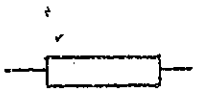
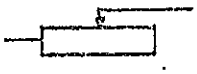
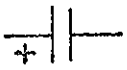
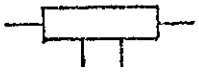
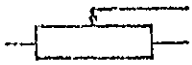
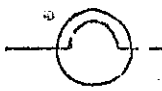
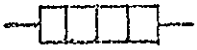
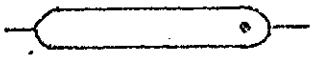
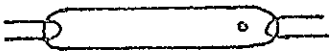
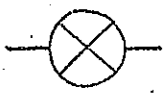
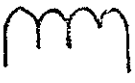
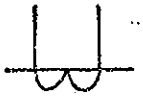
TITLE :- ELECTRICAL DIAGRAMS

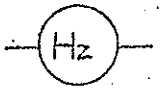
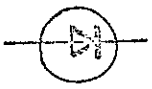
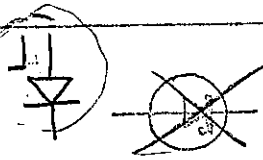
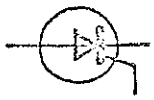
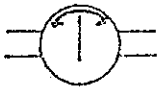
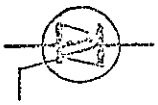
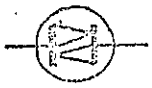
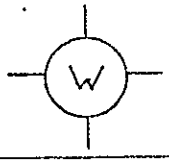
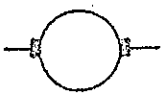
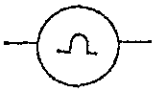
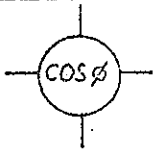
LECTURER :-

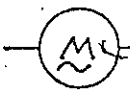
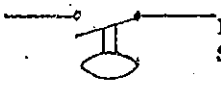
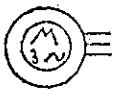
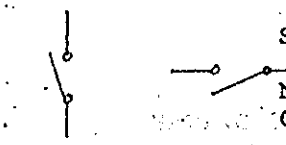
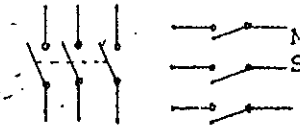
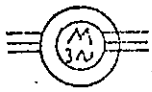
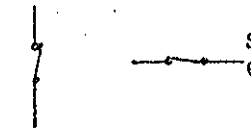
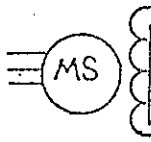
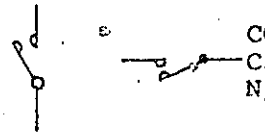
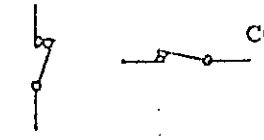
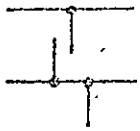
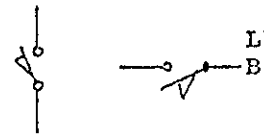
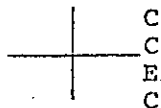
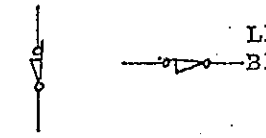
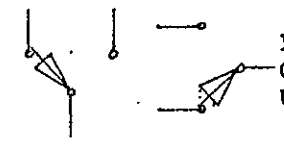
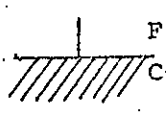
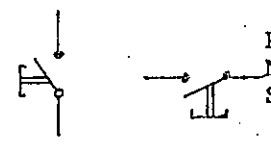
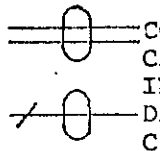
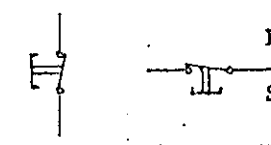
DATE :-

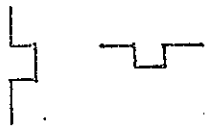
EQUIPMENT :- VARIOUS PLANT DIAGRAMS

The following are selected standard electrical symbols extracted from A.S. 1102

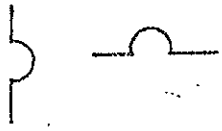
 RESISTORS	 CAPACITOR
 VARIABLE RESISTOR MOVING CONTACT	 POLARIZED CAPACITOR
 FIXED RESISTOR WITH TAPPING	 CIRCUIT BREAKER
 VOLTAGE DIVIDER	 FILAMENT LAMP
 HEATER	 DISCHARGE LAMP
 COKE COIL INDUCTANCE	 HOT CATHODE FLUORESCENT LAMP
 INDUCTOR WITH IRON CORE	 SIGNAL LAMP
 WINDING WITH TAPPINGS	 SINGLE PHASE DOUBLE WOUND TRANSFORMER
 INDUCTOR VARIABLE	 AUTO TRANSFORMER
 FUSE	 CURRENT TRANSFORMER

 POTENTIAL TRANSFORMER	 FREQUENCY METER
 RECTIFYING DIODE	 TACHOMETER
 VOLTAGE REFERENCE DIODE (ZENER DIODE)	 OSCILLOSCOPE
 SILICON CONTROLLED RECTIFIER (THYRISTOR)	 SYNCHROSCOPE
 BI-DIRECTIONAL TRIODE (TRIAC)	 RECORDING INSTRUMENT (GENERAL) REPLACE ALL CIRCLES WITH SQUARES
 BI-DIRECTIONAL DIODE (DIAC)	 WATT/HOUR METER
 AMMETER	 D.C. MOTOR (GENERAL)
 VOLTMETER	 D.C. GENERATOR (GENERAL)
 WATTMETER	 D.C. ARMATURE M OR G TO BE ADDED TO SYMBOL AS REQUIRED
 GALVANOMETER	 D.C. MACHINE SHUNT WINDING
 OHMMETER	 D.C. MACHINE SERIES WINDING
 POWER FACTOR METER	 D.C. MACHINE INTERPOLE WINDING

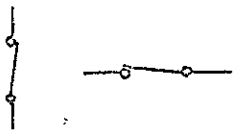
 SINGLE PHASE A.C. MOTOR (GENERAL)	 ELECTRIC BELL (GENERAL SYMBOLS)
 SINGLE PHASE SQUIRREL CAGE INDUCTION MOTOR	 FLUID LEVEL SWITCH
 3 PHASE SQUIRREL CAGE INDUCTION MOTOR HAVING 3 STATOR CONNECTIONS	 SWITCH OR CONTACT N/O CONTROL CIRCUIT
 3 PHASE SQUIRREL CAGE INDUCTION MOTOR HAVING 6 STATOR CONNECTION	 MULTIPLE PART SWITCH
 3 PHASE WOUND ROTOR INDUCTION MOTOR	 SWITCH OR CONTACT
 SYNCHRONOUS MOTOR ADD GS INSTEAD OF MS FOR A SYNCHRONOUS GENERATOR	 CONTACTOR POWER CIRCUIT N/O
CONDUCTOR	 CONTACTOR N/C
 JUNCTIONS OF CONDUCTORS NOTE: 4 CONDUCTORS MAY NOT CONNECT AT ONE JUNCTION	 LIMIT SWITCH N/O BIASED OPEN
 CONDUCTORS CROSSING WITHOUT ELECTRICAL CONNECTION	 LIMIT SWITCH BIASED CLOSED
 EARTH	 LIMIT SWITCH CHANGE OVER UNBIASED
 FRAME OR CHASSIS CONNECTIONS	 PUSHBUTTON N/O START
 CONDUCTORS IN A CABLE OR CONDUCTORS IN A CABLE WHERE n DENOTES NUMBER OF CONDUCTORS	 PUSHBUTTON N/C STOP



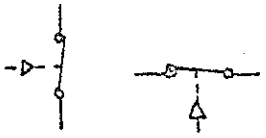
OVERLOAD ELEMENT
THERMAL EFFECT



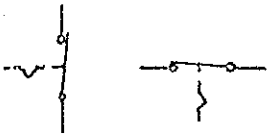
OVERLOAD ELEMENT
MAGNETIC EFFECT



OVERLOAD CONTACT
GENERAL



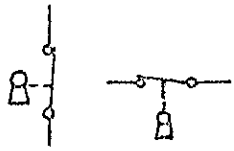
OVERLOAD CONTACT
*
AUTOMATIC RESET



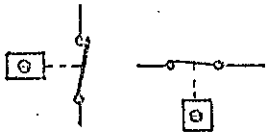
OVERLOAD CONTACT
*
MANUAL RESET

* USE ONLY IF ESSENTIAL TO INDICATE TYPE TIME SWITCH

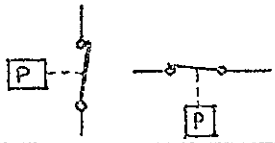
TIME SWITCH



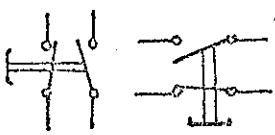
KEY OPERATE
SWITCH



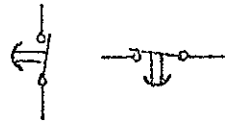
TEMPERATURE
OPERATED SWITCH
THERMOSTAT



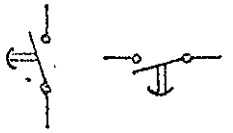
PRESSURE
SWITCH



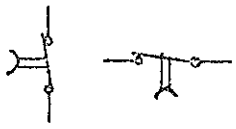
PUSH BUTTON
D.P.
N/O N/C



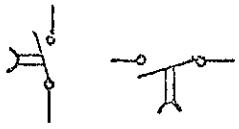
DELAY CONTACT
N/C
DELAY BREAK



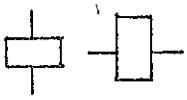
DELAY CONTACT
N/O
DELAY MAKE



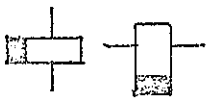
DELAY CONTACT
N/C
DELAY MAKE



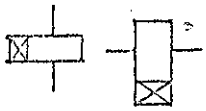
DELAY CONTACTS
N/C
DELAY BREAK



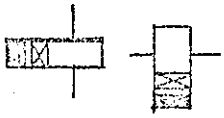
COIL RELAY
OR CONTACTOR
GENERAL



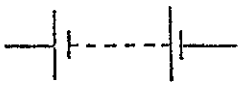
COIL OR DELAY
RELEASING RELAY



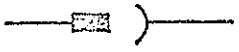
COIL OF DELAY
OPERATING
RELAY



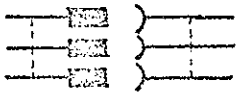
COIL OF RELAY
OPERATE DELAY
RELEASE RELAY



