

# TRIPPING AND CONTROL OF DIESEL GENERATOR

P-409

## PROJECT REPORT

Submitted By

K. CHENTHIL SIVAMURUGAN  
V. PRIYA  
M.K. GANESH RAM  
B.N. VENKATRAMAN

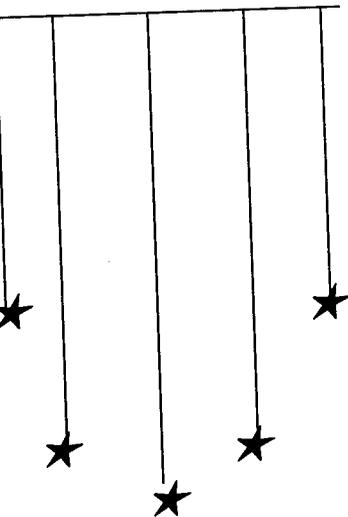
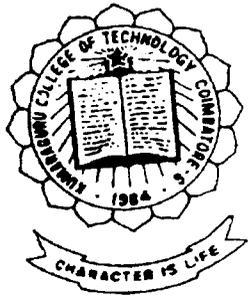
*Guided By*

**Mr.R.KrishnaKumar**, M.E.,MISTE  
Lecturer, Dept of EEE

Submitted in partial fulfillment of the  
requirements for the award of the degree of  
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**1999 - 2000**

**Department Of Electrical & Electronics Engineering**  
KUMARAGURU COLLEGE OF TECHNOLOGY  
COIMBATORE



# KUMARAGURU COLLEGE OF TECHNOLOGY

Coimbatore - 641 006

Department of Electrical and Electronics Engineering

## Certificate

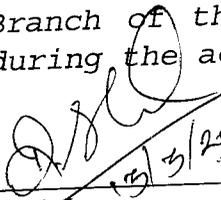
This is to Certify that the report entitled

### "TRIPPING AND CONTROL OF DIESEL GENERATOR"

has been submitted by

Mr. K. Chentil Sivamunyan, V. Priya, M.K. Ganeshran, B.N. Venkatesh

in partial fulfillment for the award of the Degree of Bachelor of Engineering in the Electrical and Electronics Engineering Branch of the Bharathiar University, Coimbatore - 641 046 during the academic year 1999 - 2000.

  
\_\_\_\_\_  
Guide  
Date 13/3/2000

Dr. K. A. PALANISWAMY, B.E., M.Sc. (Engg) Ph.D.  
MISTE, C. Engg (I), C. Engg (II)

Professor and Head  
Department of Electrical and Electronics Engineering  
Kumaraguru College of Technology,  
Coimbatore 641 006

Certified that the candidate with the University Registration No..... was examined in the project viva-voce held on .....

.....  
Internal Examiner

.....  
External Examiner

HRD/TRG/2000  
04-March-2000

**PROJECT CERTIFICATE**

This is to certify that the following B.E. Electrical and Electronics, Final year students of Kumaraguru College of Technology, Coimbatore have done their project on "Tripping and Control of Diesel Generators" in our organization :-

1. **Mr.K.Chenthil Sivamurugan**
2. **Mr.M.K.Ganeshram**
3. **Ms.V.Priya**
4. **Mr.B.N.Venkatraman**

Period of project : December 1999 to February 2000

Process / Department : Plant Maintenance Department

During this period their attendance and conduct were found to be *Good*.

We wish them the very best for a bright future.



**ANTHONY THIAGARAJAN**  
DEPUTY MANAGER-HRD



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## SYNOPSIS

Heavy machinery industries like PRICOL, wherein Production have to be carried out continuously, the Power supply should be continuous with no fluctuations. The E.B supply is not always reliable. So these industries go in for medium power gensets. But, on continuous operation at high load, certain shortcomings occur due to rise in coolant temperature.

The existing protective system is not reliable. Based on the drawbacks of the existing system and protective requirements, it is proposed to evolve a circuit & a control equipment, in this project work.

Further, this system sheds off the load, before the engine is tripped off. This prevents any damage to the alternator which would have occurred otherwise. The devised system was tested and the details are presented in this report.

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# CHAPTER I

## INTRODUCTION

Diesel power plants play an important role in industrial power requirements. Due to the non-reliability of the E.B supply & continuous requirement of power for Heavy machinery operation, Diesel gensets are an inevitable part of any industry.

Diesel power plants can be used as peak load plants, stand by or emergency plants. Diesel power plants can be started and stopped quickly and they can be made to share the loads instantaneously. Diesel plants are the most economical means of power generation, when considered on a small scale.

We cannot say that the system will operate perfectly at all times. At anytime, by any means, abnormal condition may arrive. In the present existing system, during the abnormal condition such as overload, high temperature etc, the engine is tripped off with the full load. This will cause the engine to get damaged.

## **CHAPTER II**

# **DIESEL ENGINE POWER PLANT**

### **2.1. INTRODUCTION**

Diesel Engine power plant is suitable for small and medium outputs. It is used as a central power station for smaller power supplies and as a stand by plants to hydroelectric power plants and steam power plants.

### **2.2. DIESEL ENGINE**

A diesel engine is a prime mover which obtains its energy from a liquid fuel known as diesel oil and converts this energy into mechanical work. An alternator (AC generators) mechanically coupled to it converts the mechanical energy developed into electrical energy. The other definition for it is that it is compression ignition type power source, in which heat for igniting the fuel charge is obtained from the compression of air in the engine cylinder before the fuel is introduced into it.

## **2.2.1 MAJOR COMPONENTS OF A DIESEL ENGINE**

For understanding the operation of Diesel Engine, the complete knowledge about the parts and their purpose is necessary.

The main working parts of a compression ignition, four stroke engines are shown in fig 2.1 and the explanations are given below.

### **i. Cylinder**

The heart of the engine is the cylinder where the fuel is burnt and power developed. The inner side of the cylinder is formed by the liner or sleeve. The inside diameter of the cylinder is called bore.

### **ii. Cylinder Head**

It closes one end of the cylinder and often contains the valves through which air and fuel are admitted and exhaust gases are discharged.

### **iii. Piston**

The other end of the working space of the cylinder is closed by the piston that transmits to the crankshaft the power developed by burning of the fuel. The distance that the piston travels from one end

of the cylinder to the other is called the stroke.

#### **iv. Connecting Rod**

The connecting rod changes and transmits the reciprocating motion of the piston to the continuously rotating crank pin during the working stroke and vice versa during other strokes.

#### **v. Crank Shaft**

The crank shaft runs under the action of piston through the connecting rod and crank pin located between crank webs or checks, and transmits the work from piston to the driven shaft.

#### **vi. Fuel Nozzle**

Fuel is delivered into the combustion space by an ejection system consisting of a pump, fuel line and the injector, also called the fuel injection nozzle or spray nozzle. Fuel is delivered by this nozzle in a fine spray under pressure in diesel engines.

### **vii. Intake Valve**

Fresh air enters through this valve operated by a cam.

### **viii. Exhaust Valve**

The products of combustion after doing useful work on the piston are removed through this valve.

### **ix. Cam Shaft**

It is driven from the crankshaft by a timing gear on a chain. It operates the intake valve and the exhaust valve through the cam, cam followers, push rods and rockers arms.

