

The Making of a London "Tube"

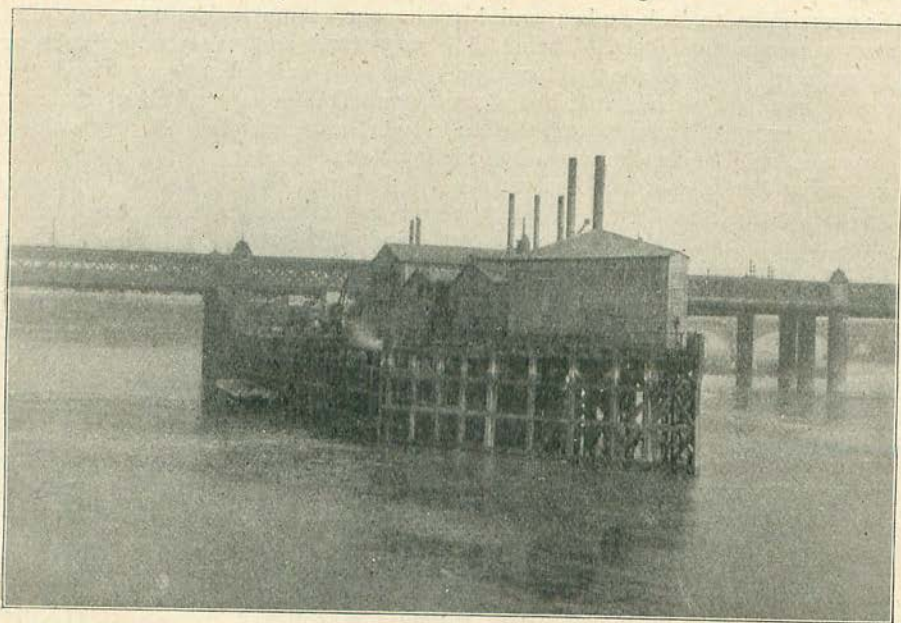
By Gertrude Bacon

THERE comes a time in the history of the mighty and ever increasing cities of the modern world when the question of how to deal with the overwhelming torrent of life rushing ceaselessly along their chief thoroughfares, becomes of the most pressing importance. It is, naturally enough, in the two great capitals of New York and London that this all-momentous problem assumes greatest proportions, and in each instance the difficulty is dealt with in a different way. The Americans seek to relieve the congested arteries of the huge heart of the West by the use of railways raised above the streets; while Londoners, on the contrary, attempt to effect the same end by burrowing underground.

That each system has its special advantages none will deny. The traveller by the New York elevated railroad breathes a purer air, no doubt, than his transatlantic cousin under London streets, and reaches

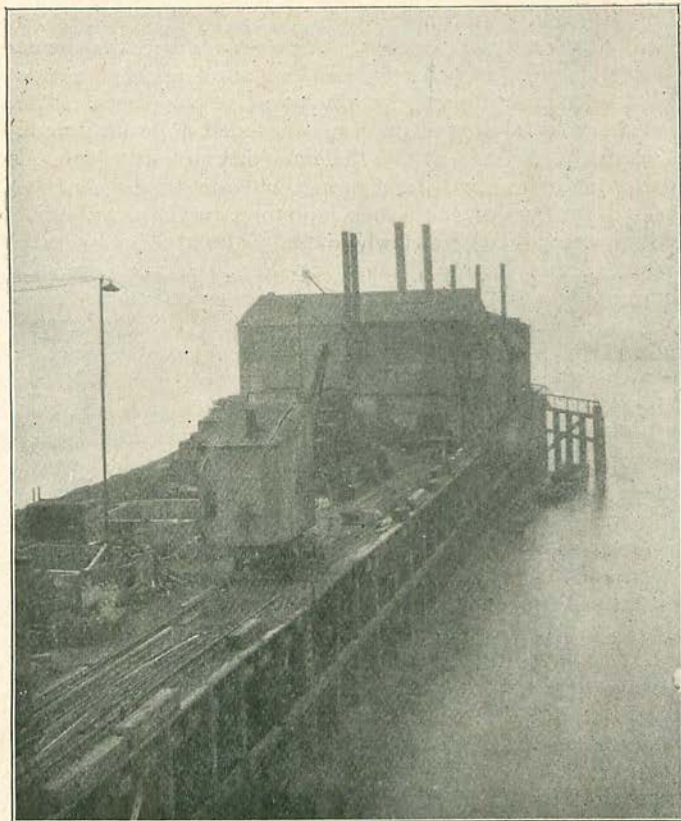
his destination in pleasanter fashion. At the same time London may well refuse to disfigure her principal thoroughfares with the unsightly supports of the overhead rails; whilst sunk deep down in the earth the electric trains can safely and punctually convey their passengers, no matter what conditions of fog and storm may prevail above. Certain it is that with the opening of the Central London Railway, the famous and justly popular "Twopenny Tube," a revolution has been effected in underground travelling, and dwellers in the metropolis apparently see clearly before them the solution, in great part, of the street traffic problem which has vexed them so long.

