PAPER No. 220.

THE WATERSUPPLY OF THE SUN ECLIPSE FAIR AT THANESAR.

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Introduction.

Thanesar or Kurukshetra is an historic town in the Karnal District of the Punjab, on the Delhi—Panipat—Ambala line of the North-Western Railway, about 26 miles south of Ambala.

It is one of the chief places of pilgrimage of Hindus in India and the most important in the province of the Punjab. Hundreds of thousands of pilgrims visit the sacred Fair which is held whenever a partial or complete eclipse of the sun is visible there.

The place is situated on alluvial strata of the Jumna catchment, part of the vast Gangetic plain of Northern India.

A list is given in the margin of dates of Sun Eclipses visible at Kurushetra since 1914.

Dates of Sun Eclipses.
21st August, 1914.
21st September, 1922.
14th January, 1926.
12th November, 1928.
21st August, 1933.
19th June, 1936.
21st September, 1941.
20th June, 1944.
9th May, 1948.

The Fair area in which the pilgrims congregate comprises about $1\frac{1}{2}$ square miles of open flat land south of the old town of Thanesar and extending round and about two large sacred tanks or reservoirs called the "Sanyahet" and the "Kurukshetra" respectively (see Plate I).

The town is said to have been of great importance in the old days and to have had a population of over 100,000 but now it is in a decayed condition with a population of only about 5000. The area is liable to inundation by the Sarusti river and is very malarial.

Although the actual eclipse only lasts for a comparatively short period of time, pilgrims start to arrive for the Fair several days beforehand and it generally takes 3 or 4 days to disperse the population after the day of the eclipse, hence a very considerable temporary population, gradually increasing to several hundreds of thousands of pilgrims on had broken new ground regarding discussions in this Congress. These discussions had tended to be what I call the learned side of engineering and limited to formulae, etc It was equally an engineer's job to consider the economics of his trade and by that I do not merely mean the economic carrying out of a certain work. Mr. Hawke's paper is a contribution to this side of engineering and I trust it will invoke a good debate on the subject.

" Although Mr. Hawkes has in the last two pages of his paper made suggestions which have the germ of getting the best out of road as well as rail transport. The best part of his paper has been written from the railway point of view. The paper strikes me as being rather defeatist because the burden of it is a long wail that railways have to meet unfair competition. Whether this competition is as unfair as Mr. Hawkes makes out would require more careful analysis than Mr. Hawkes has given. The comparative statement given by him of charges for transport by lorry and by rail per maund for various classes of goods is very valuable and also very instructive. I would request the Author of the paper to enhance the value of this paper by giving a short description of the various classes for which different rates exist. I would also request him to justify how the costs for various mileages have been worked out. From the table it appears that excepting a small fixed charge for the handling at the two terminals the cost of transport is strictly in proportion to the distances I am of opinion and I am sure most members of the Congress will agree with me that this is not a fair basis and the cost of transporting goods 500 miles will not be 10 times transporting them 50 miles.

" Before the losses to the railways, etc., could be analysed and a division formed between the legitimate sphere of railway transport and road transport it would be necessary to have before us actual figures of earnings of railways both by distances and by classes.

" To me the future of both classes of transport seems to be in a realization of their distinct utilities which do not overlap. To mention a case in point it has been said that the railways have introduced diesel coaches, to cope with competition by lorries This I think is definitely " bad engineering". Such traffic belongs legitimately to lorries and the railway should concentrate on long distance haulages.

" The duty of us engineers is therefore to put our house in order. We must analyse and scrutinize the existing state of things as regards road haulage and consider where the waste is and how this waste could be met.

" This paper has been read from the rail point of view. I hope next year a reply will be received from the road point of view and I trust before the proceedings ofthis year's Congres are published Mr. Hawkes will be able to add the data that I have asked for above.

Mr. **Hawkes** in replying to the discussions said that the criticisms in the main, had been directed against the manner in which the railways' case for a " Square deal" had been pleaded. The speakers were disposed to think that the remedies advocated in the Paper, viz., the various Regulations of Transport, were not all congenial to the legitimate and healthy development of Transport. Some even considered that unregulated competition should be allowed to continue, for, to them, that appeared to afford the cheapest mode of transport to the shipper of goods. Mr. D. P. Nayyar was against the tightening up of control of road transport, as it only stifled private venture to the detriment of individual capitalists and did more harm than good to the country. According to him all forms of transport should naturally adjust themselves to the demands and needs of the country, and co-ordination should not be aimed at by direct or indirect penalization of road transport.

Happily, other speakers did not go so far as that, and agreed, that some form of regulation was necessary, but their opinions differed as to the extent of the control. Mr. Sawhney considered that the fixing of rates for public vehicles was impracticable. That should not be impracticable if railways could do it, in fact he believed there were Road agencies in some countries that insisted upon published fares and rates Mr. Trevor Jones did not agree to the suggestion, that as additional roads were constructed money need be provided for extra police, and Mr. Halcro Johnston believed that railways could improve their position greatly in spite of the present handicaps by cutting down the rates, which they could easily afford to do.

To reply to these criticisms it was necessary to first consider what the country needed. Obviously it needed the best and the cheapest system of transportation consistent with fair earnings, which would support adequate credit and the ability to expand as needs developed and took advantage of all improvements in the art of transportation. Unregulated competition could not provide such a system; on the other hand, it tended to destroy it. It led to unjustifiable duplication and waste, as he would mention later, without doing any good even to the shippers who might, at the beginning, seem to gain by it.

Mr. Hawkes continuing his reply stated that Mr. Bashi Ram had said that to treat Road Transport as a "Service de luxe" was unfair and that the same arguments could have been used when railways " ousted" the bullock cart. If road transport could take the place of railways the Author would say " Scrap the Railways" but it would be conceded that railways were admittedly indispensable for the transportation of a great part of the nation's commerce. Such being the case they must be maintained and this would not be possible if the cream of the traffic, although only 22% of the total weight but bringing in 53% of the earnings was taken away by Road Transport.

The charges for the particular kind of transportation depended, and must continue to depend, upon the cost of producing it. It was inevitable that any public policy that 'artificially' diverted traffic from the railway, or impaired the efficiency of the plant or unduly increased its operating costs, could only have the effect of increasing the cost that must be eventually be borne by the public unless the railways were scrapped thereby eliminating the duplication of transport facilities. The word "artificially" had been used as every transportation agency should bear its full share of expenses for construction and maintenance of the plant. In addition, it should bear its full share of the general tax burden for the general administration of the country. In the case of the Road, even if all new construction was financed out of the Petrol tax, the general administration and maintenance costs were certainly paid out of the provincial revenues.

The Petrol Duty was a customs duty levied for the general administration of the country and for public purposes, and if it were conceded that road transportation had a claim for it, the same treatment should be accorded to the Railway. Then again, it was not correct to compare the Petrol tax with the contribution of the Railway Burdget to General Revenues, as the former was again spent on the Capital account of the Road while the latter, served to assist the Central Revenues. For those who argued that the Roads were financed by road transport through the Central Road Fund he would remark that of the 8-10 crores of rupees contributed annually to the fund from petrol taxation most of it comes from private cars, buses, lorries and trams in the large cities of India and on transport working on roads feeding the railways and not in competition with railways; possibly only 3 crores or so was contributed by lorries and buses in direct competition with the Railways and for this sum paid to the Central Road Fund, Government was losing through their railways a much greater amount.

Those who professed that road transportation was inherently cheaper seemed to forget that a very large part of the existing capital sunk in competitive roads had not been provided by that industry, and even if new roads were built out of the petrol tax the whole of the general administration and maintenance was borne by the Provincial Governments. Road transportation appeared cheaper because it used public property to carry on commercial business for private profit and was not taxed to the full extent of the cost incurred in providing and maintaining the "plant" they used. It was not difficult to see, therefore, that the bus and truck owners could sell transportation at the price they were doing now only as they were able to shift a large proportion of their transportation costs to the State, and through them to the tax payers. It seemed the eclipse day and then dispersing for a few days afterwards, has to be catered for.

During the 1926 Fair, the estimated number of pilgrims was 700,000 and the watersupply sources, as well as for preceding Fairs, consisted of upwards of a hundred open percolation wells scattered over the Fair area, sunk to the first water bearing subsoil below spring level, which is about 26 feet below ground level.

These wells only yielded a very limited supply of water. They were in a more or less neglected condition and were mostly on privately owned land and although the land owners garnered considerable revenue from the pilgrims, little oı no efforts were made by them to clean the wells and put them into proper condition. The water of these wells, being derived from the shallow subsoil, was of doubtful quality and there was ever present a risk of the supply being contaminated. This danger was increased a thousand fold or more during the Fairs as a result of a crowded concourse of hundreds of thousands of pilgrims from every part of India who could easily contaminate the water by direct as well as indirect methods. Like many other large religious fairs held in India, the Sun Eclipse Fairs were extremely liable to become the starting centre of great and widespread epidemics of cholera, carried by the dispersing throngs of pilgrims to all parts of the country, unless the watersupply was placed beyond risks of contamination.

Although the more recent Fairs held since the Great War had, by good luck, escaped becoming the cause of serious epidemics, nevertheless it is understood that in the past widespread epidemics had actually resulted from some of the previous fairs.

The question of providing a protected watersupply for the Fair area was first mooted in 1923 when a rough estimate for Rs. 3,53,650 was put forward for a water-supply system based on six tubewells, each with its own pumping plant. From these tubewells, water was intended to be pumped into six overhead reservoirs and thence delivered to numerous public standposts throughout the Fair area by a net work of cast iron distribution pipe-lines.

The Sun Eclipse Fair of the year 1928 was anticipated to be of exceptional importance as the date of the Eclipse coincided with two other Hindu festivals, *viz.*, Somvati Amavas and Diwali. It was decided by the authorities in May of that year that the sanitary arrangements for the Fair should be placed on an improved basis in order to ensure, so far as practicable, that the danger of spread of cholera would be reduced to a minimum. These arrangements consisted of important improvements to the watersupply, conservancy, sanitation and other public health and medical arrangements, but this Paper is confined merely to the watersupply problem.