BATTERY OF
PRIMARY OF
SECONDARY CELLS



PLUG (MALE)
SOCKET (FEMALE)



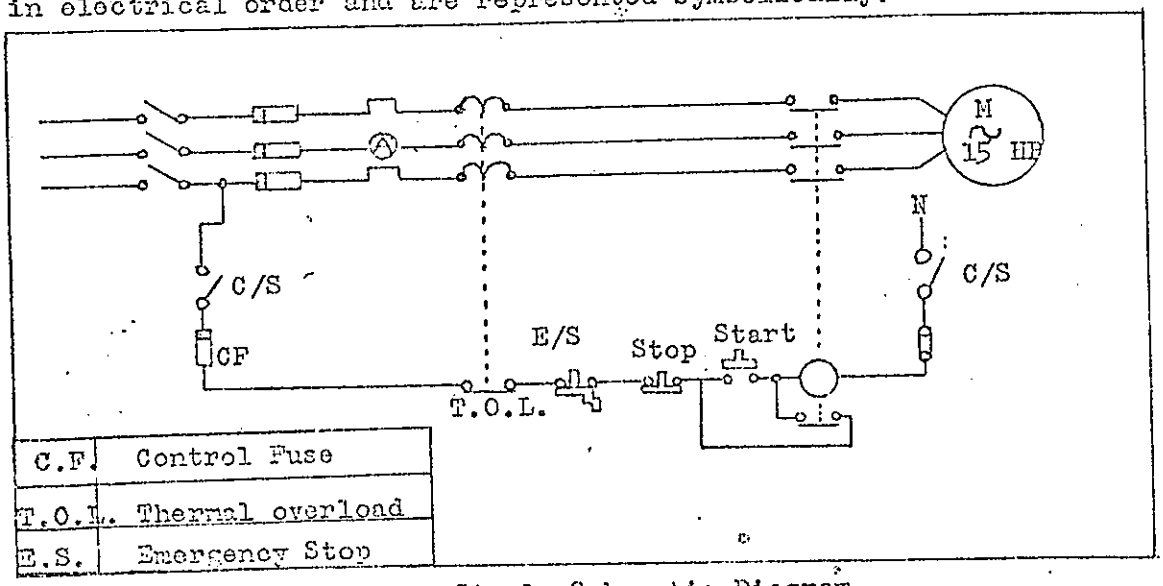
MULTIPOLE
PLUG AND
SOCKET

THIS IS NOT A COMPLETE LIST

SOME MANUFACTURERS MAY HAVE SYMBOLS PECULIAR TO PARTICULAR DRAWINGS

Electrical Diagrams
There are two main types of electrical diagrams - Schematic and Wiring. Several others are used, such as block diagrams, diagram of connections etc. These are usually encountered on building projects and as they are self explanatory from the names, need not be of great concern. The correct understanding of schematic and wiring diagrams is, however, of utmost importance to all electrical trades.

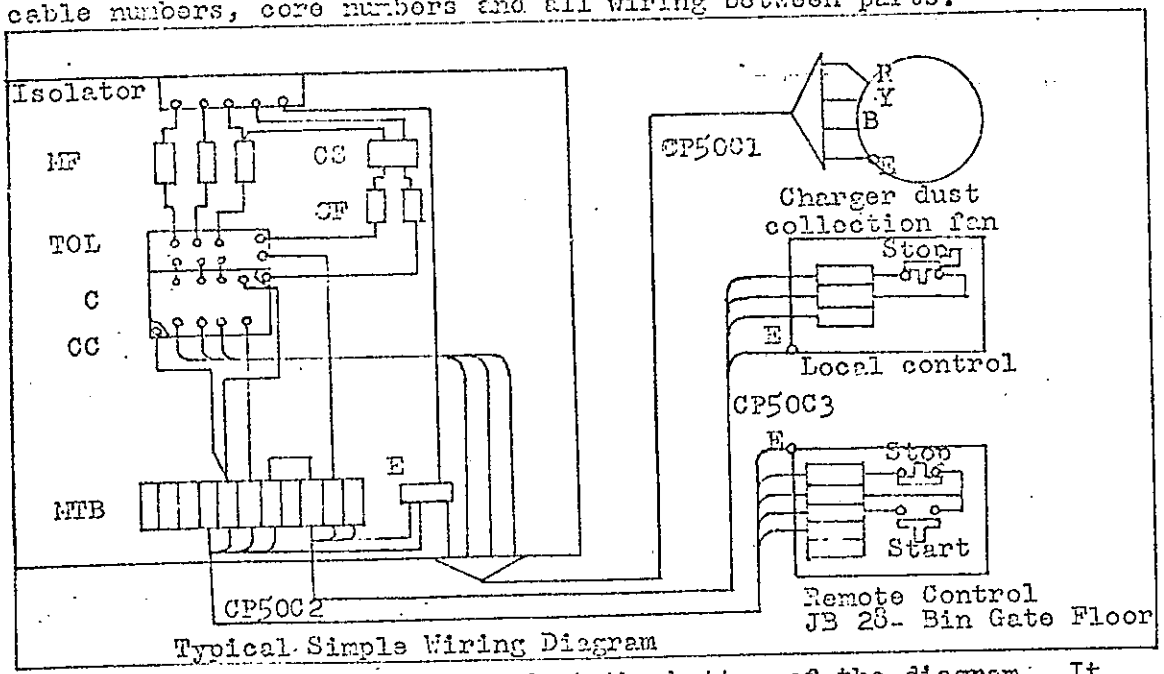
Schematic Diagrams These are diagrams which represent the electrical circuit in its simplest form. Items are put onto the diagram in electrical order and are represented symbolically.



C.F.	Control Fuse
T.O.L.	Thermal overload
E.S.	Emergency Stop

Typical Simple Schematic Diagram

Wiring Diagrams These are diagrams which represent the circuit in its correct physical order and give details of plant position, cable numbers, core numbers and all wiring between parts.



Typical Simple Wiring Diagram

Legend This is usually located at the bottom of the diagram. It gives details of:-

Plant title
Plant location
Manufacturer
Revisions and additions with a brief description and date
Diagram Reference number
Scale of diagram
Any special symbols used
A list of meanings of any abbreviations used
Sometimes notes about operation and sequence of events
Details of other diagrams giving continuation or different types of diagrams for the same plant.

TITLE:- DOMESTIC CIRCUITS

LECTURER:-

DATE:-

EQUIPMENT:-

Domestic Circuits:- This refers to circuits commonly found in domestic situations.
Apart from some large cookers and water heaters, domestic circuits are single phase, they have an active conductor "A" and a neutral conductor "N". All parts must be earthed (except where a portable item is marked "double insulated - do not earth") so there is a third conductor Earth "E".

On PERMANENT wiring the ACTIVE conductor is RED.
On PORTABLE apparatus the ACTIVE conductor is always BROWN.
On PERMANENT wiring the NEUTRAL is always BLACK.
On PORTABLE apparatus the NEUTRAL is always BLUE.
On PERMANENT wiring tho EARTH is always GREEN.
On PORTABLE apparatus the EARTH is always GREEN & YELLOW, or GREEN

These colours must always be observed, no others will be tolerated.

S.A.A. Wiring Rules 2.16.3 and 2.19.3 state:-

2.16.3 Neutral Connections The incoming and each outgoing neutral conductor shall be connected at a neutral bar or link.
No fuse or unlinked switch shall be inserted in a neutral conductor.

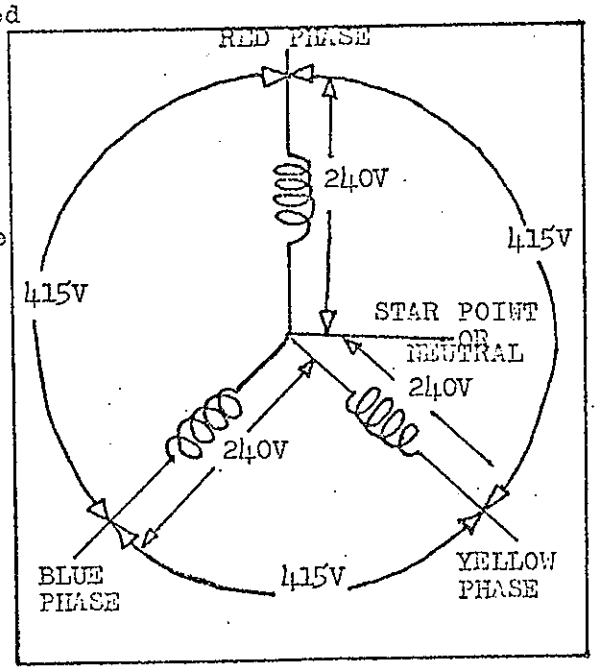
2.19.3 Switches in Neutral Conductors No switch or circuit-breaker shall operate in a neutral conductor, other than -
(a) A multi-pole switch which includes a contact intended for connection in the neutral; or
(b) A switch employed in a control circuit; or
(c) A switch linked with corresponding switches in such a manner that the neutral contact cannot remain open when the active contacts are closed.

Notwithstanding (a) to (c) above, no switch shall operate in the neutral conductor of an ESR system. ESR refers to Earth Sheath Return, not part of our syllabus.

Earthing of a domestic circuit:- All the rules of section 5 of the S.A.A. wiring rules must be adhered to. Generally, all exposed metal parts shall be earthed.

Supply Voltage

Domestic circuits, as previously mentioned, are mainly single phase. The term 'single phase' is derived from the fact that the voltage across any phase or coil of a three phase transformer connected in "Star" and the star point, or Neutral, is 240 volts, and the voltage at the ends of any two coils (two phase) is 415V. The theory of this will be explained later in A.C. theory. At present, the diagram gives the terms and voltages.



