GEOPHYSICS

Geophysics Goes To War

Physical Forces Become Scientific Sleuths, Burrow Into the Ground, Plumb the Sea and Explore the Air

By DR. MORTON MOTT-SMITH

UNSEEN scientific fingers—waves of earth, air and radio—are prying into the secrets of our enemies and bringing back information that often means the difference between disastrous surprise and militant alertness.

A sneaking airplane miles out at sea is spotted by a radio locator. A dangerous mine buried deep in the earth is located by magnetic effect. A submarine is found lurking in the ocean depths.

To the purposes of war there are adapted the clever means that physicists have been using to locate the rich pools of petroleum in the layers of the earth, to find the hidden deposits of coal and needed ore; to locate earthquake faults, to test the solidity of the ground on which dams, bridges, fortifications and other heavy structures are to be erected, or for the purely scientific purpose of determining the geological structure of the earth below ground.

Buried munitions dumps, mines, bombs and shells, underground waters, pipes and even mere cavities, can be located by the same methods that have been used to locate oil, coal and mineral deposits buried deep in the earth.

Artificial earthquakes produced by dynamite explosions, electricity, magnetism, radioactivity and the force of gravity, are some of the agents employed. These scientific sleuths can burrow as much as three or four miles into the earth and give information as to what is down there. From the purely scientific point of view, they are of enormous value in determining the geological structure of the earth below the ground.

Listening devices determine the approach of submarines or airplanes. Sound-ranging helps to locate the position of enemy guns or to determine the range of our own guns.

Echo depth sounding, which located so dramatically the wreck of the *Lusitania* and has been of inestimable service in the more exact delineation of the sea bottom, makes use of supersonic waves; sound waves whose pitch is too high to be heard by human ears. The method will doubtless find extensive use in the present war and afterwards in locating ships that have been sent to the bottom, lost equipment, sunken mines, harbor obstructions, etc. By means of echo sounding, a ship may safely navigate in a fog by keeping in constant touch, so to speak, with the bottom.

Communication between surface vessels and between surface vessels and submarines is often accomplished by sonic or supersonic means.

Land and sea mines can be controlled by radio or acoustic impulses.

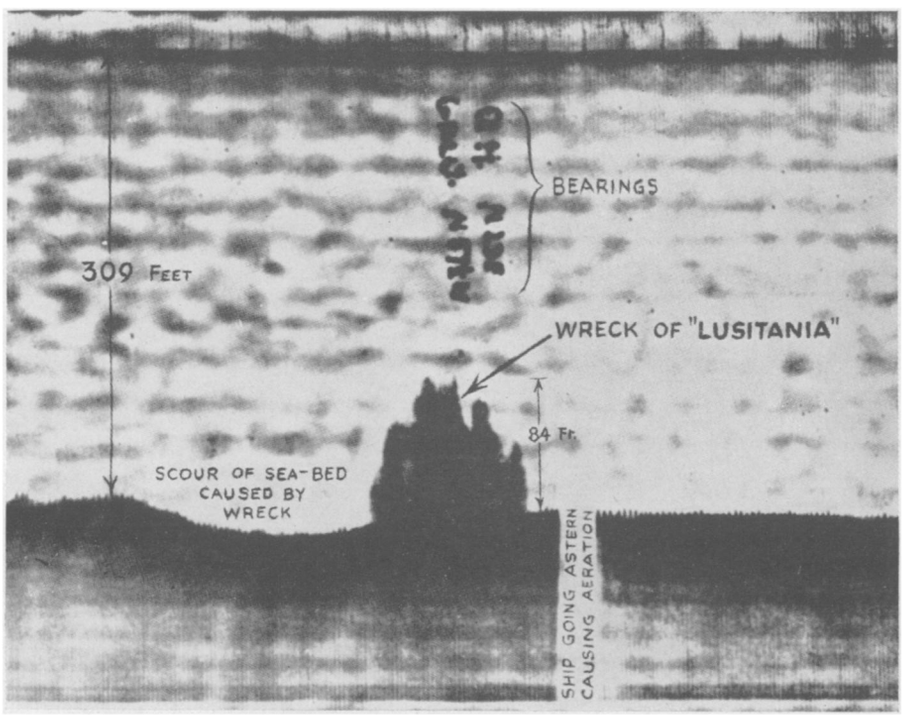
Applied to airplanes, echo sounding makes use of high-frequency radio waves, sent down by the plane and reflected back to it from the surface of the earth. The pilot can read at every moment his height above the ground on an instrument dial.

Finally there is the airplane radio locator, brought strongly to the public attention by England's call for operators, which likewise makes use of reflected radio waves to locate the enemy's airplanes.

All these methods belong to the general subject of geophysics or physics of the earth. Although some of them are applied to the sea or the air, they are the same in principle as those used in delving into the earth, and all have the same purpose—that of detecting and locating objects or dangers beyond the reach of human eyes or ears. In any case, the oceans and atmosphere are parts of the earth.

