SEISMOLOGY-MILITARY SCIENCE

Quakes Betray Big Guns

Scientific Tool for Study of Earthquakes Adapted For Tracing Origin of Earth-Shaking Explosions

By DR. FRANK THONE

HAVE you ever watched the firing of a cannon, or the explosion of a heavy dynamite blast?

If your safe point of vantage was, say, about a quarter of a mile from the place of the explosion, you undoubtedly noticed that things didn't all happen at exactly the same instant. First you saw the flash and puff of smoke. Then, a full second later, came the jar and boom. Your ears were momentarily deafened, and you felt the earth jump beneath your feet.

That doesn't arouse wonder any more: we are all taught in school that light, with a velocity of 186,000 miles a second, can be counted as instantaneous for all earthly purposes, while sound, traveling through air at only about 1100 feet a second, takes measurable time to make itself heard at even fairly short distances.

However, the chances are that you were so absorbed in the exciting spectacle that you did overlook something. Did that twitch of the earth underfoot, that miniature earthquake, reach you exactly at the same time your ears heard the noise of the explosion? Most of us would say that it did. Actually, the jar gets there at least a split second before the boom. Waves in earth and solid rock, very much like the sound waves of the air, are started by explosions on or in the ground, and they travel somewhat faster than sound waves because of the greater density of the substances through which they move.

Scientists in uniform, serving behind both confronting lines in the West, are striving now to develop methods whereby they can make use of these earth-waves in locating opposing big guns when they are fired. During the World War, physicists succeeded in working out ways to find guns by getting sound records of their explosions for analysis. Now they are undertaking to do the same kind of thing with the little earthquakes set into vibration by the same discharges. The first method is known as sound ranging. The new method will be known as seismic ranging: in the language of science, "seism" means an earthquake.

(The word isn't one of the "jaw-breakers" of scientific jargon: just say "Size, Mick!" and you have it.)

This recruiting of seismic ranging to the aid of its older brother, sound ranging, is a natural development in artillery tactics, that have been turning more and more into a gigantic deadly game of blind man's buff.

In all wars up to 1914 you had to see your enemy's battery before you could shoot at it. Until the development of smokeless powder, about the turn of the century, that wasn't difficult: the great clouds of white smoke thrown out by the guns made concealment impossible.

Guns using smokeless powder are noticeable only for an instant, by the muzzle flash. Concealment therefore became possible, and camouflage was invented for them. So the game of blind man's buff started, with Death listening very carefully for any betraying sound; for no practical way of silencing heavy gunfire has ever been devised, or is likely to be. And now, Death's groping, sensitive fingers join his ears in the search, feeling the pulse of the trembling earth for the records of the great guns' recoil.

The instruments that will be used to search for guns by catching their earth-waves are modifications of delicate mechanisms that were invented originally for the peaceful and purely scientific study of earthquakes. They are known as seismographs. The name means "earthquake writers." That is an exact description of the instruments. When the earth vibrates, no matter how slightly and imperceptibly, under a seismograph, it swings a sensitively balanced pendulum, which in turn causes a pen to sway over a moving strip of paper, or a pencil of light to dance upon a photographically sensitive emulsion. The result is a wavy-line record, which the trained scientist can interpret in terms of distance, at least approximate direction, and exact time of origin of the disturbance, wherever it was.

Seismographs in university laboratories and government observatories can detect and locate major earthquakes thousands of miles away. So sensitive are they that they have to be mounted on solid pillars of rock or concrete, in vaults or caves deep underground, to shield them from extraneous vibrations. (One instrument, at Georgetown University's famous observatory, had to be relocated because whenever there was a strong wind the vibration of a tall, massively built stone tower overhead would spoil its records!)

Since the jobs that will be imposed on seismographs in military service will be expressed in terms of thousands of yards instead of thousands of miles, such sensitivity will not be required of field instruments. They can be made more rugged, simple, and portable—all of which will be a satisfaction to soldiers, who don't like delicate things that get out of order under usual campaign conditions.

Military seismographs will almost certainly be modifications of field instruments already in wide use by oil prospectors and other geologists, and by engineers who employ them in seeking bedrock on which to base dams, bridge piers and other heavy structures. These instruments are sensitive enough for all practical purposes, and so easily portable that two or three men can carry them anywhere.

These field seismographs of course have to get earthquakes made to order for them. This is done by exploding charges of dynamite or TNT at known distances from the instrument. The earth-waves not only come along near the surface of the ground to make their records; other waves plunge into the earth and are reflected from salt dome, ore body, bedrock or whatever it is the engineers or geologists are seeking. Time of travel down and back, and character and shape of recorded waves, tell how far down the reflecting body is, and something about its nature.

Especially successful use has been made of this method by the U. S. Army Engineer Corps in exploring sites for proposed new dams in the West. Cost of bedrock locating has been materially reduced through elimination of much of the time-consuming and expensive exploratory drilling formerly necessary. The taxpayer gets more dam per dollar than he used to, thanks to seismic exploration.

The military task of the seismic locator will differ in one important respect. Whereas the civil engineer knows ex-

PORTABLE

Three men can easily transport entire field seismic locator outfit.

actly where his wave-causing explosion is, because he planted the charge himself, the military engineer will not know where his wave-source is located. That's exactly what the enemy will be trying to conceal.

The soldier-seismologist will operate on exactly the same principle as his scholarly colleague in the university observatory setup. You can't locate an earthquake from one seismological station. You take the records from three or more, at known distances apart. From each station you measure off the earthquake's distance (the records will show that) to scale on map, and strike an arc. When you have done that from several stations, you will find that the arcs intersect at one point, and at only one point. That is where the earthquake epicenter is located.

