spring: Multiply the breadth of plate in inches by the square of the thickness in sixteenths, and by the number of plates; mu tiply also the working span in inches by 11·3; divide the former product by the latter. Result, equal working strength in tuns burden.

RULE 5TH. To find span due to a given strength and number, and size of plate: Multiply the breadth of plate in inches by the square of the thickness in sixteenths, and by the number of plates; multiply, also, the strength in tuns by 11·3, divide the former product by the latter. Result, equal working span in inches.

RULE 6TH. To find the number of plates due to a given strength, span, and size of plate: Multiply the strength in tuns by span in inches, and divide by 11·3; multiply also the breadth of plate in inches by the square of the thickness in sixteenths; divide the former product by the latter. Result, equal number of plates.

The span is that due to the form of the spring loaded. Extra thick plates must be replaced by an equivalent number of plates of the ruling thickness, before applying the rule. To find this, multiply the number of extra plates by the square of their thickness, and divide by the square of the ruling thickness; conversely, the number of plates of the ruling thickness to be removed for a given number of extra plates, may be found in the same way.

THE FRENCH ATLANTIC TELEGRAPH.

From Chambers' Journal.

(Concluded from page 273.)

When the *Great Eastern* left Portland for Brest, after taking in her supply of coal, she had on board about four hundred and fifty persons, including the members of the electrical and engineering staffs, the cable hands, and the crew; and one would think, looking at the list of stores that the whole of London had been ransacked for the sustentation and inner edification of this miniature army during the voyage to Newfoundland and back. Leaving out a thousand items of but little consequence, we need only refer to the 100,000 pounds of meat and poultry, 30 tuns of vegetables, 35 tuns of bread and flour, 15,000 eggs, and over 2,000 dozen of liquors of various kinds, to give our readers some idea of the provision necessary to be made for a six weeks' trip.

We have made a rough calculation of the cargo of the ship, including her engines and boilers, when she left Portland, and believe the following to be a very near approximation—it is certainly not *over* the mark: Cable, 5,520 tuns; cable-tanks and water, 400 tuns; timber shorings for tanks, 500 tuns; paying-out and picking-up machinery, 120 tuns; ship's stores, 250 tuns; coals, 6,400 tuns; engines and boilers, 3,500 tuns; total, 16,690 tuns. Her draft at starting was about 34 feet aft, and 28 feet forward. This, of course, decreased as the cable was paid out, until, at the end of the voyage, it was only about 25 feet aft, and 23 forward.

Before proceeding with a narrative of the laying of the cable, we wish to describe the arrangements made for the electrical testing of it during submersion. These were, with one or two slight exceptions, identically the same as in 1866. Their most interesting feature is the keeping up of a constant test on ship and shore for insulation, by a plan devised by Mr Willoughby Smith in 1865, at the same time allowing of tests for the continuity of the conductor, and free communication between ship and shore to be kept up without in any way interfering with the insulation test. By this means, should a "fault" pass overboard into the sea, it is detected at once, and the paying-out may be stopped before any considerable length of the cable has been allowed to run out. The advantage of this system over the old is apparent from the fact, that formerly it was possible for three or four miles of cable to run out between the occurrence of the fault and its detection; whereas now, except under very peculiar circumstances, within two or three minutes after a "fault" passes overboard, it can be detected, and the signal given to stop the ship.

In conclusion, nothing that could in the least possible way facilitate the execution of the great work was left undone. All the arrangements were of the most complete character, and were placed in charge of men who are unrivaled for their practical knowledge of submarine telegraphy.

The expedition started from Brest on Monday, the 21st of June, and the American end of the cable was safely landed at Duxbury, near Boston, on Friday, the 23d July. The five weeks which elapsed between those two dates were enlivened with incidents of the most interesting nature, and it is to these we shall now refer.

For the first three days all went well. The weather was very fine; the paying out of the cable proceeded without a hitch, and all were beginning to indulge hopes that, as in 1866, the voyage would be made without the occurrence of those unfortunate "faults" which cause such delay and trouble. But our hopes were soon upset, for on the fourth day, the 24th June, shortly after daybreak, we were struck with consternation by the intelligence that there existed an electrical fault in the cable. The intelligence was conveyed all over the ship by means of a powerful gong, which was planted outside the electrical room, ready to be hammered upon as soon as anything of a suspicious nature was indicated on the testing instruments. In obedience to the gong, the ship was speedily stopped, and the engines reversed. The tests showed the fault to exist very near the ship; so, without any more ado, the picking-up engines were set to work, and hauling back commenced. At every three hundred or four hundred yards of cable hauled back, a fresh test was made, until, in about a couple of hours, it was found that the faulty place had come on board. Other two hours were sufficient to make a fresh splice between the cable paid out and that remaining on the ship, and then operations were resumed as if nothing had happened. Fortunately, the weather was very fine and the sea calm, and the hauling back was in consequence attended with but little danger. The occurrence of the fault was perhaps advantageous, inasmuch as it served more fully to impress the staff with the importance of having everything in c mplete readiness for an accident.

