

July 1, 1930.

D. L. SUMMEY

1,768,866

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50 Sheets-Sheet 1

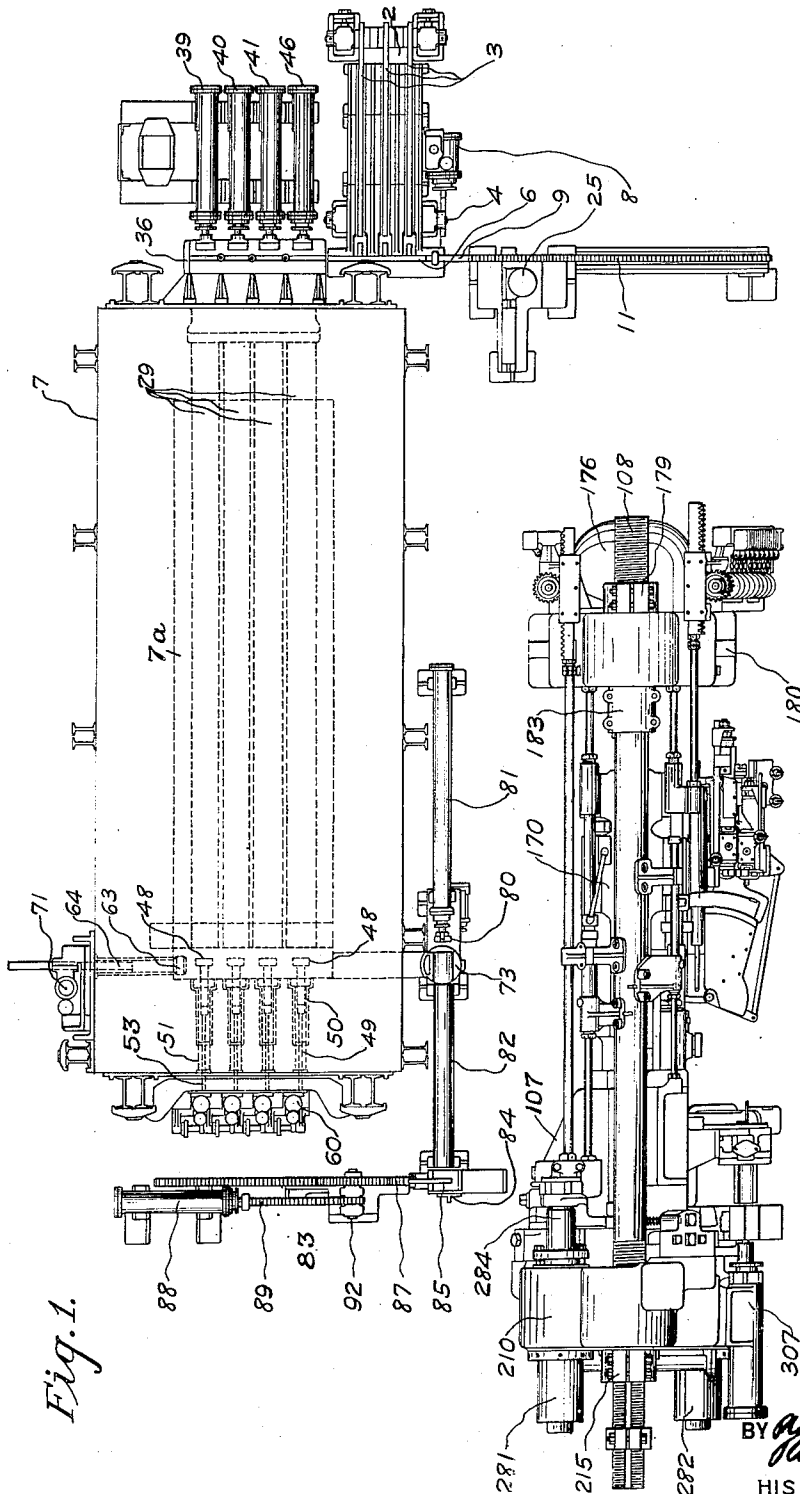


Fig. 1.

INVENTOR
David L. Summey
 BY *William H. Summey*
Attorney
 HIS ATTORNEYS.

July 1, 1930.

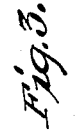
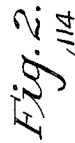
D. L. SUMMEY

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INVENTOR
David L. Sumner
BY *Kevin J. Savage, Rice*
HIS ATTORNEYS.

July 1, 1930.

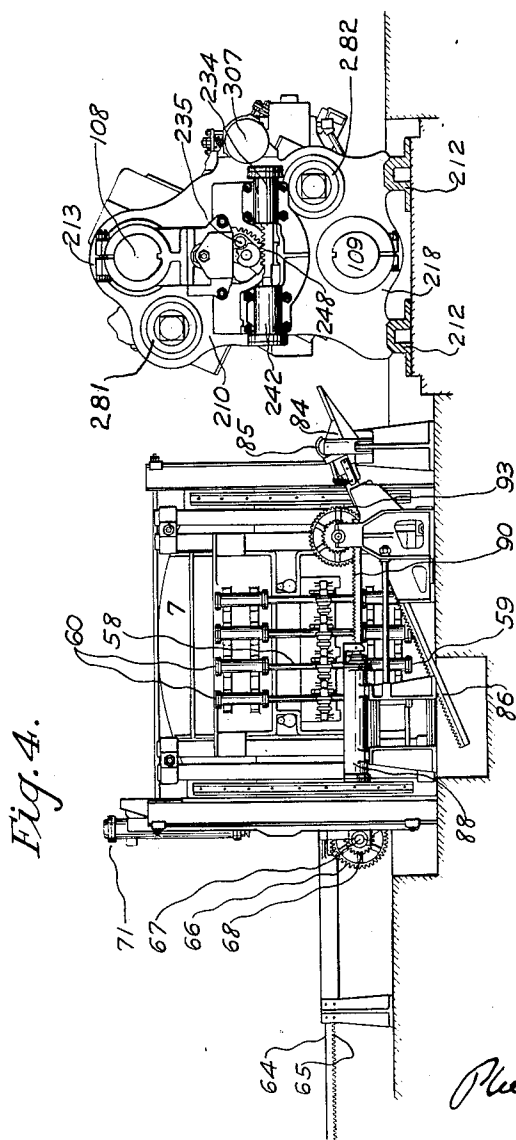
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INVENTOR
Daniel L. Summey
BY *William S. Summey*
HIS ATTORNEYS.

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D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 4

Fig. 5.

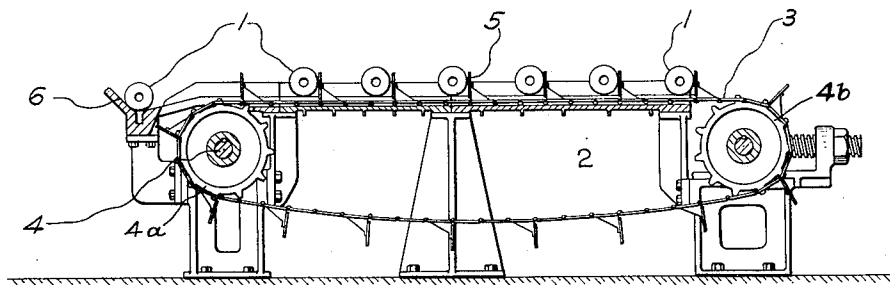
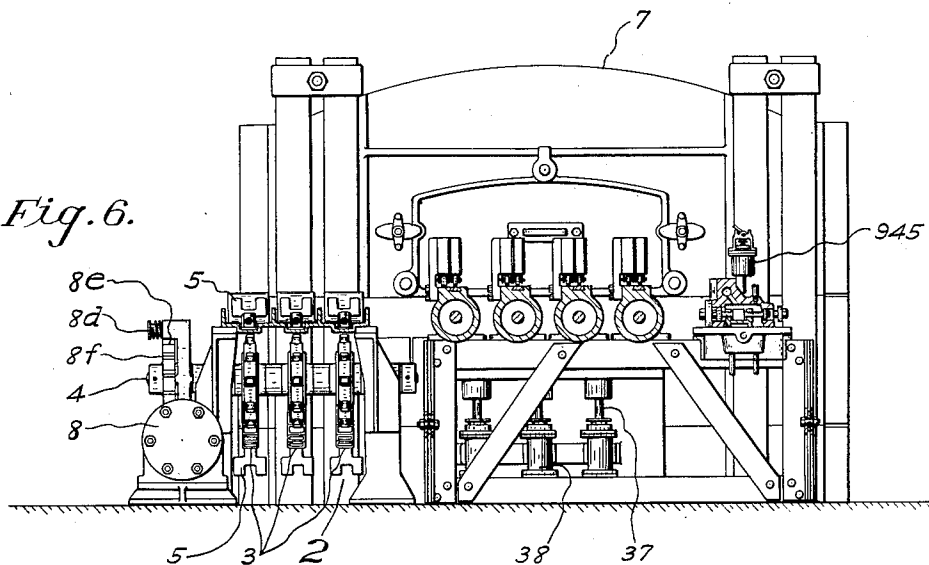


Fig. 6.



