AMERICAN AND AUSTRALIAN
IRRIGATION.

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In this paper I propose to examine shortly the latest information obtained with regard to Irrigation in America, as furnished by the reports of Mr. Deakin, M.I.A., and Mr. Derry, M. Inst. C.E., so far as regards the comparative practice, present and future, in America and in this colony, and to add some remarks on Mr. Deakin's recommendations and conclusions.

2. Mr. Deakin has with great ability collected an immense number of facts, and, if the shortness of time at his disposal is considered, the amount of results of observation or of information collected is very remarkable. Engineers may regret that the descriptions of works and methods of irrigation are wanting in clearness and precision, but the deficiencies (from a professional point of view) in Mr. Deakin's report are largely made good in the supplementary report of Mr. Derry, at least as regards the parts of Mr. Deakin's study which Mr. Derry was enabled to visit. The misfortune is not that Mr. Deakin made the report, but that Mr. Deakin is not an engineer.

3. The principal interest attached to Mr. Deakin's report is doubtless to be found in the conclusions he draws from what he observed in America, and especially in California, as bearing on the subject of irrigation in this colony—the points of resemblance and difference in the physical conditions and also in the manner in which the work of irrigation has been set about; while Mr. Derry's report furnishes interesting descriptions of works, copiously illustrated, but relating chiefly to single parts or details of a scheme, and it is our loss that the time at Mr. Derry's disposal did not admit of his giving a more general and comprehensive professional description of others of the varied
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and highly interesting systems of irrigation in the way he has treated the Kern River system.

4. In Victoria those who have dealt with the subject of irrigation may be divided roughly into two classes—first, those who would without further delay enter on extensive undertakings of a so-called "national" character, and begin works for introducing irrigation all over the northern part of the colony at all hazards and regardless of cost; and, secondly, those who are convinced of the great advantages of irrigation where it can be applied at a cost not too great in proportion to the enhanced value of the land, but who acknowledge that, like most other improvements, irrigation must be established gradually, or at least after a matured plan. In the first category are those who urge that the Government should at once commit themselves to such schemes as the Grand N.W. Canal of the late Mr. M'Coll, or the hardly less ambitious but still more vague and shadowy "Ideal canal" of Mr. Culcheth, as lately given to the public. To the second belong the men who, working singly or in combination, have already practised irrigation on a considerable scale, and have done so at their own expense, quietly and without clamouring for Government aid, showing probably quite as much energy and self-reliance as Mr. Deakin extols so highly in the Americans, but for which he seems to give his own countrymen less credit.

5. The impression I have got from this able report is that Mr. Deakin has given facts that could be used, or has put facts in such a light that they could be used, as arguments by the holders of either of the above views, and although the fairness with which he has stated the facts which might tell either way is everywhere evident, and is indeed only what one would expect, still his sympathies seem to be with irrigation at any price, and his conclusions are, I venture to think, influenced by this bias; while his admiration of the Americans, no doubt well deserved, has hindered him from seeing that anything is to be learned but from them. I would here remark that a strange idea seems prevalent here, and especially with the Press, that we must copy everything from some other country—that Victoria is incapable of working out any improvement on lines adapted to her own conditions. In this matter of irrigation neither the Indian, the Italian, nor the French, and still less the Californian methods, could be copied or reproduced, although all of them, in my opinion, may afford examples of principles which should guide projectors of works in a new country; and the ignoring of this is, I venture to think, one great blemish in Mr. Deakin's valuable paper.

6. Great stress is laid upon the similarity of conditions in Victoria and California, which State, it is said, closely resem-
bles this colony. Let us take the points of likeness as Mr. Deakin states them. 1st. The climates are similar. 2. Both are new countries, settled by the pick of the Anglo-Saxon race about the same time. 3. In soil the two countries are said to be not unlike (but on that point Mr. Deakin is not quite clear). 4. The price of labour is about equal. 5. In both countries mining preceded agriculture. 6. The products are said to be similar. 7. The agricultural lands are as level as the valleys of the Goulburn and the Murray. Now of all those seven points of resemblance, however interesting they may be to the traveller, in either country, only three—the 4th, 6th, and 7th, the price of labour, the products, and the configuration of the country—have any special bearing on irrigation. For, as to climate and soil, irrigation is successfully practised on the hard and parched plains of the Deccan, the sandy levels of parts of Holland, the rich alluvial lands of Indian and Egyptian deltas, and the valleys of Italy, France, Spain, and England. The Anglo-Saxon race has not been forward in irrigation; in fact, it is hitherto the last to practise it, and even the American system owes its origin to old Mexico, where both the natives and their Spanish conquerors were expert irrigators. The industry preceding agriculture may affect the population, but hardly the methods of agriculture, except so far as they are dependent on that factor. As regards the last point of resemblance, the irrigated lands may appear to the eye to be as level as the plains of the Goulburn and Murray; but, in reality, they have a much greater declivity, as appears from the descriptions of the works both by Mr. Deakin and Mr. Derry.

7. Among the dissimilarities, omitting the laws as they affect irrigation, are the following:—1. The rivers of California are shallow, calling only for light structures capable of elevating the water a few feet; in the Goulburn it would have to be raised 40 feet. 2. The Californian rivers are not, like ours, subject to heavy floods. 3. The Sierra Nevada traverses the district throughout its whole length, pouring from its snow fields permanent streams. With one exception, the rivers of the northern plains only run for a few months. 4. The Californian rivers run along the ridges, while the country slopes away from their banks; they thus rather resemble deltaic rivers than those of Victoria, which, although like all rivers subject to periodical floods, they have a bank higher than the country immediately beyond it, flow in deep beds, and it is only with difficulty that water can be diverted from them, and then generally only on one side. The Murray is distinctly different from the American rivers described; it is, in fact, the main central drain of an immense area. 5. Some of the rivers lose a great deal of water
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by soakage, which returns to them. Some of the Victorian rivers also lose large quantities of water, especially the Avoca; but, unfortunately, it does not return. Now, all these points of unlikeness affect irrigation, and I think it will be agreed that the unlikeness far outweighs the likeness of the two countries, and that, in fact, instead of being compared, they should be contrasted as regards irrigation. For instance, take the County of Rodney and the irrigated part of California. In the former case it will be necessary first to construct expensive headworks on the Goulburn; next to excavate a canal for at least 12 miles before it becomes productive, i.e., before the water reaches the level of the surface of the ground, and then to continue it with a very slight fall, and consequently of large dimensions, for a distance of 60 miles as a main canal. The water of the Goulburn is not available in large volume for more than four, or at most, five months, and the supply begins two months or ten weeks later than the farmer needs it. In California all these works are provided by nature in the Sierra Nevada range, which, running along one side of the country to be irrigated, may be considered as a constantly flowing main canal, or as a storage reservoir extending the whole length of the country. The rivers issuing from the range at right angles to it, and at intervals of from 10 to 20 miles, take the place of the principal distributary channels, so that these also are in a great measure already provided by nature, while, as Mr. Deakin says, the deltaic character of the rivers renders the distribution of the water easy, and favours the establishment of numerous small private undertakings. Mr. Deakin's comparison of the Murray with the American rivers, where he says that the melting of the snow supplies the water in volume, "as in the Murray," just when it is most required, is founded on a misapprehension. The Murray begins to rise towards the end of June, attains its maximum height generally in September, and falls again rapidly after the middle of October—that is, it is in flood during the rainy season and a little longer. The wheat-growing farmers informed the Water Conservancy Board that they required irrigation any time from the beginning of May till November; for other crops the supply ought to last two or three months longer.

8. In Colorado, which Mr. Deakin considers bears less resemblance to Victoria, there are really some points of analogy, among them the fact that considerable labour, and sometimes very great expense, are needed in connection with the headworks, although the weirs are not, as a rule, so high as those required for Victorian rivers. They have in most cases, apparently, the advantage of being built in rivers with rocky sides and beds, which materially reduces the cost. The main channels in that
State have a much greater fall than can be got in the northern plains of Victoria for irrigation channels, which also favours economical construction.

9. The peculiarities of the conditions in California afford, as already stated, a greater field for individual enterprise than we possess here. There the farmer can, as Mr. Deakin himself says, obtain water when he most wants it at a minimum of cost, while here the cost of headworks necessitated by the depth of the rivers renders individual enterprise hopeless, unless in favorable situations where pumping can be resorted to. Another feature in American irrigation is Artesian supply; but, as hitherto the numerous bores put down in the northern part of this colony afford no hope of this mode of irrigation coming into use, it may be passed over.

10. Considering the great differences (as regards construction of works) between the physical conditions of Victoria and the Western States, it is to me inexplicable that Mr. Deakin should be led to the conclusion that the circumstances of the Pacific States "do not appear to me more favourable to irrigation than those of Victoria." In view of the great variety of conditions prevailing in the different countries where irrigation has been successfully practised for centuries, it seems to me not only useless, but misleading, to strain after a supposed similarity between Victoria and California and the neighbouring States, and to look on those countries as the only, or, at least, the chief sources of useful information, while the longer and wider experience of other countries is ignored, for the inference from such a mode of proceeding is that this supposed similarity is the only known argument in favour of successful irrigation in Victoria. Of course the argument fails utterly if it be shown that the resemblance is only superficial or wholly imaginary. The moderate advocates of irrigation need no such far-fetched analogies as those adduced by Mr. Deakin. They have arguments and proofs in every irrigated country, and even at their own doors.

11. As to the manner of working the irrigation, Mr. Deakin informs us that all the irrigation works of Western America, with the exception of Los Angelos and Salt Lake, have been constructed and maintained wholly and solely by private persons. That circumstance, and the practice of contractors or companies constructing works and selling the land and water-rights together, had, of course, a great influence on the character of the works constructed. In a great many cases the works were built without engineers, and "nearly always without plans." No wonder that their defects are patent. Mr. Deakin says they are palpable and undisguised, and at pages 16 and 17 he enumerates many of them, but, in all probability, a great many more escaped his
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observation. I do not know whether any engineers here have begun to take instructions from their employers on the engineering points of their works, as it seems the American engineers do, but it is certain that in some quarters there is a desire that they should. Mistakes on a smaller scale have similarly been made in this country, and in some cases rectified at considerable expense. It will not be difficult in Victoria to make provision against such errors in any comprehensive scheme. It is not probable that irrigation will be taken up now as a speculation in land or for the benefit of companies.

12. The temporary works of which Mr. Deakin speaks with so much favour would hardly be possible in our rivers. It is not so much that the works themselves might not, in some instances, withstand the floods for a season or two, although they are more severe than those of the American rivers, but the banks of the rivers at the weirs will not stand without substantial protective works; and if the banks are washed out the repairs of the work become very expensive. Even in the Kern River works, California, which Mr. Derry describes as the most favourably conditioned for simple and inexpensive works, the temporary brush weirs have been abandoned, and permanent timber weirs substituted for them. No doubt it is open to a proprietor to build works of as temporary a character as he thinks will best suit his means at the time. Many squatters in these colonies prefer to build dams in their creeks every year, at a considerable expense, rather than more expensive permanent works, in view of their uncertain tenure of the land; but I think most of the members will agree with Mr. Derry when he says that, for irrigation schemes that have been well considered, the works should be built with a view to permanency, as far as the most durable timber can make them permanent. To construct temporary works on some of our rivers would be to court disaster, and innumerable law suits would certainly follow their destruction. Besides, as most of the headworks hitherto built, and those likely to be built, form part of the security given for borrowed capital, it is just possible that temporary works would not be accepted at all. The principle of substituting temporary for permanent works seems certainly, in some cases, to be carried to excess in America. Mr. Derry mentions a class of temporary storage dam of loose rubble, where a permanent stone in cement one would cost only 16 or 17 per cent. more. Wherever the headworks are of considerable importance, and where there is a rock bottom, admitting of the construction of permanent works at a moderate cost, that class of construction seems to be the rule in America, and, as we have seen, even in less favourable positions the temporary works are being replaced by permanent structures. The dam in the Bear
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Valley cost as much as it would in this country in a similar position. The North Poudre Dam is another permanent work. It is a very cheap one compared with the weirs in Victoria, if reckoned by the area of the elevation; but the same principle of construction could not be applied to the Victorian rivers in the northern counties, as it is necessary, in their case, to sheet-pile the bottom and extend the work well into the soft banks, so that there may be as great an area of work under as over the profile of the river bed. If this is taken into account, and also the great difference (200 per cent.) in the cost of timber—of which there would also need to be much more in the Victorian structures, owing to the absence of stone—the higher cost of the Victorian weirs is accounted for.

