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150 SHOP PRINTS AND WIRING DIAGRAMS

And How to Read Them

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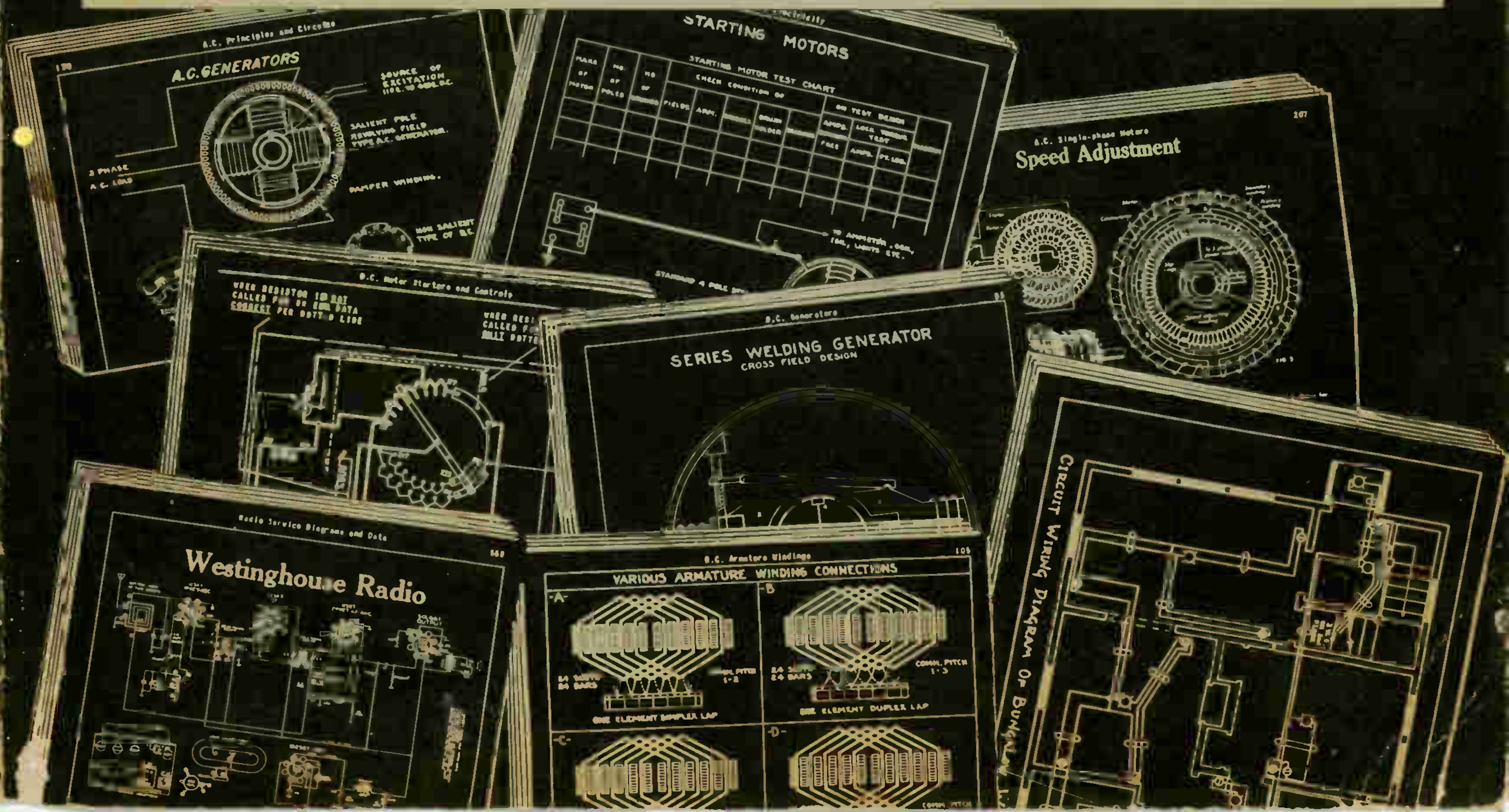


150 COYNE SHOP PRINTS *and* HOW TO READ THEM

An Instruction and Reference Book

for

Radio Men and Electricians

PREPARED AND PUBLISHED FOR HOME STUDY AND FIELD REFERENCE BY THE COYNE ELECTRICAL SCHOOL, 500 S. PAULINA ST., CHICAGO, ILLINOIS. ALL THE DATA IN THIS MANUAL, INCLUDING THE ACTUAL SHOP PRINTS AND MOTOR DIAGRAMS HAS BEEN FIELD TESTED IN THOUSANDS OF INDUSTRIAL CONCERNS THROUGHOUT THE COUNTRY.

COYNE ELECTRICAL SCHOOL
500 South Paulina Street
Chicago, Illinois

Printed in United States of America

FOREWORD

150 SHOP PRINTS and WIRING DIAGRAMS is a PRACTICAL reference book for electrical workers. This book is a selection of diagrams and data from the large 600 page Coyne Electrical Trouble Shooting Manual.

The shop prints and wiring diagrams selected for this book cover a wide variety of electrical apparatus, including MOTORS, CONTROLLERS, STARTERS, GENERATORS, TRANSFORMERS etc.

Hundreds of short-cuts for fast trouble shooting are included. Much of this material was taken right out of the electrical course of the Coyne Electrical School.

Most of the diagrams came to us as blue prints from engineering laboratories of America's leading electrical manufacturers. They have been duplicated exactly as we received them to make certain they are authentic. You will note special markings on many of the diagrams indicating inter-company departmental notations — this indicates that many engineers have examined these diagrams for absolute accuracy.

In many electrical plants as well as industrial concerns the only wiring diagrams on plant equipment the maintenance department ever had were the wiring diagrams that came when the equipment was installed. In many cases these loose sheets become lost or mislaid. This book has diagrams covering many types of equipment, much of which you may actually have in your plant. Therefore, this book can be of great value to you in the future.

Electrical shop print and wiring diagram reading is much like any other type of reading — the more you do of it the more efficient you become. This book with its dozens of diagrams gives you an opportunity to increase your knowledge. In addition to the diagrams themselves we have special explanatory material to aid the electrical worker.

The value of any reference book is determined by the use you make of it. There is much data in this book that can be used everyday on the job—other material may be referred to only occasionally. But whether you use it everyday or just occasionally you have the assurance that this material is available WHEN YOU NEED IT. The book 150 SHOP PRINTS & WIRING DIAGRAMS can be one of your most valuable reference books, so become thoroughly familiar with its entire contents.

RAY A. SNYDER, *General Manager*
EDUCATIONAL BOOK PUBLISHING DIVISION
Coyne Electrical School

ACKNOWLEDGMENTS

Through our close cooperation with the Electrical and Radio industry for over 56 years we have received invaluable assistance in preparing the material for this Manual. We wish to acknowledge our sincere appreciation to the following companies for their help in supplying data, Illustrations and material for the preparation of the COYNE BOOK OF 150 SHOP PRINTS.

General Electric Co.
Westinghouse Elec. Mfg. Co.
Cutler Hammer Mfg. Co.
Allis Chalmers Mfg. Co.
Louis Allis Co.
Allen Bradley Co.
Emerson Electric Co.
Delta Star Mfg. Co.
Square D Mfg. Co.
Century Electric Co.

HOW TO LOCATE THE VARIOUS SHOP PRINTS AND MOTOR DIAGRAMS

THE PURPOSE of this directory is to aid the user of this Shop Print Book in locating the prints he wants QUICKLY. The book is in sections, each section containing several valuable shop prints on a specific subject. Use this guide to find the prints you want—it will save time for you.

NOTE:—The **Coyne Electrical and Radio Trouble Shooting Manual** from which the material in this book was taken is especially prepared for men interested in learning how to read shop prints and motor diagrams. It is also a valuable book on the job, for Electricians and Radio men. The book has over 600 pages with more than 500 wiring plans and diagrams. For information on this book write to **Department TSP, Coyne Electrical School, 500 South Paulina Street, Chicago 12, Illinois.**

SYMBOLS FOR WIRING PLANS

GENERAL OUTLETS

	CEILING	WALL
Outlet	○	-○
Capped Outlet	Ⓒ	-Ⓒ
Drop Cord	Ⓓ	
Electrical Outlet—for use when confused with columns, plumbing symbols, etc.	Ⓔ	-Ⓔ
Fan Outlet	Ⓕ	-Ⓕ
Junction Box	Ⓙ	-Ⓙ
Lamp Holder	Ⓛ	-Ⓛ
omp Holder with Pull Switch	Ⓛ$_{PS}$	-Ⓛ$_{PS}$
Pull Switch	Ⓢ	-Ⓢ
Outlet for Vapor Discharge Lamp	Ⓥ	-Ⓥ
Exit Light Outlet	ⓧ	-ⓧ
Clock Outlet (Lighting Voltage)	◷	-◷

CONVENIENCE OUTLETS

Duplex Convenience Outlet	⊜
Convenience Outlet other than Duplex. 1=Single, 3=Triplex, etc.	⊜$_{1,3}$
Weatherproof Convenience Outlet	⊜$_{WP}$
Range Outlet	⊜$_{R}$
Switch and Convenience Outlet	⊜$\$$
Radio and Convenience Outlet.	⊜[R]
Special Purpose Outlet (describe in specifications)	●
Floor Outlet	⊙

SWITCH OUTLETS

Single Pole Switch	$\$$
Double Pole Switch	$\$_{2}$
Three Way Switch	$\$_{3}$
Four Way Switch	$\$_{4}$
Automatic Door Switch	$\$_{D}$
Electrolier Switch	$\$_{E}$
Key Operated Switch	$\$_{K}$
Switch and Pilot Lamp	$\$_{P}$
Circuit Breaker	$\$_{CB}$
Weatherproof Circuit Breaker	$\$_{WCB}$
Momentary Contact Switch	$\$_{MC}$
Remote Control Switch	$\$_{RC}$
Weatherproof Switch	$\$_{WP}$

SPECIAL OUTLETS

Any standard symbol with the addition of a subscript letter designates some special variation of standard equipment.

List the key of symbols on each drawing and describe in specifications.

○ a, b, c - etc.

⊜ a, b, c - etc.

$\$$ a, b, c - etc.

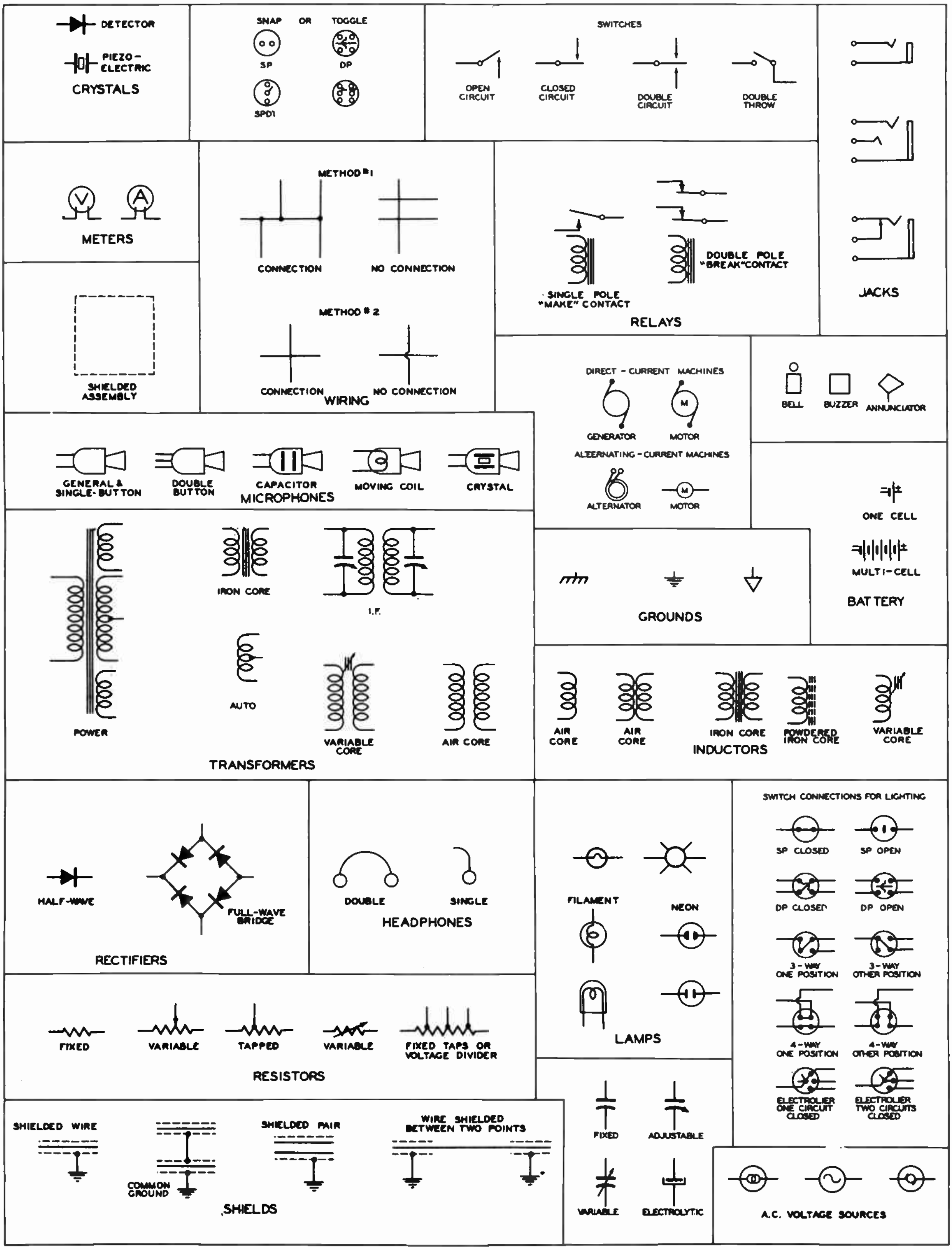
PANELS, CIRCUITS & MISCELLANEOUS

Lighting Panel	▬
Power Panel	▨
Branch 2-Wire Circuit — Ceiling or Wall	——
Branch 2-Wire Circuit—Floor	– – –
Indicate a greater number of wires: -///- (3 wires), -////- (4 wires), etc.	
Feeders. Use heavy lines and designate by number from Feeder Schedule	━━
Underfloor Duct & Junction Box — Triple System. For double or single systems eliminate one or two lines	≡□≡
Generator	Ⓖ
Motor.	Ⓜ
Instrument	Ⓘ
Transformer	Ⓣ
Controller	⊠
Isolating Switch	⧄

AUXILIARY SYSTEMS

Push Button	⊡
Buzzer	□/
Bell	□○
Annunciator	-◇
Telephone	|◁
Telephone Switchboard	[]◁
Clock (Low Voltage)	◰
Electric Door Opener	[D]
Fire Alarm Bell	[F]○
Fire Alarm Station	[F]
City Fire Alarm Station	◼
Fire Alarm Central Station	[FA]
Automatic Fire Alarm Device	[FS]
Watchman's Station	[W]
Watchman's Central Station	[[W]]
Horn	[H]
Nurse's Signal Plug	[N]
Maid's Signal Plug	[M]
Radio Outlet	[R]
Signal Central Station	[SC]
Interconnection Box	▭
Battery	|ı|ı|ı|
Auxiliary System 2-Wire Circuit	—·—·—

For a greater number of wires designate with numerals — 12-No. 18W-¾"-C., or by listing in schedule.



Symbols Used in Electrical Diagrams.

ELECTRICAL UNITS AND SYMBOLS

UNITS	SYMBOLS	DESCRIPTION
Coulomb	q	Unit of electrical quantity. The quantity which will deposit .0000116 oz. of copper from one plate to the other in a copper sulphate solution. The quantity of electricity which must pass a given point in a circuit in one second to produce a current of one ampere.
Ampere	A or Amp.	Unit of current. (Rate of flow) One coulomb per second.
Milliampere	ma	.001 amp. (The prefix "milli" means one-thousandth).
Microampere	μa	.000001 amp (The prefix "micro" means one-millionth).
Ohm	ohm or Ω	Unit of resistance (R); measure of the opposition offered to the flow of current. The resistance offered by a column of mercury 106.3 centimeters long and 1 square millimeter in cross sectional area, at a temperature of 32 degrees fahrenheit, or 0 degrees centigrade.
Megohm	Meg.	1,000,000 One-million ohms.
Microhm		.000001 One-millionth ohm.
Mho	g	Unit of conductance (g) - measure of the ease with which a conductor will permit current to flow. It is the reciprocal of resistance.
Volt	v	Unit of pressure difference. (EMF - Electromotive Force). The pressure required to force current at the rate of one ampere through a resistance of one ohm.
Millivolt	mv	.001 v One-thousandth volt.
Microvolt	μv	.000001 v One-millionth volt.
Kilovolt	kv	1000v (The prefix "kilo" means one-thousand).
Watt	w	Unit of power. One watt is equal to current at the rate of one ampere under the pressure of one volt. P=IxE.
Milliwatt	mw	.001 w One-thousandth watt.
Kilowatt	kw	1000 w Unit of power.
Watthour	wh	Unit of work. (Power x Time) w x h = wh.
Kilowatt hour	kwh	1000 wh Unit of work.
Horsepower	hp	746 w The power required to raise 33,000 pounds, one foot in one min.
Farad	f	Unit of capacitance. Capacity of capacitors (condensers).
Microfarad	mf or μf	.000001 f One-millionth farad.
Micromicro-farad	mmf or μμf	.000001 mf One-millionth microfarad.
Henry	h	Unit of inductance.
Millihenry	mh	.001 h One-thousandth henry.
Microhenry	μf	.000001 henry One-millionth henry.

Since each of these circles represents three formulas, we have a total of twelve formulas concerning Ohm's law and Watt's law.

All twelve formulas may be conveniently arranged in the so-called "WIRE" wheel, which shows three methods of finding any one of the four values, watts, amperes, ohms or volts, if we know any two of the other values. This memory device is shown in Fig. 5.

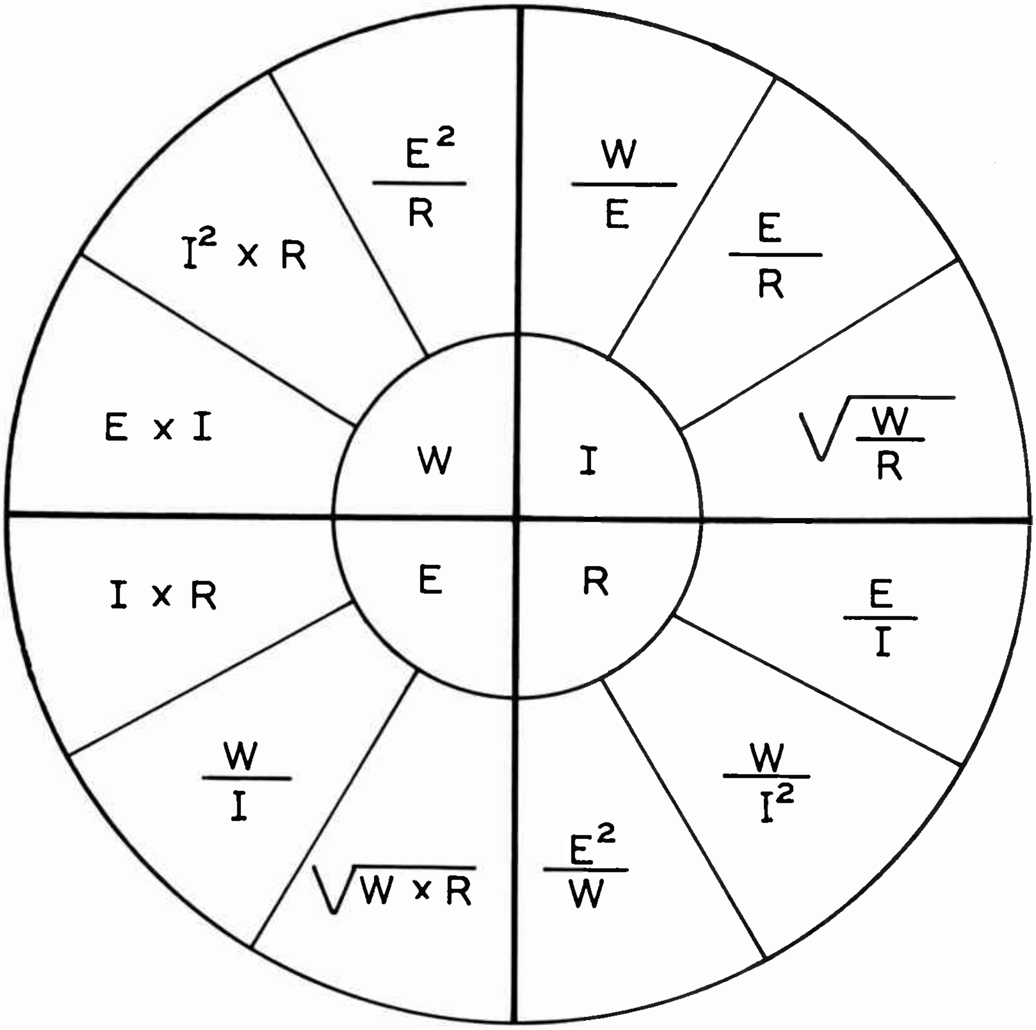
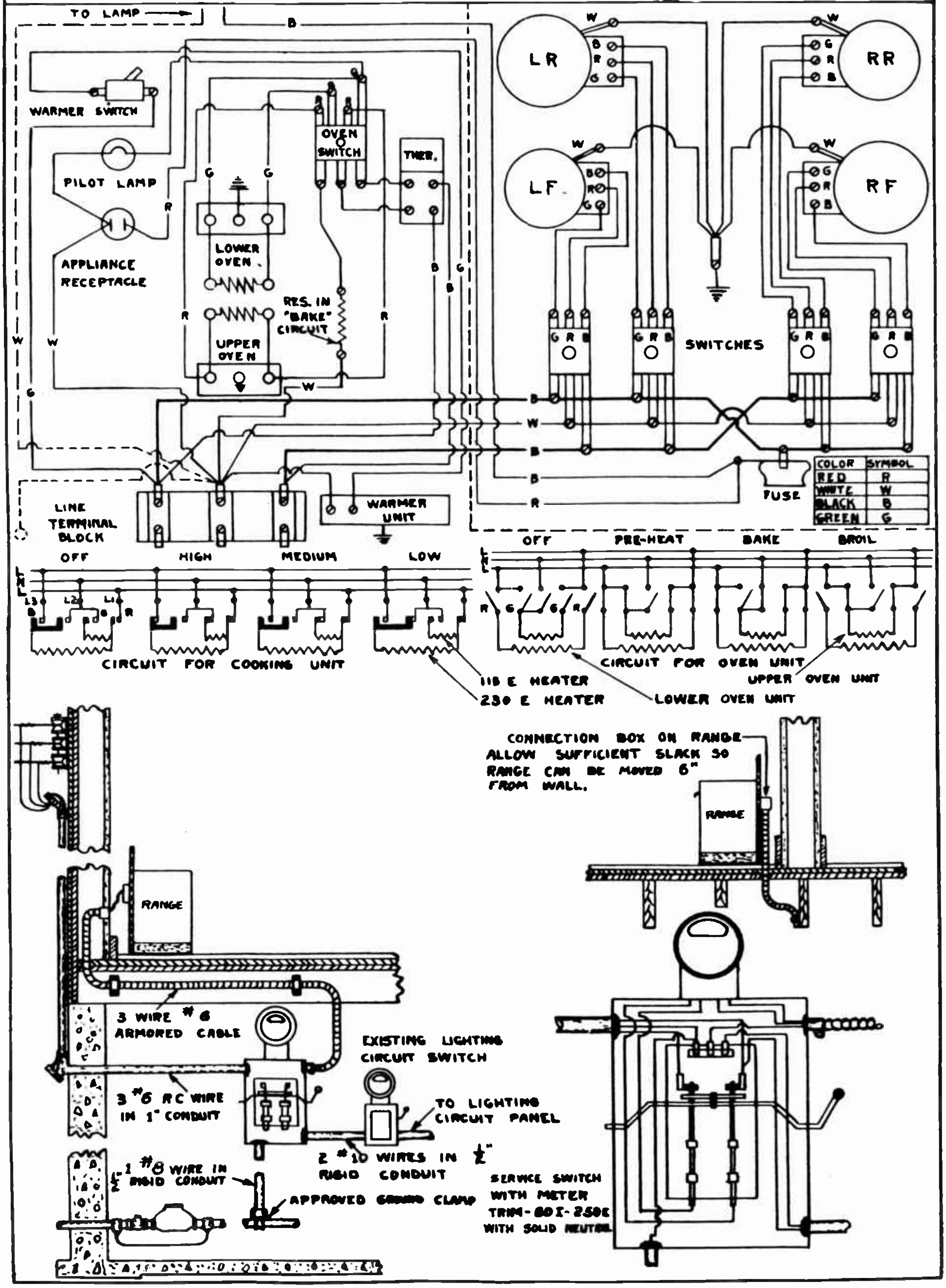
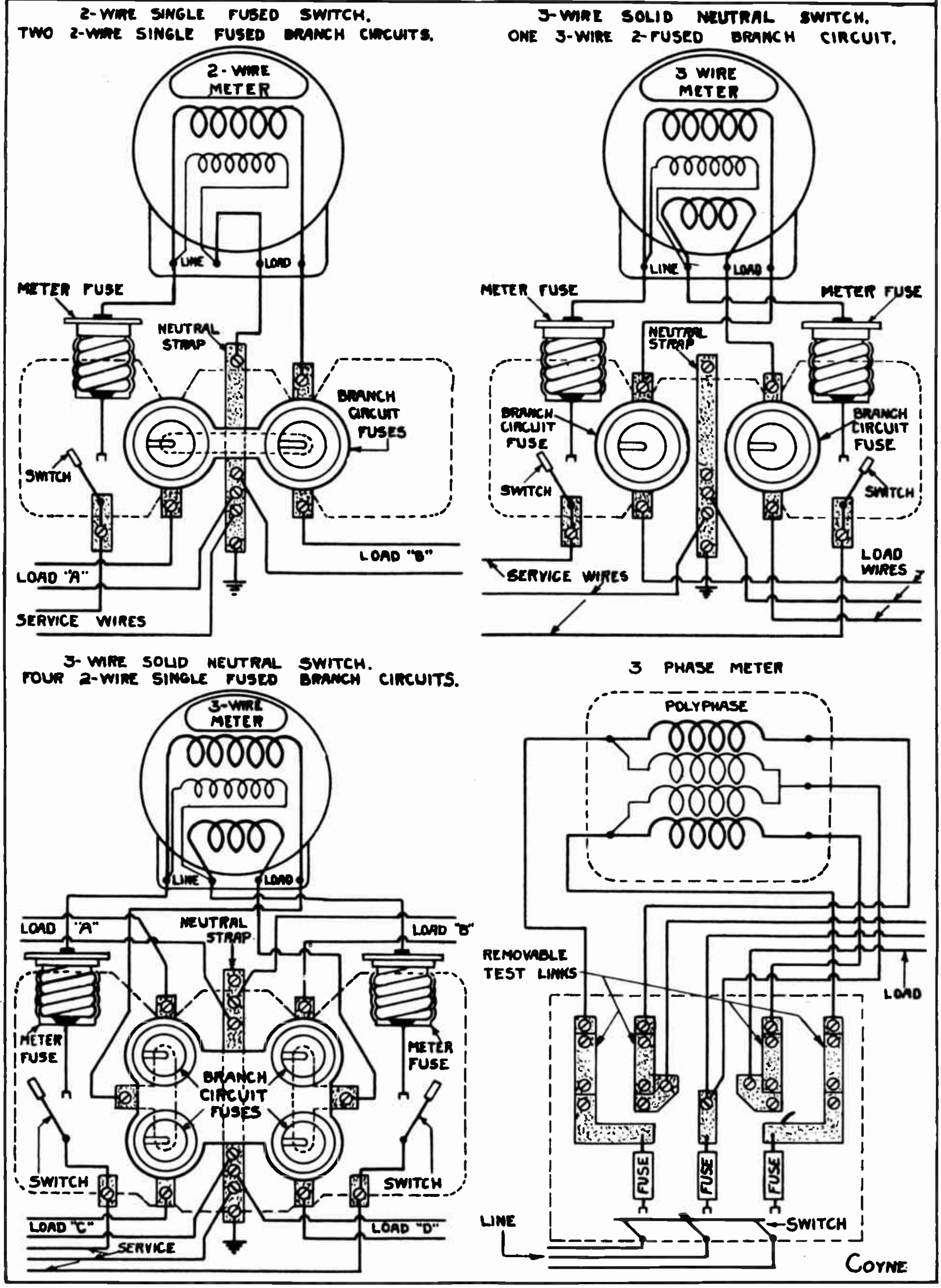


Fig. 5. Memory Circle for Formulas Using Ohm's Law and Watt's Law.

ELECTRIC RANGE CIRCUITS AND INSTALLATION



METER CONNECTIONS



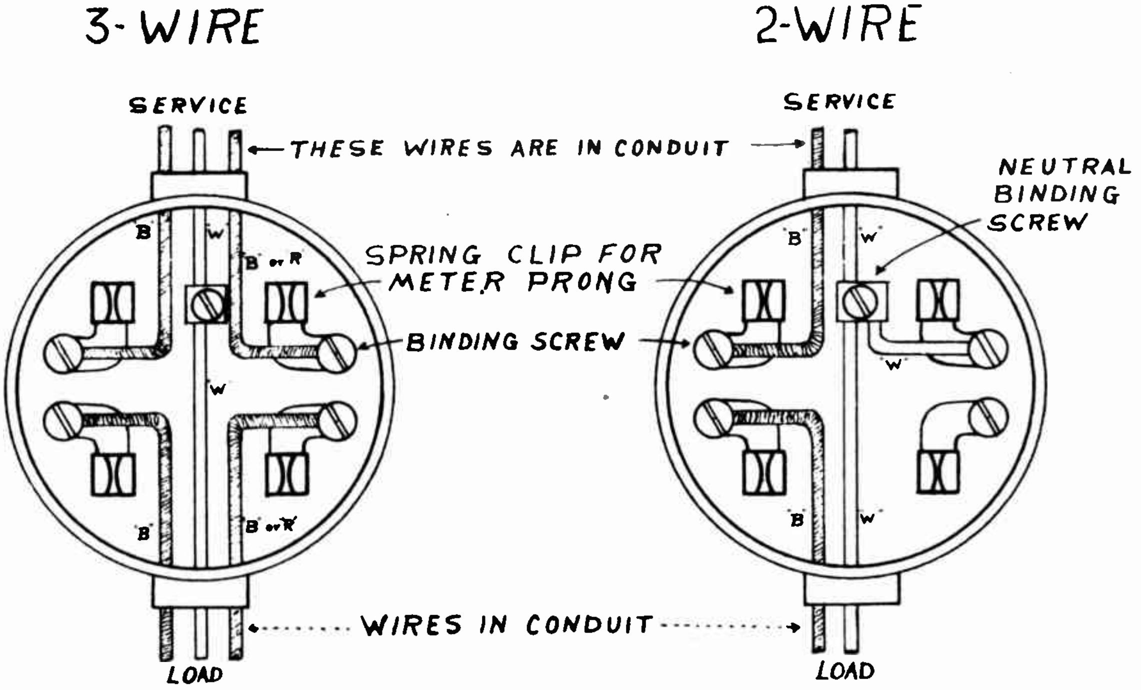
2-WIRE SINGLE FUSED SWITCH.
TWO 2-WIRE SINGLE FUSED BRANCH CIRCUITS.

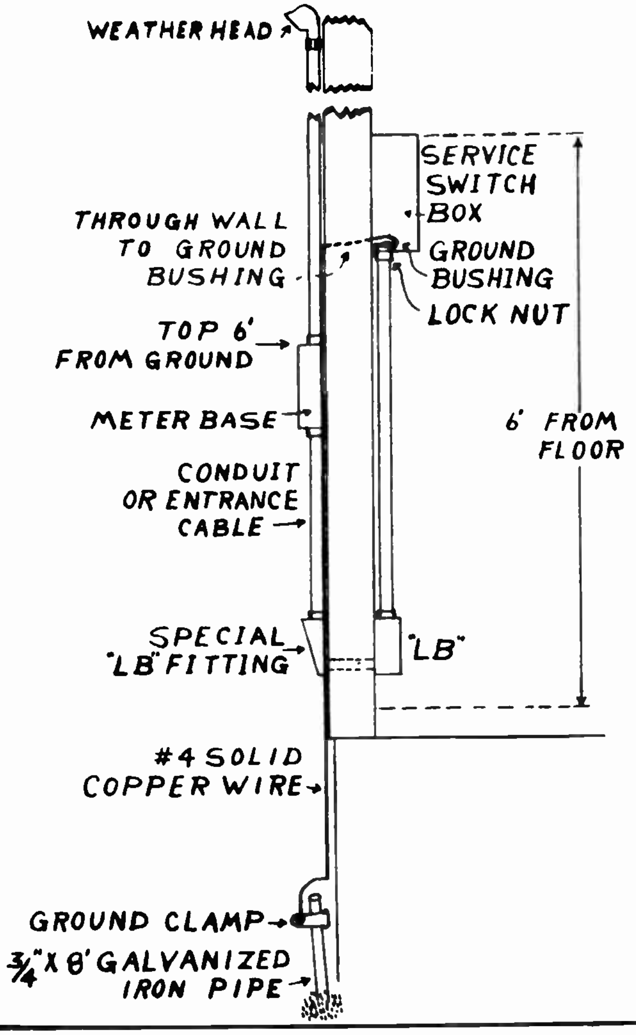
3-WIRE SOLID NEUTRAL SWITCH.
ONE 3-WIRE 2-FUSED BRANCH CIRCUIT.

3-WIRE SOLID NEUTRAL SWITCH.
FOUR 2-WIRE SINGLE FUSED BRANCH CIRCUITS.

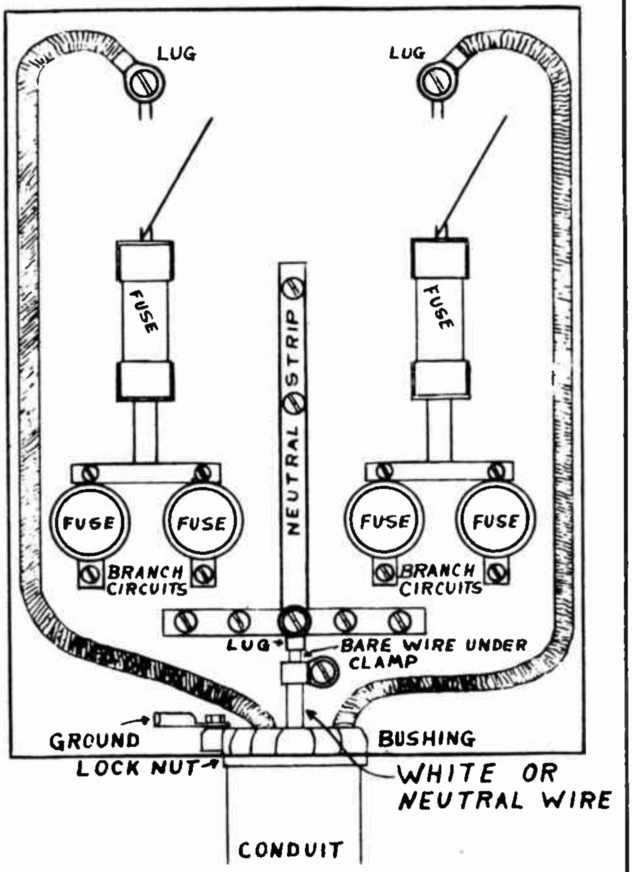
3 PHASE METER

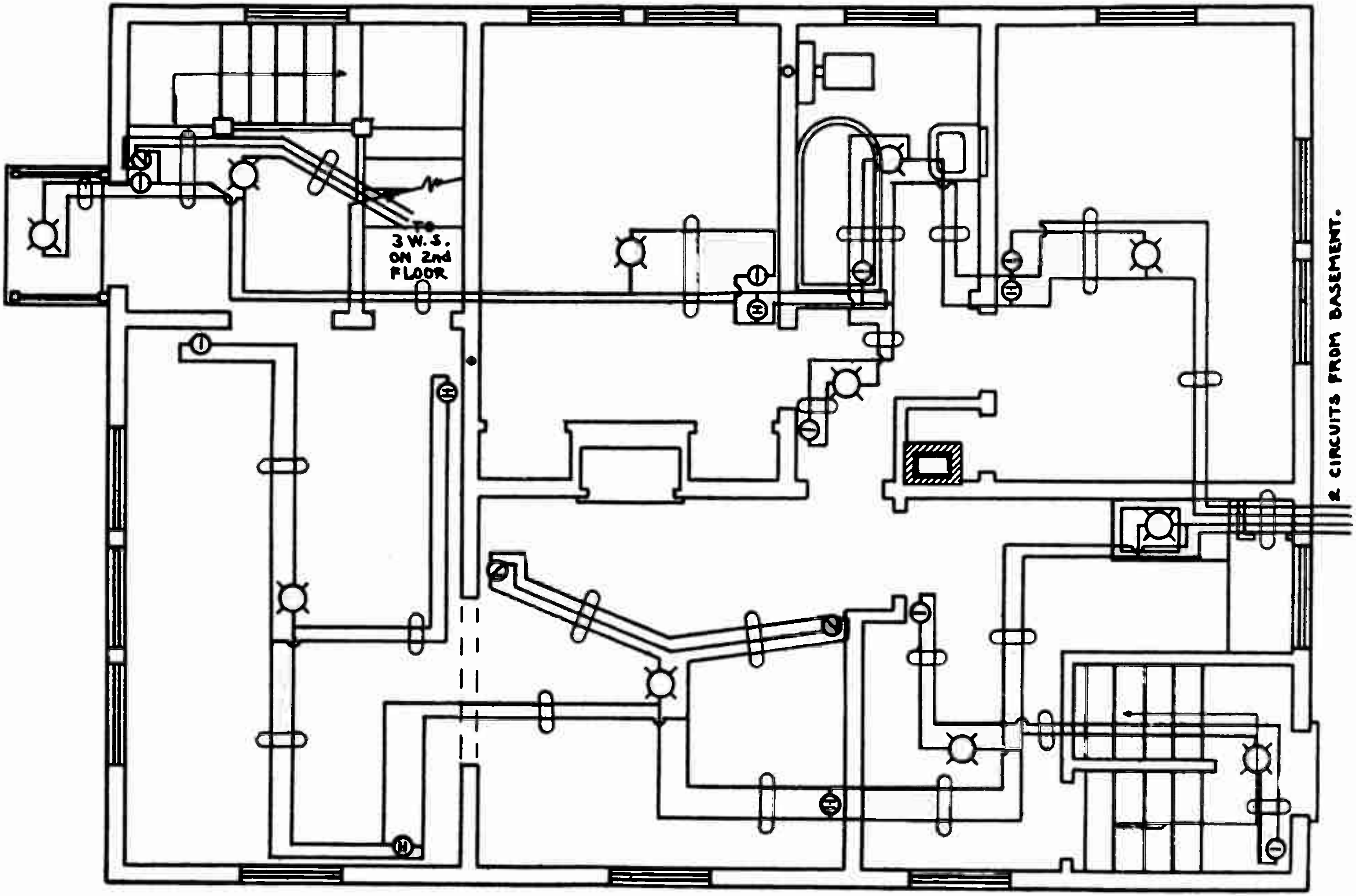
WIRING METER BASE FOR SOCKET TYPE METER





CONNECTIONS IN SERVICE BOX





CIRCUIT WIRING DIAGRAM OF BUNGALOW WIRING SYSTEM.

DIRECT CURRENT APPARATUS

This section shows internal and external wiring for devices and equipment that operate with direct current The pages are grouped in the following order of subjects:

- Motors, also general principles
- Generators or dynamos
- Armature windings
- Testing
- Starters and controllers

Except in the group devoted to starters and controllers most of the pages include explanations of the diagrams. The following additional notes apply to certain of the pages, as referred to by number.

PAGE 12

This sheet shows simple schematic diagrams for series, shunt and compound motors, and on the right-hand margin lists the connections from the power line to the motor terminals for counter-clockwise (CCW) rotation and for clockwise (CW) rotation. The following abbreviations are used:

A1 and A2. Armature connections
F1 and F2. Shunt field connections
S1 and S2. Series field connections
L1 and L2. D-c power line
Comm. Commutating winding

PAGE 18

Here, on a single chart, is the whole story of motor operating characteristics and applications. Going from left to right on the chart you find the speed characteristics, kind of electric power, construction and windings, usual horsepowers, starting and stalling torque as compared with normal full load torque, variations of speeds with loads, the principal performance features of the motor, and finally the drives or applications for which each motor is especially well suited. Careful study of this table will add greatly to your knowedge of motors and their uses.

PAGES 23 AND 24

These diagrams of General Electric direct-current machines illustrate how winding connections and external terminal connections are shown.

PAGE 37

This sheet shows how records are made and kept for armature winding repair jobs. Entries are made under the heading "REWIND DATA" as the armature is being stripped. Positions to which coil leads connect on the commutator are shown on the large central diagram. On this diagram are entered the numbers of the core slots in which lie the coil sides. Below the coil diagram are shown two sets of commutator bars as they would appear if laid out flat. On one set the center of a bar is on the center line of a coil. On the other set the insulation between bars is on the coil center line. Coil leads are run down to bars on whichever commutator arrangement is used on the armature being wound or repaired.

PAGE 40

This sheet shows the construction, winding, and connections for a growler. A growler is a device which generates voltages and currents in the coil windings of an armature laid on the field poles of the growler. Readings of armature currents are made as shown on the following page. Correct interpretation of readings allows determining the kind of trouble and its approximate location.

PAGE 46

These symbols are used in diagrams for motor starters and controllers for both direct-current and alternating-current. The following notes apply to symbols as you read from left to right across the successive lines from top to bottom of the page.

N.O. means "normally open." N.C. means "normally closed." A blowout is a device, usually an electromagnet, which lessens sparking as current-carrying contacts separate. Main circuits are those carrying line power. Auxiliary circuits usually are control circuits. An interlock is a connection, either mechanical or electromagnetic, that causes certain contacts to operate when other contacts operate, or which cause any two actions to occur simultaneusly.

Note that on double-circuit push buttons there are four small circles indicating the four terminal connections for the two lines. In a maintained contact push button one terminal always remains connected to the switch contacts. A limit switch is a switch operated automatically when some portion of a machine reaches the limit of its travel; as, for example, on a machine tool where the motor is to be stopped or reversed when the cutter reaches the end of its travel.

A thermal overload relay opens its circuit when excessive current has continued for long enough to heat and expand a member that releases the contacts.

An auto-transformer is a transformer in which part of the winding is in both the primary circuit and the secondary circuit. A potential transformer transfers voltage changes from one circuit to another without having conductive connections between the circuits. A current transformer transfers current changes from one circuit to another. Potential tansformers and current transformers often are called instrument transformers, since their usual purpose is to connect voltage-operated and current-operated instruments to circuits in which changes of voltage and current are to be measured or indicated.

PAGE 55

The lower right-hand diagram shows the motor armature and field windings connected directly to one side of the line. The other side of the line, L1, connects through a starter to the remaining terminals of the motor. Either of the starters may be used. Both starters are of the "face plate" type on which the power arm or handle is moved slowly from left to right across contact points between which are resistors mounted on the back of the starter face plate. When the handle reaches the right-hand end of its travel it is held there by an electromagnet marked "No E (voltage) or no field release coil." Should line voltage fail or should it drop below a safe operating value, this release coil is demagnetized to an extent that releases the arm. Then a spring moves the arm back to the left-hand off position.

The upper right-hand diagram shows a starter equipped with the no-voltage release coil, also with an overload release coil. The overload release coil is a magnetic switch that opens the line circuit should the current rise above a safe operating value.

PAGE 56

This is a setup diagram for testing the horsepower output of a motor with a prony brake and for testing the efficiency by measuring the amperage and voltage from which are computed the electrical power input in watts (amperes x volts). The voltmeter and ammeter are mounted on a separate panel shown at the upper right.

PAGE 59

The stationary contacts of the drum controller are shown by circles. The contact shoes which are on the drum and which move with the drum are shown by rectangular outlines. All the shoes move together, either to the right or to the left on the diagram.

PAGE 67

When the motor is to be started with the solenoid starter the start switch button (upper right) is pressed to close the switch contacts. Current from the line (L1) flows through the solenoid magnet winding to terminal C1, through the closed stop switch contacts, the closed start switch contacts, to terminal C3, and back through L2 to the other side of the line. The solenoid plunger rises, and with it the power arm. The power arm short circuits and cuts out more and more of the armature starting resistance as the motor starts and gains speed. Opening the stop switch by pressing its button opens the circuit through the solenoid winding, thus allowing the plunger and power arm to drop and open the motor circuit.

PAGE 69

In tracing the diagrams on this and following pages refer to the symbols shown and explained on page 48

In relays Type J-30 and Type J-31 closing the contacts of the control device (any suitable switch) lets control circuit current flow through the relay magnet winding represented by a circle on the right-hand heavy conductor. The magnet closes the contacts shown above the circle and allows current to flow to the load.

On the right-hand side of the page the upper diagram is a connection diagram or wiring diagram for the starter, the start and stop push button switch, and the shunt wound motor. The lower diagram is a schematic in which it is easy to trace the current paths. On the lower line of the schematic diagram the contacts in series with the motor are marked M. These contacts are closed and opened by the double wound electromagnet coil.

One winding is energized by closing the start switch. Auxiliary contacts, shown inside the starter of the upper diagram, are holding contacts which close and maintain a circuit through the second coil until the stop button is pressed to open the entire control circuit.

PAGE 70

In this starter there is a relay, AR, on the moving plunger of which is a dashpot that allows the plunger to move only slowly while the coil is energized. The slow movement of the plunger successively closes contacts that short circuit resistor sections R2, R3 and R4, thus reducing resistance in the armature circuit as the motor gradually gains speed.

PAGE 71

Of the two upper diagrams the one at the left shows terminal connections and the one at the right shows the schematic circuits. Pressing the FOR (forward) button sends current through the armature and commutating (COM.) field in one direction and caues the motor to rotate say clockwise. Pressing the REV (reverse) button reverses the direction of current in the armature and commutating field, which reverses the direction of motor rotation. On the schematic diagram the forward contacts are marked F and the reversing contacts are marked R. There are two relay magnets, one forward and the other reverse, each operating its own set of contacts.

The two lower diagrams are schematic diagrams for starters providing both time limit and reversing features. A dashpot on the magnetic relays limits the rate at which they close their contacts, thus cutting out armature resistance in one step after another at definite time intervals. The reversing feature operates similarly to that shown in the upper diagrams.

PAGE 73

This is a speed regulator that reduces the speed of the motor below normal by inserting more and more resistance in series with the armature, and that increases the speed above normal by inserting resistance in series with the shunt field winding of the motor. Armature resistance is shown by heavy lines on the controller, while field resistance is shown by light lines.

Century

ENGINEERING INFORMATION
CONNECTION DIAGRAMS FOR DIRECT CURRENT MOTORS
SINGLE VOLTAGE, REVERSIBLE, WITHOUT OVERLOAD PROTECTION

TYPE OF WINDING	TYPE DM 1/3 HP & SMALLER 60-70-80 FRAME, NO INTERPOLE	TYPE DM 1/2 & 3/4 HP, 70-80 FRAME, NO INTERPOLE	TYPE DN ANY HP, 90 & LARGER FRAMES WITH INTERPOLES

• - CONNECTIONS

	CCW	CW
	(FACING END OPPOSITE SHAFT)	

SERIES

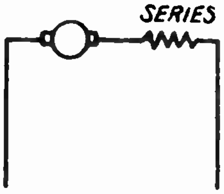


FIG. 1

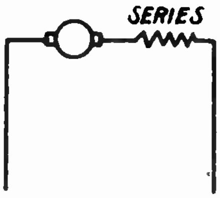


FIG. 2

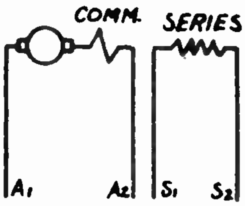


FIG. 3

CCW	CW
L_1 TO A_1	L_1 TO A_2
A_2 TO S_1	A_1 TO S_1
L_2 TO S_2	L_2 TO S_2

SHUNT

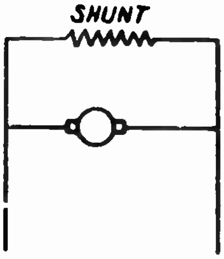


FIG. 4

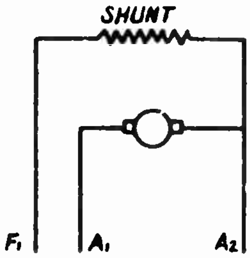


FIG. 5

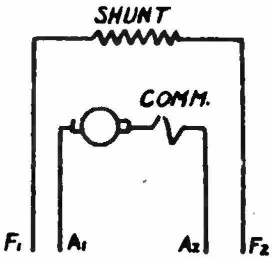


FIG. 6

CCW	CW
L_1 TO F_1; A_1	L_1 TO F_1; A_2
L_2 TO F_2; A_2	L_2 TO F_2; A_1

COMPOUND

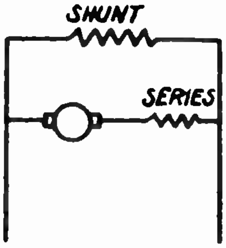


FIG. 7

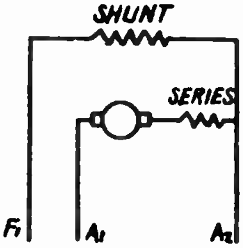


FIG. 8

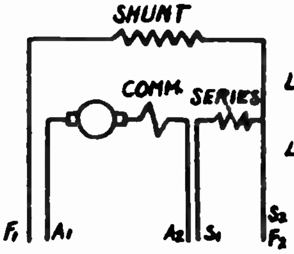


FIG. 9

CCW	CW
L_1 TO F_1; A_1	L_1 TO F_1; A_2
A_2 TO S_1	A_1 TO S_1
L_2 TO S_2F_2	L_2 TO S_2F_2

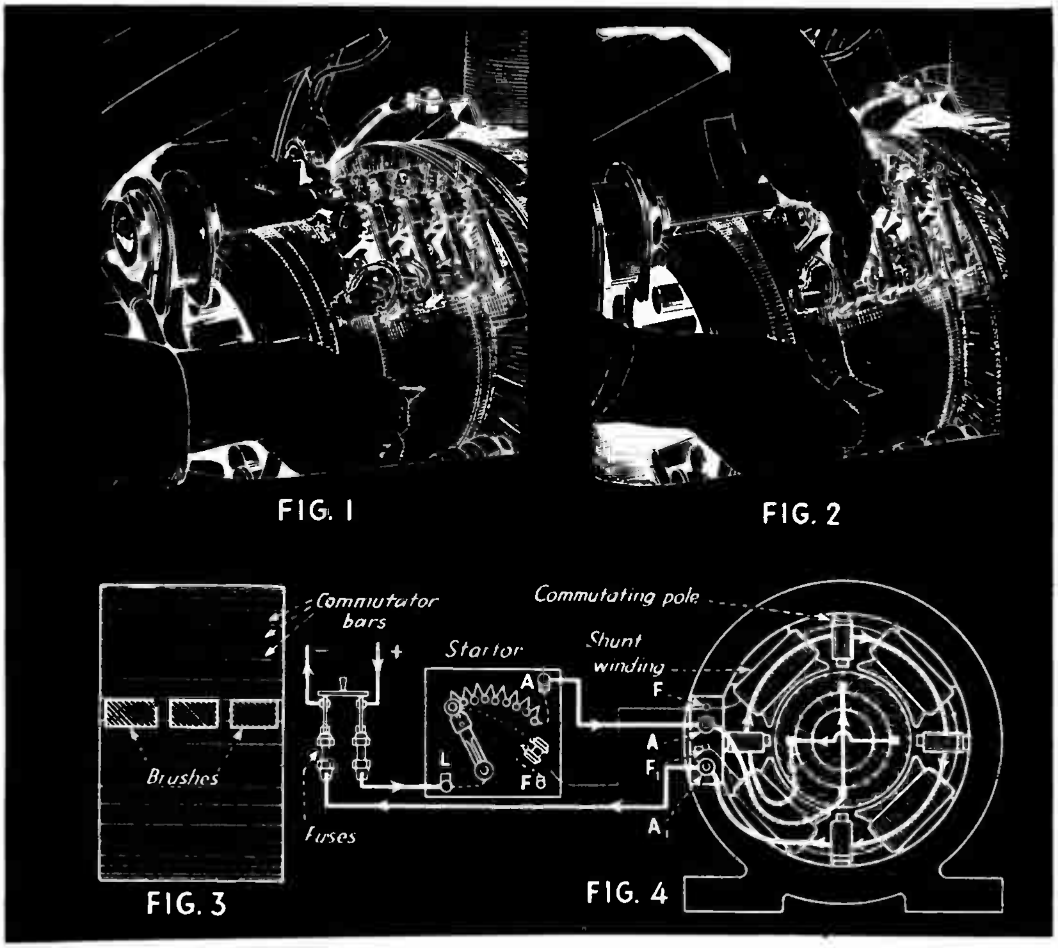
TO REVERSE ROTATION INTERCHANGE LEADS AT BRUSH HOLDER; STANDARD ROTATION IS C.C.W. FACING END OPPOSITE SHAFT

TAG 882-A IS FURNISHED WITH THESE MOTORS.

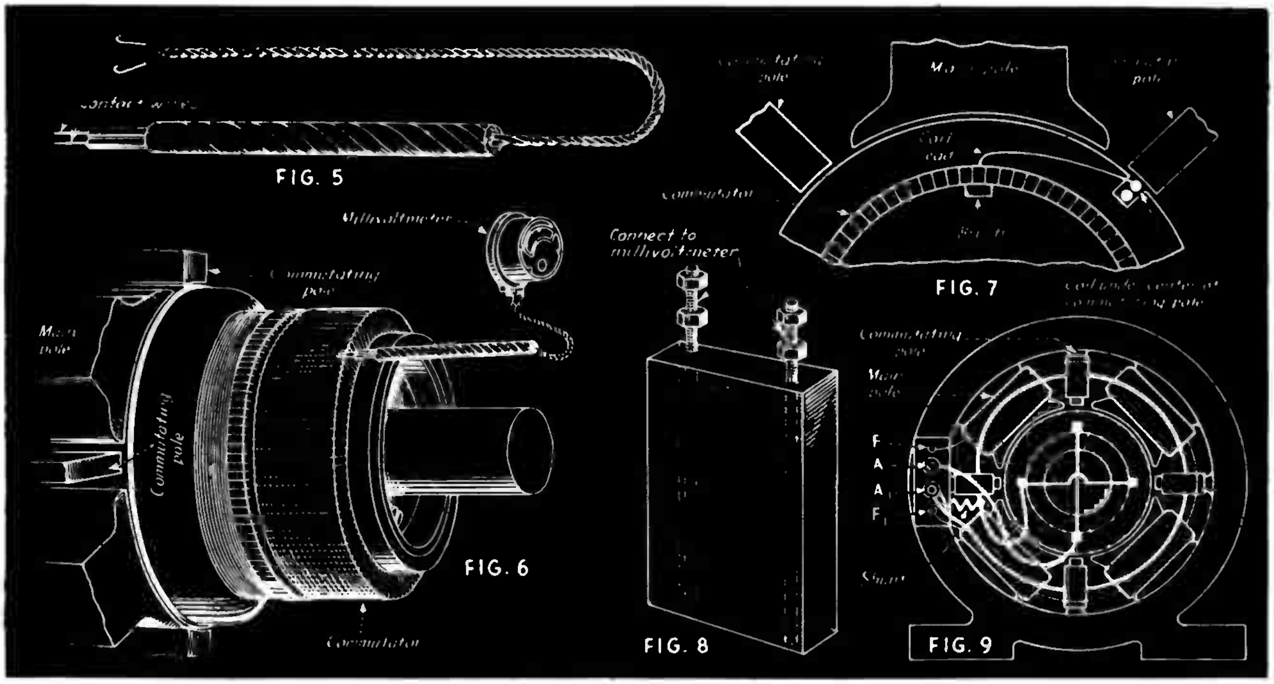
• - CONTROL NOT COVERED - CONSULT CONTROL MANUFACTURERS DIAGRAMS.

TAG 882-A AND CONNECTION DIAGRAM IS FURNISHED WITH THESE MOTORS.

Brushes and Brush Setting



Figs. 1 and 2—Fitting brushes to commutator with sand paper. Fig. 3—Brushes in each group should be in line. Fig. 4—Field circuit open to test brush location on commutator

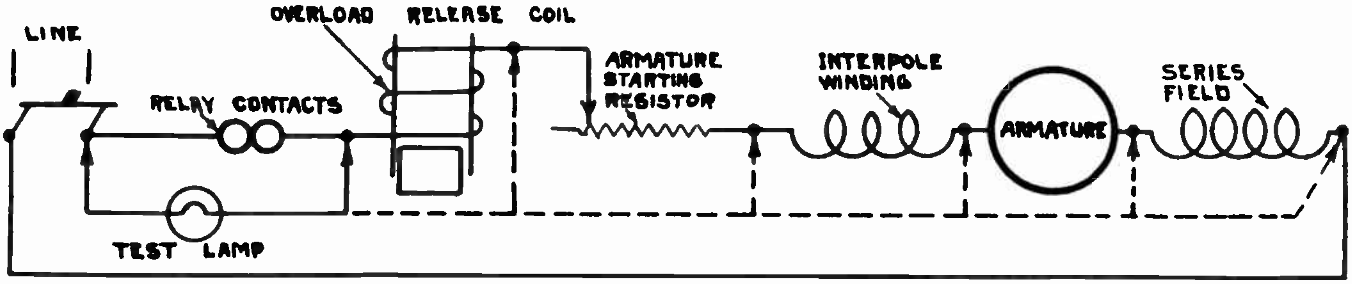


Figs. 5 and 6—Locating neutral on commutator with millivoltmeter. Fig. 7—Armature-coil lead locates neutral. Fig. 8—Fibre brush used with millivoltmeter. Fig. 9—Shunt across commutating-pole coil leads to adjust field-pole strength.

MAINTENANCE & TROUBLE SHOOTING

A MACHINE MAY FAIL TO START OR IMPROPERLY OPERATE DUE TO-

1. Opens, loose connections or high resistance contacts in the motor, line or starter. Use a test lamp or a voltmeter and make a continuity test as shown by sketch.

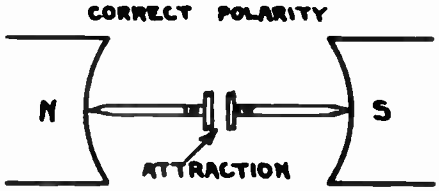


2. Worn bearings, on small machines and bearings can be tested by moving the shaft. If bearings are worn there will be a noticeable clearance between the bearing and shaft. For a more accurate test measure the air gap with an air gap or thickness gauge. For best condition the surface of all field poles should be the same distance from the armature core. Use the same position on the armature for all tests.

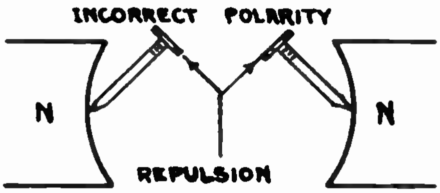
BEARINGS NOT WORN			
UPPER	LEFT	MEASUREMENT	.026"
UPPER	RIGHT	"	.026"
LOWER	"	"	.026"
LOWER	LEFT	"	.026"

WORN BEARINGS			
UPPER	LEFT	MEASUREMENT	.044"
UPPER	RIGHT	"	.044"
LOWER	"	"	.008"
LOWER	LEFT	"	.008"

3. Incorrect field pole polarity. Field pole polarity will not reverse itself. This trouble occurs when field connections are being made between coils. Adjacent poles should produce opposite polarity otherwise maximum field strength will not be produced. A weakened field will cause a motor to run at a speed higher than normal and decrease the amount of torque it will produce.



A magentic compass or large nails can be used to determine if adjacent poles are opposite polarity.

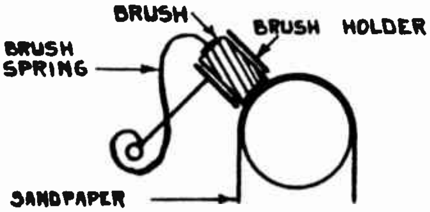


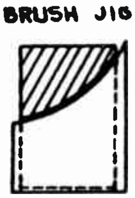
4. High or low line voltage. The armature of a shunt or compound motor will overheat if the line voltage is lower than normal if the motor is carrying its full load. High line voltage will cause the shunt field to over heat. Series motors will not be affected except the speed will vary with the voltage applied to the motor.

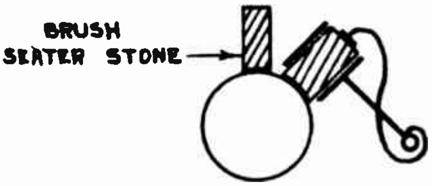
5. Operating temperatures. The temperature rating on the name plate is the amount of heat the machine will produce when operating with full load. The maximum operating temperature for any machine is the name plate temperature plus normal room temperature. Example - Name plate temperature 40 degrees centigrade - Normal room temperature is always considered to be 40 degrees centigrade. This machine will operate at a temperature of 40° plus 40° or 80° centigrade which is equal to 176 degrees fahrenheit. The following formulas are used to change fahrenheit to centigrade or vise versa. F equals (C times 1.8) plus 32 C equals (F minus 32) divided by 1.8.

MAINTENANCE & TROUBLE SHOOTING (continued)

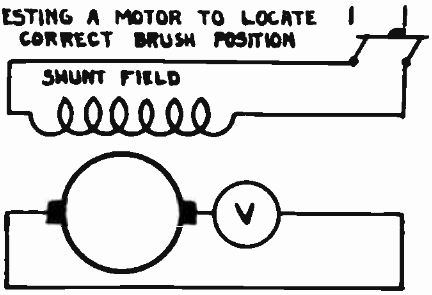
6. Brushes not properly fitted to the commutator. Use sandpaper, brush jig or brush seater stone to fit or seat brushes.

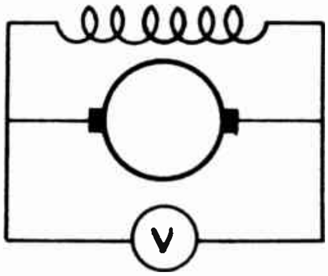


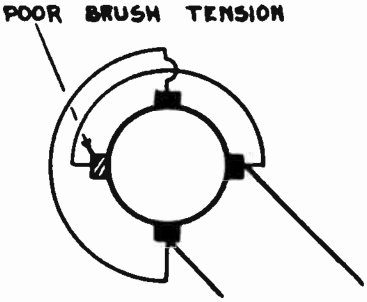




7. Brushes off neutral position. This condition will cause brush sparking and cause a motor to operate at a speed higher than name plate speed. The correct position can be located by using one of the following methods. 1. If the machine is operating with load shift the brushes to a position of sparkless commutation. 2. Connect a voltmeter across the brushes of a motor and the shunt field circuit. The brush position giving the lowest voltmeter reading will be the correct position. The motor must not rotate while the test is being made. For a generator the brush position giving the highest voltage will be the correct position. The generator should be operating without load when the test is made.


TESTING A MOTOR TO LOCATE CORRECT BRUSH POSITION


TESTING A GENERATOR TO LOCATE CORRECT BRUSH POSITION


POOR BRUSH TENSION

8. Poor or unequal brush tension. Apply equal tension of 1 to 3 lbs. per square inch of brush surface on the commutator. Measure brush tension by using a small spring scale.

9. High mica. Use hack saw blade or undercutting machine and undercut the mica about 1/16 inch.

10. Wet or oily windings. All damaged windings must be properly cleaned and repaired before drying. Use carbon tetra chloride or other agents for cleaning. Dry windings by baking a 180° F. until dry. Motors can be dried out by operating them with an ammeter and a regulating resistor connected in series with the machine windings. Adjust the regulating resistor so the current through the machine windings will not exceed name plate value. After machine has been dried out make an insulation test to determine the condition of the insulation.

11. Rough or dirty commutator. Smooth commutator with sandpaper or commutator stone. True commutator by turning it in a lathe or using tools made for that purpose. After trueing a commutator in a lathe use #000 or #0000 sandpaper to smooth commutator. Clean commutator with fine sandpaper or use a cleaning agent such as carbon tetra chloride. It is best not to use a cutting agent for cleaning. Never use emery cloth or a lubricant of any kind on a commutator.

12. Incorrect grade of carbon brush. Carbon brushes vary in capacity from 40 I to 125 I per square inch of brush surface in the commutator. When renewing brushes always be certain that the brush used has sufficient capacity to carry the load without overheating.

