CORRESPONDENCE TUITION SCHEME

COURSE FOR POWER PLANT OPERATORS

LESSON 2 - DEVELOPMENT OF THE POWER STATION SITE

Contents

List of Figures

1 INTRODUCTION

1.1 Scope of Lesson 2

The previous lesson has described the steps that lead up to the selection of a particular site on Which a power station is to be built. Having reached this stage it now becomes necessary to "Develop the Site", and this means examining all the individual features essential for the generation of electricity and assembling them together to make a complete station. This lesson does not attempt to describe the detailed design of individual plant items which are covered in later lessons it deals only with the "Outline Design" by which title initial work is often described.

1.2 Basis of Development

The basic aim in developing a power station site is to achieve the lowest capital cost, and ease of construction, together with simplicity and efficiency in the operation and maintenance of the. station. In attempting to reach this objective, there are a number of features that have to be considered. These features are listed below although, all being equally important, the order is not intended to denote priority:-

Efficient Operation

(a) Reliability of operation.

(b) Simplicity of operation.

(c) Safety in operation.

(d) Good working conditions.

(e) Ease of maintenance.

Minimum Expenditure

(f) Low capital cost.

(g) Minimum operating cost.

(h) Simplicity in design.

(k) A good integrated design.

(l) A pleasing appearance.

1.3 Types of Stations

Stations can be broadly classified under the following headings

(a) Coal-fired.[1]

(b) Oil-fired.[1]

(c) Nuclear.[1]

(c) Hydro - where the potential energy of a head of water is converted into electrical energy.

[1]Thermal - using heat energy as the source of electrical generation

The first two types are very similar, the main difference being the type of fuel used to generate steam in the boiler. Coal firing requires a more extensive plant for discharging and conveying the fuel to the boilers.

A nuclear station is the same as the first two types in all respects other than the source of heat for steam generation. In this case the steam generator gets its heat from a nuclear reactor.

A hydro-electric station is one that uses a large quantity of water stored at a relatively higher level so that there will be a pressure due to this head, as the difference in levels is called, which can be used to drive the turbine. Unlike the steam turbine with the first three types where the steam is expanded through a large number of wheels on one shaft, the water turbine has a single large diameter wheel driven by the water.

The relative features of these four types are shown schematically in Figure 1. This lesson deals with thermal stations, incorporating coal-fired boilers, which are the main type in use at the present time.

In all thermal stations, when the steam has done its useful work in the turbines it is converted back to water in a condenser and is pumped back to the boiler to be regenerated into steam.

The condensing of the exhaust steam requires large quantities of cooling water, generally referred to as circulating water. As the steam is condensed it gives up its heat to the circulating water which may then be returned to the river or other source if sufficient quantities are available, or passed through cooling towers before returning to the condenser .

The type of circulating water system used in a station depends, therefore, on the amount of water available. The systems most generally used can be described under three headings:-

(e) Direct cooled system.

(f) Closed cooling water system.

(g) Mixed cooling system.

The direct cooled system is used where there is an adequate supply available from a natural source such as the sea or a river estuary. In these cases the water is taken into the condenser at a point sufficiently far away from the point at which it is discharged so that this heated water will not recirculate to the intake. This provides maximum cooling at a minimum capital cost.

The closed cooling water system is used where there is a totally inadequate supply of water available for direct cooling. This system necessitates the use of cooling towers to reduce the temperature of the water for re-use in the condensers.

The mixed cooling system is a compromise between the first two and is used where there is only sufficient water available for partial direct cooling. The water demand in excess of this quantity is passed over cooling towers.

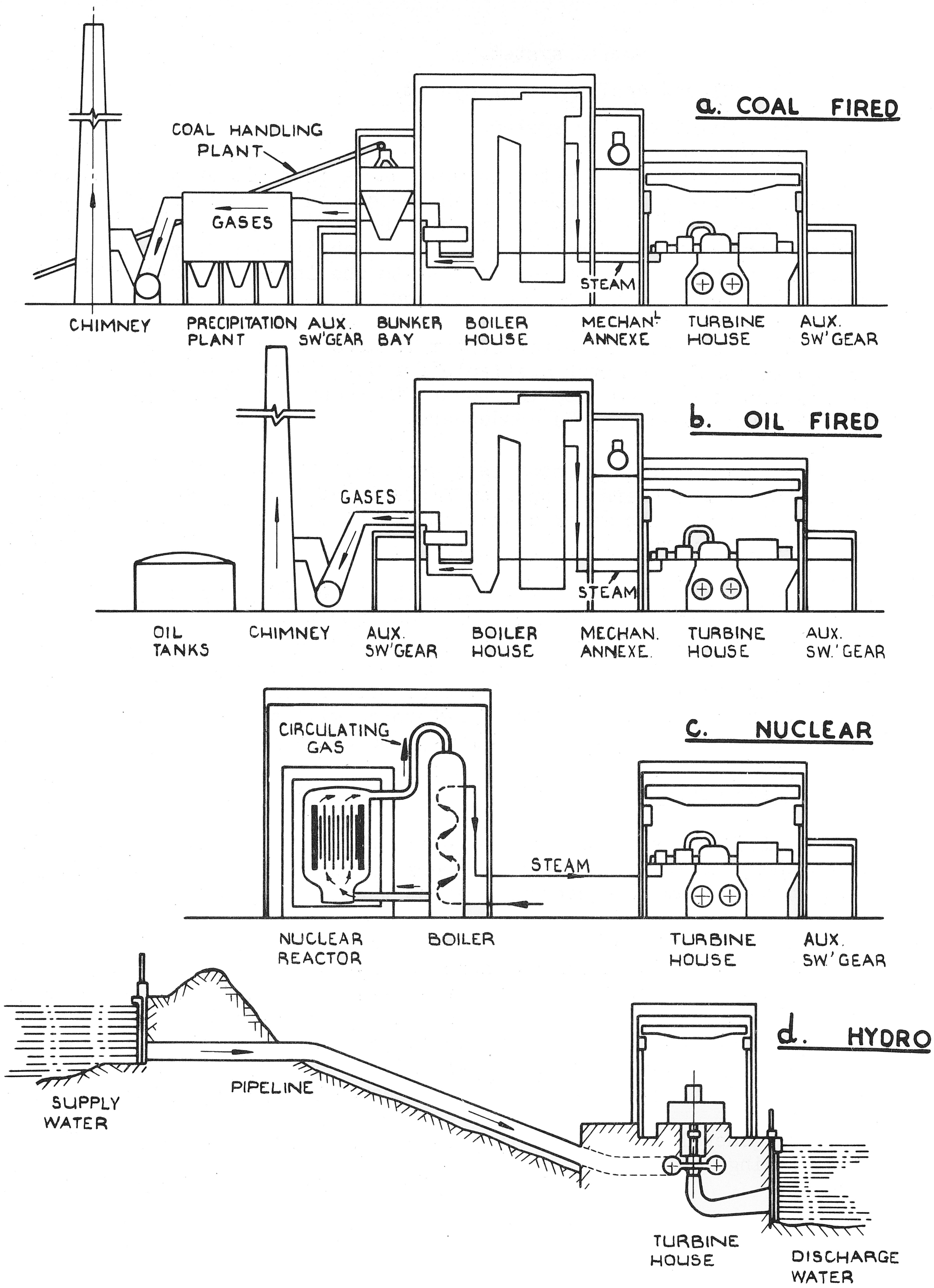

Figure 1: TYPES OF STATIONS

For the purpose of this lesson, the types of power station being considered are those constructed or under construction since 1950. Of these the majority are coal-fired stations and due to their location most rely on a closed cooling tower circulating water system. For these reasons this lesson will deal principally with stations having these two features, though reference will be made where necessary to possible departures from this concept.

1.4 Size of Unit

In 1950 the size of unit in general use was 30 MW. These units, as was the practice at that time, operated on the straight steam cycle in which the steam is expanded straight through the turbine.

Since then there has been a rapid development in the size of unit and in the steam conditions and turbines now operate on the reheat steam cycle. In this cycle, the steam exhausts from the high pressure turbine to the reheat section of the boiler, where the initial temperature of the steam is restored before passing to the IP and LP turbines. The increase in size has reduced capital cost and the higher pressures and temperatures have increased thermal efficiency.

The general development in size of unit since 1950 is shown in the following table:-

Design Year	Size of Unit M.W.s.	Steam Conditions			
		Cycle	Press lb./sq. in.	Temperature °F.	°C.
1950	30	Straight	600	850	454
1950	60	"	900	900	482
1951	100	"	1500	1050	566
1952	100	Reheat	1500	975/950	524/510
1953	120	"	1500	1000/1000	538/538
1955	200	"	2350	1050/1000	566/538
1958	275	"	2350	1050/1050	566/566
1958	550	"	2350	1050/1050	566/566

Table 1:

All units, even the 550 MW unit must be capable of operating under two cycle conditions, that is, shut down each night and re-started in the morning. This is necessary as, although the maximum day load is increasing rapidly, the average night load increases very little by comparison.

2 SITE ASSESSMENT AND LAYOUT

2.1 Site Investigations

The previous lesson has described the necessity of taking trial bores on the site to ensure that the ground is suitable to carry the large loads that will be imposed and to determine the most suitable position for locating the station on the site.

These trials having proved satisfactory, it becomes necessary to establish a preliminary layout of all the main station components, so that the ground can be examined in greater detail at the points where the major loading will occur. These points are under the main building where the heavy boiler and turbine loads are situated, the chimneys and the cooling towers.

This further examination involves taking additional borings in a predetermined pattern under the projected points of loading, so that the ground samples, when brought to the surface, will provide a clear picture of the nature and depth of strata. Such information is necessary before the design of the foundations can be finalised.

It is also necessary while carrying out the borings to take samples of ground water for analysis, to determine whether or not it will have any adverse effect on foundation works and to decide on the type of cement to be used.

It very often happens that the load bearing strata is found to slope, and by moving the station up the slope the depth of foundation necessary to reach this strata is less and therefore foundation costs are much cheaper.

In considering the best way of arranging the station on the site, there are other factors as well as good foundation conditions to be taken into account.

These are:-

(a) Proximity to Circulating Water Supply
This is most important if it is a direct or mixed cooling system where large quantities of water have to be piped from the point of supply to the condensers. This will be understood more clearly from Section 2.5 which deals with the circulating water system.

(b) Suitability of connecting to British Railways Main Line This applies most particularly to coal-fired stations where large quantities of coal have to be brought on to the station sidings.

(c) Providing a suitable route for Outgoing Overhead Lines It is necessary to ensure that there is a suitable route available for the outgoing high voltage overhead lines. It is usual for these to radiate from the station on the turbine house side, so that it is preferable for this side of the station to face the direction of this suitable route. A heavily congested building area, or a large expanse of water adjacent to the site are examples of features that would be unsuitable for an overhead line route.

Having considered the foregoing points it is now possible to prepare a site layout and a typical example of how this might look is shown on Figure 2.

