

March 12, 1940.

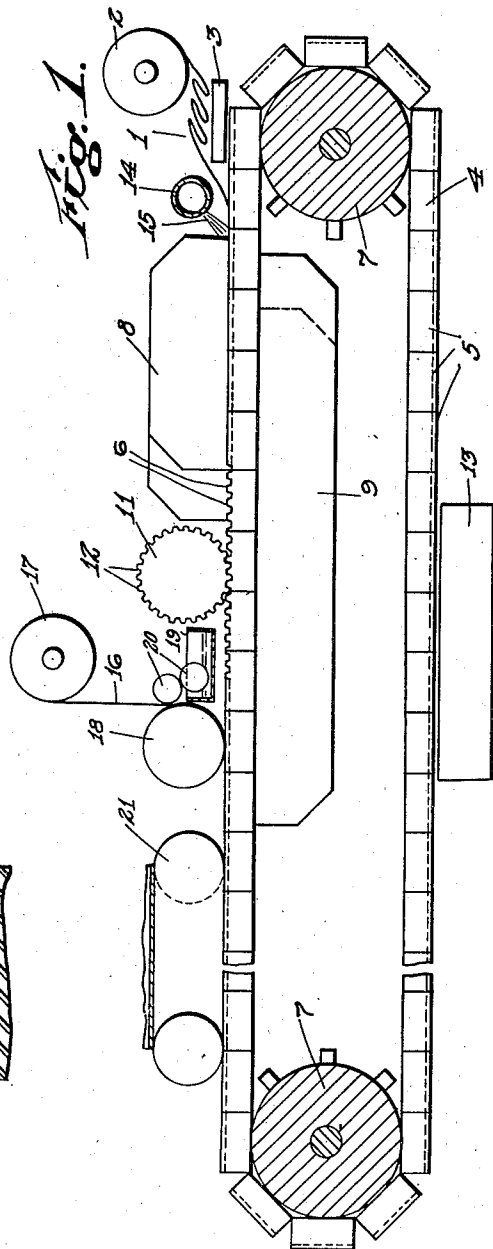
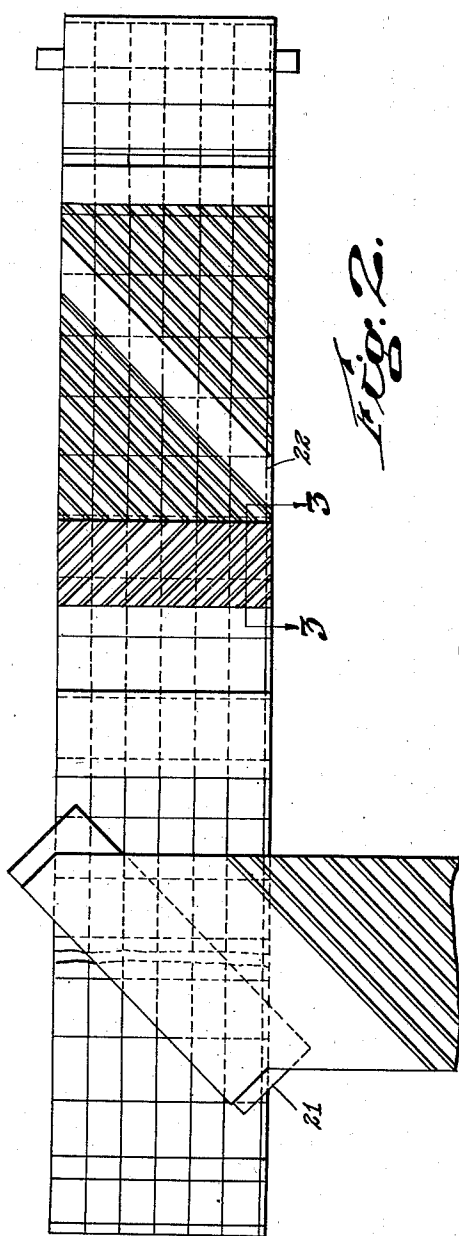
H. ATWATER

2,193,052

FORMATION OF CORRUGATED WEBS

Filed Jan. 7, 1937

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

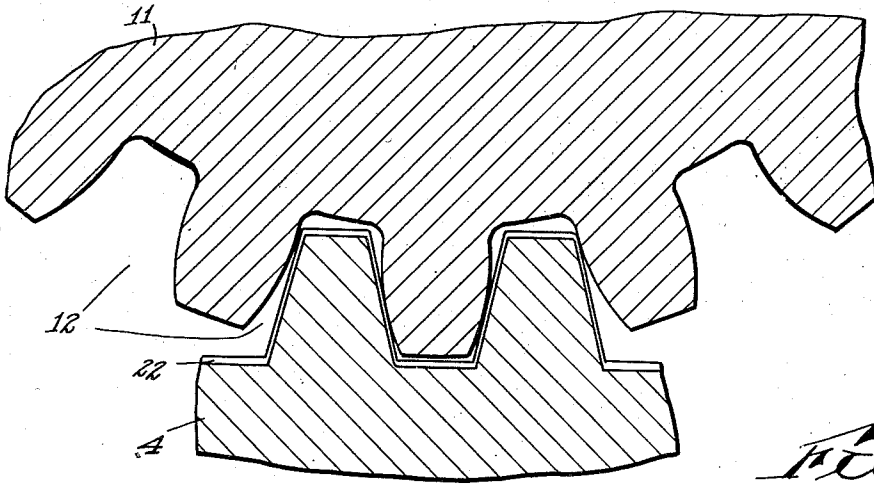


Fig. 3.