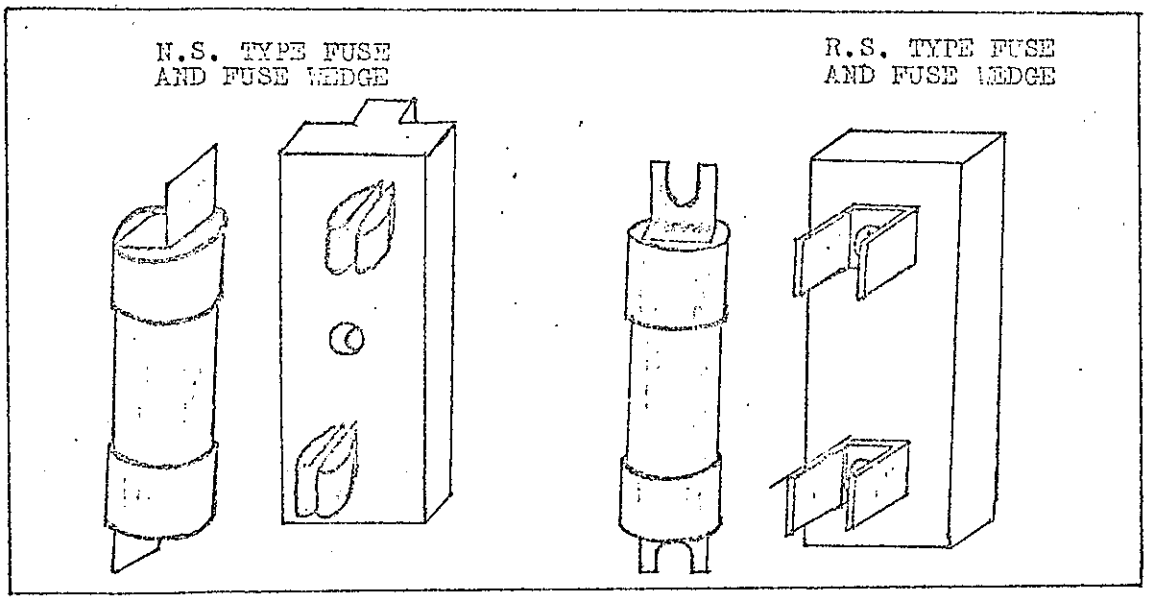
Rating refers to the current carrying capacity of the equipment (given in Amps) and the value of insulation (expressed in terms of voltage).

EQUIPMENT:

Fuse holders and Fuses There are many kinds available but the main kinds in use are the cartridge types, NS and RS.

N.S. Type The cartridge for an NS type fuse has no holes for fasteners, just strips of flat metal on each end offset. To change an NS fuse, pull out the fusewedge and turn it around. It will be seen that on the back there are two spring clips or prongs. The fuse simply lodges into these prongs. To replace the fuse make sure the indicator is clearly visible through the hole in the wedge and push it in place. Always bend over the ends of the blown fuse to prevent confusion. N.S. fuses are available up to 20 Amp.

R.S. Type The cartridge for an RS type fuse has holes for fasteners and the metal strips are set in line with the side of the fuse where the indicator is. They are held into the fusewedge by two set screws. The wedge has two knife blade contacts at each end. They are more robust and much harder to push in place or withdraw. RS type fuses are available up to almost any size. Most fuses over 20 Amp are the RS type.

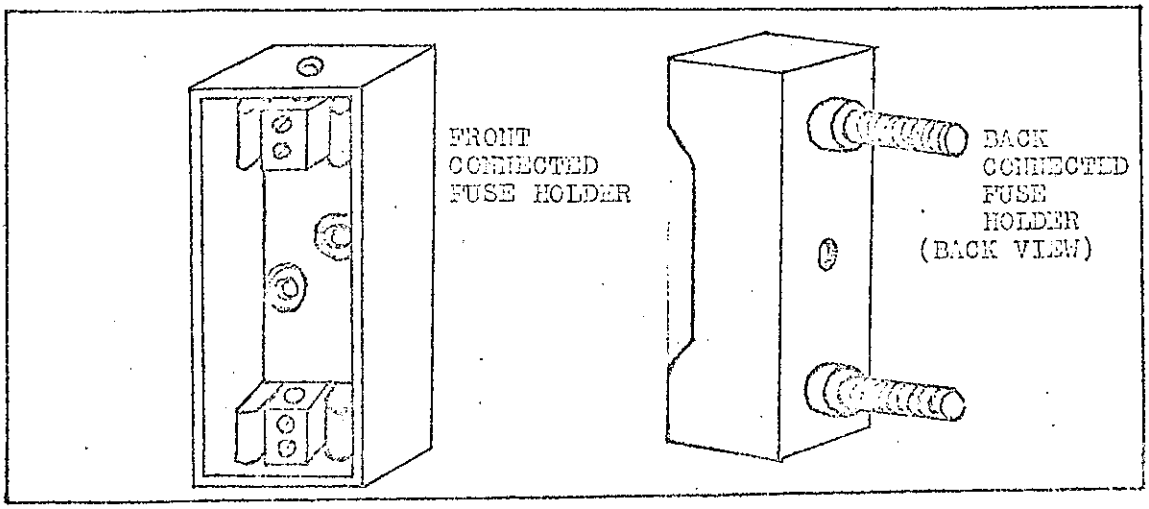


Fuse Bases These also accommodate either NS or RS; also, method of connection gives a further 2 types:-

Back connected - Have brass studs which go right through the fuse base and the connections are bolted onto these at the back of the board.

Front connected - These have holes in the top and bottom of the base and the connections are screwed into place with 2 grub screws.

Busbar The top of the fuse base should always be connected to the busbars and the load to the bottom.



Switches There are many kinds of switches used on domestic circuits, but most are simply variations of the two basic types - Toggle type and Rotary type.

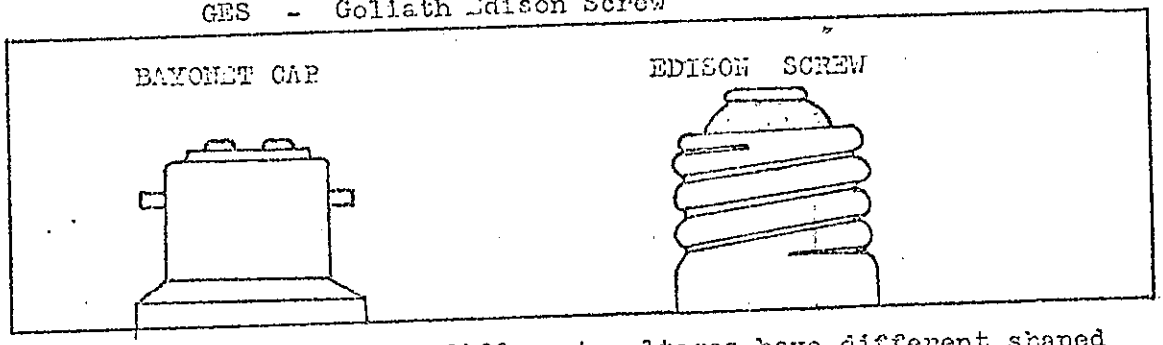
(1) Toggle type - This type uses the principle of the spring loaded lever. A pivoted arm is moved up or down; this flicks over several pairs of contacts or operates a single pair of knife contacts to short out two terminals. Included in this type are the lighting switches, linked switches, two and three pole switches and the switches included on G.P.O.'s (power points).

(2) Rotary type - These are, as the name suggests, operated in a rotary manner. They are usually operated by a central shaft, square, or round with a flat ground on. The switch part consists of a flat round insulated sheet such as paxoline, with pieces of tinned copper set into the edge. Contacts brush each side of the paxoline, and make contact through the parts with copper on. Alternatively, the shaft will open or close cams, which operate switch contacts. Rotary switches can allow for a much greater number of switching operations at a time, by adding more cams or discs, and more variation of switching by putting contacts, (up to 10), through 360°. The draw-back with them being that with the wafer type they are a sliding slow action switch and burn quickly on high currents.

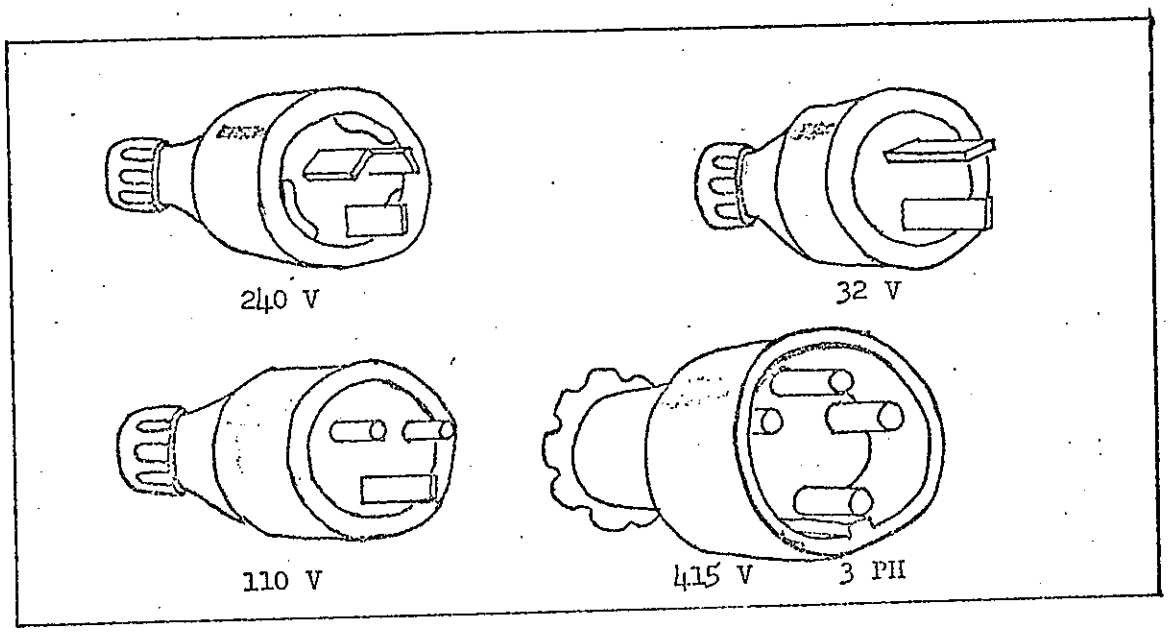
Lampholders Two types - Bayonet cap and Edison screw.

