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Transportation Engineering, A. E. F.

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ON June 1, 1917, when the writer was on his way to France on the steamship *Baltic,* as a member of the first American Expeditionary Force under General Pershing, he was informed by Colonel Harry Taylor, Chief Engineer Officer of the A. E. F., that, since he was the only railroad engineer in the expedition, it would be up to him to provide the necessary port and railroad facilities for the American Army in France. Before landing at Liverpool on June 8, numerous sketches for docks and yards had been made and tentative bills of material worked out on the basis of supplying seventy-five thousand men. Train and other transportation requirements were also given consideration.

No one could have anticipated anything like the stupendous task that was awaiting us on our arrival in France. The original conception was to send about fifty thousand to seventy-five thousand men to France within a short period and increase this to about five hundred thousand men, if necessary. The necessity, of course, arose and large contingents of troops at the rate of about three hundred thousand men per month arrived before we had an opportunity to prepare for their reception and transportation. Such an unprecedented program called for a large force of men to plan and build port and railroad facilities on a scale never before attempted in the history of mankind. The "Transportation Corps" grew to a strength of about forty-nine thousand men towards the close of the war.

The section of the front to be occupied by the American Forces was primarily determined by the availability of transportation lines, which are so vital to a modern army. The Channel ports were occupied by the British, leaving the Americans only the Atlantic and Mediterranean ports with their long lines of communication and their poorer equipment for handling our ships. Even if we had been able to use the Channel ports the overtaxed railroads of northern France could not have carried the extra burden. These circumstances made it necessary to assign the southerly portion of the front to the American Forces.

One of the first tasks after this decision had been reached was to make a survey of the available lines and ports and to establish Lines of Communication. The proper coördination of such a system of transportation, linking the New World with the Old and transporting troops and materiel over railroad lines in France which were not adapted to through service, required vision and courage far beyond anything encountered in ordinary transportation projects. There was no precedent to follow. There were no data available showing numbers of men and quantities of material to be moved. Everything had to be created "de novo."

It was necessary not only to plan for the construction of railroad facilities but also to make preparations for a complete operating system with all its ramifications. In General Order No. 8, issued July 5, 1917, the Commander in Chief outlined the duties and the scope of the Transportation Corps as follows:

Operation, maintenance and construction of all railways and canals under American control. Construction and maintenance of roads and wharves and of shops and other buildings for railway purposes.

Liaison with French authorities to insure prompt service for U. S. goods and troops in transit over railways operated by the French.

Investigation and compilation of all claims and indebtedness incurred in transporting U. S. goods and troops.

Compilation of all accounts due the U. S. for material furnished the French railways.

Procurement of railway supplies.

Control of telephones and telegraphs for railway purposes.

Railway personnel.

Compilation of statistics showing classified tonnage received at ports; that moved over railways, and that delivered at railheads.

Operation of terminals, including unloading of ships and transportation of goods to storehouses.

Control and maintenance of all rolling stock and motive power.

Disbursements incident to performance of foregoing duties.

The first paragraph sets forth the duties of the engineering section. In order, however, to construct and operate the necessary facilities, plans had to be prepared. Since the Transportation Corps was to be responsible for the operation of these projects, it naturally followed that it also must be responsible for the preparation of plans for them. But before plans could be prepared it was necessary to decide what type of organization was to be set up and how facilities should be operated under these extraordinary conditions.

The items mentioned in the other paragraphs, and a number of items not mentioned, had to be given consideration in setting up and manning a new transportation machine which was to function with the same military precision as other branches of the service, which had years of training, tradition, and voluminous statistics to fall back on.

One of the first questions that arose in the early stages, and one that will arise in connection with any similar expedition, is that of organization. The French authorities wished to operate our trains as they had done originally for the British Expeditionary Force. At the time of our entry into the war, the British were operating their own trains and also such sections of the Channel Ports as were assigned to them.

When the British took over their own transportation facilities, the Royal Engineers were at first in charge of the operations, but due to the specialized nature of the work, this arrangement was not found very satisfactory. The Transportation Corps was then organized, recruited from the railway and port personnel in England. As was expected, this organi-

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zation functioned admirably. There was centralized control, as in any large railroad system, and every man from top to bottom understood his task and his organization.

A visit to British headquarters in July, 1917, and an inspection of their ports and methods of operation, disclosed many of the shortcomings of the two earlier methods of operation and the absolute necessity of entrusting this extremely important function to our own personnel recruited from our own railroads. Therefore, since the British problem was somewhat similar to ours, though on a smaller scale, our Transportation Corps was patterned after theirs, with such modifications as were deemed necessary in harmony with our accepted form of railroad organization and methods of operation.

At first Colonel William J. Wilgus, who had been a member of a military commission sent to France shortly after the declaration of war and who was later assigned to the Chief Engineer Officer, A. E. F., was appointed Director of Military Railways with the writer as his only assistant, thus forming a "two-man corps." Although handicapped to the extreme by lack of personnel, much important missionary work was done that had a vital bearing on the future of the Transportation Corps and the success of the transportation of troops and materiel from the ports to the front. Ports were inspected and selections made of sites adaptable to our needs, Lines of Communication were projected, and available facilities analyzed with a view to using them by our forces.

These surveys proved very discouraging in so far as terminal and other facilities were concerned. The railroad lines themselves, thanks to the excellent roadbed and structures, were in very good condition, although they had suffered, as might be expected, from inferior maintenance during nearly three years of war. Terminal and other facilities, however, were either not large enough or were nonexistant, due to the fact that the French railroads were designed primarily for traffic radiating from Paris, like spokes going out from the hub of a wheel, and the "cross lines," connecting the spokes, were of secondary importance. Yet these "cross lines" were to form our main transportation arteries. The need for much new construction work was realized very early and plans were laid for constructing not only port terminals but inland terminals of all kinds as well. Requisitions were sent to the War Department for men and materials; with information as to number, types, and quantities needed. These covered tools, equipment, and materials necessary for the construction of ports, storage depots, engine terminals, and ammunition depots, as well as material handling apparatus. Freight cars, locomotives, cranes of all types, rails, steam shovels, and all kinds of engineer equipment were included.

The capacity of the structures on the lines and allowable clearances formed an important part of the early investigations, and instructions were cabled to Washington according to our findings, so that the equipment to be sent over would be within those limits. The clearance diagram used was that adopted by the European international conference at Berne in 1912. It might be interesting here to note, that had such a small item as flangeways, for instance, been overlooked, we would have had considerable trouble. The French railways have a gauge which varies slightly with the different systems. The average is about 4 feet, 8⅝ inches, as compared with 4 feet, 8½ inches in this country. The flangeways through the frogs are about 4.4 cm. or about 1¾ inches wide. Therefore, with a wider gauge and a narrower flangeway than ours, the flanges on the wheels would have hit the guard rails and this would have caused derailments. Consequently, the inside of all wheels on all our equipment had to be planed off a minimum of ⅛ inch in order to pass through these frogs. This made the inside clearance between the wheels ¼ inch greater than that prescribed by the Master Car Builders Association.

All this was done during the first few months by this "two-man" corps. Not only were we handicapped by lack of personnel, but also by the lack of proper working space and equipment. The drafting room was located in the rear of the first floor of a Paris house at 149 Boulevard Haussmann, which was shared with a number of other services, whose officers, with perhaps more military experience, requisitioned all furniture in sight, leaving only crates, boxes, and other useless paraphernalia for the two poor uninitiated and newly militarized civilians who were trying against all odds to reduce mountains with tooth picks.

Before leaving the United States, arrangements had been made with a few good railroad draftsmen and engineers to follow as soon as possible. Even after making special cable requests for their immediate departure, it was not until August 15, 1917, that they actually arrived on the scene. Naturally, they formed the nucleus for the large drafting force that was later required. These men were all militarized civilians and, though not enlisted, were required to wear the regulation uniform. The employment of civilians is not recommended, as it has been the cause of considerable trouble, not only in the engineer branch of the service but also in others. Although they were volunteers and served their country faithfully in their specialized fields and took the same risks as all others who went overseas, except the fighting forces, they have never received proper recognition and in fact have been discriminated against as not being "veterans." All of the men should be enlisted. In order to give them rank commensurate with their training, those who are qualified to design should be made master engineers, and the others sergeants.

Unfortunately, after our initial consignment, we were not permitted to select our men, and had to use such personnel as was sent us from some of the few engineering regiments then in France. Some of the men who were assigned to us were artists, others were architects, and a number of those who were engineers had no railroad experience. For instance, one of the men sent to us as a "railroad designer" had been working on the "design" of the giant animals that formed part of the attractions at the San Francisco Fair. Being of an artistic inclination, however, he at least possessed the vision and abilty to put ideas on paper which are so essential in the art of terminal design. It is a real pleasure to mention here that this man, after a period of training, proved to be one of our best

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Map Showing Lines of Communication

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designers on general terminal layouts. But war is no time to train men, as time means "blood." It is safe to say that double the work could have been done with half the number of men had they all been good railroad draftsmen and engineers, such as are found in the average well managed railroad office. It is hoped that whoever may be assigned a similar task in a future emergency may profit by this experience and secure proper personnel at the outset from the railroads of this country.

