COMPUTERIZED STARTING OF ELECTRICAL POWER PLANT

(CASE STUDY - SHIRORO POWER STATION)

BY

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PGD / 93 / 146

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March, 1998

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A project submitted to the department of Mathematics Computer Science, Federal University of Technology Minna, in patial fullfilment of the requirements for the Award of Post Graduate Diploma in Computer science.

March, 1998

CERTIFICATION

I certify that this work was carried out by G. O. Akinola of Department of Mathematics/Computer Science, School of Science and Science Education, Federal University of Technology, Minna - Niger State.

10-03-98

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(Head of Department)

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External Examiner Date

ACKNOWLEDGEMENT

My sincere gratitudes goes to the Almighty God for his infinite Mercies,Guidance and Protection through this work. May His Mercies and Love endure forever. Glory be to Him.

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I appreciate efforts of students in the department like Seyi Ojongbede and Sam Obianke for assisting me in tidying up this work.

This acknowledgement will be incomplete without appreciating my course mates' motivating spirits and support, especially B.M. Abdullahi, P.O.Osutuk and M.Adeagbo - we always sat down together to discuss when things seemed knotty.

May the Almighty God continue to support and bless us all including those I inadvertently omitted.

G.O.AKINOLA

ABSTRACT

This Project is aimed at improving Generator starting sequence. It will, apart from reduce Generator starting time, reduce (if not completely eliminate) human error encountered during starting,lower fuel consumption per Generation, and save cost thus achieveing better optimisation.

The application, in the long-run, will reduce number, extent end duration of service interruption thereby providing an improved and more reliable service to the consumers.

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CONDUCTOR

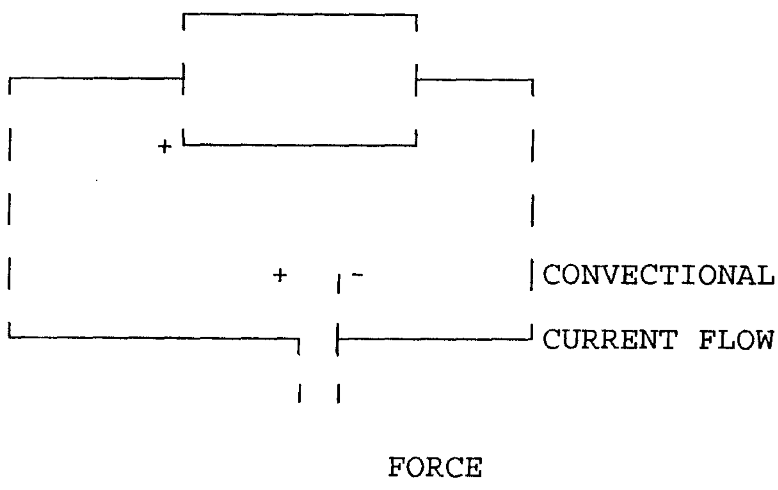


Figure 1.1.1: **ELECTRIC CURRENT FLOW**

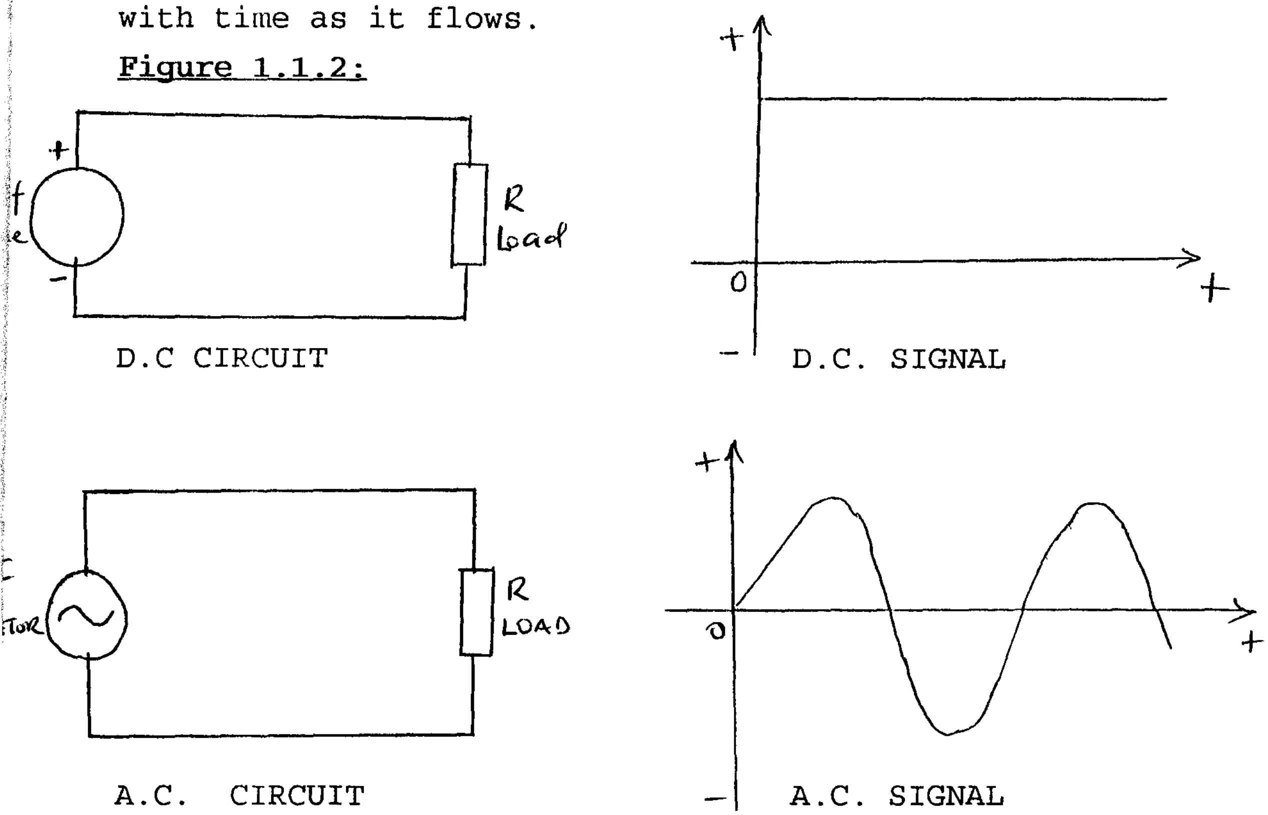
Electrons drift from the -ve end to the +ve end of the conductor (as indicated in above diagram). This is the direction of electron flows but the conventional current flow direction is taken to be from the positive end to the negative end (i.e. opposite the electron flow direction).

Electricity is the flow of charges so electric power conduction involves transmission of these charges carriers through or and by means of conductor. The process of carrying generated electrical energy to the utilizing end is TRANSMISSION. If large quantity is involved, it is distributed at the transmission end.

Electric energy is in either Alternating (A/C) or Direct (D/C) form. An alternating current or energy (A/C) is the one that periodically reverses its direction but direct current (D/C) flows in one direction only. Both forms of electric energy are useful to do work.

An electric circuit can be D/C or A/C depending on whether the EMF source (Electro-Motive Force) is direct or alternating. A battery, for example is a D/C Electro motive force source which has constant value and direction with respect to time. A 240V A/C connection (Like the common power outlets in our homes) has power which reverses its direction with time as it flows.

Figure 1.1.2:



A/C is just as suitable for heating as D.C. They are both used for illumination (Depending on which is economical and convenient). Small motors used in vacuum cleaners, head dryers, engravers etc. run on A/C. D/C is used on most electric railway and tramway systems. Other processes where D/C is used are in electron chemicals and battery charging.

Equipment or system that used D/C in environment where A/C is more accessible convert the A/C to D/C through process called RECTIFICATION. D/C can also be charged to A/C by the use of INVERTER.

Electricity supply, whether A/C or D/C basically requires an electric power generator, which may be connected via switchgear, transformer and other components to a demand point. This demand point could be different locations which have the following equipment like lighting bulb, cooker, iron, deep freezer, air-conditioner, washing machine, industrial motors etc. These equipment use electricity for operation.

Current will not flow in a circuit unless external force or pressure is applied. The force, Electro motive Force (EMF), is that required to set electrons in motion in a closed circuit.

