NEWLY DEVISED METHOD OF LIGHTING THE LAGOON OF VENICE.

(Translated from a note by Dr. DINO ALESSI, Engineer-Chief of the Civil Engineers of Venice, published in the *Annali dei Lavori Pubblici*, edited by the Minister of Public Works, for the Year LXXXVII, Vol. N° 11, November 1939, Rome) .

Summary : The following note describes the new system of lighting employed in the navigable channels of the Lagoon of Venice, which has been installed in the Basin of St. Marco and the Lido, to insure the possibility of safe navigation for fast motor boats at night and in thick weather.

It is a known fact that along the canals of the Venice Lagoon, which are artificially maintained, navigation has been made possible for steamers and other vessels by means of periodic dredging which maintains or establishes certain necessary fixed depths in all those zones in which the lack of active currents permits a more or less rapid silting or filling up of the channels.

But even though this dredging, while maintaining the depth of water essential in the various canals, assures the possibility of passage for various types of vessels, navigation cannot be maintained with the necessary security even in day-light and in the grand canals, if the navigable channel is not marked, or in other words, if the limits are not indicated by day by piles isolated or grouped in bundles, generally three to each group (1), attached to the sides of the buoy, or in the case of the most important buoys, to both sides.

Such a system of marking the channels, which dates back to the earliest days of the Republic, might be considered adequate and sufficient for all navigation in the passages through the lagoons between the city of Venice and the large islands in the vicinity at a time when the passage was made by sailing vessels or boats propelled by cars during the daylight hours or at infrequent intervals. But the ever-increasing necessity of rapid communication between Venice and the Lido, as a result of the denser population of that island and its importance as a bathing resort made it essential that these communications be assured not only by day but also by night regardless of the atmospheric conditions. For a number of years the inhabitants of the Lido complained of the lack of safety of navigation during the night and especially during the periods of fog, which from the end of autumn until the beginning of spring occur with such intensity that navigation is very much restricted and the public service for the transportation of passengers and goods between the Lido and Venice is almost paralyzed.

Numerous studies and experiments were undertaken during and after the World War by the technicians and various Companies to find some practical solution with the view to assuring the safety of navigation for mechanically propelled vessels in fog, by resort to acoustical signals (bells and electric sirens) and luminous signals (powerful lights etc.) but none of these proposed expedients produced satisfactory results. Experiments were also conducted on a cable laid along the bottom of the channel of St. Marco, along the normal

(1) *We call a "group" the combination formed by three piles, "briccole" those formed by a large number of piles, from 5 to 18, and which generally serve for mooring vessels which are caught in the upper reaches; and "dame" the piles placed at the confluents of the canals, characterized by one central pile higher than the others.*

route between landing at St. Zaccaria and the St. Marie Elisabeth of the Lido. This cable conducted an alternating current of high frequency and gave out an acoustic signal which could be picked up by the electro-acoustical devices installed on the public service vessels. However, the results of these experiments were not favorable and its use was abandoned.

The new system of luminous signals, invented by the President of the *Magistrato alle Acque* and put in operation by the Civil Engineer Service of the City of Venice by the Firm of Ferraboschi, is extremely simple and was suggested by the practical observation that at night, in time of fog, every beam of light which strikes the eye directly, not only prevents the eye from discerning other vessels or encumbrances in the channel being traversed, but scatters the light all around thus blinding one to the markings of the buoys.

It was then suggested that one might employ the daylight markings of buoyage system, rendering them clearly visible at night by subjecting them to an intense illumination and painting them over with a white varnish. It is evident that the luminous source should concentrate its rays only on the structure of the buoy itself without directly striking the eyes of the pilots of the small boats and motor launches which traverse the canals. Experiments were then undertaken with various types of projectors and detailed studies were made of the heights at which they should be placed above water-level, for both low tide and for high tide, as well as the angle of inclination necessary for the luminous cone so that the entire buoy should be lighted in the best possible manner, while avoiding to the greatest extent the reflection of the light from the surface of the water.

The firm of Ferraboschi made very efficacious studies of the experimental devices in order to insure the success of the type of projector employed and its installation on the various groups of piles. As a result the projectors have been improved to such an extent that both from the technical and the aesthetic point of view the luminous signals do not create confusion in the surrounding country nor in the characteristic aspect of the basin of St. Mark.

The type of projector chosen is represented in Fig. 1; which shows the manner of mounting the apparatus on the buoyage assembly by means of a wooden pole and the spread of the luminous cone which envelops the group of piles, while at the same time concealing the source of light from the direct view of the pilots. One is thus assured that in fog the reflected light for each group varnished in white with a black horizontal band, will not blind the eyes, while the distance of approximately 50 meters separating successive groups permits the route to be followed without difficulty or risk of losing the course.

The complete buoyage system, starts from St. Georges Island, and passing along the Orfanello Canal to the Four Fountains connects the Basin of St. Marks with the most important center of the Lido.

The entire buoyage system has a length of about 3.5 km. The points indicated on the plan show the location on one side only of the channel. There are 61 simple projectors mounted on an equal number of pre-existent or reconstructed beacons. For marking the outlet of the canals into the Basin of St. Mark and the Lateral Canal of the Four Fountains as well as the crossing of the Orfano Canal, red or green beacons have been superposed on the projectors (Fig. 3).

For the construction of the electric cable to feed the lights there was employed 5.5 km. of submarine, bipolar electric cable having a section of 2×10 mm^2 with the red electrolytic conductors insulated by multiple layers of lead, with bituminous cardboard, with tarred jute and a double armature of iron ribbon and galvanised iron, the whole enveloped in a bituminous sheathing, in conformity with the rules of the A.E.I.