Such a large operation requires about fifty good draftsmen, including ten yard and terminal designers, ten pier- and port-facility designers, ten bridge and building designers, fifteen all around railroad draftsmen, and five electrical and mechanical designers. In addition to this, there should be a junior officer in charge of each of the five branches. The Designing Engineer in charge should have a rank not lower than that of captain, or preferably major, and should be further assisted by a number of officers with good railroad training. There should also be several field corps composed of one officer and four or five assistants to make topographical and other surveys as needed.

Provision should be made not only for adequate drafting equipment, but also for blueprinting, lithoprinting, and photostating equipment. We were very much handicapped by the lack of such equipment throughout practically the entire war.

Organization

The Transportation Corps, as finally composed, was organized in September, 1917, and was headed by Brigadier General William W. Atterbury, an official of the Pennsylvania Railroad, with the title of Director General of Transportation and the rank of Brigadier General. The former Director of Military Railways was made Deputy Director General of Transportation; a General Manager, with General Superintendents in charge of Grand Divisions, had charge of the operation; the General Manager was also assisted by a General Superintendent of Motive Power in charge of erection and maintenance of equipment. A General Superintendent of Army Transport Service was in charge of all stevedoring operations at the ports. An Engineer of Construction, occupying the position usually held by a Chief Engineer, was in charge of all engineering work, having as one of his assistants a Designing Engineer in charge of all planning, a position which was held by the writer practically throughout the war. There were also a Business Manager and such other special assistants as were needed.

During practically the entire period of the war, all railroad construction work was done by the various construction regiments recruited for that purpose. Shop and Car Erecting Regiments were the only regiments reporting to the Director General of Transportation. All other units reported to the Chief Engineer Officer and later to the Director of Construction and Forestry. Both the Director General of Transportation and the Director of Construction and Forestry reported to the Commanding General of the Service of Supply. Toward the close of the war, however, all railroad construction regiments were assigned to the Director General of Transportation. Had this been done in the earlier stages of the war much unnecessary friction and many delays could well have been avoided.

A new branch, not known in civil life, had to be added to the already burdened transportation organization. This was a corps of Railway Transportation Officers. Special schools of instruction were instituted where these officers were trained in their many and various duties. Most of them were selected because of their knowledge of both French and English and, if possible, of railroad operation. They were to be prepared principally to assist American soldiers in transportation matters and in forwarding baggage, thus relieving French agents who were not familiar with the English language. Many tasks were performed by these officers that were beyond their fixed duties, such as assisting lost soldiers in finding their regiments, so that towards the close of the war they were generally looked upon as walking encyclopedias.

Whether the departmental or the divisional form of railway organization should be adopted for a military expedition is an open question. Perhaps a cross between the two forms might be the answer. Local officials charged with the operation, or the execution of projects, must, of necessity, have considerable latitude, as they are better acquainted with local conditions and it would be a waste of time and effort to require them to refer all things to headquarters for decision. This holds true also, and perhaps with more force, with reference to maintenance of way and structures for which the local superintendent is held responsible. Planning and general direction and supervision, however, must be exercised from headquarters. Particularly was this true in France, where we were operating on friendly but foreign territory, where all plans had to be approved by officials of that country and the operation had to be so arranged as to dovetail with civilian and military traffic. If we had had a strictly divisional form of organization, where all plans are prepared locally, it is safe to say that the French authorities would have requested centralized authority.

An additional reason for centralized planning is the fact that many plans had to be designed to fit the materials on hand, or known to be forthcoming, instead of fitting the materials to the plans, as is ordinarily done. Occasionally it happened that local forces would originate certain projects without our knowledge, but invariably they had to be changed as they did not conform to either American or French requirements, or were not in accordance with materials to be received. At Issur-Tille, for instance, certain track and warehouse layouts were made and construction work undertaken early in the war, before we had any knowledge of it. The mission and proper operation of this depot were misunderstood, the facilities were poorly planned, and construction had gone too far to rectify the error made. Consequently, from an operating standpoint, that portion of the depot remained an abomination and placed a great handicap on the officers who were called upon to operate it.

In the operation of a military railroad, there should be absolute centralized control, with one man responsible for transportation of troops and materials in the entire military zone, whether it be the Combat Zone or the Communication Zone, or both. If the Theater of Operations requires the

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establishment of more than one zone, and if these zones are large, such as we had in France, then the Director General of Transportation may be represented in each Zone by a Deputy in charge of the operation. There should be command relation throughout, however, and not staff relation alone, if success is to be assured. This was not the case in France, as the Director General of Transportation had only remote staff relation with transportation problems ahead of the Regulating Stations. It was necessary to introduce at these stations a Regulating Officer, who was in control of all movements toward the front and who reported directly to General Headquarters. Arguments might be advanced for and against this practice, but it is quite clear that if this officer does not understand railroad operation, then the Director General of Transportation should control the operation on instructions and priorities furnished by the Regulating Officer.

There is a fundamental difference between the operation of a military unit and the operation of a railroad. An officer may be placed in command of all military forces in a certain area and have absolute control over these forces, but a military railroad can not be operated in this manner. The fact must not be lost sight of that we were operating a large and complicated utility engaged in transporting troops and materials for the military forces, and in many instances for the civilian population also, covering a very large territory, and requiring coördinated effort. Many of our trains had to travel over four different railroad systems, each system having widely differing operating rules, and each furnishing different specifications for permitting connections to be made with our facilities. All of this added to the heavy burdens to be carried by the Transportation Corps and made centralized control imperative.

Planning

The first Lines of Communication to be utilized were those from the ports of St-Nazaire and Bordeaux, joining at Pont Vert near Bourges. From there the line proceeded to Nevers, Chagny, Dijon, Neufchâteau, and Epinal.

Due to the very long Line of Communication from our base in the United States, with a submarine infested sea to contend with, it was decided that we must have sufficient storage space in France for supplies for two million men for a ninety-day period. A forty-five-day supply should be at the ports, a thirty-day supply at intermediate storage depots, and a fifteen-day supply at advance storage depots. If Germany, therefore, had launched an extended submarine campaign and had accomplished the impossible feat of stopping all shipping, we could still have held out for three months.

The depots, of course, also served as neutralizing reservoirs and supply clearing houses for all service branches, with the exception of ammunition, for which separate storage depots had to be provided. The storage depots in the intermediate zone were to be located to permit movements of materials from these to any part of the front.

Sites were examined along the Garonne River near Bordeaux and the Loire from St-Nazaire to Nantes for possible berthing spaces for our supply steamers, and sites either at or adjacent to these ports were sought for storage depots.

Bordeaux, the first port to be investigated, was examined on July 4, 1917. None of the existing docking spaces were practical. It was, therefore, found necessary to construct our own facilities, as much as this was regretted, where we could establish berthing spaces with direct track connections. The only feasible site in that vicinity was at Bassens on the Garonne River, where the French Department of Public Works had a ten-berth dock under construction. The space we selected was downstream and adjacent to the French docks. The site chosen for storage purposes adjacent to this layout proved to be too small when our program was enlarged, and St-Sulpice was therefore chosen. This was, however, about 9 miles away from the port, and a third track had to be built, paralleling the two main Compagnie d'Orléans tracks so as to permit uninterrupted shuttle service. An excellent site for an intermediate storage depot was found at Montierchaume near Châteauroux. Due to the necessity of building our own port facilities at Bassens, construction of this depot was temporarily deferred.

The St-Nazaire line was the first one on which we established facilities, due to the fact that certain berthing spaces at St-Nazaire, as well as at Nantes and Usine Brulée, were placed at our disposal, permitting immediate operation.

The port storage depot for St-Nazaire was placed at Montoir, but due to the insufficiency of the facilities at our disposal it was felt that additional berthing space should be provided upstream at some point near Nantes. In consequence, the first port development planned along this line was at Martinière, about 20 miles from Nantes on the south bank of the Loire River. The plans also provided for a 17-mile railroad connecting this port with the Chemin de Fer de l'Etat south of Nantes. However, as extra berthing spaces at St-Nazaire and Nantes were later allotted to us, the Martinière project was dropped, and for the further development still required it was decided to build a large pier at Montoir.

The intermediate storage depot for this line was placed at Gièvres; the advance storage depot, serving both of these port branches, was at Is-sur-Tille. The intermediate storage depots at Gièvres and Montierchaume were both located just west or south of Bourges, thus permitting movements to any part of the front.

Is-sur-Tille was made to serve the dual purpose of advance storage depot and regulating station. Epinal was the tentative railhead. Engine terminals were located at these depots, but since the distances between the two depots and between them and the ports were too great, intermediate locomotive terminals had to be established. The intermediate locomotive terminal for the St-Nazaire line was established at Saumur, and for the Bordeaux line at Périgueux. The terminal on the line from Gièvres and Châteauroux to Is-sur-Tille was placed at Cercy-la-Tour.