MOTORS - POLYPHASE - ROTATING FIELD

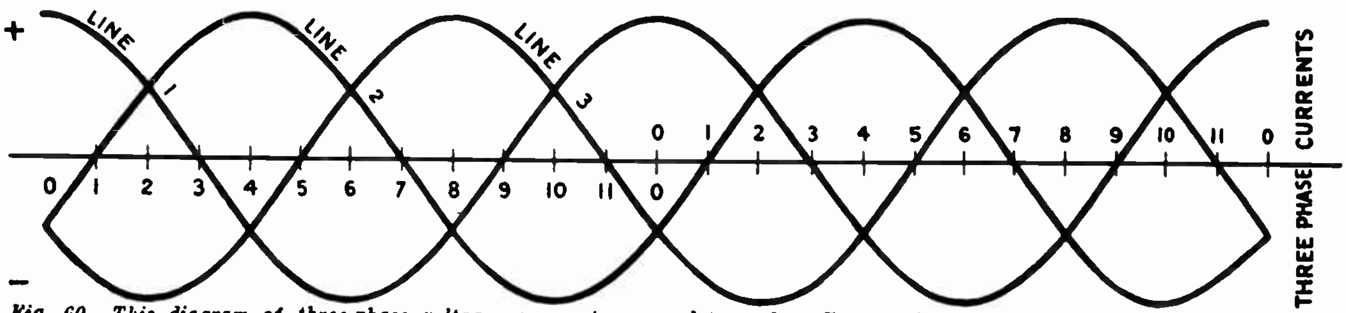
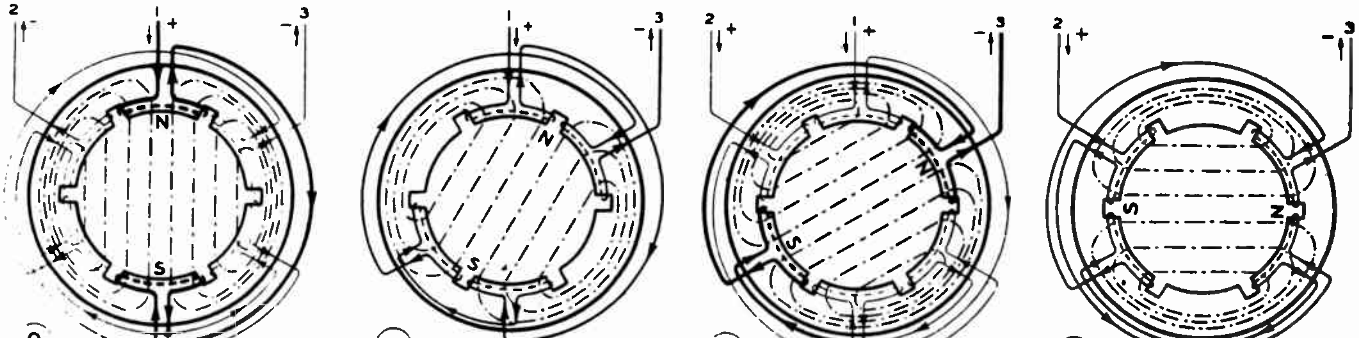


Fig. 60. This diagram of three-phase voltages covers two complete cycles. The numbers on it refer to the numbers on the diagrams below. Each diagram shows the condition in the armature at the instant indicated by the corresponding number on this curve. The action of the magnetic field is smooth and regular; the rise and fall of currents in the conductors is also smooth and regular



0

The current entering the motor on line 1 divides equally and leaves the motor on line 2 and line 3

1

Now the current in line 2 is zero and that flowing in at line 1 leaves at line 3. The magnetic field revolves clockwise

2

The current in line 1 is small and joining that from line 2 flows out in line 3 which carries a maximum negative current

3

This and the following diagrams show how the magnetic field continues to rotate throughout the remainder of the cycle

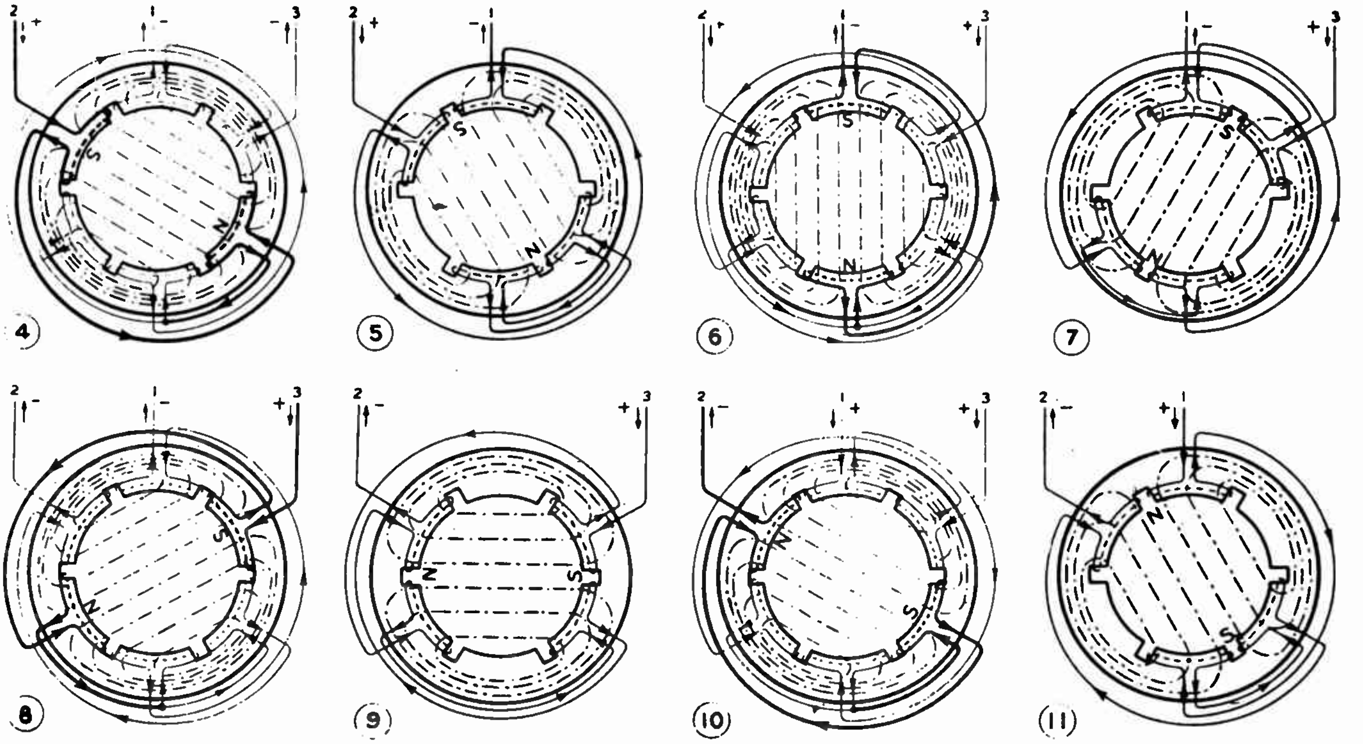


Fig. 61. This series of twelve diagrams shows the electric and magnetic conditions in a two-pole, three-phase motor at the end of twelve equal parts of one cycle

MOTOR CHARACTERISTICS

Type of Driven Machinery	Motor Type Designation	Speed R.P.M.	Approx. Starting Torque in % of Full Load Torque	Approx. Maximum Torque in % of Full Load Torque	Approx. Starting Current in % of Full Load Current	Approx. Speed Regulation % Slip	Starting Equipment	Load Conditions
Pumps (Centrifugal, Rotary and Turbine); Cotton Gins; Fans (Centrifugal and Propeller); Line Shafts; Motor Generator Sets; Shapers; Screw Machines; Planers; Milling Machines; Keyseating Machines; Lathes; Buffers; Drill Presses; Metal Grinders; Joiners; Molders; Sanders; Circular Saws (Small and Medium); Positive Pressure Blowers; Job Printing Presses; Brine Agitators; Pulp Grinders; Jordans; Laundry Washers; Small Stokers.	Type QZK	1800	125 To 180	200 To 250	450 To 550	2 To 4	Type QZK motors may be started across the line at full voltage with comparative low starting current. Starters may be reduced voltage or full voltage types. Manual or magnetic, non-reversing or reversing.	Require normal starting torque for continuous duty. Infrequent load fluctuations. Motor provides service factor for overload conditions. Constant speed. No special conditions.
		1200	125 To 180	200 To 250	450 To 550	2 To 4		
		900	115 To 140	200 To 225	450 To 550	2 To 4		
Pumps (Reciprocating and Displacement); Air Compressors; Refrigerating Compressors; Conveyors; Stokers; Crushers (without flywheels); Dough Mixers; Grinders, Hammer Mills; Ball Mills; Turn Tables; Car Pullers; Large Band Saws; Pug Mills; Dry Pans; Brick Presses; Gear Plungers; Brick and Tile Machines; Foundry Tumbling Barrels; Centrifugal Sand Mixers; Grain Elevator Legs; Bending and Straightening Rolls; Bucket-type Elevators; Conveyors starting loaded.	Type QOZK Ratings 3 H.P.& Larger	1800	225 To 275	200 To 250	450 To 550	3 To 5	Across the line, full-voltage manual or magnetic, non-reversing or reversing.	Compressors and pumps requiring less than 7½ Hp. under certain conditions may be successfully handled by type QZK Motors. Heavy starting, continuous or intermittent duty; service factor for overload conditions.
		1200	200 To 250	200 To 225	450 To 550	3 To 5		
		900	190 To 225	190 To 200	450 To 550	3 To 5		
Passenger and Freight Elevators.	Type QRZK	1800	300-400	300-400	300-350	15-20	Across the line, full-voltage reversing elevator control with master switches or drives.	Require high starting torque intermittent duty single speed reversing service.
		1200	300-400	300-400	300-350	15-20		
Hoists, Lifts, Small Cranes, Valves.	Type QLZK	1800	300-400	300-400	325-375	15-20	Same as for Type QRZK.	Intermittent duty single speed reversing.
		1200	300-400	300-400	325-375	15-20		
Punch Presses, Laundry Extractor, Shears, Power Hammers, Crushers with Flywheels, Bending Rolls with Flywheels.	Type QFZK	1800	300-350	300-350	375-450	Range 5-8 8-13	Across the line, full-voltage, manual or automatic reversing or non-reversing.	High starting torque. Heavy fluctuating loads, usually with flywheels or high inertia to accelerate; continuous duty.
		1200	300-350	300-350	375-450			
		900	300-350	300-350	375-450			
Pumps, Centrifugal and Turbine Blowers and Fans, Centrifugal and Propeller.	Type QBZK 40 H.P. & Larger	1800	75-100	150-160	350-400	3-5	Across the line, full-voltage, manual or automatic reversing or non-reversing.	Low starting and maximum torque. Low starting current. Continuous duty, service factor 1.0 and no overload capacity.
		1200	75-100	150-160	350-400	3-5		
		900	75-100	150-160	350-400	3-5		
Compressors; Conveyors; Elevators; Grinding Machinery; Hoists; Laundry Machinery; Machine Tools; Mills; Mixing Machines; Positive Displacement Blowers; Positive Displacement Pumps; Printing Presses; Pulverizing Machines; Woodworking Machines.	QXZK Multi-Speed Constant Torque	1800/900	125-180	200-250	450-550	2-4	Type QXZK motors may be started across the line at full voltage with comparative low starting current. Starters may be reduced voltage or full voltage types. Manual or magnetic, non-reversing or reversing.	Require normal starting torque for continuous duty. Infrequent load fluctuations. Motor provides service factor for overload conditions. Constant speed. No special conditions.
		1800/ 1200/ 900/600	125-180	200-250	450-550	2-4		
Machine Tools; Production Equipment; Punch Presses; Winches, Bending Rolls, etc.	QMZK Multi-Speed Constant Horsepower	1800/900	125-180	200-250	450-550	2-4	Type QMZK motors may be started across the line at full voltage with comparative low starting current. Starters may be reduced voltage or full voltage types. Manual or magnetic, non-reversing or reversing.	Require normal starting torque for continuous duty. Infrequent load fluctuations. Motor provides service factor for overload conditions. Constant speed. No special conditions.
		1800/ 1200/ 900/600	125-180	200-250	450-550	2-4		
Blowers, Fans and Pumps.	QNZK Multi-Speed Variable Torque	1800/900	125-180	200-250	450-550	2-4	Type QNZK motors may be started across the line at full voltage with comparative low starting current. Starters may be reduced voltage or full voltage types. Manual or magnetic, non-reversing or reversing.	Require normal starting torque for continuous duty. Infrequent load fluctuations. Motor provides service factor overload conditions. Constant speed. No special conditions.
		1800/ 1200/ 900/600	125-180	200-250	450-550	2-4		

SPEED CLASSIFICATION	POWER SUPPLY		N.E.M.A. CLASS	L.A. TYPE	TYPE OF MOTOR	** RANGE OF HORSEPOWER RATINGS	STARTING TORQUE PER CENT OF FULL LOAD	MAXIMUM TORQUE PER CENT OF FULL LOAD	SPEED REGULATION PER CENT SLIP	GENERAL REMARKS	AGITATORS - MIXERS	BALL - ROD - PUG MILLS	BALING PRESSES	BENDING ROLLS	BLOWERS - POSITIVE PR.	BORING MILLS	BUCKET ELEVATORS
CONSTANT SPEED	ALTERNATING CURRENT	3 & 2 PHASE	A	S	STANDARD SQUIRREL CAGE NORMAL TORQUE - NORMAL STARTING CURRENT	½ TO 300 H.P.	150	200 TO 250	2 TO 5	GENERAL PURPOSE WIDE APPLICATION SIMPLE CONTROL	●				●	●	
			B	X	SQUIRREL CAGE NORMAL TORQUE - LOW STARTING CURRENT	7½ TO 200 H.P.	125 TO 150	200 TO 225	2 TO 5		●				●	●	
			C	A	SQUIRREL CAGE HIGH TORQUE - LOW STARTING CURRENT	3 TO 100 H.P.	200 TO 250	175 TO 225	4 TO 5	HEAVY STARTING SIMPLE CONTROL		●					●
			D	K	SQUIRREL CAGE HIGH TORQUE - HIGH SLIP	½ TO 100 H.P.	200 TO 300	200 TO 300	8 TO 15	HEAVY STARTING - INTERMITTENT AND FLUCTUATING LOAD		●	●	●			●
			F	W	SQUIRREL CAGE LOW TORQUE - LOW STARTING CURRENT	40 TO 100 H.P.	50 TO 80	125 TO 150	4 TO 5	SPECIAL PURPOSE CONSTANT LOAD LIGHT STARTING					●		
			-	WX	SQUIRREL CAGE LOW TORQUE	½ TO 10 H.P.	100 TO 125	175 TO 200	4 TO 5	SPECIAL SERVICE SMOOTH REVERSAL							
			-	H	WOUND ROTOR	½ TO 300 H.P.	200 TO 250	200 TO 250	*	FREQUENT & HEAVY STARTING		●		●			●
		SING. PHASE	-	C	CAPACITOR - INDUCTION LOW TORQUE	½ TO 10 H.P.	50 TO 75	175 TO 200	4 TO 6	LIGHT STARTING DIRECT CONN. LOAD							
			-	CN CU	CAPACITOR - INDUCTION NORMAL TORQUE	½ TO 10 H.P.	150 TO 200	175 TO 200	4 TO 6	GENERAL PURPOSE INFREQUENT STARTING	●				●		
	DIRECT CURRENT		-	NA	SHUNT WOUND	½ TO 75 H.P.	150	†	5 TO 10	GENERAL PURPOSE STEADY LOADS	●				●	●	
			-	NA	COMPOUND WOUND	½ TO 75 H.P.	175 TO 200	†	10 TO 25	HEAVY STARTING FLUCTUATING LOAD		●	●				●
			-	NA	SERIES WOUND	½ TO 75 H.P.	300 TO 400	†	*	HEAVY AND FREQUENT STARTING				●			
AJUSTABLE SPEED	A.C.	3 & 2 PHASE	-	M	CONSTANT HORSEPOWER 2 - 3 - 4 SPEEDS	¼ TO 150 H.P.	125 TO 150	175 TO 200	4 TO 6	SPEED INDEPENDENT OF LOAD						●	
			-	M	CONSTANT TORQUE 2 - 3 - 4 SPEEDS	¼ TO 200 H.P.	125 TO 150	175 TO 200	4 TO 6	SPEED INDEPENDENT OF LOAD	●	●			●		●
			-	M	VARIABLE TORQUE 2 - 3 - 4 SPEEDS	¼ TO 200 H.P.	125 TO 150	175 TO 200	4 TO 6	SPEED INDEPENDENT OF LOAD							
	DIRECT CURRENT		-	NW	FIELD CONTROL	¼ TO 50 H.P.	150	†	5 TO 10	WIDE RANGE FLEXIBLE CONTROL						●	
			-	NA	VARIABLE VOLTAGE CONTROL	¼ TO 30 H.P.	150	†	*	EXTREME WIDE RANGE FLEXIBLE CONTROL							
VARIABLE SPEED	A.C.		-	H	WOUND ROTOR	½ TO 300 H.P.	200 TO 250	200 TO 250	*	LIMITED RANGE HEAVY STARTING	●	●		●	●		●
	DIRECT CURRENT	SHUNT	-	NA	ARMATURE CONTROL	½ TO 75 H.P.	150	†	*	LIMITED RANGE DEPENDENT ON LOAD	●				●		
			-	NA	FIELD AND ARMATURE CONTROL	½ TO 50 H.P.	150	†	*	WIDE RANGE LIMITED APPLICATION							
			-	NA	VARIABLE VOLTAGE CONTROL	¼ TO 30 H.P.	150	†	*	WIDE RANGE LOW EFFICIENCY							
		COMPOUND	-	NA	ARMATURE CONTROL	½ TO 75 H.P.	175 TO 200	†	*	LIMITED RANGE DEPENDENT ON LOAD		●					●
			-	NA	FIELD AND ARMATURE CONTROL	½ TO 50 H.P.	175 TO 200	†	*	WIDE RANGE LIMITED APPLICATION							
			-	NA	VARIABLE VOLTAGE CONTROL	¼ TO 30 H.P.	175 TO 200	†	*	WIDE RANGE LOW EFFICIENCY							
		SER.	-	NA	ARMATURE CONTROL	½ TO 75 H.P.	300 TO 400	†	*	LIMITED RANGE HEAVY STARTING				●			

* DEPENDENT UPON LOAD AT NORMAL SPEED.

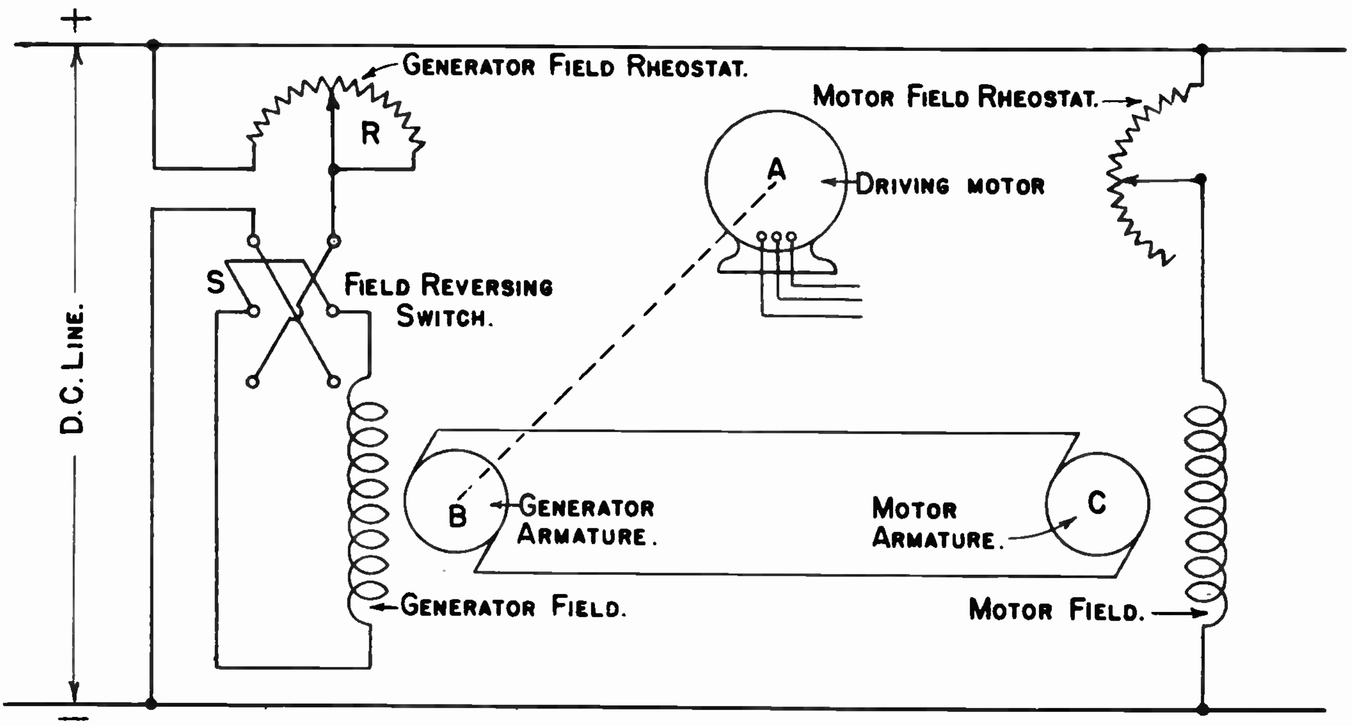
** HORSEPOWER RATINGS, TORQUE AND REGULATION DATA IS FOR 4 POLE (1800 R.P.M.) 60 CYCLE A.C. MOTO

† MAXIMUM TORQUE IS LIMITED BY COMMUTATION. UNDER NORMAL CONDITIONS D.C. MOTOR DEVELOPS 200 T

RS AND 1750 R.P.M. D.C. MOTORS.
O 400% MAXIMUM TORQUE MOMENTARILY.

																									TYPICAL APPLICATION
			●				●							●				●			●				BULLDOZERS
●													●					●			●				CAPSTANS-CAR PULLERS
														●		●		●				●			COMPRESSORS
			●				●							●				●			●	●			CONVEYORS - LOADED START
	●	●					●	●			●		●	●				●			●				CRANES-HOISTS-ELEVATORS
														●				●			●	●			CRUSHERS-GRINDERS-WITH FLY-WHEEL
															●	●							●	●	CRUSHERS-GRINDERS-NO FLY-WHEEL
									●		●				●								●	●	DOUGH MIXERS
									●			●			●	●							●	●	DRILLING MACHINES
														●					●						DRYING TUMBLERS-CYL.
											●			●				●			●				EXTRACTORS - LDRY. & CHEM.
						●	●			●					●		●			●			●	●	FANS-CENTRIFUGAL
						●	●			●					●		●			●			●	●	FANS-PROPELLER
									●			●			●	●							●	●	GRINDERS-BUFFERS
														●				●			●	●			HAMMER MILLS
									●		●			●									●	●	IRONERS-FLATWORK
									●			●			●	●							●	●	LATHES
															●	●							●	●	LINE SHAFTS
									●			●			●	●							●	●	MILLING MACHINES
																●				●			●	●	MOTOR-GEN. A.C.-D.C.
															●										MOTOR-GEN. D.C.-A.C.
															●								●	●	MOULDERS-TENONERS
															●								●	●	PLANERS-JOINTERS-SURFACERS
		●					●				●			●		●							●	●	PRINTING PRESS-JOB
		●		●	●		●				●			●											PRINTING PRESS-FLAT BED
	●	●		●	●		●				●			●											PRINTING PRESS-ROTARY & OFFSET
						●	●				●				●	●				●			●	●	PUMPS-CENTRIFUGAL-TURBINE
			●				●				●			●		●		●				●			PUMPS-DISPLACEMENT
														●				●			●				PUNCHES-SHEARS-HAMMERS
											●				●	●							●	●	SANDERS
															●	●							●	●	SAWS-CIRCULAR
														●				●				●			SAWS-BAND
									●			●			●	●							●	●	SHAPERS
							●		●		●					●							●	●	STOKERS
													●								●				VALVES
														●					●						WASHERS-REV. MOTOR

VARIABLE VOLTAGE CONTROL.



The variation in speed obtainable by field control on the ordinary D.C. motor will not, in the average case, exceed 4 to 1 due to the sparking difficulties experienced with very weak fields. Although the range may be increased by inserting resistance in series with the armature, this can be done only at the expense of efficiency and speed regulation.

With constant voltage applied to the field, the speed of a D.C. motor varies directly with the armature voltage; therefore, such a motor may be steplessly varied from zero to maximum operating speed by increasing the voltage applied to its armature. The sketch shows the arrangement of machines and the connections used in the Ward Leonard type of variable voltage control designed to change speed and reverse rotation. The constant speed D.C. generator (B) is usually driven by an A.C. motor (A) and its voltage is controlled by means of rheostat R. Note that the fields of both generator (B) and driving motor (C) are energized from a separate D.C. supply or by an auxiliary exciter driven off the generator shaft. Thus the strength of the motor field is held constant, while the generator field may be varied widely by rheostat R.

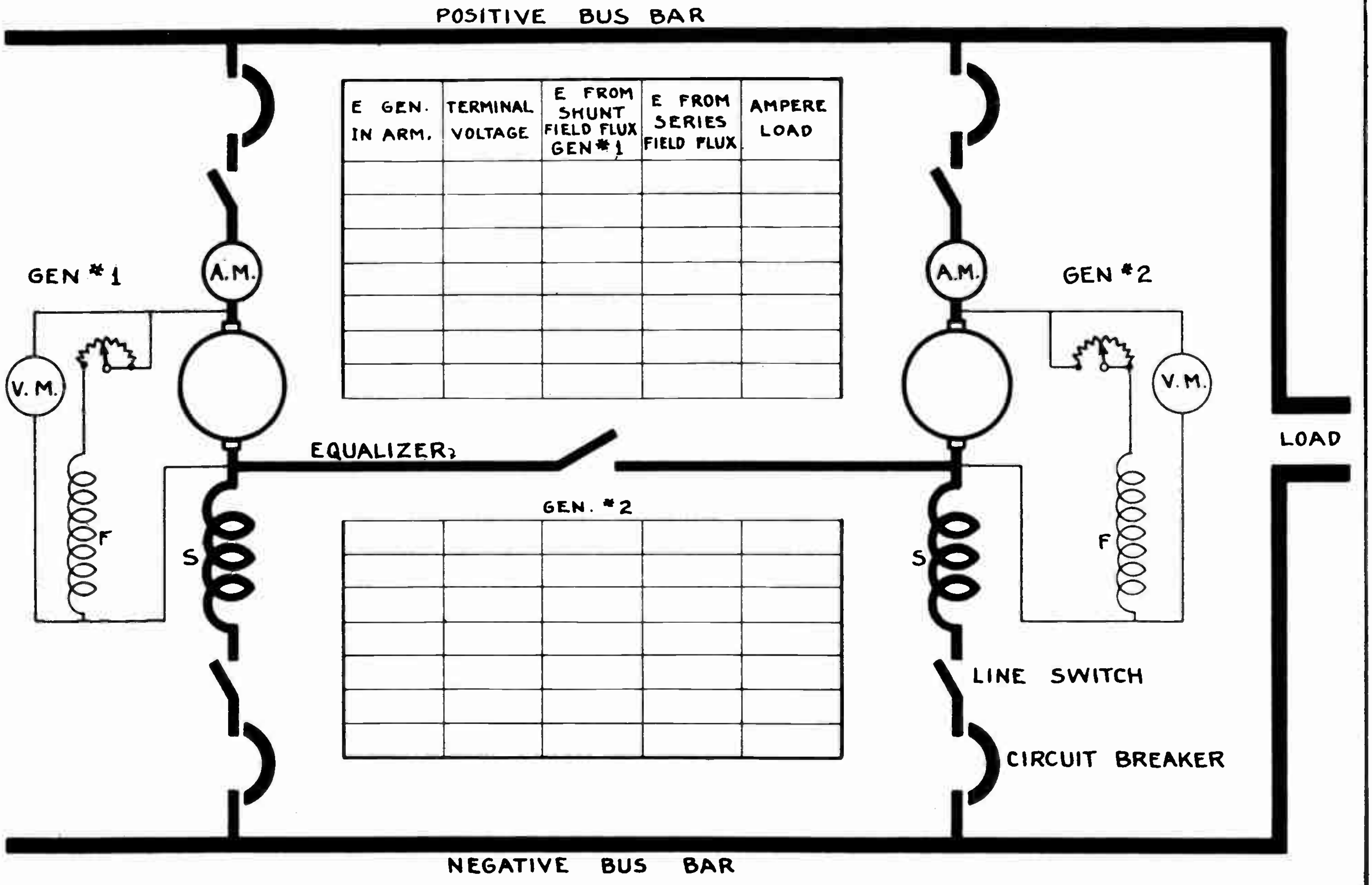
With the set in operation generator (B) is driven at a constant speed by prime mover A. Voltage from B is applied to the D.C. motor (C) which is connected to the machine to be driven. By proper manipulation of rheostat R and field reversing switch S the D.C. motor may be gradually started, brought up to and held at any speed, or reversed. As all of these changes may be accomplished without breaking lines to the main motor, the control mechanism is small, relatively inexpensive, and less likely to give trouble than the equipments designed for heavier currents.

The advantages of this system lie in the flexibility of the control, the complete elimination of resistor losses, the relatively great range over which the speed can be varied, the excellent speed regulation on each setting, and the fact that changing the armature voltage does not diminish the maximum torque which the motor is capable of exerting since the field flux is constant.

By means of the arrangement shown, speed ranges of 20 to 1—as compared to 4 to 1 for shunt field control—may be secured. Speeds above the rated normal full load speed may be obtained by inserting resistance in the motor shunt field. This represents a modification of the variable voltage control method which was originally designed for the operation of constant torque loads up to the rated normal full load speed.

As three machines are usually required, this type of speed control finds application only where great variations in speed and unusually smooth control are desired. Steel mill rolls, electric shovels, passenger elevators, machine tools, turntables, large ventilating fans and similar equipments represent the type of machinery to which this method of speed control has been applied.

PARALLELING D.C. GENERATORS.

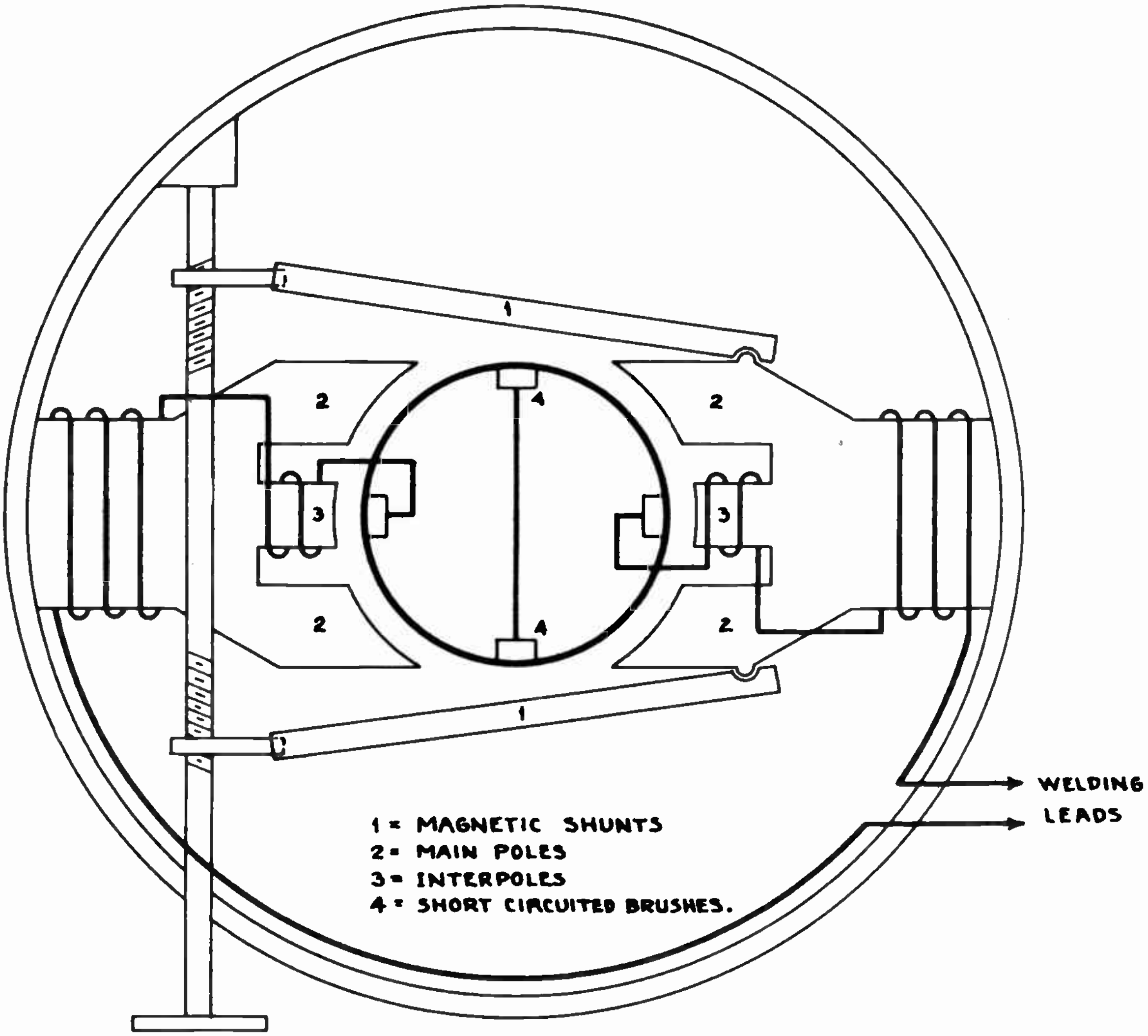


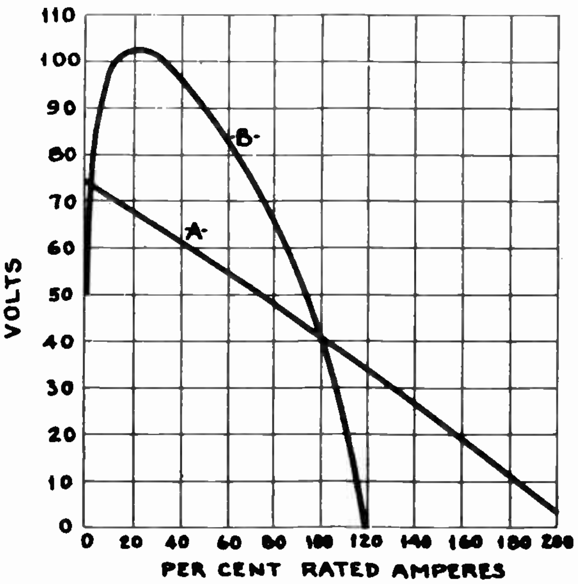
E GEN. IN ARM.	TERMINAL VOLTAGE	E FROM SHUNT FIELD FLUX GEN #1	E FROM SERIES FIELD FLUX	AMPERE LOAD

GEN. #2

SERIES WELDING GENERATOR

CROSS FIELD DESIGN





THIS WELDER ELIMINATES THE USE OF A REACTOR, EXCITER, VOLTMETER, AMMETER, METER SWITCHES, FIELD RHEOSTATS, AND FIELD DISCHARGE RESISTANCE. HOWEVER IT OPERATES VERY SATISFACTORILY HAVING FEWER PARTS THAN OTHER TYPES OF WELDING GENERATORS. THE MAINTENANCE COST IS CONSIDERABELY LOWER.

THE VOLT-AMPERE CURVE -A- IS A COMPOSITE, AND THE CURVE AT -B- IS THAT OF ONE OF THE CROSS FIELD WELDING GENERATORS.

COYNE

REVISIONS

MATERIAL

PAT. MLD. DIE

V-5835197

DRAWN BY T E Doll

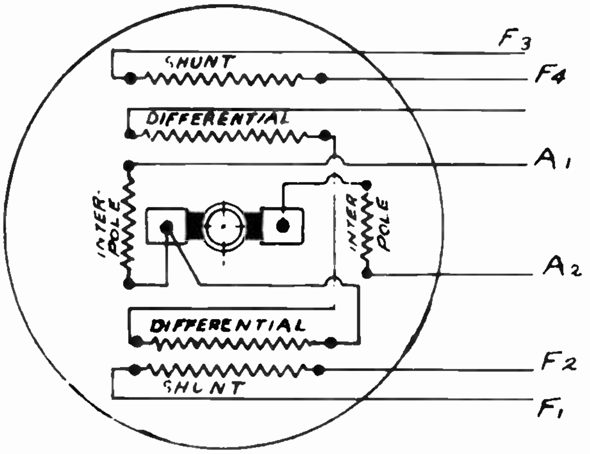
INSPECTED

EXTERNAL DIAGRAM

FIRST MADE FOR BC GENERATOR

FIRST CALLED FOR ON CPRW-740831-89

PRINTS TO
HE
B44(2)
B 15
357
3742



THIRD ANGLE PROJECTION

V

GENERAL ELECTRIC FORT WAYNE WORKS

V-5835197

REVISIONS

MATERIAL

PAT. MLD. DIE

V-5837239

DRAWN BY T E Doll

INSPECTED

EXTERNAL DIAGRAM

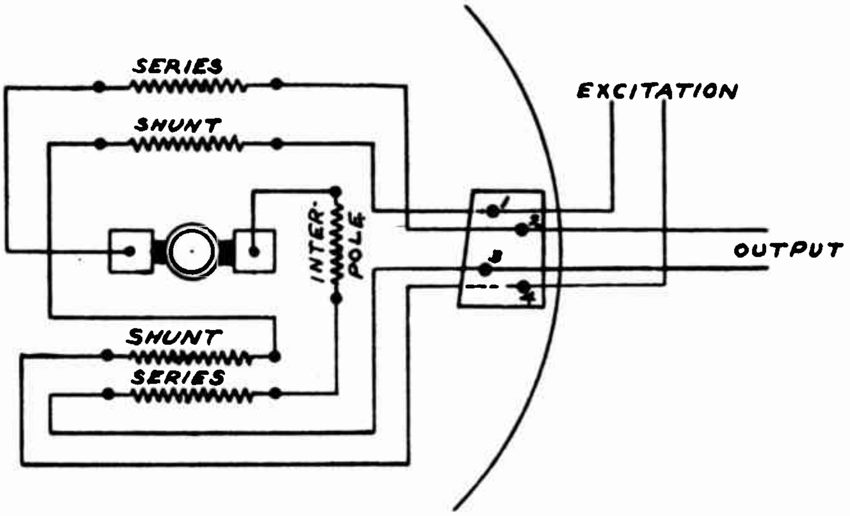
FIRST MADE FOR DC MOTORS - (CUMULATIVE COMPOUND GEN.)

FIRST CALLED FOR ON STL-84280

PRINTS TO
B3
B44:2
B45
B57
B14:2

G.E.J. TAG

NONE



THIRD ANGLE PROJECTION

V

GENERAL ELECTRIC FORT WAYNE WORKS

V-5837239

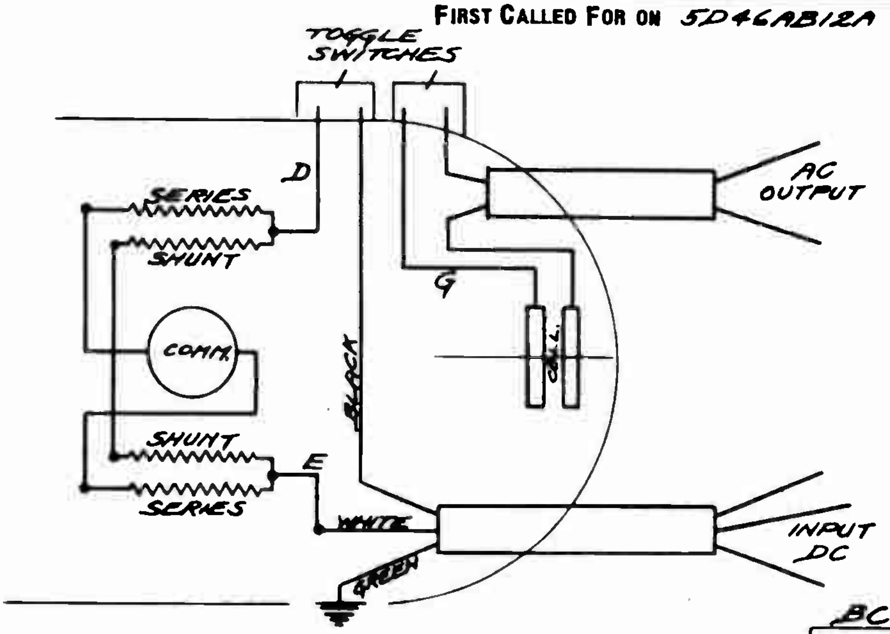
MATERIAL	**PAT. MLD. DIE**	**PART**	V-5872093

① ② ③ ④

DRAWN BY C. Hower
INSPECTED C. Hower

EXTERNAL DIAGRAM
FIRST MADE FOR DYNAMOTOR
FIRST CALLED FOR ON 5D46AB12A

GEJ TAG
NONE



B 8
B 44:2
B 57:3
B 74:2
B 106
B 128-4

BC
D-75
FILE

THIRD ANGLE PROJECTION **GENERAL ELECTRIC CO.** FORT WAYNE **WORKS**
V-5872093

MATERIAL	**PAT. MLD. DIE**	**PART**	V-5837402

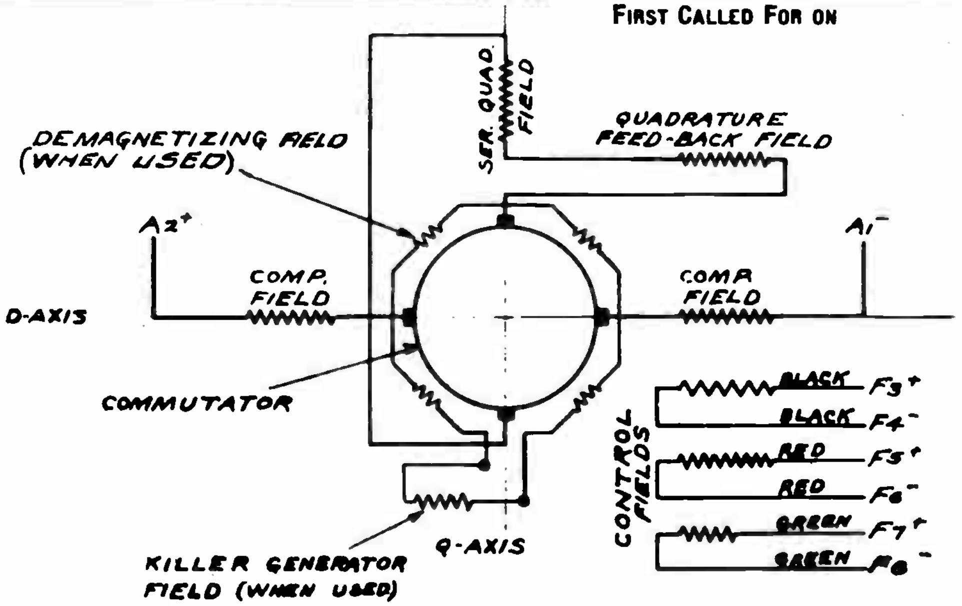
REVISIONS
① T.E. Doell ②
③ ④

DRAWN BY T.E. Doell
INSPECTED [illegible] Nov 19 194

EXTERNAL DIAGRAM

FIRST MADE FOR AM GEN. SET
FIRST CALLED FOR ON

GEJ TAGS
NONE



B8
B44:2
B57:3
B74:2
B106
B128(4)

BC
FILE
D
75

THIRD ANGLE PROJECTION **GENERAL ELECTRIC CO.** FORT WAYNE **WORKS**
V-5837402

LAP WINDING AND ARMATURE CONNECTIONS

An armature winding is an electro-magnet having a number of coils connected to commutator bars. There must be at least one start and one finish lead connected to each commutator bar. There are two types of armature windings, LAP & WAVE wound. The coil leads of a lap wound armature connects to commutator bars that are near each other and the coil leads of a wave wound armature connects to commutator bars that are widely separated. See Fig. 1 & 2.

When current flows through the coil in a clockwise direction a south pole will be produced on the surface of the armature. Fig. 3. If the current flows in a counter clockwise direction a north pole will be produced on the surface of the armature. Fig. 4. A large number of coils are used to produce a strong magnetic pole and a smoother twisting action.

FIG. 1

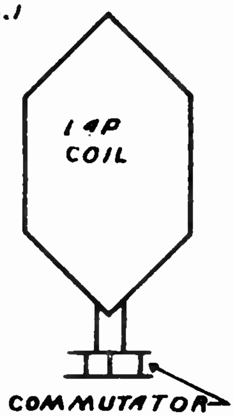


FIG. 2

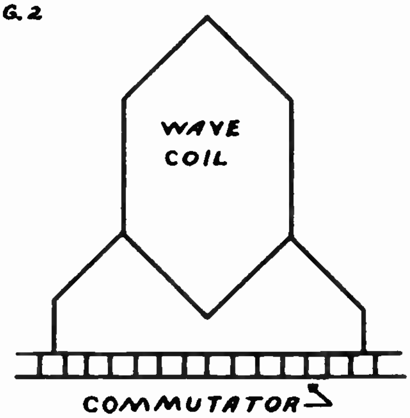


FIG. 3

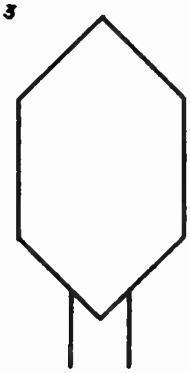
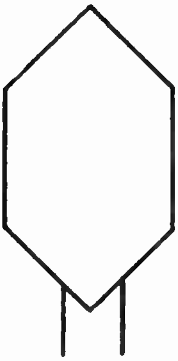


FIG. 4



ARMATURE WINDING CONNECTIONS

Although there are only two types of D.C. armature windings there are a number of winding connections that apply to either a lap or a wave wound armature.

SYMMETRICAL & NON-SYMMETRICAL CONNECTIONS. If the coil leads connect to commutator bars that are on a line with the center of the coil the connection is symmetrical. Fig. 5. If the coil leads connect to commutator bars that are not on a line with the center of the coil the connection is non-symmetrical. Fig. 6.

The brushes must always short the coil when it is in the neutral plane which means that the brushes be located on a line with the center of the field pole if the coil is connected symmetrical and located between the field poles if connected non-symmetrical.

FIG. 5 SYMMETRICAL

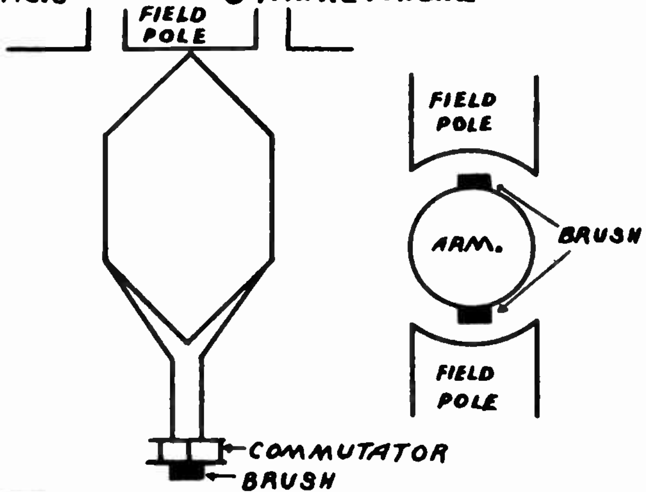
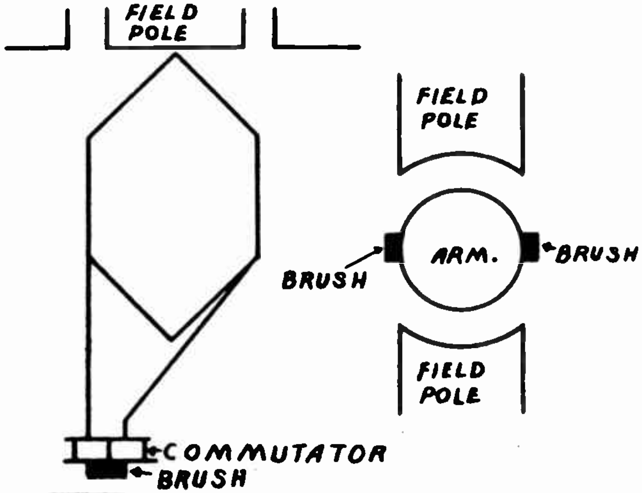


FIG. 6 NON-SYMMETRICAL



LAP WINDING AND ARMATURE CONNECTIONS (CONTINUED)

PROGRESSIVE & RETROGRESSIVE CONNECTIONS. If the start and finish leads of a coil, or the element of a coil, do not cross the connection is known as progressive. Fig. 7. If the start and finish leads of a coil, or the element of a coil, cross the winding is connected retrogressive. Fig. 8.

If a winding is changed from progressive to retrogressive, or vise versa, the effect will be reversed rotation on a motor and reversed brush polarity on a generator. Lap wound armatures are usually connected progressive and wave wound armatures retrogressive.

FIG.7 **PROGRESSIVE**

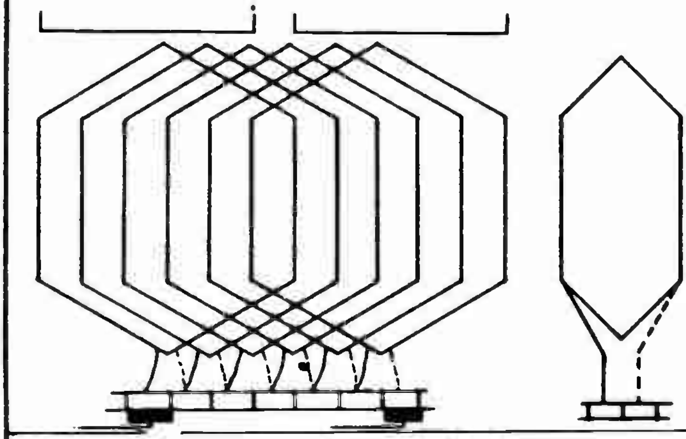
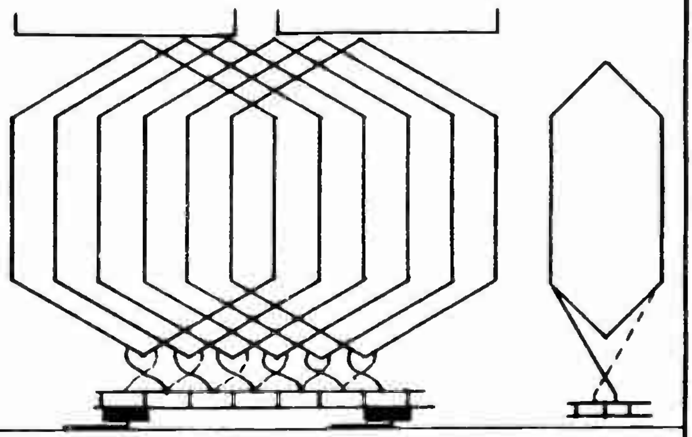


FIG.8 **RETROGRESSIVE**



ELEMENT WINDINGS are used to reduce the voltage across adjacent commutator bars and decrease the tendency of brush sparking. Example - An armature has 30 turns per coil and the voltage per turn is 1 volt or 30 E per coil. If the coil were wound in one section and connected to adjacent commutator bars the voltage across the bars will be 30 E. Such a coil would have one start and one finish lead and there would be as many bars as slots. This would be a single element winding. Fig. 9.

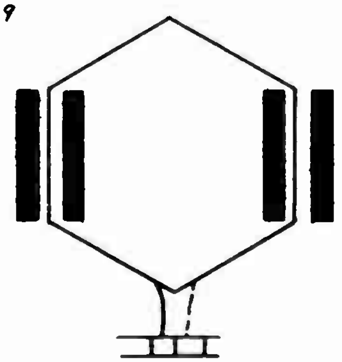
If this coil were divided in two sections (15 turns per sections) and each section connected to adjacent bars the voltage across adjacent bars would be 15 E. Such a coil would have two start and two finish leads and there would be twice as many bars as slots. This would be known as a two element winding. Fig. 10.

If the coil were divided in three sections (10 turns per section) and each section connected to adjacent bars the voltage across adjacent bars would be 10 E. Such a coil would have three start and three finish leads and there would be three times as many bars as slots. This would be known as a three element winding. Fig. 11.

Element windings are particularly desirable for high voltage machines. The practical limit is usually three or four elements.

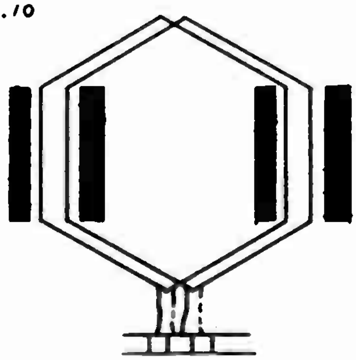
SINGLE ELEMENT

FIG.9



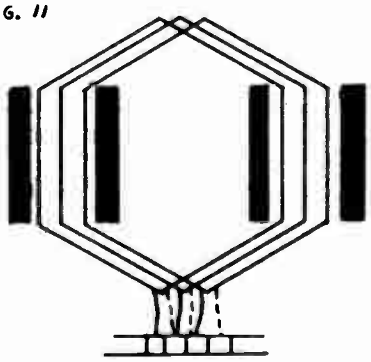
TWO ELEMENT

FIG.10



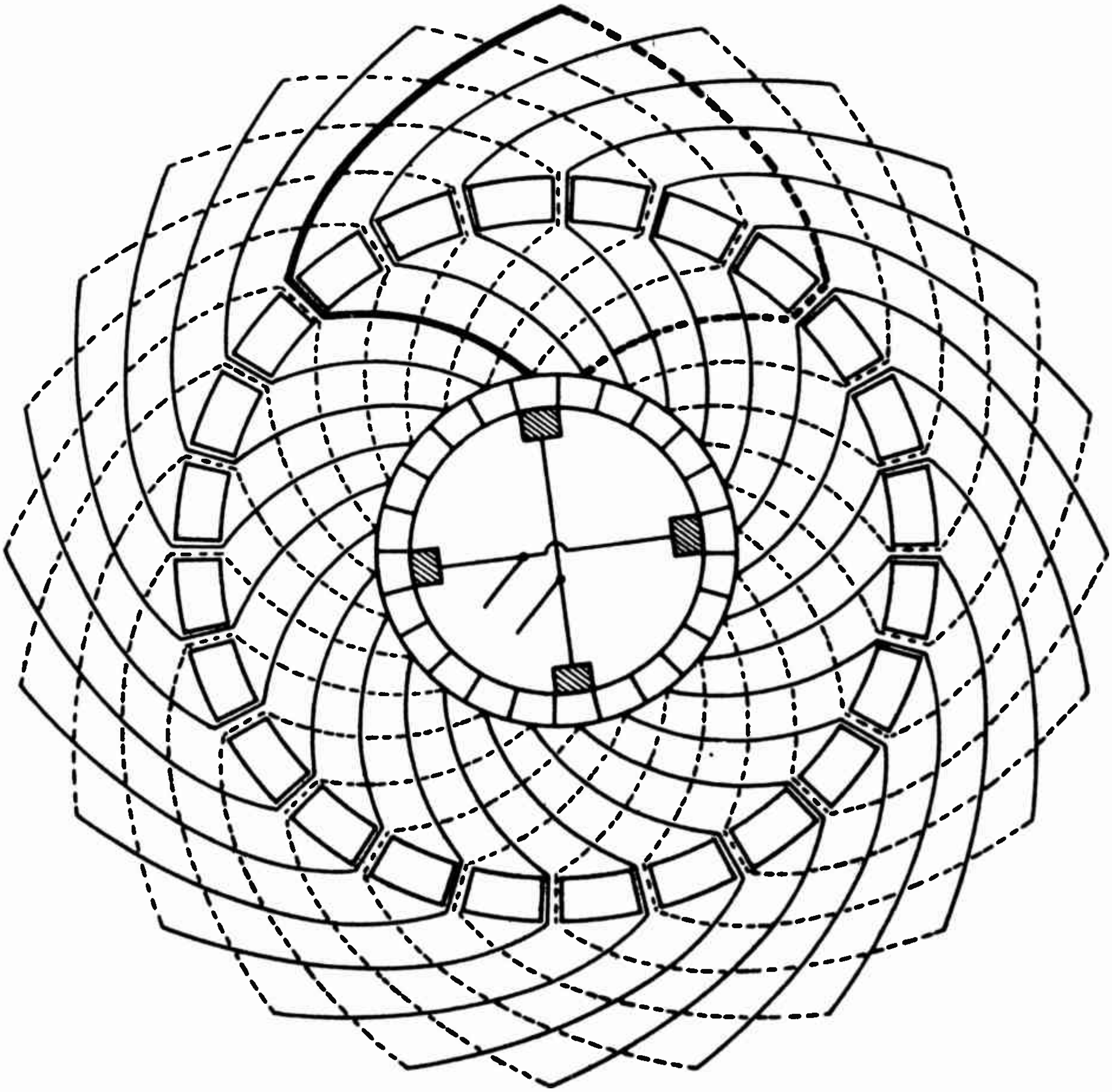
THREE ELEMENT

FIG. 11



LAP WINDING
SIMPLEX
PROGRESSIVE
SYMMETRICAL
SINGLE ELEMENT

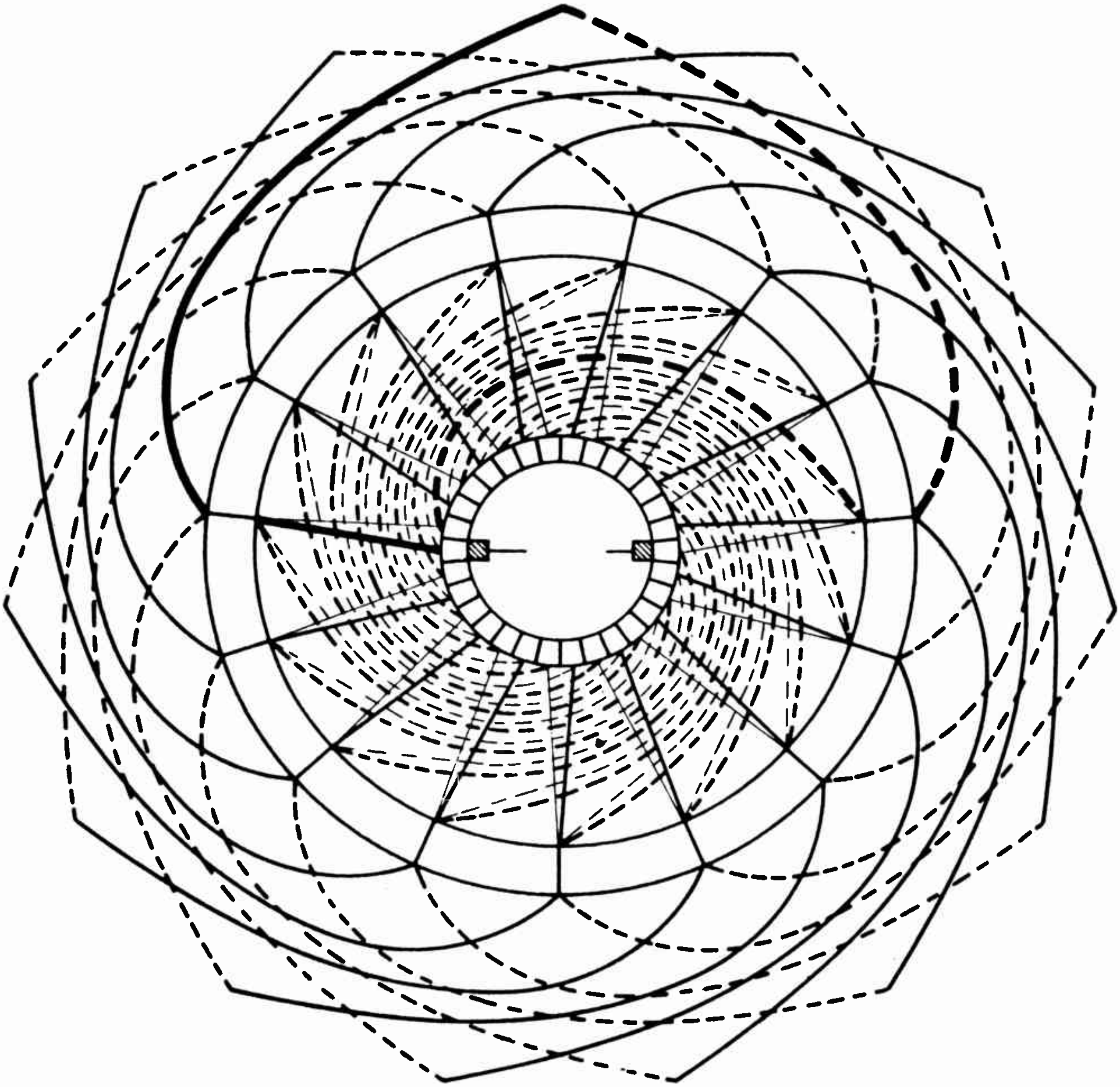
SLOTS = 24
BARS = 24
POLES = 4
COIL SPAN = 1-7



COIL SPAN = THE NEXT WHOLE NUMBER ABOVE SLOTS ÷ POLES

LAP WINDING
SIMPLEX
PROGRESSIVE
NON-SYMMETRICAL
TWO ELEMENT

SLOTS = 15
BARS = 30
POLES = 2
COIL SPAN= 1-8



COYNE

PRINCIPLES OF LAP AND WAVE WINDINGS

The lap winding is usually used on a circuit where the operating voltage is 220 E or less in value. This type of winding is desirable for general factory work. It is possible to design an armature for a higher ampere capacity by having it lap wound. The higher ampere capacity is obtained because there will be a greater number of parallel paths in the armature which increases its ability to carry current.

Fig. 1

SECTION OF A 4 POLE PROGRESSIVE LAP WINDING.

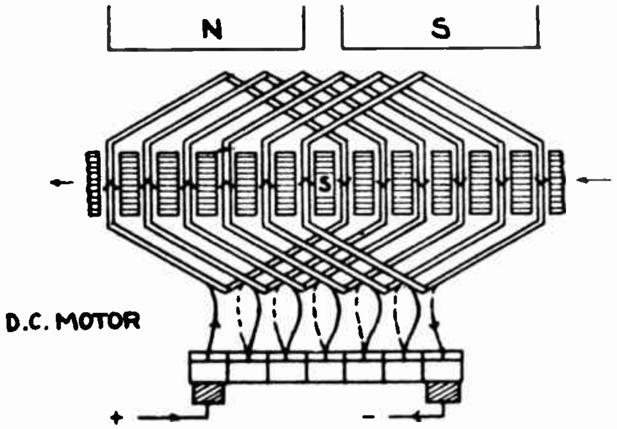
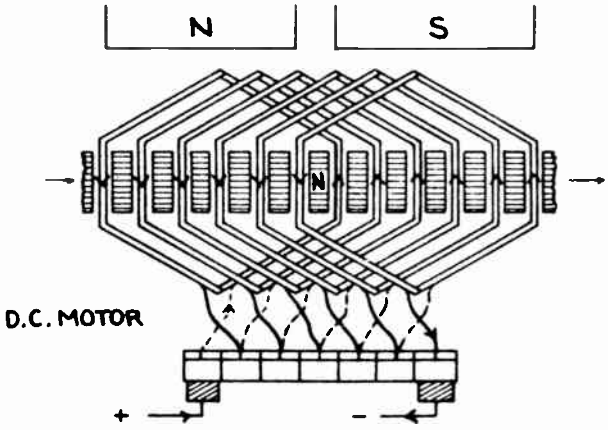


Fig. 2

SECTION OF A 4 POLE RETROGRESSIVE LAP WINDING.



The name wave wound is derived from the way the current circulates or waves through the armature. The wave type winding is usually used on a circuit where the operating voltage is 250 E or more in value. This type winding is desirable for traction work, steel mills & mine work. It is possible to design an armature for a higher operating voltage by having it wave wound. The higher operating voltage is obtained because there will be a greater number of armature coils in series between the brushes which increases the operating voltage.

Fig. 3

4 pole progressive wave winding.

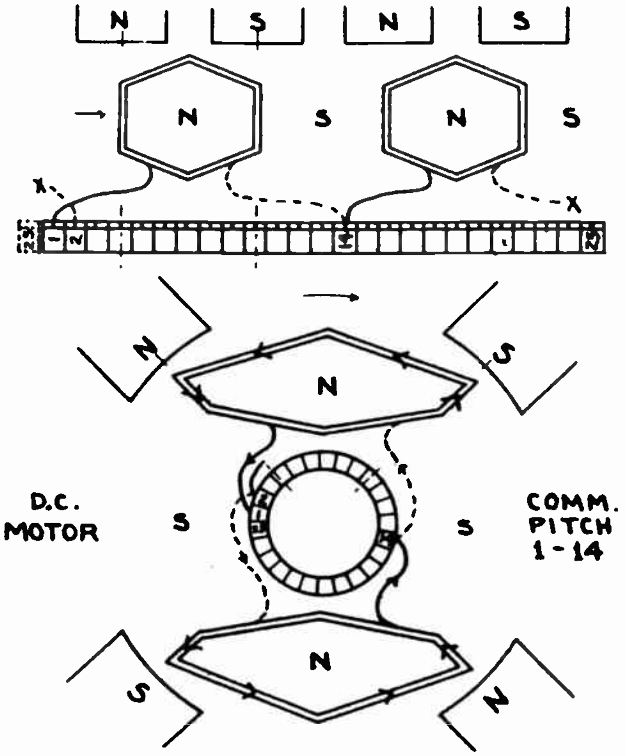
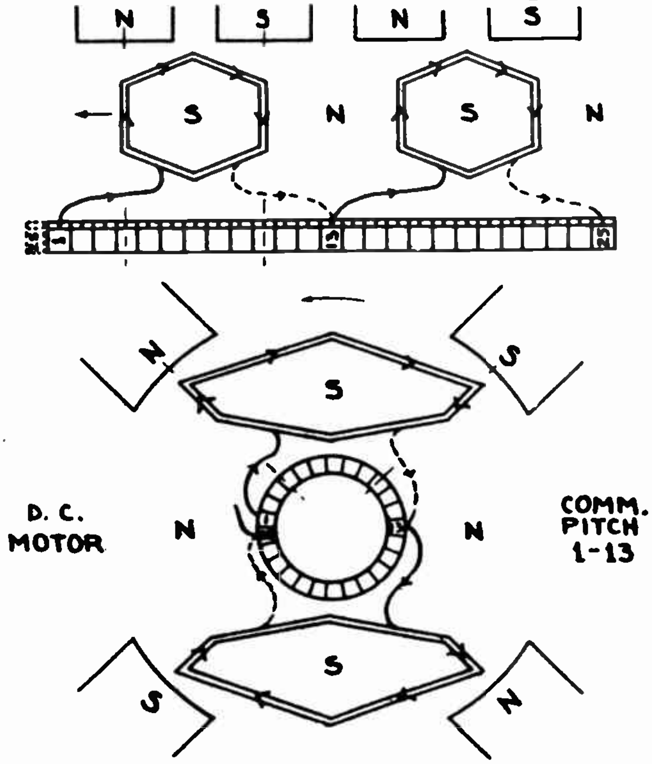


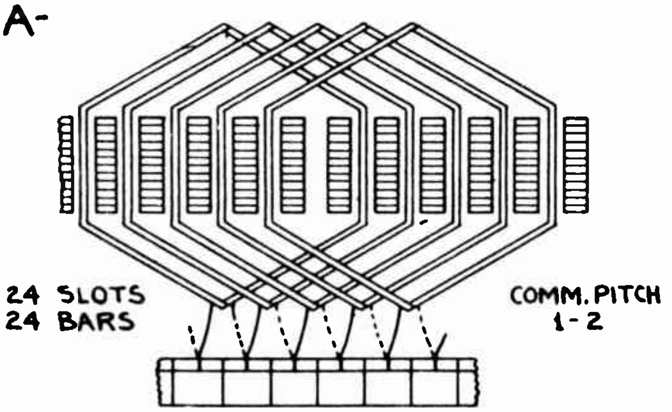
Fig. 4

4 pole retrogressive wave winding.



