United States Patent [19]

Holden

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[11] **3,928,105**

[45] **Dec. 23, 1975**

[54] **AUTOMATED APPARATUS AND PROCESS FOR MAKING MATCH MOLDED COVERING**

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[73] Assignee: **Fiberglas Canada Limited,** Canada

[22] Filed: **May 4, 1973**

[21] Appl. No.: **357,385**

[52] **U.S. Cl.** **156/200;** 156/228; 156/257; 156/461; 156/462

[51] **Int. Cl.²** **B31F 1/00;** F16L 59/00

[58] **Field of Search**... 156/62.2, 166, 167, 180–183, 156/196, 199, 200, 205, 207, 228, 231, 232, 254, 257, 259, 268, 271, 459, 461, 462, 474, 483, 581, 197; 264/116, 119, 128, 280–287; 425/303, 343, 363, 369, 370; 223/28, 34, 35; 161/132, 121, 123, 133–137, DIG. 4

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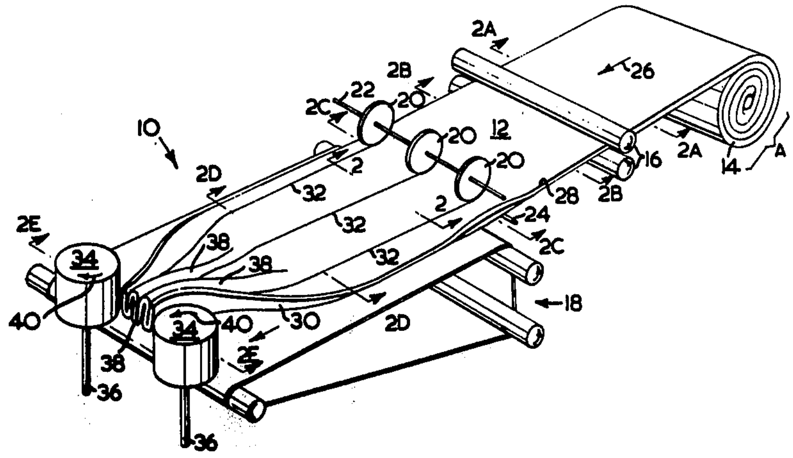
Primary Examiner—Douglas J. Drummond
Assistant Examiner—John E. Kittle
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

An automated apparatus and process are described for making a prefabricated match molded conduit covering of an insulating material. A pliable felted mass is carried along, with at least one and preferably a series of indentations formed therein by locally depressing at least one surface of the felted mass along lines parallel to the direction of feed. The felted mass or mat is deformed to create corrugations projecting out of the plane of the mass and extending longitudinally. Deforming occurs about the line of weakening and places the line interiorly of the corrugation. Successive portions of the deformed felted mat are entered into, compressed in a match mold, and then heated to harden the bonding material contained in the felted mass. The corrugated felted mass thus acquires rigidity and dimensional stability to a selected cross-sectional configuration, and a density from about 3.5 pounds to about 10 pounds per cubic foot. The dimensionally stabilized mat is released from the mold, preferably cooled and defumed, and cut to provide mating portions of match-molded conduit covering of a selected length. The felted mass or mat is deformed preferably by compression laterally and/or transversely of the felted mat. Typically, a plurality of corrugations are formed, each derived from a corresponding depression or indented line of weakening generated by rollers or scoring wheels engageable with the top and bottom surfaces of the felted mat.

19 Claims, 21 Drawing Figures



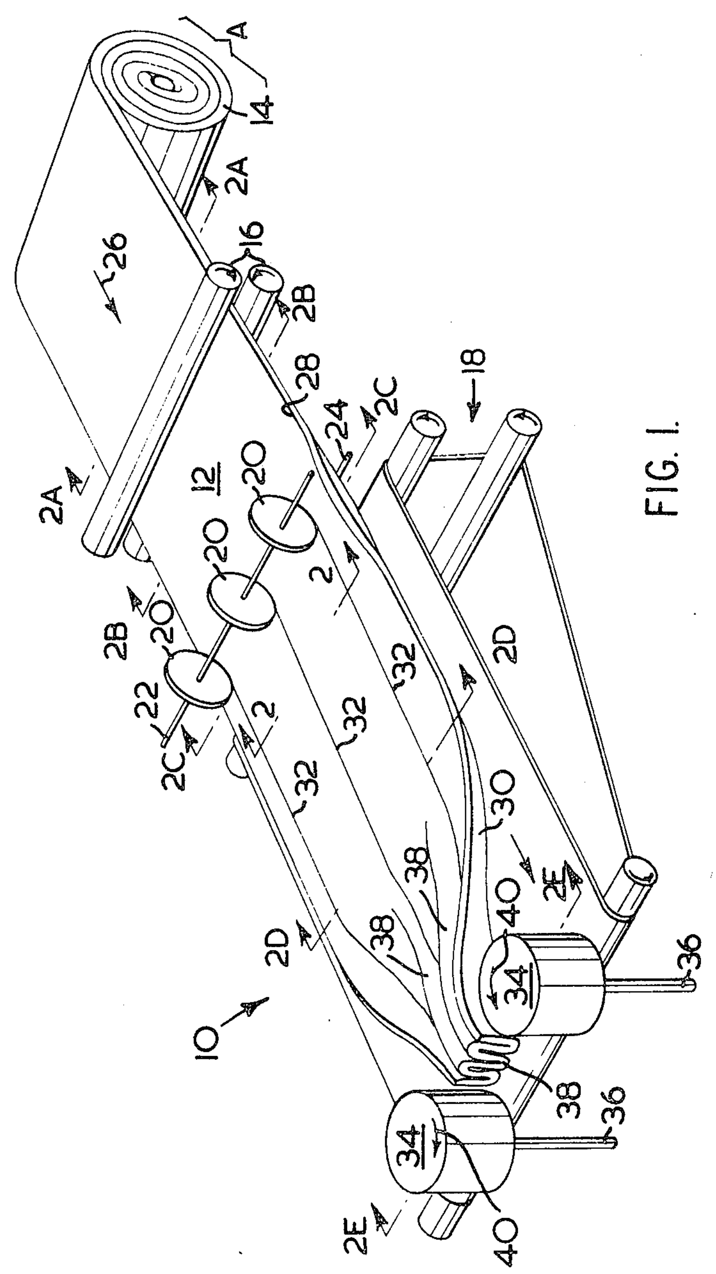

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FIG. 1.

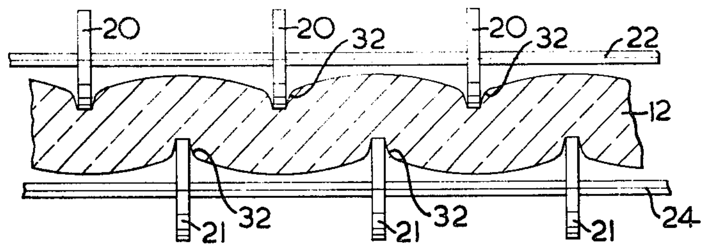
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FIG. 2.

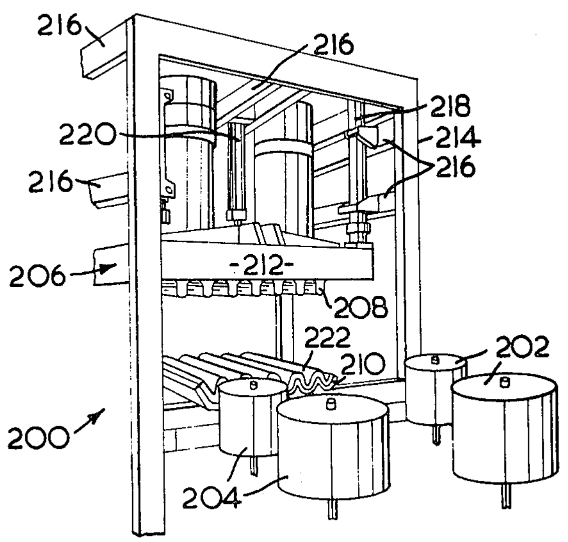
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FIG. 7.

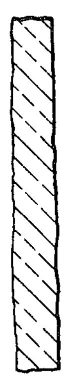
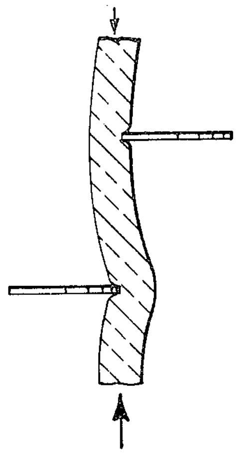


FIG. 2A.


FIG. 2B.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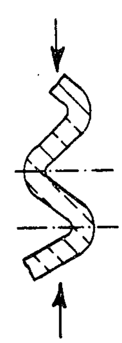
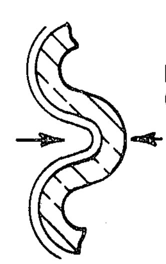


FIG. 2D.


FIG. 2E.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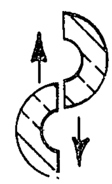
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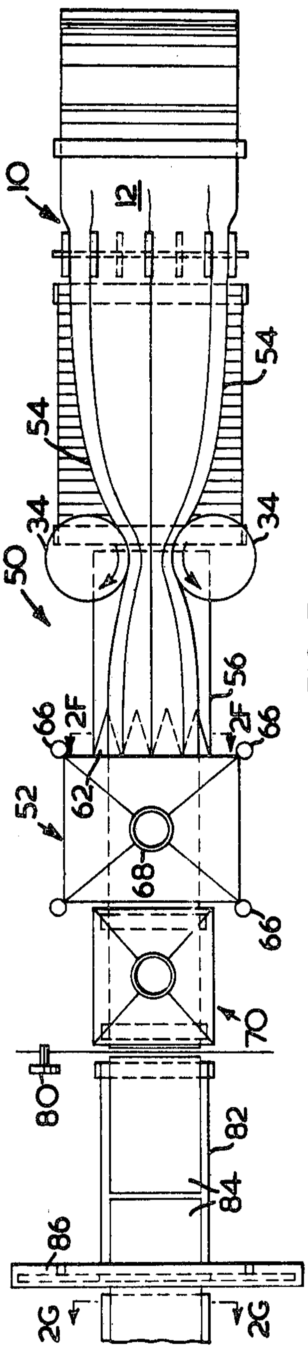
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FIG. 3

