June 7, 1955 J. L. BOYD 2,710,040

BENDING MACHINE

Filed Oct. 29, 1953 4 Sheets-Sheet 1

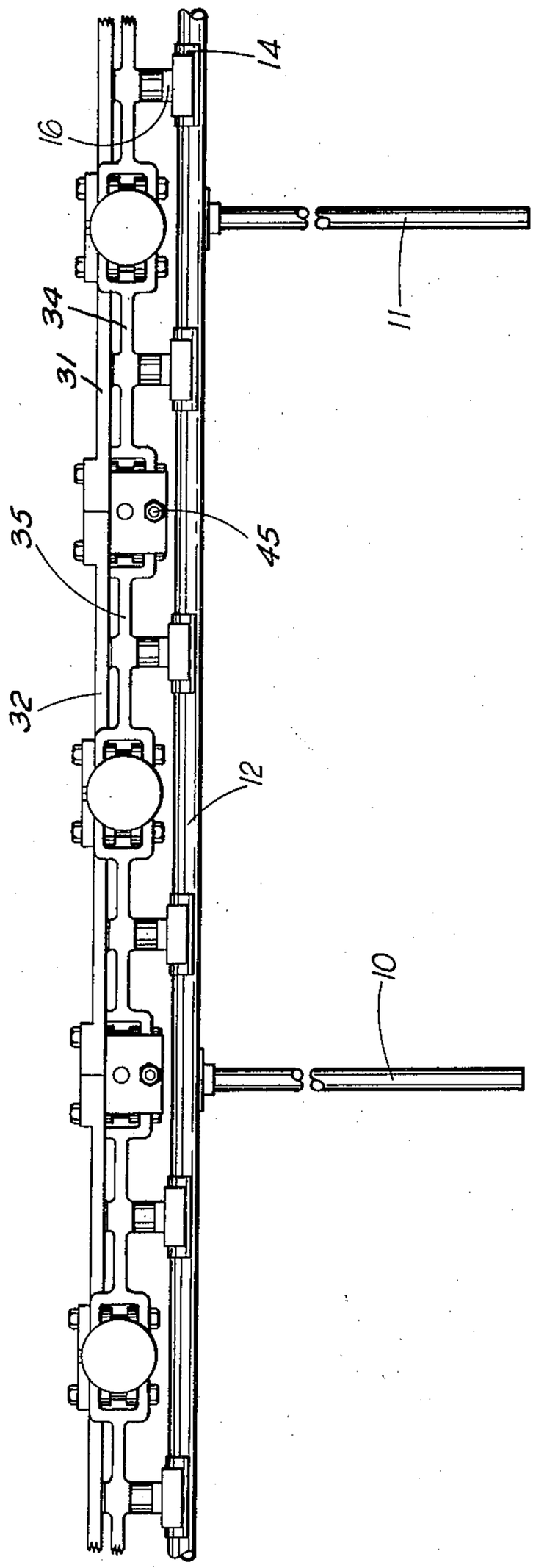

Fig. 1

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BENDING MACHINE

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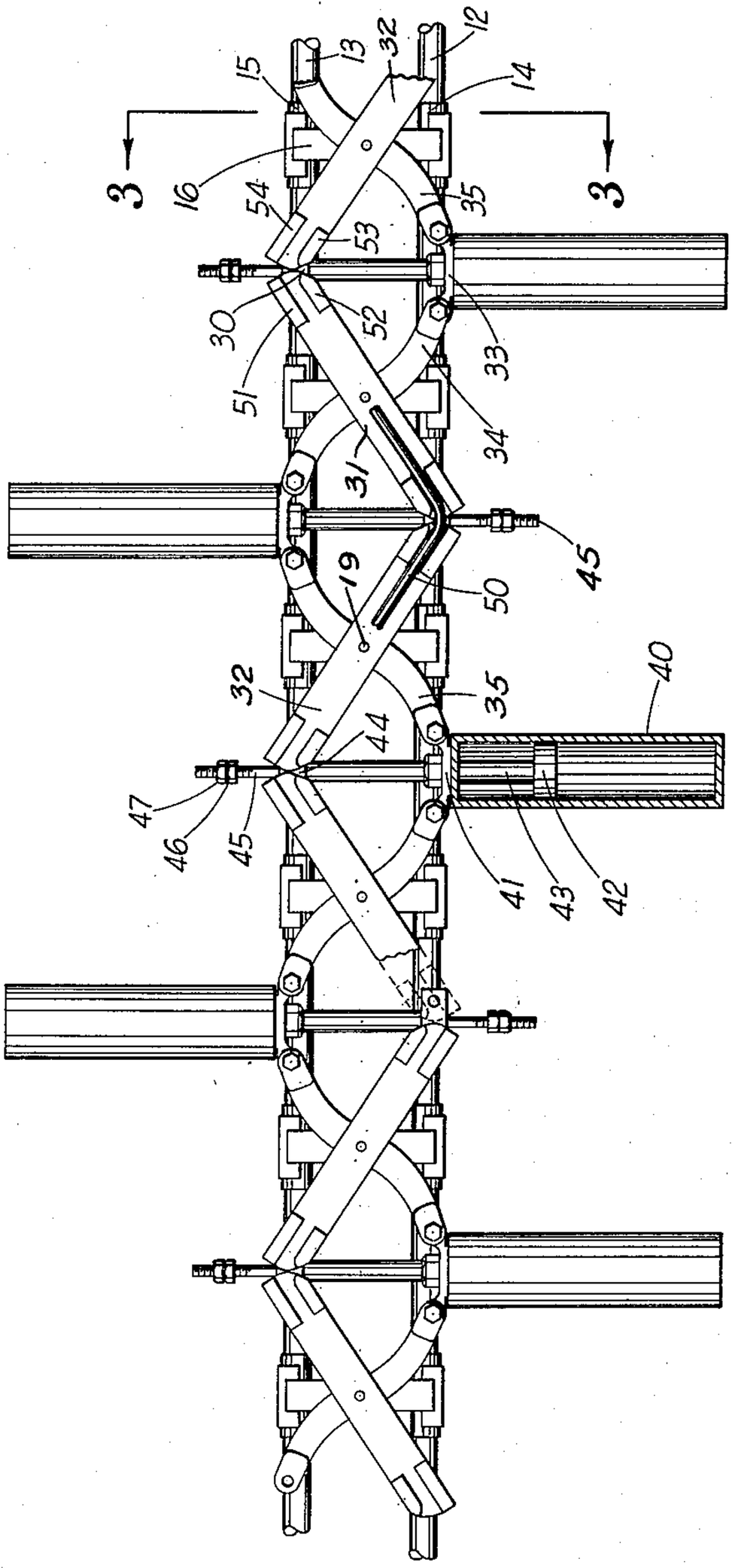

