PROTECTING TRAINS UNDER THE EAST RIVER.

BY G. W. MAC MURRAY.

When it came to operating trains between New York and Brooklyn under the East River, the management of the Interborough Rapid Transit Company decided still more fully to protect its trains than by the tripping system with fixed blocks, as in use on the express lines in New York. To this end it has installed at the Bowling Green station, where the trains enter the Brooklyn tunnel, a very interesting telltale slate, which shows the positions of the trains in the different blocks. This makes it possible properly to space trains before sending them into the tunnel, and permits the signaling of trains so they can be operated in coming from Brooklyn at a fixed time interval without interfering with the trains to South Ferry, with which they have to be interspersed. The indicator in the Bowling Green tower gives the operator a miniature reproduction of all train movements between Wall Street, New York, and Borough Hall, Brooklyn. The apparatus for reproducing the condition of the tracks under the river, and showing the location of trains passing through from New York to Brooklyn, or the reverse, consists of a box about four feet long, two feet high, and one foot wide with black glass front, behind which are placed colored lights. On the face of this glass are two narrow strips about one-half inch wide, arranged to represent longitudinal sections of each tube under the river. When there are no trains in the tubes, there are green ribbons of light extending from Borough Hall to Bowling Green. Miniature signals in their correct location are placed on this model. When a train enters the tube at either end, the green light is immediately changed to red for the block which that train occupies. This red light follows the position of the train through the tunnel. When a train passes out of a block, the green light is again displayed in its rear. It is also arranged that either track under the river can be used for traffic in reverse direction with safety. When used in this way, the automatic trips will clear up automatically as the train approaches them. The entire control of traffic through the tubes is under the jurisdiction of the Bowling Green operator.

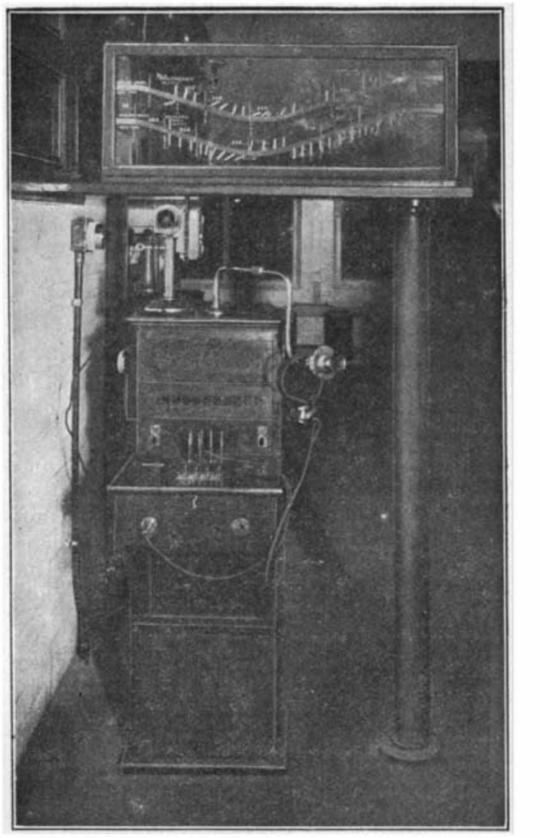
SHAFT SINKING BY THE FREEZING PROCESS.

BY OUR ENGLISH CORRESPONDENT.

An interesting engineering achievement has recently been brought to a successful issue upon the northeastern coast of England, whereby two colliery shafts have been sunk to a depth of 484 feet from the surface through water-percolated soil and quicksand by the freezing process. This district comprises one of the richest coal-bearing areas of the United Kingdom, the seams running from a point inland to the coast and extending for a considerable distance beneath the bed of the North Sea. As the coast is approached the coal measures dip considerably, and are covered by a thick strata of Permian Rocks comprising magnesian limestone, marl slates, and yellow, or quick, sand. The difficulties attending the sinking of shafts through such soil are numerous, the greatest being the presence of large pockets of water, which being strongly salt testifies to percolation from the sea, which fact of communication is substantiated by the water rising and falling in the shafts in consonance with the tides.

In 1899 preparations were made for the sinking of two shafts at Dawdon on the eastern land limit of the Durham coal field, the colliery being situated only a short distance from the coastline. The two shafts were each of 20 feet diameter, and were sunk simultaneously. The first shaft was sunk by means of pumps to a depth of 350 feet, and lined to a depth of 320 feet, when operations were stopped until the second shaft had been sunk to the same level, so that progress through the treacherous sand might be carried out simultaneously in both shafts; but when the second shaft had reached a point 200 feet deep, the head of water encountered was found to be in excess of the existing pumping plant, and gave every evidence of increasing in volume as the sand bed was approached. At this juncture over 7,000 gallons of water were being pumped out per minute, and operations were brought to a cessation to consider the expediency of erecting additional pumping machinery, or superseding this method by the freezing system. After prolonged deliberation it was considered that the latter would be the more expeditious and attended with a greater degree of success, and the contract for the undertaking was accordingly handed over, together with the whole of the plant, to Messrs. Gebhardt & Koenig, of Nordhausen, Germany, who have made a specialty of this class of work, and to whom we are indebted for the accompanying illustration and particulars.