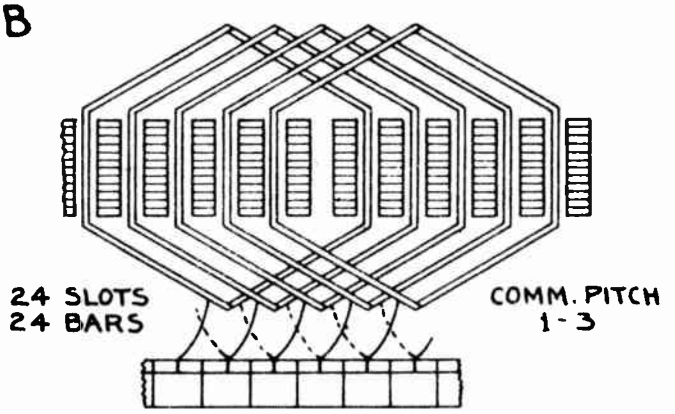
VARIOUS ARMATURE WINDING CONNECTIONS

-A-



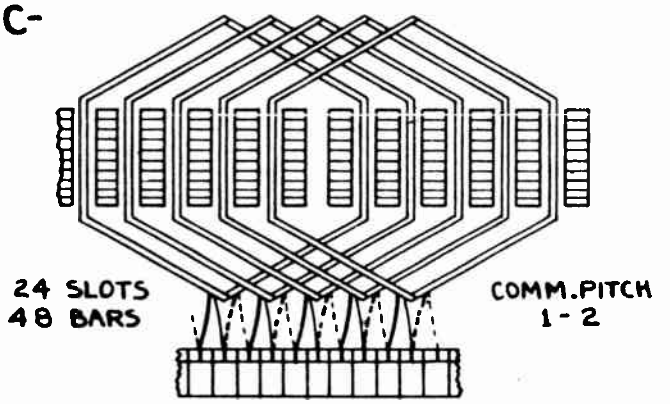
ONE ELEMENT SIMPLEX LAP

-B



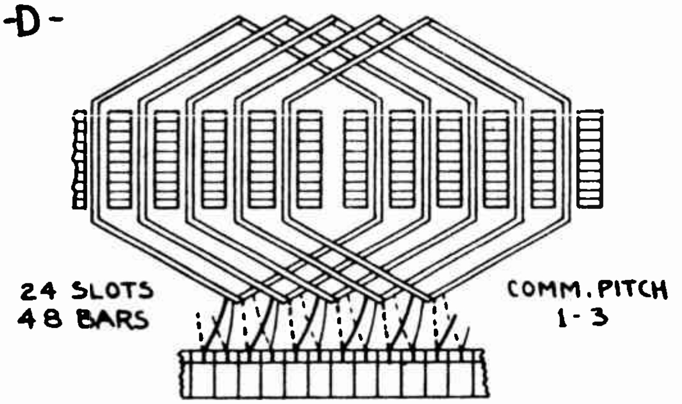
ONE ELEMENT DUPLEX LAP

-C-



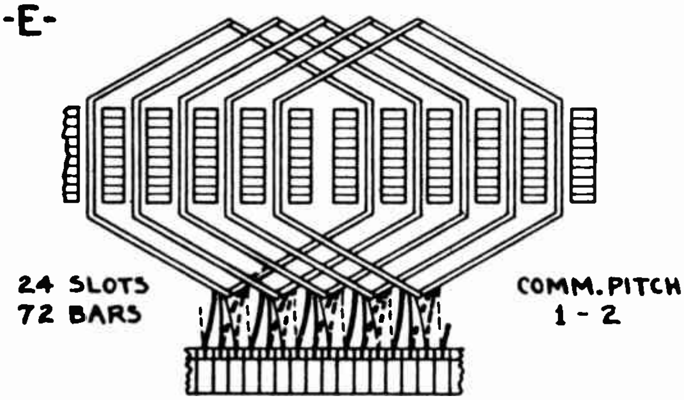
2 ELEMENT SIMPLEX LAP

-D-



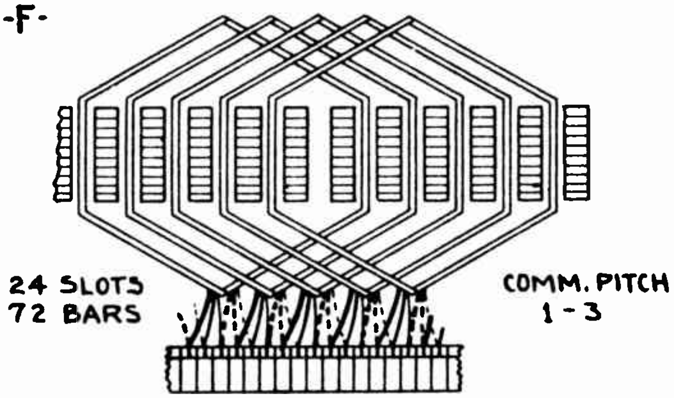
2 ELEMENT DUPLEX LAP

-E-



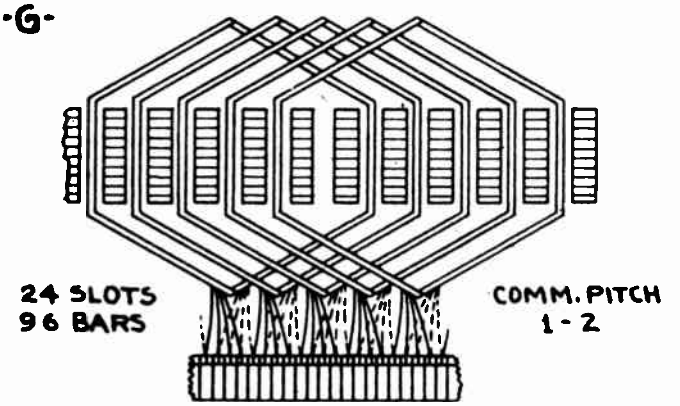
3 ELEMENT SIMPLEX LAP

-F-



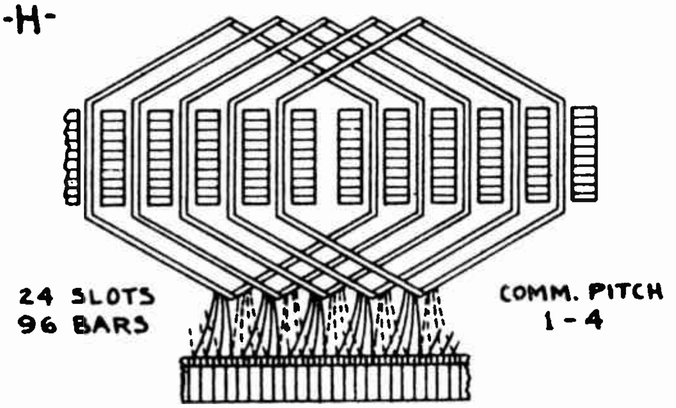
3 ELEMENT DUPLEX LAP

-G-



4 ELEMENT SIMPLEX LAP

-H-

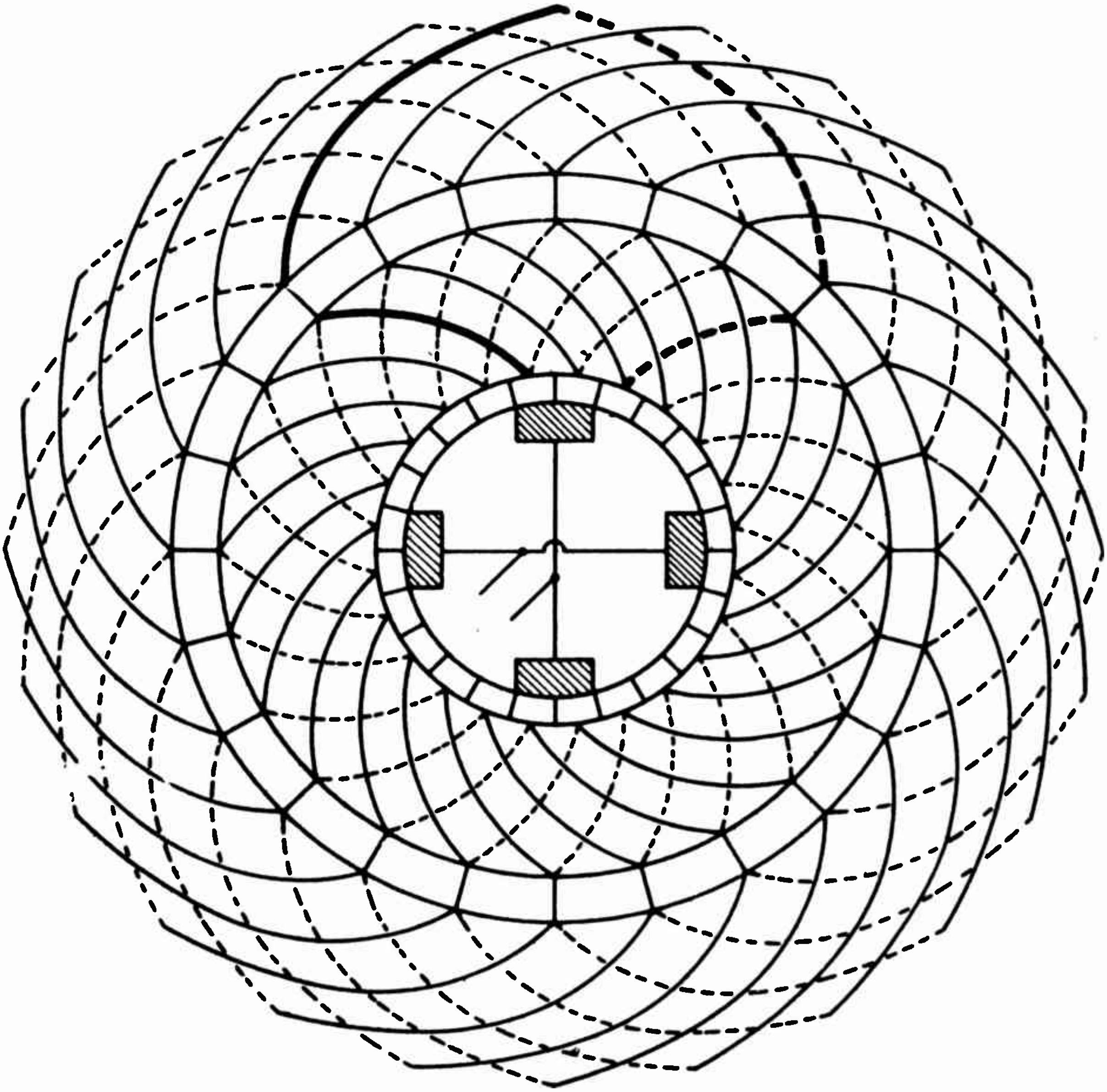


4 ELEMENT TRIPLEX LAP

COYNE

LAP WINDING
DUPLEX
PROGRESSIVE
SYMMETRICAL
SINGLE ELEMENT

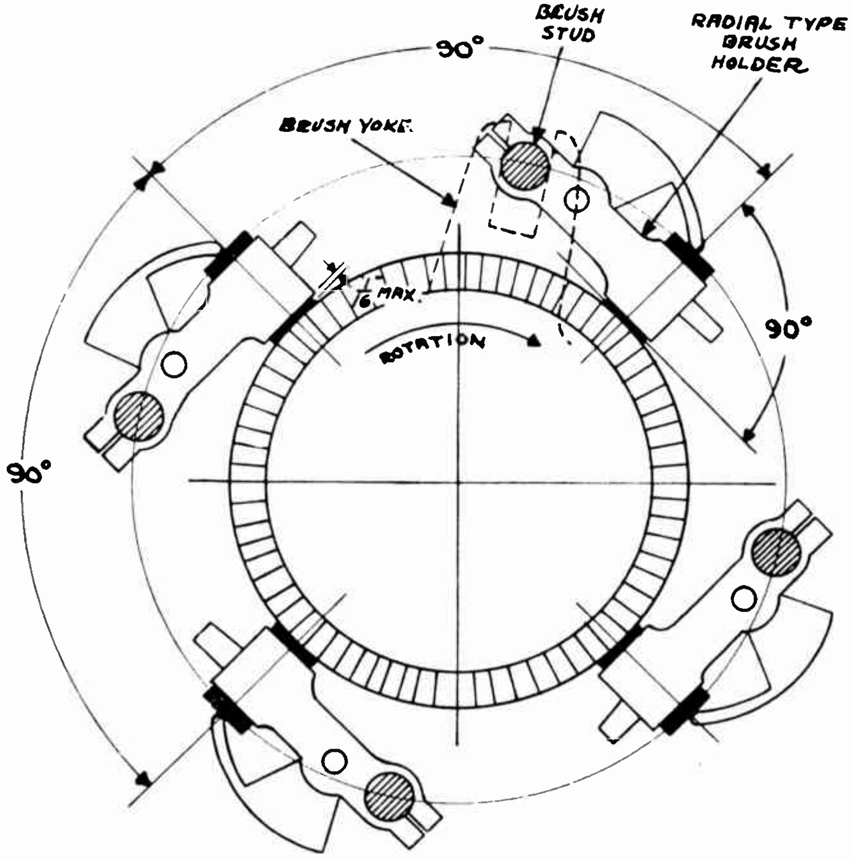
SLOTS = 24
BARS = 24
POLES = 4
COIL SPAN = 1-7



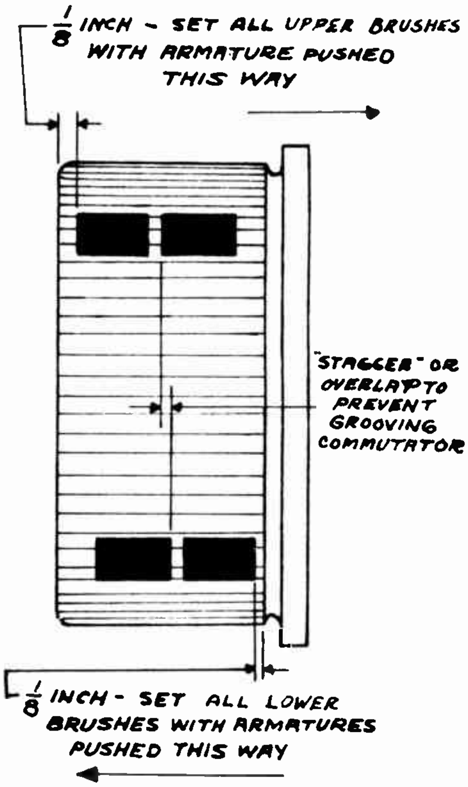
INSTRUCTIONS FOR SETTING BRUSH HOLDERS (RADIAL TYPE)

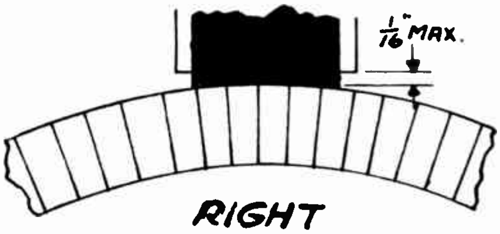
TO PREVENT INJURY TO BRUSHES AND COMMUTATOR

JANETTE MANUFACTURING COMPANY



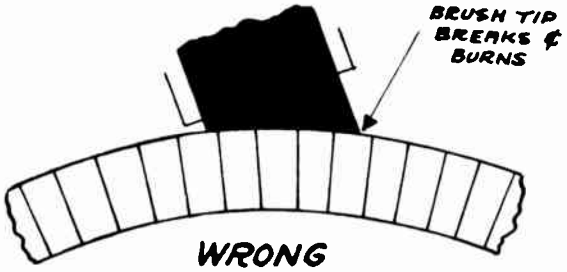
VIEW FACING COMMUTATOR





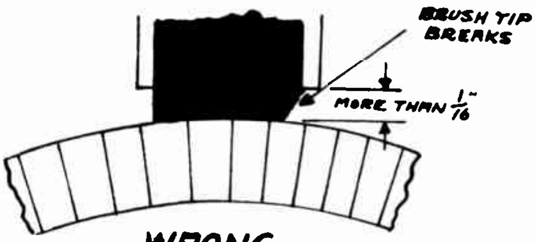
RIGHT

LOWER SIDE OF BRUSH STUD - 1 INCH FROM COMMUTATOR.
BRUSH HOLDER - 1/16" MAX. FROM COMMUTATOR.



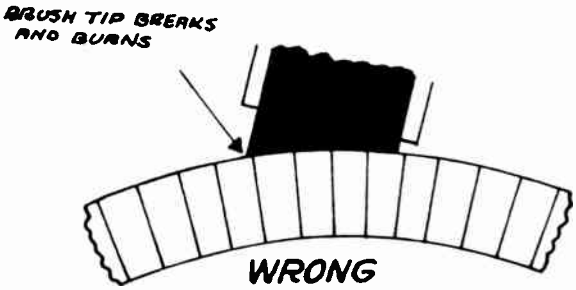
WRONG

BRUSH STUD TOO CLOSE TO COMMUTATOR.



WRONG

BRUSH HOLDER TOO FAR FROM COMMUTATOR
CONTACT AREA REDUCED BY BREAKING OF TIPS



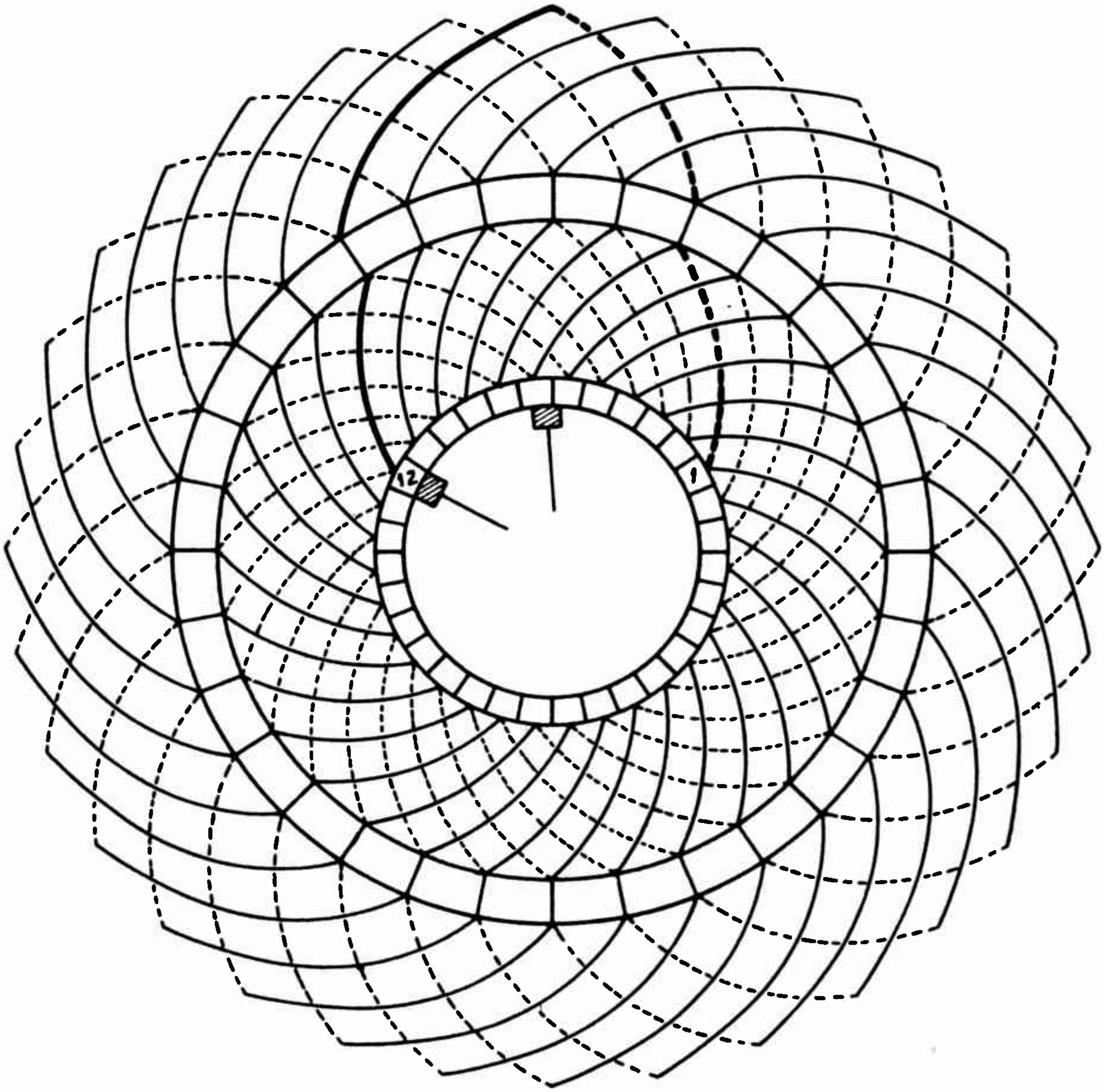
WRONG

BRUSH STUD TOO FAR FROM COMMUTATOR

SET MACHINE LEVEL TO ALLOW FREE END PLAY

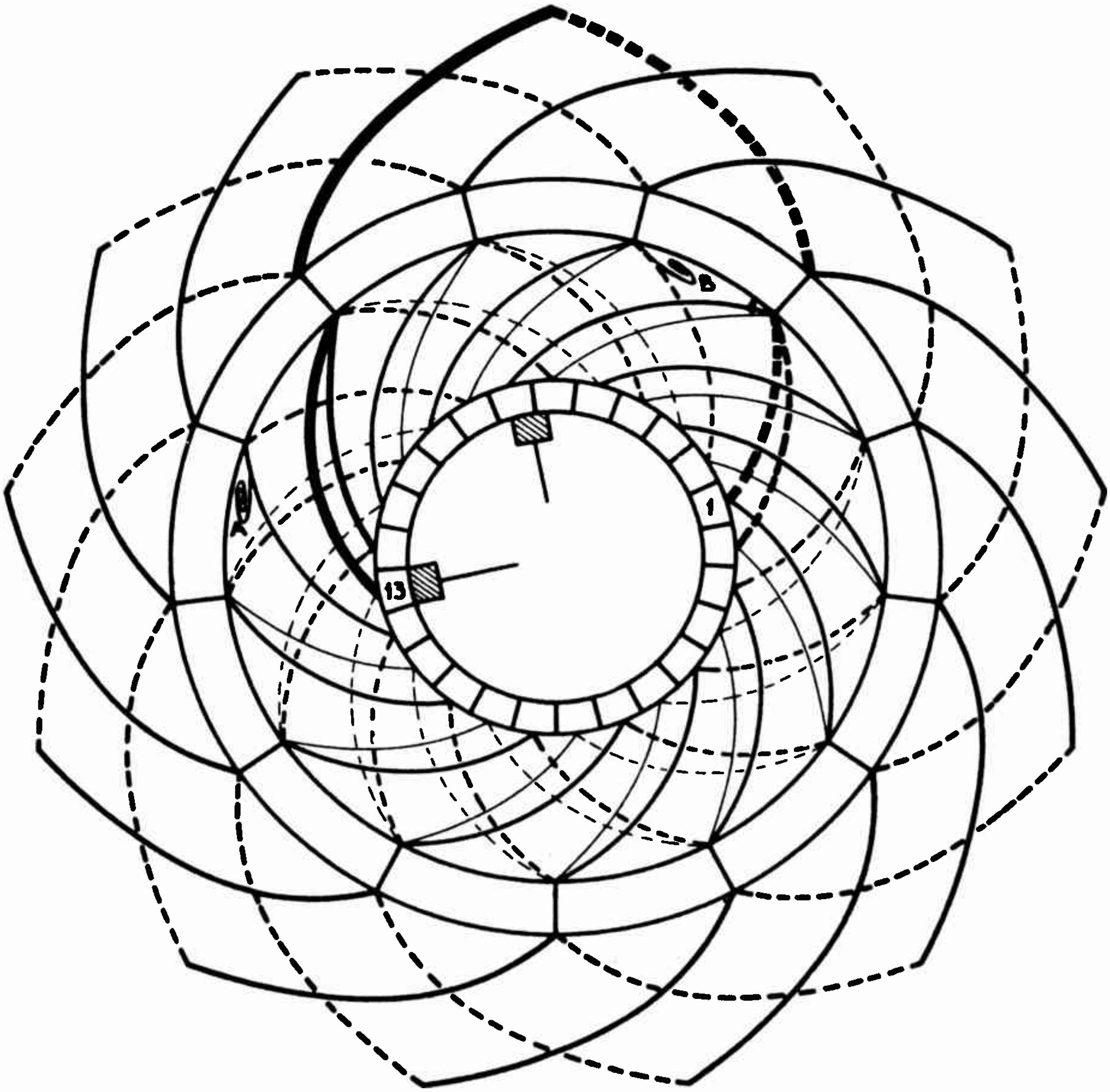
WAVE WINDING
SIMPLEX
PROGRESSIVE
SYMMETRICAL
SINGLE ELEMENT

SLOTS = 32
BARS = 32
POLES = 6
COIL SPAN = 1-6
COMMUTATOR PITCH = 1-12



WAVE WINDING.
SIMPLEX
RETROGRESSIVE
SYMMETRICAL
TWO ELEMENT

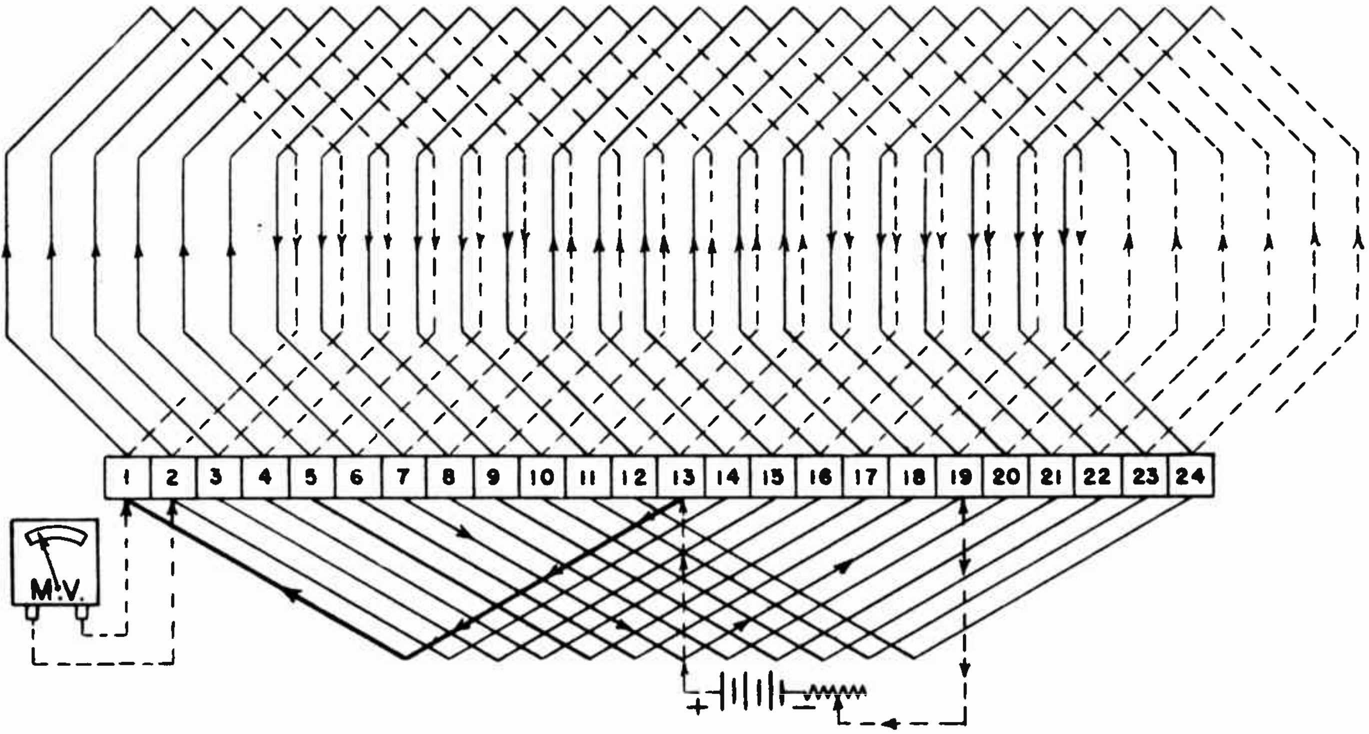
SLOTS = 13
BARS = 25
POLES = 4
COIL SPAN = 1-4
COMMUTATOR PITCH = 1-13



A - B ENDS OF DEAD COIL.

COYNE

ARMATURE EQUALIZER CONNECTIONS.



Although equalizers have been used on large armatures for many years, the application of these connections to small machines is a comparatively recent innovation that has raised questions regarding the advantages of such connections, and the method of testing such windings for faults.

Briefly, equalizer connections provide better commutation, make possible one-half the number of brushes usually used on the lap-wound machine, and provide the manufacturer with a means of avoiding the special slot and commutator bar relationships demanded by wave-type windings. Inasmuch as the equalizers here referred to are permanently connected to the commutator, and inasmuch as they make testing of the armature impossible by the regular procedure, the testing method and other information about these connections should prove of value to maintenance electricians and armature shop men.

The principal purpose of equalizers is to connect together on the armature those points which have the same polarity and which should have equal potential. For a four-pole winding this means commutator bars 180 degrees apart; for a six-pole armature, bars 120 degrees apart; for an eight-pole machine, bars 90 degrees apart. The number of bars spanned by the equalizer will equal bars ÷ pairs of poles. For the armature shown in the diagram, each equalizer will span 24÷2, or 12 bars, thereby making the connection 1 and 13, 2 and 14, etc. The pitch for any other number of bars or poles would be determined by the same method.

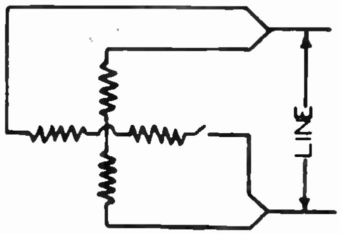
To test such an armature, current must be fed to the armature from an external low voltage D.C. supply, such as a battery, the leads being connected to commutator segments one-half the equalizer pitch apart. Since the equalizer pitch is 12 segments in this case, the leads will be spaced six bars apart or 1 and 7. Any pair of bars so spaced may be used, in a fully equalized armature; bars 13 and 15 being employed in the diagram.

The value of the test current is adjusted to give satisfactory deflection on the millivoltmeter, and volt drop readings are taken between all adjacent pairs of segments. These readings are interpreted in the usual manner, low readings indicating shorts, high readings showing high resistance connections or opens. Tracing the winding and also by actual test, it will be noted that if the readings from bars 13 and 19 are forward, then the readings from 19 to 1 will be backward. 1 to 7 will be forward, and 1 to 13 backward. This is a normal indication obtained in all windings.

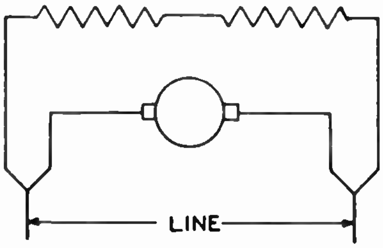
If the factors mentioned are kept in mind, the procedure given will produce consistently accurate results. It is to be noted such an armature will, when tested on a growler, give a shorted indication on all coils, even though the winding is in perfect condition. The reason for this can be seen by tracing from bar 1 through the coil to bar 2, through the equalizer to bar 14, through the coil to bar 13 and back through the equalizer to bar 2. Thus every coil on the armature is apparently short circuited by having another coil placed in series with it through the equalizer connections. This explains the need for a special testing procedure.

WIRING DIAGRAMS

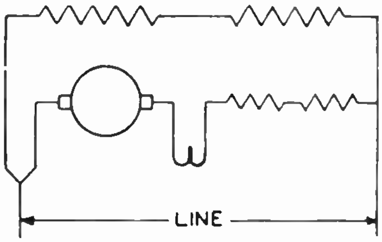
The following connection diagrams are those used with standard windings of the types indicated. Special connections are available with special windings.



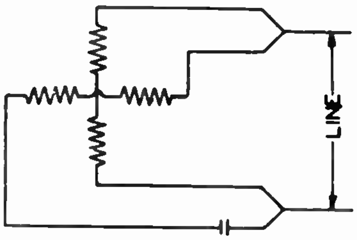
SPLIT PHASE AND SYNCHRONOUS
SPLIT PHASE 4 LEAD REVERSIBLE



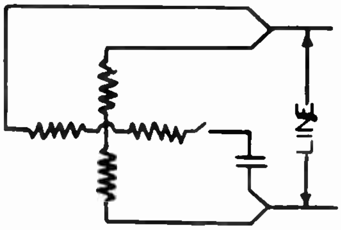
SHUNT WOUND 4 LEAD REVERSIBLE



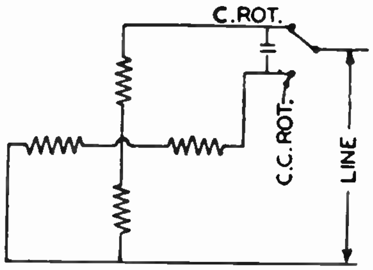
COMPOUND WOUND 5 LEAD
REVERSIBLE



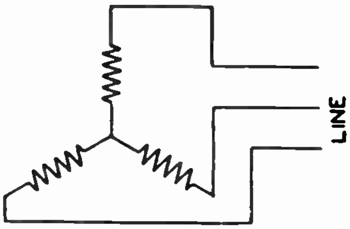
CAPACITOR AND SYNCHRONOUS
CAPACITOR 4 LEAD REVERSIBLE



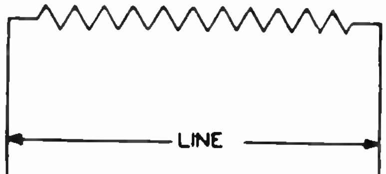
CAPACITOR START 4 LEAD
REVERSIBLE



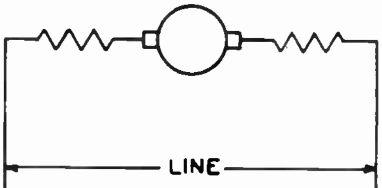
CAPACITOR AND SYNCHRONOUS
CAPACITOR 3 LEAD REVERSIBLE



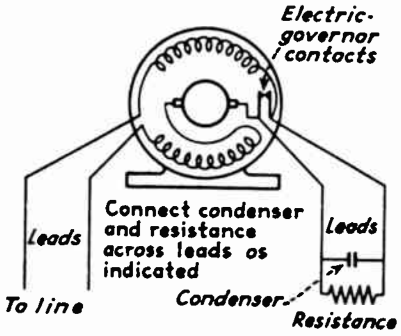
THREE PHASE AND SYNCHRONOUS
THREE PHASE



SHADED POLE 2 LEAD NON-
REVERSIBLE



SERIES 2 LEAD NON-REVERSIBLE



GOVERNOR CONTROLLED SERIES
WOUND 4 LEAD NON-REVERSIBLE

DATA SHEET FOR MOTOR AND GENERATOR REWINDING

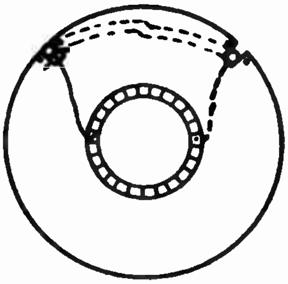
Job No. ________ Customer ________________________________
Address ____
Date received ____________________ Date promised ______________
How delivered __________________ Send __________ Will call __________
Terms of payment ____________________ Estimate ________________
Cost of materials used ______________ Total hrs. labor ______________

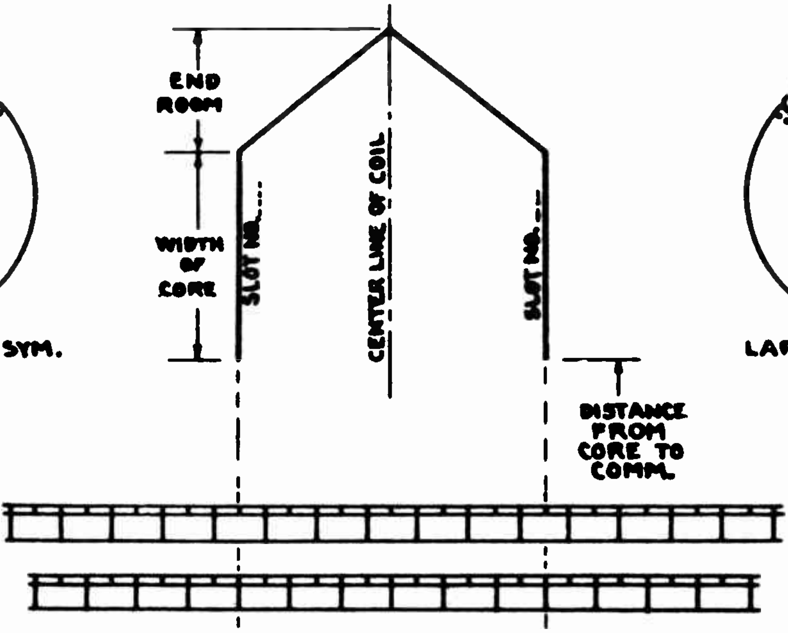
WORK TO BE DONE

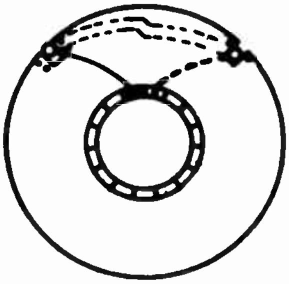
Write out in detail ____
____
____

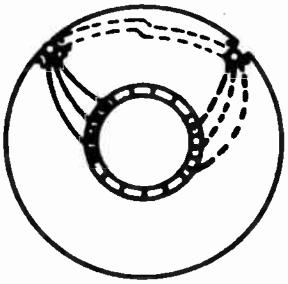
REWIND DATA

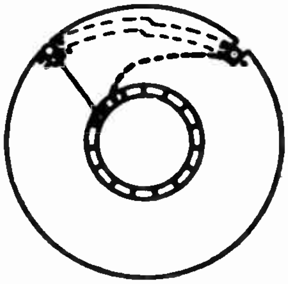
H.P. ______ Volts ______ Amps. ________ R.P.M. ________ Type ________
Serial No. __________________ Make ____________________________
No. of slots ________ Coil span ________ Turns per coil ________
Size and kind of wire ________________ Wdg. conn. ________________
No. of wires in parallel ______________ Lbs. of scrap wire removed ______
Slot insulation ____
No. of comm. bars. ________________ Comm. pitch ____________________
Dead coils __________ Dead bars ______________ Wires per bar ________
Dia. of core __________ Length of core __________ End room __________
Band wires ____ Size ______ No. of turns ______ Solder balance weights ______

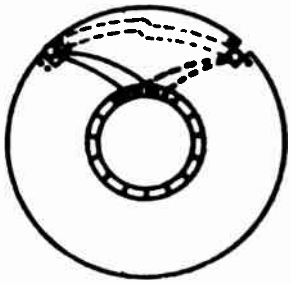

WAVE SIMPLEX SYM.




LAP SIMPLEX SYM.


WAVE SIMPLEX SYM. 3 ELEMENT


LAP SIMPLEX NON-SYM.


LAP SIMPLEX SYM. 2 ELEMENT.

Coil Forming

The sketches show the method of making the right size coils for an armature winding.

The first step is to count the number of slots and commutator segments for determining the coil span and what element it is. After the coil span is found measurements should be according to Fig. 3 which shows the size a coil should be in relation to the average size armature. Notice particularly that the coil end extends 1/2" beyond the slot, 1/4" before spanning over to another slot. It can also be noticed that the twist (or curl) made in each end of the coil must be made at the exact center, otherwise the coils will not fit in properly.

Using a ruler, measure from a point 1/2" from the commutator in the exact center of the coil, (using a coil span of 1-7, slot #4, counting from #1 would be the center) to within 1/4" of slot #7. Referring to the armature in Fig. 3 this would be from C to D or 2-1/4". Measuring from C to B would be 6-1/2", and from A to B would be another 2-1/4" making a total of 11 inches for the length of the coil.

Set the coil winder (Fig. 1) at 11" and if the armature has twice as many segments as slots, or is two element, wind the two element coils with two wires in parallel, making both of the small coils in the two element coil in one operation. After the coils are wound on the winder they should be taped with cotton tape.

Referring to Fig. 2 which shows the method to use in forming the coil and bringing out the leads for both lap and wave wound coils note that coil should be taped before forming, assuming the approximate point where the lead should come out.

Extreme care must be taken in taping the coils to overlap exactly 1/2 its width pulling each turn firmly against the wires of the coil (start taping the coil 1" from the end at which the leads are to be brought out).

The next step is shaping the coil. The slots in the coil former that will hold the coil while it is being shaped should be set 6-1/2" on the scale (the slot on the pull arm should also be the same width and height). To get the length of the coil from one point to the other, measure from the center of the coil along the 4th slot (starting within 3/4" of the commutator and letting the ruler extend out at the other end) to a point the same distance at the opposite side. Referring to Fig. 3 this would be from D to A or 8-1/2". The adjustable rings on the shaft of the coil former will slide out so the holes in the knuckles will be held this distance (8-1/2") apart. Too much pressure should not be exerted in pulling the coil into position, as there is danger of breaking the insulation. When the coil has been stretched out the knuckles should be turned in the direction shown in Fig. 2, being very careful to see that the holes that the pins go through, to hold the coils in place, are exactly in the center of the coil.

Note:- The leads that extend from the coil when winding should be only long enough to reach to the end of the commutator bar opposite the riser. These ends should never be used to wind around the coil. Short lengths of wire may be used for this purpose, removing them as the coil is taped.

Note:- It is always good practice to make but one coil, shape it and try it on the armature to see if it is the exact size desired. Then, if any alterations must be made only one coil will be wasted.

Coil Forming

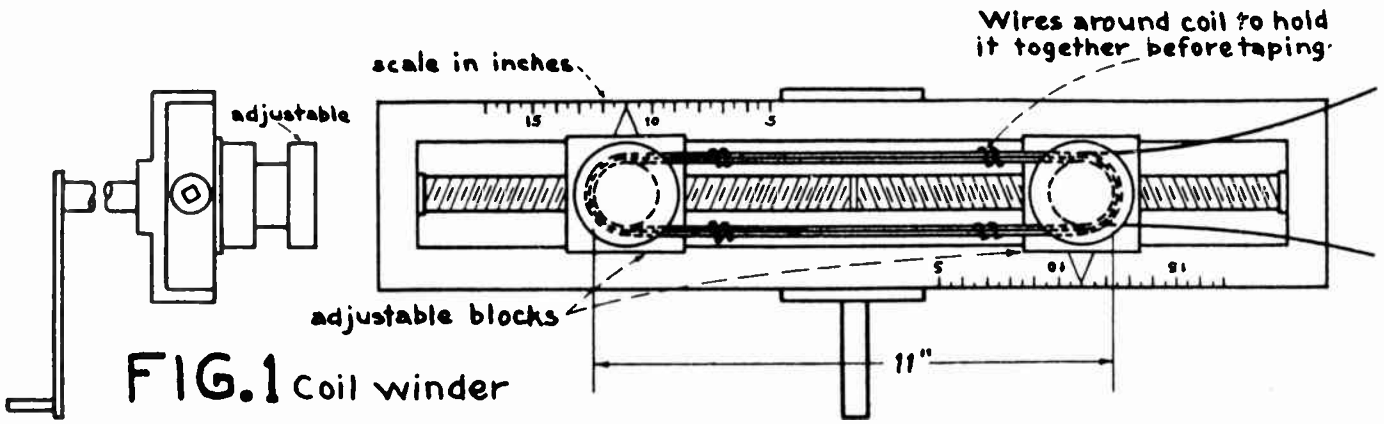


FIG. 1 Coil winder

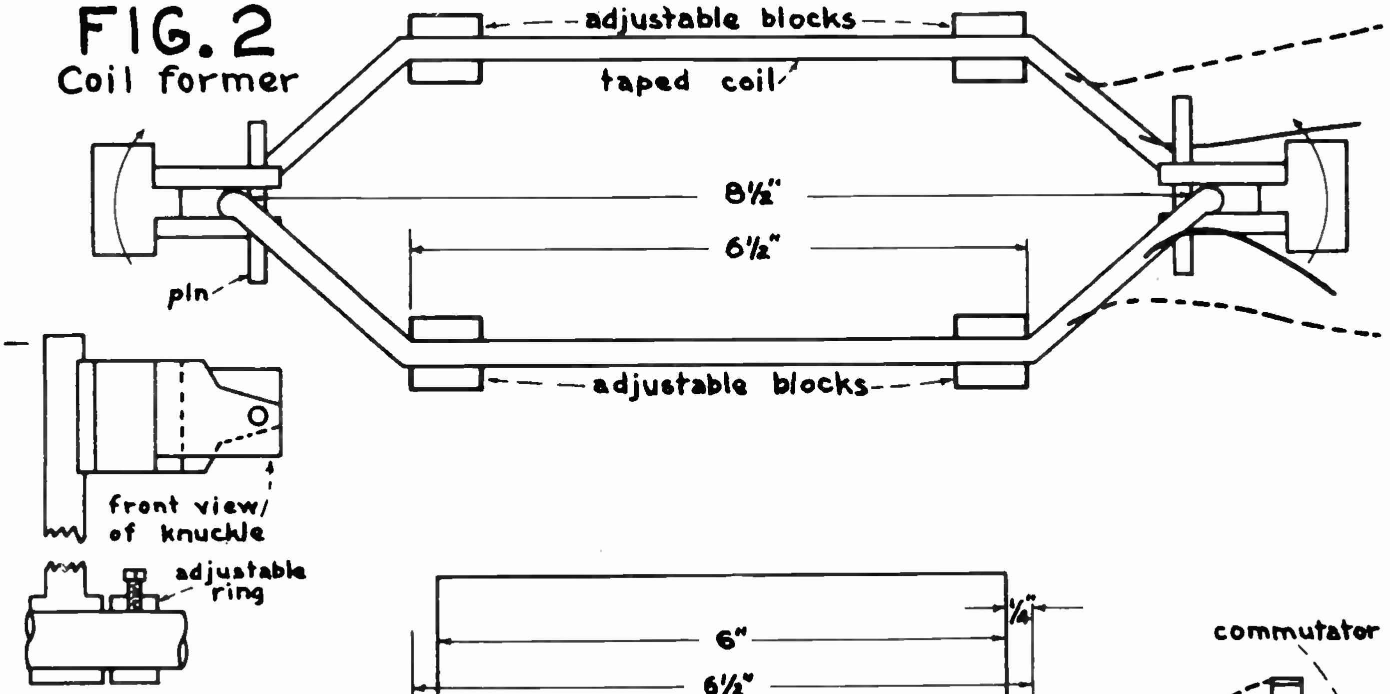


FIG. 2 Coil former

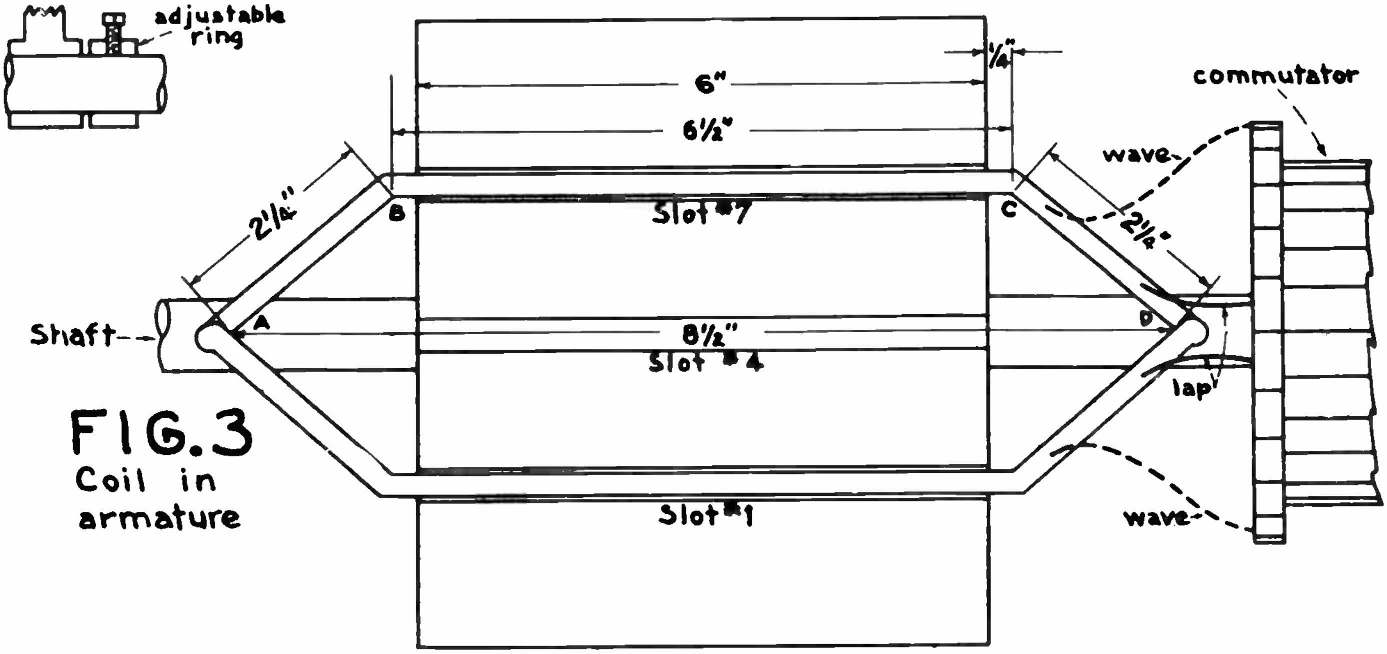
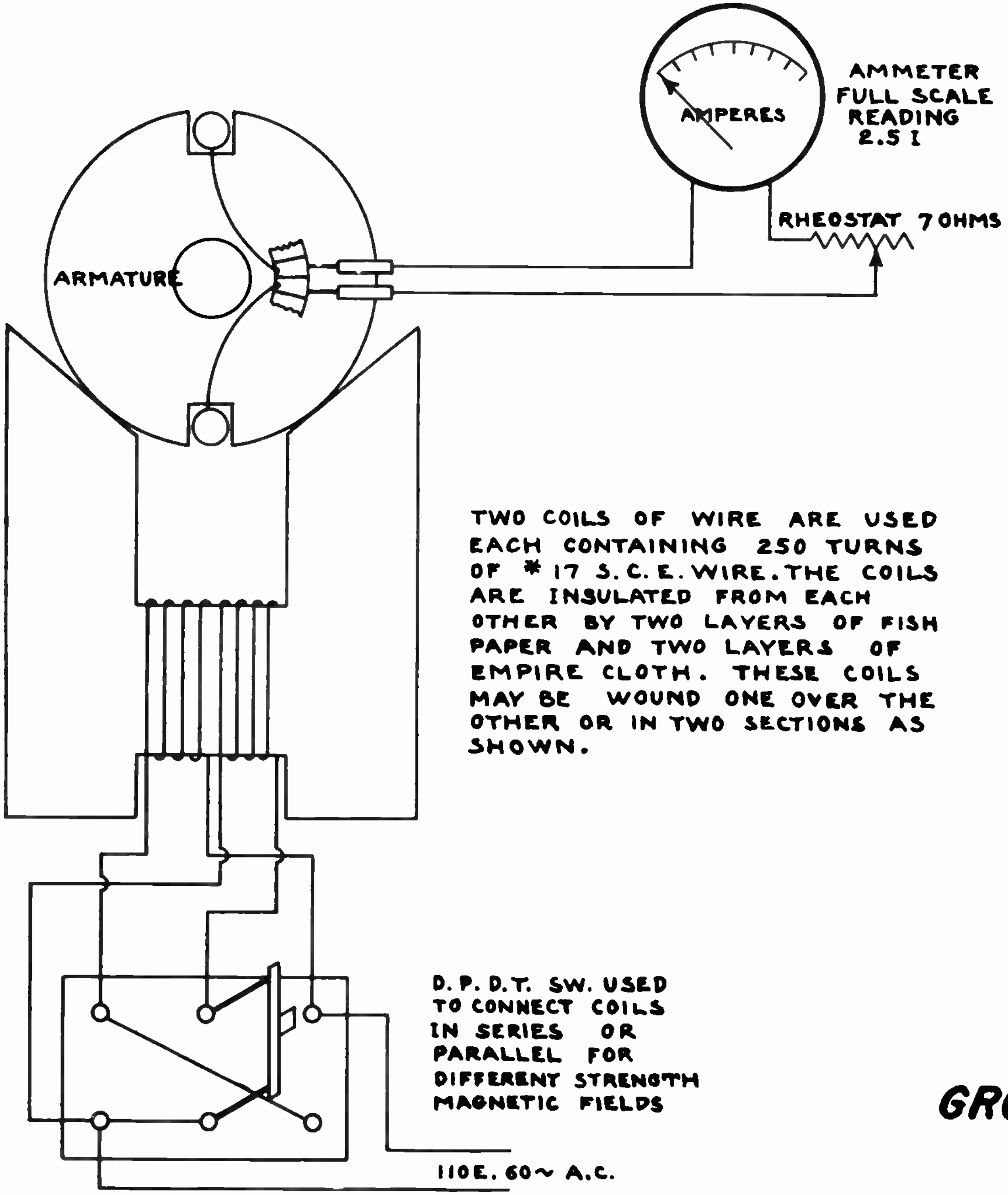
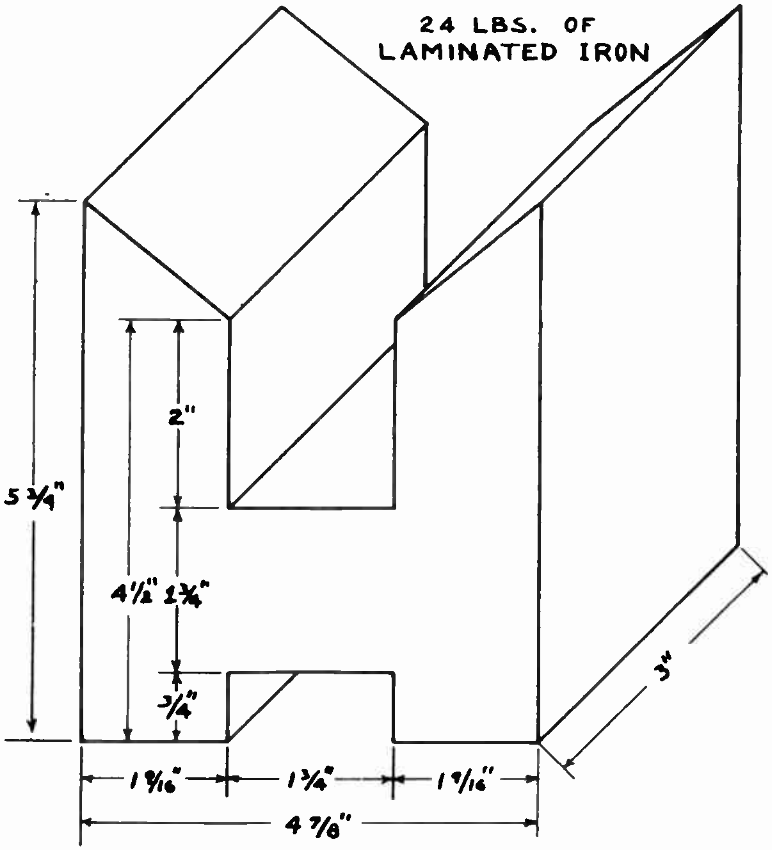


FIG. 3 Coil in armature



TWO COILS OF WIRE ARE USED EACH CONTAINING 250 TURNS OF # 17 S.C.E. WIRE. THE COILS ARE INSULATED FROM EACH OTHER BY TWO LAYERS OF FISH PAPER AND TWO LAYERS OF EMPIRE CLOTH. THESE COILS MAY BE WOUND ONE OVER THE OTHER OR IN TWO SECTIONS AS SHOWN.

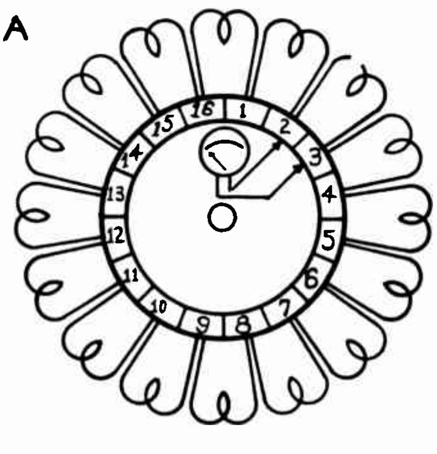
D.P.D.T. SW. USED TO CONNECT COILS IN SERIES OR PARALLEL FOR DIFFERENT STRENGTH MAGNETIC FIELDS



GROWLER SPECIFICATIONS

ARMATURE GROWLER TESTS

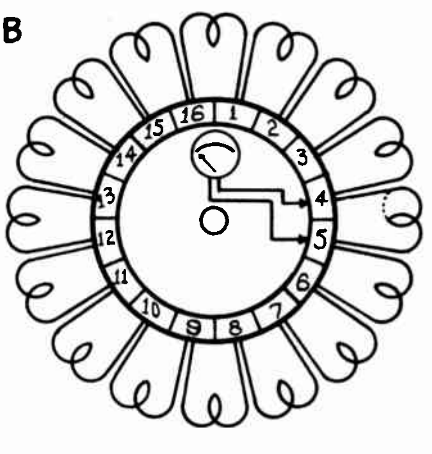
A



TROUBLE: OPEN COIL

This defect shows itself on the operating machine by excessive sparking at the brushes and burning of the bars attached to the coil. When tested on the growler, the meter reading between bars 1 and 2 will be zero. If the open is due to poor soldering at the commutator, resolder. If caused by an open in the coil itself, disconnect the leads, insulate the ends, and connect a jumper from bar 1 to bar 2.

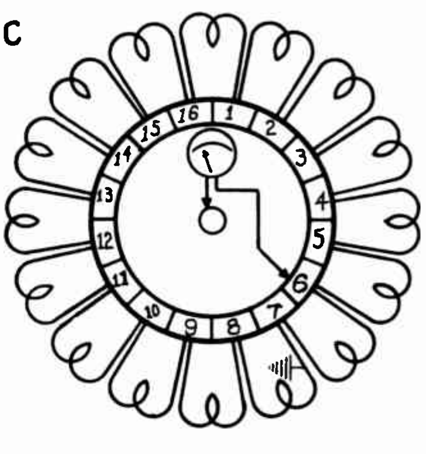
B



TROUBLE: SHORTED COIL

When the machine is in operation, a shorted coil is indicated by the excessive heat it generates. While other coils on the armature maintain a normal temperature, the shorted coil becomes so hot that it burns the insulation from the winding. On the growler, the meter reading between bars 4 and 5 will be low or zero. A hacksaw blade will vibrate over the slots in which the shorted coil lies.

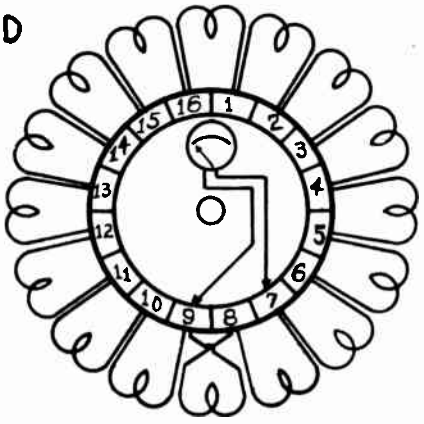
C



TROUBLE: GROUNDED COIL

A grounded coil will usually give no indication during operation unless the frame of the unit be ungrounded; in this case, a shock may be felt when touching the frame. Two grounds on the armature produce a short-circuit. On the growler, a meter reading is taken between the commutator bars and the shaft. The reading becomes less as the shorted bar is approached and is minimum when contacted.

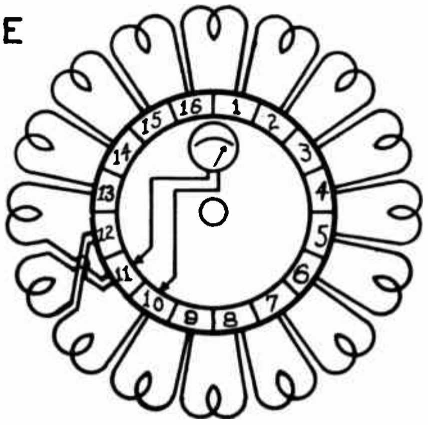
D



TROUBLE: REVERSED COIL LEADS

In operation, this defect would create unbalance in the armature circuit with the result that circulating currents would flow and tend to cause overheating. On the growler, make a 1 to 3 bar test. When testing between bars 7 and 9, the reading would be zero and the same reading would be obtained between bars 8 and 10. This would indicate that the leads of the coil attached to bars 8 and 9 are reversed.

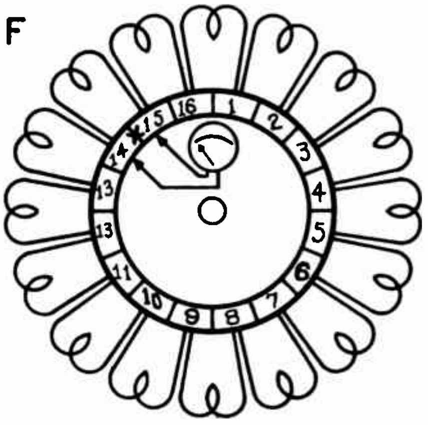
E



TROUBLE: REVERSED COIL LOOPS

This fault, which usually occurs in a rewound machine, may produce sparking at the brushes during operation. When tested on the growler, the meter will show a double reading between bars 10 and 11, a normal reading on 11 and 12, and a double reading on 12 and 13. To remedy, unsolder loops on 11 and 12 and reverse them. Hacksaw will give no indication of this fault.

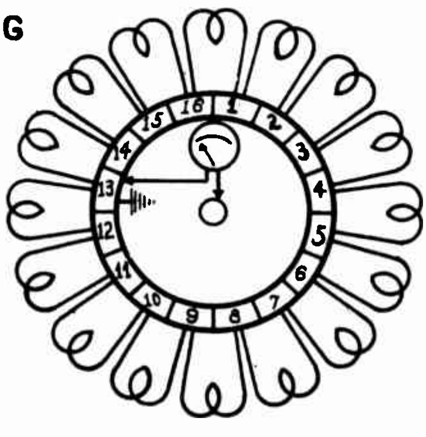
F



TROUBLE: SHORTED BARS

Indication during operation is overheating of coil attached to bars 14 and 15 and possible sparking at the brushes. On growler, hacksaw blade will vibrate over slots containing coil connected to shorted bars, and meter reading between 14 and 15 will be zero. Remedy: remove short from bars or discount coil and install a jumper from 14 to 15.

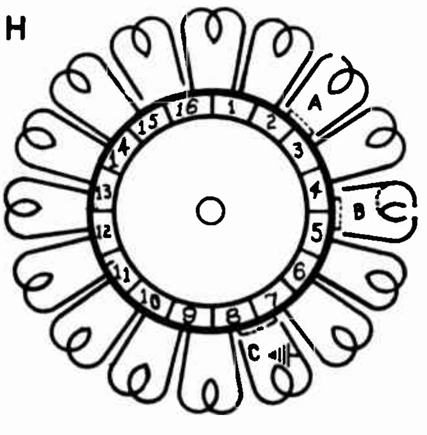
G



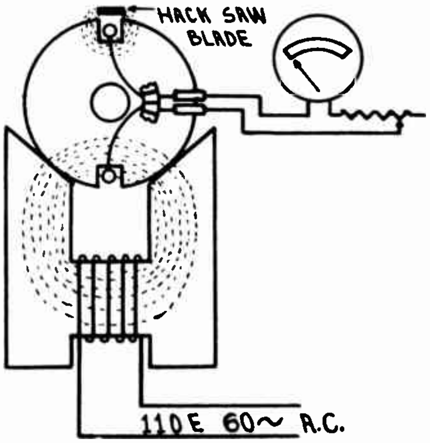
TROUBLE: GROUND BARS

If there are no other grounds on the machine, the fault will not affect the operation of the machine at all. If Other grounds are present, severe flashing at the brushes will usually occur. The test procedure is the same as employed in diagram "C". To determine if ground is coil or bar, disconnect wires from bar 13 and then test bar for ground Remedy: reinsulate bar.

