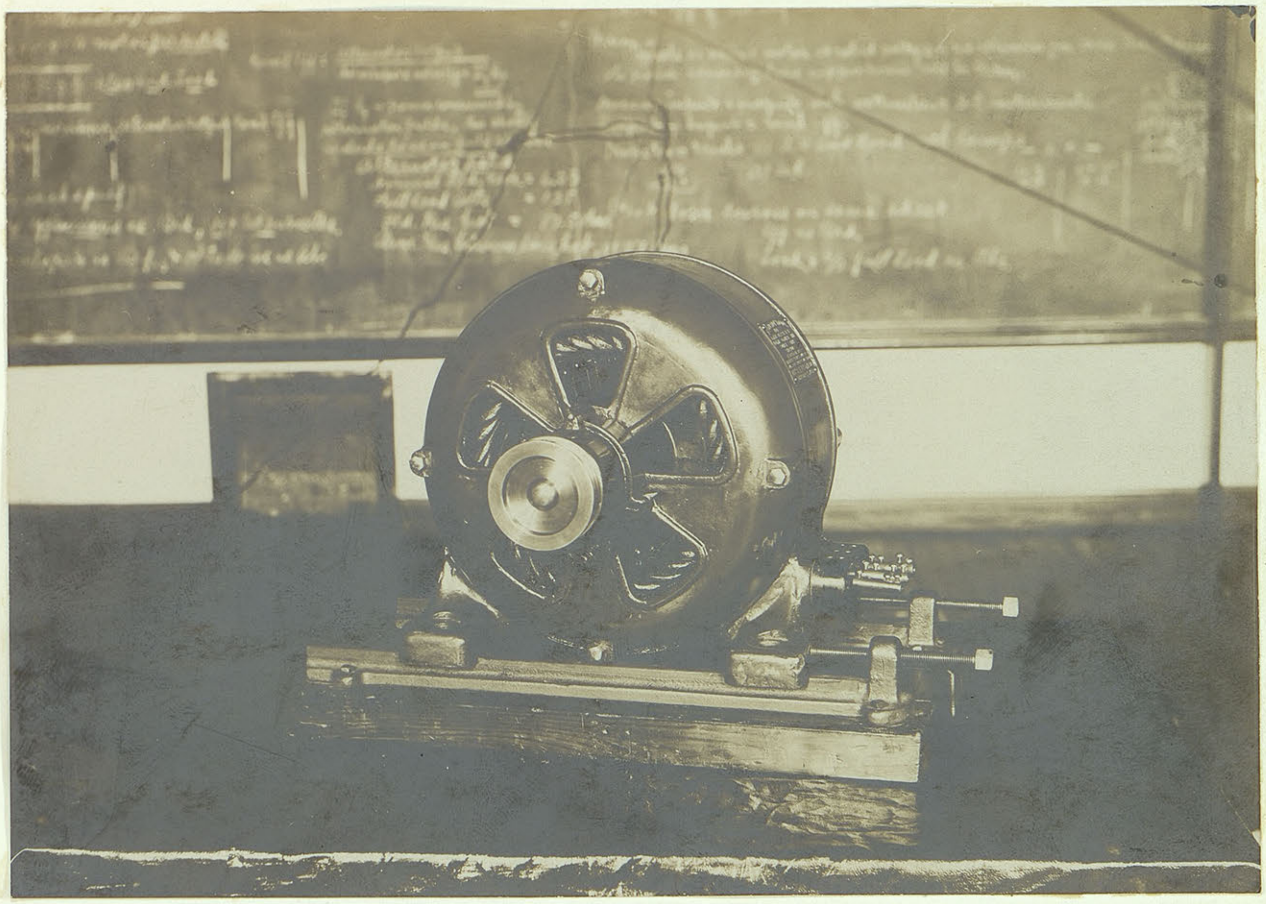
# The Induction Motor.

By H. D. Matthews

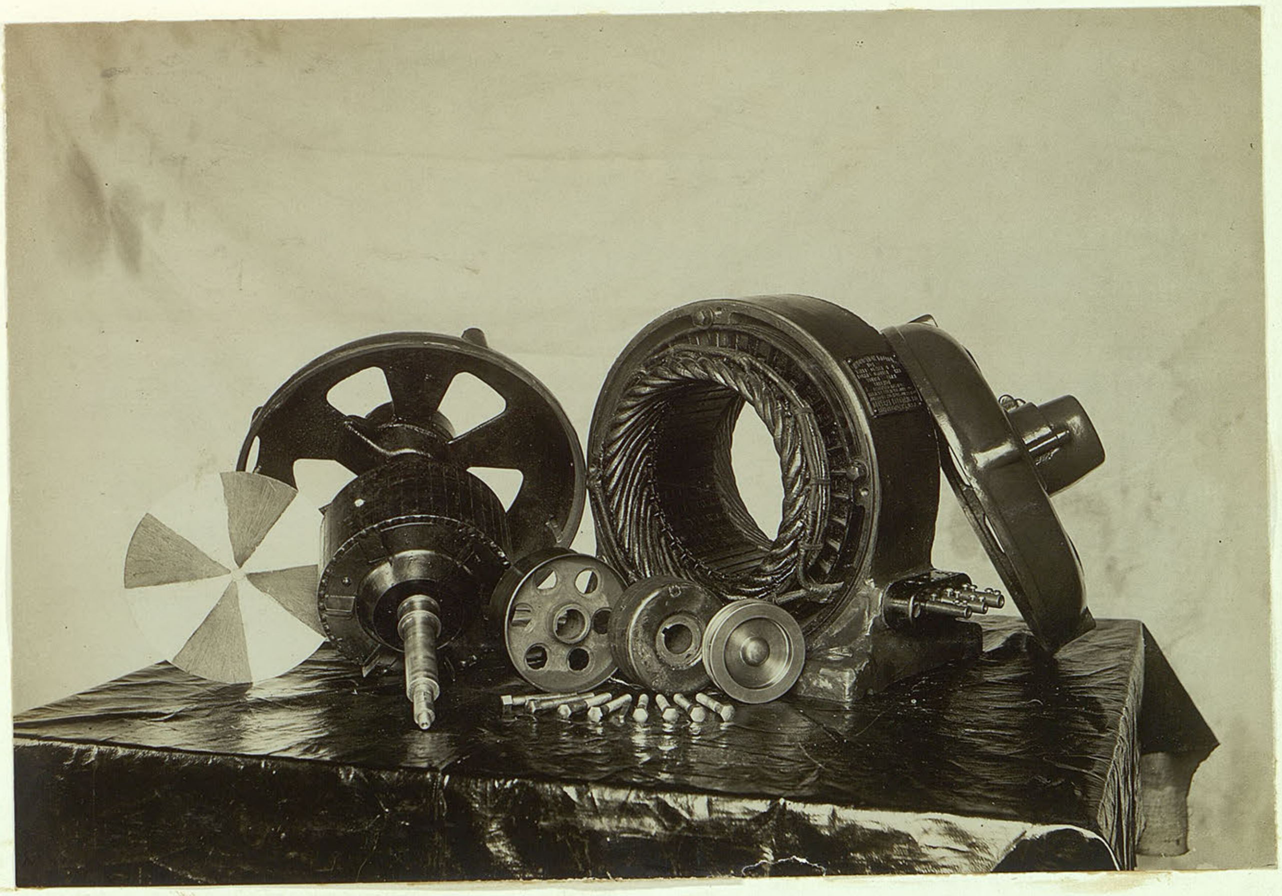
and

T. E. Dial.

" THE MOTOR ASSEMBLED "



" THE MOTOR DISMANTLED".



1. History.
2. Construction.
    a. Stator
    b. Rotor
    c. Bearings
    d. Trams.
3. Current relations.
    a. Rotor.
    b. Stator.
    c. Ratio of Transformation.
4. Flux, Density and Leakage.
5. Heat and Ventilation
6. Regulation of Speed.
    a. Starting devices.
    b. Slip.
7. Commercial Use.
8. Lubricating Tests.

