Oct. 1, 1968 J. D. BOVA 3,403,542

METHOD FOR EXPANDING ALUMINUM HONEYCOMB

Filed April 28, 1966 4 Sheets-Sheet 1

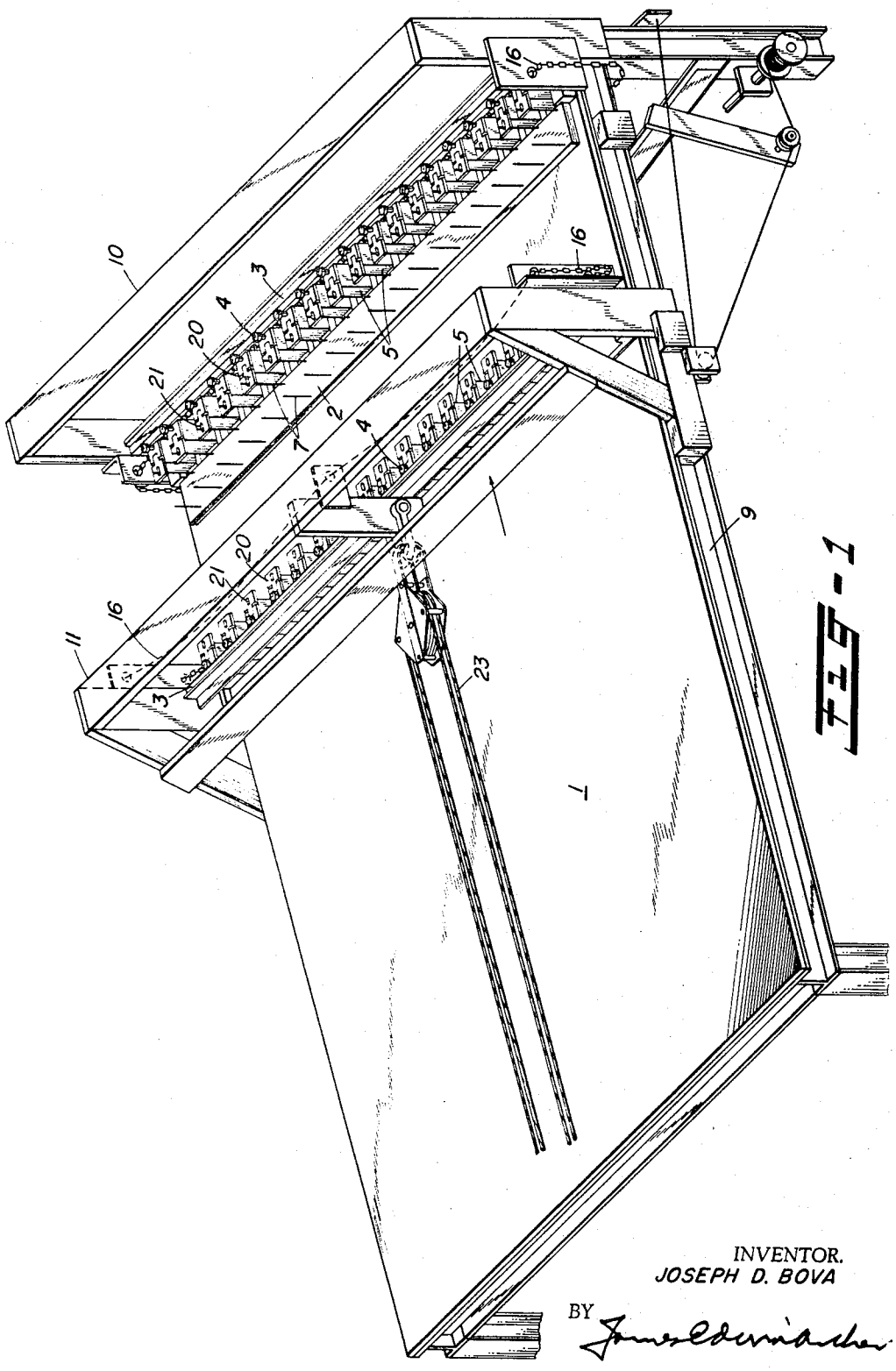


FIG-1

INVENTOR.
JOSEPH D. BOVA

BY James Edwin Archer

ATTORNEY

Oct. 1, 1968 J. D. BOVA 3,403,542

METHOD FOR EXPANDING ALUMINUM HONEYCOMB

Filed April 28, 1966 4 Sheets-Sheet 2

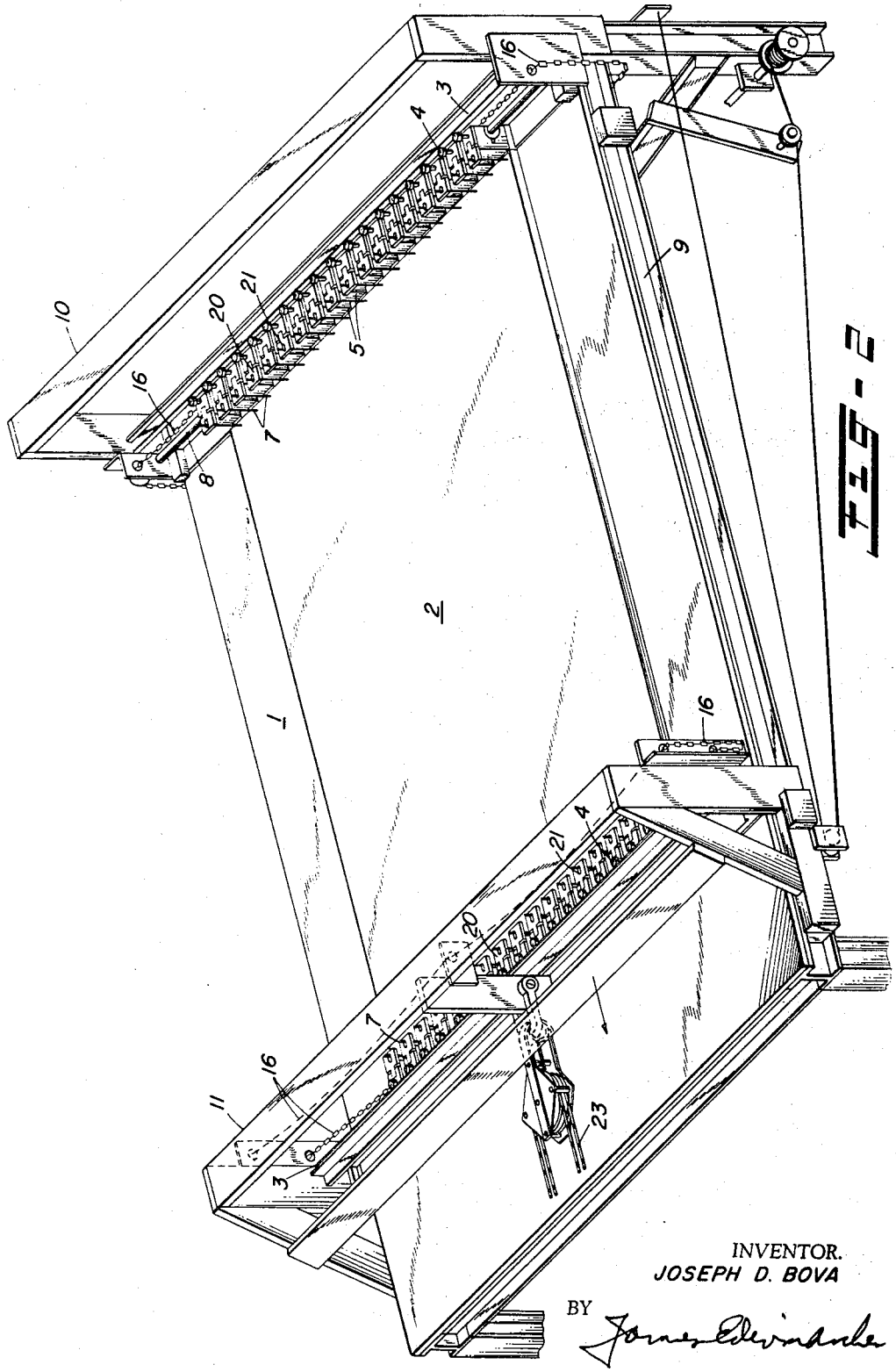


FIG. 2

INVENTOR.
JOSEPH D. BOVA

BY James Edwards

ATTORNEY

Oct. 1, 1968 J. D. BOVA 3,403,542

METHOD FOR EXPANDING ALUMINUM HONEYCOMB

Filed April 28, 1966 4 Sheets-Sheet 3

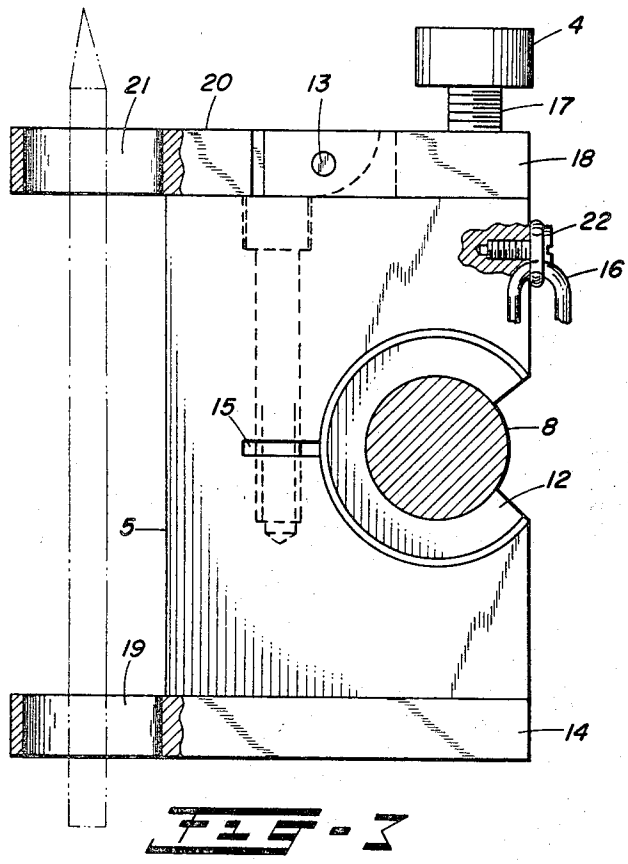


FIG-3

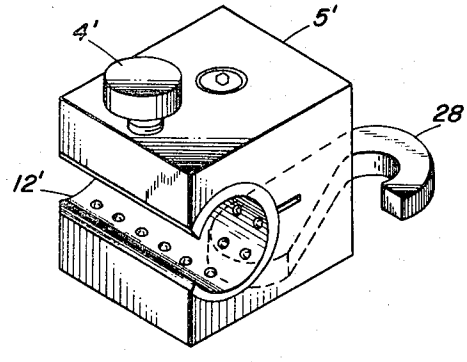


FIG-5

INVENTOR.
JOSEPH D. BOVA

BY James Edwin Archer

ATTORNEY

Oct. 1, 1968 J. D. BOVA 3,403,542

METHOD FOR EXPANDING ALUMINUM HONEYCOMB

Filed April 28, 1966 4 Sheets-Sheet 4

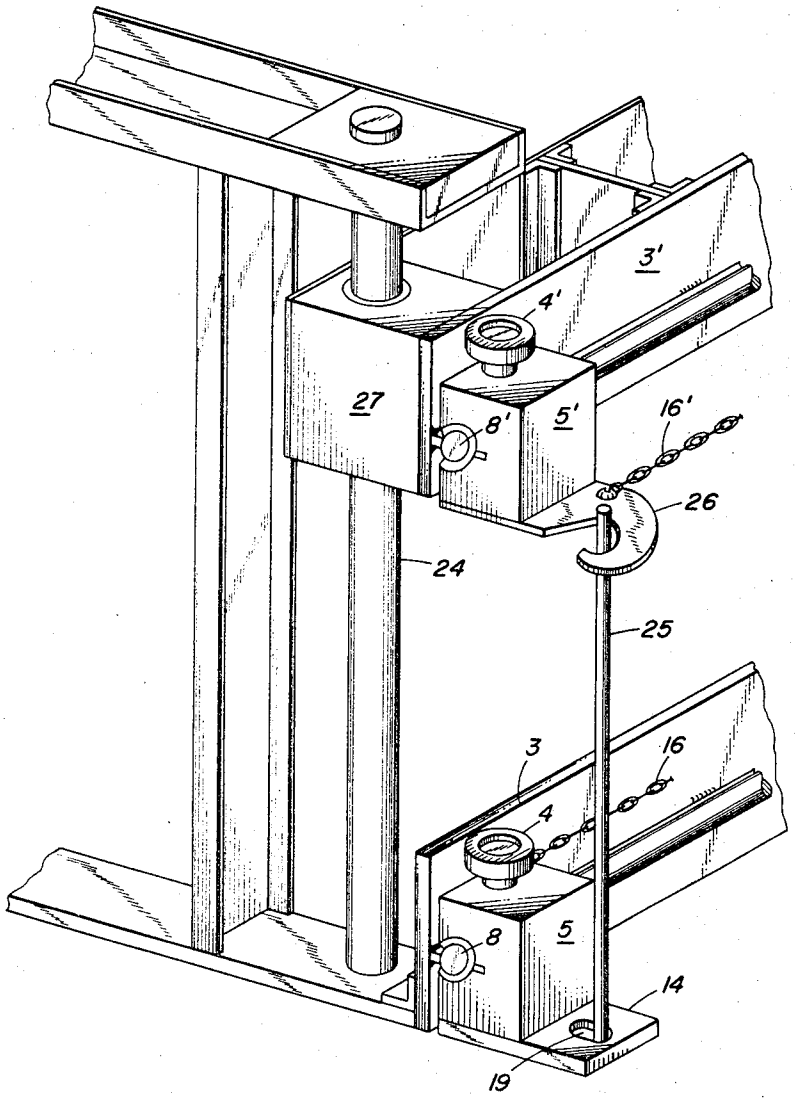


FIG - 4

INVENTOR.
JOSEPH D. BOVA

BY James Edwards

ATTORNEY

United States Patent Office 3,403,542 Patented Oct. 1, 1968

3,403,542