Bayonet cap - they are in common use at home.
Edison screw- comes in the sizes:-

LES - Lilliput Edison Screw
MES - Miniature Edison Screw
CES - Candelabra Edison Screw
ES - Edison Screw
GES - Goliath Edison Screw

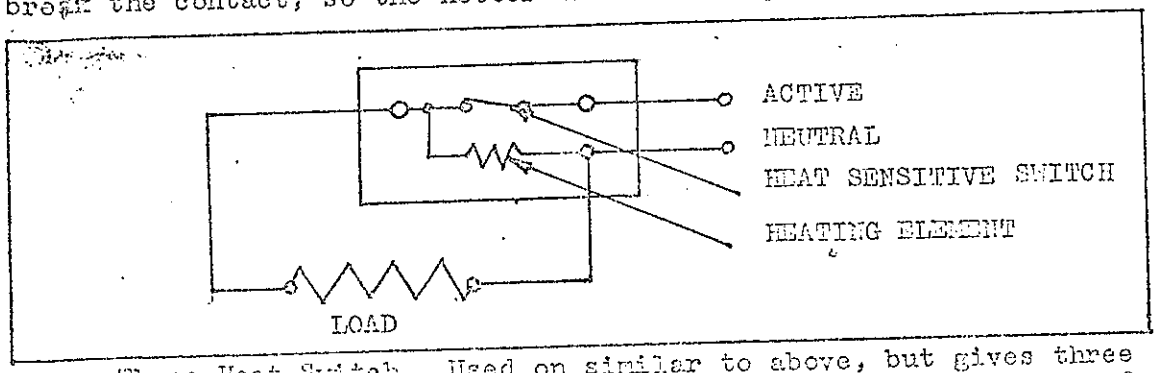


Plugs Plugs used on different voltages have different shaped or arranged pins. The diagrams below show the plugs and give the voltages on which they are used. 240V plugs must always be connected as illustrated in the diagram. If the earth pin of a 240 plug is wider than the other two, the plug is 15 amp, if not, it is a 10 amp plug.

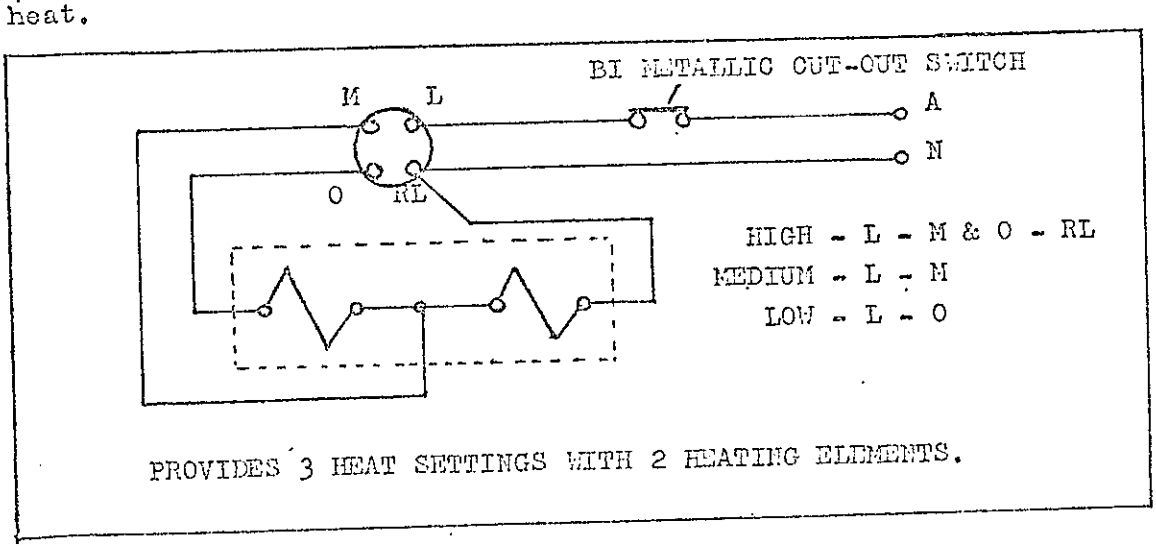


Sockets The sockets correspond to the plugs which fit into them. The 240 wall mounted sockets are called G.P.O.'s - General Purpose Outlets. The 240 and 415 outlets always have a switch incorporated with the outlet and must always be switched off before fitting or removing a plug. 240V G.P.O.'s must always be connected to correspond to the same as the plug i.e. active on the plug should plug into active on the G.P.O. The G.P.O. must always be mounted so that when the switch is up, the G.P.O. is switched off.
Always observe and never exceed the maximum voltage and current rating of a switch. G.P.O.'s are normally 10 Amp. If a larger than usual earth pin socket is on the GPO, then it is a 15 amp.
Remember, if the rating of the plant item is observed, then any fault which occurs is the manufacturer's responsibility. If the rating (voltage or current) is exceeded, then the person who connected up the item takes the responsibility.

Simmerstat Switch Used on ovens, hot plates, water heaters etc. The principle they work on being the more the control is turned, the hotter the bi-metal strip has to get to bend enough to break the contact, so the hotter the element gets before switching.



Three Heat Switch Used on similar to above, but gives three definite heat positions. Works on the principle that 2 elements of identical resistance are used, by connecting as a four position switch so that the current through the elements is increased with each position by lowering the resistance, i.e. 1. off 2. both elements in series, high resistance, low current and heat 3. 1 element only, lower resistance, higher current and heat 4. Both elements in parallel, lower resistance, higher current and heat.



TITLE:- INDUSTRIAL CIRCUITS

LECTURER:- GERRY HEVNIS

DATE:- 3-7-81

EQUIPMENT:- Relays (A.C. D.C.), Contactors, Push-buttons.

Industrial circuits differ from domestic circuits in that they are usually controlled by a separate or control circuit. This is necessary for a number of reasons:-

1. Three phase supplies are used more often in industrial situations with the result that 3 separate actives (or phases) must be broken simultaneously.

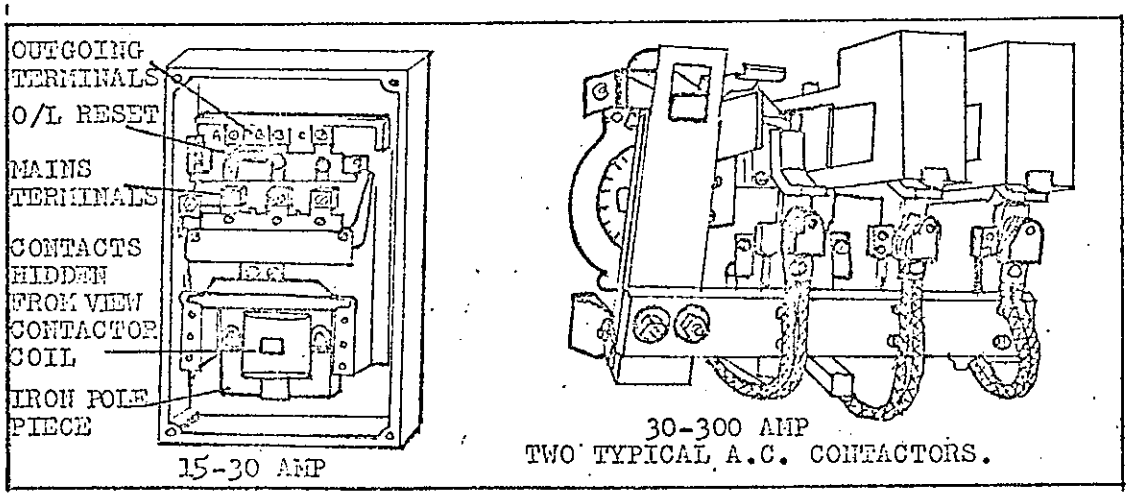
2. Much larger equipment is used in industry and so switches are breaking circuits carrying much higher voltages and currents.

3. Industrial equipment is much more spread out and diverse in nature, i.e. one item of plant will be controlled at one location, switching will be at another, and the actual item will be somewhere else. Each location may be separated by different floor levels and quite large distances.

4. Most industrial equipment is tied up into a larger pattern, i.e. switch a kettle on and it simply boils water. To start an industrial boiler, a motor has to be started to fill the boiler with water, to pull air out, to push air in, to put fuel in, to open and shut valves etc. Each item is inter-related to the other, each must be started in the correct order, i.e. if you switch a kettle on with no water, the kettle could be ruined, light an industrial boiler with no water in, and someone could be killed.

To overcome these various problems many devices are brought into use.

Contactors:- These are electrically operated power switches. They operate by means of an electro-magnet pulling a soft iron pole piece at high speed to the iron core of the electro-magnet. The contacts are either mounted on the pole piece or on a shaft fastened to it. The contacts are spring loaded and the magnet is strong enough to hold the contacts together in spite of the spring and usually against the force of gravity. When the electro-magnet is de-energised, the soft iron core loses its magnetism and the controls are thrown open by the spring. See diagram. Auxiliary contacts are often fixed to the side of contactors which are either N/O (Normally Open) or N/C (Normally Closed). N/C contacts open when the contactor closes and vice versa.

