the steel guide blades eliminated the excessive wearing of this tool.

The No. 60 grit silicon carbide grinding wheel, beveled 3" long, .008" deep on both edges, was frequently dressed off with a special template, since it wore rapidly uneven, reducing the quality of the finish.

The setting of the grinding wheel adjustment, shown in Figure 12, determined the depth of cut, but the arbitrary establishment of the zero point (1.664") was necessary each time the machine was set up. A 2' standard piece of nickel tube was used in this operation, which consisted of setting the guide blades to establish the center line of the nickel tube 1/8" above the axis of the wheels, and tightening the pressure roller pairs on both sides of the grinding wheel.

The nickel tube was steadily rolled and fed through the machine by the rotation of the pressure regulating wheel, which was set with its center line at a certain small angle (in the vertical plane) to that of the grinding wheel. A similar angular setting of the 12 pairs of guide rollers was arranged. A special "soluble oil" emulsion was used as the coolant.

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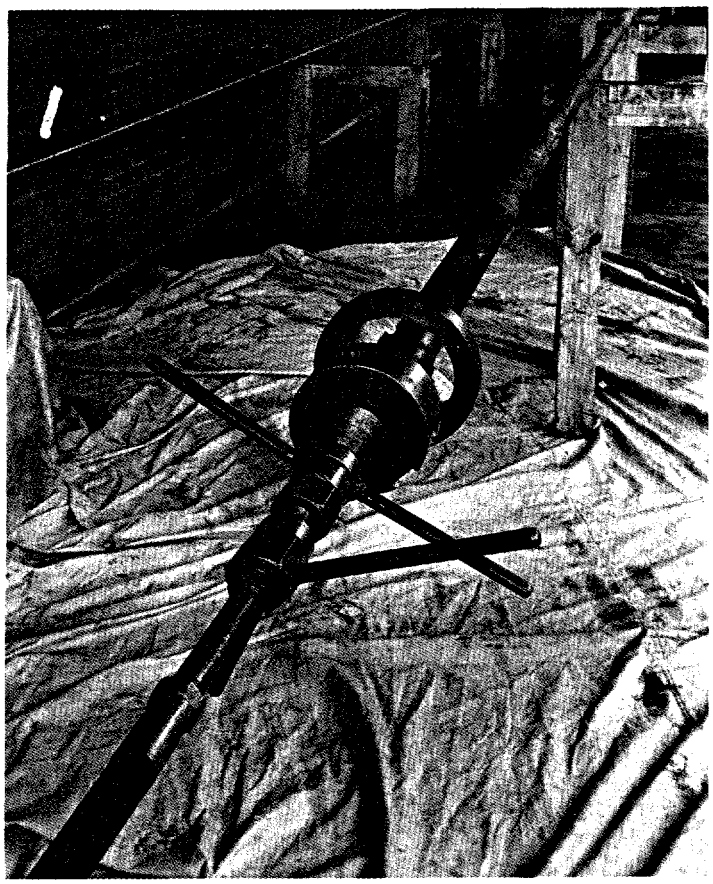
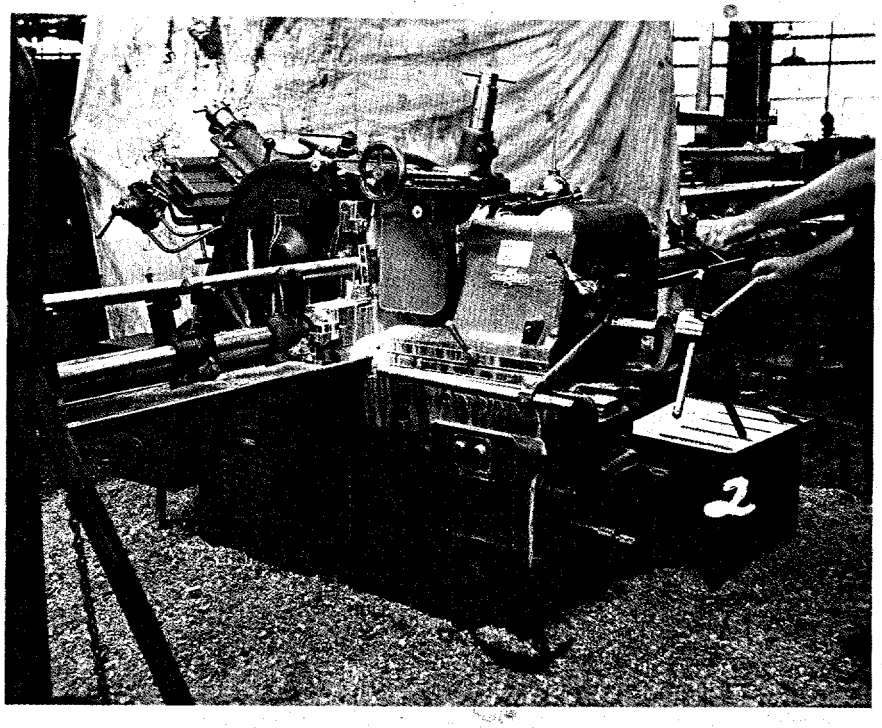


Figure 11. DISSEMBLY. "Shooting" the nickel tube out of the copper by application of oil pressure.

Figure 12. GRINDING NICKEL TUBE. The centerless grinder being adjusted for a deeper cut before starting the tube through the machine.



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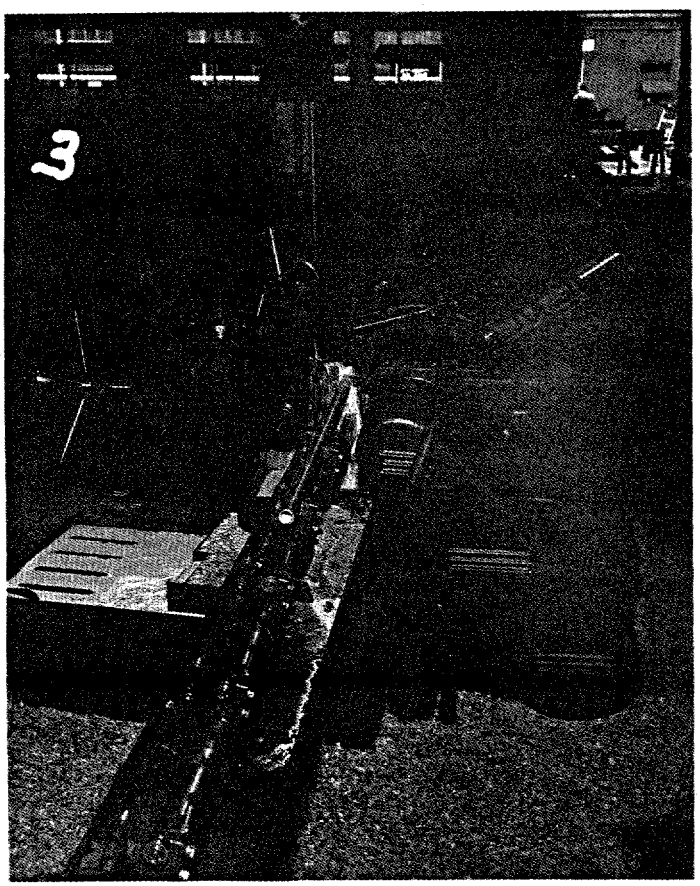
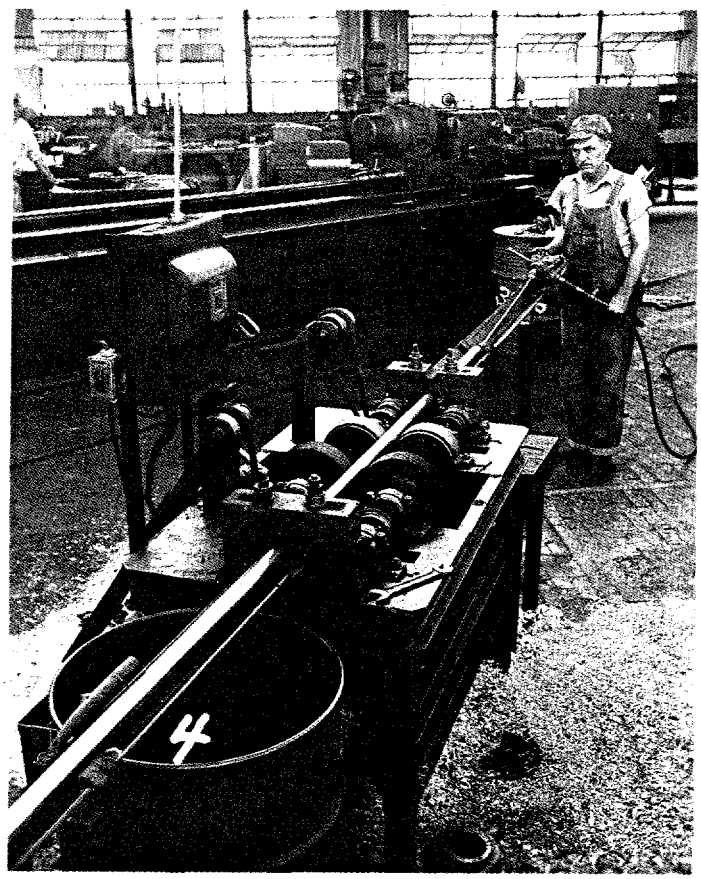


Figure 13. GRINDING NICKEL TUBE. The centerless grinder in operation, showing the nickel tube emerging. Note pressure rollers near grinding wheel.

Figure 14. BUFFING NICKEL TUBE. The two sets of buffing wheels and the wooden guide blocks are shown.



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The following procedure was usually used, giving good results: The grinding wheel was set to remove only the buttons in the first pass, pressure regulating wheel at 22 rpm. This was followed by 3 rough cut passes, removing .0015" each, at the same speed. Three finish cuts were taken, .005" each, pressure regulating wheel at 16 rpm. Two passes were now made at the same speed without resetting the grinding wheel.

The operation was found capable of grinding the used nickel tubes to the desired 1.664", with less than .0003" variation, excepting low or scarred areas. These, and other faults in the tubes themselves, resulted in large lengths of otherwise good tubes being discarded.

The greatest fault of the nickel tube was found to be ovalness, which occurred erratically at various places along the tubes. This resulted in negative areas on opposite sides, in about half of the tubes. Second in importance, bends frequently were found which resulted in excessive and rough grinding on one side, and a negative area on the other, in about one third of the tubes. A relatively infrequent fault was a sunken area resulting from overheating during spot welding.

The effects of the above defects was to reduce the nickel tube re-use to about 50%. Tubes for about 1-1/2 columns per shift could, however, be supplied by the grinding operation.

5. Buffing the Nickel Tube

The buffing machine used consisted of two pairs of buffing wheels, with axes on a horizontal plane, parallel to and a little below the center line of the nickel tube being buffed. This can be seen in Figure 14.

The tube is fed in on felt blocks spaced along a 25' length of angle iron sets as a V by means of a hand operated air driven motor. Excessive vibration caused by the rapidly rotating buffing wheels was eliminated by use of felt lined wooden guide blocks.

As the tube entered the machine, it first encountered a "Quick-as-a-Wink" buffing wheel, with No. 220 grit emery cloth based on felt, and second, a cloth wheel with No. 600 powder abrasive. As a result of the abrasion the tube became heated to about 100°C, and was cooled by means of a flow of cold water. Two or three passes through the machine yielded an approximately 50 micro inch finish. It was estimated that the operation was capable of supplying finished tubes for fabrication of 2-1/2 columns per shift.

Final inspection of the nickel tubes for 1.664 ±.0005 followed the buffing, the micrometry being done with a Sheffield Precisionaire micrometer, as shown in Figure 15. In this instrument a simple rotameter measures the change of air flow through a small inlet with variable clearance; and although the tool must be made especially for the job, the resulting micrometry is sensitive to about ± .0001.

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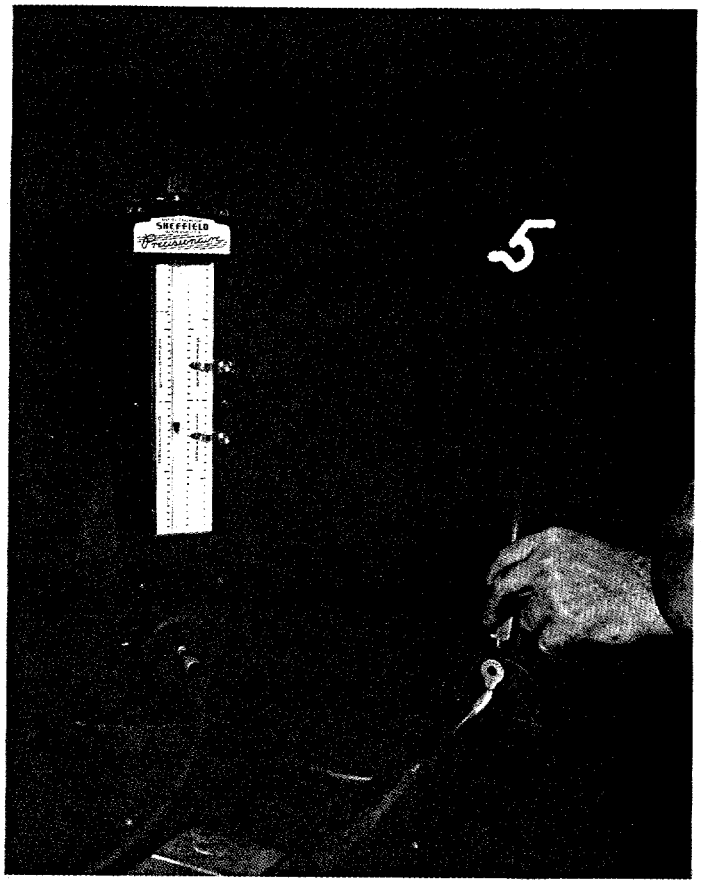

Figure 15. AIR MICROMETRY. The use of the Sheffield Precisionaire micrometer for the O.D. of the buffed nickel tube is demonstrated.

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Figure 16. BUTTON WELDING. Nickel tubes are shown ready to enter the spot welding machines for attachment of the buttons.

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6. Spot Welding and Grinding Buttons

Two National Electric SFC A.O. spot welding machines were set up and 49' of track for supporting the nickel tube during the button welding operation were provided with each. Three views of this equipment are given in Figures 16, 17, and 18.

The nickel tube being welded was moved along the track on the small grooved trucks, which also served to keep it centered and supported to the proper level. Four 1/8" buttons were evenly spaced around the tube at 6" intervals, the welding being done in four pulses of 10 cycles each (60 cycles/min.). This procedure gave nickel buttons about .012" high very thoroughly fused to the tube.

The buttons were now ground off to a definite height from the curved surface of the tube by rotating the tube past the flat edge of tool post grinding wheel. The height of the button was determined by the degree of displacement of a parallel small steel roller resting on the nickel tube from the working surface of the grinding wheel. This apparatus can be seen in Figure 19.

Usually this displacement, and the height of the resulting button, was .010". This measurement was made by use of a specially designed dial-indicator "height mike", shown in Figure 20. An alternative need was air micrometry, but the special tool constructed for this purpose gave such erratic readings that the attempt was abandoned.

The buttons were finally prepared for use in the column by carefully beveling with a small file, thus eliminating any rough or loose edges. The effect of telescoping on them was almost negligible, in constrast to the large losses of buttons which was seen to have been caused by this operation in most of the old columns dissembled. The first unsatisfactory attempt at pneumatic telescoping, in which the buttons cut deep grooves in the copper tube, resulted in no loss of buttons from the nickel tube. The operation was considered capable of furnishing buttoned nickel tubes for fabrication of 2-1/2 columns per shift.

7. Welding Nickel Tubes and Grinding Welds.

Comparison of nickel tube welds made by acetylene torch and by electric arc had shown that the latter were more desirable, since they were easier to make, stronger, and resulted in less annealing of the nickel tube. However, an analysis of the rod supplied by Fercleve for arc welding showed only 73-4% nickel. Since the assay should be 96-99%, it was decided to make a gas weld, using the available 99% nickel wire.

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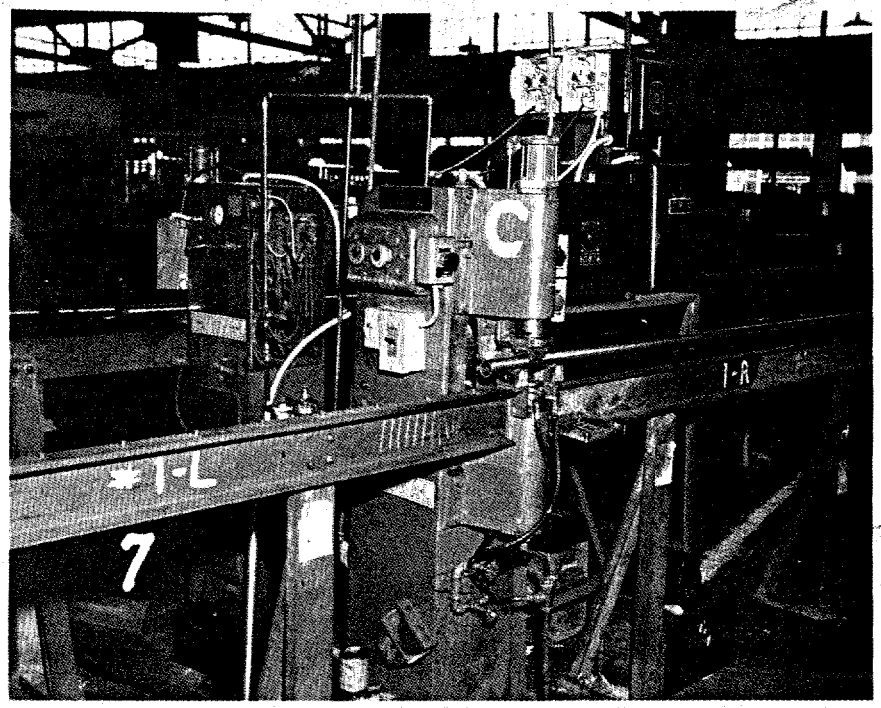

Figure 17. BUTTON WELDING
General view of the two National Electric SFC A.C. Spot Welding Machines.

