Efficiency Tests

on

Stowe Motor

by

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EFFICIENCY TEST ON STOWE MOROR.

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Apparatus:

a. For efficiency test:

Slow Motor #1322

220 Volts 8 HP

R P M 600 - 1900

(Weston Volt	(0 - 600)	#17074	)
(Whitney Volt	(0 - 300)	# 8372	)
(American Ammeter	(0 - 5)	# 7204	)
(Weston Ammeter	(0 - 50)	#20505	)

Prony Brack Scales
Speed Counter
Stop Watch.

b. For Magnetization Curve:

(Weston Volt	(0 - 600)	#17704	)
(Amer. Ammeter	(0 - 5)	#17204	)

Rheostats.

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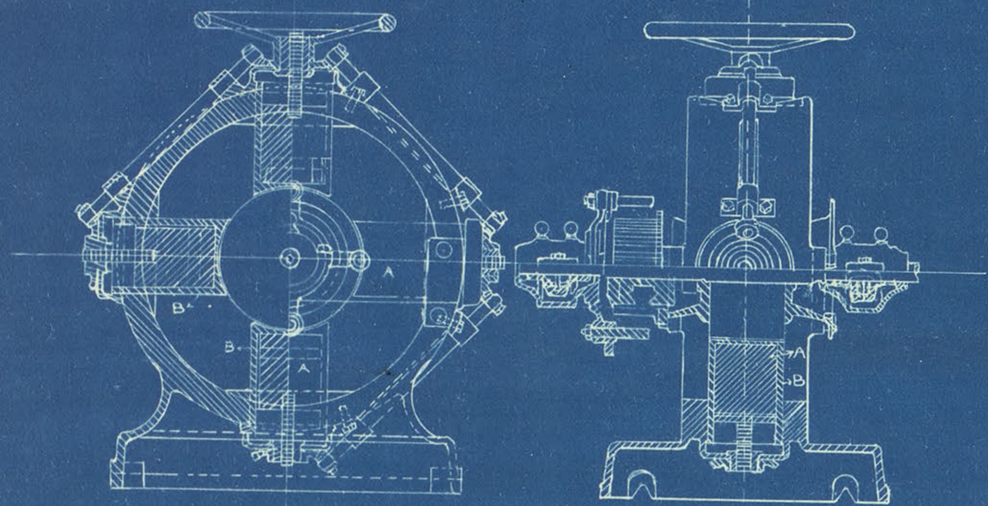
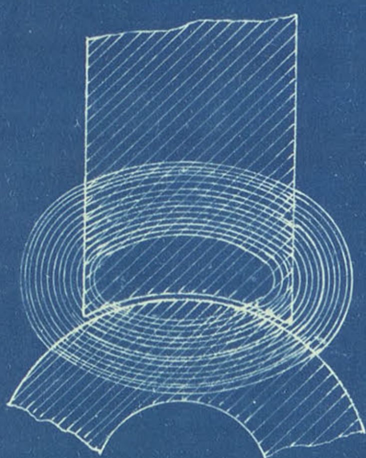
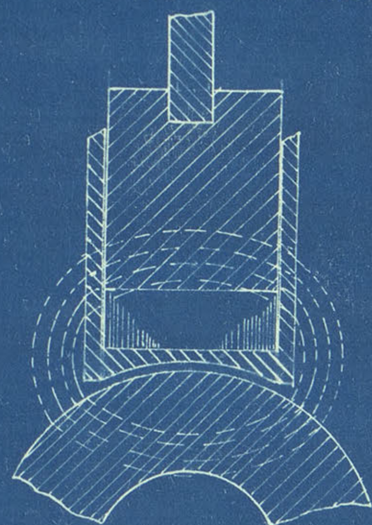
DETAILS OF THE STOW VARIABLE SPEED MOTOR



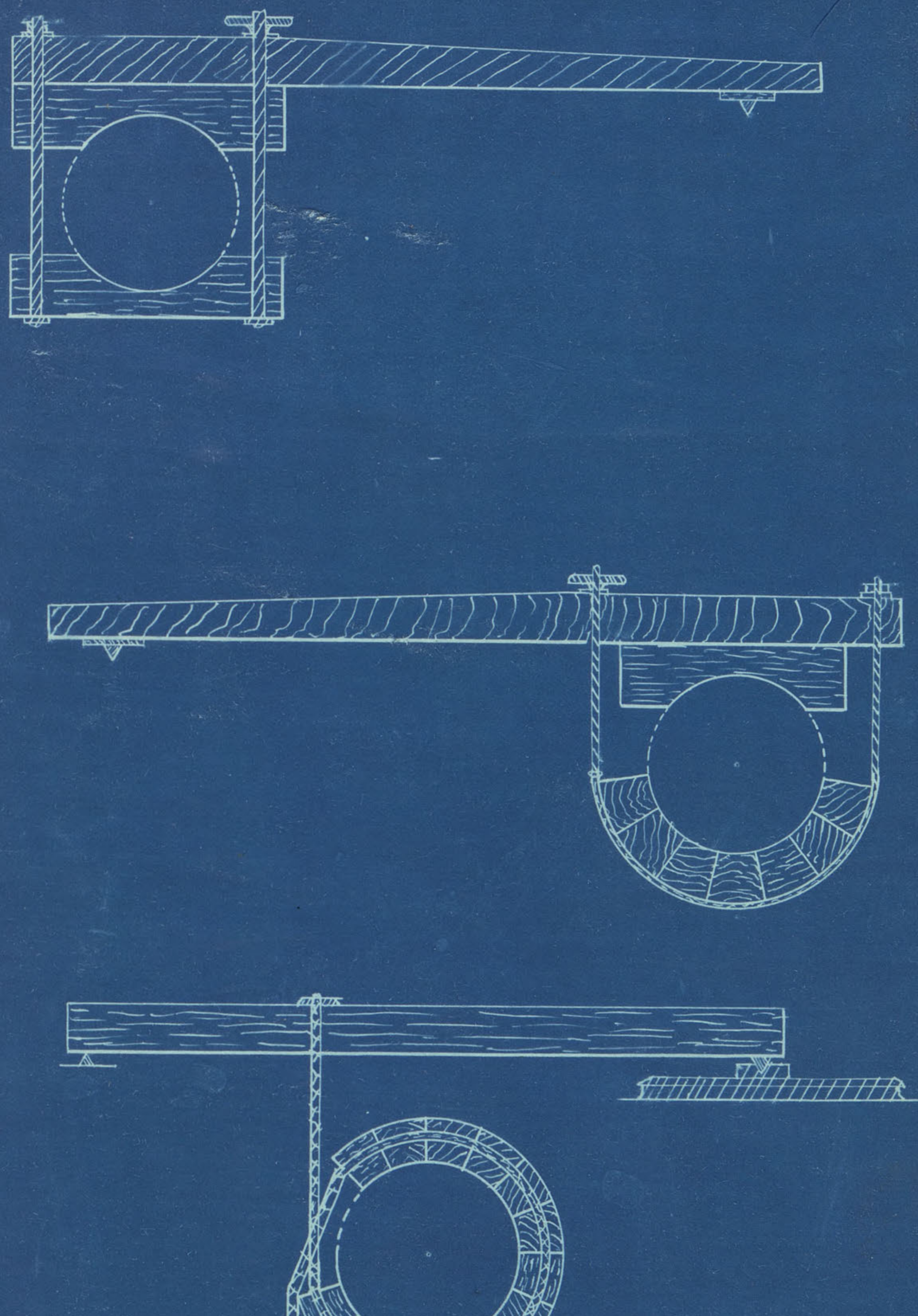
SOLID POLE PIECE



STOW MOTOR POLE PIECE



PRONY BRAKES



LAWSON

In the whole field of machinery operation no subject is receiving so much attention today as that of driving by electric motors. It shall be our aim to treat, briefly, several classes of motors; but to show that the Stowe motor is the best type of Shunt Motors. We will start by giving the principle, operation, and use of Shunt Motors in general.

Shunt Motors are composed of Field Poles, Armatures, the necessary frame work, commutator, and brushes. The field being wound with a large number of turns of small wire, while the Armature is wound with either Drum or Gramme Ring. The effect of current in the field and Armature causes a skewing of the lines of flux, causing what is known as "cross turns" and "back turns" in the Armature. The cross turns on the Armature tend to change distribution of lines of force on the pole faces, skewing them over from trailing tip to entering tip in the case of a motor. To avoid piling up of these lines of force it is necessary to increase the magnetic resistance of the air gap or equivalent at the sides of the pole pieces, or by increasing the air space under the corners.

Starting Shunt Motors.