In the field, the seismic locators will be set up in groups, at carefully surveyed distances apart. When the great gun that they are seeking booms, each will get a record telling how far away it was, and (in a very general way) its direction from the instrument. The observers will transmit their data to a common calculating center, where distances will be laid out on a map, and arcs struck. Where the arcs intersect, there is your target.

At the same time, probably, similar searching will be going on from the sound-ranging stations, for a good artillery officer is never satisfied with information from one source alone but wants confirming information from as many different angles as he can get. If there is pretty good agreement between seismic and sound locations, maybe the planes will fly over for a look-see and a few photographs. And if the firing is going on at night or in dull weather, the flash-ranging stations will be straining eyes through telescopes at the suspected spot.

Finally, when all possible information has been garnered, you tell the bombers about it, or your own heavies elevate their muzzles for a little counter-battery shooting. Maybe you hit him and knock him out; maybe you only make him so uncomfortable that he stops shooting and gets away from a place suddenly grown too hot. But in either case you've got what you want: relief from a noisy, destructive annoyance.

Seismic ranging, like sound ranging, will probably be used mainly in hunting for the heaviest guns—the eight- and nine-inch field howitzers and the twelve- to fifteen-inch monster rifles of the railway artillery. Ordinary field pieces, of six-inch caliber on down, are too numerous; unless some particular gun or battery becomes too annoying the seismic locators will leave them for other soldiers to seek by other methods. The heavy pieces, fewer, more important, and very much more costly, will be the preferred prey.

One protective device will probably be

used, whenever an especially important heavy gun is firing. Other medium and heavy pieces in the same neighborhood will become especially active at the same time, in an effort to mask the effect of the giant and confuse the records of the detectors on the other side.

This was done by the Germans, when they opened fire on Paris with their long-range guns (commonly but incorrectly called Big Berthas) in the spring of 1918. These super-guns were very deliberate in their firing—half-a-dozen shots a day was about their usual quota. Whenever they were ready to get off a shell, all the mediums and heavies in the whole St. Gobain sector worked overtime for a while, to try to throw the French sound-ranging service off the track.

It didn't work. Before the bombardment of Paris had been going on for as much as thirty hours, the French had gained at least an approximate idea of the site of the two guns that were then doing the firing, had moved up railroad guns, and were beginning to drop heavy shells so close to the Germans' emplacement that the latter were sure they had been betrayed by spies. But it was all done by the comparatively crude sound-ranging method then in use, plus a couple of suspicious-looking spots on a chance airplane photograph taken before the shooting started.

It will be at least as difficult to fool seismic locators, and probably more so. No two earthquakes ever make identical records, and neither will two guns, even of the same caliber, send exactly the same shaped waves through the earth. Every big shot will have its own signature, distinct and unforgeable, for the scientists in uniform in the opposite lines to read. And it probably will not take long for them to arrange for a return of courtesies.

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A new-born *bear cub* is smaller than a new-born kitten.

INVENTION

U. S. Patent System Spurs Enterprise of the Nation

The Commissioner of Patents in Special Article Gives Background for Sesquicentennial Celebration

By CONWAY P. COE,
U. S. Commissioner of Patents

THE NATION is now celebrating the anniversary of an event that has grown steadily in importance down through the succeeding decades.

On April 10 in 1790 President George Washington approved the first United States patent law. With the enactment of that statute, which, by the way, he had urged as a help to inventors, our present patent system had its beginning.

That system, in turn, has spurred our advancement and not only has promoted our industrial welfare, but has also brought us social and political benefits great in number and significance. It has faithfully and fruitfully served the democracy that begot it.

There were inventors, of course, before 1790, and man's inventiveness long preceded our patent system. Down through the ages his ingenuity produced many useful contrivances. But for these there was no reward but their makers' sense of achievement. There was no material return, no protection; scarcely was there renown for the creators of these new mechanisms and methods.

Gunpowder has been for centuries both a beneficent and a baneful influence in the world, but the true identity of its discoverer is hotly disputed.

The American patent system has encouraged the use of good means to worthy ends. It has succeeded in profiting the whole nation by safeguarding and recompensing the individual. It has fulfilled the purpose which the authors of our Constitution had in view when they empowered Congress "To promote the progress of science and useful arts by securing * * * to inventors the exclusive rights to * * * their discoveries."

We owe to that incentive, I believe, the invention of the cotton gin only four years after the passage of the first patent law. As this stimulus became more widely known through the inventions it fostered and recognized, it prompted more and greater efforts and accomplishments.

Within a little more than fifty years after President Washington's approval of the law of 1790 came the telegraph, the reaper, the vulcanization of rubber, the revolver, the sewing machine and the rotary printing press.

In the 104 years since the revision and refinement of the patent system in 1836, there have been granted 2,196,000 patents to many thousands of individuals, the vast majority of them citizens of the United States. Only 9,957 patents were issued before July, 1836.

Many of the inventions covered by these 2,196,000 patents supply our needs and serve our convenience every hour of every day. Such marvels as the telephone, the incandescent electric lamp, the phonograph, motion pictures, the submarine, the linotype, the airplane and the radio, including television, are covered by patents granted in the last 65 years, that is, since the birth of six or seven millions of Americans still alive.

In the first century following the establishment of our patent system 405,262 patents were issued. More than four times that number, that is to say, 1,799,000, patents were issued. More than four times alone. And it will be conceded, I think, that the inventions patented in the last five decades are no less important than any that went before.

The use of these inventions presupposes their production, distribution and operation. To make and merchandise them requires the investment of capital and the employment of labor. Many of our greatest industries are founded on