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THESIS

TESTING AND CALIBRATION OF COMMERCIAL WATTMETERS

BY

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JUNE 1908.

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INTEGRATING WATTMETERS.

Testing and Calibrating.

It is not the intention of the authors of this paper to give an exhaustive treatment of the subject, as that would require much more time than is allotted to this work. It has been their aim to gather together such data and information on the subject as to make it of some value to the non-technical worker. With this end in view this paper has been written and the authors hope that it will be of value, as the literature on this particular subject is limited.

The importance of reliable measurement of electrical power is at once evident. The increasing demand for electrical power has made it necessary that a unit of power be established, and that instruments be made that will accurately measure this power. It was because of this demand that the integrating wattmeter was invented. The old style of guessing at the amount of power sold was very unsatisfactory to both station man and consumer. It led to loss and endless trouble, poor service, and dissatisfied customers. This custom is now almost obsolete, the modern wattmeter being the cause of the change.

It might be well at this time to take up briefly the history of the progress of electrical power measuring instruments. Patents were issued as early as 1872 to S. Gardiner and 1878 to Fuller. Fuller's meter was perhaps the first alternating current meter built. Both of these meters soon went out of use due to their inpracticability and ease of derangement. They were a trifle better than guessing at the current consumed. Other meters soon followed these and in 1888 the meter system gained a permanent foothold in the electrical field.

The edison Chemical Meter was the next instrument of omportance. It is a well known fact that if a current passes through an electrolytic cell that a deposit is made which is proportional to the current. It is also known that if a shunt be placed on a conductor a certain proportion of the current will flow thru the shunt, this current being proportional to the resistance ratio of the conductors. These facts are the basis of the Edison Chemical Meter. In this instrument an electrolytic cell is placed in shunt on one line and the relation of the currents in the line and in the shunt is determined by their conductivities. From this, the total current may be measured by measuring the deposit of metal. This is an ampere hour meter and with constant voltage is quite reliable. One objection to this meter was the difficulty of reading, and hence it has been supplanted by the motor types of meters. Altho in America this meter is obsolete, in Europe the Edison meter is still used and has been improved so that it is easily read. The only chemical meter used in this country is used in connection with the maximum demand meters.

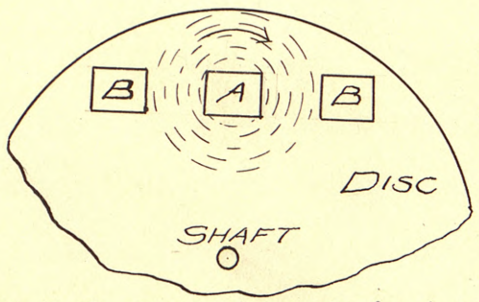
The Shellenberger meter is the next important meter, and was the first successful alternating current meter. It involved the principal of the revolving coil and in that respect marked a change in meter manufacture. The two coils giving a torque proportional to the product of the fluxes of the coils, and these fluxes being proportional to the currents in the coils, and since one current is the load current and the other the voltage current, the torque is proportional to the product of the volts and the amperes. The meter is damped so that a certain number of watts must pass for a certain number of minutes to produce a certain number of revolutions. These ratios are determined and the meter graduated to read watt hours. This principle applies to all motor meters. The damping device of this meter is peculiar in that it consists of vanes or wings on the rotating part. Their friction on the air produces the damping effect. It is doubtful if an instrument using this device can be made to read accurately, as the resistance due to windage varies as a higher power of the speed than does the resistance offered by a disc damped by magnets.

The commutator type of meter, of which the first rotating armature meters are a type, are composed of coils so arranged as to produce a torque which is proportional to the product of the current and the voltage. In direct current work such a meter can easily be understood, as in that case it is a modification of a common shunt motor. With alternating current the case is slightly different, but is easily understood if we keep in mind the fact that the voltage and current reverse at the same time, that is to say, they both reverse the same number of times in a second and if the power factor is one the reversals take place at the same instant. This being the case both fields are reversed together and so the torque remains in the same direction. This is the reason that the commutator type can be used on either direct current or alternating current circuits. The shunt winding of these instruments is on the armature, the reason for this being that the moving part of a meter should carry only very small currents, otherwise the commutator would spark seriously. With constant voltage the armature current is constant, but the field current changes with changing of load, but in all cases the torque is proportional to the load expressed in watts. This type is slightly incorrect on inductive loads due to the inductive effect of the coils.

In all meters a damping or retarding device must be used in order that the meter may be sensitive to changes of load. The now almost universal method of damping meters is by means of a disc moving between the poles of a magnet, the speed of the meter being changed by adjusting the magnets. A disc rotating in a field is the same as a conductor moving in a field and to move a conductor in a field requires a force. This force is the force of the meter that is used to run the disc and since part of the torque of the meter is used to supply this force there is less torque to produce rotation, for this reason the meter is damped. The eddy currents set up in the disc oppose the force that produces them and thus makes a load on the meter armature. The retarding effect of such a system is in proportion to the speed of the disc. But the torque is proportional to the power passing through the meter, the resulting speed of the armature will then be proportional to the power. This is true in the theoretical meter and is nearly true in the meter as it exists at the present time. The error is due mostly to friction, and this error has been reduced to a minimum by using jeweled bearings.

Another device that belongs to the commutator meter is the starting coil. This coil is part of the shunt coil wound so as to give starting torque enough to overcome friction, so that as soon as a current flows in the large coils of the meter the armature will rotate. With this coil removed it requires considerable current in the series coil to produce rotation.

In alternating current work the induction meter is the most important. The different meters in the field are practically the same in principle but differ in detail of construction. In principle it is an induction motor driving an integrating train calibrated to read power in watthours. The torque is produced by having a disc rotate in a field in which the flux is constantly changing. The essential features of these meters are shown in the sketch. B.B. are series coils and A. is the shunt coil The total current flows through B.B. In the theoretical meter the torque is equal to volts times amperes. This would be true if the magnetic flux



in B.B. was at each instant exactly proportional to the current and if the impressed electro-motive force across the supply mains were exactly balanced at each instant by the induction E.M.F. in the coil A. by the changing flux thru A. This would be the case if coil A. had no resistance. In a well designed induction Meter these conditions are approximately satisfied. Then the flux thru A. produces not only an E.M.F. in coil A. equal to impressed E.M.F. at each instant, but this flux also induces a proportional e.m.f.

in the disc along the circles shown by the arrows. The current in the disc is proportional to the impressed e.m.f. and flows thru the disc under the legs B.B. The flux of B.B. causes a torque to be set up due to the flux of B. and the current in the disc. Then since the current in the disc is proportional to the impressed E.M.F. and the flux of B.B. is proportional to the current, the torque is proportional to the product of E.M.F. and current, which is the power in the circuit. With no current in the series coil there is no torque.

The friction losses of these meters is low, as jewel bearings are used in most cases while in the Stanley the weight of the rotating part is supported by magnets.

In alternating currents the power factor must be taken into consideration as a meter may be called upon to measure other than noninductive loads. For that reason some provision must be made to take care of inductive loads. This device is usually in the form of an adjustable low resistance secondary which can be introduced in the field of the shunt coil so as to give such changes in the phase of the shunt magnetization as is necessary. The way in which this device is applied differs in the various types of induction meters.

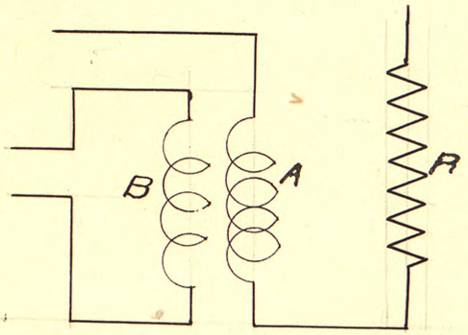
All induction meters have some form of light load adjustment similar to the shunt coil in the commutator type of meter. This device overcomes the initial friction and so the meter is able to rotate on the smallest loads. The method used may be an adjustment for distorting the shunt field flux and giving a slight rotative effect on the disc. This scheme is used on the Thompson High Torque Induction Meter. The same result may be accomplished by means of an auxillary winding on the series coil.

