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A STUDY OF PURCHASED POWER vs SELF-GENERATED
POWER AT THE ELMWOOD AVENUE PLANT OF THE UNIVERSITY
OF ROCHESTER.

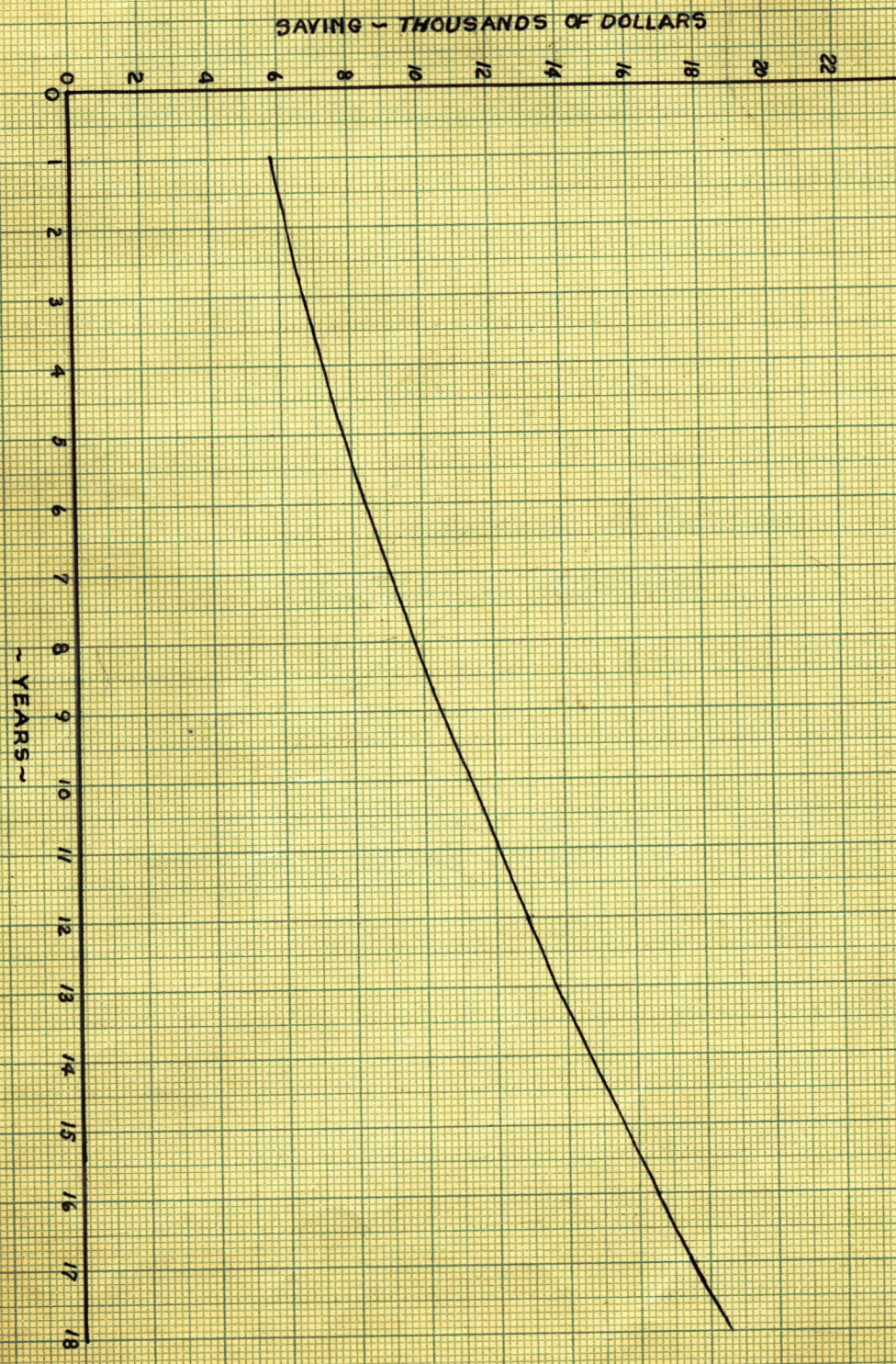
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Submitted in partial fulfillment of the
requirements for the degree, Master of Science.





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INTRODUCTION

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INTRODUCTION

This study has for its object the determination of whether or not the University of Rochester could, by purchasing and installing the necessary generating equipment, generate its own electricity at a cost less than the present cost of purchasing that electricity from the Rochester Gas and Electric Corporation.

A general picture of the present and proposed situations is this: At the present time the University has an excellent heating plant on Elmwood Avenue that produces steam at 120 lbs. gage pressure and containing about 2% moisture. This steam heats the River Campus, the Medical School, and the two hospitals. This study proposes that the University install superheaters in the boilers, build an addition to the present Boiler House, purchase steam turbines and alternating current generators, and make the necessary piping changes. Then it proposes that steam be produced in the boilers at 200 lbs. gage pressure and with 100 degrees superheat; that this steam be sent through the steam turbines which will then drive the

generators which in turn will produce the required electricity; and, that the exhaust steam from the turbines be used for heating.

Certain peculiarities were noticeable from the beginning. 1st, that the final answer to this problem depended more on the size of the initial investment than it did on the cost of the steam required to operate the turbines. This was expected because of the large quantities of steam used daily in the winter months by the University for heating. 2nd, that the 1st statement is true only for those months when the exhaust steam from the turbines can be used for heating. The reason for this is obvious. The cost of producing steam at the University of Rochester, while it is probably lower than anywhere else in Rochester, is such that if the entire cost were chargeable against the generation of electricity the cost of self-generation would be greater than the cost of purchasing that electricity from the Rochester Gas and Electric Corporation. However, when the exhaust steam can be used for heating, nearly all the cost of producing the steam can be charged against

heating just as under present conditions the entire cost of the steam is charged against heating. This means that from September 15th to June 15th, when the University buildings are being heated, that portion of the cost of the steam which would be chargeable against the generation of electricity is relatively small and so from this standpoint the economical generation of its own electricity by the University is entirely possible during that period. It also means that from June 15th to September 15th the possibility of self-generation is very remote. This last statement is further confirmed by the fact that were the University to generate its own electricity during that period the turbines would either have to be exhausted to the atmosphere or to condensers. Now the lower the exhaust pressure at which a steam turbine is operating the greater is its efficiency and so exhausting to the atmosphere would be an inefficient and expensive method of operation. Exhausting to condensers would be an efficient method of operation of the turbines but it would be very expensive due to the fact that a considerable extra expenditure of money for condensers

Proof that the 18" Heating Line is large enough to carry the maximum volume of steam that would be met in addition to an increase in maintenance and operating costs. This expenditure appears even more unwise when it is realized that such condensing equipment could be used only during the summer months and would lie idle the rest of the year. 3rd, due to the fact that under the rate system of the Rochester Gas and Electric Corporation a customer is allowed to reduce its winter demand for more than eight months of the year it was then obvious that if the University were to generate its own electricity it could do so only from October 15th to June 15th of any year and must purchase electricity during the remainder of the year. 4th, it was recognized that dependable and reliable turbines were more important than very efficient turbines. This was possible because, due to the fact that the University uses daily large quantities of steam for heating, the cost of steam chargeable to the generation of electricity is small. 5th, it was recognized that a dangerous condition might exist if the Hospital or Medical School were without electricity at any time.

The determination of the highest back pressure at

5

Proof that the 10" Heating Line is large enough to carry the maximum volume of steam that would be met at a pressure of 5 lbs. gage and 30 degrees superheat. 425 lbs. per minute.

Steam at 5 lbs. gage and 40. superheat has a specific volume of 21.6 cu ft per lb. This is the worst possible condition that might be met. 425 lbs. per min is the greatest flow of steam.

$$21.6 \times 425 = 9180 \text{ cu ft per min.}$$

$$\text{Inside diameter of pipe} = 10.19" = .85'$$

$$\text{Area of cross section of pipe} = .569' \text{ sq ft}$$

$$9180 / .569 = 16250 \text{ ft per min.}$$

Then, since permissible steam velocities are as high as 35,000 ft per min, it is plain that the heating line is plenty large enough.

Procedure: The Physical Education building is farther away from the Boiler House than any of the other buildings. Arbitrarily, the maximum pressure, under any conditions, wanted at that building is 5

The determination of the highest back pressure at which the turbines will have to operate. determine the pressure drop in the pipe line from the Boiler House

The formula used in these calculations is the from "Steam", Babcock and Wilcox. Page 360. of steam

$$P = 0.000131 \left(1 + \frac{3.6}{d} \right) \frac{w^2 L}{D d^5}$$

drop the pressure at the Boiler House is known P is the difference in pressure at the two ends of a pipe line. Lbs per sq in. and this pressure is the highest back pressure at which the turbines will have to operate.

D is the mean of the densities at the initial and final pressures. Lbs per cu ft. Sketch of the pipe line:

d is the internal diameter of the pipe. in.

L is the length of the pipe. Ft.

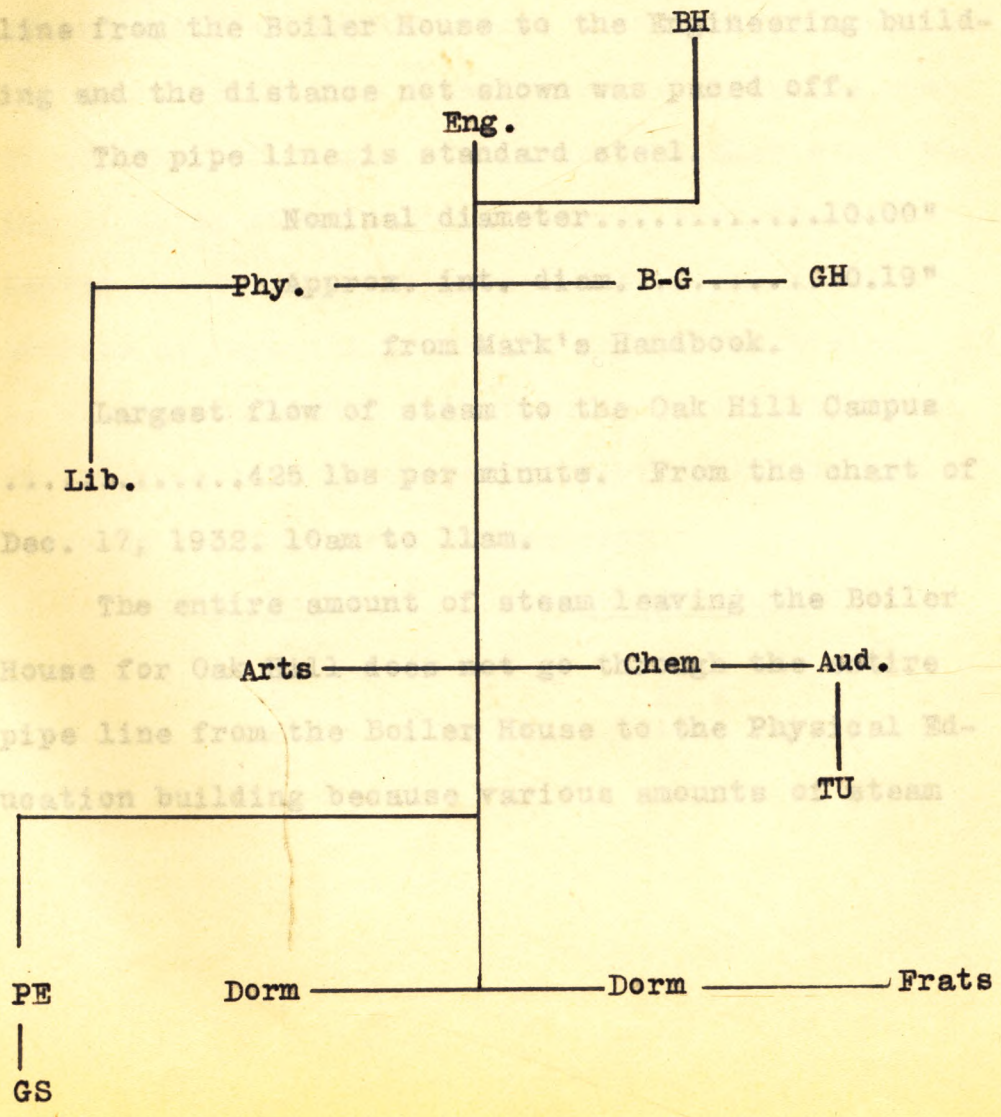
w. Lbs of steam per min.

1 elbow is equivalent to a straight length of pipe 40 diameters long.

Procedure: The Physical Education building is farther away from the Boiler House than any of the other buildings. Arbitrarily, the maximum pressure, under any conditions, wanted at that building is 5

lbs gage. Therefore, these calculations determine the pressure drop in the pipe line from the Boiler House to Physical Education such that the pressure at the latter is 5 lbs gage when the maximum amount of steam is passing through the line. Knowing that pressure drop the pressure at the Boiler House is known and this pressure is the highest back pressure at which the turbines will have to operate.

Sketch of the pipe line: did not show the entire line from the Boiler House to the Engineering building and the distance not shown was placed off.



The pipe line is standard steel
 Nominal diameter.....10.00"
 from Mark's Handbook.
 Largest flow of steam to the Oak Hill Campus
 ... Lib.425 lbs per minute. From the chart of
 Dec. 17, 1932: 10am to 11am.
 The entire amount of steam leaving the Boiler
 House for Oak Hill Campus is 425 lbs per minute.
 pipe line from the Boiler House to the Physical Ed-
 ucation building because various amounts of steam

The sketch on the preceding page shows the layout of the buildings between the Boiler house and the Physical Education building and the lines between the buildings show the pipe lines. The solid line is the main line and the dotted lines are branch lines. These calculations treat only the main pipe line. Lengths were measured on the map in Mr. Livingston's office. The map did not show the entire line from the Boiler House to the Engineering building and the distance not shown was paced off. The pipe line is standard steel.

Nominal diameter.....10.00"
 Approx. int. diam.....10.19"

from Mark's Handbook.
 Largest flow of steam to the Oak Hill Campus
425 lbs per minute. From the chart of
 Dec. 17, 1932. 10am to 11am.

The entire amount of steam leaving the Boiler House for Oak Hill does not go through the entire pipe line from the Boiler House to the Physical Education building because various amounts of steam

leave the main line at the points 1, 2, 3, and 4 to supply the buildings on the branch lines at those points. Therefore, there is one quantity flowing from the Boiler House to point 1, another quantity from 1 to 2, etc. As a result, the pressure drop is found for each of these sections and the sum of these drops is taken as the total pressure drop from the Boiler House to the Physical Education Building.

The amount of steam used by each building is taken to be proportional to the amount of radiation area that it has in comparison with the total radiation area of all the buildings. It is assumed that every building is using steam. It is assumed that the steam leaves the turbines superheated 40 F and that it arrives at Physical Education dry and saturated. It is also assumed that the steam drops its superheat in the pipe line in direct proportion to the distance it has traveled. Therefore:

<u>At Point</u>	<u>•F Superheat</u>
4	7
3	11.5
2	16
1	22

<u>Building</u>	<u>Sq. Ft. of Rad.</u>	<u>Totals</u>	<u>sections.</u>
Eng.	10614	10614	% of Point 1 steam leaving BH
Physics	12887		flowing through
B and G	21182		each of the
Library	26727		sections
GH	1217	62013	Point 2
A. BH to Eng	1517	8	100
Arts	19985	6	94.25
Chem.	14070	4	60.65
Aud.	24000	4	27.45
TU	3240	4	Point 3
Dorms.	8808		Some of the constants in the formula
Frats.	8404	17212	Point 4
PE	32870		apply over the whole line and so the formula may be
GS	615	33485	used to simplify before using it.
Total	184619		

<u>Point</u>	<u>% of total steam leaving main pipe line</u>
1	5.75
2	33.60
3	33.20
4	9.32
PE	18.13

The % of total steam leaving the main line at any point is found by dividing the sq ft of radiation supplied by that point by the total sq ft of radiation supplied on the Oak Hill Campus.

