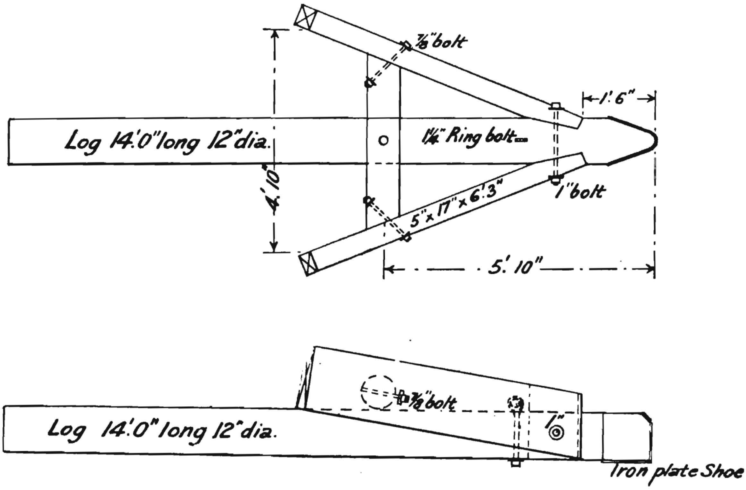
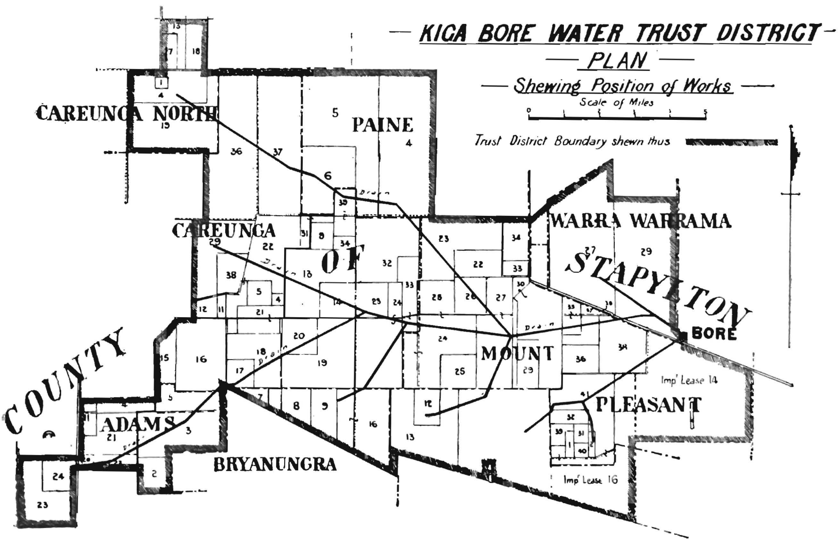


40. DELVER AT YOUENDAH.

41. DELVER, MOREE DISTRICT.

With drains constructed as described, the seepage losses are surprisingly small, the effect of stock watering, although disfiguring the sections of the drains, being to more effectively puddle them.

As showing the immense area which can be commanded by one bore, reference may be made to the works just completed in the Kiga Trust District, where 81,000 acres are efficiently watered by means of 57 miles of distributing drains, which are kept constantly running with a flow of only 717,120 gallons per diem from bore, whilst there is a surplus of water at the end of each drain, the fall of the country from bore to end of district averaging 6 feet in the mile.



Election of Trustees and Transfer of Works.

When the works under the Water and Drainage Act are drawing towards completion, the Minister appoints one Trustee (usually the District Assistant Engineer), and directs the election of two other Trustees from amongst those liable for rates, and prepares a roll of voters on the basis of one vote for an occupier of an area not exceeding 2,000 acres, two votes for an area not exceeding 10,000 acres, and three votes for an area over 10,000 acres.

Upon completion of the works, the same is notified in the *Government Gazette*, with the cost, and the Trustees at once strike a rate per acre—which may vary according to the benefit derived—so as to provide 4 per cent. interest and a 2 per cent. sinking fund (to extinguish the debt in 28 years), together with an amount for maintenance and administrative charges. The rate levied—usually from 1½d. to 2½d. per acre—can be appealed against and varied by a Police Magistrate, but so that the total assessment made for the twelve months may not be reduced. The whole management—after transfer of works—devolves upon the Trust, and payments are made within stipulated periods direct to the Treasury.

Measuring Discharges.

