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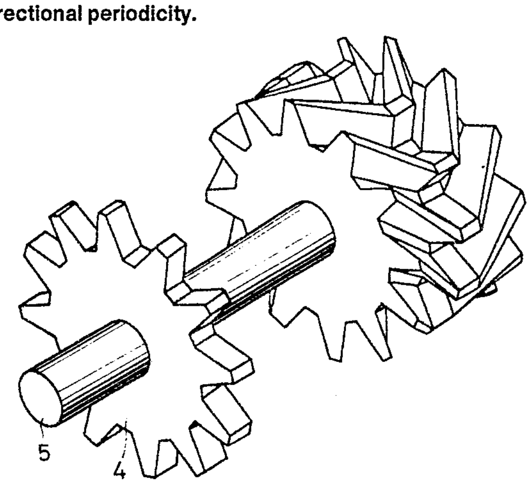
(71) Applicant: **Research Development Corporation of Japan, No.5-2, 2-chome, Nagata-cho Chiyoda-ku, Tokyo (JP)**

(72) Inventor: **Miura, Koryo, 9-7, 3-chome, Tsurukawa Machida-shi, Tokyo (JP)**
Inventor: **Kiuchi, Manabu, 12-21, 2-chome, Shinjuku Zushi-shi, Kanagawa (JP)**

(74) Representative: **Wood, Anthony Charles et al, c/o MICHAEL BURNSIDE & PARTNERS 2 Serjeants' Inn Fleet Street, London EC4Y 1HL (GB)**

(54) Method, apparatus and forming roll for forming material with a bidirectional periodicity.

(57) A sheet material (6) is passed between a pair of forming rolls (7, 8) having working surfaces with forming teeth of a wave-shape which has a periodicity within two mutually perpendicular sections. The rolls are constructed from elements in the form of helical spur gears (3) keyed on a common shaft (5) and may be interspersed with straight spur gears (4). This permits the continuous formation of a structural material having a bidirectional periodicity, that is a material (1) having a wave-form construction within each of two mutually perpendicular sections. The pitch of the waveform can be altered by changing the depth of action between the rolls. Such bidirectional material can have a structural performance comparable with that of a honeycomb sandwich material and has many other uses.



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Method, Apparatus and Forming Roll for Forming Material with a Bidirectional Periodicity

This invention relates to a roll forming method and apparatus therefor for continuously forming a structural material having a bidirectional periodicity.

The present inventor has previously proposed (in Japanese Patent Publication No. 54-23035) a structural material which is formed into a wave, each wave having trapezoidal wave head and wave bottom, said trapezoidal wave head and wave bottom being meandered in a zigzag or wave-like fashion within a surface formed by said wave head and wave bottom, and has a side inclined between the adjoining wave head and wave bottom, said side comprising a linearly woven surface having a bidirectional periodicity basically formed by a mother-line joining the wave head with the wave bottom.

The above-mentioned structural material has extremely excellent properties as follows:

(A) Shear rigidity rate within a surface vertical to an extent of the structural material is large.

(B) Elastic modulus in a direction vertical to an extent of the structural material is large.

(C) Machining and forming are easily achieved.

(D) The structural material can be designed without limitation to gage.

(E) The structural material can be used as a shock absorbing element.

Since the wave-form has a good appearance also in terms of design, the structural material can be used as an ornamental material without modification. Since a plane portion of the wave head comprises a joining surface, it can be joined with a single face plate to form a reinforcing plate having no directivity in strength. Two face plates may be joined to the wave head and wave bottom to form a sandwich construction whereby obtaining a structural material equal to a honeycomb structural material. A gap between the joined face plates is continuous to suitably restrict a flow of fluids, and a surface area is large. If this is utilized as a piping system, it may serve as a heat exchanging element. As described above, there are many uses.