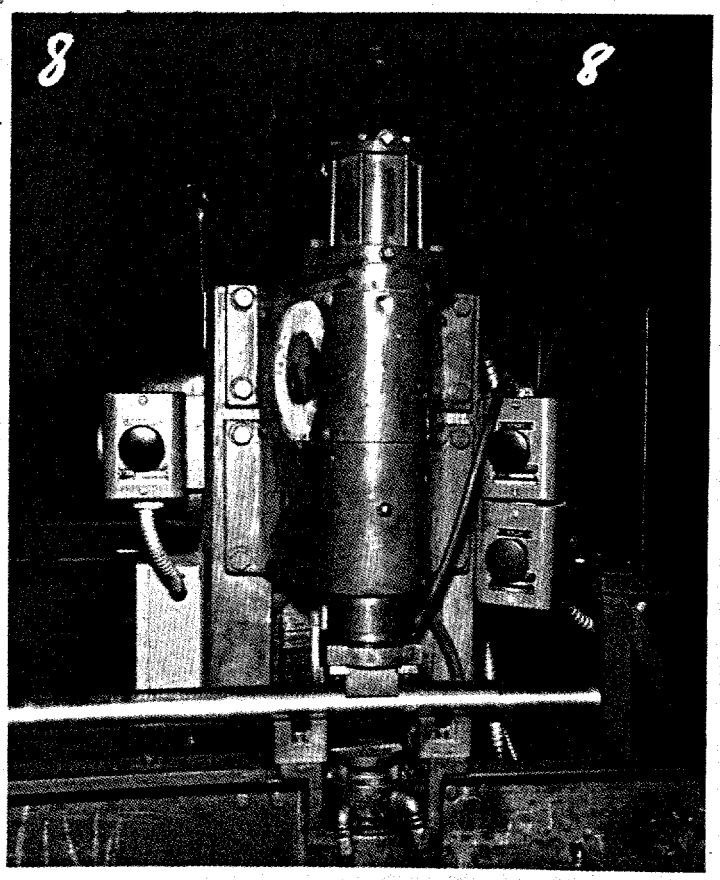

Figure 18. BUTTON WELDING
Closeup of spot welder, showing bakelite-impregnated-cloth alignment blocks.

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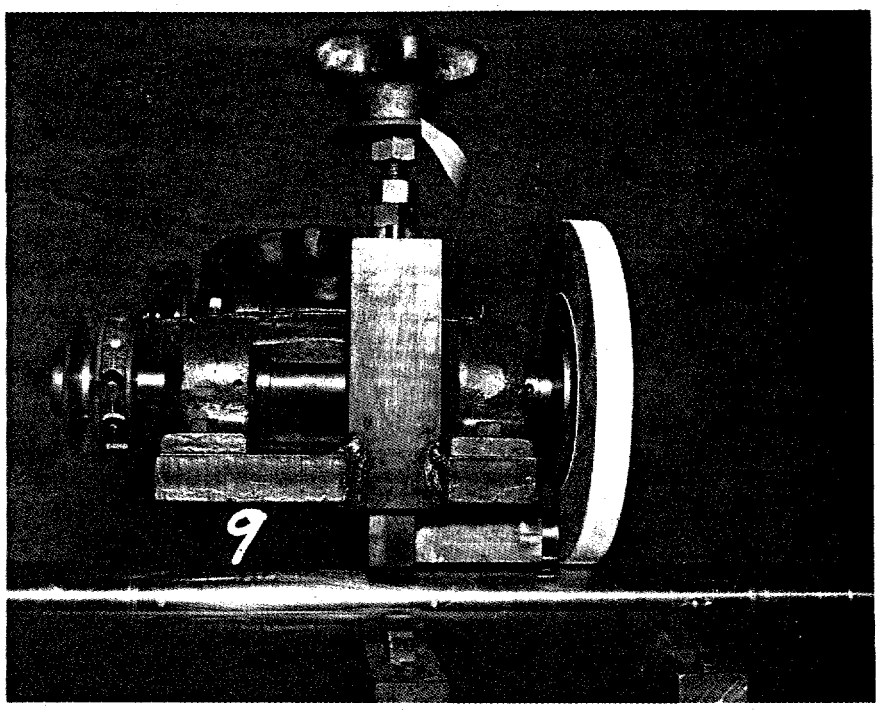

Figure 19. BUTTON GRINDING. Tool post grinding wheel with adjustable steel roller for determining height of button after grinding.

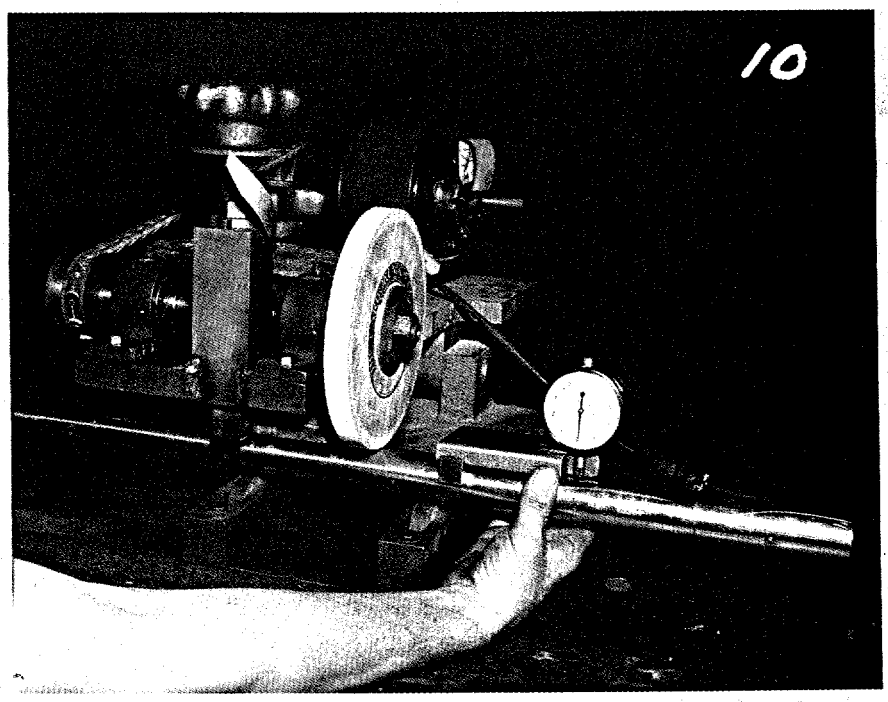

Figure 20. BUTTON MICROMETRY. Use of special "height mike" with dial indicator for checking height of buttons after grinding.

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The major difficulty encountered in welding the 3 or 4 miscellaneous lengths of nickel tube was the retention of alignment during the operation, which involved rotating the tubes through 360°. This problem was solved by mounting four special triple-bearing steel clamps on a 5' steel table, as shown in Figure 21, the tubes being turned by hand during the welding. The extended length of the nickel tubes were supported by felt-lined V-blocks.

The first welded nickel tubes were ground back to 1.664" by using a tool post grinding wheel, against which the tube was rotated while clamped between such steel rollers as shown in Figure 21. This was unsatisfactory, however, and a Foster turret lathe, equipped with a grinding wheel (Norton No. 40 grit), was provided so that faster rotation could be used without scarring caused by bearing clamps. Figure 21 shows the machine in operation, the extended and rapidly rotating nickel tube meanwhile being supported in specially constructed guide bearings. A close-up of one of these is given in Figure 23.

It was later felt, however, that the grinding was unnecessarily time consuming and productive of heat. The arrangements for fast rotation of the tube made possible the use of a cutting tool, which can be seen in Figure 24. The turning operation was faster and cooler and was used on most of the column length nickel tubes for fabrication.

After being brought to within .002" of the original diameter as above, a fine file was used, followed by polishing with crocus cloth, bringing the weld, like the rest of the tube, to 1.664 ± .005". The completed tube was finally tested by application of 4000 psi. hydrostatic pressure.

An alternative method considered for welding the nickel tube was flash welding. A nickel tube weld made by the Thompson Gibb Electric Welding Company was apparently ideal, with the positive area only about 1/4" long and high on the outside, but with considerable "flashed" metal on the inside. The weld, turned down to the proper diameter, passed a 5000 psi hydrostatic test, and reached its tensile yield point at 36,400 lbs., or 52,750 psi. The area of elongation was entirely within the 1" estimated as the limit of the annealed zone.

Although this was the most satisfactory weld obtained by any of the methods, the expenditure of about $3000 for the equipment required would be justified only if large numbers of columns were to be built.

8. Honing the Copper Tube.

The possibility of honing drawn copper tube was discussed with representatives of the Micromatic Hone Corporation, and experiments were conducted by them that demonstrated the feasibility of such a step. Honing the 46' lengths of copper tube to a definite I. D. and to suitable finish would

(1) eliminate the necessity of matching the nickel to the copper tube.

(2) assure uniform diameter.

(3) provide a standard surface.

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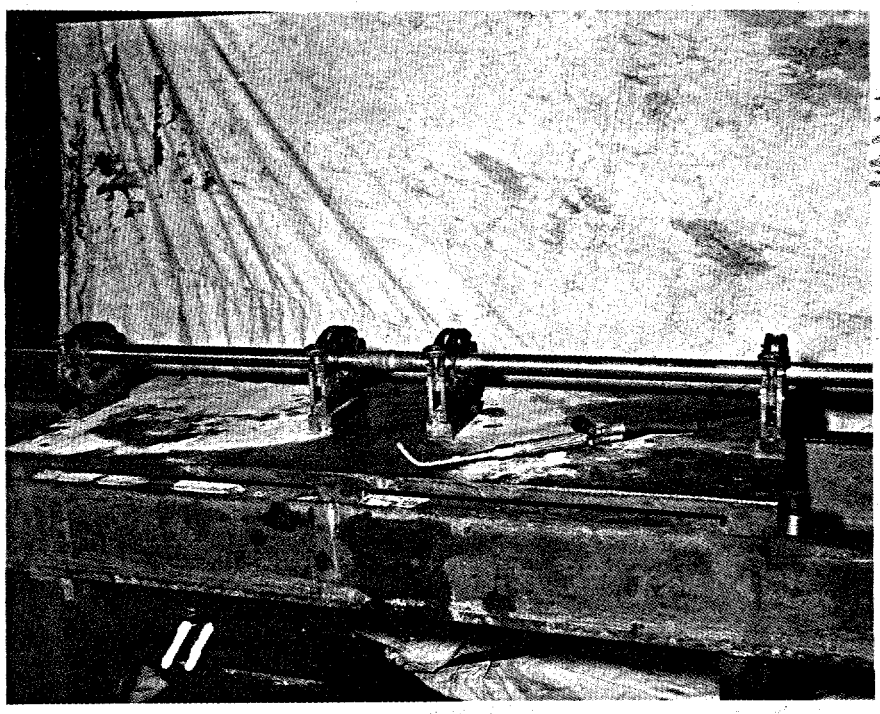

Figure 21. WELDING NICKEL TUBE. Typical gas welded nickel tubes, and the triple-bearing clamps used for their alignment, are shown.

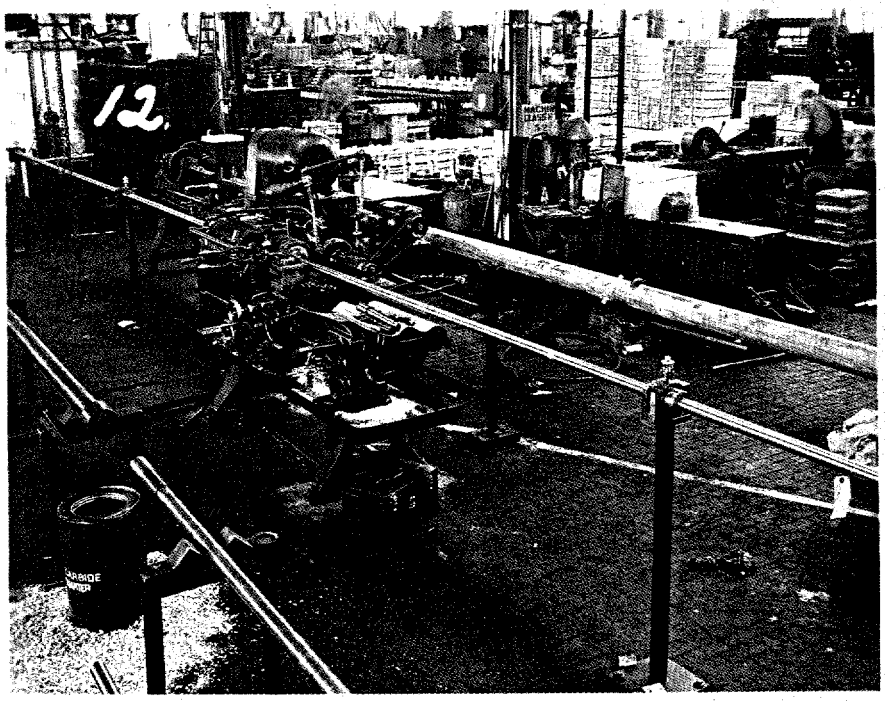

Figure 22. GRINDING WELDED NICKEL TUBES. General view of the turret lathe and wheel used for grinding weld back to diameter.

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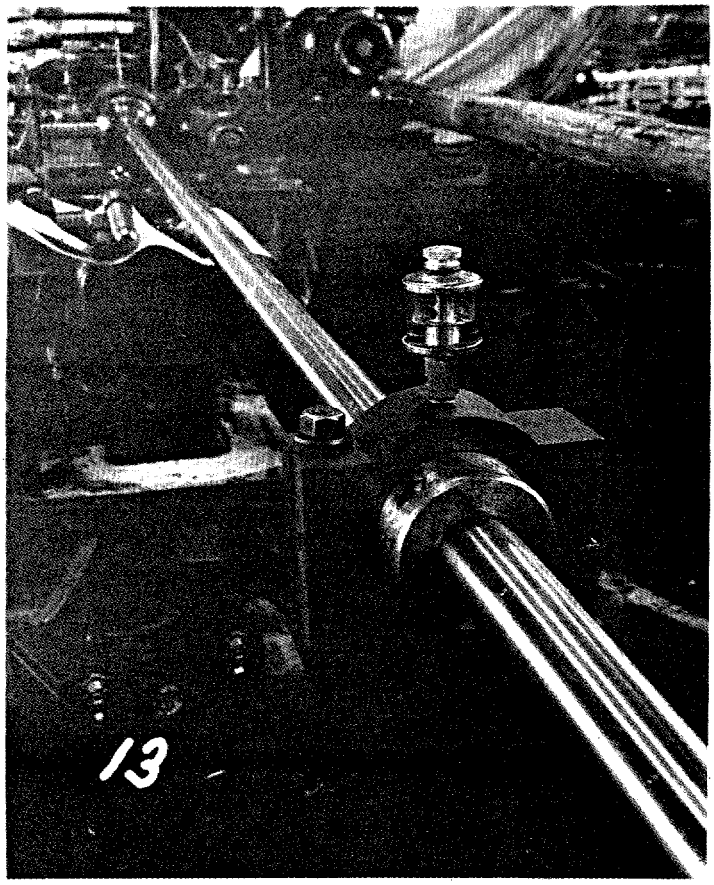

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Figure 23. GRINDING WELDED NICKEL TUBES. Special guide bearing used to support and allow fast rotation of the nickel tube during grinding the weld.

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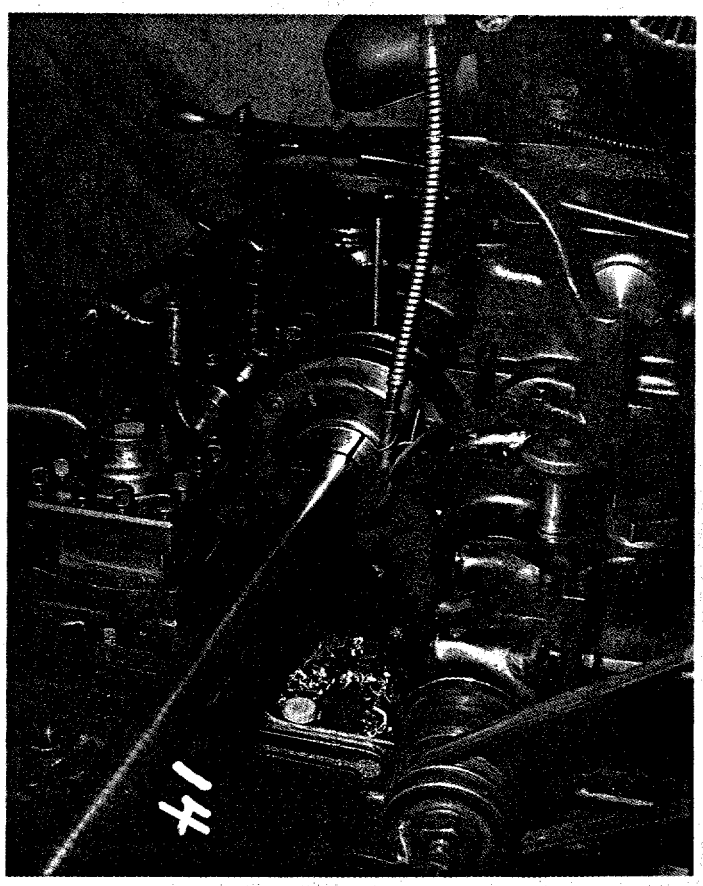
Figure 24. GRINDING WELDED NICKEL TUBES. Closeup of the equipment, showing condition of the welded area after grinding and polishing.



