

# THE WATER SUPPLY OF GREAT CITIES.

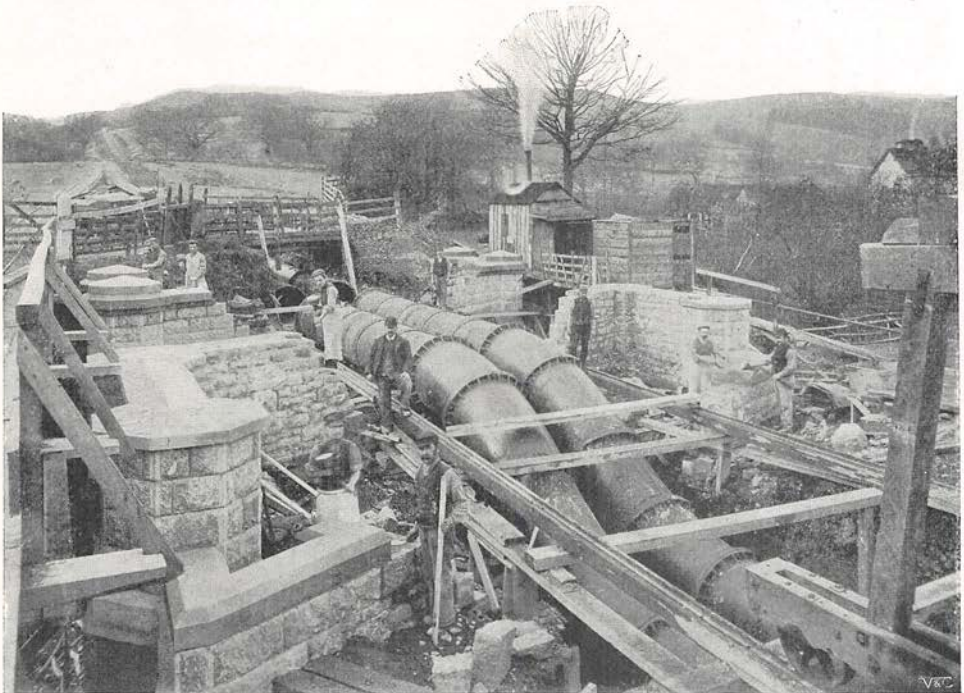
BY HARRY GOLDING.

**N**OTHING short of a burst pipe or an epidemic will induce the average householder to take more than the most casual interest in his water supply. A more than usually exorbitant charge for the harmless amusement of swinging a garden hose in the summer twilight will perhaps excite his wrath, but for the most part he is content to turn the tap and leave the rest to Providence. Sometimes his faith is justified, sometimes—but that part of the subject is best left alone.

In all seriousness, the water question is of far greater interest than is commonly supposed. How few people, for instance, realise the enormous quantity they daily use! Water experts put the minimum consumption per head per day at 25 gallons. But this is generally greatly exceeded. In London it amounts to 35 gallons per head, and Sir Alexander Binnie is of opinion that it will go up to 40. Think of it—35 gallons—560 breakfast-cupfuls per day! A man could

contrive to drown himself in little more. In London and suburbs alone the daily consumption of water amounts to over 200,000,000 gallons, enough to fill a fair-sized lake, and about equal to the entire daily flow of the Thames over Teddington Weir in dry seasons. In other words, if no more than the 200,000,000 gallons which the Thames Conservancy regard as the “irreducible minimum” were allowed to pass into the tidal portion of the river, and there were no other sources of supply, Londoners would mop up the Thames below Teddington as fast as it flows. Of course, only a small proportion of this water is actually used for drinking purposes. The citizen’s daily bath, and more or less frequent interim ablutions, and ordinary household and business uses account for the rest.

Then think of the soap. Everyone knows how much easier it is to wash in soft than in hard water, but do we all realise that this is a matter not merely of comfort, but of



THE BIRMINGHAM WATER SUPPLY: TAKING SYPHONS ACROSS A STREAM.



