TEST OF MABBS ELECTRIC ELEVATORS AT CHICAGO BOARD OF TRADE

BY

P. EICKENBERG
J. K. MABBS

ARMOUR INSTITUTE OF TECHNOLOGY

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EFFICIENCY TEST
OF
MABBS ELECTRIC ELEVATORS
AT THE
CHICAGO BOARD OF TRADE

A THESIS

PRESENTED BY

PHILIP EICKENBERG

AND

JOHN KENNETH MABBS

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ELECTRICAL ENGINEERING

Approved

L. C. Monin,
Dean of Cultural Studies

H. M. Raymond
Dean of Eng. Studies

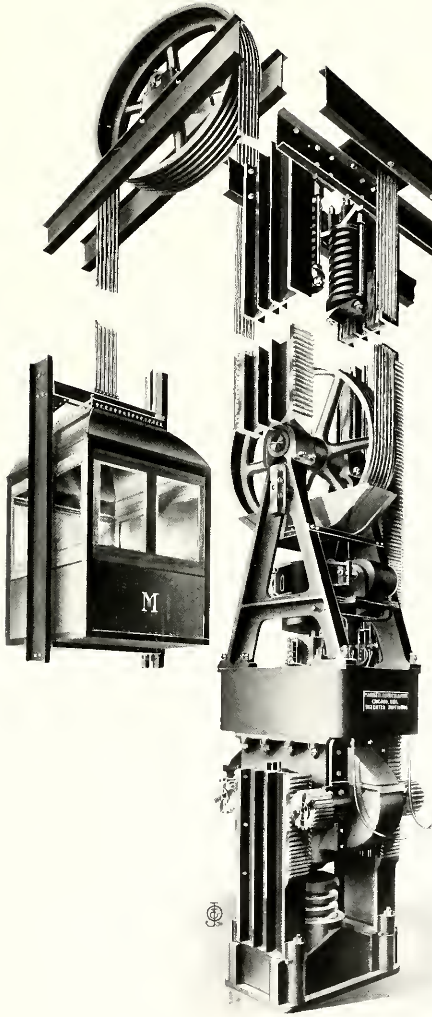

Figure 1.

DESCRIPTION AND OPERATION OF ELEVATOR.

Inasmuch as the general principle of the Mabbs electric elevator departs so radically from that involved in the ordinary electric elevator, it becomes necessary to give a rather detailed explanation of the construction and operation of this machine in order that the following article may be at all comprehensible.

The installation of the Mabbs elevators in the Chicago Board of Trade consists of five elevators, one of which was put in several years previous to the installation of the other four. The first mentioned elevator differs from the other four in its mode of control and will not be considered in this exposition.

The principle of this type of electric elevator differs from that of the ordinary counter-weight elevator in that the elevator motor constitutes the counter-balance of the car and its average load, it being the only counter-weight. The machine is geared two to one, that is, for every foot the machine travels, the car travels two feet. This is accomplished by arranging the cables by

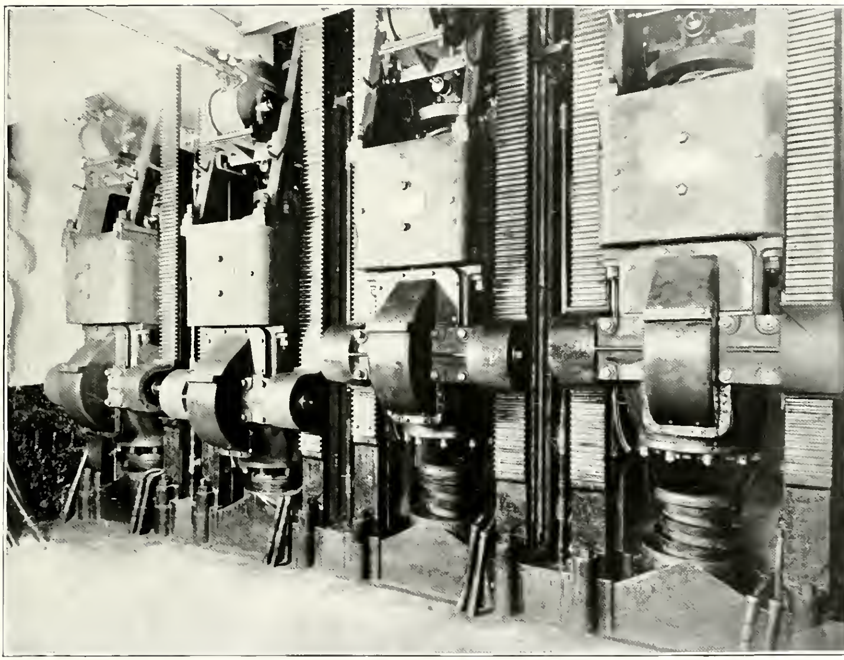

Figure 2.

which the car is suspended so that they go up from the car over the sheave at the top of the car shaft down to a sheave on the motor counter-balance and then up to the anchorage at the top of the machine shaft. By this arrangement the machine shaft extends to only one half the height of the car shaft, and when the machine ascends, the car descends, and vice versa. Figure 1 gives a good idea of the arrangement of the car, machine, cables, racks, buffers, and other parts.

The motor counter-balance is the principal feature of the elevator because of the fact that it takes the place of all ordinary counter-weights such as are used on other elevators. It is essentially a self starting and self stopping counter-weight and has the great advantage in that the car does not have to overcome the momentum of the counter-weight since, in this type of elevator, the counter-weight starts and stops the car.

The motor counter-balance, or machine as it is usually called, is geared to four vertical racks, as shown in Figures 2 and 3, and when the motor is operated the counter-balance climbs up

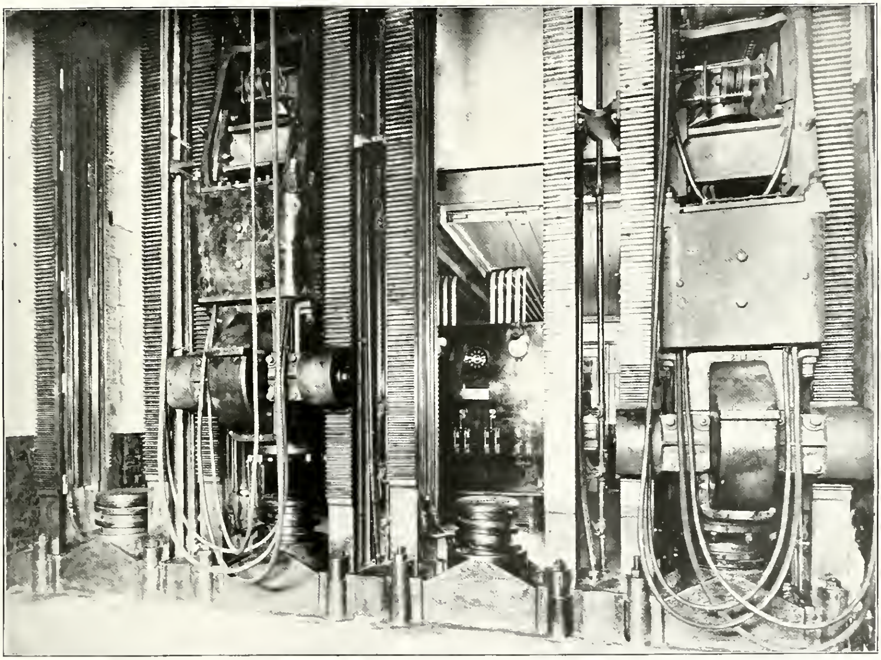

Figure 3.

and down on these racks. The general plan of operation is simple. The current supplied to the motor is carried to it by means of trolleys set in the rack column and is taken off by brushes set on the machine. When the operator throws the car switch on to the first point, the series field is fully energized as the motor starts and is cut out with the armature resistance as the car comes up to first speed. The machine is now running on the two shunt fields. When the operator throws on the second point, one of the shunt fields is weakened by about one-half by inserting resistance, thus bringing the car up to second speed. When the operator throws on the last or third point, the rest of this shunt field is automatically cut out and the speed increases to its maximum. Thus, at full speed, the motor is running as a plain shunt motor and at a speed of between 900 and 1000 revolutions per minute. The motor is stopped by two brakes: the solenoid brake and the dynamic brake. The action of both these brakes will be taken up later under the discussion of the controlling system of the elevator.

The motor counter-balance frame, which is shown in Figures 4, 5 and 6, is composed of three parts, i. e., the truss frame; the motor frame; and the gear casing. The truss frame H is of an "A" shape, as shown in Figure 4 and is bolted on to the motor frame A at its lower end. At the top of the truss frame is the idler sheave I which runs on a steel sleeve doweled on to the shaft J which is rigidly bolted to the truss frame. The idler sheave is provided with a phosphor bronze bushing which is long enough to give an abundance of bearing surface on the sleeve. The sleeve is arranged so that it can be turned over or replaced when worn out. The motor frame A is bolted on to the bottom of the truss frame and the gear casing W, in turn, is bolted on to the bottom of the motor frame, as is shown in the side and front elevations, Figures 4 and 5.

The motor frame in this machine, which also serves as the yoke, is of cast steel, the shape being that of a hollow rectangular prism, the outside dimensions being 24" x 36". The cross section of this part of the magnetic circuit is rect-

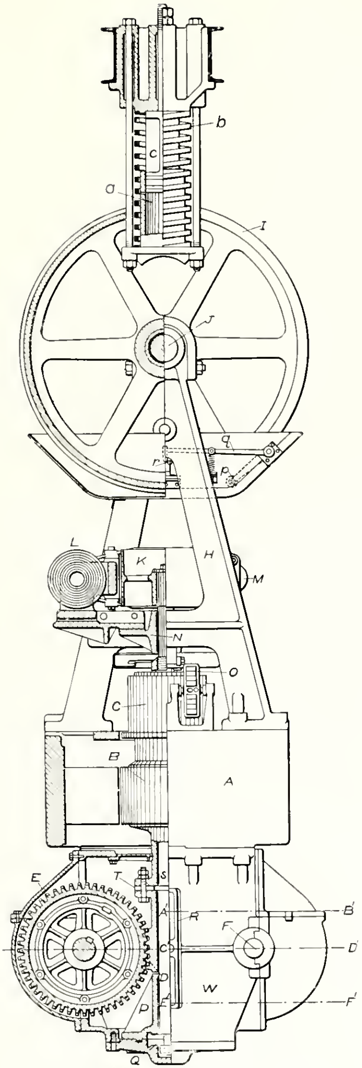

Figure 4.

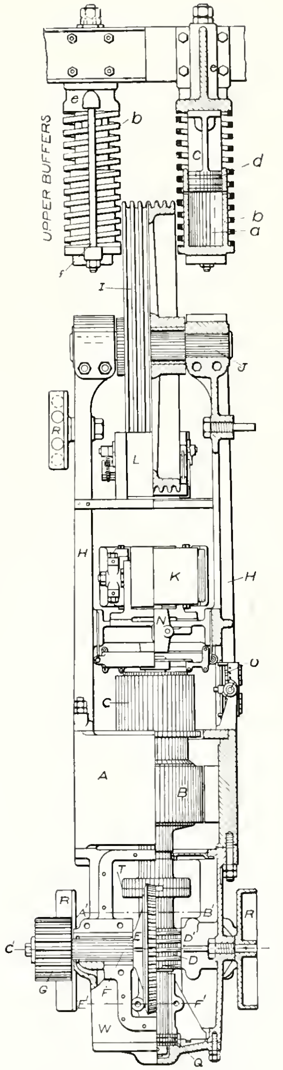

Figure 5.

angular, 17" x 2 1/2". There are four polar projections, two of which are considerably longer than the others. Upon the two long projections are wound the permanent and auxiliary shunt field windings, while the two short projections carry the series field winding, as indicated in Figure 7. All polar projections are of rectangular cross section.

In order that all working parts may be protected from dirt and be thoroughly lubricated, a cast iron, oil-tight gear case W is placed about the gearing. This casing serves as bearings for the two pinion shafts F and is filled with oil to a point just below the horizontal shaft. This gives ideal lubrication as well as insuring noiseless operation.

The steel worm D which is mounted on the armature shaft S drives two worm gears E E', each of which is keyed to a horizontal shaft F. On these two shafts are placed four pinions G, one at each end. These pinions engage four vertical racks mounted on the face of two cast iron columns, which form the structure up and down which the

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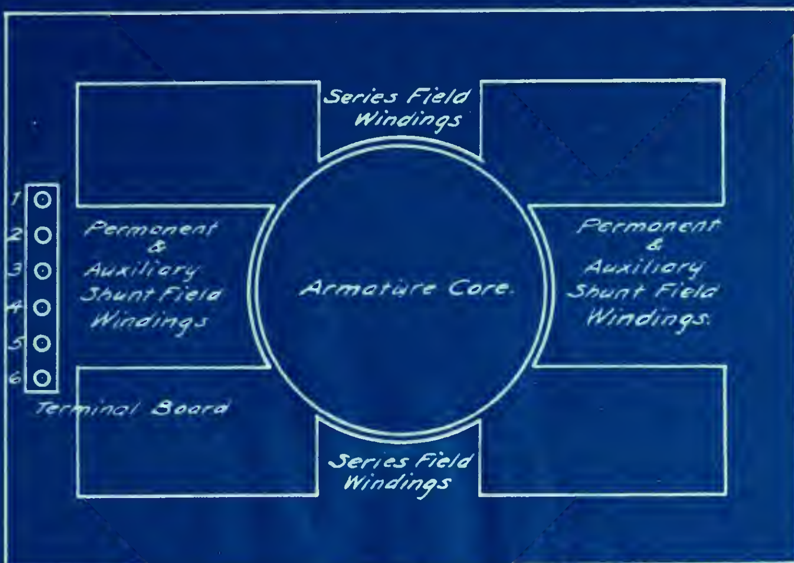

Arrangement of Field Windings and Terminal Board on Motor.

Note

1 and 6 — Series Field Terminals.
2 and 5 — Auxiliary Shunt Field Terminals.
3 and 4 — Permanent Shunt Field Terminals.

Figure 7.

machine operates.

The motor used in this machine is a 35 H P., four pole Warner-wound motor of the direct current type made by the Northern Electric Manufacturing Company of Madison, Wisconsin. When running under a full load this motor is rated to take 240 amperes at 120 volts.

The armature shaft S is mounted vertically, the lower end being held in place and supported by the roller thrust bearing Q and the upper end running in the journal N. On the upper end of the shaft above the bearing is mounted the solenoid brake pulley K and below the bearing are mounted, in order, the commutator C, the armature core B, and the worm D, which is keyed to the shaft and held rigidly by the flanged coupling T.

The armature core of the motor is rigidly keyed to a 3 1/4" vertical steel armature shaft. The armature core, which is 12 1/2" in diameter, is of the drum type and is built up of sheet iron laminations .014 inches in thickness mounted on a phosphor bronze sleeve which, in turn, is mounted directly on the armature shaft. The core is of

the slotted type, there being 45 slots 1/4" wide by 1 1/4 " deep with two conductors of 1/2 inch x 3/32" cross section in each slot, making a total of ninety inductors on the armature. The armature winding is a wave winding having a front pitch of 25, a back pitch of 21, and a commutator pitch of 23. The development of this winding is shown in Figure 8. The commutator of the motor is unusually large for an elevator motor, being 9 1/2" in diameter and 5" in length and having 45 segments 11/16" in width. This feature of the design of the motor gives a large brush and contact surface which, in turn, is an aid to sparkless commutation, thus reducing the wear.

The field cores are made of cast steel and are rectangular in cross section. The core on which the series field is wound is 2 1/4" in length and has a 7 3/4"x 11 1/2 " cross section. The core carrying both shunt fields is 8" long and of a 7 3/4" x 11 1/2 " cross section.

The series field winding is a very light winding which is only used to produce a large torque when the motor starts. It is connected in

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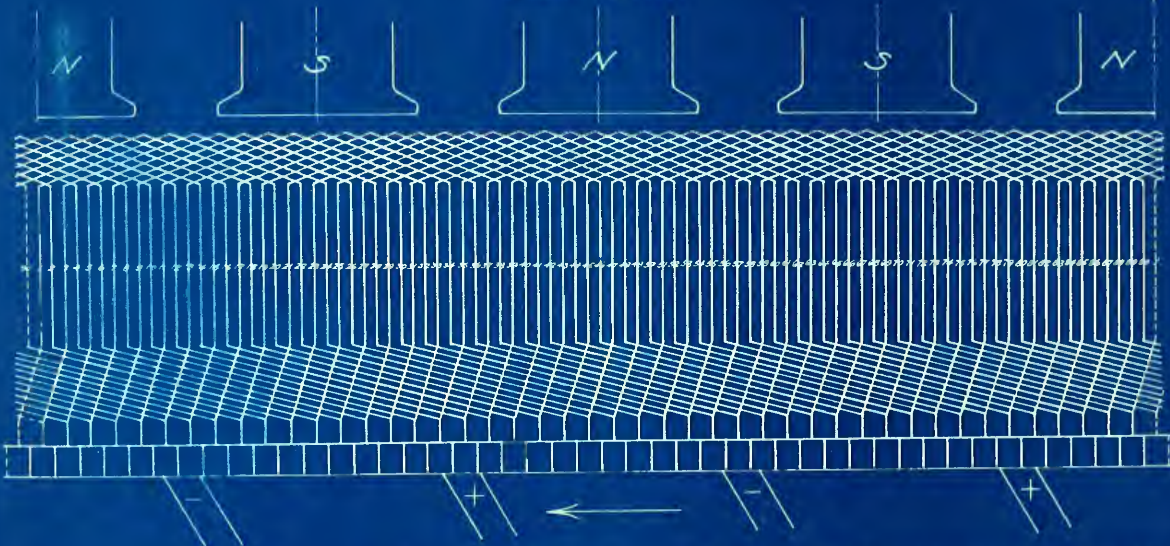


Armature Winding Diagram for 35 HP. Northern Electric Manufacturing Co. Motor.

