

July 23, 1940.

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2,208,583

DIAPHRAGM FORMING METHOD

Filed Jan. 19, 1938

4 Sheets-Sheet 1

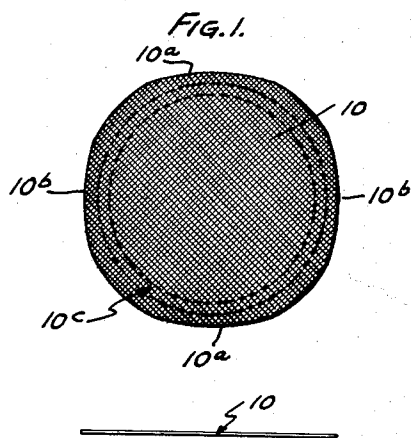


FIG. 2.

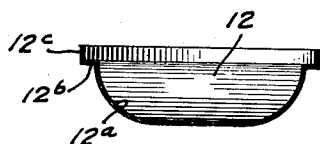


FIG. 3.

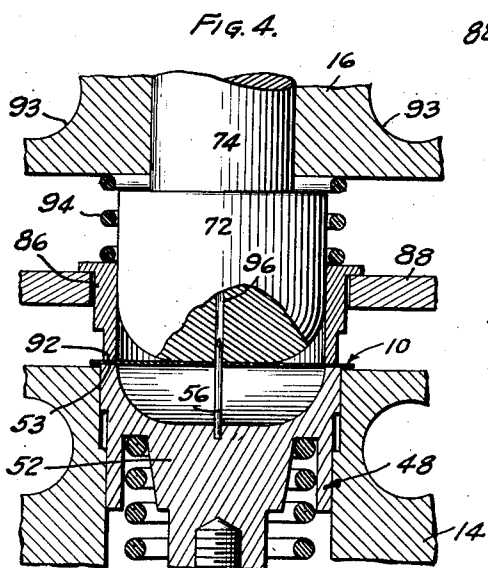


FIG. 4.

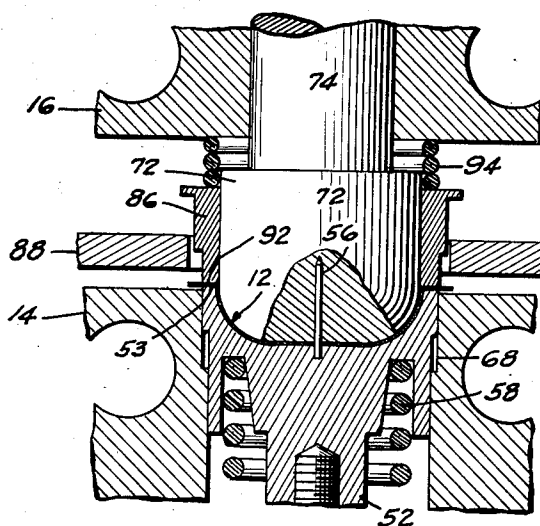


FIG. 5.

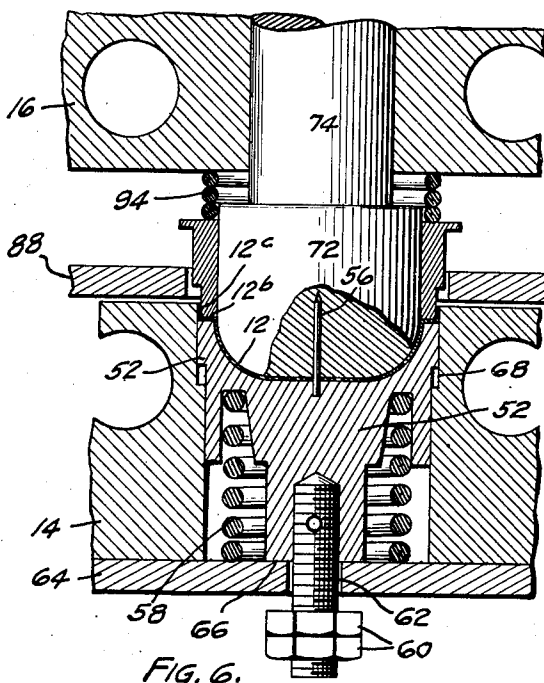


FIG. 6.