The great success of London's "tubes" has naturally led to the promotion of other similar ventures, and the time is now not far distant when another underground electric rail will be open to the public. This new tube runs through the town from north to



(G. Bacon, photo)

Temporary river stage of the Waterloo and Baker Street Railway as seen from Thames Embankment. This stage adjoins the Charing Cross Railway Bridge

*(G. Bacon, photo)*

The stage from the bridge—with ballast barge alongside. The mouths of the two shafts can be distinguished

south, extending from Baker Street to Waterloo Station; and its construction has been an engineering triumph of the highest order. It recently fell to the lot of the present writer, thanks to the unrivalled kindness and courtesy of the engineers, to inspect the actual formation of what will shortly be an accomplished fact; and with her readers' permission she would now propose, in their company, to repeat this voyage of discovery, in order that they may realise for themselves how great an achievement has been quietly and successfully carried out beneath the London streets, and may witness the actual and wonderful processes by which a "Twopenny Tube" is evolved.

For many months past passengers along the Embankment have been aware of a large and substantial wooden stage, erected on

lofty piles, and crowded with sheds and building materials, standing out in the tideway of the Thames immediately west of the Charing Cross Railway Bridge. A large notice board on the face of this bears the legend, "Baker Street and Waterloo Railway"; but the connection between the stage and railway is not immediately apparent, and probably but few of the many thousands who pass the structure daily have more than the vaguest notions concerning its origin and functions.

Access to the stage is afforded by several steep ladders and a wooden gangway affixed to the framework of the Charing Cross Bridge, and once past these we find ourselves on the temporary island itself, standing in the midst of a litter of barrows, buckets, heaps of gravel, and huge stacks of the curved iron sections which sheath the

underground tunnels. Sundry wooden sheds containing offices and engines are erected at the further end of the pier; but what chiefly attracts our attention are two circular enclosures in the centre of the stage, of considerable size, and surrounded by breast-high stout wooden fencing. Leaning over this to catch a glimpse of what is within, we find ourselves peering down the open mouth of a wide deep shaft, its sides bristling with timber, and leading some eighty feet directly downwards to black depths where the outline of a truck or rails may perhaps be faintly descried.

These two gaping pits are distant but a few feet from each other, and at present they form the main entrances to the twin tunnels of the new railway burrowed under the heart of London. Presently they will disappear,

together with the entire wooden stage and its belongings; and the river will flow on unhampered as before; but by that time the new venture will be complete, and the electric trains will be speeding their crowded coaches beneath the bed where Father Thames rolls his flood. The reason for the existence and present position of these two shafts is briefly unfolded to us by our genial guide before we undertake the descent to the subterranean regions with which they communicate.

It needs but a slight acquaintance with the map of London to see that a line stretching from Baker Street to Waterloo Station, after passing through Oxford Circus, Piccadilly Circus and Charing Cross, crosses the river in a slanting direction just above old Hungerford bridge. This is the course of the new railway, and in studying it, before commencing operations, the engineers must needs consider at what spots they would first break ground and begin their tunnelling. In making their choice they were influenced by several considerations, chief among which was the question of space. In the densely crowded area traversed by the new tube the obtaining of suitable open ground on which to work would be a matter of great difficulty and expense; moreover, the removal of the earth from the excavations to great distances through busy thoroughfares was also a serious task to be reckoned with. Also it was of importance, as will be seen later, to sink shafts in proximity to where the most difficult work of the tunnelling—that beneath the river—would be carried on; and hence it was finally decided to make the centre of operations actually in the Thames itself, where space was of little importance, and where, by means of barges, the ballast could be easily and expeditiously removed.

