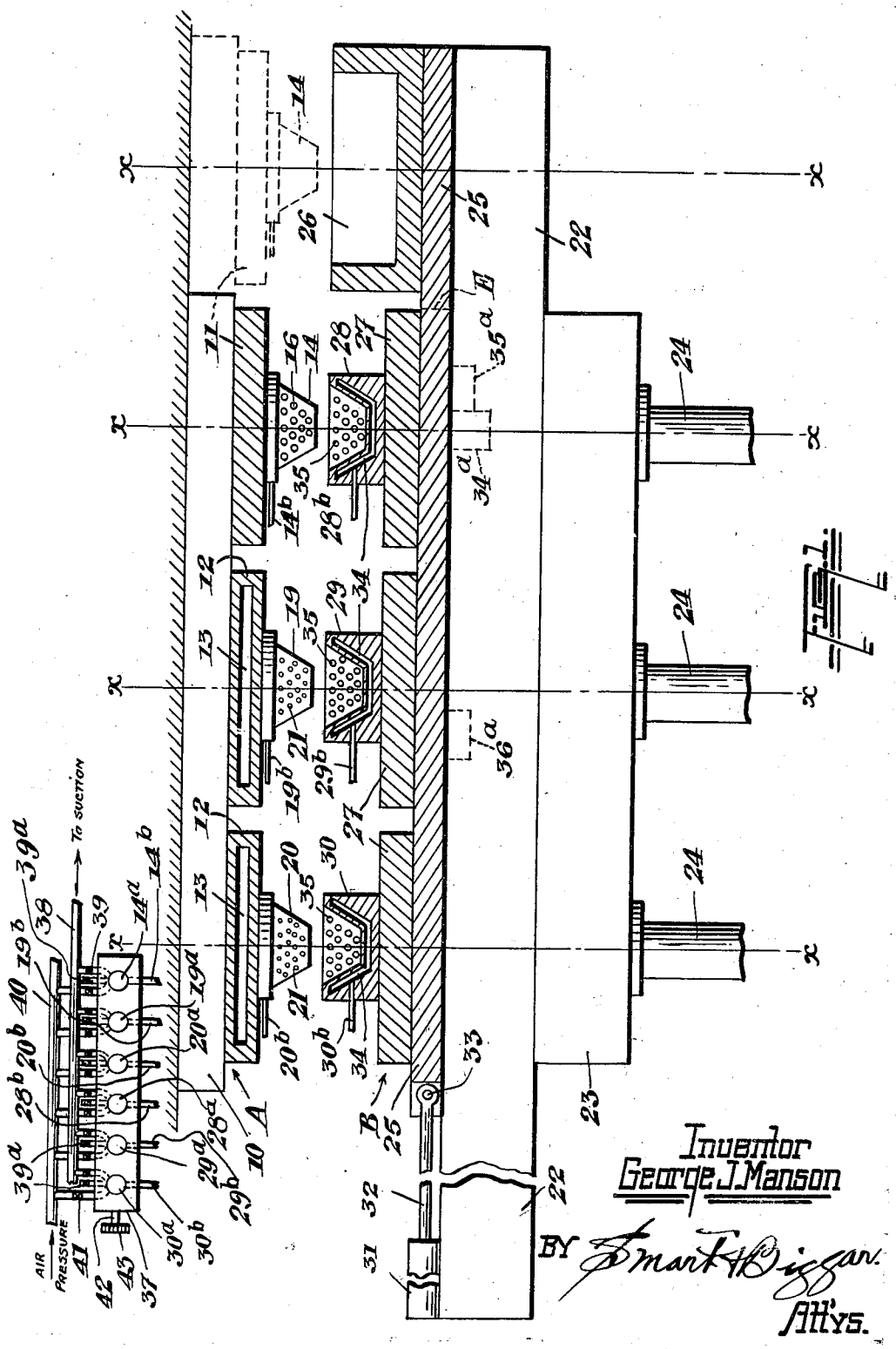
June 1, 1937. G. J. MANSON 2,082,409

METHOD OF AND APPARATUS FOR FORMING FIBROUS ARTICLES

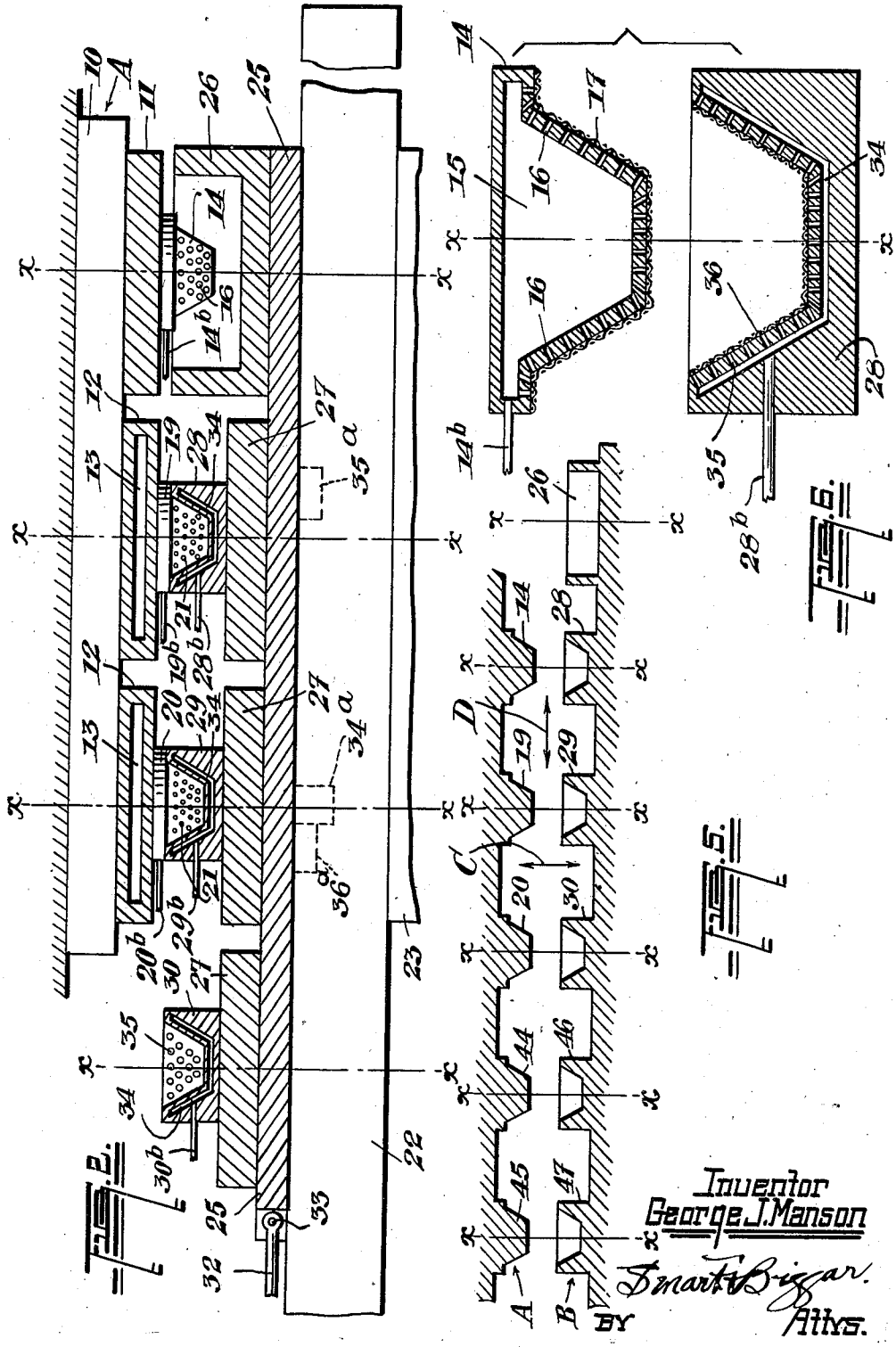
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METHOD OF AND APPARATUS FOR FORMING FIBROUS ARTICLES

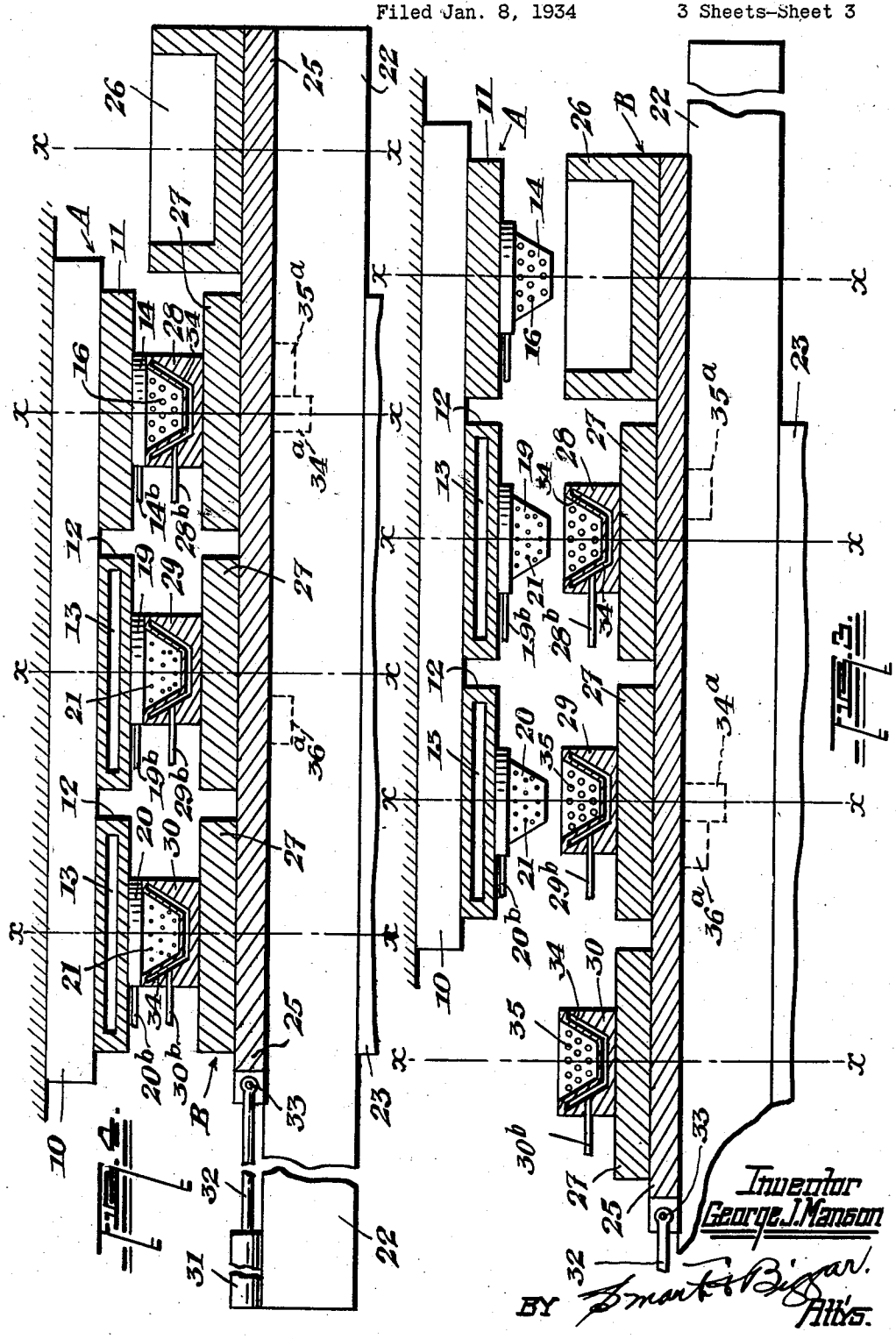
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METHOD OF AND APPARATUS FOR FORMING FIBROUS ARTICLES

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METHOD OF AND APPARATUS FOR FORMING FIBROUS ARTICLES

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6 Claims. (Cl. 92—57)

This invention relates to improvements in methods of and apparatus for making fibrous articles with particular reference to such articles as dishes, trays, containers and such like and the forming, pressing, drying and calendering thereof, and an object of the invention is to devise an improved method of and improved apparatus for carrying out the method whereby valuable and important advantages are obtained over methods and apparatus hitherto known.

