T H E S I S

ON

CONSTRUCTION AND OPERATION OF A DIRECT CURRENT

COMPOUND WOUND GENERATOR

Submitted to the Faculty

of the

O R E G O N A G R I C U L T U R A L C O L L E G E

for the degree of

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in

ELECTRICAL ENGINEERING

By

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APPROVED:

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Department of Electrical Engineering.

CONSTRUCTION AND OPERATION OF A DIRECT CURRENT COMPOUND WOUND GENERATOR.

Electricity is the name given to an invisible agent known to us only by its attendant phenomena and by various manifestations called electrical. These manifestations at first obscure and even mysterious are now well understood. Indeed its great importance to mankind can only be realized when we remember that it can be transmitted a great distance and then be transformed into power for running machinery or for lighting. Its greatest use at present is that of the latter, but there is no reason to believe that it shall not be utilized for turning the wheels in our many manufacturing plants and even for the powering of our great railroads.

Since its discovery there has been a great number of machines invented and used for generating this form of energy and they are at present known as dynamos or generators and may be defined as devices to convert mechanical power into electrical energy by means of the principles of electro magnetic induction. Inall practical cases the mechanical power is supplied in the form of rotation.

These machines may be divided into two great classes namely, direct and alternating current.

In this work we will take up the construction and

operation of the direct current Generator.

CONSTRUCTION.

The castings were received directly from the foundry and were machined in the O. A. C. shops by two of the 1908 seniors. As time did not permit them to finish the dynamos, we took up the work and completed it.

Each coil consisting of four wires was wrapped three times around a special form, and two wires placed in parallel, making six inductors in each side of the coil, or twelve inductors in one coil. There were 30 coils, thus making 360 inductors. Each of these coils were wrapped with tape in order to hold them in place and also insulate them from the armature after they were inserted in the slots. Each armature section was then given the proper shape before being put in place. There being 30 slots and 30 coils it was easily seen that one side of two coils went in each slot. The other side going in the top of a corresponding slot. Each coil was next tested out by sending a current through it and were found in good condition, none of them being short circuited or grounded.

The leads were now soldered securely to the commutator. The bottom ends were connected to the commutator at about 90° ahead of when they came out of the slots. Two ends were soldered to each segment with one segment between them, thus making two complete circuits. The winding is a 2 pole, 2 circuit, doubly reenterent double

winding.

After the coils were soldered to the commutator the windings were thoroughly saturated with insulating compound and after it had thoroughly dried the armature was placed in a lathe and the commutator turned and made smooth.

The shunt field was then connected and as the voltage of the machine was changed to 55 volts the field coils were shunted in parallel across the brushes thus making the field the same strength as if the coils were in series and were placed across terminals having twice the voltage. The machine was now set up and tested out.

OPERATION.

The first test taken was known as the "No load Characteristic" of a direct current generator. The purpose of this was to determine the relation between the exciting current and the terminal voltage of the machine at no load. The generator was driven at its rated speed of 1450 R.P.M. by a belt connected motor. An ammeter was inserted in the field circuit and a voltmeter across the terminals of the machine. The main line circuit being kept open.

The readings began with the highest possible value of the field current and were gradually reduced to zero; observations taken were field amperes, volts and speed. After this others were taken with an increasing field current in order to see the influence of residual magnetism. This gives what is known as the hysteresis loop. From this

test it is seen that the voltage of a machine depends on the field current and the speed.

Data and diagram of connections given on Plate 1, Curves on Plate 2.

VOLTAGE CHARACTERISTIC.

The machine using the shunt field only was brought up to its rated speed. Readings were taken starting at zero load and increasing to full load, recording the change in voltage at each step. Data and diagram of connections on Plate 3, Curves on Plate 4.

The series field was next connected and the above test repeated. Data on Plate 5, Curves on Plate 6, Diagram of connections same as in Plate 3 with the exception that the series field is connected.

EFFICIENCY OF THE MACHINE.