H

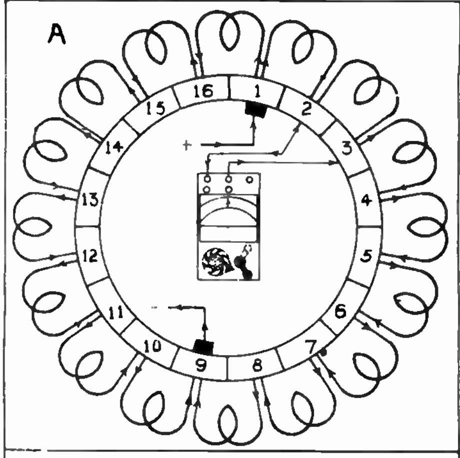


This sketch shows how the different faults above listed are remedied. The letters on the sketch refer to diagrams above in which the fault is given detailed treatment. "A" shows remedy for open coil, "B" for shorted coil, "C" for grounded coil. Dotted lines between bars represent jumpers. Note that with a shorted coil it is essential that the coil itself be cut as shown in "B" to remove the short circuit.

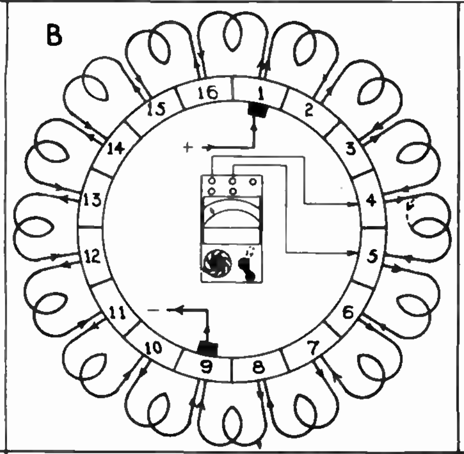


The purpose of a growler is to produce an alternating magnetic field which, cutting back and forth through the armature coils, induces in them a low voltage measurable at the commutator bars with an A.C. millivoltmeter. The resistance "R" is used to adjust the reading to approximately midscale. When a shorted coil is placed between the growler jaws, the heavy current set up in the coil causes periodic magnetization of the slot in which the coil lies, resulting in the hacksaw blade held near the slot being alternately attracted and released.

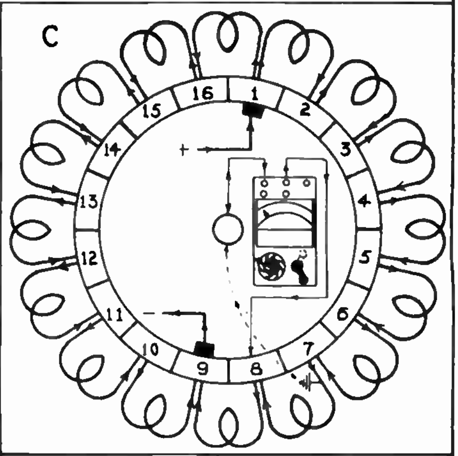
ARMATURE TESTS USING METER



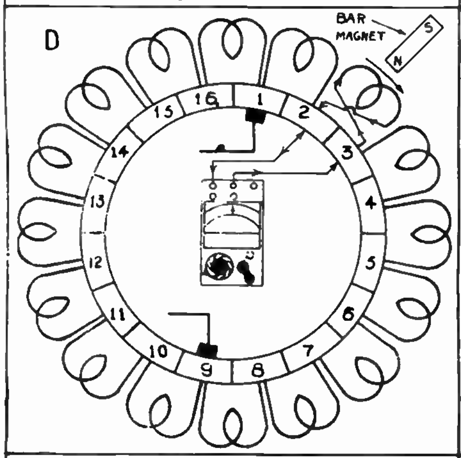
TROUBLE - OPEN COIL
To prevent injury to the meter, this test must precede all others when the millivolt method of testing is used. Set meter on the 15 volt range and, with current flowing through the armature, take readings between bars 1-2, 2-3, 3-4, etc., until all pairs of segments have been covered. A high reading between any pair of bars indicates an open coil. Note that in this method of testing the meter is used to measure the voltage drop in each armature coil, and that this is done by taking readings between commutator segments.



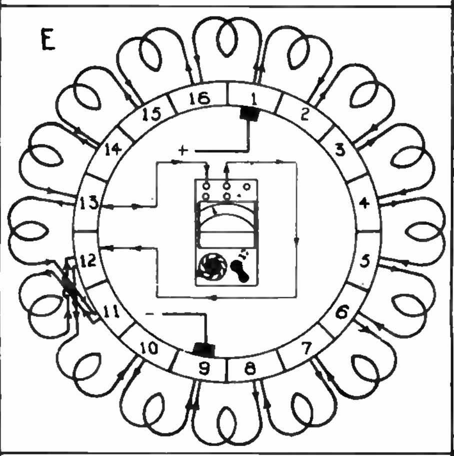
TROUBLE - SHORTED COIL
For this test set meter on the M.V. range that gives the best deflection, starting with the 300 setting and work down to the 50 M.V. range if necessary. Adjust current through armature until approximately midscale deflection is obtained on a normal coil and make a bar-to-bar test on all segments. The defective coil will give a low or zero reading depending upon how many turns are shorted. It should here be understood that this method of testing is merely a comparative one, for it is how the readings compare that is important.



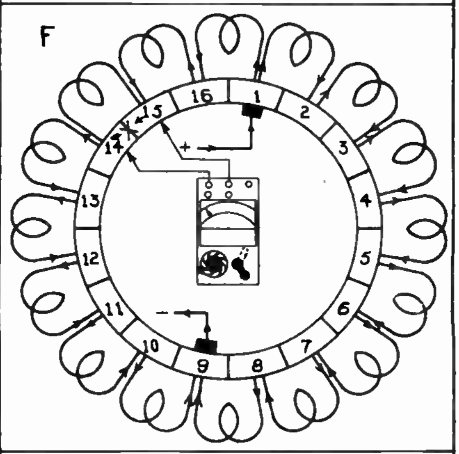
TROUBLE - GROUNDED COIL
To make this test, send a current of suitable value thru the armature and measure the voltage difference between each segment and the armature shaft. If the winding is grounded, a reading will be obtained that becomes gradually less as the bars to which the grounded coil is connected are approached. The reading will be lowest on the bars to which the grounded coil is connected. It should also be noted that as the grounded coil is passed the meter reading will reverse. To determine if the bar is grounded, disconnect the coil leads and repeat.



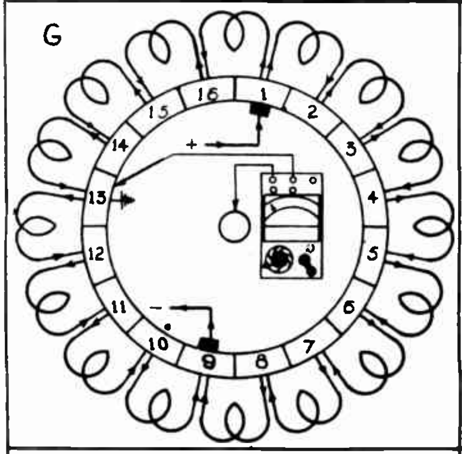
TROUBLE - REVERSED COIL LEADS
Usually encountered on armature that have just been rewound, this fault requires a different testing method. Set meter on 50 M.V. range, select the first coil to be tested, and find the segments to which the ends of this coil are connected. With the meter leads on these bars draw a magnet swiftly across the slot in which one side of the coil lies and note deflection on the meter. Repeat this test on all other coils, always moving the magnet in the same direction. When drawn across a reversed coil, the meter will read backwards.



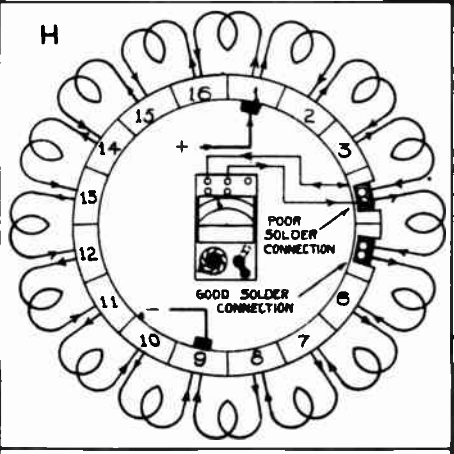
TROUBLE - REVERSED COIL LOOPS
Usually found only in rewound machines, this fault is checked by the regular bar-to-bar test. Proceed in exactly the same manner as used for locating shorted coils since the current in passing from segment 10 to segment 11 must flow through two coils, it follows that the voltage drop between bars 10 and 11 will be double the value obtained on a normal coil: the same is true for bars 12 and 13. Bars 11 and 12 will give a normal indication; thus reversed coil loops are indicated by a double reading, a normal reading, and a double reading.



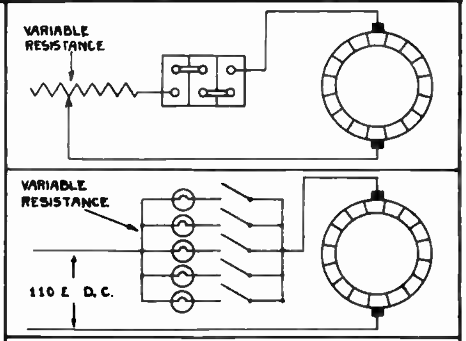
TROUBLE - SHORTED BARS
Make same test as for shorted coil. With current flowing through the armature, measure the voltage drop between segments. When the shorted bars are encountered, the meter will read zero. Inasmuch as the same indication would be obtained if the coil leads were shorted, it will be necessary to disconnect the leads from the commutator segments before it can be determined whether the low reading was caused by shorted bars or shorted coil leads. If after the coil is disconnected a zero reading is obtained, the bars are shorted.



TROUBLE - GROUNDED BARS
Test for this defect is the same as for a grounded coil. Meter reading from bar to shaft will be zero when the grounded bar is contacted. To determine whether the bar or the coil is grounded, disconnect the coil from the bar and test again; if bar now tests clear, coil is grounded. When making this test, the meter readings may change so rapidly as the ground is approached, that a satisfactory deflection cannot be obtained without turning to a different range. Therefore, as the reading falls, the meter switch should be moved to a lower range.

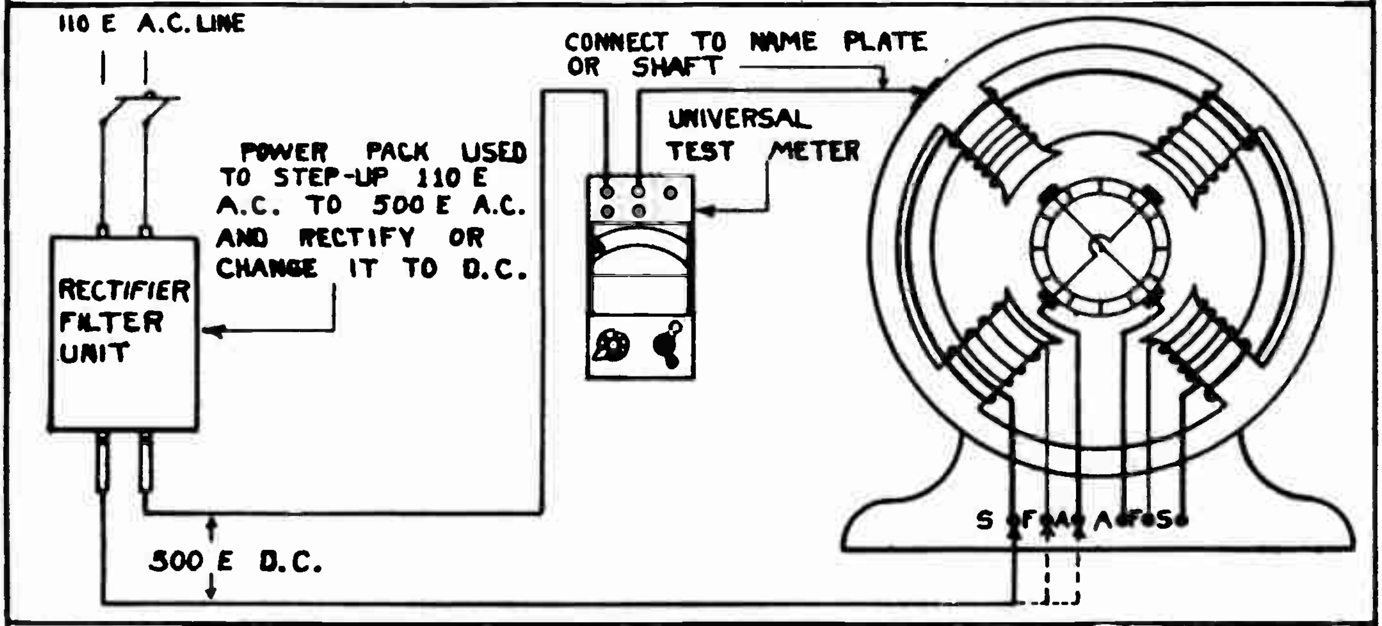


TROUBLE - BAD CONNECTIONS
Trouble frequently develops in armatures as the result of poor electrical connections between the coil leads and the commutator segments due either to poor soldering or to overheating of armature while in service. High resistance connections of this type are indicated by high reading on the millivoltmeter. To positively locate which bar has the poor connection, make the test indicated above. A poorly soldered joint will produce a readable deflection on the meter, whereas a good joint will give no reading.



TESTING PROCEDURE
Connect the armature to a 6 volt, 110 volt, or other D.C. supply with a controlling resistance in series. This resistance may consist of a number of parallel-connected lamps arranged to be switched in or out of the circuit at will. Feed current into armature through bars exactly one pole pitch apart, and adjust current until the millivoltmeter gives a midscale reading on a normal coil. The amount of D.C. current required will vary with the size of the armature, fractional H.P. units requiring about 2-4 amps, machines up to 20 H.P. about 10 amps, and the largest armature currents as high as 20 amps. After the current has been adjusted to a suitable value, take millivolt reading between bars 1-2, 2-3, 3-4, etc. if no faults are present, the readings will be approximately equal. High readings indicate high resistance connections, usually caused by poor soldering, while low readings show shorted coils or commutator segments.

INSULATION TESTS



D.C. Motor Starters and Controls

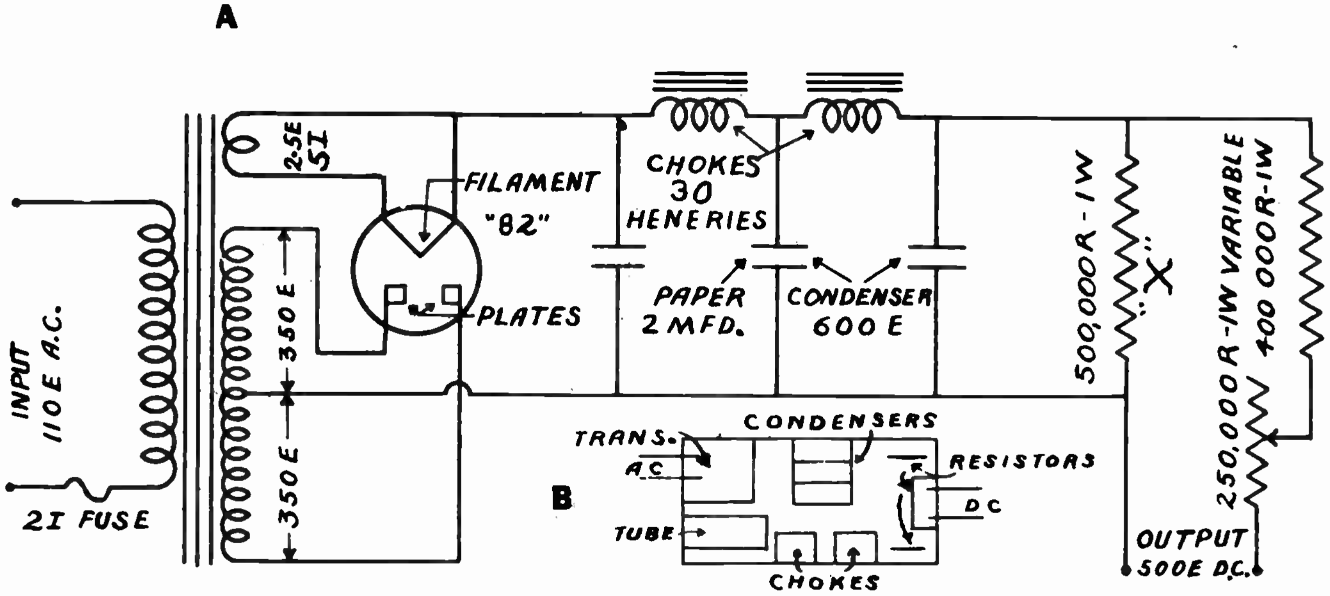
Since the quality of the insulating materials used on any eletrical machine deteriorates with age, due to the action of moisture, dirt, oil, acids, etc., it is necessary to periodically test the electrical resistance of the insulation so that weaknesses may be detected and corrected before they result in complete failure.

Insulation resistance tests are usually made up applying 500 volts D.C. between the winding of the machine and the frame; the current which this pressure forces through or over the insulation to the frame is measured by a sensitive instrument, the scale of which is usally calibrated to read in megohms. The 500 volts D.C. may be developed by a hand-operated generator as in the megger, or it may be supplied from an A.C. source by a rectifier-filter combination as shown above.

The readings obtained on any given machine will vary greatly with the temperature of the insulation, a 10 degree Centigrade rise in temperature reducing the insulation resistance as much as 50%. The dampness of the location, and the amount of oil, dust, or dirt on the winding, will also materially affect the readings. Wherever possible, the test should be made when the insulation is at the maximum operating temperature, 167 degrees F., (75 degrees C.) The minimum safe insulation resistance at maximum operating temperature should not be lower than one megohm for equipment having a voltage rating below 1000 volts.

To make the test, connect the rectifier unit to 110 volts A.C., set the control switch on the meter to the one mil position, set switch in D.C. position, make the connections shown above, and read the insulation resistance on the top scale of the dial. Usually a general test is made between one lead of the machine and the frame, and if this proves to be too low, the windings are tested individually. So after the general test, test the armature, shunt field, series field, and brush holders separately. To do this, take the brushes from the holders, disconnect the windings from each other, and test the insulation resistance of each. In this manner, the faulty element can quickly be found. This same procedure is used on A.C. equipment also. If such readings are taken at regular intervals and the values recorded, a close check may be kept on the condition of the insulation resistance of all electrical equipment, and apparatus may be removed from service and reconditioned before breakdown occurs.

POWER PACK FOR INSULATION RESISTANCE TESTER



The connecting scheme employed on unit designed to convert 110 volt, 60 cycle A.C. to 500 volt D.C. for insulation resistance testing is shown above. Many of the parts required for this rectifying and filtering device may be obtained from old radio equipment; the remainder may be purchased from any radio supply store. The material needed is listed below.

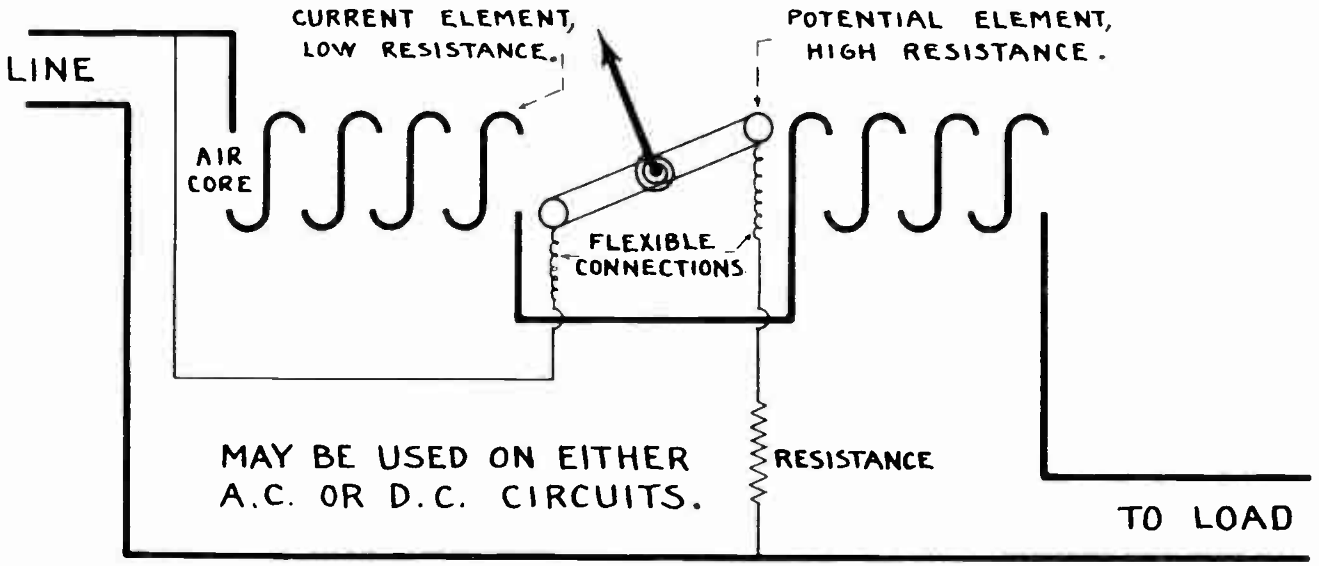
One power transformer with windings to produce voltages shown.
Three 600 volt, 2 microfarad, paper condensers.
Two 30 henry chokes. 50 Milliampere rating.
One 82 tube and socket for same.
One wooden case approximately 5x5x8.
One bakelite cover for wooden case.
One 500,000 ohm 1 watt fixed resistor.
One 400,000 ohm 1 watt fixed resistor.
One 250,000 ohm 1 watt variable resistor.
One control knob for variable resistor.
One instrument fuse base and clips.
One instrument fuse, 2 amperes.
Two tip plugs for leads (one red, one black)
Two pin jacks (one red, one black)

First experiment with parts to find the most suitable arrangement of the different items in the case. Small sketch (B) shows one method that has proved satisfactory. Tube base must be so placed as to permit replacement of defective tube without the removing other parts. All connections must be soldered.

After the unit has been constructed, test the D.C. voltage output with a 0-1 mil voltmeter. If the voltage is too high, use a lower resistance at X. A little experiment and adjustment will probably be necessary before the correct output voltage is obtained. The meter to be used in conjunction with this supply device must not require more than one milliampere to produce full scale deflection. Higher current drain will result in lowering the output voltage of the power supply; this will introduce errors in the readings taken when the unit is being used for insulation resistance tests.

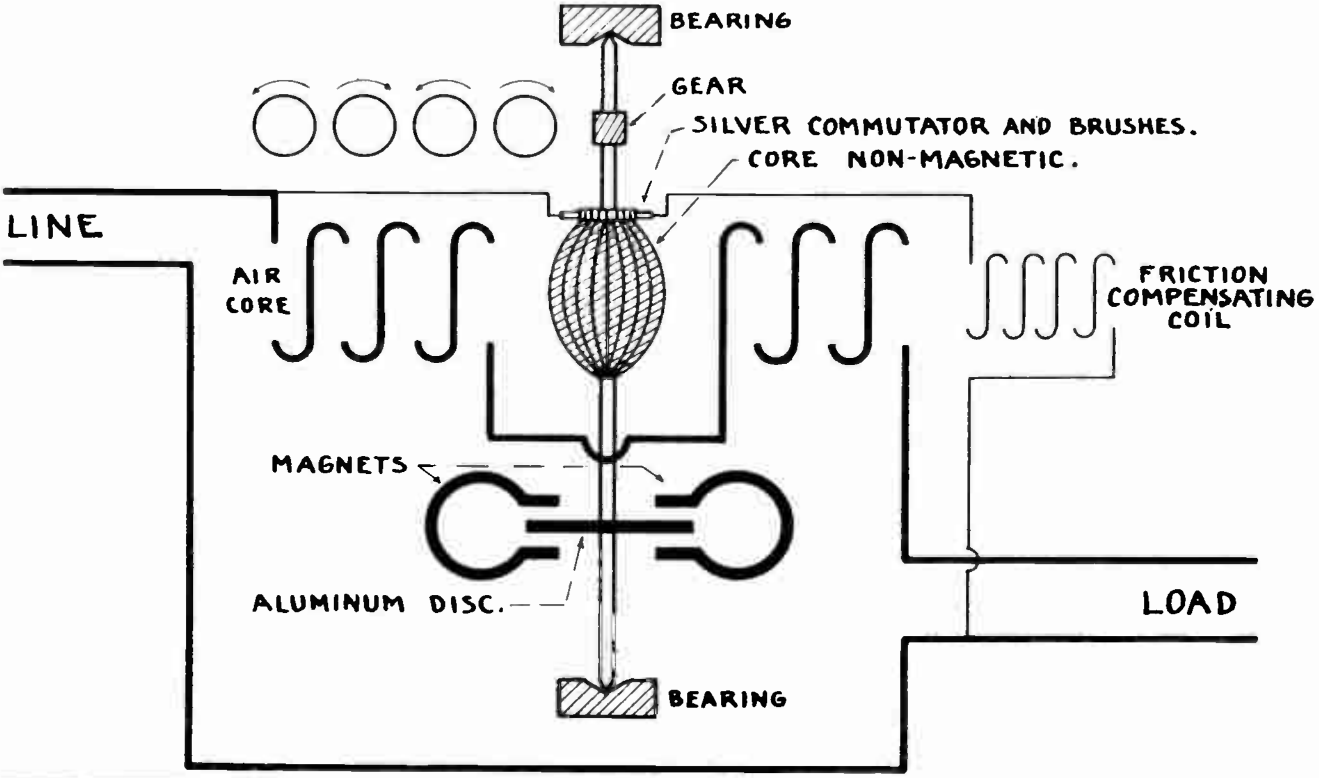
WATTMETER AND WATTHOURMETER DIAGRAMS

INDICATING WATTMETER.

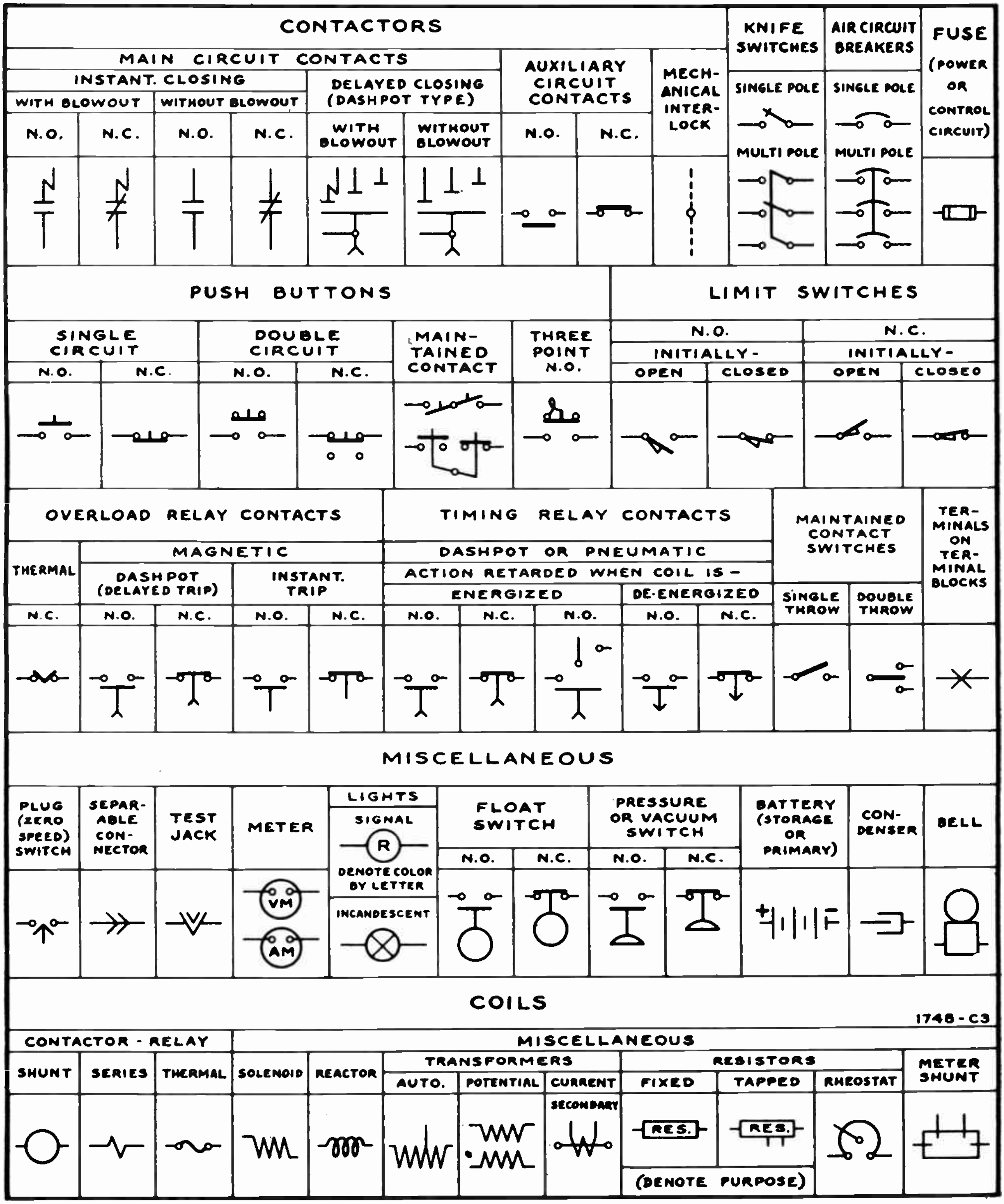


MAY BE USED ON EITHER A.C. OR D.C. CIRCUITS.

D.C. INTEGRATING WATTMETER.



Standard Line Diagram Symbols



Direct-Current Control Circuits

Ease in shooting trouble on d.c. controls depends largely on a clear understanding of the basic principles and circuits used. It is the purpose of these data sheets to give that information.

In general, d.c. motors of less than 2-hp. rating can be started across the line, but with larger motors it is usually necessary to put resistance in series with the armature when it is connected to the line. This resistance, which reduces the initial starting current to a point where the motor can commutate successfully, is shorted out in steps as the motor comes up to speed and the countervoltage generated is sufficient to limit the current peaks to a suitable value. Accelerating contactors that short out successive steps of starting resistance may be controlled by countervoltage or by definite-time relays.

For small motors used on auxiliary devices the counter-e.m.f. starter is satisfactory. The definite time starter is more widely used, however, and has the advantage of being independent of load conditions.

The following diagrams illustrate some of the circuits commonly used for d.c. motor control.

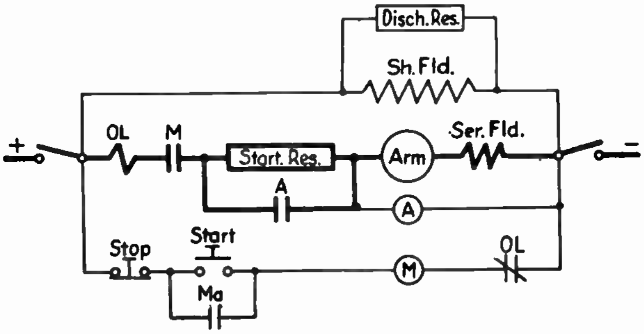


Figure 1. Basic requirements of a non-reversing d.c. starter in its simplest form.

When the start pushbutton is depressed line contactor *M* closes, energizing the motor armature through the starting resistance. As the motor comes up to speed the countervoltage, and the voltage across motor armature and series field, increases. At a predetermined value the accelerating contactor *A* closes, shorting out the starting resistance.

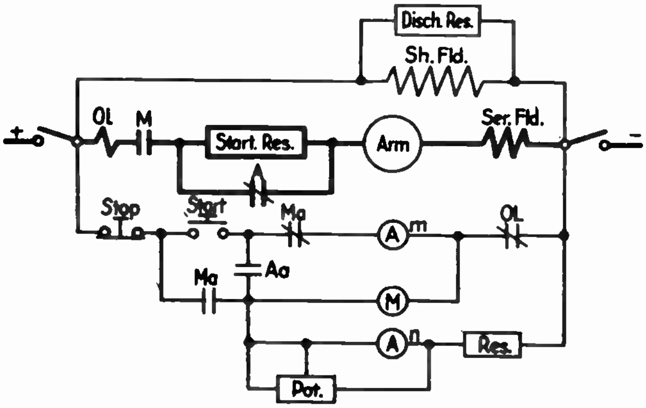


Figure 2. Typical, non-reversing constant-speed, definite-time starter. The accelerating contactor is equipped with a time-delay mechanism. This contactor, A, is of the magnetic-flux-decay type. It is spring-closed, equipped with two coils, and has a magnetic circuit that retains enough magnetism to hold the contactor armature closed and the contact open indefinitely. Main coil Am has sufficient pull to pick up the armature and produce permanent magnetization. Neutralizing coil An is connected for polarity opposite to the main coil. It is not strong enough to affect the pick-up or holding ability of the main coil but, when the latter is deenergized, the neutralizing coil will buck the residual magnetism so that the contactor armature is released by the spring and the contacts close. By adjusting the potentiometer the voltage impressed on this coil and hence the time required for the contactor to drop out can be varied. When the start button is depressed accelerating contactor coil Am is energized, causing contact A to open and auxiliary contact Aa to close. Contact Aa energizes line contactor *M*, and normally open auxiliary contacts Ma establish a holding circuit. Neutralizing coil An is also energized. Opening of contact Ma deenergizes coil Am and contactor A starts timing. At the set time the main normally closed contacts on A close, shorting out the starting resistance and putting the motor across the line.

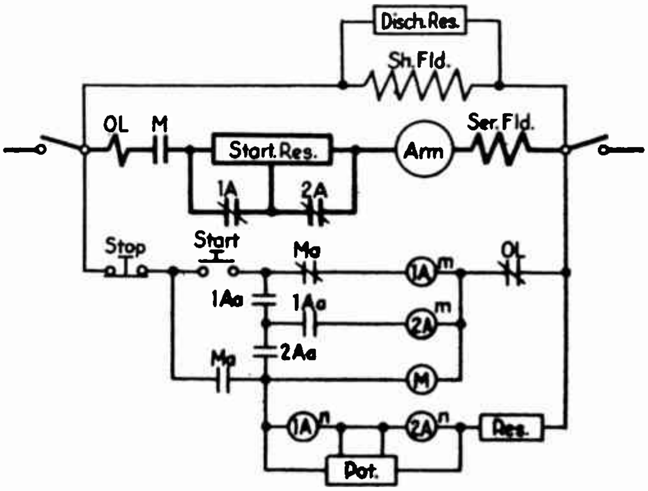


Figure 3. The same kind of a starter as in Figure 2 but designed for use with a motor of larger horsepower.

This starter provides two steps of definite-time starting. The operation is essentially the same as in Figure 2 but the first accelerating contactor, *1A*, does not short out all the starting resistance. It also starts *2A* timing, which finally shorts out the remaining resistance. The normally open auxiliary contacts on the accelerating contactors in Figures 2 and 3 are arranged so that it is necessary for the accelerators to pick up before the line contactor can be energized. This is a safety interlocking scheme that prevents starting the motor across the line, if the accelerating contactors are not functioning properly.

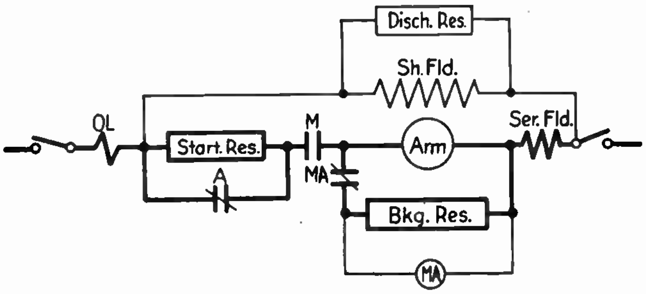


Figure 4. One way of producing dynamic braking.

Control circuits have been omitted, since they are a duplicate of those shown in Figures 2 and 3. Line contactor *M* has two poles, one normally open and the other normally closed. Both poles are equipped with an operating coil and are on the same armature, which is hinged between the contacts. In starting, when line contactor *M* closes normally closed contact *MA* opens. When the stop button is depressed the line contactor drops out and contact *MA* closes. The motor, now acting as a generator, is connected to the braking resistor and coil *MA* is energized by the resultant voltage. It causes *M* to seal in tightly, establishing good contact pressure and preventing this contact from bouncing open.

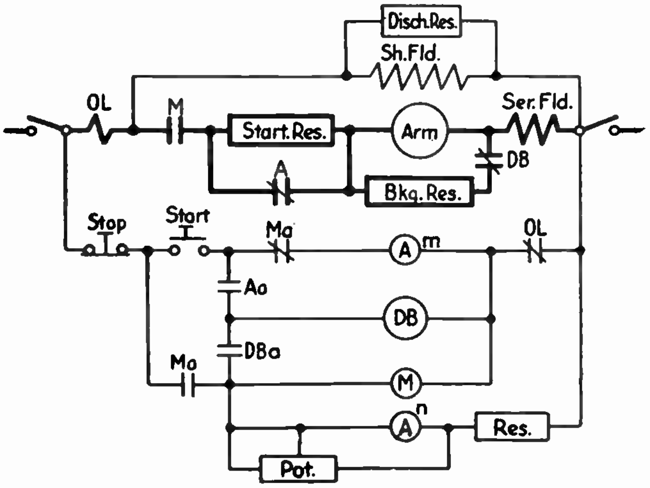


Figure 5. In the more modern types of controllers a separate spring-closed contactor is used for dynamic braking.

Operation is similar to that described for Figure 2, except that the energizing of coil *Am* and the picking up of accelerating contactor *A*, closing contact *Aa*, energizes dynamic braking contactor *DB*, which in turn energizes line contactor *M* through its auxiliary contact, *DBa*. This arrangement not only insures that the dynamic braking contactor is open, but also that it is open before the line contactor can close. In order to obtain accurate inching, such as is required for most machine tool drives, the motor must respond instantly to the operation of the pushbutton. In the scheme shown in Figure 5 the closing of the line contactor is delayed until the accelerating contactor and the dynamic braking contactor pick up.

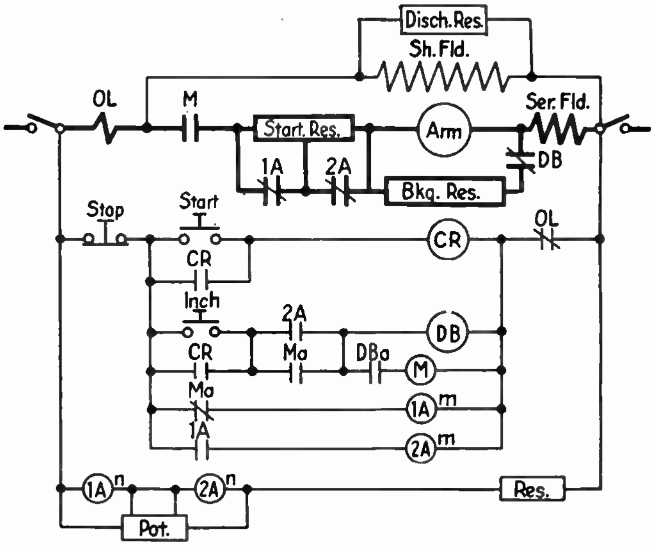


Figure 6. Arrangement to secure quicker response of motor, for more accurate inching.

Accelerating contactors *1A* and *2A* are energized in the off position. Hence, when the start button is depressed, the dynamic braking contactor picks up immediately and its auxiliary contact *DBa* picks up *M* line contactor.

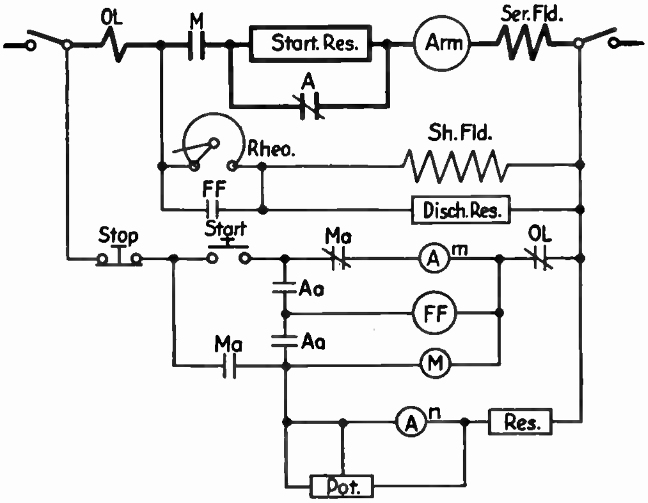


Figure 7. One method of connecting full field relay, used with adjustable-speed motors having a speed range in excess of 2 to 1. Coil *FF* is energized by the closing of the normally open auxiliary contact *Aa* and remains closed until the last accelerating contactor drops out. Contacts of the full field relay, *FF*, are connected to short out the field rheostat thereby applying maximum field strength to the motor during the starting period.

Direct-Current Control Circuits

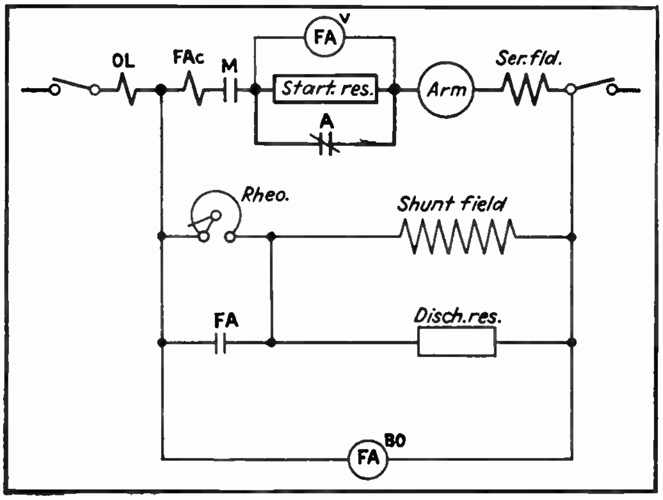


Figure 8. Another method of applying the full-field relay.

This arrangement insures full field on starting, and provides for limiting the armature current when the motor is accelerating from the full-field speed to the speed set by the rheostat. Field accelerating relay *FA* is equipped with two coils, one a voltage coil connected across the starting resistance, the other a current coil connected in series with the motor armature. See Figure 2 for the remainder of the circuit. When line contactor *M* closes the voltage drop across the starting resistor is practically line voltage, and relay *FA* is picked up quickly. When accelerating contactor *A* closes, voltage coil *FAv* is shorted, but closing of *A* produces a second current peak, and current coil *FAc* holds relay *FA* closed. As motor approaches full-field speed this current decays and allows the *FA* contacts to open, weakening the motor field. When the motor attempts to accelerate the line current again increases. If it exceeds the pick-up value of coil *FAc* the relay will close its contacts, arresting acceleration and causing a decay of line current, which again causes *FA* to drop out. High inductance of the motor field, plus inertia of the motor and drive prevent rapid changes in speed. Hence the motor will not reduce its speed, but the increased field current will reduce the armature current and cause *FA* to drop out. The fluttering action will continue until the motor reaches the speed set by the rheostat. Setting of the *FA* relay current coil determines the maximum current draw during this part of the acceleration period. Since relay *FA* must handle the highly inductive field circuit, a good blowout arrangement is necessary. Hence the relay is usually equipped with a shunt blowout coil, *FAbo*.

Figure 9. Connections of field loss relay, to prevent excessive speed if the shunt field is deenergized while voltage remains on the armature.

It usually consists of a current relay in series with the motor shunt field and is adjusted to pick up on full-field current and remain closed at any current within the operating range of the motor field current. Contacts of relay *FL* are connected in series with the overload relay contacts so that the opening of its contacts will deenergize the control by opening the line contactor. This type of field loss protection does not protect against the possibility of a short circuit across a part of the field, say across the one field coil. This would cause the motor speed to rise considerably but the current in the field circuit would also rise. Consequently, the series current relay would not respond.

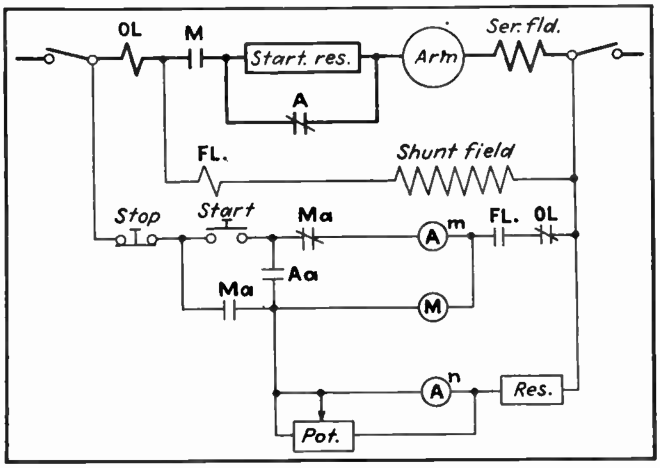
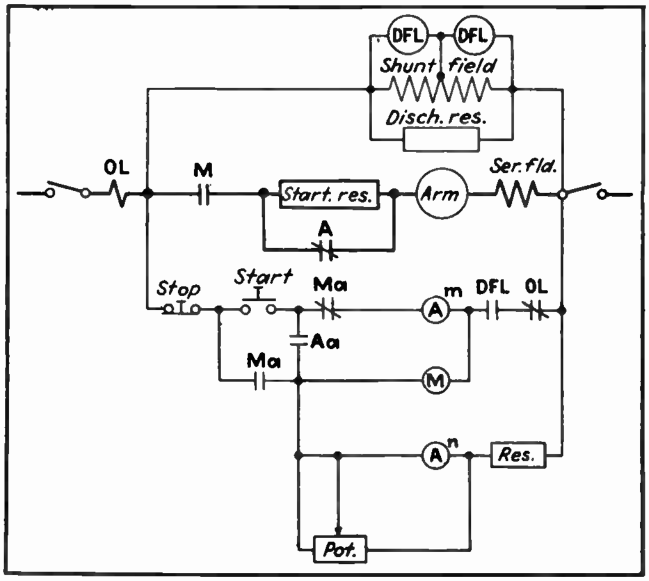


Figure 10. Application of differential field loss protection.

The differential field loss relay *DFL* is equipped with two voltage coils connected to buck each other. Each is connected across one-half of the field winding. Normally the voltage across each coil is the same, hence the relay stays in the out position with its normally closed contacts closed. Shorting out of one field coil or other failure causing an un-



Direct-Current Control Circuits

balance of these voltages causes the relay to pick up, opening its contacts and dropping out the line contactor, deenergizing the motor.

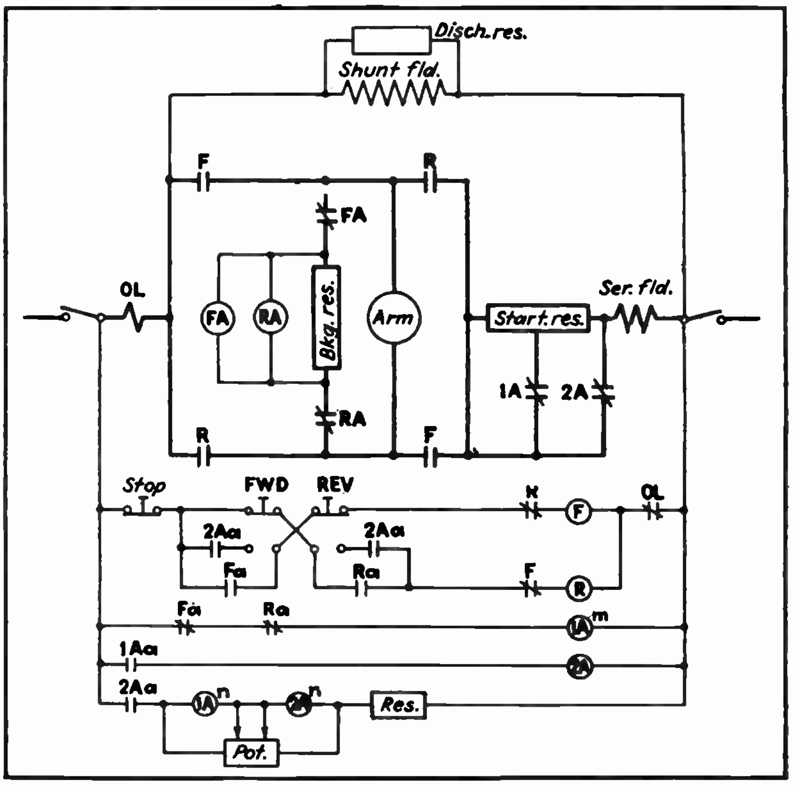


Figure 11. One form of reversing dynamic braking control, consisting of multi-pole contactors having two poles normally open and one pole normally closed. Accelerating contactors *1A* and *2A* are energized in the off position, as in Figure 6. Depressing the forward button energizes forward contactor *F*, closing the two normally open contacts *F* and opening the normally closed contact *FA*. Opening of normally closed auxiliary contact *Fa* starts the timing cycle of the accelerating contactors. Closing of the normally open auxiliary contact *Fa* establishes a holding circuit. When the stop or reverse button is depressed contactor *F* drops out, closing normally closed contact *FA* and setting up a dynamic braking circuit through the braking resistors, which energizes coils *FA* and *RA*. These coils hold the normally closed contact closed, and the normally open contacts open until the braking current drops to a low value. This action prevents bouncing of the back contacts and plugging the motor, because if the reverse button were depressed during the braking period contactor coil *R* would not have sufficient strength to overcome the pull of the *RA* coil until the motor had almost stopped.

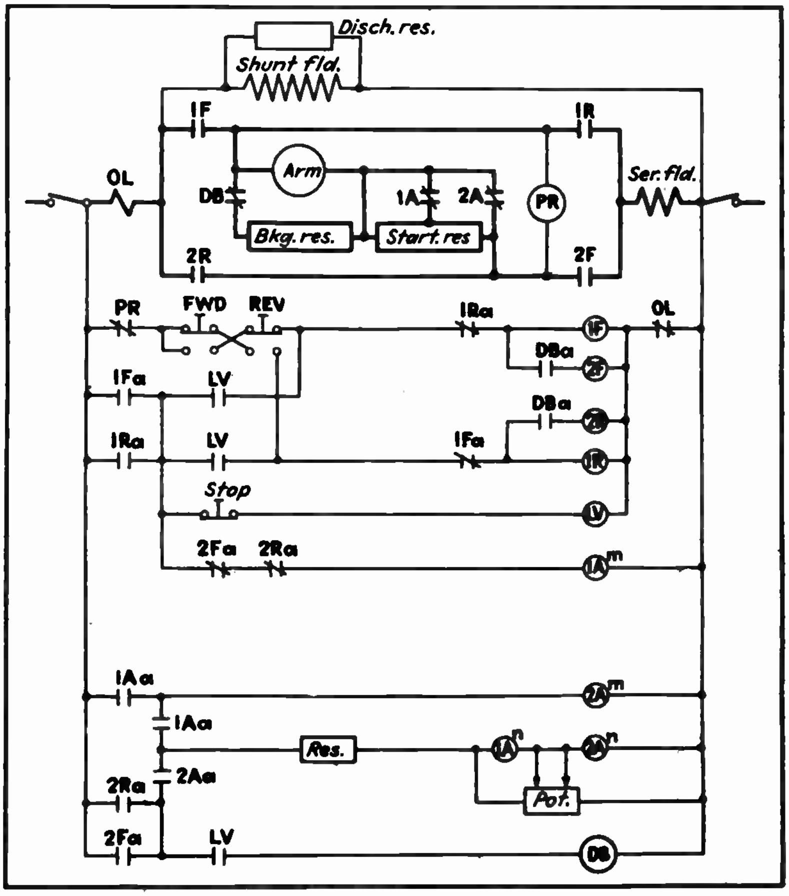
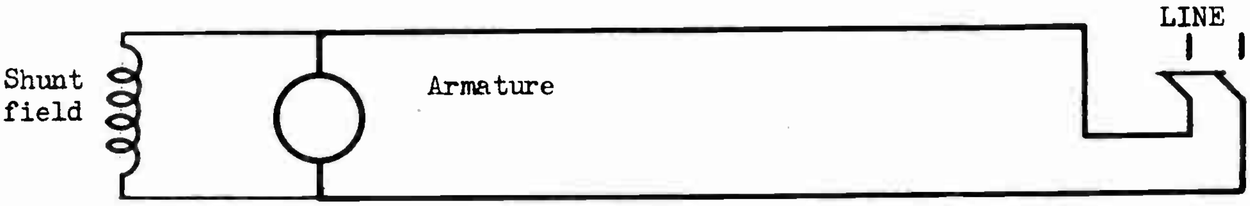


Figure 12. Another form of reversing dynamic braking starter using a spring-closed dynamic braking contactor and single-pole normally open directional contactors. When start button is depressed contactor *1F* is energized. Closing the normally open auxiliary contact *1Fa* energizes relay *LV* to establish a holding circuit and also energizes accelerating contact *1A*; *1A* contactor energizes *2A*, and *2A* energizes *DB*. In turn, *DBa* energizes *2F* and normally closed contact *2Fa* starts the accelerating timing.

Depressing the stop button drops out *LV*, closing *DB* immediately. Plugging is prevented by relay *PR*, a voltage relay connected across the motor armature. Its normally closed contacts remain open, preventing the pick up of the reverse directional contacts until the armature speed drops down to a safe value for plugging.

STARTING AND CONTROLLING THE SPEED OF D. C. MOTORS

Small D.C. motors (fractional H.P.) may be started across the line. The resistance of the armature winding is high in comparison to the resistance of larger armatures. Large armatures have low resistance because heavy wire is used to wind them.

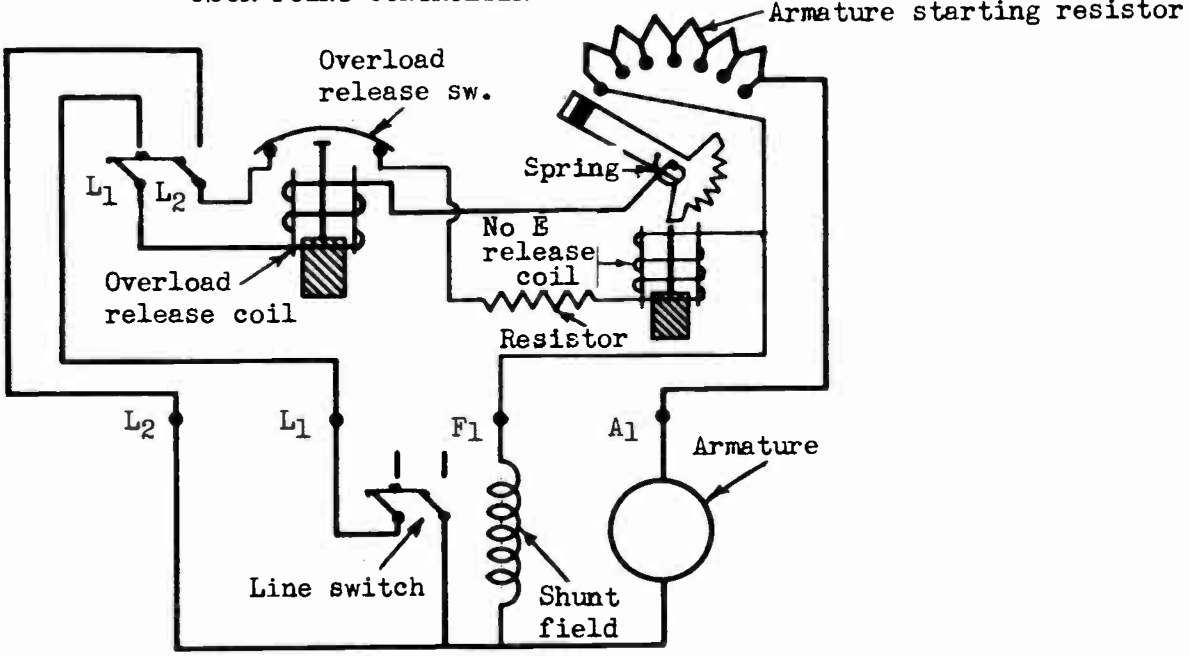


When starting a D. C. motor larger than fractional H. P. in size full line voltage should not be applied to the armature. A resistor should be connected in series with the armature to produce a voltage drop and apply a low voltage to the armature during the starting period. The starting peroid is from 10 to 45 seconds.

The starting current should be limited to 1-1/2 or 2 times full load current except when starting heavy torque leads which will require as much as 3 times full load current. After the motor attains normal speed the current through the armature can be determined by the formula; effective voltage divided by armature resistance. This value will be proportional to the mechanical load on the motor.

The shunt field must be connected so it will receive full line voltage when starting. The field must be maximum strength to produce good starting torque and for the armature to quickly generate CEMF.

FOUR POINT CONTROLLER



The NO VOLTAGE RELEASE COIL allows the spring on the power arm to return the power arm to the "off" position if the voltage on the line drops to a low or zero value.

OVERLOAD PROTECTION is provided by connecting an overload release coil in series with the load circuit. When the current reaches overload value the plunger will be drawn up and break the holding coil circuit. The spring on the power arm will return it to the off position.

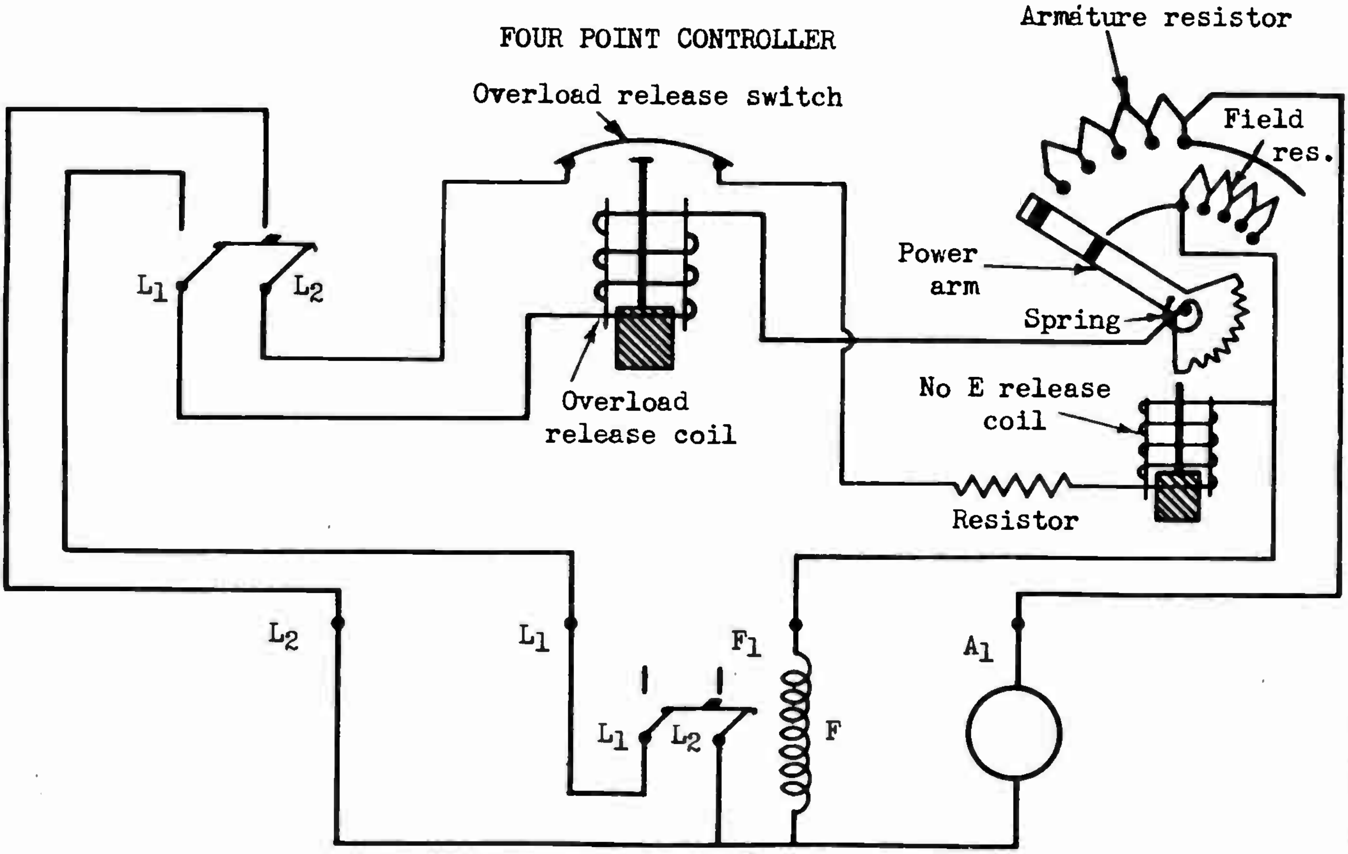
STARTING AND CONTROLLING THE SPEED OF D.C. MOTORS (continued)

The speed of a D.C. motor varies in direct proportion to the voltage applied to the armature and in inverse proportion to the strength of the field flux.

When a motor is operating with the rated voltage applied to the armature and field (with or without load) it is operating normally and the speed obtained is called NORMAL SPEED.

SPEED CONTROL BELOW NORMAL SPEED (armature control)

The speed can be controlled below normal by connecting a regulating resistor in series with the armature. The speed will vary with the voltage applied to the armature. The torque will not be affected because connecting a resistor in series with the armature does not change the amount of current throught the armature. This value will be constant if the mechanical load is constant. The H.P. output will vary with the speed because the H.P. output is proportional to the speed and torque.

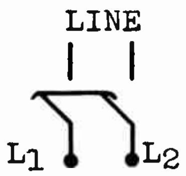

FOUR POINT CONTROLLER

SPEED CONTROL ABOVE NORMAL SPEED (field control)

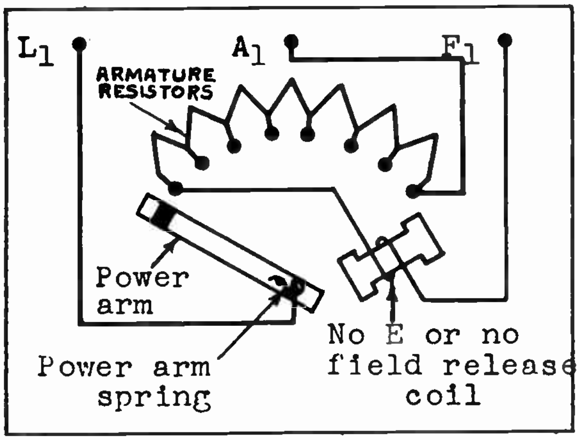
The speed can be controlled above normal on shunt and compound motors by connecting a shunt field rheostat in series with the shunt field. The speed will vary inversely with the field strength. Weakening the field will increase the speed because the armature must rotate faster to generate a sufficient amount of CEMF to limit the current through the armature in proportion to the mechanical load on the motor. Decreasing the field strength will decrease the torque. The H.P. output will not be affected because the H.P. output is always proportional to the speed and torque. When the speed increases and the torque decreases the product of the two will not change.

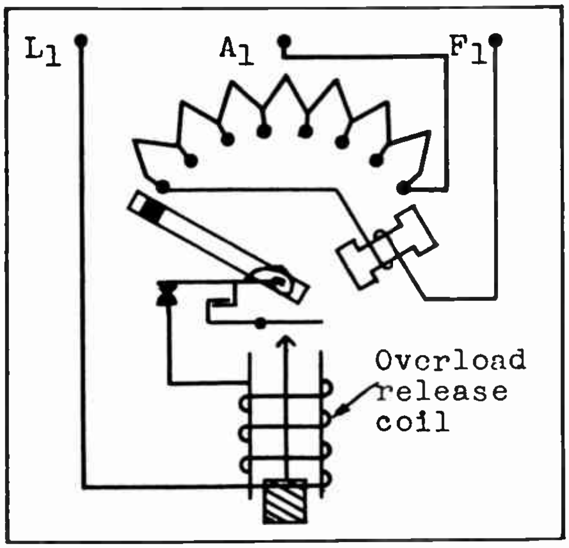
3 POINT STARTER DIAGRAMS

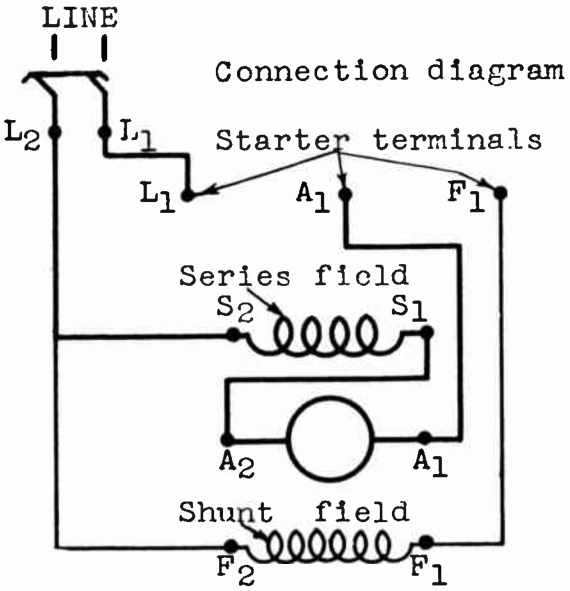
3 point starter for starting duty only.