The first task therefore was the erection of the stage out in the stream, and the sinking in the midst of it of huge jointed iron cylinders, going down deep into the bed of the river. The water being effectually excluded by these the further sinking of the shafts, lined with brickwork, was continued beneath them till the desired depth was obtained, when the tunnelling proper could begin.

How this latter process is accomplished

we can see for ourselves by descending into the workings. A crane overhangs the shafts, and shortly to its long arm is attached a rude iron cage in which we take our places. The door of the cage is fastened, and with a clank and a rattle the crane picks us off the ground gently, and swings us over the edge of the pit, and then, spinning round merrily the while, slowly lowers us to the bottom and softly deposits us there. A workman unbars the door, and we step out to find ourselves in the midst of a novel and somewhat weirdly impressive scene. A wide circular tunnel, dimly lighted by occasional electric lights from the roof, stretches in shadowy perspective on either side of us, its distance veiled in obscurity. The sides are formed of the jointed iron sections we have seen above, accurately fitted together to form a complete tube, and down the middle, on sleepers, is laid a tiny temporary rail, of perhaps two feet gauge, with a miniature electric engine and a string of trucks standing upon it. The atmosphere is warm and pleasant, and a curious stillness is in the air. It is hard to realise that above us on one side is the roaring street; on the other the rushing river. No sound or sign of either penetrates to our quiet retreat.

Which way would we like to go first; north or south? South, we say, for it will lead us directly under the river. So the word is given, and all in no time we find the trucks have been unharnessed from the little train and their place supplied by a couple of trolleys with a wooden bench on each on which we take our seats and in a moment are rushing down the dim echoing gallery, the metal walls reverberating to the clang of the train; blue electric flames flashing and sparking from the wheels. Swiftly we fly, noticing only that the iron sides glow damp in the bright light of the engine lamp, and that an occasional drop of water splashes on us from a tiny stalactite on the ceiling. And yet but fifteen feet above the top section of the tube lies the muddy bed of the great river, with the tide ceaselessly sweeping up and down its channel, and the barges floating on its bosom. Only fifteen feet of soil, and much of it mere gravel, between us and the thousands of tons of water above.

How has this modern miracle been accomplished?

We shall understand somewhat better when we have reached the termination of our run and step out of our train to examine a

in front of the shield is built up, scoop out the soil as far as they can before the next advance is made; and thus, inch by inch, slowly but surely, the shield is pushed onwards, leaving behind it a clean cut hole of



(G. Bacon, photo)

On the stage—showing piles of the iron sections with which the "tube" is lined, and the "cage" in which the workmen are lowered

curious machine lying at the end of the burrow it has eaten out, much as the wood worm lies at the end of the hole he has scooped for himself. This is nothing more or less than a large circular iron shield of the exact size of the tunnel—twelve feet in diameter in fact—fitted with appliances for urging it bodily forward into the earth, and with platforms on which the workmen take their stand. When engaged in making its way through firm ground this shield—pressed forward by hydraulic power worked from the engines above ground—slowly worms itself, a few inches at a time, into the wall of soil ahead, easing its advance by means of its sharp projecting edge on the further side. Meanwhile the workmen, removing one by one the movable panels of which the disc

the exact size and shape desired, and to which, section by section, is added the iron lining which, jointed together, forms the completed tube.

There is thus no danger of the sides of the tunnel collapsing, for even as the shield moves onward the massive sheathing is bolted into place, and as long as the boring is in firm ground the work goes forward steadily and, comparatively speaking, easily, at the rate of some ten or twelve feet every twenty-four hours. It was otherwise beneath the Thames. True for about half the distance under the river the soil is hard and firm, and, save for extra precautions, the boring could continue much as usual. But half way across the character of the soil alters completely, and the stiff London clay

gives place to loose and porous gravel, through which the water permeates freely, and than which no worse substance can be conceived in which to bore.