The unit of measurement of EMF is VOlt (V), and the unit of measurement of electric current is the AMPERE (A) which gives rate at which electrons move past a given point.

The symbol for electric current is I. Device for measuring electric current is the AMMETER and it must be placed in series with the component whose current is being measured.

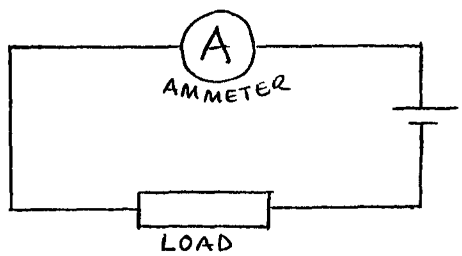


Figure 1.1.3: **AMMETER IN SERIES WITH CIRCUIT.**

Current being measured

$$= \frac{\text{Quantity of electricity}}{\text{Time}} \quad .... \quad (1.1.1)$$

The current flowing in an electrical conductor is directly proportional to the voltage (or potential difference) across it provided the temperature and all physical parameters of the conductor remain the same. This can be expressed mathematically as:

$$V \propto I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1.1.2)$$

where V is the potential difference (p.d) across the conductor and I is the current flowing through it.

The proportionality is defined thus:

$$V = RI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1.1.3)$$

where the constant of proportionality R. is the electrical resistance of the conductor

$$V = RI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1.1.4)$$

i.e $$I = V/R \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1.1.5)$$

and $$R = V/I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1.1.6)$$

ELECTRICAL POWER AND ENERGY

1.2.1 POWER

Amount of work done within a period of time is known as power.

By definition, electrical power is the watt (w). It represents the power used when one ampere of current flows through a circuit with which a pressure of one volt. In D/C circuits, the power is found by multiplying the pressure in volts by the current in amperes.

Watt = Volt x ampere (1.2)

A battery supplying electrical current to a load is said to be delivering power to that load. Power used by an electric bulb supplied with 0.25A current and 240V EMF across its ends is:

Watt = Volt x ampere

i.e. = 240v x 0.25A

= 60 watt

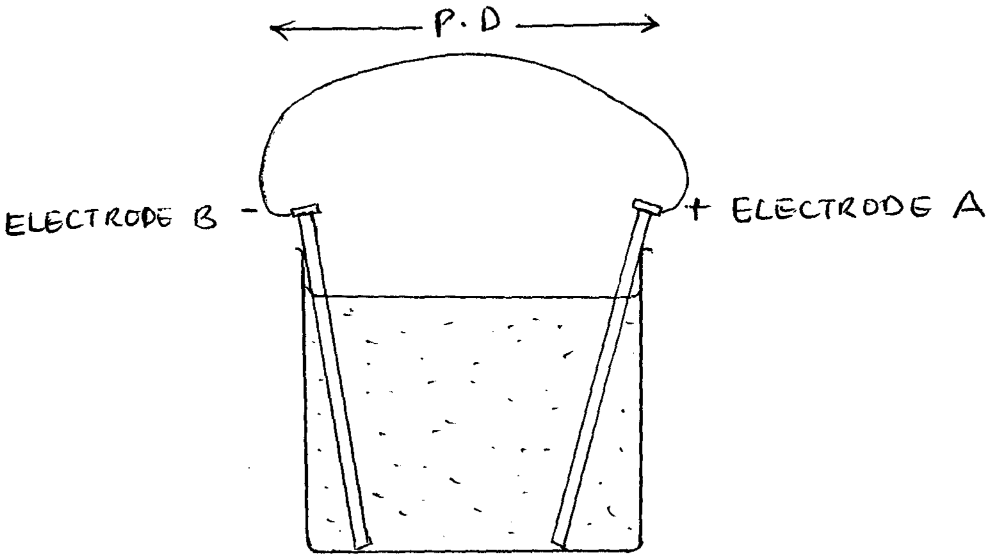
Large quantities of electrical power is expressed using the following terms;

1 kilowatt (kw) = 1,000 watt

1 megawatt (mw) = 1,000,000 watt.

Electrical power can also be expressed as the rate of delivery or transforming electrical energy i.e. time rate of blow of electrical energy. An electrical power plant is a machine that generates electrical energy. This power is supplied to some equipment to do work. That is, the electrical energy is transformed into useful work in incodescent bulb to illuminate surrounding, in motors and pumps to pump water and in electric heater and cookers to cook food.

Electrical energy can also be transformed in heat energy. This is measured in joules per second. It current flows along a wire from point A to B (in the diagram below) and the potential difference between A and B is V volts, the potential energy lost is V joules per coulomb.



<u>Figure 2.1</u> **Potential Difference Inside and outside a cell.**

Charge Q is the quantity of current passing through a point within a given period of time. That is

$$Q = I t \qquad (1.2.2)$$

Where Q => charge

I => current

t => Time

So, if Q coulombs flow along the wires, the potential energy lost is VQ joules. But it takes t seconds for Q coulombs to flow from A to B, the rate of loss of potential energy is expressed

VQ/t Joules per second.

Since Q = I t

Rate of loss of potential energy is V/t x It = Vd joules per second.

Rate is loss of potential energy is the rate of conversion of electrical to heat energy in the wire and cell. This is also the rate of conversion of chemical to electrical energy in the cell.

Therefore, rate of energy conversion or liberation per second in a device is also referred to as POWER.

1.2.2 ENERGY

Energy, as has been noticed, was made mentioned when explaining power. One cannot hardly be explained fully without mentioning the other. Energy and power are complementary.

Energy is the ability to perform work. When work is done, energy is expended for all practical purposes, the amount of energy expended is exactly equal to the amount of work done. Energy can be simply defined as the product of power and time. It is measured in joules (j).

Energy = Power X Time

Electrical energy is measured in Watt-hour. One Watt used for one hour equals one watt-hour. Similarly, one thousand watt used for one hour equals one-kilowatt-hour (KW.hr).

An 80W electric bulb used for one hour has consumed

80W x 60 seconds x 60 seconds

= 288000 Joules of Energy.

1.2.3 LOSSES AND EFFICIENCY

James Watt, the inventor of steam engine, determined by experiment that the average horse could deliver 746 watt of power which is regarded as one horsepower. That is, motor operating at 100% efficiency would deliver one horsepower for each 746 watts supplied to it.

Actually, motors are never 100% efficient. They always use some of the power in overcoming bearing, friction and windage forces in the rotor, including internal resistance losses hence, they deliver less than supplied. Their efficiency-ratio of output to the input - is always less than 100%.

$$\text{Efficiency } (\%) = \frac{\text{output}}{\text{Input}} \times 100\%$$

cm ,ptpr

The losses in a machine are present usually in the form of heat which is a vital consideration in the design and rating of all electrical equipment.

OBJECTIVE OF THE STUDY

Shiroro Power station has four major locations involved in successful operation of the power plant. They are:

i. Unit control Board (Power house)

ii Control Room (at Power house)

iii Switchyard and

iv Intake (Reservoir location)

In the absence of intercom (Communication means) it is 10 minutes drive from intake to switchyard, 5 minutes from switchyard to power house and 3 minutes step climbing from unit control Board (UCB) to the control room (C/R). Also without (Computerized) automation, it might take not less than 25 minutes to start a machine in Shiroro Power Station

With computerized automation, it takes only 3 minutes to start the same machine.

The objective of this project is to improve automation in power plant starting and running. Automation entails smoother and logical sequence of actions taking place to achieve the desired result (Operation). In this case - electricity generation - turbine, generator and their auxiliaries come into action after some pre-determined conditions have been attained in the system.

Computerized Power Plant Starting:

i. Eliminates Manual switching operation

ii. Eliminates or reduces human error

iii. Brings erroneous operation to the minimum

iv. Reduces time delay during switching and operating period (saves time)

v. Saves cost of operation - in the long run - by reducing man power dependence staff strength).Since it takes shorter time to attain synchronous speed and synchronization, it ends up generating more power over a period of time.

vii.Reduces fuel consumption per power generated thereby lowering cost of energy delivered to consumers.

viii Money saved in this wise can be directed to improved quality of service by consistently maintaining the plants and auxiliaries and coping with future energy challenges.

ix. Finally, system security is achieved because of the automatic generation control in action to regulate load/energy flow.

With proper application, this process will meet the objectives itemized above by linking automatic generation control and interactive load flow.