### **x. Cylinder Block or Crank Case**

Crank case holds together the cylinder, piston and crankshaft. It is called the cylinder block if the cylinder liners are inserted into it.

### **xi. Fly Wheel**

It takes care of the fluctuations of the cyclic variations in speed. It stores energy during the power stroke and releases during the other strokes thus giving a fairly constant output torque.

### **xii. Cooling Water Jackets**

Normally the cooling water enters the jackets in the cylinder head which is comparatively hotter and passes on to the jackets for the cylinder. The purpose is to keep the combustion space walls cool.

## **2.3. WORKING OF DIESEL ENGINE**

Diesel engine obtains its power from burning of fuel in the engine cylinder. The combustion of fuel increases temperatures and pressure in the cylinder and pressure of developed gases pushes the piston out of the cylinder. Thus the mechanical power so developed is transmitted through the connecting rod to the crankshaft resulting into a turning effort.

### **2.3.1 Four-stroke Diesel Engine**

In a four-stroke diesel engine the four operations are completed in two revolutions of crankshaft. The various operations are shown in Fig.2.2 and are explained below.

#### **i.Suction Stroke**

In the suction stroke the charge is sucked into the cylinder through the manifold and the inlet valve, the piston receding towards the crank end of the cylinder. The exhaust valve is kept closed during the suction stroke.

#### **ii.Compression Stroke**

During the compression stroke the piston moves forward i.e., towards the cover end of the cylinder. The stroke is completed when the piston has reached the extreme position at cover end. During this stroke both inlet and exhaust valves are kept closed. Air taken in during the suction stroke is compressed in this stroke, therefore this stroke is known as compression stroke.

#### **iii.Power Stroke**

At the end of compression stroke fuel is injected in atomized form resulting in ignition and an increase in the pressure of gases in

the cylinder which causes the piston to move back furnishing the power stroke.

#### **iv.Exhaust Stroke**

In the exhaust stroke the piston again moves forward, the exhaust valve being opened and gaseous products of combustion being expelled from the cylinder.

### **2.4. CHOICE AND CHARACTERISTICS OF DIESEL ENGINES**

While making a choice of diesel engines the following points need a careful consideration.

#### **a. Frame**

Engines in both horizontal and vertical frames are available. When the size is comparatively small horizontal engines are employed. In large sizes vertical engines with multi cylinder construction are commonly used.

#### **b. Speed**

It has been found that a higher rotational speed means a greater degree of compactness resulting in both engine and alternator costs reduced. Low and medium speed engines, which are

commonly employed in central station range from 500 to 1000 rpm.

### **c. Number of Cylinders**

Depending upon the power required the number of cylinders can be closer. Six to eight cylinder engines are commonly employed in power stations. The cylinders are arranged in-line.

### **d. Capacity of Engine**

Usually diesel engines are available in sizes ranging from 75 to 3,750kw. For a proper choice the approximate capacity of generator decided upon must be known.

### **e. Rating of Engine**

Rating is the net output in kW developed continuously at the crankshaft coupling by the engine in good operating condition at a temperature 32°C and barometric pressure of 717.5mm Hg (standard sea-level rating). For power plant service the rating should be such that the engine will be capable of delivering at least 10% the excess of its standard commercial sea level rating.

### **f. Super Charging**

In a diesel engine and increased amount of air is supplied in the cylinder at the beginning of compression stroke, it is possible to

burn more quantity of fuel thus enhancing the power output of the engine. Supercharging means pumping of air into the cylinder at a pressure greater than atmospheric pressure. Supercharging is employed to increase the rated power output capacity of a given engine.

### **g. Specifications of Diesel Engines**

Important Specifications would include

- (1) Capacity of the engine in kW
- (2) Rating, continuous or Intermittent
- (3) Type of fuel
- (4) Limitations of speed
- (5) Height above sea-level
- (6) Type and speed range of governing.

## **2.5. PLANT MAINTENANCE**

Diesel engine power plant maintenance depends on various factors careful supervision of the equipment used for recording temperature, pressure and electrical data are essential. The temperature inside the engine should not be allowed to exceed the

safe limits as diesel engine is an all metal machine and there is no refractory protection. The temperature and flow of coolant, lubricating oil and exhaust gases should be checked at regular interval. The fuel oil must be cleaned from dirt and other impurities by means of fitters.

## **2.6. Engine starting and stopping**

The function of starting system is to start the engine from cold by supplying compressed air. The various methods used for the starting of diesel engine are as follows.

### **2.6.1. Compressed Air System**

Compressed air system is used to start large diesel engine. In this system compressed air at a pressure of about 20kg per sq.cm is supplied from an air bottle to the engine on inlet valve through the distributor or through the inlet manifold. This type of starting system enables the engine to rotate initially while starting until the firing starts and the unit runs on its own power.

### **2.6.2. Electric Starting**

Electric starting arrangement consists of an electric motor which drives the pinion which engages a toothed rim on engine

flywheel. Electric power supply for the motor is made available by a small electric generator driven from the engine. In case of small plants a storage battery of 12 to 36 volts is used to supply power to the electric motor.

The electric motor disengages automatically after the engine has started.

### **2.6.3 Stopping the Engine**

The engine should not be stopped abruptly. To stop the engine the speed should be decreased gradually until no power is delivered by the alternator. Then the engine is disconnected from the bus bars and is allowed to run idle for some time.