18. If we inquire what there is to be learned from the reports as regards the chief points relating to the engineering of irrigation, I fear we must be content with the interesting details given by Mr. Derry, and not seek for any fresh light on the main points of design, viz.—the duty of water; its delivery as regards measurement; the cost of headworks and of the minor distribution; and the direct benefits derived. In designing a scheme of irrigation for a given area of country the first point an engineer has to take into account is the duty of water, as on that will depend not only the dimensions of his supply and distribution channels, but the sufficiency or otherwise of the sources of supply. On this important point Mr. Deakin tells us there is nothing to be learned from the parts of the country he visited; and it is not surprising, seeing he excludes older countries from his sources of information, that he thinks it would be "idle to attempt more than a guess at what the duty of water would be in Victoria."

Now, if this were so, every scheme of irrigation in this country must be the merest guesswork. Why not, therefore, pay some attention to the experience on this point of older and more perfect systems. Without assuming some standard, any consistent or intelligible plan of a system of irrigation is impossible. Those interested in this subject will find a table showing the quantity of water used in various countries in a paper on Colorado Irrigation in the 78th volume of the Proceedings of the Institution of Civil Engineers, and another in the first report on Irrigation of the Water Conservancy Board. Mr. Deakin lays great stress on the gradual diminution of the quantity of water used for irrigation, but it is to be borne in mind that this diminution is reckoned from what is acknowledged to be an excessive quantity, in a purely tentative application of irrigation, without calculation of quantity of water, levels of ground, &c. This diminution, even of an excessive quantity, cannot, of course, continue long—the minimum quantity that will effect the purpose aimed at must be
arrived at before long. The probability is that generally too much water will be used at first, as has evidently been universally the case in Western America, where, in some cases, notwithstanding the porous substratum, the ground has become waterlogged from the excessive application of water to the surface and the absence of drainage. On this point the experience of old countries is surely worthy of attention. In some the available water has been used to its utmost limit, and in others long experience has shown how much water can be usefully employed. In France especially, where all public works are discussed and treated in a more thoroughly scientific manner than, perhaps, in any other country, and, after long and patient observations, and the collection of useful data by the Government, the quantity of water required for the different kinds of irrigation has been ascertained with at least sufficient accuracy to make the undertaking of irrigation works a matter for calculation, and not for haphazard or mere guesswork. One reason for the diminished use of water after the first few years is, doubtless, the ascertained facts that, as a rule, new channels lose water by absorption when first constructed, and afterwards become very much more watertight, if not completely so. In the northern plains of this colony much loss from this cause is not to be apprehended. In the Shire of Dunmunkle the water pumped by a small centrifugal pump travelled 50 miles in a new channel, filling tanks along its course and at its end. It would not be safe in designing a work to assume that the quantity of water used in old irrigations would keep on diminishing in this colony; it could safely be assumed that, for some few years, the quantity used would be in excess of it. As this seems to be one of the matters on which the American engineers are not consulted, it will probably be long before any data that can be depended on are collected.

14. The same want of data prevents any trustworthy estimate being given of the exact effects of irrigation on the yield.

15. We learn nothing from the report as to the best way of measuring the water supplied for irrigation from the American practice, which seems to have been as loose as the employment of the various "sluice-heads" in Victoria. The weir measurement, recommended by Mr. Derry as the best, has the disadvantage in a flat country of involving a considerable loss of head. The box with a movable division, described by Mr. Dow in the Age of 4th July, 1885, is interesting as being very nearly a reproduction of an ancient Moorish measure still in use in the province of Elche, in the south of Spain.

16. As regards the cost of headworks, the circumstances of the countries are so different, especially as regards the nature of
the river beds and banks, and the height to which the water has to be raised, that we cannot expect the principal works of the kind described in the report, however interesting, to be of a kind readily applicable in this country. The large employment of timber, combined with stone, is a skilful use of the materials nearest at hand. Here timber costs about three times the Colorado, and two and a half times the Californian rates, and often stone is not procurable at any reasonable cost; and therefore other modes of construction must be resorted to. Although not in the northern plains, possibly in other parts of the colony where weirs are to be constructed, where rock foundations are met with, the drawings and descriptions by Mr. Derry will be found extremely interesting, and, probably, they may be adapted with success. A weir similar in construction, although of a different profile from the North Fork Ditch Weir, described and figured by Mr. Derry, has been successfully employed by the Esk Mining Company in Tasmania. I have not been able to ascertain the cost of it. One description of work which is new to me will, I think, probably be found useful in those parts of the colony where stone for pitching or for filling gabions is not available, and that is the sand boxes, fully described at page 19. The small dimensions of the timber used in the American works strike a Victorian engineer. The use of oregon or redwood seems to render the small dimensions admissible. At the same time I think the practice in this country tends rather to excess in strength, although the liability of the gum timbers to warp and shrink must also be taken into account. Whether it would be economical to use the redwood or oregon here would partly depend on the locality. In Rodney the price of oregon is very nearly twice that of hardwood. In the upper parts of some of our rivers, and in those with sandy or gravelly beds, the brush and mattress dams seem to be the kind that will probably come into use. One has been successfully employed on the Broken River, but it was built dry; it is pitched with stone and is a permanent work, and does not exactly correspond to the American works of the kind, which are built in the flowing water. If weirs have to be built on some of our permanent rivers with rapid currents, such as the Mitta Mitta, the Devil’s River, the Kiewa, and others, the description of the mode of handling the cribs and fascines given by Mr. Derry will be of great use to the engineers who have to construct them.

17. The secondary distribution being undertaken by the farmers, and no record kept of the cost, we have on this point also no data.

18. Perhaps the most useful parts of the reports to the practical irrigator will be Mr. Deakin’s description of the various
kinds of watering, and Mr. Derry's more detailed statement of them with sketches.

19. The price that can be paid for water will probably be decided by the Victorian farmers without reference to any outside examples. Hitherto their statements as to what they could or would afford to pay have fluctuated between 5s. and 20s. per acre per annum. The Californian practice is hardly a guide in any way, except as showing the high value of irrigated land in a country where agriculture without irrigation is impossible. When the water alone is sold it seems sometimes to fetch a higher price than has ever been thought to be payable in this colony, viz., 20s. to 25s. per acre; but in other cases 2s. 6d. to 5s. 7d. per 40,000 cubic feet, which has been assumed to be sufficient for an acre of cereals, or at the rate taken by the Water Conservancy Board for mixed crops, from 3s. 6d. to 9s. per acre. The capital value of water, as stated by Mr. Deakin, represents a much higher annual value than has been ascribed to it in this country, even reckoning the perennial irrigation of California equal to twice that of Victoria, and it would be equal, on the data assumed by the Water Conservancy Board, to 83s. per acre for the double, or 16s. 6d. for the single season. This does not include the cost of the land or its preparation, and, unless it is out of all proportion to the cost of the works, the estimates made some time ago in Victoria cannot have been so excessive, as compared with the American works, as Mr. Deakin seems to think they have been.

20. I have said that the advocates of the heroic style of planning irrigation works could draw support from Mr. Deakin's report. Such statements or expressions as the following:—

"That the property in irrigation land and works in California is estimated at £40,000,000 sterling; that it is imperative that our chief sources of supply should be tapped so as to cover the largest possible area;" that the greater the scale of the undertaking the less the cost per acre; a settlement of the million acres of irrigable lands which lie in the Northern Watershed of Victoria should establish there a population nearly equal to that of the whole colony at the present time; that no price is too high to pay for such a prospect of progress, &c."—will doubtless be quoted by the advocates of the Grand Canal scheme as evidence that Mr. Deakin favours it. I do not know whether he does or not; but the constant recurrence of references to and assumed refutations of objections made, as he says, to "irrigation," which are too numerous to quote, seem to point that way, for all these so-called "objections" to irrigation, or nearly all of them, are not objections to irrigation as such, but to the enterprise of gigantic schemes not proved to be feasible, and to
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the undertaking by the Government of costly works in districts where the supply is at too great a distance, or the construction too expensive, or the physical conditions of the country too unsuitable to admit of any prospect of a return on the outlay. I think I have read most of the irrigation literature of the last twelve or thirteen years, and I do not remember in it any objections to irrigation on a reasonable scale, although there may have been doubts as to estimates being sufficient. But the general tenor of Mr. Deakin's report is to the effect that these other objections have been met and triumphantly disposed of. Therefore, I think, he will be claimed as an advocate of the "Grand Canal" principle.

21. But the holders of more moderate views may also gather some support. All the successful systems described have been undertaken on a moderate scale. The largest scheme I find mentioned in the report, and it is not yet fully developed by a long way, is one in which the area under the canal is 250,000 acres. The area under the proposed Goulburn scheme, which is considered too small to deserve attention, is 610,000. It is true, as Mr. Deakin says, that (modern) irrigation in the Western States is yet in its infancy, i.e., it is about fifteen years old; but it is advancing gradually. Mr. Deakin does not mention that any one scheme is proposed that will command 5,000,000 acres. The argument that large schemes cost less than small ones may be pushed too far. There is evidently a limit to the distance that water can be economically carried in artificial channels, for it costs a certain sum per cube foot per mile, the cost per mile increasing with the distance as the channel diminishes in size. I have made a rough calculation of the cost of carrying water a distance of 400 miles in an imaginary case, thus: The canal beginning with a capacity of 100,000 cubic feet per minute for the first 20 miles, and diminishing by 5,000 cubic feet per minute every 20 miles, with a uniform gradient of 9 inches in the mile; supposing the section to be on the average just within soil; excavation at about 1s. 6½d. per cubic yard to cover cost of bridges, sluices, weirs, engineering and contingencies and interest during construction. The cost of the water per cubic foot per minute increases from 36s. in the first 20 miles to £41 2s. 9d. in the last 20.* As a cubic foot per minute may be taken as watering 4 acres, these figures represent 9s. and £10 per acre respectively for the cost of the main canal. If carried 200 miles, the cost at the end would be £22 15s.; and, if 100 miles, £12 14s. per cubic foot, or £5 14s. and £3 3s. 6d. respectively per acre. While the 400-mile canal would cost £2,000,000 (two millions) sterling, and irrigate 400,000 acres, it

* See Diagram.
would be possible (on the above data) to construct eleven canals of 100 miles long each, and irrigating 1,100,000 acres, for the same sum for the main channel. It may be said this is an extreme case; I mean it to be considered so. Generally speaking, the less the inclination of the supplying river the less economical will it be to carry water very long distances, because the area gained between the river and the canal increases more slowly, consequently the longer must the canal be to command a given area. When the river has a rapid fall, the canal can leave it at a greater angle, and its own declivity can increase so as to maintain, say, a uniform velocity instead of a uniform fall per mile. Therefore, it may be more economical to have several offtakes and channels than one offtake and one channel of the aggregate length of the others for the same area of irrigation. Every case must be judged by itself; no general rule can be laid down, but an _ex-cathedra_ statement that the larger a scheme the more economical it must be, as if this were an undoubted principle of universal application, may be dangerously misleading.

