Undersea Fighting of the Future

II.—Battling with Telephones

By Edward F. Chandler

The author of this article has conducted extensive researches in the art of submarine radio transmission, applying the results to defensive and offensive means of warfare. The system of submarine navigation described in this article is the result of conclusive tests.—EDITOR.

IF the war has taught us anything it has taught us that the submarine must be reckoned with both as an annihilator of battleships and as a destroyer of commerce. Of the dozens of instrumentalities invented for killing on a wholesale scale it is the most terrible. And yet how crude is this new weapon! Compared with what it can be made it is what the blunderbuss of old is to the modern rifle.

Edward F. Chandler, whose most important work thus far probably is the development of a submarine range-finding system and its application to the detection and destruction of hostile submarines

Consider for a moment how a submarine boat is handled. The commander plows along at the surface much as he would on any ship. In the offing he sees a pillar of smoke. Friend or foe? He must investigate. Changing his course, he steers for that cloud on the horizon. In fifteen minutes he has approached near enough to discover that the smoke is pouring from the funnels of a hostile collier. She flies the naval ensign of her country, and she is convoyed by a torpedo-boat destroyer. The submarine commander gives an order. Water surges into tanks in the submarine's hold. The craft sinks until only her periscope projects from the water. Heading for the collier the submarine arrives within half a mile of its prey. The commander takes the bearings of the collier by compass and orders complete submergence. In another minute the craft is completely under the surface. A sharp command, and a puff of compressed air starts a torpedo from one of the launching-tubes. In less than a minute it has reached the collier. There is a dull explosion. Fifteen minutes later a cargo of four thousand tons of coal lies at the bottom of the sea, and a hundred brave men have perished miserably.

Why the Submarine Is Crude

It seems very simple, very certain, this torpedoing of a ship from a safe place under the water. But for all that it is unscientific and haphazard. The submarine commander sees nothing below the surface; that is why he must take aim before he submerges. To strike, the target must be large and very near; otherwise he would surely miss. Suppose that you were told to shoot blindfolded at a mark one hundred yards away and that you were given two minutes to locate the target before your eyes were covered. You would be exactly in the position of a submarine commander about to torpedo a hostile ship. Is it any wonder that torpedoes must be fired at close range? Is it not obvious that the submarine could be made still more terrible if the submarine commander could locate his quarry accurately in the inky blackness in which he is immersed?

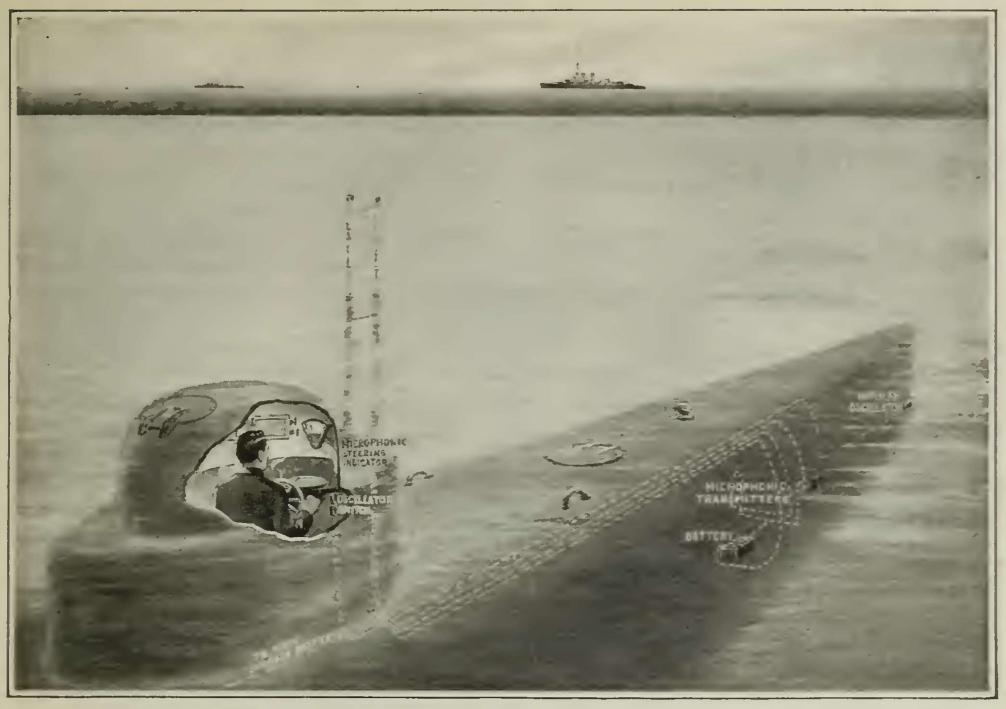
To use lights under water is hopeless. Even millions of candlepower would not reveal the presence of a ship a mile off to a submerged underwater craft. But suppose that the commander of a sub-

