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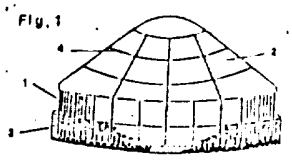
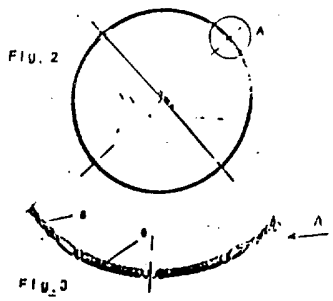
(54) Title: STORAGE SILO

(57) Abstract:

The invention relates to a silo, in particular to a silo for storage of organic and/or moisture-sensitive stock, in particular grain, comprising a cylindrical tarpaulin bottom liner(7) and a top cover tarpaulin(2), both having overhanging ends which are wound-up around a spring loaded sealing rope (5) placed in the proximity of the top edge of the surrounding grating wall. The roll so formed is successively secured with the aid of aprons (9,10) permanently fixed to each of the two tarpaulins which aprons simultaneously are fixed to the grating wall and tied to each other so to exert a pressure onto the wound-up ends of the tarpaulins (2,7). The invention relates further to a process for erection of a silo so described, and to a rain proof cover of stored stocks. Furthermore it relates to an insulation liner (18) being introduced between the stock (20) and the cover tarpaulin (2), which said insulation liner may be, if so designed, laminated with an aluminium layer (17) onto which the cover tarpaulin (2) is laid directly. The resulting advantages are that the band width of fluctuations of temperature and relative air humidity under the side of such insulation liner facing the stored stock may be kept very narrow, resulting into the effect of preventing the formation of vapor condensate with its detrimental effects exerted onto the stock





Conclusions:

The invention relates to a silo, in particular to a silo for storage of organic and/or moisture-sensitive stock, in particular grain, comprising a cylindrical tarpaulin bottom liner(7) and a top cover tarpaulin(2), both having overhanging ends which are wound-up around a spring loaded sealing rope (5) placed in the proximity of the top edge of the surrounding grating wall. The roll so formed is successively secured with the aid of aprons (9,10) permanently fixed to each of the two tarpaulins which aprons simultaneously are fixed to the grating wall and tied to each other so to exert a pressure onto the wound-up ends of the tarpaulins (2,7). The invention relates further to a process for erection of a silo so described, and to a rain proof cover of stored stocks. Furthermore it relates to an insulation liner (18) being introduced between the stock (20) and the cover tarpaulin (2), which said insulation liner may be, if so designed, laminated with an aluminium layer (17) onto which the cover tarpaulin (2) is laid directly. The resulting advantages are that the band width of fluctuations of temperature and relative air humidity under the side of such insulation liner facing the stored stock may be kept very narrow, resulting into the effect of preventing the formation of vapor condensate with its detrimental effects exerted onto the stock (Fig. 1).

D E S C R I P T I O N

Storage Silo for holding of organic and/or moisture-sensitive stock, in particular grain, and process for the erection of such silo.

The invention relates to a storage silo for holding organic and/or moisture-sensitive stock, in particular grain as per claim 1, as well as to the process of erection of a silo, in particular of a storage silo for holding grain and/or other organic and/or moisture-sensitive stock.

For medium and/or long term storage of grain storage silos consisting of a weld mesh circular wall lined with a wall and floor cover-tarpaulin are used in comparatively dry areas.

Grain bags are stacked inside the container so formed, and, after completion, the stack is covered by a tarpaulin in order to protect the stock against rain.

When such silos are used, it is particularly important to protect such silos against rodents and insect pests, which thus can enter between top cover and floor tarpaulin, requiring a good seal.

Due to climatical conditions in tropical and sub tropical zones with heavy diurnal temperature fluctuations, an almost hermetic tarpaulin cover leads to the problem that when the temperature drops below a certain limit, the residual grain moisture causes condensation of water vapor inside the tarpaulin cover. This condensation may, when heavy or appearing often, cause spoilage of at least the upper layer of grain stored.