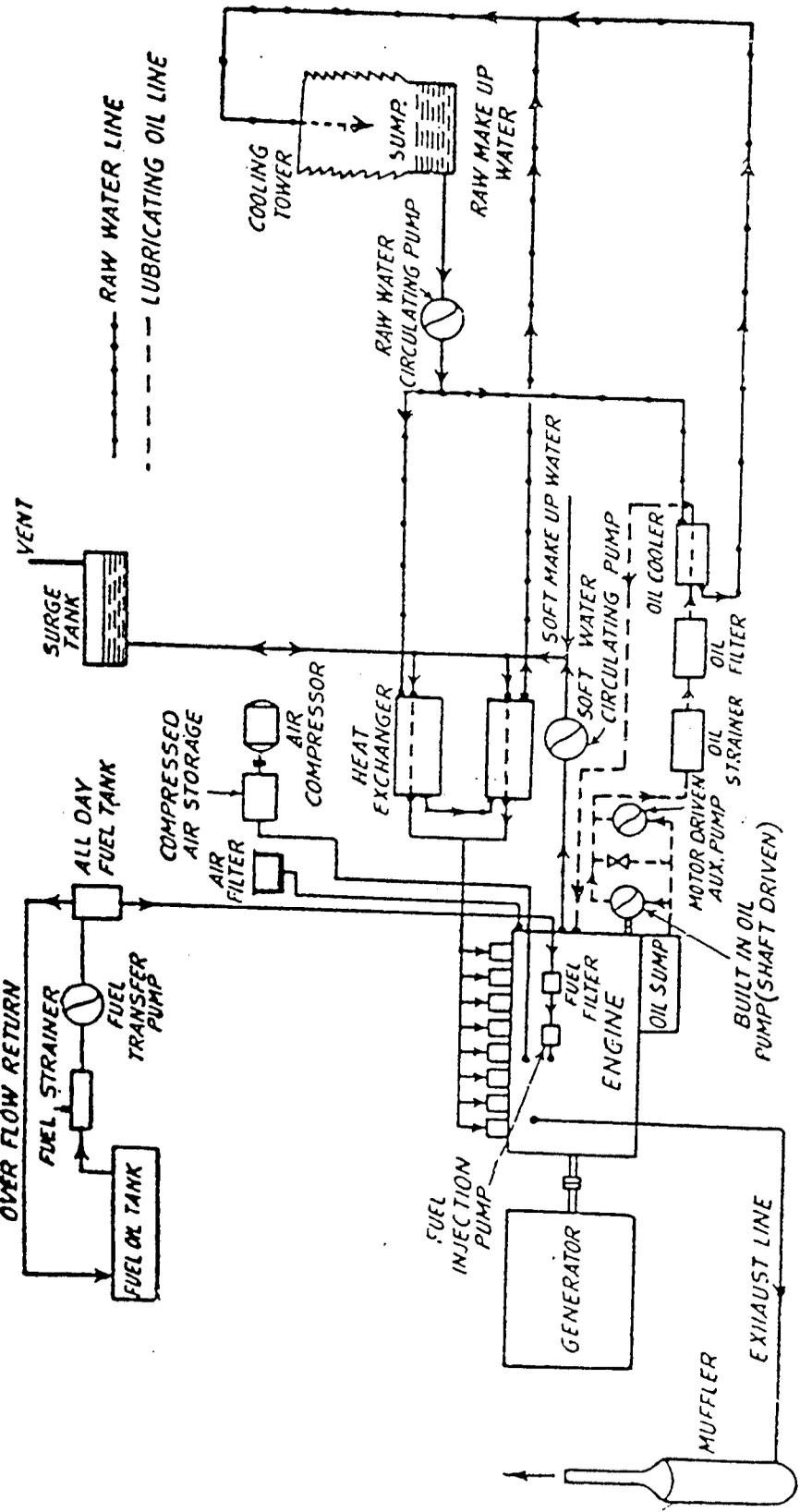
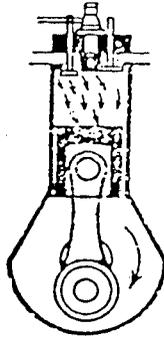


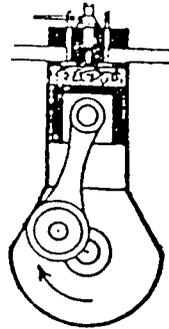
Fig 21 DIESEL POWER PLANT

The inlet valve is open and the descending piston draws in air to fill the cylinder with it.



Air Intake Stroke

(a)

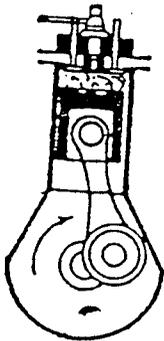


Compression Stroke

(b)

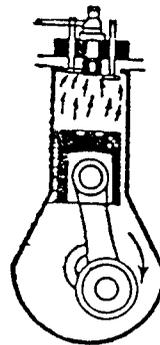
All the valves are closed, rising piston compresses the air. The injection of fuel starts near end of compression.

All valves closed, the ignited mixture of air and fuel expands and forces the piston downward. This is a power stroke.



Expansion Stroke

(c)

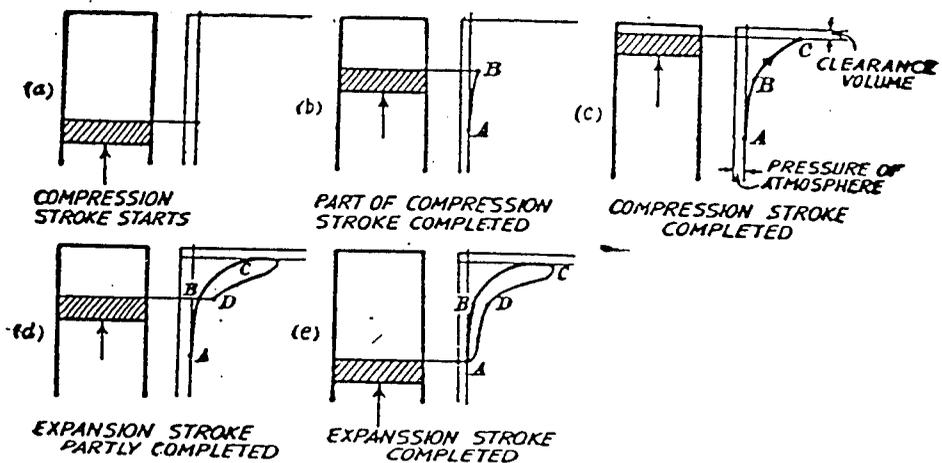


Exhaust Stroke

(d)

Only exhaust valve opens, the rising piston forces the burnt gases out of the cylinder.

Four Stroke Cycle of Diesel Engine



## CHAPTER III

### DIESEL ENGINE POWER PLANT SYSTEMS

The four important system of diesel engine are

- (i) Air
- (ii) Fuel
- (iii) lubrication
- (iv) coolant

All these systems work on by Natural law that "fluid flows from region of high pressure to region of low pressure". The block diagram of Diesel power plant is shown in Fig.3.1.

#### 3.1 FUEL SUPPLY SYSTEM

The functions of fuel system are to (i) supply fuel (ii) metering, timing & injection of fuel (ii) control of engine speed.

Supply of fuel → by positive displacement (with gear type pump)

Metering & timing → depends on pressure of fuel & time of flow  
injection is based on CAN lobe. fuel is injected when the plunger descends.

Fuel is sprayed under hydraulic pressure so that it uniformly mixes with air

### **3.2 Air intake and Exhaust System**

Air supplies oxygen to cylinder to burn fuel & carries away gases after combustion: It consists of pipes for the supply of air and exhaust of the gases. Filters are provided to remove dust etc from the incoming air. In the exhaust system silencer is provided to reduce the noise at the exhaust.

The purpose of the air intake system are as follows

- i) To clean the air intake supply
- ii) To silence the intake air
- iii) To supply air for super charging

The intake system must cause a minimum pressure loss to avoid reducing engine capacity and raising the specific fuel consumption.

### **3.3 LUBRICATING SYSTEM**

The action of providing oil between the two bearing surfaces is called lubrication. Lubrication is essential to reduce friction and wear of the rubbing parts. Lubricating system.

- i) Lubricates
- ii) Seals
- iii) Cleans
- iv) Cools the engine parts.

## **3.4 COOLING SYSTEM**

This system provides a proper amount of water circulation all around the engines to keep the temperature at reasonable level. Pumps are used to discharge the water inside and the hot water leaving the jacket is cooled in cooling ponds and is recirculated again. A water pump that works circulates the coolant on centrifugal force, the pump gets power from engine shaft.

### **3.4.1.Necessity of Cooling**

When the fuel is burnt in the cylinder the part of heat developed during combustion flows its cylinder walls. If the temperature of the cylinder walls is allowed to rise above a certain limit the lubricating oil starts evaporating, this action damages both piston and cylinder. The higher temperature developed may sometimes cause cracking of the cylinder head and piston.

