times over the measured distance, for the reason already given. The vessel was, therefore, under full steam on this trial for fully eight hours. The guaranteed speed was 18 knots, and the contract condition was that it must not fall under 17½ knots, otherwise the ship could be rejected. For each complete tenth part of a mile per hour under the guaranteed speed there was a penalty of 50,000 pesetas = 3,000%. But the speed was exceeded by half a nautical mile per hour, having been 18½ knots, notwithstanding a heavy Atlantic swell. The maximum was 18½ knots, and at no time did the speed fall below 18 knots. The steam pressure was 140 lb., and the mean power, worked out from records taken every 30 minutes, was 9,496 indicated horse power, with the engines averaging 107 revolutions. The starboard engine contributed 4,632 and the port engine 4,867 indicated horse power. There is a remarkable closeness in the power developed in the respective cylinders, and even this closeness in the mean results was excelled in several of the series of diagrams taken during the run.

The forced draught trials were run on October 14, 1893. Six runs were first made on the measured distance, and thereafter two hours' steady running to sea, concluding with four runs again on the measured distance, the total duration of trial being, therefore, 4½ hours. During the whole time the machinery worked exceptionally well. The average speed of 118 revolutions was kept up steadily, the highest revolutions counted being 120. The steam never fell below 140 lb., and maintained nearly throughout a uniform pressure of 145 lb., any excess of which the contract forbade. The mean air pressure in the stokehold was only 1 in. At the beginning of the trial it did not exceed ¾ in., and only in one stokehold was there at any time 1½ in. This was but for a limited period, instructions having been given that it was not to exceed 1 in., although 1½ in. was allowed by contract. The total power developed was 13,722 indicated horse power, of which 6,819 was developed by the starboard, and 6,903 indicated horse power by the port engines. This power was worked out from diagrams taken every 30 minutes during the run. The speed worked out to 20½ knots, a quarter of a knot over the guarantee. This might have been exceeded, of course, with the full air pressure, but it was deemed advisable to get the contract power without excess. There was no premium, but the conditions of the contract were that for every tenth of a mile per hour below the guaranteed speed of 20 knots, the firm were liable to a penalty of 26,666 pesetas = 1,000%. If the speed had been under 18½ knots, the vessel could have been rejected. As we have indicated, however, the forced draught speed of 20 knots was easily exceeded with a power of 13,722 indicated horse power.

Indicated horse power per square foot grate area:
Natural draught 11·24
Forced 16·24
Indicated horse power (forced draught)
per ton of total weight of machinery... 11·16

The fuel consumption trials were run on October 18 and 19, 1893, the weather being very fine, but with a slight swell on the sea. The vessel was, according to condition of contract, to be run for at least twelve hours with a speed of 10 knots. The coal was to be put in bags to facilitate the calculation of the consumption, which at 10 knots speed might vary, without giving rise to the imposition of fines, between 635 and 680 grammes per hour and horse power indicated, developed by the principal engines and the auxiliary apparatus connected therewith.

The vessel started at 3 o'clock in the afternoon, and six runs were made on the measured distance of 1412 knots, the cruiser thereafter continuing out to sea until 6 o'clock in the following morning—October 19. The coal was carefully weighed in the stokehold by the arsenal experts, and put into bags, each of 165 kilogrammes, and men were stationed at each of the bunker doors to prevent more coal being taken out than had been weighed, so that the results are accurate. One single-ended and two double-ended boilers were employed to supply the steam to the main engines and to the auxiliary engines connected therewith, and for the auxiliary engines (i. e., steering gear engine, electric light engine, auxiliary circulating pumps, and bilge pumps) one of the single-ended boilers was used, but without any connection to the main engines. The consumption of the coal was carefully recorded for twelve hours in the case of the main boilers, and for eight hours in the case of the auxiliary boiler. The result was that the coal consumption for the propelling machinery was found to be 650 grammes or 143 lb. per indicated horse power per hour, the engines meanwhile running at a mean of 55 revolutions and developing 1,231 horse power. From the results of this trial the radius of action of the cruiser was determined according to the bunker capacity, and this was found to be 9,800 nautical miles at 10 knots speed. The details of the engine performance are given in the table, with those of the natural and forced draught speed trials.