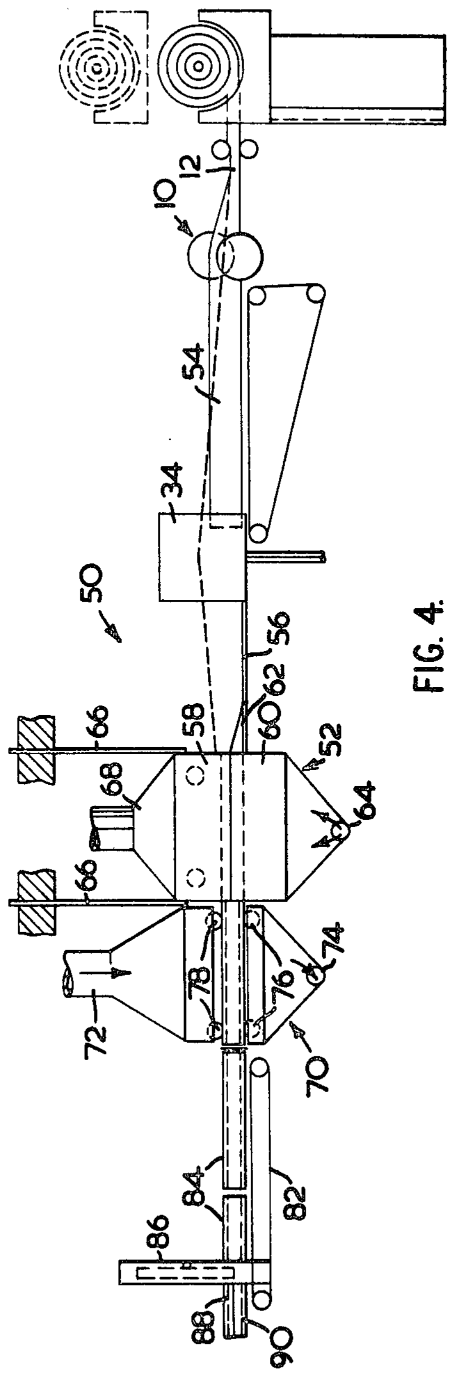
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FIG. 4

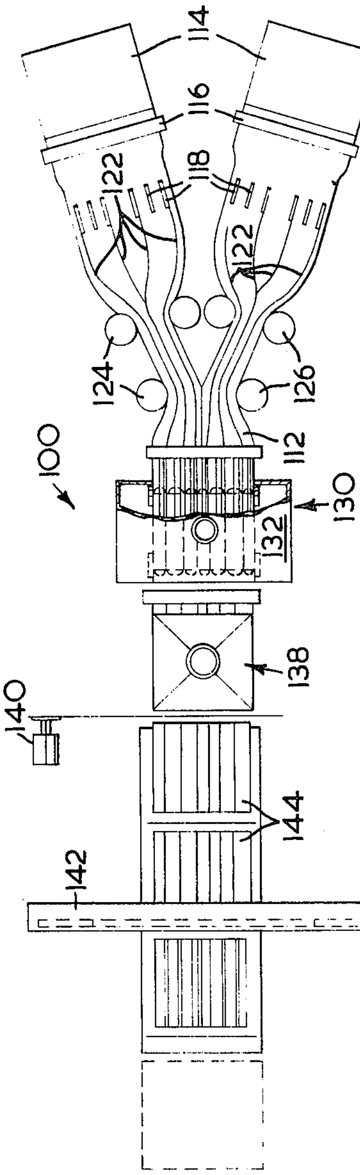
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FIG. 5.

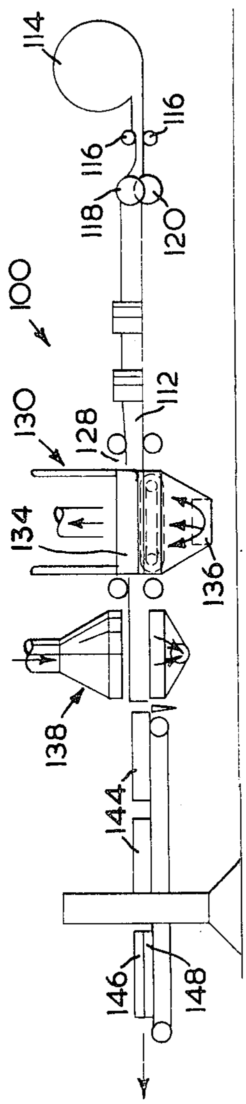
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FIG. 6.

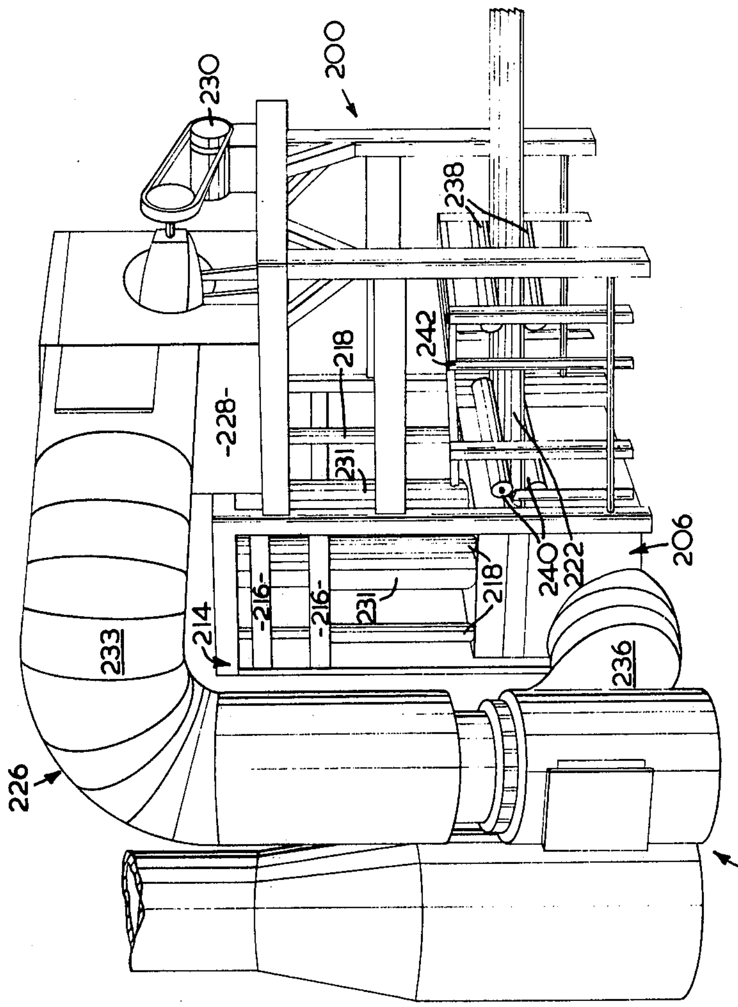

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FIG. 8.

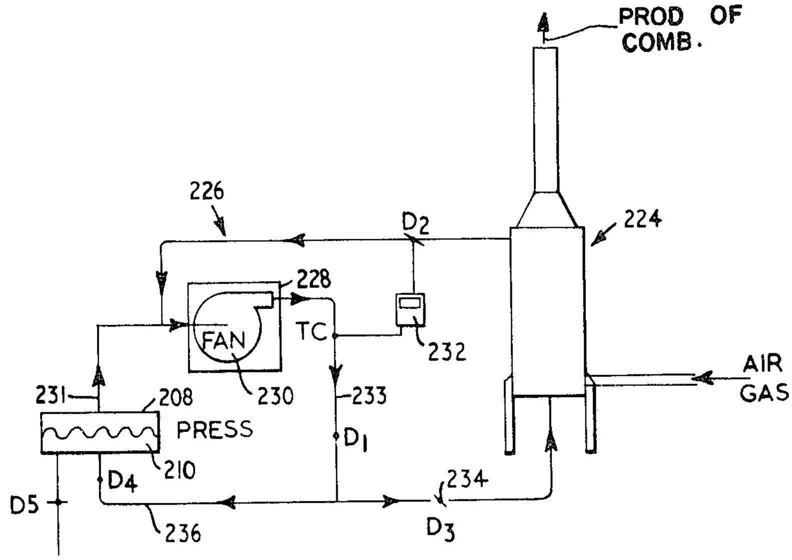
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FIG. 9.

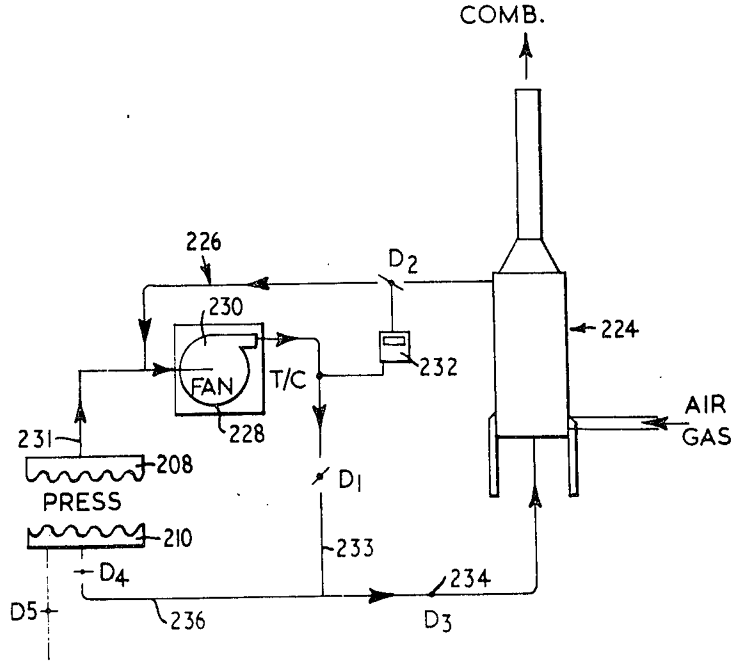
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FIG. 10.