The efficiency of a dynamo is simply the output divided by the input. The output plus the losses gives the input. The losses of a machine whether running as a motor or generator can be divided into three classes, (a) copper losses (I^2R) in the armature and field, (b) Iron losses hysteresis and eddy currents in armature core, (c) Mechanical losses (bearing friction, brush friction, and windage or air resistance).

The copper losses do not need to be determined experimentally as it is only necessary to measure the ohmic resistance and the corresponding current. Thus the

I^2R loss can be determined for any desired value of the current. The iron losses and mechanical losses are nearly constant for all loads and are determined experimentally at no load. It was driven at the rated speed and excitation at no load. The input into the motor is equal to the losses in the machine plus the losses in the motor itself. The motor was then driven with the belt off thus getting no load losses which losses subtracted from the preceeding give the losses of the generator. Data for this test is given on Plate 7, Curves 8.

Two heat runs were next taken. In the first a load of 50 amperes was put on the machine and let run for one hour. The field amperes dropped off slightly but remained constant after reaching 2 amperes. The voltage remained constant thus showing that the armature did not heat up.

In the second run we took a load of 80 amperes and let it run 30 minutes. The voltage began to drop off after it had run 20 minutes this showing that the armature was heating. From this we see that the all day capacity of the dynamo is some where between 50 and 80 amperes. The data for these two runs is given on Plate 9.

CONCLUSION.

From the results obtained the regulation has been found to be satisfactory both as a shunt and as a compound wound generator and its rating has been placed at 5 K. W.

Plate 1.

No load Characteristic of the Machine going down.

Field Amps.	Volts.	Speed.
2.9	61.5	1450
2.0	55.0	"
1.6	50.0	"
1.3	45.0	"
1.2	42.5	"
1.1	38.0	"
1.0	35.0	"
.7	25.0	"
Field Amps. going up.		
.7	30.0	1450
1.0	35.0	"
1.1	40.0	"
1.3	45.0	"
1.7	55.0	"
2.2	60.0	"
3.0	66.5	"

DIAGRAM OF CONNECTIONS.

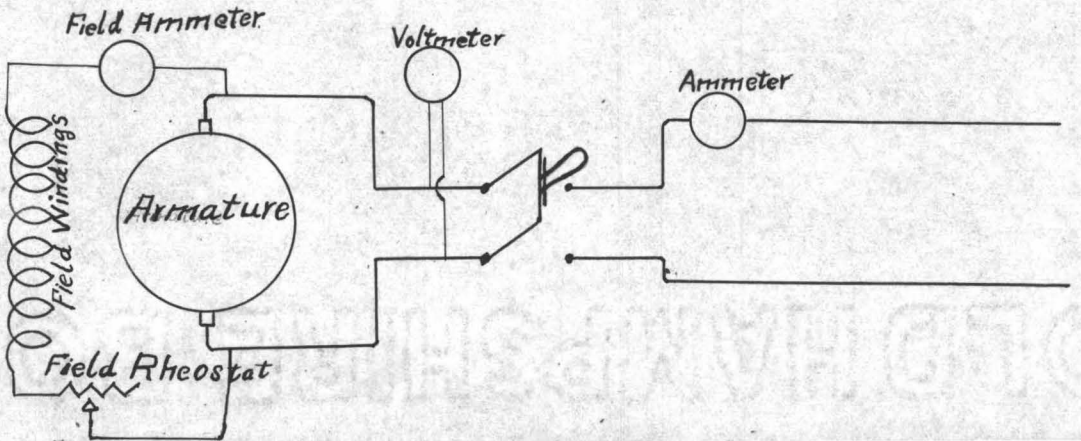

Plate 2.

