SOME PROBLEMS

OF

CENTRAL STATION SERVICE

AND

THEIR SOLUTION

- - - - -

A THESIS SUBMITTED TO THE FACULTY

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BY

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1920

PREFACE

The purpose of this paper is to present in as compact form as possible a few of the problems incident to central station power service, and the solutions for them. The problems taken are actual cases, selected from those arising during the period from February 1, 1918 to May 1, 1920, in the experience of the author with the Springfield Light, Heat & Power Company, Springfield, Ohio. They are fairly representative of the different parts of a typical central station organization, involving the Production, Distribution, and Commercial Departments. All superfluous material has been eliminated, as well as all unnecessary explanations and information, and a number of rather interesting problems have been entirely omitted, because their type is is covered by the ones selected. The situations to be met and correctly solved in the experience of a central station organization are, of course, very numerous.

The author wishes to acknowledge his indebtedness to Mr. T.H.Harvey, Works Manager of the Ohio Steel Foundry Company, Springfield, Ohio; to Mr. J.C.Galvin, Chief Melter of the same company; to Mr. E.J.Newnham, Chief Engineer, and Mr. R.F. MacNett, Supervisor of Power, both of the Robbins & Myers Company, Springfield, Ohio; and to Mr. C.I. Weaver, Treasurer and General Manager of the Springfield Light, Heat & Power Company, Springfield, Ohio.

L.E.Brown.

Springfield, Ohio.
May 1920.

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CONDITIONS AND CORRECTION

SPRINGFIELD LIGHT, HEAT, & POWER CO.,
SPRINGFIELD, OHIO.

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About the middle of 1918, the Springfield Light, Heat, & Power Company began, for a number of reasons, to investigate the power factor conditions obtaining throughout its plant and distribution system. Trouble with low voltage on the unregulated three-phase power lines had for some time been experienced in various sections of the city, and complaints were becoming frequent. The Robbins & Myers Company reported low voltage, and tests made at once showed that, while the line voltage at the plant was slightly above normal, (normal value 6600 volts), the line voltage at their factory was below normal, and the transformer secondary voltage seriously low. At that time, their 15-minute peak load was about 750 K.W., and they were, and are, the only customer of any size on a 3/0 line about 7600 feet long. The step-down transformer capacity at their factory was ample for the K.W. load. A test showed that their power factor stood normally at 60% to 65%. This condition was reported to Mr.E.J.Newnham, then Chief Engineer of the Robbins & Myers Company, and they instituted an investigation, the findings and results of which are given hereafter.

The distribution losses were high, and for the eight months ending August 14, 1918, the average by months was 15.82 %. This figure does not include the line losses of the downtown direct-current system. One important reason for this high loss lay in the fact that several circuits were badly overloaded, and subsequent changes have reduced the losses slightly more than 2%. Nevertheless, the general condition of low power factor was, and is, a vital factor in the distribution losses.

The peak load on the power station during 1917 was 5500 K.W., and the anticipated peaks for 1918 and 1919 were 7800 and 8300, respectively. The station generating capacity totaled 9000 K.W., at a power factor rating of 80%, so that the peak load for 1919 would require all the capacity, leaving no reserve capacity whatever. Indeed, there was no reserve capacity for 1918, since the anticipated peak could not be carried, in case of loss of the 5000 K.W. unit. On account of the conditions incident to the War, the installation of another turbo-generator set before the summer of 1920 was out of the question, and for this reason it was increasingly important that everything possible be done to relieve and assist the station equipment. Future conditions also dictated present corrective and preventive action in connection with the power factor conditions.

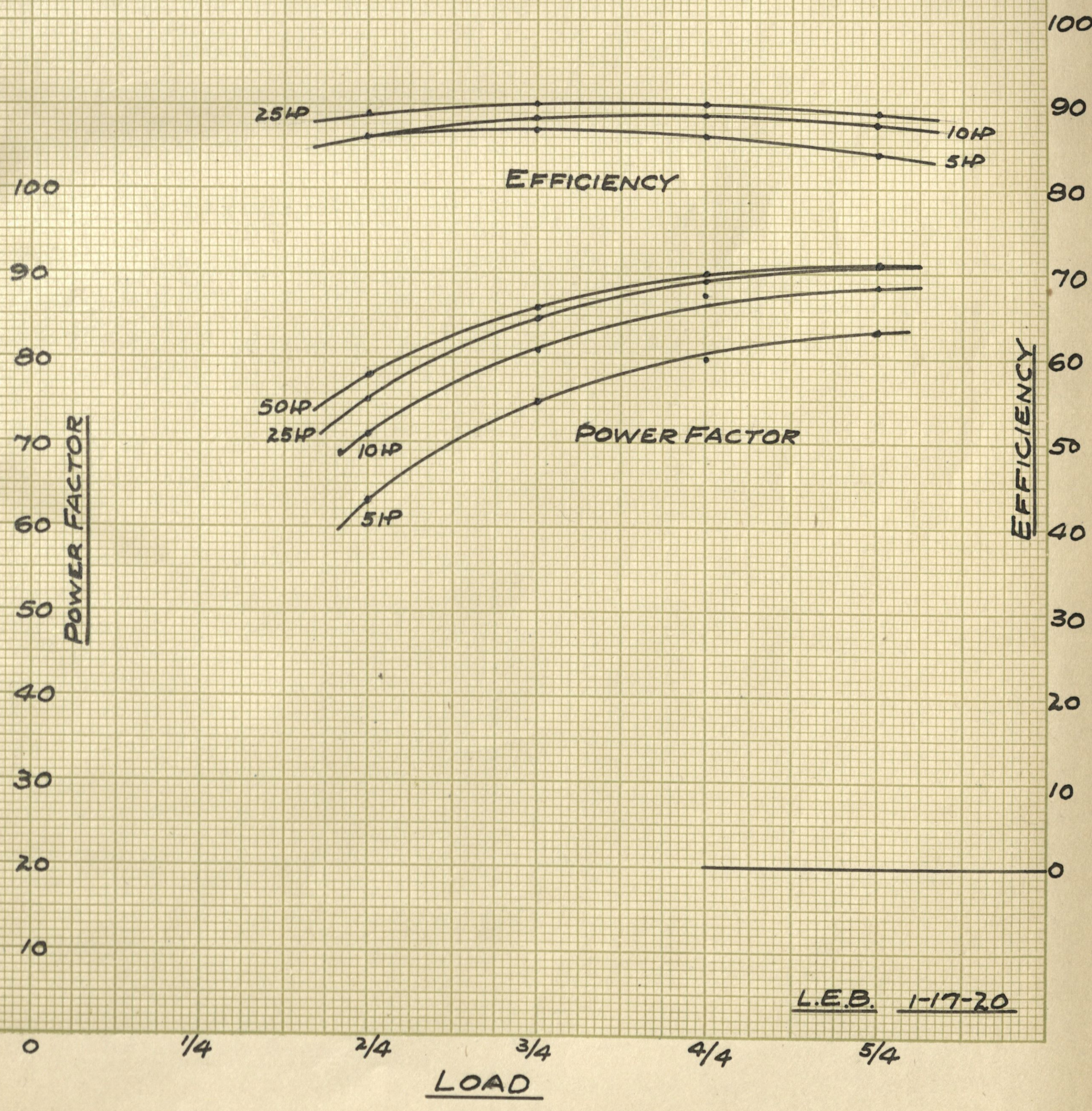
Motor application had in the past been left very largely in the hands of the electrical contractors, with the natural result that in the majority of cases, the applications were badly over-motored. One common rule found was to standardize upon one size of motor for all line shafts, regardless of the individual shaft loads, and actual cases were found where 25 horsepower motors were carrying loads as low as 5 horsepower. The rule of one factory electrician was to "figure the motor twice as large as he thought necessary, and then double that", and he quite evidently followed his rule to the letter. It was little wonder that he could boast of the fact that his motors seldom burned out or even ran hot. Another natural cause for the serious over-motoring is the fact that in the past gas-engines have been a cheap and popular form of prime-mover, and the motor sizes have been very often determined on the gas-engine basis.

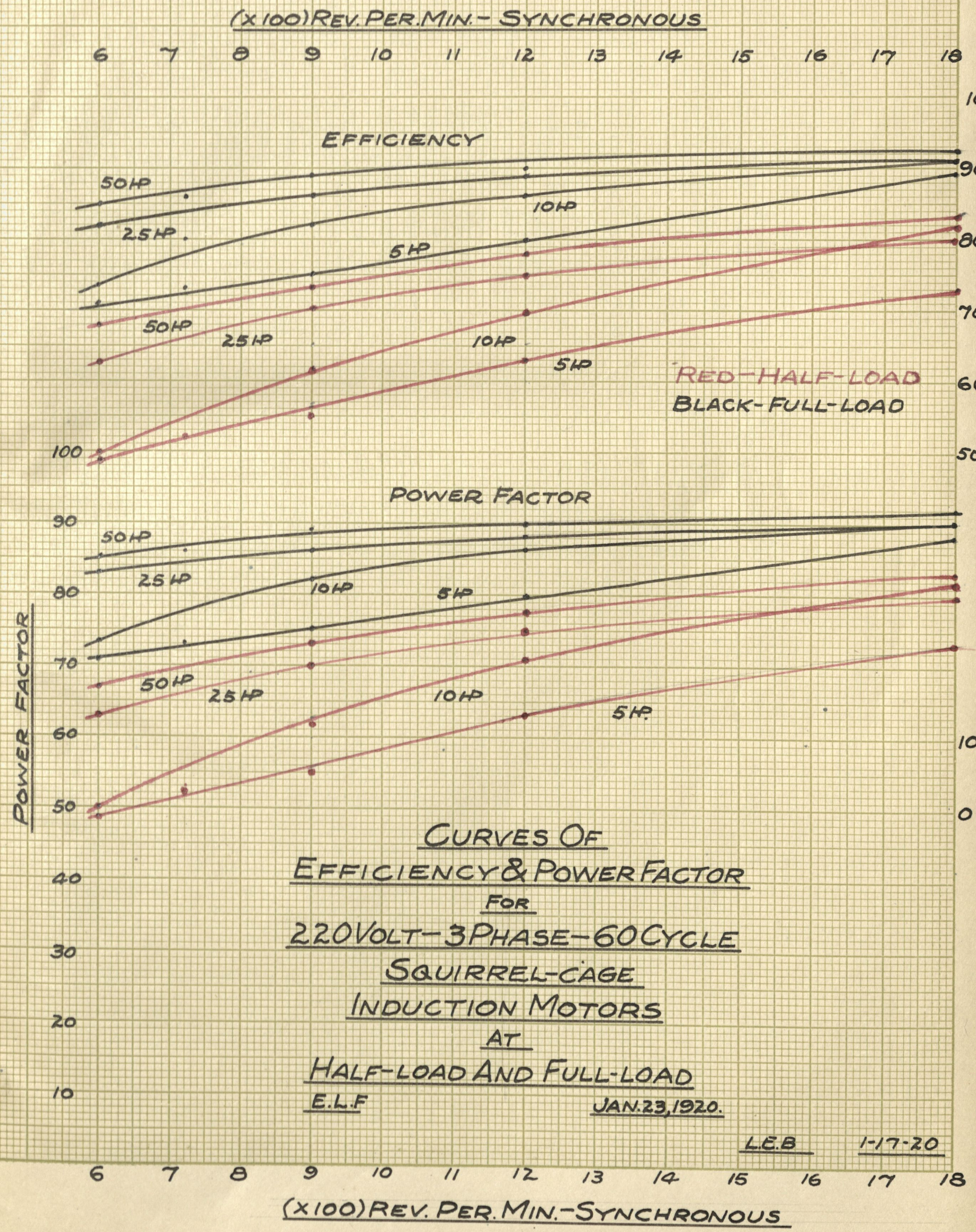
Under the above conditions, the Springfield Light, Heat, & Power Company determined to aggressively enter the motor application game, with the main idea of protecting itself as much as possible. As a result, even though motors in many cases have been sold by competing contractors, the sale has in most cases been made in accordance with the company's recommendation, with marked improvement in the operating characteristics. The power factor at the plant of the E.W.Ross Company, where the installation was selected by the power company, was found to be 85%, under the average conditions of loading. The 15-minute demand at the time this power factor reading was taken was about 70 K.W.

As a part of the motor application plans, a set of curves was prepared, using the guarantees of one of the two large electrical manufacturing companies, showing the relations of efficiency and power factor to load and rated motor speed. These curves are for the 40 degree-rated motors. Briefly, the efficiency and power factor are better for large motors than small, increase with the rated speed, and are better at full-load than at fractional loads. In the last respect, the effect upon power factor is much more serious than upon efficiency. At half-load, a motor will have

Curves of Efficiency & Power Factor for 220 Volt–3 Phase–60 Cycle 1200 Rev. Per Min. Squirrel-cage Induction Motors

E.L.F. Jan. 23, 1920.




(x 100) Rev. Per Min. - Synchronous
6 7 8 9 10 11 12 13 14 15 16 17 18
Efficiency
50 HP
25 HP
10 HP
5 HP
50 HP
25 HP
10 HP
5 HP
Red - Half - Load
Black - Full - Load
100 90 80 70 60 50 10 0
Efficiency
Power Factor
50 HP
25 HP
10 HP
5 HP
50 HP
25 HP
10 HP
5 HP
100 90 80 70 60 50 40 30 20 10
Power Factor
Curves Of
Efficiency & Power Factor
For
220 Volt - 3 Phase - 60 Cycle
Squirrel-cage
Induction Motors
At
Half-load And Full-load
E.L.F
Jan. 23, 1920.
L.E.B
1-17-20
6 7 8 9 10 11 12 13 14 15 16 17 18
(x 100) Rev. Per. Min. - Synchronous

approximately the same efficiency as at full-load, whereas the power factor will be as much as 15% lower. In the case of the 5 horsepower 1200 R.P.M. motor, the power factor drops from 80% at full-load to 63% at half-load. These are intended to serve only as indications of what may be expected; certain sizes and speeds deviate from them, on account of differences in design, but on the whole, they represent very well the conditions which will obtain. These curves have served as valuable guides in the many applications made. Of course, it is realized that in many cases, perhaps most of them, the size and speed are dictated by mechanical and other considerations.

POWER FACTOR MEASUREMENT.

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Since three-phase power factor is not yet a defined quantity, and no instrument is available for measuring it, it was necessary to devise some method, at least approximate, for obtaining an indication of the power factor in the power and motor circuits. In the Electrical World for June 28, 1919, the following article was published:

IMPROVED POWER FACTOR RESULTS FROM INVESTIGATION

With Simple Testing Apparatus Central Station Has Been Able to Show Customers Advantages to Be Gained.

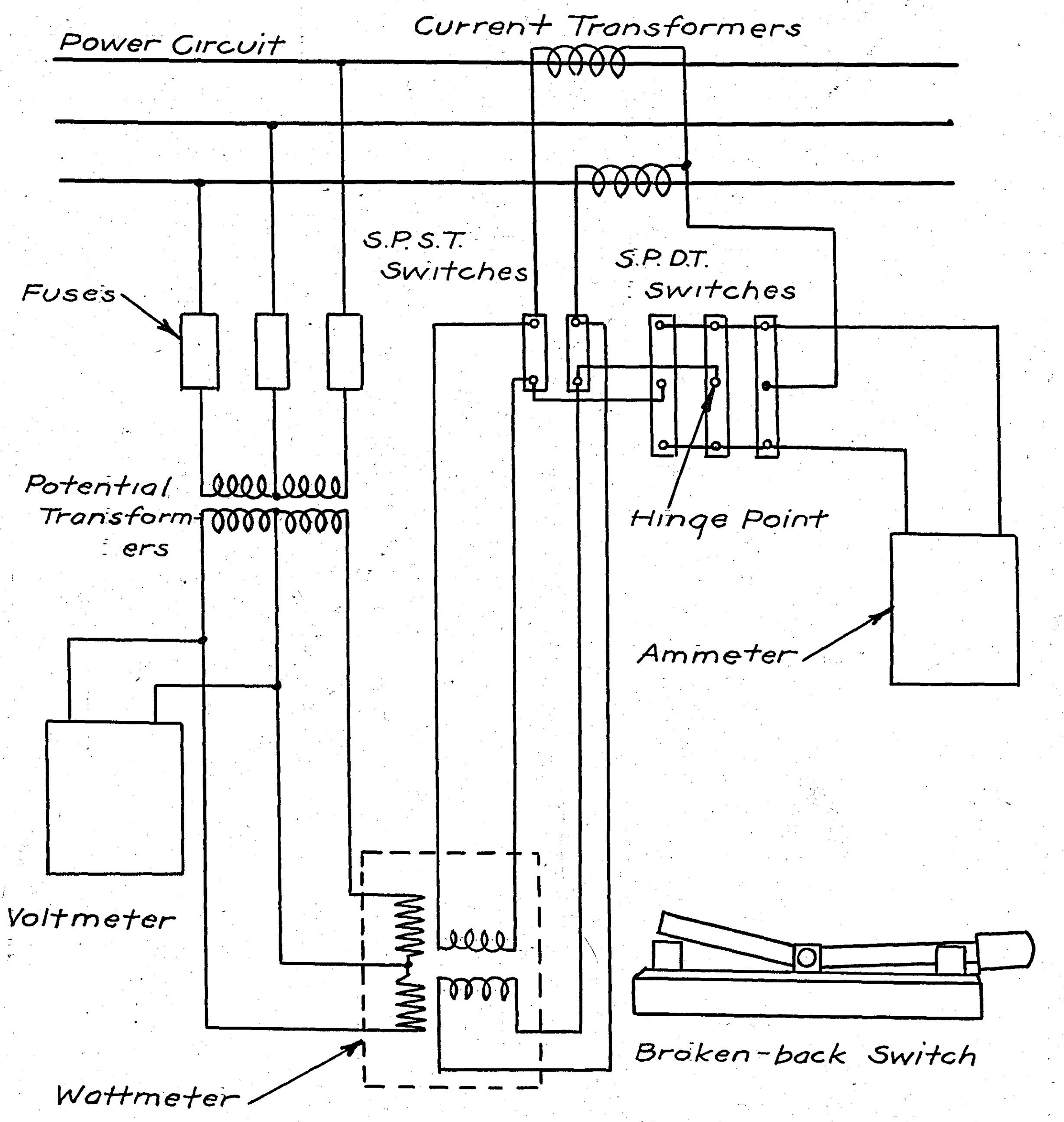
In connection with a thorough investigation of the power-factor conditions obtaining over its entire plant and distribution system, the Springfield (Ohio) Light, Heat & Power Company has devised the following scheme for determining power factor:

Three single-pole, double-throw 15-ampere knife switches were provided with a blade extension which makes them similar to broken-back switches. When placed in a single ammeter circuit, as shown, they eliminate the possibility of opening the secondaries of the current transformers at any time, and indicate the current flowing in each leg of a three-phase circuit. Properly combined with simultaneous voltages, these readings give the Kva. of the system.

The normal position of the switches, with no current flowing through the ammeter, will be A-B. Closing the switches one at a time to the position B-C will give the currents flowing. A three-phase wattmeter inserted in the circuit gives the K.W., and the power factor can be thus determined. For convenience in inserting and removing this wattmeter, two single-pole, single-throw knife-switches are used.

The two-wattmeter method, using a polyphase instrument, was first tried out, but soon abandoned because of the fact that in most cases the load is unbalanced. However, this method is used to some extent for testing individual motors.

Tests have been made of all power circuits, both generator and feeder, at the power station, and of most of the primary meter installations of this company. (See subsequent data covering plant tests). A number of the larger power customers whose load has a low



POWER FACTOR TESTING
EQUIPMENT
SPRINGFIELD LT. HT. & PWR. CO.
SPRINGFIELD, OHIO
APR. 26, 1920 E.L.F.

power factor, are arranging to change their induction motors to load them up and reduce the connected horse-power, and in two cases synchronous motors are being installed. One company in particular is installing a 300 H.P. synchronous motor and a 100 K.W. synchronous converter, the former to displace a steam engine, the latter to provide current for variable speed drive. This customer has a 15-minute demand of about 150 K.W. at 65% power factor, which with the new installation will be increased to approximately 95%. (See subsequent section "Installation of 300 Horsepower Synchronous Motor and Power Factor Conditions at The Victor Rubber Company, Springfield, Ohio").

The power contracts of this company contain no power factor clause, so that all changes are being made on the basis of reduced motor horse-power, decreased losses, and improved service. L.E.Brown,
Springfield, Ohio. Superintendent of Distribution.

This article was reprinted in the Bulletin of the Ohio Electric Light Association, with an introductory paragraph as follows:

Mr. L.E.Brown, Superintendent of Distribution of the Springfield Light, Heat & Power Company, reports that they are going into the power factor conditions of their company very carefully and thoroughly, and expect to make a very considerable improvement from the improved application of motors and other devices, A number of their larger power customers, including the Robbins & Myers Company, are co-operating with them, and are making changes in their induction motors installations tp operate all motors as nearly as possible at their full-load ratings. In several cases synchronous motors are being installed. (See subsequent sections covering work at the Robbins & Myers Company and at the Victor Rubber Company). Mr. Brown gave the Electrical World a very excellent article in which they are arriving at improved results from their power factor investigations. The article taken from the Electrical World is as follows:

* * * * * * * * * * * * * * * * * *

This method of measuring power factor was referred to the Electric Journal, Pittsburgh, Pennsylvania, and approved by Mr.C.R.Riker, Technical Editor.

POWER FACTOR TESTS ON GENERATOR AND FEEDER CIRCUITS

In January of 1919, tests were made of the power factor on the three generator circuits and on all the three-phase power feeder circuits, including the totalizing bus and the Series Street Light totalizing bus, at the Rockway Power Plant. It is considered unnecessary to give the detailed readings for these tests in this paper, since they are similar to those shown for the tests at the Robbins & Myers installation, and the results only follow:

CIRCUIT	POWER FACTOR
Generator No. 1	50.5 %
Generator No. 2	not running.
Generator No. 3	85.7 %
Totalizing Bus	70.3 %
R. & M. - I.H.C. 3-Ø 6600 Volt	67.5 %
East End 3-Ø 6600 Volt	65.0 %
Ohio Steel Foundry 3-Ø 6600 Volt	83.0 %
Lagonda 3-Ø 2300 Volt	69.2 %
North Central 3-Ø 2300 Volt	71.3 %
West End 3-Ø 2300 Volt	69.9 %
South End 3-Ø 2300 Volt	61.6 %
South West 3-Ø 2300 Volt	77.8 %
Series Street Lights, Totalizing	50.4 %

It is understood that the above values are averages over the period at which the readings were taken, and represent normal conditions.

The readings on the Totalizing Bus checked very well with the indications of the station power factor meter.

The Ohio Steel Foundry Line has an unusually high power factor, for the reason that about three years ago the Ohio Steel Foundry Company made very careful investigations of their motor loading, and completely rearranged their applications to fully load all motors. They are the only customer on this line. It is interesting to note that the power factor of the furnace is approximately the same as that of the motor load, as nearly as it is possible to measure the furnace input.

The power factor of the Series Street Lights is especially low on account of the high reactance of the line itself, and because of the fact that each incandescent lamp is served from an individual series transformer. This power factor was checked by opening one element of the watthour meter, and it was found, of course, that when the right element was opened, the instrument stopped.

The reduction in line, transformer, and generator capacity resulting from the above conditions of power factor, and the attendant bad regulation, can readily be calculated and appreciated, and wherever possible correction is to be made.

POWER FACTOR TESTS AND CORRECTION AT THE ROBBINS & MYERS CO., SPRINGFIELD, OHIO.

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In August of 1918 the Robbins & Myers Company complained that their voltage was low. A test was made, which showed that while the line voltage was somewhat above normal (normal 6600 volts), the secondary voltage was indeed low. At that time, this was assigned to the fact that they have a double transformation, from 6600 volts to 2300 volts, and from 2300 volts to 110, 220, or 440, depending upon the service. This was, of course, a valid reason, since they were suffering the regulation incident to the double transformation.

In January of 1919, the first test of the power factor at their transformereinstallation was made, in accordance with the attached tabulation, which shows the average power factor to be 62%, at that time. This condition was reported to Mr. E.J.Newnham, at that time Chief Engineer of the Robbins & Myers Company, and several conferences with him held. As a result, Mr. R.F.McNett was appointed Power Supervisor, with instructions to improve the power factor and other conditions relating to their power supply and service.

Mr. McNett has made, and is yet making (April 1920) a careful study of the conditions obtaining. He has adapted the previously described method of measuring power factor to their conditions, and two articles appearing in the Electrical World of January 3 and 10, 1920 relate quite adequately the changes which he has accomplished.

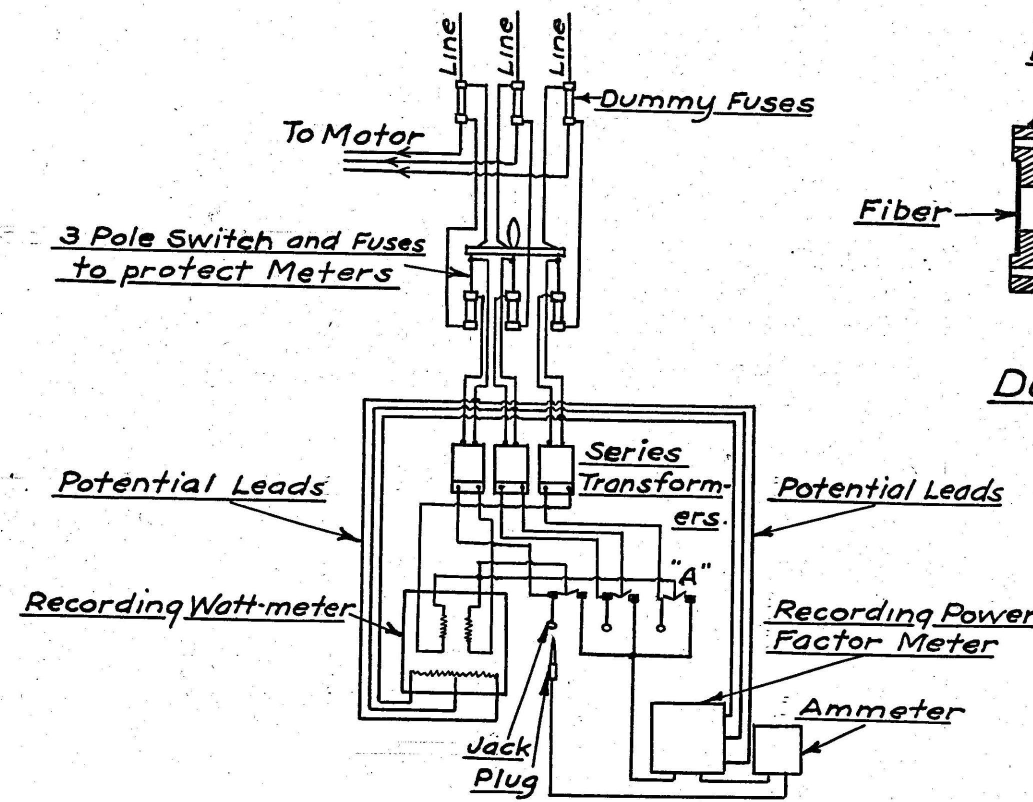
PORTABLE TESTING OUTFIT USED IN POWER SURVEY

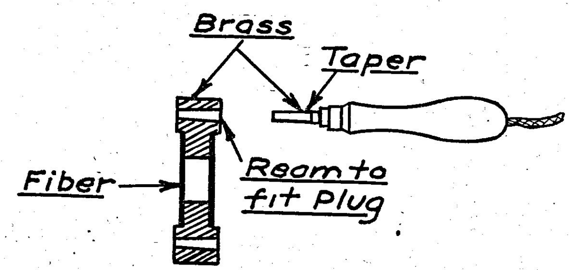
By Its Use, the Motor-Rating of One Factory Has Been Decreased by 150 Hp.- Dummy Fuses Facilitate Connection of Meters in Line.

