United States Patent [19]
Saucke

[11] 3,828,563
[45] Aug. 13, 1974

[54] **METHOD AND APPARATUS FOR TIGHTENING THE WATER-SUBMERGED JOINTS BETWEEN WALL-FORMING ELEMENTS**

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[22] Filed: **Aug. 8, 1972**

[21] Appl. No.: **278,875**

[30] **Foreign Application Priority Data**

Aug. 11, 1971 Germany 2140250

[52] **U.S. Cl.** **61/60**
[51] **Int. Cl.** **E02d 5/00**
[58] **Field of Search** 61/59–62; 52/743; 29/401

[56] **References Cited**

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Primary Examiner—J. Karl Bell

[57] **ABSTRACT**

A method and apparatus for tightening the water submerged joints between wall forming elements, particularly the interlocking joints of steel sheet pilings, characterized by the use of a compound to be injected into the joint and curing inside said joint to an elastic body but under the pressure against which the tightening has to be effected into a sufficiently stable body.

5 Claims, 4 Drawing Figures

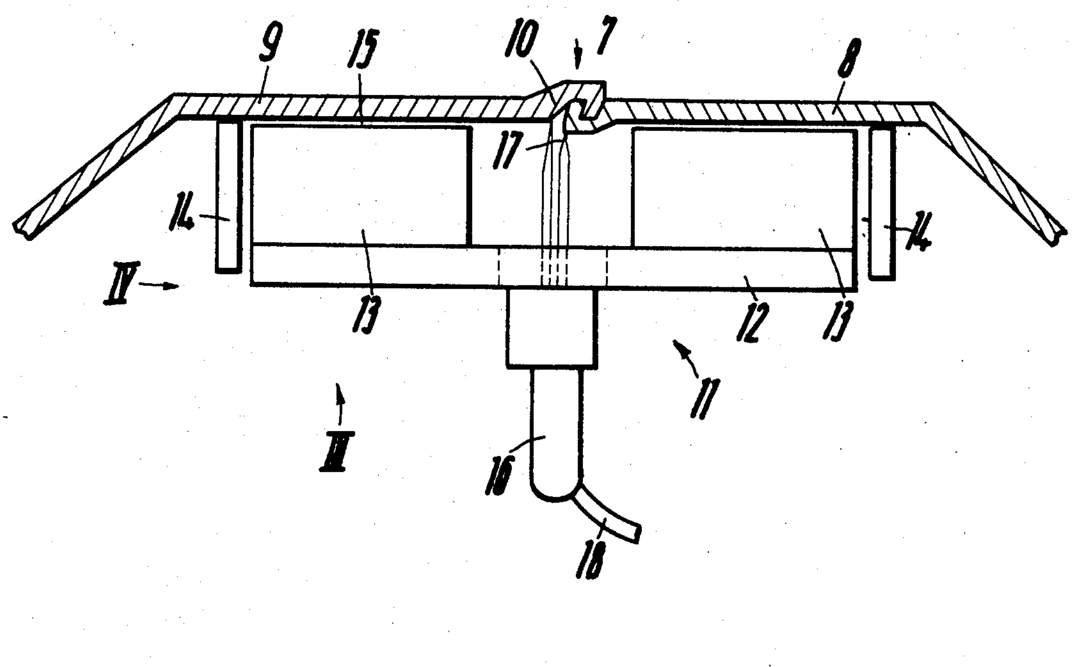

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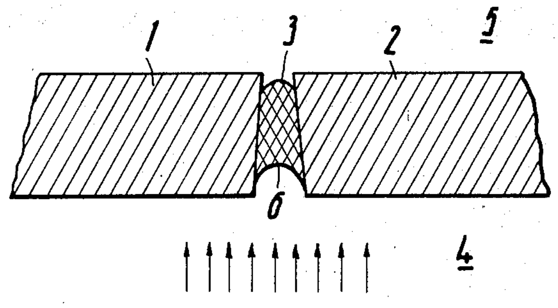
Fig.1