The damping of an induction meter is done with magnets on the same disc that is used to produce rotation. The magnets are so placed that stray fields from the shunt, and the series coils will produce the least effect on them. The magnets are adjustable and by this means the meter may be adjusted.

There is another type of meter which has made its appearance within the last few years, this is the mercury meter. The first were of the ampere-hour type, rather than the watthour meter, and were used for direct currents only. Recently this meter has been developed until now it can be used on either direct or alternating currents. The principle of this type of meter dates back nearly three-fourths of a century. It is the Faraday disc or Barlow's wheel experiment put into practical use. If a disc be placed with its axis horizontal and so that it can rotate freely, and a strong magnet be placed so that the disc will rotate between its poles, if the lower edge of the disc be placed in a merucry bath and electrical contact be made through the mercury and the spindle of the disc, the current in the disc will cause a torque to be set up when the current flows between the poles of the magnet, and the disc will rotate. If this were used as a meter it would be an ampere-hour meter. If instead of the magnets a series coil be substituted we would have a wattmeter. Only a general description of the mercury meter will be given here. The armature in this meter consists of a copper disc immersed in mercury and held within a chamber of insulating material. This is so arranged that the mercury cannot be spilled; electrical contact is made with the armature through the mercury; a pair of poles is arranged very close to the disc on the lower side. they are opposite each other and are near the edge of the disc. On the upper edge of the disc is a soft iron plate which acts as a return for the flux of the magnets. These magnets are energized by means of a shunt coil in the direct current meters and a series coil in the alternating current meters. In the direct current meter the torque is produced by the current in the disc which is either all or part of the load current and the field due to the shunt magnets. In the alternating current meter a small transformer steps the voltage down to very low potential before it goes through the armature. The series coil energizes the magnets in this case, and as the direction of the flux and current change at the same time these fluxes produce a torque which drives the meter. The mercury carries most of the weight of the armature and hence there is little wear on the jewel bearing.

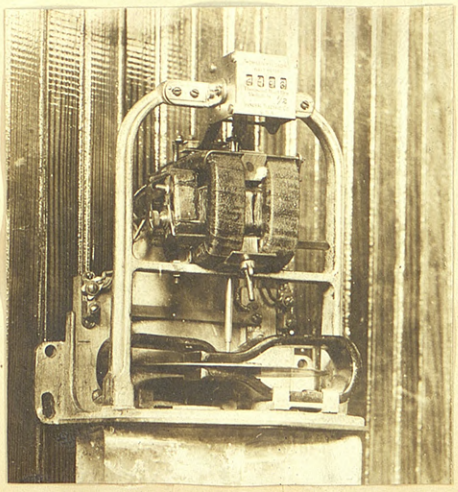
The Thompson Commutator Meter.

As an introduction to this meter it will be well to take up the ordinary indicating watt-meter and show how the commutator meter bears a definite relation to it. The principle of an indicating wattmeter is shown in the cut. Coil A. is the shunt coil and



is the movable coil. Coil B. is the stationary coil thru which the current flows. Then the torque is due to the fields of both coils which at any instant is equal to the current at that instant times the voltage at the same instant, which is the power of the circuit, whether the current be direct or alternating. The work done by this torque is used in overcoming the opposition of a spring on the needle staff. Now if some arrangement be made so that the rotating element can make complete revolutions and a method of recording these revolutions used, we will have a recording wattmeter. This is accomplished by having a commutator on the shunt coil so that the torque will be continuous.

The accompanying photograph shows the essential features of this meter. The large coils are the series coils while the small



coil is a shunt coil in series with the armature. The damping disc is of copper and the magnets are located far enough away from the coils so that the field of the coils will not demagnetize the magnets. The bearing is a jewel on which a hardened steel point runs. A high resistance is connected in series with the armature, this is to cut down the voltage over the armature and thus reduce sparking. The shunt coil in this instrument is the compensating coil and is used to overcome friction, so that when the current flows in the series coil the armature will rotate. The recording device on the instruments tested was of the old type in which the pointers did not move continuously. This style of recording device is no longer used as it introduces a large error due to the unequal load it throws on the armature when all the discs are moving.

It should be remembered that the meters tested were old style worn out meters and do not represent the modern Thompson commutator meter. From the curves it can be seen that the greatest error is in the light load part of the curve and is probably due to the excessive friction of the old meters. These meters would do for places where the load was constant, but would be unsatisfactory for house meters. Another point is that these meters when set for direct current are not correct for alternating currents but require readjusting. Changes of voltage affect these meters, this is probably due to the fact that with a drop in voltage the shunt coil is weakened and a larger series current is needed to start the meter. In the modern improved meters of this type most of the old objections are overcome.

Data on Thompson Commutator Meter.

5 Ampers 110 Volts 60 cycles.

Direct Current 110 Volts.

Watts	Wattmeter Watts.	% of full load.	% Error.
80	54	14.5	48
200	172	36.4	16.5
380	360	69	5
540	551	98	1.5
750	730	136	3.5
900	910	164	1

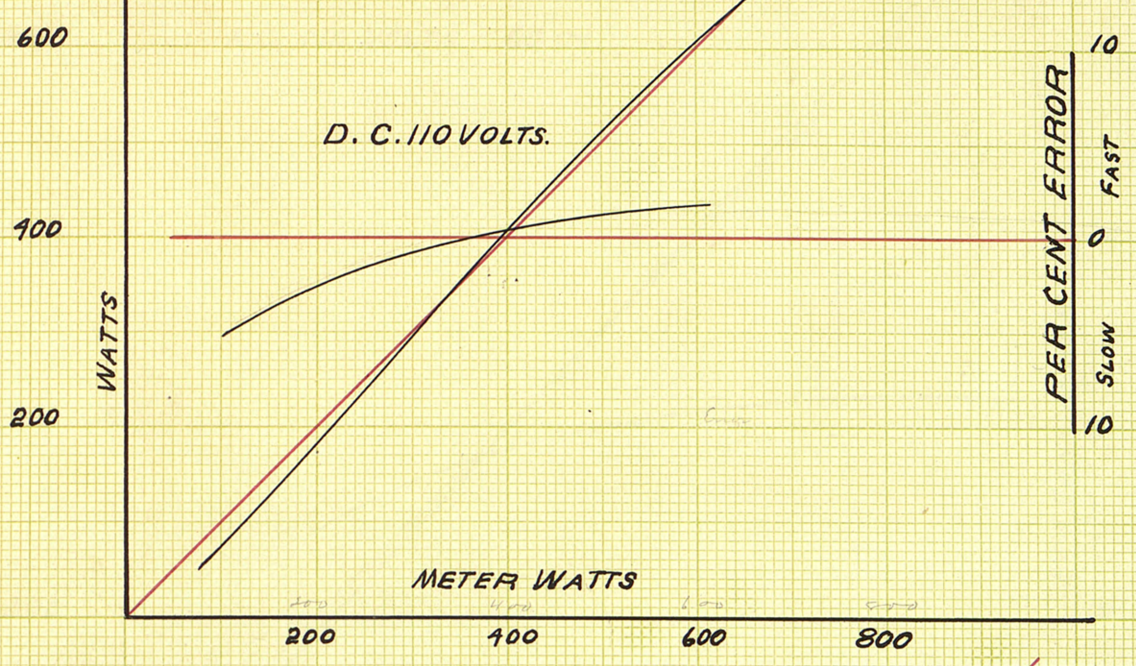
Alternating Current. Non-inductive 100 Volts 60 Cycles.