THE BIRMINGHAM WATER SUPPLY : BUILDING THE CRAIG COCH DAM.

economy? The hardness of water generally depends on the quantity of salts of lime held in solution. London water contains from 15 to 20 grains of bicarbonate of lime to the gallon. This means that each day's supply holds in solution about 182 tons of soap-destroying materials, or no less than 66,430 tons a year. They calculate in Glasgow that they have saved £40,000 a year in soap since the supply was obtained from Loch Katrine. In Birmingham, when the new supply from Wales is available, they look forward eventually to a saving of £120,000 a year on this head alone, reckoning soap at the moderate price of  $2\frac{1}{2}d.$  per lb. Nor is this all. Hard water means the incrustation of kettles and boilers. This is bad enough in ordinary households, but in the large boilers used for commercial purposes the deposit of "scale" is an intolerable nuisance and its removal a costly matter. The incrustation of pipes of comparatively small diameter soon reduces their effective area, and they require renewal long before they are really worn out. Mr. Thomas Barclay estimates that the excess of lime in the Birmingham water obtained locally over that which is to be brought from

Wales causes, in a daily boiler use of 2,000,000 gallons, a difference of no less than 320 tons of incrustation a year.

The same process of calcification goes on to some degree in our own bodies, and an ingenious writer has calculated that the lives of drinkers of hard water are shortened by from ten to twelve years by this means. It is only fair to say, however, that there is a considerable difference of opinion on the point, and many hold that a moderate proportion of lime salts in water is not only an advantage, but an absolute necessity.

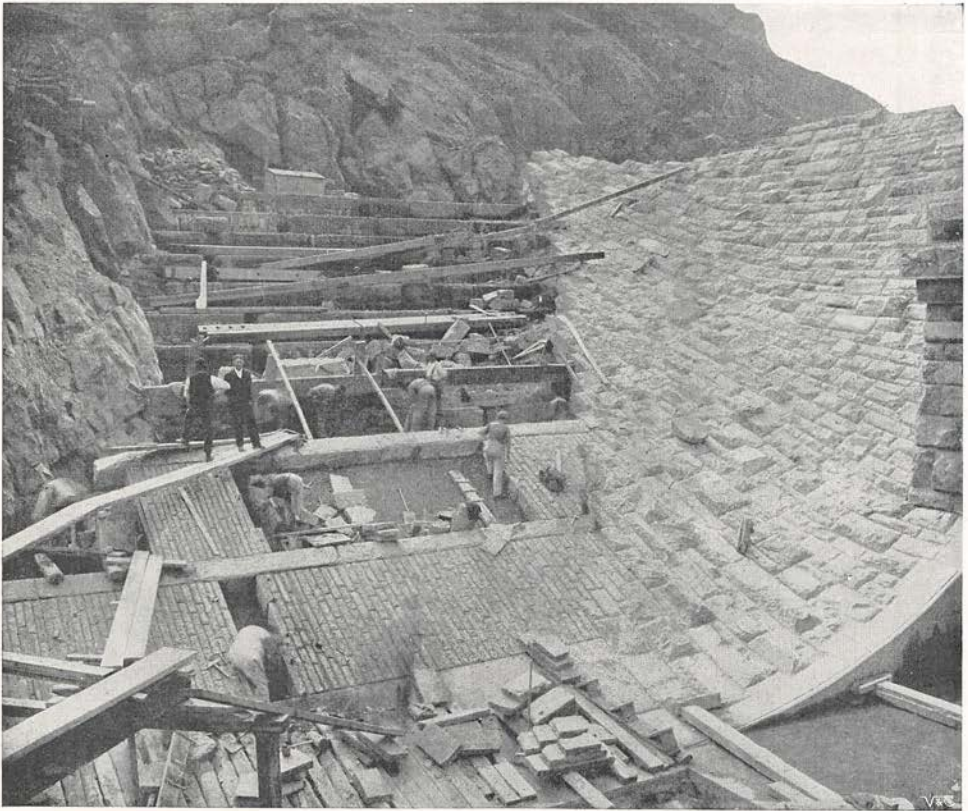
All this, however, is merely by way of introduction, and to show that the subject of water is not necessarily a "dry" one. Indeed, how could it be?

The vitally important question of the future water supply of London is again very much to the fore, owing to the Government proposals to buy out the Companies and constitute a Water Board. Without going into controversial matters, it may be of interest to give a short account of the various proposals and to show what other great cities have done in similar circumstances.