Because the Robbins & Myers Company manufactures motors, it has been very easy for the operating departments to become over-motored, particularly during the war period when machines were running night and day at top speed and there was no time to question what size motor was best adapted to a particular drive. At that timeit time it was considered good policy, in view of the fact that new machinery was being purchased wherever it could be found, to put on each line shaft a motor large enough to take care of any probable future growth. When the armistice was signed, however, and the necessity for high-speed production became less, the load also became less, with the result that the power factor of the entire plant was reduced considerably. Obviously, the remedy for low power factor was to reduce the connected horse-power, so tests upon each motor were made in order that all machines be correctly motored. Smaller ones could be installed if needed, or they could be rearranged to operate to the best advantage.

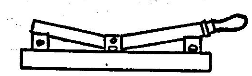
The instruments available for the testing consisted of a portable recording wattmeter, a portable recording power-factor meter, an ammeter with 5-ampere scale, a voltmeter, and a tachometer. In addition, there were three instrument transformers, each with ratios of 100, 50, and 25 to 5 amperes. These were connected to the motor line through leads terminating in switchboard plugs. The transformer secondaries are connected- the two outside ones- to the current coils of the wattmeter and the middle one to the ammeter and to the current coil of the power-factor meter, which are in series. In these circuits are placed "broken-back" switches which allow the measuring of current in any phase without opening the secondaries. It was found necessary to meter each phase because the voltage was slightly unbalanced and reading the.power-factor meter would be incorrect. By measuring the power-factor of all the three phases and averaging the readings, the true power-factor was obtained. In front of the transformers is a heavy protecting switch and a set of fuses connected so that the fuses are always in circuit whether the switch is open or closed. The portable meters rest on a pad of $\frac{3}{4}$-inch felt, the combination being mounted on a rolling meter table with swiveled, rubber-tired wheels. Nearly all connections are back of the board. (See accompanying photograph).

For connecting the current coils of the meter in the line, dummy fuses are used. In each end of them are tapered holes reamed to receive the switchboard plugs. With this arrangement it is a very simple matter to connect the meter leads to any size of dummy fuse, to take out one running fuse at a time from a motor circuit (the motor operating single-phase for a moment) and slip the dummy in its place. For convenience, and to avoid mistakes, the wooden handles of the switchboard plugs are painted different colors for "line" and "load", so that the wattmeter connections are always correct.

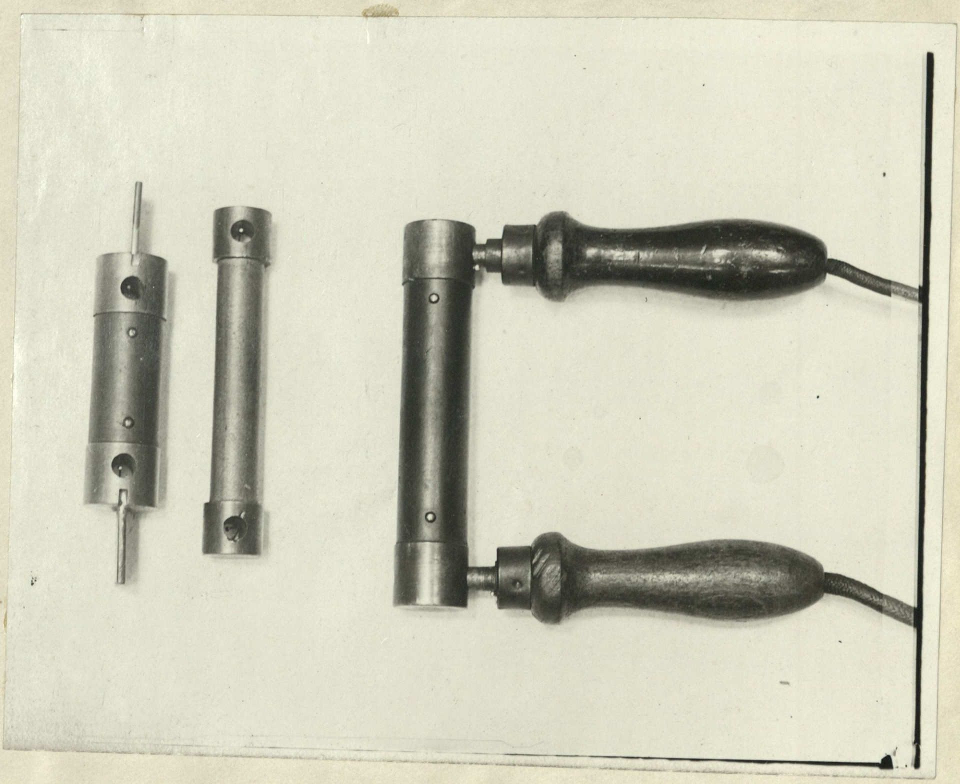




Detail of Dummy Fuse & Plug



Broken-back Switch Detail-"A"



No data are available at this time upon the savings effected because the work is not completed, but it has been possible to eliminate more than 150 connected horsepower in the first few months of the test, despite increasing power requirements due to greatly increased production. (The maximum 15-minute demand to April 1, 1920 is 905 K.W., compared to 750 early in 1919). As a matter of fact, production is on the increase and the changing of motors and fitting them to their loads is responsible for the fact that the power bill has increased only slightly.

R.F.McNett,
Supervisor of Power.
The Robbins & Myers Company, Springfield, Ohio.

TEST RESULTS TABULATED ON FACTORY MOTOR CARD

Comparison of Records Bearing Motors Ratings and Characteristics Allows a Complete Analysis of Power Conditions in Plant

When making a complete power survey of the installed motors in its plant, the Robbins & Myers Company recorded the results of the tests on 5-inch by 8-inch filing cards. These cards are provided with spaces for shop serial and frame numbers, the name-plate data, the department, data on driving and driven pulleys, size of belt, machinery driven, and the load readings of the motors. In addition to this information there is a space for the specifications which are necessary in order to permit a complete analysis of the motors. Of course it would be impossible for every plant to have performance curves for all its motors, but in this case it is possible, because practically all the motors are manufactured in the plant. There is therefore available a complete file of these curves, and with the data gathered from the test each motor's performance can be analyzed. This analysis allows the determination of whether or not it is economical to make changes, and what changes are necessary. Motors are provided that will operate at the highest efficiency and power factor on the determined load, but often it is necessary to take future extensions into account.

R.F.McNett,
Supervisor of Power.
Springfield, Ohio.

POWER FACTOR TEST
AT
ROBBINS & MYERS
6600 V. 3-PHASE
* * *
Friday, Jan. 17, 1919
by
J.B.Bronson.
\- - -

TIME	I-1	I-2	I-3	Av.I	Av.E	Watts (X ½)	V.A.	P.F.
1:45 P.M.	4.5	5.5	4.4	4.8	110	1100	915	60.3
2:00	4.5	5.5	4.5	4.8	109	1100	911	60.5
2:30	4.0	5.0	4.0	4.3	110	1100	821	67.0
2:45	4.6	5.5	4.3	4.8	110	1100	915	60.2
3:00	4.8	5.5	4.5	4.9	108	1150	916	62.8
3:15	4.4	5.0	4.3	4.5	110	1100	856	64.3
3:30	4.5	5.5	4.5	4.8	108	1100	900	61.3
3:45	4.0	5.0	4.5	4.5	109	1050	850	61.9
4:00	3.5	4.5	4.0	4.0	110	1090	765	71.4 (?)
4:15	4.0	4.5	3.5	4.0	108	1050	745	70.5 (?)
4:30	4.25	4.5	3.8	4.1	108	1080	768	70.3 (?)
4:45	4.3	4.9	3.9	4.3	108	1100	805	68.4 (?)

Average Power Factor - - - -62.0 %

5 ampere Ammeter, R.& M., Serial No. 18255
150 volt voltmeter, Co. No. 2, Weston Serial No. 5203
2000 watt Wattmeter, Co. No. 14, Serial No. 143418.

Current transformer ratio 60:1
Potential transformer ratio 20:1

NOTE: Last four readings, marked (?), are not used in figuring the average P.F., because the values are high, on account of the lighting load coming on.

POWER FACTOR TEST
AT
ROBBINS & MYERS
6600V. 3-PHASE
* * *
Wednesday, June 4, 1919
by
J.B.Bronson
\- - - - .

TIME	I-1	I-2	I-3	Av.I	Av.E	Watts $(X\frac{1}{2})$	V.A.	P.F.
12:15 P.M.	4.0	4.1	5.1	4.4	110	1100	837.3	65.7
12:25	4.2	4.2	5.1	4.5	110	1090	856.3	63.6
12:40	4.1	4.2	5.0	4.4	110	1090	837.3	65.5
1:00	4.3	4.3	5.3	4.6	110	1100	875.3	62.8
1:20	4.2	4.3	5.2	4.5	110	1090	856.3	63.6
1:30	4.1	4.3	5.2	4.5	110	1090	856.3	63.6
1:45	4.0	5.0	4.2	4.4	110	1090	837.3	65.5
2:10	4.2	4.2	5.2	4.5	110	1100	856.3	64.2
2:30	4.0	5.0	4.2	4.4	110	1100	837.3	65.7
3:00	4.2	5.0	4.3	4.5	110	1100	856.3	64.2
3:15	5.4	5.1	5.1	5.2	110	1200	989.5	60.6
3:45	5.0	5.0	5.0	5.0	110	1180	951.5	62.0
4:00	4.0	4.5	5.0	4.5	110	1120	856.3	65.4
4:30	4.2	5.0	4.3	4.5	110	1160	856.3	67.7

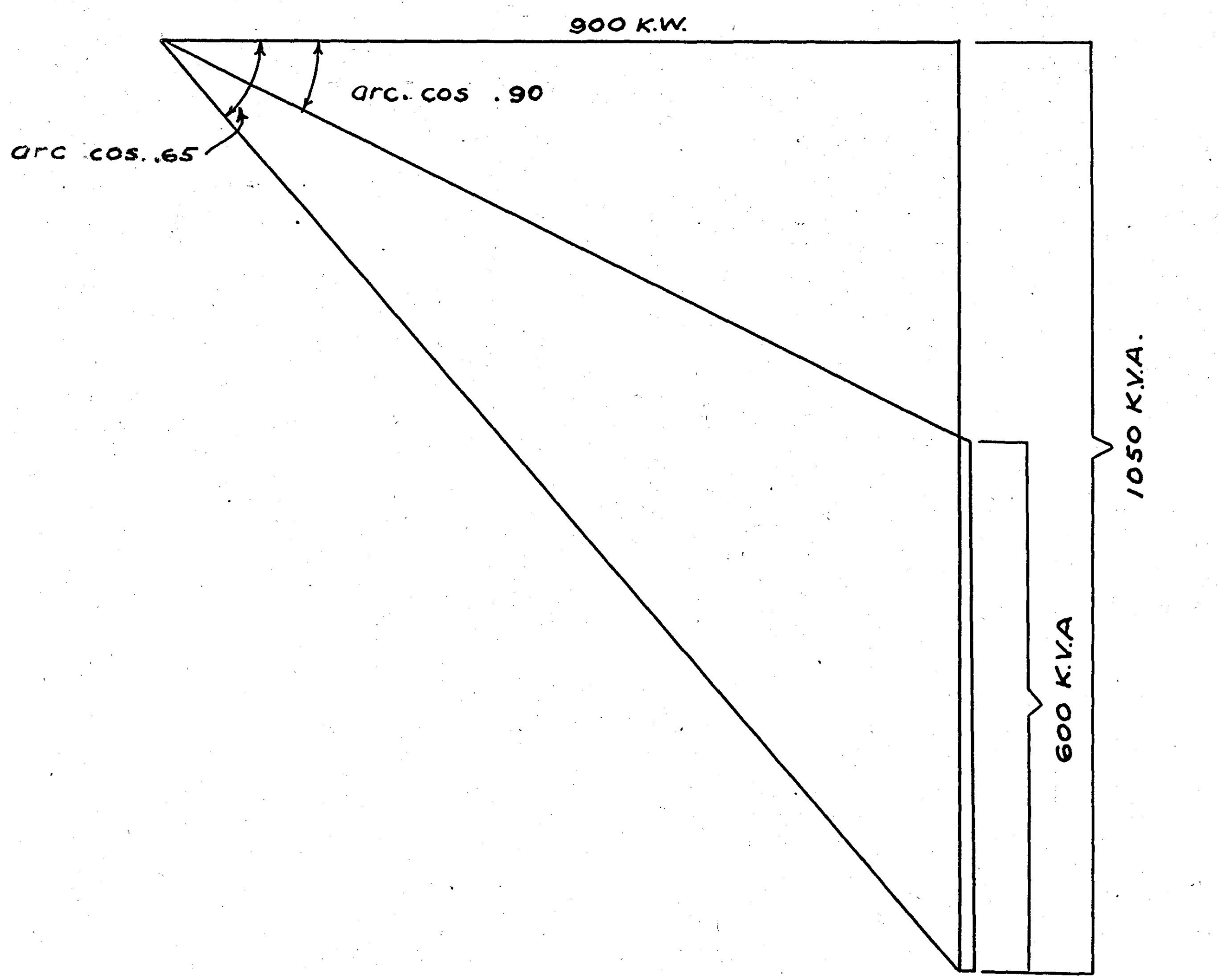
Average power factor 64.3 %

Current transformer ratio 60:1
Potential transformer ratio 20:1

10 ampere Ammeter, serial No. 535569.
150 volt Voltmeter, serial No. 5203, Co. No. 2.
3-Ø Wattmeter, serial No. 143418, Co. No. 14.

Average K.W. Demand 630 (15-minute).

The Robbins & Myers Company has just placed an order with the General Electric Company (April 20, 1920) for three 200 K.V.A. static condensers, to be placed at the most advantageous points in their factory to give power factor correction. These condensers are built for 2300 volts, since the distribution is made at that potential, and also since that potential is standard for the condensers. The present load (15-minute peak) at the factory is about 900 K.W., and the power factor is about 65%. The attached vector diagram shows the results which will be obtained by the application of these static condensers.



The improvement in service which will result is obvious. Not only will the line regulation be reduced, but also the regulation of the transformers at the Robbins & Myers factory and of the station step-up transformers. Aside from the bettered service, which is the chief consideration from the point of view of the customer, the line losses will be reduced to about one-half their value at the present power factor, and the generator, transformer, and other station equipment materially relieved.

INSTALLATION

OF

300 HORSEPOWER SYNCHRONOUS MOTOR

AND

POWER FACTOR CONDITIONS

AT

THE VICTOR RUBBER COMPANY,

SPRINGFIELD, OHIO.

1919-1920

INSTALLATION OF 300 HORSEPOWER SYNCHRONOUS MOTOR

AND

POWER FACTOR CONDITIONS

AT

THE VICTOR RUBBER COMPANY, SPRINGFIELD, OHIO.

A test of the power factor of the line supplying the Victor Rubber Company and a few smaller consumers was made at the power plant on January 3, 1919, with results and findings as shown in the accompanying sheet. The load at the rubber factory is very fluctuating, and the motors operate most of the time at comparatively light loads, which accounts for the unusually low power factor.

On January 14, 1919, preliminary to submitting to the Victor Rubber Company a proposition covering the replacement of their steam engine with motor drive, a card test was made of the steam engine. This engine was direct-connected to a line shaft placed under the floor of the factory, and driving eight rubber mills. All other equipment in the factory had already been motorized, or rather, had been equipped with motors when installed. The engine was in need of a thorough overhauling, and the demand upon the boilers for steam used in process work and heating had reached the point where, in the near future, additional boiler capacity would be necessary, if the operation of the engine were to be continued. The results of this card test are given in the accompanying sheet.

Since the Rubber Company was very anxious to arrive at a decision, the data taken were worked up in the field, and recommendations made that a motor of 250 to 300 horsepower capacity be purchased and installed. In the light of the power factor test made a few days previously, the installation of a synchronous motor was highly desirable. This was presented to the Rubber Company, and they agreed to purchase that type, if one of the proper rating were immediately available. Fortunately, a good 300 horsepower, 2060 volt, 600 R.P.M. motor was found in second-hand stock, and at once purchased, with the idea in mind of its immediate installation. As a matter of fact, this installation was made exactly one (see p. 30)

POWER FACTOR TEST
ON
VICTOR RUBBER LINE
2300 volts- 3 phase.

\- - - -

by

H.E.Miller
J.B.Bronson,

Saturday, Jan. 11,1919

\- - - -

TIME	WATTS (x$\frac{1}{2}$)	I-1	I-2	I-3	AV.I	AV.E	V.A.	P.F.(%)
9:00 A.m	290.0	0.8	1.0	1.2	1.0	118	2204	71.1
9:01 "	190.0	0.5	0.6	0.7	0.6	118	123	77.2
9:45 "	233.0	0.9	1.2	1.1	1.06	118	217	53.7
10:00 "	188.3	0.8	1.0	0.9	0.9	118	184	51.5
10:30 "	246.6	1.1	1.0	1.0	1.03	118	211	58.5
11:00 "	243.3	1.0	1.1	1.0	1.03	118	211	57.8
11:15 "	150.0	0.7	00.8	0.8	0.71	118	145	51.7
11:30 "	100.0	0.7	0.7	0.7	0.7	118	143	35.0(?)
11:45 "	90.0	0.4	0.5	0.3	0.4	118	81.8	55.0
12:00 M	101.7	0.4	0.5	0.3	0.4	118	81.8	62.2
1:00 P.M.	100.0	0.5	0.5	0.3	0.43	118	88	56.8

AVERAGE POWER FACTOR 56.0 %

2000 watt Wattmeter- Co. No.14
5 ampere Ammeter- Co. No. 9
140 volt Voltmeter- Co. No. 2

NOTE:- The first two sets of readings are doubtful and are not considered in figuring the average power factor. Also, the readings taken at 11:30 are not considered. Load fluctuates so rapidly that accurate readings are difficult, especially with the poorly damped ammeter available.

ENGINE TEST
AT
THE VICTOR RUBBER CO.
SPRINGFIELD, OHIO.

Jan. 14, 1919

by

Dan Teach
H. E. Miller
Frank Nagley
L. E. Brown

- - -

ENGINE DATA:-

Tandem Compound
H.P. Cylinder - 16" by 48"
L.P. " " - 30" by 48"

Piston Rod Diameters:-

H.P.	C.E.	2 59/64"
L.P.	C.E.	3 59/64"
L.P.	H.E.	2 59/64"

Piston Net Areas:-

H.P.	H.E.	201 square inches
	C.E.	194 " "
L.P.	H.E.	699 " "
	C.E.	694 " "

- - - - - - -

Readings were taken simultaneously on high and low pressure cylinders, head end and crank end. Mean effective pressures taken from cards by means of direct-reading planimeter.

Indicator Springs:-

H.P. Cylinder 60 lb.
L.P. " " 12 "

Abbreviations:-

M.E.P.- Mean effective pressure, lbs./sq. in.
HPP.- High pressure. L.P.- Low pressure.
H.E.- Head end. C.E.- Crank end.
L - Length of stroke, in feet
A - Nest area of piston, in sq. in.
N - Revolutions per minute.

CARD NO.1 11:00 A.M.

Cyl.	End	M.E.P.	L	A	N	I.H.P.	Remarks
H.P.	H.E.	34.0	4	201	72	59.7	Millman
	C.E.	31.5	4	194	72	53.3	says load
L.P.	H.E.	9.0	4	699	72	55.0	heavy as
	C.E.	7.4	4	694	72	44.8	usually
							obtained.
		Total	I.H.P.-	-		-212.8	
At 90 % eff.,		"	B.H.P.	-	-	192.0	

CARD NO. 2 11:35 A.M.

Cyl.	End	M.E.P.	L	A	N	I.H.P.	Remarks
H.P.	H.E.	6.5	4	201	76	12.0	All load
	C.E.	6.6	4	194	76	11.8	off except
L.P.	H.E.	3.14	4	699	76	20.2	engine fric-
	C.E.	3.23	4	694	76	20.7	tion losses
							and line
		Total	I.H.P.	-	-	41.1	shaft.
	Probable	"	B.H.P.	-	-	20.0	

CARD NO. 3 12:45 P.M.

Cyl.	End	M.EP.	L	A	N	I.H.P.	Remarks
H.P.	H.E.	46.0	4	201	72	80.7	Note that
	C.E.	47.0	4	194	72	79.7	load is
L.P.	H.E.	9.0	4	699	72	54.8	heavier
	C.E.	8.6	4	694	72	52.1	than in
							No. 1
		Total	I.H.P.	-		-267.3	test.
At 92% eff.,		"	B.H.P.	-		240.0	

\- - - - - - - -

Indications from observance of engine are that cards taken were not for maximum load. Further tests not made for reason that decision was reached regarding size of proposed motor to replace engine.

year later, when the increased demand for steam for process work precluded the further operation of the steam engine without the installation of additional boiler capacity.

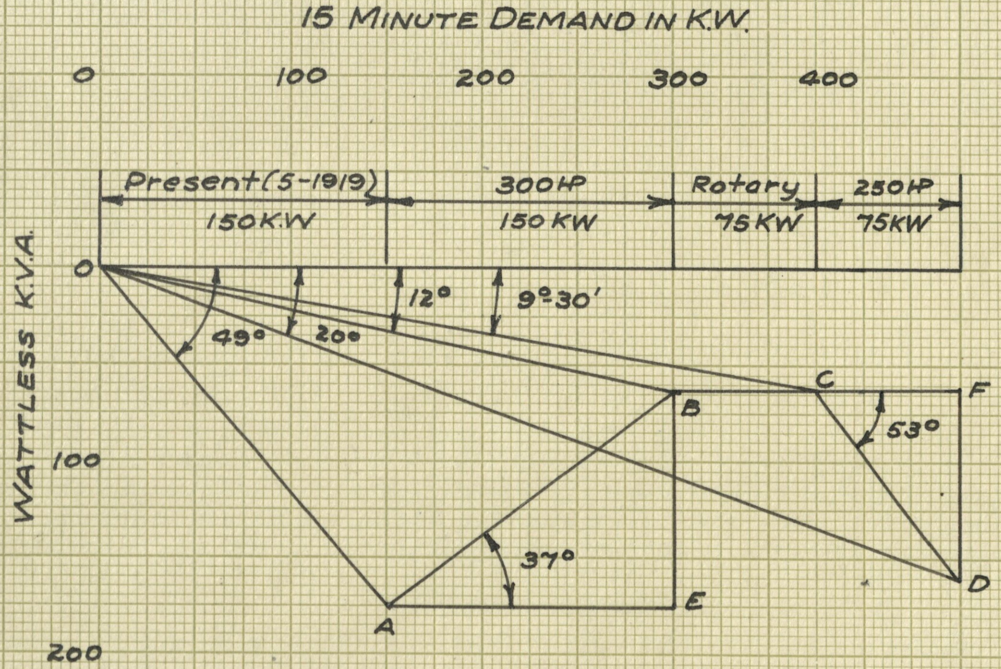
Meanwhile a variable speed calender was purchased, the motor of which was supplied from a 100 K.W. synchronous converter, and beside this, a 250 horsepower induction motor was bought, to drive a new mill. This additional power load led to careful consideration of the probable necessity for changing the line voltage from 2300 to 6600 volts. The accompanying vector relations were accordingly developed, based upon assumptions made as to the power factor of the individual additions and upon the probable contribution of each to the maximum 15-minute demand. As can be noted, it was calculated that the demand with the added equipment would be 450 K.W., and it was decided to postpone the change-over to 1921. However, the 300 horsepower motor contributed so much more than its estimated quota, in addition to other load added, including a 60 horsepower motor driving a 300-pound air-compressor, that the 15-minute demand in January of 1920 attained the value of 576 K.W., and that with the 250 horsepower motor not yet installed. Accordingly, it is now necessary (February 1920) to convert the line to 6600 volts as soon as possible, and this is now under way.

At the time of the installation of the 300 horsepower synchronous motor, no switchboard or other control equipment except a starter and exciter field rheostat, had been secured, and therefore there were no means available for indicating the conditions of operation of the motor. A test was therefore made, showing the relation of the exciter (motor field) voltage to the motor power factor, at no-load and at full-load, using the two-wattmeter method. The result is shown in the accompanying curve. The position of the exciter rheostat contactor corresponding to a full-load power factor of 80%, current leading, was marked, and the motor is operated with the contactor at this mark.

It was noted during this test that at times the voltage at the motor terminals exceeded the value of 2400 volts maintained on the plant bus. Proper manipulation of the rheostat would increase this voltage to even 2500 volts. The accompanying vector diagram shows the condition obtaining with a total load on the line of 350 K.W. at an approximate power factor of 85%, current leading, and a motor input of 275 K.W. at a power factor

Power Factor
Data & Calculations
At
The Victor Rubber Co.
Springfield, O.

L.E.B 5-23-19



OA = Present condition
OB = Cond. with 300 HP Syn. at 80%, I leading – 300 K.W. @ 97.8% P.F.
OC = " " 100 K.W Rotary at 100% P.F – 375 K.W @ 98.6% P.F.
OD = " " 250 HP. Ind. at 60% P.F. I lagging – 450 K.W @ 94.0% P.F.

