PAPER No. 104.

THE CONSTRUCTION OF THE RAWALPINDI CITY WATER-SUPPLY EXTENSION SCHEME.

By Mr. J. A. R. BROMAGE, A. M. Inst. C. E.,
Executive Sanitary Engineer.

Rawalpindi is one of the most important garrison towns of India, and this, together with the fact that it is the railhead for Kashmir makes the city one of the most important in the Punjab.

Rawalpindi City first received a piped water-supply in 1887, and this supply has been in use since that date until the present time. The water is drawn from wells sunk in gravel beds alongside the Kurang river at Rawal, about seven miles away, and flows by a gravity duct to the city boundary, whence it is taken over the city area by a network of pipe lines.

At the time this work was built the population of the city was 45,000 and the supply far exceeded the demand of the city alone and in 1888 the scheme was taken over by the Military authorities in consideration of a cash payment. It has since been run by them as a joint supply, 8/13ths normally going to Cantonments and 5/13ths of the water going to the city, the total normal flow being 1,690,000 gallons daily.

As, however, in dry years the city's share of the supply may fall as low as 250,000 gallons daily, and as the population was increasing, the Municipality in 1921 consulted the Sanitary Engineer to Government, Punjab, on the possibility of increasing its share of the supply.

The possibility of increasing the existing duct supply was first investigated but it was finally decided that it would be advisable to augment the existing supply from an independent source.

On geological considerations a site for a trial boring was selected on the Saidpur Road about one mile beyond the Northern boundary of the city and here, at about 57 feet below ground level, water bearing gravel beds were struck. In order that the new source might be thoroughly tested, an experimental well 20 feet in diameter was sunk at this spot. The occurrence of rock and the large volumes of inflowing water made the sinking of this well exceptionally difficult.

The well curb is of reinforced concrete with a steel cutting edge and the steining below water level is 2' 3" thick, above water level 1' 10½". The whole is tied in by 16 anchor bolts 1 inch diameter extending to an anchor ring well above water level. Excavated earth was removed by a steam winch operating " Orange peel " pattern grabs. Water level was kept down by means of pulsometers, and for the later stages of the work four of these with an aggregate capacity of over 35,000 gallons hourly were simultaneously at work. The test results in 1923 were so

promising that the project now to be described was prepared, and received technical sanction in 1924. The well already mentioned, together with a second well 15 feet in diameter form the new source of supply and water from these, together with that from the existing duct is pumped into a new raised service reservoir of 300,000 gallons capacity, whence it flows through a new 18 inch main to the existing city distribution system. The first 20 feet well forms the centre of the headworks and round it the pumping station has been built. This new project thus fulfils the double purpose of augmenting the existing supply and of increasing the pressure of the whole supply. This increased pressure raises the terminal head at the commencement of the city pipe lines from about seven feet to about forty feet and thus increases the capacity of the existing pipe lines, without reducing the terminal pressures at the stand-posts.

The project may be divided into three subworks :—namely Head-works, Supply Main and New City Pipe Lines, the total of the sanctioned estimate for these works (excluding land acquisition) being Rs. 6,43,133).

The mixed well water and duct water is not filtered but the question of chlorination is under consideration. The Municipality resolved to entrust the execution of the scheme to the Public Works Department and funds to the extent of half the total cost of the scheme became available in May 1924. Tenders for suitable pumping plant in accordance with the specification had already been called.

The population of Rawalpindi City according to the 1921 census was 55,251 and the scheme has been designed to supply a *minimum* of 17 gallons per head daily for a population of 75,000 or 1,250,000 gallons daily. The city's share of the original duct supply may rise to 650,000 gallons daily and therefore the pumping plant for this part of the supply has to be capable of delivering 680 gallons per minute over a 16 hours day. In such times the total capacity of the scheme would be 1,650,000 gallons daily or 23 gallons per head for a population of 75,000. At the time of minimum flow in the duct, the well pumps would be required to deliver 1,000,000, gallons daily or 1,050 gallons per minute over a 16 hours day.

In view of the fact hat Rawalpindi was about to have (and now has) a public electricity supply, the advisability of using electric or other power was considered, but finally it was decided that crude oil engines would be used. In the first place the Electric Supply Coy. was not in a position to supply current at a rate which would compete with crude oil and secondly the maintenance of a public water-supply being such a vital matter it was felt that absolute independence from an outside source of power was essential. The order for the pumping plant was finally placed in June 1924 with Jessop & Coy. of Calcutta.

The existing duct supply is brought in a brickwork egg-shaped conduit 1,000 feet long 1′8″ × 2′ 6″ falling at 1 in 500 to a sump well adjacent to the pumping station. For raising this supply duplicate

pumping sets are provided, each consisting of a 30 B. H. P. Tangye cold starting crude oil engine driving by means of an inclined belt a 6 inch Tangye medium lift centrifugal pump. Each set delivers 680 gallons per minute against a total head of 65 feet and is capable in a 16 hour day of dealing with the maximum yield of the duct. The water is discharged through a 10 inch rising main and Leeds Helix Meter to the common 15 inch main and thence to the service reservoir. The rising main of both these and the high lift pumps inside the pumping station are of Cast Iron with "Victaulic" joints. These joints allow a certain amount of flexibility and have so far proved most satisfactory.

For raising water from the wells duplicate pumping sets are again provided each consisting of a 77 B. H. P. Tangye cold starting crude oil engine driving a three throw single acting well pump through a friction clutch and double helical gearing. Each pump was designed to deliver 1,050 gallons per minute against a total head of 110 feet, when running at 36 R. P. M.

The engines at first sight may appear to be somewhat in excess of the actual power required, but, when due allowances have been made for elevation and temperature,* it will be seen that the powers provided enable them to run at about 75 % to 80 % of maximum power, a most desirable margin with pumping engines running long hours. In designing the pumps it was assumed that they would be running for sixteen hours daily and so the staff work in two complete shifts.

The three throw pumps have been specially designed for the work and to fit the well and their construction shown diagramatically in figure I is somewhat unusual. They are single acting with rams $3\frac{1}{2}$ inches diameter by 21 inches stroke, the upward stroke being the working one. These rams run through the pump casing on the lower side and adjustable glands at each end of the working barrel give a perfectly tight water seal. A coupling connects the ram to the operating rod and by releasing this the ram can be lowered clear of the pump on to a trolley on which it is run clear of the pump for lifting to ground level. Each barrel has two suction and two delivery valves, all working vertically and each valve can be independently removed without disturbing any other part of the pump.