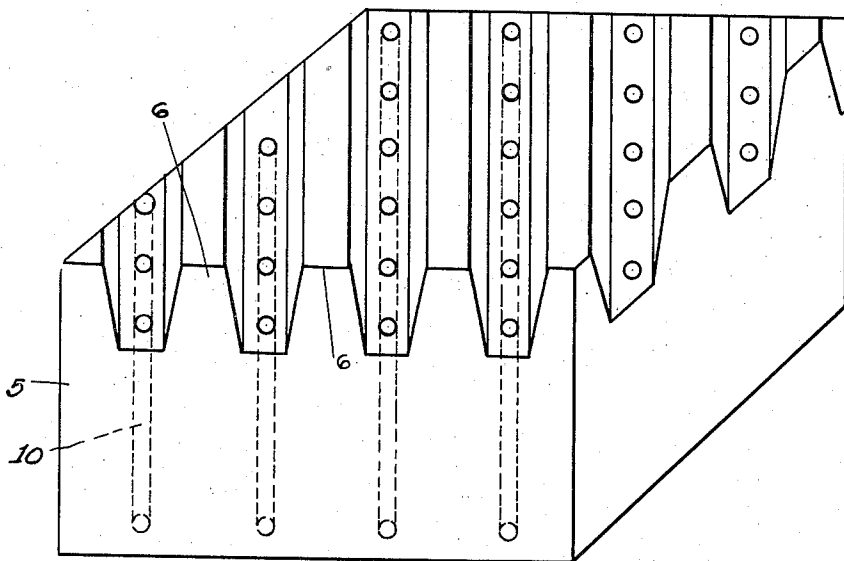


Fig. 4.

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5 Sheets-Sheet 3

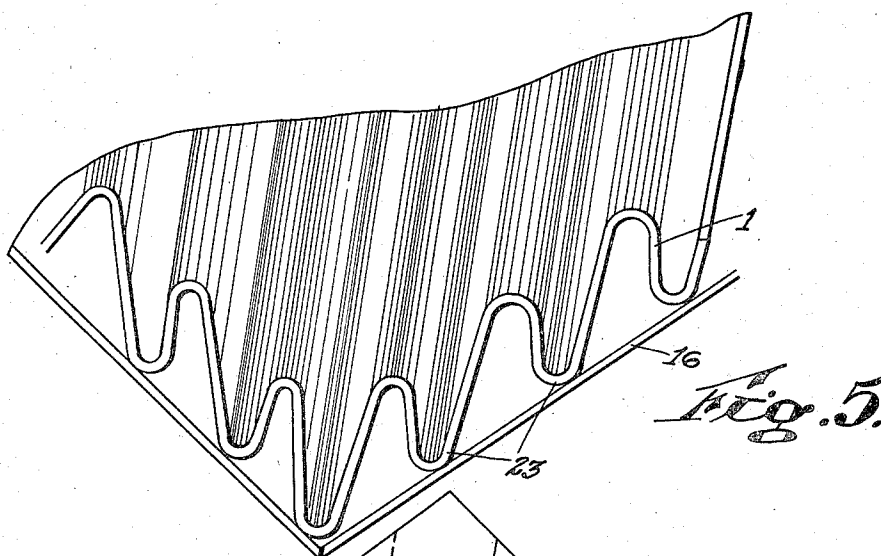


Fig. 5.