22. An important item in irrigation works wherever the rivers are intermittent, or where the summer discharge is less than that required by the area commanded, is _Storage_. So far as is yet known there are very few sites in Victoria where water can be stored at a price that would be remunerative for any but the most valuable crops, and high farming or "intense" cultivation. Mr. Deakin, after mentioning the Storage Reservoir of the Bear Valley (and another projected one), where, owing to "exceptional natural advantages," water has been stored at a cost of less than £10 per million cubic feet, says, "If it will pay to construct such storage works in California, one must seek for a reason why it should not pay in Victoria." For my own part, I have no hesitation in saying that it would pay to construct them as additions to irrigation schemes, if such sites could be found, for the cost of water for summer irrigation would probably be only about 1s. 6d. per acre, supposing the distribution works to be in existence. But it is extremely doubtful whether any sites equal to the Bear Valley exist in Victoria. I have examined the Mitta Mitta, the Kiewa, the Ovens, the Campaspe, the Loddon, and the Wimmera, and I am certain that no such favourable sites as the Bear Valley exist on any of them. The most favourable one I know is the Waranga Basin, and storage there will cost £40 per million cubic feet, and will, in my opinion, still pay, that amount being equal to about 5s. or 6s. per acre for the summer season for mixed irrigation, or less than half that for cereals, or twice that for "intense" cultivation. The problem is not why exceptionally cheap storage works should pay in California and not in
Victoria, but, at what cost will it pay to conserve water for irrigation, and are there sites in Victoria where water can be stored in large quantities at that rate? But if, as Mr. Deakin thinks, the duty of water is mere guesswork, that problem can only be solved by a very expensive experiment. However, it is a subject which, it is to be hoped, the Royal Commission of Water Supply will think it worth while to take up. The cost of storing water in Victoria, including the estimate of the Waranga Basin and its supply channel, and taking the Yan Yean at two-thirds of the actual cost, owing to the excessive rate of wages at the time of its construction, has been as follows per million cubic feet:—Waranga Basin, £40; Yan Yean, £98; Malmsbury, £215; Spring Gully, £311; Stony Creek, £332; Barker's Creek, £338—average of sites, about £220. This would make the cost per crop of mixed cultivation about 27s. 6d.

23. Passing over Mr. Deakin's observations on the different methods of irrigation, which are extremely interesting and instructive, I now come to his "negative results." I have occupied so much of your time already that I fear I must refer to these only very briefly. Mr. Deakin gives the following list of refutations of certain presumptions, which are:—1. That there is anything in our soil or climate which forbids the profitable introduction of irrigation; 2. That the limited nature of our water supply renders the field of its application so minute as to be unworthy of attention; 3. That our population is too small to admit of extensive operations; 4. That the wages are too high; 5. That expensive drainage works are essential; 6. That artificial fertilisation must be resorted to; 7. That irrigation deteriorates the quality of the produce; 8. That it rapidly exhausts the soil; 9. That grain will not pay for flooding; 10. That the cost of canals is necessarily "enormous;" 11. That the works must be permanent and not temporary; 12. That irrigated areas are invariably pestilential; 13. That the State alone can undertake irrigation on a great scale, and that private enterprise is incapable of dealing with it; and 14. That only a poverty-stricken population can be maintained by its means. On Nos. 1, 2, 7, 9, and 14 I have no remark to make. I have never heard these objections raised, unless it be in the case 7; it is stated that some grasses are injured by irrigation, but there is, I believe, no one who believes this of the bulk of crops. But I feel obliged to ask your indulgence for a few minutes while I notice Nos. 3, 4, 5, 6, and collaterally 8, 11, and 12. No. 10 is so vague that it can hardly be dealt with, and No. 13 is a matter into which there is no time to enter in this paper, nor does it come within the scope of it.

24. As regards the objection No. 3, that our present population
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is insufficient for carrying on irrigation on a very extended scale, Mr. Deakin has, I submit, brought no evidence whatever to disprove it. I cannot find in the report any distinct statement of the area cultivated per head of the population in California, which would have been satisfactory proof. Mr. Deakin says the population of California scarcely exceeds that of Victoria, and that they have 1500 miles of main channels, but that gives no information. At page 9 he says that the whole of the 150,000 people who inhabit Southern California are directly or indirectly dependent on irrigation, and at page 2 he gives the irrigated area of California at 650,000 acres. I do not know if I am right in taking these two figures together, but, if I am, the area of irrigation per head is less than 4½ acres. The Water Conservancy Board in their remarks on this head allowed 5 acres, and that involved for extensive schemes an enormous increase of the present population of the northern plains. Even for the construction of such a work as the Goulburn scheme in any reasonable time there must be a large influx of people, for it is well known that the Water Trusts had almost to suspend operations during the harvest. Mr. Deakin, since writing his report, has learned that at Bacchus Marsh "12 men constantly employed, and a number of boys for several months," cultivate 40 acres. This is probably less than one acre of high farming per head. I maintain that the opinion of the Water Conservation Board—that, in order that one-third of the occupied area of the northern plains should be irrigated, the population must increase from 8.3 to about 42 per square mile—has not been refuted by anything in Mr. Deakin's report. (No. 4.) The board also drew attention to the high rate of wages, making works more expensive than similar works on the Continent of Europe, but they never said it was a bar to operations. The question is simply one of cost and labour supply. I have never heard it stated that the rate of wages "virtually prohibits" the construction of irrigation works. (Nos. 5 and 12.) As to drainage works being unnecessary, this novel proposition is so opposed to all experience, other than that quoted by Mr. Deakin, that I must notice it more particularly. Mr. Deakin says:—"The farmer in America has left the water to settle the problem of drainage for itself," and in some places it has settled in these ways: it has "super-saturated adjoining lands," and given rise to claims for compensation; it has "created patches of artificial morass;" it has waterlogged the soil below the surface; and it has produced malaria. The State engineer for California says neighbourhoods formerly noted for their healthy climate have been rendered unhealthy by irrigation, "owing to deficient drainage and careless use of water." Dr. Orme says (Appendix J.):—"Irrigation, to be innocuous, must go
American and Australian Irrigation.

Hand in hand with drainage. This fact has been demonstrated time after time." Dr. W. R. Fox says:—"I do not think that sufficient irrigation, with proper cultivation upon well drained land will produce malaria to any appreciable extent." Dr. A. F. Kerecheval says "That no increase in malarial diseases has followed irrigation, and the reason is obvious. All our lands requiring irrigation are of a peculiar porous or sandy character, underlying which are strata of gravel boulders and sand of unknown depth, giving the most thorough under-drainage." Dr. Chester Rowell says:—"Irrigation on a large scale where water is used to such an extent as to saturate and fill up the soil, and continued during the summer months, will produce a general malarial influence. Where the soil is loose and porous with a rapid under-drainage, it is doubtful whether malaria will ever be seriously felt." Thus these medical authorities all recognise the necessity of drainage, artificial or natural. In Mr. O'Meara's paper on Colorado Irrigation, quoted by Mr. Deakin, and in the discussion which followed it, both the author and every one of the speakers who mentioned drainage, and they were all men experienced in irrigation works, insisted on the principle that, "Irrigation must be accompanied by drainage." Mr. Deakin's evidence is only negative; most of the American irrigators do not practice drainage. As well might he argue against the use of manure in farming dry land, because most of the Victorian farmers do not use it. I maintain that no estimate of an irrigation scheme in Victoria is complete that does not include drainage, unless it be in one or two exceptional cases, and that the view that drainage will not be needed in Victoria for years, and then only in exceptional cases, is one too sanguine to be entertained by business men. It is needed, not only for the better cultivation of the land, but on sanitary grounds, and if it be objected that malaria is unknown in Victoria, and need not be dreaded, I say consumption is not unknown, and that in the opinion of some of the most eminent English physicians the presence of an excess of water in the soil is, if not the primary cause, a very active contributary cause of the spread of that disease. I think it is as criminal to encourage the saturation of land with water without any provision for relieving it as it is to fill up the waste grounds of the towns with filthy rubbish, and then encourage the building of houses on them. In a general system of irrigation each farmer must take his water when his turn comes or leave it. Suppose a man has just flooded his wheat with 4 inches of irrigation when a week's rain sets in, what is likely to become of his crop if he cannot unwater his paddocks? Or what is to be done with the water in the many miles of main and secondary channels when rain sets in and the water is not wanted on the fields? It will, of course, be shut
off at the head, but the quantity in the channels of a comprehensive scheme is enough to ruin many hundred acres. (Nos. 6 and 8.) As to manure: In order to maintain the theory that artificial fertilisation is unnecessary, Mr. Deakin has recourse to another, that the Victorian rivers contain as much fertilising matter as is needed. This can easily be settled, for it is simply a matter of analysis; if they do not, manure must be used; if they do, it need not, and it will be very encouraging to hear it, although, when one thinks of the quantity of manure used by good farmers, one cannot help thinking such water must be rather unwholesome to drink. However, this is a matter which the Royal Commission will probably be able to settle in a month or two. (No. 8.) I need not repeat what I have said about the temporary or permanent nature of works. (No. 10.) Mr. Deakin says that he has proved that the cost of canals is not necessarily "enormous." What is "enormous?" Will Mr. Deakin say my estimate of £5 14s. per acre? I think it is the highest Victorian estimate he mentions. This is not, as Mr. Deakin says, for an irrigation that would only secure the farmer against bad harvests—a result he anticipates from one emergency, watering late in the season—I fear the farmers will not bear him out in that—it was for a supply that would give him that security and make his average crop equal to his present maximum. This was the estimated cost of the Goulburn scheme. Another much smaller one which I strongly recommended was estimated to cost, including pumping plant for giving an early watering, £3 3s. per acre, and the annual cost about 5s. 6d. These estimates allow for watering once in twenty days. It is easy to reduce the estimate by extending the interval to six weeks or two months, but if at the end of a severe drought the river at last came down and made water available, would the man who had to wait six weeks for his water after his neighbour had got his be likely to pay his water-rate? I do not think the cost of the works just given can be called "enormous." I admit that I have objected to gigantic schemes on account of their great cost, and I do so still, as Mr. Deakin has given no proof or reason for thinking that they will cost less than my estimates. Mr. Deakin says fruit-growers do not grudge £10 an acre for pumping plant, and £7 for pipe irrigation, making £17 an acre, and, as I have already stated, he gives the capital value of works in some cases at a much higher figure than any of my estimates. Mr. Deakin says that 2½ million acres of irrigation in the Pacific States has cost many hundreds of millions of dollars; he does not say how many, but if he means only three, that makes the cost per acre £24. I apologise for the personal character of
some of these references to my own opinions and estimates, but I think it due to myself and Mr. Black to show that Mr. Deakin's boast that he has refuted what he considers the fallacies in the Water Conservation Board's reports (to which it is plain he alludes in some of his "negative conclusions") is not sustained, and I, having thought it well to do so where, I feel sure, my statements will receive fair and unbiased consideration, and where they will be subjected to professional criticism.