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4 Sheets-Sheet 2

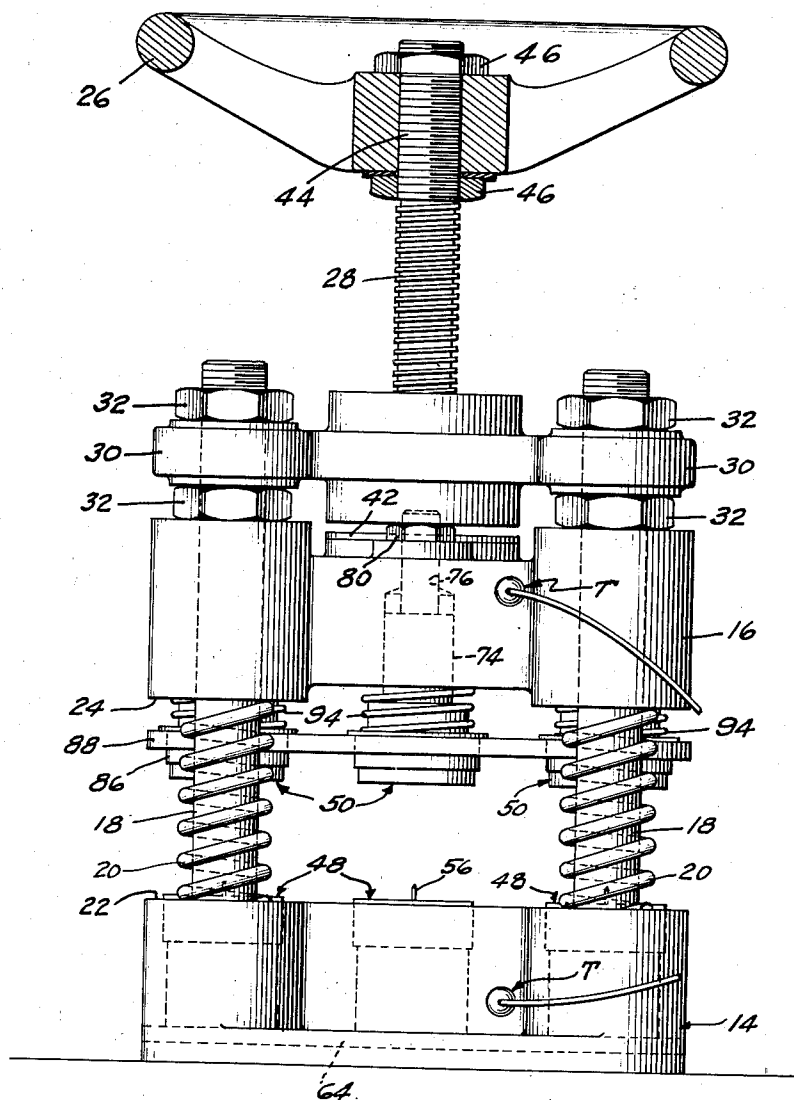


FIG. 7.