METHOD FOR EXPANDING ALUMINUM HONEYCOMB

Joseph Don Bova, Fallston, Md., assignor to American Cyanamid Company, Stamford, Conn., a corporation of Maine

Filed Apr. 28, 1966, Ser. No. 545,941
8 Claims. (Cl. 72—302)

ABSTRACT OF THE DISCLOSURE

A honeycomb blank expanding machine provided with a table, two frameworks, rods with pin carrying members having rollers bearing on a track carried by the framework is improved by providing each pin carrying member with a ball bearing bushing sliding on the rod. Flexible, inextensible, spacing elements are attached to each pin carrying member the length of the elements corresponding to the spacing of the pin carrying members at the beginning of honeycomb blank expansion. During operation as the frameworks with their rods move apart axial movement of the pin carrying members on their rods proceeds with minimum friction and without binding. Initial pin carrying member spacing is restore after expansion and removing of the honeycomb by pulling the spacing elements. The framework is provided with columns and the upper rod and track of each framework are mounted in carriages vertically slidable on the columns so that blanks of different thickness can be expended.

This invention relates to an improved device for expanding honeycomb structure and more particularly to elements thereof which connect to honeycomb structure to be expanded.

Expanded honeycomb structures, particularly of light metals such as aluminum, have achieved wide use in formation of relatively stiff and light structural elements for aircraft and other purposes. These structures are normally first made in relatively compact form and then are stretched out on a suitable table to assume the final expanded honeycomb structure. It should be noted that in the art the term "honeycomb" is used rather loosely and is not limited to structure in which closed, hexagonal cells are formed, as in natural honeycombs.

The general mechanisms used for expanding honeycomb structures involve a series of members slidable on a metal rod which are attached on both sides to the honeycomb structure through pins extending through suitable openings in the elements. It is also common to provide a framework with a suitable channel or track which is moved with the bar or rod and along which the elements can slide. Normally one of the frames is stationary on the expanding table and the other frame is moved away, for example in suitable tracks or channels at the sides of the table. As the movable frame separates from the stationary frame, the honeycomb structure is pulled out laterally and expanded. Obviously, of course, the expansion of the honeycomb structure in one direction requires that the material contract in the other direction at right angles thereto. This is provided for by making the pin-carrying members slidable on the rod or shaft carried by the frames, and as the honeycomb structure expands, the members carrying the pins move closer to each other to provide for the contraction referred to above.