INVENTOR
David L. Summey
BY
Julius Sanger Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

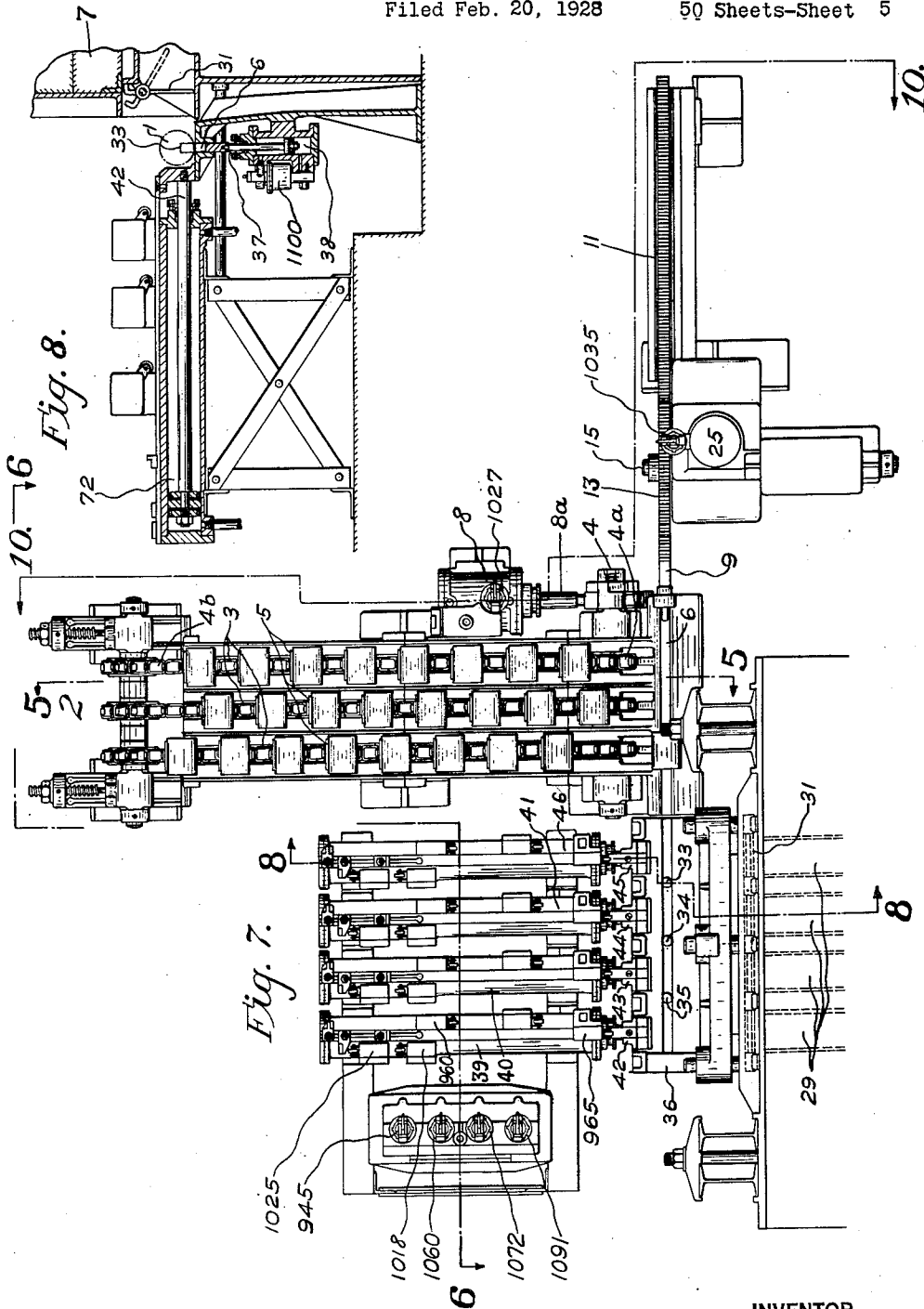
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 5



INVENTOR
David L. Summey
BY
Philip Sawyer & Co. Kansas City, Mo.
HIS ATTORNEYS.

July 1, 1930.

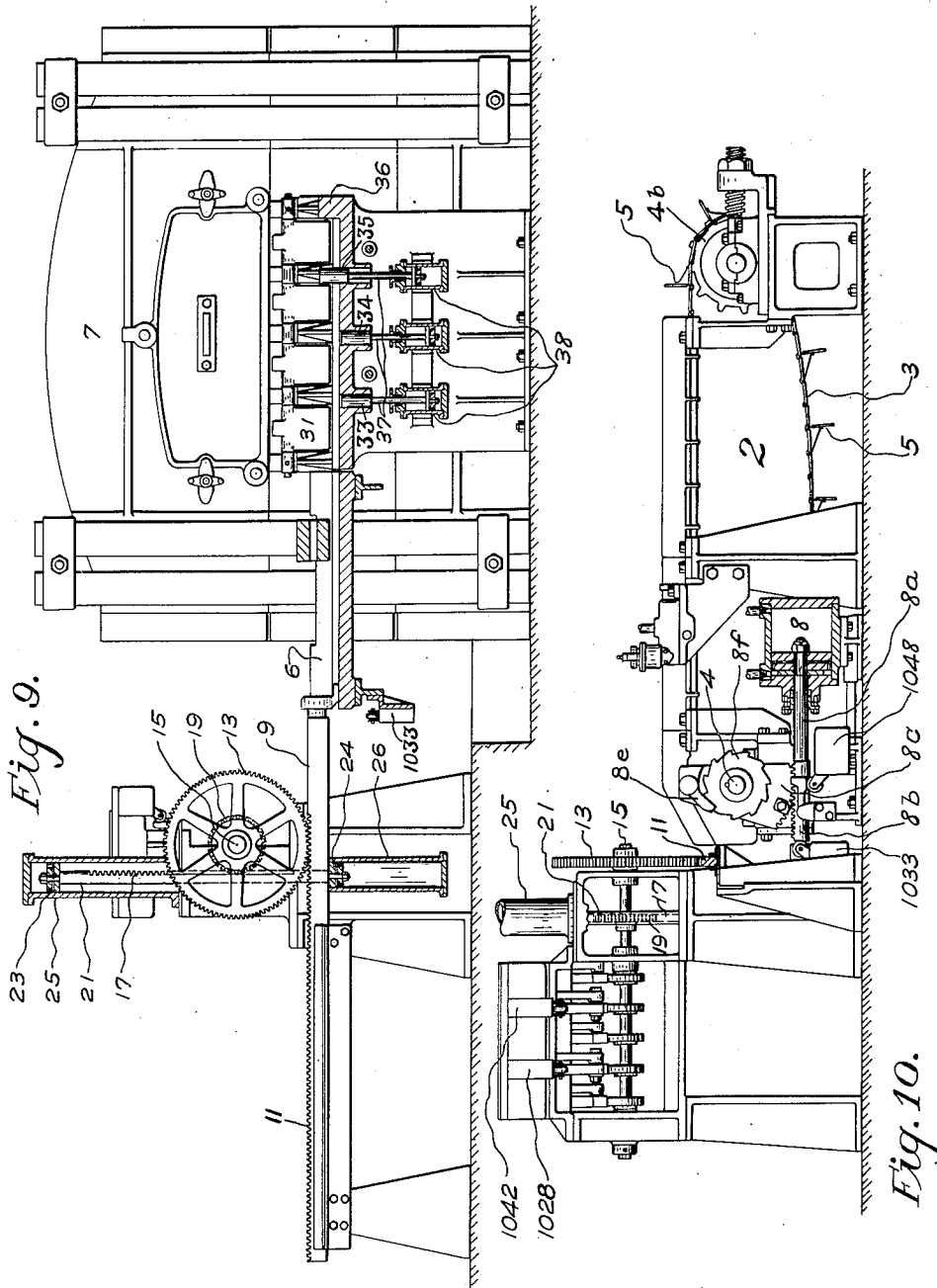
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 6



INVENTOR
David L. Summey
 BY *Frederic Sawyer Rice*
 HIS ATTORNEYS.