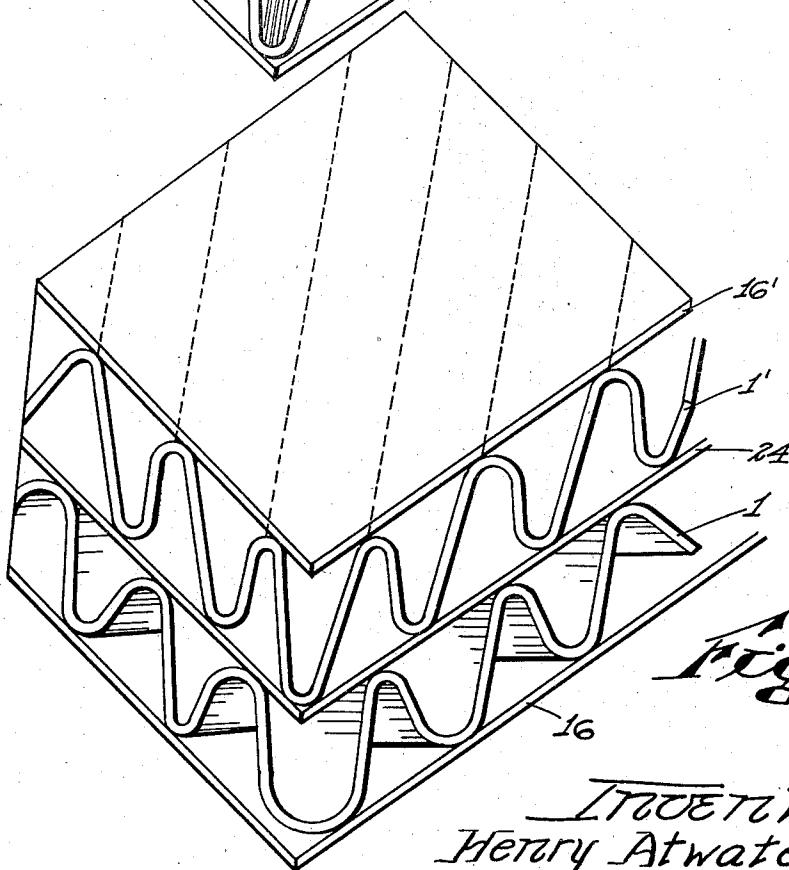


Fig. 6.

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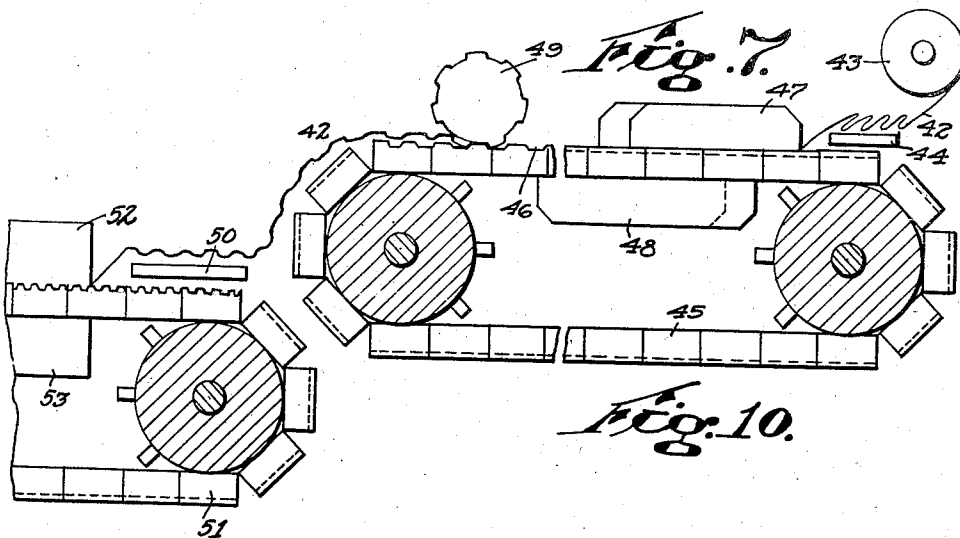
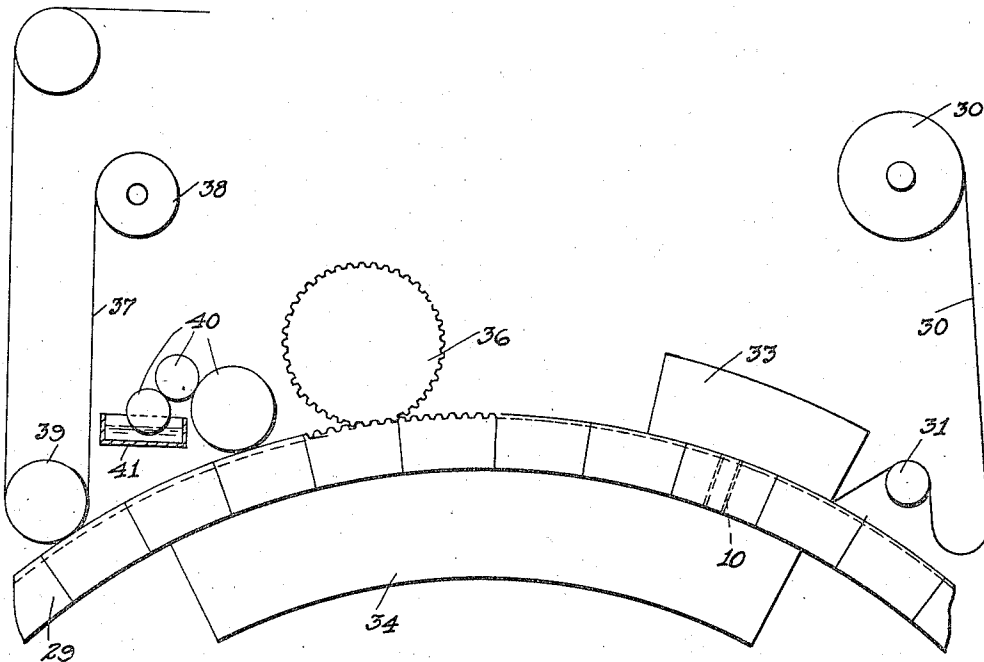
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FORMATION OF CORRUGATED WEBS