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A Barnes No. 6 Double Spindle Honing Machine was obtained from the Wheland Company, Chattanooga, and set up with the aid of the Barnes Drill Company service man (see Figure 25).

Putting the machine in final operation required the assistance of the micromatic Hone Corp. service man. A No. 300 grit hone was supplied for rough-honing to diameter, and a No.400 grit cork bond hone for obtaining the desired finish. The coolant liquid to be used consisted of 30% kerosene, 70% Sinclair Union Base Oil.

The first tests of the honing machine indicated that additional guide bearings were needed along the lead half of the 25' shaft. Three sets of these were made and attached over a 10' interval behind the honing tool, which mounted 9 stones of either type (Figure 26).

The copper tubes, which ranged from .001 to .004" smaller than the desired 1.688" I.D., were brought to diameter with the rough hone at a rate of .0002" per pass, followed by about 5 passes with the fine hone, which removed only about .00005" each pass.

Since the shaft was just 25' long, each pass consisted of thrusting the rotating honing tool through half the length of the tube, a 6" overlap of the subsequent honing from the other end being allowed. The optimum speeds were found to be:

rotation	165 rpm
reciprocation	50 fpm. (corresponding to 1 pass per minute)

The copper tube could, with care, be ground to 1.688 ± .0005". I.D., the measure being made along the entire length of the tube by means of the special "Sheffield" Precisionaire Micrometer shown in Figure 27.

9. Final Assembly Operation

The final steps of assembling the parts of the column according to CB-1195-A, Figure 10, are as follows:

The 1.988" O.D. copper tube was swaged down .011" to 1.977 for 3-1/8" on each end. The 11-1/2" Monel sleeves, constructed according to CB-1190-B, Figure 9, were heated to dull redness with a torch at the large ends, inserted over the swaged ends of the copper tube, and immediately quenched with cold water.

The joint assembles were now successively locked in a special cast iron alignment block, and the rolling of the copper accomplished by moving the clamped joint back over the lathe-rotated rolling tool. Four to five passes with progressive outward adjustment of the effective diameter of the rollers brought the I.D. of the copper back to .001-2" of the 1.688". Honing the inside sleeve areas with a simple two stone hone driven by a hand operated air motor restored this original I.D.

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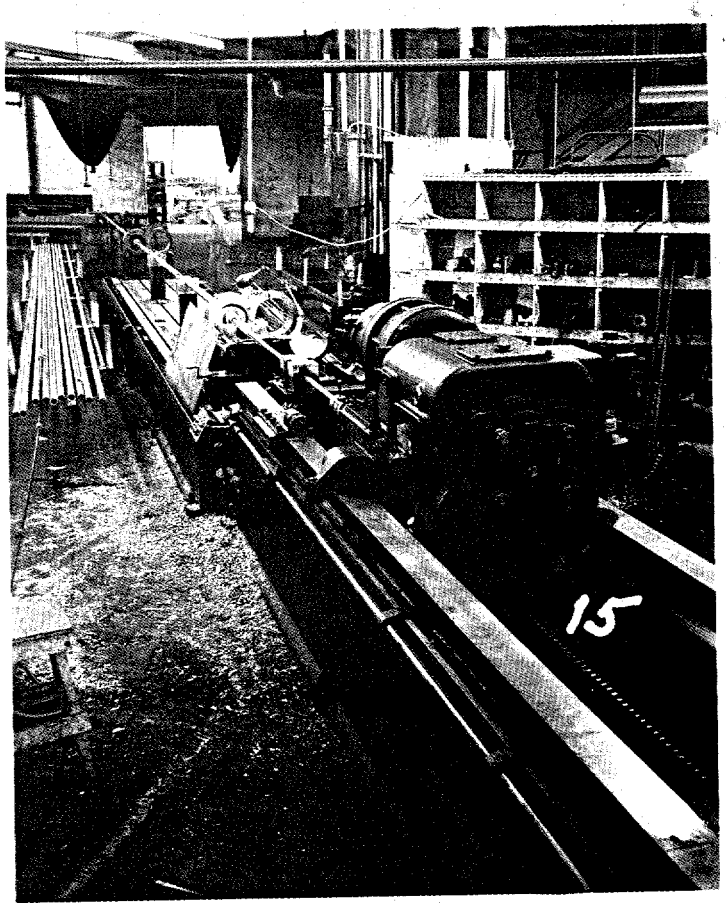

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Figure 25. HONING THE COPPER TUBE. General view of the Barnes Honing machine in operation, with the hone advancing in the tube.

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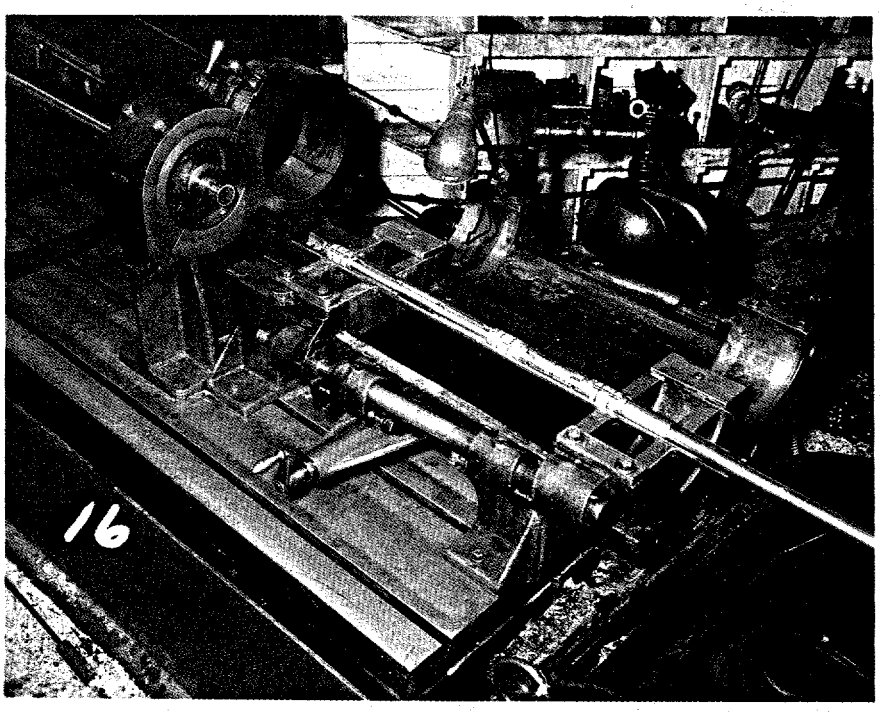
Figure 26. HONING THE COPPER TUBE. Closeup of the honing tool. Note the supports for maintaining alignment.



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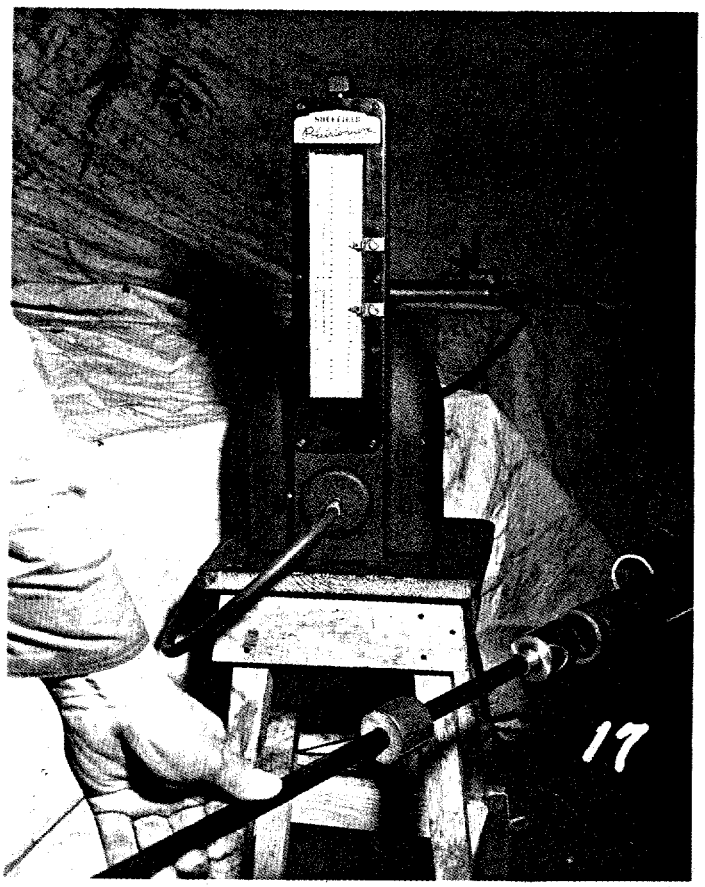

Figure 27. AIR MICROMETRY
Accurate measurement of the inside diameter of the honed copper tube with a special "air mike"

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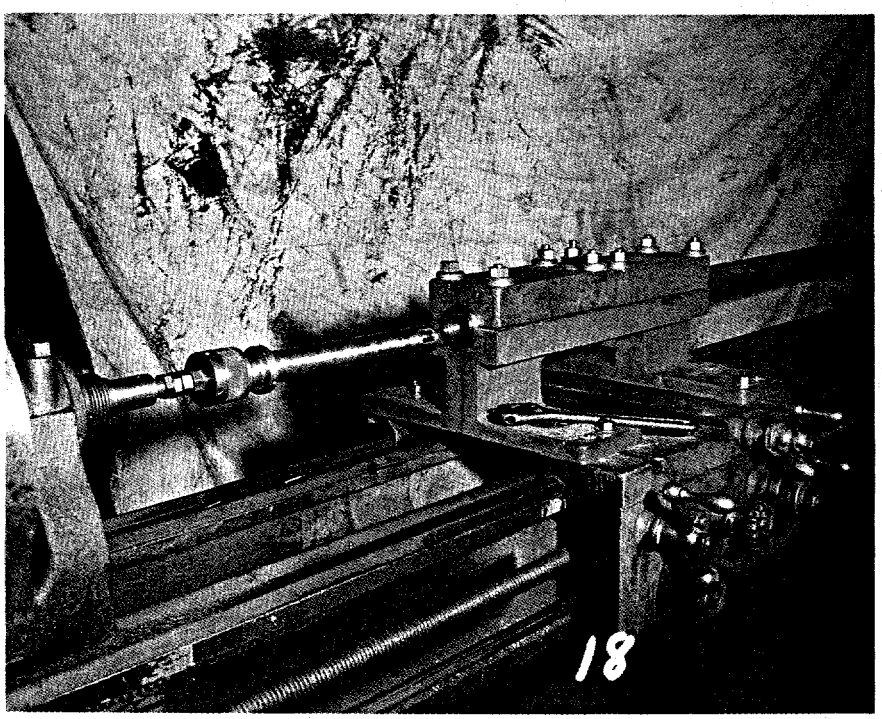
Figure 28. ROLLED COPPER JOINT. The rolling tool is shown ready to enter the sleeve. Note massive cast iron alignment block.



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The nickel tube was now telescoped into the copper tube assembly by one of two methods. In the first method, hand telescoping, a plunger 1.684" O.D. was inserted in the end of the tube, which was then simply thrust slowly into the oil filled copper tube assembly, a special steel guide sleeve first being slipped over the end joint, if desired, as in Figure 29.

The second method, pneumatic telescoping, involved the use of a special oil filled "gun". The nickel tube "missile" was capped with a lead plunger and a gasketed rear plunger, the "gun" being muzzled, as in Figure 30, to the bottom sleeve of the then oil filled copper tube assembly. Oil pressure was now applied through the breech connection shown in Figure 31, and the nickel tube forced through the copper tube by opening the valve clamped to the top sleeve.

The first attempt to use this method resulted in deep button scratches on the bottom side of the copper tube, shown by cutting in half lengthwise, as in Figure 33. To eliminate this difficulty, the idea was then conceived of replacing the oil with a liquid heavy enough to float the capped nickel tube during the operation. Such a liquid, Sp.g.2.3-2.5, could be found among organic halogen compound of the type now being used to rinse oil from the annulus. There was not sufficient time to put this method into routine operation.

The top end of the telescoped nickel tube was immediately rolled out into the end of the sleeve, from 1.375" to about 1.43" I.D. at the rolled section, by 3 to 4 passes with the special rolling tool shown as seen in Figure 32. The column assembly was now reversed in the shortened casing, and the stuffing boxes tightened to allow circulation of tap water. A 100 psi. steam line was now loosely inserted into the rolled end of the nickel tube, the other end being capped off by an expander plug. The steam flow was adjusted to secure a static 5/8" expansion of the nickel tube (as in Figure 32), after which the final nickel roll was made.

The column assembly was removed, and the steel collar (FER. SK-102, Figure 39) tack (arc) welded to the bottom sleeve. The bottom stuffing box detailed in XB-11522, XB-11521, XA-11523, Figures 34, 35, and 36, was now threaded into the bottom tee, the column assembly being inserted until the steel collar seated against its root, as shown in CB-1105-A, Figure 10. The other stuffing box was assembled, both tightened, allowing the tits to be welded to the Monel sleeves. (74% nickel welding rods).

The assembly was completed by welding the fillister head rivet spacers (XA-11724, Figure 37) and arc welding the Schedule 80 seamless carbon steel 1" pipe nipples to the nickel tube ends (FER. SK-102, Figure 38), the nickel welding rods again being used.

The annulus, which had been rinsed out with dichloroethylene or a similar solvent to remove oil, was now given a 2000 psi. hydrostatic (water) test, and the casing inspected for leaks during application of 40 psi water pressure.

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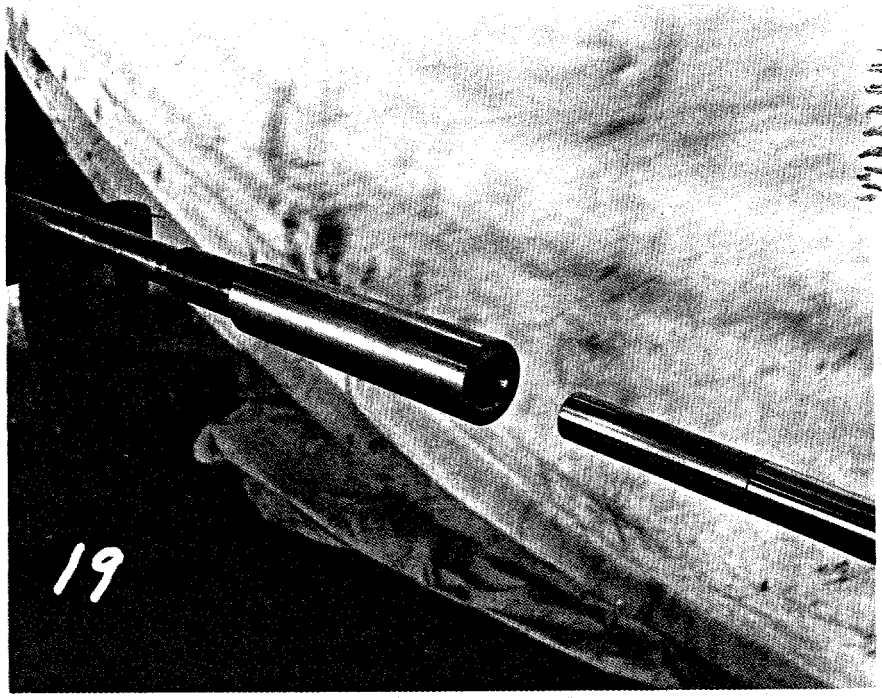

Figure 29. TELESCOPING THE NICKEL TUBE
The nickel tube (with plunger) is shown ready to enter the guide sleeve during hand telescoping.

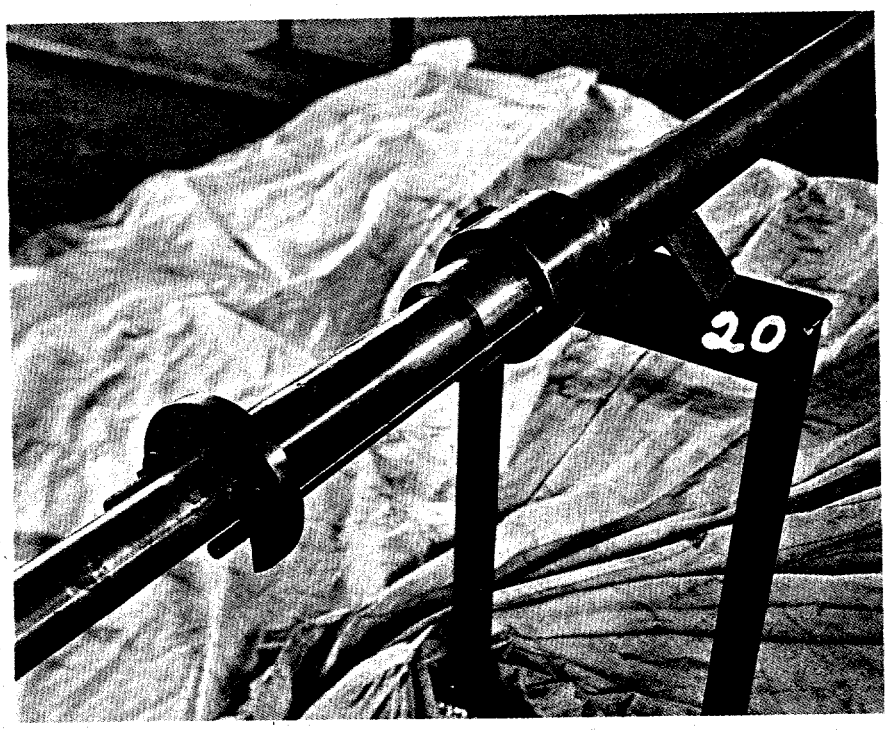

Figure 30. PENUMATIC TELESCOPING. The bottom sleeve is shown clamped to the muzzle of the special "gun" constructed for pneumatic telescoping.