It might well be judged a hopeless task to drive a tunnel through such a crumbling, disintegrating substance, with all the terrific weight of the water above; and the way in which the difficulty was overcome is a veritable triumph of modern engineering. Briefly stated, the water was kept out of the tunnel while the boring was in progress by the use of compressed air. By means of the powerful machinery upon the stage above, air was forced into the tunnel below the water where the excavations were going on to such an extent that the pressure within was raised to "three atmospheres," that is to say, the air in the tube was made three times as dense as ordinary air, and therefore was pressing

on all within the tube with a weight three times as great as that with which our atmosphere presses on all things—or in other words forty-five pounds, roughly, to the square inch. This pressure was constantly maintained by pumping in fresh supplies of air incessantly, and the compressed air of the tube, struggling with tremendous force to escape through every chink and cranny of the porous soil, most effectually prevented the ingress of the smallest drop of water by the same course.

With such violence, indeed, did the imprisoned air burst its way upwards into the river, that all the while the boring was in progress the surface of the water above was heaving and boiling as with some underground fountain. Quite a curious disturbance was thus created in certain places across the stream, sufficient to interfere with the course

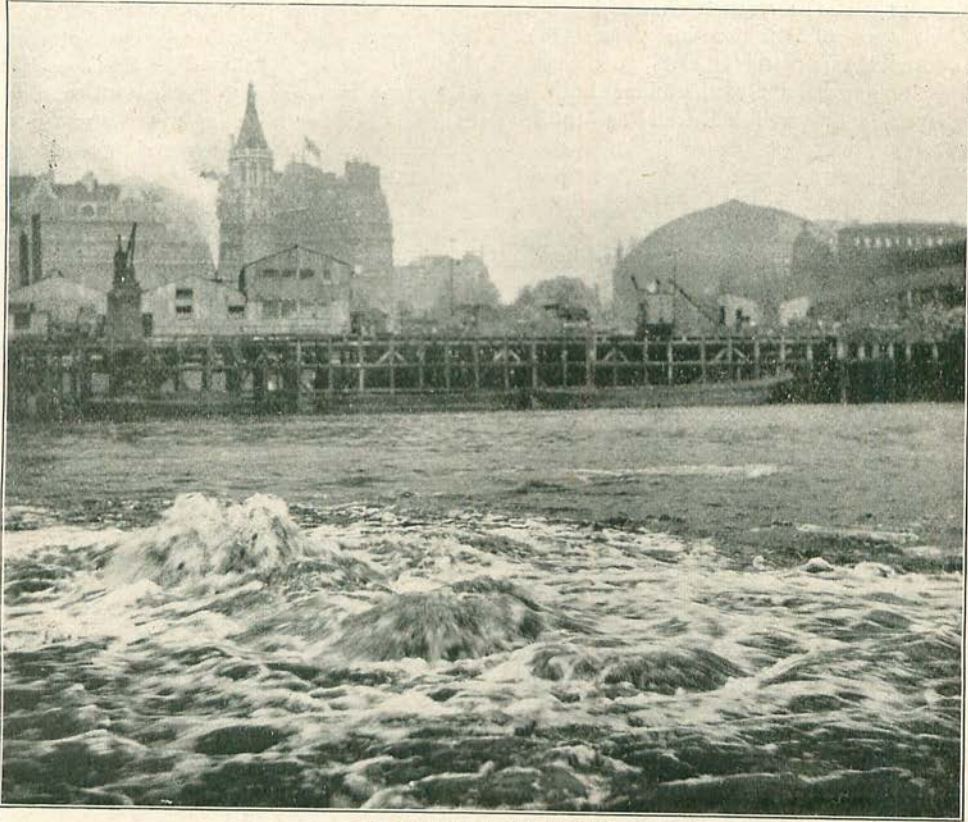


(S. B. Bolas & Co., photo, 68 Oxford Street, W.)