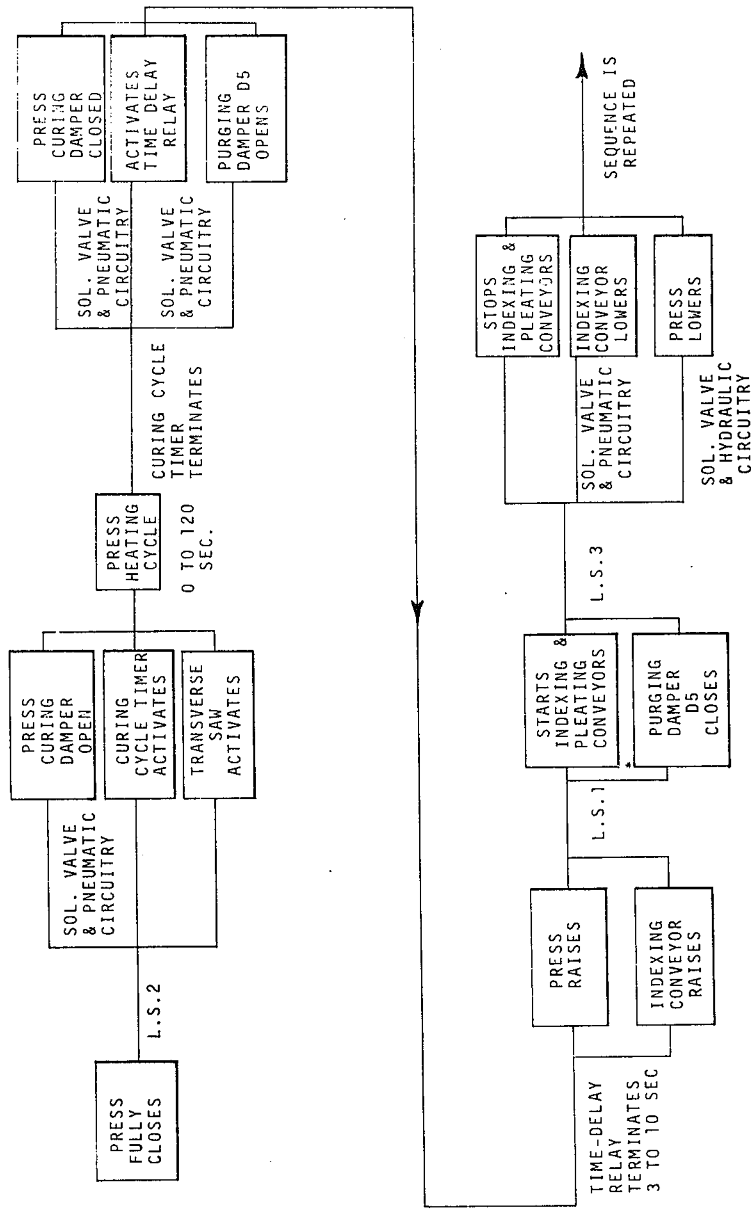
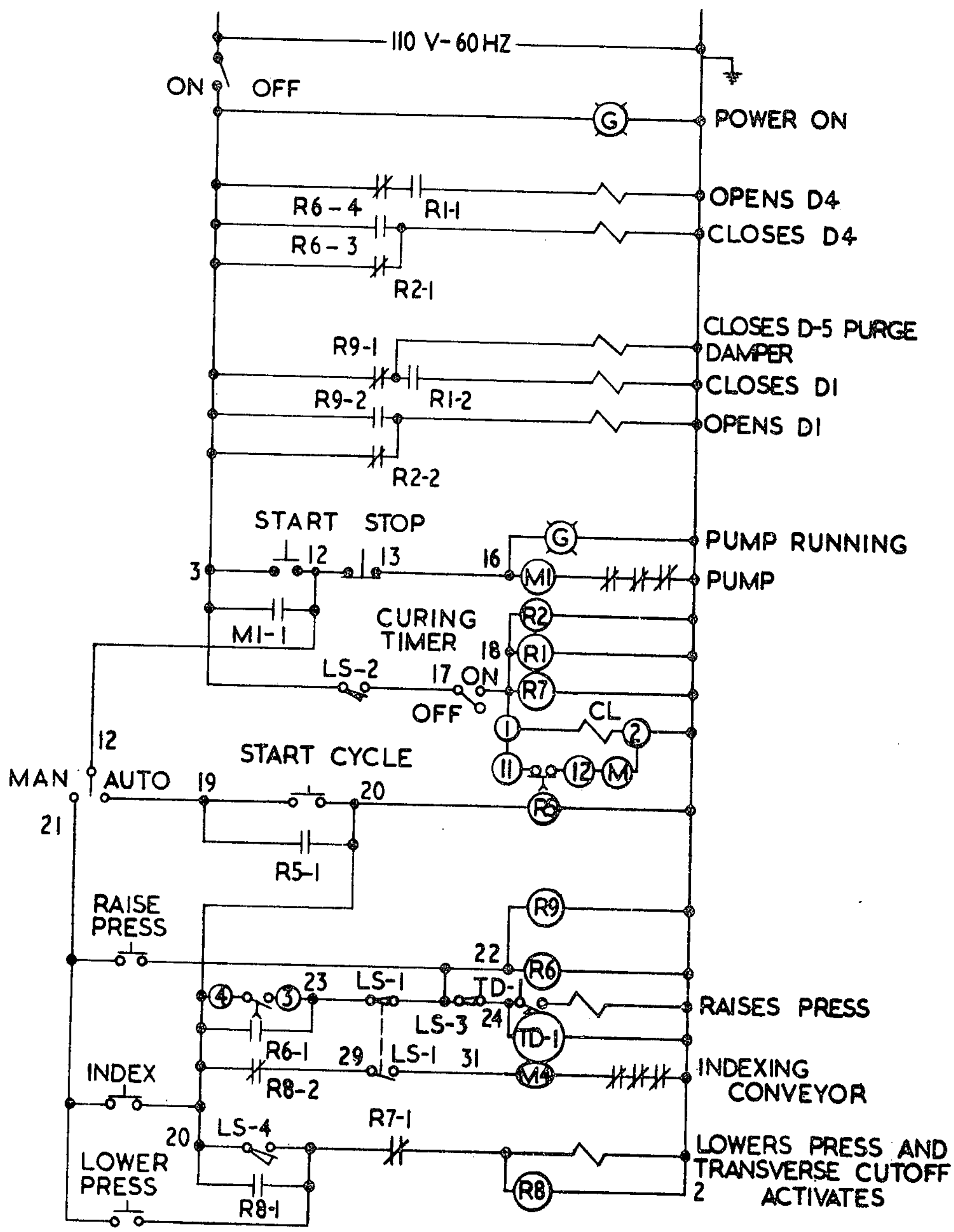

PRESS FULLY CLOSES
L.S.2
SOL. VALVE & PNEUMATIC CIRCUITRY
PRESS CURING DAMPER OPEN
CURING CYCLE TIMER ACTIVATES
TRANSVERSE SAW ACTIVATES
PRESS HEATING CYCLE
0 TO 120 SEC.
CURING CYCLE TIMER TERMINATES
SOL. VALVE & PNEUMATIC CIRCUITRY
SOL. VALVE & PNEUMATIC CIRCUITRY
PRESS CURING DAMPER CLOSED
ACTIVATES TIME DELAY RELAY
PURGING DAMPER D5 OPENS
TIME-DELAY RELAY TERMINATES 3 TO 10 SEC
PRESS RAISES
INDEXING CONVEYOR RAISES
L.S.1
STARTS INDEXING & PLEATING CONVEYORS
PURGING DAMPER D5 CLOSES
L.S.3
SOL. VALVE & PNEUMATIC CIRCUITRY
SOL. VALVE & HYDRAULIC CIRCUITRY
STOPS INDEXING & PLEATING CONVEYORS
INDEXING CONVEYOR LOWERS
PRESS LOWERS
SEQUENCE IS REPEATED

FIG. 11.



LS-1 ADJUSTABLE, ACTIVATED WHEN PRESS RAISED.
LS-2 ACTIVATED WHEN PRESS CLOSED.
LS-3 ACTIVATED WHEN PRESS FULLY OPENED.
LS-4 ACTIVATED WHEN RACK HAS TRAVELLED TO TRANSVERSE SAW WHICH ACTIVATES TRANSVERSE CUTOFF.

FIG. 12.

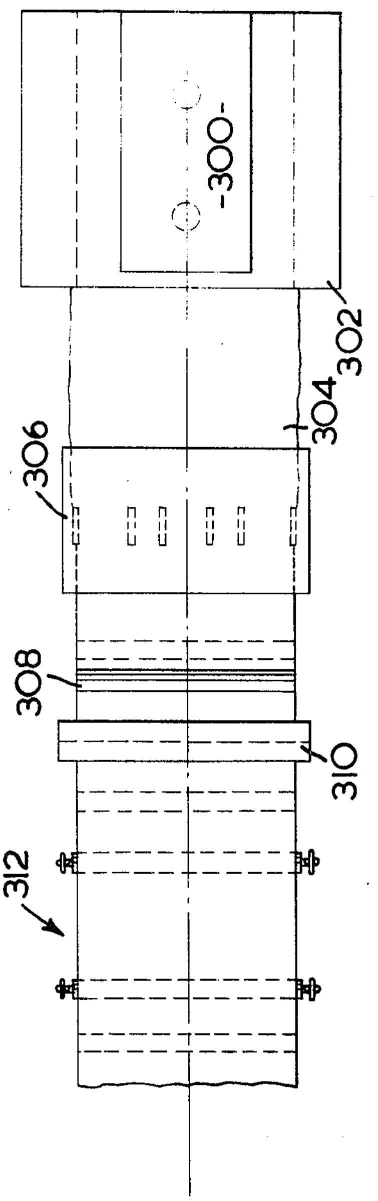


FIG. 13.

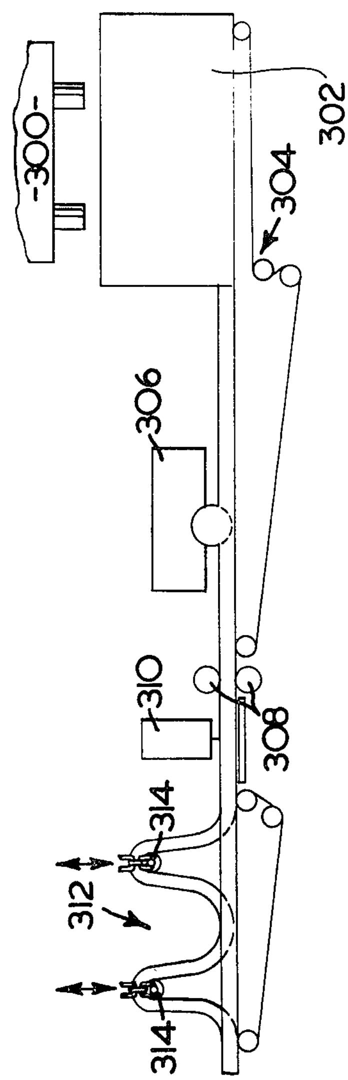


FIG. 14.

AUTOMATED APPARATUS AND PROCESS FOR MAKING MATCH MOLDED COVERING

This invention relates to a process and apparatus for making a prefabricated, match molded conduit covering of an insulating material. In particular, the invention pertains to an automated process for preshaping uncured insulating material and molding, a conduit covering, to a selected cross-sectional configuration and final density which preferably is in the range from about 3.5–10 pounds per cubic foot.

BACKGROUND OF THE INVENTION

Conduits for hot or cold fluid piping, electrical conduits, or those used in heating and ventilating systems have normally been made of one of a flexible, a semi-rigid, or a rigid insulating material. Flexible insulating materials have included, for instance, felt wraps and blankets, foamed rubber, or urethane foam. The semi-rigid coverings have been made of glass wool in a form which could be referred to as "snap-on". Rigid pipe or conduit covering has been made, for example, of organic foams such as polystyrene or urethane, of foam glass, molded mineral or glass wool, asbestos, calcium silicate, or expanded perlite.

The insulating conduit covering made from flexible and semi-rigid materials is usually supplied, and applied, as a single piece. The conduit coverings of rigid materials are sectional, often being semi-cylindrical or tri-segmented, in each instance being retained bu straps, stapling, jacketing material, and/or other surface finishes.