It was desired to keep the number of valves to a minimum, but with only one suction and one delivery valve to each plunger the sizes would have been too great. All valves are interchangeable and are spring controlled. The adjustment of these springs can be made while the pump is running and in practice the arrangement gives very smooth working. The valves have faces of phosphor bronze and no leather buckets or packing are used anywhere in the pump.

Steel ladders and platforms give access to all lubricating points and arrangements are provided to prevent oil falling into the well. High

* Rawalpindi is about 1,700 feet above sea level and has a shade temperature ranging from 30° to 118° F.

speed hearings are ring lubricated and low speed bearings are wick lubricated. Pump glands are packed with greased packing.

Priming valves and pressure release valves operated from the main control platform at floor level are provided and each pump is equipped with suction and delivery gauges and revolution counter.

The two wells spaced at 200 feet centres are connected by an 18 inch steel main laid as a syphon with vertical arms 18 feet long in each well. This pipe is laid below water level and 34 feet below ground. In order to keep the excavation for the pipe to a minimum, a length of trench forty feet long by six feet wide thirty-two feet deep and suitably timbered was cut midway between the two wells and from this a heading 6 feet by 4 feet and 120 feet long was driven to the well in the pumping station. This heading had to be closely timbered throughout, being in wet clay. A trench 2 feet square was then dug in the heading in which the 18 inch syphon pipe was laid, this trench just filling with water and so making the syphon self-priming.

The pipe having been laid from the pumping station well up to the open excavation, the heading towards, the second well was commenced, the earth excavated being used to fill the first heading, so saving the cost of lifting. As this first heading was filled, the timbering was removed and used in the second heading. The pipe was then laid in the second heading as before. The original trench was then refilled, timbering at the same time being withdrawn.

Timbering after removal, was transferred to another similar work elsewhere and so was put in at a minimum of cost, out of all comparison with the large cost which would have been involved, if an open untimbered trench had been employed. To avoid any chance of these workings disturbing the walls of the pumping station, the latter, over the alignment of the pipe tunnel and 10 feet on each side thereof are carried on reinforced concrete laid as a lintel spanning the area in question.

The crude oil is stored in a steel reservoir of 3,650 gallons or 15 tons capacity 8′ 0″ diameter and 11′ 0″ high with dished ends, outside the engine house and oil is forced from here to the engine service tanks by compressed air under a pressure of 20 lbs. per square inch, supplied from the main engine air receivers. Suitable arrangements for warming the crude oil reservoir and piping in cold weather by means of the engine exhaust gases have been fitted. Gauge glasses fitted to the tank enable the stock of oil to be verified at any time.

When tenders were called for the pumping plant, they were also called for the supply and erection of a service reservoir of 300,000 gallons capacity. The relative advantages and costs of cast iron, steel and reinforced concrete were considered and designs prepared, but finally the tender of Jessop & Coy. for a steel tank was accepted. The tank is in two compartments, each with floor level 24 feet above mean ground level at the headworks site. As this ground level is 12 feet above the full supply level of the old gravity duct at the point where the city pipe

work, pipes and similar stores arriving was considerable, careful arrangements had to be made for their proper unloading and stacking on the headworks site. For this purpose a plan was prepared of the headworks area and thereon was marked the position for storing the respective materials as and when they arrived, such storage sites being as near as possible to the final resting place of the articles concerned.

The pipes for the distribution system were stacked at several sites conveniently placed for subsequent laying. In this way heavy machinery was not inadvertently dumped on a site where subsequently a building had to be erected, double handling of material was eliminated and checking of stores facilitated.

On August 22nd, the erection of the pumping machinery commenced. The low lift pumps are fixed in a chamber ten feet below the pumping station floor and are driven by the 30 B. H. P. engines by inclined belt drives. Necessary priming valves are fitted and access to the pump chamber is obtained by a steel stairway. Any surplus water collecting in this chamber is removed by a semi-rotary hand pump. The walls of the chamber and also those of the pumping station are covered with white glazed tiling and this, together with a black and white tiled floor, makes a very clean building.

The well pumps are carried on a girder framework at and below spring level in the 20 feet well, these girders being 30 feet long to give a proper bearing surface in the steining and ground each side. The lowering of this framework was an exceedingly difficult operation in the 20 feet well and headings had to be driven at and below spring level through the steining and into the natural ground beyond to receive the girder to enable it to slide into position. As these headings were largely below spring level, close timbering was employed therein and excavation was done by shovels made locally for attaching to ordinary pneumatic rivetters. Water was kept down continuously during the tunnelling and lowering operations. After fixing the girders in position the spaces for about two feet below and around were filled up solid with cement concrete (1 : 2 : 4), and the remaining cavities were filled with wet clay in cement bags, such cavities being finally filled with cement concrete after the well steining was rebuilt. This refilling was a decidedly dangerous operation as the 77 H. P. engines were overhead, and the cavities had to be filled up absolutely solid after the timbering was removed.

Radiating from this main girder framework is a gallery of girders carrying a chequer plate platform covering the whole well and from which the pumps can be attended.

Erection of the pumps then proceeded from the girders upwards and the engines were aligned on the pumps after the latter had been erected. Access to the under sides of the pumps for adjusting glands and removing plungers is obtained from a platform 10 feet below spring level, but which is uncovered when one pump is working. The fixing of this platform had to be done after the pumps were fixed in order that one pump might run to keep the water down for men working on this fixing.

In order to reduce friction during sinking, excavation for the well was carried to a depth of 25 feet with a diameter 2 feet in excess of the well diameter. The large engines are directly over this space and so, in order to provide a foundation not liable to settlement this 25 feet was filled with 9 feet of stone ballast over which was laid 14 feet of cement concrete.

As the well rests on rock the chances of any settlement occurring are so remote as to be negligible. As a further precaution the top girders of the pumps carrying the crank shaft and gearing were carried through into this concrete and the engine foundations were also reinforced by steel girders tied thereto.

Cooling water for all four engines is circulated by force pumps. Each engine has its own force pump, and all are inter-connected so that if one fails the pump of any engine can deliver circulating water to any other engine. The flow of water through the cylinder jackets and combustion chambers can be separately controlled.

