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Dr L. K. Ward
with compliments
12/1/40 R G Wilton.

K I N G S C O T E   A N D   B O R D E R T O W N

W A T E R   S U P P L I E S.

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By R.G. Wilton, A.M.I.E.Aust.

THE KINGSCOTE AND BORDERTOWN WATER SUPPLIES.

The town of Kingscote is situated on the western side of Nepean Bay, Kangaroo Island, at the foot of the Gulf St. Vincent and about 90 miles south-west of Adelaide, South Australia. It enjoys a particularly mild summer climate, and for this reason, and by virtue of the facilities for boating and fishing, is a popular summer resort. During recent years, modern methods of pasture development have led to the opening up of a good deal of land previously regarded as of very doubtful value, and the Island generally, as well as the town, is increasing in importance.

The settlement at Kingscote dates from July, 1836, six months before the official inauguration of the colony of South Australia. Since its inception, water supply has been one of its main problems. Whilst it enjoys a reasonably good rainfall (average 19½ inches per annum), there are no perennial streams, no high lands of any importance (particularly in the immediate vicinity of the town), and no natural features favourable to the artificial storage of rainfall. Attempts to locate underground supplies have been unsuccessful and the geological formations are not encouraging for further investigation of this possibility. Until last year the town has relied principally upon the storage in galvanised iron tanks of the rain shed from roofs of buildings, augmented by a Government tank of about 50,000 gallons capacity storing surface runoff from a very limited catchment, and by the Cygnet River.

The Cygnet River enters Nepean Bay about three miles south of the town. It drains an area of about 190 square miles. It has never been gauged, but judging from records of other streams in the State its average annual discharge is probably not less than 600 million gallons. Unfortunately, it has very little fall in its lower reaches, and is subject - or was prior to 1915 - to tidal influence for some miles from its entrance to Nepean Bay. In common with practically every stream in South Australia, except the River Murray, it discharges only during the winter and spring.

In 1915 a timber barrage, consisting of a single line of timber sheet piling about 30 feet deep below the bed of the stream

Timber Barrage at Kingscote.

and removable flash boards between high and low water, was constructed by the Government across the Cygnet River at a point about two miles upstream from its mouth. Its purpose was to retain the water above the barrage free from tidal intrusion, the flashboards being removed during the winter and replaced in spring as stream flow decreased. Generally speaking, it has fulfilled that purpose, and the comparatively fresh water stored in the lower reaches of the River above the barrage has been of inestimable value to the settlers for stock purposes. Unfortunately, however, the quality of the water so stored rapidly deteriorates through infiltration of saline water from the surrounding flats. Whilst the water is sufficiently good for sheep until quite late in, and sometimes right through, the summer, it generally is quite unfit for domestic purposes by the end of December, and sometimes earlier than that.

Here then was the obvious source of supply for the town of Kingscote; a river with an average annual discharge considerably in excess of requirements, but lacking in all other desirable features. The solution of the problem was sufficiently obvious. As no natural storage which could be developed to store the winter flow of the river existed, artificial storage must be constructed. Furthermore, this storage should preferably be at an elevation sufficient to command the town, and consequently the water to be stored in it must be pumped thereto during fresh water periods of the river. In any case, the storage must be above the river level, as maximum flood level of the river is only eleven feet above low water ordinary spring tides. If a suitable site for an excavated earthen reservoir had existed at an elevation intermediate between river level and that necessary to command the town, it might have proved economical to pump to such a storage and again thence to the town. Actually, surface and subsurface conditions in the vicinity of Kingscote are such that artificial waterproofing of any storage is essential, and consequently the site selected for the storage was such that it commands the town by gravitation.

As an alternative to the utilisation of the waters of the Cygnet River, and to avoid the cost of pumping, proposals were considered for the construction of an artificial catchment to

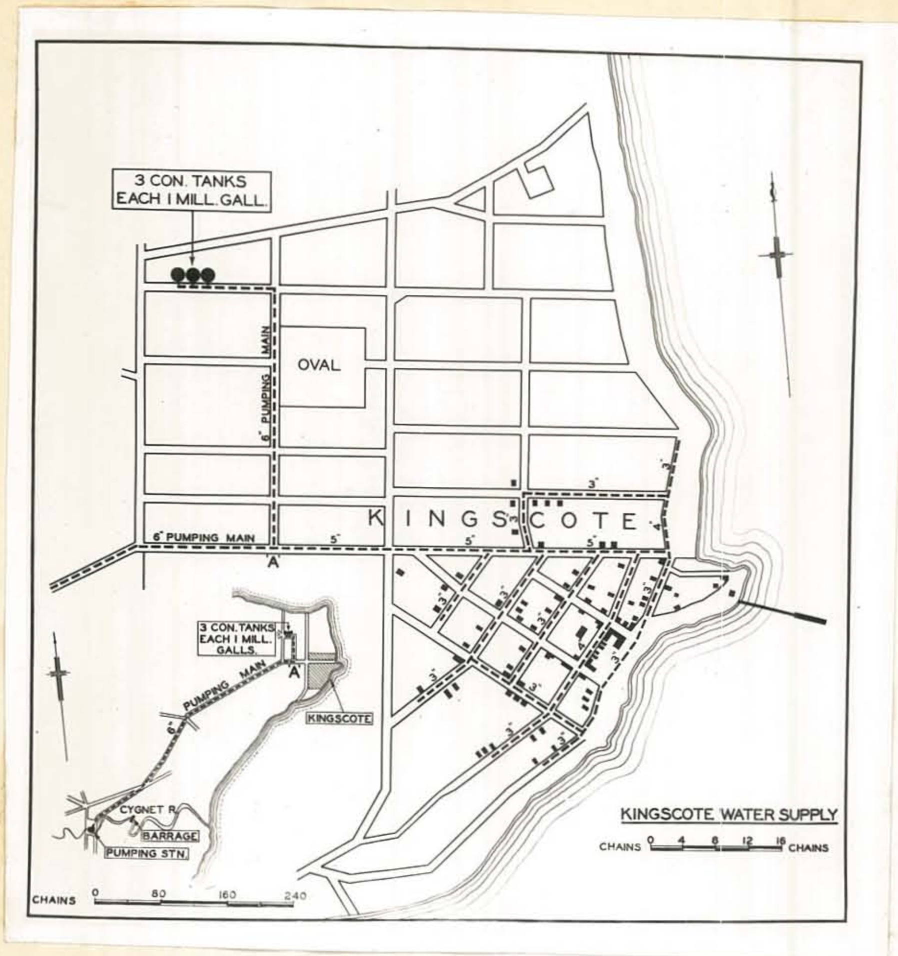
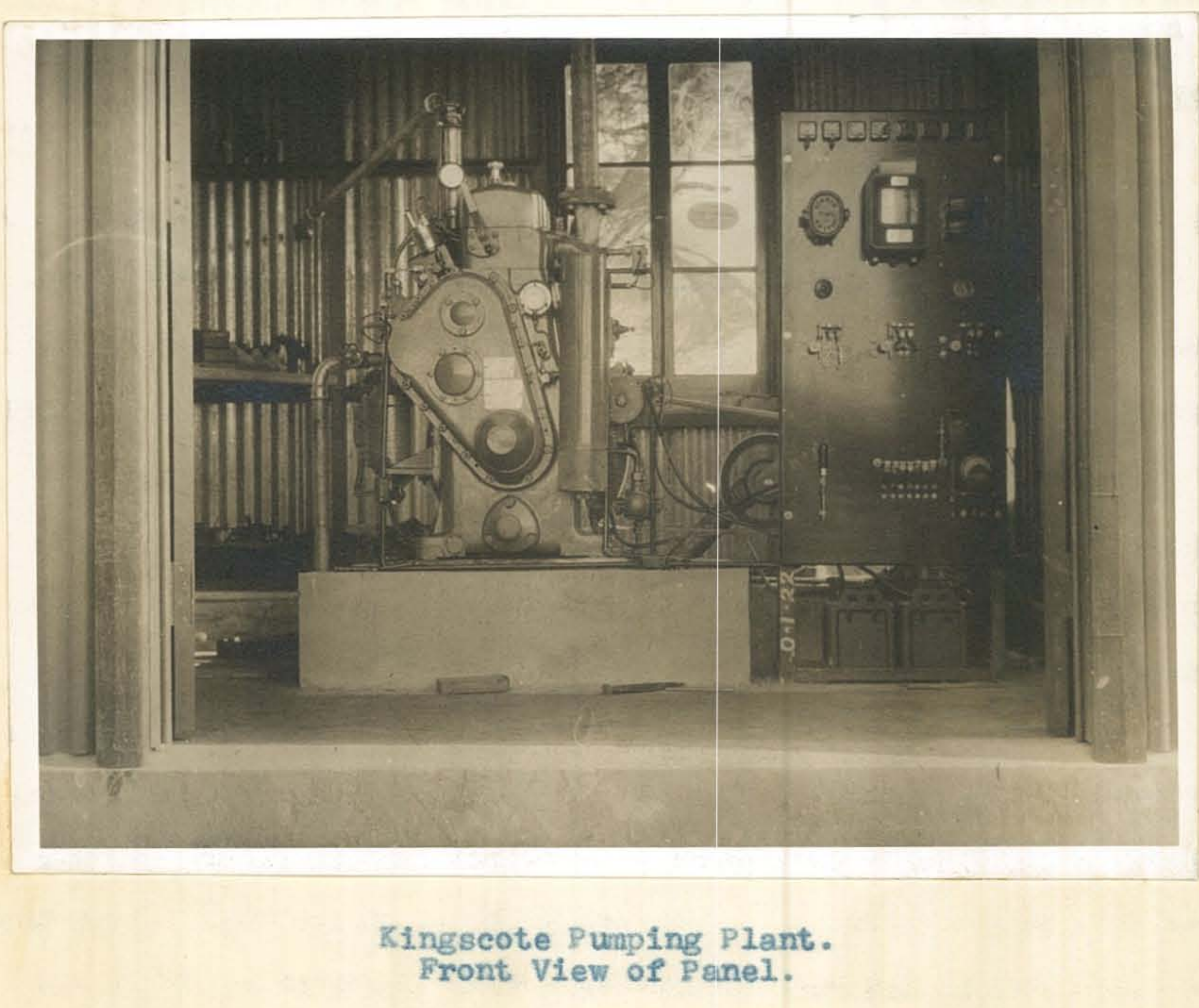