Fig. 2

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BENDING MACHINE

Filed Oct. 29, 1953 4 Sheets-Sheet 3

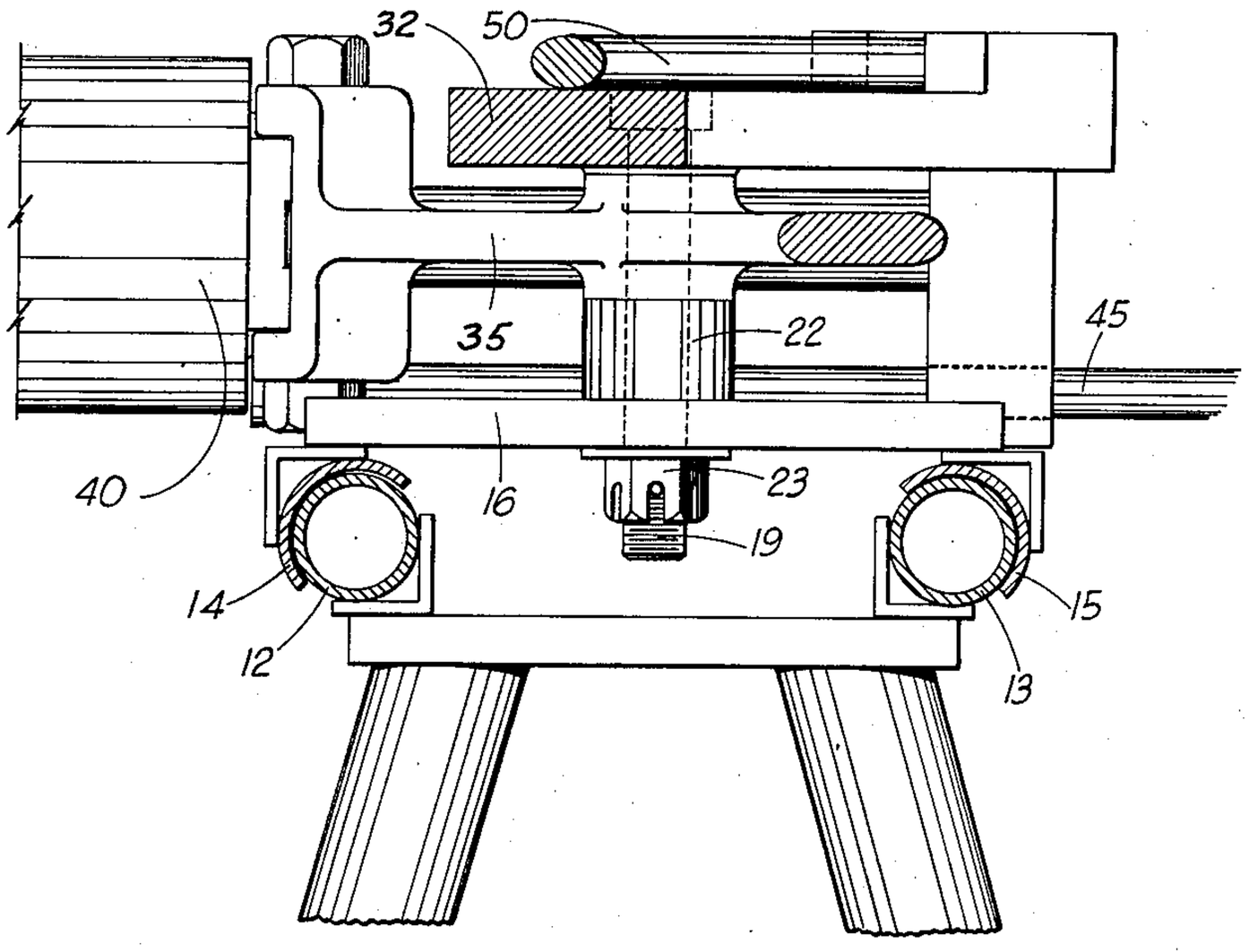


Fig. 3

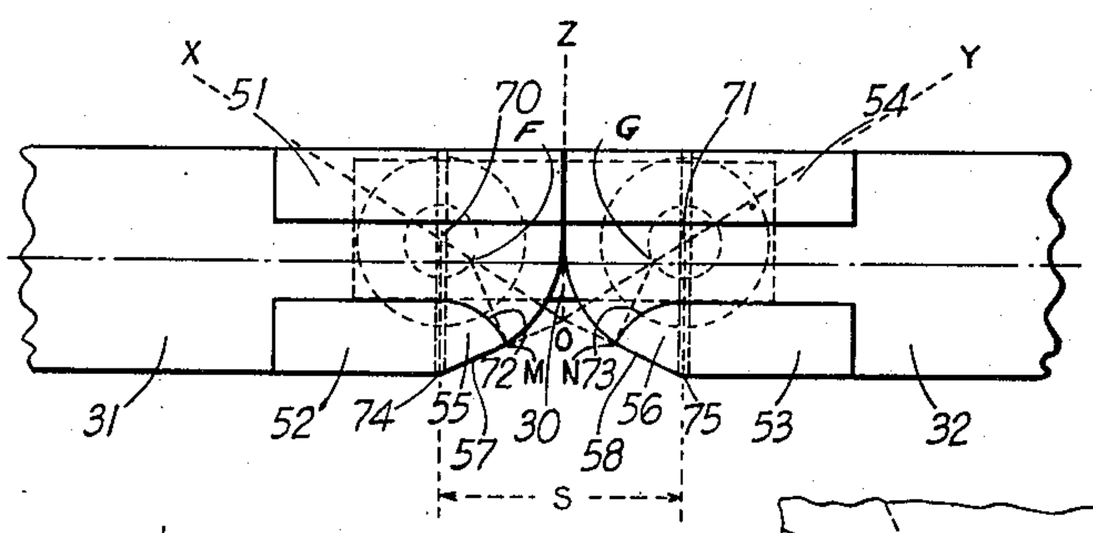
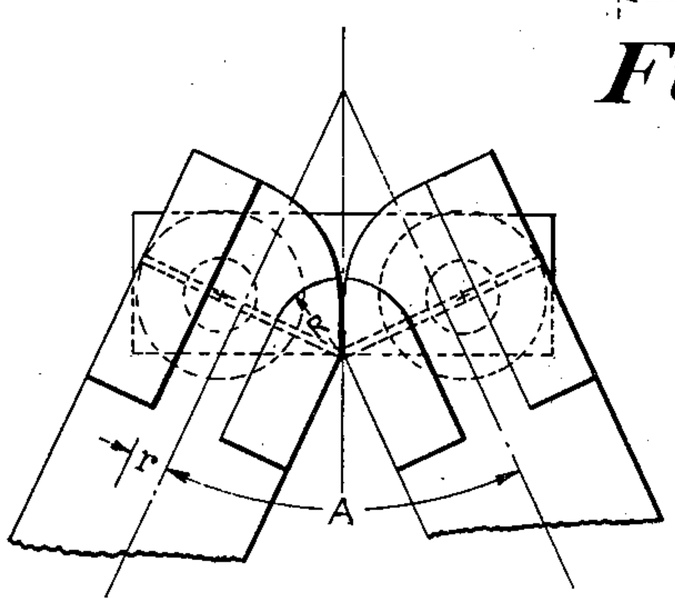