The pipe line is divided into 5 sections.

<u>Section</u>	<u>Length Feet</u>	<u>No. of Elbows Included</u>	<u>% of total steam leaving BH flowing through each of the sections</u>
A. BH to Eng	1517	8	100
B. Eng to 2	500	6	94.25
C. 2 to 3	390	4	60.65
D. 3 to 4	403	4	27.45
E. 4 to PE	569	4	18.13

Some of the constants in the formula apply over the whole line and so the formula may be reduced to simpler terms before using it.

$$\begin{aligned}
 P &= 0.000131 \left(1 + \frac{3.6}{d}\right) \frac{w^2 L}{D d^5} \\
 &= 0.000131 \left(1 + \frac{3.6}{10.19}\right) \frac{w^2 L}{D (109600)} \\
 &= .1618 \times 10^{-8} \times w^2 L V
 \end{aligned}$$

V is specific volume and equals 1/D.

Then, since for each section, w and L are constants P varies directly with V.

$$\begin{aligned}
 L &= 569 \\
 P_4 &= .1618 \times 10^{-8} \times 569 \times 20.5 \\
 &= .19 \\
 20.5 &\text{ is } V \text{ at 5 lbs gage and dry and saturated.}
 \end{aligned}$$

To use the formula exactly as it is involves the use of a cut and try method in finding the right value of V . While that method is not difficult it allows too many chances for error to creep into the calculations. These calculations do not use the formula exactly as it is. Rather, they follow a method which, while it is strictly in error, errs on the safe side and abolishes the cut and try method. The method is this: Instead of trying to find with the Eillenwood Charts and by a cut and try method the exact value of V as it has been previously defined it is assumed that V is the specific volume of the steam at the point where the steam leaves the section under consideration. $.1618 \times 10^{-8} \times 66700 \times 390 \times 20.4$

Section E. PE to 4. gage.

$$w = 425 \times .1813 = 77.1$$

Section $w^2 = 5940$.

$$L = 569$$

$$P_4 - 5 = .1618 \times 10^{-8} \times 569 \times 20.5$$

$$= .10$$

20.5 is V at 5 lbs gage and dry and saturated.

Section B. 2 to 1.

13

Section D. 4 to 3. 3425 - 401

$$w = 425 \times .2745 = 116.7$$

$$w^2 = 13600$$

$$L = 403 \text{ lbs gage}$$

$$P_3 - 5.10 = .1618 \times 10^{-8} \times 13600 \times 403 \times 20.5$$

Section a. 1 to BH = .18

$$P_3 = 5.28 \text{ lbs gage.}$$

$$w^2 = 180000$$

Section 6. 3 to 2.

$$w = 425 \times 1.6065 = 258 \text{ } 0^{-8} (180000) (1517) (19)$$

$$w^2 = 66700 = .8.4$$

$$L = 390 \text{ lbs gage}$$

$$P_2 - 5.28 = .1618 \times 10^{-8} \times 66700 \times 390 \times 20.4$$

$$= .86$$

The $P_2 = 6.14 \text{ lbs gage.}$ back pressure at which
the turbines will have to operate will be 17 lbs gage.

Section B. 2 to 1.

$$P_1 - 6.14 = .1618(10^{-8})(151000)(500)(19.9)$$

Section B. 2 to 1. produced in each hour of the 24

hour day $w = 425 \times .9425 = 401$ lbs of the total

steam produced $w^2 = 161000$ lbs 24 hours.

$L = 500$

The $P_1 = 8.61$ lbs gage compiled from data taken from the circular charts of the Cochran meters on the

Section a. 1 to B.H. in the Boiler House of the

University $w = 425 \times 1.00 = 425$ lbs of these figures was

not a problem. They were available

before $L = 1517$ lbs was begun.

$P_{BH} = 8.61 = .1618 (10^{-8}) (180000) (1517) (19)$

Hour $\bar{x} = .8.4$ Hour \bar{x}

Hour	\bar{x}	Hour	\bar{x}
AM 12-1	$P_{BH} = 17$ lbs gage	PM 12-1	6.17
1-2	2.37	1-2	5.25
2-3	2.27	2-3	5.17
3-4	2.47	3-4	4.91
4-5	2.97	4-5	4.70
5-6	4.90	5-6	4.26
6-7	5.55	6-7	3.55
7-8	5.57	7-8	3.52
8-9	5.73	8-9	3.05
9-10	5.50	9-10	2.95
10-11	5.50	10-11	2.95
11-12	5.50	11-12	2.53

Therefore, the highest back pressure at which the turbines will have to operate will be 17 lbs gage.

Section B. 2 to 1.

$P_1 = 6.14 = .1618(10^{-8})(161000)(500)(19.9)$

steam are produced in any 24 hours then .0216 W lbs are produced from 12 to 12.

The amount of steam produced in each hour of the 24 hour day expressed as a percentage of the total steam produced in the 24 hours.

These figures were compiled from data taken from the circular charts of the Cochrane meters on the fronts of the boilers in the Boiler House of the University. The determination of these figures was not a part of this problem. They were available before this problem was begun.

<u>Hour</u>	<u>%</u>	<u>Hour</u>	<u>%</u>
AM 12-1	2.16	PM 12-1	5.17
1-2	2.37	1-2	5.25
2-3	2.37	2-3	5.17
3-4	2.47	3-4	4.91
4-5	2.97	4-5	4.70
5-6	4.90	5-6	4.26
6-7	5.75	6-7	3.95
7-8	5.67	7-8	3.42
8-9	5.75	8-9	3.27
9-10	5.73	9-10	3.05
10-11	5.60	10-11	2.95
11-12	5.50	11-12	2.53

These mean, for example, that if W lbs of steam are produced in any 24 hours then .0216 W lbs are produced from 12 to 1am.

The determination, for each month, of a curve representing the maximum electrical consumption of the University during the month.

The records of the electrical consumption, September 1931 to August 1932, of the Elmwood Ave. Plant of the University were obtained from the Rochester Gas and Electric Corporation. These records show the average kilowatt and kilovolt-ampere consumption during each half-hour of the above period. A sample of these records is on Page. The pen of the recording instrument moves over the record in the following manner:

Line of zero kw

"a" reads the average kva during that half hr

"b" reads the average kw during that half hr

"c" means nothing.

The meter constant was 600.

A sample of the records: cards revealed the following peculiarities:

1. During each 24 hours there were 4 high points of electrical consumption: 10 to 11:30 am, 2 to 3 pm, 4 to 5:30 pm, and 7 to 8 pm.

2. The rise or fall of electrical consumption between these high points either followed a straight line or a concave curve and never followed a convex curve.

3. The lowest point of electrical consumption during any 24 hours occurred almost invariably at 1 am.

4. The fall of electrical consumption from 8 pm to 1 am either followed a straight line or a concave curve and never followed a convex curve.

5. The electrical consumption rose at one rate from 1 am to 6 am and at another rate from 6 am to 10 am. These rises also followed straight lines or concave curves.

A study of these records revealed the following peculiarities:

1. During each 24 hours there were 4 high points of electrical consumption: 10 to 11:30 am, 2 to 3 pm, 4 to 5:30 pm, and 7 to 8 pm.
2. The rise or fall of electrical consumption between these high points either followed a straight line or a concave curve and never followed a convex curve.
3. The lowest point of electrical consumption during any 24 hours occurred almost invariably at 1 am.
4. The fall of electrical consumption from 8 pm to 1 am either followed a straight line or a concave curve and never followed a convex curve.
5. The electrical consumption rose at one rate from 1 am to 6 am and at another rate from 6 am to 10 am. These rises also followed straight lines or concave curves.

Method of obtaining data from the records:

1. For each month the highest kw recorded between the hours of 10 and 11:30 am was found.
2. For each month the highest kw recorded between the hours of 2 and 3 pm was found.
3. For each month the highest kw recorded between the hours of 4 and 5:30 pm was found.
4. For each month the highest kw recorded between the hours of 7 and 8 pm was found.
5. For each month the highest kw recorded at 6 am was found.
6. For each month the highest kw recorded at 12 midnight was found.

12 midnight was chosen instead of 1 am as noted on Page 18 because it would be very difficult to draw a line between the hours of 8 pm and 1 am. No error was introduced by this choice.

The straight line from 12 midnight to 1 am at 1 am was connected by a straight line with the kw value at 6 am.

Method followed in drawing the curve for each month:

2 - 2 to 3 1. Ordinates: kilowatts.

3 - 4 to 5:30 Abscissae: the 24 hours of a day, 12

4 - 7 to 8 pm midnight to 12 midnight.

5 - 12 midnight 2. Straight lines (horizontal) were drawn from 10 to 11:30 am, from 2 to 3 pm, from 4 to 5:30 pm, and from 7 to 8 pm at the kw values for those periods found by the method on Page 19.

Feb 1932 3. The kw values at 12 midnight and at 6 am were marked.

Apr 1932 4. Straight lines were drawn between the ends of the horizontal lines and between the horizontal lines and the marked points.

Oct 1931 5. The straight line from 12 midnight to 1 am is an extension of the straight line from 8 pm to 12 midnight.

6. The kw value struck by the straight line from 12 midnight to 1 am at 1 am was connected by a straight line with the kw value at 6 am.

Where the data for these curves was obtained:

