PROJECT REPORT FORM

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Howells (2)
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PROJECT NO. 1625
COOPERATOR The Institute of Paper Chemistry
REPORT NO. 1
DATE September 9, 1955
NOTE BOOK
PAGE TO
SIGNED Frans Vaurio
Frans Vaurio

DILTS CONTRACOATER

The Dilts Laboratory Contracoater is a four-roll precision coater. It is designed for speeds up to one thousand feet per minute. The used machine we have came equipped with two one-horsepower Reeves drives. There was no rewind drive with the unit.

The width of paper that can be coated is 12 inches.

In addition to the coater we obtained a 12-foot long drier section consisting of a retraction unit with six 28 x 44-inch infrared glass cloth surfaced heaters. The drier section was fitted with aluminum exhaust hoods or panels and flexible plastic covered tubing and manifold. No blower came with the exhaust system. The retraction unit consists of four 7-1/2 foot standards with screws which raise or lower the framework to which the heater panels are fastened. A 3 h.p. gearhead motor fitted with a magnetic brake operates the retraction screws through a continuous chain at the base of the retraction unit frame. The position of the heaters in relation to the paper is controlled by the retraction unit. In case of machine stoppage, the heaters can be retracted. In order to use the Contracoater it will be necessary to add a drive to the rewind stand, or to use the rewind stand now made available by the Container Division.

The drive requirements for this machine are somewhat complicated because of the number of possible ways in which the basic machine can be used. The four rolls on the coater are preferably driven independently, with the possibility of changing speed and direction of the rolls as desired.

Based on their experience in their own laboratory, the Dilts Machine Works Division of Black-Clawson Co., Inc. suggested (see Haskell's letter of August 3, 1955 to Dr. Howells) that the top rubber roll be tied mechanically to the line speed of the machine. See Figure 1 for the parts mentioned in the following discussion.

The metering roll should preferably be driven with a motorized variable speed transmission. The suggested speed range is from 0 to 60 r.p.m. with provisions for changing the direction of rotation.

The pickup roll and the applicator roll could be driven independently through two P.I.V. units. A 3-to-1 wipe ratio is normally used on the applicator roll, according to Mr. Haskell.

The pickup roll (or pan roll as it is also called) speed should be about 1/10 to the same speed as the applicator roll. Provision should be made for reversing the direction of both rolls. According to Mr. Booth, the engineer in charge of the Dilts coating laboratory, the dip roll should continue to turn when the machine is stopped.

The drive requirements outlined by Mr. Haskell, who makes no mention of power requirements, cannot be achieved with the simple drive now available.

In order to get the machine going it is proposed that we try to operate it with the minimum of added equipment. This should give us some experience on which to base any recommendations for a more satisfactory drive.

We plan to use one of the Reeves units to drive the top rubber-covered web roll. The other Reeves drive could be used to drive both the dip roll and the applicator roll. We plan to borrow a 1 h.p. Graham drive to use on the metering roll to determine what will be needed for more satisfactory operation.

In order to establish the speeds of rotation of the Dilts Contra-coater rolls now available with the Reeves drives and to determine the range of web speeds, the following information was obtained:

Reeves drives, maximum r.p.m.	95.8
minimum r.p.m.	15.9
Number of teeth on Reeves drive sprockets	18
Countershaft A	
Number of teeth on chain sprocket run by Reeves drive	23
Number of teeth on output sprocket	19
Countershaft B	
Number of teeth on chain sprocket run by Reeves drive	23
Number of teeth on output sprocket	16
Top (web) roll sprocket, no. teeth	54
Applicator roll sprocket, no. teeth	48
Dip roll sprocket, no. teeth	36

Metering roll

Idler sprocket, no. teeth	54
Spur gear drive idler sprocket, no. teeth	29
Spur gear driving roll, no. teeth	114

Calculation of roll speeds:

Top web roll, r.p.m. (maximum) $= 95.8 \times \frac{18}{23} \times \frac{19}{54} = 26.4$

Top web roll, r.p.m. (minimum) $= 15.9 \times \frac{18}{23} \times \frac{19}{54} = 4.4$

Applicator roll, r.p.m. (maximum) $= 95.8 \times \frac{18}{23} \times \frac{18}{48} = 28.1$

Applicator roll, r.p.m. (minimum) $= 15.9 \times \frac{18}{23} \times \frac{18}{48} = 4.7$

Metering roll - variable if used with Graham drive or 1 to 5.5 r.p.m. if driven with the dip roll and applicator roll as originally recommended by Dilts.

Dip roll, r.p.m. (Maximum) $= 95.8 \times \frac{18}{23} \times \frac{18}{36} = 37.5$

Dip roll, r.p.m. (Minimum) $= 15.9 \times \frac{18}{23} \times \frac{18}{36} = 12.4$

The direction of rotation of the applicator and dip rolls may be changed by reversing the Reeves drive motors through a switch. The Graham drive is not reversible, so changes in direction of the metering roll will involve changing the method of mounting.

The web speeds available with this arrangement will run between 11 and 68 feet per minute--assuming a roll diameter of about 9.88 inches.

It was suggested by Mr. McKee that the unwind stand with tension control and the double roll rewind stand in the Container Laboratory might be available for use in conjunction with the Dilts Contracoater.

According to Mr. Root the surface speed range of the rewind unit is from 80 to 330 feet per minute if the tension is very low. At a tension of 8 pounds per inch on a 12-inch web, the maximum speed is 150 feet per minute due to a tendency for the belt to slip on the 1 h.p. U. S. Varidrive. Thus it would be necessary to adjust the speed range of the rewind to fall within the range of the Contracoater.

The approximate dimensions of the rewind unit are:

Height	61 inches
Width	48 inches
Length	32 inches.

The unit is mounted on 26-inch high concrete footings.

The unwind stand is 70 inches wide and requires about 52 inches of lengthwise floor space. It stands on 12-1/2 inch high footings. It was suggested by Mr. Root that space be provided for easy access to the right side (looking in the direction of web travel) where the tension controls are located.

The maximum roll size used by the Container Laboratory is about 41-1/2 inches in diameter and weighing about 450 pounds.

If faster speeds are required, it will be highly desirable to consider an integrated drive consisting of a line shaft with P.I.V. units and driven by a Reliance d.c. unit. Such units are somewhat costly but have proved successful in many installations we have observed. A 5 h.p. unit should handle a web speed of 1000 feet per minute at a maximum tention of 10 pounds per inch width plus a safety factor of about 1.36 h.p.

A 5 h.p. unit would cost around $1,012.00, plus the cost of the line shaft and P.I.V. units. A 15 h.p. unit would cost around $2,000.00, plus the cost of the line shaft and the P.I.V. units. This would give a usable range of speed of 8 to 1. Any further spread in operating speed would probably have to be handled by a speed-changing transmission in the line shaft.

FV

fv/mk

Figure 1.

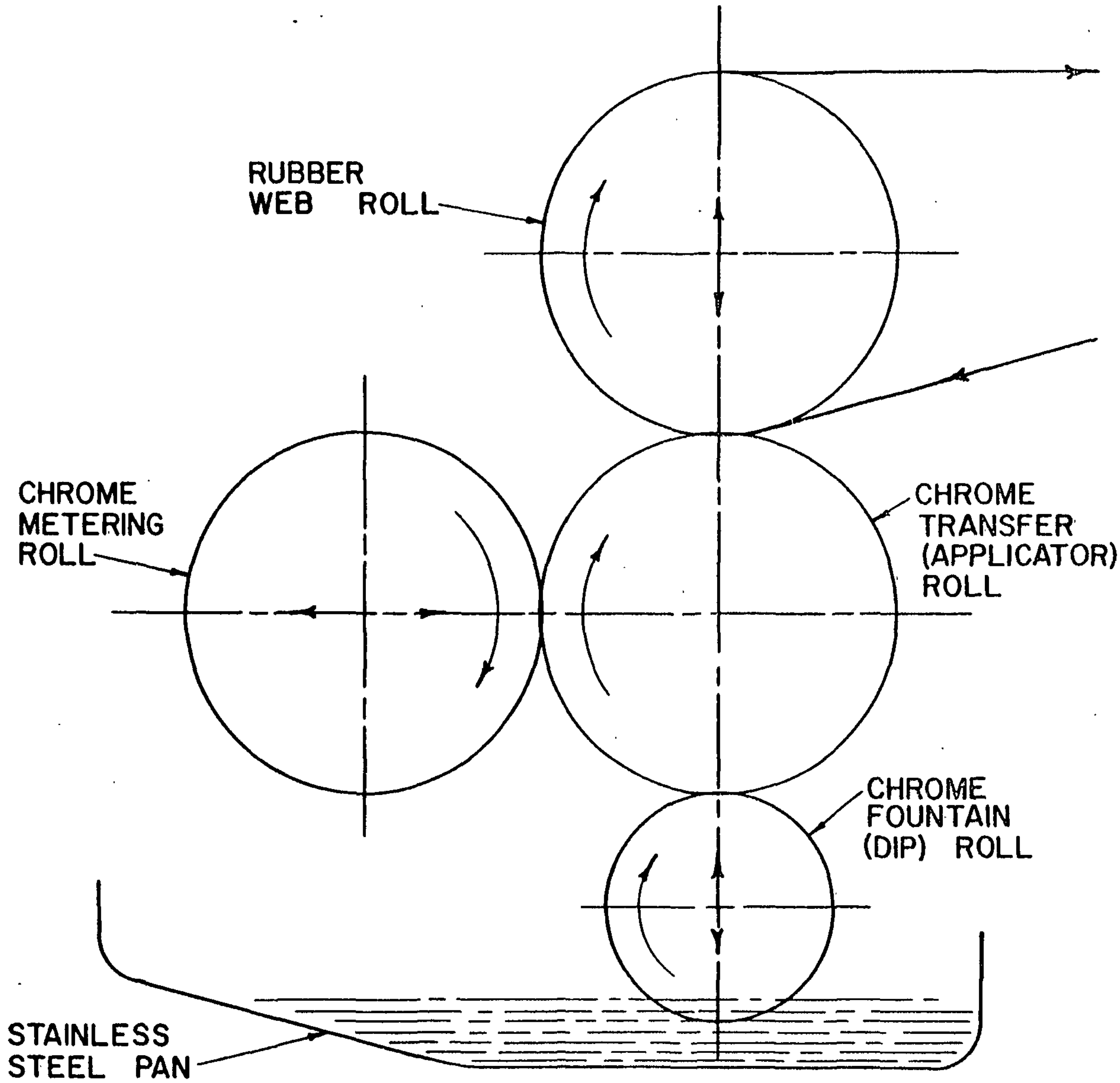

DIAGRAM OF "CONTRACOATER"

PROJECT REPORT FORM

PROJECT NO. 1625
COOPERATOR I.P.C.
REPORT NO. 2
DATE August 21, 1956
NOTE BOOK 1098
PAGES 64 to 74 and 140 to 144
SIGNED Bernard Pesetsky
Bernard Pesetsky

Frans Vaurio
Frans Vaurio

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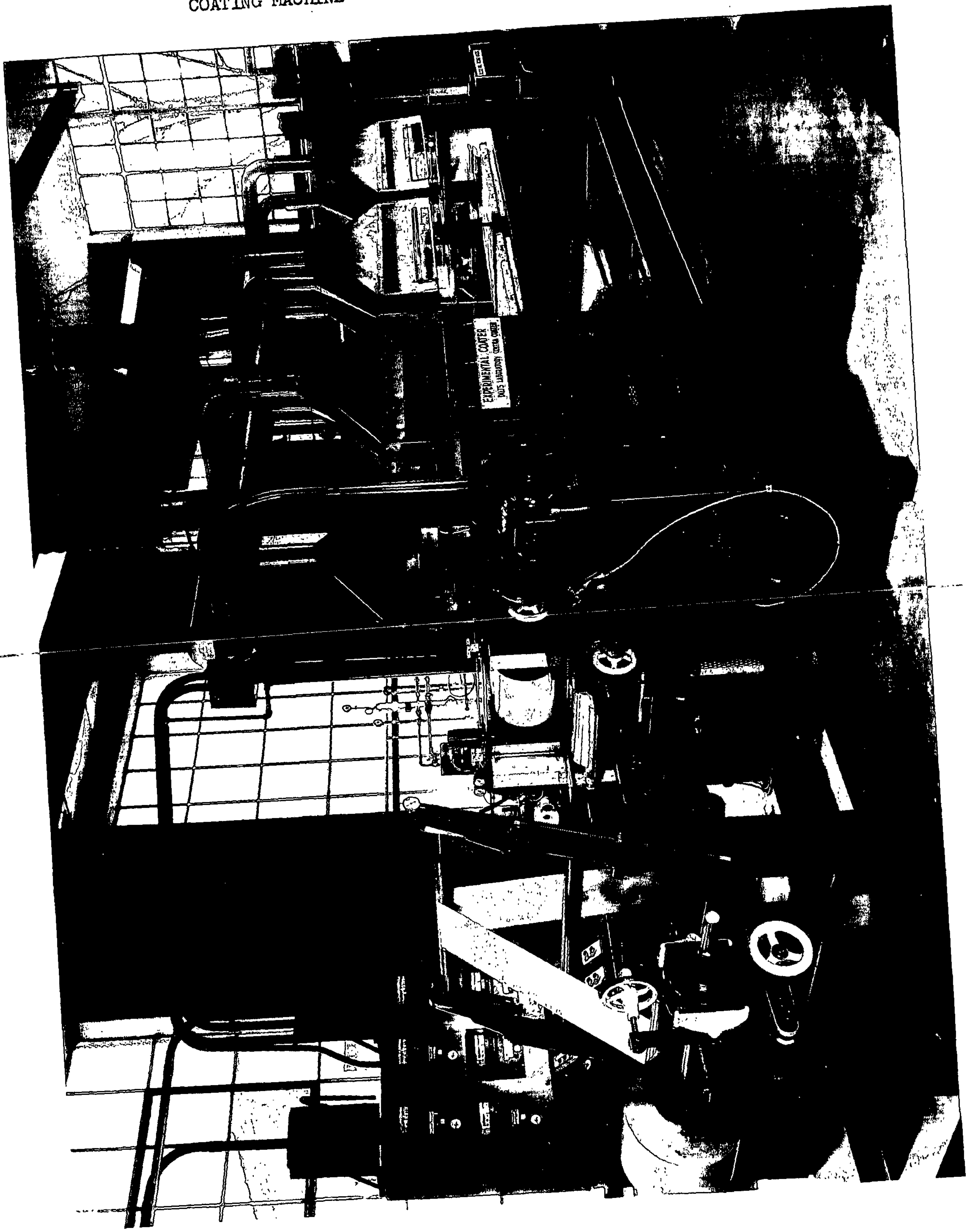
DESCRIPTION AND CALIBRATION OF THE INSTITUTE OF PAPER CHEMISTRY PRECISION EXPERIMENTAL COATING MACHINE

The Institute of Paper Chemistry now has in operation an experimental coater for use in studying the coating or other treatment of paper. This coater (see Figure 1) consists of a constant tension unwind, a four-roll coating station, a retractible infrared drying section, and a two-roll surface-type rewind. The dryer is fitted with individually controlled ventilation hoods.

The coating station is designed to handle a twelve-inch wide web in a wide range of basis weights. The mechanical design speed is a thousand feet per minute. However, the present drives which came with the coating station and dryer (which, incidentally, were bought "used") are limited to much lower speeds. The web is pulled through the machine by the rewind drive which is powered by a $1\frac{1}{2}$ h.p. constant torque U.S. Varidrive with a 3-to-1 speed range. A speed transmission was added to the rewind drive to extend the range in web speed to better match the range available with the coater drive.

The coating station consists of a Contracoater reverse-roll coating arrangement manufactured by the Black-Clawson Co., Dilts Division.

Figure 1. THE INSTITUTE OF PAPER CHEMISTRY PRECISION EXPERIMENTAL COATING MACHINE



However, it may be used in a number of different ways and should be adaptable for a wide range of experimental work. The Contracoater has four rolls (Figure 2) which are used for usual reverse-roll coating. The bottom chromium-plated steel roll is called the fountain, dip or pickup roll. It has a diameter of 8 inches and is usually turned at a relatively slow rate of speed. It may be driven in either direction desired. Its function is to pick up the coating mixture from the stainless steel pan, which has a capacity of five gallons. The pickup roll is driven by a 1 h.p. Reeves drive through a range of 10 to 64 surface feet per minute.