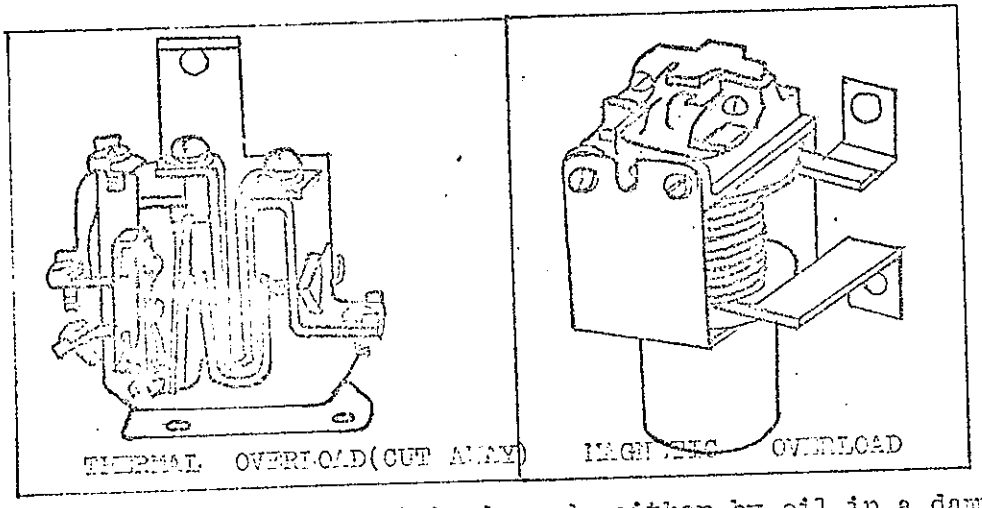


Relay:- These are similar to a contactor but are not used on power circuits; usually used for control.

A.C.B's (Air Circuit Breakers) These are large contactors which operate on high voltages and currents. The contacts are separated and the sparks given off when the contacts break, are dissipated by arc shields. On larger A.C.B.'s, air is blown onto the contacts as they make or break and blow the spark into the arc shield.

O.C.B.'s(Oil Circuit Breakers) These are large contactors in which the contacts break in oil. The oil cools and dissipates the heat and spark when the contacts break. Used on very high voltages and currents.

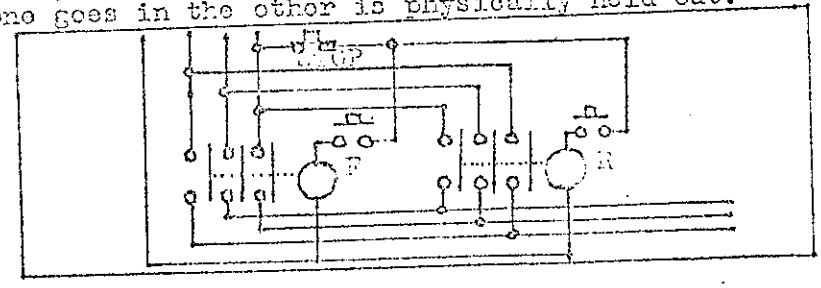
Overload Relays:- As previously mentioned, on industrial circuits all the actives must be broken simultaneously. To do this, an overload relay is used. These can either be thermal or magnetic.
The Thermal O/L is worked by the expansion of metal in any of the phases pushing open a set of N/C contacts in the contactor coil circuit, thus dropping out the contactor.
The magnetic overload works by the current in each phase passing through a coil. The coil, as the current increases, sets up a magnetic field, proportional in strength to the current. After the stage where too much current is flowing, an iron rod is pulled into the coil which again breaks a contact in the contactor coil circuit.



With the magnet O/L the rod is damped, either by oil in a damper or simply against a spring.

Push Buttons Starting and stopping of an industrial circuit is usually done with push buttons. The push buttons are usually marked Red for stop, Green for start. The contacts are spring loaded so that they operate against spring pressure; after being released they fly back to the original position. Stop buttons are normally closed (N/C) i.e. press the button and the circuit is broken; release and it re-makes. The start button is normally open (N/O) i.e. press the button and the circuit is made, release and the circuit is again broken.

Reversal of Three Phase:- To reverse a straight forward three Phase motor, all that is required is that any two phases are changed round. So with many industrial circuits, a contactor for forward and a contactor for reverse are fitted and forward and reverse buttons are provided and clearly marked. If both contactors were operated at the same time if the diagram below is traced, it can be seen that two phases will be completely shorted out. To prevent this happening, a mechanical or electrical interlock or both must be fitted. Usually a metal pivoted arm is fixed between the contactors so that if one goes in the other is physically held out.



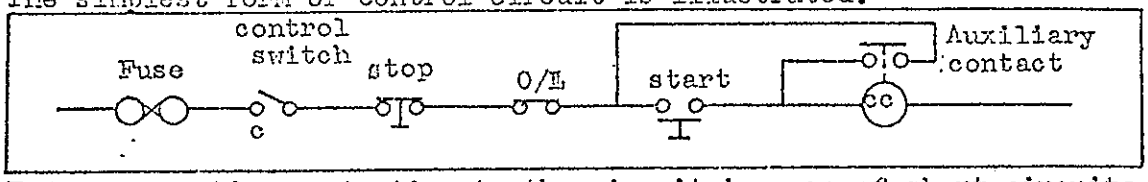
TITLE:- CONTROL CIRCUITS

LECTURER:-

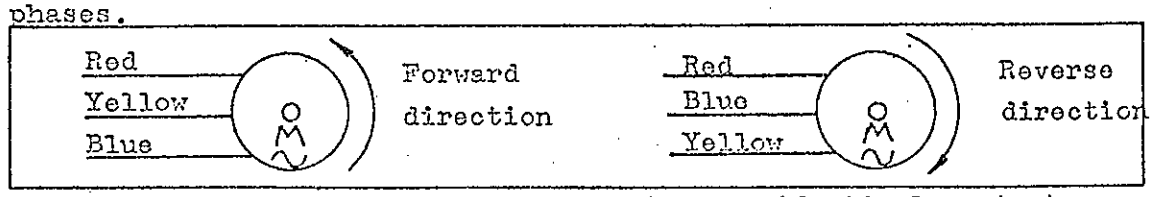
DATE:-

EQUIPMENT:-

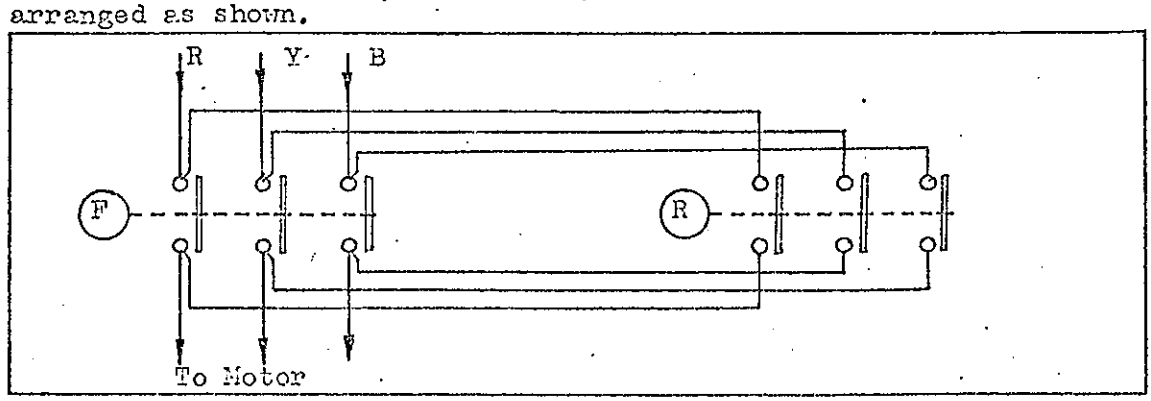
In industry, electrical plant and equipment often require high currents and/or voltages to allow them to perform their function. This means that the switching on or off of power or the adjustment of power must be done by quick acting, and heavy duty switchgear and contactors. This switching etc, is carried out electrically by means of contactors etc. as previously explained.
The contactors in turn are operated by various items of equipment connected together to produce a CONTROL CIRCUIT.
The simplest form of control circuit is illustrated.



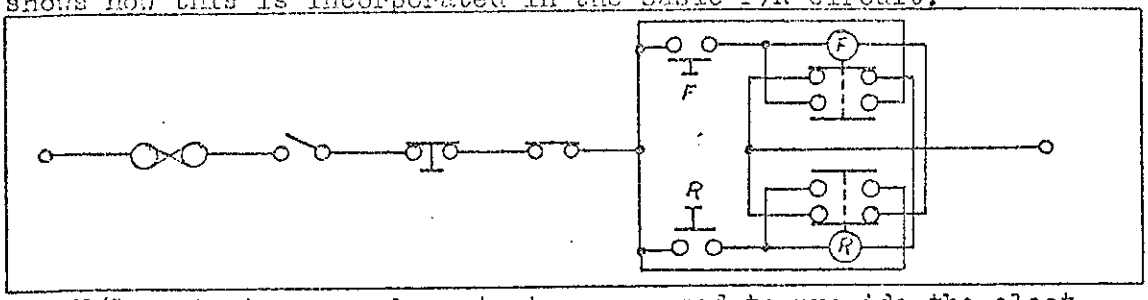
Fuse:- provides protection to the circuit in case of short circuits and/or earth faults. Its rating should be just large enough to carry the current required for the contactor coil.
Control Switch:- allows the circuit to be isolated for maintenance and repairs.
Stop is a spring loaded push-button having a pair of normally closed (N/C) contacts. Any number of stop buttons may be connected in circuit, including the latching type "emerging stop", but all must be connected in SERIES.
Overload:- The normally closed contacts are operated when the current in the POWER circuit exceeds the safe, predetermined level. Most overload devices must be RESET by hand, but provision can be made for automatic resetting.
Start:- is a spring loaded push-button having N/O contacts. Any number of start buttons or other starting devices may be used, but must be connected in PARALLEL.
Auxiliary Contact:- also known as retaining or holding in contacts are a set of N/O contacts built into the main contactor. When the contactor is ON, then the auxiliary contacts CLOSE. The purpose of these contacts is to prevent SELF STARTING in the event of power failure, or the interruption of the control circuit by the STOP, OVERLOAD, FUSE, or CONTROL SWITCH.
Forward & Reverse control:-
Many motors must be made to rotate in both directions at various times, i.e. forward or reverse. In most cases a 3 phase motor is used, and reversal is achieved by interchanging any 2 of the 3 phases.



