DIRECT CURRENT MARINE MOTORS AND CONTROLLERS

INSTRUCTIONS FOR OPERATION AND MAINTENANCE

INSTRUCTION BOOK 8585-3

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
EAST PITTSBURGH, PA.

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PURPOSE

The information in this Instruction Book should enable those who are responsible for the operation of direct current motors, generators and controllers on Merchant Marine ships, to keep the equipment in good operating condition at all times and prevent serious breakdowns and delays.

In case of serious trouble or in case of doubt, contact the nearest Service Shop (see list on page 40) where prompt and courteous advice is always available.

PART I

Direct Current Marine Motors

DESCRIPTION OF MOTORS

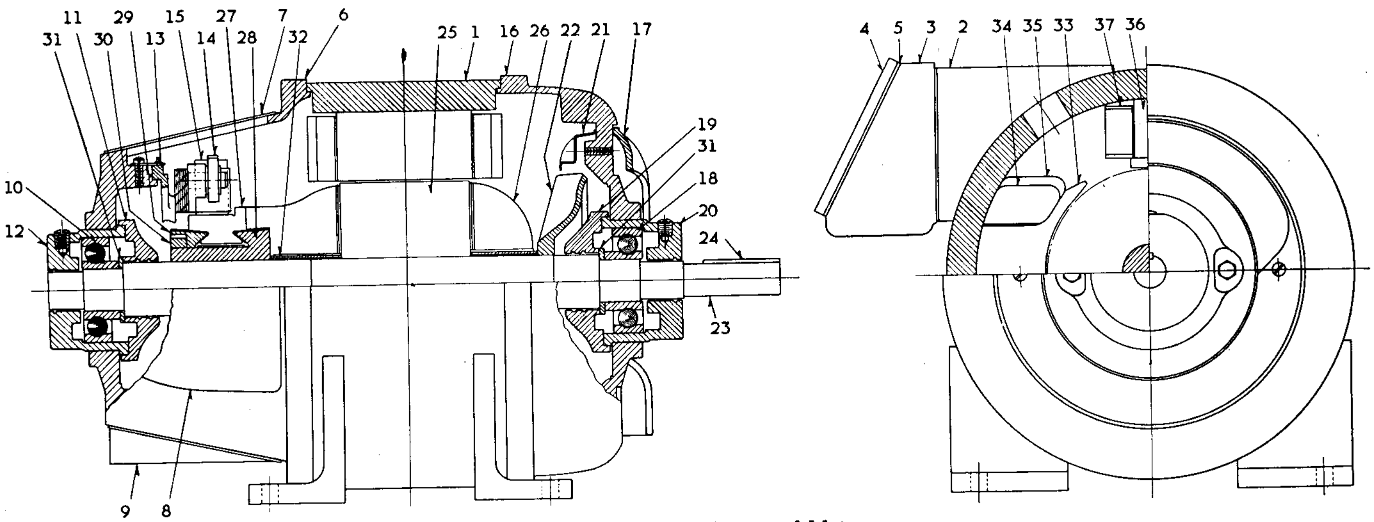


FIGURE 1—Small Horizontal Motor

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Conduit Box Adapter
3	Conduit Box
4	Conduit Box Cover
5	Conduit Box Cover Gasket
6	Front Bracket
7	Front Bracket Cover—Top
8	Front Bracket Cover—Side
9	Front Bracket Cover—Bottom
10	Front Bearing
11	Front Bearing Cap
12	Front Cartridge
13	Rocker Ring
14	Brush Holder
15	Brush
16	Rear Bracket
17	Rear Bracket Cover
18	Rear Bearing
19	Rear Bearing Cap
20	Rear Cartridge
21	Air Shield
22	Blower
23	Shaft
24	Key
25	Armature
26	Armature Coil
27	Commutator
28	Commutator Bushing
29	Commutator Ring
30	Commutator Nut
31	Bearing Spacer
32	Steel Spacer
33	Main Pole
34	Shunt Coil
35	Series Coil
36	Commutating Pole
37	Commutating Coil

Figure 1 shows the construction used in small horizontal underdeck motors (Frame sizes 204SK to F225SK). The motors have solid covers on the top bracket openings and screened covers on the bottom to make the machine drip proof protected. The covers on the commutator end are held by thumb screws and hinged for easy access to the brushes and commutator. The motors have grease lubricated ball bearings. The cooling air enters the commutator end and exhausts at the rear.

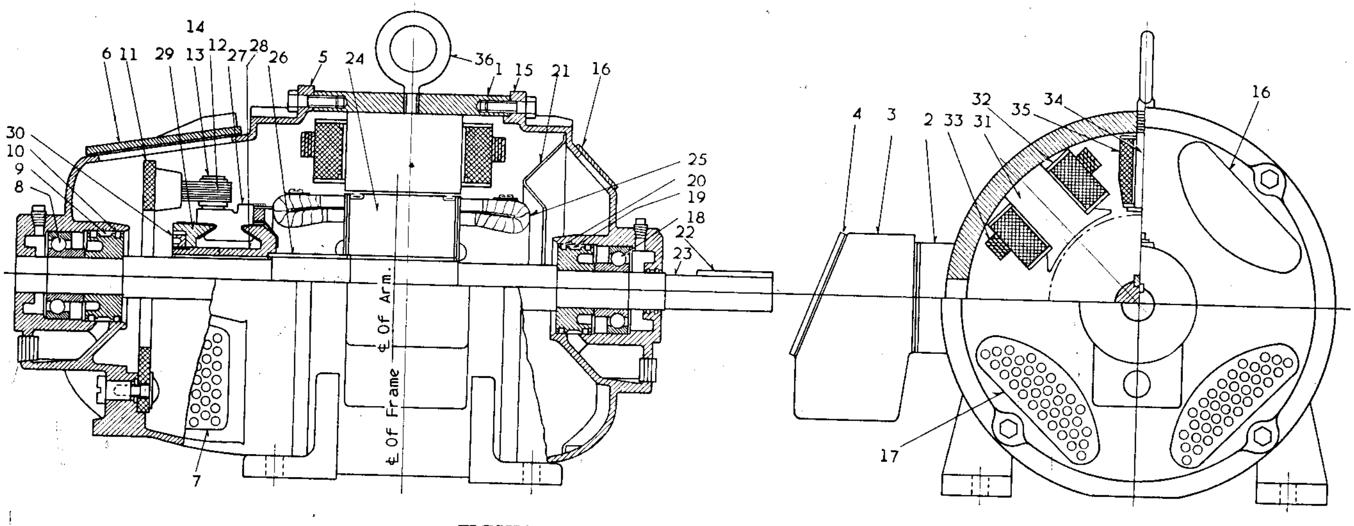


FIGURE 2—Intermediate Horizontal Motors

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Conduit Box Adapter
3	Conduit Box
4	Conduit Box Cover
5	Front Bracket
6	Front Bracket Cover—Top
7	Front Bracket Cover—Bottom
8	Front Bearing
9	Front Ring Retainer
10	Front Piston Rings
11	Rocker Ring
12	Brush Holder Rod
13	Brush Holder
14	Brush
15	Rear Bracket
16	Rear Bracket Cover—Top
17	Rear Bracket Cover—Bottom
18	Rear Bearing
19	Rear Ring Retainer
20	Rear Piston Rings
21	Air Shield
22	Shaft
23	Key
24	Armature
25	Armature Coil
26	Spacer
27	Commutator
28	Commutator Bushing
29	Commutator Ring
30	Commutator Nut
31	Main Pole
32	Shunt Coil
33	Series Coil
34	Commutating Pole
35	Commutating Coil
36	Eye Bolt

Figure 2 shows the construction used in intermediate horizontal underdeck motors (Frames 254SK and 284SK). The motors have covers similar to the small motors (Figure 1). The cooling air enters the rear bracket and is exhausted out the front bracket. No fan is used.

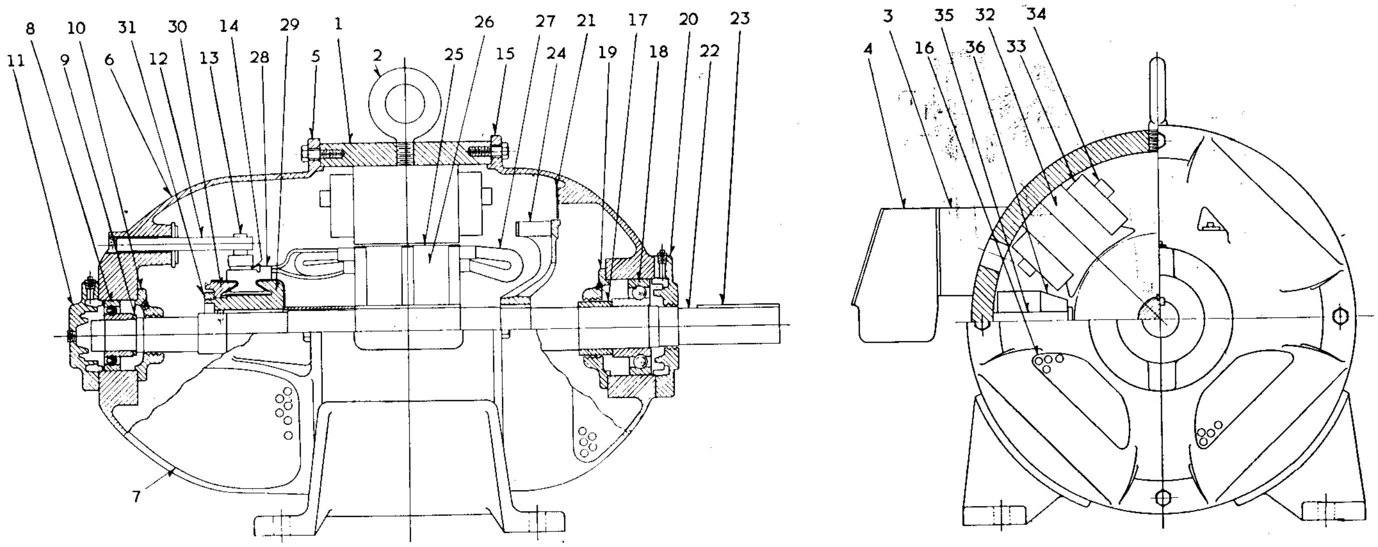


FIGURE 3—Large Horizontal Motors

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Eye Bolt
3	Conduit Box Adapter
4	Conduit Box
5	Front Bracket
6	Front Bracket Cover—Top
7	Front Bracket Cover—Bottom
8	Front Breaing
9	Front Bearing Spacer
10	Front Bearing Cap—Inner
11	Front Bearing Cap—Outer
12	Brush Holder Rod
13	Brush Holder
14	Brush
15	Rear Bracket
16	Rear Bracket Cover—Bottom
17	Rear Bearing Spacer
18	Rear Bearing
19	Rear Bearing Cap—Inner
20	Rear Bearing Cap—Outer
21	Air Shield
22	Shaft
23	Key
24	Blower
25	Armature Assembly
26	Armature Punchings
27	Armature Coil
28	Commutator
29	Commutator Bushing
30	Commutator Ring
31	Commutator Nut
32	Main Pole
33	Shunt Coil
34	Series Coil
35	Commutating Pole
36	Commutating Coil

Figure 3 shows the construction used on large horizontal underdeck motors. These motors have similar protective covers to those in Figures 1 and 2. These motors are ventilated with large fans drawing air in the lower rear bracket and exhausting it out the front bracket. The Brush Holder Rods are pressed into reamed holes in the bracket arms.

This same construction is used for small generators. In many cases of engine drive the rear bracket is omitted and a special adapter is used between generator and engine.

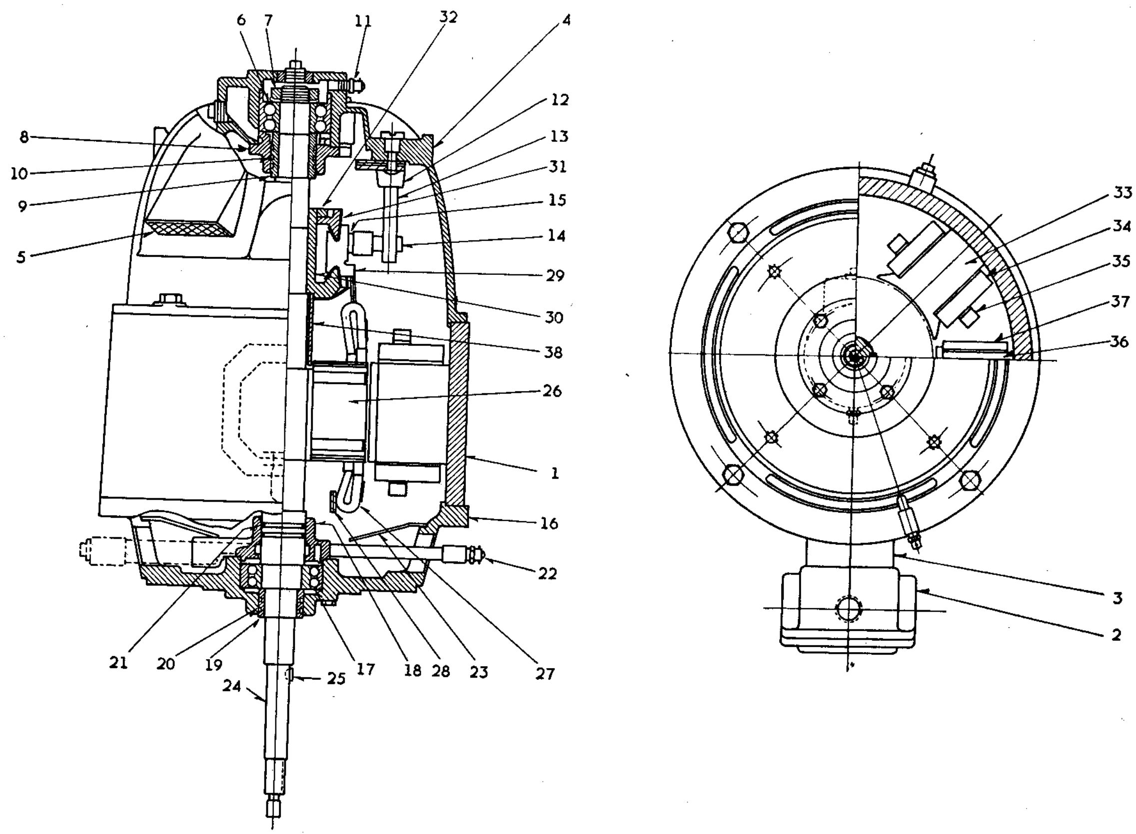


FIGURE 4—Small Vertical Motors

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Conduit Box
3	Conduit Box Adapter
4	Upper Bracket
5	Upper Bracket Cover
6	Upper Bearing
7	Upper Bearing Nut
8	Upper Bearing Cap
9	Upper Ring Retainer
10	Upper Piston Rings
11	Upper Alemite Fitting
12	Rocker Ring
13	Brush Holder Rod
14	Brush Holder
15	Brush
16	Lower Bracket
17	Lower Bearing
18	Lower Bearing Cap
19	Lower Ring Retainer

ITEM NO.	DESCRIPTION OF PART
20	Lower Outer Piston Rings
21	Lower Inner Piston Rings
22	Lower Alemite Fitting
23	Air Shield
24	Shaft
25	Woodruff Key
26	Armature Assembly
27	Armature Coil
28	Armature Coil Support
29	Commutator
30	Commutator Bushing
31	Commutator Ring
32	Commutator Nut
33	Main Pole
34	Shunt Coil
35	Series Coil
36	Commutating Pole
37	Commutating Coil
38	Shaft Sleeve

Figure 4 shows the construction used on small Vertical motors (frames 204SK to 284SK). The general construction is similar to that for the horizontal motors (Figures 1 and 2). The lower bracket is machined to provide the mounting support. The top bracket is equipped with louvre type covers to provide the necessary openings for ventilation and still keep the motors dipproof.

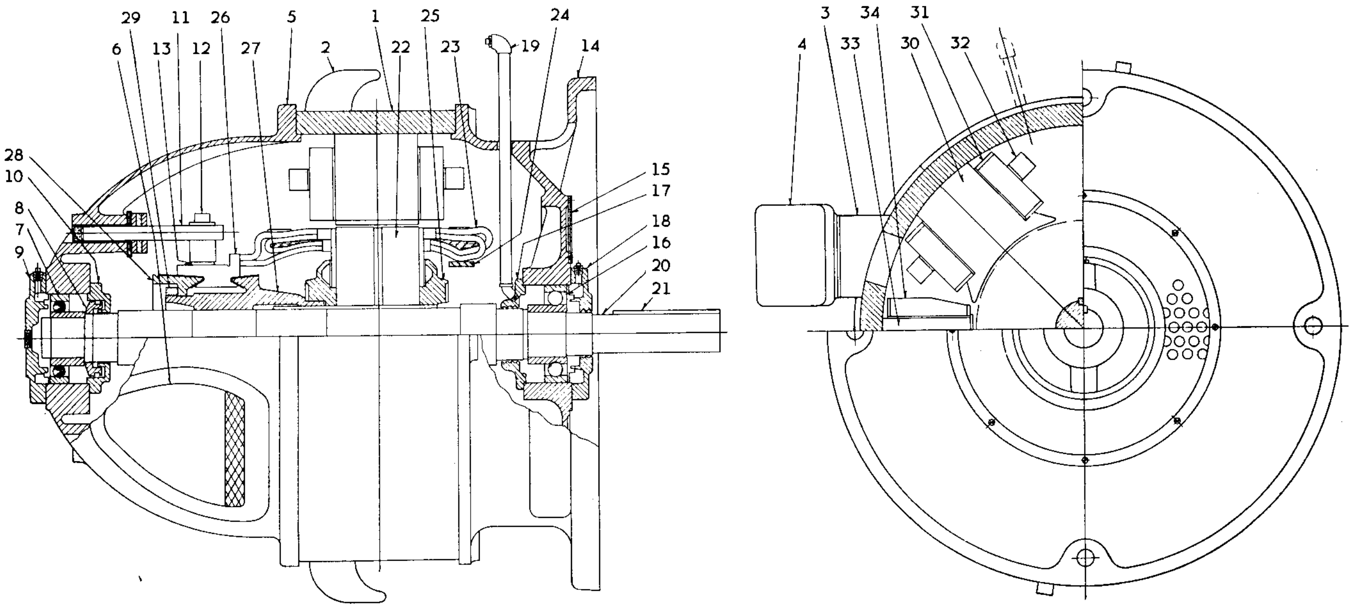


FIGURE 5—Large Vertical Motors

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Lifting Lugs
3	Conduit Box Adapter
4	Conduit Box
5	Upper Bracket
6	Upper Bracket Cover
7	Upper Bearing
8	Oil Thrower
9	Upper Bearing Cap—Inner
10	Upper Bearing Cap—Outer
11	Brush Holder Rod
12	Brush Holder
13	Brush
14	Lower Bracket
15	Lower Bracket Cover
16	Lower Bearing
17	Lower Bearing Cap—Inner
18	Lower Bearing Cap—Outer
19	Grease Inlet
20	Shaft
21	Key
22	Armature Assembly
23	Armature Coil
24	Armature Coil Support
25	Armature End Plates
26	Commutator
27	Commutator Bushing
28	Commutator Ring
29	Commutator Nut
30	Main Pole
31	Shunt Coil
32	Series Coil
33	Commutating Pole
34	Commutating Coil

Figure 5 shows the construction used in the large vertical motors (frame 43SK and up). These motors are the same as the horizontal motors shown on Figure 3 except for the lower bracket, frame feet and covers. The lower bracket has a large flange for the support of the motor. Louvre type covers are provided on the upper bracket for ventilation and protection.

ITEM NO.	DESCRIPTION OF PART
1	Frame
2	Conduit Box
3	Conduit Box Cover
4	Front Bracket
5	Front Bearing
6	Front Inner Bearing Cap
7	Front Outer Bearing Cap
8	Front Alemite Fitting
9	Commutator Cover
10	Rocker Ring
11	Brush Holder Rod Assembly
12	Brush Holder
13	Brush
14	Rear Bracket
15	Rear Bearing
16	Rear Inner Bearing Cap
17	Rear Outer Bearing Cap
18	Rear Alemite Fitting
19	Revolving Seal
20	Shaft
21	Extension Key
22	Washer
23	Nut
24	Lock Washer
25	Drain Cock
26	Armature Assembly
27	Armature Punchings
28	Armature End Plate
29	Armature Coil
30	Armature Coil Support
31	Commutator
32	Commutator Bushing

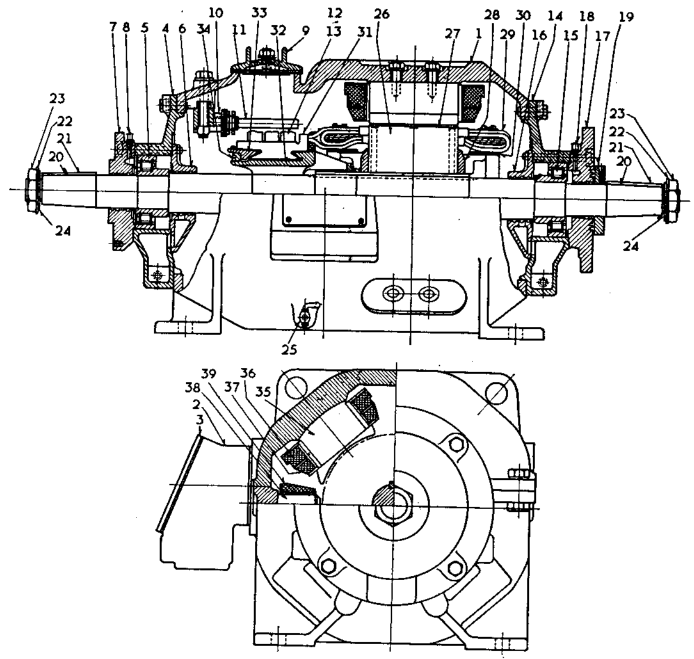


FIGURE 6—Deck Motors

ITEM NO.	DESCRIPTION OF PART
33	Commutator Ring
34	Commutator Nut
35	Main Pole
36	Shunt Coil
37	Series Coil
38	Commutating Pole
39	Commutating Coil

Figure 6 shows the construction used in the waterproof deck motor. The frame is split horizontally for easy access to repair the armature. The brushes are on two arms located in the top of the motor and easy access to the brushes is through one large cover.

OPERATION OF MOTORS

Normally the operation of motors consists of pushing the start and stop button or manipulating the master switch. Never attempt to operate any motor with the control "shorted out" as the motor will draw dangerous currents and probably flash over and cause severe damage to the commutator and brush rigging.

If motor fails to start properly or does not come up to normal speed investigate immediately. Usual causes for failure to start are:

1. Blown fuse or open knife switch.
2. Frozen bearing on motor or driving auxiliary.
3. Broken wire.
4. Trouble in starting switch or control circuit; check to be sure all contacts and relays are operating in the normal fashion.