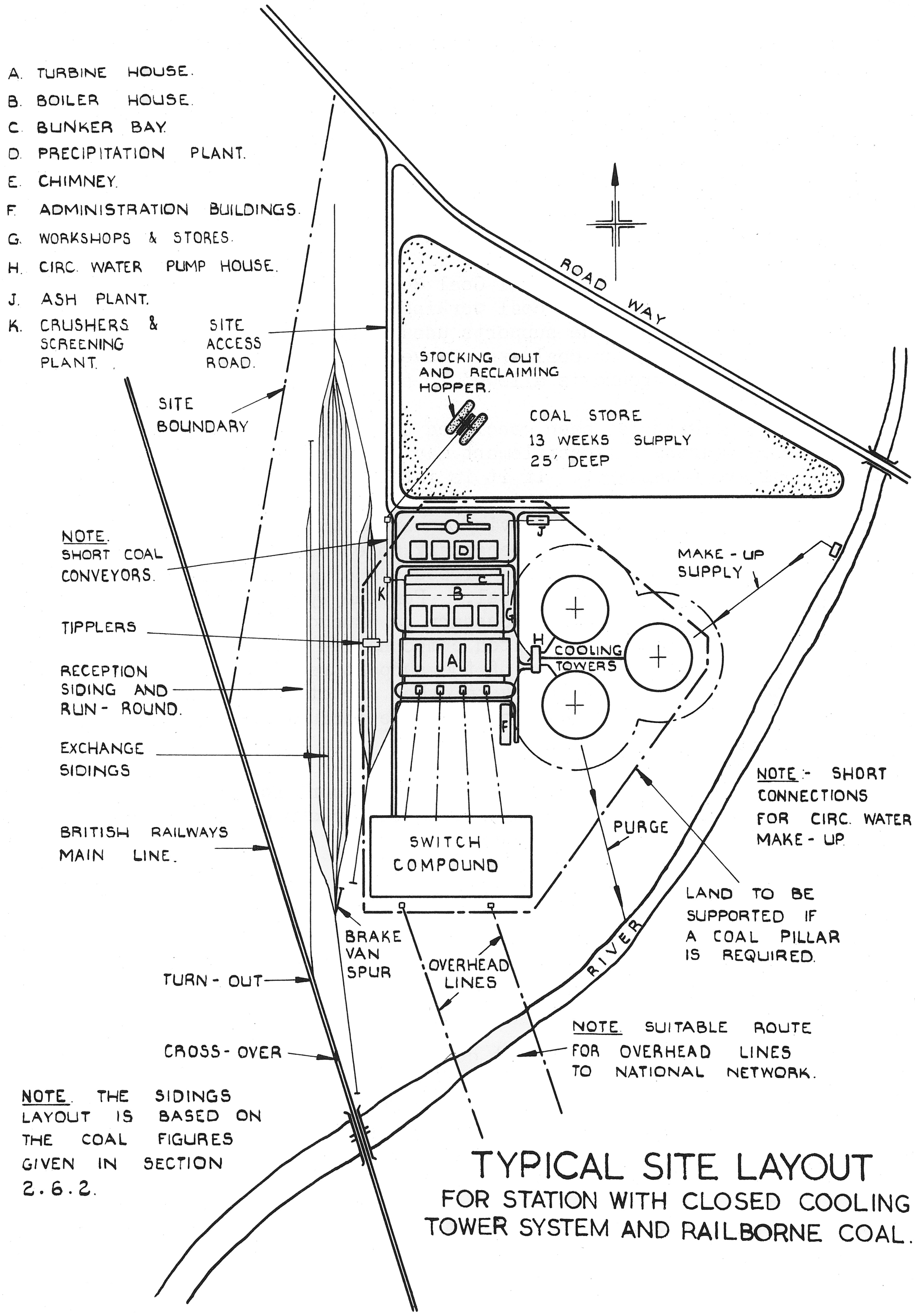

Figure 2: TYPICAL SITE LAYOUT FOR STATION WITH CLOSED COOLING TOWER SYSTEM AND RAILBORNE COAL.

2.2 Site Access

Reference has been made in the previous lesson to the necessity of good site access. Most stations have a rail connection to British Railways main line and this is used extensively in the constructional stages for bringing in building materials and plant. Unfortunately, there are restrictions on the size and weight of load that can be carried by rail and for this reason abnormal loads such as generator stators and the large transformers must be brought by road transport. For these heavy loads, special permission must be obtained and a route agreed with the Ministry of Transport. A suitable access road must be provided across the site to bring the loads into the station area.

2.3 Hanging Support

Another factor to be considered in the assessment of the site is the necessity to provide against ground settlement.

An approach to the National Coal Board will show if there has been, or is likely to be any coal working under the site. The effect of coal working is that the supports used in the headings during the process of extracting the coal are removed when the seam of coal is worked out and the ground is allowed to settle.

If the working has been concluded some time before station construction starts, full settlement may have taken place and no precautions are necessary. If it is intended to extract coal in the future, it becomes necessary to negotiate a "Pillar of Support" with the Coal Board. This means leaving unworked under the station such an area of the coal seam as is necessary to ensure that no settlement takes place on the surface and an agreed sum of money is paid as compensation for this unworked coal. For the typical site layout Fig. 2, it could be assumed necessary to "support" the main building cooling towers, chimneys and switch compound and a line would be drawn as shown to indicate the extent of the support required. If damage due to settlement would be likely to other structures such as coal tipplers or hoppers, then they too would be included in the area to be supported.

It would not be necessary to provide support for the coal store or for the sidings. In the latter case the tracks can readily be packed up if settlement does occur.

2.4 Choice of Layout

From the foregoing investigation of the site, a preliminary site layout has been prepared which satisfactorily meets the basic requirements and is compact, in that length of condenser/cooling tower connections and coal conveyors are reduced to a minimum.

For the purpose of efficient construction it is necessary to have adequate space available for the storage of contractors' materials. For contractors working in the boiler house there is readily accessible space on the coal store, which if required can easily be rail connected. For work in the turbine house and for other contractual requirements there is space available by the switch compound.

The layout can now be considered as established in principle and subject only to minor modifications as detailed design proceeds. It now becomes necessary to establish the level at which the station is to be constructed relative to the existing site level.

2.5 Site and Station Levels

There are two important factors that govern the choice of station level.

(a) The necessity of protecting the station against the risk of flooding.

(b) The cost of pumping circulating water.

For economy and general convenience on the site, it is in most cases desirable to construct the station basement, roads and rail sidings at the existing ground level. This avoids the necessity of extensive excavation and removal of spoil, or the importation of filling material. This being the case, if a site is above the predicted maximum sea or river level the necessity for protection against flooding, factor (a) does not arise, see Figure 3 Sketch 'A'.

If, on the other hand, the site is below flood level there are different ways of affording protection. The surest way is to lift the station basement and all other installations essential to the safety of the station above flood level, as in Figure 3 Sketch 'B'. This method would probably be adopted where the cost of the required filling material is cheap.

Another way would be to locate the station basement at existing ground level and raise the level of the surrounding area to above flood level as in Figure 3 Sketch 'C'.

A third way should be to locate the station basement at existing ground level and rely on flood banks at the outer perimeter of the site The banks may be an existing feature, or specially erected for the purpose. This method as shown in Figure 3 Sketch 'D' would most likely be adopted where the cost of bringing filling material to the site would be very high.

The method used to protect the station against flooding, factor (a) must be considered in conjunction with the pumping of circulating water, factor (b).

Considering now the cost of pumping circulating water, the three systems referred to in Section 1.3 can be classed under two heads, the closed cooling tower system, and the direct or mixed cooling system.

With the closed cooling tower system the circulating water has to be pumped through the condenser and then over the cooling tower. This system is not related to the adjacent sea or river level and in consequence it does not affect the choice of station basement level.

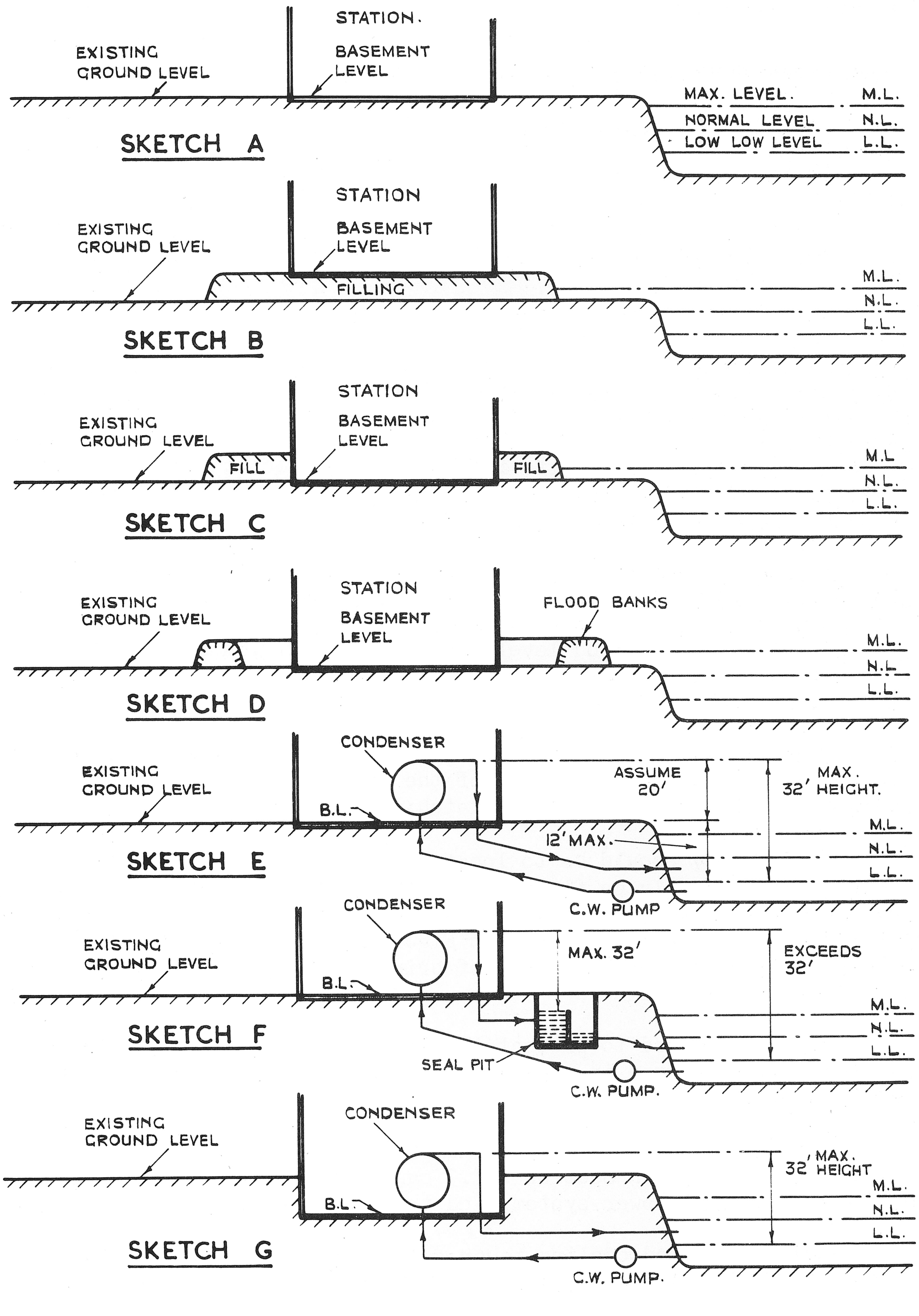

Figure 3: ALTERNATIVE LEVELS OF STATION BASEMENT FOR FLOOD PROTECTION AND TO SUIT PUMPING

With the direct or mixed cooling systems the water has to be pumped from the adjacent sea or river and the height between the station level and the water level is very important. This water level is itself constantly changing particularly where tidal variations are encountered, so that the maximum pumping head is associated with the lowest water level.

To reduce pumping costs to a minimum in direct or mixed cooling systems, the fullest advantage should be taken of syphonic recovery. In this system, water is pumped from the river and returned to the river and consequently no energy is expended in raising the water from one level to a higher level. Provided that no air is allowed to enter, the system may rise to about 30 feet above the river water level without requiring any increase in pumping power. This is because the water descending by gravity from the higher level of the condenser to the lower level of the river, provides the energy required to lift a corresponding quantity of water to replace it. Therefore, the only pumping power required is that to overcome friction in the pipes, condensers and coolers. See Figure 3, Sketch 'E'.

If the height from the top of the condenser to the basement level is 20 feet, in order to take advantage of syphonic recovery, the basement level cannot be more than a maximum of 12 feet above the lowest known water level in the river.

There are sites, however, where, with the station basement at site level, the top of the condenser would be considerably more than 32 feet above the lowest level from which the water has to be pumped. If this is the case one of two alternative arrangements is usually adopted. Either a seal pit is introduced into the discharge from the condenser, see Figure 3, Sketch 'F', or the condenser is lowered relative to the site level to reduce the height, Figure 3 Sketch 'G'. Where it becomes necessary to adopt one of these two methods, the choice is usually made by examining the advantages and costs of both schemes. It may be that if the station is founded on rock the cost of excavation to lower the condenser and basement level would be very high in which case a seal pit would be adopted. On the other hand if the ground on site is sloping it may be more convenient to have the turbine basement lower than the boiler basement, and advantage could be taken of this slope to locate the condenser at a lower level.