The population of "Water London" is

upwards of six millions, of whom about a million and a half live outside the strictly metropolitan area. The consumption amounts in round figures, as has been said, to 200,000,000 gallons per day. Thanks to the system of intercommunication between the mains of the various Companies now adopted, there is rarely difficulty, at present, in providing this quantity. But London, especially Outer London, is rapidly growing, and there is every probability that in another thirty years no less than twelve million people will

at Teddington Weir below the necessary 200,000,000, and still another 225,000,000 from the Lea and other sources. It is simply, in fact, a question of storage, of taking water in times of plenty and reserving it for times of drought. They are, accordingly, constructing enormous reservoirs at Staines and elsewhere from which an additional 35,000,000 gallons daily may be drawn, or in times of emergency 45,000,000 gallons. The Staines reservoirs will be capable of holding 3,300,000,000 gallons.



THE BIRMINGHAM WATER SUPPLY: INSIDE THE CABAN DAM.

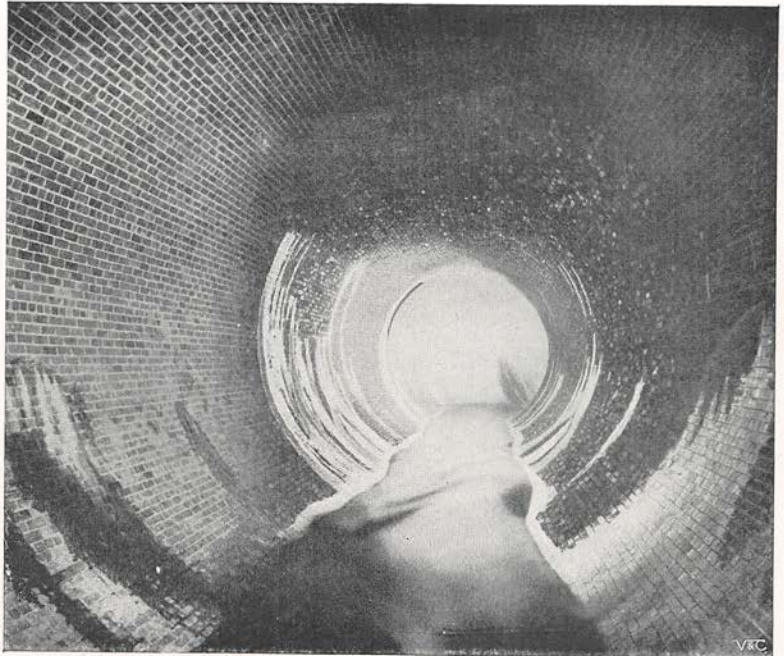
look for their modest 35 to 40 gallons per day. The Thames is an accommodating river, with an average daily flow of over 1,000,000,000 gallons, but can it be safely expected to yield, during a prolonged drought, more than double its present quantity, and still leave plenty for the penny steamboats and the newly introduced salmon? The Water Companies say "Yes," and that, if necessary, no less than 400,000,000 gallons of water fit for use can be obtained daily from the Thames without reducing the flow

The London County Council, on the other hand, contend that no more than 300,500,000 gallons can be safely drawn from the Thames and Lea valleys, and that though the present supply is sufficient, at least 447,000,000 gallons a day will be required by 1931. Consequently the deficiency must be made up from some other source, and there is no adequate watershed available nearer than Central Wales. They argue, too, that it is extremely unwise to leave London dependent to so large an extent on the Thames, con-

sidering the rapid growth of population in the river valley and the increased risks of pollution. The question is emphatically one for experts. All we can do is to give an outline of Sir Alexander Binnie's scheme.

Briefly, then, the retiring Engineer to the London County Council proposes to bring, by the simple action of gravitation, an additional 200,000,000 gallons a day all the way from Wales to London. This will ensure a total supply of 500,000,000 gallons a day, but

if at some distant date even this enormous quantity should prove insufficient, the scheme provides for a second line of aqueduct to bring yet another 200,000,000 gallons.