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5 Sheets-Sheet 4



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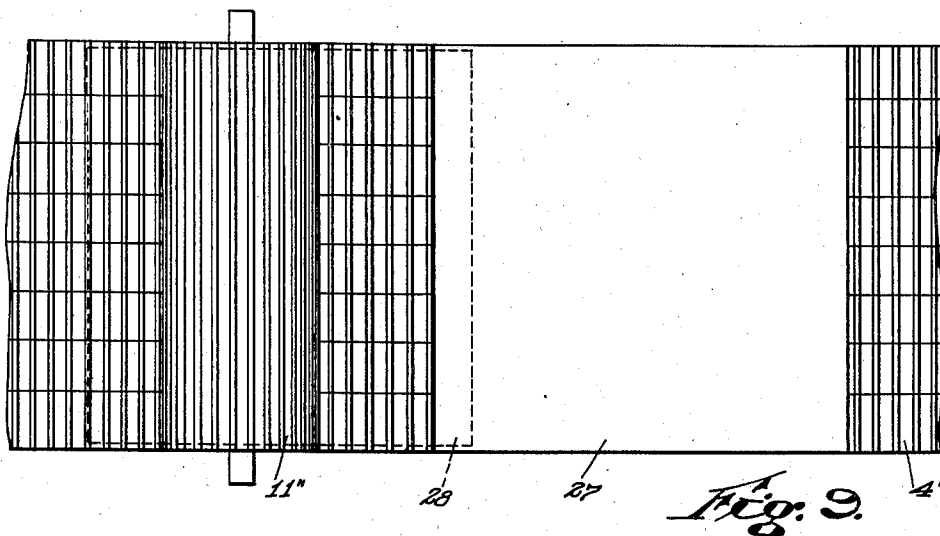
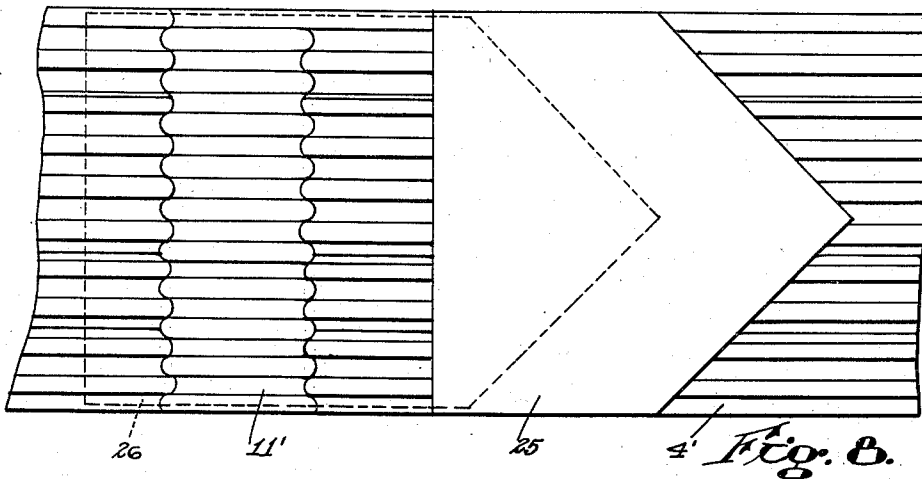
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FORMATION OF CORRUGATED WEBS

Filed Jan. 7, 1937

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,193,052

FORMATION OF CORRUGATED WEBS

Henry Atwater, Worcester, Mass.

Application January 7, 1937, Serial No. 119,451

13 Claims. (Cl. 154—30)

The present invention relates to the formation of a corrugated web, such as paper, and especially to an apparatus by which corrugations may be formed continuously in an elongated web with the corrugations extending longitudinally of, diagonally of, or at right angles to the direction of the web.

In the formation of corrugations in a web one of the difficulties encountered is the insertion of the web into the corrugations in a corrugated plate or roller without the formation of objectionable creases in the web and without tearing the web or crushing the fibres thereof. One of the objects of the invention is to provide for the formation of corrugations by forcing the web into a corrugated form by the use of fluid pressure.

After a web has been forced into the corrugations of a plate or roller the usual method for holding the web in place in the plate or roller has been by the use of fingers which engage with the corrugations and which frequently tear or damage the material of the web. A further object of the invention is to eliminate the necessity for the use of holding fingers or similar elements by the use of fluid pressure which will retain the web in its corrugated form until the paper has received a permanent set.

The invention also contemplates the formation of corrugated board made up of a corrugated web to the opposite sides of which a flat web is secured, the complete structure being formed by a continuous process, which makes possible the rapid production of the article.

A further object of the invention is the provision of an apparatus by which a corrugated web may be formed with the corrugations extending diagonally of the web. In accordance with this feature of the invention the apparatus embodies a plate or roller having diagonal corrugations therein, together with structure by which fluid under pressure may be applied to the web for forcing it into corrugations in the plate or roller and for holding the web in position until it has received a permanent set.

Other and further objects and advantages of the invention will hereinafter more fully appear from the following detailed description taken in connection with the accompanying drawings in which—

Fig. 1 is a front elevation of a machine embodying the invention, the machine being shown diagrammatically.

Fig. 2 is a plan view of the device of Fig. 1.

Fig. 3 is a fragmentary vertical section along the line 3—3 of Fig. 2.

Fig. 4 is a sectional view on a larger scale of one of the corrugated blocks.

Fig. 5 is a perspective view of the corrugated and covering webs as they are removed from the endless belt.