Figure 2

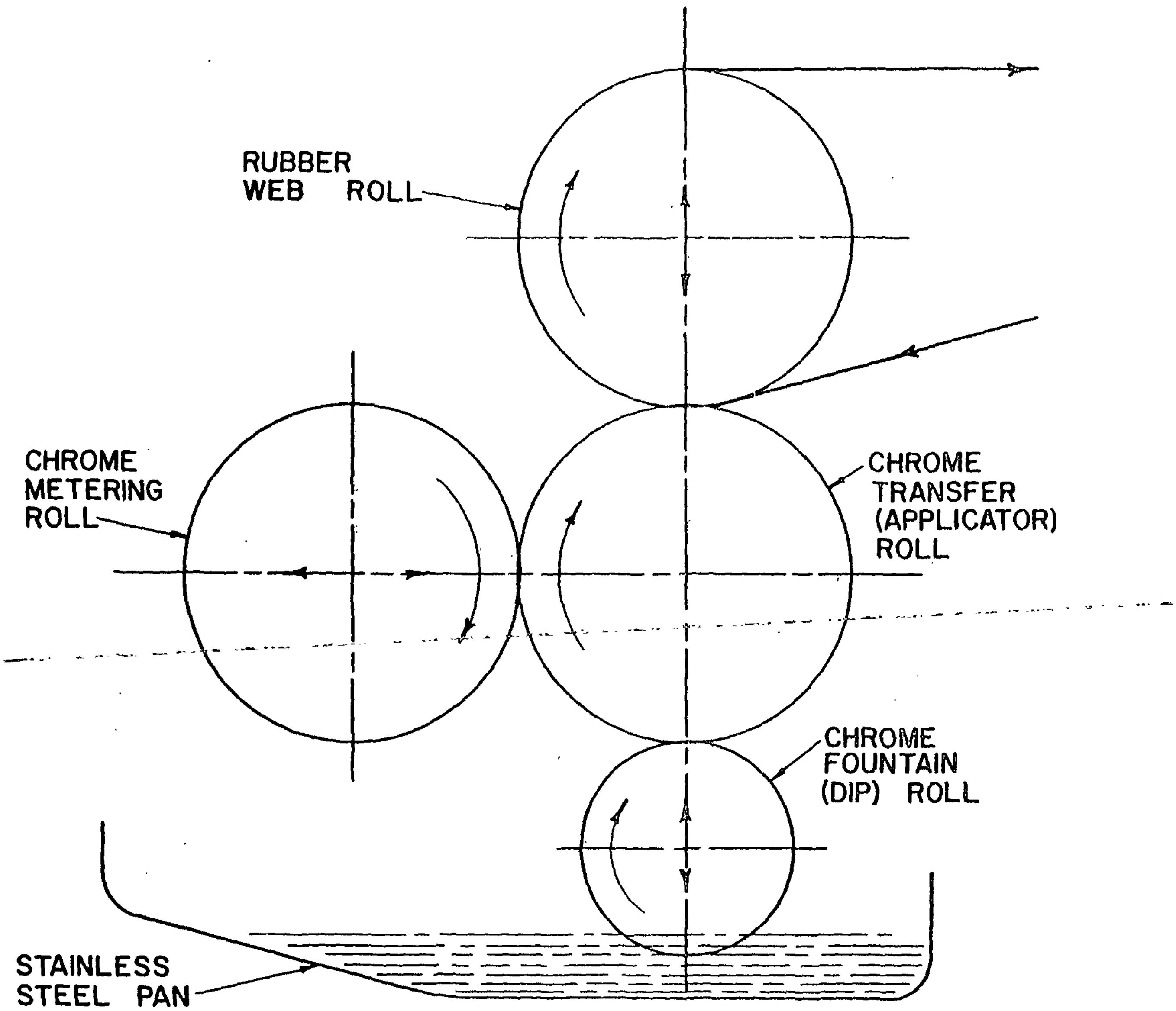


DIAGRAM OF "CONTRACOATER"

In reverse roll operation, the coating is applied to the casting or applicator roll, which is the second roll in the series and is also driven by a 1-h.p. Reeves unit. The chromium-plated steel casting (or applicator) roll is 10 inches in diameter and has a speed range of 10 to 64 feet per minute and is reversible. The excess coating is metered off the applicator roll with an 8-inch diameter chromium-plated metering roll, which is driven in either direction by a 1-h.p. Graham Drive through a range of surface speeds from 0 to 87 feet per minute.

The back-up or rubber roll is 10 inches in diameter and is covered with neoprene rubber having a Shore Durometer A hardness of 62 to 65.

Figure 3 illustrates 29 different ways to thread the coater as suggested by the manufacturer. These may be described as follows:

1. Reverse - 4-roll coater "Contracoater"
2. Direct - 4-roll coater--Reverse pickup, direct meter, with doctor blade
3. Direct - 4-roll coater--Reverse pickup, direct meter
4. Direct - 4-roll coater--Direct pickup, reverse meter
5. Direct - 4-roll coater--Direct pickup, direct meter
6. Reverse - 3-roll coater--Reverse meter with doctor blade
7. Direct - 3-roll coater--Reverse meter, with doctor blade
8. Direct - 3-roll coater--Direct meter
9. Squeeze - 2-roll coater
10. Squeeze - 2-roll coater with doctor blade

11. Saturating - 2-roll coater--Rubber press roll

12. Kiss - 2-roll coater--Reverse roll metering

13. Saturating - 2-roll coater--Steel press roll

14. Kiss - 2-roll coater--Reverse kiss, reverse roll metering

15. Kiss - 2-roll coater with metering bar

16. Kiss - 2-roll coater--Reverse kiss, direct metering

17. Reverse - 4-roll coater--Reverse pickup, direct metering

18. Reverse - 4-roll coater

19. Reverse - 4-roll coater--Direct pickup, direct metering

20. Reverse - 3-roll coater--Direct metering

21. Kiss - 2-roll coater--Direct metering

22. Reverse - 2-roll with doctor blade on web

23. Direct - 3-roll coater--Direct metering

24. Reverse - 3-roll coater--Direct metering

25. Direct gravure - 2-roll coater

26. Offset gravure - 3-roll coater

27. Knife coating

28. Laminating - 2 ply

29. Laminating - 2 ply

POSSIBLE THREADING VARIATIONS OF "CONTRACOATER"

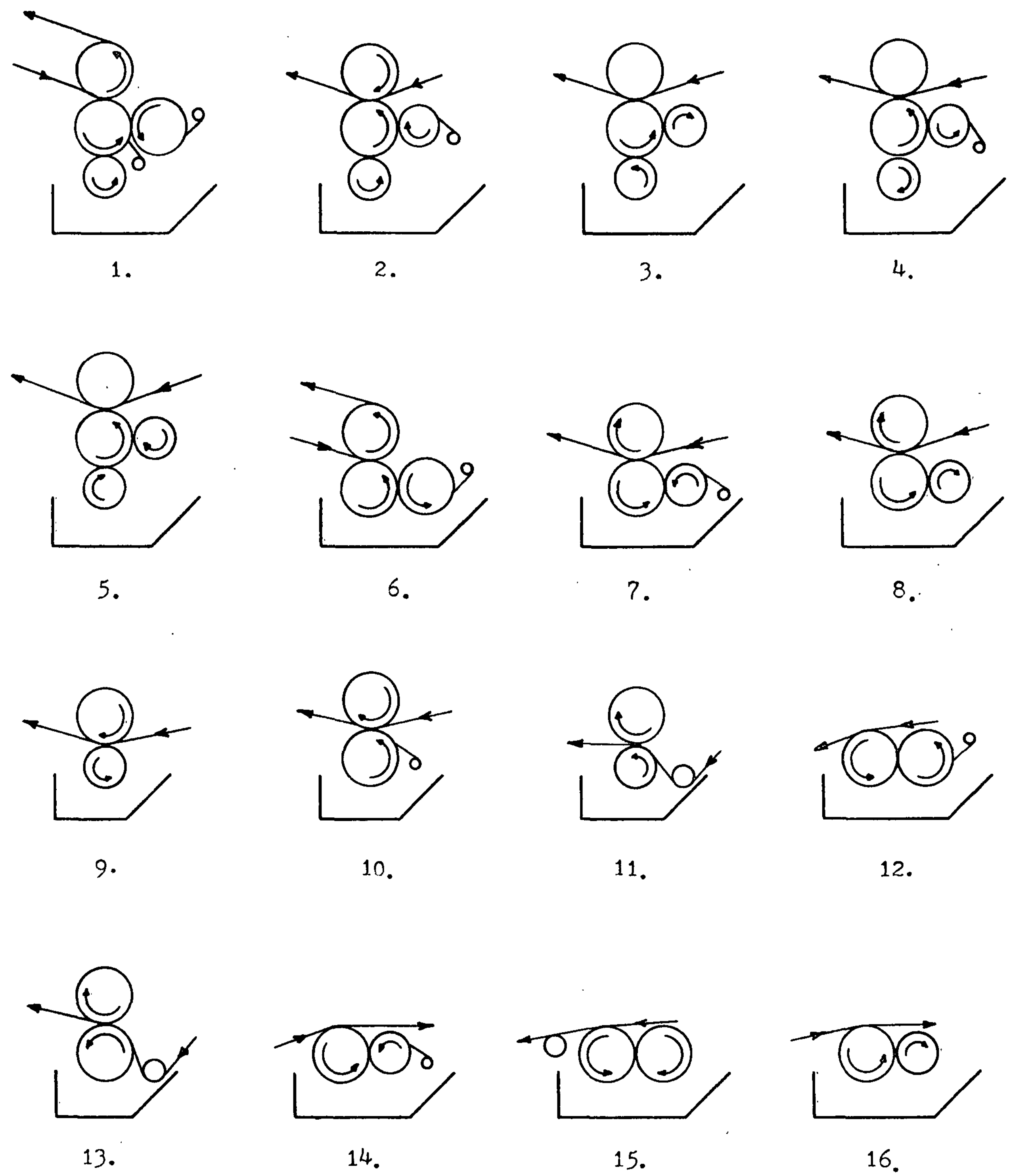


Figure 3.

POSSIBLE THREADING VARIATIONS OF "CONTRACOATER"

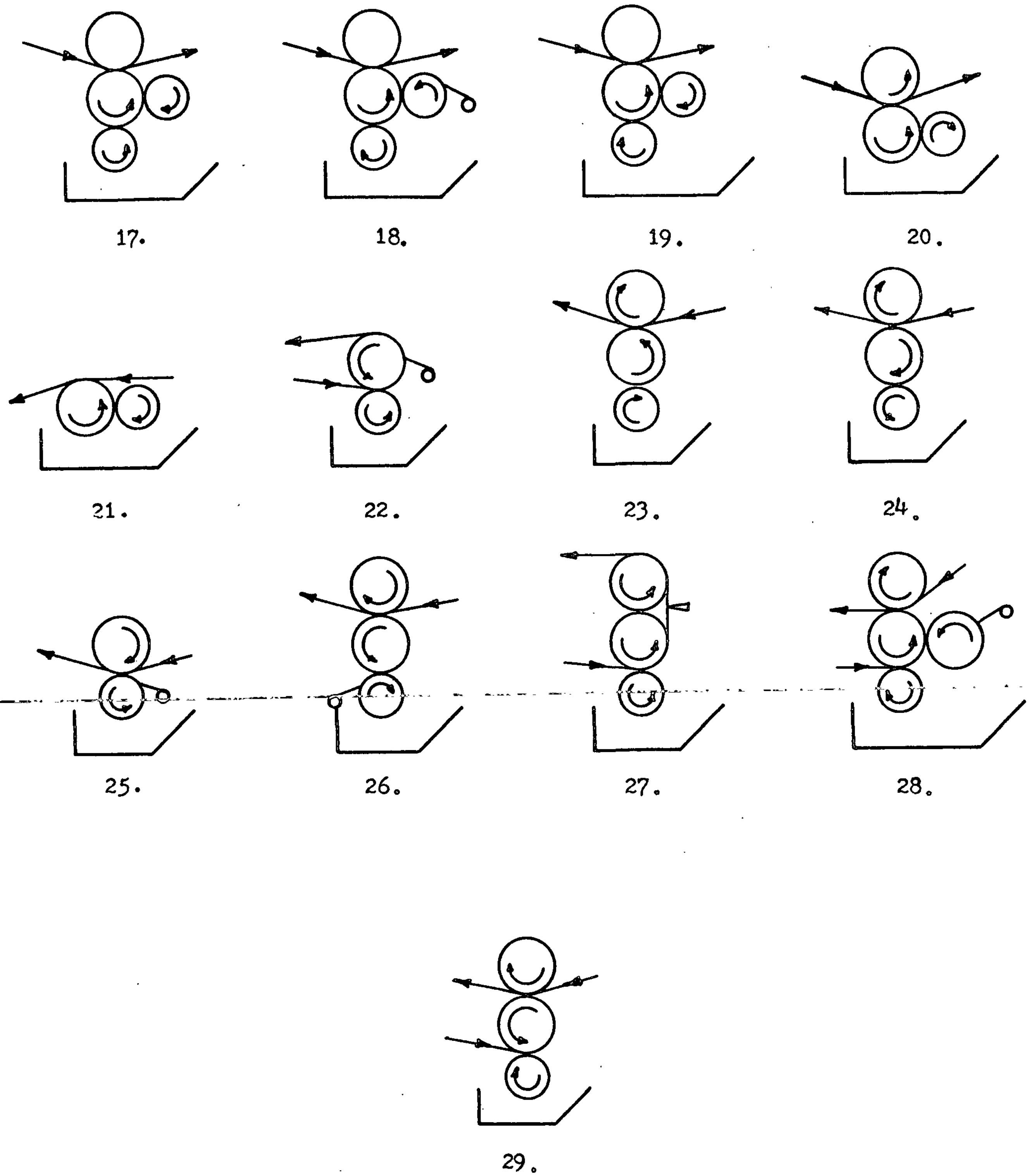


Figure 3 (Continued)

The unwind and rewind units were adapted from equipment already available; they had been designed and built by the Fox Tool Company of Menasha, Wisconsin. The unwind stand rolls are 25 inches long. The unwind roll shaft is fitted with screw-tightened cone chucks capable of taking a wide range of core sizes. A spring-loaded dancer roll is used to smooth out starting jerks. A mechanically linked automatic tension control applies or releases a brake acting on the unwind shaft. Manual edge control is achieved by handwheel-operated screw which shifts the unwind shaft position.

The rewind unit is a two-roll surface winder type with knurled rolls 25 inches long. A special spring-loaded quick-acting shaft simplifies paper-roll changes and can handle a 3-inch paper core. An electric hoist on an overhead rail is used in loading and unloading.

The control panel (Figure 4) is fitted with the push button start-stop and reverse controls, the raise-and-lower control for the retraction unit, and six Exactline indicating controls for the heater units. A safety switch at the rewind unit may be used to stop the machine and turn off the heaters. The air valves and air-pressure regulators are mounted on the frame of the Contracoater (Figure 5).

The information which may be of interest is collected on a form (Figure 6) and includes pertinent information concerning the coating used, such as solids content, viscosity, and solvents, and concerning the paper or base stock used and the operational details.

The rolls are bored for pipe fittings and it may be possible to do waxing or hot-melt coating with the Contracoater by heating the rolls with steam, oil or electric heaters.

The coater is sturdily built with precision bearings and large diameter shafts. The roll openings are controlled by screw-operated wedges with pneumatic cylinders to move the rolls together and apart. One turn of the handwheels controls 0.001 inch of travel of the metering roll. The other controls are somewhat less sensitive. The wedges may be retracted and pneumatic loading may then be used to control the amount of coating being applied for certain operations such as waxing and squeeze coating.

The dryer section is approximately 15 feet long and 40 inches wide, with six infrared glass-cloth surfaced heaters each measuring 28 inches wide by 44 inches long. The heaters are 220-volt units of 3,490 watts each, and are controlled in temperature through a thermocouple laid on the surface of the heater. Brown Instrument Company Exactline indicating controllers regulate the heaters. A retraction device consisting of four 7½-foot high standards with screws which raise or lower the frames carrying the heater panel serves as a safety device in case of machine stoppage and simplifies threading the paper through the machine. A 3-h.p. gearhead motor fitted with a braking device operates the retraction screws through a continuous chain and sprockets at the base of the retraction unit frame. The raising and lowering of the retraction unit is controlled by push buttons on the control panel.