July 1, 1930.

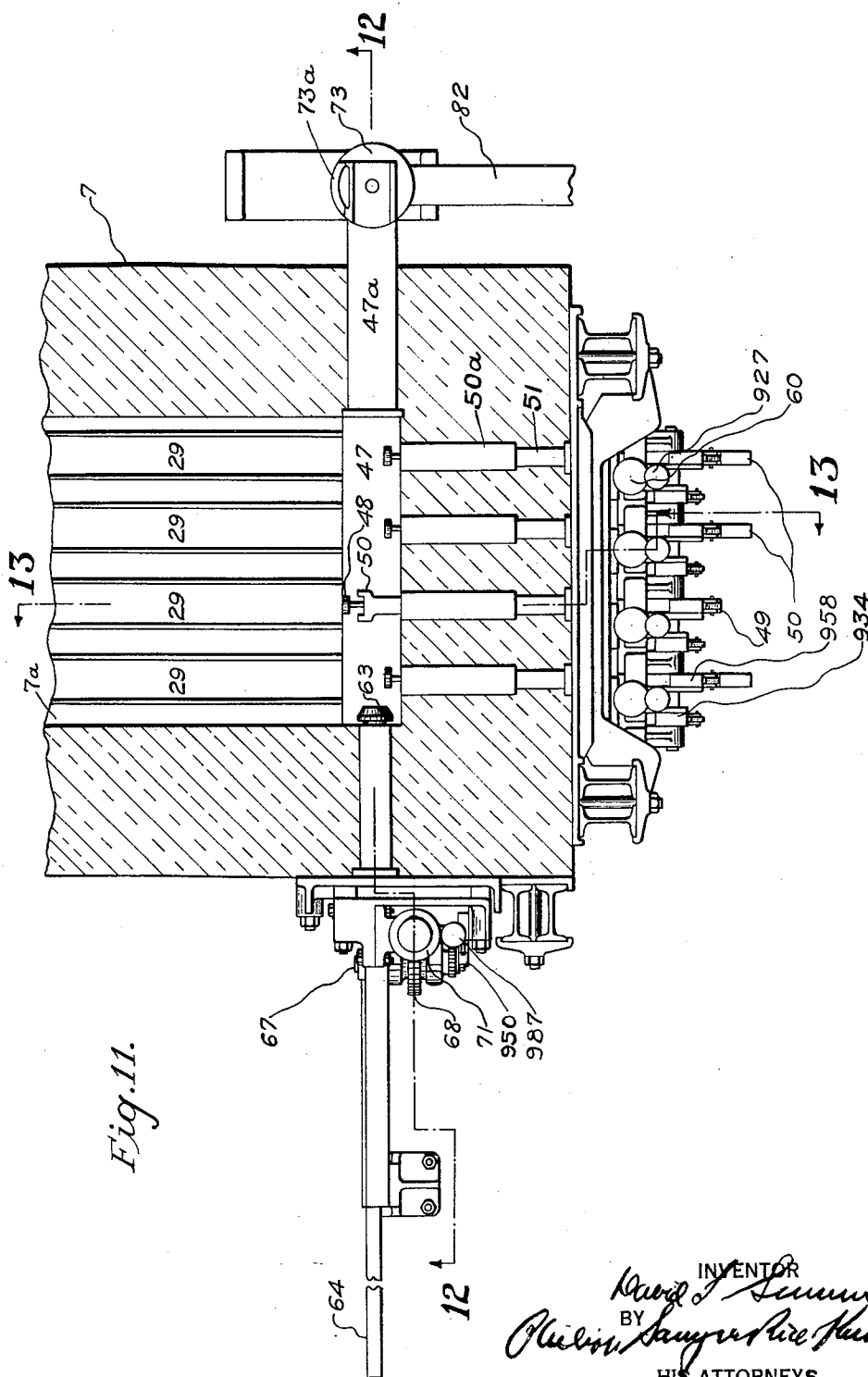
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 7



July 1, 1930.

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 8

Fig. 16a.

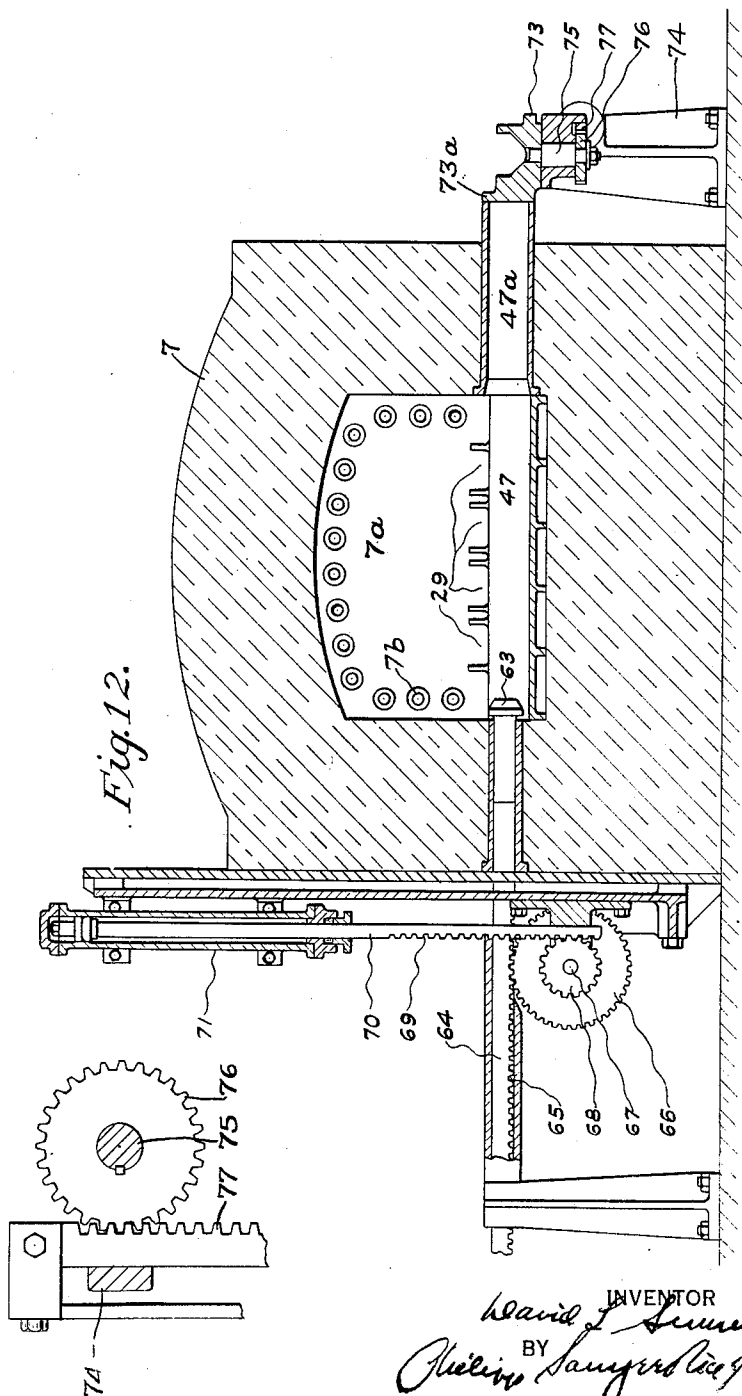


Fig. 12.

INVENTOR
David L. Summey
BY *Charles S. Summey*
HIS ATTORNEYS

July 1, 1930.