The induction motor is a type of alternating current motor in which the magnetic flux is furnished by either a single phase or a polyphase current. Consider the action of a compass suspended over a magnetic field, the needle thus suspended will take a position parallell to the lines of force, which flow from pole to pole. Now if the nagnet be rotated the needle will change position relative to it. If the magnet be substituted for a four pole electro-magnet as shown in Fig. 1 Plate 1 and a current of electricity be allowed to flow about either of the sets of poles, and the needle be allowed to swing freely in the center, it will set its self parallel to the lines if a current is flowing in all four poles at the same time this needle will set itself diagonally half way between the sets of poles, as illustrated by Fig. 2. Plate 1.

It is now easily conceivable that if one of these currents, in the windings of the poles is becoming weaker as the other is growing stronger, the needle will be attracted to the former until the flux reaches its maximum value. Where an alternating current is used this process of rapidly changing from maximum to minimum tends to rotate the needle. If, now, a cylinder consisting of copper conductors be used, instead of a needle, the machine becomes an Induction Motor The direction of rotation is determined by the phase relation of the currents, The direction of rotation may be reversed by interchanging any two wires of a three phase three wire circuit. Thus by means of polyphase currents it is very easy to produce rotating fields.

The Induction or Polyphase Motor consists essentially of two parts first the part wound with coils of copper wire to receive the current from generator and produce poles which rotate relatively to the coils (6). The part carrying conductors which is arranged to rotate by the torque set up by the rapidly shifting poles. The first part, usually stationary, is called the stator or primary; the second part is called the rotor or secondary. It is possible to interchange these making what is now the Rotor Stationary and making the Stator to revolve, but this requires the use of slip rings, and brushes, to supply the exciting current, and also subjects the fine windings to centrifugal force and does not allow of so high an efficient insulation. This plan has the advantage of requiring less material in the Stator part and producing slightly less magnetic leakage. It has not been followed in recent practice on account of the objections enumerated. The duty of the Stator is to receive the alternating current from the line which, owing to the high induction set up in the coils of wire, produces a magnetic field whose lines travel from the inner cylindrical surface in a radial direction, traverse the rotor of a certain distance, returning radially to the Stator thus completing a magnetic circuit as shown in Fig. 3 Plate 1. producing north and south poles which move rapidly over the surface of the Stator and sweep the conductors of the Rotor as a simple rotating field would do. The number of these pairs of poles depend upon the frequency for which the motor is designed and the speed for which it is designed to run.

Progression of Field.

To show clearly the progression of the Magnetic field consider the stator and rotor layed out in a straight line instead of being cylindrical in form. Consult Fig. 164 Plate 2 . Let the holes through which the stator conductors pass be represented by the upper row of circles, the lower row representing the holes for the rotor conductors. This representation is

PLATE-1

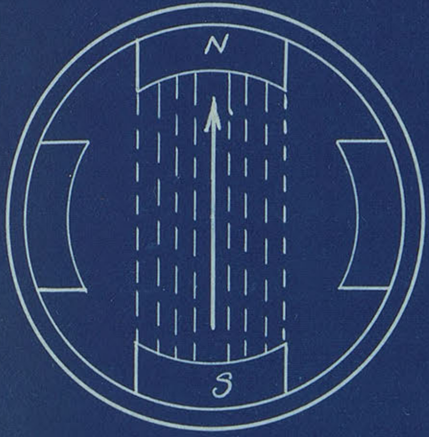



FIG. 1.

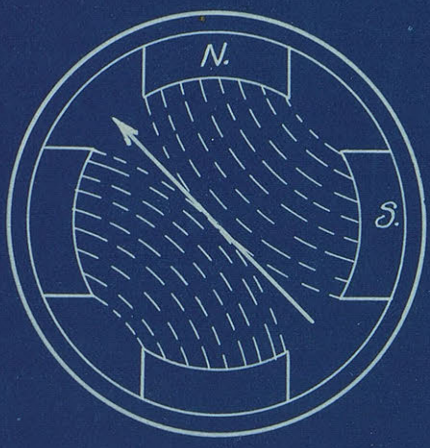



FIG. 2

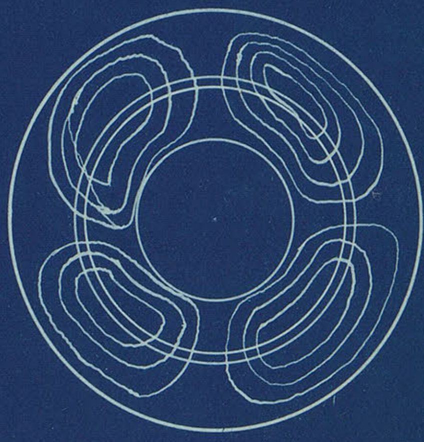
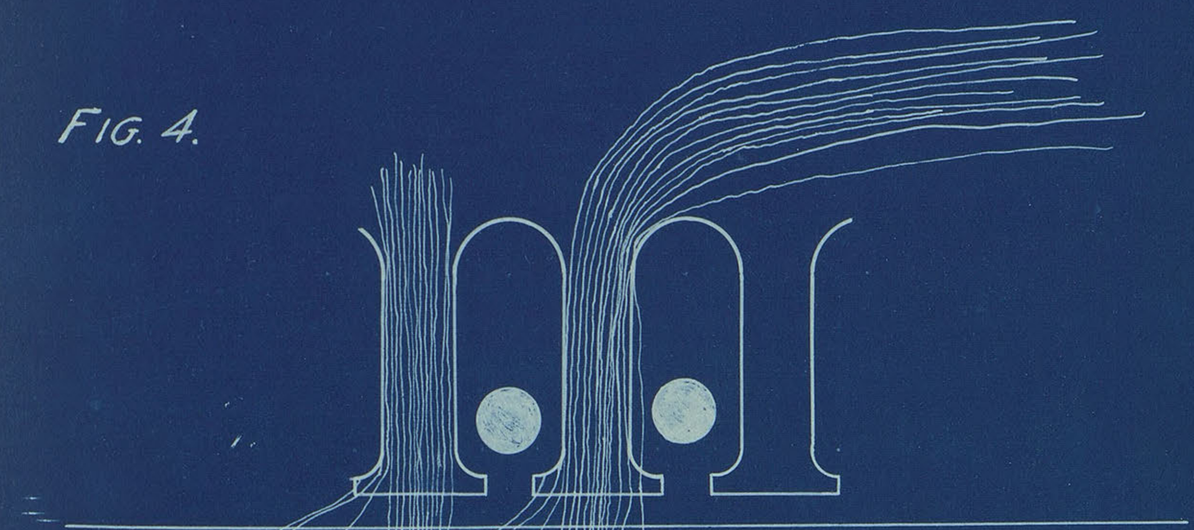


FIG. 3.

FIG. 4.



T.E.D.

that of a two phase winding, assuming also that the rotor circuit is open.

The Phase relation of the current is shown by the clock diagram at the right of the figure in question. Let the pointer (A) be proportional to the current at that instant in the stator coils. In Fig 1. the current is shown at a maximum, in circuit No.1, circuit No.2 is carrying no current. These conductors carrying alternating current will set up magnetic lines of force in the iron as shown in Fig. 1. The magnetic motive force extended by the stator coils at each point along the surface of the stator is shown by the square cornered curve below each figure. Let the conductors, indicated by an × be covered as conductors carrying current, out of the plane of the paper, while those with a dot be assumed as carrying current into the paper. These curves are plotted from the different current values, the radius of the circle or clock diagram being the maximum current propelled over from the clock diagram. Let pointer (A) represent proportionally the maximum value of the current in circuit No.1. Make (ML) the same length as (AO) and perpendicular to the axis (×) taking the distance (MN) equal to the distance between conductors (1&2). The ordinates of (MN) represent approx. the magnet motive force at each point along the surface between the poles ( ). Between the conductors (2 & 3) the magnetic force falls to zero, this being due to the conductors on one side neutralizing the effect of the conductors on the other. Between the conductors (3&6) the force is reversed and is represented by the curve (P.Q.R.S.) below the zero line. In Fig. 3 the phase is shown as having advanced 1/16 of a period, so that the currents in the two circuits are equal. In another 1/16 paperoid the curve would assume a shape as that of No. 2, showing the maximum point of the curve having advanced the distance of two holes to the right.

