be likely to have, and we are confident that the "sill" built across it by Capt. Eads does not divert from it any of the normal volume to which it is entitled. We intend only to build works in the mouth of this pass, in the Gulf of Mexico, and we believe that this is all that is required to give a permanent channel of much greater dimensions in width and depth than it is possible to make in the little pass. E. L. CORTHELL,

Pres. Southwest Pass Imp. Co.
71 Broadway, New York City, Nov. 23, 1893.

THE NORTH SEA-BALTIC CANAL.

ONE of the greatest marine engineering achievements of the present century will, undoubtedly, be the canal which is to connect the North Sea and the Baltic, and which is now approaching completion. From an engineering point of view, the work excels that of the Suez, Corinth and Manchester Canals, and the commercial and strategic importance of the new waterway can only compare with those of the first mentioned. Truly, the North Sea-Baltic Canal is styled the "Suez Canal" of Europe, and it is *en passant* curious that this great work, tending to the "solidification" of Germany, was conceived by Prince Bismarck, and commenced by him in spite of all the opposition of Moltke and a host of other famous strategists, who argued that the canal would require an army corps for its protection, and on that ground was undesirable. And now, just as the Bismarck sand glass appears to be running out, this great monument of his foresight and of German engineering skill is rapidly nearing its completion, as the engineers of the canal assured H.M. the German Emperor, on his recent visit to the works, that it should be opened, without fail, next year, *i. e.*, seven years

curves having radii not under 3,000 yards. Only some small curves have a radius of 1,000 yards, and 63 per cent. of the line of the canal is practically straight.

At Holtenau the great locks are already in full working order. The basins are 150 yards in length and 25 yards in breadth. In order to render the building pit dry, the energetic course has been taken of attacking the land water trickling down toward the same above it by sinking wells and using steam pumps. Thus the water-carrying layer is drained before it is laid bare in the bottom excavations for the sluice structures. The latter, by the way, are principally built of bricks, while cement work with admixture of lime is also largely employed in the construction, whereby a more plastic mortar is obtained, and whereby, too, the brickwork is said to become more compact. The mixture of the mortar is effected in pug mills with vertical rollers. This process is most interesting to structural engineers, and deserves a fuller description than we can give now.

From Holtenau the canal is already navigable for steam launches in part by the old Eider Canal, but several of the most interesting engineering sections should be inspected on foot. Everywhere the great dredgers and excavators, Hollanders or Dutchmen, as they are called through their origin, meet the eye, and of one of these at work we give an illustration. The material raised is either emptied into barges, *i. e.*, where there is now water, or shot into railway trucks. All along the works the great importance of the steam engine and machinery is apparent. Huge brickworks have been established especially for the supply of the canal by the well-known firm of Philip Holzmann & Co., Frankfort-on-the-Main, and called the Rosenkrantz Brickworks. Bricks are used not only for the

During the summer some 5,000 men have been at work on the canal, one-half of whom live in barracks erected by the canal authorities, where they are excellently treated and housed. There are about 12 such barracks along the canal, besides 3 hospitals for 60 men. The construction of the sluices at each end has been assigned to a Dutch firm of *entrepreneurs*. The wages on the works run rather high for Germany, viz., from 2s. 9d. to 3s. for ordinary laborers per diem, and from 4s. to 6s. a day for piecework. Foremen, inspectors and enginemen receive upward of 10s. a day. A large number of the men are Swiss and Italian, these nationalities being preferred to German on account of their sober habits and by their giving less trouble than the natives. In autumn and winter, of course, the number of men is greatly reduced. Up to the present nearly 80,000,000 cubic meters of earth, etc., have been excavated and shifted at a cost of some £3,500,000. The construction is carried out by a maritime board under the immediate supervision of Geheimebaurath Fulcher, who has under him four sectional engineers, *i. e.*, at Kiel, Holtenau, Rendsburg and Grunthal, whose assistants, of course, are legion. The entire cost of the North Sea-Baltic Canal is estimated at £7,800,000, of which Prussia contributes £2,500,000 and the empire the balance.—*The Engineer*.

Further description and illustrations of this great work will be found in SUPPLEMENT No. 810.

CURIOUS BEVEL WHEELS.

