1903

A polyphase generator of the Missouri School of Mines

Cornelius Mark Daily

THESIS

--FOR THE--

Degree of Bachelor of Science

-IN-

CIVIL ENGINEERING.

SUBJECT:

"A Polyphase Generator of the Missouri School of Mines."

C. M. DAILY,
For C. E.

MAY, 1903.

INTRODUCTION. -

In the earliest ages of the world power was obtained from the muscular energies of man, but the weariness of this caused investigation for a more powerful and less wearisome method. Beasts, running water and the wind were next harnessed and machines were made capable of transforming their energies into movement susceptible to the requirements of the arts and manufactures of the day, but the progress of human industry, besides necessitating motors capable of being put where the want is felt, they should be subsequent to the human will.

The problems of the past ages formed an incentive to invention which lead to the search for perpetual motion, for which illusionists still strive.

The expansion of steam by rise of temperature was next discovered by Dennis Papin, and he constructed motors founded on this principle.

The next important agent used as a motive power was electricity.

The first knowledge of this agent was about 600 B.C., pieces of amber which were rubbed together was found to attract light objects. This phenomenon was thought to be a property of amber from which the name "Electricity" was derived.

Symmer advanced a theory that electricity is composed of two fluids, "Positive and Negative". A modification of this was made by Benjamin Franklin who advanced the "One Fluid" theory, but both of these theories have gradually been rejected, and now electricity is known to be stresses in the universal ether.

The knowledge of electricity as applied to industrial use is of recent date. The first electric light was produced by Davy in 1810 by connecting two pieces of charcoal between a battery of 2000 cells.

In 1832 Mr. Schultlers promulgated the idea of an electric motor at a meeting of the Society of Engineers of Zurich in which he asked, "If a force such as we obtain by interrupting an electric current and re-establish it, could not be used advantageously in mechanics". From this time on there have been numerous inventions of electric motors, many of them merely demonstrating the possibility of a motor.

In 1831 Michael Faraday discovered the principle which is the basis of production of electric energy at the present time; i. e., a closed conductor moving relative to a magnet.

The present problem is the utilization of natural forces; namely, water-falls, tides and the wind.

The most important of the three at the present time are the water-falls. In few places the power derived from the falling water can be utilized close to the falls, while in many cases the power must be transmitted long distances. To accomplish this economically the energies are usually transformed into the energy of the electric current. Here the "Poly-phase Generator" plays an important part, for the power lost in the line is proportional to the square of the current and from Ohms Law we see that by doubling the voltage the same power can be delivered with one fourth the loss, and the ease in which the voltage can be changed makes this class of machines almost universally used for this purpose.

I have taken for the subject of my investigation a four pole, three phase generator marked 220 volts, 5 amp. per terminal, 1.87 K.W. capacity.

In these experiments I have endeavored to find the characteristic features with as much precision as possible with the instruments at my command. The motive power used was a 2 K.W. continuous current motor deriving its power from a small dynamo which was driven by a 5 H. P. vertical engine.

In finding the efficiency of the dynamo, the motor was run empty with the speed required to drive the dynamo and the power measured by means of an ammeter and voltmeter, this being deducted from the power required to run the motor driving the dynamo at its various loads.

In finding the curve of instantaneous voltage four instruments were available. Thompson Electrostatic voltmeter, cardew voltmeter, Simens electrodynamometer and Weston's direct current voltmeter. In the two former no reading could be obtained as the contact was only for so short a period; in Simens dynamometer such a large current was required that caused excessive sparking of the brushes of the contact maker and the pointer would be in constant vibration. In the Weston voltmeter the pointer would vibrate rapidly over about one division of the scale and the maximum voltage obtained only equaled about one fiftieth of the actual maximum voltage, but this ratio remained practically constant, giving precise relative values.

Armature Windings. -

There are two general methods of winding the armature known as △ and Y connections.

If the windings were of △ connections, the resistence between two collecting rings would equal to $\frac{2}{3}r$ [illegible] connecting two of the collecting rings with a very low resistence; the resistence between them and the third ring would equal to $\frac{r}{2}$.

If of a Y connection the resistence between two collecting rings would equal to $r + r$ and connecting two of the rings with low resistence, the resistence between them and the third ring would equal to $\frac{r}{2}+r$

Where r = resistance of one coil.-

The resistance between any two of the collecting rings were found to be 2.5 ohms, and with any two of the rings connected with a low resistance the resistance was found to be equal to 1.88 ohms.