### **3.4.2.Requirements of a Cooling System**

In order to have proper cooling incase of diesel engine, following condition must be met:

- 1) An uninterrupted flow of cooling water must always be maintained through the engine jacket.
- 2) The maximum temperature rise permitted in the jacket should not be more than 10°C approx.
- 3) The water used for jacket cooling should not be of corrosive nature
- 4) The cooling water should be free from scale forming impurities.
- 5) The outlet temperature of the jacket cooling water should be within the permissible limit as prescribed by the manufacturer.
- 6) The water inlet and outlet temperatures should be maintained constant provided the load on the engine remains constant.

### **3.4.3. TYPES OF COOLING SYSTEM**

The design of cooling system depends mostly on the quantity of water (or) the capacity of station and the type of cooling medium available.

Mainly cooling systems are of two types

- i) Open cooling system
- ii) Closed cooling system

A plant near the river may utilize the river water for cooling and discharging again the hot water into the river, this type of cooling system is called open cooling system.

In the closed cooling system the water is recirculated and only make up water is taken up from the supply source. The closed cooling system may be classified into the following.

- 1) Radiator cooling
- 2) Evaporative cooling

## **1) RADIATOR COOLING**

The radiators are used for cooling the diesel engines of small output. The radiators are of fin and tube type similar to that used in automobiles. The heat in water is rejected to the air. As the specific heat of air is about one fourth that of water and surface coefficient between metal and air is very low as compared to water and metal,

so a very large surface area is needed to dispose the heat of the water. The surface area is generally increased by adding the metal fins to the metal tubes. A fan is used to suck fresh air. A pump is used to circulate the water.

## **2)Evaporative Cooling**

If the water, in the cylinder jacket is allowed to evaporate it can take much more heat from the cylinder. The system is quite simple in which neither pump nor radiator is required. This system is generally not useful for power plants having higher output.

### **3.4.4.Cooling Equipment**

For power station mostly closed system of cooling is used. The system uses soft water for jacket cooling. The hot jacket water from the engine is passed through the heat exchanger, where it is cooled by raw water. The raw water in turn is cooled by cooling towers etc.

A complete closed system comprises the following equipments.

- 1) Soft water circulating pump
- 2) Soft water circulation pipes
- 3) A surge tank or on expansion tank
- 4) Soft water heat exchanger or cooler
- 5) Thermometer for measuring inlet and outlet temperatures
- 6) Temperature regulator to control the outlet temperature
- 7) Safety device to control the excessive jacket

temperature.

- 8) Raw water softening plant
- 9) Raw water circulating pump
- 10) Raw water circulation pipes
- 11) Raw water cooling tower

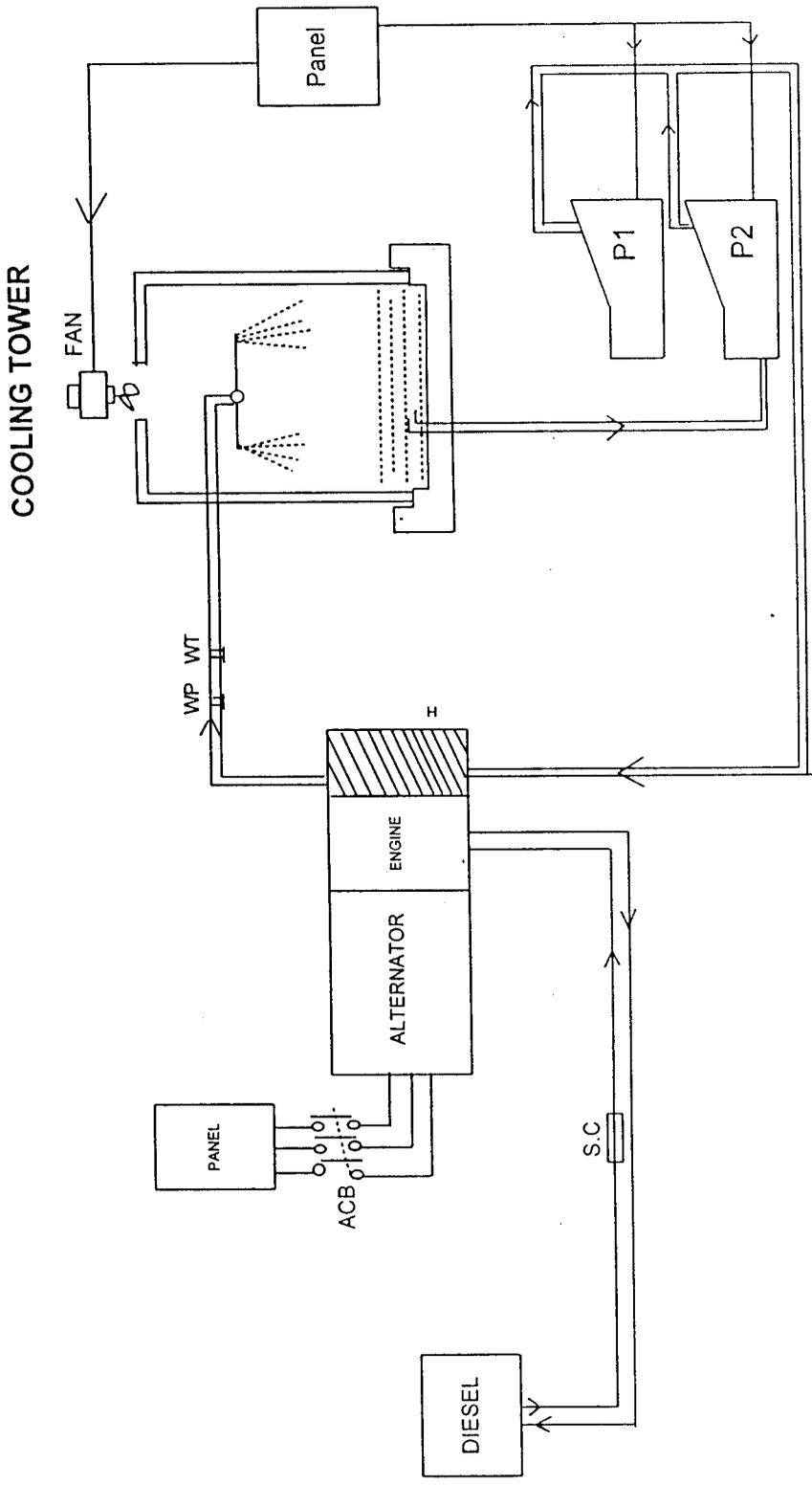


Fig 3.1 BLOCK DIAGRAM OF DIESEL POWER PLANT

## **CHAPTER IV**

### **EVOLUTION OF THE CIRCUIT**

The shortcomings of the existing system were analyzed and based on the requirements, a new control circuit is evolved.

#### **4.1 PROBLEMS FACED BY ENGINE WORKING AT HIGH LOADS**

Due to various requirements, the Diesel engine might be forced to run continuously at maximum load.

The load current may reach as high as 1000 A under these circumstances, the factors that come into consideration are

- i) Coolant temperature
- ii) Lubricating oil pressure
- iii) Engine speed

The coolant that circulates around the engine cylinder jackets may rise to temp as high as 95°C. At these temperatures, the piston valves may get damaged and the engine operation gets struck.