Fig. 3.
General Plan of Kingscote.
Showing Location of Pumping Plant, Tanks, etc.



Kingscote Pumping Plant.
Front View of Panel.

consist of five acres of graded and surfaced land at an elevation which would enable the discharge from the catchment to drain into the storage tanks. This proposal was abandoned because, first, the uncertainty of summer rainfall (particularly where so small a catchment area was involved) made reduction of storage capacity inadvisable; secondly, the cost of the artificial catchment would have been approximately the same as that of the pumping main from the Cygnet River; and thirdly, the annual cost of maintaining the catchment was estimated to be more than that of pumping from the Cygnet River.

The scheme as finally adopted provided for pumping from the Cygnet River during the late winter and early spring into storage tanks of a total capacity of three million gallons, and the reticulation of the township therefrom. The pumping main is of 6" nominal diameter, 4 miles 57 chains long, about 60 chains of which also do duty as the main delivery to the town. Reticulation mains comprise 47-1/3 chains of 5", 29¼ chains of 4", and 1 mile 60½ chains of 3" pipes. All pipes are of cast iron lined centrifugally with cement mortar, the lining reducing the nominal diameters by approximately ¼" in each case.

Pumping Plant.

The pumping plant is situated on the left bank of the Cygnet River about one hundred yards upstream from the road bridge on the Kingscote-Penneshaw Road, and about five miles from Kingscote. To compensate for vagaries of stream flow through seasonal conditions and to provide for expansion of the system, the capacity of the plant was made large relative to the storage, and the designed discharge of 100 gallons per minute is sufficient to fill the storage tanks in two months if the plant is worked for eight hours per day only.

In order to keep operation costs at a minimum, the plant is equipped for unattended running. In the circumstances, all the automatic safeguards developed in previous installations of this type have been included. Although there is no serious reason why the plant should not run continuously from the time at which the water in the River becomes suitable for use until the tanks have

Kingscote Pumping Plant.
General View.

been filled, it was considered desirable to limit the length of the running period each day, and, as automatic starting equipment did not constitute an appreciable item in the total cost, it was incorporated, the length of run being controlled by a clock switch.

The engine is a twin cylinder vertical diesel of 25 B.H.P. running at 920 R.P.M. When the clock switch contacts close, the main contactor operates to rotate a horizontal arm upon which is mounted a number of mercury switches. The angles at which these switches are mounted on the arm determine the time intervals between the various operations involved in the starting up of the plant. Briefly, the sequence is as follows:- The starter motor is engaged with the ring gear on the flywheel to turn the engine over, the fuel pumps being inoperative at this stage. As speed is attained, the fuel pumps are brought into operation by means of a solenoid, and the engine fires. As engine speed further increases, the load is taken up by means of a centrifugal clutch pulley. At the same time, the generator is put in circuit with the battery through a voltage regulator for recharging purposes. The system operates at 12 volts, the batteries consisting of two 6-volt 19-plate standard car batteries in series. Safety devices as enumerated below are incorporated in the control circuits, and if any one operates, a shutter is released revealing a printed card giving particulars of the control which has caused the plant to stop:-

If the starter motor operates for thirty seconds without the engine starting, a thermal relay opens the circuit;

An exhaust thermostat similarly operates a thermal relay if exhaust temperature increases beyond a predetermined value;

Float switches protect the plant in the event of fuel oil or cooling water tank levels falling too low;

A thermostat in the cooling water circulating system operates a thermal relay to open the control circuit if the water becomes too hot. A pressure switch opens the circuit if the lubricating oil pressure is not maintained. A pressure switch on the pump delivery opens the circuit if pumping pressure is not maintained;

Aerial View of Kingscote.

When the plant is stopped, either by operation of the clock switch or any of the protection devices, the fuel pumps are immediately thrown out of operation and the engine comes to rest without fuel injection, but with oil circulation (unless, of course, failure of the latter is the cause of stoppage);

An operation recorder supplies a weekly chart of the times of operation of the plant.

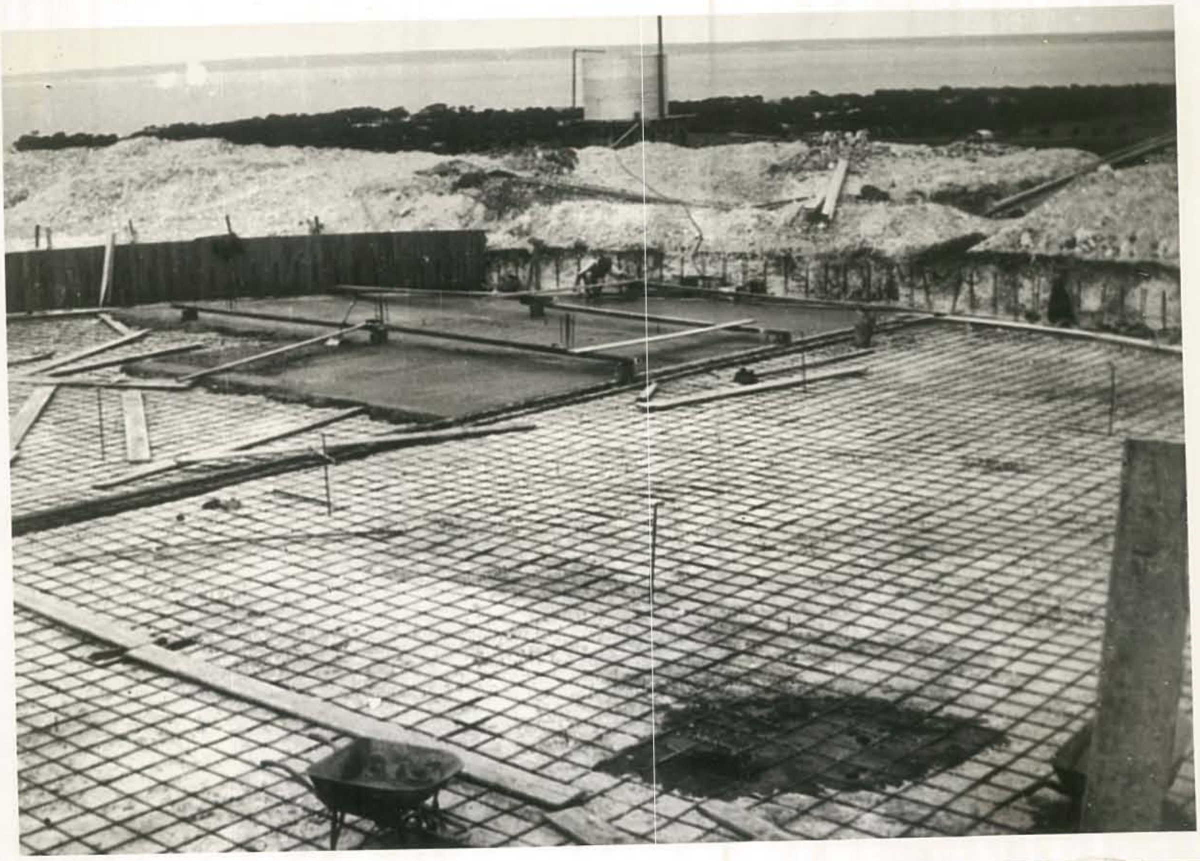
The pump is a three stage 2½" centrifugal, capacity at 1620 R.P.M. 100 g.p.m. against a total head from all causes of 290 feet, and driven by three Vee belts, tension of the belts being maintained by a Lenix type pulley. The suction head is about five feet and the suction pipe is fitted with a footvalve. To minimise the possibility of damage to the pump through failure of the footvalve, the non-return valve usually fitted on the delivery side of pumping units has in this case been located on the suction pipe as far back towards the footvalve as possible. This arrangement ensures that the pump will always be fully charged with water, and reduces the possible air content of the suction pipe to a minimum.

