

once primed does not get empty again, and remains always ready to operate.

These pumps may be used for pumping water charged with solid substances. The peculiar form of the piston has the effect of bringing all solid bodies into the current, and experience has proved that these generally make their exit intact, although the apparatus is strong enough to crush any obstacles that might oppose themselves to its running.—*Le Genie Civil*.

RAILWAY SURVEYS—CAMP AND FIELD LIFE ON THE UNION PACIFIC.

By C. H. MIDDLETON, C.E.

As I am many miles from my books, maps and drawings, and the only interesting engineering works I have recently seen are those of nature, it has occurred to me that, in lieu of something more scientific, an account of the way in which railroad surveys are made in this country might be of interest to many of the club who have never had to "rough it."

The Union Pacific Railway is the pioneer, and to-day makes more locations, explorations, and examinations into undeveloped parts of the country than any of the other Pacific companies, and its methods are fairly typical of the others.

The growth of business in newly settled parts of the West is so rapid that it offers quite an inducement to the railroads, and a lively competition for the control of those districts among the railroads near them is sure to follow. This creates a demand for, and gives employment to, a large number of engineers.

As a rule, the engineers who have acquired all their experience in the West do not have the great variety of experience in construction which most of their Eastern brethren are favored with, but in "location" and reconnaissance the Western engineer is most favored. The Union Pacific Railroad Company has some old men who have spent all their time at this kind of work. Some of them have been engaged in similar work in Mexico and Peru. These older heads guide and direct those of less experience, with very good results. In this country, where so many hundreds of miles of railroads are built annually, it is of prime importance that the best and most economical location be had, and it is secured here with less time and expense than in the East.

The engineer who makes a specialty of railroad location and construction has a very favorable field in the West, while in the East it is becoming smaller and less profitable every year. In a prairie country, like Kansas and Nebraska, where it costs very little per mile to construct a railroad, and where the demand for them is always urgent, a number of locating parties are constantly in the field.

The party live in tents all the year round, and are furnished with two teams with which to move camp and haul supplies. Usually there are fourteen men in a party, including a cook and two teamsters. When the topography of the country is such as to require contours to be taken on the preliminary lines, two more men are furnished the topographer. Three tents, 14x16 feet, are furnished, as well as all other camp equipment. The members of the party merely provide their own blankets for bedding.

The "office tent," is furnished with drafting tables, stationary chest, and all supplies necessary to make finished maps and profiles of the work. The engineer in charge of the party and transitman, levelman, topographer, and rodman occupy this tent. A small wrought iron stove of the Franklin pattern, without any grate, gives ample heat, and if the party manages to carry their lamp without getting it broken they have a good light.

The "mess tent," when presided over by a good cook, is always sure of unwavering popularity. The railroad company provides everything that is necessary to prepare the food, and they give the engineer in charge of the party full and entire discretion as to what to provide the cook with.

The parties all live well and even enjoy a great many delicacies. Of course there are times when the supplies do not come in on time, and sometimes the cook stove will not draw, and there are many little accidents that will now and then conspire to spoil a good dinner, but in general the mess tent is sure to contain comfort and good cheer, no matter how gloomy the remaining part of the camp is. The remaining tent is used by the rank and file of the party as parlor, sitting room, gymnasium, and dormitory combined. This is always an interesting place, and one that is not affected by anything external. The inmates of this tent are never troubled by the fluctuation of stocks or the war clouds that threaten the destruction of a nation. They are of all ages, from all parts of the country, represent all temperaments and all conditions of servitude. Vital questions of religion, science, politics, and business are discussed with astonishing freedom.

In the winter, when the party is working where there is no shelter, a tent is provided for the horses. One team is usually kept with the party, taking them to and from camp, and, when practicable, moving the transitman from one point to the next. When the party is making ten miles a day, this assists very materially. All the stakes for the day's running, the dinner, and sometimes coats that are not needed on the work, are carried by this team. The other team is kept busy as soon as the party begins to get away from their base of supplies. At one time last winter, when the roads were bad on account of snow drifts, we had to send forty miles for supplies. Once every week we had to send map and profile and a report of the week's work to the chief engineer's office; the team was sent with that and for our mail; then there was fuel to haul, and sometimes we had to haul water. Between times, when there was no hauling to do, they were kept busy scouring the country in search of milk, eggs, poultry, etc.

At one time in the spring, after the snow was gone and we no longer had any to melt, we had to haul all the water we used ten miles over hilly roads. It was in an unsettled country where there were no wells or springs, and the nearest stream, Platte River, was ten miles away.