In the past, a serious problem has arisen. It should be realized that the force pulling the two edges of the honeycomb structure is very great, particularly if the metal of the structure is of substantial gauge or the final

panels are quite long or both. Theoretically, the pins should pull perfectly normal to the rod on which the pin-carrying elements slide. In practice, this is an ideal which is not closely approached; and as a result, there is a considerable tendency to turn the pin-carrying elements on axes at right angles to the rod. This causes great increase in friction on the shaft, and serious binding and wear can result. Of course, if the expanded honeycomb structure is to be uniform, the pin-carrying elements must move freely and cause no distortion in the honeycomb structure. The problem has resulted in two unfortunate phenomena: first, the likelihood of non-uniform honeycomb structures increasing the possibility of rejects; and second, that in order to avoid non-uniformity to as great a degree as possible, the expansion has been kept relatively slow, thus making for reduced outputs from a given machine. Another important problem is the spacing of the pin-carrying members initially, and this must be effected without undesired binding. In addition to the principal problems set out above, increased power is required and increased wear results.

The problems are solved by the present invention by providing the pin-carrying members with ball bearing bushings through which the main rod of each framework passes. These bushings are also provided with means for clamping them to a sufficiently tight fit on the rod so that no non-uniformity due to looseness can occur. It is not practical to clamp plain bearings onto the rod so tightly, as the increased friction and binding would then become so great as to be intolerable.

The ball bearing bushings take care of movement in two directions. The pin-carrying members slide easily along the rod even though being pulled with great force and the members can turn slightly about the rod with equal ease. It should be noted that while the members can turn slightly about the rod, this should be limited and should not result in any binding. This is effected by having the top portion or plate of the pin-carrying members being provided with a short projection on which a roller 4 turns freely and bears against a track on the stationary and movable frameworks of the machine. The rollers may be pressed against the track with a great deal of force, which would bind but for the rolling action, which permits limiting the amount the pin-containing members can turn on the rod. Improved quality, increased output and reduced wear and power consumption are all obtained at the same time without any offsetting disadvantages. In other words, the present invention does not represent a compromise in which certain qualities are obtained at the loss of others and gives optimum results without any offsetting disadvantages. Needless to say, lubrication problems are also simplified, although these have not been the most serious problems in the past.

Another important feature of the present invention is that a flexible connection is provided which is fastened to the backs of the pin-carrying members out of contact with and not interfering with movements of the plate carrying the pin resulting from slight turning of the bushing on the rod. This connection is fastened so that the dimensions between pin-carrying members is precisely that required for the spacing of the pin carrying members initially before the honeycomb structure has been formed. During formation, as the honeycomb blanks are pulled out, the contraction along the rod, which has been referred to above, causes the pin-carrying members to move closer together, and the links of chain hang down in curves. The fastenings of the connection to each pin-carrying member must be at a point where this slack between pin-carrying members does not jam in any part of the mechanism. This is essential. When the honeycomb has been

fully pulled out and the pins are removed, the connection, such as a chain, is then pulled, and the pin-carrying members are slid out into their initial positions. The chain can be permanently fastened to each pin-carrying member if a constant spacing is always used or it may be attached so that different spacings can be produced. Chains which permit ready fastening of a link are a practical form, but the invention of course is not limited thereto, as any flexible but substantially inextensible element can be used. An example of a flexible but inextensible connector is a piece of cable with loops on each end which can be bolted or otherwise fastened to the pin-carrying members. It is also possible to use telescoping tubes between the pin-carrying members, and these operate satisfactorily but are not quite as simple in construction.

When the height of the honeycomb structure is not excessive, it is advantageous to have the pin-carrying members of the same height as the blank. This makes for a rugged and simple construction, but it is not well suited for very tall blanks, and in such a case long pins may be used with top and bottom pin-carrying members, each moving on a separate rod.

In most cases the pins can go through spaces in the honeycomb blank itself, and with blanks of moderate height this is both a simple and rugged construction. However, when greater heights are involved, it is sometimes desirable to attach a series of individual flexible loops to the outside of the blank, through which loops the pins pass. These loops may be attached to the honeycomb blanks by any suitable means, the simplest being by means of adhesives. The loops should be so arranged that the pull on them exerts a pull in shear on the adhesive line and not in a direction which would tend to peel the flexible material off from the blank.