Supposing the windings to be of the Y connection, then $r = \frac{2.5}{2} = 1.25$ and $1.88 = 1.25 + \frac{1.25}{2} = 1.875$ which are quite within the limits of experimental error.

If the windings were of the Δ connection, then $2.5 = \frac{2}{3} r$ and from our 2nd equation $1.88 = \frac{r}{2}$ which proves the windings were not Δ connection.

Resistance of the field coils at temperature 19° C. 50.7 ohms.

Fig. 1 represents a Y connection of the armature.

Fig. 2, b, a, c, are electromotive forces of the coils and b - a, a - c and c - b, represent the relative magnitude and direction of the emfs.

The power of the dynamo is the product of the emf. and the vector sum of the current into the cosine of the angle of lag.

The vector sum of the current $= 5\sqrt{3}$

$\therefore P = 220 \times 5\sqrt{3} \cos\theta$

But [illegible] = 1.87 K.W.

$\therefore \cos\theta = \frac{5 \times 220 \times \sqrt{3}}{1870} = .989$

Fig. 1.

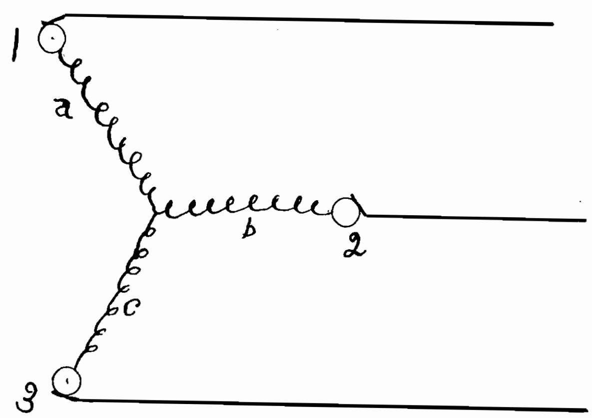


Fig. 2.

