Army Topographical Division Co-ordinates Work of Map Makers in Air and on Ground

Existing French Maps Used as Basis for New Work—Aerial Photographs, Taken by Our Own Machines, Bring Valuable Data from Enemy Territory—Relief Maps a Specialized Work in Which U. S. Details Are Trained

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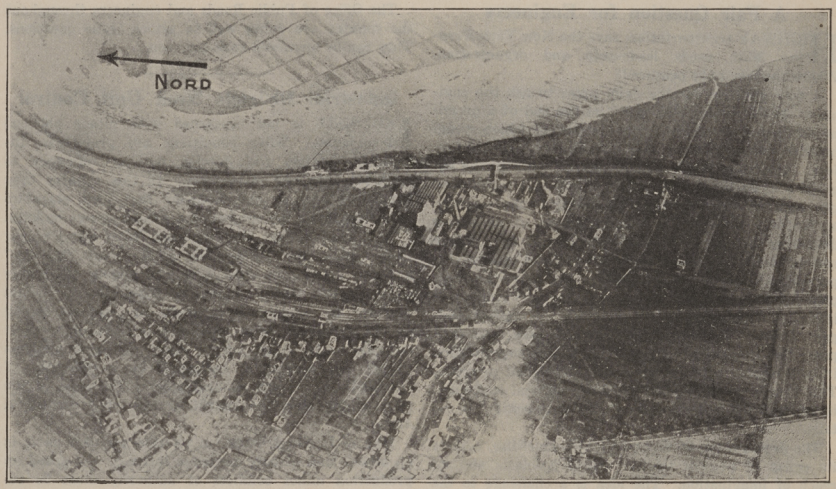
USING French army maps and civil records from various local sources as a basis, the topographical division of the intelligence section, American Expeditionary Forces, which has been passing through the organization and training stages for some months past, has been developed to a point where it is now furnishing to our staff and field officers in France maps on which the more recent information represents the work of American engineers; coöperating with them is our air service, which is responsible for the taking of all aërial photographs for map-making purposes. This statement I am in a position to make as the result of an interview at American Army headquarters with Col. A——, Corps of Engineers, U.S.A., commanding our topographical division. Its significance can be appreciated only when it is realized that the present war has revolutionized methods of map making, that a new art has been created, and that men, even though topographical specialists in civil life, must be put through an extended course of training before they can become useful in the new work at the front, which involves the taking and, of equal importance, the interpretation of aërial photographs. It has been this task, this rounding up of the technically qualified men, molding them into an engineer organization and training them in the various details of the service, that has occupied much of the time of the topographical division. But now the results of this preliminary work have begun to bear fruit, and week by week the scope of operations is being extended. Where formerly we were entirely dependent on the French Armies for maps of both sides of No Man's Land, we are, at this writing, drawing more and more upon our own resources for this information, and will continue to do so in larger measure as time goes on.



WHEN THE LENS IS NOT HORIZONTAL, CURIOUS EFFECTS FROM DISTORTION APPEAR
Height, 1700 meters—The river is the Moselle

The topographical division must be able to furnish at quick notice maps of enemy ground and also that occupied by our own troops, the latter including not only the advance areas but also the territory in the rear, such as sites of supply bases, hospitals, aviation training stations, artillery and machine gun ranges, storage yards and camp areas. Obviously, it would be difficult, if not impossible, for a single detached organization to do the field and air work necessary for the production of all of these maps, especially on an extended front. The plan is, therefore, to have each Army map the territory along its own front, while the topographical division of the intelligence section, a headquarters unit, acts as the general clearing house for map informa-

form. To contend that any officer can get results out of a labor crew, on either skilled or unskilled work, is to say that the construction man is no better on construction work than the lawyer or the business man.

It is estimated that in order to give proper construction leadership to infantry regiments there will be required about 6000 commissioned and 15,000 noncommissioned officers to each million privates. There should be no difficulty in obtaining this number of competent men, partly from the engineer troops already mobilized, partly by selecting the men brought into the service through the draft who have had construction experience, and partly by bringing in men past the draft age who are competent to assume such positions.

Leading American engineers are urging on the attention of the highest officers of the Government a reorganization of the army on the lines above suggested. It is to be hoped that their efforts may be successful.

A Fair Question for Engineers

HIGHWAY transportation, says the New York *Evening Mail*, needs leadership and organization. Where are they to be procured?