3 point starter for starting duty only. The overload release coil protects the motor against overloads.



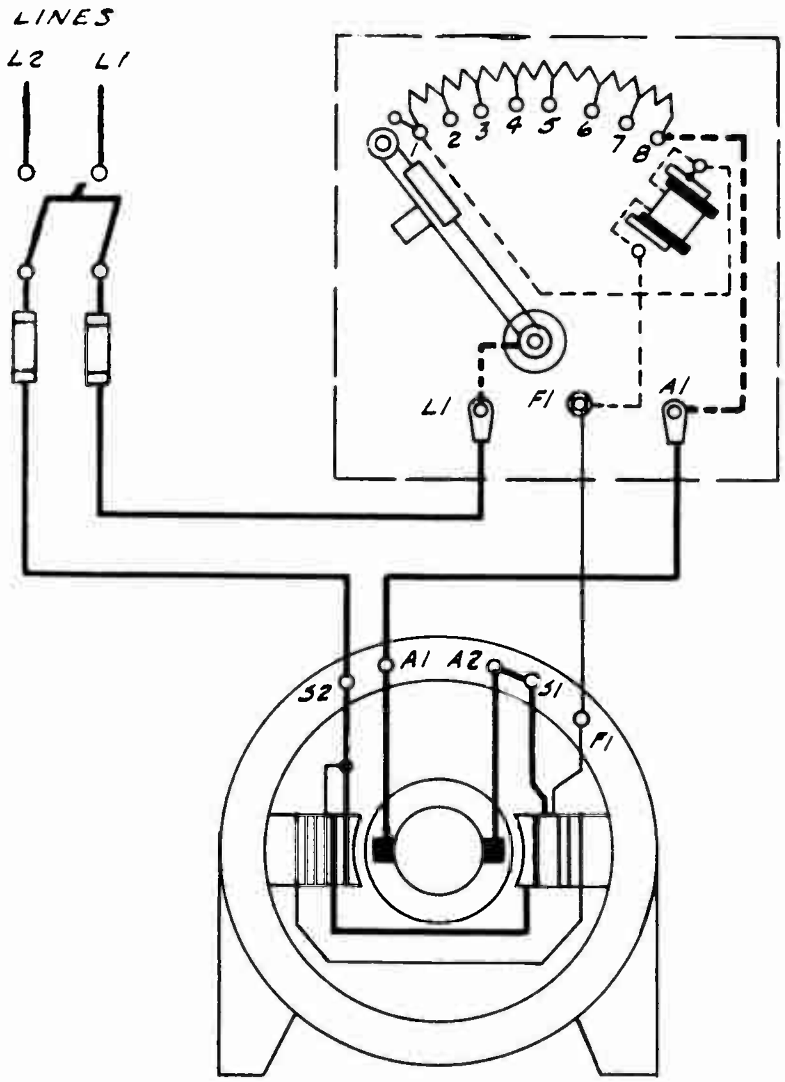




Connect as shown for compound motor.
For shunt motor connect A_2 to L_2.

Draw a detailed diagram of the motor. Show all parts such as field poles, brushes, armature, terminals and the position of the terminal board. Test the motor terminals with test lamp to identify them. Connect the motor to the starter as shown by the connection diagram.

19273D



IF MOTOR IS SHUNT WOUND
TERMINALS "S1" AND "S2"
WILL BECOME COMMON

TITLE CONNECTIONS FOR DIRECT CURRENT MOTOR STARTING RHEOSTAT WITH LOW VOLTAGE PROTECTION.

RETRACED BY	TRACED BY LEO. M. ZEMAN	TYPE "A"	SUP. NO
CHECKED BY	APPROVED BY	BULL NO 2110 & 2111	SUP BY NO.
A B C D		ORDER NO STANDARD	19273D

CUTLER-HAMMER. INC. MILWAUKEE NEW YORK

ORIGINAL TRACING FILED WITH PATENT DRAWINGS

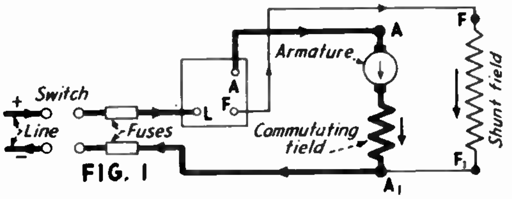


FIG. 1

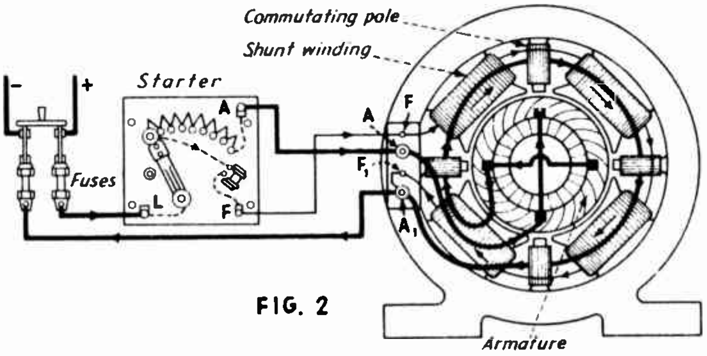


FIG. 2


FIG. 3


FIG. 4


FIG. 5

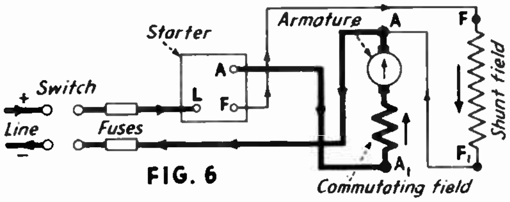


FIG. 6

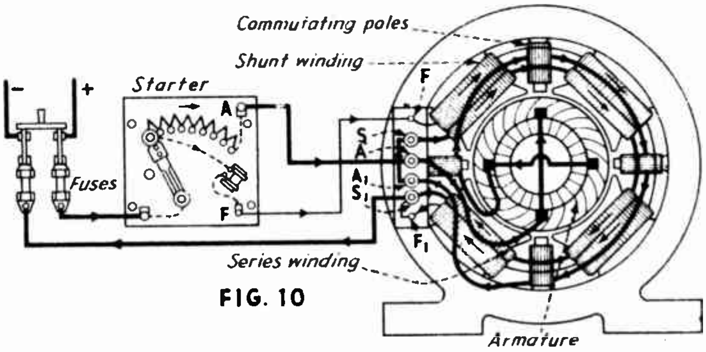


FIG. 10

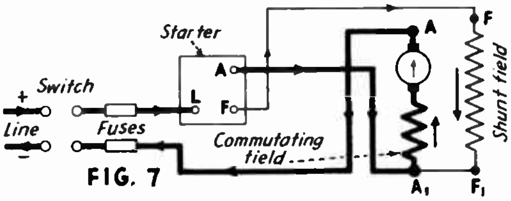


FIG. 7

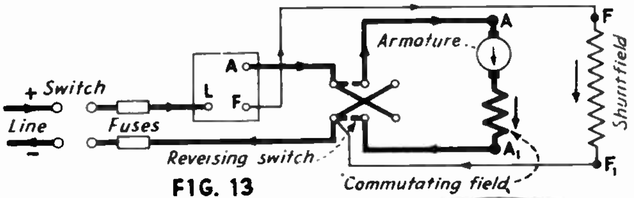


FIG. 13

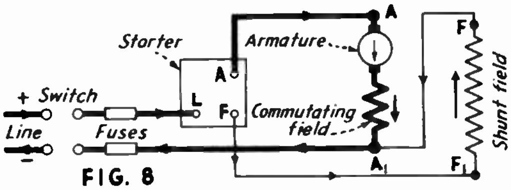


FIG. 8

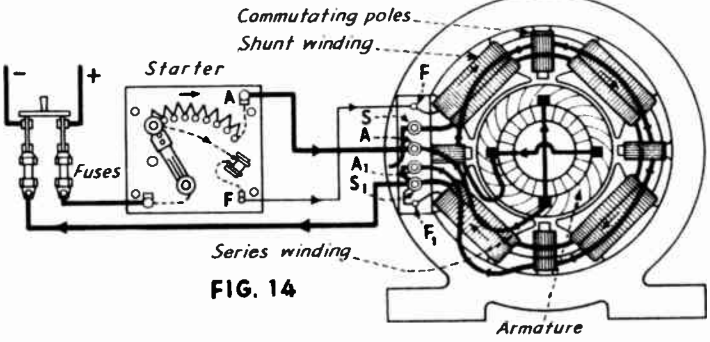


FIG. 14

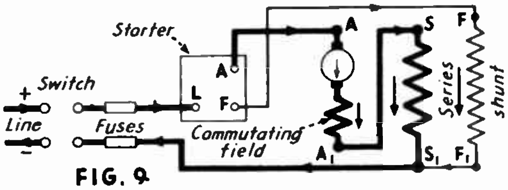


FIG. 9

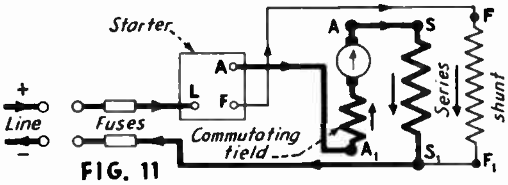


FIG. 11

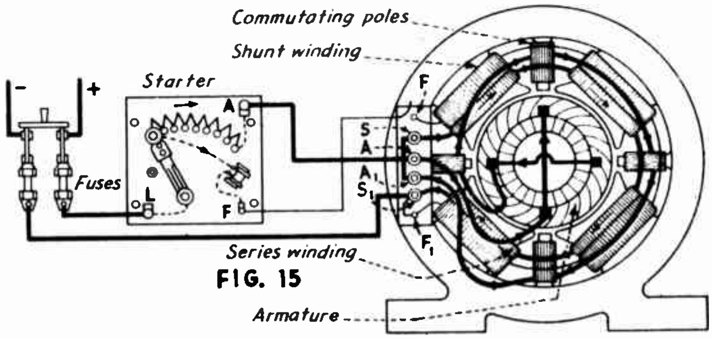


FIG. 15

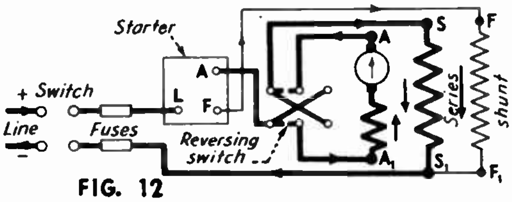
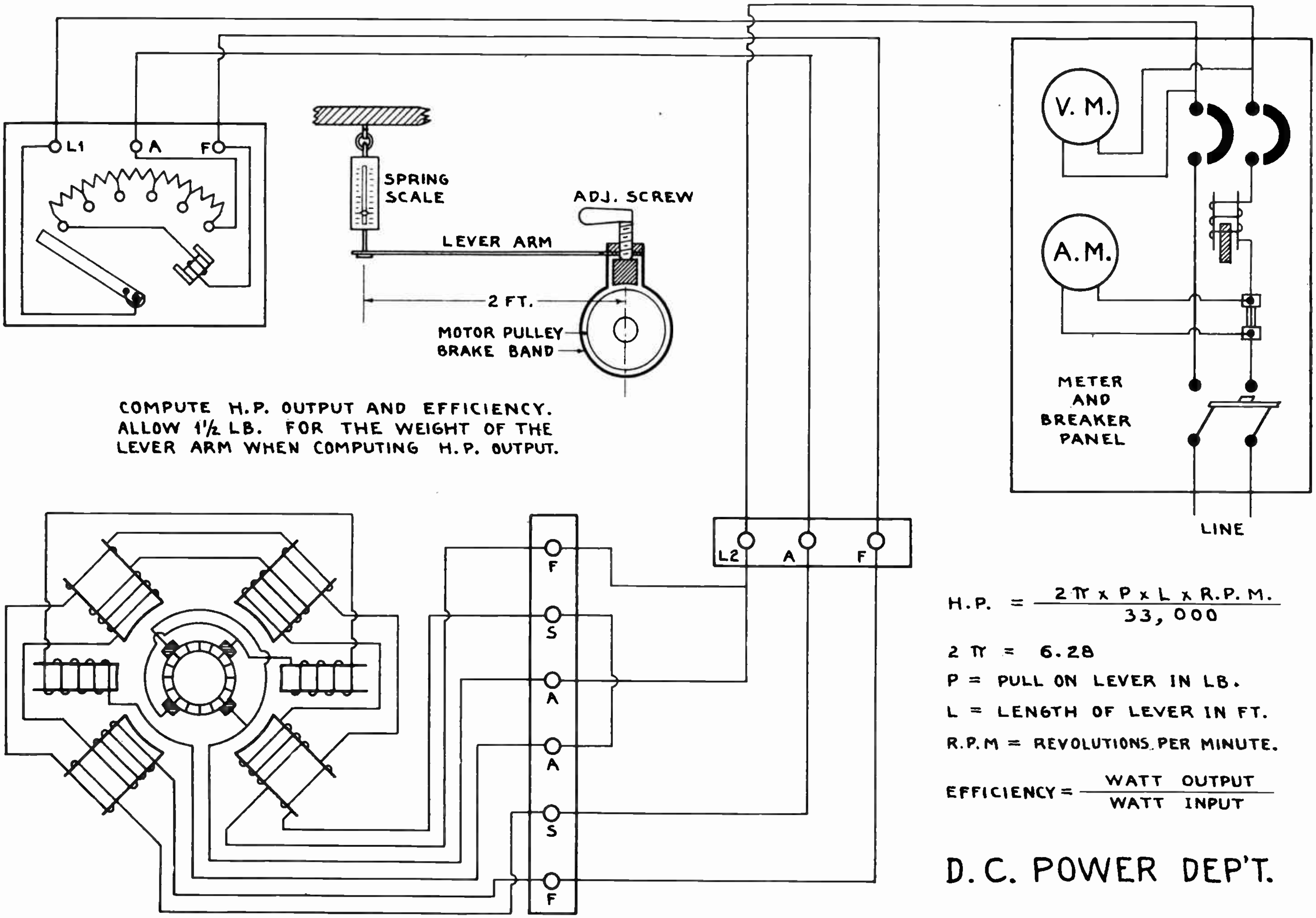


FIG. 12

Fig. 1—Diagram of shunt motor and starter, Fig. 2. Figs. 3 and 4—Symbols for coils. Figs. 4 and 5—Symbols for resistance. Fig. 6—Same as Fig. 1, but current reversed in armature circuits. Fig. 7—Wrong connection for reversing shunt motor. Fig. 8—Same as Fig. 1, except current is reversed in shunt field coils. Fig. 9—Diagram of compound motor and starter, Fig. 10. Fig. 12—Reversing switch connected in armature circuit of compound motor. Fig. 13—Reversing switch connected in armature circuit of shunt motor. Fig. 14—Series winding cut out of compound motor to test polarity of shunt-field coils. Fig. 15—Shunt winding cut out of compound motor to test polarity of series coils.



COMPUTE H.P. OUTPUT AND EFFICIENCY. ALLOW 1½ LB. FOR THE WEIGHT OF THE LEVER ARM WHEN COMPUTING H.P. OUTPUT.

$$\text{H.P.} = \frac{2\pi \times P \times L \times \text{R.P.M.}}{33{,}000}$$

$2\pi = 6.28$

P = PULL ON LEVER IN LB.

L = LENGTH OF LEVER IN FT.

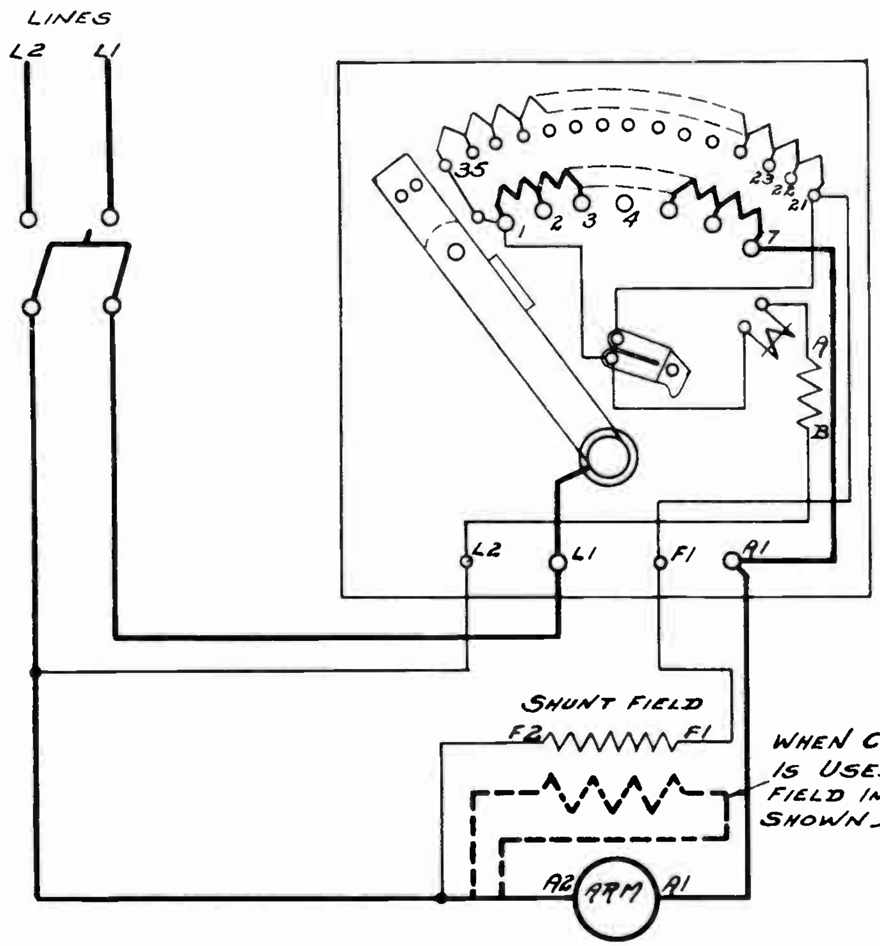
R.P.M = REVOLUTIONS PER MINUTE.

$$\text{EFFICIENCY} = \frac{\text{WATT OUTPUT}}{\text{WATT INPUT}}$$

D. C. POWER DEP'T.

ORDER NO	NO. REQ'D	DEPARTMENT	RAW MAT. SPEC. WITH PART NO. & AMOUNT REQ'D

20311D



WHEN COMPOUND MOTOR IS USED CONNECT SERIES FIELD INTO CIRCUIT AS SHOWN BY DOTTED LINES.

BULL. NO. 2230
CLASS NO. 74446
TYPE A

STANDARD ORDER NO.
CONNECTIONS FOR COMPOUND MOTOR STARTER WITH NO VOLTAGE

NAME	FINISHED PART NO.	FINISH
RELEASE FOR SHUNT OR COMPOUND MOTOR		

SUPERSEDES NO.	SUPERSEDED BY NO.	FIRST ASSEMBLY WHERE USED
T14163-D		

A				D		
B				E		
C				F		

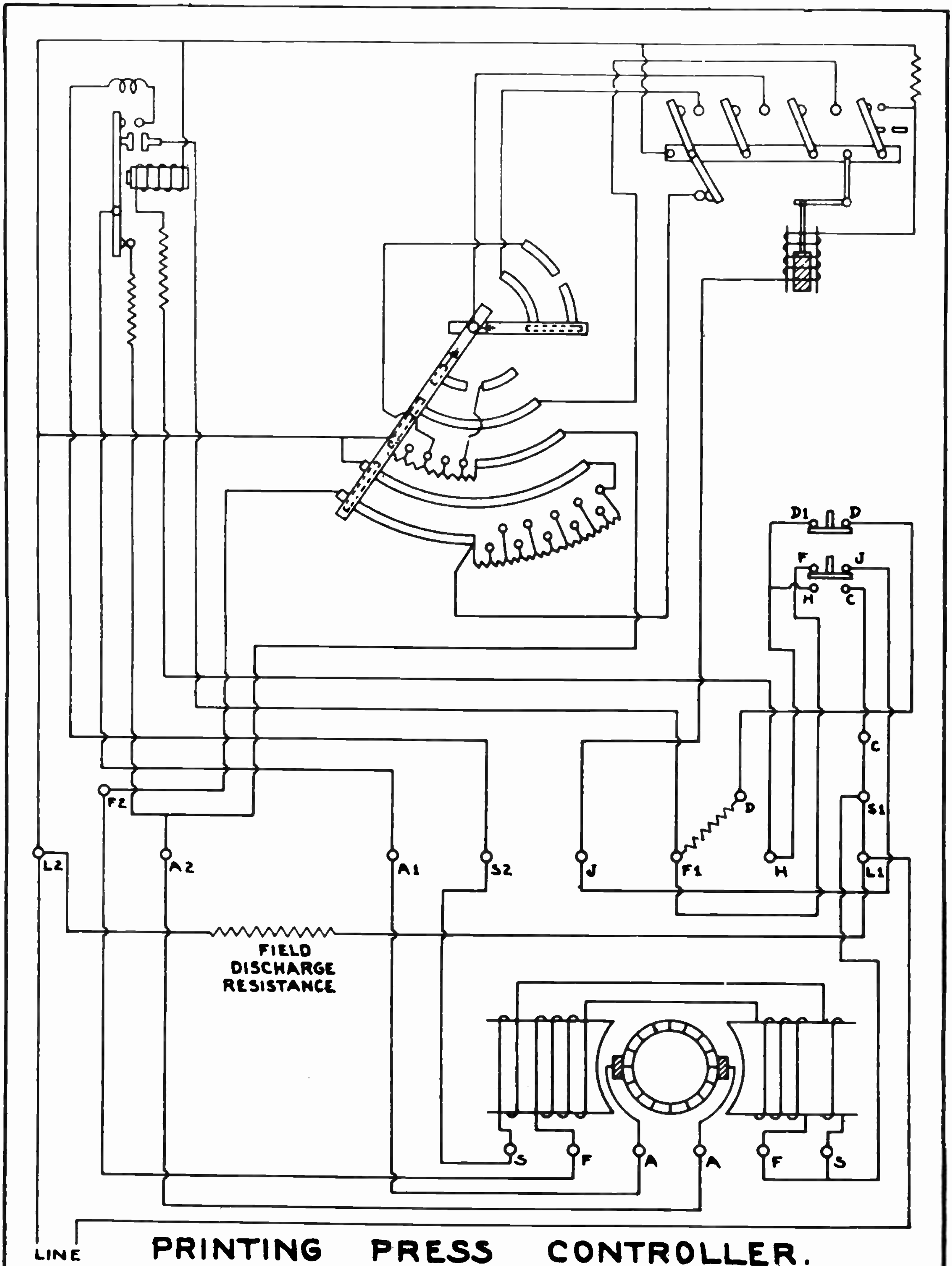
SCALE	DRAWN BY	CHECKED BY	APPROVED BY
		H.R. HUTH	H.R. HUTH

TOLERANCES ON ALL FRACTIONAL MACHINED DIMENSIONS TO BE ± .015
TOLERANCES ON ALL DECIMAL DIMENSIONS TO BE ± .005" UNLESS OTHERWISE SPECIFIED.

C-H THE CUTLER-HAMMER MFG. CO., MILWAUKEE, WIS.

20311D

FORM-357 'ORM. 35734

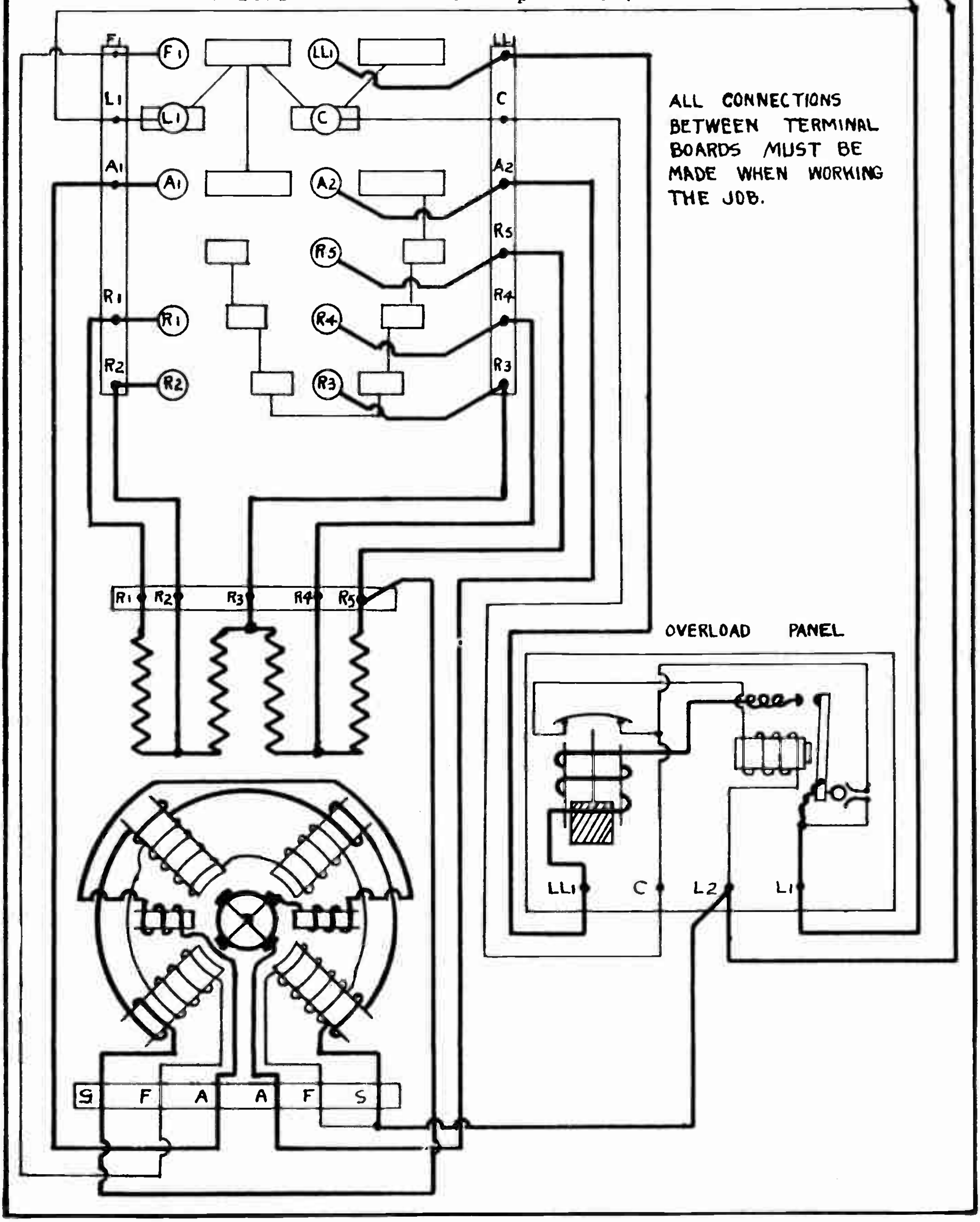


PRINTING PRESS CONTROLLER.

COYNE

DRUM CONTROLLER WITH OVERLOAD PANEL

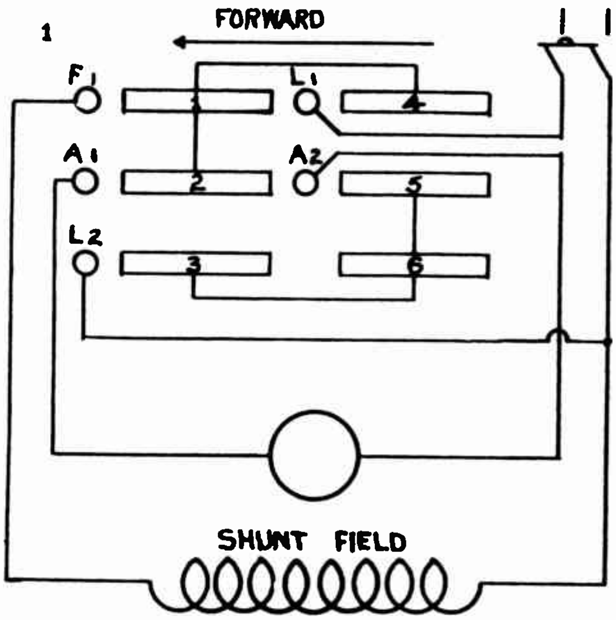
This diagram illustrates how an overload panel is used to protect the motor against overload and "no voltage" conditions, by using contacts "L1" and "C" to complete the relay circuit when the controller is in the "off" position.



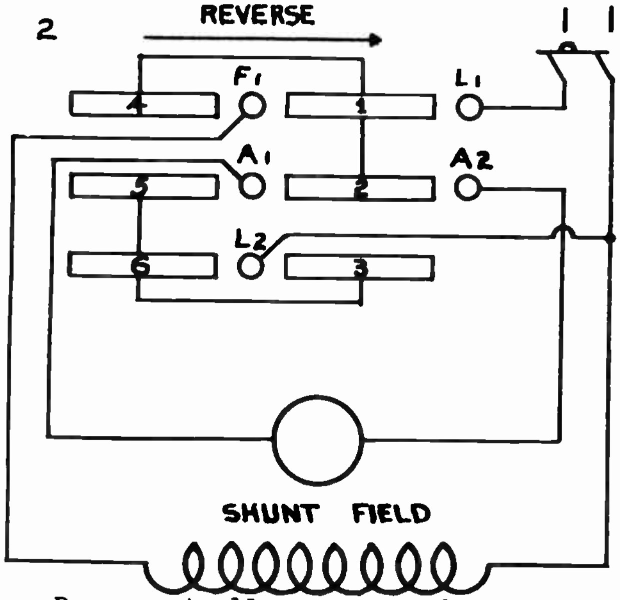
ALL CONNECTIONS BETWEEN TERMINAL BOARDS MUST BE MADE WHEN WORKING THE JOB.

DRUM CONTROLLERS

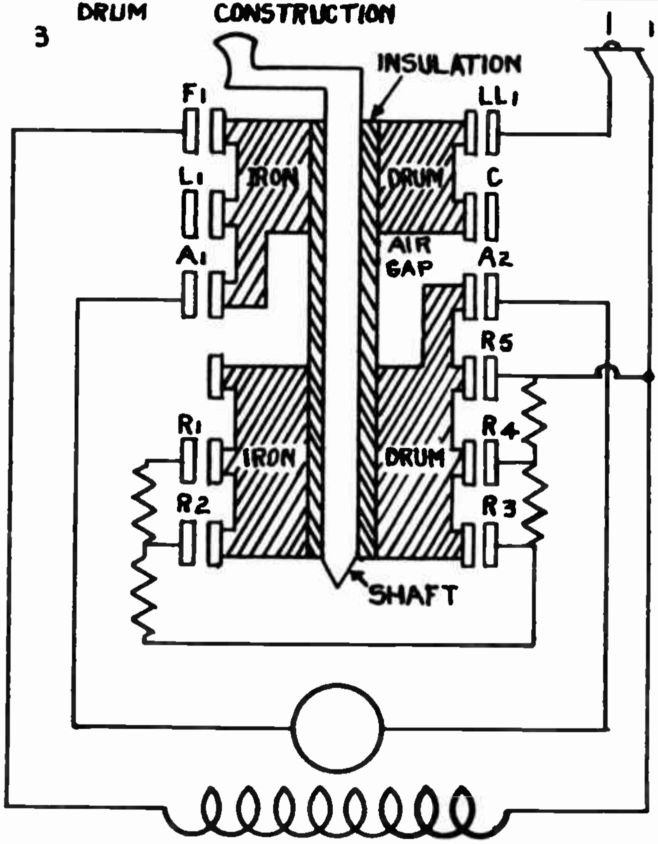
1



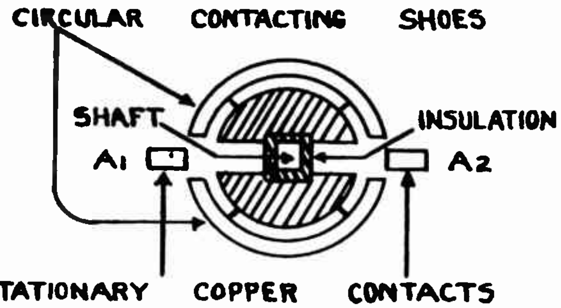
2



3



4



Drum controllers are used extensively in the operation of D.C. motors where they must be started, stopped, reversed, and have their speed varied, as on street cars, electric trains, hoists, cranes, etc.

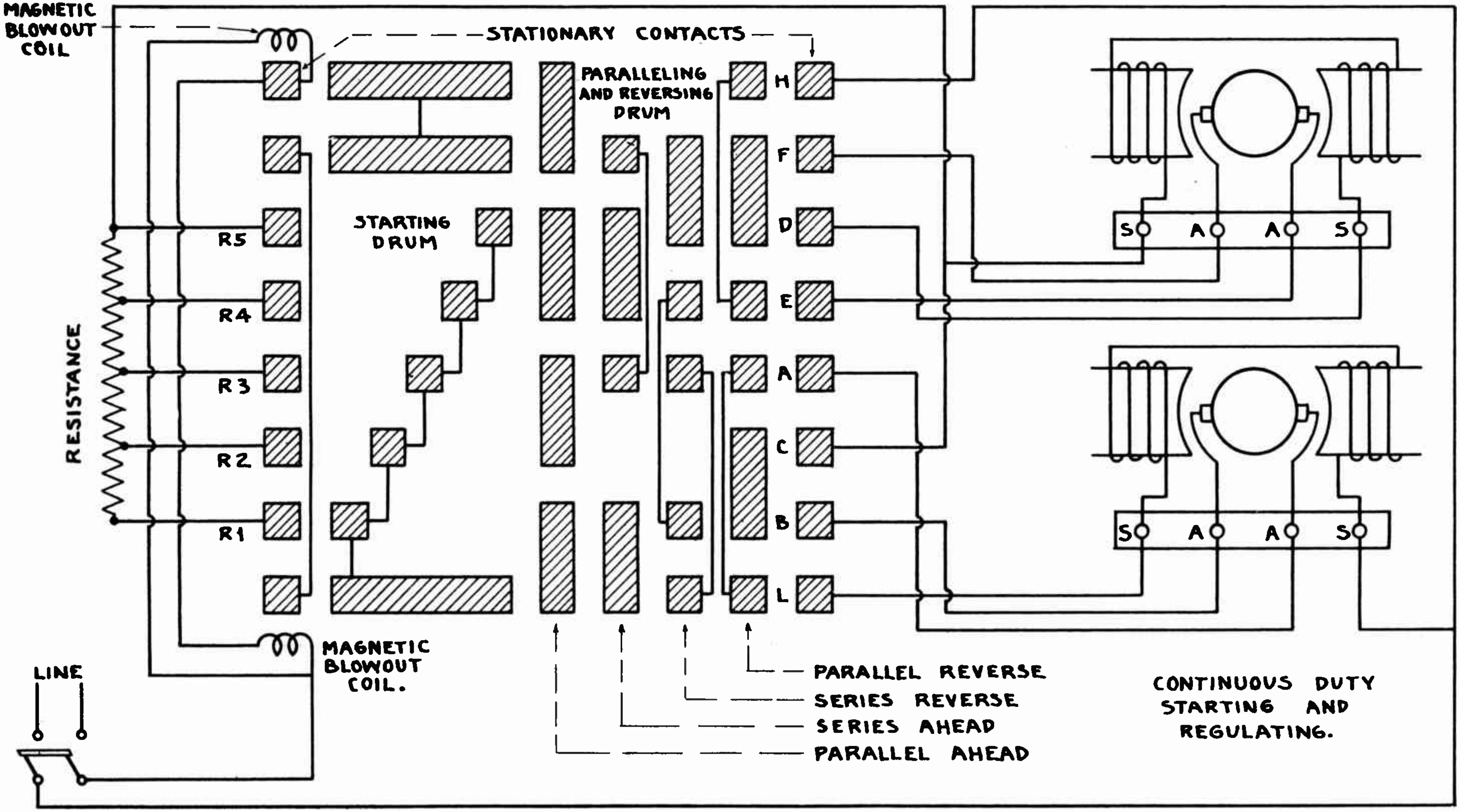
The name is derived from their shape and the manner of mounting contacts on a round iron drum. The cylindrical arrangement of the contacts allows the drum to be rotated part of a revolution in either direction, and brings into connection one or more stationary contacts with the iron drum. The iron drum serves as a mechanical support for the shoes and forms a part of the conducting path.

A drum controller, designed for reversing duty, is divided into two parts, completely insulated from each other and from the shaft by fibre insulation.

When the controller in Fig. 2 is in running position, current will flow from positive line to stationary contact "L1" (Called "contact finger") and enter the iron drum at circular shoe #1, and then flows through the iron drum to shoe #2, which is connected "A2", completing the circuit through the armature. The return circuit for the armature is from "A1" to shoe #5, through iron drum to shoe #3, which is connected to "L2".

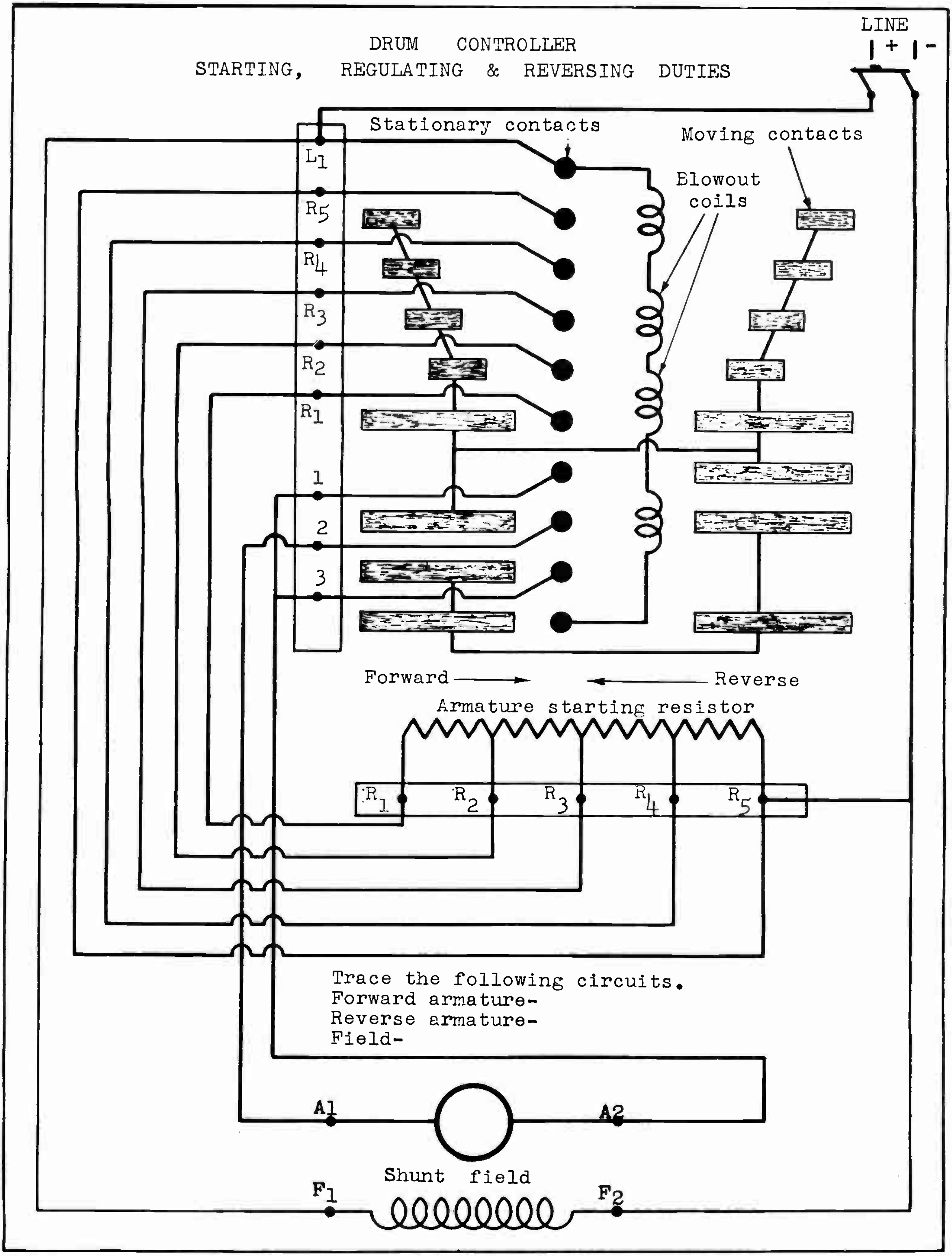
Drum controllers are very rugged and will give excellent service with a minimum of maintenance. The contact fingers and bars may be replaced when burned or worn. Drum controllers may be equipped with auxiliary contacts that close when the drum is in the "OFF" position. These contacts are used to complete a dynamic brake circuit or to operate relays for overload protection.

DRUM CONTROLLER & SERIES MOTORS.



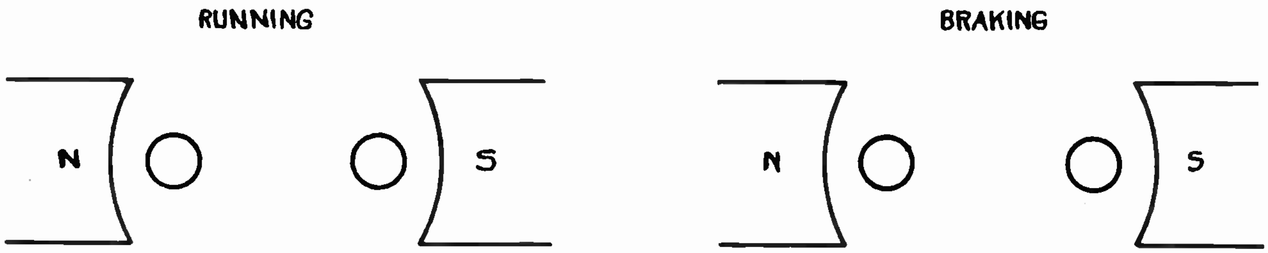
CONTINUOUS DUTY
STARTING AND
REGULATING.

DRUM CONTROLLER
STARTING, REGULATING & REVERSING DUTIES



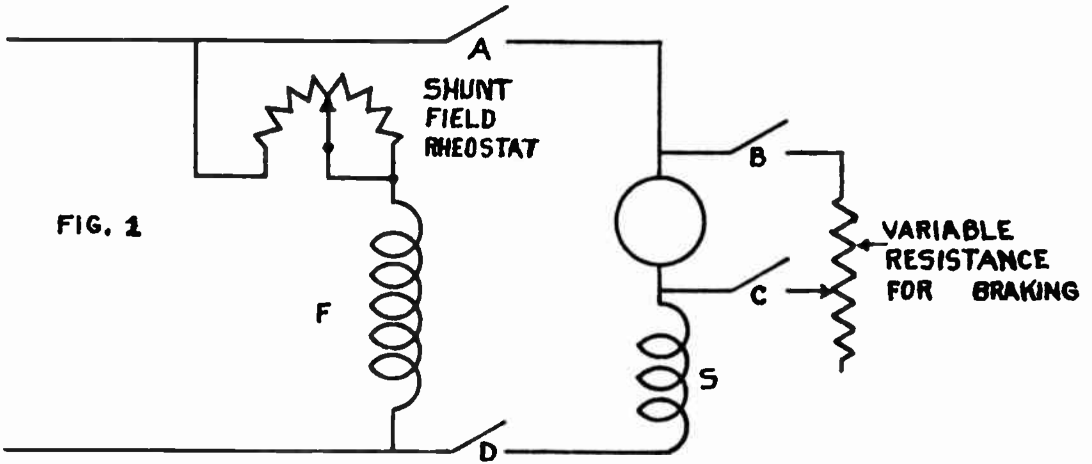
Trace the following circuits.
Forward armature-
Reverse armature-
Field-

DYNAMIC BRAKING



IN FIGURES 1, 2 & 3 SWITCHES A & D ARE CLOSED AND B & C ARE OPEN WHEN RUNNING. SWITCHES B & C ARE CLOSED AND A & D OPEN WHEN BRAKING

FIG. 1



SCHEMATIC DRAWINGS SHOWING DYNAMIC BRAKE CONNECTIONS FOR SERIES MOTORS

FIG. 2

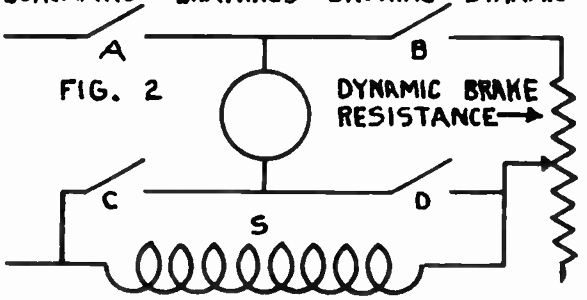
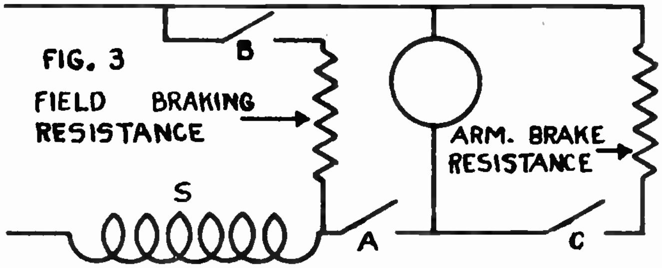


FIG. 3



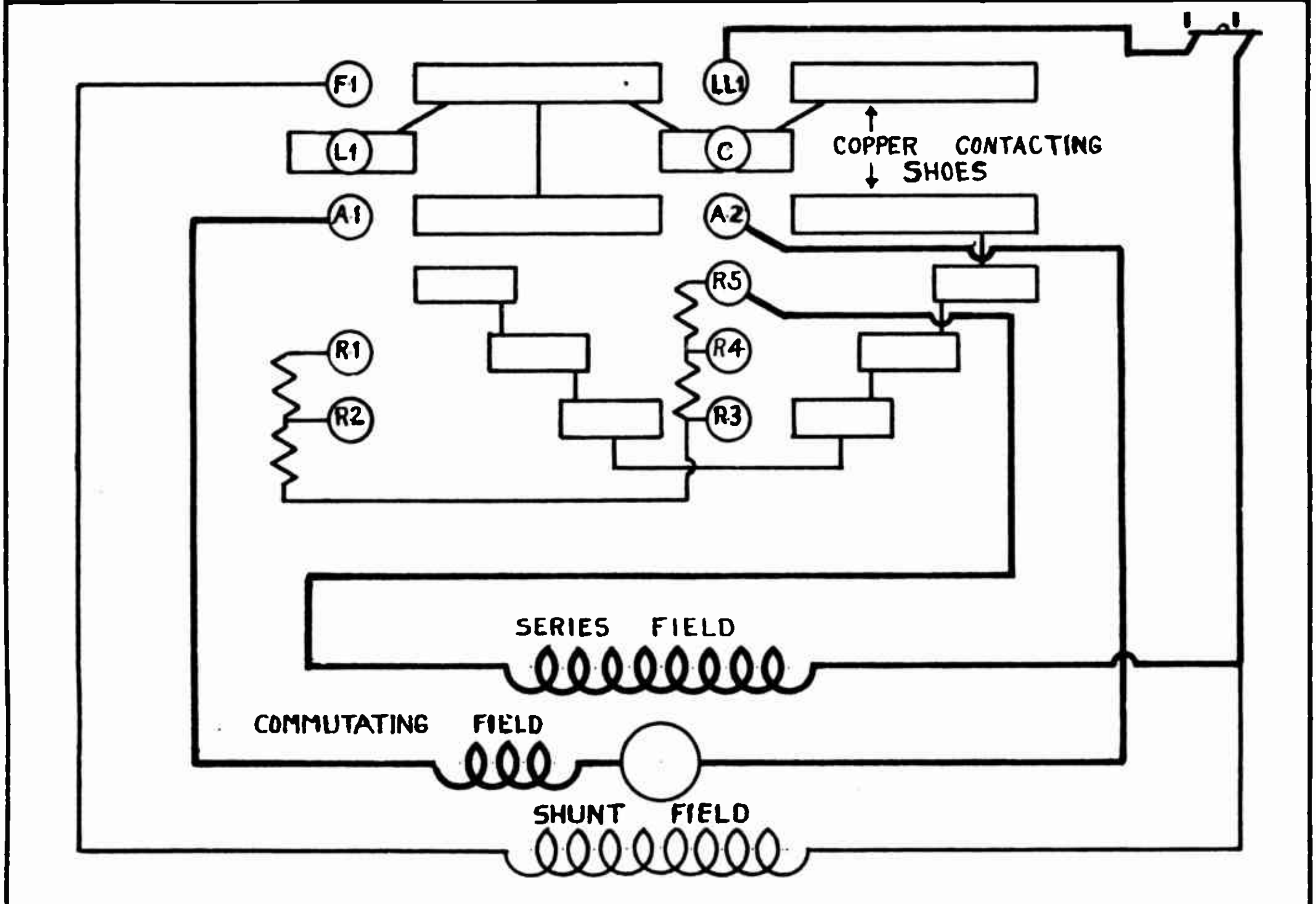
The above diagram in Fig. 1 shows the connection used in dynamic braking, using a compound motor. Fig. 2 shows similar connections for a series motor.

When the source of supply is shut off from a motor, the armature will continue to turn or coast because of its momentum. Any load connected to the motor will also continue to operate. In cases where motors must be stopped quickly, this momentum may be used to generate energy for dynamic braking.

If the shunt field of the motor is excited during the coasting period, the motor will act as a generator and the armature will generate EMF until it stops. By connecting a suitable resistance in the armature circuit, as shown above, the generated armature EMF will cause the armature current and the armature poles to reverse. The reversed armature poles, reacting with the field poles, will now tend to reverse the armature rotation and this action will result in stopping the motor and load.

This form of braking provides a quick, smooth, magnetic form of braking that has many advantages over mechanical methods.

DRUM CONTROLLER USED FOR DYNAMIC BRAKING



This diagram shows a compound motor controlled by a drum controller having auxiliary contacts for dynamic braking.

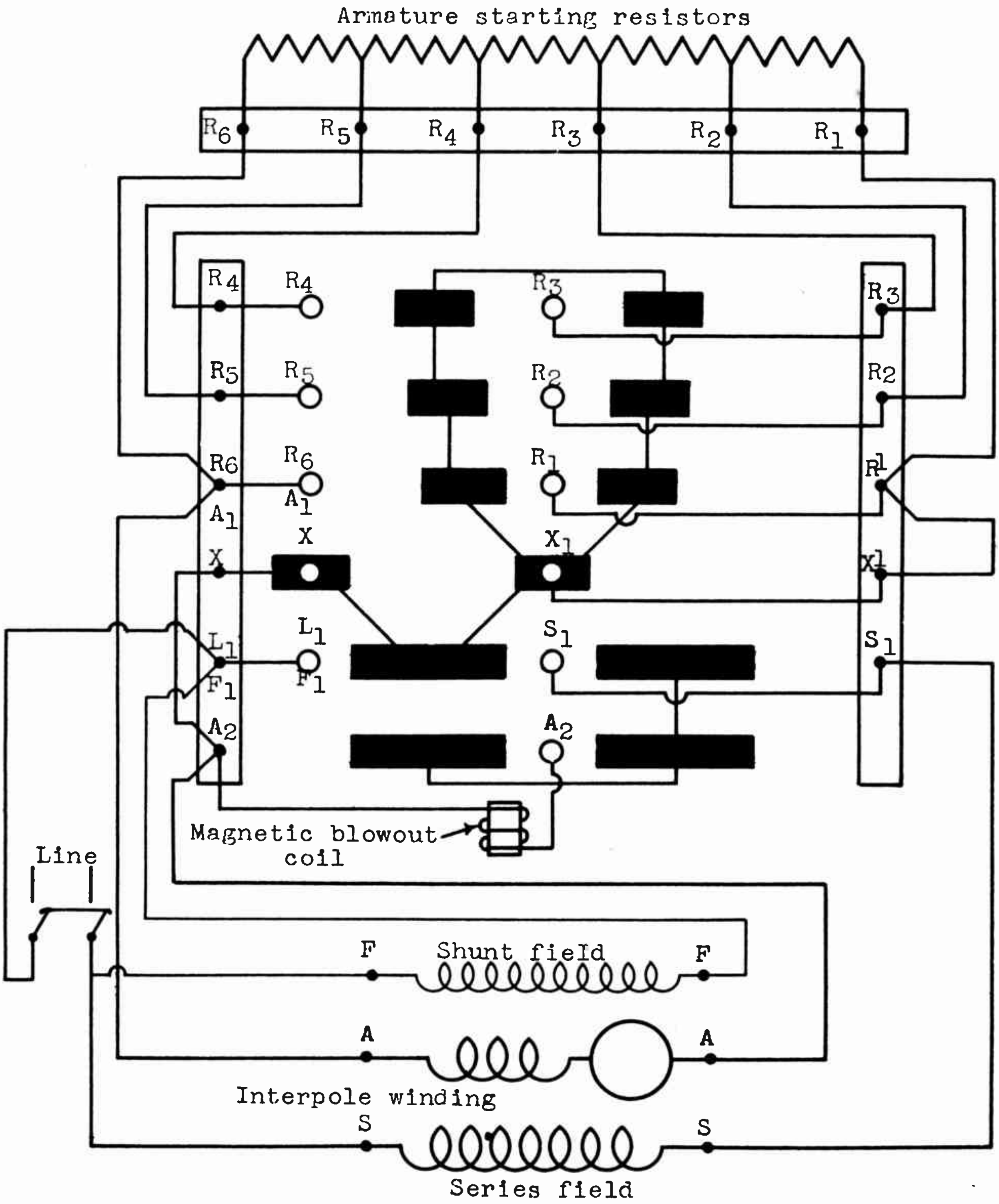
Advantages of this type of braking are: no mechanical wear, less maintenance, economical, effective and, although powerful, will not damage the motor is properly applied.

Caution must be used, when applying dynamic braking, to prevent an overload of current through the armature. This is accomplished by connecting a resistance in series with the armature braking circuit, or by decreasing the field strength to lower the CEMF generated.

Dynamic braking is known as "regenerative braking," when the current generated by the CEMF is fed back into the power line. By leaving the armature connected to the line and over-exciting the field, the CEMF becomes greater than the line voltage. This means that the motor will now act as a generator and will help to carry the line load. This method is used on electric trains which run down long grades. In some systems, as much as 35% of the power used is generated in this manner.

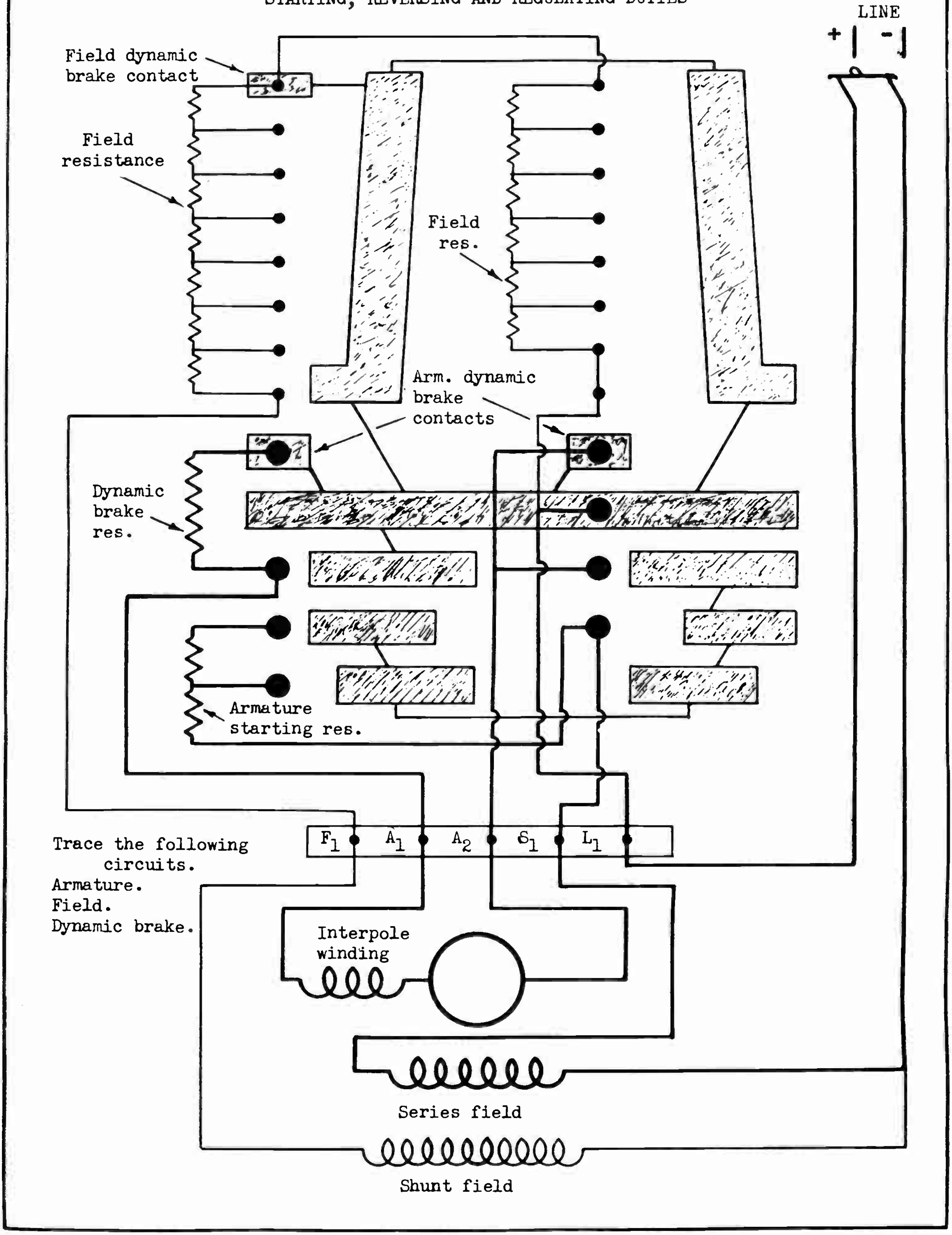
Dynamic braking, or regenerative braking, is only effective when the armature is rotating. Therefore, where it is necessary to hold a load which tends to revolve after brought to a stop, some form of magnetic or mechanical brake must be used in conjunction with dynamic braking.

DRUM CONTROLLER
STARTING, REGULATING, REVERSING AND DYNAMIC BRAKE DUTIES.



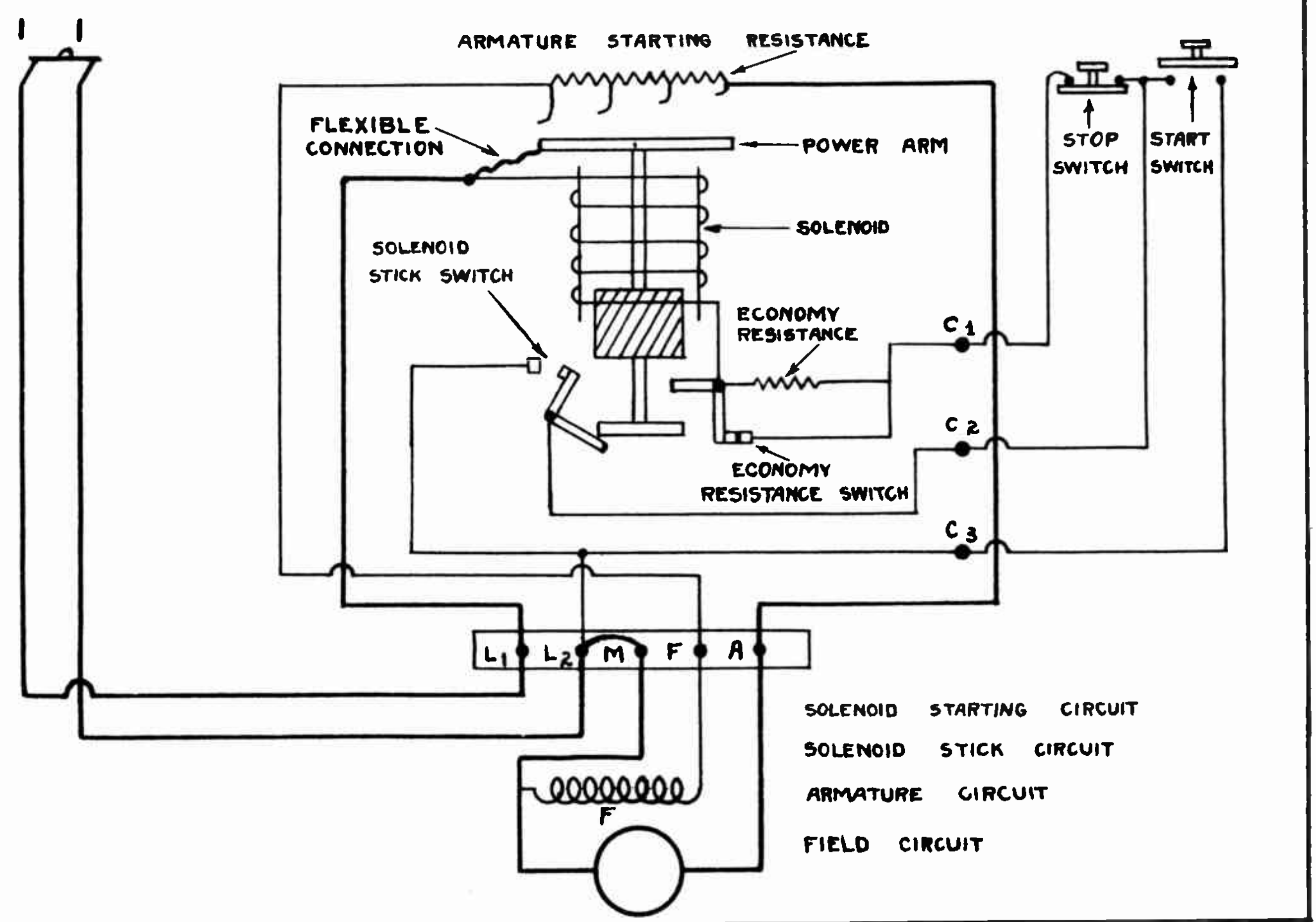
Trace armature, field and dynamic brake circuits.

STARTING, REVERSING AND REGULATING DUTIES



Trace the following circuits.
Armature.
Field.
Dynamic brake.

SOLENOID STARTER

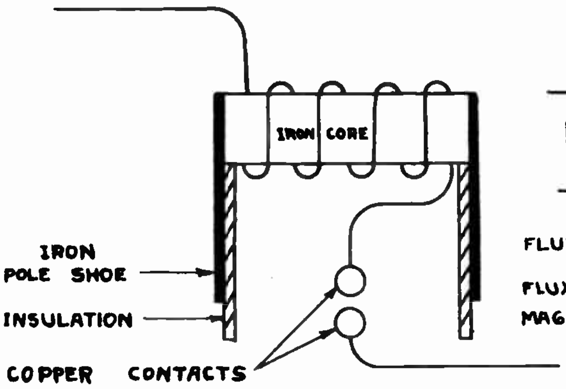


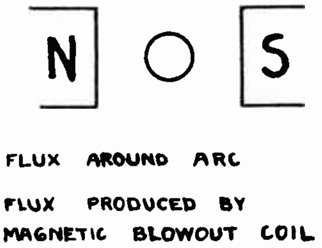
MAGNETIC BLOWOUT COIL

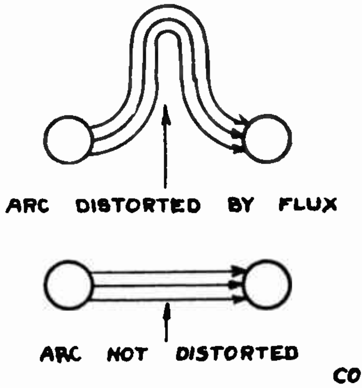
A magnetic blowout coil is for the purpose of providing a strong magnetic field to extinguish the arc drawn when the circuit is broken. It consists of a few turns of heavy wire wound on an iron core which has its poles placed on either side of the contacts where the circuit is broken. This arrangement provides a powerful magnetic field where the circuit is broken.

The arc is a conductor and has a magnetic field set up around it. This field will be reacted upon by the flux of the blowout coil distorting the arc so that it is quickly broken or extinguished. This prevents the arc from burning the contacts.