Conduit coverings have thus been used to provide thermal insulation of pipe lines of steel, copper, stainless steel, etc., and carrying a medium such as water, steam, petro-chemicals, or gases, at temperatures which have ranged from −120°F. to +1200°F. A conduit covering having a length of 36 in. plus or minus 1/16 in. has been the industry's standard. Dimensionally, conduit coverings are available in a variety of sizes, ranging from about ⅜ in. up to, say 21 in., and even larger as required. Cross-sectional shapes have preferably been circular or rectangular. Depending upon operating temp., the conduit covering is usually in the range from ½ in. to several inches thick. Thicknesses of greater than about 2-½ inches have been assembled usually from several layers of up to 2 inches thickness for each layer.

Rigid or semi-flexible insulating conduit covering has been commonly made from what in this art is designated as "basic wool". This is a felted mat or mass consisting of glass or mineral wool fibres of controlled average fibre diameter, random length and largely random orientation, combined with a thermosetting bonding material in the uncured state. The conduit covering is produced, for instance, by compressing precut, preshaped lengths of such a felted mat in a matched mold and heating it to cure the bonding material. The resulting product is resiliently rigid and retains the cross-sectional configuration and dimensions of the mold.

Felted mats or basic wool are made in a continuous fiberizing operation such as is known per se in this art. The basic wool is produced in indeterminate length, at a predetermined width, generally from 36 to 48 inches and up to 96 inches wide, and to a specified weight per unit area. Because of the inherent resiliency of the fibrous mass and the tack imparted to it by the uncured bonding material, no definite thickness can be assigned to the felted mass as long as it remains uncured.

The slowest fiberizing operation delivers felted mat, as a rule, at a faster rate than prior art pipe insulation forming processes can economically convert into a cured product. Thus, the common practice has been to produce and temporarily store the basic wool in roll form, or in pre-cut sizes as batts. Such pre-cut batts can be stored flat or can be pre-pleated as per U.S. Pat. No. 2,684,107 to R. W. Schultz, and then stored. Any of these are processed individually at some later time having possibly undergone physical and/or chemical deterioration. The efficiency of prior art processes has therefore been less than the maximum possible, as regards both material use and labor complement.

Prior art forming methods have utilized two basic approaches for making conduit coverings. In one, precut batts of basic wool plain or prepleated, are intermittently shaped and cured in a matched mold press. This yields molded half-sections of insulation which require trimming to accurate length, as well as along the longitudinal edges to insure an accurate fit on the conduit. Certain losses of material are thus incurred. Further yet, every step in this process requires a considerable amount of manual labor.

Another basic approach has utilized pre-cut lengths of basic wool wound onto a mandrel of the desired pipe size, usually in multiple layers. The wound wool is then cured, with or without, the use of an outer mold to shape the outside diameter. Winding of the basic wool onto the mandrel, can be done intermittently with subsequent layers being wound coaxially. Alternatively, the layers of basic wool could be wound continuously and spirally with successive layers overlapping. This approach requires trimming at the ends for length, as well as cutting length-wise, but does not incur the trim losses of the first approach. These two prior art fabricating methods have definite technical and economical limitations.

Firstly, the rates at which basic wool can be converted into conduit cover are so much slower than the rates at which the basic wool itself can be manufactured, that the two operations have to be carried out separately. This necessitates intermediate storage and additional handling of the uncured basic wool. Secondly, the intermittent fabricating methods entail repeated material handling in several stages. Thus a large input of manual labor is needed, with additional material losses arising due to physical damage incurred during handling. Further, some of the product of the prior art methods must be trimmed to size in at least one dimension, with corresponding trim losses.

In order to better appreciate the significance of the repeated references to losses due to interim storage and multiple handling of the basic wool, the peculiar consistency and characteristics of this material have to be kept in mind. This understanding is also necessary for better appreciation of the merits of the present invention.

Even when made by the best of the known glass fiberizing processes, basic wool is a felted mass of largely randomly oriented fibers which, in the process, are combined with from 5 to 25 weight percent of a heat curable bonding material. Such material most frequently contains heat curable phenol-formaldehyde, or similar, resins in the uncured stage. This is commonly referred to by those knowledgeable in that art, as "B-Stage"; that is, that of a heat hardenable viscous, tacky liquid, finely distributed over the fibres. This fibrous mat is deposited originally at an average density of one pound per cubic foot, or less. For convenience, it will be compressed to average densities of from 1.5 to 3 pounds per cubic foot, for better handling. Neither the fibres nor the bonding material are altogether uniformly distributed. As a consequence, density variations of as much as +15% to −15% from the average may be observed when an 8 sq. ft. piece of basic wool is cut into eight individual test pieces of 1 sq. ft. area each.

Accordingly, when the felted mass is subjected to tensile or compressive forces, it will stretch or compress locally and non-uniformly. The low density areas are naturally weaker and most vulnerable. These density differences may be attributable to fibre length and fibre orientation. They are further aggravated by variations in the distribution and in the tack or lubricity of the uncured bonding material. Tack and lubricity depend on quantity, on the degree of conversion of the originally aqueous bonding resins to the B-Stage, and are even affected by the atmospheric conditions prevailing during the storage and subsequent processing of the basic wool into the final conduit cover. Thus, temperature and humidity "conditioning" of the felted mass may be needed. Keeping all this in mind, it becomes readily understandable that there are limits to the size of an individual piece of basic wool which an operator can handle. The method of U.S. Pat. No. 2,684,107 is designed to increase that limit, but in practice adds process and handling limitations of its own due to the concertina effect of batts consisting of multiple, low amplitude corrugations. Going beyond those limits exposes the basic wool to deforming, stretching, tearing or other damage, e.g. by leaving deep finger indentations. Similarly, repeated handling of a piece of basic wool entails cumulative deterioration which will be reflected in the finished product.

For the same reasons, the nature, consistency and variability of basic wool renders it impossible to use such methods or apparatus as have been previously devised for folding sheets of paper, or for the shaping of sheet metal into corrugated configurations. These, in comparison to basic wool are thin, high-density and essentially isotropic materials of greater tensile and uniform flexural strength. Basic wool is deficient in these particular characteristics. Further limitations are imposed upon a designer of equipment for continuous fabrication of conduit covering by the surface tack and abrasiveness characteristic of the fibrous mat.

SUMMARY OF THE INVENTION

The present invention reduces or eliminates the severe limitations of prior art processes, and restrictions in match molding processes and equipment in particular.

The automated process and apparatus for molded conduit covering to be described herein, is capable of output rates matching those of modern glass fiberizing processes and equipment. Labor requirements are drastically reduced in comparison to prior art processes. Continuous lengths of insulating conduit cover can be molded and cut to any desired length independent of limitations imposed by the length, width and configuration of the molding tools as experienced in past practice.

The present invention has recognized that suitably dimensioned basic wool can be automatically and continuously corrugated (pleated) starting from uncured felted mat, with adequate accuracy longitudinally of the direction in which the mat is conveyed. The present invention has further recognized this finding to be the key to a fully automated process comprising steps to be described below. Such steps lend themselves to automation only after having first accomplished the inventive step of longitudinally pleating the basic wool.

Suitably spaced tools such as scoring wheels, rollers, or the like, can locally depress a surface of the felted mat to form indentations or lines of weakening in that mat. The application of a compressive force, preferably laterally of the felted mat, then causes the mat to deform. In deforming, the felted mat forms a corrugation projecting out of the plane of that mat with deformation occurring about that line, and nowhere else, to place said line interiorly of the corrugation. The corrugations extend longitudinally and parallel to the path along which the felted mat is being carried.

Applicant's technique of locally depressing the surface to make indentations or lines of weakening in the felted mat has been found to be effective in yielding folds or corrugations in the numbers and accuracy required to conform to mold configurations. Moreover, the technique has yielded corrugations of uniform height and wool weight (i.e. within specified tolerances) on felted mat of greater width, than has been possible before. An important practical advantage can thus be obtained. Further, the need to transfer batts of basic wool into matched mold presses by hand has also been eliminated. Higher production speeds can thus be achieved, for example, by using felted mat of greater width than has previously been possible. The present invention thus enables the process and apparatus in which it is embodied to be operable with full compatability with the rates of production of basic wool in felted mat form of indeterminate length, as produced in continuous fiberizing operations well known, per se.

Accordingly, one embodiment of this invention contemplates an automated process for producing a prefabricated, match molded conduit covering in which a pliable felted mass is conveyed along a path, the felted mass being of indeterminate length and disposed generally in a plane, the felted mass containing a heat sensitive bonding material in uncured condition; including steps of locally depressing one surface of the felted mass to form a line of weakening extending parallel to said path, deforming the felted mass out of said plane to create a longitudinally extending corrugation, such deforming occurring about the line of weakening, and not anywhere else, to place said line interiorly of the corrugation; and compressing successive portions of the corrugated felted mass while subjecting said mass to heat causing hardening of the bonding material, and impart rigidity and dimensional stability of the corrugated felted mass. The dimensionally stabilized corrugated felted mass has a final density preferably in the range from about 3.5 to 10 pounds per cubic foot. The dimensionally stabilized felted mass is preferably cooled and defumed, and cut longitudinally, to provide mating portions of the match molded conduit covering.

The felted mass or mat is deformed by applying a compressive force laterally thereof to cause deformation out of the plane in which the felted mass is being carried. Preferably, the compressive force is applied laterally and transversely of the felted mass.

In a preferred embodiment, the automated process described herein employs the step of deforming the felted mass by exerting forces continuously to that mass as it is conveyed along a path, said forces being applied to opposed surfaces of the felted mass along a plurality of lines extending parallel to said path, said forces being applied in planes perpendicular to the plane of the felted mass, the forces applied in adjacent planes being exerted in opposite directions, thereby preparing the felted mass for deformation by lateral and transverse forces into at least one longitudinally extending corruguation.

The present invention is also embodied in an automated apparatus which is operable for carrying out the process described herein. The present invention therefore contemplates an automated apparatus for producing a prefabricated match molded covering for a conduit of a selected cross-sectional configuration, in which a pliable felted mat of an indeterminate length of an insulating material is supplied with a density of about 1 to 2 pounds per cubic foot, the felted mat containing a thermo-sensitive bonding material in uncured condition; and wherein conveying means are provided, movable for carrying the felted mat along a path with the felted mat being disposed generally in a plane. Compressing means are mounted in operative relation to the conveying means to locally depress one surface of the felted mat along a line extending parallel to the path along which the mat is being moved. The localized pressure causes an indentation or line of weakening to be formed along said parallel lines. The automated apparatus herein also includes deforming means engageable with the felted mat to cause deformation of the mat into at least one corrugation projecting out of the plane in which it is being carried, deformation occurring about the line of weakening to place said line interiorly of the corrugation. A section of the corrugated felted mat is then exposed to pressure and heat in a corrugated mold. The mold has the selected cross-sectional configuration required of the conduit covering, and operates to compress the felted mat uniformly and to harden the bonding material. A number of different heat sensitive bonding materials can be used, although it is preferable herein to utilize a thermo-setting phenol-formaldehyde-amine-copolymer composition. Curing of the bonding material imparts rigidity and dimensional stability to the portion of corrugated mat which has been simultaneously shaped and compacted to a density preferably in the range from about 3.5 to about 10 pounds per cubic foot. The dimensionally stabilized (cured) corrugated felted mat is released from the mold, and advanced to cutting means positioned to cut the felted mat to provide elongated mating portions of match molded conduit covering. Cutting to the desired length can be done before or after longitudinal cutting takes place.