There exists the possibility to use a somewhat vapor permeable cover tarpaulin which consists of canvas impregnated with water repellents. In case of heavy rains but this is insufficient, and water may penetrate through the cover and enter the silo, particularly at spots where the tarpaulin rests on the stock.

An object of the invention is to provide a portable silo suitable for storage of organic and/or moisture-sensitive stock, especially

grain, characterized in that the stock is protected by a water proof tarpaulin cover under which said tarpaulin cover the formation of water condensate on the part of the said cover which faces the stored stocks is largely reduced or totally avoided. Another object of the invention is to design such a silo for simple and cost saving erection, for a large security against entry of pests and other animals, and for allowing a wind proof bracing of the cover tarpaulin. A further object of the invention is the process for the erection of a silo, in particular of a silo to hold organic and/or moisture sensitive stock, without expensive mechanical aids, and which ensures a fast and safe erection of the silo.

These objects are fulfilled by the inventions specified in the claims. Positive developments of the invention are specified in the sub-claims.
The storage silo in accordance with the invention is characterized in that an insulating layer, which preferably consists of a thermally set polyester felt, is introduced between the stock and the cover tarpaulin. This insulation considerably reduces the diurnal temperature fluctuations on the surface of the stock, so that formation of vapour condensate by temperature drop to below dew point is considerably reduced or totally prevented. The insulation liner is preferably placed over the apex of the silo cone, it may, however, also be placed so as to cover the whole cone if difficult climatical conditions do prevail at the site of placement of the silo. For large silos the insulation liner is preferably designed to form two parts, i.e. a toroidal lower cone shaped shell and a cone shaped upper shell, both of which are connected to each other by straps, whereby the upper shell overlaps the lower shell. Between the outer tarpaulin cover and the insulation liner a certain vapor condensation may occur at low ambient temperatures which but because of the small distance between cover tarpaulin and insulation liner is so small that it may be neglected. In no case this leads to dangereous moistening of the stocks.

Moreover such condensate is distributed over a larger zone of the insulation liner due to capillary action of the insulation liner, and not transferred to the stocks.

An aluminium coating of the insulation liner further reflects heat radiation and thus reduces heating of the stored stocks during daytime, and further considerably reduces the diurnal temperature fluctations of the stocks.

The invention has a positive effect towards the long term storeability of the stored stocks. It further prevents certain critical temperatures of the stored stocks to be exceeded.

The invention furthermore permits the storage of stocks, in particular grain having a larger initial moisture content as compared to the storage otherwise permitted, the design in accordance with the invention preventing the formation of water condensate which is otherwise unavoidable.

The silo in accordance with the invention distinguishes itself further by easy erectability, thus permitting the use also at sites with limited availability of mechanical aids. The components used are easily put together and easily available. After execution of the erection procedure invented, a siio is erected which offers a large scale safety against penetration by pests, and where the upper cover tarpaulin is firmly connected to the side wall, thus permitting the storage e.g. of grain over a longer period.

Following the invention is explained as displayed in the accompanying drawings:

The figures display:

Fig. 1 : a total view of an erected Silo.
Fig. 2 : a plan view of the silo
Fig. 3 : a sectional view for display of the spring loaded rope
Fig. 4a-d: process steps leading to the connection of the two tarpaulins
Fig. 5 : a sectional view to display the toroidal ring which is arranged on the top edge of the grating wall.
Fig. 6 : a sectional view of the apex of a silo in accordance with the invention, showing the conically stacked bags with covers according to the invention.

Fig. 7: a graphical display of the thermal conditions inside a storage silo in accordance with the invention

Following is a description of the construction of a silo as invented.

