THE CONSTRUCTION DIVISION OF THE ARMY.*

BY

BRIGADIER GENERAL R. C. MARSHALL, JR., U. S. A.,

Chief of Construction Division, War Department, Washington, D. C.

THE subject upon which I am invited to address you this evening is the work of the Construction Division of the Army during the World War. This is a subject so far reaching in extent, embracing so many angles, and of such large significance, that I have devoted considerable thought to what phase of it I had best take up and what method of approach I should employ. In view of the fact that in 18 months the Construction Division completed or had under way 581 construction operations, located in every state of the Union, except Nevada, involving an expenditure of more than twelve hundred million dollars, it is manifestly impossible to give any detailed résumé of its operations, for its accomplishment is too vast to be made intelligible by the mere recital of statistics, and the spirit of its men and their remarkable teamwork is too elusive for the camera to record. Neither figures nor photographs can adequately tell its story.

The Construction Division of the Army is an independent staff corps. It has no relation to the Quartermaster Corps, nor to the Corps of Engineers, with both of which it is sometimes confused in the mind of the public. It is a separate entity, which had its genesis in the Construction and Repair Department of the Quartermaster General's Office. This small subdivision, before the war, was charged with the construction and repair work at the Regular Army Posts. In no year did it expend more than 15 million dollars. In 1916 it had prepared typical plans for temporary mobilization camps in view of possible trouble along the Mexican Border, but nothing had been done in anticipation of the extensive requirements made necessary by our entry into the World War.

Upon the declaration of war the immediate problem con-

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fronting this Government was that of raising an army of millions and of providing accommodations for its housing and training. In the Regular Army Posts, scattered throughout the country, there was accommodation for less than 100,000 men in small isolated posts, totally inadequate for the training of men, in large groups. The task of providing camps and cantonments ready to receive the citizen soldiery as soon as it could be called to the colors was assigned to Colonel I. W. Littell, who was relieved of his duties as Chief of the Construction and Repair Division of the Quartermaster General's Office and placed in charge of the Cantonment Division. From this small beginning, with its force of three officers and less than 30 civilian assistants, there was developed the Construction Division of the Army. Its personnel was recruited almost entirely from civilian experts. Engineers, architects, construction men, material men, auditors and contractors were called to Washington and commissioned for a definite service. Every man was a picked man and his ability and reputation personally known to at least two members of the rapidly growing organization. At the signing of the Armistice there were 1429 commissioned officers in the Division, of whom less than a half dozen were officers of the Regular Army, and the civilian personnel totalled over 30,000 employees, and there had been employed on its projects more than 427,000 laborers.

With the growth of the Division came increased responsibility. Before the construction of the sixteen original army cantonments was well under way, the Division was directed to construct within two months' time sixteen additional tent camps for the National Guard, with a capacity of 684,000 men. Before any of these were completed, orders were received to build a Quartermaster training camp at Jacksonville, Florida, and ports of embarkation in the vicinity of New York, Norfolk and Charleston, so that the men when trained could be readily shipped to France.

On October 5, 1917, the Secretary of War directed that all construction work for the Army within the United States should be performed by the Construction Division. Under this order, work was done for every division and bureau of the War Department, involving every class of engineering construction, and costing more than 10 per cent. of the total expenditures made by this country for war. Because of the spectacular performance in connection with the construction of the camps and the publicity

given them by reason of their occupancy by men from all parts of the country, they are thought by the public generally to be the principal work done by the Construction Division. In matter of fact, their cost represents less than half of the total sum spent by the Division. In addition to housing accommodations for more than two million men, this Division built arsenals, storage depots, industrial plants, gas plants, proving grounds and other such projects for the Ordnance Department; hospitals, with a capacity of more than 121,000 beds, for the Medical Department; huge interior storage depots similar to the one in this city, and port terminals at Boston, Brooklyn, Norfolk, Charleston and New Orleans, for the Quartermaster Department; warehouses and flying fields for the Signal Corps and the Division of Military Aeronautics; mechanical repair shops for the assembling and repair of automobiles and trucks for the Motor Transport Corps; and embarkation and debarkation facilities for the Transportation Service.

A body of tremendous assistance to the Construction Division, especially in the early days of the war, was the Emergency Construction Committee of the Council of National Defense. Under the chairmanship of Mr. W. A. Starrett, of New York, later commissioned Colonel; Mr. Frederick Law Olmstead, of Boston; Mr. C. W. Lundorf, of Cleveland; Mr. M. C. Tuttle, of Boston, and Major William Kelley, of the United States Army, this committee laid down many of the fundamental policies for handling construction work. It was a "Ways and Means Committee," whose counsel was sought and valued. It was in part responsible for the wise decision to utilize every available construction agency which had been perfected by years of commercial competition, as a part of the working machinery of the Construction Division. By utilizing the large contracting firms of the country and their efficient organizations, it was possible to keep their trained personnel intact and to make available to the Government their experience and talent. There was the additional consideration of the necessity for stabilizing the economic and business life of the country and carrying these organizations through the period of war, rather than disrupt and destroy them by trying to organize their employees under direct Government control. The same policy was extended to include the consulting engineer, and on each large project there was employed an experienced engineer of national

reputation who, with his organization, took the fundamental plans supplied by the Washington office and adapted them to meet the local requirements of his job.