Amongst practical men the discharge of a bore was for many years estimated at 1,000,000 gallons per diem for every foot the water rose above 6-inch casing, so that anomalous and exaggerated flows were oftentimes reported, the water being pushed up by gas to a greater height in one bore with a reputedly larger flow than in another with a much larger actual discharge, despite the water not rising so far above the casing.

During the past eighteen months, some 100 bores have been measured by the officers of the Works Department. The largest flow yet recorded in this State is 1,657,230 gallons per diem at Munna Munna, and there is little doubt that the official measurements, being so much less than the rough guesses in the first instance, has led to the idea that the flows from many bores have diminished much more than has really been the case.

In measuring the discharge of a bore, a level length of drain is selected and so banked up as to obtain a free over-fall for the tail water. A stake is driven some 10 feet up-stream of the weir, and a gauge, with zero set with a dumpy level at crest level of weir, is then fixed to stake. The water is then turned into the drain, and after a period sufficient to allow of seepage being taken up—usually twelve hours—the cut of the water on the "Z" gauge is read, and the discharge obtained from standard tables (Appendix F, Tables 1, 2, 3, 4) supplied to each officer, calculated from Francis' formula. As a rule, the cut of the water on the gauge is taken, but where extreme accuracy is demanded a hook gauge is used, which admits of the nicest adjustment. The great point in measuring these weir discharges is to eliminate velocity of approach, which is obtained by placing weir high enough to get a level stretch of drain. Whilst the better type of weir is of the

"Cippoletti" section, yet, as many bore discharges had been measured with rectangular weirs, it was considered better for the sake of

MIDKIN BORE. MEASURING FLOW.

uniformity to continue the measurements with this latter type, and to measure the small flows with a V notch weir. The weir is made of timber, and has an iron feather-edge standing $\frac{1}{4}$ inch proud all round, the slot in board being sloped off at an angle of 60 degrees to give a clear over-fall for the water.

The formula used in Queensland (Appendix G) by Mr. J. B. Henderson, M. Inst. C.E., M. Am. Soc. C.E., Hydraulic Engineer, for measuring weir discharges is:

$$\frac{2}{3}\sqrt{\text{depth in feet,}} \times 5{\cdot}34 \times \text{area feet} = \text{discharge in cusecs};$$

which gives about 14 per cent. greater discharge than formula used in New South Wales, so that the flows given in Appendix J, Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, may be taken as somewhat conservative in comparison with the neighbouring State.

Decrease in Flow.

This State in no way differs from the other Australian States, or, indeed, other parts of the world, in regard to the diminution of flow from artesian bores, it being the usual experience for the flow, when first struck, to be much larger than when subsequently measured, which in the opinion of the writer may be taken as due to the water-bearing strata, before tapping, being in a fully charged condition with an impeded flow under high pressure; which, when released by a bore, gives off its maximum quantity of water with a gradually decreasing flow and pressure until the discharge becomes a question of the velocity with which the water from the drainage area within the influence of the bore will travel through the interstices of the water-bearing strata. It thus being only a matter of time, if supply be constant, for the flow to become normal. This appears to be borne out by the gradually increasing pressure shown when "shutting down" a bore, the flow, on opening out valve, being in all cases much above that previously measured, and taking some little time to drop again to the normal.

The writer is further of opinion that each bore has a certain "drainage area," which, if overlapped by the "drainage area" of an adjacent bore, must result in depletion, and it is with the object of determining the minimum distance apart which should obtain, that the Department is now so carefully measuring the flows and pressures of all bores within the State. Whilst if effect be given to the *Amending Water and Drainage Bill proposed to be introduced by the Hon. the Minister for Works (Mr. Lee), which provides for the licensing of all future artesian wells, and the consequent control of the artesian supply, with heavy penalties for waste, the danger of bores being sunk so close as to affect adjacent bores will be minimised, if not avoided.

The bores in this State, however, are, generally speaking, long distances apart and in marked contrast to America, where in one case as many as seventy-five shallow bores have been sunk on an area of 500 acres, and where it has been recorded from actual tests that by shutting down all but one bore, the discharge in that particular bore can be doubled.