The distances between these terminals were as follows: St-Nazaire to Saumur 110 miles. Saumur to Gièvres 88 miles, Gièvres to Cercy-la-Tour 110 miles, Cercy-la-Tour to Is-sur-Tille 136 miles. On the Bordeaux line from Bassens to Périgueux it was 74 miles, from Périgueux to Châteauroux 146 miles,

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with intermediate coaling and watering facilities at Nexon, and from Châteauroux to Cercy-la-Tour 111 miles. It is just as important a rule to have a locomotive run as long as is economical and practical in military work as it is in civil work. The suggestion advanced sometime ago of making a military operating run only 50 miles is not based on experience gained in France. All of the elements vital to economical operation in peace time apply with equal force to military operations. A run of 100 miles should be considered as an average and our runs were, generally speaking, above that. The only place where a run of only 50 or 60 miles can be recommended is from the last depot to the railhead, thus permitting a round trip without refueling, as this would not be practicable so close to the front. It was the intention in operating these railroads to run full tonnage trains from the ports to the railheads wherever possible.

After careful consideration of the equipment best suited for our purpose we requisitioned consolidation locomotives, type 2-8 with superheaters, having a tractive power of about 35,000 pounds. The weight in working order was about 150,000 to 160,000 pounds. The types of cars called for were box cars, refrigerator cars, gondolas, side cars, flat cars, and tank cars; the average weight was about 16 tons and the maximum capacity about 33 tons. The average length of cars was 40 feet. All of this equipment had to be brought from the United States.

When the various sites for terminals on the First Lines of Communication had been selected, the question of tonnage ratings had to be looked into in order to establish the length of sidings and yard tracks to be constructed at these terminals.

Based upon the characteristics of the rolling stock and the profiles of the lines, tonnage ratings were calculated and from these the track lengths were established. These lengths naturally varied considerably but some uniformity had to be observed. The St-Nazaire line, having very easy grades, gave a length of 2,800 feet, the Bordeaux line, 2,400 feet, and the line to Is-sur-Tille, 2,000 feet. At Gièvres, therefore, the receiving tracks from the port were 2,800 feet long and the departure tracks towards the front 2,000 feet long, while at Châteauroux they were 2,400 feet and 2,000 feet respectively.

All of this was done in those early hectic days when we were trying to establish a new branch in the American Army, the Tranportation Corps, with nothing to guide us except our own judgment and experience and such information as we were able to gather from the same branches in the Allied Armies. There was no precedent in the American Army for anything like this; and, due to the unpreparedness of our army, the various branches of the service were unable to state definitely the amounts to be transported by them per man per day, yet this was the basic information that was needed to calculate the actual tonnages to be handled as well as to determine the extent of the various depots and terminal facilities. The British used not quite 60 pounds per man per day and the French less than 50 pounds, but it was felt that, due to our long Lines of Communication, our standard of living, and the amount of waste inherently connected with such an operation, we would need a great deal more. Each service wanted to play safe, and at one time the totals ran as high as 125 pounds. Finally the Transportation Corps settled the argument by using tentatively 100 pounds per man per day. At that time also we were to base our calculations on an army of 500,000 men. With these two figures as a basis, the design of port plans, engine terminals, and storage depots was undertaken.

Our final consumption was approximately 60 pounds per man per day. The fact that we had calculated our depots on a basis of 100 pounds, however, proved very fortunate when our program had to be enlarged. Considerable allowance was made for expansion in all of our projects and, at the reduced rate per man per day, these projects were capable of supplying all the demands made.

As soon as plans for facilities were completed, authorization for construction had to be obtained, designating what portions of these layouts were to be built in the first, second, or third stage. Copies were then forwarded to the Chief Engineer Officer of the A. E. F., who was in charge of all engineer supply depots and who arranged for forwarding the necessary materials and equipment. The Director of Construction and Forestry, who was in charge of the construction forces during a considerable period of the war, was also furnished with the necessary number of copies of the plans and authorization and he arranged for adequate forces to undertake the work.

The Transporation Corps was represented in the various sections, where work was undertaken, by District Engineers, whose duty it was to coöperate with the construction forces and to keep the Corps posted on the progress of the work or on difficulties encountered. As soon as work had progressed to a point where some of the facilities could be operated, the Transportation Corps arranged for the necessary operating personnel.

As our program was first expanded to two million men and later to practically five million men, new Lines of Communication were added and new facilities designed to serve them. The sixth Line of Communication was the last one established. This was the double route of the Compagnie de Paris-Lyon-Mediterranée from Marseille to Lyon and Dijon. These six lines gave us a network of railroads, nearly 6,000 miles long, connecting most of the Channel, Atlantic, and Mediterranean ports with the railheads, which were later tentatively placed at Vierzy, Connantre, St-Hilaire-au-Temple, Ste-Menehould, Dugny, Toul, Nancy, Montigny, Raon-l'Etape, La Chapelle, and Petit-Croix.

Not only were the railroads used as means of transportation, but also the inland waterways. France has an excellent system of such waterways, reaching from the ports to points very close to the fighting line, in fact, in many instances, beyond that line as it existed before the final drive in 1918. Numerous barge terminals were established along these waterways and quite an assortment of equipment was acquired, much of which was built by our own forces. A dispatching system was established with a central operating chart on which the progress of the barges was indicated by numbered flags corresponding to the designation of the equipment.

As a supplement to the railroads a very elaborate system of light railways (60 cm. gauge) was installed near the front, and transfer stations were

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established for unloading from standard gauge equipment to the narrow gauge equipment.

At a later period during the war, one phase of our work, which proved to be nearly as interesting as the original inception and development, was that of planning for the advance of the army towards the Rhine. Due to the rapid advance of our forces in the late summer and early fall of 1918, this work became quite fascinating and more than offset the gloomy days of the spring of the same year.

Ports

The ports primarily used by the A. E. F. at the close of the war, including neighboring docking facilities, were: Le Havre, Rouen, Brest, St-Nazaire, Montoir, Donges, Nantes, Les Sables-d'Olonne, La Pallice, Rochefort, Tonnay-Charente, Talmont, Pauillac, Blaye, Furt, Bassens, St. Loubès, Cette, Marseille, and Toulon. At Rouen, Donges, St. Loubès, and Toulon high explosives were unloaded.

St-Nazaire and Nantes are typical of these ports and the work which had to be done at them with the exception, of course, of Bassens, Talmont, Montoir, and Brest, where new large docking facilities had to be created and much general construction work was necessary.

St-Nazaire, in common with many other French ports, has a tidal basin with locks in the passageway leading to the outer port. The tide at the French ports ranges from about 10 feet at some of the Atlantic ports to about 40 feet at Channel ports, whereas in the Mediterranean there is only an annual variation of about 2 feet. The tidal range at St-Nazaire, for instance, was about 20 feet. For this reason ships moved in and out at high tide and when the tide began to recede the locks were closed and a uniform water level was maintained in the basin. The draft in this basin varied from 23.5 feet to 28 feet, the average being about 27 feet.

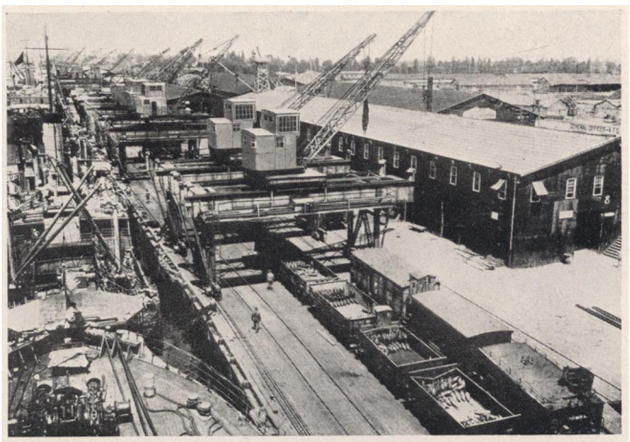
In a very large number of the French ports, or at least in many sections of these ports, no direct rail movements can be made, although track connections exist. This was the case at St-Nazaire. In order to place a car on the track nearest the string piece it was necessary to switch the car onto some rear track, then turn the car on a small turntable and move it, at right angles to the wharf, to the desired track, where it was necessary to turn it again and shift it to the desired position along the wharf. On its return trip the car would have to go through the same motions. Each car, therefore, would have to be handled separately. Many parts of St-Nazaire were served in this fashion. These turntables were too small for our cars and, as may well be understood, had we been forced to operate under such conditions, it would have been necessary to erect lunatic asylums for exhausted transportation agents. Consequently, direct track connections were installed, making it necessary in many instances to cut through buildings.

Another typical port where such changes had to be made was Nantes, on the Loire River about 39 miles inland from St-Nazaire. The tidal range here was about 18 feet. Since this port was on a river and had no tidal basin, ships had to be handled at varying water stages, as is the practice in this country. In addition to two quais used in Nantes, we also used the Quai de la Fosse, the port of Roche Maurice, and Usine Brulée, all in close proximity to Nantes.

All of the other ports gave us their share of trouble, not only in making track connections, but also in obtaining data on tidal ranges and elevations, the nature of the mud bottoms and sub-strata, all of which had a vital bearing on our plans and operations.

Bassens, near Bordeaux, was one of the most important of our port projects. A wharf was built there 4,100 feet long, permitting ten of our average steamers to be berthed at one time. On the wharf, and close to the string piece, three loading tracks were installed which were spanned by forty gantry cranes, four to each berth, with capacities of 3 and 5 tons. Transfer and storage sheds with track connections were erected directly in rear of the wharf. Inbound and outbound yard facilities, as well as engine terminal facilities, were provided between the wharf and the main tracks of the Compagnie D'Orléans, which were in close proximity. At a later date a large refrigerator plant was installed.