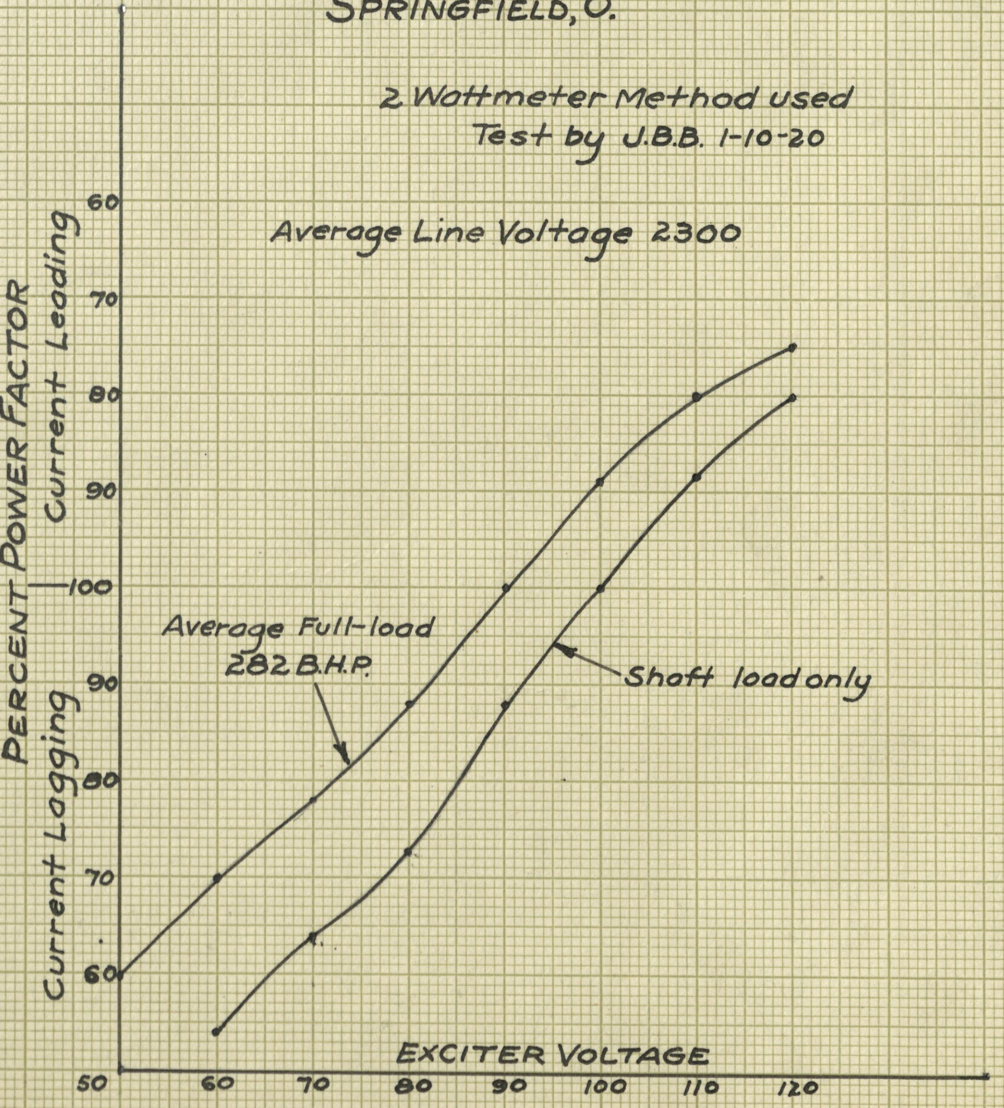
Voltage drop —

Condition
- OA = 6.25%
- OB = 6.25
- OC = 7.1
- OD = 9.8

LINE 2/0 2300 Volt, Spaced 14.5 in., 10000 ft. long.

E.L.F. 2-5-20

Relation Of Exciter Voltage To Motor Power Factor 300 HP Synchronous Motor At Victor Rubber Co. Springfield, O.

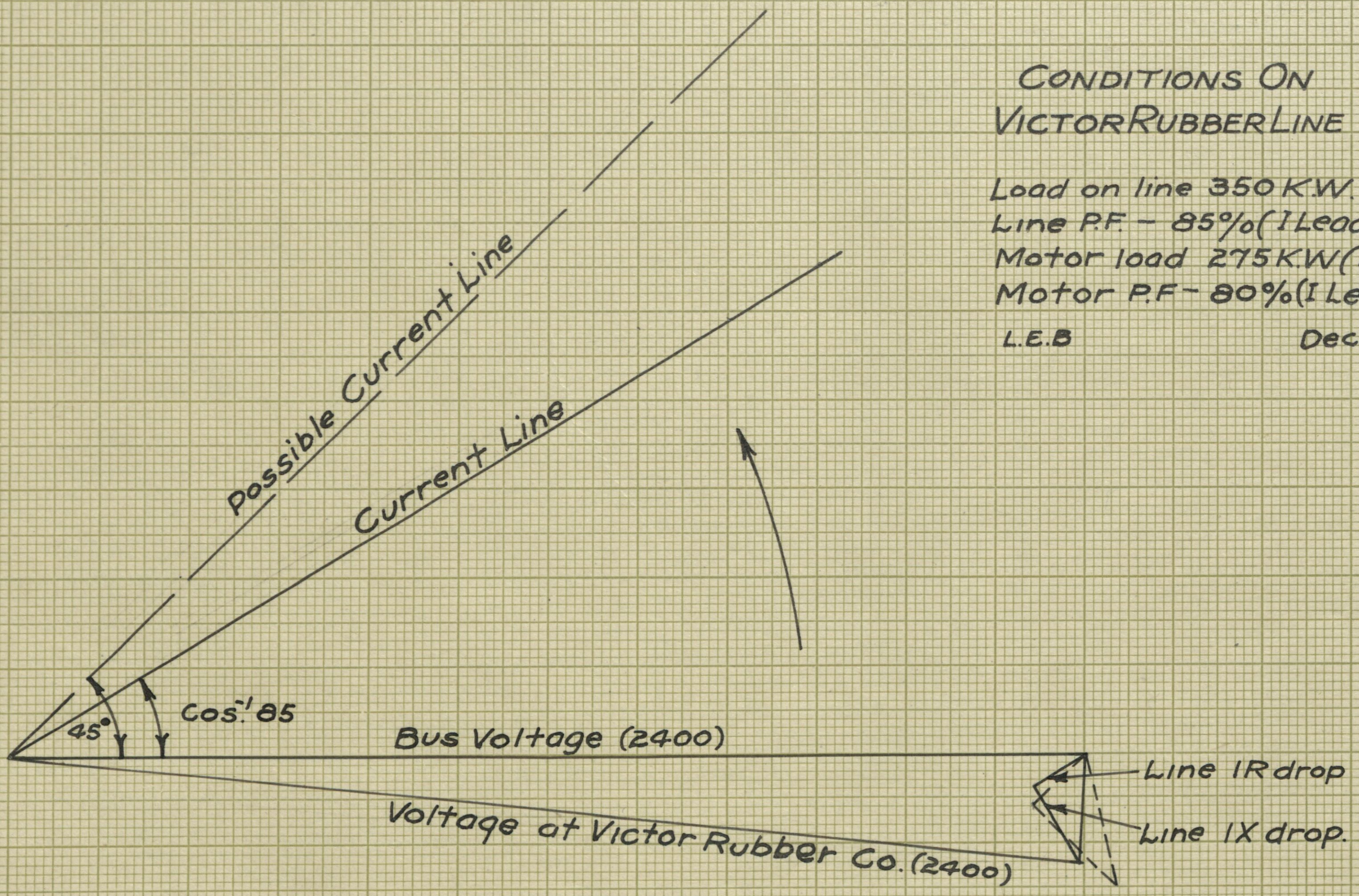


E.L.F. 2-6-20

CONDITIONS ON VICTOR RUBBER LINE

Load on line 350 K.W.
Line P.F. – 85% (I Leading)
Motor load 275 K.W. (Input)
Motor P.F. – 80% (I Leading)

L.E.B Dec. 1919



E.L.F 2-7-20

of 80%, current leading.

With the installation of the 300 horsepower synchronous motor and the 100 K.W. synchronous converter, the power factor on the line supplying the Victor Rubber Company has been raised from its former approximate value of 56% to above 90%, with attendant improvement in service rendered and reduction in line losses. The results obtained are leading to a careful consideration of future power installations, to place wherever possible more synchronous apparatus. Several definite possibilities are now being considered.

In addition to the advantages of improved service, the customer has also the very important advantage of increased production, due to the constant speed characteristic of the synchronous motor. With the mills operated by the steam engine, the speed regulation was quite marked, and sudden heavy loads would result in a proportional decrease in line shaft speed. This factor of increased production is much more important than most factory superintendents and managers realize, and it is probably not properly appreciated by the majority of application engineers.

SOLUTION OF TROUBLE
WITH
TIRRILL REGULATOR
AND
WESTINGHOUSE EXCITER.

- - -

The Springfield Light, Heat,
& Power Co.,

Springfield, Ohio.

1919.

SOLUTION OF TROUBLE WITH TIRRILL REGULATOR AND WESTINGHOUSE EXCITER.

- -

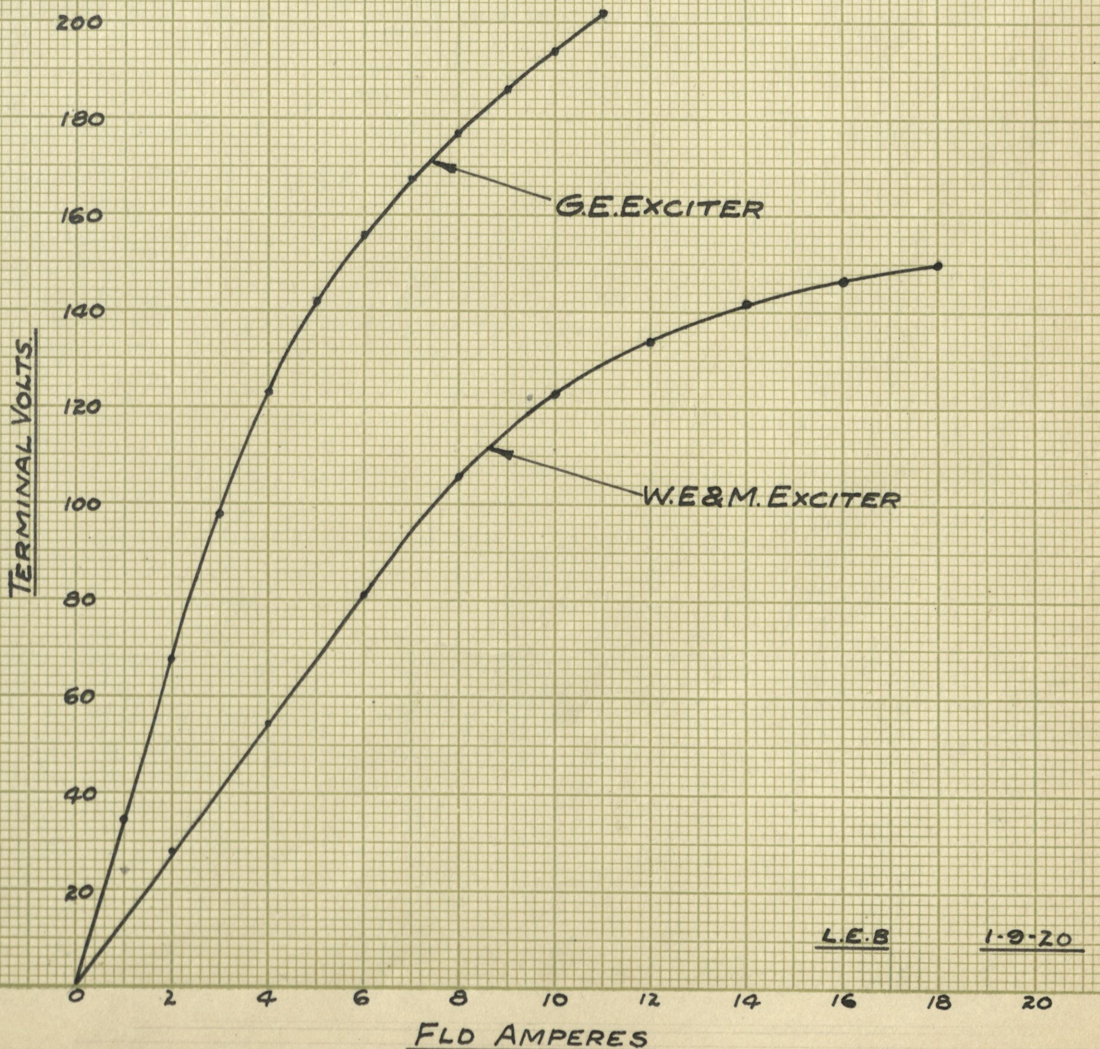
Considerable trouble had been experienced with the Westinghouse exciter ever since its installation at the time of the purchase of the 5000 K.W. turbo-generator in 1916. The station generating equipment of the Springfield Light, Heat, & Power Company consists of two 2000 K.W. and one 5000 K.W., turbo-alternators, the excitation for which is provided by two synchronous motor-driven exciter sets (a 35 K.W. steam-driven exciter is used for starting up and emergency service). One of these is a 75 K.W., 125 volt, 600 ampere, General Electric, the other a 100 K.W., 125 volt, 800 ampere, Westinghouse, machine. Attempts had been made at various times to parallel the two exciters, but without success, and most of the attempts resulted in plant shut-downs, caused by failure of the excitation. No investigations were made to determine the cause for failure to parallel. It had also been found that under certain conditions of operation, the Tirrill regulator was unable to maintain the bus voltage at its normal value of 117, when operating in conjunction withethe Westinghouse exciter. When the load became approximately 75% of the capacity of the machines in use, especially when the power factor was low, the bus voltage would invariably sag. This was especially true with the small generators in use. As a result, the Westinghouse was used as little as possible.

The first step, to determine the reason for failure to parallel, was to secure from the manufacturers the no-load saturation curves, which are shown herewith,- on the same sheet, for convenient comparison. The reason is very evident. Incidentally, the exciter for a new 8000 K.W. turbo-alternator, to be installed in 1920, will probably be made to operate in parallel with one of the present exciters, preferably the General Electric.

The next step, to determine the reason for failure of the Tirrill regulator to maintain normal bus voltage when operating with the Westinghouse exciter, with the alternators carrying a relatively heavy load, was to make tests under load conditions. Accordingly, on December 23, 1919, this test was conducted, the data for which are as follows:-

No-Load Saturation Curve
For
G.E. 75 K.W. Exciter
W.E&M 100 K.W. Exciter

E.L.F JAN. 14, 1920



TIRRILL REGULATOR TEST
Dec. 23, 1919.

No. 3 Machine only:

Load 1500 K.W.	P.F. 63 %
Bus volts 115	Exc. volts 141
Exc. Amps. 190	Gen. Amps. 570
West. Exciter.	600
Frequency 59	620

No. 2 & No. 3,- no load on No. 2:-

Load 1400 K.W.	P.F. 63 %
Bus volts 117	Exc. volts 126

	No. 2	No. 3
Generator K.W.	0	1400
Generator Amps.	220	430
	230	450
	220	440

Exciter Amps. 320
West. Exciter.
Frequency 59

No. 2 & No. 3,- both loaded:-

Load 1400	P.F. 63 %
Bus volts 117	Exc. volts 122

	No. 2	No. 3
Generator K.W.	825	675
Generator Amps.	270	300
	300	325
	305	320

Exciter Amps. 320
West. Exciter.
Frequency 59

No. 2 Machine only:

Load 1350 K.W.	P.F. 64 %
Bus volts 113	Exc. volts 142
Exc. Amps. 185	Gen. Amps. 580
West. Exciter.	575
Frequency 59	580

- - - - - - - -

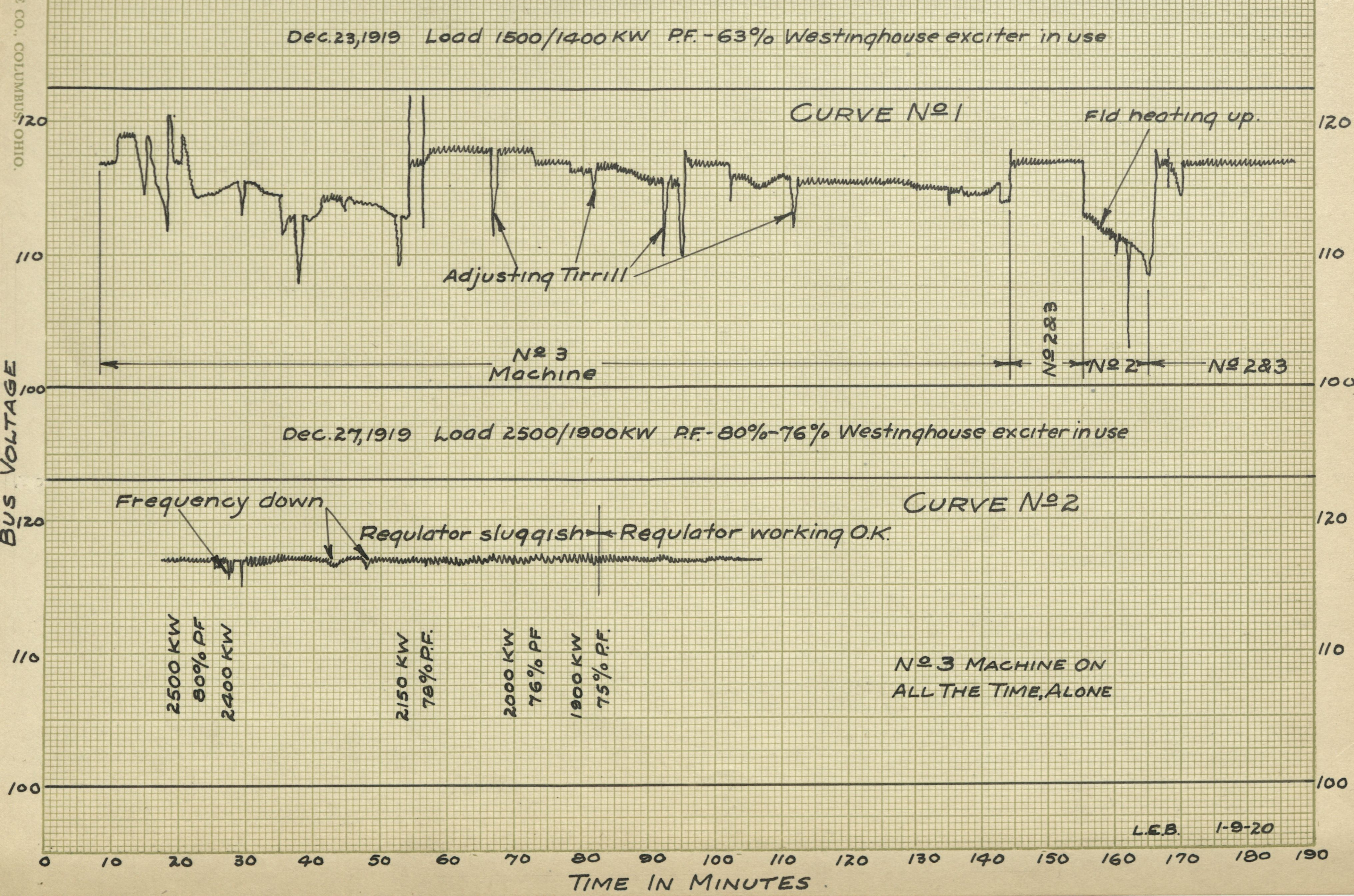
With 1500 K.W. on No. 3 Machine alone, the exciter volts went to a value of 141, at which value the short-circuiting contacts on the regulator remained permanently closed, and the bus voltage dropped to 115. The station power factor meter indicated 63%, and the frequency was 59½ cycles (a test showed that the needle was indicating ½ cycle low). No. 2 Machine was then put on the line in parallel with No. 3, but not permitted to take load. The exciter volts dropped to 126, the bus volts rose to the normal value of 117, and the regulator began operating again. The explanation of this is, of course, that the unloaded machine supplied a magnetizing cross-current, lagging with respect to itself, leading with respect to No. 3 Machine, which current helped to excite the field of the loaded No. 3 Machine.

The load was then divided between the two machines and the exciter volts went to 122, the bus voltage remained at the value of 117, and the regulator continued to operate satisfactorily. Under this condition, each machine was carrying so small a load that its inherent regulation did not reduce the terminal voltage to the point where the regulator was unable to cope with the situation. Had the load on each machine been approximately 75% of its rating, or greater, depending somewhat upon the power factor, the trouble would still have been in evidence, as shown by the test made on December 26, 1919.

No. 1 of the attached curves, which are exact copies of records made by the station recording voltmeter, shows the performance of the bus voltage during this test, and No. 2 shows that during a subsequent test, which was made following the correction of the difficulty. Note that the bus voltage drops gradually after one machine is put on by itself, due to the increase in field resistance incident to rising temperature (Curve No. 1). The "kicks" in the voltage chart were caused by adjustments made on the Tirrill Regulator while it was in operation, and are in no wise a part of its normal performance. For the purpose of this paper they might well have been eliminated from the record, but it was thought best to reproduce the curve exactly.

A test was made with the General Electric exciter in use, on December 25, 1919, with both small machines on the line, carrying a joint load of 2500 K.W. The exciter terminal voltage was 116, the bus voltage 117, and the regulator was operating satisfactorily. The power factor was much higher than during the previous test, standing at 80%. The former test was made when the plant was carrying a light industrial load and the lightly loaded distribution transformers, the latter when the

CURVE OF BUS VOLTAGE



lighting load was heavy. The data for this test are as follows:-

TIRRILL REGULATOR TEST
Dec. 25, 1919.

No. 2 & No. 3, both loaded:-

Load 2500 K.W.	P.F. 80 %
Bus volts 117	Exc. volts 116
Exc. Amps. 360	
G.E. Exciter.	

- - - -

Another test, mentioned above, was made on December 26, 1919, with the load carried by No. 1 Machine (5000 K.W. capacity), and No. 3. Under this condition the operation was satisfactory, for the same reason that obtained in the third part of the first test made, on December 23, 1919. No. 2 Machine was then put on the line and made to carry load, and No. 1 removed, and although the regulator managed to maintain the bus voltage at normal value, its operation became very sluggish, and it was almost at the point of refusing to operate altogether. The data for this test are as follows:-

TIRRILL REGULATOR TEST
Dec. 26, 1919.

No. 1 & No. 3, both loaded:-

Load 3300 K.W.	P.F. 70 %
Bus volts 118	Exc. volts 123
Exc. Amps430	West. Exciter.

	No. 1	No. 3
Generator K.W.	2200	1100
Generator Amps.	750	340
	825	350
	800	360

No. 2 & No. 3, both loaded:-

Load 3300 K.W.	P.F. 70 %
Bus volts 117	Exc. volts 135
Exc. Amps. 380	West. Exciter

	No. 2	No. 3
Generator K.W.	1500	1800
Generator Amps.	620	540
	640	560
	640	530

Regulator very sluggish, almost ready to stick fast.

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To remedy the trouble, a change was made in the series field shunt of the Westinghouse exciter. This shunt was made of three straps of German silver, two inches wide. One of these straps was removed, and a test made with a station load of 2500 K.W. at 75% power factor. Either small machine carried the load at normal bus voltage, although the exciter was operating close tb the limit, and was sluggish. Curve No. 2 shows the performance of the bus voltage during this test. Since it is not practise to operate the machines above their full-load ratings, the operation at normal loads should be entirely satisfactory, and casual inspections subsequent to this test have proved this to be true, and no further difficulty has been experienced in the operation of the Westinghouse excdter.

Although the Westinghouse exciter has an ampere output capacity of 800 amperes, the lead cable from its armature terminals to the switchboard and exciter bus are only 500,000 circular mil. A test showed that the IR drop in these leads is 4.0 volts at 385 amperes. Since the cable warms up very appreciably, the drop at full-load would be in the neighborhood of 9.0 volts. These leads will be changed to 1,000,000 circular mil as soon as convenient, which will still further improve the exciter operation.

NOTE: It has been definitely determined (April, 1920) to operate the direct-connected 60 K.W. exciter of the new 8000 K.W. Westinghouse turbo-generator in parallel with the present 75 K.W. exciter. The 100 K.W. Exciter will be used only for emergency operation, and will necessitate hand operation (as opposed to Tirrill regulator operation).

OPERATION

OF

3-TON ELECTRIC

STEEL FURNACE

AT THE

OHIO STEEL FOUNDRY CO., SPRINGFIELD, O.

1918-1919-1920

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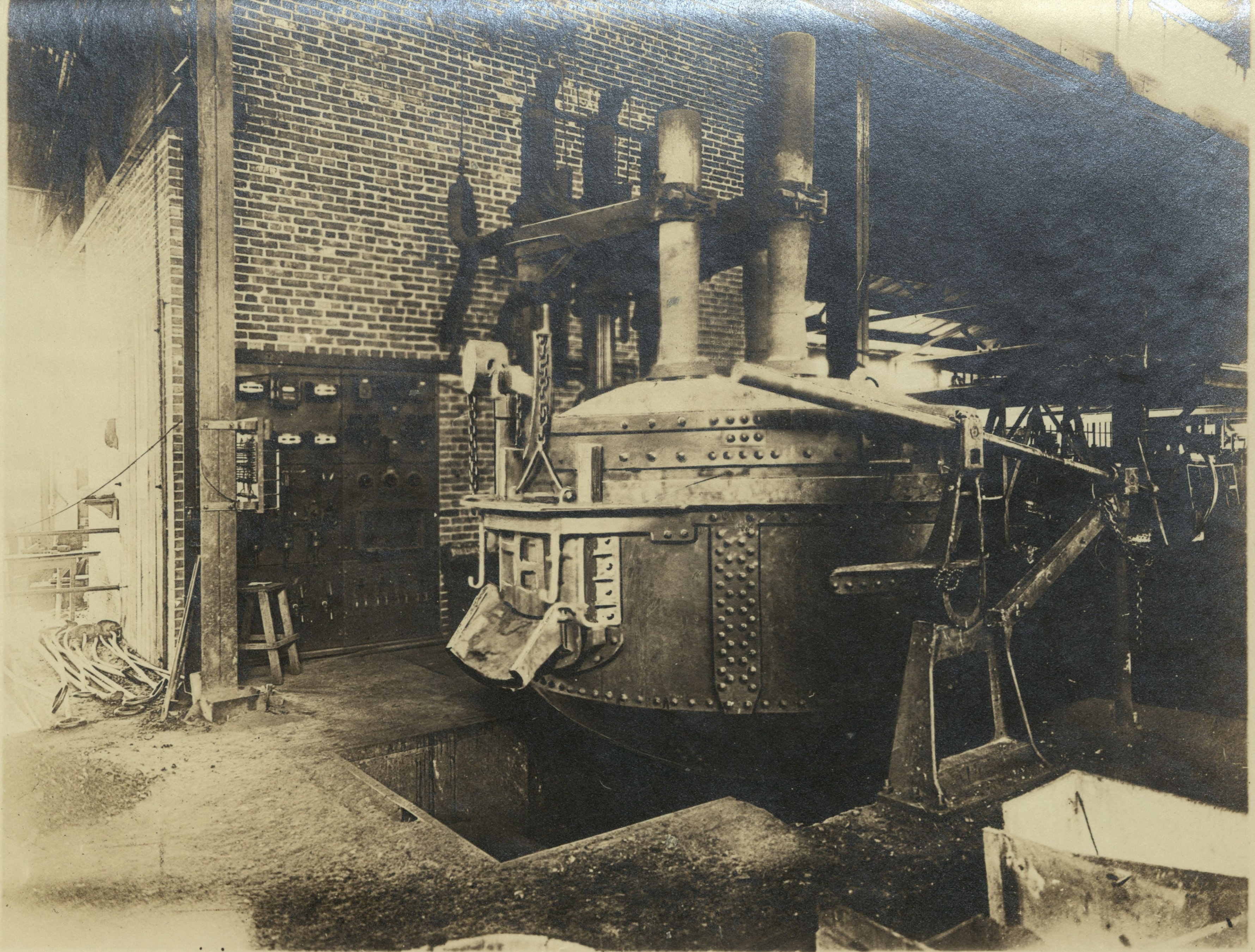


PREFACE

Early in the year 1918, the Springfield Light, Heat & Power Company contracted with the Ohio Steel Foundry Company to supply the power for a 3-ton electric steel furnace of the Moore type. Little contemporary experience and data were available at that time regarding the operation of steel furnaces, and considerable concern was felt by the officials of the power company as to their ability to successfully handle this load, without jeopardizing the service to other customers. The generating capacity of the power plant was 9000 K.W. at 80% power factor, and the normal peak about 4500 K.W. The furnace was installed and ready to operate late in July of 1918. The transformer supplying it was a special 1000 K.V.A. 3-phase unit, with 11.3% internal reactance. The voltage fluctuation caused by the furnace was so serious that a conference was held, which resulted in the iron wire test made in September of 1918, and described in the first part of the report. External reactors of 6.7 ohms impedance were installed, but were later replaced by reactors of 7.95 ohms impedance. The operation was reasonably satisfactory with these reactors in service, but it was felt that further improvement was possible, and in addition to this, the foundry company complained that the time of melting was too long. For these reasons, the series of tests described in the second part of the report were made.