3 FOUNDATIONS

3.1 Nature of Subsoil

Reference was made in the preceding section 2.1 to putting down trial bores in order to ascertain the suitability of the site for loading.

It very often happens that these bores reveal similar subsoil conditions over the whole of the site and the location of the station is influenced only by layout requirements. There are, however, other instances where subsoil conditions vary quite considerably and when this happens, providing a good layout will result the station position would be chosen where the foundation costs were the lowest.

It is also necessary to establish whether or not there are any geological 'faults' that would interfere with the location of the station. A 'fault' is the result of some long previous disturbance of the earth's crust where there has been a vertical sliding movement and along the line of this the underlying strata at each side of the fault line will be found at two different levels. Where such a condition exists the station should be constructed clear of the fault line and not across it, as this could give rise to a subsequent differential settlement in the foundations.

3.2 Choice of Foundations

There are two types of foundation in common use for construction, the choice depending on ground conditions. They are:-

(a) Piled Foundation.

(b) Raft Foundation.

In the first case the piles can be 'pre-cast' that is made beforehand and driven down as required, or 'in situ' where they are cast in the ground.

The choice of piles is made on the score of cost and the nature of subsoil revealed by the trial borings. In short, each pile when driven will support a certain load, so that the number of piles required in one location is a function of the total load to be carried at that point. With a modern boiler, one steel column in the structure can carry as much as 2,000 tons, so that if one pile will support say 50 tons, 40 piles would be required in that group. Each group of piles when driven is 'capped', to distribute the single point load to each pile in the group.

A piled foundation is usually adopted where the subsoil is inadequate to carry the required loading, and it is necessary to penetrate to some depth to reach a load bearing strata.

A raft foundation is adopted where ground conditions are suitable to carry the required loading. The raft which can be designed of solid concrete, or of cellular construction, is used to distribute the point loading's equally over the ground.

Assuming that there is no marked preference on the score of cost, the cellular raft has the advantage in that some accommodation is available for running pipes and cables below basement level.

4 STATION LAYOUT

4.1 General

For the purpose of description, the various sections of the station layout are covered under separate headings. It will be appreciated that in practice it is necessary to Consider all sections together in order to produce a satisfactorily integrated design.

The majority of modern stations are designed initially to accommodate a given.number of identical units. Some stations have been completed, by installing all units of the same manufacture, so that apart from minor changes in shape due to technical improvements in design the layout is similar throughout.

It is, however, very often the case that competitive tendering for later units introduces other manufacturers' plant of different physical sizes and though every effort is made to maintain the same overall dimension of building and general layout of plant, continuity of the original design cannot always be maintained.

Disregarding cost, which is the reason for adopting competitive tendering, there are a number of advantages in maintaining a similar make of unit throughout the station. Design work is reduced to a minimum by repetition, operation is simplified and maintenance is less costly in that maintenance equipment and spares are common to all units.

Over the years the general layout of a station has developed into a more or less standard pattern. The boiler house and turbine house arranged side by side can be regarded as the central feature of the station layout. Very often between these two there is interposed a mechanical annexe accommodating auxiliary plant items. The building is usually completed by a auxiliary switch bay and generator transformers on he side of the turbine house and a bunker bay on the side of the boiler house. Most of the earlier stations were arranged with the bunkers between the mechanical annexe and the boilers and frequently referred to as 'front' bunkers, but nowadays the more generally accepted layout is to have the bunkers at the 'rear'. The other items required to complete the concept of this standard pattern are the grit arresting units, induced draught fans, main gas flue and chimneys arranged in that order from the boiler house.

Typical station arrangements as shown in Figures 4 and 5 indicate the standard type of layout and the "carious design features referred to in Section 4 Station Layout.

As mentioned at the beginning of this section, a good design necessitates simultaneous consideration 6f all layout features and included with this are the main connections between the various items of plant. These can be listed as follows:-

- Circulating water mains.
- Main steam and feed piping.
- Coal conveyors.
- Flues.
- Electrical connections.

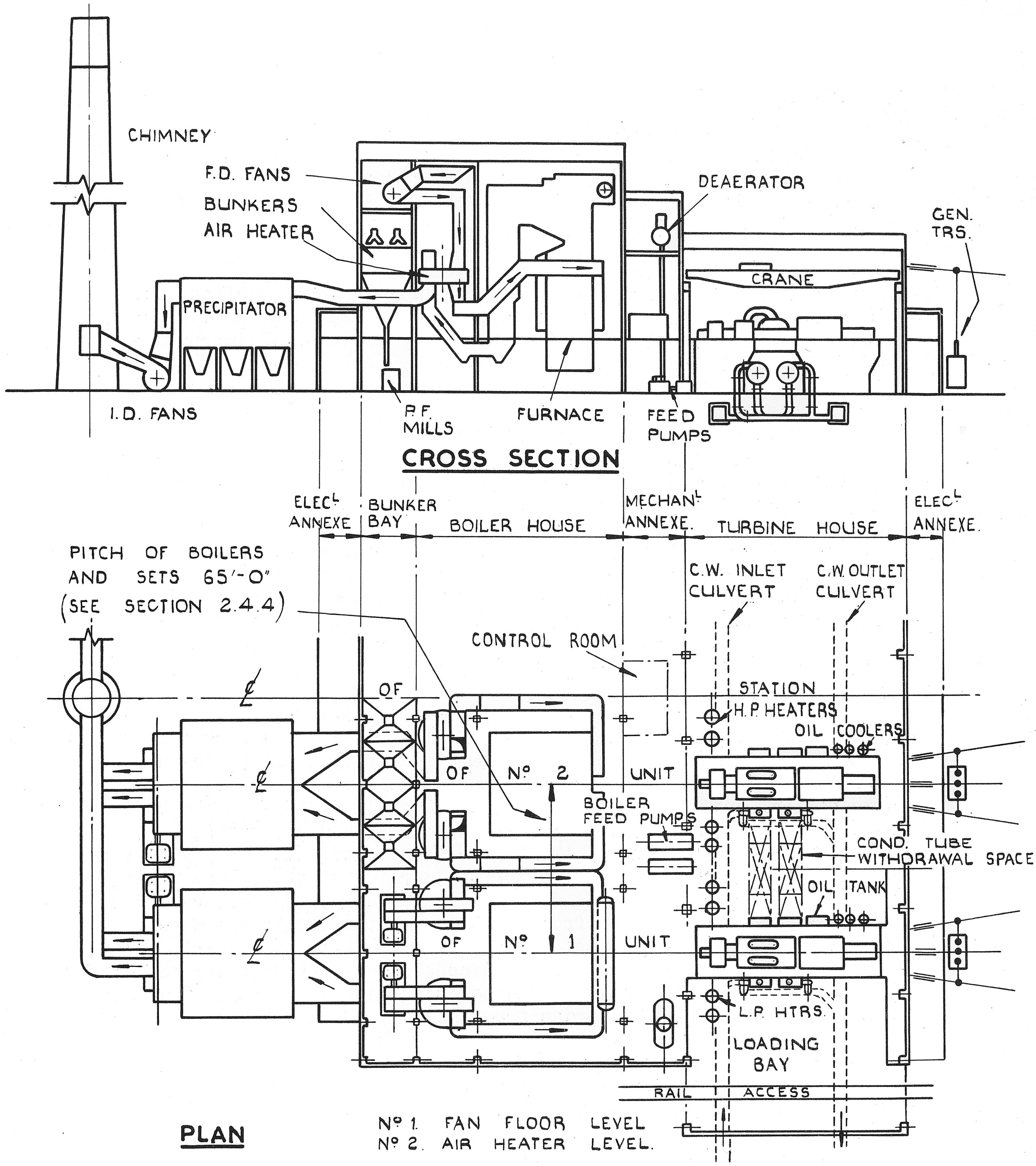

Figure 4: TYPICAL STATION ARRANGEMENT 4 × 60 M.W. UNITS (TRANSVERSE)

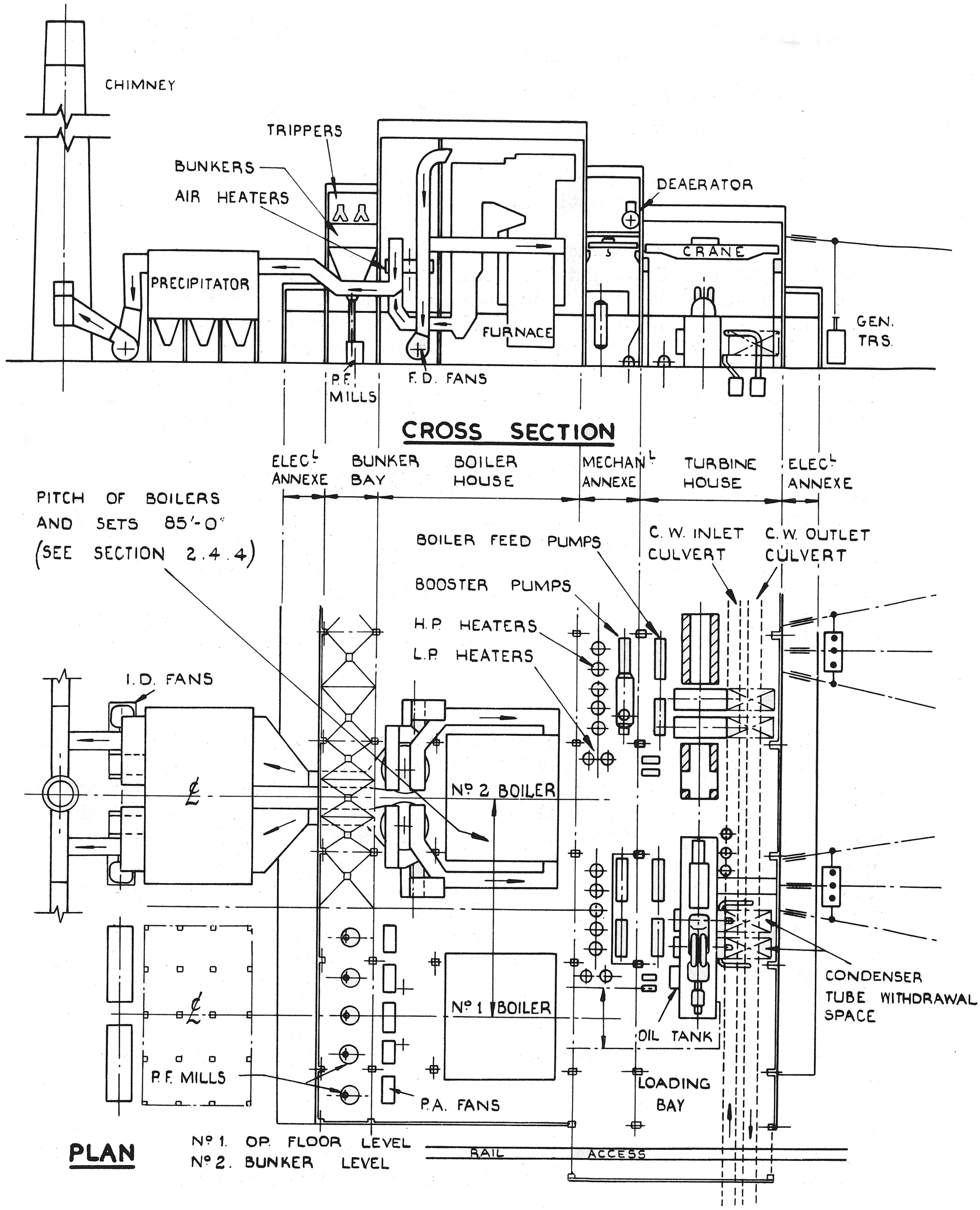

Figure 5: TYPICAL STATION ARRANGEMENT 3 × 120 M.W. UNITS (LONGITUDINAL)

For reasons of economy, the designer aims to keep the building dimensions to a minimum and the connections as short as possible. At the same time, adequate space has to be provided for plant maintenance and if steam and feed piping are too short there may be insufficient flexibility and too great a thrust on the boiler or turbine. The best design then, is the one that strikes the Correct balance between the lowest cost and the best arrangement from both constructional and operational points of view.