I spent all of last winter in camp, with nothing but a 12-ounce canvas tent for shelter at night and on days when we could not work. There were six other parties out in the fall, but some were called in by the latter part of November, and only three others were in

the field all winter. A number of the engineers have been living in tents continuously for years.

In the mountains all surveys have to be discontinued between November and May, on account of the snow. During that time some of the parties are given work in the prairie country, and some are happy to be disbanded until work is resumed.

I was on location most of the time during the winter, and the line was ninety miles in length. The maximum curvature was three degrees and maximum grade one-half of one per cent. In two places there were five miles of continuous maximum grade. On curves the grade was equated five one-hundredths of a foot per degree of curvature, and all curves of less radius than 5,730 feet were spiraled or elasticized. This equation of grades seems trifling on the line above mentioned, but on other work where six degree curves are used it is important, as every good engineer knows. The spiraling of curves is done by running the curve on an offset and at each end of the curve, and on the adjacent tangent new offsets are made every 25 feet, fixing the line of the spiral.

The length of spiral on the curve and tangent is made equal, and at the point of curvature and tangent the spiral is midway between the original point and the offset from which the curve was run. The length of spiral and the offsets vary for different curves, and for the same curve where the topography of the country requires a light or heavy spiral.

It is the prevailing opinion among Eastern engineers that the work in the West is done in a very loose and slipshod manner, but in justice to all whom I have been associated with in this country, I can say that I have seen more care exercised to insure accurate field work than I ever did in my seven years' experience with the largest railroad company in the East. Although we sometimes run ten and twelve miles a day in favorable prairie country, it is never done at a sacrifice of accuracy. All distances are measured twice, and double sights taken with the transit at every "set up;" that is, after taking a back sight and setting the point ahead, the instrument is turned half way around, a new back sight taken, and another point set ahead; if it does not coincide with the point first set, one is established midway between them to run ahead from. This insures a straight line in case the cross hairs are slightly out of adjustment. Any chance of error from parallax is diminished by reversing the direction of the instrument at each set-up.

In all estimates the prismoidal formulæ are used, and it is not considered accurate enough to average end areas and multiply by the distance between them for the cubic contents.

Last winter was a mild one, and there were but few days when we could not work out doors. I hardly think that Philadelphians would see anything very mild about it, but in Nebraska they judge by a colder standard. From November to March we had snow, and the thermometer most of the time was below zero. On several mornings the thermometer in my tent was 20 degrees below, and outside of the tent it was too low for the thermometer to record. When the wind blew, as it generally does in Nebraska, we could not work when the temperature was 10 degrees below zero, but on calm, still days we could stand it on the coldest days. We had but two genuine blizzards. One of them lasted three days, and it was with difficulty that we kept our tents from being blown away. You may realize that we were very much concerned in the matter when I say that we were miles from any other shelter, and the same storm blew down a number of buildings. In the night we would sometimes have to go out and strengthen the ropes or put in more spikes to hold them. We had the mess tent blown down and badly torn one Sunday, just in time to spoil a good dinner, and kept us busy the balance of the day in repairing the wreck.

When we had good country to work in and not too much snow to wade through, we ran from two to four miles of location per day. That would necessitate our moving camp about once a week. In winter, when the snow is deep, moving camp is the most unpleasant thing to do. If a long move has to be made and the roads are bad, the loads have to be made up and started early, in order that they may reach the next camping place and have tents pitched by night.

On moving days we usually had to turn out at half-past four and pack up and load everything on the two wagons, except the mess tent, before breakfast. The party would then go out to work, and the cook and teamsters afterward finished loading, and would try to reach the new camping place, and clear off some snow and get up one or more tents by the time the party came in from work in the evening. In the summer, when the party is running from five to ten miles per day, the moving day comes oftener.

I know of one party, on preliminary work in the Platte River Valley, that averaged ten miles of line per day, all one summer. When it did not take too much time to get connections with the section lines, they moved camp every day, and sometimes only every other day. Under such conditions a man would be apt to question whether life were worth living.

When we are in a farming district where corn is cheap and coal would have to be hauled a long distance, it is much cheaper to use corn (on the cob) for fuel. Most of the time last winter we used corn for that reason. It cost from sixteen to twenty-two cents per bushel, and coal was worth just twice as much. It burns readily and makes a hot fire. We seldom had any trouble to heat our tents even in the coldest weather. A tent will doubtless seem like very poor shelter, but after lying out with nothing but blankets for a covering, as we had to do many a night, we have learned to appreciate it.