This circulating water flows out through open tundishes fixed to the building wall, thermometers for testing the temperature can be inserted in the stream, and the existence of a proper flow can be watched. A brickwork reservoir of ample capacity is provided for the cooling water. It has two compartments, each with suction, delivery and filling connections so that either or both compartments may be used, thus facilitating periodical cleaning.

The Kerosine oil, crude oil and compressed air cylinders of each engine are placed in line along the pumping station wall. The air cylinders are interconnected and each can be charged from any of the main engines or from a separate air compressing engine situated in the workshop. The workshop, driven by this 3 B. H. P. oil engine, forms part of the main pumping station, is 44′-0″ by 11′-0″ and contains an $8\frac{1}{4}'' \times 8'$-0″ screw cutting lathe with necessary back gearing and complete sets of gear change and metric wheels, a drill, a pipe and bolt screwing machine, emery grinder and necessary bench tools for carrying out all running repairs.

An office and also a general store fitted with cupboards, shelves, oil cabinets and oil filter form part of the pumping station building.

A 3-ton overhead travelling crane running the full length of the building spans the pumping station and facilitates the execution of repair or replacement work.

The pumping station is lighted from the North by Crittall metal frame windows 9′-0″ × 5′-6″. In these large sizes the Crittall window is cheaper than wood both in first cost and erection, gives a greater percentage of light and resists attacks of white ants. No difficulty arises in fixing but care has to be taken that the frames are not used as supports for scaffolding.

The balance of the funds required for the completion of the work were received in April 1925 and tenders for the supply of piping, valves,

work, pipes and similar stores arriving was considerable, careful arrangements had to be made for their proper unloading and stacking on the headworks site. For this purpose a plan was prepared of the headworks area and thereon was marked the position for storing the respective materials as and when they arrived, such storage sites being as near as possible to the final resting place of the articles concerned.

The pipes for the distribution system were stacked at several sites conveniently placed for subsequent laying. In this way heavy machinery was not inadvertently dumped on a site where subsequently a building had to be erected, double handling of material was eliminated and checking of stores facilitated.

On August 22nd, the erection of the pumping machinery commenced. The low lift pumps are fixed in a chamber ten feet below the pumping station floor and are driven by the 30 B. H. P. engines by inclined belt drives. Necessary priming valves are fitted and access to the pump chamber is obtained by a steel stairway. Any surplus water collecting in this chamber is removed by a semi-rotary hand pump. The walls of the chamber and also those of the pumping station are covered with white glazed tiling and this, together with a black and white tiled floor, makes a very clean building.

The well pumps are carried on a girder framework at and below spring level in the 20 feet well, these girders being 30 feet long to give a proper bearing surface in the steining and ground each side. The lowering of this framework was an exceedingly difficult operation in the 20 feet well and headings had to be driven at and below spring level through the steining and into the natural ground beyond to receive the girder to enable it to slide into position. As these headings were largely below spring level, close timbering was employed therein and excavation was done by shovels made locally for attaching to ordinary pneumatic rivetters. Water was kept down continuously during the tunnelling and lowering operations. After fixing the girders in position the spaces for about two feet below and around were filled up solid with cement concrete (1 : 2 : 4), and the remaining cavities were filled with wet clay in cement bags, such cavities being finally filled with cement concrete after the well steining was rebuilt. This refilling was a decidedly dangerous operation as the 77 H. P. engines were overhead, and the cavities had to be filled up absolutely solid after the timbering was removed.

Radiating from this main girder framework is a gallery of girders carrying a chequer plate platform covering the whole well and from which the pumps can be attended.

Erection of the pumps then proceeded from the girders upwards and the engines were aligned on the pumps after the latter had been erected. Access to the under sides of the pumps for adjusting glands and removing plungers is obtained from a platform 10 feet below spring level, but which is uncovered when one pump is working. The fixing of this platform had to be done after the pumps were fixed in order that one pump might run to keep the water down for men working on this fixing.

In order to reduce friction during sinking, excavation for the well was carried to a depth of 25 feet with a diameter 2 feet in excess of the well diameter. The large engines are directly over this space and so, in order to provide a foundation not liable to settlement this 25 feet was filled with 9 feet of stone ballast over which was laid 14 feet of cement concrete.

As the well rests on rock the chances of any settlement occurring are so remote as to be negligible. As a further precaution the top girders of the pumps carrying the crank shaft and gearing were carried through into this concrete and the engine foundations were also reinforced by steel girders tied thereto.

Cooling water for all four engines is circulated by force pumps. Each engine has its own force pump, and all are inter-connected so that if one fails the pump of any engine can deliver circulating water to any other engine. The flow of water through the cylinder jackets and combustion chambers can be separately controlled.

This circulating water flows out through open tundishes fixed to the building wall, thermometers for testing the temperature can be inserted in the stream, and the existence of a proper flow can be watched. A brickwork reservoir of ample capacity is provided for the cooling water. It has two compartments, each with suction, delivery and filling connections so that either or both compartments may be used, thus facilitating periodical cleaning.

The Kerosine oil, crude oil and compressed air cylinders of each engine are placed in line along the pumping station wall. The air cylinders are interconnected and each can be charged from any of the main engines or from a separate air compressing engine situated in the workshop. The workshop, driven by this 3 B. H. P. oil engine, forms part of the main pumping station, is 44′-0″ by 11′-0″ and contains an $8\frac{1}{4}'' \times 8'$-0″ screw cutting lathe with necessary back gearing and complete sets of gear change and metric wheels, a drill, a pipe and bolt screwing machine, emery grinder and necessary bench tools for carrying out all running repairs.

An office and also a general store fitted with cupboards, shelves, oil cabinets and oil filter form part of the pumping station building.

A 3-ton overhead travelling crane running the full length of the building spans the pumping station and facilitates the execution of repair or replacement work.

The pumping station is lighted from the North by Crittall metal frame windows 9′-0″ × 5′-6″. In these large sizes the Crittall window is cheaper than wood both in first cost and erection, gives a greater percentage of light and resists attacks of white ants. No difficulty arises in fixing but care has to be taken that the frames are not used as supports for scaffolding.

