Feb. 28, 1939. E. B. HUDSON 2,148,469

PROCESS AND DEVICE FOR REDUCING SHEET METAL

Filed July 6, 1936 8 Sheets-Sheet 1

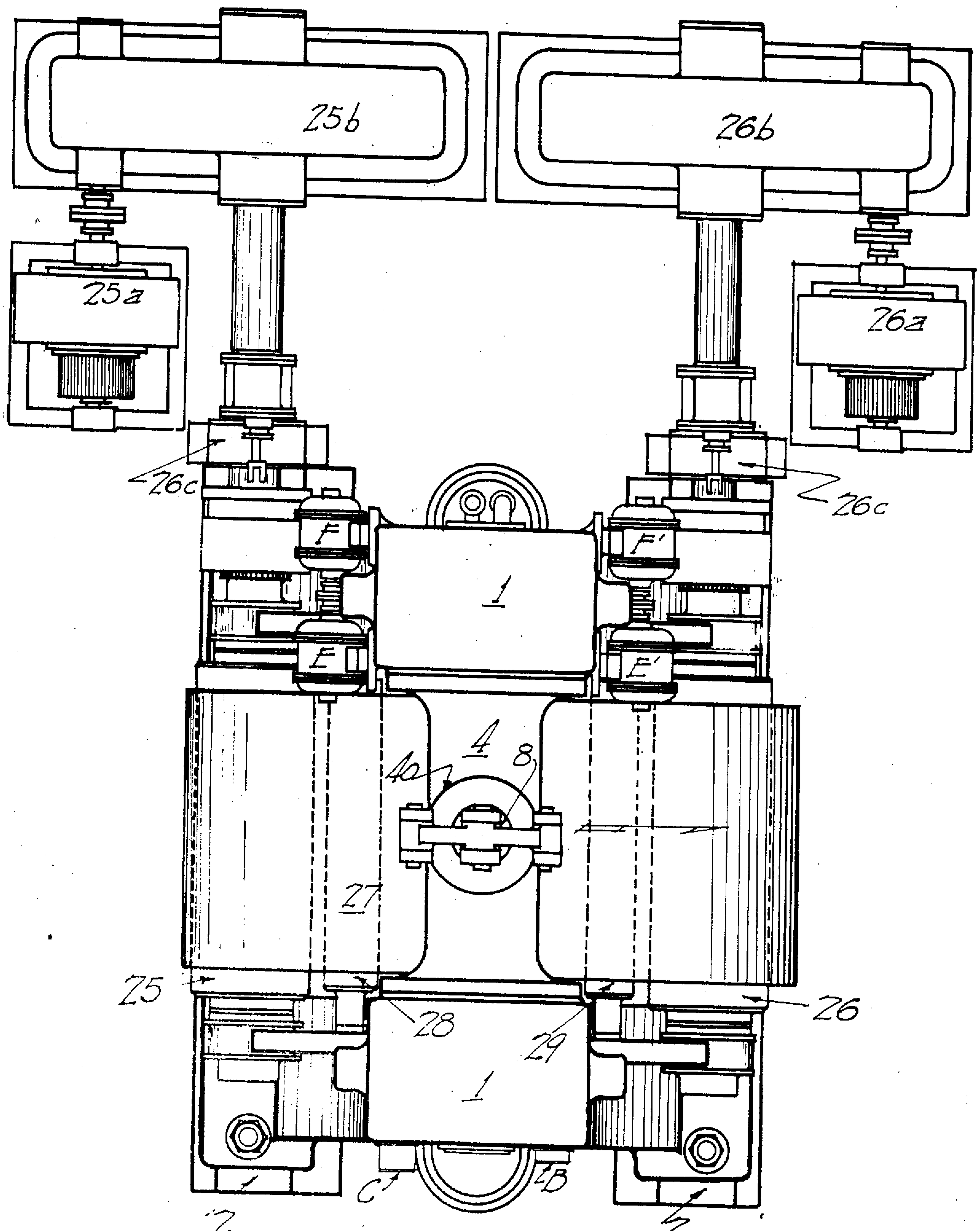

FIG. 1.

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Filed July 6, 1936 8 Sheets-Sheet 2

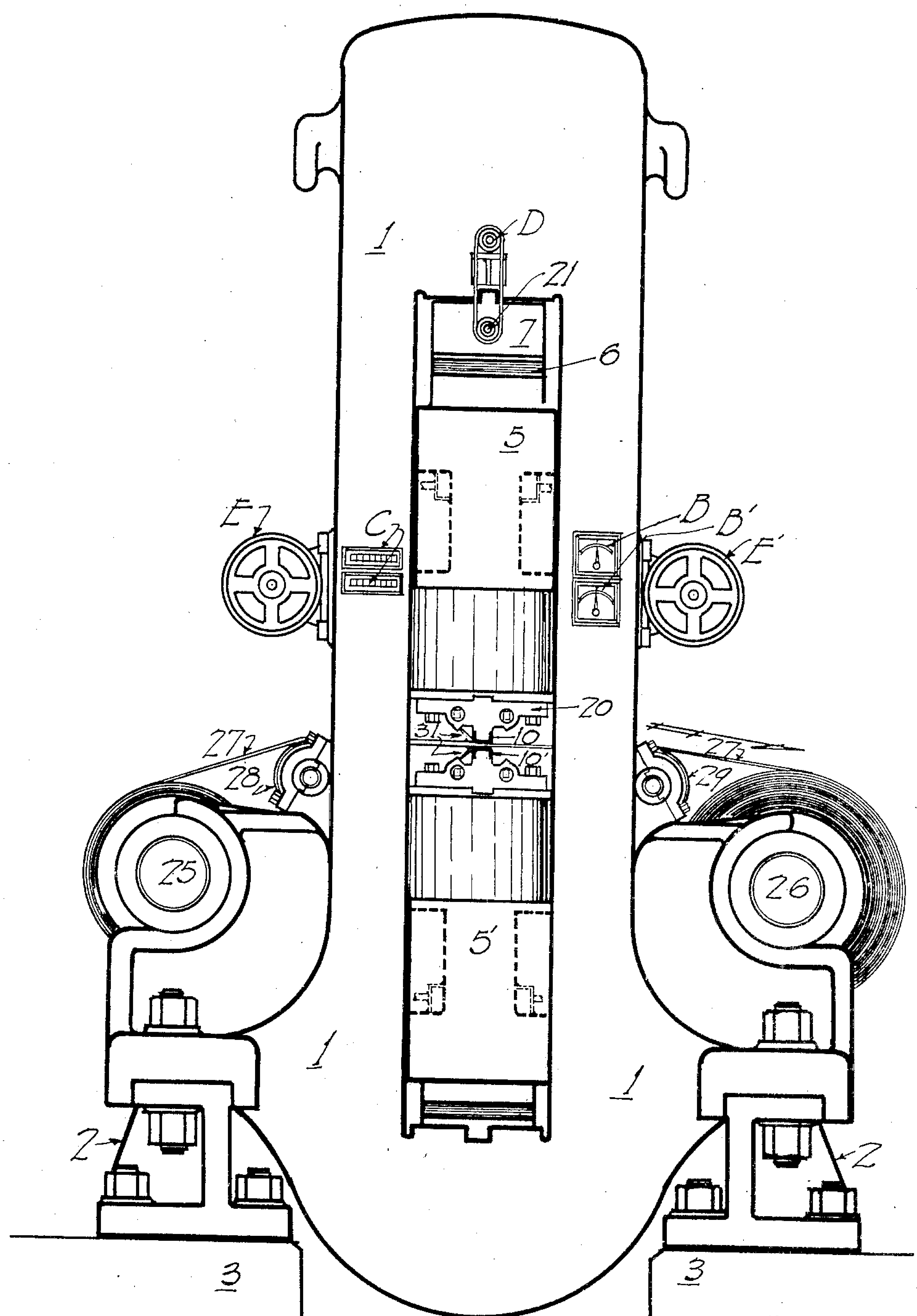

FIG. 2.

