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## The Mine That Hears

By Edward F. Chandler

*It is unnecessary to introduce Mr. Chandler to the readers of the POPULAR SCIENCE MONTHLY. In the present article he describes another one of his remarkable applications of the microphone to naval weapons—an application which is based upon a ripe experience gained in the development of torpedoes and other inventions. The "Mine that Hears" is the result of several years of constant study and experiment by the author, and is described here in detail for the first time.—EDITOR.*

EVERY one knows that in time of war harbors are protected by mines through which an enemy cannot easily pass without the risk of destroying himself. Depending on their nature the mines are called "contact" or "shore-controlled." As the names indicate, the contact mine explodes as soon as a trigger with which it is provided is actuated by a ship, or a bottle of acid is spilled on a suitable chemical; the shore-controlled mine is exploded electrically from a station at the critical moment determined by observation.

Of the two kinds the shore-controlled is the safer. The contact-mine may break loose and become a menace to neutral shipping, as the tragic incidents of the present war have abundantly shown.

The British Grand Fleet undoubtedly owes its safety in part to the submarine mine. It lies in harbors the entrances of which are sown with mines so thickly that a submarine could not worm its way through them without blowing itself up. Whether or not the feat of running through a mine-field has actually been performed in the war there is at least reason to believe that it has been attempted. Mr. Simon Lake, a leading authority on submarine boat construction in this country, not only declares that a submarine can

penetrate a mine-field but has shown how it can be done. He has devised a special type of submarine provided with an antennalike projection or "feeler" in front, which enables a submarine commander to push aside mines with reasonable safety.

If the Lake and similar systems are able to perform their functions it is obvious that no harbor is absolutely safe from submarines. In previous articles published in the POPULAR SCIENCE MONTHLY, I have shown how torpedoes can be automatically steered toward ships, which they are intended to destroy, by employing microphones to pick up the propeller vibrations, and how submarine boats, which are notoriously blind under water, can be directed accurately toward a hostile vessel by the same means. I have worked out a method of applying microphones to mines, which, it seems to me, makes it quite impossible for a submarine to enter a mine-sown harbor, and which also enables the officer in command of a station from which shore-controlled mines are fired to detect the attempt of a surface vessel to enter under the cloak of a dense fog.

The system which I have devised would render it possible to blow up a submarine trying to worm its way into a mine-protected harbor, or a battleship

seeking to enter a harbor at night or in a dense fog. In my system the mines are arranged in groups of four, each group constituting a field unit. On each mine a microphone is mounted.\* These microphones literally hear the hum of a submarine's motor. Not only that but the particular microphone which hears the submarine best, because it is the

The field units are interconnected electrically, so that the entire harbor is sown not only with charges of high explosive but with microphone detectors. Interconnection is necessary because mines 1 and 2 of one group constitute mines 3 and 4 of an adjacent group. Microphones are so remarkably sensitive (they have picked up the hum of sub-



As a submarine progresses through a mine-field in the effort to reach shipping in a harbor, the hum of its electric motor is heard by microphones on the mines. The vibrations picked up by the microphones are electrically transmitted to shore and converted into visual signals by incandescent lamps corresponding in number and position with the microphoned mines

nearest to it, can easily be located. It is simple enough to determine whether a submarine is nearer mine 1 or mine 2 of a given field unit of four mines.

\*For the benefit of those who may be unfamiliar with the microphone I may state that the microphone is an instrument for intensifying feeble sounds or for transmitting sounds and it is based on the principle that the transition between loosely-joined electrical conductors decreases in proportion as they are pressed together. The conductors form part of a circuit through which a current is passing, and the variations in pressure due to sound waves in the vicinity of the conductors produce variations of resistance and fluctuations of the current so that the sounds are reproduced in a telephone receiver. In the modern telephone the transmitter is essentially a microphone, the pressure of the sound waves being communicated to the conductors by means of a diaphragm.

marines fifteen miles away in the present war) that they need not be lavishly employed in every case. Four microphones placed in the four corners of a small field would answer in many cases, all the more so, since a ship can be blown up even though it be fifty feet from the actual explosion. Few of us realize how terrific is the disruptive effect of the gases suddenly generated when several hundred pounds of explosive are detonated.

A mine-field equipped with microphones in the manner indicated is electrically connected with a luminous annunciator. In other words, wires run from each microphone to a board which is divided into squares correspond-

ing in number with those of the mine-field units. Behind each square a lamp is mounted. As a hostile ship passes through a mine-field the nearest microphones pick up the vibrations of her propellers and the corresponding lamps on the board glow. The luminous annunciator may be twenty or more miles distant from the microphones;

it may be in Chicago and the mine-field in New York Harbor, if there were any military advantage in that great separation. It is always possible to follow the course of an intruding vessel merely by watching the lights as they flare up and die out in the squares of the luminous annunciator. The lamps actually visualize the course taken by the vessel under observation. If she enters square 22 of the field the lamp behind square 22 on the annunciator board glows; as she slips into square 23 of the mine-field, lamp 22 is extinguished and lamp 23 flares up. The accompanying diagram will explain the general principle.