THE 1928 FAIR.

Existing Percolation Wells.

The existing watersupply sources as already mentioned, consisted of upwards of about a hundred wells of various sizes, capacities and construction, sunk into the upper water bearing subsoil, water level being about 26 feet below ground level.

All the wells were in a more or less dilapidated state and a survey of them was made, as a result of which it was decided that 43 wells should be made fit for drinking purposes. 18 of these were equipped with hand operated Boulton elevators and 23 were fitted with hand operated semi-rotary pumps, while oil engine driven pumps were erected over the two more important wells, although as a matter of fact in actual practice, it was found that no well in the whole Fair area had a yield sufficient to keep a small power operated pump going continuously.

The well heads were fitted with hinged wooden covers and such repairs as were essential, were carried out to their structures. All condemned and other disused wells were closed up with brushwood, etc., to prevent their use. One or two light pressed steel tanks of 400 gallons capacity each were erected at the head of each well, into which the Boulton elevators or pumps discharged. The hand operated Boulton elevators and semi-rotary pumps were worked by kahars and the pilgrims, were only allowed to draw off the water through taps from the tanks.

As the purity of the well water was extremely doubtful, the capacities of all wells were measured before the fair and a suitable dose of chlorine in solution was introduced into each well from time to time to the requirements of the Health authorities.

Piped Watersupply System.

As soon as orders to proceed were received in April, 1928, a trial boring was put in hand at the Fair area in order to determine the suitability of the subsoil strata for tubewells. Fairly good water bearing sands containing water of good quality were met with at depths less than 300 feet below ground level and in June, 1928, orders were received to proceed with a piped watersupply system for Blocks 1, 2, 3 and 4 and parts of Blocks 5 and 6, *i.e.*, the eastern portion of the Fair area, based on three proposed tubewells, each having a designed capacity of 10,000 to 12,000 gallons of water per hour, the water to be pumped into three overhead steel reservoirs of pressed steel plates, each of 30,000 gallons holding capacity, erected on steel staging at a height of about 42 feet (full supply level) above the ground surface.

These tubewells are marked Nos. 1, 2 and 3 on the plan (Plate No. 1). Each tubewell was equipped with a 12 B. H. P. petrol and kerosene operated, 4 cylinder, high speed "Aster" engine direct coupled to a "Worthington" centrifugal pump having capacity of 10,000 gallons per hour against a total pumping head of 80 feet, installed in a brickwork pump chamber, 12 feet diameter, with floor level about 2 feet or so above normal subsoil water level.

The three tubewells with the pump chambers and reservoirs adjacent thereto were permanent structures but the pumping plants were arranged to be capable of easy removal.

Water was distributed in Blocks Nos. 1, 2, 3 and 4 and parts of 5 and 6 of the Fair area by means of a skeleton distribution system of steel pipelines laid temporarily in shallow trenches. These were joined with "Victaulic" joints, which admitted of rapid laying and dismantling after the Fair.

In all, about 3½ miles of distribution pipelines were laid, ranging from 4" i/d to 2" i/d in size with ¾" branches to standposts. These were coupled up to 125 public standposts consisting of brickwork pillars, each fitted with two ½" bib taps and the delivery of water per tap was well over 4 gallons per minute and 250 taps were provided. In addition, 9 taps were provided at standposts in the officers' Rest House and other camps. 6 No. 400 gallon steel tanks, each with ball valve controlled inlets and 3 supply taps, 22 No. special "mashak" filling taps and 9 road watering carts filling standposts, were provided at suitable points.

The time allowed for completing the installation was very short, bearing in mind that the pumping machinery and many pipes and fittings had to be imported from Europe but actually the job was ready for operation by the first week of November, 1928.

The tubewell pumping plants were operated for a total of 190·8 hours in all for 6 days from the 8th to the 13th November inclusive, the total supply pumped being 1,896,200 gallons.

No information could be obtained as to the distribution of pilgrim population throughout the Fair area in previous fairs and it was therefore impossible to lay down the distribution system with the certainty that it would be the most suitable for the population of the blocks or areas to be dealt with. Detailed observations were therefore undertaken of the approximate population density throughout the Fair area in order that for future Fairs the distribution system could be realigned in accordance with such observations. This was an advantage only got by the provision of temporary pipelines which could be removed after the Fair.

As a matter of fact, the results of the detailed observations of population indicated that an improvement in layout of the distribution system could be effected and this was made full use of in the planning of the distribution system of the Fairs held in 1933 and 1936. The distribution pipelines were raised after the Fair and all pipes, taps, valves, specials and other fittings were stored in a godown at one end of the Fair area near Kurukshetra Railway Station. This practice has been followed in the case of the later Fairs also.

Chlorination Arrangements.

Chlorine solution was prepared by a "Pulser" type Chlorination apparatus made by the Paterson Engineering Co., Ltd., installed in a permanent building constructed in the Rest house compound at Kurukshetra.

In this apparatus, the chlorine passes from a steel cylinder which contains 60 lb. of liquid chlorine, when full, through a filter to a stop valve above which a pressure gauge registers the pressure of the chlorine at that time. The gas passes through pressure reducing valves where the pressure is cut down to 10 lb. per square inch, to the regulating valve which regulates the quantity of gas required, which then passes through a glass pulsating meter partly filled with acid. The diameter of the glass tube and the stroke being known, the quantity of gas can be regulated as required. The gas then passes through vulcanite tubes to the bottom of the absorption tower containing pumice. A known quantity of water, supplied from an overhead tank on the roof of the building passes through the absorption tower and the solution flows into a chemical storage tank below which has a capacity of 400 gallons and is provided with a draw off tap and an indicator shewing the capacity. The water delivery pipe to the absorption tower is regulated to give a discharge of 60 gallons per hour. The water supply is turned on and the chlorination apparatus started to work at the proper pulsation speed according to the strength of the concentrated solution required. The chloronome was in the use altogether for 84 hours and dispensed 1,800 gallons of solution (·004 lb. per gallon) and 3,800 gallons of solution (·008 lb. per gallon) using 37·6 lb. of liquid chlorine.

The chlorination apparatus above described has been used for preparation of chlorine solution required for all later Fairs.

Population.

The total number of pilgrims attending this fair was approximately 735,000 as compared with 480,000 estimated on the occasion of the Sun Eclipse Fair of 1922 and 700,000 estimated for the Fair of 1926.

Water-borne Epidemics.

The Fair, unfortunately, was not free from cholera. On November 7th, 2 pilgrims hailing from Burma who had halted at Gaya, a cholera infected area, were found to be suffering from cholera and these were followed by other cases. In all 11 imported cases of cholera were discovered before the Fair (November 6th to 10th, 1928) and 38 cases during the Fair (November 11th to 15th). After the Fair, 84 cases were found in the Punjab and 119 in the United Provinces; thus the total number of cases of cholera associated with this Fair was 252 in all. It is practically sure that if special arrangements had not been taken to provide a protected watersupply for six blocks and to chlorinate the water of the other sources of supply, the Fair would have been the cause of a considerable epidemic of cholera.

THE 1933 FAIR.

General.

The 1933 eclipse took place on August 21st and it was decided to extend the protected watersupply system in order to further reduce the demand on the old open percolation wells, during this Fair.

Tubewells.

On testing Tubewell No. 1 put down in 1928, it was found to have deteriorated in yield to a considerable extent and in spite of every effort by air blowing and surging, the original discharge could not be restored. Therefore a new tubewell had to be sunk alongside the pump chamber.

A new Tubewell, No. 4, was put down near the Sanyahet Tank and was equipped with a "Pulsometer" centrifugal pumping set, chain driven from a 12—14 H. P. "Petter" vertical, two stroke, crude oil engine, the plant being housed in a circular pump chamber at the head of the tube-well, taken down to within a couple of feet of subsoil water level. The plant was designed to pump 10,000 gallons per hour against a total head of 100 feet and was direct coupled to an adjacent trunk distribution main. Thus the 4 tubewells had a discharge of 40,000 gallons per hour, say a maximum of 960,000 gallons per diem of 24 hours, continuous working.

Distribution System.

As a result of the observations made at the 1928 Fair, the layout of the distribution system was re-arranged to meet the requirements of the population and the pipelines were extended towards the west side of the Fair area to cover additional ground on that side. Actually about 5 miles of 4", 3" and 2" pipelines were laid. These were coupled by 1" and $\frac{3}{4}$" connections to 167 stand posts, each fitted with 2 half inch bib taps and in addition watersupply services were afforded to the field hospitals, police lines, police posts, Officers' Rest house and Rest camp.

At points where heavy demand for water was expected, batteries of

400 gallons capacity pressed steel tanks ranging from one to three or four were placed on platforms a little above ground level and coupled up to the distribution system with ball valve controls. Each tank was provided with three ½" bib taps for the draw off of water.

The total number of distribution taps provided was approximately 500. Ten road watering cart filling standposts, each capable of supplying 50 gallons per minute, were placed at suitable points, and 7 special mashak filling connections were provided for watering the ground surface in the various blocks.

It had been found that many of the rubber rings of victaulic jointed pipes required to be renewed when the pipes came to be relaid and on grounds of expense, pipes used for the extension pipelines consisted of screwed and socketted galvanized iron water pipes, with flanged joints at intervals of 300 feet to 400 feet to facilitate uncoupling.

Percolation Wells.

The number of percolation wells brought into use this time, was cut down to 15 of which 14 were fitted with "Boulton" elevators and tanks and one with semi-rotary hand pump and tank, as described for the 1928 Fair.

Some of these wells were of little use because of insufficient yield. The Boulton elevators did not behave satisfactorily, trouble being experienced with broken bands, and in some cases they had to be replaced with hand pumps during the Fair. In Blocks 8 and 9, during the last 3 days of the Fair, road watering lorries had to be brought into use to supply chlorinated drinking water in order to supplement the yield from the percolation wells.

Chlorination.