METHODOLOGY

Computerised plant starting sequence is an integral part of Energy management System (EMS). EMS is a system whereby Energy available and load are matched economically to attain system security. Its functions include:

(i) Network surveillance and control by acquiring, analyzing and converting data, accepting looping, reporting and processing alarms and signals and load shedding where and when abnormal condition requires so.

(ii) Connection Commitment and control by knowing load forecast, monitoring fuel reservoir, and economic despatch of available energy.

(iii) Achieving system security through Network Status analysis, production costing, machine scheduling to match interactive load flow.

Once computerized starting sequence is applied on a machine, its efficiency and reliability will e put to test and confirmed on a proto-type.

Application can be used on its mechanical runs like the generator condenser switch to its cooling water sequence. Next step is taken until the last item on the sequence is successfully applied on a machine and certified okay.

This system is kept under observation for a period of time say 90 days) before applying same on the next machine and until to the last.

Automatic starting sequence is applied separately on the turbine and generator and auxiliaries before their parallel operation.

Further extension of this automation is applicable on NEPA grid (Network) through interlinks to match energy available to land in the system after inter connecting all machines to form a single unit.

CHAPTER TWO

POWER PLANT OPERATION

2.1 ELECTRICAL POWER PRODUCTION

2.1.1 FORMS OF ELECTRICAL ENERGY

As explained in the introductory part (1.1), electricity is the formation and flow of charges. Electricity production involves transmission of the generated energy - by means of conductors to the utilizing end. This energy can be in alternating or direct form, depending on its source.

Apart from the properties of each briefly mentioned in part 1.1, A/C voltage can be easily stepped up or down quite economically by the use of transformers to transmit over any desired distance. Stepping up voltage before transmission reduces energy loss. Also, switching are easily carried out on stepped-up alternating power which has lower current.

A/C is just as suitable for heating as D/C, because filament lamps depend on heating effect, it is used for lighting. Gas-discharges lamps like mean, sodium and mercury run on A/C as well as D/C.

Both can be generated in small or large scale.

2.1.2 SOURCE OF ELECTRICAL ENERGY

Any form of energy that can dislodge electrons from atoms can be used to produce an EMF. This EMF is the force required to set electrons in a closed circuit thereby making current to flow.

Different methods of generating electrical energy by the use of light, heat, magnetism, pressure, chemical reaction etc. are enumerated below:

(I) Electric charge can be liberated by rubbing ebonite with fur. On rubbing ebonite and fur, there is transfer of charges between them making ebonite negatively charged and fur positively charged. This method of producing STATIC ELECTRICITY by friction is TRIBO ELECTRIC.

(II) Electrolysis is the movement of ions from one electrode of metallic composition different from another (electrode) in a solution or brine (Salt and water). This method generates electricity in small or large quantity depending on the design and use intended. A simple electrolytic process involves connection of metals of different metallic composition through a wire and inserting them in brine solution as shown in fig. 1.7.

III Ordinary dry cells commonly called battery have stored energy which causes current to flow when terminals are connected through wire. For example, the battery used in torches provide an electrical force from conversion of chemical energy into electrical energy which eventually produces the light.

A primary cell like Zinc-carbon, Alkaline or mercury, produces small amount of direct current power. though it has advantage of reliable storage means, the battery components are used up in the utilization process and the cost is prohibitive for large-scale applications.

Secondary cells like the lead-acid battery has advantage of reversing its discharging process i.e it is rechargeable. This battery and its likes are used for traction (motive power) and automobile (starting, lighting and ignition). The specific gravity of its electrolyte is used to determine the state of charge of the cell.

To recharge, when need be, a d.c charging voltage is applied to the battery's terminals with polarity of the charging voltage such as to cause current to flow into the battery in opposition to the normal direction of discharge current i.e. positive terminal of charger to positive of battery and negative of charger to negative of battery being charged.

IV **PHOTOELECTRICITY** is a principle in which some photosensitive materials are bombarded by light to release electrons. Solar cells used in aeronautic engineering work on this principle. some electronic calculators transistors and diodes are solar powered.

V **PIEZO ELECTRICITY** is a method in which some materials are subject to strain or pressure to release electric charge. This is observed in crystalline structures like quartz.

VI **THERMO ELECTRICITY** is a method of generating electricity through heat. When dissimilar metals joined together to form a thermo couple experience same amount of heat. Because of the different rate of heat transfer in the metals, free electrons are transferred from one metal to the other, thus making positive and the other negatively charged

VII **MAGNETO ELECTRICITY** is the movement of a conductor through a magnetic field to produce EMF. Electricity is produced when relative motion exists at right-angles between metals in a magnetic field (FLEMING'S RIGHT-HAND RULE). This is the principle under which large machines generate electrical energy.

2.1.3 DEVELOPMENT OF ELECTRICAL ENERGY

The law of conservation of energy states that energy can neither be created nor destroyed it only changes form. Hence, electrical energy is got from conversion of other forms of energy like mechanical chemical, wind etc.

Generation of electrical energy, through history has been:

a. tapping of energy in water falling at an altitude and or impoundment of rivers to drive hydraulic turbines.

b. Combustion of fossil fuels like coal, oil and natural gas to produce steam to drive steam turbines.

c. Bombardment of radio active materials like uranium to generate heat. Heat extracted from the nuclear fission is used in turning water into super- heated steam which, in turn, drives the steam turbine.

d. Solar, wind, geothermal steam, fuel cells etc. are currently under investigation to confirm their economic and commercial viability. Much additional research and pilot plant development will be required before it will be possible to evaluate their utilization in the overall bulk power supply.

e. Efforts are also being made to develop power from ocean-wave motion, but it is too pre-mature to evaluate at present.

Prior to the advent of electrical power, most powerv was generated by burning wood or coal in a boiler to produce steam to drive reciprocating steam engines which in turn, drove machinery by a system of belts and pulleys. Early electric power generation followed some pattern except that generator was driven to produce electricity.

Later steam turbines replaced the reciprocating engines and the generator has connected directly to the turbine shift to form the most commonly used device to generate electric power - the steam turbine - generator. This along with its boiler, is referred to as a generating unit.

Throughout the history of the electric power industry, the primary energy sources have been combustion of fossil fuels, coal gas and bombardment of radioactive materials to produce steam to drive the turbine.

Impoundment of rivers and tapping of water falls (potential energy sources) is also used to produce electricity in large quantity. This is done by transforming the potential energy using prime mover (turbine) and generator in the conversion process.

Whatever is used to drive the turbine; whether fossil-fuel which produces high-pressure (typically 2400 to 3500 p.s.g) and high temperature (most common 100°F) steam or just water, the essence is to create motion which is one of the essentials in electricity generation.

Hydro turbines run at relatively low speed (usually below 200 revolution per minute) as compared with their steam counterparts (about 3000 revolution per minute). This difference makes steam/gas unit horizontal while hydro unit is constructed vertical.

A unit refers to combination of turbine and its generator coupled together. Once magnetic flux is established within the generator field and relative motion exists between the field poles and stationary windings, induced EMF is tapped by the use of appropriate conductors.

One large machines, the size of 10KVA rating and above, magnetic flux is established by introducing direct current into generator field winding (Electro magnetism). This makes the field poles magnetic only when the D/C is introduced. This magnetism ceases to exist the moment D/C is disconnected.

For high power generation, steam-turbine drives are characterized with cylindrical rotor machines while the salient-pole construction is one of the characteristics of hydraulic turbine or large diesel-engine drive.

2.1.4 EVOLUTION OF POWER SYSTEMS

Electricity supply requires an electric power generator suitably connected via switchgear, other gadgets and cables to a demand point.

When one or more generators are interconnected to one another via transmission lines to supply fixed and variable demands located at several places (usually geographically wide spread), then an electric power systems has been established.

Isolated power systems built to meet initial demand requirement from stand along generators sets usually had surplus power capability at commencement. Growth in demand, with time, results in increasing variation in magnitude of power demanded at certain times of the day.

Peak demand usually occurs at a fixed period of the day which might not be coincident in all isolated power schemes. Inter-connection of such isolated power schemes via transmission lines enables utilization of surplus capacities of non-coincident peak time plant of this interconnection during its own peak items and vice versa.