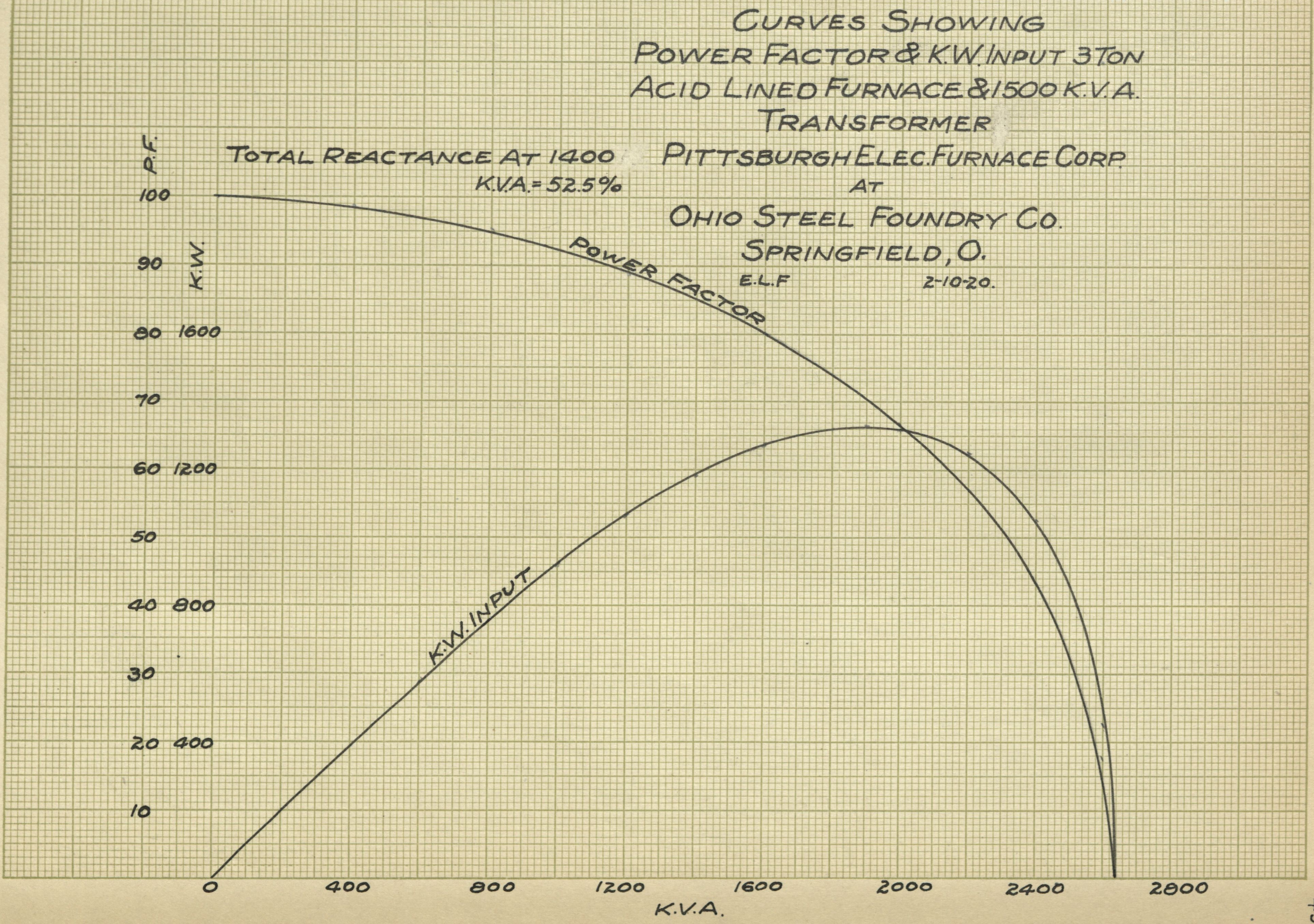
About the middle of 1919, two of the hoist motors which raise and lower the electrodes failed to function properly, allowing their electrodes to lower into the bath and remain there. No contact-making thermometers were then in use, and the transformer was badly damaged before the operator noted the trouble. Two of the low-tension coil-ends were completely burned off, and other and more minor damage done. The transformer was repaired by the power company and put back into service. The foundry company, in conference with Mr. Moore of the Pittsburgh Furnace Company, and representatives of the power company, decided to purchase and install a 1500 K.V.A. transformer, to secure greater capacity and a larger margin of safety. As a matter of interest, the old transformer failed again, on the day that the new one arrived. This new 1500 K.V.A. transformer had only 5.3% internal reactance, so that the service was again impaired, and it was decided to install still more external reactance. Mr. Moore believed that doubling the original amount would place the furnace operation on the stable portion of the attached curve, and would not increase the melting time, on account of the resulting greater arc stability. It had been noted that with only the original reactors the arc was "wild", tending to blow about the furnace, and also melting the roof rapidly. As a matter of fact, these additional reactors have not to date (April, 1920) been installed, and certain changes and developments may make this unnecessary.

In order to improve the operation of the furnace while waiting for the arrival of the additional reactors, the high-tension taps of the transformer were changed from the 6600 volt winding to a higher potential winding, which of course had the effect of increasing the internal reactance (see print of transformer connections in pocket in back of book). Meanwhile, Mr. Galvin, Chief Melter for the Ohio Steel Foundry Company, has spent a large amount of his time experimenting with the furnace, and has succeeded not only in reducing the voltage fluctuation, but also in making a remarkable reduction in the melting time, so that he can now secure a 3-ton heat in about an hour and twenty minutes, and he has a record of ten 3-ton heats in five minutes less than twelve hours. Mr. Galvin places a lump of ordinary coke under each electrode, which has the effect of providing a constant arcing distance, and he also charges the furnace initially with 6 tons; when this is melted, he removes only 3 tons, leaving 3 tons of bath in the furnace to receive a new cold charge of 3 tons. The new charge sinks into the molten charge, leaving a fairly level surface for the arc to work upon, and a mass of highly conducting metal. Mr. Galvin is securing patents upon this method of charging, and upon a secret method for reducing the slag. He has had as much as 25,000 pounds of metal in the furnace, and his initial charge is usually 14,000 pounds.

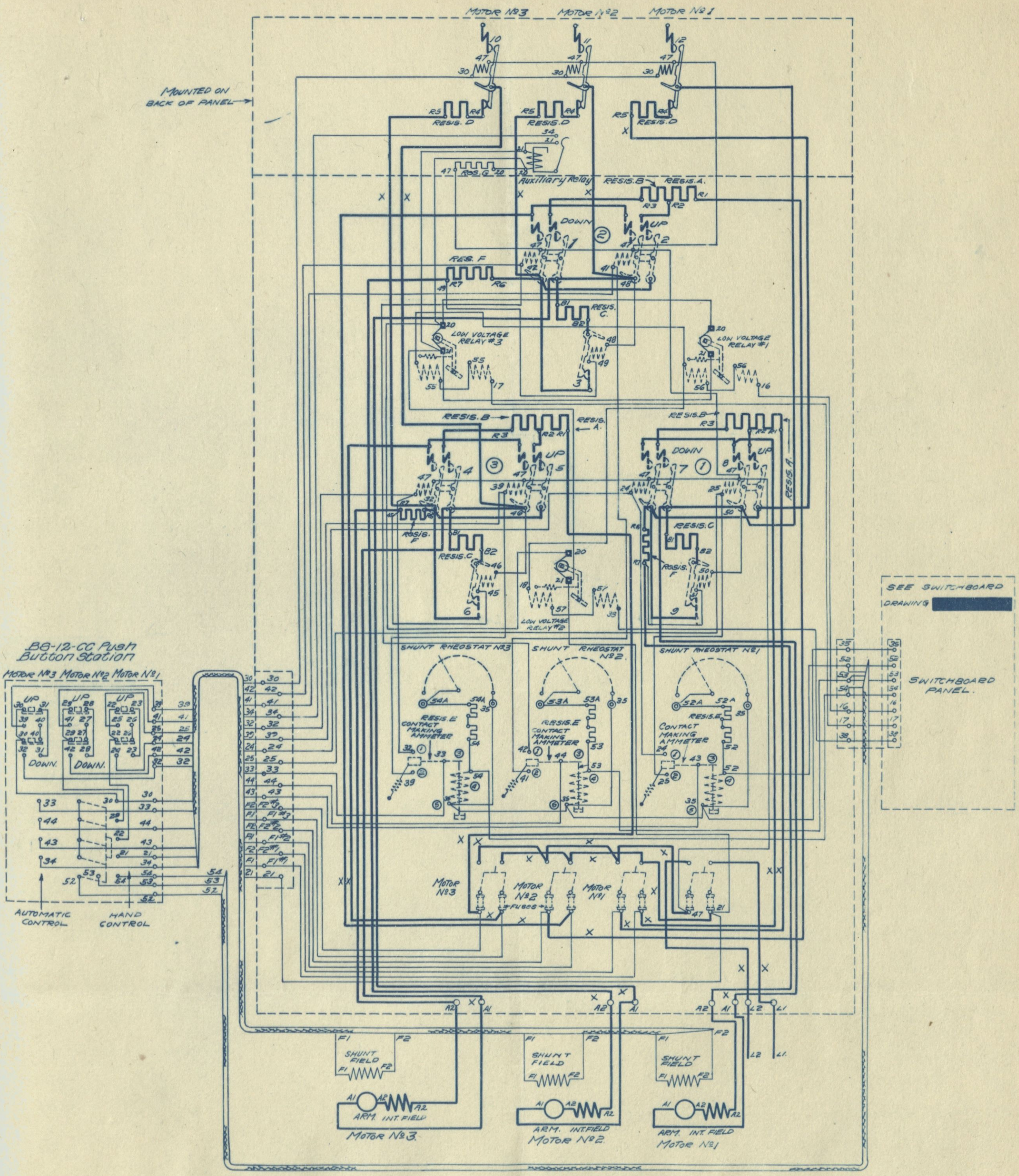
The original regulators controlling the electrode hoist motors were "Thury" walking beams, but these proved too slow in operation, and were replaced by the General Electric regulators, the wiring diagram for which is given on General Electric Drawing No. 31566, in the pocket in the back of this book.*

The neutral switch is no longer used, for the reason that the plates are burned off or are so covered with the lining of the furnace that they are no longer effective. If properly maintained, this neutral switch is a beneficial factor in the furnace operation.

* Original prints about 24" by 36". Prints secured are 8½" by 11", and are attached herewith.



CURVES SHOWING
POWER FACTOR & K.W. INPUT 3 TON
ACID LINED FURNACE & 1500 K.V.A.
TRANSFORMER
PITTSBURGH ELEC. FURNACE CORP.
AT
OHIO STEEL FOUNDRY CO.
SPRINGFIELD, O.
E.L.F
2-10-20.
TOTAL REACTANCE AT 1400
K.V.A. = 52.5%
P.F.
K.W.
POWER FACTOR
K.W. INPUT
100
90
80
70
60
50
40
30
20
10
1600
1200
800
400
0
400
800
1200
1600
2000
2400
2800
K.V.A.



BACK VIEW OF PANELS
CONTACTORS No 1 TO No 9 SUITABLY MECHANICALLY INTERLOCKED
X WIRING PER EB-13527-C AND S.O.
CONTROL NUMBERS IN CIRCLES REFER TO NUMBERS STAMPED ON TERMINALS OF CONTACT MAKING AMMETERS.
TERMINAL BOARDS TO BE SUPPLIED FOR ALL CONTROL LEADS.
TO REVERSE DIRECTION OF ROTATION INTER CHANGE LEADS F1 AND F2.

315366 CONNECTION DIAGRAM OF HAND AND AUTOMATIC CONTROL PANEL FOR 3-ELECTRODE ARC FURNACE.

INDEX E-353.2 - E-357

6 28 17

IRON WIRE TEST
ON
OHIO STEEL FOUNDRY CIRCUIT.

September, 1918.

- - - - -

On account of the excessive voltage fluctuation caused by the steel furnace at the factory of the Ohio Steel Foundry Co., it was suggested by Mr. W.E.Moore of the W.E.Moore & Company, manufacturers of the furnace, that we install in this line a section of iron wire for the purpose of producing a large voltage drop at the furnace peaks, and to limit the supply of power drawn by the furnace. From the data taken, Mr. Moore is to design a reactance to be installed in the furnace circuit, at the plant of the Ohio Steel Foundry Co. The effect of the iron wire will, of course, be quite different from that of a reactor of the same impedance, on account of the high losses in the wire and the practical absence of losses in the reactor, but it was felt by Mr. Moore that the test would give him the necessary data.

The assumptions made for this purpose were as follows:-

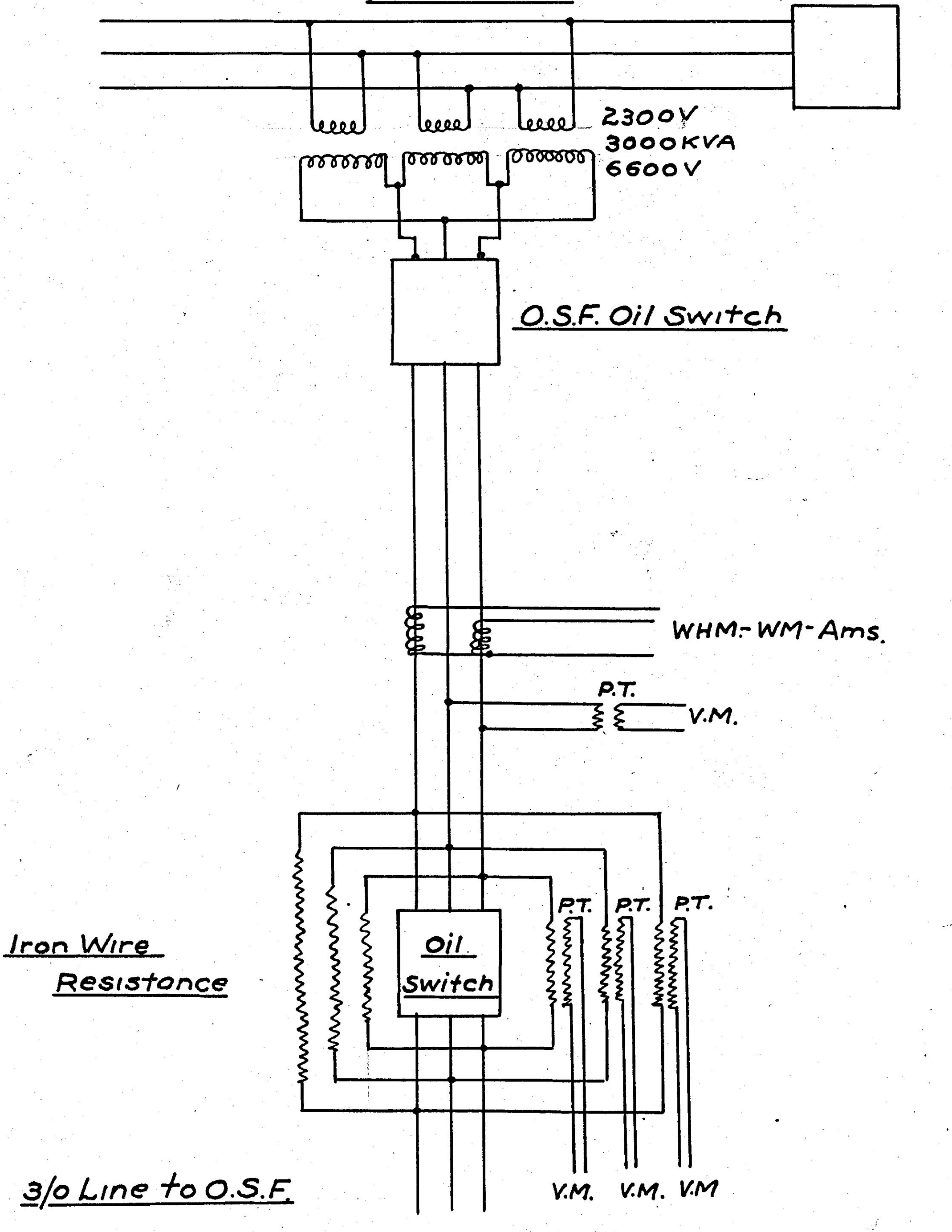
Peak on the furnace 1500 K.W. at 75% P.F.
Average load- 900 K.W., at 75% P.F.
The respective line currentssat the above loads are 175 and 105 amperes.

The accompanying sketch shows the connections used and indicates the readings which were to be taken. The test was run in the evening after the normal power load was off, and therefore the operation, as far as the turbines are concerned, was not typical of the normal operation during the day, but the readings taken gave the line and furnace characteristics in very good shape.

The aim was to produce 1000 volts drop per line at a peak load of 175aamperes, or 1732 volts per phase. The power factor for the section of iron wire was assumed to be 100%, and the line power factor to be 75%.

Since no adequate data on iron wire were available, a preliminary labaratory test was made on three different sizes of iron wire. The data taken are shown on the sheet

DIAGRAM OF CONNECTIONS USED ON MAKING TEST ON OHIO STEEL FDRY FURNACE.



9-4-18 H.E.M.

headed "Test of Iron Wire", and dated August 16, 1918. From this data and the calculations shown on the next sheet, it was decided to use approximately 1250 feet of No. 6 American Wire Gage black annealed iron wire. The current in this laboratory test was obtained by inverting a current transformer.

In the test as actually run, 1185 feet of this No. 6 wire was used. The diameter by actual measurement was 192 mils. The data obtained was somewhat disappointing from the point of view of exact calculations, in that the extremely rapid fluctuation made it impossible to obtain coincident readings. Most of the readers were inexperienced, also. However, Mr. Moore expressed himself as satisfied with the test, and it was possible to obtain the necessary general data and information from it. Readings were taken of high-tension voltage on one phase, current in all three legs, K.W. supplied, and voltage drops across all three sections of iron wire. A complete set of wattmeter readings in the engine room on the panel supplying the Rockway Substation were taken, reading time, and low, high, and average K.W. On account of the fact that the readings were not of use, they are not reproduced here. About one hundred complete readings were taken.

Comparison of the voltage charts for the operation without and with the iron wire inserted shows no improvement, but this was not to be expected, because the conditions of operation were so entirely different. The iron wire imposed a greater K.W. load upon the turbine, causing a wider range of operation of the governor.

The operation at the foundry was reported by Mr. Moore and Mr. Harvey (Works Manager) to be greatly improved, although of course, the excessive drop in voltage over the iron wire made their motor operation bad.

An investigation of the data taken showed that calculations were impractical, and the test is of value chiefly from the actual observation of the conditions and behavior of the plant and furnace while it was being run.

As soon as the reactors are installed, a set of readings will be taken to check up the voltage drop across them at different currents. At this writing, the new General Electric regulators are in service, and are giving considerably better results than the Thury regulators.

TEST OF IRON WIRE
Aug. 16, 1918.

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Sample No. 1 — Annealed, black, 3-foot length.
Diameter 175 mils, Roebling Gage No. 7

AMPERES (X50)	VOLTS	REMARKS
3.1	2.05	
2.5	2.15	Wire became hot enough to "sizzle" with moisture.
2.3	2.2	
2.2	2.23	
2.17	2.24	

Sample No. 2 — Annealed, black, 3-foot length.
Diameter 192 mils, Roebling Gage No. 6

AMPERES(X50)	VOLTS	REMARKS
3.75	1.9	
3.1	2.0	
3.0	2.0	Wire became smoking hot.
2.75	2.0	
2.45	2.08	
3.6	1.7	
3.1	1.8	
2.9	1.9	
2.55	2.0	

Sample No. 3 — Galv., 3-foot length.
Diameter 204 mils, B.W.G. No. 6

AMPERES(X50)	VOLTS	REMARKS
3.1	1.1	
3.0	1.15	
2.9	1.2	Wire became hot enough to melt galvanizing and turn blue.
3.8	2.05	
3.1	2.15	
2.85	2.2	
2.6	2.25	
2.45	2.29	

CALCULATIONS

- - -

Sample No. 1

Amperes under steady conditions- 50 X 2.17= 109
Volts drop per foot- 0.75
Feet to give 1000 volts drop at 109 amperes- 1350

Sample No. 2

Amperes under steady conditions- 50 X 2.55= 127.5
Volts drop per foot- 0.67
Feet to give 1000 volts drop at 127.5 amperes- 1500

Sample No. 3

Amperes under steady conditions- 50 X 2.45= 122.5
Volts drop per foot- 0.763
Feet to give 1000 volts drop at 122.5 amperes- 1300

Sample No. 1 will fuse at about 225 amperes.
" " 2 " " " " 265 " .
" " 3 " " " " 290 " .

Estimated amount of wire required to give 1000 volts drop at 175 amperes:-

	Length	Weight
Sample No. 1	800 ft.	66.2 Lbs.
Sample No. 2	1000	97.3
Sample No. 3	850	96.0

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Use 1250 feet of Sample No. 2. If this proves to be too much, lengths can be readily shorted out. This makes a total for three lengths of 3750 feet or 365 pounds.

OBSERVATION AND TEST OF ELECTRIC FURNACE
AT
OHIO STEEL FOUNDRY CO.,
SPRINGFIELD, O.

- - -

The following set of data was taken in order to determine whether it were possible to improve the conditions of operation of the electric furnace with respect to the power plant:

Previous to the installation of the external reactance coils, the voltage fluctuation at the plant was very serious. Readings were taken at the foundry of total time for the heat, K.W.H. consumed, and the component parts of the charge. Readings were taken at the plant of maximum, minimum, and average K.W. load during the period of each heat, and record made of the machines in service. A study of the recording voltmeter charts was made to determine the characteristics of the heat during its entire period.

The readings of K.W.H. consumed for the heat are not at all accurate, since one division of the lowest dial on the watthour meter is 2400 K.W.H. However, the average over a considerable period of time would, of course, give the K.W.H. per ton quite accurately.

The observations and tests were made over two 24-hour periods in order to get two complete cycles of operation and to observe the characteristics under all conditions, both at the foundry and at the power plant. In addition to these two cycles, a number of readings were taken during succeeding days in completing the study of different methods of charging and of adjusting the shunt rheostats on the contact-making ammeters. Heats Nos. 9 to 15 inclusive include time studies of the complete cycle of operations of the furnace, and from the readings taken a suggestive bogie for charging the furnace has been prepared.

Between Heats Nos. 8 and 9, the reactances were installed and their effect studied during the remainder of the heats.

HEAT NO. 1
OHIO STEEL FOUNDRY NO. 240.
Oct. 15, 1918.

- - -

Power on	11:05 A.M.		K.W.H. Reading	191.5
Power off	1:10 P.M.		" " "	192.25
Time	2:05		K.W.H.(X2400)	0.75
				1800.00

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CHARGE

	Lbs.	Percent		
Turnings	695	11.4	50% Silicon	35 Lbs.
Springs	300	4.9	80% Manganese	25
Forgings	1765	29.0	40% Manganese	60
Fdy Scrap	2155	35.4		
Shells & Rivets	1175	19.3		
	6090	100.0		

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Bought scrap includes springs, forgings, shells, and rivets. Load goes up momentarily when the manganese and silicon are thrown in, on account of the "boil".

Foundry scrap and bought scrap in first, shell turnings on top. Turnings are high in carbon.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load:- Minimum	3600	K.W.
Maximum	5150	"
Average	4500	"

Recording Voltmeter:-
Max. swing 9 volts. Start good. First 30 minutes worst, but not bad. Rest of curve very good. Toward end, one or two swings when "mix" was thrown in. General character of curve "good".

HEAT NO. 2
OHIO STEEL FOUNDRY NO. 241
Oct. 15, 1918.

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Power on	1:55 P.M.	K.W.H. Reading	192.25
Power off	3:55 P.M.	" " "	193.00
Time	2:00	K.W.H. (X2400)	0.75
			1800.00

- - -

CHARGE

	Lbs.	Percent		
Turnings	645	10.7	50% Silicon	35 Lbs.
Springs	400	6.7	80% Manganese	25
Forgings	1685	28.1	40% Manganese	60
Fdry Scrap	2050	34.2		
Shells & Rivest	1220	20.3	No pig.	
	6000	100.0		

- - - - -

Foundry scrap in first, then springs, forgings, shells, and rivets. Material thrown in indiscriminately, large and small. Turnings on top. Charge bulky in comparison to weight. Leveled off slightly.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load: Minimum 2250 K.W.
Maximum 5550 K.W.
Average 3900 K.W.

Recording Voltmeter:-

Max. swing 13 volts. First 30 minutes worst. Next 10 minutes quite good, followed by bad 15 minutes. Rest of curve not bad. Peaks at end when "Mix" went in. General character of curve "bad".

HEAT NO. 3
OHIO STEEL FOUNDRY NO. 242
Oct. 15, 1918.

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Power on	4:35 P.M.	K.W.H. Reading	193.0
Power off	6:50 P.M.	" " "	193.8
Time	2:15	K.W.H.(X2400)	0.8
			1920.0

- - - -

CHARGE

	Lbs.	Percent		
Turnings	680	10.6	50% Silicon	35 Lbs.
Springs	400	6.2	80% Manganese	25
Forgings	2000	31.2	40% Manganese	60
Fdry Scrap	2100	32.8		
Shells & Rivets	1230	19.2	Pig - 30 Lbs.	
	6410	100.0		

- - - -

Foundry scrap and bought scrap in first. Shell turnings on top. Considerable fine stuff in bought scrap, as well as some pieces larger than usual. Bulk considerably less than before. Charge fairly level.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000)

Load:-	Minimum	1900	K.W.
	Maximum	4150	"
	Average	3000	"

Recording Voltmeter:-

Max. swing 14 volts. First 40 minutes bad, followed by sudden settling down to fairly good curve. Swings at end show when "mix" went in. General character of curve "bad".