A MECHANICAL curiosity was exhibited in the Machinery Hall, Chicago, by the Belgram Gear Company, in the shape of three different sized bevel wheels, all gearing perfectly with a fourth. The smallest of the

STEAM EXCAVATOR, NORTH SEA SHIP CANAL.

after the turning of the first sod, as contemplated by the Iron Chancellor.

Approaching the canal works from Kiel, near its Baltic mouth, we enter it at Holtenau, also in the Kieler Fjord, and exactly in the same spot where was the mouth of the so-called "Eider" Canal, taking its name from that river, and which the new canal partly follows in its course. The canal finishes in the river Elbe, at Brunsbüttel, the length from mouth to mouth being exactly 60 miles.

The Baltic Canal is, in reality, a sectional cutting through the province of Holstein, there being no locks or sluices all along its course, but only at each end. Here there is a double set of gates in each place, in order to meet any eventuality of tide on both sides, and which thus regulate the water level in the bed. The average level of the water in the canal will be the same as that of the Baltic, inasmuch as the sluices at Holtenau are generally to be kept open, and are only to be closed when the tide in that sea rises or falls half a fathom over or below the normal tide, and eventually calculated to happen on five-and-twenty days of the year. But at the Elbe entrance, on the other hand, where the tidal waters play an important part, the gates will only remain open for three or four hours on each tide. The bed of the canal lies nine fathoms below the normal water level, and it has a width at the bottom of 22 yards. The sides—two yards below the surface—slope from 2 to 12 yards. From the banquette down to the bottom the sides are inclined at the top 1 to 2 and at the bottom 1 to 3. With this profile the depth of water on lowest tide is 6-17 yards, with a width of 36 yards, so that this would enable almost all Baltic trading steamers, which generally draw no more than 18 feet of water, with a 36-foot beam, to pass each other easily.

The line of the canal is very regular, all the greater

locks and bridges, but also for securing the slopes in the water lines; so, of course, the demand is enormous.

The canal is also connected by skillfully constructed locks with the Lower Eider, and another highly interesting point are the swing bridges with their foundations of the Flensburg-Neumünster Railway crossing the canal. The fundamental works of the foundations have been carried out by the aid of compressed air, and electricity is used as motive power for the work inside the air bell. For a considerable distance the Eider runs parallel with the canal, and in this section shoots for the transport of the excavated materials are largely resorted to for their conveyance to the banks, dams or other places. The transport is effected partly through open shoots, which are supported by the dredger or elevator itself, and partly through closed, sometimes floating, shoots or conductors, in which the debris, having been sifted in a special apparatus, is pumped up by the aid of centrifugal pumps.

At Grunthal, the canal passes the watershed between the Elbe and the Eider, and here the engineering works have been very great. A gigantic cutting has been made for the waterway, and a railway and road embankment with a bridge constructed, the latter being 130 feet in height above the water surface, and thus enabling the largest vessels to pass freely under it, while it has a span of 470 feet. Across this embankment runs the main railway from Neumünster to Heide connecting the south and north of Holstein with the rest of Prussia. The stone used for the locks, etc., comes from the quarries at Neissen, in Saxony, and the blocks are conveyed in lighters down the Elbe to Hamburg, where they are reloaded in ships and sent on to Brunsbüttel. Stone will also be used for the construction of the breakwaters, which are to protect the entrances, as well as for the lighthouses at each end. The old Eider Canal is now closed for traffic.

three bevel wheels is apparently about half the diameter of the largest of the three; nevertheless, all the wheels work quite smoothly and correctly. The possibility of such an arrangement was, we believe, first pointed out by Mr. W. J. Last, A.M.I.C.E., in a paper published some years back in the Minutes of the Proceedings of the Institution of Civil Engineers. The explanation of the apparent anomaly is that each of the smaller wheels rolls on a different pitch line on the main wheel, and the teeth of each are specially formed to suit its own pitch cone.

IMPROVED METHOD OF CONSTRUCTING FOUNDATIONS UNDER WATER BY FORCING CEMENT INTO LOOSE SAND OR GRAVEL BY MEANS OF AIR PRESSURE.*

By FR. NEUKIRCH, C.E., of Bremen, Germany.

PREPARED FOR THE INTERNATIONAL ENGINEERING CONGRESS OF THE COLUMBIAN EXPOSITION, 1893.