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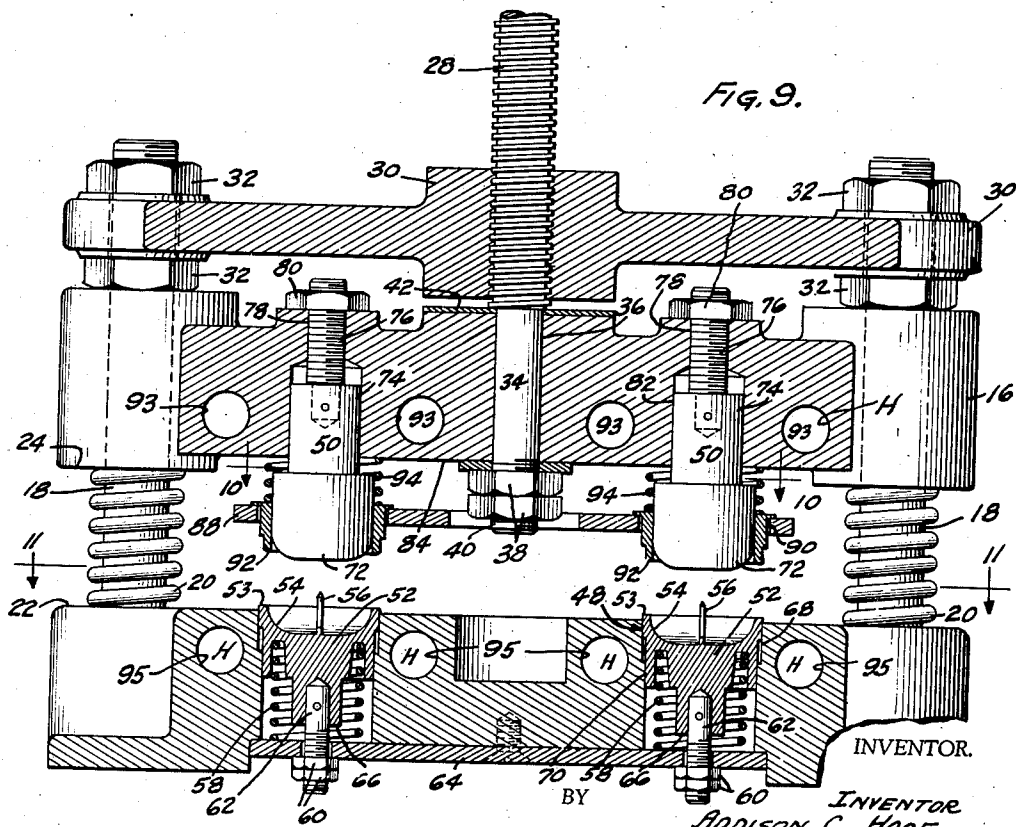
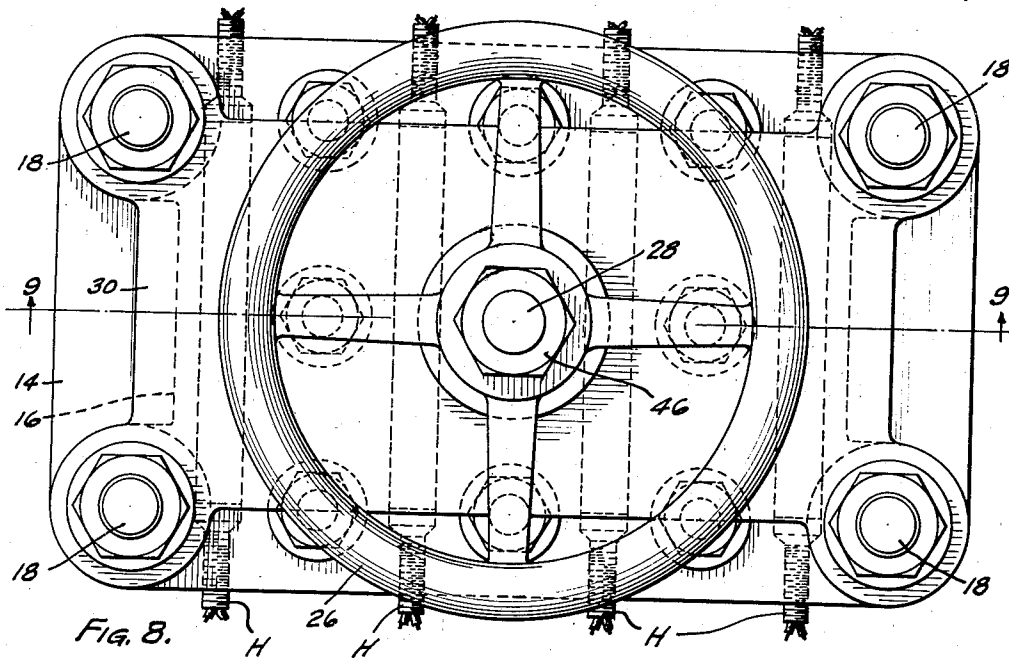
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4 Sheets-Sheet 3



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FIG. 10.