On test the plant complied with its contract guarantee of distillate fuel oil consumption of .19 gallons per 1,000 gallons of water pumped.

Storage Tanks.

One of the most difficult questions to determine was the total storage capacity which should be provided. The population resident in the reticulated area is only about three hundred, but this number is greatly increased during summer week-ends and holiday periods. The provision of an assured water supply, it was considered, might tend to increase both resident and casual population, as also might modern transport trends. Owing, however, to the necessity for providing storage to last right through the summer and autumn periods, the cost involved formed a very considerable part of the total for the scheme. A total storage of three million gallons, equivalent to about 30 gallons per capita per day for the resident population for eleven months was finally adopted. Additional tanks can be added as justification for this arises,

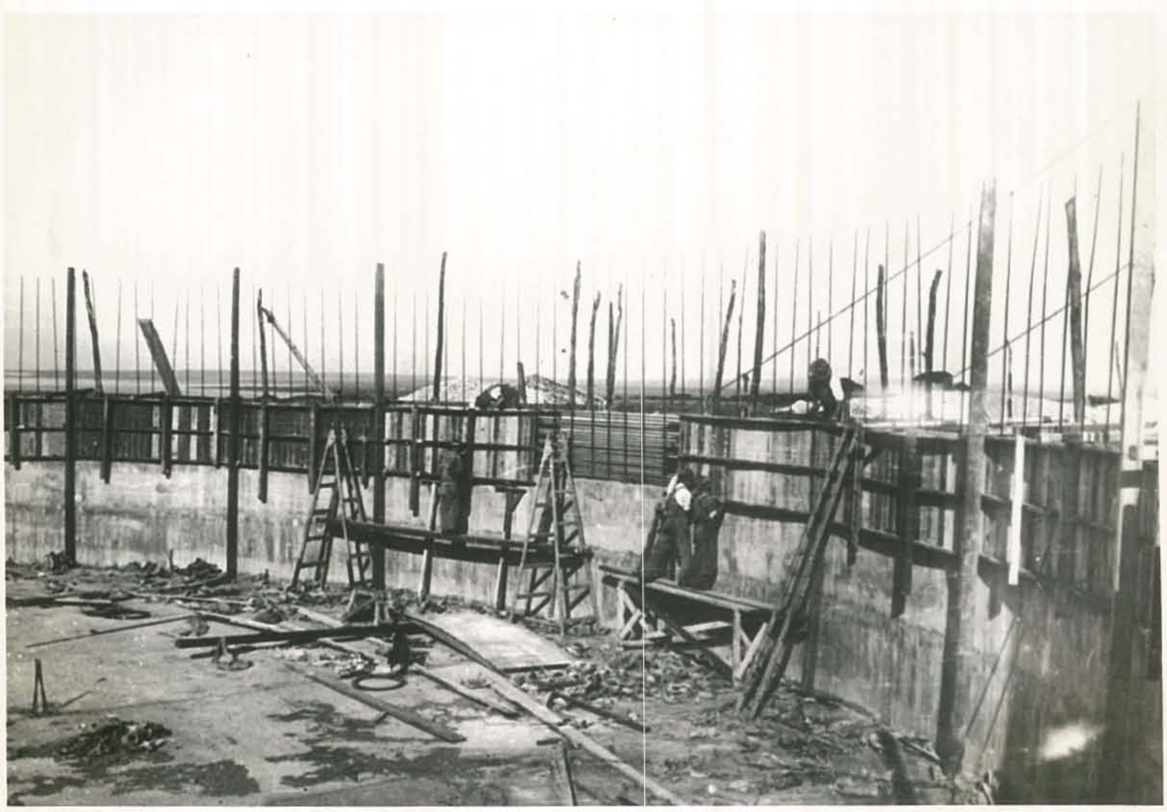
Kingscote Tanks.
Completed Work.



Kingscote Tanks.
Construction.

Kingscote Tanks.
Nearing Completion.

Kingscote Tanks.
Construction.



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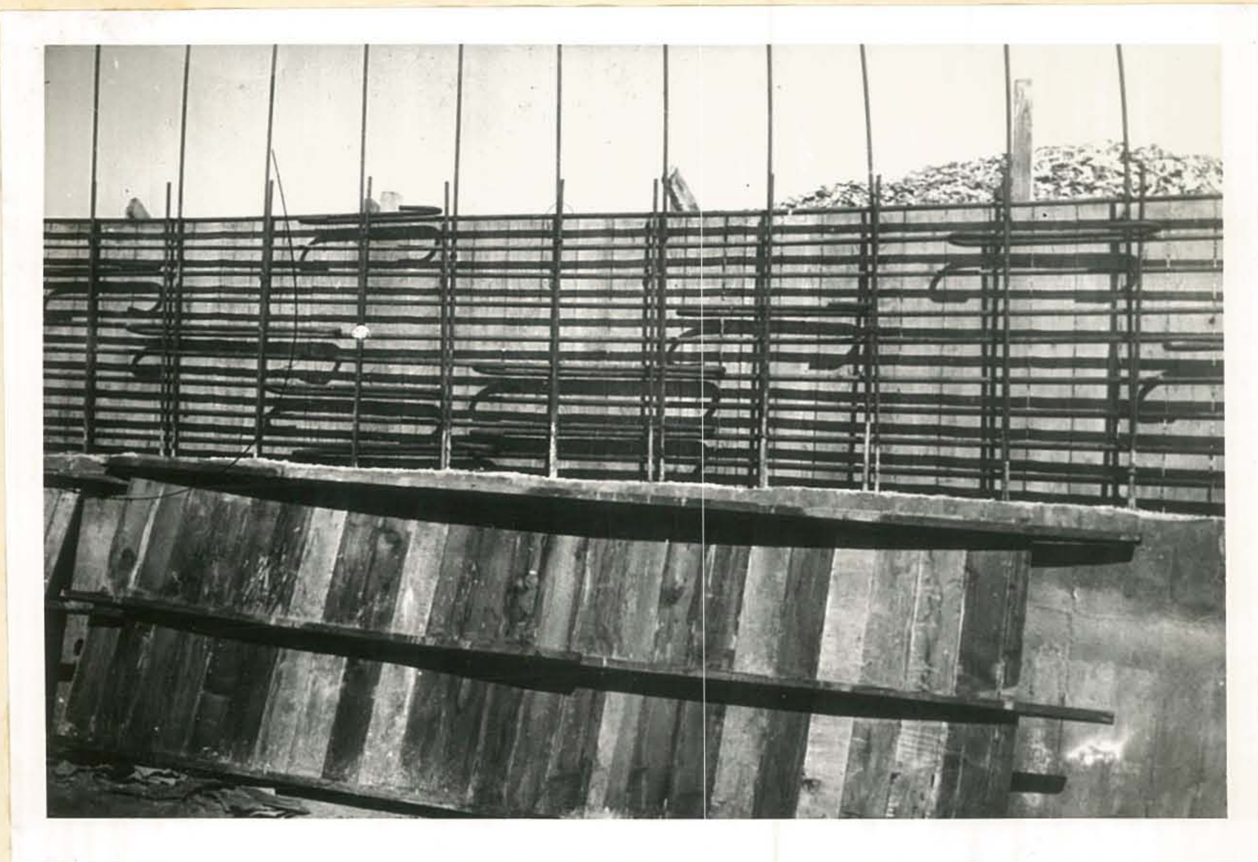