Since it is cheaper to build power stations at fuel source and transport the power to a demand points or load centers. The voltage level at which power is generated, transmitted and distributed is not the same. there is need to evolve a standard grid net-work of power supply scheme operating with common factors.

ELECTRICAL POWER SYSTEM LEVELS

In all power systems, it is constumary to divide the entire system into various levels, the operating voltage of each determined by the complexity of the system in question. Typical level classification is as follows:

(a) Generator pool level
(b) Transmission level
(c) Sub-Transmission level
(d) Distribution level.

(a) Generator level usually ends at the generator busbars or the power stations or the primary terminal of the generator transformers. Typical generator level voltages include 6.6KV (example), 11KV (example) and 16KV at (Shiroro). The voltage level is usually determined by the

MVA voltage (Power) of the generators pooled at a particular point.

(b) Transmission level is the primary transport level for the generated power from the generator to distribution injection points. In the case of large power systems a sub-transmission level exists, at a lower voltage, interposing between the transmission and distribution level. Transmission level voltages are determined by the magnitude and geographical spread of the power system.

The Nigerian (NEPA) operated national transmission grid is operated at 330kv with a sub-transmission level of 132KV.

(c) Distribution level supplied the actual demand points. they are separated transmission levels by step-down transformers operating at voltage ranges from 33kv to 415v to users voltages.

2.2 TYPES OF GENERATING STATIONS

Electricity generation in United States was started by Edison in 1882. Within the period Great Britain also had its first D.C. Power station. The advent of electric transformers - a device used in stepping up or stepping down A.C voltage - shifted the world's attention to generation of A.C. Power, its advantages over D.C. has been exhausively used.

In Nigeria, before 1950, Native Authorities at different locations in the country operated electricity organizations. It was in 1950 that these organizations were co-ordinated to form E.C.N (Electricity Corporation of Nigeria).

However, Niger Dams Authority (N.D.A) was set up in 1962 to handle power generation along River Niger course. On 29th June, 1972 both E.C.N and N.D.A were merged to form the National Electric Power Authority (NEPA), the only organization vested with constitutional power of generating, transmitting and distributing electricity throughout Nigeria.

NEPA has two major types of Generating Stations namely:

I Thermal stations; and

II Non-Thermal stations.

Generally thermal stations are power stations in which electricity is generated by the use of heat energy. This heat energy is got from heat, coal, Natural gas, steam or nuclear bombardment. Examples of thermal stations where gas is being used to produce heat energy are Egbin Thermal Station, Ikorodu Lagos and Afam Power Station, near Port Harcourt, Rivers State.

At Egbin Thermal station, the fuel used in gas or oil which is pumped through pipelines from oil refinery in Delta state to the power station.

The fuel undergoes combustion. the heat generated thereof is transferred to water in a boiler which is heated to steam. The super-heated steam which has temperature of over 500°C and pressure of 14 MPa drives the steam turbine. This turbine has been mechanically coupled to drive the rotor of a generator. The generated voltage is tapped at the generator terminals for onward transmission and distribution.

Gas Power plant operate on principle of igniting a mixture of atmospheric air and fuel in its combustion chamber. The fuel used could be oil, Natural gas or Kerosene. the hot gas develops a high pressure in the compressor before being directed full blast on the turbine blades. the turbine has been coupled to a generator rotor.

Hydro stations are non-thermal stations that harness water power to generate electricity. Though water, fuel for the station, is obtained free, high cost and cumbersome civil engineering works associated with its construction usually discourage the intender.

Electricity is generated by making water fall on the blades of the turbine which is already connected to the rotor of a generator.

Usually there is a height difference between the reservoir level and the turbine location. This vertical height difference is called the Head. There are three different types of head namely:

(1) High head (184-1500m)

(2) Medium head (40-350m)

(3) Low head (5-20m).

The type of hydraulic turbine obtainable in a station is dependent on the type of head (as will be explained later).

2.3 HYDRO ELECTRICAL POWER PLANT

The natural course of river is to lower elevation and this has provided a source of power by means of water wheels from early times. Impoundment by means of dams has provided a regulated - and in most cases more consistent - source and a higher water head to improve operation of the wheel. The natural difference in elevations at Niagara Falls was used for the motive power for the first alternating current central station in Canada.

Hydropower developments or plants can be classified as low-, medium-, or high-head. The difference in elevation between the water level in the upper reservoir and the level of water in the tailrace or tailwater is called gross operating head of the plant.

The size, location and type of power plant depend on the topography geological conditions and the amount of water and head available.

Features normally seen in hydropower stations are:

(a) Head works (including Intake gates, Gatehouse, Cranes, trashracks etc)

(b) Dam(s)

(c) Penstocks and Scrollcases

(d) Spillway

(e) Powerhouse

(f) Switchyard

DAM

A dam is an embankment to restrain or regulate flow of water. It is built to provide a head and reservoir of water for the turbines. Whether concrete, earthfill or timber-crib construction it must be designed to satisfy the requirements of stability against water pressure, up-lift at the base, maximum flood flow and other conditions required of it.

There is a great variety of dams and each is custom built to satisfy the peculiar topographical features of a particular site.

Dams are labelled according to their required function. The `Main' dam creates the head and water reservoir for the powerhouse. The `Storage' dam is used to hold excess water during periods of heavy run off. The stored water is then available for release during dry periods and in this way the main stream flow is kept constant year round, giving a more constant generating capacity.

Dams must be provided with means of controlling the discharge of water from the lake into the powerhouse for operational use. the purpose of intake gate is to control flow of water into the penstock.

Spillway gates are means of discharging water not needed for generation either to maintain downstream water level or regulate lake level.

Trashracks are screens placed at the headwork to intercept material, carried by water, which may not be readily passed through the turbines.

Penstocks are conduits that carry water from the headwork to the turbine. They are cylindrical steel pipes which are about m in diameter and m of length in Shiroro Power Station. There is usually one penstock for each turbine. There are four penstocks to four the machines in the station.

Gantry cranes are high travelling hoists mounted on rails and straddled in the Gatehouse. They are used mostly during maintenance period for repairs, placing and removing trashracks, stoplogs, gates and other hoist machinery.

Spillway is the part of the headwork through which the lake water not needed for generation is discharged.

A slice gate is one of the gates in the spillway used in controlling water discharged from reservoir (lake).

Powerhouse, as the name implies, is the generation point of the station. This is where the `cooking' takes place. The turbine, the generator and auxiliaries needed for use in generating electricity are all located in the powerhouse.

Switchyard is the `counter' where the `cooked food' is placed in readiness for serving. This is the pool where generated power is synchronized with other stations and transmitted out. In the switchyard are transformers, power circuit breaker, isolators and other switchyard. These are connected together for safe transmission of the generated power.