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Filed July 6, 1936 8 Sheets-Sheet 3

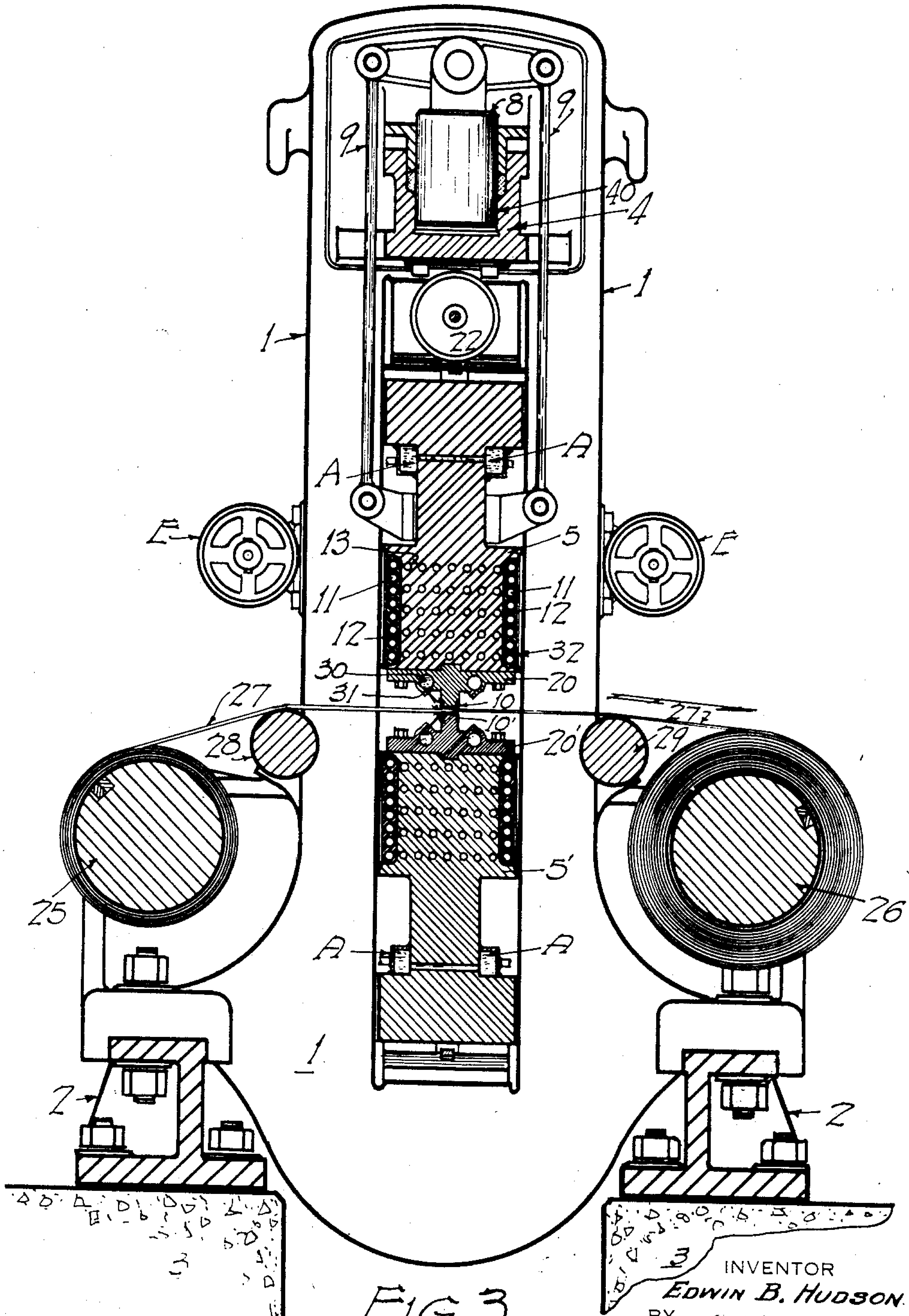

FIG. 3.

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Filed July 6, 1936

8 Sheets-Sheet 4

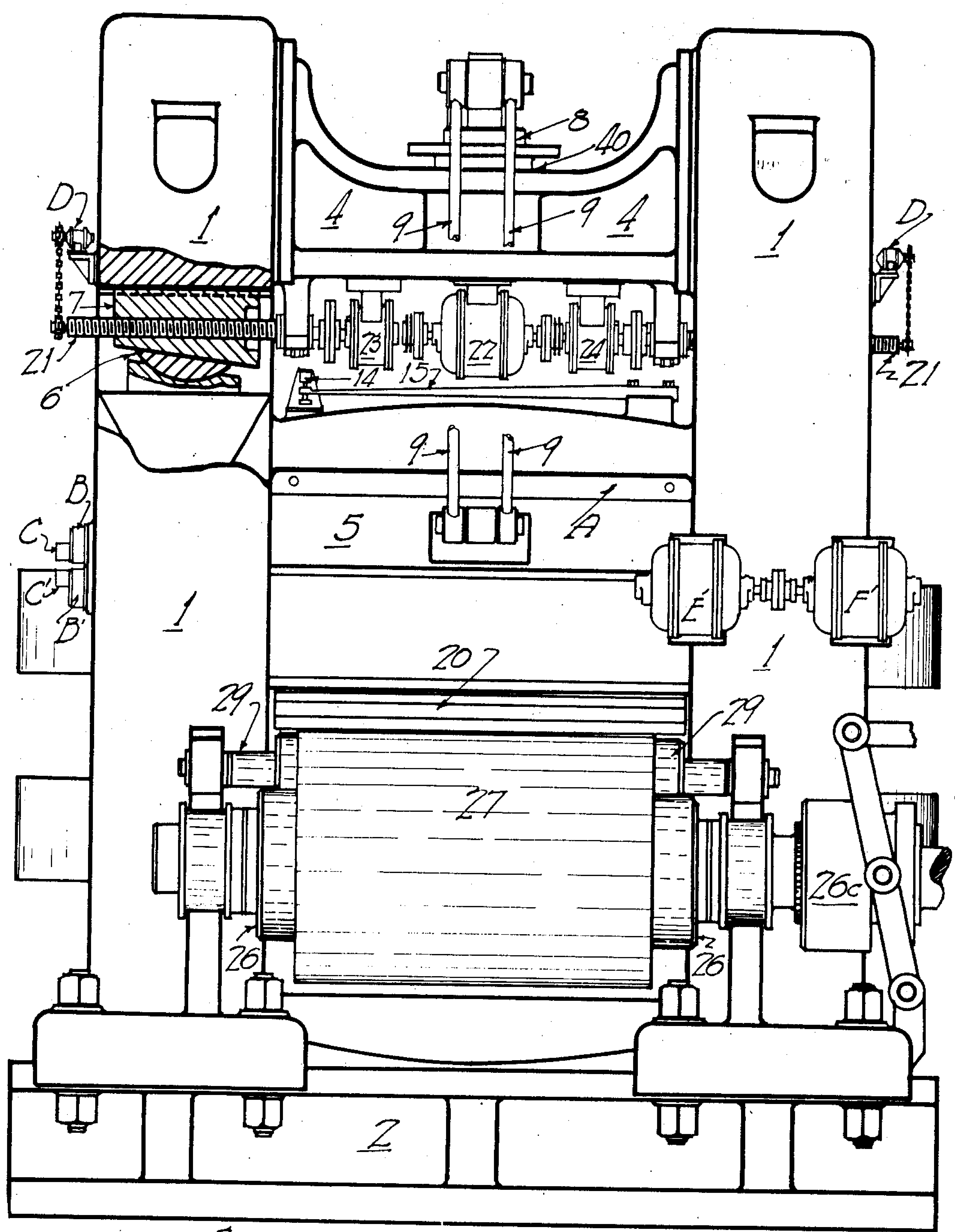

FIG. 4.