Having determined to use existing engineering and contracting firms, it became necessary to formulate a contract which would short-cut the peace-time red tape and procedure of the War Department and make it possible to get immediate action and quick results, at the same time relieving the contractor of many of the hazards growing out of the war which he would incur under a lump sum form of contract, but still protecting to the fullest possible degree the Government's interests. A number of well-established methods were considered and discarded; the lump sum contract, the lump sum contract with cost plus for changes and additions, the agency form of contract, and the unit price form of contract were all open to serious objection. They were not flexible enough to permit the changes in plan, the increase in size and scope of the work and the modifications in the type of construction, which it was known, would have to be made to meet the new and ever-changing requirements developed by experience at the front.

In no case when a construction project was begun, was the completed project clearly delineated or its final requirements known. I have in mind one job, which, when begun, was planned as a small project, costing a quarter of a million dollars, and which, before it was completed, was expanded a hundred fold and cost twenty-five million dollars. This is an extreme case, but the principle held good throughout all the work which the Construction Division did, and both its engineering and administrative organization, as well as its construction forces, had to be organized and made flexible enough to immediately adjust themselves to any change in requirements which new developments in the science of warfare might impose.

Twice the cantonment plans had to be materially altered after construction was well under way. First, because the regimental units and company quarters were laid out to fit the American Army organization as it existed previous to the war. General Pershing did not arrive in Europe until June 15, 1917. He immediately found that the experience of both the British and French Armies had demonstrated that a company of 250 men was a more convenient size for trench warfare than the smaller 150-man company

of the American Army, and the plans for the barracks buildings and regimental areas were changed accordingly. Again experience demonstrated that the health of the troops might be put in jeopardy by overcrowding and for that reason the Surgeon General revised his plans and required that at least 500 cubic feet of air space be provided in barracks and quarters for each man housed therein. To provide for such contingencies as these the contract for construction had to be of the utmost flexibility. The main point was to get started and get started immediately with the possibility of developing the details of the project as its requirements became more and more definite.

Due to the urgent necessity for speedy completion of the work, there was no time for drawing up detailed plans and specifications had it been practicable to make them. The job had to be finished in less time than it ordinarily took to prepare plans. The creation of a field organization, the drawing of plans, the procurement of the materials, the engineering work at the site and the actual building construction all had to go hand in hand and all had to be begun immediately. The only form of contract which would permit this method of procedure was the one adopted. It is generally called, in the War Department, the Emergency Form of contract. A more descriptive name, though perhaps a cumbersome one, is "the cost of the work with a sliding scale of percentage, limited by a fixed fee." Its critics have, since the Armistice, tried to discredit it by calling it the "cost plus 10 per cent. contract." This is indeed a misnomer for only on the smallest jobs, totalling less than \$100,000 in cost, and prior to October, 1917, was a 10 per cent. fee paid. (After this date a fee of 7 per cent. was the maximum fee paid.) On the greater portion of the work not more than 4 per cent. or 5 per cent. was paid the contractor.

Briefly stated, the contractor was reimbursed for the actual cost of the project, plus a percentage fee for the services of his organization. This fee grew less and less as the cost of the job increased, until the maximum limit of \$250,000 was reached, after which no more fee was paid, regardless of the size of the job. The plan worked well. Where a job was estimated at the time the work was started to cost \$100,000 the contractor might receive a maximum fee of \$10,000; if it cost less than the estimate, he received 10 per cent. of the actual expense; if it cost more than

the \$100,000 estimate, he received only the \$10,000; on work estimated to cost \$250,000 a fee of 8 per cent. was the maximum allowed and so on down, until the percentage fee on a three and a half million dollar contract was 6 per cent. At the time each job was authorized an upset fee was fixed, based on the estimated cost, beyond which the contractor would not be paid. The contract definitely provided that in no case should the total fee paid on any job, regardless of its size, exceed \$250,000. In this way a contractor might receive a \$250,000 fee on a job costing \$5,000,000, but he would receive no more than \$250,000 if his job cost twenty million dollars.