There are, however, some bores—more especially private bores, which oftentimes are not sunk to bed-rock—where the normal flow has noticeably decreased, and in regard to these Mr. Pittman, in "The Mineral Resources of New South Wales," 1900, says:—"The real reason for the diminished flow is probably to be found in the protracted drought which has visited the Colony. If it be admitted that the source of the artesian water is the rain which falls upon the porous intake beds and percolates through these beds to the bottom of the basin, it cannot

* The Bill was assented to on 29th day of December, 1906, and under its provisions much more accurate data will be obtainable and the control and use of artesian waters be under closer observation.

surely be doubted that a drought of four years' duration over the area of the intake beds must seriously affect the flow of water in the artesian wells. Until more systematic measurements of flows are made it would be impossible to ascertain how long a time would elapse before a drought over the intake beds would noticeably affect a bore 200 miles to the west of them, but seeing that the drought in this case has lasted between three and four years, when the diminished flow was observed, there cannot be much doubt as to the cause of the deficiency."

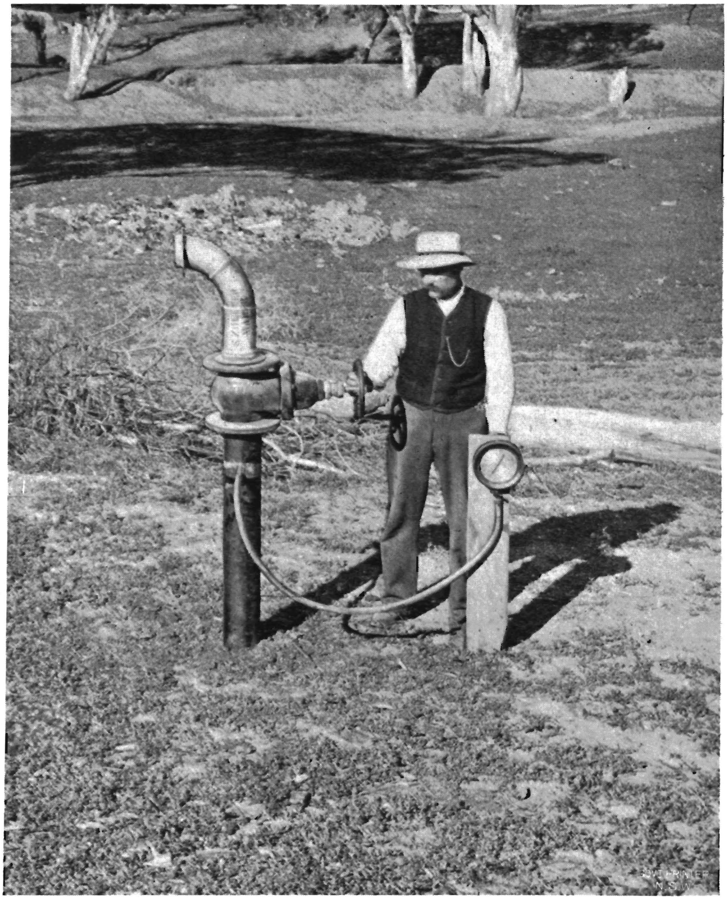
To determine the relation between the rainfall on the intake beds and the discharge of the different bores, a geological survey of the intake beds has been undertaken for the Public Works Department by the Government Geologist, which on completion, and in conjunction with the periodical measurements of the different bores, will enable some conclusion to be arrived at as to how a deficient rainfall on the catchment affects bores situated long distances away, and to reach which water would have to percolate through many miles of porous sandstone. The survey will also allow of data being obtained as to the absorption from streams crossing the intake beds.

Decrease in flow may also, in some cases, be attributed to the defective lining or bedding of casing allowing the water to find its way along the outside to a porous strata below surface.

Many bores in this State have been flowing for over twenty years, and from a bore recently measured, which had been running continuously for twelve years, the flow was registered at 542,000 gallons per diem, which, with the big fall obtaining, is to be utilised in stock-watering some 83,000 acres.

Measuring Pressure.

In measuring pressure, the $\frac{3}{8}$-inch plug is unscrewed from bore head below the valve and a hose connection is then screwed in; the pressure gauge, 6 inches in diameter recording up to 150 lb. per square inch, is attached to the hose, by means of a brass coupling, and made fast to a rigid support. The R.L. of the centre of the pressure gauge is then determined from the nearest W.C.B.M., and the valve on bore head is gradually screwed down until flow is shut off, when the time and pressure are noted, and subsequently, at short intervals, until gauge becomes stationary, when the maximum reading in pounds per square inch is recorded and the equivalent head in feet calculated, this giving the height to which the water in bore would rise if casing were carried up above surface, and when added to the R.L. of the centre of the gauge gives the "potential" or maximum height of flow line of bore above water conservation datum; the R.L. of surface is also taken, and if to these R.L.'s be added 2·93 feet, mean sea-level can be obtained. The period occupied in pressure reaching a maximum varies considerably, sometimes the gauge being left on for twenty-four hours, but usually the test is



MEASURING PRESSURE.

taken over four hours. Within the last eighteen months the pressures of some 110 bores have been recorded, the maximum pressure so far registered in this State being 150 lb. per square inch, at Oreel No. 2 bore, near Collarendabri.