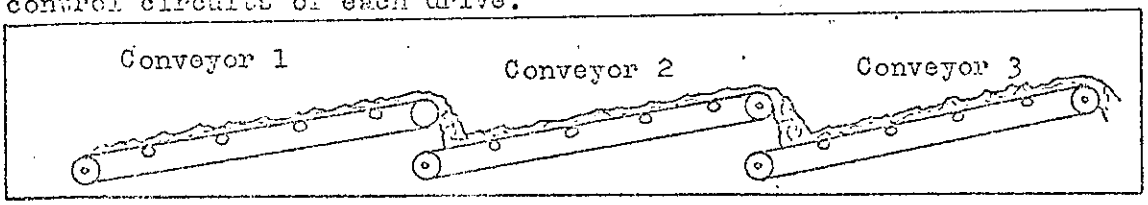
This reversal is easily achieved by using two identical contactors arranged as shown.



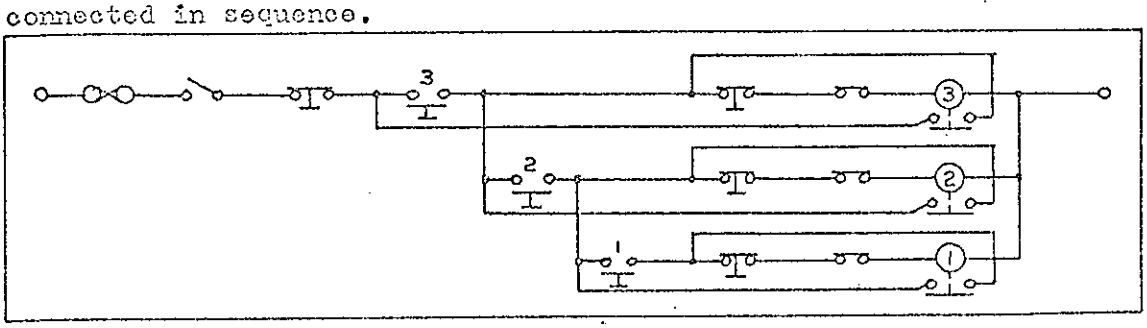
By energising contactor coil F, the phase colours from left to right would be R, Y, B and by energising contactor coil R, the phase colours from left to right would be R, B, Y.
If both contactors are energised together, the Blue and Yellow phases would be shorted out. For this reason, some form of INTER-LOCKING must be incorporated to prevent both contactors from operating together.
A mechanical interlock may be used to physically prevent both contactors closing together.
A more common method is to use electrical interlock. The diagram shows how this is incorporated in the basic F/R circuit.



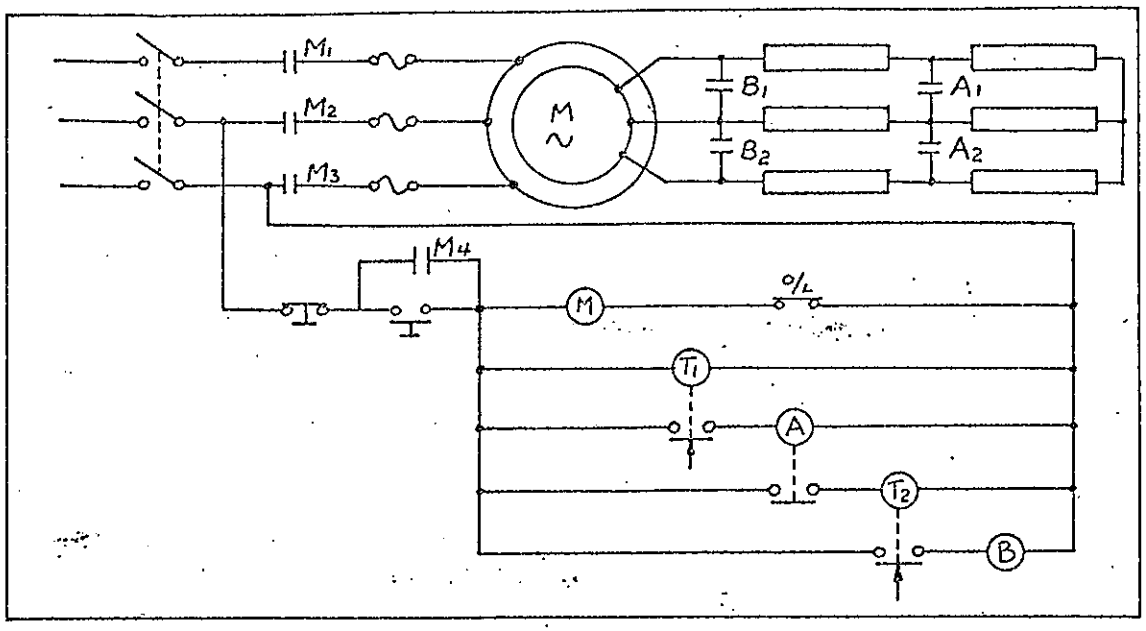
The N/C contacts on each contactor are used to provide the electrical interlock.
When contactor F is energised, the N/C contacts are opened, thereby opening the circuit for the R contactor, or vise versa.
Sequence control:-
Where a number of motors and drives form a continuous part of an installation (say with conveyor belts), it is necessary to link the control circuits of each drive.



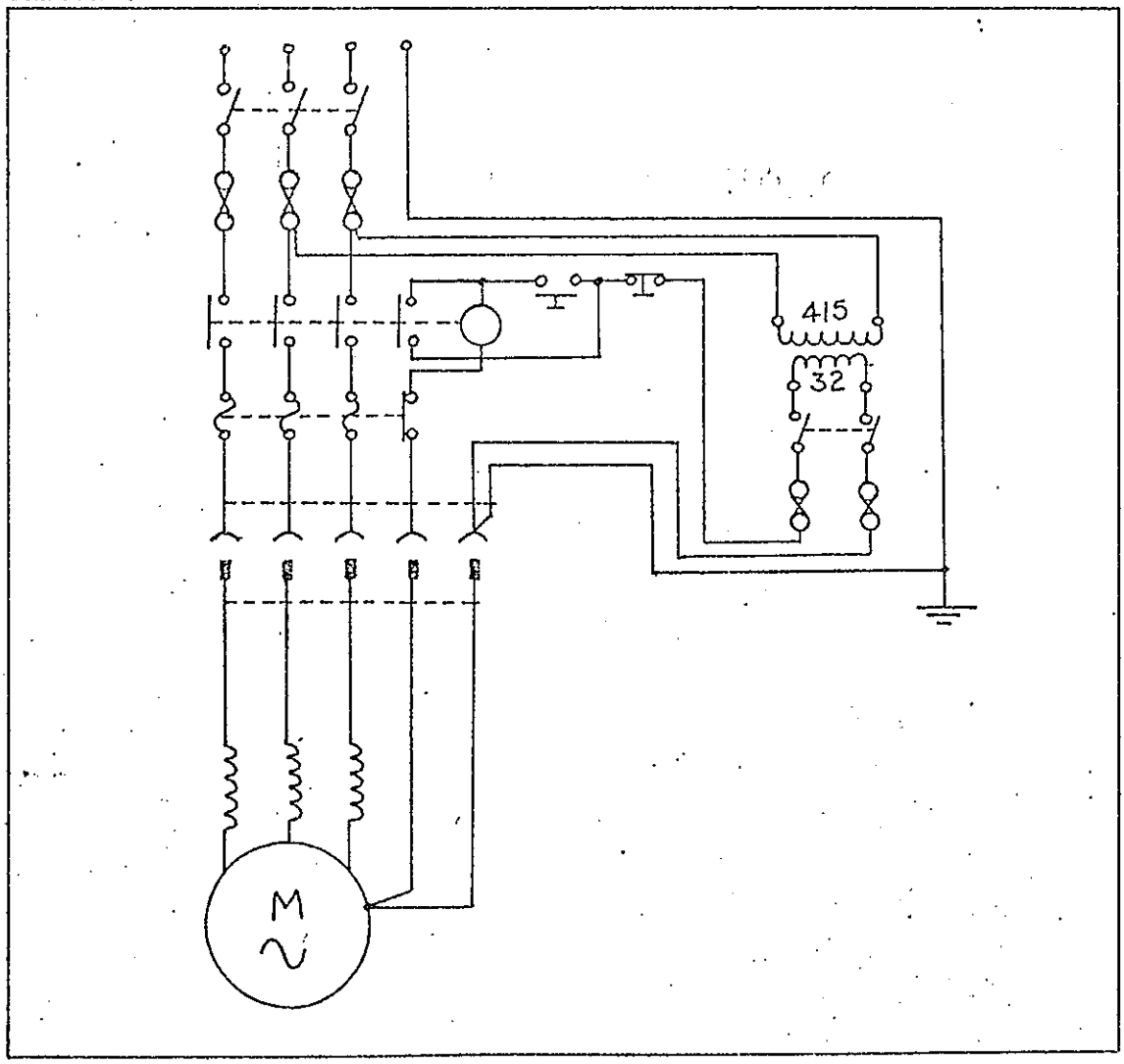
If the 3 conveyors illustrated are all running at the same time, then the material would flow through the system easily. If conveyor 2 or 3 are stopped for any reason, then conveyor 1 must also be stopped automatically to prevent a pile up of material. The three drives must then be linked together. This is usually done with the control circuits of the drives and they are said to be connected in sequence.



The circuit illustrated is a basic sequence control circuit which would be suitable for the conveyor system shown above.
Automatic starting of 1 and 2 may be accomplished by using a centrifugal switch operated by the movement of conveyor 3 and 2 respectively. Note that an emergency stop is included in the circuit - these are usually latch type.
Control devices:-
Apart from the stop, start, and overload devices, many other items can be used to start or stop any motor circuit, examples are photo-electric cells, float switches, pneumatic switches, thermal switches, flow switches, time delays, pressure cells and many others.
An example of the use of time delay switches is illustrated below using time delay relays to cut out resistances to start a wound rotor motor.