Type of winding - Simplex wave.
Number of inductors - 90.
Number of slots - 45.
Number of commutator segments - 45.
Number of poles - 4.

Number of brushes - 4.
Number of paths in parallel - 4.
Front pitch - 25.
Back pitch - 21.
Commutator pitch - 23.

Figure 8.

multiple with a resistance bank which is in series with the armature, as shown in Figure 15, the field used in this connection being known as the Warner winding. As the motor speeds up, the resistance bank is automatically cut out in steps, thus causing the series field to become weaker and weaker until, when the resistance is entirely cut out, the series field is practically cut out and the motor has attained the first step of its speed. The series field winding is composed of 500 turns of #10 D.C.C. wire, having a resistance of 3.7 ohms. As the series field is connected in parallel with the resistance grids, any arcing caused by a reduction of the current in the field is eliminated because the inductive kick is dissipated in the grids.

The auxiliary shunt field winding is connected across the line and is cut out automatically in two steps, the first bringing the machine up to second speed, and the second producing the final weakening of the field and bringing the machine up to its full speed of about 1000 revolutions per minute. The motor now runs as a simple,

four pole shunt motor. This winding is composed of 1000 turns of #11 D.C.C. wire, having a resistance of 9.7 ohms.

The permanent shunt field winding, which is also connected across the line, is never cut out of the circuit when the machine is in service. The purpose ofthis permanent shunt winding is to furnish a strong field for the motor at all times. The great advantage ofthis winding is in the fact that it provides a strong field so that the motor can start instantly and that the period of time required by other machines not having this winding for their fields to build up is eliminated. The permanent shunt field is composed of 2000 turns of #14 S.C.C. wire, having a resistance of 39.7 ohms.

There are four brush holders on the machine, each brush holder having a set of four 1" x 1" carbon brushes. These brushes bear down vertically on the commutator.

The brushes of the motor are connected to the source of power by means of two trolley shoes which run in two copper trolley rails, one on each side ofthe guide. These trolley shoes are

placed in a shoe frame which is set in a specially designed bracket mounted on the field frame. This bracket is so designed that the shoe frame is allowed free movement sideways and on its axis, thus eliminating any danger of the trolley shoes catching in the trolley rail channel. Each of the shoes has about 8 square inches of contact surface, thus insuring perfect contact and preventing any danger of arcing or burning the trolley rails. The great advantage of this large surface can be seen when, after over four years of service, no burned spots have appeared in the trolley rails of the four elevators installed.

The motor is connected to the panel board by means of a set of cables running from the machine to the side of the shaft, the cables being long enough to allow the machine to run the full length of the shaft without tightening them. This set of cables carries the current for the motor fields, the brake solenoid, and the slack cable device. Connection is made to the electrical apparatus in the car by means of a cable similar to the one used in the case of the machine. This cable

connects a terminal board on the bottom of the car with a fixed terminal board half way up in the elevator shaft.

The racks on which the four pinions of the counter-weight motor run are steel cut racks which are bolted to the outer faces of two columns and which form a continuous rack the entire length of the machine structure. The columns to which the racks are bolted are of a general I-beam section, as shown in Figure 6, heavily ribbed both horizontally and vertically to insure stiffness. The two vertical ribs on the inner side form the guides U in which the four machine guide shoes are run. The beams are made in lengths of 12 feet and are bolted and doweled together so as to secure perfect alignment which is absolutely necessary in order that the pinions may run noiselessly and without cutting. The columns are mounted on a very heavy base which is shown in Figure 9, this base also forming the support of the oil spring buffer which is also shown.

The trolley rails, from which the motor armature takes its current, are copper lined steel

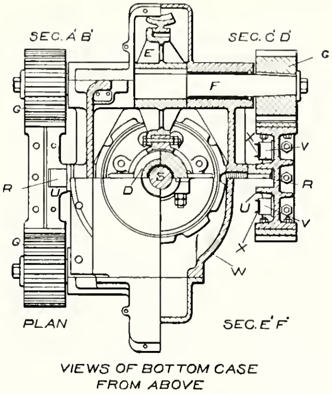


Figure 6.

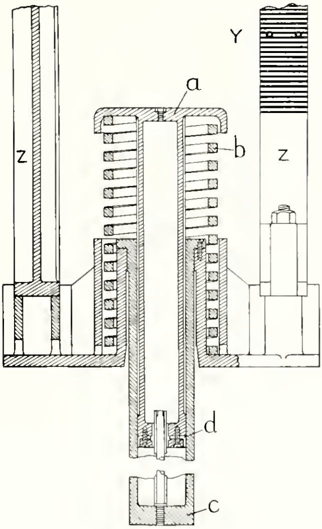


Figure 9.

channels running the entire length ofthe columns. The steel channels and copper bars break joints and both act as conductors. The channels are supported by porcelain insulating blocks bolted to the columns and separated from the blocks by leather washers in order to prevent breakage.

The controlling system for this elevator is what is known as the "full magnet type of control" and was designed and built by the J. L. Schureman Company of Chicago, Illinois.

The panel boards are of slate, the panels being mounted on an angle iron frame. All magnetic and hand operated switches with the exception of the car switch in the car are mounted on this board. The controller bank shown in Figure 10 has four side panels, one panel for each elevator, and a common front panel.

The front panel, which can be seen between the racks in Figure 3, has mounted on it four D.P.S.T. copper, knife switches which are only used for cutting off a machine from the elevator buses in the engine room. An ammeter and a volt-

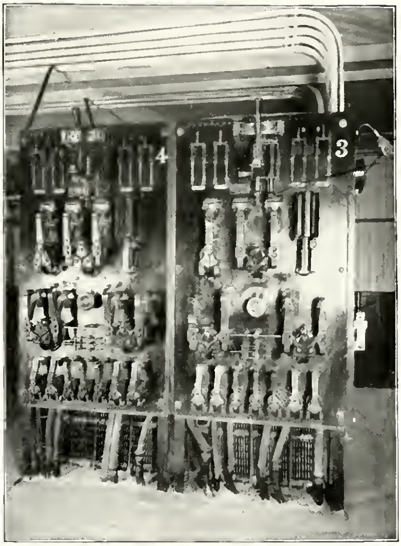


Figure 10.

meter are mounted on the board, an ammeter switch being connected in so that the ammeter may be instantly inserted in any of the motor armature circuits by simply turning the switch so the number ofthe machine in which it is desired to determine the motor current consumption. The ground detector is also mounted on the front panel between the ammeter and voltmeter.

The side panel of the controller contains all the magnet switches by which the elevator is controlled. The controller consists of an I.T.E. circuit breaker on the main line; a D.P.S.T. magnetic main line switch with copper and carbon contacts on each pole and with a magnetic blow-out; two pole-reversing switches which are of the same type as the main line switch with the exception that they have no magnetic blow-out; four S.P.S.T. magnetic switches with copper contacts only which control the cutting out of circuit of the series field; a rotating switch controlled by a master solenoid which regulates the four series field circuit switches; two S.P.S.T. magnetic switches with carbon contacts only which control the cutting out

of the auxiliary shunt field; a S.P.S.T. magnetic switch with carbon contact only, of the same type as the field switches, for the control of the mechanical or solenoid brake; and a S.P.S.T. magnetic switch with both copper and carbon contacts and a magnetic blow-out for the control of the dynamic brake circuit. The rotating switch for controlling the series field switches is mounted on the back of the board. The set of resistance grids which is connected in parallel with the series field and which is the part of the series field or Warner winding circuit cut out by the series field switches, is mounted at the back of the board. A similar but smaller set of resistance grids is mounted at the back of the board for use in the dynamic brake circuit.

The panel board also has mounted on it an auxiliary car switch whoch controls the elevator in exactly the same manner as does the car switch in the car. A 3.P.D.T. knife switch is connected up so that only one of these car switches can operate the machine at a certain time.

In the panel board shown in Figure 9, the

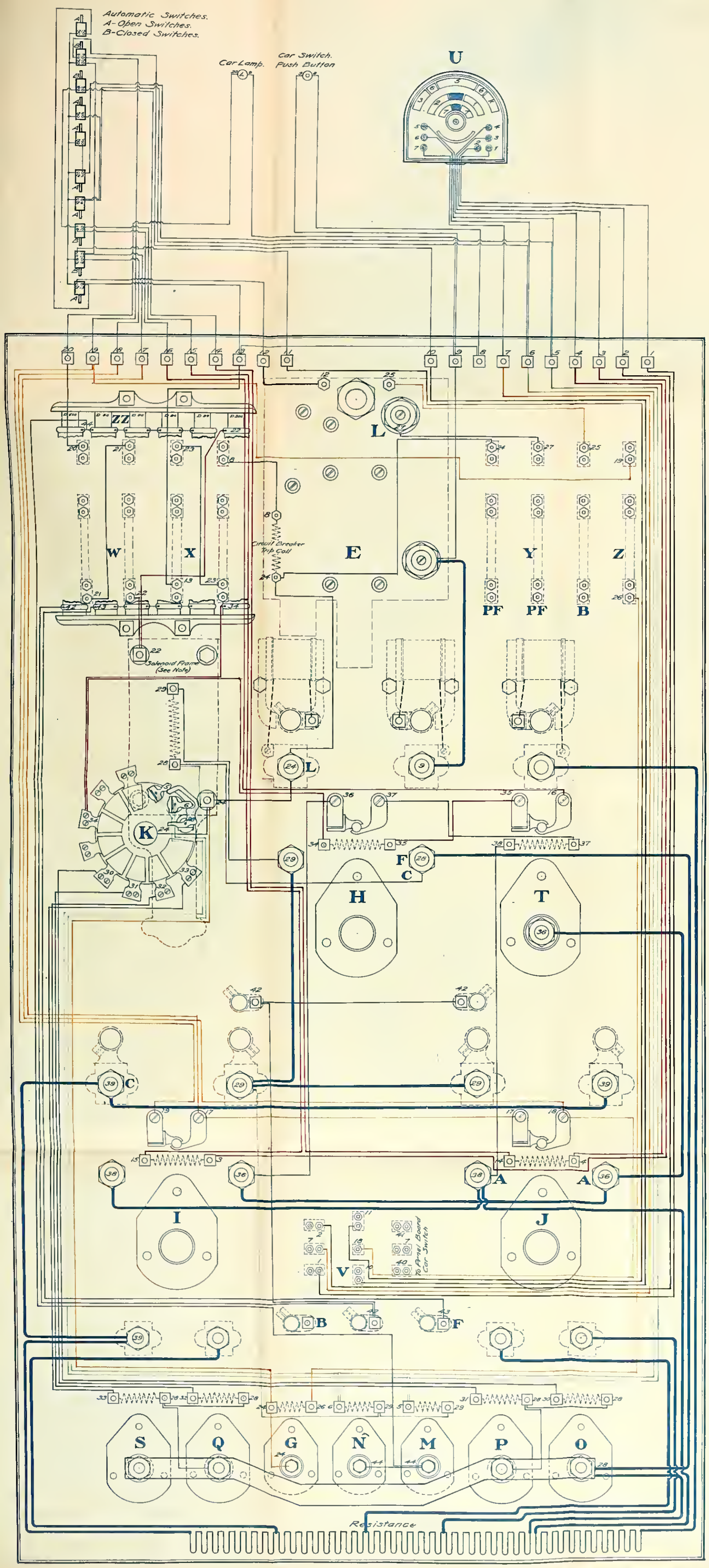
arrangement of the switches is as follows. Taking the panel board for elevator #3, the switches in the top row from left to right are:- the control switch for the field circuit; the control switch for the automatic trips; the I.T.E. circuit breaker; the control switch for the mechanical or solenoid brake circuit; and the control switch for the elevator signal lighting system. The first two and last two of these switches are small D.P.S.T. hand switches. The second row of switches contains the dynamic brake switch; the main line switch; and the master solenoid for operating the rotating switch on the back of the board. The third row contains the two pole-reversing switches; and, between them, the hand wheel for the car switch which is mounted on the back of the board and, below it, the 3.P.D.T. knife switch which throws either the car or the switch board car switch into circuit. In the bottom row from left to right are two series field switches; two auxiliary field switches; the solenoid brake switch; and two more series field switches. Underneath the panel board can be seen the bottom of a series field and dynamic brake re-

sistance grids.

The car switch is placed in a cast iron box with the contacts mounted on a slab of micanite. The arrangement ofthe contacts is shown in the car switch (U) in plate A. The car switch has three concentric rows of contacts numbered as shown. The moving element consists of four carbon blocks all pig-tailed together and arranged so that three small blocks bear side by side on the outer row of contacts. The fourth block is about twice as long as one ofthe small blocks and is arranged to span the two inner rows of car switch contacts. This carbon block is in line with the middle one of the three upper blocks.

There are four definite positions of the car switch handle on each side of the central or "off" position. When the handle is in this central position, the three upper carbon blocks all rest on contact 5 while the fourth block rests on fiber insulating blocks. The car is now stationary and the solenoid brake set.

When the handle is moved to the first position to the right, for example, two of the



CONTROLLER WIRING DIAGRAM

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CIRCUIT TERMINALS

- **A** - *Armature.*
- **B** - *Brake Coil.*
- **C** - *Compound.*
- **F** - *Auxiliary Field.*
- **PF** - *Permanent Field.*
- **L** - *Line.*

SWITCHES

- **E** - *Circuit Breaker.*
- **G** - *Brake Coil Magnet Switch.*
- **H** - *Line Magnet Switch.*
- **I** - *Reversing Magnet Switch.*
- **J** - *Reversing Magnet Switch.*
- **K** - *Master Solenoid Switch.*
- **M** - *2nd Speed Magnet Switch.*
- **N** - *3rd Speed Magnet Switch.*
- **O** - *1st Accelerating Magnet Switch.*
- **P** - *2nd Accelerating Magnet Switch.*
- **Q** - *3rd Accelerating Magnet Switch.*
- **S** - *4th Accelerating Magnet Switch.*
- **T** - *Dynamic Brake Magnet Switch.*
- **U** - *Car Switch.*
- **V** - *Controller Operating Switch.*
- **W** - *Signal Light Hand Switch.*
- **X** - *Circuit Breaker Hand Switch.*
- **Y** - *Permanent Shunt Field Hand Switch.*
- **Z** - *Brake Coil Hand Switch.*
- **ZZ** - *High Resistance Tubes.*

KEY

Starting Circuit.
Brake and Brake Magnet Switch Circuits.
Auxiliary Field Magnet Switch Circuits.
Leads Common to Above Circuits.

NOTE

Solenoid frame conducts current from 24 to 22 but is insulated from ground and other apparatus by being mounted on slate controller panel board.

three upper blocks rest on contact 5 and one on contact 6, while the fourth block spans contacts 1 and 7. This position releases the solenoid brake.

When the handle is moved to the second position to the right, one block of the upper set of three rests on each of the contacts 5, 6 and 4, the fourth block still connecting contacts 1 and 7. This position brings the car up to first speed.

When the handle is moved to the third position to the right, two of the blocks rest on contact 4, while the third block rests on contact 6, the fourth block still connecting contacts 1 and 7. This brings the car up to second speed.

When the switch handle is moved to its last or fourth position to the right, all three of the upper blocks rest on contact 4, while the fourth block still connects contacts 1 and 7. This brings the car up to its third or full speed. The sequence of events when the car switch handle is moved to the left is exactly the same as above with the exception that the car moves in the opposite direction.

The first circuits which come into action when the car switch handle is moved to its first position in either direction are the brake and brake magnet switch circuits. These circuits are shown in yellow on the controller wiring diagram (plate A) and diagrammatically in Figure 11.