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In starting shunt motors, no trouble is likely to occur in connecting the field coils to the circuit. The difficulty will be with the Armature, due to the fact that its resistance is low in order to obtain high efficiency and constant speed. The rush of current on starting would be about twenty-five times that of normal current which would be injurious to the Armature. To avoid this, a motor is started with a rheostat or starting box in the Armature circuit, then as the armature comes up to speed the resistance is cut out. The motor now is generating what is known as a C.E.M.F. which prevents an excessive current through it.

Speed Regulation.

The regulation of a shunt motor may be varied by:

1. Armature Resistance
2. Field Resistance
3. Multiple Voltage System.

Armature Resistance:

In this the speed is varied by placing a resistance in the Armature circuit; most generally a rheostat is connected in series with the Armature. Any desirable speed and torque may be obtained by this method. There are three disadvantages to its use: 1. Power is lost in proportion to speed reduction. 2. A bulky rheostat is necessary

to dissipate the heat caused by the large C^2R losses.
3. The speed varies greatly with the change of torque.

Any device that will cause a reduction of flux or total lines or force passing thru the armature of a shunt motor tends to increase the speed. This may be accomplished by placing a rheostat in the shunt field. This will do away with the complications arising from use of resistance in armature.

Multiple Voltage System:

If the field of a shunt motor be kept constant and the voltage that is applied to the armature be altered, the speed will vary in accordance with the varying voltage.

All of these methods have the same general effect; that of changing the flux that passes thru the armature. In reviewing these different methods we find varying the resistance of the field the most practicable one in as much as it is not so cumbersome and far more economical. It has one disadvantage in that if the field is made too weak, it will cause sparking at the brushes.

STOWE MOTOR.

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The operation of the Stowe motor is not unlike that of any shunt motor. The action of the flux of the field and armature is the same, the difference being in the variation of speed which can be obtained by the increase or decrease of reluctance in the magnetic circuit.

The pole pieces are made hollow and provided with a large culindrical iron corn. This core or plunger is adjusted by means of a hand wheel on the top of the machine frame; this in turn is connected by gearing to the cylindrical corn. By turning this hand wheel all the plungers will be drawn in or out at the same time. The pole shells are stationary.

In the ordinary motor we are limited to a certain range of speed, due to the fact that if the field becomes too weak, it will cause sparking. In the Stowe motor the operation is such that as the plunger is being withdrawn, the air column within the pole pieces, offers a gradually increasing varrier to the cross magnetizing effect of the armature until when the field strength is reduced to a minimum from lack of conducting path through which to act. Again the construction of the pole pieces and plungers is such that, as the volume of magnetism is reduced by outward movement of the plunger, the remaining magnetic flux is forced more and more in the direction of the pole tips, thus furnishing a magnetic field at all times of sufficient intensity to insure sparkless operation at the commutator. In these motors no resistance whatever is used in obtaining speed control; this will make the efficiency constant or nearly so thru the entire range of speed. The HP capacity is the same for all speeds which is not true with the ordinary shunt motor, due to the increased resistance at low speed.

Use of Stow Motor.

The best use of a Stow motor is where a variable speed is desired. For example;

Advantages of Slow Motor.

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1. Only one Voltage is required to operate it.
2. Total absence of auxiliary wring and apparatus.
3. Full rated HP capacity at all speeds.
4. Speed practically constant at all loads.
5. Efficiency practically independent of speed variation.
6. No controlling resistance.
7. Speed adjustable to a revolution.

The Stow motor has some points in mechanical design that could be improved upon. One is in the construction of the gearing. Considerable trouble was experienced in keeping the gears in place when the plungers were in; the gearing would frequently drop off or stop.

Another disadvantage was with pins that are placed thru the shell of the pole pieces to hold them in place. They were so arranged that they extended in against the plunger, often obstructing its free movement. This could be done by making the pins shorter.

EFFICIENCY TESTS TAKEN BY MEANS OF THE PRONY BRAKE.

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Different types of brakes were used. The one which gave the best results and was the most satisfactory was used.

Brake No. 1 consisted of maple blocks held together by ropes passing through holes bored in the blocks. The upper ends of the ropes were fastened to a beam which rested upon a knife-edge placed upon the platform scales, the pull due to the brake being measured in pounds. The load was varied by means of weights which were hung from the lower end of the rope. This brake was unused because the weight pulling down had to be too great to give a sufficient load.

Brake No. 2 consisted of two solid blocks of maple which were bolted to an arm which rested upon the scales. Friction was applied to the pulley by means of a hand screw. This brake was not used on account of the unequal friction between the friction blocks and the pulley, making the readings unsteady.

Brake No. 3 consisted of an arm similar to the one used on brake No. 2 and was essentially the same, except that the lower friction surface consisted of beveled maple blocks held together by a flexible band. The friction was varied by means of a hand screw on top of the arm. This is the brake which was used and it gave good results and steady loads. The pulley was kept cool by means of cold water applied to the inside of the pulley.

The efficiency was determined by measuring the input and output and dividing the latter by the former. The electric input was measured by means of ammeters and voltmeters placed in the field and amature windings. The electric output was measured by determing the HP output and multiplying this by 746 or the watts per horse power. The HP output was determined substitution in the formula;

$$HP == \frac{2 \quad x\, r\, x\, n\, x\, w}{33000} ;$$

in which r = radius of Am.

n = revolutions per minute

w = weight on scales.

Discussion of Curves.

Since N (rpm) appears in the numerator it will be seen that other things being equal, the output will vary directly as the speed, and hence the efficiency would be very much higher. This would be the case if it were not for the fact that as the speed increases the losses and other factorswhich cut down the efficiency enter in. In the first place the losses due to friction, windage, eddy, and hysteritic lossed increase as the speed is increased.

These factors are of small importance, however, when compared to the decrease in output, due to counter electromotot force, which is the electro-motor force opposes the induced pressure and hence, cuts down the current flowing in the armature conductors. The torque of any motor varies as the current in the armature and hence any factor which tends to decrease this current cuts down the output. The Counter electro-motor force is caused by the rotation of the armature which acts exectly as though the motor were a generator.

The counter electro-motor force is given by the formula:

$$\frac{\text{rev x no of corn x flux}}{10^8}$$

From this it is seen that the counter electro-motor force varies directly as the speed.

Let E = Impressed counter electro-motot force

e = counter electro-motot force

r = resistance of armature conductors

then current through the armature would be

$$C = \frac{E - e}{R}$$

"The power equals the current x the counter electro motot force and the power will increase as the counter electro motor force decreases, as long as the difference between the two electro-motor force's increases faster than the counter electro-motor-force.

This fact may be experimentally verified if a curve be plotted with armature current as abscesses and output as ordinate . At the beginning the output is zero but increases to a maximum when $1 = \frac{1}{2} \frac{E}{B}$

and $e = \frac{1}{2} E$

e= counter electro-motor force

2 = impressed electro-motor force.

With a further increase in current the output decreases till when $1 = \frac{E}{R}$, the counter electro-motor force is zero, the motor is still and the output is zero.

One important reason why the efficiency is greater at high speed is that the stowe motor was constructed with larger armature conductors so that the C^2 R loss would not be excessive at low speeds when the counter electromotor force was comparatively low. Hence when the speed is high there will be a much lower loss in the armature and the current can be greater, since

$$C = \frac{E}{R}$$

The theoretical conclusionss were found found to hold true on thetest for it was found that at a speed of 560 (slow) the efficiency was 82% and at a speed of 1100 (Medium) the effeciency was 85%, while at the highest speed, 2100, the highest efficiency was obtained, 92%.

This shows that as far as commercial effeciency is concerned it would be better to run the motot at the extreme speed, but unless conditions demand it, it should not be run at this high speed on account of the wear on the different parts.

Magnetization Curves.

In obtaining the magnetization curves the motor was run as a dynamo and a voltmeter placed across the brushes. The fields were separately excited and the current through the field was increased successively by small amounts. The air gap between the cast-iron core and the armature was increased by means of the hand wheel until they corresponded to the position they refused to occupy if the machine was running as a motor.

For the first part of the curves the voltageswere practically the same, showing that at low densities there was not much leakage due to the increased air gap, but at the highest point on the curves the voltage was much lower, showing that the magnet leakage had increased to a great extent. It was not possible to get a voltage high enough to reach the saturation point so these points can not be compared.

Speed 560

Scale constant 13# - 8 oz.

Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque		Input	Output	Eff.
				lb.	oz.			
222	7.5	292	1,95	no load				
222	5.5	212	1.95	14	8	1634.4	238.6	14.6
220	11.	212	1.90	20		2822.8	1622.48	57.4
220	14.5	212	1.9	23	8	3592.8	2386.	66.4
218	21.5	210	1.85	29	4	3601.	5077.	70.9
220	17.5	208	1.85	26	2	3013.	2034.	67.5
218	25.	207	1.85	23	8	5833.	4772.	81.8
222	30.	212	1.9	37	8	7062.	5726.4	81.05
228	34.	215	1.8	41		7959.	6561.50	82.2

Speed 1100

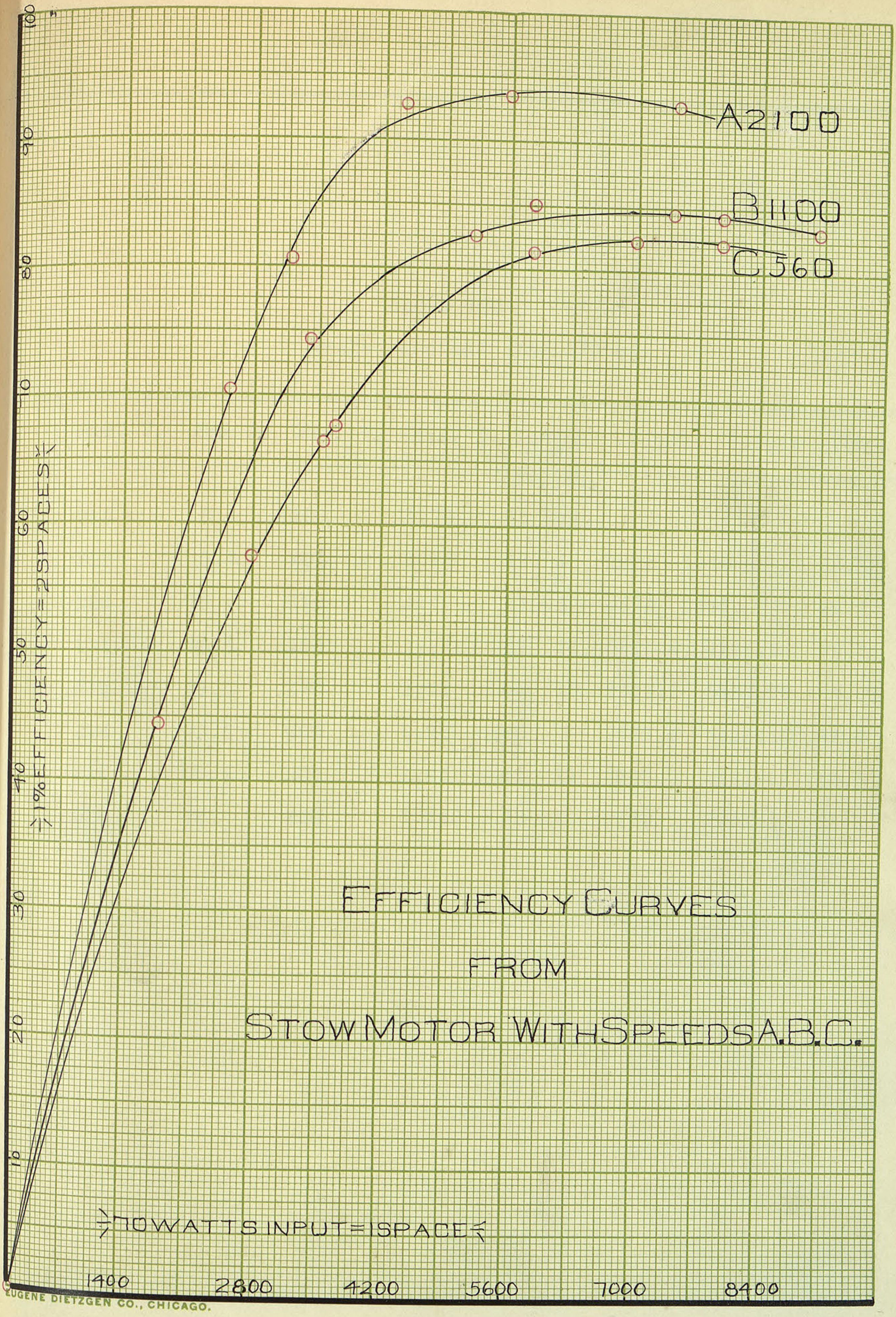
Scale constant 15# - .12.oz.

Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque		Input	Output	Eff.
				lb.	oz.			
210	2.5	203	1.82	no load.		914		
208	7.	202	1.8	17	8	1819	817	44.
206	15	200	1.8	21	2	3450	2579	74.7
204	24	199	1.75	25		5244	4320	82.3
202	27.5	199	1.75	26	8	5903	5038	85.1
202	35	198	1.75	29	2	7415	6272	84.5
200	38	197	1.75	29	15	7934.6	6653	83.9

Speed 2100

Scale constant 13# - 6 oz.

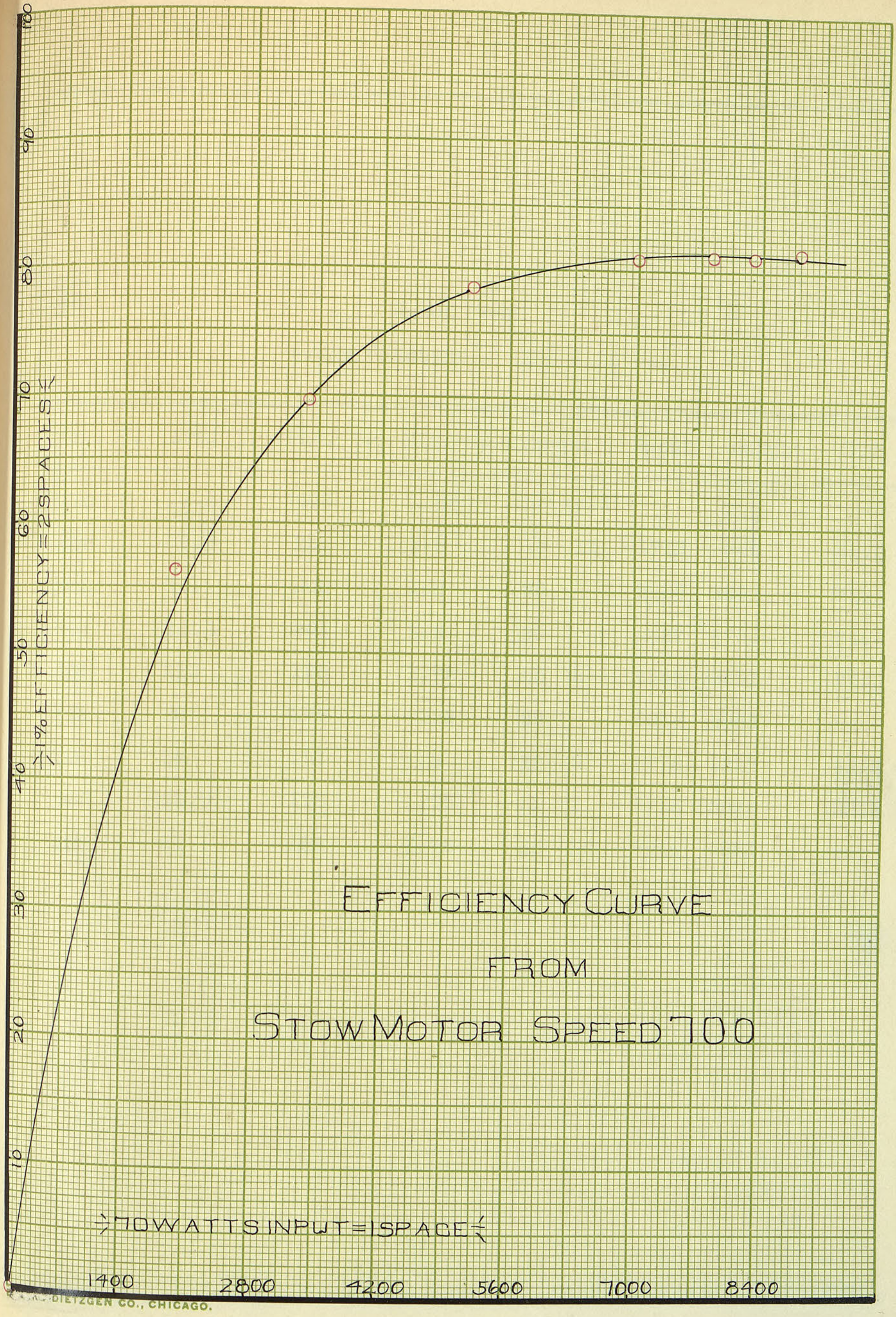
Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque lb.	Torque oz.	Input	Output	Eff.
216	3.	208	1.8	no load		1022.4		
216	10.	216	1.75	15	6	2538.	1788	70.5
212	14.	203	1.75	16	4	3323.	2684	80.79
212	19.	206	1.75	17	14	4388.5	4026.15	93.5
210	25.	202	1.75	19	3	5603.5	5188.26	92.9
200	35.	201	1.7	20	14	7531.7	6978.66	92.8


A 2100
B 1100
C 560
EFFICIENCY CURVES
FROM
STOW MOTOR WITH SPEEDS A.B.C.
1% EFFICIENCY = 2 SPACES
70 WATTS INPUT = 1 SPACE
10
20
30
40
50
60
70
80
90
100
1400
2800
4200
5600
7000
8400
EUGENE DIETZGEN CO., CHICAGO.