HEAT NO. 4
OHIO STEEL FOUNDRY NO. 243
Oct. 15, 1918.

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Power on	7:53 P.M.	K.W.H. Reading	193.8
Power off	9:53 P.M.	" " "	194.55
Time	2:00	K.W.H.(X2400)	0.75
			1800.00

- - - -

CHARGE

	Lbs.	Percent		
Turnings	745	12.1	50% Silicon	35 Lbs.
Springs	400	6.5	80% Manganese	25
Forgings	1685	27.4	40% Manganese	60
Fdry Scrap	2040	33.4		
Shells & Rivets	1265	20.6	No pig	
	6135	100.00		

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Foundry scrap of sprangly, spindling pieces, fairly uniform. Bought scrap largely small, compact material. Springs of varying sizes.

Nearly all of foundry scrap in before any of bought scrap (except springs) was started. Springs in near end of foundry scrap. Foundry scrap bulky. Foundry scrap placed toward front of furnace. Turnings started in when bought scrap was about 2/3 in. Bought scrap small and compact. Surface of charge reasonably level. Turnings about 2/3 in by time bought scrap was all in. Charge bulkier than preceding one, on account of foundry scrap.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load:-	Minimum	1750 K.W.
	Maximum	3700 K.W.
	Average	2700 K.W.

Recording Voltmeter:-

Max. swing 7 volts. First 50 minutes worst, but not bad. Swings at end, when "mix" went in. General character of curve "good".

HEAT NO. 5
OHIO STEEL FOUNDRY NO. 244
Oct. 15/16, 1918.

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Power on	10:57 P.M.		K.W.H. Reading	194.55
Power off	12:53 A.M.		K." " "	195.35
Time	1:56		K.W.H.(X2400)	0.8
				1920.0

- - - -

CHARGE.

	Lbs.	Percent		
Turnings	740	12.2	50% Silicon	35 Lbs.
Springs	400	6.6	80% Manganese	25
Forgings	1740	28.8	40% Manganese	60
Fdry Scrap	2425	40.0		
Shells & Rivets	750	12.4	No pig.	

- - -

n . Foundry scrap largely of small, compact pieces. Bought scrap somewhat bulky and sprangly. Large percentage of springs large.

Bought and foundry scrap all in at once. Springs all in at start. Foundry scrap all in when bought scrap was about half in. Turnings started in about time foundry scrap was all in. Bought scrap all in when turnings were about 2/3 in. Top layer of turnings. Surface of charge not very,- peaked toward front. Charge compact, not bulky.

Rheos changed from Pt. 8 to 3 during latter part of heat. Operated at ½ -taps at end of run, waiting for ladle.

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POWER PLANT

Machines on- No. 1 (5000) and No. 2 (2000).

Load- Minimum 1500 K.W.
Maximum 2500 K.W.
Average 1900 K.W.

Recording Voltmeter:-

Max. swing 15 volts. 13 volt swing at end when "mix" went in. Curve bad all along. Last 50 minutes, however, much better than previous part. General character of curve "bad".

HEAT NO. 6
OHIO STEEL FOUNDRY NO. 245
Oct. 16, 1918.

- - -

Power on	1:51 A.M.	K.W.H. Reading		195.35
Power off	3:57 A.M.	" " "		196.25
Time	2:06	K.W.H.(X2400)		0.9
				2160.0

- - - -

	Lbs.	Percent
Turnings	720	12.0
Springs	400	6.6
Forgings	1650	27.4
Fdry Scrap	2370	39.4
Shells & Rivets	875	14.6
	6015	100.0

50% Silicon	35 Lbs.
80% Manganese	25
40% Manganese	60

No pig.

- - -

Foundry scrap half and half compact and sprangly pieces. Springs large. Forgings sprangly. Shells and rivets compact.

Foundry and bought scrap all started in at the same time. Foundry scrap all in when bought scrap was about ½ in. Turnings started in just before foundry scrap was all in. Turnings and bought scrap finished together. Surface of charge peaked.

Heat finished with rheostats on point 6. Operated at half taps at end of run while waiting for return of ladle. Slag very bad.

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POWER PLANT

Machines on- No. 2 (2000) and No. 3 (2000).

Load-	Minimum	2100
	Maximum	3000
	Average	2500

Recording Voltmeter:-

Max. swing 20 volts. Curve bad all along. General character of curve "very bad".

HEAT NO. 7
OHIO STEEL FOUNDRY NO. 246
Oct. 16, 1918.

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Power on	5:45 A.M.	K.W.H. Reading	196.25
Power off	8:11 A.M.	" " "	197.10
Time	2:26	K.W.H.(X2400)	0.85
			2040.0

- - - -

CHARGE

	Lbs.	Percent		
Turnings	750	12.2	50% Silicon	35 Lbs.
Springs	400	6.5	80% Manganese	25
Forgings	1813	29.5	40% Manganese	60
Fdry Scrap	2425	39.4		
Shells & Rivets	760	12.4	Pig iron	40
	6148	- 100.0		

- - -

Foundry scrap of large pieces, half and half compact and sprangly. Springs large. Forgings large and sprangly. Heat should show especially the effect of large, bulky scrap.

Foundry and bought scrap all in together. Turnings started in when scrap was about 2/3 in. Bought and Foundry scrap finished together. Charge peaked and toward front. Scrap and turnings finished together.

Hard to get heat up at end of run.

- - -

POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000)

Load-	Minimum	2200
	Maximum	4900
	Average	3500

Recording Voltmeter:-

Max. swing 13 volts. First 30 minutes worst. Remainder not bad. General character of curve "not good".

HEAT NO. 8
OHIO STEEL FOUNDRY NO. 247
Oct. 16, 1918.

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Power on	9:02 A.M.	K.W.H. Reading	197.1
Power off	(not recorded)	" " "	(not recorded).

- - - - -

CHARGE

	Lbs.	Percent		
Turnings	670	11.4	50% Silicon	35 Lbs.
Springs	400	6.8	80% Manganese	25
Forgings	1635	27.8	40% Manganese	60
Fdry Scrap	2030	34.5		
Shells & Rivets	1150	19.5	No pig	

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Bought scrap half and half large and small, compact and sprangly. Springs unusually large and heavy. Foundry scrap extra large, sprangly and bulky. This heat also should show effect of large, bulky scrap.

Foundry scrap started in first, then springs. Foundry scrap practically all in before bought scrap (except springs) was started. Charge bulky. All scrap in before turnings were added. Charge peaked and near front.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	4000	K.W.
	Maximum	5600	"
	Average	5400	"

Recording Voltmeter:-

Max. swing 12 volts. Start good. First 30 minutes worst. Remainder not bad. General character of curve "not good".

HEAT NO. 9
OHIO STEEL FOUNDRY NO. 309
Oct. 25, 1918.

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Power on	11:34 A.M.	K.W.H. Reading	247.75
Power off	2:20 P.M.	" " "	248.50
Time	2:46	K.W.H.(X2400)	0.75
			11800.0

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CHARGE

	Lbs.	Percent		
Turnings	650	10.7	50% Silicon	30 Lbs.
Forgings	1760	28.9	80% Manganese	35
Fdry Scrap	2340	38.4	40% Manganese	60
Shells & Rivets	1345	22.0	No pig.	
	6095	100.0		

- - - -

Foundry scrap average. Bought scrap heavy and compact, with a number of large pieces. Foundry scrap in first, nearly all in before bought scrap was started. Foundry scrap fairly well leveled off in bottom. Shells, forgings and rivets all in together. Scrap all in before turnings were started.

Rheos on point 10.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000)

Load-	Minimum	2600
	Maximum	4700
	Average	4000

Recording Voltmeter:-

Max. swing 9 volts. First 40 minutes worst, followed by 40 minutes fairly good, after which conditions suddenly settled down to "very good". Operation very much better than before reactors were installed. General character of curve "bad".

HEAT NO. 10
OHIO STEEL FOUNDRY NO. 310
Oct. 25, 1918.

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Power on	3:01 P.M.	K.W.H. Reading	248.5
Power off	5:40 P.M.	" " "	249.3
Time	2:39	K.W.H.(X2400)	0.8
			1920.0

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CHARGE

	Lbs.	Percent		
Turnings	710	10.8	50% Silicon	30Lbs.
Forgings	2130	32.3	80% Manganese	35
Fdry Scrap	2025	30.6	40% Manganese	60
Shells & Rivets	1735	26.3	No pig.	
	6600	100.0		

- - - -

Foundry scrap large and sprangly. Bought scrap compact. Shells and rivets mixed.

Foundry scrap started in first. All in before bought scrap started in. Bought scrap in without discrimination as to size. Turnings in last. Charge rather bulky. Some of large pieces of bought scrap near top. Surface leveled off slightly.

Rheos on point 10.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	3200
	Maximum	4900
	Average	4100

Recording Voltmeter:-

Max. swing 7 volts. First 30 minutes worst, followed by 45 minutes fair, remainder quite good. General character of curve "not good".

HEAT NO. 11
OHIO STEEL FOUNDRY NO. 311
Oct. 25, 1918.

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Power on	6:22 P.M.	K.W.H. Reading		249.3
Power off	8:41 P.M.	"	" "	250.1
	2:19	K.W.H. (X2400)		0.8
				1920.0

- - - -

CHARGE

	Lbs.	Percent		
Turnings	685	11.0	50% Silicon	35 Lbs.
Forgings	1740	27.9	80% Manganese	35
Fdry Scrap	2075	33.3	40% Manganese	60
Shells & Rivets	1730	27.8	Ore	30
	6230	100.0		

- - -

Foundry scrap large, with many heavy, compact pieces. Bought scrap rather fine and compact.

Foundry scrap practically all in before bought scrap was started. Turnings started in before scrap was finished, so that the two finished together. This heat should show especially the effect of having large pieces at the top. Several large pieces were exposed on top. Charge not leveled.

At end of heat, while waiting for return of ladle, power was put on again; carbons broke through heavy slag and ammeters hung in corner for several seconds, before carbons were lifted out of bath.

Rheos on point 7.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	3200	K.W.
	Maximum	4200	"
	Average	3800	"

Recording Voltmeter:-

Max. swing 10 volts. First 35 minutes very bad, remainder only fair. General character of curve "bad".

HEAT NO. 12
OHIO STEEL FOUNDRY NO. 312
Oct. 25, 1918.

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Power on	9:46 P.M.		K.W.H. Reading	250.1
Power off	11:54 P.M.		" " "	250.9
	2:08		K.W.H.(X2400)	0.8
				1920.0

- - - -

CHARGE

	Lbs.	Percent			
Turnings	1045	17.4	50%	Silicon	35 Lbs.
Forgings	1775	29.5	80%	Manganese	30
Fdry Scrap	2295	38.2	40%	Manganese	60
Shells & Rivets	895	14.9		Ore	30
	6010	100.0			

- - - - -

Foundry scrap rather sprangly, with a few heavy, compact pieces. Foundry and bought scrap mixed together on floor. Bought scrap rather bulky and sprangly, with large amount of fine, compact material.

Foundry scrap and bought scrap started in together, with no discrimination as to size. Turnings started when scrap was about half in. Scrap finished slightly ahead of turnings. Charge not leveled. Large pieces of scrap near top. This heat should show especially the effect of large pieces near the top.

Rheos on point 7.

Power on for short time at end, holding heat while waiting for return of ladle.

Night man says he gets heat out in two hours or a little more because he peaks charge and keeps it away from charging door. He also shifts the rheos, which may be the main reason.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	2200
	Maximum	3000
	Average	2600

Recording Voltmeter:-

Max. swing 5 volts. Curve quite uniform throughout duration. General character of curve "very good".

HEAT NO. 13
OHIO STEEL FOUNDRY NO. 313
Oct. 26, 1918

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Power on	1:02 A.M.		K.W.H. Reading	250.9
Power off	3:06 A.M.		K.W.H. Reading	251.8
	2:04		K.W.H.(X2400)	0.9
				2160.0

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CHARGE

	Lbs.	Percent		
Turnings	1170	19.3	50% Silicon	35 Lbs.
Forgings	1930	31.9	80% Manganese	30
Fdry Scrap	2065	34.1	40% Manganese	60
Shells & Rivets	895	14.7	Ore	30
	6060	100.0		

- - - -

Foundry scrap rather compact, with some large pieces. Bought scrap mixed large and small. Bought and foundry scrap mixed together on floor.

Foundry scrap and bought scrap started in together, with no discrimination as to size of material. Turnings started in when scrap was about2/3 in. the two finishing together. Large pieces of scrap near top, as before. Charge near front. No leveling done.

Rheos started at point 7 and advanced by steps to point 3 during latter part of heat.

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POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000) until 2:30, No. 1 alone after that.

Load-	Minimum	2000
	Maximum	2500
	Average	2200

Recording Voltmeter:-

Max. swing 7.5 volts. Curve quite uniform throughout duration of heat. General character of curve "not good".

HEAT NO. 14
OHIO STEEL FOUNDRY NO. 314
Oct. 26, 1918.

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Power on	3:40 A.M.	K.W.H. Reading		251.8
Power off	5:39 A.M.	"	" "	252.7
	1:59	K.W.H. (X2400)		0.9
				2160.0

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CHARGE.

	Lbs.	Percent
Turnings	1125	18.7
Forgings	1985	32.9
Fdry Scrap	1980	32.8
Shells & Rivets	945	15.6
	6035	100.0

50%	Silicon	35 Lbs.
80%	Manganese	30
40%	Manganese	60

- - -

Foundry scrap sprangly, bulky. Bought scrap mixed odds and ends, with considerable fine stuff. Bought and foundry scrap mixed together on floor.

Foundry scrap and bought scrap all started in together. Turnings started in when scrap was about ½ in. Scrap and turnings finished together. No leveling done.

Rheos at 3 at start. Set back to 5,6, and 7 during middle of heat. Finished at 3.

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POWER PLANT

Machines on- No. 1 (5000)

Load-	Minimum	2350
	Maximum	3000
	Average	2700

Recording Voltmeter:-

Max. swing 5 volts. First 20 minutes worst, but not at all bad. At end of that time, curve suddenly settled down to a swing of about 2 volts, and continued good during the duration of the heat. General character of curve "very good".

HEAT NO. 15
OHIO STEEL FOUNDRY NO. 315
Oct. 26, 1918.

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Power on	6:45 A.M.	K.W.H. Reading	252.7
Power off	8:59 A.M.	" " "	253.5
Time	2:14	K.W.H.(X2400)	0.8
			1920.0

- - -

CHARGE.

	Lbs.	Percent
Turnings	1210	19.4
Forgings	2055	33.0
Fdry Scrap	2070	33.2
Shells & Rivets	895	14.4
	6230	100.0

50% Silicon	35 Lbs.
80% Manganese	30
40% Manganese	60

- - -

Foundry scrap sprangly. Bought scrap mixed large and small. Both scraps mixed together on floor.

Large foundry scrap in first. Bought scrap started in before foundry scrap was finished. Scrap all in before turnings were started. Charge piled up in front of door. Leveled off slightly. Rheos started at point 8, changed to 6 in a few minutes. Back to 8 again in a few more minutes. Furnce operated 1-phase from 7:07 to 7:14, and from 7:22 to 7:26. Power off furnace from 7:26 to 7:34. Rheos set at 6 at 7:53, at 5 at 7:56, at 4 at 8:04, at 3 at 8:30. Heat ready at 8:55, waited 4 minutes for ladle.

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POWER PLANT

Machines on- No. 1 (5000).

Load-	Minimum	4200
	Maximum	5700
	Average	4900

Recording Voltmeter:-

Max. swing 6 volts. At end of 90 minutes, curve suddenly settled down to condition almost as steady as when furnace load is not on. General character of curve " good".

HEAT NO. 16
OHIO STEEL FOUNDRY NO. 328
Oct. 29, 1918.

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Power on	8:17 A.M.	K.W.H. Reading	263.7
Power off	10:12 A.M.	" " "	264.3
	1:55	K.W.H. (X2400)	0.6
			1440.0

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CHARGE.

	Lbs.	Percent
Turnings	620	10.2
Forgings	2030	33.5
Fdry Scrap	1975	32.5
Shells & Rivets	1440	23.8
	6065	100.0

- - - -

Turnings all in on top.
Rheos started at point 8.
" advanced to " 6 at 8:44
" " " " " 5 " 9:00
" " " " " 4 " 9:15
" " " " " 3 " 9:34

G-2 demands:- 960,1120,1380,1344,1440,1504,1216.

- - - -

POWER PLANT

Machines on- No. 1 (5000) and No. 2 (2000).

Load:-	Minimum	3900
	Maximum	5000
	Average	4500

Recording Voltmeter:-
Clock stopped after 40 minutes run of heat.
Max. recorded swing 7 volts. General character of curve "bad".

HEAT NO. 17
OHIO STEEL FOUNDRY NO. 338
Oct. 30, 1918

- - - -

Power on	11:24 A.M.	K.W.H. Reading	271.4
Power off	1:42 P.M.	" " "	272.2
Time	2:18	K.W.H. (X2400)	0.8
			1920.0

- - - -

CHARGE.

	Lbs.	Percent
Turnings	695	11.3
Forgings	2010	32.8
Fdry Scrap	1765	28.8
Shells & Rivets	1661	27.1
	6130	100.0

- - -

Foundry scrap large, heavy, compact. Bought scrap small and compact.

Foundry scrap started in first. Bought scrap mixed in with it. Turnings started before bought scrap was all in, bought scrap finishing slightly ahead of turnings. Charge peaked near front of furnace.

Rheos started at point 8.
" advanced to " 7 at 11:49
" " " " " 6 " 12:03
" " " " " 5 " 12:21
" " " " " 4 " 12:33
" " " " " 3 " 12:47

Unusually heavy slag caused trouble and delayed heat. Power off furnace from 1:25 to 1:27, from 1:29 to 1:33.

- - -

POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	3500
	Maximum	5000
	Average	4300

Recording Voltmeter:-

Max. swing 6 volts. No swing over 4 volts after first 20 minutes. General character of curve "good".

HEAT NO. 18
OHIO STEEL FOUNDRY NO. 346
Oct. 31, 1918.

- - - -

Power on	12:30 P.M.	K.W.H. Reading	277.9
Power off	2:18 P.M.	K.W.H. Reading	278.6
Time	1:48	K.W.H.(X2400)	0.7
			1680.0

- - -

CHARGE.

	Lbs.	Percent
Turnings	785	12.6
Forgings	2055	33.1
Fdry Scrap	2280	36.7
Shells & Rivets	1095	17.6
	6215	100.0

- -

Foundry scrap compact, heavy, with some large pieces. Bought scrap miscellaneous, with a large number of heavy tube ends and considerable fine stuff.

Foundry scrap started in first. Bought scrap started in when foundry scrap was 90% in. Turnings started in when bought scrap was 75% in. Top coat of turnings. Charge distributed over bottom of furnace, but not leveled. Toward front of furnace.

Rheos started at point 8
" advanced to " 7 at 12:58
" " " " " 6 " 1:12
" " " " " 5 " 1:26
" " " " " 4 " 1:35
" " " " " 3 " 1:43

- - - -

POWER PLANT

Machines on- No. 1 (5000) and No. 3 (2000).

Load-	Minimum	3100
	Maximum	5000
	Average	4200

Recording Voltmeter:-

Max swing 8 volts. Max. swing first hour 6 volts. 8 volt swing at 70 minutes. Only four swing over 4 volts. General character of curve "very good".

TIME-STUDY
FOR
CHARGING ELECTRIC FURNACE
AT
OHIO STEEL FOUNDRY.

Oct. 25/26, 1918.

- - -

HEAT NO.	POURING	PULLING SLAG, REPAIRING	CHARGING	WT. OF CHARGE	NO. MEN CHARGING	TIME FOR HEAT
9-309	4	9	20	6095	5	2:46
10-310	3	14	23	6600	5	2:39
11÷311	4	19	18	6230	6	2:19
12-312	22	25	18	6010	4	2:08
13-313	32	21	14	6060	4	2:04
14-314	8	16	10	6035	5	1:59
15-315	24	19	22	6230	5	2:14
Tentative bogie for complete cycle						
	5	15	15	6000	4	2:00

The time for pouring for heats No. 12, 13 , and 15 was long, because it was necessary to make two trips with the ladle. Note that pouring, and pulling slag and repairing, are for previous heat to one given.

Note that charge for heat No. 14 was made in 10 minutes. The actual time was a few seconds over 9:30.

Above bogie would give 9.3 heats per 24 hours. Allowing for delays and accidents, an average of nine heats seems possible. The furnace is rated at 10 heats per day by its makers.

NOTE:- The record for this furnace to March 1, 1920, about 16 months subsequent to the date of preparing this report, is ten 6000-pound heats in 11 hours and 55 minutes. This marked saving in time has been effected in several ways, notation of which is made in the preface.

CONCLUSIONS

- - -

Following the foregoing tests and observations, the following points have been noted and conclusions drawn from them:-

Near the end of each heat there will be noted on the recording voltmeter chart a few individual swings of considerably greater magnitude than the rest of the curve about them. These are due to the boiling up of the metal into contact with the electrodes when the silicon, manganese, pig iron or ore is thrown into the furnace. These peaks cannot, of course, be avoided.

The reactors have limited the momentary peaks very noticeably, and have greatly reduced the voltage fluctuation at the plant, and, at the same time, have served to stabilize conditions so that by proper adjustment of the shunt rheostats on the contact-making ammeters, the time of the heat has not been increased over what it was formerly. When first installed, there was considerable objection on the part of the Foundry Company, because the heat time was prolonged one-half hour or even more. It was found, however, that by the aforesaid adjustment of the shunt rheostats that this time could be brought down to two hours instead of two and a half hours or two hours and forty minutes, without in any way impairing the plant operation. As nearly as can be determined, the reactors have reduced the power factor very little,- probably not more than 2 or 3%. As far as the foundry motors are concerned, the operation is markedly better, since the amplitude of the voltage fluctuation has been greatly reduced, and it has been noted that the motors are running much cooler than before the reactors were installed. It is difficult to determine just what effect the reactors have had upon the plant peak, but they have certainly reduced the momentary peaks and the rapid fluctuation in power and voltage upon the turbo-alternators.

During the last ten heats, a study was made of the results to be obtained by adjustment of the shunt rheostats on the contact-making ammeters. The function of these rheostats, as shown on General Electric Drawing No. 31566*(see pocket in back of book), is to shunt a portion of the current supplied to the contact-making ammeters by the three current transformers mounted in the secondary busses. Thes contact-making ammeters are adjusted to maintain a certain current at the arc, and shunting any portion of this current tends to increase the total current flowing. It was determined that by means of proper adjustment of these rheostats, not only could the starting peaks be reduced, but also the total time for the heat could be reduced, and probably controlled. After approximately the first thirty minutes, conditions become quite stable, and it is then feasible to begin cutting part of the resistance of the rheostats. Following the study made, the accompanying curve was plotted to show the proper method of adjustment of these rheostats, as nearly as it could be determined for average conditions. This curve or schedule should be carefully followed, in order to give the best operation and to reduce the time per heat as much as possible.

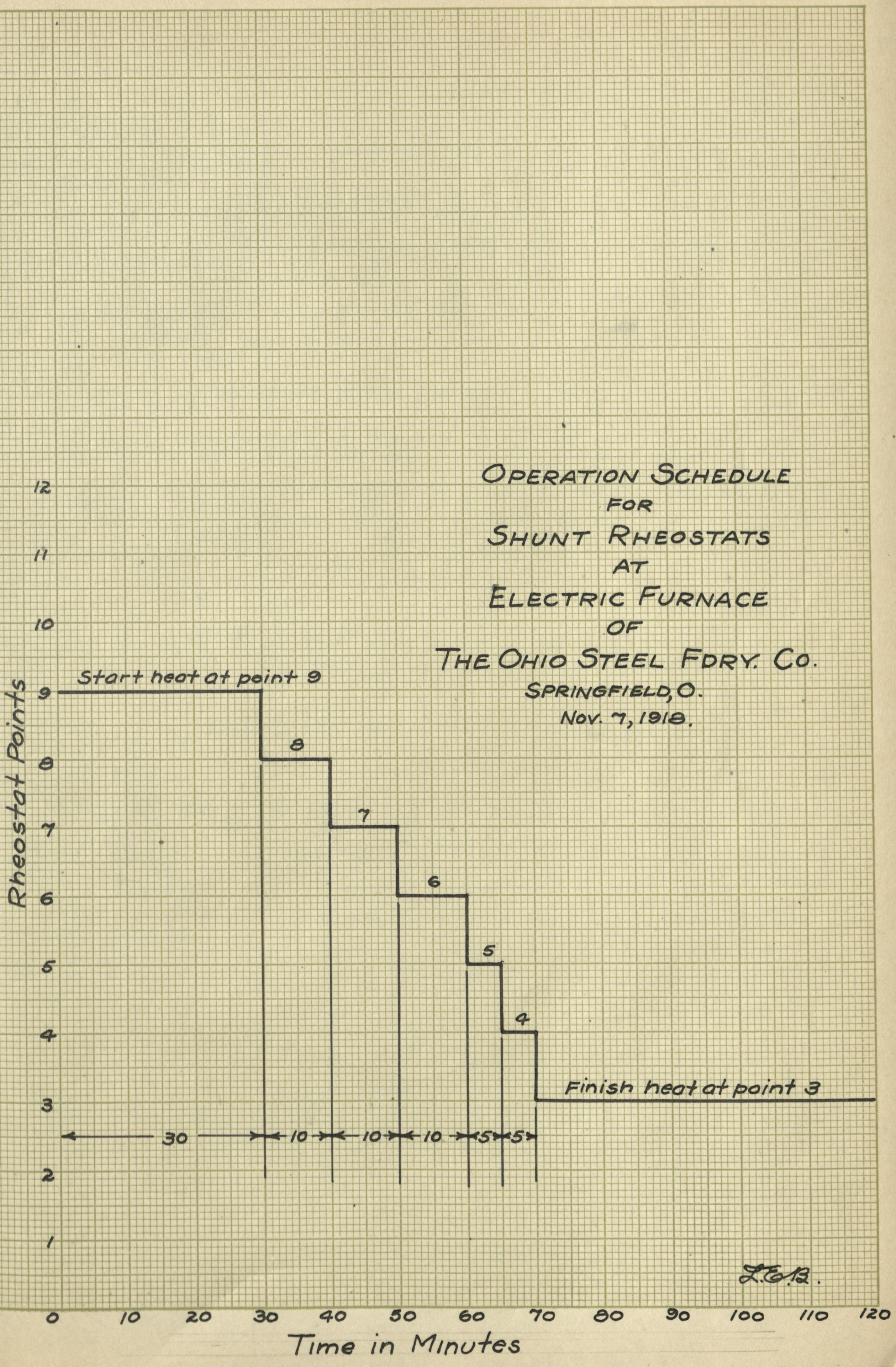
The study of the operation indicates that the conditions are somewhat more stable with the neutral switch closed, and therefore this switch, which is mounted on the side of the furnace, should be kept closed, except, of course, when samples are being taken.