When the car switch handle is moved to the first position to the right (machine up), contacts 1 and 7 are connected together. This closes the brake magnet switch coil circuit, current flowing from line 24 through the brake magnet switch coil (24-26), one side of the brake hand switch (Z) (26-19), one side ofthe D.P.S.T. solenoid brake limit switches (#4) (19-17, 17-18), the controller operating switch(Y) (18-7), the car box (U) (7-1), the controller operating switch (V) (1-10), the other side of the upper D.P.S.T. solenoid brake limit switch (#4) (10-12), and then to line 12 on the circuit breaker. When the car switch is moved to the first position to the left (machine down), the circuit is completed through one side of the lower D.P.S.T. solenoid brake limit switch (11-12) instead of through one side of the upper switch

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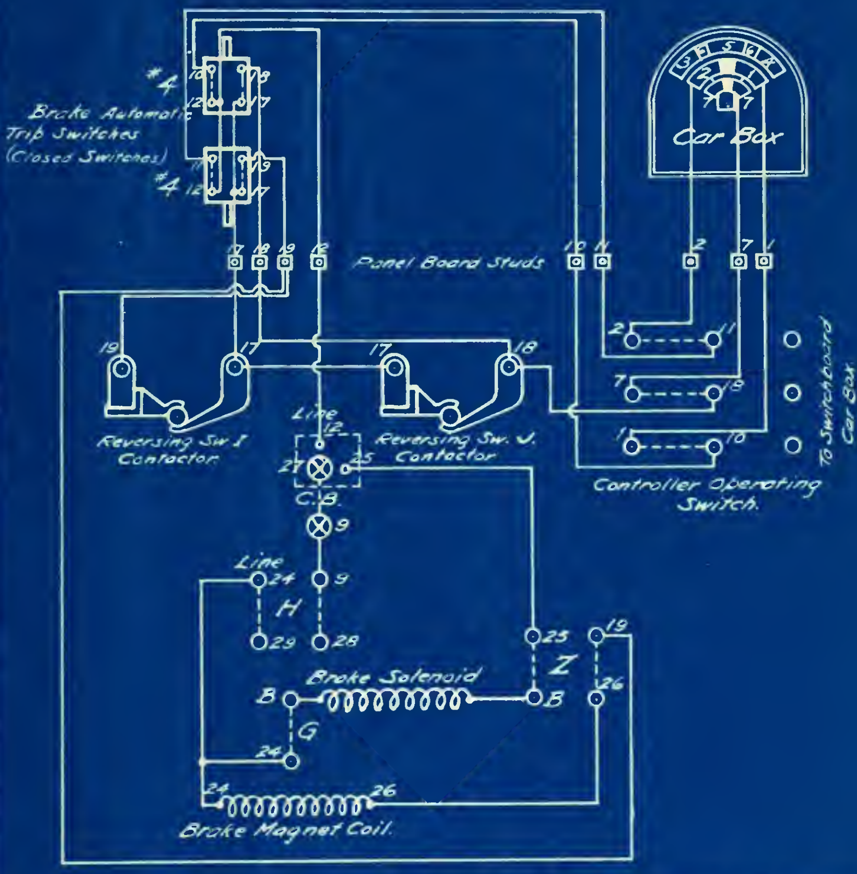

Brake and Brake Magnet Switch Circuits.

Note

B-B are brake solenoid terminals on controller panel board

G- Brake Coil Magnet Switch.

H- Line Magnet Switch.

Z- Brake Coil Hand Switch.

Figure 11.

(10-12), through (2-11) instead of (1-10) in the controller operating switch (V) and through (7-2) instead of (7-1) in the car box (U). Succeeding positions of the car switch handle in either direction do not affect this circuit, current flowing as when the handle is in the first position.

The reversing switch (I) contactor is in parallel with one side of the lower solenoid brake limit switch (#4) (19-17) and the reversing switch (J) contactor is in parallel with one side ofthe upper solenoid brake limit switch (#4) (17-18). These contactors in no way affect the circuit unless one of the trips is open. If the upper trip is open, for example, current is shut off from 10 and, hence, 1 in the car box, thus opening the line switch and brake magnet switch coil circuit and setting the solenoid brake. If the reversing switch which would tend to make the machine go farther in the same direction (up, in this case) should by any chance be closed, its contactor would be open, thus opening the brake magnet switch coil circuit, and setting the brake. It is thus

impossible to make the machine go farther without setting the brake.

The brake solenoid is connected to line 24 through the brake magnet switch (G) (24-B), and to line 25 through one side of the brake hand switch (Z) (B-25). The closing of the brake magnet switch (G) energizes the solenoid, thus releasing the brake.

The permanent field is connected directly across the line through the D.P.S.T. permanent field hand switch (Y).

The next circuit to come into action is the starting circuit. This is shown in red on the controller wiring diagram (plate A) and diagrammatically in Figure 12.

When the car switch handle is moved to its second position to the right (machine up), contacts 1, 4, 5, 6, and 7 are connected together. Current flows from line 24, through the master solenoid frame (24-22), a resistance of 200 ohms (22-34), the line switch (H) magnet coil (34-35), the dynamic brake switch (T) contactor (35-16), the upper first speed automatic trip switch (#3)

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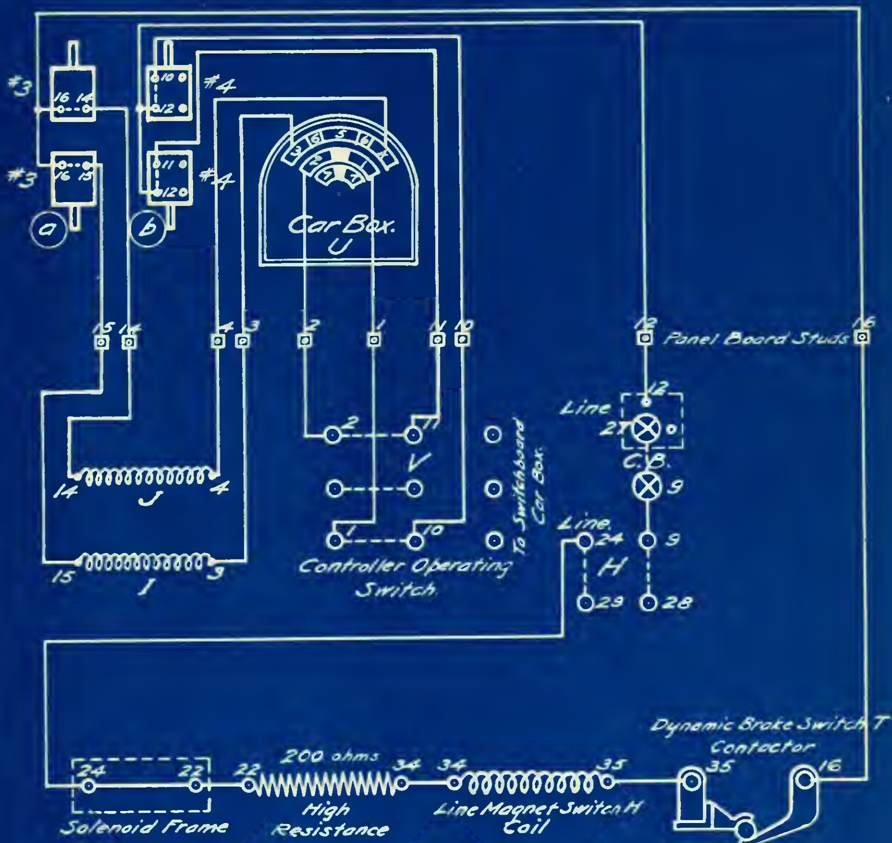

Starting Circuit.

Note.

ⓐ 1st Speed Automatic Trip Switches. (Closed Switches).

ⓑ Brake Automatic Trip Switches. (Closed Switches).

H – Line Magnet Switch.

I – Reversing Magnet Switch I Coil.

J – Reversing Magnet Switch J Coil.

Figure 12.

(16-14), the pole-reversing switch (J) magnet coil (14-4), the car box (U) (4-1), the controller operating switch (V) (1-10), one side of the upper D.P.S.T. solenoid brake limit switch (#4) (10-12), and then to line 12 on the circuit breaker.

When the car switch handle is moved to the left the circuit is completed through the lower first speed automatic trip switch (#3) (16-15) instead of the upper one (16-14) and through the magnet coil of the other pole-reversing switch (I) (15-3), the other side of the car box (U) (3-2), the controller operating switch (V) (2-11), the lower solenoid brake limit switch (#4) (11-12) instead ofthe upper one (10-12), and then to line 12 on the circuit breaker. This reverses the direction of rotation of the motor. The limit switches in this circuit are all closed switches and they are arranged so that when open the magnet coil of the pole reversing switch which would drive the machine farther in the same direction is open circuited.

The auxiliary field magnet circuits are

next to come into action. These circuits are shown in green on the controller wiring diagram (plate A) and diagrammatically in Figure 13.

While the car switch handle is still in the second position to the right, contacts 1, 4, 5, 6, and 7 are connected together. Current flows from line 24 through the auxiliary field switch magnet coils (M) (29-5) and (N) (29-6), to (5 and 6) in the car box (U), these magnet coils being in parallel, out of the car box on (1), through the controller operating switch (V)(1-10), the upper solenoid brake limit switch (#4) (10-12), and then to line 12 on the circuitbreaker.

When the car switch handle is moved to the third position to the right, contacts 1, 4, 6, and 7 are connected together, leaving contact 5 open circuited. This demagnetizes the magnet coil of the auxiliary field switch (M), opening it, thus weakening the field and allowing the motor to come up to second speed.

When the car switch handle is moved to

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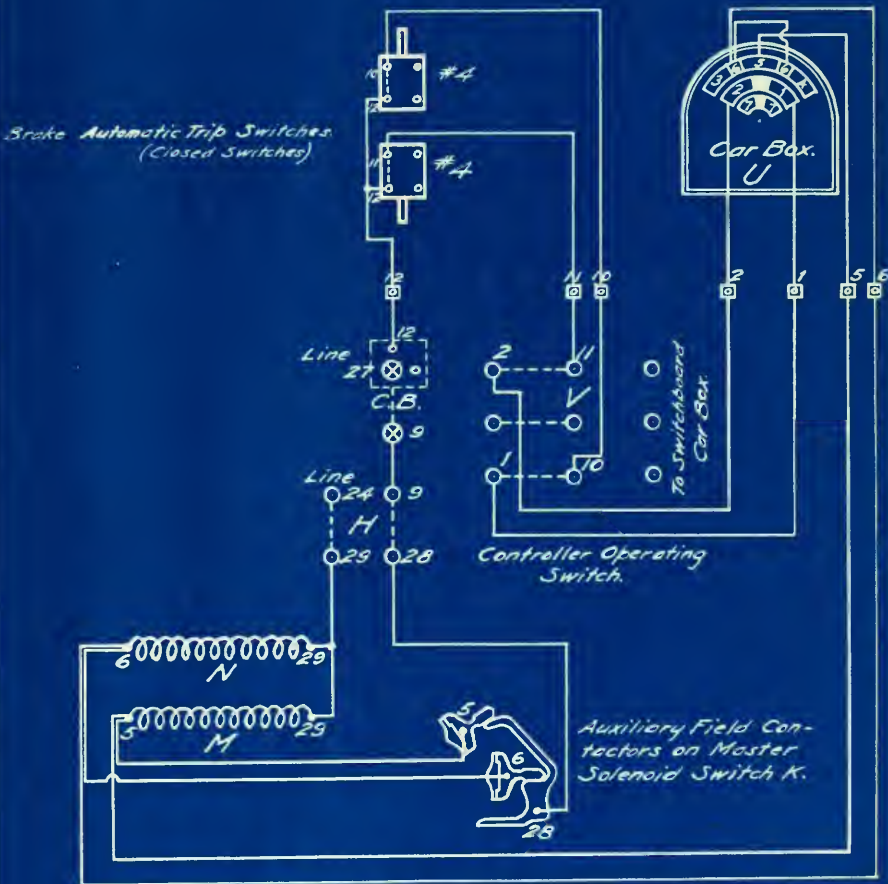

Auxiliary Field Magnet Circuits.

Note
H – Line Magnet Switch.
M – 2nd Speed Magnet Switch Coil.
N – 3rd Speed Magnet Switch Coil.

Figure 13.

the fourth or last position to the right, contacts 1, 4 and 7 are connected together, leaving contact 6 open circuited. This demagnetizes the magnet coil of the auxiliary field switch (N), opening it, thus still further weakening the field and allowing the motor to come up to third or full speed.

When the car switch handle is moved to the left, the current flows through contact 2 instead of contact 1 in the car box (U), from thence to the controller operating switch (V) (2-11), the lower solenoid brake limit switch (#4) (11-12), and then to line 12 in the circuit breaker.

The auxiliary field contactors 5 and 6 on the master solenoid switch (K) are arranged in parallel with the contacts 5 and 6 in the car box (U). These contactors are operated by the master solenoid switch (K) and are not opened until all of the grid switches are cut into circuit. This holds in the auxiliary field switches (M) and (N), thus providing a strong field for starting, and preventing the operator from weakening the field too rapidly. Thus, if the car switch handle is thrown to its extreme position at once, the field

is automatically weakened in the proper manner by the action of these contactors. One or both of the auxiliary field switches may be held in independently of the contactors depending upon the position of the car switch handle, since the car switch and contactors are in parallel.

The auxiliary field is connected as shown in plate A and diagrammatically in Figure 14. When the auxiliary switches (M) and (N) are both in, current flows from line 24, through the switch (N) (42-44), the switch (M) (44-43), the auxiliary field (F-F), and then to line 27 on the circuit breaker.

When the switch (M) is open, current flows from line 24, through the switch (N) (42-44), a resistance of 22.5 ohms (44-43), the auxiliary field (F-F), and then to line 27 on the circuit breaker. This is the first step in the weakening of the auxiliary shunt field and corresponds to the second speed of the motor.

When both switches (M) and (N) are open, current flows from line 24, through a resistance

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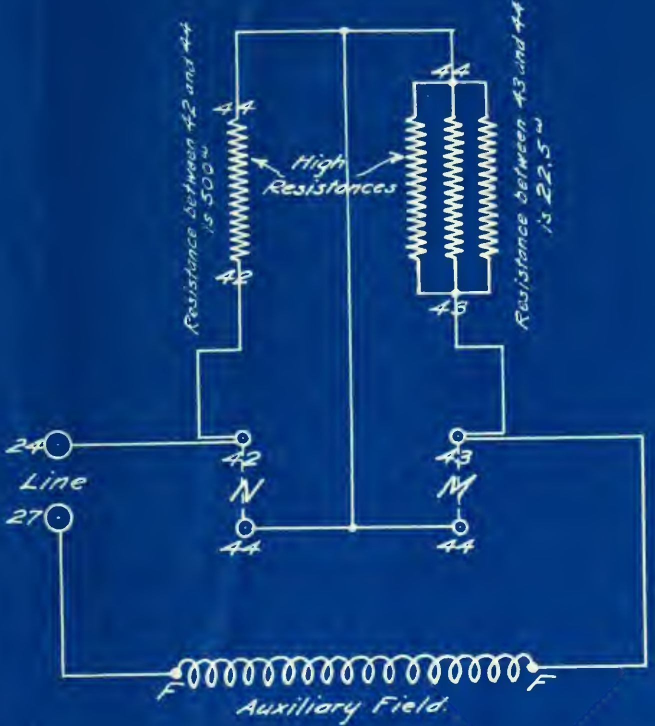

Auxiliary Field Circuit.

Note
M - 2nd Speed Magnet Switch.
N - 3rd Speed Magnet Switch.

Figure 14.

of 500 ohms (42-44), a resistance of 22.5 ohms (44-43), the auxiliary field (F-F), and then to line 27 on the circuit breaker. This is the second or final step in the weakening of the auxiliary shunt field and corresponds to the third or full speed of the motor.

Due to this arrangement of connections, the auxiliary field is never actually out of circuit while the line magnet switch (H) is in, but when switches (M) and (N) are open, the current is so extremely low that the motor is practically running on the permanent field only.

The master solenoid switch (K) coil is connected as shown in plate A directly across the dead side of the line magnet switch (H) (28-29). When the line switch (H) closes, the master solenoid switch coil is energized and operates the solenoid switch (K), rotating a contact finger over a series of copper contacts. This rotating finger is connected to line 24 through the master solenoid frame, and the copper contacts are connected in order to one side of each of the grid switch magnet coils (O, P, Q, and S) (30, 31, 32, and 33 respectively).

The other side of these coils is connected directly to the line switch (H) (28). While contact is still made between contacts 24 and 33, the auxiliary field magnet switch contactors 5 and 6 are operated as explained above.

The armature is connected as shown by the heavy blue lines in plate A, and diagrammatically in Figure 15. Current flows from line 24 through the line magnet switch (H) (24-29), one or the other of the pole-reversing switches (I and J), the armature (A-A), either through the resistance grids and series field which are connected in parallel, or some one of the grid magnet switches (O, P, Q, and S) to bus bar 28, the line magnet switch (H) (28-9), and then through the circuit breaker to line 27.

The arrangement of the series field in parallel with the grids, as shown in Figure 15, is known as the Warner winding. When the entire grid is in circuit, the current divides between the grids and the series field, which gives a strong field for starting. When a section of the grid is

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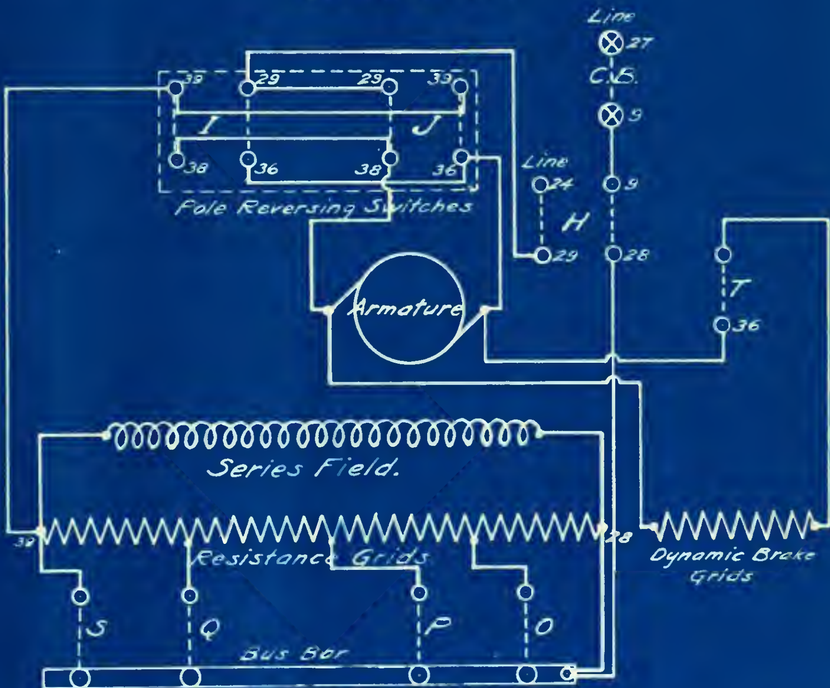


Armature, Warner Winding, and Dynamic Brake Circuits.