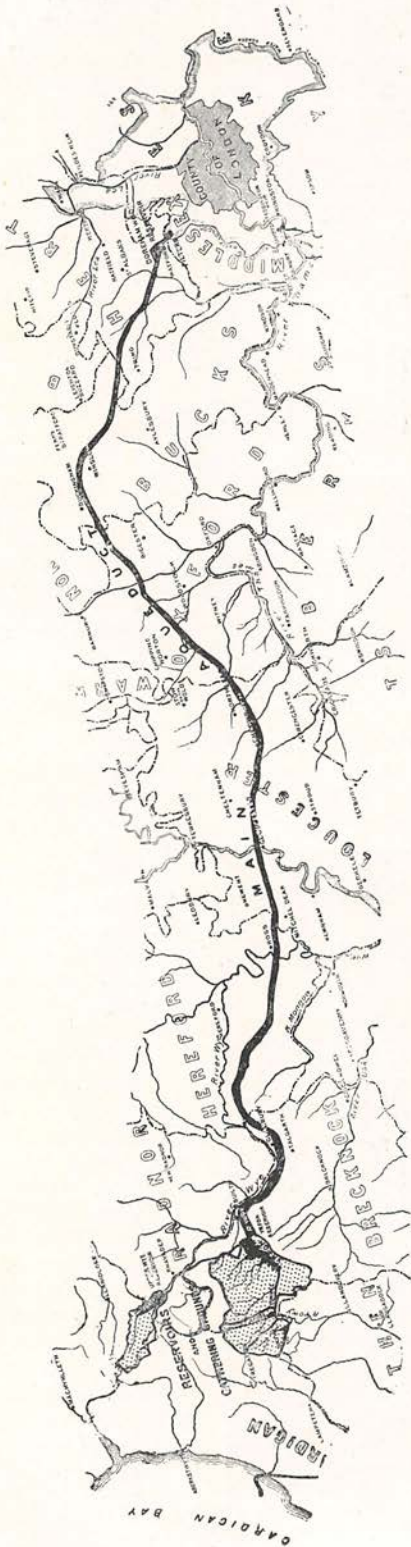
THE BIRMINGHAM WATER SUPPLY: INSIDE THE CRAIG COCH CULVERT.

The maps on pages 362 and 363 show the course of the proposed aqueduct and the three catchment areas. The project involves the formation of a reservoir in each of the three districts. The

great Yrfon Reservoir would form a magnificent lake of some 3,000 acres, as nearly as possible the size of Windermere. The total capacity of this lake would be about 39,000,000,000 gallons, the capacity available 35,750,000,000 gallons. The top water level would be 610 feet above the sea. It would be formed by damming up the Yrfon River on the eastward side with a great dam 166 feet in height. The reservoir on the Upper Wye would



THE BIRMINGHAM WATER SUPPLY: MAKING THE GREAT AQUEDUCT.



WATER FROM WALES: HOW THE COUNTY COUNCIL PROPOSE TO SUPPLY LONDON.

be about 900 acres, and the Towy Reservoir of smaller size. Both would be connected by tunnels with the great Yrfon Reservoir, which they would help to feed. As will be seen, the gigantic conduit would extend from Llangorse Lake, in Radnorshire, right across the counties of Hereford, Gloucester, Oxford, Bucks, and Hertford, to the Elstree Hills, twelve miles north-west of Charing Cross, where it would discharge into an enormous reservoir, 300 feet above sea level, capable of holding 3,200,000,000 gallons, or sixteen days' supply. The aqueduct would be 150 miles in length, and would be formed of masonry and concrete, except at valley crossings, where parallel iron and steel pipes would be used. The masonry portions would be 16 feet in width, and the water would flow to a depth of about 11 feet. Thus the conduit would be practically an underground "Tube," conveying water instead of people. And just as in the construction of electric railways full advantage is taken of inclines to lessen the amount of propulsive force required, so the conduit would have a gentle fall the whole distance in order that the water might run by simple gravitation, pumping, needless to say, being a very expensive performance. The watershed consists of 312,400 acres, or 488 square miles, in the heart of Wales. Over this area the rainfall is at least twice as heavy as in the Thames Valley, and it is estimated that 415,000,000 gallons a day can be drawn, after making every allowance for dry seasons and evaporation, without depleting the local rivers. The cost is put at £17,500,000, but the London Water Companies contend that this is far too low. Should the second aqueduct (which it is proposed should serve the south of London from a reservoir at Banstead) be required, the cost would be more than doubled. The work would take from ten to fifteen years to complete.