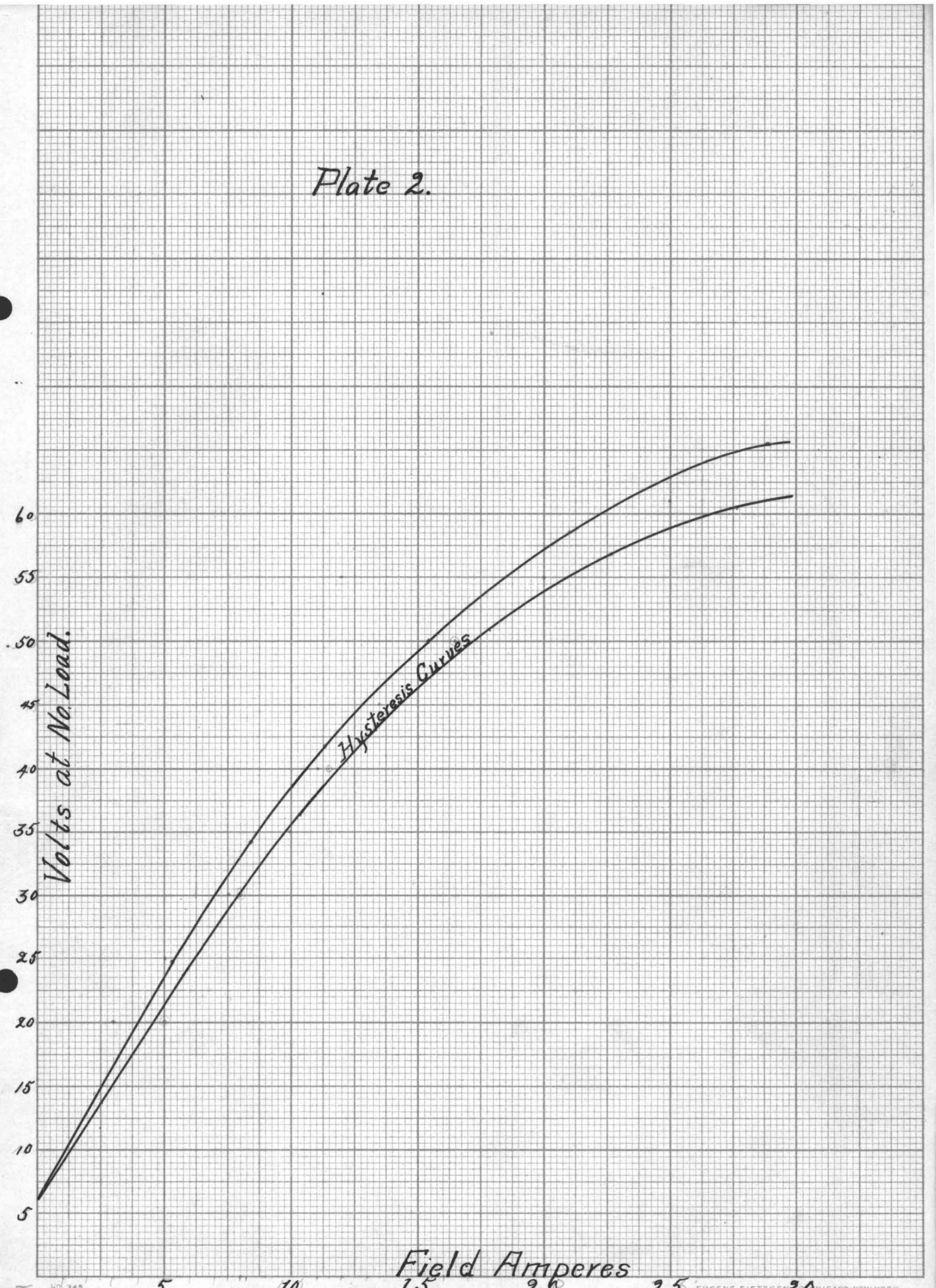
Volts at No Load.
60
55
50
45
40
35
30
25
20
15
10
5
Hysteresis Curves
.5
1.0
1.5
2.0
2.5
3.0
Field Amperes
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK.

Plate 3.

The Voltage Characteristic. No load at 55 volts.

Field Amps.	Load Amps.	Volts.	Speed.
2.0	0.0	55.0	1450
1.9	5.0	53.0	"
1.85	10.0	51.0	"
1.8	15.0	48.5	"
1.6	20.0	46.5	"
1.5	25.0	42.5	"
1.4	30.0	41.0	"

It was impossible to get normal Voltage at full load.

No external resistance in the field.