Fig. 4



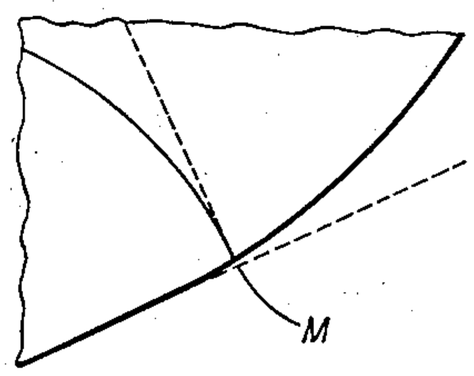


Fig. 4b

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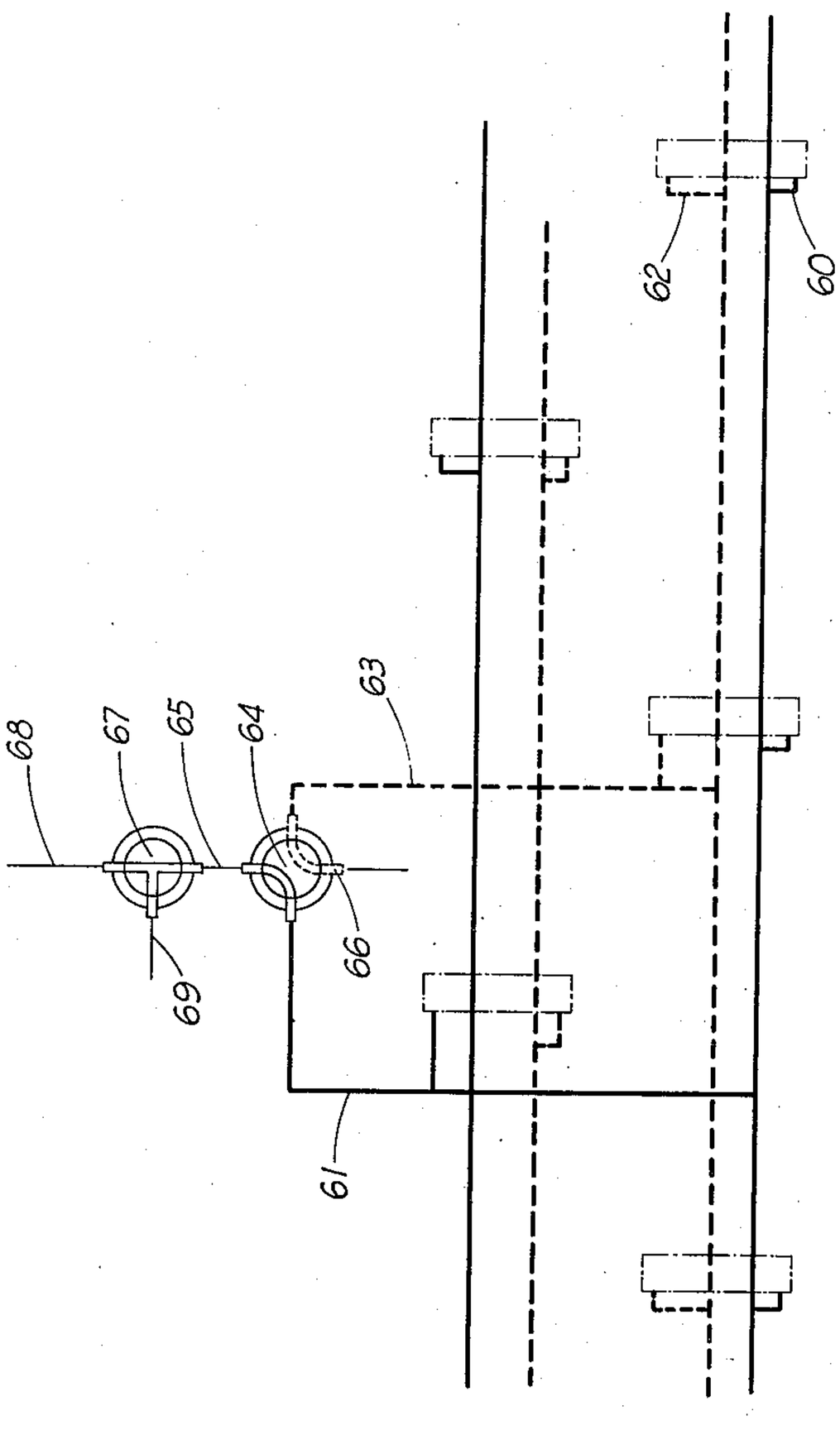