By observing this schedule, the operation should be such that the maximum voltage fluctuation indicated upon the plant recording voltmeter is not more than 6 volts during the day and evening when the normal load is comparatively large and Machine No. 1 (5000 K.W.) is in use. The fluctuation is still quite serious at night when the normal load is light and the two small machines (2000 K.W. each) are in use. The trouble seems to be more with the use of the small machines than with the size of the normal load.

The effect of the reactors and of a proper manipulation of the rheostats will be to reduce materially the wear and strain upon the equipment of the Ohio Steel Foundry Company, as well as upon the equipment of the Power Company, and since the time per heat has not been increased, the reactors are a benefit to both companies.

As far as the maximum demand is concerned, it is approximately the same as before the reactors were installed, due to the fact that whereas the momentary peaks are less, the stabilized conditions have resulted in a more continuous use of power over the 15-minute interval. However, the demand is less than it would be if the reactors had not been installed and at the same time the adjustment of the shunt rheostats were carried out.

* See page 48



OPERATION SCHEDULE
FOR
SHUNT RHEOSTATS
AT
ELECTRIC FURNACE
OF
THE OHIO STEEL FDRY. CO.
SPRINGFIELD, O.
Nov. 7, 1918.
Start heat at point 9
Finish heat at point 3
8
7
6
5
4
30
10
10
10
5
5
Rheostat Points
1
2
3
4
5
6
7
8
9
10
11
12
0
10
20
30
40
50
60
70
80
90
100
110
120
Time in Minutes
L.E.B.

A test was made of the voltage and current on one of the reactance coils, and from the readings taken, the impedance calculated. It will be noted on the curve, plotted from these readings, that the line, if drawn according to the values plotted, would not pass throught the zero point. The explanation of this is that the iron frame and pipe work from which the coils are suspended act as a core which becomes saturated at a very low current value.

The main object of the study, as originally outlined, namely that of the proper method of charging the furnace, was somewhat obscured by the discovery that the results desired were to be obtained by the adjustment of the rheostats, and as nearly as can be determined, the method of charging does not seriously affect the operation. In general, however, the following procedure should be observed:-

> Place large, heavy foundry scrap in the bottom. When the foundry scrap is about half in, start in the bought scrap, and when the bought scrap is about half in, start in the turnings, so that when the bought scrap is about all in, about two-thirds of the turnings will remain to be thrown in.

The idea is to keep all heavy and large material in the bottom and gradually grade the charge so that the fine material is at the top. It is not necessary to level the charge, but as nearly as possible uder the average working conditions, it should be distributed over the furnace and the central peak should be located centrally with respect to the electrodes.

MEASUREMENT OF REACTANCE OF EXTERNAL REACTORS AT OHIO STEEL FOUNDRY CO.

Oct. 25, 1918.

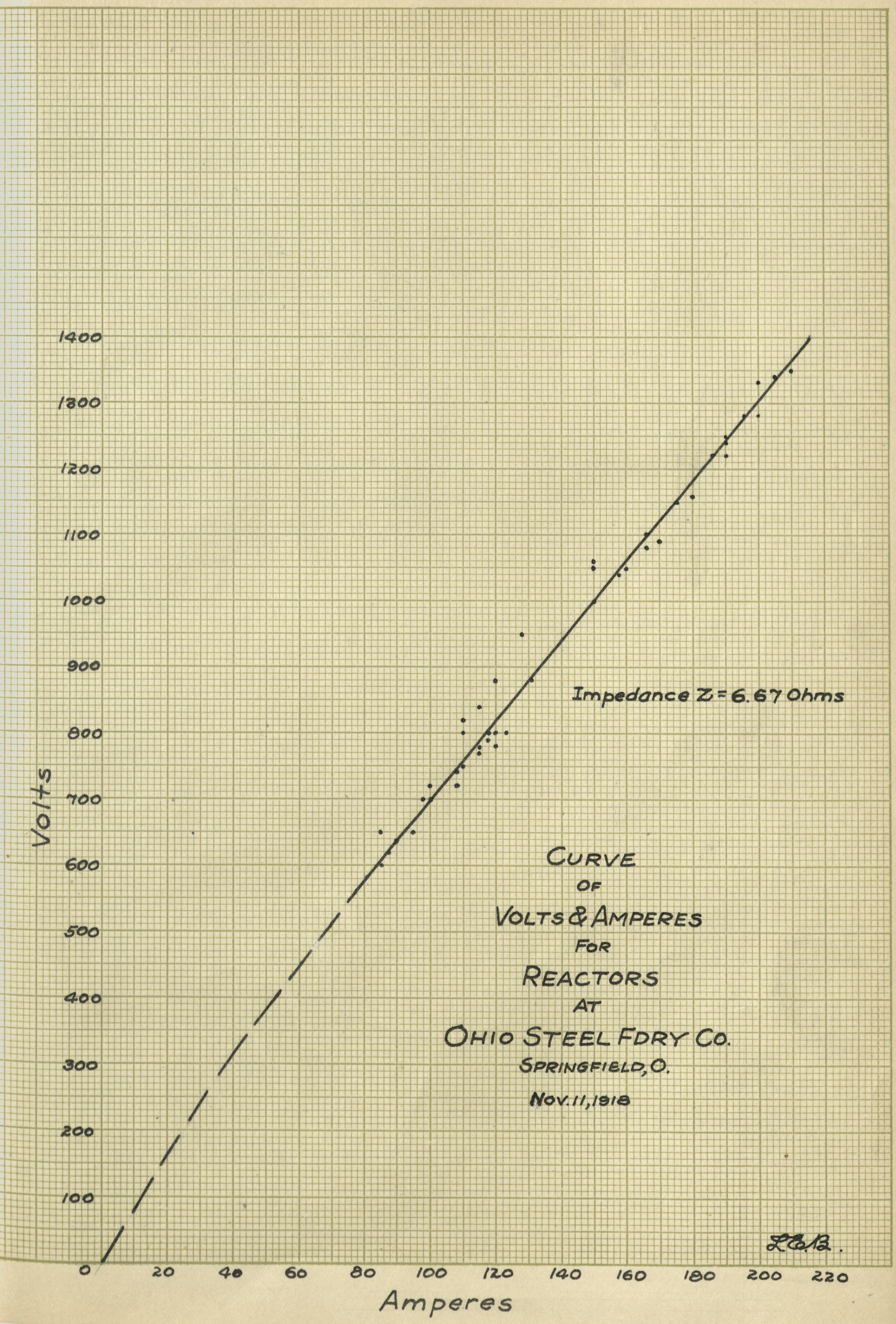
TEST NO. 1

Volts (X20)	Amps. (X50)
30.0	1.7
37.5	2.2
32.0	1.8
39.0	2.3
38.0	2.3
35.0	2.0
40.0	2.4
37.0	2.15
40.0	2.35
39.0	2.35
35.0	1.95
32.5	1.9
31.0	1.75
41.0	2.4
35.0	2.0
36.0	2.15
39.0	2.4
40.0	2.45

TEST NO. 2

Volts (X20)	Amps. (X50)
41.0	2.2
44.0	2.6
36.0	2.0
32.5	1.7
40.0	2.2
42.0	2.3
47.5	2.8
46.0	2.55
44.0	2.4
64.0	4.0
62.0	3.8
62.5	3.8
52.5	3.2
55.0	3.3
54.0	3.4
61.0	3.7
54.0	3.3
58.0	3.6
50.0	3.0
52.0	3.15
65.0	3.6
61.0	3.8
66.5	4.0
67.0	4.1
57.5	3.5
53.0	3.0
53.0	3.0
67.5	4.2
52.5	3.0
64.0	3.9
62.5	3.9

See attached curve for calculation of impedance Z (6.7 Ohms).



Volts
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
20
40
60
80
100
120
140
160
180
200
220
Amperes
Impedance Z = 6.67 Ohms
CURVE
OF
VOLTS & AMPERES
FOR
REACTORS
AT
OHIO STEEL FDRY CO.
SPRINGFIELD, O.
NOV. 11, 1918
L.E.B.

ENGINEERING REPORT

OF

PROPOSED POWER SUPPLY

TO THE

NORTHWESTERN OHIO LIGHT COMPANY,
URBANA, OHIO

BY

THE SPRINGFIELD LIGHT, HEAT, & POWER CO.,
SPRINGFIELD, OHIO.

Compiled by: L.E.B.
Jan. 26, 1920

Copies to: E.J.B.
F.A.N.
C.W.J. (L.R.P.)
C.H.P.
File

PREFACE

- -

This report, covering the details of the proposed supply of energy by the Springfield Light, Heat, & Power Company, Springfield, Ohio, to the Northwestern Ohio Light Company, at Urbana, Ohio, is given exactly as prepared for the consideration of the officials of Hodenpyl, Hardy & Company. Items which are clear to them may not be so obvious to the casual reader, and for that reason the following explanatory notes will be given:-

The initials to be noted on the cover sheet indicate the following officials and employees:

E.J.B. - E.J.Bechtel, Vice-President and Chief Electrical Engineer, Hodenpyl, Hardy & Co., New York City.

F.A.N. - F.A.Newton, Rate Engineer, Hodenpyl, Hardy & Co., Jackson, Michigan.

C.W.J. - C.W.Johnson, New Business Manager, Hodenpyl, Hardy & Co., Jackson, Michigan.

L.R.P. - L.R.Parker, Assistant to Mr. Johnson, in charge of Power Sales.

C.H.P. - C.H.Purdy, Commercial Engineer, Springfield Light, Heat, & Power Company, Springfield, Ohio.

In addition to these, there occur in the body of the report the initials C.I.W. and J.B.B., indicating respectively C.I.Weaver, General Manager, and J.B.Bronson, Distribution Engineer, of the Springfield Light, Heat, & Power Company.

On account of the fact that the Springfield company had on hand and idle, 3-400 K.V.A. 2300 to 13,200 volt transformers, and because a 13,200 volt line could be tied to the Urbana company's lines without the installation of step-down transformers or other equipment, the first plan considered was that of the installation of a 13,200 volt substation and line. The line was to be No. 1 B.& S. Gage copper, because that would be the approximate economic size with a load of 2000

K.W. at the prevailing power factor and a line voltage of 33,000 (It would be necessary to go to a higher voltage than 13,200 when the load increased beyond 1000 K.W., and 33,000 is standard with the Northwestern Ohio Light Company, as well as 13,200). However, when the load becomes 2000 K.W., Urbana would be too important to be dependent upon a single transmission line, and an additional line over another route, or local steam standby, would be necessary. For that reason, and on account of the high price of copper, No. 4 B.& S. Gage was decided upon, as was also the voltage of 33,000. The table on page 2 shows clearly the reason for this choice, from a financial point of view. With the estimated increase in load (see page 8), the pointtof most economic operation of the line would come in 1923. It is understood, of course, that this point of most economic operation of the line occurs at the point at which the cost of the line losses is equal to the fixed charges (interest, depreciation, taxes, and insurance) on the copper.

Gross Revenue includes the total billing receipts. Gross Income includes only the amount left after the deduction of the Operating Expenses, including Maintenance & Clerical, from the Gross Revenue. Gross Income must, therefore, provide for the items of depreciation, taxes, insurance, and last and most important of all, interest on the Investment. Depreciation is arbitrarily taken at 4%, Taxes and Insurance at 2%, and return at 8% as a minimum. In connection with this, the fact confronts us that 8% is not an adequate return for this class of investments. The table on page 2 summarizes the Gross Incomes from the various proposed plans in percentages of the Total Investment. A percentage below 14 indicates a return of less than 8%, whereas a percentage above 14 indicates a return of more than 8%, assuming that 6% will cover Depreciation, Taxes, and Insurance. The "Margin", shown on the sheets "Details of Load, Investment, Operating Expenses, and Revenue", pages 15 to 23, is the difference between the Gross Income and the sum of the Operating Expenses and 14% of the Investment. In other words, it shows the amount available for interest and dividends after the accepted minimum of 8% has been secured.

The overhead items in the estimates are explained by the following extract from Hodenpyl Hardy Circular Letter No. 1147-G:-

CONSTRUCTION ESTIMATES AND EXPENDITURES

Overhead Charges

* * * * * * * * * * *

Compilation of Construction Estimates -

	A Material	B Labor
1-Total of Detailed Estimate	$	$
2-Contingencies at rates used by your company (10%), computed on 1-A and 1-B	$________	$________
3-Total Estimate for Material and Labor	$	$
4-Injuries & Damages at rates outlined in C.L. 1068-B, or as amended by special letter, computed on 3-B (6.6% for Transmission)	- -	$
5-Office & Local Management at rates prescribed for your company (4%), computed on 3-A and 3-B. (For companies that carry this item as an accrued account)	- -	$
6-Construction Engineering at rate prescribed for your company (6%), as outlined in C.L. 1147-E or as amended by special letter, computed on 3-A and 3-B	$________	$________
7-Total of 3,4,5, and 6	$	$
8- Interest during Construction at rate prescribed for your company, as outlined in C.L. 1103 and 1103-A or as amended by special letter, computed on 7-A and 7-B	$________	$________

9-Total Estimated Cost $ $

NOTE:- Interest is not figured on estimates amounting to less than $2500.00, nor for estimates made for work which will require less than 60days for execution.

- - - - -

It is understood throughout the report that the energy sold to the Northwestern Ohio Light Company will be metered at the transmission line terminus at Urbana, at the transmission potential.

It will be noted on page 11 and in Estimates VI and VII, pages 27 and 28, that provision is made for the installation of special switches for one transformer of the proposed closed-delta bank. The expenditure for this will total about $750.00 for the 33,000.volt station, including Labor and the overhead items. That this expenditure is justified is proved as follows:-

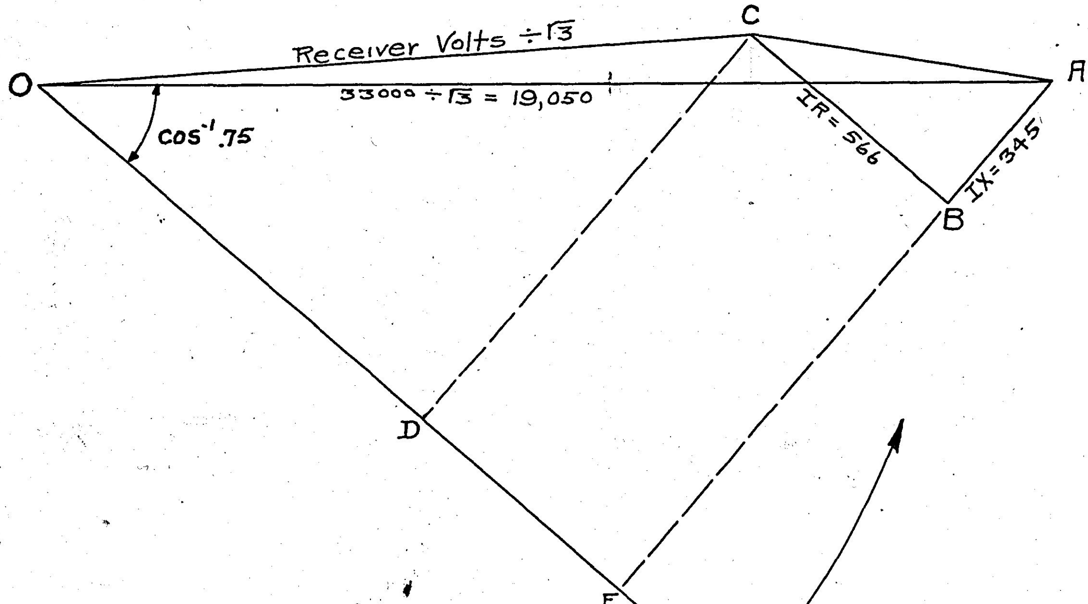
Total hours per year - - - - - - - - -	8760
Hours requiring 3 transformers - - -	2860
Difference - - - - - - -	5900

The estimated saving in copper and iron loss, which is largely iron loss, will be about 1% of the transformer rating, or 6.67 K.W. Over the period of a year, this will be 6.67 X 5900, which approximately equals 40,000 K.W.H. and is the equivalent of $400.00, at the energy cost of 1¢ per K.W.H. delivered to the switchboard. This saving justifies an investment of $2860.00, allowing 14% for Interest, Depreciation, Taxes, and Insurance, or yields a return of approximately 55% on the total cost of the extra switches ($750.00).

On the next page is given a sample calculation of the line drop, showing how the figures in the table on page 9 were obtained. This calculation is for the conditions obtaining in 1922. The effect of the charging current is negligible and is not considered. Note that for ease in calculating, the power factor is that at the generating end, and the percent drop is based upon the voltage at the same end. The route is by way of Tremont and Westville.

SAMPLE LINE CALCULATION

Voltage at generator end - 33,000
Frequency 60-cycles. Spacing 59 inches.
Length of line 18½ miles, which equals 97.9 M feet.
Total Resistance of one wire- 24.3 ohms. } Wire No. 4
Total Reactance of one wire- 14.8 ohms. } B.& S. Gage.
Load 1000 K.W. at 75% power factor.
Line current obtaining- 23.3 amperes.



Receiver volts - $\sqrt{3}$ OC
OC equals $\sqrt{\overline{OD}^2 \text{ plus } \overline{CD}^2}$

OD equals 19050 X 0.75 minus 566, equals 13734
CD equals 19050 sin($\cos^{-1}$ 0.75) minus 345, equals 12225

OC equals 18,400
Receiver volts - 31,900
Percent drop - 3.3

NOTE:- Results are from slide-rule operation.

February 14, 1920.

INDEX

- - - - -

SUMMARY OF
LOAD, REVENUE, & INVESTMENT.

- - -

	1920	1921	1922	1923	1924
K.W.Demand (est.)	750	1850	1000	1200	1450
K.W.H. Cons. "	2250000	2550000	3000000	3600000	4350000
* Gross Revenue:-					
Schedule "B" - -	$43,500.00	$49,100.00	$57,500.00	$68,700.00	$82,700.00
Schedule "C"	45,200.00	51,000.00	59,750.00	71,400.00	85,960.00
* Rev. per K.W.K. (in cents):-					
Schedule "B" - - -	1.93	1.925	1.915	1.905	1.9
Schedule "C"	2.01	2.00	1.99	1.985	1.975

* Not including sale of energy to Tremont and Westville. For details of such sale, see pages 2, 23, 24, and 25.

Investment in Substation Equipment and Line by S.L.H.& P. Co.:-

Route via Tremont & Westville, not serving them - - - - $59,000.00
Route via Tremont & Westville, serving them - - - - - 61,000.00
Route via Erie Railroad right of way - - - - - - - - - 53,000.00

33,000 volt, No.4 B.& S. Gage Copper line, 3-667 Kva. Transformers.
Station Investment at $100100 per K.W. of 15-minute demand.

<u>Erie Route preferred</u>

TABLE SHOWING GROSS INCOME
IN PERCENT OF
TOTAL INVESTMENT.

- - - - -

	1920	1921	1922	1923	1924	Details on page
SCHEDULE "B":-						
13200 V.#1 Line via Tremont	12.75	13.3	14.0	14.6	15.0	15,16
33000 V.#1 and Westville, but	12.6	13.25	14.3	15.35	16.3	17,18
33000 V.#4 not serving them.	13.5	14.2	15.05	15.95	16.8	19,20
*1 33000 V.#4 Line via Erie R.R.	14.5	14.8	15.7	16.6	17.4	21,22
*2 33000 V.#4 " serving Tremont and Westville.	13.7	14.65	15.6	16.5	17.25	23,24,25
SCHEDULE "C":-						
13200 V.#1 Line via Tremont	14.0	14.7	15.4	16.1	16.7	15,16
33000 V.#1 and Westville, but	13.8	14.6	15.65	16.8	17.8	17,18
33000 V.#4 not serving them.	14.7	15.5	16.45	17.5	18.4	19,20
*1 33000 V.#4 Line via Erie R.R.	15.45	16.2	17.2	18.2	19.05	21,22
*2 33000 V.#4 " serving Tremont and Westville.	14.95	15.95	16.95	18.0	18.8	23,24,25

*1 First choice of route.
*2 Second choice of route.
Rate Schedule "C" recommended.

NOTE:- Schedules "B" and "C" apply only to energy sold to the Northwestern Ohio Light Company, and not to that sold to Tremont and Westville.

TABLE OF
PROPOSED RATE SCHEDULES.

- - -

RATE SCHEDULE "B" -

$30.00 per K.W. per year- first 100 K.W. of demand.
25.00 per K.W. per year- next 100 K.W. of demand.
20.00 per K.W. per year- all over 200 K.W. of demand.

1½¢ per K.W.H.- first 100 hrs. use per mth. of max. demand.
1 ¢ per K.W.H.- all over 100 hrs. use of max. demand.

RATE SCHEDULE "C" -

$30.00 per K.W. per year- first 100 K.W. of demand.
25.00 per K.W. per year- next 100 K.W. of demand.
20.00 per K.W. per year- all over 200 K.W. of demand.

1½¢ per K.W.H.- first 100 hrs. use per mth. of max. demand.
1⅛¢ per K.W.H.- all over 100 hrs. use of max. demand.

The maximum demand interval is 15 minutes.

Note that the demand charge is the same for both rates.

Schedule "C" is recommended.

MARKET- PRESENT AND FUTURE.

- - - -

With reference to present business, the following larger companies are taking their power from the plant at Urbana:-

Greenville Gravel Pit. - Owned by the Big 4 Railroad. Is supplied by a 12-mile, 13200 volt transmission line and 3-100 K.W. transformers, and according to Mr. Auger, local Manager at Urbana for the Northwestern Ohio Light Company, they expect to operate three more years in the present location. At the end of that time, when it it is estimated the gravel supply will be exhausted, they will probably move to another location across the road, an option on which they now hold.

The Desmond & Stephens Company. - Manufacturers of emery wheel dressers, have a connected load of 10 horsepower.

The United Paper Board Company.x- Are absorbing about 100 horsepower.

The Johnson Manufacturing Company. - Have 90 horsepower in motors.

The Urbana Broom Company. - Have 30 horsepower.

The Urbana Tool & Die Company. - 30 horsepower.

The Murphy Lumber Company. - 80 horsepower.

The Urbana Packing Company. - 150 horsepower.

The W.B.Marvin Company. - 100 horsepower.

In addition to the above industries and some minor power and the lighting load at Urbana, the plant supplies 13200 volt transmission lines supplying the following small towns:-

Mechanicsburg	Woodstock	Middleburg
Catawba	North Lewisburg	East Liberty
Mutual	Cable	West Mansfield

Except in the case of North Lewisburg and East Liberty, the company does a retail business. In these two towns they wholesale to a local company. Mr. Auger states that they greatly prefer to retail the current themselves, on account of the fact that in nearly all cases the local companies will not push the development of their markets or the sale of appliances.

With respect to future business, there is considerable room for development. A number of plants are at the present time operating with gas engines, and others by steam equipment. The gas situation in this section of Ohio is becoming more acute each year, and during December and January of 1919 and 1920, rsepectively, all factories depending upon gas have suffered from the shortage.

The Howard Paper Company has a steam plant of 2400 horsepower engine capacity, which plant they have been repairing quite extensively, installing a new stack and other equipment. Mr. F.H.Hooper, Vice-President of the Northwestern Ohio Light Company, with headquarters at Lima, states that 150 horsepower of the Howard Paper Company's load can be secured for central station service whenever they have the capacity to handle it. This load is too far removed from the rest of the factory to permit line-shaft operation.

The Central Glass Company may start operations again, with need for approximately 100 horsepower.

The villages of Tremont and Westville want service, and this fact would be of considerable assistance in the matter of securing right of way through these two towns, in case it should be decided to build the line over that route.

PLANT DESCRIPTION AND DATA, URBANA.

- - -

The power plant at Urbana consists of the following major equipment:-

1-500 K.W. Curtis turbo-alternator, operating condensing at a steam pressure of 160 pounds gage and an average vacuum of 28 inches.

1-250 K.W. Woods System alternator, direct-driven by a Buckeye engine, which is operating non-condensing.

2-250 horsepower hand-fired boilers.

2-250 K.V.A., 2300 to 13,200 volt, 60-cycle, indoor type, oil-insulated, self-cooled, transformers.

Necessary switchboard equipment.

The ordinary 15-minute peak load delivered to the switchboard is about 550 K.W. The 15-minute peak for the period December 1, 1918 to December 1, 1919, was 670 K.W., and occurred at 5;00 P.M. on October 30, 1919. The K.W.H. delivered to the switchboard for this period was 2,081,544, the load factor was 35.4 %, and the coal in pounds per K.W.H. delivered to the switchboard 5.52 . The monthly coal consumption for this same period was as follows:-

December 1918	1059288
January 1919	1040374
February	824477
March	867890
April	839480
May	956525
June	1027289
July	960075
August	1033727
September	925898
October	984741
November	973390
Total - -	11493154

The demand and consumption data for four representative months of the period are as follows:-

	Max. 60-min. peak	Cons.	Load Fac.
January	420	159490	51.0 %
April	410	141230	47.8
July	470	194592	55.5
October	560	201978	48.4

The figures used in the above tabulation and in the accompanying curves, it will be noted, are the maximum average load over an hour's period, which makes the load factor considerably higher than would be obtained on the basis of a 15-minute interval. However, the load factor for the period from December11, 1918 to December 1, 1919 has been on the 15-minute peak of 670 K.W. which occurred at 5:00 P.M., Thursday, October 30, 1919, and which actually lasted about 20 minutes.

The coal per K.W.H. delivered to the switchboard for this period seems rather high, but Mr. Auger confirms the figure and explains that during the summer of 1919 he received a considerable amount of very poor coal and that also, he had to charge off during this year a certain shortage which came up. It will be noted that the coal per K.W.H. for December 11,1919 (load curve for which day is shown) was 4.8 pounds. On Sunday, when it is necessary to operate the Buckeye engine in order to permit inspection of the turbine and cleaning of the condenser, the coal per K.W.H. delivered to the switchboard runs as high as 7.0 or 8.0 pounds.

Mr. Auger states that the average power factor at the plant is 70 percent.

The distribution system at Urbana is in reasonably good shape; probably better than in the average town of the same size. A considerable amount of tree-trimming is necessary, or at least desirable, although Mr. Auger says that they have had no serious trouble from this source.


Monthly peak is on a 60 minute basis and
load factor is figured on same basis.
POWER STATION CURVES
FOR
NORTHWESTERN OHIO LIGHT CO
PLANT
AT
URBANA, OHIO
L.E.B 12-3-19
Pounds of Coal
Monthly
1918-1919
Future Growth
1919 1920 1921 1922 1923 1924
Monthly Load Factor 1919
Monthly Peak 1919
Monthly Output
in K.W.H. 1919
LOAD CURVE
Mon. Dec 1, 1919
(Gravel Pit not working)
520 K.W. 7500 K.W.H.
Coal 4.8 lbs. per K.W.H.
×1000 = K.W.H. OUTPUT
210
200
190
180
170
160
150
K.W. Load ×1,000 = Lbs Coal ÷10 = Load Factor in %
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
MN 1 2 3 4 5 6 7 8 9 10 11 M 1 2 3 4 5 6 7 8 9 10 11 MN
A.M.
P.M.
Dec 1918
Jan.
Feb.
Mar.
Apr.
May
June 1919
July
Aug
Sept
Oct.
Nov.
Dec.
E.L.F.
JAN. 27, 1919

DESCRIPTION OF
PROPOSED SUBSTATION AND LINE.