Fig 1 shows a silo in its ready appearance. The silo consists of an all round closed grating wall, preferably formed of individual elements, each for instance of 127 x 245 cms size. The individual elements consisting of wire gratings are equipped with angular steel profiles, through which they are connected to each other by means of screw connectors. In the process of erecting a silo, the individual elements are initially firmly screwed together. After loading the stock into the silo, the gap between the elements is widened somewhat by readjusting the screws in order to reduce the tension resting on the grating wall. The basal surface of the silo is of circular shape as displayed in Fig. 2 and e.g. has a diametre of approx. 15 metres for a silo holding 500 tons. Before commencement of loading stock into the silo, a tarpaulin liner (7) covering the whole floor space inside the grating wall, and furthermore extending approx. 30 cms beyond the upper edge of the grating wall, is applied. After completion of introduction of the stock into the silo, for instance of grain bags which are stacked to form a cone beyond the upper edge of the grating wall, a cover tarpaulin (Fig. 2) is placed over the stacked stock. the lower edge of this cover tarpaulin extends beyond the upper edge of the grating wall. After alignment of the cover tarpaulin, the protruding ends of the cover tarpaulin (2) as well as of the tarpaulin lining the floor and wall (7) are folded under the spring loaded rope (5) and thereafter rolled around this rope. After completion of this process, therefore, a toroidal roll is formed encircling the upper edge of the grating wall. This roll forms a tight connection of the upper cover tarpaulin (2) and the liner (7), so that there is no possibility for any insect pests to enter into the silo at this point.
Fig. 4 shows the procedure of the winding up sealing in detail.

Fig. 4a displays the two ends of the tarpaulins which extend beyond the grating wall. Both ends of the tarpaulins 2 and 7 are folded under the spring loaded tensioning rope 5 from below, and further wound-up manually until the complete portions of the tarpaulins protruding are firmly wound up. This state is displayed in Fig. 4c.
Both tarpaulins 2 and 7 have aprons firmly attached to them. The joining edge of the apron 9 of cover 2 is, after winding-up of the lower portion of this tarpaulin, in a position approx. at level with the upper edge of the grating wall. A corresponding apron of tarpaulin 7 is also positioned at approx. the level of the upper edge of the grating wall. These two aprons are now joined together and fixed to the grating wall, preferably by tensioning with the aid of at least one guy rope (15) passed through eyelets (14) distributed all round the aprons (9, 10). Thereby it is possible to secure the wound-up edges of the tarpaulins as well as to load tension onto the tarpaulins.
Fig. 4d shows a display of both aprons enclosing the wound-up ends of the tarpaulins. As a means of protection of the grating wall, and to prevent injuries of the tarpaulins 7 and 2 a toroidal ring (11) is preferably arranged on the top edge of the grating wall, which, for instance may be in the form of a pipe with comparatively solid walls. This pipe may, for instance as displayed in Fig. 5, be joined with the top edge of the grating wall with the aid of detachable fixing straps (12). The toroidal all round hoop (5) is preferably composed of individual sections which are joined together with the aid of correspondingly smaller joining pipes introduced into them.

The silo according to the invention comprises only few components which are of simple design. All components are detachably joined together, as to permit dismantling of the silo after fulfillment of its duty, and to permit re-erection at other sites. The process of erection and sealing of the silo may be carried out by unskilled staff, although ensuring a fast erection and safe storage of the stock over prolonged periods.

