Jan. 25, 1966 K. A. OESTERHELD 3,231,647

METHOD OF AND APPARATUS FOR CORRUGATING SHEETS OF FIBROUS CEMENT

Filed June 7, 1960 3 Sheets-Sheet 1

FIG. 1

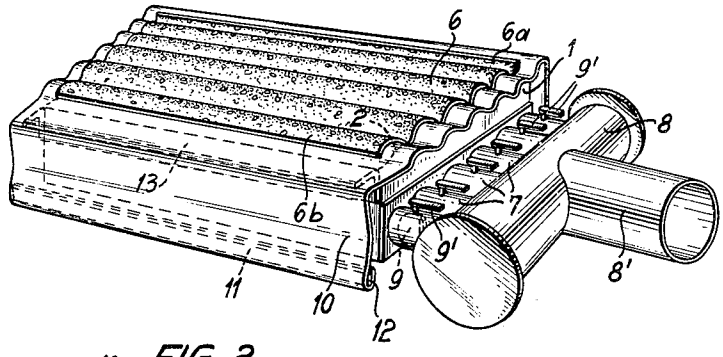


FIG. 2

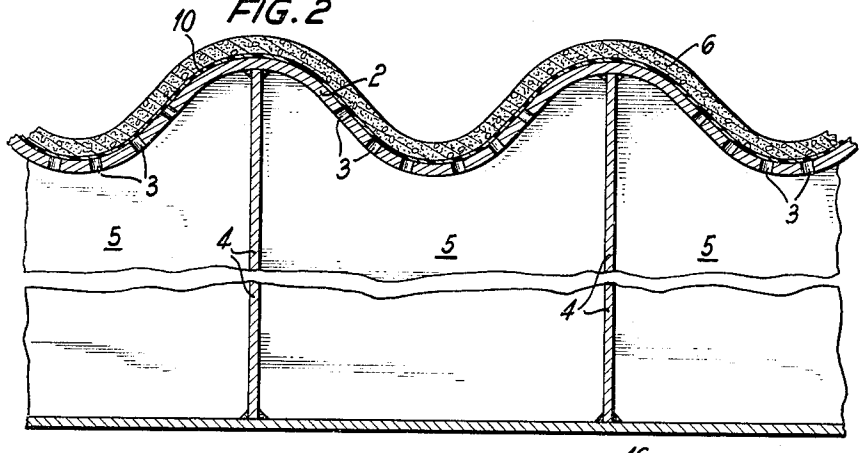
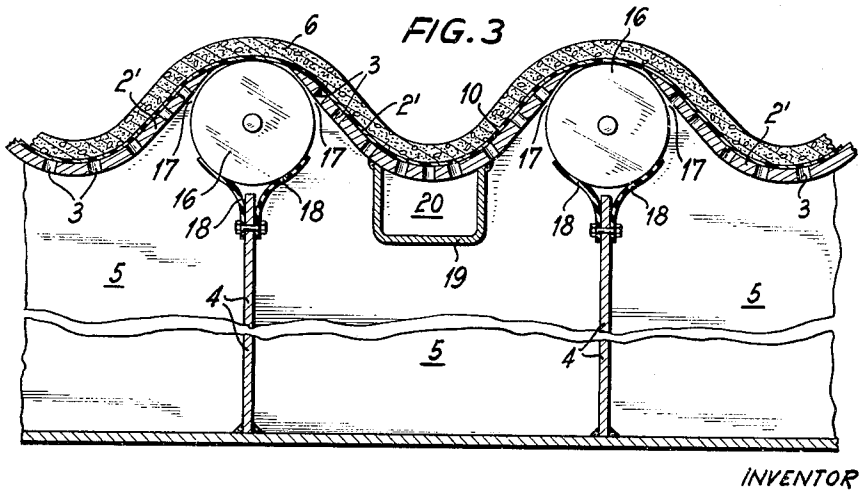


FIG. 3



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METHOD OF AND APPARATUS FOR CORRUGATING SHEETS OF FIBROUS CEMENT

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FIG. 4

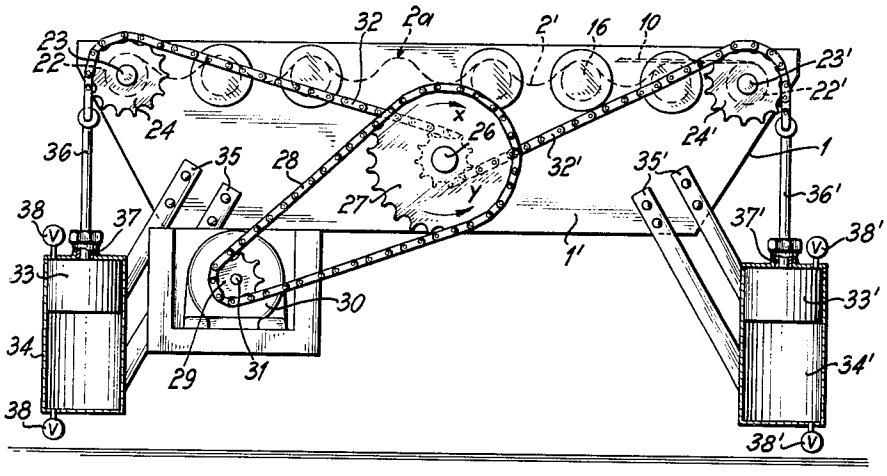
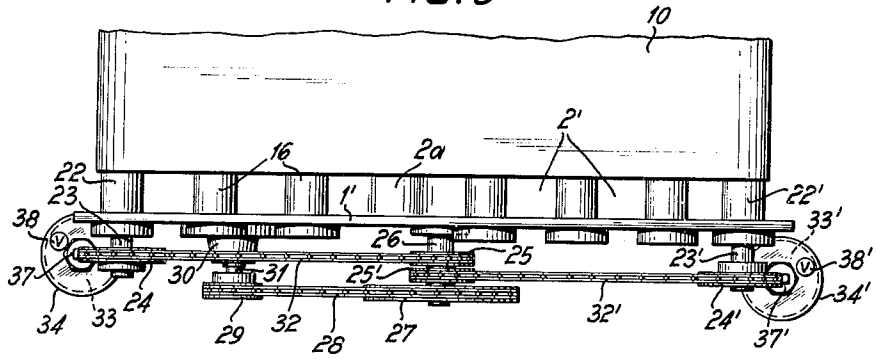