A method using a press has heretofore been proposed to manufacture such bidirectional structural materials (For example, Japanese Patent Publication No. 52-44866). Such a manufacturing method is an extrusion forming which mainly relies upon ductility of a workpiece, in which an increase in surface area of an extruded portion is covered by a decrease in wall thickness of a workpiece of said portion with the result that the wave head and wave bottom which are locally large in deformation are liable to result in excessive decrease in wall whichness and breakage.

Therefore, a method has been heretofore employed wherein a wave-form protrusion of a die for the press is gradually increased in height from one end to the other to intermittently feed a metal plate pitch by pitch thereby enhancing the machining degree successively to prevent the breakage of material. In such a method, however, the manufacturing device becomes complicated and it is difficult to increase the productivity.

In accordance with the present invention, a bidirectional structural material is formed at one effort by male and female forming rolls having the same wave-form as that of the bidirectional structural material as mentioned above tothereby obtain a forming device having a high productivity without being suffered from those disadvantages as noted above.

According to the forming method using rolls, a material has a small portion to be restricted by rolls when it is processed, a folding effect of the material is brought forth at the time of forming, a formed article is shortened with respect to longitudinal and lateral lengths of the material to relieve the extrusion machining through that amount, and continuous forming at one effort is rendered possible.

Generally speaking, however, it is extremely difficult to produce the male and female forming rolls having the same wave-form as that of the bidirectional structural material. In the present invention, the forming rolls are divided into a number of segments, each segment having a shape of a helical spur gear and a straight spur gear, which are combined to form a forming roll. Accordingly, the rolls may be produced very easily.

The present invention will now be described in detail with reference to the accompanying drawings.

Figures 1 and 2 are respectively perspective views showing one example of a structural material formed by a forming device in accordance with the present invention;

Figures 3(a) and 3(b) are plan views showing embodiments of a forming roll in accordance with the present invention;

Figures 4(a) and 4(b) are perspective views showing embodiments of a forming roll;

Figures 5 and 6 illustrate the function of a roll forming machine in accordance with the present invention;

Figures 7(a) and 7 (b) illustrates tandem forming devices.

Fig. 1 is a perspective view of one example of a structural material 1 having a bidirectional periodicity formed by a forming device in accordance with the present invention, a zigzag vertical angle α formed between the wave head and wave bottom being 90^{O}. Material is liable to be broken at the time of forming in the vicinity of zigzag top portions encircled by dotted lines, and in order to relieve deformation of said portions, the vertical angle α can be made to have 120^{O} or a parallel portion 2 is provided in the vertical angle portion as shown in Fig. 2.

In the present invention, a roll for forming a structural material 1 shown in Fig. 1 or Fig. 2 from a flat plate such as metal is formed with forming tooth-forms associated with the surface of the roll in a zigzag fashion which shows only the wave head in Fig. 3. There are a lateral type forming roll in which forming tooth-forms are continuous in an axial direction of the roll as shown in Fig. 3(a) and a longitudinal forming roll in which forming tooth-forms are continuous in a peripheral direction of the roll as shown in Fig. 3(b). The lateral type forming roll is more realistic than the other in terms of fabrication as will be described hereinafter.

That is, as shown in Fig. 4, the forming roll is divided into segments corresponding to individual linear portions of the forming tooth-forms, and accordingly, each segment is in the form of a helical spur gear 3 or a straight spur gear 4, which is slipped round a shaft 5 by means of a key or the like as is well known. Each segment may be readily manufactured by a conventional technique for manufacturing gears.

A material 6 may be passed through between the pair of forming rolls as described to thereby continuously form a structural material 1 at one effort. In this forming method, such formation seems to be rendered possible because a restricted portion by the rolls is small, a shrinkage of length about 10 to 30% is appeared in the lengthwise direction of the material 6 at the time of machining, and extrusion machining is relieved through that amount. However, it is still desirable to slightly round off corners of the forming tooth-forms.

In Fig. 5, the wave height or pitch of the structural material 1 is not determined by the tooth height of the forming rolls 7, 8 but determined by a position 9 at which the tooth top touches with the material. Therefore, the depth of action between both the forming rolls 7, 8 may be adjusted to thereby manufacture a structural material different in pitch by the same forming device.