An important object of the invention is to effectively overcome and obviate the fouling of the drainage faces of the dies during operation whereby not only is greatly improved operation thereof obtained but the quality of the articles produced is greatly improved.

Other objects of the invention will appear in the course of the following specification.

The present invention consists of an improved method and apparatus for making fibrous articles wherein the article is initially formed on a forming die having a drainage face and is then progressively presented for pressure against a series of dies consisting of said forming die and a succession of heated drying dies, the presentation of the article to such dies of said series being by means of pressing and transferring dies, there being an individual pressing and transferring die cooperating with each die of said series and the next succeeding die thereof, such pressing and transferring die operating to press the article against the first of its associated dies, remove it therefrom, press it against and transfer it to the second of its associated dies and then withdraw therefrom, leaving the article upon said second associated die, whereupon the next pressing and transferring die repeats such operation with respect to the article and its two associated dies of the series, whereby the article is progressively presented to all the dies of the series, all as hereinafter more particularly described and illustrated diagrammatically in the accompanying drawings in which:

Figure 1 is an elevation, partly in section and with certain parts broken intermediately of their length to economize space, of a purely diagrammatic form of apparatus for carrying out the present invention, a valve system for controlling fluid pressure, such as suction and air pressure, to the dies of the apparatus being indicated diagrammatically and detached from the major portion of the structure.

Figure 2 is an elevation, partly in section and also with a portion broken intermediately of its length, showing portions only of the structure of Figure 1, in the relative positions occupied during one step in the operation wherein the forming die is immersed in a liquid stock tank and certain pressing dies are in operative engagement with certain heated drying dies.

Figure 3 is an elevational view of the same portions shown in Figure 2, the parts being in the relative positions occupied in another step in the operation, following that shown in Figure 2, in which the dies have separated and the forming die is clear of the liquid stock tank.

Figure 4 is a further elevational view of the same portions shown in Figures 2 and 3, the parts being in the relative positions corresponding to yet another step in the operation, in which the stock tank has been moved to the right to clear the forming die and certain pressing dies are in operative engagement with the forming die and certain heated drying dies respectively.

Figure 5 is a diagrammatic view indicating, in simple skeleton form, a modified form of the apparatus, in which the number of heated drying dies and pressing dies have been increased over that shown in Figures 1 to 4 inclusive.

Figure 6 is a sectional elevation, to a larger scale, of the forming die and of one of a number of pressing and transferring dies forming part of the apparatus.

In the drawings, like characters of reference indicate corresponding parts in the various views.

In the forming, pressing, drying and calendering of pressed fibrous articles such as contemplated in the present invention, a serious difficulty hitherto encountered has been the tendency for the drainage faces of the dies employed to become fouled, which obviously seriously interferes with the proper functioning of the apparatus and also disadvantageously affects the articles produced and it is one of the principal objects of the present invention to rectify and effectively overcome such troubles.

In accordance with this invention, the article is carried progressively from one die to the next so as to be progressively presented to a series of dies in succession.

The applicant has discovered that if the article is dried on the die upon which it is formed or on the die to which it is first transferred from the forming die, the pulp adheres to the drainage face so that such drainage face becomes badly fouled. According to the present invention the article is never dried on the forming die or on the die to which it is first transferred from the forming die but is transferred from the forming die to the drying die by means of an intermediate

die. Likewise it is transferred from each drying die to the next succeeding drying die through the medium of an intermediate pressing and transferring die.

A feature is also that a separate and distinct transferring die is employed for transferring the article from the forming die to the first drying die and from each drying die to the next succeeding drying die.

The diagrammatic form of apparatus illustrated comprises an upper fixed unit and a lower movable unit indicated collectively, respectively by the letters A and B, the two units co-operating as will hereinafter be explained.

The upper fixed unit A comprises what may be termed a fixed head member 10 which carries an unheated platen 11 and heated platens 12, 12, which platens 12, 12, may be heated in any suitable manner, as for instance, by the hot fluid chambers 13. Carried by the platen 11 is a forming die 14 formed with a drainage face. The forming die may be of any suitable construction and, as shown in Figure 6, may be formed with a hollow interior 15, its working face being provided with drainage perforations 16 communicating with the hollow interior. The working face is covered with the usual wire mesh cloth 17. The platens 12, 12 carry smooth faced drying dies 19 and 20, which may be heated in any suitable manner and as shown would be heated from the heated platens 12, 12. These drying dies 19 and 20 are smooth faced and are formed with a hollow interior, being provided with small openings 21 in their working faces, which openings communicate with the hollow interior similarly to the corresponding construction in the forming die 14 above described. The openings or perforations 21 of the drying dies 19 and 20 usually are small as compared to the drainage openings 16 of the forming die 14 to permit fluid pressure, such as suction, air pressure or atmospheric air pressure to be exerted at the die faces, as will be later explained. The heated dies, however, such as 19, may have a steam drainage surface; that is a surface similar to the forming die. The disposition of these openings 21 is such that those of no two dies agree.

The dies 14, 19 and 20 forming part of the upper unit A are in alignment and are equally spaced apart.

In the form of the apparatus which will first be described and as is shown in Figures 1 to 4 inclusive, these dies 14, 19 and 20 are all substantially fixedly carried by the upper unit A, although a certain amount of resiliency may be provided in the mounting in any well known manner, as for instance, by the provision of springs between the platens 11, 12, 12 and the fixed beam 10. In a modified embodiment of the apparatus, however, which will later be described and which is indicated in broken lines in Figure 1, the forming die 14 may be so mounted upon the upper unit A that it may reciprocate horizontally thereon to move into positions either overlying or clear of a liquid stock tank.