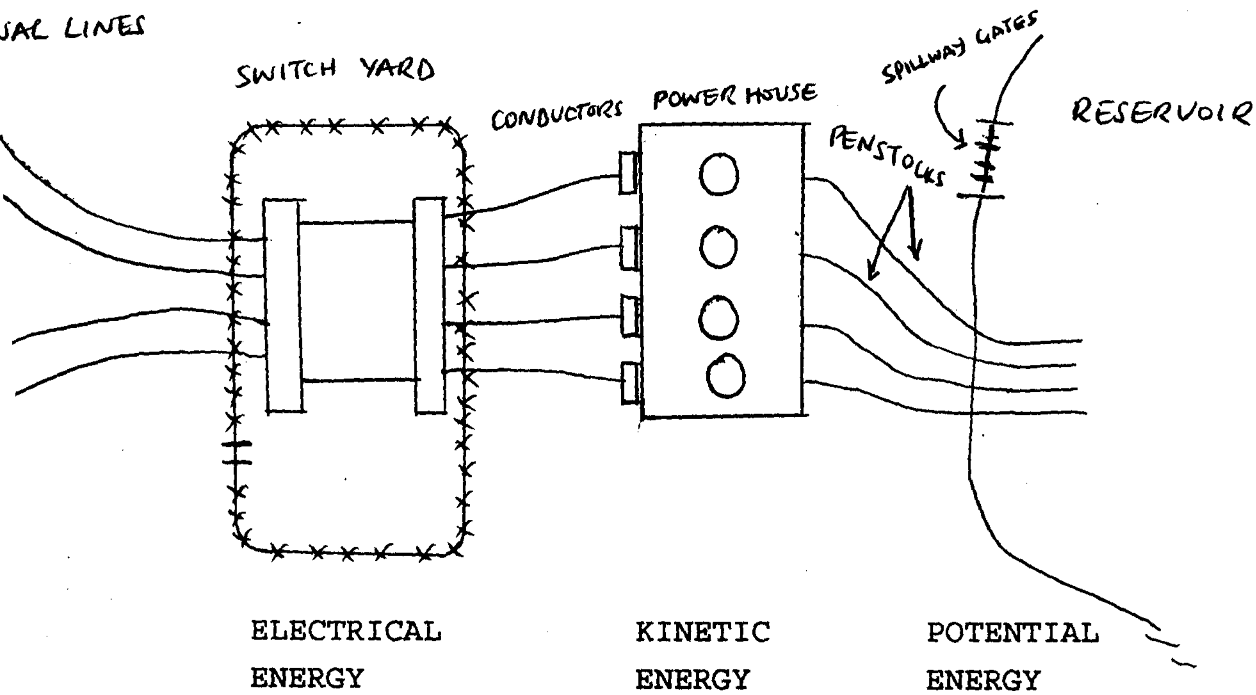


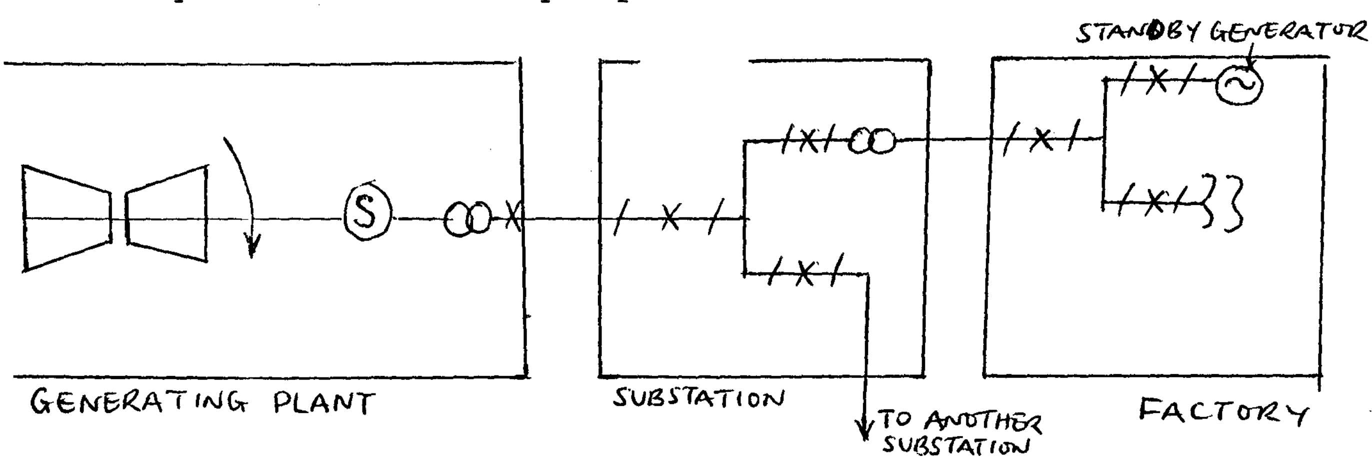
Figure 2.3.1 SITE PLAN; SHIOROR POWER STATION.

2.4 OPERATION OF ELECTRICAL PLANT

Electrical plant is set up to make power available to each users (consumers) at all times. To achieve this aim and also ensure safety of personnel and plant during the process, certain standards of operation and levels of perfection must be strictly adhered to.

Some sensitive consumers like the cement factories, steel rolling mills and other manufacturing houses must have uninterrupted power supply in their production process. Failure of this could have serious and irreparable damage on their product. For this reason, means of ensuring reasonable level of security limiting or eliminating chance of interruption of electricity - must be provided. Although the possibility of a power interruption can not be entirely ruled out, power system design and standard operating techniques can reduce chance of interruption to the minimum. These electrical plants are subjected to human management control and operation techniques by personnel employed and properly trained to serve as the Electrical Operators.

Electrical Operators are the first line staff in any power industry (e.g. NEPA) involved directly in the operation of the various machineries employed in the generation, transmission and distribution of electricity to consumers. They are therefore very important to the establishment.



<u>Figure 2.4.1</u> TYPICAL POWER SYSTEM NETWORK. OR PLANT

The fig above shows a representation of typical power system in which energy flows from the generating station through transmission line to various loads. At every stain along the line, starting from the stations, electrical operators are located. This men have direct control over the way generating units, electrical switches and equipment are operated. From the production point of view, they can make or break the power system.

Regards to the basic minimum qualification (School Certificate or equivalent) and training, the electrical operator is aware and maintains acceptable standard of operation in performing his duties and responsibilities.

Main Duties and Responsibilities of the Electrical Operator are summarily itemized below:

(a) Monitoring the System by

(i) Observing and recording meter readings at intervals taking necessary actions based on these.

(ii) Receiving and recording audible and visual alarms observed or reported by subordinates and others delegated to perform some duties.

(iii) Identifying deviations from, or changes in, established performance requirements and adjusting these quantities to as necessary to maintain service

(iv) Carrying out routine inspections on system and auxiliary equipment as required by standing instructions.

(v) Carrying out potential problem analysis of power and auxiliary systems.

(b) Supervising of operating activities and subordinates "ON SHIFT STAFF" by:

(i) Organizing and directing operating activities of the shift and plan future activities to aid subsequent shifts.

(ii) Guiding, instructing and assigning duties to subordinates as and when deemed necessary thereby developing the staff.

(iii) Monitoring quantity and quality of work of subordinates and the work method applied.

(iv) Ensuring that operating practices and safety standards are adhered to.

(v) Providing on-the-job training and development of subordinate thereby motivating through attitude and personalexample.

(c) Processing and co-ordinating request for approval to undertake work on system or auxiliary equipment by:

(i) Providing information and cooperating with work groups and other operating authorities in prelim stage of planning work on equipment.

(ii) Making detailed assessment of the effect of proposed work on system performance judging whether best overall system performance will be achieved within imposed system limitations.

(iii) Receiving and recording written or oral requests.

(d) Carrying out planned switching operations by:

(i) preparing switching orders and carrying them out sequentially after contacting proper authorities and obtaining final approval to proceed.

(ii) Updating operating diagrams to show changes and reporting such to proper authority or officers who need to know.

(iii) Identifying planned switching operations and developing a switching procedure for operators to be undertaken.

(e) Reacting to system disturbance and direct restoration operations

The Operator

(i) detects abnormality in power or service system from alarms (audio and oral) meter reading, verbal reports etc.

(ii) identifies and records status of system based the information available (indicating time of occurrence).

(iii) Accesses and analyses status of equipment in his station or system based on above information, then takes action to secure parts of the system in service or attempt to restore.

(iv) Reports station status to higher operating authority and other pertinent stations

(v) Collects additional information available identifying source of trouble thereby making efforts to restore the system as quickly as possible.

(vi) logs all pertinent information and report details as necessary to higher operating authorities and costumers (if need be).

(f) Preparing Operating Records and Reports

The following routine records are required:

(i) Station log of activities during his shift and other shifts.

(ii) Interruption reports

(iii) Daily KS/H reports

(iv) Energy flow reading sheets

(v) Equipment Data Records

(vi) Station Reading sheets

(vii) Requests for outages

(viii) Hydraulic and/or Gas/oil turbine reports

(ix) Month end reports.

From the above, we can see how sensitive Electrical Operator is to the system. His academic background, quality of training and whether or not he remains calm and composed to carry out these duties and responsibilities could make the system accident-free or otherwise.

CHAPTER THREE

3.0 SYSTEM ANALYSIS AND DESIGN

3.1 ANALYSIS ON POWER PLANT DESIGN (SHIRORO AS CASE STUDY)

As already enumerated in 1.3, main conditions that come into service before a unit is successfully starting are not located, at approximate position. The powerhouse is about 100m distance from the intake-as the crow files, but to get access to intake from powerhouse, one has to either climb over 500 steps take 5km access road. The switchyard, though in between intake and powerhouse using access road is not less cumbersome. For a generator or unit to come into service, operation must be carried out, either locally or remotely, in these locations. Hence the need for inter-connection arises to achieve smooth efficient and time-saving operation. Due to cable links, remote operation assists in achieving close to this objective. But smooth and time saving operation is not attained.