Reference has been made in Section 2.5 to station basement level. This is usually a common level throughout the station, though there have been instances where the boiler house and turbine house have been arranged at different levels to Suit ground formation. It is also common practice to have the turbine floor at the same level as the firing floor, the latter being adjusted where necessary to suit. With the modern boiler the term firing floor is really outdated and it would be more correct to refer to it as the operating floor level.

4.2 Boiler House

The principle dimension to be fixed in the layout of the station, is the distance between the centre lines of two adjacent boilers. This is important because not only does it control the overall length of the boiler house, but it also influences the dimension between the sets in the turbine house since it is preferable to keep the centres the same to ensure repetition in design. This dimension is usually arrived at by placing two boiler units as close together as possible consistent with there being adequate space for construction operation and maintenance and sufficient clearance for the withdrawal of sootblowers. With the larger boiler units the number of pulverised fuel mills and the space required for their maintenance has been the factor determining the boiler centres.

The depth of the boiler, house, i.e. the dimension from front to back is arranged to provide sufficient clearance for construction, operation and maintenance.

When considering clearances round a boiler, adequate space should be allowed for ventilation, particularly where a boiler design is likely to produce 'hot spots'. Ventilation can be assisted by locating the forced draught fan suction in the position most suited to drawing in hot air from such hot spots.

The forced draught fans are arranged either at basement level or at a higher level above the air heater. The choice of position is influenced by the particular arrangement of boiler and air heaters and the associated air and flue gas ducting. Though it is sometimes more economical arrangement of ducting to locate the fans at the higher level, they are frequently arranged at basement level to avoid Vibration troubles in the supporting steelwork.

As mentioned previously in this section, the bunkers are now usually arranged at the back of the boiler, though there are a number of Stations where they are at the front, nearest the turbine house. Closely associated with the bunkers are the pulverised fuel mills which must be immediately below so that there is a natural gravity feed of Coal to the mills. The mills are, in turn, connected to the burners on the boiler by fuel pipes and it is desirable to keep these as Short as possible.

4.3 Bunker Bay

It is common practice in designing the bunkers to provide a Capacity sufficient for 24 hours steaming at the full load of the boiler. This is generally accepted as an adequate supply to cover the periods between shifts when the coal handling plant is shut down.

The bunker outlet, usually about 2 to 3 feet square, is provided with a coal gate to cut off the coal feed when necessary. Immediately below this gate is a coal chute connecting to the coal feeder and thence down to the mill. Coal weighers are sometimes used for test purposes in the coal feed to the mills, in which case they are interposed temporarily to the coal chute immediately below the bunker.

The majority of the coal used in power stations does not flow readily and stoppages occur at the bunker outlets and elsewhere. Various methods are adopted to assist the flow of coal, such as vibrators, either mounted externally on. the plating or internally as probes on the modern large boilers, an attempt is being made to improve the flow by removing the restriction imposed by the relatively small bunker opening. This is being increased to something like 10 feet by 3 feet, with a chain link feeder immediately underneath to control the rate of supply to the mills.

4.4 Turbine House

Reference was made in Section 4.2 to the influence of the boiler centres on the set centres in the turbine house. It has usually been the case that the pitching of the boilers dictated the spacing of the sets and the following table gives the generally adopted dimensions for different sizes of unit:-

Size of Unit	Pitching of Boilers and Sets
30 MW	50 feet
60 MW	65 feet
100 MW	80 feet
120 MW	85 feet
200 MW	120 feet

Table 2:

The overall length of a turbo-generator up to 120 MW capacity is usually in excess of the desired pitch of boilers and unless the boilers are opened out the sets cannot be accommodated longitudinally in the turbine house. For this reason the majority of stations with sets of this capacity have a transverse arrangement in the turbine house.

With the higher capacity units the desired pitch of boilers is usually equal to if not greater than the length of a set, with the result that these larger machines are nearly all arranged longitudinally.

It follows, therefore, that with the larger units, longitudinal machines do not make the building any longer than transverse machines would do, but they do afford economy in width of turbine house with a consequent saving in building cost.

With the transverse machines there is adequate space between sets to accommodate the condenser tube withdrawal space and a number of the more important auxiliary units in the feed. train so that an annexe between the turbine house and boiler house is only required for deaerators and possibly control equipment. The width of turbine house for transverse arrangement is dictated by the necessity to give crane coverage to the full length of the set to have adequate space at the electrical end of the set for withdrawing the generator rotor and to permit the passage of a generator stator if being carried by the crane to or from an adjacent set.

With the longitudinal machine the location of the auxiliary units can be either alongside the set, or in the annexe and both arrangements have been adopted in station layouts. The width of turbine house, is, therefore, dictated by the necessity to accommodate auxiliary plant on one side of the set if located in the turbine house and space for condenser tube withdrawal on the other side of the set. The width occasioned by the latter is usually adequate to permit the passage of a stator if such is required.

A loading bay is required in the turbine house for use in the constructional stages and for subsequent maintenance. This is usually arranged at the end of the station from which, construction is started but in the stations with a large number of sets there is frequently a bay at each end. This provides additional space for placing covers if two sets are being overhauled simultaneously, reduces the travelling distance for the overhead crane and reduces the necessity of lifting over running plant during construction. In some stations the loading bay has been arranged in the centre of the turbine house.

The turbine room crane is usually equipped with a main hook to handle the heaviest lift, the generator stator and an auxiliary, faster moving hook for the smaller loads. In some stations a second light duty crane is installed to facilitate construction and permit crane use for maintenance while construction is taking place. The height of the crane in the turbine house is determined by the highest lift necessary on the sets, usually the L.P. cylinder cover clearing the turbine blades, or lifting the L.P. spindle out of the bottom half casing. The height of turbine house roof is in turn arranged to provide a safe clearance between its underside and the crab on the crane.

Reference has been made to the necessity of having an annexe to accommodate the deaerator. The reason for this is that the height required for the deaerator above the feed pumps at basement level, is too great for inclusion in the turbine house and there is usually insufficient space available in the right position in the boiler house. For satisfactory operation the deaerator should be arranged in such a position over the feed pumps that the feed connection down to the pump suction is as near vertical as possible. This condition is met, where, with a longitudinal arrangement of sets the feed pumps are arranged in the annexe and, with a transverse arrangement with the feed pumps in the turbine house, the suction end of the pump is located in the annexe.

The condensate extraction pumps are normally arranged at basement level where the condenser is a sufficient height above to provide the required static head on the pump suction. There are, however, occasions when there is insufficient height, in which case to avoid the cost of arranging the condenser at a higher level the extraction pumps are placed in a pit.

There is no standard practice for running the circulating water mains in the turbine house. They are usually arranged below basement level and clear of the turbo-generator foundations, so that their position is dictated by the space available between the machine and building foundations. The supply and return mains are frequently arranged one on either side of the set, but in other instances due to insufficient space in this position they have had to be located outside the turbine house.

4.5 Precipitators and Chimneys

The modern boiler is, in the majority of cases, equipped with mechanical and electrostatic precipitation plant to remove as much as possible of the solids in the flue gas before this is discharged from the chimney. The mechanical collector is installed in the flue gas trunking before the electrostatic precipitators with which by comparison it is quite a small piece of equipment.

Each boiler is equipped with its own induced draught fans, which draw the flue gases through the grit arresting plant to the chimney. It is common practice for a chimney to handle the gases from two or more boilers, so that it is necessary to connect the discharges from the I.D. fans to a common main gas flue which in turn connects to the chimney. Dampers are fitted where necessary to isolate plant out of service.

The one time practice of erecting steel chimneys on the boiler house roof, with which only mechanical grit arresting plant was used, has disappeared with the adoption of P.F. firing and chimneys are now independent structures supported at ground level. In recent years the potential chimney emission has increased due to the larger capacity boilers and to keep ground concentration to a minimum, chimney heights have been increased considerably. A height of 500/600 feet is now common for a modern power station.

The majority of these tall chimneys, particularly when in the vicinity of an airfield, are equipped with red aircraft warning lights. The positions of the lights as required by the Air Ministry are usually at the top and at other prescribed intermediate levels and arranged round the periphery at 120° so as to be visible from any direction.

4.6 Auxiliary Switchgear

The location in the station of the high voltage auxiliary switchgear is influenced by the wish to keep the cabling costs to a minimum. On this score the first choice is the mechanical annexe and a number of stations have been so designed. With the more recent stations, due largely to this space being occupied by feed heating plant and because of the fire risk associated with oil filled switchgear in the prevailing high ambient temperatures, the practice has developed of locating the switchgear external to the main station building. The two positions usually adopted are immediately outside the turbine house for controlling the turbine auxiliaries and outside the boiler house wall for the boiler auxiliaries. These positions are shown in Figure 4 and 5.

4.7 Steam and Feed Piping

It was common practice in the design of stations up to about 1950 to provide boiler capacity in excess of turbine capacity, so that full station output could be maintained while some boiler plant was down for overhaul.

This flexibility in operation was made possible by connecting all units together on the steam and feed sides on the 'range' principle. On the steamside this usually involved a series of 'steam receivers' into each of which a number of boilers and turbines would be connected and these were in turn interconnected throughout the station. All connections on a receiver were controlled by a stop valve, so that plant could be isolated as required.

This practice was followed by connecting a boiler and turbine together on the 'unit' principle, with a consequent saving in boiler and pipework costs. The table in Section 1.4 shows the rapid development in the capacity and working conditions of the boiler/turbine unit since this change took place. This development has brought about a very noticeable increase in the required number and thickness of steam and feed pipes as shown in the following table:-

Size of Unit MW.s	Main Steam			Reheater Steam						Feed		
				Set to Boiler			Boiler to Set					
	No.	Bore ins.	Approx. Thickness ins.	No.	Bore ins.	Approx. Thickness ins.	No.	Bore ins.	Approx. Thickness ins.	No.	Bore ins.	Approx. Thickness ins.
30	2	8	$\frac{3}{4}$	-	-	-	-	-	-	1	6	17/32
60	2	9	$\frac{3}{4}$	-	-	-	-	-	-	1	8	$\frac{3}{4}$
120	2	8	$1\frac{7}{16}$	2	15	9/16	2	16	11/16	1	10	$1\frac{7}{8}$
200	2	8	$2\frac{1}{2}$	2	18	$\frac{3}{4}$	2	18	25/32	2	$8\frac{1}{2}$	$2\frac{1}{8}$
550	4	9	3	4	20	1	4	20	$1\frac{5}{8}$	4	10	$2\frac{1}{2}$

Table 3:

With the smaller units the required steam and feed piping did not influence the-layout for reasons Other than keeping the runs as short as possible, on the score of cost. The pipe sizes and temperature conditions were such that the necessary flexibility could be built into the system by the. use of expansion loops.

With the introduction of the reheat units and the associated changes in pipe size and working conditions, he layout of the pipework has become a very important feature, and has to be studied closely, on the score of cost, flexibility and in the case of the reheater pipework pressure drop.

As an indication of the importance of cost, the two 8" bore steam pipes used on a 30 MW unit would cost approximately £100 per foot run. On the 550 MW reheat unit, the twelve pipes would cost approximately £1,500 per foot run.

In order to obtain the necessary degree of flexibility in the connections for the larger units, the pipe runs have to be carefully designed to ensure that the permissible thrusts on boiler and turbine are not exceeded. This influences the layout considerably and the relative position of the boiler and turbine are determined very largely to meet the required pipe layout. Consideration has also to be given in the reheater pipework to keeping the lengths to a minimum to avoid incurring too great a pressure drop between the boiler and turbine.

5 CIRCULATING WATER SYSTEM

5.1 General

In designing a circulating water system the intention is to meet the following requirements :-

(a) To supply the designed water quantity to each condenser.

(b) To ensure that in the event of a pump failure, a continuity of supply will be available to all sets.

(c) To provide overall control of the C.W. system to meet all station load requirements and varying conditions at the source of the water supply.

(d) To make adequate provision for efficient maintenance.

(e) To achieve the foregoing with the minimum capital and Operating costs.

There are a number of problems that have to be examined in the design of the system, the majority of Which are associated with conditions at the source of supply. These are:-

(f) Variation in water level due to tidal Changes at coast or estuary stations, or changes in flow at non-tidal river stations.

(g) Variations in temperature of cooling water.