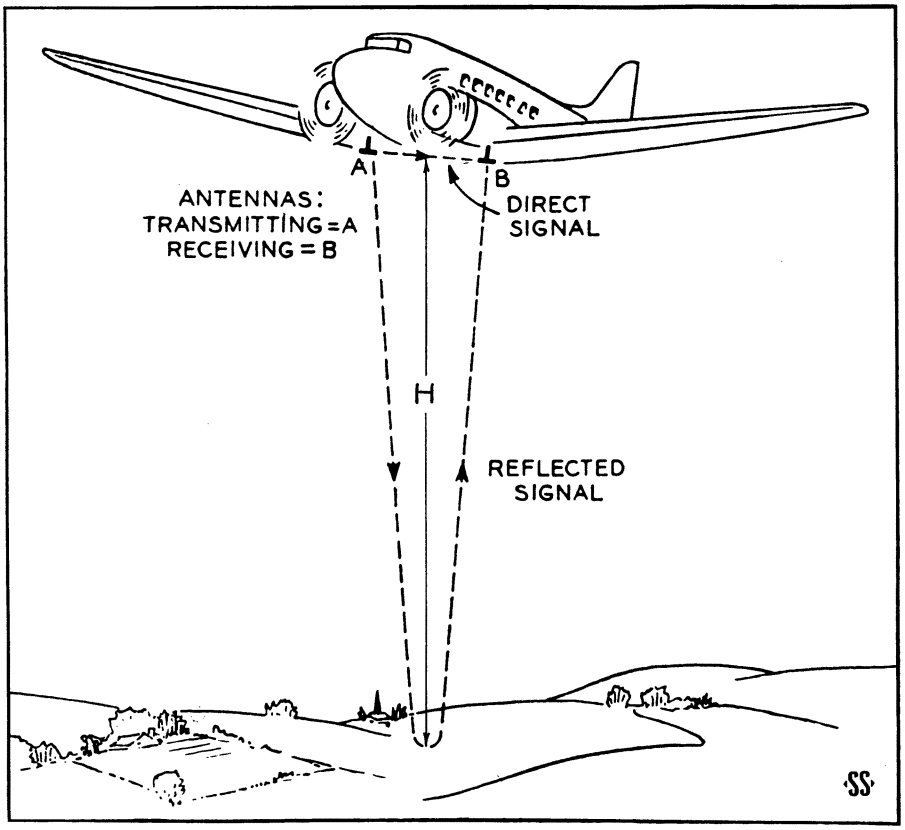
Doubtless many advances over what is now generally known of geophysical methods have been made by the great army of government scientists who are employing all their time and talents to get there first with the most and best inventions. What advances they have made or will make, what new instruments and methods they may devise, will be known after the war. Nothing can or will be told here that would be of value to our enemies.

It may be worth while, however, to tell something of the ingenious methods



SEARCHING SEA BOTTOM

How sound waves reveal vessels on the ocean floor is shown by this actual record of the finding of the Lusitania. Photo from "Precision Echo Sounding and Surveying" by Lieut. Comdr. D. H. Macmillan, R.N.R.



INDICATING HEIGHT ABOVE GROUND

This diagram is from the Colorado School of Mines Quarterly.

and devices that are now used in exploring the earth, sea and air.

One of the most used in prying up underground secrets is the method of the artificial earthquake—called seismic exploration. The "earthquake" is produced by exploding a charge of dynamite in a hole five or six inches in diameter and 20 feet or more in depth. The seismic wave spreads out in all directions. Some of it travels directly along the ground; a part of it bends around again by refraction, similar to a mirage, and returns to the ground; the rest penetrates deeply and is reflected back wherever layers of sufficiently differing densities exist.

Some distance from the shot hole, a number of receptors or pick-ups are strung along the ground. These are nothing other than miniature portable seismographs, similar to the large instruments that pick up real earthquakes. The agitations of these receptors are transported electrically to an instrument truck where they are recorded as wavy lines on a moving strip of photographic paper, one line to each receptor.

An accurate tuning fork makes time marks on the paper from which the time of arrival of each impulse can be read to a thousandth of a second. From such a record, the depths and inclinations of the reflecting beds can be calculated.

This method is particularly useful in determining underground geological structure. It does not directly detect oil or other desired minerals. But geologists know that these various minerals are associated with particular geological structures, so that when the latter are found, the former are likely to be present also.

Other methods of exploring the depths of the earth consist in measuring the variations from place to place in the force of gravity or of the earth's magnetic field, or of shooting electric currents into the earth and exploring the resulting electric fields. The electrical methods are many because continuous or alternating currents may be employed. In the latter case there is a wide range of frequencies to choose from. Or sudden transient impulses may be employed.

A variety of electrical properties are thus determined. By exploring the whole field produced at each set-up, even the depths at which the materials lie can be ascertained. Where the lines of electric or magnetic force come up, indicates the depth of the materials they passed through in somewhat the same way that the refracted or mirage seismic ray does.

All of these methods are indirect in that the geologist has to identify the materials by correlating their properties as found in the field with those determined in the laboratory.

The only direct geophysical methods are the finding of magnetic ores by means of the magnetic needle or magnetometer, and the finding of oil by scientifically smelling out the gases given off by it.