In the event the depth of action between both the forming rolls 7, 8 is made to be shallow in order to have a smaller pitch, a gap between the forming tooth-forms is increased, and therefore, if it is designed so that only one roll 8 is a drive roll and the other roll is a driven roll, the wave-form of the structural material 1 has a sharp inclination at the front side in the moving direction of the material 5 and has a gentle inclination at the rear side thereof. Thus, in order to form a wave-form having equal inclinations at front and rear, it is necessary that both the rolls are driven so as to equalize the gap of the forming tooth-form at front and rear.

If forming is accomplished with the depth of action between the forming rolls made to be shallow, as described above, the wave head and the wave bottom 10 of the wave-form of the structural material 1 are curved to fail to provide a plane. Therefore, it becomes difficult to utilize this for use in joining with the face plate as in the case of utilizing it as a heart-material for a sandwich structural material. Because of this, a plurality of forming stands are used and forming is accomplished by the forming roll 11, as shown in Fig. 7 (b) after which a sizing roll or a setting roll 12 may be used to improve a flatness of the wave head and wave bottom. Sometimes, the inclined surface joining the wave head with the wave bottom has its mother-line which is not a straight line or which is not a linearly woven surface in a sense of accuracy. However, it is often the case that the strength is satisfactory without modification.

In addition, in case of forming a material which is difficult in machining or in case of particularly requiring precision, it is desired that a plurality of forming stands are used to serve as a tandem forming method whereby a material is formed by a preforming roll 13 into a shape close to a required structural material, and then the thus obtained material is finished to a final shape and dimension. In Figure 7(a), reference numeral 15 designates a gap adjusting means for the roll 13, which can be in the form of a suitable well-known mechanism such as a mechanism in which a bearing portion is moved up and down by a screw.

CLAIMS

1. A method for forming sheet material into a structural material with a bidirectional periodicity (1) characterised by passing the sheet material (6) between a pair forming rolls (7,8) having working surfaces with forming teeth of a wave-shape which has a periodicity within two mutually perpendicular sections.

2. Apparatus for forming sheet material into a structural material with a bidirectional periodicity (1) characterised by a pair of cooperating forming rolls (7,8) each having a working surface with forming teeth of a wave-shape which has a periodicity within two mutually perpendicular sections.

3. Apparatus according to claim 2 characterised by means for adjusting the depth of action between said rolls.

4. Apparatus according to claim 2 or claim 3 characterised in that each said roll is a driven roll.

5. Apparatus according to any one of claims 2 to 4 characterised by a pair of finishing rolls (12) downstream of said forming rolls to improve the flatness of the peaks and troughs of the wave-shape in the formed material.

6. Apparatus according to any one of claims 2 to 5 characterised by a pair of pre-forming rolls (13) upstream of said forming rolls to partially form said sheet material towards said structural material.

7. Apparatus according to any one of claims 2 to 6 characterised in that each said forming roll (7,8) is constructed from a plurality of elements in the form of helical spur gears (3).

8. Apparatus according to claim 7 characterised in that each said forming roll includes an element in the form of a straight spur gear (4) between two said helical spur gears (3).

9. A forming roll for shaping sheet material, characterised in that said forming roll (7,8) is constructed from a plurality of elements in the form of helical spur gears (3) to provide a forming roll having a working surface with forming teeth of a wave-shape which has a perodicity within two mutually perpendicular sections.