Note.

H – Line Magnet Switch.
I – Reversing Magnet Switch.
J – Reversing Magnet Switch.
O – 1st Accelerating Magnet Switch.
P – 2nd Accelerating Magnet Switch.
Q – 3rd Accelerating Magnet Switch.
S – 4th Accelerating Magnet Switch.
T – Dynamic Brake Magnet Switch.

Figure 15.

short-circuited by one of the grid magnet switches (O, P, Q and S), the grid takes a greater percentage of the current and the series field is weakened, until, when the entire grid is short circuited, but little or no current flows through the series field winding. This brings the motor up to first speed, the armature current remaining comparatively constant during the starting operation, the increase in speed being effected by the automatic cutting out of the series field.

The dynamic brake switch (T) magnet coil is connected across the armature through the line magnet switch (H) contactor, as shown in plate A. When the motor is running and the line switch opens the generated voltage of the motor causes a current to flow through the now closed line magnet switch (H) contactor and the dynamic brake switch (T) magnet coil, closing this switch. The closing of this switch short circuits the armature through a small bank of resistance grids.

The circuit breaker limit switches (#5) and the car switch push button are connected in

parallel, as shown in plate A, so that any one can close the circuit through the D.P.S.T. circuit breaker hand switch (X) and the circuit breaker trip coil, thus opening the circuit breaker.

The car lighting system is connected through the D.P.S.T. circuit light hand switch (W) to line 9 on the lower side of the circuit breaker and to line 24.

The particular feature of this elevator is its safety due to its principle. In addition, it is provided with a number of safety devices. The principle eliminates the dangers of pulling the counter-weight over onto the car; running the car up into the overhead work; and throwing the cables off the sheaves.

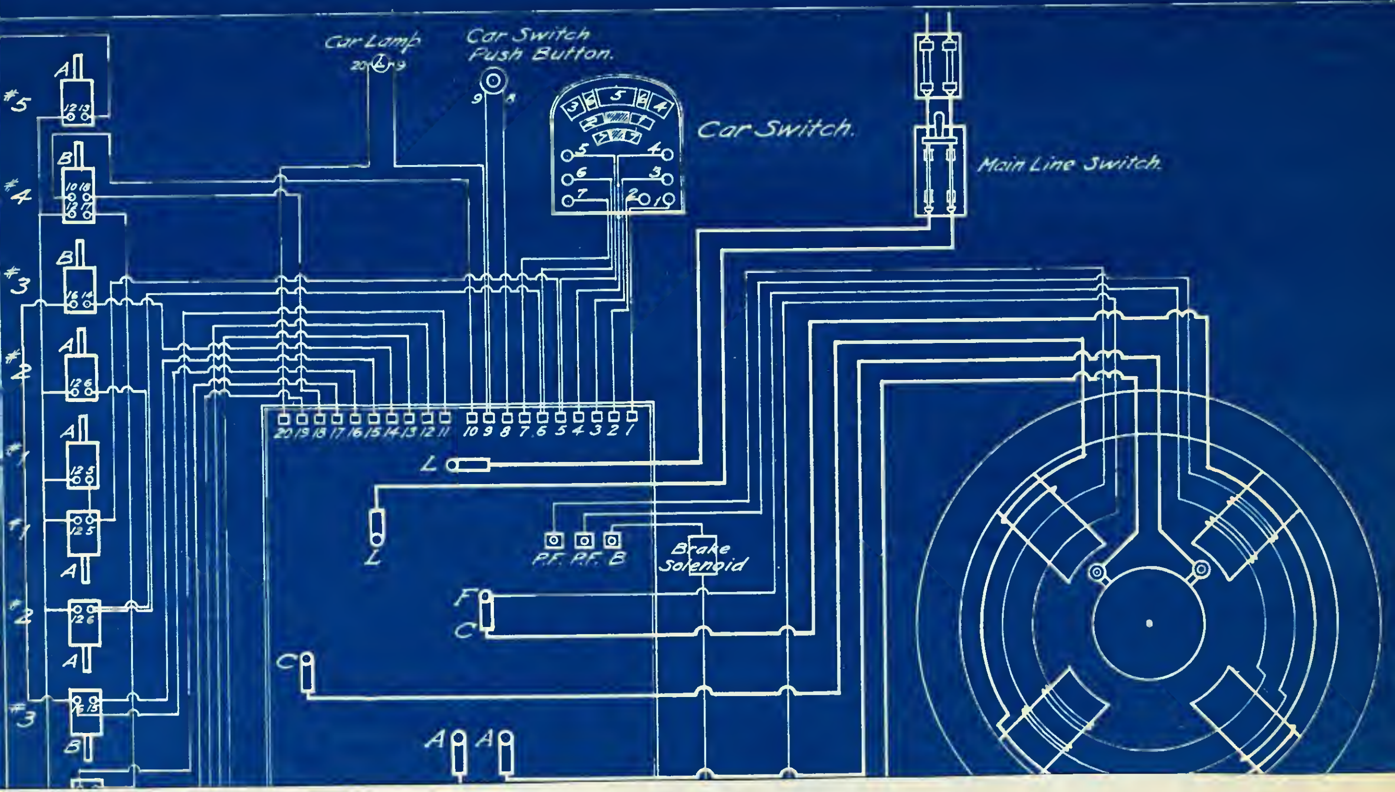
The elimination of these dangers makes the elevator much safer than other electric elevators but, as an additional precaution, the following electrical and safety devices are provided:- a push button in the car which trips the main circuit breaker; a set of five automatic trip switches at both the top and the bottom of the rack; the dynamic brake which has already been described; the

solenoid brake; the main circuit breaker with its overload release and its tripping coil; a slack cable device; an oil spring type of buffer at each end of the machine shaft; and a set of car "dogs" or clamps.

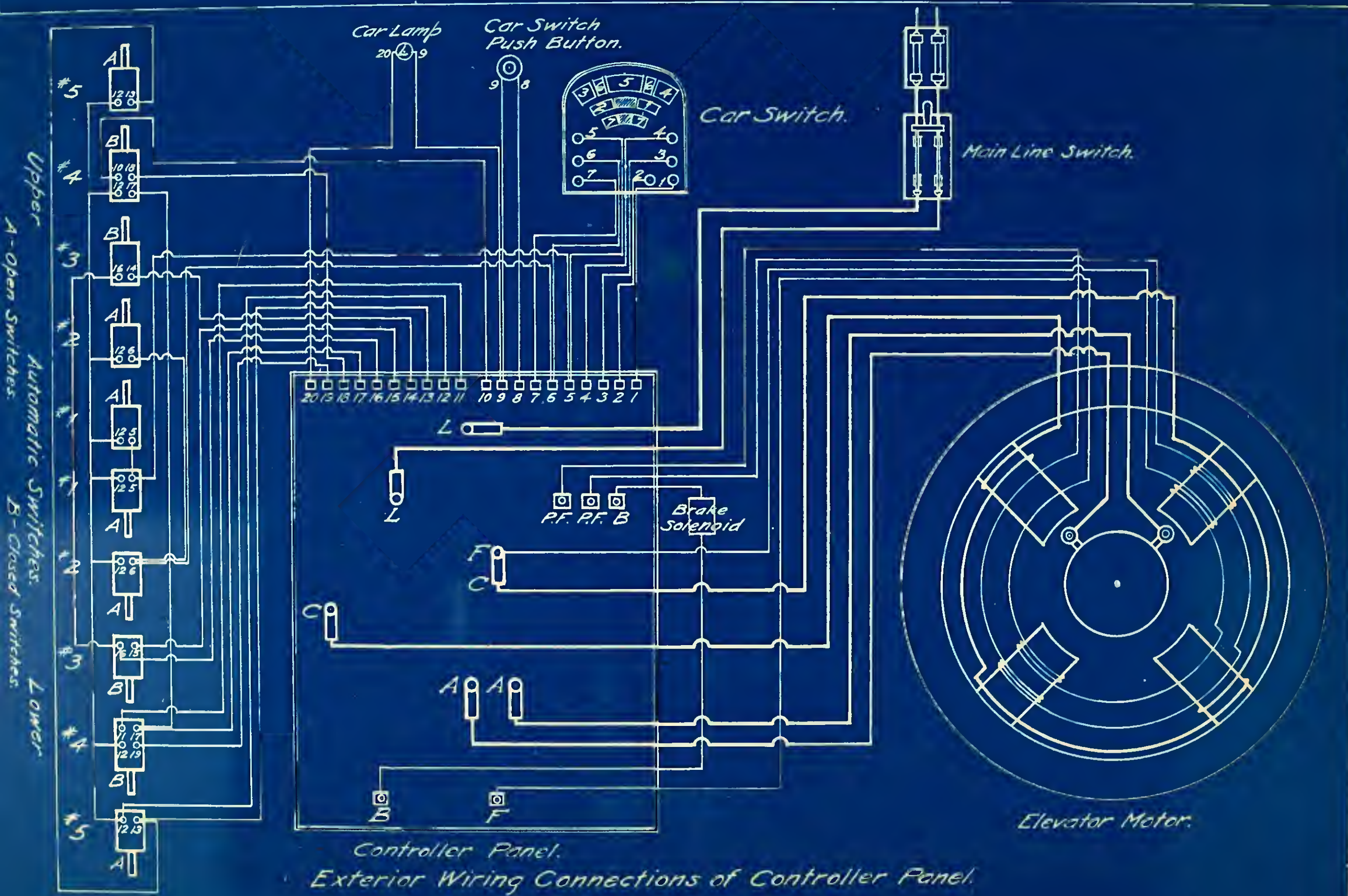
The main circuit breaker is thrown out by the overload release coil when the current is too high and by the tripping coil when the push button, the automatics, or the slack cable device, act.

The five automatic trip switches are set in order on the rack alongside of the trolley so that the third speed of the motor is cut off by the first; the second speed of the motor by the second; the first speed of the motor by the third; the solenoid brake set by the fourth; and the main circuit breaker tripped by the fifth switch.

The solenoid brake uses a powerful solenoid L, shown in Figure 4, to hold the brake shoes off the brake pulley K. When the operator throws on the brake, the current is shut off and the solenoid releases the brake shoes, and a spring



Car Lamp
Car Switch Push Button.
Car Switch.
Main Line Switch.
Brake Solenoid
P.F. P.F. B
#5
#4
#3
#2
#1
#1
#2
#3



Exterior Wiring Connections of Controller Panel.

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Figure 16.

M causes them to grip the brake pulley.

The oil spring type of buffer has a great advantage over ordinary buffers in that there is no recoil. The buffer is shown in section in Figure 9 and is the type used for a lower buffer. The buffer is composed of two cylinders, the lower cylinder being filled with oil, and a tapered plunger runs from the lower chamber through an orifice into the upper. When the machine comes down onto the buffer, the latter is pressed down and makes the orifice through which the oil escapes into the upper chamber smaller and smaller. At the same time the air in the upper chamber is compressed by the depression of the buffer and the rise of the oil, and, when this compression reaches a certain point and when the orifice decreases to such a small size that no oil can enter the upper chamber, the machine is stopped. When the machine moves off, the buffer rises, and the expansion of the air helps force the oil back into the lower chamber.

The slack cable device is a safety device

which trips the main circuit breaker when the cables of the car hang so loose as to touch a roller under the idler sheave I on the machine.

The elevator is provided with the customary car "dogs" or clamps. These clamps are set so that, if the car exceeds a certain predetermined speed, they will engage the guide rails in the elevator shaft and bring the car to an immediate stop. These clamps act so quickly that they are liable to wreck the car and they are not considered a very desirable safety device.

THE TEST.

The testing of the motor of the Mabbs electric elevator presents several difficulties which are not met with in an ordinary test. The motor itself moves up and down on a rack and it was necessary to bring the machine down until it rested on the lower buffer, fasten the car with chain falls at the top of its shaft and then remove the pinions which mesh with the racks. This left the machine resting on the buffer with the armature free to rotate, turning the worm wheels and pinion shafts, but not moving the machine. In making the load test, the solenoid brake was removed entirely to eliminate any friction which might occur there. The motor shaft is vertical and the lower end terminates in a roller thrust bearing which is placed in an oil-tight gear case and immersed in oil. A centrifugal tachometer was used and, as the speed of the pinion shaft was far too low for accurate measurement with this type of instrument, the upper end of the armature shaft had to be used. Accordingly, a bolt with a center in its head was put into the

top of the shaft and the speed measured with the tachometer.

The electrical connections were as shown in Figure 17. The armature and the two field circuits all contained rheostats and ammeters so that all conditions of running might be obtained. The series field was disconnected throughout both tests. Volt meters were connected so that the line and armature voltages could be read, and a circuit breaker was put in one side of the line.

The first operation was to determine whether or not the magneto-motive forces of the two field coils opposed or aided each other in producing flux. Quite a little resistance was cut in on the armature rheostat and a fairly strong current sent through the auxiliary field, thus giving a very strong magneto-motive force. The armature switch was now thrown in and the motor allowed to come up to speed. A weak current was now sent through the auxiliary field and it was noted that the motor speeded up. This showed that the magneto-motive forces opposed each other and so the permanent field terminals were reversed, and, when

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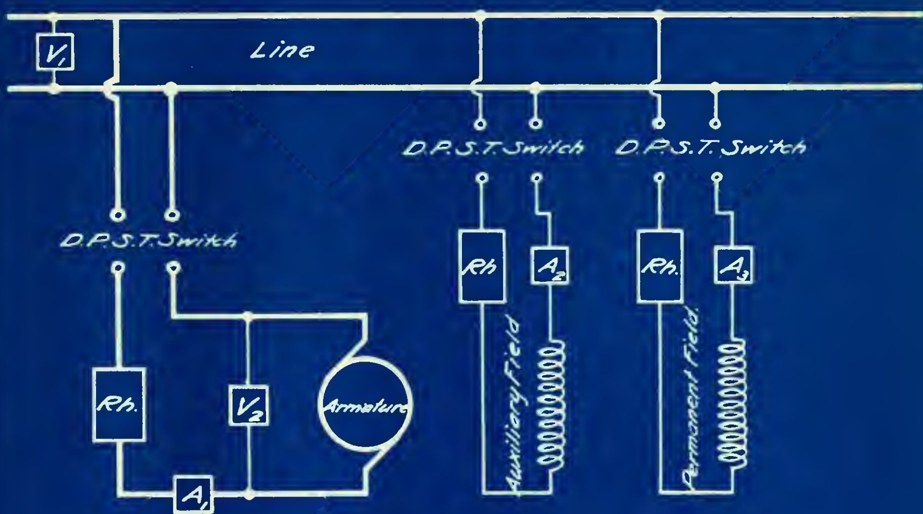

Scheme of Connections
for
No Load and Load Tests

Instrument Numbers

Instrument	No Load Test	Load Test
Armature Ammeter (A_1)	7527	1405
Auxiliary Field Ammeter (A_2)	8424	8424
Permanent Field Ammeter (A_3)	8488	106
Line Voltmeter (V_1)	8668	14830
Armature Voltmeter (V_2)	14830	4320

Figure 17.

the current was sent through again, the motor speeded down showing a strengthening of the resultant field. The currents in the fields were adjusted so that resultant magneto-motive forces from 5000 ampere-turns to 14,000 ampere-turns were obtained and, with the armature rheostat nearly cut out of circuit, readings were taken as shown on the no load data sheet.

The connections for the load tests were the same as those for the no load tests. As the shaft is vertical, the ordinary prony brake rigging could not be used, but a brake was suspended by means of chains and clamped about the brake pulley. The adjustment of the load was accomplished by means of the clamp bolts. The pull on the lever arm could not be measured with an ordinary platform balance because it was exerted in a horizontal direction and so a spring balance was used for accomplishing this purpose. The field magneto-motive forces were varied as in the no load test, readings for various loads being taken for each value of the magneto-motive force.