FIG. 5



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METHOD OF AND APPARATUS FOR CORRUGATING SHEETS OF FIBROUS CEMENT

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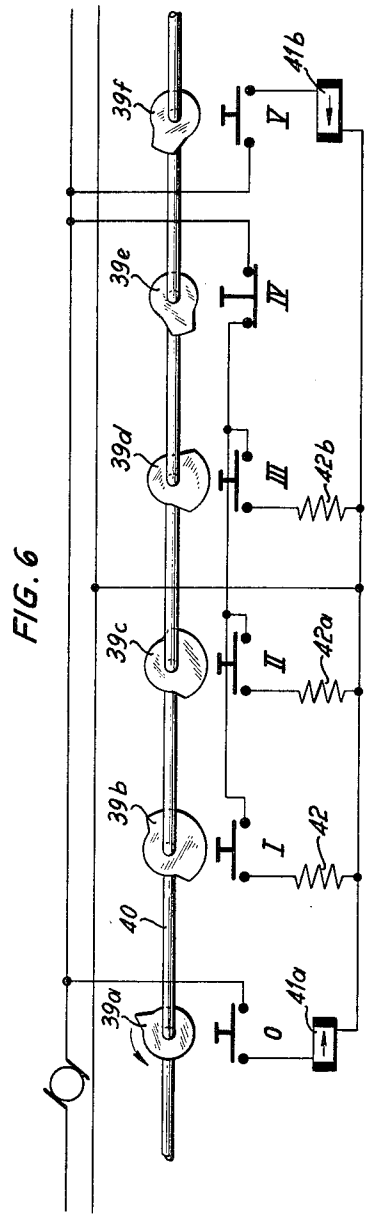


FIG. 6

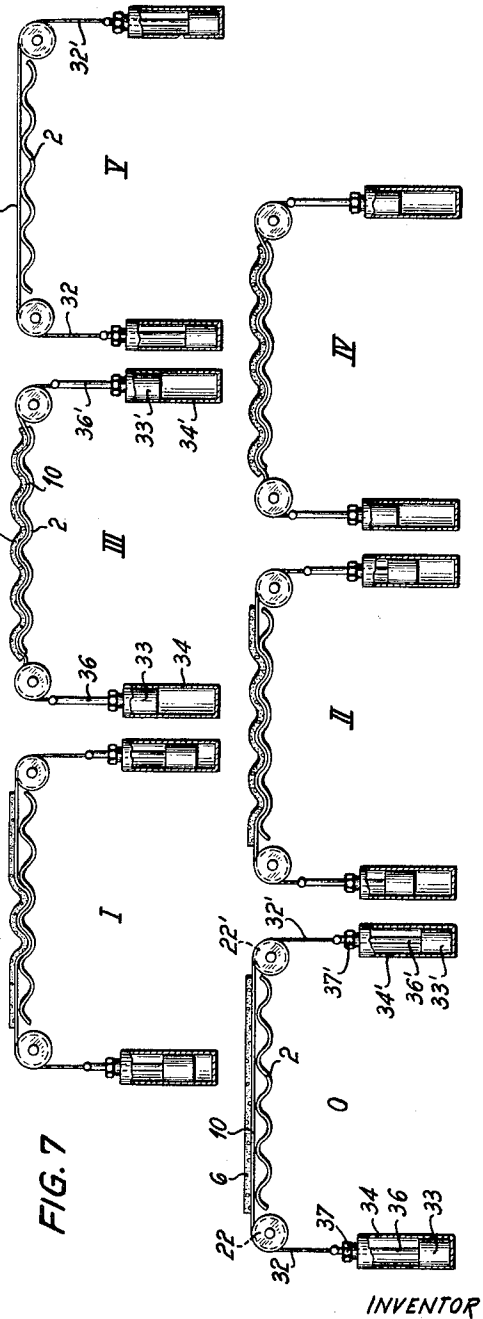


FIG. 7

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METHOD OF AND APPARATUS FOR CORRUGATING SHEETS OF FIBROUS CEMENT

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12 Claims. (Cl. 264—99)

For the formation of corrugated sheets from plane sheets of fibrous cement fed by a format roll several methods are known. One of the known methods comprises the steps of placing a fresh sheet of fibrous cement on an undulated rigid moulding structure and exposing the sheet to the influence of pressure exerted by a counter mould in the form of rolls which are arranged on a vertically movable frame. The rolls are suspended from lowerable frames at different levels in such a manner that the roll serving to mould the middle corrugation, on the frame being lowered, first comes to rest on the sheet of fibrous cement and then after the middle corrugation has been moulded, the rolls arranged at either side of the middle roll will produce, simultaneously and in pairs at a time, two corrugations, the lateral portions of the fibrous cement sheet being moved up stepwise towards the first corrugated middle zone of the sheet.