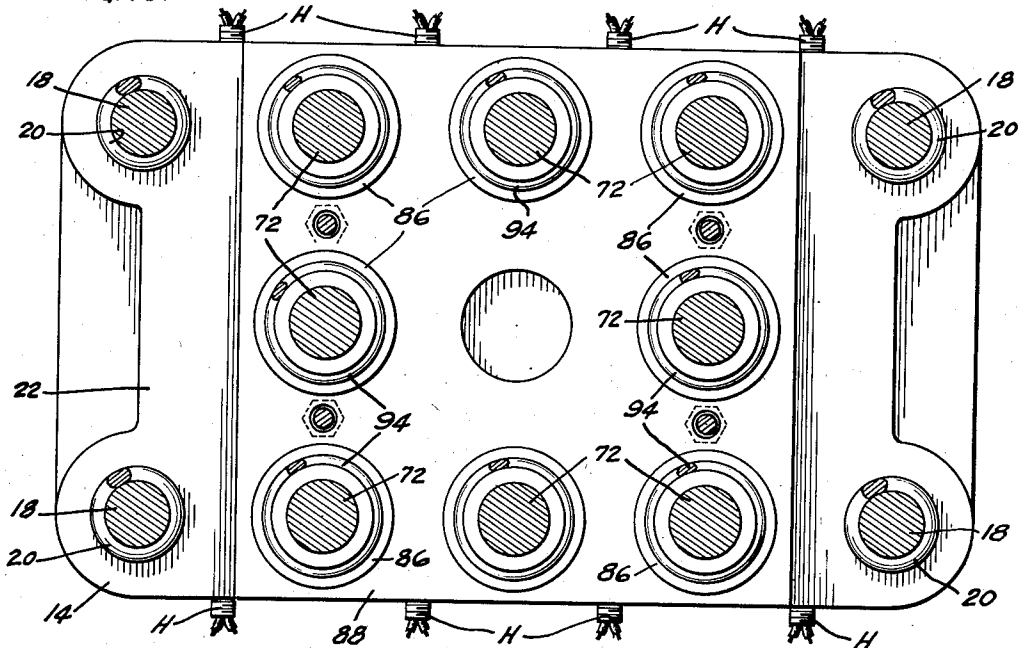
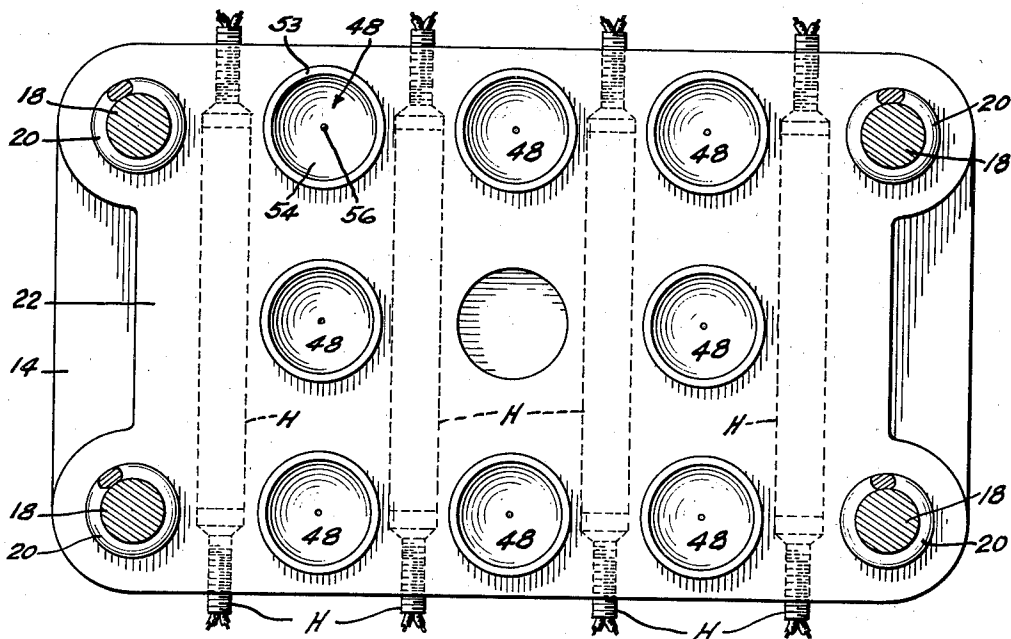


FIG. 11.



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## UNITED STATES PATENT OFFICE

2,208,583

## DIAPHRAGM FORMING METHOD

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Application January 19, 1938, Serial No. 185,748

2 Claims. (Cl. 18—56)

My invention relates to diaphragms and the like and to an improved process of forming diaphragms.

In a great many industries flexible diaphragms of material such as rubber coated fabric or synthetic rubber coated fabric are used, particularly so-called pre-formed diaphragms. These diaphragms are usually disc-shaped having a central bulge or bowl shape and a right angle or other peripheral flange portion capable of fastening between retainers so that the diaphragm can be securely held about its edge.