A storage silo preferred for embodiment of the invention is almost hermetically sealed. The airtight seal is preferred and required to avoid penetration of rain water into the silo as well as to permit the building-up of a carbon-dioxide

atmosphere inside the silo, which ensures better storage stability of the stocked grain. This airtight seal but has the disadvantage that the residual grain moisture which in many cases is 12 to 14 percent (of wet basis), partly evaporates and, when the temperature falls below dew point, has the effect of vapour condensation on cold surfaces, in particular the inner face of the cover tarpaulin (2), forming dew droplets. Such dew will be either directly transferred to the stocked grain by direct contact or, where there is no direct contact, accumulate at certain lower spots of the conically shaped cover tarpaulin where the drops fall onto the grain. In case of heavy or frequent condensation the upper layer of grain may become too wet with the effect of increasing risks of mould growth, which will also no longer be pevented by the formation of carbondioxide. Where climatical conditions with a fast and considerable temperature increase by solar radiation in the morning do prevail, the grain may even be "boiled". After prolonged storage real danger does exist that at least the upper layer of grain stored will be spoiled and become unfit for consumption. It is, therefore, considered that grain stored in airtight silos requires a considerably lesser percentage of moisture as compared to conventional "open" storage, generally at least 2 % less.
Fig. 6 shows the composition of layers of a storage silo according to the invention. The outer cover tarpaulin consists of a polyester fabric coated with PVC and polyurethane being blended with UV-inhibitors. Between the stock (20) and the outer tarpaulin cover (2) an insulating layer (18) is introduced according to the object of the invention, consisting of a felt-like polyester fabric having a thickness of 2 to 5 mm, and which is thermally set (sintered), having very high mechanical strength. Due to the felt-like structure of the insulation liner (18), any dew droplets which may still develop will not be transferred onto the stock. The insulation layer (18) is air permeable so to permit exchange of air between the gap (16) formed between the two layers (2 and 18) and the space (19) in between the stock (20) and layer (18). In a preferred version of embodiment of the invention, an aluminium coating (17) is laminated on the insulation layer (18), serving additionally as a reflector against thermal radiation. In order to maintain the air permeability of the insulation layer (18) the aluminium coating (17) is perforated. This but does not negatively affect the

radiation reflecting properties of the aluminium coating. When the aluminium coating is applied, the insulation liner preferably has a thickness of approx. 2 mm. In a preferred version of embodiment of the invention, the cone surface line of a silo holding 500 tons grain is 8.50 metres, and that of a silo holding 1000 tons is 11.50 metres approx. For the purpose of easy application the insulating layer may be divided into two cone shaped shells. The upper shell in such case will be designed to overlap the lower shell by about 20 cms. Both shells are joined together with the aid of straps and eyelets. The eyelets are, however mounted only in the overlapping shell to avoid thermal conduction. In areas with comparatively lesser risk of vapor condensation the introduction of the insulation layer may be limited to the upper portion of the conical stack only. In such cases only the upper cone shell is introduced, the lower shell may be deleted.

The relative air humidity which is the decisive factor for the formation of vapor condensation, depends on the air temperature. Soon as the temperature falls below a certain value, the relative air humidity may reach and exceed the saturation point (100 % R.H.) in which case the now excessive air moisture condenses and forms water deposits on the colder spots. The embodiment of the invention and the process of erection of a silo according to the process as invented, prevent the temperature inside the silo, particularly at the most critical points from falling below saturation point. For reason of the latent heat stored in the stock, particularly in the grain stock and gained or regained during day, and which said latent heat is largely retained by the insulating layer (18), a cooling down of the air in the upper layers of the stock to below saturation point is prevented. Between the insulating layer (18) and the cover tarpaulin (2), however the temperature gradient may become large enough to allow formation of vapor condensate. Because of the small quantity of air affected, such condensation is so minimal only, that it may be neglected. Fig. 7 shows a graphic display, side by side the band width of temperature variations and the corresponding relative air humidities as measured in a storage silo executed according to the invention. The curve 2 shows the variation of relative air humidity in a silo without the introduction of the insulation liner as invented, measured between the stored stock and the

cover tarpaulin (2). The graph 22 shows the corresponding development of the temperature and relative air humidity in a silo as invented equipped with insulation liner, measured between insulation liner (18) and cover (2) tarpaulin. Curve 23 finally shows the development of relative air humidity and temperature in a silo constructed and erected according to the invention, measured between the insulation liner (18) and the stored grain stock (20), i.e. inside the air space (19) shown in figure 6, which the critical zone for formation of condensate.