Another known method makes use of an arrangement wherein a lower moulding structure and an upper moulding structure consist of individual elements which have a working surface adapted to the corrugation to be moulded, are of elongated shape and, on the upper moulding structure being lowered, are shifted together transversely of their longitudinal extent towards the middle individual element. Thus, on the upper moulding structure being lowered and the individual elements being shifted together, the fresh sheet of fibrous cement applied on to a flexible layer of rubber or like elastic material loosely placed on the individual elements of the lower moulding structure is corrugated between the flexible layer of the lower moulding structure and a likewise flexible layer arranged on the underside of the upper moulding structure. To ensure a good adherence of the flexible layers to the individual elements, the individual elements are made hollow and provided with holes in the walls constituting the working surfaces, to which holes the flexible layers snugly adhere by means of a vacuum created in the individual elements.

Likewise based on the use of relatively movable rigid moulding bodies is the mode of operation of yet another corrugating apparatus, wherein, however, the use of a lower moulding structure with relatively movable individual elements is dispensed with. The relatively movable bodies of the upper moulding structure are accommodated in a suction die formed by a flexible envelope and having several chambers of variable volumes. Since the lower portion of the envelope is permeable to air, the suction die can receive and carry, due to the suction effect, a plane fibrous cement sheet to be deformed. The sheet is corrugated by a mechanically effected shifting together of the rigid moulding bodies, whereas the envelope together with the sheet to be deformed is retained by suction at the underside of the moulding bodies.

Also known is a method of corrugating prefabricated fresh sheets of fibrous cement wherein a mould table is used the upper surface of which has the shape of the corrugated sheet to be made. The sheet of fibrous cement is deposited on the surface of the mould table by a travelling conveyor means in such a manner that its own weight causes it to lay itself in corrugated shape on to the surface of the mould table and by a vertical smoothing pressure is made to snugly adhere to the moulding surface. The smoothing pressure is produced either with the aid of light rolls and/or by an underpressure acting upon the corrugation troughs of the mould table surface. The underpressure, at the same time, also causes that portion of the fibrous cement sheet already deposited in corrugated shape, to be fixed with the corrugation troughs on the surface of the mould table which is located immediately in front of the place where the sheet is deposited.

The difficulty involved in the corrugation of fresh sheets of fibrous cement is chiefly based on the fact that when the corrugation crests and the corrugation troughs are formed, the portions of convex shape are stressed in tension and the portions of concave shape, in compression. This may entail the risk that the surface structure of the soft fresh sheets of fibrous cement are liable to undergo a structural change and as a result cracks are caused at the corrugation crests which may lead to an increased absorption of water and consequently to damages resulting from frost.

It is the object of this invention to overcome the aforedescribed drawbacks, to simplify the corrugating and finally to improve the accuracy to shape of the corrugated sheets of fibrous cement.

This object is attained by providing a method of corrugating prefabricated fresh sheets of fibrous cement on a moulding structure, which comprises in combination the steps of placing a flexible layer of fabric or the like penetrable by air over the corrugated cover provided with suction holes of a rigid suction box, exposing said flexible layer during the entire corrugating procedure to the influence of strong tensional forces acting in the transverse direction, placing said prefabricated fresh sheet of fibrous cement on said flexible layer, and exposing said sheet of fibrous cement on said flexible layer to the action of a vacuum initiated preferably in the middle of the sheet of fibrous cement and enlarged progressively towards the longitudinal edge portions thereof to draw said sheet of fibrous cement on said flexible layer towards said cover and form corrugations therein.

This method is distinguished from all hitherto known corrugating methods by the fundamental fact that the corrugating procedure is not effected, as hitherto practised, by the sole or additional use of means moving to and fro or vertically up and down but exclusively by a vacuum acting upon one side of the sheet and successively expanding over the various zones of the sheet and by the use of a flexible layer penetrable by air and brought up in steps. In this case, in the critical zones, i.e., in the corrugation crests and in the corrugation troughs, the fibres are by far not so heavily stressed as they would be under direct influence of mechanical or pneumatic pressure exerted on the sheet of fibrous cement in vertical or in horizontal direction. The crest of a corrugation already formed immovably adheres by suction to the moulding structure and when, in the course of the formation of further corrugations, the lateral portions of the flexible layer together with the sheet of fibrous cement are brought up towards the middle zone already corrugated of the fibrous cement sheet, remains free from any tensile and compressive stresses.

On a sheet of fibrous cement being corrugated according to the suction method as proposed by the invention, in the individual layers of the corrugation crests no distortions will take place but the sheet of fibrous cement is rather pulled gently around the corrugation crests of the suction box cover without a structural change occurring in the sheet of fibrous cement. The same applies to the formation of the corrugation troughs. Thus the main cause responsible for surface cracks is eliminated.

As the moulding structure provided on its entire area with a plurality of holes of small diameter forms a body

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rigid in itself and having an invariably accurate surface and the formation of the corrugations is effected exclusively under the influence of a vacuum, the suction components acting in transverse direction being taken up by the flexible layer, a moulding of smooth-surfaced sheets accurate to shape is ensured.

Yet another method is known to make corrugated sheets of fibrous cement, wherein a pasty mixture of fibrous materials and cement is applied to the corrugated and apertured cover of a suction box covered with a fabric layer permeable to liquid. In this known method the fabric layer snugly adheres in advance to the corrugated cover of the suction box by closely following its undulated shape and it remains so without undergoing any change on the cover of the suction box during the moulding of the corrugated sheets by means of distributor rolls and pressure rolls. By the suction effect of the suction box excess water is removed from the pasty mixture of fibrous material and cement, the fabric layer serving as a filter. Moreover, the suction effect of the suction box causes the fabric carrying the mass of the mixture to adhere to the cover of the suction box whenever the distributor rolls and the pressure rolls are moved to and fro across the mass of the mixture for moulding the mass to form a corrugated sheet.