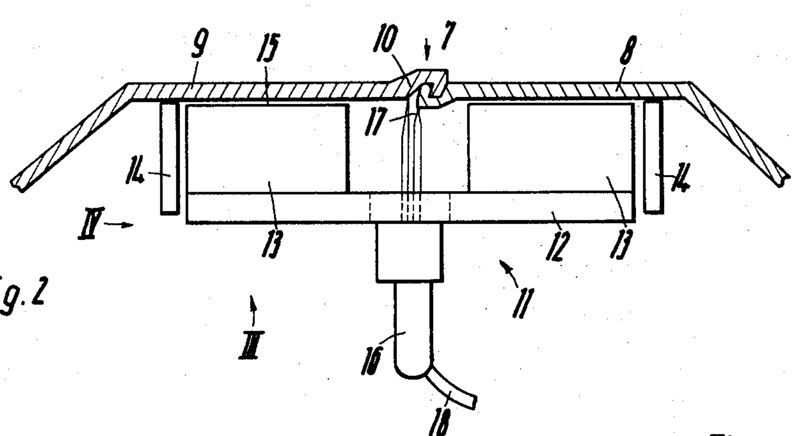


Fig.2

Fig.3

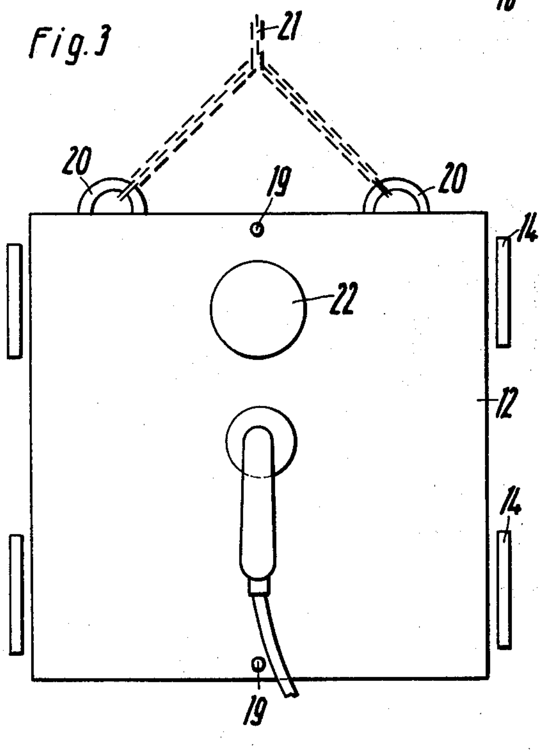
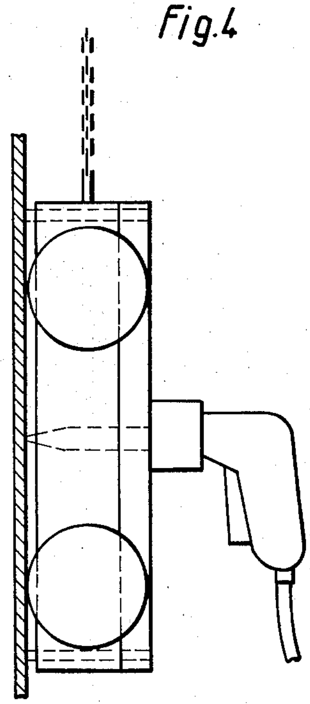


Fig.4



METHOD AND APPARATUS FOR TIGHTENING THE WATER-SUBMERGED JOINTS BETWEEN WALL-FORMING ELEMENTS

The invention relates to a method and an apparatus for tightening the water submerged joints between wall-forming elements, especially the interlocking joints of steel sheet piling.