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PROCESS AND DEVICE FOR REDUCING SHEET METAL

Filed July 6, 1936 8 Sheets-Sheet 5

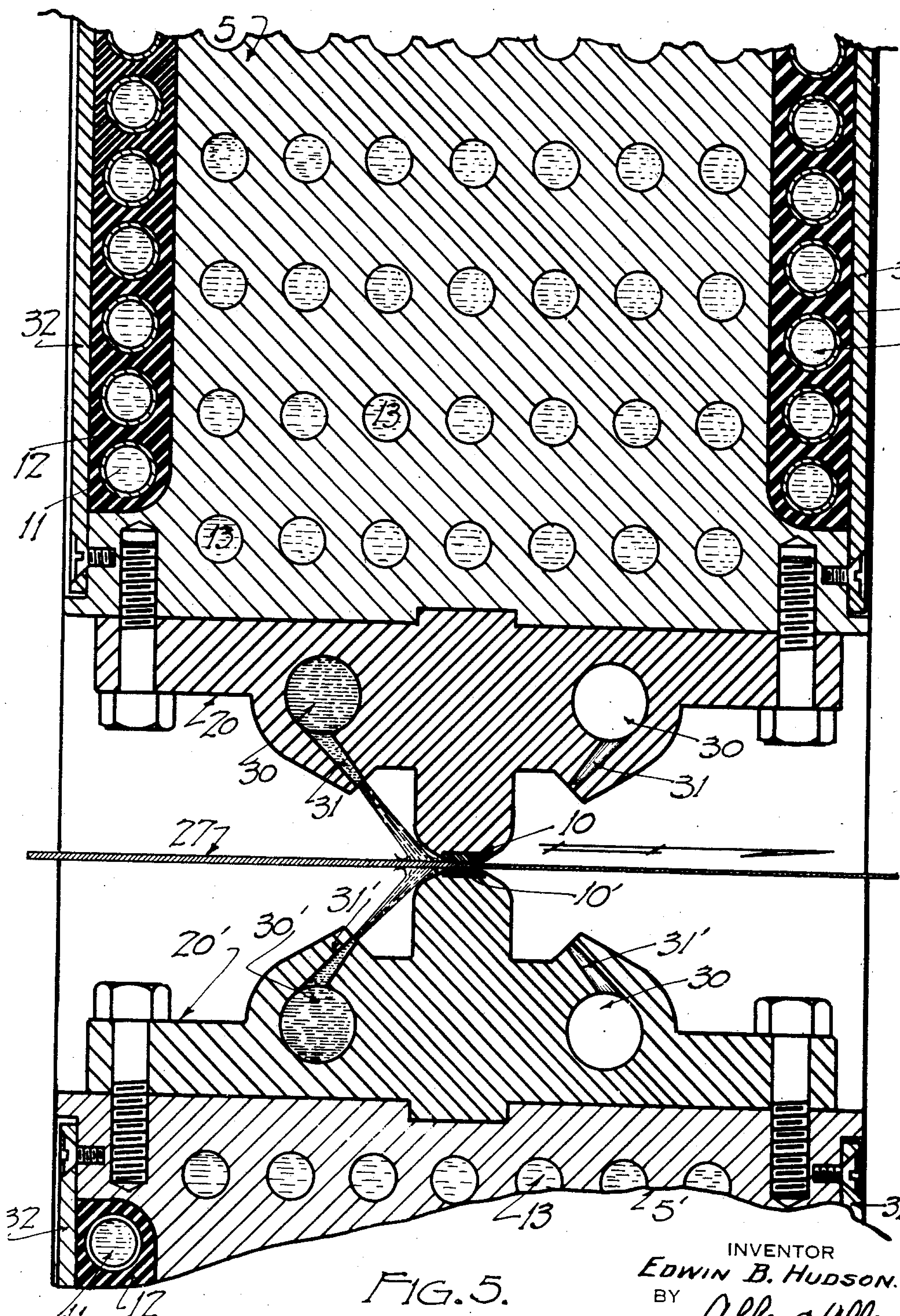

FIG. 5.

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PROCESS AND DEVICE FOR REDUCING SHEET METAL

Filed July 6, 1936 8 Sheets-Sheet 6

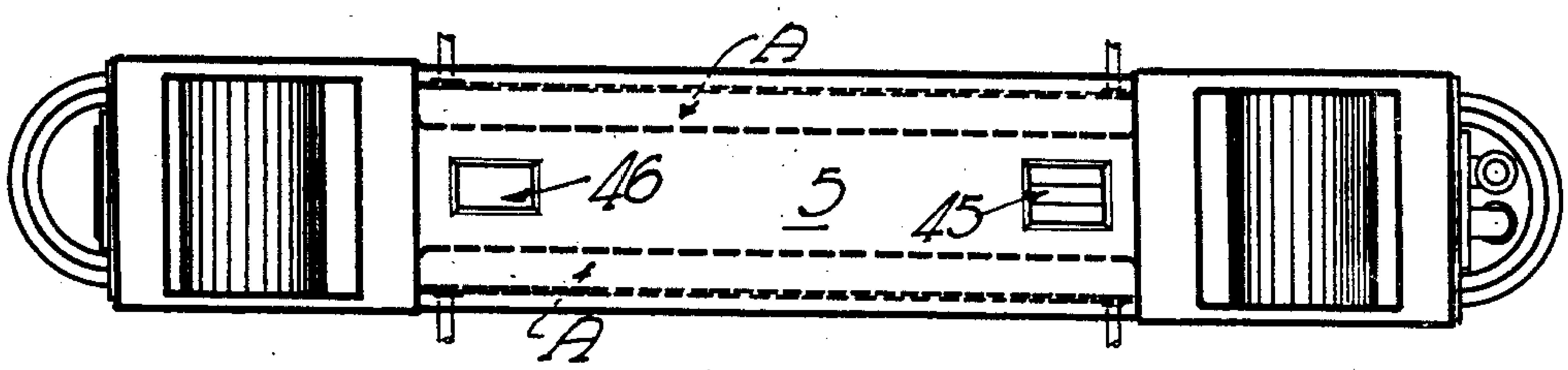

FIG. 6.