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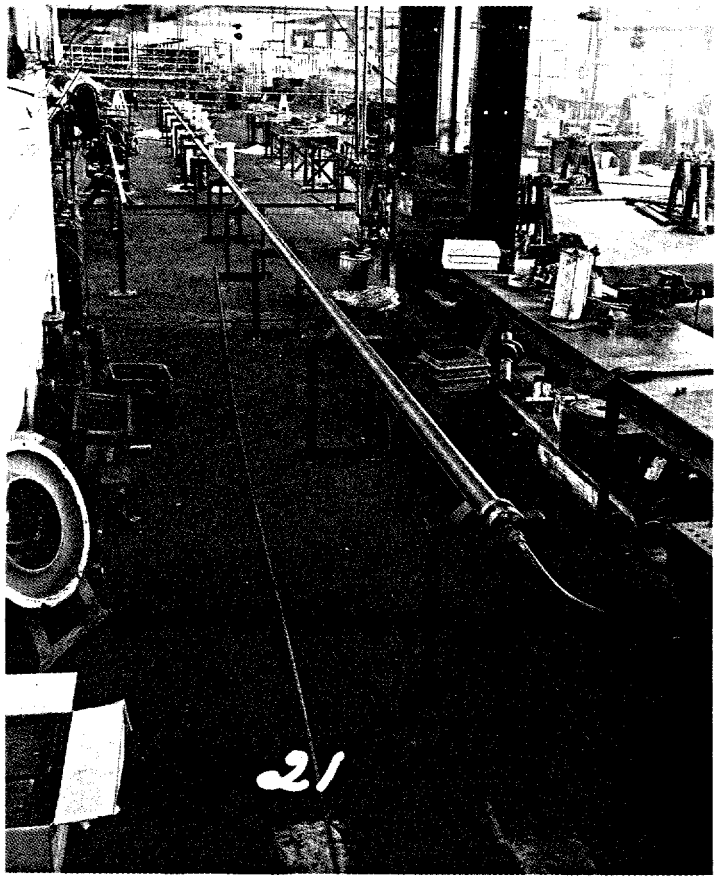

Figure 31. PNEUMATIC TELESCOPING. Breech end and general view of the "gun" for pneumatic insertion of the nickel tube.

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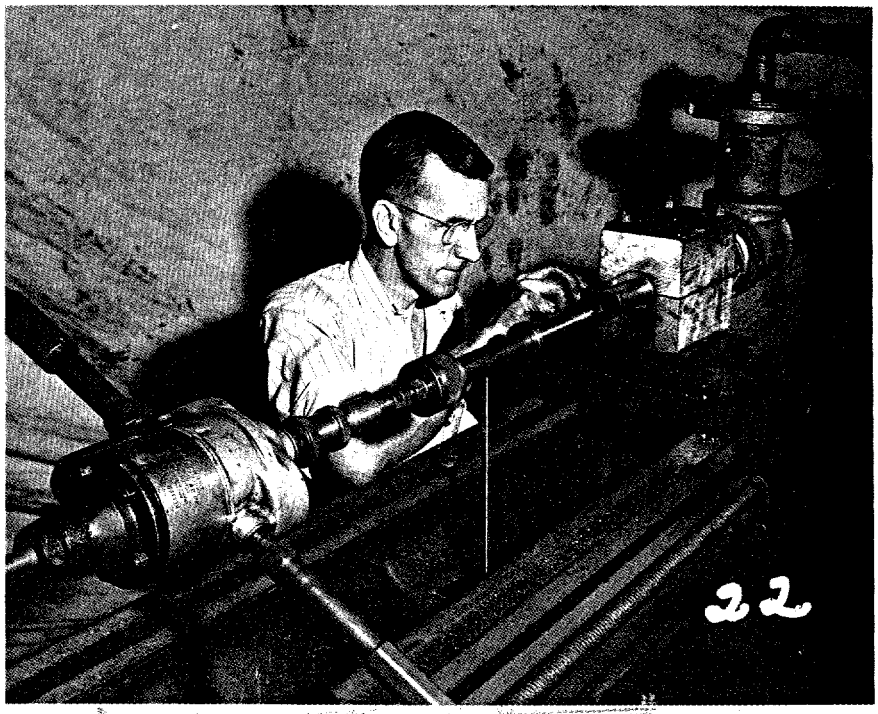
Figure 32. ROLLING THE NICKEL TUBE. Rolling tool is shown in readiness for final nickel tube roll, after the 5/8" expansion.



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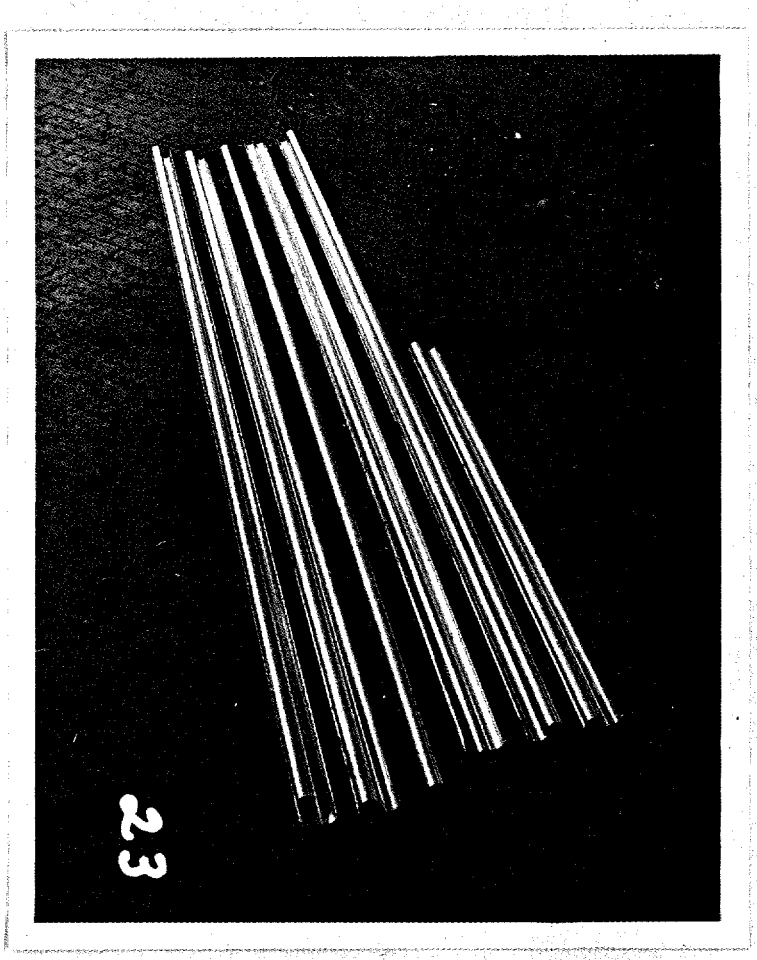

Figure 33. DISSEMBLY BY SPLITTING COPPER TUBE. Examination of the scarring effect of the first pneumatic telescoping attempt.

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To provide reliable values for the exact annulus size and other critical column measurements, it was requested that the micrometry indicated on the attached blank Column Data Sheets be supplied by the Continental Gin Co. for each column constructed. Lack of a sufficient sizes of "air mike" tools for determining the I.D. of the copper tube made it impossible to obtain these data except in the region of 1.688 ± .001".

Fabrication of 15 columns using nickel tube and casings taken from the 132 broken columns which had been dissembled, was expected to be complete by September 29.

IV CONCLUSIONS

Conclusions drawn from the experimental work of Project No. 41 follow:

1. Silver soldering a copper center joint by induction heating is much preferable to that by torch heating, since annealing of the copper tube outside the sleeve can be eliminated by water cooling. However, the annealed copper in the sleeve area itself still constitutes a point of weakness.

2. Silver soldering of ferrules for Lunkenheimer fittings can be accomplished rapidly and conveniently by induction heating.

3. The Monel-sleeve rolled center joint involves no annealing of the copper tube and has superior strength, but is difficult to fabricate. It would eliminate the major weaknesses of the present silver solder copper center joint. However, need for such a joint has now been eliminated by use of single 46' lengths of copper tube.

4. The Monel-sleeve rolled end joint with welded nickel stub also involves no annealing of the copper, achieves a strength equal to the copper tube itself, and is very easy to fabricate. The slight annealing of the nickel stub is unimportant.

5. The double rolled joint is probably the strongest type connection possible, or at least necessary to obtain, since the rolled copper connection equals the strength of that tube, and the rolled nickel connection is stronger than the welded regions of the nickel tube. Its incorporation in the design of the new column seemed to be a justifiable step.

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NICKEL TUBE

COLUMN DATA SHEET I

COLUMN NO. CG- _____ DATE _____

INSPECTOR _____ RECORDED _____

LENGTH (WELDED) _____

Components	Top	2nd.	3rd.	Bottom
Length (Ft.)				
O.D. Max.				
O.D. Min.				

O.D. RANGE AT WELDS: 1. _____ 2. _____ 3. _____

Maximum and Minimum outside diameter measurements every 5' starting 19-1/2" from reference (top) end (cut 1" from first set of buttons):

Distance	Max.	Min.
(1) 1' 7-1/2"		
(2) 6' 7-1/2"		
(3) 11' 7-1/2"		
(4) 16' 7-1/2"		

(5) 21' 7-1/2" _____ _____

(6) 26' 7-1/2" _____ _____

(7) 31' 7-1/2" _____ _____

(8) 36' 7-1/2" _____ _____

(9) 41' 7-1/2" _____ _____

(10) 46' 7-1/2" _____ _____

Special Characteristics _____

_____

_____

_____

_____

_____

Exact Expansion _____

I. D. Rolled End: Top _____ Bottom _____

Note: The numbers assigned to the nickel tube O.D. measurements above correspond longitudinally, but not necessarily radially, to the numbers given the copper tube I.D. measurements on DATA SHEET II.

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SECRET

COPPER TUBE

COLUMN DATA SHEET II

SECRET

COLUMN NO. CG- _____ DATE _____

INSPECTOR _____ RECORDED _____

LENGTH _____

Maximum and Minimum inside diameter measurements starting 9" from reference (top) end.

Before Honing	Max.	Min.
(1) 9"		
(2) 5'9"		
(3) 10'9"		
(4) 15' 9"		
(5) 20' 9"		
(6) 25' 9"		
(7) 30' 9"		
(8) 35' 9"		
(9) 40' 9"		
(10) 45' 9"		

After Honing

	Max.	Min.
(1) 9"		
(2) 5' 9"		
(3) 10' 9"		
(4) 15' 9"		
(5) 20' 9"		
(6) 25' 9"		
(7) 30' 9"		
(8) 35' 9"		
(9) 40' 9"		
(10) 45' 9"		

Special Characteristics

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SECRET

COPPER JOINT

ASSEMBLY

COLUMN DATA SHEET III

COLUMN NO. CG-_____ DATE_____

INSPECTOR_____ RECORDED_____

OVERALL LENGTH TO SLEEVE ENDS _____

		Top	Bottom
I.D. Copper	Max.	_____	_____
After Swaging	Min.	_____	_____
I.D. Copper	Max.	_____	_____
After Rolling	Min.	_____	_____
O. D. Range	Distance from edge of sleeve		
Copper Just Beyond Sleeve	(A) 1/2"	_____	_____
	(B) 1"	_____	_____
	(C) 1-1/2"	_____	_____
	(D) 2"	_____	_____

I.D. Range of Sleeve Area after Honing	Distance from end.		
	3-1/2"	_____	_____
	4-1/2"	_____	_____
	7-1/2"	_____	_____
	10"	_____	_____
	11-1/2"	_____	_____
(A)	12"	_____	_____
(B)	12-1/2"	_____	_____
(C)	13"	_____	_____
(D)	13-1/2"	_____	_____

Remarks _____

Note: The corresponding letters in the O.D. & I.D. meas. above refer to positions which are longitudinally adjacent.

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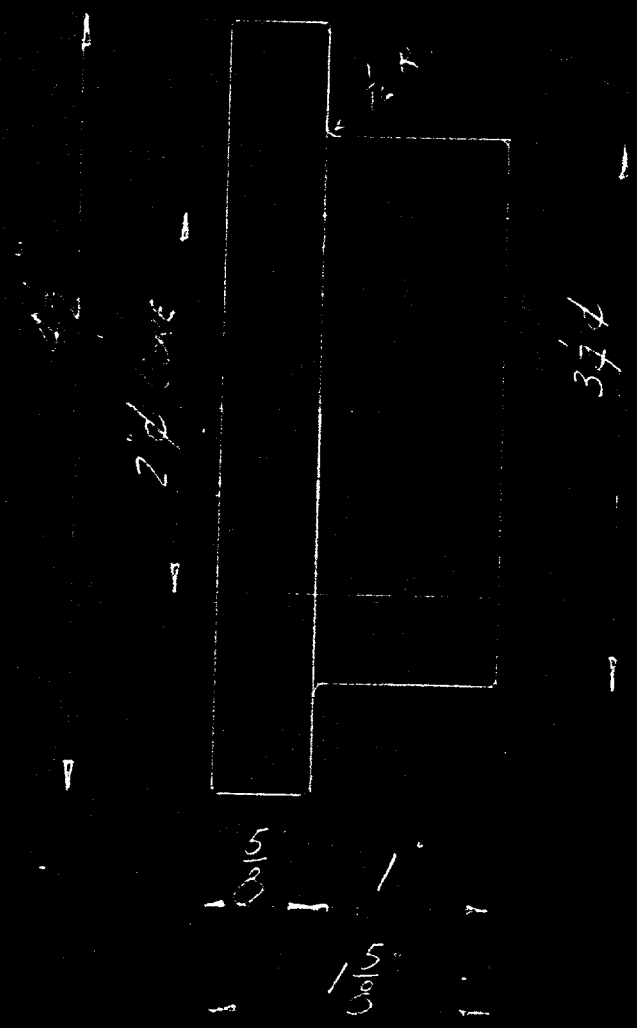

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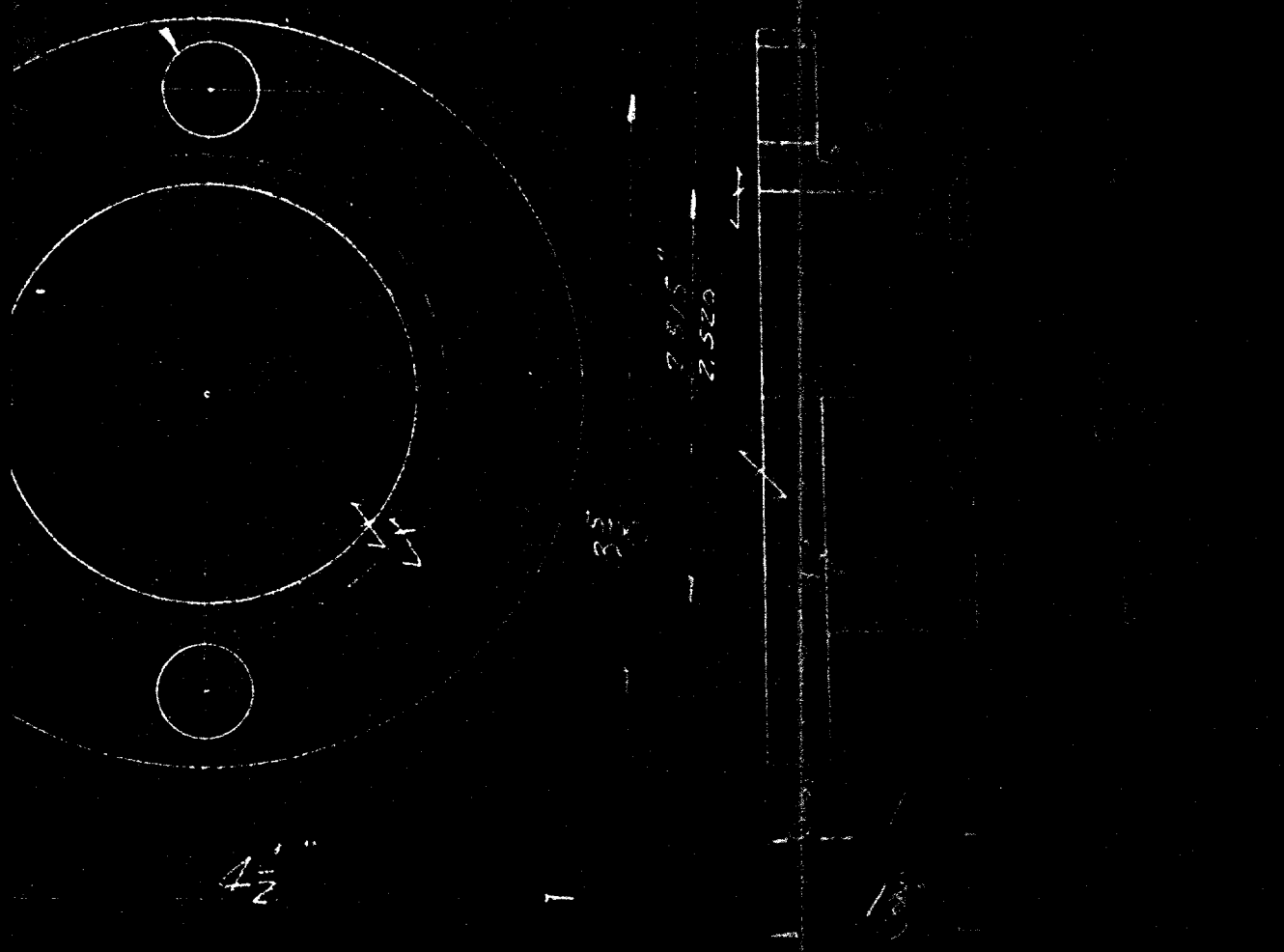