Magnetic blowout coils are connected in series with the line or in series with the contacts being protected

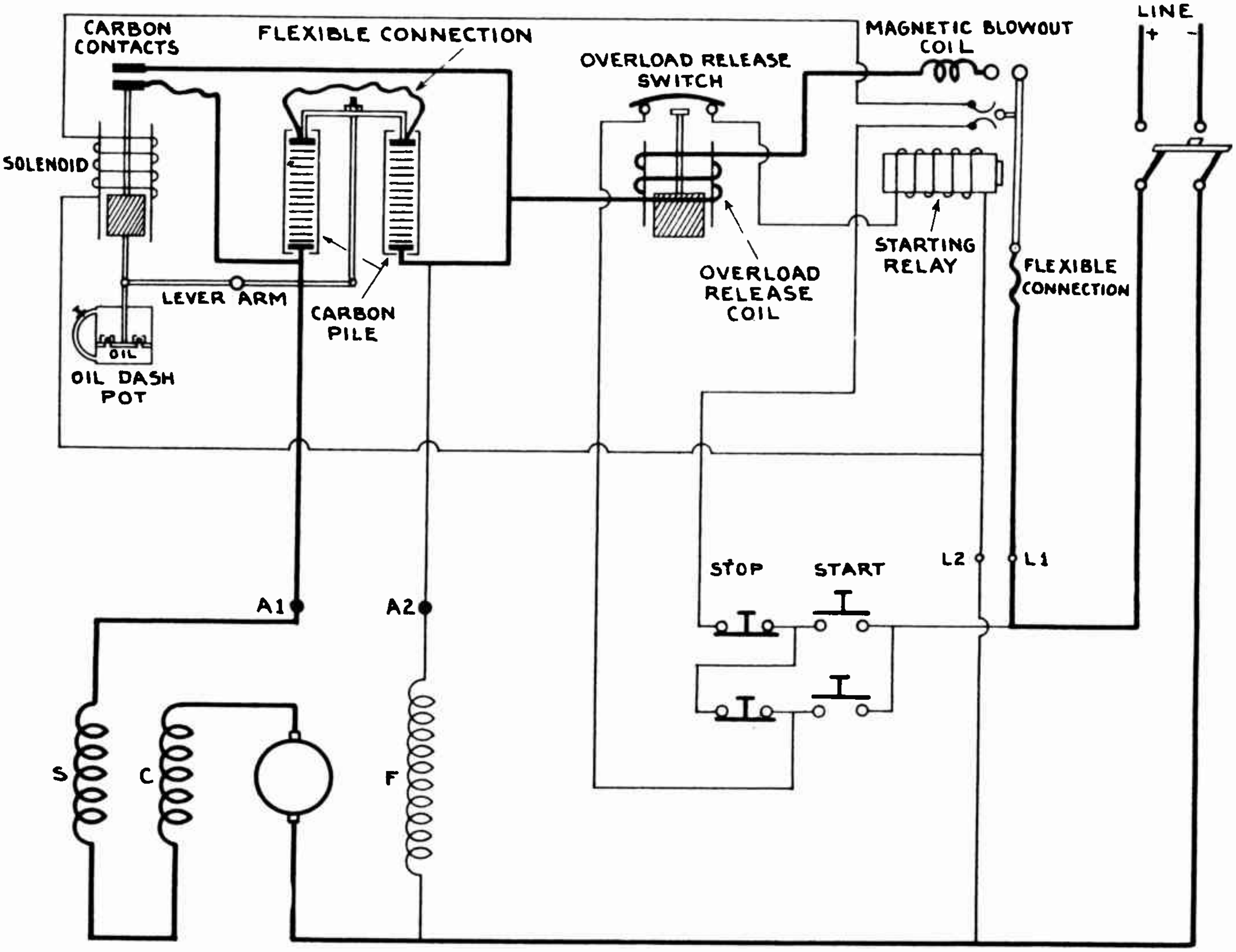






COYNE

CARBON PILE STARTER
(ALLEN - BRADLEY)



In certain classes of work it is desirable to have very gradual application of the starting torque of the motor when the machine is first put in operation. To accomplish this, it is necessary to start the motor with extremely high resistance in the armature circuit, and limit the starting current to a very low value.

For this purpose, carbon pile starters are made with resistance elements consisting of small carbon disks stacked in tubes of non-combustible material with an insulating lining.

As long as these disks are left loose in the tube, the resistance through them is very high. If pressure is applied to these carbon disks, their combined resistance will be lowered because the greatest resistance is at the contacts between disks. As pressure increases, resistance decreases allowing more current to flow.

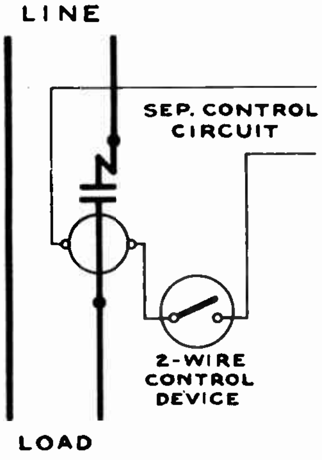
This allows the motor to start very slowly, and its speed will gradually increase until normal speed is attained.

WIRING DIAGRAMS

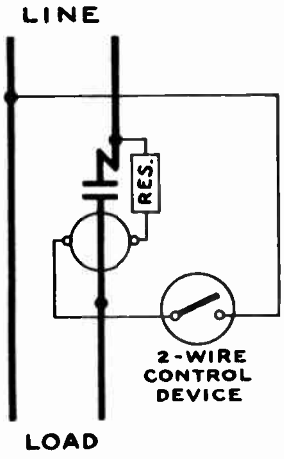
D. C. MAGNETIC RELAYS AND LINE VOLTAGE STARTERS

CLASSES 7001, 7032

Class 7001



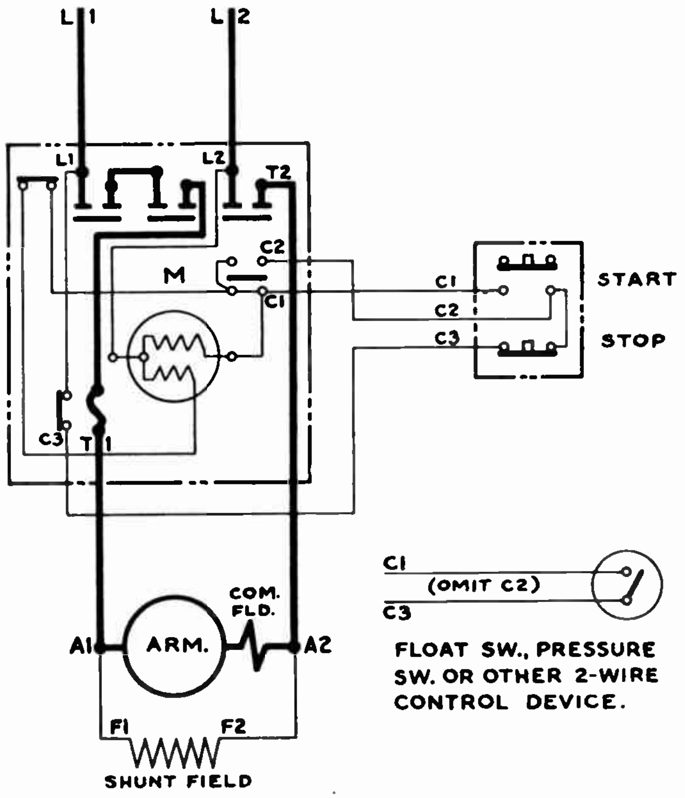
TYPE J-30



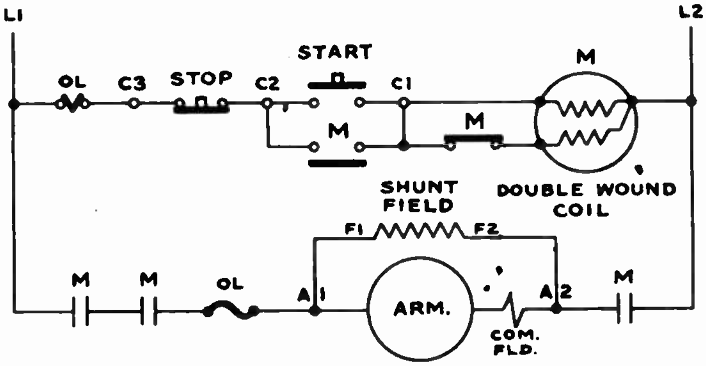
TYPE J-31

NOTE: CLASS 7001-TYPE K RELAYS ARE WIRED THE SAME AS CLASS 8501 TYPE K. SEE CLASS 8501 WIRING DIAGRAMS.

Class 7032



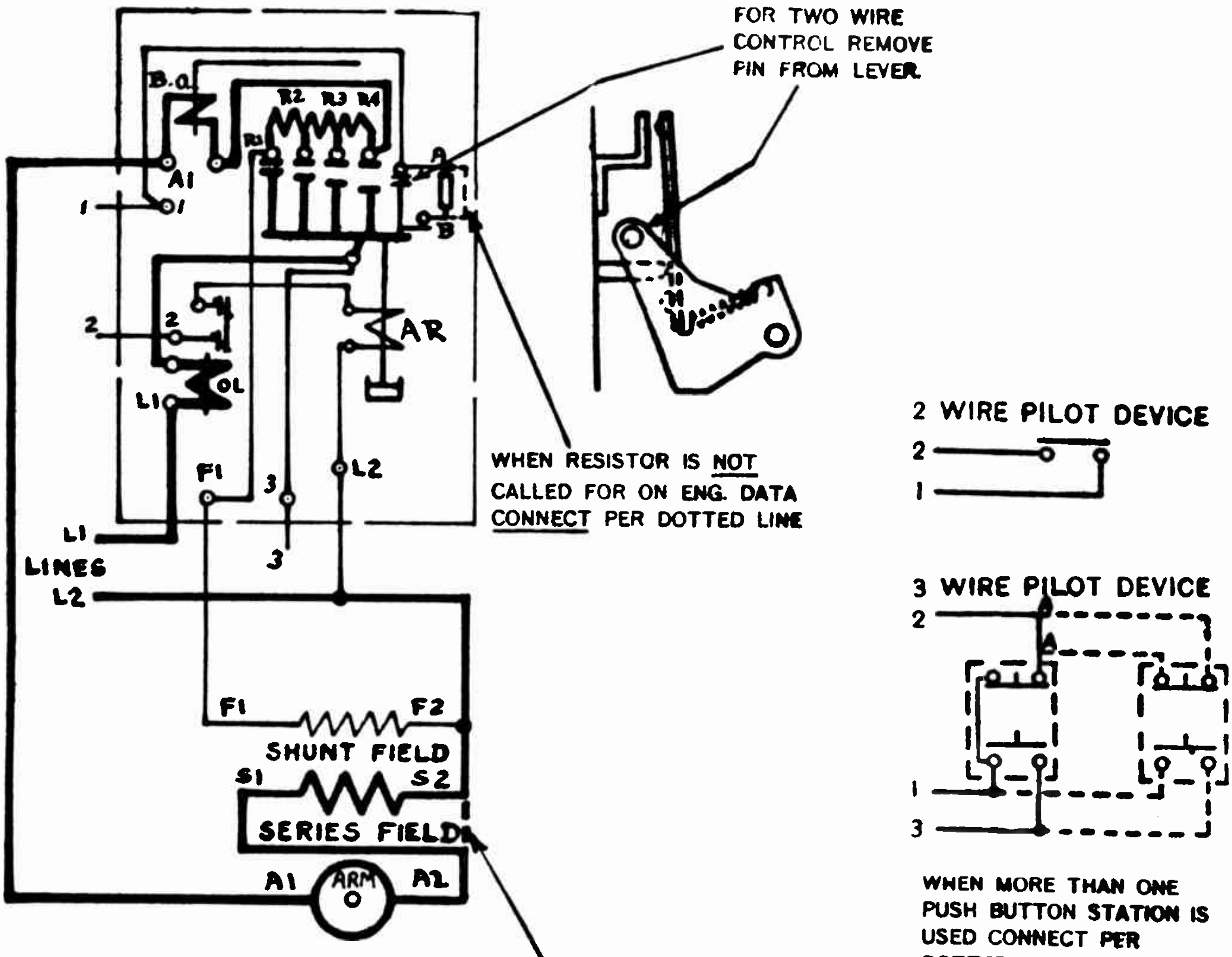
CLASS 7032 TYPE S-2
D.C. LINE VOLTAGE STARTER



ON GROUNDED SYSTEMS, L2 IS GROUNDED LINE.

FRONT VIEW DIAGRAM

WHEN AUTOMATIC RESET O.L.RELAY IS USED 2 WIRE PILOT DEVISE SHOULD NOT BE USED



FOR TWO WIRE CONTROL REMOVE PIN FROM LEVER.

WHEN RESISTOR IS NOT CALLED FOR ON ENG. DATA CONNECT PER DOTTED LINE

WHEN SERIES FIELD IS NOT USED CONNECT PER DOTTED LINE

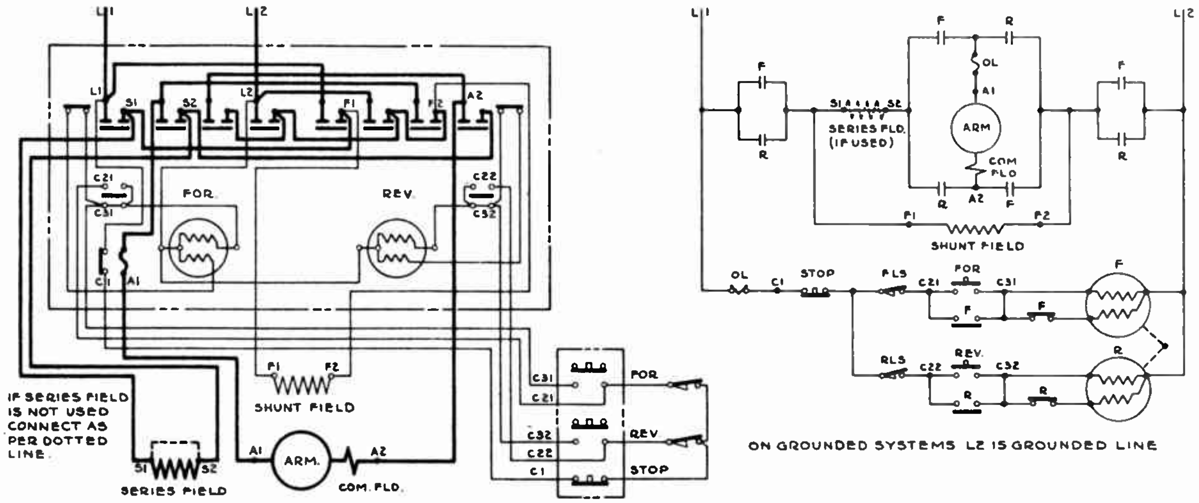
WHEN MORE THAN ONE PUSH BUTTON STATION IS USED CONNECT PER DOTTED LINES OMITTING CONNECTION "AA".

LINE DIAGRAM = 87026DI

TITLE CONNECTIONS FOR D. C. TIME LIMIT AUTOMATIC STARTER.								
DRAWN BY C. MINOR		TRACED BY N.W. LENTEN				TYPE A	SUP. NO. 50439DI	
CHECKED BY A.F. WEISS		APPROVED BY C. STANSBURY				BULL. NO. 6106	SUP. BY NO.	
A	G.M.H. R.E.M.	B	G.M.H. L.R.B.	C	R.W.C. R.S.	D	L.R.S. W.G.F.	ORDER NO. DEV. 1378-11
CUTLER-HAMMER INC. MILWAUKEE NEW YORK								39915DI

WIRING DIAGRAMS

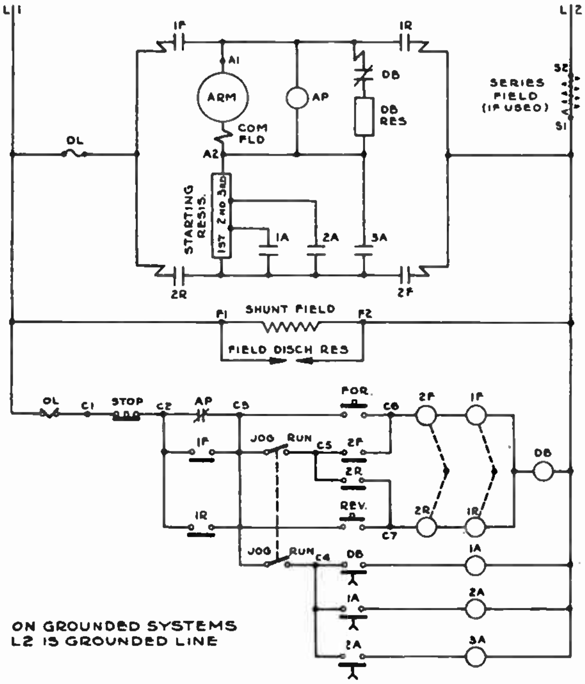
D. C. REVERSING LINE VOLTAGE STARTERS CLASS 7732



ON GROUNDED SYSTEMS L2 IS GROUNDED LINE

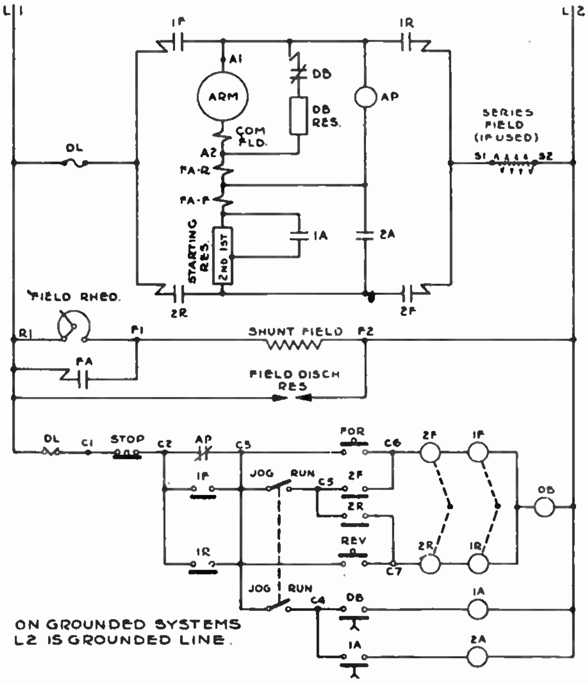
LINE DIAGRAM AND WIRING DIAGRAM FOR CLASS 7732, TYPE S-4 D.C REVERSING LINE VOLTAGE STARTER

D. C. REVERSING TIME LIMIT ACCELERATION STARTERS CLASSES 7735, 7736



ON GROUNDED SYSTEMS L2 IS GROUNDED LINE

LINE DIAGRAM FOR CLASS 7735 D.C. TIME LIMIT ACCELERATION REVERSING STARTER WITH FOUR POINTS OF ACCELERATION.

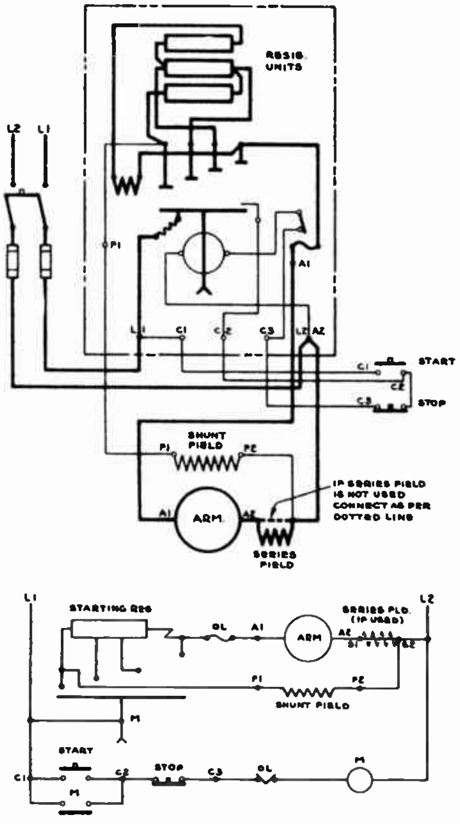


ON GROUNDED SYSTEMS L2 IS GROUNDED LINE.

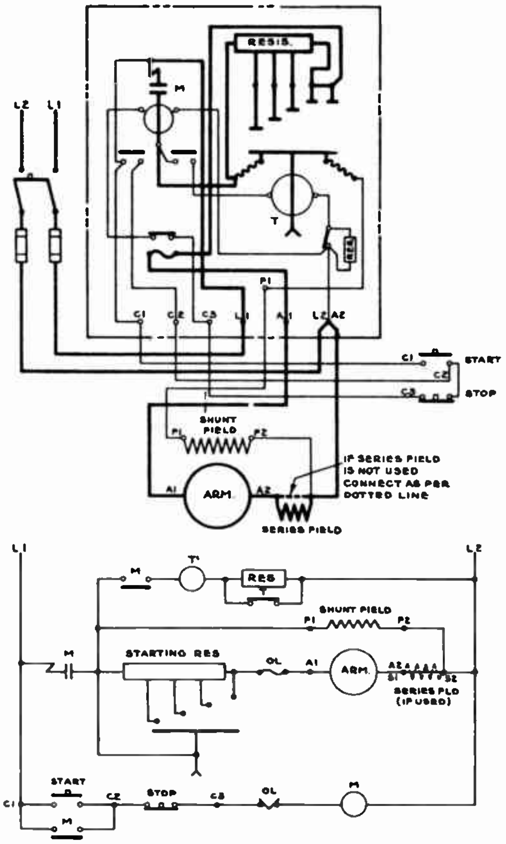
LINE DIAGRAM FOR CLASS 7736 D.C TIME LIMIT ACCELERATION REVERSING STARTER WITH THREE POINTS OF ACCELERATION.

WIRING DIAGRAMS

CLASSES 7107, 7120 — D. C. TIME LIMIT ACCELERATION STARTERS

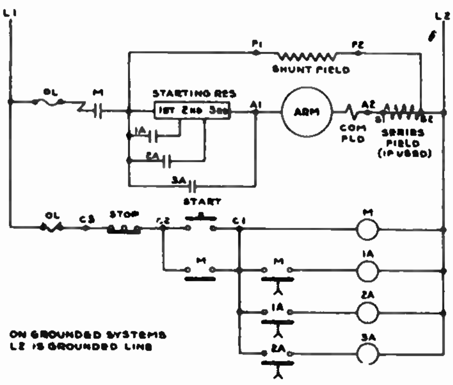


CLASS 7107 D.C. STANDARD DUTY TIME LIMIT ACCELERATION STARTER.



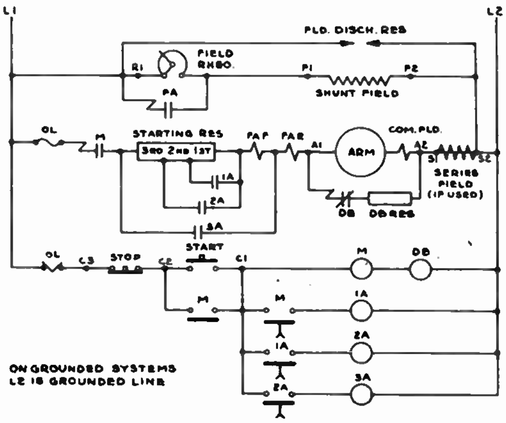
CLASS 7120, TYPE EM-2 D.C. STANDARD DUTY TIME LIMIT ACCELERATION STARTER.

CLASSES 7135, 7136 — D. C. TIME ACCELERATION STARTERS



ON GROUNDED SYSTEMS L2 IS GROUNDED LINE

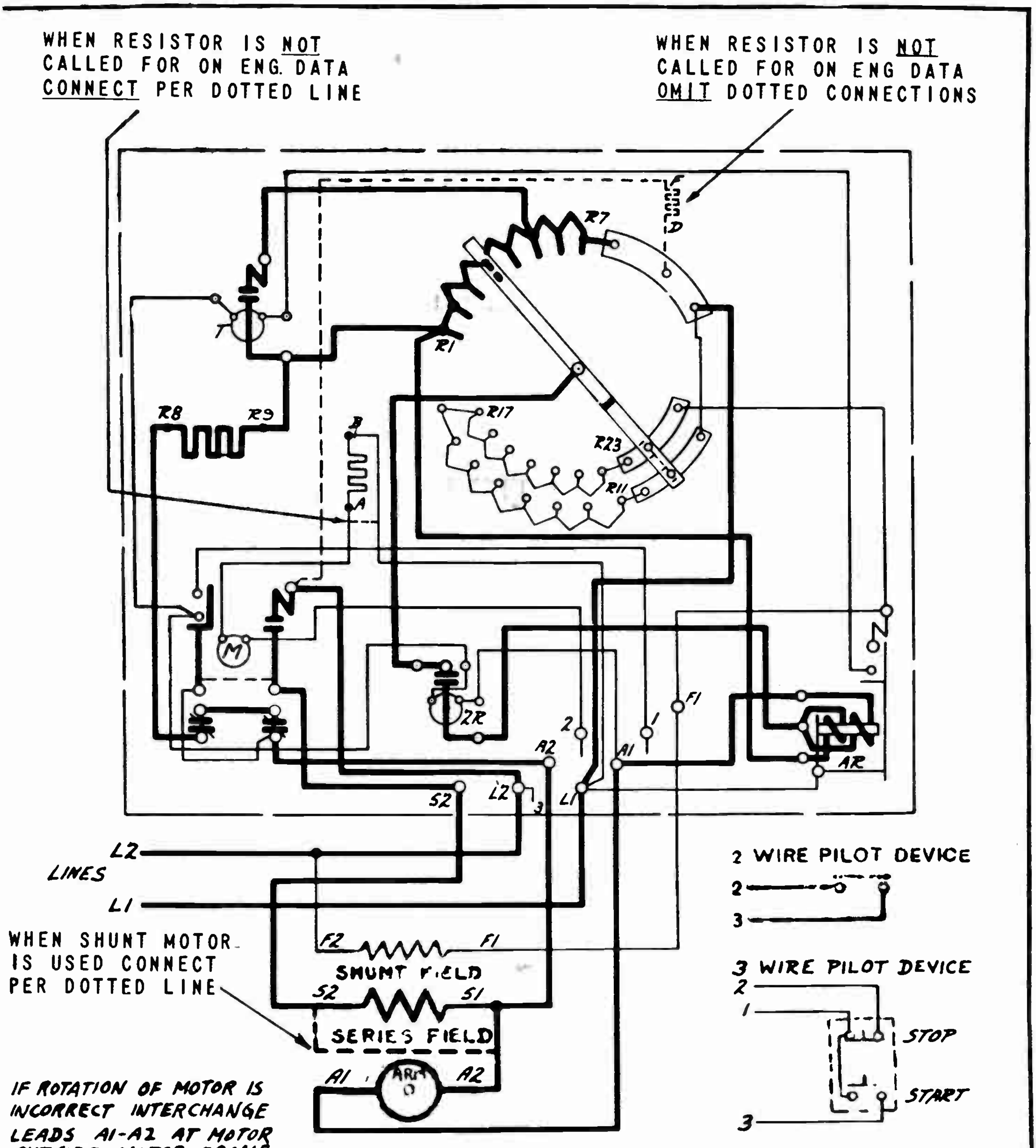
LINE DIAGRAM FOR D.C. CLASS 7135 HEAVY DUTY TIME LIMIT ACCELERATION STARTER WITH FOUR POINTS OF ACCELERATION.



ON GROUNDED SYSTEMS L2 IS GROUNDED LINE

LINE DIAGRAM FOR D.C. CLASS 7136 HEAVY DUTY TIME LIMIT ACCELERATION STARTER WITH DYNAMIC BRAKING.

1748-B14



WHEN RESISTOR IS NOT CALLED FOR ON ENG. DATA CONNECT PER DOTTED LINE

WHEN RESISTOR IS NOT CALLED FOR ON ENG DATA OMIT DOTTED CONNECTIONS

WHEN SHUNT MOTOR IS USED CONNECT PER DOTTED LINE

IF ROTATION OF MOTOR IS INCORRECT INTERCHANGE LEADS A1-A2 AT MOTOR OUTSIDE MOTOR FRAME

LINE DIAGRAM-70575D1

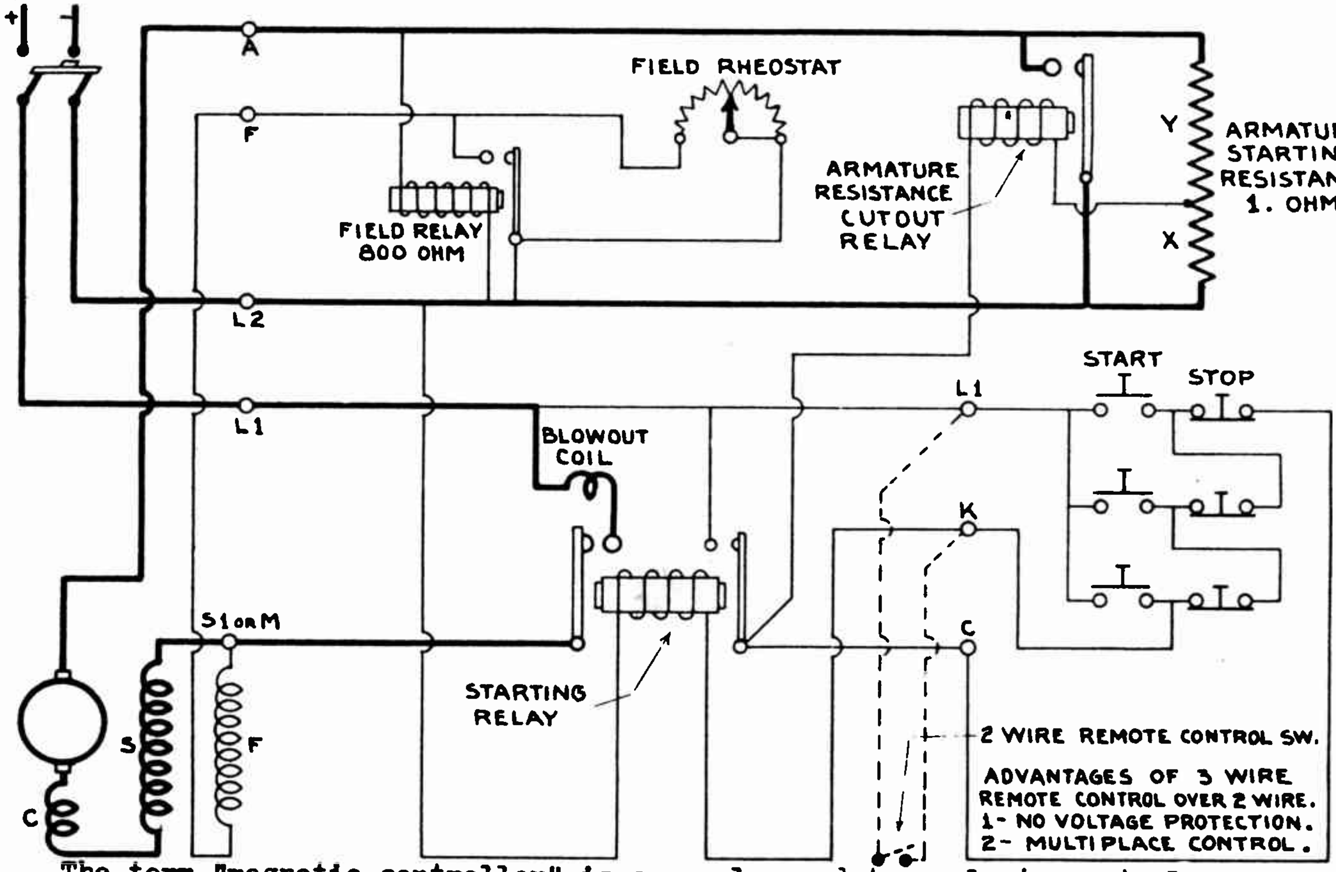
TITLE CONNECTIONS FOR D.C. SPEED REGULATOR.

DRAWN BY McMueller
TRACED BY McMuelly
TYPE
SUP NO
CHECKED BY Hildhausen
APPROVED BY
BULL. NO.
SUP BY NO.
A
B
C
D
ORDER NO A696719

CUTLER-HAMMER, INC. MILWAUKEE NEW YORK

70577D1

MAGNETIC CONTROLLER



ADVANTAGES OF 3 WIRE
REMOTE CONTROL OVER 2 WIRE.
1- NO VOLTAGE PROTECTION.
2- MULTIPLACE CONTROL.

The term "magnetic controller" is commonly used to apply to controllers on which the operation depends almost entirely on relays. Controllers of this type have a number of separate circuits, each operated by a relay switch.

These controllers are used extensively on large industrial motors, steel mill motors, and elevator motors. They can be designed to give any desired operation.

Example: Let us assume we start a 110E, 40I, 5 h.p. motor without a load.

Starting current equals $1\frac{1}{2}$ x 40I or 60I.

Armature starting resistance equals 1 ohm.

Voltage drop across arm. starting res. equals 60I x 1R=60Ed.

Voltage drop across section of res. marked "X" equals 1/3 of Ed across entire res. or 20Ed.

Therefore, the voltage applied to the armature resistance cut-out relay when starting, equals 110E —20Ed or 90 volts. This relay is adjusted so that it will not close its switch until it receives approximately full line voltage. The voltage across the relay increases as the current through "Y" + "X" decreases. Current flow will decrease to approximately 6I, because of C.E.M.F. built up in the motor as it increases in speed. This may be proven by the following figures:

Total voltage drop across "Y" + "X" after motor attains normal speed equals 6I x 1R=6Ed.

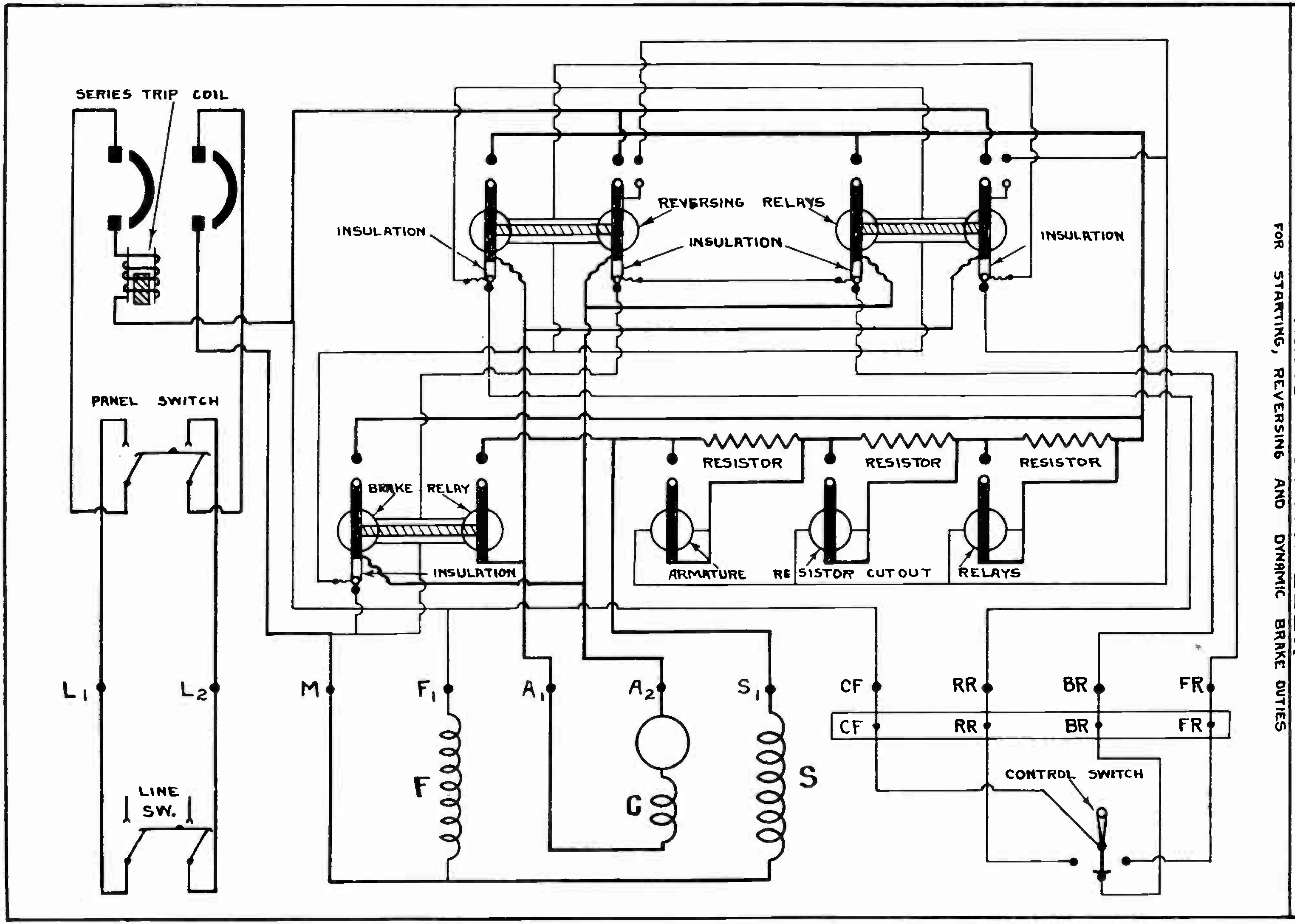
Now the voltage drop across "X" will be 1/3 of 6 or 2Ed, leaving 110 minus 2 or 108E to operate the armature res. cut-out relay. This voltage is high enough to operate the relay and close its switch, which cuts out or shunts the armature starting resistance.

The field relay closes when starting to give full strength field. When the armature res. cut-out relay closes, the field relay is shorted out of the circuit. This allows the speed to be controlled above normal by adjusting the shunt field rheostat.

COYNE

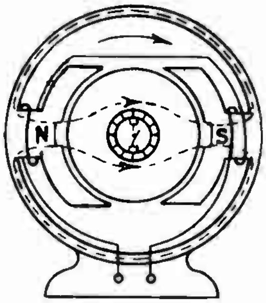
MAGNETIC CONTROLLER

FOR STARTING, REVERSING AND DYNAMIC BRAKE DUTIES



AMPLIDYNE GENERATORS.

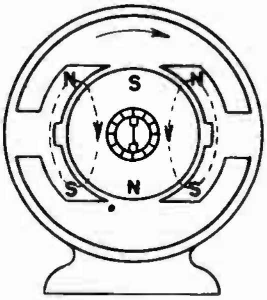
If a D.C. generator designed as shown and operated with a very weak field be driven at constant speed, the main brushes may be short circuited as indicated. This action results in relatively heavy currents in the armature that in turn produce an intense armature cross field with the polarities shown and, if the poles are especially designed to provide a magnetic circuit of low reluctance to this cross field, a strong magnetic field will be developed in the air gap. The armature, rotating in this field, produces a relatively high voltage at right angles to the normal brush axis and if extra brushes are placed as shown, power almost equivalent to the normal rating of the machine may be obtained.



A

SIGNAL FIELD.

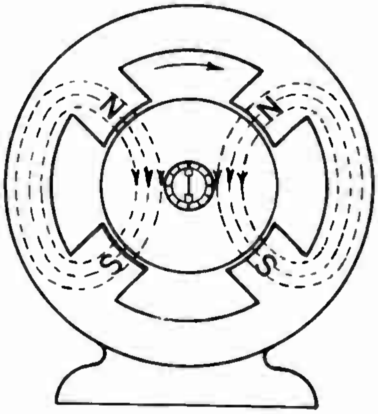
As the operating point for the field magnetism is set on the steep part of the magnetization curve, a small variation in the magnetizing force produced by the field coils will produce a relatively great change in the short circuit current produced by the armature, and this in turn will greatly increase the generated output voltage. Therefore, if special control coils be placed on the poles, and if these coils be fed from a low voltage or low power source, the variations which these coils produce may be caused to reappear in the output circuit in a greatly amplified form. This is the principle of operation of the Amplidyne Generator.



B

CROSS FIELD.

The Amplidyne Generator may be regarded as a two stage electrical power amplifier, and its use is concerned with control situations in which small controlling impulses are employed to handle equipment that demands a large amount of power to operate it. The small control power is fed to the field coils where it effects a relatively high variation in field magnetism; this variation is amplified in the cross field and again in the output circuit. Amplifications of 20,000 to 1 are common and 100,000 to 1 are possible. Thus a variation of one watt in the input control circuit may produce a change in generator output of 20 kilowatts, a range impractical for any electronic amplifier. The range may be extended by the use of a preamplifier using ordinary radio tubes.

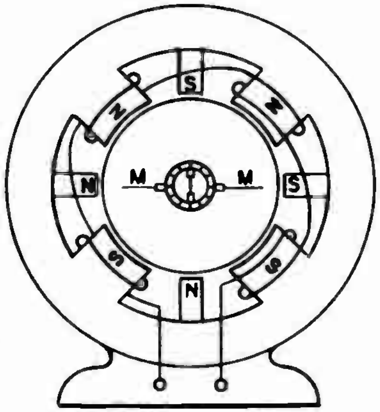


C

SPLIT POLE DESIGN SHOWING CROSS FIELD.

Instead of the split-pole construction shown above, the arrangement indicated in fig. C shows the constructional features of a modern amplidyne unit. Although four poles are shown, adjacent groups are wound with the same polarity, and the machine is therefore a two pole unit.

Figure D shows the construction of an Amplidyne unit using interpoles. Although several field windings are employed in an actual machine, only the signal winding is shown. The brushes M are the output brushes from which the amplified energy is obtained.

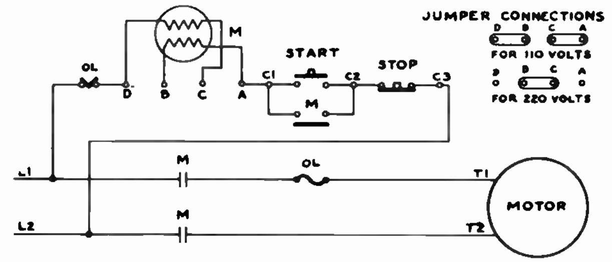


D

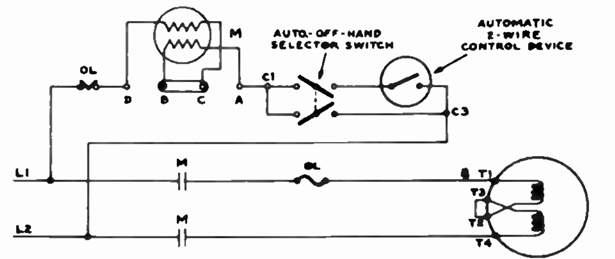
SIGNAL FIELD WINDING.

WIRING DIAGRAMS

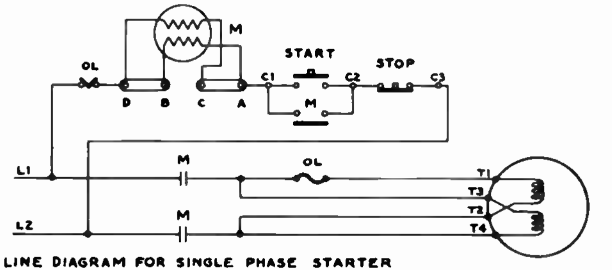
A. C. LINE VOLTAGE MAGNETIC STARTERS—SINGLE PHASE CLASS 8536



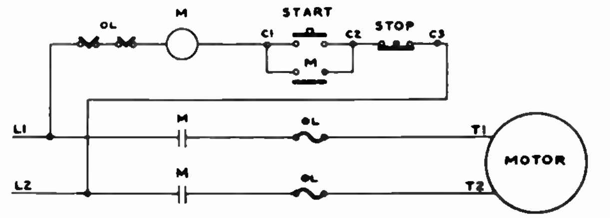
LINE DIAGRAM FOR SINGLE PHASE STARTER USED WITH SINGLE VOLTAGE MOTOR



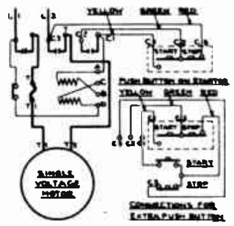
LINE DIAGRAM FOR SINGLE PHASE STARTER WITH SELECTOR SWITCH USED WITH DUAL VOLTAGE MOTOR CONNECTED FOR 220 VOLTS



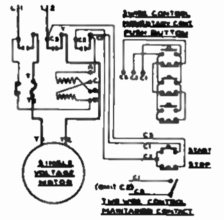
LINE DIAGRAM FOR SINGLE PHASE STARTER USED WITH DUAL VOLTAGE MOTOR CONNECTED FOR 110 VOLTS



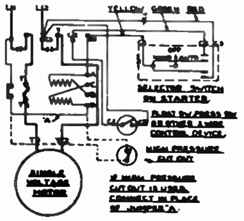
LINE DIAGRAM FOR SIZE II OR III THREE POLE STARTER USED ON SINGLE PHASE



TYPE R-8A

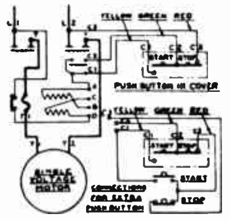


TYPE R-8B

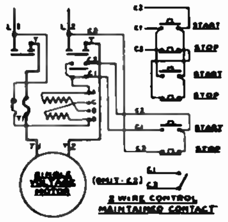


TYPE R-8C

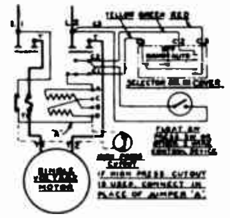
WIRING DIAGRAMS FOR SIZE O, SINGLE PHASE STARTERS USED WITH A SINGLE VOLTAGE MOTOR. SEE RIGHT HAND COLUMN FOR COIL JUMPER POSITIONS AND CONNECTIONS FOR DUAL VOLTAGE MOTORS.



TYPE S-14A

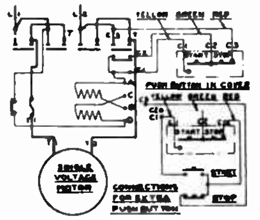


TYPE S-14B

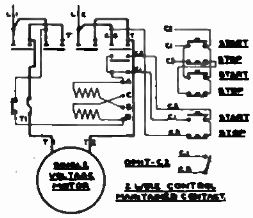


TYPE S-14C

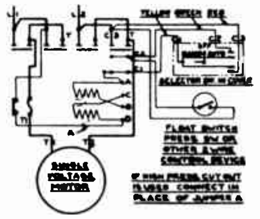
WIRING DIAGRAMS FOR SIZE I, SINGLE PHASE STARTERS USED WITH A SINGLE VOLTAGE MOTOR. SEE RIGHT HAND COLUMN FOR COIL JUMPER POSITIONS AND CONNECTIONS FOR DUAL VOLTAGE MOTORS.



TYPE S-16A



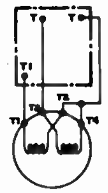
TYPE S-16B



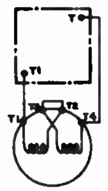
TYPE S-16C

WIRING DIAGRAMS FOR SIZE 1½, SINGLE PHASE STARTERS USED WITH A SINGLE VOLTAGE MOTOR. SEE RIGHT HAND COLUMN FOR COIL JUMPER POSITIONS AND CONNECTIONS FOR DUAL VOLTAGE MOTORS.

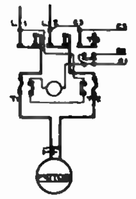
WIRING DIAGRAM FOR SINGLE PHASE STARTER USED WITH DUAL VOLTAGE MOTOR CONNECTED FOR 110 VOLTS.



WIRING DIAGRAM FOR SINGLE PHASE STARTER USED WITH DUAL VOLTAGE MOTOR CONNECTED FOR 220 VOLTS.

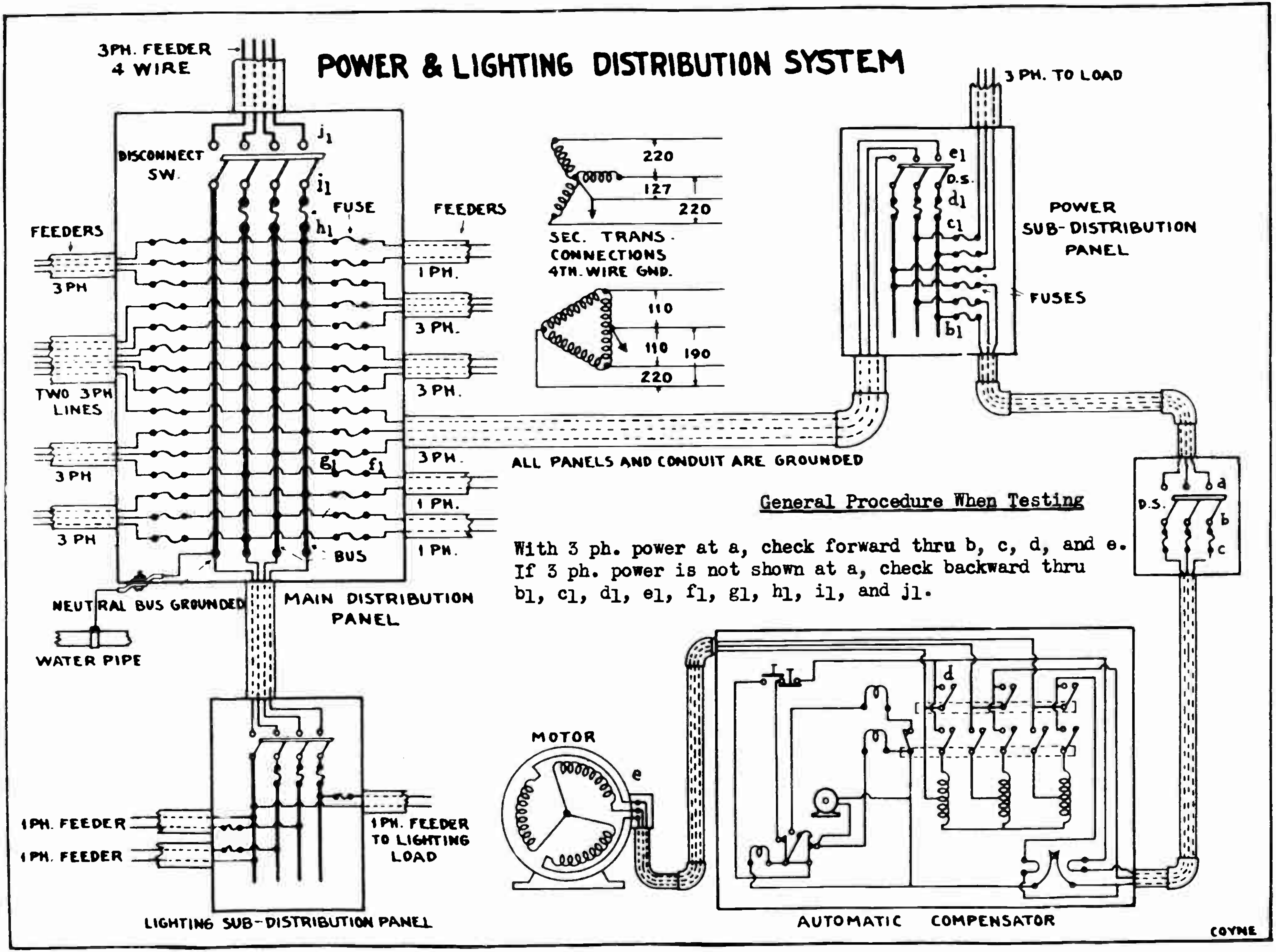


JUMPER CONNECTIONS FOR SIZES 0, I, AND I½ SINGLE PHASE STARTERS



WIRING DIAGRAM FOR SIZE II OR III THREE POLE STARTER USED ON SINGLE PHASE

POWER & LIGHTING DISTRIBUTION SYSTEM



General Procedure When Testing

With 3 ph. power at a, check forward thru b, c, d, and e. If 3 ph. power is not shown at a, check backward thru b1, c1, d1, e1, f1, g1, h1, i1, and j1.

HOW THE NEUTRALIZER QUENCHES A FAULT

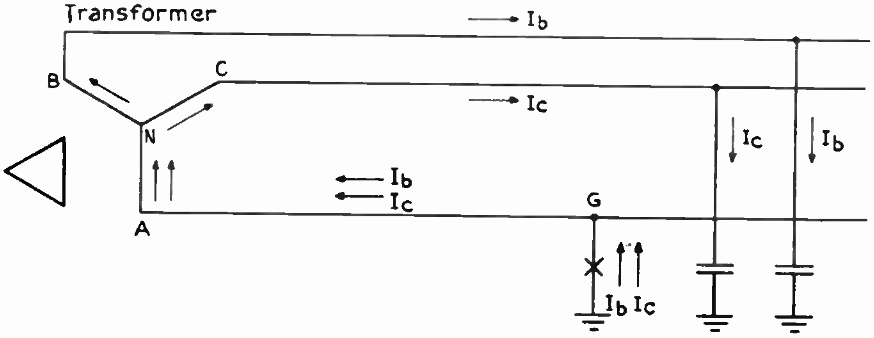


Fig. 2. Ground-fault currents, isolated-neutral system

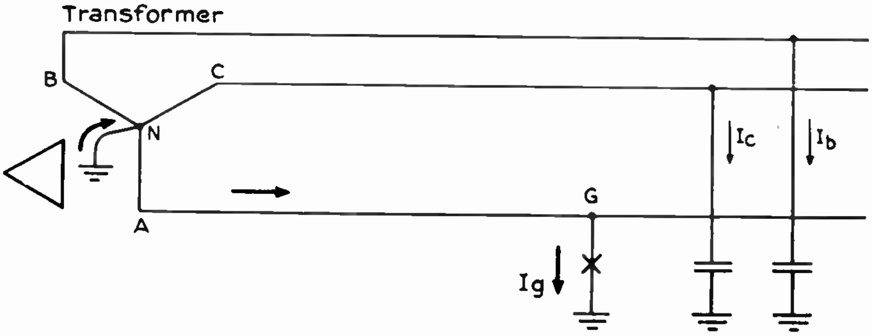


Fig. 3. Ground-fault currents, solidly grounded neutral system

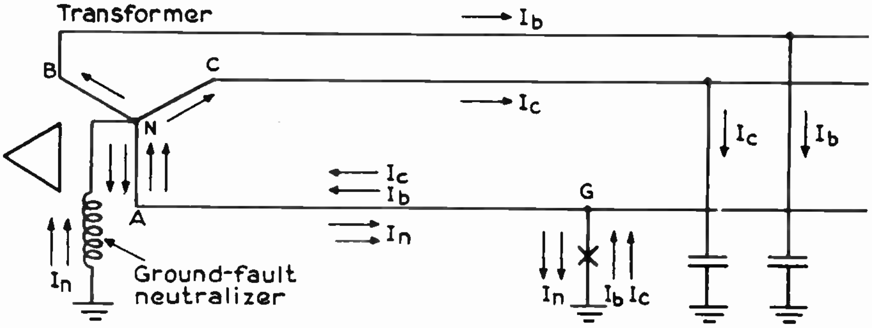


Fig. 4. Ground-fault currents, with neutralizer

● **When the System Neutral Is Isolated,** the current in a line-to-ground fault consists solely of charging current through the line-to-ground capacitances of the other two line conductors (Fig. 2). However, operating experience shows that such disturbances frequently result in transient overvoltages sufficient to cause a second flashover on one of the unfaulted phases, thus causing a short circuit and an interruption to service. Relaying is difficult because the second fault usually occurs at a point remote from the first—frequently in terminal apparatus—necessitating expensive repairs.

● **When the System Neutral Is Solidly Grounded,** a line-to-ground fault short-circuits the faulted phase, causing current to flow through the fault, as shown in Fig. 3. This short-circuit current, I_g, is lagging, and is usually so much greater than the charging current of the unfaulted lines (I_b and I_c) that the effect of the latter is negligible. The fault persists until the circuit-breaker is tripped. This means a service interruption.

● **When the System Neutral Is Grounded through a Ground-fault Neutralizer,** transitory arcs to ground are extinguished without an outage, without even a momentary interruption of service, and without the aid of any moving parts. The line-to-ground fault causes line-to-neutral voltage to be impressed across the neutralizer, which then passes an inductive current, I_n, 180 degrees out of phase and approximately equal in magnitude to the resultant of the system-charging currents from the two unfaulted phases, I_b and I_c (Fig. 4).

These inductive and capacitive currents neutralize each other, and the only remaining current in the fault is due, mainly, to corona, insulator leakage, etc. This current is relatively small, and, as it is in phase with the line-to-neutral voltage, the current and voltage reach a zero value simultaneously, hence, the arc is extinguished without restriking. In this way, flashovers are quenched without removing the faulted line section from service.

Squirrel-Cage Motors

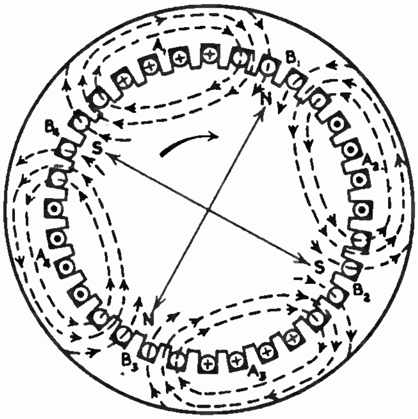


FIG. 4

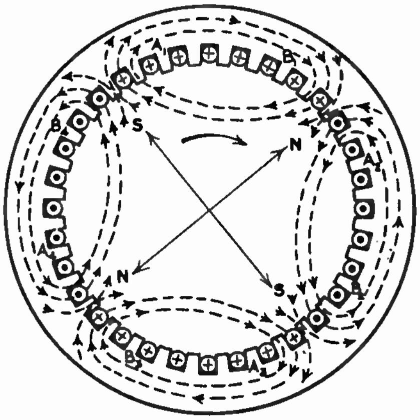


FIG. 5

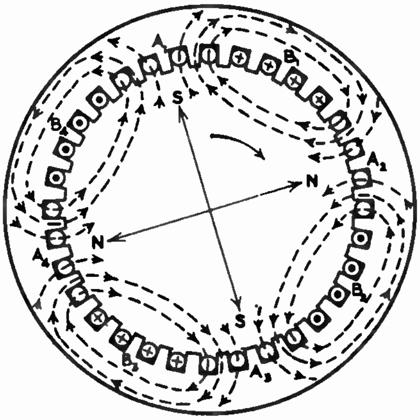


FIG. 6

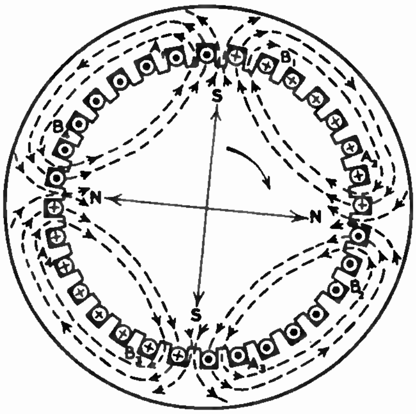


FIG. 7

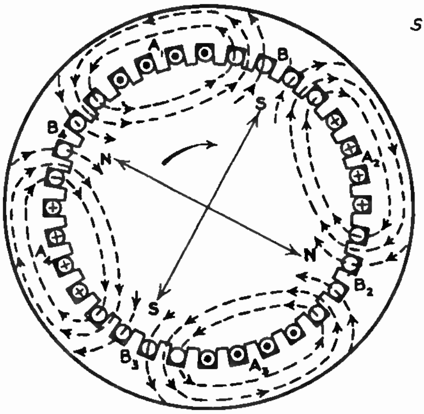


FIG. 8

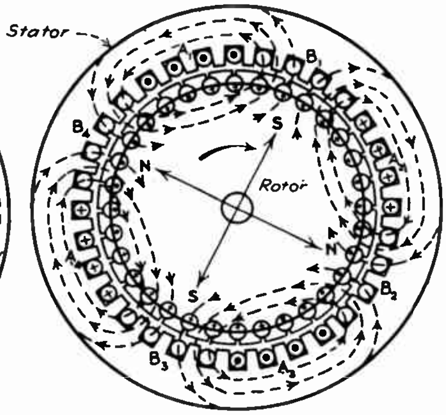


FIG. 9

Figs. 4 to 8—How the magnetic field in an induction-motor stator can be made to rotate when its windings are connected to a 2-phase circuit. Fig. 9—Direction of current generated in a rotor winding shown by dots and crosses on the rotor bars

Fig. 1

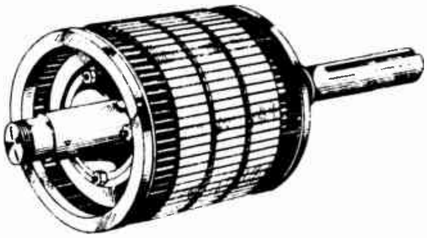


Fig. 2

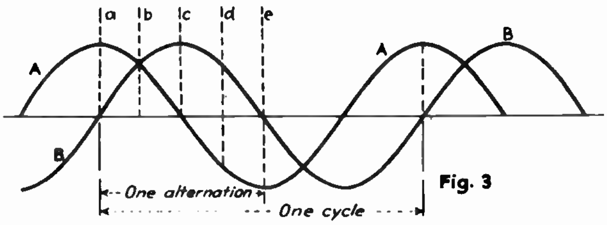


Fig. 3

Fig. 1 Stator of an induction motor. Fig. 2—Squirrel-cage rotor of an induction motor. Fig. 3—Two-phase voltage or current curves

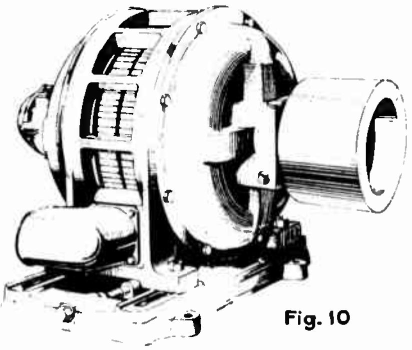


Fig. 10

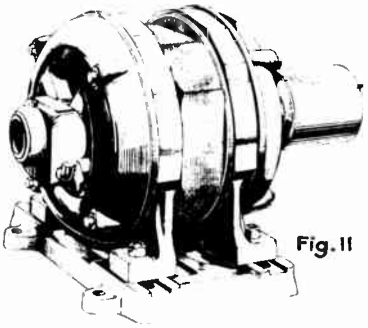


Fig. 11

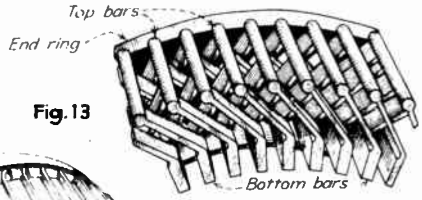


Fig. 13

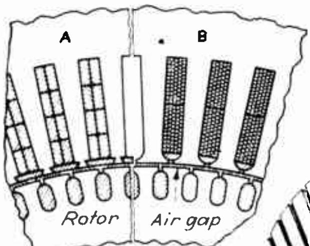


Fig. 12

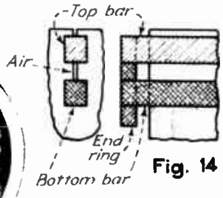


Fig. 14

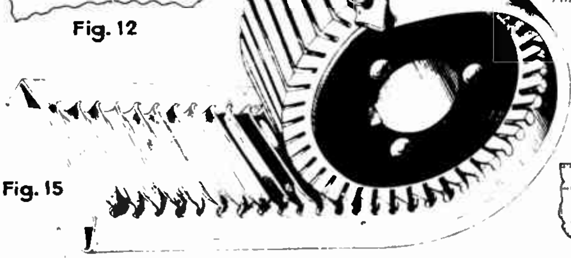


Fig. 15

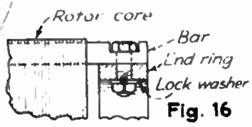


Fig. 16

Fig. 10—Skeleton stator frame. Fig. 11—Riveted stator frame. Fig. 12—*A*, stator open slots; *B*, semiclosed slots. Fig. 13—Section of cast, interconnected double-squirrel-cage winding. Fig. 14—Section of simple double-squirrel-cage winding. Fig. 15—Squirrel-cage winding formed from a copper plate. Fig. 16—Joint between rotor bar and end ring

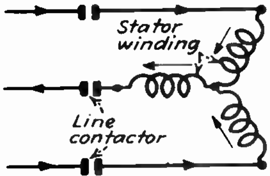


FIG. 1

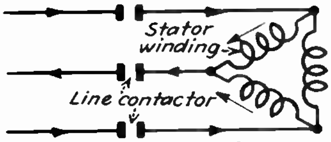


FIG. 2

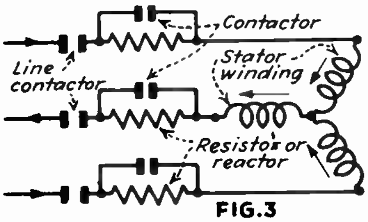


FIG. 3

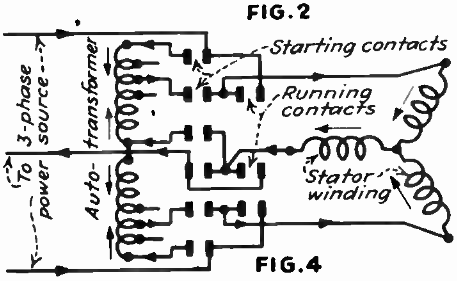


FIG. 4

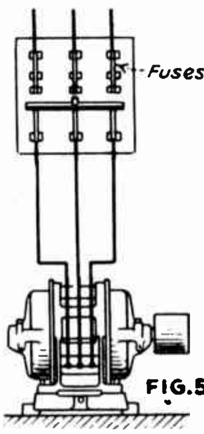


FIG. 5

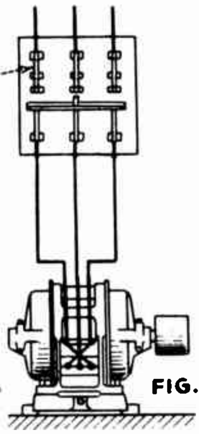


FIG. 6

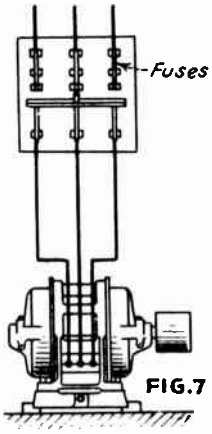


FIG. 7

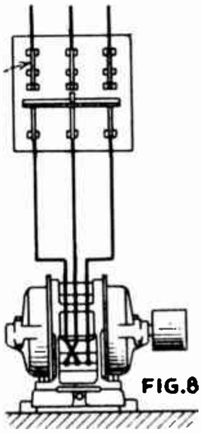
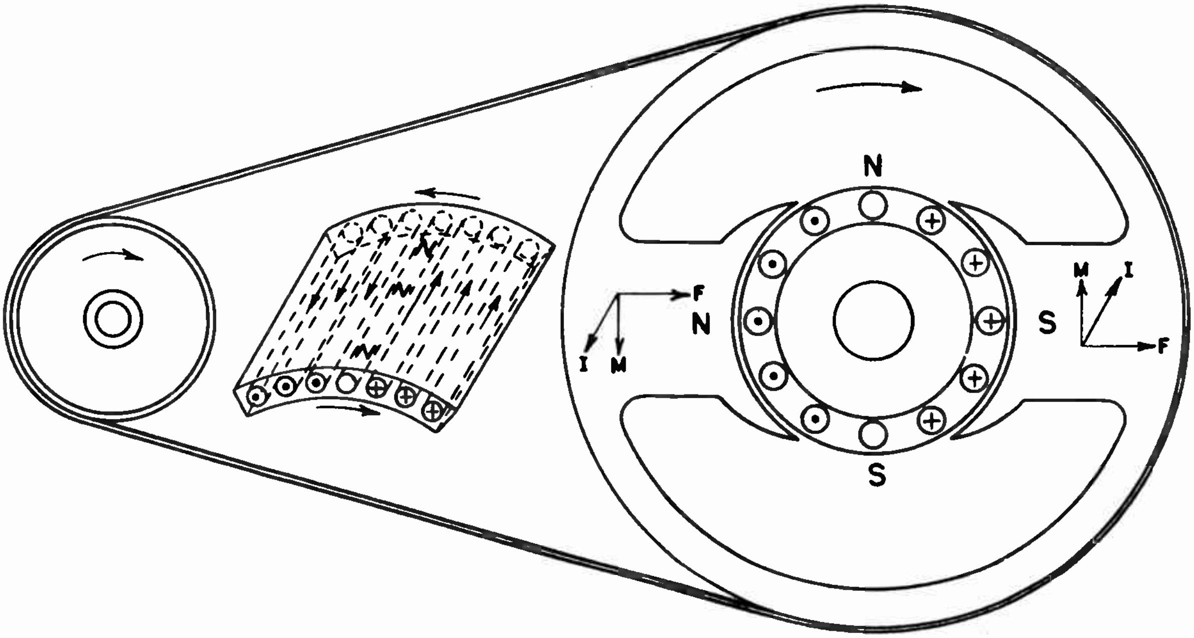


FIG. 8

Fig. 1—Diagram of star-connected stator windings. Fig. 2—Stator windings connected delta. Fig. 3—Connections for starting with resistors or reactors in series with stator windings of a 3-phase motor. Fig. 4—Two auto-transformers connected to start a 3-phase motor. Fig. 5—Connections for one direction of rotation and Fig. 6, opposite direction of rotation of a 3-wire, 2-phase motor. Figs. 7 and 8—Connections for opposite directions of rotation of a 3-phase motor

ROTATING MAGNETIC FIELD.