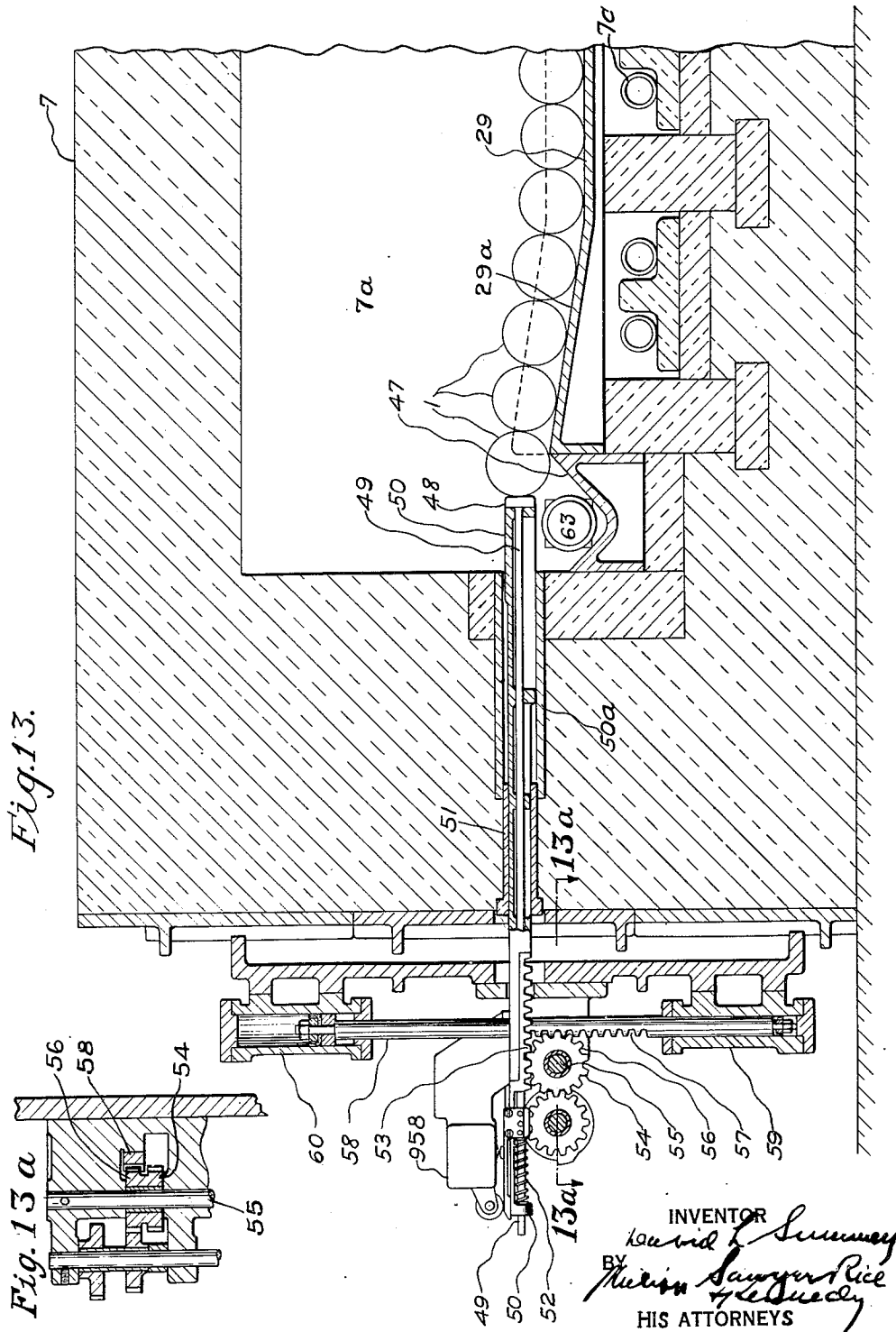
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 9



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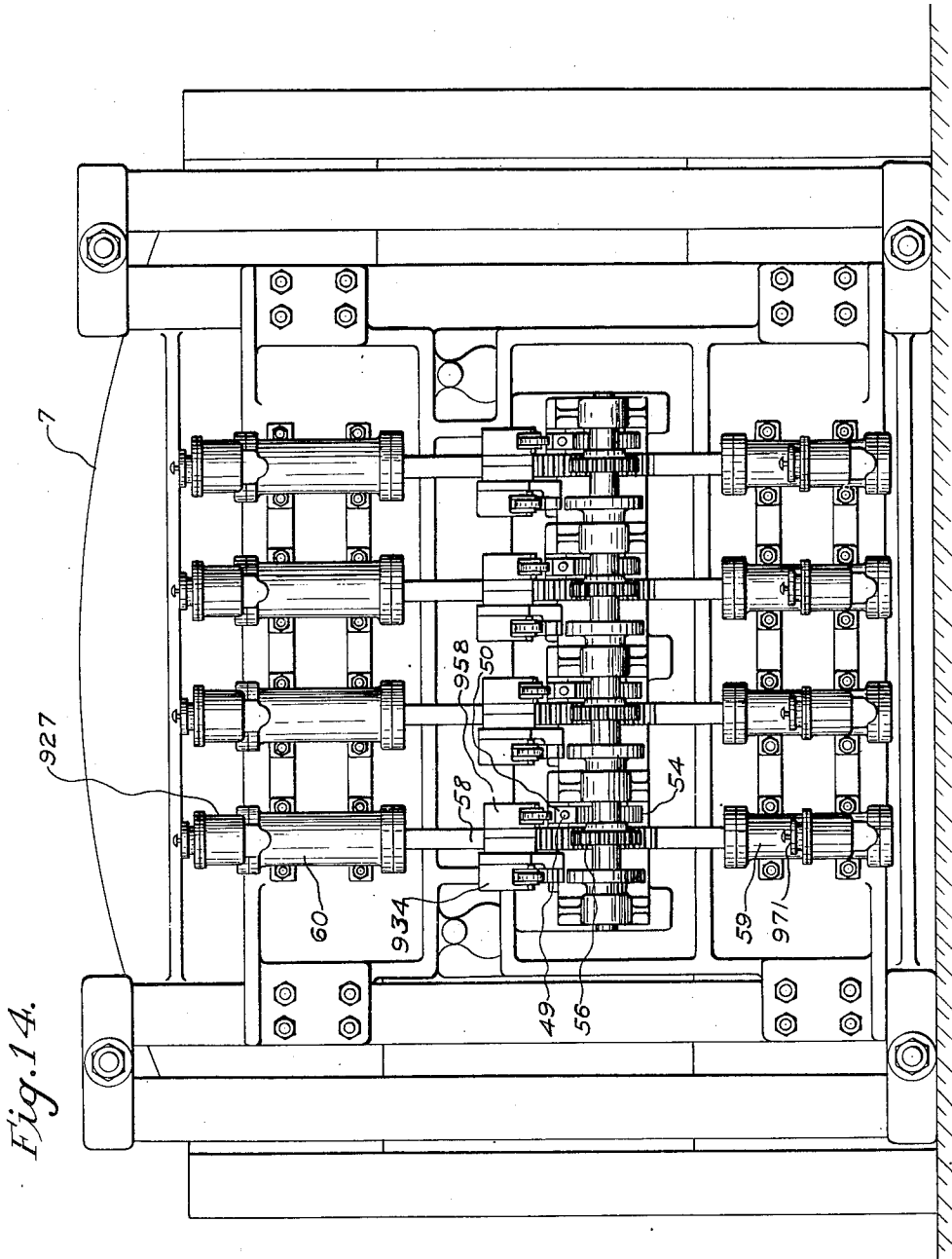
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 10



INVENTOR
David L. Summey
BY *William H. Rice*
Wm. H. Rice
HIS ATTORNEYS

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D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 11