The three overhead reservoirs of the protected watersupply system were cleaned and filled and then treated with chlorine solution, before the pilgrims began to arrive for the Fair but the results of the bacteriological examination of the water subsequently was still not satisfactory, so further chlorination of the distribution system had to be resorted to. This was done by introducing gradually a suitable quantity of chlorine solution into each tubewell and pumping the water, heavily charged with chlorine, through the various distribution pipelines. The third dose of chlorine was administered on the day preceding the eclipse date.

The probable cause of the trouble was that the long lengths of distribution pipelines recently relaid had been contaminated while in course of being handled in relaying and jointing and the sources of contamination had not been washed out of them.

The open percolation wells were chlorinated in the same manner as described for the 1928 Fair, and disused wells were kept heavily charged with permanganate of potash solution and protected.

Population and Quantity of Water Supplied.

The number of pilgrims who attended this fair has been estimated at about 450,000 to 460,000. The fair being held in the monsoon, rendered it more difficult for pilgrims to travel by road from their homes than in the dry season and owing to the rainy weather and the heat and humidity, the conditions of life in the Fair area must have been uncomfortable.

The total supply of water pumped by the tubewell pumping plants for the whole Fair period was 3,078,000 gallons. Owing to frequent showers of rain the demand for water was below expectations.

Water-borne Epidemics.

It is gratifying to mention that although the Fair was held in the cholera season and that at that time no less than eleven Districts in the Punjab had reported cases of cholera, besides districts in other provinces, no outbreak of cholera occurred. Three imported cases were detected however, of which one died in the Isolation hospital and the rest recovered.

THE 1936 FAIR.

General.

The 1936 Eclipse took place on June 19th and as this was in the hottest season of the year, it was anticipated that an abnormal demand for water would have to be met.

It was decided therefore that the protected water-supply system should be further extended to cover substantially the whole of the Fair area and that an additional tubewell with 30,000 gallons capacity overhead service reservoir, should be provided.

Tubewells.

Tubewells Nos. 1, 2, 3 and 4 were put into order and re-equipped with their pumping plants.

The yield of Tubewell No. 4 was found to be considerably reduced when it was tested and resort had to be made to the use of airlift plant to blow the well and to surge the water.

This improved the yield considerably but in order to avoid risk of failure, a new tubewell No. 4-A, was drilled alongside the old tubewell.

It was imperative therefore that some means or other should be found for supplying water to the tanks before the Fair. There were serious difficulties involved as the nearest canal, the Western Jumna, was twenty miles away and below the level of the sacred tanks, hence a scheme for bringing in canal water would involve pumping operations, besides which the cost of the work was likely to amount to Rs. 50,000. It was not likely, moreover, that the water could be spared, while the absorption losses in a long length of new channel would be very heavy.

There was no practicable alternative therefore except to replenish the tanks from tubewells.

The Kurukshetra tank being nearly 4000 feet long by about 2000 feet wide, it was impracticable to provide at reasonable cost, sufficient water for replenishing the full area of this reservoir.

Luckily all the bathing ghats are along or adjacent to the northern side of the tank, so an earth bank nearly 4000 feet long was constructed roughly parallel to the north side and about 250 to 300 feet away from it. Work on this bank was commenced on February 17th and finished by the end of March, while the depth of water in that part of the tank was still about four feet or more.

In the meantime, 2 portable oil engine driven pumping sets were installed on the bund and these pumped water across from the south side of the bund to the north side, from March 10th till April 11th. In the meantime also a large tubewell (No. 6) was sunk to a depth of 309 feet near the north east corner of the Kurukshetra tank and equipped with a 40 H. P. portable steam engine driving an air compressor and airlift plant. This was ready on April 17th and was put into action immediately, while Tubewells Nos. 4 and 4-A were equipped with a 27 H. P. diesel engine driven airlift in addition to the "Petter" 12—14 H. P. oil engine driven centrifugal pumping plant normally installed, and put into action at the end of March, 1936.

A discharge of 23,000 to 24,000 gallons per hour was given by Tubewells Nos. 4 and 4—A combined and about 29,000 to 30,000 gallons per hour by Tubewell No. 6. These discharges were passed into the isolated northern portion of the Tank, by which means the water was easily maintained at an average depth of 4 to 5 feet, the inflow more than balancing the absorption and evaporation losses.

Early in May, action was taken to replenish the Sanyahet tank from Tubewell No. 6 while Tubewells Nos. 4 and 4-A continued to deliver into the Kurukshetra tank.

These operations were continued until the day of the Eclipse and a total of 35,608,000 gallons of water was passed into the tanks.

Water-borne Epidemics.

The Fair was held in the cholera season and at a time when fourteen Districts in the Punjab and at least four other provinces were reported to be infected with cholera.

Only four cases of cholera, including one death, was reported at the Fair. These were imported cases and no case of cholera was reported from amongst returning pilgrims.

Drawings.

Six plates of drawings are attached—one showing the general layout of the watersupply system as finally carried out for the 1936 Fair and the others shewing details of tubewells, chlorination apparatus, etc.

Water Analysis.

A copy of the analysis of the water of Tubewell No. 4-A is attached This is typical of the water yielded by all tubewells. The water is hard but otherwise of good quality.

Conclusion.

The construction of the watersupply works described in the paper, cost about Rs. 2,00,000. They are the largest temporary works of watersupply carried out for Fairs in the Punjab. They are not claimed to be perfect, especially as the section of the works carried out initially for the 1928 Fair had to be rushed through and completed in a very great hurry in order to be ready in time, but they have proved of great usefulness in the provision of a safe watersupply for the pilgrims and other population of the three last Fairs and were no doubt the principal agency in preventing the spread of serious cholera epidemics therefrom.

APPENDIX.

Extract from analysis of Chemist, Public Health Department, Punjab on a sample of water taken from Borehole for Tubewell No. 4-A at a depth of 268 feet for the Thanesar Fair Watersupply.

Physical Characteristics.

Turbid, tasteless and odourless, with a deposit of *iron* oxide.

Results of analysis expressed in Parts per 100,000.

Reaction.	Free CO_2.	Oxygen absorbed in 2 hours at 27°C.	Chlorides (NaCl).	Nitrates.	Nitrites.	Sulphuretted Hydrogen.	Lime.	Sulphates.	Total solid matter.	Hardness.			Free Ammonia.	Albuminoid ammonia.	Phosphates.	Poisonous metals.	
										Permanent.	Temporary.	Total.				Iron.	Other metals.
Alkaline.	Present.	—	1·65	Absent.	0·00	Absent.	Traces.	Absent.	31·0	4·5	17·5	22·0	0·00	0·00	Present.	Present.	Absent.