VALVE BRONZE
Cu 87% Tin 7%
Lead
Zinc

						DRAWN		SCALE
		CHANGE ORDER NUMBER	DATE	NUMBER OF REVISIONS	REVISION NUMBER	CHECKED	MSG 6-29-45	XB 11521
						APPROVED	HSC	

DRAWING PERTAINS TO

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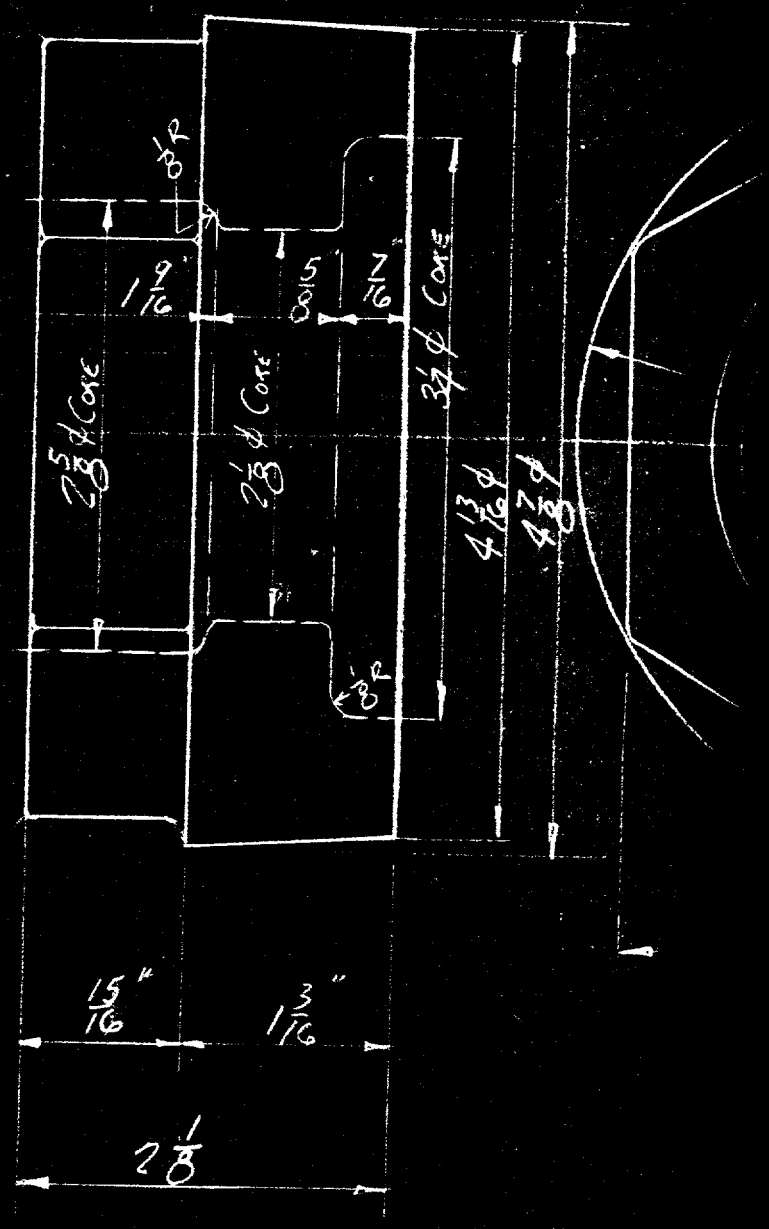
TAP $\frac{5}{8}$" DEEP - 2 TAPS



PATTERN DIMENSIONS.

VALVE BRONZE
Copper 87.0 Tin 7.0 Lead 1.0
Max Iron .06 Zinc REMAINDER.

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FRACTIONAL + FINISHED	$\frac{1}{64}$
DECIMAL	
ANGULAR	
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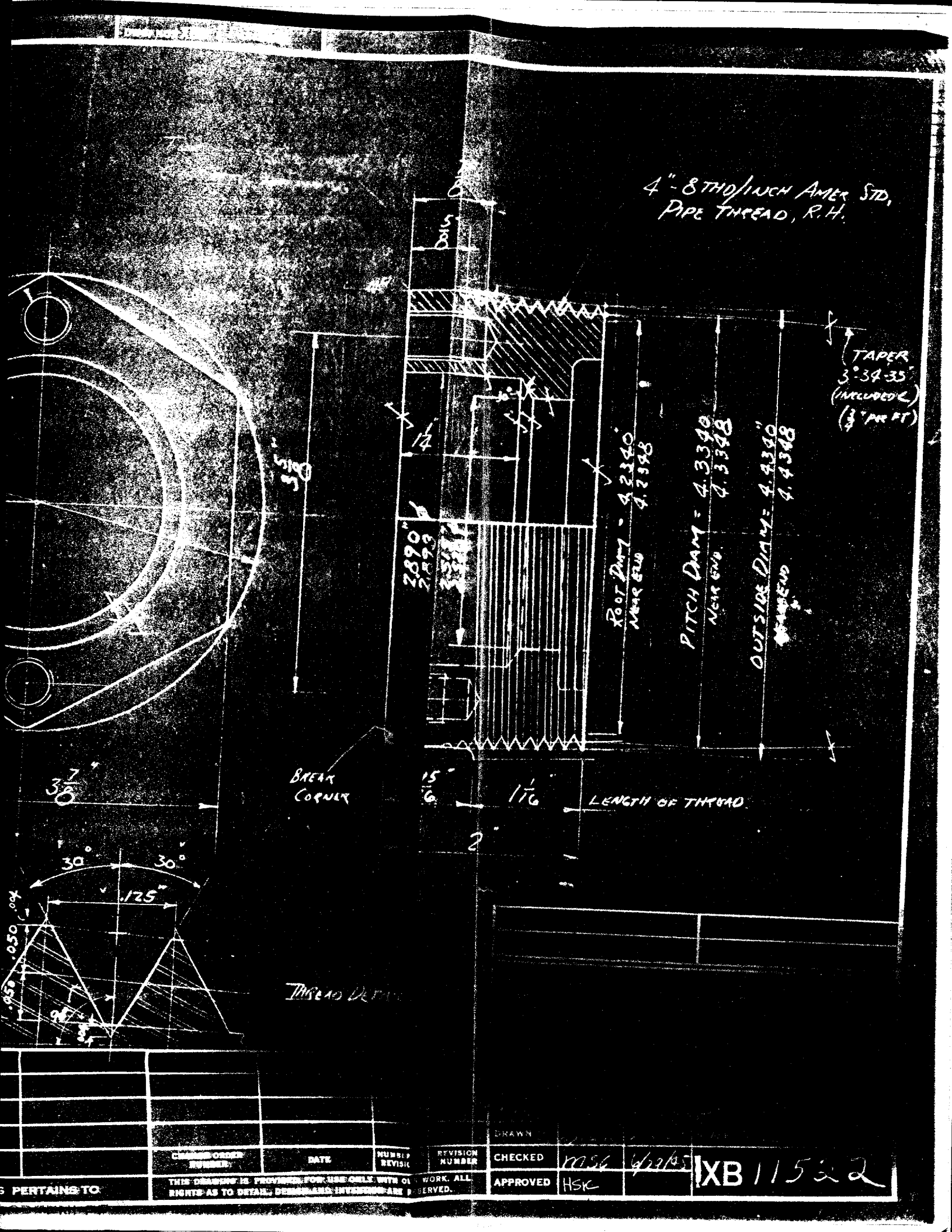
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PIPE THREAD, R.H.
TAPER
3°34'35"
(INCLUDED ∠)
(3/4" PER FT)
ROOT DIAM - 4.2340
4.2348
NEAR END
PITCH DIAM = 4.3340
4.3348
NEAR END
OUTSIDE DIAM = 4.4340
4.4348
BREAK CORNER
LENGTH OF THREAD
30°
30°
.125"
.050
.004
THREAD DETAIL
DRAWN
CHECKED
APPROVED
HSK
XB 11522
DATE
REVISION NUMBER
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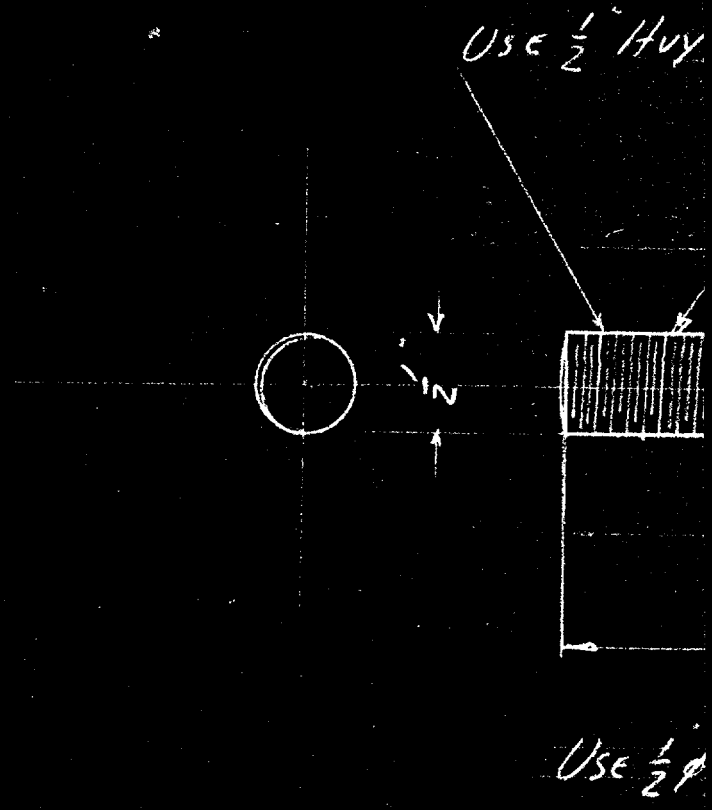

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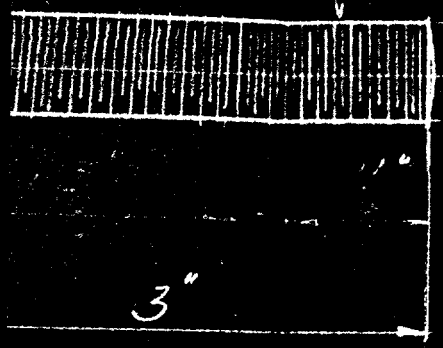

X 3 LG. C.R. STEEL

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STUD. FOR STUFFING BOX

CONTINENTAL GIN COMPANY

BIRMINGHAM CGC ALABAMA

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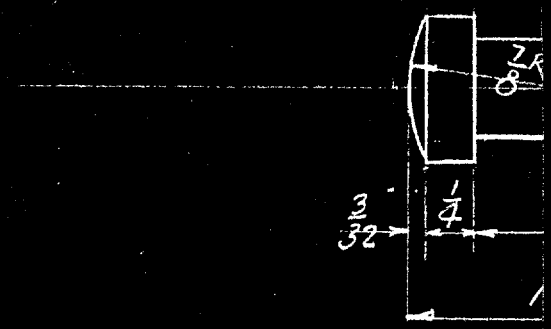
APPROVED			

XA-11523



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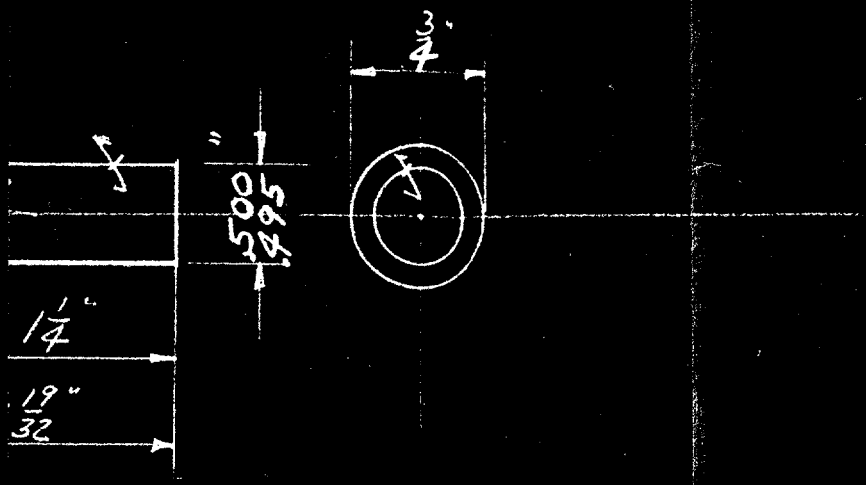

RIVET SPACER 1/2" DIA x 1 1/4 LG.
FILLISTER HEAD.

CONTINENTAL GIN COMPANY

BIRMINGHAM ALABAMA

MAT. SPEC. 3/4 ϕ MILD CRS.

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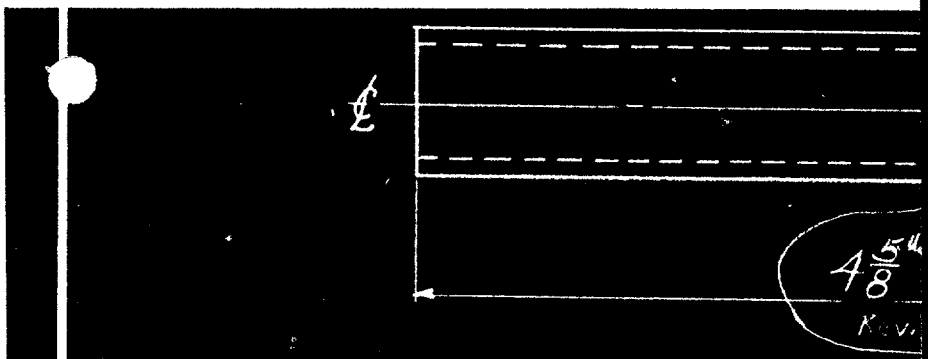

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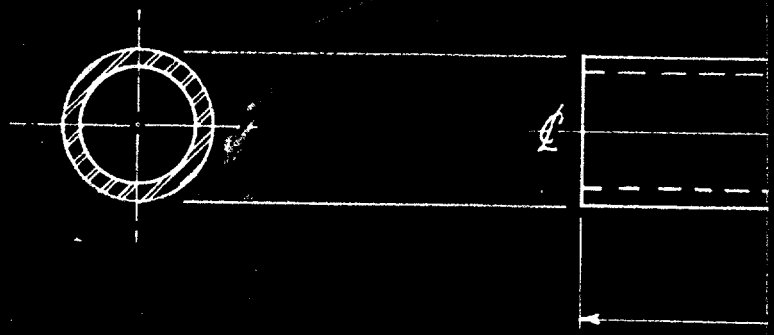

BOTTOM NIPP

1" SCHEDULE 80 SEAMLESS CAR

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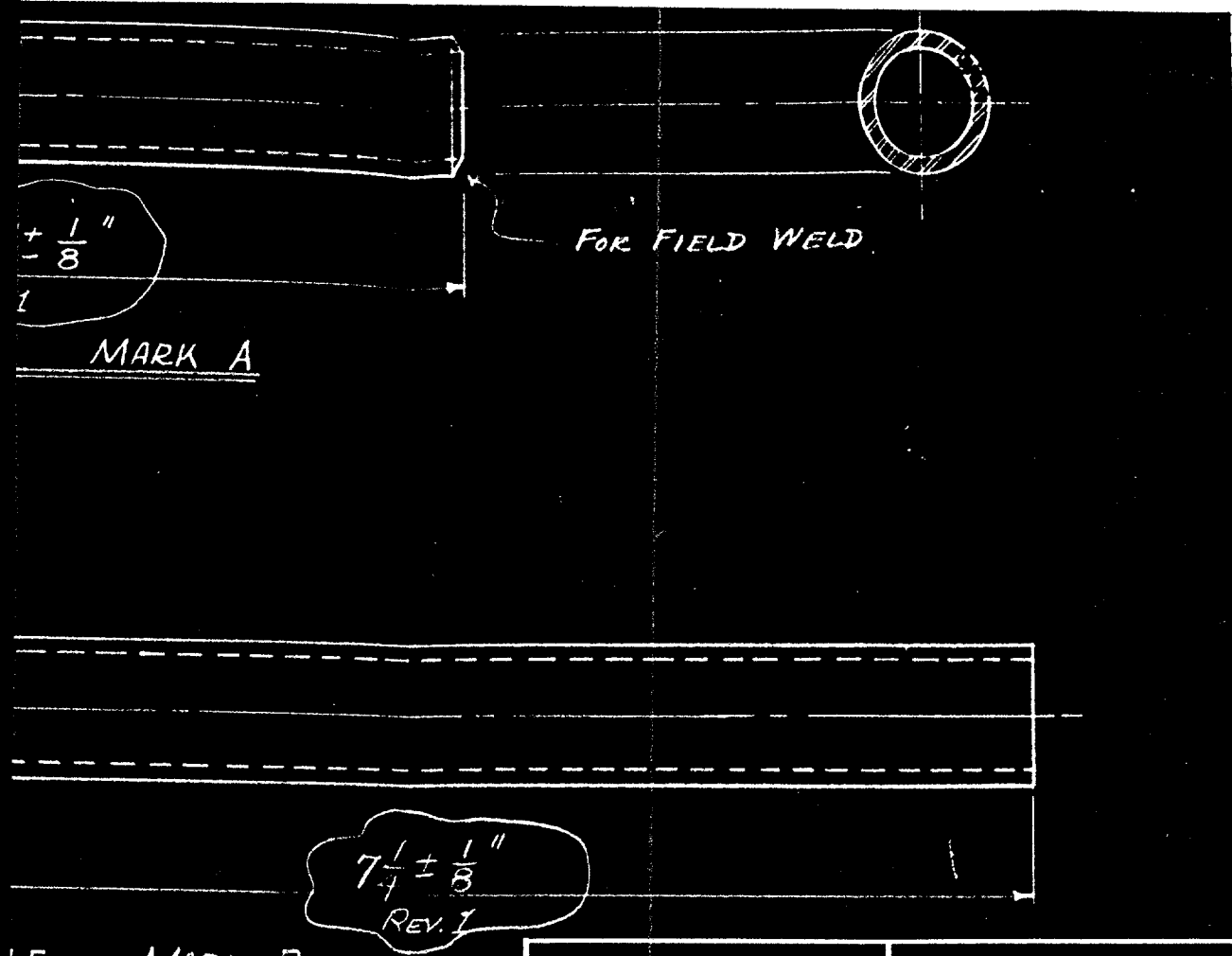

BON STEEL PIPE

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PIPE NIPPLES, SPECIAL FOR WELDING.