# PLATE-12.

Fig. 1

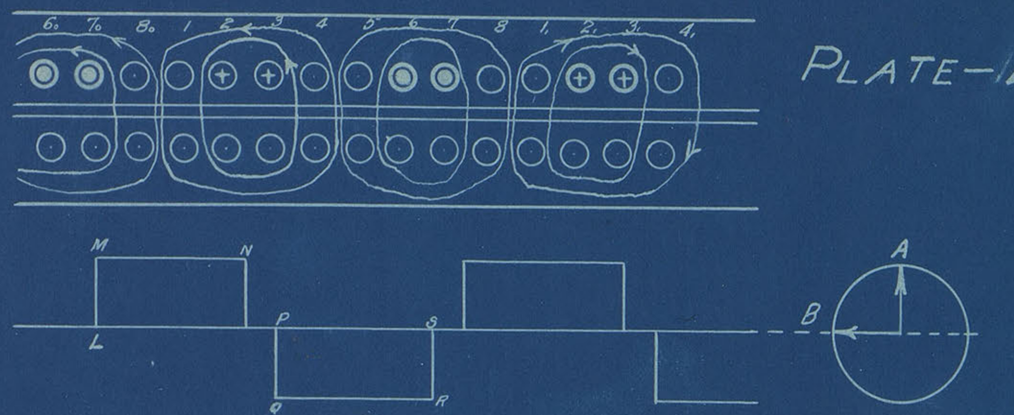



Fig. 2

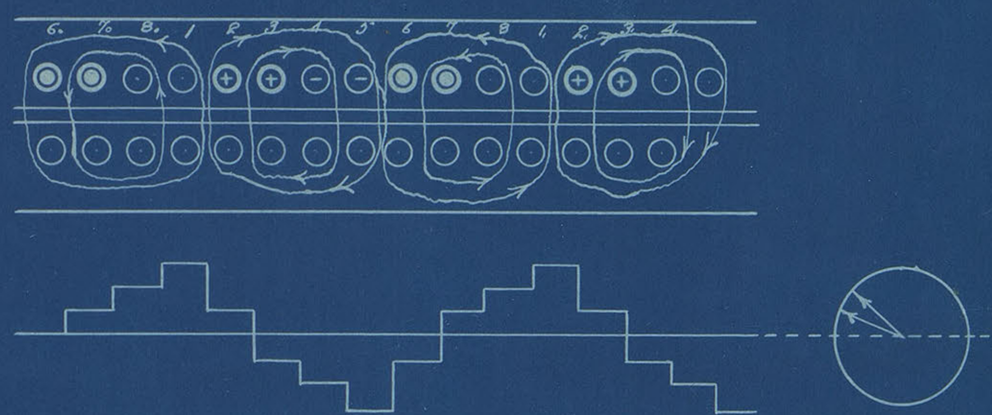


Fig. 3

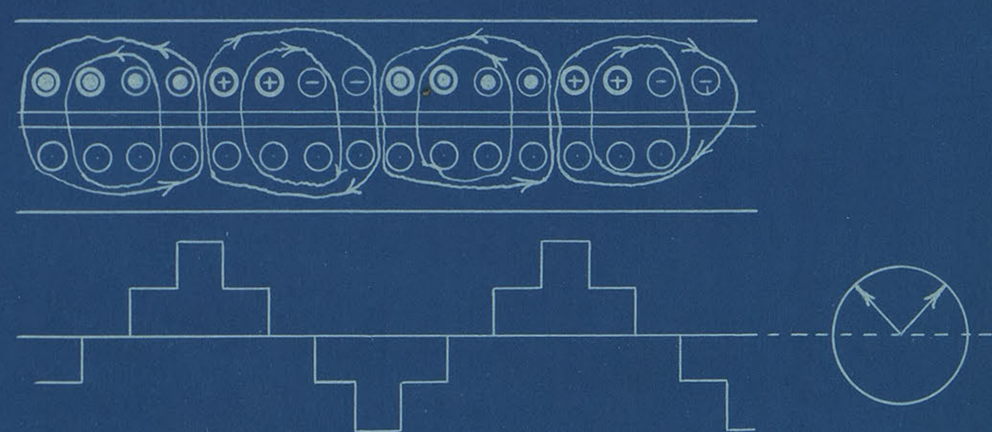
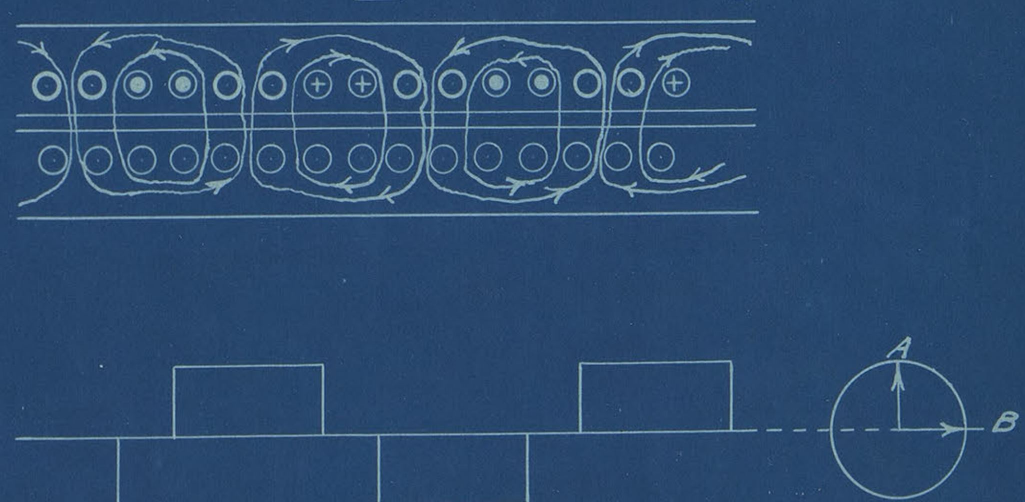


Fig. 4




T.E.D.

Fig. NO. 4 shows the phase having advanced another (1/16) of a period the current in the circuit No. 1 having sank to zero while that of circuit No. 2 has risen to maximum. This curve is similar to No. 1 but is shifted forward through the space of two holes. At a quarter of a period later it is shifted in past another two conductors and after another half period has passed all eight holes and is in the position of No. 1 relatively to the next set of coils. THis carries the poles through a complete cycle. These curves as so constructed, with square corners, may approximately represent the magnetic flux distributor for as the flux spreads out, and as these poles change rapidly, and gradually from Max. to Min., the true curve followed by this change is that of a Sine Curve.

Magnetic Leakage.

In Fig. 1. Plate 2 it has been shown that if there are no currents in the rotor the maximum point of the magnetic curve would be between the conductors of the stator carrying currents. But in a Motor, since the coils on the rotor are short circuited, its conductors carry current, this current in turn sets up a magnetic flux around its conductors which tends to oppose the flux of the stator, this opposition tends to distort or skew the lines of force of the stator.

In Fig. 3 Plate 1 is shown the crowding of the lines of force in the iron of the teeth, the distortion due to the stator and rotor currents being distributed discontinuously, the shielding effect of the iron that surrounds the slots, and the obliquity of the field in the air gap. Considering this same figure, it is very hard to determine what are leakage lines and what are useful.

To show more clearly what is meant by leakage consider Fig. 1.