One of the trying things peculiar to the West which we have to do is to get connection with all the section lines and corners near our surveys. These corners have been established by all kinds of methods except the proper one, and it is rarely that we find them as they should be. They were originally put in by contract, and if the contracts were not awarded to the lowest bidder, they surely must have been given to the most incompetent ones. It was a poor policy which led to this false economy on the part of the government, and it has cost the people interested in it more than would have been required to do it properly at first. The trouble which is experienced by the railroad companies arises from the fact that the sections are recorded at the surveyor-general's office as being

established accurately, just as the contractors were paid for doing it. Now, in order to hold a location and for government information, our maps, reduced to a scale of 2,000 feet per inch, showing all townships and sections, etc., have to be filed with the government at Washington. These connections are shown just as they occurred on the ground and in a line of 100 miles long. Some places are going to be badly displaced when they plat the line on a section map, which is not as it is on the ground.

This sometimes makes wonderful changes in the geography of the country. I know of one place that is not within five miles of where it is recorded to be in the surveyor-general's office. We found a river recorded as being one mile from where it actually flowed, and it had not changed its channel. A long line seldom passes through all the sections which it would have to in making it fit a government map, and if it goes through them at all, it is not as it really does on the ground. The result of it all is that instead of a line being where it is recorded to be, it is a mile or more away.

The Union Pacific Railway Company have three parties in the Rocky Mountains besides mine, and two parties up in the range on reconnaissance. They also have two parties in the Bitter Root Mountains in Idaho.

I am on the western slope of the "Continental Divide" in Southern Wyoming, and we are running southward to cross the "Divide" near Hantz Peak, at or near the northern line of Colorado.

The gold and silver mines in Northern and Western Colorado, and the coal which is yet undeveloped, are the inducements which led the company to make the surveys. The company now owns and operates a system of narrow gauge railroads in Colorado, which were built in times of mining excitement and before the value of the different fields was determined or even questioned.

All surveys being conducted at present are for broad gauge, and the territory to be developed is undergoing the examination of the company's experts.

The snow on the mountains this far north lasts much longer than it does farther south in Colorado. The parties working down there have not had as much trouble with the snow and water as we have who are in Wyoming. The melting snow floods the streams, so that at times it is impossible to ford them or cross in any other way. The water is cold as ice and runs like the tail race of a mill. Not many of the streams have bridges, and it is often impossible to get to those that exist. Sometimes a party are cut off from their supplies, just when they need them, by a stream suddenly rising a couple of feet and preventing the return of the teams. Boats are not often to be had, and cannot always be managed when procured. The snow usually thaws during four hours in the middle of the day and then freezes during the night. An unusually warm day or a rain (which is rare) makes a flood, and it is hard to tell when it is coming.

Last month a member of one of the parties who are north of us tried to cross the Platte River in a dugout at a rope ferry. The current was so swift that it swamped the boat and drowned the man, although he held on to the cable which was securely suspended over the stream.

The stream along which I am working is so full of rocks that a boat would be crushed as soon as it was launched. It is too deep and wide to fell trees so as to make a foot bridge, and we cannot cross it at all.

We are running a preliminary line, and no matter how sharp a bend the creek takes, or how inviting the land on the opposite bank, we remain on one side all the way. A location in such a place would have to be made late in the summer or early in the fall.

Most of the snow, below the snow line, is melted by the middle of July, and the streams then become very small.

The men in the mountains on reconnaissance obtain their elevation with the adjusted barometers, which show the equivalent height of a column of mercury to the one-twentieth of an inch, and the corresponding elevation in feet up to 12,000 feet above sea level. We are all furnished with exactly the same instruments, and twice each day note the variation between the correct elevation of camp and that shown by the barometer. When these reports are compiled, and it is found which were local and which general variations, and how the relative elevations affect the variation, it will be of great assistance in determining the allowance to make for the results of the reconnaissance. On May 15 my barometer read 320 feet lower than the correct elevation, and on the 21st, 280 feet above, showing a variation corresponding to 600 feet. This variation was at an elevation of 7,020 feet, and is the greatest that has yet been reported by any of the parties. The greatest variation on one day in my camp is 240 feet, and the least is 25 ft.