Although the submarine is blind after it dives it can be made to hear with the aid of microphones. If two hostile submarines were equipped so that they could hear each other there is no reason why they should not fight under water. Torpedoes would be the weapons used—torpedoes directed solely by the sound emanating from the craft to be destroyed

marine could locate his prey by sound; suppose that he could hear a ship and locate her by sound more accurately, for example, than a blind man can locate the position of a ticking clock in a room? Might not that solve the problem?

With this thought in mind, I have worked out a method of utilizing microphones—a method which is a modification and extension of that which I described in the POPULAR SCIENCE MONTHLY for October, 1915. Those who read that article will remember that I showed how it was possible to make a torpedo guide itself toward the beating propellers of a ship with the aid of microphones—"electrical ears," as I call them. A microphone is found in every telephone transmitter. It is an instrument for intensifying feeble sounds, or for transmitting sounds, and it is based on the principle that the transition between loosely joined electric 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 hence 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.

In a torpedo of the type I described in the POPULAR SCIENCE MONTHLY, the microphones are mounted in pairs on both sides of the nose. So long as the sound of the hostile ship's beating propellers, traveling through water far more readily than sounds travel through air, affect all microphones with equal intensity, the torpedo rushes on straight to its mark. But if the vessel should change its course, the vibrations of the propellers would no longer strike the two pairs of microphones with equal force; one pair would be more affected than the other—the pair directly ex-



In order that a submerged submarine may direct its course accurately toward a hostile ship it may be provided with microphones on its port and starboard bows. The difference in the volume of sound received by the two microphones indicates the course to be pursued. The sound can be converted into movements of a finger playing over a dial

posed to the vibrations. At once electrical circuits are closed and automatic mechanism started which swings the rudders of the torpedo and points the nose of the torpedo toward its mark. As soon as the microphones on both sides are restored to electrical equilibrium, in other words as soon as they hear with equal clearness, the torpedo keeps on a straightaway course.

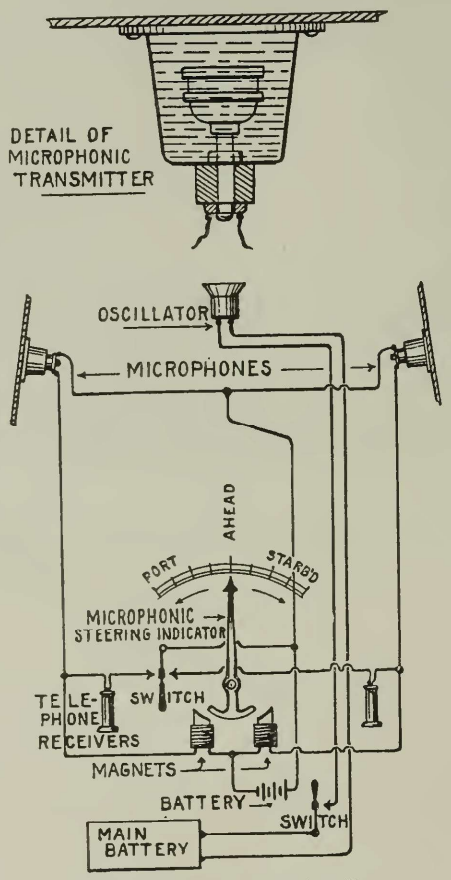
It is evident that the same principle can be applied to submarine boats traveling under water, with the difference that since the submarine is manned by intelligent human beings, the microphones can be made merely to indicate the course to be pursued, leaving to the commander the task of steering a true course. As in the case of the sound-controlled torpedo, the submarine is provided with microphones on its port and starboard bows. Telephone ear-pieces are provided which enable the submarine commander to listen to the sounds gathered by the microphones. If the submarine is not pointed head on toward the ship to be destroyed the microphone on the off side will hear less than the other, and the difference in the volume of sound received by the two microphone detectors will be noted at once in the telephone receivers. The commander changes his course until he hears equally well with both ear-pieces.