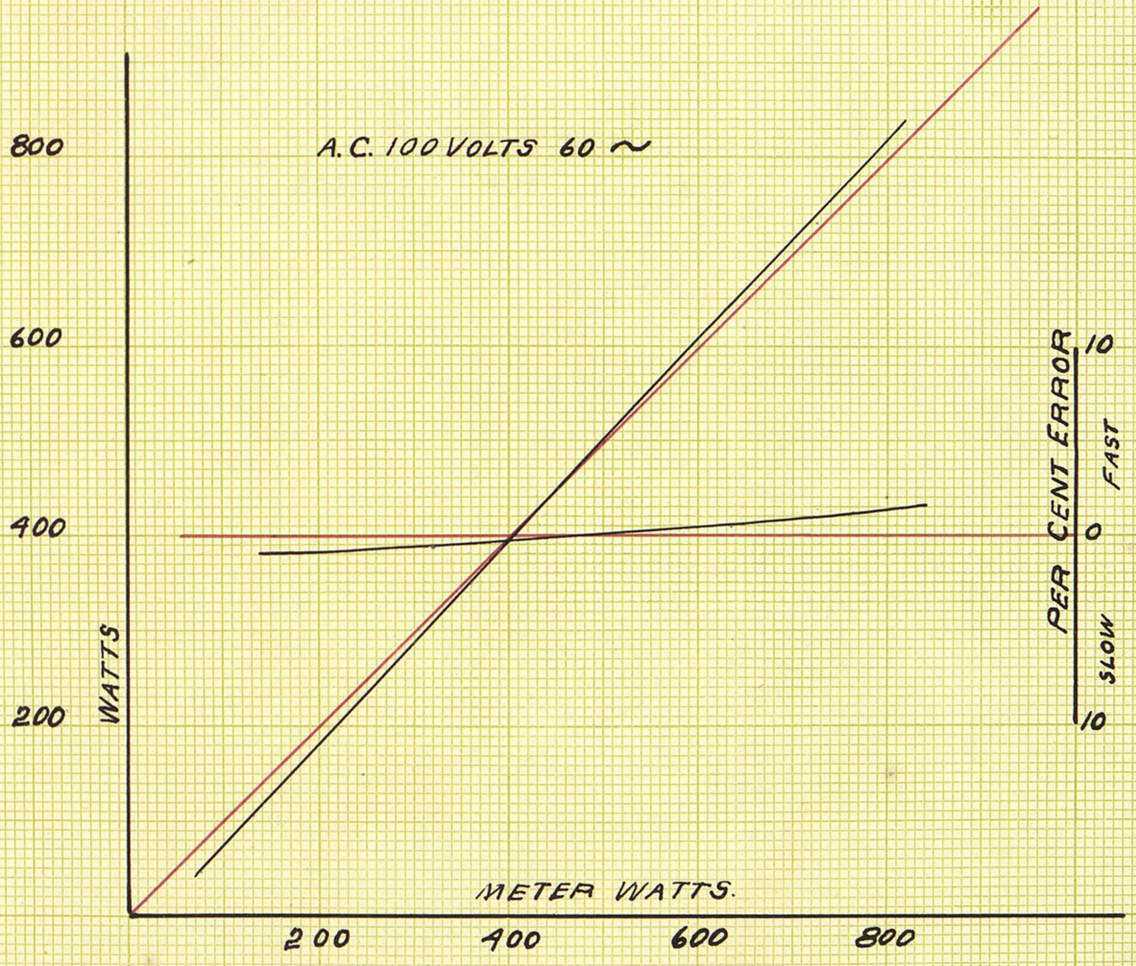
130	108	23.6	21
247	247	45	0
360	350	65	.3
497	500	91	.5
725	732	132	1.
800	820	145	2.

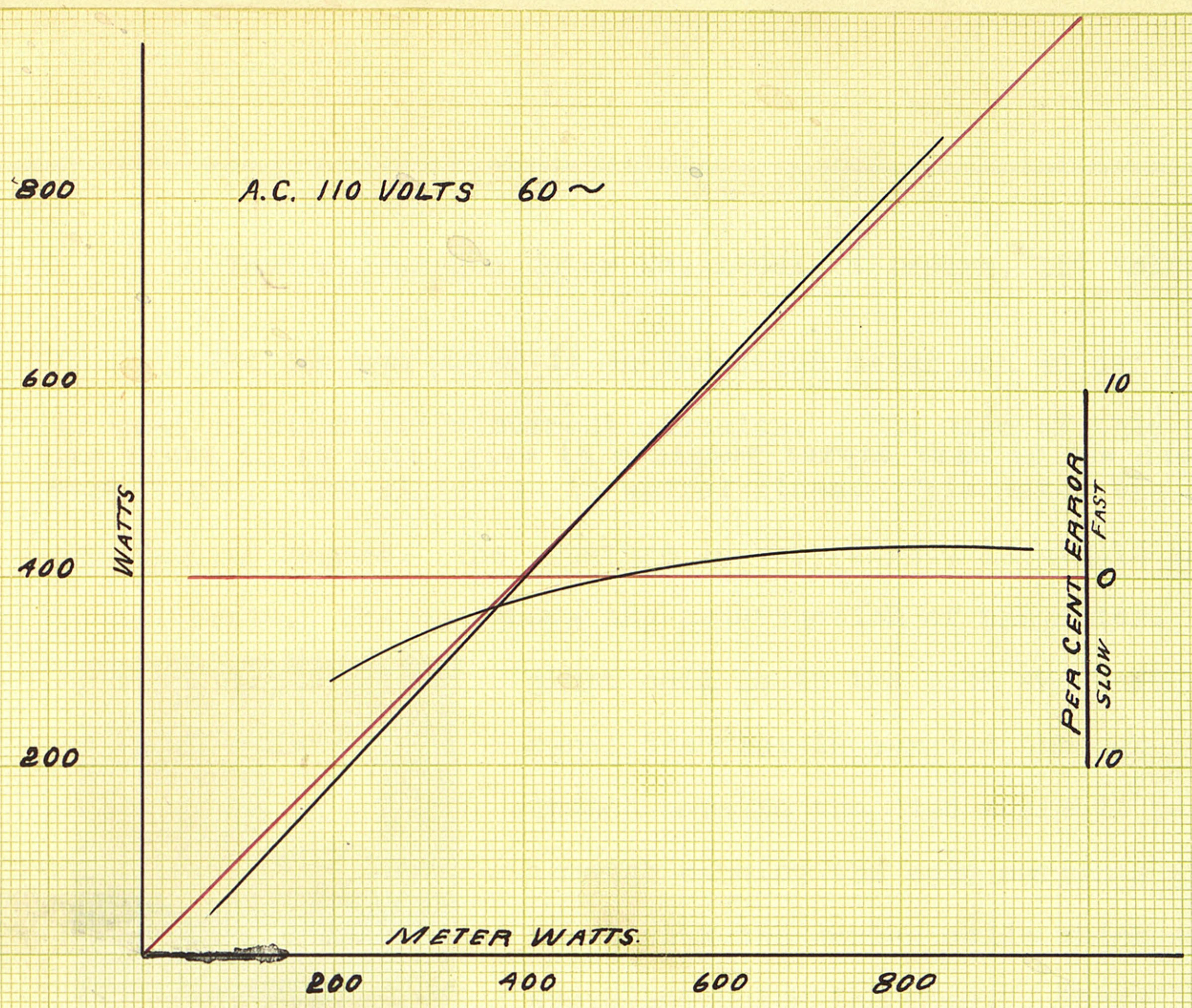
Alternating Current Non-inductive 110 Volts 60 Cycles.

165	153	30	8
270	258	49	4
465	467	84.4	.5
675	686	122	1.7
837	850	152	1.2
995	1015	180	2.

THOMPSON METER
NO. 2437.