When we came into this country on the first of May, we left the railway at Laramie, and just as the church bells were ringing we started out over the "Laramie Plains" with three teams and fifteen men. It is always customary in this country for the party to walk when moving camp, and as we were not novices, we followed the teams, and kept following them for seven days and tramped just 135 miles. It took a week to get in to where we began work on the survey.

On account of the more direct routes being impassable by snow and the streams too high to ford, we had to go southwestward into Colorado and then northwestward back into Wyoming. On the first day we crossed the plains and reached the foothills of Medicine Bow. It was good country for tramping, and we made 30 miles. After that we had mountain roads and hard traveling all the way. Two of the teams gave out in the first three days and had to be replaced with fresh ones. In many places where there was timber the snow along the roads was six feet deep. One team was stuck in a snow bank an hour and had to be shoveled out. There were places where the roads were so steep that all the horses would have to be put on to each load in succession until all were hauled up.

In the valleys there were some bad marshes to go through, and many a time were the wagons stuck fast in mud axle deep. Sometimes the horses would sink into the knees, and then we had to take the load off and get the wagon out before we could put horses to it. In fording some of the streams, the loads had to be lightened and arranged so as to keep the bedding and supplies dry; the horses had to swim.

We made but one attempt to cross the country by a short route. After climbing Independence Mountain, where we were 10,200 feet above sea level, we found the road blocked by snow, so that we had to turn back and go down 1,200 feet to the road that went around the long way.

While on the move we did not pitch the whole camp every night, but merely the mess tent and what was necessary for the cook. After supper we would pick out a place where the rocks were fewest and roll our beds out. Some one would have a big camp fire started by that time, and the musicians of the party would enliven our spirits with the violin and banjo, and sometimes the flute. One by one we would leave the fire and roll up in our blankets, and the trials of the day were soon forgotten. A couple of inches of snow fell one night while on the move, but we had an extra tent up and were ready for it.

Not long after getting in here the "mountain fever" began its work on the party, and at one time five of the men were down with it. Three of them left and two others had to be sent to the Union Pacific hospitals. Two more are now sick and not able to be out.

The company has three hospitals, at Omaha, Denver, and Ogden, which are supported by an assessment of 25 cents per month on all employees. Treatment at the hospital, or by any of the company's physicians along their lines, is furnished gratis to employees. When a man is sent to hospital his pay is continued for one week, but he is kept there under treatment without any charges whatever until cured. In cases where an employe cannot get treatment and medicine from a

PONTOON AND FLOATING DOCKS.*

IN this paper, any floating structure having open ends, and sides of equal and uniform section throughout, by which ships are lifted out of the water, will be called a "floating dock," but structures having sides varying in height and of less displacement than the bottom tanks will be called "pontoon docks." The sides are supposed to commence at and rise above the deck. The deck is the platform on which the keel blocks rest.

In designing an open-ended floating or pontoon dock to lift a ship of given maximum size and weight it is necessary: (1) For the under deck displacement of the dock to be greater than the combined weight of ship and dock; (2) the dock should be sufficiently strong not only to support the intended maximum ship, but so strong that it will not be injured if the ship has been built or damaged in such a way that a great part of the ship's weight rests either amidships or at the ends; (3) the sides should be made as low and narrow as efficiency will permit, so that a wide working platform may be secured and light and air have access to the ship, and that the top weight and displacement be a minimum; (4) the water should only have a limited cross range in the tanks; (5) if the dock is emptied by pumps, the pumps should be close to the bottom of the dock, so that the water may, as far as possible, run into the pumps without having to be drawn in.

The pontoon built under the writer's letters patent for the Tyne Pontoons and Dry Docks Company,