1 - 10 to 11:30 am

2 - 2 to 3 pm

3 - 4 to 5:30 pm

4 - 7 to 8 pm

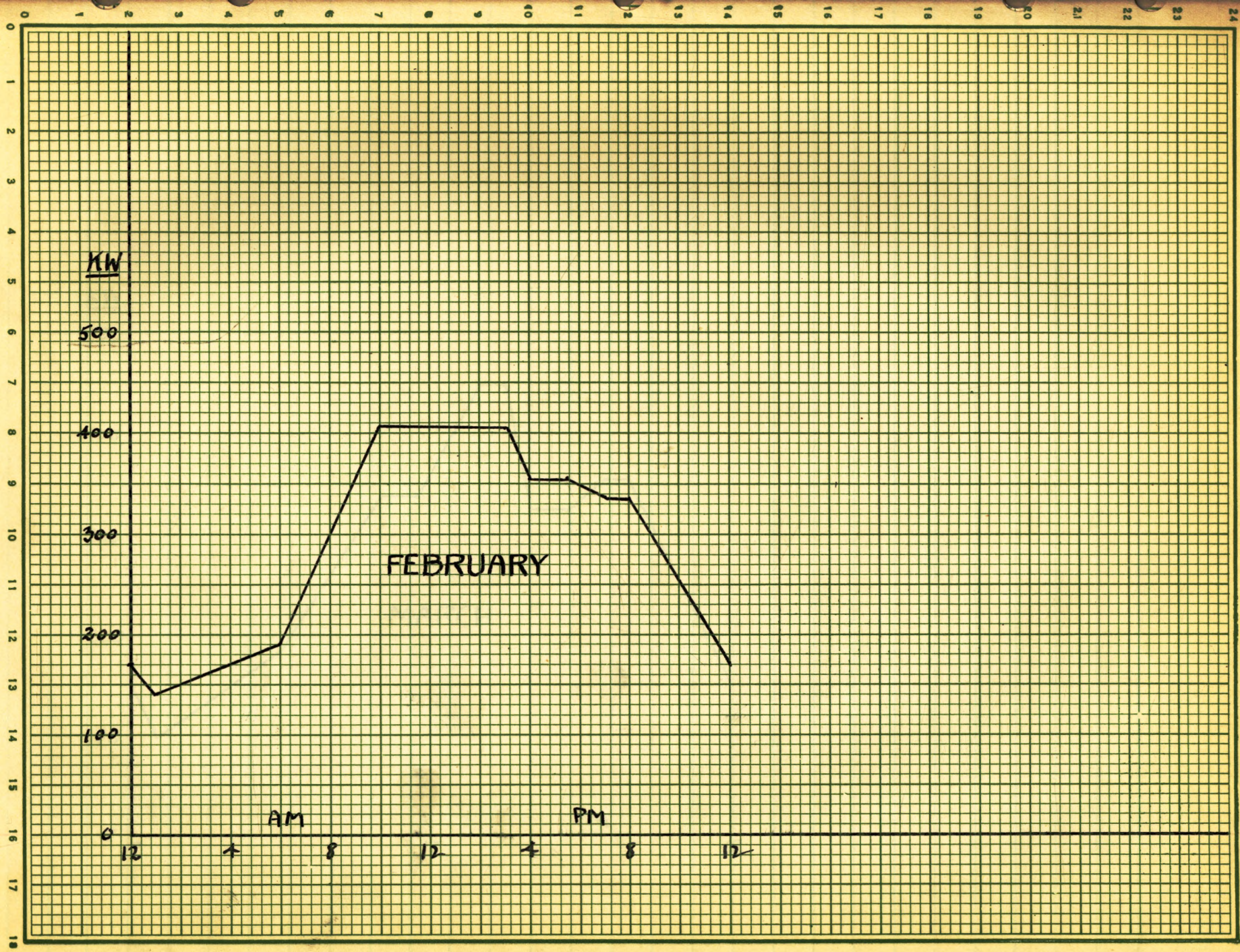
5 - 12 midnight

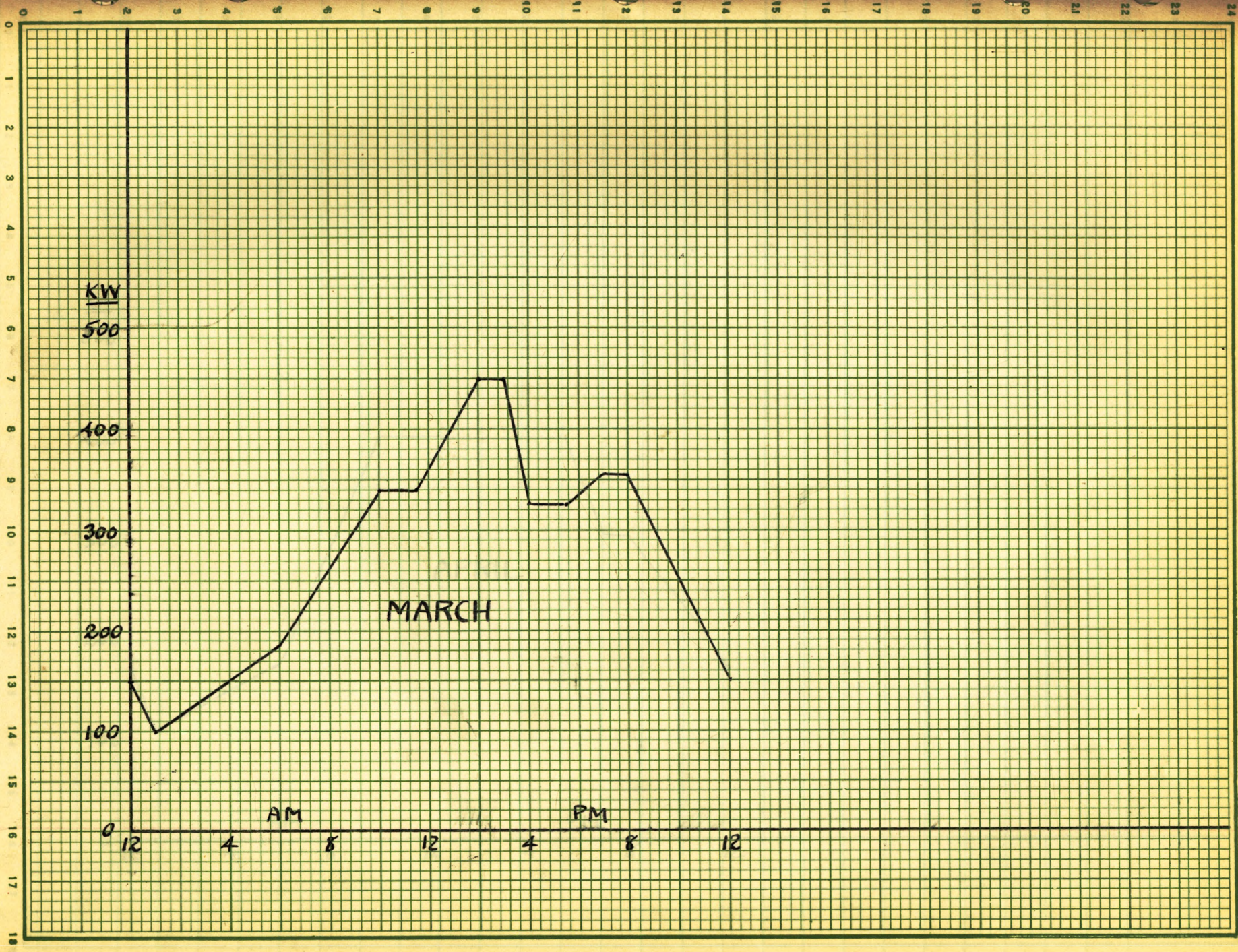
6 - 6 am

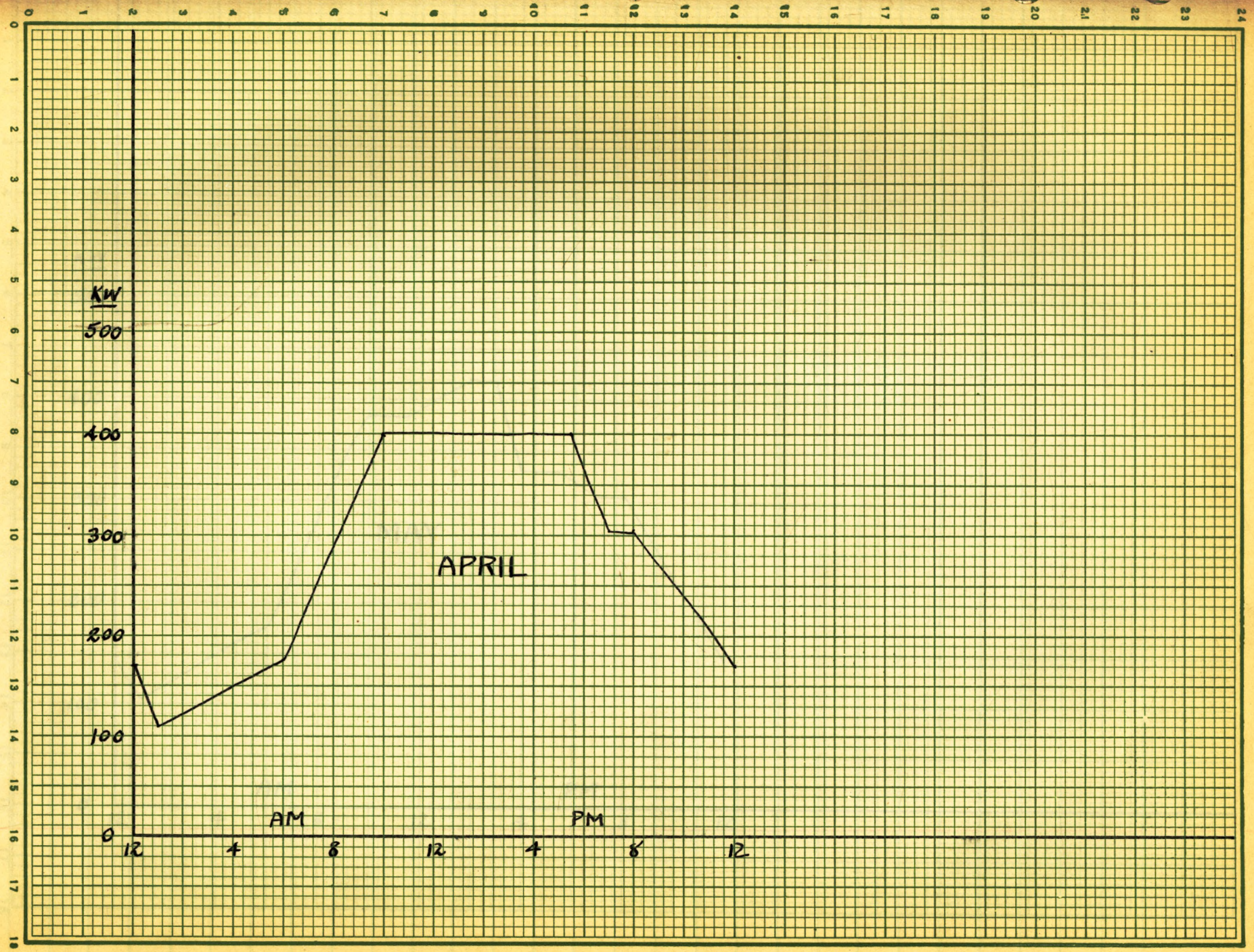
<u>Month</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Jan 1932	27	15	15	14	23	9
Feb 1932	8	29	11	15	27	5
Mar 1932	22	19	18	25	7	22
Apr 1932	9	25	8	11	23	12
May 1932	10	9	11	9	20	8
Jun 1932	13	8	3	2	13	1
Oct 1931	14	14	14	19	29	20
Nov 1931	18	30	30	23	19	4
Dec 1931	14	11	17	14	5	18

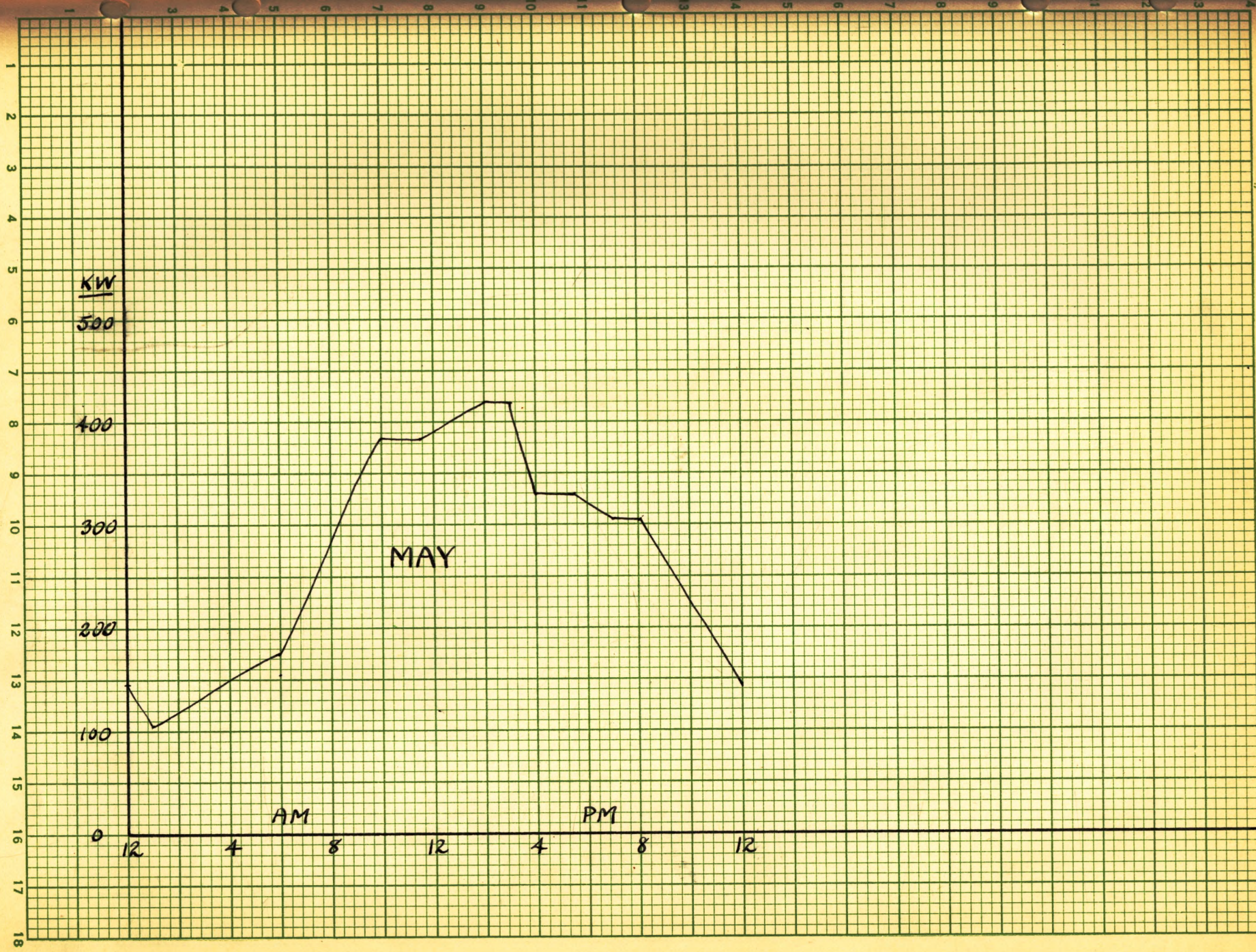
Columns 1, 2, 3, 4, 5, and 6 are dates.