Safety Circuit:- Electrical equipment supplied through a flexible cable can become dangerous if the earth wire breaks, and if an earth fault occurs on the machine. Any person touching the machine and standing on an earthed floor would receive a shock.
The safety circuit is designed to disconnect the power from the cable in the event of the earth breaking. To allow this to happen, the earth of the flexible cable is used to carry a low current at a low voltage (up to 32V). The diagram below illustrates this circuit.



TITLE:- CIRCUIT PROTECTION

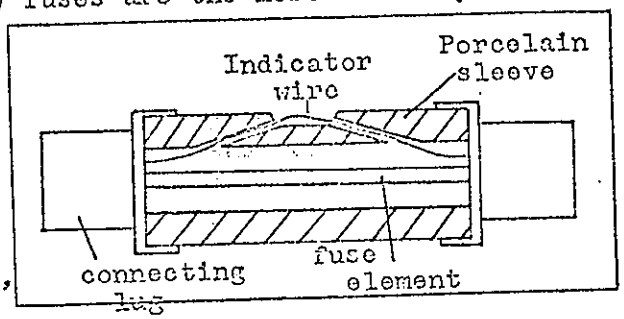
LECTURER:-

DATE:-

EQUIPMENT:- Fuses, thermal overload, magnetic overload, thermistor, controller with U.V. relay.

Electrical equipment which is designed, manufactured, installed, and operated to 100% accuracy, would function perfectly for an indefinite period. As this is NEVER achieved, there will always be faults developing within electrical systems. If these faults are not dealt with when they occur, damage and injury will result. For these reasons, EVERY electrical circuit must be provided with some form of PROTECTION. The type of protection required for a particular installation will depend on the type of equipment used, the work it performs, its location, current and voltage ratings, and many other factors.
Some of the more common protective devices are dealt with below -

1. Fuse
A fuse is the simplest protective device used. It acts to break the circuit when current exceeds the safe predetermined value.
When a fuse "blows", it must be replaced by another fuse of the same rating - NOT LARGER. If the fuse protecting a particular circuit blows repeatedly, it is essential that tests be carried out to determine the cause - DO NOT INSERT A LARGER FUSE.
Re-wirable type fuses are rarely used due to the risk of fire occurring when the fuse ruptures. This danger is even greater where high currents are encountered.
High Rupturing Capacity (H.R.C.) fuses are the most commonly used in industry.
They are constructed as shown in the diagram. The end caps are fitted with suitable tags for quick and easy connection to the insulated fuse holder. The fuse element is housed in a porcelain tube which is filled with silica, sand or quartz. When the fuse ruptures, the hot metal of the fuse combines with the quartz to form an insulator. To eliminate the need for testing a fuse with a meter to check if it is "blown" or not, an indicator is usually built into the fuse. This is a very thin wire in parallel to the fuse element. When the fuse ruptures, the current is directed through the indicator wire causing it to burn very rapidly. It actually causes a minor explosion which in turn blows off a piece of thin paper which is pasted over the indicator hole. More modern fuses have a small plastic bead which falls from the indicator wire when it ruptures.

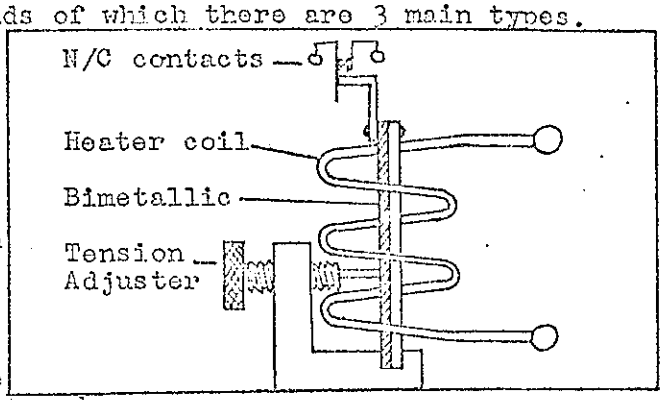


Fuses are generally used to protect against short circuits and earth faults. Where sustained overloads are encountered with electrical machines, a further protective device is required.

2. Overloads
The insulation material used in electrical equipment is designed to operate below a specific temperature. If that temperature is exceeded, then permanent damage will result. The temperature is related to the current which a machine draws from the supply which in turn depends on the amount of work which the machine is doing.
Each machine is manufactured to perform a certain amount of work over a given period of time, i.e. 1 HP, 100 HP, 3 KW, etc. at either continuous or intermittent work cycles. If these ratings are exceeded, current and temperature will also increase.
It is therefore obvious that monitoring of current or temperature is essential and that these monitoring devices be capable of switching off the electrical equipment should either I or t become too great.

This is done by using overloads of which there are 3 main types.

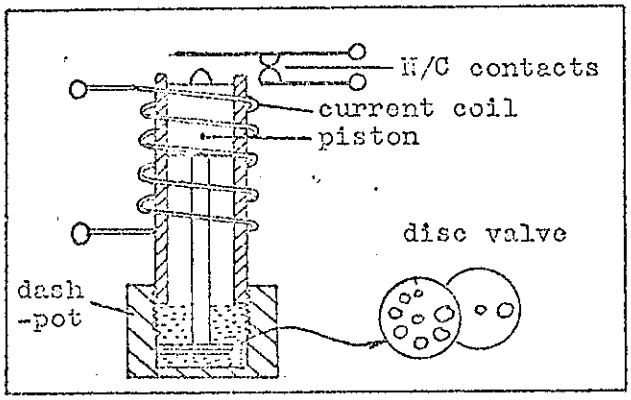
(A) Thermal Because current generates heat when passing through a conductor or resistor, by arranging a suitable "heater coil" in close proximity to a bi-metal, we can cause the bi-metal to bend. This movement may then be used to operate a pair of contacts and break the circuit to the load. A typical Thermal Overload is illustrated, one of which would be used in each phase being monitored.



Provisions are made to allow for slight excesses of load, or for a specific time lapse before the bi-metal operates the contacts. This is usually done by applying a greater or lesser spring pressure against the movement of the bi-metal, or by moving the bi-metal further away from the contacts.

Overloads will NOT protect a circuit against short circuit or earth faults as their speed of operation is too slow. It is therefore necessary to use fuses as well to achieve full protection.

(B) Magnetic A current passing through a coil produces a magnetic field. This is the principle of the magnetic overload. A coil of wire (the gauge of which must be heavy enough to carry the load current) is would around a cylinder containing a moveable ferrous plunger which is free to move in a vertical direction. Connected to the bottom of the plunger is a piston which incorporates a disc valve. This piston is enclosed in a cup which is filled with a special oil. This cup or "Dashpot" may be vertically adjusted by screwing it up or down the cylinder which houses the plunger.



A current passing through the coil causes a "pull" on the plunger tending to lift it. The oil and valve disc allow the plunger to rise slowly (the speed of rise depends on the setting of the disc valve). Sustained current and sustained pull will cause the piston to rise completely from the oil thus allowing the plunger to strike a contact bar and open a set of contacts which in turn switches off the power to the load being protected.

The actual current required to pull the piston out of the dashpot is determined by the position of the plunger in the cylinder.

The higher the plunger, the lower the current required.

The lower the plunger, the higher the current required.

Actual tripping current is determined (within specific limits) by screwing the dashpot up or down.

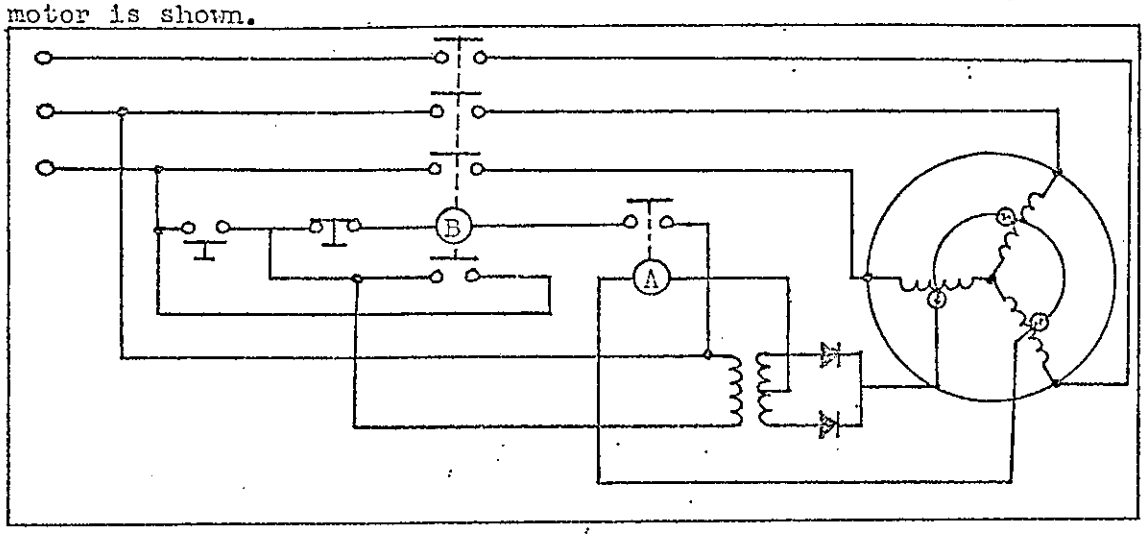
A one-way return valve in the disc valve allows the plunger to reset quickly once the magnetic pull has been removed.

With both types of overload, the contacts, once they have been opened, must be reset before the power to the load can be reinstated. This may be achieved by either manually pressing a RESET button or it may be achieved automatically.

If an overload trips frequently, steps should be taken as quickly as possible to determine the cause of the overload so that it may be rectified before serious damage occurs.

(C) Thermistor Modern methods of overload protection employ the use of a THERMISTOR. This is a semiconductor device which has a low resistance at normal temperatures, yet drastically changes above a predetermined temperature. It is this change of resistance which is

used to operate a relay, which in turn switches off the power to the load (usually a motor).
Because thermistors are so small, they may be built into a motor winding where they are affected instantaneously by the winding temperature.
The circuit of a thermistor overload as used to protect a 3 phase motor is shown.