The compressing means which cause deformation of the felted mat can be in the form of a pair of oppositely disposed rollers or drums, the axes of which are perpendicular to the plane of the mat. The drums usually have a roughened exterior surface to exert a force laterally of the felted mass, and also to generate friction for propelling that felted mat forwardly. Auxiliary conveying means can also be provided for assisting in advancing the felted mat. Further yet, stationary guide surfaces can be provided in a configuration shaped to exert pressure forces on the felted mat laterally thereof, to aid in deforming the felted mat out of the plane thereof.

It will be evident from the following description that the present invention affords a number of improvements over prior art processes and apparatus used previously in the manufacture of conduit coverings. That description should now be read in connection with the accompanying drawings which illustrate by way of example only, a number of embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view showing schematically a pleater device embodied in the present invention;

FIGS. **2, 2A–2G** are elevation views taken in section across the felted mat, with FIGS. **2** to **2E** being taken along lines **2—2** to **2E—2E** of FIG. **1**; and FIGS. **2F** and **2G** being taken along lines **2F—2F** and **2G—2G** of FIG. **3**; FIG. **2** appears with FIG. **7**.

FIGS. **3** and **4** are a plan and a side view of another embodiment of this invention;

FIGS. **5** and **6** are plan and side elevation views, respectively, of yet another embodiment of this invention;

FIG. **7** is a fragmentary view showing in perspective an inlet portion of a curing press or mold used in a preferred embodiment of this invention;

FIG. **8** is a perspective view showing schematically a portion of a preferred embodiment of this invention, and is taken roughtly at 180° to the view seen in FIG. **7**;

FIGS. **9** and **10** and schematic views showing some features of the apparatus of FIGS. **7** and **8**;

FIG. **11** is a flow chart illustrating the operational sequence of the apparatus illustrated in FIGS. **1–10;**

FIG. **12** is a diagram setting out the electrical circuitry of the apparatus illustrated in FIGS. **1–10;** and

FIGS. **13** and **14** show schematically an installation using the longitudinal pleater of FIG. **1**, "in line" with the basic wool fiberizing and forming machinery, for replacing the portion of equipment bracketed at A in FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates one embodiment of a pleater or deforming apparatus encompassed by this invention. The apparatus is indicated over all by the numeral **10.** The pleater apparatus **10** draws insulating material in the form of a felted mass or mat **12,** from a storage roll **14,** or directly from fiberizing/forming machinery (FIGS. **13** and **14**). The storage roll **14** is rotatably supported in a take-off stand (not shown), to be replenished as the felted mat is used up. The mat **12** of insulating material on roll **14** is preferably glass fiber, however, other similar insulating materials such as mineral wool, asbestos, or the like are envisaged for use in this invention. The felted mat **12** is commonly made from the output of one of a variety of continuous fiberizing processes well known, per se. The output of such processes is frequently referred to as basic wool, as mentioned earlier. One or more storage rolls **14** of insulating material may be used as a source of the felted mat **12,** depending upon the width and thickness desired of the conduit covering being manufactured at a particular time.

The felted mat **12** is carried along a path, usually in a plane at least initially, and is passed between two rollers **16,** to compact and compress the felted mass as needed. This contributes to uniformity in the consistency and thickness of the felted mass or mat **12.** Assistance in advancing the felted mass **12** through the pleater apparatus **10** is provided, for instance, by an endless belt conveyor or forwarding means **18**, or the like at a substantially constant velocity. The conveyor means **18** is adapted to be driven by a suitable drive system which is not described here, since it is well known per se. Such conveyor means may not be needed, e.g. if the distance between scoring wheels **20** and traction drums **34** is short, for narrow width felts.

FIG. **1** shows the upper series of a plurality of upper and lower scoring wheels **20** and **21**, rollers, or the like. These rollers **20** and **21** are commonly provided in operative relation to the conveyor means **18** and for convenience, can be driven by the same drive system used to operate the conveyor means **18.** Scoring wheels **20** and **21** are best seen in FIG. **2.** These wheels **20** and **21** are mounted respectively on an upper cross-shaft **22** and a lower cross-shaft **24**, preferably to be rotatable with such shafts. The shafts **22** and **24** normally are driven in synchronism with the conveyor means **18** and are adjustably positionable to vary the vertical spacing between the wheels **20** and **21.** In this way, scoring wheels **20** and **21** are maintained in engagement with the felted mass **12**, despite a change in the thickness of that mass, say, from one storage roll **14** to another. Such positioning changes would depend upon any change in the thickness of the conduit covering being produced.

It will be seen from FIG. **1** that scoring wheels **20** and **21** engage the felted mass or mat **12** along lines **32.** These lines **32** are parallel to the direction of feed of the felted mat **12**, indicated by arrow **26.** Each set of scoring wheels **20** and **21** is operable to engage the felted mass **12** along a top surface **28** or a bottom surface **30**, thereof, and locally depress and displace the insulating material of which the mass is made. The individual scoring wheels **20** and **21** can be considered to be disposed in planes adjacent and parallel to one another. It is evident from FIG. **2** that the upper and lower scoring wheels **20** and **21** apply compressive forces to the top and bottom surfaces **28** and **30.** The forces in adjacent planes are directed in opposite directions when complementary sets of scoring wheels **20** and **21** are used.

Local depression of the insulating material by each scoring wheel **20** and **21** causes an indentation **32** or line of weakening to be formed in the surface compressed by that wheel. This is best seen in FIGS. **2A** to **2E.** Each line of weakening **32** also extends parallel to the direction **26** of feed of the felted mat **12.** Preferably, a series of both upper and lower scoring wheels **20** and **21** are provided, and these wheels are staggered apart as seen in FIG. **2.** The wheels **20** and **21** normally are spaced equally apart in each series, especially if conduit covering of a circular, oval or square cross-section is being made.

Scoring wheels **20** and **21** will usually be provided as an upper and lower series of cooperating wheels. As an alternative, it is visualized that either an upper series, or a lower series alone, might be acceptable. Further, yet, the spacing between each of the wheels **20**, or **21**, will usually be equal. This can be varied, however, should the need arise.

In order to deform the felted mass **12** which now has at least one and usually a plurality of lines **32** of weakening or indentations therein, means are provided to exert a compressive force laterally of the felted mass. In FIG. **1**, such means are illustrated as traction rollers or drums **34.** These traction drums **34** are carried on drive shafts **36**, and are positioned inwardly of the lateral side edges of the felted mass **12** prior to deformation. Thus, the spacing between drums **34** will be less than the initial width of the felted mass **12**, and sufficient to cause the felted mass to be deformed out of the plane in which it was being carried. In deforming out of that plane, the felted mass **12** buckles or folds about the line of weakening, and only there to form a corrugation. The folding action forms at least one and usually a plurality of corrugations **38** which project out of the plane of the felted mass **12** with each line of weakening placed interiorly of a corrugation. The corrugations or folds **38** extend longitudinally, colinearly with the lines of weakening **32** and thus, are parallel to the direction **26** of feed of the felted mass **12.** Horizontal rollers (not shown) inhibit the arching of the mat **12** vertically.

Each of the drive shafts **36** is adapted to be driven in synchronism with the conveyor means **18**, frequently by a common drive system. Thus, drums **34** are rotated as indicated by arrows **40** in FIG. **1.** The drums or rollers **34** act as traction drums or rollers which engage the felted mass **12**, deform it, and also cause it to be pulled forwardly for delivery to a curing press. Traction drums **34** are each rotated in opposite directions to generate a frictional pulling force on the deformed felted mass **12.** Friction is obtained by roughening of the exterior surface of each drum **34**, if required, or by mounting a collar or sleeve thereon which itself has a roughened outer surface.

FIGS. **3** and **4** illustrate one exemplary embodiment of an automated apparatus contemplated by this invention. Thus, an embodiment of automated apparatus used for producing match molded conduit covering is shown overall at **50.** This apparatus **50** utilizes the pleater or folding apparatus **10** of FIG. **1** to deliver corrugated felted mat to a curing press or mold **52.** As a slight modification of the pleater apparatus **10** of FIG. **1**, the corresponding apparatus in FIGS. **3** and **4** includes laterally spaced apart guide plates **54**, which aid the traction drums **34** in causing gradual deformation of the felted mat **12.** From the converging arrangement of these guide plates **54**, it will be seen that a laterally oriented compressive force is applied by those plates to the forwardly movable felted mat **12.**

As the corrugated felted mass **12** is moved past traction drums **34**, it slides or otherwise moves over support means **56** to be spread and delivered into the mold **52.** The mold **52** commonly comprises an upper and a lower press member shown at **58** and **60** in FIG. **4.** The upper and lower press members **58** and **60** are of a corrugated cross-sectional shape, conforming to the preselected configuration of molded conduit covering being made at the time. To facilitate easy delivery of the corrugated felted mat **12** into the mold **52**, inlet guide means **62** are provided. Inlet guide means **62** include portions of a tapered conical form, and spread open the corrugations in the felted mat **12.** The downstream end of each portion of the inlet guide means **62** conforms to the cross-sectional shape of the press members **58** and **60.**

Each of the press members **58** and **60** is of a cross-sectional configuration corresponding to the selected shape desired of the conduit convering being made. To provide for curing of the heat sensitive, thermosetting bonding material contained in the felted mat **12**, the lower press member **60** is operatively connected to an inlet conduit **64** adapted to conduct a hot gaseous medium through the curing press **52** and felted mat therein. A conventional blower or fan can be used, coupled to a suitable heating arrangement to provide the hot gaseous medium in a manner known in this art. Frequently, that hot gaseous medium is hot air, or a mixture of combustion gases with air. The upper press member **58** is adapted to be reciprocally movable in a vertical direction, by virtue of being supported at its corners by columns **66.** These columns **66** are slideably mounted in suitable bearings on support structure not shown. A hydraulic piston and cylinder arrangement similar to that illustrated in FIG. **7** below, is selectively actuatable to move the upper press member **58** toward, or away from, the lower press member **60.**

The upper press member **58** has an exhaust hood and outlet conduit combination associated with it, as shown at **68.** The inlet conduit **64** has a damper or baffle contained therein which is selectively movable to either open or close this conduit. It is preferable to have the damper or baffle controlled automatically. The flow of hot gaseous medium can thus be regulated to provide the heat necessary to harden the bonding agent contained in the felted mat **12.** As stated earlier, the bonding material is preferably a thermosetting phenol-formaldehyde-amine copolymer composition.