Field Amps.	Volts.	Load Amps.	Speed.	Watts.
2.6	62.0	0.0	1450	0.
2.5	61.0	5.0	"	155
2.5	59.0	10.0	"	442
2.45	57.5	15.0	"	718
2.4	56.5	20.0	"	995
2.35	55.0	25.0	"	.1247
2.3	53.0	30.0	"	1468
2.25	52.0	35.0	"	1700
2.2	50.0	40.0	"	1880
2.15	46.0	45.0	"	1970
1.9	42.5	50.0	"	2210

DIAGRAM OF CONNECTIONS.

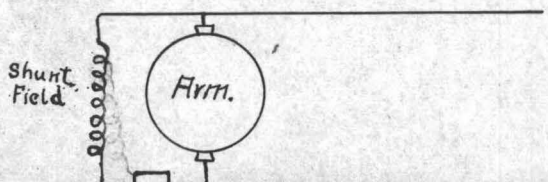

Plate 4.

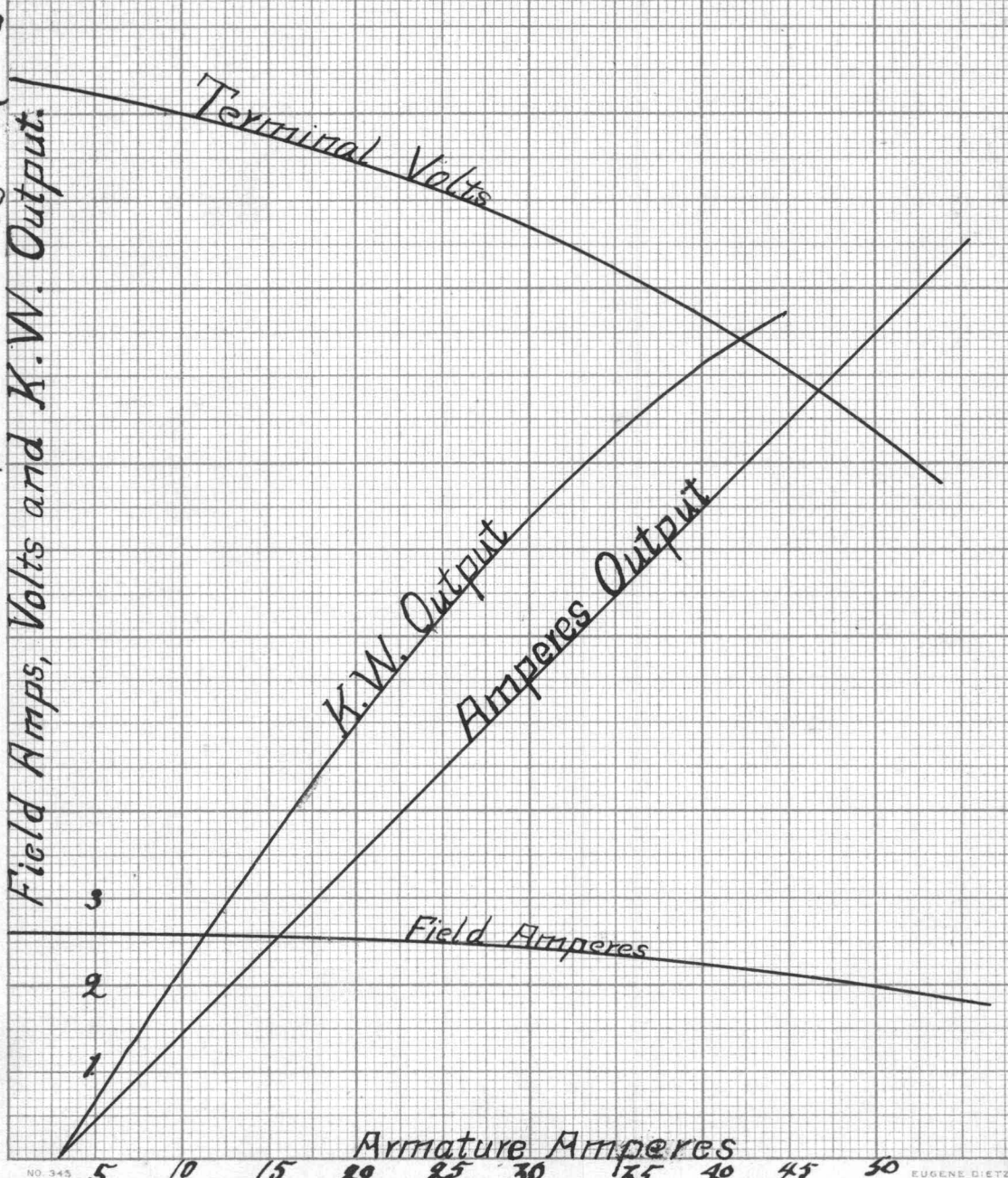

Plate 5.

Voltage Characteristics of the machine under compounded.

Field Amps.	Load Amps.	Volts.	Speed.
2.0	0.0	55.0	1450
1.98	5.0	64.0	"
1.97	10.0	53.0	"
1.97	15.0	53.0	"
1.97	20.0	53.0	"
1.95	25.0	53.0	"
1.94	30.0	52.0	"
1.92	35.0	52.0	"
1.92	40.0	51.5	"
1.9	45.0	51.0	"