Iso-potential Lines.

Upon the following map is shown the iso-potential lines or lines of equal head above water conservation datum, which have been compiled from the potentials of 110 bores, plotted at varying altitudes of

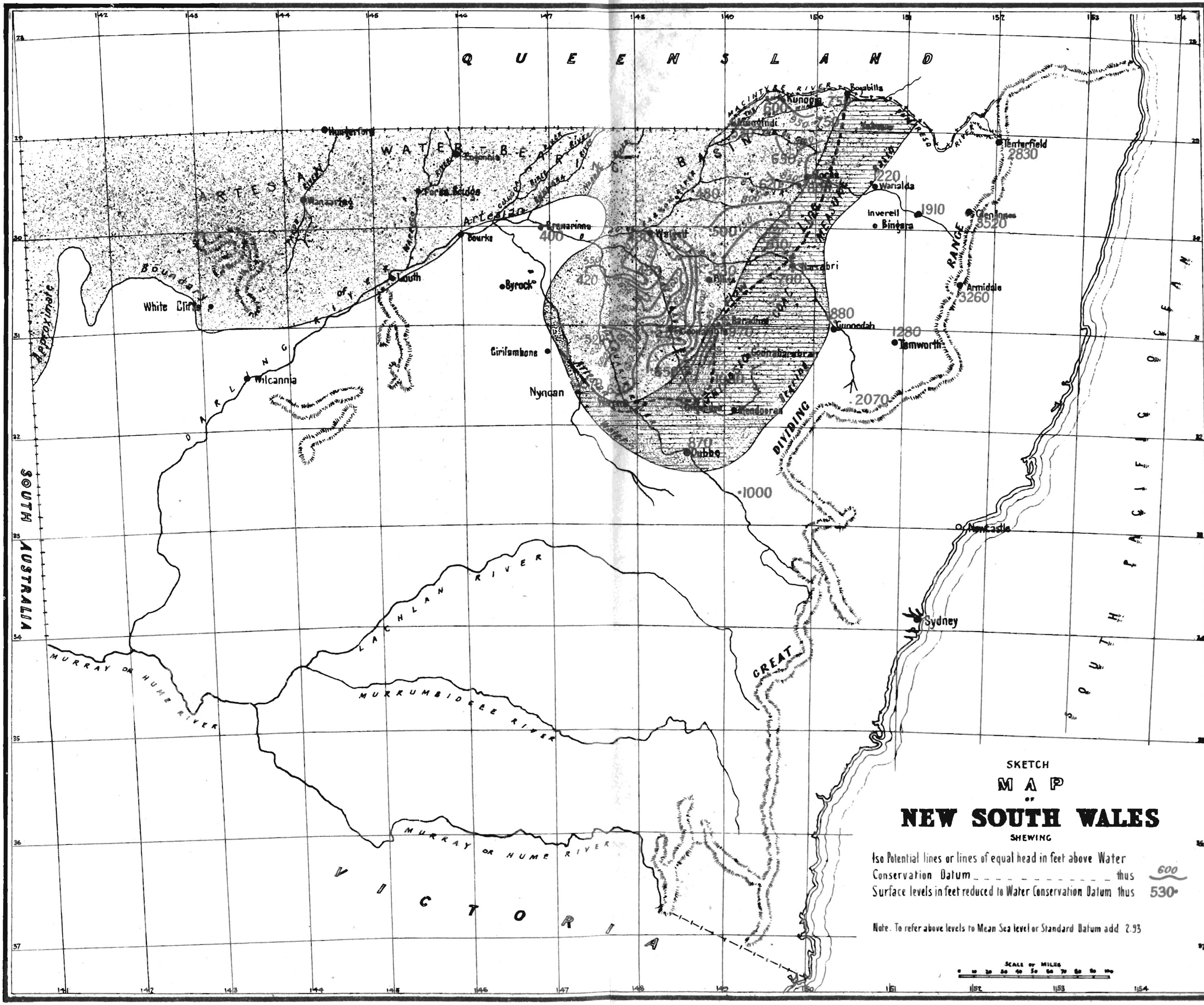


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PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