A fair question for the daily press to ask the engineer. The *Evening Mail* put it at the end of a prominently displayed editorial the reading of which would broaden thinking—even among engineers—on this subject. Asserting that trucking costs as much in the aggregate as railway transportation, and that perhaps 60 per cent. of this is waste, the editorial characterizes as half-way measures the establishment of store-door deliveries and of return-load bureaus, and advocates a national solution of the problem through an express corporation similar in organization to the American Telephone & Telegraph Co. As many engineers know, this is the kind of organization in which the central company holds 51 per cent. of the stock of each local company, the remaining control of the branch organization in each locality being in the hands of resident interests. This type of organization combines national leadership in meeting the large problems with local control of details.

The presentation of this proposal is startling, both in its grasp of present transportation problems and its reach of imagination. The idea is a challenge to the engineer. Can a national corporation of this sort organize effectively our trucking and highway transportation interests? Can it coöperate in road and street construction and maintenance—the great task of determining, building and keeping up the best types of roads to carry the traffic?

These questions can be answered only by engineering analysis. They must be answered in the affirmative before assent can be given to the broad proposition put forth by the *Evening Mail*. If study should compel the engineer to answer in the negative either of the questions, it would be a foregone conclusion that such a national trucking company could not succeed in producing the most desirable results.

The railroads locate, design, build and maintain the tracks over which their traffic passes. The street railways and the telephone companies do likewise, asking no more of the cities in which they operate than permission to use the space required for the most efficient service. A forwarding company under national control would be handicapped in every locality by varying ideas as to what kind of track should be provided for its traffic, what loads should be permitted, how the track should be maintained and how the maintenance bills should be paid.

In fact, the analysis of road construction and maintenance has not proceeded to the point where it is known what are the most economical loads, what the proper motor-truck speeds for city and country, what the most economical types of roads under each of the classes into which motor-truck traffic will divide itself.

Would it not be best, therefore, to proceed with store-door deliveries, return-loads bureaus, investigations of the cost and scope of motor-truck transportation, studies of economical road types, and to work out the solution of these and other perplexing problems, before attempting to say to what extent the control of motor traffic in this country should be centralized?

The Office of Public Roads and engineers throughout the country are doing well to attack these questions. They can be answered none too soon.

Industrial Districts Need Unit Control

INDUSTRY is not concerned with minor political boundaries. When conditions are propitious, industrial districts will develop without reference to arbitrary city and state lines. In this country they have grown up in such numbers that their statistics have been made the subject of a special census bulletin.

New York harbor, the Delaware River district near Philadelphia, the Minneapolis & St. Paul "Midway" and the Pittsburgh steel mills are among the better known areas whose industrial population is bound together by commercial interests at least as strong as the claims of local governments controlling their separate parts. And yet in nearly all such districts proper development is hampered by a diversity of administration which subordinates to the good of the political divisions the benefit of the whole industrial area.

War is focusing attention on this problem as it is on others long of only academic interest. To speed up production minor conflicts of authority must be removed. In all industrial centers the questions of transportation and housing must be studied from something higher than a political viewpoint. Under forced draft the Federal Government is assuming authority and establishing a unity of control which waves aside local interest. Thus the new Port and Terminal Commission will doubtless make short work of the interstate feud which has long retarded the proper growth of New York harbor. Elsewhere, as along the Delaware River, efforts described on another page are being made to settle similar difficulties without resort to Federal control, which may terminate with the war.

Whatever the present solution, the problem will remain with us. It is one on which engineers may well focus their attention, for while the essential difficulties are political, it is chiefly engineering problems which are affected by the present lack of coördination, and on the engineer will fall the responsibility of proving that any new system of control is superior to the old.

tion, and outlines the broad questions of policy by which the special map-making forces in each Army are guided. Its work involves, of course, very close coöperation with the air service.

Fortunately, the American Expeditionary Forces have not had to start from the very beginning in the matter of maps. Those portions of the front which we are taking over have been completely mapped, as the result of more than three years' occupation by the Armies of our Allies, although the changing conditions on both sides of the line, involving the location of new field gun positions, roads, railways, and similar data of military importance, call for a large amount of work by our men. And it is pertinent to emphasize that our map-making forces must concern themselves with the sections of the rear as well as those of the front, and that while the aviator and observer with their photographic apparatus are now bringing back information from areas occupied by the German armies, engineer detachments, with transit, level, sketching-board and the rest of the equipment needed, are performing equally valuable service back of our lines and in other zones, at supply and ordnance bases, for example, where sizable cities must be created, at railroad yards, at artillery training grounds, and aviation fields.