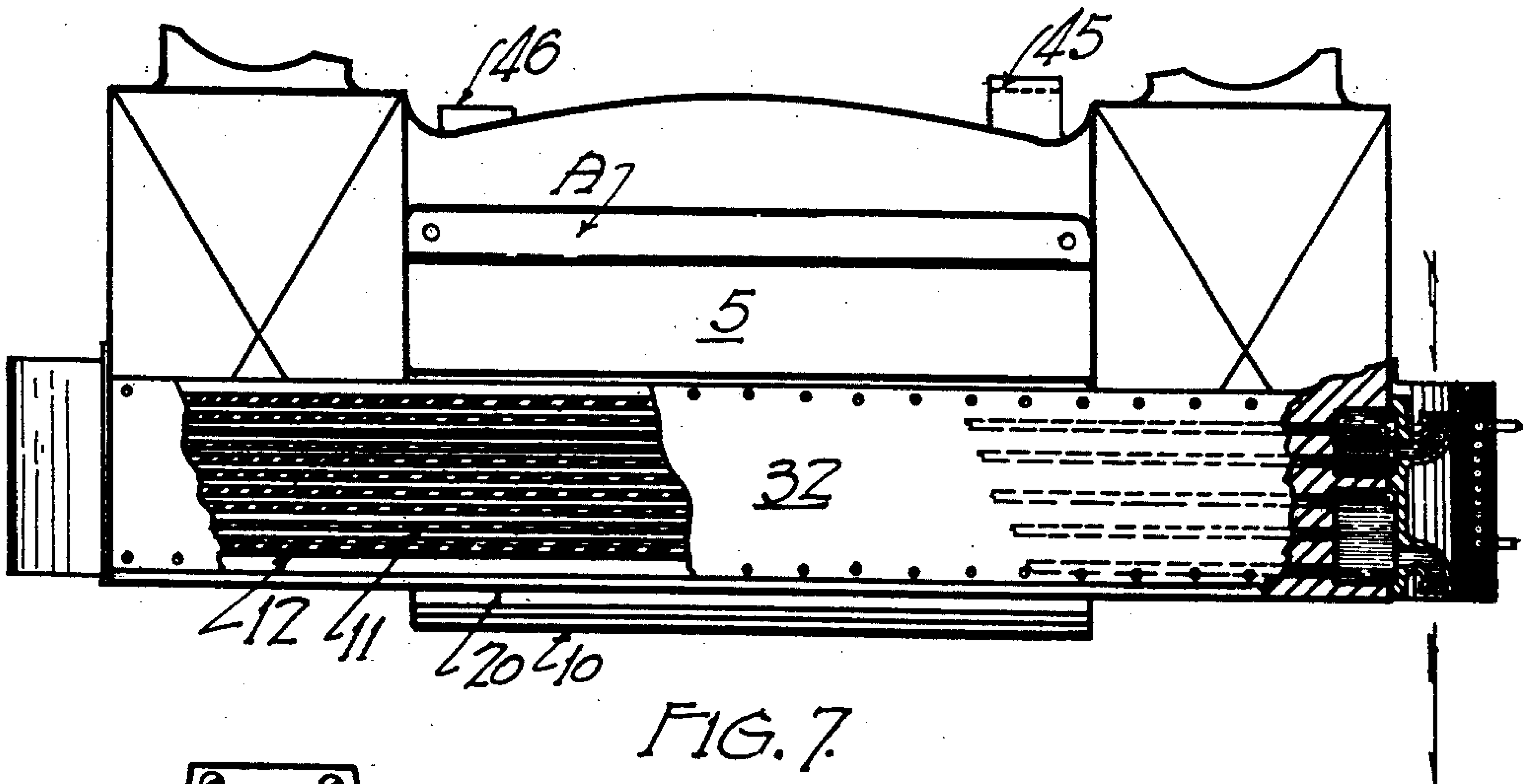

FIG. 7.

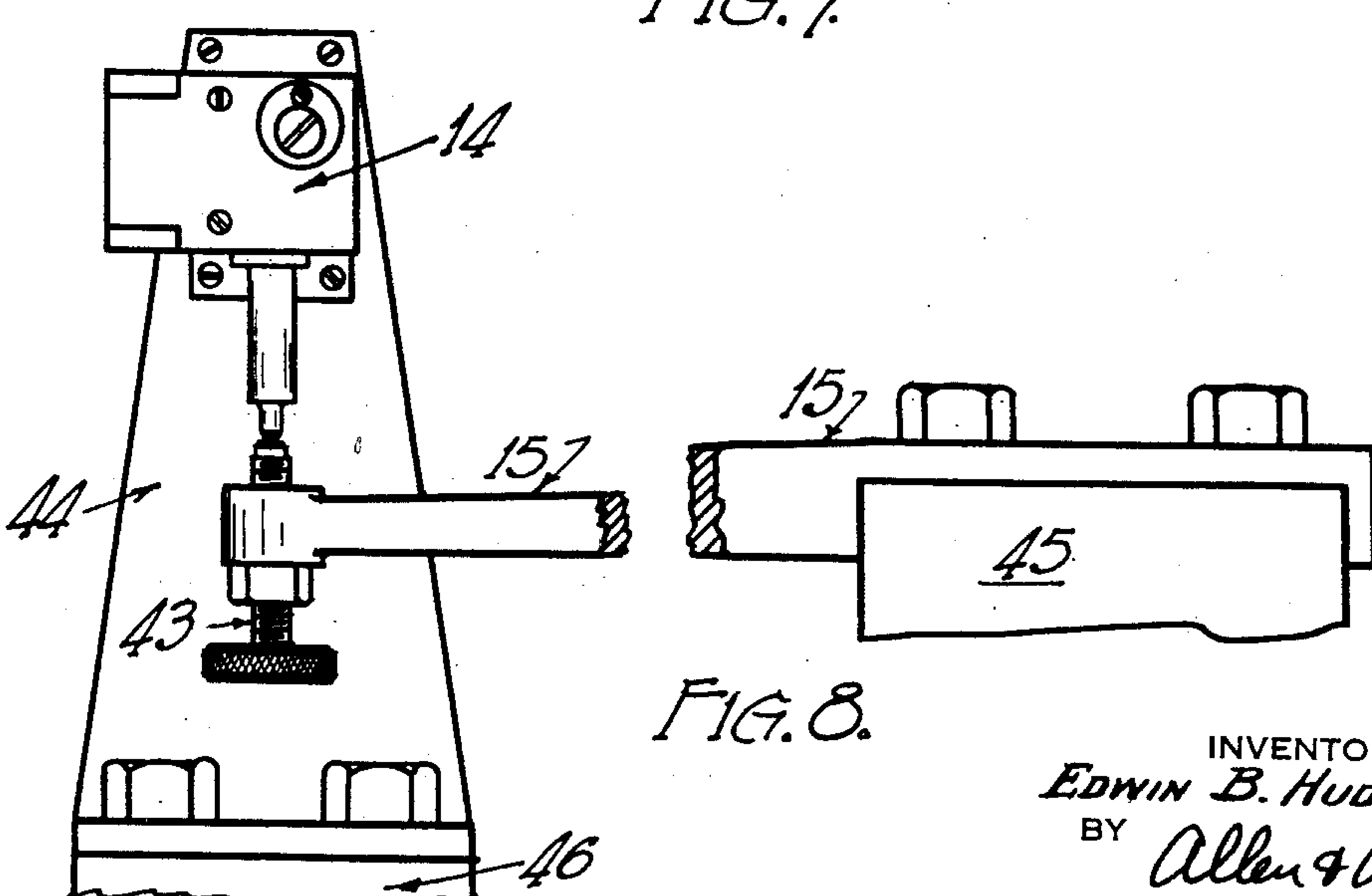

FIG. 8.