Figure 4. CONTROL PANEL

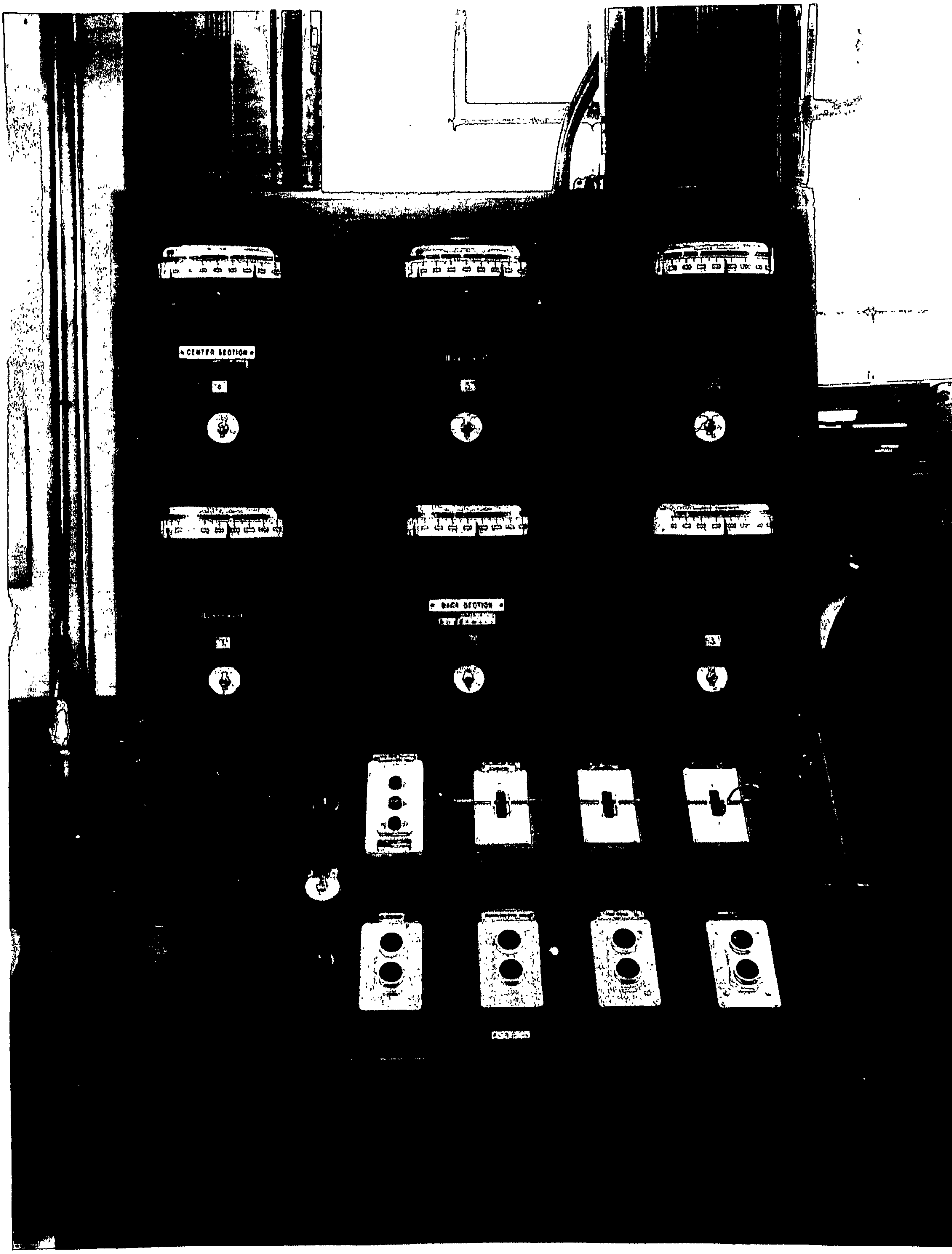


Figure 5. AIR CONTROLS

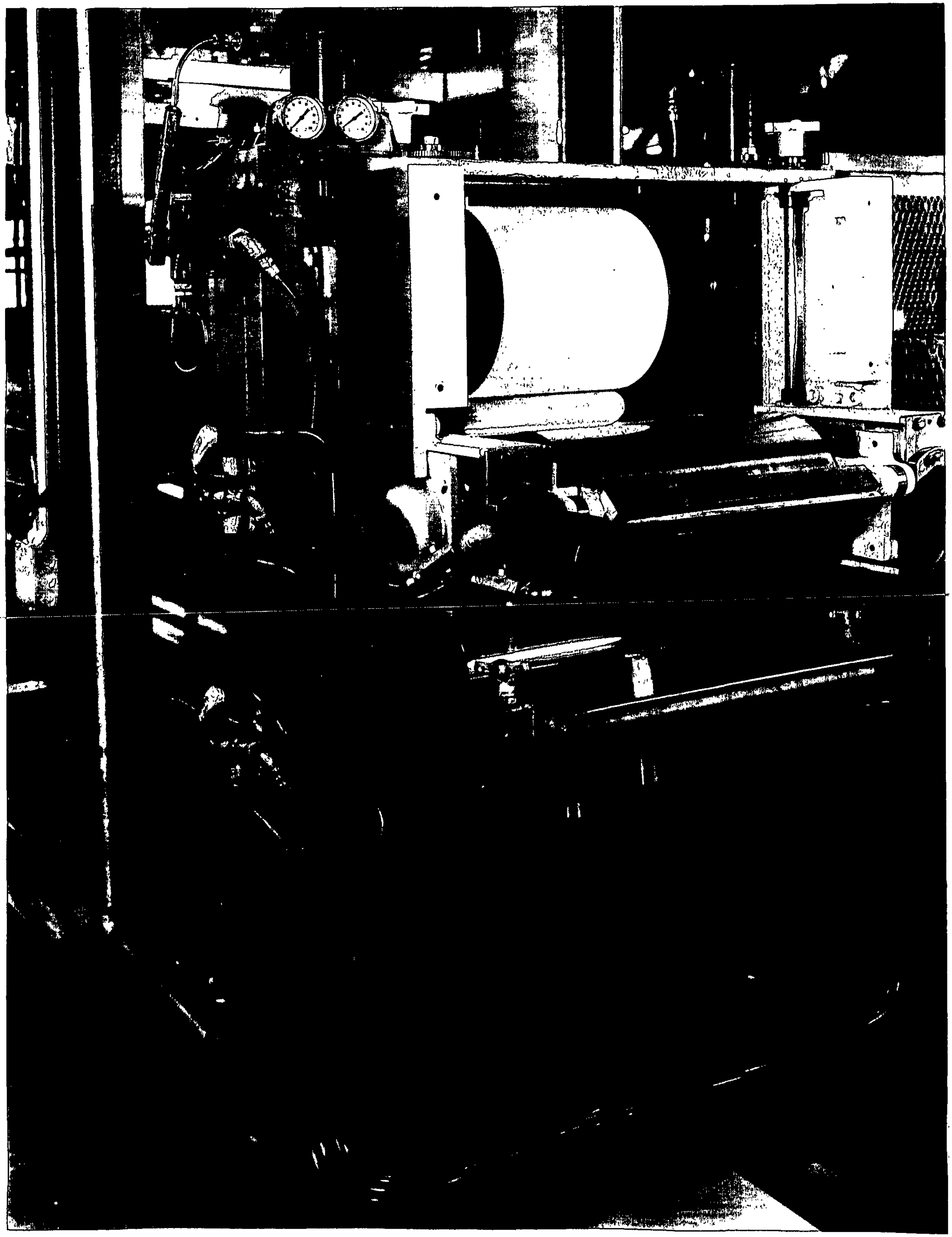


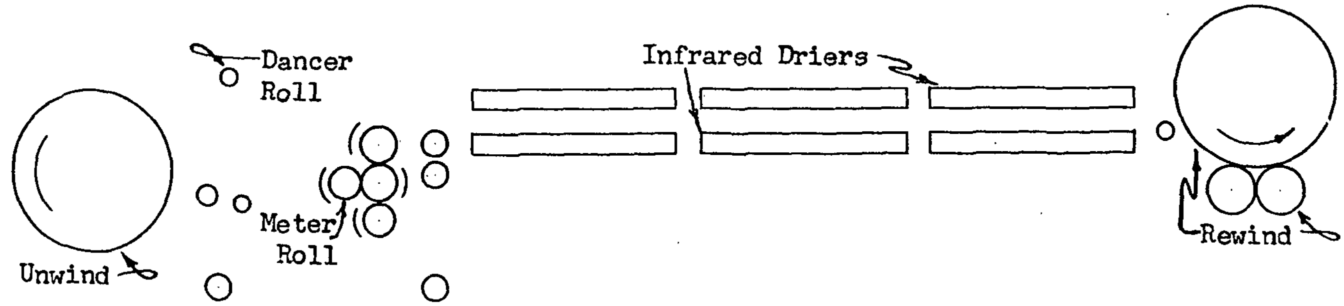
Figure 6. CONTRACOATER DATA SHEET

PROJECT: DATE: ____________

WEB:

COATING:

RUN NO.						
% SOLIDS						
SOLVENTS						
VISCOSITY						
TEMP. OF HEATERS #1						
#2						
#3						
#4						
#5						
#6						
WEB SPEED, FT./MIN.						
AIR PRESSURE, WEB ROLL						
TRANSFER ROLL, RPM						
METER ROLL SPEED, RPM						
PAN ROLL SPEED, RPM						
TENSION UNWIND SECTION						
DRIER SECTION						
REWIND SECTION						
CLEARANCE - INCHES CAST.& METER. ROLL						
CLEARANCE - INCHES PICKUP & CAST. ROLL						
CLEARANCE - INCHES CAST.ROLL & PRESS.ROLL						
COVERAGE -- LB./3000 SQ. FT.						



REMARKS:

OPERATOR: ____________

The present location of the unit limits its use to water-based systems, plastisols, or hot-melt applications as explosionproof facilities are not yet available.

The continuous coater should be considered supplementary to laboratory test methods and should correlate with commercial requirements more closely as to speed, tension, nip pressures, roll diameters, and viscosity or rheological characteristics of the coating solutions which can be successfully applied. The drying means will not compare with usual paper machine driers; the heated-roll type of drying may be added at some future time if it is found desirable. Other modifications such as the addition of an air knife may also be added.

CALIBRATION OF THE BLACK-CLAWSON COMPANY DILTS CONTRACOATER

The Black-Clawson Company Dilts Contracoater has, as mentioned previously, four rolls which may be adjusted and driven independently. In order to facilitate the use of the machine, it was decided to make some tests to establish the machine settings required for different roll clearances, machine and individual roll speeds, and to calibrate a tension-measuring device.

NIP OPENING BETWEEN METER AND TRANSFER ROLLS

The nip opening between the meter and transfer rolls is controlled by means of wedges which serve as positive stops for the rolls. Pneumatic cylinders move the meter roll away from or toward the transfer roll and up against the wedges. The wedges are controlled by means of handwheel-operated screws at the top of the machine. The wedge screws are equipped with a type of turn indicator consisting of one gear with 96 teeth in mesh with another having 21 teeth. The teeth of the larger gear are marked off so that the zero of the smaller gear for each revolution will mesh with a unit on the larger. Fractional turns are measured by the markings on the small gear. The large gear is marked off in units from 2 to 15, and the small gear is marked off at 5, 10, and 15, with the zero unmarked. Calibration was made using feeler gages to determine nip openings. The air pressure was set at 50 lb. per sq. in. Both wedges were adjusted simultaneously to avoid cocking the meter roll in its races. See Table I and Figure 7 for calibration.

TABLE I

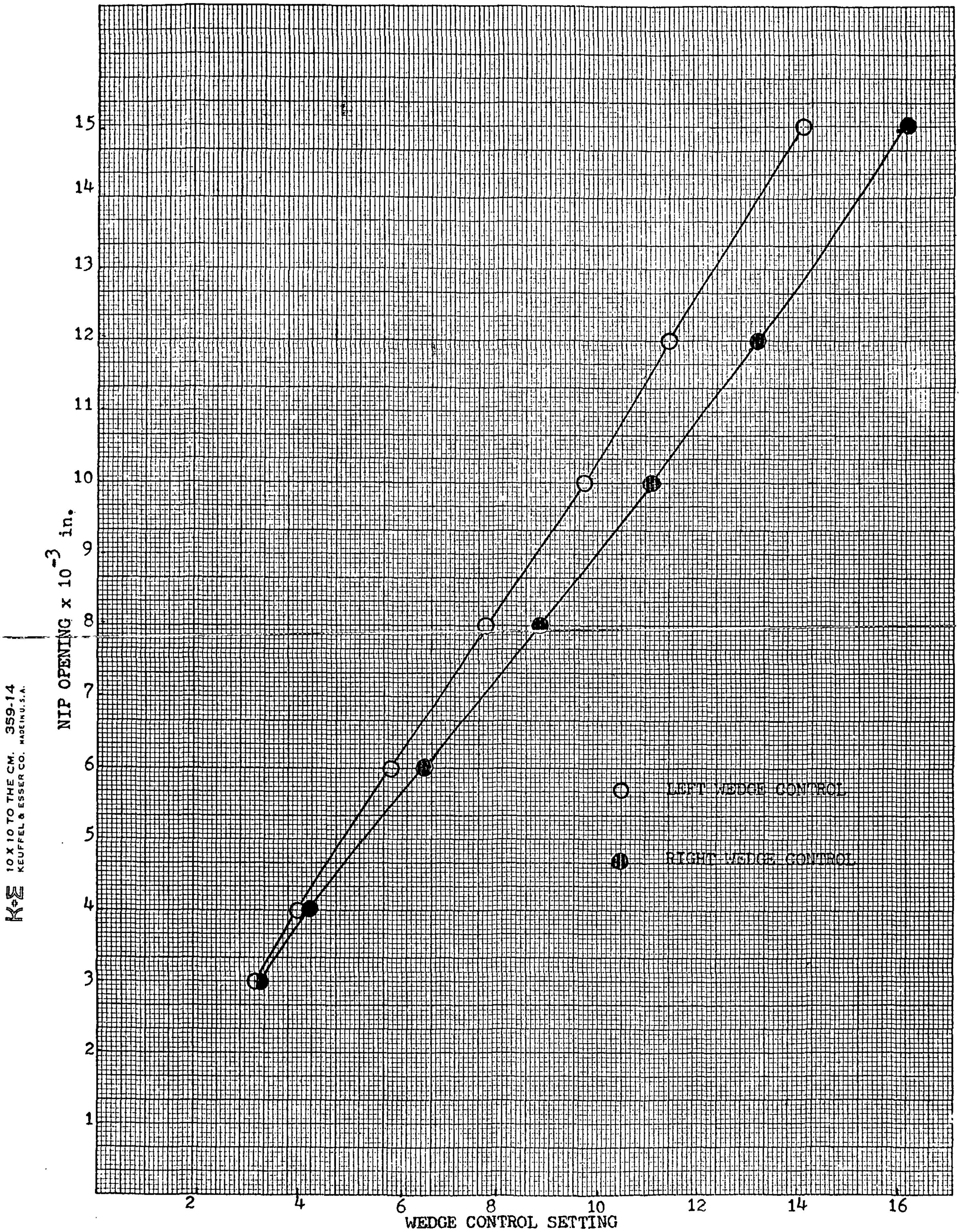
NIP OPENING BETWEEN METER AND TRANSFER ROLLS

Left Wedge Control Setting	Feeler gage, in.	Right Wedge Control Setting
3-3/21	0.003	3-5/21
4	0.004	4-5/21
5-16/21	0.006	6-9/21
7-16/21	0.008	8-18/21
9-15/21	0.010	11-1/21
11-9/21	0.012	13-4/21
14-2/21	0.015	16-4/21

The wedges were equipped with stops which prevent the rolls from bottoming or being brought closer than approximately 0.001 of an inch together.

Figure 7

METERING TO TRANSFER ROLL NIP OPENING



NIP OPENING BETWEEN WEB AND TRANSFER ROLLS

The nip opening between these two rolls is controlled by square-head screws at the back of the coating section. No revolutions counter was available so a paper disk was cut out and marked in 5° intervals to 360°. The disk was centered over the wedge screws. Because of the softness of the rubber web roll, it was difficult to use a feeler gage to determine the nip opening. Therefore, two dial indicators were mounted, one on each end of the web roll shaft. With the web roll in the downward position (nip closed), the rolls were adjusted to zero nip opening. This is the point at which only the slightest traces of light were visible through several portions on each end of the rolls. At this point the dial indicators were set to read zero. The air pressure was 50 lb. per sq. in. (gage). The wedge screws were then turned counterclockwise to cause the nip opening to become larger. The number of degrees of turn for a range of nip openings was determined (see Table II and Figure 8).

TABLE II

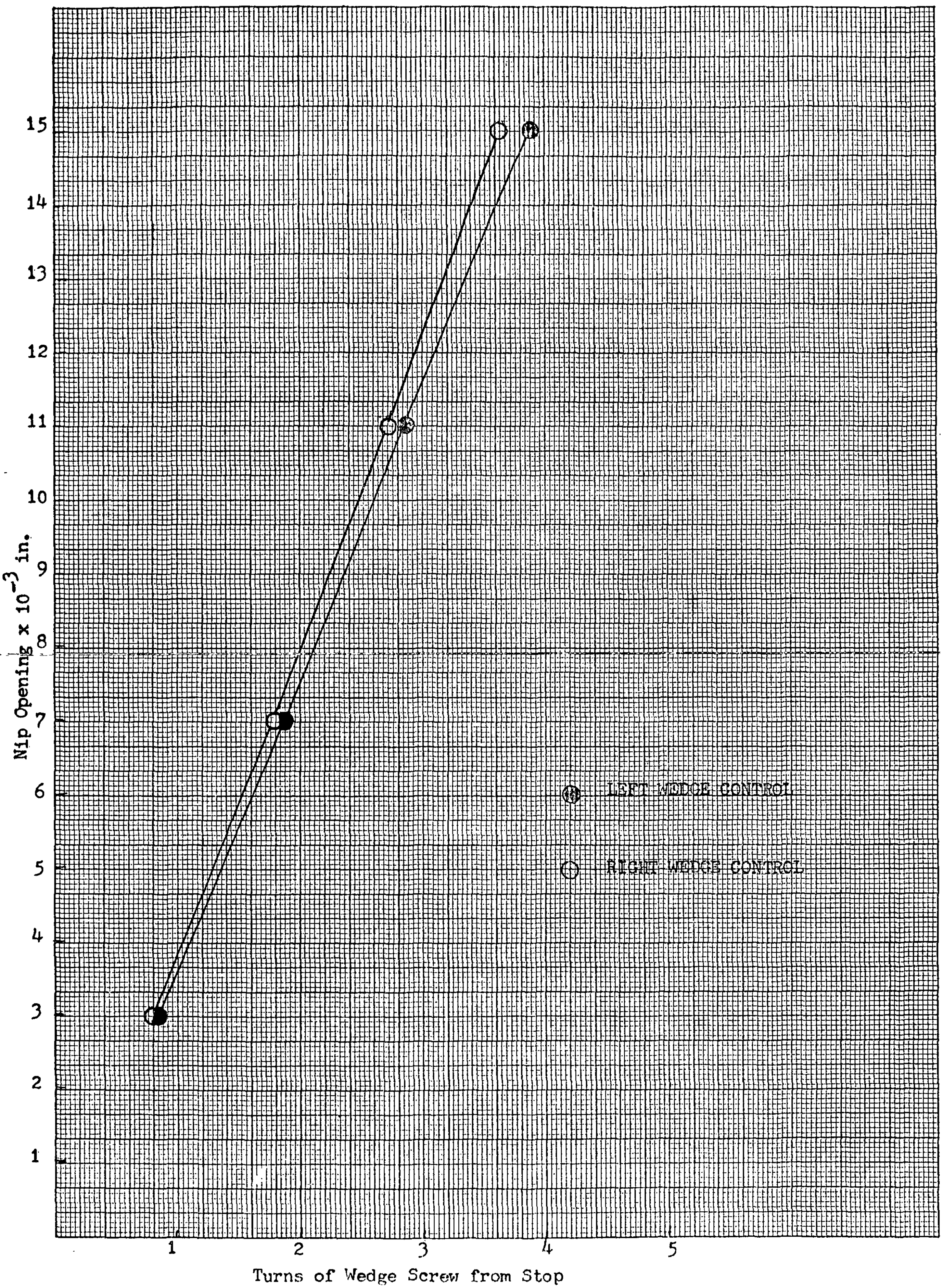
NIP OPENING BETWEEN WEB AND TRANSFER ROLL

Left Wedge Screw, Total Turns	Nip Opening from 0.000 to 0.015 in.	Right Wedge Screw, Total Turns
0.847	0.003	0.806
1.88	0.007	1.79
2.86	0.011	2.72
3.89	0.015	3.63

These controls are located at the back of the coating station near the top and are designated left and right of the machine while facing the rewind end of the coater. The wedge stops are set for zero opening.