Usual causes for failure to come up to speed are:

1. Motor may be overloaded.
2. Bearing may be tight (evidenced by local heating).
3. Accelerating contacts may be sticking and some starting resistance may be in the circuit.
4. Field rheostat may be set for slow speed.

While the motor is running occasionally check the operation. Check for overheating, in case of doubt use a thermometer. The name plate will give the permissible rise above the ambient or room temperature. Check the commutation. There should be practically no visible sparking—small blue pin sparks are not harmful. In normal operation the commutator will take on a dark color but will become highly polished. In general disregard any general coloring of the commutator. If harmful sparking is occurring it will be evidenced by a burning and pitting of the surface. If the commutator becomes rough have it smoothed up, often a piece of sandpaper is sufficient.

The usual causes of poor performance are:

POOR COMMUTATION

1. Incorrect brush position.
2. Poorly fitted or worn out brushes.
3. Rough commutator.
4. Short circuit in armature.
5. Overload.
6. Brushes tight in the holders.
7. High mica on the commutator (should be undercut $\frac{1}{32}''$).

OVERHEATING

1. Overload on motor.
2. Short circuit on one or more armature coils (usually severe and eventually results in a burned out coil).
3. Grounded circuit resulting in a short circuit drawing heavy current to ground.

HOT BEARINGS

1. Bent shaft.
2. Misalignment of motor and auxiliary.
3. Lack of grease or too much grease.
4. Broken bearing or dirt in the bearing.
5. Rubbing of the bearing cap and resultant scoring of the shaft.

When the motor is stopped be sure all switches are left open. Check to be sure motor stops when stop button or master switch is manipulated to be sure the circuit is opened. While motor is at rest keep it dry and clean. If excess moisture is present take steps to reduce it as much as possible.

If motors have been idle for a long period (several months) or have been submerged they should be carefully inspected and thoroughly dried out, if necessary. If the motors have been submerged it is best to call in a service man who can advise the proper procedure for reconditioning the apparatus.

GENERATORS: Electrically there is very little difference between a direct current motor and a direct current generator. In the normal operation of small generators always keep all switches open and the field rheostat set for minimum voltage when the set is at rest. After the set is brought up to speed—then adjust field rheostat to get normal voltage and close the line switch or circuit breaker placing generator on the line.

The normal procedure for inspection and maintenance of motors will apply to the small generator sets. It is recommended that the generators be included in the same inspection and maintenance routine.

MAINTENANCE OF MOTORS

GENERAL

The most important item in maintenance of electrical equipment is cleanliness. Always keep the equipment clean, dry, and free of foreign materials. Covers are provided to protect the equipment and should always be kept in place and securely fastened. Never leave loose metallic pieces around the machines, especially magnetic parts as these may be attracted by the field of the machine and become wedged in the air gaps and damage the armature or field coil insulation.

Occassionally blow out the machine using an air blast (not over 15 pounds pressure as too high a pressure will lift the insulation wrappings on the coils and blow the dirt into these cracks resulting in damaged coils and eventual failure).

When replacing worn out parts always replace with the same new part. Use the spare parts provided for each application and be sure and reorder the spare at the first opportunity. Be careful in replacing parts to get them in the same relative position, especially on the field coils as otherwise the polarity may become reversed.

If machines are kept clean and properly lubricated they will require very little attention and care.

INSULATION

INSULATION RESISTANCE—The best index to the condition of the insulation on any machine is through the insulation resistance. This can be easily measured directly with a "megger" which will give the resistance in ohms or megohms. If a megger is not available the resistance can be calculated. A 500 volt voltmeter and any source of direct current voltage from 100 to 500 volts is required. The method of making resistance measurement with the voltmeter is to first read the voltage of the line, then connect the resistance to be measured in series with the voltmeter and take a second reading. The measured resistance is calculated from the formula:

$$R = \frac{r\,(V-v)}{v} \text{ or } R = r\left(\frac{V}{v} - 1\right)$$

Where V=Voltage of the line.
v=voltage with resistance in series with voltmeter.
r = resistance of voltmeter in ohms (given on the inside cover of voltmeter).
R = insulation resistance.

If a grounded circuit is used in making this measurement care should be taken to connect the grounded side of the line to the frame of the machine. The voltmeter should be connected between the windings and the other side of the circuit.

Periodic measurement of the insulation resistance will give a good index of its condition. In general a slight variation in readings is to be expected and the exact readings will vary from machine to machine. The best use can be made only by comparing the readings on a particular machine with former readings on the same machine. In general the insulation resistance of the machine when cold should not be less than one megohm. The resistance in megohms when motor is hot should not be less than

$$\frac{\text{Rated Voltage}}{\dfrac{\text{Volts} \times \text{current} + 1000}{1000}}$$

If the resistance is low it usually indicates dampness. Mild amounts of moisture can be removed by local heating. A light bulb provides a suitable source.

CARE OF INSULATION: Always be careful of the insulation around any machine. Keep all coils clean and free of oil and salty water. A dry rag will usually be sufficient to remove most dirt and if done often enough it will be sufficient. In extreme cases the windings may be cleaned by using carbon tetrachloride. Use this sparingly (a small amount on a rag) and in a well ventilated place because of the nauseating effect of the fumes. Wipe carefully all windings with a dry rag after using carbon tetrachloride and keep the solution away from the bearings.

Never use a sharp instrument on any coils as it is very easy to damage the insulation.

After machines have been in operation several years it is good practice to apply a coat of baking varnish to all coils. Baking varnish is much superior to air-drying varnish. Varnish can be obtained from the nearest Westinghouse dealer and the Westinghouse service shops are equipped to bake machines.

BALL AND ROLLER BEARINGS

Quietness and life of ball and roller bearings depends largely on cleanliness and proper lubrication.

INSPECTION. Never open the bearing housing under conditions which would permit entrance of dirt.

External inspection of the bearings is usually sufficient at the time of greasing. Check to see if housing is exceptionally hot (much higher temperature than neighboring parts of bracket and frame). If bearing is noisy it should be investigated. (Noise is usually accompanied by overheating and the same remedy will satisfy both—See Hot Bearings under Operation of Motors (P. 7).

If practicable, it is desirable for the most satisfactory service, to open the bearing housings once a year, or after every 5000 hours operation, to check the condition of the bearings and grease. If difficult to inspect the pulley or pinion end bearing, the condition of the bearing at the opposite end will usually be representative of both.

If grease deterioration has occurred or if dirt has gained entrance to the housing, the bearing and housing parts should be thoroughly cleaned out and new grease added.

LUBRICATION. Grease is used as a lubricant. Ordinary cup greases are not satisfactory because of great tendency to deteriorate under the severe churning action of the bearings. To be suitable for ball or roller bearing lubrication a grease should be compounded from a pure mineral oil and a sodium base soap. It should have minimum free oil or separation in storage. It should be free from dirt and fillers, such as powdered mica, flake graphite, etc. It should be free from acid or alkali or from ingredients which will form these compounds. It should have maximum resistance to drying, gumming or oxidation. The melting point or dropping temperature should be about 300° F (by The Ubbelohde method). The grease should have a medium consistency. In general use a grease of a reliable manufacturer especially recommended for ball or roller bearings. Always keep grease clean using only closed containers.

A small amount of lubricant is essential, sufficient to maintain a film of lubricant over the surface of the balls and races. Too much grease will cause churning, overheating and grease leakage. If grease leakage occurs the bearing has been over filled, or the grease used is not suitable for the particular application.

If high pressure guns are used, great care should be used to avoid over lubrication.

As a guide, it is suggested that grease should be added every three months of operation in amounts as indicated in the following table. If experience indicates that these quantities result in a surplus of grease in the bearing, the quantity should be reduced or the greasing periods lengthened or both. The ideal condition is that the bearing housing be from 1/3 to 1/2 full of grease.

As the shaft extension diameter is easily determined and is roughly proportional to the bearing size the following table for grease additions is prepared on this basis.

SHAFT EXTENSION DIAMETER	WT. OF GREASE TO BE ADDED
3/4 to 1 1/4	3/4 oz.
1 1/4 to 1 7/8	1 oz.
1 7/8 to 2 3/8	2 oz.
2 3/8 up	3 oz.

1 oz.—1 1/4 cu. in.

Horizontal motors may be cleaned with flushing oil without dismantling the motor. Remove inlet and outlet grease plugs and force the flushing oil through the bearing. Refill bearing immediately with new clean grease.

Vertical motors cannot be cleaned without dismantling the motors.

MECHANICAL DAMAGE: In mounting or removing bearings pressure should be applied only against the inner race, always using a sleeve or other intermediate piece if mounting or removal is accomplished by hammer blows. Cover bearing carefully during these operations if there is danger of flying particles getting in among the balls or rollers.

Figure 7 shows a bearing puller which can be easily made for removing the bearings.

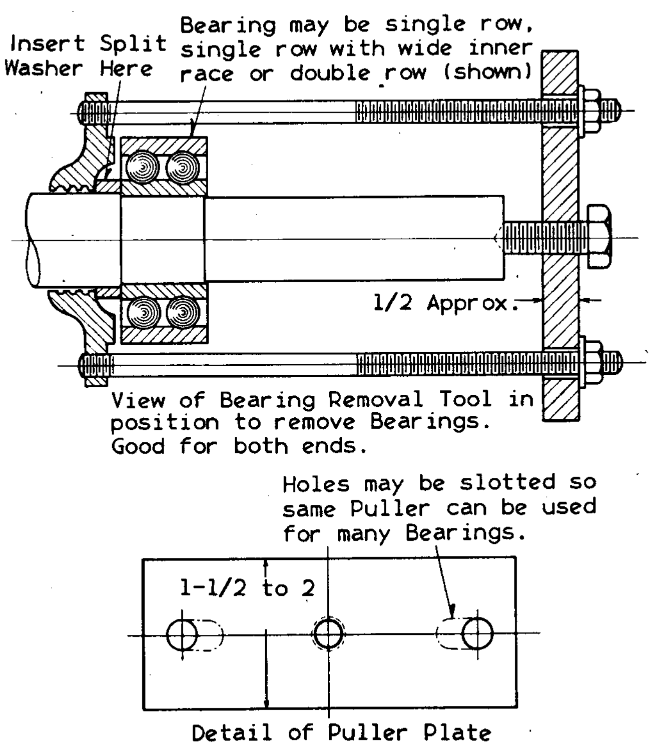


FIGURE 7—Bearing Puller

In mounting or removing pulleys, couplings or pinions, the bearing must not be subjected to axial pressure, especially hammer blows as when these accessories are driven on to the shaft with a mallet. Any pressure of this kind should be taken by supporting the opposite end of the shaft against a stop of some kind.

BRUSHES AND BRUSHHOLDERS

FIT AND WEAR: Occassionally check the brushes and brushholders. The brushes should always be free to slide in the holders. The tension fingers should be resting firmly on the brush and should be of such tension as to give a pressure of approximately two pounds per square inch at the surface of the commutator.

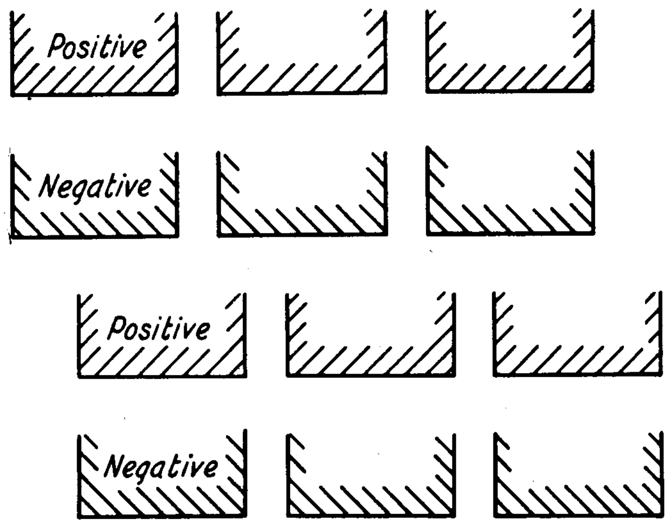


FIGURE 8—Correct Method of Staggering Brushes

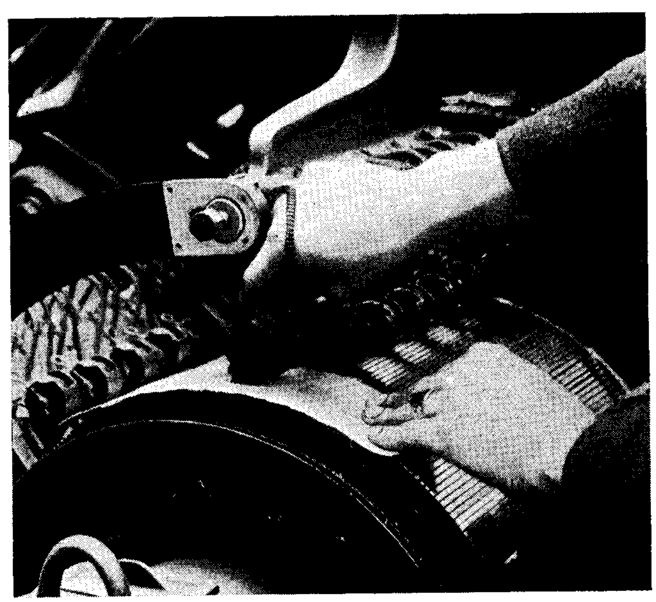


FIGURE 9—Proper Method of Seating Brushes

The brushholders should be set so that the lower edge is approximately $\frac{1}{16}$ to $\frac{1}{8}$ inch from the face of the commutator.

The brushes should be staggered wherever possible. Figure 8 shows the correct method of staggering.

REPLACEMENT: The brushes should be replaced when they have worn to the extent that the pressure finger is about to rest on the holder and no longer bear on the brush. Replace the brushes with the same grade of brush and avoid mixing grades on one machine as brushes of different grades have slightly different characteristics and there will be selective action if the grades are mixed on the machine. Included in the spares are one set of brushes, as soon as these are used new replacements should be ordered.

When new brushes are installed they must be sanded in to be sure the wearing surface conforms to the commutator. Figure 9 illustrates the proper method. The procedure is to insert a piece of sandpaper between the brush and commutator and while pressing down on the brush, withdraw the sandpaper pulling in the direction of rotation. Release pressure and reinsert the sandpaper. The process should be continued until the brush is fitted over its entire surface. Be careful to keep sandpaper next to the surface of the commutator to avoid rounding the edge of the brushes. Use a grade "1½" sandpaper for the initial cut and grade "0" for the finish cut.

After sanding in the brushes, blow out the surplus carbon with an air hose (not over 15 pounds pressure).

NOTE: There are available on the market many brush seaters which help to seat brushes. When brush seater is used, the brushes still should be given a preliminary sanding and then use the brush seater while the machine is running. Be careful not to use brush seater to excess as the dust can be harmful.

ARMATURE

COILS: Keep armature coils clean and free of foreign particles. If excessive carbon dust or other dirt tends to collect, wipe with a damp cloth and blow out with an air hose (not over 15 pounds pressure). In handling the armature, never rest or support it on the coils or commutator as they can be very easily damaged; always use a rope sling on the shaft or steel punchings.

COMMUTATOR: With use the commutator should take on a uniform dark color and the surface should become highly polished. If it does this it need be given but very little attention. Occasionally wipe the face using a canvas cloth free of lint. If the commutator shows signs of roughness it should be smoothed with a piece of sandpaper (grade 2/0). If the commutator has become too rough it will be necessary to remove the armature and turn the commutator in a lathe. Be careful to keep the copper particles out of the windings. The mica should be undercut $\frac{1}{32}$ of an inch after turning.

DRAINING DECK MOTORS

All deck motors are equipped with either an automatic drain valve or a hand operated drain cock. If the former is used check to be sure the float is operating properly and the passage is not obstructed. On motors equipped with the hand cock the drain should be opened periodically (approximately once a month). A small amount of water is to be expected from the normal "breathing" of the motor. Any unusual amount (more than ½ cupful) should be investigated. Possible reasons are: loose covers, broken gaskets, improper sealing of frame, etc.

SPARE PARTS FOR MOTORS

GENERAL

Always use the same part when replacing a worn out item unless a change has been recommended by the manufacturer. As soon as a spare part is used reorder a replacement so as to maintain the stock of spares. When ordering spare parts always give the following information: Name the part and the quantity wanted and give the complete name plate reading of the apparatus for which it is intended. Include the style number if known. State whether shipment is desired by express, freight or by parcel post. Send all orders and correspondence to the nearest Sales Office of the Company (See list in back of this book). Small orders should be combined so as to amount to a value of at least $1.00 net. Where the total of the sale is less than this, the material will be invoiced at $1.00.

ESSENTIAL SPARES

The following list of spares are considered essential to proper maintenance of the motors aboard ship. This is based on total units aboard ship. In many cases the same part is used on motors of different applications, so in order to obtain a minimum amount of spares it is necessary to examine all motors. It is suggested an index be prepared listing all motors aboard ship and under each motor list the identification of each spare part. From this tabulation can be determined the minimum amount of spares to be carried.

NOTE: If a detailed list giving identification for all parts for each motor is not included in the drawings in the Chief Engineers File consult with the nearest Sales representative giving them the name plate data for all machines involved and they will be glad to supply a complete list for all the recommended spare parts.

SPARE PARTS	QUANTITY PER VESSEL
Bearing (Ball or Roller)	1 for each 4 or less
Bearing Lining with oil Ring (Sleeve bearing)	1 for each 4 or less
Brushholder	1 for each 10 or less
Brushholder Spring	3 for each 10 or less
Brush Stud Insulator	1 set for each 10 sets or less
Brushes	1 set* for each 2 sets or less
Armature	1**

* Where the number of brushes per set varies the amount considered as one set shall be for the maximum number.

** For each auxiliary considered vital to the operation of the ship.

DESIRABLE

For the desirable list of spares increase the essential list to double the quantities and also add one armature complete for each auxiliary.

SPECIAL TOOLS FOR MOTORS

The following is a list of tools that are recommended for the proper service of direct current motors:

1. Megger for measuring insulation resistance.
2. 4 pound spring balance for checking brush spring pressure.
3. Air gap feeler gage (could be omitted).
4. Bearing puller (See Figure 7 for one that can be made).
5. Industrial Analyzer (a combination instrument which can be used as a voltmeter, ammeter and ohmmeter. They are available through our local Sales Office).

PART II

Direct Current Controllers

DESCRIPTION OF PARTS

LINE CONTACTORS AND ELECTRICAL INTERLOCKS

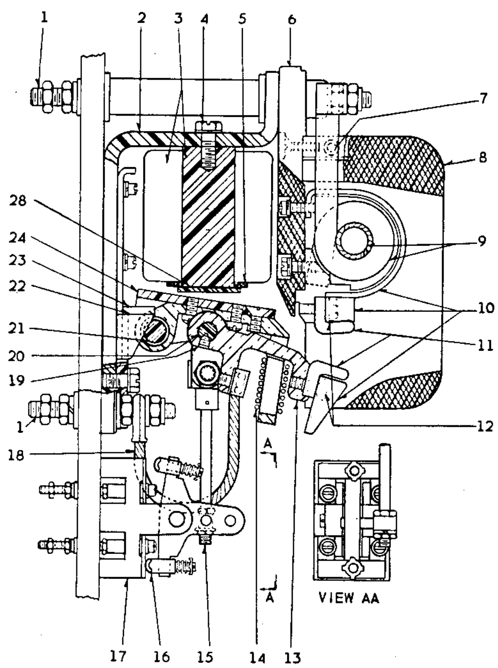


FIGURE 10—Line Contactor

ITEM NO.	DESCRIPTION OF PART
1	Terminal Stud
2	Frame
3	Operating Coil & Core
4	Bolt for Core
5	Insulated Washer
6	Insulated Base
7	Hinge for Arc Shield
8	Arc Shield
9	Blow Out Coil & Core
10	Arc Horns
11	Contacts
12	Contact Screw
13	Moving Contact Support
14	Moving Contact Spring
15	Interlock Lever
16	Interlock Contacts
17	Interlock Base
18	Shunt
19	Set Screw
20	Moving Contact Hinge Pin
22	Locking Bar for Arm Shaft
23	Bearing Bracket
24	Armature
28	Non-Magnetic Plate

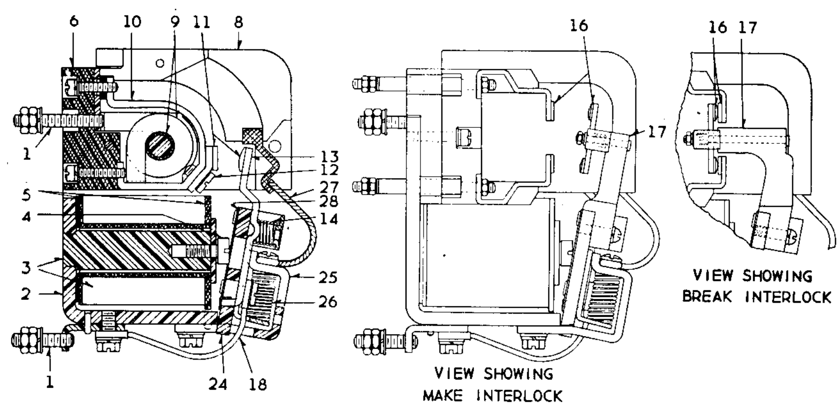


FIGURE 11—Line Contactor

ITEM NO.	DESCRIPTION OF PART
1	Terminal Studs
2	Frame
3	Operating Coil & Core
4	Bolt for Core
5	Insulating Washer
6	Insulated Base
8	Arc Shield
9	Blowout Coil & Core
10	Arc Horn
11	Contacts
12	Contact Screw

ITEM NO.	DESCRIPTION OF PART
13	Moving Contact Support
14	Moving Contact Spring
16	Interlock Contacts
17	Interlock Base
18	Shunt
24	Armature
25	Armature Stop
26	Kickout Spring
27	Arc Shield Shunt
28	Non-magnetic Plate

The line contactors shown in Figs. 10 and 11 close or open the circuit from power supply to motor. They are equipped with blowout devices, 8 and 9, that quickly extinguish arcs that would otherwise persist and burn nearby parts. When the coil, 3, is energized the movable armature, 24, turns about the pivot point and the contacts, 11, are forced together. The contact pressure is determined by the contact spring, 14. When the coil, 3, is de-energized the contacts, 11, are opened by gravity and the pressure of spring, 14.

The contactor in Fig. 10 uses a pin type bearing. The unit shown in Fig. 11 uses a knife-edge type bearing.

The coils and contacts of Fig. 10 and Fig. 11 are indicated by 1M and 2M in the typical diagram Figs. 18 and 22.

ELECTRICAL INTERLOCKS

Electrical interlocks are mechanically attached to magnetic contactors. They open or close control circuits of small current valves. An electrical interlock, 16, is shown below the contactor in Fig. 10. In Fig. 11 the interlock is mounted directly on the contactor. Interlocks are shown at 1Ma and 1Mb in the typical diagram Figs. 18 and 22.