Topography and geological condition of this area makes the key locations of operation not on the same elevation. This seeming disadvantage qualifies it for a medium head plant (which needs lesser quantity of water-though higher pressure - to generate electricity). Lesser quantity of water is used, as compared with low load plants, to generate the same unit of energy.

Figure 2.3.1 which shows energy conversion and flow diagram does not actually give the true geographical picture using access road.

In achieving this objective of improving automation in power plant starting and running, proper coordination of various locations and auxiliaries has to be made to ensure that they come into service as at when due.

It is noteworthy that for a unit to get started and maintain service, almost all its major components must function at one time or the other.

These components apart from not being located under the same roof, are not on the same elevation. Improper coordination causes waste of time if operation is successful.

The first step to take when starting a machine is to reset the relays and check pre-start conditions. These conditions must be ascertained NORMAL before going to the next step. Proper coordination is achieved if good communication means exists and remote operation functions.

The next step is to start the auxiliaries associated with the machine and ensure they come into service as at when due. Failure of any of these auxiliaries could cause trouble for the generator successful start and operation.

From experience, a lot of explosive noise is made when opening the breaker and closing the isolator so that operating means are best located in control room which is a strategic position from the switchyard. Remote operation, with indicating lamp as guide, show whether its operation is successful or not.

3.2 CHANGE-OVER PROCEDURE

Change-over procedure is the process of changing from the old system to the newly developed system.

There are four (4) methods of changing from old to new system:

a. PILOT METHOD

This method involves some parts of the systems being installed initially. Based on mutual agreement, the rest part of the system can be arranged to the installed later.

b. DIRECT METHOD

In this method, the existing system is dismantled completely to be replaced by the new one.

c. <u>PARALLEL METHOD</u>

This is a situation where the old system and the new one are run concurrently using the same input data. The output from the old system continues to be operational until it is discontinued with and fully replaced with new system.

d. <u>PHASED CONVERSION METHOD</u>

This is a method of integrating components of the old system into the new system. By so doing, the old system is gradually phased out.

From the foregoing and methodology in chapter 1, one will suggest parallel and phased conversion methods to be used. The reason being that, for such a gigantic project with so many auxiliaries - which are complete systems on their own- attached to it. Phased conversion method is used on these components while parallel method is used on a complete unit (generator).

Using this process will, apart from making the station operative during change-over, new system will be gradually mastered.

It is worthy to indicate that, in as much as unnecessary cost should be avoided, cost reduction should not take priority.

3.3 ALGORITHM (FLOW CHART)

Steps taken to successfully start a unit are listed below:

1. CHECK PRE-START CONDITIONS - NORMAL
   - Reset all the relays
   - Open associated circuit breaker before closing generator isolator
   - Ensure field circuit breaker closed
   - Ensure Excitation is off
   - Ensure Gate Limit/Gate position indications at `O'
   - Ensure unit vented.

Note that the generator isolator is interlocked with associated breaker in such a way that the isolator is closed only when the breaker is first opened during generator starting.

2. **START GENERATOR AUXILIARIES**

- Release Generator brakes
- Release serw locks
- Open cooling water line
- Start generator thrust bearing pump
- Open Gate Limit to 20%

3. **START GENERATOR**

Note;

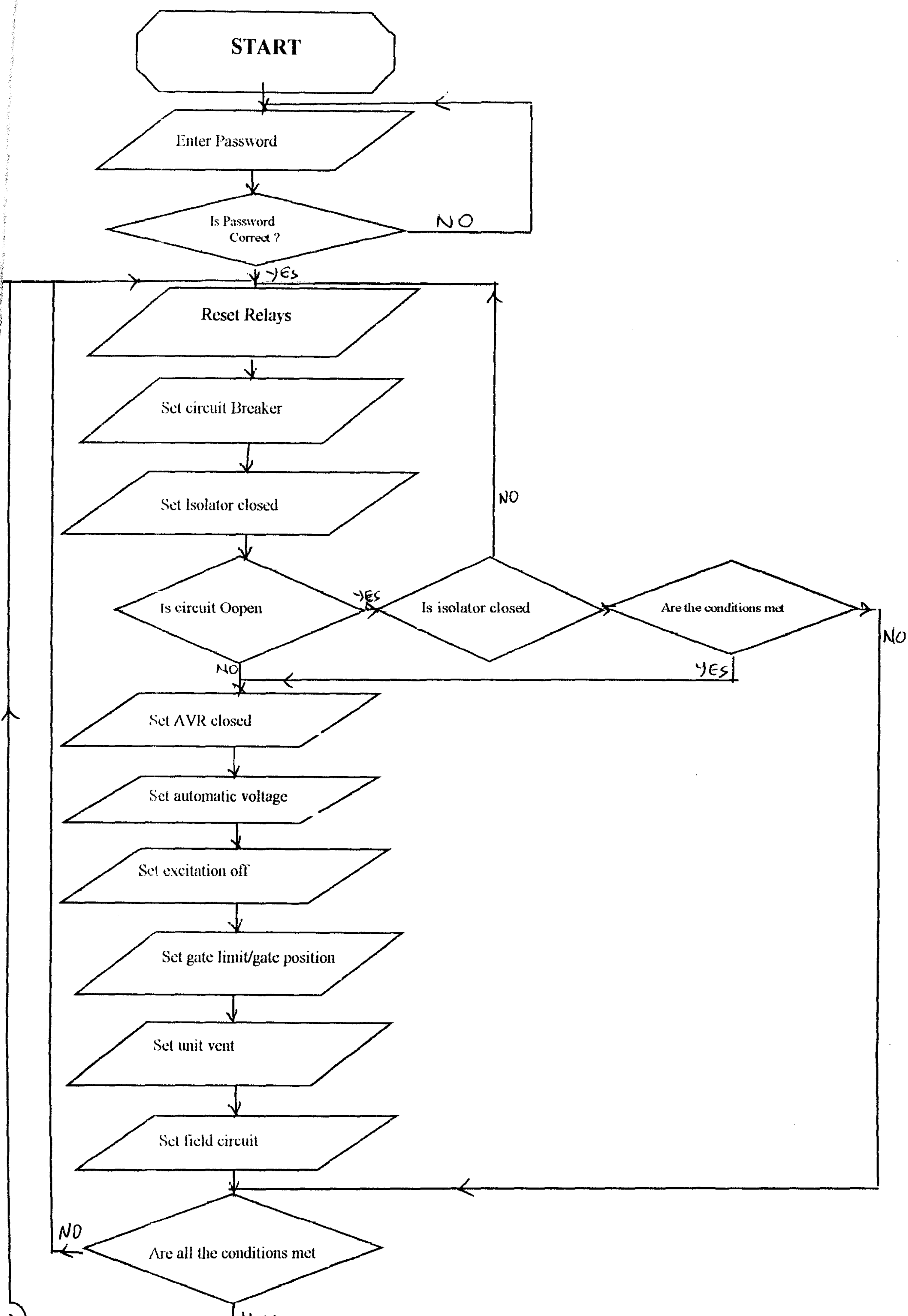
- Observe the generator start and accelerates towards synchronous speed
- At 50% speed, stop thrust bearing oil pump
- At 75% speed, apply field flashing
- At 95% to 100% speed (synchronous speed) the generator builds up its terminal voltage, 16KV.