Plate 3. . Let (A) represent a slotted iron stator tooth, and (B) that of a tooth of the rotor. If these teeth are placed in juxt-position and a magnetic flux pass down from the stator tooth to the rotor consider 10 lines 5 will pass to left of slot and the other five to the right. Next consider that no flux is passing down from stator tooth, but, that each conductor as in Fig. 2. A.& B. carries currents these currents will set up fluxes which link each conductor respectively. It is evident that such a field does not tribute anything to the driving forces of the Motor. Now to show how a torque is set up between the stator and Rotor let (Fig.3) represent the same poles as before considered, but the flux of these set of poles consists of the superposition of the fluxes of Fig. 1&2 that is let a flux flow from stator to rotor and at the same time a flux in each of the conductors A.& B. as shown in Fig. 3 seven lines pass to right of slot A down to rotor obliquely to left side of (B) while 3 lines pass down on either side of the conductors. It is plainly seen that these seven oblique lines of force are the resultant lines of the two forces as shown in Fig. 1&2 Plate 3 . In accordance with the principle that there is a tension along the lines of the field there will be a tangential component of force tending to drag the rotor toward the right with an equal reaction tending to urge the Stator toward the left. It is evident than that if those lines passing obliquely across the right of A obliquely to the left of (B) constitute simply the driving forces, that the lines that pass down respectively to right and left of the slots, do not constitute a driving force and are known as leakage flux. Hence our definition of a leakage flux, any magnetic lines which surround any conductor, or any two or more conductors belonging only to either of the two parts, contribute nothing to the driving

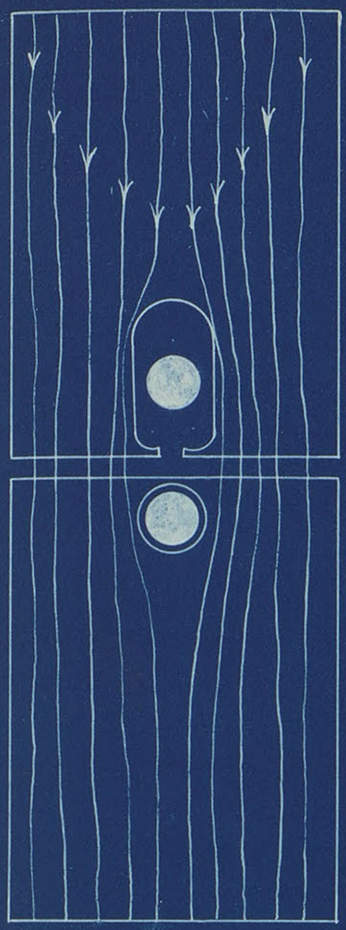


Fig. 1.

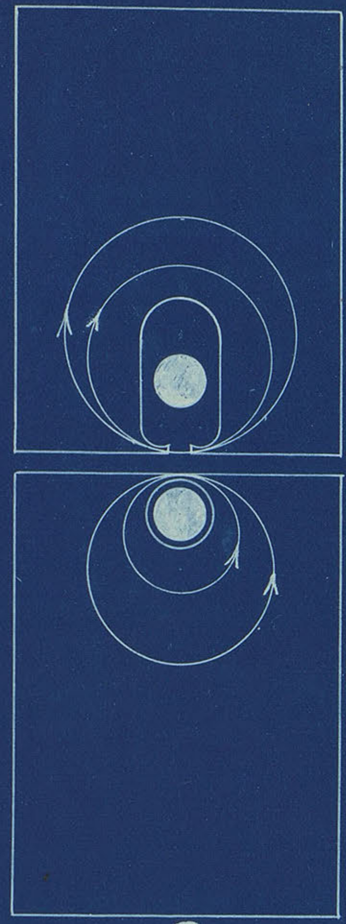




Fig. 2.

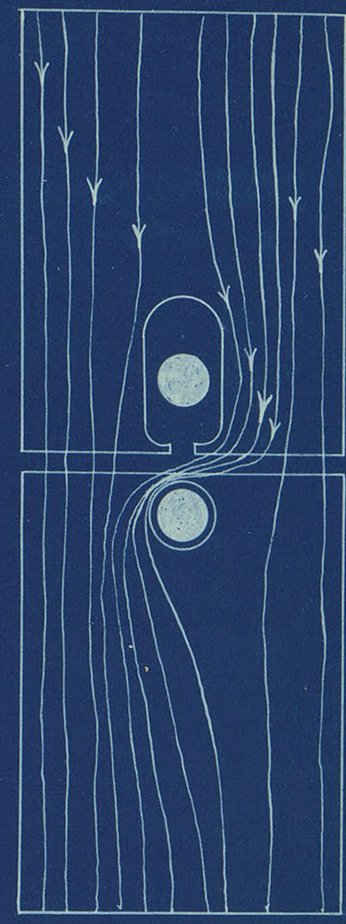


Fig. 3.

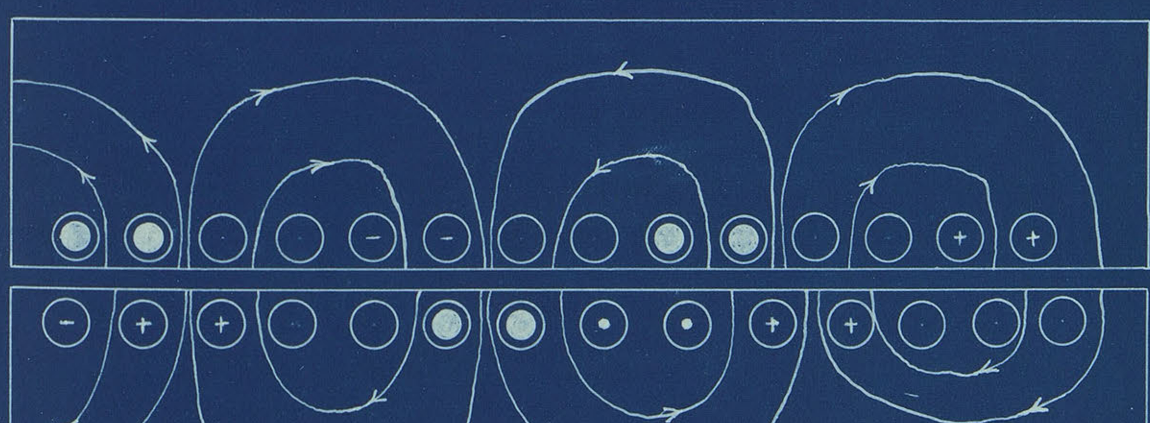


Fig. 4.

T.E.D.

forces, and sre so much magnetic leakage. To reduce this magnetic leakage the air gap must be made as small as possible and the copper conductors of both stator and rotor should be as close to the surface of the air gap as possible. Any flux which goes along the gap from one tooth to another tooth of the same part, that is from stator to stator or from rotor to rotor without embracing the conductors of the latter is a magnetic leakage. This true magnetic leakage as it passes along the gap, compounds with the useful flux causing a distortion, causing the main flux in turn to leak in that it so far avoids enclosing conductors which it would, had it not been compounded with the true leakage flux.

A second way in which magnetic leakage may take place, namely, at the flanks of the machine. Any leakage that occurs in either of these two directions increases self-induction of the stator winding, thereby decreasing the torque, and in decreasing this torque the efficiency of the motor is decreased.

Heat and Ventilation.

Undue heating in any motor or dynamo working under the designed load, allows of criticism as to poor design. Since in the induction motor the armature is stationary, the conductors used must be of such a size as to stand the $I^2R$ loss, and, admit of a large factor of safety concerning the burning of wires. The heat generated in the coils must not be of sufficiently high temperature as to burn or even soften the insulation. If this be the case after the motor has had a fair trial, it could not be recommended to give satisfaction for any length of time. There are several ways that these motors are constructed so as to prevent heating- first- the shield is so cast that at regular intervals over its surface are holes which allow of the circulation of air around the coils. Second- attached to the rotor especially the squirrel cage type, one small brass projection, which serves as a fan while the rotor is revolving. This fan serves to keep the air in motion, by this means the coils are always kept cool, and if there should be an excessive rush of current in the motor, heating the armature coils, this fan would soon carry away the heated air and thereby protect the coils against excessive heating. In the motor tested, thermometers were placed , one in shield, one in oil bearings at each end of rotor shaft, and on the rotor after it was stopped. At any of these points after a run of several hours no excessive heating was observed. ( Note Data ).

Construction.

The principle parts of an induction motor are (1) Frame. (2) Stator. (3) Rotor.

The stator is the stationary part that contains the windings. It consists of iron stampings built up in a cast iron case or frame. These stampings are made of the best of soft annealed iron and are from twelve to twenty mills in thickness. The laminal are insulated from each other by a coating of Japan varnish. This prevents eddy currents which would tend to be set up, parallel with the windings. The stampings are shown in Fig. 3 Plate 4. The stator consists of thirty six slots, in which the windings are laid. Each slot is lined with mica insulation or some other insulating material.