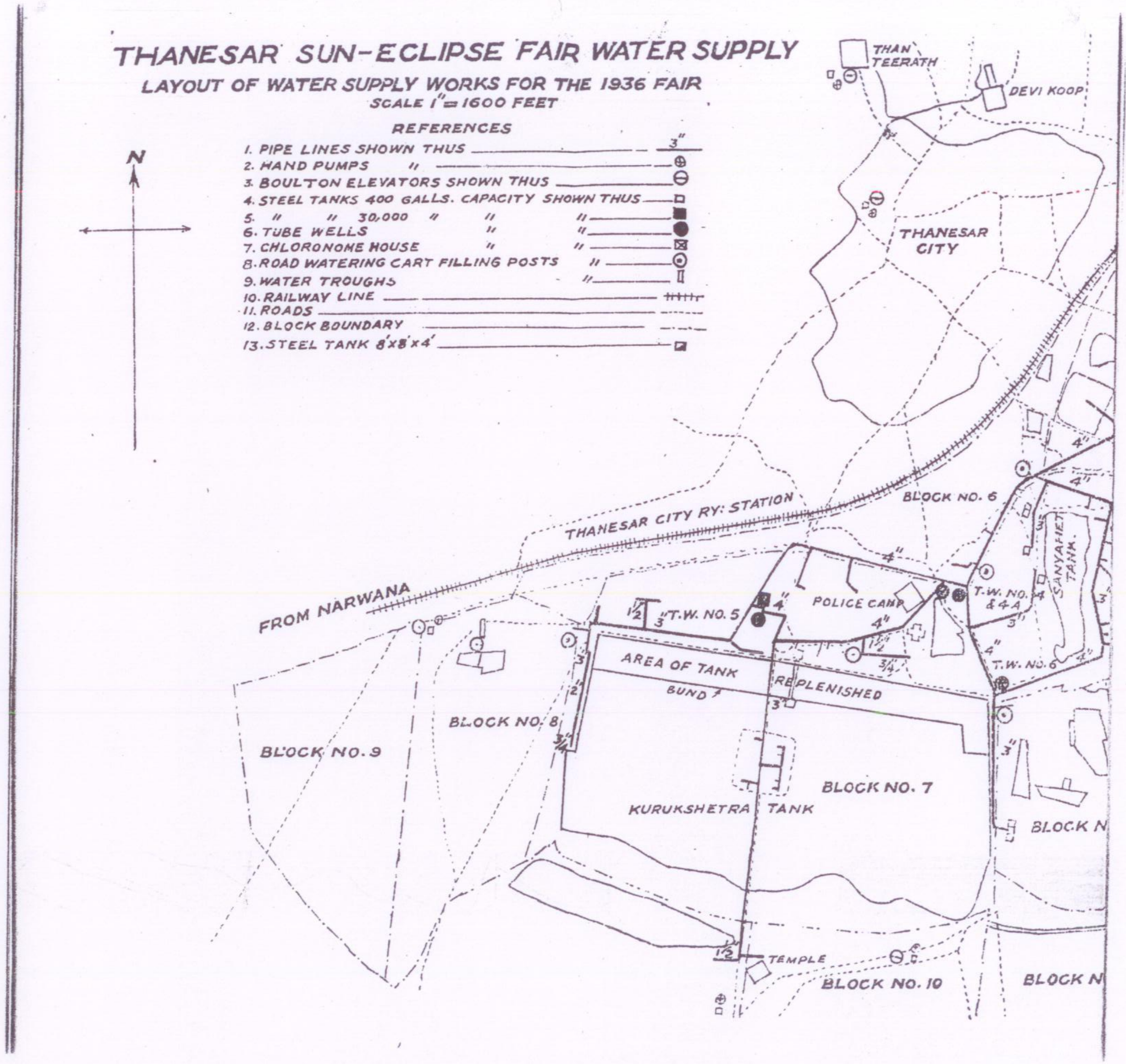
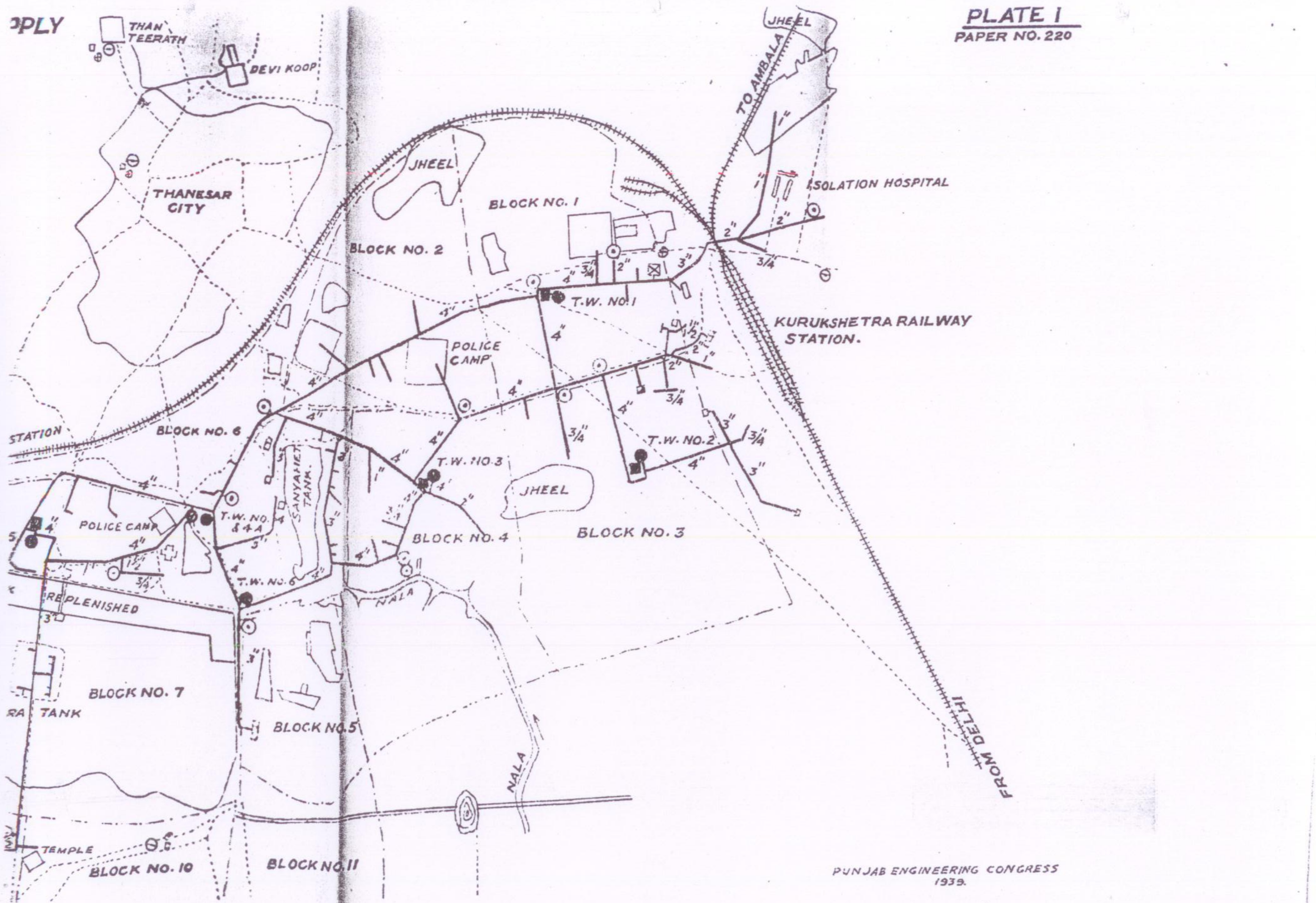
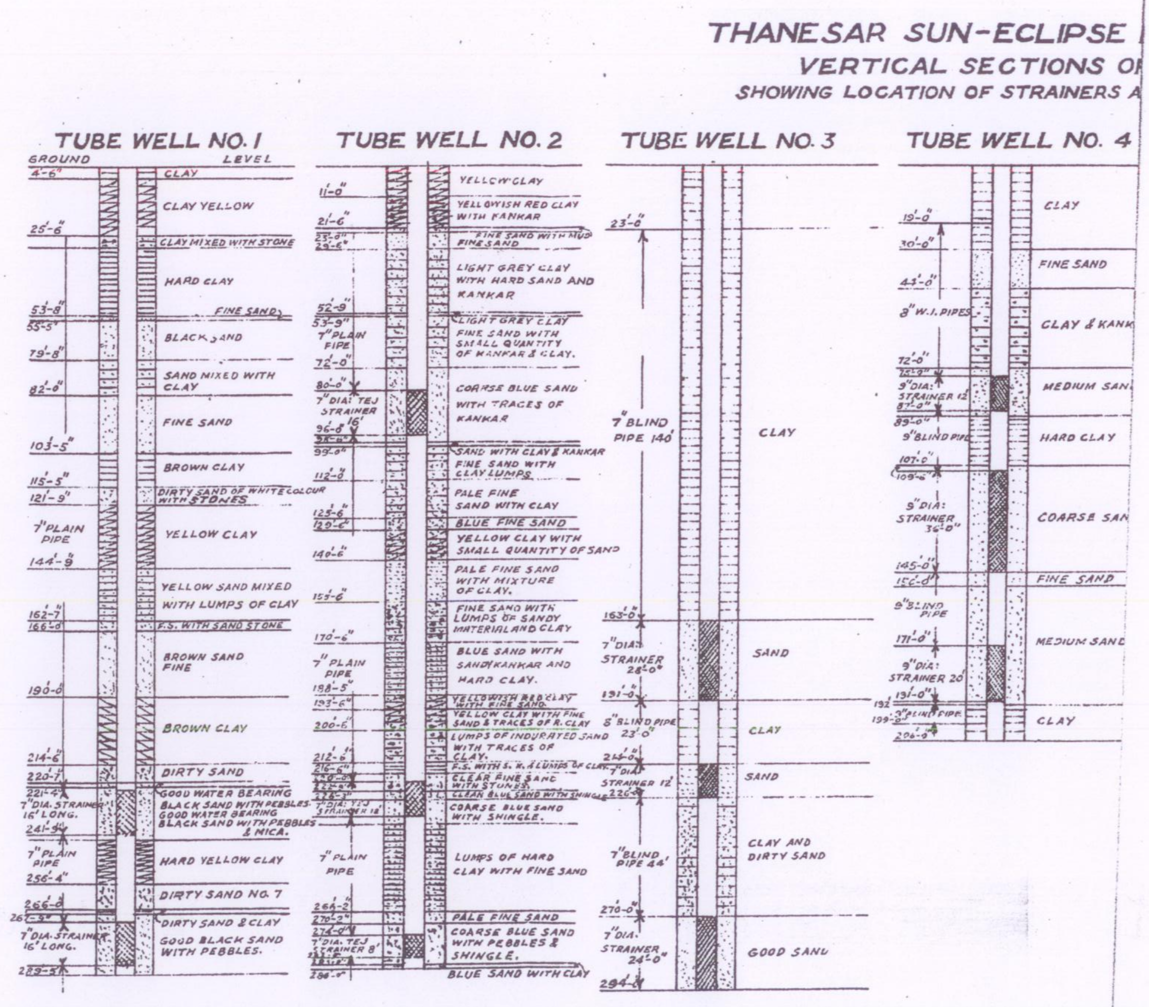

THANESAR SUN-ECLIPSE FAIR WATER SUPPLY
LAYOUT OF WATER SUPPLY WORKS FOR THE 1936 FAIR
SCALE 1" = 1600 FEET
REFERENCES
1. PIPE LINES SHOWN THUS
2. HAND PUMPS
3. BOULTON ELEVATORS SHOWN THUS
4. STEEL TANKS 400 GALLS. CAPACITY SHOWN THUS
5. " " 30,000 " " "
6. TUBE WELLS
7. CHLORONOME HOUSE
8. ROAD WATERING CART FILLING POSTS
9. WATER TROUGHS
10. RAILWAY LINE
11. ROADS
12. BLOCK BOUNDARY
13. STEEL TANK 8'x8'x4'
N
THAN TEERATH
DEVI KOOP
THANESAR CITY
THANESAR CITY RY: STATION
FROM NARWANA
BLOCK NO. 6
POLICE CAMP
T.W. NO. 4 & 4 A
T.W. NO. 5
T.W. NO. 6
SANYAHET TANK
AREA OF TANK REPLENISHED
BUND
BLOCK NO. 7
BLOCK NO. 8
BLOCK NO. 9
BLOCK NO. 10
KURUKSHETRA TANK
TEMPLE
BLOCK N
BLOCK N

PLATE I

PAPER NO. 220



PUNJAB ENGINEERING CONGRESS
1939.