In the method according to the invention, the suction acting on the corrugated apertured moulding structure can be applied uniformly or variably to the total area of the fibrous cement sheet in such a manner that the mass of fibrous cement is conveniently consolidated at all places, irrespective of whether the sheet of fibrous cement in its fresh plane initial condition has some differences in thickness resulting from the manufacture yet remaining within tolerances or whether the sheets of fibrous cement to be sucessively treated vary in their thicknesses. Careful treatment of the soft mass of fibrous cement is favoured by the flexible layer which is tautly stretched over the moulding structure and can also be attained in that the amount of vacuum and the operative period of the vacuum are so applied as to conform to the peculiarity of the fibrous cement material in each individual zone to be corrugated. Accordingly, in order to maintain the surface structure of the fresh sheet of fibrous cement as it is, it may be of advantage to carry out the moulding of the first corrugation of each sheet at a slower rate and the rest of the corrugations at a quicker rate. The total corrugating procedure will take considerably less time than the hitherto known methods of corrugating used to take with the result that a higher rate of output and an increased profitableness are derived from the simply devised machine.

In order to maintain intact the surface structure of the sheet of fibrous cement in the crests of the corrugations it has proved advantageous to exempt the crest portions from the suction effect. This can be attained in a simple manner in that the corrugated crest portions of the moulding structure are left without holes.

It is of importance that the corrugation crests of the fibrous cement sheet, whenever a corrugation has been formed, are immovably positioned on the perforated moulding structure. To this end, on either side of the crest region longitudinally extending narrow slots are provided in that the crest regions of the moulding structure consist of fixed or rotatable rolls and the lateral edges of the individual suction box cover portions terminate short of the roll surface.

The basic idea of the invention allows further development to the effect that each individual corrugation is moulded under the influence of a slight vacuum (of about 30%) and when the corrugation has been moulded the vacuum is enhanced (to about 80%) to act on the zone of the corrugation trough.

To carry out this method the invention provides an apparatus which comprises in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of the corrugations in said rigid cover of said suction box, a suction pipe connected to all suction chambers, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air, for example a layer of fabric consisting of threads of synthetic plastic material of high tensile strength, laid over said rigid cover of said suction box, and loading weights yieldingly tightening said thin flexible layer.

The shut-off means can be preferably automatically actuated by an electric control device. By exchanging the loading weights it is possible to adapt the force tensioning the fabric to the weight of the fibrous cement sheets to be corrugated.

When the corrugating procedure has been finished, the loading weights must be arrested in the reached maximum position lest they might drop when the corrugated sheet of fibrous cement is lifted off the cover of the suction mould box by means of a suction die of known type, and thus deform or damage the freshly corrugated sheet through an uncontrollable tensioning of the fabric layer.

The invention further proposes to fix the longitudinal lateral edges of the flexible layer on rolls and to provide, for the counterrotation of the rolls against the torques acting upon them by weight load, a positive drive in the form of a geared braking motor which is controlled by an electric contact mechanism effecting the chronological setting to work of the individual suction chambers, in such a manner that the loading weights are lifted at a relatively slow hoisting speed in accordance with the widths of the flexible layer zones necessary for covering respective portions of the suction box cover acted upon by vacuum, and are lowered again to their initial positions by the automatically reversed braking motor when the completely corrugated sheet of fibrous cement has been removed.

At the same time the flexible layer with the fresh sheet of fibrous cement lying thereon slidingly follows slowly and in close synchronism with the actuation of the individual suction chambers, the corrugating of the individual portions of the fibrous cement sheet being effected at a constant speed of corrugation and at so slow a rate that there is sufficient time left for the sheet to be deformed or corrugated according to its thickness. When the corrugating procedure has been finished and the completely corrugated fibrous cement sheet removed from the cover of the suction box, the geared braking motor is automatically switched to reverse. At the same time the loading weights which keep the flexible layer stretched over the suction box cover are slowly lowered to their initial positions without excessively high tensional forces acting upon the flexible layer.

Two preferred embodiments of the apparatus for carrying out the method according to the invention will now be described by way of example and with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a suction mould box and a suction pipe according to the invention with a corrugated sheet of fibrous cement lying on the box cover;

FIG. 2 is a fragmentary section, on a larger scale, through the suction box of FIG. 1;

FIG. 3 is a sectional view similar to FIG. 1, showing another form of the invention;

FIG. 4 is a front elevational view of an apparatus for corrugating sheets of fibrous cement according to the suction method, showing a drive assembly for the periodic stepwise lifting and lowering of the loading weights serving to tension the flexible layer;

FIG. 5 is a top plan view of FIG. 4 disclosing part of the form of the invention shown in the suction box;

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FIG. 6 is a wiring diagram of a contact mechanism controlling the setting to work of the individual suction chambers and the operation of the geared braking motor for regulating the tensioning and the gradual yielding of the flexible layer, and

FIG. 7 discloses a sequence of schematic views showing the individual operative stages corresponding to the individual switching positions of the contact mechanism.

Referring to FIG. 1, the numeral 1 designates a prismatic sheet-metal box of elongated or rectangular form and of a length and width slightly larger than the length and width of the sheets of fibrous cement 6 which are to be corrugated. As shown in FIG. 2, the prismatic sheet-metal box 1 has at its top a corrugated cover 2 which is provided with a plurality of holes 3 distributed over the entire surface of the cover 2. The interior of the sheet-metal box 1 is divided, by means of vertical partitions 4 extending parallel to the longitudinal walls of the sheet-metal box 1, into a plurality of individual chambers 5 the number of which is by one greater than the number of corrugations to be formed in the sheets.