Kingscote Tanks.
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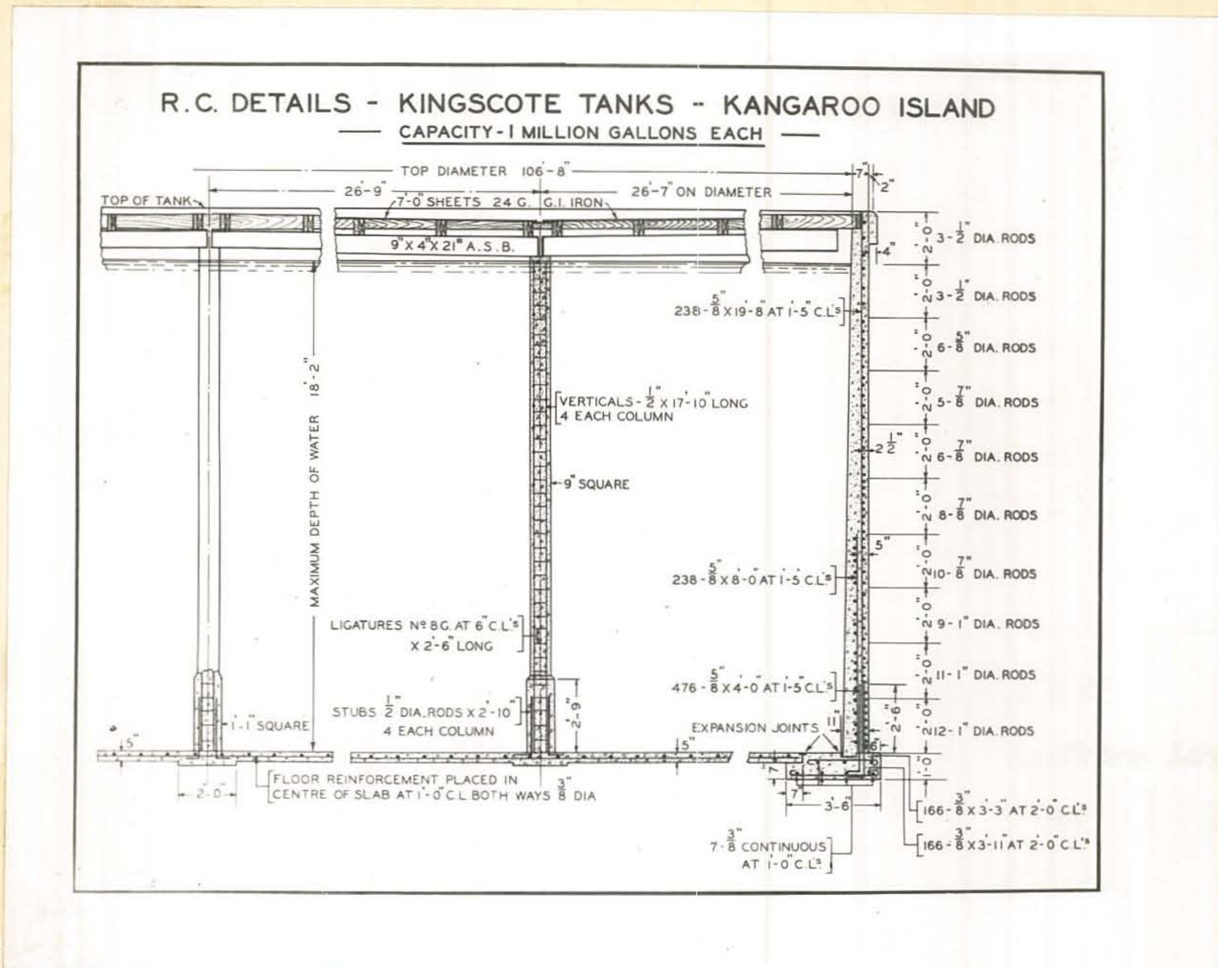


Fig. 1.
Kingscote Tanks.
Details of Reinforcements, etc.

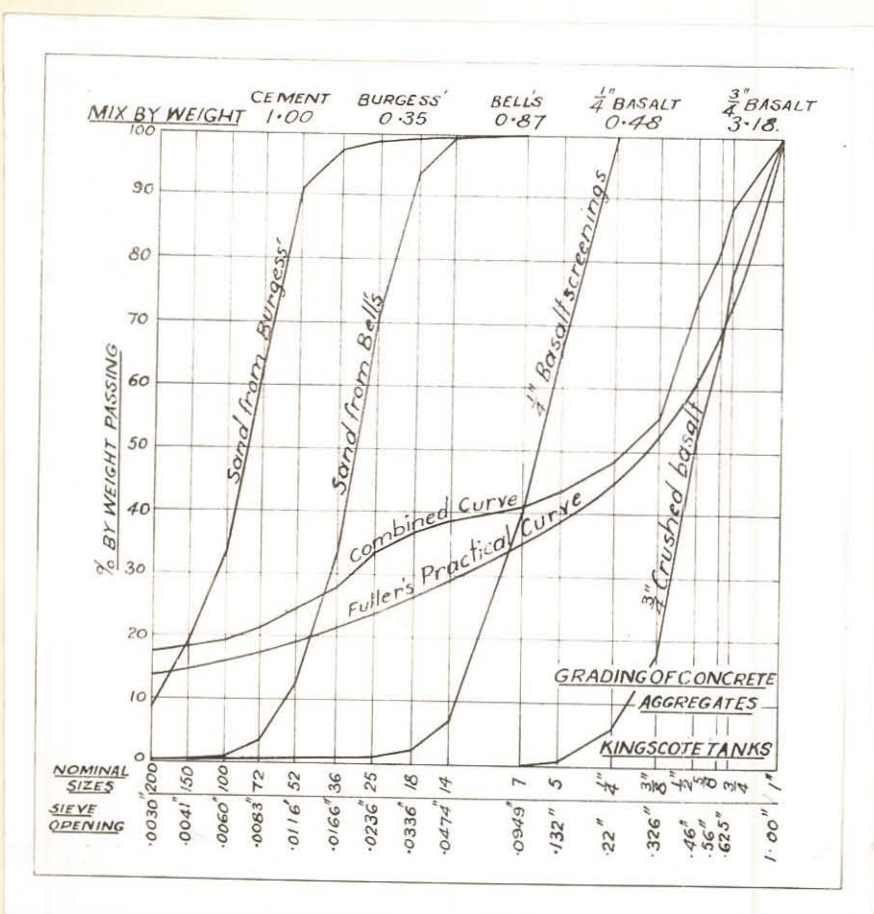


Fig. 2.
Kingscote Tanks.
Details of Concrete Aggregates.

the remaining parts of the system - pumping plant, rising main and reticulation having been made of ample capacity to meet considerably greater demand than is likely for many years.

The storage was constructed in three units, each of one million gallons capacity. Each tank is of reinforced concrete, circular, mean diameter 146'4", and depth of water 18'. To reduce evaporation losses and to prevent contamination, they are roofed with galvanised iron. Details of reinforcement, etc., are illustrated in Fig. 1.

The average depth of the floors of the tanks below the natural surface of the ground is about six feet, and they are supported by an excellent foundation of broken basalt, the interstices of which have been filled with infiltrations of limestone carried down from the surface travertine. The nominal concrete mix specified was 1:2:3 by volume, the permissible variation being from 1:1-2/3:3-1/3 to 1:2-2/9:2-7/9. Some difficulty was encountered in obtaining sand of the requisite grading. The fine screenings (under ¼") from the crushed basalt used for coarse aggregate (¾") were used as sand, but were deficient in the finer gradings. To obtain a satisfactory mix two other sands were added, the gradings of these, of the coarse aggregate, and the final mix adopted being illustrated in Fig. 2. Water-cement ratio was approximately .9 by volume and slump generally about 3". The mix was a very workable and satisfactory one, and the forms stripped to a good clean surface.

Very few compression tests were made of the concrete and those which were carried out were for the purpose of obtaining early information. Consequently, the cylinders were tested at seven days. In all cases, strengths were in the vicinity of 2,500 lb. per square inch.

The location of the pumping plant, rising main and tanks and the details of the town reticulation system are illustrated in Fig. 3.

The total cost of the three tanks, including supervision, pipe connections, and all overhead charges was slightly under £11,350, and the total cost of the whole work approximately £23,000.

Fig. 4.
Bordertown Water Supply.
Plan of Artesian Basin.

Bordertown Water Supply.

Bordertown is situated in the northern portion of what is known in this State as "The South East." It is on the Adelaide-Melbourne railway about 200 miles from Adelaide and 12 miles from the Victorian border. It is within the River Murray sub-artesien basin, but the underground waters in most of the south-east are derived from the Lowan intake in Victoria and not from the Murray. The known boundaries of the Murray basin and of the area fed from the Lowan intake are shown in Fig. 4.

Prior to the construction of the works to be described hereunder, the District Council of Tatiara operated a small water supply system for the benefit of a few consumers, the water being obtained from a well about 65 feet deep. The water obtained from this stratum (polyzoal limestone) was of poor quality, containing 133.7 grains (.3 ozs.) per gallon of dissolved salts, and having a hardness of 46 degrees English. Of this hardness 29.6 degrees were due to magnesium, and 23.6 degrees permanent.