The tightening of joints of walls or wall parts which are water submerged and therefore never dry and are also mostly contaminated with foreign particles and mud, and which are continually or at least during frequent periods or tides below water level, offers considerable difficulties in practice, especially in river and harbour building. This applies especially to the tightening of steel sheet piling which consists of a plurality of steel profiles jointed by sliding locks. Referring to the slidability required for the pole driving, the locks have a certain clearance and therefore cannot be completely tight by themselves. In some single cases one may content oneself to continually exhaust an area by pumping the space screened off from the water by the steel sheet piling. But complete dryness of this space can not be achieved by this method alone. Besides it cannot be avoided, especially in river harbours, that simultaneously with the penetrating water considerable amounts of mud will enter the enclosed space which can have disastrous consequences, for example, when the mud contaminates the sand required for purposes of foundation or when even due to the alternating effect of the tides, mud is washed in and sand washed out.

It has been previously tried to tighten steel sheet piles by the under water welding of the interlocking joints. Since such method has to be carried out by helmeted divers, is not only extraordinarily costly but also to a great extent ineffective. Under the changing water pressure the steel sheet pilings will "work" with corresponding relative movements in the locks whereby the weld seams tear open. Weld seam fractures by excessive stresses will also occur by the extremely fast cooling off after welding.

Furthermore, the idea has been expressed to tighten the interlocking joints by caoutchouc strips placed in front of them on their water submerged side which should be fastened by a plurality of screws in close neighbourhood to each other. This remedy promises more success than a weld seam because the caoutchouc strip can yield to the relative movements of neighbouring steel profiles. However, this remedy is still more costly than welding because it requires far more of the diver's time.

It is an object of this invention to provide a method and an apparatus for tightening the water submerged joints between wall forming elements, especially, the interlocking joints of steel sheet piling which produce sufficient effectiveness at tolerable costs.

According to this invention the solution there is injected a tightening compound into the joint which is cured inside the joint to a body which is yielding on one hand but on the other hand is stable under the pressure against which the tightening is effected. Preferably, a continually elastic curing compound, such as a cold curing silicone caoutchouc is used. Also, preferably there is employed a compound which has an accelerated curing effect under the influences of moisture.

It is known to use such like compounds for tightening purposes. But the manufacturers of such compounds always give the strict directive for their use that the joint which has to be tightened must be dry and clean before applying the compound. A moisture film on the inner surfaces of the joint prevents, after hitherto existing experiences, an effective bonding between the compound and the joint walls. Capillary clefts form out by which by the suction effect of such clefts and possibly more moisture might be transported into the joint to be tightened than would be the case without the presumptive tightening. Besides, the tightening strip has no support inside the joint and there is the danger that it might fall out under low outer force influence (i.e., wind, shock).

These view points are of course valid to an increased degree for water-submerged joints in which the joint walls are not only wet but covered with water and in which there also prevails heavy contamination. Therefore, it is absolutely understandable that those skilled in the art until now have taken the employment of such compounds for tightening purposes of water submerged joints not to be at all feasable.

This invention is based on overcoming those prior art prejudices. The supposition of those skilled in the art that in employing the designated compounds in presence of no water an insufficient bonding between compound and joint walls would result is correct for those penetration methods and applications as they have been used until now in common practice.

This invention recognizes the fact that when applying such bonding method for water submerged joints, a sufficient bonding will result when the compound is brought into the joint under such pressure that the water is extensively pushed away. The remaining moisture of the pores later on reacts with the compound and effects its complete curing within short time intervals. Afterwards, the bonding of the compound is so strong that it stands even stronger dashes of the waves in a storm. Also, the extensions and compressions caused here by the "working" of the interlocking joints remain without influence. Besides, in many cases neither for the purpose of tightening nor for positioning, the curing strip is a bonding actually required. The capillary effect which is so dangerous with normal use and which occurs by insufficient bonding of the compound with the joint walls is unimportant under water because the prevailing differential forces are always much larger than the capillary forces. In any case, the amount of fluid which might penetrate the capillary clefts is of a minimal extent compared with the amount which could penetrate an untightened joint. Under the influence of such differential pressures the strip in the joint also wouldn't get loose and fall out to the side from which the pressure acts which has to be tightened because the pressure presses the strip into the joint. Therefore, safe positioning, is always taken care of when the joint has a cross-sectional shape which maintains a form-fitting strip of cured compound against the effective differential forces. This form-fitting bonding is given in narrow clefts by the roughness of the surfaces. In the interlocking joints of steel sheet piling the strong curving of the joint in the direction transversal to the wall plane acts in a sense of a form-fitting positioning of the compound strip in the joint. It is especially advantageous to use the method according to this invention with joint shapes which are narrowed in the direction of the tightening.