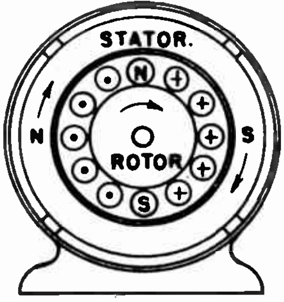
NOTE; FLEMING'S RULE IS APPLIED TO MOTION OF THE CONDUCTOR.
FLUX MOVING UP IS EQUIVALENT TO CONDUCTOR MOVING DOWN.



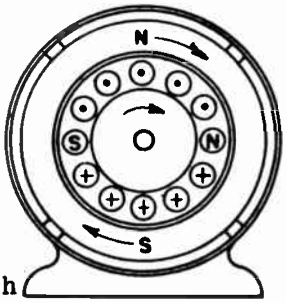
If a permanent magnet of the type shown above rotated about a squirrel cage rotor, the flux of the magnet will cut across the squirrel rotor bars and induce voltage in them. The direction of these voltages at any instant may be determined by Fleming's Right Hand Rule. Application of this rule to the diagram above shows that currents will be flowing toward the observer under the North pole, and away from the observer under the South pole.

Viewed from above, current is circulating counter-clockwise around the rotor thereby establishing a North pole at the top and a South pole at the bottom. As the magnetic field is rotated, the rotor poles move at the same speed and in the same direction and maintain the same relative position; that is, midway between the stator poles.

A



B



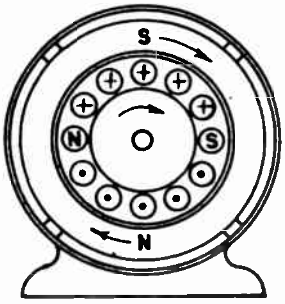
Diagrams A B C D show the relative position of the rotor and stator poles for four different points in one revolution.

In A there exists at the instant shown the same condition described above. In this case however, the rotating magnetic field is produced by a different method.

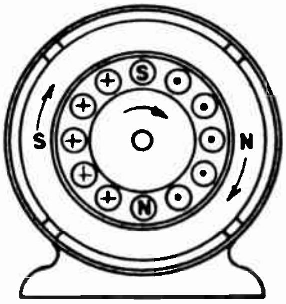
In B the revolving field has moved through one-quarter revolution. Note the change in current distribution in the rotor bars and the movement of the rotor poles. Diagrams C and D show the condition at later points in the revolution. Reversal of current in rotor bars causes rotor poles to revolve

Although the diagrams show the current in the rotor bars changing direction in groups, the rotor bar currents actually reverse one at a time as the stator flux sweeps by. This produces a smooth progression of the poles around the rotor.

D



C



POSITION INDICATORS.

Position indicators are employed to transmit motion by electrical means between points which cannot be readily connected mechanically. In Figure A rotation of the arm on the sender rheostat varies the current through the receiver which is used as a receiver. When properly calibrated, the meter needle motion will be proportional to the motion at the sender. Thus the amount of gasoline in the tank may be indicated on the instrument panel of a car.

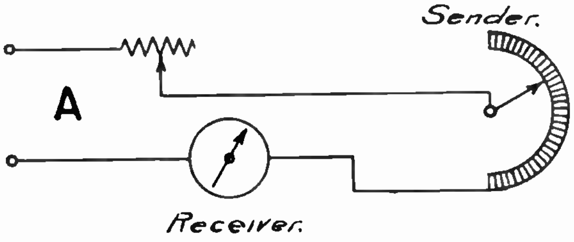


Figure B shows a similar arrangement except that clockwise rotation of the sender increases the voltage applied to the receiver and the deflection is in proportion to it.

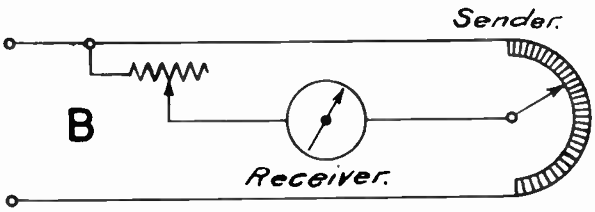
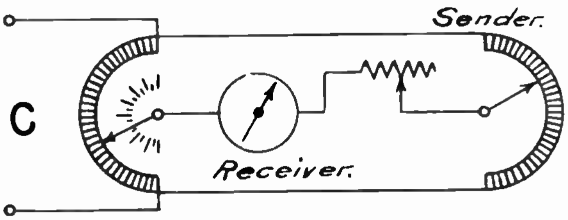
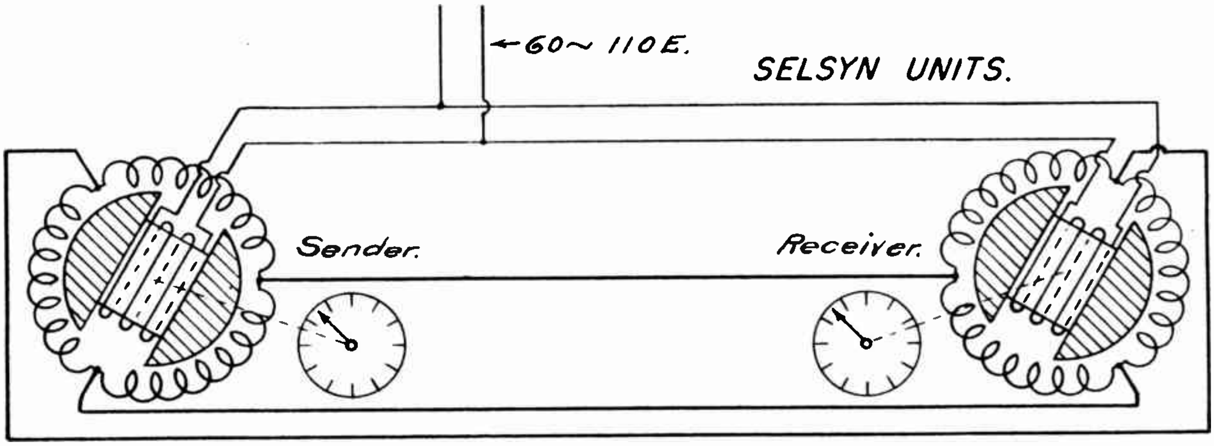


Diagram C shows a bridge type circuit in which the meter needle is returned to zero by manipulating a rheostat at the receiving end. When balanced, both rheostat arms are in identical positions.

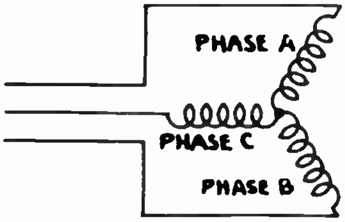


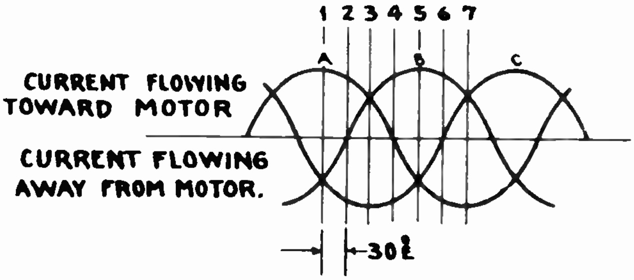
There are many other circuit arrangements but the basic operating principle is the same. The electrical method is particularly suited to most applications because the units may be any distance apart, and several receivers may be attached to one sender.

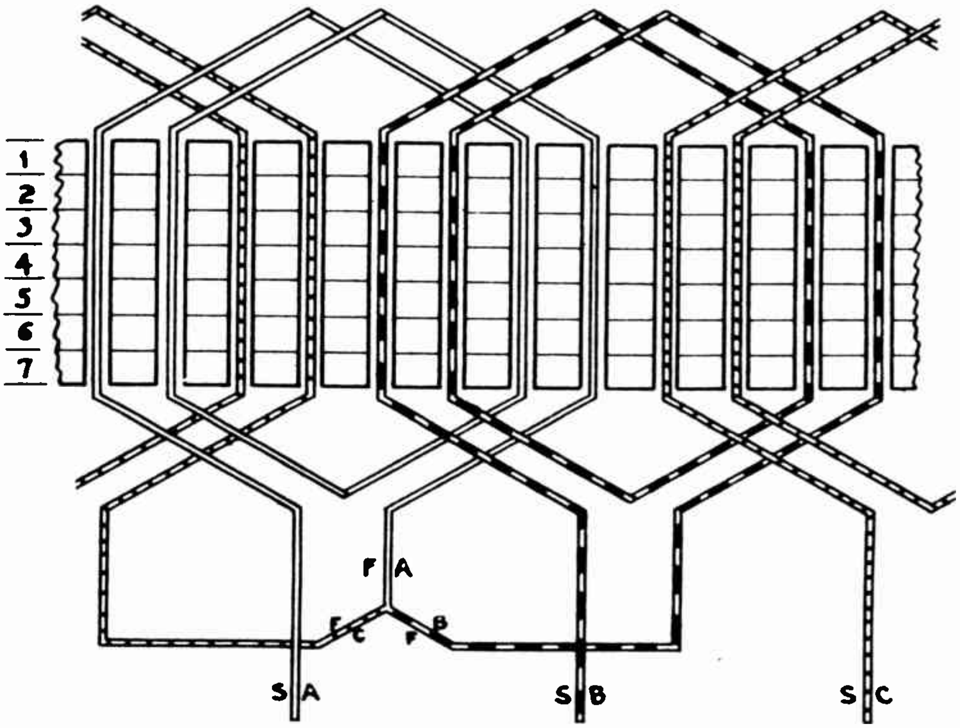


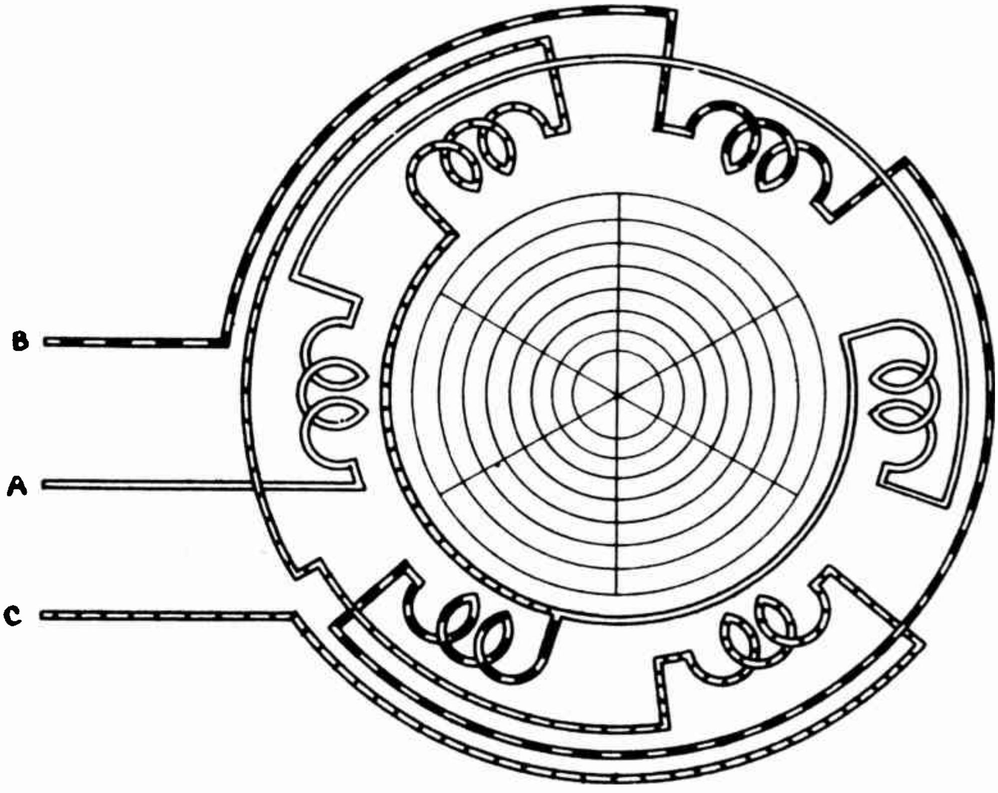
If two small motors of the type shown above are connected together and the rotors are energized from a single phase A.C. source, the varying flux produced by the rotors will induce voltages in the stator windings. If the rotors are in identical positions, the induced stator voltages will be in direct opposition and no current will flow in the leads connecting the stators together. Should one rotor be moved, this voltage balance is disturbed and current will flow through the other stator winding in such a direction as to cause its rotor to move to a corresponding position. This self synchronizing action which is characteristic of many types of A.C. motors is utilized in the Selsyn position indicator.

With the indicators arranged as shown, movement of the sender rotor is duplicated by the receiver and, whether the sender is rotated through a small angle or several revolutions, the receiver follows the motion exactly. Where several indications are required, several receivers may be attached to the same sender. In this way motion of the sender may be reproduced at any number of remote points.







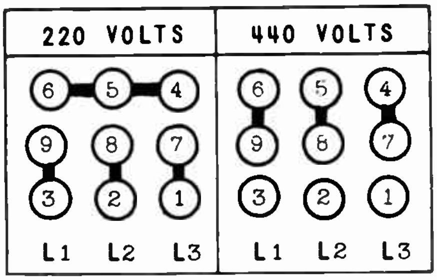


ASSUME CURRENT FLOWING CLOCKWISE TO SET UP A SOUTH POLE, AND CURRENT FLOWING COUNTER-CLOCKWISE TO SET UP A NORTH POLE

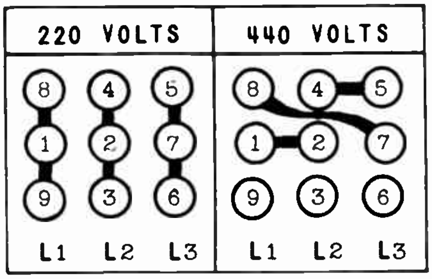
MOTORS - POLYPHASE - SQUIRREL CAGE

3 PHASE SINGLE SPEED

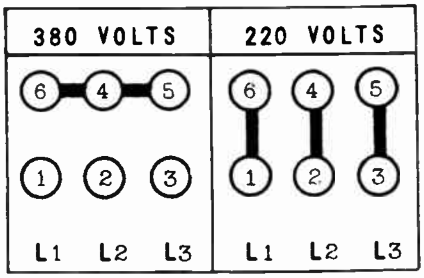
NO. 1 STAR-Y-CONNECTION



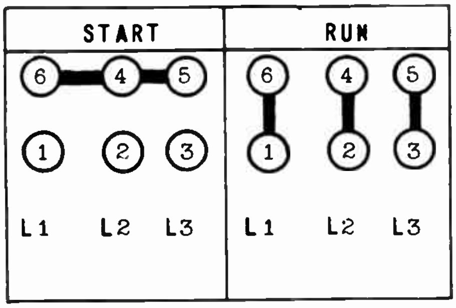
NO. 2 DELTA-CONNECTION



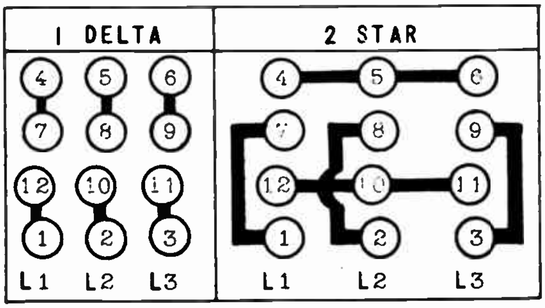
NO. 3 STAR-DELTA CONNECTION



NO. 4 STAR START DELTA RUN

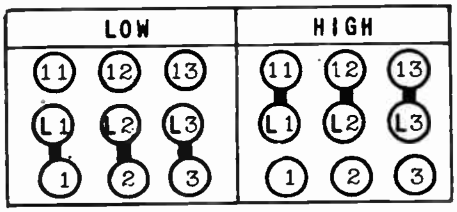


NO. 5 1 DELTA CONNECTION 2 STAR CONNECTION



3 PHASE 2 SPEED

NO. 6 TWO SPEED TWO WINDING



NO.7 TWO SPEED SINGLE WINDING CONSTANT TORQUE or VARIABLE TORQUE

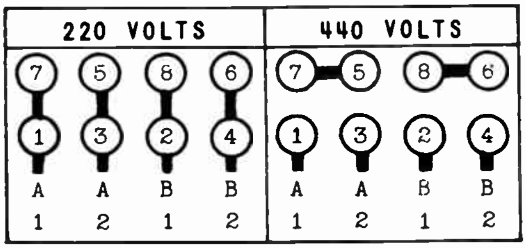
SPEED	L1	L2	L3	
LOW	T1	T2	T3	T4, T5, T6. Open
HIGH	T6	T4	T5	T1, T2, T3 Together

NO.8 TWO SPEED SINGLE WINDING CONSTANT HORSEPOWER

SPEED	L1	L2	L3	
LOW	T1	T2	T3	T4,T5,T6, Together
HIGH	T6	T4	T5	T1,T2,T3 Open

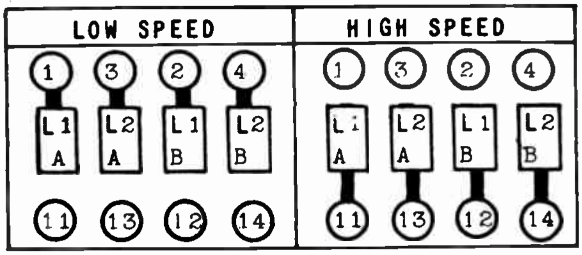
2 PHASE SINGLE SPEED

NO. 9 DUAL VOLTAGE



2 PHASE TWO SPEED

NO. 10 TWO SPEED TWO WINDING



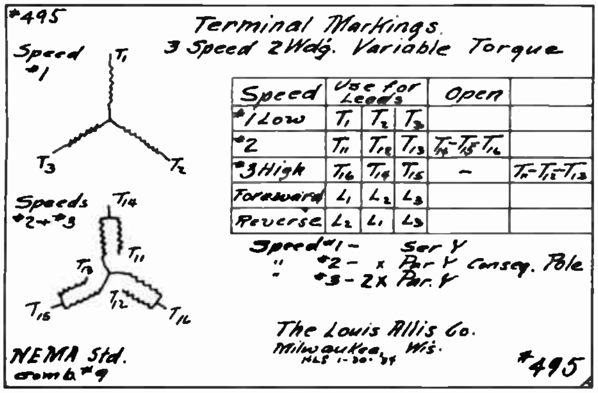
NO. 11 TWO SPEED ONE WINDING VARIABLE TORQUE

Speed	L1 A	L2 A	L1 B	L2 B	Open
Low	T1	T5	T2	T6	T3, T4
High	T1.T5	T3	T2.T6	T4	

TERMINAL MARKING & CONNECTIONS

A.C. MULTI-SPEED MOTORS

3 SPEED - 3 PHASE - 2 WINDING



#495

Terminal Markings.
3 Speed 2 Wdg. Variable Torque

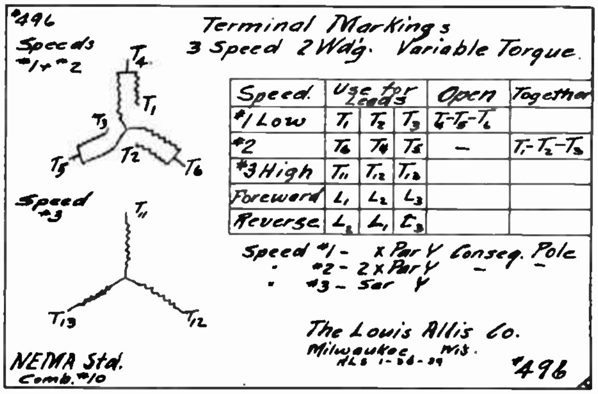
Speed	Use for Leads			Open	
#1 Low	T_1	T_2	T_3		
#2	T_{11}	T_{12}	T_{13}	T_{14}-T_{15}-T_{16}	
#3 High	T_{16}	T_{14}	T_{15}	–	T_{11}-T_{12}-T_{13}
Foreward	L_1	L_2	L_3		
Reverse	L_2	L_1	L_3		

Speed #1 - Ser Y
" #2 - x Par Y Conseq. Pole
" #3 - 2X Par. Y

The Louis Allis Co.
Milwaukee, Wis.
HLS 1-30-34

NEMA Std.
Comb #9

#495



#496

Terminal Markings
3 Speed 2 Wdg. Variable Torque.

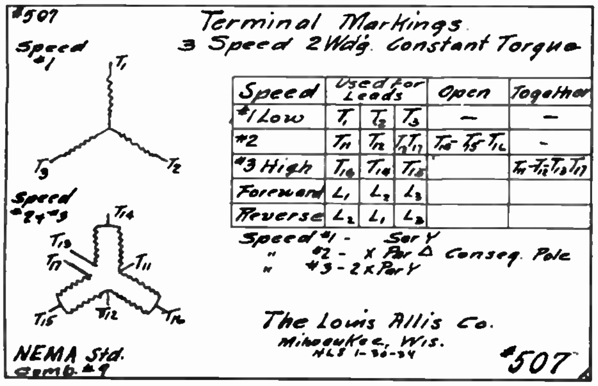
Speed.	Use for Leads			Open	Together
#1 Low	T_1	T_2	T_3	T_4-T_5-T_6	
#2	T_6	T_4	T_5	–	T_1-T_2-T_3
#3 High	T_{11}	T_{12}	T_{13}		
Foreward	L_1	L_2	L_3		
Reverse	L_2	L_1	L_3		

Speed #1 - x Par Y Conseq. Pole
" #2 - 2 x Par Y " "
" #3 - Ser Y

The Louis Allis Co.
Milwaukee, Wis.
HLS 1-30-34

NEMA Std.
Comb. #10

#496



#507

Terminal Markings.
3 Speed 2 Wdg. Constant Torque

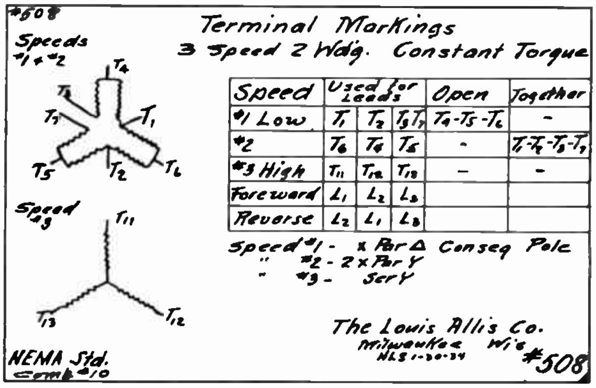
Speed	Used for Leads			Open	Together
#1 Low	T_1	T_2	T_3	–	–
#2	T_{11}	T_{12}	$T_{13}T_{17}$	T_{14}-T_{15}-T_{16}	-
#3 High	T_{16}	T_{14}	T_{15}		T_{11}-T_{12}-T_{13}-T_{17}
Foreward	L_1	L_2	L_3		
Reverse	L_2	L_1	L_3		

Speed #1 - Ser Y
" #2 - X Par Δ Conseq. Pole
" #3 - 2 X Par Y

The Louis Allis Co.
Milwaukee, Wis.
HLS 1-30-34

NEMA Std.
Comb. #9

#507



#508

Terminal Markings
3 Speed 2 Wdg. Constant Torque

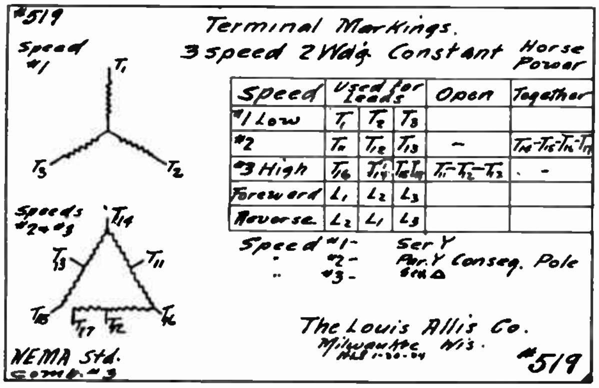
Speed	Used for Leads			Open	Together
#1 Low	T_1	T_2	T_3T_7	T_4-T_5-T_6	-
#2	T_6	T_4	T_5	-	T_1-T_2-T_3-T_7
#3 High	T_{11}	T_{12}	T_{13}	–	-
Foreward	L_1	L_2	L_3		
Reverse	L_2	L_1	L_3		

Speed #1 - x Par Δ Conseq Pole
" #2 - 2 x Par Y
" #3 - Ser Y

The Louis Allis Co.
Milwaukee Wis
HLS 1-30-34

NEMA Std.
Comb #10

#508



#519

Terminal Markings.
3 speed 2 Wdg. Constant Horse Power

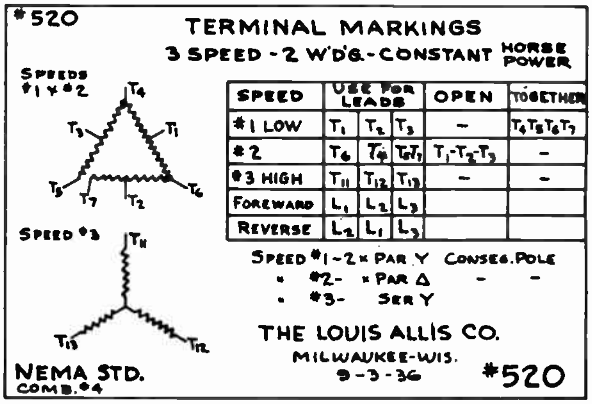
Speed	Used for Leads			Open	Together
#1 Low	T_1	T_2	T_3		
#2	T_{11}	T_{12}	T_{13}	–	T_{14}-T_{15}-T_{16}-T_{17}
#3 High	T_{16}	T_{14}	$T_{15}T_{17}$	T_{11}-T_{12}-T_{13}	-
Foreward	L_1	L_2	L_3		
Reverse	L_2	L_1	L_3		

Speed #1 - Ser Y
" #2 - Par. Y Conseq. Pole
" #3 - Ser Δ

The Louis Allis Co.
Milwaukee, Wis.
HLS 1-30-34

NEMA Std.
Comb. #3

#519



#520

TERMINAL MARKINGS
3 SPEED - 2 W'D'G. - CONSTANT HORSE POWER

SPEED	USE FOR LEADS			OPEN	TOGETHER
#1 LOW	T_1	T_2	T_3	–	$T_4T_5T_6T_7$
#2	T_6	T_4	T_5T_7	T_1-T_2-T_3	–
#3 HIGH	T_{11}	T_{12}	T_{13}	–	–
FOREWARD	L_1	L_2	L_3		
REVERSE	L_2	L_1	L_3		

SPEED #1 - 2 x PAR Y CONSEQ. POLE
" #2 - x PAR Δ " "
" #3 - SER Y

THE LOUIS ALLIS CO.
MILWAUKEE-WIS.
9-3-36

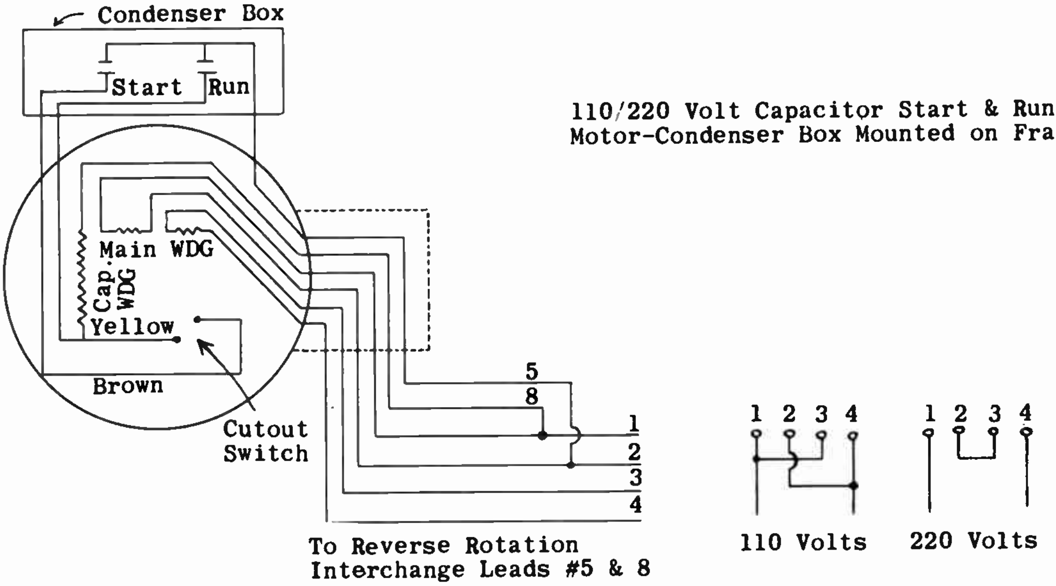
NEMA STD.
COMB. #4

#520

MOTORS - SINGLE-PHASE - CAPACITOR

WD-633

110/220 Volt Capacitor Start & Run
Motor-Condenser Box Mounted on Frame



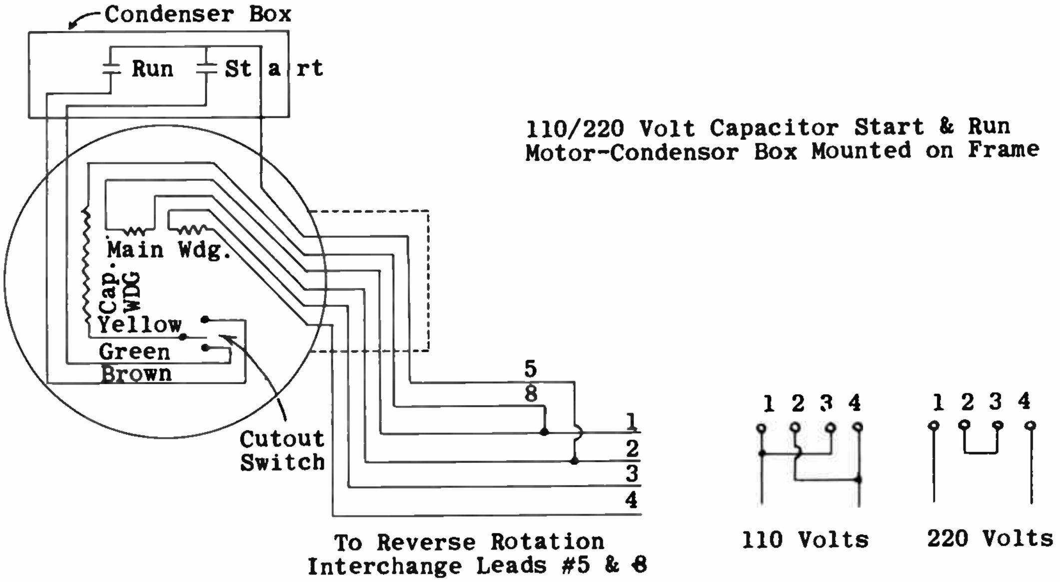
To Reverse Rotation
Interchange Leads #5 & 8

Feb.1,1944 - R.C.W.

Janette Mfg.Co.
Chicago,Ill.

WD-447

110/220 Volt Capacitor Start & Run
Motor-Condensor Box Mounted on Frame

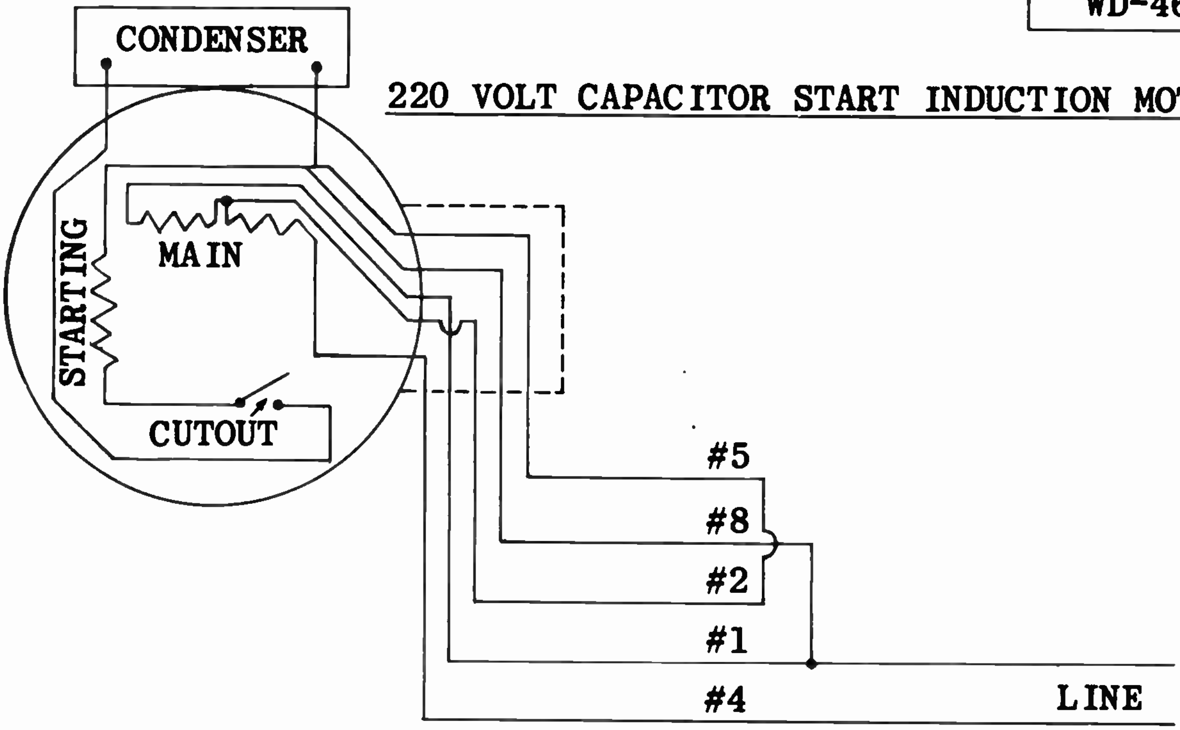


To Reverse Rotation
Interchange Leads #5 & 8

JANETTE MFG. CO.
Chicago, Ill.

WD-460

220 VOLT CAPACITOR START INDUCTION MOTOR

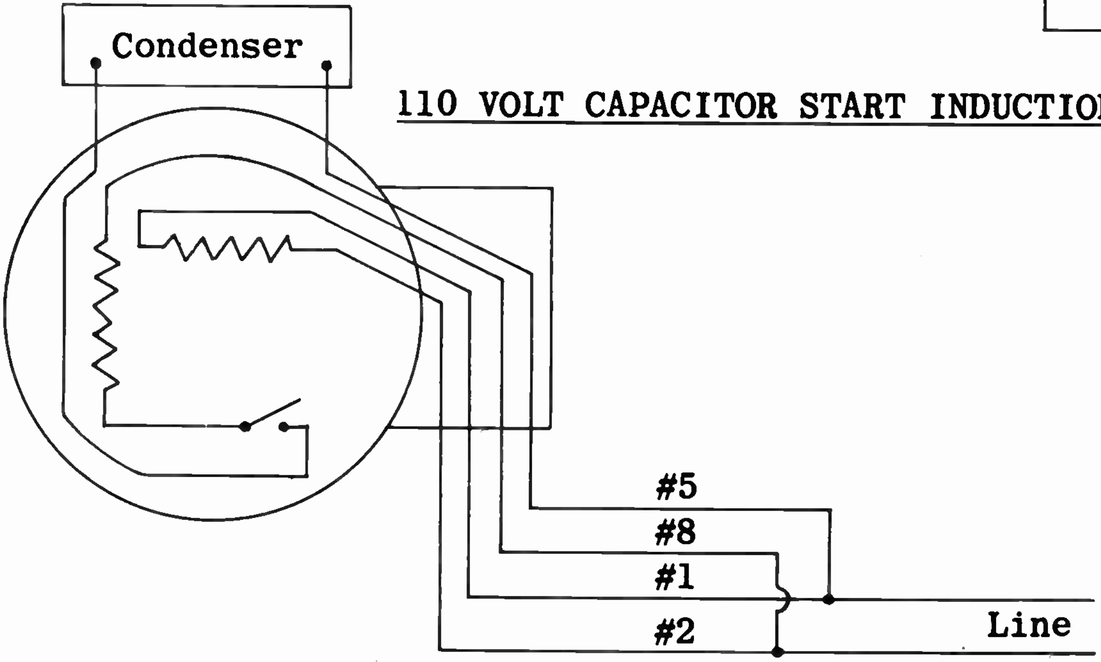


TO REVERSE ROTATION INTERCHANGE
LEADS #5 & #8

JANETTE MFG. CO.,
CHICAGO, ILL.,

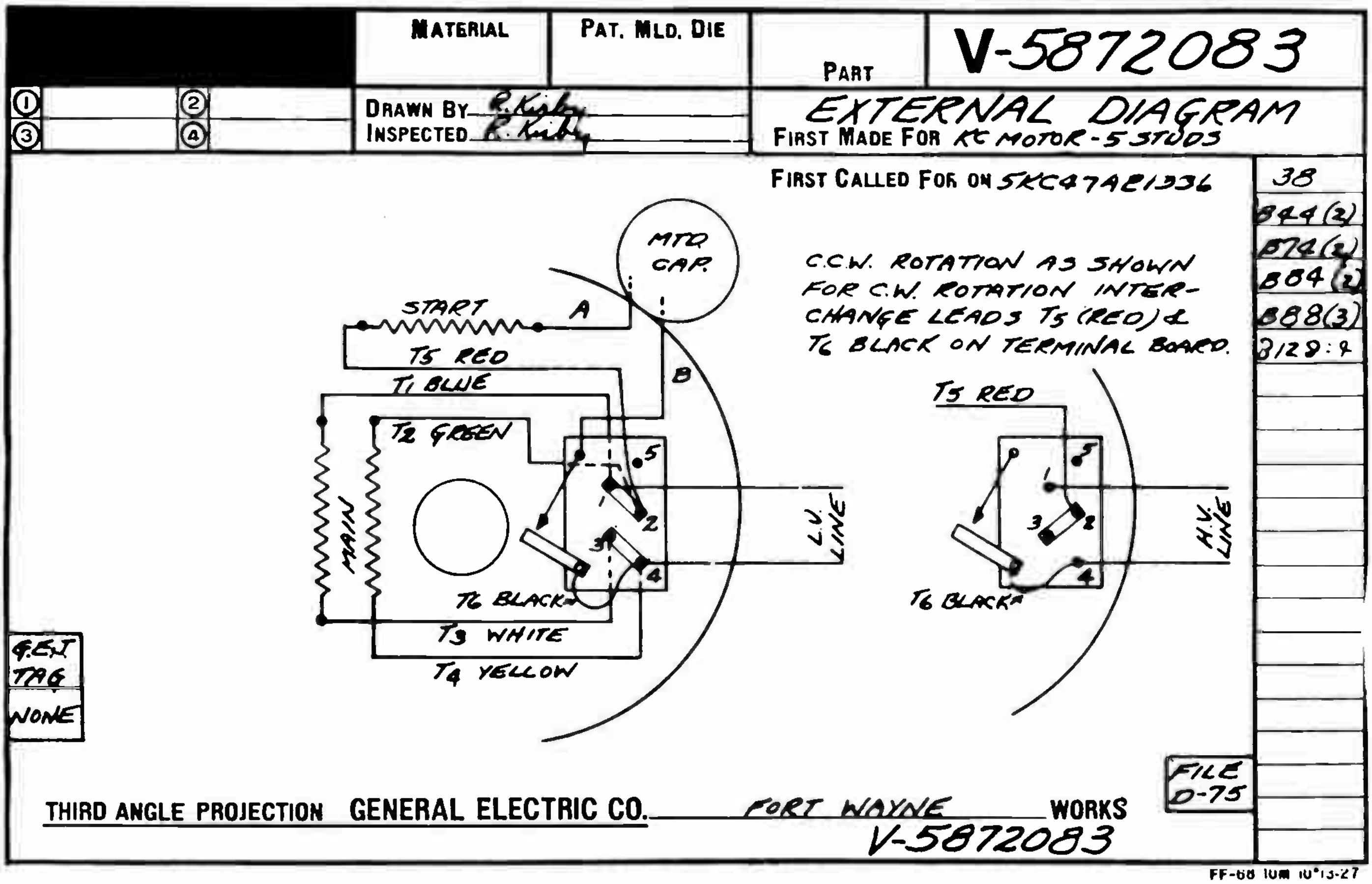
WD-620

110 VOLT CAPACITOR START INDUCTION MOTOR



To Reverse Rotation Interchange
Leads #5 & #8

Janette Mfg.Co.
Chicago, Ill.



MATERIAL

PAT. MLD. DIE

PART V-5872083

DRAWN BY R. Kirby

INSPECTED R. Kirby

EXTERNAL DIAGRAM

FIRST MADE FOR KC MOTOR - 5 STUDS

FIRST CALLED FOR ON 5KC47AE1336

38
B44(2)
B74(2)
B84(2)
B88(3)
B128:9

C.C.W. ROTATION AS SHOWN FOR C.W. ROTATION INTERCHANGE LEADS T5 (RED) & T6 BLACK ON TERMINAL BOARD.

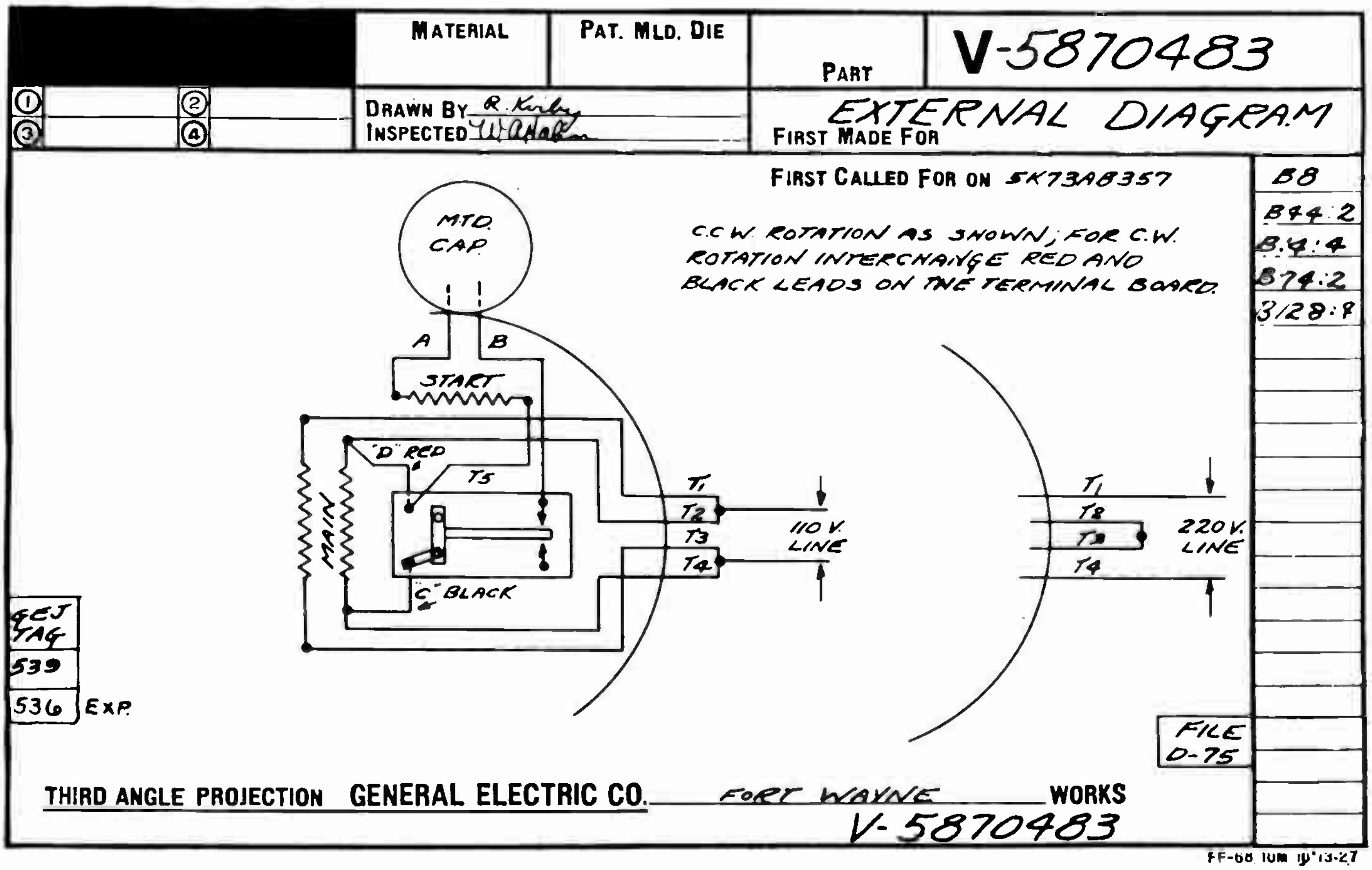
G.E.T. TAG
NONE

FILE D-75

THIRD ANGLE PROJECTION **GENERAL ELECTRIC CO.** FORT WAYNE WORKS

V-5872083

FF-68 10M 10-13-27



MATERIAL

PAT. MLD. DIE

PART V-5870483

DRAWN BY R. Kirby

INSPECTED

EXTERNAL DIAGRAM

FIRST MADE FOR

FIRST CALLED FOR ON 5K73AB357

B8
B44:2
B4:4
B74:2
B128:9

C.C.W. ROTATION AS SHOWN; FOR C.W. ROTATION INTERCHANGE RED AND BLACK LEADS ON THE TERMINAL BOARD.

GEJ TAG
539
536 EXP.

FILE D-75

THIRD ANGLE PROJECTION **GENERAL ELECTRIC CO.** FORT WAYNE WORKS

V-5870483

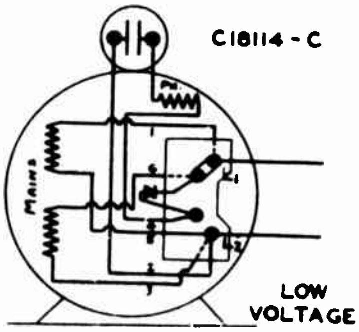
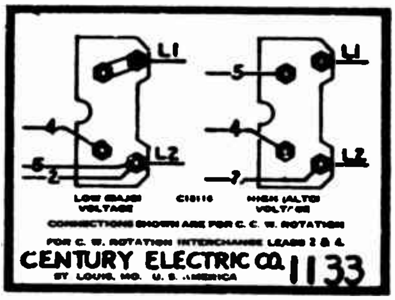
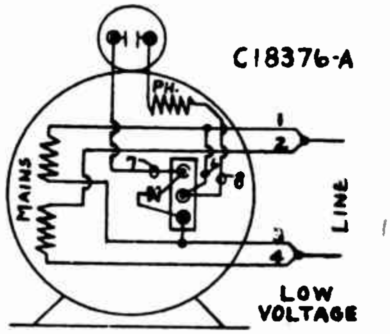
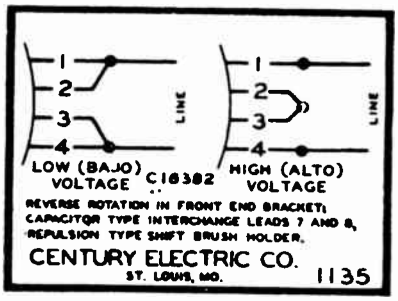
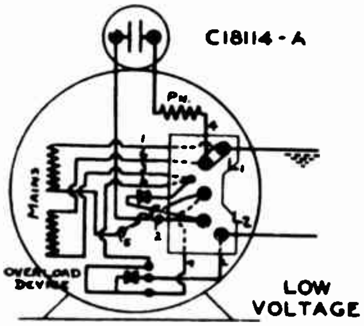
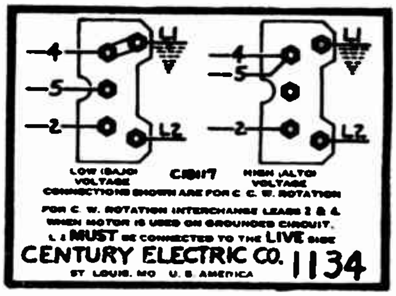
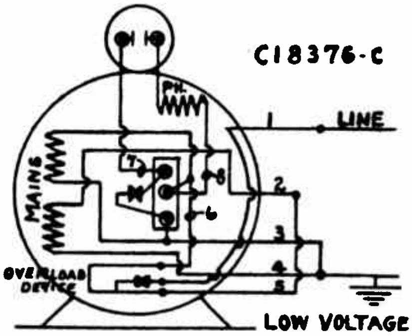
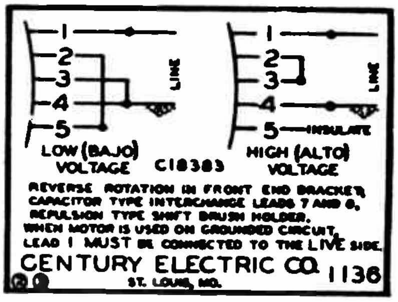
FF-68 10M 10-13-27

Century

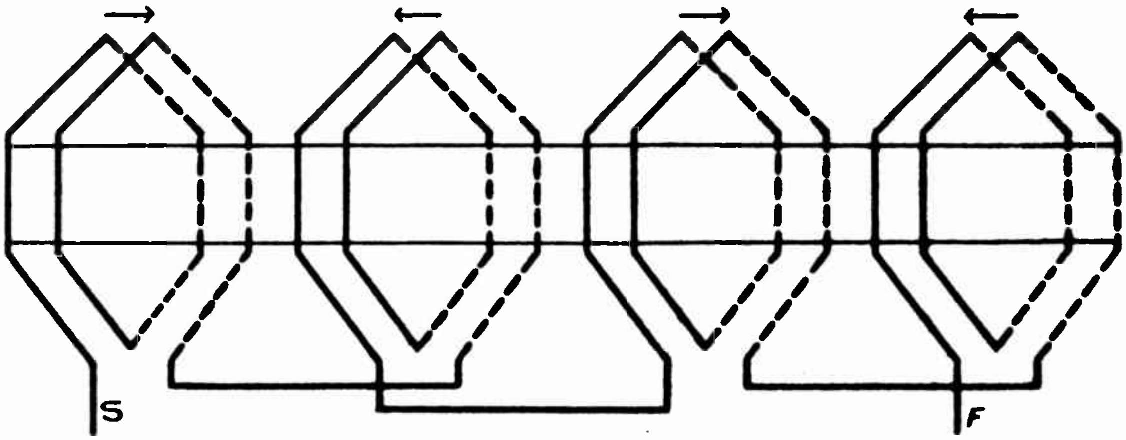
ENGINEERING INFORMATION

CAPACITOR START INDUCTION MOTORS

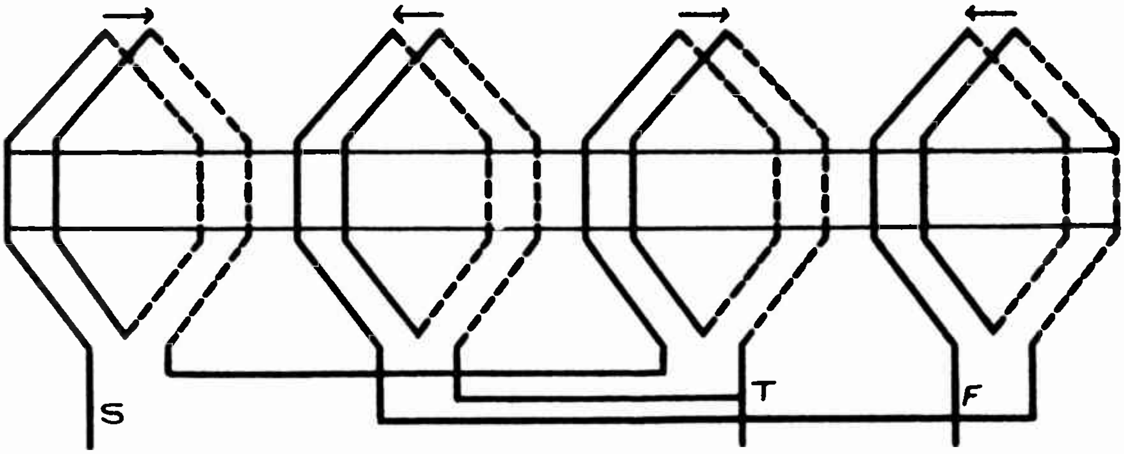
TYPES CSH & CSX; * 110/220 VOLTS; REVERSIBLE

Location of Terminals	* Frame	Internal Connection Diagrams (Counter Clockwise Rotation)	Label (Attached To Cover Over Terminals)
WITHOUT OVERLOAD PROTECTION			
In Front Bracket	63G, 65G, 67G, 65L, 67L		 CONNECTIONS SHOWN ARE FOR C. C. W. ROTATION FOR C. W. ROTATION INTERCHANGE LEADS 2 & 4. CENTURY ELECTRIC CO. ST. LOUIS, MO. U. S. AMERICA 1133
In Frame	71, 73, 81, 83, 91, 93		 REVERSE ROTATION IN FRONT END BRACKET; CAPACITOR TYPE INTERCHANGE LEADS 7 AND 8, REPULSION TYPE SHIFT BRUSH HOLDER. CENTURY ELECTRIC CO. ST. LOUIS, MO. 1135
WITH OVERLOAD PROTECTION			
In Front Bracket	63G, 65G, 67G, 65L 67L		 CONNECTIONS SHOWN ARE FOR C. C. W. ROTATION FOR C. W. ROTATION INTERCHANGE LEADS 2 & 4. WHEN MOTOR IS USED ON GROUNDED CIRCUIT. L1 MUST BE CONNECTED TO THE LIVE SIDE CENTURY ELECTRIC CO. ST. LOUIS, MO U. S. AMERICA 1134
In Frame	71, 73, 81, 83, 91, 93		 REVERSE ROTATION IN FRONT END BRACKET, CAPACITOR TYPE INTERCHANGE LEADS 7 AND 8, REPULSION TYPE SHIFT BRUSH HOLDER. WHEN MOTOR IS USED ON GROUNDED CIRCUIT, LEAD 1 MUST BE CONNECTED TO THE LIVE SIDE. CENTURY ELECTRIC CO. ST. LOUIS, MO. 1136

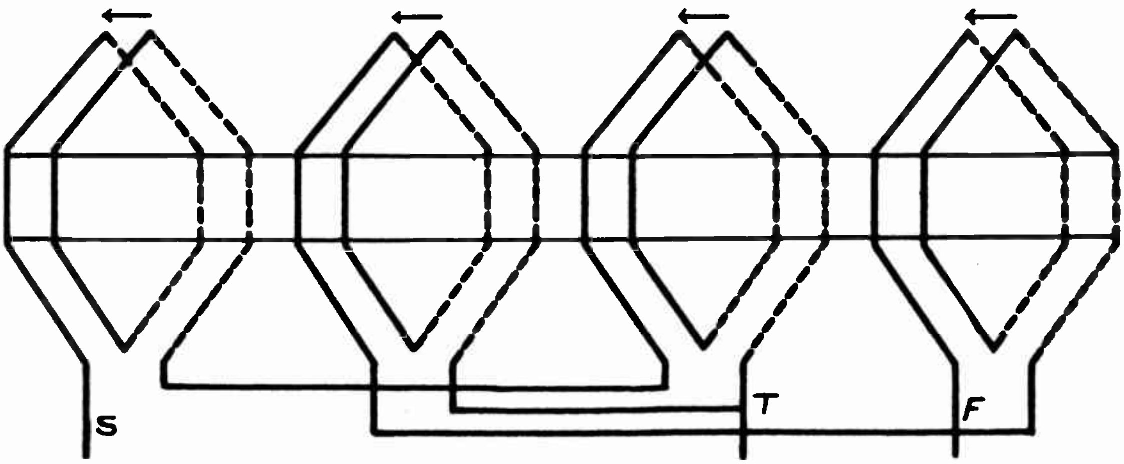
PRINCIPLES OF CONSEQUENT POLE WINDINGS FOR 3 PHASE INDUCTION MOTORS.



Slots = 24, Poles = 4, Fractional Pitch Coil Span = 1 to 5.
"A" Phase only of a 3 phase winding illustrating common method of short jumpers. (Top to Top, Bottom to Bottom) Trace the circuit and mark the polarities in the proper position. This type of jumper connection is not suitable for consequent pole windings.

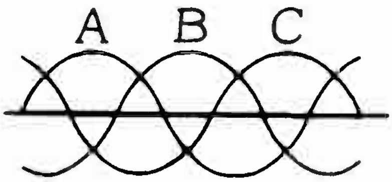


"A" Phase only of 3 phase winding illustration long jumper method of connection. (Top to Bottom, Bottom to Top) Trace the circuit for 4 poles disregarding the center tap, and mark the polarities in the proper position. Note that the poles are established in the same position as for the common method of connection.

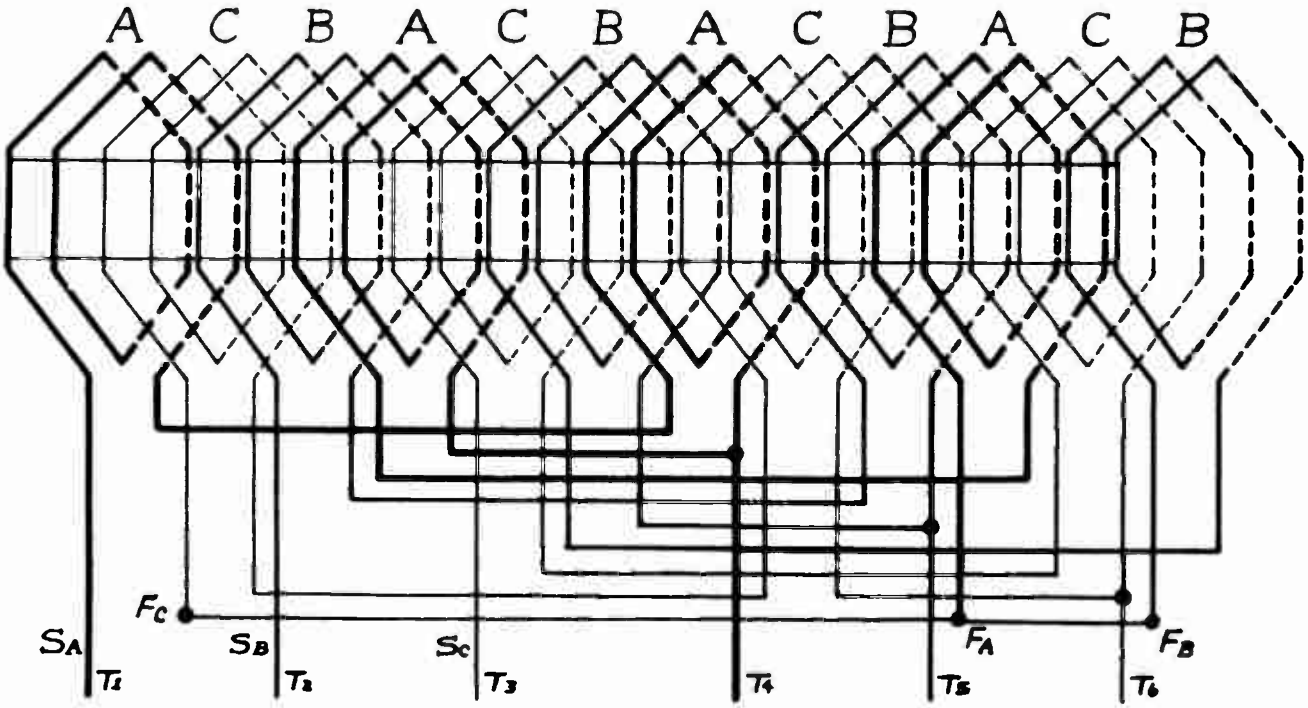


Same connection as shown above. Trace the circuit from the center tap. This places the 2 sections of the phase winding in parallel, reversing the current in 1/2 of the coil groups, producing 4 regular & 4 consequent poles. Note that phase rotation is reversed and it will be necessary to reverse 2 leads on this connection to obtain the same rotor rotation.

SIMPLE DIAGRAM, 4-8 POLE, 3 PHASE CONSEQUENT POLE STATOR WINDING.

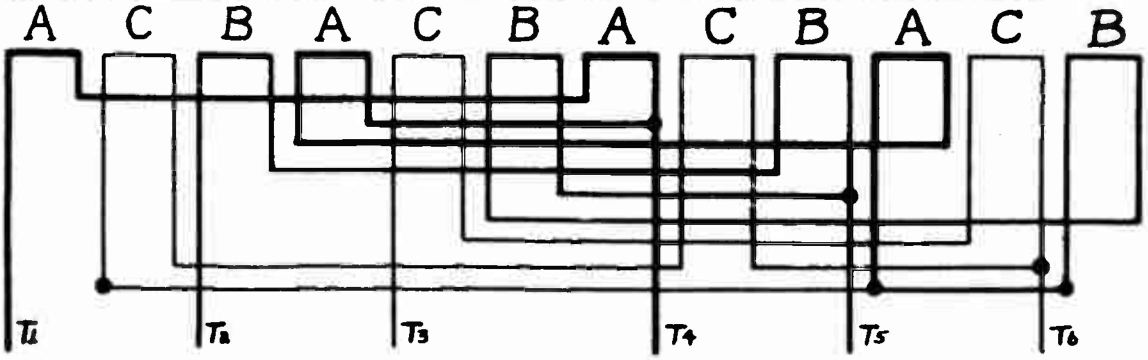


VARIABLE TORQUE, CONSTANT HORSEPOWER.
3 PHASE, LAP WINDING, SLOTS = 24.
POLES = 4-8, COILS PER GROUP = 2.
FRACTIONAL PITCH COIL SPAN = 1 TO 5.
COIL PITCH = 66.6% OF FULL PITCH.
ELECTRICAL DEGREES PER SLOT = 30-60.



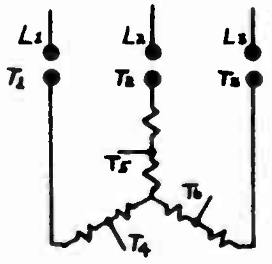
INDICATE DIRECTION OF I FLOW AND POLARITIES FOR 4 POLES IN SPACE BELOW.

INDICATE DIRECTION OF I FLOW AND POLARITIES FOR 8 POLES IN SPACE BELOW.



