THE RECENT REVOLUTION IN MAP-MAKING

ONE of the large-scale maps of a section of northern France looks very different from the same map issued by the Paris government four years ago. Over the original map there stretches what looks like an irregular lacework of red lines—broken zigzag lines, continuous lines, lines of dots, lines of little red crosses, and here and there spaces covered by small red dots, and in others large patches of red print. Each of these signs has its special meaning. The red markings are a large-scale map of the enemy's trenches printed over the original map; and studying it with the help of the key printed in the margin, one can make out the successive line of fighting-trenches, the communication-trenches linking them together, the zones of wire entanglements marked by red crosses, the redoubts and gun positions—in a word, all the details of the enemy's defensive organization. In the words of Mr. A. Hilliard Atteridge in *Chambers's Journal:*

"There are indications which show if a trench has been abandoned, or if it is still kept in good order for fighting. Crowds of red dots here and there mark the effect of bombardment, for they indicate ground extensively cratered by shell-fire. How is it all this information is obtained, and that it is possible to mark the enemy's entrenchments so fully, not only in the first line, but in line after line behind it, perhaps for the depth of several miles?

"These results are due to a skilful application to war purposes of two inventions of the last few years—the aeroplane, and the camera which is used for producing cinematograph films. No sooner had the aeroplane come into existence than its value for military reconnaissance was recognized. But even the most skilful observer flying rapidly over an enemy's lines could not collect the detailed information now shown on the maps. He collects it by using the eye of the camera. The instrument is of the same general type as that used for cinematograph work. During the flight over the trenches the camera, pointed downwards, with the film running past its lens, supplies a negative which is brought back to our lines and handed over to experts in the work of development. In a few minutes it is developed and a proof printed off."

To most of us this picture would not give much information, but it is put into the hands of men who have had long practice in interpreting the details shown on aerial photographs. The first step is to compare it with the large-scale map. Roads and villages are picked out on the photograph, a comparison with the map shows their precise position, and then it is possible to transfer to the map the details of the enemy's trenches between these points as revealed by the photograph. The fact that much of the fighting has taken place in chalk districts facilitates the work, for the trenches appear as well-marked white lines in sharp contrast to the unbroken ground around them. By taking a succession of photographs day after day, the enemy's positions can be watched to see how this or that part of the line is being strengthened, or reserve-trenches are being constructed behind it, and new communication-trenches opened from front to rear. Note can also be taken of the cutting down of woods, the destruction of buildings, the laying down of new branch-railways, the making of stations, the formation of depots and ammunition-dumps — all useful information for the attacks of our airmen. The work is heavy, because it is not a case of making a trench map once for all, but the map has to be continually revised and kept up to date.

"The work of collecting the material for the map-maker entails a certain amount of fighting in the air. The aeroplane which carries the photographer and his camera has to be protected by fighting-aeroplanes armed with machine-guns and ready to attack and drive down any hostile aircraft that attempts to interfere with the reconnaissance. Indeed, those

BEFORE THE CRAZE FOR CAMOUFLAGE

Here we see a simple, unsophisticated landscape after the superfluities of vegetation have been burnt and purged away by the purifying shell and shrapnel. This is the foundation of the revolution in map-making, altho in our period of the war the surface here shown would be elaborated to deceive the eye of the camera.

aerial surveys could not be regularly and effectively carried out unless we held a more or less complete command of the air. There is also the danger of coming under the fire of anti-aircraft guns. In the early days of the war, before this kind of gun became very effective, aerial reconnaissance was carried out at two thousand or three thousand feet from the ground; but before the end of the first year the development of anti-aircraft guns forced the aeroplanes to fly higher, and aerial photographs are now taken at a height of five thousand or six thousand feet, or even at still greater heights. The photographic apparatus available gives so much detail and such perfect definition, even on a very narrow band of film, that an enlargement can be secured after development and all the details brought out."

The placing on the map of the information collected by the airmen is only one part of its preparation for practical use. It is important to find ways for describing accurately the precise position on the ground of guns, troops in movement, &c., in giving orders, and selecting the targets for artillery fire. Before the war, in our peace maneuvers very rough-and-ready methods were used for describing points on the map—"so far and in such a direction from a farm or cross-road," or, again, some chance letter on the map would be taken and the distance and direction from it given. One found in orders and reports such expressions as "Four hundred yards north of the 'L' in 'Blackwater.'" Much more precise methods are now adopted. The system had already been in use in most countries for directing the fire of coast-defense guns. The sea on a coast map is mostly a blank; so, in order to signal to the gunners the exact position of a hostile ship, the sea spaces on the maps used in the batteries were divided by a system of squares.