25. With most of the points in Mr. Deakin's summary professional men will, I think, be inclined to fall in, but surely the statement that the available population of the parts of Victoria capable of being irrigated (a little over 8 to the square mile) is equal to that of the Western States requires confirmation. As to one of the "further recommendations," the proposal to offer prizes for studies of the best methods of utilising our water supply is surely premature. Until the state has furnished the "fullest information as to the natural capacities of its territory," which is recommended to be done, any competitive designs would be worse than useless. Without a large outlay for surveys of reservoir sites, gauging of rivers, and levels of the country, any such studies would want the only foundation on which they could properly be made. To require the competitors to ascertain these for themselves would be unreasonable, and if they did so it would be a waste of labour.

26. It will give me pleasure if this paper provokes intelligent discussion on the subject of irrigation, so that its benefits may be more widely made known, and if, at the same time, the probability or otherwise of gigantic political schemes ever becoming accomplished facts be enquired into. So long as these are dangled before the farmers' eyes so long will the introduction of practicable schemes be retarded, and the time delayed when the northern plains of Victoria can be described in words similar to the very eloquent and graphic description Mr. Deakin gives of the irrigated parts of the Western States.

27. The chief points I have wished to insist on in this paper are:

(a.) That the irrigation works of one country cannot be taken as models to be copied or reproduced in another,
(b.) That the introduction of irrigation in a new country should, if possible, be made after proper investigation of the physical condition.
(c.) That the study of the irrigation systems of old countries is at least as useful, and probably more so, than that of tentative and hurriedly initiated works such as those of Western America.
(d.) That it is impolitic to persistently under-estimate the cost of irrigation works.
(e.) That it is probable that works costing from £5 to £7 10s. per acre, first cost, are likely to be remunerative if undertaken by the persons who are to benefit by them.
(f.) That the continual diminution of the quantity of water used for irrigation is an impossibility.
(g.) That irrigation and drainage must go hand in hand on economical as well as sanitary grounds.
(h.) That very large schemes, instead of being more economical, are likely to be less so than smaller ones.
DISCUSSION.

The President said the next business before the meeting was the discussion of a paper by Mr. G. Gordon, C.E., on "American and Australian Irrigation." The Hon. A. Deakin had forwarded a letter in response to an invitation sent to him, which letter he would ask the Secretary to read.

Mr. Sherrard then read the following letter from Mr. Deakin:

Department of Public Works,
Melbourne, November, 1885.

The President of the Victorian Engineers Association.

Sir,—Allow me to thank your Association for the invitation to be present during the consideration of Mr. Gordon’s criticism of my report upon "Irrigation in Western America," and to express my regret at not being able to listen to its discussion. At the same time, after a careful perusal of his comments, I can see nothing in them demanding any elaborate explanation or reply. Indeed, though Mr. Gordon himself appears to be under a different impression, I can discover no noteworthy difference between us, except that the report presents a more sanguine rendering of the prospects of irrigation in Victoria than he adopts. Our agreement may be estimated from the circumstance that the report supports, just as much as his criticism does, the first five of the eight conclusions in which he sums up his position; and that it supports the remaining three of them, only qualifying them somewhat according to the lessons of American experience. The apparently antagonistic tone of parts of his criticism is therefore rather perplexing. In some cases, it is evident that this proceeds from a misapprehension, as in paragraphs 6 to 10 of his paper. Here a comparison between the physical conditions of Victoria, and the Western States generally, is confused with a parallel between Victoria and California particularly. While even as regards California, the
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differences dwelt upon in paragraph 7 are balanced by likenesses not referred to; they are altogether out of relation to the Western States taken as a whole, and consequently have no bearing upon my argument.

Again, by equally evident misconceptions, it appears as if, according to the report, no provisions for drainage or fertilisation are required in any cases, or at any time; while, as a matter of fact, the particular conditions under which either may be deferred are carefully laid down.

The gradual diminution of the quantity of water required in irrigation, and the sufficiency of a population such as ours for the development of extensive works, are the first lessons of American experience, and cannot be affected by any reasoning about them. On all these matters the report carries its explanation and justification on the face of it; but my critic may safely be challenged to point to a single sentence in it justifying, in any degree, his charge that it advocates a slavish copying of any foreign engineering practice, or to put his finger upon a single word which can be construed, by the most liberal interpretation, into the "boast" to which he takes exception. It is a little surprising that the very title of the report did not forbid his complaint that the irrigation experience of older countries is "ignored," and "excluded" from its pages. The scope and nature of the task set before me prevented the admission of foreign evidence, just as it did all reference to the local board report, to which allusion is erroneously inferred. Indeed, the solitary point upon which the report and its critic are really and definitely at issue is its statement as to the timeliness of the annual rise of the Murray; and here I am supported by the facts quoted in the criticism itself, as well as by the recent evidence tendered to the Royal Commission on water supply. In his final conclusion as to the greater costliness of large, contrasted with small schemes, Mr. Gordon is opposed to the bulk of the American testimony. Conscious as I am of my want of professional knowledge, and of his lengthened experience and ability, I do not attempt to contend with him upon these points. My part has been simply that of the careful observer and impartial collater of facts. If they clash with any theory I can only say so much the worse for the theory.

In conclusion, I desire to acknowledge warmly the courteous, and even complimentary tone of the criticism; and to apologise for the inevitably personal and egotistic nature of this brief rejoinder.

I am, Sir, Yours faithfully,
(Signed) ALFRED DEAKIN.
The following letter from Mr. J. Tipping was also read—

Nagambie, 26th September, 1885.

DEAR SIR,—I much regret being debarred by pressure of business and distance from attending the discussion on Mr. Gordon's paper, having during many years been practically engaged on irrigation works in Southern India, I take considerable interest in the subject.

I will be glad therefore if your chairman will have the goodness to accept this short contribution to the discussion.

I regard Mr. Gordon's paper as setting forth eminently sound, and am disposed to think much-needed doctrine, although at the same time the high value of Mr. Deakin's report on irrigation in Western America must be acknowledged.

The best agricultural lands of the colony are mostly composed of dark or chocolate clay; on such lands I fail to understand how irrigation, excepting for a few seasons, could be continued without providing drainage.

From experiences gained in this locality and elsewhere, I find that water can, by my system of economical steam power and perfect pumps, be pumped from a depth of 100 feet, primary and secondary channels cut, and water applied to every acre of say a 340 acre patch in rotation every eight weeks at a prime cost of £4 per acre; cases will doubtlessly occur where the cost may be £6. I consider a fair all round average of £5 amply sufficient; which coincides closely with Mr. Gordon's estimate of £5 10s. for irrigating by means of channels, which gives me additional reason for confidence in that gentleman's ability to deal with the subject.

There are areas in the colony where suitable water can be procured in abundance at from 70 to 100 feet below ground surface, and on those areas I have for years past been urging farmers to irrigate by sinking and pumping. Those farmers are for the most part sufficiently "well to do," to purchase plant and carry out the work, but so long as there is dangling before them a prospect of State aid, progress is paralysed. To all my representations of the advantages derivable from independent action, I am met with the rejoinder, "Oh! there will be a canal coming this way soon, and then I will perhaps try it." I can only say that if the State lays on water for such people, I fail to see on what principle it can decline to lay on bread to another section.

Of course, well water will require airing to warm and, perhaps, sweeten it, and will probably require "lining," as cooks say of their soup, with a medium of fertilising material, or, in cases, its acids and salts modified and rendered useful by slight chemical additions. I am of opinion that similar treatment will, more
or less, be found advantageous in using most other waters in the colony.

I observe that agricultural societies are awarding prizes for irrigation pumping plants, on what principle cannot be explained. The societies do not test these machines by duty performed for power applied, the only correct method of testing; consequently, jockeying is rampant. Plenty of power, a small lift, and a great display of water are the leading features at these exhibitions. As to gallons discharged per minute to a certain height, and at what cost in power, there is never the slightest information. It's the spray and paint that win; if not, what then?

Our institute would do a considerable service in the cause of irrigation if it urged upon all agricultural societies and farmers throughout the colony the importance of being furnished with reliable information as to the actual working capacity of such machines, which can only be obtained by submitting every plant to the inspection and testing of competent engineers. Much worthless stuff is being foisted on purchasers for want of reliable and proper guidance. Thus, when the plants have been erected, and the expense incurred, the results fall far short of expectations, and discourage, rather than promote, the progress of irrigation.

I am, Sir,
Yours faithfully,
J. TIPPING,
Irrigation Engineer.

To The Hon. Sec. Victorian Engineers' Institute.

PART I.—INTRODUCTORY.

Captain Kelly said—

Mr. President and Gentlemen,—

As I moved at the last meeting that the discussion on Mr Gordon's very able paper be adjourned until this meeting, I suppose it is my place to initiate the discussion this evening on the subject of American and Australian Irrigation.

2. Before entering upon the discussion of the main question, however, I must say that I fully concur in Mr Gordon's opinion, that Mr Deakin has, with great ability, collected an immense number of facts in the very short time which was at his disposal.

I have no doubt that Mr Deakin's report possesses considerable merit from a literary point of view also; but on that question I am not qualified to judge.

I allude to it now simply for the purpose of reminding the meeting that, when a number of secondary circumstances are well arrayed and brought forward with great ability, they can be made to assume a very important aspect; and, in such a case,
we are apt to overlook the main points at issue. It is necessary, therefore, in considering the question under discussion, that we should not be led away from the main question by other comparatively trifling questions. In short, it is necessary we should bear in mind that the question of irrigation for this colony is the most important question which has arisen since the lands of the colony were thrown open for free selection; and that it has become almost a necessary consequence of the free selection Land Bill. Without some scheme of irrigation that Land Bill is not complete.

3. I was very much interested in Mr Derry’s able report; and I think the members of this Association are indebted to Mr. Deakin for having provided them with an opportunity of reading both his own report and that of Mr Derry.

From the information contained in both, we are able to form a very fair opinion of the nature of the works they visited in America.

4. There is one other subject which is indirectly allied to the subject under discussion, and regarding which I am glad to have this opportunity of expressing an opinion.

When it became publicly known that Mr. Deakin intended to proceed to America for the purpose of visiting the irrigational works there, an idea arose and spread throughout this colony that the engineers obtainable in the colony are, as a matter of course, inferior to American engineers in qualifications and experience in irrigational matters.

It was also stated in the newspapers here that Victoria was dependent on engineers who had come from India for professional advice on irrigation questions; and it was implied that those engineers were not equal to the occasion.

I trust, therefore, this meeting will permit me to make a few remarks on this subject; and I hope that my remarks will receive the same publicity which the other remarks have already received.

As I believe that I served longer in the Indian Irrigation Department than any other engineer in these colonies, and as hitherto I have had no connection with the irrigational schemes of Victoria, it appears to me that I may, without impropriety, answer the statements which have been made.

5. I trust, however, it will be clearly understood in any remarks I may make that I have not the slightest intention to depreciate, in any way, American engineers.

Indeed, in the general branches of engineering, they have attained such a high standard that they can afford to be independent of the opinion of the world.

But, while acknowledging the great abilities, the magnificent works, and the readiness of resource of American engineers, it is
by no means necessary that we should deliberately set aside the
grand achievements accomplished by our own engineers in India
in providing for the wants of 250 millions of people.

Their general works, whether in the Himalayas or in the plains,
whether bridging great rivers, or constructing railways and roads
over high mountains, are equal to the greatest works ever con-
structed by any nation at any period.

But the irrigational works of India are unequalled by any
similar works in the world; and, although many of them existed
before India came under our rule, still those old works have
been improved and extended in a manner and to an extent never
even dreamed of, or thought possible, by the original occupiers
of the land; so that we may consider them to be virtually new
works.