One single-ended boiler supplied steam to the following auxiliary engines: Two auxiliary circulating pumps, two fire and bilge pumps, steering gear engine, electric light engine, and auxiliary feed pump, the total horse power developed being 197. The total coal consumed per hour in the single-ended boiler was 239·5 kilogrammes, which gives 122 kilogrammes or 268 lb. per indicated horse power per hour. The auxiliary engines above referred to are single cylinder engines, with the exception of the electric light engine, which is compound, having cylinders 7½ in. and 13½ in. in diameter by 8 in. stroke.

The contract further stipulated for a trial with one screw, the rudder being thrown over to maintain a straight course, and the guaranteed speed being 12 knots. This trial, under natural draught, was run on October 19. The port engine was used, the rudder being from 12° to 15° over. The mean speed of three runs on the measured mile was 12·56 knots, with the engine running at 85 revolutions. Steam was supplied from one single-ended and two double-ended boilers.

On the same day the starting, stopping and reversing trials were gone through, with the following results: From "full speed ahead" to "stop," 7 seconds; from "full speed astern" to "stop," 6 seconds; from "full speed astern" to "full speed ahead," 7 seconds.

SPANISH CRUISER INFANTA MARIA TERESA. OFFICIAL TRIALS AT FERROL.

	Natural draught, September 18, 1893.	Forced draught, October 14, 1893.	Coal consumption, October 18, 1893.
Revolutions per minute	107	118	55
Indicated horse power, starboard high pressure cylinder	1,592	2,069	259·38
Indicated horse power, starboard intermediate pressure cylinder	1,553	2,290	211·38
Indicated horse power, starboard low pressure cylinder	1,487	2,460	120·14
Indicated horse power, port high pressure cylinder	1,626	2,075	273·65
Indicated horse power, port intermediate pressure cylinder	1,606	2,515	190·00
Indicated horse power, port low pressure cylinder	1,635	2,313	176·65
Total	9,499	13,722	1231·2
Steam pressure	140	143	110
Vacuum, starboard	27	27½	26½
" port	27	27	27
Receivers, starboard high pressure	117	134	33
Receivers, starboard intermediate pressure	36	52	3 lb. vacuum
Receivers, starboard low pressure	7	13	9½ in. vacuum
" port high pressure	112	140	34
" intermediate pressure	38	50	2 lb. vacuum
" low pressure	7	15	10 in. vacuum
Mean pressures, starboard high pressure	46·2	54·4	14·7
Mean pressures, starboard intermediate pressure	20·7	27·6	5·5
Mean pressures, starboard low pressure	9·0	13·5	1·42
" port high pressure	47·2	54·6	15·45
" intermediate pressure	21·4	30·4	4·9
Mean pressures, port low pressure	9·9	12·7	2·08
Cut-offs, high pressure	62·5	73	55
" intermediate pressure	70	75	60
" low pressure	70	75	67½
Speed	18·5	20·24	10
Duration of trials	6	4	12

Mean air pressure in stokeholds at forced draught trial = 1 in. of water.
Coal consumption per indicated horse power per hour = 650 grammes = 143 lb.

The contract also stipulated for a trial of the engines to ascertain the least number of revolutions required to enable the engines to work with perfect regularity with the valves sufficiently closed, with the normal vacuum in the condenser, and with 145 lb. boiler pressure. This proved to be 13 revolutions, equal to a speed of ship of about 2½ knots. At this speed the engines were kept running for about ten minutes.

The naval commission, after the trials were completed, expressed themselves as being highly delighted with the results of the severe and exhaustive tests to which the machinery had been subjected, and expressed the opinion that no navy in the world had a finer ship, or machinery which had been put to such severe tests, and with such excellent results.