The balance of the funds required for the completion of the work were received in April 1925 and tenders for the supply of piping, valves,

At the time of writing the second well is not complete as owing to lack of funds a start could not be made until the end of 1925. Excavation and sinking are proceeding on usual lines but progress through the upper strata of thick clay has been slow. For breaking the rock which it is anticipated will be encountered at about 55 feet below ground, compressed air drilling plant will be used. This plant was also used for breaking open the fissures in the rock bottom of the first well.

etc., were called at once. The 18 inch supply main is of British Mannesmann steel tubing ¼ inch thick in 24½ feet lengths with spigot and socket lead run joints and is just under one mile in length. The length of these pipes enables half the number of joints as compared with cast iron to be used. The pipes are coated in the same manner as cast iron and in addition are wrapped with Hessian to prevent corrosion. As compared with Cast Iron, steel pipes are about 20 per cent. cheaper in first cost and 50 per cent. cheaper to lay. This main and all mains were tested to a minimum pressure of 80 lbs. per square inch. The 18 inch main is designed to give a discharge of 2,700 gallons per minute or 2½ times average flow, friction being calculated by Kutter's formula.

Inside the city there were a number of new areas which were without water supply facilities and pipe lines have, as part of this scheme been laid in these areas. These lines vary from 6 to 3 inches in diameter and have an aggregate length of about 6 miles. The contract for the supply of cast iron pipes and specials for this work was placed with the Bengal Iron Coy. All pipes are of British Standard Specification Class B and specials of class C and D. All sluice valves have been supplied by Messrs. Glenfield and Kennedy, and are, with a few exceptions of the double socket type.

A number of 10 inch steel mains have also been laid.

The site of the city being by no means flat, in order to ensure an even flow at fill times of demand, a balancing reservoir of 10,000 gallons capacity has been built adjacent to the old fort, the highest point in the city. The floor of this tank is 12 feet above ground and 20 feet below the floor of the service reservoir at the headworks. Overflowing is prevented by the inlet being controlled by an equilibrium ball valve, and a non-return valve on the outlet only opens when the terminal head at this, the highest point, falls below the water level in the tank.

The refinery of the Attock Oil Coy. is 8 miles from the headworks and a metalled road being available the wholeway, a 1½ ton motor tank lorry for carting crude oil is provided as part of the scheme. A garage with inspection pit and petrol store is provided at the headworks and herein lifting tackle is fitted for removing the oil tank from the main chassis, thus enabling the vehicle to be used for general municipal purposes.

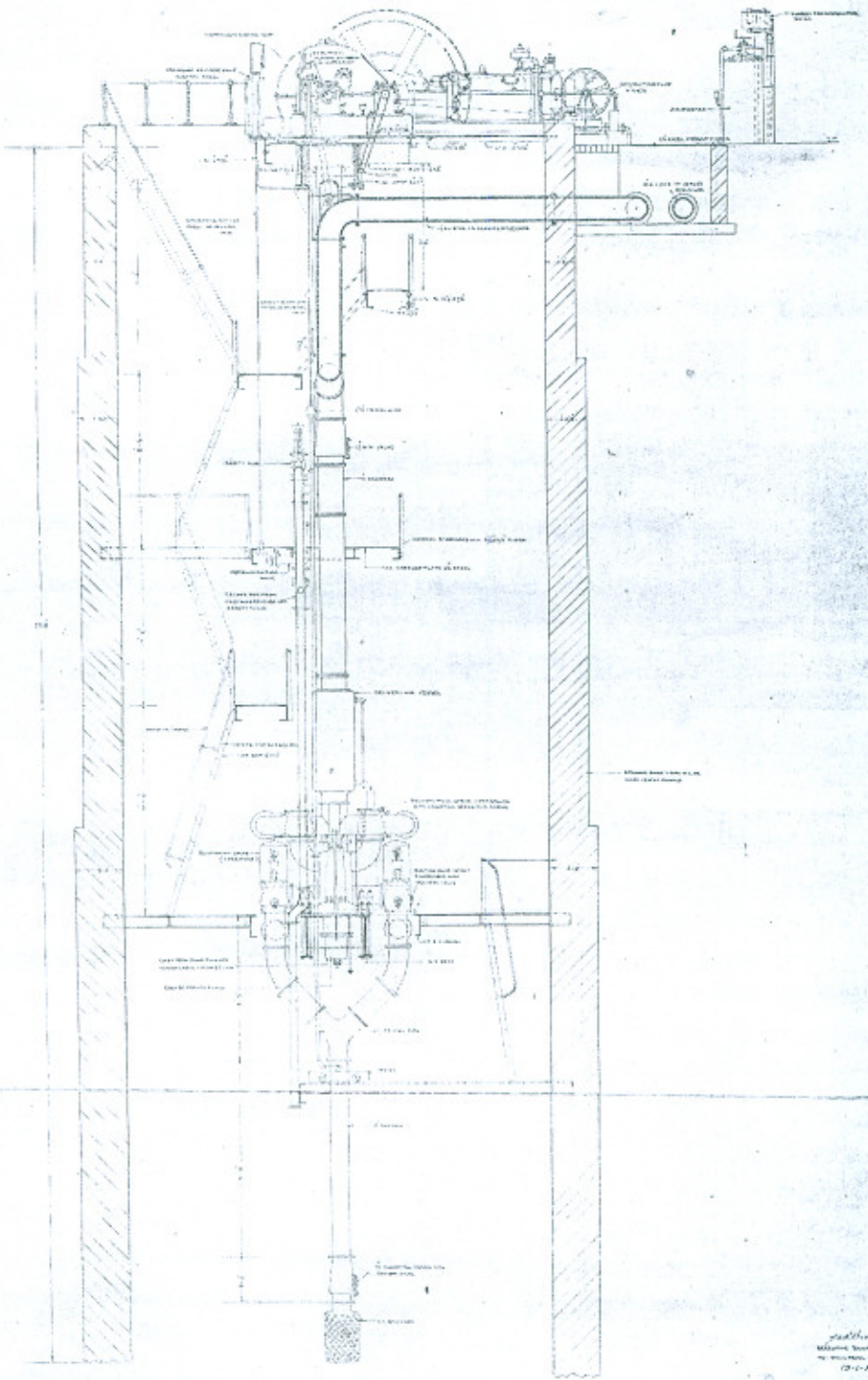
The lorry tank has coupling arrangements for connecting with the crude oil storage tank and is emptied by compressed air. The air is supplied from the main engine air pipes and is supplied to the lorry tank through a flexible pipe and non return valve. The transferring of one tin of fuel oil from the lorry to the reservoir takes about three minutes. Thus nowhere is crude oil (always a messy substance) carried in open vessels.

