

EMERGENCY ENGINEERING FOR HARBOR DEFENSE.

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During the recent difficulty with Spain I had the honor of being the executive and technical officer of the Volunteer Electrical Corps, which was formed in Boston to aid the United States Engineer Corps, and which was charged with the construction of the mining defenses and other emergency work in and about Boston harbor. This corps had, I believe, the distinction of being the first volunteer organization called into the service of the United States on the occasion of the Spanish War, being actually called out for active duty on April 4th, 1898, more than two weeks prior to the actual beginning of hostilities. It had its origin in the resolve of a small knot of electrical engineers headed by Mr. C. D. Haskins, who has dealt with one phase of the subject to-night, to give the best volunteer aid in their power to facilitate the arduous task set before Lieut. John S. Sewell in organizing the defenses of Boston. Lieut. Sewell was in actual command of the work during a large portion of the war, Col. Mansfield, who was officially in command of the station, having been detailed for court-martial duty, which lasted all the earlier portion of the time.

The preliminary organization was formed early in March, 1898, and before the end of the month had grown far beyond the original plan of its projectors. It was an organization in many respects unique. It drew from the strongest electrical organizations in and about Boston and from the ranks of the constructing and consulting engineers who were available for service. The original roster, which was placed on file at the War Department

when the plan received official sanction, numbered something over one hundred men, and about one hundred and fifty were engaged in the service at various times. The force consisted of three divisions, one charged with the preparation and loading of mines, another with the laying and maintenance of mines, and the third with the miscellaneous work of establishing communications and performing some of the heavier engineering work which fell to the lot of the corps. Each division was commanded by a division officer, and was again split up into several squads under the direction of squad officers, as responsible foremen. What was practically an adjutant's office was set up, through which the clerical work, purchasing and accounting of the corps was carried on, to be later reported in due form to the office of the U. S. Engineers.

Many of the important electrical organizations in Boston responded most promptly and patriotically to the call for men, telegraph and telephone companies, electrical manufacturers and contractors, joining hands not only in supplying workmen of the most reliable and competent character, but in permitting responsible and able electricians, high in their employ, to drop their regular work and take up their part in the organization of a national defense. It was fortunate that general business was slack during the war, for more than one concern would have found itself seriously crippled had there been anything like the usual pressure.

The corps was never mustered into service; in the first place, for the obvious reason that prior to the declaration of war there was no possible authority under which it could have been mustered in; and second, the body of men was such that they could not have been got together, unless in case of dire emergency, for working under purely military routine. Anticipating a sudden demand for work, an elaborate call system was arranged from headquarters to division and squad officers, and from them to the men, so that the entire body to the last man, I think, could have been gathered ready for orders in two hours from the time that their services were requested.

One fact worth mentioning for future record, in case a similar condition should again arise, is that all members of the organization were pledged to absolute secrecy regarding its operations, and, until it went into service, regarding even its existence; and it is a matter of some pride that its operations were actually kept from the public so long as any secrecy would have been of the slightest service from a military standpoint

The corps was actually called out in part on April 4th and practically the entire work of the establishment of mine defenses, communications and range-finding stations in and about Boston harbor was done directly by it under the direction of Lieut. Sewell, the only extraneous assistance being given by a sergeant and four men, who ultimately were sent up from Willet's Point.

It is not my purpose here to review at length the work which was done. In brief it was as follows:

Two electric lighting plants for the forts were installed, together with search-lights and lighting systems for the casemates; three sections of submarine cable for telephonic and telegraphic communication were laid, connecting the forts with the mainland; a long semi-circle of telephonic communications was arranged, reaching from Nahant on the north to Hull on the south, in part composed of lines segregated from the system of the New England Telephone & Telegraph Co., and in part of aerial lines strung by the communications division of the corps.

Several hundred service mines were loaded, laid and maintained throughout the period of hostilities, following the scheme of defense outlined for the main channels by Lieut. Sewell. An equal number of temporary mines were prepared and made ready for service, for the extension of the mine defenses, by a pair of skirmish lines each nearly three miles in length. Firing stations and range-finding stations were constructed in connection with these skirmish lines and so arranged as to be serviceable for general range-finding purposes. In case of actual hostilities in the district, it would have fallen to the lot of the corps to fight, as well as to lay and maintain mine defenses, and the men were properly instructed in the handling of the mining casemates, which they had equipped.