As can be seen from FIG. 1, the apparatus according to the invention is designed for the production of corrugated sheets terminating, as usual, in an ascending corrugation side 6*a* at one longitudinal edge and in a descending corrugation side 6*b* at the other longitudinal edge and having, for exampule, five corrugations. In the embodiment shown in FIG. 2, the partitions 4 are arranged below the vertex lines of the individual corrugation crests of the corrugated cover 2 of the sheet-metal box 1 and hermetically seal the individual chambers 5 against each other. Each individual chamber 5 is connected, as shown in FIG. 1, by a connecting piece 7 to a T-shaped suction pipe 8 having a branch pipe 8^1 which is connected to a vacuum generator (not shown), for example a suction fan of known construction. In each connecting piece 7 there is incorporated a shutoff means 9 which can be opened and closed manually by means of an operating lever 9^1, or automatically by means of any suitable control device.

A flexible layer 10 penetrable by air, for example a layer of fabric consisting of threads of synthetic plastic material of high tensile strength, is laid over the corrugated cover 2 of the sheet-metal box 1. The longitudinal edge sections of this flexible layer 10 hanging down over brackets 13 at the two longitudinal walls of the box 1 are provided with hollow seams 11 in which metal bars 12 are inserted which act as loading weights. The weight of the metal bars 12 is so adapted to the weight of the sheet of fibrous cement to be corrugated that the flexible layer, when in stretched condition, is capable of carrying the plane sheet of fibrous cement laid thereon.

The mode of operation of the corrugating apparatus according to the invention, the essential parts of which have been described above, is as follows:

After the sheet of fibrous cement 6, fed in a soft and mouldable state as a flat sheet by a format roll (not shown) and previously cut to conform to the true size, has been applied on to the layer 10 penetrable by air, the lever 9^1 at the connecting piece 7 leading to the central chamber 5 of the sheet-metal box 1 is operated to create a vacuum of about 30% in this chamber. This causes the central longitudinal zone stripe of the sheet of fibrous cement 6 together with the layer 10 to be drawn into the section of the corrugated cover 2 which is located above the chamber acted upon by the vacuum. Thus the first corrugation is formed in the sheet of fibrous cement 6. Subsequently, simultaneously opening the shutoff means 9 of the chambers 5 adjacent the central chamber 5 establishes the connection of these chambers to the suction pipe 8 so that two further corrugations are formed in the sheet of fibrous cement 6 on either side of the first corrugation. This is followed by the production of the two outer corrugations in the same manner. Finally connected is the chamber 5 which is disposed behind the longitudinal wall of the box 1 lying in front in FIG. 1, to cause the longitudinal edge portion of the sheet forming the descending corrugation side 6*b* of the corrugated sheet to join closely the surface of the corrugated cover 2 of the sheet-metal box 1.

By the periodically successive setting to work of the individual chambers 5, the sheet of fibrous cement resting on the layer of fabric 10 is drawn in a stepwise manner from either side toward the middle of the sheet. The frictional resistance occurring herein is small due to the interposition of the smooth flexible layer and can further be reduced by the installation of rolls in the sheet-metal box, as described further below.

As soon as all chambers 5 are set to work one after the other in the manner hereinbefore described and the production of the corrugations is completed, all shutoff means 9 are closed at the same time. In order to prevent the flexible layer 10 from causing a re-deformation of the corrugated sheet at that instant, the metal bars 12 must be arrested at the height they have reached in the end stage of the operation. This necessitates a mechanically or electrically operated locking device which may preferably be so constructed that it holds the metal bars 12 for some time and permits them slowly to return into their initial positions while the finished corrugated sheet is lifted from the cover 2 by means of a suction die and deposited on a stacking truck. It must be avoided by all means that the loading weights drop because this would lead to damage to the freshly moulded sheet and to premature unserviceability of the flexible layer 10.

In the foregoing the method according to the invention has been described in its simplest form of performance which enables to achieve thoroughly satisfactory results. As shown in FIG. 2, the partitions 4 separating the individual chambers 5 from each other are supposed to extend up to the underside of the corrugation crests of the corrugated cover 2 of the box 1. The zones of the cover 2 extending along the vertex lines of the corrugation crests are kept free from holes 3. This has the purpose of preventing the critical vertex region of the corrugation crests of the corrugated sheet of fibrous cement from being acted upon by the vacuum to avoid any structural change of the surface of the vertex of the corrugations because this might lead to cracks.

On the other hand, the vertex region of the corrugation crest between a corrugation of the sheet of fibrous cement already formed and another one sequentially to be formed is protected against lateral displacement and tensile stress in that it is held at the holes 3 of the chamber 5 set to work previously and, on setting to work the adjacent chamber 5, that zone of the sheet of fibrous cement is the first to join closely, together with the layer 10 penetrable by air, the holes 3 now being in operation which belongs to the corrugation crest which has already been semi-finished in the preceding working stage. In this manner distortion of the fibrous cement material in the vertex region of the corrugation is reliably excluded so that the vertex region is firmly held in position on the corrugated cover 2.

FIG. 3 shows another form of construction of the cover of the sheet-metal box 1 which is particularly suitable for use in securing in position the zone strips of the sheet of fibrous cement lying on either side of the vertices of the corrugation crests. In the sheet-metal box there are incorporated rolls 16 which constitute the corrugation vertices of the corrugated cover of the box. The cover is completed by sheet-metal strips 2^1, bent in V-shape and provided with the holes 3, which extend close up to the roll shells, narrow slots 17 being left between the strips and the roll shells. These narrow slots 17 extend over the total length of the sheet-metal box and effect a very reliable adherence of the sheet of fibrous ce-

ment on either side of the vertex zone when a vacuum is generated in the chambers **5** lying thereunder.