Speed 700

Scale constant 13# - 8 oz.

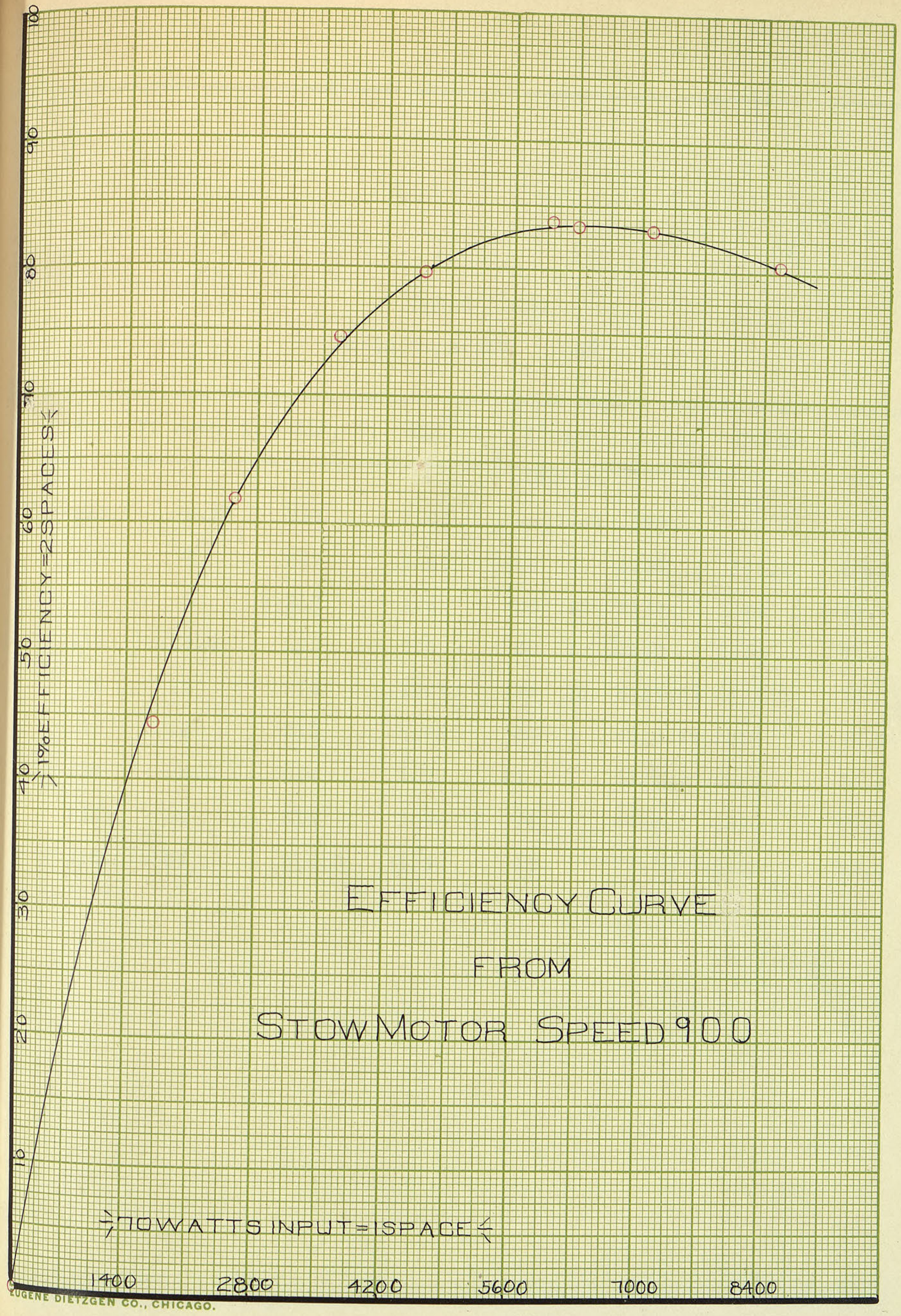
Arm. V.	Arm I.	Fld. V.	Fld. I.	Torque lb.	oz.	Input	Output	Eff.
210	3	200	1.75	No load.				
210	7.5	200	1.75	17	4	1925	1074	56.6
206	15	196	1.7	21	8	3423	2386	69.7
204	24.5	194	1.7	27	14	5227.8	4295.5	78.7
212	31.5	202	1.75	32	10	7031.5	5667.70	80.69
212	35.5	202	1.75	35		7879.5	6413.45	81.2
212	37.5	202	1.75	35	14	8303.5	6681.92	80.5
210	42.	200	1.75	38	8	9170	7457.5	81.2


100
90
80
70
60
50
40
30
20
10
1% EFFICIENCY = 2 SPACES
EFFICIENCY CURVE
FROM
STOW MOTOR SPEED 700
70 WATTS INPUT = 1 SPACE
1400
2800
4200
5600
7000
8400
DIETZGEN CO., CHICAGO.

Speed 900

Scale Constant 15# - 12 oz.

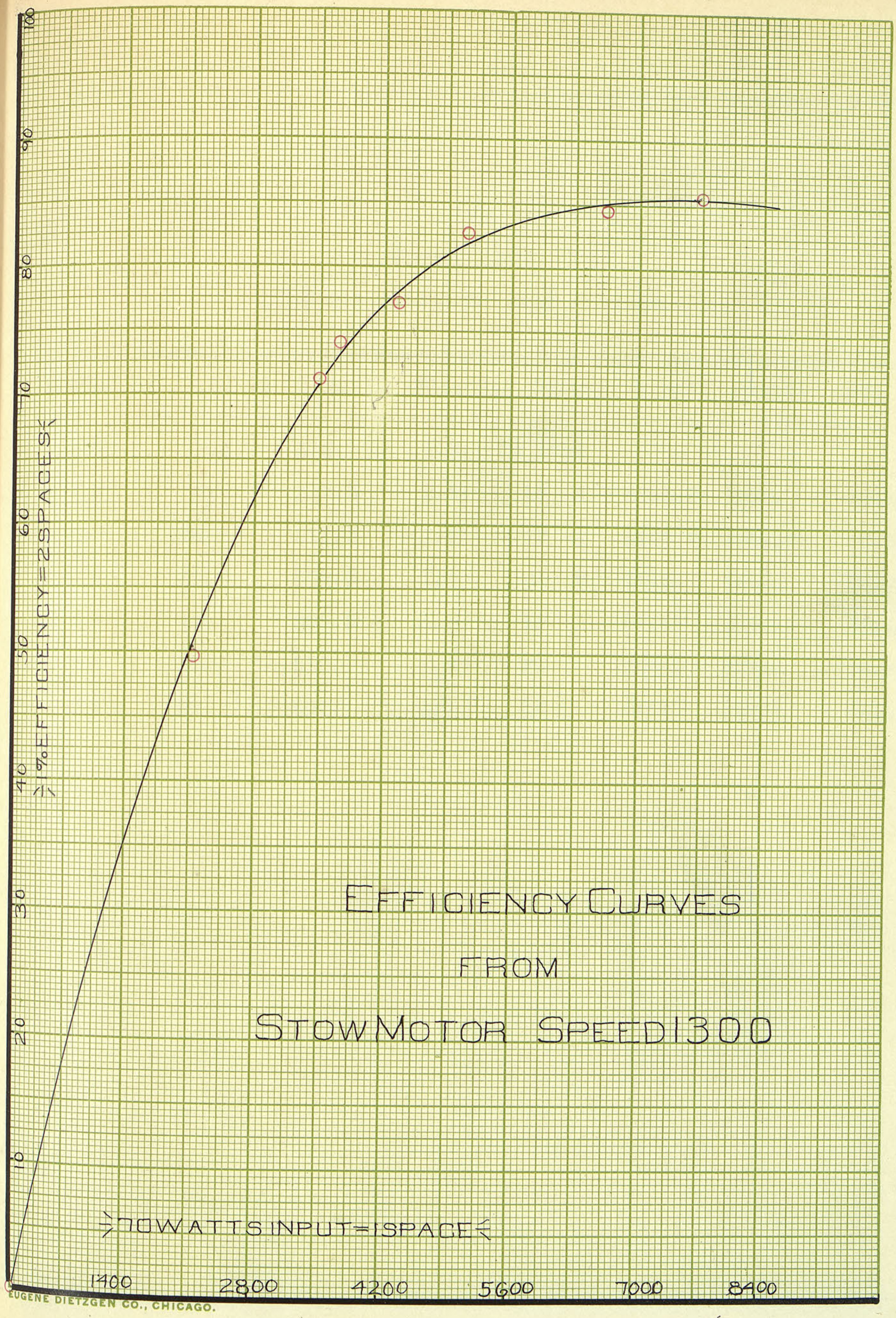
Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque	Imput	Output	Eff.
210	2.5	208	1.85	no load			
208	6.5	201	1.8	17 11	1713	760	44.3
206	11.	200	1.8	20	2626	1632	62.1
204	16.5	201	1.8	23	3727	2784	74.6
204	21.	198	1.75	25 5	4640	3681	79.5
202	28	199	1.8	29	6014	5082	84.
204	29	199	1.8	29 6	6274	5217	82.8
202	33.5	198	1.75	31 2	7113	5895	82.8
200	41	198	1.75	33 10	8546	6843	80.