CONTINENTAL GIN COMPANY
INDUSTRIAL DIVISION
BIRMINGHAM ALABAMA

SEE NOTE FER. SK 101

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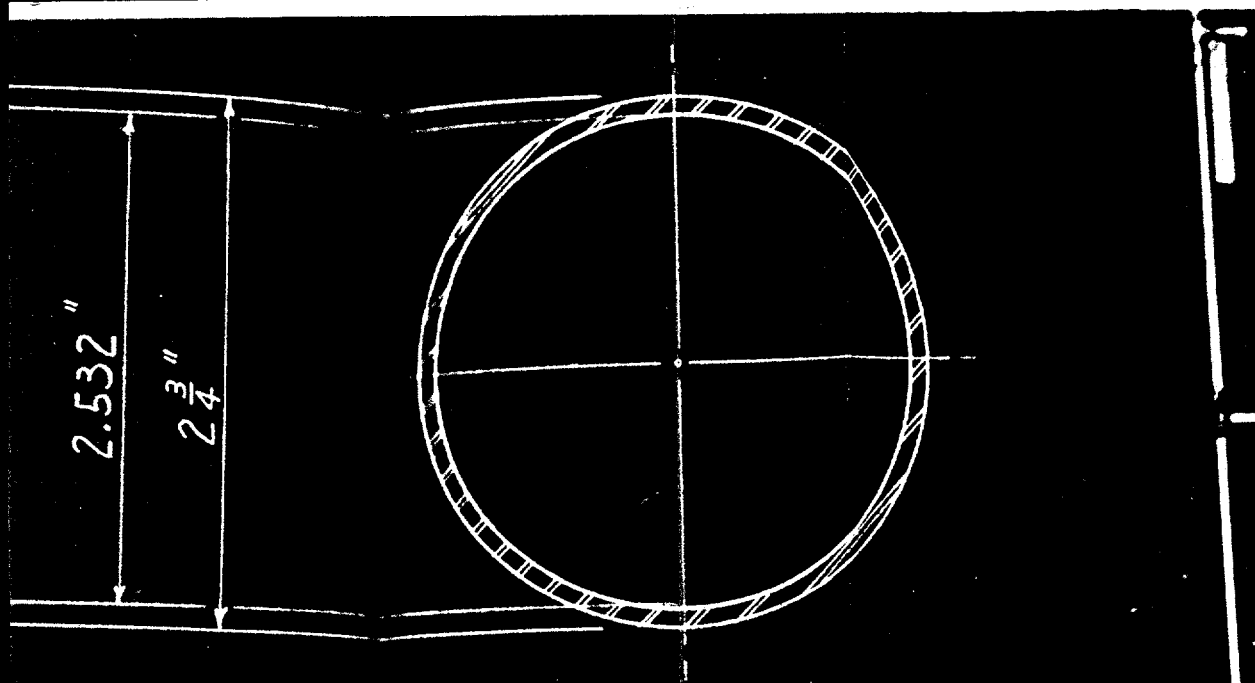

2 3/4" STEEL TUBING

COLLAR FOR SLEEVE, SPECIAL

CONTINENTAL GIN COMPANY
INDUSTRIAL DIVISION
BIRMINGHAM ALABAMA

FER.-SK102

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Tab

41-a

SECRET

UNCLASSIFIED

MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 41-a

TEST OF A ROLLED JOINT COLUMN UNDER NORMAL AND ABNORMAL CONDITIONS

UNCLASSIFIED

By: R. Van Winkle
W. Binger

R Van Winkle
W W Binger

SECRET

SECRET

UNCLASSIFIED

TEST OF A ROLLED JOINT COLUMN UNDER NORMAL AND ABNORMAL CONDITIONS

Object:

A special eight foot column was constructed by the Continential Gin Company in which the copper section was installed by means of rolled joints rather than the standard silver soldered joints. The details of this column are shown in the drawing numbered 1178-A by the Continential Gin Company. It was desired to test this column under normal and abnormal operating conditions to determine how well this type of joint would stand up.

Progress During Month:

A letter from C. A. Todaro to Dr. Barnett F. Dodge lists the steps to be followed in testing this special column. The letter reads as follows:

Program for Testing New Type Joint on Column.

1. Install in system (Replace Column 51, Rack 21). Install Steam gauge at top.

2. Condition according to latest accepted method.

3. Fill with material (after turning on water and steam) from bottom of circuit through one tit only, with a gauge attached to a second bottom tit. Record weight of material required to fill the column.

4. Remove link line required for filling after column reaches 1500 psi.

5. Allow to sit in this fashion for one week recording material pressure once a shift.

6. If pressure is still 1500 after one week, shut off steam and condensate valve and prepare to control steam pressure on column.

7. Throttle steam pressure on column to 400 psi. Fill column with material (1500 psi) at this steam pressure. Remove link line.

8. Raise steam pressure slowly (about 50 lb. every 15 min.) taking material pressure readings every 5 min. until column fractures.

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SECRET

Note: 1000 psi. steam will give approximately 3700 psi. material pressure if column is filled to 1500 psi. at 400 psi. steam.

9. Drain remaining material from column by blowing it into duct out tits, clean out thoroughly, and remove column from the rack.

10. Ship to G. F. Nellett at Continential Gin Company.

The column was substituted for Column No. 51 on Rack 21 and the steam and water line connections were extended to fit the column. The standard conditioning procedure was followed through moisture testing at which point the steam was turned off twice and the column allowed to cool. This was done to see if the column leaked. The steam was turned on and the column was again moisture tested. The second moisture test showed that there were no apparent leaks.

The column was then "fresh-aired" and filled with material from the adjacent circuit. A small pressure gauge was connected to the column and the column was then isolated from the circuit.

The column was then allowed to "sit" and pressure readings were taken every eight hours to see if the pressure dropped due to leaks. The pressure data obtained was as follows:

Date	Time	Press. Rdgs.
8-31	1030	1730
	1200	1760
	2000	1750
9-1	0400	1740
	1200	1775
	2000	1780
9-2	0400	1760
	1200	1740
	2000	1700
9-3	0400	1670
	1200	1700
	2000	1695
9-4	0400	1660
	1200	1675
9-6	0830	1720

It was found that water was dripping on the column from the top of the rack and this accounted for the lower pressures during the run. The water leak was stopped and the pressure came up to 1720 which showed that the column did not leak.

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The column was then overloaded with material by reducing the steam pressure to 400 psi. and filling the column from the adjacent circuit at 1500 psi. The steam by-pass at the bottom of the column was opened and the steam pressure raised to 1000 psi. The material pressure was controlled by opening and closing the by-pass. (Closing the by-pass increased the material pressure and vice versa). The by-pass was gradually closed and the material pressure increased gradually. The following data were obtained:

	Material Pressure, psi.		
Time	Gauge 1	Gauge 2	
1337	2050	2100	@ 400 psi. steam pressure
1341	2200	2000	
1342	2300	2250	
1343	2350	2350	
1344	2520	2450	
1345	2700	2670	
1346	3200	3100	
1347	3300	3200	
1348	3300	3200	
1349	3500	3500	
1350	3600	3530	
1351	3600	3530	Steam pressure gradually increased to 1000 lbs.
(Steam Pressure Reduced to 400 psi.)			
1407	2050	1950	
1409	2130	2050	

The material pressure was raised from 2000 to 3600 in thirteen minutes without the column failing.

To give the column an additional over-load, the steam pressure was dropped to 200 psi and the column filled from the adjacent circuit at 1500 psi. The steam pressure was again increased with the following results:

Time	Pressure
1600	2300
1602	4200
1606	4500

In an attempt to break the column the by-pass was opened completely and the material pressure dropped to 1500 psi.

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The by-pass was then quickly closed and the material pressure increased to 4600 psi. in ten seconds without the column failing.

Another attempt was made to break the column by filling it as completely as possible. This was done by raising the material pressure on the adjacent circuit to 1900 psi. and hooking the test column into this circuit. The steam was then turned off the column and allowed to cool thus drawing as much material into the column as possible. When this was accomplished the 1000 pound steam was turned on as rapidly as possible. The material pressure increased rapidly to 7500 psi. (maximum gauge reading) in only a few seconds. The column did not rupture under this severe test which would easily break an ordinary column, but a slight leak developed where the right hand tit was welded to the column.

After testing, the column was removed for inspection. The material was blown out of the column and the column washed with water.

The column was then removed from the rack and the water jacket removed. The O. D. of the copper section of the column was 2.039" from one end to the other. From this uniform O. D. it was assumed that the copper section did not change dimensions during the severe testing.

Final Conclusions

The results of these tests indicated that the design and fabrication of the copper-nickel joints in this column were far superior to those in the standard columns now in use.

Recommendations for Future Work

It appears that the next step should be the construction of a standard sized column. This column should then be tested in the same manner as was the short test column.

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Tab 42

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 42

COMPARISON OF ACTUAL PRODUCTION RATES WITH THOSE PREDICTED FROM RATE-OF-RISE DATA

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By: William B. Daly, Jr.

William B Daly Jr.

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COMPARISON OF ACTUAL PRODUCTION RATES WITH THOSE PREDICTED FROM RATE-OF-RISE DATA

Purpose:

The purpose of this investigation was to compare the actual production rates of columns, for which rate of rise data were available, with the rates predicted from such data.

Method:

Upon completion of Project No. 19-III Rack 1 was reconverted to four circuits on top leaving the test columns of that project isolated at the top but in the circuit at the bottom. The circuits and test columns were then milked heavily to bring the contents of the column to a normal level. This was necessary since the rack was not milked during the course of Project No. 19-III.

Using the time of the last of the milking on each circuit and column as zero time the following milking schedule was followed for this project:

Circuit 1 - Every 7 hours

Circuit 2 - Every 6 hours

Circuit 3 - Every 6 hours

Circuit 4 - Every 4 hours

Columns 2, 6, 7, 9, 20, 29, 30, 36, 40, 52, 53, 54, 63 and 67 - A No. 4 capsule every 24 hours.

Columns 85, 90, 92, 94 and 100 - A No. 4 capsule every 12 hours.

Bottom samples were scheduled to be taken daily from the first and last column in each circuit.

The operating conditions were the same as for Run II of Project No. 19-III. These were:

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Inlet cooling water temperature - 140° F.

Steam pressure - 450 lbs.

Material pressure:

Circuit 1 - 1500 lbs.

Circuit 2 - 1000 lbs.

Circuit 3 - 1250 lbs.

Circuit 4 - 1900 lbs.

During the course of this project each No. 120 capsule from Rack 1 and each No. 4 capsule was sampled by the Material Section. A record was kept of the date and time of capsule removal, capsule number, capsule tare weight, capsule gross weight, net weight of material in each capsule, column or circuit from which capsule was taken and sample number.

After the test was in progress Circuit 1 was put on a six hour milking schedule in order to ease the burden on the rack crews.

Results:

The results of the individual column milkings and 16 columns are listed in Table I. In most cases the actual values of separation factor compare fairly well with the values predicted from Figures I, II, III and IV. The curves shown in these figures were calculated from rate-of-rise data of Project No. 19-III. At the lower milking rates a good check is obtained for all columns, good, bad or average. At the higher milking rates the values check for the two good columns, 85 and 100, and for the average column, 92, but did not check for the two exceptional columns.

The circuit milkings show the following results:

Circuit	Milking Rate gms/(col.)(Day)	Actual S	Predicted S
1	106.2	1.260	1.256
2	82.5	1.262	1.244
3	96.6	1.229	1.225
4	136.3	1.203	1.282

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The predicted separation factor is the average of the values for the test columns of that circuit at the rate shown. The actual and predicted value, check very well for Circuits 1 and 3; not quite so well for Circuit 2; very poorly for Circuit 4.

Discussion of Results:

The curves of Figures I through IV were plotted using the rate of rise data of Run II Project 19-III. See report for Project No. 19-III. The rate predictions based on rate of rise data compare fairly well with the actual rate necessary to give a certain assay for all but the exceptional columns. A check within 0.015 points in the separation factor is taken to be good because (1) the product assays themselves deviated by about 0.013 points (on an average) from the mean assay, the column-hold-up values used in determining the predicted values of S were not as accurate as desired.

In the case of Columns 90 and 94 it is evident that either some factor in column construction prohibits going beyond a certain production rate if the curves of Figure IV are to apply or the rate of rise data were misinterpreted. The latter is unlikely since for each of the two runs of Project 19-III these columns were found to be considerably better than the other columns of that same circuit which were under test. Although no data are available for these columns milking at a lower rate, it is felt that the actual and predicted values of S would check more closely in the lower range.

It was deemed inadvisable to include columns 7, 9 and 20 in the results since the product assays for these columns were so erratic. The average deviation from the mean product assay was in the neighborhood of 0.03 for each of these columns.

From the circuit data and results it is obvious that the columns chosen for test in Circuits 1 and 3 were a fairly good cross-section of these circuits. On the average the test columns of Circuit 2 were slightly poorer than the rest of its columns and, as was expected, the test columns of Circuit 4 were much better than the circuit as a whole.

Conclusions:

1. The production rate as predicted from rate of rise data is, in general, applicable to actual production over a fairly wide range.

2. It appears that, for columns having very low X values, the rate of rise predictions are not reliable at high production rates.