The invention will be described in conjunction with two specific preferred modifications, but it should be understood that the basic new combination of the present invention is not to be considered as limited to the exact structural details of the preferred modification set forth in the specific description.

The invention will also be described in connection with the drawings, in which:

FIG. 1 is a perspective of an expander with the honeycomb at the start of its expansion;

FIG. 2 is a similar view with the honeycomb nearly fully expanded;

FIG. 3 is a side elevation of a pin-carrying member;

FIG. 4 is a perspective of a double rod pin-carrying member for high blanks, and

FIG. 5 is a detail view of a modified form of upper pin-carrying member.

The honeycomb expander in FIGS. 1 to 3 is shown at **1** with a honeycomb blank **2** and a stationary frame **10** carrying a rod **8** and a channel track **3**. The movable frame is shown at **11**, the other elements bearing the same reference numerals as in the stationary frame. The movable frame is moved in a channel track **9** by a conventional block and tackle **23**. On the rods **8** there are mounted a series of pin-carrying members **5** with rollers **4** rolling on the tracks **3**. The rollers permit exerting a great deal of force on the pins without binding, which would interfere with the free lateral sliding of the pin-carrying members on the rod.

Each element **5** is provided with a ball bearing bushing **12** and a slot **15**. On the bottom there is a plate **14** with a pin receiving opening **19**. On the top there is a similar plate **18** which, however, does not extend beyond the main part of the member **5** and is connected to a member **20**, pivoted on the pin **13**. Through **20** extends a pin receiving opening **21** registering with the opening **19** in the bottom plate **14**. The member **18** is clamped onto the main body **5** by means of a bolt **17** which carries the roller **4**. On the back of the pin-carrying member **5** a chain **16** is mounted by means of a bolt or pin **22**. The number of links between each pin-carrying member correspond to the spacing between pin-carrying member **5** and the start of the expansion. This can be seen at the right of FIG. 1.

At the start, as represented in FIG. 1, the honeycomb blank **2** is placed and the members **20** of the pin-carrying members **5** on both sides are folded up. Pins **7** are then passed through the honeycomb blank into the openings **19**, and then the members **20** folded down so that the openings **21** pass over the top of the pins **7**. The machine is started and the framework **11** moves to the right under the pull of the block and tackle **23**, pulling with it the right hand edge of the honeycomb blank **2**. As the latter stretches out, it contracts in a direction parallel to the rods **8**, and the members **5** slide on the rods **8** but do not bind regardless of the large force used in expanding the honeycomb blank. Similarly, binding on the track **3** is prevented because the rollers **4** turn readily thereon even when the force exerted is very considerable. Finally, when the honeycomb blank is fully expanded as shown in FIG. 2, the machine is stopped, the members **20** folded up, the pins **7** withdrawn, and the expanded honeycomb blank removed. The framework **11** is then moved back to the position in FIG. 1 and the members **5** are pulled out by pulling the chain **16**. This causes them to assume the positions shown in FIG. 1, and the operation described above is repeated with another honeycomb blank. The number of chain links **16** between each pair of members **5** is the right distance for the spacing of these members in the initial position shown in FIG. 1, so that a pull on the chain **16** brings them into the proper position without requiring any individual adjustment.

It should be noted that since the openings **19** and **21** are quite a bit larger than the pins **7**, it is possible for the members **5** to turn slightly on the shafts **8** until the pull is directly horizontal on the pins **7**. This turning is very slight but is just as effectively aided by the ball bushing as is the primary sliding action of the members **5** as the honeycomb blanks are expanded.

A principal feature of the present invention, namely the ball bearing bushings in the members **5**, is enjoyed regardless of how these bearings are mounted. However, the slot **15** constitutes a preferred way of mounting so that the bearing can be slid in and the member **5** clamped tightly onto it by turning down the bolt **17**. This, however, is only one way of mounting the ball bearing bushing, and any other suitable method may be used.