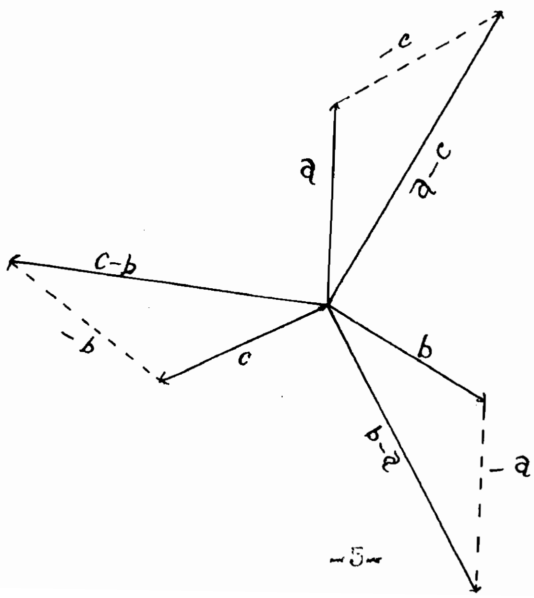
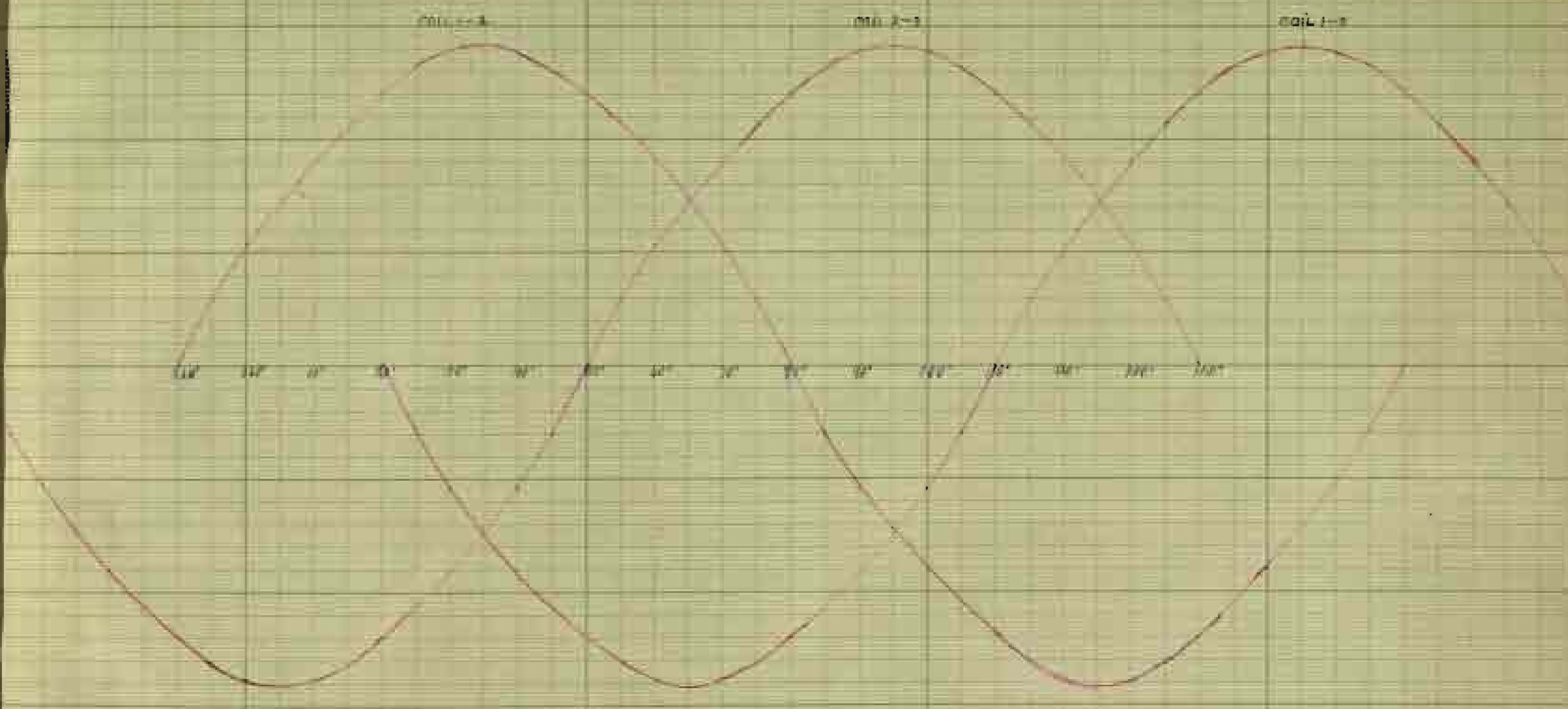
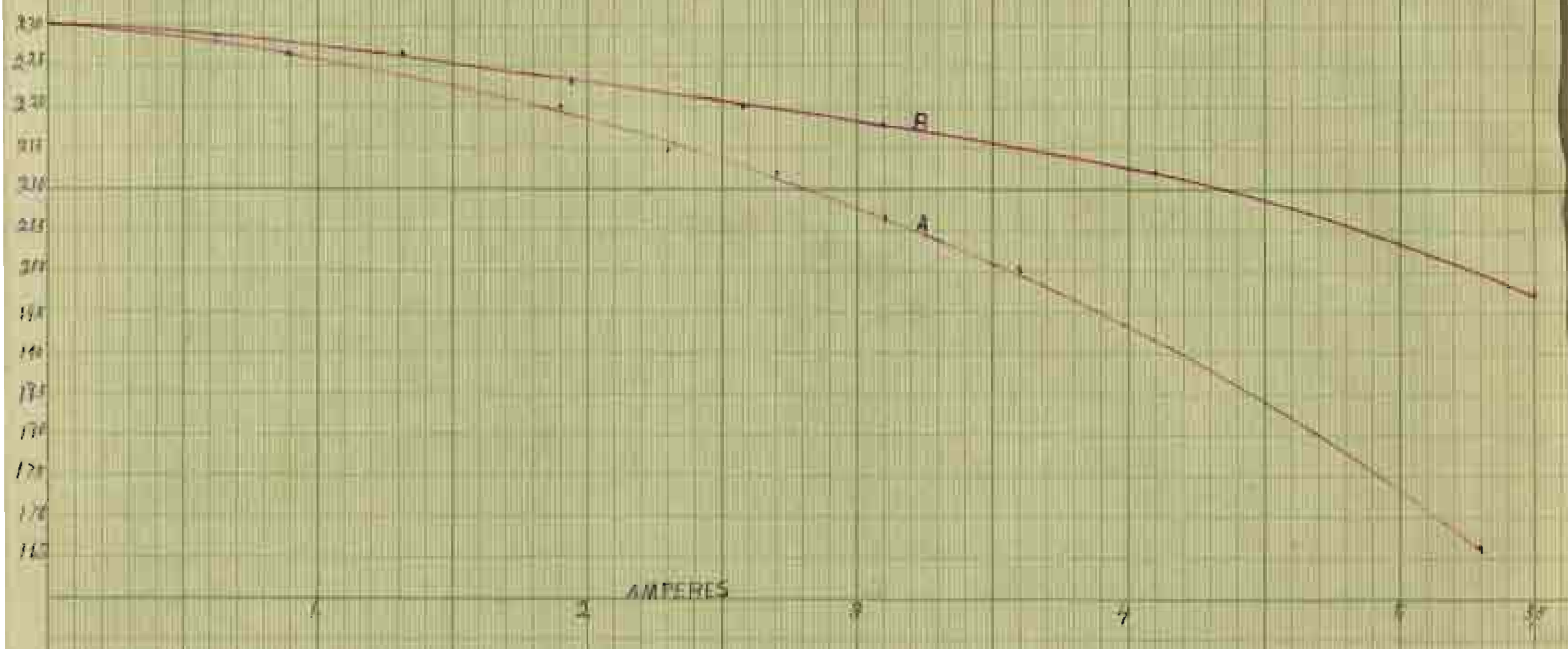