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NO LOAD TEST DATA SHEET

No.	NI_f	E_L	E_A	I_{PF}	I_F	I_A	Speed	$I_A R_A$	Int. E_A
	amp. turns	v	v	a	a	a	r.p.m.	v	v
1	5000	125	55	2.5	0	25	500	.8	54.2
2			60			25	550	.8	59.2
3			65			25	600	.8	64.2
4			70			25	640	.8	69.2
5			75			25	700	.8	74.2
6			80			25	730	.8	79.2
7			85			25	800	.8	84.2
8			90			25.5	830	.8	89.2
9			95			26	880	.8	94.2
10			100			26	930	.8	99.2
11			105			26.5	980	.8	104.2
12			110			27	1020	.9	109.1
13			120				1110		
14	6000	125	65	0	6.0	25	500	.8	64.2
15			70			25	550	.8	69.2
16			75			25	600	.8	74.2
17			80			25	650	.8	79.2
18			85			25.5	680	.8	84.2
19			90			26	700	.8	89.2
20			95			26.5	750	.8	94.2
21			100			27	800	.9	99.1
22			105			28	840	.9	104.1
23			110			28	870	.9	109.1
24			115			28.5	910	.9	114.1
25			120				950		

No.	NI_f	E_L	E_A	I_{PF}	I_F	I_A	Speed	$I_A R_A$	Int. E_A
	amp. turns	v	v	a	a	a	r.p.m.	v	v
26	8000	125	65	0	8.0	25	400	.8	64.2
27			70			25	450	.8	69.2
28			75			25	500	.8	74.2
29			80			25.5	520	.8	79.2
30			85			26	550	.8	84.2
31			90			26.5	600	.8	89.2
32			95			27	630	.9	94.1
33			100			27	650	.9	99.1
34			105			28	700	.9	104.1
35			110			28.5	730	.9	109.1
36			115			29	750	.9	114.1
37			120				780		
38	10000	125	65	0	10.0	25	380	.8	64.2
39			70			25	400	.8	69.2
40			75			25.5	440	.8	74.2
41			80			25.5	460	.8	79.2
42			85			26	500	.8	84.2
43			90			26.5	520	.8	89.2
44			95			27.5	570	.9	94.1
45			100			27.5	590	.9	99.1
46			105			28	640	.9	104.1
47			110			28.5	670	.9	109.1
48			115			29	700	.9	114.1
49			120			29	710	.9	119.1

No.	NI_f	E_L	E_A	I_{PF}	I_F	I_A	Speed	$I_A R_A$	Int. E_A
	amp. turns	v	v	a	a	a	r.p.m.	v	v
50	12000	125	65	2.5	7.0	25	350	.8	64.2
51			70			25.5	390	.8	69.2
52			75			25.5	400	.8	74.2
53			80			26	430	.8	79.2
54			85			26.5	460	.8	84.2
55			90			27	500	.9	89.1
56			95			27	520	.9	94.1
57			100			27.5	560	.9	99.1
58			105			28	580	.9	104.1
59			110			28.5	610	.9	109.1
60			115			29	650	.9	114.1
61			120			29.5	680	.9	119.1
62	14000	125	70	2.5	9.0	25	350	.8	69.2
63			75			25.5	390	.8	74.2
64			80			26	410	.8	79.2
65			85			27	450	.9	84.1
66			90			27.5	480	.9	89.1
67			95			27.5	500	.9	94.1
68			100			28	530	.9	99.1
69			105			28.5	560	.9	104.1
70			110			29	590	.9	109.1
71			115			30	630	1.0	114.0
72			120			31	650	1.0	119.0

Number of turns in permanent field — 2000
Number of turns in auxiliary field — 1000
R_A = .0318 ohm.

Sample Calculation.

No Load Test.

The following data was obtained either directly from run #59 on the no load test or from the Northern Electric Manufacturing Company:

Number of turns in permanent field ---- 2000

Number of turns in auxiliary field ---- 1000

$I_{pf} = 2.5$ amp. $I_f = 7.0$ amp.

$E_l = 125$ volts $E_a = 110$ volts

$I_a = 28.5$ amp. $R_a = .0318$ ohm

Speed = 610 R.P.M.

The following calculations are required to obtain the necessary results. The first calculation is the determination of the strength of the field in ampere terms.

No. of amp.-turns $= N_{pf}I_{pf} + N_fI_f$

$= = 2000 \times 2.5 + 1000 \times 7.0$

$= 5000 + 7000$

$= 12{,}000$

The second calculation is a determination of the I.R. drop in the armature.

Drop $= I_aR_a = 28.5 \times .0318 = .9$ volt

The counter E.M.F. then is: $E_a - I_aR_a = 110 - .9$

$= 109.1$ volts

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LOAD TEST DATA SHEET

No.	NI_F	E_L	E_A	I_{PF}	I_F	I_A	Brake Load	Speed.	Torque	Output Brake HP.	$E_A I_A$	$I_F^2 R_F$	Input Total Watts	Input Elec. HP.	Com. Eff.	$I_A^2 R_A$	Elec. Output.	Elec. Eff.	Elec. Output.	Mech. Eff.
	amp. turns	v	v	a	a	a	lbs.	r.p.m.	lbs. ft.	HP	w	w	w	HP	%	w	w	%	HP	%
1	5000	125	110.5	2.5	0	95	14	1000	45.5	8.67	10500	P.F. = 248 A.F. = 0 Total = 248	10748	14.40	60.2	287	10213	95.0	13.70	63.3
2			106.5			130	24	910	78	13.52	13840		14088	18.88	71.6	540	13300	96.0	17.82	75.8
3			103			180	38.4	840	124.5	19.91	18550		18798	25.20	79.0	1035	17515	93.3	23.50	84.8
4			102			245	57	800	185	28.20	25000		25248	33.80	83.4	1915	23085	91.4	30.95	91.1
5			98			320	74.4	790	242	36.45	31350		31598	42.40	86.0	3260	28090	88.9	37.65	96.8
6						240			176.1											
7	6000	125	104	0	6.0	90	13	890	42.2	7.15	9360	P.F. = 0 A.F. = 345 Total = 345	9705	13.00	55.0	258	9102	93.8	12.20	58.6
8			98			120	21	830	68.2	10.78	11770		12115	16.25	66.3	460	11310	96.2	15.17	71.0
9			97.5			170	36	770	117	17.15	16570		16915	22.70	75.6	920	15650	94.5	21.00	81.7
10			95			245	58	720	188.3	25.80	23250		23595	31.60	81.8	1915	21335	90.4	28.60	90.2
11			92.5			290	69.6	710	226	30.50	26800		27145	36.40	83.9	2680	24120	88.8	32.30	94.5
12			90.5			345	83	700	269.5	35.90	31250		31595	42.30	84.9	3800	27450	86.8	36.95	97.5
13						240			179											
14	8000	125	108.5	2.5	3.0	60	7.2	810	23.4	3.67	6500	P.F. = 248 A.F. = 87 Total = 335	6835	9.16	39.4	115	6385	93.5	8.56	42.2
15			108.5			90	17.6	750	57.1	8.16	9760		10095	13.48	60.6	258	9502	94.1	12.75	64.1
16			104.5			160	40	680	130	16.83	16720		17055	22.85	73.7	818	15902	93.3	21.30	79.1
17			100.5			215	58.4	650	189.5	23.50	21600		21935	29.60	79.3	1470	20130	91.7	27.00	79.7
18			96.5			275	77	620	250	29.50	26500		26835	35.95	82.1	2410	24090	89.8	32.30	91.4
19			94.5			345	99.4	600	323	36.85	32600		32935	44.10	83.6	3800	28800	87.5	38.60	95.5
20						240			214											
21	10000	125	110.5	2.5	5.0	45	3.6	750	11.7	1.67	4970	P.F. = 248 A.F. = 242 Total = 490	5460	7.32	22.8	65	4905	89.8	6.58	25.4
22			110			75	14	710	45.5	6.15	8250		8740	11.72	52.4	179	8071	92.3	10.82	56.8
23			109.5			110	26	670	84.5	10.80	12050		12540	16.82	64.2	385	11665	92.9	15.62	69.1
24			108			165	47.4	630	154	18.50	17820		18310	24.55	75.4	868	16952	92.5	22.73	81.5
25			105.5			265	86	580	279.5	30.90	27950		28440	38.10	81.1	2240	25710	90.4	34.45	89.7
26			99			320	103	560	334.5	35.70	31700		32190	43.15	82.6	3260	28440	88.5	38.15	93.5
27						240			245											
28	12000	125	110	2.5	7.0	60	8.8	700	28.6	3.81	6600	P.F. = 248 A.F. = 475 Total = 723	7323	9.82	38.8	115	6485	88.5	8.70	43.8
29			110			70	13	690	42.2	5.55	7700		8423	11.30	49.1	156	7544	89.6	10.11	54.9
30			109.5			115	29.6	640	96.2	11.73	12600		13323	17.85	65.7	421	12179	91.3	16.33	71.8
31			107.5			165	50.2	600	163	19.25	17730		18453	24.75	75.2	868	16862	91.3	22.55	85.3
32			106			215	71	570	230.5	25.00	22800		23523	31.50	79.3	1470	21330	90.8	28.60	87.4
33			102.5			275	93.6	550	304	31.90	28200		28923	38.75	82.3	2410	25790	89.2	34.60	92.2
34						240			261											
35	14000	125	110.5	2.5	9.0	65	12	660	39	4.90	7180	P.F. = 248 A.F. = 785 Total = 1033	8213	11.00	44.5	135	7045	85.8	9.44	51.9
36			108			155	48.6	570	158	17.15	16750		17783	23.85	72.0	765	15985	89.3	21.40	80.2
37			105.5			215	76.4	530	248	25.05	22650		23683	31.75	78.8	1470	21180	89.4	28.40	88.2
38			98.5			255	90	510	292.5	28.60	25100		26133	35.05	81.0	2070	23030	88.2	30.90	92.5
39			95.5			320	117	480	380	34.70	30600		31633	42.40	81.9	3260	27340	86.4	36.65	94.7
40						240			276											

Brake lever arm = 39" = 3.25'
R_F = 9.7 ohms.

R_A = .0318 ohm.
R_{PF} = 39.7 ohms.

In order to complete the speed field curve at 120 volts, it was necessary to make use of the relation of speed and E.M.F. and determine these points for fields of 5000, 6000 and 8000 ampere turns. The calculation of the speed at a field of 5000 turns, for example, was made as follows:

When E_a = 110 volts, speed = 1020 R.P.M.

Since the speed varies directly as the counter E.M.F., therefore, when E = 120 volts

$$\text{Speed} = \frac{120}{110} \times 1020 = 1110 \text{ R.P.M.}$$

Load Test.

The following data was obtained either diectly from run #19 on the load test or from the Northern Electric Manufacturing Company:

Number of turns in permanent field ---- 2000

Number of turns in auxiliary field ---- 1000

R_a = .0318 ohm; R_{pf} = 39.7 ohms; R_f = 9.7 ohms

E_1 = 125 volts E_a = 94.5 volts

I_{pf} = 2.5 amp.; I_f = 3.0 amp.; I_a = 345 amp.

Brake load = W = 99.4 lbs.

Speed = S = 600 R.P.M.

Brake lever arm = l = 39" = 3.25 ft.

No. of amp.- turns = $N_{pf}I_{pf} + N_fI_f$ =

$= 2000 \times 2.5 + 1000 \times 3.0$

$= 8000$

Torque = W l = 99.4 x 3.25 = 323 lbs. ft.

$$\text{Brake output (H.P.)} = \frac{2\pi S\ T}{33000}$$

$$= \frac{2\pi \times 600 \times 323}{33000}$$

$= 36.85$ H.P.

Power supplied to armature = E_aI_a

$= 94.5 \times 345$

$= 32{,}600$ watts

Permanent field copper loss = $I_{pf}^2 R_{pf}$

$= (2.5)^2 \times 39.7$

$= 248$ watts

Auxiliary field copper loss = $I_f^2 R_f$

$= (3.0)^2 \times 9.7$

$= 87$ watts

Total field copper loss = 248 + 87 = 335 watts

Total input (watts) = 32,600 + 335 = 32,935 watts

$$\text{Total input (Elec. H.P.)} = \frac{32935}{746} = 44.1 \text{ H.P.}$$

$$\text{Commercial efficiency} = \frac{\text{Output (Brake H.P.)}}{\text{Input (Elec.H.P.)}}$$

$$= \frac{36.85}{44.1} \times 100$$

$$= 83.6\ \%$$

$$\text{Armature copper loss} = I_a^2 R_a = (345)^2 \times .0318$$

$$= 3800 \text{ watts}$$

The electrical output (watts) = Input - Total copper losses = $(E_a I_a + I_{pf}^2 R_{pf} + I_f^2 R_f) - I_a^2 R_a -$

$$- I_{pf}^2 R_{pf} - I_f^2 R_f$$

$$= E_a I_a - I_a^2 R_a = 32600 - 3800$$

$$= 28800 \text{ watts}$$

$$\text{Electrical efficiency} = \frac{\text{Output}}{\text{Input}}$$

$$= \frac{E_a I_a - I_a^2 R_a}{E_a I_a + I_{pf}^2 R_{pf} + I_f^2 R_f}$$

$$= \frac{28800}{32935} \times 100$$

$$= 87.5\%$$

Electrical output (H.P.) = Mechanical input

$$= \frac{28800}{746} = 38.6 \text{ H.P.}$$

$$\text{Mechanical efficiency} = \frac{\text{Brake output}}{\text{Mechanical input}}$$

$$= \frac{36.85}{38.60} \times 100$$

$$= 95.5\ \%$$

In order to obtain points for a torque - field curve at full load (240 amperes at 120 volts), the readings on either side of 240 amperes were taken and the torque found by interpolation in the following manner.

When I = 275 amp., torque = 250

" I = 215 amp., torque = 189.5

Subtracting:

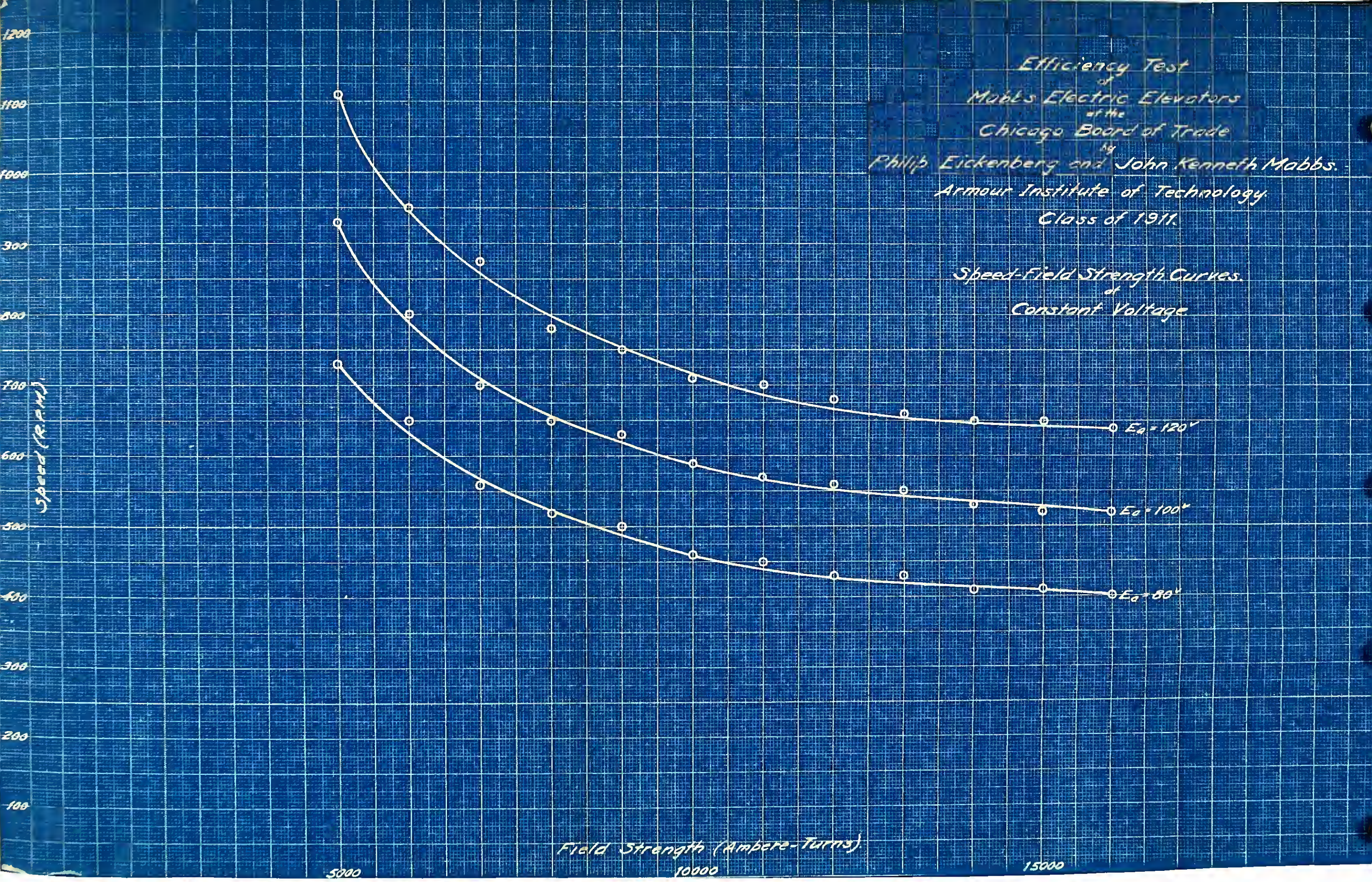
I = 60 amp., torque = 70.5

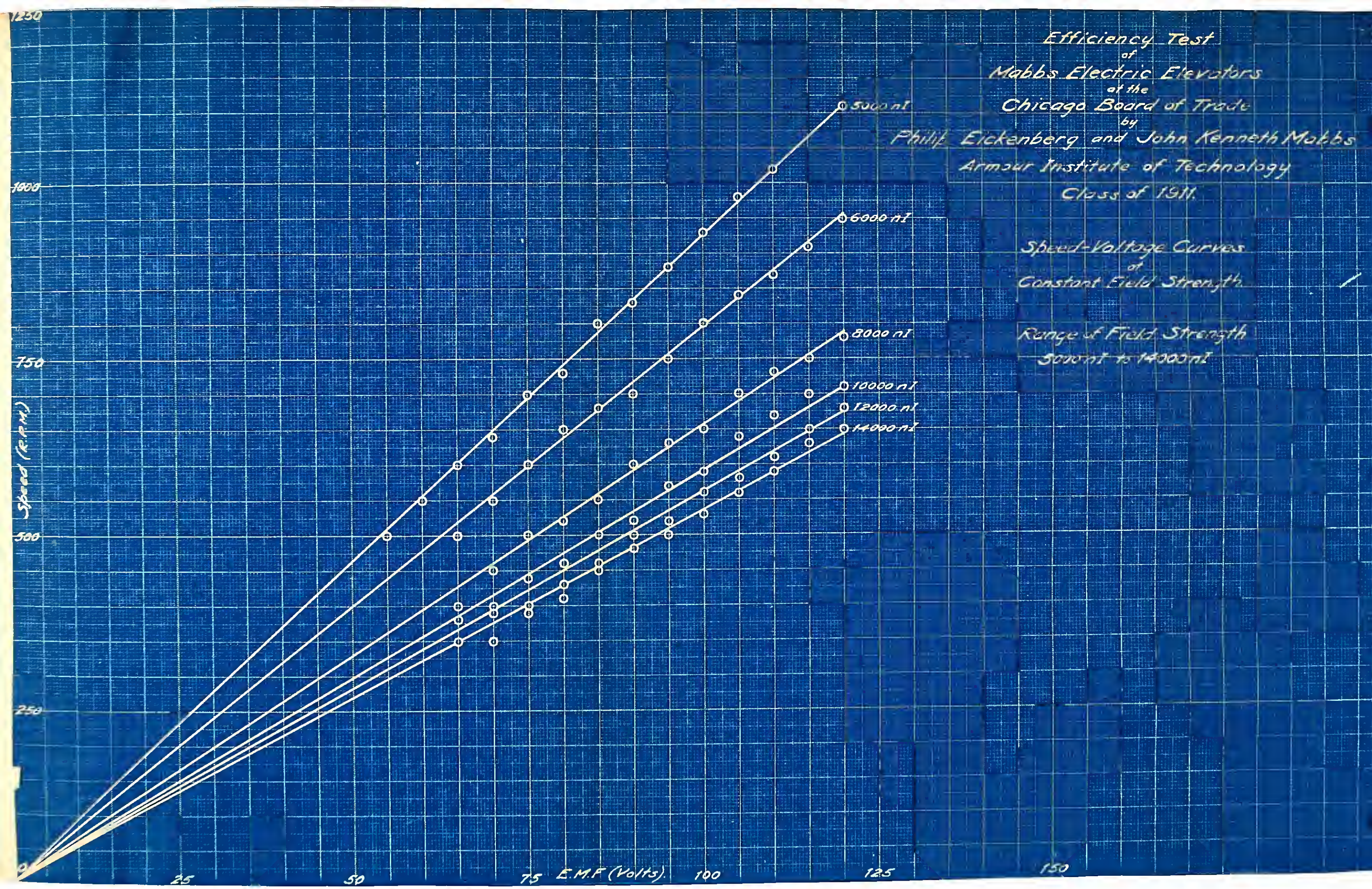
The difference between 240 and 215 being 25:

$$\frac{25}{60} \times 70.5 = 24.5$$

Therefore: Torque (at 240 amp. and 120 volts)

= 189.5 + 24.5 = 214 lbs. ft.