FIG. 1

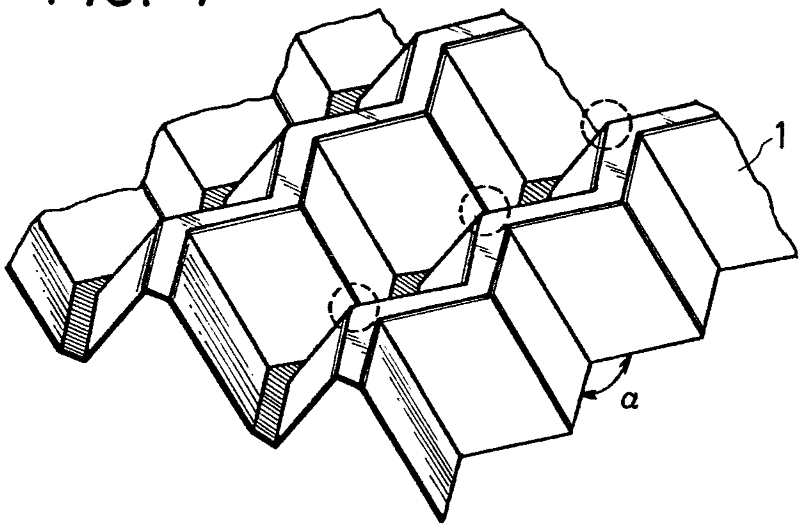

FIG. 2

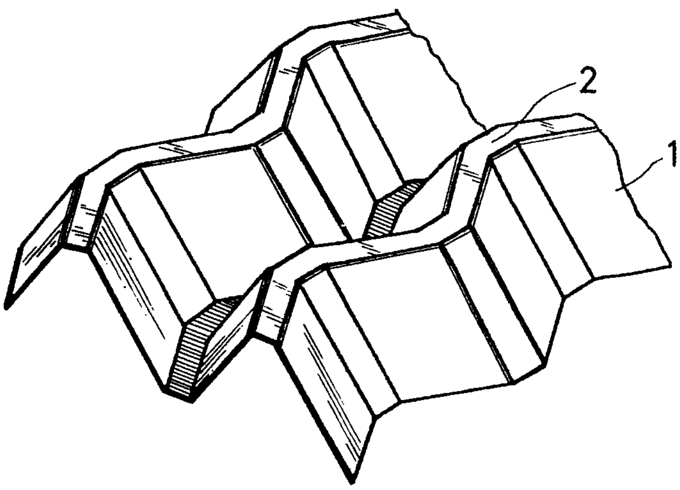

FIG. 3(a)

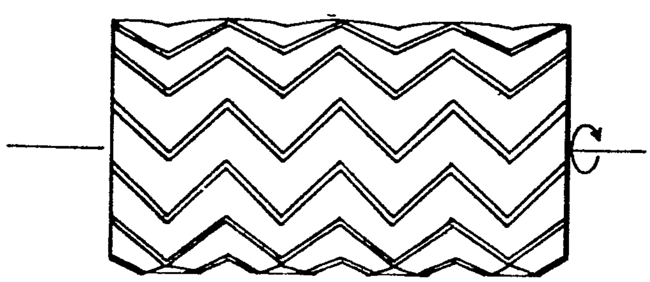

FIG. 3(b)

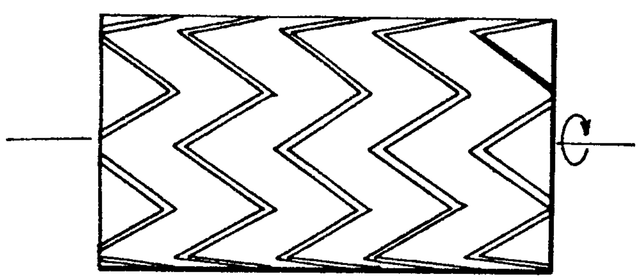

FIG. 4(a)