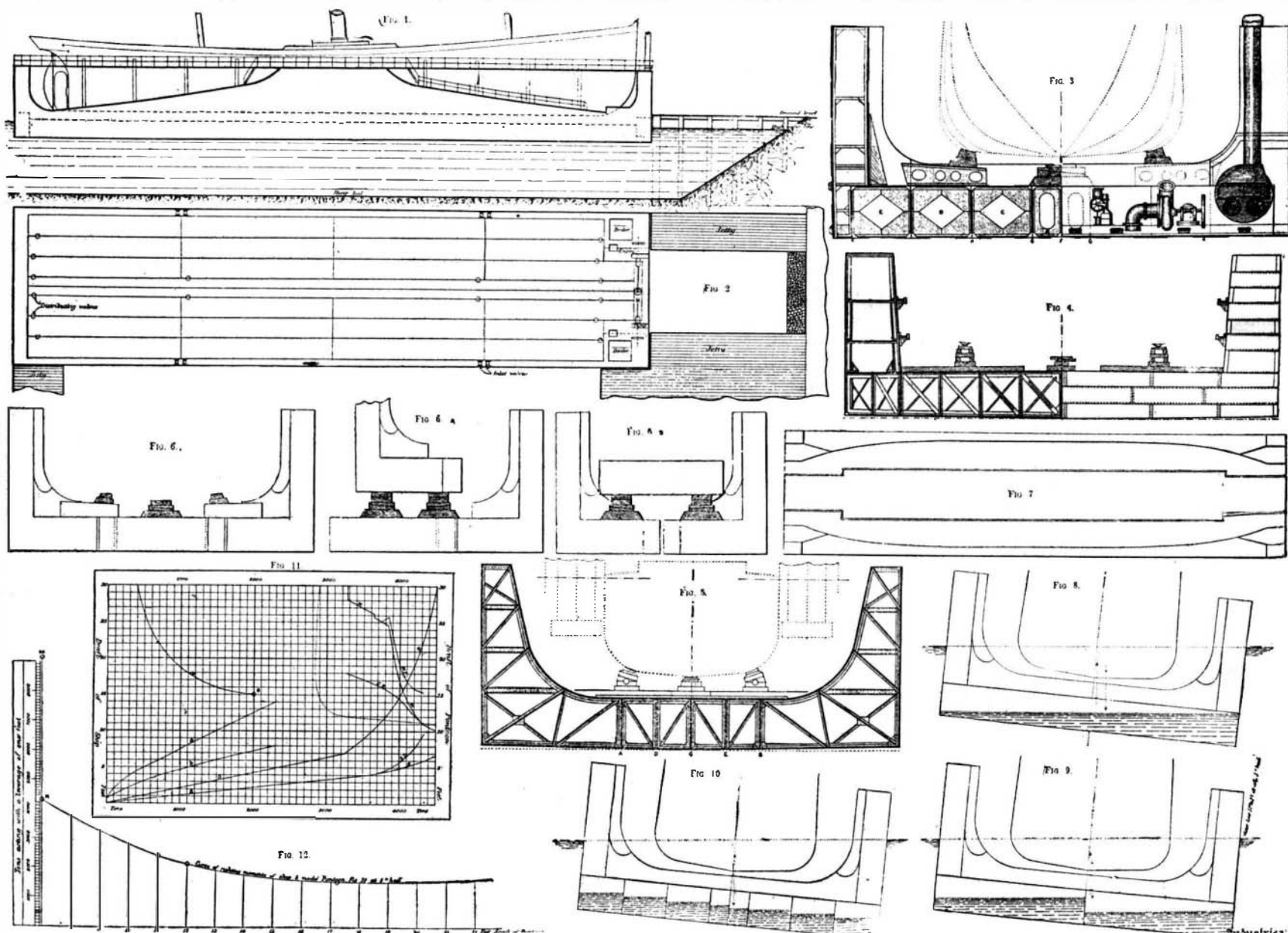
pumps from the port tanks and the starboard pump from the starboard tanks. Before sinking the dock the distributing valves shown on Fig. 2 are opened, and remain open until the dock is completely raised again. In fact, it would be better not to have these distributing valves, but to draw direct from the end of each tank, and thus each longitudinal set of tanks would be entirely independent of its neighbors.

The water coming in or going out is entirely controlled by the admission or exclusion of air from the various tanks; i. e., if in lifting the dock it was considered necessary to keep the water in any particular tank, the air pipe for that tank would be kept shut, and this gives the necessary control over the water.

The pumps are run full speed during the lifting of a ship, and the man in charge is on the dock or ship, and controls the air pipes, as above described. There are two donkey pumps and a range of piping, by which the tanks can be drained or the dock washed or ships supplied with water to test tanks, fill boilers, etc.

The pontoon was successfully launched, broadside on, in a nearly finished condition, into a space little wider than twice its breadth. The launching ways were an arc of a circle. A ship was docked and lifted within a week after the launch. It has been in constant use for three years, and has lifted 170 steamers in that time. The largest ship lifted measured 300 ft. long, 37'3 ft. beam, and 27'3 ft. depth of hold to upper deck; the ship overhung the pontoon 25 ft. at one end and 15 ft. at the other.

A ship carrying 100 tons can be lifted and sighted in about an hour. To show its adaptability, and the



PONTOON AND FLOATING DOCKS.

company physician, or get to a hospital, the cost of treatment is paid for from the hospital fund.