THIS improved method of constructing foundations has for its object to convert the sand or gravel, existing under water at the locality where the foundations are to be made, into a solid body in the form of sand or gravel concrete. This conversion is effected *in situ*, so that no excavation to the solid bottom is required. The sand is converted into sand concrete by forcing cement in the form of powder, as it occurs in commerce, through a pipe by air pressure into the submerged sand. The pipe has an internal diameter of about 1½ in., and is drawn to a point at the lower end, in which there are three or more holes of about ⅜ in. diameter. The upper end is connected by a bend and rubber tubing

* From the Transactions of the American Society of Civil Engineers.

with the air pressure supply pipe in such manner that the pipe can be raised, lowered, and moved while the air pressure is flowing through it.

In the air pressure supply pipe, provision is made by means of suitable branches and stop cocks for connecting therewith an apparatus which by means of an injector device enables any desired quantity of cement powder to be fed into the air current. The air pressure, together with the cement powder, issues through the small openings at the lower end of the lance pipe, and is driven with considerable pressure into the sand foundation; this is very mobile, as it is entirely under water, and consequently the blowing in of the cement produces a motion in the foundation pit similar to that in a vessel of boiling water, the steam bubbles instead of air bubbles being formed. The cement carried by the air is retained by the wet sand and combines with this to form sand concrete.

By the boiling motion an intimate mixture of the wet sand with the cement is effected.

After the injection of air has ceased, the grains of sand in subsiding adhere very firmly together, and experiments have shown that a natural bed of sand, after having one-fifth of its volume of cement injected into it, will after the operation occupy a smaller space than before; this was shown by the fact that the surface of the sand concrete lay deeper than that of the surrounding natural sand bed.

The introduction of the lance tube into the sand bed is effected by first blowing air through it, so that the air issuing from the lower end forces back the sand, and in setting it in motion renders the sinking of the

For warming the air a small cast iron stove is employed, consisting of two cylinders inserted one within the other and connected together air-tight. In the inner cylinder is a fire grate on which a light fire is maintained. The air pressure is made to circulate through the annular space between the two cylinders. The inner cylinder has external ribs formed on it, so that the air pressure is brought in contact with a considerable heating surface on its way through.

The steam boiler and compressor can be arranged as a portable engine, so as to enable the apparatus to be readily transported from one foundation pit to another.

This method of constructing foundations may be compared with the ordinary method of making concrete foundations, in a similar manner as the Bessemer process compares with the puddling process in the manufacture of iron. In the Bessemer process the blowing of air into the molten pig iron causes the carbon to be burned and a solid metal steel is produced, while in the puddling process this conversion is effected only by laborious stirring. In the new process of making foundations the blowing of the cement into the stratum of liquid sand, as it were, converts it into a solid body, while up to the present time this was also only effected by laborious stirring.

As the entire process is mainly carried out by machinery and requires only a small amount of manual labor, foundations can be carried on rapidly by this process.

If it be desired to transmit the pressure which the foundations have to bear to a substratum below that

made perfectly tight and secure for a length of about 500 ft.

Fig. 2 shows an application of the process in the harbor of Vegesack, near Bremen. For the quay wall a bulkhead of rolled iron was used. Wood could not be used for this purpose, because the bed is very stony, and because in consequence of the ebb and flood the dam is not always altogether under water. Such iron dams are with difficulty made completely tight. By blowing in cement behind the dam, it was rendered perfectly tight and safe.

Fig. 3 shows the arrangement employed for experiments.

A simple tripod is in this case erected for suspending the lance tube, while in the previously described arrangements a movable frame was employed.

IMPROVEMENT IN BOILER CONSTRUCTION.

THE accompanying illustrations show a novel improvement in boiler construction, introduced by the "Advance" Boiler Co., Limited, of St. Mary's

IMPROVED BOILER.

