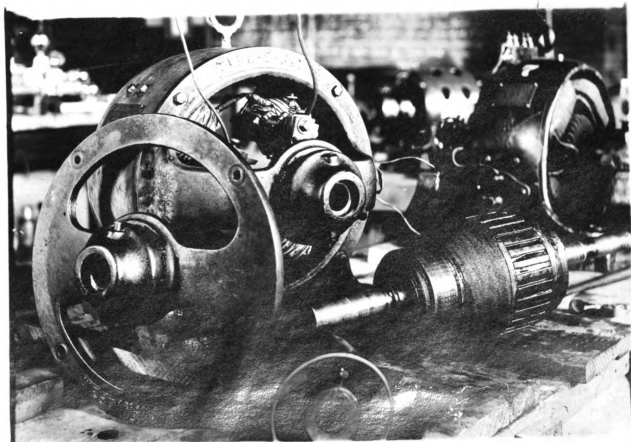
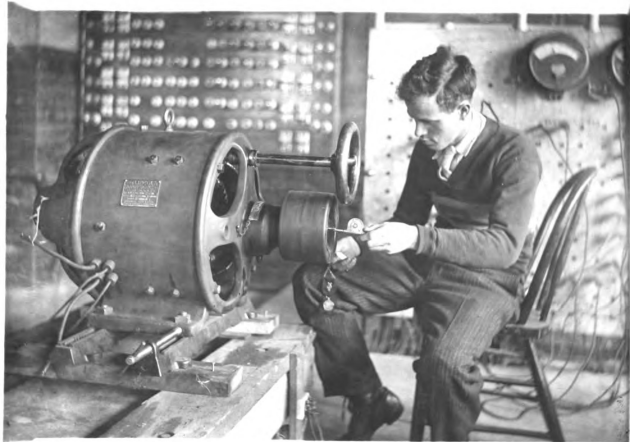




THESIS

The

Building of an Interpole Variable Speed Motor

and the

Testing of a Lincoln Variable Speed Motor

by

W.R. Stauffer

F.H. Valentine

June

1909

has a record in The Proceedings of The American Institute of Electrical Engineers, Vol. 23, No. 5, Page 487. As before stated, the did not permit us to do a thorough test of the poles to really put in. A number of trials showed that negative was not quite correct but just that, is still a mystery. The motor actually runs on it at 220 volts, 1700 r.p.m. and machine with the motor runs in. It was on to running well with the system. Next-- The generator, which was in a room on oil machine, was not running, but the generator of oil, were not left on the machine; and when the generator was started the coils, was too small and had no contact with each other in surface for the coils. This was a failure to be sure that it would be for several hours run. I was four hours on 1 1/4 over of over. Course the coil is not at the limit of it stand, so cool it off.

The Generator Data is as follows:

Number of slots 31.

Number of coils 31 (21 closed) and one for .

Number of turns per coil 2 (22 turns per slot)

Style of field Two or three.

Number of parallel paths or branches 2.

Turns of coil Slots 1 & 2.

Current for slots 1 & 21 (1 bar to 1-1)

Number of commutator bars 31.

Other data, such as size of coils, can be obtained from the manufacturer's data.

The data is similar to that of Vol. 2, p. 1, which is a copy of the

by 12 1/2" per second. This line is 2000 turns per second or 2485 in one turn of coil.

The inner coil winding is 40 W.I.C. wire, two layers deep. There are 41 1/2 turns per coil, 22 coils in the outer layer and 21 1/2 in the top. There are 200 turns in 1 series. The total resistance is 1.1 ohm in 1 series.

The data for this is as follows:

Place	Wt.	Area	Resistance	Length
Frame	320,000	7.8	42,000	4.0
Pole	340,000	8.1	108,000	3.0
Air Gap	473,000	11.0	43,000	0.0025
Top of Top	473,000	5.8	81,500	0.675
" Bottom	473,000	2.9	164,000	
		Av.	122,300	
Core	238,500	9.0	31,000	1.5

Place	Material	RI ²	TI
Frame	C.I.	161	405
Pole	Iron W.I.	137	412
Air Gap	Air	13500	245
Wood Top	Iron W.I.		
" Bottom	"		
" Av.	"	300	700
Core	"	32	72
Total			2500

2' = 473,000 11.00.

Let $\alpha = 1.3$ or for $\alpha = 1.3$.

Lincoln, Nebraska 8-10-1952.

This variable type of motor illustrated in the accompanying cross-section and shown in the Electric Motor Co. No. 10, of Cleveland, Ohio, (later purchased by the Bell Telephone Co. of America, Co.) is subject to the action described in a thin film of the present invention. The motor is designed and installed as any direct current motor would be. The motor is reversible and will run with its speed in either direction. The speed variation is caused by withdrawing the armature from the influence of the field coils. As the armature is withdrawn, the magnetic induction between the field coils and the armature is decreased, the speed of rotation is increased and the armature is eventually reversed.

[illegible]

Each is provided with special compensating rollers, under the influence of which the structure of the film is withdrawn into its position of rest. These special compensating rollers provide super films compensating rollers in order to reach to 100 percent overlap. Practically the same structure are secured with this construction. A reduction of 10 to 1 is easily reached and other reductions can be easily obtained if desired. Changes in the weight of the paper in the rollers are 300 to 1200.

The reason that this meter exhibits so few rider variations in speed time, and obtained by the ordinary method, of still remaining, is that there is less attraction of the magnet film at high speeds than at low speeds. This is due to the fact that the full film thickness is not so great at the head of the meter as at the tail.

A final wheel 1 is used in connection with a hand mechanism 1 to move the acenture lat religion. By means of this hand wheel it is possible to adjust latitudinal variation of the acenture from the lowest to the highest, and a large wheel, usually, is provided for the same. The variable roll of the acenture is carried on roll thrust bearings which eliminate all friction. The rollers 3 are mounted on the same structure as the thrust bearing and, as the thrust roller, are placed on rollers for all movement, hence there is no relative motion between the rollers and thrust rollers. The rollers 3 are mounted on the same structure as the thrust rollers and, as the thrust rollers, are placed on rollers for all movement, hence there is no relative motion between the rollers and thrust rollers. The rollers 3 are mounted on the same structure as the thrust rollers and, as the thrust rollers, are placed on rollers for all movement, hence there is no relative motion between the rollers and thrust rollers.

end of the armature, carrying an auxiliary ball-bearing D to take both the thrust and the radial load due to the slight eccentricity of the armature core, to serve the field. This thrust bearing is actuated by a split lever E having a central ball on opposite sides of the thrust bearing, one end of the lever being accomplished as means of the gear mechanism and the hand wheel as illustrated in the section, a spring F around the lever connecting rod being attached to balance the magnetic pull of the armature. The pinion or wheel is carried on the shaft I which is also the bearing and into which the armature shaft H is keyed so that the pulley contact occurs only in the structure on 2.

The field and armature coils are placed in series, so as to provide the best regulation and utilization.

With the particular design illustrated, the machine will vary a variation in speed of 200 to 1200, and will be capable of regulation as high as 2500 to 2750 r. p. m.

Armature data is as follows:

Number of armature coils	22 (22 slots)
Number of turns per coil	3 (42 turns per slot)
Style of winding	3 phase or Wave.
Number of paths in parallel from armature	2.
Turns of coil	1100 1 3 3.
No. of turns per pole	1 2 50 (1 per 10 r. p. m.)

The Shop Motor.

The Shop motor herein referred to is a 1 H.P., 110 volt, 2 pole type machine. It is made by the Westinghouse Co., in model, 5.5. The speed range is from 1100 to 2200 r.p.m. The change in speed is effected by turning a belt wheel which withdraws vertically a core from bit in the roller non-slip motor, thus at the same time actually increasing the diameter, decreasing the magnetic flux, and increasing the speed. The withdrawal of the plunger also directs the line or part of the radial flux into the pole tips where it is the most effective in the production of sparks, and at the same time introduces a further increase in distance in the path of the cross-flux.

The Westinghouse 5 H.P. Generator.

This machine is a standard Westinghouse No. 4, four pole type. There are no coils of this type of machine in common use that no induction is present according to the.

Explanation of Tests.

The Lincoln Motor.

The following tests were run on this machine:

1. The Test Run.
2. The Stray Power Test.
3. The Generation of Stray Power Losses.
4. Insulation Resistance Test.
5. Characteristic Curves.
6. Torque Test.

The Test Run.---

The object of this test was to determine whether the machine could operate at its full rated load without overheating, and in general to study the temperature rise of the various parts of the machine.

The motor was run at full load on high speed until no part of the machine rose in temperature above a normal limit of 110° F. Then the air core resistance was taken. The machine was then run for one hour on full overload and readings taken as before, so that the machine was not run with excessive temperature rise.

Curves were plotted showing the relation between the temperatures of the different parts and elapsed time for both cases.

It was intended to take a test run at low speed also but time was not available for doing so.

The Stray Power Test.----

A stray power test was run at the various speeds and loads. The resistance of the armature (found in the test run) was used in order to compare the losses due to journal friction, air resistance, and other

currents. The efficiency of a motor is

$$\frac{\text{input} - \text{losses}}{\text{input}} = f$$

this we were able to determine by running some part of the rated output, as 1/4 or 1/2 or etc., and finding the efficiency at this load and then multiplying the result and so on, as shown above.

Let $P = \text{output}$.

$E_t = \text{terminal volts.}$

$I_a = \text{armature amperes.}$

$I_f = \text{field amperes.}$

$R_a = \text{resistance of armature across terminals.}$

$R_f = \text{resistance of field.}$

$f = \text{efficiency.}$

$S = \text{stray power.}$

$n = \text{speed.}$

$I_1 = \text{line current.}$

$L = \text{losses}$

Then

$$f = \frac{\text{input} - \text{losses}}{\text{input}} = \frac{P}{\text{input}} = \frac{P}{E_t I_1}$$

$$L = S + I_a^2 R_a + I_f^2 R_f$$

$$f = \frac{E_t I_1 - (S + I_a^2 R_a + I_f^2 R_f)}{E_t I_1}$$

$$= 1 - \frac{S + I_a^2 R_a + I_f^2 R_f}{E_t I_1}$$

and

$$E_t I_a = P + S + I_a^2 R_a$$

$$I_a = \frac{E_t}{2R_a} - \sqrt{\frac{E_t^2}{4R_a^2} - \frac{P+S}{R_a}}$$

$$= \frac{E_t - \sqrt{E_t^2 - 4R_a(P+S)}}{2R_a}$$

then

$$\eta = 1 - \frac{S + \frac{1}{2} (E_t - \sqrt{E_t^2 - 4R_a(P+S)}) + I_a^2 R_a}{E_t (I_f + \frac{E_t - \sqrt{E_t^2 - 4R_a(P+S)}}{2R_a})}$$

Substituting in the formula for η the values at 2000 r. p. m. where $S = 470$ watts we obtain the efficiency of 30.8%

The other results are shown in the table.