After the contractor had paid out of this fee the cost of his main office and the salaries and expenses of the members of his firm engaged on the work, his surety bonds and the interest on the capital required to finance his job, only a small part of his gross fee remained as net profit. On the sixteen National Army cantonments the gross fee paid to the contractor ran between 2 and 3 per cent. of the cost of the work. On some of the larger jobs, because of the \$250,000 maximum limit, it was not more than 1 per cent., whereas had these projects been let on a lump sum basis, under the hazard of war-time construction, the contractor would have been obliged to add from 10 to 25 per cent. to his estimate of cost to cover his profit and his contingencies. A criticism of this form of contract generally implies a lack of appreciation of the conditions under which this work had to be done. The fixing of an upset fee on each job, regardless of its size, beyond which the fee paid to the contractor could not go, had a tendency to check extravagancies or any desire to prolong the job. It was to the decided interest of the contractor to finish his work in the shortest possible time, to do it as cheaply as he possibly could and thereby establish his reputation for good work and thus win favorable consideration for additional work.

This contract has stood successfully against every assault and there has never been a successful refutation of the form used as protecting the interest of the Government and allowing the utmost flexibility and freedom of action. It must not be confused with an ordinary cost-plus-a-percentage contract, under which the more the job costs the more the contractor receives, for it was far from such.

The Secretary of War appointed a committee, including the

Presidents of the National Engineering Societies, the Chamber of Commerce of the United States, the Construction Employees' Association and the American Federation of Labor, to review every form of contract which might be used for war work, and compare it with the Emergency Form, to determine whether or not any other kind of instrument would permit the Government to carry forward its construction program to better advantage. They reported briefly as follows: "No reasonable objection can be pointed out by anyone possessing a full understanding of its equitable operations and practice, and finally this scheme possesses one qualification which must commend it to all thinking men: it permits starting actual work weeks and even months before the details are completely worked out and delineated and permits the Government to push the job at any speed it may elect, changing at will its plan and scope and paying only what the work actually costs, plus a fee which is so reasonable as to be above the reach of fair-minded criticism."

The organization plan of the Construction Division is a simple one. There is a central organization in Washington, which lays down the fundamental requirements for each project, procures the authority and funds for its construction and follows the work through from its inception to completion. The details of the job are handled in the field at the site of the work. They are directly under an officer called the Constructing Quartermaster, who is responsible to the Government for the satisfactory completion of his job and for the proper disbursement of funds. He is the commanding officer during construction and all other agents, both engineer and contractor, report to him. His organization is built up to meet the requirements of the particular project under his charge and is a miniature of the main organization in Washington, having its engineering, materials, administrative, accounting and labor departments. In cases where difficulties are experienced or where advice is needed, he takes the matter up direct with a Supervisor in Washington, who is the point of contact between the Washington Office and the field. This Supervisor has a group of jobs under his direction and sees to it that his several Constructing Quartermasters in the field are kept in daily touch with the material and labor situation, furnished plans, and that materials purchased directly by the Washington organization have clearance and are shipped to the jobs and that

all legal and auditing matters are in accord with Government practice. The Supervisor in turn reports to a Section Chief, who is generally responsible for the work of some particular bureau, such as hospitals for the Surgeon General's Office, ordnance plants, or aircraft work. These Section Chiefs and their groups of jobs make up the Building Division and report to the Officers in Charge thereof.

The Engineering, Contracts, Administrative, Accounting, Requirements and Procurement Divisions act as service sections for the Building and Utilities Divisions, furnishing to the field forces expert technical data which the requirements of the job demand. The work of these several service sections is fairly well indicated by their names. The Engineering Division is responsible for all engineering matters from the survey of sites to complete and detailed plans for buildings and utilities, water supply, sewage disposal plants, heating, lighting, camp sanitation and the like. The Contracts Division prepares the contracts and interprets them, and acts in a similar capacity to a general counsel of a large business organization. The Administrative Division is charged with the employment of civilians, adjusts all wages, the settlement of labor disputes and the clerical work in the Washington Office. The Accounting Division attends to the money matters, including the auditing and checking of the expenses of the jobs. The Requirements Division presents the requests for authority to the Secretary of War, through the Director of Operations, and secures the necessary funds. The Procurement Division keeps in touch with the markets of the country and mobilizes and arranges for the transportation of the huge quantities of building materials required for the many projects under the jurisdiction of the main office. The Building Division is responsible for the conduct of the actual operations in the field and during the War was the manufacturing department of the business, its finished project being camps, hospitals, ordnance plants, etc., with the other departments assisting it in its stupendous task. The Utilities Division maintains and operates the project after its completion. The present organization differs but little in its plan from that which was laid down at the beginning of the war and the basic principle then established has controlled its activities since its inception.