Figure 8.

NIP OPENING BETWEEN WEB AND TRANSFER ROLLS



When a web is left in the coater overnight or longer, the web should be blocked open with wooden blocks to avoid flattening the rubber web roll.

NIP OPENING BETWEEN PAN AND TRANSFER ROLLS

These controls are also located at the back of the coater near the bottom. Calibration of nip opening was made with the protractor described above. Nip openings were measured with feeler gages. The wedge stops were set at 0.015 in. nip opening. The calibration of the nip opening appears in Table III and Figure 9. The nip was forced open by turning wedge screws right.

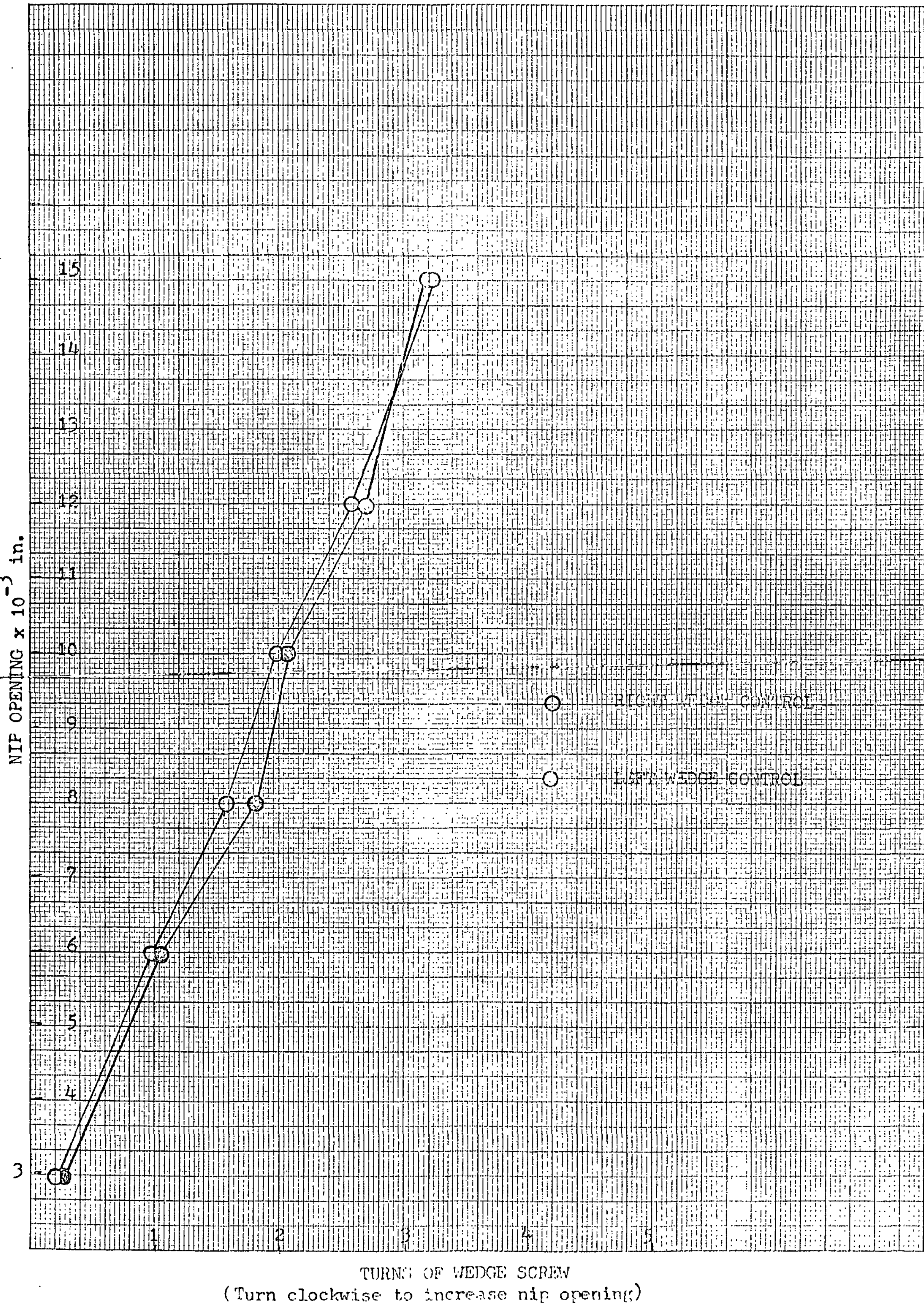
TABLE III

NIP OPENING BETWEEN PAN AND TRANSFER ROLLS

Right Wedge Screw, Total Turns	Nip Opening, inch	Left Wedge Screw, Total Turns
0.000	0.002	0.000
0.250	0.003	0.236
1.04	0.006	1.00
1.82	0.008	1.58
2.07	0.010	2.00
2.69	0.012	2.58
3.19	0.015	3.25

Figure 9

NIP OPENING BETWEEN PAN AND TRANSFER ROLLS



METER ROLL SPEED

The surface speed of the roll was obtained by determining the number of feet traveled by the surface as measured with a Productimeter having a turning wheel 1 ft. in circumference in a given period of time. The meter roll was driven by a $1\frac{1}{2}$ h.p. Graham Drive having a speed control indicator dial marked off in 39 units, each of which can be read to the nearest 1/10 unit. The calibration was made as in Table IV and Figure 10.

TABLE IV

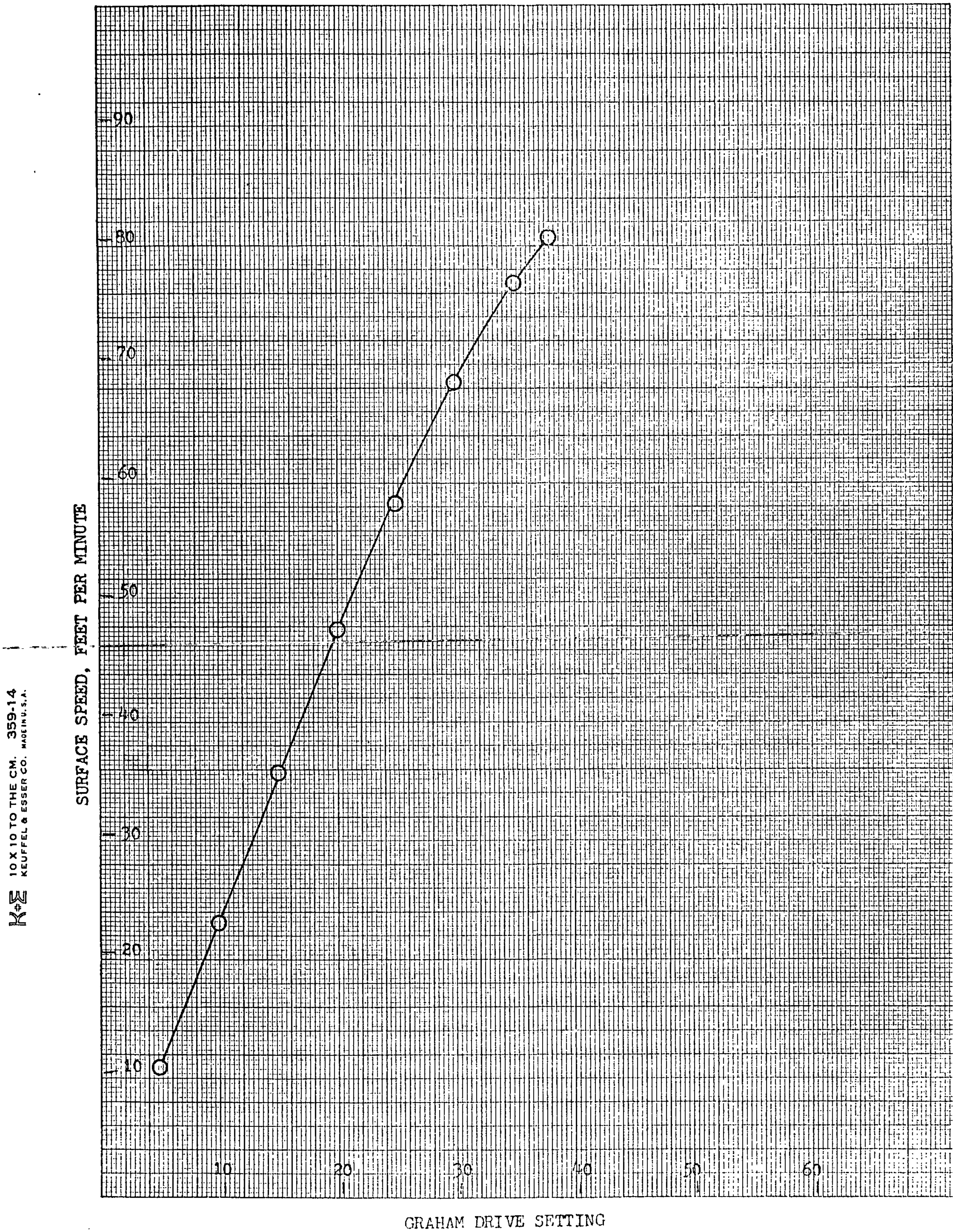
METER ROLL SURFACE SPEED

Graham Drive Control Dial Setting	Surface Speed, ft. per min.
5	10.9
10	23.1
15	35.8
20	47.7
25	58.2
30	68.4
35	76.8
38	80.7

The roll diameter was measured and found to be 7.877 inches.

Figure 10

METER ROLL SURFACE SPEED



TRANSFER ROLL SPEED

The transfer roll is driven by a 1-h.p. Reeves Drive. The drive speed indicator is marked off in units of 1 through 6 and subdivided into quarters. The speed indicator was calibrated into corresponding transfer roll speeds as in Table V and Figure 11 as follows:

TABLE V

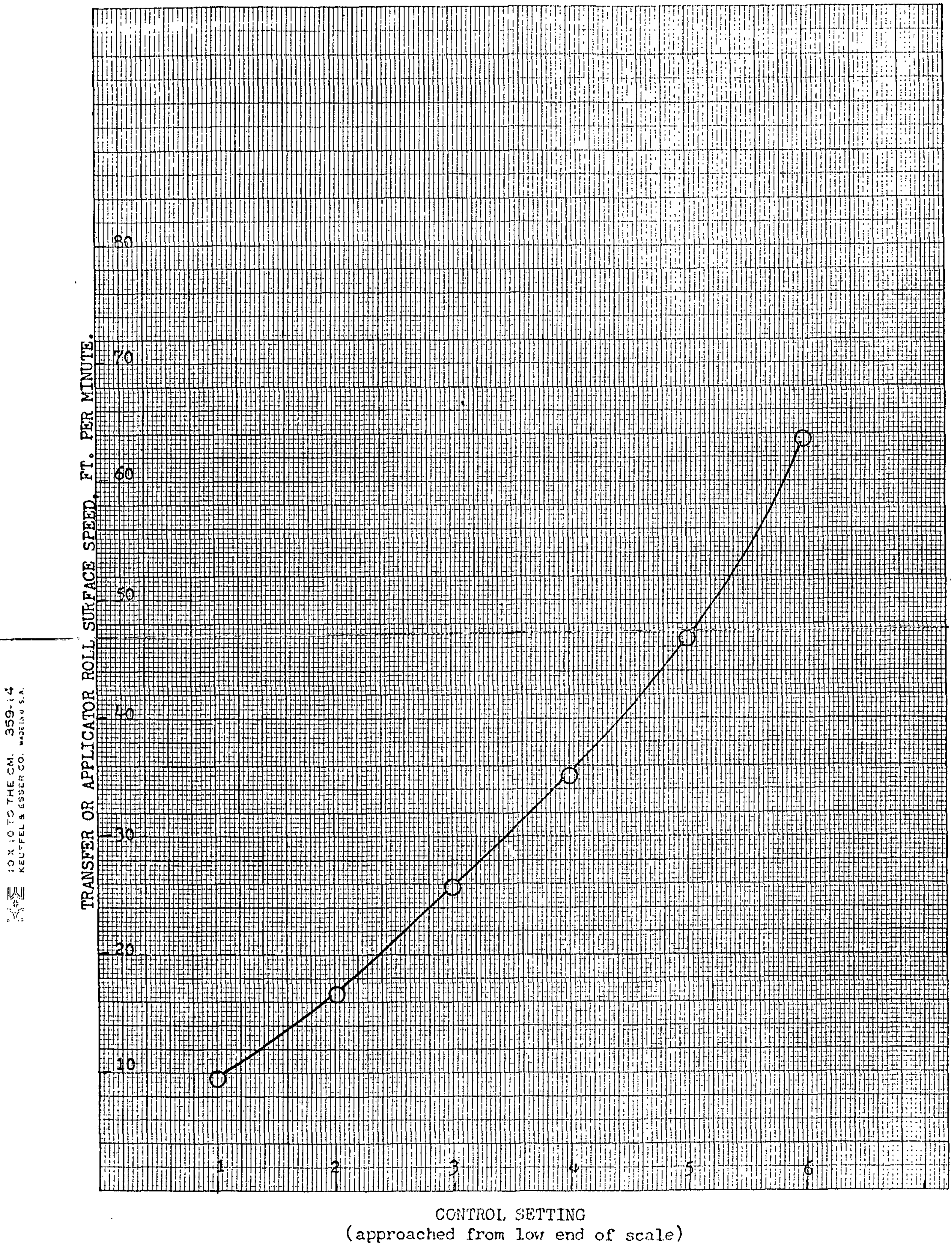
TRANSFER ROLL SURFACE SPEEDS

Reeves Drive Control Dial Setting	Surface Speed, ft. per min.
1	9.5
2	16.6
3	25.9
4	35.1
5	46.8
6	63.5

The transfer roll diameter was 9.863 inches.

Figure 11

TRANSFER ROLL SURFACE SPEED



PAN ROLL SPEED

This roll was driven by a 1-h.p. Reeves Drive of the type mentioned above. Its calibration was much as in Table VI and Figure 12.

TABLE VI

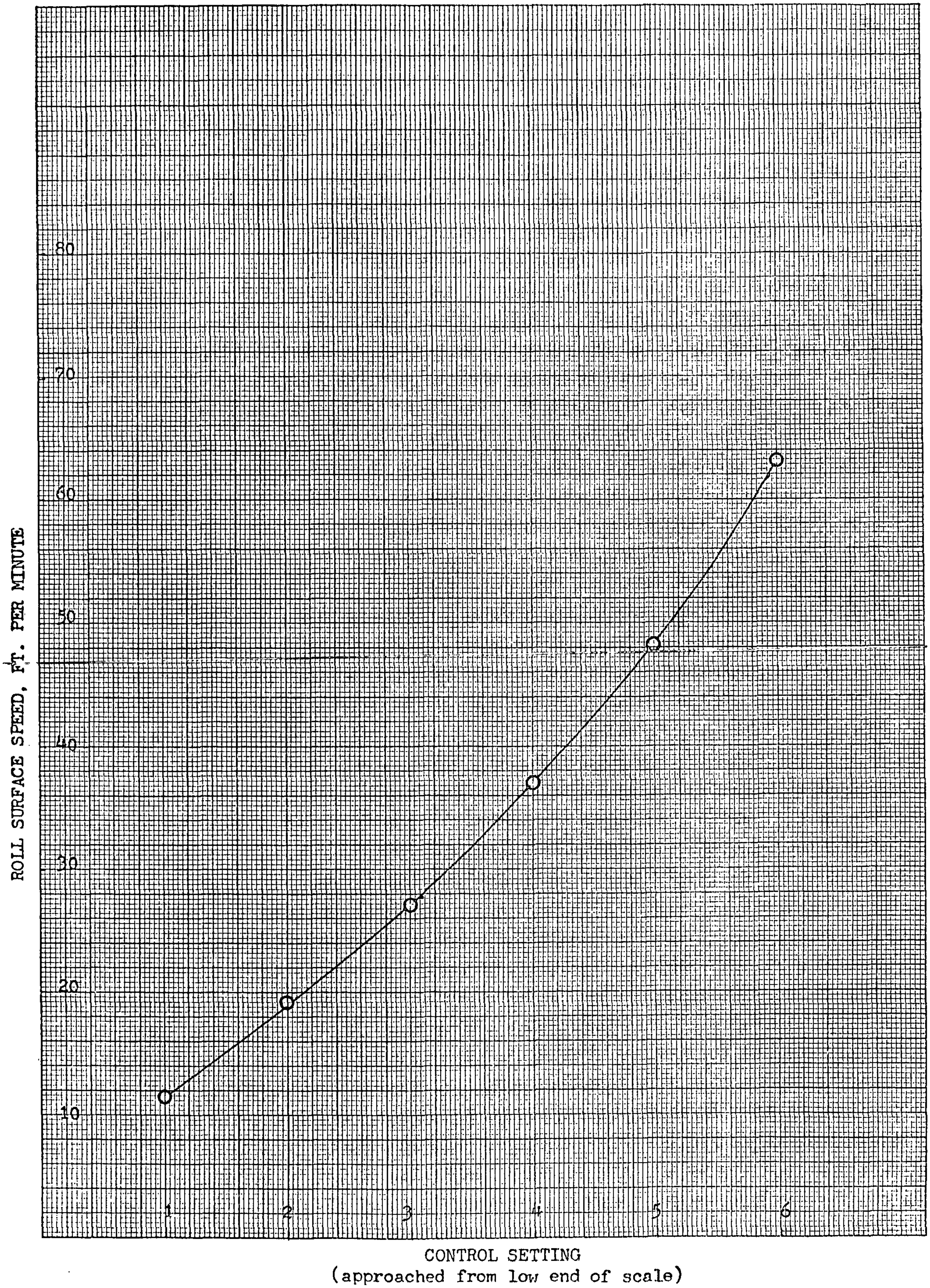
PAN ROLL SURFACE SPEED

Reeves Drive Control Dial Setting	Surface Speed, ft. per min.
1	11.5
2	19.1
3	27.1
4	37.0
5	48.1
6	63.1

The pan roll diameter was 7.878 inches.