Besides those improved old works, entirely new works, which
were originated altogether by English engineers, have been
constructed; and some of these new works are the marvel of the
world.

My opinion on this subject will naturally be regarded as a
partial one; but, fortunately, there exists independent evidence,
of a very high order indeed, which shows clearly the relative
experience of Indian and American engineers in irrigation
works.

It is, moreover, evidence which will, I think, be admitted to
be very appropriate on this occasion.

6. In the month of April, 1873, when General Grant was Presi-
dent of the United States, his Government appointed a Board of
Commissioners to report on the possibility and propriety of
introducing irrigation into California.

That Board consisted of Colonel Alexander and Major Med-
dall, both officers in the Corps of Engineers in the United States
Army.

The third member of the Board was Professor Davidson, of the
United States Coast Survey.

Their report was dated 23rd March, 1874, or only 11½ years
ago; and we have in this period the full extent of the experience
of the engineers and of the farmers of California in irrigation.

However, with your permission, I will read a few very brief
extracts from the report of that Board, and it will be perceived
that although the members were of high standing as engineers,
their tone in referring to Indian irrigation is very different from
that which has recently been adopted by some in this colony.

The report states:—"India affords us the most conspicuous
example of irrigation on a grand scale, and it is here more than
anywhere that a great systematic scheme is in course of develop-
ment."
“Irrigation in some other countries is merely an incident. In many parts of India irrigation is the very condition of existence.

“More than half the revenue of India comes directly from the products of the soil. The great extent of the country, its topographical features, its enormous population, and the volume of its largest rivers permit and require canals of length and section, surpassing beyond all comparison any to be found elsewhere, unless it be in the single instance of the Imperial Canal of China.

“The Ganges canal is, indeed, an artificial river. It is intended to carry 7000 c. ft. of water per second. Including its principal branches, it is 900 miles in length, which much exceeds the aggregate of all the irrigation lines in Lombardy and Egypt combined.

“It is the unrivalled instance of modern times.

“This canal is purely the work of the English.”

Such, gentlemen, is the opinion of distinguished American engineers, and I can safely leave the decision in their hands.

I have shown that in America irrigation is in its infancy; and they have shown that in India it is a science systematically pursued for the welfare of the people.

PART II. AMERICAN IRRIGATION.

7. I shall now, with your permission, turn to Mr. Gordon’s paper, and as that gentleman has divided the subject into two parts:

1st, American Irrigation;
2nd, Australian Irrigation;

I shall adopt the same course, and consider each part separately, beginning with American irrigation.

Furthermore, as Mr. Gordon’s paper has reference to American irrigation as it is represented in Mr. Deakin’s report, it will be more convenient for me to refer directly to the same report.

8. My impression, on reading the report of Mr. Deakin, was that he had become not only an advocate for irrigation, but an enthusiastic advocate for the American system of irrigation.

The result is that, rightly or wrongly, this colony will probably be committed to a system which is based on a short and hurried visit to America.

There is not time this evening to enter upon a detailed examination of the various points relied upon in the report to support the American system; but, when examined, they do not appear to rest upon a very firm foundation.

It is admitted that, out of all the States, there are only two
annual reports in existence to show the progress made during the past 11 years.

Probably, neither of the two engineers who made those reports had made irrigational engineering a special study. Indeed, Mr. Deakin's report contains indirect evidence that they had not. It is also stated that information could be obtained only from private sources; that opposite conclusions were drawn from the same facts; and that there was a diversity of local opinions.

Now, gentlemen, if those persons living on the spot, and interested in the works, held different opinions on the same subject, it is not at all impossible that Mr. Deakin should sometimes have arrived at incorrect conclusions in deciding upon the evidence before him.

With all due deference to Mr. Deakin, I am of opinion that if he had had the sole control and management of the works for five years, his opinion would probably be the very reverse of what it is now.

9. Doubtless it was convenient to refer to the works visited as the "American system of irrigation."

But, to me, there appears to be no system which can claim to be distinct from the systems of irrigation pursued in other countries. At least, I have failed to discover any trace of a distinct system in the reports of Mr. Deakin and Mr. Derry. It is true that the American engineers have utilized the resources at hand in the construction of dams, weirs, sluices, &c.; but this is only the duty of engineers in every country in the world, and the mere use of loose stone or timber in the construction of a weir or a dam does not constitute a distinct system of irrigation.

10. The river Jumna, in India, is a very much larger river than any Mr. Deakin saw in America used for irrigational purposes. In Molesworth's book, which is in the hands of every engineer, there is a section of a weir on that river. It is formed of loose stone, with nucleus walls, which are built on hourglass sand; and I do not hesitate to say that when the size of the river is taken into account, and the character of its bed, it is a far bolder design, in every way, than any Mr. Deakin saw in America.

It is 10 feet high; yet I never heard this weir was considered to belong to a distinct system of irrigation.

11. The reports are full of facts fairly brought forward; but they are disconnected facts, and it is not the fault of Mr. Deakin or Mr. Derry that they are so; because, if there had been a distinct system pervading the works they visited, they would probably have observed it. I should not dwell upon this subject were it not that it seems to have been deemed unworthy of consideration.
in all that has been published on the subject in this colony during the past two years.

The mere existence of channels, dams, weirs, and sluices does not necessarily constitute a good system of irrigation. All those works may be executed in the most permanent and expensive manner, and yet the combined system which they form may be a very bad one.

To form a good system of irrigation, the several parts must bear a certain subtle relation to each other; and the whole system must bear a certain subtle relation not only to the people it is intended to supply, but also to the soil, climate, crops, physical characteristics of the ground, &c., &c.

And it is only when we can examine and compare all those circumstances, that we can form an opinion as to whether a system of irrigation is a good one or a bad one.

Moreover, it is not everyone who is qualified to make such a comparison. Hence it is that Mr. Deakin heard contradictory statements in America; hence it is that the men who design and construct the weirs and dams are not authorities on irrigation; hence it is that the farmers who use the water are not authorities on irrigation; and hence it is, also, that many of the other officials who were consulted are not authorities on irrigation.

12. I had charge, in one district, of about 350 irrigation canals, and there were several thousand private channels opening from them; yet I never saw two irrigation channels, or two systems of irrigation channels, which were worked exactly alike. Even when they ran quite close together for many miles, and were similar in every respect at the head, each channel had its own specialities, which required to be taken into consideration in the working.

Hence, general comparisons between the soil, climate, &c., of California and Victoria are but of little practical use.

13. I shall pass over the secondary details described in the reports. At present, they are quite beside the main question at issue, and a discussion of them would only serve to distract attention from that question.

The real question at issue is to ascertain what is the best and most suitable system of irrigation for Victoria at present, and with a view to the future.

This is the question which has to be solved:

14. There are difficulties connected with all systems of irrigation, and I have no doubt that the American farmers and American engineers are manfully endeavouring to overcome the special difficulties connected with their own system, and that they will eventually overcome them.
But I am decidedly of opinion that they have not yet overcome them, and that their system of irrigation is certainly not superior to the systems in use in the older countries.

On the contrary, judging from the reports of Mr. Deakin and Mr. Derry, I consider it inferior to them.

15. Before concluding this branch of the subject, it may be advisable to point out one mistake commonly made in contrasting American with Indian irrigation. The comparatively small works in America are compared with the greatest works in India, instead of being compared with the works of their own class to be found in any one of the numerous minor Indian systems.

16. I shall pass over the city water works described in the reports. If necessary, and if time permitted, there would be no difficulty in showing that they are not superior to those constructed in accordance with English practice.

I shall now pass to the second part of Mr. Gordon's paper, which deals with Australian irrigation, and my remarks on that subject must necessarily be very brief.

PART III. AUSTRALIAN IRRIGATION.

16. So far as I understand, the following is the present condition of affairs:

Messrs. Gordon and Black were appointed by the late Government to draw up a scheme of irrigation for this colony.

The present Government did not approve of that scheme, and accordingly they appointed a Royal Commission to inquire into the water supply system of the colony generally. Mr. Culcheth, C.E., was appointed a member of that Commission, in order, I suppose, to act as its professional adviser on irrigation questions.

I am aware that there are other professional gentlemen on the Commission; but as they have had no practical experience of irrigation work, we can take it for granted that the decision on irrigational questions rests with Mr. Culcheth.

Thus, at present, the matter rests between Mr. Gordon's scheme and any scheme which may be proposed by Mr. Culcheth; but Mr. Culcheth's scheme will have one advantage over Mr. Gordon's—it will have the weight which will attach to it as being the product of a Royal Commission.

Whatever the result, no outsider can form an opinion regarding either scheme; because the data and the details of both schemes are known only to the two gentlemen who have been employed by Government to prepare them, and it would require long and careful study to form a reliable opinion upon either of them.
Therefore, I shall not make any comment upon the details furnished in Mr. Gordon's paper in reference to his own scheme.

17. I have already stated my reasons for not discussing the various details in Mr. Deakin's report.

I feel I have trespassed on your attention this evening beyond the time allowed to each member for discussion; but I trust the importance of the subject will be my excuse.

18. In conclusion, I may add that I think we are deeply indebted to Mr. Gordon for his very able and comprehensive precis of the most important points in the reports of Mr. Deakin and Mr. Derry, as well as for his sketch of Australian irrigation.

The President, Mr. R. Shakespear, said—

I am sure Mr. Gordon may rest satisfied that he has the thanks of the Association for having placed the question of irrigation before it in such form that the subject may be discussed, and the opinions of the members obtained.

The subject is most opportune for agitation, is rife in a large portion of the colony on this question, and the Government are preparing, according to Mr. Deakin, a scheme to be considered during the next session, which shall be even more liberal than has been anticipated.

Whether we individually endorse all the statements and opinions advanced by either the author of the paper under discussion, or by Mr. Deakin, of whose report it is a criticism, there is no doubt that full deliberate consideration should be given by the people to the question before legislation involving expenditure and interests amounting to many hundreds of thousands of pounds is adopted.

The first and weightiest question is by whom are the works to be constructed? whether by the Government, or by the residents in the areas immediately benefited by the water.

At a conference held at Sandhurst on the 28th October of this year, resolutions were passed on this subject, that the Government should defray the cost of all head works throughout the colony, as well as that of the main or trunk canals.

This then amounts virtually to constructing all irrigation works by the State for the term main canal might soon come to include principal sub-mains, leaving but the ditches to be constructed by the residents, and the serious question arises whether such action would not ultimately injure the very districts now crying out for not merely State assistance but a State constructing department.

It may appear wise to some to hold up the cry of country versus towns, and to assert, as one speaker at the conference did, that the country districts were sufficiently powerful to force the
hands of any Government, but such statements are not only impolitic but untrue. Supposing that the good sense of the community, whether resident in the country or town districts, would not endeavour to act for the common benefit of all, recognising that there is such a community of interests between towns and country, that the former cannot exist if the latter is impoverished, and that the advantage of the agricultural interest is theirs also, the agricultural interest in the irrigable areas is not so powerful as to force a large expensive policy upon the rest of the community unless it is satisfied of its wisdom, and much has to be done in ventilating the subject of irrigation before the community is able to form a sound opinion.

The Royal Commission advocate that loans should under certain conditions be granted by the Government to watershed trusts, to be eventually recouped by charging at first a merely nominal rate of interest, to be increased as the lands rise in value. And thus the third resolution of the conference which is to the effect that the Government would sell water to the trusts at a nominal rate to be subsequently increased is to a great extent met, but in a more satisfactory manner, for, as in the proposition carried at this conference the trusts would become merely middle persons without responsibility as regards the main works, the country as a whole would be disadvantageously placed. The trusts would have everything to gain without risk, whilst the country at large through the Government would have to stand any loss.