Much of the material for this work had to come from the United States, particularly piles and



The Dock at Bassens

stringers. Many 70-foot piles were needed and when, after waiting for months, this material finally arrived, it was found that someone, in loading the piles, had sawed off 20 feet of the butt and sent us the two pieces. It was claimed that it was necessary to do this in order to put them in the hold. Apparently this government agent had not been in the lumber or shipping business before, or he would have seen such long articles fastened to the decks. To make things still worse, many of the piles were worm eaten and could not be used. The explanation was that the worms must have been very busy on the way over, as all of this material had been inspected before being loaded. Of course anyone knows that worms could not do such damage in two weeks. This is merely an example of some of the things we had to contend with. Often parts of a piece of machinery or equipment would be missing or had been shipped on different steamers. Such vicissitudes added greatly to our troubles and discomfort.

We made good progress, nevertheless, and on August 2, 1918, there were 32,000 feet of berthing space at French ports in use by the American Expeditionary Forces. This space was distributed

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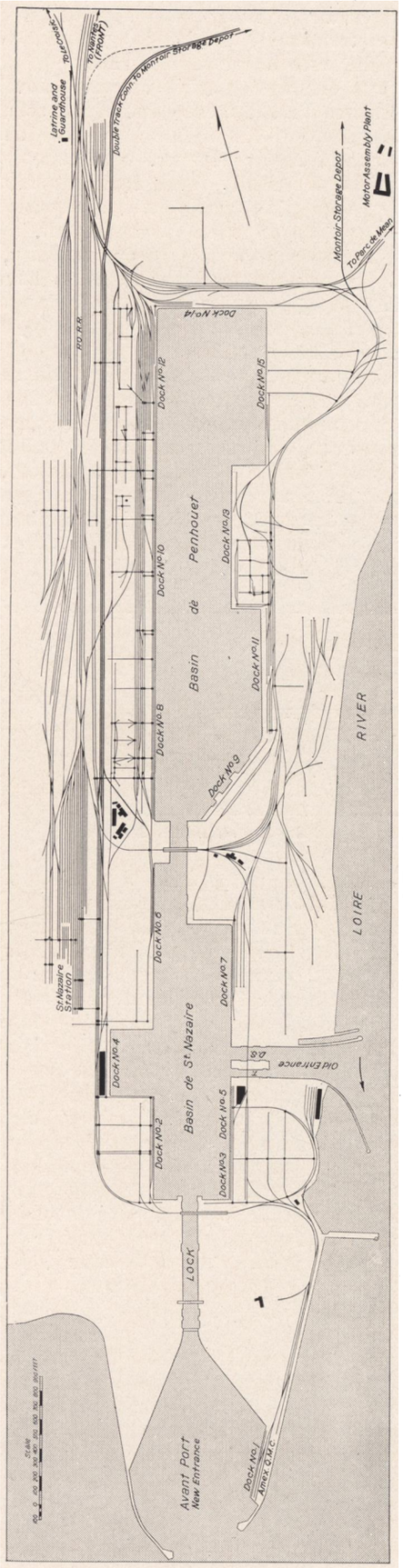
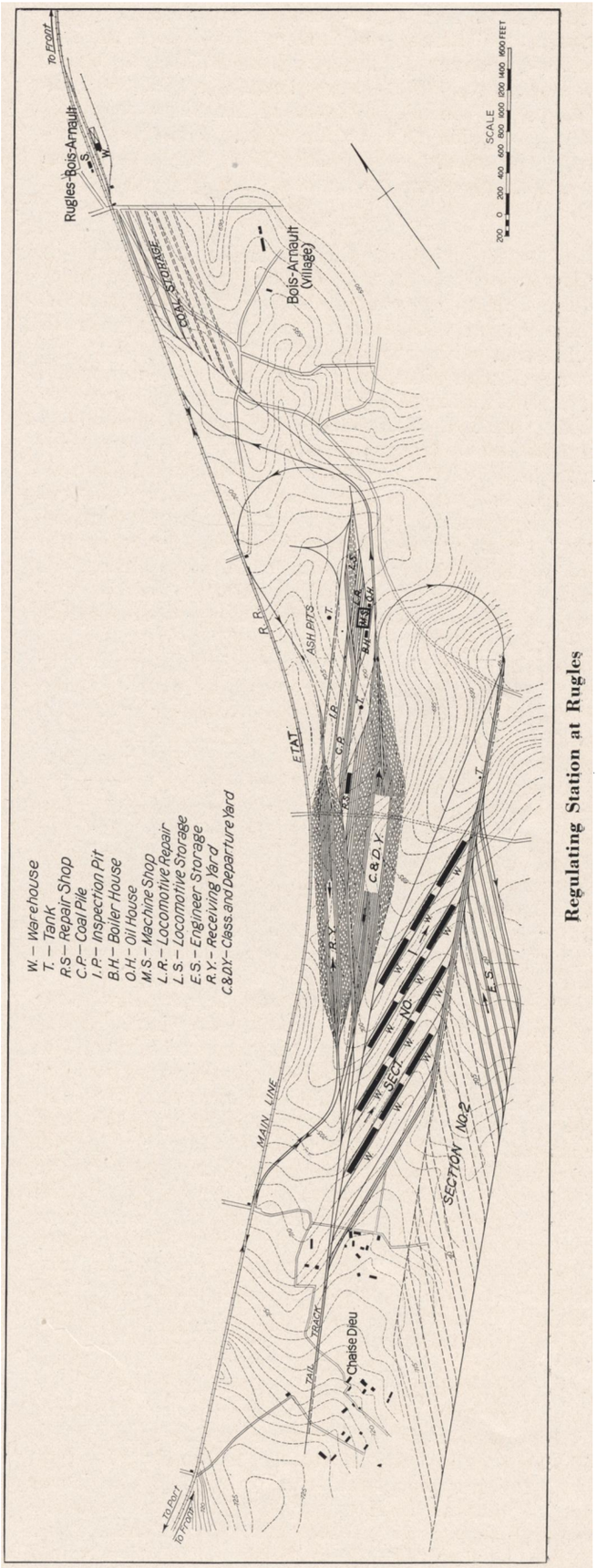


Docks and Track Connections at St. Nazaire



Regulating Station at Rugles

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as follows: 800 feet at Le Havre, 1,700 feet at Brest, 7,942 feet at St-Nazaire, 910 feet at Usine Brulée, 2,576 feet at Nantes, 2,000 feet at Les Sables-d'Olonne, 2,352 feet at La Pallice, 880 feet at Rochefort, 800 feet at Pauillac, 6,590 feet at Bassens, of which 4,100 were of American construction, and 5,550 feet at Marseille. Additional construction amounting to 5,380 feet was in progress at Brest, Montoir, St-Loubès, and St-Vincent.

Engine Terminals

At a majority of the engine-house layouts in this country the locomotives are turned on a turntable. Due to the compactness of this arrangement, consideration was given to the use of turntables in connection with our locomotive terminals, but the plan was soon discarded. The reasons for this were: first, the material required would not be easy to obtain; second, turntables could not be erected by inexperienced troops; and third, they were too vulnerable, that is, too easily destroyed by an enemy. A simple loop track was, therefore, adopted as our standard, modified by the installation of "Y" tracks where the terrain or the layout would not permit the construction of a loop. The loop was preferred, however, because it required only one switching movement as against three movements for the "Y."

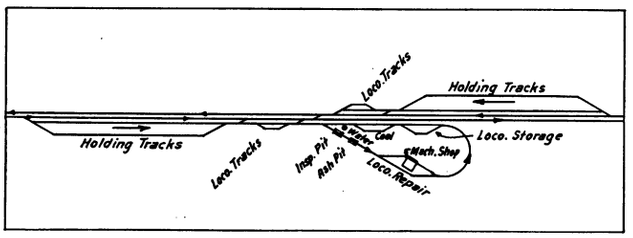
It is the practice with many railroads, to supply coal and water before placing the engine in the roundhouse. Since some of the coal and water has to be used in starting the fires, the locomotive would not be fully loaded when leaving the terminal. Although the amount used is not great, it was felt that the locomotive should be fully charged when leaving the terminal so as to be prepared for any emergency. In other words, we did not want to take any chances whatever. The difference between a full or a diminished reserve supply of coal and water, however slight, might be the margin between success or failure.

The general arrangement of the facilities composing a locomotive terminal was the same, whether at a depot or at an intermediate terminal. Sketch "A" shows graphically the arrangement at an intermediate terminal. These terminals were installed merely for the purpose of changing locomotives and this operation was to be accomplished with the least amount of delay to the train. Before the arrival of a train a locomotive was placed on the locomotive track at the head end of the train. As soon as the train came to a stop its locomotive was disconnected and switched to the inspection pits. Immediately, the waiting locomotive was backed against the train, coupled, and sent on its way, all of which was accomplished very quickly.

The locomotive entering the terminal was first inspected at the inspection pit and then had the ashes dumped in the ash pit. From here it proceeded to the locomotive storage space. If minor repairs were needed, they were usually made while it was standing on the storage tracks, but for general repairs the machine shop and its adjacent tracks were used. Heavy repairs were made at the general shops erected for this purpose at Nevers. When leaving the terminal, the locomotive would move to the coal track and take coal and water. It was then placed, fully loaded, on the proper locomotive track, facing in the direction from which it originally came (having been turned in going through the terminal), ready to proceed to its place of origin with a returning train.