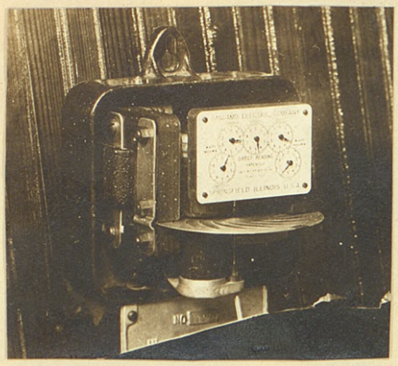





A.C. 110 VOLTS 60 ~
800
600
400
200
WATTS
METER WATTS
200
400
600
800
PER CENT ERROR
FAST
SLOW
10
0
10

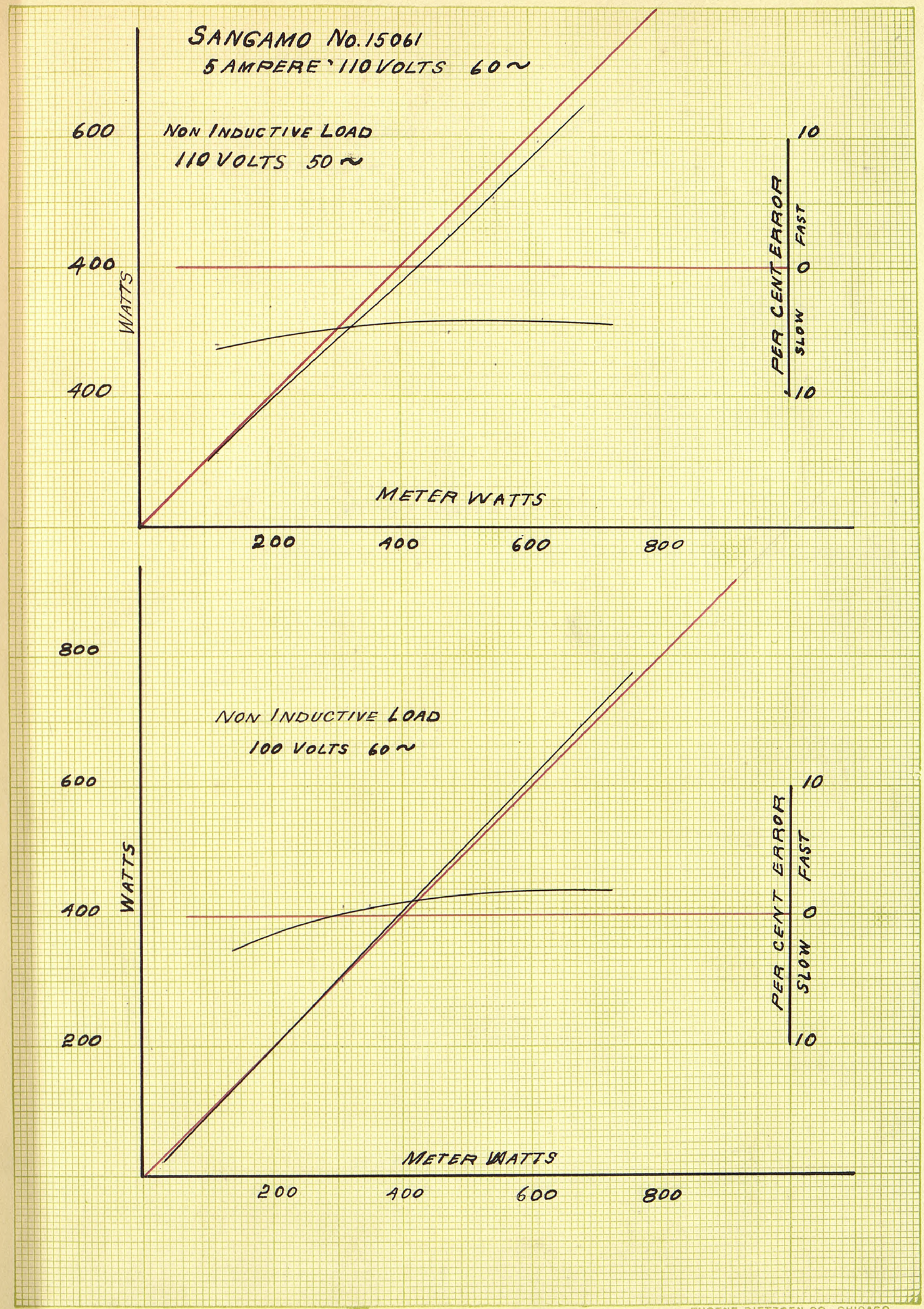
Test on Sangamo Meter No. 15061, 5 Ampers, 110 Volts.

The Sangamo meter is an induction meter and so can only be used on alternating current circuits. The disc of this meter has slots in it which give it a higher torque than if the disc were blanks. The slots run in spiral lines. This meter has only one damping magnet. The armature is very light, is simple and easy to calibrate. The cut shows the construction of the meter. The shunt coil is in the back and left side of case; its flux is carried through the laminated core to the disc where it passes through causing the eddy currents which react with the series coils which are above and below the disc. There is an airgap in the magnetic circuit of this meter other than the gap through which the disc passes; this gap is just above the coil. The phase relation adjustment for this meter is a short-circuited copper bar around the core of the shunt coil. The resistance of this bar can be varied. This meter gives fairly good results, especially on non-inductive loads, and is a good house meter, as its error on small loads is small.