The windings on the stator are of the distributed type, there being six slots to each set of coils and twelve slots to each phase winding. One end of each phase meets in a common point and the other three ends go to the terminals of the machine. The star connection is the form most commonly found in practice, and is illustrated in Fig. 3. Plate 5. The coils are firmly held in the slots by thin wedges of hard wood driven in between the coils and the flanges in the slots. This protects the coil from mechanical injury, and magnetic pull, due to the currents in the conductors. The wire used is ample to carry the full load current ( twelve amperes) without excessive heating, and also the starting current ( about twenty five amperes on no load ) for a short time without injury.

The rotor is the name applied to the revolving part. It is also made up of iron stampings well insulated from each other. The material used is the same as is used in the stator. The form of stamping used is shown in

Fig. 3. Plate 4 . As the frequency of the flux is not so great in the rotor as it is in the stator, it is not necessary that the laminae be so thin. The slots in which the conductors lie are near the circumference of the rotor and have good mechanical protection. The air gap between the stator and rotor is made as small as possible, to prevent magnetic leakage. The rotor is shown in (Fig. 2. Plate 4), and is called the squirrel cage winding. It consists of copper bars placed in the slots, the ends of each being fastened to a short-circuiting copper ring. There are forty two slots with a copper bar in each slot. The other form of winding used is the common star or Y connection. The windings must be of sufficient size to carry the induced currents, without causing excessive heating. They must be numerous enough to give a large induced E.M.F. in the rotor coils. On each end of the rotor are small fans for the purpose of maintaining a circulation of air to keep the temperature as low as possible when the machine is in operation. It is customary to make the distance between the slots on the rotor a little less than on the stator, and also less than the width of each slot.

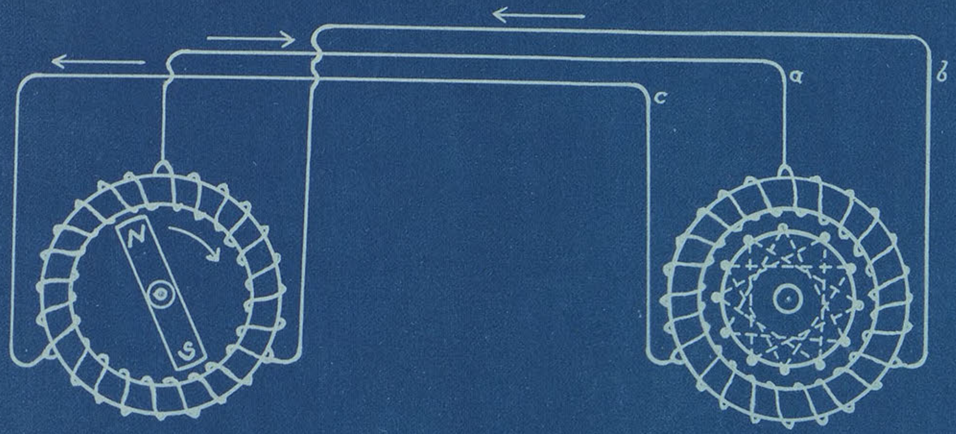
The shaft is made of steel and turns in brass boxings. The oil is supplied from the oil chambers to the shaft by oil rings. There are two rings in each bearing . A lid on the top of the bearings gives a means by which oil can be put in the bearings, and the rings inspected.

The frame is made of cast iron and fits very closely to the stator. This is true only in small machines. In large machines it is customary to have a space between the frame and the laminae, for ventilation.

The motor rests on a wooden base and operates on two V ways by means of two screws. The belt can, therefore, be tightened when necessary. The

PLATE 4.

FIG. 1.




GENERATOR. MOTOR.

FIG. 4.

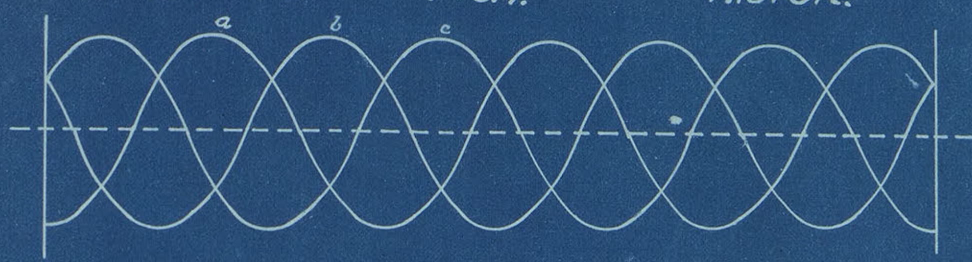



FIG. 3.

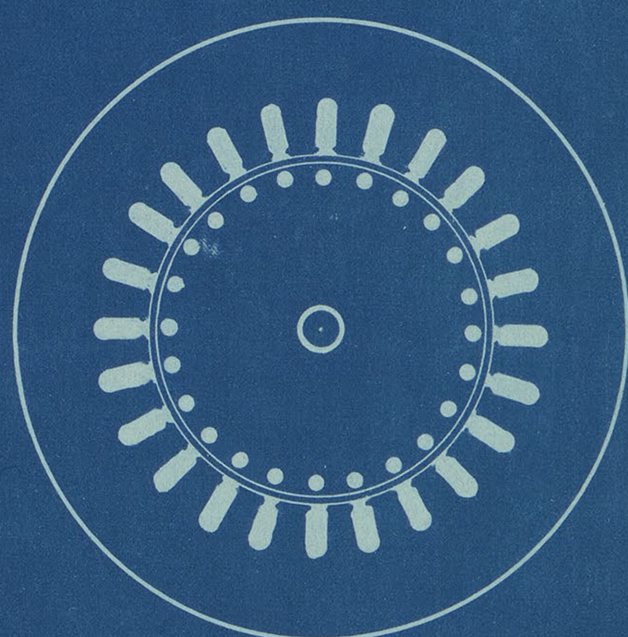
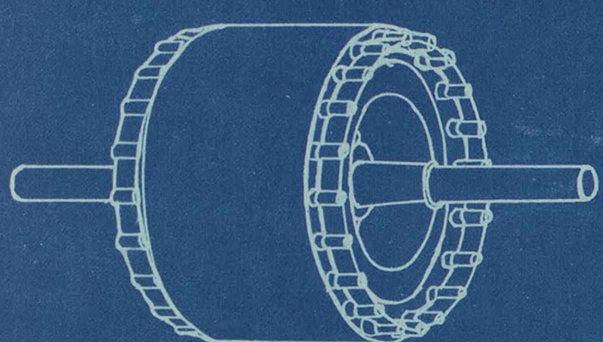


FIG. 2.



THE INDUCTION MOTOR.

THREE PHASE.

H.D.M.

pulley, which is made of hard wood, is fastened on the shaft by means of a feather key and set screw.

Current Relations.

The current in the rotor coils is a function of the E.M.F., the frequency and self induction of the windings. The resistance is very small ,- about .122 ohms for each phase winding. The starting current is very large and lags approximately 90 degrees when running light. The wattless current depends upon the leakage,- that is,- the number of lines that are set up in the stator that do not cut the rotor. The current in the rotor is produced by its tendency to go slower than the revolving field flux, and as the flux cuts the rotor conductors an E.M.F. is set up and produces a current in the rotor coils. The ratio of transformation has no particular effect upon the operation of the machine. For motors of the same capacity it is customary to use the same size of rotor and stator for different voltages, but vary the windings only. The frequency of the current in the rotor is"s"times that of the frequency when the rotor is standing still. The voltage induced in the rotor is " s t " times the operative pressure of the stator, "s" being the slip and "t" the ratio of transformation. The current produced is dependent in magnitude and phase upon the motor windings. The resistance and inductance of the rotor windings are very small.

Regulation of Speed.