The scheme for the supply of the town comprised the sinking of a 10" bore to an estimated depth of 450 feet, the provision of a pumping plant capable of delivering 6,000 gallons per hour, the construction of a water tower of 100,000 gallons capacity and the reticulation of the town. If the construction of the various works had followed the simple outline of these proposals there would have been little or nothing of interest for the writer to record. The pitfalls which await those who seek the waters under the earth were, however, encountered; and by the - happily successful - conclusion of the work, those charged with its execution were, if not sadder, at least wiser.

The estimated depth of 450 feet for the bore was arrived at from a general consideration of the somewhat meagre information available concerning bores previously sunk in the Lowan intake portion of the Murray basin, and particularly from experience gained at Pinnaroo, about 90 miles north of Bordertown. At Pinnaroo the water table stands at about 200 feet below ground level, the top aquifers carrying water containing about ¼ oz. of dissolved salts per gallon. In the Pinnaroo waterworks bore, the top aquifer was

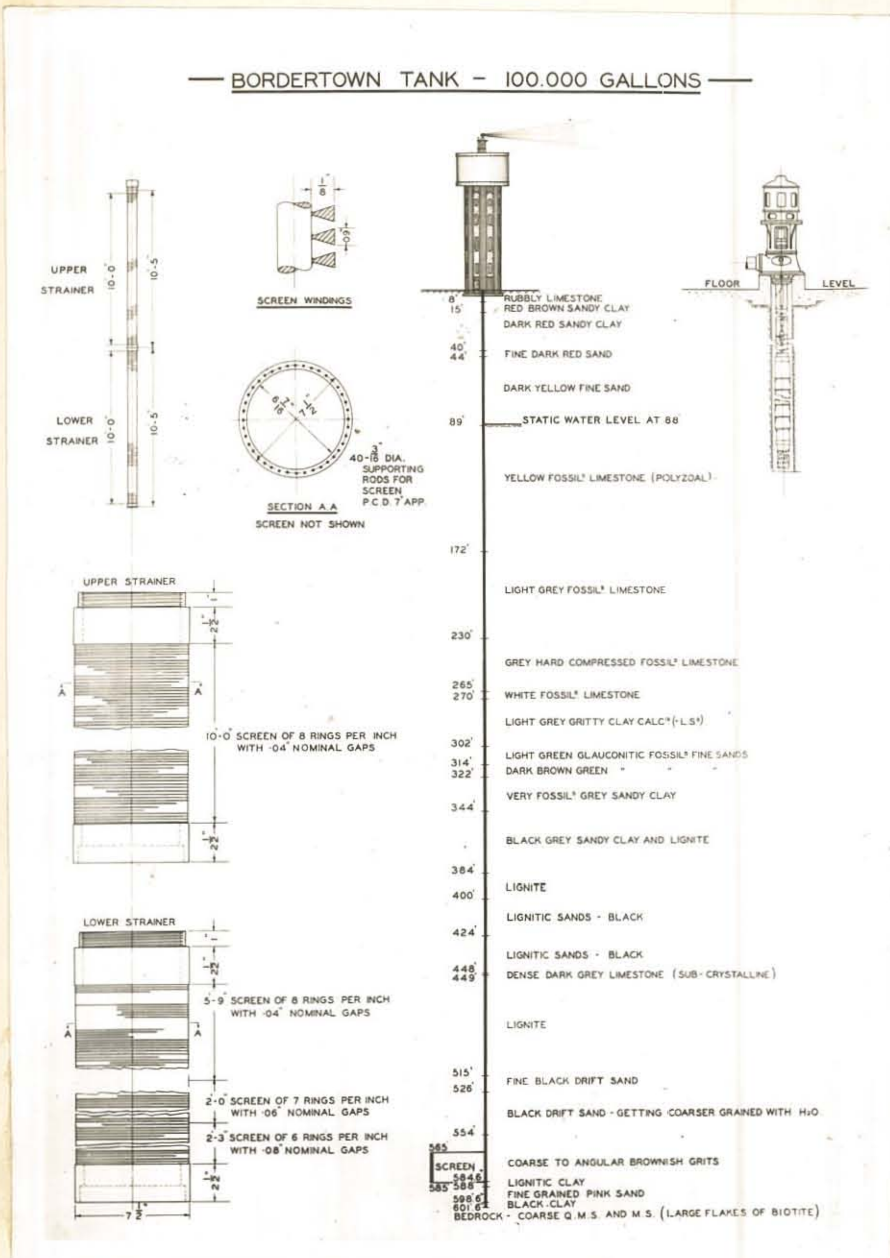
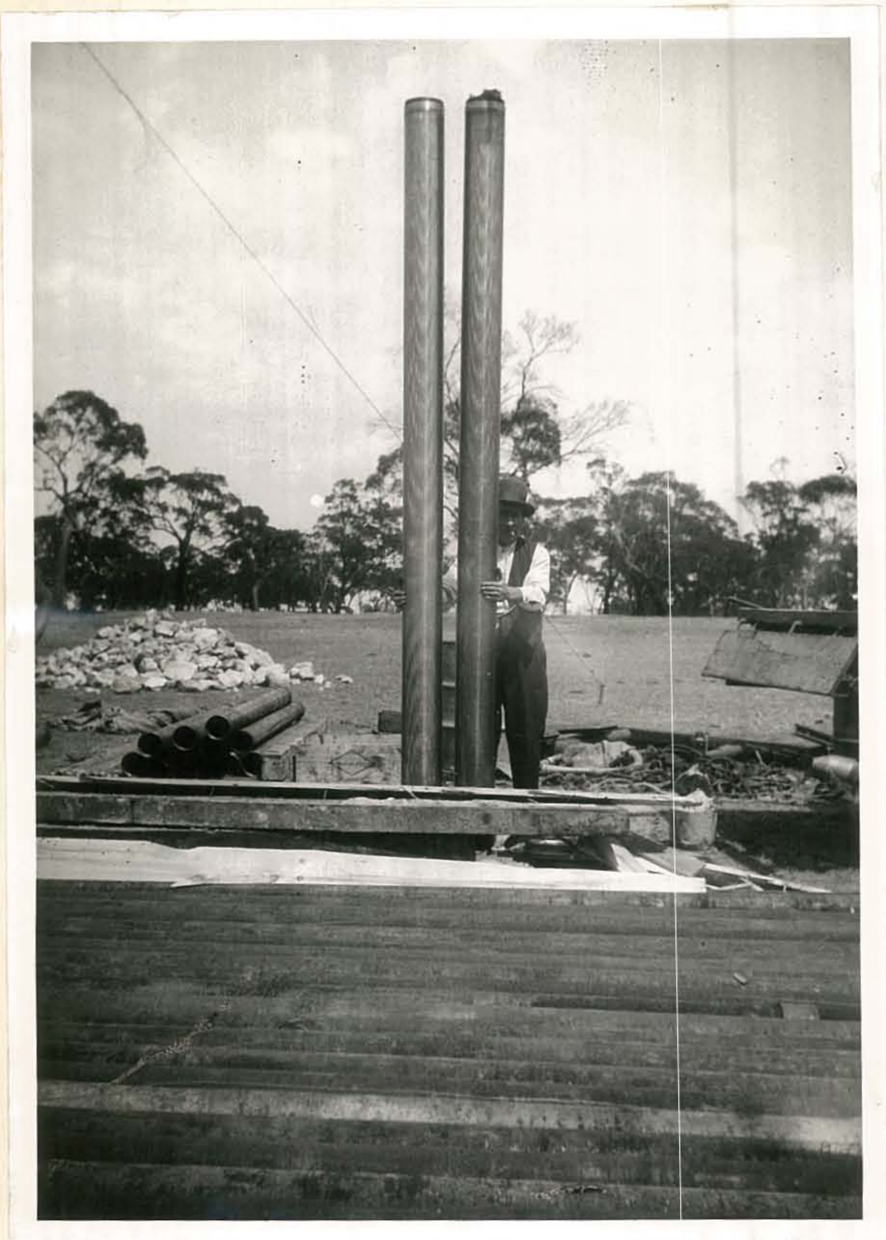


Fig. 5.
Bordertown Water Supply.
Screen, Bore, Tank and Pump.

cased off and the bore continued to a depth of 600 feet. Two further aquifers in the polyzoal limestone were encountered at 510ft. and 555ft. respectively, the water from these containing only about $\frac{1}{8}$ oz. of dissolved salts per gallon, and having a hardness of only 19 degrees (1.5 permanent). The water from the lower aquifers rose to the height of top water table - 200ft. below the surface. As the Bordertown top water table stood at about 85-90 feet below the surface (the bore site being about 20ft. higher than the Council's well site), it was considered reasonable to expect to obtain better quality water from lower aquifers and to encounter at least one of these before a depth of 450ft. had been reached. It was also anticipated that the lower aquifers would be found in polyzoal limestone known to exist over a wide area.