From the data so obtained the η vs. ω efficiency curves are plotted. The efficiency curves are fairly well straight lines, as shown, and it is almost a flat curve for all speeds. The efficiency is still slightly increased.

Separation of stray power.---

This test is run to determine the amount of stray power loss. In order to obtain this data we will operate at 1 H.P. 3000 R.P.M. 100% motor. This is done by direct connection to the machine under test and in no way connected.

The test is in four parts.

1. A run with brushes down and field on.
2. A run with brushes down and no field on.
3. A run with brushes up and field on.
4. A run with brushes up and no field on.

1. --- This run gives us the same data as a regular survey power test, i.e., we obtain brush, or journal friction, windage, hysteresis, and eddy current losses.

2. --- This run gives us the brush and journal friction and windage losses.

3. --- This test shows the journal friction, windage, hysteresis, and eddy current losses.

4. --- By this we obtain the windage and journal friction losses.

The four tests allow us to determine the following results:

1. Windage and journal friction loss.
2. Brush friction loss.
3. Core loss consisting of hysteresis and eddy current losses.

Confidence in this method has been experienced in order to get the total stray power loss obtained in this manner to check with that found in the regular manner.

Insulation Resistance.-----

This was tried by using a Weston voltmeter and noting the deflection when a voltage near the range of the instrument was applied at its terminals and then a ^{first} ~~higher~~ rounded turn the armature and second turn the field. The insulation resistance was so high that no deflection could be noticed.

Characteristic Curves.---

These curves were taken at five different speeds and show the drop in speed from no load to full load, other conditions being the same. The regulation is obtained from this data.

The following values are the regulation at the several speeds:

750 r.p.m.	3.8%
1000	5.1
1300	2.0
1500	3.8
1700	2.1

There does not seem to be any fixed relation between regulation and speed, very likely due to the change in flux caused by the main field and the auxiliary commutating poles.

Torque Test. ---

Let T be the torque in pound-feet exerted by the field magnet on the armature for given values of field current and armature current. If it were not for frictional losses, including eddy current loss and hysteresis loss, a torque equal to T would suffice to drive the armature at any speed, n , in spite of the opposing torque exerted on the armature by the field magnet, so that the mechanical power which is converted in the armature into electrical power is $2\pi nT$ foot-pounds per second or $3.412nT$ watts where n is the speed in revolutions per second. But the electrical power developed in the armature is $E_a I_a$ watts so that

$$E_a I_a = 3.412nT \quad \text{or}$$

$$I_a = \frac{3.412nT}{E_a}$$

If the torque T exerted on the armature by the field is not so observed, say, as standstill, for a given value of field current and armature current, I_a , then one can calculate by equation (1) the voltage, E_a , which would be induced in the armature on the machine at a prescribed speed, n , for the given values of field current and armature current. In this way, by varying the field current, one may obtain the characteristic magnetization curve of the machine at any given speed and with given armature current.

From the data obtained in this experiment it is interesting to calculate also the armature flux, ϕ , corresponding to various values of field current. For this purpose the value of E_a in terms of ϕ may be substituted in the equation (1) from the fundamental equation of the dynamo, as ely:

$$E_a = \frac{p\phi Zn}{p' \times 10^8} \quad (2)$$

and the resulting equation solved for ϕ , giving:

$$\phi = \frac{3.42p'T \times 10^8}{p'I_a} \quad (3)$$

The values of torque were determined by clamping an arm fast to the motor pulley and applying a spring dynamometer to this arm at a measured distance, r , from the center of the pulley, the spring balance being adjusted so that its axis is at right angles to r .

The balance readings must be corrected for the unbalanced weight of the arm and the observations must be arranged so as to eliminate as nearly as possible the errors due to journal and brush friction.

Errors due to journal and brush friction were eliminated as follows:- A reference point was fixed opposite to the end of the

and duplicate readings of the dynamometer were always taken "Up" and "Down", that is, (a) while the arm was being raised slowly past the reference point, and (b) while the arm was being lowered slowly past the reference point. The sum of these two readings was nearly free from errors due to friction.

The correction applied to the readings to allow for the unbalanced weight of the arm was determined by taking the "Up" and "Down" readings when no current was flowing either thru the field or armature of the machine. The mean, M , of these two readings gave the reading due to the unbalanced weight of the arm.

The final corrected value of the spring balance reading for given values of field and armature current was obtained by subtracting M from the sum of the "Up" and "Down" readings of the dynamometer obtained with the given values of field and armature currents.

Loads.

We used as loads for this motor a Westinghouse 5 K.W. generator which latter was loaded by a lamp bank.

General.

The performance of this machine were very satisfactory. We were highly pleased with the results obtained from the tests made.

Inter-pole Motor Tests.

The tests run on this motor were:

1. Test run.
2. Stray power test.

Test run.-----

This was run at slightly above full load to start and finally
 ran to full load. The curves and data show the results.

The Stray Power Test.-----

This was run to find the efficiency with the interpoles and at
 the constant speed of approximately 1700 r.p.m. The motor was
 run on 220 volts.

General.

The performance of this machine was not as good as expected
 but this was due, very likely, to the hurry with which the tests were
 necessarily made, the time not allowing of replacing the defective
 parts.

Curves and data of all tests on all machines follow. Also the
 detail drawings of the Testimonials Interpole Machine.

Data for Heat Run on Test Machine 3 H.P. - 220 volt motor.

Time.	Speed.	Air	Frame	Pulley	Front	Field
a.m.	r.p.m.	Temp.	Temp.	Bearing.	Bearing	Temp.
8:00	1130	19.3	19.4	20.5	18.0	21.3
8:30	1205	22.0	27.3	41.0	37.0	43.5
9:00	1225	22.0	35.0	40.4	42.0	53.0
9:30	1245	22.5	40.4	43.0	51.0	53.0
10:00	1255	22.3	44.0	43.0	54.0	53.5
10:30	1255	22.5	42.5	43.5	55.5	60.5
11:00	1230	22.7	43.2	47.2	53.0	61.3
11:30	1215	24.5	42.5	42.0	53.5	63.0
12:00	1235	22.5	50.5	50.0	57.0	64.5
12:30	1275	23.5	52.1	50.0	53.0	66.5
p.m.						
1:00	1215	24.0	53.0	45.1	63.5	70.0

Time.	Speed.	Armature	Amperes	Volts	Amperes	Volts
a.m.	r.p.m.	Temp.	Temp.	Arm.	Field	Field
8:00	1130	20.0	13.65	215.	.33	215.
8:30	1205		12.75	215.	.30	214.
9:00	1225		12.00	214.	.75	214.
9:30	1245		12.00	214.	.75	214.
10:00	1255		12.00	214.	.74	214.
10:30	1255		11.30	213.	.72	212.
11:00	1230		11.30	212.	.71	212.
11:30	1215		11.30	212.	.71	212.
12:00	1235		11.35	213.	.71	212.

12.30	1275	11.00	212.	.71	212.
1.00	1205	11.00	212.	.70	212.

Cold resistance of Armature across brushes and including the Interpole winding.

Ammperes.	Volts.	Ohms.
3.5	3.3	.943
4.5	4.15	.922
5.0	4.5	.900
13.25	12.1	.909
	Av.	.922

Hot resistance of Armature across brushes and including the Interpole Winding.

Ammperes.	Volts.	Ohms.
1.5	1.75	1.16
2.5	2.9	1.16
3.5	4.1	1.17
4.5	5.1	1.13
7.75	9.1	1.17
13.5	14.4	1.06
	Av.	1.14

Cold resistance of field coils.

When the commutator end of the shaft is towards one, then coil number one is on the lower right hand pole-piece.

Number two is the lower left hand coil.

Number three is the upper right hand coil.

Number four is the upper left hand coil.

Coil No.	Resistance.
1	50.47
2	21.05
3	63.71
4	<u>22.32</u>
	<u>241.74</u>

These resistances were measured on a Wheatstone bridge.

Coil No. 2 was removed June 2, '09 and the resistance now again measured and the one given above is nearly correct for the present coil.

Hot resistance of field coils as determined from volts a-mperage readings of the last five readings in the heat run.

Total resistance is 200.0 Ohms.

$$\text{Regulation} = \frac{1400 - 1022}{1022} = 13\%.$$

Stray Power Test on Westinghouse 3 H.P. 220 volt motor.

Speed	Armature	Armature	Field	Field	Armature
r.p.m.	Volts	Amp.	Volts	Amp.	Watts
1340	213.	1.3	212.	0.215	234.7
1210	133.	1.22	211.	.21	241.53
1113	132.6	1.15	210.	.22	250.33
990	153.	1.07	212.	.31	133.22
830	143.	1.24	212.	.31	143.72

Speed	Armature	Stray	Field	E_a
r.p.m.	I^2R	Power	Resistance	
1340	1.044	232.73	231.3	217.5
1210	1.712	233.35	233.1	193.3
1115	1.521	233.35	237.1	181.2
920	1.313	135.51	230.1	154.3
350	1.044	147.43	230.1	141.3

Refer. to 1200 r.p.m.

$$E_a = 180.$$

$$\text{Stray Power} = 230 \text{ Watts.}$$

Data for Efficiency Curve for 3 H.P. Westinghouse Motor on 220 volts at 1200 r.p.m.

Speed	Load	Field I^2R	Arm. & Interspo	Stray	Total I^2R
r.p.m.		Loss	I^2R Loss	Power	Loss.
1200	.25	133.3	7.42	230	133.22
	.5		91.33		133.23
	.75		33.77		227.37
	1.0		113.94		273.74
	1.25		135.72		313.33
	1.5		237.35		423.25

Speed	Total	Total	Total	Efficiency
r.p.m.	Loss	Input	Output	Percent
1200	333.22	957.52	560.5	57.4
	423.23	1532.23	1110.	72.3
	457.37	2135.37	1273.5	73.5

500.4	9747.34	2237.	31.4
570.13	12773.13	2737.7	32.3
657.45	4215.05	3257.	33.3

Data on Tests on

XX Centia-Lowac Generator.

Field Resistance.

Volts	Amperes	Obs.
104	3.13	33.3
103	3.2	33.15
103	3.27	33.
110	3.23	33.2
110	3.31	33.2
72	2.13	33.45
72.3	2.32	33.4
33	2.37	33.4
32	2.77	33.2
33.5	3	33.2

average 33.13 Obs.

Armature resistance

Across Terminals.