The Construction Division, during the period of its war activi-

ties, was the largest construction organization in the history of the world and the largest employer of labor. In addition to its commissioned and clerical personnel, its working force numbered 427,000 laborers, more than twice as great an army as that which fought at Gettysburg on both the Union and Confederate sides, and more than four times the number of our Regular Army at the time of the declaration of war. This construction force had to be housed and fed during the construction period and this in itself was no simple problem, for many of the sites chosen for the camps were located on remote and virgin fields without a single facility for the accommodation of the labor which must build them. The outstanding feature of this work was the magnitude of the operation combined with the speed of its accomplishment. The individual buildings which made up the project were in themselves neither intricate of design nor difficult of construction, but the task of assembling them into a complete whole within the short time available so that they might be ready to serve their purpose was one of the things that made victory possible. Upon the continuity of supply of men and munitions the destinies of the overseas forces were absolutely dependent. Once a project was conceived it took its place in a definite schedule and it had to be completed in accordance with that schedule, or else all of the arrangements of the War Department based upon its being ready to perform its function at a given time would have been thrown into confusion by the failure of one step in the process. Can you imagine the resulting confusion had the operation of the draft been delayed because these camps were not ready to receive the men, or what might have happened had the newly made soldiers not been able to sail for France because of the lack of embarkation facilities? The Construction Division was one Government agency which delivered the goods on time.

Previous to the War the several bureaus of the War Department did their construction work independent and oftentimes in competition with each other. After the camps and cantonments were completed and the advisability of concentrating construction under a single head had been so clearly proven, the Secretary of War delegated to the Construction Division all the construction work required in this country. Each bureau made known its requirements, plans and estimates were then prepared by the Construction Division, authority for the expenditure of the neces-

sary funds was secured from the Secretary of War, a contractor was recommended by the Council of National Defense and approved by this Division and the construction work immediately started. Full authority for every detail of the work was placed upon the Construction Division and it was held accountable only for results.

In order that you may appreciate some of the phases of the work a few words may be in order as to how the building of the National Army camps was carried out. There were 16 of these projects, whose location was selected by a special Board of Regular Army officers in May and June of 1917. The last site was not approved until July 6th. Upon each of these sites it was required to build a camp capable of housing 40,000 men and accommodating 14,000 animals. Each one of these camps had to be a self-contained community with every modern facility for the comfort and health of the men who would be trained there. Barracks, mess halls, lavatories, administration buildings, officers' quarters, storehouses, refrigerating plants and laundries had to be built, water and sewer systems installed, roads constructed and railroad tracks laid, and lighting and heating provided. Each camp was in itself a veritable modern city, costing from 8 to 12 million dollars, which had to be created from the ground up within the short space of three months. If you can picture in your mind what it would mean to have to provide in that short space of time housing accommodations for all the people in Philadelphia, while New York, Baltimore and Pittsburgh were all equally busy on similar rush work and therefore fighting for the available labor and materials and freight cars which your job required, you will have some idea of the size of the task and the difficulties involved.

The fundamental engineering principle laid down by the Washington Office for adaptation to the conditions in the field were based on both Army and Municipal experience in this country modified by information received from our Allies. The Town Planner and Landscape Architect, together with the Fire Prevention Experts, prepared typical layout plans, indicating the amount of space required for the various buildings and the arrangement of the regimental areas. The varying topography at the several sites made it necessary to adjust these typical layouts to fit the ground in the field. To give an idea of the size and character of a complete camp, Camp Grant at Rockford, Illinois, may be

taken as a fair illustration. This cost approximately \$11,000,000 and has a capacity of 43,000 men and 12,000 animals housed in 1600 buildings. The water supply system includes 6 wells, 38 miles of pipe and a reservoir of 550,000 gallons capacity. The electric lighting system required 1450 miles of copper wire, 1200 poles and 35,000 incandescent lamps. About 50,000,000 feet of lumber was required for its construction, which was erected at the rate of 500,000 board feet per day. The Division Hospital has a capacity of 1000 beds. Camp Lewis, at American Lake, Washington, is one of the most beautifully located of all the cantonments and is even larger than Camp Grant. It cost, in 1917, about \$215 per man to provide complete housing accommodation in the National Army Camp and about \$88 per man in the National Guard tent camps.

The water supply for the camps presented another serious problem. It was determined that 50 gallons per capita per day should be allowed for each man in camp and 15 gallons for each animal. This is about 80 per cent. more water than was supplied to the British, French, Canadian, Belgium or German camps. The primary requisite, of course, was to provide a water of unquestioned purity and where there was any possible danger from pollution to filter and sterilize it before distribution. In some cases existing water works systems in the nearby cities were available but even in such cases the strictest sanitary control was exercised over the plant and many betterments and extensions made. In some cases these extensions were financed by the Government, the municipality reimbursing the Government for the expenditure in free water. Where water was purchased the average cost was approximately 8 cents per 1000 gallons. In many locations independent plants were built including the most modern pumping and filtration apparatus. In all, some 275 different water supply installations were made, involving construction of 1100 miles of pipe from six to thirty inches in diameter, 700 miles of service pipe, $\frac{3}{4}$ inch to 2 inches in diameter, with a combined pumping capacity of 650,000,000 gallons per day; the reservoir capacity in tanks was 67,000,000 gallons, while impounding reservoirs capable of holding 3,000,000,000 gallons were constructed; filter plants were built having a daily capacity of 40,000,000 gallons and more than 4,000,000 troops and 2,000,000 civilians were supplied with water. Up to date there has not been a single case of

typhoid fever or other water-borne disease attributed to the impurity of any water supply, designed, operated or controlled by the Construction Division, which in itself is one of the outstanding facts in the history of this war.