Our topographical division's first work was a study of existing French maps. There is, to begin with, a set of maps with 20-m. contours, and drawn to a scale of 1 to 200,000. These maps, prepared by the *Service Géographique*, correspond in a general way to those issued by the United States Geological Survey. They are useful for certain military purposes, but obviously the scale is too small for detail work. For Army staff work the French use the *cartes d'état major*, maps on a scale of 1 to 80,000. There is a series of these maps covering the whole of France, and they give information of military value, such as the location of bridges, roads, railroads and canals. Topographical features, however, are shown by hachures instead of contour lines, the elevations of strategic points being indicated by lettering. There are also maps on a somewhat larger scale, 1 to 50,000, but these are merely enlargements of the *cartes d'état major*. In the vicinity of all fortified places special large-scale maps had been prepared by the French before the war. These maps contained a considerable amount of detail, such as the location of trenches, mines, etc.

Next in the list comes the *plan directeur*, on a scale of 1 to 20,000, equivalent, approximately, to 3 in. to the mile, which is, practically, the standard for use in every day field operations at the front. Existing supplies of these maps, however, did not cover the training areas and our topographical division has been filling in the gaps by plotting the results of old French surveys which has never before been completed in the form of battle maps. For this work American engineers are using old civil records, such as those involving titles to land, and department tax maps, which correspond, in a general way, to those which would be on file in the office of a county surveyor in the United States. In connection with the work of making the new *plans directeurs* the American topographical division is also producing for special purposes a number of maps on still larger scales, 1 to 10,000 or about 6 in. to the mile,

A MUCH-BATTERED HILL—DOUAUMONT—2400 METERS

and even 1 to 5000, the latter, for infantry use, showing machine gun emplacements and practically every other detail along the front.

One of the first field operations which the topographical division of the American Expeditionary Forces carried out in France was the establishment of triangulation stations and the making of a network of traverses covering the zone of our army operations in the rear areas. To this task the division assigned picked men of its organization who had specialized in just this kind of work, many of them having held important posts in the United States Geological Survey and the United States Coast and Geodetic Survey. This triangulation work has been completed and is serving not only as a means of coördinating the individual large scale maps which are being produced, but also is of extreme value in the establishment of reference points for the guidance of our artillery fire.

Early in the war, when the fighting in France ceased to be in the open and developed into trench warfare, the conditions became, practically, those of a siege, and large-scale maps were in demand in numbers greater than had ever before been considered necessary. This state of affairs was responsible for the widespread production of the 1 to 20,000-scale map, this scale being now practically a standard on the French, British and American fronts. These 1 to 20,000-scale maps are known under different names, *plans directeurs* in the French armies, "trench maps" in the British, and "battle maps" in the American, but they are of practically the same type for all the armies. The contour interval is 5 m. Each map covers an area 20 x 16 km., and is divided into squares 1 km. on a side. These main grid lines are numbered for general reference, and a secondary system of coördinate numbers is applied to the 1-km. squares for the closer location work required by the artillery. It is not strictly accurate, by the way, to say that the grid lines form true squares, for they are actually projections, by the Lambert system, of imaginary north and south, and east and west lines on the ground. Due to the earth's curvature, the projection of the lines produces a slightly distorted "square."

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TRENCH SYSTEM SHOWS PLAINLY AT 1900 METERS

The origin of the coördinate system applying to all of the *plans directeurs* is fixed at a point so that all horizontal map distances are measured toward the east, and all vertical distances toward the north. The same scheme applies to the indication of positions within the 1-km. squares where the southwest corner of the square is always the origin of coördinates. Thus, in reference to a gun emplacement by coördinates there are not both plus and minus numbers; all are plus. These *plans directeurs* show the position of the enemy trenches, but not our own, except on secret editions for our staff. They also indicate German battery locations, roads, etc.

In connection with the use by artillery of the *plans directeurs*, the topographical division furnishes the means for locating the position of each fieldpiece by means of reference points on the ground. These reference points are tied in to the permanent triangulation points. If any movement of batteries forward or backward occurs, the topographical division must see to it that new points of reference are quickly available. By their aid the battery commander can readily determine the coördinates for the position of each of his guns, and having been given similar data for his objectives behind the German lines, the setting of the proper ranges becomes a simple matter.