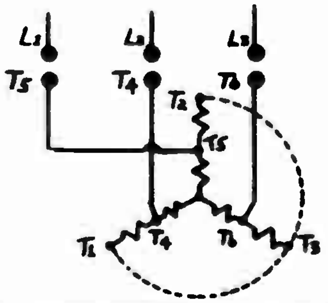
SERIES STAR
4 POLES
T_1, T_2, T_3 TO LINE

T_4, T_5, T_6 OPEN

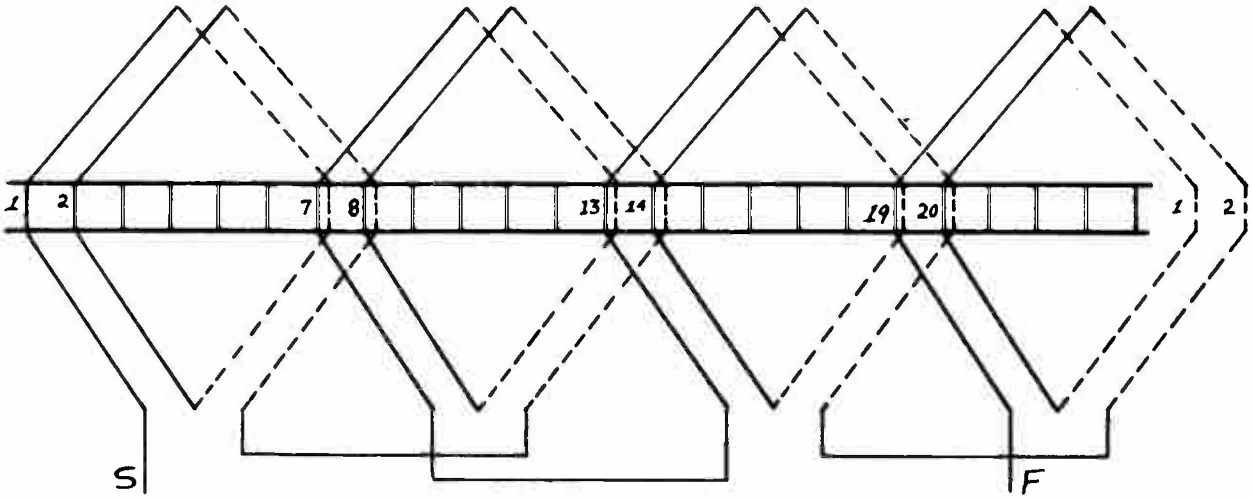


PARALLEL STAR
8 POLES
T_4, T_5, T_6 TO LINE

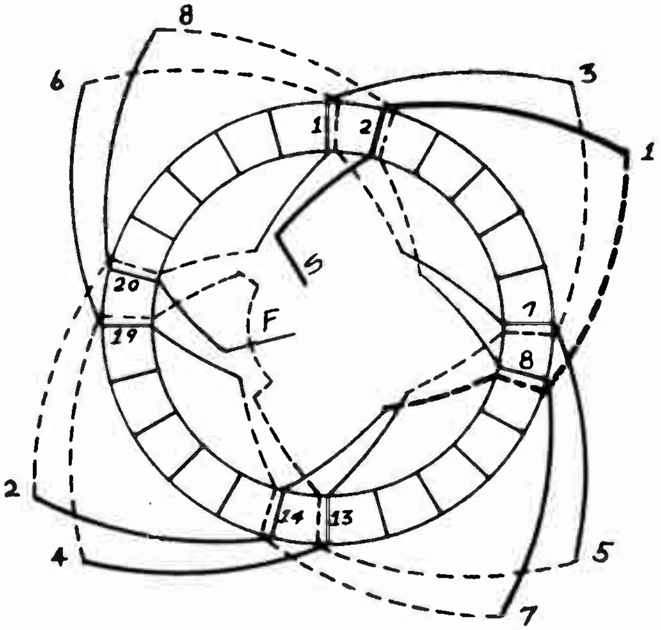
T_1, T_2, T_3 SHORTED



COMPARISON OF LAP AND WAVE WINDINGS.



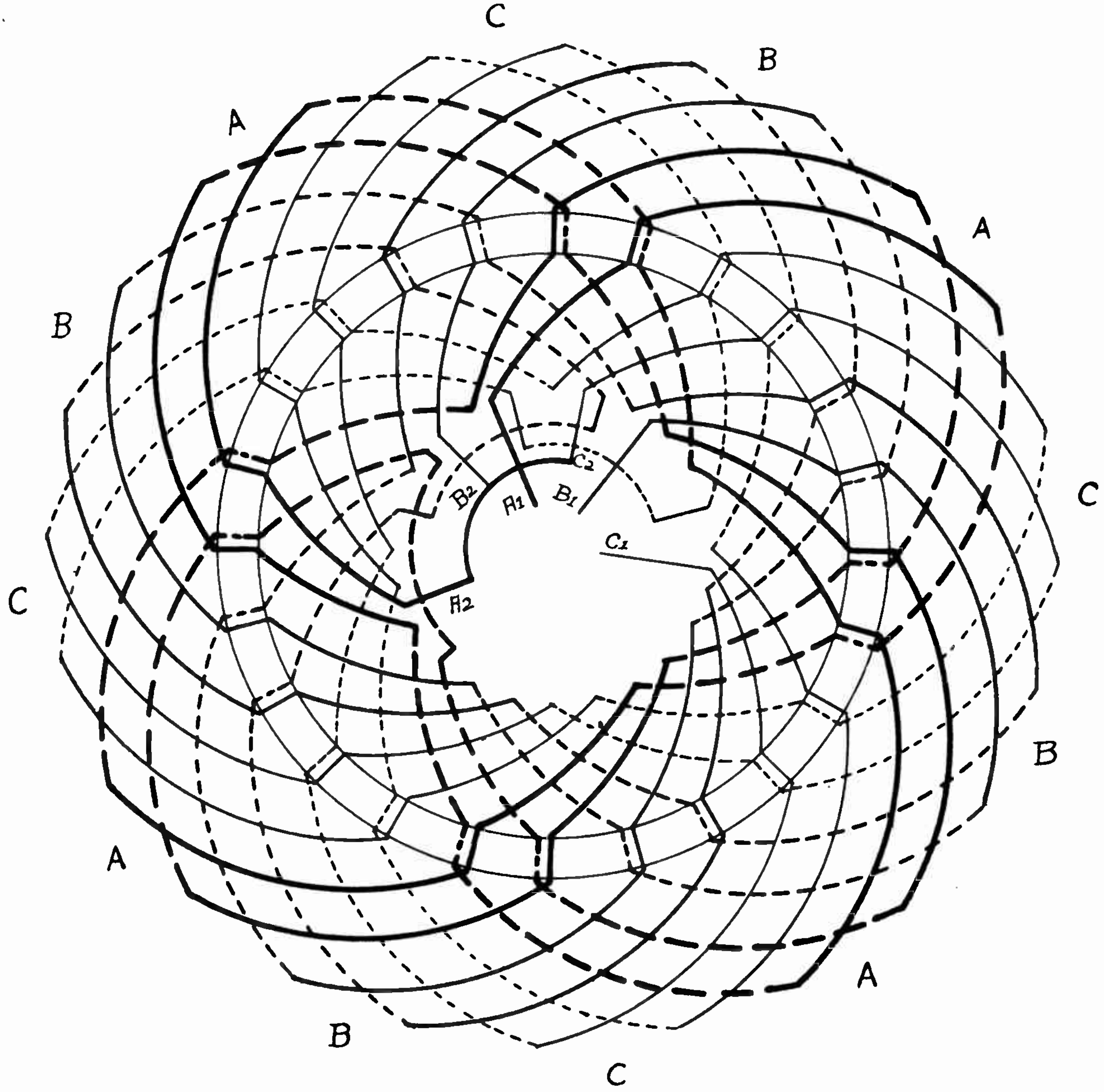
A LAP WINDING is one in which the coils of each pole phase group are connected directly in series with each other or forward and back on itself. Lap windings are generally used on A.C. machines because they are more readily adaptable to stators with various numbers of slots.

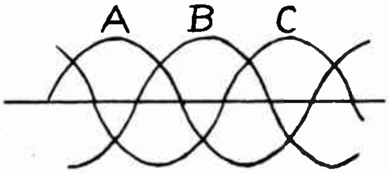


A WAVE WINDING is one in which correspondingly placed coils under adjacent poles are connected in series so that the circuit proceeds from pole to pole one or more times around the stator core, and not forward and back upon itself as on a lap winding. On a wave winding, the circuit re-enters the first coil group after it has passed thru at least one other coil group of the winding. The total number of these circuits must be a multiple of the number of phases and is ordinarily two times the number of phases. Wave windings in large machines are always of strap or bar copper coils with two layers. Principal use is for wound rotors of large slip ring motors because such windings have greater mechanical strength at end connections when made of bar or strap copper. WAVE WINDINGS in stators of induction motors must be electrically balanced, ie., each phase must contain the same number of coils or turns. The number of active slots in each phase and section must be a multiple of poles times phases. For 4 pole, 3-phase, slots would have to be 12-24-36-48-60-72, etc.

THREE PHASE WAVE WINDING.

PHASES CONNECTED STAR.





THREE PHASE, WAVE WINDING.

SLOTS = 24, POLES = 4.

FULL PITCH COIL SPAN = 1:7.

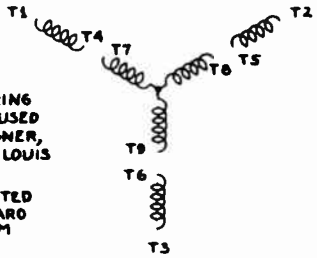
COILS PER POLE PHASE GROUP = 2.

ELECTRICAL DEGREES PER SLOT = 30.

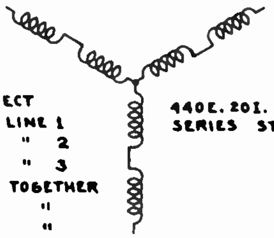
CONNECTIONS FOR TWO VOLTAGE MOTORS.

NUMBERING SYSTEM USED BY WAGNER, GE., AND LOUIS ALLIS.

SUGGESTED STANDARD SYSTEM

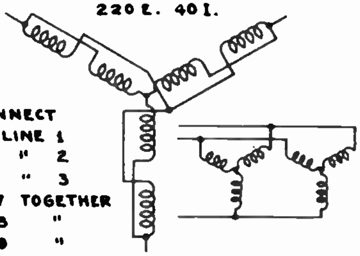


CONNECT
T1 TO LINE 1
T2 " " 2
T3 " " 3
T4 - T7 TOGETHER
T5 - T8 "
T6 - T9 "



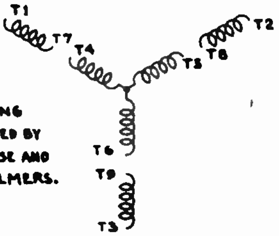
440E. 20I. LINE.
SERIES STAR

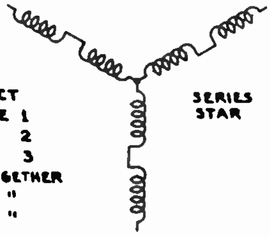
2 CIRCUIT STAR
220 E. 40 I.



CONNECT
T1 TO LINE 1
T2 " " 2
T3 " " 3
T1 - T7 TOGETHER
T2 - T8 "
T3 - T9 "
T4 - T5 - T6 "

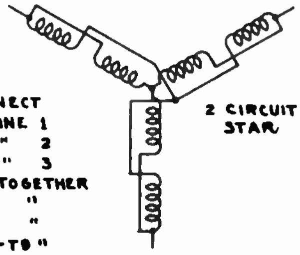
NUMBERING SYSTEM USED BY WESTINGHOUSE AND ALLIS CHALMERS.





CONNECT
T1 TO LINE 1
T2 " " 2
T3 " " 3
T4-T7 TOGETHER
T5-T8 "
T6-T9 "

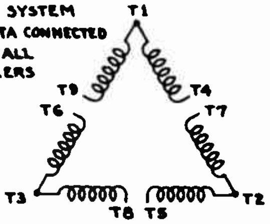
SERIES STAR



CONNECT
T1 TO LINE 1
T2 " " 2
T3 " " 3
T1-T4 TOGETHER
T2-T5 "
T3-T6 "
T7-T8-T9 "

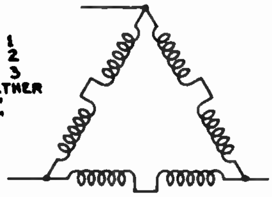
2 CIRCUIT STAR

NUMBERING SYSTEM USED ON DELTA CONNECTED MOTORS, BY ALL MANUFACTURERS

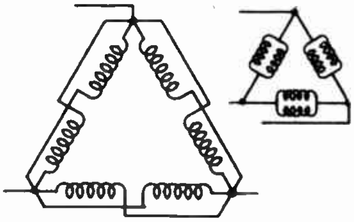


SERIES DELTA

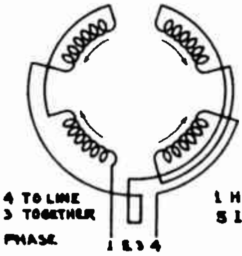
CONNECT
T1 TO LINE 1
T2 " " 2
T3 " " 3
T4-T7 TOGETHER
T5-T8 "
T6-T9 "



CONNECT T1-T6-T7 TO LINE 1
" T2-T4-T8 " " 2
" T3-T5-T9 " " 3



2 CIRCUIT DELTA

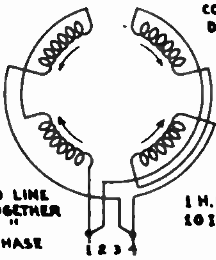


220E { 1-4 TO LINE
2-3 TOGETHER

SINGLE PHASE

1 H.P. 220E.
5 I. 1750 R.P.M.

NOTE:- CHANGING CONNECTION DOES NOT ALTER H.P. OR SPEED WHEN MOTOR IS DESIGNED FOR TWO VOLTAGES



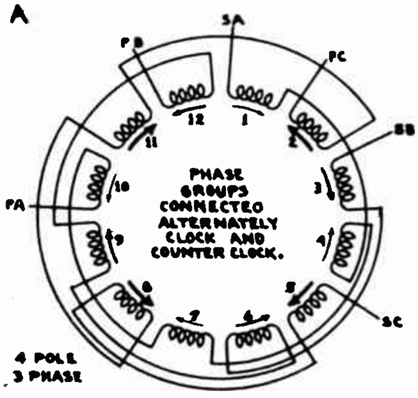
110E { 1-4 TO LINE
1-3 TOGETHER
2-4 "

SINGLE PHASE

1 H.P. 110E.
10 I. 1750 R.P.M.

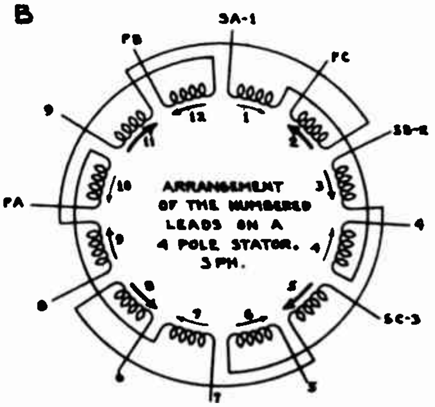
Connections for applying D.C. when testing an A.C. winding with a compass. If the winding is properly connected, the compass will reverse on each pole phase group and indicate three times as many poles as the machine actually has.

A

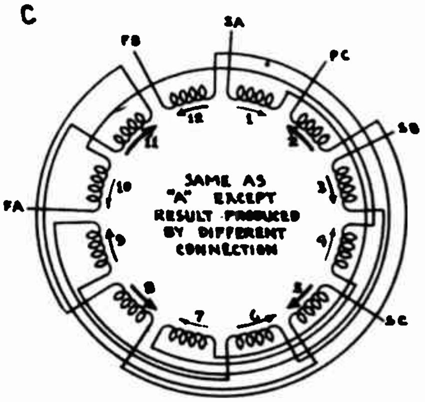


4 POLE
3 PHASE

B



C



REDRAW "A", "B" AND "C" AND PRACTICE CONNECTING THEM FOR ALL ABOVE CONNECTIONS.

COYNE

STAR OR Y
CONNECTED

ENGINEERING INFORMATION

POLYPHASE INDUCTION MOTORS

TYPES SC, SCN, SCH, SCT, SCX, AS, SR - 3 PHASE

Three Phase motors may be either Star or Delta connected and no general rule can be set down for use of either connection. Individual ratings must be checked by the general office.

Our standard method of marking leads and the schemetic representation of circuits* is as follows:

DUAL VOLTAGE*(110/220, 190/380, 220/440 etc.)

Consider T_1 and T_4 (Fig. 1) as the end of one circuit* and T_7 and the center of the star as the ends of the other circuit, in one phase. Do the same for each of the other two phases. To connect the stator winding for the higher voltage, the circuits in each phase are connected in series; therefore, connect T_4 to T_7, T_5 to T_8, and T_6 to T_9. Line connections will be made to T_1, T_2, and T_3 fig. 2 and 5 show these connections.

To connect the stator windings for the lower voltage, the circuits in each phase are connected in parallel, therefore connect T_1 to T_7, T_2 to T_8, and T_3 to T_9. T_4, T_5 and T_6 are connected together to form a point, thereby forming a second star in parallel with the star whose ends are T_7, T_8, and T_9. Line connections, as before, will be made to T_1, T_2 and T_3. Fig. 3 and 6 show these connections.

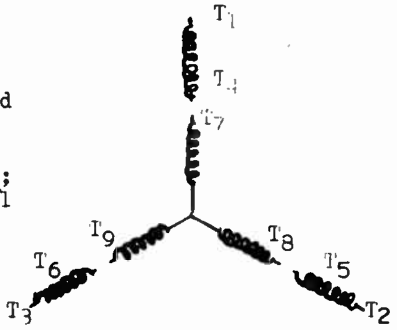


FIG. 1
All terminal lugs are stamped in accordance with this diagram.

These motors have permanent connection plate near terminal box.

SINGLE VOLTAGE*(199,208,220,440,550,2200 etc.)

Only leads T_1, T_2 and T_3 are brought out as shown in fig. 4 and 7 (Single voltage motors usually have single section windings rather than the double section winding shown in Fig. 1)

Connections are indicated on lubrication tags sent with motor.

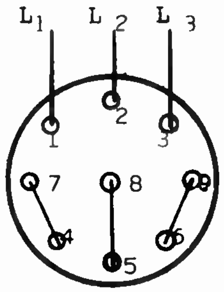


FIG. 2
High Voltage

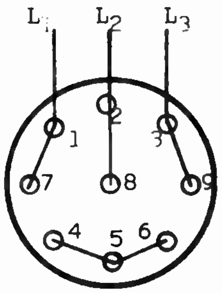


FIG. 3
Low Voltage

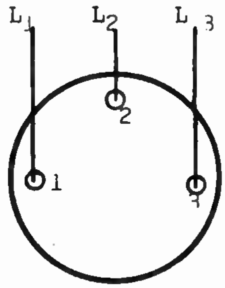


FIG. 4
Single Voltage

DUAL VOLTAGE CONNECTIONS (Similar to B6671 & B7203)

All Form A 204 and smaller; Form W, 224 to 326; Form T 204 and larger. (T superseded by W)

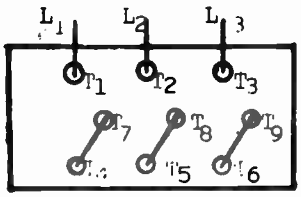


FIG. 5
High Voltage

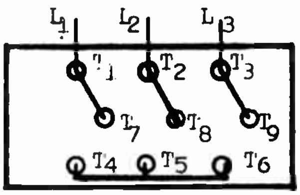


FIG. 6
Low Voltage

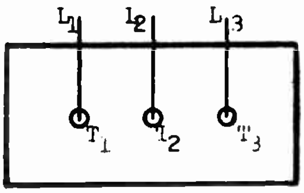


FIG. 7
Single Voltage

DUAL VOLTAGE CONNECTIONS (Similar to B4270 & B4271)

All Form S motors. Form T motors 444 and larger.

Century

ENGINEERING INFORMATION

POLYPHASE INDUCTION MOTORS

TYPES SC, SCN, SCH, SCT, SCX, AS, SR - 2 PHASE

Our standard method of marking leads, and the schemetic representation of circuits✗is as follows:

TWO PHASE FOUR WIRE

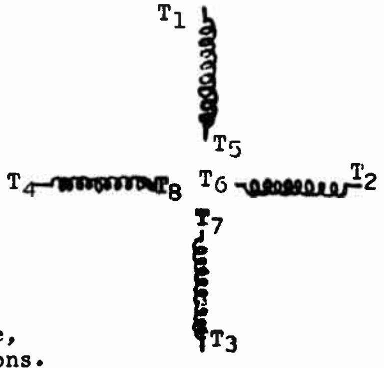


FIG. 15
All terminal lugs are stamped in accordance with this diagram.

DUAL VOLTAGE*(110/220, 220/440 etc.)

Consider T_1 and T_5 (Fig.15) as the ends of one circuit ✗, and T7 and T3 as the ends of the circuits in the second phase. To connect the stator windings for the higher voltage, the circuits in each phase are connected in series; therefore, connect T_5 to T7, and T_6 to T8 Line connections will be made to T_1, T_2, T_3 and T_4. FIGS. 16 and 19 show these connections.

To connect the stator windings for the lower voltage, the circuits in each phase are connected in parallel; therefore, connect T1 to T7, T_5 to T_3, T_2 to T_8, and T_6 to T_4. Line connection, as before, will be made to T_1, T_2, T_3 and T_4. Figs 17 and 20 show these connections.

These motors have permanent connection plate near terminal box.

SINGLE VOLTAGE* (199, 208, 220, 440, 550, 2200 etc.)

Only leads T_1, T_2 and T_3 are brought out as shown in Fig. 18 and 7 (Single voltage motors usually have single section windings rather than the double section winding shown in Fig. 15)

Connections are indicated on lubrication tags sent with motor

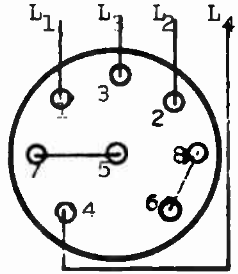


FIG. 16
High Voltage

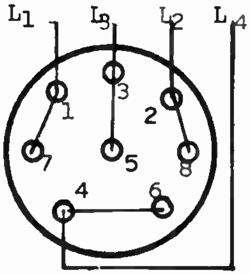


FIG. 17
Low Voltage

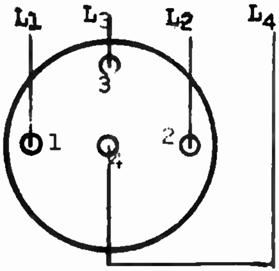


FIG. 18
Single Voltage

DUAL VOLTAGE CONNECTIONS (Similar to B6672 & B7204)

All Form A 204 and smaller; Form W, 224 to 326; Form T 204 and larger (T superseded W)

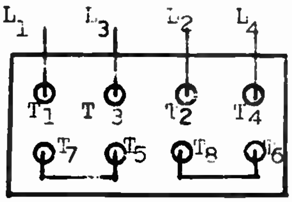


FIG. 19
High Voltage

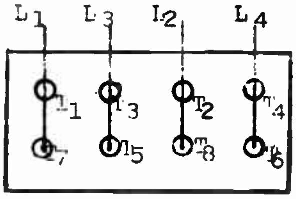


FIG. 20
Low Voltage

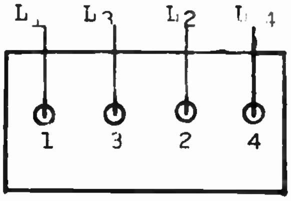


FIG. 21
Single Voltage

DUAL VOLTAGE CONNECTIONS (Similar to B4269 & B4272)
All Form S motors. Form T motors 444 and larger.

TWO PHASE THREE WIRE

For connection to a three wire system, connect motor leads T_3 and T_2, together. Line connections will then be made to T_1, T_{3-2}, and T_4; the common (or return wire) being connected to T_{3-2}.

✗ - The terms "circuit" as here used refers to one-half of the number of poles in one phase.

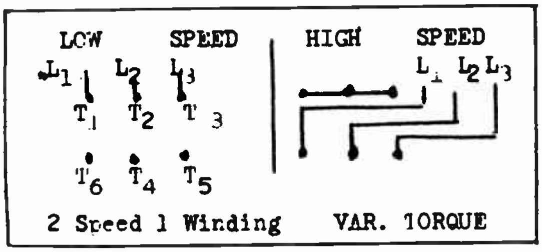
* - See price sheet for standard voltage and horsepower of individual ratings.

Century

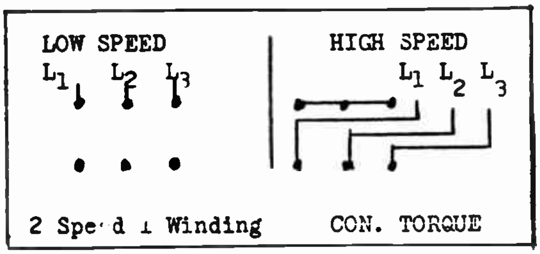
ENGINEERING INFORMATION
CONNECTION PLATES MULTI-SPEED SQUIRREL CAGE MOTORS
2 SPEED 1 AND 2 WINDINGS

3 PHASE

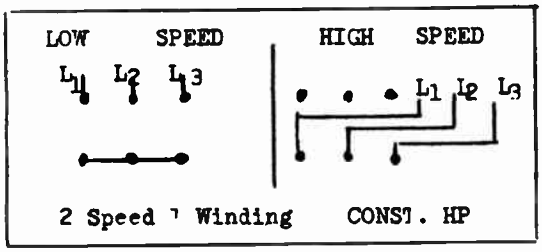
STAMPING OF AUXILIARY NAME PLATE 2 SPEED 1 WINDING 3 PHASE



SIMILAR TO B4494

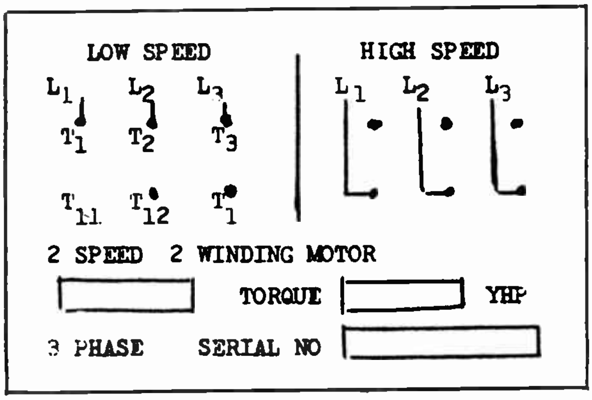


SIMILAR TO B4494



SIMILAR TO C17131

AUXILIARY NAME PLATE 2 SPEED 2 WINDING 3 PHASE



SIMILAR TO B4248

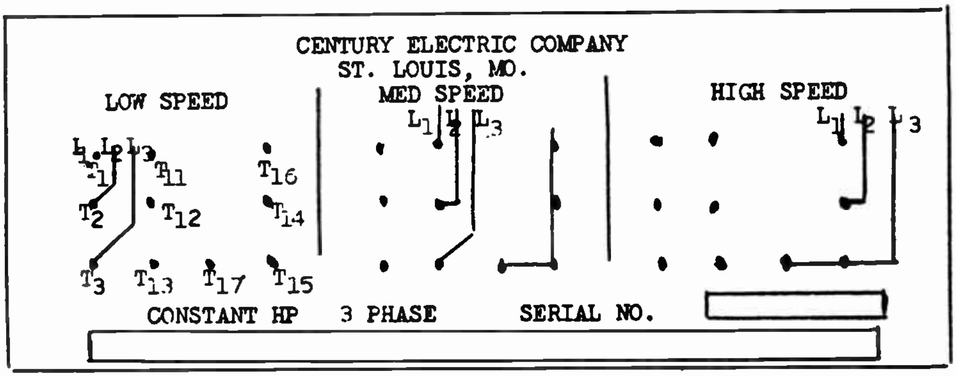
THESE DIAGRAMS ARE REPRODUCTIONS OF PLATES ATTACHED TO MOTORS WHEN THEY LEAVE THE FACTORY.

Century

ENGINEERING INFORMATION
CONNECTION PLATES MULTI-SPEED SQUIRREL CAGE MOTORS
3 SPEED - 2 WINDING - CONSTANT HP

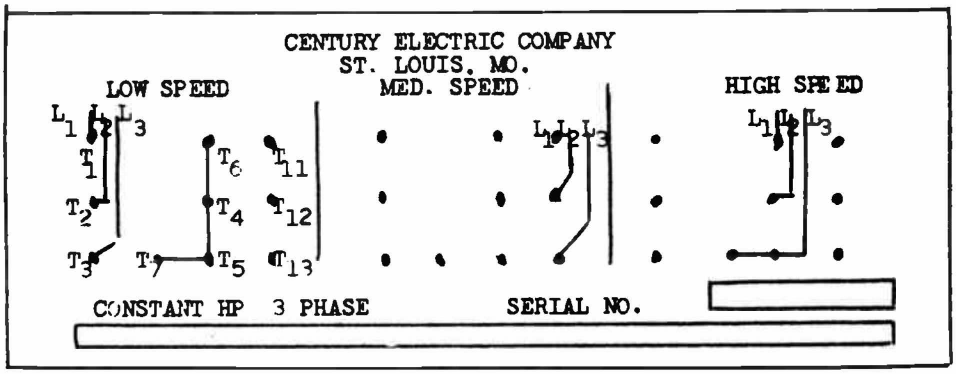
3 PHASE

AUXILIARY NAME PLATE 3 SPEED 2 WINDING CONSTANT HORSEPOWER
2-4-6; 4-8-12; 6-12-16 POLE



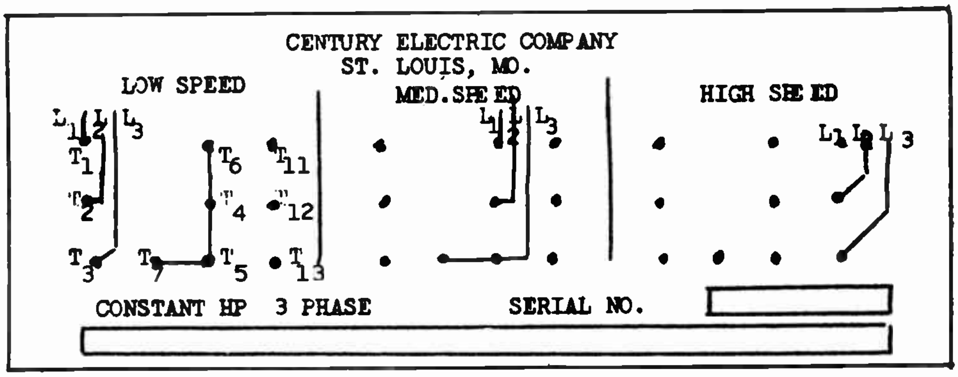
SIMILAR TO C17132

AUXILIARY NAME PLATE 3 SPEED 2 WINDING CONSTANT HORSEPOWER
4-6-8; 6-8-12; 8-12-16 POLE



SIMILAR TO C17134

AUXILIARY NAME PLATE 3 SPEED 2 WINDING CONSTANT HORSEPOWER
4-6-12; 6-8-16 POLE

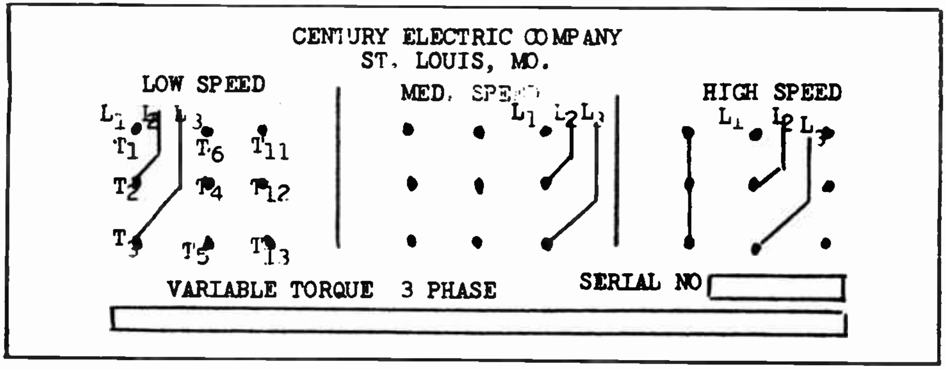


Century

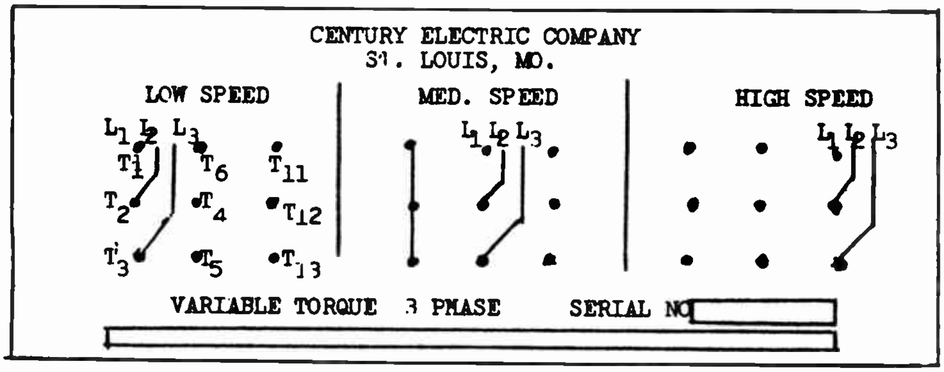
ENGINEERING INFORMATION
CONNECTION PLATES MULTI-SPEED SQUIRREL CAGE MOTORS
3 SPEED - 2 WINDING - VARIABLE TORQUE

3 PHASE

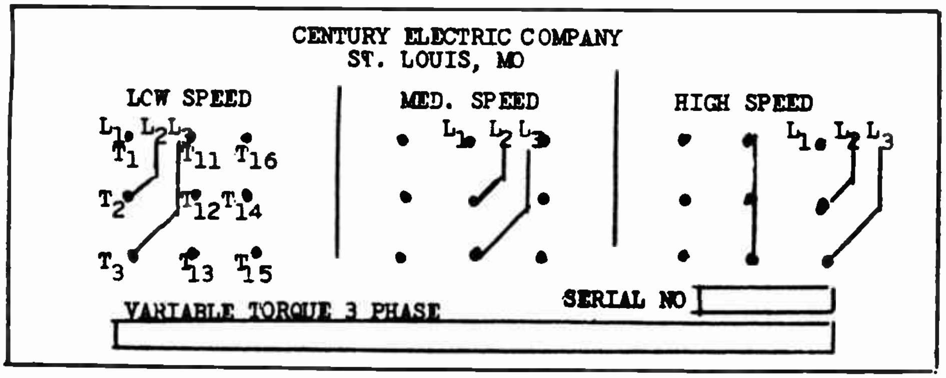
AUXILIARY NAME PLATE 3 SPEED 2 WINDING VARIABLE TORQUE
4-6-8; 6-8-12; 8-12-16 POLE



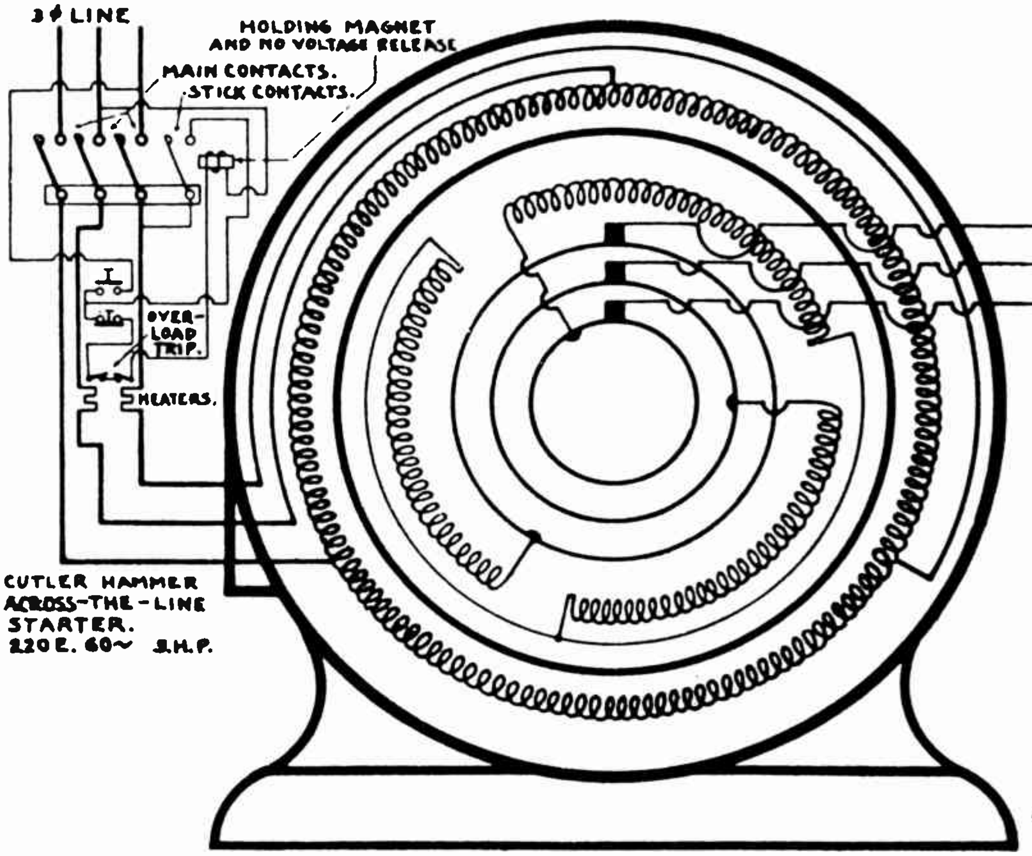
AUXILIARY NAME PLATE 3 SPEED 2 WINDING VARIABLE TORQUE
4-6-12; 6-8-16 POLE



AUXILIARY NAME PLATE 3 SPEED 2 WINDING VARIABLE TORQUE
2-4-6; 4-8-12; 6-12-16 POLE

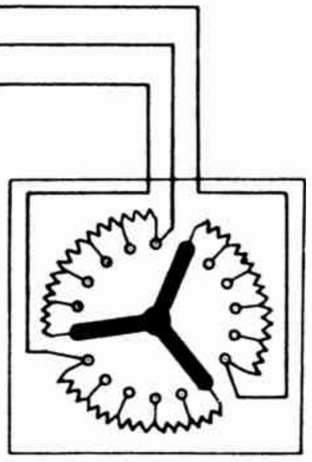


SLIP RING INDUCTION MOTOR



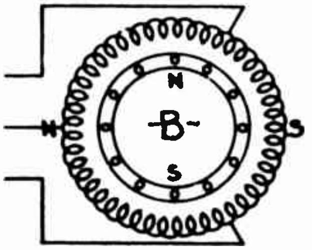
CUTLER HAMMER ACROSS-THE-LINE STARTER. 220 E. 60~ 3 H.P.

NOTE THAT THERE IS NO ELECTRICAL CONNECTION BETWEEN THE RESISTANCE BOX AND THE LINE.

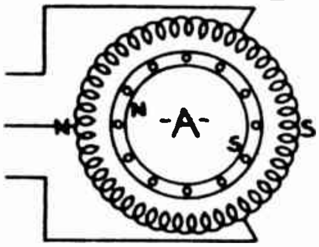


ROTOR RESISTORS.

HIGH RES. TYPE



LOW RES. TYPE



Diagrams A and B are used to show that an increase in rotor resistance causes the rotor poles to move into a more favorable position with respect to the stator poles thereby increasing the starting torque. If the rotor resistance is increased above a certain critical value, the torque will be reduced as indicated by the curves in the diagram below.

The slip ring induction motor operates on the same principle as the squirrel cage type, the revolving magnetic field set up by the stator winding reacting with the induced rotor poles to produce rotation. Insertion of resistance in the rotor circuit produces the following advantages: 1. High starting torque 2. Low starting current 3. Smooth starting action 4. Adjustable speed.

CHARACTERISTICS

The average slip ring motor will produce 3 times normal full load torque with 2.5 times normal full load current.

With all the external resistance cut out, the variation in speed from no load to full load will not exceed 5% of the full load speed. As resistance is inserted, the speed regulation becomes rapidly poorer.

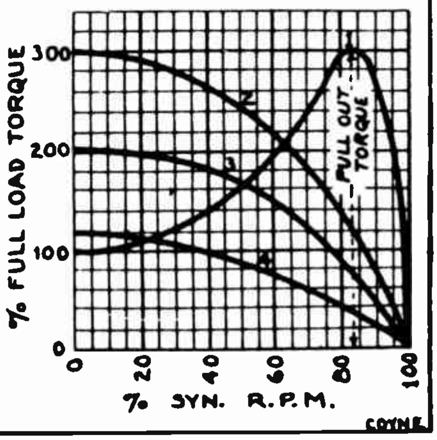
APPLICATION

Air compressors, large ventilating fans, conveyors, punch presses, printing presses, lathes, elevators, etc. may be used wherever a high starting torque, a smooth starting action, or adjustable speed is desired.

PRINCIPAL TROUBLES

Sliprings, brushes, brush holders, external rotor resistance, loose connections, bearings, insulation.

CURVE "1" ROTOR RES. ALL CUT OUT.
" "2" RES. FOR MAX. TORQUE.
" "3" MORE RES. THAN "2"
" "4" MORE RES. THAN "3"



COYNE

Speed Adjustment

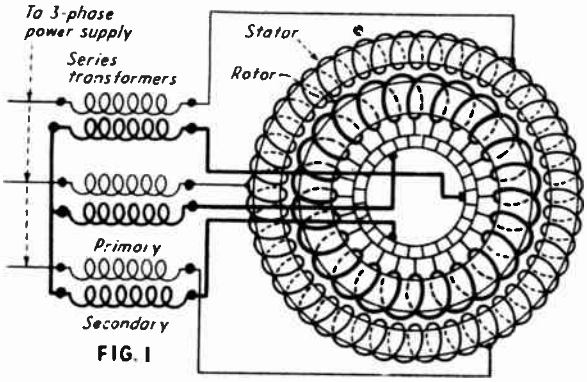


FIG. 1

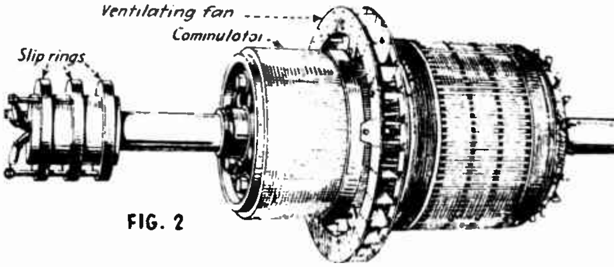


FIG. 2

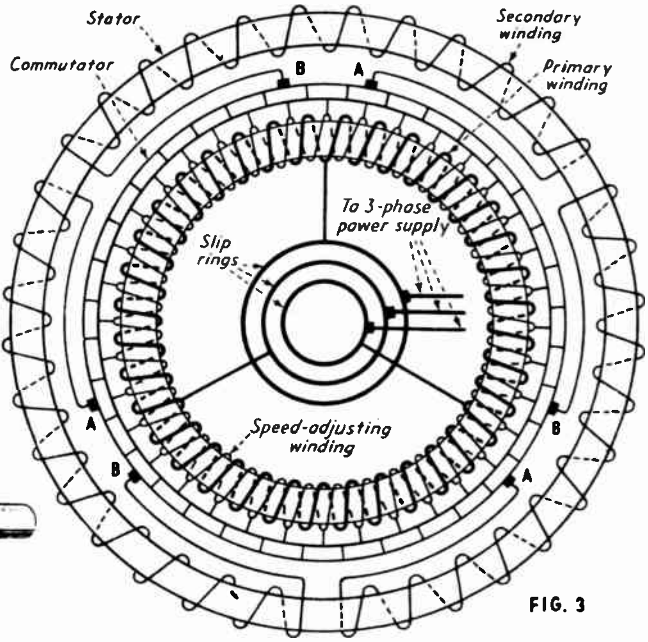


FIG. 3

Fig. 1—Diagram of polyphase commutator motor, speed of which is varied by changing position of brushes. **Fig. 2**—Rotor for adjustable-speed polyphase motor. **Fig. 3**—Diagram of rotor and stator circuits for a polyphase adjustable-speed motor

Wound-Rotor Motors

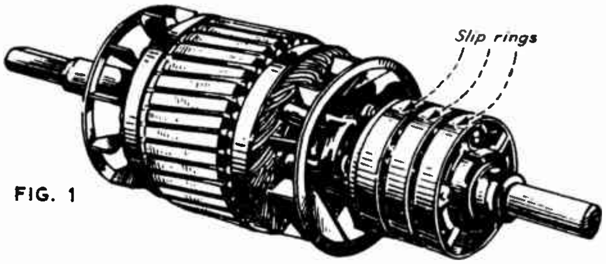


FIG. 1

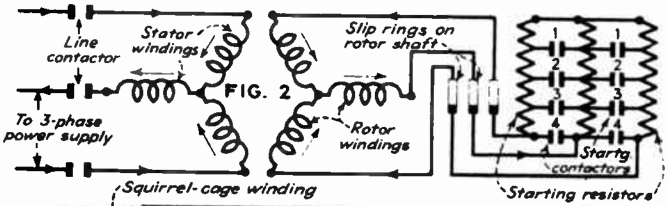


FIG. 2

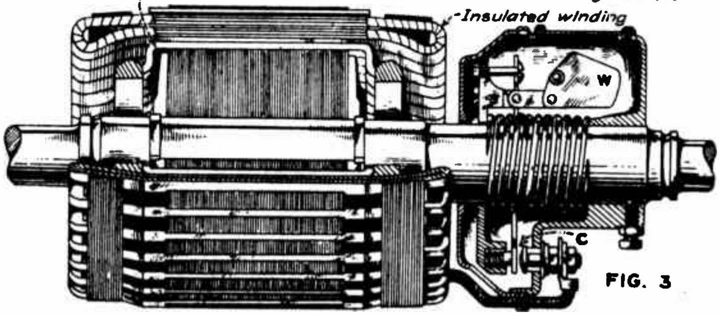


FIG. 3

Fig. 1—Rotor for a wound-rotor or slip-ring motor. **Fig. 2**—Diagram of wound-rotor motor and its starting resistance. **Fig. 3**—Combination of a squirrel-cage and a coil winding on rotor, for automatic starting.

Synchronous Motors

How They Operate

Fig. 2 shows the rotor and stator assembly of a synchronous motor. When the stator winding is connected to a polyphase alternating-current source, it produces a rotating magnetic field as in an induction motor. When the rotor field coils are connected to direct current, their *N* and *S* field poles lock into step with *S* and *N* poles of the rotating magnetic field and both rotate at the same speed or in synchronism. This speed is fixed by line frequency and number of rotor poles.

Synchronous motors are designed for two standard full-load power factors: unity and 80% leading. Unity-power-factor motors, at full load and normal field current, have 100% power factor. At less than full load, their power factor is less than unity leading, but can be regulated by adjusting the field current.

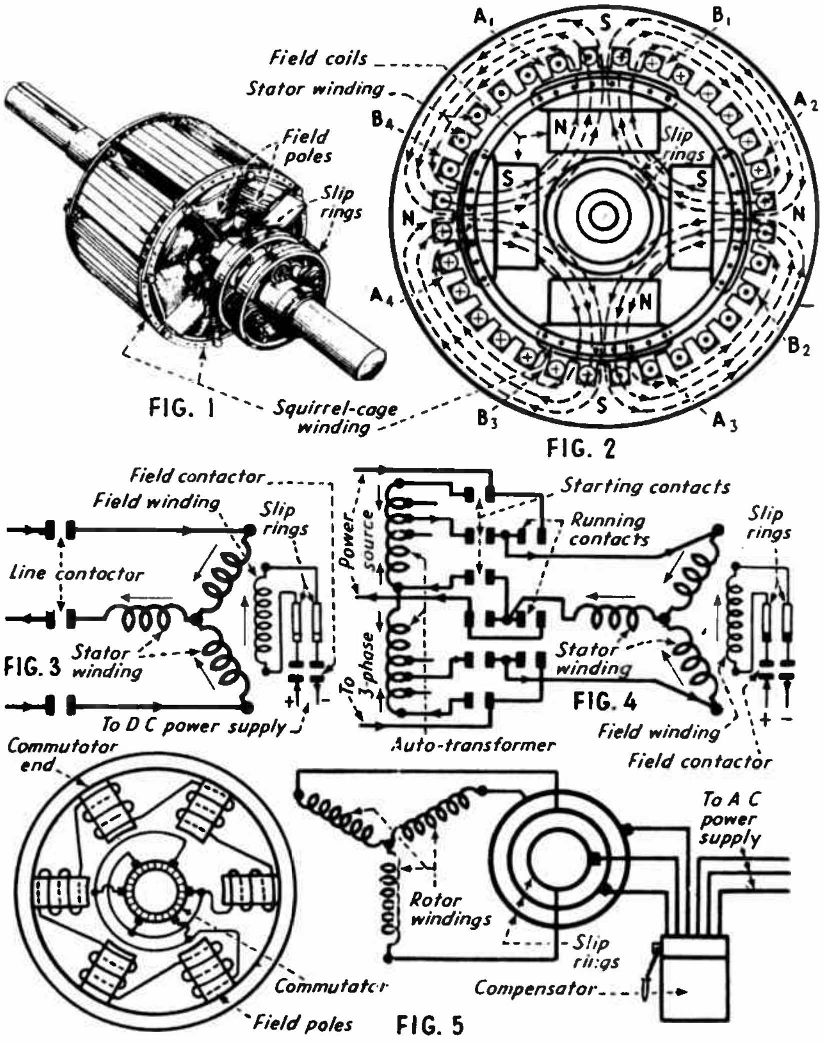
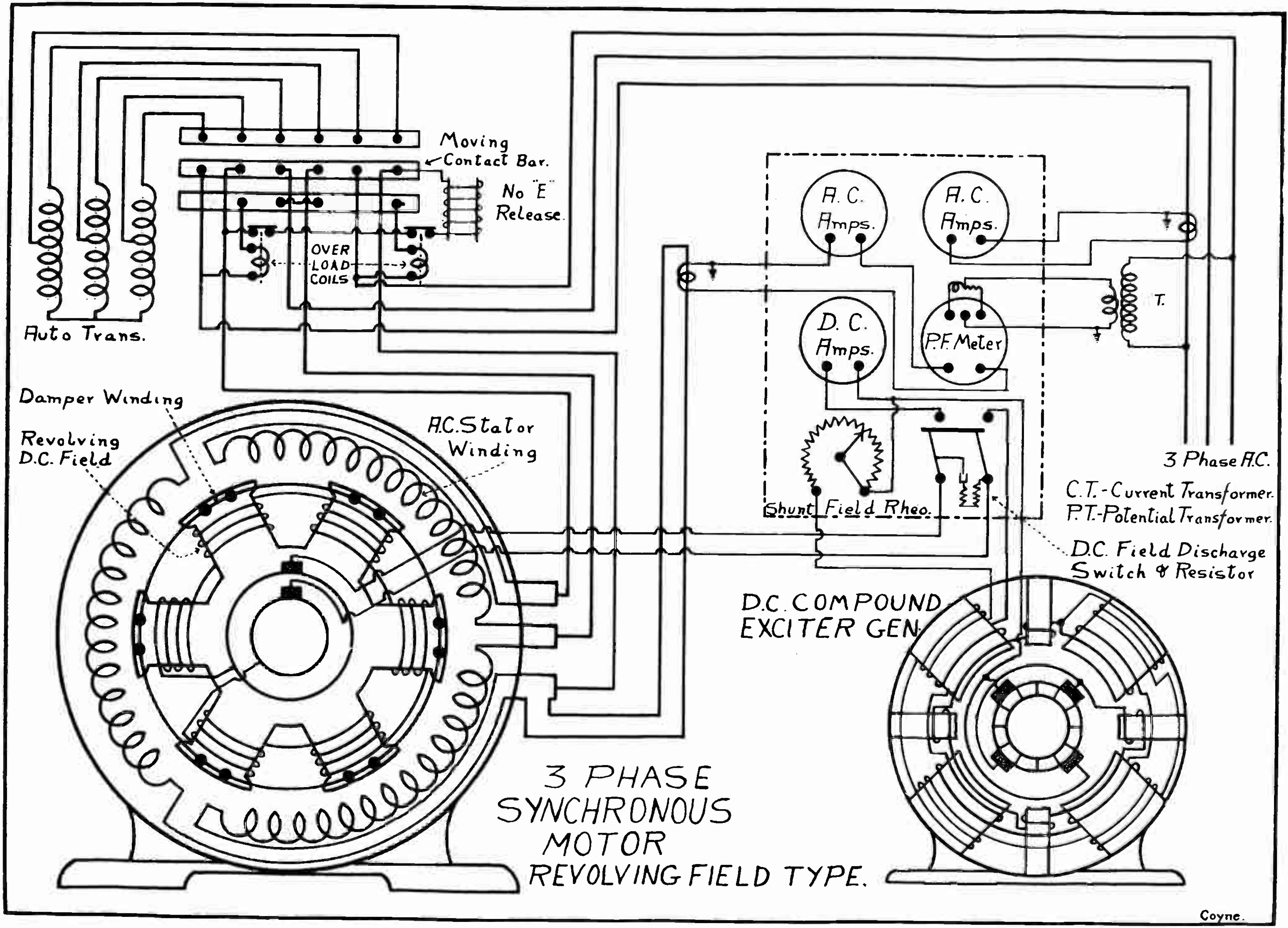


Fig. 1—Synchronous-motor rotor. Fig. 2—Diagram of synchronous-motor stator and rotor assembly. Fig. 3—Diagram of synchronous-motor connections for full-voltage starting. Fig. 4—Diagram of connections for reduced-voltage starting. Fig. 5—Diagrams of stator and rotor connections for self-synchronizing motor

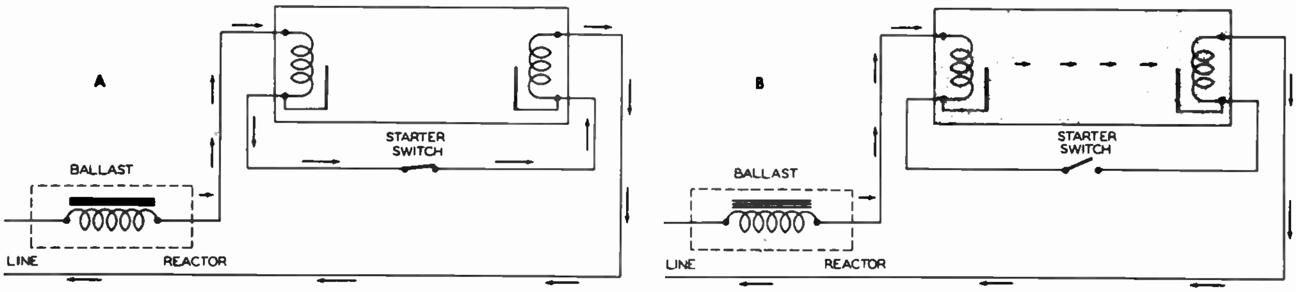
TABLE II—HORSEPOWER AND SYNCHRONOUS-SPEED RATINGS OF GENERAL-PURPOSE INDUCTION MOTORS FOR DIRECT CONNECTION

Cycles	*60*	*60*	*60*	*60*	*25*	*25*
Hp	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*	*Rpm*
25	3,600					
30	3,600					
40	3,600					
50	3,600	1,800			1,500	
60	3,600	1,800			1,500	
75	3,600	1,800			1,500	
100	3,600	1,800	1,200		1,500	
125	3,600	1,800	1,200		1,500	
150		1,800	1,200	900	1,500	
200		1,800	1,200	900	1,500	750

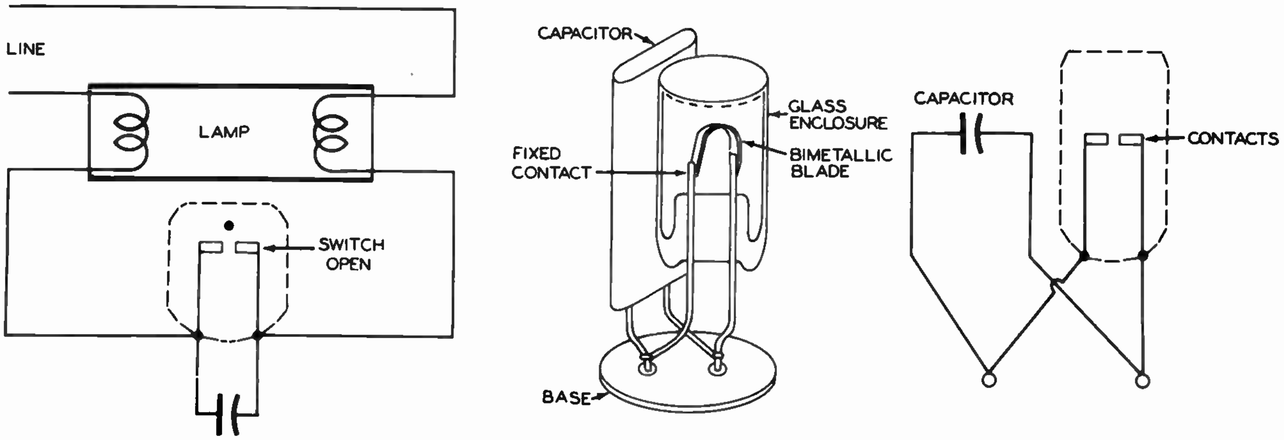


3 PHASE SYNCHRONOUS MOTOR REVOLVING FIELD TYPE.

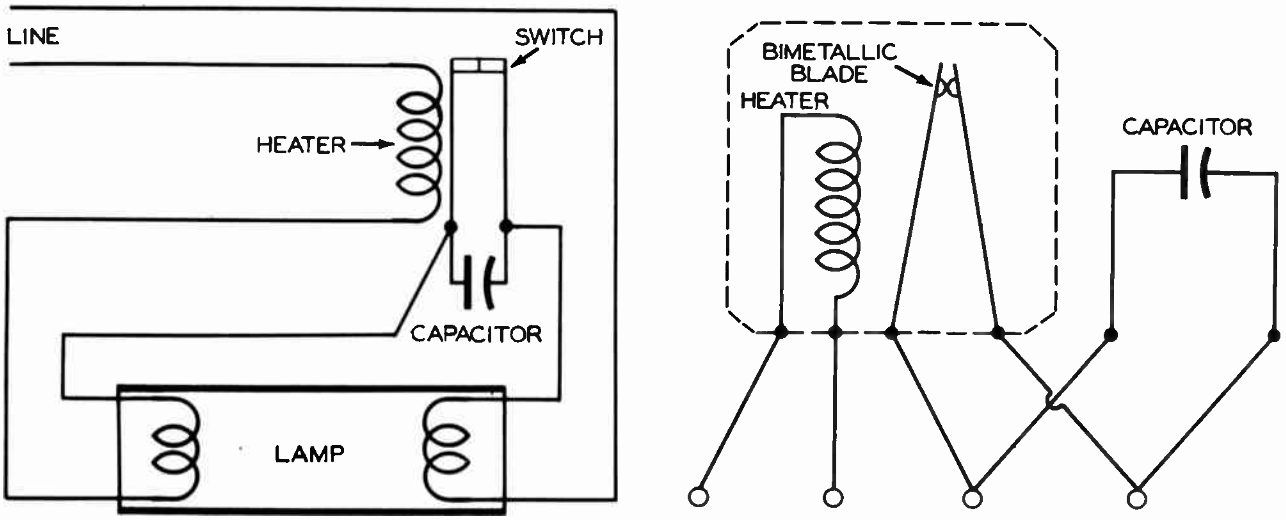
Coyne.



Starting and Operating Circuits of a Fluorescent Lamp.



Construction and Connections of a Glow Switch Starter.



Construction and Connections of a Thermal Starter.

Thermal Starter —
This type includes a resistive element which carries the filament current and is heated by this current. The heater elements heats the bi-metallic thermostat blade and causes this blade to bend and open the filament connection after the filaments have been heated enough to glow.

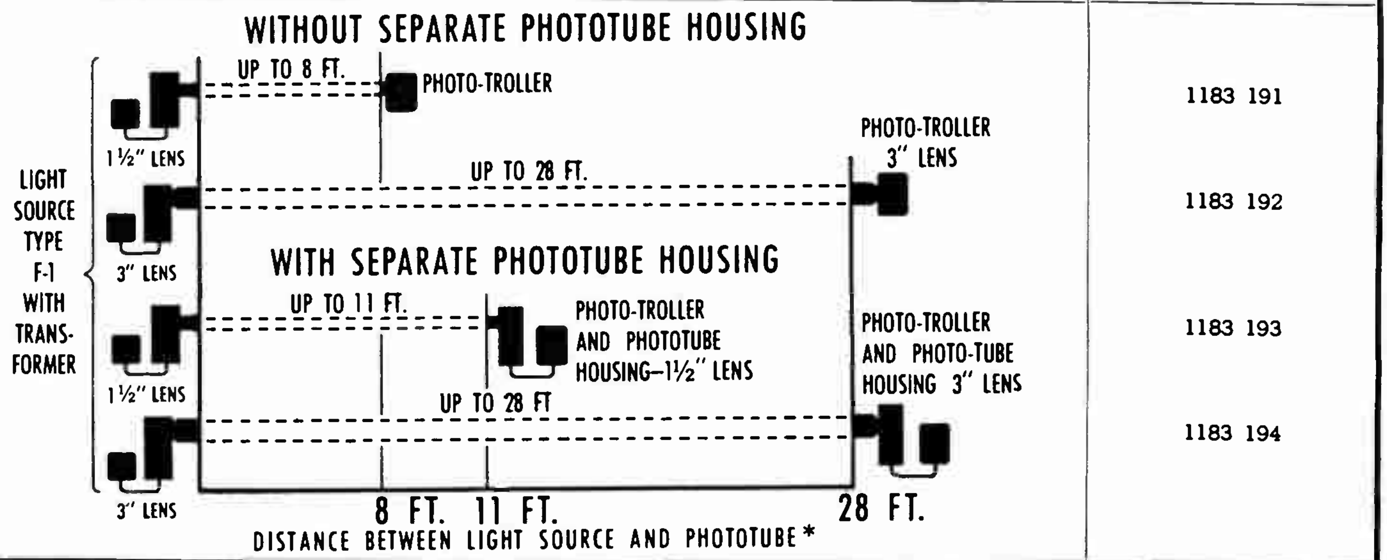
PROCEDURE FOR SELECTING COMPLETE PHOTO-TROLLER EQUIPMENT

1. Measure the distance between Photo-Troller and light source on your proposed installation.
2. Refer to charts below or on page 7 and select Photo-Troller type based on distance between light source and phototube; also on service required.
3. Check the specification of the type chosen (pages 4 to 11) to determine if it is suitable for the following variables.
   - A. Sufficient interruption of light beam necessary for maximum operating distance as explained in paragraph under Contactor or Load Relay. Ratings are based on complete interruption of a visible light beam under ideal conditions.
   - B. Speed of operation. See paragraphs under Speed of Response and Operations per Minute.
   - C. Operating conditions such as temperature, dust and weather conditions. See general description.
   - D. Space for mounting the light source, phototube housing and/or Photo-Troller.

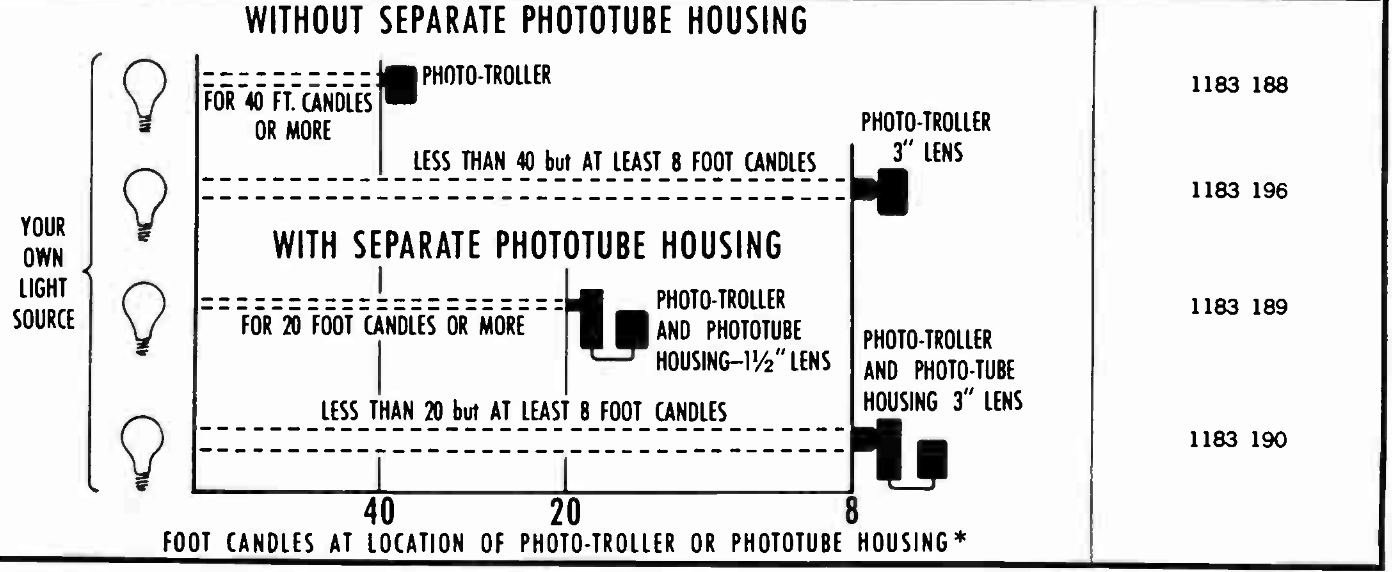
TYPE RQ—FOR INDOOR USE ONLY

Style Numbers Include All Components Shown In Chart

INCLUDING LIGHT SOURCE—Measure Distance and Select Control Here | **STYLE NUMBER**



USING YOUR OWN LIGHT SOURCE—Measure Light Intensity at Phototube Location



* The maximum operating distance is reduced to one-third of above distances when a 10% transmission light filter is used.