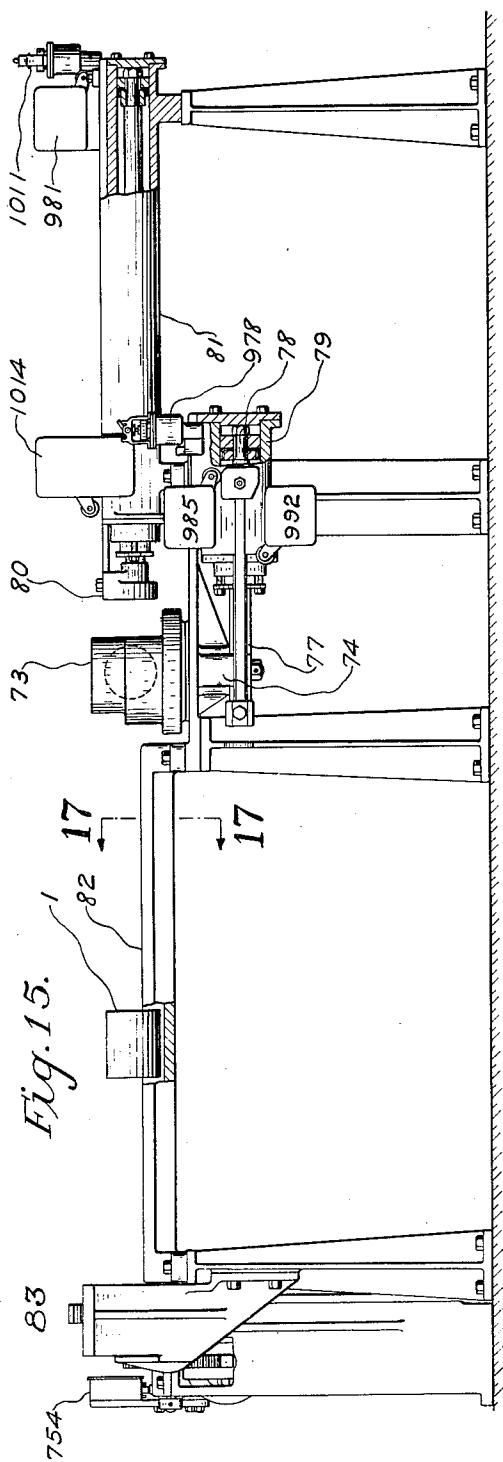


Fig. 15.

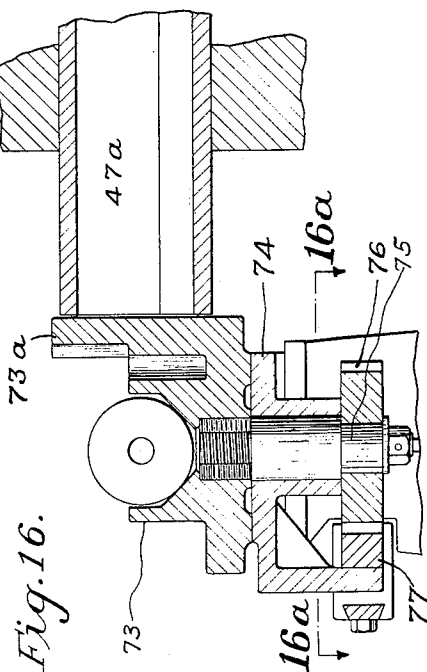


Fig. 16.

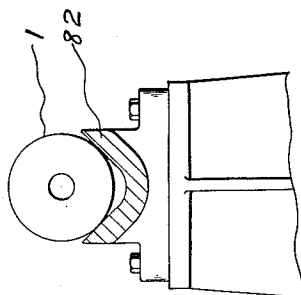


Fig. 17.

INVENTOR
David L. Summey
BY *Pauline Summey*
HIS ATTORNEYS.

July 1, 1930.

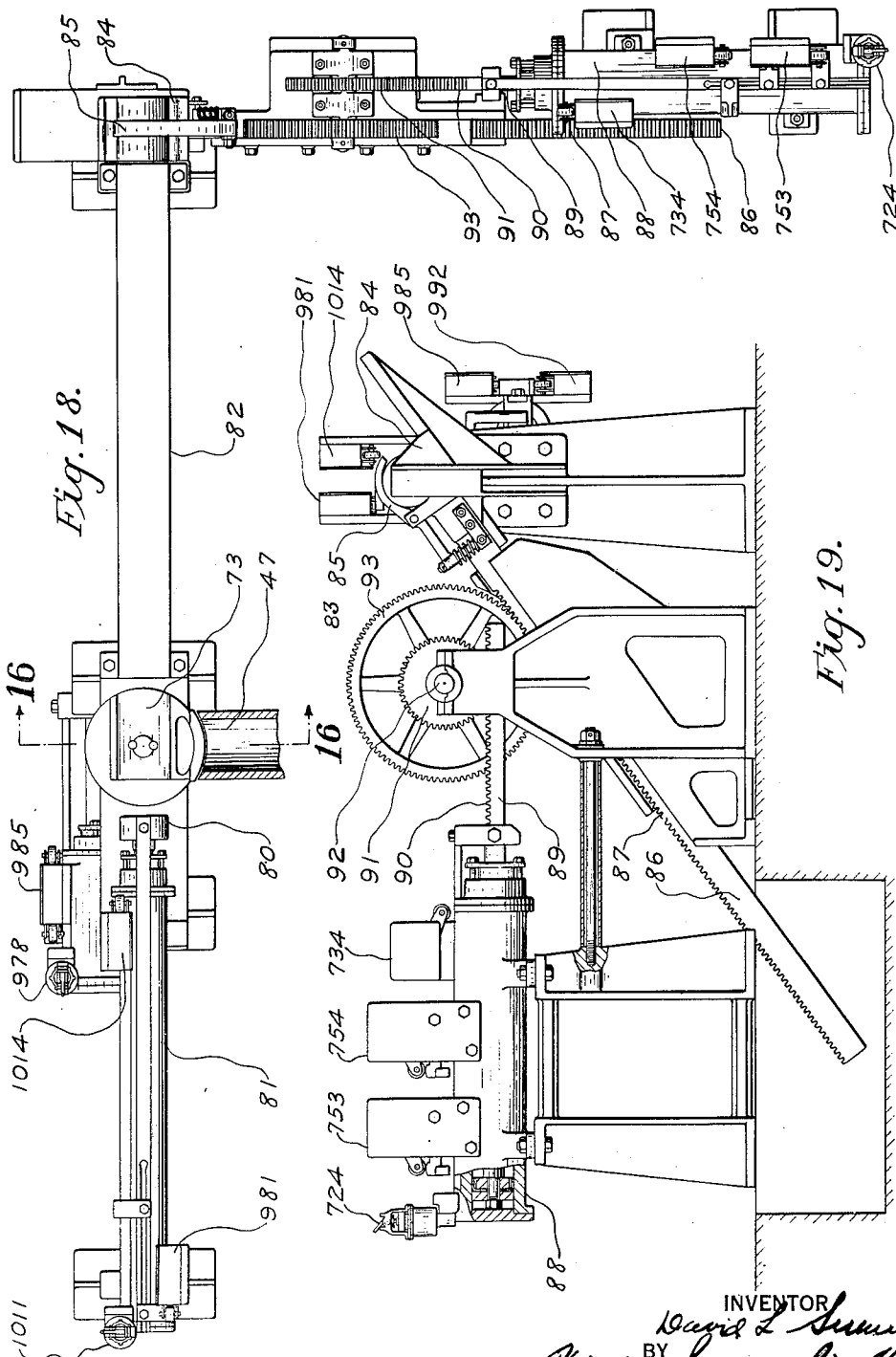
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 12



INVENTOR
David L. Summey
BY Philip S. Langer & Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 13

Fig. 78.

July 1, 1930.

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Filed Feb. 20, 1928

50 Sheets-Sheet 14

Fig. 22.