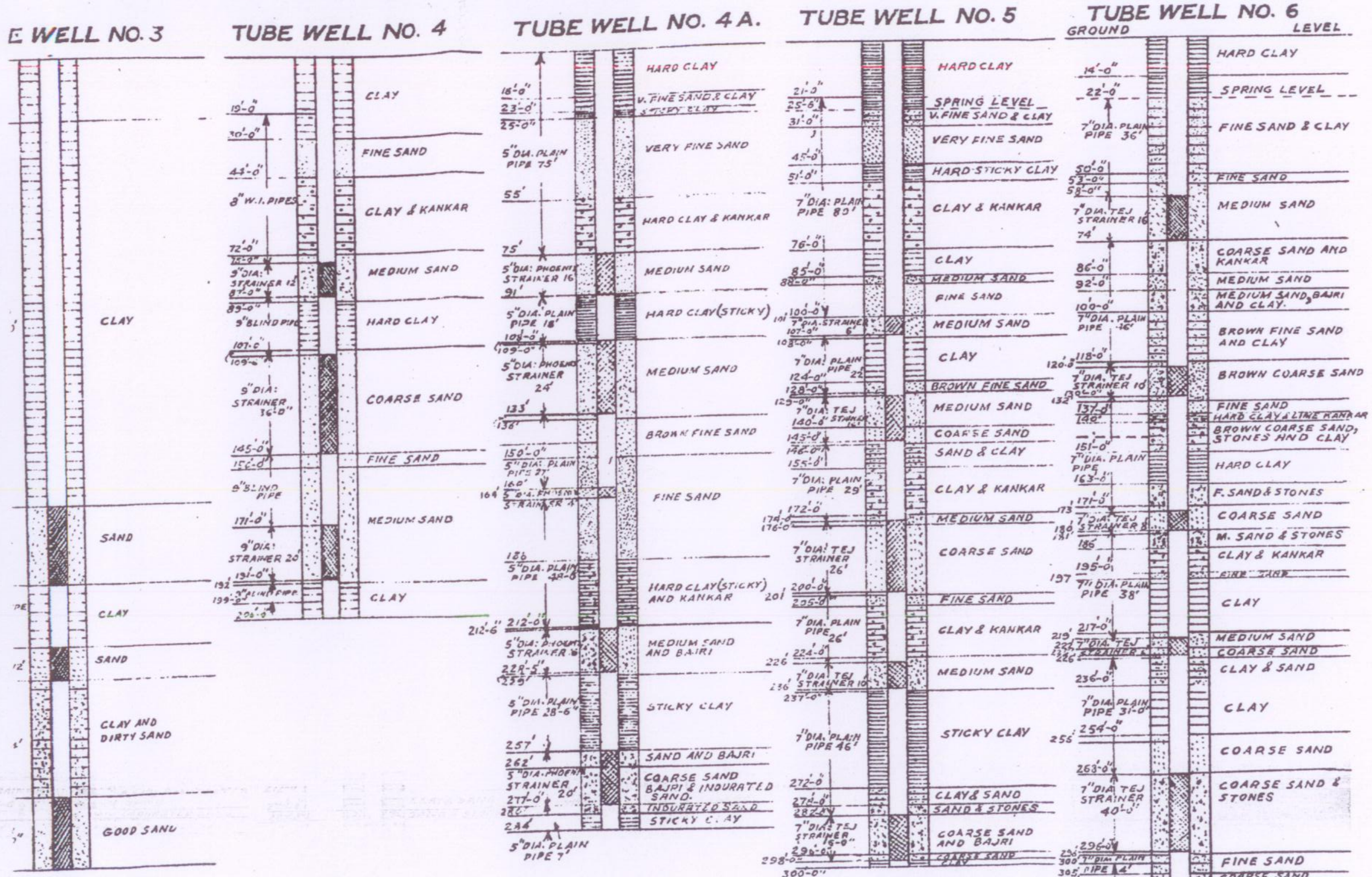


THANESAR SUN-ECLIPSE
VERTICAL SECTIONS OF
SHOWING LOCATION OF STRAINERS A
TUBE WELL NO. 1
TUBE WELL NO. 2
TUBE WELL NO. 3
TUBE WELL NO. 4
GROUND LEVEL
CLAY
CLAY YELLOW
CLAY MIXED WITH STONE
HARD CLAY
FINE SAND
BLACK SAND
SAND MIXED WITH CLAY
FINE SAND
BROWN CLAY
DIRTY SAND OF WHITE COLOUR WITH STONES
YELLOW CLAY
YELLOW SAND MIXED WITH LUMPS OF CLAY
F.S. WITH SAND STONE
BROWN SAND FINE
BROWN CLAY
DIRTY SAND
GOOD WATER BEARING BLACK SAND WITH PEBBLES
GOOD WATER BEARING BLACK SAND WITH PEBBLES & MICA.
HARD YELLOW CLAY
DIRTY SAND NO. 7
DIRTY SAND & CLAY
GOOD BLACK SAND WITH PEBBLES.
7" PLAIN PIPE
7" DIA. STRAINER 16' LONG.
YELLOW CLAY
YELLOWISH RED CLAY WITH KANKAR
FINE SAND WITH MUD
FINE SAND
LIGHT GREY CLAY WITH HARD SAND AND KANKAR
LIGHT GREY CLAY
FINE SAND WITH SMALL QUANTITY OF KANKAR & CLAY.
COARSE BLUE SAND WITH TRACES OF KANKAR
SAND WITH CLAY & KANKAR
FINE SAND WITH CLAY LUMPS
PALE FINE SAND WITH CLAY
BLUE FINE SAND
YELLOW CLAY WITH SMALL QUANTITY OF SAND
PALE FINE SAND WITH MIXTURE OF CLAY.
FINE SAND WITH LUMPS OF SANDY MATERIAL AND CLAY
BLUE SAND WITH SAND/KANKAR AND HARD CLAY.
YELLOWISH RED CLAY WITH FINE SAND
YELLOW CLAY WITH FINE SAND & TRACES OF R. CLAY
LUMPS OF INDURATED SAND WITH TRACES OF CLAY.
CLEAR FINE SAND WITH STONES.
CLEAN BLUE SAND WITH SHINGLE
COARSE BLUE SAND WITH SHINGLE.
LUMPS OF HARD CLAY WITH FINE SAND
PALE FINE SAND
COARSE BLUE SAND WITH PEBBLES & SHINGLE.
BLUE SAND WITH CLAY
7" PLAIN PIPE
7" DIA. TEJ STRAINER 16'
7" DIA. TEJ STRAINER 8'
CLAY
SAND
CLAY
SAND
CLAY AND DIRTY SAND
GOOD SAND
7" BLIND PIPE 140'
7" DIA. STRAINER 28'-0"
8" BLIND PIPE 23'-0"
7" DIA. STRAINER 12'
7" BLIND PIPE 44'
7" DIA. STRAINER 24'-0"
CLAY
FINE SAND
CLAY & KANK
MEDIUM SAN
HARD CLAY
COARSE SAN
FINE SAND
MEDIUM SAND
CLAY
8" W.I. PIPES
9" DIA. STRAINER 12'
9" BLIND PIPE
9" DIA. STRAINER 36'-0"
9" BLIND PIPE
9" DIA. STRAINER 20'

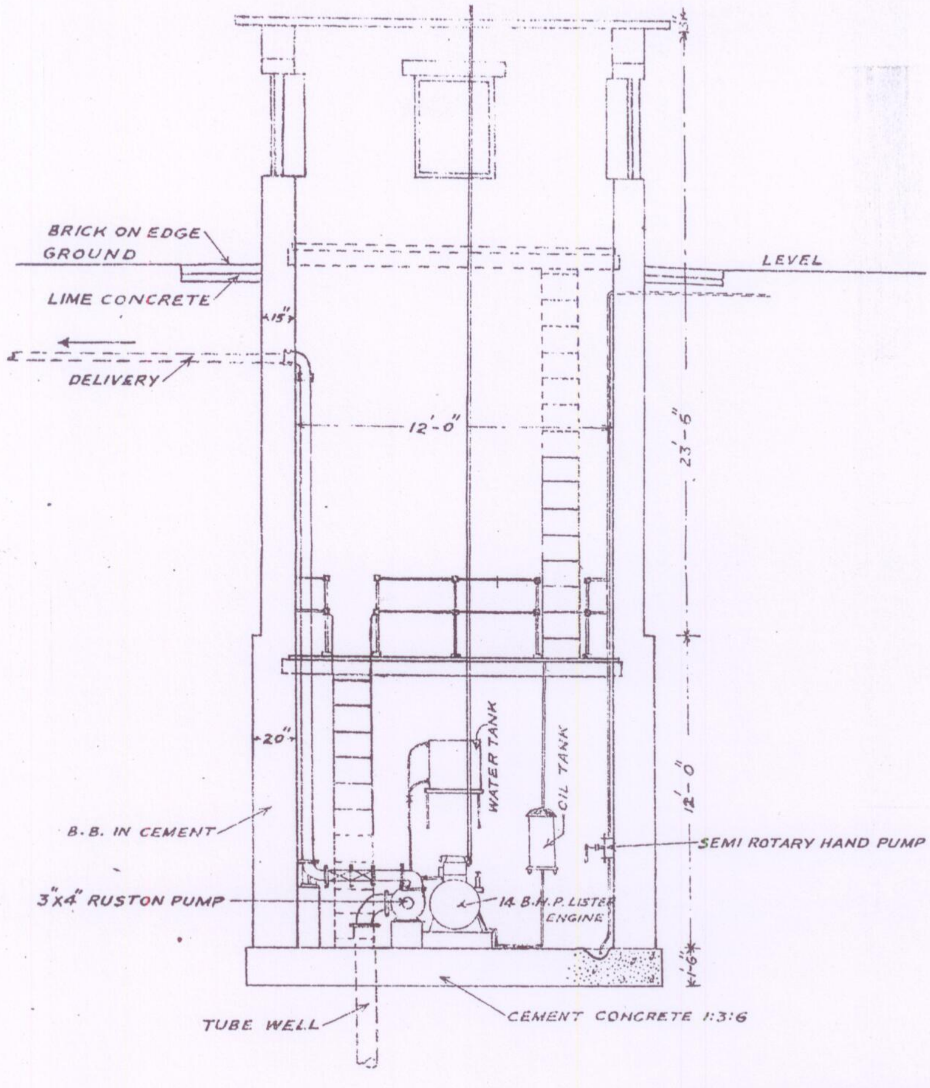
THANESAR SUN-ECLIPSE FAIR WATER SUPPLY

VERTICAL SECTIONS OF TUBE WELLS

SHOWING LOCATION OF STRAINERS AND PLAIN PIPES



PUNJAB ENGINEERING CONGRESS, 1939.