Fig. 6 is a perspective view of a portion of one form of a completed corrugated board which may be formed by the apparatus.

Fig. 7 is a fragmentary front elevation of a modified form of a machine embodying the invention.

Fig. 8 is a plan view of a modification for forming corrugations longitudinally of the web.

Fig. 9 is a fragmentary plan view of a modification, especially adapted for the formation of corrugations extending at right angles to the web.

Fig. 10 is a modified form of apparatus for corrugating a web.

Like reference characters refer to like parts in the different figures.

With reference first to Figs. 1 and 2, a web 1 of material, such as paper, is delivered from a suitable source, which may be a roll 2, and is laid loosely upon the upper side of a plate 3 at one end of a continuous belt 4. The web is drawn from the plate onto the belt, which is made up of a plurality of relatively small blocks 5, each having diagonal corrugations 6 in the outer side thereof. The endless belt is substantially wider than the individual blocks and accordingly, for a formation of the complete belt, a plurality of blocks are arranged side by side, as shown in Fig. 2, to make a belt of the desired width. The several blocks are connected together laterally so that in the upper pass of the belt the adjacent blocks are in engagement with each other and the diagonal corrugations of adjoining blocks are in line to form continuous corrugations extending the entire width of the belt. The adjacent blocks lengthwise of the belt are also connected together so that the belt may pass around supporting and driving sprockets 7 and so that the upper pass of the belt will present a continuous longitudinal surface for the corrugating of the web.

A chamber 8 is positioned above the upper pass of the endless belt adjacent to the plate 3 and is open at its underside. A suitable fluid under pressure is admitted to the chamber, this fluid being air or steam, or in certain cases, water or other liquid, and forces the web 1, which is between the chamber and the belt, into the corrugations in the belt. It will be noted that the

chamber 8 is relatively narrow, as shown in Fig. 2, and is parallel to the direction of the corrugations in the endless belt. It will be apparent that the fluid pressure acts individually on each successive corrugation in the plate so that the web is forced into each successive corrugation the entire length thereof before any action by the fluid pressure enforcing the web into the successive corrugation. Suitable sealing means may be provided between the edges of the chamber and the belt, if desired.

For retaining the corrugations in the web after they have been formed therein by the pressure in the chamber 8, a supplementary chamber 9, or other suitable fluid pressure mechanism, is positioned below the upper pass of the belt and the fluid in this chamber is maintained at a pressure less than atmospheric pressure, with a result that the web is held against the belt by the fluid pressure differential between the upper surface of the web and the underside thereof. As shown in Fig. 4, each of the blocks 5 has vertical orifices 10 to provide fluid connection between the bottoms of the grooves in the blocks and the suction chamber. It will be understood that, in certain cases, the suction chamber 9 may form the only fluid pressure means for forcing the web into the corrugations, so that no pressure chamber 8 is necessary.

After the corrugations have been formed in the web by the fluid pressure mechanism, the web is subjected to a pressing or ironing action by a roller 11 positioned above the upper pass of the belt and having helical ribs 12 which engage with the diagonal corrugations in the belt. The roller is preferably spaced from the belt a distance equal to the thickness of the web to avoid damaging the web as it passes between the belt and the roll.

The roll 11 is preferably heated to assure a more positive ironing action and to effect a partial drying of the web to provide a permanent set in the web. To cooperate with the heated roller 11 the belt itself may be heated from a suitable heater 13 which may be located beneath the under pass of the belt or within the suction chamber 9. An alternative method for heating the belt is to incorporate within the several blocks 5 electrical heating elements which can be suitably connected together and also connected to a source of electrical power.

In forcing the web into the corrugations by fluid pressure, the web is preferably moistened and this may be accomplished either by the use of a moistening fluid in the pressure chamber 8, or, in certain instances, by a steam jet positioned between the plate 3 and the pressure chamber 8. This jet preferably comprises a pipe 14 extending laterally of the belt and having a plurality of orifices 15 in the underside thereof for directing steam or other moistening gas or liquid onto the web.

After the web passes between the roller 11 and the endless belt, a covering web 16, of paper or other material, is applied to one side of the corrugated web. The web 16 is delivered from a supply, which may be in the form of a roll 17, and is passed around a roller 18 positioned above the endless belt and in engagement therewith. Before the web 16 engages with the corrugated web, adhesive from a tank 19 is applied to the under surface of the web by means of small parallel transfer rolls 20, one of which engages with the web and the other of which dips into the adhesive in the tank 19. The covering web 16

having been adhesively secured to the corrugated web, the combined webs are picked up from the endless belt by passing the combined webs around a diagonally positioned roller 21. The covering web having the corrugated web attached thereto will withdraw the corrugated web from the grooves in the endless belt without materially changing the shape of the corrugations. It will be understood that the roller 21 is preferably parallel to the grooves in the belt 4, although this is not entirely necessary.

The endless belt is driven by any suitable driving mechanism associated with one of the sprockets 7 and the roller 11 is driven from the endless belt by means of a rack 22 located at one edge of the endless belt. This rack (see Fig. 3) which has teeth corresponding in shape to the corrugations in the belt is elevated sufficiently above the plane of the remainder of the belt to hold the roller 11 in spaced relation to the belt sufficiently to allow the web to pass therebetween. It will be apparent that the rack teeth engage with the corrugations at the end of the roller 11, with these corrugations acting as gear teeth.