Figure 12

PAN ROLL SPEED



WEB SPEED

The web is pulled by a $1\frac{1}{2}$-h.p. constant torque Varidrive Syncrogear motor with a minimum r.p.m. of 400 and a maximum r.p.m. of 1200 operated at 220 volts. The Varidrive is followed by a speed transmission and various reduction gears to a two-roll surface winder. The web speed is controlled by the Varidrive setting and the transmission. Calibration was as follows in Table VII and Figure 13.

TABLE VII

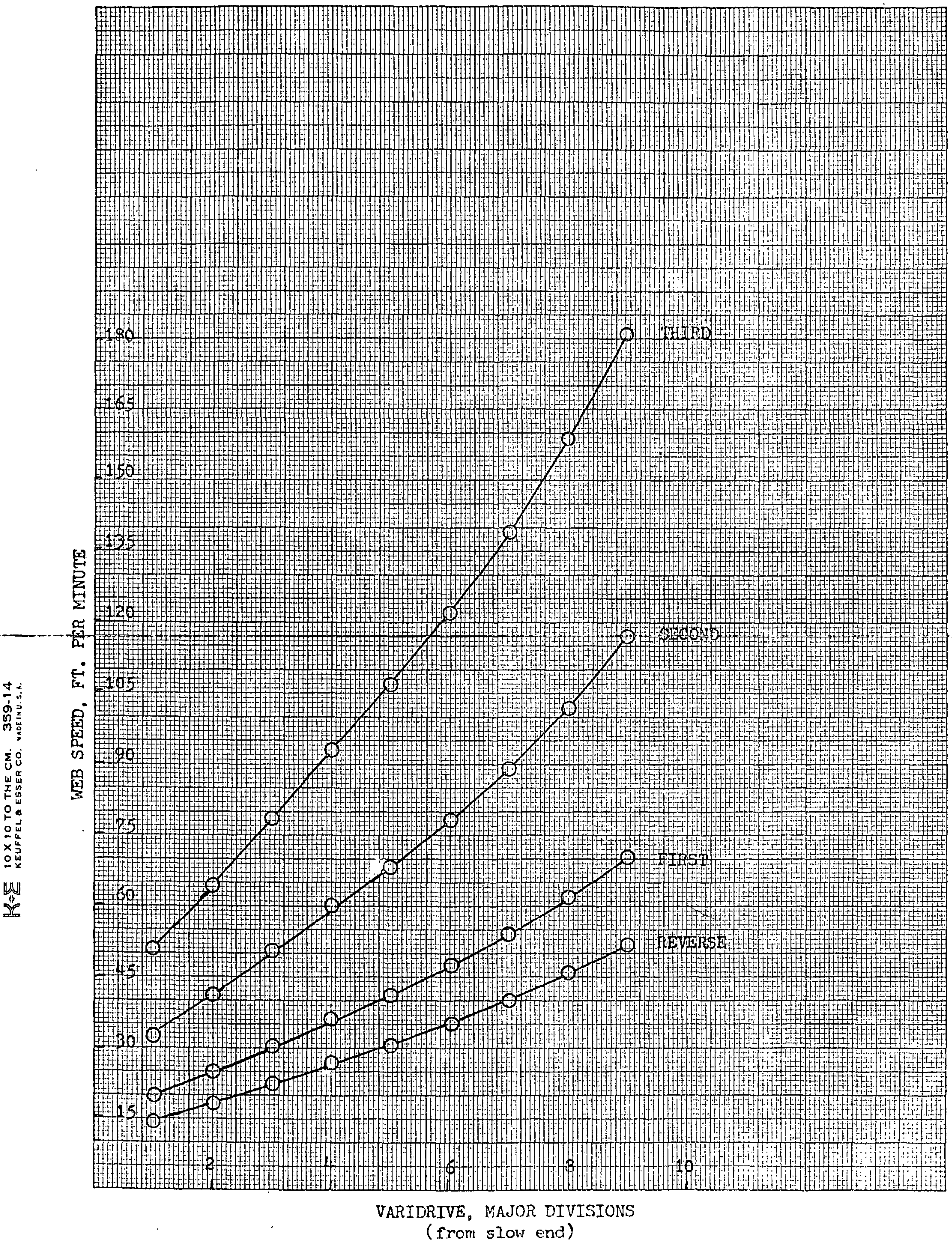
REWIND CALIBRATION

Major Divisions on Varidrive control dial from slow end	Speed for Transmission Gear, ft. per min.			
	First	Second	Third	Reverse
First	20.0	32.6	51.0	14.8
Second	25.0	41.2	64.3	18.6
Third	30.5	50.5	78.5	22.6
Fourth	36.0	60.0	93.0	27.0
Fifth	41.5	68.5	107	30.8
Sixth	47.5	78.3	122	35.3
Seventh	54.0	89.0	139	40.1
Eighth	62.0	102.0	159	46.1
Ninth	70.5	117.0	181	52.0

These calibrations were made with no web on the rewind; thus the only load on the rewind was due to its own friction.

Figure 13

REWIND DRIVE SPEED CALIBRATION



METER ROLL RUNOUT

A dial indicator marked in 0.001-inch divisions was clamped securely to the frame of the coater with its detecting arm against the meter roll. Readings were taken at four intervals along the roll as the roll was run at a relatively slow speed and are given in Table VIII.

TABLE VIII

METER ROLL RUNOUT

Location	Dial Indicator Deviation, in.
Left end	0.0005
5 in. from left	0.0012
10 in. from left	0.0010
Right end	0.0010

APPLICATOR ROLL RUNOUT

Measurements of the applicator roll runout were made in the same way as above and are given in Table IX.

TABLE IX

APPLICATOR ROLL RUNOUT

Location	Dial Indicator Deviation, in.
Left end	0.0020
5 in. from left	0.0008
10 in. from left	0.0008
Right end	0.0006

PAN OR FOUNTAIN ROLL RUNOUT

The measurements were made as described above and are given in Table X.

TABLE X

PAN ROLL RUNOUT

Location	Dial Indicator Deviation, in.
Left end	0.0015
5 in. from left	0.0010
10 in from left	0.0012
Right end	0.0015

TENSION CALIBRATION OF WEB ON CONTRACOATER

The web tension, as mentioned in the general description of the coater, is controlled by a braking device on the unwind stand. By passing the web over a spring-loaded dancer roll, the deflection of the roll shaft gives an indication of the tension. The angle of web approach to the dancer roll was made equal to its angle of departure, these angles being measured from the plane of movement of the dancer roll. The angle was found to be 21° 3'. The movement of the dancer roll was measured with a dial indicator. Calibration of the dancer roll springs was accomplished by loading the end of the dancer roll being calibrated with a spring balance and noting the corresponding deflection on the dial indicator. The web tension was then found by the following equation:

$$\text{web tension} = \frac{\text{load on one dancer roll spring}}{\cos 21^\circ 3'}$$

The calibration was made as in Table XI and Figure 14. This calibration assumed that the load of the web is distributed equally on both ends of the dancer roll.

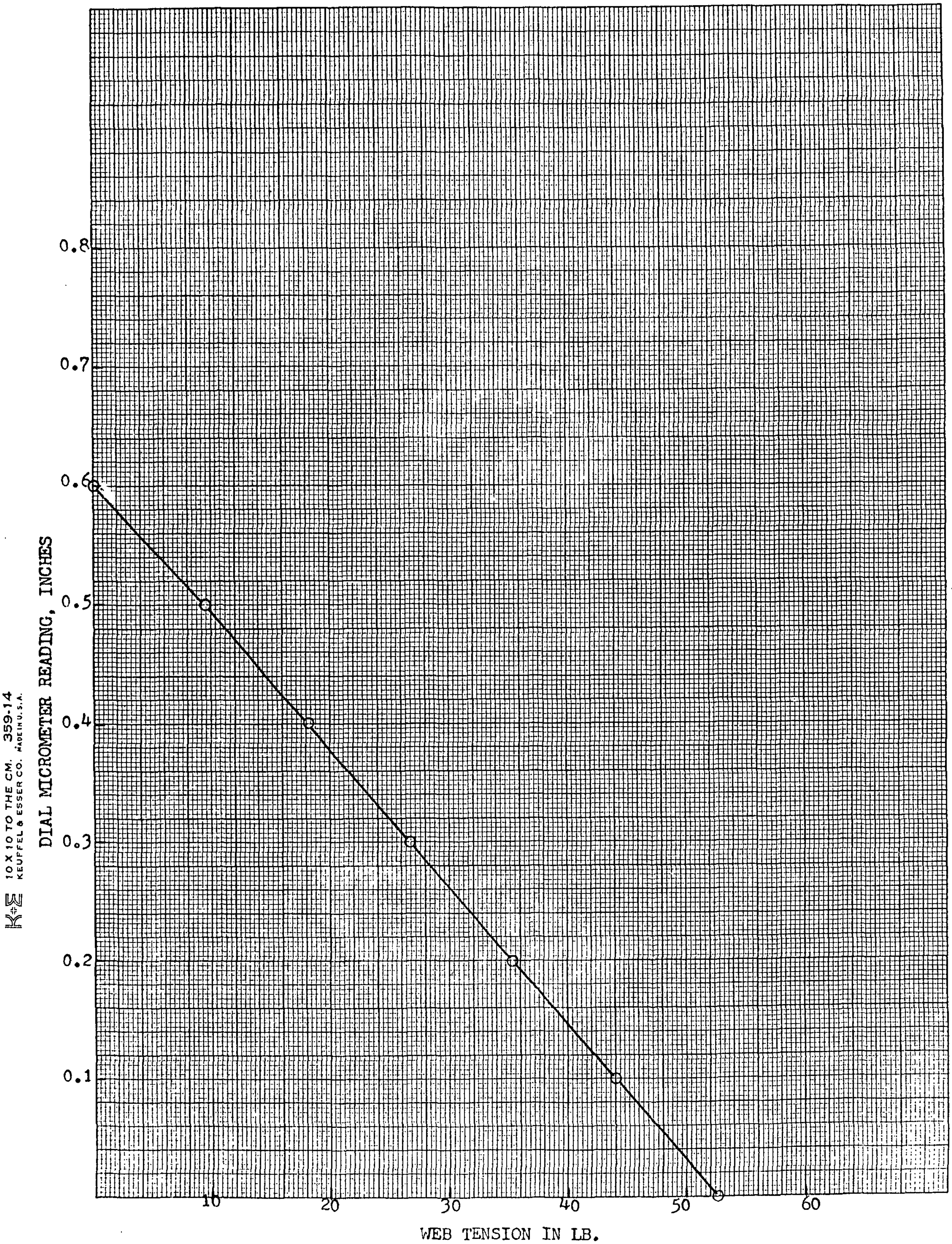
TABLE XI

CALIBRATION OF WEB TENSION

Dial Indicator Reading, Inches	Load on one dancer roll spring, lb.	Web Tension, lb.
0.6000	0.0	0.0
0.5000	8.9	9.5
0.4000	16.9	18.1
0.3000	24.9	26.7
0.2000	32.9	35.3
0.1000	40.9	43.9
0.0000	48.9	52.4

Figure 14

CALIBRATION OF WEB TENSION INDICATOR



PROJECT REPORT FORM

PROJECT NO. 1625
COOPERATOR I.P.C.
REPORT NO. 3
DATE September 4, 1956
NOTE BOOK 1098
PAGE 74 TO 96
SIGNED Bernard Pesetsky
Bernard Pesetsky

Copies to: Files
Howells
Vaurio
Pesetsky

CALIBRATION OF DRYING SECTION FOR DILTS CONTRACOATER

HEATER CONTROL CALIBRATION

The paper is dried by six radiant heaters after it leaves the Dilts coating station. These heaters are located so that three of them dry the web from below and three from above. They have the following description:

Maker: Industrial Radiant Heat Corp.

Voltage: 220 a.c.

Phase: 3

Kw. per section: 2.84

Model: 18 x 36

Each heater is controlled by a separate Brown Instrument Co. Pyr-O-Vane. The heater temperature is detected by a welded iron-constantan thermocouple, and the temperature is controlled by the Pyr-O-Vane. The temperature can also be read on the Pyr-O-Vane.

The lower heaters are numbered from 1 through 3 from the unwind stand end and the upper ones from 4 through 6. Each Pyr-O-Vane and each corresponding thermocouple is numbered for the heater it controls.

The thermocouples which control the heaters are enclosed in a 12 in. long steel well, 1/8 in. in diameter. They were calibrated at known temperatures according to the reading they imparted to a Leeds and Northrup Speedomax recording potentiometer. In addition, a control iron-constantan thermocouple was calibrated which was placed in a stainless steel well 7-1/2 in. long and 1/4 in. in diameter.

THERMOCOUPLE IN MOLTEN ZINC

The thermocouples were calibrated in reagent grade molten zinc said to have a melting point of 787°F. as follows:

Thermocouple	Leeds and Northrup Recorder Reading at Melting Point, °F.
Control	780
1	786
2	785
3	785
4	790
5	785
6	785

THERMOCOUPLE CALIBRATION IN MOLTEN LEAD

Lead of known purity was not available at the Institute at the time the tests were made. Therefore, we used some old lead which we obtained from the millwright shop, for a second calibration point. Pure lead is said to have a melting point of about 621°F. The calibration was as follows:

Thermocouple	Leeds and Northrup Recorder Reading at Melting Point, °F.
Control	614
1	614
2	614
3	614
4	618
5	614
6	618

The actual melting point of the lead in question was probably about 614°F.

THERMOCOUPLE CALIBRATION IN MOLTEN TIN

Reagent grade tin was used having a melting point of about 450°F., and the calibration was made as follows:

Thermocouple	Leeds and Northrup Recorder Reading at Melting Point, °F.
Control	450
1	450
2	445
3	449
4	452
5	448
6	449

THERMOCOUPLE CALIBRATION IN OIL BATH

An oil bath held at a temperature of 135.5°C. or 276°F., determined with a glass laboratory thermometer made by E. S. Sargent and Co., was used as a fourth calibration point for the thermocouple as follows:

Thermocouple	Leeds and Northrup Recorder Reading, °F.
Control	277
1	274
2	275
3	273
4	276
5	272
6	275

THERMOCOUPLE CALIBRATION IN WATER BATH

A water bath held at 72.0°C. or 161.6°F. was used as a fifth calibration point for the thermocouples. A Wilkins-Anderson thermometer was used to measure the actual water temperature, and the calibration was as follows:

Thermocouple	Leeds and Northrup Recorder Reading, °F.
Control	160
1	161
2	161
3	161
4	161
5	160
6	160

CALIBRATION OF PYR-O-VANE HEATER CONTROL

The Pyr-O-Vane calibration was accomplished by use of three iron constantan thermocouples leading to the Leeds and Northrup Recorder from each heater being calibrated. Two shielded and one unshielded thermocouples were used. One shielded thermocouple was the regular controlling element and was connected to the Pyr-O-Vane being calibrated. Settings were made on the controlling Pyr-O-Vane and the heater turned on. Both the heater-controlling and recording thermocouples were kept close together on the surface of the heater and under essentially the same conditions. Thus the well-type thermocouples used to detect the temperature being recorded were transmitting to the Leeds and Northrup Recorder about the same changes as the heater-controlling thermocouple was showing to its corresponding Pyr-O-Vane. The loose thermocouple, by virtue of its smallness, was detecting more closely the actual lag and overshoot of the heaters. However, due to its small size, it was less apt to pick up the average surface temperature of the heater but might very easily be on a local hot or cold spot. The radiant heat absorption characteristics of the different couples was an important uncontrolled variable. Tables I through VI show calibrations of the Pyr-O-Vanes numbered 1 through 6. Graphs were made of the average recorded temperature of the shielded thermocouple versus Pyr-O-Vane setting and are set out in Figures 1 through 6.