The curves do clearly show that the temperature in the ciritical zone (19) varies only between 18 and 29 degrees Celsius, i.e. a fluctuation of 11 degrees Celsius, the corresponding relative air humidity varying between 35 and 47 % only. Without the application of the insulating liner (18) the temperature fluctuations would have been, as displayed in curve 21, between 8 and 28 degrees Celsius, i.e. by 20 degrees Celsius, the corresponding fluctuations of relative air humidity being between 30 and 95 %. A condensation could, thus not have been avoided.

The graphs do indicate the important advantage of the invention relating to reduction of temperature fluctuations as well as to the small variation of relative air humidity, thereby providing a high degree of security against the formation of condensate. By this method it is also possible to introduce grain into such described silo, which initally has a higher percentage of moisture, without such higher moisture content resulting into increase risks of wate condensation and thus spoilage. This facilitates in particular the introduction of grain into such described silo during the rainy season without the necessity to have the grain dried before it may be stocked. The small band width of variationb of relative air humidity and temperature does not only permit the introduction for storage of grain having a higher moisture content but furthermore serves to increase the storage stability and for the conservation of the quality of the grain stock stored. A silo constructed and erected according to the invention can, furthermore, be used in zones having larger fluctuations of temperature and ambient air humidity as well as in zones of lower absolute temperatures without the risk of condensation and successive damage to the stocks.

Gerhard Meyer & Co

Claims

1. Storage silo for holding organic and/or moisture-sensitive stock, in particular stacked grain bags, with a rain-proof cover tarpaulin, which is laid on the stock, characterized in that an insulation liner covering the piled stock (20) at least in the physically uppermost region is introduced between the stock (20) and the cover tarpaulin (2) and has the cover tarpaulin (2) lying directly on top of it.

2. Storage silo according to claim 1, characterized in that the insulation liner (18) is made of thermally set polyester felt.

3. Storage silo according to claim 2, characterized in that the insulation liner (18) is provided on the side facing the cover tarpaulin (2) with a gas-permeable aluminium lining (17).

4. Storage silo according to claim 2, characterized in that the insulation liner has a thickness of approximately 5 mm.

5. Storage silo according to claim 3, characterized in that the insulation liner has a thickness of 2 - 4 mm and in that the perforated aluminium coating (8) is laminated on the insulation liner (7) in a thickness of 0.1 mm.

6. Storage silo for holding organic stock, in particular stacked grain bags, consisting of an all round closed grating wall (1), the inside of which is covered by a first tarpaulin (7) and wherein the upper cover of the filled silo is formed by a second rain-proof cover tarpaulin (2), characterized in that a spring-loaded rope (5) is held taut on the outside around the closed grating wall (1) in the vicinity of the top edge, in that the upper end of the first tarpaulin projecting beyond the top edge of the grating wall (1) and the lower end (13) of the second cover

tarpaulin (2) projecting beyond the top edge of the grating wall (1) can be wound together around the rope (5).

7. Silo according to claim 1, characterized in that the ends (8, 13) of the tarpaulins (2, 7) wound together around the rope (5) can be covered by aprons (9, 10) attached to each tarpaulin in the vicinity of the wound-up ends, and in that the aprons (9, 10) have eyelets (14) which are distributed all around their border and by which the aprons can be fixed to the grating wall with the aid of at least one rope (15) running through the eyelets.

8. Silo according to claim 1, characterized in that a toroidal ring (11) is arranged on the top edge of the grating wall (1).

9. Storage silo, consisting of a cylindrical lower part (1), into which stock stored in bags has been introduced, which stock is piled up in the shape of a cone beyond the upper edge of the lower part (1) and covered by a conical, rain-proof cover tarpaulin (2), according to claim 1 or 6, characterized in that the insulation liner (18) covers the cone-shaped pile at least in the region of the cone tip.