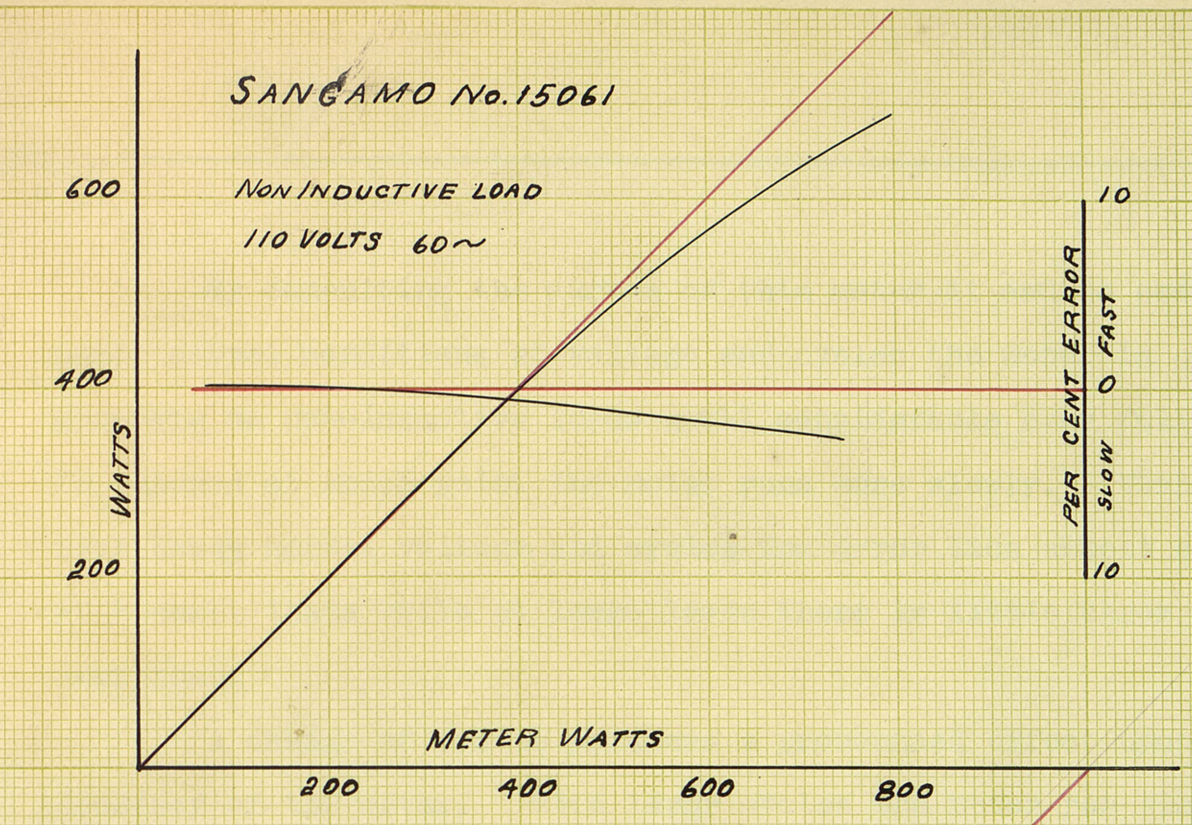


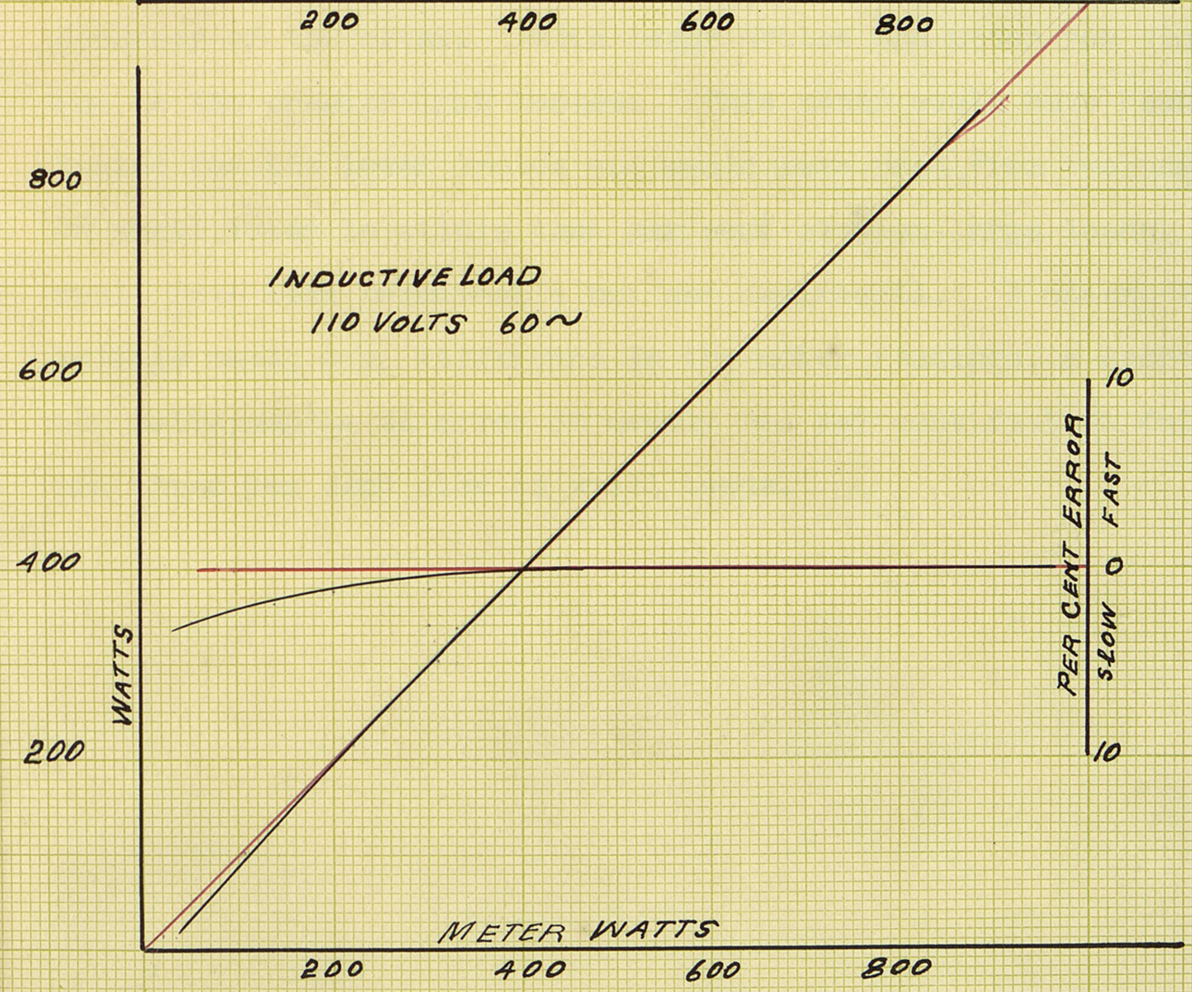
Data Sangamo. 110 Volts. 5 Ampers. 60 Cycles.

Watts	Meter Volts, non-inductive.	% full load 60 cycles.	% error 110 Volts.
55	55	10.2	0
95	95	18	0
260	260	48	0
464	456	84.4	1.5
660	643	120	2.5
750	750	136	0
Inductive load		110 Volts	60 Cycles.
23	21.2	4.2	8.5
57	54.5	10.3	5.5
140	136	25.5	3
222	219	40.3	1
310	301	56.5	3
330	342	60	3.3
Non-Inductive		110 Volts	51 Cycles.
118	113	21.4	6
190	184	39.5	3
323	309	59	4.5
475	452	86	5.2
546	508	99	7.6
615	592	112	4
Non-inductive		100 Volts	60 Cycles.
30	26.6	5.5	11
777	75	14.2	2.5
255	257	46.4	.6
376	379	68.4	.7
570	568	103.5	1.3
676	692	123	2.



EUGENE DIETZGEN CO., CHICAGO.


SANGAMO No. 15061
NON INDUCTIVE LOAD
110 VOLTS 60~
600
400
200
WATTS
METER WATTS
200
400
600
800
10
0
10
PER CENT ERROR
FAST
SLOW


INDUCTIVE LOAD
110 VOLTS 60~
800
600
400
200
WATTS
METER WATTS
200
400
600
800
10
0
10
PER CENT ERROR
FAST
SLOW

By consulting the curves of this meter it can be seen that under normal conditions of voltage and cycles the meter is quite accurate on non-inductive loads until considerable over full load is reached at which point the meter runs more slowly. With inductive loads normal voltage and cycles the error lies almost entirely with small loads while at large loads there is little error even on over load.

A change of cycles produces a pronounced effect upon the accuracy of the meter. With lower cycles the meter ran slower, due to the greater iron losses. This meter could have been adjusted for the lower cycles and would have read from two per cent on small loads to within that per cent slow on large loads. This would have been permissable but not desireable. A change in voltage makes some difference in the meter readings, a decrease of ten volts making an error of nearly two per cent fast on full load and three per cent slow on small loads.

Calibration and Testing.

Some of the possible tests which may be applied to wattmeters are: Accuracy of calibration and recording, effect of presence of iron, creeping, variable voltage, change of frequency, effect of inductive loads, effect of foreign electrical fields, and effect of change of temperature. Of these the most important is that of calibration, the other tests being used in the manufacturers labratory and the meters being designed to withstand the effects due to these conditions.

Assuming that the tester is not familiar with the previous conduct of the meter he is first to look for apparent physical defects. Next the circuits should be tested for "shorts" and "burn outs." Defective jewels are found by passing the point of a fine cambric needle, normal to the surface, over the wearing part. If the jewel is found defective renew it, and also the shaft end at the same time. The jewel and the worm gear should be cleaned by the use of chamois skin or a fine brush.

Crooked shafts and crumpled discs are corrected mechanically. The top bearing stud may be cleaned by inserting a piece of soft pine and rotating. The damping magnets should be equally distributed about the circumference of the disc and symmetrically placed with respect to the shaft.

Weak magnets are detected by their lack of attraction for the iron blade of an ordinary screw driver.

In the commutator type the brushes should be ar sufficiently hard so as not to rattle when raised three eighths of an inch and allowed to fall against the commutator. Commutators and brushes are best cleaned by use of a piece of worn coarse cloth.

The cover should be examined for holes which might allow tampering with the meter mechanism.

Coils which have a bluish color or show blisters of shellac upon them have been over-heated by over-load or otherwise in which case the running conditions should be examined.

These simple tests and examinations should be gone through before calibration, because it is obviously wrong to calibrate a defective meter.

Before proceeding with the calibration the theory should receive some slight notice.

The unit of electric power measurement is the watt-hour, which is frequently reduced to kilowatt hours, i.e. thousand watt hours, a watt being equal to a joul per second.

The amount of energy registered by the meter depends upon four factors, viz: The electric pressure, the flow of current, the time, and the meter constant. The electric pressure and current combine to make the watt. For convenience the time is made the unknown and the watts are read upon a finely calibrated indicating wattmeter; while the constant is fixed for any make of instrument. Under these conditions we have that a watthour will be represented by the time necessary for the disc to make a definite number of revolutions. By using a stop watch the time may be taken in seconds which gives the following relation:

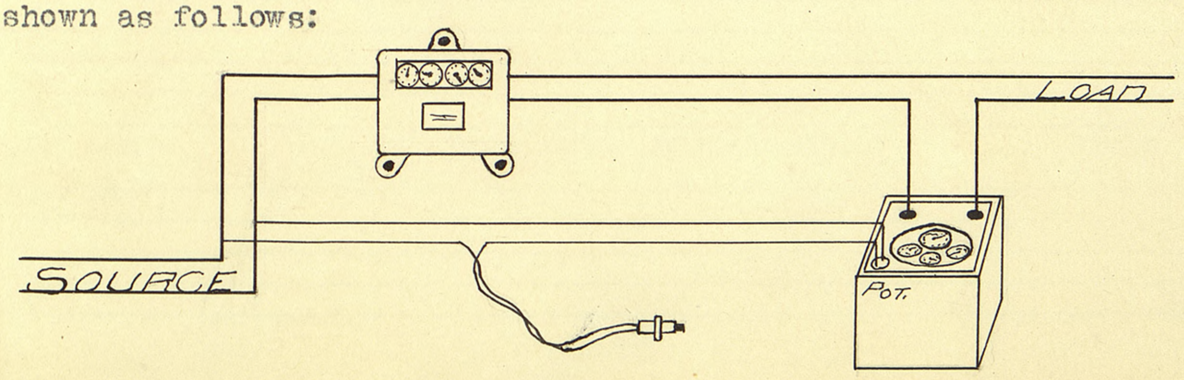
$$\frac{\text{Number of sec. in one hour X constant}}{\text{Watts}} = \text{Sec. per revolution.}$$

Ten or more revolutions of the disc should be counted to assist accuracy.