Geophysical prospecting has achieved its greatest successes in discovering petroleum. Applied to other materials, its methods are not so definite or certain, perhaps because there has been no such tremendous demand for geophysical work in these fields as there has been in the petroleum field.

But a government-sponsored program is under way to improve and apply geophysical methods to the search for vitally needed new sources of our scarce war metals—aluminum, chromium, manganese, mercury, nickel, tin, tungsten and others. Any and all of the various geophysical methods are applied according to circumstances, and all are indirect. These and other war uses of geophysics have been described by Dr. C. A. Heiland and published in the Colorado School of Mines quarterly.

Thus bauxite, the ore of aluminum, cannot be directly detected. But it occurs in connection with intrusive igneous rocks which have magnetic properties that can be detected by the magnetometer. The seismograph determines the depths at which these rocks lie and their contour.

Chromite is associated with heavy ultra-basic rocks and both gravity and magnetic methods help to locate the host rock.

Manganese is traced by magnetic and electrical methods through its association with igneous and metamorphic rocks.

The method has been used in Russia, Cuba, and Virginia.

The ore of mercury is cinnabar, very heavy and practically a non-conductor of electricity. But the deposits are too small to affect sufficiently the overall density or conductivity of the host rock. However, it occurs in conjunction with dikes and faults which can be found by electrical and magnetic methods.

Most of our nickel comes from Canada. It occurs in connection with pyrrhotite, a very heavy rock easily magnetized and a good conductor of electricity. This one is easy.

Tin, our chief headache, occurs largely in placer deposits like gold. It is frequently associated with magnetite which can be traced by its magnetic properties. Tin is heavy and usually sinks through the gravel beds to the bed rock. The contour and depth of the latter can be determined by seismic and electrical methods. These methods have been successful in locating placer gold deposits. But neither these nor other methods have disclosed any but the most meager and expensive sources of tin in this country.

Tungsten occurs as wolframite, which is dense and moderately magnetic. But, like cinnabar, it occurs in quantities too small to sensibly affect the properties of the surrounding rocks. However, it has one outstanding property, fluorescence. Unfortunately, this property is of no use until samples suspected of ore are found and tested.

Science News Letter, April 4, 1942

CHEMISTRY

Poison Gases May Be Used By Retreating Armies

Persistent Contaminants Such as Mustard Gas or Lewisite May Be Spread After Men Are Safely Away

POISON GAS, thus far unused in World War II, may presently appear in a new role. It may be added to fire and dynamite in "scorched earth" tactics, to render pursuit difficult and occupation of evacuated areas risky for the enemy, suggests Lieut. Col. Alden W. Waitt of the Chemical Warfare Service. (*Army Ordnance,* March-April).

Some of the so-called poison gases, like mustard gas, Lewisite and other vescicants or blister-raisers, are not really gases at all, but liquids which are distributed for tactical purposes in the form of fine sprays or mists. They settle on foliage, soil, anything else they touch and cling there persistently. Any person unlucky enough to make contact with such contaminated objects is certain to be more or less severely poisoned.

To be sure, such contaminated areas may be de-contaminated with suitable chemicals, but this process is both costly and slow, hampering swift pursuit of a retreating foe and forcing occupying troops to move about in a suspected area only with extreme caution.

As retreat-covering weapons, these persistent contaminants may be applied in any one of several ways. Artillery or mortar shell will probably not be used; those are weapons of attack on active enemy positions. But retiring troops can drop small cylinders or other containers that will give out their dangerous contents after the men have moved on to a safe distance. Planes can swoop back and forth, releasing the spray like a curtain.

Specially equipped trucks have been experimented with by some powers: "The principle of action is the same for portable and vehicle appliances and consists of spraying the agent from the container by compressed air or by special pumps operated by hand or motor. The Italian regulations describe similar devices for what they term soil contamination. These seem rather complicated and dangerous. If mustard is to be sprayed, it is best to be a safe distance away. Certainly pumping mustard by hand from a portable sprayer would be anything but healthy."

What seems like an especially effective method of using chemical means for covering a retreat is the chemical mine. It is like the high-explosive land mine now familiar in anti-tank defense, but is loaded with mustard gas or the like, with only enough explosive to throw it out in a great cloud when the firing mechanism is tripped by an incautious enemy. This has a double effect: it looses a high concentration of the deadly mist so suddenly that the unwarned troops may not have time to get their masks on, and it creates a contaminated area which cannot be safely entered until the decontamination squad has completed the clean-up.

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● RADIO

Saturday, April 11, 1:30 p.m., EWT

"Adventures in Science," with Watson Davis, director of Science Service, over Columbia Broadcasting System.

Dr. P. W. Bridgman, of Harvard University, will discuss the problems and techniques of high pressures.

Tuesday, April 7, 7:30 p.m., EWT

Science Clubs of America programs over WRUL, Boston, on 6.04, 9.70 and 11.73 megacycles.

T. Russell Mason, of the Massachusetts Audubon Society, will talk on "Are You Ready for the Birds?"

One in a series of regular periods over this short wave station to serve science clubs, particularly in the high schools, throughout the Americas. Have your science group listen in at this time.