In the following specification, the description generally deals with that embodiment wherein the forming die 14 is fixed upon the upper unit A in its relation to the drying dies 19 and 20, dealing only with the modified embodiment of the horizontally reciprocating forming die, when the context makes it clear that the reference is to such modified embodiment of the apparatus.

Mounted in the apparatus in any suitable manner below the head member 10 is what may be termed a table, carriage or movable bed member 22, which is mounted for a vertical rising and falling motion. In the diagrammatic form of apparatus shown this vertical reciprocating movement is obtained by mounting the member 22 upon the head 23 of a hydraulic press, the pistons of which are indicated by the numerals 24. The means for operating the member 23 vertically up and down, however, as illustrated, is purely diagrammatic and is intended merely to indicate any suitable way of accomplishing this, as obviously there is no novelty in this feature by itself and it might be accomplished equally well in a great many different well known ways. As illustrated, through the medium of the pistons 24 the member 22 may be reciprocated vertically.

The lower unit B is mounted upon the member 22 and comprises a slide 25 upon which is mounted, in spaced apart relation, a liquid stock tank 26 and a series of platens 27. Upon the platens are mounted pressing and transferring dies 28, 29 and 30 which are equally spaced apart and together with the liquid stock tank 26 are disposed in alignment with each other and with the upper dies 14, 19 and 20 as well as said upper dies.

The slide 25 is slidably mounted for horizontal reciprocation upon the member 22, reciprocation being effected in any suitable well known manner as, for instance, by the cylinder 31 and piston rod 32, the cylinder being mounted upon the member 22 and the piston rod 32 being connected to the slide at 33.

All the corresponding dies are of the same general form and adapted for co-operation, it being apparent, as hereinafter more fully explained, that the lower unit B comprises a liquid stock tank and a series of dies mounted for reciprocation both vertically and horizontally with respect to the upper series of dies which are designed for co-operative engagement therewith. In Figure 6 one of the upper dies is shown in section along with the forming die on a somewhat larger scale.

Each of the lower dies is provided with a chamber 34 and has its working face formed with drainage perforations 35 (see Figure 6) communicating with said chamber and covered with the usual wire mesh cloth 36.

The extent of the horizontal sliding movement or horizontal reciprocation of the lower unit B upon the member 22 is between the two extreme positions as illustrated respectively in Figures 1 and 3. Any suitable form of stop may be provided for positively and accurately limiting the horizontal reciprocation of the lower unit such, for instance, as a stop 34a on the slide 25 adapted for engagement, in these extreme positions, with co-operating stops 35a and 36a carried by the member 22.

In the right hand extreme position of the slide 25, as shown in Figure 1, the liquid stock tank 26 is displaced to the right so as to be clear of the forming die 14 and the lower dies 28, 29 and 30 exactly underlie the upper dies 14, 19 and 20 respectively, so that when the lower unit B is raised the apparatus assumes the position shown in Figure 4, in which the upper and lower series of dies move into operative engagement, the forming die 14 being engaged by the first pressing die 28 and the heated drying dies 19 and 20 being engaged by the second and third pressing dies 29 and 30 respectively.

In the left hand extreme position of the slide 25, as shown in Figure 3, the entire lower unit B has moved, as a complete unit, to the left so

that the liquid stock tank 26 underlies the forming die 14, while the first pressing die 28 underlies the first drying die 19 and the second pressing die 29 underlies the second drying die 20, the third pressing die 30 being displaced to the left so as to be entirely clear of the upper series of dies. When in this left hand extreme position, if the lower unit B is raised, the apparatus assumes the position shown in Figure 2, in which the upper and lower units cooperatively engage each other so that the forming die 14 becomes immersed in the liquid stock in the tank 26, while the heated drying dies 19 and 20 become operatively engaged by the first and second pressing dies 28 and 29 respectively and the third pressing die 30 simply rises with an idle motion, clear entirely of all the upper dies for the removal of the finished article.

In all the views, the axes of the dies and of the stock tank 26 is indicated by the lines X—X.

It will be noted that in one embodiment of the apparatus as illustrated, the entire lower unit B moves as a unit with the slide 25 so that the lower series of dies 28, 29 and 30 and the stock tank 26 do not at any time alter their positions relatively to each other but that their movement is entirely as a unit with the slide 25 upon which they are all mounted.

In a modified embodiment of the apparatus indicated in broken lines in Figure 1 and to be later referred to, the stock tank 26 is separate from the slide 25 and is fixedly mounted upon the member 22 so that in that case this stock tank does not partake of the horizontal reciprocation of the slide 25 and lower unit B with the dies 28, 29 and 30, which dies in this modification reciprocate horizontally relatively to the stock tank 26.

Arrangements are provided for exerting fluid pressure, such as suction, air pressure or atmospheric air pressure, at the faces of the various dies, as may be desired during the operation of the apparatus, and this may be accomplished in any of many well known ways and may be in the nature of a system of connecting pipes or conduits with the necessary valves for opening and closing communication between such pipes and sources of suction, compressed air or the atmosphere.

In the diagrammatic apparatus chosen for purposes of illustration, there is provided a valve casing 37 (see Figure 1) in which there is contained a number of four-way valves 14a, 19a, 20a, 28a, 29a and 30a. One port of each of the aforesaid four-way valves is connected by a pipe to a suction header 38 and a manually controlled shut-off valve 39 may be provided in each of said connecting pipes. Another port of each of said valves is connected by a pipe to an air pressure header 40 and a manually controlled shut-off valve 41 may be provided in each of the connecting pipes. The third port of each of said valves is designed to be brought into registry with the pipes 39a for the admission of atmospheric pressure and a suitable valve 39b may be provided in each of these pipes for individual control. The fourth port of each of said four-way valves is connected by a suitable flexible pipe to one of the dies of the apparatus, the connecting pipes between the valves and dies being as follows:

A pipe 14b connects the valve 14a to the hollow interior 15 of the forming die 14.