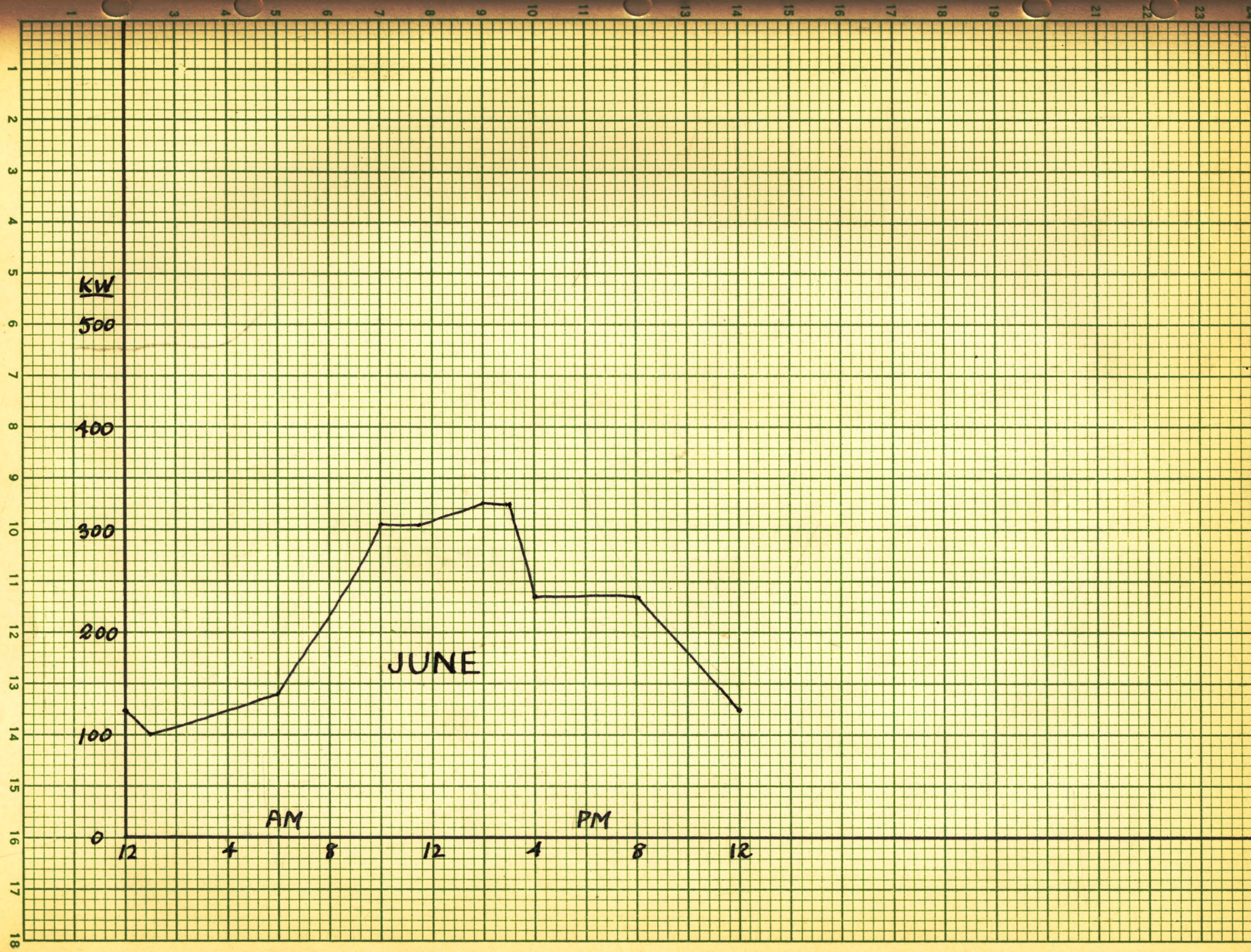


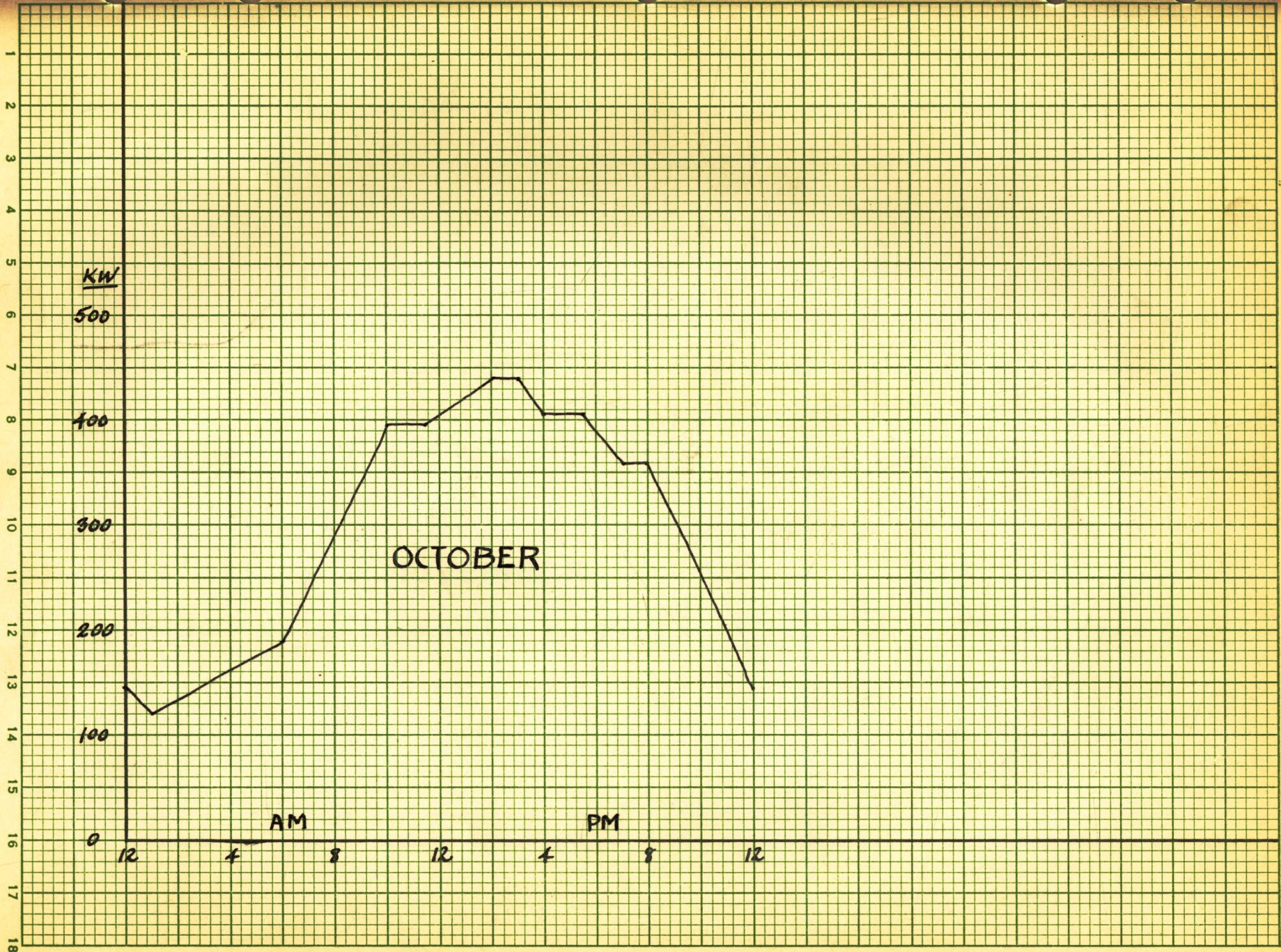


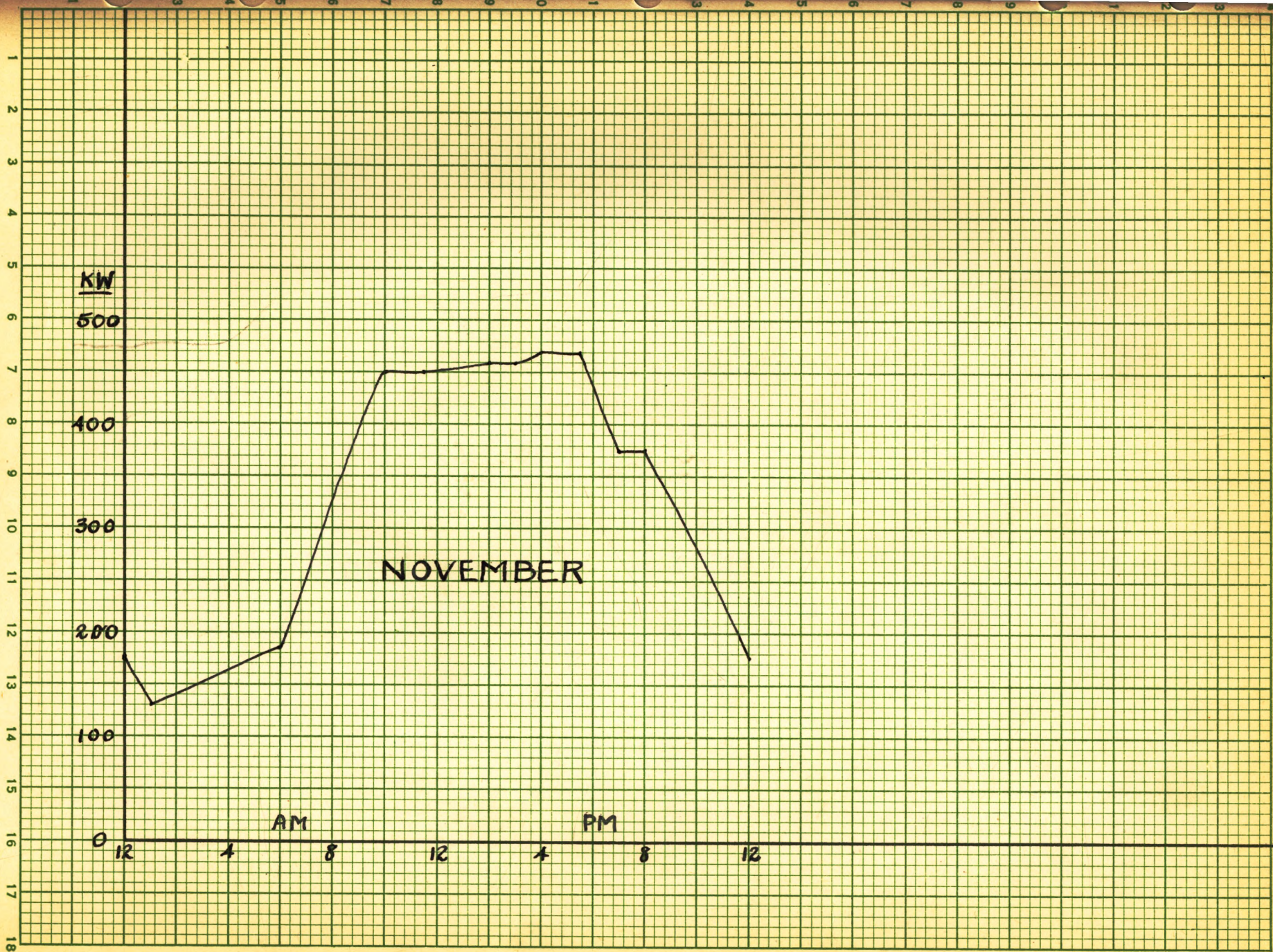


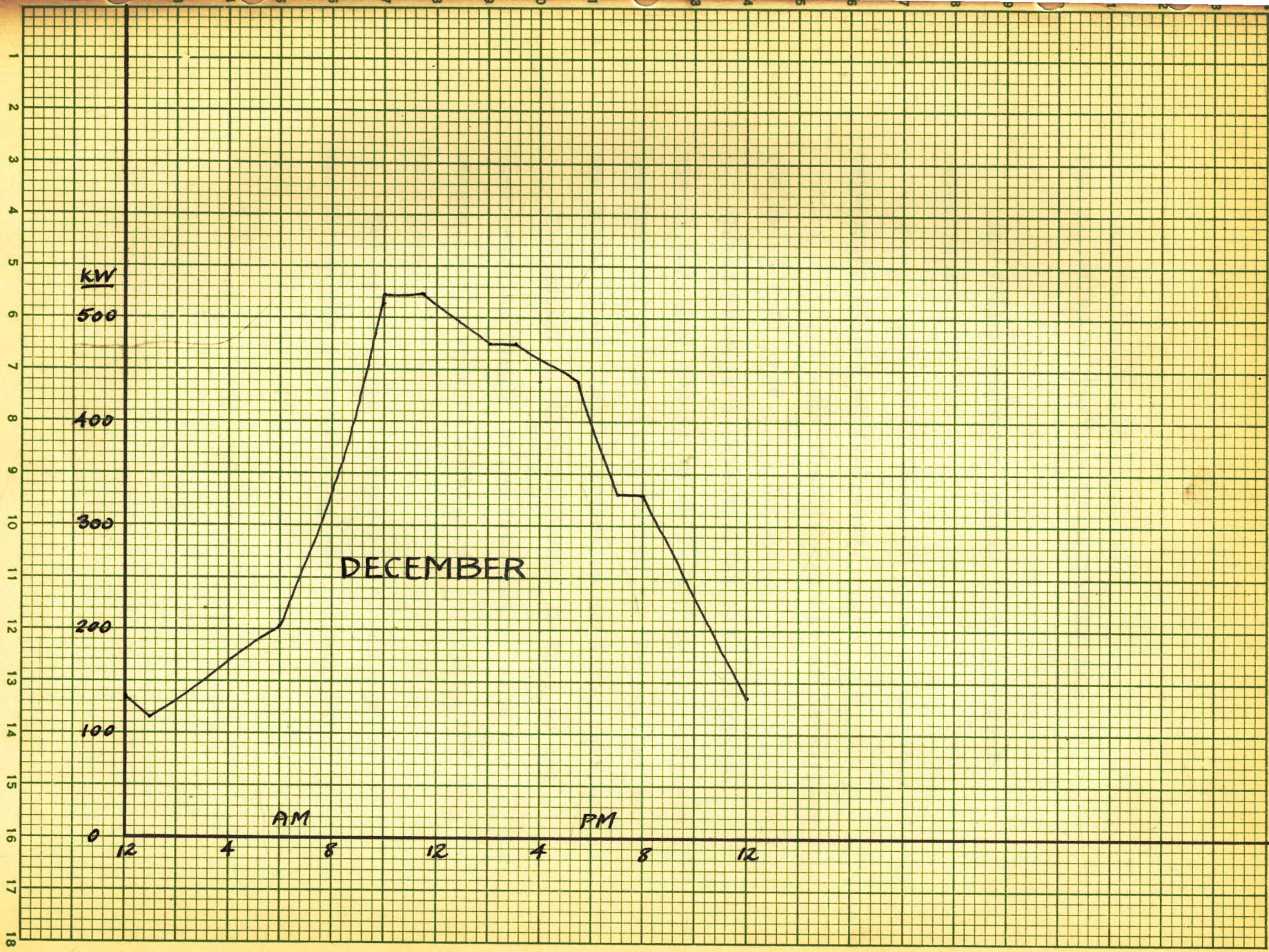












The Selection of Turbine-Generator Units:

The following units appear to be the best selections:

1. 2 units, each of which is capable of developing 300 kw at full load.

2. 1 unit that is capable of developing 200 kw at full load.

These provide a potential ability to generate at any time 800 kw which is 275 kw greater than the University has ever consumed in the past at any one time. Thus, future expansion is taken care of.

The actual sizes were chosen so that no one of them, working singly or in combination with one of the others, would ever be working at less than 50% of full load.

The actual type (single stage, axial flow) was chosen for dependability and reliability.

The correlation of the electrical demand with the 32

Specifications of the turbine-generator units:

Turbine speed. 4800 rpm.

Generator speed. 1200 rpm.

Herringbone reduction gears.

Single stage, axial flow, 2 row, impulse turbines.

Constant speed governor.

Throttle steam pressure. 185 lbs gage. 100°F superheat.

Generator voltage. 4250.

Each 300 kw unit. \$6200.

Each 200 kw unit \$5500.

Freight allowed to Rochester.

Each 300 kw unit. 14000 lbs.

Each 200 kw unit. 11000 lbs.

80 % power factor.

The correlation of the electrical demand with the steam output.

It is assumed that every day of each month the maximum electrical demand will have to be generated.

It is assumed that 45 lbs of steam will be required to generate each kw-hr.

Procedure: Refer to Pages 34-42. The figures in column "kw" are from the maximum electrical curves. Each of the figures in the column "kw x 45" represents the amount of steam that must be produced in that hour to generate the maximum kw of that hour. The column "%" is explained on Page 15. Column "Lbs" is obtained by dividing column "kw x 45" by column "%" and each of its figures represents the amount of steam that must be produced in 24 hours in order that enough of it will be produced in the corresponding hr to generate the max electrical demand of that hour.

January

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	150	6750	.0216	313000
1-2	135	6070	.0327	256000
2-3	145	6530	.0327	275500
3-4	157	7070	.0247	286500
4-5	170	7650	.0297	257500
5-6	180	8100	.0490	165200
6-7	220	9900	.0575	172000
7-8	290	13050	.0567	1234500
8-9	360	16200	.0575	282000
9-10	430	19350	.0573	2337000
10-11	462	20800	.0560	372000
11-12	460	20700	.0550	276500
PM 12-1	458	20600	.0517	398500
1-2	457	20550	.0525	391000
2-3	455	20500	.0517	396500
3-4	448	20200	.0491	412000
4-5	440	19800	.0470	422000
5-6	435	19580	.0426	460000
6-7	357	17400	.0395	440000
7-8	360	16200	.0342	473000
8-9	335	15100	.0327	462000
9-10	290	13050	.0305	4428000
10-11	243	10950	.0295	4372000
11-12	198	8920	.0253	3353000
		<u>345020</u>		

February

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	160	7200	.0216	333000
1-2	145	6520	.0237	275000
2-3	157	7060	.0237	298000
3-4	167	7510	.0247	304000
4-5	177	7960	.0297	268000
5-6	187	8410	.0490	171600
6-7	220	9900	.0575	172000
7-8	275	12370	.0557	218000
8-9	327	14700	.0575	255500
9-10	380	17100	.0573	298500
10-11	407	18300	.0560	327000
11-12	407	18300	.0550	333000
PM 12-1	407	18300	.0517	354000
1-2	407	18300	.0525	349000
2-3	407	18300	.0517	354000
3-4	380	17100	.0491	348000
4-5	353	15880	.0470	338000
5-6	350	15770	.0426	370000
6-7	342	15380	.0395	389000
7-8	335	15070	.0342	441000
8-9	317	14260	.0327	436000
9-10	277	12460	.0305	408000
10-11	328	10700	.0295	363000
11-12	198	8910	.0253	352000
		<u>315740</u>		

March

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	125	5620	.0216	260000
1-2	108	4860	.0237	205000
2-3	125	5620	.0237	237000
3-4	143	6430	.0247	260000
4-5	160	7200	.0297	242500
5-6	177	7960	.0490	162400
6-7	205	9240	.0575	160500
7-8	242	10880	.0567	192000
8-9	282	12680	.0575	220500
9-10	322	14480	.0573	253000
10-11	342	15380	.0560	275000
11-12	347	15600	.0550	283500
PM 12-1	387	17400	.0517	336500
1-2	428	19280	.0525	367000
2-3	450	20250	.0517	391500
3-4	385	17320	.0491	352500
4-5	325	14620	.0470	311000
5-6	330	14860	.0426	349000
6-7	343	15420	.0395	391000
7-8	353	15880	.0342	464000
8-9	325	14620	.0327	447000
9-10	275	12370	.0305	406000
10-11	225	10120	.0295	343000
11-12	175	7870	.0253	311000
		<u>295960</u>		

April

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	145	6530	.0216	302500
1-2	117	5270	.0237	222500
2-3	128	5760	.0237	243000
3-4	143	6440	.0247	261000
4-5	155	6980	.0297	235000
5-6	168	7560	.0490	154300
6-7	205	9210	.0575	160000
7-8	260	11700	.0567	206500
8-9	318	14300	.0575	249000
9-10	375	16850	.0573	294000
10-11	402	18100	.0560	323000
11-12	402	18100	.0550	329000
PM 12-1	402	18100	.0517	350000
1-2	402	18100	.0525	345000
2-3	402	18100	.0517	350000
3-4	402	18100	.0491	369000
4-5	402	18100	.0470	385000
5-6	395	17750	.0426	417000
6-7	340	15300	.0395	387000
7-8	305	13720	.0342	401000
8-9	288	12950	.0327	396000
9-10	257	11560	.0305	379000
10-11	225	10120	.0295	343000
11-12	195	8770	.0253	347000
		<u>307470</u>		

May

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	125	5620	.0216	260000
1-2	112	5040	.0237	213000
2-3	127	5710	.0237	241000
3-4	142	6390	.0247	259000
4-5	157	7060	.0297	237500
5-6	167	7510	.0490	153300
6-7	207	9300	.0575	161500
7-8	257	11570	.0567	204000
8-9	307	13820	.0575	240000
9-10	360	16200	.0573	283000
10-11	385	17320	.0560	309000
11-12	390	17550	.0550	319000
PM 12-1	400	18000	.0517	348000
1-2	413	18600	.0525	354500
2-3	420	18900	.0517	365000
3-4	375	16860	.0491	343000
4-5	330	14850	.0470	316000
5-6	325	14630	.0426	343000
6-7	313	14080	.0395	357000
7-8	305	13720	.0342	401000
8-9	283	12750	.0327	390000
9-10	243	10950	.0305	359000
10-11	203	9140	.0295	310000
11-12	163	7330	.0253	290000
		<u>292630</u>		

Hour	Kw	June Kw x 45	%	Lbs
AM 12-1	113	5080	.0216	235000
1-2	103	4630	.0237	195300
2-3	113	5080	.0237	214000
3-4	120	5400	.0247	218500
4-5	128	5760	.0297	194000
5-6	137	6160	.0490	125700
6-7	160	7200	.0575	125100
7-8	203	9140	.0567	161200
8-9	243	10950	.0575	190500
9-10	285	12820	.0573	224000
10-11	305	13730	.0560	245000
11-12	306	13760	.0550	250000
PM 12-1	313	14100	.0517	273000
1-2	322	14480	.0525	276000
2-3	325	14620	.0517	283000
3-4	280	12600	.0491	257000
4-5	235	10570	.0470	225000
5-6	235	10570	.0426	248000
6-7	235	10570	.0395	267000
7-8	235	10570	.0342	309000
8-9	220	9900	.0327	303000
9-10	193	8680	.0305	284000
10-11	165	7420	.0295	251000
11-12	140	6300	.253	249000
		<u>230080</u>		