(h) Changes in regime of the sea or river bed. These may be occasionally brought about by the introduction of the circulating system itself and for a number of stations models have been prepared to simulate the actual working condition and thus enable the best location for intake and outfall to be chosen.

(j) The possibility of recirculation between the-outfall and the intake with a consequent increase of intake temperature to impair station efficiency.

(k) The extent of silt in. suspension in the water-that can settle out in various parts of the system.

(l) The extent of floating debris for which adequate screening has to be provided.

(m) Marine growths that impair the flow in the mains and the heat transfer in condenser tubes. These are usually treated by the chlorination process.

(n) An analysis of the water to determine any possible corrosive action in the condensers.

(o) To ensure that the construction Or operation of the intake or outfall will not interfere with or be affected by shipping, or be detrimental to other interests in the vicinity.

(p) The observance of any statutory restrictions imposed on the quantity of water to be abstracted, or the quality and temperature or discharge.

Reference has been made in Section 1.3 to the three types of 4 circulating water system in common use and the conditions that each one is intended to meet. Whichever system is adopted to obtain the required quantity of water for condenser cooling the way in which it is connected into the condensers is similar in most stations, This usually comprise, s a supply.and return main running the full length of the turbine house to which the inlet and the outlet branches of the condenser water-boxes are connected. With the earlier stations the comparative small quantities. of water could be handled by a single main, but with the more recent stations the large quantities have made it necessary to use more than one main. Figure 6 shows a typical diagram of connections to a condenser. Sluice valves are fitted to each branch on the condenser water-boxes for the purpose of isolation. Adjacent to these valves, expansion joints are fitted to provide flexibility.between the movement of the condenser and the mains anchored in the basement floor.

5.2 Direct Cooled Systems

This system is usually adopted when the station is sited on the coast or on a river estuary, where there is an adequate supply of water available at all times.

It is necessary to establish the correct relative position of the intake and outfall. If they are too close together, recirculation will take place and this will increase running costs. If they are moved further apart the capital cost of the connecting mains may be increased. They should,therefore, be in the position relative to each other that produces a balance between these two costs.

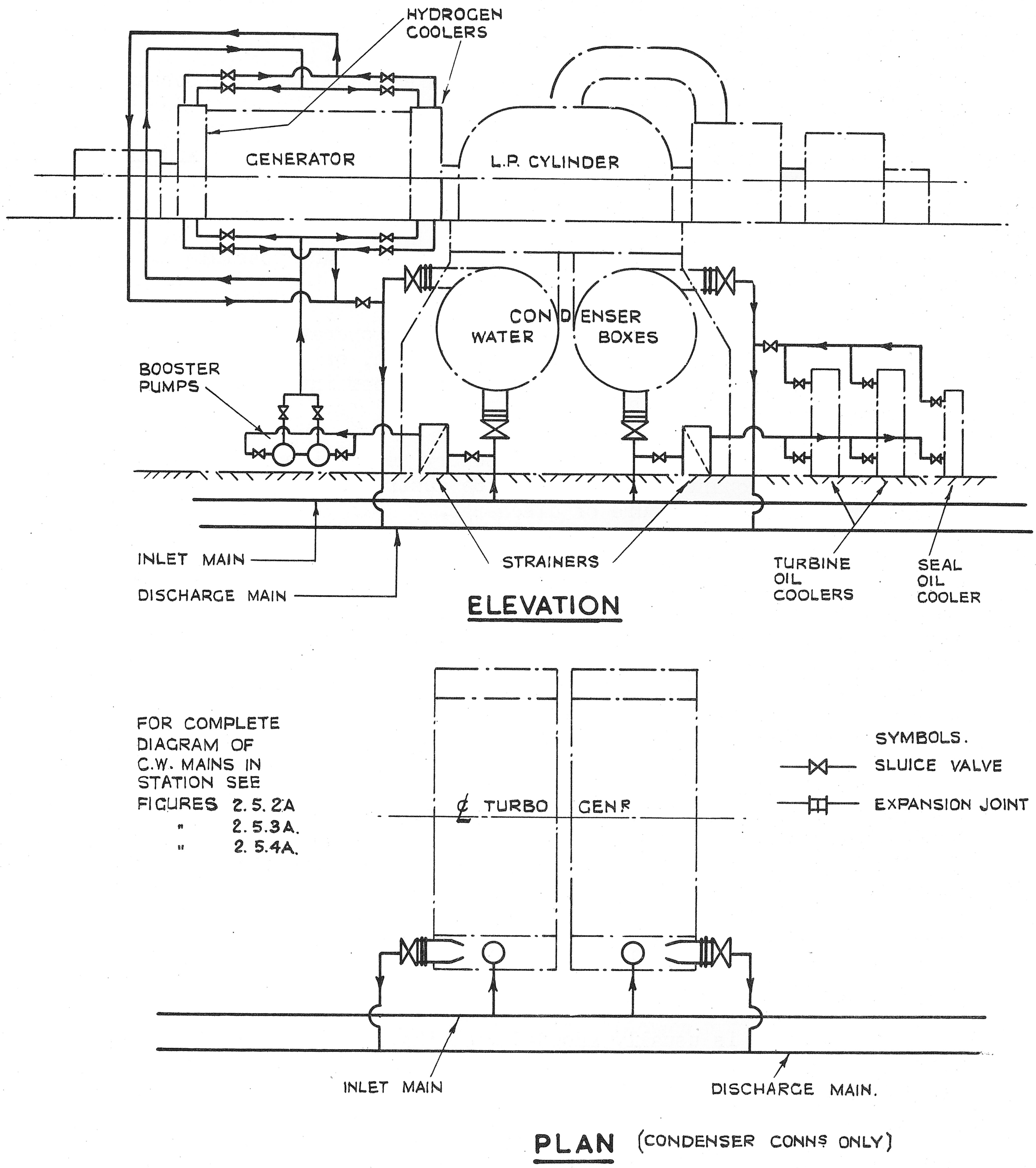

Figure 6: TYPICAL DIAGRAM OF CONNECTIONS CIRC WATER TO CONDENSER & AUXILIARIES

For the Connecting mains from the intake to the station and the return to the outfall, reinforced concrete culverts, spun concrete pipes, cast iron, or steel pipes are used depending on the quantity and quality of the water, the ground conditions, the availability of materials and the relative costs based on capital and running costs.

All direct cooled systems should be designed to take the fullest advantage of syphonic recovery, (see previous reference in Section 2.5)

A diagrammatic layout of a typical direct cooled system is shown in Figure 7.

5.3 Closed Cooling Water System

This system is used when the supply available is inadequate for any direct cooling at all and the condensers operate on a closed circuit. In such stations the only supply of water required is that necessary to make-up the amount used in purging the system of dissolved solids and to replace the amount lost by evaporation from the cooling towers.

The amount of make-up to replace purge depends on the quality of the water supply, but is usually about 2% of the quantity circulated. The water required for evaporation loss is usually about 1%, so that the total quantity of water required for make-up purposes is approximately 3% of the quantity circulated in the system. Although this quantity is taken into the station the 2% used is purged and is returned, so the loss to the source of supply is 1% of the quantity circulated.

This system permits a large measure of flexibility in the availability of water, or a temporary failure in the pumping equipment. Providing the cooling tower ponds are of sufficient capacity the station can operate for an appreciable time possibly as long as a day, without make-up.

The most common problem with a closed cooling tower system is siltation. The usual method of dealing with this is to permit settling in the tower ponds, from which the silt must be removed from time to time.

A diagrammatic layout of a typical closed cooling tower system is shown in Figure 8.

5.4 Mixed Cooling System

This system is used where the water available is only sufficient for partial direct cooling and it is economic to use this to the full and circulate the balance over towers, rather than adopt a completely closed circuit.