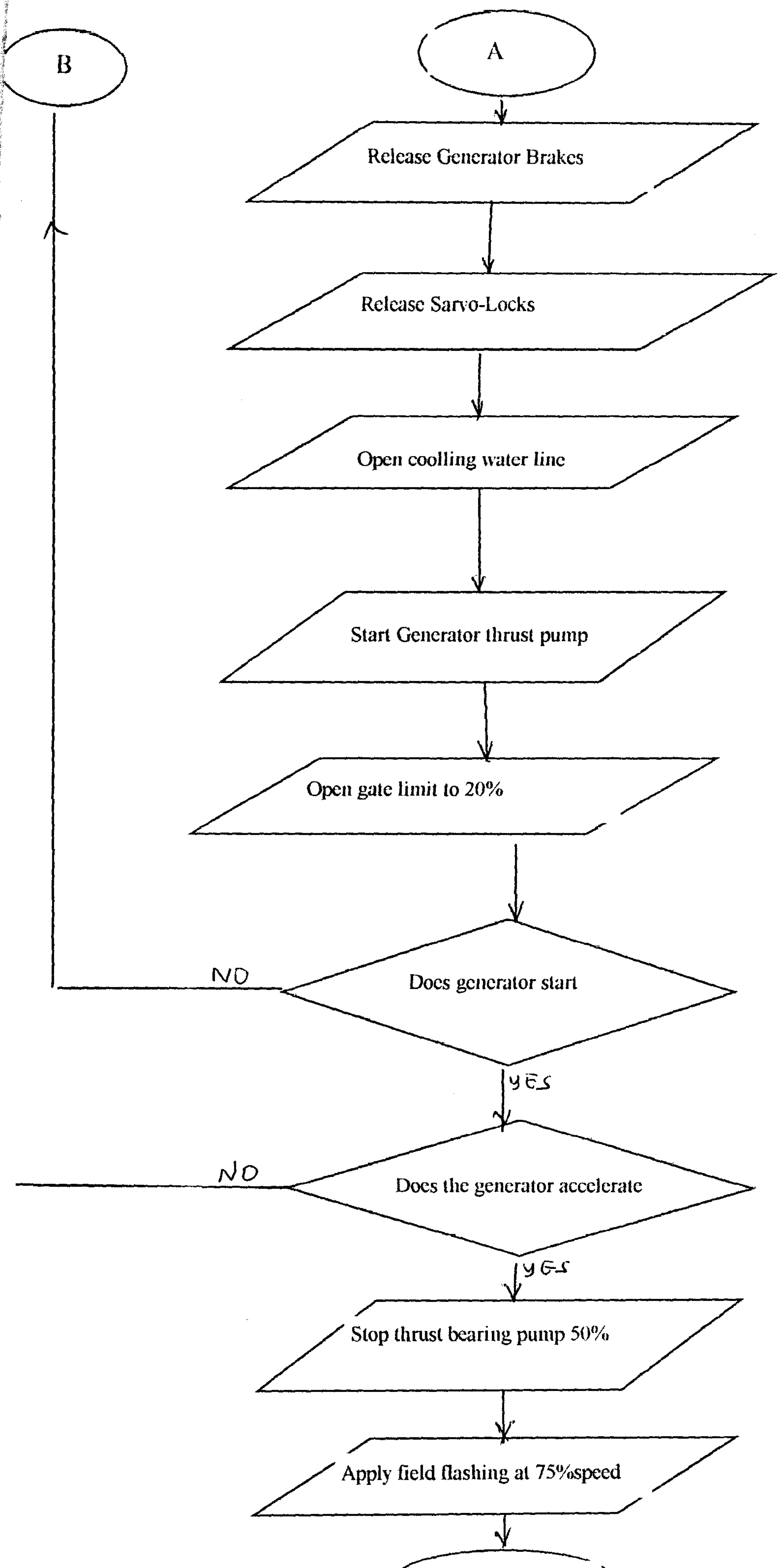
As can be observed in the objective of study (1.3) and above, a lot of problem is usually being encountered during local/manual starting of some auxiliaries. These are problems associated with noise, time and sequence of operation, and operational error.

To successfully start this machine, operational man power must be sufficient to the four major locations on the site i.e. The headwork, switchyard, control room and the unit control Board. During test operation of some auxiliaries towards starting, reliable means of communication must also be ascertained.

Because this auxiliaries are not located at a point, and without proper coordination, clumsiness might set in and hence hamper the generator successful start.

GENERATOR STARTING SEQUENCE




B
A
Release Generator Brakes
Release Sarvo-Locks
Open coolling water line
Start Generator thrust pump
Open gate limit to 20%
NO
Does generator start
YES
NO
Does the generator accelerate
YES
Stop thrust bearing pump 50%
Apply field flashing at 75%speed

CHAPTER FOUR

PROGRAMMING CONCEPT (EXPERIMENTATION AND TESTING)

4.1 PROGRAM DEVELOPMENT

4.1.1 INTRODUCTION

Programming is the act of writing or designing a program towards solving a specific problem.

A program can be defined as a set of instructions describing logical steps the computer will follow towards solving a particular problem.

Program writing involves program definition i.e. knowing the nature and complexity of the problem. A commercial data processing may involve sorting, editing and many sub-tasks that must be well defined and formulated using mathematical statements and operators. Mathematical problems are usually easier to define since formulae are used and are well defined.

The second stage in program writing is analyzing the various procedures and routines defined so as to find solution. These procedures could come in form of pseudo codes, flow chart, algorithms.

Another stage in programming is the development of the program. Without proper analysis development and execution, desired output might not be obtained when tested.

In order to ensure that the system functions effectively its efficiency, maintainability, flexibility and security are also considered and ensured.

4.1.2 CHOICE OF LANGUAGE

Computers and software have been in used for quite some time. Apart from reducing time waste and inefficiency, it almost eliminates boredom. Computer has been able to achieve this feat because its software development is greatly improving with time. Computer is gaining ground because it has become more powerful and at the same become compact and more accessible to nearly everyone.

Software development, of late, has been very explosive with the bestsellers trying to outdo each other. Amongst the leading software houses like WORDSTAR, MICROSOFT, BORLAND, COMPUTER ASSOCIATES etc. MICROSOFT is said to be leading.

The choice of language for the development of this package is C program. It is a general purpose programming language which was developed in other to produce the Unix Operating System. C, unlike most other languages is a free format language and therefore has no restrictions on the layout of the source code. This language was designed and implemented by B.M. Stroustrip in 1986 at Bell Laboratory.

4.1.3 FEATURES OF C LANGUAGE

As mentioned earlier, C program is a general purpose language with free format and has no restrictions on the layout of the source code.

C language has a wide range of capability and uniqueness due to the following reasons;

- Compared with other high level languages, it is a relatively low level language which deals with some sort of objects that computers do, like characters and addresses.
- Because it is independent of a particular design, its easy-to-write portable program provide some degree of flexibility.
- A typical C program tends to have less syntax errors and more run-time errors than a corresponding high level language.
- The problem under discussion, being a procedure oriented one needs a structured programming language to solve. A structured language encouraged modular programming which allows easy tracking of errors.

4.2 DOCUMENTATION AND IMPLEMENTATION

4.2.1 IMPLEMENTATION

System designs, feasibility computations and accepted resource proposals remain on paper, but a new improved system comes alive only through series of implementation steps.

Implementation can be defines as the necessary steps to place the proposed system into operation. This could be done in one outlet first. On satisfactory result, it is then implemented at other locations. Gradually the existing system is phased out as the new one replaces it.

At the end of the implementation phase, a new improved system achieves full operational status.

In order to ensure that the system functions effectively, the following are considered - efficiency, maintainability, flexibility, and security. There must be proper control so as to ensure that data are entered correctly and validated.

In the security area, the operator is expected to enter the correct password so as to enable access to the environment.

Proper implementation of this system provides automatic control of machine during generation and also monitoring of its auxiliaries. This allows higher power system reliability as reduction in number, extent and duration of service interruption is achieved it is not eliminated.

Due to time saved during starting, fuel consumption per generation is reduced thereby lowering capital cost per generation.

Since the system monitors the machine and its auxiliaries when in service overall system security is achieved.

4.2.2 DOCUMENTATION SYSTEM

Documentation consists of narrative descriptions, flow charts, lists, documents and other explicit means of defining the objectives and features of an information system as well as the manner in which it should perform. Standardized documentation aids control framework since it serves as a reliable source of information for people who must operate, improve and evaluate information system. Thus, it helps new employees to learn how to operate the information system. It also enables system analysts and programmers to establish a sound starting point when undertaking the design of a new system, and it provides reference materials for auditors during their examinations of the transaction systems.

System documentation describes the purpose of a processing system which may include computer system flowcharts, input description, output descriptions, file descriptions, error messages and list of controls.

4.2.3 DOCUMENTATION DESCRIPTION

This application program comes in a floppy diskette and its needs to be loaded into the computer memory before any operation can be carried out. The safety of data accuracy in this project is very important. Computerized starting of Shiroro Plant is a menu driven package.

The security of the program is not overlooked so the following procedure should be followed:

The menu driven package has an opening menu with (2) options.