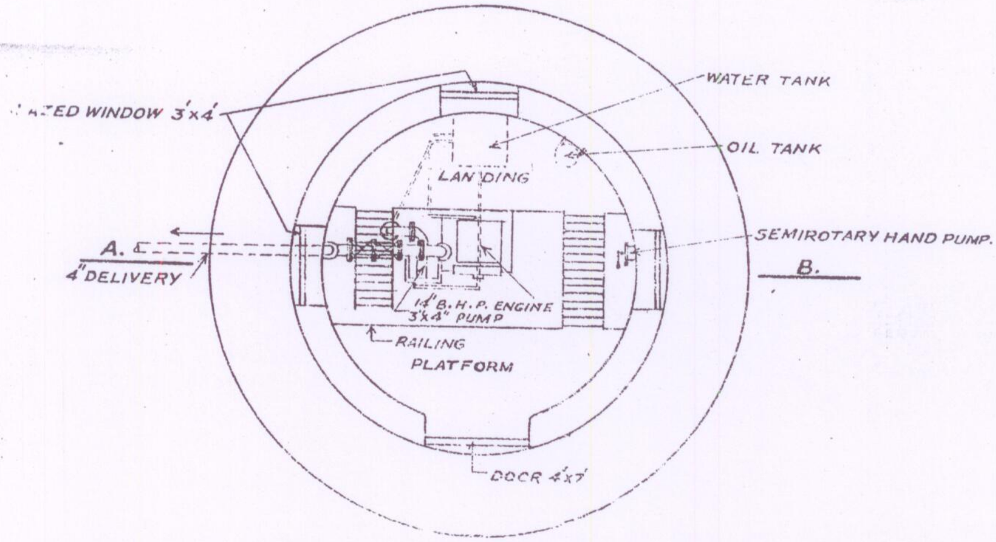
PUNJAB ENGINEERING CONGRESS.
1939.

PLATE III
PAPER NO. 220

THANESAR SUN-ECLIPSE FAIR WATER SUPPLY

CIRCULAR PUMP CHAMBER
(WELL NO. 5)
SCALE 3/16" = 1 FOOT

PLAN



SECTION ON A.B.

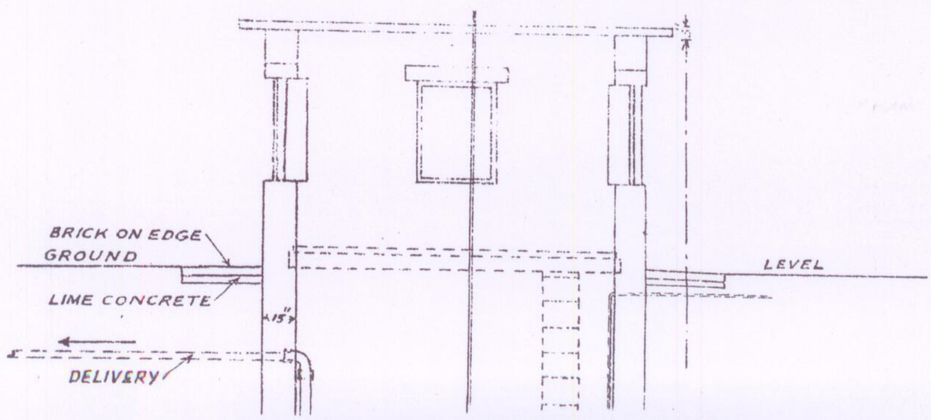


PLATE IV

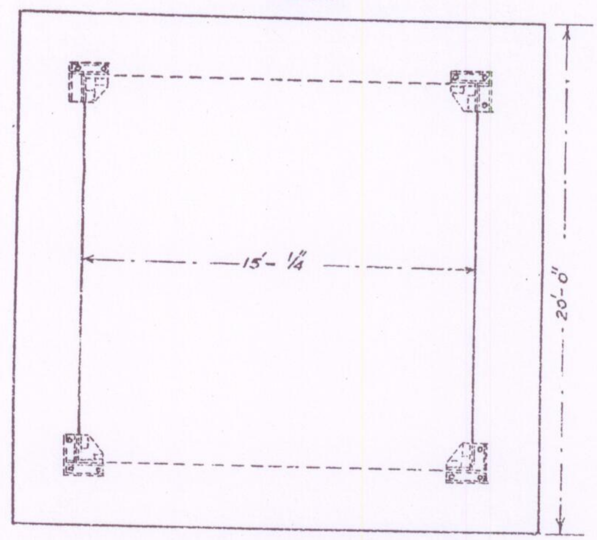
PAPER NO. 220

THANESAR SUN-ECLIPSE FAIR WATER SUPPLY

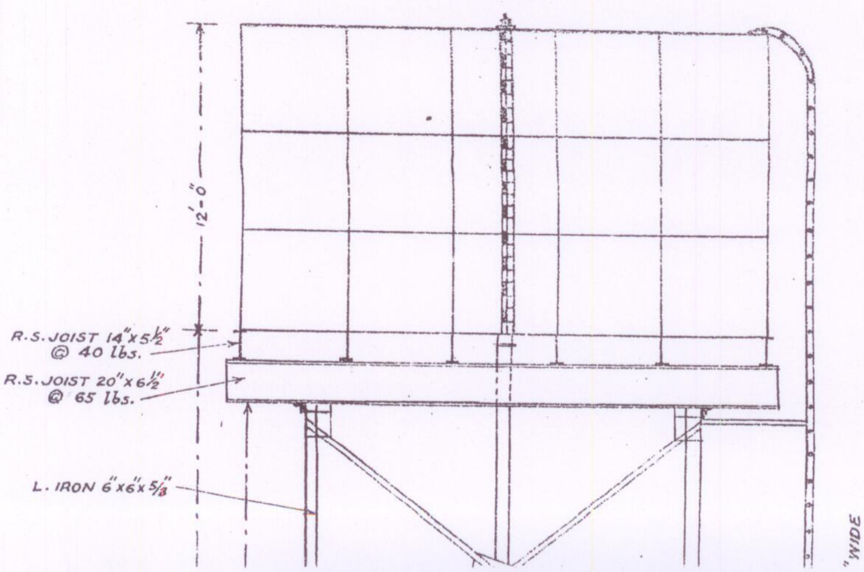
PRESSED STEEL RESERVOIR 30,000 GALLONS CAPACITY

SCALE 3/16" = 1 FOOT

PLAN



ELEVATION

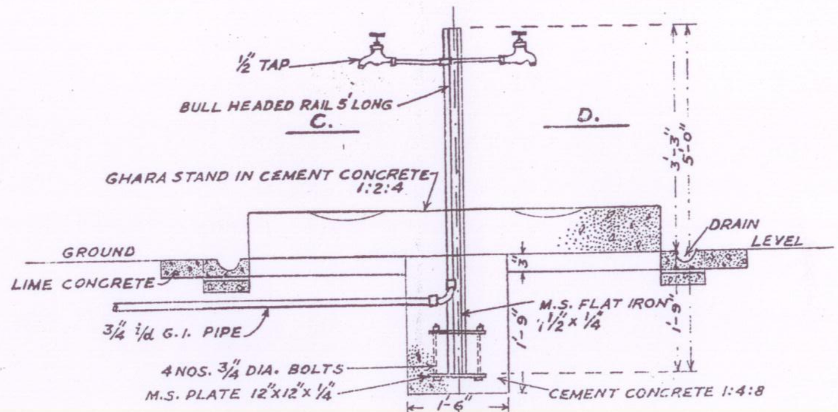


THANESAR SUN-ECLIPSE F

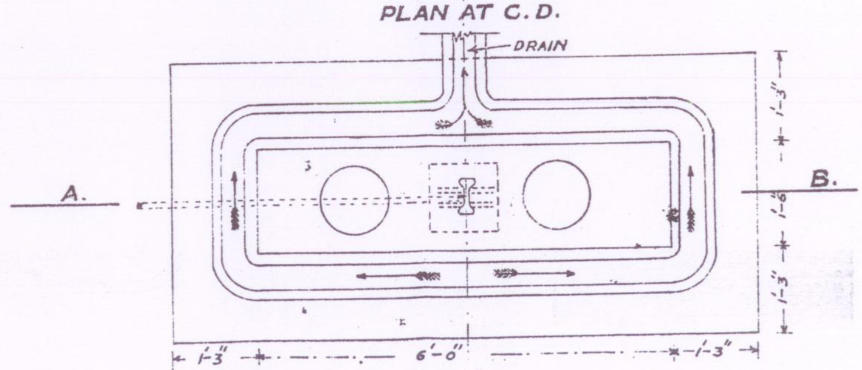
PUBLIC STAND PO

SCALE 1" = 2 FEE

SECTION ON A.B.