1.9	50.0	51.0	"
1.9	55.0	50.0	"
1.89	60.0	50.5	"
1.89	65.0	50.5	"
1.88	70.0	50.0	"
1.88	80.0	49.0	"

Compounded with no external resistance.

				Watts.
2.5	0.0	61.0	"	0
2.45	10.0	59.5	"	450
2.4	20.0	58.5	"	740
2.35	30.0	57.5	"	1030
2.34	40.0	57.0	"	1590
2.33	50.0	56.5	"	2130
2.32	60.0	56.0	"	2700

Field Amps.	Load Amps.	Volts.	Speed.	Watts.
2.3	70.0	55.0	1450	3230
2.3	75.0	55.0	"	3710
2.29	80.0	54.5	"	3960
2.28	85.0	54.5	"	4240
2.27	90.0	54.0	"	4740

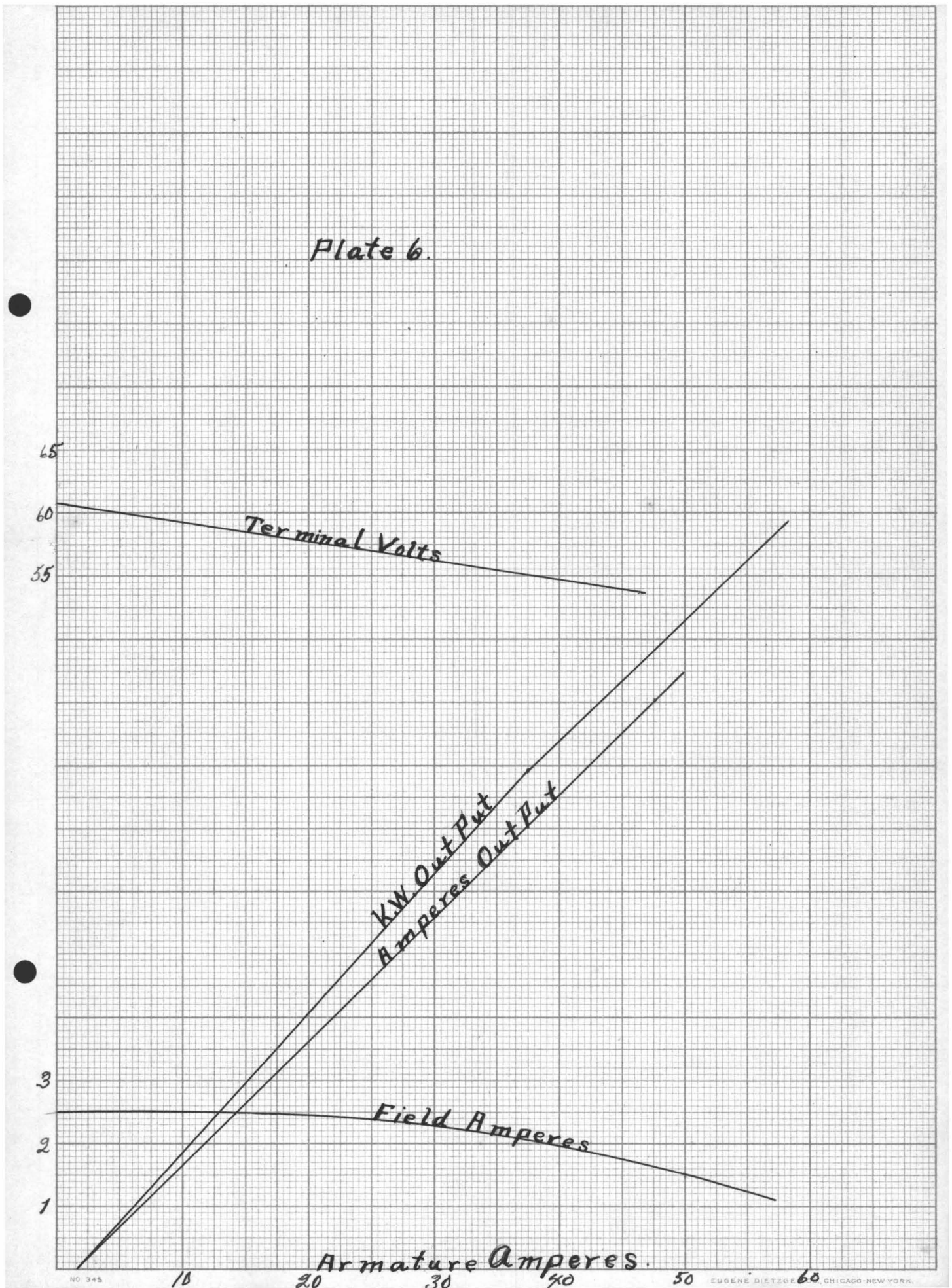
Plate 6.
65
60
55
Terminal Volts
KW. Out Put
Amperes Out Put
3
2
1
Field Amperes
Armature Amperes.
10
20
30
40
50
60
NO. 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK.