The subject of the greatest interest at present in connection with this work is the matter of securing and utilizing of emergency material for mine defenses. A sufficient number of standard mines were available to equip in the main the principal channels. Many of the accessories were also put in stock, but the question of obtaining sufficient cable was a grave one. Some standard cable was secured through the U. S. Corps of Engineers, but much had to be bought in any place available and it was hard to find. One of the experts connected with the corps finally unearthed in a neighboring wire factory a couple of machines which could be used at a pinch for armoring, and a considerable

amount of cable was constructed to eke out the otherwise scant supply. For telephone cable nothing suitable for submarine use could be obtained from stock or prepared on short notice, and as a last resort a four-wire cable of good quality was lead-covered and laid, with some misgivings as to its durability. It gave excellent service through the period of the war and the first break-down, oddly enough, occurred on the day the protocol was signed. Wire cable for mooring the mines was obtained on the ground, and for supplementary anchors, where such were needed, a lot of old rails answered the purpose excellently. Gutta-percha wire for certain of the mine connections was troublesome to obtain and some special rubber-covered wire, made carefully to size, was tried in experimental fashion, and ultimately we secured a sufficient quantity of the standard wire. The question of explosives was easily solved. A sufficient amount of Kieselguhr dynamite, mostly in long sticks, was obtained for filling most of the standard fuse plugs, but for filling the mines it was necessary to fall back on commercial products and the bulk of them were loaded with No. 1 wood-pulp dynamite, carrying nearly 75% nitro-glycerine and packed rather loosely in 5-lb. paper cartridges. A considerable quantity of blasting gelatine in 5-lb. packages was also used, and on the whole with very good results.

For the emergency mines, after considerable deliberation, we relied on standard beer barrels of the usual size. These were extremely well-made casks, heavily iron-bound and with oak heads $2\frac{1}{2}$ inches thick. For these mines fuse plugs closely resembling the service fuse plugs were made, the firing device being, however, slightly more sensitive. The fuse cans connected to these plugs were filled at the end away from the fuse and sealed with corks and red lead, which appeared to make a joint excellently water-tight, for at least a considerable time. The body of the plug was made to take a large hexagon nut and was cut with a slightly taper thread. The casks were bored by a $3\frac{3}{4}$ -inch ship auger, rigged with long handles and supported by a temporary drill press, and the hole was then cut conical with a special tap made to match the threads on the plugs.

Armored cable could not be obtained in quantities sufficient for supplying the needs of the long skirmish lines of the temporary mines which had been prepared and we therefore fell back upon lead-covered wire. The Spanish fleet was located before the skirmish lines were laid down, so that only experimental

mines of this construction were put out, but our results showed that while the lead-covered wire was adequate for all ground cables the risers to the mines would have required constant attention on account of insufficient mechanical endurance of the lead-covering in case the mines swayed and turned for a considerable period in the tideway. For the grouping of the emergency mines, small cast-iron junction boxes were designed and made, which, after the joints were formed in them, were filled with Edison compound, such as is used in the underground service of the Edison Company. This construction appeared to give a tight and durable box, although not one well adapted to stand heavy mechanical strains.

Anticipating some leakage from the long lines of lead-covered cable, a firing plant was erected, consisting of a small 500-volt dynamo connected to a 5 h.p. oil engine, so that even in spite of severe leakage a firing current could still have been passed through the fuses. On account of the great length to be covered, the temporary mines for the skirmish lines were arranged to be fired in groups, separate cables leading back to the firing station from each group. As contact mines, connection was made between the fuse plugs of each group and a firing relay, which served to admit current to the group as a whole. To economize in material, individual mines were designed to carry a charge considerably in excess of the ordinary service charge and were spaced more widely than usual, the interstices being occupied by small kegs carrying contact-firing plugs, only without charge and arranged to admit current to the firing relay for the group.