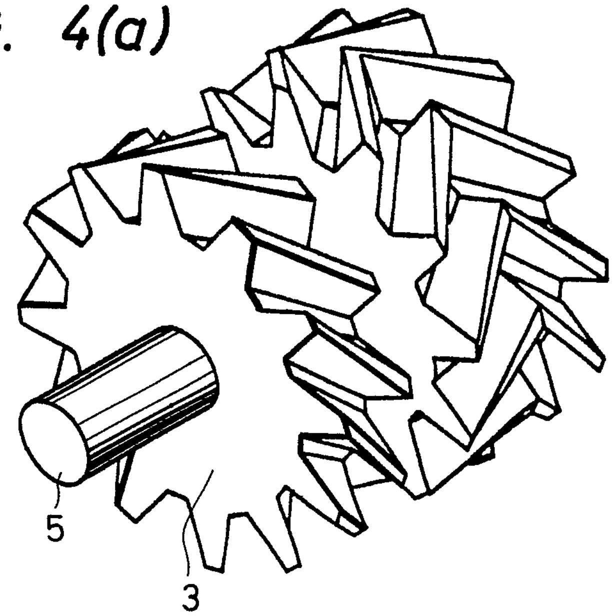

FIG. 4(b)

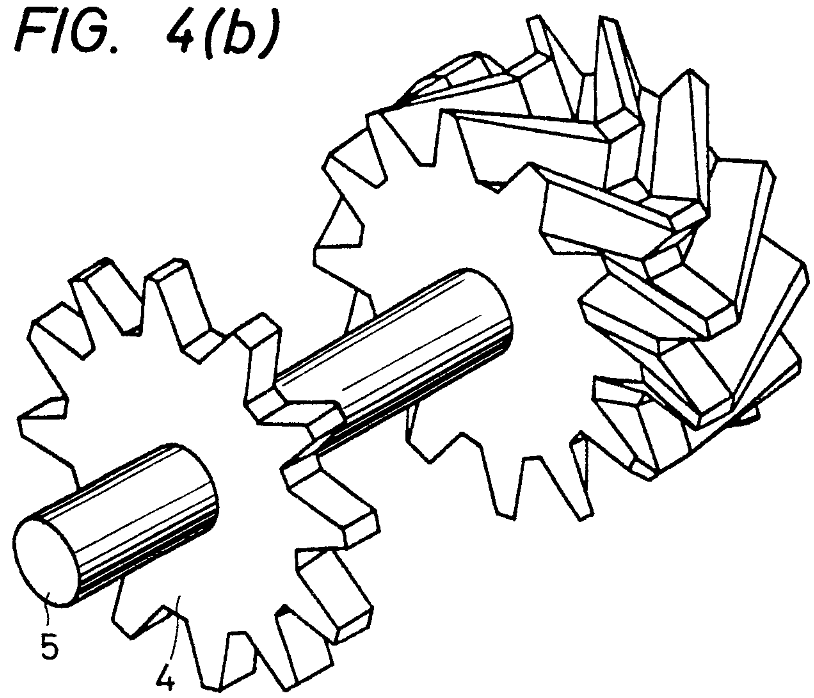

FIG. 5

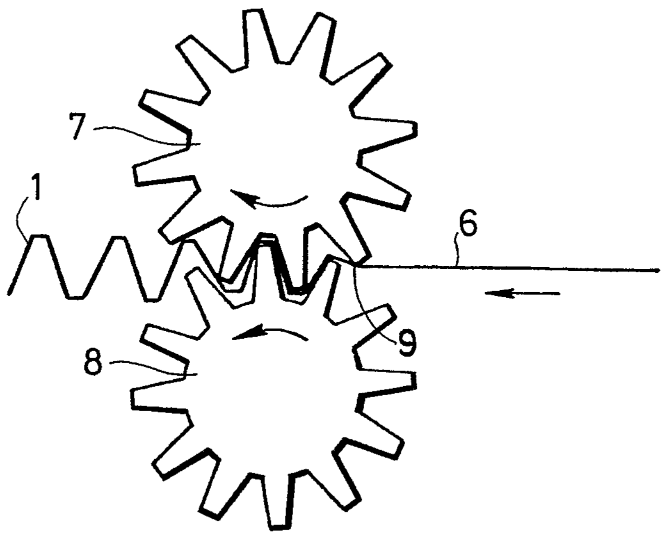