Owing to the shortage in iron and the need for this metal for munitions, cast-iron and steel pipe was not available for the camp water systems except in limited quantities. Wood-stave pipe of Canadian white pine and California redwood was used, resulting in a large saving, both in money and time of laying. California redwood tanks of 200,000 gallons' capacity were largely used for the storage of water, their cost was much less than either steel or concrete, and the time and labor required for their erection only a fraction of that necessary for steel or concrete reservoirs.

Hand in hand with the need for providing a safe water supply was the necessity for disposal of sewage and other wastes in the most sanitary possible manner. With populations ranging from five to sixty thousand men and with a density of population in many cases much higher than found in cities, it was necessary to take every possible sanitary precaution. Standard designs and general specifications for the construction of sewer systems and sewage treatment plants and for garbage incinerators and can-washing equipment were prepared in the Washington Office and turned over to the Supervising Engineer on the job for adaptation and execution.

The standard tanks for sewage treatment were the multiple compartment horizontal flow type, provided with cross baffles so as to facilitate sedimentation and to permit the withdrawal of sludge. The bottoms were pyramidal and where the effluent was discharged into a large stream, no other treatment than dosing the effluent with chlorine was required. In some cases sprinkling filters and secondary sedimentation tanks were installed. In designing the sewage treatment plants an allowance was made for 60 gallons per capita. In hospitals 150 gallons per bed, and 60 gallons for each attendant was assumed as the basis for design. More than 1000 miles of sewer pipe were laid, over 100 sewage disposal plants were built, with a combined capacity of 20,000,000 gallons. The total area of the sprinkling filters constructed is over 500,000 square feet. The cost of the tanks

complete, with filters, at each of the 40,000 men camps was about \$200,000, or \$5 per capita.

It early developed that the amount of grease in the kitchen waste was far in excess of that encountered in ordinary municipal sewage. To relieve the sewage of this excessive grease load and prevent its interference with the operation of the disposal plants, a special type of grease trap was developed by means of which it was possible to recover about 95 per cent. of the grease contents in the sewage. It was found that about 13 pounds per capita per year of grease valuable for commercial use could be obtained from the wastes from the kitchens. Much of the camp waste was of commercial value. Garbage stations were erected and the waste material carefully classified was generally separated into garbage, fats, grease, bones, bottles, tin cans, paper and manure and so much as was of value sold under contract to Waste Disposal Companies. Special incinerators were designed and built by the Construction Division to destroy the wastes which had no market value. In some cases piggeries were established and the camp garbage thus profitably converted into fresh meat for the Army. As a result the Government received over a million dollars a year income from what would otherwise have been a total loss.

Many of the ideas developed in connection with the sanitation and waste disposal work were original in character and will be a permanent contribution toward the science of sanitary engineering.

The necessity for providing roads to carry the heaviest possible traffic, after some experiment, led to the choice of concrete as the most suitable type of pavement, but other types were used, such as brick, gravel, macadam and bitulithic, where the materials could be quickly procured.

It may not be out of place to once more call attention to the tremendous decrease in the proportion of deaths from disease brought about by the intelligent supervision and exercise of stringent sanitary regulations during the present war. As a proof of the efficiency of such measures as pure water and proper sewage facilities, drainage, mosquito control, comfortable housing and adequate hospitals, it is interesting to compare the figures during this war with those of our previous wars: In the Mexican War the deaths from disease amounted to 110 per thousand men; in

the Civil War, this was reduced to 65 per thousand men; in the Spanish-American War, 26 per thousand, and in the Russian-Japanese War the deaths among the Japanese troops which at that time represented the highest attainment in sanitary practice was 20 per thousand.

In July and August, 1918, when the camps and cantonments were in full operation, the death-rate from disease was 2.8 men per thousand, which is less than half of the death-rate for men of military age in civilian life. The rate from the beginning of the war up to the outbreak of the influenza epidemic was less than five per thousand men.