From the date the first order was placed to the date of opening was 18 months and from the date access was obtained on the headworks site to the date of opening was 14 months.

RAWALPINDI WATER WORKS EXTENSIONS

COMPLETION PLAN

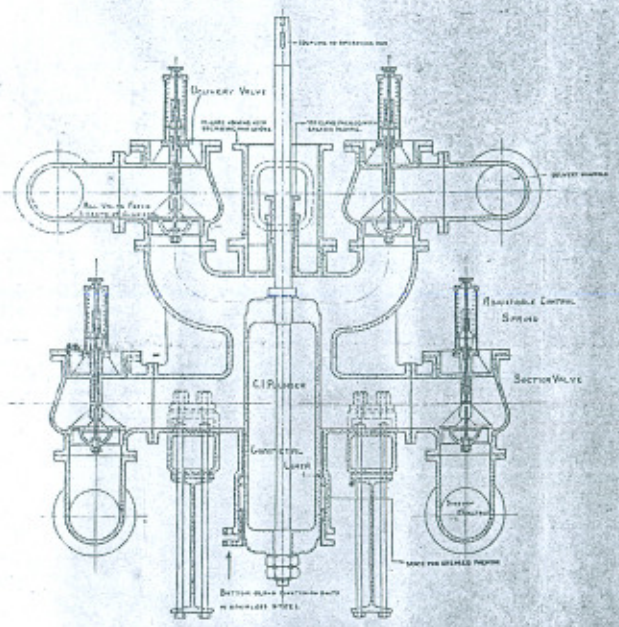
WEST PUMPING PLANT



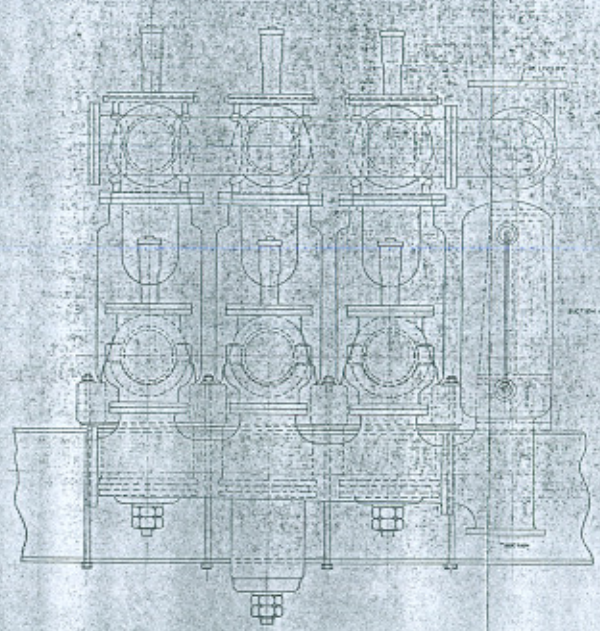
RAWALPINDI WATER WORKS EXTENSIONS

DIAGRAM OF RAM PUMPS

CROSS. SECTION



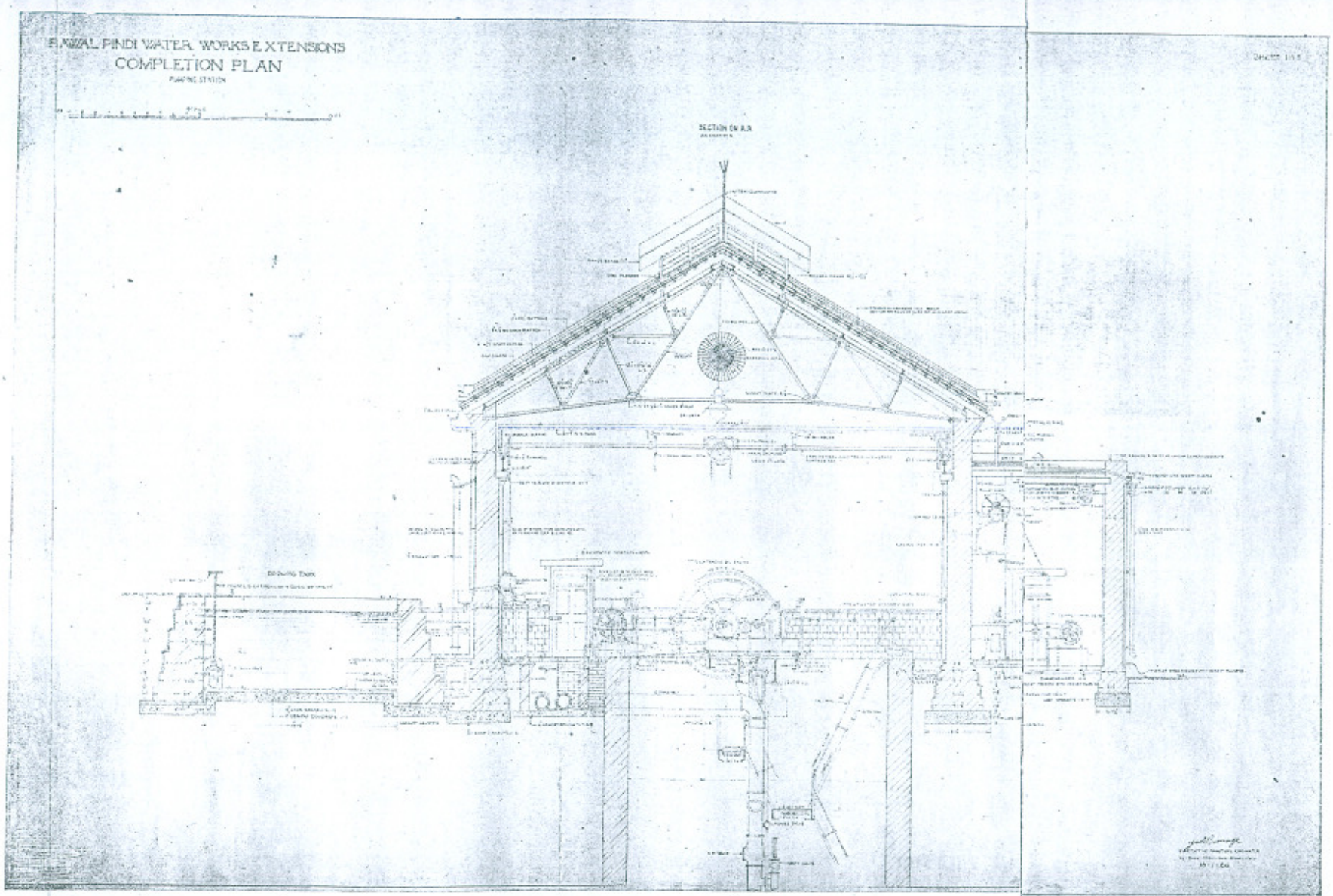
SIDE ELEVATION



RAWAL PINDI WATER WORKS EXTENSIONS

COMPLETION PLAN

PUMPING STATION



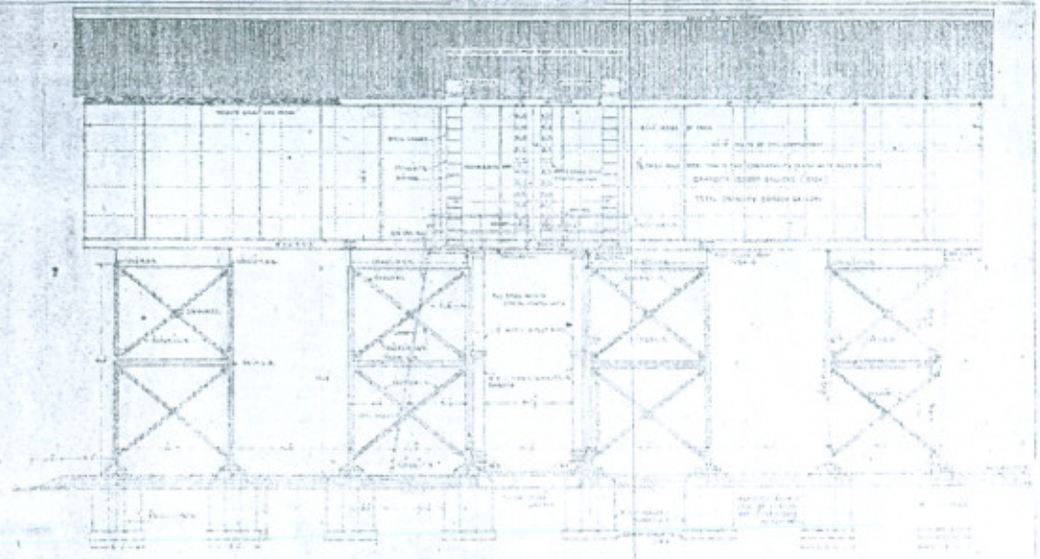
COMPLETION PLAN

RAWALPINDI WATER WORKS EXTENSIONS

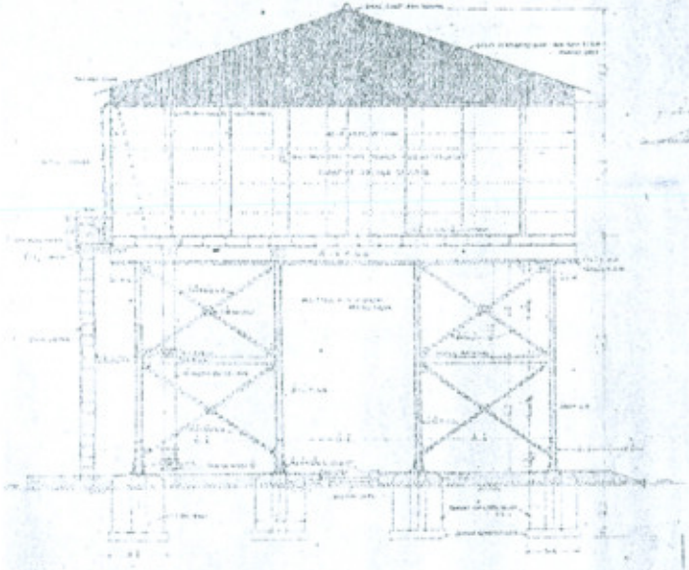
STEEL SERVICE RESERVOIR

SHEET NO. 2 A

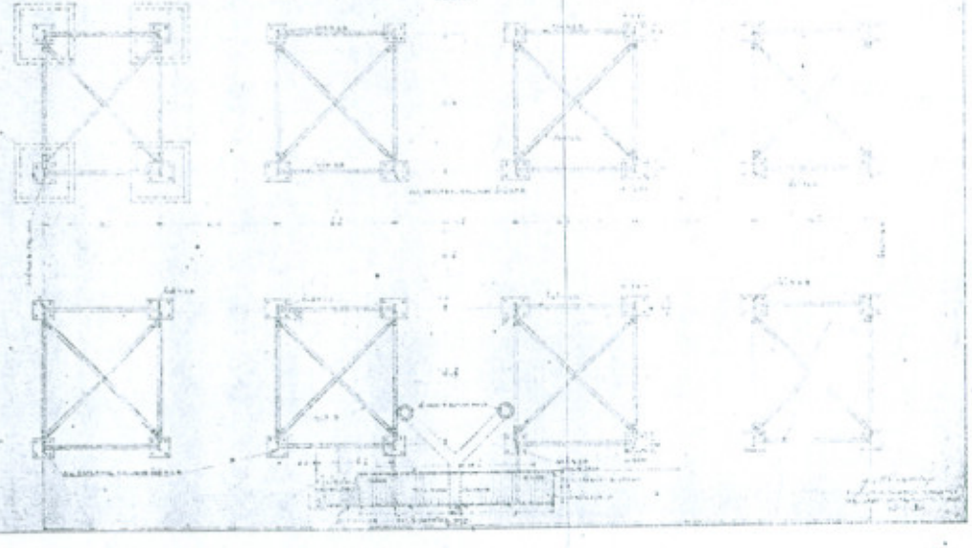
FRONT ELEVATION

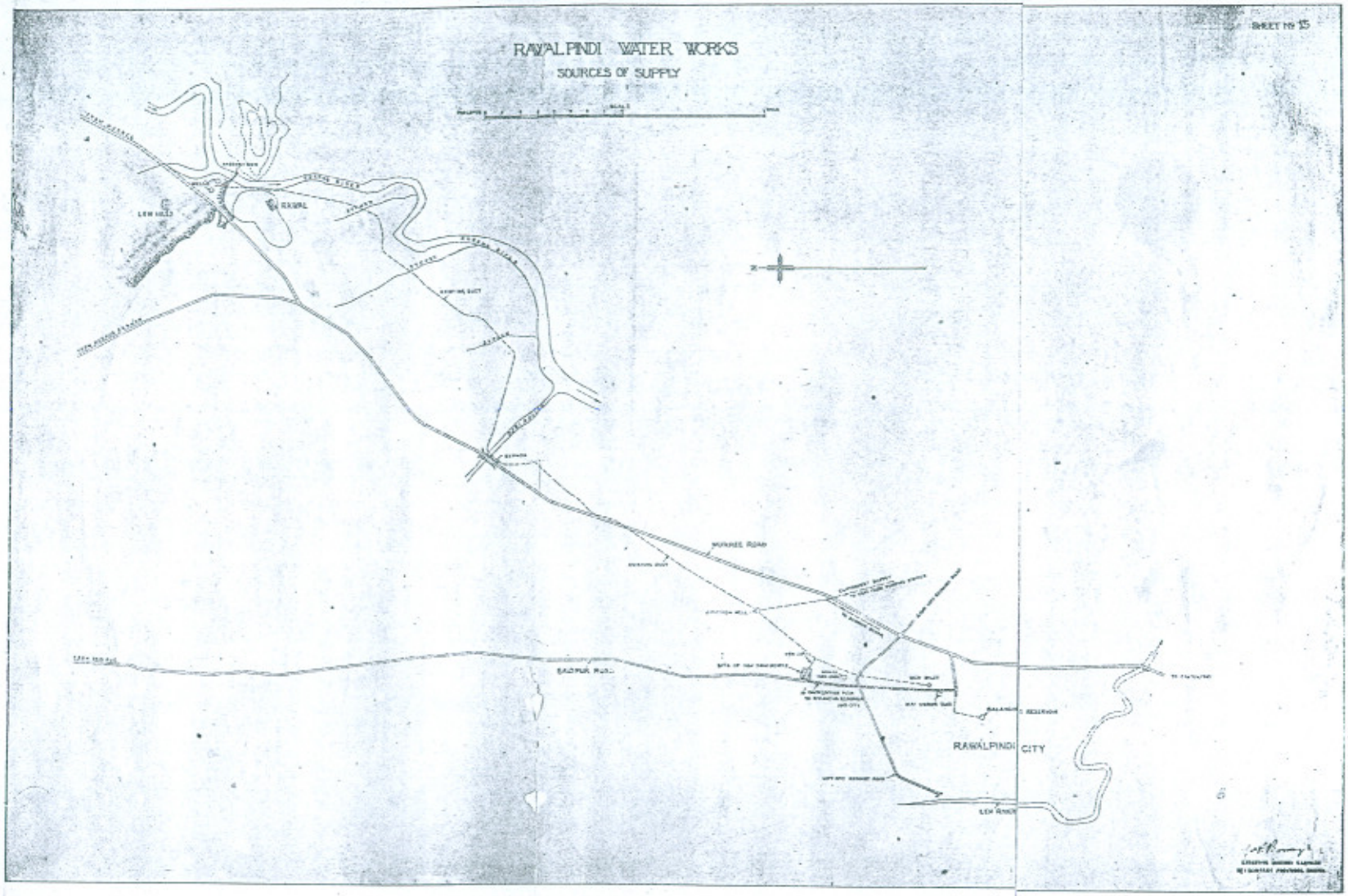


END ELEVATION



PLAN

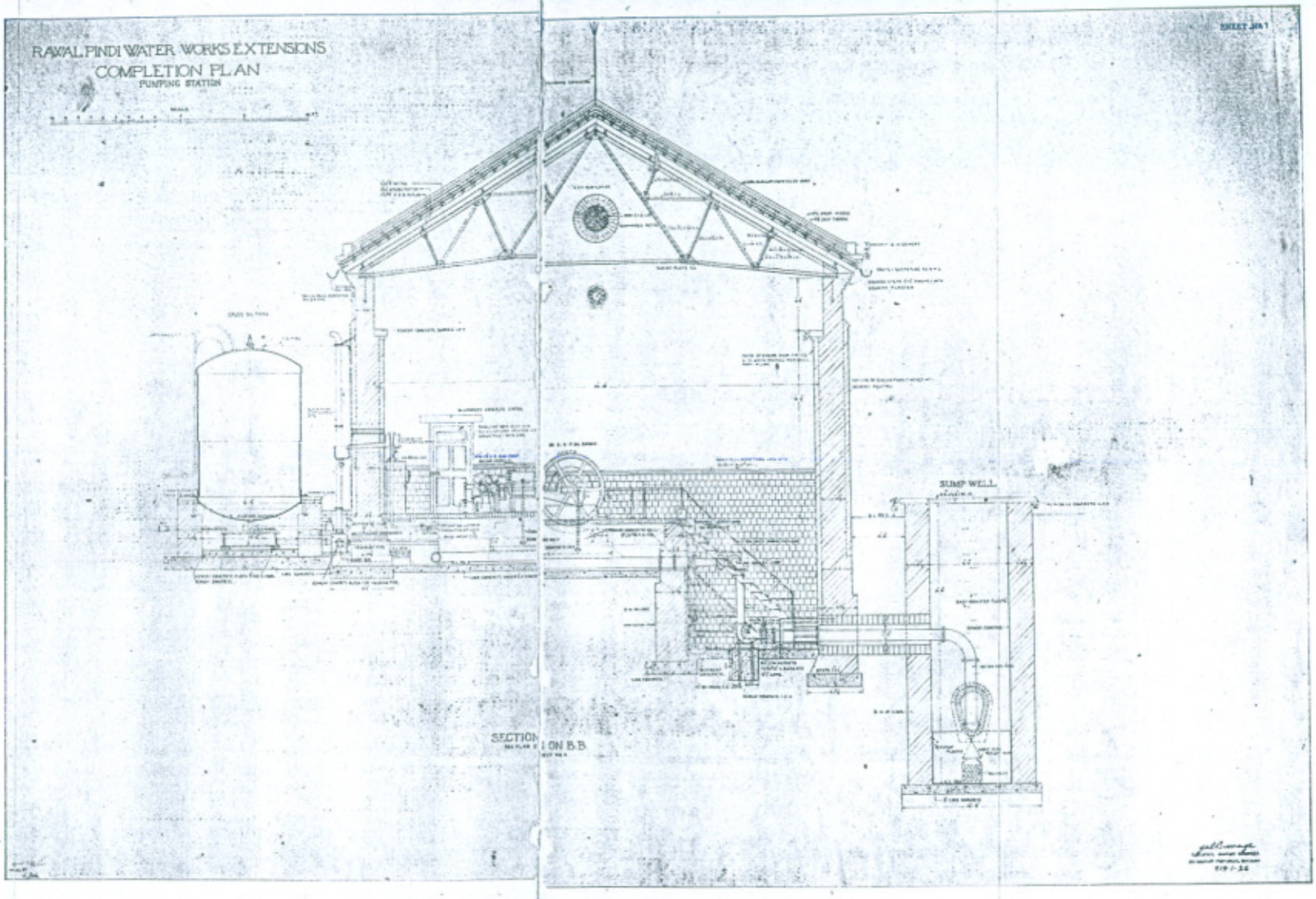



RAWALPINDI WATER WORKS
SOURCES OF SUPPLY
SHEET No 15
RAWAL
MURREE ROAD
RAWALPINDI CITY

RAWALPINDI WATER WORKS EXTENSIONS

COMPLETION PLAN

PUMPING STATION



SECTION ON B.B

was 5 times the average yield obtainable from ordinary percolation wells in the plains. He described the cement concrete curb and said it had stood the pressure stresses quite well. The speaker mentioned another feature which was good from a sanitary point of view, *i. e.*, the efficient arrangements made to prevent oil falling into the well, and also the arrangements for transferring fuel oil from the lorry to the reservoir described on page 95 of the Paper.

He approved of the provision of the special self-contained septic-tank-type latrines for the staff because the headworks were some miles away from the city ; and noticed the attention paid by Mr. Bromage to the ' lay-out ' of the work, a point on which Mr. Hadow had laid stress while talking of the concrete work at Orki.