At this conference an argument was adduced that as the hitherto State schemes of Sandhurst, Ballarat, Melbourne, and Geelong had proved financially unsuccessful, and yet had been constructed at the national cost, therefore the country districts should be similarly treated, and the works constructed by the Government; but surely the argument tends entirely to the opposite direction. If State Government works have been shown to be financially unprofitable, there should be no more of them, but the work should be left to local Government.

To show that no private persons would have constructed the Coliban Reservoir on a lower site, when a far better and comparatively cheaper site existed, and had been recommended at a higher point commanding a far larger area of ground, capable of being supplied with water; or that the sources of the supply to Geelong were not the best obtainable, is but to show most clearly that trusts or local Governments can at least be as well trusted to ascertain what is best to their own interests in the construction of works under a supervision, only to guarantee the value of the works as against monies advanced by the State.

It is the more surprising that such an argument should be
advanced by the irrigating districts, as it was put forward by a member from a town that has but recently supplied itself with water at the cost of the inhabitants.

It may be that for the reasons advanced by Mr. Gordon, the head works, such as the weirs or dams must be constructed by the State in some cases, but there is no reason advanced why the cost of the canals should not be distributed amongst those holding the lands to be benefited, and if the cost of conveyance of the water is borne by the localities, there is some guarantee that unnecessary head works will not be pressed upon the State.

In respect to the paper read, it appears to me that there is an actual agreement with the experiences adduced by Mr. Deakin, and the opinions he has advanced from them. Although Mr. Gordon apparently combats the latter, for instance in regard to drainage, all agree that irrigation and drainage must go hand in hand, but Mr. Deakin merely points out that expensive drainage works are not essential at the outset of a scheme. Nor does it appear to me that the evidences and results therefrom as given by him show anywhere that drainage can be neglected—either it must to some extent exist naturally, or be supplied, or otherwise, as he points out evils will ensue, and the opinion that a very primitive system of drainage is successful in occasional flooding is expressed by Mr. Gordon as a member of the Water Conservation Board.

As to copying the works of any other country, no one, as far as I know, advocates such a course; but whilst one is disposed to rely mostly upon the experience of India and the Continent, the other relies most upon America, whilst probably the mean between the joint experiences will prove the best guide, that of the older countries being most suitable to a dense, and that of the newer being more in the direction advantageous for a thinly populated country. And I do not think that any would thus dispute either a, b, c, or d, of clause 27 of Mr. Gordon's paper; the propositions are self-evident, and do not require to be stated.

The proposition g, with regard to drainage, I have already shown, is one agreed to by all; and that of f, that the continual diminution of water used for irrigation has a limit, is not disputed by any. Mr. Gordon has assumed that Mr. Deakin asserts that the quantity is continually diminishing, whilst he only says that it is a steadily decreasing quantity, and the irrigable area steadily increasing, at all events a long way beyond the area which can be commanded at first. Thus there is no real difference of opinion and no point debateable out of the chief points adduced in conclusion by Mr. Gordon, excepting e and h, e, as to the remunerative cost of works, and h, that very large schemes are likely to be less economical than smaller ones.
Even in his last case, Mr. Deakin's assertion is not opposed to that in the paper under review, for what he says is that "the greater the scale of the undertaking, the less the cost per acre;" but he is arguing only on schemes reaching a maximum of 150,000 acres, and does not attempt to push this to apply to the case such as supposed by Mr. Gordon of 400,000 acres, and speaks of extension and of secondary canals which would take off from the main canal, and thus might command a large area and become an extensive scheme without unduly extending the main. And again, Mr. Deakin in asserting that water is dearest where the schemes are smallest, cannot be contradicted. Mr. Gordon's figures showing the progressive increase of cost due to extension of the main canal, does not therefore refute the propositions advanced, except in a special case assumed by himself.

The last point, that in e, that it is probable that works costing from £5 to £7 10s. per acre first cost, are likely to be remunerative if undertaken by the persons who are to benefit by them, is one that is founded after all upon assumption. Evidence has been given before the Water Supply Commission that 10s. per acre per annum would willingly be paid for water. Others deny this, and the fact is that the amount that could be paid for first cost and maintenance must depend upon the special circumstances of each case. Nor is there anything as yet to show that irrigation works will not pay in the hands of others than those immediately benefiting by the use of the water.

On the whole I think that whilst the paper by Mr. Gordon is most valuable as a means of opening up discussion, yet that being taken as adverse criticism on the report by Mr. Deakin of American experiences, the result is to prove the value of the latter still more clearly, and to support the principles laid down therein, so that although much has yet to be learnt as to the duty of water in Victoria, yet there is no work to which we can turn with better assurance of finding the general principles applicable to this colony than this report to the Royal Commission.

Mr. Wannan: There is no doubt that the subject of water supply and irrigation is one of the most important questions to this country. The cry for irrigation, and the necessity for the question being properly dealt with, caused Mr. Deakin and Mr. Derry to go to America in order to procure information, and we are very much indebted to them for the mass of information they have placed before the public of this colony. I am very glad that Mr. Deakin is not a mere theorist, because if he had been so he would have so classed his facts that the general public would not have understood them or read them with profit.
Most theorists when they make a scientific report, make it so scientific that the general public cannot understand it. Any non-scientific person can read Mr. Deakin’s reports and understand them. He does not pretend to say that they are scientific reports, but merely records what he saw in America, and presents the facts to the people here as examples of what is being done in America in irrigation and water supply. The question of water supply and irrigation deserves more attention in this country than even in America. There are vast tracts of excellent land in this country which are practically useless for six months of the year for want of water supply and irrigation. I hardly agree with the arguments that the Government should undertake this water supply and irrigation entirely. I consider that the supply of water and irrigation through a country bears exactly the same relation as the making of roads and streets through a town. No municipality would go to the State to borrow money to make its roads; it borrows upon its own resources, and I think the persons in the various districts which would be benefited by water supply and irrigation, are the proper parties to take it up, and bear the responsibilities. I quite agree with Mr. Gordon that the circumstances are so different in this country that the American system of water supply and irrigation is not altogether suitable here. We have not here, as in America vast mountain ranges, but immense plains, demanding more water, and, as a natural consequence, receiving less rain. I think one of our principal means of getting water supply in this country will be not so much by making dams, as by lifting water out of the beds of the rivers without going so many miles to bring water by a canal, which could be lifted by pumping, in such a manner as to form a water supply as well as irrigation. Mr. Deakin points out in his report that the American companies are supported by private enterprise, and not by State aid, as in Victoria. The Victorian people seem to be excessively fond of being legislated upon. They want the Government to do everything. If water supply and irrigation are carried out by the Government, many of the farmers will want compensation. Not very long ago I had to go through the country in order to observe the means of making a water race, and in going through the different farms, the general cry was “you will have to pay me for bringing the race through my ground.” They did not see that a race would benefit them. They only saw that some one would benefit, and they wanted to be paid. It is very necessary to have the examples of other countries before us; but Australia has many peculiarities and circumstances of its own, and I do not think it advisable to copy too closely the systems of other countries. It is only necessary that our engineers
should devote more time to this all-important subject, and we will soon have systems of water supply and irrigation suitable to the circumstances of Australia.

Mr. DERRY: I am sorry I am not prepared to speak as fully on this subject as I could wish, having left some notes in my camp that I intended to produce to show that the population of districts entirely dependent on irrigation is not so large as Mr. Gordon estimates to be necessary. He considers one person to every 7½ acres irrigated to be required to carry on a mixed system of farming. For the rearing of stock by means of lucerne cultivation on a large scale, only one person to every 80 acres is employed on a farm I visited in California. (See Appendix A.) For high-class cultivation, such as orchards, I have no doubt such a population, as Mr. Gordon names, will be necessary.

As to our chances of obtaining good storages in this country, which Mr. Gordon doubts will be remunerative, it is impossible to say until the explorations for these are completed; but it is encouraging that some good storages have already been discovered which will cost much less than the examples given by him. One (the Wartook), to store 900 million cubic feet, will cost less than £4 per million cubic feet; another, to store 6000 million cubic feet, will cost about £10 per million cubic feet. It is reasonable to hope that others approaching these in excellence may yet be found.

With reference to some remarks that have been made as to want of energy on the part of Victorians, I think the extent to which many have gone into pumping operations, as reported by the Royal Commission, free them from the stigma of a lack of enterprise. We should remember that the people who ask for Government aid are altogether differently situated from the people of California, where they have large snow storage, which we lack here, and, therefore, I think the Victorian people are right in asking the Government to aid them in obtaining what nature has done for the Californians. In support of this view, it may be interesting to know the conclusions arrived at by a Commission appointed by the United States to report on the prospects of irrigation in California. (See Appendix B.)

Since I accompanied Mr. Deakin to California, it may be expected that I should communicate all that I saw bearing on irrigation questions; but although I collected and noted a quantity of valuable information that I have mentally digested and combined with my previous experience, it is difficult to communicate the same to others in words, from the fact of the practice observed being so mixed up with what is apparently self-evident and unimportant accompaniments, that relation would be tedious repetition; but I hope, if this discussion is continued, to elimi-
Note. The blue lines represent the discharge of the Canal in C.Ft. per min. for every 20 miles in length, and the red lines the cost per C.Ft. per min. for the same sections. The curve shows the total cost increasing with the mileage; A, B & C show the cost of Canals 100, 200, & 400 miles long respectively.
nate from my notes further subjects that may be instructive or interesting. This will be more valuable if combined with the results of the application of some of the ideas learned there to works in this country. Some of the earth-excavating apparatus I have been using in the Wimmera with great advantage.

Mr. G. J. Burke, C.E.: I should like to make a few remarks. I have had much experience of waterworks and irrigation, though not in California or Victoria, but in India, and have had many opportunities of studying the systems in Lombardy and northern Italy. As regards the title of Mr. Gordon's paper, I do not feel qualified to express an opinion; but I hardly agree with the remark that it would be undesirable to copy any particular system. There are merits in all systems, and, perhaps, also in all there are many defects to be avoided. The great point is to combine the merits of the different systems, and adapt them to the different requirements of this country. In the 12th paragraph of Mr. Gordon's paper he deals with the question of headworks. While, of course, it is very hard to lay down any general rule, in fact, impossible, about headworks, I think it may be generally stated that in countries where labor is very abundant and very cheap, temporary headworks may be used with advantage, and I may quote cases within my own personal experience, when, as executive engineer, I had charge of some of the irrigation works in the north-west provinces of India. Some of them were supplied by the torrents in the mountains dividing Afghanistan from India. In all cases our works were temporary, and liable to be swept away by every fresh that came down from the mountains, and even if our headworks were washed away a dozen times in the year it made very little difference, for there was always abundance of labor on the spot, and the people were expert in the construction of temporary dams; in fact, the speciality of the Indians was the devising of temporary means to meet these emergencies. With all respect to what we have heard about California, I think a great deal may be learned from India, where there are as many systems of irrigation as there are provinces; and a system suitable to one province may be found entirely unsuited to another. In different provinces I have had charge of irrigation from the hill torrents, from temporary dams—canals deriving their supply from the river Indus for about five months in the year, when the river was in flood, and dry during the cold season. At the same time I was conducting surveys for a large scheme providing for the construction of a dam across the river Indus. To take the Indian system as a general system is misleading. There are dozens of different systems. I have no doubt Mr. Gordon will bear me out in that statement. Where labour is abundant, and easily obtainable at cheap rates, temporary headworks may
be resorted to with advantage: but in a colony like Victoria, where the rate of labor is high, and the difficulty of obtaining it is sometimes very great, more permanent provision should be made for headworks. In paragraph 16, Mr. Gordon mentions the weir constructed by the Esk Mining Company in Tasmania. I could give a little information about that weir; but I do not know that it is advisable or pertinent to the question under discussion. I think Mr. Gordon speaks very fairly when he says that "every case must be judged by itself. No general rule can be laid down; but an ex-cathedra statement that the larger a scheme the more economical it must be, as if this were an undoubted principle of universal application, may be dangerously misleading." With that opinion I entirely concur. Because a large or a small scheme has been successful in one locality, that is no reason why a similar scheme should be successful in another. Reasoning from analogy in such cases is, I think, very often misleading. On the point of drainage, I must say I disagree with the opinion expressed by the President. In the whole course of my experience, the great defect in every system of irrigation, whether in Italy or India, has been the want of efficient drainage. The low-lying tracts in irrigated countries become converted into swamps, which exercise a most injurious effect upon the health of the inhabitants. Some information on this subject has lately been published in Italy, and I regret that I am unable to give details. I saw an interesting report by the Italian Government, in which it was conclusively proved that a want of drainage is one of the great causes of the malaria prevailing in some parts of that country. I think, from the inception of any irrigation scheme, large or small, the question of drainage should be dealt with at first, and that it can be deferred for ten or twenty years is not taking a proper view of the question. I think irrigation and drainage should go hand in hand. That seemed to be the general opinion of all the speakers on the last occasion that I took part in a discussion of this kind in London. I think the question of drainage in connection with irrigation should not be deferred for one single day.