The rolls **16** may be hollow or, as shown in FIG. 3, solid and rotatably supported by the transverse walls of the sheet-metal box. In the latter case they perform a rotary motion at the time the lateral longitudinal portions of the sheet of fibrous cement are moving inwards on the flexible layer **10**, so that this stepwise moving action takes place almost without the occurrence of any frictional resistance.

When using sheets of fibrous cement of a particularly large width and/or of a particularly high number of corrugations, the rolls **16** can be driven synchronously.

The partitions **4** terminating below the rotary rolls **16** at a small distance are sealed against the rolls **16** by rubber strips **18** which rest against the roll shells from either side and one or the other of which at a time is caused sealingly to engage its associated roll shell due to the suction effect of the adjacent chamber **5**.

FIG. 3 shows also a further possibility of construction of the sheet-metal box which consists in that a tubular channel **20** is provided below the corrugation trough region of each corrugation of the cover by fitting a hollow section **19** open at the top. As soon as the formation of the corrugations in the sheet of fibrous cement is accomplished by the action of a vacuum of about 30%, the channel **20** is connected to a strong vacuum of about 80%. This enables additionally to condense the fibrous cement material of the corrugation trough.

Referring to the form of construction shown in FIGS. 4 and 5, the longitudinal edges of the flexible layer **10** are secured to the cylindrical outer shells of two tensioning rolls **22** and **22¹** rotatably supported by the two end walls **1¹** of the box **1** at the height of the rolls **16** forming the corrugation crests of the cover of the box. At the end face of the box remote from the suction air supply, shafts **23** and **23¹** carrying the tensioning rolls project through the end wall **1¹** of the box.

Fixed to the free end of each of the two shafts **23** and **23¹** are sprocket wheels **24** and **24¹**, respectively, the appertaining pinions **25** and **25¹** of which are seated on a shaft **26** mounted at a central point of the end wall **1¹** of the box. On to the forward end of the shaft **26** there is keyed a larger sprocket wheel **27** which is connected through an endless chain **28** to a driving pinion **29** which is fixed on a shaft end **31** of an electric geared braking motor **30** arranged underneath the sheet-metal box.

The torque of the electric motor **30** is transmitted to the sprocket wheels **24** and **24¹** through the driving pinion **29**, the endless chain **28**, the larger sprocket wheel **27**, and chain strands **32** and **32¹**, the chain strand **32** being hinged to a point of the rear pinion **25** and the other chain strand **32¹** to a diametrically opposite point of the second pinion **25¹**. The transmission of the torque causes the rolls **22** and **22¹** to rotate oppositely directed inwards, or oppositely directed outwards. On the inward rotation, which is indicated by the arrow *x* in FIG. 4, the tension of the flexible layer is relaxed, loading weights **33** and **33¹** acting on the tensioning rolls **22** and **22¹** being lifted at the same time, whereas on the outward rotation, indicated by the arrow *y* in FIG. 4, the loading weights **33** and **33¹** are lowered, thus tightening the flexible layer **10**.

The loading weights **33** and **33¹** are fixed to the depending end sections of the chain strands **32** and **32¹**, which end sections are guided over the appertaining sprocket wheels **24** and **24¹**. The size of the loading weights **33** and **33¹** has to be adapted to the weight of the sheet of fibrous cement to be corrugated in such a manner that the flexible layer remains tightened when it is loaded with the weight of the sheet to be corrugated, and that also the suction power of the vacuum acting through the holes in cover strips **2***a* and **2¹** of the individual chambers is not sufficient by itself to draw in the flexible layer **10** together with the sheet laid thereon towards the cover **2** of the box, but that it is rather necessary to combine therewith the driving power of the electric motor **30** to lift the loading weights **33** and **33¹** and thus to allow the flexible layer together with a fresh sheet of fibrous cement lying thereon to follow.

The loading weights **33** and **33¹** are constructed as pistons moving in vertically upstanding cylinders **34** and **34¹** and having piston rods **36** and **36¹** which are guided in stuffing-boxes **37** and **37¹** on the cover of the cylinders. The free ends of the piston rods **36** and **36¹** are engaged by the chain strands **32** and **32¹**. The hollow cylinders **34** and **34¹** are closed by a cover and a bottom which are each equipped with regulating valves **38** and **38¹**, respectively. These regulating valves present possibility of regulating additionally the lifting and lowering speed of the weights by the change of the cross-section of the air inlet and the air exhaust, respectively, to obtain in each case the true speed of the corrugating procedure. The loading weights **33** and **33¹** constructed as pistons also provide a damping and buffer action. The cylinders **34** and **34¹** are fixed to the end wall **1¹** of the sheet-metal box **1** by means of struts **35** and **35¹**.

The electric geared braking motor **30** is so controlled by an electric contact mechanism effecting also the successive opening and the closing of the valves arranged in front of the individual chambers that it rotates first through a predetermined turning range in forward direction and then runs back again through the entire turning range.

In the following the contact mechanism and its mode of operation will be described by reference to the wiring diagram shown in FIG. 6. The operations taking place in the individual switching positions of the contact mechanism are shown in FIG. 7.