AMERICAN MILITARY ROADS AND BRIDGES.*

By Prof. P. S. MICHIE, U. S. Military Academy.

THE United States, by reason of its fortunate situation, its free institutions, its vast resources, and constantly increasing population, is happily free from the necessity of maintaining a large standing army and of devoting any considerable portion of its revenues to the expensive art of war. In the ordinary acceptance of the term it cannot therefore be regarded as a military nation. It presents a strong contrast to the powerful military states of Europe; for its immediate neighbors, both north and south, are friendly and peaceable people, whose armed forces are as insignificant in numbers as are those of her own. Year by year, as her population approaches the round hundred million, the possibilities of war become more and more remote with even the most powerful nation on the globe. Throughout the extensive domain that acknowledges its sovereignty, the sentiments of loyalty to the existing constitutional government are continually being strengthened and a more perfect homogeneity developed among its people. To all present appearances there seems to be no reasonable apprehension that any question can arise in the near future that will divide her citizens into two hostile parties separated by geographical boundaries. The thorough intermingling, caused by social and commercial interests, aided by the abundant means of intercommunication, the rapid interchange of opinion, and the frequent opportunities for political decision on all national questions, tends to make the political machinery move with the least possible friction.

From this preliminary statement, the truth of which is manifestly self-evident to the most casual observer, it is not surprising that, since the termination of the rebellion, there is little progress to be noted in anything relating to the military profession in this peace-loving country. Prudential considerations, however, have forced the nation to devote its attention of late to the subjects of modern war ships and great guns, in order that its vulnerable coast line may be, in some measure, protected.

With regard to the subject of "Military roads and bridges from an American standpoint," upon which I have been requested to submit a paper, I am at a loss to find anything of interest to say, whether new or old. Strictly speaking, we have never had any military roads in this country, and we owe the purely military bridges that have from time to time been in use in our service to the French and other military nations of Europe. Since the close of the rebellion no modification has had the benefit of experimental service, and the total bridge equipage of the U. S. Army to-day is reduced to a bridge train at West Point, employed to instruct the cadets of the United States Military Academy, and another at Willets Point with the Battalion of Engineers, U. S. Army.

MILITARY ROADS.

From the time of the early settlements on the Atlantic seaboard until the introduction of railways, about the year 1827, the only means of communication between

* Read before the International Congress of Engineers at Chicago, and published in the *Journal* by permission of the late Maj. Clifton Comly, Chairman of the Division of Military Engineering. From the *Journal of the Military Service Institution*.

the outlying settlements and the towns from which they drew their supplies were mere surface roads, which, from time to time, have been improved both in character and in location as the necessity has arisen. The regular army of the United States, which has always been maintained at the least possible minimum strength for the multifarious duties assigned to it, has been constantly kept on the frontier of civilization to protect the ever-advancing pioneer settlements. To preserve its communications, so-called military roads have been established and built by the troops under the direction of army officers. A road was known as a *military* road when it could be used by wagons hauling supplies for the advanced military posts. In location it was often so directed as to require the minimum labor for its construction, taking advantage of such grades of the natural surface of the ground as would permit the passage of the rough wagons of that day, drawn by oxen, mules or horses. As the country increased in population and prosperity, the traffic over many of these roads became much heavier, so that in parts, at least, they were improved in location and made of a better character by macadamizing. Examples of these earlier types of the military road are that from Detroit, Mich., to the Maumee River, constructed by Bvt. Maj. John Anderson, Topographical Engineer, in 1817; the military road through Mississippi, by Lieut. William M. Graham, Corps of Artillery, 1819-20; those in Florida to St. Augustine, by Lieuts. Lacy and Trenor, 1824, 1825 and 1826, and from the Georgia State line to Smyrna, Fla., by Lieuts. Phillips, Anderson and Clay, Fourth Infantry, 1827-28; in Arkansas to Little Rock, by Lieut. Archer, Third Infantry, 1837; and from Fort Leavenworth, Kan., to Fort Smith, Ark., by Capt. Dimmick and Lieut. Prince, Fourth Infantry, 1837-38.