Volts	Amperes	Obs.
4	10.75	.233
3	11.5	.231
2.5	3.0	.233
2.3	7.5	.327

1.72 5. .345

1.48 4. .37

Average .300 Obs.

Across Bars.

<u>Volts</u>	<u>Amps.</u>	<u>Obs.</u>
1.7	17.25	.0035
1.5	12.	.003
1.1	12.	.002
1.1	12.	.002
1.1	12.1	.001
1.1	12.	.002
1.05	11.0	.0035
1.75	12.3	.004
1.75	16.75	.0045
Average		.0054 Obs.

Stray Power Data.

<u>Speed</u>	<u>Voltage</u>	<u>Amps.</u>	<u>Watts</u>	<u>I²R</u>	<u>Arm. & Field Total Watts</u>
315	42	2.2	92.4	1.45	413.85
400	50	2.3	112.3	1.9	423.3
500	62.5	2.5	171.25	1.75	535.1
600	72.5	2.5	182.5	2.	562..
700	90	2.7	213.9	2.2	593.4
810	104	2.8	231.2	2.4	654.4
900	104	3.2	232.7	3.1	675.3
900	115	3.3	270.5	3.3	741.3

993	121	3.5	415.0	3.7	350.9
1105	142	3.5	427.0	3.7	353.0
1133	154	3.4	522.2	3.5	335.7
1205	153	3.5	511.	3.7	342.0
1405	180	3.505	532.0	3.7	391.2
1435	195	3. 2	522.4	3.7	1043.3
1523	215	3.75	733.75	4.2	1132.15
1595	220	3.75	325.0	4.2	1135.4

Speed	Stray Power	Speed	Stray power as taken from Curve.
315	22.95	300	20
400	112	400	115
500	150.1	500	155
605	171.5	600	173
700	240.3	700	245
800	310.3	800	305
900	375.2	900	353
1000	444.3	1000	410
1105	493.3	1100	470
1133	520.1	1200	523
1205	577.3	1300	587
1405	222.2	1400	145
1435	232.7	1500	195
1523	724.5	1600	755
1595	820.2	1700	825
		1800	882
		1900	940

Field Loss in 300.0 watts = $22.12 + (2.39)^2$

S.E.P. = 3730 watts.

Then

Load	Watts	I	I^2	$I^2 R$
1/4	932.5	3.47	12.0	1.23
1/2	1365	12.44	273	28.67
3/4	2747.5	52.4	2747	282.7
Full	3730.	61.9	1155	110.3
1 1/4	4132.5	64.4	1500	171.2
1 1/2	5045	71.0	2520	247.2

Data for Efficiency Curve.

1/4 Load.				1/2 Load.		
Speed	Input	Output	Eff'cy.	Input	Output	Eff'cy.
300	1365	932.5	67.63	2337.2	1265	70.93
400	1420		55.7	2372.2		73.7
500	1430		33.0	2412.2		77.5
600	1533		32.0	2453.2		73.0
700	1650		30.9	2501.2		74.3
800	1691		52.2	2553.2		73.2
900	1652		50.3	2610.2		71.5
1000	1715		54.4	2637.2		70.0
1100	1775		32.5	2727.2		63.5
1200	1833		50.3	2735.2		27.0
1300	1892		40.2	2844.2		35.3
1400	1950		47.7	2922.2		34.3

Input	Output	Efficiency	Input	Output	Efficiency
2010	2002.5	42.14	2002.2	1305	31.2
2070		43.0	2002.2		31.3
2100		42.4	2002.2		30.5
2130		42.3	2110.2		31.5
2240		41.5	2107.2		53.4
2315		40.5	2207.2		57.3
3/4 Load.			Full Load.		
3305.3	2737.5	84.7	4305.2	3730	37.2
3340.2		51.3	4300.2		33.5
3380.2		50.7	4300.2		25.2
3420.2		51.2	4400.2		34.7
3470.2		50.7	4450.2		33.2
3521.3		73.5	4501.2		32.2
3578.3		73.2	4553.2		31.2
3633.2		77.2	4615.2		30.2
3685.2		71.3	4675.2		72.2
3753.2		74.5	4733.2		72.2
3812.3		73.5	4792.2		77.2
3870.2		72.4	4850.2		72.2
3930.2		71.2	4912.2		72.2
3990.2		70.2	4970.2		75.1
4050.2		69.2	5030.2		74.2
4100.2		68.2	5092.2		73.4
4155.2		67.3	5145.2		72.3
4225.2		37.5	5205.2		71.3

12.30	1275	11.30	213.	.71	212.
1.00	1295	11.00	212.	.70	210.

Gold resistance of Armature across brushes and including the Interpole winding.

Ampere.	Volts.	Ohms.
3.5	3.7	.043
4.5	4.15	.032
5.0	7.5	.0325
13.25	12.1	.0237
	Av.	.0237

Gold resistance of Armature across brushes and including the Interpole Winding.

Ampere.	Volts.	Ohms.
1.5	1.75	1.13
2.5	3.0	1.2
3.5	4.1	1.17
4.5	5.1	1.13
7.75	9.1	1.17
13.5	14.4	1.032
	Av.	1.149

Gold resistance of field coils.

When the commutator end of the shaft is towards one, then coil number one is on the lower right hand pole-piece.

Number two is the lower left hand coil.

Number three is the upper right hand coil.

Number four is the upper left hand coil.

Coil No.	Resistance.
1	50.47
2	51.65
3	51.41
4	<u>52.82</u>
	<u>206.34</u>

These resistances were measured on a Wheatstone bridge.

Coil No. 2 was removed June 2, '09 and the resistance was again measured but the one first given is nearly correct for the present coil.

Hot resistance of field coils as determined from volts a-ampere readings of the last five readings in the test run.

Total resistance is 200.00 ohms.

$$\text{Regulation} = \frac{1400 - 1032}{1032} = 13\%.$$

Stray Power Test on Westinghouse 3 H.P. 220 volt Motor.

Speed	Armature	Armature	Field	Field	Armature
r.p.m.	Volts	Amp.	Volts	Amp.	Watts
1340	213.	1.3	213.	0.415	234.7
1210	193.	1.22	211.	.41	241.53
1115	182.5	1.15	210.	.42	200.33
990	153.	1.07	212.	.41	123.09
850	143.	1.04	213.	.41	143.72

Speed	Armature	Stray	Field	V_a
r.p.m.	I^2R	Power	Resistance	
1340	1.044	202.73	231.3	217.5
1210	1.712	223.35	233.1	193.3
1115	1.521	203.35	237.1	181.2
920	1.313	165.31	230.1	154.3
850	1.244	147.43	230.1	141.3

Reduced to 1200 r.p.m.

$$V_a = 180.$$

$$\text{Stray Power} = 220 \text{ Watts.}$$

Data for Efficiency Curve for 2 W.P. Westinghouse Motor on 220
volts at 1200 r.p.m.

Speed	Load	Field I^2R	Arm. & Interpole	Stray	Total I^2R
r.p.m.		Loss	I^2R Loss	Power	Loss.
1200	.25	132.3	7.42	220	139.02
	.5		92.32		130.23
	.75		93.77		227.37
-	1.0		113.94		273.34
	1.25		135.72		312.32
	1.5		237.35		423.25

Speed	Total	Total	Total	Efficiency
r.p.m.	Loss	Input	Output	Percent
1200	139.02	957.52	800.5	83.4
	420.23	1530.23	1112.	72.3
	457.37	2123.37	1273.3	74.5

599.14	2747.54	2137.	31.4
573.33	2373.13	2707.5	30.3
557.45	4015.25	2997.	23.3

Data on Tests on

II Westinghouse Generator.

Field Resistance.

<u>Volts</u>	<u>Amperes</u>	<u>Ohms</u>
104	3.19	32.6
106	3.2	33.15
108	3.27	33.
109	3.33	32.9
110	3.31	33.2
72	2.15	33.45
70.5	2.33	30.4
38	2.57	33.4
32	2.77	33.2
30.5	3	33.2

average 33.18 Ohms.

Armature resistanceAcross Terminals.

<u>Volts</u>	<u>Amperes</u>	<u>Ohms</u>
4	16.75	.237
3	11.5	.261
2.5	8.0	.312
2.3	7.5	.307

1.70 5. .745

1.40 4. .87

Average .300 Ohms.

Across Bars.

Volts	Ampere	Ohm.
1.7	17.25	.0035
1.5	12.	.003
1.1	12.	.002
1.1	12.	.002
1.1	12.1	.001
1.1	12.	.002
1.25	11.4	.0035
1.75	13.3	.004
1.75	13.75	.0045
Average		.0054 Ohm.

Stray Power Data.

Speed	Volts	Ampere	Watts	I ² R	Arm. & Field Total Watts
315	42	2.2	92.4	1.45	413.85
400	50	2.3	110.3	1.3	423.3
500	62.5	2.5	171.25	1.75	535.1
600	72.5	2.6	182.5	2.	562..
700	90	2.7	243.0	2.2	593.4
810	104	2.8	291.2	2.4	654.4
900	104	3.2	332.8	3.1	675.3
900	115	3.3	379.5	3.3	741.3

993	121	3.5	437.0	3.7	810.9
1105	140	3.6	497.0	3.7	853.0
1193	154	3.4	522.2	3.6	935.7
1295	173	3.5	591.	3.7	943.0
1405	180	3.505	630.0	3.7	991.2
1495	195	3.2	689.4	3.7	1043.3
1523	205	3.75	733.75	4.2	1132.13
1595	220	3.75	825.0	4.0	1139.4

Speed	Stray Power	Speed	Stray power as taken from Curve.
315	20.05	375	70
470	113	490	115
590	150.1	590	135
695	191.5	690	173
790	240.3	790	215
890	300.3	890	270
990	375.2	990	353
1090	444.3	1090	410
1195	493.3	1190	470
1293	520.1	1290	523
1395	577.3	1390	577
1495	632.2	1490	645
1495	632.7	1590	705
1538	724.5	1590	735
1595	820.2	1720	895
		1890	993
		1990	940

Field Loss in 335.2 watts = $22.12 \pm (2.30)^2$

S.F.P. = 3730 watts.

Then

Load	Watts	I	I^2	$I^2 R$
1/4	932.5	2.47	7.1	6.23
1/2	1865	4.94	27.3	22.57
3/4	2797.5	7.41	54.7	42.7
Full	3730.	9.8	115.5	110.3
1 1/4	4662.5	12.2	179.0	171.3
1 1/2	5595	15.0	225.0	217.7

Data for Efficiency Curve.