The contact mechanism connected to an electric mains supply possesses a shaft **40** having a plurality of cams **39***a*, **39***b*, **39***c*, **39***d*, **39***e*, and **39***f* which are driven by a small synchronous motor (not shown) similarly supplied with current from the electric power supply. In the zero position of the contact mechanism and the electric geared braking motor **30** the loading weights **33** and **33¹** are lowered to the lowermost position and act to tighten, through the tensioning rolls **22** and **22¹** turned outwards, the flexible layer **10** over the cover **2** of the sheet-metal box **1**. During the first operation **0** shown in FIG. 7 the plane fresh sheet of fibrous cement **6** is applied on to the flexible layer **10**, whereupon the contact mechanism is switched on. The electric circuit leading over the contactor **41***a* is closed by the cam **39***a* of the contact mechanism, whereby the forward speed of the geared braking motor **30** is switched on.

During the second switch step I the cam **39***b* of the contact mechanism closes the electric circuit leading over electric vales **42** which release the suction air supply to the chambers located on either side of the central corrugation crest of the cover **2**. This causes the suction chambers located on either side of the vertex of the central corrugation of the cover of the box to be acted upon by vacuum, so that the flexible layer **10** and the sheet of fibrous cement lying thereon are sucked into the corrugation troughs of the cover of the box which are acted upon by vacuum, at a low speed depending on the turning speed of the tensioning rolls **22** and **22¹** which is determined by the electric motor **30** running ahead, the flexible layer **10** being drawn inwards from either side and the loading weights **33** and **33¹** lifted. At the same time the flexible layer together with the sheet of fibrous cement lying thereon is fixed in the region of the central corrugation crest of the cover of the box (see working phase I in FIG. 7) since, as already mentioned, under this corrugation crest there is disposed an additional vacuum chamber adapted to be acted upon by vacuum for itself, or connected to the adjacent two suction chambers.

On further rotation of the shaft **40** of the contact mechanism, in the third switch position II, those electric valves **42***a* and, in the fourth switch position III, those electric

valves 42*b* are opened which lead to the suction chambers of the box following successively in outward direction the central suction chambers acted upon first.

The corrugating procedures taking place herein will be apparent from the individual working phases II and III shown in FIG. 7. The forward speed of the electric geared braking motor 30 is so adapted to the successive setting to work of the individual suction chambers that the tensioning rolls 22 and 22[1] always liberate the flexible layer 10 to such an extent as is required for permitting the individual surface areas of the flexible layer 10 and of the sheet of fibrous cement 6 lying thereon to slide at a uniform corrugating speed into those corrugation crests of the cover 2 of the box which are acted upon by the vacuum.

When the shaft 40 of the contact mechanism has reached the position of rotation designated by IV in FIG. 7, the multistage corrugating procedure is completed and the cam 39*a* of the contact mechanism breaks the electric circuits leading via all electric valves 42 42*a* and 42*b*. Owing to this the electric valves leading to the individual suction chambers are closed. At the same time the electric geared braking motor 30 is instantly stopped. The finished corrugated sheet can now be removed from the flexible layer 10 the tension of which is relaxed.

After the removal of the corrugated sheet the shaft 40 of the contact mechanism continues to run a small distance and closes in the switch position V through the cam 39*f* a circuit leading via a contactor 41*b* whereby the reverse motion of the electric geared braking motor 30 is switched on. The flexible layer 10 over the cover 2 of the box is again tightened by the tensioning rolls 22 and 22[1] now turned outwards (in the direction of rotation indicated by the arrow *y* in FIG. 4). When the shaft 31 of the electric motor 30 has turned back to its initial position the flexible layer 10 lies tightened over the cover 2 of the box and is prepared for receiving the next sheet of fibrous cement to be corrugated. The electric motor 30 is automatically switched off after the reverse motion of the shaft 31 is finished. Only when the next sheet of fibrous cement is applied on to the tightened flexible layer 10 the contact mechanism is again switched on by a switch to be operated by hand or released automatically. Then the switching and working operations described above are repeated.

It is possible to use also a pneumatic or hydraulic device for controlling the corrugating procedure instead of the electric contact mechanism shown and described by way of example.

When corrugating sheets of fibrous cement with extremely small corrugations it is advisable mechanically so to drive the rolls 16 disposed at the corrugation crests of the cover 2 of the box that the peripheral speed of the rolls is equal to the speed of inward movement of the flexible layer 10.

The corrugating method according to the invention permits two or more sheets of fibrous cement laid above each other to be corrugated simultaneously in one working operation thin flexible interlayers being interposed and it being necessary and advantageous under certain circumstances to work with the aid of a strong vacuum. Thus the efficiency of the plant can be considerably increased.

The invention based on the method of deforming material in pliable condition to bodies of predetermined shape by suction effect is particularly adapted for use in the production of corrugated sheets of fibrous cement having nonuniform or irregular corrugations for example so-called corrugated decorative display plates as well as in the manufacture of other products for example gutters, corrugated templates, dishes, flower boxes, or the like from fibrous cement or synthetic plastic material, in addition to the production of corrugated sheets of fibrous cement having uniform corrugations.

It is understood that the process may be used for corrugating or moulding objects from other material than fibrous cement mass, for example thermoplastic synthetic plastic material, as long as the synthetic plastic material is in a deformable condition.

While the method herein described, and the apparatus used for carrying out this method into effect constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

I claim:

1. A method of corrugating prefabricated fresh sheets of fibrous cement on a moulding structure, comprising the steps of placing a flexible layer of material penetrable by air over a corrugated apertured cover of a rigid suction box, exposing said flexible layer during the entire corrugating procedure to the influence of strong tensional forces acting in the transverse direction, placing a prefabricated flat fresh sheet of fibrous cement on said flexible layer, and exposing said sheet of fibrous cement on said flexible layer to the action of a vacuum initiated in the middle of the sheet of fibrous cement and enlarged progressively towards the longitudinal edge portions thereof to draw said sheet of fibrous cement on said flexible layer towards said cover and form corrugations therein, each individual corrugation being initially formed under a light vacuum of about 30%, after which initial forming the corrugation trough zone is acted upon by an increased vacuum of about 80%.