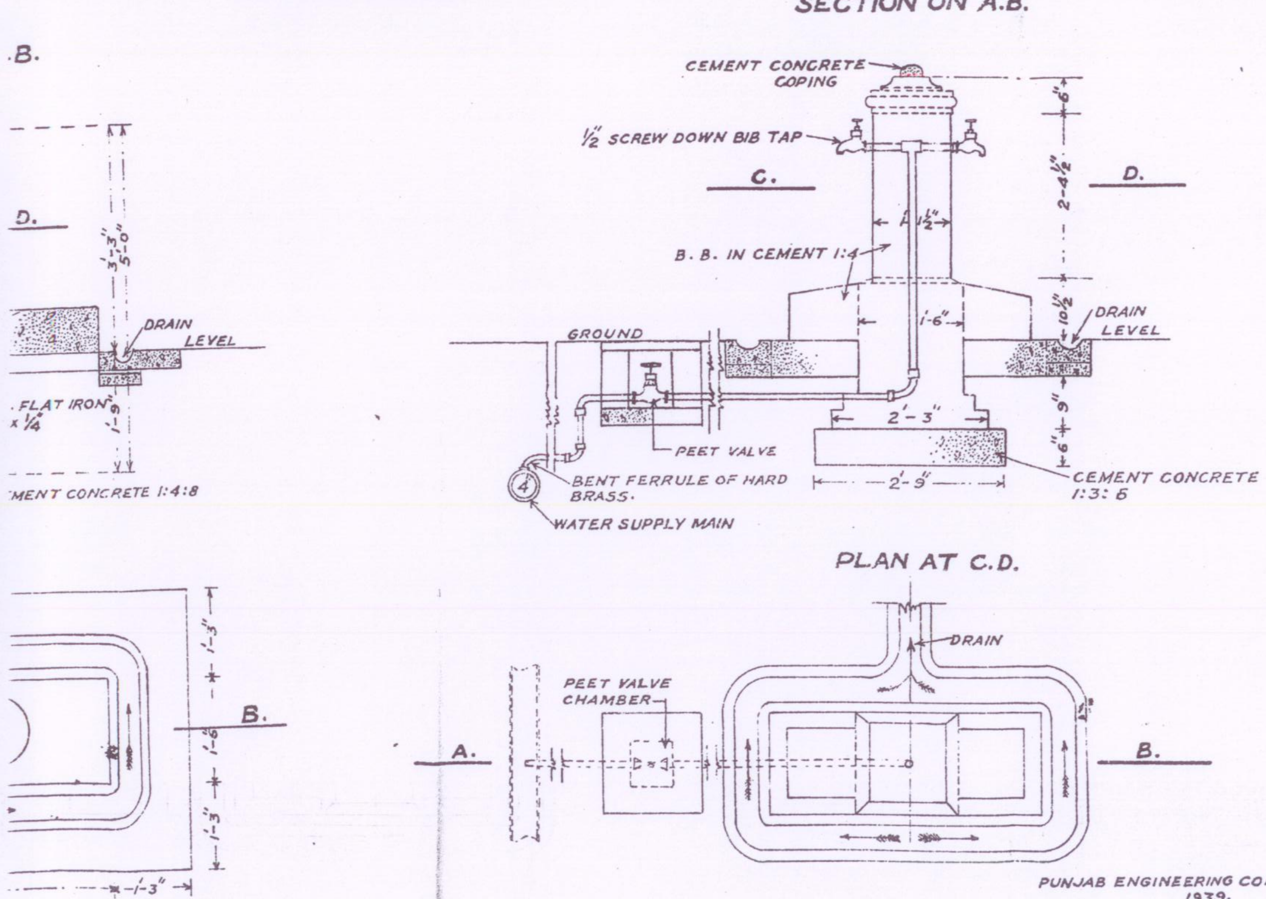
PLAN AT C.D.



THANESAR SUN-ECLIPSE FAIR WATER SUPPLY

PUBLIC STAND POSTS.

SCALE 1" = 2 FEET



PUNJAB ENGINEERING CONGRESS.
1939.

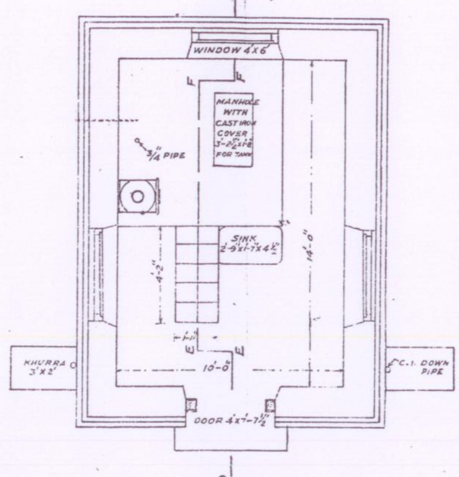
PLATE VI
PAPER NO 220

THANESAR SUN-ECLIPSE FAIR WATER SUPPLY

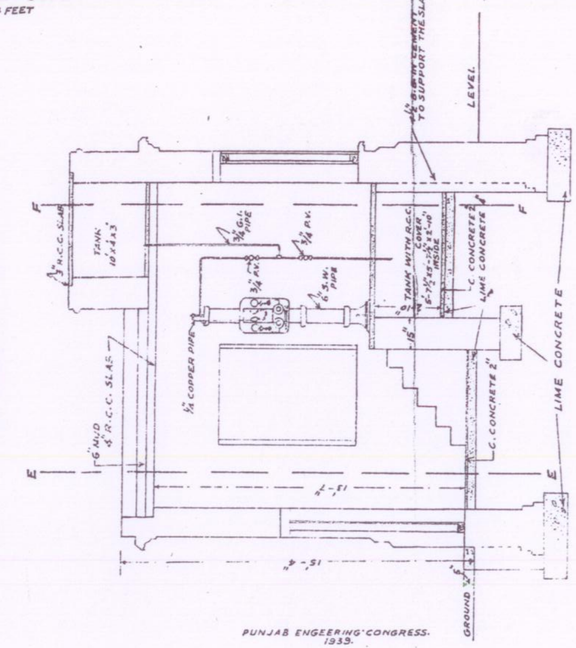
CHLORONOME HOUSE

SCALE 1" = 4 FEET

PLAN



SECTION ON D. E. F. G.



PUNJAB ENGEERING CONGRESS.
1933.

DISCUSSION.

The **Author** introduced his paper saying that he had tried to give an account of the largest Fair water supply works attempted in the Punjab. He did not claim that the scheme carried out was the best that could be devised. At the same time, in spite of the fact that the work had to be executed in a piecemeal manner and under conditions of extreme urgency, they had been successful in solving the problem of watersupply and preventing the spread of water-borne epidemics.

S. Hukum Singh stated that the source of water supply was a controlling factor in the design of water supply pumping or lifting arrangements.

At Kurukshetra the source of supply consists of tube wells in which the spring level was about 26 feet below the surface and the arrangements for lifting water consisted of oil engine driven centrifugal pumping plants, except at Tube well No. 6 where an air lift was employed. From the data given on plate II, the areas of strainers in various tube wells were as follows :—

Tubewell	No. 1	.. 59 square feet.
,,	No. 2	.. 66 ,, ,,
,,	No. 3	.. 117 ,, ,,
,,	No. 4	.. 160 ,, ,,
,,	No. 4-A	.. 105 ,, ,,
,,	No. 5	.. 136 ,, ,,
,,	No. 6	.. 143 ,, ,,

The Author has not given the yield and depression head of any of these tube wells other than tube well No. 4 which was 14,000 gallons per hour at 10 feet depression head; this worked out to 87·5 gallons per square foot of area of strainer or nearly 9 gallons per square foot of strainer area per ft. depression head which was very much less than the average yield obtained in other parts of the Punjab.

Out of the seven tube wells provided at Kurukshetra, tube well No. 1 was put in 1928, its yield deteriorated in 1933 while tube well No. 4 was put in 1933 and its yield decreased in 1936.

An attempt was made to improve the yield of tube well No. 1 by blowing and surging, a process by which air was compressed into the tube well to something like 60 lb. per square inch or more, thereby trying to depress down the spring level and then releasing the pressure suddenly to allow the water to rise quickly and thus clear the slits by its fast passage or great velocity through them.

It remained to be proved however whether actually the water level was depressed or not by this method and in the speaker's opinion, water being more or less incompressible, the water level was not depressed and this was the reason for this operation being unsuccessful.

Incrusting material formed around the strainers, by chemical and electrolytic action, had in a few cases been successfully removed by dissolving it in hydrochloric acid introduced in the tube well by various methods.

From these facts it was clear that the yield and life of the tube wells put in at Kurukshetra was rather short and was due to clogging of strainers.

On page 33, it was given that the combined capacity of six tube wells *i.e.*, tube wells 1 to 5 was 63,000 gallons per hour or 98 gallons per square ft. of strainer which, according to the yield of tube well No. 4 showed that these tube wells were being worked at 10 to 11 ft. depression head. These tube wells were operated by oil engine driven, centrifugal pumps except tube well No. 6 which was worked by air lift.

On page 35 the Author stated that a large tube well *i.e.*, tube well No. 6 was bored to a depth of 309 ft. with 78 ft. length of strainer.

It was a pity that this tube well although taken down so far below, had actually less strainer area than tube well No. 4 due to the diameter of the strainer being less.

This was presumably due to the dia : of boring being small and if a 9″ *i/d* strainer had been provided in place of 7″, the yield would have been easily 40 per cent more.

On the same page, the Author stated that by employing air lift, tube well No. 6 gave 29,000 gallons per hour. This worked out to 203 gallons per square ft. of strainer area which was 2·1 times the yield per sq. ft. of strainer area as compared with other tube wells.

For a fair watersupply scheme it was necessary to get the required quantity of water for a few days in a year or in few years, even at sacrifice of efficiency which would not make any appreciably great difference in cost, etc., and accordingly there was no reason whatever why these tube wells should not be worked to 40 or 50 ft. depression head and thus extract out of the tube wells three to four times the quantity of water now being extracted. The positions of strainers in tube wells No. 1 to 5 on plate No. II rendered this practicable.

The working of tube wells to a depression head of 40 to 50 ft. would not only increase the yield but would also considerably add to keeping the strainer silts clear by the increased velocity through the silts and thus increase the life of the tube wells and obviate the necessity of putting in bigger tube wells or tube wells with greater strainer area.

To obtain this, either oil engine driven multistage bore hole turbine pumps driven by belt and geared head ; or oil engine driven compressors to provide compressed air for lifting water should have been provided in place of the oil engine driven horizontal centrifugal pumps.

The cost of either turbine pump with head, fitted above ground level or air lift arrangement with pump-house would not have been very much more than the existing pumping plants and pump houses with floor level 21 ft. below ground level.

In water supply schemes, selection of proper type of pumping machinery suitable for particular conditions was a matter of great importance and it would be very interesting if the Author could supply more information on this aspect. In the speaker's opinion, the horizontal centrifugal pumps installed were not the right type of pumps for the kind of service they were called upon to render, in this particular case, as well as in other cases where the depression head was rather less and pumping very infrequent taking into consideration the life and yield of the tube wells.