One feature of the work of the Construction Division that contributed largely toward this remarkable record was the provision all over the United States of ample hospital accommodations. Plans were prepared in conjunction with the office of the Surgeon General, not only for the hospitals in each of the Divisional Camps, but for special hospitals at many other places, including those for the treatment of tuberculosis, shell shock, for reconstruction work and other special requirements growing out of service in the theatre of operations. Altogether accommodations were provided for 121,000 patients, 12,000 nurses, 34,000 enlisted men and 4000 doctors. Many of these hospitals were built on heretofore unoccupied ground and required in addition to the buildings the installation of the necessary sewers, water and electric lighting systems, roads, and railroads. The camp hospital buildings were generally of one-story wooden construction connected by closed corridors so that patients might be readily wheeled in roller chairs from one building to another. These corridors were cut off from the main buildings by fire walls to prevent the spread of possible fires. Provision was made for every appliance of the modern hospital. X-ray laboratories, bacteriological laboratories, hydrotherapeutic wards and the most complete operating rooms and special laboratories for research work were installed. As the war progressed, the hospital plans were modified and terra-cotta block and stucco on metal lathe substituted for wood, and the buildings made two and three stories in height, thus bringing the units closer together and facilitating administration. At a number of the Regular Army Posts departmental hospitals were established, using the original post hospital as a nucleus and remodelling other buildings to meet the requirements and at certain

places throughout the country general hospitals, some of them containing from 2000 to 4000 beds, were constructed. Such commercial buildings as the old Siegal-Cooper store and the Grand Central Palace in New York were converted and made into large reception hospitals for the sick and wounded soldiers returning from overseas. At Ashville, N. C., and Denver, Colorado, special hospitals were constructed for the treatment of tuberculosis and other lung troubles.

The German drive in the spring of 1918, with its resulting large number of casualties, made it evident that a decided increase in the hospital accommodations would have to be provided immediately. There was no time to build new construction and in consequence a number of private buildings, such as museums, industrial plants, the Ford automobile factories and properties of like nature were taken over and converted by the Construction Division into reasonably satisfactory hospitals. In all, the Construction Division provided through new construction, purchase or remodelling a total of 294 hospitals, costing approximately \$128,000,000. These ranged in cost from \$750 per bed up to \$2000, depending upon the isolation of the site and the character of construction.

Practically all of the buildings in the camps were of frame construction and therefore very inflammable. The fire hazard in the camps and hospitals was one which caused a great deal of concern until the effectiveness of fire prevention measures and inspections was so clearly demonstrated. A number of fires have started, but in only three cases has the fire spread beyond the buildings of its origin. The records for the year of 1918 show that the per capita loss by fire throughout the United States was \$2.70, whereas the total per capita loss at the various Construction Division activities for the year ending June 30, 1918, was only 67 cents.

Of all of the construction projects, those built for the Ordnance Department are of the greatest interest, embracing as they do many new problems of construction and manufacture, plant layout, and shop arrangement. There were sixty of these projects costing a total of \$175,000,000. One of the largest is the Proving Ground at Aberdeen, Maryland. Here are accommodations for 8000 men, a plant 165 feet wide and 500 feet long for assembling gun carriages and mounts for artillery and the

largest machine shop in the United States. The reservation contains 35,000 acres of land with facilities for every conceivable test, which may be desired of the many different types of guns and munitions developed during the war. There is also a bombing field where airplanes may practice aero bombing and 4000 acres are given over to the manufacture and testing of gas shells. This latter area is known as Edgewood Arsenal and its facilities cost approximately \$30,000,000. There are quarters for 10,000 men and a gas-filling plant with a capacity of 120,000 loaded shells per day. Here mustard gas, phosgene, caustic soda, picric acid and other weapons of chemical warfare were produced on a large scale.

Explosives from their very nature must be stored by themselves and far away as possible from thickly settled sections, and at the same time this storage must be convenient to railroads and docks so that the contents of these magazines could be delivered to ocean-going vessels without unnecessary handling. The difficulty of finding such sites which were suitable for such construction within reasonable distance of deep water and rail facilities was apparent at the outset. Five of these projects were located along the Atlantic Coast, one at Metuchen, N. J., Pedricktown, Del., Pig Point, Va., Curtis Bay, Md., and Charleston, S. C. The Raritan Arsenal, which is at Metuchen, N. J., is the largest of these projects. This reservation comprises 2200 acres of salt marsh, which to prevent its submersion at high tide, had to be protected with a dike around the entire reservation. The soil itself was such that every structure erected had to be supported on piles. An Ordnance School was also located at this point with accommodations for 10,000 men. Fifty miles of railroad were required and a dock of 2000 feet in length with warehouses and other facilities were provided at a cost of about \$14,000,000.