We are now encamped in a canon where there is just width of bottom land sufficient for a tent. In front of the tents the Encampment Creek rushes over the rocks, making as much noise and fuss as the Atlantic Ocean. Just back of us the granite wall runs up hundreds of feet nearly vertical, and then slopes gradually to a height of 1,000 feet above the creek. There is no road near us, and we have to move our camp with pack mules, and get our supplies in the same way.

I had to send down into Colorado, 100 miles, to get as many mules as we need to pack our camp with. We have 16 mules, burros, mustangs, and bronchos, and two experienced men drive and care for all of them. Each animal is provided with a pack saddle, and when properly loaded can carry 300 pounds over a very steep trail. Our cook stove and some other things have to be taken apart to load on the saddles. The tent poles and mess chest and table have to be abandoned and temporary ones made at each new camping place. Moving camp with a train of pack mules involves the party in a number of risks, inconveniences, denials, and sometimes considerable labor. With no road or trail to follow, and with endless rocks, underbrush, and trees to avoid, the mule and its load are liable to an occasional accident. All these things, however, are taken as a matter incidental to the work, and are not of as much annoyance as they may seem to engineers who are not familiar with them.

There is much to look after in addition to the engineering work, and it is entirely new to an Eastern man, but he gradually becomes familiar with the new duties and finds quite a variety of demands on his resources.—*Proc. Engineers' Club of Philadelphia.*

Limited, Wallsend, fairly fulfills the above conditions. Fig. 1 is a longitudinal view of the pontoon, Fig. 2 is a plan, Fig. 3 is a half midship section and half cross section through sill, showing the keel blocks supported on three longitudinal girders, G, F, and G¹.

These girders are stiffened by intercostal plates, A, on every third frame. Stanchions are fitted to the intermediate frames. The frames throughout are 31 in. from center to center. The transverse gusset plates in tank, C, are on every third frame, but in tanks, D and E, are only on every sixth frame. The frames between the gusset plates are fitted with stanchions. The longitudinal water tight girders are shown by F, G, H, I, and K. Three transverse bulkheads divide the pontoon tanks into four longitudinal parts, as shown on the plan (Fig. 2), forming altogether twenty-eight separate tanks.

The plan also shows that the main tanks terminate some distance within the ends and sides of the pontoon. This arrangement permits of an all-round internal examination and free communication between the two engine rooms when the pontoon is sunk. The outside shell plates, up to and a little above the tank top, are $\frac{7}{8}$ in. thick. They and the tank top plates are double riveted in seams and butts throughout.

Two centrifugal pumps, engines, and boilers are placed in the forward end. The pumps are placed, and draw from the main cross drain, M (Fig. 2), which forms part of the structure, and is in communication with the various tanks adjoining. The pumps appear to be well placed, for they have pumped freely.

There is a sluice valve in the cross drain in the longitudinal center line, so that usually the port pump only

ease with which it can be worked, it may be stated that a steamer was undocked and the pontoon lifted, and all the keel blocks moved and set in two rows to suit a center ladder steam hopper dredger, and again sunk and the dredger lifted, all in one tide. The pontoon is lighted by gas throughout.

Some such reasoning as the following led to the sides being made in form as shown by Fig. 1. A ship to be moved into a dry dock or on to a slip must have sufficient stability in herself, or ballast must be added to give the necessary stability before she can be moved; therefore, in this condition she requires no external aid.

A pontoon, when sunk, ready to receive a ship, must in virtue of its construction have the combined center of gravity of the structure and contained water some distance below its center of buoyancy, and consequently it must remain upright even if totally submerged. Now, as it has been shown that the ship must be stable, and the pontoon has enormous stability, it is evident the pontoon requires no sides above the water to give it stability at the time when it and the ship are combined; but while the water is being pumped out of the pontoon, the combined center of gravity of the ship, pontoon, and its contained water will rise, and the combined center of buoyancy will fall; and, therefore, the dock must have sides to give stability as it rises, until ultimately the sides are made the full length, and the maximum stability is secured with a minimum of top weight and displacement. The sides, being low, allow light and air free access to the ship, and the ship's bottom is thus easily seen and rapidly dried.

Fig. 4 is a cross section of the Rotterdam harbor authorities' two floating docks. They have been in use about four and a half years, the work upon them is

* Paper read by Mr. Alexander Taylor, before the North-east Coast Institution of Engineers and Shipbuilders, April 11, 1888.—*Industries.*