The United States possessed a vast territory west of the Mississippi River, which was greatly increased by the acquisition of other lands ceded by Mexico after the war. Most of this was an unknown wilderness, which had from time to time been pierced by adventurous explorers from 1800 to 1844, notably by Capt. Lewis and Clarke, 1804, 1805 and 1806; by Maj. Pike in 1805 and 1806, and by Maj. Long in 1819-23; by Capt. Bonneville, 1832-36; Commander Wilkes, U. S. Navy, 1838-42; Lieut. Fremont, 1842; Capt. Boone and Capt. Allen, 1843, and Josiah Gregg in 1844. From 1843 to 1852 many other army officers were detailed to continue these explorations and to locate military roads in the wilderness, and from 1852 to 1857 additional important duties were assigned to them relating to the survey and location of railway routes to the Pacific Ocean. The details of these explorations, surveys, road locations, etc., are given in Lieut. Warren's memoirs of the War Department, March 1, 1858, an epitome of which is published in Vol. I. of Capt. Wheeler's "Surveys West of the One Hundredth Meridian." The whole is a magnificent monument to the thorough training, ability, endurance and devotion of the officers of the U. S. Army and their companions in this most dangerous and difficult branch of their service.

RAILROADS.

It would have been impossible to have conducted the tremendous operations of such a war as that of the rebellion by means of the ordinary wagon roads existing at that time in this country. Railways, which had reached a state of very great development, especially in the North, in 1860, became therefore the true military roads, and require some brief mention in this connection. A reference to Gen. Cullum's biographical register of the graduates of the Military Academy shows that to these officers much of the credit for their location, operation and management is justly due. He says:

"In 1827 the railroad mania began to rage in this country. At that time there were existing only a few insignificant local short roads, aggregating in length less than 20 miles, and there were few educated civil engineers in the United States to conduct larger works. Under these circumstances the government adopted the wise policy of loaning officers of the army, scientifically educated at the Military Academy, to assist railroad companies in carrying out more ambitious projects. In this manner our army engineers became the pioneers in railroad construction and the educators of an able body of civil engineers, who to this day have continued the inherited traditions, methods, discipline, *esprit de corps* and high bearing of their distinguished predecessors."

The general geographical boundary that separated the hostile armies during the earlier stages of the conflict was that indicated by the Potomac, the Ohio and the Missouri Rivers. The main theater of operations of the East, being the triangular portion of Virginia bounded by the Allegheny Mountains, the Potomac River and Chesapeake Bay, was drained by a parallel system of rivers—the Rappahannock, Rapidan, Pamunkey, James and Appomattox—each of which formed an admirable defensive line against an advance southward, for the river crossings were easily destroyed or obstructed. To supply the Army of the Potomac operating against Richmond, reliance could only be placed on the ordinary country roads, which were but fair in good weather, but almost impassable for army wagons and artillery in wet. With roads of such a character the lengths of haul must needs be short from the main supply depots, in order that the large army might be supplied with provisions, forage, ammunition, and the multifarious other less necessary things so requisite for its success. The Confederates depended upon the uninterrupted service of their railway lines that drained the rich granaries of the South to fill their main supply depots, while the Union forces relied on water transportation for the same end. As illustrations of the great difficulties of supply by military roads, it may be well to quote the following statements of two great generals.

Speaking of the Virginia campaign of 1864, Gen. Grant says:

"During the campaign of forty-three days, from the Rapidan to the James River, the army had to be supplied from an ever-shifting base by wagons, over narrow roads, through a densely wooded country, with a lack of wharves at each new base from which to conven-

* See Cullum's "Biographical Register," Vol. I., p. 163.