Boring proceeded without incident into the top limestones underlying about 90ft. of clay and sand. The top waters were cased off and boring continued through the limestone series to a depth of 344ft., when lignite was encountered. Although this had not been anticipated, it was not altogether surprising, as very extensive beds of lignite have been located in the Murray basin, particularly in the western portion. Some concern was, however, felt when the bore reached its full contract depth of 450ft., still in lignite, and without cutting any water in the few small sand seams contained in this series.

After consultation with the Government Geologist, boring was continued until at 515ft. lignite gave place to fine sand, which immediately shot up and blocked the casing for a depth of about 100ft. No free water was, however, found on top of the plug of sand in the bore. The foreman driller, therefore, reported having entered dry sand - which caused considerable anxiety to the recipient of the report. While awaiting further instructions, the foreman proceeded with sinking operations, driving the casing ahead of sand baling. The prevent the continual rise of sand, he kept the bore "loaded" with water, and by the time representatives of the Department arrived to consider the problem on the ground, the bore had reached a total depth of 565ft., the sand becoming coarser. During the last fifteen feet or so the foreman had not



Bordertown Bore.
Screen - full length.

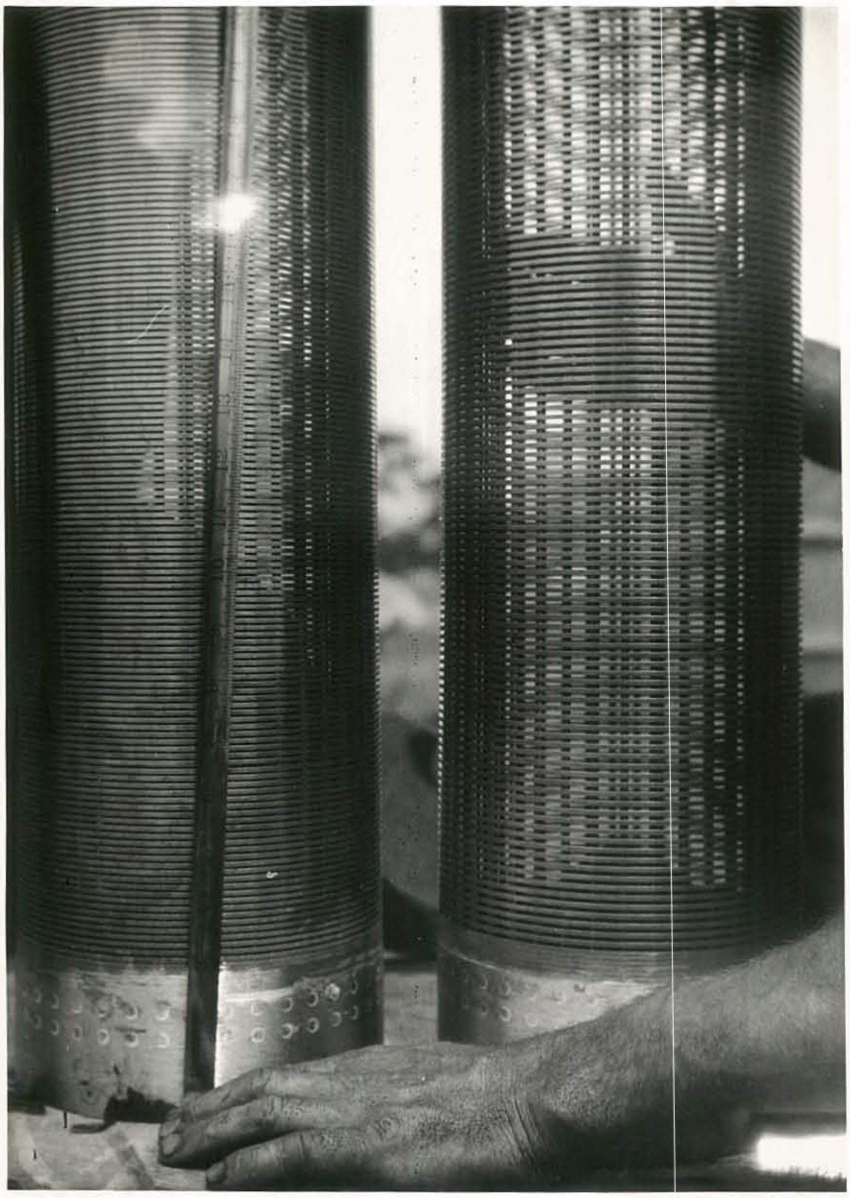
had to add water to make good baling losses, and had begun to suspect that the sand might be water-bearing after all.

To test the presence of water, the plant was put in operation baling. The water level was lowered about fifteen feet very rapidly, and then sand suddenly shot up inside the casing for a depth of about 150ft. The bore was then water-loaded again and the sand baled out. By baling slowly, so as to draw into the bottom of the bore the water carried by the sand, it was possible to obtain from this depth a sample of water for analysis. This disclosed that the water was of much better quality than, and possessing entirely different characteristics from those carried by the upper limestone aquifer.

The bore contractor suggested a sand screen as the solution of the problem, but experience in this State with sand screens had not been a happy one. Several cases had come under notice where screens, though effective for short periods, had blocked up and been impossible to clear.

Some Departmental officers had had a wide experience with sand obstructed bores in the western suburbs of Adelaide, where a large number had been encountered during 1934/5, when it was necessary to augment the metropolitan supply from underground sources. In these cases air lift pumping plants had been used to clear the sand, the velocity of water in the eduction pipe being sufficient to carry the sand with it. The operation had been continued until, by withdrawal of the sand surrounding the bottom of the casing, or by the packing of coarser material from which the finer had been withdrawn, a condition of stability had been reached.

As a result of this experience, the method was tried at Bordertown, but it was completely unsuccessful. In every case when the air lift was started, water discharge practically ceased after a few minutes pumping, and, upon stopping, bore and eduction pipe were found plugged tight with sand for a depth of about 150ft. above the bottom of the bore. Various depth settings and sizes of air line and eduction pipe were tried, but the result was the same in each case. It is difficult to explain so complete a failure in this instance of a method which had proved so consis-



Bordertown Bore.
Screen - Close up.

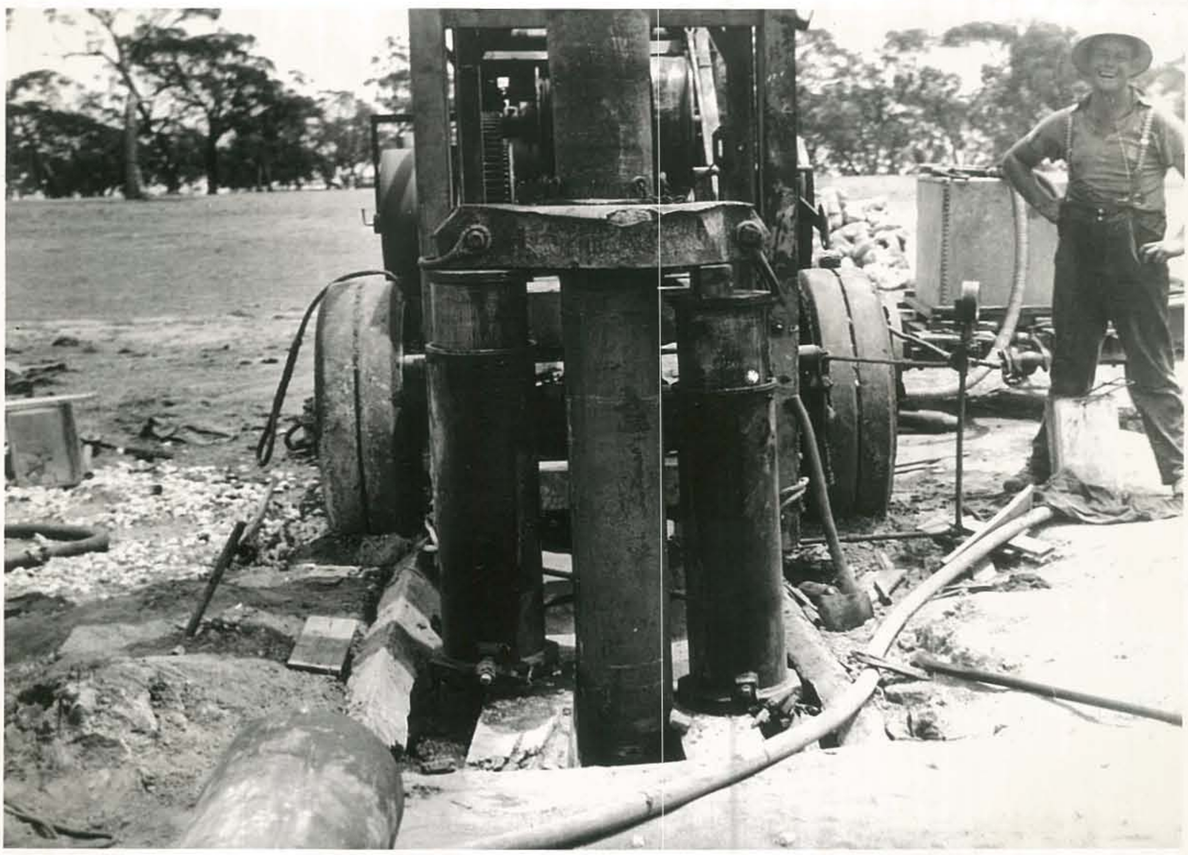
tently satisfactory in other apparently comparable cases. Possibly it was due to the sand being well graded from fine to coarse, the particles being not waterworn, but very sharp. The grains would tend to interlock, and the difficult passage for the finer sands through the coarser might have caused a tendency to packing, thus preventing free flow of water. The whole body of the sand, however, moved very freely, as is instanced by the great height to which it was forced when the water pressure inside the bore casing was reduced by only 15 to 20 feet.