The chief objection to induction motors is speed regulation. It is possible to change speed by altering the number of poles in the stator, but this method requires so complicated a set of windings as to be impracticable. The only way that speed can be changed to any great extent, is by changing the frequency of the supply current. This method requires a frequency transformer and, as they are limited in operation, they are not used in actual practice. The speed can be changed to a small variation by changing the impressed voltage but this gives rise to such heavy currents at slow speed as to be inconvenient to use for wide variation. When an induction motor is thrown on a circuit, there is an enormous rush of current, which grows less as the machine attains speed. To prevent this rush of current, various starting devices have been employed. The method used in the laboratory was to gradually increase the generator voltage from zero to maximum, and so not much can be said of the different starting devices from an experimental knowledge. The ordinary form of a starting box is shown in Fig. 1 Plate 5 . This form is manufactured by the General Electric and the Westinghouse Co's. By means of auto-transformers with several taps on the compensating coils, the voltage is supplied to the motor much lower than the line voltage. As the motor attains speed the voltage is raised and when normal speed is reached, the motor is connected directly to the line by means of a double-throw switch. The torque of a motor in starting can be regulated by having a variable resistance placed in the rotor windings. When the motor is started the resistance is thrown out of the rotor circuit by means of a knob on the end of the shaft. This resistance serves two purposes, it produces a high starting torque and prevents a rush of current when the motor is started. The resistance causes a drop in the E.M.F. and this causes a greater slip for the same current produced, and the motor runs at a lower speed and has full load starting torque, which is equivalent to a large torque when it starts. The General Electric Company make motors in which the resistance is cut out by means of a centrifugal clutch.

The slip is the ratio of the drop in speed to the normal speed when the load is varied. A motor tends to run at a synchorono^us speed and the slip on running light is very small. The E.M.F. produced in the rotor is just sufficient to overcome the running losses. A fall in speed causes the conductors on the rotor to cut more lines of force. This produces a higher induced voltage which raises the torque, and the speed tends to assume its normal value. So in this respect it resembles a shunt direct current motor. If there were no losses on no load, the otor would run at synchronous speed and no currents would flow in its windings. The slip can be found by two methods.- (1) Belt tochometer. (2). Special slip counter. The first consists of an ordinary belt tochometer connected to the motor shaft. By knowing the speed of the revolving field the slip can be found for any load on the motor. The second method is shown in (Fig. 2, Plate 5). It consists of a circular disk, which is divided into four black and four white segments, corresponding to the four poles in the stator. The disk is connected directly to the shaft. When the machine is in operation, the light from an arc lamp, which is in parallel with one phase of the motor, is thrown on the disk and it appears to be slowly turning in a direction opposite to its rotation. The apparent speed is proportional to the slip. The number of times the disk appears to turn around is the drop in speed. This subtracted from the speed of the fields gives the rotor speed. The theory of this fact is due to the pulsations of the light acting on the disk. If there was no slip, the disk in reality would make one revolution for each pulsation of the arc light, and it would appear to be standing still. As the slip increases the position of the black segments fall a little behind their normal position when the pulsation of light occurs and the disk appears to slowly revolve in an apparently opposite direction due to the

FIG. 1.

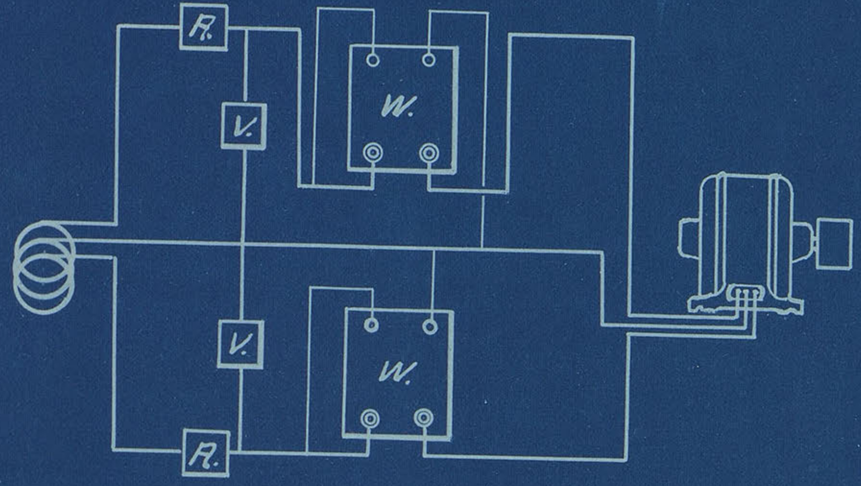
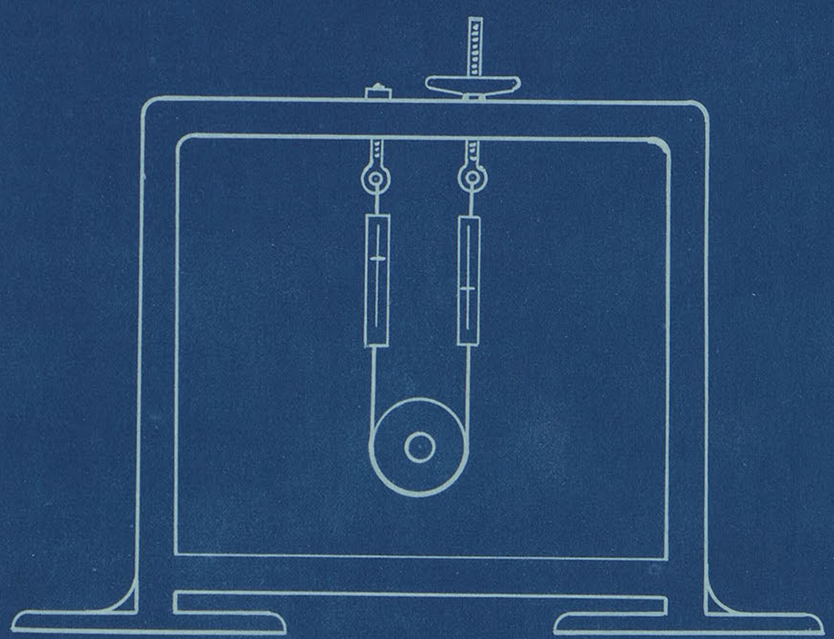



FIG. 2.



H.D.M.

moving picture phenomenon. The slip on no load is very small and the revolutions are easily counted, but on full load when the slip becomes maximum it is very difficult to count the number of revolutions and hence this is one main objection to this method. Another objection is that at least thirty seconds are needed to estimate the slip and on varying loads this would be unreliable. This method was originated by the General Electric Company and was tried in the labratory with success.

Curve Discussion.

The two curve sheets show the result of a belt load test and a brake test. The variation in the results obtained is probably due to the difficulty in obtaining a break test that was entirely satisfactory. The rapid speed of the rotor causes so much heat in the brake that the readings had to be taken quickly, at the expense, perhaps, of constancy. The curves on curve sheet No. 1 are plotted from data obtained from the belt load. This consisted of belting the induction motor to a calibrated dynamo and taking readings on various loads. The input of the motor is the algebraic sum of the watt meter readings. Care must be used when the motor is running light, in determining the signs of each watt meter reading. The diagram shown in Fig. 1. Plate 6 shows the connection of the instruments for finding the date taken. The curve marked "B" is the efficiency curve of the motor as obtained from the tests. It has the general form of an efficiency curve, perhaps its main pecularity is that it rises slowly and then turns down and does not have a continuation of its highest efficiency for a wide variation near its maximum output. It is seen that its highest efficiency is at about three fourths full load. This would not be very desirable for continuous operation on full load. When it is over loaded, its efficiency falls rapidly until it breaks down.

Curve "C" is drawn with power factor as ordinates and watts output as abcissa. The power factor increases with load rapidly due to the leakage of the magnetic flux. The curve rises very fast then turns and tends to become parallel to the "X" axis. It is this condition that gives poor regulation for lamps when placed on the same circuit with an induction motor with variable load.

Curve "D" is drawn with amperes as ordinates and watts output as abcissas. The curve is slightly convex to the "X" axis which shows that the ratio of the current to the load is not constant. At break down point the current rises very rapidly due to the fact that the self induction of the coils is lowered.