Saumur was the first engine terminal developed by us in France and was the result of combined efforts of the Designing Engineer and the General Superintendent of Motive Power. Since the terrain at Saumur was practically level, it was possible to adhere fairly closely to the general schematic plan already adopted as an ideal arrangement.

At Etais, the terrain was more or less hilly, and, in order to lay out the facilities so as to have the least amount of grading, a different arrangement was necessary. The holding tracks had to be placed opposite each other, instead of at opposite ends of the terminal as was done at Saumur. This necessitated a light engine run for the length of the yard for all westbound movements. Also, the locomotive repair and storage tracks could not be placed in sequence, necessitating a switchback movement. This layout serves to illustrate, however, that perhaps more ingenuity must be exercised in planning military terminals than is ordinarily the case, as sites are limited and, in order to expedite the construction, labor must be reduced to a minimum. The operation at Etais was the same in principle, as that planned for Saumur, which was strictly adhered to at all of our engine terminal layouts, although a great variety of modifications had to be made in the general plan and arrangement of facilities, due to the necessity of being forced to use whatever sites were available in the vicinity of the locations fixed for such terminals.



Sketch *A*.—Typical Engine Terminal

Coaling facilities provided at these terminals differed somewhat. In some instances coaling platforms were installed and coal was loaded by hand, whereas at other terminals the plans called for a large coal pile between two tracks and the use of a locomotive crane for loading. The latter method is much to be preferred, but for a smaller military operation the former may be satisfactory. In addition to the regular coaling facilities at such terminals, it was necessary to provide for large coal depots holding about 250,000 tons each so as to assure a continuous supply. The coal consumption per locomotive per day, of course, varied considerably, depending on either the run or the type of service to be performed, and no hard and fast rule can be set. Our locomotives had a capacity of from 6 to 9 tons of coal. The consumption at these terminals varied from about 8 to 20 tons per day per locomotive handled. The average may be considered at about 15 tons per locomotive per day.

Water was fully as important an item as coal, and the installation of an adequate water supply

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at these depots was a considerable task in itself. In many cases the water had to be brought in pipe lines many miles in length. In addition, at a large number of our plants it had to be purified to prevent boiler scale or corrosion.

The average water consumption for a full tonnage train was about 100 gallons per mile, varying about 30 gallons above or below this figure, depending on the grades of the line. Our locomotive tanks held about 5,000 gallons of water. A locomotive may be held up on the road and while so held, it is consuming water as well as coal. It is not considered good practice to go below a 1,000-gallon reserve. For this reason, it was felt that locomotives should not have to travel more than 30 miles, or preferably 25 miles, before refilling the tanks. Since our depots were about 90 to 120 miles apart many intermediate watering stations had to be planned. Fortunately, many of the French plants could be used for this purpose.

At our terminals, provisions were made for 5,000 gallons per road engine handled per day and 10,000 gallons for each switch engine. In addition to this, and depending on the facilities, about 25,000 to 100,000 gallons per day were provided for boiler washing and power plant purposes. The water tanks had, generally, a 50,000-gallon capacity, although a few 25,000- and 15,000-gallon tanks were installed. If standardization is desired, the tanks should have a capacity of not less than 25,000 gallons, with the greater percentage of the 50,000-gallon type. A 10-inch water crane served the locomotives. On the basis of supplying one million men, and depending, of course, on the density of the particular portion of the Lines of Communication and the facilities established thereon, 10,000 to 20,000 gallons of water were used per mile per day.

About forty locomotive terminals were required. The smallest handled eleven locomotives a day while the largest accommodated more than one hundred.

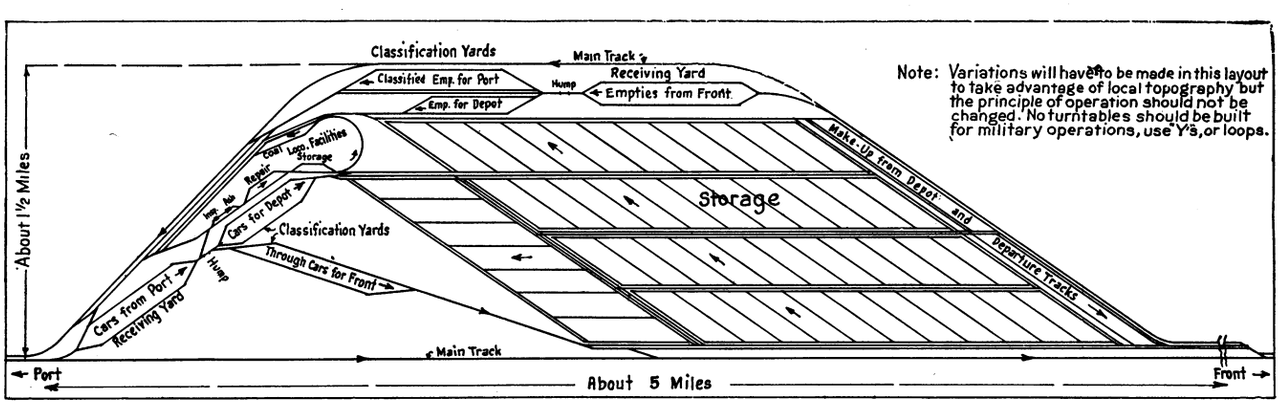
Storage Depots

The storage depots which had to be provided were of mammoth proportions. Great receiving, classification, and departure yards for operation in both directions, separate classification yards for loaded cars to and empty cars from storage had to be provided as well as a large storage layout and a large locomotive terminal.

Sketch "B" shows, schematically, the general arrangement of a storage depot and as an aid in understanding the operation the train movements are indicated by arrows.

In all such layouts, it is important to arrange the various facilities so as to make the locomotive runs as short as possible, consistent with good railroad practice. Where large areas have to be laid out, and provisions made for future expansion, it is necessary to make the plan symmetrical. This permits the building of additional units without sacrificing operating efficiency or introducing movements at variance with those already in use. The importance of this is apparent, for once the operating personnel is accustomed to certain train movements, it would cause confusion to change them, even though some of the runs might be shortened. The shortening of such runs would not be good railroad practice, as it would be necessary to scatter the facilities and introduce switching movements that would interfere with each other. Particularly is this true for military operations. It should always be borne in mind that the personnel is thrown together from all over the country, and that not all of these men are experienced yard men, even though they may have been working for a railroad. The aim, therefore, was to make the layout as simple as possible. The larger the layout the greater is the necessity for doing this. Symmetry, simplicity, and safety in operation must also be carefully considered in laying out the various individual yards in a terminal.

It is often the practice to use an angle for the ladder track that is twice the angle of the frog to be used, in this case a double number-eight ladder. In some of our early studies that practice was followed in order to save space. After more careful study, it was changed to the maximum angle that could be taken by using single number-eight turnouts, instead of double eights (see Sketch C). A slight curve behind the frog was consequently introduced which, however, is not objectionable. Ladders with single turnouts were used for military reasons and applied particularly to classification yards. In civil life in a large percentage of our yards, and particularly in classification yards, the switches are thrown mechanically, whereas military yards built under war conditions of necessity have to be hand operated. With the double angle ladder, or any other type of layout except the single turnout angle as explained above, it would be necessary for yardmen, at the risk of their lives, to cross tracks on which cars are moving. With the single angle



Sketch *B*.—Typical Storage Depot

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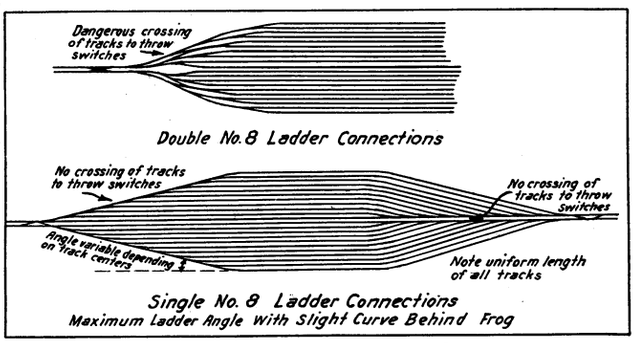
ladder they can move on the outside of the ladder track, throwing any one of the switches without being in any danger whatever. This is particularly necessary when green men have to be used, or men not accustomed to yards handling such heavy traffic.

The storage portion of the depots also received special consideration. The first thing to be settled was the useful length of the tracks in the storage areas. Too short a train length would add to the yard movements and too long a train would slow up operations. It was decided that a forty-car train would meet the average condition and, since the cars were 40 feet long, the useful length of the tracks was fixed at 1,600 feet. This in turn established the same length of track for the classification yard for storage. The angle between storage tracks and depot ladders was made 23 degrees.



Sketch *C*.—Double and Single Ladder Connections.