TIMETACTORS combine the functions of a contactor and timing device in one unit. The contacts, 11, are open when the main coil, 3, is energized and closed by spring, 31, in a time determined by neutralizing coil 3A, after main coil, 3, is de-energized. Interlock contacts, 16, are mounted directly on the TIMETACTOR. Main contacts, 11, are shown as 1A and 2A connected to R1-R2 and R3 in Fig. 18. Main coils, 3 and 3A, are shown at 1AM, 2AM and 1AN, 2AN respectively in Fig. 18. Interlock contacts, 16, are shown at 1A and 2A connected to points 1, 5, 6 and 7.

TIMETACTORS are used to accelerate motors by short-circuiting the starting resistor in one or more steps.

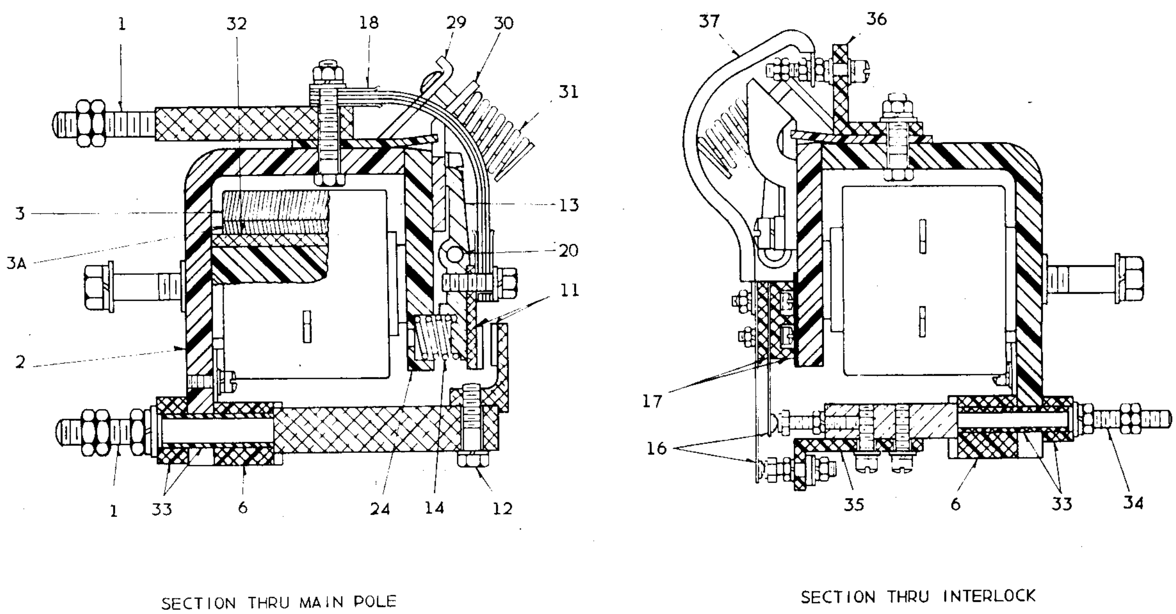


FIGURE 12—Accelerating Timetactor

ITEM NO.	DESCRIPTION OF PART	ITEM NO.	DESCRIPTION OF PART
1	Terminal Stud	20	Moving Contact Hinge Pin
2	Frame	24	Armature
3	Operating Coil & Core	29	Armature Support
6	Insulated Base	30	Armature Bracket
11	Contacts	31	Armature Spring
12	Contact Screw	32	Copper Tube
13	Moving Contact Support	33	Insulation Tubes
14	Moving Contact Spring	34	Interlock Terminal Stud
16	Interlock Contacts	35	Interlock Contact Bracket
17	Interlock Base	36	Interlock Shunt Bracket
18	Shunt	37	Interlock Shunt

OVERLOAD RELAYS

Overload relays must not operate on current peaks that occur during the starting periods of motors. They must trip if overloads persist long enough to endanger a motor or if currents of short circuit values occur.

The overload relay, Figure 13, is magnetically operated by coil, 3. Delayed tripping when small overload currents exist for a short time is provided by the oil dashpot, 51, and the piston, 53. Upward motion of the piston is retarded by the oil which must pass beneath the piston. Finally a by-pass point is reached and the piston strikes a blow against stem, 49, to open the contacts, 11. Rapid downward motion of the piston occurs because the free washer or valve, 54, uncovers holes in the bottom of the piston to permit rapid passage of the oil above the piston.

The tripping point of the relay is adjusted by screwing the dashpot, 51, up or down to change the air gap between plunger, 52, and the operating stem, 49.

Reset lever, 41, holds contacts, 11, open until released by hand. Automatic reclosing of contacts, 11, is provided by omitting reset lever, 41.

The coil, 3, and contacts, 11, are marked OL in the typical diagram, Figure 18.

Fig. 14 illustrates an overload relay that provides delayed tripping, for usual overloads, by the thermal element, 44. The relay also provides instantaneous tripping for extremely high currents through the magnetic coil, 3.

The heater element, 44, is a special material called "Invar" that loses its magnetic properties at approximately 240°C. The left end of the armature, 24, is then magnetically released from "Invar" heater, 44, and magnetically pulled upward against the lower end of the sliding part, 42. The upper end of 42 opens the contacts, 11.

When extremely high currents occur the "Invar" heater element, 44, will not heat quickly enough to operate the relay to protect the motor but coil, 3 will pull armature bracket, 30, against the coil core; the upper end of 30, will strike armature, 24, and break its magnetic seal on, 44. Tripping will then occur as previously described.

Adjustments for thermal tripping are made by setting the left end of armature, 24, on small sections (hot spots) or large sections (cooler spots) of heater element, 44. This adjustment is made by loosening the adjusting screw, 45, and moving the adjusting plate to the desired position. The instantaneous tripping point is adjusted by turning screw, 39.

The relay coil, heater and contacts are designated as OL on diagram Fig. 18.

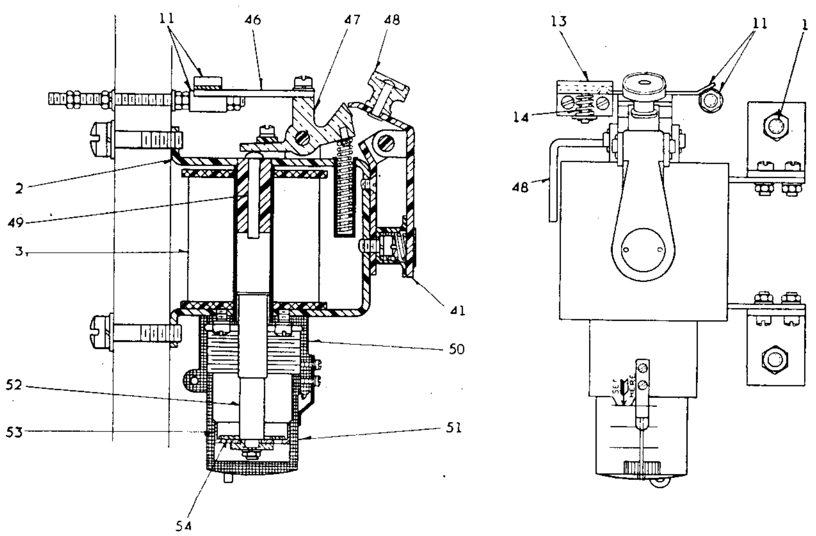


FIGURE 13—Dashpot Overload Relay

ITEM NO.	DESCRIPTION OF PART
1	Terminal Stud
2	Frame
3	Operating Coil and Core
11	Contacts
13	Moving Contact Support
14	Moving Contact Spring
41	Reset Lever
46	Contact Lever

ITEM NO.	DESCRIPTION OF PART
47	Contact Lever Support
48	Counter Weights
49	Stem
50	Sleeve
51	Dash Pot
52	Plunger
53	Piston
54	Valve

The relay can be set for hand or automatic operation by turning reset button, 41, for the desired operation. Relay should always be set for hand reset operation on low voltage release circuits.

GENERAL PURPOSE RELAY

Many control schemes require a relay that responds to either current in the motor circuit or to a potential circuit in the control scheme or both. Such a relay is shown in Fig. 15.

Two coils are provided and located one behind the other in Fig. 15. Both coils may be used in the motor circuit as current elements; both may be voltage coils or one of each type coil may be used. Coils may be connected to assist or oppose each other. The contacts, 11, provide a normally open and a normally closed circuit. It may be used as a low voltage relay, CR on diagram Fig. 23 or as relays 1FR and 2FR on diagram Fig. 29.

MAGNETIC BRAKES

Magnetic brakes perform the double duty of helping to stop a motor and holding a load when the motor is stopped. They are part of the equipment on cargo winches, windlasses and capstans.

When the coil, 17, Fig. 16, is energized the plunger, 16, is pulled downward, spring 3 is compressed, the brake arms, 11 and 14, turn outward about the pivot points at the lower ends and the brake shoes, 12, move away from the brake wheel, 8. When power fails or the brake coil is de-energized the spring, 3, forces the brake shoes, 12, against the wheel to stop the motor and hold the load.

Mounting

Brakes should be mounted with the brake wheel in a mid-position on the shoes and on the same horizontal centerline as the motor. The magnet plunger 16 should be free to move without undue friction.

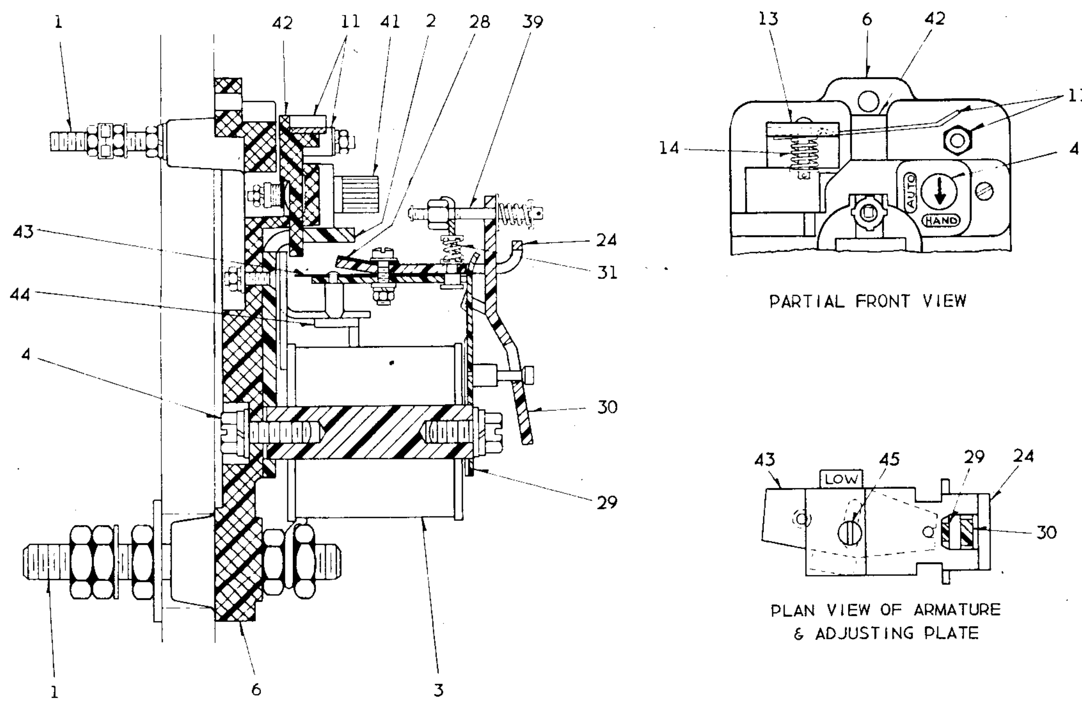


FIGURE 14—Thermal and Instantaneous Overload Relay

ITEM NO.	DESCRIPTION OF PART
1	Terminal Studs
2	Frame
3	Operating Coil and Core
4	Bolt for Core
6	Insulated Base
11	Contacts
13	Moving Contact Support
14	Moving Contact Spring
24	Armature
28	Non Magnetic Plate

ITEM NO.	DESCRIPTION OF PART
29	Armature Support
30	Armature Bracket
31	Armature Spring
39	Adjusting Screw
41	Reset Button
42	Reset Slide
43	Adjusting Plate
44	Heater
45	Adjusting Plate Screw

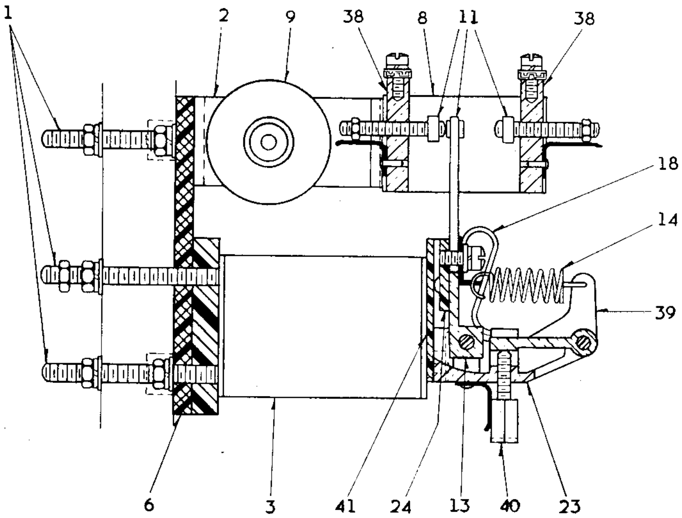


FIGURE 15—Current or Voltage Relay

ITEM NO.	DESCRIPTION OF PART
1	Terminal Studs
2	Frame
3	Operating Coil and Core
6	Insulated Base
8	Arc Shield
9	Blow Out Coil and Core
11	Contacts
13	Moving Contact Support
14	Moving Contact Spring
18	Shunt
23	Bearing Bracket
24	Armature
38	Stationary Contact Supports
39	Adjusting Lever
40	Adjusting Screw
41	Pole Face

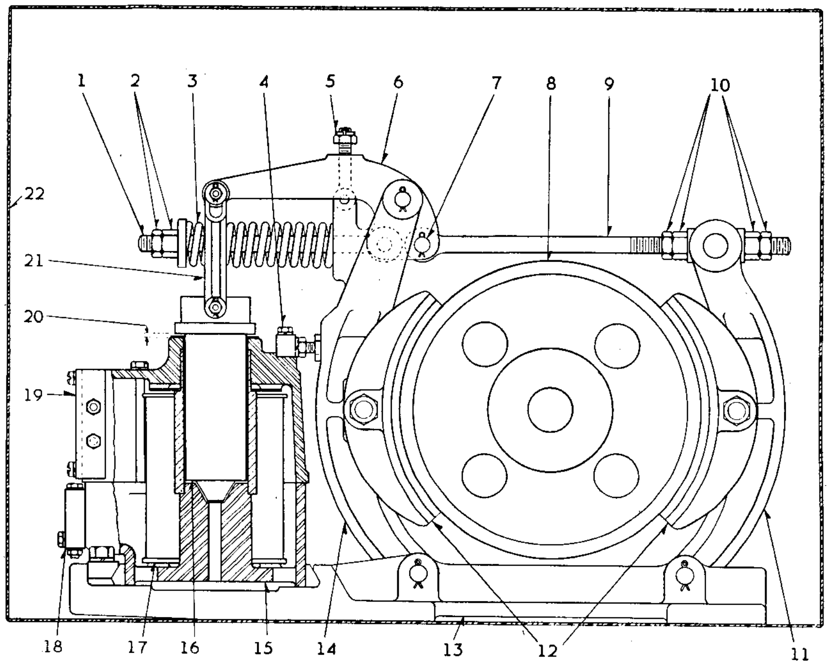


FIGURE 16—Magnetic Brake

ITEM NO.	DESCRIPTION OF PART
1	Spring Rod
2	Spring Adjusting Nuts
3	Spring
4	Clearance Adjusting Screw
5	Manual Release Nut
6	Brake Lever
7	Connecting Rod Pin
8	Brake Wheel
9	Connecting Rod
10	Connecting Rod Adjusting Nuts
11	Front Brake Arm

ITEM NO.	DESCRIPTION OF PART
12	Brake Shoes
13	Base
14	Rear Brake Arm
15	Magnet Housing
16	Plunger
17	Coil
18	Wood Cleat
19	Terminal Board
20	Magnet Travel
21	Connecting Link
22	Watertight Case

Coil Replacements

To replace a coil, the entire magnet assembly should be removed from the base. The magnet assembly can then be dismantled to remove the coil. Before the magnet assembly is removed, suitable marks should be placed on it and the base to assist in proper alignment when the magnet assembly is replaced.

Adjustments

Adjustment of the brake parts to obtain proper travel of the shoes and proper spring compression is important for obtaining maximum wear on shoe linings and pivot points. Instructions for making all adjustments are given on a name plate attached to the brake. Spring pressure is adjusted by the nut, 2. Magnet travel at 20, is adjusted by the nuts at 10. Shoe clearances may be equalized by means of screw, 4.

Brake Release

When the brake must be released manually for inspection, or replacement of brake linings the nut, 5, must be turned down or the spring compressed and arm, 6, blocked down until the shoes clear the wheel. For operating conditions the nut, 5, should be at the top of the screw and held there by cotter pin.

The brake coil, 17, is illustrated by coil marked "BRAKE" with its coil terminals B_1 and B_2 connected respectively to BR_2 and R_1 in Fig. 28.

FUNDAMENTAL ELECTRICAL SYMBOLS

WIRING DIAGRAMS

The symbols used to represent the essential parts of a starter or controller in a wiring diagram are based upon the fundamental symbols shown in Fig. 17. On diagrams the fundamental symbols such as contacts and coils are grouped together to represent contactors or relays with any number of contacts and coils. Power connections are shown by heavy lines. Control connections are shown by light lines.

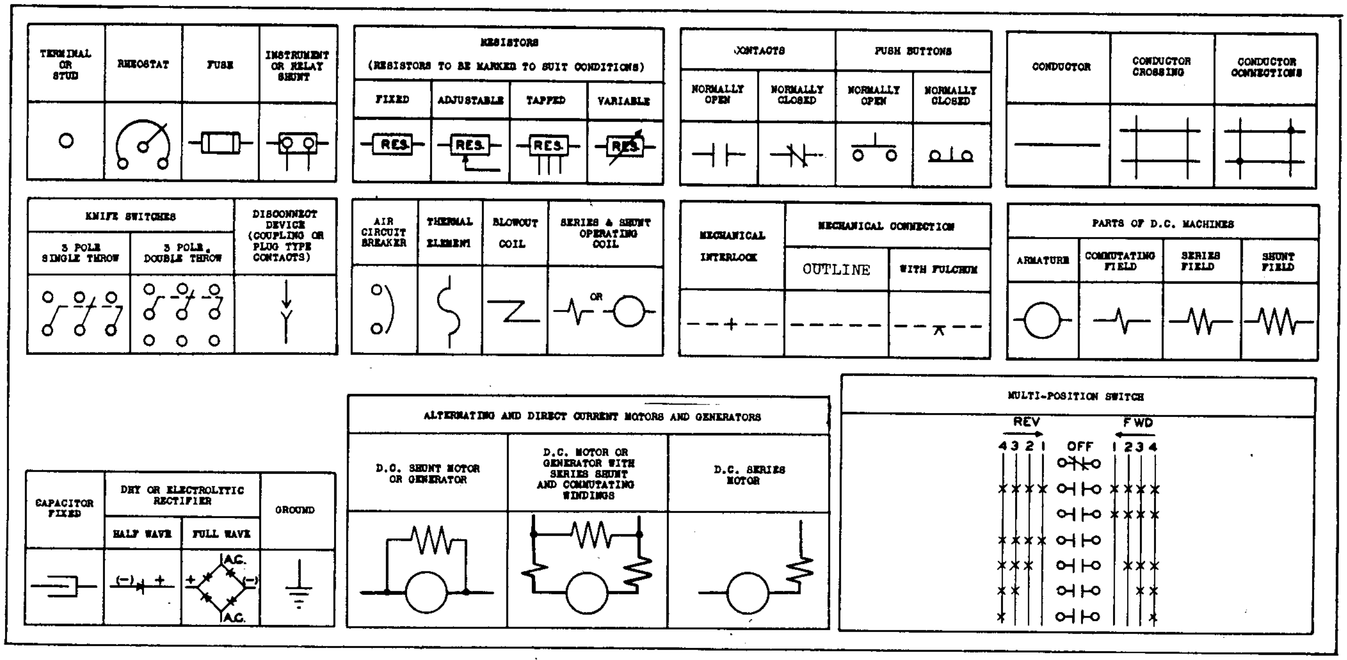


FIGURE 17—Symbol Legend

OPERATION OF MOTOR STARTERS AND CONTROLLERS

Operation by Low Voltage Release

A low voltage release circuit permits a motor to restart automatically when voltage returns, after a power failure. The master switch is a maintained contact type and requires two control wires. Pressure switches, thermostats and maintained contact type push buttons are typical forms of master switches. A hand reset overload relay is necessary to prevent rapidly repeated restarting cycles when an overload condition exists.

Operation by Low Voltage Protection

A low voltage protection circuit does not permit the motor to restart automatically when voltage returns after a power failure. The operator must restart the motor. This circuit is used on machine tool and similar applications where unexpected starts would be dangerous to the operating personnel. The master switch is usually a momentary contact push button and three control wires are required. The overload relay may be either hand or automatic reset.

OPERATION OF UNDERDECK CONTROLLERS

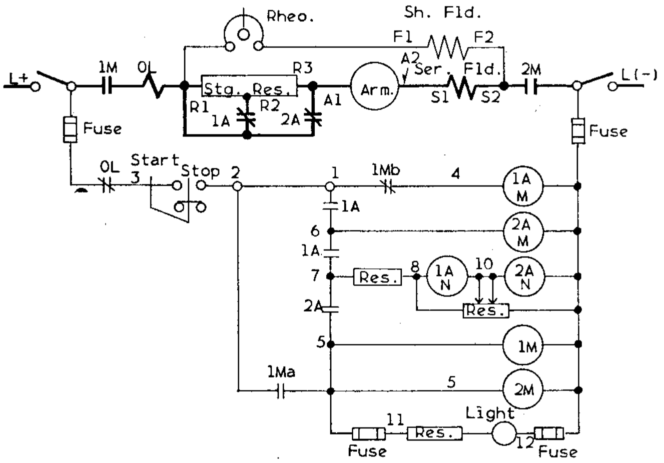


FIGURE 18—Low Voltage Release

LOW VOLTAGE RELEASE

Fig. 18 illustrates an elementary diagram of the circuits used to provide low voltage release on a pump motor drive. The main or motor armature connections are shown in heavy lines. The control and motor field connections are shown in light lines.

A two pole single throw knife switch provides means to disconnect the motor from the power supply.

Two single pole magnetic contactors, 1M and 2M, apply power to and disconnect the motor terminals from the power supply when the master push button station is operated to start and stop the motor. A single pole contactor is sometimes used in only one of the power lines. The other line is then not opened to stop the motor.

The starting resistor, R_1-R_2-R_3, is short-circuited by "Timetactors", 1A and 2A, each of which provides a time period of several seconds.