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Fig. I

Project 42

Separation Factor vs. Production Rate

Circuit 1 Rack 1

Col.	X	V	Pressure
2	100	0.270	1500
6	87	0.325	1500
7	96	0.260	1500
9	85	0.270	1500
20	107	0.250	1500

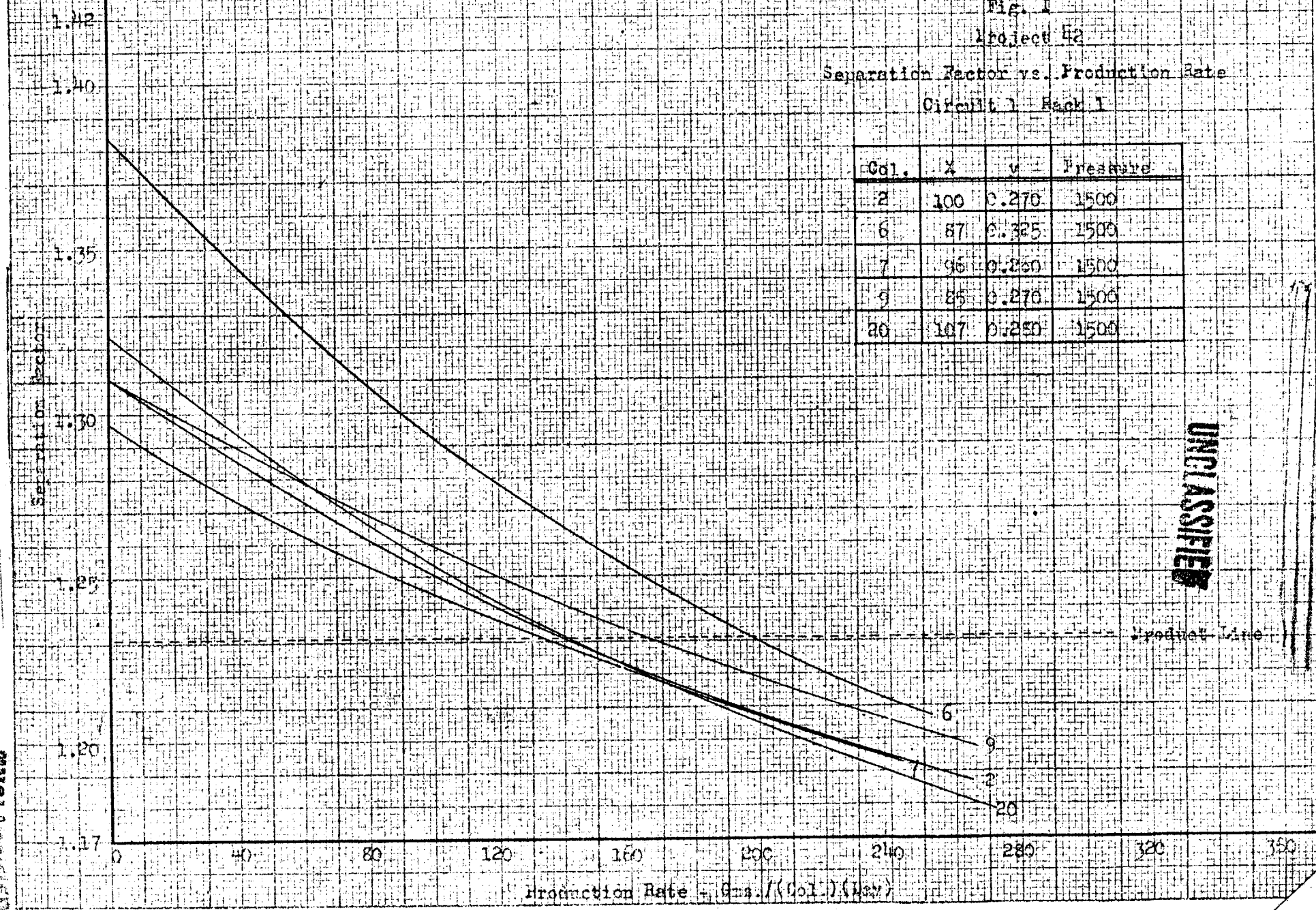

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Fig. II

Project 42

Separation Factor vs. Production Rate

Circuit 2 Rack 1

Col.	X	y	Pressure
29	132	0.270	1000
30	125	0.265	1000
36	143	0.270	1000
40	106	0.290	1000

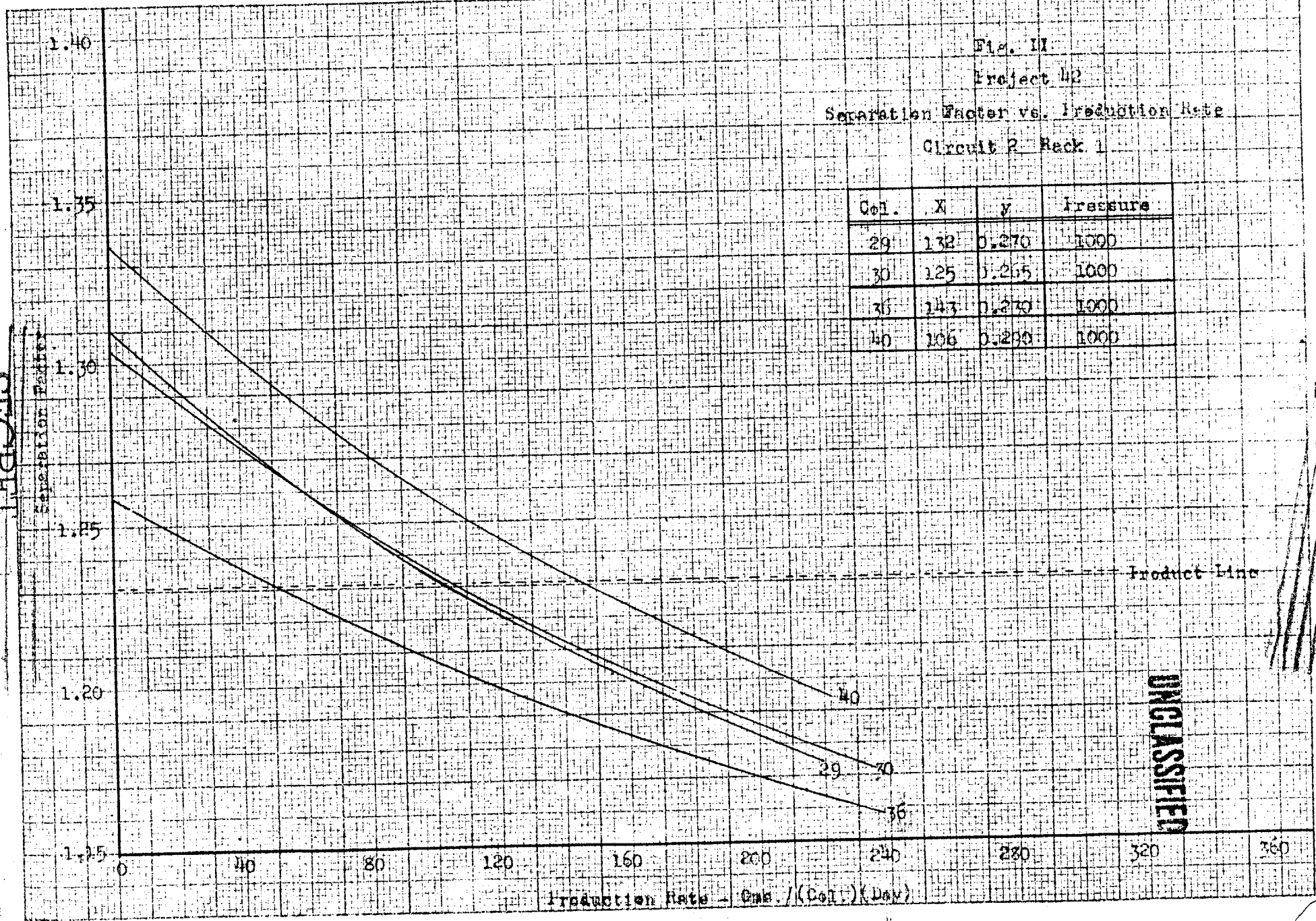

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Fig. III

Project 42

Separation Factor vs Production Rate

Circuit 3 Rack 1

Col.	X	y	Pressure
52	146	0.217	1250
53	133	0.250	1250
54	101	0.257	1250
63	108	0.277	1250
67	110	0.260	1250

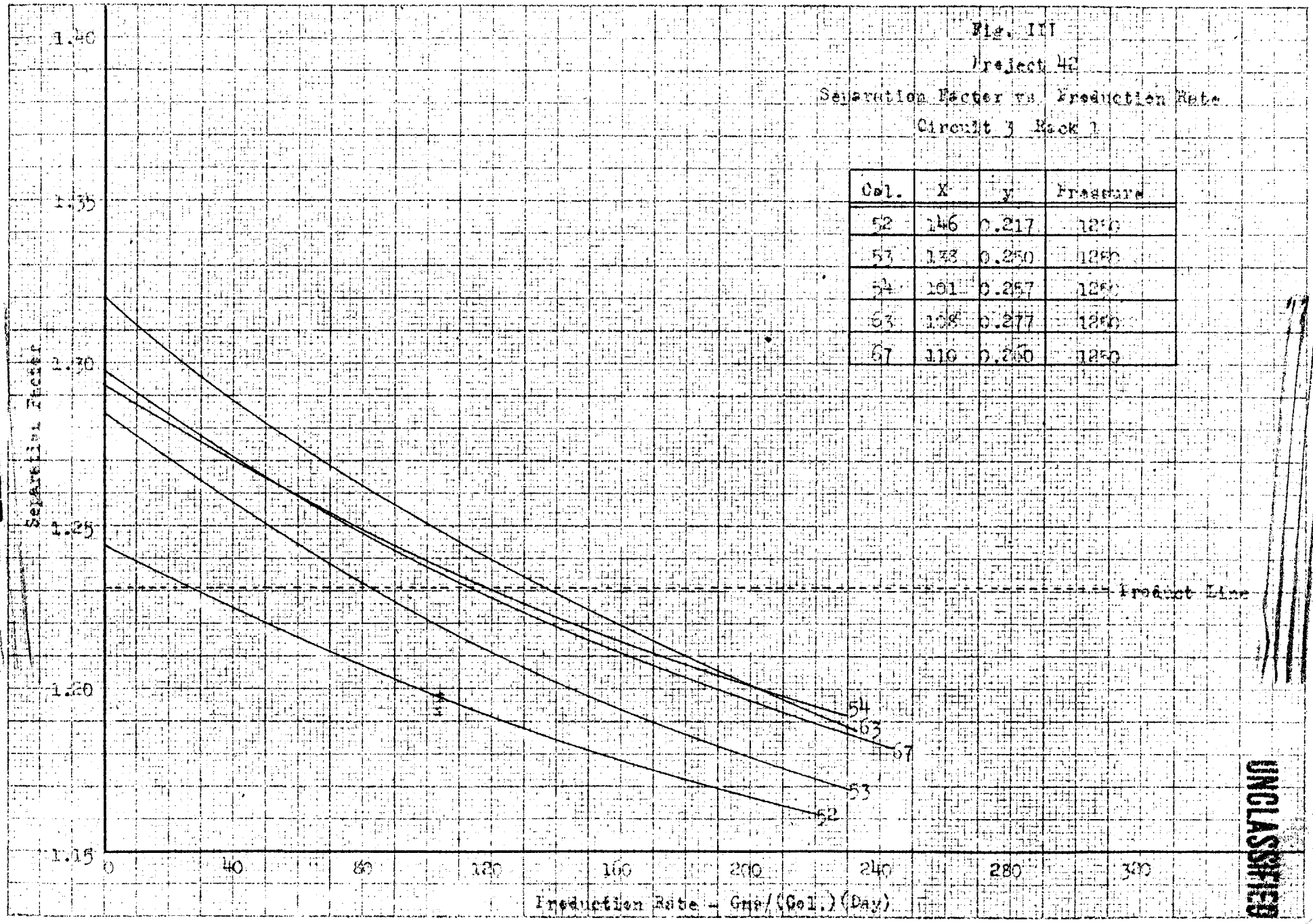

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Fig. IV

Project 42

Separation Factor vs. Production Rate

Circuit 4 Rack 1

Col.	X	y	Pressure
85	71	0.325	1900
90	53	0.345	1900
92	108	0.260	1900
94	53	0.350	1900
100	83	0.340	1900

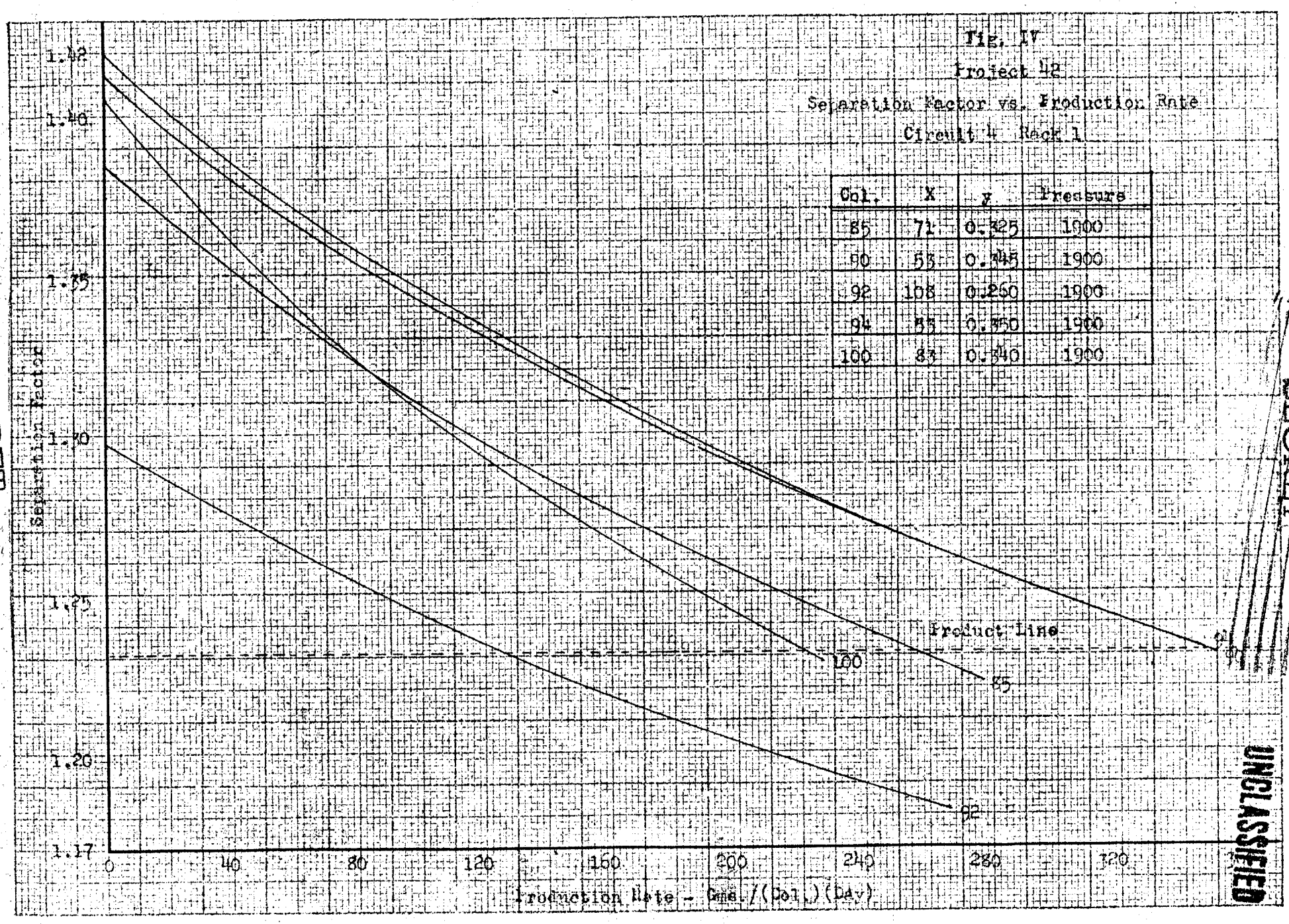

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TABLE NO. I

Col.	Press.	Milk. Rate gms/day	Ave. Bott. Assay	Ave. Prod. Assay	No. of Prod. Assays	Ave. Dev. From Prod. Assay	S Actual	S Predicte
2	1500	83.4	0.964	1.209	9	0.009	1.252	1.259
6	1500	91.7	0.964	1.249	10	0.013	1.294	1.299
29	1000	94.9	0.940	1.176	11	0.009	1.250	1.233
30	1000	85.7	0.940	1.177	12	0.007	1.251	1.243
36	1000	87.6	0.940	1.126	12	0.010	1.198	1.213
40	1000	85.2	0.940	1.193	12	0.010	1.270	1.267
52	1250	87.0	0.941	1.121	12	0.013	1.192	1.204
53	1250	88.3	0.941	1.136	12	0.013	1.208	1.227
54	1250	92.6	0.941	1.171	12	0.013	1.248	1.242
63	1250	92.4	0.941	1.192	12	0.009	1.269	1.255
67	1250	88.7	0.941	1.177	11	0.009	1.250	1.243
85	1900	179.0	0.962	1.219	17	0.010	1.268	1.265
90	1900	181.6	0.962	1.203	19	0.009	1.252	1.298
92	1900	181.8	0.962	1.159	19	0.010	1.204	1.209
94	1900	182.6	0.962	1.210	18	0.012	1.260	1.299
100	1900	178.5	0.962	1.191	18	0.011	1.240	1.249

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Recommendations:

1. This work should be repeated on a number of columns for which rate of rise data are available, varying the milking rate so as to check a number of points along the curve of Separation Factor vs. Production Rate.

2. Columns having a very low X value should be milked at varying rates in order to determine how well the rate of rise predictions hold at the low milking rates and to determine at what point the predictions fail as well as the reason for the failure.

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 43

INVESTIGATION OF SOLENOID VALVE PERFORMANCE

Reported by: R. Van Winkle
W. W. Binger

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INVESTIGATION OF SOLENOID VALVE PERFORMANCE

Purpose:

The purpose of this project was to study the operation of solenoid valves under accelerated operating conditions in an attempt to determine why they have been giving trouble in the plant, and to develop a procedure for maintaining the solenoid valves in good operating condition.

Discussion:

In the plant, considerable trouble has been encountered by frequent failure of the water solenoid valves. The most common type of failure is the "leaking solenoid".

In a water solenoid valve, the seating of a piston upon a rubber gasket stops the flow of water through the valve. The piston is driven by a lever system which is actuated by an iron plunger moving up and down inside a solenoid coil. When the coil is actuated by an electrical current, the iron plunger is pulled by the magnetic field up into the solenoid coil. This operates the lever system, forcing the piston down until it seats over the water opening. If the piston fails to seat properly, the valve will leak.

A poor seating action may be caused by two things--(1) a poor or worn rubber gasket, or (2) insufficient force on the piston to overcome the pressure of the water. It was planned to determine which of these two factors is more important.

By opening and closing the valve a sufficient number of times, the rubber gasket should eventually wear out. This necessitates an accelerated test in which the valve will be opened and closed a great many times in the space of a short time.

The factors which influence the force exerted on the piston are (1) the power of the electromagnet, and (2) the efficiency of the lever mechanism. Obviously the valve company has designed the electromagnet so that it is powerful enough if the lever system operates efficiently, and the rated water pressure is not exceeded. The water pressure on our freeze-off system is well below the rated pressure of the valve. This leaves only the lever mechanism to be considered.

In this lever mechanism, there are several moving parts, which can be easily fouled by corrosion and dust. It was observed when this test was first initiated that the "reconditioned" valves received from the warehouse had sluggish lever systems. After cleaning, the levers operated better.