+ "Gen. Grant's Memoirs," Vol. II., p. 572.

ently discharge vessels. Too much credit cannot, therefore, be awarded to the quartermaster and commissary departments for the zeal and efficiency displayed by them. Under the general supervision of the chief quartermaster, Brig.-Gen. R. Ingalls, the trains were made to occupy all the available roads between the army and our water base, and but little difficulty was experienced in protecting them."

Gen. Sherman says:*

"To be strong, healthy, and capable of the largest measure of physical effort, the soldier needs about three pounds gross of food per day, and the horse or mule about twenty pounds. . . . Our base of supply in the campaign of 1864-65 was at Nashville, supplied by railroads and the Cumberland River, thence by rail to Chattanooga, a 'secondary base,' and thenceforward a single track railroad. The stores came forward daily, but I endeavored to have on hand a full supply for twenty days in advance. These stores were habitually in the wagon trains, distributed to corps, divisions and regiments, in charge of experienced quartermasters and commissaries, and became subject to the orders of the generals commanding these bodies. . . .

"An ordinary army wagon drawn by six mules may be counted on to carry 3,000 pounds net, equal to the food of a full regiment for one day, but, by driving along beef cattle, a commissary may safely count the contents of one wagon as sufficient for two days' food for a regiment of a thousand men; and as a corps should have food on hand for twenty days ready for detachment, it should have three hundred such wagons as a provision train; and for forage, ammunition, clothing and other necessary stores, it was found necessary to have three hundred more wagons, or six hundred wagons in all for a *corps d'armée*. . . . The value of railways is also fully recognized in war, quite as much, if not more so, than in peace. The Atlanta campaign would simply have been impossible without the use of the railroads from Louisville to Nashville—155 miles—from Nashville to Chattanooga—151 miles—and from Chattanooga to Atlanta—137 miles. Every mile of this single track was so delicate that one man could in a minute have broken or moved a rail, but our trains usually carried along the tools and means to repair such a break. . . . Our trains from Nashville forward were operated under military rules, and ran about ten miles an hour in gangs of four trains of ten cars each. Four such groups of trains daily made 160 cars, of ten tons each, carrying 1,600 tons, which exceeded the absolute necessity of the army and allowed for the accidents that were common and inevitable. But, as I have recorded, that single stem of railroad, 473 miles long, supplied an army of 100,000 men and 35,000 animals for the period of 196 days, viz., from May 1 to November 12, 1864. To have delivered regularly that amount of food and forage by ordinary wagons would have required 36,800 wagons of six mules each, allowing each wagon to have hauled two tons twenty miles each day—a simple impossibility in such roads as then existed in that region of country. Therefore I reiterate that the Atlanta campaign was an impossibility without these railroads; and only then because we had the men and means to maintain and defend them, in addition to what were necessary to overcome the enemy."

It is thus evident that railways have become the true military roads of an army, and that their location in the future will have a determining influence on the plans of campaign to be adopted. When armies relied only on wagon roads there was comparative equality in celerity of movement with the successful and the defeated, whereas, hereafter, the greater advantage in this respect will be on the side of the retreating army, provided it can hold the line of railway in its rear. The history of the rebellion scarcely presents a single instance, in such a case, of a successful and, at the same time, of a rapid pursuit. Even in Sherman's Atlanta campaign, with a greatly superior force, the advance was greatly delayed by the frequent necessity of repairs to the railway and bridges, and the urgency for immediate restoration to a working condition led to the organization of an efficient construction corps commanded by specially skilled engineers, of whom Col. W. W. Wright, in Sherman's army, and Col. Herman Haupt, in the Army of the Potomac, were illustrious examples.

CORDUROY ROADS.