MR. ASTBURY spoke of the limitations made by the Chief Engineer on the carrying out of the work and of the financial limitations. He said that these limitations were necessary because local bodies were not always able to fulfil their promises and Government had to place some limitations.

He further described the present scheme and said it was an extension of the original scheme of 1887 which had been carried out by the Municipality ; and said that on account of unskilled advice and of lack of power in the pumps and appliances, it had formerly been impossible to fully tap the source of supply.

He spoke of the different sites proposed for the scheme, and said that the supply wells which were usually at a distance, were in this case at the centre of the system.

He went on to say that the reading of this paper showed what a valuable thing to engineers a good mechanical engineering training was.

MR. POUND remarked that the economy of the pump placed in the well was not worthy of such a big scheme.

SIR GANGA RAM challenged the wisdom of only providing 2 engines, one working one standing. At the Renala Hydro-Elctric Scheme they had 3 turbines to work ; 2 were spare and one was a standbye. He said it would have been better to have had 4 engines of 12 H. P. than 2 of 20 H. P. Referring to Railway tanks he said 680 gallons per minute meant only 1·8 cusecs. He gave the following formula :—

Cusecs × Head × 2·9 gives the Brake H. P. on the basis of 50 per cent. efficiency.

1·8 × 65 × 2·9=26 B. H. P.

4 to 6 H. P. must always be added for the engine to drive itself. 3 engines of 12 H. P., or 4 engines of 12 H. P. would be better still.