Beyond the curing press of mold **52** is a cooling and defuming system. This is illustrated schematically at **70.** This system **70** is connected to an inlet conduit **72** which has a blower or fan therein for drawing ambient air into the system. Such ambient air is at a much lower temperature than the now-cured, felted mass **12.** The cooler ambient air is passed through the dimensionally stabilized felted mass **12,** and aside from cooling that mass, it acts as a scavenging air flow to flush any residual fumes or gases out of interstitial spaces in the cured and dimensionally stabilized corrugated felted mat **12.** As stated earlier, the felted mat **12** now has rigidity as well as being shaped identically to the cross-sectional configuration of the press members **58** and **60.**

The scavenging, ambient air along with any fumes carried thereby are discharged through an outlet conduit **74** to a purification system such as a scrubber, or the like. Such purification systems are not part of the present invention and need not be described at this time. Moreover, the construction and operation of such systems are known.

A pair of lower and upper drive rollers **76** and **78** are operatively disposed in the area of the cooling and defuming system **70.** The drive rollers **76** and **78** are mounted on shafts arranged to be rotatably driven by a drive system not shown. Preferably, drive rollers **76** and **78** are driven at a speed slightly greater than the speed of forwarding means **18** in the pleater apparatus **10.** Rollers **76** and **78** advance the felted mass **12** periodically, in response to activation of a curing cycle timer associated with operation of the curing press **52.** A cut-off saw **80** (FIG. **3**) is mounted adjacent to, and exteriorly of the cooling and defuming system **70.** For example this cut-off saw **80** is a circular saw mounted for reciprocal movement transversely across the path in which the felted mass **12** is being carried. As indicated earlier, the cut-off saw **80** functions to cut the stabilized, corrugated felted mat selectively to length as required. A discharge conveyor **82** subsequently carries sections **84** of corrugated and now transversely cut felted mat **12** through a slitter saw **86.** The slitter saw **86** functions to cut or split the sections **84** of felted mat **12** longitudinally and horizontally thereof, into mating portions **88** and **90** of match molded conduit covering. The structure and method of operation of both the cut-off saw **80** and the slitter saw **86** are known in this art.

The operation and various features of the automated apparatus **50** will now be described briefly, and in greater detail in connection with the preferred embodiment of FIGS. **7, 8** and **9.**

After the felted mass **12** is conveyed into the press **52,** the press member **58** is moved downwardly to apply pressure to that mass. The pressure causes compaction of the felted mat **12** to a density preferably in the range from about 3.5 to about 10 lbs. per cubic foot. In addition, pressure from the press members **58** and **60** shapes thhe corrugated felted mat **12** to the final configuration required, as chosen from the multitude of configurations which are normally needed for commercial utilization.

The upper and lower press members **58** and **60** are provided with apertures or perforations therein, in order that hot air or other hot gaseous medium can be blown through the felted mat **12** to expose the thermosensitive bonding material therein to heat. Heat derived from the hot gaseous medium causes hardening, i.e. curing of the thermo-sensitive bonding material. As the bonding material hardens, the felted mat **12** acquires rigidity and dimensional stability conforming to the cross-sectional configuration of the press members **58** and **60.**

If required, stop members can be provided conveniently on the walls of the press **52** exteriorly thereof. These stop members exert a downward thrust upon the dimensionally stabilized felted mass **12** when press member **58** is being moved away from the member **60,** and that thrust frees the cured mat **12** from the upper press member. Release of that pressure allows the dimensionally stabilized felted mat **12** to be moved forwards into the cooling and defuming system **70.** If necessary, means could also be provided to engage the bottom surface of the felted mat **12** to ensure that it is released from the lower press member **60** when the two press members **58** and **60** are separated.

Cool ambient air is passed through the stabilized corrugated felted mass **12** to cool the latter and to cause defuming at the same time of those fumes generated by heating of the thermo-sensitive bonding material. The stabilized corrugated felted mat **12** is carried after cooling and defuming to saws **80** and **86** which cut that felted mat **12** to length and lengthwise, to provide mating portions of the match molded conduit covering. The cut-off saw **80** may be adjustably mounted to be positionable longitudinally of the felted mat **12,** in order to cut that mat to any desired length. The desired length need not conform to the **36** inch length which has commonly been used in the past. Indeed, it will be recognized that this invention has the distinct advantage of providing mating portions **88** and **90** of match molded conduit covering which can be cut to any repetitive length, say, segments 2, 4, 8 or even 12 feet in length, as is the case when dealing with boards or panels in the building arts.

It will be evident from the schematic drawing in FIGS. **3** and **4** that the automated apparatus **50** lends itself to intermittent operation. In an operation carried out on an intermittent basis, the felted mat **12** would be advanced periodically with an indexing motion conveniently controlled by means of a timer, operably connected in the control circuitry of the drive system of various constituent parts of the pleater apparatus **10.**

Various thermo-sensitive bonding materials which are commonly used in this art in the production of match molded conduit covering may require different times for curing, i.e. hardening. In some instances, a higher temperature of the gaseous medium will yield a shorter cure time, a factor which is to be taken into consideration when establishing the timing sequence for automatic operation of the apparatus **50.** In other instances, a thicker felted mat **12** will also require a longer cure time which must also be taken into consideration when the timing sequence is established.

Another embodiment contemplated herein is illustrated in FIGS. **5** and **6.** An automated apparatus shown overall at **100** in those Figures is basically similar to the embodiment shown in FIGS. **1** to **4.** The insulating material from which match molded conduit covering is to be made, is derived from two storage rolls **114** that are spaced laterally apart, in order to yield a double width felted mat **112** at a location just prior to entry into a curing oven **130.** Each storage roll **114** is mounted on a conventional take-off stand to deliver felted mat for passage between pinch rollers **116** and then an upper and lower series of scoring wheels or rollers **118** and **120.** These scoring wheels **118** and **120** function in the same manner as scoring wheels **20** and **21** of FIGS. **1** and **2,** to compress the upper and lower surfaces of the felted mat locally. This local compression forms indentations or lines of weakening in the felted mat. These indentations are shown schematically at **122.** Beyond the scoring wheels **118** and **120,** the felted mass passes between cooperating pairs of traction rollers or drums **124** and **126.** These traction drums **124** and **126** are mounted on shafts (not shown) adapted to be driven selectively in a manner similar to that of traction drums **34** of FIG. **1.** The traction drums **124** and **126** are, of course, disposed on opposite sides of the branches of felted mat and in operative relation to a support table or conveyor system (not shown) over which the felted mass is advanced for delivery into the curing oven **130.**

The automated apparatus **100** of FIGS. **5** and **6** is intended to conduct felted mat **112** continuously through the curing oven **130,** as opposed to the intermittent and periodically indexed movement of the apparatus shown in FIGS. **1–4.** Accordingly, the traction rollers **124** and **126** deliver the two branches of the formed felted mat **112** to a converging inlet **128** (FIG. **6**) between conveyorized and movable top and bottom mold sections **132** and **134** or press members. Although delivered initially along a straight path, the felted mat **112** is deflected at the pleating stage. After deflection, the mat **112** is introduced into the curing oven **130** and between mold sections **132** and **134.** The movable mold sections **132** and **134** are carried along by a conveyor system whose drive is connected in synchronism with that of the pleater section and traction drums **124** and **126.** The mold sections **132** and **134** are in the form of multiple matching pairs of mold segments. As in the other embodiments, it is preferable to harden the thermo-sensitive bonding material contained in the felted mass **112** by exposing that mass to a hot gaseous medium such as hot air. The hot gaseous medium is conducted and blown continuously through the curing oven **130** and felted mat therein by means of a conduit system illustrated at **136.** In being advanced through the curing oven **130,** the corrugated felted mat **112** is compacted and molded to the cross-sectional configuration of the mold sections **132** and **134** which themselves conform to the configuration of conduit covering desired.

Beyond the curing oven **130,** the now rigid and dimensionally stabilized felted mat **112** is passed through a cooling and defuming system illustrated at **138.** That cooling and defuming system **138** is constructed to operate in the same manner as the system **70** of FIG. **4.** Beyond the cooling and defuming system **138,** the felted mass **112** is cut transversely to the desired length as shown at **140,** into segments **144.** The segments **144** are conveyed to a slitter saw indicated schematically at **142.** The slitter saw **142** functions in a conventional manner to slit double width segments **144** of felted mat longitudinally thereof to provide mating portions **146** and **148** of match molded conduit covering. Those mating portions **146** and **148** can then be forwarded to some other facility where additional surface treatment, inspection and packaging is carried out.

Further details of the operation of an automated apparatus **200** and method as contemplated herein, will be described shortly in connection with the preferred embodiment of FIGS. **7–12** inclusive. There, it is to be understood that felted mat has been deformed in a manner described in relation to the pleater or folding device **10** of FIGS. **1** and **2,** and more specifically, the arrangement illustrated in FIGS. **5** and **6.** In brief, one and preferably two branches of felted mat are conveyed between scoring wheels which locally compress the upper and lower surfaces of that mat to form indentations therein. In being pulled ahead or advanced by traction drums **202** and **204** (FIG. **7**) the felted mat is deformed by compressive forces applied transversely, to assume a longitudinally corrugated form which is fed into a curing press or mold **206.**

The mold **206** includes upper and lower mold members **208** and **210,** removably held in press member retainers, of which the upper retainer is shown in FIG. **7** at **212.** The lower press member retainer has been omitted from FIG. **7** for purposes of clarity. Such press member retainers are known, per se, in this art for their construction and mode of operation. As in previous embodiments, the cross-sectional configuration of the mold members **208** and **210** is identical to that desired. Such press members **208** and **210** are, however, replaceable whenever another configuration is desired, and are thus removably secured by the press member retainers. Further details of the press members **208** and **210,** and of their retainers are not needed for an understanding of this invention, and are in any event known, per se.

The upper and lower press members retainers are supported in a main frame **214** seen partly in FIG. **7** and more completely in FIG. **8.** A number of cross members **216** serve to support columns **218** which are connected to the upper press retainer **212** adjacent to the corners thereof. The columns **218** are guided in order to accommodate vertical reciprocal movement of the upper press retainer **212** and mold member **208** contained therein. A solenoid actuated and hydraulically operated piston and cylinder combination **220** is provided, being secured to the upper press retainer **212** generally centrally thereof. This can best be seen in FIG. **7.** The piston and cylinder combination **220** is adapted to be actuated by a solenoid-operated valve controlled by the electrical circuitry of FIG. **12.** As a result, the top press member **208** periodically is moved downwardly to compress or compact a segment of corrugated felted mat shown in FIG. 7 as **222**, in cooperation with the lower press member **210**. The mat **222** is thus compacted to a density in the range from about 3.5 to about 10 lbs. per cubic foot, as compared to the initial density of 1 to 3 lbs. per cubic foot which it had when carried on storage rolls.