100
90
80
70
60
50
40
30
20
10
1% EFFICIENCY = 2 SPACES
70 WATTS INPUT = 1 SPACE
1400
2800
4200
5600
7000
8400
EFFICIENCY CURVE
FROM
STOW MOTOR SPEED 900
EUGENE DIETZGEN CO., CHICAGO.

Speed 1300

Scale constant 34#

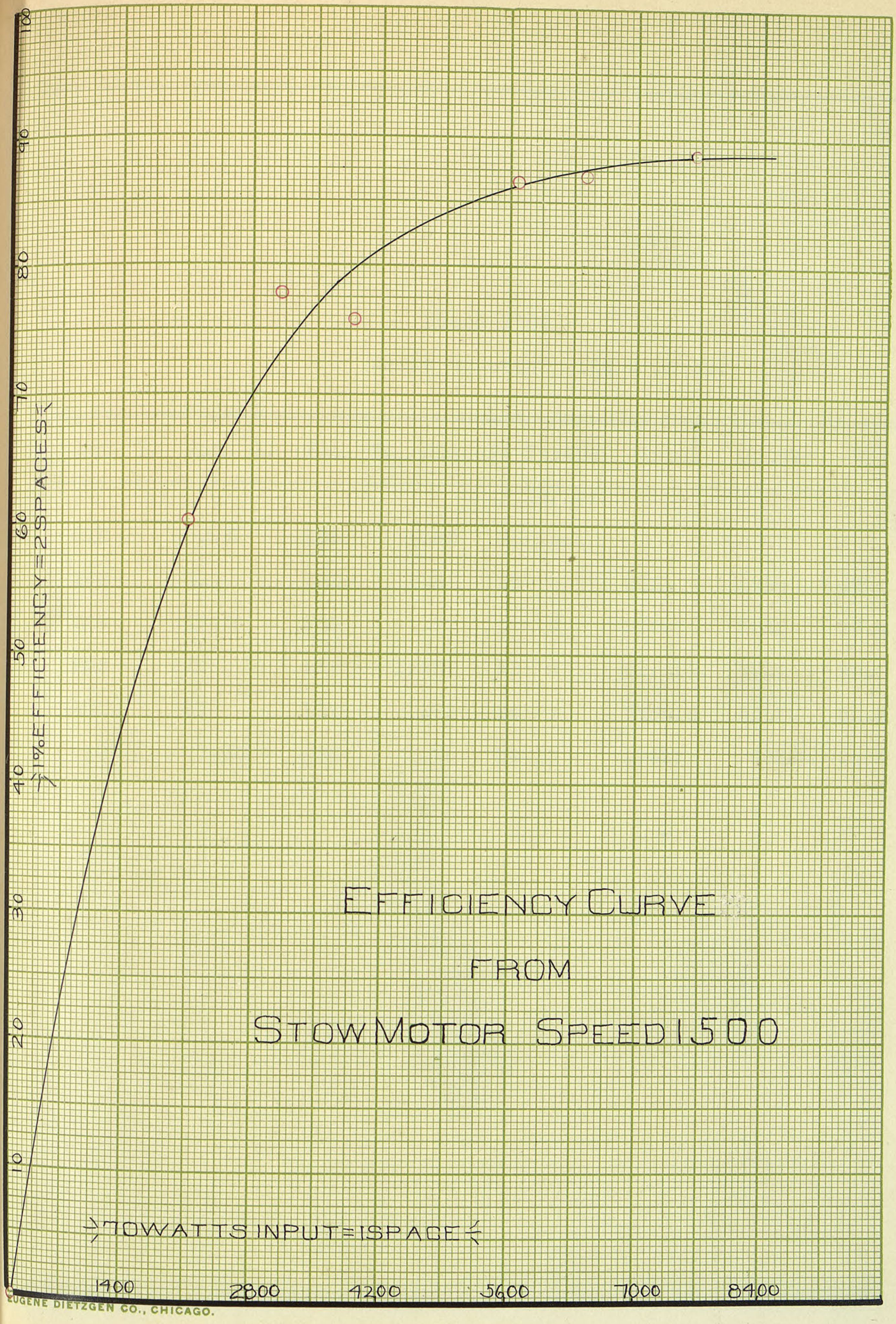
Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque lb.	Torque oz.	Input	Output	Eff.
220	2.5	217	1.95	no load		573		
220	4	217	1.95	34	4	1303	138.2	10.6
220	8	217	1.9	35	15	2172	1078	49.4
216	14.5	215	1.9	38	9	3540	2518	71.1
216	15	216	1.92	38	15	3654.72	2722	74
218	18	216	1.92	40		4338.72	3324	76.7
214	22.5	214	1.9	41	8	5133	4150	82.8
212	30	214	1.9	44		6676.6	5570	84.4
215	34	215.5	1.9	45		7713.76	6593	85.4


EFFICIENCY CURVES
FROM
STOW MOTOR SPEED 1300
70 WATTS INPUT = 1 SPACE
1% EFFICIENCY = 2 SPACES
1400
2800
4200
5600
7000
8400
10
20
30
40
50
60
70
80
90
100
EUGENE DIETZGEN CO., CHICAGO.

Speed 1500

Scale constant 13# - 10 oz.