In a military depot, open and covered storage spaces must be provided, the open storage representing about 70 per cent of the total. The storage spaces were laid out in alternating echelons of covered and open sections. There were two tracks on each side of the warehouses. This permitted the use of locomotive cranes for loading or unloading from one track or the other as needed. Due to lack of time and materials, in many instances only one track was laid first to permit immediate operation. The warehouses for the covered storage were one story structures, 49 feet wide and either 400 or 504 feet long. In one covered echelon, serving a 1,600-foot track, two 504-foot and one 400-foot warehouses were placed with about 100 feet of open space between them. Each service of the army was assigned certain groups of these sections of open and covered storage in accordance with their needs, and, in addition, special layouts were made for some of the services, such as oil storage tanks, hay storage, remount depot facilities, special engineer depot facilities, et cetera.

The question of proper allocation of storage space to the various services, and the tonnage that can be stored on a unit area under military operation, was the subject of much discussion and analysis. A special board was finally appointed to investigate this matter and to determine how much space was actually occupied by the various services at the depots then in use, and to fix the areas that should be allocated to each service.

The report of this board was made about August, 1918, and since the data contained therein was thereafter used as a basis for depot development, an abstract of its more important features is given.

Abstract of Report of Board Appointed to Study Storage for A. E. F.

The board finds that at Gièvres about 18 per cent of space is devoted to aisles and 17 per cent to dead space, a total of 35 per cent, but it is the opinion of the board that this space can be reduced to 11 per cent when depots are in full operation, allowing 2½ feet from piles to walls of buildings. The board also finds that the piles can be on an average 12 feet in height.

Engineer storage is piled approximately 4 feet high at present, but the board believes this can also be increased to 12 feet on an average.

Recommendation of Board

Height of material 12 feet.

Loss due to aisles 11 per cent.

Average weight per cubic foot 25 pounds.

Weight per square foot floor area—12 feet × 25 pounds × (100—11=89%)=265 pounds.

Two hundred and forty-seven thousand, six hundred and twenty square feet are required for 10 days' storage for 250,000 men, and for 4,000,000 men a 90 days' supply will require 35,657,280 square feet of covered storage.

Authorized for construction now—26,416,628 square feet. Ultimate capacity—33,255,184 square feet or 2,402,096 square feet less than required for 4,000,000 men for 90 days. Board recommends authorization to construct the full amount.

Storage to be distributed as follows:

Base Section	17,633,449 square feet	49%
Intermediate Section	11,638,507 square feet	33%
Advance Section	6,385,324 square feet	18%
	35,657,280	100%

The following figures were prepared to show the future status of covered storage which will be available on January 1, 1919.

	Square Feet
Amount of depot covered storage completed August 1	6,863,524
Constructed during July	1,130,669
Estimated depot covered storage available January 1, 1919	12,516,869
Troops to be in France, January 1, 1919	2,032,000
Covered storage for 2,032,000 men for 90 days	18,096,070
Number of days' supply, for troops scheduled to be in France on January 1, for which covered storage will be available	62 days

Storage Recommended for 10 Days for 250,000 Men.

Corps	Covered Storage Square feet	Per-cent	Open Storage Square feet	Distribution % Base Section	Intermediate Section	Advance Section
Quartermaster	76,000	31	153,109	50%	33%	17%
Motor Transport	32,500	13	----	23	61	16
Ordnance	57,000	23	55,000	50	33	17
Air	36,000	15	150,000	41	35	24
Medical	20,000	8	3,000	35	45	20
Engineers	11,800	4	118,000	50	33	17
Lt. Rys and Roads	8,000*	3	100,000	---	---	100
Signal	4,850	2	3,150	25	50	25
Chemical	1,470	1	836	35	35	30
Total	247,620	100	583,095	41%	37%	22%

* Not including 40,000 square feet covered storage and 64 acres open storage regardless of number of troops.

The most important of the depots were those at Gièvres, Montoir, Montierchaume (Châteauroux), and Miramas.

Gièvres was the first depot to be designed. A topographical survey was made in August, 1917, and as soon as this was received a number of

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schemes were prepared to determine the best development of this site, which was about 6 miles long and about 1½ miles wide.

Due to the 1-meter gauge railroad running practically across the center of this site it was extremely difficult to make what might be considered an ideal layout. Nevertheless, the general priciples established for this depot formed the basis for all future developments of this type. Uniformity and ease of expansion of all facilities without changing the method of operation were of prime importance. Therefore a plan was prepared for the maximum development, which could be built in successive stages as required, and where each added stage was merely an enlargement of an existing unit which was complete within itself.

As it was the first storage depot to be built, it is natural that a large percentage of the facilities were placed in operation at an early date and for this reason Gièvres long formed the backbone for supplies needed in the forward area.

During the German drive in the spring of 1918, instructions were issued to arrange the facilities here in such a manner as to permit this depot being used as a regulating station in case the drive should succeed. Fortunately it never had to be used for that purpose, although the facilities were arranged to permit it.

Montoir was the port storage depot for the St-Nazaire region. The first portion of this depot was built very early in the war. It was a small open storage layout along the Compagnie d'Orléans tracks near the Montoir station. This was commonly known as the "Wilgus yard" and was named in honor of Colonel W. J. Wilgus, who was Director of Military Railways at the time this work was undertaken. This yard was later expanded to provide space for engineer storage. The need of a large depot soon became apparent and, early in the fall of 1917, surveys were made of the site and the plan was prepared. Yard and locomotive facilities, similar to those at Gièvres, were designed and provisions were made for four warehouse sections. At a later date two other sections had to be added and special ordnance storage warehouses had to be provided.

The practically level terrain permitted an ideal arrangement of the storage sections. The plan of operation at all of these sections was to push the cars alongside of a warehouse unit from the switching tracks and to pull the cars from the opposite end. In this fashion cars could be placed and pulled at any time without the two operations interfering with each other.

In addition to serving the port of St-Nazaire, this depot was designed to serve a 16-berth pier. About 2,000 feet of this pier had been built at the close of the war, affording docking space for ten ships. Four storage sections were also completed and two other sections were under way. The yard facilities were advanced correspondingly. It can thus be seen that, since this huge depot was practically completed, and the greater part in operation with many of the storage sections well filled up, we were in a good position insofar as the port section of St-Nazaire was concerned.

Montierchaume (or Châteauroux) was the intermediate storage depot serving the Bordeaux line. The terrain here was practically level and the facilities could be arranged to make this a nearly ideal layout that might serve as a basis for any similar developments in the future.

The facilities were at first made more nearly parallel to the railroad, with the engine terminal loop encircling a cluster of buildings at the Château Montaboulin. The château was surrounded by forests that were famed as a hunting ground. Only a very small portion of forest along the railroad would have had to be destroyed, however. The owner of the château, a lady, brought pressure to bear through the French War Department to have our facilities farther removed from the railroad, with consequent loss of time and the sacrifice of a perfect layout requiring less material to construct and less locomotive mileage to operate. To quote a report on this, "the lady graciously explained that she did not mind having the château isolated in a great railroad terminal, nor her estate covered with unsightly yards and warehouses, but, in that particular forest was a rare collection of bird and animal pets which she felt could never become reconciled to the capers of those enormous American locomotives. The birds would fly away and the animals would scatter to other forests." Here, indeed, was a predicament! Engineering ingenuity was challenged, and, if nothing else, American gallantry put at stake. Many similar incidents could be related that might seem strange in contrast with the manner in which projects were carried out in this country. The principal difference may be found in the fact that people in this country live for the Business of Life, whereas in France they live for the Living of Life.

Miramas was the port storage depot for Marseille. The principle of operation, insofar as the yards were concerned, was changed in this layout. Instead of having two separate sets of receiving, classification, and departure yards, as was done at the other depots, these were combined into one set of yards. This might be considered an advantage from a construction standpoint, but not from an operating standpoint. The planning of this depot brought out a very interesting spectacle. The port connection was from the right and it was planned originally to enter the depot directly from the port side, as was done at all other depots, and classify the cars towards the west. While the writer was examining this site, sometime in the summer of 1918, it was discovered that the French were operating their facilities at the south end in an apparently awkward manner. The receiving yards for cars coming from the east, or port, were at the west end of the classification yard and classification was done in an easterly direction. At the moment of this inspection the *Mistral*, a strong wind greatly feared in this section, was blowing with gale velocity from the west, actually pushing ahead cars that were standing still on a siding. The reason for the reversed order of operation was at once obvious, and information obtained from Paris proved the inadvisability of classifying in any other way.

Traffic was handled here in three directions: From the port, over the line leading north at the east end of the yard, and over the line going west from this yard. The last two lines formed the double route, one on each side of the Rhône River, to Lyon and

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the front. All traffic, therefore, had to enter the west end of the depot and depart from the east end, in some instances making a complete loop.

The storage and locomotive facilities were laid out in accordance with our standard practice. Since there was available space in two French roundhouses at the east end of the depot, our locomotive facilities were to be built only when required. As this depot was started at a late date comparatively little construction work had been done at the close of the war.

Two other storage depots of great importance were planned and practically completed at the close of hostilities. They were the port storage depot at St-Sulpice, serving the Bordeaux region, and the advance storage depot and regulating station at Is-sur-Tille. A great deal of tonnage passed through these depots. Plans for depots at Pleyber-Christ, Ste-Luce, Thouaré, Aigrefeuille, and Talmont, serving the ports; Rugles, Montargis, Poinçon, and Tavaux, serving the intermediate zone; and Liffol-le-Grand and Troyes in the advance zone, had been prepared and construction was in various stages of progress, when the Armistice was signed.