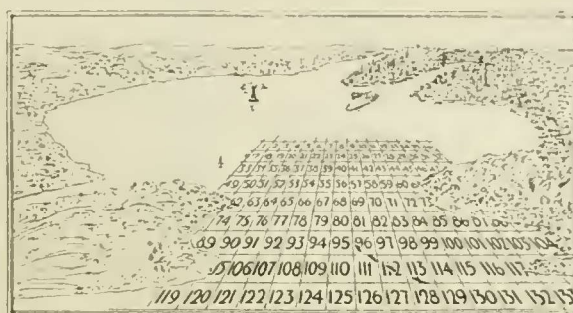
Mines are expensive. To provide them with microphones and to wire the microphones to a luminous annunciator board adds to the cost of the installation. Suppose that it were possible to use fewer mines, in other words, to use rather large squares, and suppose that

it were possible to determine not merely the particular square into which a hostile vessel has found its way but the particular mine of that square nearest which it happens to be—would not that solve the problem of cheapening the installation and heightening its effectiveness?

With this idea in mind I have connected

with the luminous annunciator board what may be called a "precision indicator," the purpose of which is to show which mine is to be exploded in order to destroy the interloper. A single precision indicator serves for all the mines; for the wiring is such that the precision indicator can be switched into the circuit of any mine-square at will. The details cannot be revealed at the present time, because they are the subject of a patent application awaiting official action.

It may be stated, however, that the devices employed accurately locate a vessel in a square by averaging the momentary responsiveness of the four microphones at the corners of the square. It is very much as if a pencil were attached by four cords to as many pulling devices, the pull on each cord coming from a different point of the compass and representing the intensity of the sound heard in a microphone. Pulled in all



VIEW OF PROTECTED AREA

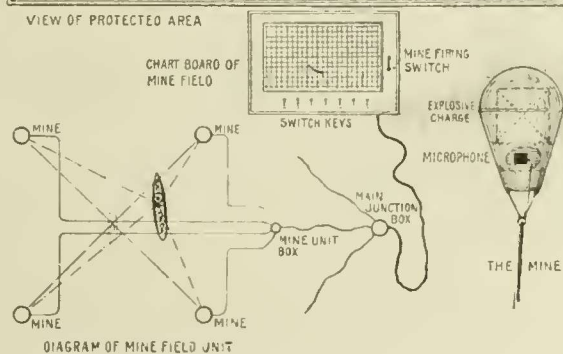


DIAGRAM OF MINE FIELD UNIT

The mines, provided with microphones to hear the vibrations of ships which seek to enter a harbor, are arranged in numbered squares. A luminous indicator on shore, marked off into squares corresponding in number with those of the mines is electrically connected with the microphones. Each mine-square is represented on the indicator by a lamp, which glows in its proper square on the luminous board as soon as a hostile ship enters and is heard. Thus it is possible to follow by the successive flaring up of lamps the course of a submarine or battleship threading its way through the mine-field and to explode the right mine



four directions at once, but with different intensities, the pencil will rest at that point where all the forces are equalized. That point, in the case of the precision indicator, is the spot in which the hostile vessel is to be found.

Imagine New York Harbor mined and microphoned in the manner that I have described; imagine the mines connected with a luminous annunciator at Fort Wadsworth and with a precision indicator provided for the purpose of determining which microphone in a square hears the most; imagine a submarine crawling very, very cautiously through the field, thrusting aside with careful antenna, the anchor-chains of the buoyant mines in its path. An American officer glues his eyes on the luminous board. One by one the squares glow before him—19, 36, 53, 66. Unwittingly the submarine's commander plots his course in a trail of light. He cannot be seen with human eyes; and yet he is as visible, electrically at least, as a goldfish in a glass bowl. "Square 78," says the American officer to himself, as a new light flashes up. The time has come for decisive action. He pulls a handle and switches the precision indi-

cator into electrical connection with square 43. The submarine is nearest mine "A" of that unit. For the microphone on mine "A" is intensely active. He presses a button. Miles away a column of water is tossed into the air. An unseen enemy has been destroyed with awful suddenness; twenty brave sailors have been killed with merciful swiftness by a man who never saw their faces.

The naval and military strategist will note at once that the system which I have described has this advantage over the rather haphazard method of utilizing the contact mines at present employed. It renders it possible to destroy a whole fleet, ship by ship, as it progresses into a harbor which is protected. The officer at the luminous indicator board has only to wait until the lamps show that the entire squadron has entered the field to blow up ship after ship at his pleasure. It is also apparent that the system is not limited in its application to the detection of battleships or submarines in a mine-field, but that it can also be adapted to the firing of coast-defense shore-batteries.

### Automobile Scale-Demonstrator

ON the principle that if you can't get the buyer to come to you, you will have to take your product to the buyer, a large manufacturer of scales recently fitted up one of his scales on a light automobile and sent it out through several of the western states as a demonstrator. As shown in the accompanying illustration, the car was fitted with a complete scale and in addition a portable elevator to



An automobile used for demonstrating scales. The owner travels from town to town, the scale enclosed in canvas and the portable elevator carried on the side

raise the grain to the former, so that it really was a working model for the prospective buyer to inspect.

The car travels from town to town, the scale proper being enclosed in canvas enroute and the portable elevator is carried on the side. The power for driving the elevator is secured from the motor of the automobile.

The money-making ability of this outfit has been clearly shown.