The main menu is executed by using the following commands and password:

(i) At the Dos Prompt, i.e. C:\ type CSHPLANT and press <ENTER> key

(ii) This command displays the main menu

The password GOASH is typed with <ENTER> key pressed

(iii) You are then prompt to enter the desired option.

The first options allow entry of new parameters while the second allow retrieval of existing data from a file.

1. Enter (N) for new Parameters
2. Enter (R) to retrieve existing data

The first option chosen enables one to enter the new parameters. If it is for retrieval of information you can now take the second option.

4.3 RESOURCES TO BE USED

4.3.1 HARDWARE REQUIREMENT

With the advent of microcomputers, many small business firms have discovered they can afford to purchase and have one.

However, selecting a particular computer is not an easy task. Hundreds of models of micro computers are available.

The first step in deciding which micro-computer is appropriate is to analyse exactly what it is needed for. Is the computer to be used primarily for transactions, processing, planning or combination of the above?

Furthermore, hardware component should include a visual display terminal and printer.

Depending on its use, there might be need for a central processor with a high megabyte (about 800 megabyte) of magnetic disk storage.

4.3.2 SOFTWARE REQUIREMENT

Software requirements for this project include the DOS (DISK OPERATING SYSTEM) which has unrestricted access on the layout of the source code.

Features of the software has been enumerated in 4.1.2 and 4.1.3.

CHAPTER FIVE

MAJOR ACHIEVEMENTS OF THIS PROJECT

5.1 POST PROGRAM IMPLEMENTATION REVIEW

For a successful project, one is bound to face one problem or the other. During collation of information from various departments in Shiroro NEPA and Cross-checking of facts in other NEPA stations, poor communication system hampered information flow. Long distance between Egbin Thermal station in Lagos and Shiroro Dam did not help matter.

Unavailability of computer system within close reach also prevented easy access to information feed.

Need to contact other stations arise because Shiroro is just one of the stations in NEPA Network hence it should not be treated in isolation if we want to achieve successful Energy Management System.

5.2 CONCLUSION

Computers and their applications are ubiquitous in electrical industries. One can say they compliment each other because computers need electricity to function. Likewise computers and their applications have become very essential in decision making process in energy management system.

The introduction of computer application to power plant starting and running has contributed tremendously to the system improvement.

The concept used in this study is not restricted to Shiroro or hydro power station alone. With modifications here and there, the package can be extended to other station to form a network system toward Energy Management System.

This will, in the long run, improve system response to power demand thereby adequately and timely balancing power/load flow. System collapse will be at last reduced if not completely eliminated.

Computerised starting is abound to generate most power over the same period of time. This in turn reduces cost of generation thereby lowering price of energy to consumers.

The cost of fuel used per energy generated is also reduced. Money saved in this wise can be channeled towards improving quality of service to consumers. Other prospective generated stations can be started with the view of coping with the present and future energy challenges.

5.3 RECOMMENDATIONS

For effective and efficient functioning of this system, we hereby make the following recommendations:

(1) We recommend that the security of this system be reserved exclusively to the electrical Operator, who is in charge.

(2) Adequate measures be taken regarding hardware and software by making it accessible to only trained personnel, to ensure proper control and functioning of the system.

(3) Also, the auxiliaries be regularly maintained to avoid unexpected fault which may affect the final output.

REFERENCES

BOOKS

1) ADEDIRAN, A.Y.& KUKOYI, O.O. (1995), FUNDAMENTALS OF ELECTRIC CIRCUITS, KUNLE PRESS,LAGOS (NIGERIA).
2) BISHOP, O.N. (1983),BASIC ELECTRONICS, MACMILLAN PRESS ,LAGOS (NIGERIA).
3) NELKON, M.& PARKER, P. (1983) ADVANCED LEVEL PHYSICS, HEINEMAN PRESS, (BRITAIN).
4) ROGER, H.& JOHN, S. (1988) COMPUTERS AND COMMONSENSE, PRENTICE HALL PRESS,(NEW YORK).
5) RUSHFORTH, J.N. & MORRIS, J.L. (1973) COMPUTERS AND COMPUTING, JOHN WILEY AND SONS PRESS, (BRITAIN)

JOURNALS

1) LAWAL,E.Y. (1995) INTRODUCTION TO THE ROLES OF THE ELECTRICAL PLANT OPERATORS, SERIES I, (NEPA) NIGERIA.
2) OKITIKA, O.O. (1995) SYSTEM OPERATIONS I & II, SERIES IV, (NEPA) NIGERIA.

APPENDIX

```
/*COMPUTERISED SHIRORO PLANT SYSTEM */
#include <stdio.h>
#include <conio.h>
#include<stdlib.h>

Void enter_par (void)
Void decision (chart rr);

main ()
{
Char password {} = "Complaint";

Clrscr();
gotoxy (30,12);
printf("ENTER PASSWORD:");
textcolor (BLACK);
textcolor (BLACK);
Gotoxy (46,12);
Cprint f("% 95", PASSWORD);
if (strimp (Password, "Complaint") = = (Nvil)
Enter part);

else

Gotoxy (30,20);
Cprint f("INVALID PASSWORD: PRESS ANY KEY TO EXIT"),
return;

}

ibid enter-par (void)

}

Char rr, cb, 180    ;
dos(rc);
Gotoxy (3,);
cprintf ("IS THE RELAY SET (Y/N)->");
escanf ("%C", & rr);
If (rr = = `N' & rr = `n')
decision (rr),
else
decision (rr);
return

void decision (char rr)
{
char  atmv,feb,exct,vnvent,gigp,avr,cb,180,rgb,  rsl,  opcl,
sgtbp, ogl, stgen;
```

```
if (rr == `Y' || rr = `y'
 {
Gotoxy (3,4),
cprintf("IS THE CIRCUIT BREAKER OPEN (Y/N) ->");
cscanf ("%C", Scb);
Gotoxy (3.5);
cprintf ("IS THE ISOLATOR CLOSED (Y/N) ->");
cscanf ("%c" Si i80);

Gotoxy (3,6)
Cprintff("SET AVR CLOSED (Y/N) ->");
Gotoxy (3,7),
Cprintf ("SET AUTOMATIC VOLTAGE (Y/N) -> ");
cscant ("%C", Satmv);
Gotoxy (3,8);
cprintf("SET FIELD CIRCUIT BREAKER (Y/N) ->");
cscanf ("%c", sfcb);
Sotocy (3,7);
cprint f("SET EXCITATION (Y/N)->");
csanf ("%C", &fcb);
Gotoxy (3,8);
cprintf("SET GATE LIMIT/GATE POSITION (Y/N) -> ");
scanf ("%c", &glgp);
gotoxy (3,9);
cprintf("SET UNIT VENT")
scanf ("%c", &unvent);
gotoxy (3,10);
cprintf("RELEASE GENERATOR BRAKES (Y/N)->2);
scanf ("%c", & rgb);
Gotoxy (3,11);
cprintf ("RELEASE SARVO-LOCKS (Y/N) ->);
CSEANF ("%C", &RSL);

Gotoxy (3.12)
cprint f("OPEN COOLING LINE (Y/N) ->"),
cscanf ("%c", &iopcl);
gotoxy (3,3),
cprint f("START GENERATOR THRUST BEARING PUMP");
goto (3,14);
cprint "(OPEN GATE LIMIT TO 20% (Y/N) ->");
scanf ("%", &ogl);
goto (3.15);
cprintf("START GENERATOR (Y/N) ->");
cscanf ("%c" &stgen);
textcolor (WHITE + BLINK);
goto (3,17);
cprintf ("THE GENERATOR HAS STARTED"),

return

}
else {
```

```
Gotoxy (3,4),
cprintf("IS THE CIRCUIT BREAKER OPEN (Y/N) ->");
cscanf ("%C", Scb);
Gotoxy (3.5);
cprintf ("IS THE ISOLATOR CLOSED (Y/N) ->");
cscanf ("%c" Si i80);
cprintf("IS THE ISOLATOR CLOSED (Y/N) ->");
SCAN/("%C" &iso);

goto(3,7;
cprint f("THE OPERATION IS NOT SUCCESSFUL");
&e/ch();
cprintf ("DO YOU WANT TO RESET RELAYS (Y/N)->");
cscanf("%c" &ior);
decision (rr);
}
{
```