By this time, grave doubts were entertained concerning the prospects of success. To some it seemed that there could not be water in appreciable quantity, or the air lift method must have succeeded in pumping a mixture of sand and water. Others found it difficult to understand how the sand could have behaved as it did unless it was water-bearing and under high pressure, which, unless conditions were most extraordinary, would suggest considerable extent of the aquifer. The boring contractor now repeated his offer to instal a sand screen under guarantee that a discharge of 10,000 gallons per hour would be available; undertaking further to refund the cost of installation if the discharge should fall below this value within ten years of installation.

After further staff consultations, this offer was held in abeyance while boring was continued in the hope of meeting improved conditions. Rather coarser sand was encountered to 585ft. when another lignitic series was entered. This, however, was of small extent and bed rock was struck at 601'6". The casing had not been driven past 585ft. and, as this depth appeared to be the limit of water possibilities, the exploratory hole below it was back filled.

The boring contractor now carried his offer a step further by agreeing to accept payment at the end of the ten-year guarantee period, with annual interest payments at the rate of 5%; and on this basis his offer was finally accepted.

The length of screen decided upon was 20 ft. and it was to be placed at 565-585ft. depth. Samples of the sand from this range were screen analysed at Melbourne University and the results



Bordertown Bore.
Jacking Casing Back.

forwarded to the screen manufacturers. The screen consists of a series of rings spot welded to internal supporting rods, the whole being compounded of a non-corrodible bronze. In vertical section the rings are triangular with the bases outward, so that if a grain of sand can pass through the outer aperture between adjoining rings it has a clear passage through an increasing aperture to the inside of the screen. The object of the development work undertaken after installation of the screen is, by means of a surging action forcing water to and fro through the screen to draw into the bore the fines from the surrounding sand and in the process to pack coarser sand around the screen. Surging operations are suspended from time to time to permit of the sand drawn through the screen being baled, and the two processes are continued until no more sand can be drawn in. The screen openings are usually designed to admit 50%-60% of the sand, and in the case of Bordertown the nominal openings are .08" for the bottom 2'3", .06" for the next 2', and .04" for the balance of the 20ft. length. Measurement of these with feeler gauges shewed all openings to be .003 to .004 less than the nominal; possibly the manufacturer made them slightly under nominal size to compensate for the effects of abrasion during development.

The screen is in two halves screwed together. To the top of the assembly is screwed a collar, the top of which consists of a lead ring 4½ inches in height.

The assembly was lowered to the bottom of the casing and the casing then jacked back until its lower end was just covering the top collar of the screen. A few strokes of an expanding tool, which was mounted on the end of a heavy string of boring tools, forced the lead ring firmly against the inner surface of the casing to provide a sand seal at that point. Here a tribute must be paid to the accuracy with which the bore had been sunk. To test its straightness a steel cylinder sixteen feet long with a diameter one half inch less than the internal diameter of the bore was lowered to the bottom. During its passage it was stopped at frequent intervals, and at no point was it possible to detect any deflection of the supporting cable from the centre of the casing

Bordertown Bore.
Screen Top and Expanding Tool.

Bordertown Bore.
Surge Plunger.

at ground level. To jack back a single string of 10" casing 585ft. long for 20ft. could not be considered an easy task. It was accomplished with only minor troubles, but it is doubtful if it could have been if the bore had been less truly drilled, especially as the casing had been standing undisturbed for some months before the screen was installed.

The development operations occupied four days, the first day and a half being taken up mainly in ascertaining by trial and error methods, the type of surge plunger which would be most effective in drawing sand through the screen. The plunger finally used was 9" diameter made up of three old motor car brake drums with rubber belting between them to make a close fit in the bore casing, the diameter of which is slightly over 9¼". Through the plunger four 1½" holes were drilled, these being covered on the top by a rubber flap to give a valve action, making the upstroke of the plunger more forceful than the downstroke. In the early part of the surging operations, the flap was tied up over two holes making lighter working, but the latter part was carried out with all holes closed during the upstroke. The runs were generally of one hour's duration between baling operations and were continued until no sand was drawn in by a run of this length. Altogether, sand equivalent to a depth of 42'8" in the screen was drawn through it and baled out, the volume being about 11½ cubic feet.

The installation described above is of a type new to South Australia, both as regards the screen itself and the developmental work carried out following its placement. It would seem that, although the screen design has certain obvious advantages, the continued success of such an installation must depend largely upon the care with which development is carried out. This is believed to have been thorough at Bordertown, but only time will tell the full story.

Upon completion of the development work, a pumping test was run for a period of 24 hours at a discharge of 17,000 gallons per hour. After a shut down of three hours for adjustments of the pumping plant, a continuous pumping test of three weeks' duration was carried out, the rate of discharge being 11,000 gallons per

Bordertown Bore.
Test Pump.

Bordertown Bore.
Test Measuring Weir.

hour, which was increased to 17,000 gallons per hour for the last eighteen hours of the three weeks' run. The depth of the water level in the bore was determined during the run by means of an air line of ½" galvanised piping and a pressure gauge.

The following table shows the results of the test:-

Date.	Time.	Pumping Rate.	Water Level below Surface.	Remarks.
1938. Jan.24	9.45 a.m.	-	88 ft.	Static level.
" 24	10 a.m.	17,000 g.p.h.	109 ft.	Start 24 Hours'Test.
" 25	10 a.m.	17,000 g.p.h.	115 ft.	Finish 24 Hours'Test
" 25	1 p.m.	11,000 g.p.h.	103 ft.	Start 3 weeks' Test.
Feb.14	1 p.m.	11,000 g.p.h.	115 ft.	
" 14	6 p.m.	17,000 g.p.h.	124 ft.	
" 15	1 p.m.	17,000 g.p.h.	129 ft.	Finish 3 weeks' Test
" 15	1.2 p.m.	-	110 ft.	
" 17	1 p.m.	-	103 ft.	
" 21	1 p.m.	-	94 ft.	
Mar. 1	1 p.m.	-	89 ft.	Plant removed.

During the pumping tests over 6,000,000 gallons were pumped from the bore, or enough to supply all requirements for more than twelve months. At the conclusion it was found that about 9"-12" of sand had accumulated in the bottom of the screen, but the contractor had in the meantime removed his plant to other contracts, and it was not considered necessary to compel him to remove this small quantity.

Analyses of the water show it to be of excellent quality. The total dissolved salts amount to only 89.7 grains per gallon. The hardness is 18.4 degrees English, all temporary, there being no sulphates or chlorides of either calcium or magnesium present, a most unusual condition for deep supplies in this State.

The complete analyses of the water and of that from the top aquifer are as follows:-

Bordertown Water Supply.

Inorganic Analyses - Results in Grains per Gallon.