A pipe 19b connects the valve 19a to the hollow interior of the drying die 19 and a pipe 20b connects the valve 20a to the hollow interior of the drying die 20.

Pipes 28b, 29b and 30b connect the valves 28a, 29a and 30a respectively to the chambers 34 of the pressing dies 28, 29 and 30.

It will thus be clear that, by means of the four-way valves 14a, 19a, 20a, 28a, 29a and 30a connected as above described, fluid pressure in the form of suction or air above or at atmospheric pressure may be exerted as desired at the working face of any of the dies and the timing of such periods of suction and air pressure for the various dies may be arranged as desired and will be as hereinafter more fully explained.

Any suitable well known manner of automatically operating these valves in proper determined timing and synchronism from and with the main apparatus may be employed but as there is obviously no novelty in such, it is merely indicated by the valve shaft 42 and gear 43 mounted thereon, which gear would be suitably connected to and driven from the main apparatus.

In the drawings the central portions of the pipes 14b, 19b, 20b, 28b, 29b and 30b have been broken away so that the valve mechanism appears detached from the main portion of the apparatus, but this of course is only to avoid confusion in the drawings, it being of course intended that the two indicated ends of each of these pipes form parts of one continuous pipe.

The suction header 38 would be in communication with any suitable source of suction such as a suction pump or fan (not shown) while the pressure header 40 would be similarly in communication with any suitable source of air pressure such as a compressor (not shown). If air pressure above atmospheric is to be used or if atmospheric pressure is to be used the various pipe lines are put into communication with the pipes 39a.

The arrangement, it will thus be noted, is such that there is provided fluid pressure means communicating with the various dies and which is automatically timed and synchronized as may be desired in relation to the operation of the apparatus.

The manual valves 39, 41 and 39a are provided to enable the complete cutting out of any of the pipes from the suction header 38 or from the pressure header 40, or from atmosphere, should such be for any reason desired.

In the diagrammatic skeleton form of apparatus illustrated in Figure 5 the dies are merely illustrated in outline form, but it is to be understood that the form, construction and operation of these dies correspond to that of those in the other views, the only difference in this case being that additional dies have been added to the series of dies forming parts of the upper and lower units A and B.

As illustrated in Figure 5, two additional heated drying dies 44 and 45 have been added to the series of dies forming part of the upper unit A, while a corresponding number of additional pressing dies 46 and 47 have been added to the series of dies forming part of the lower unit B.

These additional dies 44, 45, 46 and 47 would be connected preferably through four-way valves to the suction and pressure headers 38 and 40 and to atmosphere in a similar manner to the other dies.

The fact that two dies have been added to each of the upper and lower units is intended merely to indicate that any desired number of such dies may be added as may be found desirable to meet the requirements of the articles

being produced and not as indicating that the addition of two such dies is of any vital or critical significance or importance. The actual number of dies provided in the upper and lower series of dies may be varied within any limits as may be found desirable.

In the showing in Figure 5 the fact that the lower unit B is adapted for reciprocation both vertically and horizontally is indicated at the right by the arrows C and D.

In the showing of the apparatus in Figures 1 to 4 inclusive, it will be obvious that the dies are not illustrated in full detail as the purpose of these views is to illustrate the operation of the apparatus rather than the detailed mechanical construction of the dies.

The operation of the apparatus in the production of pressed fibrous articles in accordance with the improved method will now be fully explained.

In the operation of the apparatus fluid pressure (suction, air pressure or atmospheric pressure) is applied to the working faces of the various dies at various stages of the operation through the control valves *14a*, *19a*, *20a*, *28a*, *29a* and *30a*, each valve controlling the fluid pressure to the correspondingly numbered dies **14**, **19**, **20**, **28**, **29** and **30** and the operation is identical in each case. For instance, in the case of the die **14** and valve *14a*, when this valve opens communication between the pipe *14b* and suction header **38**, suction is applied to the drainage face of the forming die **14**; when the valve *14a* opens communication between the pipe *14b* and the pressure header **40**, air under pressure is applied to the drainage face of the forming die **14**. On the other hand if the valve *14a* communicates with pipe *39a* atmospheric pressure is applied to the drainage face of the forming die and when the valve *14a* closes all communication between the pipe *14b*, the headers **38** and **40** and pipe *39a* are cut off so that no fluid pressure is directly applied to the drainage face of the forming die **14**.

The above described operation is identical in the case of all these valves and their associated dies, and for brevity in the following description it will merely be stated that at a certain stage or step in the operation either suction or air pressure, as the case may be, is applied to a particular die, it being understood thereby that the application of such suction or air pressure is accomplished as above explained or in any other well known and suitable manner.

Wherever the context permits, the term "fluid pressure" is intended to include atmospheric pressure and pressure above and below atmospheric, it being apparent that all these forms of pressure may be used as instanced in the headers **38** and **40**, pipes *39a* and the various control valves for applying the desired form of pressure.

The actual mechanical construction of the four-way valves and the manner of operating them in proper synchronism with the main apparatus may be carried out in any of a multitude of well known ways and is merely indicated diagrammatically by the shaft **42** and gear **43** in Figure 1 of the drawings.

In the operation of the apparatus it is to be understood that, in all movements of the lower unit B in which it is reciprocated horizontally upon the member **22** by means of the piston rod **32** and vertically by means of the press head **23**, this entire lower unit B moves at all times as a unit and there does not occur at any time any relative movement of the lower dies **28**, **29** and **30**, all of which are carried by the slide **25** and fixed in their spaced relation to each other.

In one embodiment of the apparatus the stock tank **26** is also carried by the slide **25** and therefore reciprocates horizontally with the lower unit B, while in another embodiment this stock tank is separate from the slide **25**, being mounted upon the member **22**, in which case it does not reciprocate horizontally with the lower unit and thus relative horizontal movement occurs between the dies **28**, **29** and **30** and the stock tank **26**.