2. Apparatus for corrugating prefabricated fresh sheets of fibrous cement comprising in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of the corrugations in said rigid cover of said suction box, a suction pipe connected to each suction chamber, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air laid over said rigid cover of said suction box, and loading weights yieldingly tightening said thin flexible layer in a direction transverse to the corrugations, separate channels being formed below the zones at the corrugation crests of the cover of the suction box and means for providing an increased vacuum in said separate channels after the generation of a light vacuum in the suction chambers surrounding them.

3. Apparatus for corrugating prefabricated fresh sheets of fibrous cement comprising in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of corrugations in said rigid cover of said suction box, a suction pipe connected to each suction chamber, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air laid over said rigid cover of said suction box, and loading weights yieldingly tighhtening said thin flexible layer in a direction transverse to the corrugations, the vertex regions of the corrugation crests of the cover of the suction box being closed and free from suction holes.

4. Apparatus for corrugating prefabricated fresh sheets of fibrous cement comprising in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of the corrugations in said rigid cover of said suction box, a suction pipe connected to each suction chamber, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air laid

over said rigid cover of said suction box, and loading weights yieldingly tightening said thin flexible layer in a direction transverse to the corrugations, the vertex regions of the corrugation crests of the cover of the suction box being constituted by rolls and sheet-metal sections provided for completing the cover of the suction box, said sheet-metal sections extending towards the shells of said rolls and leaving narrow slots between them and said shells, which slots extend over the total length of the cover of the box.

5. Apparatus as claimed in claim 4, wherein said rolls are rotatably mounted and rubber strips are disposed at partitions terminating below said rotatable rolls and bear against the shell of said rolls to serve as a means for sealing the individual neighbouring suction chambers against each other.

6. Apparatus for corrugating prefabricated fresh sheets of fibrous cement comprising in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of the corrugations in said rigid cover of said suction box, a suction pipe connected to each suction chamber, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air laid over said rigid cover of said suction box, and loading weights yieldingly tightening said thin flexible layer in a direction transverse to the corrugations, said loading weights for tightening said thin flexible layer being variable and consisting of metal bars mounted preferably exchangeably at either longitudinal edge of said layer.

7. Apparatus as claimed in claim 6, wherein means is provided for locking the loading weights in their elevated positions assumed by them after the total sheet of fibrous cement has been corrugated.

8. Apparatus for corrugating prefabricated fresh sheets of fibrous cement comprising in combination a suction box possessing a rigid cover having a corrugated upper surface and a plurality of suction holes, a plurality of longitudinally extending individual suction chambers provided in said suction box and corresponding to the number of the corrugations in said rigid cover of said suction box, a suction pipe connected to each suction chamber, shutoff means fitted to said suction chambers for chronologically setting said suction chambers to work in stages, a thin flexible layer penetrable by air laid over said rigid cover of said suction box, and loading weights yieldingly tightening said thin flexible layer in a direction transverse to the corrugations, the longitudinal edges of said flexible layer being fixed to rotary tensioning rolls and an electric geared braking motor being arranged to provide a positive drive for the counter-rotation of said tensioning rolls in a direction opposite to that of the torque acting upon them and generated by the loading weights, said electric geared braking motor being controllable by automatically operated means effecting the chronological setting to work of the individual suction chambers, in such a manner that the loading weights are lifted at a low lifting speed in proportion to the zone widths of the flexible layer required to cover the sections of the cover of the suction chamber acted upon by the vacuum respectively and again lowered to the initial positions by the geared braking motor automatically

changed over to turn in the reverse direction after the removal of the finished corrugated sheet of fibrous cement.

9. Apparatus as claimed in claim 8, wherein chain strands are hinged at diametrically opposite places to pinions of said tensioning rolls seated on a common shaft driven by said electric geared braking motor through a driving pinion, an endless chain, and a large sprocket wheel, said chain strands causing the tensioning rolls being under the influence of the loading weights positively to rotate in opposite direction inwards to relax the tension of the flexible layer, and positively outwards to tighten the flexible layer.

10. Apparatus as claimed in claim 9, wherein the loading weights are suspended from the end sections of said chain strands extending beyond chain wheels of said tensioning rolls.

11. Apparatus as claimed in claim 10, wherein the loading weights consist of pistons arranged to move in cylinders and having piston rods engaged by the chain strands, and wherein said cylinders closed at the top and the bottom are equipped with regulating valves for adjusting the lifting and lowering speed of the loading weights by the change of the cross-section of the air inlet and the air exhaust.

12. A method of corrugating prefabricated fresh sheets of fibrous cement on a moulding structure, comprising the steps of placing a flexible layer of material penetrable by air over a corrugated apertured cover of a rigid suction box, exposing said flexible layer during the entire corrugating procedure to the influence of strong tensional forces acting in the transverse direction, placing a prefabricated flat fresh sheet of fibrous cement on said flexible layer, and exposing said sheet of fibrous cement on said flexible layer to the action of a vacuum initiated in the middle of the sheet of fibrous cement and enlarged progressively towards the longitudinal edge portions thereof to draw said sheet of fibrous cement on said flexible layer towards said cover and form corrugations therein, the tension on said flexible layer being released at the end of the corrugating of the fibrous cement sheet until the fibrous cement sheet has set.

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