The fault was afterwards found to consist of a minute hole penetrating the coatings of gutta-percha; whether caused accidentally or purposely it is impossible to say. It may be asked why it could not have been discovered before it left the tank. The answer probably is, that it was of too minute a nature to indicate its existence on the testing instruments, until, by passing through the paying-out machines, and then undergoing the pressure of the sea, it became more fully developed.

To give our readers some idea as to how a fault is detected, we may (for this purpose only) compare the cable to a long pipe, sealed up at one end into which water is being forced. As long as the pipe remains perfect, only a certain amount of water can be put into it, according to its capacity, and once filled, there is no flow of water; but if, when the pipe is full a small hole be made in it, the water will of course rush out at once, indicating the existence of the hole by causing a fresh flow of water into the pipe. Now, the cable is always kept charged with electricity up to its full capacity—or, in other words, till it can take no more—and as long as it remains perfect, there is practically no current flowing from the battery into it; but immediately on the development of a fault, or communication between the conductor of the cable and the earth, a portion of the charge escaping through the fault causes a fresh supply of electricity to flow from the battery. By having a delicate instrument fixed between the battery and the cable, this increased flow is at once made apparent.

Another similar fault occurred on the 26th, fortunately unattended with any more serious consequences than in the first case.

On the 29th June, the weather, which had up to that time been so fine, suddenly changed. A strong breeze sprung up towards evening, which, by the morning of the 30th, had increased to a heavy gale. The sea was very rough indeed; and the frequent violent lurches of the ship began to cause some apprehensions as to the safety of the cable. Everybody devoutly hoped that we might get through the gale without having to stop and haul back on account of a fault; but our hopes were frustrated, for just in the very hight of the gale, the dismal notes of the gong announced that another fault had indicated its existence on the testing instruments. The engines were reversed, and hauling back commenced, amid the greatest excitement. At every lurch of the ship, the strain indicated on the dynamometer rose to an alarming extent, and as the hauling in proceeded, it seemed continually as if nothing could prevent the breakage of the cable. Still the testing showed the fault to be outside the ship, and still the strain on the cable kept increasing, until at last, in one tremendous lurch of the ship, a whiz was heard, sending a thrill of horror into the bosom of every one on deck. The cable had parted; but by the greatest good fortune the rupture occurred inside the ship, and by a most admirable promptness, the breaks were successfully put on before the broken end could run out over the stern.

The gale was still far too heavy to risk hauling in any longer, so, with not a moment's delay, the end of the cable was secured to a huge buoy, and sent adrift, to be picked up again as soon as the weather became more moderate. The remainder of that day and the whole of the next were spent in steaming about in the vicinity of the buoy, keeping as near to it as possible—the great ship continually rolling in a most ungainly fashion.

On Friday, the 2d of July, the weather was sufficiently fine to enable us to pick up the buoy to which the cable was attached, and a very few hours sufficed to get the end of the cable on board. After hauling in about a quarter of a mile of cable, the faulty place, which had been the original cause of the stoppage, was brought on board, and very speedily the ship resumed her course.

These three faults well illustrated the advantages of the system of testing employed; for in each case, the existence of the fault must have manifested itself within three minutes after it left the ship—in fact, as soon as the pressure of the sea could force the water into the flaw. After stopping the engines, of course the "way" of the ship would carry her seven or eight hundred yards before the paying out could come to a dead stop, and this, added to perhaps a quarter of a mile run out previous to the detection of the fault, would account for the three fourths of a mile, more or less, which in each case had to be hauled in before the fault was secured. Practically, however, we may say that each of the faults was discovered immediately on its leaving the ship—and this is the great advantage of Smith's system. Neither of the faults was bad enough to prevent the most perfect communication taking place between ship and shore while the tests for localizing the fault were being made, so that the ship could give any instructions whatsoever to the shore which were considered necessary.

On the 5th July, we experienced another heavy gale; but as the testing of the cable remained perfect, the paying out was not interrupted at all. In fact, after the 2d July, nothing occurred to interfere with the progress of the work. The St. Pierre shore end had been laid in readiness for our arrival by the *William Cory*, and the work of the *Great Eastern* was completed on the 13th July.