At high temp the lubricating oil loses its properties. Lubricating oil pressure is to be properly maintained otherwise there may not be proper pumping, as fluid flow is maintained as per natural law that

"fluid flows from region of high pressure to low pressure region".

If there is no proper lubrication the piston gets jammed with cylinder walls.

The engine speed should be maintained within the safe limits. Over speed may affect the alternator & its windings coupled with the engine. Under practical condition, it is the water temperature that causes concern & has to be monitored.

## **4.2 EXISTING PROTECTIVE SYSTEM**

The makers install an electronic fuel control (EFC) governor along with the engine.

EFC controller monitors the lubricating oil pressure, coolant temperature, oil temperature at the engine jacket and the engine speed.

Lubricating oil pressure is sensed by a pressure transducer. Coolant temperature is monitored by a thermocouple installed in it.

A magnetic pickup sense the engine speed at the flywheel gear and generates AC voltage with frequency proportional to the speed. The governor controller compares this with the preset speed

reference and based on the difference change the current in the actuator.

The actuator (NC) open depending on the current through the coil a change in the current causes the shaft to rotate and the valve open. This and changes the fuel flow and hence the speed.

#### **4.2.1 Circuit of the Existing Protective System**

The existing protective system shown in Fig4.1, monitors the four parameters viz.

- i) Coolant temperature at engine jacket
- ii) Low Lubricating oil pressure
- iii) Engine over speed
- iv) Lubrication oil temperature

The operation is performed by relays:

In case any of the above fault is detected, the corresponding relay switches ON, this causes an indication of the occurred fault and a hooter sounds till the fault is manually acknowledged.

#### **4.2.2 Drawbacks of the Existing Protective System**

The inbuilt water temperature monitor trips off the engine only

when the water temperature has reached as high as about 97°C, this being very nearer to the boiling point of water, causes undesirable effects on the jacket walls. More over, the engine is tripped by cutting off the fuel supply, but with full load connected to the alternator.

If the engine is stopped abruptly at fuel load, that may damage the piston valves and cylinders and also the alternator and its windings.

#### **4.3 PROPOSED IDEA FOR SAFETY TRIPPING**

The existing controller monitors the temperature of the coolant that is circulated within the engine jackets. But as per the idea proposed, the temp of water circulated between the heat exchanger of the engine and the cooling tower is considered generally the temperature will be about 10°C less than that at the engine jackets.

So the external coolant cycle is considered for the design of control equipments.

##### **4.3.1 Problems that would occur in the external Coolant Cycle**

- i) The coolant water may not flow as
  - a) the pump may not be switched ON

- b) Air lock at the foot valve of pump
- c) leakage or obstacle in the flow path
- ii) The temperature of this water may increase as
  - a) The fan in the cooling tower might have failed
  - b) No fresh water flow into the tower

The problem (i) mentioned above can be monitored by providing a pressure switch in the flow path. The switch remains closed as far as there is water flow or pressure.

The problem (ii) mentioned above can be monitored by providing a temperature controller which remain closed as long as the temp is below the set value.

#### **4.3.2 Functional Requirements of the Control Equipment**

- i) The A.C.B. at the Control panel is tripped off before the engine is stopped. The engine is stopped by de-energising the fuel solenoid coil.
- ii) A specific time delay is provided through programmable timer for manual acknowledgement and to reset the detected fault.
- iii) At the time of starting, the timers are actuated, if the flow pressure is not maintained within the specified time and

the trip system is operated.

- iv) If the feed water temperature is above set value, the timers are activated and the trip circuit is operated, only after the temperature is brought down the solenoid coil is energized.
- v) The whole system is operated through 24V battery supply
- vi) Indication for the detected fault
- vii) provision for by pass in case of system failure.

#### **4.4 CIRCUIT OF CONTROL EQUIPMENT AND ITS OPERATION**

The circuit of the control equipment is shown in Fig4.2.

Fuel supply to the generator is maintained when the fuel solenoid coil "K" is energized.

The coil "K" is energized by 24V dc through a contactor C1 (N.O)

Contactor `C1' is energized by 24 V dc only when contactor C2, the temperature controller(tc) and pressure switch(ps) are closed.

`C2' and `C3' are energized by 230V ac only when water pump is ON.

The A.B. coil at the panel is also fed through contactor, C1.

#### 4.4.1.WORKING

- 1) The water pump is on, when 230V a.c. is maintained. This energize coils C2 & C3  
The temperature controller contact closes when 230V is maintained  
The pressure switch is closed where there is waterflow/pressure  
When C2, tc, ps are closed, C1 is energized & hence 'K'. This starts the Generator to run.
- 2) (Only) at the time of starting, ie before the pump and hence the ps is ON,  
The supply to C1 is maintained through the electronic timer T1  
T1 (N.C.) remains closed till the set time (t1) seconds.  
Coil supply to T1, is maintained through an ON delay timer T2, which cuts off supply after the set time t2, (> t1) seconds.
- 3) During the change over, i.e., the supply to pump is changed from the EB main to autostart Generator panel or the other way, the pump is OFF for a while. At this time, the supply to C1 is maintained through contactor C3 and off delay timer T3

- 4) While running,
- a) If the temperature rises above the set value, tc opens instantly & hence C1
  - b) If water pressure is not maintained ps opens instantly and hence C1

In both (a & b), opening of C1 trips off the AB coil at the Generator panel. The engine stops with a few second delay after AB trip, by provision of delay timer T4.

- 5) In case the, whole system fail, the supply to solenoid 'K' is maintained through the by pass switch.

#### **4.4.2 Indication are provided in the panel for the following conditions.**

The indication lamps circuit is shown in Fig.4.3

The DC section of the circuit includes.

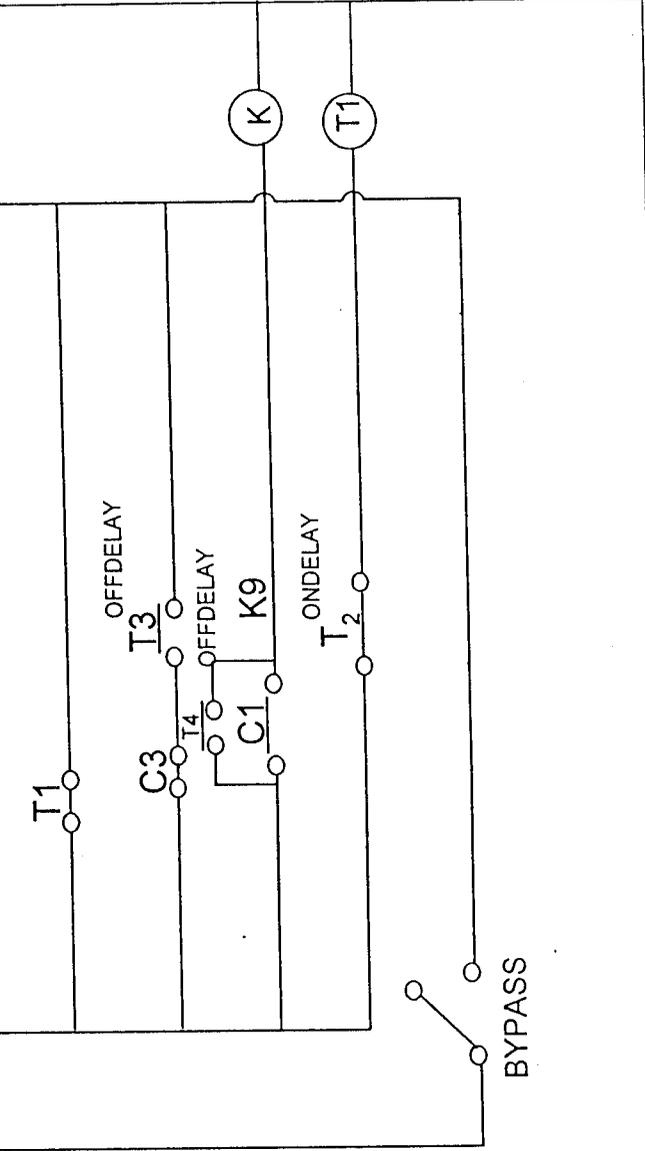
- i) DC 24V ON from ON/OFF switch
- ii) GNR ON from C1 (N.O) Point
- iii) ps ON from C1 (N.O) Point
- iv) ps Fail from ps (N.O) Point
- v) Temp high from tc (N.C) Point