By far the most valuable source of information for making maps of forward areas is the aërial photograph. It is, however, a subject on which few details can be given. The work divides itself into three phases, the taking of the picture, its interpretation after development and reconstruction of the data in map form. Our topographical division has developed a force of specially trained men for the last two steps of this work, which calls for the highest type of technical skill, long experience and thorough familiarity with almost everything connected with modern warfare. To the uninitiated some of these pictures would be absolutely meaningless. Ofter the exposures are made at great heights, when machines are forced upward by anti-aircraft fire; conditions of light may be poor; the machine not be flying horizontally when the exposure is made, causing distortion in distances. In fact, scores of variable factors enter into the work, and the interpreter of photographs taken in the air must be a man of seasoned judgment, able to evaluate each streak or spot and discover its true meaning. His work is made doubly difficult by attempts to camouflage the positions of enemy guns. The photograph reader, therefore, must be a student of camouflage in all of its many variations. After a picture is made, no attempt is made to enlarge or reduce it to some uniform scale. It is put under lenses of high power, as well as stereoscopes, which bring the details out in relief, and the man who reads its message must be able to make the proper allowances for the height at which the exposure was made. The usual height for taking a picture from an airplane for map-making purposes, I was told, is 2500 meters.

In addition to its standard maps, the topographical division is called upon for many special maps, which must be prepared and issued quickly to staffs. Speed and accuracy are both essential. If an attack is being planned, for example, orders from headquarters must be illustrated by diagram maps. The topographical division, therefore, must be well supplied with all the map data which could be demanded, and must be ready to send it out at almost a moment's notice.

As to the accuracy of maps of enemy areas based largely on information from aërial photographs, the English and French, after the advance in the valley of the Somme was made, had an opportunity of checking their maps. I am told that the degree of accuracy discovered was, on the whole, very satisfactory, although the results of field surveys disclosed some points which needed revision. During a recent trip to the front I saw an enemy map which was found on the charred body of a German aviator who had been shot down behind the allied lines. Half of it had been burned away, but on what remained was plotted accurately in red ink the location of a light railway spur of one of our Allies which had been constructed only three days before the map was taken from the dead body of its owner.

Having begun with the use of French maps, the American Expeditionary Forces have adopted the metric system for all of our topographical work. To change to

miles, instead of kilometers, at this date, would, it is believed, result in considerable confusion, especially as there are many situations demanding the interchange of maps between our own armies and those of our allies. Nevertheless, on our maps, in addition to the standard metric scale, is surprinted in red a scale in miles, and also a conversion table for metric and English linear measurements. French terminology also will be retained on new maps, although a glossary of terms is issued to facilitate their interpretation.

A tour of the "plant" of the topographical division at headquarters disclosed the work of map making in many of its phases. Leaving the offices of the chief of this service we went first to the filing room, in which is classified and stored a large stock of maps ready for immediate issue. An entire room was devoted to map storage, and piles of prints were arranged in rows on wooden shelves extending from floor to ceiling. Then we inspected the photo-lithography equipment, the printing presses, the gelatine process (used only when a limited number of copies is needed), the blueprinting machines, the drafting-room, the photographic copying apparatus and the various other features which the production of maps for use in war demands. By the gelatine process, which is patented, an impression is secured directly from a blueprint and transferred by inking the gelatine film and applying blank sheets over which a roller is passed. The gelatine process is employed extensively for color work, and especially for making over-prints—that is, adding new information to an existing map.

THE AIR CAMERA IS FLEXIBLY MOUNTED

One of the interesting sights in the topographical division was a collection of relief maps. They are used

HOW A RIVER, A RAILWAY JUNCTION, BILLETS AND FORTIFICATIONS APPEAR FROM 3200 METERS UP

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to quite an extent in staff work, and a detachment of our forces has been sent to a shop in Paris to learn how to make these maps. One method is to mold them directly while the other involves the cutting up of copies of a map, mounted on cardboard, along every contour and the arrangement of these sections, one above the other, forming a series of steps. The angles of the steps are then filled with putty and a casting in plaster of paris is taken, giving a reverse relief map. A second casting, from the reverse, gives a true relief map, and over it a contour map is stretched and pasted down. The process is said to require a good deal of skill, as the application of the contour map to the casting involves the stretching of the map fabric (it looked like paper) over the mounds representing hills.