A shunt field rheostat provides speed control of the motor.

Overload protection is provided and the control circuit is protected by two fuses.

A pilot light, protected by a resistor and two fuses, indicates when the motor is in operation.

In the diagram, Fig. 18, all contacts are shown in the deenergized position. When the main knife switch is closed power is available but no operations occur until the start push button is operated.

When the start button is operated the "Timetactor" contacts, 1A and 2A, that short circuit the starting resistor must be opened before the line contactors, 1M and 2M, close to apply power to the motor. When the start button is operated the main coil, 1AM, of "Timetactor", 1A, is energized and main contacts, 1A, open. At the same time two auxiliary or interlock contacts on 1A close and main coil, 2AM, of "Timetactor", 2A, is energized and main contacts, 2A, open. The starting resistor is not now short-circuited and is definitely in circuit in series with the motor armature. Neutralizing or timing coils of "Timetactors", 1A and 2A, are now energized but they are ineffective while the main coils, 1AM and 2AM, are energized.

When main contact, 2A, opens the interlock contact, 2A, closes and operating coils, 1M and 2M, of the two main contactors are energized. The contacts, 1M and 2M close, power is applied to the armature and shunt field simultaneously and the motor starts with all starting resistor in the circuit.

Interlock contact, 1Ma actuated by contactor, 1M, is now closed and coils, 1M and 2M, are maintained energized through the stop push button and interlock, 1Ma.

A second interlock, 1Mb, actuated by main contactor, 1M, is now open and main "Timetactor" coil, 1AM, is deenergized. The neutralizing coil, 1AN, which is on the same core as main coil, 1AM, but connected in reverse polarity, now starts neutralizing all magnetism in the magnetic circuit of 1A and after a time its spring will cause main contacts, 1A, to reclose and short-circuit the first part, R_1 to R_2, of the starting resistor. The timing on 1A will depend upon the adjustment of the adjustable resistor unit in parallel with the coil, 1AN. Shortest timing occurs when current and voltage of coil 1AN, are maximum values.

When the main contacts, 1A, closed to short-circuit starting resistor section, R_1 to R_2, the two interlock contacts, 1A, which are connected from 1 to 6 and 6 to 7 both opened and deenergized main "Timetactor", coil 2AM. Since the main coil of "Timetactor", 2A, is deenergized, its neutrlizing coils, 2AN, now determines its timing period in the same manner as previously described for "Timetactor", 1A. After a timing period the main contacts, 2A, close to short-circuit the last section, R_2 to R_3, of the starting resistor. The motor now runs at an operating speed depending upon the setting of the rheostat.

When "Timetactor", 2A, operated to close its main contacts, the interlock contacts, which are connected from 7 to 5 opened and deenergized both neutralizing coils, 1AN and 2AN. At operating speed, therefore, coils 1M, 2M and the indicating light are the only energized items in the control circuit.

If a voltage failure occurs while the motor is operating, line contactors 1M and 2M and the indicating light are deenergized and the motor is disconnected from the power supply. When the power returns the motor will restart automatically unless the stop button has been operated. This is a LOW VOLTAGE RELEASE Circuit.

If the stop button is depressed while the motor is running the main contactor coils, 1M, 2M and the indicating light are de-energized and the motor stops.

Since the overload relay contacts are in series with the push button contacts the motor is stopped by operation of the overload relay in the same manner as by operation of the stop button. The overload relay, in this circuit, must be hand reset type which is latched in the open position when an overload occurs and must be reclosed by an operator. If this overload relay were automatically reset its contacts would open on overload, then immediately reclose and restart the motor. This action would repeat indefinitely, the starting resistor would become overheated and the motor would be subjected to severe starting duty until the stop button was operated. The hand reset overload relay latches open and prevents repeated motor starting.

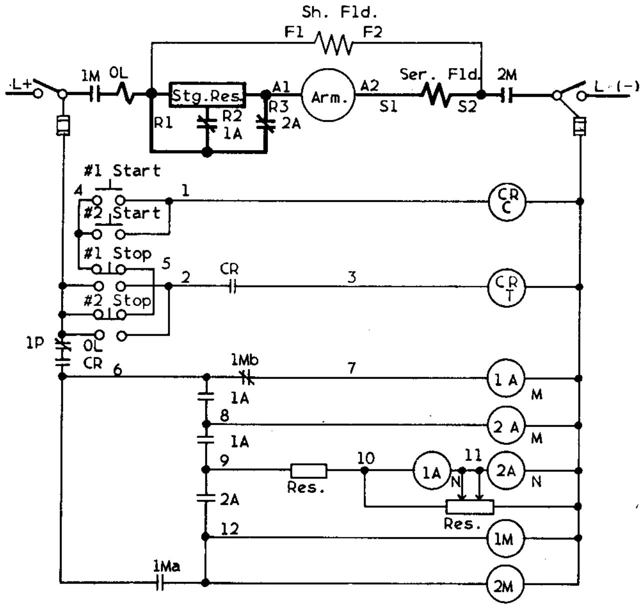


FIGURE 19—Low Voltage Release from Several Push Button Stations

Low Voltage Release from Several Push Button Stations

Sometimes it is desirable to have low voltage release with two push button stations. Two maintained contact buttons could be used. This arrangement, however, is not very satisfactory because both start buttons must be in the depressed position to run the motor. A more convenient arrangement uses momentary contact push buttons and a latched in relay.

A latched in relay has two coils: a closing coil and a trip coil. When the closing coil is energized, the relay closes and remains closed even through the closing coil is no longer energized. When the trip coil is energized, the relay will open.

Diagram Fig. 19 is for an application which uses the scheme as described above. When either of the stop buttons is pressed, neither of the start buttons can energize the closing coil. Hence it is impossible to energize both the closing and the tripping coils if a start and stop button are operated simultaneously.

In the diagram Fig. 19 the closing coil, CRC, of the latched-in relay, CR, is energized when either start button is operated. It is then held by the latch even though power should fail. When power returns the two contacts of the relay, CR, have been held closed by the latch and the motor immediately starts without operating the start button.

Either stop button will energize the trip coil, CRT, of the latched-in relay, open the relay and stop the motor. After such a stop a start button must be used to restart the motor.

The method and sequence of operations for main line contactors and accelerating timetactors is otherwise the same as for the low voltage release circuit previously described and shown as Fig. 18.

Low Voltage Release with Selective Hand or Automatic Operation

Fig. 20 illustrates a low voltage release circuit in combination with selective hand or automatic operation with an automatic master switch such as a pressure switch.

For automatic operation the contacts of the selector switch marked "hand-auto" must be opened and the maintained contact start push button contacts must be closed. Under these conditions the contacts, 2 to 3, of the automatic master switch marked, AS, will control the motor operation. When closed the motor will run, when open the motor will be idle.

For hand operation the "hand-auto" selector switch contacts are closed. These contacts then parallel the automatic switch contacts and the motor can be started and stopped by the start-stop push button regardless of the position of the automatic switch, AS.

The motor can always be stopped by the stop button on either hand or automatic operation.

Delayed Low Voltage Release

When voltage is again available after a power failure, the load on the generator may be much larger than its rated load if too many motors start up at the same time. To prevent excessive voltage drop, it is sometimes desirable to start large motors—controlled by low voltage release starters—at different times when voltage returns after a power failure.

A timing relay circuit that permits sequence or staggered starting of motors is shown by Fig. 21. Timing relay 1 T has two coils; holding coil 1 TH and closing coil 1 TC. It has a normally closed and a normally open contact.

When voltage is applied the condenser is charged and coil, 1 TC is energized to operate relay 1 T. One contact of relay, 1 T, energizes coil, 2 T. The other contact opens the circuit to coil, CR.

When coil, 2 T, operates relay, 2 T, a holding circuit is established through contact, 2 to y, of relay 1 T. Relay, 2 T, will remain energized through its

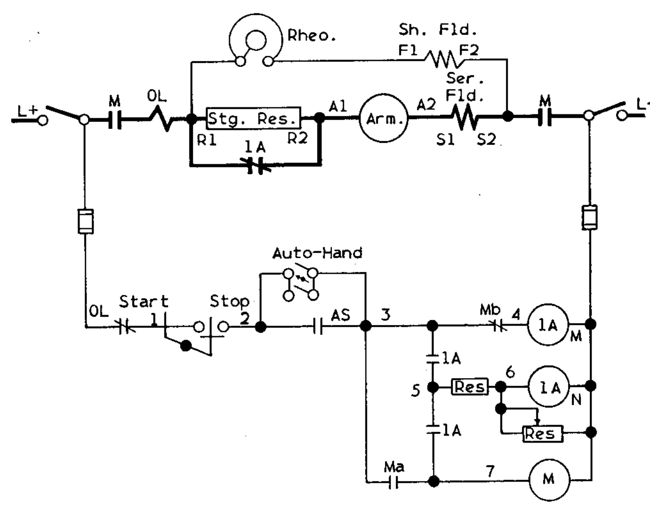


Fig. 20

Figure 20—Low Voltage Release with Selective Hand or Automatic Operation

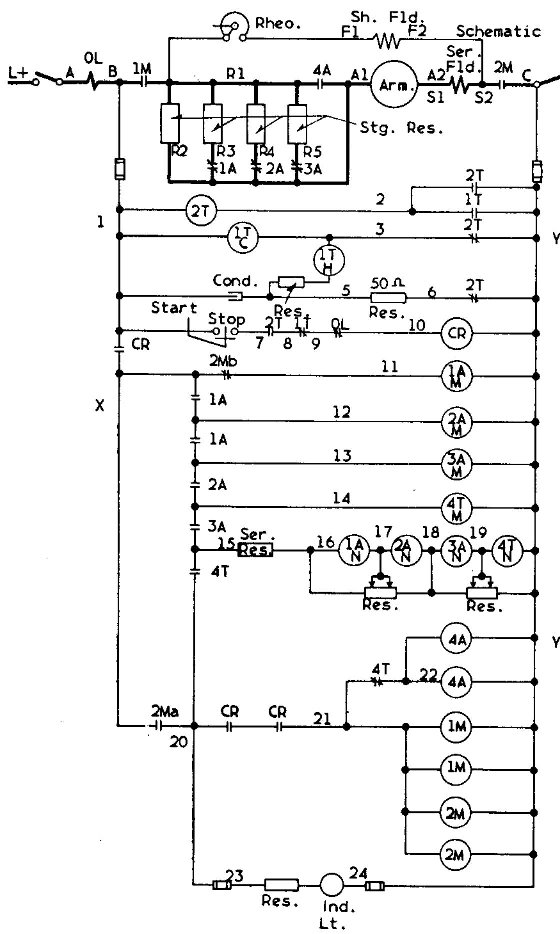


FIGURE 21—Delayed Low Voltage Release

own contact, 2 T, until power fails or the disconnecting knife switch is opened. Contact, 7 to 8, of relay, 2 T, closes the circuit to coil, CR, but this circuit is not completed because contact, 8 to 9 of relay, 1 T, is open. Two contacts, y to 3 and, y to 6 open the circuit to coils, 1 TC and 1 TH of relay IT and to the condenser. The condenser now discharges through the two coils of relay, 1 T in series with the discharge resistor. The discharge of the condenser maintains energy on the coils of relay, 1 T, and the timing obtained is adjustable by spring tension and non-magnetic shims in the relay.

At the end of the predetermined timing period relay, 1 T is de-energized; its contact, 8 to 9 recloses and the circuit to coil CR is completed provided the start button has been operated. Further operation is dependent upon operation of the start or stop button and is the same as for low voltage release circuits previously described in Fig. 18.

Low Voltage Protection

Fig. 22 illustrates a motor and control diagram similar to Fig. 18 except that low voltage protection is provided.

These push buttons are momentary contact, spring return type.

When the start button is depressed coils, 1 AM 2 AM, 1 AN and 2 AN of the two "Timetactors" and coils, 1 M and 2 M, of the line contactors are energized in order named. Interlock contact, 1 Ma, closes with contactor, 1 M, provides a holding circuit in parallel with the start button contacts for coils, 1 M and 2 M, and permits the start button to be released. The motor continues to run.

Acceleration of the motor is started by the opening of interlock, 1 Mb, connected from 1 to 4 in the same manner as described for Fig. 18.

Operation of the stop button or the overload relay will denergize coils, 1 M and 2 M.

After a failure of power, operation of the stop button or the overload relay the motor will not start again unless the start button is operated. The overload relay may be either hand or automatic reset. This is a LOW VOLTAGE PROTECTION Circuit. It does not permit unexpected starts.

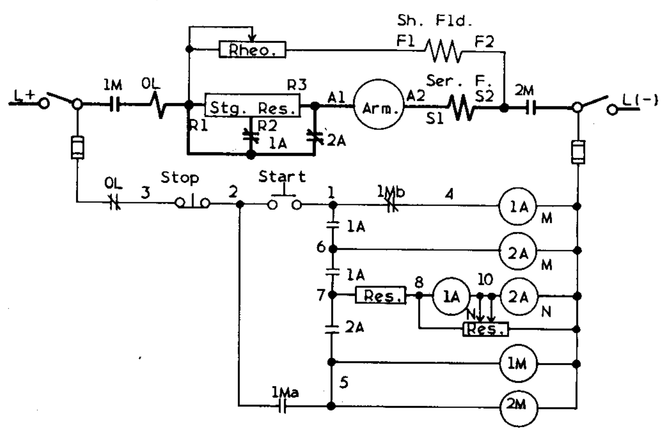


FIGURE 22—Low Voltage Protection

Low Voltage Protection with Selective Hand or Automatic Operation

Fig. 23 shows circuits for low voltage protection in combination with selective hand or automatic operation with an automatic master switch. This circuit is similiar to Fig. 20 except that low voltage protection is provided instead of low voltage release.

The low voltage protection feature requires momentary contact start and stop buttons and a relay marked, CR. The selective switch and automatic switch are similar to those of Fig. 20.

To put into operation the start button is operated which energizes coil, CR. Contacts, CR, close and parallel the start button contacts. The start button may then be released and CR will remain closed until the stop button is operated, an overload occurs or a voltage failure occurs.

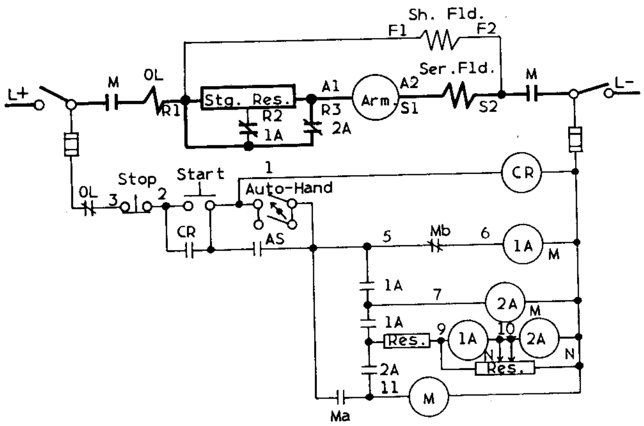


FIGURE 23—Low Voltage Protection with Selective Hand or Automatic Operation

With CR contacts closed either hand or automatic operation is obtained as in the previous diagram, Fig. 20.

After a voltage failure the motor will not restart, upon the return of power, unless the start button is operated to close relay, CR. If a stop has occurred because of low voltage, overload or stop button operation the start button must be operated before another start can be made. The motor can be stopped at any time by operating the stop button.

Steering Power Transfer Cubicle

To make certain that the steering gear motors always have a source of power, the steering power transfer cubicle has an automatic bus transfer. The principle components of the unit are two 600 ampere breakers without trip units for the port and starboard steering gear motors, a 15 ampere breaker for the gyro pilot motor, a motor driven bus transfer switch, a bus transfer relay, two indicating lights, and a hand-automatic switch.

The transfer switch may be operated either automatically or by hand; the method of operation being determined by the "hand-auto" switch.

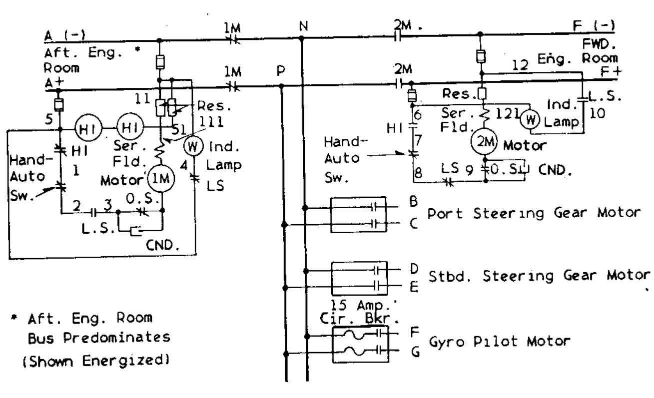


FIGURE 24—Steering Power Transfer

For automatic operation, Fig. 24, the "after" engine room bus predominates and the hand auto switch is closed. As long as the voltage on this bus does not drop below the setting of the bus transfer relay (HI), the circuit breakers will be connected to this bus. If the voltage fails or drops below the setting of the HI relay, its contact 1 to 5 will open and contact 6 to 7 will close to energize motor 2 M. This motor will transfer the connection of the breakers to the "forward" room bus. Motor 2 M is disconnected from the line at the end of the bus transfer switch's travel by a limit switch. When the voltage on the "after" engine room bus comes back to normal, the HI contacts will again transfer and motor 1 M will transfer the circuit breakers back to the "after" engine room bus. The motor is disconnected by a limit switch.

Indicating lamps are turned off and on by limit switches. Each is lighted only when the bus to which it is connected is energized.

Current Limit Acceleration

Although definite time acceleration is most frequently used, there are some applications, upon which the inertia of the load to be started is so high that the forced acceleration by the definite time principle does not provide enough time for acceleration and excessive motor currents occur. These currents trip the overload protective devices and prevent starting the motor. For such applications, starters using cur rent limit method of starting are required. Such starters limit the current that flows in the motor armature and permit motor acceleration in whatever time the motor requires without exceeding the predetermined current values.

Connections for a current limit acceleration type starter are shown in Fig. 25. Timetactor units are used for accelerating the motor but they are modified to provide the current limit feature.

Non-magnetic shims are added in the air gap of the "Timetactors" to entirely eliminate the timing feature. Except for the shims the apparatus to build a time starter is the same as for a current limit start-

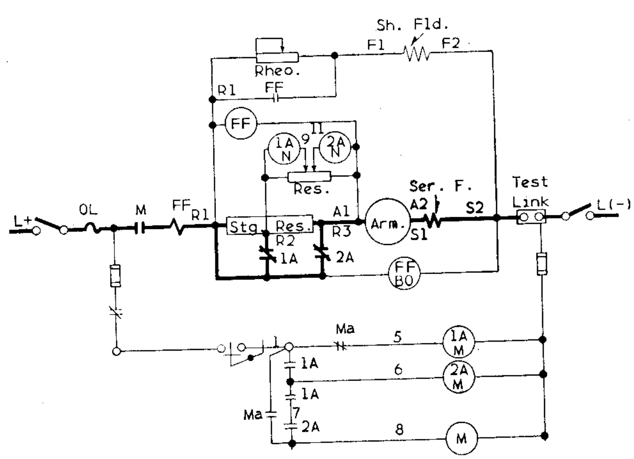


FIGURE 25—Current Limit Acceleration

er. The wiring connections and operation of the accelerating units are different.

In the diagram Fig. 25, the coils, 1 AN and 2 AN that serve as neutralizing or timing coils in a definite time starter are now connected in parallel with the last step of the starting resistor, R_2 to R_3 and are connected with polarity the same as that of the main coils, 1 AM and 2 AM, instead of opposite polarity as on the definite time starter. The coils, 1 AN and 2 AN, are now holding coils that hold the main contacts, 1 A and 2 A in the open position after coils, 1 AM and 2 AM have been deenergized.

The voltage on coils, 1 AN and 2 AN depends upon the voltage drop across resistor step, R_2 to R_3 and this voltage, in turn depends upon the current in the starting resistor and the motor.

When the motor starts a high current flow in resistor, R_2 to R_3 and the coils, 1 AN and 2 AN, exert a maximum holding power.

When the line contactor M closes its interlock Ma opens and de-energizes coil, 1 AM. Only the coil, 1AN, is now holding the main contacts, 1A, open. As the motor accelerates the current decreases until, due to the adjustment on the variable resistor, connected to R_2 to R_3, the coil 1AN is no longer able to hold contacts, 1A, open and its spring closes them to short circuit the first resistor step R_1 to R_2. The closing of contact, 1A, therefore depends upon the voltage drop across starting resistor, R_2 to R_3, which in turn depends upon the motor current, and the setting of the adjustable resistor connected to R_2 and R_3. The motor current must decrease to a value at which coil, 1AN, is overpowered by the spring. The contacts then close. There is no limit to the time required for this operation. It is a matter of motor current values.

When main contact, 1A, closes, its auxiliary contacts, 1A, connected to points 1, 6 and 7 open and main coil, 2AM, is de-energized. The peak motor current that followed the closing of contact, 1A, provides ample voltage on resistor R_2 to R_3 for coil, 2AN, to hold contacts, 2A open. This voltage however does not open contacts, 1A, because coil, 1AN, can never open them without the aid of the main coil, 1AM. As motor acceleration progresses the motor current again decreases until coil, 2AN, can no longer hold open contacts, 2A, against its spring.

Closing of contact, 2A, short circuits the entire starting resistor, hence while running the coils, 1AN and 2AN, have no voltage impressed upon them.

For current limit acceleration, time is required but it is not a definite time, forced acceleration. Acceleration depends entirely upon motor current values. Acceleration occurs in whatever time the load conditions require.

Adjustable Speed Controllers

When speed adjustments are required they are generally obtained by using a rheostat in the shunt field circuit. If the speed adjustments provide more than twice the base or full field speed a field accelerating relay is supplied. This relay has both a potential coil and a current coil and the contacts are connected in parallel with the field rheostat.

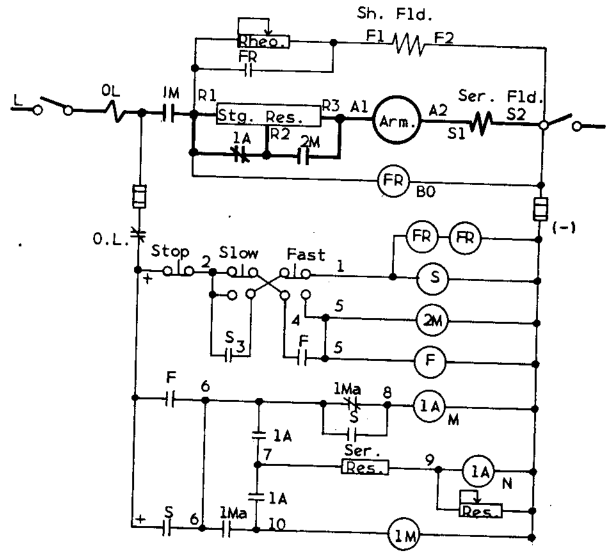


FIGURE 26—Adjustable Speed Controllers

The potential coil is connected across the starting resistor and positively closes the relay contacts to short circuit the field rheostat until all the starting resistor is short circuited. Thereafter the potential coil is ineffective but the current coil, connected in the armature circuit, will intermittently close the relay contacts to short circuit the rheostat if the armature current rises to excessive values.