Speed	1/4 Load.			1/2 Load.		
	Input	Output	Eff'cy.	Input	Output	Eff'cy.
300	1365	932.5	67.63	2337.2	1865	79.83
400	1420		65.7	2372.2		73.7
500	1460		63.9	2412.2		77.5
600	1503		62.0	2455.2		73.0
700	1550		59.9	2500.2		74.3
800	1601		58.2	2553.2		73.2
900	1653		56.4	2610.2		71.5
1000	1715		54.4	2667.2		70.0
1100	1775		52.5	2727.2		68.5
1200	1833		50.7	2785.2		67.0
1300	1892		49.2	2844.2		65.3
1400	1950		47.7	2902.2		64.3

Speed	Input	Output	Eff'cy.	Input	Output	Eff'cy.
1500	2010	932.5	46.4	2032.2	1305	64.2
1600	2070		45.0	2040.2		61.8
1700	2130		43.3	2040.2		59.5
1800	2188		42.3	2140.2		59.5
1900	2245		41.5	2197.2		53.4
2000	2305		40.5	2257.2		57.3
3/4 Load.			Full Load.			
300	3305.3	2737.5	82.7	4305.2	3730	87.2
400	3342.3		81.3	4320.2		85.5
500	3380.3		80.7	4330.2		85.3
600	3423.3		81.3	4402.2		84.8
700	3472.3		80.7	4450.2		83.2
800	3521.3		79.5	4501.2		82.2
900	3578.3		78.2	4553.2		81.2
1000	3633.3		77.0	4615.2		80.2
1100	3685.3		75.8	4675.2		78.2
1200	3753.3		74.5	4733.2		78.2
1300	3812.3		73.5	4792.2		77.2
1400	3872.3		72.4	4850.2		76.2
1500	3930.3		71.2	4912.2		75.2
1600	3990.3		70.2	4970.2		75.1
1700	4050.3		69.0	5030.2		74.2
1800	4105.3		68.2	5098.2		73.4
1900	4155.3		67.3	5145.2		72.8
2000	4225.3		67.5	5205.2		71.8

Speed	1 1/4 Load.			1 1/2 Load.		
	Input	Output	Eff'cy.	Input	Output	Eff'cy.
300	5230	4531.5	86.4	5273.3	5535	89.0
400	5235		87.0	5323.3		89.5
500	5335		87.0	5323.3		89.0
600	5333		88.5	5403.3		87.4
700	5445		85.7	5453.3		86.7
800	5433		84.0	5504.3		86.0
900	5553		84.0	5551.3		85.3
1000	5510		83.0	5513.3		84.0
1100	5370		82.3	5373.3		83.3
1200	5723		81.5	5723.3		83.0
1300	5727		80.7	5735.3		82.4
1400	5815		79.3	5833.3		81.5
1500	5925		79.0	5913.3		80.0
1600	5925		78.3	5973.3		80.2
1700	5935		77.5	7033.3		79.5
1800	5933		76.7	7001.3		78.0
1900	3140		75.0	7143.3		77.4
2000	3220		75.3	7203.3		77.7

Data for Tests on Lincoln Motor.

Field Resistance.-----

Volts	Ampere	Resistance
200	.31	355
210	.31	371
213	.31	373
214	.31	374
220	.33	350
212	.31	363
214	.31	373
220	.31	373
213	.32	370
213	.32	374
213	.32	370
213	.31	373

375 Ohms.

Armature Resistance across Brushes.---

Average resistance from first speed test run = 1.32 Ohms.

Armature resistance across terminals.---

Ampere	Volts	Ohms
3.2	3	1.34
7	10	1.37
10.1	14	1.375
14.1	19	1.35

1.323 Ohms.

Stray Power Test.

Speed	Amperes	Volts	Watts	I R	Stray Power Computed From Above	
300	.3	220	132	.4	171.6	
400	.3	220	132	.4	171.6	105
500	.41	212	133	.4	172.6	125
600	.51	202	132.4	.4	173.	143
700	.7	210	157	.5	172.5	170
800	.8	217	174.5	.7	172.8	190
900	.84	220	186.	.75	184.25	200
1000	.95	220	209.	.95	203.05	212
1100	1.0	212	222.5	1.5	231.	222
1200	1.22	213	262.	1.3	234.4	235
1300	1.23	218	275	1.7	273.3	272
1400	1.32	210	280.	1.2	237.1	232
1500	1.40	210	311.5	2.1	300.4	310
1600	1.52	213	333.	2.45	330.35	320
1700	1.6	210	330.5	2.7	347.3	343
1800	1.75	212	335.5	3.15	370.35	363
1900	1.8	210	363.	3.45	392.55	370

This is a 3 1/2 H.P. motor or 2311 watts.

Load	Watts	Amperes	$I^2 R$
1/4	851.25	2.25	2.3
1/2	1303.5	3.25	37.5
3/4	1757.75	6.2	34.0
Full	2311	11.25	150.0

1 1/4	3238.01	14.82	233.5
1 1/2	3913.5	17.73	295.0

Field I²R loss is 183.2 watts.

Data For Efficiency Curve.

Speed	Input	Output	Eff'cy.	Input	Output	Eff'cy.
300	335.75	332.25	73.7%	1537.0	1335.5	83.4%
400	370.75		72.3	1584.0		82.5
500	392.75		70.7	1634.0		81.4
600	443.75		69.4	1682.0		80.5
700	507.75		68.3	1670.0		79.7
800	577.75		69.7	1650.0		78.7
900	637.75		65.3	1670.0		77.2
1000	1015.75		64.2	1687.0		73.2
1100	1033.75		62.1	1718.5		73.2
1200	1052.75		61.2	1734.0		75.4
1300	1072.75		60.3	1734.0		74.5
1400	1093.75		59.3	1771.0		73.6
1500	1127.75		58.3	1713.0		73.2
1600	1127.75		57.3	1692.0		72.2
1700	1145.75		55.2	1687.0		71.4
1800	1155.75		55.2	1647.0		71.3
1900	1165.75		55.2	1637.0		69.2
2000	1201.75		54.2	1633.0		69.3

3/4 Load

Full Load

300	2241.25	1957.75	83.4	2011.0	2111	87.5
400	2232.25		83.2	2000.0		87.2

Speed	Input	Output	Efficiency	Input	Output	Efficiency
500	2300.05	1037.75	45.1	3000.0	2011	67.0
600	2370.05		44.3	3040.0		63.0
700	2337.05		42.7	3037.0		65.1
800	2357.05		43.0	3077.0		64.0
900	2377.05		42.3	3097.0		64.4
1000	2395.05		41.6	3115.0		63.0
1100	2413.05		41.1	3133.0		63.1
1200	2432.05		40.6	3150.0		62.0
1300	2452.05		40.3	3170.0		62.4
1400	2469.05		40.2	3188.0		61.9
1500	2487.05		40.3	3207.0		61.4
1600	2507.05		40.0	3227.0		60.2
1700	2525.05		40.3	3245.0		60.4
1800	2545.05		40.0	3265.0		60.0
1900	2565.05		40.3	3285.0		70.5
2000	2561.05		40.7	3301.0		70.1

1 1/4 Load.

1 1/2 Load.

300	3711	3000.05	33.0	4105.7	3011.5	37.7
400	3723		37.0	4400.7		67.3
500	3743		37.0	4500.7		37.0
600	3753		38.0	4600.7		38.7
700	3781		38.3	4637.7		68.3
800	3803		38.0	4657.7		38.0
900	3793		38.5	4677.7		68.5
1000	3841		38.0	4700.7		68.0

Speed	Input	Output	Eff'cy.	Input	Output	Eff'cy.
1100	3850	3253.25	84.5	4013.7	3313.5	82.5
1200	3872		84.2	4022.7		84.5
1300	3893		83.8	4052.7		84.0
1400	3915		83.4	4082.7		82.7
1500	3933		83.0	4097.7		83.2
1600	3953		82.7	4107.7		83.3
1700	3971		82.3	4125.7		82.3
1800	3991		82.0	4145.7		82.0
1900	4011		81.5	4165.7		82.3
2000	4027		81.2	4181.7		82.0

Data of Fast Speed Heat Run.

Time.	Speed	Field	L. Pole Temp.	E. Pole Temp.	Leaving Water	
a.m.	r.p.m.	Temp.	Temp.	Temp.	Temp.	Temp.
1:00	1970	35	32	32.5	40.5	22.75
1:30	1950	43	31	34.	40.5	22.
2:00	1935	45	30	33.5	40.	21.7
2:30	1925	48	27.5	33.	40	23.2
3:00	2020	43.7	33	33.5	40	24.2
3:30	2010	43	33	33	40	24.5
4:00	2010	40	32	33	40	24.5

Time	Speed	Pressure	Amperes	Volts	Amperes
a.m.	Temp.	Temp.	Ans.	Ans.	Field
1:00	22.4	30	13.3	205	.31
1:30	22.4		13.3	205	.2

Time	Room	Air Temp.	Air-flow	Volts	Amperes
a.m.	Temp.	Temp.	Arm.	Arm.	Field
2:00	22.3		13.3	205	.51
2:30	22.3		13.3	205	.53
3:00	22.3		13.3	205	.53
3:30	22.3		13.3	205	.53
4:00	22.3	40.5	13.3	205	.53

Generator output for this run

Time	Speed	Amperes	Volts	Volts
a.m.	r.p.m.	Arm.	Arm.	Field
1:30	1740	3.3	220	105
2:00	1750	4.75	213	101
2:30	1750	4.3	213	101
3:00	1735	4.3	210	101
3:30	1805	4.3	210	101
4:00	1805	4.2	210	101

Overload run for 2 hours.

Time	Speed	Field	L. Pole Tip	T. Pole Tip	Bearing	Frame
a.m.	r.p.m.	Temp.	Temp.	Temp.	Temp.	Temp.
4:30	1000	47	33	37	45	33.5
5:00	1070	43	33	39	49	34
5:30	2010	43.7	33.5	39.5	47	34.3
6:00	1030	50	39.5	40	49	35.5
6:30	1000	51	39.5	40	49	35.2

Time	Load	Armature	Ammeter	Volts	Ammeter
a.m.	Room	Temp.	Ans.	Ans.	Field.
4:30	22.8		17	205	.30
5:00	22.8		17	205	.30
5:30	22.3		17	205	.30
6:00	22.3		17	205	.30
6:30	23.2		17	205	.30

Generator Output for This Run.

Time	Load	Ammeter	Volts	Volts
a.m.	Temp.	Ans.	Ans.	Field
4:30	1750	5.35	2.23	100
5:00	1770	5.3	213	100
5:30	1800	6.35	213	100
6:00	1790	33	213	100
6:30	1800	6.3	213	100

Characteristic Curves.