The curves shown on Sheet 2 were obtained from the results of a make test on the motor. They compare favorably with those on sheet NO. 1. The frame used in making the break test is shown in Fig. 2. Plate 6. By means of the two spring dynamometer readings the torque on the wheel was computed. Various materials were used for the strap on the brake, rope, leather and zinc were tried, with the rope giving the most satisfactory results. The curve "C" was drawn with cycles as ordinates and motor speed as abcissa. It gives practically a straight line which shows that the speed varies directly with the frequency for wide limitations.

At break down point the current reaches 50 amperes which is very injurious to the windings and therefore a fuse in the line is of the utmost importance for the protection of the motor.

The data sheet shows the result of the temperature test and also the locked test. The latter consisted of locking the rotor and raising the im-

## TABLE NO. 1.

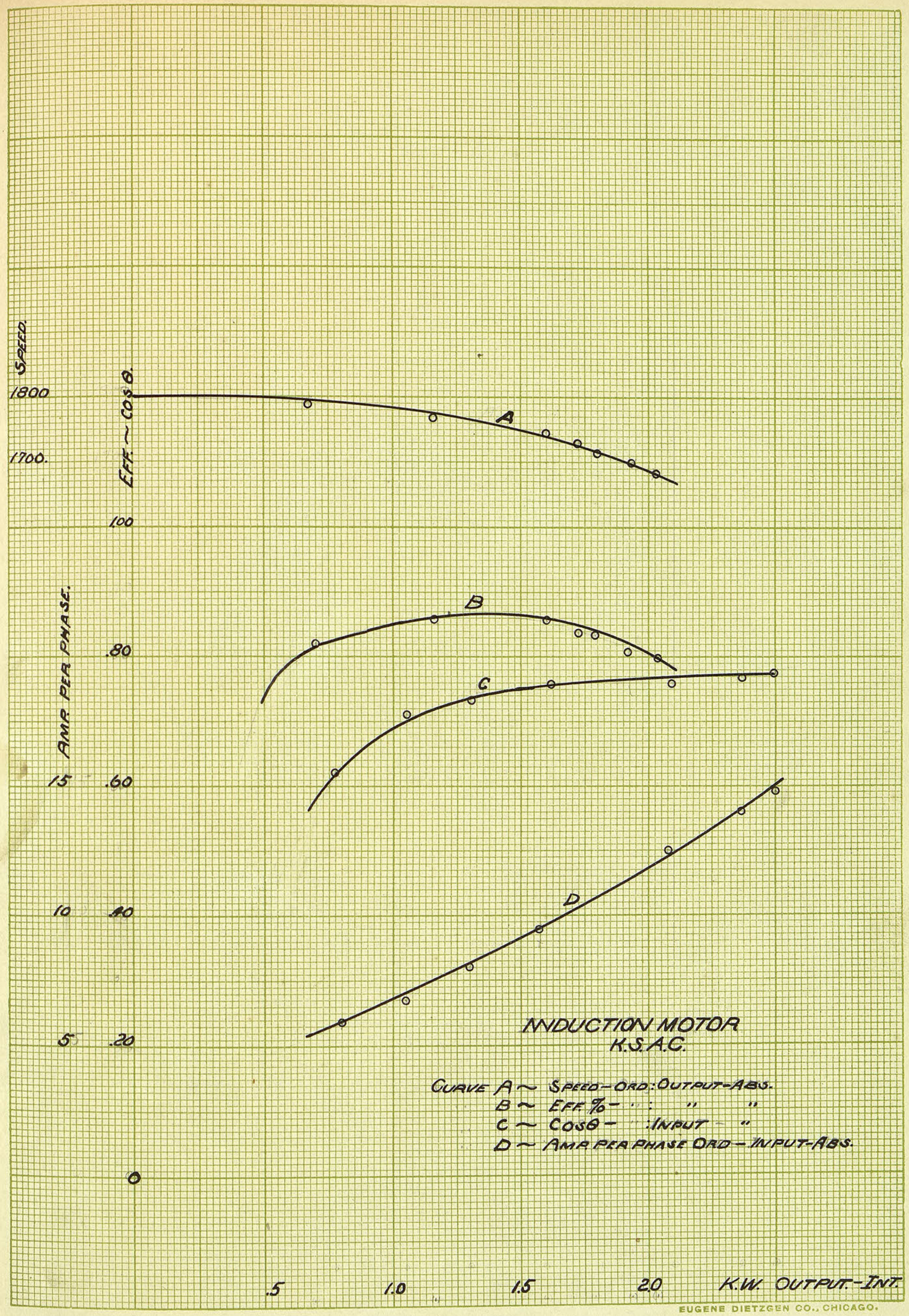
| Temperature Test C° | | | | | |
|---|---|---|---|---|---|
| | | | Bearings | | |
| Air | Frame | Windings | Belt Side | Op. Side | Rotor Coils |
| 21 | 21 | 21 | 21 | 21. | |
| 21. | 21.5 | 22.5 | 26 | 25 | 35.6 |
| 22 | 23 | 24 | 28.5 | 26.4 | |
| 22 | 23 | 25 | 30. | 27.2 | |
| 22 | 23.5 | 26. | 31.5 | 28.1 | |
| 22 | 23.5 | 26.2 | 31.5 | 28.5 | |

## TABLE NO. 2

| Locked Test | | | | |
|---|---|---|---|---|
| Watts' | Watt² | Amp. | Volts | Imp. |
| 280 | 0 | 12 | 27 | 2.2 |
| 1200 | 115 | 24 | 54 | 2.2 |
| 1390 | 150 | 26 | 58.5 | 2.2 |
| | | | | |
| | | | | |
| | | | | |

## TABLE NO. 3

| Brake Horse Power Test. | | | | | | |
|---|---|---|---|---|---|---|
| Watts | Amp. | Volts | E.H.P. | B.H.P. | % Slip | % Eff. |
| 430 | 4.3 | 110 | .567 | .198 | .8 | 34.3 |
| 730 | 5.3 | 110 | .979 | .571 | 1.6 | 58.2 |
| 880. | 6.0 | 110 | 1.18 | .817 | 2.7 | 69.2 |
| 990 | 6.5 | 110 | 1.33 | .991 | 2.8 | 75.0 |
| 1150 | 7.1 | 110 | 1.54 | 1.18 | 3.0 | 76.6 |
| 1340 | 8.2 | 110 | 1.79 | 1.35 | 3.5 | 75.5 |
| 1550 | 9.0 | 110 | 2.07 | 1.47 | 4.1 | 75.3 |
| 2300 | 14.0 | 110 | 3.08 | 2.01 | 7.8 | 65.5 |



SPEED.
1800
1700.
EFF. ~ COS θ.
100
AMP. PER PHASE.
.80
15
.60
10
.40
5
.20
0
A
B
C
D
INDUCTION MOTOR
K.S.A.C.
CURVE A ~ SPEED-ORD: OUTPUT-ABS.
B ~ EFF. % - " : " "
C ~ COS θ - " : INPUT "
D ~ AMP. PER PHASE ORD - INPUT-ABS.
.5
1.0
1.5
2.0
K.W. OUTPUT-INT.

FIG. 1.

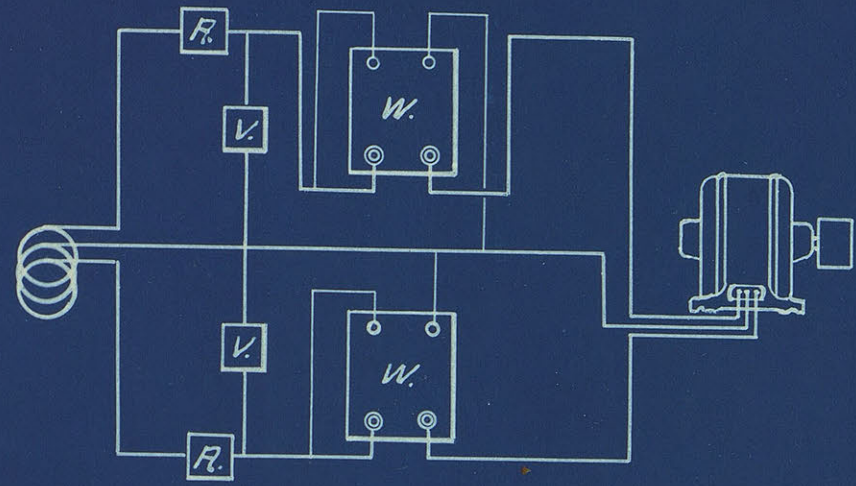



FIG. 2.