TABLE OF INSTANTANEOUS VOLTAGE.-

Between coil 1 - 2.		Between coil 2 - 3.		Between coil 1 - 3.	
Angle in degrees.	Relative voltage	Angle in degrees	Relative voltage	Angle in degrees	Relative voltage.
350	0				
355	5	50	0	20	0
0	9	55	5	25	- 5
5	12	60	9	30	- 9
10	15	65	12	35	-12
15	18	70	15	40	-15
20	20	75	18	45	-18
25	22	80	20	50	-20
30	23	85	22	55	-22
35	23. 5	90	23	60	-23
40	23	95	23. 5	65	-23. 5
45	22	100	23	70	-23
50	20	105	22	75	-22
55	18	110	20	80	-20
60	15	115	18	85	-18
65	12	120	15	90	-15
70	9	125	12	95	-12
75	5	130	9	100	-9
80	0	135	5	105	-5
		140	0	110	- 0



CURVES OF INSTANTANEOUS VOLTAGE



CHARACTERISTIC CURVES

Drop in volts in armature.

A. - for an inductive load.

B - for a noninductive load.

A.		B.	
Volts between collecting rings	Amp.	Volts between collecting rings	Amp.
230	0	230	0
226	.9	228	.35
220	1.9	226	1.32
214	2.3	223	1.95
212	2.7	220	2.58
206	3.1	218	3.1
200	3.6	212	4.1
194	4.1	197	5.5
167	5.3		