After the corrugated web and the covering web 16 are removed from the endless belt, a second covering web, not shown, may be applied to the opposite side of the corrugated web for the formation of a completed corrugated board. It will be apparent that, depending upon the use to which the corrugated web will be put, either of the covering webs may be eliminated, in which case the covering web 16 is applied to the corrugated web only long enough to lift the corrugated web out of the endless belt.

One example of a corrugated board which may be formed on apparatus of the type above described is best shown in Fig. 5. In this figure the corrugated web 1 has corrugations 23 which extend diagonally of the web, and the tops (or bottoms) of the corrugations are secured to the covering web 16.

In certain instances, especially in boxes to be used for shipping purposes, the corrugated board from which the box is made is of double thickness, as shown in Fig. 6. When a corrugated board of this character is formed from a corrugated web produced by the apparatus above described, it will be apparent that the corrugated web 1 having the covering web 16 applied to one side thereof has a second covering web 24 secured to the opposite side thereof with the corrugations extending, as will be apparent, in a direction diagonally of the longitudinal direction of the web. A second corrugated web 1' with a covering web 16' is applied to the sheet 24, with the corrugations in the web 1' extending at right angles to the corrugations in the web 1, thereby producing a double thickness corrugated board which is reinforced in all directions, and with all of the corrugations extending diagonally of the longitudinal direction of the web. It will be understood that a double thickness corrugated board of this character may readily be formed by placing two webs formed by similar apparatuses, as shown in Figs. 1 and 2, in superposed relation. When the double ply board is formed in this manner, one of the boards formed by one apparatus has a covering web applied to both sides of the corrugated web, and the other board has a covering web on only one side of the corrugated web. Then, when the two boards are put together with the corrugations in one board at right angles to the corrugations in the other

board, a double-ply board, as shown in Fig. 6, is produced.

With reference now to Fig. 8, there is shown a modified form of the apparatus of Figs. 1 and 2 adapted especially for the formation of corrugations extending longitudinally of the web. In this arrangement of the apparatus the corrugations provided in the endless belt 4' extend longitudinally, as will be apparent, and the pressure chamber 8 is replaced by a V-chamber 25, having a V-shaped front end, into which fluid under pressure is directed. The V-shaped point of the chamber is located midway of the belt 4' and the V points in a direction opposite to the direction of movement of the belt. Cooperating with the pressure chamber 25 is a suction chamber 26 having a V-shaped end located directly beneath the chamber 25 and on the underside of the belt for holding the corrugations in the paper by fluid under pressure after they have been formed therein by the pressure from the chamber 25. In this arrangement the corrugated web, when permanently shaped, is picked up from the endless belt in the manner above described in connection with the diagonally corrugated web.

The use of a pointed front end on the pressure chamber causes the web to be forced into the middle corrugation first, and subsequently into the adjacent corrugations, one by one, making possible a gradual narrowing of the web as the web is forced successively into the corrugations as the belt carries the web along underneath the chamber. This successive forcing of the web into adjacent corrugations is frequently referred to as corrugating "en échelon" when the corrugating is done by cooperating rollers which force the paper into its corrugated form.

It will be apparent that the corrugated web formed as in Fig. 8 may readily be creped by a creping blade shaped to conform to the flutes in the pressing and drying roller 6', or to the corrugations in the endless belt. In this arrangement the web would preferably be held in position by fluid pressure until the web reached creping position.

A further modification is shown in Fig. 9, in which the belt 4'' has the corrugations extending at right angles to the belt for the formation of corrugations at right angles to the longitudinal direction of the web. In this arrangement a pressure chamber 27 extends straight across the belt above the web to be corrugated, and is open on the underside thereof to provide for directing fluid under pressure within the chamber against the web to force it into the corrugations. This arrangement also has a suction chamber 28 beneath the belt for holding the corrugated web in the belt until the pressure roller 11'' has acted upon the web. In this arrangement the pressure chamber may be omitted and the suction chamber positioned to cooperate with the roller 11'' and aid in forcing the web into corrugated form, the fluid pressure action cooperating with the action of the roller 11''.

It will be understood that either of the pressure chambers 8 or 9 may be omitted so that the entire fluid pressure action for forcing the web into corrugated form in any of the arrangements described, is produced entirely either by the chamber above the web, or by the chamber below the belt. In either case the chamber in use must be so shaped as to provide for forcing the web into the corrugations of the belt and for holding

the web in the corrugations until the web has received a permanent set, or until it is desired to remove the web from the belt. As shown in Fig. 1, and as will be apparent, the leading edge of the suction chamber is preferably parallel to the leading edge of the pressure chamber and the leading edge of the pressure chamber in diagonal corrugating or in lateral corrugating is preferably parallel to the corrugations. It will be further noted that in the apparatus of Figs. 1 and 2, or in the apparatus of either Figs. 8 or 9, the suction chamber is preferably so located as to extend beyond the ironing roller and thereby to hold the paper in its corrugated form at least until the covering web 16 has been attached thereto, since, after this has been effected, the corrugations in the corrugated web are held in position by the covering web.