An idea of the tremendous proportions of the storage facilities, which had to be provided in the various zones, may be gained from the table on this page.

Up to this point we have been concerned only with creating ports, storage depots, and engine terminals. In order, however, to have the military transportation machine function properly, it was necessary to create a new type of terminal, a "call" station within operating radius of the front. This depot was called a Regulating Station, and its function is exactly what the word implies, namely to regulate and control all railway traffic from this point to the railheads. For the purpose of military coördination the regulating stations and the traffic from these stations to the railheads, were placed under a Regulating Officer. This officer was not a member of the Transportation Corps, but a regular army officer responsible only to the officer in charge of the General Headquarters Division (G-4), handling transportation in the Advance Zone.

From this point forward, barring all accidents, the daily quotas for each military division operating at or near the front were known. Knowing the number of military divisions the station had to serve, it was possible to prepare daily standard make-up trains of a fixed number of cars for each division. In addition to this, however, a regulating station was apt to be called upon to furnish, on short notice, additional standard trains or special trains to meet special requirements due to either exhaustion or destruction.

The problem, therefore, was that of preparing a layout that would provide a certain number of holding tracks on which standard trains, fully loaded, would be waiting to move forward. A classification yard in which loaded cars were placed according to commodities made it easy to make up any special train on short notice. In addition to these facilities it was also necessary to have receiving and departure tracks as well as engine terminal facilities.

Towards the close of the war a small amount of storage was also provided, thus creating what might be termed a small advance storage depot and regulating station. Although the function of a regulating station is not that of a storage warehouse, but

	Covered Storage Square Feet	Open Storage Square Feet	Number of Warehouses	Miles of Track
At Ports				
Pleyber-Christ (Brest)	815,808	1,996,400	36	92
Montoir (St-Nazaire)	4,215,008	9,812,400	180	236
Ste-Luce (Nantes)	273,788	956,450	12	23
Thouaré (Nantes)	544,000	1,500,000	24	35
Aigrefeuille (La Rochelle)	679,830	1,400,000	30	43
Talmont (Gironde)	2,243,472	7,285,400	132	117
St-Sulpice (Bordeaux)	3,263,232	6,864,000	144	147
Miramas (Marseille)	2,895,808	9,768,600	120	108
	14,930,946	39,583,250	678	801
Intermediate Zone				
Rugles	2,293,472	2,800,000	33	51
Gièvres	4,418,960	10,387,500	195	263
Montierchaume	4,079,040	9,600,000	180	226
Montargis	815,808	1,573,000	36	33
Poinçon	1,019,760	3,327,400	50	77
Tavaux*	1,500,000	4,000,000	65	100
	14.127,040	31,687,900	559	750
Advance Zone				
Is-sur-Tille (Regulating Station)	1,867.500	3,200,000	73	100
Liffol-le-Grand (Regulating Station)	407,900	1,144,000	20	65
Troyes	747,824	1,996,400	33	57
	3,023,224	6,340,400	126	222
Grand Total	32,081,210	77,613,550	1,363	1,773

*Proposed only, data approximate.

It should be noted that, in addition to these facilities, which had to be created, existing storage facilities were utilized.

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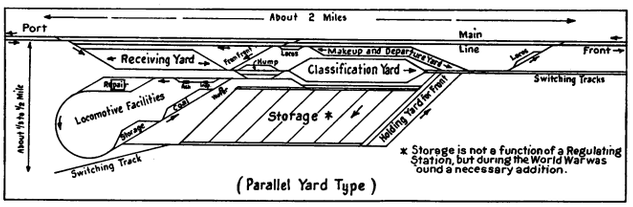
that of a mobile depot where goods are held in cars, the storage addition has its advantages due to the possibility of breakdowns that must be reckoned with on any military line of communication.

Two types of regulating stations were developed. In principle the operation is identical, but due to the configuration of the terrain the general arrangement of the facilities of necessity must differ. The parallel type, such as was planned at Rugles and



Sketch *D*.—Typical Regulating Station

Poinçon, is shown on sketch "D." A right angle type was used in some cases.

Ammunition Depots

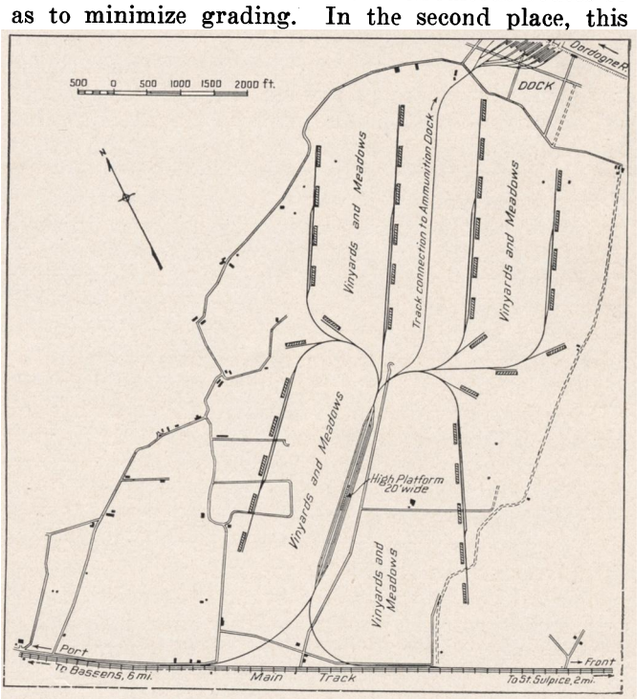
None of the storage and regulating facilities described were planned to handle ammunition. Since this commodity is of a highly explosive nature, special facilities must be provided and these must be specially arranged. Although much of our ammunition was unloaded at our regular docks, this was considered a dangerous procedure, and special ammunition docks were designed at some of the ports; at others the ammunition was unloaded from the off-shore side of the ship onto barges, and these were towed to specially designed docks where they were unloaded. Thus, for instance, at Donges, near St-Nazaire, our plans provided for a dock where ocean liners could be unloaded directly, whereas, at Bassens, near Bordeaux, our plans later provided for unloading ammunition from the off-shore side and conveying the barges to St-Loubès, on the Dordogne River, where a barge dock was provided, supported by a large ammunition depot, originally designed to be served from Bassens by rail.

Had it not been for the many restrictions set up by the French Ministry of Munitions, the design of an ammunition depot would have been a comparatively simple matter. Hardly had we completed a layout when added restrictions were imposed, making it almost impossible at times to follow them. The restrictions were all with reference to distances between the warehouses for certain types of ammunition, and distances between these as well as the yards and the nearest habitations, with minimum distances from villages. All of these were, of course, designed to protect the civilian population. Besides these restrictions, we were also interested, for our own protection, in scattering the warehouses and dumps to guard against the destruction from aerial attacks, which had caused considerable damage to French and British depots earlier in the war.

Early in August, 1917, it became apparent that such depots would have to be built, but no one knew how. A committee was appointed, composed of a French officer, who had designed similar depots, our Chief Ordnance Officer, and the writer. Several French plans were reviewed and on August 30 the French depot at Mitry-Claye was visited. This depot, however, was only a fraction of the size of the ones we later designed for our use, and the facilities did not conform to the restrictions then in force, and much less to the restrictions furnished us at later periods. The ammunition depot at Foëcy (Mehun) was the first such depot we built and this was patterned after the French layouts. The two most important depots were the port depot at St-Loubès and the "Advance Ammunition Depot" at Villiers-le-Sec, where the arrangement of the facilities was a radical departure from the Foëcy layout. All of the later depots differed materially in design, depending on location or requirements. A large depot was also planned near the ammunition dock at Donges. Plans for this were started in midsummer, 1918, and it was not until October 8 that French approval was finally obtained. It was not always a pleasant task to satisfy everybody, but this particular project was the most troublesome of all, insofar as obtaining French approval was concerned.

The depot at St-Loubès, being so far removed from the front, was not subject to aerial attack and the warehouses could be placed closer together. Furthermore, only certain classes of ammunition were to be stored here.

The depot at Villiers-le-Sec was unique and all-American in every respect. In the first place, the terrain was quite hilly and it was necessary to make the tracks follow the contours in circuitous routes so as to minimize grading. In the second place, this



Ammunition Depot, St. Loubès

depot was subject to aerial attacks and for that reason considerable distances had to be allowed between the various warehouses. In the third place, such high explosives as fuses, grenades, et cetera, had to be stored, and these required special precautions. Since this was our depot nearest the front, it was planned and used as what might be called a regulating station for ammunition. Special groups of holding tracks were provided where solid trains, loaded with ammunition, were held for forwarding on short notice. This location, as well as the function of this

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depot, required locomotive facilities, receiving tracks, and a classification yard in addition to the holding tracks mentioned above.

From these different classes of ammunition depots it is apparent that no fixed type of layout can be followed. The function of the depot has to be determined first, and then, with due consideration for the proximity of the front, the best layout consistent with good railroad operation for war purposes will have to be fitted into the available site.