Speed	Load	Volts	Ammeter
700	.25	210	4.
835	.5	210	7.
865	.75	210	10.0
900	1.0	210	12.3
930	.25	210	4.4
960	.5	210	7.4
970	.75	210	10.5
985	1.0	210	12.5

Speed	Load	Volts	A. amp.
1300	.95	210	5
1380	.5	210	3
1330	.75	210	10.3
1340	1.0	210	12.8
1280	1.25	210	15.5
1180	1.5	210	10.5
1000	.25 2.5%	210	3.5
1110	.75	210	10.3
1500	1.0	210	14.1
1435	1.5	210	13.5
1200	.5	210	2.7
1235	.75	210	14.3
1310	1.25	210	17.5
1735	1.5	210	10.2

Characterization of Stray Power.

Test 1. (See Indication on page 10)

220 volts on terminals of field of Lincoln motor.

Speed	Terminal Volts	Amp. Volts	Amp. Arm.	Amp. Input	Amp I ² R
300	133	31	5.1	153.1	30.37
400	133.5	42	4.3	180.3	26.07
600	134	40	4	180	22.51
900	133	40	4.7	227.3	31.15
700	134	39	3.2	227.2	20.33

Speed	Horizontal Folts	Ann. Folts	Ann. Ann.	Ann. Front	Ann. I ² 3
800	134	75	4	330	22.53
800	133.5	75	4.4	330	22.22
1000	134	73	4.3	342.4	22.27
1100	134	70	5.0	412.3	22.13
1200	133	102	4	432.	22.53
1300	133.5	123	3.3	437.4	22.32
1400	133	123	3.2	437.4	22.32
1500	133	133	4.1	512.3	23.70
1600	133	133	4.2	571.2	23.27
1700	132	132	4.5	591.	23.65
1800	132	132	5.1	573.2	23.27

Test 2.

Speed	Ann. Ann.	Folts Ann.	Hor. Folts
300	2.2	20	135
400	2.3	41	135
500	2.3	40	134.5
640	2.3	64	135
700	3.1	24	134.5
800	3.1	21	134
900	3.1	70	134
1000	3.1	27	134
1100	3.2	22	134
1200	3.2	107	134
1300	3.3	122	134
1400	3.3	134	134

Speed	Am. Amp.	Volts. amp.	Temp. Volts
1500	3.1	134	134
1600	3.7	133.5	133.5
1700	3.9	133.5	133.5
1800	4.0	133.5	133.5
1900	4.5	133	133

Test 3.

220 volts across the terminals of the Lincoln Motor Field.

300	4.0	31	133
400	3.4	33	133
500	4.1	37	133
600	3.3	44	132.5
700	3.2	49	133
800	3.	77	133
900	3	77	133
1000	2.	92	133
1100	3.1	103	133
1200	3.2	113	133
1300	3.2	125	133
1400	3.2	133	133
1500	3.3	133	133
1600	3.5	133	133
1700	3.7	133	133
1800	4.	133	133

Test 4.

Speed	Arm. Amp.	Arm. Volts	Ter. Volts.
300	1.75	23	135
400	1.5	22	135
500	1.35	42	135
600	1.8	52	135
700	1.2	32	135
800	2.1	71	135
900	2.2	80	135
1000	2.3	90	135
1100	2.4	90	135
1200	2.5	107	135
1300	2.3	113	135
1400	2.3	122	135
1500	2.7	135	135
1600	2.35	126	135
1700	3.	134	134
1800	3.25	134	134.

Torque Test.

Speeds indicated here are such as would be obtained if the armature were free to move, i.e., the pulley wheel was rotated till we had the armature in the position that with free armature we could obtain this speed. The terminal voltage on the field of the motor was 200 volts.

Speed "Up" Pull "Down" Pull Acc. lbs.

300	7	5	7
	11	9	9
	14	12	9
	13.5	13	12
	21	17	13
	24	22	13
400	3	4.5	3
	9	7.5	3
	12	10	3
	15	13	12
	18	13	13
	21.5	12.5	13
700	9	4.5	3
	9.5	7.5	3
	12.5	10.5	9
	13	13	12
	13	13	13.5
	22	22	17
1000	4	3	3
	5.5	3.5	3
	7	5	3
	9	9	12
	9	7	14.5
	11	9	12.5

Speed	"Up" Pull	"Down" Pull	Area. lbs.	
1200	4	2.5	3	
	5	3.5	3	
	6	4.5	0	
	7	5.5	10	
	8	6.5	11.7	
	9.5	3.	12.5	
1500	3.75	2.25	3	
	4.5	3.25	3	
	5.5	4	0	
	6.25	5	10	
	7	5.5	14.5	
	7.25	5.75	12	
1800	2.25	2.5	3	
	4	3	3	
	5	3.75	0	
	6	4.5	10	
	6.5	5	13	
	7.5	8	12.5	
Speed	"Up" Pull	"Down" Pull	Area. Area.	Field Volts
400	3	7	3	130
	4.5	7.5	3	130
	5.75	7.5	3	137.5
	6	7.5	3	130
	6.5	7.75	3	112.5
	7.5	7	3	122.5

Steel	"Up" Rail	"Down" Rail	Arm. A. C.	Field Folios
400	13.5	11.75	12	130
	13.5	11.75	12	130
	14	12	12	17
	14.25	12.25	12	130
	15	13	12	212.5
	15.5	13.5	12	225

Length of crane arm = $3 \frac{1}{4}$ ft.

Unbalanced weight of arm = 97 = 1.

There are 1534 increments.

Following is the solution for a part of the above data. The solution of the data will be left to the student as an exercise.

Steel	Arm. A. C.	Field Folios	"Up" Rail	"Down" Rail	Av. Cor. Rail
400	8	130	8	7	1.5
		130	8.5	7.2	5.25
		137.5	8.75	7.5	8.13
		210	9	7.5	2.25
		212.5	9.25	7.75	3.5
		225	9.5	8	3.75
400	12	130	13.5	11.75	19.25
		130	13.5	11.75	19.25
		137	14	12	11
		137	14.25	12.25	11.25
		212.5	15	13	12
		225	15.5	13.4	12.5

Speed	Arm. Amp.	Field Volts	"No. 1" Bell	"No. 2" Bell	Ar. Cor. Bell
100	3	220	7	5	4
	5		11	7	3
	9		14	12	11
	12		13.5	13	15.25
	15		21	19	13
	18		24	22	21

Torque in %ft.	δ	Σ_a
17.85	730000	133
18	840000	177
22.3	820000	135
21.1	835000	127.7
21.3	870000	204
24.5	725000	152
24.3	725000	133
25.5	735000	132
26.3	810000	173.5
30.0	830000	125.5
40.7	800000	122.5
12.0	1145000	124.5
25.0	1145000	124.5
35.7	1050000	174
45.0	1050000	130.5
52.0	1000000	173
63.3	1075000	172.

Summary of the Data for the Year 1933.

Year	Int. A. S.	Total	Total	Total	Total	Total
1933	1.	33	170.3	31	1.41	171.3
433	1.	34	171	31	1.41	172.3
533	1.	43	173	43	1.41	174.3
633	1.	53	174	53	1.41	175.3
733	1.	64	175	64	1.41	176.3
833	1.	79	176	79	1.41	177.3
933	.3	85	177	79	1.41	177.33
1033	.33	89	177	84.33	1.47	178.33
1133	1.	91	178	85	1.41	179.3
1233	1.	113	179	113	1.41	180.3
1333	1.	113	179	113	1.41	181.3
1433	1.33	134	180	133.2	1.45	181.32
1533	1.31	131	180	131.3	1.43	181.31
1633	1.	131	181	131	1.41	182.3
1733	1.	133	182	132	1.41	183.3
1833	1.	133.	183.	133.	1.41	184.3

Winding Diagram

0 10 20 30 40 50 60 70 80 90 100 110 120

120°

8 wires .064 dia in series.
24 " per coil.
48 " " slot.

8 wires .064 dia in series.
24 " per coil.
48 " " slot.

24 " per coil.
48 " " slot.

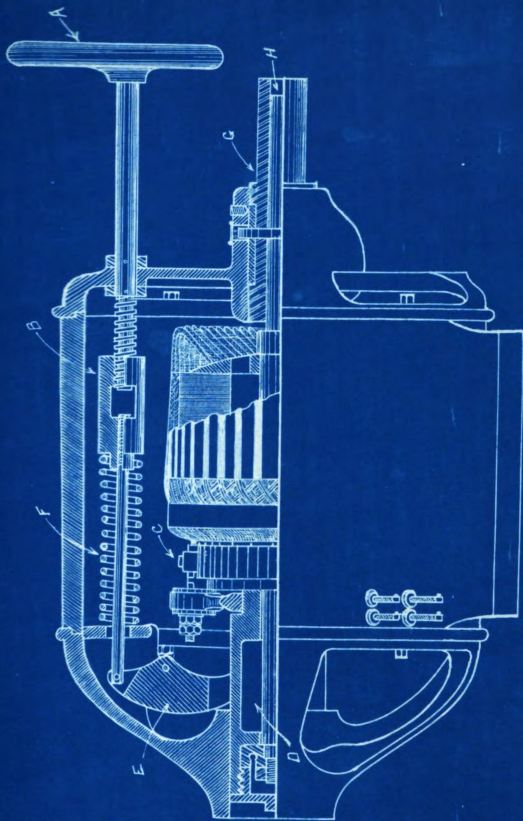
48 " " slot.