With reference now to Fig. 7, there is shown a modified form of device for corrugating a web, in which the corrugated plate into which the web is forced to form the corrugations, instead of being in the form of an endless belt, as in Figs. 1 and 2, is a large diameter hollow roller 29 which may be formed from blocks similar to the blocks 5, having curved outer surfaces, and also having openings 16' therethrough for cooperation with a suction chamber. In this arrangement a web 30 is directed from a supply roll 30' over a small diameter roll 31 located slightly above the large diameter roller 29, which, as above stated, has a corrugated outer surface with the corrugations running laterally, circumferentially, or diagonally, as desired.

A pressure chamber 33 outside of the large diameter roller 29 forces the web into the corrugations in the periphery of the roller and the corrugations in the web are retained therein by the pressure chamber and by a suction chamber 34 located within the roller and communicating with the corrugations in the periphery thereof through the small orifices 10' extending between the inside of the roller and the bottoms of the corrugations formed therein. A pressing or ironing roller 36 similar to the roller 11 provides for a pressing or ironing action on the corrugated web and a covering web 37 delivered from the supply roll 38 is subsequently applied to the corrugated web by a roller 39 which directs the web 37 against the tops of the corrugations in the web. Instead of applying adhesive to the web 37, the adhesive may be applied to the corrugated web 30 by the use of transferring rolls 40 which convey the adhesive from a tank 41. By this arrangement only a small amount of adhesive is required, since it is necessary to apply adhesive only to the tops of the corrugations in the web. The corrugated web with the covering web attached thereto may be removed from the roller 29 by leading the webs around the roller 39 in the same manner that they are carried around the roller 21 in the apparatus of Figs. 1 and 2 described.

In the modification of Fig. 7 the roller 36 is held a slight distance away from the roller 29 by an arrangement similar to that shown in Fig. 3. The large diameter roller 29 is provided, at one side thereof, with a gear, not shown, slightly larger in diameter than the remainder of the roller, and having teeth thereon engaging with the corrugations in the roller 36. It will be apparent that the roller 29 is of sufficient diameter to provide for the insertion of a heater inside of the roll for heating the periphery of the roller, as well as the suction chamber.

In the formation of the endless belt or the roller 29, if the corrugations are formed in relatively small blocks, such as the blocks 5, these blocks may be formed by die casting, in which case the corrugations and the orifices in the blocks may be formed in a single operation. When this is done it will be apparent that openings for electrical heating elements may be simultaneously cast within the blocks, providing a readily controlled means for heating the blocks to assure the blocks remaining at the desired temperature throughout the operation of the machine.

In certain cases, the fluid pressure in the pressure chamber may be a fireproofing or waterproofing liquid with which the web is to be impregnated, and the fluid under pressure thus effects a treatment of the web as well as a formation of the web into a corrugated form. It may also be possible or desirable to apply adhesive to the web by using, as the pressure fluid, a suitable liquid adhesive.

Since the pressure fluid may thus be dry or wet, and since the amount of liquid in the web may be controlled, it is apparent that the apparatus will function even if the web as it reaches the machine is extremely wet. Thus in corrugating paper the web may come directly from a paper making machine without being thoroughly dried first.

With reference to Fig. 10, the corrugating of the web is performed in two successive steps rather than in a single step, as in the structure described, in order that extremely heavy paper may be corrugated or in order that the machine may be adapted for high production. As shown in this figure, a web 42 of paper is directed from a suitable source, which may be a roll 43, onto a plate 44 which is positioned above one end of an endless belt 45 corresponding in general to the endless belt 45 above described. This endless belt is made up of blocks and the corrugations 46 formed in the surface of these blocks extend in a direction parallel to the desired direction of corrugating, which, in the arrangement shown, is diagonally of the web. A pressure chamber 47 is positioned above the upper pass of the belt and this chamber extends diagonally of the web in a manner similar to that of the chamber 8 for forcing the paper into the corrugations in the belt. In addition to, or in place of the pressure chamber there may be a suction chamber 48 positioned below the upper pass of the belt, communication from the suction chamber to the corrugations being provided by the openings, not shown, through the belt corresponding to the openings 10.

The corrugations in the belt 45, as shown, are much shallower than the final corrugations in the web are to be, but the distance from the base of one corrugation to the next, measured over the surface of the belt, is equal to the length of the web from the base of one corrugation to the next in the completed corrugations. The web is thus partially corrugated by this apparatus, which may also include a pressing and ironing roller 49 corresponding to the roller 11. From the belt 45 the partially corrugated web is directed onto a plate 50 located above one end of an endless belt 51 corresponding in all respects to the belt 4. The partially corrugated web passes unto the upper pass of the belt and is forced into the deeper corrugations by fluid in a pressure chamber 52 which may be replaced or supplemented by a suction chamber 53. From

this point on, the treatment of the web is the same as that disclosed in Figs. 1 and 2. It will be understood that in this arrangement the partially corrugated web can be more readily forced into the deeper corrugations of the belt 51 than would be possible if the web were entirely flat, as in the arrangement of Figs. 1 and 2, so that it is possible to corrugate webs of heavier material, or to corrugate webs of a similar weight at a faster rate of speed.