Plate 7.

EFFICIENCY.

Generator			Motor (driving)
Field Amps.	Volts.	Arm. Amps.	Volts.
2.5	58.0	13.0	152
2.0	55.0	12.0	152
	No field on Generator.		
0.0	0.0	11.0	152
	Brushes lifted on Gen.		
		9.0	158
	Driving motor running light.		
		6.0	158

LOSSES.

Generator + motor = 13 x 152 = 1976 watts.

Motor losses = 6 x 158 = 948 "

Generator losses =1976 - 948 = 1028 "

1028 x .02 (belt friction) = 20.56 belt friction.

Core losses = 1028 - 20.56 = 1007.64 watts.

K.W. output	I^2R armature Watts.	I^2R in field Watts.	total loss	Eff.
0	0	180	1187.5	0%
.450	10.5	172.5	1190.56	27.4%
1.030	42.0	165.8	1215.36	45.7%
1.59	94.5	158.0	1260.05	56.0%
2.13	168.0	157.6	1333.16	61.5%
2.71	262.5	155.8	1425.86	65.5%

K.W. output	I^2R armature Watts.	I^2R in field Watts.	total loss	Eff.
3.23	378.0	155.0	1540.0	68.0%
3.71	514.5	152.5	1674.8	69.0%
4.24	672.0	150.0	1829.6	70.0%
4.74	850.5	148.0	2006.1	70.5%

$$\text{Eff.} = \frac{\text{K. W. output}}{\text{K.W. output + losses}} .$$

Resistance found by drop off Potential method.

Armature R = .105 ohms. Field R = 28.75 ohms.

Plate 8.