Consider the apparatus to be in the position shown in Figure 2 and the stock tank **26** to be properly charged with liquid stock.

In this position the perforated forming die **14** is immersed in the liquid stock in the tank **26** and, upon the apparatus being put in operation, suction is applied to the drainage face of the forming die **14** so that the article is initially formed by suction upon the forming die **14** in the form of a deposited layer of material.

The lower unit B now descends vertically into the position shown in Figure 3 so that the forming die **14** clears the liquid stock tank **26**, suction being meanwhile continued upon the forming die so that the initially formed article is held thereon.

The lower unit B is now moved, through the medium of the piston rod **32**, into its extreme right hand position as shown in Figure 1, the engagement of the stops **34** and **35** serving to accurately locate it in such position.

In this position the stock tank **26** is displaced to the right so as to be entirely clear of the forming die **14** and the lower dies **28**, **29** and **30** of the lower unit B exactly underlie the dies **14**, **19** and **20** respectively of the upper unit A. Suction is still maintained on the forming die **14**, to retain the initially formed article thereon.

The lower unit B is now raised and the lower series of dies **28**, **29** and **30** thereof move into operative pressing engagement with the upper series of dies **14**, **19** and **20** carried by the upper unit B, the position of the apparatus being then as shown in Figure 4.

In this operation the initially formed article (not shown in the drawings) is pressed between the first pressing die **28** and the forming die **14**. During this pressing of the article suction may still be maintained upon the forming die **14** and air pressure applied to the pressing die **28** so that air is blown through the drainage face of this pressing die **28**, through the article itself, and through the drainage face of the forming die **14**. On the other hand suction may be maintained on the face of pressing die **28** or air pressure may be applied to the face of the forming die **14** and suction to the pressing die **28** or the forming die **14** may be connected to the atmosphere with suction on pressing die **28**.

At the completion of the preceding first pressing operation the forming die **14** is connected with fluid pressure (air pressure or atmosphere) and pressing die **28** is connected to suction before the lower unit B descends into the position shown in Figure 1, in which descent the upper and lower series of dies of course separate. At the commencement of this descent and just as the dies separate, if desired, a momentary air pressure may be applied to the forming die **14** so as to blow the article therefrom onto the die **28** or the forming die may be connected to atmosphere. The article is now upon the first

pressing die 28 and is held thereon by suction which is maintained upon this die.

The lower unit B now moves into its extreme left hand position as shown in Figure 3, the article being still held by suction upon the first pressing die 28.

The lower unit B now rises into the position shown in Figure 2 so that the first pressing die 28, with the article thereon moves into operative pressing engagement with the first heated drying die 19, so that the article is presented by the die 28 to the heated face of this first drying die 19 and is pressed between these dies 28 and 19. During this first hot pressing and drying operation suction is still continued on the first pressing die 28 so that all vapor generated during the drying action by contact of the article with the heated face of the drying die 19 is removed or evacuated by suction through the drainage face of the pressing die 28. In other words there is provided a system of suction vapor removal of the vapor generated during the hot pressing or drying operation.

Suction is now discontinued upon the pressing die 28 and is applied to the first drying die 19, being effective through the small openings 21 in the smooth face of this die and the lower unit B descends into the position shown in Figure 3. As the dies 19 and 28 separate in this descent the article is held upon the drying die 19 by the aforementioned suction thereon and if desired to assist the transfer of the article from the pressing die 28 to the drying die 19 at the moment of separation of the dies, a momentary air pressure may be applied to the pressing die 28 or the die may be opened to atmosphere. The article is now held upon the first drying die 19.

The lower unit B now moves into its extreme right hand position, as shown in Figure 1, suction still being continued upon the first drying die 19 to hold the article thereon.

The lower unit B now rises into the position of Figure 4 wherein the second pressing die 29 moves into operative pressing engagement with the first drying die 19 and the article is subjected to a second pressing against this first drying die 19. During this pressing of the article between the dies 29 and 19, suction may be discontinued upon the drying die 19 and applied to the pressing die 29 so as to again provide for suction removal, through the pressing die 29, of the vapor generated during the pressing and drying of the article. If, however, drying die 19 is provided with a drainage face, suction will be maintained on it until just before the dies move out of pressing engagement when the face of the die 19 will be connected either to air pressure or atmosphere.

The lower unit B now descends into the position of Figure 1, suction still being continued upon the lower pressing die 29 so that the article remains thereon. In order to assist the transfer of the article from the drying die 19 to the pressing die 29, if desired, a momentary air pressure may be applied to the drying die 19 at the instant of separation of the dies 19 and 29 or the drying die may be connected to atmosphere. The article is now upon the second pressing die 29, having been transferred thereto from the first drying die 19.

The lower unit B now moves into its extreme left hand position as shown in Figure 3, the article being still held by suction upon the second pressing die 29.

The lower unit B now rises into the position of Figure 2 so that the second pressing die 29 moves into operative pressing engagement with the second heated drying die 20 and the article is presented by the die 29 to the heated drying die 20 and subjected to a pressing operation between these dies. During this pressing operation suction is still continued upon the pressing die 29 so that the vapor generated is evacuated by suction through the die 29.

At the completion of the preceding pressing operation between the dies 29 and 20, suction is discontinued upon the pressing die 29 and is applied to the drying die 20 so as to retain the article upon the drying die 20.

The lower unit B now descends into the position of Figure 3, the article being retained upon the upper drying die 20, and if desired to assist the transfer of the article from the lower pressing die 29 to the upper drying die 20, a momentary air pressure may be applied to the lower die 29 at the instant of separation of the dies 29 and 20 to blow the article onto the die 20. The article is now on the second drying die 20 and is retained thereon by the suction which is continued upon this die and the lower die 29 may be connected to the atmosphere.

The lower unit B now moves into its extreme right hand position of Figure 1, the article still being upon the second drying die 20.