The ordinary dirt roads over which the various armies moved during the rebellion were very soon cut up by the heavy traffic to which they were subjected, that even in good, dry weather they were unfit for the purpose of travel by the army wagon; and in wet weather they became absolutely impassable. This was especially the case from the main depots of supply of an army to the several corps, divisions, brigades, or other subdivisions. Fortunately, in nearly all cases, the country was well wooded and furnished abundance of small timber to make a semi-permanent covering for the much-traveled roads. The usual method employed was to lay a sufficient number of stout sill timbers lengthwise, and to place crosswise on these saplings of about four to six inches in diameter, which were tied down by side rails, secured by anchor pickets or other means. Many hundreds of miles of these roads were built during the war for the armies in cantonments, and often it even became necessary to do so for the single passage of an army in advance or retreat. A marked example of this is seen in the advance of Sherman's army over the low, swamp ground between Savannah and Columbia, in his onward movement toward Goldsboro, where, for a time, every foot of road had to be corduroyed. The American volunteer soldier displayed such an adaptability to his surroundings and such ingenuity that he soon acquired a marvelous aptitude for road and bridge building, so as to cause little delay in the army's progress, no matter what difficulties offered themselves to bar its advance.

MILITARY BRIDGES.

Prior to the Mexican war there was no organized bridge train in the United States service, but during that war two complete trains of India-rubber pontoons were constructed and sent to the army in the field. Subsequently these trains were sent to West Point for the instruction in pontoon bridge drill of cadets and engineer troops stationed there. In 1858 they became unserviceable by the deterioration of the vulcanized

rubber of which they were made, and in the fall of that year experiments were undertaken to fix upon a suitable bridge train for the exigencies of the army service. After two years' careful investigation the French wooden pontoon was adopted for the reserve bridge train and the Russian canvas pontoon for the advance bridge train. Owing to the length of the reserve pontoon boat, the wagon required to transport it over the narrow and crooked roads of the country was designed on the principle of the four-horse truck, which, by means of a fifth wheel over the front axle and an inclined wagon bed, permitted the forward wheels to reverse completely under the load and the wagon to turn in a very short space. As an adjunct to these bridge trains, for the bays nearest the shore, the Birago trestle was adopted to form part of the bridge equipage. During the winter of 1861-62 five reserve trains of thirty-four pontoons and eight trestles each were constructed, and several canvas trains were also organized, all of which were thoroughly tested in the war of the rebellion. It was soon found, as the result of experience, that the trestles could be dispensed with in most cases, as the wooden pontoon was sufficiently stiff to be used in shallow depths, or even over marshes and swamps.

Of the numerous examples of the use of pontoon bridges in the rebellion, the following may be cited for illustration:

In the month of February, 1862, a pontoon bridge, composed of sixty boats of the reserve train, was thrown across the Potomac at Harper's Ferry. The river was then a perfect torrent, the water being fifteen feet above the summer level and filled with driftwood and floating ice. The greatest difficulty was experienced in pulling the pontoons into position, and it was necessary to make use of ship anchors and chain cables to hold them in place. Notwithstanding these unfavorable circumstances, the bridge was completed in about eight hours, and the corps of General Banks, with all its trains and artillery, passed over it without accident or delay.

Several of these trains accompanied the army in the peninsular campaign. The pontoons were used in discharging quartermaster and commissary stores at Ship Point; in disembarking General Franklin's command at West Point, and in constructing bridges over Hampton Creek, the streams in front of Yorktown, and the upper Chickahominy. Finally a bridge was built over the lower Chickahominy about 2,000 feet long, over which nearly the whole Army of the Potomac, with its immense trains, artillery and cavalry, passed with promptness and safety.

"During the Fredericksburg campaign it became necessary to force the passage of the Rappahannock. The enemy having entrenched themselves on the bank, prevented for some time the construction of the bridge, until at length troops were embarked in the pontoons and ferried across, where they stormed the rifle pits and held them until the bridge was completed.