Fig. 5

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2,710,040

BENDING MACHINE

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Application October 29, 1953, Serial No. 389,070

8 Claims. (Cl. 153—20)

This invention pertains to bending machines and more particularly to such machines used for bending rods to form the webs of fabricated beams.

It is an object of the invention to provide a simple inexpensive machine for simultaneously making a plurality of bends in a rod.

A further object of the invention is to provide a bending machine that will require a minimum force or pressure to be employed for each bend.

Another object of the invention is to provide such a machine that requires no more force or pressure to be employed than is required to produce a single bend.

Still another object of the invention is to provide a bending machine that will not cause any elongation of the rod between bends.

Yet another object of the invention is to provide a bending machine which will produce uniform controlled bends.

Other objects and advantages of the invention will appear from the following detailed description of a preferred embodiment thereof, reference being made to the accompanying drawings wherein:

Figure 1 is a side elevation of a portion of a bending machine embodying the invention;

Figure 2 is a plan view of the machine shown in Figure 1;

Figure 3 is a section taken on the line **3—3** of Figure 2;

Figure 4 is a plan view to an enlarged scale of the ends of a pair of adjacent supporting arms;

Figure 4*a* is a view similar to Figure 4 except that the parts are in the position corresponding to completion of the bending operation.

Figure 4b is a view similar to Figure 4 except on a much larger scale and showing only a portion of the apparatus shown in Figure 4.

Figure 5 is a schematic diagram showing the arrangement of the conduits for supplying pressure fluid to the machine.

Referring first to Figure 1, the machine is supported on a plurality of legs such as shown at **10, 11.** These legs carry a pair of parallel pipes **12** and **13.** (See also Figure 2.)

Slidably disposed on top of the pipes are a plurality of cylindrical bearings **14** and **15.** (See also Figure 3.) Adjacent pairs of bearings on the respective pipes are connected by plates **16.**

The machine includes a plurality of sets of arms, each set including a supporting arm **31** or **32** and a cross arm **34** or **35,** the sets **31—34** and **32—35** differing only as the left hand from the right. The arms of each set are pivotally connected together intermediate the ends thereof and are pivotally connected to one of the plates **16** by means of a pin **19,** best seen in Figure 3. The head of the pin is secured in a recess in the supporting arm **31** or **32** and the body of the pin passes through holes in the respective cross arm **34** or **35,** and through a washer **22** and a hole in the support **16.** The end of the pin

is threaded and a nut **23** is screwed thereon to hold the parts together.