The President: I thank you for your remarks; but I think you misunderstood my meaning. I was saying that there was no essential difference between Mr. Deakin's and Mr. Gordon's report on one question. Mr. Deakin said expensive works were not required for the present, and Mr. Gordon said that an occasional flooding from a primitive system would be sufficient; only at the first inception of the scheme Mr. Gordon says a primitive, while Mr. Deakin says an inexpensive system of drainage would be required.

Mr. Burke: My contention is that from the very inception of any scheme of irrigation the question of drainage should be kept in view, and should be provided for.
American and Australian Irrigation.

Mr. Gordon: The first remarks that were made were by letter from Mr. Tipping. He proposed to irrigate by means of a small plant pumping from wells. There were some points in his letter that were not quite clear. I think he was to be asked the question how much water he allowed per acre. However, I do not think it was of very great consequence, because he mentioned pumping from 70 to 80, or even 100 feet, and I do not think that could be made to pay. It was also proposed to spread irrigation over a period of eight weeks; but that is too long for any irrigation, except in some cases of cereals; but for the higher kind of cultivation, which is the only kind that could afford to pay for pumping, it should be at least every fortnight. Now, the actual cost of raising water at Horsham about 95 feet is 2d. per thousand gallons. That would be sufficient, with \( \frac{2}{3} \) inches of water once a fortnight, for lucerne or any of the higher kinds of cultivation, and they could do little more than two acres per day. They could irrigate a block of 25 acres with their engine and pump, supposing it were divided into sections, at a cost of 7s. 2d. per acre for each watering, or £117 for the season, for a block of 25 acres; that would be £4 14s. per acre for water supply alone, without interest on the cost of the pumping plant, or the distribution, or anything, except merely pumping the water. If the water were applied to cereals in the same way, it would cost per season £117, and it would irrigate 24 acres; but it would not be necessary to pump the whole time. A very different result is got if you have only to raise the water a small height, and in large quantities. I made a very careful estimate of the cost of irrigating 500 acres of lucerne, allowing \( \frac{2}{3} \) inches of water once a fortnight; the pump to be worked 10 hours a day for 156 working days; the water to be raised 24 feet by a centrifugal pump at the rate of 300,000 gallons an hour, sufficient for 42 acres a day, and it amounted to £197 for the season, or about 8s. per acre. That is for pumping only. The same machinery applied to irrigating cereals would cost 2s. 8d. per acre, and would irrigate 400 acres. I have made some estimates for large and small quantities, for different heights of lifting, and the result is shown in the following table:—

<table>
<thead>
<tr>
<th>Quantity (cubic ft. per minute)</th>
<th>Height of Lift (ft.)</th>
<th>Cost of Pumping per 1000 Cubic feet</th>
</tr>
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<tbody>
<tr>
<td>No. 1. 33.7</td>
<td>100</td>
<td>1 10d.</td>
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<tr>
<td>2. 635.</td>
<td>24</td>
<td>0.32d.</td>
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<tr>
<td>3. 2,222</td>
<td>39(\frac{1}{2})</td>
<td>0.83.</td>
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<tr>
<td>4. 4,600</td>
<td>25</td>
<td>0.42.</td>
</tr>
<tr>
<td>5. 9,500</td>
<td>6</td>
<td>0.19.</td>
</tr>
</tbody>
</table>
American and Australian Irrigation.

Altogether I do not think that anything except a very large plant would pay for pumping for irrigation, but in some places I think that would be the most economical way. Mr. Black and I were engaged in drawing up a report (which we were not allowed to finish), on the irrigation of the Gunbower district, and it was a question whether or not it would be cheaper to irrigate by pumping from the Murray, rather than by a gravitation canal. The cost of the plant in the cases above would be about 1s. 2d. to 1s. 9d. per acre per annum. Mr. Deakin says the main points insisted on in my paper did not differ from his own report, except that the latter presents a more sanguine view of the prospects of irrigation in Victoria. There are, however, in my opinion, a good many points of difference as regards matters relating to the engineering of irrigation, although you, Mr. President, seem to think there is not so much difference. Mr. Deakin says for instance that parts 6 to 10 of my paper, I have misapprehended the report, and have confused a comparison between the physical conditions of Victoria and the Western States generally, with a parallel between Victoria and California particularly. I selected California because it was said most to resemble Victoria, and I endeavoured to point out that even in that state the differences were more apparent than the likenesses from an engineering point of view to which I confined myself. Then Mr. Deakin says that by an equally evident misconception it appears as if no provisions for drainage or fertilisation are required in any cases or at any time. I did not intend to represent Mr. Deakin as going so far as that, but I took exception to Mr. Deakin’s opinion that (p. 67), with a deep subsoil or a good fall drainage always be unnecessary, and his hope (p. 64) that it will only be demanded in some parts of Victoria, and even there only some years after irrigation on an extensive scale shall have been in operation.

Mr. Deakin speaks of the diminution of water, but if we go by experience of other countries, and put a proper quantity of water on to the land at first, I do not see how it can diminish. It certainly cannot keep on diminishing, or it will come to nothing in the end. If an excessive quantity is used at first, as seems to be commonly the case, experience will no doubt cause it to be reduced. In his consideration of the population required for the development of extensive works, Mr. Deakin takes the total population of a district in California entirely dependent upon irrigation, and he compares that with the total population of Victoria, which is not a fair comparison. If he could give a comparison of the irrigated district, as I hope Mr. Derry will do, per square mile, it would be very valuable information. Some of the instances he gives in the report seem to bear out what I
said that the present population in the Northern Plains is not sufficient to support a scheme of irrigation.

In my remarks about the tendency of people here to think that we must copy works of other countries, I did not charge Mr. Deakin with recommending it, but I said that it was a common idea especially with the press. My remark was not so misunderstood by the members who were present when my paper was read, as was evidenced by the remarks made afterwards. Mr. Deakin speaks of the close resemblance of the people of California and Victoria in their social and political conditions, and of the success of irrigation, but I do not think it can be said that the irrigation described by Mr. Deakin is successful. He describes some schemes that have been made several times over, and he says the people admit that they made a great many mistakes, and that in some cases four or five times the necessary quantity of water has been used. All that I wish to say in reply to that is that we should rather go to older countries for examples where irrigation is better understood than it is in America. And although Mr. Deakin in his letter seems to admit that such examples are not to be rejected, he evidently (page 12) considers them as inferior to that of Western America. As Mr. Deakin says no reference was made in his report to the opinions expressed by the Water Conservancy Board, I withdraw willingly my remarks on page 15 of my paper so far as they refer to that board, while I maintain that in general the points there alluded to have not been disproved.

Mr. Deakin says the only point now at issue between his report and my paper is as to the timeliness of the annual rise of the Murray. Mr. Deakin says the Murray begins rising just at the time it is wanted for irrigation. He says the melting snow supplies water in volume. The melting of the snow and the time for irrigation on a large scale is in the summer. The Murray is at flood during the rainy season, and it continues high till November and then falls quickly. It is down in December quite low, and does not rise again until June or July. I think Mr. Deakin has been misinformed on that subject. There is nothing to show that there would be a sufficient supply from the Murray in summer for very extended irrigation.

Mr. Murray: I think that is what he intends to imply. The only irrigation from the Murray that has been mooted is that referred to as the Gumbower scheme. The rise of the Murray is suitable for cereal irrigation.

Mr. Gordon: Mr. Deakin says cereal cultivation will not pay for irrigation.

Mr. Murray: I think they (the witnesses) told us the water would be required from the middle of June to the end of October.
Mr. Gordon:—They very often need water supply early in the year. I do not think it can be said that the Murray is in flood during the season that water is most wanted for irrigation, although it may afford sometimes a very valuable supply for the irrigation of cereals late in the season of their growth, and so save them; but that is hardly what is understood by systematic irrigation.

If the Murray were flooded by snow water, as those Californian rivers are, irrigation could be carried on during the summer. To return to the questions of drainage and fertilisation: I know that irrigated lands in old countries need drainage, and have been drained. Even at the beginning of irrigation, this is sometimes at least necessary. Mr. Garden has a scheme of drainage in connection with his irrigation works at Cohuna. I have noticed that all the irrigated land has to be heavily manured. It is Mr. Deakin's theory that the rivers carry as much fertilising matter as is needed. A farmer at home will put 10 to 15 tons of farmyard manure on the acre. If we assume a depth of 12 inches of water for irrigation, it must be equal to this quantity of manure; contain as much fertilising material as would be represented by 50 or 60 lbs. of stable manure put into a 400-gallon tank of rain-water. But the people habitually drink the river water.

I am sorry that Mr. Deakin thinks I have shown a spirit of antagonism towards his report. I did not intend to express any such feeling, but only to show where I differ from him on professional points on which he challenged criticism. I did not wish to be generally antagonistic to his report, which I think a most clever one. But my impression is that the newspapers conveyed exactly the same idea to the public of the drift of the report as I had gathered from reading it, and there were points which I thought it necessary to take up and express my opinion upon. The newspapers said that the report should be put into the hands of every farmer as a guide; but I thought several points in it were misleading, and especially the tendency all through it to minimise the estimated cost of irrigation. I think Mr. Deakin made a mistake when he said that Mr. Culcheth's scheme for the Tragowel Plains was to cost 14s. an acre. Mr. Culcheth's estimate is 41s. an acre. The total area would give 14s.; but Mr. Culcheth only proposed to irrigate one-third of that, and he says the scheme would cost 41s. or 42s. per acre, and that for a very precarious supply. As regards the cost of large schemes as compared with small ones, I did not mean to compare a scheme such as those described in the report, of 150,000 acres, with a smaller one; but I was comparing such a scheme as is alluded to as capable of irrigating the whole of
the North-Western Plains, or such a one as that lately put forward of a canal 400 miles in length, commanding five million acres; and capable of irrigating 700,000 acres. This was the class of work I wished to show was not necessarily more economical, or, indeed, likely to be more economical than one of moderate size, and Mr. Deakin has no means of judging of the question from his American experience; for even the largest work mentioned in his report is smaller than the Rodney irrigation scheme reported on by Mr. Black and myself.