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PROCESS AND DEVICE FOR REDUCING SHEET METAL

Filed July 6, 1936 8 Sheets-Sheet 7

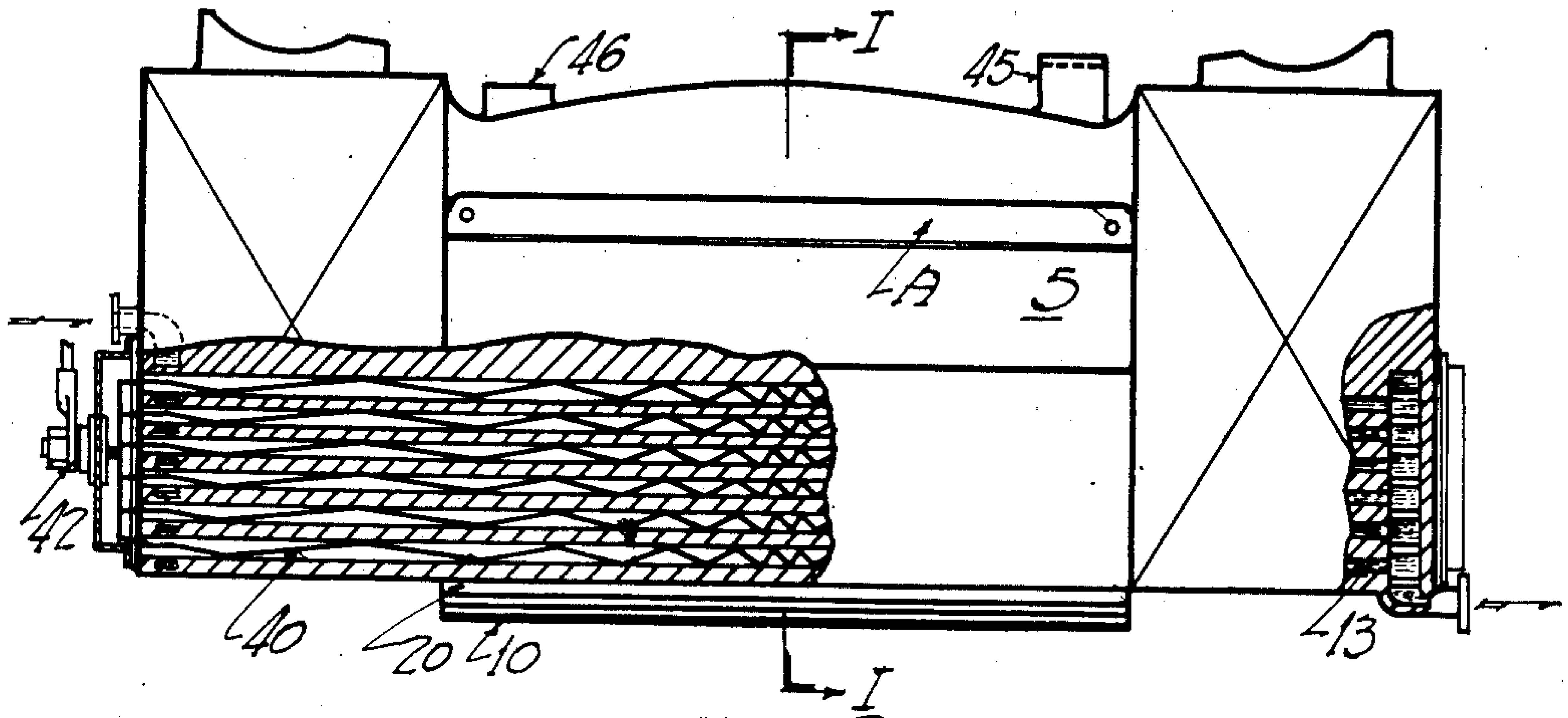

FIG. 9.

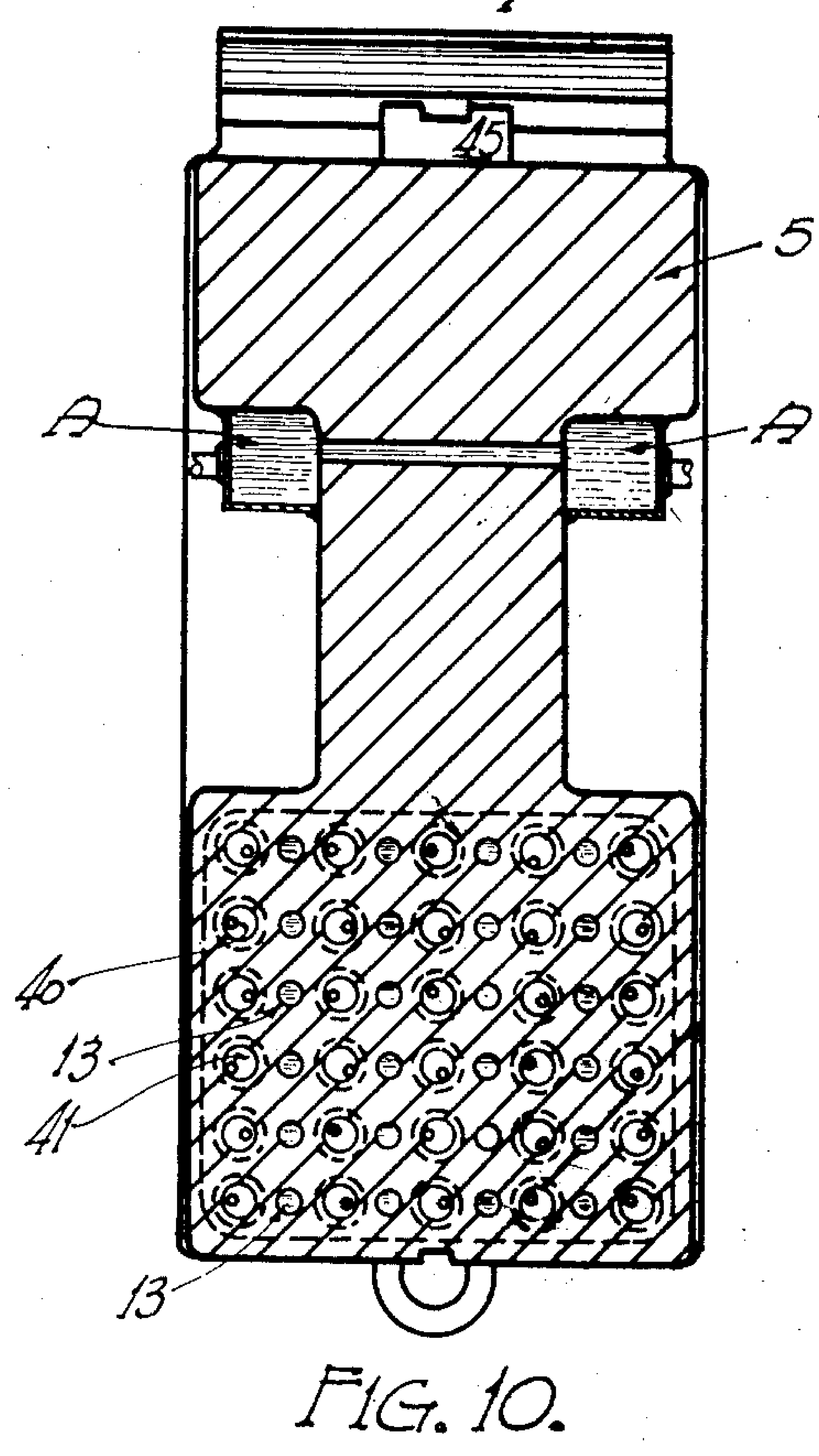

FIG. 10.