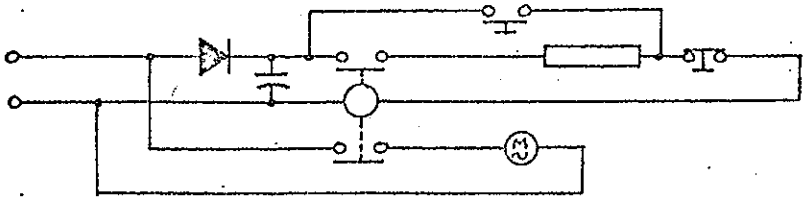
Relay A and B operate together when the start P.B. is operated. When the resistance of the thermistors increases, the voltage drop which occurs across them reduces the voltage across relay coil A causing it to switch off. This in turn opens the circuit for relay B, which switches off the power to the motor.
The motor may not be re-started until its temperature drops below the critical value of the thermistors.

Under voltage

In certain installations, it is necessary to use some form of voltage reducing device to start a motor so that initial starting current is reduced to a value where it cannot overheat the motor. If this type of motor is switched directly to the supply without using the appropriate starting equipment, then it may become damaged.
It is necessary then to give protection to this type of motor and prevent inadvertant connection to mains voltage before the motor has built up speed. This inadvertant connection could occur in two ways.

1. If the motor is running at normal speed and the starting gear is by-passed, any fall in voltage would cause the motor to run at a reduced speed. If this speed drop were too great, then once the voltage returned to normal, the motor would draw excessive current until it had built up its speed to normal.
2. Similarly, if the mains power was interrupted completely, the motor would slow down to a standstill. On reinstatement of the power, the motor would again draw excessive current and possibly burn out.

To prevent this from occurring, hand operated controllers are equipped with UNDER-VOLTAGE RELAYS which serve to release the controller in the event of voltage drop or voltage failure, necessitating the starting cycle to be repeated.
In circuits employing contactors with holding-in facilities, no further protection is required.
Provisions may also be made so that in the case of a voltage drop of only short duration, where the motor does not reduce speed too rapidly, the starting cycle need not be repeated. This may be accomplished by the use of time delay circuits.



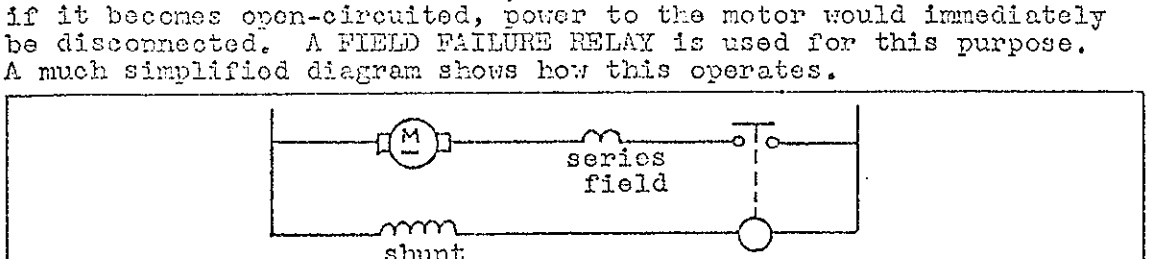
Time delay circuit gives undervoltage protection

Field Failure

In a D.C. compound motor, both SERIES field and SHUNT field windings are used to rotate the motor. If the series field becomes disconnected, or open circuited, then the motor would continue to operate as a shunt motor. This is not detrimental nor dangerous. On the other hand, if the shunt field is open circuited, then the motor would continue to operate as a SERIES motor. This, under certain circumstances, can be dangerous.

It is a characteristic of the series motor, that if it is allowed to operate with no load on the shaft, then its speed would rise unchecked until it destroyed itself.

For this reason it is necessary to monitor the shunt field so that if it becomes open-circuited, power to the motor would immediately be disconnected. A FIELD FAILURE RELAY is used for this purpose. A much simplified diagram shows how this operates.



TITLE:- FAULT FINDING

LECTURER:-

DATE:-

EQUIPMENT:- Various Circuit Diagrams

Fault Finding - a major part of most electrical maintenance work. It need not be a frightening prospect if a logical approach is adopted and certain procedures are followed.

Get the facts

1) Listen carefully to instructions from the Leading Hand or Foreman
2) Clarify any points that are not clear.
3) Carry a note book and write down the instructions.
4) Cross-examine operating staff regarding fault.

Diagrams

1) Each firm's diagrams have their particular pecularities. Get to know the systems of the major manufacturers of the equipment in the area.

2) Where a particularly complex item is a source of repeated problems, break the drawing down into smaller sections and draw the sections in a note book.

3) Don't be overawed by diagrams, read everything on the legend, identify the main parts, then by checking with the operator, the trouble can usually be narrowed down to a small section of the diagram.

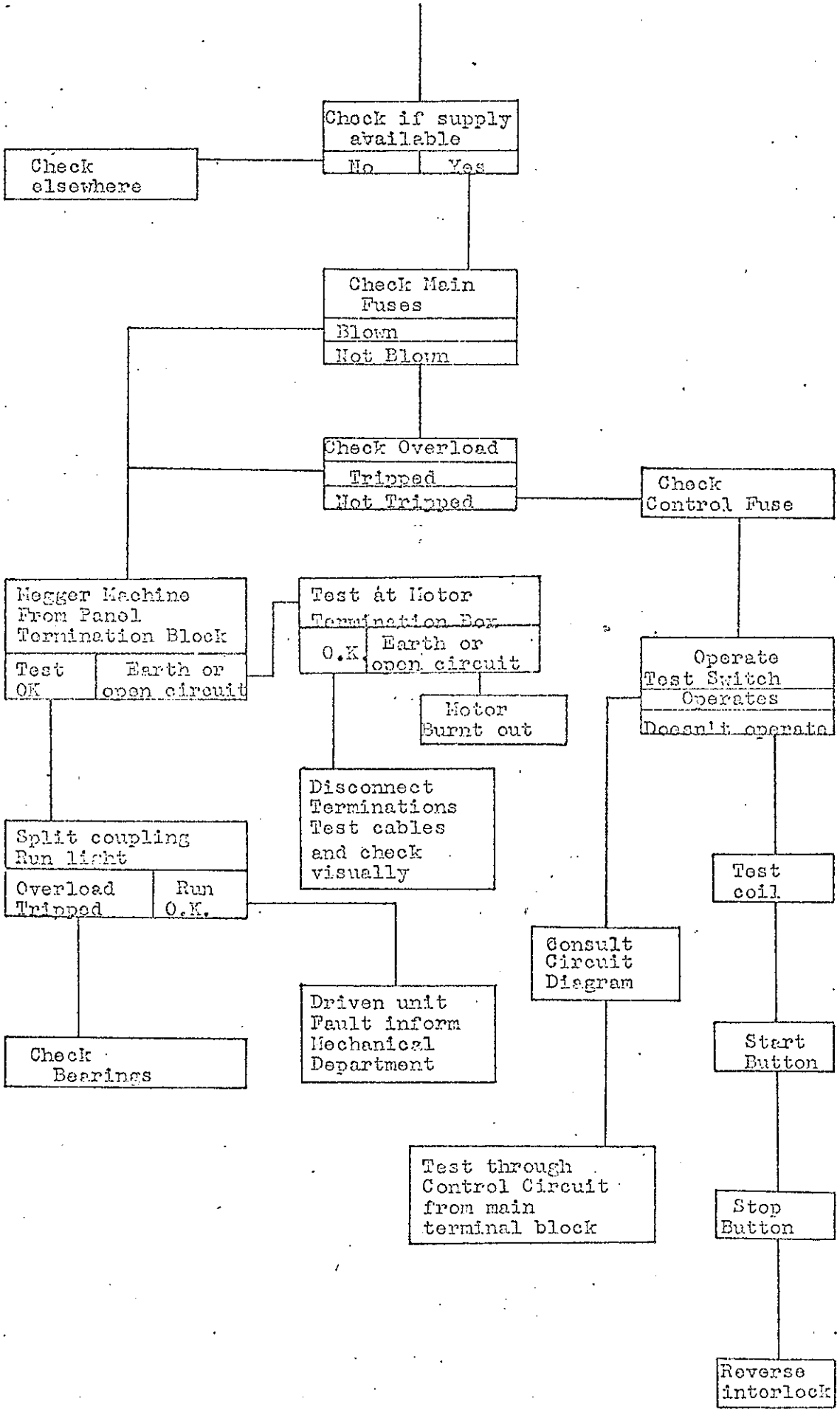
Help yourself before faults occur

1) Get to know plant layout.
2) Get to know plant titles.
3) Get to know plant purpose or operation.
4) When plant is down for maintenance, get to know how it works. Ask how it works. Ask what it does. Ask how it does it.

Fault Finding Procedures

Below is a logic diagram which gives an orderly manner in which to test through a typical circuit. Most plant items have a main Switch Panel in a switch room, remote control position either in a pulpit or control room or panel. The motor will be out on the plant and often there will be pressure, flow, sequence or limit switches somewhere else. These different locations can represent quite a large amount of moving about. When a fault occurs, time is of the essence and so moving about must be reduced to a minimum. This can usually be done by working from the switch panel, as the cables to the various items usually start there and can be checked from a large terminal block in the panel. Operation of the motor can be monitored from the ammeter on the panel.

It must be stressed that testing only of the various items is done at this point. ON NO ACCOUNT MUST EMERGENCY STOPS OR OTHER SWITCHES BE SHORTED OUT WITH THE POWER SWITCHED ON.


Check if supply available
No
Yes
Check elsewhere
Check Main Fuses
Blown
Not Blown
Check Overload
Tripped
Not Tripped
Check Control Fuse
Megger Machine From Panel Termination Block
Test OK
Earth or open circuit
Test at Motor Termination Box
O.K.
Earth or open circuit
Motor Burnt out
Operate Test Switch
Operates
Doesn't operate
Disconnect Terminations Test cables and check visually
Split coupling Run light
Overload Tripped
Run O.K.
Test coil
Consult Circuit Diagram
Driven unit Fault inform Mechanical Department
Start Button
Check Bearings
Test through Control Circuit from main terminal block
Stop Button
Reverse interlock