All along the side of the buoys the cable is run out in the lagoon to a depth of 0.50 meters. For the crossing of the canals at great depths the cable is simply laid out to the bottom and anchored by means of heavy iron rings taken from old chains, attached to the cable itself.

At each group of beacons and for each pole the cable is led up to the brass watertight box and passes out of it to a metallic armature comprised of galvanised iron tubes of 60 mm. diameter. These brass connection boxes serve as distributers and are provided with accessories to feed the current to the various projectors. The projectors, manufactured by the firm of Ferraboschi are provided with special mirrors furnished by the Zeiss-Ikon Co,

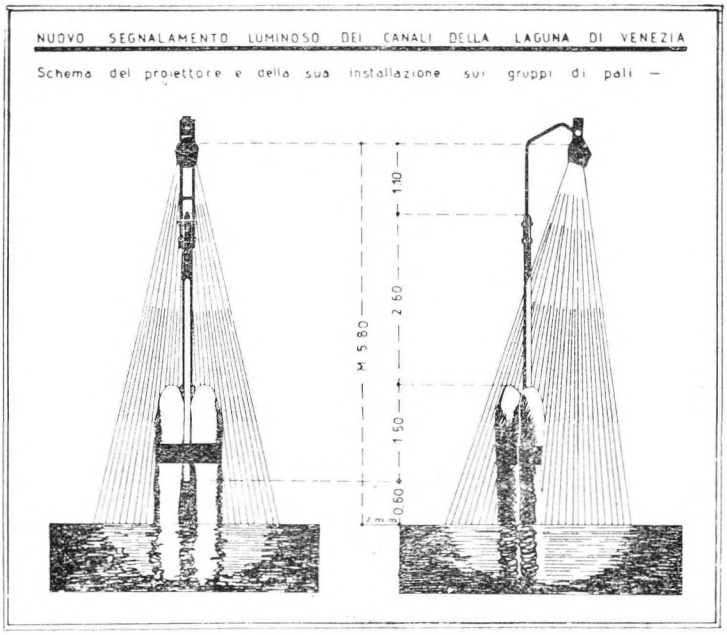

FIG. 1.

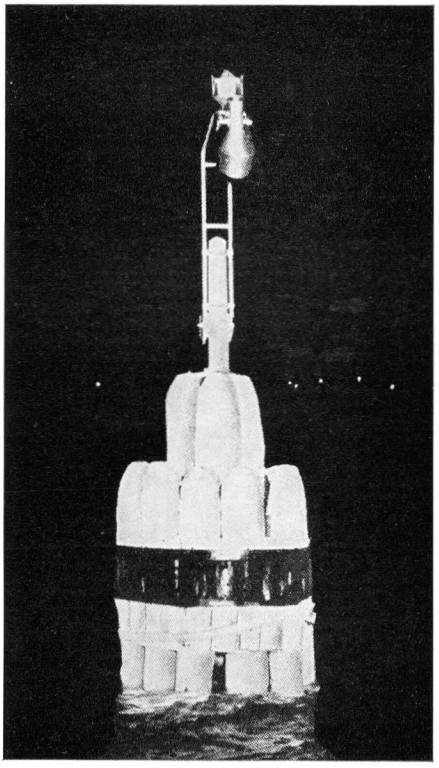

FIG. 2. — *Dauphin d'entrée avec projecteur d'éclairage et fanal coloré.*

Entrance dolphin with lighting projector and coloured lamp.

and comprise a brass head with a cone of sheet aluminium. The mirrors are secured by means of screws soldered in the cone and are provided with a device for regulating and adjusting the electric lamps in the focal center.

The electric lamps are of the ordinary type with metallic filament with a luminous flux of 2000/2500 lumen, functioning on direct current of 6.6 amps.

A transformer station for the electric current coming from the public service supply lines was erected on the island of St. Servolo. In this there was installed the principle 3-phase transformer with natural oil cooling, having a capacity of 25 K VA, with a transformation ratio of 6000/220-127 V, with 3 transformer auto-regulators with natural air cooling, for continuous service at 5,5 K VA, a transformation from feed to supply to 220 V furnishing a direct current of 6,6 amps.

The distribution system is subdivided into three series circuits each fed by one of the three secondary transformers and in which are connected 22 to 24 lamps.

The entire system is controlled by an automatic clock mechanism, electrically operated but designed to function autonomously for 36 hours in the event of failure of the current.

The hourly consumption of energy, calculated theoretically and not counting the losses, is established as follows :—

Number of lights 69 $\times$ 6.6. A $\times$ 22 V = 10018 watts = 10.018 KW.

The hourly cost, calculated on the base price of 0.25 lire per K.W. hour is consequently about 2.50 lire. The complete cost of the installation, including the transformer station and all apparatus amounted to 350,000 lire, or about 100,000 lire per kilometer of canal lighting.

The lighting is maintained on the average for about 10.5 hours per night, or 3,832 hours per year, which at the price of 2.50 lire per hour, gives an annual cost of 9,380 lire approximately.

To these expenditures for the consumption of energy must be added the cost of supervising the installation, for changing the lamps, repairs to damage, all of which is estimated at 15,000 lire annually, so that the total cost of maintainance may be assumed to be somewhat under the limit of 25,000 lire.

Following the practical results obtained since this system of lighting was put in service on the canals in the lagoons, much appreciation was expressed by the competent authorities and by the civil population and the system rendered excellent service by assuring regular communications between Venice and the Lido during the season of fogs. It is hoped therefore that it will be possible to make other practical applications of the system to insure the important communications in the lagoons.