MR. CHETTLE said it might be asked " Why not have burnt oil under boilers and used steam pumps." The reply was that the approximate thermal efficiency from a steam plant was 25 per cent. where as that of internal combustion engines was 35 per cent. First cost and number of staff required would also have been more. Regarding Sir Ganga Ram's remarks *re* standbyes, it might be taken generally that the smaller a power

unit the lower its efficiency. In contradistinction to Sir Ganga Ram's remarks on standbyes however there was much industrial machinery, which could only justify its capital cost by working 24 hour per day withou tany standbye, *e. g.*, modern flour-mills, oil presses, some automatic machine tools, etc., but—and this was a point to emphasise—that plant had to be efficiently and faithfully served. It did not do one month to cut down the quality of the lubricating oil, the next to cut down the quality of the fuel, the third to cut down the quality of the staff without noting on the other side the deterioration of the machinery. Rawalpindi Water Works have 100 per cent. standbye, a very wise provision in all waterworks in this country, considering the rapid growth of towns the availability of spares, the quality of attention received and the technical knowledge of the Municipal Committees. It had been said that Indian-made railway wagons compared favourably with imported ones, and there was evidence from various sources that the standard of structural, mechanical and electrical workmanship in India, *under good and efficient supervision* was not of an inferior quality.

Regarding Mr. Pound's suggestion of the well external to the engine house, to obtain best efficiencies, the suction head must be kept at the minimum possible. An external well would have involved bends and extra suction pipe, which would have increased the suction head by several feet, an undesirable feature.

MR. BROMAGE in reply to L. Jagan Nath said that the position of the pumps in the well could not be foreseen at the time of sinking as the well was sunk as an experiment two years before the project was prepared.

To Mr. G. T. Pound he said that the oil-catching arrangements were such that the chances of oil falling on to the water were very remote. Even if oil did so fall it would remain on the top surface of the water and would not get into the supply.

The 16 hours daily pumping was from 6 A.M. to 10 P. M. and in the real sense of the term there was no night shift. As between 10 P.M. and 6 A. M. the demand was practically nil, the capacity of the Service Reservoir was ample to supply the needs of this period.

Regarding Sir Ganga Ram's remarks he said that one point against multiplying the numbers of pumping units was that of expense both in first cost of the plant and also of the pumping station. A second was that a large unit (other things being equal) was more efficient than a small one. It should be remembered, moreover, that here there were not only duplicate pumping plants, but also duplicate sources of supply.

As regards the question as to why all quantities were given in gallons per minute and not cusecs it might be pointed out that this was the standard waterworks practice in England and America and therefore no departure therefrom had been made.

In reply to Mr. D. A. Howell he said that the number of valves had been kept small and the individual valves large firstly, for simplicity,