The lower unit B now rises into the position of Figure 4, in which the third pressing die 30 moves into operative pressing engagement with the second pressing die 20 and the article is subjected by the die 30 to a second pressing against the drying die 20. During this pressing operation suction is discontinued upon the drying die 20 and is applied to the lower die 30 so that all vapor generated is evacuated by suction through the lower die 30.

The lower unit B now descends into the position of Figure 1, suction being continued upon the lower die 30 so that the article is transferred thereto and carried downwardly thereon. In order to assist the transfer of the article from the drying die 20 to the pressing die 30, a momentary air pressure may be applied to the die 20 at the instant of separation of the dies 20 and 30 to blow the article onto the latter die or drying die 20 may be connected to atmosphere.

The lower unit B now moves into its extreme left hand position of Figure 3, the article being upon the third lower die 30.

If the article is now complete, it is collected or delivered in its finished state from the third or last lower pressing die 30.

In the foregoing description the article has been presented to two successive heated drying dies, but of course any number of such successive drying stages may be provided as may be desired or required to properly dry and finish the article and the number of such drying dies provided may be varied to suit, depending upon the length of time required to dry and finish the article.

For instance, in some cases one heated drying die only might be sufficient, in which case the second drying die 20 and the third pressing die 30 would be omitted. On the other hand, three or more drying dies might be provided with the necessary additional lower pressing dies for co-operation therewith in cases where the thickness or nature of the article required more drying stages or a longer period of drying.

In the case where more than two drying dies are provided, the article would not be collected in its completed condition from the third pressing die **30** as above stated, but would be presented and transferred by that die to a third heated drying die and the above mentioned sequence of operations would be successively repeated until finally the completed article would be collected in its finished state from the last die of the lower series of pressing dies.

As stated, the upper and lower series of co-operating dies may comprise any desired number of drying stages, and, as shown in Figure 5, there are four such heated drying dies provided.

In the foregoing, for reasons of clarity and to avoid hopeless confusion in identifying successive articles in their passage through the apparatus, only one article has been considered and the progress of this one article has been traced through the apparatus. It will, however, be quite apparent that each time the apparatus assumes the position of Figure 2, in which the forming die **14** is immersed in the liquid stock in the tank **26**, a new article is initially formed thereon, so that when in operation there is a continuous succession of articles passing through the apparatus.

Also in the drawings and description there has been shown and described only one forming die **14** together with only one series of upper dies and one series of lower dies carried by the platens **11**, **12** and **27**, but it is of course clear that the platen **11** may carry a number of forming dies **14**, while the platens **12** and **27** may carry a corresponding number of heated drying dies **19** and **20** and pressing dies **28**, **29** and **30**, so that the capacity of the apparatus would be suitably increased by providing a plurality of forming dies with an upper series of heated drying dies and a lower series of pressing dies co-operating with each forming die.

If desired to have a higher calendered surface finish upon the completed article than could be obtained with a wire faced pressing die, the cycle could include as a final step the pressing of the article between smooth faced heated dies, either one or both of which could be smooth faced and heated, depending upon whether the article was to be highly finished on one or both of its faces. This would merely be a matter of suitably choosing the working faces of the final dies of the upper and lower series of dies, for instance, dies **45** and **47** of Figure 6.

The cycle of operations may be briefly summarized as follows:—

First.—The article is initially formed by suction upon a forming die by immersion thereof in a tank of liquid stock.

Second.—This initially formed article is pressed between the forming die and a first pressing die with or without the simultaneous blowing of air through the drainage faces of the dies and through the article.

Third.—Article is withdrawn from the forming die upon the first pressing die and presented thereby for pressure against a first heated drying die, with simultaneous suction removal of generated vapor through the first pressing die.

Fourth.—First pressing die withdraws from the first drying die leaving the article transferred to the first drying die.

Fifth.—A second pressing die operatively engages the first drying die and subjects the article to a second pressing against this first heated drying die with simultaneous suction removal of generated vapor through the second pressing die.

Sixth.—The second pressing die withdraws from the first drying die carrying the article thereon and presents it for pressure against a second heated drying die, with simultaneous suction removal of generated vapor through the second pressing die.

Seventh.—The second pressing die withdraws from the second drying die leaving the article transferred to the second drying die.

Eighth.—A third pressing die operatively engages the second drying die and subjects the article to a second pressing against this second heated drying die, with simultaneous suction removal of generated vapor through the third pressing die.

Ninth.—The third pressing die withdraws from the second heated drying die carrying with it the article which, if the apparatus comprises only two drying dies or drying stages, is now completed and it is then delivered or collected from this third or last pressing die. If, however, the nature or thickness of the article is such that further drying stages are required to properly dry or finish it, it will be presented by the third pressing die to a third heated drying die and the number of drying dies and pressing dies co-operating therewith may be arranged as desired and the finished article will finally be collected or delivered from the final pressing die.

The dies **14**, **19** and **20**, it will be noted, constitute a first or upper series of dies which are equally spaced apart and disposed in alignment. The die **14** is a forming die having a drainage face and the dies **19** and **20** are smooth faced heated dies, thus this upper series of dies consists of a drainage faced forming die and a plurality of heated drying dies.

The dies **28**, **29** and **30** constitute a second or lower series of dies which are disposed in alignment below and spaced apart to correspond to the spacing of the dies of the upper series. These dies **28**, **29** and **30** are in the form of drainage faced pressing dies and are mounted for co-operative engagement with the dies of the first or upper series.

The lower series of dies are mounted for reciprocation, as a unit, both vertically and horizontally with respect to the upper series of dies. That is, provision is made for relative reciprocation, both vertically and horizontally, of the two series of dies.

The relative vertical reciprocation permits simultaneous operative engagement and disengagement of the dies of the two series, while the relative horizontal reciprocation permits the positioning of each die of the lower series into registration alternately with either of two successive dies of the upper series.

The manner of co-operation between the dies of the upper and lower series is such that the article is successively pressed against each die of the upper series and is transferred from each die of the upper series to the next succeeding die thereof by an individual and distinct die of the lower series, each die of the lower series alternately co-operating with a die of the upper series and the next succeeding die thereof.