- Winding Diagram -

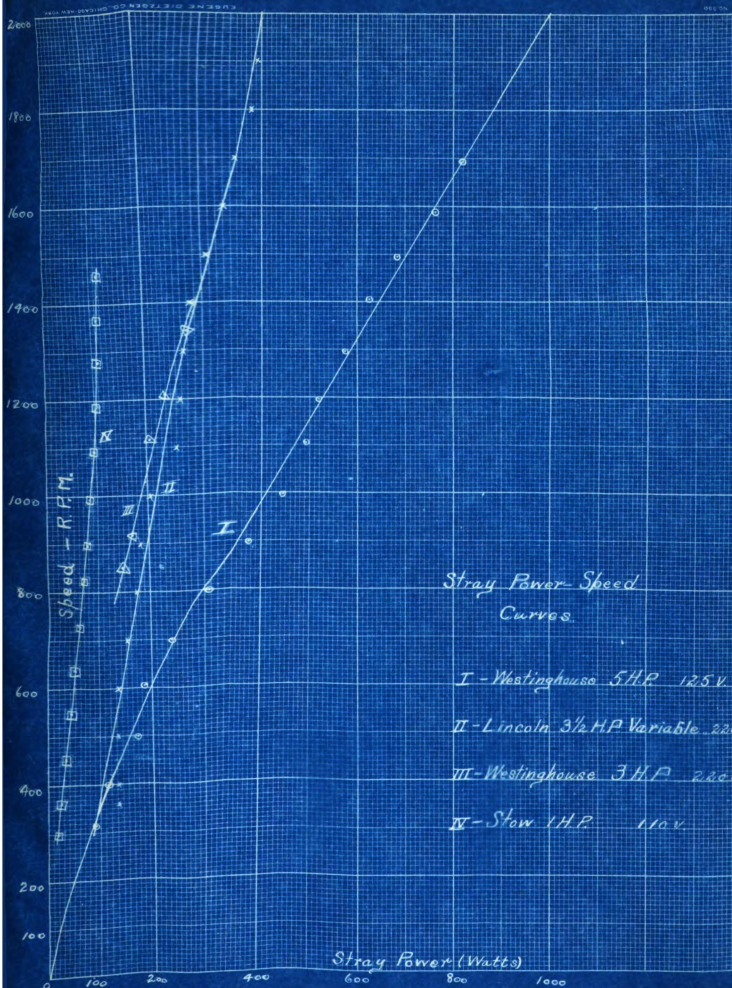
"E" Arm - 3 1/2 HP - 220 Volts
33 Slots - 99 Bars

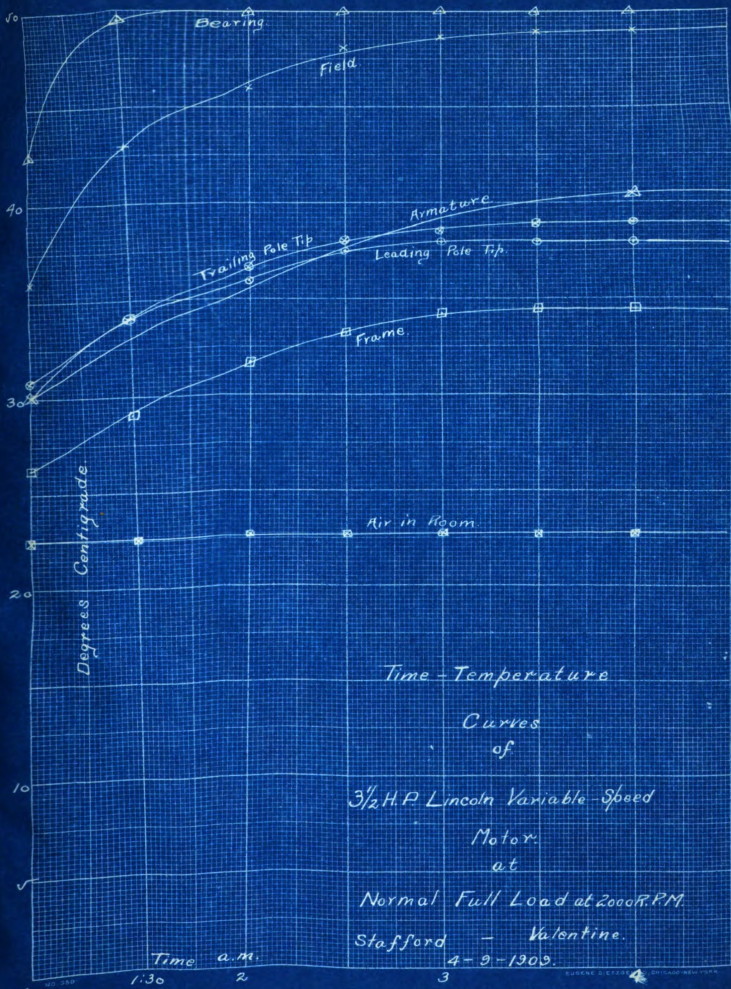
33 Slots - 99 Bars.

THE LINCOLN MOTOR WORKS CO



Lincoln Variable-Speed Motor





Time - Temperature Curves
of
High-Speed - Overload Heat Run
on
3 1/2 H.P. Lincoln Variable-Speed
Motor

Stafford — Valentine

4-9-'09

Degrees Centigrade.

Field
Bearing

Trailing Pole Tip

Leading Pole Tip

Frame

Air in Room

Time - a.m.

4:30 5 5:30 6 6:30 7

Speed in R.P.M.

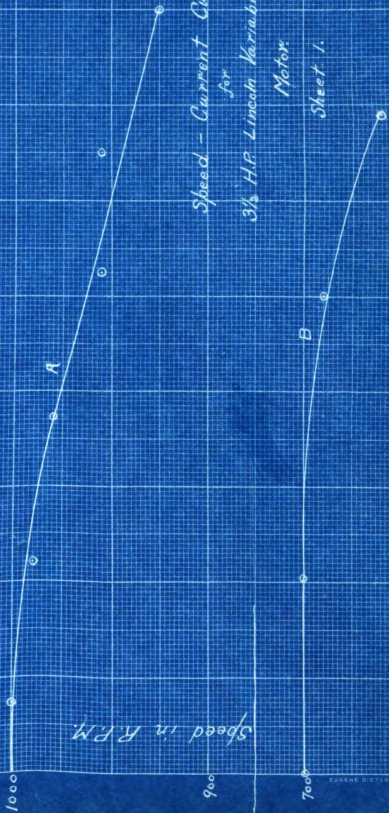
Speed - Current Curves
for
3 1/2 H.P. Lincoln Variable Speed
Motor.

Sheet 1.

Stafford
Valentine

4-11-1903.

Current in Amperes.



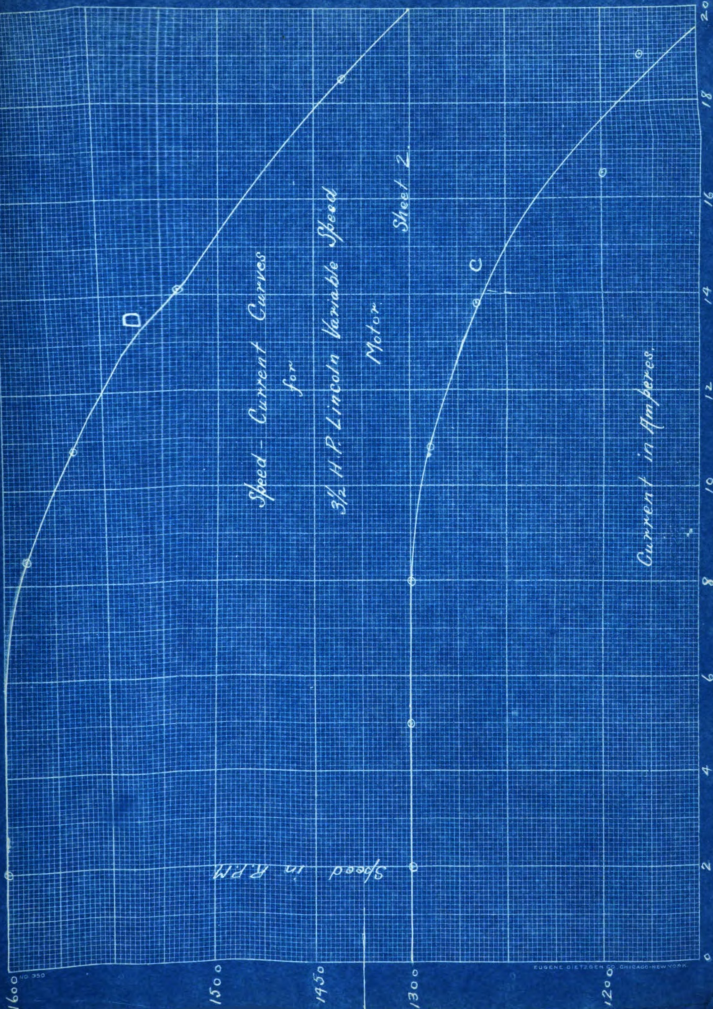
Speed in R.P.M.

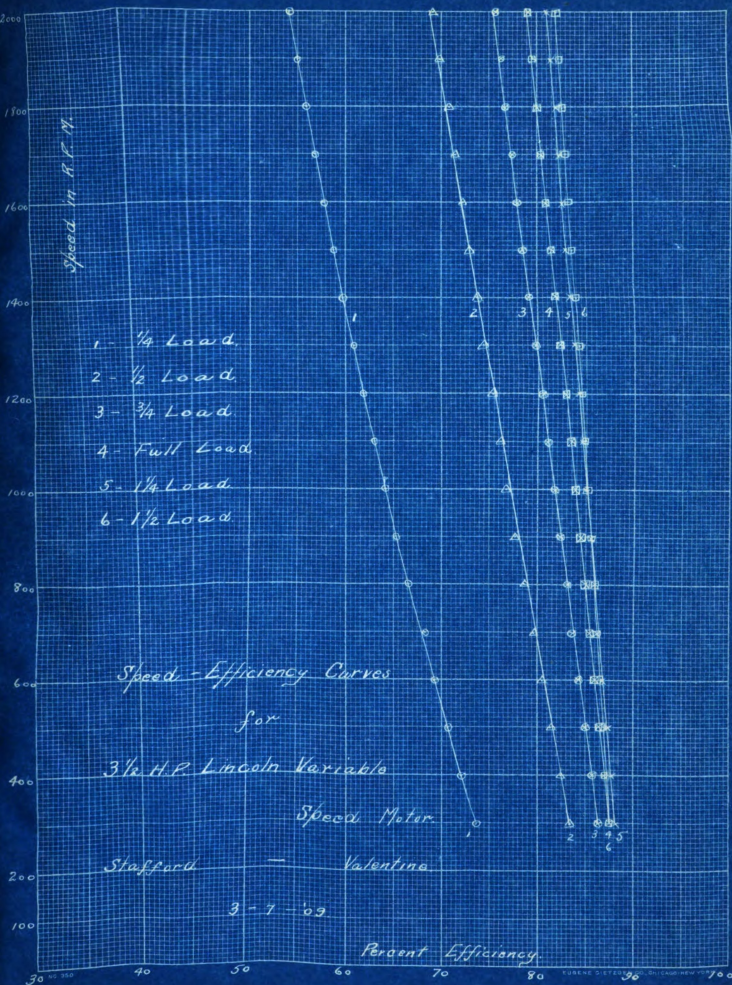
Speed - Current Curves
for

$3\frac{1}{2}$ H.P. Lincoln Variable Speed
Motor

Sheet 2.

Current in Amperes.





Speed in R.P.M.