By means of the above equation the time is computed and compared to that determined by observation. If the results differ by less than 2% the meter is considered sufficiently accurate. A complete series of loads covering the entire range of the meter is run and the comparison at each load made as described above. The majority of meters are slow on light load and fast on full load, the object of calibrating being to balance these, and secure a small percentage of error throughout the greater part of the meter range.

Creeping is caused by the torque from the pressure coil, which is always exerted, and may be detected by slightly fanning the meter causing it to turn. Creeping is undesirable though usually of little expense to the consumer. It may be stopped by clamping a small piece of iron wire over the edge of the meter disc. This clamp should not extend under the magnet jaws and necessitates recalibration after its application.

House calibration, where the meter is already in good repair, is recommended by many as being more desirable than labratory calibration. In house calibration an especially well constructed finely calibrated integrating wattmeter is used, the operation being merely a comparison between the house meter and the testing standard. Sufficient directions for conducting a house test accompanying each test meter the method of connecting being shown as follows:



A good form of test sheet is shown as follows:

Test-Page No. A____________

Special No.__________Shop No____________District___________________

Route____________Period____________Date___________190______________

Consumers name____

Address____

Occupied as____

Location(Erected on____
of (In____
Meter (Occupied as____
Meter

Name____________Type_________Form-____________Cat. No______________

(________Amperes (Dial______Disc.____________
(
Capacity(________Volts Constant (Test________Coils___________
(
(________Wire (Bill_____________________

Potential___________Volts Information Card No.-----------------

Circuit_________Wire________Volts at Meter---------Phase-----------

(Lamps_________S.C.P.__________16 C.P.________32 C.P.________Base
Load(Motors_________________Arcs____________________Fans____________
(Miscellaneous

Wattmeter No.___________S.L.No._______Stop Watch No._______Seal____

Time Enter Test Before Adjustment Dials

%	Volts	Amperes	Rev's	Standard Watts	Meter Watts	%
5						
25						
30						
100						

Time Leave Test After Adjustment Dials

5						
25						
30						
100						

Lamps required to start. before Adj. After Adj.

Reason for Test New Exchange Meter

Adj.	A	B	C C	C K	D	E	F	G	J	L	M	P	R	S	T	U	V	Box SEAL

Remarks:

Tested By Ass't.

Last Test: Page No. Date Seal Left Seal Found

"In order to lessen the work of recording the adjustments, etc., various codes have been adopted, one of which is as follows:

Code

A.	Armature.
B.	Brushes.
C.	Commutator.
C.C.	Compensating Coil.
D.	Disc.
E.	Shaft End.
F.	Field Coils, Main Coils.
G.	Gearing in Counter, Counter.
H.	Hands on Counter.
I.	Impedence Coil.
J.	Jewel.
K.	Compensator.
L.	Level, Leveled.
M.	Magnets.
N.	Wing Nuts.
O.	Cover (The "Outside.")
P.	Phasing Coil or Coils.
Q.	Shunt Circuit, Secondary.
R.	Resistance.
S.	Shaft.
T.	Top Bearing.
V.	Vibration.
U.	Wiring (Condition, Size, etc.)
W.	Worm.
W.W.	Worm Wheel.

Rountine to be Followed When Making a House Test.

1. Notify the consumer that the meter is to be tested, and exhibit the meter inspector's badge.

2. Check the shop number of the meter with the number entered on the test page.

3. See that the current is on the meter and that the test can be made as otherwise the time spent in connecting, etc. will be wasted.

4. Enter the time of arriving at the premises.

5. Before the cover is removed the dials should be read by both the tester and assistant, independently, and the results compared, entered on the test page, and verified.

6. Examine the seal very carefully to see that it is intact; also record under "Seal Found" on the test page the number of letter on the seal. The old seal must be defaced.

7. Examine the wires and fuses to see that they are in good order and that no tampering has been done, that the fuses are of the proper size, that the connections, erection and manner of installation are correct, and enter anything not correct under "Remarks." Note also any departure from the standard method of connection.

8. Remove the cover, being careful that it does not strike any parts of the meter, particularly the dial hands.

9. Connect the instruments and translating device in circuit, being careful that the meter does not measure the potential current of the instruments, and vice versa.

10. Test the meter as found, without in any way cleaning or adjusting it and also determine the number of lamps required to start

it. This will show the meter has been operating.

11. Note under "Level" whether the meter is found level or not. Level it accurately.

12. Examine, adjust, clean and repair the meter as may be necessary. If the meter is damaged to such an extent as to necessitate its removal or repair by a shop man, note this on the test page under "Remarks."

13. Calibrate the meter.

14. Take the statement at the end of the test in the same manner as required in Art. 5 and turn the counter back to its original reading, except when the meter is bridged and the consumer uses current during the test.

15. Enter under"Adj." the necessary information, and enter under "Remarks" any information or suggestions which will be of value.

16. Disconnect the instruments, reconnect the meter and see that all connections are secure and properly made.

17. Replace the cover and verify the statement in the same manner as required in Art. Mo. 5.

18. Seal the meter.

19. See that the meter is in proper operative condition, and that the consumer has current, particular attention being paid to each side of a three wire circuit.

20. Enter the time of leaving the premises.

21. See that all data, etc., as required on the test page, is entered.

Thompson High Torque Induction Meter.

In general this meter is compact in form. In it is embodied most of the recent improvements and it represents a well-constructed and efficient meter. It is fitted with two large magnets placed diametrically opposite and separated from the coils by means of a flux shield. Two current coils and one voltage coil are used, all of which are placed in the back of the meter. In front between the magnets is placed a small coil called the light load adjustment which effects the adjustment for light loads, independently of the large coils, and should be considered a desirable improvement. The rotating part is very light. The recording mechanism is of the worm and screw and gear train type.

For transportation a locking device in the form of a ring which takes the weight off the jewel is supplied.

Thompson High Torque Induction Meter.

#738310.

Watts	Meter Watts	% of full load	%Error.
233	235	42.4%	3.5. slow
457	470	83	1.25 fast
620	635	112.7	1.1 "
837	845	152	0
		Inductive Load.	
35	35.9	6.36%	.57 fast
82	81.3	14.9	.87 slow
170	169	31	.5 "
256	260	46.5	1.5 fast
310	312	56.4	.8 "
376	382	68.4	2. slow
		Low Voltage.	
30	29.2	5.45%	2.75 slow
127	123	23.08	2.5 "
225	222	41	1. "
400	397	72.75	.8 "
532	540	96.8	.25 fast
690	693	125.5	.6 "
		Low Frequency.	
25	20.5	4.65%	12.14 slow
80	80	14.5	0
250	264	40.5	1. fast
455	462	82.7	1.25 "
610	606	110.8	5.5 slow
740	745	134.5	.6 fast

Effect of Presence of Iron.

