paper is placed a reinforcing mesh, usually expanded metal of about No. 12 gauge, and then about ¾ inch of mortar is shot. The especial reason why the contractors have preferred expanded metal is because it presents a true plane and aids in keeping a true surface. These surfaces are shot to definite lines and then screeded to true planes, after which finishes of various types are employed. Cornices, mouldings and other ornaments are shot directly into place without the use of any forms.

INSTALLATION OF A 13,000-FOOT SUBMARINE POWER TRANSMISSION CABLE.*

To bring electric current from the mountain hydro-electric power plants direct to the city of San Francisco necessitated laying of a power transmission cable system under water across Golden Gate at a point where the channel is 13,000 feet wide. For this work contract was let to A. J. Pahl, San Francisco, who, some years previously had devised the method described below, and who, on this contract, gave evidence of skill and ingenuity in surmounting many difficulties.

Method of Installation.—In considering the installation it was known that the cable of the size required could not be made in one continuous length, and that it would be necessary to make at least ten splices for the completed cable. Furthermore, the problem of how to reduce splice and joint tension in the laying of the cable became a most important problem. This is due to the fact that experience has well demonstrated that it is impossible to lay successfully a cable which has been spliced on shore and mounted on a reel, because the tension in the joints invariably results in electric failure of the splice.

Not only this, for in making this installation consideration had to be given to the six-knot tide which prevailed in this channel, to the depth of the water, which exceeded 200 feet, and to the possibility of ships' anchors fouling the cable in the event of having to drop anchor in the vicinity. The question of repairing the cable should failure at any time occur was also important, since the strain in lifting it from a two hundred-foot bottom would be excessive.

It was, therefore, determined to use the messenger method of installation, which had been successfully developed by A. J. Pahl, of San Francisco. In this system a steel rope, known as the messenger, is first laid from shore to shore and anchored securely at both ends. This rope can be laid quickly when tide conditions are favorable and serves as a guide line for laying the power cable. When ready to lay this cable, the messenger is picked up at the shore end and is laid across a barge on which are mounted the reels for the power cable and an ordinary grip, such as were formerly used on street railway cable cars.

The messenger cable passes over sheaves and through the grip, which is operated by one man. At his will the messenger is allowed to slide through or to be clamped in the grip, and thus the operator absolutely controls the movement of the barge while it is being towed across the water by a launch. It should be understood, of course, that the messenger cable must be of sufficient size to withstand all strains imposed upon it, and that the power of the launch towing the barge must not be in excess of the holding power of the grip.

With the messenger laid over the barge, the launch proceeds to tow at a rate determined by the man at the grip. As the power cable is paid out, it is attached to the messenger until a whole length of cable has been sunk. At this point the barge is anchored fast to the messenger, a splice is made at sea, and the towing proceeds.

This operation is continued until the barge (which in this case held four reels of cable, approximately 5,000 feet in length) is empty. The free end of the cable is then sealed with a special lead sealing cap, securely attached to the messenger, and lowered into the water, after which process the barge returns to shore, underrunning the messenger to receive another load of cable.

When ready to start laying again, the messenger is picked up at the free shore end, laid across the barge, and underrun until the free end of the cable comes up, when the splicing and laying is repeated as before. In this manner, the messenger takes all the strain and relieves the cable and all joints of tension.

The Messenger and Anchors.—The messenger in this case was a thirty-seven wire, galvanized steel strand, 1⅜ inches in diameter, in one continuous length of 14,000 feet, having a breaking strength of 90 tons, and weighing about 4½ pounds per foot, so that the total weight of each messenger on the reel was approximately 30 tons

Since there is no beach on the Marin shore, and since the bluff rises in almost perpendicular fashion for over 120 feet, the landing at Yellow Bluff was by no means ideal. In order to anchor the messengers at the base of this bluff and just above the water's edge, short heading tunnels were driven into the rock about fifteen feet, and in these the anchor sheaves were located and held in place by concrete enclosure. The two tunnels, one for each cable, were located about 100 feet apart.

The anchorage on the San Francisco shore was constructed on a sandy beach about 100 feet from the water's edge. On this account, the design was somewhat different from the others, although the iron structure in all the anchorages was the same.

To hold the messenger in the anchorage, a series of three-bolt and single-bolt clamps were used, and over these a mass of melted zinc was poured in order to assist the clamps. The bridge socket type of anchor was not used, for the reason that it might be desirable to change the tension in the messenger at some later date. The anchorages were designed to withstand a tension equal to the maximum strength of the messengers.

The Power Cable.—The submarine cables were three-conductor, 250,000 C. M. copper, each conductor having an insulation of 6/32-inch thirty per cent. Para rubber, over which was placed a 4/64-inch layer of varnish cambric. These three conductors were laid together in circular form with a jute filler, and over all a 10/64-inch varnish cambric belt was applied. The enclosing sheath was 5/32-inch layer of pure lead, over which two ⅛-inch layers of jute were applied. The latter substance was used in order to form a cushion for the wire armor, consisting of forty-two wires of No. 4 B. W. G. extra galvanized iron wires. Over all was placed a ⅛-inch layer of jute, with a layer of sand and asphaltum for mechanical protection. The shore ends were of the same specifications as the main submarine cables, except that the conductors were 350,000 C. M.

The shore ends were each 800 feet long, the main power cables being manufactured in lengths of 1,275 feet to the reel. The length of each completed cable was 13,250 feet. The 250,000 C. M. cable was four inches in diameter and weighed 19 pounds per foot, whereas

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