The rate of paying out the cable was from five and a half to six knots per hour, the ship running five to five and a half knots. Very likely this speed might have been increased without incurring danger; but, considering the immense size and weight of the ship, and the difficulty of handling her in case of accident, it was no doubt best to keep the speed within narrow limits.

As to the track of the cable, it seems from the soundings taken that the bottom is composed, the greater part of the distance, of the fine mud usually called "ooze" consisting of very minute shells—so minute that without a microscope the shape is not discernible. This "ooze" constitutes the very best bed for a submarine cable. In fact, judging from the experience of 1866, the cable lies in it as securely and as free from harm as when coiled in the tanks at the manufactory; and if picking up should become necessary, the softness of the "ooze" renders the grappling of the cable comparatively easy.

The position of the present cable has one advantage over that of the English cables—namely, that it has been kept carefully off the Newfoundland Banks, and will therefore not be liable to the breakage by icebergs which have already caused such expense and trouble to the English company. The cable is conducted several miles to the south of the "Great Newfoundland Bank," and then proceeds in a north-westerly direction to the western side of St. Pierre Island, passing along a deep gully between the "Green Bank" and the "St. Pierre Bank." The length of the course selected is about 2,330 knots, and the amount of cable paid out 2,580 knots—making about ten per cent allowance for "slack," or spare cable paid out to cover the inequalities of the bottom, and to allow of picking up, should such become necessary Without taking notice of the 300 knots from the Brest shore, and the 500 knots from Newfoundland, where the water is shallow, the depth varies from 1,700 to 2,700 fathoms, the deepest part being situated in about 45° north, and longitude 43° west.

Two days after the completion of the Brest and St. Pierre section, the laying of the section from St. Pierre to Boston was commenced. The cable was divided into three pieces, coiled respectively in the *William Cory*, the *Scanderia*, and the *Chiltern*.

The course of this cable runs through shallow water nearly the whole distance, and therefore the paying-out of it was not attended with that excitement which existed during the voyage from Brest to Newfoundland. It was felt that if even the cable should break, and be for a time lost, it would be a perfectly easy matter to grapple for it and pick it up; so that when, on the 20th July—through a "foul-flake" or tangle in the tank of the *Scanderia*—the cable did actually snap, a very few hours sufficed to drop the grappling-iron, haul up the cable, make a fresh splice, and resume operations in the usual way. The foul-flake was about the only thing that caused any considerable delay in the paying out of the cable, which was completed on Friday, the 23d July, in the presence of a large number of spectators, including about a hundred representatives of the American press, who came down *en masse*, each of them struggling to obtain the earliest information.

The landing place of the cable was at Duxbury, a few miles from Plymouth, celebrated as the spot whereon the Pilgrim Fathers first landed—a coincidence which the Americans did not fail to make the most of in the speechifying which followed the completion of the work.

The length of this shorter section of the cable was 750 knots; adding which to the 2,580 knots from Brest to St Pierre, we have continuous submarine communication for 3,330 knots. The signals through the whole of this immense length are as distinct and readable as between any two places on an English land line, and can be sent at a much greater speed than the business of the line is likely to require. The signals at present consist of the oscillations of a spot of light on a screen, reflected from the mirror of a "Thomson's Reflecting Galvanometer," as in the English cables; but we believe this is likely to be superseded by a very delicate printing instrument, also, if we are rightly informed, the invention of Sir W. Thomson.

Thus is completed the first direct line of submarine communication between Europe and the United States. No doubt there will be found plenty of room for it, without injuring, in any material degree, the interests of the English companies. We notice that the latter have already reduced their tariff, in order to keep up with the French company. This, of course, will be a great boon to a large section of the commercial fraternity, to whom the high tariff hitherto existing has been an insuperable barrier to frequent communication with America.

But, setting aside the interests of private companies, which are of comparatively little consequence, we believe that the present cable will serve still more strongly to unite in sympathy the Old World to the New, and to make it more apparent that the interests of the two worlds are bound up together. We would fain hope that by the increase of traffic, induced by a decreased tariff, there will be found room for still another cable across the Atlantic.

We confess to a slight feeling of pride that this great work has been accomplished by Englishmen; but waiving this, we rejoice that the three greatest nations of the world—England, France, and the United States—have joined in the execution of a work which cannot fail to help forward in a high degree the progress of civilization.

THE material growth of the South during the last four years is strikingly shown by the statistics in some of the Southern papers. The official figures at the Department estimate that the cotton crop of the Southern States this year will be worth $240,000,000; while the total value of the exports of the South is set down at $328,500,000. At this rate, the value of Southern products is about $31·32 per head for the entire Southern population.