In other words, the operations comprise successively presenting the article to the forming die and all the drying dies and in transferring it between each die and the succeeding die by

means of a different pressing and transferring die.

It might also be noted that the disposition of the small openings 21 in the drying dies is different in each die and also the drainage markings of the pressing dies 28, 29 and 30 will not coincide.

The present invention is of course not limited in any way to any particular die shape or form or to the form illustrated, as obviously the die shape may be varied as dictated by the shape or form of the article to be made.

Also it is immaterial whether the upper series of dies are male dies and the lower series are female dies as illustrated or whether these are reversed, as either arrangement is equally embraced within the scope of the present invention.

Moreover it is immaterial whether the upper series of dies are stationary and the lower series movable or vice versa, since it is apparent that either mode of operation will produce exactly the same useful result and there is no mechanical problem involved to operate in either way.

A study of the cycle of operations of the apparatus will show that whenever the lower unit B is descending into the position illustrated in Figure 1, all articles will be on the dies of the lower series and be carried downwardly thereon, while whenever it is descending into the position illustrated in Figure 3, all articles will be held upon the dies of the upper series and those of the lower series will be empty.

Also during the operation of the apparatus each time the lower unit B moves into its left hand position, as shown in Figure 3, a finished article will be delivered upon the last or left hand pressing die of the lower series.

In the embodiment of the apparatus illustrated and hitherto described the forming die 14 is fixed in relation to the dies 19 and 20 of the upper series and the stock tank 26 is part of and reciprocates horizontally with the lower unit B; that is, the forming die 14 is fixed and the liquid stock tank 26 reciprocates horizontally therebelow.

If desired this arrangement may be reversed so that the stock tank 26 has no horizontal reciprocation but the forming die 14 is reciprocated horizontally above the tank.

This modification may readily be provided simply by having the slide 25 terminate at the broken line E in Figure 1 and mounting the liquid stock tank 26 in fixed relation upon the member 22. The platen 11 would then be slidably mounted upon the head member 10 and provision made for reciprocating it horizontally from the full line to the broken line position of Figure 1 so that the forming die 14, when in the broken line position, overlies the stock tank 26. This horizontal reciprocation of the platen 11 may be accomplished in any suitable well known manner, such, for instance, as another cylinder and piston rod as is shown for reciprocating the slide 25.

The timing of the horizontal reciprocation of the platen 11 would be such that when the slide 25 moves to the left to move the lower unit B into its left hand position, as shown in Figure 3, the platen 11 would move into its right hand broken line position where the forming die overlies the tank 26.

From the foregoing it will be apparent that the invention provides an improved method of and apparatus for making fibrous articles whereby the objects set forth have been attained.

Various modifications may be made in the invention without departing from the spirit thereof or the scope of the claims and, therefore, the exact forms shown are to be taken as illustrative only and not in a limiting sense, and I desire that only such limitations shall be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

What I claim as my invention is:—

1. Apparatus of the class described comprising a first series of dies consisting of a forming die adapted initially to form the article thereon from liquid stock and a plurality of heated drying dies, and a second series of dies consisting of a plurality of pressing dies mounted for co-operative engagement with the dies of the first series, and means for causing relative oscillation of the two series whereby each pressing die alternately co-operates, in pressing engagement, with two successive dies of the first series.

2. Apparatus of the class described comprising a first series of dies consisting of a drainage faced forming die adapted initially to form the article thereon from liquid stock, and a plurality of heated drying dies, and a second series of dies consisting of a plurality of drainage faced pressing dies mounted for co-operative engagement with the dies of the first series, means for causing relative oscillation of the two series whereby each pressing die alternately co-operates, in pressing engagement, with two successive dies of the first series, and means for permitting fluid pressure to communicate with the various dies.

3. Apparatus of the class described comprising an upper series of equally spaced apart dies consisting of a drainage faced forming die adapted initially to form the article thereon from liquid stock, and a plurality of heated drying dies, and a lower series of dies consisting of a plurality of drainage faced pressing dies mounted for movement as a unit and spaced equally with those of the upper series to permit simultaneous engagement and disengagement of the dies of the two series, means for oscillating the lower series whereby each pressing die thereof alternately engages with two successive dies of the upper series, and means for permitting fluid pressure to communicate with the various dies.

4. Apparatus of the class described comprising an upper fixed unit and a lower movable unit co-operating therewith, an upper series of dies carried by the upper unit, said upper series consisting of a drainage faced forming die adapted initially to form the article thereon by suction and immersion of the die in liquid stock, and a plurality of heated drying dies, the dies of said upper series being in alignment, a lower series of dies and a liquid stock tank, the lower series of dies carried by the lower unit and movable as a unit therewith, and stock tank mounted below the forming die, the lower series of dies consisting of a plurality of drainage faced pressing dies, said lower series of dies and the stock tank disposed in alignment and adapted for operative engagement with the dies of the upper series, means for reciprocating the lower series of dies and the stock tank vertically to engage and disengage the dies of the two series and to immerse the forming die in the liquid stock tank, means for reciprocating the lower unit horizontally to bring each die of the lower series into registration alternately with either of two successive dies of the upper series, and means for bringing the forming die into registra-

tion with the stock tank when the lower unit is at the extremity of its horizontal reciprocation remote from the stock tank.

5. Apparatus of the class described comprising a forming die adapted initially to form the article from liquid stock, a drying die and pressing dies, means for causing the forming die and drying die to move relatively to said pressing dies, in parallel planes, to selectively register the forming die and drying die with said pressing dies, and means for moving said registered dies towards each other for a pressing operation.

6. Apparatus of the class described comprising a forming die adapted initially to form the article from liquid stock, a liquid stock tank, a drying die and pressing dies, means for moving said liquid stock tank, and the pressing dies relatively to said forming die and drying die, in parallel planes, to selectively register the forming die with the liquid stock tank and the drying die with a pressing die and for reversing the operation to register the forming die and drying die with the pressing dies, and means for moving said dies towards each other for a pressing operation.

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