Procedure:

An accelerated test was outlined in which three water solenoid valves would be operated at such a rate that one day of accelerated operation would approximate a full month of normal operation. This test would indicate the length of time a rubber gasket should stand up without excessive wear.

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The three water solenoid valves to be used in this experiment were installed on the top of Rack No. 12. They were hooked up in parallel and receive water from a manifold which is connected to the freeze-off water header. (See Figure I).

To operate the valves at an accelerated rate, a timer was made (See Figure II), which operates on a 7 minute 29 second cycle--the valves are open 3 minutes 40 seconds and closed 3 minutes 49 seconds. During normal operations, the valves operate about six times per day and in the accelerated test, they operate about 190 times per day.

A test was started at 1500 on August 9, 1945, using three reconditioned solenoid valves (new ones were not available). The test has been in progress for 22 days without a failure. This is equivalent to about 22 months of normal operations.

Results and Findings:

It appears that wear on the rubber gasket is not the major cause of the difficulties encountered in the use of water solenoid valves.

From observations that have been made so far, it appears that the major fault of the valves lies in the lever mechanism. Various moving parts of the lever system get covered with corrosion products and dust, which foul the action of the lever arms, causing insufficient force to be transmitted from the iron plunger to the piston. Because this was an accelerated test, sufficient time had not elapsed for appreciable fouling to occur.

Recommendations for Future Work

1. Repeat the above procedure using water with air purge.

2. Repeat using steam purge.

3. Plan and follow through a definite routine cleaning and checking of all solenoid valves in service.

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Diagram for Solenoid Testing

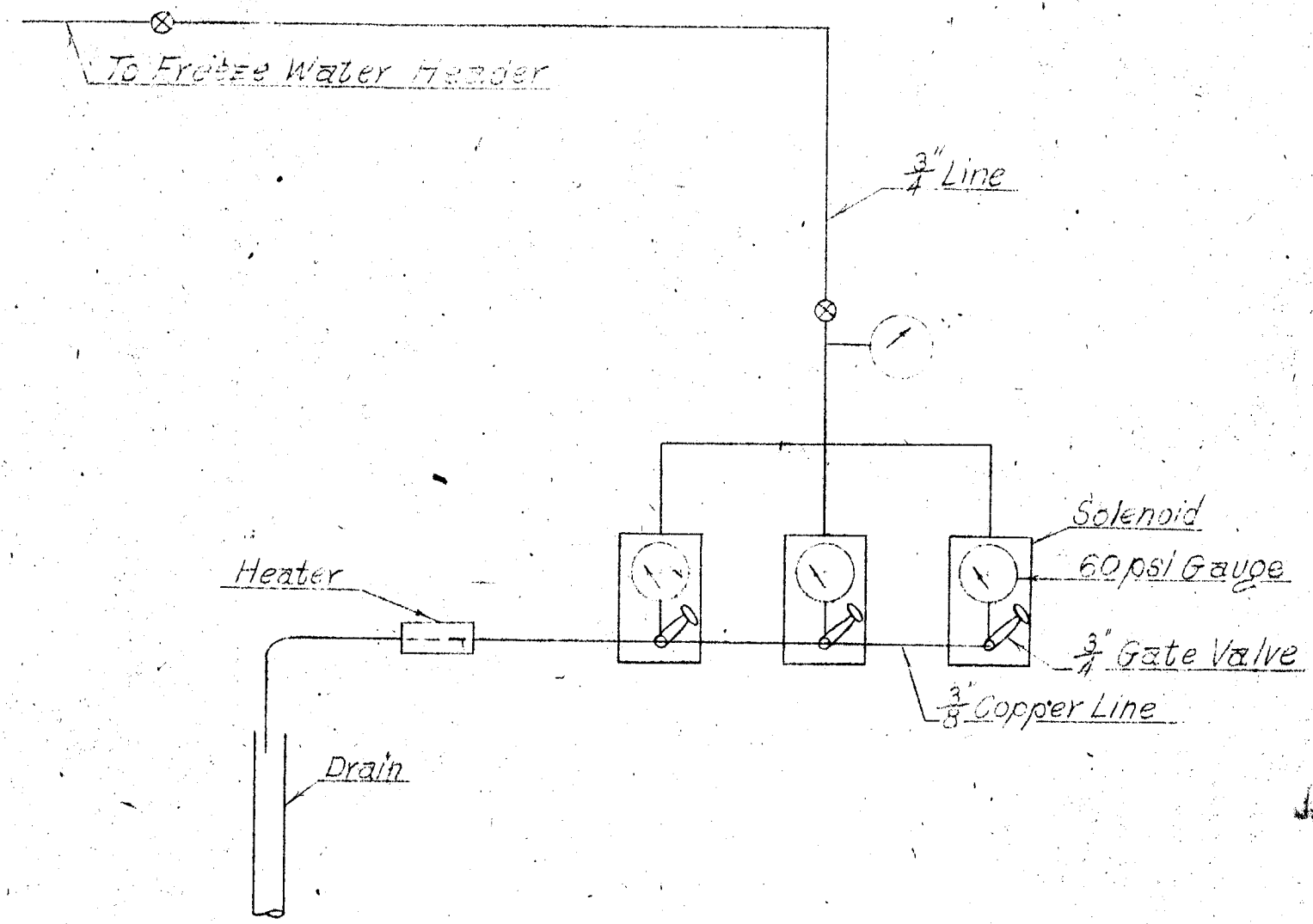

Fig I

Project 43
Aug. 31, 1945.

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Project 43
Aug. 31, 1945

Electric Timer

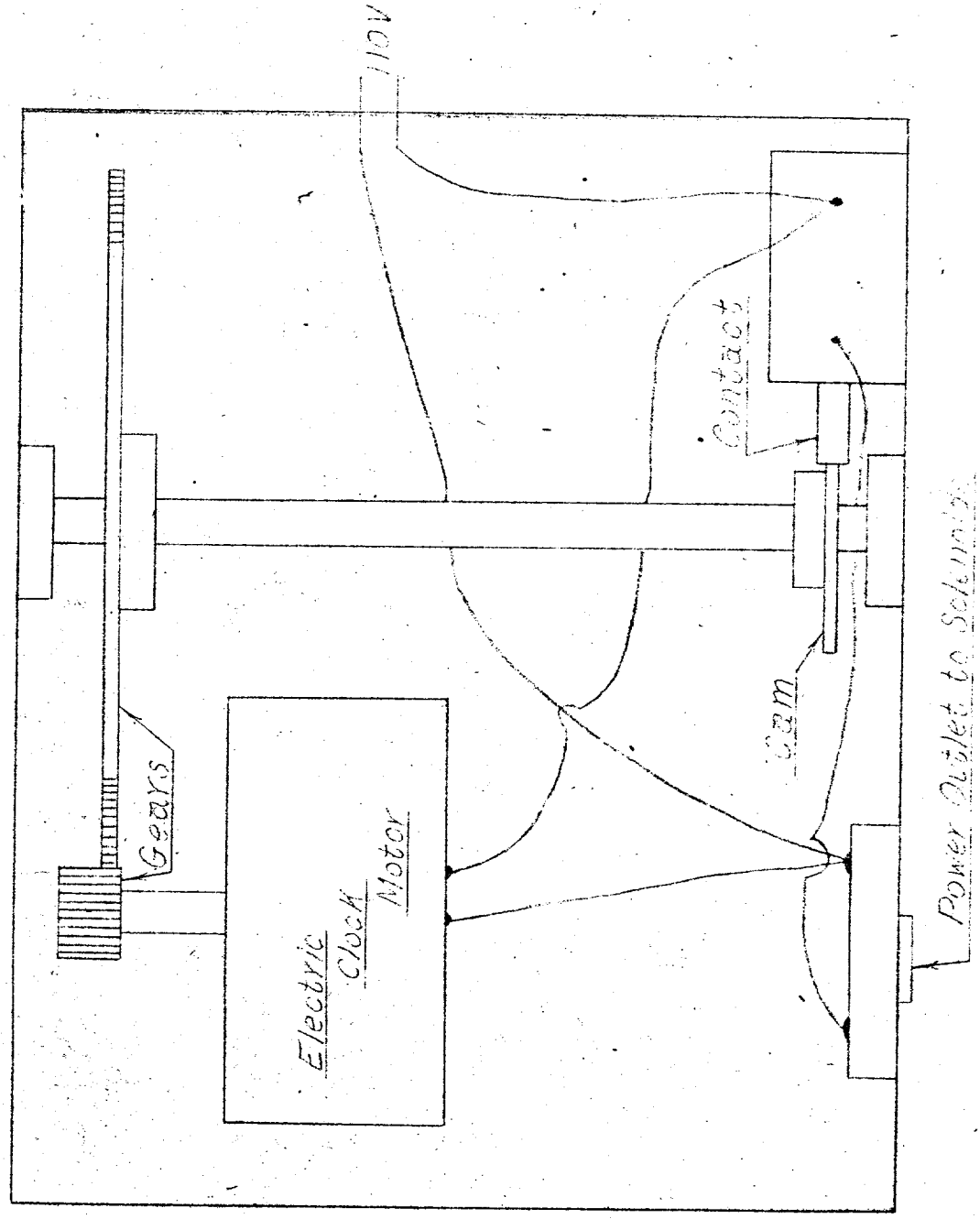

Fig II

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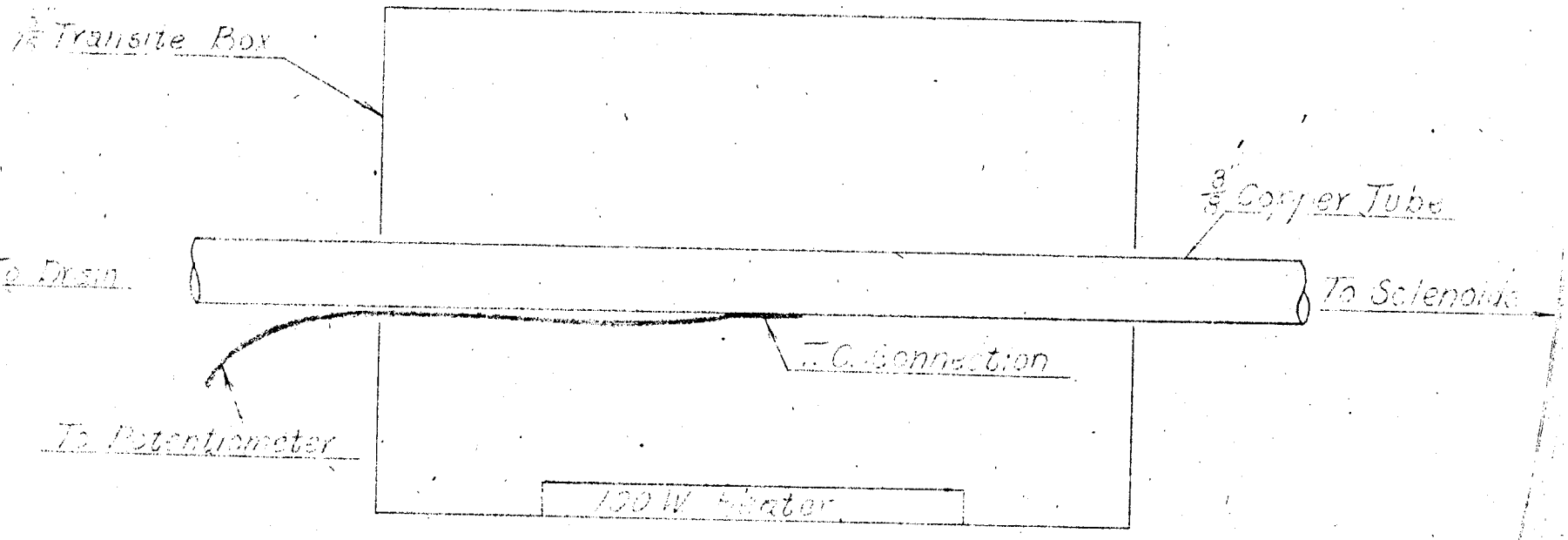
Heater



Project 43
Aug. 31, 1945

Fig. II

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MONTHLY REPORT FOR PERIOD ENDING

August 31, 1945

PROJECT NO. 44

INVESTIGATION OF THE REASONS FOR DIFFERENCES IN COLUMN PERFORMANCE

C. A. Todaro

By: C. A. Todaro
R. Van Winkle
W. W. Binger
J. D. Hoffman
M. D. Snyder

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INVESTIGATION OF THE REASONS FOR DIFFERENCES IN COLUMN PERFORMANCE

OBJECT

Projects 1 and 19 of this division have established the fact that there were great differences in the performance of columns. Some columns were found to be capable of producing 3 times as much as the average run-of-the-mill columns. An attempt to determine the reasons for these differences was begun in August.

PROCEDURE

A general procedure as outlined by Dr. Barnett F. Dodge was as follows:

Select 6 columns in the plant on the basis of Project 1 data; two of them to be very good ones, two of them average and the other two very poor. The following columns are suggested:

Very good . . . . . Cols. 14 and 15 Rack 6
Average . . . . . Cols. 18 and 20 Rack 5
Very poor . . . . . Cols. 31, 36, and 43 Rack 7

Clean the columns thoroughly in order to make certain that none of the differences in performance is due to foreign material partially plugging the annulus. Detailed directions will be issued giving an exact procedure for the cleaning operation. When the columns are drained, record the amount of material obtained from each column.

Make the following measurements on the thoroughly cleaned columns:

1. Average annulus by the nitrogen flow method with the columns cold.

2. Repeat (1) with steam on the column.

3. Annulus as a function of height with cold column.

4. Separation factor for helium - CO_2 mixtures.

Then fill with process fluid and carefully check the actual performance characteristics by two methods:

1. Measure separation factor vs. time with columns isolated. From the data obtained, calculate the production vs. assay curve.

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2. Check the calculated production rates by milking at two different rates until a steady state is attained.

During operation under milking conditions, measure to 0.1° F. the temperature rise of the cooling water in order to calculate the steam comsumption of each column. This will involve the assumption of equal water flow rates to all columns on a rack. It does not appear worthwhile to install steam or water meters since it is doubtful if the steam consumption will be a very significant factor.

Then drain all the columns and again determine the amount of material held in each one. Clean thoroughly, remove from the rack, place on the test stand outside of the process building and measure:

1. Average annulus by gas flow.

2. Average annulus by liquid displacement.

When these tests have been completed, the columns should be handled with unusual care and every effort made to avoid flexing. They are then to be shipped to the Continential Gin Company at Birmingham, Alabama, where they will be dismantled and thoroughly inspected. First remove the water jacket and accurately measure the O.D. of the copper tube and solder-joint sleeves at a large number of points. Then remove the nickel inner tube and measure its diameter at all the spacers and also of the tube between spacers. Also measure the I.D. of the copper tube. Inspect both tubes for any defects such as scratches, depressions, lost spacers, etc., and for the presence of foreign material. This examination of the boundary surfaces of the annulus can perhaps best be done after cutting the tube assembly into short lengths.

PROGRESS DURING MONTH

Part - a Conditioning of Columns:

The columns listed above were by-passed top and bottom and the material drained into No. 120 capsules. The residual material in the columns was blown out with nitrogen and then the steam and circulating water were turned off to allow the columns to cool. The following steps were followed in conditioning each column (including all tits on each column).

(1) Water washed until water came through clear.

(2) Dilute HCl wash until acid came through clear.

(3) Water washed until neutral to litmus.

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(4) Ammonium Oxalate wash -- 1 to 2 quarts.

(5) Water wash -- 1 to 2 quarts.

(6) Partial drying by blowing nitrogen through the column.

Following this procedure, the tits were capped and the columns turned over to Hoffman for annular space measurements.

Column No. 36 of Rack No. 7 was found to have an internal plug. Nitrogen at 1200 psi would not flow through the column when the steam and circulating water were on . The column was evacuated from the top, and then ammonium oxalate was allowed to fill the annular space above the plug. After 48 hours, the plug was partially removed by this method, but not enough to allow water to pass through the column. Two No. 31 capsules of ammonium oxalate were then blown through the column using 1800 psi, nitrogen pressure to force it through. This procedure opened the plug sufficiently to allow water to flow through the column. From this point on, the procedure as described above was followed in conditioning the column.

Part - b Measurement of Annulus:

Apparatus and Procedure:

All annulus measurements were made by the nitrogen flow meter method (for details of method, see Project 21). This flow meter consisted of a calibrated orifice of the venturi type which would deliver 2 to 20 cc's of nitrogen per second under the conditions of the test. Differential water manometers were used for indicating both the rate of delivery of the orifice and the pressure drop through the column. The temperature of each column was measured during the tests and was found to be about 105° F. for the "cold" tests; during the "hot" tests the temperature of the exit nitrogen was measured and found to have an average value of 350° F. The orifice temperature was kept at approximately 65° F. by cooling both the entering nitrogen and the orifice itself with water. Corrections were made as under project 21-A.

The table below summarizes the results:

Rack	Column	S_{100}	Annulus; inches x 10^{+3} Cold	Hot
5	14	1.35	13.4	10.9
5	15	1.35	14.7	10.9
5	18	1.22	14.4	11.7
5	20	1.20	15.3	12.4
7	31	1.16	14.9	12.4
7	43	1.10	15.7	11.9

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These data are inconclusive except for the indication that the good columns have slightly smaller hot annuli than the average and poor ones.

CONCLUSIONS AND RECOMMENDATIONS

Since this project was begun at such a late date, very little is known about the reason for the difference in columns. Speculations and predictions have been offered by many individuals. However, unless a program similar to the one outlined above is properly carried out, no valid conclusions can ever be reached.

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