- - -

The two routes shown on the accompanying map have been selected in preference to two or three others, on account of the fact that they are quite free from trees and pole lines, and are on high ground. In addition to this, they follow the only feasible way for us to leave the city with a 33,000 volt line,- over the Victor Rubber pole line to Maitland. The route by way of the Erie Railroad is better than that by way of the D.T.& I. and the Valley Pike, because of the fact that it is shorter, straighter, and almost entirely free from trees. The other routes considered are fully occupied by telephone and other power lines, notably the Ohio Electric, or are badly built up with trees, or are over low, swampy ground.

We investigated the possibility of building our line to Urbana over the same pole lead with the Ohio Electric, but their lines are in bad condition and would constitute a hazard to our service, and at many points it would be impossible to place another 33,000 volt circuit on the poles without going to considerable changes in the construction.

Neglecting the effect of the current to supply the villages of Tremont and Westville, the voltage drop at the yearly peaks for No. 4 B.& S. Gage solid copper wire and a line potential at Springfield of 33,000 volts, assuming a power factor of 75 %, would be as follows:-

		VOLTS DROP IN PERCENT	
YEAR	K.W.	TRE'T & W'LLE	ERIE R.R.
1920	750	2.4	2.0
1921	850	3.0	2.5
1922	1000	3.3	2.8
1923	1200	4.1	3.4
1924	1450	5.2	4.3

The line by way of Tremont and Westville would be approximately 18½ miles long, by way of the Erie Railroad approximately 15½ miles long.

For map showing proposed routes, see pocket on inside of rear cover.

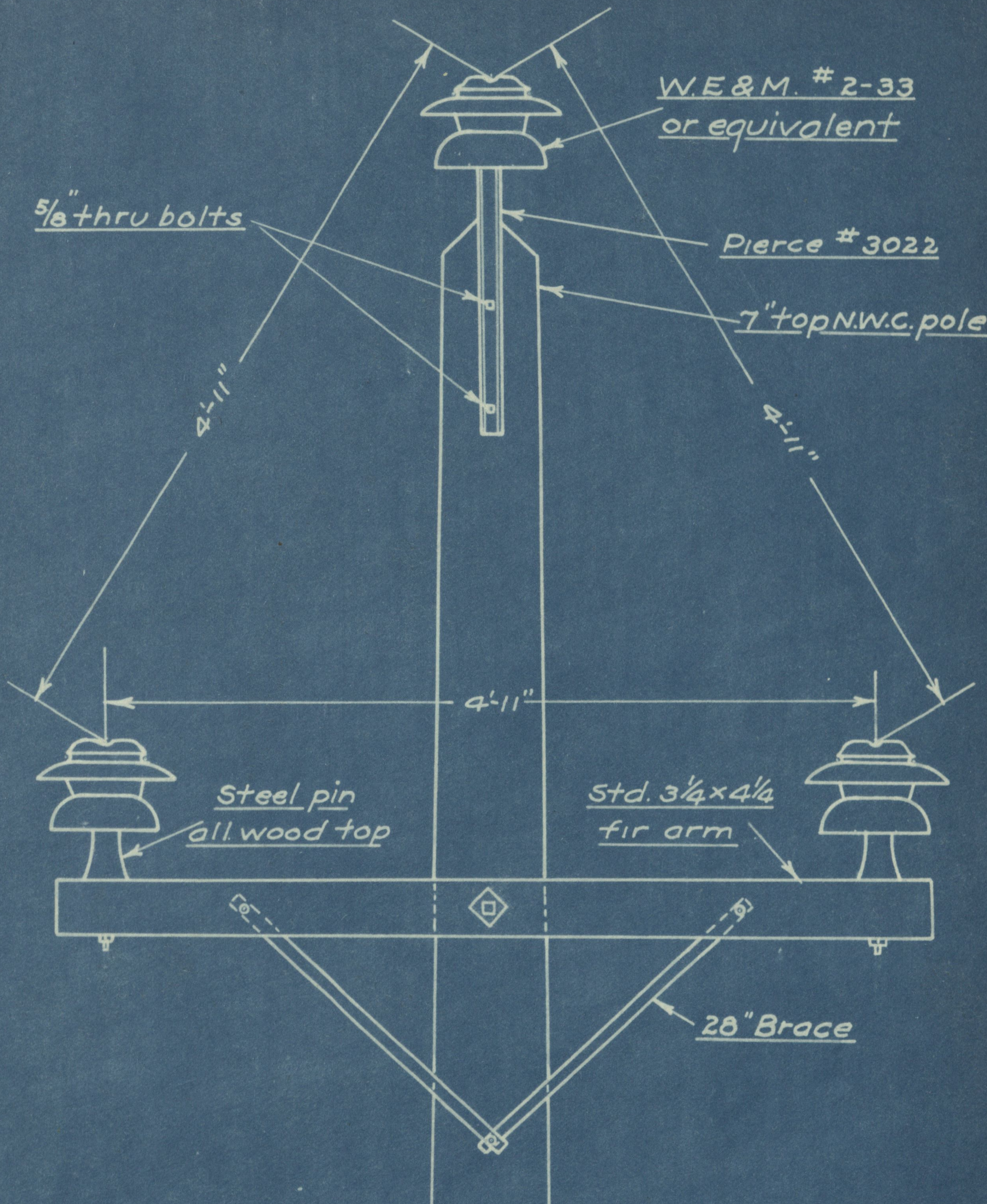
The poles shall be Northern White Cedar, 7-inch tops, strictly woods run, treated in accordance with the specifications of the "B" Treatment. The lengths will, of course, depend upon the location, but the larger percentage will be 35-foot poles, and this length will be the minimum.

The attached prints show fully the proposed line construction for straight-away locations, and for crossing and dead-end locations.

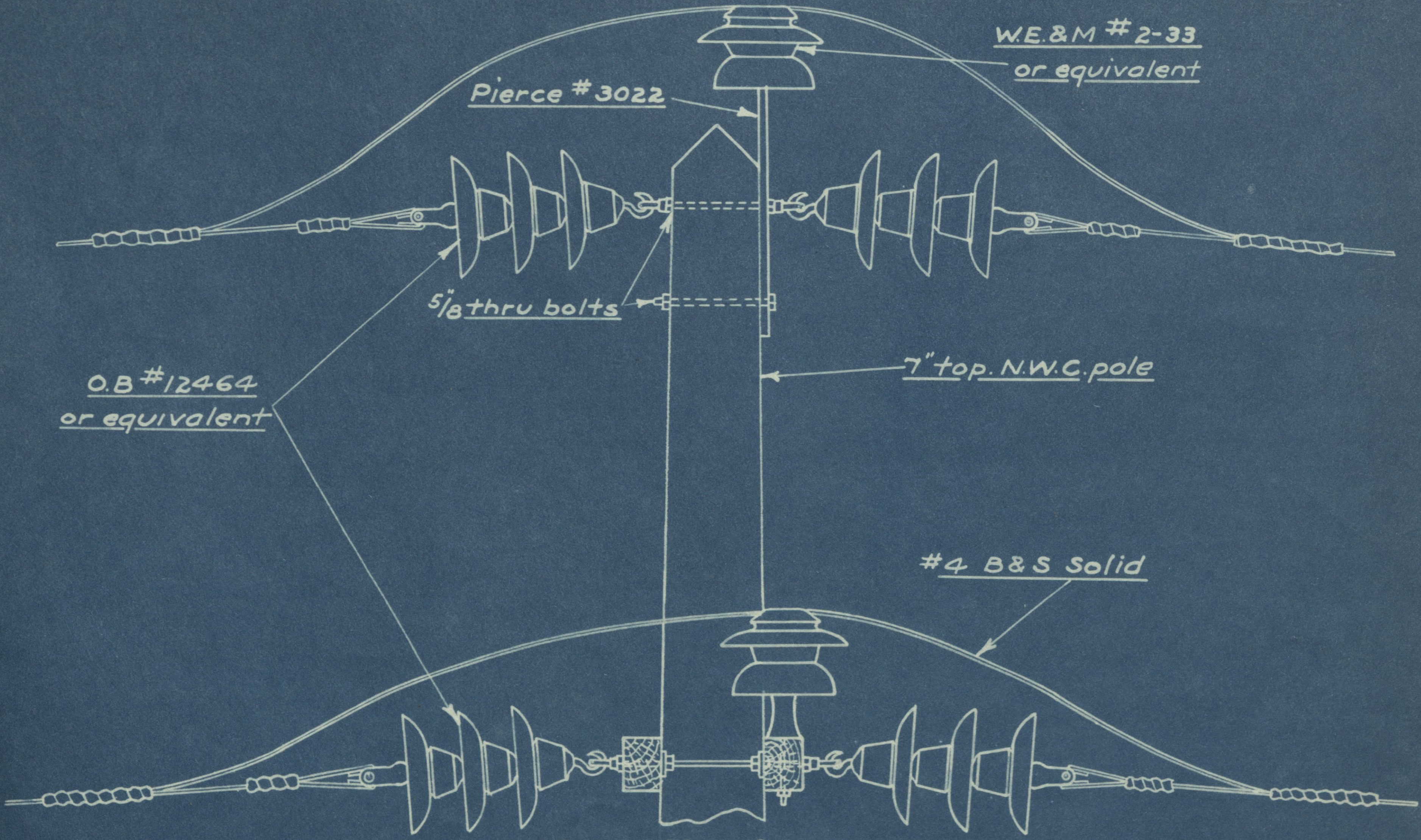
Poles will be properly guyed where necessary, and in general the construction will be such as to render the maximum of reliability and to reduce troubles and service interruptions to a minimum.

The step-up substation at Springfield will consist of 3-667 K.V.A. transformers, 60-cycle, 6600 to 33000 volt, outdoor type, oil-insulated, self-cooled, controlled by an automatic switch on the low-tension side, and protected from lightning and other transient disturbances on the high-tension side , by an electrolytic or oxide-film arrester. One transformer unit will not be put into service at once, but will be necessary from the viewpoint of assured service. When put into service, it will be provided with a non-automatic oil switch on the low-tension side and an air-break switch on the high-tension side, so that at periods of light load it can be removed from the line, thus reducing the transformer iron losses.

The accompanying sketch shows the proposed station and line arrangement, including the supply of energy to Tremont and Westville.



STRAIGHT LINE
CONSTRUCTION

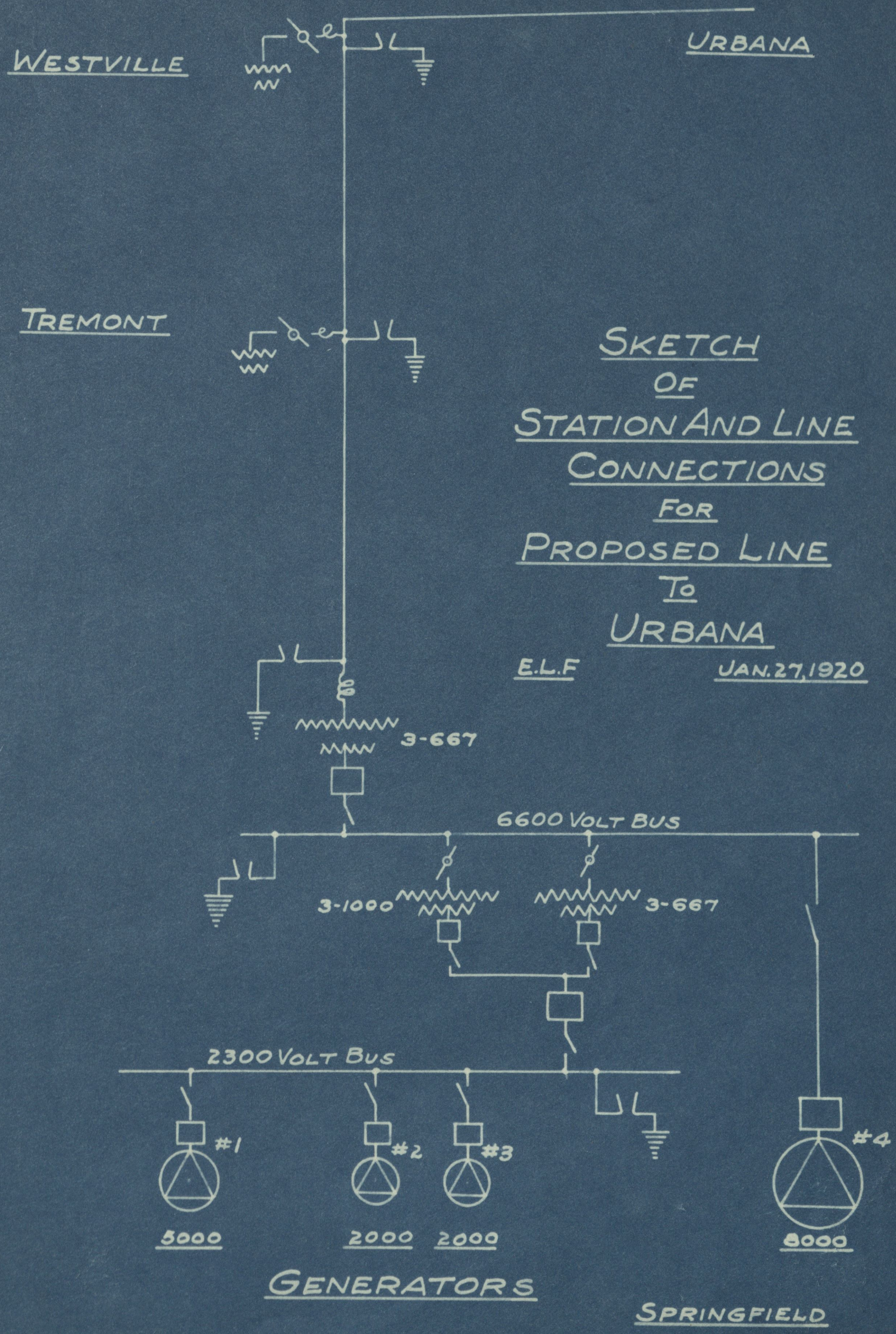


DEAD END & CROSSING
CONSTRUCTION

Sketch of Station and Line Connections for Proposed Line to Urbana

E.L.F

Jan. 27, 1920



DETAILS OF LOAD, INVESTMENT,
OPERATING EXPENSES, & REVENUE.

- - - - -

13,200 VOLT LINE, No. 1 COPPER, VIA TREMONT & WESTVILLE,
BUT NOT SERVING THEM.

- - - -

		1920	1921	1922	1923	1924
K.W.Demand - - - - - - - - - - - - -		750	850	1000	1200	1450
K.W.H. Consumption - - - - - - -		2,250,000	2,550,000	3,000,000	3,600,000	4,350,000
Line loss in K.W.H. - - - - - -		143,000	183,000	253,000	365,000	532,000
Transf. loss in K.W.H. - - - - -		150,000	160,000	175,000	195,000	225,000
Total K.W.H. dlvd to swbd -		2,543,000	2,893,000	3,428,000	4,160,000	5,107,000
Station Investment - - - - - - -		$75,000.00	$85,000.00	$100,000.00	$120,000.00	$145,000.00
Substation and line - - - - - -		58,800.00	58,800.00	58,800.00	58,800.00	58,800.00
Total Investment - - - - - -		$133,800.00	143,800.00	158,800.00	178,800.00	203,800.00
Int.,Dep.,Taxes, & Ins.@14%		$18,750.00	$20,150.00	$22,250.00	$25,050.00	$28,500.00
Cost of energy @1¢ K.W.H. swbd		25,430.00	28,930.00	34,280.00	41,600.00	51,070.00
Maintenance & Clerical - - - -		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total Cost of service - - - -		$45,180.00	50,080.00	57,530.00	67,650.00	80,570.00
Schedule "B"	Revenue - - -	$43,500.00	$49,100.00	$57,500.00	$68,700.00	$82,700.00
	Margin - - - - -	1,680.00	980.00	30.00	1,050.00	2,130.00
Schedule "C"	Revenue - - -	$45,200.00	$51,000.00	$59,750.00	$71,400.00	$85,960.00
	Margin - - - - - -	20.00	920.00	2,220.00	3,750.00	5,390.00
Cost of line I^2R loss - - - - - -		$1430.00	$1830.00	$2,530.00	$ 3,650.00	$5,320.00
Int.,Dep.,Taxes,Ins. on copper -		2310.00	2310.00	23310.00	2,310.00	2,310.00

Most economic point between 1921 and 1922.

ENG. BLDG

106

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. I

DISTRIBUTION ~~DISTRICT~~/DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Install 13200 volt 1200 K.V.A. substation and build 33000 volt No.1 copper line to serve the Northwestern Ohio Light Company at Urbana. Route by way of Tremont and Westville, but not serving them.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No.

REQUESTED 12-1 1919 BY C.I.W.	APPROVED 191 BY		CHF. ENGR.
MADE 12-10 1919 BY J.B.B.	" 191 BY		MGR.
CHKD 12-12 1919 BY L.E.B.	" 191 BY		GEN. MGR.
CTFD 191 BY	AUTHORIZED 191 BY		PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
Substation (See Est. VI, page 27)		5,750	00	750	00
Poles		11,500	00	3,000	00
X-arms		900	00	250	00
Insulators		4,400	00	200	00
Pins		560	00	100	00
Guys and anchors		200	00	200	00
Wire- No. 1 B.& S. Gage		16,500	00	1,500	00
Dead-ends		300	00	200	00
Rightof way		1,000	00		
Freight and cartage		500	00		
Contingencies @ 10 %		4,150	00	600	00
Injuries and damages				400	00
Office and Local Management @ 4%				2,100	00
Construction Engineering @ 6%		2,740	00	400	00
Interest during Construction		500	00	100	00

ACTUAL COST MATERIAL $

ACTUAL COST LABOR . $

TOTAL ACTUAL COST . $

ESTIMATED COST MATERIAL $ 49,000.00

ESTIMATED COST LABOR . $ 9,800.00

TOTAL ESTIMATED COST . $ 58,800.00

DETAILS OF LOAD, INVESTMENT,
OPERATING EXPENSES, & REVENUE.

- - - - - -

33000 VOLT LINE, No. 1 COPPER, VIA TREMONT AND WESTVILLE,
BUT NOT SERVING THEM.

- - - -

	1920	1921	1922	1923	1924
K.W. Demand - - - - - - - - - - - - -	750	850	1000	1200	1450
K.W.H. Consunption - - - - - - - -	2,250,000	2,550,000	3,000,000	3,600,000	4,350,000
Line loss in K.W.H. - - - - - - -	23,000	29,900	41,000	59,000	86,000
Transformer loss in K.W.H. - - -	150,000	160,000	175,000	195,000	225,000
Total K.W.H. dlvd to swbd - -	2,423,000	2,739,000	3,216,000	3,854,000	4,661,000
Station Investment - - - - - - -	$ 75,000.00	$85,000.00	$100,000.00	$120,000.00	$145,000.00
Substation and Line - - - - - -	69,800.00	69,800.00	69,800.00	69,800.00	69,800.00
Total Investment - - - - - - -	$144,800.00	$154,800.00	$169,800.00	$189;800.00	$214,800.00
Int., Dep., Taxes, Ins. @ 14% - -	$20,250.00	$21,700.00	$23,750.00	$26,550.00	$30,150.00
Cost of energy @ 1¢ K.W.H. swbd	24,230.00	27,390.00	32,160.00	38,540.00	46,610.00
Maintenance & Clerical - - - - - -	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total Cost of Service - - -	$45,480.00	$50,090.00	$56,910.00	$66,090.00	$77,760.00
Schedule "B" Revenue - - -	$43,500.00	$49,1000000	$57,500.00	$68,700.00	$82,700.00
Schedule "B" Margine - - -	1,980.00	990.00	590.00	2,610.00	4,940.00
Schedule "C" Revenue - - -	$45,200.00	$51,000.00	$59,750.00	$71,400.00	$85,960.00
Schedule "C" Margin - - - -	280.00	910.00	2,840.00	5,310.00	8,200.00
Cost of Line I^2R Loss - - - - - -	$230.00	$290.00	$410.00	$590.00	$860.00
Int., Dep., Taxes, Ins. on copper	2310.00	2,310.00	2,310.00	2,310.00	2,310.00

Most economic point not reached.

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. II

DISTRIBUTION ~~DISTRICT~~/DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Install 33000 volt 2000 K.V.A. substation at Springfield and build 33000 volt No. 1 copper line to serve the Northwestern Ohio Light Company at Urbana. Route by way of Tremont and Westville, but not serving them.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No. ______

REQUESTED 12-1 1919 BY C.I.W.	APPROVED ______ 191__ BY ______	CHF. ENGR.
MADE 1-19 1920 BY J.B.B.	" ______ 191__ BY ______	MGR.
CHKD 1-20 1920 BY L.E.B.	" ______ 191__ BY ______	GEN. MGR.
CTFD ______ 191__ BY ______	AUTHORIZED ______ 191__ BY ______	PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
Substation (See Est. VII, p.28)		14,750	00	750	00
Poles		11,500	00	3,000	00
X-arms		900	00	250	00
Insulators		4,400	00	200	00
Pins		560	00	100	00
Guys and anchors		200	00	200	00
Wire- No. 1 B.& S. Gage		16,500	00	1,500	00
Dead-ends		300	00	200	00
Right of Way		1,000	00		
Freight and cartage		500	00		
Contingencies @ 10%		5,050	00	620	00
Injuries and damages				400	00
Office and Local Management @ 4%				2,470	00
Construction Engineering @ 6%		3,340	00	410	00
Interest during Construction		600	00	100	00

ACTUAL COST MATERIAL $ ______	ESTIMATED COST MATERIAL $ 59,600.00
ACTUAL COST LABOR . $ ______	ESTIMATED COST LABOR . $ 10,200.00
TOTAL ACTUAL COST . $ ______	TOTAL ESTIMATED COST . $ 69,800.00

DETAILS OF LOAD, INVESTMENT, OPERATING EXPENSES, & REVENUE.

- - - - -

33000 VOLT LINE, No. 4 COPPER, VIA TREMONT AND WESTVILLE, BUT NOT SERVING THEM.

- - - -

		1920	1921	1922	1923	1924
K.W. Demand		750	850	1000	1200	1450
K.W.H. Consumption		2,250,000	2,550,000	3,000,000	3,600,000	4,350,000
Line Loss in K.W.H.		46,000	58,000	82,000	118,000	172,000
Transformer Loss in K.W.H.		150,000	160,000	175,000	195,000	225,000
Total K.W.H. dlvd swbd		2,446,000	2,766,000	3,257,000	3,911,000	4,744,000
Station Investment		$ 75,000.00	$85,000.00	$100,000.00	$120,000.00	$145,000.00
Substation and Line		59,000.00	59,000.00	59,000.00	59,000.00	59,000.00
Total Investment		$134,000.00	$144,000.00	$159,000.00	$179,000.00	$204,000.00
Int.,Dep.,Taxes,Ins.@ 14%		$18,750.00	$20,150.00	$22,250.00	$25,100.00	$28,550.00
Cost of energy @ 1¢ KWH.swbd		24,460.00	27,660.00	32,570.00	39,110.00	47,440.00
Maintenance & Clerical		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total Cost of Service		$44,210.00	$48,810.00	$55,820.00	$65,210.00	$76,990.00
Schedule "B"	Revenue	$43,500.00	$49,100.00	$57,500.00	$68,700.00	$82,700.00
	Margin	710.00	290.00	1,680.00	3,490.00	5,710.00
Schedule "C"	Revenue	$45,200.00	$51,000.00	$59,750.00	$71,400.00	$85,960.00
	Margin	990.00	2,190.00	3,930.00	6,190.00	8,970.00
Cost of I^2R Line Loss		$ 460.00	$ 580.00	$ 820.00	$1,180.00	$1,720.00
Int.,Dep.,Taxes, Ins.on copper		1,140.00	1,140.00	1,140.00	1,140.00	1,140.00

Most economic point in 1923.

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. III

DISTRIBUTION ~~DISTRICT~~-DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Install 33000 volt 2000 K.V.A. substation and build 33000 volt No. 4 copper line to serve the Northwestern Ohio Light Company at Urbana. Route by way of Tremont and Westville, but not serving them.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No.

REQUESTED 12-1, 19 19 BY C.I.W.	APPROVED 191 BY		CHF. ENGR.
MADE 1-19 1920 BY J.B.B.	" 191 BY		MGR.
CHKD 1-20 1920 BY L.E.B.	" 191 BY		GEN. MGR.
CTFD 191 BY	AUTHORIZED 191 BY		PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
Substation (See Est.VII,p.28)		14,750	00	750	00
Poles		11,500	00	3,000	00
X-arms		900	00	250	00
Insulators		4,400	00	200	00
Pins		560	00	100	00
Wire- No. 4 B.& S. Gage		8,200	00	1,500	00
Dead-ends		300	00	200	00
Right of Way		1,000	00		
Freight and cartage		400	00		
Contingencies @ 10%		4,120	00	600	00
Injuries and damages				400	00
Office and Local Management @ 4%				2,110	00
Construction Engineering @ 6%		2,770	00	390	00
Interest during Construction		500	00	100	00

ACTUAL COST MATERIAL $

ACTUAL COST LABOR $

TOTAL ACTUAL COST $

ESTIMATED COST MATERIAL $ 49,400.00

ESTIMATED COST LABOR $ 9,600.00

TOTAL ESTIMATED COST $ 59,000.00

DETAILS OF LOAD, INVESTMENT,
OPERATING EXPENSES, & REVENUE.