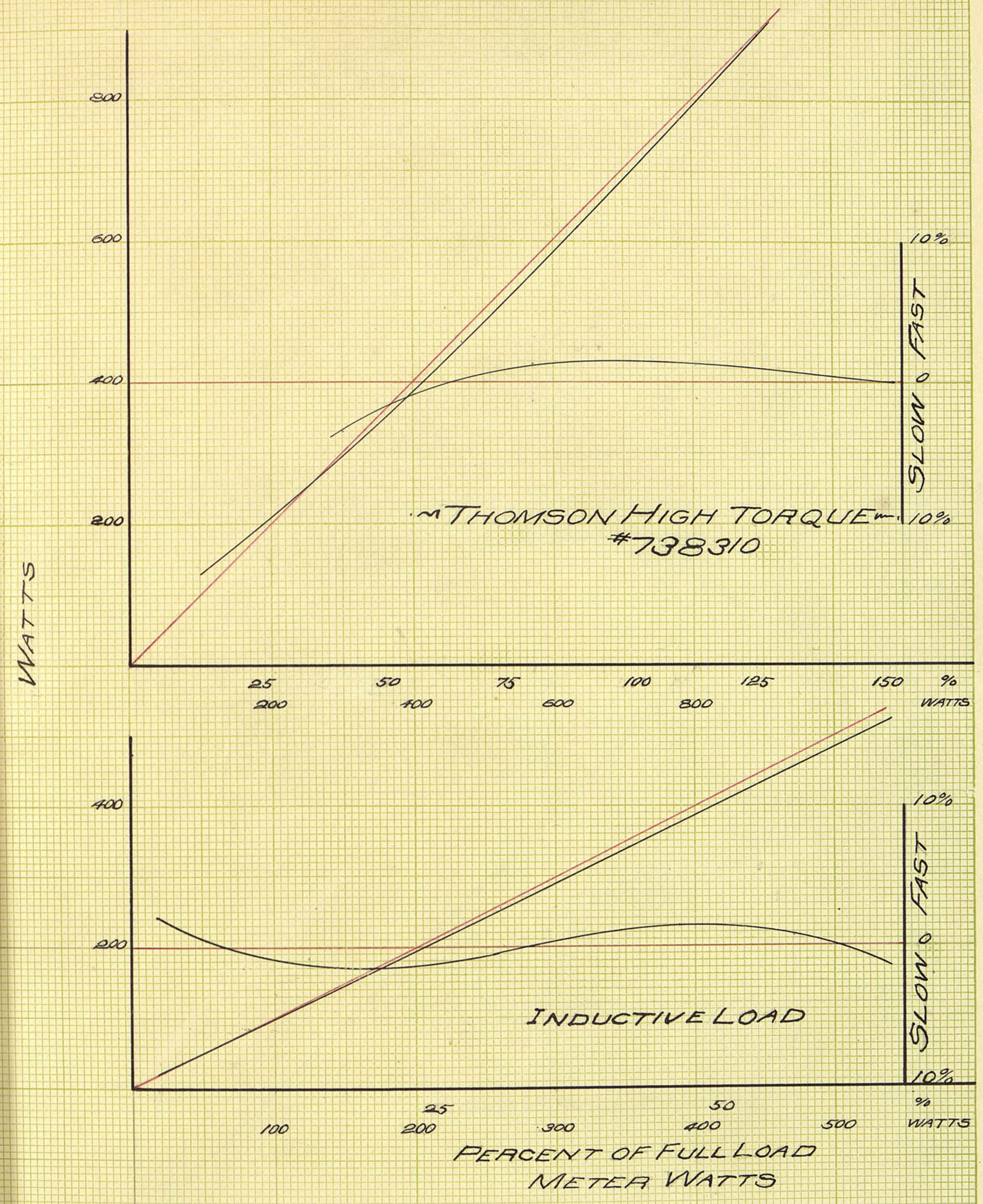
With Cover Removed.

233	235	42.4%	.75 fast
463	470	84.2	1.25 "
620	635	112.7	2.2 "
845	844	153.5	0

With Cover on.

232	235	42.4%	1.5 fast
463	470	84.2	2. "
620	635	112.7	1.1 "
835	845	151.5	1.5 "

PLATE I



800
600
400
200
WATTS
10%
FAST
0
SLOW
10%
~THOMSON HIGH TORQUE~
#738310
25
50
75
100
125
150
%
200
400
600
800
WATTS
400
200
10%
FAST
0
SLOW
10%
INDUCTIVE LOAD
25
50
%
100
200
300
400
500
WATTS
PERCENT OF FULL LOAD
METER WATTS

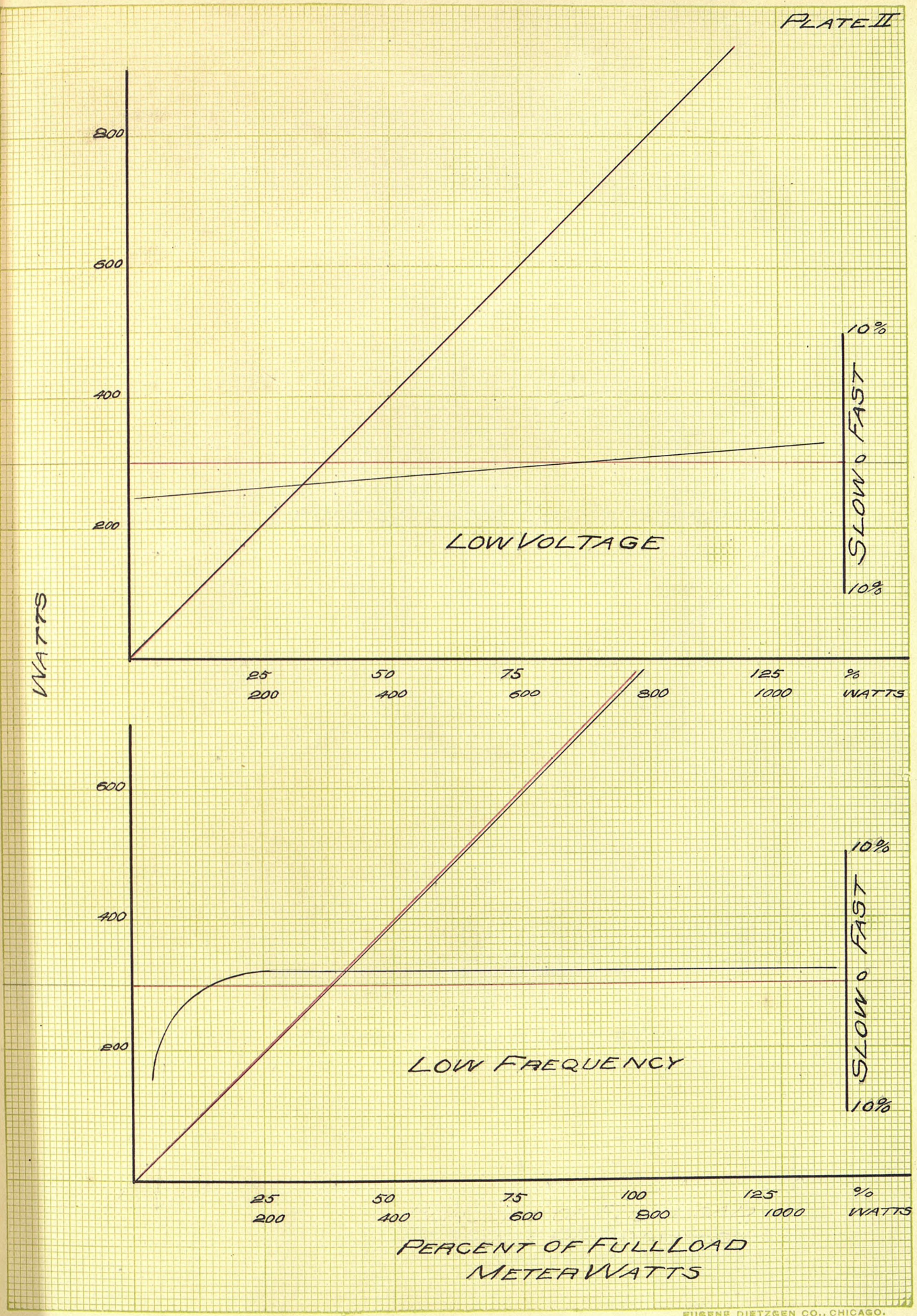


PLATE II
WATTS
800
600
400
200
10%
FAST
SLOW o
10%
LOW VOLTAGE
25
200
50
400
75
600
800
125
1000
%
WATTS
600
400
200
10%
FAST
SLOW o
10%
LOW FREQUENCY
25
200
50
400
75
600
100
800
125
1000
%
WATTS
PERCENT OF FULL LOAD
METER WATTS
EUGENE DIETZGEN CO., CHICAGO.