October

Hour	Kw	Kw x 45	%	Lbs
AM 12-1	145	6520	.0216	302000
AM 1-2	127	5720	.021	241000
2-3	141	6340	.021	267500
3-4	155	6970	.021	282500
4-5	168	7560	.021	255000
5-6	183	8230	.021	168000
6-7	215	9670	.041	168000
7-8	268	12040	.051	212500
8-9	320	14390	.051	250000
9-10	370	16630	.051	290500
10-11	395	17770	.051	317500
11-12	400	18000	.051	327000
11-12	451	20300	.0550	369000
PM 12-1	514	18650	.0517	361000
PM 1-2	432	19400	.051	370000
2-3	440	19780	.051	382500
2-4	423	19000	.051	382600
4-5	407	18300	.041	389500
5-6	400	18000	.041	423000
6-7	375	16860	.041	427000
7-8	360	16180	.031	473000
8-9	335	15080	.031	462000
9-10	290	13040	.031	428000
10-11	240	10780	.031	366000
11-12	193	8680	.021	343000
11-12	200	9000	.0253	356000
		323590		
		347735		

November

<u>Hour</u>	<u>Kw</u>	<u>Kw x 45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	150	6750	.0216	3125000
1-2	135	6075	.0237	2565000
2-3	147	6620	.0237	2795000
3-4	158	7110	.0247	2885000
4-5	168	7560	.0297	2550000
5-6	180	8100	.0490	1653000
6-7	220	9900	.0575	1722000
7-8	285	12820	.0567	2265000
8-9	350	15750	.0575	2740000
9-10	418	18800	.0573	3285000
10-11	450	20250	.0560	3615000
11-12	451	20300	.0550	3690000
PM 12-1	452	20350	.0517	3940000
1-2	454	20400	.0525	3885000
2-3	455	20400	.0517	3960000
3-4	458	20600	.0491	4200000
4-5	462	20750	.0470	4410000
5-6	455	20450	.0426	4800000
6-7	405	18220	.0395	4620000
7-8	378	17000	.0342	4970000
8-9	350	15750	.0327	4820000
9-10	300	13480	.0305	4420000
10-11	250	11250	.0295	3810000
11-12	200	9000	.0253	3560000
		<u>347735</u>		

The amount of heating December used daily by the

<u>Hour</u>	<u>Kw</u>	<u>Kwx45</u>	<u>%</u>	<u>Lbs</u>
AM 12-1	138	6210	.0216	287000
1-2	123	5530	.0237	233000
2-3	142	6390	.0237	270000
3-4	160	7200	.0247	291500
4-5	178	8010	.0297	270000
5-6	197	8860	.0490	180500
6-7	247	11100	.0575	193200
7-8	325	14620	.0567	258000
8-9	405	18220	.0575	317000
9-10	483	21700	.0573	379000
10-11	522	23500	.0560	420000
11-12	520	23400	.0550	426000
PM 12-1	507	22800	.0517	441000
1-2	493	22200	.0525	423000
2-3	485	21800	.0517	422000
3-4	462	20800	.0491	423000
4-5	440	19800	.0470	422000
5-6	430	19330	.0426	454000
6-7	368	16550	.0395	419000
7-8	330	14840	.0342	434000
8-9	310	13940	.0327	426000
9-10	265	11910	.0305	391000
10-11	225	10120	.0295	343000
11-12	180	8100	.0253	320000
		<u>356930</u>		

The amount of heating steam used daily by the University.

Date	1932	1932	1931	1931	1931	Jun 1931
1	500000	835500	485500	554000	505500	275000
2	These figures represent heating steam only.					244000
3	422500	830000	693000	560000	568500	206000
4	They do not contain the 65000 lbs of steam					141000
5	624000	712500	672500	394000	291000	134000
6	used daily at high pressure in the Medical School.					196500
7	810500	475000	865000	534500	160000	177500
8	They do contain the amount of steam used					333000
9	627000	736000	668500	419500	278500	365000
10	Daily at high pressure on Oak Hill but this amount					209500
11	797500	540500	706500	452000	354000	138500
12	is unknown and according to Mr. Gavett is relatively					5000
13	479500	654000	692000	392500	380500	127500
14	small and may be ignored.					109000
15	479500	828500	471500	463500	329000	129000
16	These figures are minimum amounts. For example,					
17	434000	696000	408500	392500	319000	
18	the amount of steam produced in 1932 was smaller than					
19	672000	635500	380500	275000	178500	
20	the amount produced in January 1931 so the figures of Jan-					
21	628500	544500	563500	210000	284500	
22	uary 1932 are used in this study rather than the figures					
23	628500	697500	562000	528500	467000	
24	of January 1931.					
25	739000	733000	524000	474500	464000	
26	640000	620500	544000	396000	305500	
27	642000	639000	542000	612000	262500	
28	642500	451000	556500	592000	174500	
29	601000		440000	570000	148000	
30	641500		651500	531500	118500	
31	576000		597500		129500	

<u>Date</u>	<u>Jan 1932</u>	<u>Feb 1932</u>	<u>Mar 1931</u>	<u>Apr 1931</u>	<u>May 1931</u>	<u>Jun 1931</u>
1	500000	835500	485500	584000	505500	275000
2	605500	725500	709000	590500	506500	244000
3	425500	630000	693000	560000	368500	206000
4	699500	661500	697000	534000	429000	141000
5	624000	712500	672500	394000	291000	134000
6	576000	650000	680000	496500	210500	196500
7	610500	476000	665000	534500	180000	177500
8	624500	739000	498000	504000	350000	333000
9	627000	736000	668500	419500	278500	365000
10	452000	675000	688500	423000	195500	209500
11	797500	540500	706500	452000	354000	138500
12	673000	581500	579500	378000	410000	135000
13	479500	684000	692000	392500	380500	127500
14	456000	515000	642500	450000	335500	109000
15	439500	828500	471500	463500	329000	129000
16	610000	764500	631000	425500	241500	
17	434000	696000	608500	392500	319000	
18	682500	718500	604000	389500	295000	
19	672000	635500	580500	275000	175500	
20	644500	746000	587500	267500	139500	
21	628500	544500	563500	210000	284500	
22	579500	627000	406000	238500	352500	
23	628500	697500	562000	528500	457000	
24	478000	760000	513500	514500	398000	
25	736000	733000	524000	474500	464000	
26	640000	620500	544000	396000	305500	
27	642000	639000	552000	612000	262500	
28	642500	451000	556500	572000	174500	
29	601000	441500	440000	570000	148000	
30	641500	372000	651500	531500	115500	
31	576000		597500		129500	

The determination of the amount of steam, extra to the 45

Date	Oct 1931	Nov 1931	Dec 1931
1		371000	634000
2		581000	684500
3		543500	630500
4		559500	603500
5		566500	703500
6		628000	548000
7		582000	788500
8		399500	806500
9		365000	722000
10		348000	634500
11		517000	581500
12		407000	529500
13		487000	435500
14		513500	613000
15		390500	671000
16	403500	384500	651000
17	498500	325000	635500
18	407000	425500	586500
19	496000	498500	567500
20	365500	356000	439000
21	366500	312500	667500
22	415500	279500	547500
23	319000	303000	519500
24	254000	347500	482000
25	303000	569500	425000
26	427000	418000	677500
27	415500	611500	505500
28	320500	625500	714000
29	367500	441500	647500
30	445000	672000	658000
31	478500		657000

electrical demand for those days. Such days are those that have their amounts of heating steam in red on Pages 44-45.

The determination of the amount of steam, extra to the heating demand, necessary in each month to be able to generate the electrical demand for the month.

This method goes back to Pages 33-42

It is assumed that every day of each month the maximum electrical demand, represented by the curves on Pages 22-30, will have to be generated.

It is assumed that every day of each month the heating demand, represented by the figures on Pages 44-45, will be a minimum.

Obviously, there are some days when the amount of steam necessary for heating is more than enough to generate the maximum electrical demand for those days. Such days are those that have their amounts of heating steam in black on Pages 44-45.

It is also to be expected that there are some days when the amount of steam necessary for heating is not enough to generate the maximum electrical demand for those days. Such days are those that have their amounts of heating steam in red on Pages 44-45.

Method of determining whether the heating steam on a given day is or is not enough to generate the maximum electrical demand for that day:

This method goes back to Pages 33-42 where the amount of steam necessary to generate the maximum electrical demand for each month was found. Examining these pages it will be noticed that the largest of the figures in column "Lbs" is in red. That figure is hereby defined as that amount of 24-hour steam that will have enough of itself produced in every hour of the 24 hours to generate the maximum electrical demand of every hour of the 24. Therefore, examining Pages 44-45, it is seen that every day that has an amount of heating steam greater than the red amount of its month on Pages 34-42 is a day on which the amount of heating steam is more than enough to generate the maximum electrical demand for that day. Similarly, every day that has an amount of heating steam less than the red amount of its month is a day on which the heating steam is not enough to generate the maximum electrical demand of the day.

Therefore, in each hour of the day

Method of determining for each day, on which the heating steam was not enough to generate the maximum electrical demand for the day, the exact amount of steam that would have to be produced in addition to the heating steam to be able to generate the maximum electrical demand for the day:

At first it appears that this amount is equal to the difference between the amount of heating steam for the day as given on Pages 44-45 and the red amount for the day's month as given on Pages 34-42 but this is not so and the reason will be plain as this method is explained.

The actual method is this: Take any day on which the amount of heating steam is not enough to generate the maximum electrical demand for the day and multiply its actual amount of heating steam by the ϵ 's given on Page 15. This will give the amount of heating steam produced in each hour of that day. Having these hourly amounts, it will be noticed that some of them are greater than the hourly amounts for the corresponding hours in the column "Kw x 45" on Pages 34-42. Therefore, in each hour of the day

in question in which the amount obtained by the multiplication is greater than the amount for that hour in column "Kw x 45" there is more than enough heating steam to generate the max electrical demand for that hour. It will also be noticed that some of the hourly amounts obtained by the multiplication are less than the amounts for the corresponding hours in column "Kw x 45". Then, the difference between the actual amount of heating steam in an hour and the amount in column "Kw x45 for that hour is the exact amount of steam that must be produced in that hour in addition to the amount of heating steam for that hour to be able to generate the max electrical demand of that hour. (This difference is taken only for those hours in which the amount in column "Kw x 45" is greater than the actual amount of heating steam for the hour.) Adding up these differences gives the exact amount of steam that must be produced in the 24 hours of the day in addition to the amount of heating steam for the day to be able to generate the max electrical demand for the day.

Notice also that the amount of heating steam for the day as given on Pages 44-45 is greater than the amounts in column "Lbs" on pages 34-42 in the hours in which the amounts in column "Kw x 45" are less than the actual hourly amounts of heating steam for the day by the percents on Page 15. Knowing this it can be seen at a glance when, during the day, the heating steam is more than enough to generate the max electrical demand and when it is not.

Referring to the following pages of this section, the figures in column "Lbs per 24 hrs" come from Pages 44-45. The hours in column "Hour" were detected as deficient hours in the manner described in the paragraph above. The figures in column "Lbs Available" were obtained by multiplying the "Lbs per 24 hrs" by the %'s for those hours from Page 15. These figures show the amount of heating steam produced in each of the hours under column "Hour". The figures in column "Lbs extra" are the differences of the second paragraph above.

		January		
<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
3	425500	PM 5-6	18100	1480
		6-7	16800	600
		7-8	14550	1650
		8-9	13900	1200
		9-10	12950	100
				<u>5030</u>
March				
10	452000	PM 5-6	19250	330
		6-7		
		7-8	15450	750
		8-9	148000	300
				<u>1380</u>
22	406000	PM 7-8	13850	2030
		8-9	13250	1370
14	456000	PM 5-6	19400	180
		7-8	15580	620
		8-9	14900	200
				<u>1000</u>
29	440000	PM 7-8	15050	1330
		8-9	14400	320
				<u>1650</u>
15	439500	PM 5-6	18700	880
		7-8	15050	1150
		8-9	14380	720
17	434000	PM 5-6	18500	1080
		6-7	17150	250
		7-8	14850	1350
		8-9	14200	900
				<u>3580</u>

<u>Date</u>	<u>Total Lbs Extra</u>
Jan	13740

February

The heating steam in February is more than enough every day to generate the max electrical demand.

394000	PM 5-6	16800	980
	7-8	13450	270
	8-9	12850	100
			<u>1320</u>

12	378000	PM 4-5	March	17750	350
		5-6		16100	1650
		6-7		14900	400
		7-8		11500	60
		8-9		13250	1370
					<u>3400</u>

<u>Date</u>	<u>Lbs 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
22	406000	PM 7-8	13850	2030
		8-9	13250	<u>1370</u>
				<u>3400</u>
13	392500	PM 5-6	16700	1050
		7-8	13400	300
29	440000	PM 7-8	15050	830
		8-9	14400	<u>220</u>
				<u>1050</u>

17	392500			1520
18	389500	PM 5-6	16600	1150
		7-8	13300	420
		8-9	12750	200
				<u>1770</u>

19	275000	AM 12-1	5950	550
		9-10	15750	1100
		10-11	15400	2700
		11-12	15150	2950
		PM		

On next page.

April				
<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
5	394000	PM 5-6	16800	950
		7-8	13450	270
		8-9	12850	100
				<u>1320</u>
12	378000	PM 4-5	17750	350
		5-6	16100	1650
		6-7	14900	400
		7-8	12950	770
		8-9	12350	600
		9-10	11500	60
		<u>3830</u>		
13	392500	PM 5-6	16700	1050
		7-8	13400	320
		8-9	12800	150
		<u>1520</u>		
17	392500	PM 12-1	13850	1520
18	389500	PM 5-6	16600	1150
		7-8	13300	420
		8-9	12750	200
		<u>1770</u>		
19	275000	AM 12-1	5950	580
		9-10	15750	1100
		10-11	15400	2700
		11-12	15150	2950
		PM		

On next page.

April

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
19	275000	PM 12-1	14200	3900
		1-2	14450	3650
		2-3	14200	3900
		3-4	13500	4600
		4-5	12900	5200
		5-6	11700	6050
		6-7	10850	4450
		7-8	9400	4320
		8-9	9000	3950
		9-10	8400	3160
		PM 10-11	8100	2020
		11-12	6950	1820
				<u>54350</u>
20	267500	AM 12-1	5750	780
		1-2	15350	1500
		10-11	15000	3100
		11-12	14700	3400
		PM 12-1	13850	4250
		1-2	14050	4050
		2-3	13850	4250
		3-4	13150	4950
		4-5	12550	5550
		5-6	11400	6350
		6-7	10550	4750
		7-8	9150	4570
		8-9	8750	4200
		9-10	8150	3410
		10-11	7900	2220
		11-12	6750	2020
				<u>59350</u>

On next page.

April

<u>Date</u>	<u>Lbs per 24hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
21	210000	AM 12-1	4550	1980
		1-2	5000	270
		2-3	5000	760
		3-4	5200	1240
		4-5	6250	730
		8-9	12050	2250
		9-10	12000	4850
		10-11	11750	6350
		11-12	11550	6550
		PM 12-1	10850	7250
		1-2	11000	7100
		2-3	10850	7250
		3-4	10300	7800
		4-5	9850	8250
		5-6	8950	8800
		6-7	8300	7000
		7-8	7200	6520
		8-9	6850	6100
		9-10	6400	5160
		10-11	6200	3920
		11-12	5300	3470
				<u>103600</u>
22	238500	AM 12-1	5150	1380
		2-3	5650	110
		3-4	5900	540
		8-9	13700	600
		9-10	13650	3200
		10-11	13350	4750
		11-12	13100	5000

PM

On next page.