Each pair of adjacent sets of arms is connected together. This connection includes in each case a first link **30** (see Figures 2 and 4), which is pivotally connected at its ends to the ends of the adjacent supporting arms **31** and **32,** and a second link **33** pivotally connected at its ends to the ends of the adjacent cross arms **34, 35.**

Means are provided between each of the links **30, 33** to push them apart and draw them together as desired. This means comprises in each case a cylinder **40** (Figure 2) secured to the links **33, 41,** a piston **42** reciprocable within the cylinder **40,** and a piston rod **43** connected at one end to the piston and passing through a suitable packing gland or seal in one end of the cylinder and connected at its other end to link **30.**

Beneath each of the piston rods is disposed a tie rod **45.** It is connected at one end to the link **33** and at the other end passes through a hole in link **30.** On the end of rod **45** are screwed a pair of nuts **43, 47,** which provide an adjustable stop which limits the separation of links **33** and **30.** As will apear, the degree of separation of links **33** and **30** determines the angle of bend of the rod being bent.

Means is provided at the end of each of the supporting arms adjacent the link **30** for receiving a rod, such as **50** placed thereon to be bent, and holding the rod against lateral motion relative to the supporting arm during the bending operation. This means comprises in each case a pair of blocks **51, 52,** on arm **31** and blocks **53, 54** on arm **32** (see Figures 2 and 4). During the bending operation these blocks support the sides of the rod **50** so that a pure bending moment is applied to the part of the rod therebetween and no tension or compression is applied to the rods between the bends.

In order to support the inner radius of the bend during the bending operation, the adjacent ends of the blocks **52, 53** are curved as shown at **55** and **56** to provide cylindrical surfaced abutments which push the rod laterally outwardly from the axis of the machine so that there is no flat formed at the point of bend. It will be noted that the axes of curvature of the surfaces of abutments **55, 56** are initially spaced apart in the direction of the axis of the machine and that these axes approach each other during the bending operation as shown in Figure 2. The inner faces **57, 58** of these abutments are relieved, as are also the adjacent surfaces of the arms **31, 32,** so that there will be no interference with the pivotal motion of the arms during the bending operation. When the machine is in position corresponding with maximum bend of the rod the axes of curvature of the surfaces of abutments **55, 56** will substantially coincide.

Referring to Figure 5 each of the power cylinders is provided with a connection at one end such as shown at **60,** which in turn is connected to a manifold **61** and a connection at the other end such as shown at **62,** which in turn is connected to manifold **63.** Manifolds **61** and **63** are connected to two ports of a four way valve **64.** The other two ports of valve **64** are connected to a line **65** supplying pressure fluid and to a pipe **66** exhausting to atmosphere. Depending on the position of the valve either one of manifolds **61** and **63** may be connected to the source of pressure fluid while the other is connected to the atmospheric exhaust line. By shifting the position of valve **64** pressure fluid may be applied to either end of each of the power cylinders. A three way valve **67** in pipe **65** makes it possible to connect pipe **65** either to pipe **68** connected to the source of pressure fluid (not shown) or to pipe **69** to atmosphere.

To use the machine valve **64** is turned to connect the inner ends of the power cylinders to the pressure fluid so that the supporting arms are all aligned. This is the

position illustrated fragmentarily in Figure 4. The rod to be bent is then placed on top of the supporting arms between the lateral supporting blocks **52—54**. Valve **64** is then turned so as to apply pressure fluid to the outer ends of the power cylinders, which causes the links **30, 33** to separate, which in turn causes the supporting arms to turn at angles to each other, thereby bending the rod around the curved abutments such as **55, 56**. When the machine has reached the end of its stroke, the valve **67** can be turned to exhaust position to relieve the pressure, and the rod **50** may then easily be lifted from the supporting arms, this being by virtue of the fact that the rod tends to spring back and straighten out slightly after it has been bent, so as to free itself from the arms.

If it is desired to produce rods for the webs of fish-belly joists in which the lengths of the straight portions of the rod between bends are progressively shorter from the center toward the ends of the rod, it is only necessary to provide the machine with shorter supporting arms near the ends and adjust the stroke of the power cylinders accordingly. In general, by varying the lengths of the arms any desired variation of web width can be produced.

Referring now to Figure 4 and 4*a* the location of axes **70, 71** of the pivotal connections between the links **30** and the supporting arms **31, 32**, is determined as follows:

1. Place **74** and **75** each at a distance $R+r$ from center line of machine when in position to receive unbent rod. R is radius of bend and *r* is radius of rod.

2. Space **74** and **75** apart from each other a distance equal to length of neutral axis of bent portion of rod. If neutral axis is assumed to be the central axis, then this distance is

$$S=2\pi(R+r)\left(\frac{180-A}{360}\right)$$

where A is internal angle between portions of rod on opposite sides of a bend.