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PROCESS AND DEVICE FOR REDUCING SHEET METAL

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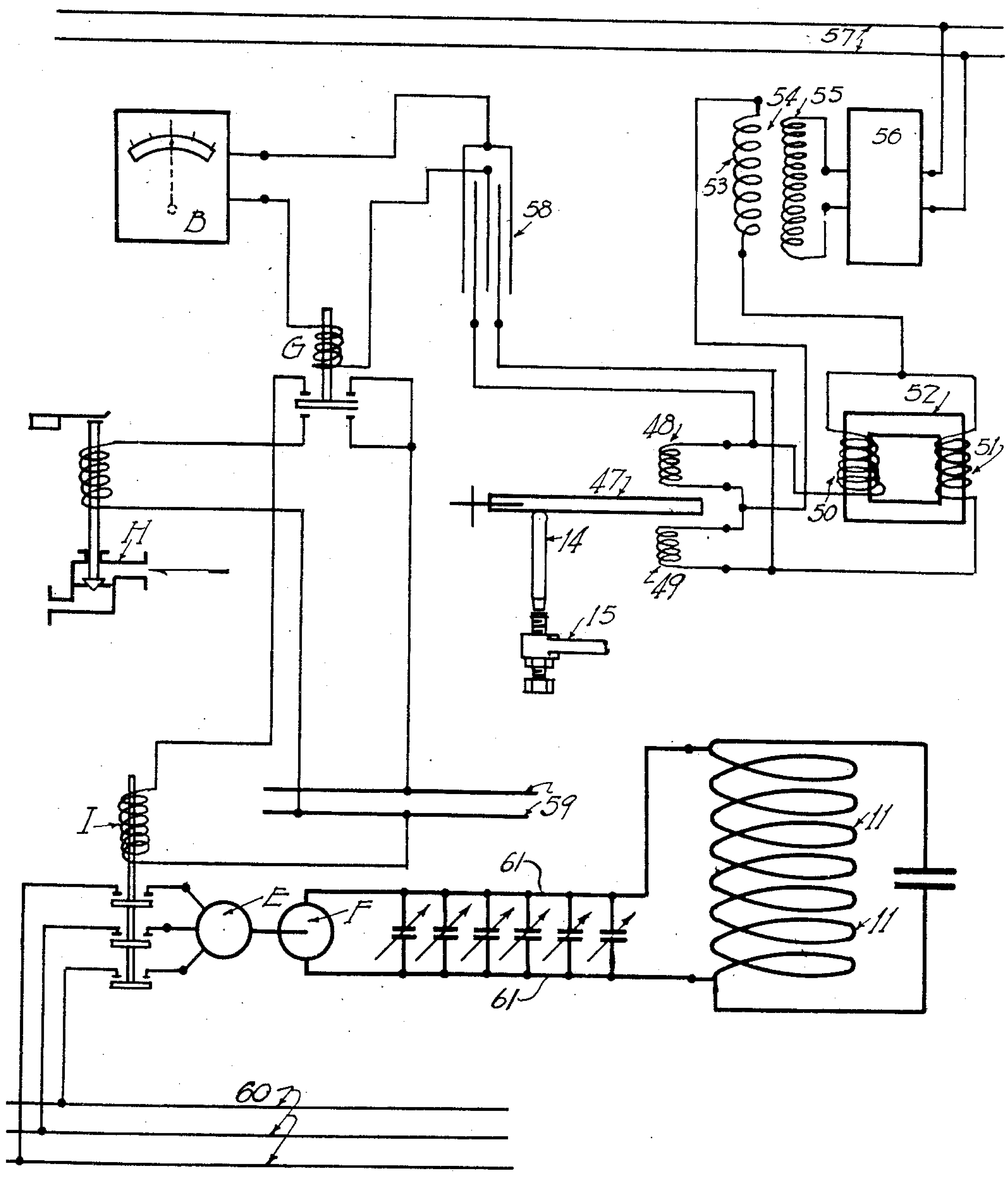

FIG. 11.

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Patented Feb. 28, 1939

2,148,469

UNITED STATES PATENT OFFICE

2,148,469

PROCESS AND DEVICE FOR REDUCING SHEET METAL

Edwin B. Hudson, Middletown, Ohio, assignor to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

Application July 6, 1936, Serial No. 89,027

14 Claims. (Cl. 205—25)

My invention relates to a new process and apparatus for reducing sheet metal in gauge; and the several objects and advantages of my invention will be set forth hereinafter or will be clear to one skilled in the art from the description which follows.

Essentially, in the practice of my invention, I depart from conventional methods, such as rolling, for reducing metal of sheet width, and follow a drawing practice in which the metal is pulled under tension between reducing dies. By sheet metal I mean to include rolling pieces substantially unlimited as to gauge but characterized by the fact that the width of the pieces is very many times the thickness thereof. My process and apparatus is particularly useful both in giving to heavy sheet materials accurate sizing and transverse shape or contour, and also in reducing finer materials to thin gauges very accurately. As a consequence, I do not desire the term sheet materials to be construed as limiting my claims otherwise than to materials in which the width is so much greater than the thickness that reduction in gauge of such materials is taken up substantially entirely in elongation thereof.

It will be understood, of course, that my process is not applicable to materials heated to the degree which is proper for hot rolling, but is essentially a cold reduction process, since it is a process involving the exertion of tension to cause the piece to pass through the reducing and/or sizing dies.

The problems connected with sizing materials of sheet width by a drawing process are quite different from the problems met with in the drawing of wire or rod. With materials which are substantially as thick as they are broad and in which both of these dimensions are relatively small, no problem of current control of die shape is involved. In using a long die member on each side of the piece, the stresses set up are such as to spring the reducing members in a way that is quite analogous to the springing of the rolls in cold rolling processes. As a consequence, the control of die shape becomes very vital, and a part of my invention is concerned with the maintenance of accurate die contour under the conditions.

My invention is especially well adapted for reduring metals to the gages thinner than 20 gage. When the conventional mill is used in this range of reduction great cost is experienced in maintaining bearings and mill rolls. In the manufacture of wire, the rolling of wire rod stops at No. 5 gage (.22); and the rod is then further reduced by drawing, which is the most practicable method. I propose in accordance with my invention, that metal strip be rolled to .040 thick, and then further reduced by drawing. Thus I reduce the cost of manufacture and give more accurate gage than is possible by rolling.

The various objects of my invention are accomplished in that process and by the use of that arrangement and organization of mechanism of which I shall now describe an exemplary embodiment.

Reference is now had to the drawings, wherein:—

Figure 1 shows the mill in plan complete with devices and coiling reels.

Figure 2 shows the mill in elevation on the operating side.

Figure 3 shows the mill in section along the center line of the work.

Figure 4 shows the mill in elevation front view.

Figure 5 shows an enlarged sectional view of the die block and die beam together with induction coil and cooling pipes.

Figure 6 shows the die beam of the induction heated type in plan.

Figure 7 same as Figure 6 except in elevation.

Figure 8 shows deflection indicating device (Patent 1,928,457).

Figure 9 shows another type of die beam heated by a resistance coil.

Figure 10 shows section I—I of Figure 9.

Figure 11 shows wiring diagram of deflection indicating and controlling means of the induction circuit for heating the die beam and means for controlling the flow of cooling water.