The differential pressure presses the strip into the narrowing so that it is not only safely positioned there but there is also an increased pressing against the joint walls which becomes effective and therewith produces an excellent tightening effect. Narrowings of this kind are always somehow existent in practically occurring shapes of interlocking joints of steel sheet pilings.

The already mentioned characteristic of the elasticity of the compound cured in the joint is important in two concerns. Firstly, the compound should be able to yield to relative movements of the two joint walls facing each other and secondly, the elasticity of the compound should make possible the pressing of the compound strip under the prevailing differential pressure into the narrowing of the joint and therewith the desired tightening effect.

The compound may be injected into the joints to be tightened with well known equipment. By injection it is understood to be a method by which the liquid or viscous compound is extruded out of a nozzle directed to the joint under such pressure as to make it penetrate into it sufficiently deep. The viscosity of the compound during the injection process should be low enough to enable it to penetrate into the joint deep enough under the prevailing conditions but also large enough so as not to be rinsed out of the joint under the influence of gravity or under the influence of differential pressures which might become active during injection. For tightening the joints of steel sheet piling the following compound has proved satisfactory: Lugatolastic (registered trade mark) which is a permanently elastic one-component tightening compound on silicone caoutchouc basis by Lugato — Chemie & Co., Hamburg 70.

Advantageously, the compound is injected under water from the pressure side into the joint. After injection and before curing the water pressure then has an effect in the sense of pushing the compound further into the joint. If it is feared that the water pressure might be too heavy so that the compound might be pressed out of the joint at its inner side again, the water pressure may be screened off for a time until curing of the compound by any suitable means, for instance by adhesive strips which are applied outwardly to the joint immediately after injection and which need only to have a limited durability. In any case, especially at higher differential pressures, it is advantageous to use a very fast curing compound.

It is understood that when the expression "curing" is being used, all processes are to be understood to be those which lead chemically or physically to the desired change of consistence from liquid or viscous to substantially form-stable, i.e., polymerization, vulcanization or cross-binding.

The indication of the compound strip cured in the joint as a substantially form-stable body means that this body possesses such an internal coherence that it may not be pressed out of the joint which has to be tightened, under the differential pressures which have to be expected. Preferred are those compounds which solidify to a permanently elastic body, but in many cases, also permanently plastic compounds are employable if they solidify from the originally liquid or viscous condition to a toughness great enough to be kept inside the joint under the prevailing conditions in consequence of the form-fitting cooperation with the joint.

The method according to the invention and an apparatus to carry it out will be explained in greater detail with reference to the accompanying drawings, wherein:

FIG. **1** illustrates a joint in cross-section, which is to be tightened in accordance with this invention;

FIG. **2** shows a cross-sectional view through the connected edges of two steel sheet piles with an apparatus applied for the injection filling the joint;

FIG. **3** is an elevational view of the apparatus of this invention in direction III as shown in FIG. **2,** and

FIG. **4** is an elevational view of the apparatus in direction IV as shown in FIG. **2.**

As seen in FIG. **1,** two wall forming elements **1** and **2** form a joint **3** on which from side **4** is a water pressure indicated by arrows. On the other side **5,** lower or no water pressure is effective. The joint **3** narrows from side **4** to side **5.** It is partly filled out by a strip **6** of permanently elastic compound which is cured inside the joint and has been pressed into the narrowing of the joint **3** by the pressure effective on side **4,** and therethrough is kept even so that it should undergo no sufficient bonding with the walls of joint **3.** It is pressed tightly against the joint surface so that a good tightening is achieved.