The scheme is a daring and ambitious one, but from an engineering point of view quite feasible and simple. It has been criticised on the ground that in the event of invasion so long a line of aqueduct would be likely to fall into the hands of an enemy, and London would then be at his mercy. There is some force in the objection, as recent experience in South Africa has shown; but, after all, Paris, which in our own time has sustained so severe a siege, is content to derive its water from sources at a distance of from eighty to a hundred miles.

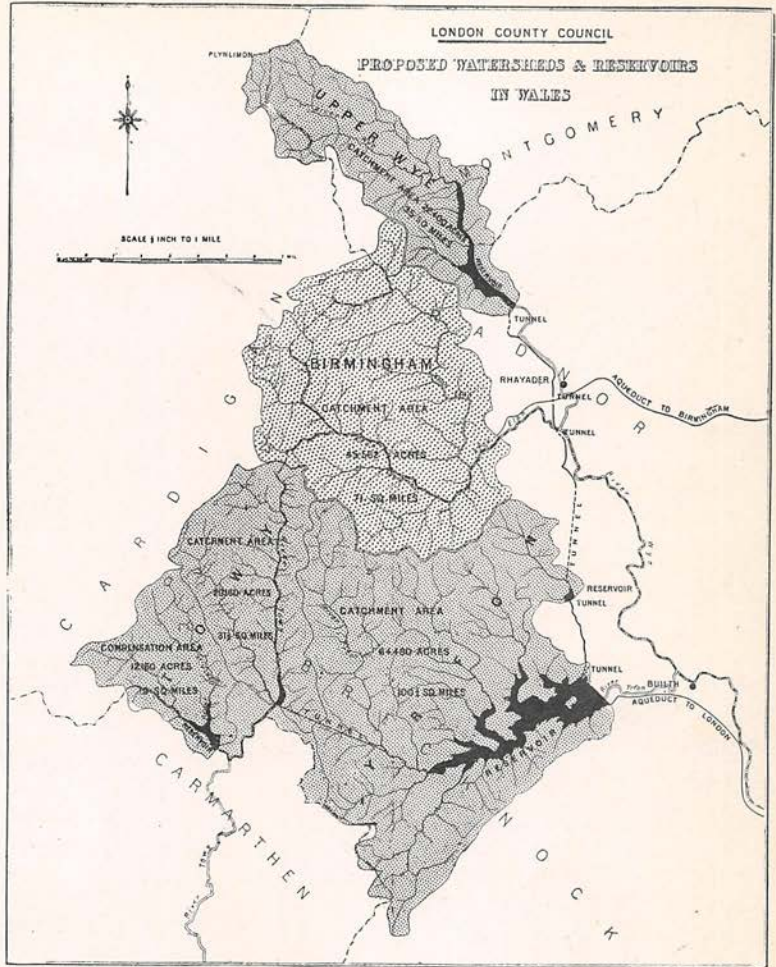
What is proposed for London has actually been accomplished, or is in process of accomplishment, in practically all our great cities. Indeed, at such a pace has the race for watersheds proceeded in recent years that almost every available source of supply is now ear-marked.

Glasgow was the first, nearly fifty years ago,

to adopt a scheme on a sufficiently large scale to ensure, as was then thought, an adequate supply for all time. A natural reservoir, admirably adapted to the purpose, was found in Loch Katrine, thirty miles away, the lake of the lady of Sir Walter Scott's classic poem. The venture was regarded as hazardous in the extreme, and My Lords of the Admiralty seem to have been seriously concerned as to what would become of the Firth of Forth if Glasgow were allowed to give full vent to its drinking and washing capacities. The Act was obtained in 1855, and four years later Queen Victoria herself turned the water on. At first a supply of 8,000,000 gallons a day was sufficient, but now the "ceety" consumes

over 50,000,000, and has even taken steps, by doubling the aqueducts, to provide 100,000,000.

Manchester bought out the local water company so long ago as 1847, and immediately set about supplementing the supply by the construction of reservoirs in the Longdendale valley, eighteen miles distant, at a cost of over £3,000,000. Supply seems to have created demand, for it was found in 1864 that three times as much was used as in 1851, though the population had not increased in anything like the same proportion. By 1875 it was generally recognised that further sources of supply would have to be found; and after much discussion it was resolved to go in for a comprehensive scheme that would settle the question once for all. It was at first suggested that Manchester



WATER FROM WALES: THE AREA FROM WHICH IT IS PROPOSED TO SUPPLY LONDON; THE CENTRAL AREA WILL SUPPLY BIRMINGHAM.