The field accelerating relay therefore permits acceleration from zero speed to the speed as determined by the rheostat setting without excessive armature currents. One of these relays with coils and contacts marked FF is shown in Fig. 25.

If speeds below the base or full field speed are required they are few in number and usually only one such low speed is necessary. For such applications a three button push button station marked "Stop", "Slow" and "Fast" may be used as illustrated in Fig. 26.

If the slow button is operated, with the motor at rest it will start and run with the field rheostat short circuited and all starting resistance in the armature circuit. No acceleration occurs. The starting resistor provides operation below the base or full field speed.

If the fast button is operated, with the motor at rest, the motor starts and accelerates to the speed determined by the rheostat setting.

When the motor is running it may be alternately operated at either fast or slow speed by operating either the fast or slow button. Operation of the stop button will not be necessary to change from one speed to the other.

Reversing Controllers

When reversing service is required a three button push button station marked "Forward", "Reverse" and "Stop" is normally used.

Four single pole contactors or two double pole contactors are required for reversing service. Two of the contacts are required for forward operation and two for reverse operation. The forward and reverse contactors are mechanically interlocked to prevent closing of both at the same time. Reversed operation is obtained by reversing the armature circuit. An additional line contactor may be supplied.

The control circuits are illustrated in Fig. 27 and are quite similar to those previously described for non-reversing starters except that a start must be possible for each direction of rotation.

The forward and reverse push buttons are electrically interconnected so that no action results if both are operated simultaneously and operation of one button while operating in the other direction will first disconnect the motor and then reconnect it for the new direction of operation. Under such operation the motor will be reduced to low speed by dynamic braking and anti-plugging means will prevent reconnecting the motor for the reverse operation before low speed has been achieved.

Dynamic braking is common on most reversing starters although it may be omitted.

Starters are arranged so that the directional push buttons close the respective directional contactors, open the accelerating "Timetactors" to make the starting resistor effective and then close the main line contactor. Acceleration then occurs by the definite time principle as determined by the "Timetactors".

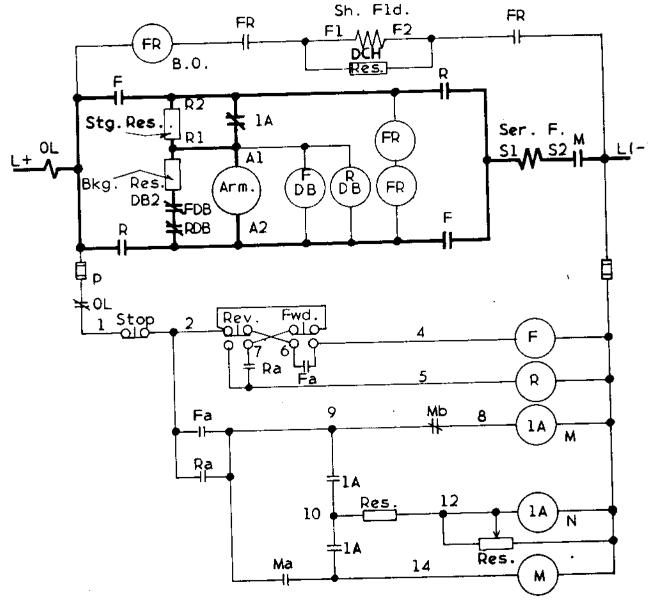


FIGURE 27—Reversing Controllers

In the diagram Fig. 27 a field relay, FR, is used to open the shunt field circuit when the motor is idle. A blowout is provided to positively interrupt the field circuit. This field relay may or may not be used.

OPERATION OF DECK CONTROLLERS

CARGO WINCH

The connections for a cargo winch control and motor are shown in Fig. 29. The various motions and operating speeds are obtained through a watertight pedestal mounted master switch, Fig. 28, suitable for use above deck. The control panel is either in a drip-proof cabinet or open type on an angle iron frame. Open type resistors are used. The motor and brake are watertight construction for use above deck.

Heater circuits are provided for the master switch, the magnetic brake, the motor and the control panel to prevent accumulation of moisture from condensation or similar causes.

A magnetic brake is provided to aid in stopping the motor and to hold a load in mid-air. The brake is always released when power is applied to the motor terminals.

The diagram Fig. 29 includes a relay, 2-FR, that opens the shunt field circuit, when the master switch is in the off position and the emergency switch, in the master switch, is in the open position. The relay, 2-FR, may not always be provided. It is used only when it is necessary to disconnect both the armature and shunt field circuits of the motor when the motor is not in use.

When the knife switch is closed to apply power to operate the winch the blowout coil, 1FRBO on relay 1FR will be energized.

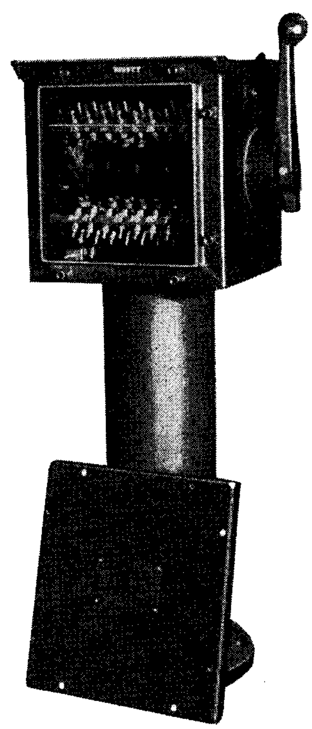
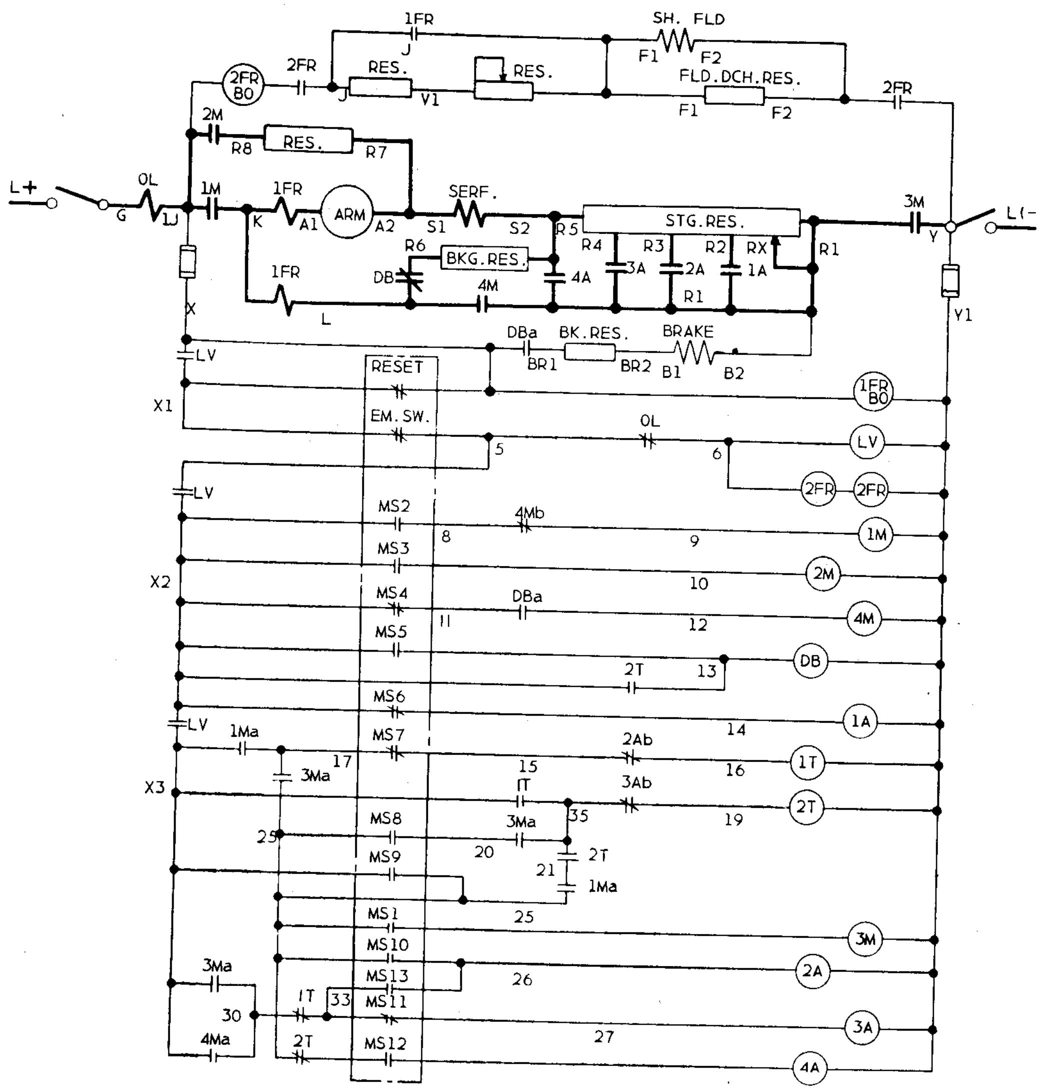
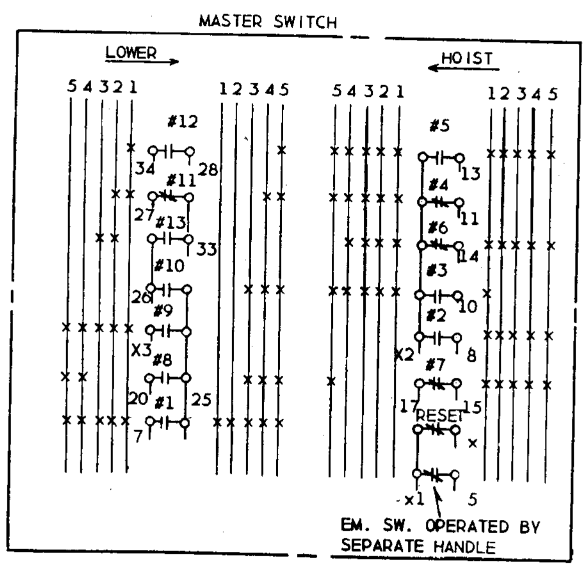


FIGURE 28—Watertight Master Switch





CONTACTOR SEQ. TABLE

Contact No.	Lower 5	Lower 4	Lower 3	Lower 2	Lower 1	Off	Hoist 1	Hoist 2	Hoist 3	Hoist 4	Hoist 5
1M							O	O	O	O	O
2M	O	O	O	O	O		O				
3M	O	O	O	O	O		O	O	O	O	O
4M	O	O	O	O	O						
1A		O	O	O	O	O	O	O	O	O	O
2A			O	O					O	O	O
3A				O	O					O	O
4A					O						O
DB						O					

FIGURE 29—Cargo Winch Controller Diagram

With the master switch in the off position and the emergency switch closed relays LV and 2FR, contactor 1A, blowout coil of relay 2FR, resistor J to V_1, resistor V_1 to F_1, the motor shunt field and the field discharge resistor will be energized. Coil DB will not be energized but its spring closed contacts will be closed.

When the master switch is moved to the first position for hoisting operations, contactors 1M-2M-3M-1A and DB will be energized. Note that DB is a spring closed unit while all other contactors in the motor armature circuit are magnet closed units. The motor operates with resistor R_7 to R_8 in parallel with the armature and resistor R_2 to R_5 in series with both. The shunt brake is energized and released. The small diagram Fig. 29-A illustrates the effective power connections in heavy lines and the unused power connections in light lines.

Fig. 29-B illustrates the power connections with the master switch in the second hoisting position. Contactor 2M opens. The motor now operates without the armature shunt resistor R_7 to R_8 but with resistor R_2 to R_5 in series with the armature.

Fig. 29-C for the third point hoisting indicates that contactor 2A is now closed and the resistor in series with the motor armature is R_3 to R_5 instead of R_2 to R_5 as on the second point.

Further movement of the master switch to the fourth point hoisting causes contactor, 3A, to close as shown in Fig. 29-D. The armature resistance is now only the section R_4 to R_5.

The power connections for the fifth and last point hoisting are shown in Fig. 29-E, Contactor 4A has closed and no resistors are included in the armature circuit. The motor armature now operates at full voltage and maximum speed.

The first point of the master switch provides a slow speed for hoisting by using both armature shunt and series resistors. Increased speeds are obtained on successive points by first eliminating the armature shunt resistor and then reducing the series resistor until maximum speed is obtained on the last point. The motor may be operated with the master switch on any point.

The power connections for the first point lowering are shown in Fig. 29-F. Contactors 2M, 3M, 4M, 1A, 3A and 4A are closed. DB coil is energized and its contacts are open. The armature and series field are in parallel which makes the motor operate more like a shunt machine than a heavily compounded one as in hoisting operations.

When compared to hoisting operations the armature current is reversed but the series field current is not reversed. Resistor R_7 to R_8 is in series with both the armature and the series field.

On the second point lowering, Fig. 29-G resistor R_4 to R_5 is added to the series field circuit by opening contactor 4A. This weakens the series field and produces increased motor speed. Contactor 2A closes.

On the third point lowering, Fig. 29-H, more resistance, R_3 to R_4 is added in the series field circuit by opening 3A. The series field circuit is thereby weakened further and the speed further increased.

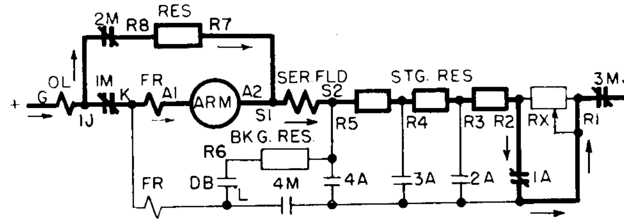


FIGURE 29A—First Point Hoisting

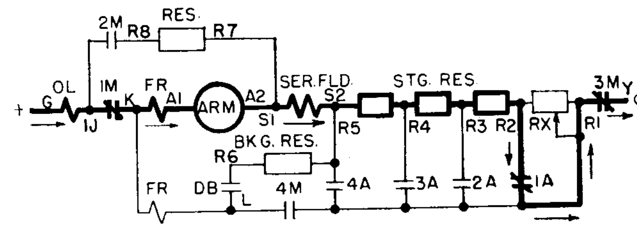


FIGURE 29B—Second Point Hoisting

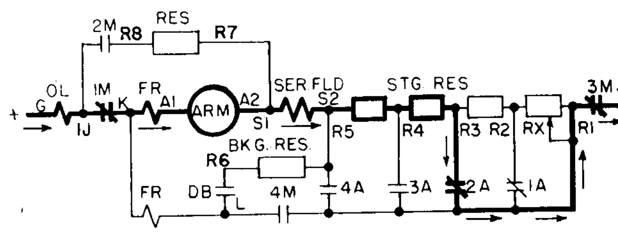


FIGURE 29C—Third Point Hoisting

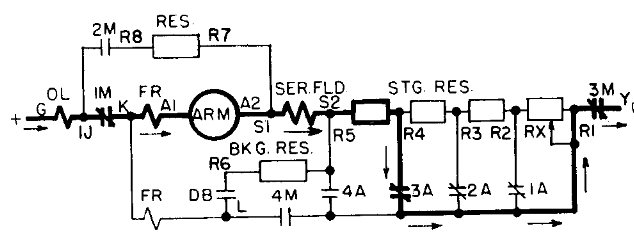


FIGURE 29D—Fourth Point Hoisting

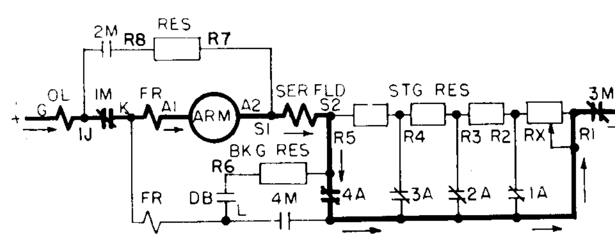


FIGURE 29E—Fifth Point Hoisting

The fourth point lowering, Fig. 29-J, provides still further weakening of the series field circuit and increased speed by opening 2A to add resistor R_2 to R_3 to the series field circuit.

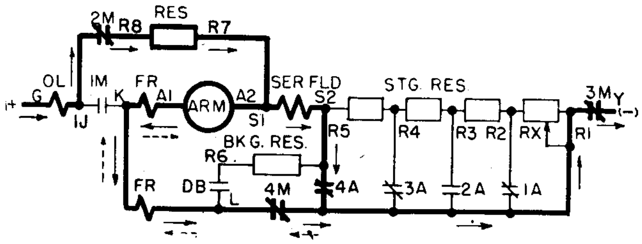


FIGURE 29F—First Point Lowering

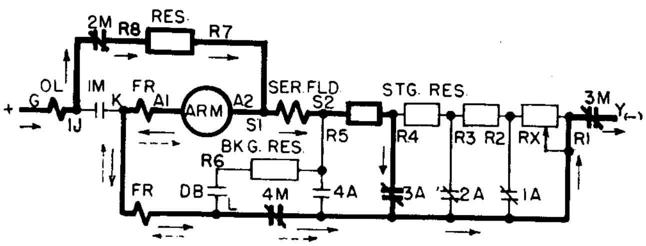


FIGURE 29G—Second Point Lowering

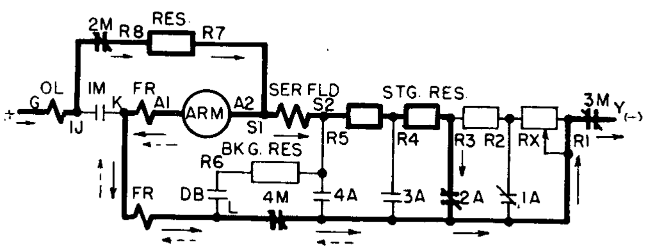


FIGURE 29H—Third Point Lowering

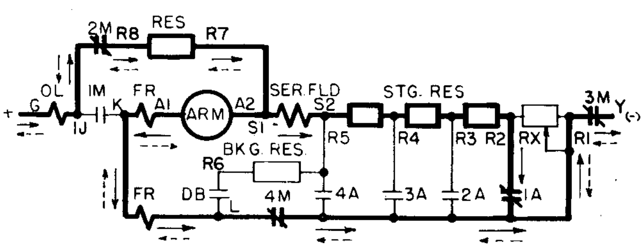


FIGURE 29J—Fourth Point Lowering

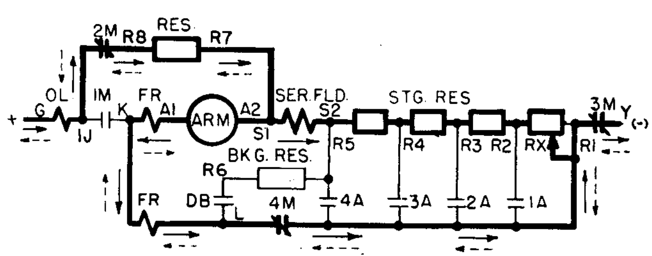


FIGURE 29K—Fifth Point Lowering

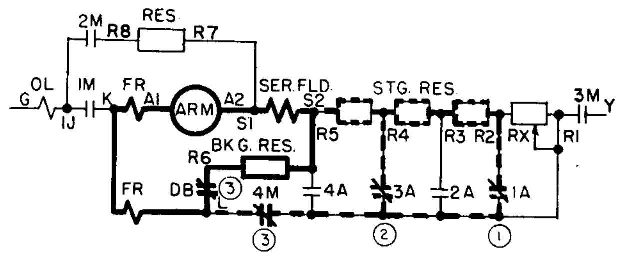


FIGURE 29L—Dynamic Braking in "OFF" Position

On the fifth point lowering the entire resistor R_1 to R_5 is in the series field circuit. This provides maximum motor speed for lowering operations. Contactors 2M, 3M and 4M are closed as shown by Fig. 29-K.

Fig. 29-L illustrates several graduated effective dynamic braking circuits that prevail when the master switch is moved rapidly from the fifth to the off position.

At first contactors 1A and 4M are closed and the dynamic braking resistor is sections R_2 to R_5 as indicated by #1 dotted circuit.

Approximately one second later timing relays open contactor 1A and close 3A as illustrated by a dotted connection #2 from R_1 through 3A to R_4. The braking resistor is reduced to section R_4 to R_5.

After another timing period, contactor DB closes and resistor R_5 to R_6 which is less than resistor R_4 to R_5 is the effective breaking resistor. The final dynamic braking circuit #3 is shown in heavy solid lines.

Graduated dynamic braking maintains strong braking effect as the motor slows down without the excessive strain on the equipment when braking is suddenly applied from a high speed point.

If the armature current exceeds a definite value when lowering, the relay, IFR, will operate and short circuit resistor J to V_1 to F_1 in the shunt field circuit. With full voltage on the shunt field the motor will run at normal speed.

If the master switch is moved rapidly from one position to another the acceleration or deceleration is automatically controlled by timing relays.

If an overload occurs relay LV will open, control circuits will be deenergized, power will be removed from the motor and the brake will set.

If a voltage failure occurs the motor and control circuits will be deenergized and the brake will set.

After an overload or voltage failure the master switch must be returned to the off position to reclose relay LV before the motor can be started again.

CAPSTAN—(Definite Time Acceleration)

Capstan controllers are built with either definite time acceleration or current limit acceleration. The definite time scheme of acceleration, however, is the most frequently used. Schemes have also been used that provide either five or six points on the master switch.

Fig. 30 using a five point master switch with definite time acceleration and Fig. 31 using a six point master switch and current limit acceleration are both analyzed for capstan circuits.

The master switch is watertight, pedestal mounted, suitable for use above deck as shown by Fig. 28.

Heaters may be used to prevent moisture from condensation.

Panels and resistors are open type.

After the line switch on the panel and the emergency switch on the master switch have been closed, relays LV amd FR, Fig. 30, will be energized. LV by-passes the "reset" contact and completes the connection to the positive control bus. FR connects the motor shunt field to the line with the discharge resistor in parallel and resistor 21-F1 in series. Timing relays 1T, 2T, and 3T are likewise energized. Their make-contacts close and their break-contacts open.

If the master switch handle is turned to 1ST POINT FORWARD, contactors M, 1F, 2F close and connect the motor armature and series field as shown in Fig. 30-A. Coil DB is not energized hence its spring closed contacts are closed and the motor operates with resistor R_4 to DB_1 in parallel with the armature. Interlock Ma energizes and releases the shunt brake and interlock 1Fa closes. MS-9 connects the shunt field to full line voltage.

On 2ND POINT FORWARD contactor DB opens the armature shunt circuit (Fig. 30-B).

On 3RD POINT FORWARD 1T becomes de-energized and after about 1 sec. drops out, causing 1A to reduce the armature series resistor to R_2-R_4 (Fig. 30-C).

On 4TH POINT FORWARD 2T becomes de-energized and after a similar delay permits 2A to reduce the resistor to R_3-R_4 (Fig. 30-D).