The exemplary embodiment of my mechanism which I shall now describe is one employing a framework analogous to the framework of known cold rolling mills. Indeed it is possible to adapt to present mills the novel mechanism which I shall describe. Thus I have shown in Figures 1, 2, 3, and 4 a mill comprising interspaced housings 1, of ordinary form. Instead of journaling rolls in these housings, however, I slidably mount a pair of beams therein, designated respectively at 5 and 5'. The mill housings, of course, rest upon suitable supporting members 2, on a foundation 3. The housings may be held apart at the top by a suitable bridge indicated at 4. The beams 5 and 5' bear reducing dies 20 and 20' which will be more particularly described hereinafter. The lower beam 5' may rest, as shown, on suitable blocks in the lower portions of the slots in the mill frame. I provide a screw down arrangement which may be of any suitable type.

I have disclosed a relatively simple form of motor driven screw down, in which wedges 7 are introduced between the upper portions of the mill housings and the portions of the beam 5 which enter the slots in the housings. Actually the wedges 7 may contact a bearing and rocker block 6 resting on the end of the beam 5. The wedges are moved in and out in opposite directions by means of shafts 21 threaded therein and driven by a motor 22 through two sets of suitable planetary or other gear reductions 23 and 24. The motor and the gearing may be mounted, as shown, on the bridge 4. If it is desired to raise or lower one end of the beam 5 more than the other end, it will be competent to attach a separate motor to one of the shafts 21 and provide a suitable clutch mechanism between this shaft and its appropriate gearing. It is likewise possible to employ a separate motor for each of the shafts 21, or to use a single motor and provide clutches between it and the two shafts 21, so that either or both of them can be driven. All of this is within the skill of the worker in the art to provide, together with the necessary controls therefor. Since I have shown a wedge screw down, I have shown also means for pulling up the beam 5 when the screw down is relieved. These means may comprise a fluid pressure cylinder 40 mounted on the bridge and having a piston 8, which is suitably connected by means of rods or links 9 with the beam 5, as shown. Pressure may be maintained on the cylinder 40 at all times. Equivalents both of the screw down mechanism and of the pull back mechanism may be provided without departing from my invention.

It will be observed that by reason of the use of beams 5 and 5′ in my mill instead of rolls or a series of rolls, narrower mill housings may be employed and considerable space and expense saved, because it is not necessary to provide space in the housings for roll neck bearings and the like. Moreover, since the beams 5 and 5′ are of relatively great depth, my mill is very much more rigid than a rolling mill would be.

As I have indicated, the die members 20 and 20′ are connected to the lower and upper faces of the beams 5 and 5′ respectively. These die members are attached in any suitable way and are preferably keyed, as shown, to the beams to resist transverse displacement. They are provided with die faces 10 and 10′ forming a constricted die throat through which the metal is drawn. They are made removable, as indicated, for replacement, and they are the only parts of my mill structure subject to heavy wear. Where the mill is, as shown, a reversible mill, the die faces 10 and 10′ are so shaped as to permit drawing in either direction. I have shown in connection with my mill two tight coilers 25 and 26 to which the ends of a strip to be rolled may be attached, and which are provided with suitable drives comprising motors 25a and 26a and gearing 25b and 26b. They will also be provided with alternatively acting brake means and with clutch means as at 26c (Figure 4). The strip is indicated at 27 and it passes from one coiler to the other over knee rolls 28 and 29 between the die faces 10 and 10′. The die members are preferably drilled as at 30, and provided with jet openings 31 so that on both sides a spray or bath of lubricant can be projected against the piece as it enters the die, for cooling and lubricating.

In spite of the great vertical thickness of the beams 5 and 5′, there is bound to be a normal deflection thereof under the stresses of reduction, which deflection will vary the contour of the die throat. Considering the upper beam 5, when metal is being drawn through the die throat, this beam will be very heavily loaded from beneath. In deflecting, the lower edge of the beam contracts and the upper edge of the beam expands. I do not attempt to correct this deflection by external pressures applied to the beams. On the contrary, I have found that a deflected beam may be brought back to an undeflected position either by heating the contracted edge of it, or cooling the expanded edge of it, making use of the contraction and expansion of the metal forming the beam under conditions of temperature variation. It will be clear that if cooling and heating means are both employed, these need be applied to but one edge of the beam to secure the same effect. Any heating and cooling means may be employed. The most feasible cooling procedure known to me is to employ a fluid cooling medium and pass it through a series of perforations 13 in the lower end of the beam 5, as shown. These perforations may be connected in series or multiple, or portions in series and portions in multiple, and a cooling fluid sent therethrough by means of a pump or some other pressure means.

Where it is possible to control the temperature of the fluid means referred to and to vary that temperature rapidly, it will be possible to use the fluid means both for heating and for cooling, as will be readily understood. However, the variation of the temperature of a fluid means rapidly and accurately involves some problems, and I find it preferable to use the fluid means as a cooling medium and to apply to the beam some other direct or indirect acting heating means. Thus, the heating may also be done by fluid or it may be done by electrical resistance, or it may be done by electrical induction. In my drawings, Fig. 3, I have shown at 11 an inductive winding about the lower end of the beam embedded in a suitable insulative material 12 and covered by a face plate 32. This winding may be energized by alternating current of relatively high frequency from any suitable source and in known ways, to produce the heating effect when it is necessary to expand the lower edge of the beam 5. Other means may likewise be employed for changing the contour of the beam, in spite of the load thereagainst, by varying the physical state of expansion or contraction of selected portions of the beam directly. A magnetostrictive effect may be relied on for this under some circumstances. Moreover, the heating and cooling means may, if desired, be applied locally to different portions of the beams so as to permit the production of special contours. This, however, is not ordinarily necessary or desirable, the general object being to maintain the die throat of constant width throughout its length, in spite of variations of load, temperature, and the like.

In Figures 9 and 10, I have shown the beam 5 equipped not only with the cooling passageways 13 in its lower portion, for the flow of a cooling fluid as hereinabove described, but also with electrical resistance heating means. These means comprise resistance heaters indicated at 40 contained within bores 41 in the beam 5. It will be understood that the resistance wires are either sheathed with insulative substance, or that the bores 41 are lined with insulative substance. As shown, it is desirable to increase the effective length of the resistance wire near the center of the beam so as to increase the heating effect there. This can be accomplished by winding the turns of resistance wire closer together on a suitable core near the center of the beam, or in other ways known to the art. Suitable electrical connections are of course provided as at **42**.

The mid section of the beam may be reduced as shown. Where the heating and cooling are effective essentially at one edge of the beam, it is well to provide means inhibiting heat transfer from one edge of the beam to the other. To this end, I have shown cooling means A, comprising chambers through which a cooling fluid may continuously be circulated, located at the reduced portion of the beam and adjacent that edge which is not provided with contour controlling means. These means can be seen in Figures 2, 3, 7, 8, 9 and 10.

Inasmuch as the contour of the die throat tends to vary with these variables, it is advisable to provide automatic means for controlling the die throat contour by varying the heating and cooling media which I have described. The measurements effecting the automatic control may be derived from various sources, including calipering of the piece being rolled; but I have found it most convenient automatically to control the contour by means of a measurement of the deflection of the beam. To this end I employ a deflection gauge comprising a rigid arm **15** (see Figures 6, 7, and 8) mounted near one end of the beam on a block **45** and bearing at its other end an adjustable actuating means **43**. This operates a controlling device **14** mounted on a bracket **44** mounted on a block **46** near the other end of the beam.