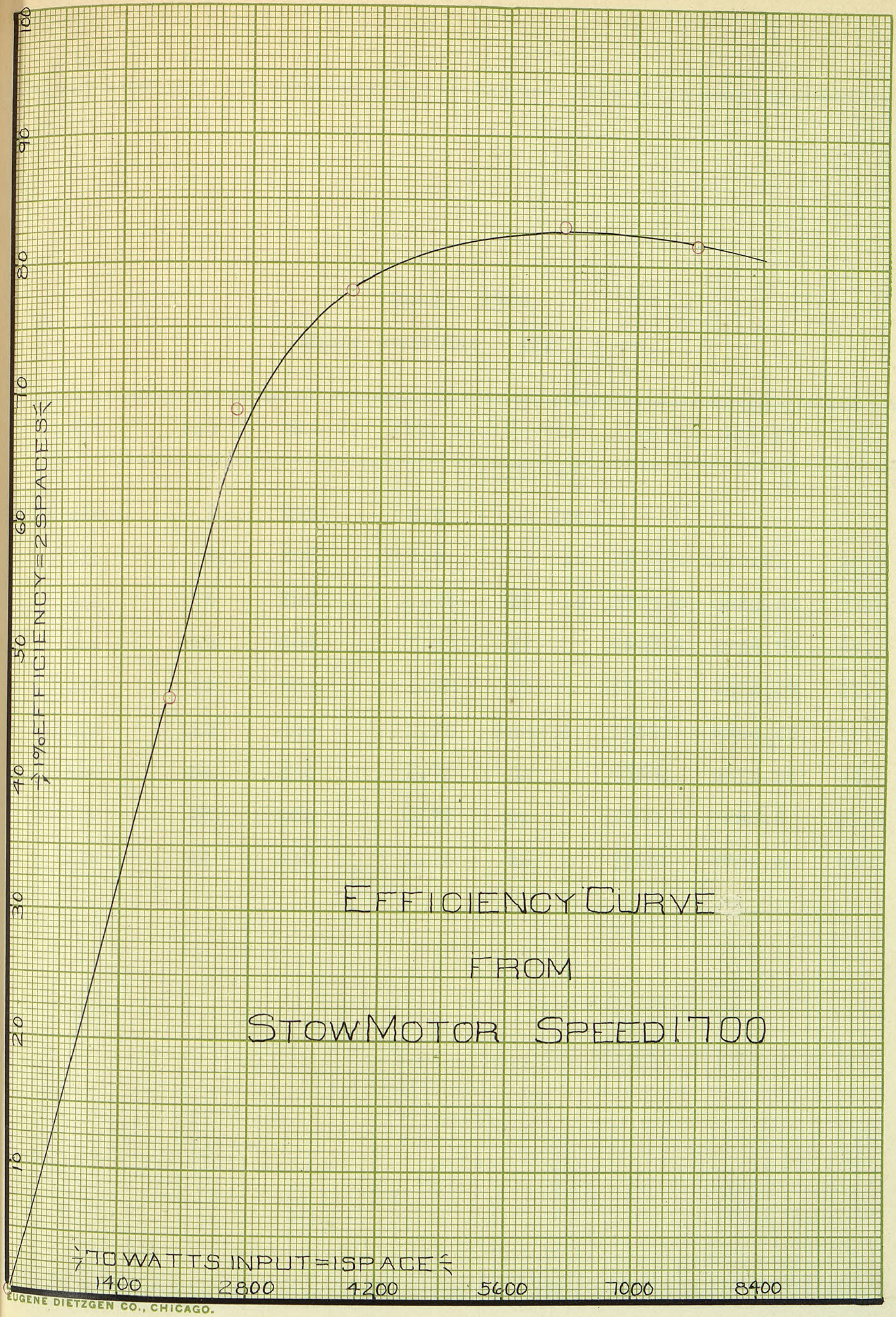
Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque lb. oz.	Input	Output	Eff.
220	3.5	212.	1.9	No load	[illegible]	[illegible]	
216	8.	212.5	1.9	15 2	2121.7	1278.	60.2
222	12.	212.5	1.9	17 2	3057.7	2396.79	78.3
214	25.	209.5	1.9	21 2	5710.	4953.	86.7
220	16.	209.5	1.9	18	5918.	2956.	75.4
214	34.	210.	1.8	24	7654.	6791.	88.8
203	30.	200.	1.7	22	6439.	5592.	86.9


EFFICIENCY CURVE
FROM
STOW MOTOR SPEED 1500
1% EFFICIENCY = 2 SPACES
70 WATTS INPUT = 1 SPACE
10
20
30
40
50
60
70
80
90
100
1400
2800
4200
5600
7000
8400
EUGENE DIETZGEN CO., CHICAGO.

Speed 1700

Scale constant 15# - 12 oz.

Arm. V.	Arm. I.	Fld. V.	Fld. I.	Torque lb. oz.	Input	Output	Eff.
210	2.5	203	1.82	No load			
208	11.	202	1.8	18	2651	1838	69
206	17.5	200	1.77	19 6	3959	3082	77.8
202	29	199	1.75	22 8	62.6.2.	5124	92.5
200	37	197	1.72	24 4	7738.8	6312.	81.5
210	7.50	204	1.75	14-13	1941.	905.5	46.6

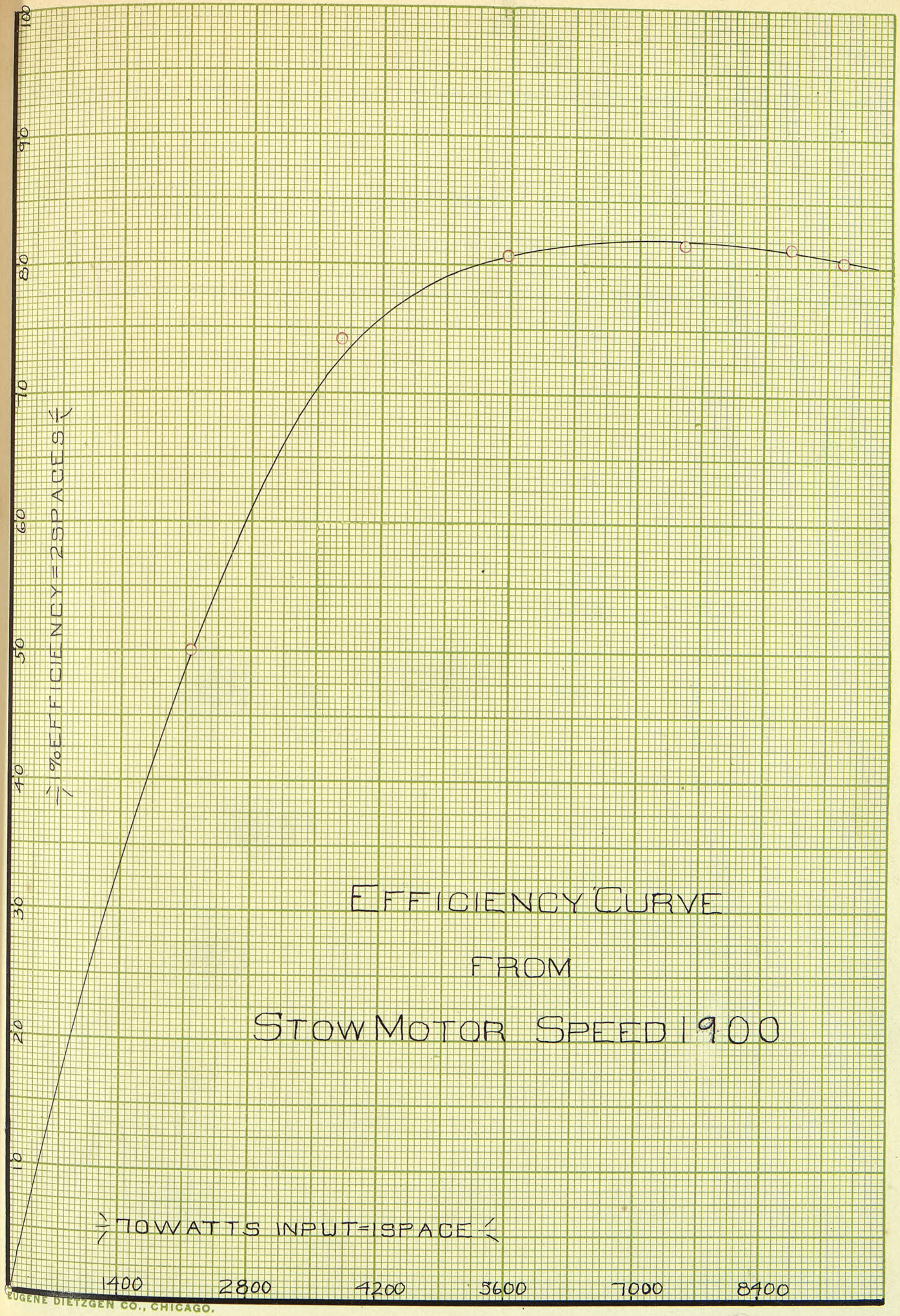


EUGENE DIETZGEN CO., CHICAGO.

Speed 1900

Scale constant 13# - 6 oz.