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
		April		
		7-8		
		8-9		
22	238500	Pm 12-1	12300	5800
		1-2	12500	5600
5	291000	AM 2-3	12300	5800
		3-4	11700	6400
		4-5	11200	6900
		PM 5-6	10150	7600
		6-7	9400	5900
		7-8	8150	5570
		8-9	7800	5150
		9-10	7250	4310
		10-11	7050	3070
		11-12	6050	2720
		7-8	9930	80400
		8-9	9500	3250
26	396000	PM 5-6-10	16900	850
		7-8-11	13550	170
				1020
6	210500	AM 12-1	4550	1070
		1-2	5000	40
		3-4	5000	710
		5-6	5200	1190
		4-5	6250	810
		8-9	12100	1720
		9-10	12050	4150
		10-11	11800	5520
		11-12	11550	6000
<u>Date</u>	<u>Total Lbs</u>	<u>Extra</u>		
Apr	308680			

PM On next page

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
3	368500	PM 7-8	12600	1120
		8-9	12050	700
				<u>1820</u>
5	291000	AM 10-11	16300	1020
		11-12	16000	1550
		PM 12-1	15050	2950
		1-2	15250	3350
		2-3	15050	3850
		3-4	14300	2560
		4-5	13650	1200
		5-6	12400	2230
		6-7	11500	2580
		7-8	9950	3770
		8-9	9500	3250
		9-10	8850	2100
		10-11	8600	<u>540</u>
9	378500	AM 9-10	18250	30950
6	210500	AM 12-1	4550	1070
		1-2	5000	40
		PM 2-3	5000	710
		3-4	5200	1190
		4-5	6250	810
		8-9	12100	1720
		9-10	12050	4150
		10-11	11800	5520
		11-12	11550	6000
		PM 8-9	On next page	3650
		9-10	8500	2450
10-11	8200	940		
11-12	7050	<u>230</u>		
		38530		

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
6	210500	PM 12-1	10850	7150
		1-2	11050	7550
		2-3	10850	8050
		3-4	10350	6510
		4-5	9900	4950
		5-6	8950	5680
		6-7	8300	5780
		7-8	7200	6520
		8-9	6900	5850
		9-10	6400	4550
		10-11	6200	2940
		11-12	5300	2030
				<u>88770</u>
7	On next page.			
8	On next page.			
9	278500	AM 9-10	15950	150
		10-11	15600	1720
		11-12	15300	2250
		PM 12-1	14400	3600
		1-2	14600	4000
		2-3	14400	4500
		3-4	13700	3160
		4-5	13100	1750
		5-6	11850	2780
		6-7	11000	3080
		7-8	9500	4220
		8-9	9100	3650
		9-10	8500	2450
		10-11	8200	940
		11-12	7050	280
				<u>38530</u>

May

<u>Date</u>	<u>Lbs per 24hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
7	180000	AM 12-1	3900	1720
		1-2 1-2	4250	3790
		2-3 2-3	4250	1460
		3-4 3-4	4450	1940
		4-5 4-5	5350	1710
		7-8 7-8	10200	1370
		8-9 8-9	10350	3470
		9-10 9-10	10300	5900
		10-11 10-11	10100	7220
		11-12 11-12	9900	7650
		PM 12-1 12-1	9300	8700
		1-2 1-2	9450	9150
		2-3 2-3	9300	9600
		3-4 3-4	8850	8010
		4-5 4-5	8450	6400
		5-6 5-6	7650	6980
		6-7 6-7	7100	6980
		7-8 7-8	6150	7570
		8-9 8-9	5900	6850
		9-10 9-10	5500	5450
		10-11 10-11	5350	3790
		11-12 11-12	4550	2780
				<u>115490</u>
8	350000	PM 1-2 1-2	18350	6250
		2-3 2-3	18100	800
		6-7 6-7	13800	280
		7-8 7-8	11950	1770
		8-9 8-9	11450	1300
		9-10 9-10	10650	300
				<u>4700</u>
13	380500	PM 7-8 7-8	13000	720
		8-9 8-9	13400	300
				<u>1020</u>

May

<u>Date</u>	<u>Lbs per 24hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
10	195500	AM 12-1	4200	1420
		1-2	4650	390
		2-3	4650	1060
		3-4	4800	1590
		4-5	5800	1260
		7-8	11100	470
		8-9	11250	2570
		9-10	11200	5000
		10-11	10950	6800
15	323000	PM 12-1	10100	7900
		1-2	10250	8350
		2-3	10100	8800
		3-4	9600	7260
		4-5	9200	5650
		5-6	8350	6280
		6-7	7700	6380
		7-8	6700	7020
		8-9	6400	6350
		9-10	5950	5000
		10-11	5750	3390
16	241500	11-12	4950	2380
				<u>101690</u>
11	354000	PM 1-2		
		2-3	18300	600
		6-7	13950	130
		7-8	12100	1620
		8-9	11550	1200
		9-10	10800	150
				<u>3700</u>
13	380500	PM 7-8	13000	720
		8-9	12450	300
				<u>1020</u>

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
14	335500	PM 12-1	17350	650
		1-2	17600	1000
		2-3	17350	1550
		3-4	16500	360
		5-6	14300	330
		6-7	13250	830
		7-8	11450	2270
		8-9	10950	1800
		9-10	10250	700
				<u>9490</u>
15	329000	PM 12-1	17000	1000
		1-2	17250	1350
		2-3	17000	1900
		3-4	16150	710
		5-6	14000	630
		6-7	13000	1080
		7-8	11250	2470
		8-9	10750	2000
		9-10	10000	950
				<u>12090</u>
16	241500	AM 12-1	5220	400
		3-4	5950	440
		9-10	13850	2350
		10-11	13550	3770
		11-12	13300	4250

On next page.

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May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
16	241500	PM 12-1	12500	5500
		1-2	12700	5900
		2-3	12500	6400
		3-4	11850	5010
		4-5	11350	3500
		5-6	10300	4330
		6-7	9550	4530
		7-8	8250	5470
		8-9	7900	4850
		9-10	7350	3600
		10-11	7150	1990
		11-12	6100	1230
				<u>63520</u>
17-	319000	PM 12-1	16500	1500
		1-2	16750	1850
		2-3	16500	2400
		3-4	15700	1160
		5-6	13600	1030
		6-7	12600	1480
		7-8	10900	2820
		8-9	10450	2300
		9-10	9750	1200
				<u>15740</u>
18	295000	AM 10-11	16500	820
		11-12	16200	1350
		PM	On next page.	
		3-4	8250	820
		4-5	8250	820
		5-6	7500	7130
		6-7	6950	7130
		7-8	6000	7720
		8-9	5750	7000
		9-10	5350	5600
		10-11	5150	3390
		11-12	4450	2880
				<u>118980</u>

Mzy

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
18-	295000	PM 12-1	15250	2750
		1-2	15450	3150
		2-3	15250	3650
		3-4	14500-	2360
		4-5	13850	1000
		5-6	12600	2030
		6-7	11650	2430
		7-8	10050	3670
		8-9	9650	3100
		9-10	9000	1950
		10-11	8700	440
				<u>28700</u>
19	175500	AM 12-1	3800	1820
		1-2	4150	890
		2-3	4150	1560
		3-4	4350	2040
		4-5	5200	1860
		7-8	9950	1620
		8-9	10100	3720
		9-10	10050	6150
		10-11	9800	7520
		11-12	9650	7900
		PM 12-1	9050	8950
		1-2	9200	9400
		2-3	9050	9850
21	234500	AM 3-4	8600	8260
		4-5	8250	6600
		5-6	7500	7130
		PM 6-7	6950	7130
		7-8	6000	7720
		8-9	5750	7000
		9-10	5350	5600
		10-11	5150	3390
		11-12	4450	2880
				<u>118990</u>

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
20	139500	AM 12-1	3000	2620
		1-2	3300	1740
		2-3	3300	2410
		3-4	3450	2940
		4-5	4150	2910
		5-6	6850	660
		6-7	8050	1250
		7-8	7900	3670
		8-9	8050	5770
		9-10	8000	8200
		10-11	7800	9520
		11-12	7700	9850
		PM 12-1	7200	10800
		1-2	7350	11250
		2-3	7200	11700
		3-4	6850	10010
		4-5	6550	8300
		5-6	5950	8680
		6-7	5500	8580
		7-8	4750	8970
		8-9	4550	8200
		9-10	4250	6700
		10-11	4100	5040
		11-12	3500	3830
				<u>153600</u>
		AM 10-11	17100	220
		11-12	16800	750
21	284500	AM 10-11	15900	1420
		11-12	15650	1900

PM

On next page.

May
May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
21	284500	PM 12-1	14700	3300
		1-2	14950	3650
		2-3	14700	4200
		3-4	14000	2860
		4-5	13350	1500
		5-6	12100	2530
		6-7	11250	2830
		7-8	9700	4020
		8-9	9300	3450
		9-10	8650	2300
		10-11	8400	740
		11-12	7200	130
				<u>34830</u>
22	352500	PM 1-2	18500	100
		2-3	18200	700
		6-7	13900	180
		7-8	12050	1670
		8-9	11500	1250
		9-10	10750	200
				<u>4100</u>
24	398000	PM 7-8	13600	120
				<u>120</u>
26	305500	AM 10-11	17100	220
		11-12	16800	<u>750</u>
		PM	On next page.	

28

Same as the 19th.

118990

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
26	305500	PM 12-1	15800	2220
		1-2	16050	2550
		2-3	158000	3100
		3-4	15000	1860
		4-5	14350	500
		5-6	13000	1630
		6-7	12050	2030
		7-8	10450	3270
		8-9	10000	2750
		9-10	9300	1650
		10-11	9000	140
		11-12		
				<u>22650</u>
27	262500	AM 9-10	15050	1150
		11-12	14450	2620
		11-12	14450	3100
		PM 12-1	13550	4450
		1-2	13750	4850
		2-3	13550	5350
		3-4	12900	3960
		4-5	12350	2500
		5-6	11200	3430
		6-7	10350	3730
		7-8	8950	4770
		8-9	8600	4150
		9-10	8000	2950
		10-11	7750	1390
		11-12	6650	680
				<u>49080</u>
28	Same as the 19th.			118990

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
29	148000	AM 12-1	3200	2420
		1-2	3500	1540
		2-3	3500	2210
		3-4	3650	2740
		4-5	4400	2660
		5-6	7250	260
		6-7	8500	800
		7-8	8400	3170
		8-9	8500	5320
		9-10	8450	7750
		10-11	8300	9020
		11-12	8150	9400
		PM 12-1	7650	10350
		1-2	7750	10850
		2-3	7650	11250
		3-4	7250	9610
		4-5	6950	7900
		5-6	6300	8330
		6-7	5050	8670
		8-9	4850	7900
		9-10	4500	6450
		10-11	4350	4790
		11-12	3750	3580
				<u>145200</u>

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
30	115500	AM 12-1	2500	3120
		1-2	2750	2290
		2-3	2750	2960
		3-4	2850	3540
		4-5	3400	3660
		5-6	5650	1860
		6-7	6650	2650
		7-8	6550	5020
		8-9	6650	7170
		9-10	6600	9600
		10-11	6450	10870
		11-12	6350	11200
		PM 12-1	6700	11300
		PM 12-1	5950	12050
		1-2	6050	12550
		2-3	5950	12950
		3-4	5650	11210
		4-5	5450	9400
		5-6	4950	9680
		6-7	4550	9530
		7-8	3950	9770
		8-9	3800	8950
		9-10	3400	5740
		10-11	3400	5740
		11-12	2900	4430
				<u>177650</u>

Date Total Lbs Extra

May 1505050

May

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
31	129500	AM 12-1	2800	2820
		1-2	3050	1990
		2-3	3050	2660
		3-4	3200	3190
		4-5	3850	3210
		5-6	6350	1160
	244000	AM 6-7	7450	1850
		7-8	7350	4220
		8-9	7450	6350
		PM 9-10	7400	8800
		10-11	7250	10070
		11-12	7100	10450
		PM 12-1	6700	11300
		1-2	6800	11800
		2-3	6700	12200
		3-4	6350	10510
		4-5	6100	8750
		5-6	5500	9130
		6-7	5100	8980
		7-8	4400	9320
		8-9	4250	8500
	206000	AM 9-10	3950	7000
		10-11	3800	5340
		11-12	3300	<u>104050</u>
				163650

<u>Date</u>	<u>Total Lbs Extra</u>
May	1505050

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June

70

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
1	275000	PM 1-2	14450	30
		2-3	14200	420
		7-8	9400	1170
		8-9	9000	900
		9-10	8400	2800
2	244000	AM 10-11	13650	70
		11-12	13400	360
		PM 12-1	12600	1500
		1-2	12800	1680
		2-3	12600	2020
		3-4	12000	600
		5-6	10400	170
		6-7	9650	920
		7-8	8350	2220
		8-9	8000	1900
		9-10	7450	1230
		10-11	7200	220
11-12	6150	150		
			13040	
3	206000	AM 12-1	4450	630
		2-3	4900	180
		PM 3-4	5100	300
		9-10	11800	1020
		10-11	11550	2170
		11-12	11300	2460

PM On next page

June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
3	206000	PM 12-1	10650	3450
		1-2	10800	3680
		2-3	10650	3970
		3-4	10100	2500
		4-5	9700	870
		5-6	8800	1770
		6-7	8150	2420
		7-8	7050	3520
		8-9	6750	3150
		9-10	6250	2430
		10-11	6050	1370
		11-12	5200	1100
				<u>36990</u>
4	141000	AM 12-1	3050	2030
		1-2	3350	1280
		2-3	3350	1730
		3-4	3450	1950
		4-5	4200	1560
		7-8	8000	1140
		8-9	8100	2850
		9-10	8050	4770
		10-11	7900	5820
		11-12	7750	6010

PM

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June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
4	1410000	PM 12-1	7300	6800
	134000	1-2	7400	7080
		2-3	7300	7320
		3-4	6950	5650
		4-5	6600	3970
		5-6	6000	4570
		7-8	4800	5770
		8-9	4600	5300
		9-10	4300	5300
		10-11	4150	3270
		11-12	3550	2750
				<u>91020</u>
5	134000	AM 12-1	2900	2180
	196000	1-2	3150	1480
		AM 2-3	3150	1930
		3-4	3300	2100
		4-5	3950	1810
		7-8	7600	1540
		8-9	7700	3250
		9-10	7650	5170
		10-11	7500	6220
		PM 11-12	7350	6410
				On next page.