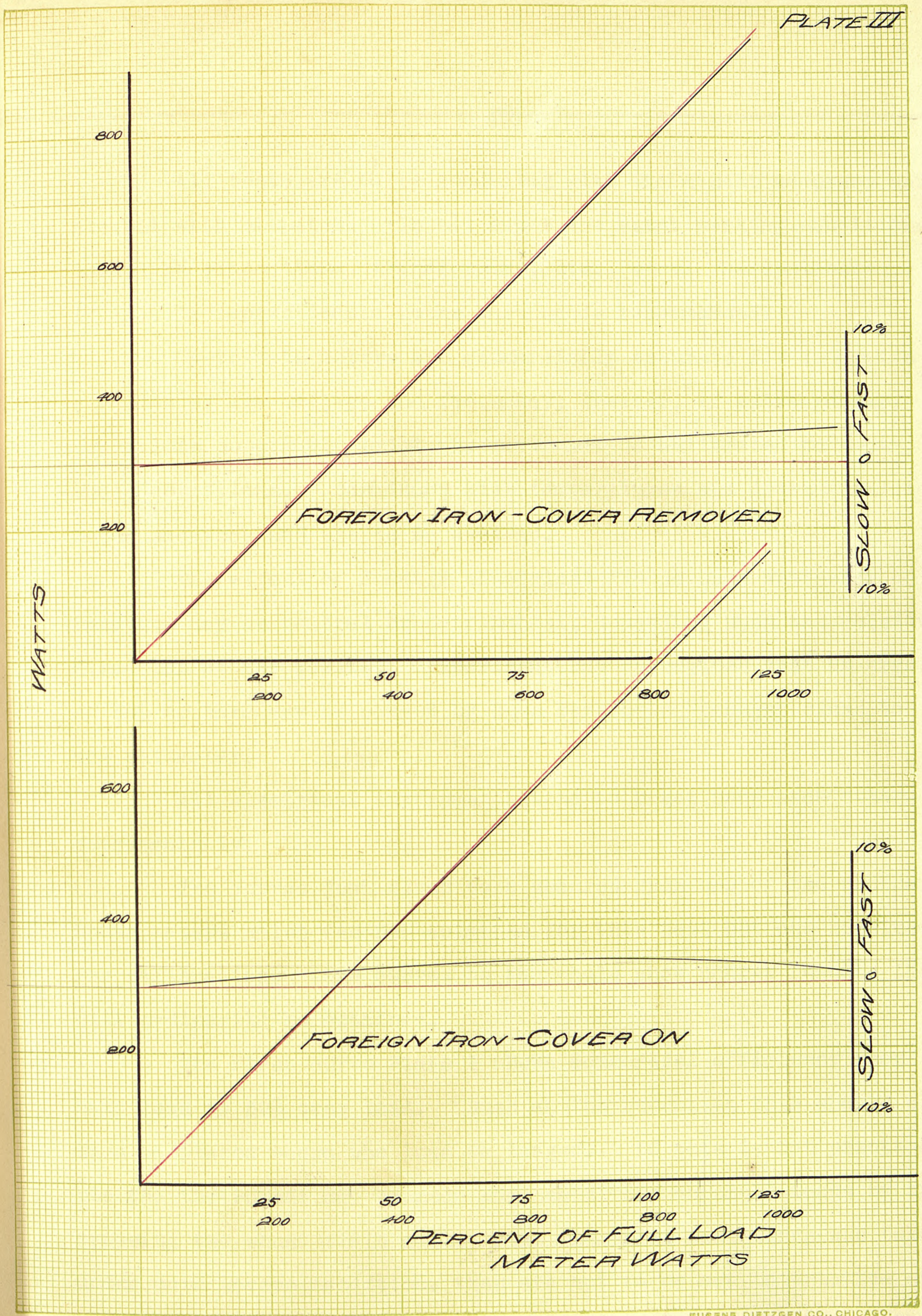


PLATE III
WATTS
800
600
400
200
10%
FAST
0
SLOW
10%
FOREIGN IRON - COVER REMOVED
25
50
75
125
200
400
600
800
1000
600
400
200
10%
FAST
0
SLOW
10%
FOREIGN IRON - COVER ON
25
50
75
100
125
200
400
800
800
1000
PERCENT OF FULL LOAD
METER WATTS

All tests are to be conducted with the utmost accuracy consistent with dispatch. In all cases the exact working conditions including connections, transformers, etc., should be duplicated. If this is impracticable house testing is recommended.

Up-to-date meters are commercially accurate for inductive circuits or low voltage and frequency; however, if extraordinary conditions constantly exist the meter may be calibrated to meet these conditions. Continued high temperatures are detrimental to meter accuracy and are to be avoided.

The effect of foreign electrical fields upon wattmeter readings may be neutral or detrimental, depending upon the relative direction of the fields. Experiment has determined that an error of 50% or more may be caused by buss bars being brought close to the wattmeter.

All electrical instruments tend to react upon each other detrimentally.

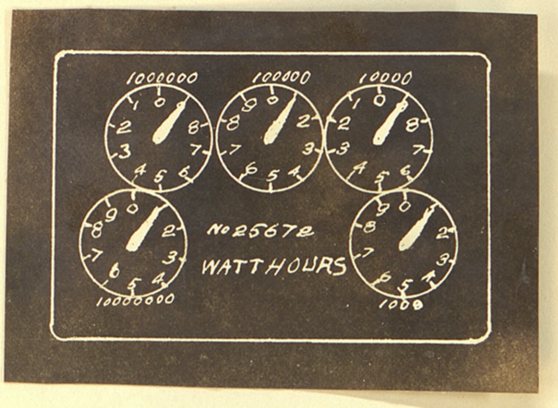
The curves just given were secured from one of the ordinary house meters which was not selected for this test but one received for calibration. The curves on the whole show poorer results than will ordinarily be obtained.

The first curve Plate I shows commercial efficiency from half load to 50% over load. Such an instrument as this should always be placed where the load is larger. If this is not practicable the instrument may be made more sensitive on small loads by increasing the shunt field coil. The inductive load curve was taken under more severe conditions than are apt to be met in practice and gives a creditable result. By the peculiar form of the curve the inductive error is seen to bear a distinct relation to the load.

Plate II gives curves of low voltage and low frequency which may occur in practice and shows this particular meter to be able to care for each case correctly.

Plate III shows the effect of foreign masses of iron, which condition, however, seldom or never occurs in practice. With the cover in place the effect of the foreign iron is greatly reduced. This assumes that the effect of foreign electric fields would be shielded from the machinery by the cover. Throughout the entire series of tests the meter has met the conditions as laid down by the manufacturers and for a general commercial meter should meet the approval of the station trade.

Meter reading presents a point of possible error especially when the pointer is directly over one of the figures. The position of the pointer can be determined by reference to the next lower, bearing in mind that it must have completed its revolution before the next above appears directly over the figure. This is illustrated in the following dial.



The reading in this case is 09,091,000, instead of 19,191,000, as apparent at first glance.

Meters may be read direct, or the position of the pointers indicated upon a suitable card and the reading determined at the office.

The growth of the meter business together with the various parts played by the meter may be indicated by a partial list of freak meters some of which are growing in demand. A partial list is, A Maximum Demand Meter, a Pay in Advance Meter, Storage Battery Meters, A Self Reading Meter and one computing the dollars and cents of the bill instead of the K.W. output.

SUMMARY.

Owing to the inherent vibration of alternating current meters the jewel deteriorates quite rapidly. Magnet adjustment allows a retardation range of about 16%.

Modern meters allow a total range of voltage of 20% without seriously effecting the meter accuracy.

In general all meters now on the market should be wired with the generator upon the left and the load upon the right side, forcing the meter.

All meters should be mounted upon a firm support, especially avoiding wooden partictions containing doors.

Always protect the jewel during transportation.

Little or no oil should be used and that only of the best grade.

Reducing the shunt coil stops creeping.

Monthly reading and biennial calibration is recommended.

Meters for resident lighting should be adjusted and calibrated so as to be especially accurate on small loads.