	Top Aquifer 100-340ft.	Lower Aquifer 515-585ft.
Chlorine	57.4	32.9
SO_4 Radicle	11.1	7.9
CO_2 Radicle	13.8	13.5
Sodium and K	32.8	27.5
Ca	6.8	2.4
Mg	7.2	3.0
Silica	2.2	1.4
Assumed Composition of Salts.		
$Ca\ CO_3$	17.0	6.0
$Mg\ CO_3$	5.0	10.5
$Mg\ SO_4$	14.0	-
$Mg\ Cl_2$	11.4	-
$Na_2\ CO_3$	-	4.4
$Na_2\ SO_4$	-	11.6
NaCl	80.6	54.2
Undetermined	3.5	1.6
Silica	2.2	1.4
Total	133.7	89.7
Hardness (in English Degrees).		
Total	46.6	18.4
Temporary	23.0	18.4
Permanent	23.6	-
Due to Ca	17.0	6.0
Due to Mg	29.6	12.4

On completion of the pumping test, the work of constructing the water tower was put in hand. The layout originally proposed was with the bore and pumping plant alongside the water tower, but that adopted was with the water tower built centrally over the bore. The arrangement is one of those obviously right things that are so easily overlooked. The base of the tower forms the housing for the pumping machinery, switchboard and lifting gear, the building

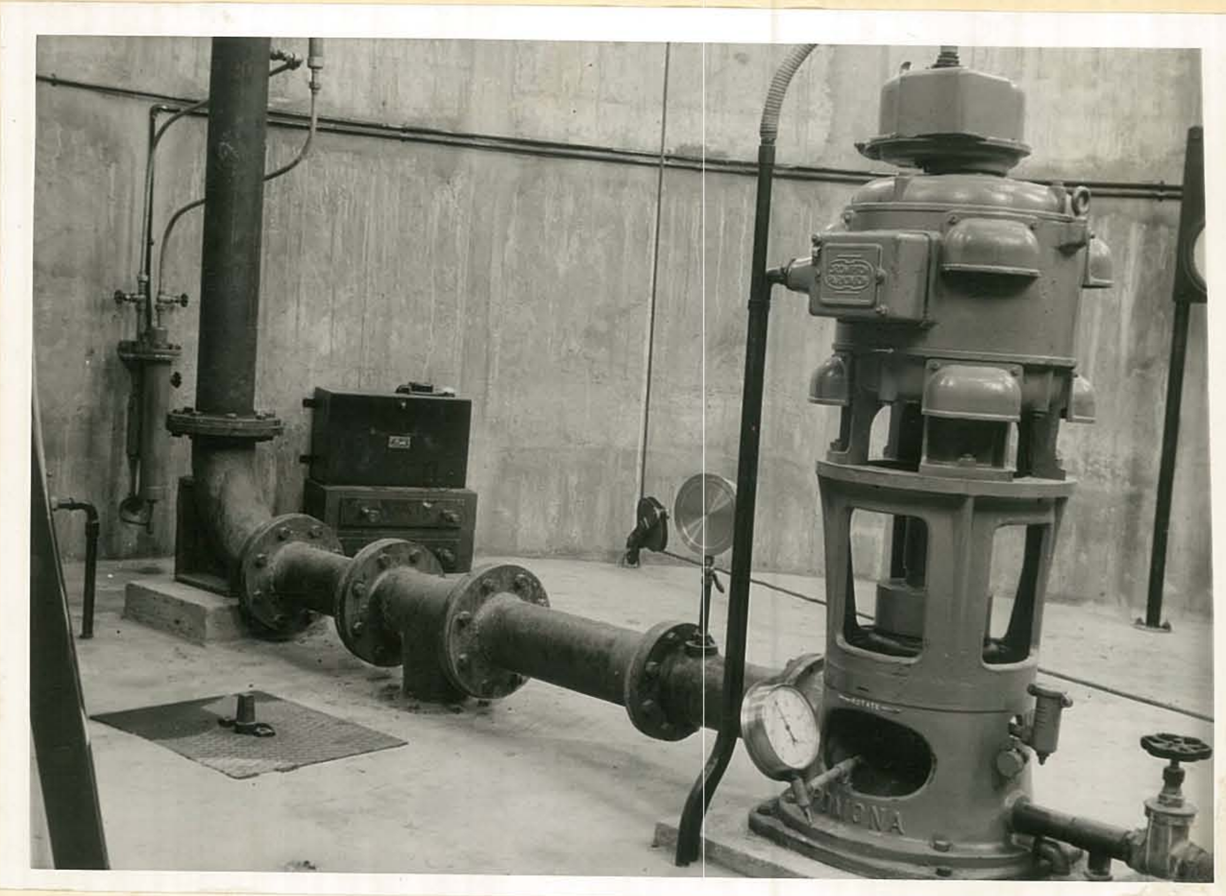
Bordertown Water Supply.
Water Tower.

for which might have been comparatively unsightly, and the layout is very compact. The water tower itself consists of a single shell 23ft. internal diameter and 68'6" high, supporting a 100,000 gallon tank 32'6" diameter with a depth of water 19ft. and total depth 20ft., the height of the structure to the top of the tank being 90ft. In horizontal section the tower shell consists of sixteen sections, eight of which form recessed panels whose faces are curved to a radius of 11'11", these alternating with straight sections constructed tangentially to a circle with radius 12'4". The purpose of the flats is to add depth to the panels, and the appearance of the completed work has been generally approved. All ladder-ways are internal, access to the tank being by means of a central tube 4ft. in diameter. As the tower houses machinery, it was necessary for it to be weatherproof. Consequently, the openings in the panels were glazed instead of, as usual, being protected by bird-proof netting only. The effect was so unexpectedly pleasing in appearance that the practice will probably be adopted by the Department as a standard.

Bordertown is on the direct air route between Melbourne and Adelaide, and proposals for the erection of a rotating aerial beacon at that town were under consideration by the Commonwealth authorities while the work of constructing the water tower was in progress. Some interested party suggested that it be mounted on the water tower, and arrangements to that end were concluded. The central tube of the tank was extended high enough to give access, through a door in the side of the tube above high water level, to a platform cantilevered from the tube; and at the top of the tube a reinforced concrete slab was constructed to support the beacon. The total height of the beacon lamp above ground level is 102ft.

The nominal concrete mix was 1:2:3½ for the tower and 1:1½:3 for the tank, the coarse aggregate (¾") being a good local limestone. Concrete strengths averaged about 3,800 lb. per square inch for the tower concrete and 5,480 lb. per square inch for the tank proper, at 28 days. Water-cement ratio in each case was approximately .9 by volume and slump about 3".

During construction of the water tower, a contract had been



Bordertown Pumping Plant.
Pump Headgear.

Bordertown Pumping Plant.
Switchboard.

entered into for the pumping machinery and the installation of this followed. The capacity originally proposed for the pump was 6,000 gallons per hour, but after the successful three weeks' test of the available discharge, this was increased to 10,000 gallons per hour. The pump is of the borehole turbine type, the bottom of the suction strainer being 140ft. below the surface. The impellers are of the semi-open type, and there are fourteen stages, the insides of the bowls being procelain lined. The shaft is $1\frac{3}{8}$" diameter in 10ft. lengths, the water lubricated rubber bearings being carried in cages secured between the ends of the ten feet discharge pipe sections, which are joined by screwed collars. The diameter of the discharge pipe is 5" and the overall diameter of the pump bowls $7\frac{1}{2}$". Drive is by means of a 15 B.H.P. slip ring motor mounted on the pump head gear and direct connected to the pump shaft by means of a flexible coupling. Operation of the plant is automatically controlled by means of float switches in the tank. Power is purchased from the District Council of Tatiara and, as arrangements had been made for the Council's electrical engineer to supervise pumping operations on behalf of the Department, the receiver of an electrical depth indicator was mounted on the power station switchboard. The operation of the pump is recorded by means of an electric flow meter employing an orifice plate in the discharge pipe. On test, the pump discharge was 10,000 gallons per hour against a total head of approximately 192 feet, the water horse power being 9.7. The power consumption was 12.5 K.W., the overall efficiency of the installation being 58% - a very satisfactory result. Details of bore, screen and pump are illustrated in Fig. 5.

During the three weeks' pumping test, the water at its discharge from the pump gave a distinct odour of hydrogen sulphide, which disappeared very rapidly - within a few minutes - on exposure to air. It was, in fact, impossible to obtain a sample in which, even when the sample bottle was sealed in transit, more than a "trace" could be detected on analysis. However, to guard against the possibility of trouble from the gas, the discharge pipe from the pump was carried above H.W.L. of the tank and the water allowed to flow from a bell mouth. Although the odour from the water is very distinct to an observer on the tank access platform while the pump is running, the aeration provided by the above means is quite adequate. No taste or odour is perceptible in the water delivered to consumers.

Means of removing and re-installing the pump are provided within the base of the water tower. A steel girder is mounted across the diameter of the shell 30ft. above floor level to carry lifting tackle, the wire rope from which runs to a lead block anchored on one side of the floor and thence to a crab winch on the opposite side.

The reticulation mains for the town comprise cement-lined cast iron pipes of 6", 5", 4", 3" and 2" diameter, the total length being about 2½ miles. The total cost of the completed works was under £9,500.

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