It stands to reason that if you must carry water two or three hundred miles in an artificial channel, with a slight fall, it must cost a good deal at the end of the distance. I quite agree with Mr. Deakin that if facts clash with theories so much the worse for the theories; but, with all deference, I submit that in regard to the questions of drainage, fertilisation, and the standard of quantity of water required, the facts, i.e., the experience of old countries, are on my side, and Mr. Deakin is the theorist.

Mr. Keily has an impression that a late Government deputed Mr. Black and myself to bring out a scheme of irrigation, and not being satisfied with our work, appointed a Royal Commission. This is not quite correct. Our first duty was to prepare schemes of water supply for domestic purposes, and the use of stock and irrigation was to be considered afterwards. We sent in two reports on irrigation, one general, and one on the Goulburn scheme, and we were about to send in another when we were suddenly relieved of our duties in that respect.

The question raised by the President as to by whom the works are to be constructed is a very large one, and I am not prepared to enter upon it at present, though I quite agree with the view expressed by the President and Mr. Wannan that as much as possible should be done by the people themselves. That was the opinion that Mr. Black and I formed. We modified it afterwards by saying that it was quite possible in some difficult cases, where a great many different trusts would be supplied by one large headwork, that the Government should construct it, but not necessarily at the Government expense. The amount I mentioned of £5 to £10 per acre, first cost, is the cost at which I think it would in almost any part of the country pay the people to construct irrigation works; but I do not think it would pay a company, who would expect to get ten per cent. out of it; or, rather, I do not think it would pay the people to pay so much as would yield a company ten per cent. As a rule, irrigation companies have not been a financial success, though they have been very beneficial to the people. As to the quantity of water, I do not think there should be such a great mystery as Mr. Deakin
thinks. Where it has been ascertained by actual measurement, I think there is a certain guide given. Otherwise, going into irrigation at all must be very haphazard work. It is the first thing that is needed to be known. It is possible that Mr. Black and I would have recommended pumping for the greater part of the Gumbower scheme of irrigation. Unless supplemented by pumping from the Murray, there would be only irrigation for half the year, including the winter months; whereas, with pumping, irrigation could be carried on during the whole year.

The President: Does not your own experience and knowledge show that there is a very large variation in the maximum and minimum of the same crops in the same ground.

Mr. Gordon: Not very much. Of course, for cereals it varies very much. Sometimes no water would be required for cereals, and sometimes they do want it. Each different kind of rice cultivation takes pretty nearly the same quantity of water. In Madras, they reckon a nearly fixed quantity, and when they are extending works, or extending the area, they lay their canals out to carry a certain quantity. I think you will find in the table of quantities of water required that the same crops take nearly the same quantities in different countries. Mr. O'Meara, in the paper quoted by Mr. Deakin, gives a table of the quantity of water and yearly rainfall, which is very instructive. I partly agree with Mr. Derry's remarks that the Victorian people have not shown any great want of energy; but I also agree with what Mr. Wannan said that the people are always crying out for Government assistance. Individuals have shown a great deal of energy; but at all these meetings we hear too much about appeals to the Government to take the task of constructing the works.

Mr. Derry: I certainly think the people should carry out the greater part of the work for themselves; but they are in a difficult position.

Mr. Gordon: The greater part of the people are not able to get the water for themselves individually. I should like to ask Mr. Derry whether the 9,000,000 cube feet proposed to be stored in the Grampians represents the quantity stored, or that available for irrigation.

Mr. Derry: That is the contents when full. The average depth would be eight feet. In the storage per acre I would deduct three feet or more for loss by evaporation.

Mr. Wannan: I did not allude to any want of energy on the part of the Victorian people. I know well they have shown a great degree of energy; but I refer to the want of individual enterprise, independent of State aid.
APPENDIX A.

IRRIGATION IN CALIFORNIA.

Notes on labor employed, and cost of irrigating the Poso Ranche, Kern Island:

This is one of numerous farms on Messrs. Huggin and Carr's property of 300,000 acres, 35,000 acres of which are devoted to the cultivation of lucerne. The whole of this area was worthless without irrigation. The principal works on this irrigation scheme have been described in my addendum to Mr. Deakin's report. Messrs. Huggin and Carr are very wealthy, and quite independent of the success or failure of their irrigation scheme. The whole is conducted by a large staff of well-paid officers, so that greater economy would be expected were the managers the proprietors. Consequently, up to the present the scheme has not been a financial success by return from the produce of the land as a whole, although some of the tenants have done well; but when the water rights are secured, and the land cut up and sold in areas from 100 acres upwards, they will secure a very large return for their expenditure. The Poso Ranche had 1,720 acres under lucerne cultivation for stock raising. The following account of expenditure and return I obtained from the superintendent, Mr. Chapman. It was being irrigated at the time of visit, so that I was able to see the system in operation by which so few men would irrigate such large areas. The system is described in my report, at page 42, as "Flooding," and is the cheapest mode of applying water to land. When the area to be irrigated is favorable, and it has been skilfully "checked" or terraced, four men irrigate 100 acres in 24 hours with a supply of water at 30 to 40 cubic feet per second. On this 1,720 acres 2,150 head of cattle were kept.
American and Australian Irrigation.

The labor employed was as follows:—

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
<th>Rate per month</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 men for 3 mowing machines</td>
<td>17</td>
<td>8,160</td>
<td>8,160</td>
</tr>
<tr>
<td>horse-rake</td>
<td>4</td>
<td>1,440</td>
<td>1,440</td>
</tr>
<tr>
<td>3 waggons (2 men pitching)</td>
<td>25</td>
<td>975</td>
<td>975</td>
</tr>
<tr>
<td>stacking</td>
<td>1</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>stableman</td>
<td>1</td>
<td>10,575</td>
<td>10,575</td>
</tr>
<tr>
<td>“vacharo,” or herdsman</td>
<td>1</td>
<td>12,075</td>
<td>12,075</td>
</tr>
<tr>
<td>general work</td>
<td>1</td>
<td>25,800</td>
<td>25,800</td>
</tr>
<tr>
<td>for cook</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total labor cost: 21 men.

The following is Mr. Chapman’s estimate of return:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2150 head of stock give a profit of 12 dol. per head</td>
<td>25,800</td>
</tr>
<tr>
<td>Deduct expenditure as above</td>
<td>12,075</td>
</tr>
<tr>
<td>Interest on stock, valued at 20 dol. per head—</td>
<td>2,580</td>
</tr>
<tr>
<td>48,000 at 6 per cent.</td>
<td>2,580</td>
</tr>
<tr>
<td>Land value, and share of cost of irrigation works for 1,720 at 2 dol. per acre; Mr. James’ estimate</td>
<td>18,095</td>
</tr>
<tr>
<td>Estimated annual profit</td>
<td>7,705</td>
</tr>
</tbody>
</table>

= 4 ½ dollars per acre, or about 18s. 9d., or £1,600 on 1,720 acres.

From the above it is shown that for stock raising on lucerne on a large scale, one man per 80 acres is the required population, and I believe it will be largely on lucerne or other stock feed cultivation that profit from irrigation must depend. In other words, the above example only shows that irrigation on the “flooding” system can be carried on on a large scale with one man for 80 acres, and this will be confined to such areas
that it can be conveniently applied, so that other systems of applying water, as the character of the land varies, must be considered at the same time. I only give the above as one item in the calculation to assist in arriving at the population necessary to justify expenditure on irrigation works. In Colorado Mr. Deakin found that farms of 80 acres and upwards were managed by a single family, with hired labour for only a few months in the year. Here the production was entirely dependent on irrigation.

APPENDIX B.

GENERAL CONCLUSIONS.

The Commissioners conclude their report with the same conclusions which are presented as a summing up of the whole matter. The principal ones not previously mentioned are as follows:

That the experience of other countries appears to prove that no extensive system of irrigation can ever be devised or executed by the farmers themselves, in consequence of the impossibility of forming proper combinations or associations for that purpose. That, while small enterprises may be undertaken by the farmers in particular cases, it would not be in accordance with the experience of the world, to expect of them the means or inclination to that co-operation which would be necessary to construct irrigating works involving large expenditures. That enterprises of this character, if built at all, must be built by the State or by private capital.

LAND AND WATER SHOULD BE INSEPARABLE.

As a matter of public policy it is desirable that the land and water should be joined together, never to be cut asunder; that the farmers should enjoy in perpetuity the use of the water necessary for the irrigation of their respective lands; that when the land is sold the rights to water shall also be sold with it, and that neither shall be sold separately. That the State and country will be directly benefited by the appreciation of land and by the increase of wealth in there revenues from taxation. That consequently it may be good policy for them to aid such enterprise. That there is this difficulty in the way of the proposition that the lands shall pay for the canals, namely: that in many places, the lands at present are not worth more than five dollars per acre, if so much, and that the irrigation works may cost ten dollars per acre. That whatever aid is given by the State or country, should be extended in a cautious way. That in many parts of the country where irrigation will ultimately best repay
expenditure, there are now no people; that the population must be imported, the houses, barns, and equipments of the farms must be created, before returns can follow investment. That for these reasons, we must look for a comparatively slow development of the country.

PRIVATE ENTERPRISE SHOULD BE INVITED.

That, while we believe, as we have already stated, that the best policy is for farmers to build and own the canals, we also believe that where the farmers are unable to build, and where the State is unable or unwilling to build, it may be, and it probably will be, the best policy to invite the aid of private enterprise. We refer to numerous instances in Spain and Italy, where this system is now in successful operation, in support of our opinion. The private companies undertaking such enterprises should be subjected to certain conditions, some of which are as follows: That, after a stated period, the franchise shall lapse in favor of the State, or of the irrigators; or that, after a certain same period, the State shall have the right to purchase on certain previously-defined conditions. That the price of water shall be fixed by agreement; each party in interest being represented by arbiters; that the State shall have the right to charter an association of irrigators to administer the works, the company merely selling the water and having nothing to do with it after it leaves their channels; the association making all arrangements for its distribution and the collection of the water rates. This latter provision has several advantages. It relieves the company from the arduous duty of discriminating in times of scarcity, and from the endless disputes which attend the distribution of water, and puts the responsibility where it belongs—on the irrigators. It favors each irrigator, for he becomes a member of a company which is strong enough to stand up for its rights in any contest with the capitalists.

NOT AN INVITING FIELD FOR CAPITAL.

That there is no reason to suppose that for a long time capital will look upon this kind of investment with favor. The financial history of most irrigating enterprises in other countries is not favorable, so far as the interest of stockholders are concerned. It may be a question for the State to consider whether it is good policy to offer any inducements in aid of such enterprises.

THE DUTY OF THE GENERAL GOVERNMENT.

That most of this land cannot be cultivated under existing circumstances. That it has no value except for pasturage during part of the year. That if irrigated its value would be increased manifold; that under these circumstances it may be a question
whether the United States ought not in some way to encourage the irrigation of these lands. That when any canals are built the State should establish a system of inspection, by which a proper construction shall be assured. That the quality of water to be taken from a river at its main stage, for the irrigation of a definite quantity of land, should be fixed by a reasonable rule, so that those who come later shall not find all the water taken up, and so that proper drainage shall be secured. That the water rights of the streams now taken up for mining purposes in the mountains do not conflict with the irrigation of the plains, the water being returned to the natural channels above the points where it will be taken out for irrigation, at least for many years to come.
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