Eighty feet below Cockspur-street—Workmen excavating the tunnel by means of the "shield"

of a small boat, though powerless to affect a craft of any considerable size. Matters so turned out, it chanced, last summer, that while this troubling of the waters was continuing the famous annual race of the Thames watermen for "Doggett's coat and badge" was rowed, the course including that portion of the river where the disturb-

necessarily implies a considerable and unnatural strain upon the system, a doctor was always upon the spot, ready to render medical assistance if need be, while the men, of course, received increased wages. The actual sensation of working in compressed air is somewhat difficult to define. The most noticeable effect is experienced when



(E. Milner, photo, Wandsworth)

Disturbance in the Thames due to the escape of compressed air from the tunnel, sufficient to capsize a small boat

ance was taking place. One of the competitors, though previously warned of the danger, got his boat involved in the broken water and capsized and so failed to secure the prize. He has since sued the company for damages!

The workmen engaged, then, in burrowing beneath the Thames had to labour in an atmosphere three times denser than ordinary air, and because work under such conditions

the change from ordinary conditions to those of increased pressure is taking place. At the entrance to that part of the workings where compressed air was employed is an "air lock," a small chamber between double air-tight doors, where those passing to or from the excavations were detained while the atmosphere was "adjusted," in precisely the same way as a boat is held in the lock of a river while the water is rising or sinking to

the desired level. While the pressure in the lock is being quickly augmented or diminished curious sensations in the ears are felt, similar to those which the aeronaut, rapidly carried upwards or downwards into rarer or denser strata, experiences, and which can be relieved by the simple act of swallowing. One of the most curious results of compressed air is the strange change it causes in the tone of the human voice. The "timbre" is completely altered, so that the sound appears weirdly unfamiliar both to the speaker himself as well as to his hearers.

It is scarcely necessary to say that tunnelling beneath the river, what with the increased difficulties met with, and the elaborate precautions needed in case of accident, did not proceed by any means as fast as under the town. Indeed the daily progress averaged some five feet a day only, a day moreover signifying the whole twenty-four hours, for in these subterranean regions, lit by electricity, the alternation of light and darkness makes no difference to the carrying forward of the work. The boring completed, the iron sections once fitted in place and most carefully jointed together, the nozzle of a hose is passed through the sheathing at different places, and, by means of a powerful blast of compressed air, a stream of lime and water, technically known as a "grout," is forced behind the sections, between them and the soil, filling up each interstice and drying in a firm, hard cement. In this and other ways water from the river above is excluded from the hermetically sealed tube in which the trains will shortly be running to and fro.

Having completed our investigations beneath the water, and returned to our starting-point, we mount into our queer little train afresh, and are rattled off on a new tour of inspection, northward, under the busiest thoroughfares of London. Through interminable dim vistas of echoing iron corridors we speed, the iron tubing occasionally widening out into considerably broader spaces

where presently will be the stations of the new line. Occasionally, through openings in the walls, we catch glimpses of the twin tunnels running alongside. For the greater part of their distance the two tunnels lie side by side, at the same level. South of the river, however, one burrows deeper and deeper into the ground, until finally it runs directly under the other. The reason of this manœuvre is apparent when we learn that to avoid all cause of complaint and possible claims for damage for vibration and the like, the new railway is made to run as far as possible beneath the streets and not beneath the houses, and certain of the streets in the Borough being very narrow the twin lines have had to be arranged one above the other in order to fit into the straitened space.

At one spot, Regent Circus, the new line crosses the track of the Central London Railway, passing above it so closely that only six inches of soil separate the sheathings of the two tubes. Further south in Trafalgar Square excavations run near Nelson's column just out of reach of his lions. Very shortly, therefore, a portion of the ever-increasing traffic that the great sailor has watched from his lofty pinnacle, surging every year more densely down the roaring thoroughfares he overlooks, will be speeding swiftly and safely seventy feet below the base of his pedestal. Nor will this fact, as some alarmists love to foretell, affect Lord Nelson in any way. Too much has been said concerning the damage inflicted by the vibrations of the underground railways. Many of the cracks and settlements in buildings, hastily attributed to the action of the "tubes," are more properly due to the altered conditions of drainage and other kindred causes. There is little indeed to fear from the certain multiplication of the quick, safe, and easy method of transit but now only just beginning to make its influence felt in our midst; and everything to hope from the salutary effect it will have upon the congested arteries of the great heart of our Empire.