On 5TH POINT FORWARD 3T becomes de-energized and after a further delay drops out. 3A will then place full voltage on the motor (Fig. 30-E).

Going from "off" to **1st point reverse** will result in closing of contactors M, 1R, and 2R, completing

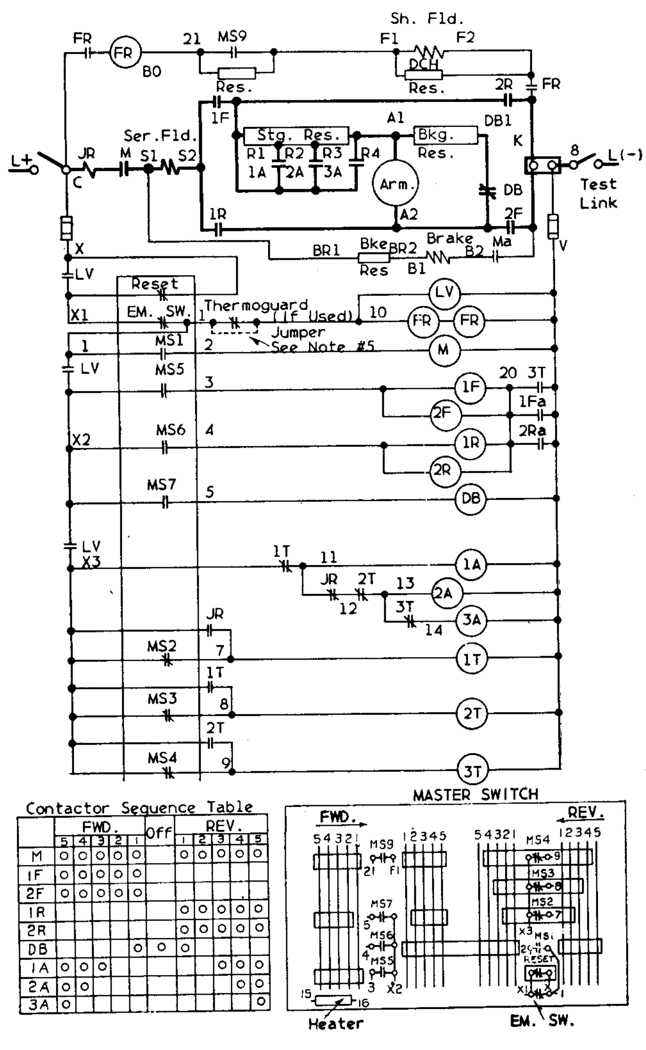


FIGURE 30—Capstan Controller Diagram—Definite Time Acceleration

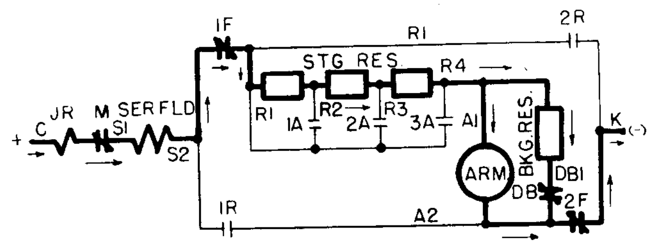


FIGURE 30A—First Point Forward

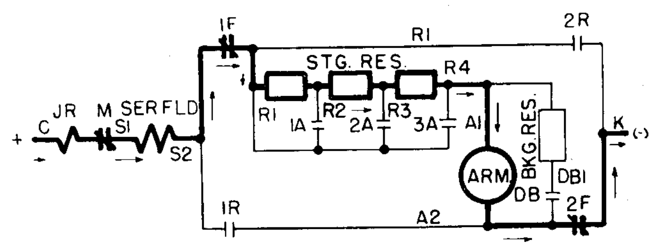


FIGURE 30B—Second Point Forward and Stalled Condition

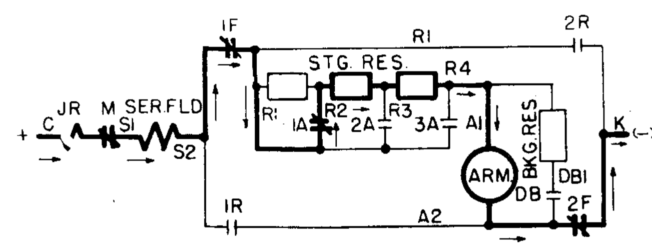


FIGURE 30C—Third Point Forward

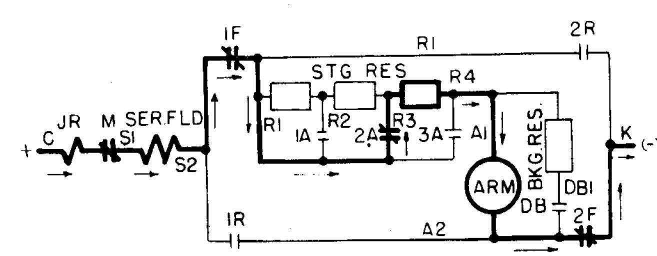


FIGURE 30D—Fourth Point Forward

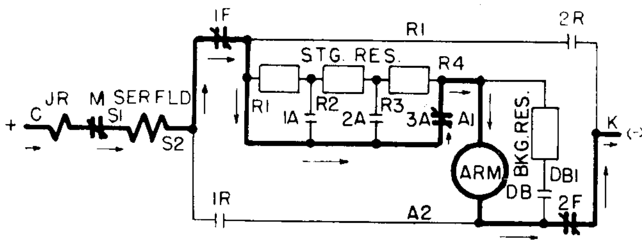


FIGURE 30E—Fifth Point Forward

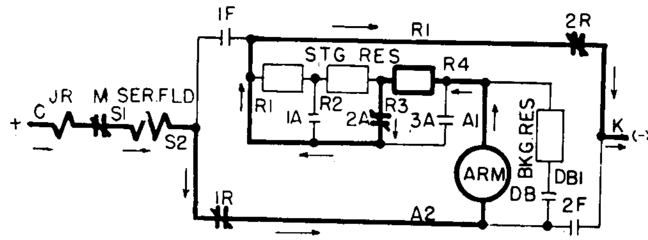


FIGURE 30J—Fourth Point Reverse

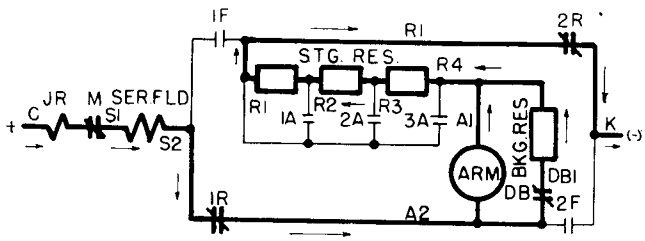


FIGURE 30F—First Point Reverse

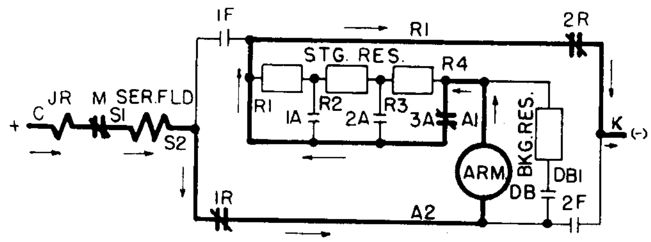


FIGURE 30K—Fifth Point Reverse

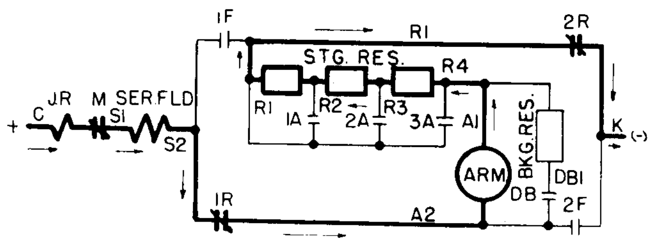


FIGURE 30G—Second Point Reverse and Stalled Position

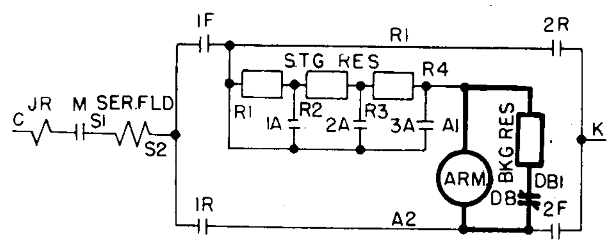


FIGURE 30L—Dynamic Braking in "OFF" Position

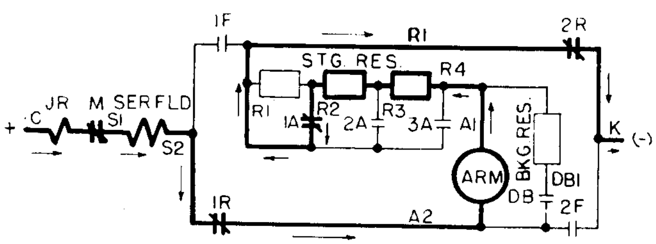


FIGURE 30H—Third Point Reverse

a connection shown in Fig. 30-F. DB contacts are closed and resistor R_4 to DB_1 is in parallel with the armature as for the first point forward operation. Interlock Ma energizes and releases the brake and interlock 2Ra closes. MS-9 connects the shunt field to full line voltage. The conditions now are similar to those of Par. 2 except that the armature current has been reversed, making the motor turn in opposite direction.

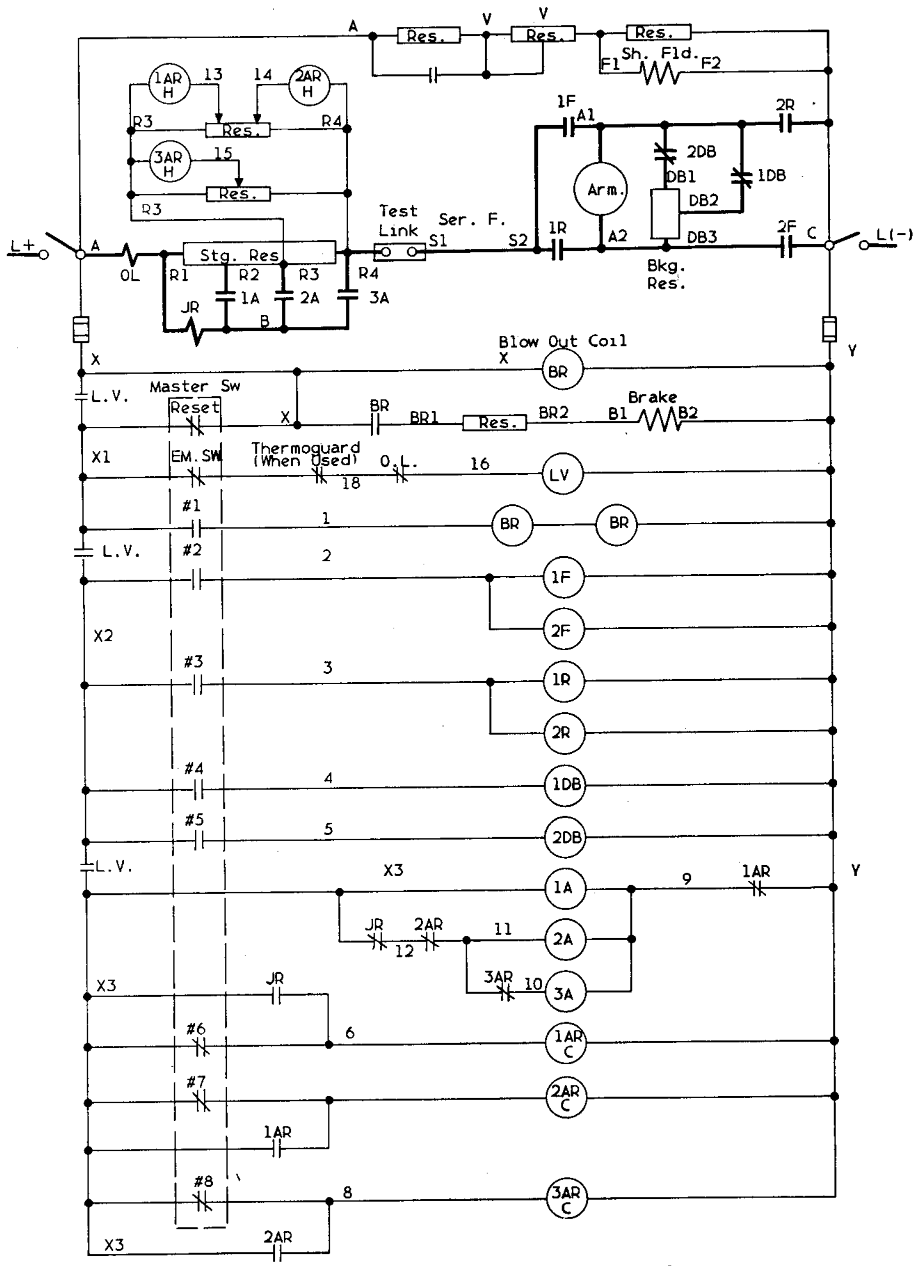
On point 2 to 5 in reverse direction connections are established similar to 2nd to 5th point forward, except that the armature current has been reversed and the motor runs in opposite direction (Figs. 30-G, 30-H, 30-J and 30-K.

Some DYNAMIC BRAKING is obtained when going from one of the operating points to "off" and at power failure, in addition to the braking force of the shunt brake. The weakened shunt field will generate a braking current in the circuit shown in Fig. 30-L.

If the master switch handle is thrown rapidly to higher points in either direction, the TIMING RELAYS [will retard closing of the ACCELERATING CONTACTORS 1A-2A and 3A to prevent excessive starting current.

The JAMMING RELAY JR is set to pick up if the motor current reaches a value that could cause excessive strain on the warping hawser. Timing relays 1T, 2T, and 3T will be picked up and contactors 1A, 2A and 3A drop out, inserting resistor R_1-R_4 into the armature circuit as on 2nd points forward and reverse (Figs. 30-B and 30-G). The motor will stall at this moment, and the hawser pull is limited to a safe value even if the hawser pull should force the motor to reverse its rotation. After the motor is again allowed to turn freely, the timing relays will re-accelerate the motor.

At failure of the power supply, contactors and relays will drop out. To resume operation after the supply voltage has been restored, the master switch handle must first be returned to "off".



CONTACTOR SEQUENCE TABLE

Con-tact No.	Forward 6	5	4	3	2	1	Off	Reverse 1	2	3	4	5	6
1F	O	O	O	O	O	O							
2F	O	O	O	O	O	O							
1R								O	O	O	O	O	O
2R								O	O	O	O	O	O
1DB						O	O	O					
2DB					O	O	O	O	O				
1A	O	O	O								O	O	O
2A	O	O										O	O
3A	O												O

MASTER SWITCH

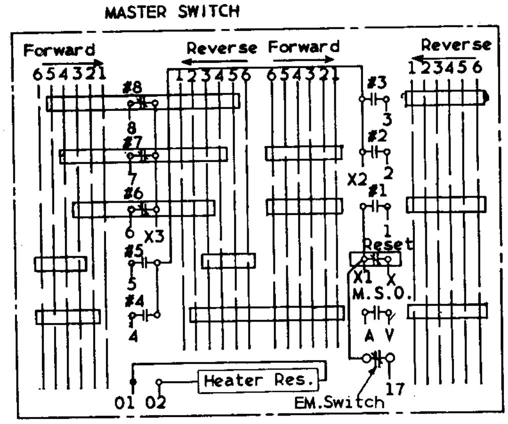


FIGURE 31—Capstan Controller Diagram Current Limit Acceleration

CAPSTAN—(Current Limit Acceleration)

The circuits for a capstan controller using current limit acceleration are shown in Fig. 31.

After the line switch on the panel and the emergency switch in the master switch have been closed, relay LV will be energized. LV by-passes the "reset" contact and completes the connection of the positive control bus. The motor shunt field is energized with resistor A-F1 in series and the discharge resistor in parallel. Accelerating relay closing coils 1AR to 3AR are energized and make-contacts 1AR to 3AR close and break-contacts 1AR to 3AR open. The blowout coil of brake relay BR is energized.

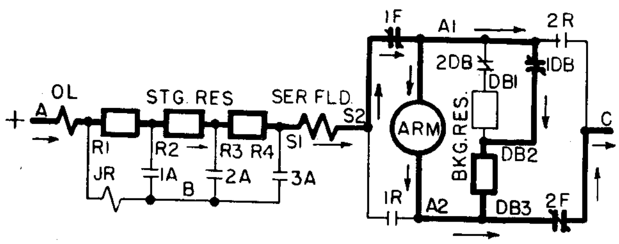


FIGURE 31A—First Point Forward

If the master switch handle is turned to 1ST POINT FORWARD, contactors 1F and 2F close and relay, BR, energizes and releases the brake. Spring closed contacts 1DB and 2DB are closed. MS-0 shorts out shunt field resistor AV, armature and series field of the motor are now connected as shown in Fig. 31-A.

On 2ND POINT FORWARD contactor, 1DB, opens and increases the armature shunting resistor to DB1, DB3 (Fig. 31-B).

On 3RD POINT FORWARD contactor 2DB opens the armature shunt circuit (Fig. 31-C).

On 4TH POINT FORWARD coil 1AR-C becomes deenergized. After the voltage on holding coil 1AR-H has been lowered by the decreasing starting current through resistor R_3-R_4, 1AR drops out, energizes contactor 1A and opens make-contact 1AR. The armature series resistor is now reduced to R_2-R_4 (Fig. 31-D).

On 5TH POINT FORWARD coil 2AR-C is deenergized. After the voltage on R_3-R_4 drops again (the current peak caused by reduction of resistance on point 4 had increased the voltage on R_3-R_4), 2AR drops out and energizes contactor 2A. Make-contact 2AR opens. The armature series resistance is now R_3-R_4 (Fig. 31-E).

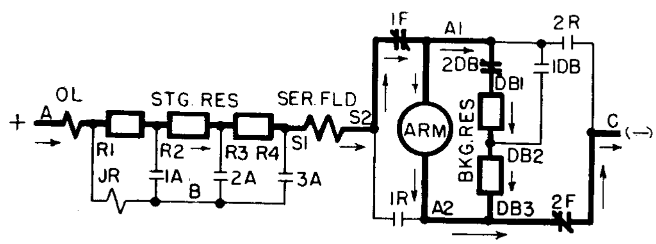


FIGURE 31B—Second Point Forward

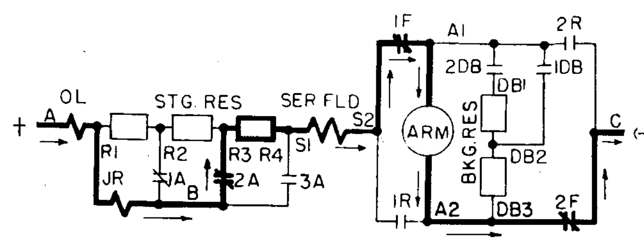


FIGURE 31E—Fifth Point Forward

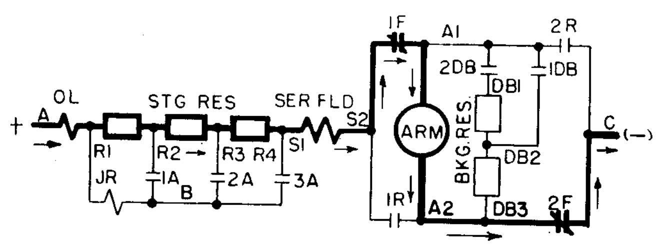


FIGURE 31C—Third Point Forward and Stalled Condition

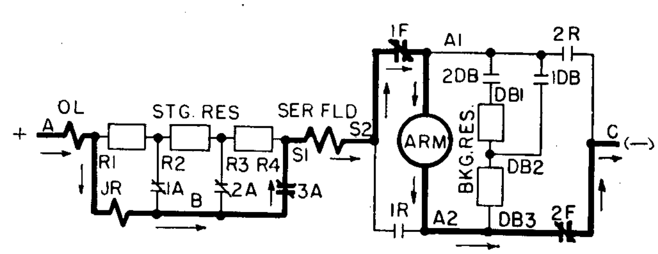


FIGURE 31F—Sixth Point Forward

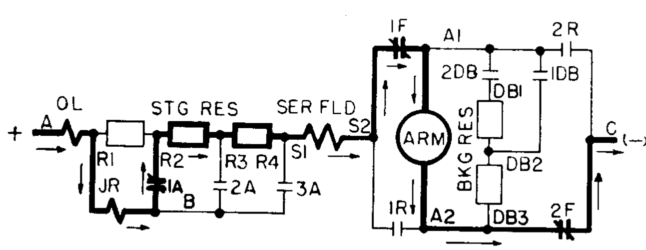


FIGURE 31D—Fourth Point Forward

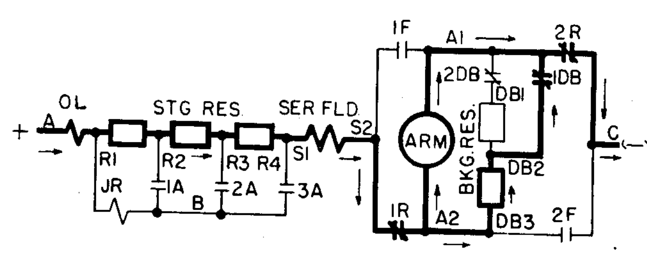


FIGURE 31G—First Point Reverse

On 6TH POINT FORWARD 3AR brings in contactor 4A and the motor is now on full line voltage (Fig. 31-F).

Going from "off" to 1ST POINT REVERSE contactors 1R and 2R close and relay BR energizes and releases the brake. Spring closed contacts 1DB and 2DB are closed. MS-0 shunts out Shunt field re sistor AV. Armature and series field are connected as shown in Fig. 100. This connection is similar to 1st point forward (Fig. 31-G) except that the armature current is reversed and the motor runs in opposite direction.

SECOND TO 6TH POINT operation in REVERSE direction is similar to operation on the corresponding points in forward direction, except that the armature current is reversed, causing the motor to rotate in opposite direction (Fig. 31-H, 31-J, 31-K, 31-L and 31-M.

The effect of DYNAMIC BRAKING is obtained when going from one of the operating points to "off" and at power failure, in addition to the braking force of the shunt brake. The dynamic braking circuit is shown in Fig. 31-N.

If the master switch handle is thrown rapidly to higher points in either direction, the CURRENT LIMIT ACCELERATING RELAYS 1AR to 3AR will retard closing of the accelerating contactors 1A to 3A to prevent excessive starting currents.

The jamming relay JR is set to pick up at excessive motor current. This will energize relays 1AR to 3AR and trip contactors 1A to 3A, inserting resistance R_1-R_5 in series with the motor. The motor will be stalled. After the motor has been permitted to turn again, the accelerating relays will gradually bring it up to speed again.

WINDLASS AND WARPING WINCH

Windlass controllers sometimes perform the double function of a windlass or a warping winch controller.

The circuits for single windlass operation and those for dual operation of windlass and warping winch are somewhat different.