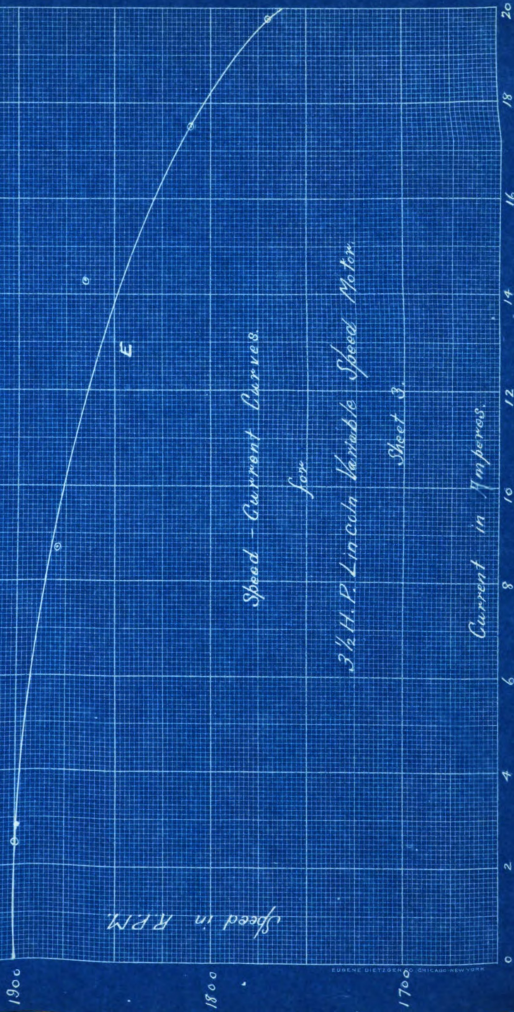
Current in Amperes

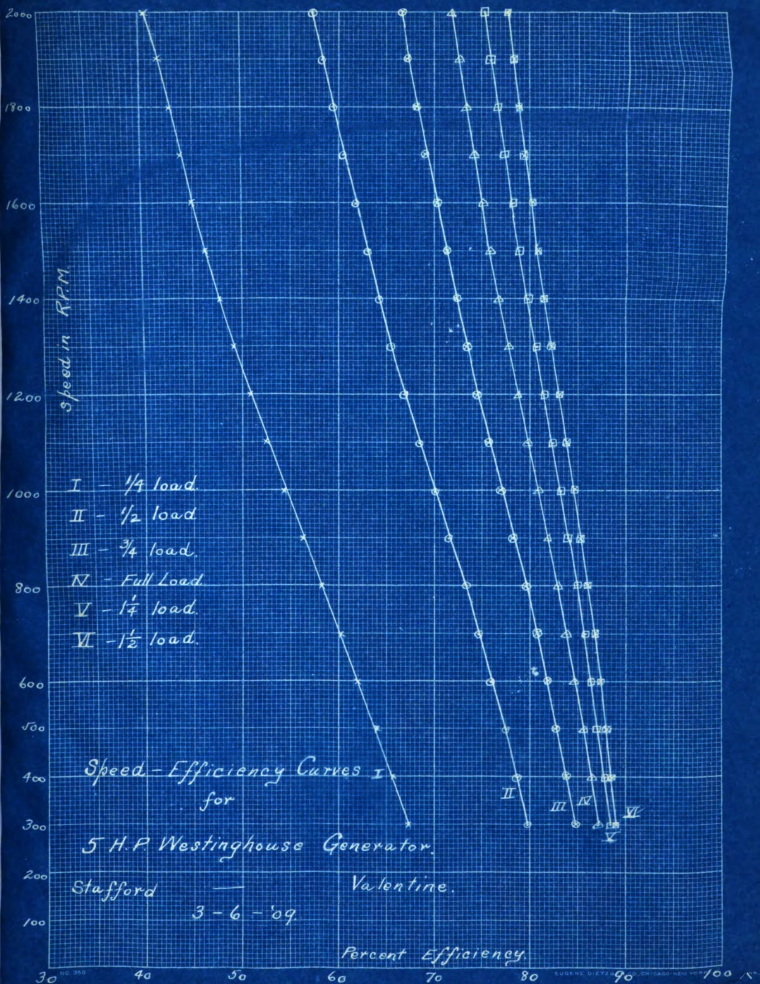
Speed - Current Curves
for

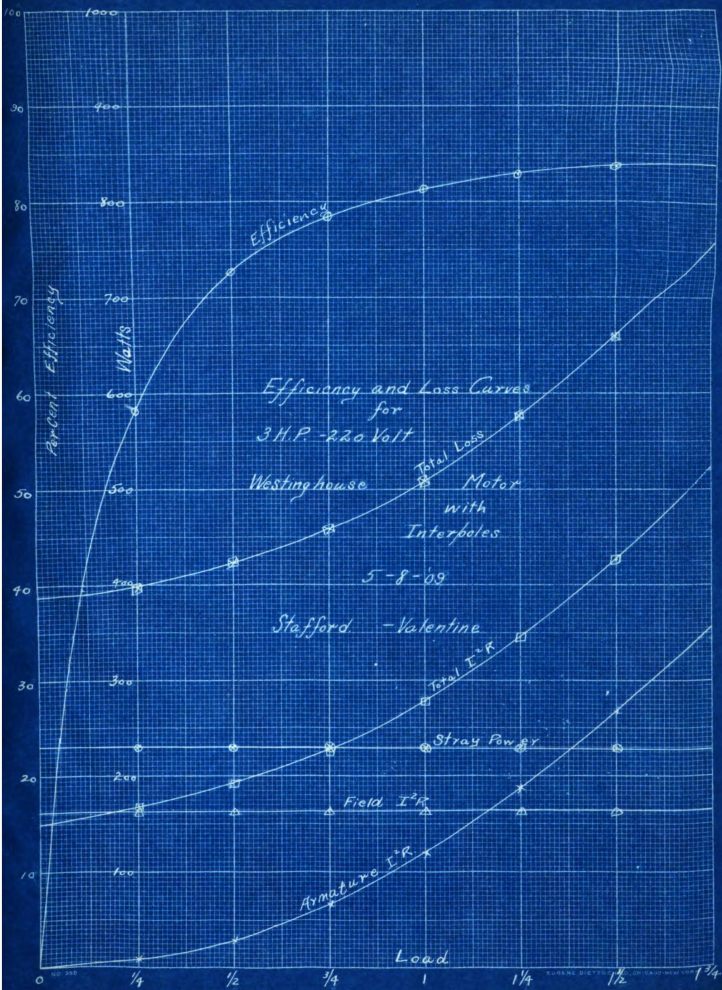
3 1/2 H.P. Lincoln Variable Speed Motor

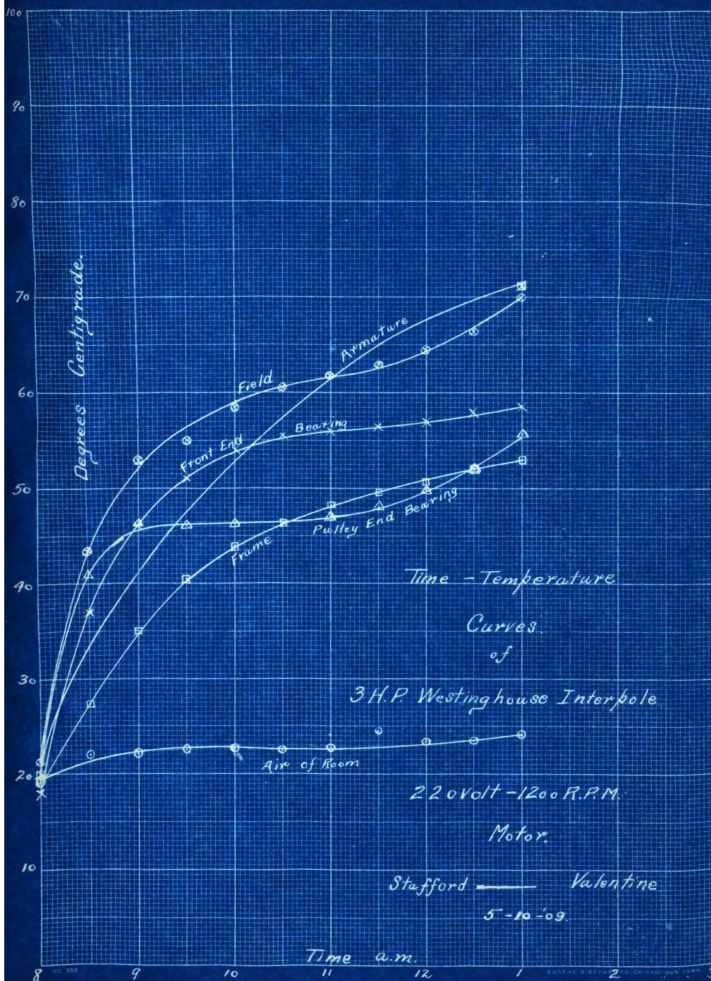
Sheet 3.

E









M9

36 SPEED MOTOR

FFME

TO - VALENTINE -

DIS, 1908

FOR DIMENSIONS OF SECTION

SEE M

SCALE FULL SIZE.

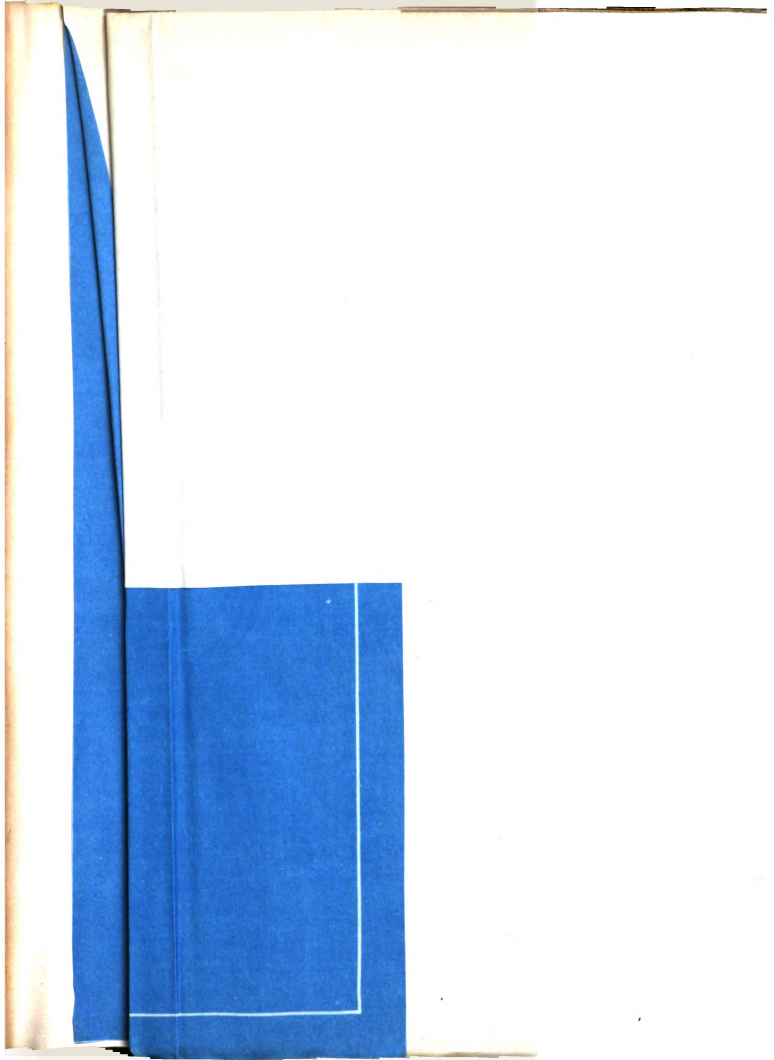
M. 3C

ADJUSTABLE SPEED MOTOR.