TABLE I

HEATER NO. 1 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Controlling Thermocouple Recorded, °F.			Thermocouple No.3 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	180	195	188	168	175	172	180	210	195
300	255	270	263	230	245	238	245	295	270
400	320	335	328	300	315	308	320	377	348
500	380	400	390	355	368	362	375	425	400
600	450	465	458	420	430	425	440	490	465
700	525	545	535	485	500	493	510	565	533
800	600	618	609	560	575	568	580	625	603
860	645	665	655	600	615	608	625	680	653

Thermocouple No. 3 was found to have loose connections.

TABLE II

HEATER NO. 2 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Controlling Thermocouple Recorded, °F.			Thermocouple No. 3 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	170	185	178	180	200	190	180	220	200
300	240	265	253	250	283	267	250	335	293
400	315	343	329	315	343	329	310	400	355
500	380	405	393	380	410	395	385	485	435
600	425	455	440	430	470	450	425	572	499
700	495	517	506	500	536	518	500	635	568
800	585	597	591	585	597	591	625	665	645

TABLE III

HEATER NO. 3 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Thermocouple No. 4 Recorded, °F.			Thermocouple No. 6 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	170	180	175	170	180	175	173	197	185
300	230	250	240	250	265	258	230	270	250
400	295	305	300	305	325	315	305	350	328
500	365	385	375	365	385	375	375	420	398
600	435	450	443	450	470	460	450	490	470
700	490	505	498	505	520	513	515	555	535
800	565	580	573	565	590	578	590	625	608

TABLE IV

HEATER NO. 4 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Thermocouple No. 5 Recorded, °F.			Thermocouple No. 6 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	195	205	200	195	208	202	210	228	219
300	290	310	300	290	310	300	315	360	338
400	398	400	399	398	402	400	440	460	450
500	490	500	495	490	500	495	545	570	558
600	590	598	594	590	598	594	645	660	653
650	635	645	640	635	645	640	685	700	693

TABLE V

HEATER NO. 5 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Thermocouple No. 1 Recorded, °F.			Thermocouple No. 6 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	200	215	208	205	225	215	205	245	225
300	298	298	298	298	298	298	305	315	310
400	395	395	395	395	395	395	415	420	418
500	495	495	495	495	495	495	505	513	509
600	590	590	590	590	590	590	607	611	609
650	643	643	643	643	643	643	663	666	665

TABLE VI

HEATER NO. 6 CONTROL CALIBRATION

Pyr-O-Vane Setting, °F.	Thermocouple No. 1 Recorded, °F.			Thermocouple No. 3 Recorded, °F.			Loose Thermocouple Recorded, °F.		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
200	140	160	150	140	160	150	140	170	155
400	295	320	308	295	320	308	290	345	318
500	365	400	382	365	400	382	360	420	390
600	445	480	463	445	480	463	445	507	476
700	520	560	535	520	560	540	520	582	551
800	610	630	620	605	615	610	600	655	628
860	670	680	675	655	665	660	680	700	690

Figure 1

TEMPERATURE ADJUSTMENT FOR INFRARED HEATER NO. 1

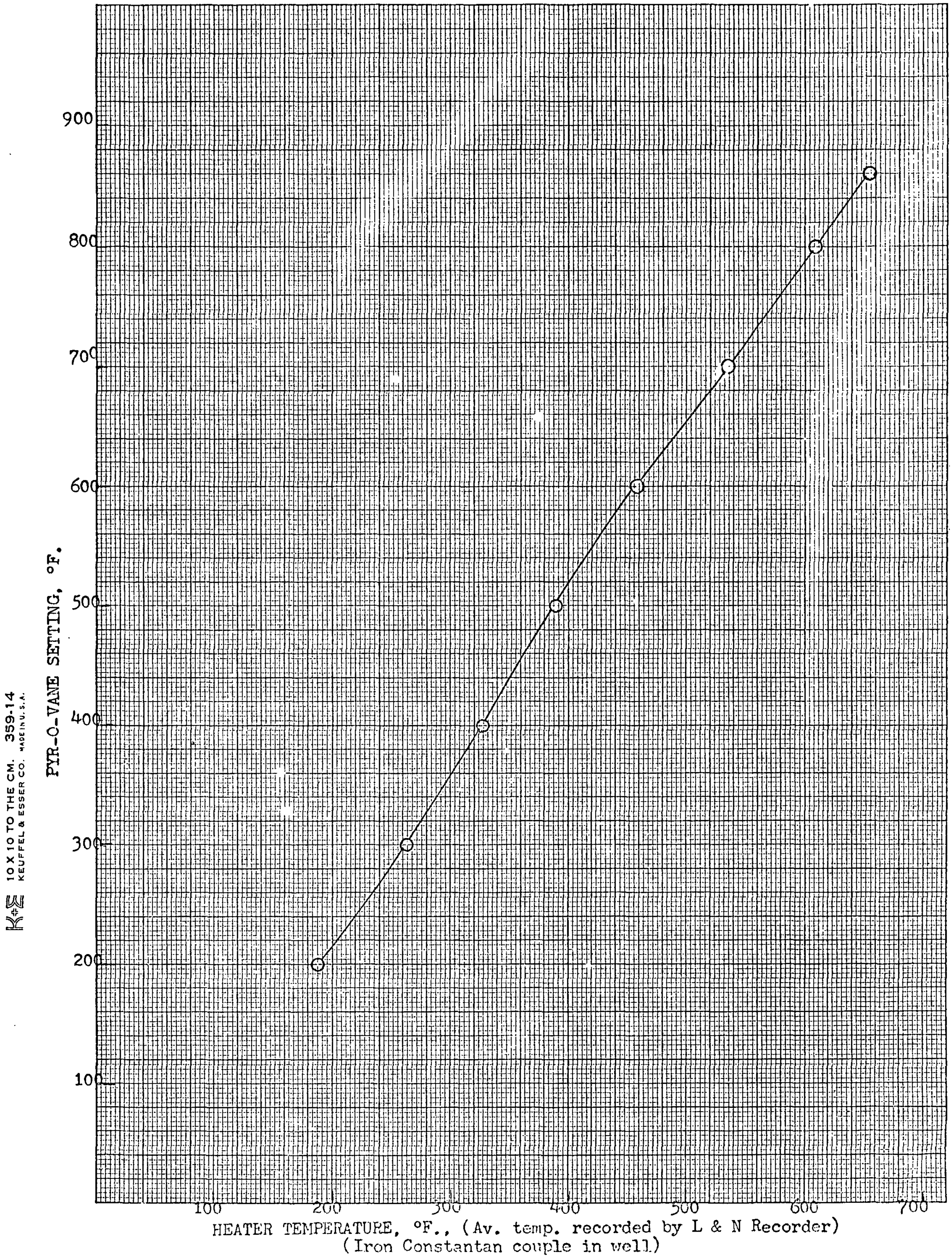


Figure 2

TEMPERATURE ADJUSTMENT FOR INFRARED HEATER NO. 2

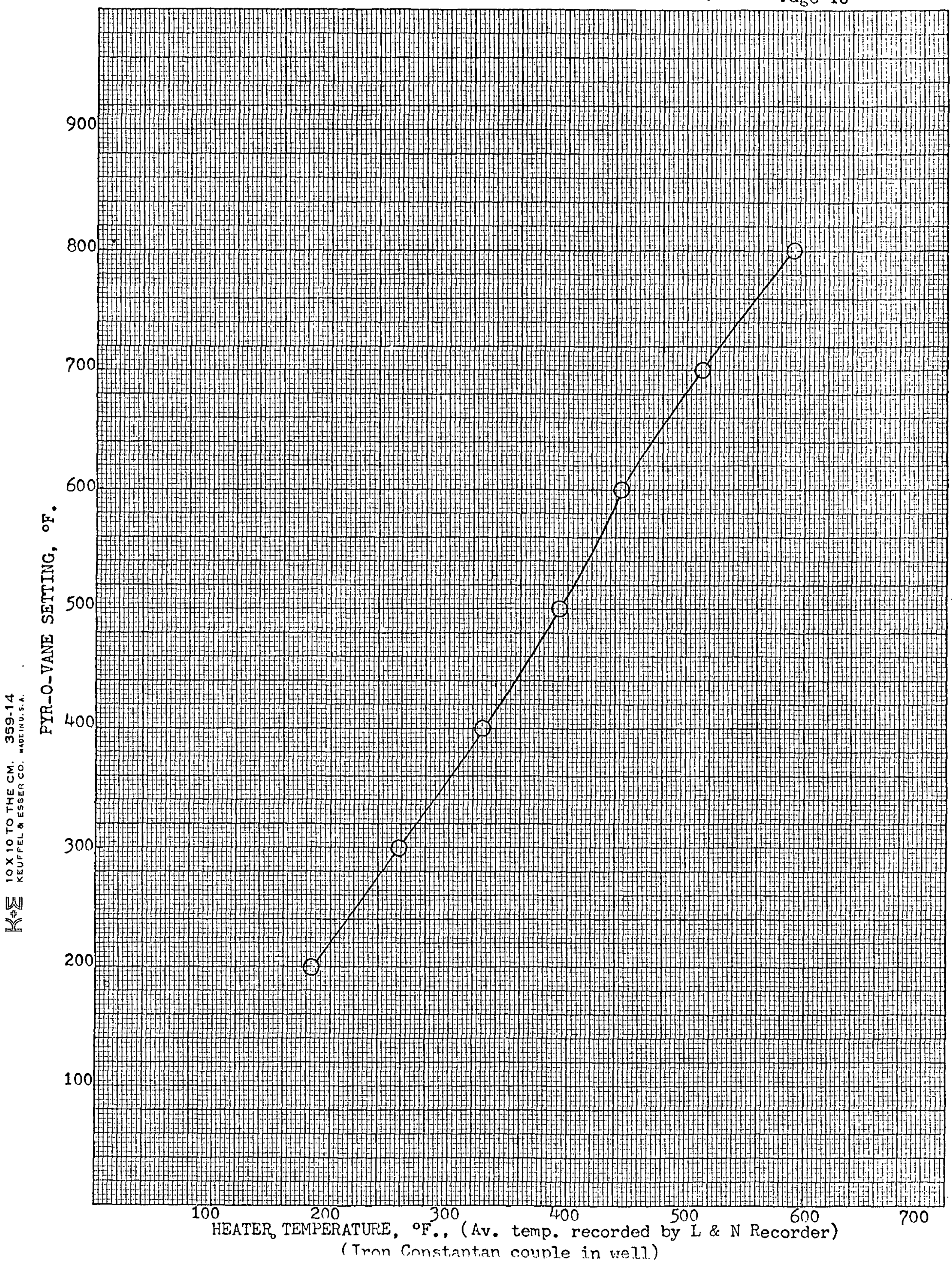
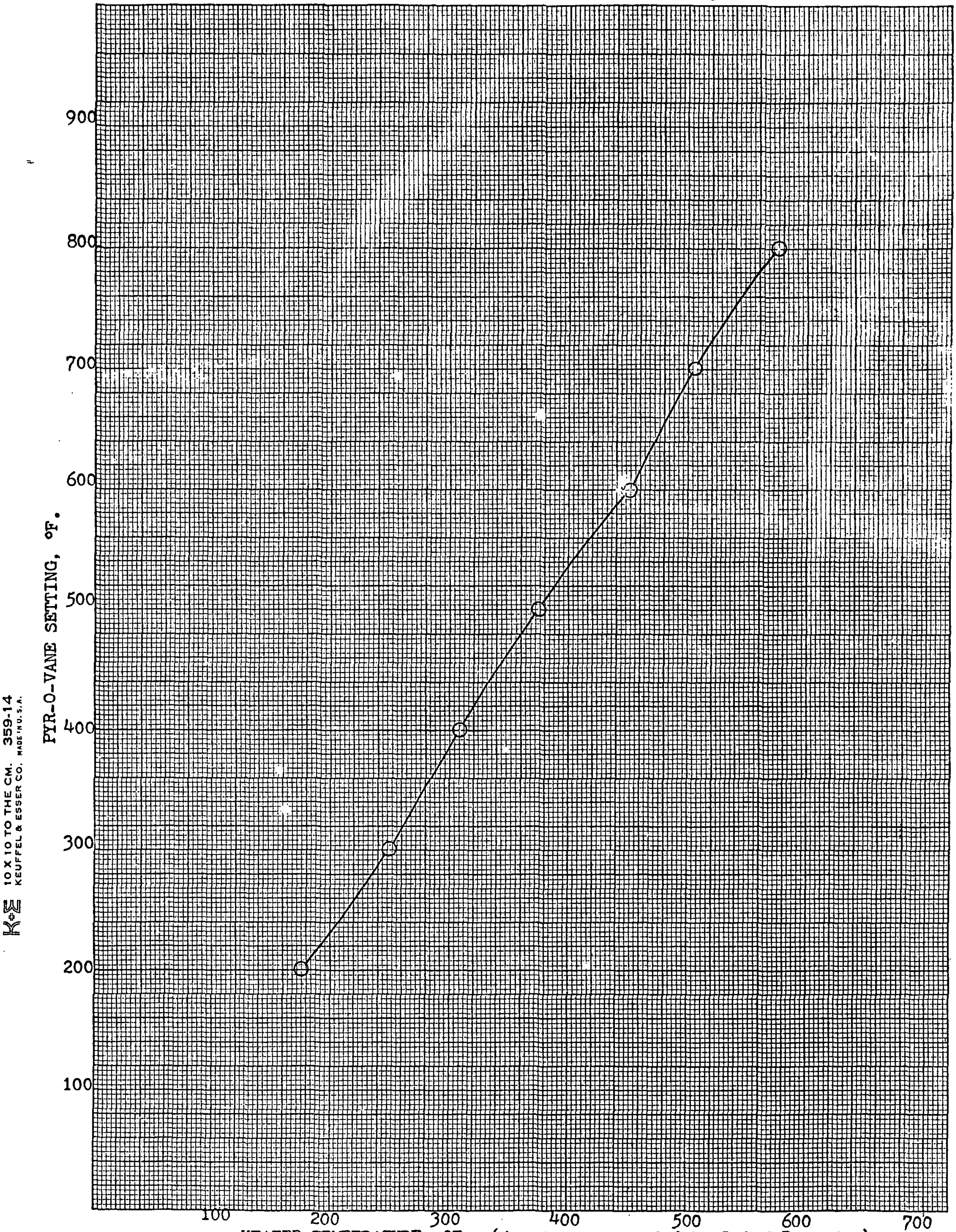


Figure 3

TEMPERATURE ADJUSTMENT FOR INFRARED HEATER NO. 3



HEATER TEMPERATURE, °F., (Av. temp. recorded by L & N Recorder)
(Iron Constantan couple in well)