Seeing Sounds on a Dial

While it is perfectly feasible to direct a submarine by telephone it is much more effective to convert the microphone vibrations into visual signals. As a result the commander of a submarine has only to watch a finger move over a dial in order to know what course he should steer. In a sense he sees the sound which the microphone detectors hear. The accompanying diagram sets forth the essential principles of this conversion of the microphone vibrations into visual signals so clearly that an extended description seems hardly necessary.

While a visual steering indicator is

primarily depended upon to guide the submarine on its deadly errand, telephones are connected with the microphones, to be used when the occasion arises. With their aid the commander learns a new language. He realizes the meaning of strange grindings, hums, moans, blows, murmurs and vibrations —the many tongues of the sea. If we but knew it the water of the ocean is a veritable Babel; it is a great reservoir of sound, the recipient of ten thousand different vibrations, ranging from the grinding of pebbles to the pounding of steamship engines. Just as a woodsman learns the meaning of the weird soughing of wind in tree tops, the "woof" of a bear, the patter of deer's feet and the call of quail, so a submarine commander can distinguish one underwater sound from another and interpret it correctly. A tramp steamer can be microphonically distinguished from a *Mauretania*, a torpedo-boat from a superdreadnought, and above all a subsurface craft from a surface craft. Thus the character of an unseen ship miles away can be ascertained.



A diagram showing the Chandler system of converting sounds heard through a microphone into visible signals

But apart from listening to passing ships, the telephones will be required to receive messages from an admiral on a battleship five miles away. Both warships and merchantmen are equipped with submarine signaling devices — devices which send forth either bell sounds or rhythmic vibrations. It is easy to see how useful they can be made to telegraph orders to a submarine under water five miles or more away.

Under Water Echoes and How They Are Applied

In the foregoing account of my invention I have assumed that the vessel to be attacked with the aid of the microphonic steering-indicator is in motion—that its engines are giving audible sounds and that its propellers are churning up water noisily. But suppose the vessel to be attacked is at anchor—what then? Is not the submarine commander helpless?

The difficulty is easily overcome if we can make the submarine produce a characteristic sound and if we can have that sound echoed back from the ship to be sunk and picked up by the submarine's own microphones. Fortunately Professor Fessenden has provided an instrument ideally suited for the purpose. Called an oscillator, it may be regarded as a kind of underwater klaxon horn, the diaphragm of which is electrically vibrated to emit a characteristic bleat. By means of a switch, located near the hand of the submarine commander, the oscillator can be turned on or off.

The oscillator will be of use not only to locate a ship at rest but to save the submarine in a nerve-racking emergency. Imagine the commander of a U-boat bent on the destruction of a ship entering a harbor and traveling along at the surface with only his periscope exposed. A fast armed motorboat looms up—a type of craft which has proved to be a most formidable enemy. The submarine must act quickly. There is but one course—to sink quickly. Valves are opened and tanks filled. The craft