The skirmish system was laid out in a pair of long, straight lines. Nearly opposite the middle of each line and far inshore was a signal station with a transit instrument in telephonic communication with the firing stations, which were supplied with observation telescopes, the alignment of the line of mines being established by the latter. The particular group over which an enemy might approach could be instantly designated from the bearing obtained from the signal stations, so that the proper group could be fired by observation without difficulty. Incidentally, the firing stations were at sufficient elevation to locate the groups by depression angles, if the communication had been interrupted. Experiments conducted with these temporary mines showed that they had sufficient explosive efficiency and could be spaced at substantially the distance of the standard mines without throwing each other out of action by the explosion.

The principal difficulty encountered in the mining work, was the maintenance of the standard mines in the channels frequented by shipping and where the tide ran rather swiftly. In spite of the most explicit orders and patrol kept up by revenue cutters, vessels sneaked up and down the channels under cover of night and caused almost constant trouble from fouling of cables. At certain points in the channel the mines were kept out of the way by being shackled down low on the anchors as ground mines, but where they were installed in the usual way, keeping them in order was a matter of incessant work and the division charged with this job found itself and a couple of lighters busy nearly all the time.

A considerable number of mines were struck by propellers of passing vessels and sometimes cut open and sunk. I have seen one of the larger service mines, carrying 150 pounds of explosives, cut open by a propeller blade from near the top to down within six inches of the charge. Only Providence, that looks out for fools when it ought not to, prevented at least one steamer from having her stern blown off. Every few days one or several crippled mines had to be taken up, brought back to Fort Independence, which was used as a base for the mining operations, and replaced by another mine. The damaged mines were taken out into the shallows off the channel and exploded, as the easiest way of getting rid of a somewhat dangerous neighbor.

It was found that the wood-pulp dynamite would not stand salt water well, the pulp being apparently unable to hold the nitro-glycerine with anything like the tenacity of the Kieselguhr dynamite. In one instance a striking and nearly calamitous evidence of this was furnished. A large mine had been brought up from the bottom with a damaged fuse plug. It was taken into Fort Independence and one or two men of the corps with a couple of engineer soldiers started to take out the dynamite to examine into the condition of affairs. The whole packages were removed easily enough. Some of those which had come open from exposure to the water were scooped out in the best manner possible, and finally all the dynamite was removed and the interior wiped out with waste. This was before we had had much experience with damaged dynamite, and becoming a bit suspicious of the condition of the mine, which was lying on the parade ground where loading was frequently going on, I directed the soldiers to take it outside the fort and fire a couple of primers into the interior to make sure that it was free from nitro-glycer-

ine. With some covert scoffing they carried out this instruction, and five minutes later I heard a tremendous detonation and as I jumped out through the sally-port I was met with a suffocating volume of smoke. The body of the case, weighing some 400 pounds had been thrown end-over-end a distance of perhaps 50 feet, and with the head complete, was found later in shallow water about 200 yards away from the point of explosion. The nitro-glycerine from the damaged dynamite had soaked into all the crevices of the case and formed a coating over its interior in sufficient quantity to produce this unpleasant result when a couple of service primers had been exploded in the interior.

It was usually found that the dynamite which had been wet was not in good explosive condition, and a detonating charge in a small keg was usually placed in or alongside a damaged mine to insure its complete destruction. On one occasion I obtained a fine example of an explosion of the second order in a large mine fired in this way. The detonating charge exploded with great violence, while the mine itself seemed to hang fire for a small fraction of a second, and then came an explosion of a second order throwing up a comparatively small volume of water to a very moderate height. One point with reference to these submarine explosions is worth noting. It was our uniform experience that while after the explosion of a 100 or 150-lb. charge a good many small fish were found floating on the surface killed, nearly all of the larger ones, in fact, perhaps the majority brought to the surface, recovered and swam away; a fact, which may possibly account for the absence of floating fish, alleged to have been noted shortly after the destruction of the *Maine*.

Damaged dynamite which had been removed from mines was sometimes exploded experimentally when merely repacked in the cases from whence it came. Under these circumstances it was sometimes remarkably insensitive, only exploding properly when a cartridge of dry dynamite was used as a primer. The blasting gelatine was subject in a measure to the same defect, and showed a slight tendency to leak nitro-glycerine if a cartridge were left on end, where it was exposed to the warmth of a summer day for some time. This slight instability appeared to be due to the character of the nitro-cellulose used in making it. It did not seem to be uniformly of the nitration required for the production of a first-class gelatine, and commercial gelatine should be employed for military purposes with great caution.