Figure 4

TEMPERATURE ADJUSTMENT FOR HEATER NO. 4

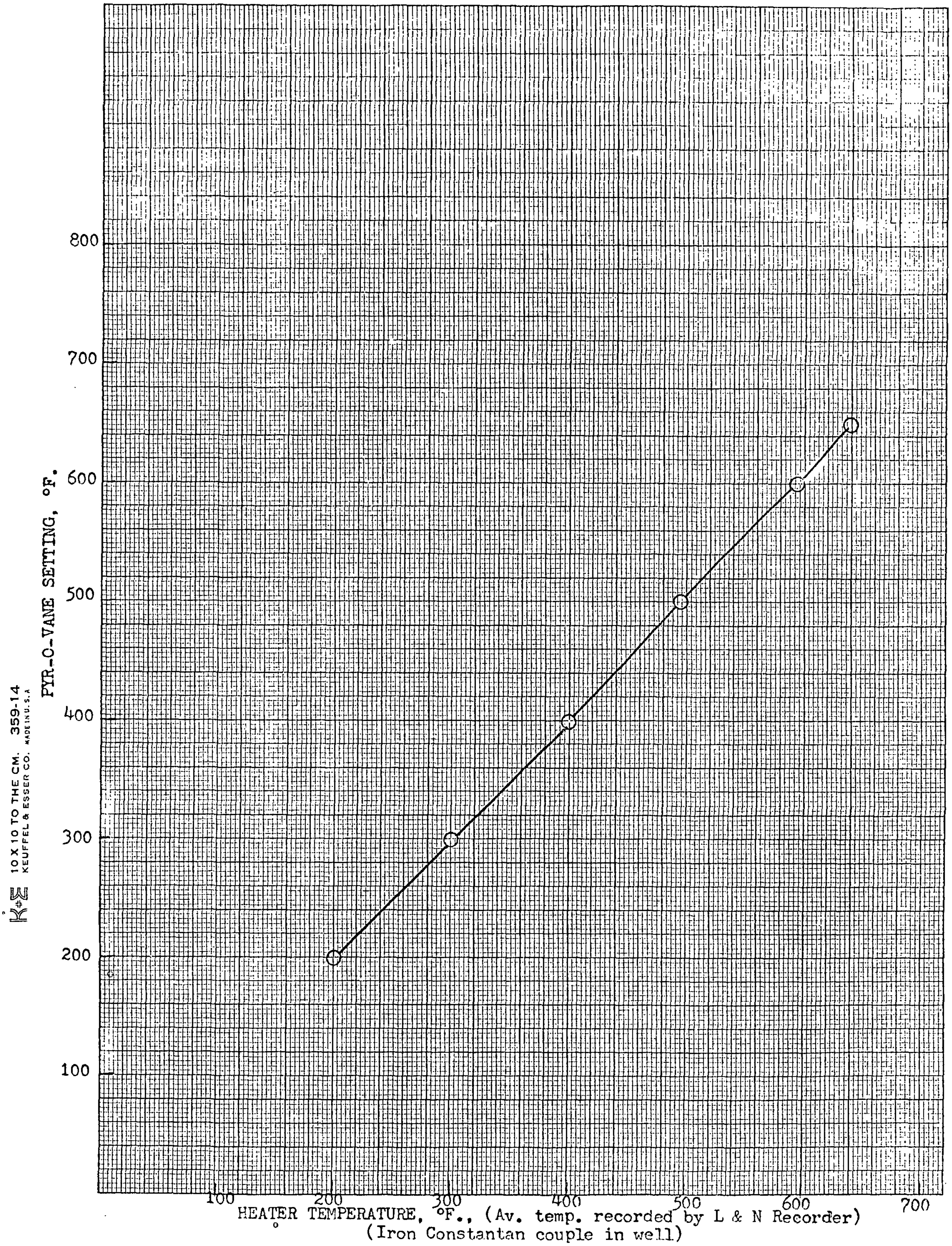


Figure 5

TEMPERATURE ADJUSTMENT FOR INFRARED HEATER NO. 5

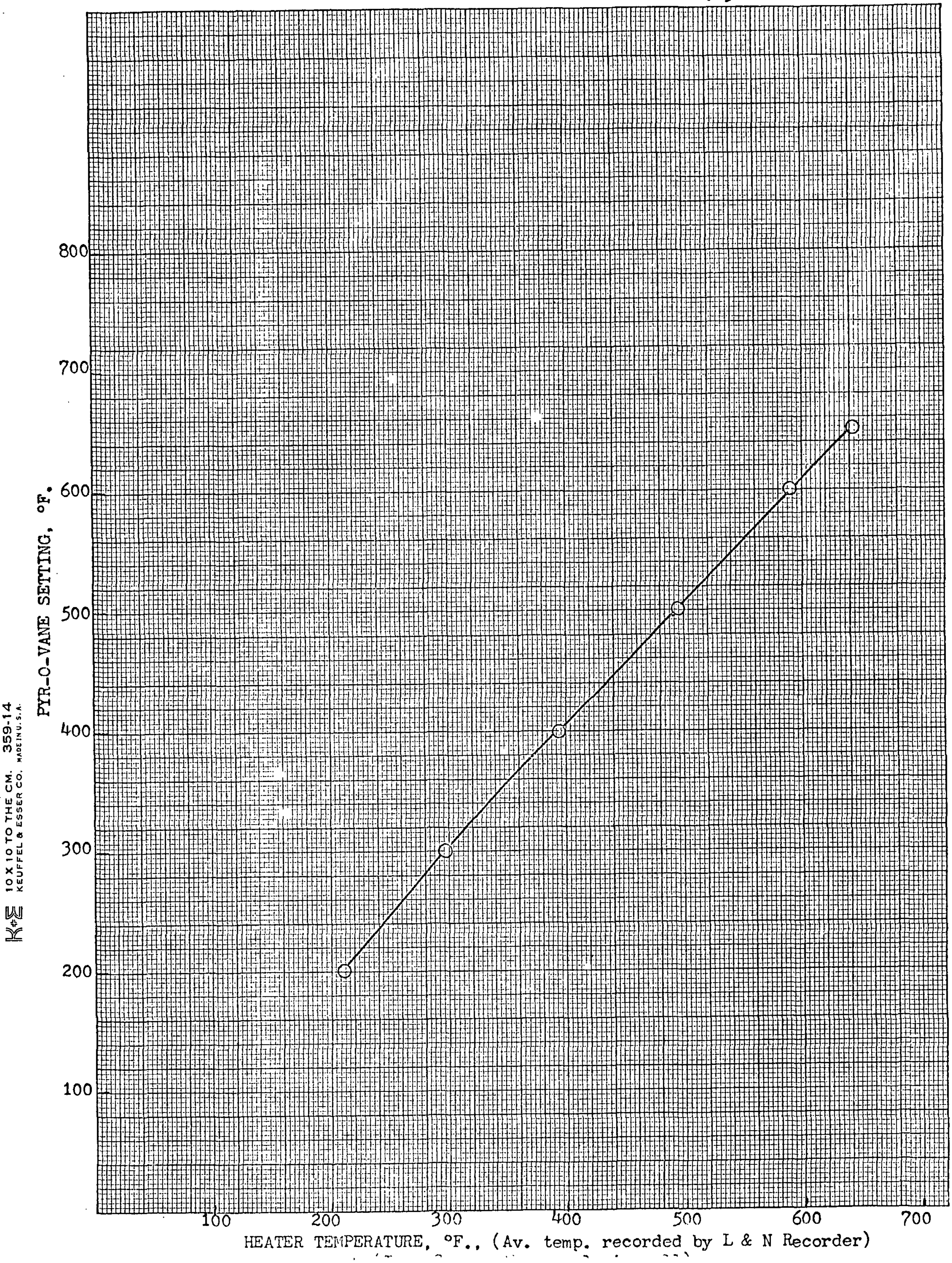
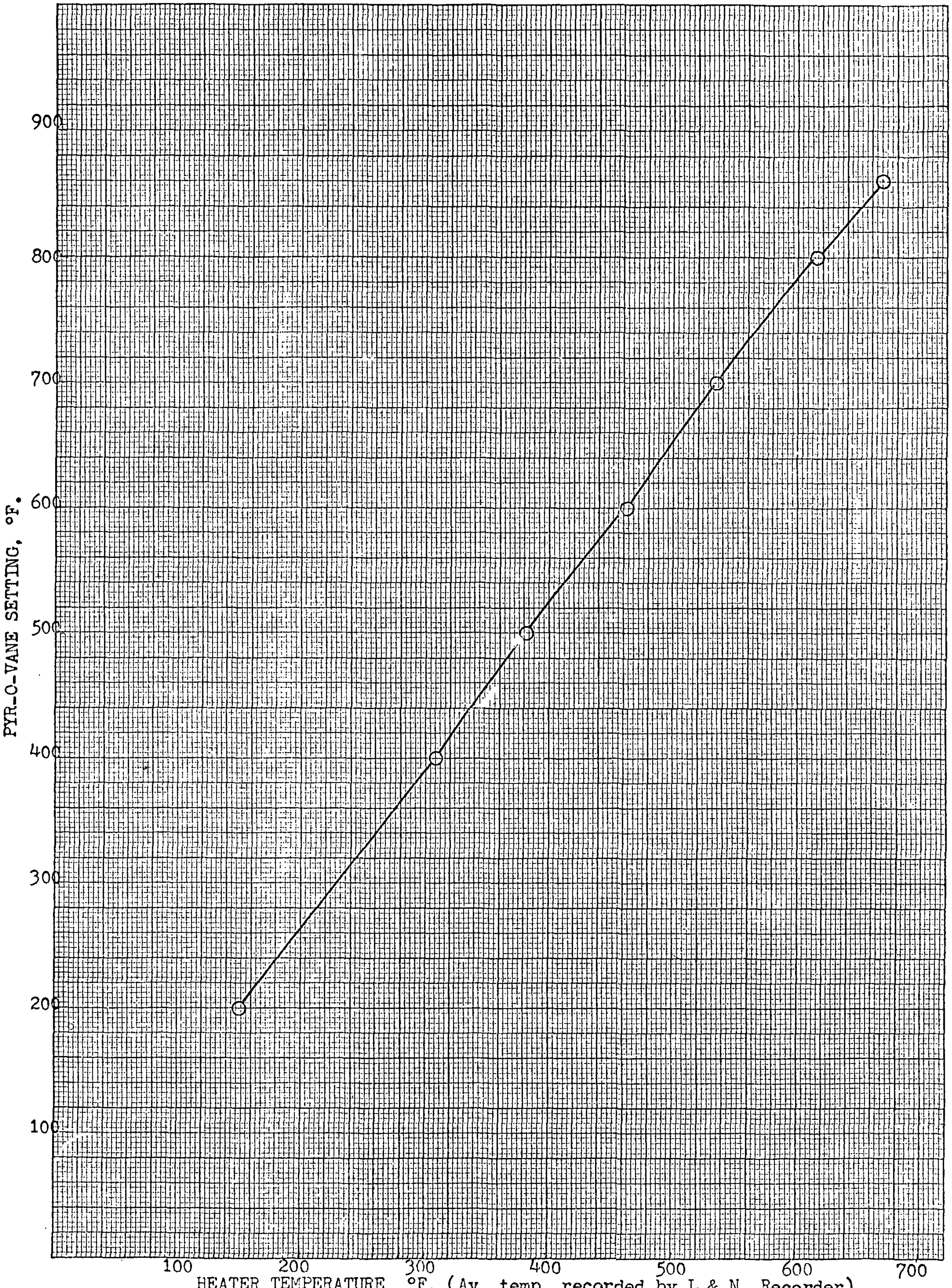


Figure 6

TEMPERATURE ADJUSTMENT FOR INFRARED HEATER NO. 6



PYR-O-VANE TEMPERATURE CALIBRATION

In addition to controlling the temperature, the Pyr-O-Vanes also indicate the temperature of the heaters. The calibrations were made by holding the thermocouples feeding the Pyr-O-Vanes at known temperatures and reading their indicated temperature. All plugs were disconnected from the heater during calibrations. It was noticed that when the Pyr-O-Vanes were read with the heater switch off, with the heater switch on and the red indicator light on, and with the heater switch on and the yellow indicator light on, each set of conditions caused the Pyr-O-Vane to read differently. When the yellow light was on, it meant that electricity would have been supplied to the heaters had they been connected. At this point the highest temperature was indicated by the Pyr-O-Vane. It was believed that this is an anticipating overshoot device in the meter and that by doing this, the meter prevents a great actual overshoot. Tables VII through XII and Figures 7 through 12 show these calibrations.

TABLE VII

PYR-O-VANE CALIBRATION,

Thermocouples at 275°F.

Pyr-O-Vane	Indicator Reading: Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	283	302	325
2	278	298	320
3	335	345	365
4	255	263	278
5	260	273	287
6	300	325	350

TABLE VIII

PYR-O-VANE CALIBRATION,

Thermocouples at 355°F

Pyr-O-Vane	Indicator Reading: Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	390	405	430
2	380	403	428
3	440	455	480
4	338	340	358
5	338	349	363
6	410	430	459

TABLE IX

PYR-O-VANE CALIBRATION,

Thermocouples at 406°F.

	Indicator Reading		
Pyr-O-Vane	Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	458	480	500
2	450	470	500
3	515	530	550
4	385	390	410
5	388	400	417
6	480	500	530

TABLE X

PYR-O-VANE CALIBRATION,

Thermocouples at 450°F.

	Indicator Reading		
Pyr-O-Vane	Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	505	430	550
2	500	525	550
3	570	580	600
4	422	430	445
5	428	440	455
6	525	545	570

TABLE XI

PYR-O-VANE CALIBRATION,

Thermocouples at 614°F.

Pyr-O-Vane	Indicator Reading Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	710	745	760
2	705	730	750
3	765	800	830
4	585	595	615
5	590	605	617
6	730	765	790

TABLE XII

PYR-O-VANE CALIBRATION,

Thermocouples at 787°F.

Pyr-O-Vane	Indicator Reading Switch Off, °F.	Red Light On, °F.	Yellow Light On, °F.
1	935	970	985
2	905	955	970
3	990	1030	1040
4	760	765	780
5	765	777	790
6	960	980	1005