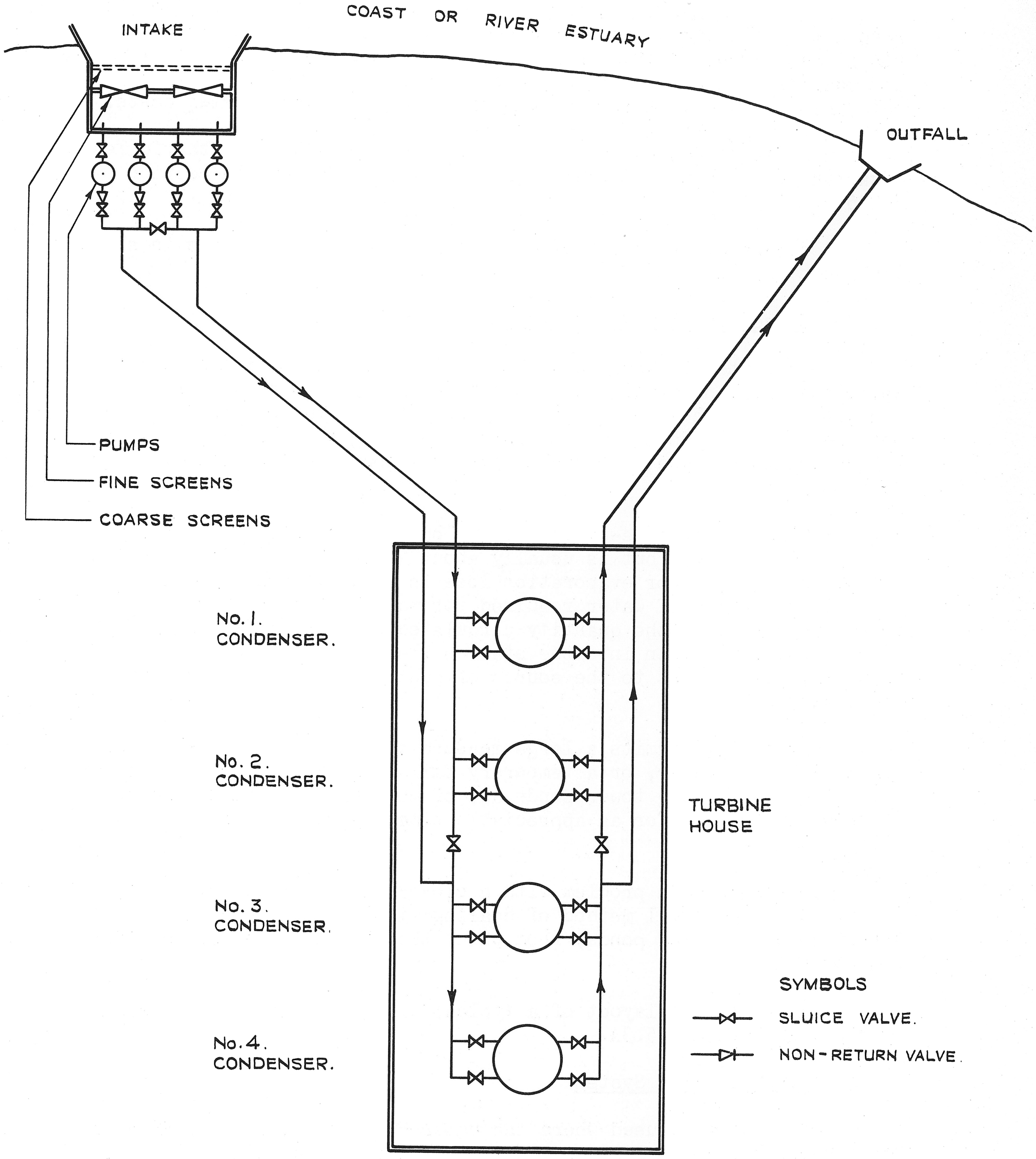

Figure 7: TYPICAL DIAGRAM OF DIRECT COOLING WATER SYSTEM

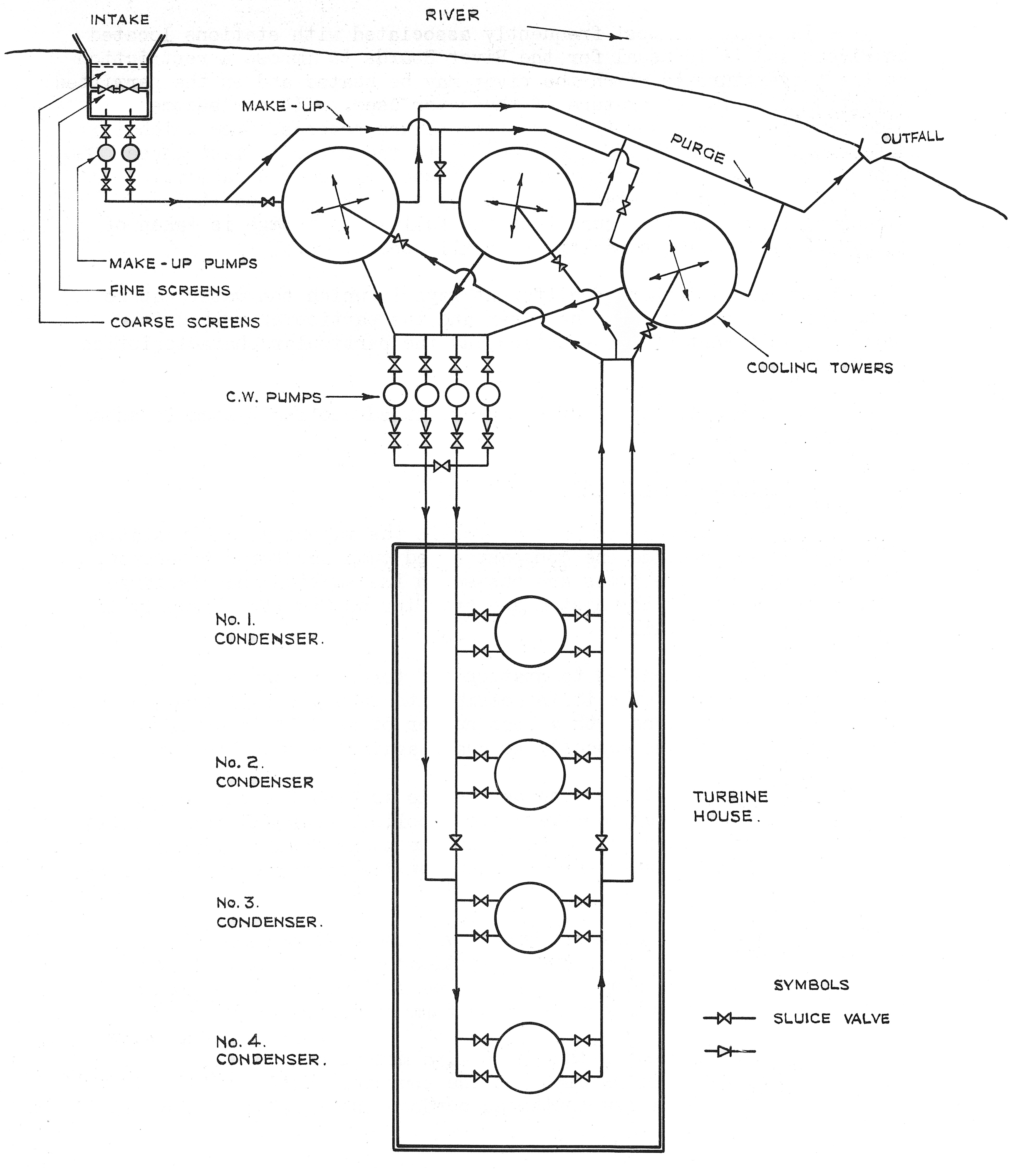

Figure 8: TYPICAL DIAGRAM OF CLOSED-COOLING WATER SYSTEM

This system is most frequently associated with stations located on rivers and it is usual for the River Boards to impose a restriction on the temperature to which the river may be heated and on the permitted permitted rise in temperature of the water used. It now becomes necessary to study river flow and temperature records, from which is determined the permitted heat rejection to the river to meet these restrictions and the required amount of cooling tower capacity. The river flow and temperature are subject to changes and it is necessary in design to ensure that the fullest advantage is taken of the available cooling Capacity under all conditions.

There are a number of different ways in which the water can be taken from and returned to the river and the particular method is chosen to suit cost of construction, and the particular characteristics of the river.

A diagrammatic layout of a typical mixed cooling system is shown in Figure 9.

5.5 Pumping and Screening

It has now become common practice in the majority of circulating water systems to provide one constant speed pump per turbo-generator, without a spare. The pumps are bussed on the suction and discharge sides, thus balancing the system and ensuring Continuity of supply in the event of a pump failure.

This practice applies to stations of three or more sets, in which case if a pump fails it is possible to maintain full load on the remainder. In stations with a less number of sets it is usual to provide additional pump capacity to guard against a possible failure.

This principle of one pump per set is adopted for the supply to the condensers in direct cooled, closed cooling tower and mixed cooled systems, but the number and capacity of the pumps for the cooling towers in the mixed system are dependent on the capacity of the cooling towers.

In order to control water quantity, some stations use variable speed-pumps, but in the majority of Stations the-fully bussed system in which the number, of pumps in use can be varied., is considered to provide the cheapest and most reliable form of control.

It is usual to locate the pumps with motors and associated control gear in a separate house as close to the source of water supply as possible, although in a few instances outdoor installations have been adopted.

Where pumps are taking their supply-from a natural source such as the. sea or a river, screening plant is provided before the pumps. The screens may be of the cup or disc type, but due to the variations in water level, direct cooled stations generally use band screens. These fine screens are self-cleaning, the debris being removed to a point for disposal. Coarse bar screens are usually placed before the fine screens to prevent the ingress of large debris such as tree trunks, frequently brought down rivers by flood.

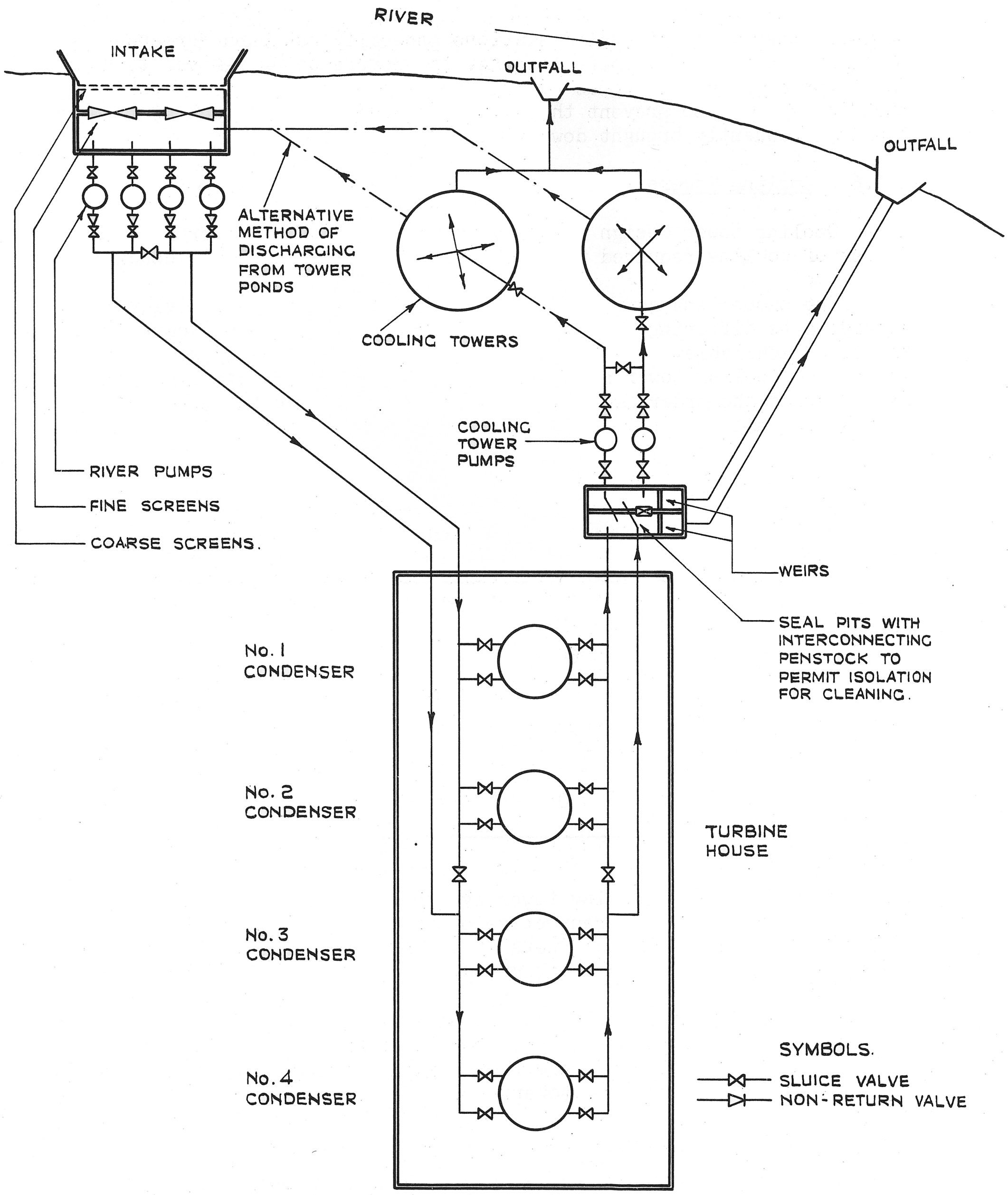

Figure 9: TYPICAL DIAGRAM OF MIXED COOLING WATER SYSTEM

5.6 Cooling Towers

Cooling tower design is based on the quantity of water and the degree of cooling required under all anticipated atmospheric conditions.

The number and capacity of cooling towers at a station vary according to differing design conditions and in a number of cases to the space available. The following table shows typically how with the closed cooling tower system the growth of unit and station capacity has reversed the order from number of units per tower to number of towers per unit:-

Typical Station Capacity MW.s.	Unit Size MW.s.	Number of Units	Number of Cooling Towers
180	30	6	3
360	60	6	4
600	100	6	4
1000	200	5	5
1400	350	4	6
1100	550	2	6

Table 4:

With the closed cooling tower system it is usual to bus the cooling towers, so that irrespective of the number of pumps in use during the summer months when sets are down for overhaul, all towers can be used to provide maximum cooling.

In arranging the cooling towers on a site layout it is usual to provide a minimum clearance between towers of half a tower base diameter and a similar clearance to any adjacent structure likely to impede the air flow into the tower.

5.7 Chlorinating Plant

As referred to in Section 5.1 one of the problems that has frequently to be overcome is marine growth. This can take the form of mussel growth on the walls of the intake works and culverts and is treated by injecting chlorine near the intake. The growth of algae in the condenser tubes is overcome by injecting the chlorine into the inlet mains immediately before the condenser.

In the majority of stations, chlorine injection is automatic in operation; predetermined quantities are injected at the different points in a timed sequence under the control of a master clock.

The chlorine plant house and adjacent drum store are usually arranged in a separate building as close to the injection points as possible.

6 COAL HANDLING

6.1 General

The handling of coal at a station can be classified and described under the following headings:-

(a) Railborne reception and unloading.

(b) Waterborne reception and unloading.

(c) Roadborne reception and umloading.

(d) Direct reception from colliery.

(e) Conveyance from unloading point to bunkers and store.

(f) Coal storage.

6.2 Railborne Reception and unloading

The majority of stations are equipped to receive all or part of their coal intake by rail.

In the older stations the sidings arrangement varied very considerably. With the growth in station capacity and the associated increase in coal intake, a standard pattern of sidings was evolved and this has become well established.

This standard pattern can be divided into three well defined groups, reception and departure sidings, exchange sidings, and hopper or tippler sidings. (See typical siding layout Figure 10).

The reception and departure sidings are connected to the main line by ”turn-outs”. The reception sidings consist of one or two tracks on to which British Railways can run to give immediate clearance to the main line and a ’run round’ which permits the locomotive to transfer from the front to the rear of the train in readiness for propelling the wagons into the exchange sidings. The departure siding usually consists of a single track on which an empty train can be held in readiness for running on to the main line. The movement of all traffic into and out of these sidings is under the control of ”British Railways”.