We arranged a little testing laboratory, where we regularly sampled and inspected the explosives delivered and tested them

from time to time to assure ourselves that all in the magazine were in good condition. The Kieselguhr dynamite is certainly much superior to the ordinary commercial product in stability and capacity for holding a large percentage of nitro-glycerine. I am convinced that the very grave accident costing the lives of several men, which occurred after the war, while a squad of engineer soldiers was unloading some of the mines which had been taken up, was due to the instability of the explosive producing a hyper-sensitive state, which resulted in detonating the contents of a mine by a very trivial fall.

From our experience with the service mines, which first and last was considerable, I find myself very unfavorably impressed with the contact device then in use and with the method of placing the floating mines. We found constant trouble in the tideway from the twisting off of the mooring cables. The mines in parts of the channels were in a perpetual state of slow revolution, making two or three turns in one direction and then two or three in the other within a period of half a minute or so, and with the result of damaging either the mooring cable or the firing cable in a very large number of cases. Some relief was obtained by allowing more slack, but were I again directing similar operations from a technical standpoint, I should certainly be inclined to employ heavily charged ground mines, used mainly or entirely for observation firing, to a very much larger extent than was the case in 1898. We tested both service plugs and the plugs for the temporary mines, which were decidedly more sensitive than the service plugs, on a number of occasions by running down a dummy mine with one of our tugs, and in most instances the mine was merely pushed aside without making contact. At high speed, or when hitting the mine very squarely, contact would doubtless be made, but were a ship proceeding with the caution necessary in a fog, when observation firing would be impracticable, I think her chance of going through an ordinary line of mines, as then arranged, without firing one by its contact mechanism, would have been very good. In fact, I very much doubt whether, with a mine as near the surface as it is likely to be when a considerable rise and fall of the tide has to be allowed for, it can be provided with a contact device certain to act when struck by a ship and be at the same time sufficiently insensitive to avoid frequent contacts from waves and tidal swinging. I am disposed to think that reduction of the contact feature of the mining system to a set of tentacles, controlling the firing of a deep shackled or ground mine with a very heavy

charge, would render it more useful in an emergency and vastly easier to keep in operative condition. I believe such an arrangement is used in the British service. Explosive is cheap and the fewer actual mines the greater is the deadly radius of action of each of them, and the less likely is the fundamental cable system used for observation firing to become disarranged. With contact devices serving merely as tentacles, I think a careful operator in the casemate would soon become acquainted with their idiosyncrasies, so as to fire the mine manually in response to the action of the tentacles with far more certainty than could be secured by contact mines of the ordinary kind. Incidentally, ground mines, with the cables lying on the ooze at the bottom of the channel, are far more difficult to put out of action than mines lying nearer the surface, with a network of mooring cables which can be damaged or cut loose.

Our experience showed what will be of service in future emergencies, that starting with a force of trained electricians and workmen such as can be obtained in almost any large city, the intricacies of a mining system can be very quickly mastered by men having no previous experience with them and mining defenses very quickly and thoroughly organized. This was also the experience at several other points where efficient volunteer organizations were in service.

I presume that had the necessities of the case been more severe, interference with the mining defenses by straggling vessels could have been and would have been very much reduced, but it is a serious matter and one which should be averted, if necessary, by very drastic measures in time of war.

In point of fact, we had but one real alarm at Boston. Once, just after our force had got through its day's work and was scattering, a telegram came from the War Department announcing the appearance of a fleet of uncertain aspect off the coast. There was scurrying for a time and the firing squads were promptly assembled and sent to the casemates. For that night, at least, the mines were thoroughly ready for business, but in the morning our suspense was relieved by the announcement that we had been victims of a false alarm.

After about ninety days' service, the Spanish fleet having been snugly located at the bottom off Santiago, the Volunteer Electrical Corps passed out of existence, but the experience was a valuable one, in showing both the amount of material and men which could be gathered at short notice and in teaching some of the limitations involved in hurried and temporary construction.