Efficiency Test
of
Mabbs Electric Elevators
at the
Chicago Board of Trade
by
Philip Eickenberg and John Kenneth Mabbs.
Armour Institute of Technology.
Class of 1911.
Speed-Field Strength Curves.
at
Constant Voltage
1200
1100
1000
900
800
700
600
500
400
300
200
100
Speed (R.P.M.)
$E_a = 120^V$
$E_a = 100^V$
$E_a = 80^V$
Field Strength (Ampere-Turns)
5000
10000
15000


Efficiency Test
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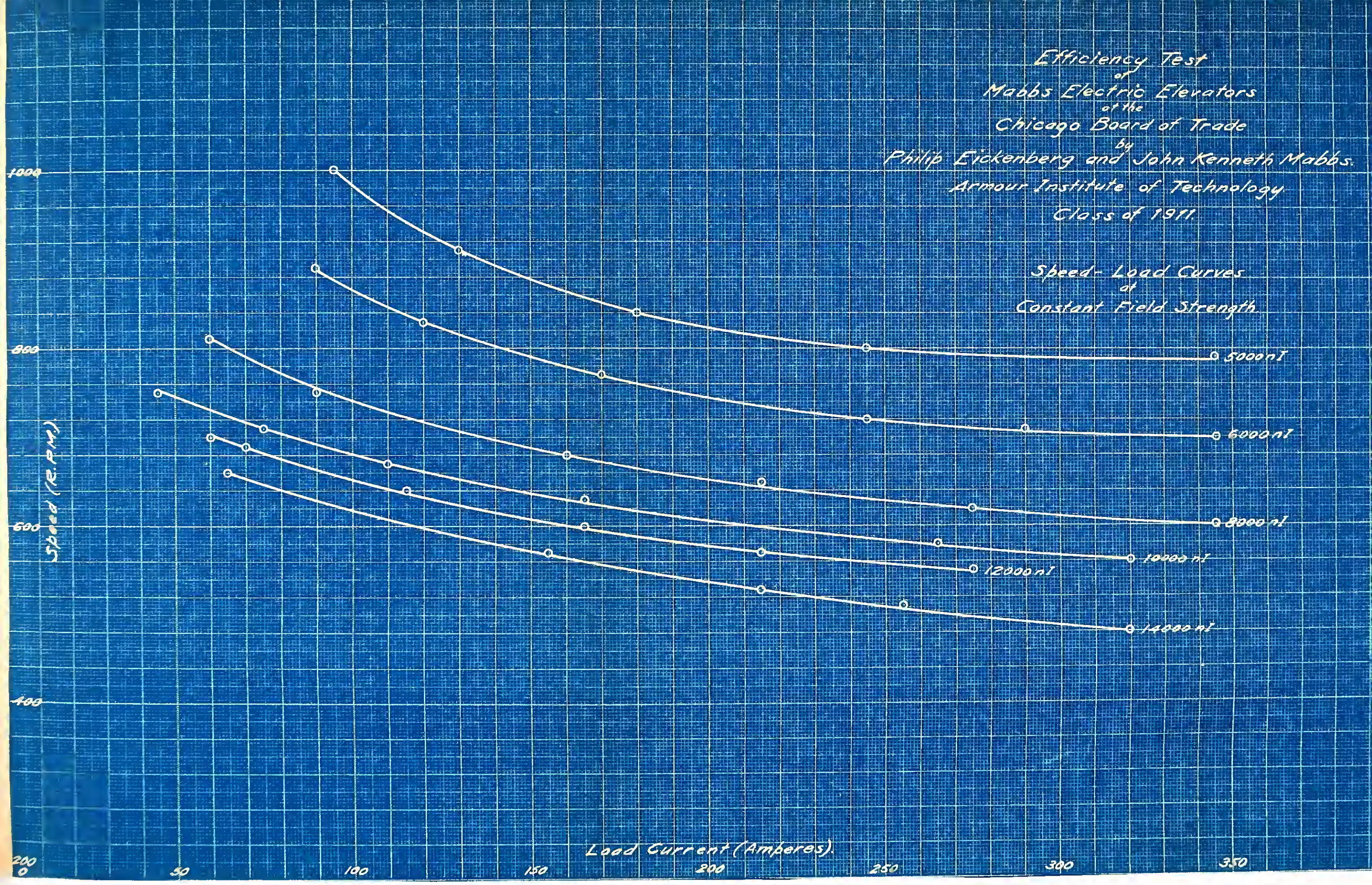
Class of 1911.
Speed-Voltage Curves
at
Constant Field Strength
Range of Field Strength
5000 nI to 14000 nI
5000 nI
6000 nI
8000 nI
10000 nI
12000 nI
14000 nI
Speed (R.P.M.)
E.M.F (Volts)
1250
1000
750
500
250
0
25
50
75
100
125
150



Efficiency Test
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Chicago Board of Trade
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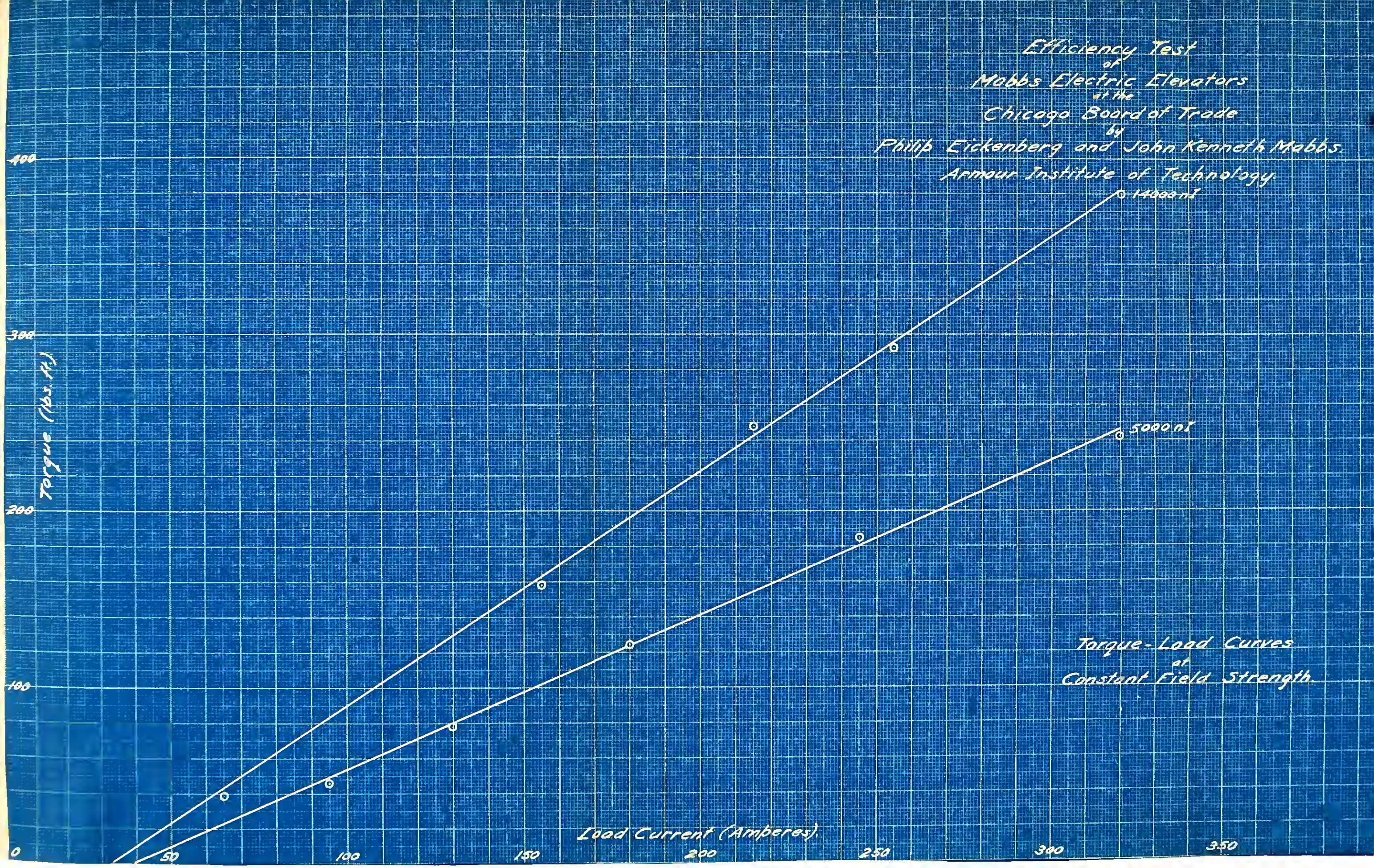
Armour Institute of Technology
Class of 1911.
Speed-Load Curves
of
Constant Field Strength
Speed (R.P.M.)
Load Current (Amperes)
1000
800
600
400
200
0
50
100
150
200
250
300
350
5000 nI
6000 nI
8000 nI
10000 nI
12000 nI
14000 nI


Efficiency Test
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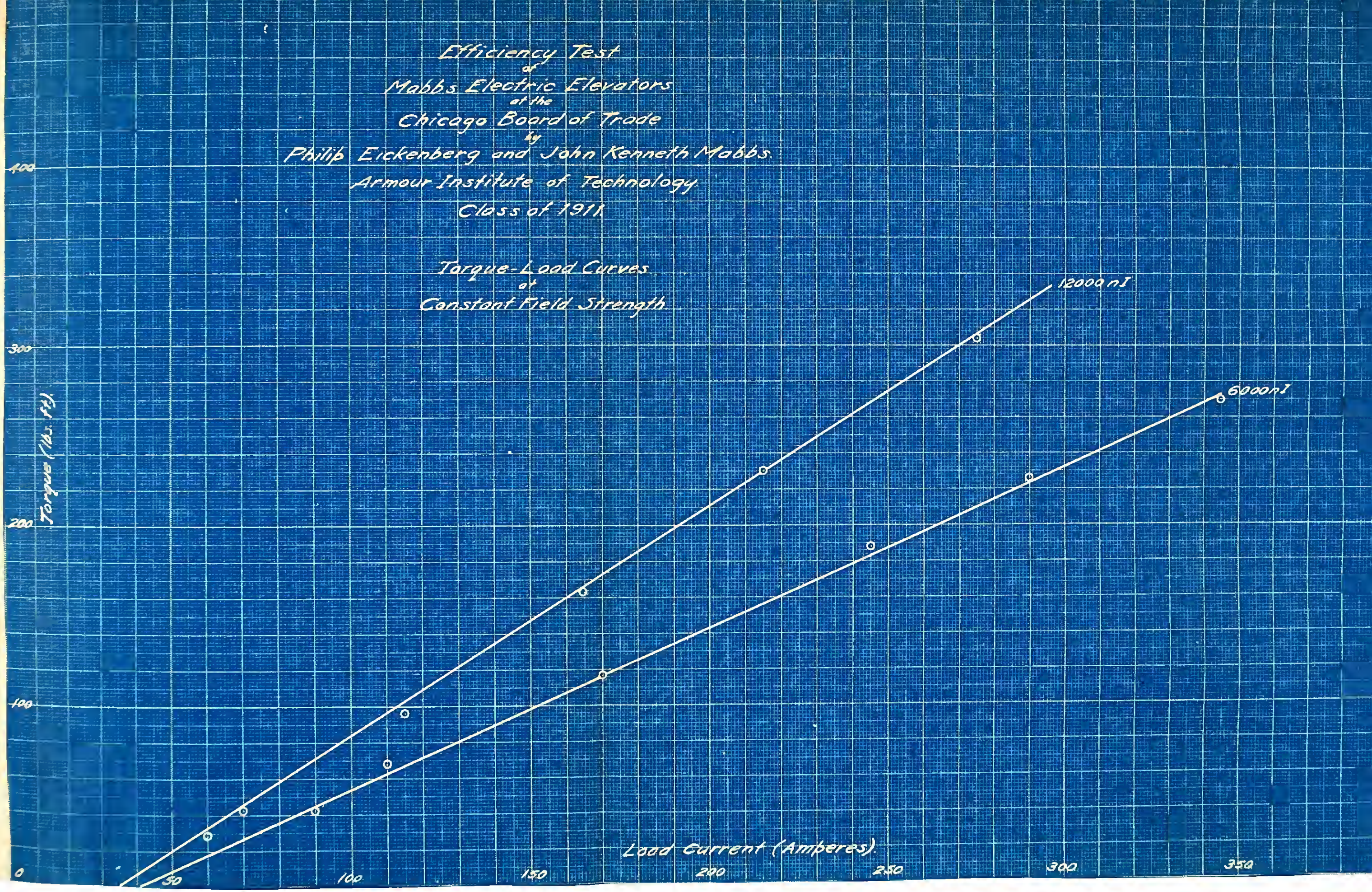
Armour Institute of Technology.
14000 n I
5000 n I
Torque-Load Curves
at
Constant Field Strength.
Torque (lbs. ft.)
400
300
200
100
0
50
100
150
200
250
300
350
Load Current (Amperes)

[illegible]