FIG. **2** shows the edges of two steel sheet piling elements **8** and **9** facing each other and connected to each other by lock **7.** In the lock **7** there is an interlocking joint **10** which is to be tightened. A device suitable for this purpose is indicated in a purely schematical drawing at **11.** It consists of a carrier frame **12** to which magnets **13** are fastened facing the steel sheet piling and which may be permanent or electro-magnets. Further provided are wheels **14** on which the device is drivably mounted along the steel sheet piling. The magnets **13** are adjusted in a manner so that there remains only a small interstice **15** between them and the steel sheet piling elements **8** and **9.** In the carrier frame **12** an injection mechanism **16** is positioned with nozzle **17** which is directed to joint **10** and which is supplied with the compound to be injected via pressure hose **18.** Aside the nozzle mouth tightening means (not shown), may be provided preferably in the form of rails effecting the tightening compound which is supplied under high pressure, not to be squeezed out sidewise but to penetrate deeply into the joint.

So as to exactly guide the whole apparatus, different means may be provided, for instance, above and below nozzle **17** the pins **19** may be fastened on the carrier frame **12** and the steel sheet piling ends seen in the direction of FIG. **2** are in aligned position to nozzle **17** so as to be suitable as guiding means along lock **7.** Instead of or additionally the wheels **14** may be positioned so that under an oblique angle and during forward movement of the apparatus a continuous lateral power component originates which presses the nozzle, the pins and/or the tightening rails against the edges of the joint to be tightened.

Magnets **13** are provided which are dimensioned strong enough to keep the device attached to the steel sheet piling also under the highest forces which might occur during the injection process.

The device is provided on its upper side with ears **20** to which a chain **21** or a rope is fastened which leads to a winch. In the plate **12** a watching hole **22** is provided. Means may also be provided so as to de-rust the joint and/or the area in which the rollers **14** are running.

The invention operates in the following manner:

While suspended in a winch the apparatus will be attached to the steel sheet piling **8, 9** in such a way that the guiding means fix the nozzle mouth in the correct position in front of the joint. If necessary, the guiding means and respectively, the nozzle **17** are adjusted to their correct position after the magnets **13** have been switched on the device and are attracted against the steel sheet piling by the originated magnetic field.

When suspended by the winch, the device may be moved up and down on the steel sheet piling. The diver accompanying the device, if necessary, may only have to supervise its function. The working speed will be adjusted so that a sufficient filling of the joint is warranted. It may be automatically controlled by the pressure by which the compound is supplied to the nozzle.

Obviously, the embodiment shown is exemplary only and a wide variety may be devised without departing from the spirit and scope thereof.

What is claimed is:

1. A method of tightening a joint defined between facing walls of forming elements that lie adjacent each other and are submerged in water, comprising the steps of

a. injecting a permanently elastic compound, in a liquid form and under pressure into the joint along the length thereof; said pressure being sufficient to push the water from the joint and the facing walls of the forming elements in the area of which the compound is injected; and

b. allowing the liquid compound to cure to an elastic inside the joint and to adhere to said facing walls while under the pressure of the water against which the tightening is effected so as to form a stable body.

2. The method according to claim **1**, wherein said compound is a cold vulcanizing silicone caoutchouc.

3. The method according to claim **2**, wherein the curing of said compound is accelerated by moisture.

4. The method according to claim **1**, wherein said compound is applied in joints having a cross-sectional shape which keeps the cured tightening compound form-fitting.

5. The method according to claim **1**, wherein said compound is applied to joints having a narrowing in the direction of the insertion of said compound.

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