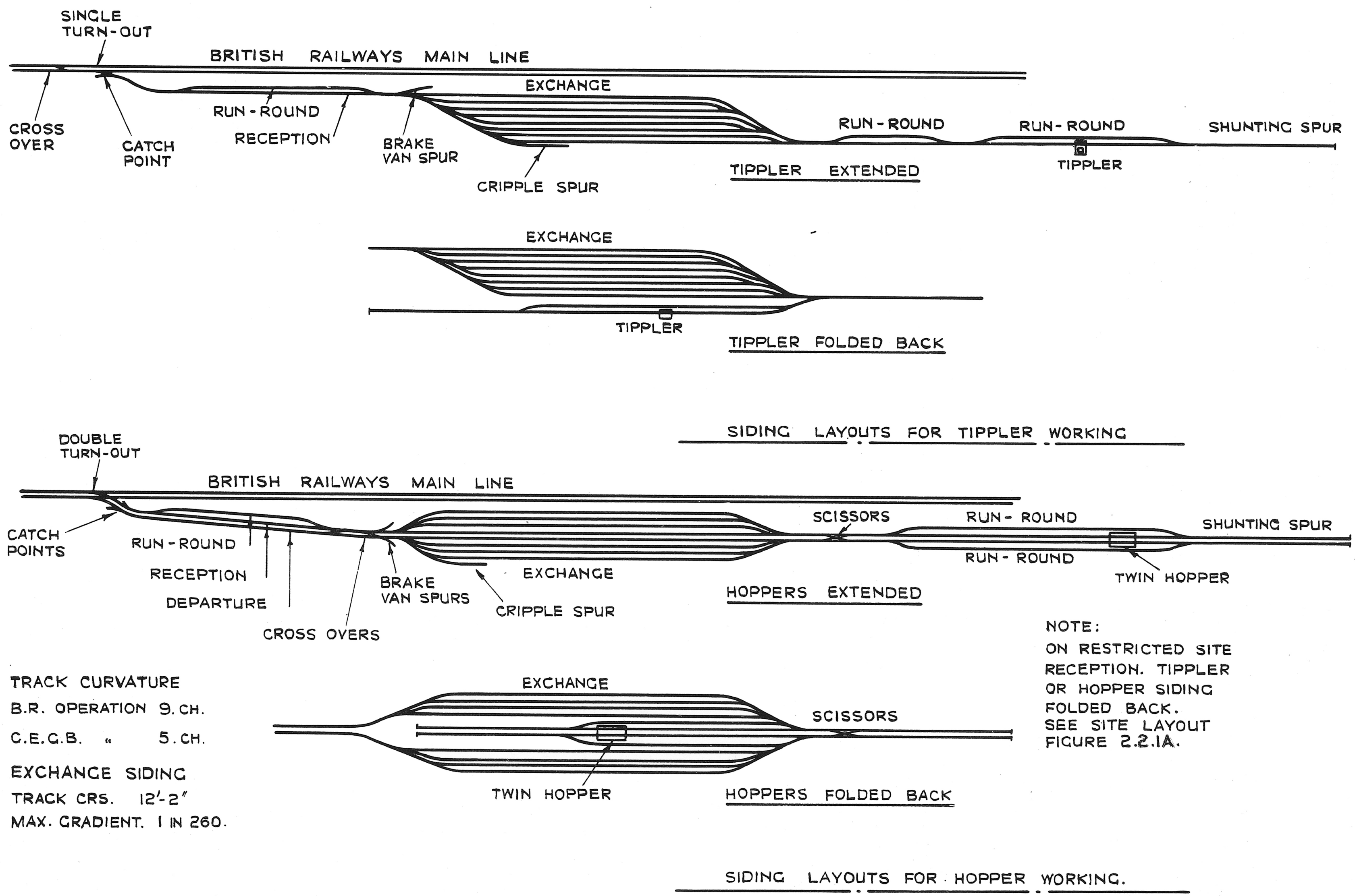

Figure 10: TYPICAL SCHEMATIC SIDING LAYOUTS

The exchange sidings are a separate group in which full wagons are exchanged for empty wagons. British Railways propel 'fulls' in and haul 'empties' out at the one end, while the Board haul out 'fulls' and propel back 'empties' at the other end. They are designed to accommodate a number of wagons representing approximately one day's 'fulls', plus one day's 'empties', thus providing for possible. fluctuations in deliveries due to unforeseen circumstances. To simplify train working, the tracks are of sufficient length to accommodate one or two complete trains, plus a working clearance. This design of sidings is based on two fundamental requirements for satisfactory operation.

(a) By each operator having the exclusive use of their own end of the sidings, there is no possible confliction of movement between the main line and site locomotives and thus no interference during operation.

(b) The tracks are not segregated for operation, so that there is complete flexibility of use for 'fulls' and 'empties'.

British Railways operate as follows:-

Having 'run round' the train in the reception siding the loco propels the wagons in to an empty siding in the exchange group, detaches the brake van and parks it on a spur. It then hauls out an empty train and after attaching the brake proceeds to the departure siding.

The hopper or tippler sidings are designed so that wagons can be hauled out of the exchange sidings by a site locomotive and after being worked through the tippler or over the hopper, returned to the sidings, in the most efficient cycle possible. Two methods are adopted for feeding wagons over tipplers, mechanical haulage devices mounted between the tracks which engage a wagon with retractable arms, or a site locomotive. With either system it is the wagons only that pass over the tippler platform and they are propelled on one at a time, the 'full' going on, propelling the 'empty' off. With hopper working, the site locomotive takes the draft of wagons over the hopper. Weighing of wagons full and empty is carried out as part of the tippler operation, but with hoppers it is usual to install a separate weighbridge, over which the wagons are passed before and after unloading. In order to minimise the time of unloading in recent high capacity plants a system of check weighing has been adopted involving approximately one train per day.

The types of coal wagon in use are as follows.

The majority of the older stations use flat bottomed or box wagons, the capacity of which vary from 12 to 24½ tons and for these, tipplers are required. For the more recent stations, the considerably increased coal intakes have necessitated a quicker turn-round of wagons resulting in the bottom door hopper design, which can be continuously discharged over a hopper without the need to separate wagons as for a tippler. This type of wagon has been used for a number of years with two bottom doors, but to improve discharge characteristics negotiations have been concluded with British Railways for a four door design. This will ultimately be of two sizes, 21 ton and 24½ ton, the former being used when colliery restriction on size precludes the use of the latter. It is the policy of the Board that on all future stations, hopper wagons of the maximum capacity shall be used wherever possible.

Although the four door hopper wagon has very good self-discharging characteristics, wagon shakers are installed to assist discharge of sticky or frozen coal.

The following summarises the factors used in designing sidings and gives a typical example.

GENERAL

Annual Consumption	Calculated	Say 1.5 million tons
Average daily intake	Usually assumed that coal is delivered over 5 days per week for 50 weeks per year.	$\frac{1.5 \times 10^6}{250} = 6,000$ tons
Capacity and type of wagon	Assume 16 ton box wagon. Average capacity in use.	15 tons
Number of wagons per day	Daily intake divided by average capacity of wagon.	400
Number of wagons per train	This is specified by British Railways to suit their conditions or working.	Say 50

RECEPTION SIDINGS

Length of reception sidings	This is the minimum clear length inside the switches for the loco run-round. Number of wagons / trains × length of wagon with coupling taut + loco + brake + clearance.	$50 \times 20'3" + 75'$ $+25' + 50'$ $= 1,162'6"$.

EXCHANGE SIDINGS

Number of trains per day	Wagons/day divided by number of wagons/train	8
Number of trains per track	With 50 wagons/train, more than one train length per track would make site loco operation uneconomic.	1
Length of tracks in exchange sidings	Number of trains/track, × number of wagons/train x length of wagon with coupling taut, plus clearance.	$1 \times 50 \times 20'3"$ $+50 = 1,062'6"$.
Track centres	Minimum safe clearance for wagon inspection.	12' 2"
Track curvature	Minimum for British Railway loco. Minimum for site loco.	9 chains. 5 chains.
Gradients	Maximum for wagons to stand unattended by a locomotive	1 in 260

TIPPLERS

Handling rate of tipplers	This figure varies according to design of tippler and operation.	Say 15 wagons/hour
Number of tipplers required	If 8 hour single shift (7 hours effective). If 16 hour double shift (14 hours effective).	$\frac{400}{7 \times 15} = 3.8 \therefore$ 4 req. $\frac{400}{14 \times 15} = 1.9 \therefore$ 2 req.

6.3 Waterborne Reception and Unloading

Waterborne coal is received in one of the two following ways:-

(a) Sea going collier.

(b) River or canal barges.

Sea going colliers are used at stations located on the coast, or on navigable river estuaries. Vessels of varying tonnages are in service at different stations, the largest and most economical being of 4,600 tons dead weight. These carry approximately 4,400 tons of coal, are approximately 340 feet long and draw 20 feet of water fully laden.

In locating the quay from which the colliers will be discharged, it is necessary to avoid interference with other shipping, make provision for turning the ship round and have a sufficient depth of water for berthing. To permit berthing at all states of the tide it may be necessary to construct the quay well offshore, or to carry out extensive dredging. To avoid this expense it is usual to construct the quay in such a position that water is available for berthing daring possibly two hours before and after high tide. It is necessary, of course to ensure that the bed is level and of such material that the vessel can be aground during the low water periods.

The length of quay depends on the number of colliers to be discharged at one time and the frequency of arrival. For a station capacity similar to the example used in the previous section,, the average daily intake of 6,000 tons. would be met by three cargoes of 4,400 tons in two days. At this rate the frequency need not exceed one collier per tide, with discharging plant to suit. For these conditions it is usual to make the length of berth to suit two vessels, so that one can wait While the other is being discharged.

For discharging; either level luffing cranes or 'unloaders' are usually installed. "They are mounted on tracks built into the quay to permit the necessary movement for positioning in the hold. With both types, the coal is removed by grab and deposited in a hopper from which Conveyors discharge to the station bunkers or coal store. Four cranes or unloaders with a capacity of 250 tons/hour each would discharge the daily intake of 6,000 tons in a single shift, allowing time for collier movements.

The use of barges for inland coal transport is not extensive though there are a few stations that get the whole or part of their supplies in this way.

In these cases a quay is required on the Sank of the river or canal, with a layby of sufficient length to accommodate a string of barges. Unloaders or cranes are mounted on rails, as with colliers, to traverse the holds and feed back to a conveyor system.

A typical river installation had a daily intake of 2,400 tons in barges of 250 tons. Two unloaders of 125 tons/hour each effect discharge in. 9/10 hours.

6.4 Roadborne Reception and Unloading

Roadborne coal is usually regarded as a supplementary supply though there are stations that take a large proportion of their coal in this way.

Where it is considered advisable to install equipment for dealing with roadborne coal, a ground hopper would be provided into which vehicles could, discharge and from which a conveyor would deliver into the coal handling plant system.

For occasional deliveries, as in the case of some emergency, vehicles can discharge direct on to the coal store, from where supplies can be handled-by the stocking or reclamation equipment.

6.5 Direct Reception from Colliery

There are one or two stations that are located adjacent to a colliery. In these cases a conveyor system from the colliery to the station has been found more economic than road or rail transport.

6.6 Conveyance from Unloading Point to Bunkers and Store

Considering first the three types of unloading plant from which coal has to be conveyed. The tipplers empty box wagons into hoppers and these feed to conveyors running beneath. Hopper bottom wagons discharge direct into a ground hopper from which the coal is removed by paddle feeders on to conveyors and quay cranes discharge their grabs into hoppers which feed on to conveyors.

From any of these the coal has to be carried by the conveyors to the boiler house bunkers and for economy and maximum reliability these should be as short as possible. It is common practice to provide screening and crushing plant in the run of the bunker conveyors and it is usually at this point, after the crushers that the supply to and the return from the coal store is introduced.

To ensure continuity of supply in the event of a belt failure, the conveyors to the bunkers are usually run in duplicate. The supply to and return from the coal store is frequently a single reversible conveyor.

In designing a system, a conveyor inclination should not exceed 18° to the horizontal and a height of approximately 10 feet Should be allowed at transfer points for the inclusion of a chute.

Referring to the typical example in Section 6.2, the daily intake of 6,000 tons could be handled by four tipplers at a rate of 900 tons per hour, in seven hours. A suitable conveyor system for this would be twin belts to the bunkers of 450 tons/hour each. If one belt should fail, the other could handle the daily intake in 14 hours. The single coal store reversible conveyor would be of 900 ton/hour capacity.