The AC section includes

- i) Mains ON from ON/OFF switch
- ii) Pump ON from C2 (N.O) point
- iii) A.B.Coil ON from AB (N.O) point
- iv) A.B. Coil OFF from A.B.(N.C)point

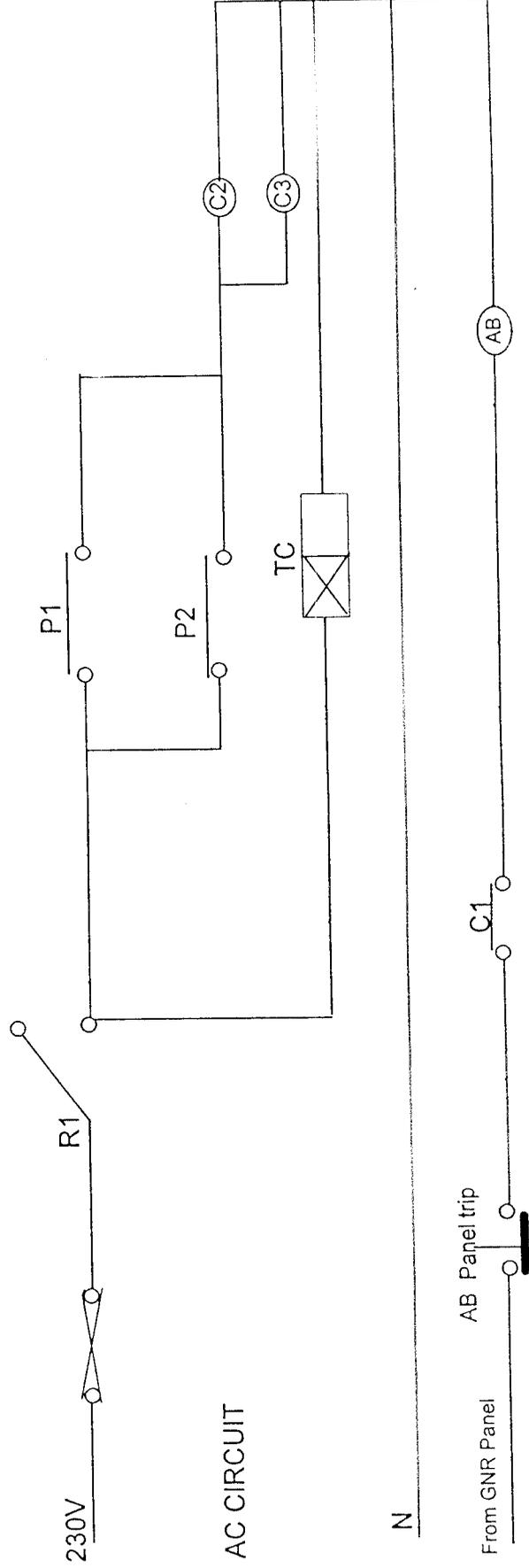


DC CIRCUIT



24V-

AC CIRCUIT

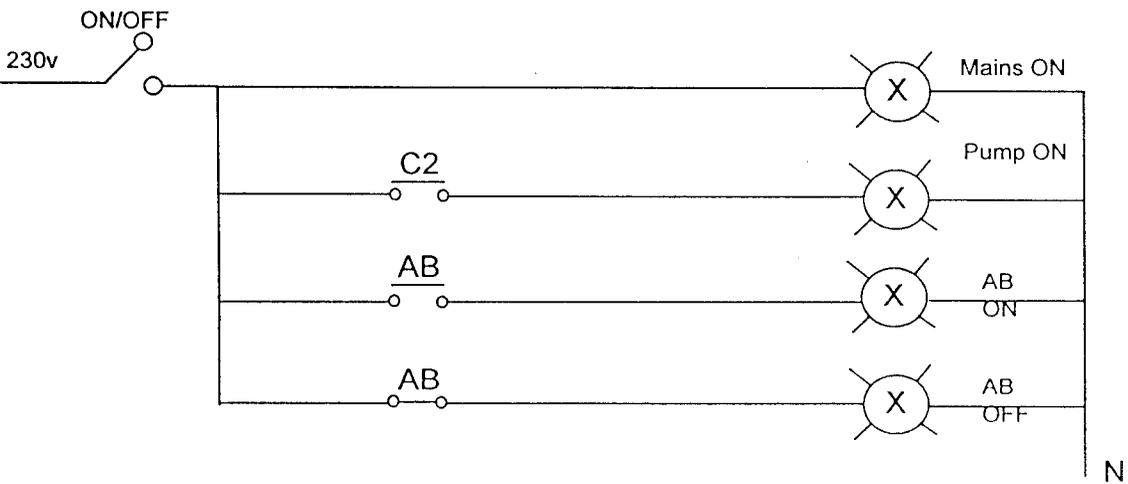
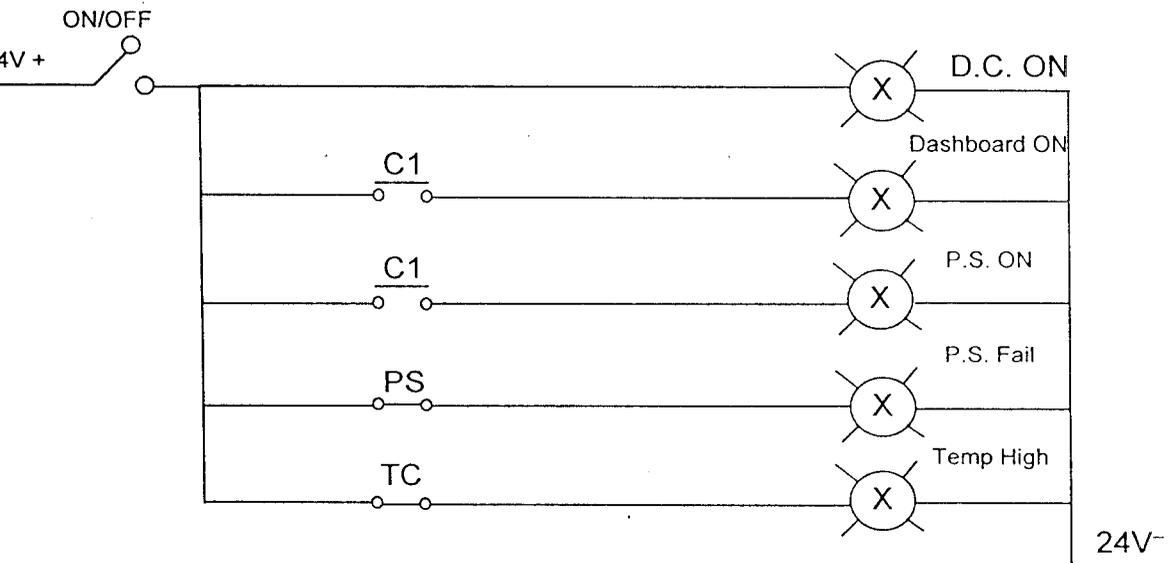