Efficiency Test
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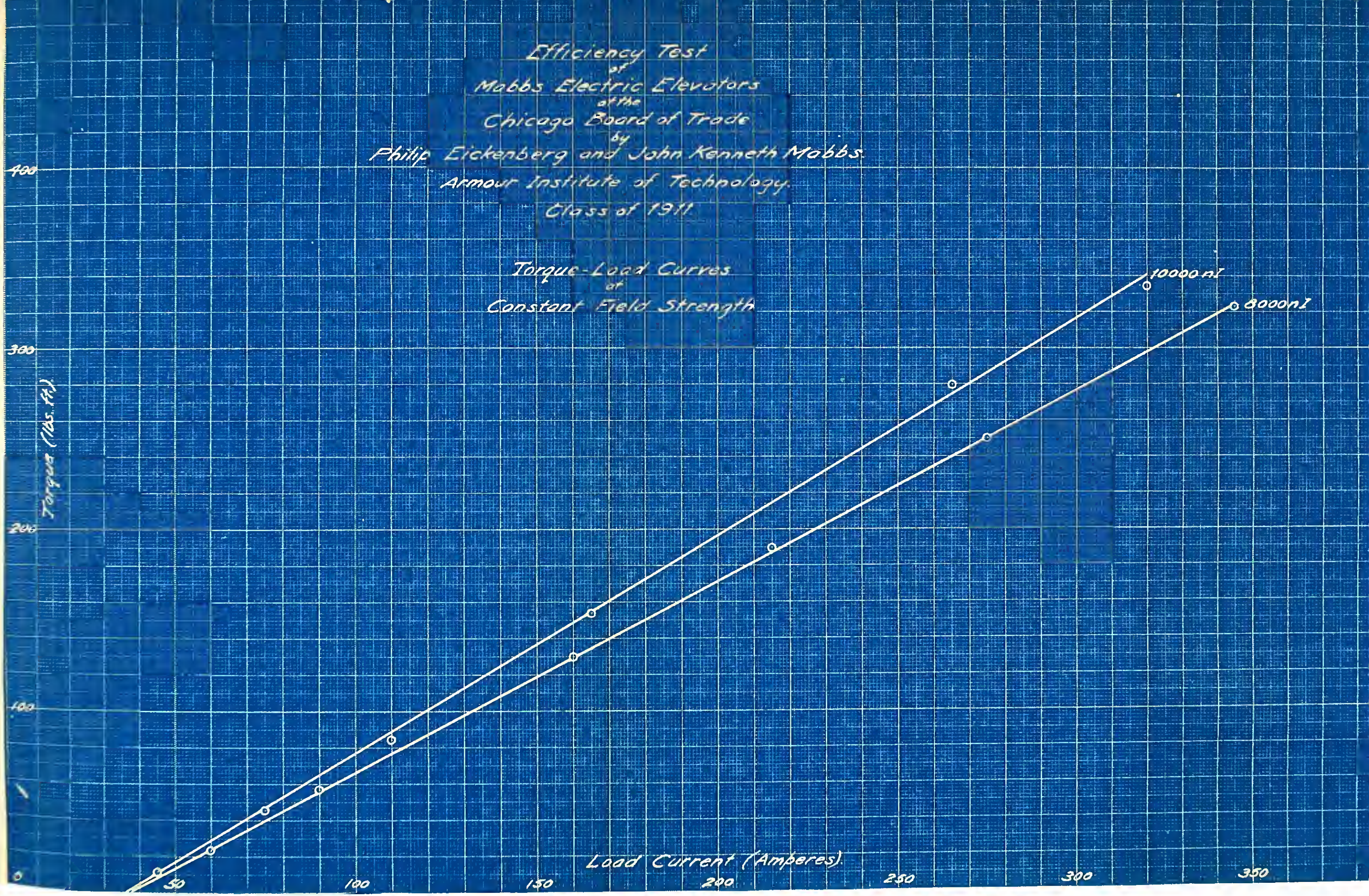
Class of 1911
Torque-Load Curves
at
Constant Field Strength
12000 nI
6000 nI
Torque (lbs. ft.)
400
300
200
100
0
Load Current (Amperes)
50
100
150
200
250
300
350


Efficiency Test
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Chicago Board of Trade
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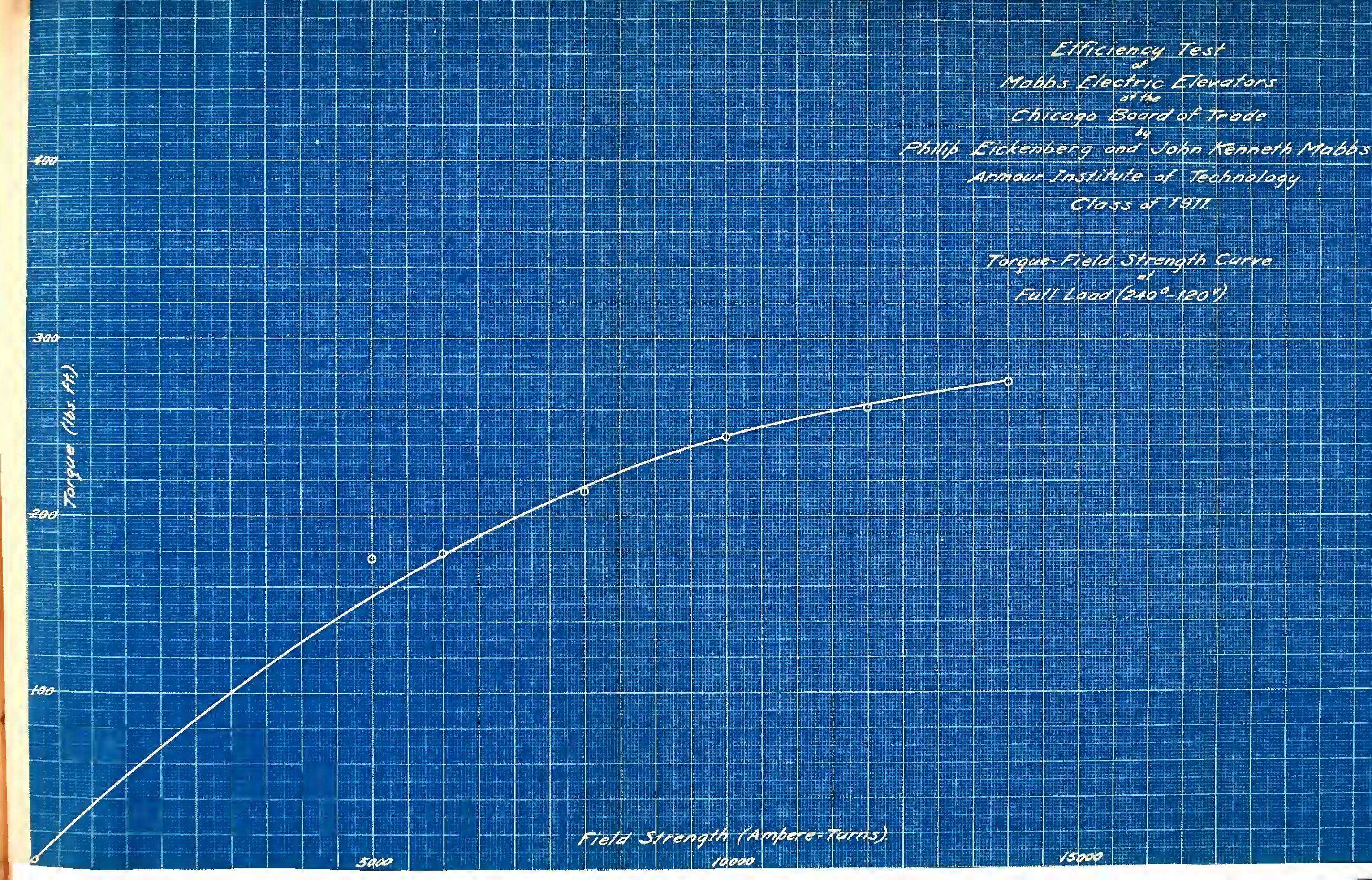
Armour Institute of Technology
Class of 1911
Torque-Load Curves
at
Constant Field Strength
10000 nI
8000 nI
Torque (lbs. ft.)
400
300
200
100
0
Load Current (Amperes)
50
100
150
200
250
300
350


Efficiency Test
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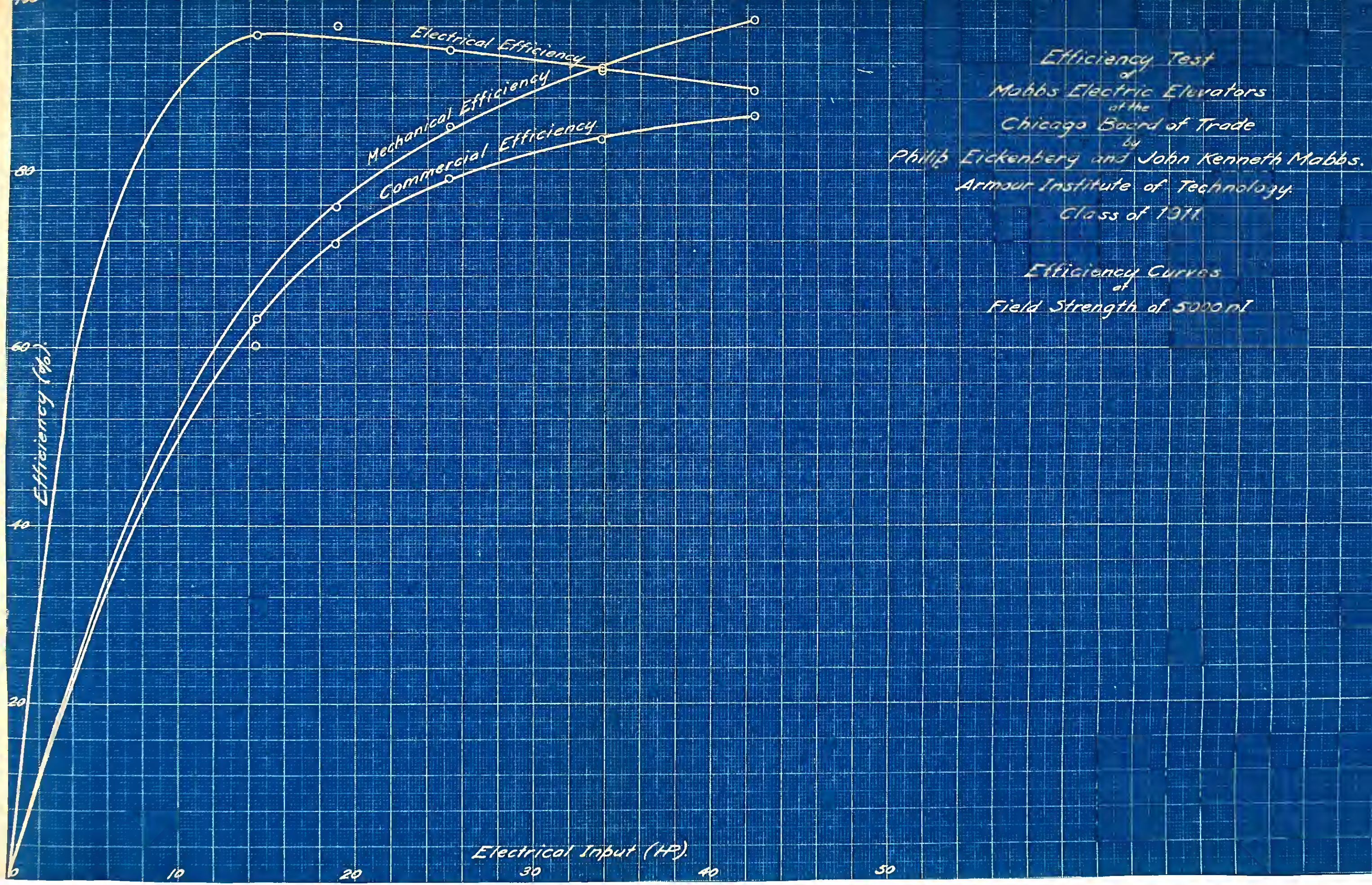
Class of 1911.
Torque-Field Strength Curve
at
Full Load (240°-120°).
400
300
200
100
Torque (lbs. ft.)
Field Strength (Ampere-Turns).
5000
10000
15000


Efficiency Test
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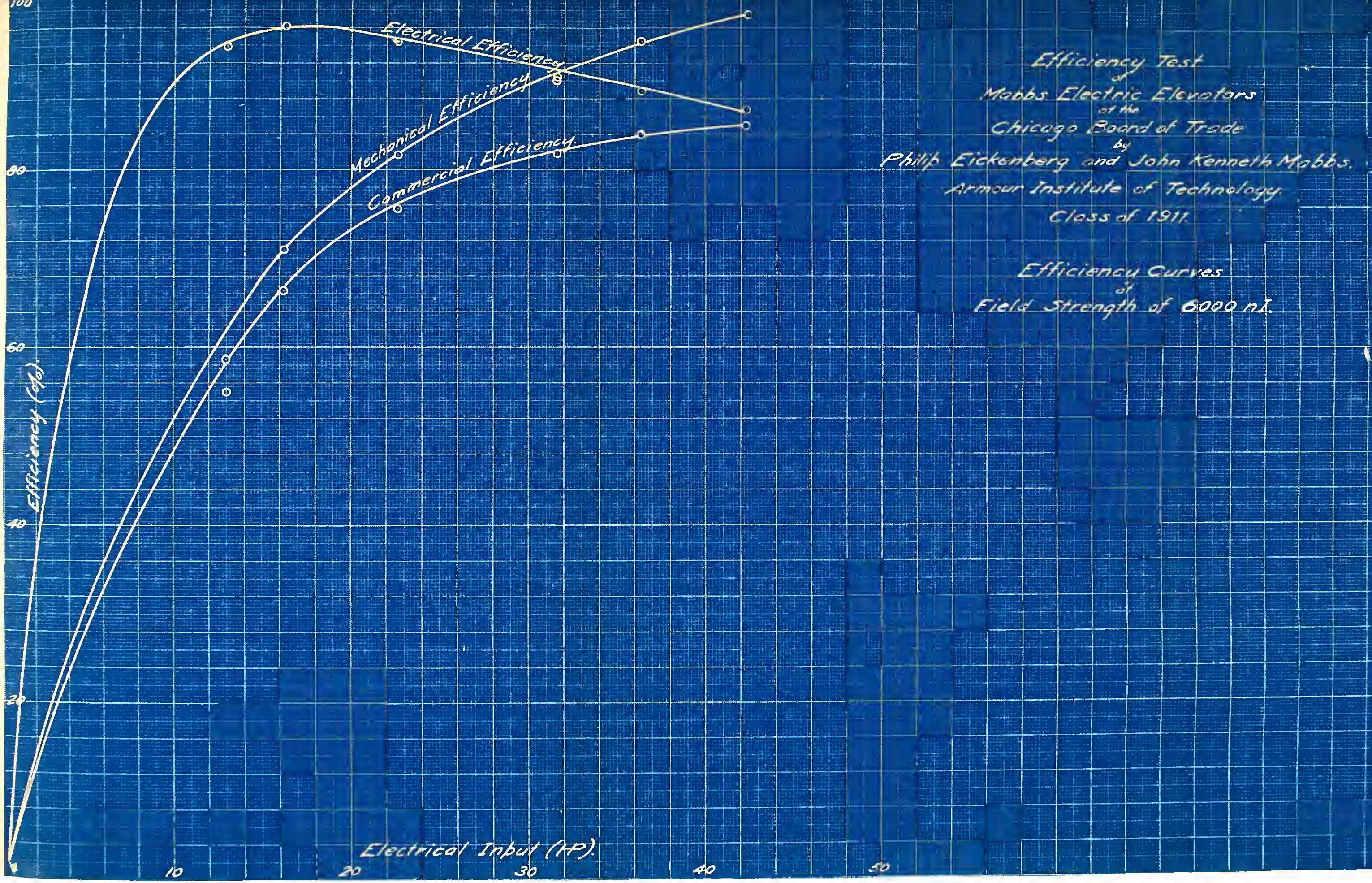
Class of 1911.
Efficiency Curves
at
Field Strength of 5000 nI
Electrical Efficiency
Mechanical Efficiency
Commercial Efficiency
Efficiency (%).
Electrical Input (HP).
0
10
20
30
40
50
20
40
60
80


Efficiency Test
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Chicago Board of Trade
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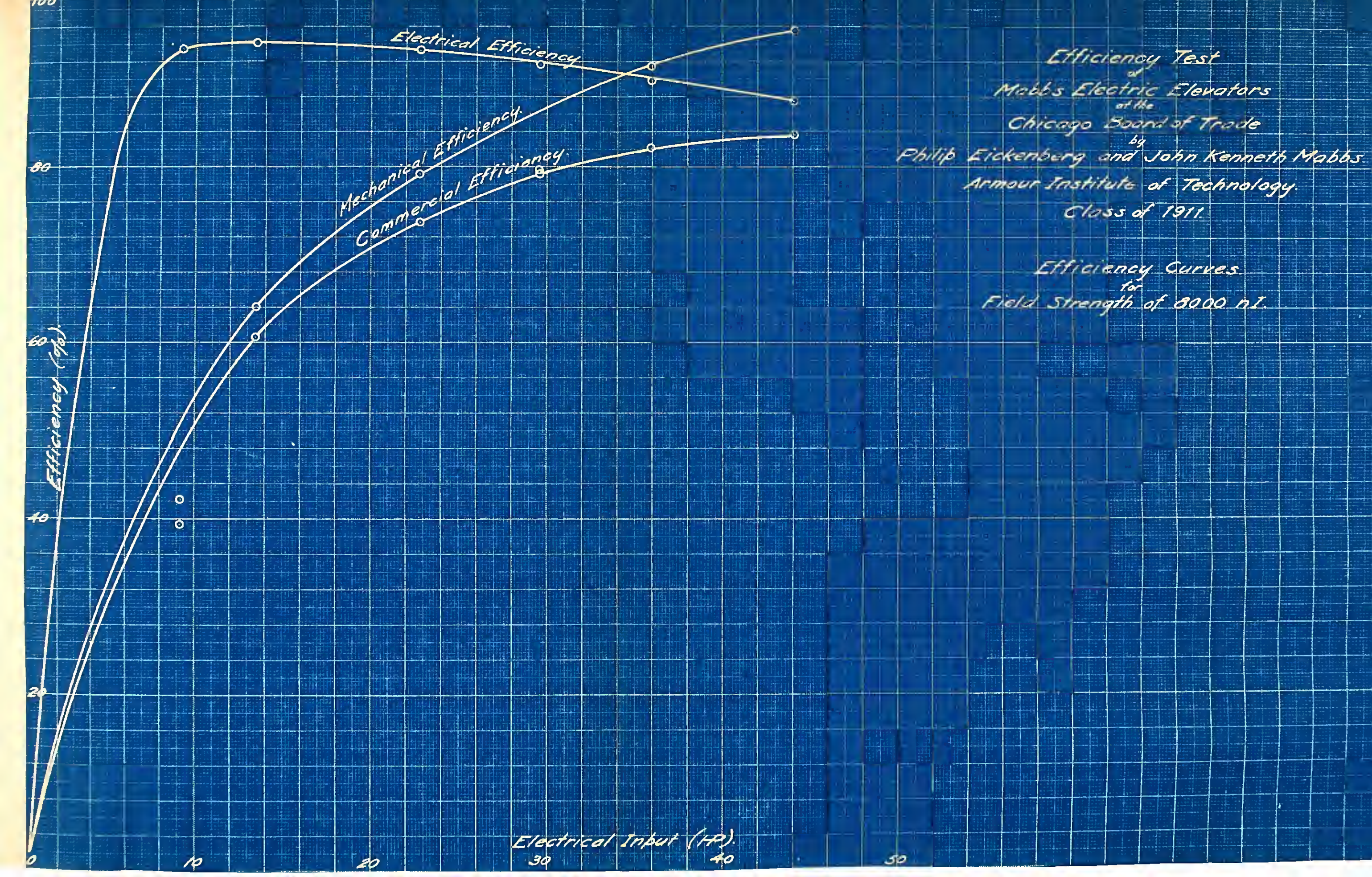
Efficiency Curves
of
Field Strength of 6000 nI.
Electrical Efficiency
Mechanical Efficiency
Commercial Efficiency
Efficiency (%).
Electrical Input (HP).
100
80
60
40
20
10
20
30
40
50