On page 31 a reference was made about employment of G. I. Pipes with victaulic joints. These types of joints were used by reason of the so called elasticity of joints and quickness in laying. Could the Author give any further information as to the necessity of providing this expensive type of jointing and whether any flexibility more than that provided by ordinary screwed G. I. Pipes was required ; also whether if the pipes were threaded and flanges put on say at every 300 to 400 ft. it was not just as quick and also cheaper to joint and dismantle threaded G.I. Pipes as compared with victaulic jointed pipes, taking into consideration the cost of rubber joints said to have required replacement as early as in 1933 ?

The speaker was of opinion that ordinary threaded G. I. Pipes were cheaper and easier to lay and dismantle than pipes provided with victaulic or other patent jointing.

It appeared that a 4" *i/d* distribution system was rather on the small side taking into consideration the large quantity of water such as 10,000 gallons per hour passing through it, and it would be interesting to know from the Author as to what was the terminal head like at various stand posts.

In tube well No. 6 the strainer was also located in surface water. Could the Author tell us as to what precautions were taken to keep this water free of contamination if used for drinking purposes.

Dewan Bahadur **Amar Nath Nanda** pointed out that Hardwar and Kurukshetra were the two most important places in Northern India where big fairs are held and people flocked from all over India. As it was from these fairs that country-wide epidemics had originanted the importance of providing a protected water supply at these places would be readily realized. It was for the fair of 1928 that a beginning was made in this direction so far as Kurukshetra was concerned and, as the Paper revealed, considerable extensions to the water supply had been carried out since.

Originally, more of the shallow subsoil water from percolation wells, had to be supplied to the pilgrims but as the supply of such water was attendant with grave risks in the spread of water-borne diseases, it was found necessary to chlorinate the supply. Experience showed that people were shy of using chlorinated water. It was a peculiar happening that most of the recent eclipses occurred during the summer when the demand for water was the maximum and risks for the spread of epidemics greatest. The task of the water engineer, entrusted with the supply of the most important amenity of life, the water, therefore became most onerous. In view of the general disinclination of the public to use chlorinated water, it appeared to the speaker to be most advisable to abandon the percolation wells, which were invariably liable to contamination, and derive the entire supply from deep seated tubewells. In 1928 the supply was derived from three tubewells and 43 percolation wells. There should be more tubewells and less percolation wells. The ideal supply was the piped water supply from deep-seated tubewells, but unchlorinated, and this could be possible if it was derived entirely from tubewells. Chlorination if at all found necessary should be reduced to a minimum. In the speaker's opinion it would be advisable to have piped water supply all over the area.

As regards the deterioration in the yield of the tubewells, he drew attention to the Author's remarks regarding back blowing and surging of tubewell No. 4 at the 1936 fair and felt that it was the most satisfactory arrangement to improve the yield. He however advised that the tubewells should be worked at least twice a year because otherwise during their quiescent state for many years—the interval between fairs—the strainers would tend to clog up and deteriorate which would reduce the life of the tubewells. The Paper revealed a variety of pumping plants installed on the various tubewells and percolation wells although the conditions were similar. Some sort of uniformity in this behalf appeared to be necessary. Probably the variations were due to the estimates being sanctioned in bits at various times when it may not have been possible to adopt a uniform practice on account of plant of a common type not being always available in the market.

Mr. **G. R. Sawhney** congratulated the Author on his paper and said that the watersupply arrangements at the Thanesar fair had been well thought out and executed. They were a fitting tribute to the importance of this famous and historic place and must have contributed largely to the comfort of the pilgrims besides acting as a real check against spread of epidemics, which were usually started at such large gatherings.

Mr. **M. T. Gibling** wrote that Mr. Howell had very kindly recorded what were presumably his own experiences in providing at very short notice a temporary water supply in an area where sub-soil water was available. and as it might be the lot of any one of the Members to have to undertake such a work in the future his experiences might be of considerable value.

He would like to ask Mr. Howell for a little more information about the tube wells themselves and their operation. He had taken out certain data from Plate II and from the text of the Paper, which he thought were important to those interested in the tube well side of the scheme.

T.W. No.	Depth.	Diameter.	Type.	Strainer length.	Discharge.
1	290′	7″	?	32′	10,000 g.p.h.
2	284′	7″	Tej	36′	,,
3	294′	7″	?	64′	,,
4	205′	9″	!	68′	23,000 g.p.h. (Nos. 4 and 4A)
4A	284′	5″	Phoenix	80′	
5	300′	7″	Tej	74′	14,000 g.p.h.
6	309′	7″	Tej	80′	29,000 to 30,000 g.p.h.

It would be seen that five out of the seven pipes were 7″ in diameter, but Nos. 4 and 4A were 9″ and 5″ respectively. He would like to know if this was due to a larger discharge being required when No. 4 was sunk and a lesser discharge being required when No. 4. A was sunk or whether there was any other reason for adopting these 9″ and 5″ tubes. In the case of tubewell No. 3, although the strainer length was twice the length of Nos. 1 and 2, the same discharge was obtained, with the same power plant. In the case of No. 5 it would be seen that with a length of 10 feet of strainer more than No. 3, an increased output of 4,000 gallons p.h. was obtained, but in the case of No. 6 with only 6 feet more strainer than No. 5, the discharge was more than doubled. On No. 6, however, the power plant was a 40 H. P. engine against a 12—14 H. P. engine on the other wells.

It appeared that the discharge from a tube well varied with various factors such as diameter of tube, length of strainer, nature of subsoil, depth of porous strata, power of plant available for pumping, etc. It would be interesting to know which of these factors affected the discharge most, and how the discharge could be increased at least cost. It would be noticed that the total discharge from the wells was about 90,000 g. p. h. which could have been supplied from three wells similar to No. 6. It was easy to be wise after the event, particularly in a case like this where the work had to be carried out very hurriedly and where the actual water requirements were unknown, but it would be helpful if Mr. Howell could state how he would go about the job now, knowing what he did of the conditions. Presumably, there was no time to undertake extensive boring to ascertain the nature of the sub-soil and to carry out discharge tests.

The level of the water table was shown on Plate II in the case of wells Nos. 5 and 6, but not in the other cases. It would be interesting to know if it was lower at other sites, as Nos. 5 and 6 were near the tank, and the water table may have been affected by seepage from it. A higher water table would undoubtedly improve the discharges.

It would be of use for future reference if Mr. Howell could give the cost of each of the tube wells and the cost of pumping per thousand gallons per hour from each well.

The paper showed that additional tube wells had to be sunk each time the fair took place, from which it was clear that tube wells were not suitable for a spasmodic water supply of this nature. The speaker would like to know, whether, under those circumstances, it would be possible to keep the tube wells in order by pumping from them say for a few hours regularly every month or perhaps every three months.

The **Author** replying to the remarks of S. Hukum Singh stated that it was usually possible to force down the water level in tube-wells by surging with compressed air but experience had shewn that very often such method did not increase the discharge through an old incrusted strainer.

The various tubewells had to be put down in a hurry and the time available was the most important factor in selecting the size of boring and strainer.

If the number of tubewells had been reduced, the distribution system would have had to be made larger and more expensive hence the Author did not think it would have been more economical to have less wells ; but he agreed that air lifts would have enabled more water to be extracted per tubewell. Borehole type turbine pumps and compressors were not available quickly, hence the reason for installing horizontal centrifugal pumps. If these tubewells ever had to be re-equipped, air lift cum horizontal centrifugal pumps for boosting would probably be the most suitable as the sizes of the tubewells were too small for installing borehole type pumps. The speaker did not think that the victaulic jointed pipes were unduly expensive but he agreed that experience had shown that they gave little of any real advantage over ordinary screwed and coupled pipes with flanges set every 300 or 400 feet, in case of laying and dismantling.

The 4" distribution pipes were found in practice to be of adequate size for the supply of the water required. Pressure gauge readings of terminal heads were not available but the Author knew that each standpost supplied its fair share of the water and no difficulties were experienced on that score.

The Author agreed with Dewan Bahadur Amar Nath Nanda as to the advisability of doing away with the old percolation wells—that is why the tube-well scheme was extended for the last two fairs. The tubewells were being pumped for short periods every year and the reason for the variations on the kinds of plants installed were simply that work had to be done in a hurry and whatever plant was available had to be used. In reply to Mr. Gibling, the Author stated that he knew of no method whereby the figure of yield of tubewells could be accurately prognosticated. Even in the Central Punjab, where numerous wells had been put down, the yield varied from 8 to 30 gallons per square foot of strainer per foot depression head. Beds of alluvial strata were often ventricular in shape and there was always a possibility that some of these in which a bore hole might be placed would be of small area and might be partially or even completely isolated. This was an unknown factor the effect of which was liable to mark all other considerations. The yield of a tubewell was normally proportionate to the depression head ; hence so long as a tubewell was designed with an adequate factor of safety in the form of a suitably low initial depression head, the designed discharge would still be obtainable, provided that the pumping plant could deal with the greater depression head at which the designed discharge was obtained in practice. Bearing in mind that tubewells could be operated by means of bore hole pumps or airlifts almost to any depression head within reason, the kind of pumping plant to be installed had a very considerable bearing on the discharge. Nevertheless the thickness and nature of the water bearing strata, type, length and diameter of strainer and also, of course, the size of the tubewell itself were factors which also had important functions. It was impossible to discuss the inter-relations between these factors in detail in this reply. The water supply for the fair could probably have been got from three tube wells but this would have meant a considerable increase in the cost of distribution system which would have exceeded the saving on the tube-wells.

The Kurukshetra and Sanyahet tanks were dry when the tubewells in their vicinity were put down, hence there was no evidence available as to the influence of these tanks on the water table.

In the case of this fair, tubewells had to be used because there was no alternative source of supply available.

ERRATA.

Page 48 Line 1 " better" should be "wetter"

Page 48 para (d) Sub-para 2, line 3

" 12 months " should be " 2 months"

Page 54 line 4 (below the tabular data)

beginning " ∴ Average rate = 863·89/54·1 "
should come as line 1 immediately below the tabular data.