Heaters are supplied to prevent moisture from condensation when necessary.

The master switch is watertight pedestal mounted suitable for use above deck as shown in Fig. 28.

Control panels and resistors are generally open type.

When a controller is used only for windlass operation the circuits are comparable to those previously described for a capstan controller in Fig. 30. The

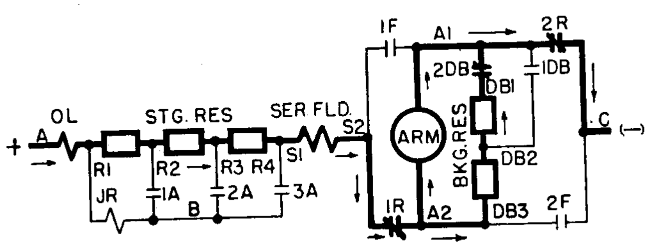


FIGURE 31H—Second Point Reverse

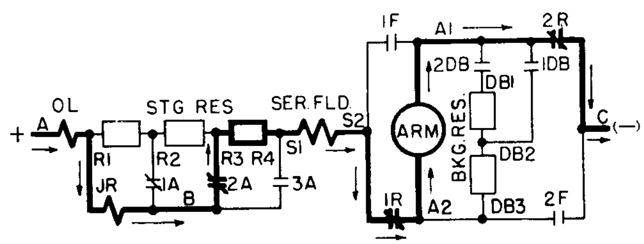


FIGURE 31L—Fifth Point Reverse

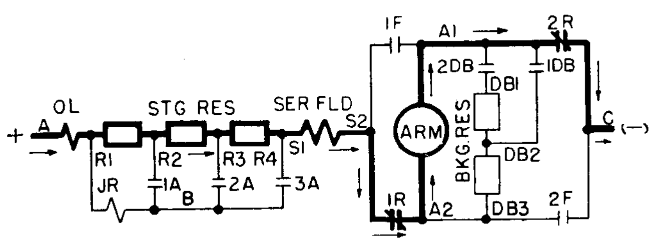


FIGURE 31J—Third Point Reverse and Stalled Condition

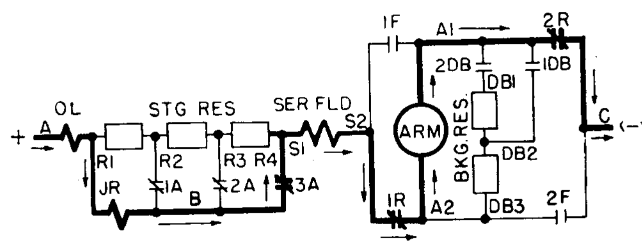


FIGURE 31M—Sixth Point Reverse

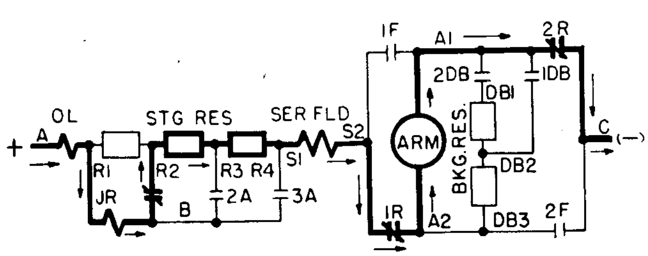


FIGURE 31K—Fourth Point Reverse

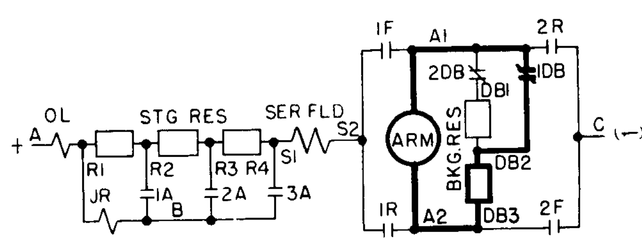
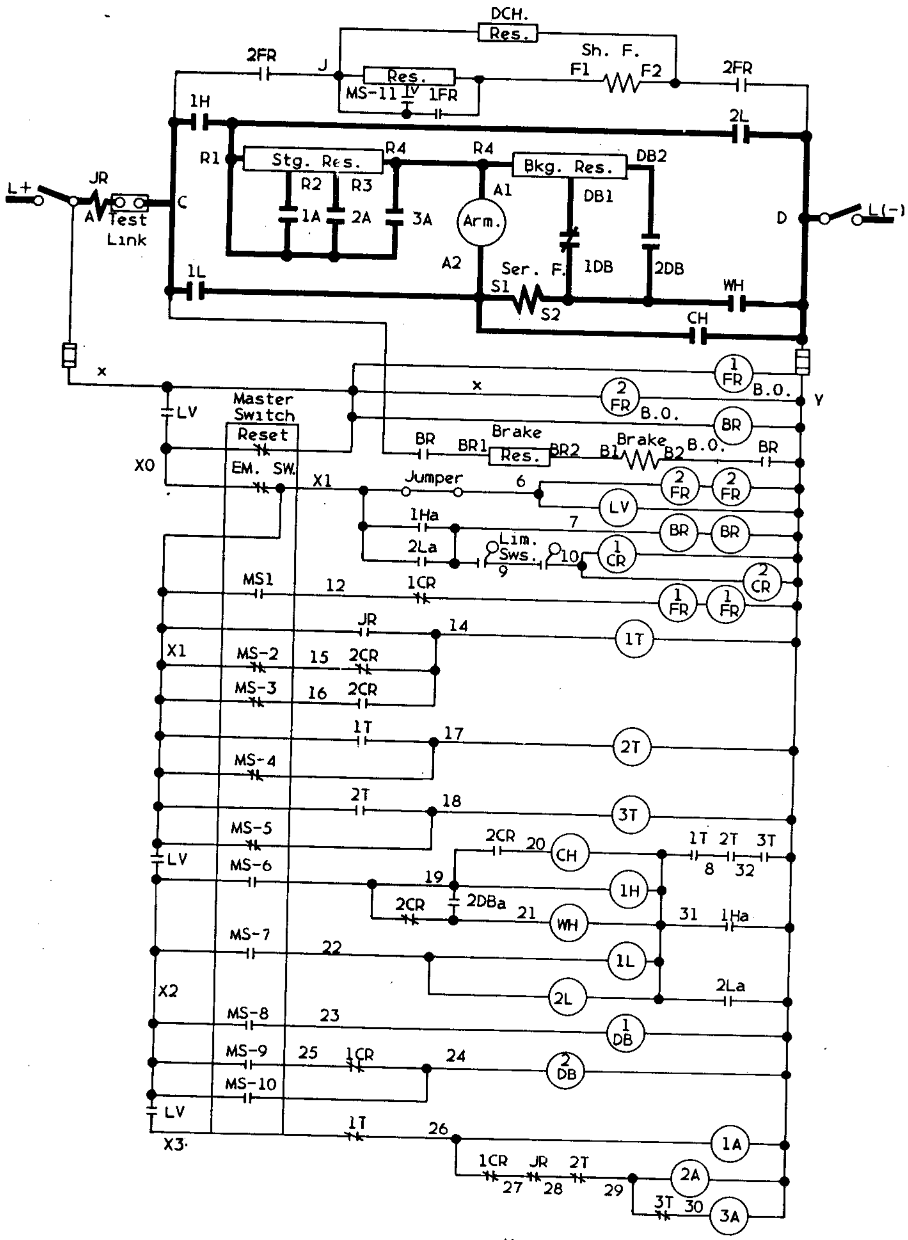


FIGURE 31N—Dynamic Braking in "OFF" Position



CONTACTOR SEQUENCE TABLE

Windlass Operation													Con-tact	Warping Operation												
Hoist							Lower							Hoist							Lower					
6	5	4	3	2	1	Off	1	2	3	4	5	6		6	5	4	3	2	1	Off	1	2	3	4	5	6
O	O	O	O	O	O								1H	O	O	O	O	O	O							
O	O	O	O	O	O								WH					O	O							
													CH	O	O	O	O	O	O							
							O	O	O	O	O	O	1L								O	O	O	O	O	O
							O	O	O	O	O	O	2L								O	O	O	O	O	O
					O	O	O						1DB						O	O	O					
				O	O		O	O	O	O	O	O	2DB					O	O		O	O				
O	O	O											1A	O	O										O	O
O	O												2A													
O													3A													
O	O	O	O	O	O		O	O	O	O			1FR													
O	O										O	O	MS-11	O	O										O	O

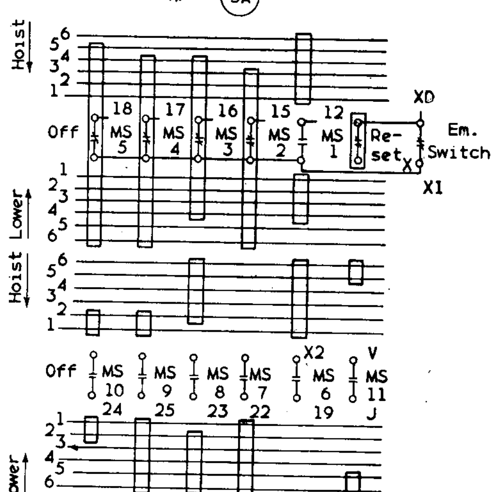


FIGURE 32—Windlass and Warping Winch Diagram

circuits for dual operation of windlass and warping winch are shown in Fig. 32.

WINDLASS OPERATION

One or both limit switches are open if one or both wildcats are locked to the shaft, or if one or both brakes are released. Transfer relays 1CR and 2CR will remain un-energized and the controller will be set up for anchor handling, after the line switch on the panel and the emergency switch in the master switch have been closed.

With the master switch handle in the "OFF" POSITION, relays 2FR, LV 1T, 2T, and 3T, Fig. 32 are energized. The blowout coils of relays 1FR, 2FR, and BR are energized independently from the emergency switch. Relay 2FR energizes the shunt field winding of the motor with resistor J-F1 in series and the discharge resistor in parallel. Relay LV by-passes the reset contact in the master switch and completes the positive control feeder connection. 1T, 2T, and 3T close their make-contacts and open their break-contacts.

Moving the master switch handle to 1ST POINT HOIST, Fig. 32-A will energize 1FR, which places the shunt field on full voltage. Contactors 1H and WH connect the motor armature and series field in series with resistor R_1-R_4, while armature and series field are paralleled by R_4-DB1. Spring closed contacts 1DB are closed. Coil of 2DB is energized and its contacts close. An onterlock 1Ha energizes relay BR which in turn energizes and releases the shunt brake. A second interlock 1Ha closes, also interlock 2DBa.

On 2ND POINT HOIST contactor 1DB opens and increases the armature and series field shunting resistor to R_4-DB2 (Fig. 32-B).

On 3RD POINT HOIST contactor 2DB opens the shunting circuit (Fig. 32-C).

On 4TH POINT HOIST 1T deenergized and after about 1 sec. drops out, energizing in turn contactor 1A which reduces the armature series resistance to R_2-R_4 (Fig. 32-D).

On 5TH POINT HOIST 2T is deenergized and after 1 sec. drops out, causing 2A to reduce the armature series to R_3-R_4 (Fig. 32-E).

On 6TH POINT HOIST, 3T is deenergized and after 1 sec. drops out, causing 3A to short all armature series resistance (Fig. 32-F).

In moving the master switch handle from "off" to 1ST POINT LOWER, relay 1FR again places full voltage on the shunt field. Contactors 1L and 2L connect resistor R_1-R_4 in series with the armature while the series field and resistor R_4-DB1 are in parallel to the armature. 2DB closes, also interlock 2DBa, and a second interlock 2La. The current through the armature is now reversed causing the motor to turn in opposite direction. An interlock 2La energizes relay BR, whereby the shunt brake becomes energized and released. Another interlock 2La closes likewise (Fig. 32-G).

On 2ND, 3RD, AND 4TH POINTS LOWER contactor 1DB increases the armature shunting resistor to R_4-DB2 (Fig. 32-H).

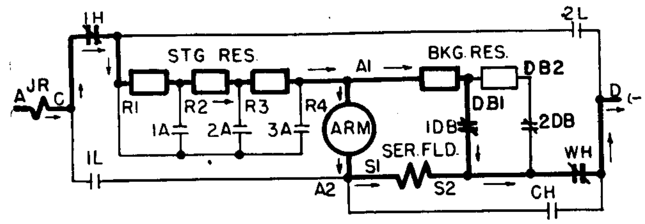


FIGURE 32A—First Point Anchor Hoisting

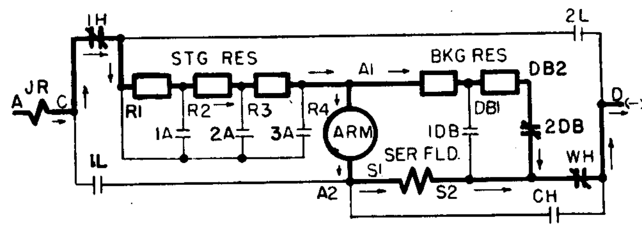


FIGURE 32B—Second Point Anchor Hoisting

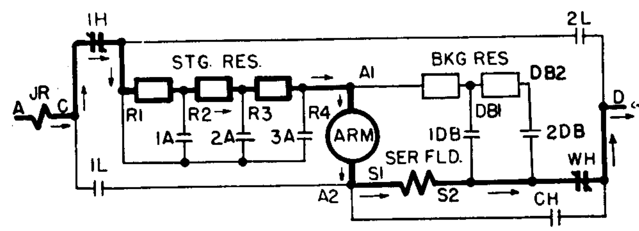


FIGURE 32C—Third Point Anchor Hoisting and Stalled Condition

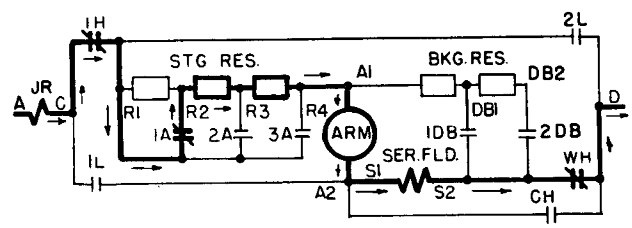


FIGURE 32D—Fourth Point Anchor Hoisting

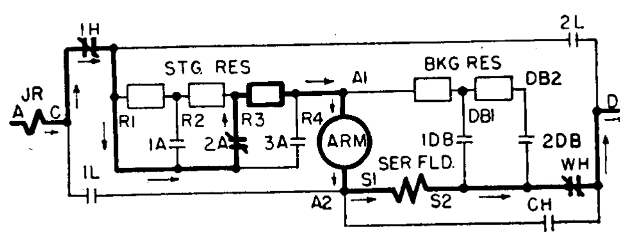


FIGURE 32E—Fifth Point Anchor Hoisting

On 5TH AND 6TH POINTS LOWER, 1FR opens and MS-11 closes, so that resistance V-F_1 is placed in series with the shunt field winding. The main circuit remains as in Fig. 32-H.

WARPING OPERATION

The controller is set up for warping when both transfer or limit switches are closed. This condition exists when both wildcats are disengaged from the shaft, or if both wildcat brakes are set.

With the controller handle in the "off" position, relays 2FR, LV, 1CR, 2CR, 1T, and 3T are energized. The blowout coils of relays DR, 1FR and 2FR are energized independently from the emergency switch. 2FR energizes the shunt field winding of the motor with resistor J-F1 in series and the discharge resistor in parallel. LV by-passes the reset contact in the master-switch and completes the positive control feeder connection. 1T, 2T, and 3T close their make-contacts and open their break-contacts.

Moving the master switch handle to **1st point hoist** will energize contactor 1H. Interlock 1Ha close, one of them energizing relays BR, 1CR, and 2CR. BR energizes and releases the shunt brake. 1CR opens its contacts; 2CR opens its break-contacts, and closes its make-contacts, hereby contactor CH becomes energized. Contactor 2DB closes and its interlock 2-DBa energizes WH. The main circuit is now connected as shown in Fig. 32-J. The sereis field is shorted out in this connection, and the armature shunted by resistor R4-DB1, while R1-R4 is in series.

On 2ND POINT HOIST contactor 1DB opens and increases the armature shunting resistor to R4-DB-2 (Fig. 32-K).

On 3RD AND 4TH POINTS HOIST contactor 2DB opens the armature circuit. Contactor WH opens. Interlock 2DBa opens. (Fig. 32-L).

On 5TH POINT HOIST, 1T becomes de-energized and after 1 sec. drops out, energizing contactor 1A which reduces the armature series resistor to R_2-R_4. 2T also becomes de-energized but does not bring in 2A (Fig. 32-M). Contact MS-11 strengthens the shunt field, leaving resistor V-F_1 in the circuit.

On 6TH POINT HOIST, 3T becomes de-energized but the other connections remain as on point 5. (Fig. 32-M).

Moving the master switch handle from "off" to **1st point lower** energizes contactors 1L and 2L. An interlock 2La energizes relays BR (which again releases the shunt brake), 1CR, and 2CR. LCR opens its contacts. 2CR opens its break-contacts, and closes its make-contacts. Contactor 2DB closes and its interlock 2DBa also. Resistor R1-R4 is in series with the armature. The series field and R4-DB1 form a branch circuit parallel with the armature (Fig, 32-N).

On 2ND POINT LOWER contactor 1DB opens and increases the armature shunting resistor to R4-DB2 (Fig. 32-0).

On 3RD AND 4TH POINTS LOWER contactor 2DB opens the armature shunting circuit. Interlock 2DBa opens (Fig. 32-P).

On 5TH POINT LOWER, 1T becomes de-energized and after 1 sec. drops out, energizing contactor

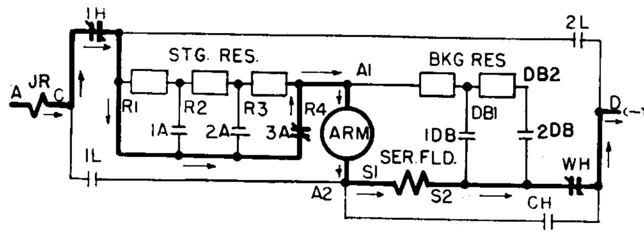


FIGURE 32F—Sixth Point Anchor Hoisting

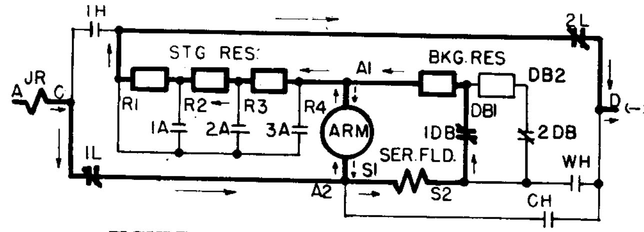


FIGURE 32G—First Point Anchor Lowering

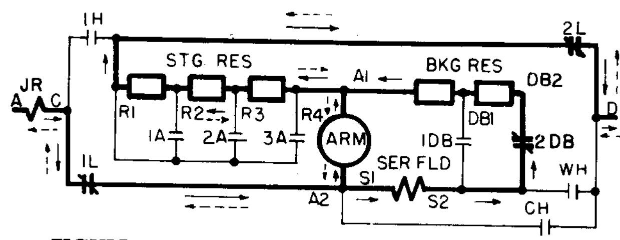


FIGURE 32H—Second to Sixth Point Anchor Lowering (The Shunt Field is Weakened on Fifth and Sixth Point)

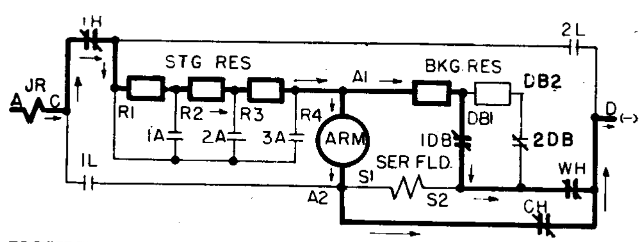


FIGURE 32J—First Point Warping in Direction Marked "Hoist"

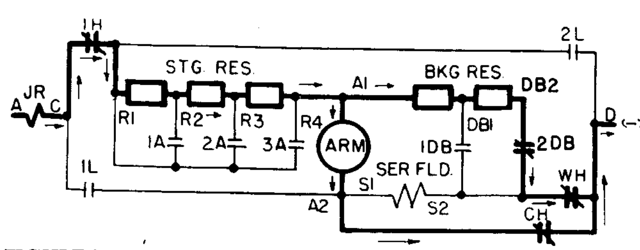


FIGURE 32K—Second Point Warping in Direction Marked "Hoist"

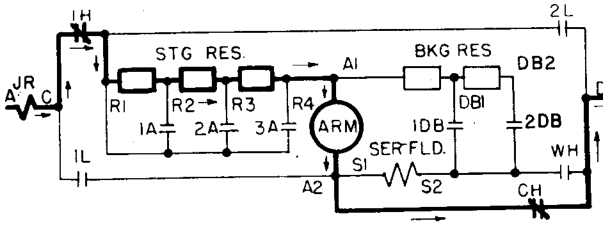


Fig. 32L—Third and Fourth Points Warping in Direction Marked "Hoist" and Stalled Condition

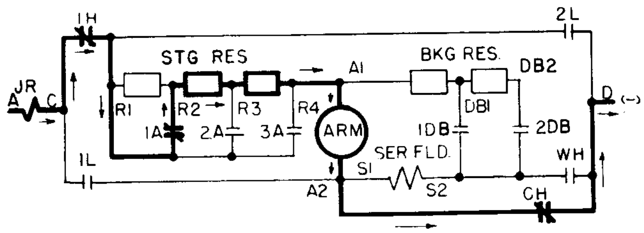


FIGURE 32M—Fifth and Sixth Points Warping in Direction Marked "Hoist"

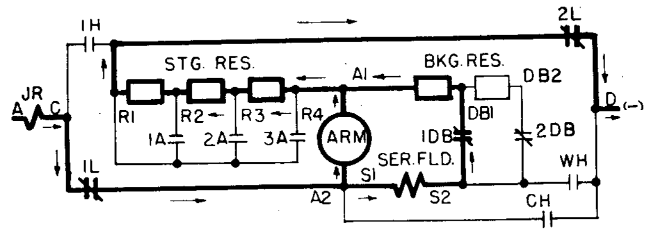


FIGURE 32N—First Point Warping in Direction Marked "Lower"

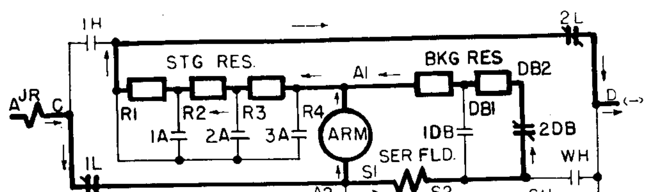


FIGURE 32O—Second Point Warping in Direction Marked "Lower"

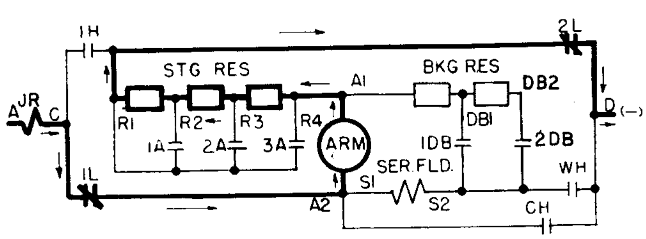


FIGURE 32P—Third and Fourth Points Warping in Direction Marked "Lower" and Stalled Condition

1A which reduces the armature series resistor to R2-R4. 2T also becomes deenergized but does not bring in contactor 2A. (Fig. 32-R). Contact MS-11 strengthens the shunt field, leaving resistor F-F1 in the circuit.