Arm. V.	Arm I.	Fld V.	Fld. I.	Torque lb.	oz.	Input	Output	Eff.
218	3	208	1.8	no load				
216	8.5	208	1.8	14	12	2210.4	1113.21	50.3
214	16	206	1.75	16	14	3784.5	2833.64	74.8
214	20	204	1.8	17		4647.2	2934.84	64.
210	25	204	1.75	19		5617.	4554.07	81.
210	30	200	1.75	20	8	6650.	5768.49	86.7
212	34	204	1.75	21		7555.	6673.29	82.
210	40	206	1.75	22		8760.5	7286.5	81.8
212	44	210	1.75	23		9995.	7792.5	80.3

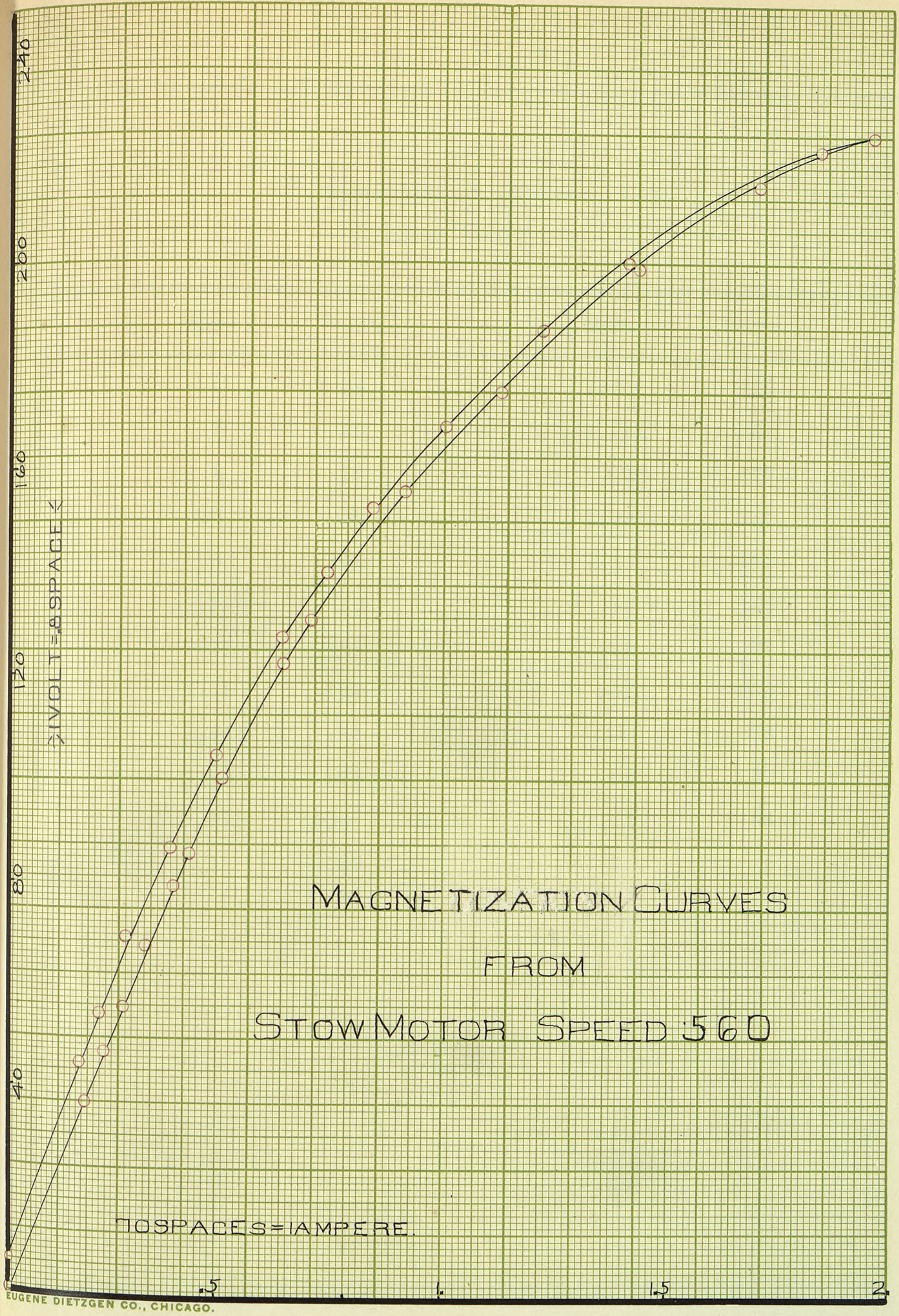


EFFICIENCY CURVE
FROM
STOW MOTOR SPEED 1900
1% EFFICIENCY = 2 SPACES
70 WATTS INPUT = 1 SPACE
100
90
80
70
60
50
40
30
20
10
1400
2800
4200
5600
7000
8400
EUGENE DIETZGEN CO., CHICAGO.

Magnetization curve

Speed 560.

Amp.	Volts.	Amp.	Volts.
.0	4	1.6	208
.2	38	1.7	215
.25	48	1.85	224
.3	56	1.95	225
.34	68	1.85	220
.41	80	1.75	214
.45	86	1.6	208
.51	100	1.41	200
.61	108	1.22	185
.65	123	1.	169
.7	128	.85	152
.75	140	.75	140
.925	156	.65	128
1.12	176	.5	105
1.3	180	.4	86
1.44	200	.3	69
		.25	55
		.2	45.5
		0	5.

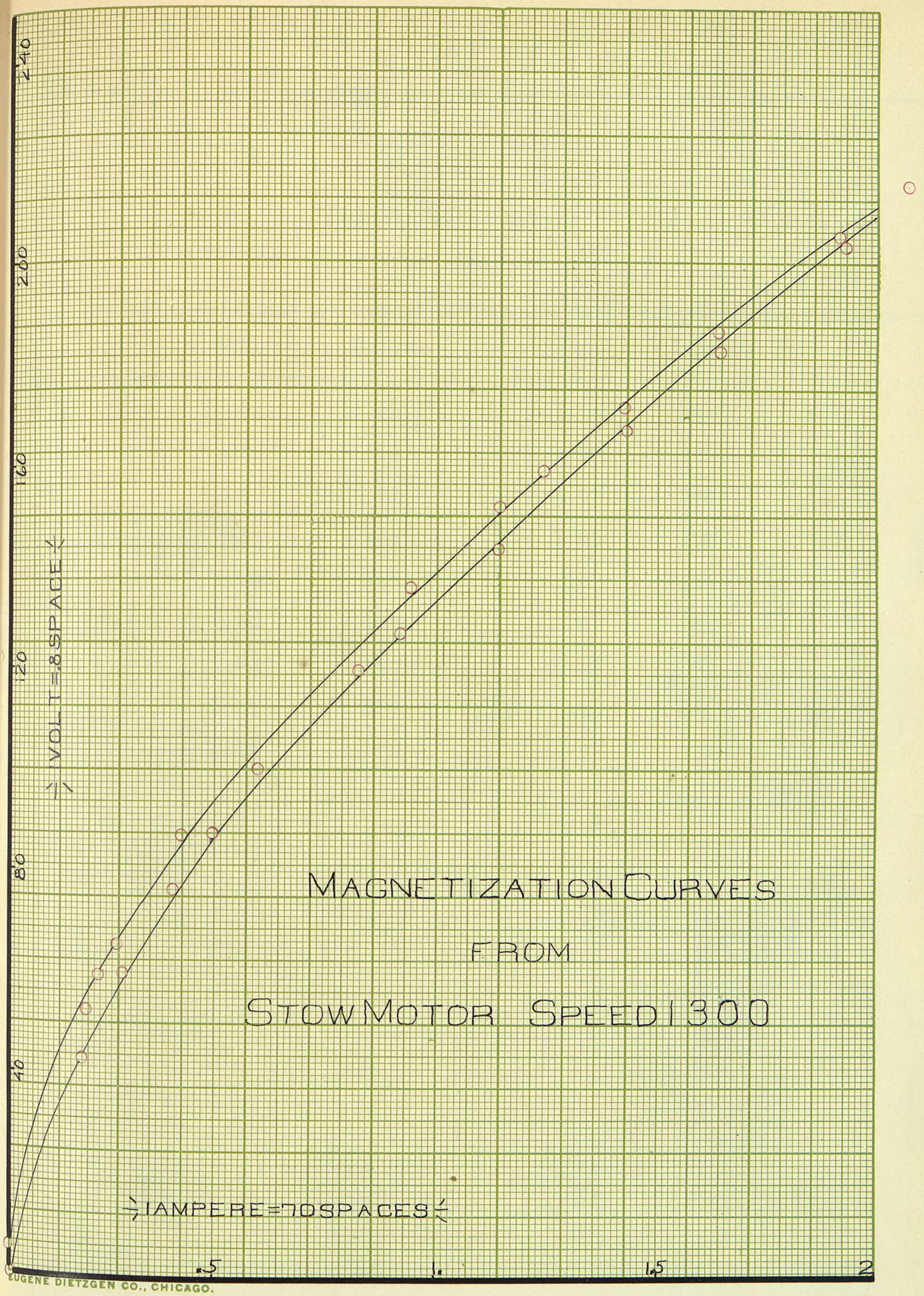


EUGENE DIETZGEN CO., CHICAGO.