The construction of a diaphragm of this type has presented many difficulties. To use uncured synthetic rubber coated fabric would require large and complicated multiple dies. The cost would be considerable and the completed product would have inherent weaknesses which would cause a large percentage of the finished diaphragms to break easily during use. Cured synthetic rubber coated fabric as a commercial product is at present on the market as "DuPrene" or "NeoPrene," this is a cured fabric of high quality and is desirable for use in manufacturing flexible diaphragms.

After considerable experimentation, I found that this material could be reheated and formed to a desired shape without destroying the strength of the fabric by the use of properly constructed dies, correct temperature of heat applied and the correct length of time of the applied heat.

Accordingly, the principal object of my invention is to provide an improved process of manufacturing formed diaphragms from cured synthetic rubber fabric.

A further object is to provide an improved process of manufacturing diaphragms easily and simply carried out and capable of producing the formed diaphragms in a minimum amount of time.

A further object is to provide an improved machine for manufacturing formed diaphragms.

A further object is to provide a machine of this type capable of producing a plurality of formed diaphragms in each operation.

A further object is to provide an improved machine of this type having means associated therewith for stretching, heating and forming the diaphragm all in one operation.

A further object is to provide an improved structure capable of easy dismantling or change and one capable of long and hard usage without easily becoming broken or out of order.

Other objects and advantages will be more apparent from the following description wherein

reference is had to the accompanying four sheets of drawings, upon which

Fig. 1 is a plan view of a piece of cured synthetic rubber coated fabric;

Fig. 2 is a side elevational view thereof;

Fig. 3 is a cross-sectional view through a formed diaphragm made from the piece of cured synthetic rubber coated fabric;

Fig. 4 is a fragmentary sectional view through the diaphragm forming machine illustrating the first step in the process of forming the diaphragms;

Fig. 5 is a similar fragmentary sectional view illustrating the second step;

Fig. 6 is a similar cross sectional view illustrating the third and final step;

Fig. 7 is an end elevational view of my improved diaphragm forming machine with parts broken away in section;

Fig. 8 is a plan view thereof;

Fig. 9 is a longitudinal sectional view through the machine taken generally on the lines 9—9 of Fig. 8;

Fig. 10 is a plan sectional view taken generally on the lines 10—10 of Fig. 9, and

Fig. 11 is a similar plan sectional view taken generally on the lines 11—11 of Fig. 9.

In carrying out my preferred method of manufacturing formed diaphragms, I select a sheet of cured synthetic rubber fabric of the desired thickness and cut the pieces 10 to the shape shown in Fig. 10. It will be observed that the so-called fabric comprises a thermo setting resinous plastic sheet reinforced by an impregnated fabric comprising warp and weft threads. While the object of the disclosed illustrated process is to manufacture a substantially circular diaphragm, it should be noted that the blank 10 is cut so that the transverse dimension at the points where the warp and weft threads run substantially radially of the piece, is relatively greater. In other words, at points where the threads approximate a radial direction additional material is provided as compared with intermediate peripheral portions wherein the threads are located at an angle to the radial direction.

It is important to point out that this configuration results from the discovery, in accordance with the present invention, that the present sheet material cannot and should not be stretched in a direction where the threads or fibers run radially, where as at intermediate portions where the threads of the warp and weft make an appreciable angle with the radii, stretching and compressing or compacting of the fibers in the

plane of the web is readily accomplished. This is of extreme importance in connection with the present invention wherein the diaphragms are to be employed for control purposes in connection with delicate pressure responsive devices where the threads must accordingly be free from appreciable longitudinal stressing.

At the same time it is of great importance to note that when material is molded in a circular female die without stressing of the threads, peripheral material must obviously and necessarily be drawn into the die. In other words, the flat material normally superposed above the die is clearly insufficient to conform to the additional length of the curved surface of the die recess. Peripheral influx of material, however, while supplying the necessary radial demand, necessarily adds an excess material in an annular direction and thus would result in crumpling or other defects completely fatal in the manufacture of a control diaphragm of the present kind. In accordance with the present invention, however, as will appear hereinafter more in detail, the material is fed radially from the periphery at points where the threads run substantially radially while being relatively positively held at annular peripheral points where the threads make a substantial angle with the radii. As a result, stretching and compressing take place at intermediate portions where the threads make an angle with the radii in order to compensate for the material supplied at other peripheral points.