50 feet. From these lines the direction of the flow of the artesian water may be gleaned, the water taking the shortest cut from the high to the low potential; whilst, by plotting a section showing the different iso-potential lines with the surface levels under same, a fair estimate may be made as to where a continuation of the "flowing line curve" will meet the rapidly rising surface levels approaching the boundary of the flowing supply. Thus an opinion may be formed as to whether a flowing or pumping supply is to be anticipated; whilst by taking the difference between the red and blue figures, shown on preceding map, the height to which water will rise above surface at any point can be ascertained.

It must, however, be remembered, that whilst in the case of Government bores, the records have been well kept, and the different flows determined, until bed-rock has been obtained; yet in the case of private bores such data is not available, and there is the consequent possibility of the recorded pressure in a private bore being for a flow in a much higher sheet of water-bearing strata than that noted in connection with an adjacent bore. This necessitates the iso-potential lines being taken as tentative.

Irrigation.

Mr. J. C. H. Mingaye, of the Mines Department, has carried out many analyses of artesian waters (Appendix H, Tables 1, 2, 3, 4, 5), and from these it may be gathered that, in some cases, the mineral salts in the artesian waters of this State exceed in quantity that obtaining in the artesian waters of America; however, in America, the soil usually contains a quantity of salts, as against the comparative freedom therefrom in the western district of this State, the quantity of salts in the water and soil combined thus being oftentimes greater in irrigated areas in America than would be the case in New South Wales.

Although very satisfactory results have been achieved at the Pera and Moree Government Farms by irrigating with artesian water, yet the settlers in the adjacent districts have made little effort to profit by the excellent examples afforded. The present policy of the Public Works Department is to open up as much country as possible with bores for stock-watering, leaving it to the settlers themselves to subsequently apply for additional bores to permit of irrigation being undertaken. A bore with a flow of 1,000,000 gallons per diem, whilst only capable of properly irrigating some 400 acres, will provide sufficient water for stock purposes over an area of from 70,000 to 90,000 acres.

Summary of Works under the Artesian Wells and Water and Drainage Acts.

Under the Artesian Wells Act, thirteen bores have been sunk, at a cost of £26,583, including distributing works to water 381,230 acres, the assessments made by the Land Board totalling £1,192 per annum, or an average of 4·48 per cent. on capital outlay.

Under the Water and Drainage Act, twenty-five Bore Trusts have been constituted, the districts embracing 1,646,304 acres, to be watered by 878 miles of distributing drains, making a total area of 2,027,534 acres, commanded by bores under the provisions of these two Acts. When it is remembered that, in addition to the 2,027,534 acres referred to, there are 280 private bores watering large tracts of country, besides public watering-place bores, the immense value of the artesian supply can be readily grasped, more especially as without an efficiently distributed water supply, a great portion of this arid, or semi-arid, portion of the State could not be profitably occupied. In Appendix J, Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, are given particulars of bores in New South Wales, as far as available, up to 31st December, 1906.

Conclusion.

The author has purposely given some prominence to the financial results obtained in carrying out works under the provisions of the Artesian Wells and Water and Drainage Acts, with the special object of impressing on the younger members of the profession the great necessity of closely studying the "business end" of all propositions, by which the value of their engineering work will be so certainly determined, as tersely indicated by the popular American definition of an engineer, as "A man who can do with one dollar what any fool can do with two."

In conclusion, the author desires to record his acknowledgments of the courtesy of the Acting Under Secretary for Public Works, Mr. W. J. Hanna, in permitting Mr. Degotardi to prepare the necessary slides illustrating this paper; and to refer to the good work done by Messrs. Newman and Slade, under the immediate direction of Messrs. Dare, Assoc. M. Inst. C.E., and Marshall, in the designing of the works, and the carrying through of the somewhat intricate details involved in formulating the Trusts referred to in the paper; whilst any success achieved in the field has been due to the efforts of Messrs. District Assistant Engineers Jenkins, Tibbits, and Neilley, in regard to the engineering side; and to Messrs. Kenny and Wade for the engineering surveys made by them. The whole work has been carried out under the direction and control of Mr. L. A. B. Wade, M. Inst., C.E., Chief Engineer for Rivers, Water Supply, and Drainage.