"This system of squares is now used on the war maps in a very elaborate form. First there are large squares marked with a capital letter. These are subdivided into smaller squares denoted by a number, these squares being one thousand yards long and wide; these are again divided into quarters—squares of five hundred yards—always described by the letters *a, b, c, d*. Transparent celluloid scales are provided with the five hundred yards square ruled on them, and divided into ten rows of ten little squares each. By laying this on the map and counting the small squares from the lower left-hand corner, one can tell, for instance, that there is a battery in the fifth square of the sixth row. This defines the position within fifty yards, and one can be still more precise by noting that the guns are in the middle of the square or in one of its corners, or at some point between these. Thus a position can be described with quite sufficient accuracy for opening fire upon it even at long range, the further regulation of the fire being carried out by 'spotting' from an aeroplane or an anchored balloon."

ONE OF THE GREAT UNSOLVED PROBLEMS OF MODERN PHYSICS

THE newest of the problems of physics, according to Professor Robert Andrews Millikan, is at the same time the oldest. The brilliant professor of physics at Chicago University, in his recent study of the electron, takes up the nature of radiant energy as one of the most alluring of the unread riddles of our day. Nothing, he points out, is earlier in the experiences of the child or of the race than the sensation of receiving light and heat from the sun. But how does light get to the sun and the stars through the empty interstellar spaces? The Greeks answered this query very simply and very satisfactorily from the standpoint of people who were content with plausible explanations but had not yet learned perpetually to question nature experimentally as to the validity or invalidity of a conclusion. They said that the sun and all radiators of light and heat must shoot off minute corpuscles whose impact upon the eye or skin produces the sensations of light and warmth.

This corpuscular theory was the generally accepted one up to 1800 A. D. It was challenged, it is true, about 1680 by the Dutch physicist Huygens, who, starting with the observed phenomena of the transmission of water-waves over the surface of a pond or of sound-waves through the air, argued that light might be some vibratory disturbance transmitted by some medium which fills all interstellar space. He postulated the existence of such a medium, which was called the luminiferous or light-bearing ether.

Partly no doubt because of Newton's espousal of the corpuscular theory, the ether or wave theory gained few adherents until some facts of interference began to appear about 1800 which baffled explanation from the standpoint of the corpuscular theory, but which were easily handled by its rival. During the nineteenth century the evidence became stronger and stronger, until by its close the corpuscular theory had been permanently eliminated for four different reasons: (1) The facts of interference were not only found inexplicable in terms of it, but they were completely predicted by the wave theory. (2) The fact that the speed of propagation of light was experimentally found to be greater in air than in water was in accord with the demands of the ether theory, but directly contrary to the demands of the corpuscular theory. (3) Wireless waves had appeared and had been shown to be just like light-waves save for wave-length, and they had been found to pass over continuously, with increasing wave-length, into static electrical fields such as could not possibly be explained from a corpuscular point of view. (4) The speed of light had been shown to be independent of the speed of the source as demanded by the ether theory and denied by the corpuscular theory.

By 1900, then, the ether theory had become apparently impregnably intrenched. A couple of years later it met with some opposition of a rather ill-considered sort, as it seems to Professor Millikan, from a group of extreme advocates of the relativity theory, but this theory is now commonly regarded, he thinks, as having no bearing whatever upon the question of the existence or non-existence of a luminiferous ether. For such an ether was called into being solely for the sake of furnishing a carrier for electromagnetic waves, and it obviously stands or falls with the existence of such waves *in vacuo*.

Up to 1903, then, the theory which looked upon an electromagnetic wave as a disturbance which originated at some point in the ether at which an electric charge was undergoing a change in speed, and was propagated from that point outward as a spherical wave or pulse, the total energy of the disturbance being always spread uniformly over the wave front, had met with no serious question from any source. Indeed, it had been extraordinarily successful, not only in accounting for all the known facts, but in more than one instance in predicting new ones. The first difficulty appeared after the discovery of the electron and in connection with the relations of the electron to the absorption or emission of such electromagnetic waves. It was first pointed out by Sir J. J. Thomson thus:

X-rays unquestionably pass over or pass all but an exceedingly minute fraction of the atoms contained in the space traversed without spending any energy upon them or influencing them in any observable way. But here and there they find an atom from which they hurl a negative electron with enormous speed. This is the most interesting and most significant charac-