Thus in Fig. 3, which shows a diaphragm 12 of a desired shape, it will be seen that it is formed with a cup-shaped central depression 12a, a horizontal flange 12b and a vertical flange 12c.

The machine which I employ to form the diaphragm may comprise a rectangular base member 14 adapted to be positioned upon a suitable support. A rectangular platen 16 which may carry the upper die sections, is adapted to be mounted above the base upon a plurality of suitable upright guide posts 18 rigidly mounted in the four corners of the base. The platen may be normally held in an inoperative position spaced away from the base by comparatively strong compression springs 20 positioned about the guide posts 18 and disposed between the upper surface 22 of the base 14 and the lower surface 24 of the platen 16.

Means for raising and lowering the platen 16 may comprise a hand wheel 26 and a screw 28 associated therewith. The screw member 28 meshes with a stationary plate 30 mounted above the platen 16 upon the uprights 18 between pairs of lock nut members 32 screw threadedly mounted at the upper end of the uprights 18. The screw 28 may have a reduced shank portion 34 extending through a vertical bore 36 in the center of the platen 16, and be secured thereto by the nut members 38 mounted on a screw-threaded portion 40 at the lower end of the shank 34. A suitable anti-friction washer 42 may be disposed below the end of the screw 28 on the plate 16. The hand wheel 26 may be screw-threadedly mounted upon the upper end 44 of the screw 28, being held in position by suitable lock nut members 46. It will be noted that the major length of the screw member 28 is formed with an acme thread to provide fairly rapid action to the raising or lowering of the platen 16.

As thus far described, a base, platen and screw member of an ordinary screw press have been provided. However, in the base and in the platen I have provided a plurality of male and female

die assemblies, the female die assemblies 48 being located in the base and the male die assemblies 50 being located in the platen 16. Since all of the male die members are similar and all of the female die members are similar, only one of each will be explained in detail. Accordingly, each female die assembly may comprise a cylindrical plunger member 52 formed with a generally cup-shaped depressed upper surface 54 which has a vertical pin member 56 projecting upwardly therefrom. A comparatively strong compression spring 58 normally tends to hold the die assembly in the position shown in Figs. 4 and 9, the upward movement being limited by a pair of nut members 60 secured to the lower end of a pin 62 that extends from the plunger through a base plate 64. The downward movement of the plunger is also limited by the lower end 66 of the plunger striking the upper side of the base plate 64. The plunger 52 is formed with a slightly enlarged ring sector adjacent its upper end which reciprocates in an enlarged bore 68 in the base. The plunger 52 may be mounted for reciprocation in the bore 70.

The male die assembly 50 may include a piston shaped member 72 having a reduced shank portion 74. The piston member may be rigidly positioned in the platen 16 by means of a screw-threaded stud 76 which extends from the end of shank 74 through an appropriate vertical bore 78 in the platen 16 and is screw-threadedly locked in position by a nut member 80. The shank 74 may extend from the bore 82 below the lower surface 84 of the platen. It will be noted that the lower end of the piston member 72 is rounded to conform to the contour or the cup-shaped upper surface 54 of the plunger 52.

I provide a collar member 86 mounted in a rectangular plate 88 below the lower surface of the platen 16. The collar member is mounted in a suitable opening 90 in the plate 88 and is capable of reciprocation therein. The collar is formed with a lower ring surface 92 slightly smaller than the upper ring surface 93 of the plunger 52 so that they may meet throughout substantially their surface area. A spring member 94 normally holds the collar in its lowermost position.

I have found that in treating cured synthetic rubber fabric in the manner employed, that it is necessary to provide heating die elements for this purpose. Accordingly I provide a plurality of electric heating elements H positioned upon the sides of the male and female die assemblies in the horizontal bores 93 in the platen, and similar horizontal bores 94 in the base. These heaters may be of any commercial type found suitable for the purpose of heating the die members to 275 to 300 degrees Fahrenheit, and capable of maintaining this heat for a desired length of time. Suitable thermostatic controls T may be provided in the base and platen to regulate the temperatures.