From the foregoing it will be apparent that the present invention provides for the formation of a corrugated web by forming the corrugations in the web by the use of fluid pressure. The method for forming these corrugations and the apparatus by which the method may be carried out, is susceptible of corrugating either laterally, longitudinally, or diagonally of a continuous web, making it possible for the formation of a corrugated web by a continuous process. The fluid pressure mechanism acts in conjunction with a corrugated plate which may be in the form of an endless belt or may be a large diameter roller, as in Fig. 7.

I claim:

1. The method of corrugating a web which involves providing a continuous belt having corrugations in the surface thereof, forcing a web progressively into the corrugations of the belt by fluid pressure acting individually on each successive corrugation and ironing the web while engaged with the corrugations by a cooperating corrugated roller so that the web will remain in permanently corrugated form.

2. The method of corrugating a web which involves providing a continuous belt having corrugations in the surface thereof, forcing a web progressively into the corrugations of the belt by fluid pressure acting individually on each successive corrugation, treating the web while engaged with the corrugations in the belt by a cooperating corrugating roller so that the corrugations in the web will be permanent, and subsequently removing the corrugated web from the belt.

3. The method of corrugating a web which involves providing a continuous belt having corrugations in the surface thereof, forcing a web progressively into the corrugations of the belt by fluid pressure acting individually on each successive corrugation, treating the web while engaged with the corrugations in the belt so that the corrugations in the web will be permanent, securing a flat web to one side of the corrugated web and subsequently removing the corrugated web and attached flat web from the belt.

4. Apparatus for corrugating a web which comprises a plate having corrugations therein, fluid pressure means cooperating therewith for forcing a web into the corrugations, and cooperating corrugated roller engageable with the web after the latter is forced into the corrugations for treating the web while in the corrugations so that the web will retain the corrugated form when removed from the plate.

5. Apparatus for corrugating a web which comprises a continuous belt having corrugations in the surface thereof, a corrugated roller cooperating with said corrugations in the belt, and fluid pressure means associated with the belt for forcing a web progressively into the corrugations of the belt prior to its engagement with the corrugated roller.

6. Apparatus for corrugating a web which comprises a plate having corrugations in the

surface thereof, a corrugated roller engageable with the plate for an action on a web as it passes between the plate and roller, and fluid pressure means acting individually on each successive corrugation for forcing the web progressively into the corrugations of the plate before the web reaches the roller.

7. Apparatus for corrugating a web, comprising a plate having corrugations in the surface thereof, fluid pressure means acting individually on each successive corrugation and over the entire length of each corrugation for forcing a web into the corrugations and for holding the web therein, and means for removing the web in its corrugated form from the plate, said fluid pressure means being inoperative at the point where the web is removed.

8. The method of corrugating a web which involves forming corrugations in the web to a depth less than the desired final depth of the corrugations, and then subsequently forcing the partially corrugated web into corrugations in a corrugated plate by fluid pressure.

9. The method of corrugating a web which involves forming corrugations in the web to a depth less than the desired final depth of the corrugations, and then subsequently forcing the partially corrugated web into corrugations in a corrugated plate by fluid pressure, the shallow corrugations first formed being spaced apart further than the final corrugations so that the length of the web between the bases of adjacent corrugations in the first step will be the same as the length of web in the final corrugations.

10. Apparatus for corrugating a web which comprises a plate having diagonally extending corrugations therein, suction means acting upon the corrugations in the plate for placing a web successively into adjacent corrugations in the plate, said suction means acting on each corrugation successively and throughout the length of each corrugation simultaneously, and a corrugated roller cooperating with the plate to perform an ironing action on the web after the formation of the corrugations therein.

11. Apparatus for corrugating a web which comprises a plate having diagonally extending corrugations therein, suction means acting upon the corrugations in the plate for placing a web successively into adjacent corrugations in the plate, said suction means acting on each corrugation successively and throughout the length of each corrugation simultaneously, a corrugated roller cooperating with the plate to perform an ironing action on the web after the formation of the corrugations therein, and a roller having its axis substantially parallel to the corrugations in the plate and over which the corrugated web is drawn for removal from the plate.

12. Apparatus for corrugating a web which comprises a plate having diagonally extending corrugations therein, suction means acting upon the corrugations in the plate for placing a web successively into adjacent corrugations in the plate, said suction means acting on each corrugation successively and throughout the length of each corrugation simultaneously, a corrugated roller cooperating with the plate to perform an ironing action on the web after the formation of the corrugations therein, and means for applying a smooth web to one side of the corrugated web while the latter is in the corrugations of the plate.

13. Apparatus for corrugating a web which comprises a plate having diagonally extending corrugations therein, suction means acting upon the corrugations in the plate for placing a web successively into adjacent corrugations in the plate, said suction means acting on each corrugation successively and throughout the length of each corrugation simultaneously, a corrugated roller cooperating with the plate to perform an ironing action on the web after the formation of the corrugations therein, and a smooth surfaced roller having its axis substantially parallel to the corrugations in the plate and over which the combined webs are drawn for removing the combined webs from the plate.

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