Because of the easy sliding motion of the members **5**, it is practical to make the rods **8** of precise dimensions, preferably chrome plated, and long, trouble free operation is made possible. When a plain bearing is used, as was employed before, the problems of wear make it necessary to have a softer material for members **5** or a soft lined bushing, which is not required with the ball bushings of the present invention. Another advantage of the present invention is that if a ball bushing should wear or a ball break, it is a simple matter to replace with a new bushing, whereas in the past it was necessary to replace the whole member **5** if serious wear took place. This is an addtiional maintenance advantage of the present invention.

FIG. 4 illustrates a modified construction for high blanks. This utilizes two rods, two tracks and two sets of pin-carrying members. As the bottom set is the same as in FIGS. 1 and 2 except that the pin-carrying members **5** are provided only with the lower plate **14** with its pin opening **19**, these elements receive the same reference numerals as in FIGS. 1 and 2.

The upper set of pin-carrying members, rods, channels and rollers are essentially similar. Their common elements will be given the same reference numerals as in FIGS. 1 and 2, but primed. Each upper pin-carrying member **5'** has a bottom plate **26** developed into a hook so that the long pin **25** can be more readily grasped than with an opening such as **19** in the bottom plates of the lower pin-carrying members. Rod **8'** and channel track **3'** are both mounted on movable carriages **27** which can slide

up and down on columns **24**. This permits adjustment for pins of different lengths. Of course, neither the lower pin-carrying members **5** nor the upper pin-carrying members **5'** have any articulated upper plates. The former does not need one and the latter utilizes its specially shaped lower plate **26** for this purpose.

FIG. 4 shows the plate **26** bolted to the member **5'**. It is, however, possible to fasten only a hook-shaped member **28** to the pin-carrying members **5'**, and this is shown in FIG. 5. The operation is, of course, the same. It will be noted that since the plates or hooks **26** and **28** respectively project suitably, they can be used as attachment points for the chain **16'** and this is illustrated in FIGS. 4 and 5. The lower chain **16** fastens on the back of the lower pin members **5** in the same manner as is shown in FIG. 3, but as this fastening is obscured in the view in FIG. 4, the chain **16** is only shown extending beyond the member **5** in order to obviate confusion in the drawing by showing the attachment in phantom.

I claim:

1. In a honeycomb blank expanding machine, including a table, two frameworks, rods provided with pin-carrying members and rollers on said members bearing on a track carried by the framework, the improvement which comprises ball bushings in each pin-carrying member sliding on a rod and flexible, inextensible spacing elements attached to each pin-carrying member, the length of the elements between pin-carrying members corresponding to spacing of the members at the beginning of honeycomb blank expansion, whereby in operation when the frameworks with their rods move apart, axial movement of the pin-carrying members on their rods results with minimum friction and without binding, and initial pin-carrying member spacing can be restored after expansion and removing of the honeycomb by a pull on the elements.

2. A honeycomb blank expanding machine according to claim **1** in which the pin-carrying members are provided with a bottom having a pin receiving opening, the top member hingeably attached and likewise provided with a pin-carrying opening.

3. A honeycomb blank expanding machine according to claim **2** in which the pin carrying elements are spaced with suitable lengths of chain.

4. A honeycomb blank expanding machine according to claim **2** in which the upper pin receiving members are hinged on a separate member which is clamped by a bolt carrying the rollers operating on the track.

5. A honeycomb expanding machine according to claim **4** in which the pin carrying member is provided with a slot at the back of a ball bushing receiving cavity and the bushing is clamped tight by the bolt carrying the roller.

6. A honeycomb expanding machine according to claim **1** in which each framework is provided with two rods and two tracks, each rod carrying pin-carrying members and rollers, the lower pin-carrying members being provided with pin receiving openings and the upper set being provided with pin engaging members, the rods and channels in each framework being capable of vertical adjustment whereby pins of different lengths of blanks of different heights are accommodated.

7. A honeycomb blank expanding machine according to claim **6** in which the upper pin-carrying members are provided with hook-shaped pin engaging projections.

8. A honeycomb blank expanding machine according to claim **7** in which each framework is provided with a plurality of columns and the upper rod and track of each framework are mounted in carriages vertically slidable on said columns.

References Cited

UNITED STATES PATENTS

2,870,693	1/1959	Steele et al.	72—392
3,302,437	2/1967	Dolney	72—302

CHARLES W. LANHAM, *Primary Examiner.*

L. A. LARSON, *Assistant Examiner.*