"During the year 1863 the pontoon trains accompanied the army in all its marches backward and forward through Virginia, frequently bridging the Potomac, Rapidan, and Rappahannock. In the latter stream the bridges remained in position all winter; and, notwithstanding the frequent floods and quantity of ice formed, but few interruptions occurred upon these thoroughfares. During the campaign of 1864, trains composed of fourteen pontoons and two trestles accompanied each of the three army corps of the Army of the Potomac. These trains attended their corps in the long march from Culpeper to the James River, and, although the roads were frequently very bad, in no instance did they delay the march of the troops or arrive late when a bridge was to be laid. The headquarters train was followed by a canvas train, which, when a crossing was to be made by surprise, was sent forward with the cavalry, who covered the construction of the bridge and held the position till the main body arrived."

In the campaign of 1864, the position of the Army of the James at Bermuda Hundred required much bridge building. The bridge equipage of this army comprised one new reserve train of fifty boats, twelve trestles, with wagons and harness complete; one advance guard train of twenty-five boats, with wagons and harness; and twenty-five canvas and thirty-three surf boats belonging to the Tenth Corps of that army. On the 20th of June the James River was bridged at Deep Bottom, where its width was 575 feet. This was accomplished by silently launching the wooden pontoons a mile and a half above the designated location after dark, and ferrying 1,400 troops across to the point previously selected on the enemy's side of the river, to cover the pontonniers while constructing the bridge. The landing was effected in thirty minutes, and by 11 o'clock the bridge head was defensible against attack.

Another successful passage of the James River occurred on September 29, by the Army of the James, which resulted in the capture of the outer line of the Richmond defenses. In this instance the engineer officer charged with the duty of constructing the bridge had several days' notice of the contemplated movement, so that he was able by personal reconnaissance to select the most suitable point of crossing. The bridge was constructed by successive pontoons at night, in the strictest silence and secrecy, and as it progressed was covered with long manure and hay to deaden all sounds of the necessary labor. The bridge, when completed, was 1,320 feet in length, required six hours for its construction, and was in complete order for the passage of the assaulting column an hour before the time designated for its arrival.

The Appomattox River was bridged at Point of Rocks to connect the armies of the Potomac and James, which, owing to swampy approaches, required a length of 2,625 feet in all; and at Broadway Landing, on August 3, for the passage of the Second Corps to cross Bermuda Hundred to fight the battle of Strawberry Plain on the left bank of the James; and at the same place a canvas bridge, 460 feet long, on August 19, which, not being under the enemy's fire, required only an hour and a quarter for its completion, the abutments having been previously prepared.

The wooden pontoons were found to meet all possible requirements for actual service, especially in the tidal rivers in the eastern theater of the war,

* See United States bridge equipage. Washington: Government Printing Office, 1870.

but the canvas pontoon had many defects when it was put to a severer use than that for which it was designed. Its buoyancy was less, and its canvas subject to rot from the manure covering and to leakage from many accidents. While it served its purpose admirably in the Western armies, it could not meet the demands of the heavier traffic in the East.

As an example of the remarkable availability of the wooden pontoon, the passage of the James River by Grant's army in June, 1864, is worth noting. It was highly important that General Lee should be kept in ignorance of the probable movements of the Army of the Potomac after the battle of Cold Harbor, and of the point of crossing the James River. To Lieutenant Michie, Corps of Engineers, United States Army, was intrusted the selection of the bridge site, with the understanding that but twenty-four hours' notice was all that could be given from the beginning of the preparation of the approaches till the arrival of the column for crossing. The site chosen was at Fort Powhatan, where the width of the river was 1,992 feet, and so efficiently was the service performed that approaches on both sides, aggregating over 1,000 feet in length, were corduroyed, and abutment piers on each side of 150 feet in length were built fifteen minutes before the specified time had elapsed. Had it not been for an inexcusable delay of twelve hours in the arrival of the boats, the troops might have marched, without halting, across the river straight on to Petersburg. The bridge, being over 2,000 feet in length, was constructed over a tidal river of great depth, and of necessity the usual methods of anchorage could not be adopted, and the expedient of attaching the anchor lines to a line of schooners moored above and below the bridge was happily devised. Over this bridge the bulk of the troops, trains, artillery, and baggage of the Army of the Potomac was passed without accident or delay, beginning at midnight of June 14 and completed at midnight of the 16th.