On 6TH POINT LOWER, 3T is deenergized, but the other connections remain as on point 5. (Fig. 32-R).

DYNAMIC BRAKING IN "OFF" POSITION

A self-generating dynamic braking circuit is established, aiding the shunt brake, when going from operation in "lowering" direction to "off" or in case of power failure. This circuit is shown in (Fig. 32-S).

JAMMING PROTECTION

If the line current exceeds the pick-up value of the jamming relay JR, which corresponds to a considerably smaller motor torque in the warping set-up then in the anchor handling connection, this relay will trip contactors 1A-2A and 3A and thereby stall the motor and reduce its torques to safe values. After anchor chain pull or warping hawser pull have been released and the motor permitted to turn again, the jamming relay drops out and the timing relays, which have been picked up by JR will automatically re-accelerate the motor.

This may occur during anchor hoisting, where the step-back condition is established corresponding to the 3rd point (Fig. 32-C) or during warping in both directions, corresponding to the 3rd or 4th points (Figs. 32-L and 32-P).

AUTOMATIC ACCELERATION

If the master switch handle is moved rapidly in hoist direction while hoisting an anchor, or in either direction for warping, the time relays retard closing of the accelerating contactors long enough to prevent excessive starting current.

LOW VOLTAGE PROTECTION

At failure of the power supply, the contactors and relays drop out and the brake sets. To resume operation after return of normal voltage, the master switch handle must first be returned to "off".

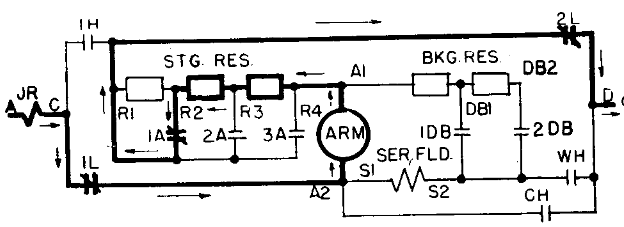


FIGURE 32R—Fifth and Sixth Points Warping in Direction Marked "Lower"

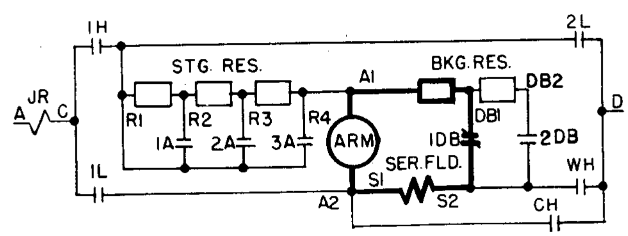


FIGURE 32S—Dynamic Braking[in "OFF" Position

MAINTENANCE OF CONTROLLERS

MAGNETIC CONTACTORS AND RELAYS

The coils, contacts and other parts of contactors and relays that may require replacements are arranged to permit quick and easy access for such replacements. Many designs are complete unit assemblies so that an entire unit may be quickly replaced by another one. The damaged unit then can be put in good condition in the repair shop.

BEARINGS

Do not lubricate the bearings of contactors and relays. The accumulation of hard grease and dirt will eventually do more harm than good. The bearings are designed to operate without lubrication. Surfaces that have been much worn, such as pole faces, may rust because the protective finish has been destroyed. They may be wiped with oiled cloth to prevent rust. A heavy coating of oil or grease will cause "sticky" action; therefore, the surface must be wiped and all excess lubrication removed.

CONTACTS

Deeply pitted and burned contacts, and contacts that have been worn very thin should be replaced by new ones. For most satisfactory results they should be replaced by sets. Do not operate one new contact with a worn one unless emergencies require such temporary conditions. The surface against which contacts are fastened should be thoroughly cleaned when replacements are made.

If contacts are not badly burned they may be cleaned with sandpaper or a fine file. Do not use emery paper. If filed, some care should be taken to maintain the contact shape otherwise the contacts may touch unevenly.

Contact surfaces need not be entirely smooth. A slightly rough surface, if clean, is entirely satisfactory. Much contact material may be unnecessarily wasted by attempting to keep contacts smooth at all times.

Contact screws must hold the contacts tightly in place. A loose contact will overheat. Fig. 33 illustrates a check for tight contact tips.

Most contacts are made of copper although silver is frequently used. Blackened copper contacts should be cleaned. Blackened silver contacts need not be cleaned. These different conditions exist because the darkened surface of copper is a resistance material whereas the dark surface of silver is a good electrical conductor.

If contacts bounce when they close or are subjected to extreme arcing conditions they may "freeze" or "weld" together. They, of course, will not open when the coil is deenergized. They must be forced apart and contacts must be reconditioned or replaced.

SPRINGS

Springs are important parts of contactors. Through them suitable contact pressures are provided and maintained as the contacts wear. When contacts wear very thin the spring pressure decreases and if too low the contact will overheat. Springs are often used to open or close devices.

A much used, overstressed spring will be irregular in shape. One that has been overheated will have lost its temper and will provide decreased pressure. Such springs should be replaced by new ones. A comparison between a used spring and a new one of same design will quickly indicate whether or not a replacement is necessary.

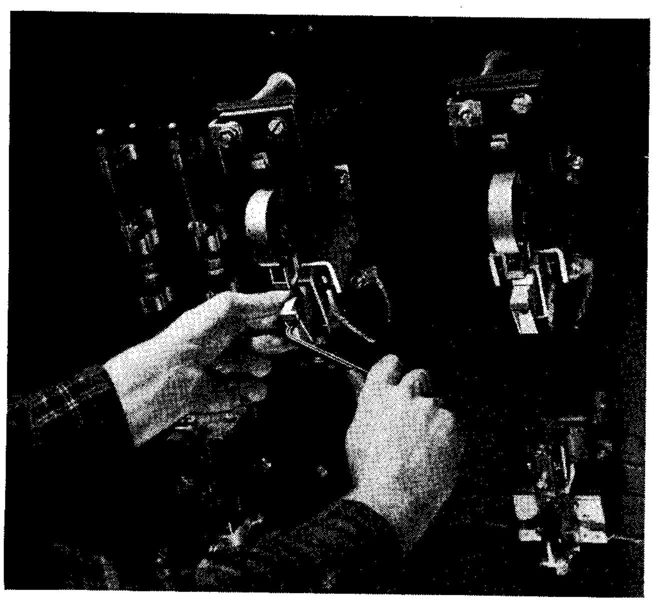


FIGURE 33—Changing and Tightening Contacts

FIGURE 34—Measuring Contact Spring Pressure

Springs should be checked for signs of weakening in tension or compression. Excessive heating or burning of contacts may be due to contact springs that should be readjusted or replaced. Where it is desired to measure the contact pressure, a spring scale may be attached to the moving contact part and a thin piece of paper placed between the two contact parts. The pull required to permit removal of the paper is the contact pressure, provided the pull is exerted in a direction vertical to the contact surface and the line of pull projects through the center of this surface. For reasons of safety, it is preferable to hold the contactor closed mechanically for this test rather than by energizing its coil. The measurement of spring pressure is illustrated in Figure 34.

COILS

Defective coils can be replaced easily and promptly. An open-circuited coil cannot operate the device. A short-circuited coil will soon overheat. Fig. 35 shows a contactor coil being replaced.

When a double coil is used on a relay or contactor or when one is operated by two coils the connections to the coils are often made to obtain certain polarities. When coil changes are made the connections must be replaced in exactly the original manner.

SHUNTS

The flexible shunts of fine stranded copper must be tightly connected and must not have broken strands. Broken strands increase the current on the remaining strands and cause overheating.

ARC SHIELDS

The arc shields that surround the contacts of units that must interrupt high or inductive currents are part of the magnetic blowout structure. For effective arc interruption the arc shields must be firmly in the correct position. They must not be "almost" in place. Arc shields are hinged or easily removable to permit inspection and renewal of contacts. Fig. 36 shows two arc shields in proper operating position and a third one almost in the correct position.

DASHPOTS

When dashpots are used they should be kept free from dirt, friction and anything that will cause sluggish action.

The proper oil level should be maintained at all times.

The oil for dashpots is a special grade that changes very little in viscosity with wide temperature changes. Only the special oil should be used. If substitute oils are used the calibration of the relay will be changed and the relay may not operate under any circumstances.

FAILURE TO CLOSE

A magnet may fail to close a contactor or relay for any one of the following reasons:

1. The voltage may be too low to operate the coil or power may be disconnected.
2. The wire to the operating coil may be broken or disconnected.
3. The operating coil may be open-circuited.
4. There may be mechanical friction in the unit.

FAILURE TO OPEN

A contactor or relay may fail to open for any one of the following reasons:

1. Mechanical interference.
2. Contact tips may be "welded" together.

BRAKES

Complete instructions for making adjustments to obtain correct travel of the brake magnet and shoes are given on the instruction nameplate attached to the brake.

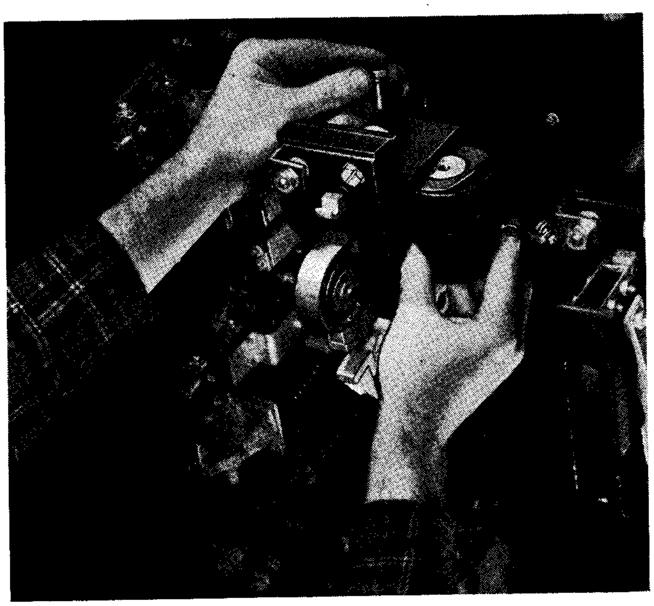


FIGURE 35—Changing Contactor Coil

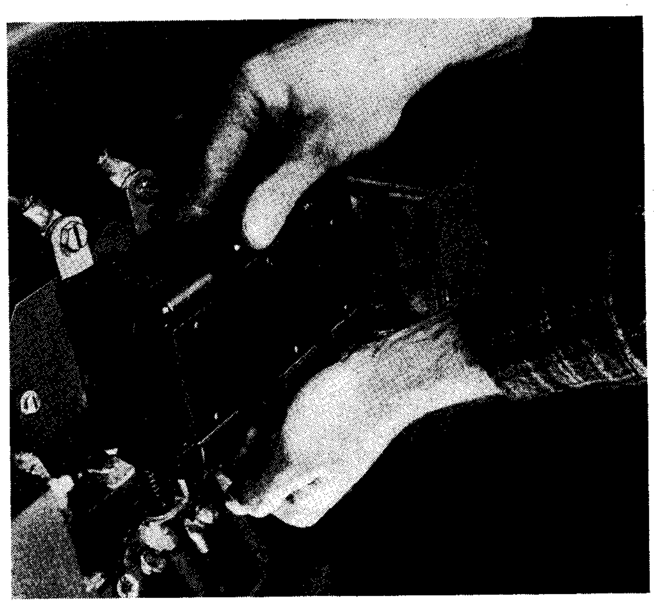


FIGURE 36—Arc Shields must be in Correct Position for Good Operation

LUBRICATION

All bearings are provided with oilers, however, judgment should be used when to use and when not to use oil. Oil collects dirt and if the dirt is abrasive the combination of the two will form a good cutting compound which is very destructive to bearings.

BRAKE SHOES

The brake shoes should be inspected regularly and as the lining wears the excess clearance between the wheel and the brake shoe should be corrected as directed on the instruction nameplate.

When brake shoes must be relined the brake can be released by screwing down the release nut on top of the brake. Then remove the connecting rod pin and the shoe pivot bolt. The shoe can then be slid toward the top of the wheel.

BRAKE LINING

Only the best grades of brake shoe lining should be used. The following brands of lining have proven satisfactory by test and experience and are recommended without preference for either.

1. Raybestos Gold Edge Brake Lining
2. U.S. Industro Truck Brake Lining
3. Ferodo Brake Lining

MASTER SWITCHES, PUSHBUTTONS AND RESISTORS

The auxiliary apparatus such as master switches, selector switches, pushbuttons, limit switches, pressure regulators and resistors require very little maintenance except regular inspections to keep the contacts in good condition, movable parts free of excess friction and all connections tight.

Bearing surfaces should not be lubricated.

COMPLETE MOTOR CONTROLLERS

Only skilled personnel should service the electric equipment. It is assumed that all possible safety precautions will be taken, not only at the controller but also at the distribution board, feeder lines, motor and driven machines before opening the controller cabinet or other control equipment.

INSPECTION: Periodic inspections of the control will save time and expense and often avoid expensive replacement of complete apparatus under breakdown and emergency conditions.

CLEANING: Accumulations of dirt should be removed and dust blown out with compressed air. Where compressed air is not available, careful cleaning may be sufficient. Oil and moisture should be eliminated at all times.

MECHANICAL PARTS: Moving parts should be tried by hand to locate loose pins, bolts, or nuts. All moving parts should move freely and without excessive friction. Parts subject to wear or liable to change in adjustment due to vibration deserve special attention.

INSULATION: Insulating surfaces whether the main panel upon which the contactors and relays are assembled or a part of an individual unit should be inspected for leakage circuits that will develop between live parts if the creepage distance between them is reduced by accumulation of moisture, oil or dirt. If leakage circuits have existed the surface should be thoroughly cleaned and if necessary, scraped and re-insulated.

The insulation of coils, cables and wires may be damaged by rubbing against other parts where excessive vibration occurs. In such cases the cause of the wear should be eliminated and the insulation repaired or replaced by a new part.

LUBRICATION: The bearing surfaces of contactors, relays, drums, master switches, etc., are designed to operate without lubrication of any kind. If oiled or greased, dirt accumulates and causes sluggish action that eventually does more harm than good.

OVERHEATED PARTS: Excessive heating is always a sign of electrical trouble. However, many electrical designs are designed to operate at temperatures that are uncomfortable to the bare hand. Frequent observations on a part that appears to be too hot will soon reveal the need for further investigations. Any signs of smoking parts should receive immediate attention.

LOOSE CONNECTIONS: Electrical connections should always be tight. Loose connections are an evasive but annoying source of trouble. Changing temperatures and vibration cause nuts to become loose. Periodic inspection of vital contact connections will locate possible sources of trouble.

GROUNDS: Grounded circuits in the conduits or cableways that interconnect complete controllers, motors, resistors, pushbuttons, master switches, limit switches, etc., should be prevented. If they exist they may cause unexpected and incorrect motor operations. Common causes of grounds are water in the conduits and damaged insulation on the wires in the conduit. The insulation resistance of cables in conduits can be checked with a "megger" in the same manner as outlined for insulation tests on motors.

SPARE PARTS FOR CONTROLLERS

An ample supply of spare parts should be kept on hand at all times. Depleted stocks of parts should be replenished as promptly as possible. Make-shift parts should be used only in case of extreme emergencies. A poorly fitted part or one of incorrect design will eventually be the cause of trouble instead of a cure for it.

ESSENTIAL SPARE PARTS

Suggestions for essential spare parts and quantities for the same are listed below. These quantities are based upon the total number of spare parts used on the entire ship.

SPARES FOR CONTROLLERS

Contacts	50 for first 100 contacts plus 1 for each additional 10.
Springs	1 for each 10 or less.
Operating Coils	1 for each 10 or less.
Shunt Coils	1 for each 10 or less.
Resistors	1 for each 20 or less.
Fuses	1 for each 1

SPARES FOR BRAKES

Shoe Linings..........1 for each 4 or less.
Springs...............1 for each 4 or less.
Operating Coils.......1 for each 10 or less.

DESIRABLE SPARE PARTS

No additional items need be added to the list of essential spare parts for a list of desirable ones. An increase in the quantity of essential spare parts should suffice for the needs of a desirable list of parts. The increase quite naturally depends upon the space available for such parts and the time the ship will be away from ports where spares can be obtained. However, an increase of 50% to the quantities of essential spares should be sufficient.

When ordering spare parts, name the part and give the complete name plate reading. State whether shipment is desired by express, freight or by parcel post. Send all orders or correspondence to nearest Sales Office of the Company. Small orders should be combined so as to amount to a value of at least one dollar net. Where the total of the sale is less than this, the material will be invoiced at $1.00.

SPECIAL TOOLS

1—Socket screw wrenches for changing contact tips on magnetic contactors. (Furnished by Westinghouse Electric & Manufacturing Company)
2—Twenty-five pound spring scale for checking spring pressures on contactors.

PART III

Sales Offices and Service Shops

Foreign and Domestic Parts for Repairs and Spare Parts for D-C Motors, Generators and Controllers.

Lists of the foreign and domestic parts at which repair service and spare parts may be obtained or ordered are given on the following pages.

DOMESTIC PORTS WHERE WESTINGHOUSE REPAIR SERVICE AND SPARE PARTS CAN BE OBTAINED

Baltimore	118 E Lombard Street, Baltimore, Maryland
Boston	10 High Street, Boston, Massachusetts
Bridgeport	540 Grant Street, Bridgeport, Connecticut
*Charleston	7 Yoemans Road, Charleston, South Carolina
*Corpus Christi	115 W. Travis Street, San Antonio, Texas
*Galveston	1314 Texas Avenue, Houston, Texas
*Gray's Harbor	1115 "A" Street, Tacoma, Washington
*Gulfport	333 St. Charles Street, New Orleans, Louisiana
Hampton Roads	2600 Hampton Boulevard, Norfolk, Virginia
Houston	1314 Texas Avenue, Houston, Texas
*Jacksonville	37 South Hogan Street, Jacksonville, Florida
*Key West	11 N.E. Sixth Street, Miami, Florida
Los Angeles	420 S. San Pedro Street, Los Angeles, California
*Miami	11 N. E. Sixth Street, Miami, Florida
*Mobile	1407 Comer Building, Birmingham, Alabama
Newark	1180 Raymond Boulevard, Newark, New Jersey
*New Bedford	16 Elbow Street, Providence, Rhode Island
*New Haven	42 Church Street, New Haven, Connecticut
New Orleans	333 St. Charles Street, New Orleans, Louisiana
New York	40 Wall Street, New York, New York
Oakland	1 Montgomery Street, San Francisco, California
*Pensacola	1407 Comer Building, Birmingham, Alabama
Philadelphia	3001 Walnut Street, Philadelphia, Pennsylvania
*Port Everglades	11 N. E. Sixth Street, Miami, Florida
*Portland	9 Bowman Street, Augusta, Maine
Portland	309 S. W. Sixth Avenue, Portland, Oregon
*Providence	16 Elbow Street, Providence, Rhode Island
Sabine Dist.	1213 Amer. Natl. Bank Bldg., Beaumont, Texas
San Diego	861 Sixth Street, San Diego, California
San Francisco	1 Montgomery Street, San Francisco, California
Savannah	1299 Northside Drive, Atlanta, Georgia
Seattle	3461 E. Marginal Drive, Seattle, Washington
Stockton	1 Montgomery Street, San Francisco, California
Tacoma	1115 "A" Street, Tacoma, Washington
*Tampa	417 Ellamae Avenue, Tampa, Florida
Willapa Harbor	1115 "A" Street, Tacoma, Washington
Wilmington, Del	3001 Walnut Street, Philadelphia, Pennsylvania
*Wilmington, N.C	210 E. Sixth Street, Charlotte, North Carolina

***Advance notice must be given to obtain repair service and spare parts.**

WESTINGHOUSE SUPERVISORS IN FOREIGN COUNTRIES

Argentina Uruguay Paraguay	Mr. A. Alvarez Mr. L. Lannes Cia, Westinghouse Elec. Intl. Paseo Colon 221 Buenos Aires, Argentina
Brazil	Mr. C. E. Dreher Westinghouse Electric Co. of Brazil Caixa Postal 1320 Rio de Janeiro
Australia	Mr. J. W. G. Henderson Westinghouse International, Box 23 Waterloo Sydney
Colombia Jamaica, B.W.I.	Mr. E. W. Sours, Jr. Westinghouse Elec. Intl. Co Apartado Nacional 405 Apartado Aereo 41 Baranquilla, Colombia
Central American Zone including Costa Rica Guatemala Honduras British Honduras Nicaragua Panama Salvador	Mr. J. C. Stocker Westinghouse Electric Co. S. A. Apartado 742 Panama R. F.
Chile	Mr. W. E. Morrison c/o Wessel, Duval & Cia., S.A. Casilla, 86-D Santiago, Chile
Cuba	Mr. D. Y. Bowman Cia, Westinghouse Elect. de Cuba Apartado 2298, Havana
England	Mr. G. R. Shephard Westinghouse Elec. Int. Co. 2, Norfolk Street, Strand, London, W. C. 2
India	Mr. P. H. Lissenden Mr. G.B. Sujan Westinghouse Elec. Co. of India, Ltd. 294A Bazargate Street Bombay
Mexico	Mr. E.F. Miller Cia. Westinghouse Elec. Intl. Apartado 78-Bis, Mexico, D.F.
South Africa and Portugese East Africa	Mr. F. E. Ingham Westinghouse Elec. Co. of So. Africa, Ltd. P.O. Box 6067 Johannesburg, South Africa
Bolivia Ecuador Peru	Mr. A. Bueno Westinghouse Electric International Co. Casilla 1685 Lima, Peru

WESTINGHOUSE SUPERVISORS IN FOREIGN COUNTRIES—Cont'd

Venezuela including British Guiana Dutch Guiana Netherlands West Indies Trinidad Tobago Barbados	Mr. E. J. Herzog Westinghouse Electric International Co. P.O. Box 1889 Caracas, Venezuela
Dominican Republic Haiti Puerto Rico Virgin Islands	Mr. K. Ingerslev Westinghouse Elec. Intl. Co. P.O. Box 1748 San Juan, Puerto Rico

WESTINGHOUSE DISTRIBUTORS IN FOREIGN COUNTRIES

Bermuda Electric Light, Power & Traction Company, Ltd.
Serpentine Road, Pembroke
Bermuda

Heap & Partners Newfoundland, Ltd.
St. Johns
Newfoundland

H. W. Clarke & Company, Ltd.
Wellington
New Zealand

Masons, Ltd.
Port of Spain, Trinidad
British West Indies