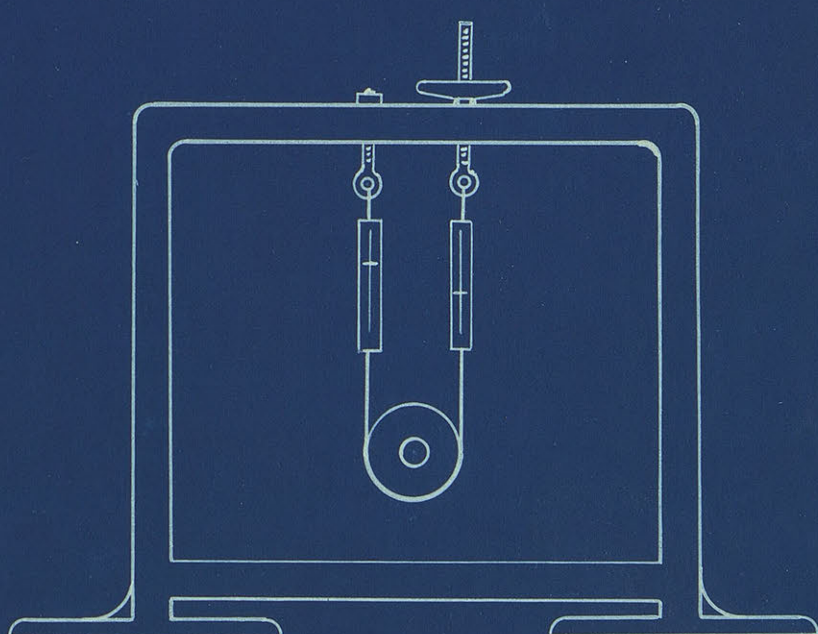


TABLE NO. 4

| BELT LOAD TEST | | | | | | | |
|---|---|---|---|---|---|---|---|
| WATTS | AMP. | SPEED | VOLTS | OUTPUT | COS θ | SLIP % | EFF. % |
| 850. | 5.7 | 1785 | 110 | 697. | .62 | .8 | 82. |
| 1360 | 6.8 | 1775 | 110 | 1167 | .71 | 2.5 | 85.8 |
| 1880. | 8.1 | 1760 | 110 | 1601 | .73 | 3.8 | 85.2 |
| 2030 | 9.5 | 1750 | 110 | 1690 | .76 | 4.2 | 83. |
| 2140 | 12.5 | 1717 | 110 | 1776 | .763 | 4.3 | 83 |
| 2410 | 14.0 | 1708 | 110 | 1938 | .771 | 6.2 | 80.4 |
| 2530 | 14.7 | 1690 | 110 | 2025 | .773 | 6.3 | 80. |

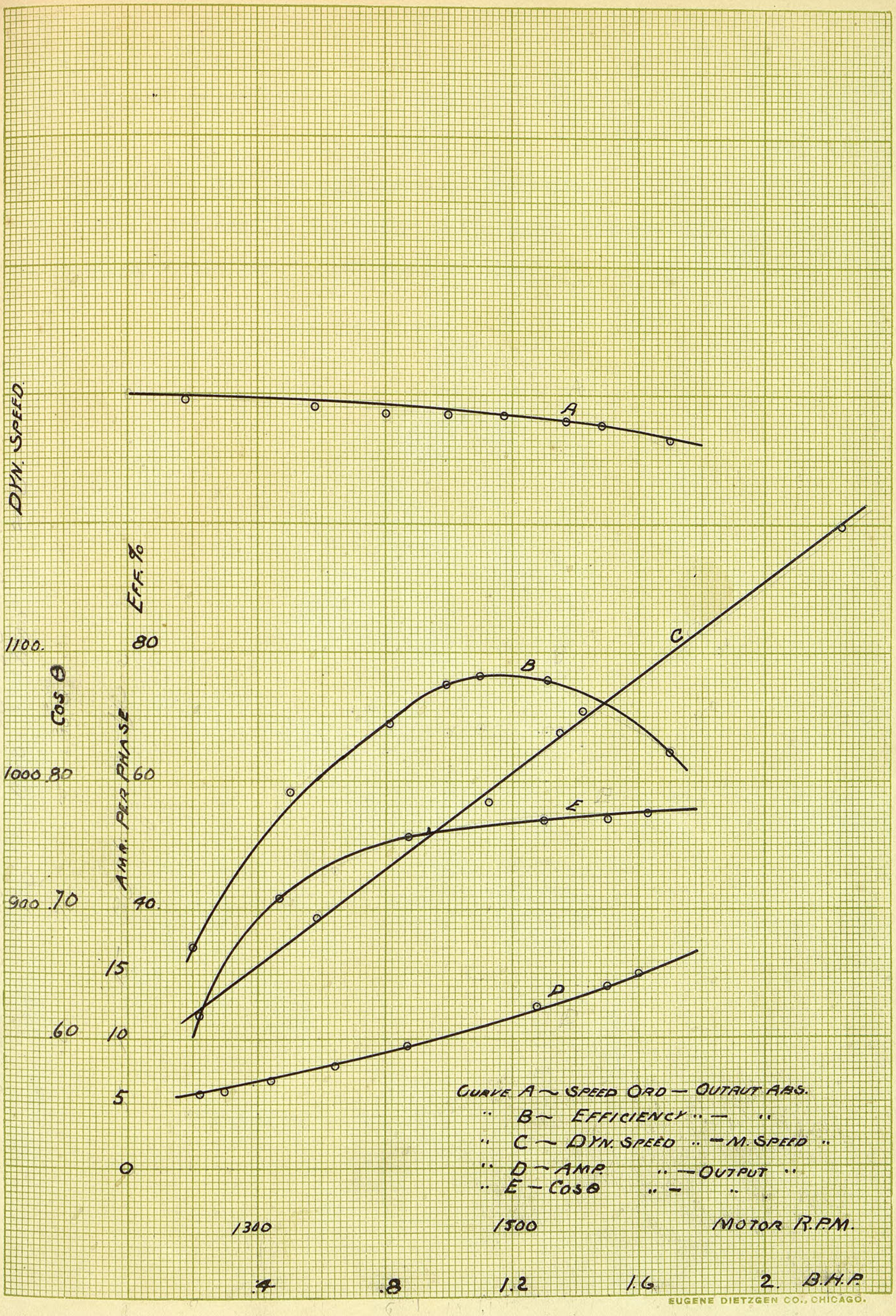
TABLE NO 5

| SPEED TEST | | | | |
|---|---|---|---|---|
| WATTS | AMP. | DYN. | MOTOR | RATIO |
| 170 | 3.9 | 1200 | 1760 | 1.5 |
| 150 | 4.2 | 1100 | 1664 | 1.5 |
| 150 | 4.5 | 1040 | 1536 | 1.5 |
| 150 | 4.7 | 985 | 1482 | 1.5 |
| 150 | 4.8 | 895 | 1346 | 1.5 |

RUNNING LIGHT — 205 WATTS. 3.8 AMP.

OHM-RES OF STATOR COILS.
.127
.119
.123

SPEED 1800. VOLTS 110
CYCLES 60. AMP 12.
H.P. 2.


DYN. SPEED
EFF. %
COS θ
AMP. PER PHASE
1100.
80
1000 .80
60
900 .70
40.
15
.60
10
5
0
A
B
C
D
E
CURVE A ~ SPEED ORD — OUTPUT ABS.
" B ~ EFFICIENCY " — "
" C ~ DYN. SPEED " — M. SPEED "
" D ~ AMP. " — OUTPUT "
" E — COS θ " — "
1300
1500
MOTOR R.P.M.
.4
.8
1.2
1.6
2. B.H.P.

pressed E.M.F. 'till the maximum point was reached. With 110 volts, 50 ampere were produced in the stator coils which would be very injurious if allowed to remain for [illegible] length of time.