FIG. 6

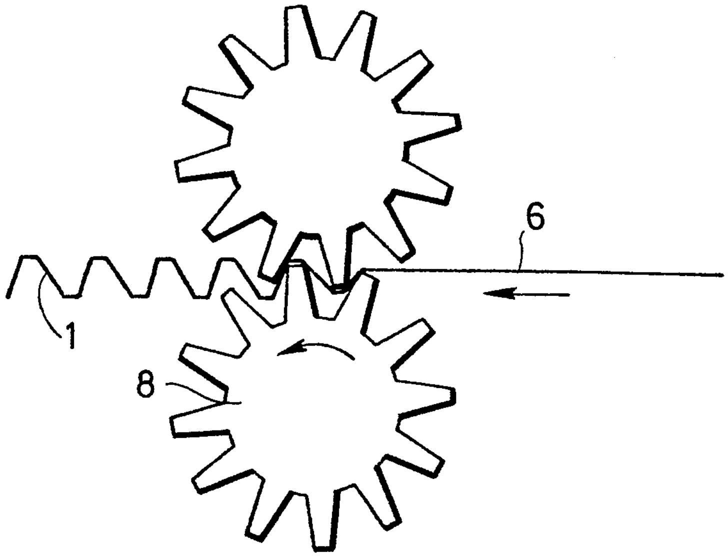

FIG. 7(a)

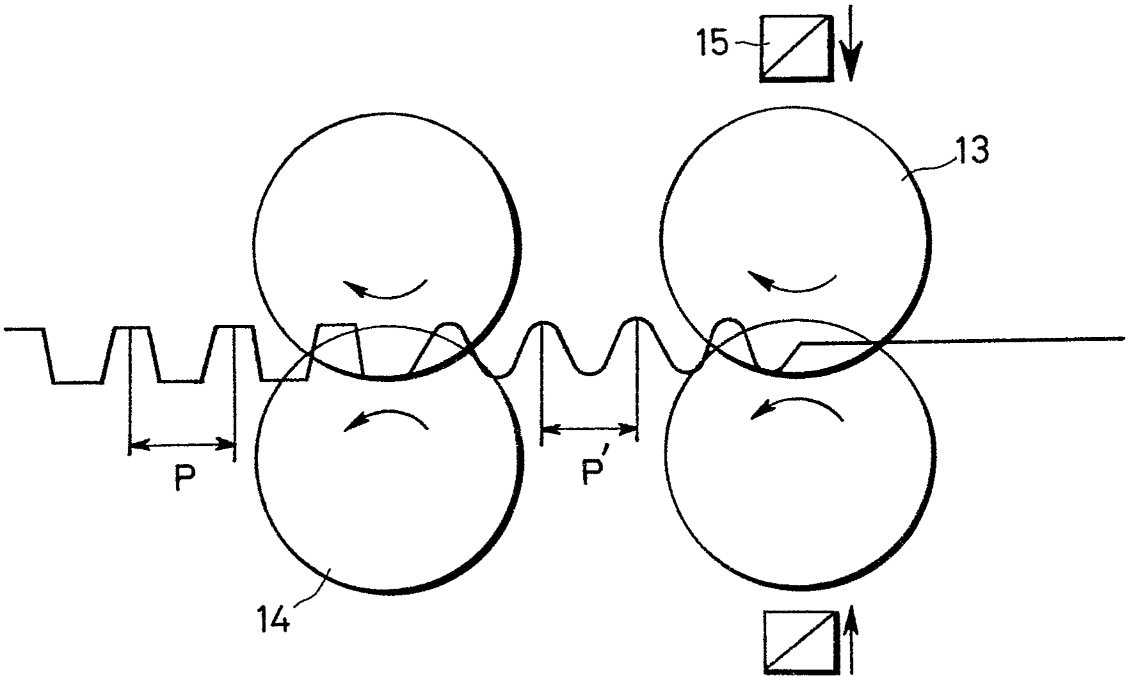

FIG. 7(b)