10. Storage silo according to claim 9, characterized in that the insulation liner (18) is formed by sheets sewn together.

11. Storage silo according to claim 10, characterized in that the insulation liner (18) consists of a conical upper part and a toroidal, conical shell-shaped lower part, which are joined together by means of loops passed through eyelets.

12. Process for the erection of a silo, in particular of a grain silo, in which a connection is made between a first tarpaulin (7) arranged on the closed all round inner wall of the grating wall of a silo and a second tarpaulin (2) forming the upper cover of a filled silo, characterized in that initially the upper end of the first tarpaulin (8) is laid over the top edge of the

wall of the silo, in that, once the silo has been filled, the lower end (13) of the second cover tarpaulin (2) is laid outside over the top edge of the wall of the silo and in that subsequently the two ends of the tarpaulins are wound into a roll around a rope (5) tightened on the outside at the upper end of the wall of the silo, the winding up of the ends of the tarpaulins being commenced by introducing the ends underneath the rope (5) from below.

13. Process according to claim 12, characterized in that the wound-up ends are covered by aprons (9, 10) attached to the tarpaulins, wherein the apron (9) attached to the second cover tarpaulin (2) is laid over the outside and the apron of the first tarpaulin (7) is laid over the inside of the roll, the edges of the aprons being joined together underneath the roll and fixed to the grating wall (1) by tensioning with the aid of at least one guy rope (15) passed through eyelets (14) distributed all round the aprons (9, 10).

14. Process according to claim 12, characterized in that the top edge of the wall of the silo is cushioned, before stock to be stored is introduced, by fitting a toroidal ring (11), which is formed by detachably fixing an all round loop with the aid of fixing straps (12) on the top edge of the wall.

DATED this 29th day of June 1987.