A hot gaseous medium which is preferably hot air is generated by a combined furnace-incinerator shown schematically at **224.** The hot air is conducted by a suitable network of ducting part of which is shown overall at **226** in FIG. **8**, and schematically in FIGS. **9** and **10.** The hot gaseous medium generated in the furnace-incinerator **224** has a temperature in the order of 1600° F., and is drawn through a mixing box **228** (FIG. **8**) by a suitable recirculating fan **230.** Recirculated air and gases delivered by a discharge line **231** at a temperature of about 400°F. from the curing press **206**, are mixed with the 1600° F. air in proportion, to provide a flow of gases from the mixing box **228** at a discharge temperature of approximately 700°F. This discharge temperature is regulated by a temperature controller **232** (FIGS. **9** and **10**) which adjusts positioning of a damper D2 (FIGS. **9** and **10**) to vary the volume of high temperature air delivered into the mixing box **228.**

The hot gaseous medium undergoes some heat loss in being conducted via a delivery line **233** containing a damper **D1**, to the curing press or mold **206.** The temperature is, however, still quite high, being in the order of about **500°–550°F**. when the compacted felted mat is exposed to that gaseous medium. The heat absorbed by the binder material causes curing, i.e. hardening thereof to give the corrugated felted mat **222** rigidity and dimensional stability. The cure time in which the felted mat **222** is exposed to the hot gaseous medium can range up to about 120 seconds for the temperature range mentioned earlier. Preferably, the cure time is in the range of about 10 to 60 seconds. The cure time can vary, however, depending on the binder composition being used, and upon the thickness of the felted mat from which conduit covering is being made.

As mentioned above, the hot gaseous medium which causes curing of the binder material is recirculated. From FIGS. **9** and **10** it will be seen that a throttling damper **D3** is provided in a return line **234.** The damper **D3** is operatively controlled to be positionable for regulating the volume of hot gaseous medium bled off the main flow line and conducted to the furnace-incinerator **224**, where fumes and other pollutants therein are incinerated.

A damper **D4** is provided in a delivery line **236** to control the volume flow rate of hot gaseous medium being conducted through the curing press **206.** Also associated with the press, **206**, and particularly the lower or fixed press member **210** thereof, is a fresh air inlet damper **D5.** This damper **D5** is operatively controlled by the circuit of FIG. **12** to be opened just at the end of the curing cycle for a time period of about 1–3 seconds, following closure of the delivery damper **D4.** Under these circumstances, the suction fan **230** draws fresh air into the system, through the lower press member **210**, to purge the hot gaseous medium from the now cured corrugated felted mat **222.** At the same time the lower press member **210** is cooled, and this prevents singeing and pre-curing of the next segment of felted mat **222** when it is fed into the curing press **206.** Also, escape of fumes, etc. into the ambient air is prevented, thus eliminating a possible source of air pollution.

Following curing, the dimensionally stabilized felted mat **222** is advanced beyond the curing press or mold **206.** Thus, co-acting pairs of rotatable drive rollers **238** and **240** are suitably journalled in a support stand **242** positioned just beyond the downstream side of the mold **206.** The drive rollers **238** and **240** are adjustable vertically, and are operable to grip the stabilized felted mat **222** therebetween. The rollers **238** and **240** are connected to suitable drive means (not shown) which are operable in conjunction with the traction drums **202** and **204** to move the felted mat forwardly through the apparatus **200.** It is preferable to have the drive rollers **238** and **240** driven at a speed slightly in excess of the speed of traction drums **202** and **204**, thereby exerting a pulling force on the limp, uncured felted mat prior to the curing press **206.** It will be evident from FIGS. **11** and **12** that the rollers **238** and **240** are actuatable in a timed sequence along with the traction drums **202** and **204.**

The drive rollers **238** and **240** are adjustable in order to accommodate various sizes and cross-sectional configurations of conduit covering. In addition, the rollers **240** are adapted to be movable vertically in order to assist in moving forwardly the felted mat **222** by reducing contact and friction of the latter with lower mold member **210.** The drive rollers **240** are movable to ensure that the cured felted mat **222** is freed from upper mold member **208** as the latter is moved upwardly at the end of the curing cycle. Alternately, a release bar or other means could be provided, attached to the frame, to cause such release of the cured felted mat.

It is to be emphasized that both a transversely movable cut-off saw and slitter saw are provided beyond the drive rollers **238** and **240**, with such rollers delivering the dimensionally stabilized felted mat to those saws. The transversely movable cut-off saw cuts the felted mat to length, while the slitter saw functions to cut the felted mat longitudinally to produce mating halves of match molded conduit covering. This has been described previously in connection with FIGS. **3–6.** As indicated there, the cut-off saw and slitter saw are well known per se, and a detailed description thereof is not needed at this time for an understanding of this embodiment of the present invention. It is further noted that one and preferably both of these saws are to be connected electrically to the control circuit of FIG. **12.** Thus, although FIG. **12** illustrates only the transversely movable cut-off saw as being connected in the control circuit, it is to be understood that the slitter saw could similarly be connected therein. If the transversely movable cut-off saw is connected to the control circuit of FIG. **12**, the dimensionally stabilized felted mat is cut into segments of a predetermined length before being delivered to the slitter saw. Consequently, visual inspection and rejection of any unsatisfactory segments could take place prior to actual slitting of the acceptable segments longitudinally into mating halves or portions of match molded conduit covering. Thus, there may be instances when it is indeed unnecessary to connect the slitter saw into the control circuits of FIG. **12.**

OPERATION

The operation and sequence of steps performed in practicing the present invention will now be described, with particular reference being made to the preferred embodiment of FIGS. **7–12.** It is to be understood, however, that this same sequence of operations is applicable to the embodiments of FIGS. 1–4, and FIGS. 5 and 6.

The production line for utilizing the present invention is made ready by feeding felted mat from a storage roll or directly from the basic wool manufacturing line, between cooperating series of scoring wheels which produce lines of weakening or indentations in the top and bottom surfaces of that felted mat. The indentations are formed by locally creasing or depressing the top and bottom surfaces. The felted mat is then deformed by feeding it through a pleating or deforming zone in which compressive forces are applied to the mat laterally thereof and create corrugations which project out of the plane of the mat, and extend longitudinally thereof. An initial portion of the corrugated felted mat is delivered and fed into a molding press, between the upper and lower press members thereof. In the event of the automated apparatus **200** being operated for the first time, or following replacement of felted mat on the storage roll from which the latter is being fed this will usually have involved selected activation of the drive system for the pleater apparatus described earlier in connection with FIG. **1.** Selected manual activation of the drive mechanism or system of the pleater apparatus contemplated herein can take place as seen from FIG. **12** in the selected manual mode of operation by pressing the "index" button which causes indexing of the felted mat to occur. It will be evident that the movable upper press member will have been in some raised position during indexing to advance felted mat into the curing press. It is appropriate, for convenience, to maintain the apparatus **200** in the manual mode and now push the "lower press" button which will then energize relay R8 and cause the movable upper press member to be moved downwardly. When the movable upper press member has reached the full extent of its downward travel and has compressed the felted mat to the desired extent, the press closes the normally open limit switch LS2. At this point in time it is appropriate to place the apparatus **200** into the automatic mode, at which time the following operations are undertaken following closure of limit switch LS2.

Closure of the limit switch LS2 activates a curing cycle timer which in turn allows relay R7 and R1 to become energized. Energization of relay R1 causes the normally open relay contact R1-1 to become closed and this in turn activates a solenoid valve and pneumatic piston and cylinder arrangement to cause damper D4 to be positioned open. Opening of the damper D4 allows hot air to flow into the curing press or mold and upwardly through the uncured felted mat **222.**

Closure of the limit switch LS2 also activates the transversely movable cut-off saw which cuts the previously cured felted mat into a predetermined length. This length may be the standard 3 feet commonly in use today, or it could be any odd length as desired.

The press curing cycle timer is adapted to provide a cure time which can range up to 2 minutes (i.e. 120 seconds) and preferably 10 seconds to 60 seconds, depending upon the thickness of felted mat, the temperature at which the hot gaseous medium is supplied to the curing press, and the volume flow rate of hot gaseous medium passing through the felted mat. When the press curing cycle timer has run out at the end of the cure time, the felted mat will have acquired dimensional rigidity with the thermo-setting bonding agent contained therein having been hardened and cured.

When the press heating cyle has run out and the circuit opened, the previously energized relays R1 and R7 are now deenergized, and the following steps occur:

De-energization of relay R1 allows the normally open relay contact R1-1 to again open, allowing the normally closed relay contact R2-1 to activate the solenoid valve and pneumatic circuitry which returns the damper D4 to a closed position. Closing damper D4 will cut off the flow of hot gaseous material through the press and felted mat therein. It will be seen from FIG. **12** that when the automatic mode of operation was initially activated, coupled with pressing of the "start cycle" button, relay R5 was energized. That in turn closed the normally open relay contact R5-1 which in turn allowed the time delay relay TD1 to become energized through the normally closed limit switch LS3. Activation of the time delay relay TD1 energized a solenoid valve and associated pneumatic piston and cylinder to open a normally closed fresh air damper D5 associated with the lower press member **210.** Suction by the fan **230** draws ambient air into the curing press. This ambient air cools the lower press member **210** as well as causing de-fuming of the now cured felted mat within the curing press. The time delay relay is adjustable so as to provide a purging flow of cool ambient air through the curing press for a period of 3 to about 10 seconds.

After the 3 to 10 seconds has elapsed, the activated time delay relay will itself transmit energy to close a normally open time delay relay contact TD1 which in turn initiates a "raise press" motion of the movable press member **208.** Movement of the upper press member **208** is, of course, derived from the hydraulic piston and cylinder **220** shown in FIG. **7** which had been activated by a solenoid operated valve which was energized when the relay contact TD1 was closed. The cured and now dimensionally stabilized felted mat adheres to the upper mold member **208** because of a suction or negative pressure condition existing for a short period of time in the duct system leading from the upper press member **208.** A limit roller, stop means, or the like can be used to separate the felted mat from the upper press member **208** before complete retraction of that member has occurred. Alternatively, it may be found that the inherent porosity of the cured felted mat is such that after a short period of time has elapsed, sufficient air will have penetrated the felted mat to eliminate the lower pressure condition which previously existed, and this will allow the cured felted mat to fall back onto the lower press member **210** by gravity.

Energization of the time delay relay is also adapted to cause upward movement of the drive roller **240** (FIG. **8**) by activating a solenoid operated valve and pneumatic circuit to raise the cured felted mat clear of the lower press member **210.** Consequently, friction between the lower press member and the felted mat is greatly reduced during the indexing period.

When the upper press member **208** has reached its fully retracted position, the limit switch LS1 is activated. It will be seen from the circuit diagram that this limit switch has ganged contacts, one of which is normally closed and the other of which is normally open. Activation of that limit switch will open the normally closed contact and cause upward movement of the press member **208** to cease; while closure of the normally open limit switch contact will energize the drive mechanism for the indexing conveyor and drive platens

238 and 240. Energization of motor M4 shown in the circuit diagram of FIG. 12 will also activate conveyor means 18 in the pleater apparatus 10 of FIG. 1, and will also close the fresh air inlet damper D5 by de-energizing the solenoid valve and pneumatic circuit associated therewith.