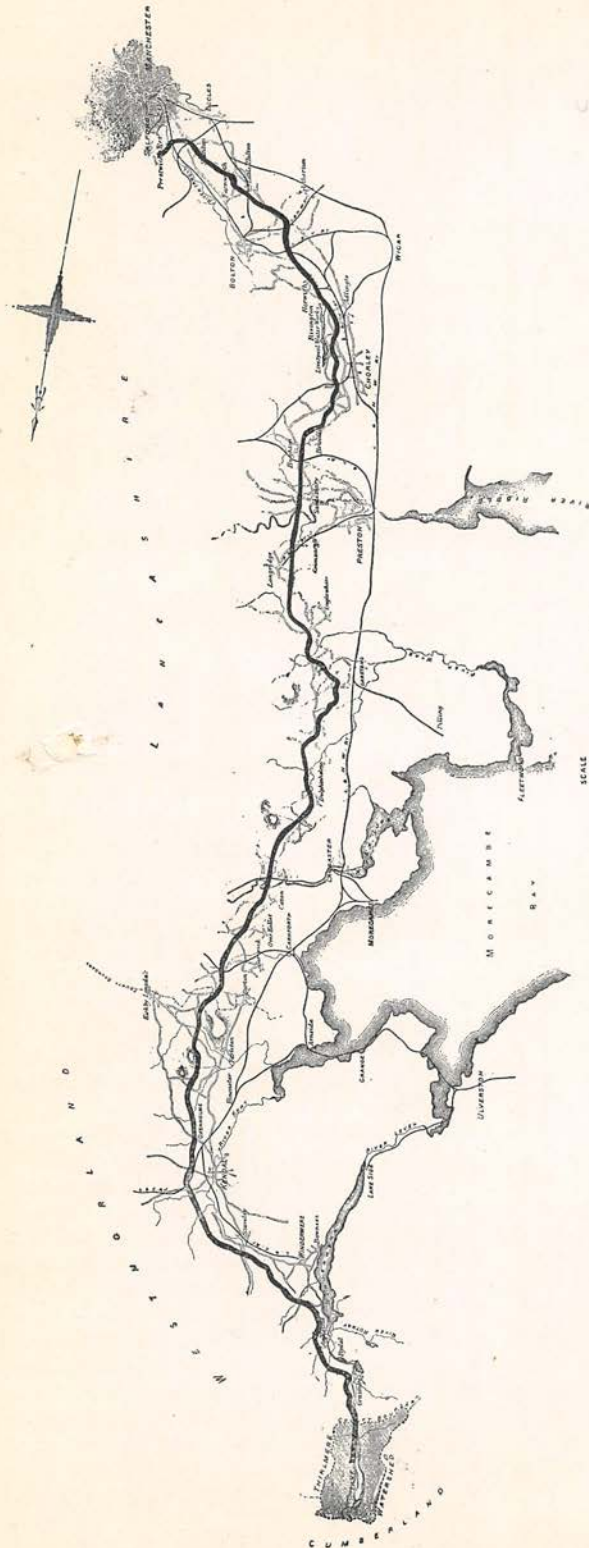
and Liverpool should obtain a joint supply from Ullswater, in the Lake District. Eventually Manchester annexed Thirlmere, much to the indignation of local residents. "Are we to invite tourists and lovers of the picturesque to come for a trip to the tanks?" facetiously asked the then Bishop of Carlisle. As visitors to the Lakes are aware, a huge embankment has been constructed at one end of Thirlmere, and the natural level of the water raised twenty feet, giving a supply of 10,000,000 gallons a day. Should it be found necessary, the lake can be raised another thirty feet, more than trebling the present capacity. The plan on page 364 shows the route taken by the aqueduct, which has a length of more than ninety-five miles, about a half of which consists of piping. Although Manchester has sunk

£6,000,000 in waterworks, it derives an annual net profit from them of over £200,000.