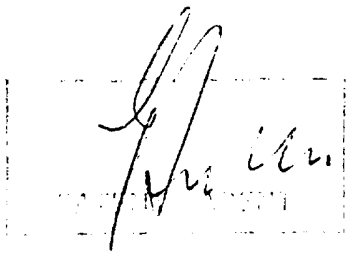
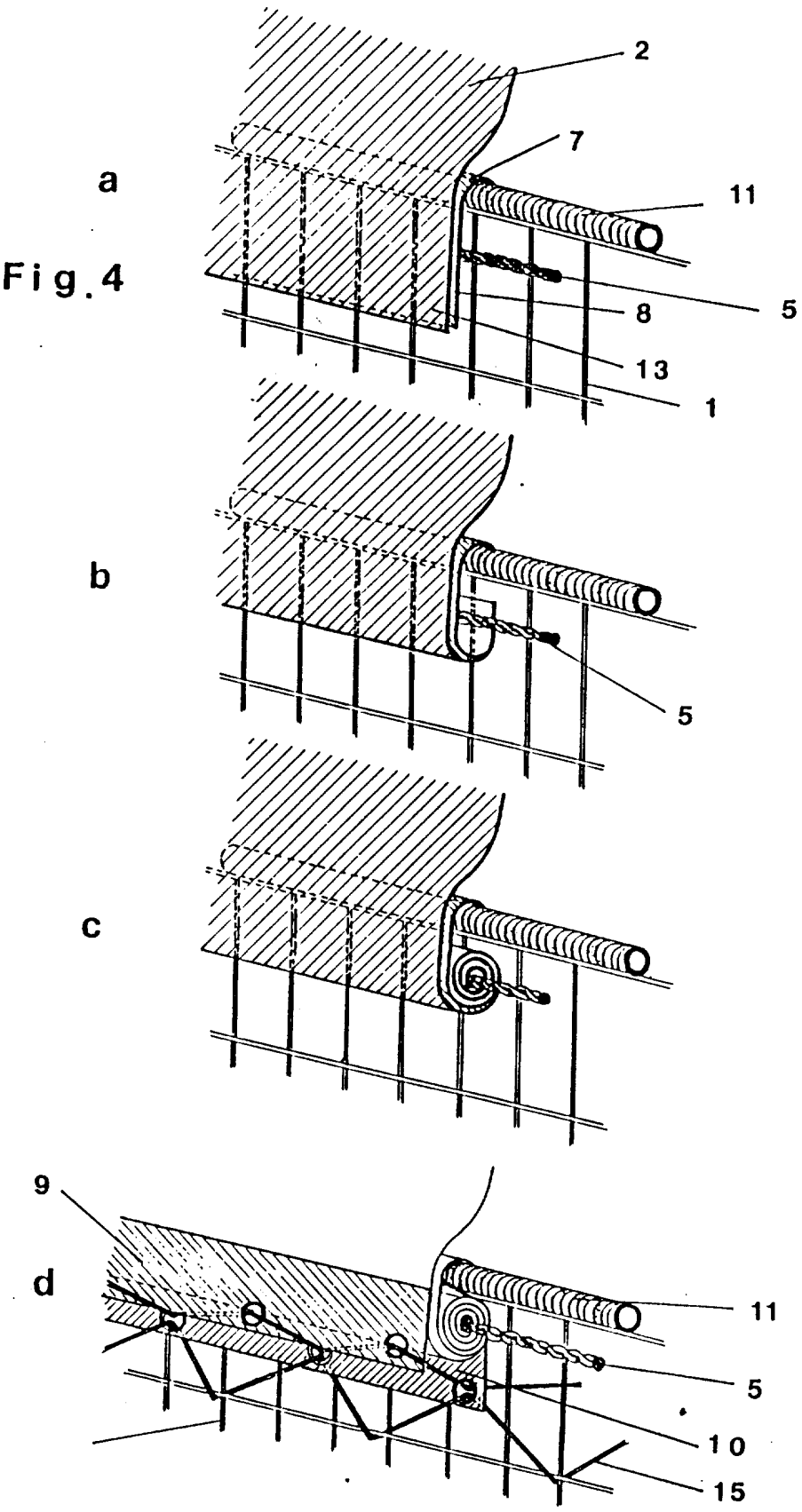