230V

N

From GNR Panel

AB Panel trip



 - LAMP INDICATIONS

Fig 4.3 LAMP INDICATIONS CIRCUIT

# CHAPTER V

## CIRCUIT COMPONENTS

The main section of the designed circuit are the (a) ACB and the (b) fuel solenoid coil other functional elements are

- i) Contractors
- ii) timers
- iii) Temperature Controller
- iv) Float switch

### 5.1 SOLENOID COIL

The fuel solenoid coil is placed in the path of fuel flow from the tank to the engine. The fuel flows through, only if the Coil is energized. A 24V D.C, is applied for energizing the coil.

In general, a solenoid is an electromagnet that applies a Straight line force in a push or pull motion, they are used for control purposes.

Solenoids are operated along with solenoid valves. In selecting the solenoid valve the points that must be considered are:

- i) Hydraulic fluid to be controlled
- ii) Allowable pressure drop
- iii) Quantity of fluid that must flow through
- iv) Maximum operating & working pressure
- v) Electrical characteristics for Coil operation

## **5.2 AIR CIRCUIT BREAKER**

### **5.2.1. Working Principle**

The air at atmospheric pressure is used as an extinguishing medium in Air Break circuit breakers. These circuit breakers employ high resistance interruption principle. The arc is rapidly lengthened by means of the arc runners and arc chutes and the resistance of arc is increased by cooling, lengthening and splitting the arc. The arc extinction increases to such an extent that the voltage drop across the arc becomes more than the supply voltage and the arc is extinguished.

### **5.2.2. CONSTRUCTION**

In the air-break circuit breaker the contact separation and arc

extinction takes place at atmospheric pressure. Fig 5.1 (a) show the closed current carrying contacts as the contacts are opened arc is drawn between them. The arc is a conducting path of plasma. The surrounding medium contains ionized air by cooling the arc, the diameter of arc core is reduced. The arc is extinguished by lengthening the arc, cooling the arc and splitting the arc. The arc resistance is increased to such an extent that the system voltage cannot maintain the arc and arc gets extinguished at current zero of AC wave.

Fig (5.1 (b) Illustrates the normal arrangement of air break circuit breaker.

There are 2 sets of contacts. Main contacts and Arching contacts. Main contacts conduct the current in closed position of breaker. They have low contact resistance and are silver plated. The arching contacts (2) are hard, heat resistant and are usually of copper alloy. While opening the contact, main contacts dislodge first. The current is shifted to arching contacts. The arching contacts dislodge later and arc is drawn between them. The arc is forced upwards by electromagnetic forces and thermal action. The arc ends

travel along the Arc runner (Arching horns). The arc moves upwards and is split by splitter plate (5) as shown by arrow (4). The arc is extinguished by lengthening, cooling splitting etc.

### **5.3 CONTACTORS**

A contactor is a mechanical switching device capable of making, carrying, and breaking electric current under normal circuit conditions including operating overload condition.

Fig(5.2) shows details of electromagnetic contactor with its contacts and coil. The contactor is shown having 3 main contacts and 2 auxiliary contacts the Main contacts are used in switching ON and OFF the power circuit. Whereas the auxiliary contacts are used on the control circuit. The contactor coil is to be energized from a source of supply. Contactors are available for different voltage ratings, either AC or DC contact combination.

#### **5.3.1.Working of Contactor**

Contactors are protective devices which keep the input output terminals normally opened (or) normally closed during operating condition, due to the restoring force of spring. The N.O position

becomes N.C / N.C becomes N.O during abnormal conditions due to the electromagnetic force of attraction produced by an electro magnet.

Contactors have two contacts

- i) Fixed contact
- ii) Movable contact and electromagnetic coil

The moving contacts are connected with iron plates.

During abnormal conditions, the current passes through' the coil and gets energized. The electromagnetic force of attraction is developed by air electromagnet which tend to lift that upward, so that the movable contact gets connected with the fixed contact.

#### **5.4 TEMPERATURE CONTROLLER**

The details of temperature controller are shown on Fig.5.3. A thermocouple senses the temperature and converts its into a equivalent voltage. A temperature setting potentiometer, which is a part of a voltage divider network sets a reference voltage. The

voltage is compared with amplified thermocouple output. If there is any difference between these, it is further amplified and this activates the relay. The relay contacts in turn issue commands to main contactor which connects or disconnects the supply to heater coils.

## **5.5 PRESSURE SWITCH**

Pressure switch in this circuit is used to sense the flow of water. The pressure controller is set by rotating a knob.

The signal to the control circuit is transmitted by the switch unit which is activated by a mechanical valve assembly. In this mechanical valve assembly, when the pressure falls below the set value, it lifts down and thus the control circuit receives the signal from switch unit through a wire passage.

## **5.6 TIMERS**

### **5.6.1. Electronic Programmable Timer**

The electronic timer installed in the circuit is programmable in the range of 3 sec to 30 minutes. It consists of coil terminals A1, A2 which is energized by 24V dc. The contact points are normally

closed for a predetermined time.

Once the set time is attained by the internally installed counter, the N.C contact of contractor turns opened.

The resetting of the timer is achieved when the system is again switched ON.

### **5.6.2.OFF delay & ON delay Timers**

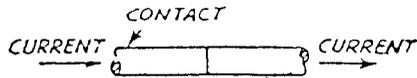
In ON delay timer the delay cycle starts when the clutch is energized and the same time, instantaneously contacts get actuated.

At the end of the set time the delayed contacts get actuated.

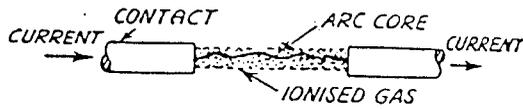
In OFF delay timer, the time delay cycle starts when the clutch is de-energized. This delayed contacts get actuated at the end of the set time.

Off delay timer is useful for application where an equipment has to be kept ON for a period after the main system is switched off. The ON or OFF delay is achieved by a Mechanical torsional spring that is activated by energising or de-energising the clutch terminals.