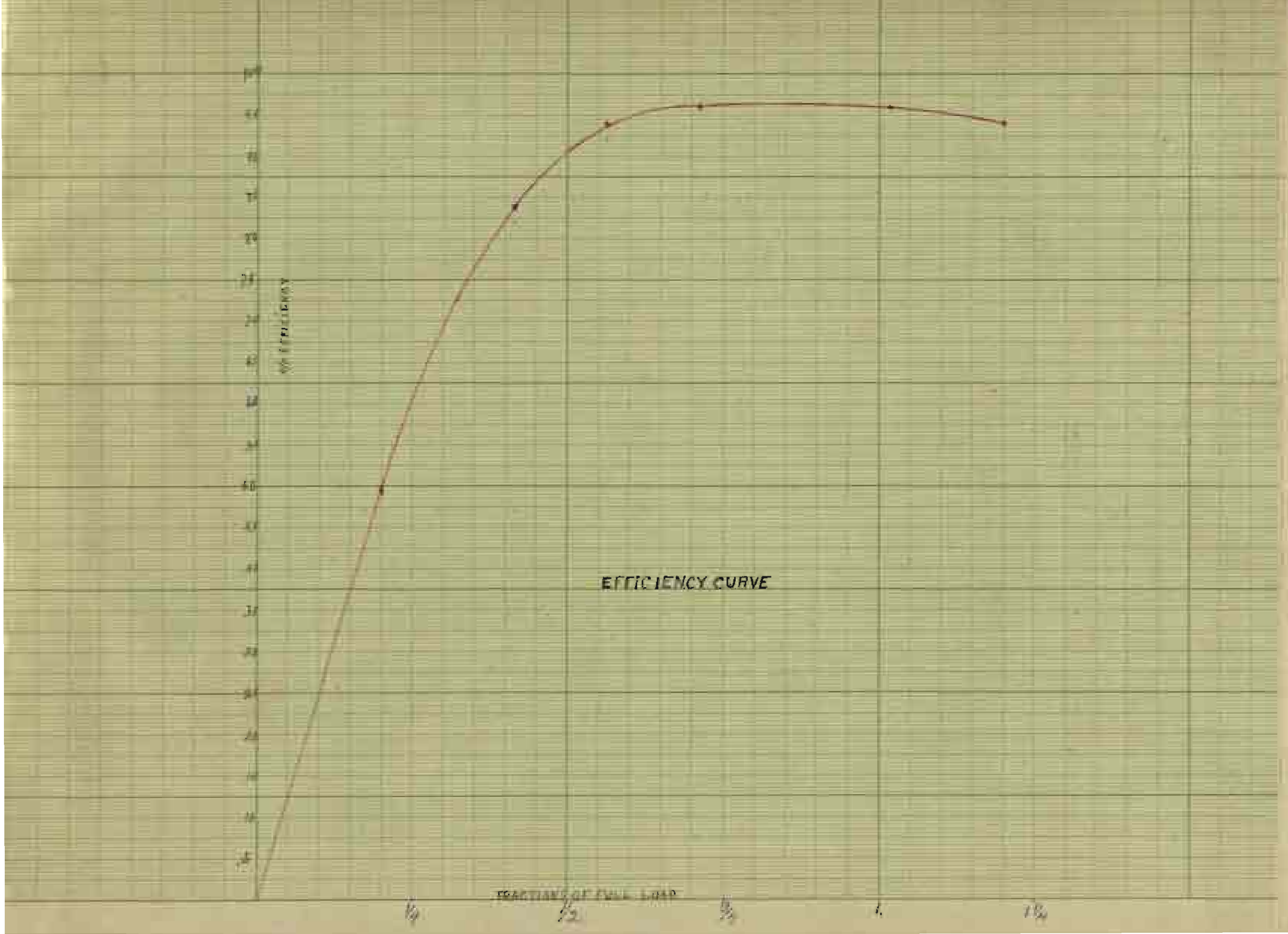
EFFICIENCY OF DYNAMO WITH NON-INDUCTIVE LOAD. -

Speed of dynamo 1350 rev. per minute.

Current in field of dynamo 1.5 amp.

Power required to run motor empty with speed sufficient to drive dynamo 1350 rev. per minute, 350 watts.

Work done on system.	Work done on dynamo	Work done by dynamo	Efficiency of Dynamo.
1075 Watts	725 watts	360 watts	49 %
1277 "	927 "	780 "	84 "
1488 "	1138 "	1080 "	94 "
1762 "	1412 "	1356 "	96 "
2329 "	1979 "	1900 "	96 "
2738 "	2388 "	2240 "	94 "



EFFICIENCY CURVE
% EFFICIENCY
FRACTIONS OF FULL LOAD

HEATING TEST.-

The dynamo was run for two hours with .6 full load.

The temperature of field was noted every 15 min. and tem. of armature at the end of the experiment.

Time	Tem. of Room	Tem. of Field	Tem. of Armature
1-15	26°	26°	26°
1-30	26°	28.5°	
1-45	26°	30°	
2	26°	31°	
2-15	26°	32°	
2-30	26°	33°	
2-45	26°	33°	
3	26°	33°	
3-15	26°	33°	35°

-CONCLUSION.-

I have found in the course of my investigation, the difficulty of maintaining a constant speed of the motor at no load, which was probably due to change of frictional resistance of the brushes; and in my attempt to determine the relation between power and velocity such variable results were obtained that I have omitted them.

To find out what cannot be done is of no little importance. With this thought in my mind, I feel that the results of my efforts are worth the time and labor spent.

Respectfully,

C. M. Daily

May, 28, 1903.