While the work of our topographical division is proceeding its personnel is gradually being enlarged, and many new men are now being instructed in the details of the several branches of this service. Every day sees changes on both sides of the front which must be recorded on maps. Thus the work of the division is a never-ending one, and its members must continually be on the alert in order to be ready night or day to supply our forces with maps that are both accurate and up-to-date.

Lawrence Thawed Services at Low Cost

ELECTRICITY was used to thaw some forty of about one hundred frozen water services at Lawrence, Kan., last winter. According to information supplied to *Engineering News-Record* by E. H. Dunmire, city engineer and superintendent of the water department of Lawrence, the department borrowed a transformer from the local electric light company, two resistance boxes from the electrical department of the University of Kansas, and purchased about 1200 ft. of No. 8 insulated wire. The services thawed varied from 25 to 100 ft. in length, taking an actual use of current in each case from 5 to 90 min. The full capacity of the transformer was used, connected to 2300-volt primary wires and stepped down to 110 volts. The amperage varied from 70 to 110, depending largely upon the length of wire used.

All equipment was placed in a wagon, which was used as a trailer to a small auto truck. The apparatus was taken to the nearest point of the services to be thawed and connected by the local electric light company's man. For the man the city paid 60c. per hour for the time required to connect to the wires and for the current 10c. per kw.-hr., with a minimum charge for current of $1 for each connection. The equipment was then left in charge of two of the water department's men, who were paid 35c. and 28c. per hour. They laid out the wire, connected it to the service, closed the circuit and guarded the apparatus until the service was thawed, at which time the electric light company's man was called to disconnect the transformer from the primary line and go with the equipment to the next place.

With this arrangement, the department was able to thaw about twelve services a day, not only rendering quick service but saving the cost of tearing up the streets in order to thaw the frozen pipes by other methods. The average cost of thawing the 40 services was about $3.25.

Kansas Flood Studies Prompted by Food and War Conditions

FLOOD losses in Kansas average about $4,000,000 a year. As the state is largely agricultural and these losses have a vital relation to food production and the war, the 1917 legislature created a State Water Commission to investigate floods and suggest possible remedies. From a somewhat lengthy paper on the work of the Commission, submitted recently to the Kansas Engineering Society, the following notes have been taken:

Broadly speaking, the rivers of Kansas have small minimum flows and heavy flood discharges. For example, the Blue and Republican Rivers are affected by severe summer rains and have shallow beds with rapid descent. The Marais des Cygnes and the Neosho are overhung with heavy growths of trees which fall into the streams and retard their flow, and their valleys and banks are low. Another source of danger is the congesting of river channels, especially in the cities, by bridges and other structures.

The mean annual rainfall in Kansas ranges from 37 in. in the east to 15 in. in the west. In the eastern third of the state, including the lower reaches of the rivers named, the mean rainfall during the crop-producing season is 25.97 in.; and generally 71 to 76% of the annual amount of rain falls during the season.

"Destructive floods," the report states, "have occurred so frequently, especially in some of the smaller watersheds, that the most optimistic farmers are disheartened. Unless constructive measures for protection are worked out the psychological effects of such failures are easily apparent. Tenants with small capital prefer to farm less productive uplands rather than experience the uncertainties of loss by inundation of the more fertile bottom lands by these ever-recurring floods. Although disastrous floods do not occur throughout the valleys every year, there are many places where the lands are so low that they rarely escape some damage every season."

Work on these problems has been done by various Federal, state and local agencies, and some constructive flood protection has been afforded. These efforts have shown the need for records of stream flow, for coördination of effort, and generally for a governing body with power to direct work along the line of some statewide conservation policy.

The state water commission consists of Governor Capper, ex officio, Prof. H. A. Rice of the University of Kansas School of Engineering, and Roger C. Rice, district engineer of the United States Geological Survey. Its work, in coöperation with the United States Geological Survey, the United States Weather Bureau, and the local drainage districts, has been to outline the gathering of data and to establish means of recording stream flow and weather. River-gaging stations have been established at twenty "strategic" points on the Kansas, Marais des Cygnes, Neosho, Verdigris and Arkansas rivers and their tributaries. Rainfall records have been provided for. The work of the various drainage districts has been coördinated as far as might be with that of the commission. On this basis the commission will request the legislature of 1918-19 for appropriations sufficient to make the program effective.