After the felted mat has been indexed a distance equal to, or shorter than, the length of felted mat which had just been cured during one pressing operation, it will have been operative to pull additional uncured felted mat into the curing press for the next pressing or curing cycle. A normally open limit switch LS4 is closed when the cured felted mat has travelled the predetermined one length of cured conduit covering downstream of a transversely movable cut-off saw, to initiate the following operations:

Closure of the normally open limit switch LS4 will deactivate the indexing means 18 of the pleater apparatus 10 of FIG. 1, and driving movement of the drove rollers 238 and 240 in FIG. 8. The drive rollers 240 will also be lowered by de-activation of the solenoid operated valve and pneumatic circuitry associated therewith, thus allowing the uncured felted mat to come to rest on the lower press member 210.

Closure of the normally open limit switch LS4 will also cause energization of the relay R8 and closure of the normally open relay contact R8-1 to cause activation of the hydraulic piston and cylinder 220 by means of a solenoid operated valve. Downward movement of the upper press member 208 continues until the uncured felted mat contained in the curing press has been compacted to the thickness desired, and that press member has reached its maximum extent of downward travel. When that maximum extent of downward travel has been reached, closure of the normally open limit switch LS2 occurs and this in turn activates the curing cycle timer. The sequence described above is then repeated.

Although it is not shown in the circuit diagram of FIG. 12, a thermocouple is normally located in the conduit 233. For reasons of safety, should that thermocouple sense an extreme temperature condition as in the event of a fire in the curing press, the thermocouple would cause termination of 1) the main gas supply to the incinerator, 2) supply of the press curing cycle, 3) cause separation of the press members 208 and 210, and 4) stop operation of the motor or motors which activate the drive mechanism of the pleater apparatus 10 of FIG. 1, as well as that of the drive rollers 238 and 240 shown in FIG. 8. It will also be evident from FIG. 12 that the main ON-OFF switch can be activated in the event of an unsafe condition to cut all power to the apparatus 200.

The description above has referred mainly to arrangements in which interim storage rolls of basic wool are used as a source for the wool fed to the longitudinal pleater of this invention. Very important advantages are obtained, however, by using the present invention to receive basic wool directly from fiberizing and forming machinery, in an in line configuration. In other words, such machinery can be used in line with the longitudinal pleater and other apparatus contemplated herein. Such an arrangement is illustrated in part by the schematic of FIGS. 13 and 14.

There, a conventional furnace/fiberizing device is shown at 300. This device 300 produces elongated fibers of glass, mineral or other such insulating material. The fibers are confined in a suction box arrangement 302 for collection as a felted mat or mass of basic wool, on a collecting and forming conveyor 304. These structures and their modes of operation are known to practioners in this art. It will suffice to state here, that basic wool is produced and fed forwardly on a continuous basis.

The basic wool may be trimmed along the marginal edges, if needed, by a slitter device 306. From here the felted mass of basic wool is carried forwardly between a pair of pressure or pinch rollers 308. These rollers 308 compress the felted mat slightly. The compressed felted mat next passes through a normally inactive chopper device 310. The chopper device can be actuated selectively, as when specimens are needed for checking quality, weight, job changes and other such purposes.

Beyond the chopper device 310 the felted mat enters an accumulator section 312. Here the basic wool mat is fed over a number of rollers 314 which are included in an accumulator or festooning device. The rollers 314 are moveable reciprocally in a vertical direction, to absorb i.e. accumulate felted mat, or to feed such mat to the equipment downstream, while continuously receiving more felted mat from the fiberizing and forming machinery 300, 302. Further details of the accumulator or festooning device are not needed at this time, since these devices are themselves known, especially in the textile art.

The apparatus of FIGS. 13 and 14 just described can be used to feed felted mat being formed continuously, to the longitudinal pleater 10 of FIG. 1, and from there to an oven or press in which curing takes place. The apparatus of FIGS. 13 and 14 would thus replace the storage roll, bracketed at A in FIG. 1. The accumulator section 312 receives and absorbs the continuously produced felted mat during those periods of time when curing is occurring. At that time forward movement of the felted mat is normally stopped, at least downstream of the accumulator.

It will be apparent that the feed rate of felted mat through the pleater and associated downstream apparatus is related to at least two factors. One is the storage capacity of the accumulator section. The other is the production capability of the fiberizing and forming machinery 300 and 302. These two will naturally be balanced to avoid excessive buildup in the accumulator, and avoid unwanted runout or depletion of basic wool therein. Feed rates will also depend on other factors such as the thickness of fitted mat being produced. That is itself determined by the thickness of pipe insulation to be produced at a particular time. Cure times, the heat or temperatures used, the characteristics of a particular binding composition are other factors which must also be taken into consideration.

Put simply, the operating parameters of the pleater and curing oven will more or less match the production capacity of the source of basic wool.

The foregoing description has disclosed a number of embodiments of this invention and has also suggested some alternative arrangements for constituent parts of the invention. It is contemplated within the spirit of this invention to include all such modifications and changes as would be obvious to those skilled in this art and which are encompassed by the claims below.

I claim:

1. In an automated process adapted to produce a prefabricated, match molded covering for a conduit of a selected precisely dimensioned cross-sectional con-

figuration the steps of,

conveying a pliable felted mass of an insulating material along a path, the felted mass being of indeterminate length and disposed generally in a plane, said felted mass containing at least 75% by weight of randomly oriented, discrete or discontinuous, glass or mineral fibers and a substantially liquid heat sensitive bonding material in uncured condition, and having a density of up to 2 pounds per cubic foot;

forming a line of weakening in one surface of the felted mass, by locally depressing said surface along a line parallel to said path;

deforming the felted mass to create a corrugation projecting out of said plane and extending longitudinally by applying a compressive force laterally and along the longitudinal side edges of the felted mass, the deforming occurring about the line of weakening to place said line interiorly of the corrugation;

compressing successive portions of the deformed felted mass while subjecting said mass to heat, to cause hardening of the bonding material and impart rigidity and dimensional stability to the corrugated felted mass to a density ranging from about 3.5 to 10 pounds per cubic foot and having said selected precisely dimensioned cross-sectional configuration;

releasing the dimensionally stabilized, corrugated felted mass from pressure; and

cutting the stabilized, corrugated felted mass longitudinally to provide mating portions of the match molded conduit covering.

2. In the process defined in claim **1** wherein said pliable felted mass has a density in the range of about 1 to about 2 pounds per cubic foot.

3. In the process defined in claim **2**, wherein the pliable felted mass is conveyed along said path at a substantially constant velocity.

4. In the process defined in claim **2**, wherein the pliable felted mass is conveyed intermittently along said path with an indexed movement governed by the time taken to harden the bonding material.

5. In the process defined in claim **2**, wherein the stabilized corrugated felted mass is cut selectively to length.

6. In the process defined in claim **2**, wherein the laterally applied force also causes forward driving movement of the felted mass.

7. In the process defined in claim **2** wherein the deformed felted mass is compressed by separable portions of a mold, and wherein hardening of the bonding material is caused by passing a hot gaseous medium through the compressed felted mass in the said mold.

8. In the process defined in claim **7**, wherein the dimensionally stabilized corrugated felted mass is cooled and defumed prior to cutting.

9. In the process defined in claim **8**, wherein defuming is caused by passing scavening air through said stabilized corrugated felted mass.

10. In the process defined in claim **2**, wherein the line of weakening is provided by exerting a crushing compressive pressure perpendicularly of the plane of the felted mass, the line of weakening so formed causing increased pliability to the felted mass.

11. In the process defined in claim **2**, wherein said locally depressing of the felted mass is caused by exerting forces continuously to the felted mass as the latter is moved along said path, said forces being applied to opposed surfaces of the felted mass along a plurality of lines parallel to said path, and perpendicular to the said plane of the felted mass, the forces along adjacent parallel lines being exerted in opposite directions.

12. An automated apparatus for producing a prefabricated match molded covering for a conduit of a selected cross-sectional configuration; comprising;

means for supplying a pliable felted mass of an indeterminate length of an insulating material, having a density of up to 2 pounds per cubic foot, the felted mass containing at least 75% by weight of randomly oriented, discrete or discontinuous, glass or mineral fibers and a substantially liquid heat sensitive bonding material in uncured condition;

conveying means for moving said felted mass along a path, with the felted mass being disposed generally in a plane;

indenting means mounted in proximity to said conveying means, and operable to indent one surface of the felted mass along a line extending parallel to said path, the indenting means causing a line of weakening to be formed along said parallel line as the felted mass is conveyed along;

deforming means engageable with the felted mass to deform said mass into a corrugation extending longitudinally and projecting out of said plane in which it is being conveyed, said deforming means providing compressive forces laterally and along the longitudinal side edges of the felted mass, the deformation occurring about the line of weakening to place said line interiorly of the corrugation;

a corrugated mold having said selected cross-sectional configuration for receiving the corrugated felted mass therein, said mold being operable to compress and to heat the corrugated felted mass for hardening the bonding material and imparting rigidity and dimensional stability to the corrugated mass to said cross-sectional configuration, the stablized corrugated mass having a density of about 3.5 to about 10 pounds per cubic foot;

release means to free the dimensionally stabilized corrugated mass from the mold;

control means operable selectively for activating the conveying means to move the stabilized felted mass along; and

cutting means positioned to cut said corrugated felted mass longitudinally thereof into elongated mating portions of said match molded covering.

13. The apparatus defined in claim **12**, wherein auxiliary conveying means are also provided to assist said conveying means in moving the felted mass along, said auxiliary conveying means being disposed adjacent the deforming means and adapted to provide an additional driving force.

14. The apparatus defined in claim **12**, wherein said deforming means includes stationary guide surfaces shaped to exert pressure forces on the felted mass laterally thereof.

15. The apparatus defined in claim **14**, wherein restraining roller means are provided for inhibiting dislocation of the corrugated felted mass under laterally applied forces.

16. The apparatus defined in claim **12**, wherein said deforming means includes roller means adjacent the longitudinal side edges of the felted mass.

17. A process for producing pleats in a material having a density of up to 2 pounds per cubic foot and being in the form of a pliable felted mass of insulation containing at least 75% by weight of randomly oriented, discrete or discontinuous, glass or mineral fibers and a substantially liquid heat sensitive bonding material in uncured condition, comprising; the steps of

conveying said material along an initially straight path in a plane, the material being of finite width and indeterminate length;

locally depressing said material on at least one surface thereof to form an indentation therein extending longitudinally and parallel to said path; and

deforming the material to create a corrugation projecting out of said plane by applying a compressive force laterally and along the longitudinal side edges of the material, the deformation occurring about the longitudinally extending indentation to place said indentation interiorly of the corrugation.

18. The process defined in claim **17,** wherein said material is an insulating wool of a mineral composition.

19. The process defined in claim **18,** wherein said mineral composition is a glass and the wool is formed from fibers of a controlled average diameter and random length.

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