The steps in my improved process will now be described. Referring to Fig. 4, assume that one of the pieces 10 of fabric has been placed in the position shown over the lower die assembly 48, with the pin member 76 piercing the same and extending through the complementary opening 96. The platen 16 and the male die assembly is now lowered so that the first contact between the dies will be between the lower surface 92 of the collar 86 and the upper surface 53 of the plunger 52. This will cause a gripping of the piece 10 around a peripheral area 10c indicated by dotted

lines in Fig. 1. As the platen is advanced and the male die portion 72 stretches the material to the shape shown in Fig. 5, the piece 10 will still be held in the area 10c, due to the pressure of the compression spring 94, except adjacent extremities of the warp and filler threads wherein there is no appreciable stretching and the excess material must be necessarily supplied externally. Thus only the body of material within this circular area will be stretched to the cup shape of the dies. Further downward movement of the platen 16 will cause the plunger 52 to be depressed against the action of the spring 58 to the position shown in Fig. 6, where the upright ledge 12c of the diaphragm is formed. In this position, with the dies heated to a temperature of between 275 and 300 degrees Fahrenheit, the diaphragms are maintained for a period of from five to eight minutes, so that a revulcanization of the synthetic rubber may take place. After the elapse of the above specified time, the hand wheel 26 may be rotated to withdraw the platen 16 and the male die members, after which the formed diaphragms may be withdrawn.

From the above description it will be apparent that a comparatively simple and inexpensive diaphragm forming machine has been provided. It will be obvious that the exact shape or construction of the die assemblies may be varied or changed, and that, depending upon the type of material employed, the length of time or the amount of heat required in the dies may be changed. From the foregoing it will be apparent that the present process results in a diaphragm which is uniform, regular in character and free from undesired stressing or straining of the threads longitudinally of their length. Thus it will be apparent that the foregoing process, as a result of the approach of the male and female portions of the die, results in the flat sheet being drawn into a curved shape. During this drawing action any substantial stressing of the threads is prevented by virtue of the fact that the stresses longitudinally of the thread only occur in an appreciable degree where the threads run radially to the circular blank. At intermediate peripheral portions, however, peripheral supply of material in any appreciable degree is unnecessary for the reason that the threads are not longitudinally stressed and a normal angular arrangement of the fabric threads, with respect to the radial application of the forming stresses, permits the fabric to re-arrange itself to absorb these stresses. This would be of only minor significance were it not for the fact that the influx of certain peripheral portions necessarily carries with it a quantity of material of increased annular extent which is accommodated within the die without crumpling or even corresponding microscopic irregularity. The present invention solves this problem by accommodating this excess material at the inter-

mediate portions wherein stretching would ordinarily otherwise occur. In other words, it might be said that the present invention reconciles the necessity for a peripheral supply of material with a coincidental supply of an excess of material in an annular direction in such a manner that an un-stressed, uniform product results. It has been found in accordance with the present invention that the final molded diaphragms have a dense, uniform, non-stressed structure wherein the threads, particularly in the outer portion of the concave part, are actually held in closer association than that in which they exist in the original fabric. I do not wish to limit myself to the exact details shown nor to the specific steps of the method explained; rather what I desire to secure and protect by Letters Patent of the United States is:

1. A method of producing flexible diaphragms of a substantially concave, lateral section from moldable, plastic sheet material reinforced with a base comprising a fabric having warp and weft threads, which comprises supplying a blank of material, clamping the peripheral portions of said blank under a predetermined clamping force, and distorting the central portion of the blank to said concave diaphragm form while the periphery is so held, said clamping force being of such degree as to hold the threads without slippage in the bias direction so that the required stretch is given in said direction, said force permitting slippage of the threads in the warp and weft direction without breakage of the warp and weft threads, said slippage corresponding to the stretch given to the fabric in the bias condition and terminating the molding distortion of the diaphragm before substantial slippage in the bias direction or breakage of the warp and weft threads.

2. A method of producing flexible diaphragms of a substantially concave, lateral section from moldable, plastic sheet material reinforced with a base comprising a fabric having warp and weft threads, which comprises supplying a blank of material, clamping the peripheral portions of said blank under a predetermined clamping force, and distorting the central portion of the blank to said concave diaphragm form while the periphery is so held, said clamping force being of such degree as to hold the threads without slippage in the bias direction so that the required stretch is given in said direction, said force permitting slippage of the threads in the warp and weft direction without breakage of the warp and weft threads, said slippage corresponding to the stretch given to the fabric in the bias condition and terminating the molding distortion of the diaphragm before substantial slippage in the bias direction or breakage of the warp and weft threads, and subjecting the blank while so deformed to curing under elevated heat and pressure.

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