3. Draw arcs with **74** and **75** as centers and tangent to near edges of rod holders.

4. Locate end points M, N of arcs distances

$$\left(\frac{180-A}{2}\right)\left(\frac{2\pi R}{360}\right)$$

from tangent points.

5. Draw lines **74**–M and **75**–N. These lines may also be located by drawing lines through **74** and **75** at angles A/2 with respect to base line **74—75**.

6. Draw vertical line OZ through intersection O between lines **74**–M and **75**–N.

7. Draw lines OX and OY bisecting the angles **74**–O—Z and **75**–O—Z.

8. Erect perpendiculars to **74**–O and **75**–O at points M and N, intersecting OX and OY at F and G.

Centers **70, 71** can be located anywhere on lines OX and OY. If located farther from O than F and G, the sides **57, 58** must be bevelled off at their ends, as shown, to prevent interference. Centers **70, 71** are preferably located, as shown, at the intersection of the lines OX and OY with perpendiculars to line **74—75** erected from points **74, 75**. This tends to prevent stresses on the rod between the bends. With A equal to 60 degrees this locates points **70, 71** close to the far edge of the rod from **74, 75**. It is desirable that **70, 71** be on the opposite side of the rod's central axis from **74, 75** in order that the axes formed by pins **19** will always move together during the bending operation, so that the machine operates smoothly, as contrasted with the uneven operation which would occur if the pivot axes **70, 71** were on the same side of the rod axes as cylinder axes **74, 75**, in which case the initial motion of pivot pins **19** would be one of separation, followed by a motion together after links **30** passed dead center.

The action of the cylindrical surfaced abutments **55, 56**, in shaping the bend is to be contrasted with the action taking place when a rod is bent around a single cylindrical pin or die. According to the invention, in which it may be said that a split pin or die is used, the contact between the rod and the split pin is initially only at the outer ends of the bend and progresses in toward the center of the bend as the bend it made. In bending around a solid pin the initial contact is at the center of the bend.

It will be noted that since there is one power cylinder per bend in the machine the total force or pressure required is no greater than that required to produce a single bend. Furthermore, since a pure bending moment is applied in each bend, there being no tension or compression of the rods between the bends, no force is needed beyond that required for the bending alone. By applying the bending force perpendicular to the rod axis, a minimum force or pressure is needed for each bend. The efficiency of the machine is thus so high that it can be operated with available air pressures instead of requiring the use of hydraulic pressure.

While a preferred embodiment of the invention has been shown and described, it is apparent that many changes and modifications thereof could be made by one skilled in the art without departing from the spirit of the invention, and it is desired to protect by Letters Patent all forms of the invention falling within the scope of the following claims.

I claim:

1. A bending machine comprising a plurality of sets of arms disposed serially alongside of each other in a line forming the axis of the machine, each set comprising a supporting arm and a cross arm, means pivotally connecting together the arms of each set intermediate their ends, means connecting together each pair of adjacent sets of arms, each of the last said means including a first link, axially spaced apart means pivotally connecting said first link to each supporting arm at a point removed from the above described intermediate connection, a second link, and axially spaced apart means pivotally connecting said second link to each cross arm at a point removed from said intermediate connection, support means on each supporting arm adjacent said first link to prevent lateral motion relative to the supporting arm of a member or members placed thereon to be bent, and means connected between each adjacent pair of first and second said links to move said links away from each other to cause said member to be bent at a part thereof in between the pairs of said support means adjacent each of said first links.

2. A bending machine comprising a plurality of sets of arms disposed serially alongside of each other in a line forming the axis of the machine, each set comprising a supporting arm and a cross arm, means pivotally connecting together the arms of each set intermediate their ends, means connecting together each pair of adjacent sets of arms, each of the last said means including a first link, axially spaced apart means pivotally connecting said first link to each supporting arm at a point removed from the above described intermediate connection, a second link, and axially spaced apart means pivotally connecting said second link to each cross arm at a point removed from said intermediate connection, support means on each supporting arm adjacent said first link to prevent lateral motion relative to the supporting arm of a member or members placed thereon to be bent, means connected between each adjacent pair of first and second said links to move said links away from each other to cause said member to be bent at a part thereof in-between the pairs of said support means adjacent each of said first links, and second support means on each supporting arm farther from said intermediate connection than the first said support means to cause a predetermined outward lateral motion of said member relative to the axis of the machine during the

bending operation to provide the desired shape of curve of said part of the member that is bent.