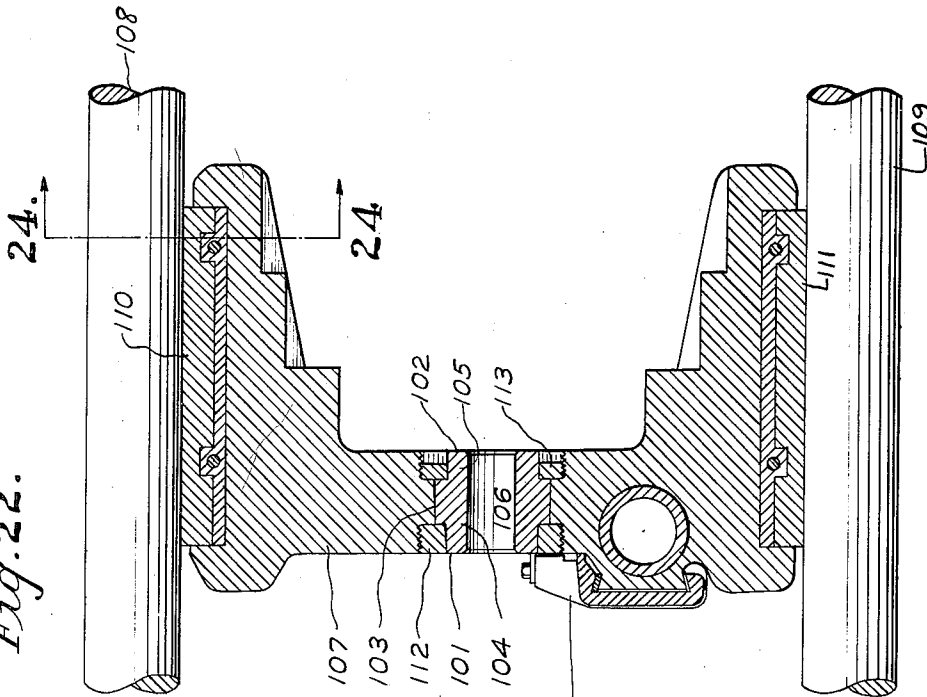
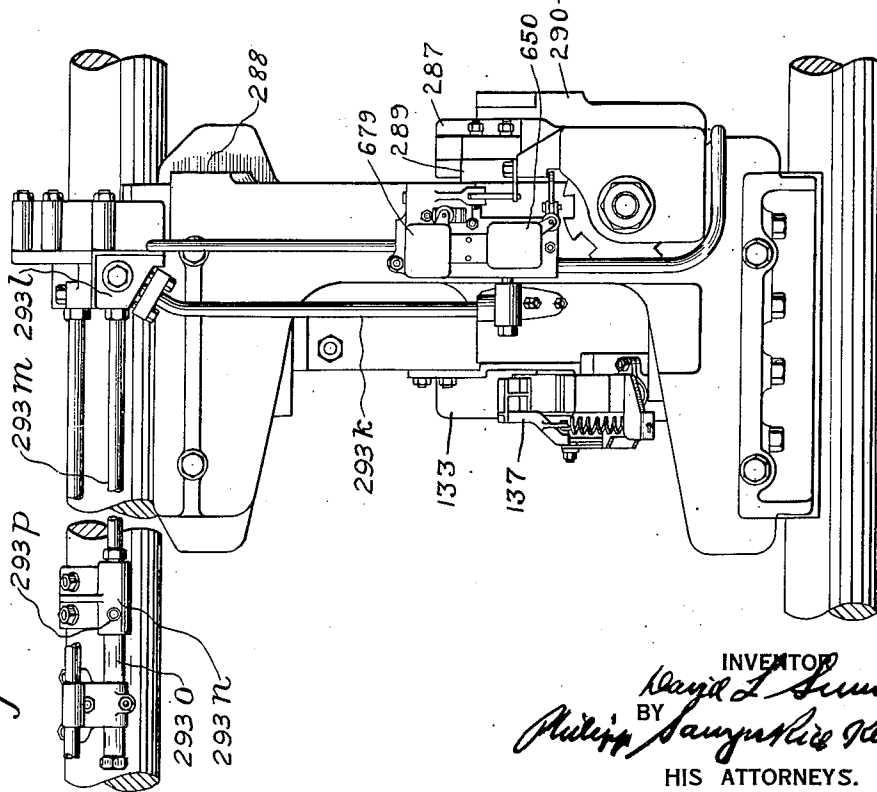


Fig. 21.



INVENTOR
David L. Summey
BY *Philip Sanyal & Kennedy*
HIS ATTORNEYS.

July 1, 1930.

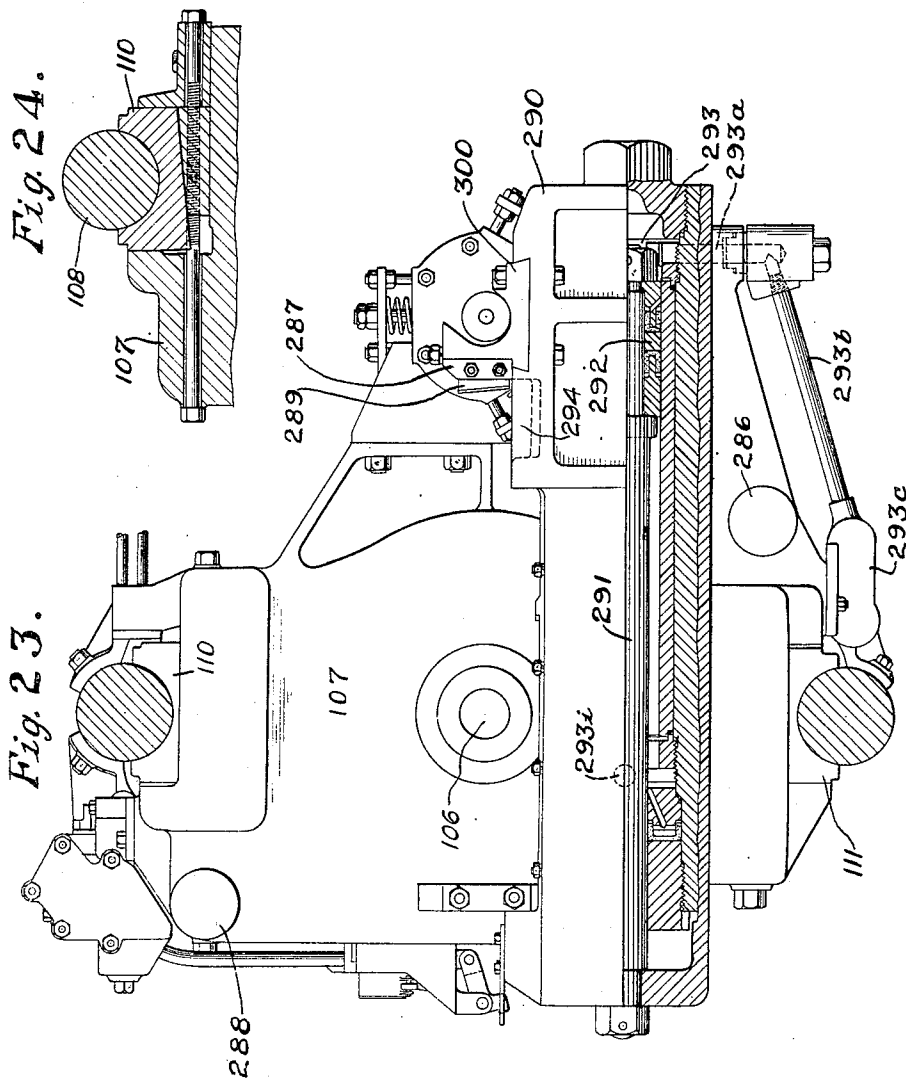
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Filed Feb. 20, 1928

50 Sheets-Sheet 15



INVENTOR
David L. Summey
BY *Philip Sanger Rice*
HIS ATTORNEYS.

July 1, 1930.