- - - - -

33000 VOLT LINE, No. 4 COPPER; VIA ERIE R.R. RIGHT OF WAY.

- - - - - - -

	1920	1921	1922	1923	1924
K.W. Demand - - - - - - - - - - - -	750	850	1000	1200	1450
K.W.H. Consumption - - - - - - -	2,250,000	2,550,000	3,000,000	3,600,000	4,350,000
Line Loss in K.W.H. - - - - - - -	38,500	48,500	68,700	99,000	144,000
Transformer Loss in K.W.H. - - -	150,000	160,000	175,000	195,000	225,000
Total K.W.H. dlvd swbd - - -	2,438,500	2,758,500	3,243,700	3,895,000	4,719,000
Station Investment - - - - -	$75,000.00	$85,000.00	$100,000.00	$120,000.00	$145,000.00
Substation and Line - - - - -	53,000.00	53,000.00	53,000.00	53,000.00	53,000.00
Total Investment - - - - - -	$128,000.00	$138,000.00	$153,000.00	$173,000.00	$198,000.00
Int.,Dep.,Taxes,Ins.@ 14% - -	$17,900.00	$19,300.00	$21,400.00	$24,200.00	$27,700.00
Cost of energy @ 1¢ KWH.swbd -	24,900.00	27,600.00	32,450.00	38,940.00	47,200.00
Maintenence & Clerical - - - -	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total Cost of Service - - -	$43,300.00	$47,900.00	$54,850.00	$64,140.00	$75,900.00
Schedule "B" Revenue - - -	$43,500.00	$49,100.00	$57,500.00	$68,700.00	$82,700.00
Schedule "B" Margin - - -	200.00	1,200.00	2,650.00	4,560.00	6,800.00
Schedule "C" Revenue - - -	$45,200.00	$51,000.00	$59,750.00	$71,400.00	$85,960.00
Schedule "C" Margin - - -	1,900.00	3,100.00	4,900.00	7,250.00	10,060.00
Cost of Line I^2R Loss - - - -	$385.00	$475.00	$687.00	$990.00	$1,440.00
Int.,Dep.,Taxes,Ins.on copper -	980.00	980.00	980.00	980.00	980.00

Most economic point in 1923.

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. IV

DISTRIBUTION ~~DISTRICT~~/DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Install 33000 volt 2000 K.V.A. subatation and build 33000 volt No. 4 copper line to serve the Northwestern Ohio Light Company at Urbana. Route by way of Erie Railroad right of way from Maitland to Urbana.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No. ______

REQUESTED 12-1 19 19 BY C.I.W.	APPROVED ______ 191__	BY ______	CHF. ENGR.
MADE 1-19 191 20 BY J.B.B.	" ______ 191__	BY ______	MGR.
CHKD 1-20 191 20 BY L.E.B.	" ______ 191__	BY ______	GEN. MGR.
CTFD ______ 191__ BY ______	AUTHORIZED ______ 191__	BY ______	PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
Substation (See Est.VII,p.28)		14,750	00	750	00
Poles		9,400	00	2,700	00
X-arms		750	00	210	00
Insulators		3,800	00	170	00
Pins		270	00	175	00
Wire- No. 4 B.& S. Gage		7,000	00	1,200	00
Dead-ends		250	00	200	00
Right of way		1,000	00		
Freight and cartage		400	00		
Contingencies @ 10%		3,750	00	530	00
Injuries and damages				400	00
Office and Local Management @ 4%				1,900	00
Construction Engineering @ 6%		2,480	00	365	00
Interest during Cinstruction		450	00	100	00

ACTUAL COST MATERIAL $ ______ ESTIMATED COST MATERIAL $ 44,300.00

ACTUAL COST LABOR $ ______ ESTIMATED COST LABOR $ 8,700.00

TOTAL ACTUAL COST $ ______ TOTAL ESTIMATED COST $ 53,000.00

DETAILS OF LOAD, INVESTMENT, OPERATING EXPENSES, & REVENUE.

- - - - -

33000 VOLT LINE, No. 4 COPPER, VIA TREMONT & WESTVILLE, SERVING THEM.

- - - - - - -

	1920	1921	1922	1923	1924
K.W. Demand - - - - - - - - - - - - - -	775	875	1,025	1,225	1,475
K.W.H. Consumption - - - - - - - -	2,280,000	2,590,000	3,045,000	3,650,000	4,400,000
Line Loss in K.W.H. - - - - - - -	46,000	58,000	82,000	118,000	172,000
Transformer Loss in K.W.H. - -	154,500	165,000	180,500	201,000	231,000
Total K.W.H. dlvd swbd - - -	2,480,500	2,813,000	3,307,500	3,969,000	4,803,000
Station Investment - - - - -	$77,500.00	$87,500.00	$102,500.00	$122,500.00	$147,500.00
Substation, Line, & Transf's	61,000.00	61,000.00	61,000.00	61,000.00	61,000.00
Total Investment - - - - - -	$138,500.00	$148,500.00	$163,500.00	$183,500.00	$208,500.00
Int.,Dep.,Taxes,Ins. @ 14% -	$19,400.00	$20,800.00	$22,900.00	$25,700.00	$29,200.00
Cost of energy @ 1¢ KWH.swbd -	24,800.00	28,130.00	33,080.00	39,690.00	48,030.00
Maintenance & Clerical - - - -	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
Total Cost of Service - - -	$45,400.00	$50,130.00	$57,180.00	$66,590.00	$78,430.00

		1920	1921	1922	1923	1924
Schedule "B"	Revenue - - -	$45,000.00	$51,100.00	$59,750.00	$71,200.00	$85,200.00
	Margin - - - -	400.00	970.00	2,570.00	4,610.00	6,770.00
Schedule "C"	Revenue - - -	$46,700.00	$53,000.00	$62,000.00	$73,900.00	$88,460.00
	Margin - - -	1,300.00	2,870.00	4,820.00	7,310.00	10,030.00
Cost of Line I^2R Loss - - - -		$ 460.00	$ 580.00	$ 820.00	$1,180.00	$1,720.00
Int.Dep.,Taxes,Ins. on copper		1,140.00	1,140.00	1,140.00	1,140.00	1,140.00

Most economic point in 1923.

TABLE OF ESTIMATED
LOAD, REVENUE, AND LOSSES
FOR
TREMONT AND WESTVILLE.

- - - -

YEAR	DEMAND	K.W.H.	REVENUE	LOSS IN K.W.H.
1920	25	30,000	$1500.00	4500
1921	25	40,000	2000.00	5000
1922	25	45,000	2250.00	5500
1923	25	50,000	2500.00	6000
1924	25	50,000	2500.00	6000

A flat demand of 25 K.W. is assumed, and added to the Urbana demand in calculating data for serving Tremont and Westville fron the line to Urbana. An everage revenue per K.W.H. of 5 cents is assumed.

See attached estimate for cost of installing transformers (2-25 K.V.A.) to serve Tremont and Westville. Assumption is made that power will be metered and sold at the secondary terminals of the transformer.

GENERAL DATA

Tremont- Population 1910, 478.
Load- Residence lighting.
Street lighting.
Garment factory.
Mill and elevator.

Westville- Population 1910, 285.
Load- Residence lighting.
Street lighting.
Two elevators.

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. V

DISTRIBUTION ~~DISTRICT~~ DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Make transformer, switching, and meter installations at Tremont and Westville, to serve those towns from 33000 volt line to the Northwestern Ohio Light Company at Urbana.

CHARACTER OF EXPENDITURE CONSTRUCTION   CHARGE ACCOUNT No.

REQUESTED 1-19 19 20 BY C.I.W.
MADE 1-20 191 20 BY L.E.B.
CHKD 191 BY
CTFD 191 BY

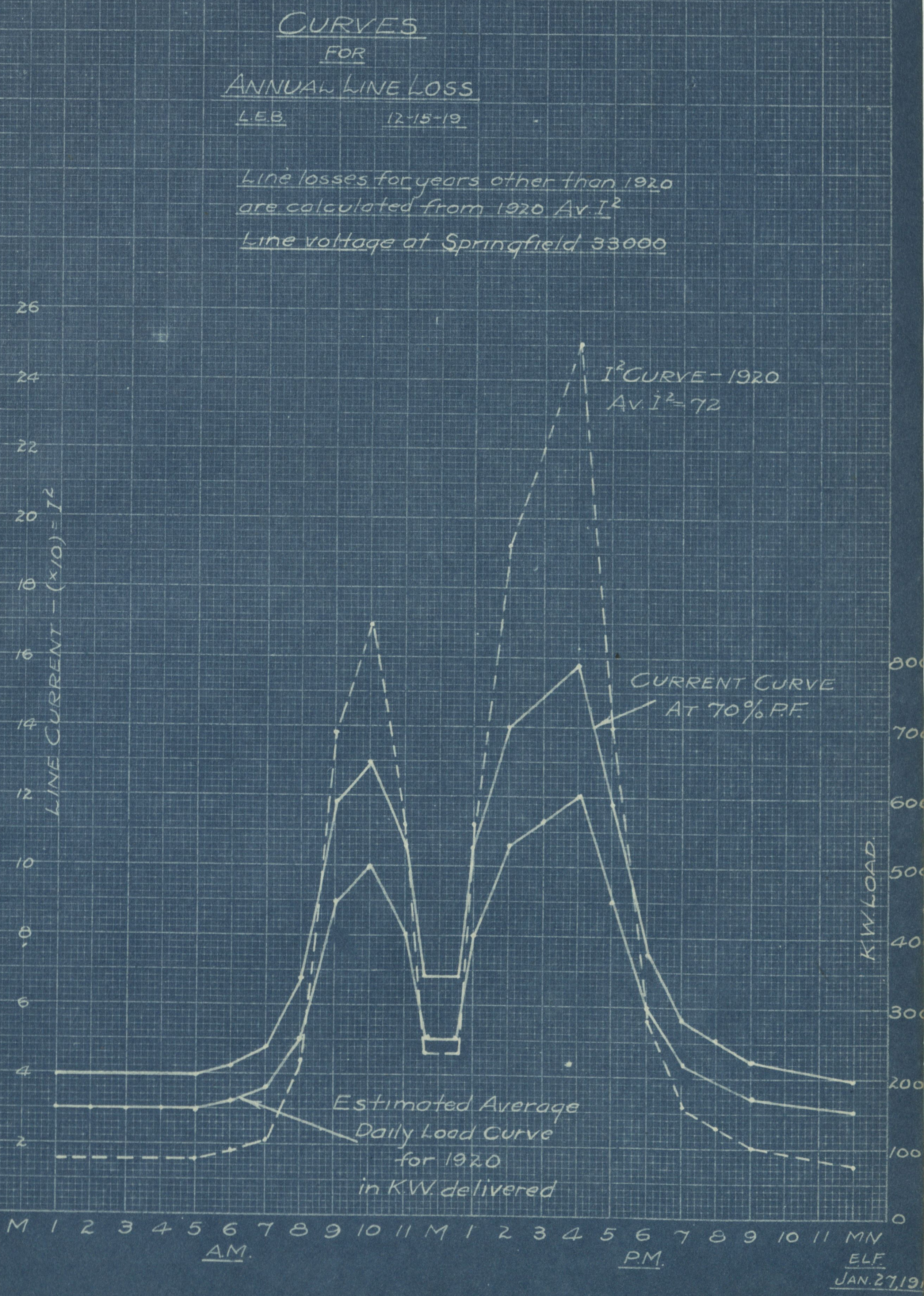
APPROVED 191 BY CHF. ENGR.
" 191 BY MGR.
" 191 BY GEN. MGR.
AUTHORIZED 191 BY PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
2-25 K.V.A. transformers		950	00		
Switching & protective equip't		225	00	100	00
Mounting & connecting to line		100	00	100	00
Meter equipment (secondary).		100	00	50	00
Freight and cartage		25	00		
Contingencies @ 10%		140	00	25	00
Injuries and damages				10	00
Office and Local Management @ 4%				70	00
Construction Engineering @ 6%		90	00	15	00

NOTE:- In computing data for serving Tremont and Westville, the amount of this estimate is added to that for the substation and No. 4 line to Urbana by way of Tremont and Westville, but not serving them. See pages 19 and 20.

ACTUAL COST MATERIAL $
ACTUAL COST LABOR $
TOTAL ACTUAL COST $

ESTIMATED COST MATERIAL $ 1,630.00
ESTIMATED COST LABOR $ 370.00
TOTAL ESTIMATED COST $ 2,000.00


CURVES
FOR
ANNUAL LINE LOSS
L.E.B. 12-15-19
Line losses for years other than 1920
are calculated from 1920 Av. I²
Line voltage at Springfield 33000
I² CURVE - 1920
Av. I² = 72
CURRENT CURVE
AT 70% P.F.
Estimated Average
Daily Load Curve
for 1920
in K.W. delivered
LINE CURRENT - (×10) = I²
K.W. LOAD
26
24
22
20
18
16
14
12
10
8
6
4
2
800
700
600
500
400
300
200
100
0
M 1 2 3 4 5 6 7 8 9 10 11 M 1 2 3 4 5 6 7 8 9 10 11 MN
A.M.
P.M.
ELF.
JAN. 27, 191

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. VI

DISTRIBUTION ~~DISTRICT~~ DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Build 13200 volt substation at the Rockway Steam Plant, to supply a line to serve the North-western Ohio Light Company at Urbana.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No.

REQUESTED 191 BY	APPROVED 191 BY	CHF. ENGR.	
MADE 12-10 1919 BY L.E.B.	" 191 BY	MGR.	
CHKD 191 BY	" 191 BY	GEN. MGR.	
CTFD 191 BY	AUTHORIZED 191 BY	PRESIDENT	

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL	ESTIMATED COST LABOR
3-400 K.V.A. transformers (in stock)		4,000 00	
2300 V. automatic oil switch (in plant)		300 00	
Concrete slab		75 00	Inc.
Wires, cables, and supports		500 00	
Fence		125 00	Inc.
Lightning arresters		650 00	
Special switches for one transformer		250 00	
Labor of installation			600 00

NOTE:- Contingencies and overhead items are included in total estimates of which this estimate is a part. Estimate I, page 16.

ACTUAL COST MATERIAL $

ACTUAL COST LABOR . $

TOTAL ACTUAL COST . $

ESTIMATED COST MATERIAL $ 5,900.00

ESTIMATED COST LABOR . $ 600.00

TOTAL ESTIMATED COST . $ 6,500.00

CONSUMERS POWER COMPANY

PROPOSED EXPENDITURE

No. VII

DISTRIBUTION ~~DISTRICT~~-DEPARTMENT
NAME OF DISTRICT OR DEPARTMENT

IT IS PROPOSED TO Build 33000 volt substation at Rockway Steam Plant, to supply 33000 volt line to Northwestern Ohio Light Company at Urbana.

CHARACTER OF EXPENDITURE CONSTRUCTION CHARGE ACCOUNT No. ______

REQUESTED ____ 191__ BY ______	APPROVED ______ 191__ BY ______		CHF. ENGR.
MADE 12"10 1919 BY L.E.B.	" ______ 191__ BY ______		MGR.
CHKD ____ 191__ BY ______	" ______ 191__ BY ______		GEN. MGR.
CTFD ____ 191__ BY ______	AUTHORIZED ______ 191__ BY ______		PRESIDENT

DETAILS	ACCOUNT NUMBER	ESTIMATED COST MATERIAL		ESTIMATED COST LABOR	
3-667 K.V.A. transformers		11,500	00		
6600 volt automatic oil switch		350	00		
Concrete slab		100	00	Inc.	
Wires, cables, and supports		650	00		
Fence		150	00		
Lightning arrester		1,500	00		
Special switches for one transformer		500	00		
Labor of installation				750	00
NOTE:- Contingencies and overhead items are included in the total estimates of which this estimate is a part. See Estimates II, III, and IV, pages 18, 20, and 22.					

ACTUAL COST MATERIAL $ ______	ESTIMATED COST MATERIAL $ 14,750.00
ACTUAL COST LABOR $ ______	ESTIMATED COST LABOR $ 750.00
TOTAL ACTUAL COST $ ______	TOTAL ESTIMATED COST $ 15,500.00

PROFESSIONAL RECORD
OF
L.E.BROWN

- - -

May 29, 1920

June 1, 1913 to Sept. 1, 1913,- Lineman with A.T.& S.F. Rwy Co., Eastern Div. of Signal Dept.

Sept. 1, 1913 to Aug. 1, 1914,- With Lawrence Rwy & Light Co., Lawrence, Kansas, in charge of meter testing and drafting.

Aug. 15, 1914 to Mch 15, 1916,- Apprentice with Westinghouse E.& M. Co., Pittsburgh, Pa.
8 months shop work.
7 months test floor.
4 months motor application office.

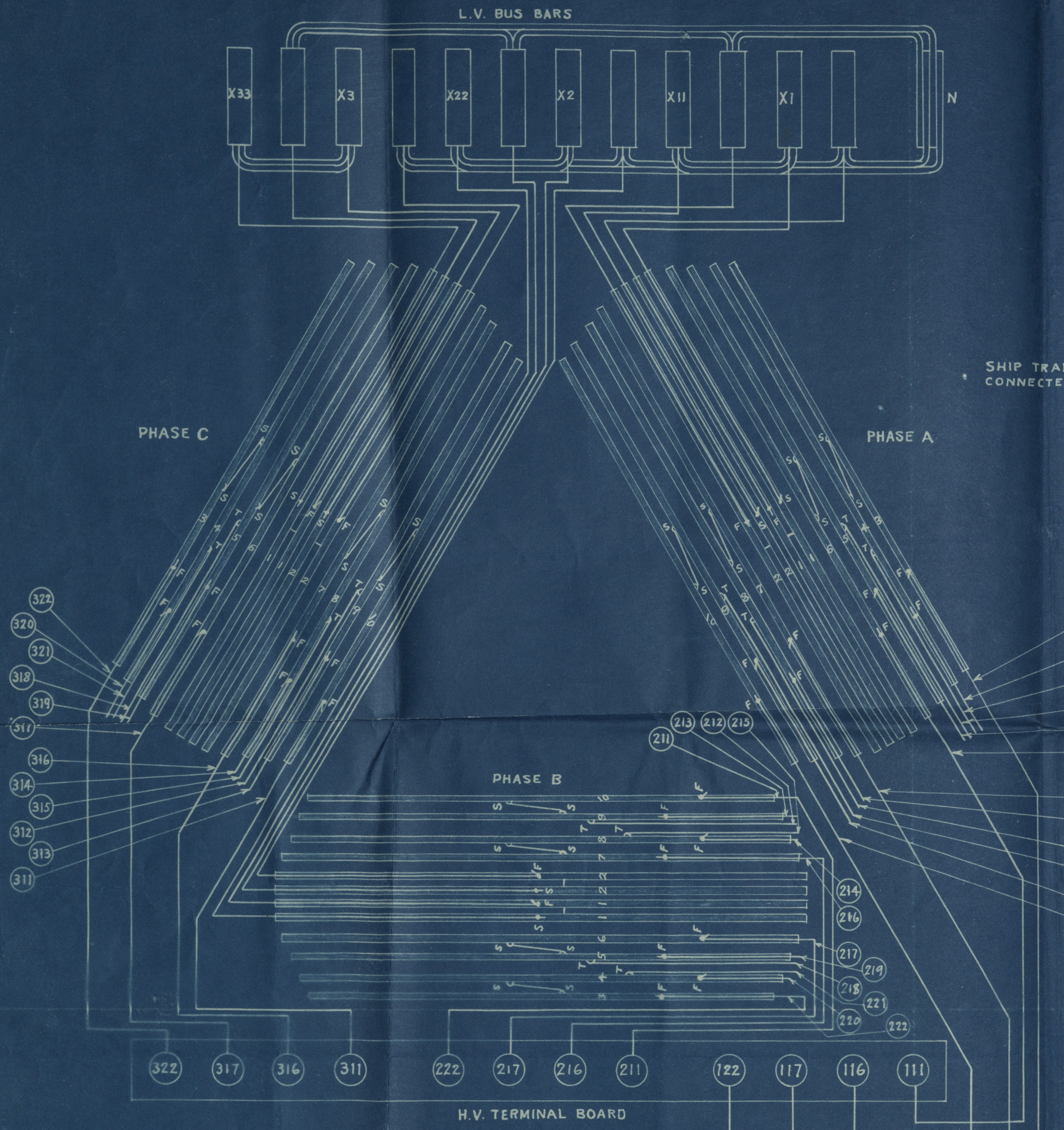
Mch 15, 1916 to Feb 15, 1918,- In Construction Dept. of Consumers Power Co. of Michigan, in responsible charge of work, covering station design, ordering of materials, and supervision of installation. Experience also includes limited transmission line and distribution work, both factory and field test and inspection of high-tension porcelain insulators, and a small amount of cost and standardization work.

Feb. 15, 1918 to May 1, 1920,- Superintendent of Distribution for Springfield Light, Heat & Power Co., Springfield, Ohio, in charge of all electrical equipment, all construction, lines, and meters. Had charge of Power Sales during 1919, and still act in advisory capacity on power applications.

May 1, 1920 to date,- Production Manager for Springfield Light, Heat & Power Co., Springfield, Ohio, in charge of power plant construction and operation.

NOTE: The Consumers Power Company of Michigan and the Springfield Light, Heat & Power Co., Springfield, Ohio are controlled by the same holding company, namely Hodenpyl, Hardy & Co., of New York.


HARRISON
ADAMS
WAYNE
SALEM
CONCORD
JOHNSON
UNION
MADRIVER
JACKSON
URBANA
ST. PARIS
WESTVILLE
URBANA
MUTUAL
KINGSTON
CABLE
THACKERAY
TERRE HAUTE
POWHATTAN
P.C.C. & ST. L. RY.
Mad River Valley Pike
Dialton
Tremont City
Chapmans Cr.
TREMONT & PARIS PIKE
Bowlusville
New Moorefield
GERMAN
MOOREFIELD
North Hampton
Lawrenceville
Eagle City
Villa
Sinking Creek
Lagonda
COLUMBUS ROAD
Beaver Cr.
Harmony
NATIONAL PIKE
OHIO ELEC. R.R.
Snyder's Mill
Sugargrove
Anlo
Donnelsville
Durbin
Limestone City
Cold Springs
Melrose
SPRINGFIELD
CLEVELAND CINCINNATI CHICAGO & ST
Snyderville
Locust Grove
Thorp
Enon Sta
Enon
Beatty
Emery Chapel
Medway
Mad River
Lisbon
BETHEL



CONNECT 111 TO H1, 116 TO H4, 117 TO H7, 122 TO H10
211 TO H2, 216 TO H5, 217 TO H8, 222 TO H11
311 TO H3, 316 TO H6, 317 TO H9, 322 TO H12

H.V. LINES ON H1, H2 & H3.

H.V. CONNECTIONS

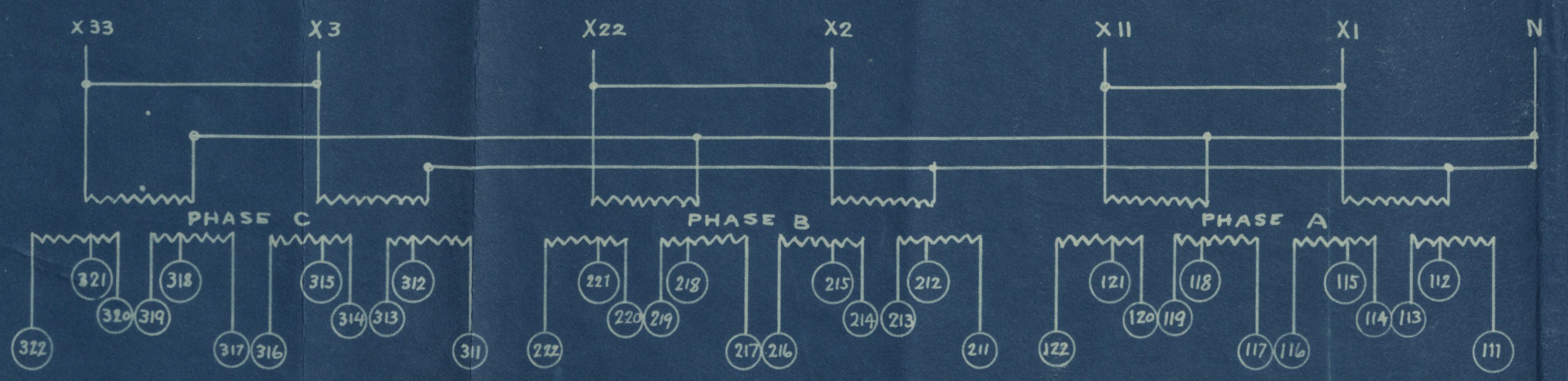
SHIP TRANSFORMER CONNECTED AS PER → 2

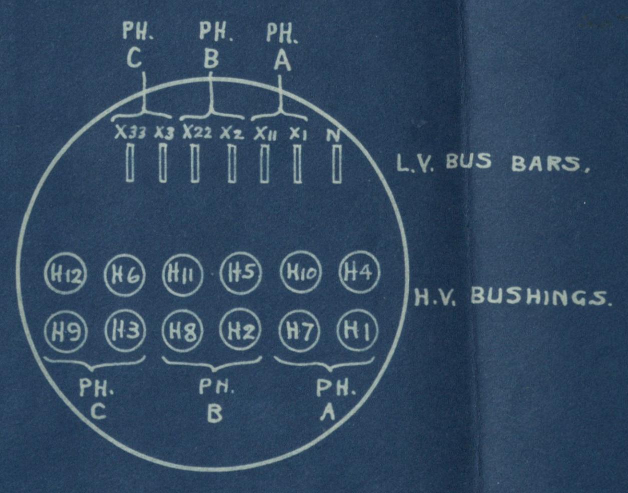
Nº	VOLTS	CONN.	INSIDE CONNECTIONS	OUTSIDE CONNECTIONS
1	7260	MULT. △	113 TO 114 119 TO 120 213 TO 214 219 TO 220 313 TO 314 319 TO 320	H1 TO H7 TO H6 TO H12 H4 TO H10 TO H2 TO H8 H5 TO H11 TO H3 TO H9
2	6600	MULT. △	113 TO 115 119 TO 121 213 TO 215 219 TO 221 313 TO 315 319 TO 321	SAME AS Nº 1
3	5940	MULT. △	112 TO 115 118 TO 121 212 TO 215 218 TO 221 312 TO 315 318 TO 321	SAME AS Nº 1
4	7260	SERIES △	SAME AS Nº 1	H1 TO H12 H4 TO H7 H10 TO H2 H5 TO H8 H11 TO H3 H6 TO H9
5	6600	SERIES △	SAME AS Nº 2	SAME AS Nº 4
6	5940	SERIES △	SAME AS Nº 3	SAME AS Nº 4
7	7260	MULT Y	SAME AS Nº 1	H4 TO H10 TO H5 TO H11 TO H6 TO H12 (NEUTRAL) H1 TO H7 H2 TO H8 H3 TO H9
8	6600	MULT Y	SAME AS Nº 2	SAME AS Nº 7
9	5940	MULT Y	SAME AS Nº 3	SAME AS Nº 7
10	7260	SERIES Y	SAME AS Nº 1	H10 TO H11 TO H12 (NEUTRAL) H4 TO H7 H5 TO H8 H6 TO H9
11	6600	SERIES Y	SAME AS Nº 2	SAME AS Nº 10
12	5940	SERIES Y	SAME AS Nº 3	SAME AS Nº 10

L.V. CONNECTIONS

Nº	VOLTS TO NEUTRAL	OBTAINED WITH H.V. CONNECTIONS
1	132	1, 2, OR 3
2	76	7, 8, OR 9
3	66	4, 5, OR 6
4	38	10, 11, OR 12

NOTE COILS 4, 6, 8, & 10 TO BE TURNED OVER WHEN ASSEMBLING





1A-1904
DLE 5201

Traced from Allis Chalmers Mfg Co Blue Print June 11-1919

85673

C.J.B.

FILE 9A

CONNECTION DIAGRAM
1500 K.V.A.
ALLIS CHALMERS TRANSFORMERS