Fig.4



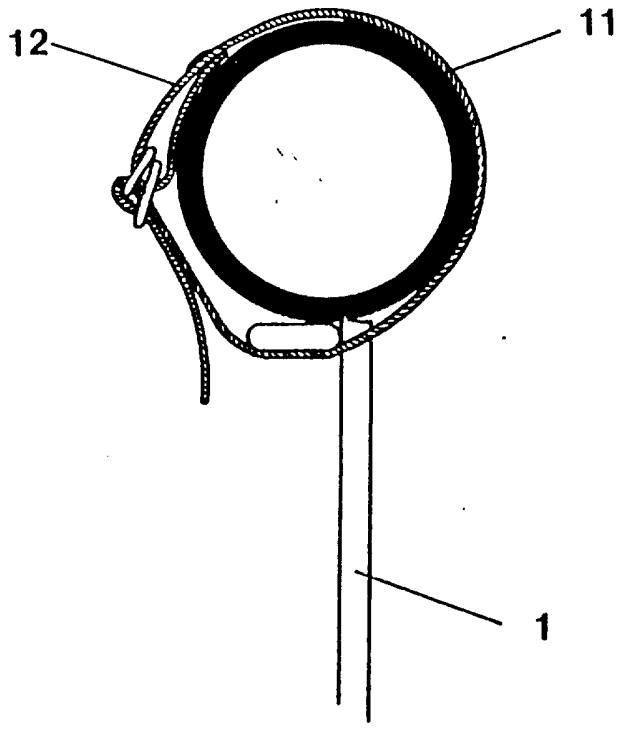


Fig. 5

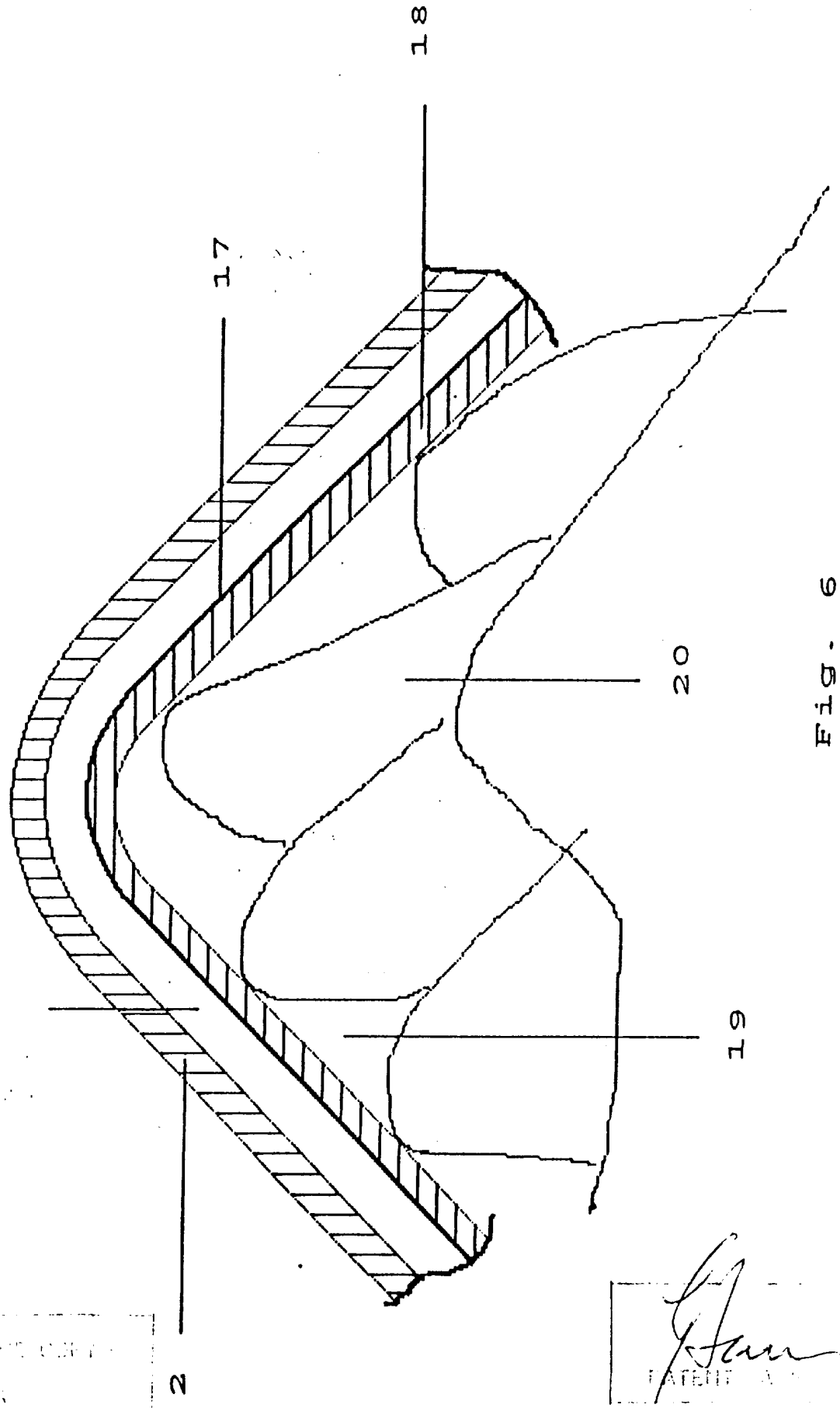


Fig. 6

Fig. 7