Bag-loading plants were another development made necessary by the War. Guns up to, and including 4.7 calibre, used ammunition in which the explosive is loaded in a metal cartridge case, similar in appearance to small arms ammunition, but guns of larger size used what is known as unfixed ammunition, that is, the powder is packed in silk bags of the diameter of the gun and after the projectile is placed in the bore of the gun a bag or number of bags, depending on the size of the gun, are loaded into the breech to form the propelling charge. The filling of these

bags must be done with the utmost accuracy, after the explosive itself has been carefully blended in order that no variation in the propellant force of the charge may occur. Three of these plants were constructed, one at Woodbury, N. J., one at Tullytown, Pa., and one at Seven Pines, Va. Because of the character of the work and the danger incident to the operation of the plant, these had to be as isolated as possible. So that complete quarters for the employees, many of whom were women, had to be built to provide for the operating personnel. These plants involved many new problems of engineering details and yet they were completed within three months' time.

Practically all of the shipping facilities required for the War were under the direction of the Shipping Board; the Construction Division, however, built and placed in operation 276 barges and lighters for use in handling supplies in connection with the Newark Terminal and for the loading and transportation of munitions from the Pig Point and Curtis Bay Storage Depots to the outward-bound ships.

At the beginning of the war, construction pertaining to the Air Service was under the jurisdiction of the Signal Corps, but after October, 1917, the Construction Division began taking over the construction work which was then in progress and after the early part of 1918 did all of this work. Flying fields were established in many parts of the country and housing provided for their personnel. Special buildings were constructed for housing of dirigible balloons and there is now in course of construction at Langley Field, Virginia, the largest dirigible hangar in the world. The R-34, which made the Trans-Atlantic flight, is 78 feet in diameter. This new hangar will accommodate a dirigible 100 feet in diameter and still leave space in the clear for a 16-foot car. Balloon schools were also constructed at Lee Hall, Virginia, and Arcadia, California, and used for the training of aerial observers. In the design of the dirigible hangars which are 168 feet high and 680 feet long, the problem of the door design is a difficult one. These doors are 70 feet in height and 40 feet wide. Their structural makeup and the method of opening them when they are in place, is one of considerable interest to a structural engineer, as well as the large amount of bracing required to withstand the heavy pressure of the wind against such a large surface.

For the Motor Transport Corps, maintenance and repair shops were constructed for assembling tanks, tracks and trucks used in connection with the Mobile Artillery, as well as for the ordinary passenger automobile. At Baltimore, Atlanta, and San Antonio, large projects for this purpose included enormous shops and garages and training schools. The buildings are fitted with the finest types of machine tools, cranes and other equipment and compare favorably with the most up-to-date automobile factories.

While the activities of the Construction Division have been confined to this side of the Atlantic, a notable exception may be mentioned in the case of the refrigerating and cold storage plants, designed, purchased, and shipped to France. Immediately upon the assemblage of the necessary materials for these plants, the Construction Division also organized the personnel for their operation. When the United States entered the war, there was available for the use of the American soldiers in France a storage capacity of only 750 tons of beef. This was later increased to 4000 tons capacity. During the same time the Construction Division provided in this country a capacity for 24,000 tons of beef. Owing to the distance that this beef had to be transported, a sharp freezer plant had to be provided where chilled beef could be hard frozen at a temperature of 15 degrees above zero in order to make it easy and safe for transportation. To meet this emergency, the Construction Division erected at Chicago the largest sharp freezer plant in the world. It is the most modern type of concrete and brick construction, insulated throughout with cork. It has a daily freezing capacity of 1400 tons, equivalent to 5000 animals, and a storage capacity of 14,000 tons of frozen beef.

Refrigerating and ice-making plants were designed and constructed at many of the camps and hospitals, but these were generally small in size, being designed to produce from 50 to 200 tons of ice per day, adequate for the army population of their particular locality.

Among the largest projects built by the Construction Division are the huge terminals at Boston, Brooklyn, Norfolk, Charleston and New Orleans. In them was concentrated the vast store of materials required by the overseas forces. Here these supplies were collected and loaded on ships. Tributary to these embarka-

tion terminals or Army Supply Bases were interior Storage Depots located at important railroad junction points and convenient to the great manufacturing centres of the country. Depots of this character were established at Philadelphia, New Cumberland, Pa., Schenectady, New York, Columbus, Ohio, St. Louis, Chicago, Jeffersonville, Ind., Pittsburgh and Baltimore. They provide a total storage space of 12,000,000 square feet.