Figure 7

PYR-O-VANE NO. 1 TEMPERATURE CALIBRATION

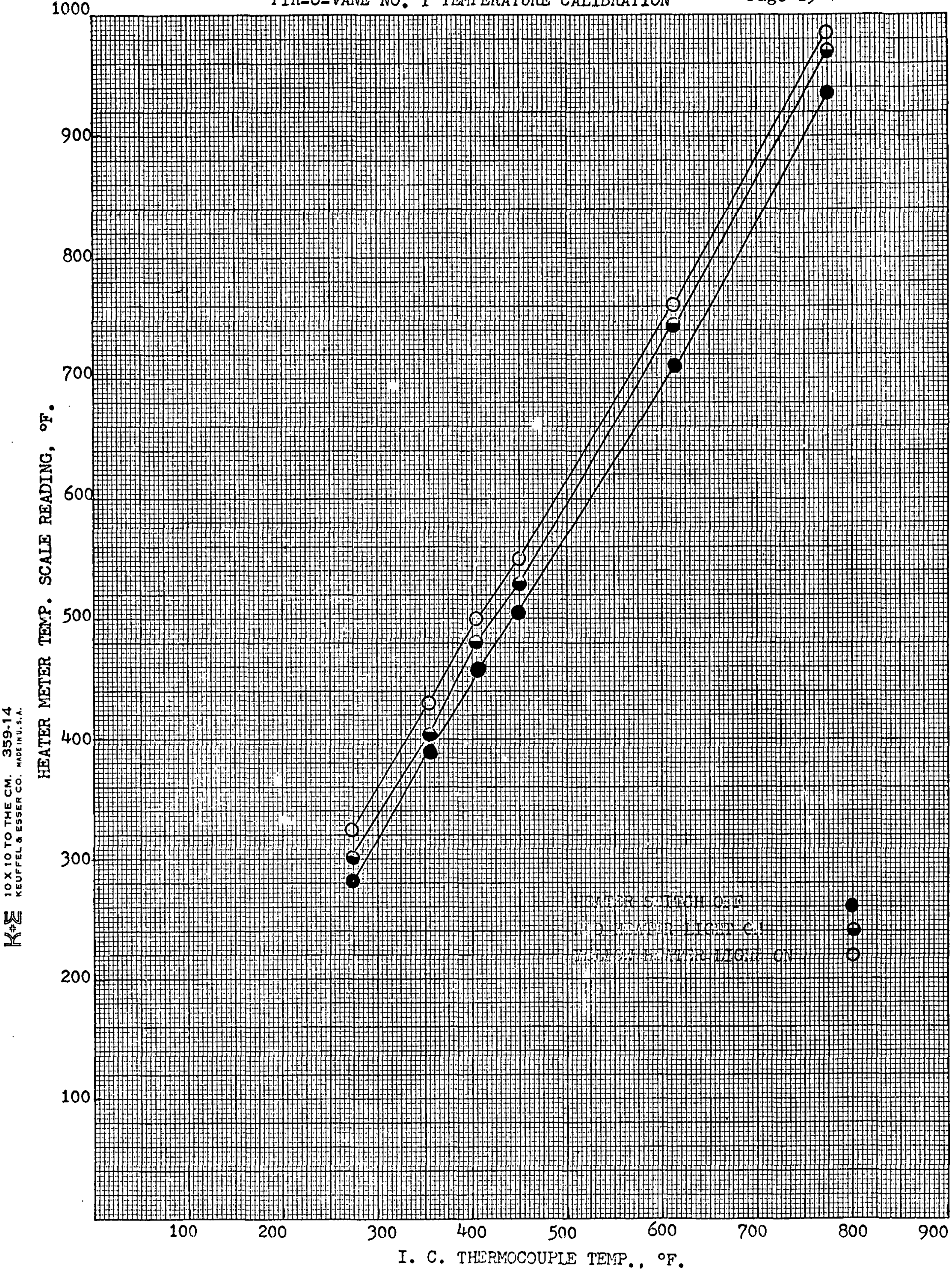


Figure 8

PYR-O-VANE NO. 2 TEMPERATURE CALIBRATION

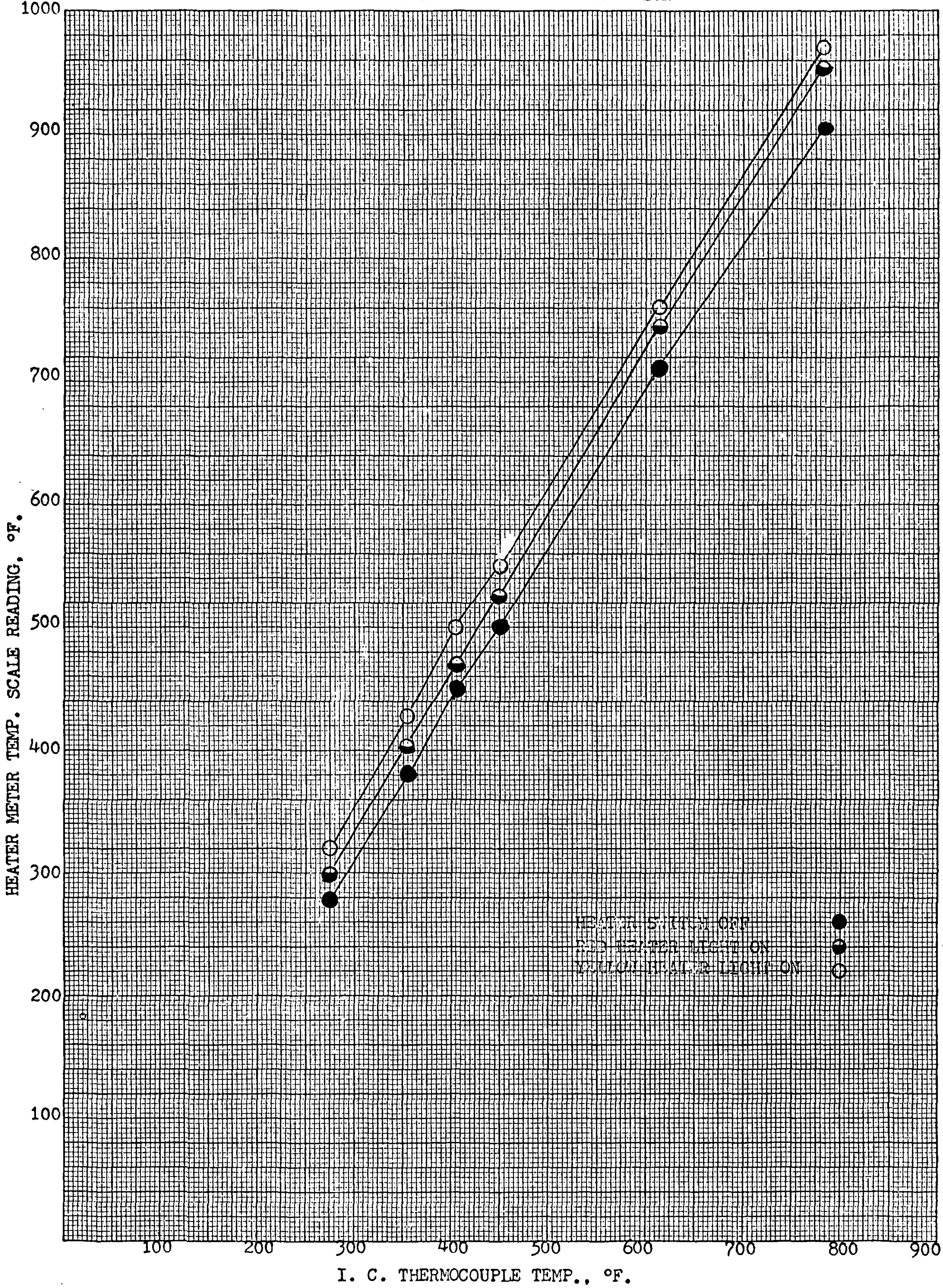


Figure 9

PYR-O-VANE NO. 3 TEMPERATURE CALIBRATION

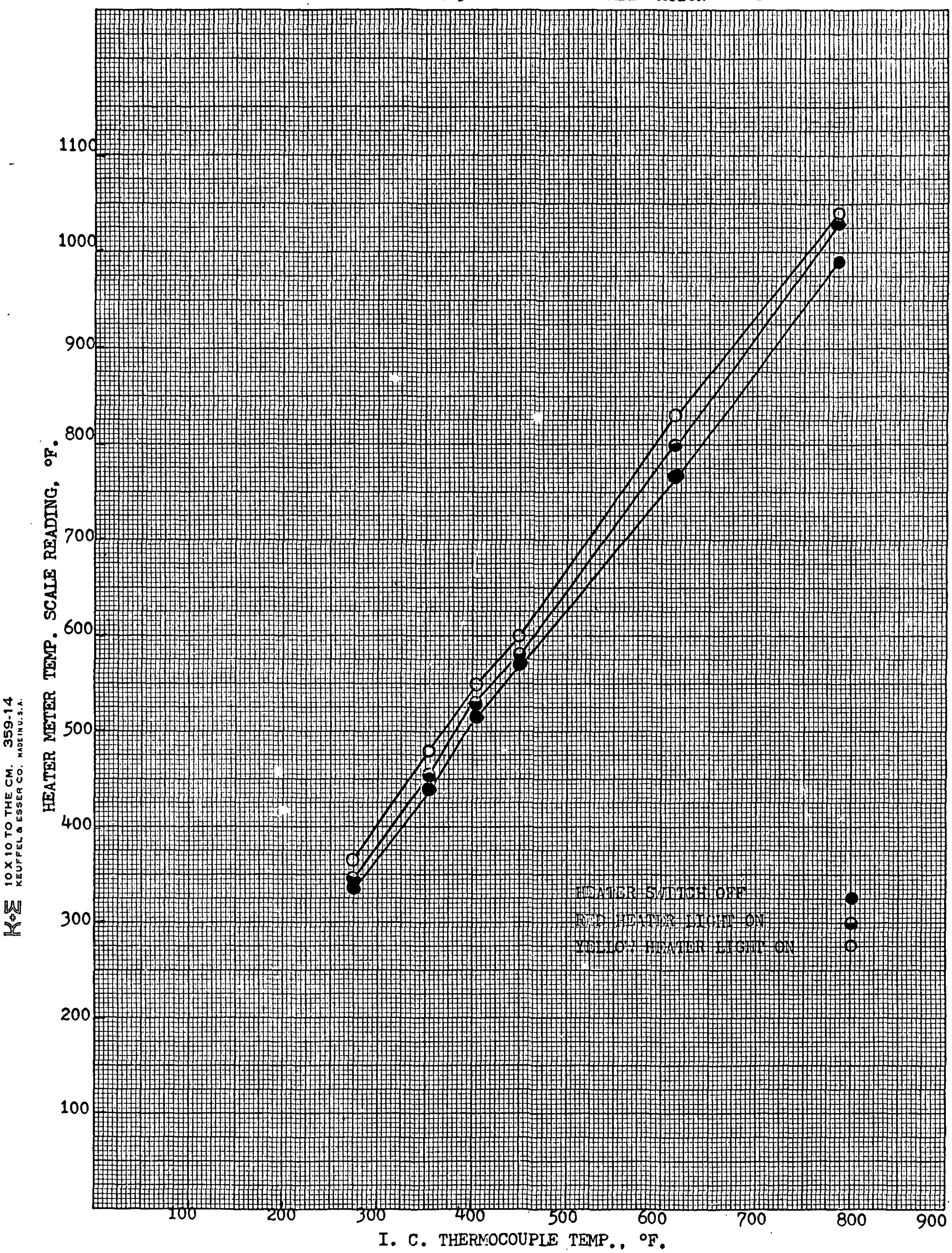


Figure 10

PYR-O-VANE NO. 4 TEMPERATURE CALIBRATION

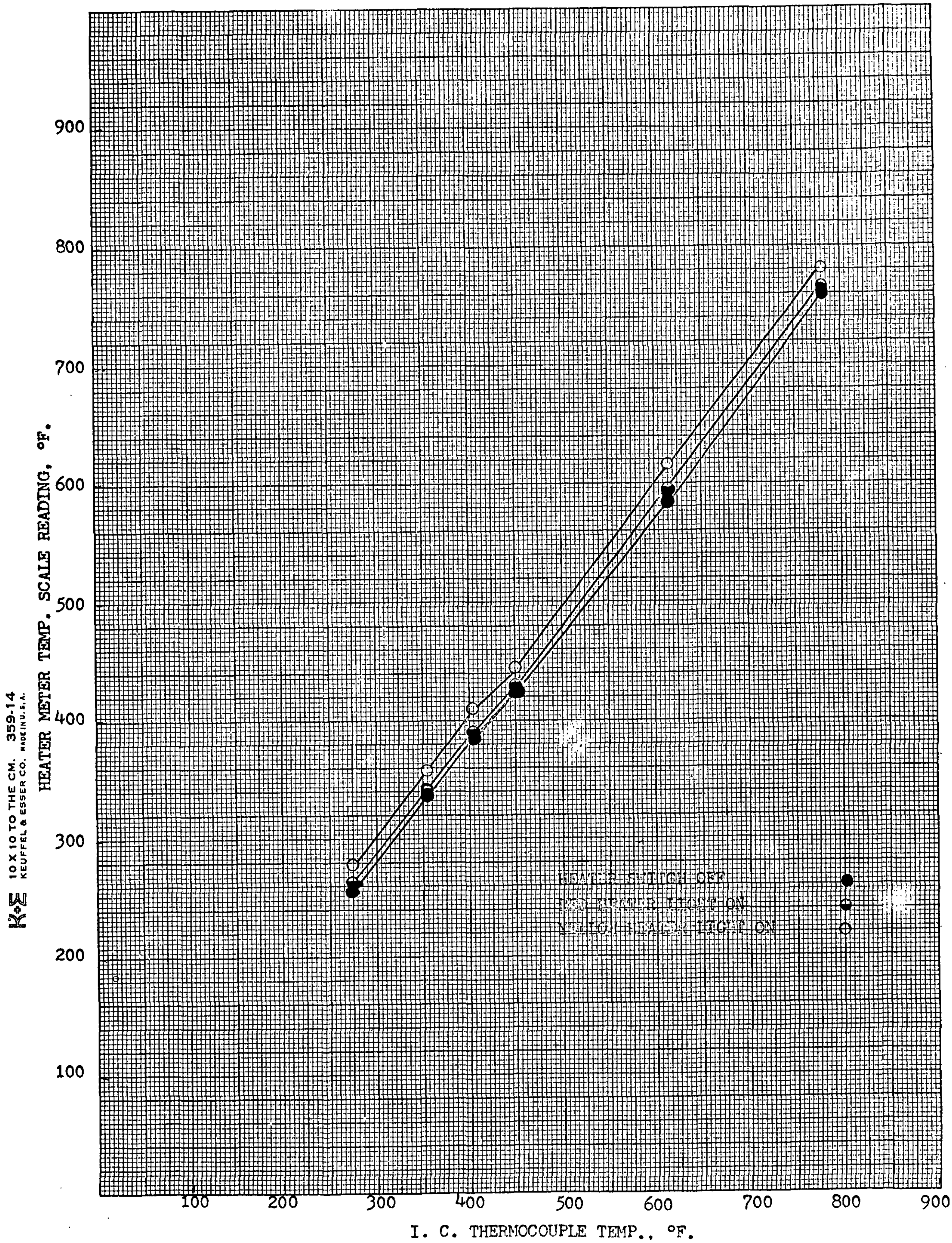
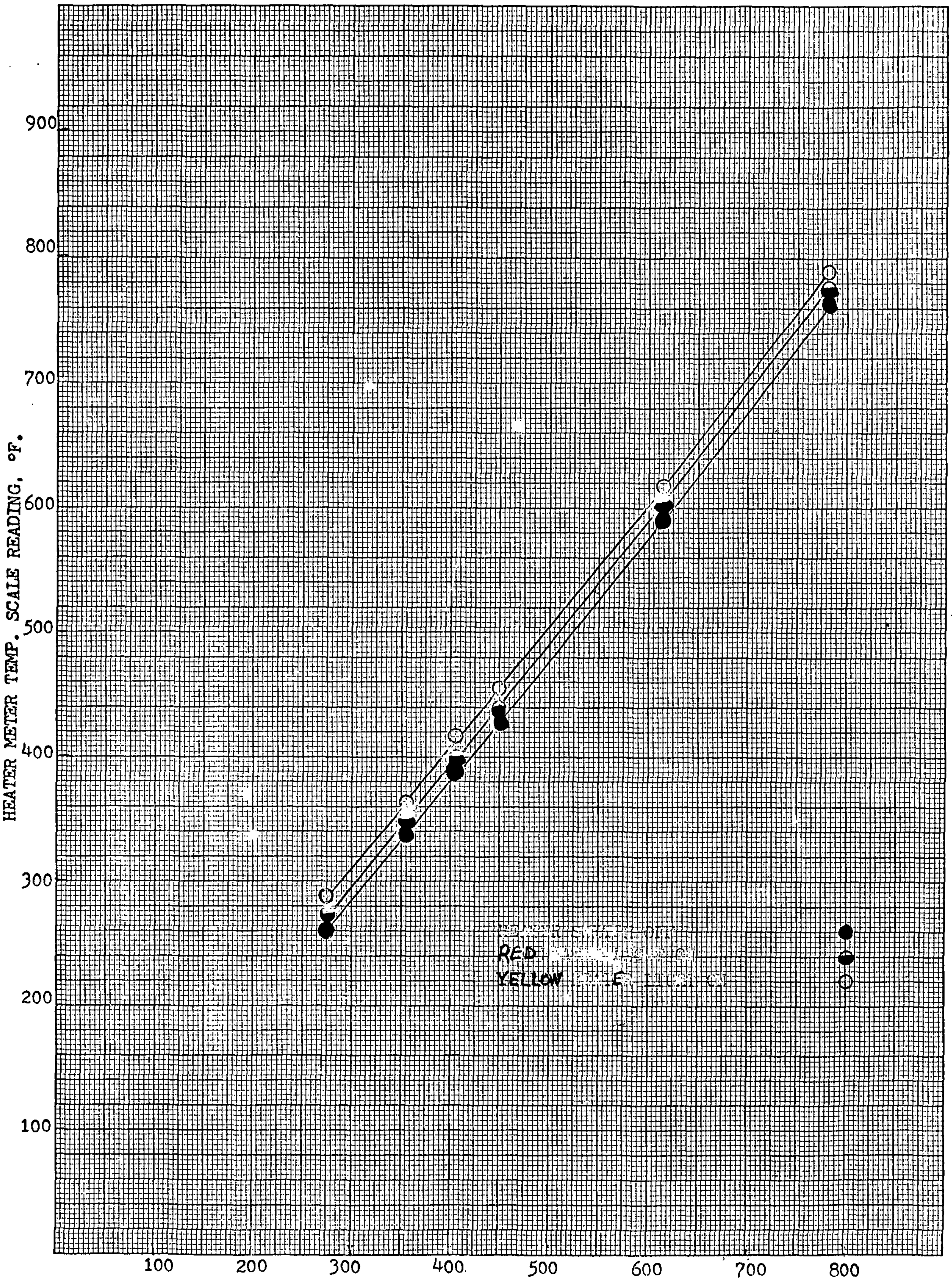


Figure 11

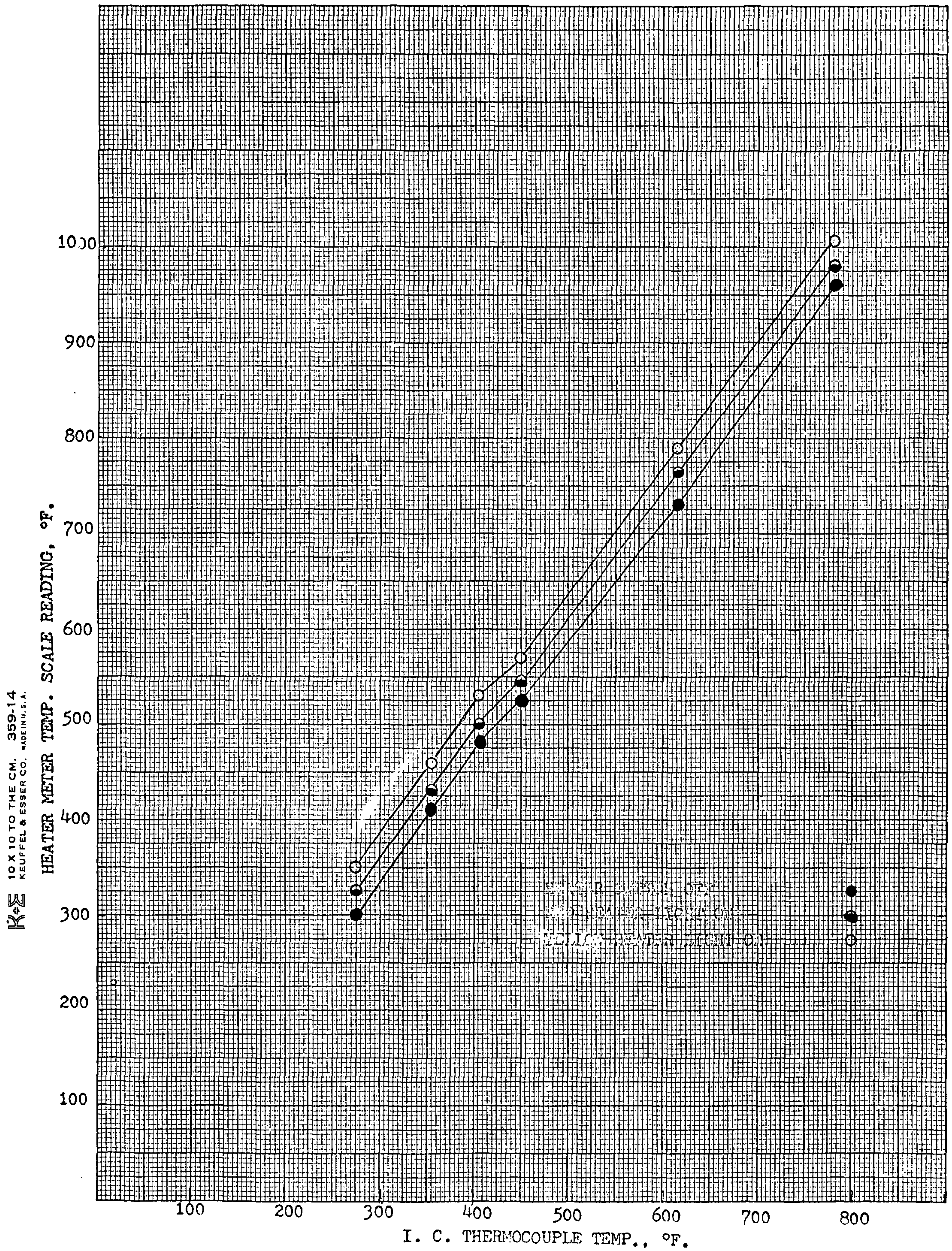
PYR-O-VANE NO. 5 TEMPERATURE CALIBRATION



10 X 10 TO THE CM. 359-14
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 12

PYR-O-VANE NO. 6 TEMPERATURE CALIBRATION



The thermocouples were kept at the temperatures of 275°F. to 406°F. in an oil bath the temperature of which was read from the Leeds and Northrup Recorder. The other temperatures were obtained from molten tin, lead, and zinc at their respective melting points as observed on the Leeds and Northrup.

The problem of measuring the temperature of radiant heaters is complicated by the effect of the radiant heat on the thermocouples and the effect of shielding and air currents. It is suggested that a thermocouple, bolometer or other radiant energy sensing devices, be explored as a means for studying the temperature of the infrared heaters.