June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
5	134000	PM 12-1	6900	7200
		1-2	7050	7430
		2-3	6900	7720
		3-4	6600	6000
		4-5	6300	4270
		5-6	5700	4870
		6-7	5300	5270
		7-8	4550	6020
		8-9	4400	5500
		9-10	4100	4580
		10-11	3950	3470
		PM 11-12	3400	2900
			<u>97320</u>	
6	196500	AM 12-1	4250	830
		2-3	4650	430
		3-4	4850	550
		9-10	11250	1570
		10-11	11000	2720
		11-12	10800	2960
		PM 12-1	10150	3950
		1-2	10300	4180
		2-3	10150	4470
		3-4	9650	2950
		4-5	9250	1320
		5-6	8350	2220
		6-7	7750	2820
		7-8	6700	3870
		8-9	6400	3560
		9-10	6000	2680
		10-11	5800	1620
		PM 11-12	4950	1350
			<u>43990</u>	

June
June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>	<u>YY</u>
7-	177500	AM 12-1	3850	1230	
		1-2	4200	430	
		2-3	4200	880	
		3-4	4400	1000	
		4-5	5250	510	
		8-9	10200	750	
		9-10	10150	2670	
		10-11	9950	3770	
		11-12	9750	4010	
		PM 12-1	9200	4900	
		1-2	9300	5180	
		2-3	9200	5420	
11	138500	AM 13-4	8700	3900	
		4-5	8350	2220	
		5-6	7550	3020	
		6-7	7000	3570	
		7-8	6050	4520	
		8-9	5800	4100	
		9-10	5400	3280	
		10-11	5250	2170	
		11-12	4500	<u>51800</u>	
		11-12	7600	59330	
10	209500	AM 12-1	4500	580	
		2-3	4950	130	
		3-4	5200	200	
		9-10	12000	820	
		10-11	11750	1970	
		11-12	115500	2210	
		PM 7-8	On next page.		
		8-9	4500	5400	
		9-10	4200	4480	
		10-11	4100	3320	
		11-12	3500	2800	
				<u>93270</u>	

June
June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs p Available</u>	<u>Lbs Extra</u>
10	209500	PM 12-1	10850	3250
		1-2	11000	3480
		2-3	10850	3770
		3-4	10300	2300
		4-5	9850	720
		5-6	8950	1620
		6-7	8250	2320
		7-8	7150	3420
		8-9	6850	3050
		9-10	6400	2280
		PM 10-11	6200	1220
		11-12	5300	1000
				<u>34340</u>
11	138500	AM 12-1	3000	2080
		1-2	3300	1330
		2-3	3300	1780
		3-4	3400	2000
		4-5	4100	1660
		7-8	7850	1290
		8-9	7950	3000
		9-10	7900	4920
		10-11	7750	5970
		11-12	7600	6160
13	127500	AM 12-1	7150	6950
		1-2	7250	7230
		2-3	7150	7470
		3-4	6800	5800
		4-5	6500	4070
		5-6	5900	4670
		6-7	5500	5070
		7-8	4750	5820
		8-9	4500	5400
		9-10	4200	4480
		PM 10-11	4100	3320
		11-12	3500	2800
				<u>93270</u>

June

<u>Date</u>	<u>24 hrs</u>	<u>Hour</u>	<u>Available</u>	<u>Extra</u>
12-	135000	AM 12-1	2900	2180
		1-2	3200	1430
13	127500	PM 1 2-3	3200	1880
		3-4	3350	2050
		4-5	4000	1760
		7-8	7650	1490
		8-9	7750	3200
		9-10	7700	5120
		10-11	7550	6170
		11-12	7400	6360
		PM 12-1	7000	7100
		1-2	7100	7380
		2-3	7000	7620
		3-4	6650	5950
		4-5	6350	4220
14	109000	AM 5-6	5750	4820
		6-7	5300	5270
		7-8	4600	5970
		8-9	4400	5500
		9-10	4100	4580
		10-11	4000	3420
		11-12	3400	3880
				95370
13	127500	AM 12-1	2750	2330
		1-2	3000	1630
		2-3	3000	2080
		3-4	3150	2250
		PM 4-5	3800	1960
		7-8	7250	1890
		8-9	7350	3600
		9-10	7300	5520
		10-11	7150	6570
		11-12	7000	6760

PM

On next page.

June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
13	127500	PM 12-1	6600	7500
14	109000	PM 1-2	6700	7780
		2-3	6600	8020
		3-4	6250	6350
		4-5	60000	4570
		5-6	5450	5120
		6-7	5050	5520
		7-8	4350	6220
		8-9	4150	5750
		9-10	3900	4780
		10-11	3750	3670
		11-12	3200	3100
				<u>102970</u>
14	109000	AM 12-1	2350	2730
15	129000	AM 1-2	2600	2030
		2-3	2600	2480
		3-4	2700	2700
		4-5	3200	2560
		5-6	5350	810
		6-7	6300	900
		7-8	6150	2990
		8-9	6300	4650
		9-10	6250	6570
		10-11	6100	7620
		11-12	6000	7760
		PM	On next page.	
		PM	On next page.	

June
June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
14	109000	PM 12-1	5650	8450
		1-2	5700	8780
		2-3	5650	8970
		3-4	5350	7250
		4-5	5100	5470
		5-6	4650	5920
		6-7	4300	6270
		7-8	3700	6870
		8-9	3550	6350
		9-10	3300	5380
		10-11	3200	4220
		11-12	2750	3550
				<u>121280</u>
15	129000	AM 12-1	2800	2280
		1-2	3050	1580
		2-3	3050	2030
		3-4	3200	2200
		4-5	3800	1960
		7-8	7300	1840
		8-9	7450	3500
		9-10	7400	5420
		10-11	7200	6520
		11-12	7100	6660

Date
June

Total Lbs
893490

PM

On next page.

October
June

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
15	129000	PM 12-1	6650	7450
		1-2	6750	7730
		2-3	6650	7970
		3-4	6350	6250
		4-5	6050	4520
		5-6	5500	5070
18	407000	PM 6-7	5100	5470
		7-8	4400	6170
		8-9	4200	5700
		9-10	3900	4780
		10-11	3800	3620
		11-12	3250	3050
				<u>101770</u>
20	365500	PM 1-2	19200	200
		2-3	18900	880
		3-4	17920	1050
		4-5	17150	1150
		5-6	15600	2400
		6-7	14400	2460
		7-8	12500	3680
		8-9	11960	3130
		9-10	11180	1890
				<u>16840</u>
21	Same as the 20th.			16840
22	415500	PM 5-6	17700	300
		6-7	15400	480
		7-8	14200	1930
		8-9	13600	1480
		9-10	12650	390
				<u>4610</u>
<u>Date</u>	<u>Total Lbs</u>	<u>Extra</u>		
June	893490			

October

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>	
16	403500	PM	5-6	17200	800
			6-7	15900	960
			7-8	13800	2380
			8-9	13200	1880
			9-10	12300	740
18	407000	PM	5-6	17350	650
			6-7	16050	2810
			7-8	13900	2280
			8-9	13300	1780
			9-10	12400	640
20	365500	PM	1-2	19200	200
			2-3	18900	880
			3-4	17950	1050
			4-5	17150	1150
			5-6	15600	2400
			6-7	14400	2460
			7-8	12500	3680
			8-9	11950	3130
			9-10	11150	1890
21	Same as the 20th.			16840	
22	415500	PM	5-6	17700	300
			6-7	16400	460
			7-8	14200	1980
			8-9	13600	1480
			9-10	12650	390

October

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
23	319000	AM 11-12	17550	450
		PM 12-1	16500	2150
		1-2	16750	2650
		2-3	16500	3280
		3-4	15650	3350
		4-5	15000	3300
		5-6	13600	4400
		6-7	12600	4260
		7-8	10900	5280
		8-9	10400	4680
		9-10	9700	3340
		10-11	9400	1380
		11-12	8050	630-
				<u>39150</u>
24	254000	AM 12-1	5500	1020
		2-3	6000	340
		3-4	6250	720
		9-10	14550	2080
		10-11	14200	3570
		11-12	14000	4000
				555
		PM 12-1	13100	5550
		1-2	13350	6050
		2-3	13100	6680
		3-4	12500	6500
		4-5	11950	6350
		5-6	10800	7200
		6-7	10000	6860
		7-8	8700	7480
		8-9	8300	6780
		9-10	7750	5290
		10-11	7500	3280
		11-12	6400	2280
				<u>82030</u>

October

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
25	303000	AM 10-11	16950	820
		11-12	16650	1350
		PM 12-1	15650	3000
		1-2	15900	3500
		2-3	15650	4130
		3-4	14900	4100
		4-5	14250	4050
		5-6	12900	5100
		6-7	11950	5910
		7-8	10350	5830
		8-9	9900	5180
		9-10	9250	3790
		10-11	8950	1830
		11-12	7650	1030
				<u>48620</u>
26	427000	PM 7-8	14600	1580
		8-9	13950	1130
		9-10	13000	40
				<u>2750</u>
27	Same as the 22nd.			4610

Date Total Lbs Extra

Oct 285220

October

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs per Available V</u>	<u>Lbs Extra</u>
28	320500	AM 11-12	17600	400
		PM 12-1	16550	2100
		1-2	16800	2600
		2-3	16550	3230
		3-4	15700	3300
		4-5	15050	3250
		5-6	13650	4350
		6-7	12650	4210
		7-8	10950	5230
		8-9	10450	4630
		9-10	9750	3290
		10-11	9450	1330
		11-12	8100	580
				<u>38500</u>
29	Same as the 20th.			16840
30	445000	PM 7-8	15200	980
		8-9	14550	530
				<u>1510</u>

<u>Date</u>	<u>Total Lbs Extra</u>
Oct	285220

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
1	371000	PM 12-1	19200	1150
		1-2	19480	920
		2-3	19200	1250
		3-4	18200	2400
		4-5	17440	3310
		5-6	15800	4650
		6-7	14650	3570
		7-8	12680	4320
		8-9	12130	3620
		9-10	11300	2180
		10-11	10950	300
				<u>27670</u>
8	399500	PM 3-4	19600	1000
		4-5	18800	1950
		5-6	17050	3400
		6-7	15800	2420
		7-8	13650	3350
		8-9	13050	2700
		9-10	12200	1280
				<u>16100</u>
9	365000	AM 11-21	20100	200
		PM 12-1	18850	1500
		1-2	19150	1250
		2-3	18850	1600
		3-4	17950	2650
		4-5	17150	3600
		5-6	15550	4900
		6-7	14400	3820
		7-8	12480	4520
		8-9	11930	3820
		9-10	11120	2360
		10-11	10770	480
				<u>30700</u>

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
10	348000	AM 10-11	19500	750
		PM 11-12	19150	1150
		PM 12-1	18000	2350
		1-2	18250	2150
		2-3	18000	2450
		3-4	17100	3500
		4-5	16350	4400
		5-6	14800	5600
		6-7	13750	4470
		7-8	11900	5100
		8-9	11350	4400
16	334800	PM 9-10	10600	2880
		10-11	10250	1000
		11-12	8800	200
				<u>40400</u>
12	40700	PM 3-4	20000	600
		4-5	19150	1600
		5-6	17300	3150
		6-7	16100	2120
		7-8	13950	3050
		8-9	13300	2450
		9-10	12400	1080
17	325000	AM 9-10	13800	14050
		10-11	13200	2050
13	487000	PM 7-8	16650	<u>350</u>
				350

On next page.

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
15	390500	PM 12-1	20200	150
		2-3	20200	250
		3-4	19200	1400
		4-5	18350	2400
		5-6	16650	3800
		6-7	15400	2820
		7-8	13350	3650
		8-9	12750	3000
		9-10	11900	1580
				<u>19050</u>
16	384500	PM 12-1	19850	500
		1-2	20200	200
		2-3	19850	600
		3-4	18900	1700
		4-5	18100	2650
		5-6	16400	4050
		6-7	15200	3020
		7-8	13150	3850
		8-9	12550	3200
		9-10	11700	1780
				<u>21550</u>
17	325000	AM 9-10	18650	150
		10-11	18200	2050
		11-12	17850	2450
		PM	On next page.	

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
17	325000	PM 12-1	16800	3550
		1-2	17050	3350
		2-3	16800	3650
		3-4	16000	4600
		4-5	15250	5500
		5-6	13850	6600
		6-7	12850	5370
		7-8	11100	5900
		8-9	10650	5100
		9-10	9900	3580
		10-11	9600	1650
		11-12	8200	800
				<u>54300</u>
18	425000	PM 4-5	19950	800
		5-6	18100	2350
		6-7	16800	1420
		7-8	14550	2450
		8-9	13900	1850
		9-10	12950	530
				<u>9400</u>
20	356000	AM 10-11	19950	300
		11-12	19600	700
				<u>1000</u>
		PM	On next page.	

November
November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
20	356000	PM 12-1	18400	1950
		1-2	18700	1700
		2-3	18400	2050
		3-4	17500	3100
		4-5	16750	4000
		5-6	15150	5300
		6-7	14050	4170
		7-8	12150	4850
		8-9	11650	4100
		9-10	10850	2630
		10-11	10500	750
		11-12		
				<u>34600</u>
21	312500	AM 9-10	17900	900
		10-11	17500	2750
		11-12	17200	3100
		PM 12-1	16150	4200
		1-2	16400	4000
		2-3	16150	4300
		3-4	15350	5250
		4-5	14700	6050
		5-6	13300	7150
		6-7	12350	5870
		7-8	10700	6300
		8-9	10200	5550
		9-10	9500	3980
		10-11	9200	2050
		11-12	7900	1100
				<u>62550</u>

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>	
22	279500	AM 12-1	6050	700	
		3-4	6900	2100	
		9-10	16000	2800	
		10-11	15650	4000	
		11-12	15350	4950	
		PM 12-1	14450	5900	
		1-2	14650	5750	
		2-3	14450	6000	
		3-4	13750	6850	
		4-5	13150	7600	
		5-6	11900	8550	
		6-7	11050	7170	
		7-8	9550	7450	
		8-9	9150	6600	
		9-10	8500	4980	
24	347800	AM 10-11	8250	3000	
		11-12	7050	1950	
				<u>85060</u>	
23	303000	AM 12-1	6550	220	
		9-10	17350	1450	
		10-11	16950	3300	
		11-12	16650	3650	
		PM	On next page.		
		6-7	14500	5850	
		7-8	11850	5150	
		8-9	11350	4400	
		9-10	10800	2880	
		10-11	10250	1000	
11-12	8800	200			
		<u>70650</u>			

November
November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
23	303000	PM 12-1	15650	114700
		1-2	15900	204500
		2-3	15650	174800
		3-4	14900	275700
		4-5	14250	216500
		5-6	12900	77550
		6-7	11950	1116250
		7-8	10350	6650
29	441500	PM 8-9	189900	155850
		9-10	179250	84230
		10-11	158950	192300
		11-12	147650	131350
		9-10	13450	69000
24	347500	AM 10-11	19450	800
		11-12	19100	1200
<u>Date</u>	<u>Total Lbs</u>	PM 12-11	18000	2350
		1-2	18250	2150
Nov	543250	2-3	18000	2450
		3-4	17100	3500
		4-5	16350	4400
		5-6	14800	5650
		6-7	13700	4520
		7-8	11850	5150
		8-9	11350	4400
		9-10	10600	2880
		10-11	10250	1000
		11-12	8800	200
				<u>40650</u>

November

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
26	418000	PM 3-4	20500	100
		4-5	19650	1100
		5-6	17800	2650
		6-7	16500	1720
20	439000	PM 7-8	14300	2700
		8-9	13650	2100
		9-10	12750	730
				<u>11100</u>
25	425000	PM 11-12	23300	200
29	441500	PM 5-6	18800	1570
		6-7	17400	820
		7-8	15050	1950
		8-9	14400	1350
		9-10	13450	30
				<u>5720</u>

<u>Date</u>	<u>Total Lbs Extra</u>
Nov	543250

What the cost of 1000 lbs of steam would be if the steam were produced at 200 lbs gage and 100° F

December

<u>Date</u>	<u>Lbs per 24 hrs</u>	<u>Hour</u>	<u>Lbs Available</u>	<u>Lbs Extra</u>
13-	435500	PM 12-1 5-6	22500 18550	300 780 <u>1080</u>
20	439000	PM 12-1 5-6	22700 18700	100 630 <u>730</u>
25	425000	AM 12-12	23300	800
		PM 12-1 5-6	22000 18100	800 1230
		7-8	14500	340
		8-9	13900	40
				<u>2510</u>

<u>Date</u>	<u>Total Lbs</u>	<u>Extra</u>	
Dec	4320		\$.1975
			1257
			1190
			1.055
			.1975 x 1.055
			\$.2086
			\$.011
			\$.231

What the cost of 1000 lbs of steam would be if the steam were produced at 200 lbs gage and 100°F superheat.