The movable column of the Army of the James, in its flanking march to Appomattox, was obliged to move with great celerity. For the repair of roads, bridges, etc., two companies of engineer troops under the command of a field officer marched in advance of the infantry, while the remainder of two battalions followed the leading infantry division. The pontoon train moved with the headquarters train, and in this instance consisted of fifteen canvas boats and four trestles, or in all 380 feet of bridging, requiring for transportation twenty-two pontoon wagons, eight forage wagons, one wagon for spare chests, and one traveling forge. In this march of seven days 20 miles of road and twelve bridges were repaired and built. The weight drawn by the eight mule teams, over poor roads, amounted to 3,168 pounds, which, with the weight of the wagon, 1,278 pounds, made an aggregate of 4,446 pounds to be drawn by each team.

OTHER MILITARY BRIDGES.

The impassability of the ordinary American roads in wet weather often prevents the transportation of the movable bridge equipage, and therefore necessitates other devices for the crossing of streams and rivers. During the rebellion many instances occurred of these improvised bridges, for a full account of which a reference to the admirable volume of Colonel Herman Haupt, on "Military Bridges," will give all the requisite information. Many of the constructions there described are embodied in the "Organization of the Bridge Equipage of the United States Army," adopted for the service in 1869, and published by the War Department in 1870. This system was the result of the studies and investigations of a board of officers, consisting of Generals Duane and Abbot, and Colonel Merrill, of the Engineer Corps, United States Army, each of whom had the advantage of a wide and varied experience in his profession during the war of the rebellion.

THE PASSAGE OF RIVERS BY CAVALRY.

THE importance of cavalry in war, in spite of the strides made of late years by arms of precision, appears likely, if we read the signs of the times correctly, to increase rather than to diminish. The *arme blanche* may possibly not be able to assert its powers on the battlefield itself as in the golden prime of Zieten and Seydlitz, but it will find other opportunities; and the manner in which it can turn them to account will still influence, though less directly so than hitherto, the issue of campaigns. And the gathering masses of horsemen on the western frontiers of Russia, confronted by growing bodies of Austrian and German *retirees*, warn us how the next storm on the Continent will first burst on us. The portents are certainly full of encouragement for the enthusiastic *sabreur*, and it is small wonder that he is throwing himself everywhere into the study of his arm with increased and increasing zeal. Mobility being as the breath of life to cavalry, it is naturally striving to train itself to be equal to every difficulty which may check its activity. It is seeking, not only to be able to brush aside the irritating opposition which comparatively small bodies of well-posted riflemen may throw in its path, but to overcome the natural obstacles which may impede its free and unhampered progress. Horse artillery, and perhaps machine guns, lend it aid for one purpose, and it may fight effectively on foot without sacrificing the dash and rapidity on which it will ultimately rely. A small ditch or rivulet, however, has ere now disordered and paralyzed the splendid intrepidity of a Murat. Therefore much attention is being given abroad to training troop horses to leap such obstacles freely. But an unbridged river may render a well-planned reconnaissance unavailing, if the eagersquadrons are to be brought to a standstill by it; and yet, since horses and men can easily learn to swim, such a barrier need never prove quite impassable. Squadrons that are not accustomed to dealing with the difficulties which streams may throw in the way of their unrestricted march are not, in fact, trained as they should be, to be equal to all the exigencies which war may impose upon them. Hence it is that, on the Continent, great attention has of late been given to the passage of rivers by cavalry, and that, especially in Russia, the actual swimming of them has become a very familiar feature of the exercises of regiments and divisions.

Perhaps the memories of the great wars at the com-

* Gen. Sherman's Memoirs, Vol. II., p. 339.