Gate, Manchester, for promoting and increasing evaporation. The improvement, which is applicable to land or marine boilers, secures a greatly increased evaporative efficiency without introducing any complicated parts. The system consists of a simple arrangement of angle irons, riveted longitudinally on to the inside of the furnace flue and on the outside of the boiler shell in the side flues, the function of these angle irons being to arrest and absorb the heat and transmit it to the water. A test boiler, of the Cornish type, 15 ft. long by 5 ft. diameter, has been constructed on the above system. On this boiler there are ten 3 in. by 3/8 in. angle irons riveted on to the first and second plates in the tube over the fire grate. Beyond the bridge, the angle irons are 3 in. by 5 in. by 3/8 in., and are riveted around the flue, the 5 in. part of the angle iron being presented to the flames and forming the rib, or heat absorber. On the outside of the shell the angles are 3 in. by 6 in. by 3/8 in., with the 6 in. part radiating from the shell into the side and bottom flues. Beyond these additions the boiler has in no way been altered from the plain Cornish construction. With this boiler a series of tests were made of five hours duration. During the test the average draught was 237.33 ft., and the average

temperature of the feed water was 57.25 deg. Fah., and that of the gases, 772.50 deg. Fah., the average temperature of the atmosphere being 64 deg. Fah. The coal consumed was 5 cwt., less 40 lb. of ashes, or 520 lb. of fuel, and the water evaporated was 4.730 lb. With the boiler in its normal condition as a simple Cornish boiler, and before any angle irons were affixed, the evaporation was 4.67 lb. of water per lb. of coal. The results of the test made showed an improvement of nearly 100 per cent. in the evaporative power of the boiler upon its former self. Besides the advantages secured as shown by the tests, other collateral advantages claimed for this system are that not only do the angle irons arrest the heat and transmit it to the water, but they form channels along which the flames sweep in close contact with the boiler, in this respect also increasing its efficiency while the boiler is materially strengthened by the addition of the angle irons, which form a series of longitudinal ribs external to the flue and shell. Reports have been obtained from several leading engineers who are authorities on boiler construction, and all of these are of a most satisfactory character, as to the very greatly increased

FORCING CEMENT INTO SAND FOUNDATIONS.

tube to considerable depths, such as 16 to 19 ft., readily possible in a comparatively short space of time; this operation is rather more difficult only when the bed is not purely sand, but contains larger stones, wood, etc. In this case it may be necessary to raise the tube up again and to insert it at a different place, so as to avoid the obstructions.

In order to insure a uniform mixture in the foundation pit, it is divided into small fields of from 8 to 12 in. square, and into each of these the required quantity of cement, which is ascertained by dividing the cubic contents of the field by the required proportion of the admixture, is blown. The lance tube is first sunk in each field down the solid substratum by means of air pressure alone; when it has attained this depth, cement is supplied to the air current, and during the continued introduction of the cement powder the tube is slowly drawn upward until the required quantity of cement has been introduced.

In order to enable the lance tube to be readily handled, it is suspended from a tripod or traveling stage having a small winch by means of which the tube can be readily raised and lowered. The movable stage has the advantage that it enables every field of the foundation pit to be easily reached. The steam boiler and compressor for producing the air pressure can be placed at a greater distance from the foundation pit; the air pressure can readily be conducted through wrought iron pipes to the point required. It is of advantage to warm the air in the vicinity of the cement apparatus, as otherwise moisture might be separated by the cooling of the air, which would be very inconvenient in working and easily produce a clogging of the cocks and injector nozzles.

upon which the sandbed lies, this can be effected by driving in piles to the required depth before the cementing process is commenced. These piles will then be completely embedded in the sand concrete and be firmly united therewith, so that they may be considered as part of the structure.

If it be desired to sharply limit the lateral dimensions of the body of sand concrete, or to protect it against external influences, the foundation pit is in the first instance surrounded by a coffer dam.

The hardening of the sand concrete formed as above described takes several weeks, and the complete hardening several months, as in the case of ordinary concrete under water.

On the accompanying drawing is shown the necessary plant for carrying out the above described process, as also the application thereof for some cases.

Fig. 1a shows the arrangement of the steam boiler, compressor, air reservoir and heating stove for the air pressure supply, which should always be situated near the place of operation. Fig. 1 shows the application of the process for consolidating the soil round a brick sewer so as to insure its being water-tight against the surrounding aqueous sand stratum, and to afford it a rigid bed therein.

The sewer, which is 5 ft. internal height, lies in quicksand, and had become so leaky that the sand penetrated into it in considerable quantity. Owing to this, the road pavement and also the neighboring houses subsided, so that it became urgently necessary to provide a remedy. This could not readily be done in the usual manner, as it appeared very hazardous to drive coffer dams in the somewhat narrow street. By applying the above described invention the sewer was