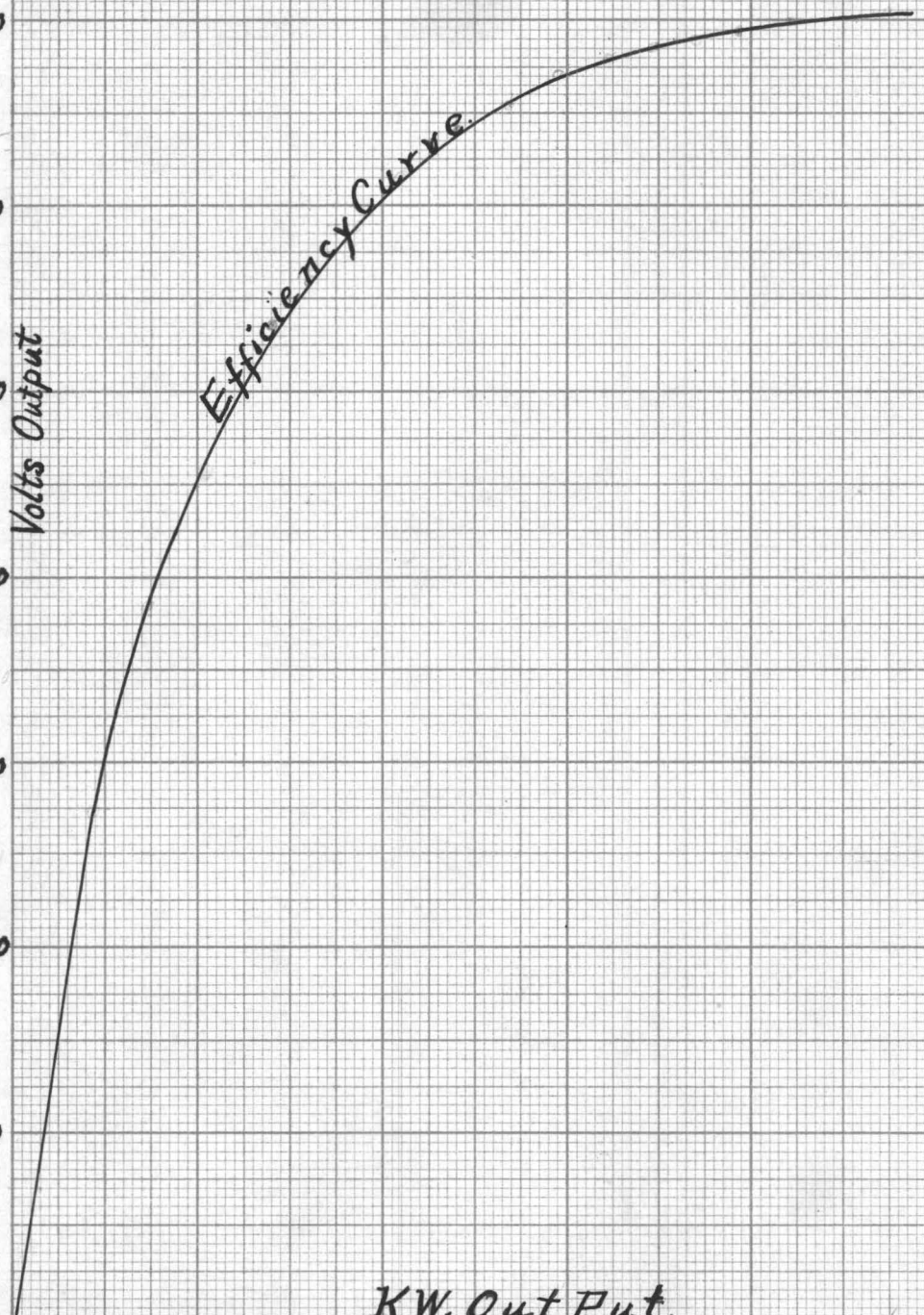

Plate 9.

May 25, 1909.

Heat Run.

Field Amps.	Load Amps.	Volts.	Speed.	Time.
2.2	50	56	1450	9:30
2.2	"	"	"	9:40
2.15	"	"	"	9:50
2.0	"	"	"	10:00
2.0	"	"	"	10:10
2.0	"	"	"	10:20
2.0	"	"	"	10:30

The armature was not hot at that time.

1.85	80	54.5	1450	10:50
1.85	"	"	"	11:00
1.85	"	"	"	11:10
1.85	"	"	"	11:20
1.65	"	50.5	"	11:30

The commutator began to spark and the armature was too hot.