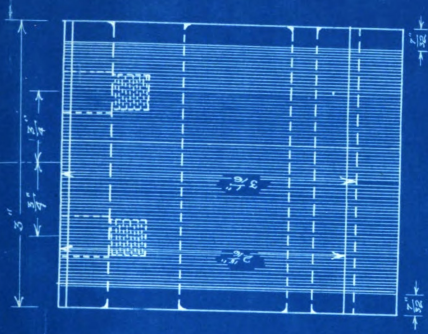
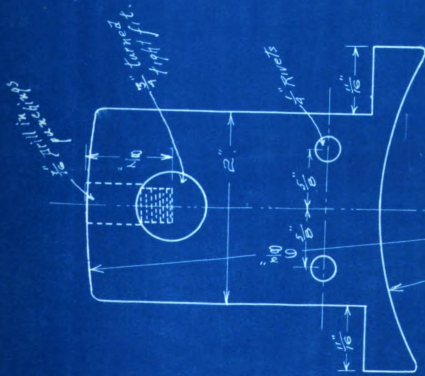
FRONT SHIELD.

FORD — VALENTINE.

ckd JAN. 29, 1909.







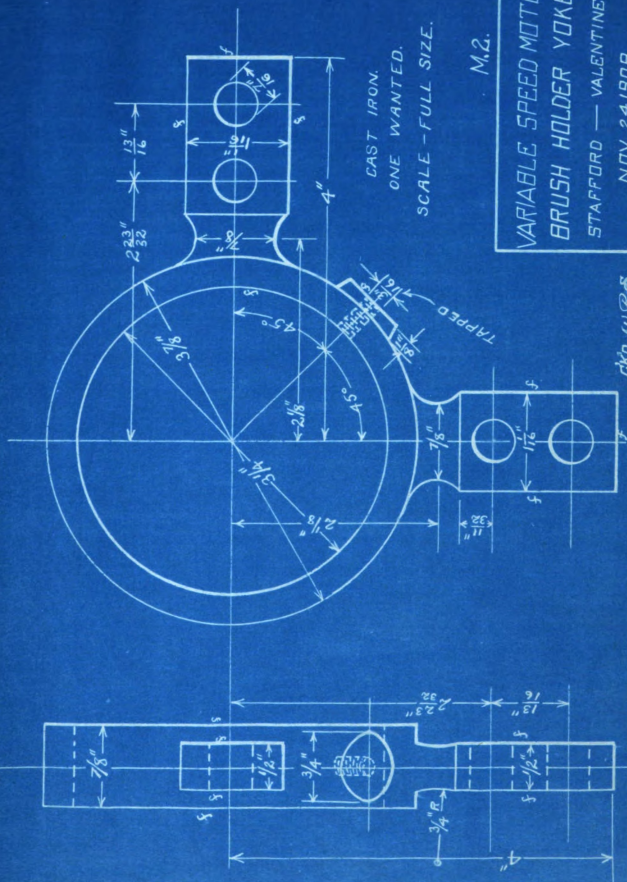
assembled pole & wanted
steel punchings 30 per inch
scale full size.

M6 VARIABLE SPEED MOTOR POLE

STAFFORD. — VALENTINE.

DEC. 24. 1905.

C.K.D.-W.C.S.



CAST IRON.
ONE WANTED.

SCALE - FULL SIZE.

M.2.

VARIABLE SPEED MOTOR.

BRUSH HOLDER YOKE.

STAFFORD — VALENTINE.

NOV. 24, 1908.

CKD, W.P.S.



BEARING END PLATE
TO ARMATURE SCALE 1'-1"
TWO WANTED D.L.

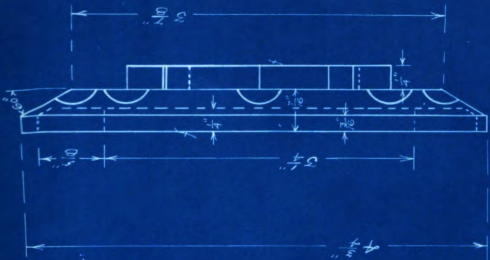
CKD-wrs

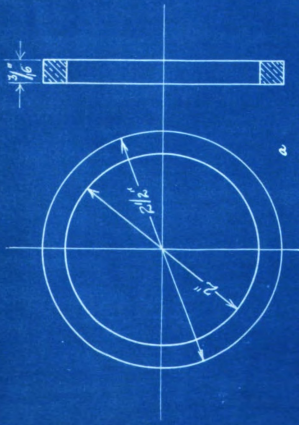
M7

VARIABLE SPEED MOTOR
ARMATURE DTL.

STAFFORD.— VALENTINE.

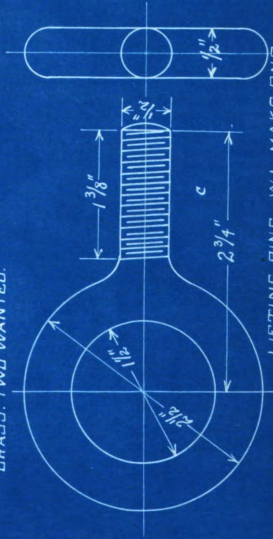
DEC-21, 1905.



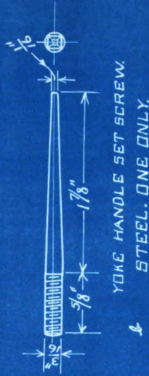


OILER RING.

BRASS. TWO WANTED.



LIFTING RING. W.I. MAKE ONE.



YOE HANDLE SET SCREW.
STEEL. ONE ONLY.

SCALE FULL SIZE.

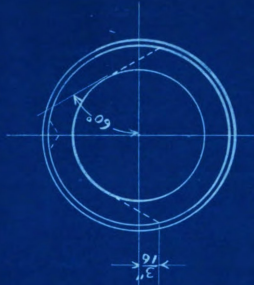
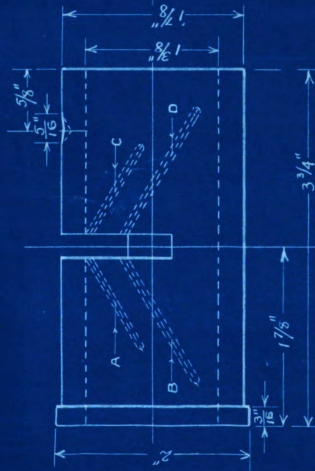
M. 4.

CK'D - W.P.S.

VARIABLE SPEED MOTOR.
DETAILS.

STAFFORD — VALENTINE.

DEC. 7 - 1908.



BRASS-TWO WANTED

SCALE FULL SIZE

FINISH ALL OVER.

-A-B-C-D- ARE OIL
GROOVES $\frac{1}{16}$ " DEEP
AND OF
TRIANGULAR SECTION

M.I.

VARIABLE SPEED MOTOR.
BEARING BRASSES.

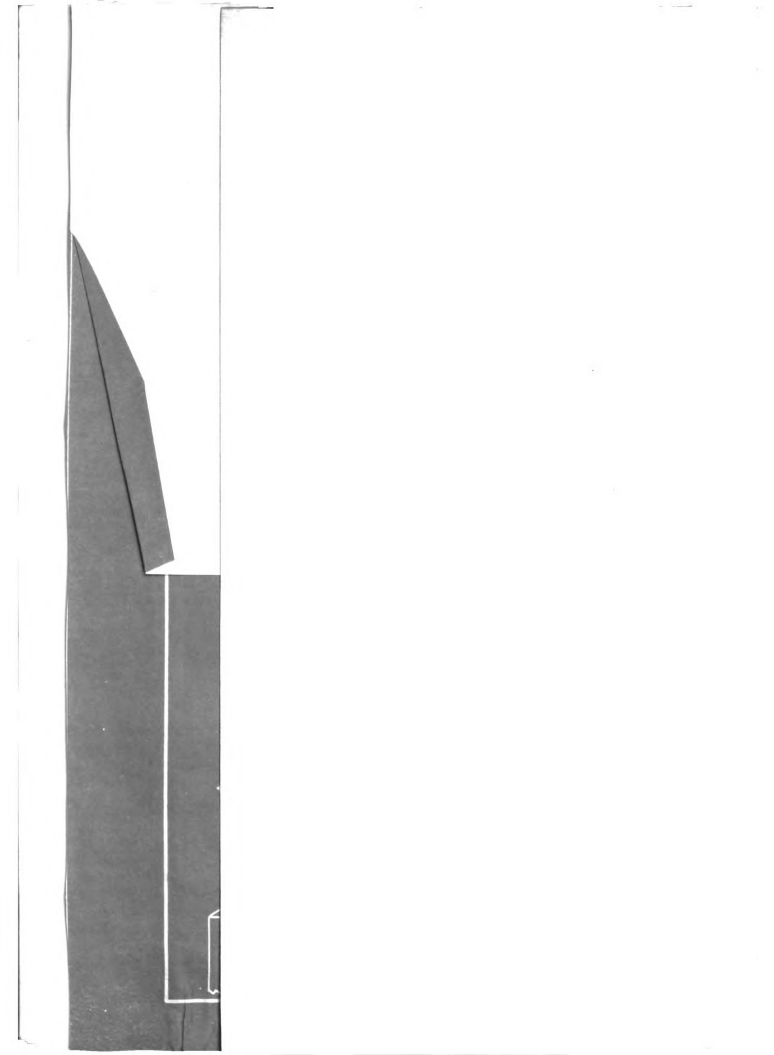
STAFFORD — VALENTINE.

NOV 21 1908

58'

SECTION a a'







BRU



BRUSH HOLD

Tap 5/16" with set screw 5/16"



TENSION A

BRASS-2



VA/

L

ST

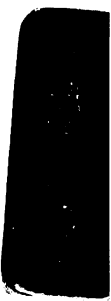
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11/23/78
11/23/78





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