Magnetization curves

Speed 1300

Amp.	Volts	Amp.	Volts.
.2	44	1.9	206
.3	60	1.625	188
.4	76	1.425	172
.5	88	1.25	160
.6	100	1.15	152
.825	120	95	136
.928	128	.55	96
1.15	144	.425	86
1.425	168	.3	68
1.65	184	.25	60
1.925	204	.225	52
2.1	220	0	4

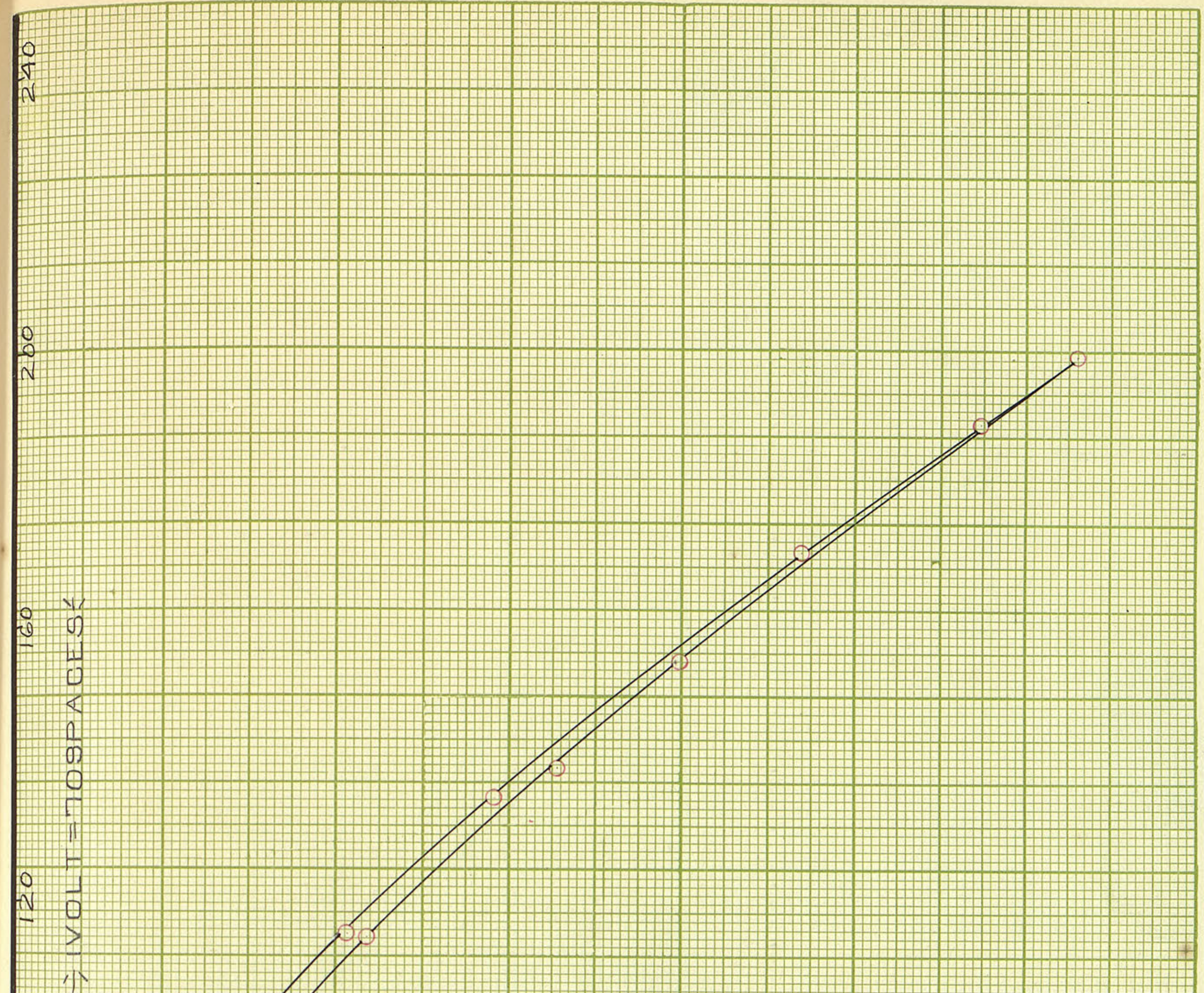


MAGNETIZATION CURVES
FROM
STOW MOTOR SPEED 1300
1 VOLT = .8 SPACE
1 AMPERE = 70 SPACES
40
80
120
160
200
240
.5
1.
1.5
2

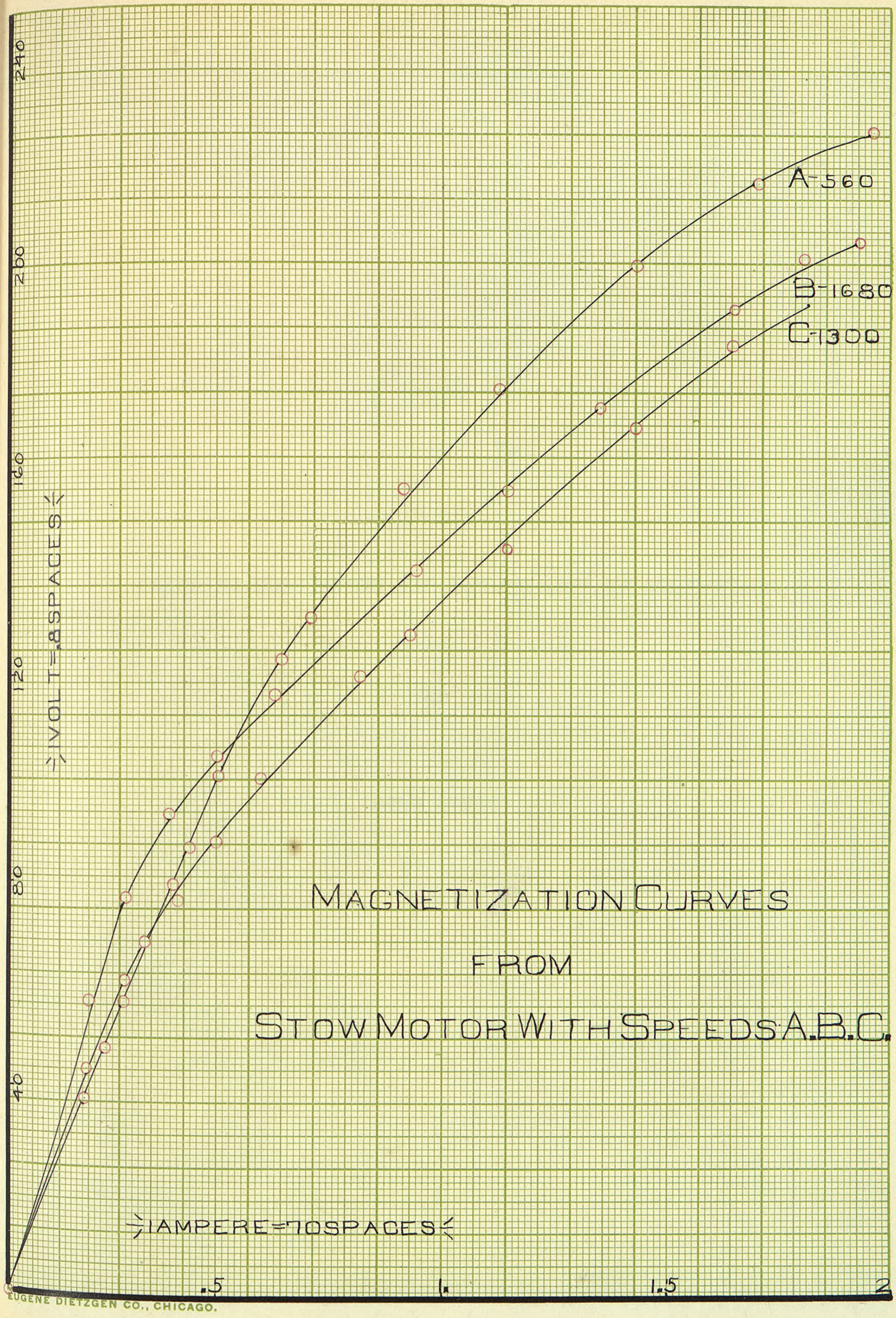
Magnetization curves

Speed 1680

Amp.	Volts.	Amp.	Volts.
.2	56	1.55	180
.3	76	1.8	200
.4	92	1.95	208
.5	104	1.65	190
.625	116	.6	116
.85	136	.4	98
.95	140	.25	76
1.15	156	.2	64
1.35	172	0	5



240
200
160
120
80
40
1 VOLT = 70 SPACES
1 AMPERE = 70 SPACES
.5
1.
1.5
2
MAGNETIZATION CURVES
FROM
STOW MOTOR SPEED 1680



240
200
160
120
80
40
1 VOLT = .8 SPACES
A-560
B-1680
C-1300
MAGNETIZATION CURVES
FROM
STOW MOTOR WITH SPEEDS A.B.C.
1 AMPERE = 70 SPACES
.5
1.
1.5
2
EUGENE DIETZGEN CO., CHICAGO.