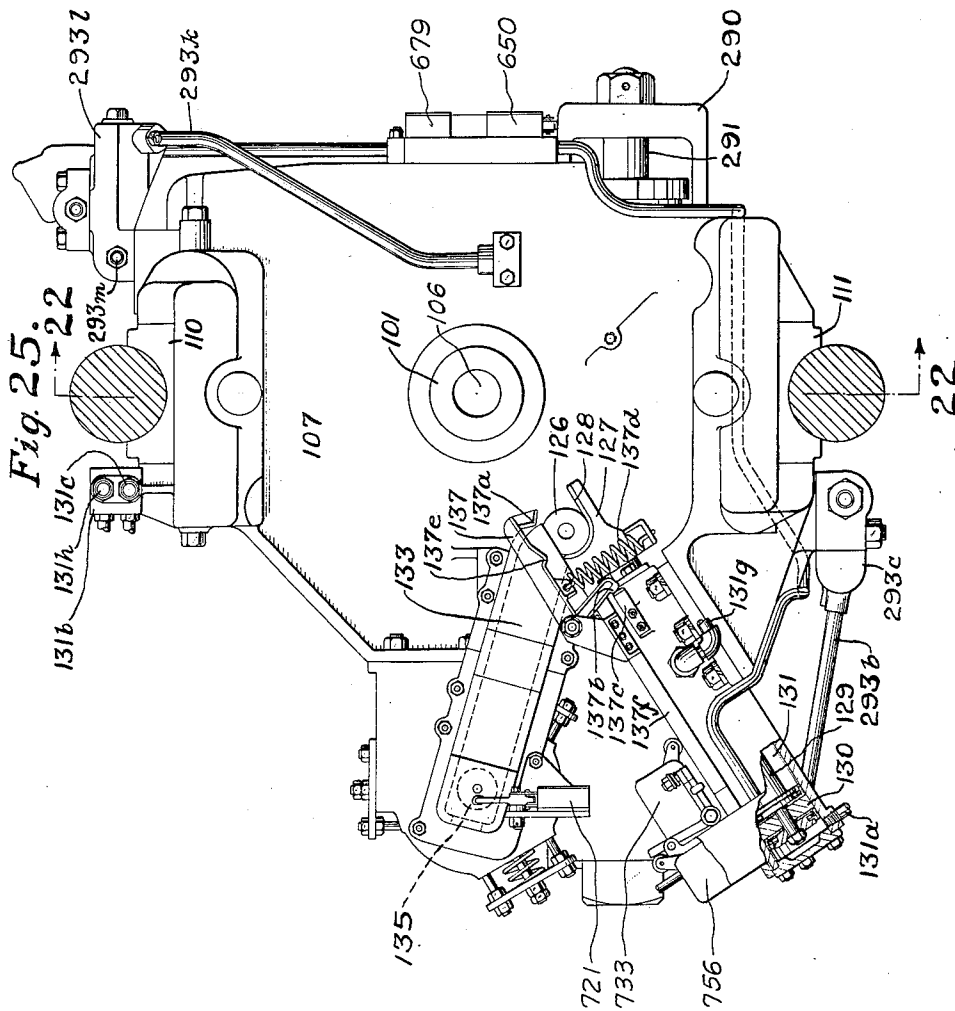
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INVENTOR
Herold L. Summey
 BY *Philip S. Summey*
Philip S. Summey
 HIS ATTORNEYS.

July 1, 1930.

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 17

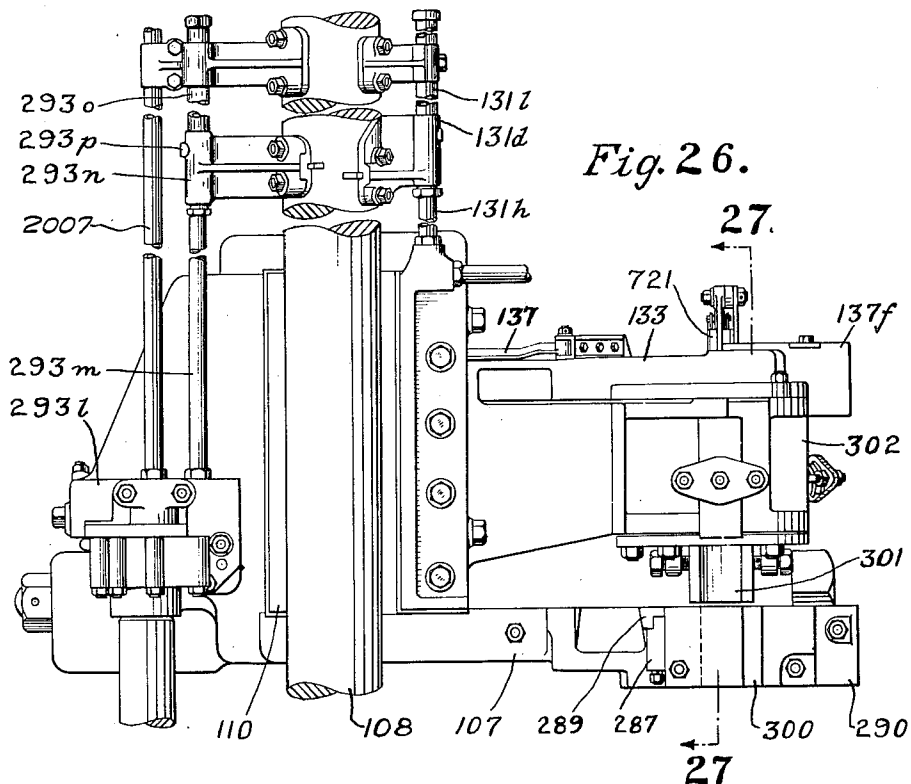


Fig. 26.

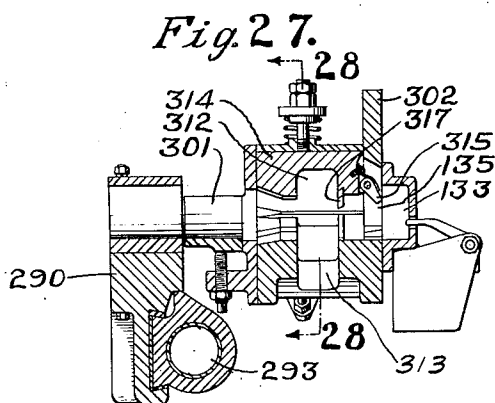


Fig. 27.

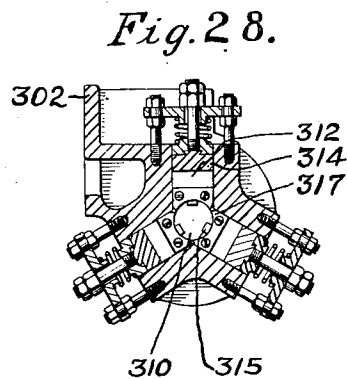


Fig. 28.

INVENTOR
D. L. Summey
 BY *Philip J. Kennedy*
 HIS ATTORNEYS.

July 1, 1930.

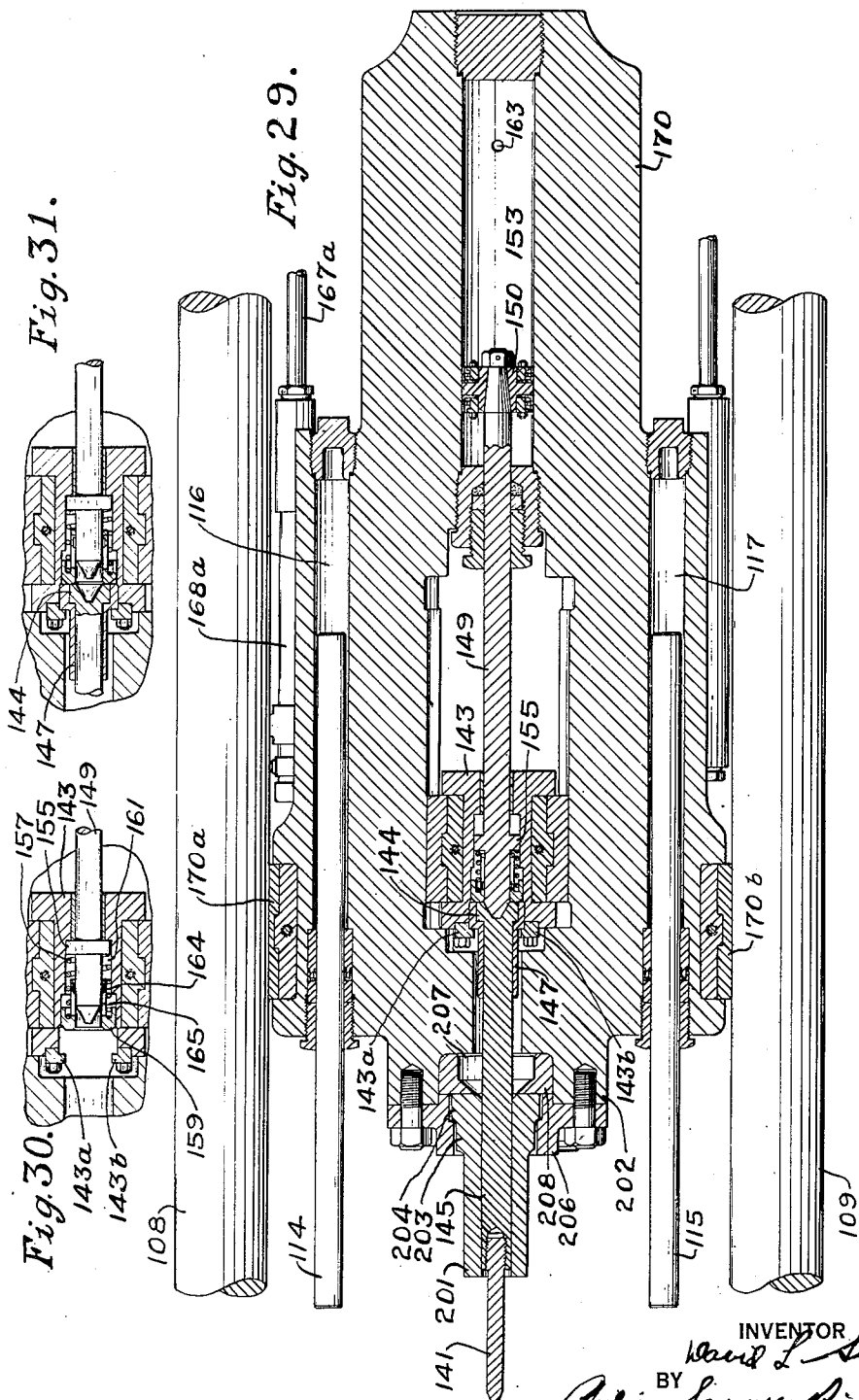
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Filed Feb. 20, 1928