3. A bending machine comprising a plurality of sets of arms disposed serially alongside of each other in a line forming the axis of the machine, each set comprising a supporting arm and a cross arm, means pivotally connecting together the arms of each set intermediate their ends, means connecting together each pair of adjacent sets of arms, each of the last said means including a first link, axially spaced apart means pivotally connecting said first link to each supporting arm at a point removed from the above described intermediate connection, a second link, and axially spaced apart means pivotally connecting said second link to each cross arm at a point removed from said intermediate connection, support means on each supporting arm adjacent said first link to prevent lateral motion relative to the supporting arm of a member or members placed thereon to be bent, means connected between each adjacent pair of first and second said links to move said links away from each other to cause said member to be bent at a part thereof in between the pairs of said support means adjacent each of said first links, a support extending axially the length of the machine, and means pivotally connected to each pair of arms at said intermediate connection and slidably mounted on said support to support said pairs of arms while permitting said intermediate connections thereof to move closer together during the bending operation.

4. A bending machine comprising a plurality of sets of arms disposed serially alongside of each other in a line forming the axis of the machine, each set comprising a supporting arm and a cross arm, means pivotally connecting together the arms of each set intermediate their ends, means connecting together each pair of adjacent sets of arms, each of the last said means including a first link, axially spaced apart means pivotally connecting said first link to each supporting arm at a point removed from the above described intermediate connection, a second link, and axially spaced apart means pivotally connecting said second link to each cross arm at a point removed from said intermediate connection, support means on each supporting arm adjacent said first link to prevent lateral motion relative to the supporting arm of a member placed thereon to be bent, and means connected between each adjacent pair of first and second said links to move said links away from each other to cause said member to be bent at a part thereof in-between the pairs of said support means adjacent each of said first links, the last said means comprising a cylinder connected at one end to one of said links, a piston in said cylinder, and a piston rod connected at one end to said piston and at the other end to the other of said links.

5. A bending machine comprising a plurality of arms disposed serially along the axis of the machine, a link disposed between each adjacent pair of said arms, axially spaced apart means pivotally connecting each link to each adjacent arm, support means on each arm adjacent each link to prevent lateral motion relative to the arm of a member placed thereon to be bent, and means connected to each pair of adjacent arms and the link there-between to decrease the angle between the arms of the pair to cause said member to be bent at a part thereof in-between the pairs of said support means adjacent the link.

6. A bending machine comprising a plurality of arms disposed serially along the axis of the machine, a link disposed between each adjacent pair of said arms, axially spaced apart means pivotally connecting each link to each adjacent arm, support means on each arm adjacent each link to prevent lateral motion relative to the arm of a member placed thereon to be bent, means connected to each pair of adjacent arms and the link therebetween to decrease the angle between the arms of the pair to cause said member to be bent at a part thereof in-between the pairs of said support means adjacent the link, and second support means on each supporting arm nearer the centers of said links than the first said support means to cause a predetermined outward lateral motion of said member relative to the axis of the machine during the bending operation to provide the desired shape of curve of said part of the member that is bent.

7. A bending machine comprising a plurality of arms disposed serially along the axis of the machine, a link disposed between each adjacent pair of said arms, axially spaced apart means pivotally connecting each link to each adjacent arm, support means on each arm adjacent each link to prevent lateral motion relative to the arm of a member placed thereon to be bent, means connected to each pair of adjacent arms and the link therebetween to decrease the angle between the arms of the pair to cause said member to be bent at a part thereof in between the pairs of said support means adjacent the link, and second support means on each supporting arm nearer said links than the first said support means to cause a predetermined outward lateral motion of said member relative to the axis of the machine during the bending operation to provide the desired shape of curve of said part of the member that is bent, each of the second support means comprising an abutment having a surface of cylindrical curvature, the axes of curvature of each pair of adjacent abutments of adjacent arms being spaced apart along the axis of the machine and approaching each other as said arms are moved to bend said member.

8. The combination of claim 7 in which the pivot axes of the connections of the first links with the supporting arms are on the opposite side of the axis of the member to be bent from the axes of said abutments.

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