6.7 Coal Storage

For coal storage and reclamation it is now common practice to use mobile handling plant The reversible conveyor when feeding to store would form an initial pile from which bulldozers could feed to stock. When reclaiming, the coal would be fed back on to the reversible conveyors through a ground hopper.

The space allowed for a coal store at most station is a quarter of the annual burn. The coal stocked in the immediate vicinity of the initial pile and ground, hopper is looked upon as the working store and the remote area of storage as the emergency reserve. For design purposes it is usual to has the required storage area on a coal depth of 25 feet, though if space requirements demand this can be increased if the coal is properly consolidated. In this case it may be necessary to introduce probe thermometers to watch for any rise in temperature denoting the presence of spontaneous combustion.

7 ASH AND DUST HANDLING

7.1 Removal from Boiler Plant

various systems are in use for removing ash from the boilers, but the one principally used is the sluicing system. With this the ash that collects in the hopper below the boiler furnace is washed into a sluiceway by high pressure water jets. This sluiceway is led to an ash sump usually located outside the boiler house and the ash is kept in suspension by a series of jets set at intervals in the bottom of the sluiceway.

The dust from the boiler is collected in hoppers the principal ones being under the precipitation plant, from which dust is removed by pipeline or sluiceway to the ash sump.

7.2 Handling on Site

The sump into which the ash and dust is sluiced is connected through fixed screens to the dust pump suction chamber. The fine ash and dust passes through this screen and is pumped either to overhead bunkers or to a disposal area. The coarse ash is grabbed out of the sump, allowed to drain on a draining apron, then removed for disposal.

7.3 Disposal from Site

The three principal methods used for disposal are by pipeline, by road vehicles and by barges. Pumping to disposal is used for dust only. At the disposal point the water borne dust settles out over the ground, the water being allowed to drain away to waste, or collected in a sump and pumped back to the station for recirculation. There is no practical limit to the length of pipeline, though it may be necessary to introduce booster pumping stations. The ash is not usually pumped because of its abrasive action on the pipes, though there are one or two stations pumping ash and dust to local disposal. Pipelines are usually run in duplicate to allow for repairs and maintenance.

Road vehicles are used on occasions for disposal of dust when distances are short, when the disposal areas are small and scattered, or when disposal is more convenient in a semi-dry state. In recent years there has been a commercial development in the use of dust in the making of bricks and concrete, the works set up for this purpose being adjacent to a station for convenient road transport. The coarse ash, after being allowed to drain, is nearly always handled by road vehicles. This is because as previously stated it is not suitable for pumping and because the quantities involved are comparatively small. There is usually a big local demand for ash for constructional works.

Barge disposal is used by some stations situated on or near the coast. By this means the dust and the ash unless wanted for other purposes, are loaded into barges and dumped at sea in areas prescribed for this purpose.

It is possible that the gradual infilling of areas adjacent to load centres, particularly in the Midlands and the increasing quantities for disposal from the large modern stations will bring about disposal by rail. The disadvantage with this system lies in the necessity for double handling. For easy removal from rail wagons the dust would have to be conveyed in a dry state and this would necessitate feeding it through conditioning plant into road vehicles at the rail head for local disposal.

8 WATER SUPPLIES

8.1 Source of Supply

One of the first consultations that has to be carried out after a site had been selected is with the local Water Supply Authority, to negotiate a supply for boiler make-up and domestic uses. This usually involves laying a water main to the site from the nearest point at which there is an adequate supply available.

On one-or two sites, due either to insufficient supplies being available, or the point of supply being too remote, boreholes have been sunk and pumping, plant installed to meet station requirements,

8.2 Boiler Make-Up

According to the analysis of the supply, suitable water treatment plant is installed to remove scale forming impurities that would impair boiler efficiency. After passing through this plant the water is pumped up to high level storage tanks from which it is fed by gravity into the feed system through the condenser. These tanks are usually of a capacity to maintain ¾ hours, supply to the boilers in the event of a failure in the supply mains. There have been instances where the tanks, are located at low level to save building space and minimise the cost of supporting steel.

8.3 Domestic Supplies

If there are restrictions imposed on the quantity of towns main water available, a domestic supply from such source is limited to drinking, washing and food preparation. Other station requirements including sanitation would be met by suitably treating a supply from the circulating water system.

9 ELECTRIC WORK

9.1 Generator Connections and Switch Compound

It has now become standard practice to switch the generators on the high voltage side of the generator transformers, either in an indoor switch house, or an outdoor switch compound. The cost of providing indoor gear has been much higher than outdoor, so that unless there have been special circumstances such as spray on coastal sites impairing insulation efficiency, or space restrictions, outdoor switchgear has been used.

As mentioned under Station Layout, Section 4.1 the generator transformers are usually located immediately outside the turbine house and in line with the generator in order to minimise the length of connections. In front of the transformers and parallel to the turbine house is an access road and on the remote side of this is the outdoor switch compound. The distance between turbine house and compound is kept as short as possible, but it is sometimes necessary to allow space for ancillary buildings and rail tracks to the turbine house loading bays.

For connecting the high voltage side of the generator transformers to the switchgear, overhead lines are preferred to cables on the score of cost The generator and outgoing feeder switches in line and parallel to the turbine house are balanced with half the station capacity on each side of a section switch, the generator switches being arranged as nearly opposite the transformers as possible. By this means the overhead connections, usually attached to the turbine house wall with down leads to the transformer terminals, have the most direct span across to the switches. The outgoing feeder circuits are taken away on the side remote from the turbine house.

To avoid the possibility of spray from cooling towers blowing on to the switchgear, consideration should be given in the site layout to providing adequate separation.

9.2 Auxiliary Switchgear and Supply System

Reference has been made under Section 4.6 to the location of the auxiliary switchgear for which a voltage of 3.3 or 6.6 kV has generally been used but has now been increased to 11 kV where the large size turbine/boiler units are being installed. It is common practice to supply the main auxiliaries on each unit from a separate unit board taking its supply from a unit transformer connected between the generator and generator transformers. It is also usual to provide two station boards at a similar voltage, their supply being taken through station transformers from the high voltage bars in the switch compound on each side of the section switch. From these boards a supply is taken to the standby plant on the main auxiliaries so that in the event of electrical failure on any unit, a standby supply is available.

The common auxiliaries such as circulating water pumps, coal and ash handling plant are supplied from each of the station boards.

10 PLANT CONTROL

10.1 System of Control

In the older stations, before the advent of the unit boiler and turbo-generator, it was usual to have an independent gauge board for each boiler and each turbine. The first move to centralise control came with the unit system when the boiler and turbine boards on one unit were brought together and enclosed in a separate room. This was followed by bringing the controls for two units into one room and in some stations where this has been adopted the boilers and turbines are controlled from this plant control room.

It has been the general practice in the past to locate the generator and transmission controls together in the station control room. In some of the later stations, the generator controls have been considered part of the plant control system and located in the plant control room. The latest intention in station planning is to abolish the independent rooms, and group all plant and transmission into one central control room.

10.2 Control Room

The generally accepted location for the control room is in the mechanical annexe. This is convenient for operation to both boiler and turbine and keeps the length of numerous boiler control connections to a minimum.

11 BUILDING ARCHITECTURE

11.1 Building Volume

As mentioned previously in Section 4.1 it is the designers aim on the grounds of economy to keep the building dimensions to a minimum consistent with good facility for operation. It does not, of course, follow that a smaller building is a cheaper one. It may be more expensive for instance to have a number of different roof heights rather than one common level. With these limitations in mind, it has become common practice to compare building costs for different installed capacities, on a volumetric basis, expressed as cubic feet per kW installed.

Since 1950, the introduction of the larger units and an improvement in station design have led to a marked reduction in building volume per kW as shown in the following table:-

Unit Size MW	Station Size		Boiler House cu.ft/kW	Turbine House cu.ft/kW	Total cu.ft/kW
	Sets MW.I.	Boilers k.lb/hr.			
30	6 x 30	6 x 300	24.3	15.1	39.4
60	8 x 60	8 x 550	19.8	13.4	33.2
100	3 x 100	3 x 755	22.4	10.3	32.7
120	5 x 120	5 x 860	16.0	12.9	28.9
200	5 x 200	5 x 1400	16.7	11.1	27.8
275	4 x 275	4 x 1900	15.9	10.9	26.8
550	2 x 550	2 x 3750	13.0	9.1	22.1

Table 5:

11.2 Form of Construction

For a number of years lightweight cladding has been generally used on new stations as opposed to brick construction. This does not of course, apply to an extension to an existing station where the existing form of construction would be followed.

The use of lightweight cladding shows considerable savings in material, erection costs and time and reduces expense in foundations. It is usual to construct from ground level to about seven feet above operating floor in solid walling of brick or concrete. Above this level the cladding is usually in some form of sheeting such as aluminium, asbestos or protected metal, with glazing where necessary.

The ancillary buildings for offices, canteens, workshops and stores, either attached to the main building or as separate structures, are usually constructed in similar material to the lower solid walling of the main building.

11.3 Amenities

It is the obligation of the Board to consider the visual effect that a station will have on the surrounding countryside. For this purpose architects are engaged and it is their responsibility to study the aesthetic design of the station, which involves the treatment of the station buildings and all external plant items. The type of cladding is chosen by the architect to balance economy in construction against the most pleasing appearance in the environment of which the station is situated.

On recent projects the Board have also appointed landscape architects to advise on the most suitable treatment of the site as a whole.

11.4 Constructional Requirements

Where it is not expected to have the station building completed before the first unit is commissioned, it is common practice where convenient to arrange for the C.W. culverts and the coal feed to bunkers to enter the building at the end from which construction will start. By this means, as future units are installed it is only necessary to extend these services and this avoids constructing round working culverts and having to erect temporary supports under the bunker conveyors. It is usual to locate the ancillary buildings at the initial end of the station.

For efficient construction it is necessary to have adequate areas available adjacent to the station for site offices and the storage of contractors' materials. Rail access is usually arranged to these areas and from them into the station, so that materials, particularly steelwork, can be run in directly under the erection cranes. The coal store is frequently used in part for the purpose of storage.

Where stations are built in a location remote from available living accommodation, it is often necessary to provide a 'labour camp'.

This lesson has given some indication of the planning work and knowledge necessary before a power station design can be developed and applied to a particular site. Such knowledge has been accumulated from previous experience obtained in the construction and operation of power stations.

It is desirable that a plant operator should realise the reasons lying behind the arrangement and layout of the various items of plant in his station and the degree of skill and special knowledge exercised by other members of the Board's team before the plant could be placed in position for him to operate. He should regard himself as a full member of the Board's team and should use his skill and special knowledge to bring to light any points where he finds in operating the plant, that improvements might have been possible.

Questions on Lesson 2 - Development of the Power Station Site

Please answer any four of the following questions

1. A station is to be constructed on a site in the locality of which coal working is known to be taking place.

   (a) Describe what action should be taken and why.

   (b) Assuming that coal is to be extracted under site, what action would be necessary to safeguard against settlement.

2. The ground level of a projected station is subject to flooding when the river is at maximum flood level. Describe the different ways of affording protection, and how the choice would be influenced by the cost of importing filling material.

3. A station layout is being prepared.

   (a) Describe the principal consideration in deciding on a transverse or longitudinal layout of turbo-generators.

   (b) Why is it an advantage to adopt a similar make of unit throughout the station?

   (c) Why is it an advantage to have a loading bay at each end of the turbine house?

4. A projected station will need to circulate 15 million gallons of water per hour through the condensers, and there is insufficient water available in the adjacent river for any direct cooling.

   (a) State which system of cooling would be adopted.

   (b) Explain for What purpose, and what quantity of water would need to be abstracted from the river.

5. Define the three distinct sections in a standard sidings layout, and describe the system of working. What are the two fundamental advantages in operation?

6. A projected station will have an annual coal consumption of 2.25 million tons. Assuming coal deliveries over 5 days per week for 50 weeks a year, in 21 ton hopper wagons (average load 20 tons) and 45 wagon trains. (Wagon length 24'6" over buffers plus 9" extended chain coupling = 25'3".)

   (a) What clear length would be required in the reception siding allowing 100' for loco and brake, and 50' clearance?

   (b) How many trains per day would there be, and what length of track should be provided in the exchange siding, assuming one train per track?