Efficiency Test
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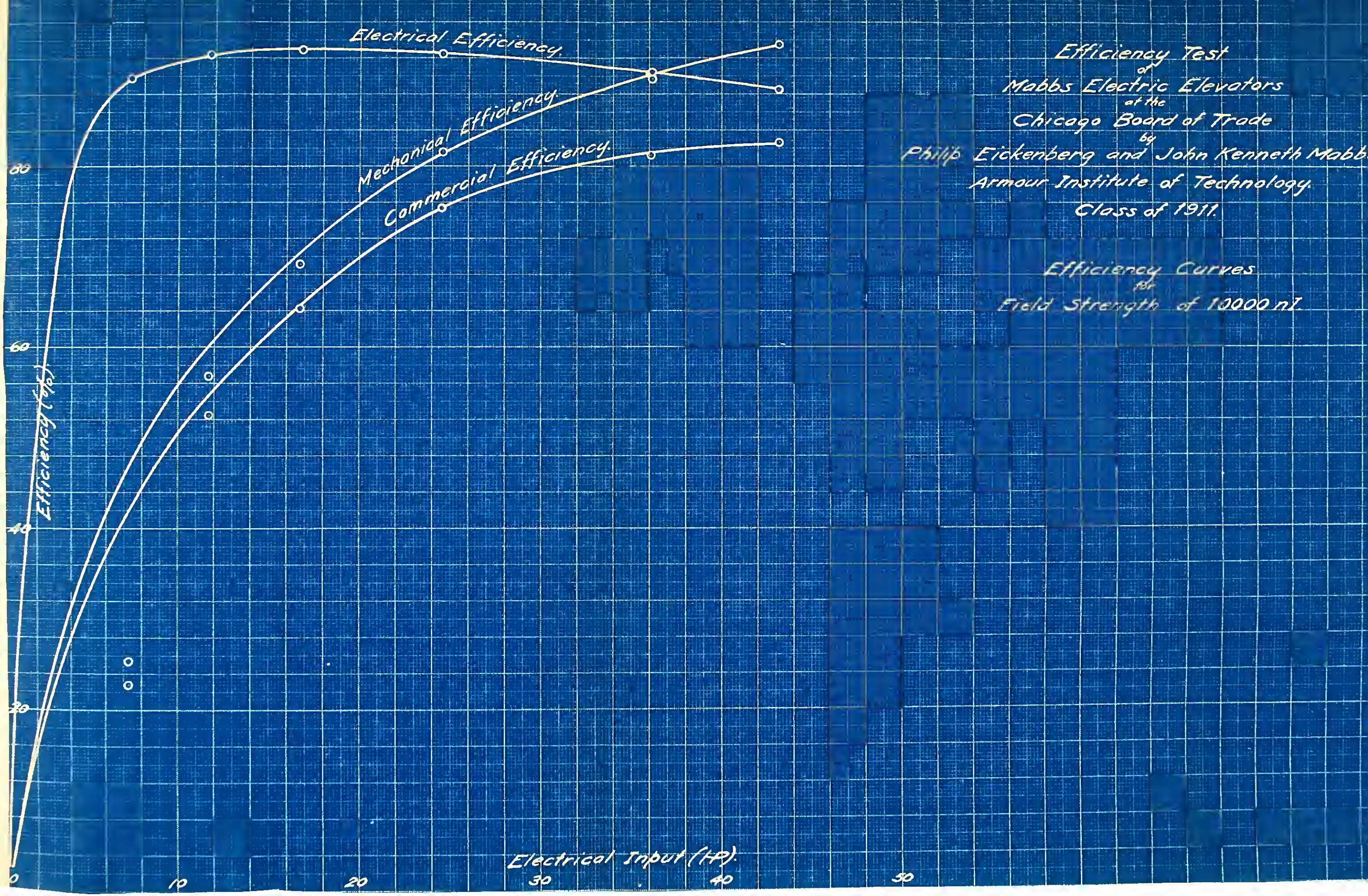
Class of 1911.
Efficiency Curves.
for
Field Strength of 8000 nI.
Electrical Efficiency
Mechanical Efficiency.
Commercial Efficiency.
Efficiency (%).
Electrical Input (HP).
0
10
20
30
40
50
20
40
60
80
100


Efficiency Test
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Mabbs Electric Elevators
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Chicago Board of Trade
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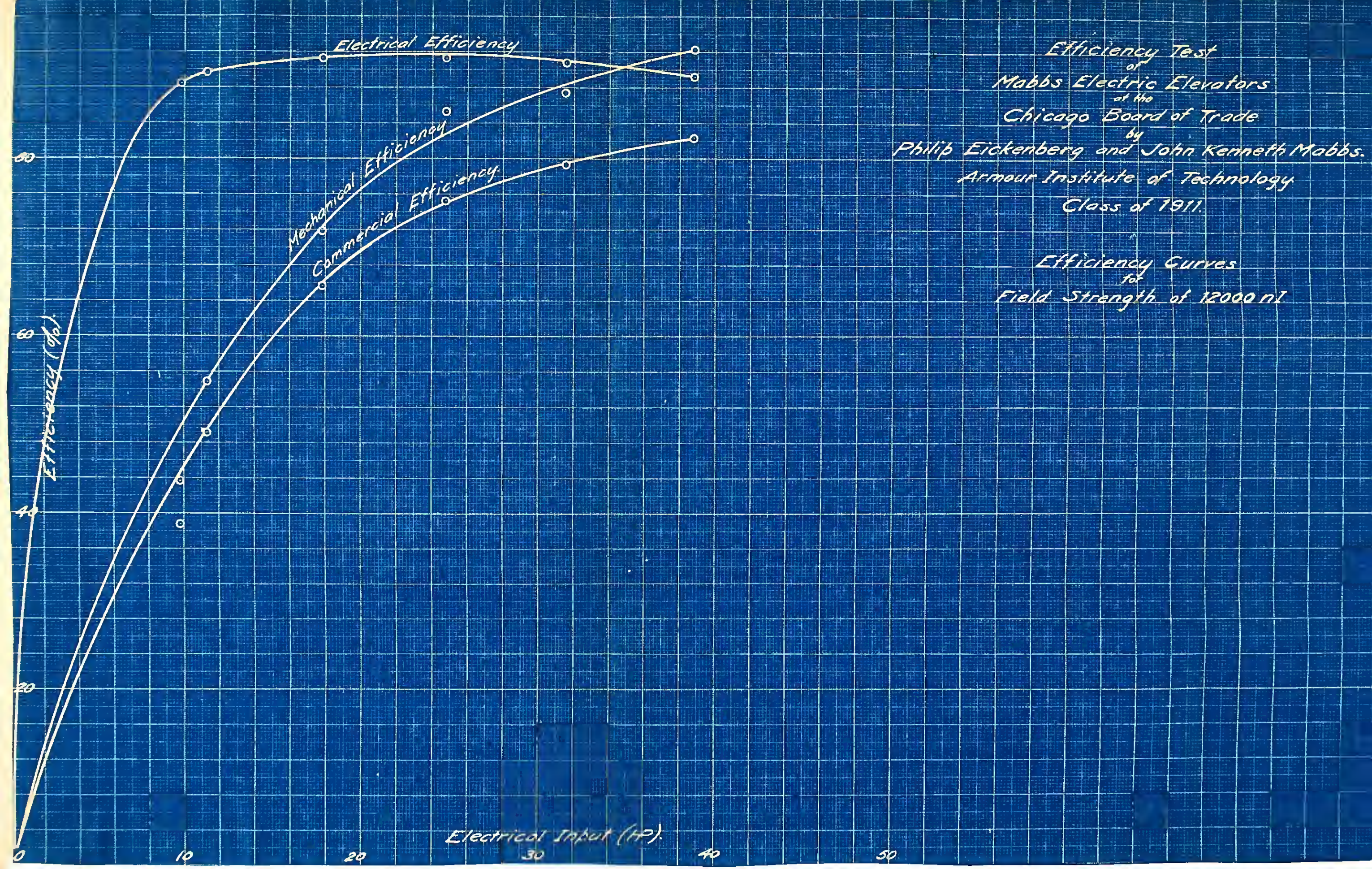
Philip Eickenberg and John Kenneth Mabb
Armour Institute of Technology.
Class of 1911.
Efficiency Curves
for
Field Strength of 10000 nI.
Electrical Efficiency.
Mechanical Efficiency.
Commercial Efficiency.
Efficiency (%).
Electrical Input (HP).
0
10
20
30
40
50
20
40
60
80



Efficiency Test
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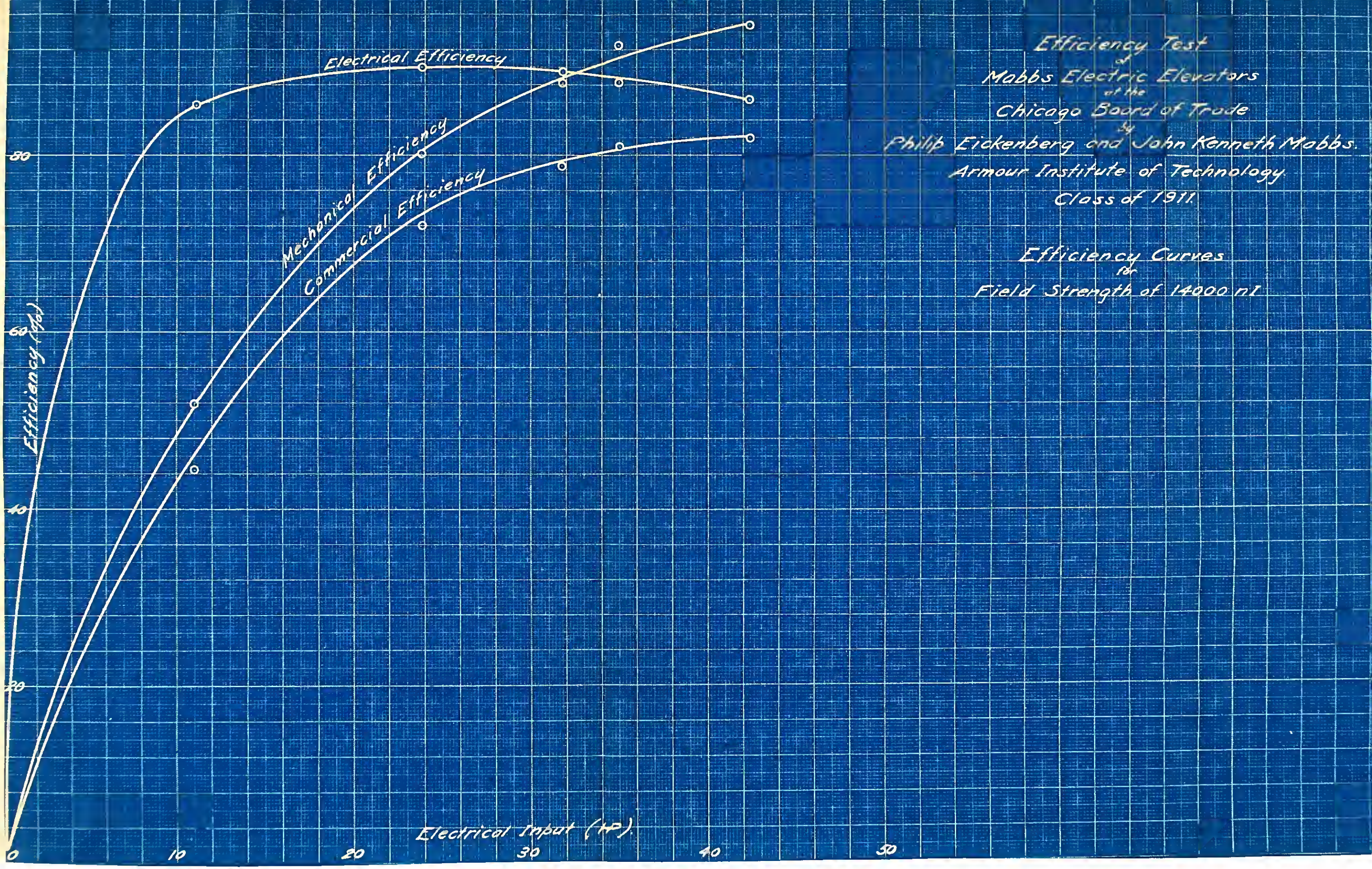
Armour Institute of Technology.
Class of 1911.
Efficiency Curves
for
Field Strength of 12000 nI
Electrical Efficiency
Mechanical Efficiency
Commercial Efficiency.
Efficiency (%).
Electrical Input (HP).
0
10
20
30
40
50
20
40
60
80



Efficiency Test
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Chicago Board of Trade
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Philip Eickenberg and John Kenneth Mabbs.
Armour Institute of Technology
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Efficiency Curves
for
Field Strength of 14000 nI
Electrical Efficiency
Mechanical Efficiency
Commercial Efficiency
Efficiency (%)
Electrical Input (HP).
0
10
20
30
40
50
20
40
60
80

Discussion -- (No Load Test)

From the data obtained in the no load test, the following terms were plotted:-

No.	Arm. E.	Abscissae		Ordinates	
1	120	M.M.F.	(amp.turns)	Speed	(R.P.M.)
2	100	"	"	"	"
3	80	"	"	"	"
	M.M.F.				
4	5000 NI	Volts		"	"
5	6000 NI	"		"	"
6	8000 NI	"		"	"
7	10000 NI	"		"	"
8	12000 NI	"		"	"
9	14000 NI	"		"	"

The M.M.F. speed curves indicate that at an excitation of about 5000 ampere turns the iron of the magnetic circuit is being worked at the knee of the magnetization curve and as this is the normal or running excitation this fact points to proper design and efficient running. At higher excitations, the curve becomes nearly horizontal, indicating that for a given voltage a slight change of field would not mean much change in speed but

at the normal excitation a slight change of field means a comparatively enormous change of speed.

The volts - speed curves are straight lines, showing that for a given excitation the volts vary directly as the speed. This is in accordance with motor theory and points to normal conditions in this respect.

Discussion -- (Load Test).

For each of the six values of excitation used in the load test, the following curves were plotted:-

Abscissae	Ordinates
Speed (R.P.M.)	Load (amperes)
Torque (lbs.ft.)	Load (amperes)
Input (H.P.)	Electrical efficiency
Input H.P.	Mechanical efficiency
Input H.P.	Commercial efficiency

In addition to the above curves, a cross curve with excitation (ampere turns) as abscissae and torque(lbs.ft.) at a load of 240 amperes as ordinates was plotted.

The torque - load curves are straight

lines approximately radiating from a point on the axis of abscissae corresponding to no load current The maximum torque is obtained with no load field. The normal or weak field gives the highest electrical, mechanical and commercial efficiency curves, an increased excitation giving a lower curve according to the amount of increase.

As efficiencies for very low power inputs were difficult to obtain, the efficiency curves were brought down to the origin of coordinates instead of following the low points as shown on the curve sheets. A shunt motor efficiency curve does not pass through the origin of coordinates because the efficiency is zero when the field is on and the armature current is zero. This makes the curve cut the axis of abscissae theoretically at a point corresponding to the field input but practically at a point a little farther out due to friction.

The 240 ampere load excitation - torque curve is a cross curve plotted from the torque - load curves and falls away, becoming nearly horizontal at the top. This curve should be and is of

a shape similar to that of the magnetization curve because the torque varies directly as the armature current and the flux, and the flux varies with the excitation as indicated by the magnetization curve.

The use of the cross curve insofar that it indicates that, if the three variables could be plotted in three dimensions, the resulting surface would be a smooth, warped surface.

The Northern motors used in the counterweights were guananteed to give a commercial efficiency of 85% at full load with the normal excitation. However, when the motors were first put into operation, excessive eddy current losses in the armature core reduced the full load efficiency to below 60%. This excess of loss was due to the flux passing through the motor shaft. This defect was remedied to a large extent by cutting the armature core laminations which originally rested directly on the shaft, and setting in a brass sleeve. In doing so, however, the magnetic cross section of the armature core was reduced, thus affecting the original design and keeping the

commercial efficiency from attaining its guaranteed value, as is shown by the test, although, at overloads, the commercial efficiency becomes higher and even exceeds the guaranteed value.

Although the motor runs slightly below its guaranteed value of efficiency it runs economically, as is indicated by the following data calculated from readings taken at the Board of Trade from day to day.

Number of trips per year ---------------	127485
" " " " week (6 days)------	2259
" " " " elevator per day --	376
Total car mileage ----------------------	5719
Power consumption ----------------------	20270 K. W.
K.W. per car mile ----------------------	3.545