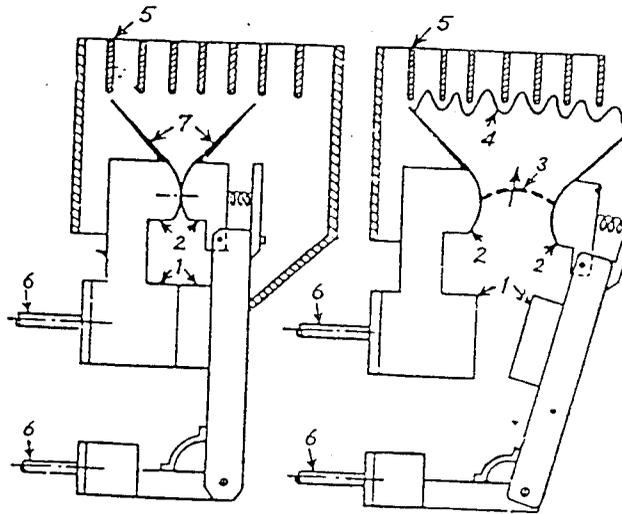
These timers can be set within range of 1-180 sec.



(a) Contacts in closed position



(b) Contacts Separated in air at atmospheric pressure



(I) Contacts Closed (II) Contacts Open

Principle of air-break circuit-breaker

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1. Main contacts</li> <li>2. Arcing contacts</li> <li>3. Arc rising in the direction of the arrow</li> </ul> | <ul style="list-style-type: none"> <li>4. Arc getting split</li> <li>5. Arc splitter plates</li> <li>6. Current carrying terminals</li> <li>7. Arc runners</li> </ul> |
|---|---|

Fig- 5.1. Arc extinction in air-break circuit-breaker.

Fig 5.1 AIR CIRCUIT BREAKER

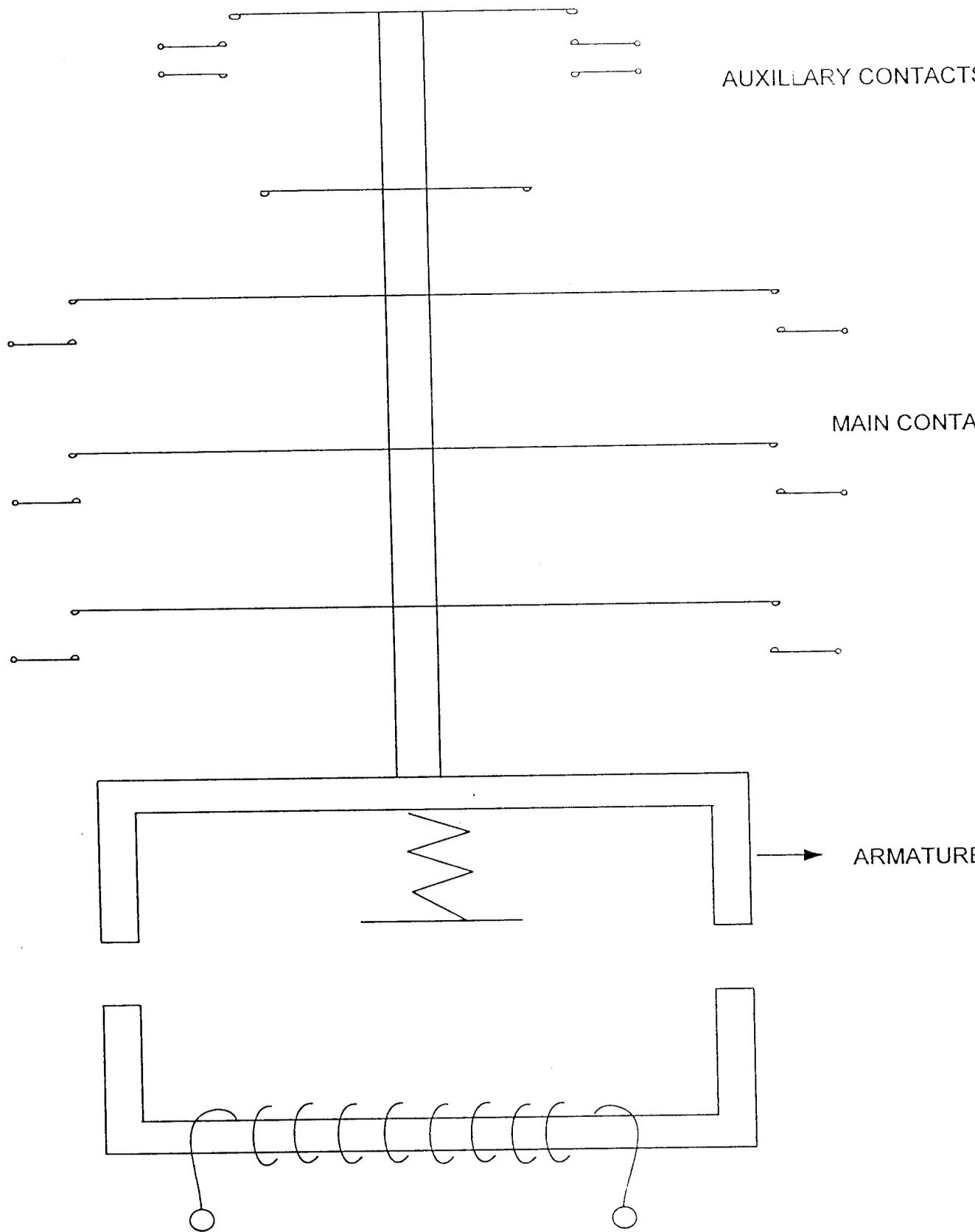


Fig 5.2 CONTACTOR COIL

## CHAPTER VI

### FABRICATION AND INSTALLATION

The control circuit discussed about in the previous chapters was fabricated and the control equipment were installed in a 1250 KVA genset.

#### 6.1 SPECIFICATIONS OF THE 1.25 MVA GENSET

Make: CUMMINS INDIA LTD.,  
4S, 16 cylinder 'V' arrangement

The ratings of the engine are generally 10-15% more than that of the coupled alternator

Power ratings : 1470 BHP @ 1500 rpm  
1635 BhP @ 1800 rpm

#### 6.2 FABRICATION OF CONTROL PANEL

The listed components are assembled on an M.S. sheet of size 500 x 350 MM and the required wiring were done.

The sheet is kept enclosed in a control box of size 600x450x250 mm.

The outer section of the control panel has the necessary indications provided in it as per the circuit demonstrations.

### **6.3 COST ESTIMATION**

The break-up of various components, their quantity were listed and the total cost estimation of the project was worked, the expenses stood at a reasonable level. The cost estimation is shown in Table 6.1.

### **6.4 TESTING**

After the control equipment was installed the various fault conditions analysed, were simulated and the circuit operation was found to be satisfactory under all conditions.

## **CHAPTER VII**

### **CONCLUSION**

A circuit for safety tripping of the diesel generator, considering the cooling system has been developed, implemented and tested. The developed system is far more reliable than the existing one. Moreover the developed circuit is quite simple and scope for fault is limited. Even incase of fault, the bypass provision help to run the generator continuously.

The cost of developing this system is quite reasonable considering the cost of repair that would occur otherwise.

Further improvements can be made in the system by considering the other factors that affect the engine operation.

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