Nevers Cut-off

In addition to the types of projects mentioned above, a great variety of other problems had to be solved and plans prepared. At Nevers, for instance, it had been proposed that we use the existing overtaxed railroad arteries through that city, building some yards there that could later be used by the French railroads. The location of these yards did not fit well into our program. Furthermore, we were extremely anxious to avoid the traffic congestion prevailing at this point. A cut-off was built, therefore, about 5 miles long with a bridge across the Loire River, making the total distance about 6 miles shorter and completely avoiding the already serious congestion.

Car and Locomotive Erection Shops

Cars and locomotives were received from the United States in a knocked down condition and for that reason erection plants had to be constructed. At La Rochelle we built car erecting facilities and a regiment of shop troops was stationed there in charge of the assembly. This layout was arranged so that the trucks could be assembled on one set of tracks and then switched to a second set where the car floor was added. If it was a box car, it was shifted to a third set of tracks where the car was finished. All finished cars were then switched to the paint tracks where the paint was applied in the shop with sprays. The drying process was forced and the necessary markings were added. At the close of the war a larger layout was under consideration.

The locomotive erection shops were at Parc de Mean, just outside of St-Nazaire. The parts were unloaded from steamers onto cars and these were conveyed to the erection plant where they were assembled and finished. At the La Rochelle car erecting plant ninety cars per day were assembled and the proposed second plant would have had a capacity of about two hundred cars per day. Three locomotives were erected each day at St-Nazaire. Large car and locomotive repair facilities were installed at Nevers, where new French shop buildings were made available. All heavy repairs were made here and this was the headquarters of the shop regiment which formed part of our operating forces.

Such projects as sidings to hospitals, track connections to training camps, connections to and special layouts at aviation camps, aeroplane assembly layouts, remount stations, tank erection depots, motor transport shops and sidings, ordinary station sidings and passing sidings on the various lines required special consideration and the preparation of plans, subject to approval by various authorities. Plans for barges and lighters, all of which were built by our forces, also had to be made. In all of this it was necessary for the Designing Engineer to maintain close liaison with French railroad officials and the 4th Bureau of the French War Department.

Due to the fact that many of our early topographical surveys were made in too much of a hurry, they did not reveal important differences in some of the contours. Consequently, difficulties arose when construction was undertaken, and it was often necessary for the Designing Engineer to proceed to these sites, on very short notice, and in many instances make changes in the layouts while on the ground.

Besides the preparation of plans for all these various projects, there was considerable work to be done by the office of the Designing Engineer, such as working out tonnage ratings, developing operating charts from which time-tables were prepared, and a few other sundry tasks. This may account for the fact that a check-up made in the late summer of 1918, using a nine-hour day as being 100 per cent occupied, found the Designing Engineer and some of his assistants 150 per cent occupied.

Operation

With all of these facilities built or under construction, and with heavy troop movements under way, it is natural to suppose that the traffic over these railroads reached considerable proportions, making an orderly procedure quite essential. Special trains often had to be dispatched and shortly before the close of the war a total of three hundred and forty-two American trains were operated in one day, requiring the assistance of French railway personnel. It should be noted here that French personnel had to be relied upon very often due to the insufficiency of trained American personnel.

In order that the operating department might prepare time-tables for these train movements, it was necessary for us first to prepare train operating charts. In preparing such charts, careful consideration must be given to all existing train movements. An endeavor should be made not to change established schedules unless it becomes necessary, and then to make only minor changes. It should always be borne in mind that civilian traffic may be just as essential as military traffic. The civilian population must be fed and clothed. Business must be carried on, factories must be supplied with raw materials and, as many of the manufactured articles may be needed ultimately by the military establishment, civilian traffic must not be disrupted if possible to avoid it. In case of an extreme emergency, requiring excessive movements of troops and materiel, all civilian traffic may have to be curtailed or even temporarily abandoned.

The preparation of operating charts for our lines was not easy. The traffic on the French railroads was very heavy and a large number of military trains had to be superimposed. The heaviest traffic was from Bordeaux and St-Nazaire, where practically one-half of the forty to fifty daily eastbound trains were American trains. Of course a like number of trains had to make the return trip. Had the war lasted longer there would have been a considerable increase in the density on all lines, especially from Marseille. With such an elaborate railroad system as this to operate it is easy to understand that operating charts were also quite complicated.

For operating purposes, the Lines of Communication were first divided into Grand Divisions; these

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were then subdivided into Divisions. By way of example, the Bordeaux line with connecting branches was one Grand Railway Division, the St-Nazaire line and the Marseille line were others. Ordinary Divisions were such sections as were covered by an engine run, as for instance, Bordeaux to Périgueux, Périgueux to Châteauroux, St-Nazaire to Saumur, Saumur to Gièvres, Châteauroux and Gièvres to Cercy-la-Tour, Cercy-la-Tour to Is-sur-Tille. At the close of the war we had five Grand Divisions in the Service of Supply and one in the Advance Zone.

On the principal railroads in this country the trains are operated by the central dispatching system, requiring a complete telephone or telegraph system on the lines. In fact, most of the roads use both of these systems of communication for this purpose. The railroads in France were not equipped with such a system. In order to superimpose so large a number of trains on these railroads, requiring many close connections, it was necessary to install our own dispatching system. As the French wires were already crowded we built our own lines, so as to enable all services to be in closer touch with their various units along the railroads from the ports to the front. The installation was made by the Signal Corps. New poles and brackets were installed, carrying from twenty to thirty wires, and at the signing of the Armistice this enormous system extended from St-Nazaire to Is-sur-Tille (450 miles); from Bordeaux to both Bourges and Vierzon (284 miles); from Bourges to St-Florentin and Liffol-le-Grand (250 miles), a total of 984 miles. Both the Selector Telephone and the Telegraph were used for dispatching which was controlled by a Chief Dispatcher for each Grand Division. This system rendered excellent service and compared favorably with the best installations in this country.

Up to the advent of the American troops in France, no air brakes were used on the freight trains in France. All our rolling stock was equipped with air brakes, but the French rules did not permit their use. This handicap, however, was later removed and permission had been obtained to operate even mixed trains consisting of French and American equipment, in which case the American equipment had to be placed at the head end of the train.

Summary

The Transportation Corps planned all its Lines of Communications and designed all its projects, which were constructed by various Engineer regiments. It erected and repaired its own locomotives and cars. At the close of the war the engineer construction forces had completed 967 miles of track, and a great number of warehouses, barracks, and hospital wards. The Corps unloaded tonnages which increased from nothing in May, 1917, to 160,000 tons in May, 1918, and 921,000 tons in November, 1918, an average of over 30,000 tons per day. A total of more than 9,500,000 tons of all kinds of materials and supplies was unloaded and about two million men were disembarked. The corps also operated a maximum of one hundred and sixteen vessels plying between old world points and carrying as much as 285,000 tons in one month.

At the time of the Armistice the Corps had in service two floating cranes, nineteen tugs and tenders, fifty-one barges and lighters, and about thirteen hundred locomotives and fourteen thousand cars. In erecting and heavy repair facilities it had one locomotive erecting shop, two car erecting shops, one general repair shop for locomotives, and four ship repair plants. More than sixteen hundred locomotives and eighteen thousand cars had been erected in these shops. Plans had been prepared by the Designing Engineer's office for three hundred and sixteen projects ranging from a simple passing siding to hospital layouts, remount depots, miscellaneous repair plants, erecting plants, engine terminals, port plans, ammunition depots, regulating stations, and finally storage depots having about 250 miles of track, 4,000,000 square feet of covered storage space and 6,000,000 square feet of open storage.

In personnel, the Corps had grown from the two neophytes of June, 1917, to about forty-nine thousand men. Even then we had to rely upon the French for the operation of some of our trains.

The gigantic size of the achievement may be appreciated when it is realized that in mileage, rolling stock, freight tonnage, and passengers the Transportation Corps handled about as much as such American systems as the Atlantic Coast Line, the Baltimore and Ohio, the Illinois Central, or the Louisville and Nashville.

Conclusion

It may be seen from this article that a tremendous task was performed by the Transportation Corps and by the Construction Regiments in France.

With all, we did not do as much as we should have done, or could have done had we had a free hand and tools and materials to work with. Troops with their equipment were sent faster than we were able to take care of them, due to the demand for fighting forces made by the high command. This, however, was placing the "cart before the horse" and the armistice saved the crisis which we saw fast approaching, and which might have seriously handicapped our fighting forces.

Transportation is the key to success in a modern military establishment. This fact is recognized by all who are willing to face the truth. Eminent military writers, for instance, are giving the transportation forces the same important position as the Infantry. Just as the Infantry forms the backbone of the fighting forces, so the Transportation Corps forms the backbone of the entire military structure. To weaken this supporting structure is equivalent to undermining the foundation of a building with the resultant collapse of the whole structure.

The Corps of Engineers is charged with organizing transportation forces and with planning for the needs of this branch of the service in a future emergency. This fact was given recognition about two years ago when a Railway Section was authorized in the Office of the Chief of Engineers. The force assigned to this work is small, it is true, but it is a move in the right direction and progress is being made. It is unfortunate, however, that the duties of the Corps of Engineers are of such magnitude that very little opportunity is afforded other officers of the Corps to become acquainted with this work. Something should be done to improve this situation, at least *"Essayons."*

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Captain Ernest Peixotto

Unloading War Material at St. Nazaire

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