In their undertaking this firm undertook to freeze the ground around the shafts into a solid mass to a depth of 484 feet from the surface, which was sufficient to penetrate beyond the treacherous strata, and to maintain it as long as required, subsequently thawing the ice and ground, when the lining or tubing had been completed. The first stage in the process comprised the sinking of the freezing tubes, by which the ground was to be converted into a solid mass. Twenty-eight holes were drilled in a



DEVICE FOR INDICATING POSITION OF TRAIN IN TUNNEL.

circle 30 feet in diameter. The bore holes were carried down to the required depth of 484 feet and were then lined. For a depth of 130 feet from the surface the lining tube was 9.5 inches in diameter, and for the succeeding 330 feet the lining was 7.5 inches in diameter. Within this tube was inserted an inner lining 6.25 inches in diameter to the total depth, the object of this lining being to keep the bore holes clean and to admit of the easy insertion of the freezing tubes themselves.

The freezing tubes each consisted of an outer tube 5 inches diameter, closed at the bottom and sunk to the entire depth of the borehole. Within this was lowered an inner tube, 2.5 inches in diameter, to a point 33 feet above where the existing tubing had been completed, at which point it was connected with the outer tube by a special type of double nipple. The annular space formed between the inner and outer tubes acted as an insulating chamber, preventing any direct communication with the ground and protecting the tubing from the effects of the severe cold. At a point midway between the double nipple and the bottom of the tube in each hole an expansion joint was placed. A third or central tube 1.25 inches in diameter was then inserted. This was open at its lower end, and was lowered until about three feet from the bottom of the borehole. This work completed, the borehole lining tubes were withdrawn, and the freezing tubes were coupled up to the brine circulators for freezing the ground.

Freezing was carried out by the ordinary ammonia-compressing system, the plant installed being of 2,000,000 British thermal units capacity per hour, there being four compressors driven by two 135-horse-power steam engines. The ammonia was compressed to 150 pounds per square inch and then circulated through the coils of a cooling condenser, of which there were five in all, and liquefied by the extraction of heat caused by the circulation of 14,000 gallons of water per hour. The liquid ammonia then passed to the four refrigerating tanks, containing 10,000 gallons of brine, and subsequently to the compressors for recompression to 150 pounds per square inch. The water for the condensers was pumped from the sea below. The brine consisted of a 26 per cent solution of chloride of magnesia at a temperature of 1.4 deg. F. and was pumped from the refrigerators at a speed of 330 gallons per minute through the sunken freezing tubes circuit and thence back to the refrigerators.

The bottoms of the shafts were filled with concrete, which was found to form an excellent seal to the water feed, and the formation of the ice wall was then carried out expeditiously. When freezing operations were stopped, it was found that in the No. 1 shaft the ice wall was formed for a depth of 40 feet above the concrete around the sides of the shaft, varying from a thin skin at the top to about 3 feet in thickness at the base; while in the second shaft the ice wall was found to be formed to a thickness of 3 feet 6 inches at the bottom. So thoroughly was the ground frozen in the process, that during the freezing of the second shaft, when it was deemed advisable to sink an additional borehole to assist in the operations, the scheme had to be abandoned after a depth of 284 feet had been gained, as the sinking tools became repeatedly frozen in the ground. The time occupied in carrying out the formation of the ice wall was 165 days in the case of No. 1 shaft, and 296 days—owing to several difficulties encountered during operations with the water flow—for No. 2 shaft. In the case of the former the ice wall was maintained 353 days, and in the second instance 186 days for sinking and tubing purposes, giving a total duration of the ice walls of 538 and 578 days respectively.

So solidly was the ground frozen by this means, that the work of excavation within the shafts had to be carried out by blasting, but extreme care had to be exercised in this direction, so that the resultant concussion might not damage the surrounding freezing tubes and thus set up a leakage of brine. Only one shot was discharged at a time. The holes drilled for the insertion of the charges were kept from freezing by using solutions of 6 per cent caustic soda or 10 per cent washing soda. During this stage of operation the workmen had to wear goggles to protect their eyes from flying fragments of rock, and gloves to prevent frost bite.

When the sinking operations and tubing had been completed, the work of thawing the frozen ground commenced. It was essential that this work should be carried out so gradually as not to allow too great a pressure to be brought to bear upon the tubing of the shaft. For this purpose one of the refrigerator tanks was disconnected from the ammonia circuit. To the spiral crest within a steam pipe was connected, and steam passed through the coils, thereby raising the temperature of the brine within the tank, which was then circulated by means of the pump through the freezing tubes. While the warm brine was thus being circulated through the freezing tubes, a brazier of live coke was passed up and down the shaft, so that the air within might be heated and the ice present on the upper lengths of the tubing melted. Thawing occupied a period of 57 and 66 days for shafts 1 and 2 respectively.

The ground once more restored to its original condition, the work of withdrawing the freezing tubes proceeded. For this work a special drawing appliance was utilized, which was lowered into the tube and secured, while upward pressure was imparted to the whole by two hydraulic jacks of 2,581 atmospheres per square inch maximum capacity; but the greatest lifting pressure required at any one hole was 1,355 atmospheres per square inch. As a rule, after a tube had once been "started" by this means, it could be easily withdrawn by means of a steam winch or hand block. The whole task of sinking boreholes, freezing, and thawing the ground to a depth of 484 feet occupied three years.

Picking the Ice Wall and Frozen Quicksand.

SHAFT SINKING BY THE FREEZING PROCESS.