These Army Supply Bases may be described as a combination railroad terminal and storehouse for the protection of merchandise and its transshipment to ocean-going vessels. The Boston Base is eight stories in height and is 128 feet wide and 1628 feet long. It has a storage space of 2,750,000 square feet. This building is paralleled by a wharf shed of the same length, two storied in height, while at the outer end of the 4000-foot pier, carrying these buildings, are two upper sheds, each 924 feet, by three stories. The terminal yard includes 30 miles of railroad track, extending to and through the various buildings, as well as along the sides of the dock. This huge project was built in five months and cost 25 million dollars. At Brooklyn there are two 8-story concrete warehouses, each 980 feet in length, one being 200 and the other 300 feet in width. These buildings contain four million square feet of storage space. Serving them are three double-deck piers, each 150 feet in width and 1300 feet long, and an upper pier 60 feet wide and 1300 feet long. The storage tracks will accommodate 1300 freight cars and the docks permit twelve 800-ton ships to be loaded at one time. With the mechanical equipment it is possible to load a vessel in 24 hours. This project was completed in approximately one years' time, and cost \$28,000,000.

The Norfolk Base contains two million square feet of storage space, a mile of dock and terminal tracks for freight cars. This project required the reclamation of 217 acres of mud flats, the building of concrete pile bulkhead, and the filling in with material removed from the harbor to give the required depth to accommodate deep draught vessels. Here a cantonment was erected for a regiment of stevedores and a battalion of guards, including a 120-bed hospital. This project was completed in about 12 months' time and cost \$25,000,000.

The Army Bases at Newark and at Charleston, S. C., are the one-story type and similar to Norfolk, while that at New Orleans was of reinforced concrete and comparable with the Brooklyn and

Boston projects. These Army Supply Bases and the Interior Storage Depots have a combined storage capacity of 27,502,300 square feet. With an additional 2,176,000 square feet of storage capacity and open sheds, an area equivalent to a building seventy feet wide and eighty-one miles long, the docking space is capable of accommodating 65 ships at one time. Eight hundred and forty-four miles of railroad track and 1061 miles of concrete road serve these projects.

This, in brief, is an outline of the scope of the work done by the Construction Division. It is a remarkable fact to my mind that such an organization could be suddenly created and built up in a period of 18 months into the greatest construction outfit of all time, and that, by the welding together of peace-trained engineering and building organizations into a military unit with a single purpose, it could undertake and carry to successful completion a building program on a vaster scale than was ever before conceived in the mind of man. Out of its success there is engendered a new feeling of respect in the Army for the capacity of the civilian scientist, engineer and constructor and his value as a military asset, a feeling that he may be depended upon in any future emergency, to quickly divert his talents to warfare as effectively as he follows his normal, peaceful pursuits, for he has proven his worth and established his war value. His contact with the Army has also given him a new viewpoint which enabled him to better sense the military problem of the country and to contribute understandingly towards its solution.

Much of the work which the Construction Division did was of necessity a part of the waste of war, in the same sense that the powder shot on the battle front was waste, and it has no permanent value as a peace-time asset, and yet there are many of its projects which have already become an important part of the economic fabric of our nation. The Army Supply Bases at Brooklyn and Boston, and at Norfolk, Charleston and New Orleans represent the finest port terminal facilities in the world. In connection with an American Merchant Marine, they will become as useful for peace as they were in time of war, and they were designed and built with this thought in view.

Against the huge sums spent by the War Department, there is the offset of such improvements as these terminals. In many other localities there have been provided new roads, new manufac-

turing developments, enlargement of electric, steam and gas plants, provision for better sewage disposal and adequate water supply, rehabilitation of both steam and electric railroads, the establishment of steamship and railroad terminals, the drainage of malarial areas and reconstruction of buildings and communities to improve living conditions, all of which the demands of war forced into existence, and which now remain as a vast asset to the country. Thus have our "shields been beaten into plowshares and our swords into pruning hooks."

To few men have fortuitous circumstances brought such an experience as has come to me as Chief of the Construction Division. I have felt a thrill in directing the efforts of this great creative body of men. I have seen the engineer, the highly specialized technical expert, the contractor, the auditor, the engineer, the clerk and the laborer rise at their country's call and for the time being throw off the hampering jealousies and restrictions of their normal life and accomplish the impossible; and the credit for this achievement rests largely upon men, such as you, who make up the membership of Franklin Institute, the American Society of Civil Engineers and the other national technical associations, and who more and more are dominating the future course of this great nation.

Electrolytic Chromium. (Advance sheets of a paper by GEO. J. SARGENT, Res. Chemist, from the 37th general meeting of the Amer. Electrochemical Society, Boston, April 8-10.)—Brief allusion is made to the history of the deposition of chromium, including some unpublished work by Skillman of Cornell University. Details are given of the various mixtures of chromic sulphate and chromic acid showing that the yield of metal is greatly increased by the presence of chromic sulphate. Comparisons of results with rotating and stationary cathodes and of the differing temperatures and strength of solution are tabulated. Very good deposits of chromium were obtained in some of the experiments, low temperatures yielding fair ampere-hour efficiency at comparatively low current density. The chromium deposit is very resistant to corrosion by ordinary influences, for which reason the author concludes that such plating has important commercial possibilities.

H. L.