Liverpool, instead of cooperating with Manchester, resolved to go to Wales for an independent supply. The consequence was the formation of Lake Vyrnwy, the largest sheet of artificial water in the world, being  $4\frac{3}{4}$  miles long and about half a mile broad, the surface area being no less than 1,120 acres. All who have seen it will agree that it is a distinct addition to the beauties of Wales. Its construction involved the submergence of an entire village, comprising a parish church, two chapels, a schoolhouse, three public-houses, and about forty other houses. The aqueduct is 77 miles long. The average quantity drawn from the lake is about 12,000,000 gallons per day, but the supply can be increased if necessary to 40,000,000. The masonry in the great dam weighs 510,000 tons.

Many other large towns have in recent years carried through similar schemes, but limitations of space render details impossible. Generally speaking, it may be said that the capital invested in municipal waterworks throughout the country already amounts to nearly fifty million pounds, yielding an average annual net profit of nearly two million pounds.

But by far the most interesting scheme is that of Birmingham, commenced in 1893 and now fast approaching completion. Here Londoners may see in actual progress work of a similar character to that proposed for the Metropolis. Reference to the map on page 363 will show that the catchment area of 45,000 odd acres acquired by Birming-



HOW MANCHESTER GETS ITS WATER: THE AQUEDUCT FROM THIRLMERE, MORE THAN NINETY-FIVE MILES LONG.  
From Sir J. J. Harwood's "History of the Thirlmere Water Scheme."



THE BIRMINGHAM WATER SUPPLY: THE NAVVY VILLAGE.

ham is sandwiched in between the districts longingly regarded by the London County Council. The aqueduct in this case will extend a distance of 73 miles, and the water will travel at the rate of two miles an hour. Thus any given portion of the stream will

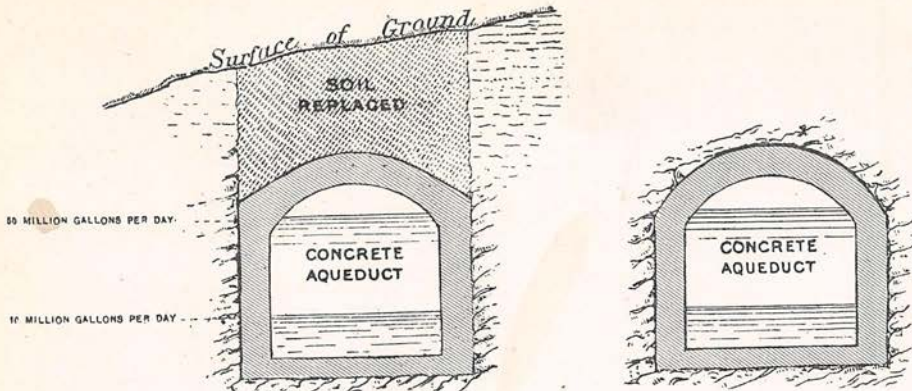
take a day and a half to complete its journey. Not only Birmingham, but a number of Midland towns on the line of route will be entitled to "draw." By damming the rivers Elan and Claerwen a series of six large reservoirs is being formed, covering 1,500

acres and having a storage capacity of 17,360,000,000 gallons. After allowing 29,000,000 gallons daily for what is known as "compensation," it is estimated that there will be 72,000,000 gallons available for supply. The expenditure authorised by Parliament was £6,600,000, but, though the scheme is being carried out in instalments, it is already evident that this amount will be greatly exceeded. To accommodate the army of navvies and others employed on the works, a village



THE BIRMINGHAM WATER SUPPLY: THE HOSPITAL.



*in Cut and Cover.**in Tunnel.*

DIAGRAMS ILLUSTRATING THE "CUT AND COVER" METHOD OF CONSTRUCTING UNDERGROUND AQUEDUCTS.  
 From Sir J. J. Harwood's "History of the Thirlmere Water Scheme."

of wooden huts has been constructed on the bank of the Elan, a few miles from Rhayader. There are three classes of huts, a canteen, library, school, and other conveniences. A hospital for the treatment of accidents is, unfortunately, an essential adjunct of all

great public works. For the photographs, by Mr. J. Hudson, of Lewisham, illustrating the village and the methods of work, we are indebted to the courtesy of Mr. James Mansergh, the eminent engineer under whose direction the scheme is being carried out.



THE BIRMINGHAM WATER SUPPLY: BORING THE AQUEDUCT.