The type of controlling device which I prefer to use is a device indicated diagrammatically in Figure 11, and is an adaptation of gauging means shown in the patent to Mershon et al., No. 1,928,457, issued Sept. 26, 1933. It operates on the principle of unbalance due to changes in the magnetic reluctance of one or more arms in a Wheatstone bridge. The actuating means hitherto described includes a member of magnetic material **47** adapted to be moved upon changes in the deflection of beam, with relation to two magnetic coils **48** and **49**. These two coils form two of the arms of a Wheatstone bridge and the other two arms are formed of equal and opposed windings, **50** and **51** on a core **52**. Current is supplied across one diagonal of the bridge from the secondary **53** of a transformer **54** the primary **55** of which may be connected through a suitable switch and fuses, panel **56** to power leads **57**. As an alternative of course a motor generator may be used. The Wheatstone bridge is energized by alternating current of a frequency such as to be outside any natural vibrating frequency of the member **47**.

Across the other diagonal of the Wheatstone bridge there may be connected a meter B on which the deflection can be read and a sensitive relay G, through a rectifier **58**.

In operation the movement of the member **47** varies the magnetic reluctance of the coils **48** and **49** thereby unbalancing the bridge. This gives an appropriate leading on the motor B and a controlling movement of the relay G. The motor as shown in Figure 2 may be mounted on the mill housing in a position of convenience to the mill operator.

The relay G may be caused through an appropriate circuit to operate a solenoid valve for control of the cooling fluid in the passageways **13**. This valve is diagrammatically indicated at H. It may be caused alternatively by an appropriate circuit to actuate a solenoid switch I for control of the heating medium the relay and solenoid circuits may have a direct current supply through leads **59**.

I have shown in this figure also a heating means controlled by the solenoid switch I and comprising a motor E deriving its current from power leads **60** while this motor is coupled to a high-frequency generator F the output of which is passed through suitable leads to the high frequency inductive heating coils **11**. It will be clear that the switch I may be used to control any other type of heating means.

It will be understood that the construction of the lower beam **5'** is a counterpart of the construction of the upper beam **5** inasmuch as contour control from both sides is necessary, and that like control, and heating and cooling means are provided for the beam **5'**.

A mill of this character is, as compared with other mills, relatively inexpensive to build and it is of great utility in the reduction of sizing of metal pieces with extreme degrees of accuracy. Considerable reductions can also be effected as will be understood, depending somewhat upon the kind and character of metal being treated. Wide, thin sheet metal can be produced in a mill of this type without substantial variations in gauge across the width thereof. The mill is economical in operation because, as has been indicated, the die members are the only parts subject to great wear and the only parts which have to be renewed during the life of the machine. The mill is not a driven mill, the power being applied to the piece to draw it through the die. Thus when the mill of Fig. 1 is operating in the direction of the arrow, power will be applied to the tight coiler **26** by braking means, or a lesser degree of power may be also applied to the coiler **25** so as to extert a back tension on the piece. Means for the maintenance of tension to a constant value in spite of sporadic variations in elongation may likewise be employed as set forth in my copending applications, Serial No. 31,346, filed July 15, 1935, and Serial No. 668,101, filed Apr. 26, 1933.

It will be clear that in the following of my process different apparatus may be employed; and modifications may be made in my invention without departing from the spirit thereof.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A process of sizing or reducing metal of sheet width which comprises drawing it under tension between interspaced die elements forming a long narrow constricted throat, backing up said die elements by means of substantially rigid, non-rotative beam members and varying the distance between said beam members to control the amount of reduction, while varying the contour of said beam members to control the contour of the reduced piece.

2. A process of sizing or reducing metal of sheet width which comprises drawing it under tension between interspaced die elements forming a long narrow constricted throat, backing up said die elements by means of substantially rigid, non-rotative beam members and varying the distance between said beam members to control the amount of reduction, and compensating for deflection of said beam members by controlling the temperature of parts thereof, selectively.

3. A process of sizing or reducing metal of

sheet width which comprises drawing it under tension between interspaced die elements forming a long narrow constricted throat as set forth in claim 2, and continuously flowing on said metal as it enters between said die elements, a bath of lubricating material.

4. A method of contour control in mills which comprises providing substantially rigid, non-rotative beams for resisting the outward forces of metal being reduced, and compensating for deflection of said beams by selectively controlling the expansion and contraction of portions thereof which are interspaced relative to each other substantially in the plane of said deflection.

5. A method of contour control in mills which comprises providing substantially rigid, non-rotative beams for resisting the outward forces of metal being reduced, and compensating for deflection of said beams by selectively controlling the expansion and contraction of portions thereof which are interspaced relative to each other substantially in the plane of said deflection, by controlling the relative temperatures of said inspaced portions.

6. In a sheet metal reduction mill, housing means, a pair of substantially rigid, non-rotative beams, die members attached to said beams, means for moving at least one of said beams relative to the other, and means for varying the contour of said beams.

7. In a sheet metal reduction mill, housing means, a pair of substantially rigid, non-rotative beams, die members attached to said beams, means for moving at least one of said beams relative to the other, and means for compensating for deflection of said beams by heating and cooling at least one edge of each.

8. In a sheet metal reduction mill, housing means, a pair of substantially rigid, non-rotative beams, die members attached to said beams, means for moving at least one of said beams relative to the other, and means for compensating for deflection of said beams by heating and cooling at least one edge of each, said means comprising means for passing a fluid in heat exchange relationship to said edge.

9. In a sheet metal reduction mill, housing means, a pair of substantially rigid beams, die members attached to said beams, means for moving at least one of said beams relative to the other, means for compensating for deflection of said beams by heating and cooling at least one edge of each, said means comprising means for passing a fluid in heat exchange relationship to said edge, and means for electrically heating said edge.

10. In a sheet metal reduction mill, housing means, a pair of substantially rigid, non-rotative beams, die members attached to said beams, means for moving at least one of said beams relative to each other, and means for compensating for the deflection of said beams, said means comprising passageways in adjacent edges of said beams for a cooling medium, and means for applying an expansible force electrically to said edges of said beams.

11. In combination in a mill, housings, substantially rigid, non-rotative beams extending across said housings, one of which at least is slidably mounted therein, screw down means for effecting the movement of said slidably mounted beam in said housings, pull back means for effecting movement thereof in the opposite direction, and means for controlling the deflection of said beams under load, said means comprising means for heating and cooling an edge portion of each of said beams.

12. In combination in a mill, housings, substantially rigid beams extending across said housings, one of which at least is slidably mounted therein, screw down means for effecting the movement of said slidably mounted beam in said housings, pull back means for effecting movement thereof in the opposite direction, and means for controlling the deflection of said beams under load, said means comprising means for heating and cooling an edge portion of each of said beams, means for measuring the deflection of said beams and a connection between said measuring means and said heating and cooling means to effect the automatic maintenance of a desired contour in said beams.

13. In combination in a mill, housings, substantially rigid, non-rotative beams extending across said housings, one of which at least is slidably mounted therein, screw down means for effecting the movement of said slidably mounted beam in said housings, pull back means for effecting movement thereof in the opposite direction, and means for controlling the deflection of said beams under load, said means comprising means for heating and cooling an edge portion of each of said beams, said means comprising passageways in said beams for a cooling fluid, and means in connection with said beams for applying electrical heat thereto, inductively.

14. In a sheet metal reduction mill, housing means, a pair of substantially rigid beams, die members to said beams, means for moving at least one of said beams relative to the other, and means for compensating for deflection of said beams by heating and cooling one edge of each, and means for preventing heat transfer from said edge to the opposite edge of each.

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