Steam is now produced at 120 lbs gage, dry and saturated, at a cost of \$.52 per 1000 lbs. If the steam were to be produced under the conditions specified above the only item, of all the items that comprise the present cost of steam, that would change would be the fuel cost. The present fuel cost would increase in the ratio of the present and future total heats of the steam.

Present fuel cost		\$.1975
Total Heat (200 lbs gage, 100°D)		1257
Total Heat (120 lbs gage, dry, sat)		1190
Ratio of total heats		1.055
New fuel cost	.1975 x 1.055	\$.2085
Difference, old and new fuel costs		\$.011
New cost of 1000 lbs of steam		\$.531

The maximum steam charge against the generation of electricity.

This maximum steam charge is made up of two charges: the cost of extra steam necessary to be able to generate the electrical demand and an extra charge for steam due to the increased cost of each 1000 lbs.

The cost of extra steam is \$.531 per 1000 lbs. The amounts of extra steam come from Pages 51-92.

The extra charge for steam is \$.011 per 1000 lbs. The amounts that go through the turbines and are obtained by adding up all the columns "Kw x 45" on Pages 34-42. On the average, each lb of steam exhausted from the turbines will have a total heat very nearly the same as each lb of steam used for heating at present. Therefore, the amount of by-pass steam will be less than the difference between the amount of heating steam (As given on Pages 44-45)

and the amount of steam through the turbines because each lb of the by pass steam will have a greater total heat than each lb of the present heating steam and so less of it will be needed than is at first supposed. As a result there is not extra charge against the by-pass steam.

Note that the cost of extra steam is for those days when the heating steam is not enough to generate the electrical demand while the extra charge for steam is for every day of the year.

Month	Lbs	Cost
January	13740	7
February	0	0
March	4480	2
April	30800	167
May	150000	890
June	593490	478
October	235220	151
November	543250	288
December	4320	2

The maximum cost of extra steam necessary to be able to generate the electrical demand.

<u>Month</u>	<u>Lbs</u>	<u>Cost</u>
January	13740	\$ 7
February	0	0
March	4450	2
April	308680	167
May	1505050	800
June	893490	475
October	285220	151
November	543250	288
December	4320	2

Maximum extra charge for steam due to the
increased cost of steam.

<u>Month</u>	<u>Max lbs steam per 24 hrs going thru turbines</u>	<u>Max lbs steam per month going thru turbines</u>	<u>Cost</u>
Jan	345020	10700000	\$ 118
Feb	315740	8850000	97
Mar	295960	9170000	101
Apr	307470	9230000	101
May	292630	9070000	100
June	230080	3450000	38
Oct	323590	5170000	57
Nov	347735	10430000	115
Dec	356930	11050000	122

Super Maximum steam charge against electrical generation.

<u>Month</u>	<u>Superheat Charge</u>		
Jan	\$ 125		
Feb	97		
Mar	103		
Apr	268		
May	900		
June	513		
Oct	208		
Nov	403		
Dec	<u>124</u>	400	800
		460	<u>920</u>
	\$ 2641		1720

1720 x \$4.50 = \$7740

\$ 2280 is allowed in this study for the tearing down of furnace walls and for other minor costs in the installation that are overlooked here.

Estimated Cost of Superheaters: \$10,000.00

Superheaters.

Estimated cost: \$8000.

Specifications are in the back of this report.
 Superheaters would have to be installed and it is advisable that they be large enough to superheat all the steam that the boilers are capable of producing. Apparently it would not be necessary to put a superheater in Boiler No. 5.

Babcock and Wilcox charge \$ 4.50 per rated boiler horsepower for their superheater.

Rated boiler horsepower of the University's boilers:

2 - 400	800
2 - 460	<u>920</u>
	1720

1720 x \$4.50 \$7740

\$ 2260 is allowed in this study for the tearing down of furnace walls and for other minor costs in the installation that are overlooked here.

Estimated Cost of Superheaters: \$10,000.00

The Switchboard.

Estimated cost: \$8000.

Specifications are in the back of this report.

Chain Hoist

5 ton, 12' x 48' floor space

Ricker Mfg. Co.

\$269.

Oil Filters.

3- Cuno.

Hery and Burns. Cutler Building.

Each: \$50.

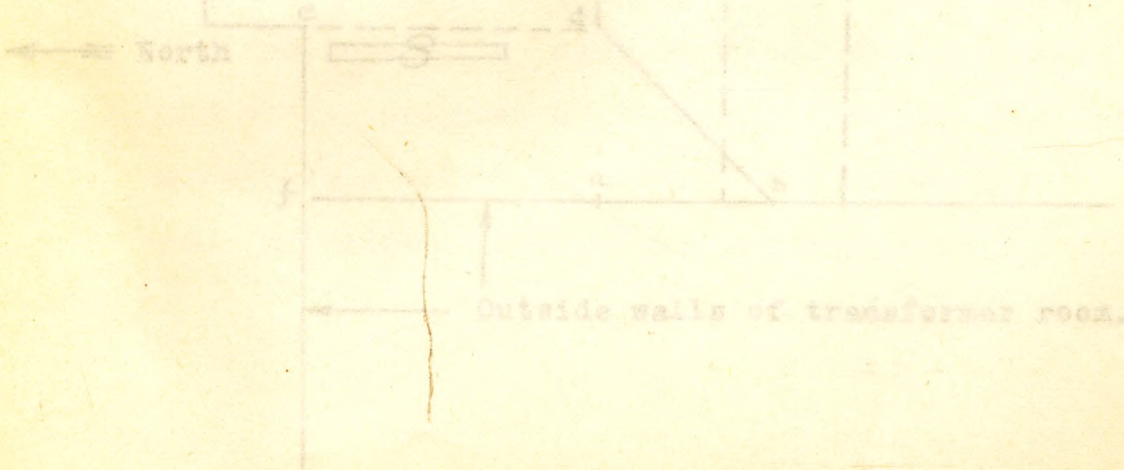
The Building.

Estimated cost: \$12000

Specifications are on the next page.

Building Specification. *turbine-generator building.*

1. 3 ft excavation. *1 ft. S is the switchboard.*
2. Building to be built on a concrete mat.
3. Turbine room floor to be on a level with the boiler room floor.
4. Turbine room
30' x 45' floor space
15' high
5. Space under turbine room to contain only piping. *turbine room. Outside*
6. No overhead piping in the turbine room.
7. South wall at least 8' away from the tunnel to the Medical School.
- 8- West wall at least 8' away from the east wall of the Boiler Houses
9. A monorail chain hoist in the turbine room. *Tunnel to Medical School.*

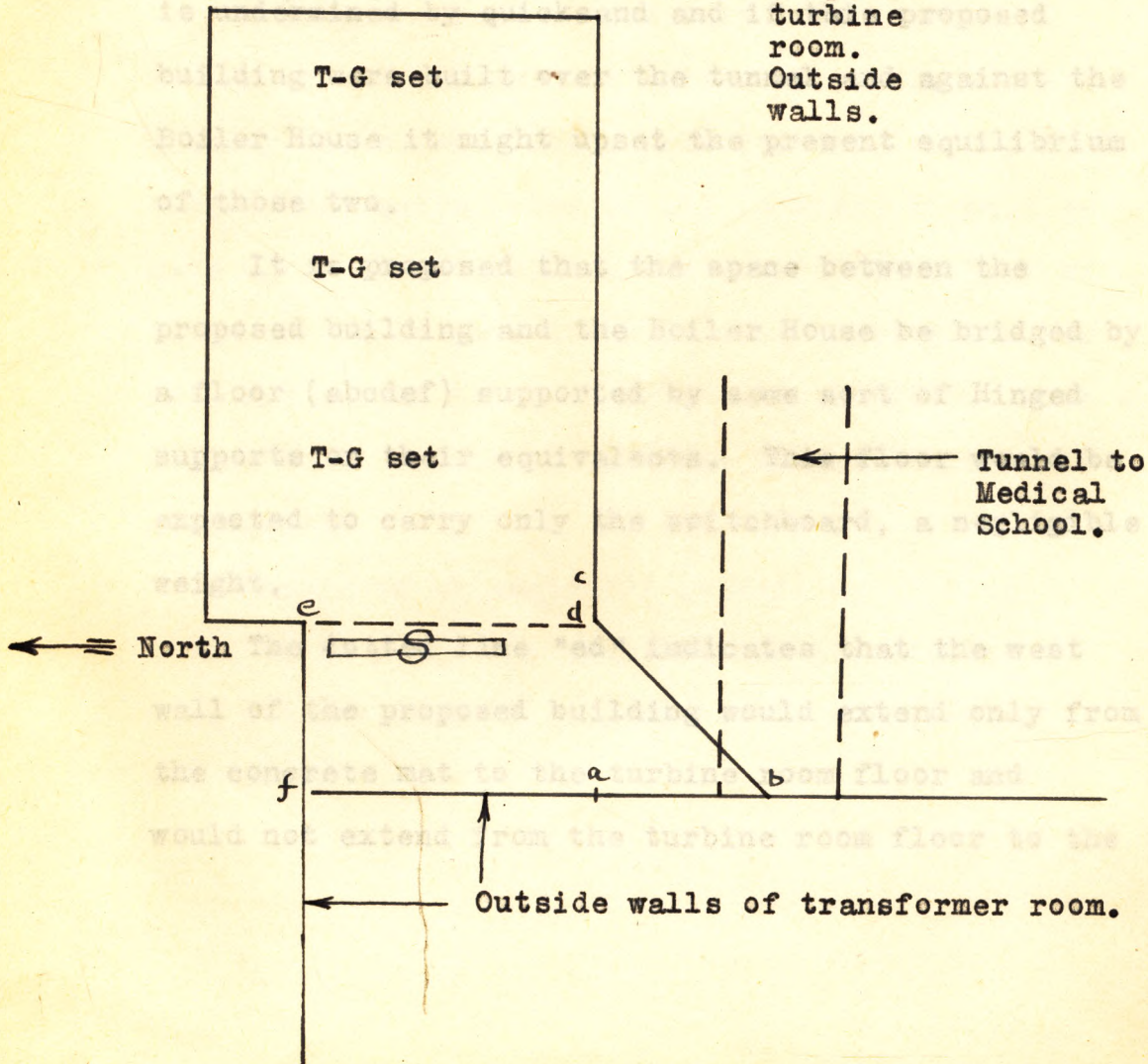


The best location for a turbine-generator building.

Scale: 1/16" equals 1 ft. S is the switchboard.

Discussion on Page 103.

Proposed turbine room. Outside against the walls.



Discussion of the turbine-generator building.

turbine room ceiling.

The sketch on Page 102 shows what appears to be the best location for the building to house the turbine-generator sets. The actual building would have to be at least 8' away from the tunnel to the Medical School and at least 8' away from the wall of the Boiler House because the ground at this location is undermined by quicksand and if this proposed building were built over the tunnel and against the Boiler House it might upset the present equilibrium of those two.

It is proposed that the space between the proposed building and the Boiler House be bridged by a floor (abcdef) supported by some sort of Hinged supports or their equivalents. This floor would be expected to carry only the switchboard, a negligible weight.

The dotted line "ed" indicates that the west wall of the proposed building would extend only from the concrete mat to the turbine room floor and would not extend from the turbine room floor to the

turbine room ceiling.

"ab", which is now a part of the east wall of the Boiler House, would be the opening from the Boiler House into the turbine room.

changes in the heating system, plus special electrical and steam controls to make the plant automatic, plus steam meters.

Labor.

This plant must be entirely automatic or nearly so. Otherwise the estimated saving will be greatly decreased. The reason for this is the fact that if any extra labor at all is hired it must be made up of three men, one for each shift. Each of these men would have to be paid at least \$1500 per year and so the labor charge would be \$4500. Such a charge would eliminate any hope of profitable self-generation.

According to engineers practicing in this field it is perfectly possible and permissible to make a plant such as is proposed here entirely automatic.

Estimated cost of piping.

\$3000

Estimated cost of necessary changes in the heating system, plus special electrical and steam controls to make the plant automatic, plus steam meters.

\$5000

Estimated cost of another 4" high pressure line to the Medical School.

\$1200

1. Turbine-Generator sets	\$13000
2. Building	12000
3. Chain hoist	300
4. Controls plus steam meters	5000
5. Piping	3000
6. Changes in heating system plus special electrical and steam controls plus steam meters	5000
7. Additional high pressure line to Medical School	1200
8. Oil Filters	150
	<hr/>
	\$38350
Estimated cost of investment:	\$60000

The Investment.

1. Turbine-Generator sets	\$18000
2. Building	12000
3. Chain Hoist	300
4. Switchboard	8000
5. Superheaters	10000
6. Piping	3000
7- Changes in heating system plus special electrical and steam controls plus steam meters	5000
8. Additional high pressure line to Medical School	1200
9. Oil Filters	150
	\$58650
 Estimated cost of investment	 \$60000

Operating Costs.

1. Interest on investment at 5.5%	\$ 3300
2. Depreciation at 5.5%	3300
3. Oil, waste, supplies	250
4. Steam charge	2000
5. Insurance	50
6. Maintenance	1250
7. Make-up water	50
8. Charge for standby of 300 kw	800
	<u>\$11000</u>

Estimated operating cost each year after the first \$11000

year the problem might be credited with interest on the sum of the savings of the preceding years plus interest on the product of \$1500 times the number of years of self generation that have passed plus interest on the sum of the amounts set aside for depreciation in the preceding years of self-generation.

Saving each year with self-generation.

Apparent saving	\$ 4450
Saving on summer bills	1300
Cost of purchasing electricity	\$15450
Cost of self-generation	<u>11000</u>
Saving 2nd year.	\$ 4450
Apparent saving	\$ 4450

In addition, due to the fact that the University would be generating its own electricity during peak months the summer bills would not contain any peak demand charge and the bills from June 15th to October 15th would be \$1300 less.

In addition, for each year after the first year the problem ought to be credited with interest on the sum of the savings of the preceeding years plus interest on the product of \$1300 times the number of years of self generation that have passed plus interest on the sum of the amounts set aside for depreciation in the preceeding years of self-generation.

Saving. 1st year.

Saving. 3rd year.

Apparent saving	\$ 4450
Apparent saving	\$ 4450
Saving on summer bills	1300
Saving on summer bills	<u>\$ 5750</u>
Interest on 1st year's saving	316

Saving. 2nd year. 2nd year's saving

Apparent saving	\$ 4450
Saving on summer bills at year	1300 81
Interest at 5.5% on 1st year's	
depreciation in saving car	316 81
Interest on money set aside for	\$ 6771
depreciation in 1st year	<u>\$ 6281</u>

Saving. 4th year.

Apparent saving	\$ 4450
Saving on summer bills	1300
Interest on 1st year's saving	316
Interest on 2nd year's saving	343
Interest on 3rd year's saving	372
Interest on 3 years of depris.	843
	<u>\$ 7274</u>

Saving. 3rd year.

Apparent saving	\$ 4450
Saving on summer bills	1300
Interest on 1st year's saving	316
Interest on 2nd year's saving	343
Interest on money set aside for depreciation in 1st year	181
Interest on money set aside for depreciation in 2nd year	181
	<u>\$ 6771</u>

Saving. 4th year.

Apparent saving	\$ 4450
Saving on summer bills	1300
Interest on 1st year's saving	316
Interest on 2nd year's saving	343
Interest on 3rd year's saving	372
Interest on 3 years of depris.	543
	<u>\$ 7274</u>

April 27, 1933.

Conclusions.

The result of this study speaks for itself. There can be absolutely no doubt that the University can generate its own electricity at a cost much less than the cost of purchasing that electricity.

All calculations were made on the assumption that the worst possible conditions of operation would be met. In addition, in those cases where actual costs were not available, the estimated costs are much more than they would actually be. As a result, it may be safely said that the calculated savings are minimum savings and that in all probability the actual savings would exceed the calculations.

Gerald B. Troy

April 27, 1933.