50 Sheets-Sheet 18



INVENTOR
David L. Summey
BY *Julius Sawyer Rice Kernal*
HIS ATTORNEYS.

July 1, 1930.

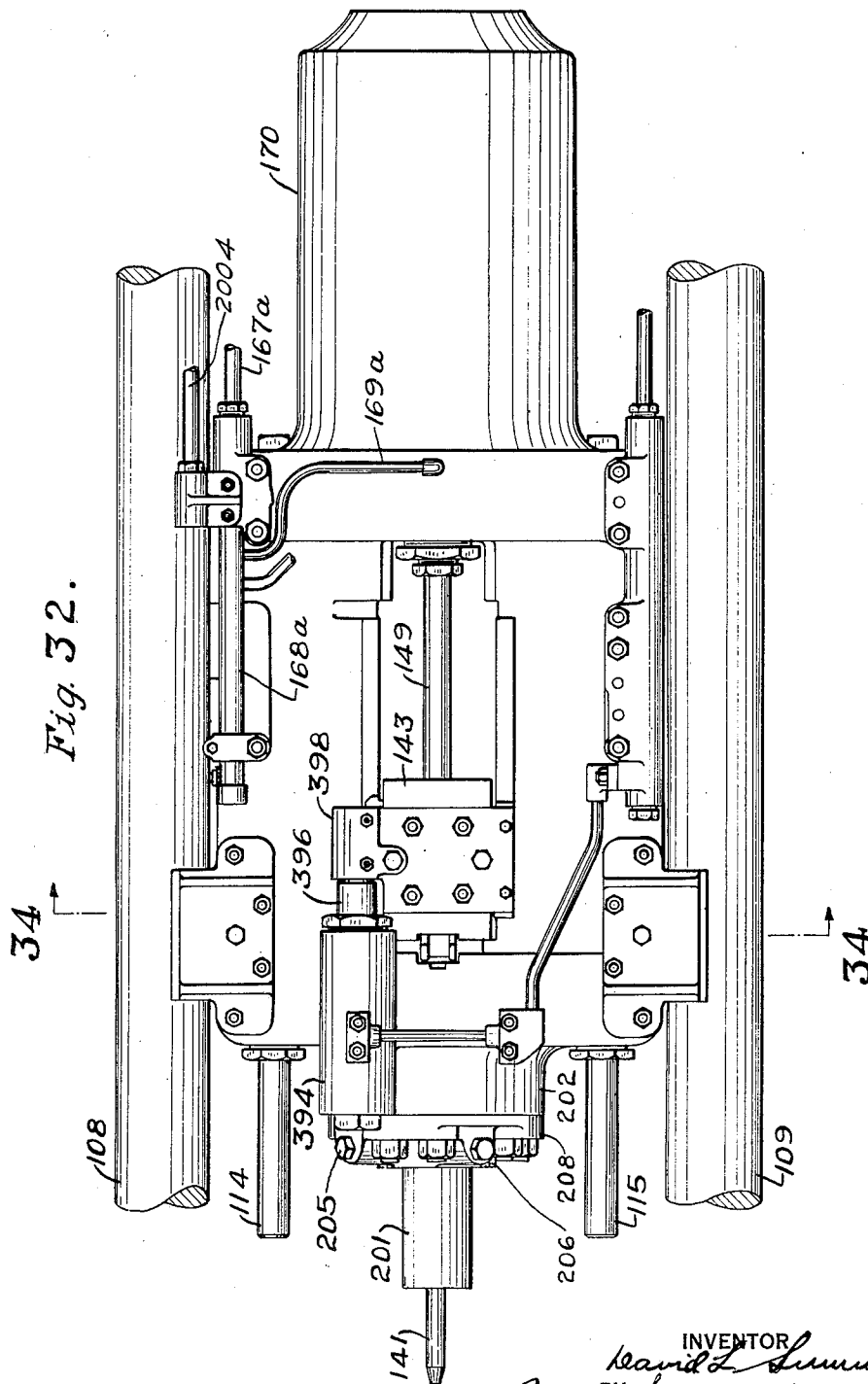
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INVENTOR
David L. Summey
BY *Philip S. Sumner*
HIS ATTORNEYS.

July 1, 1930.

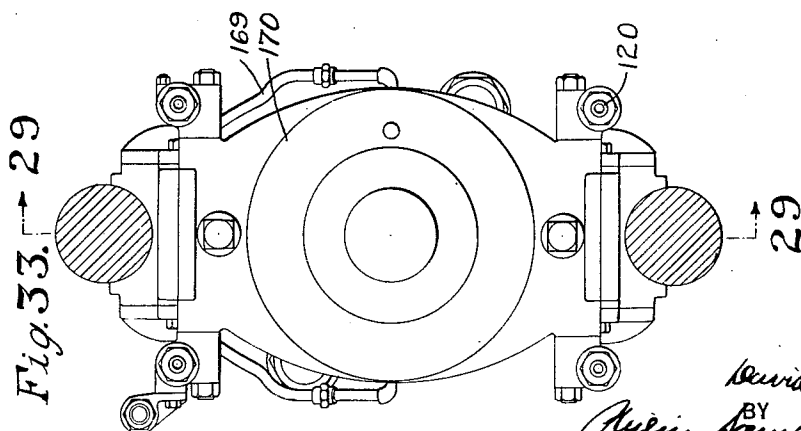
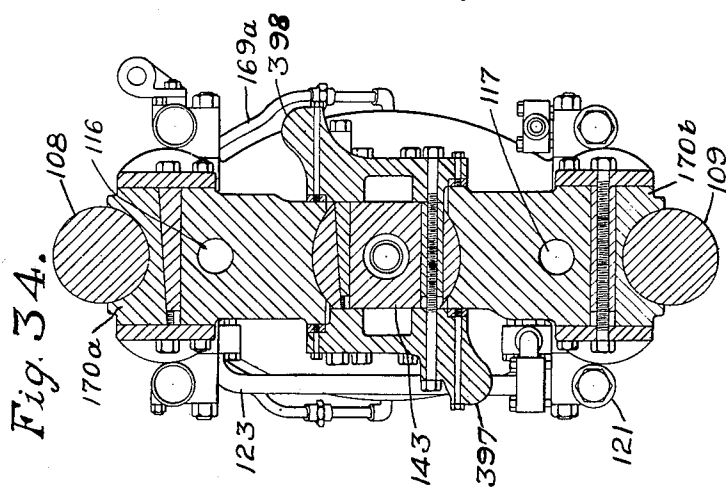
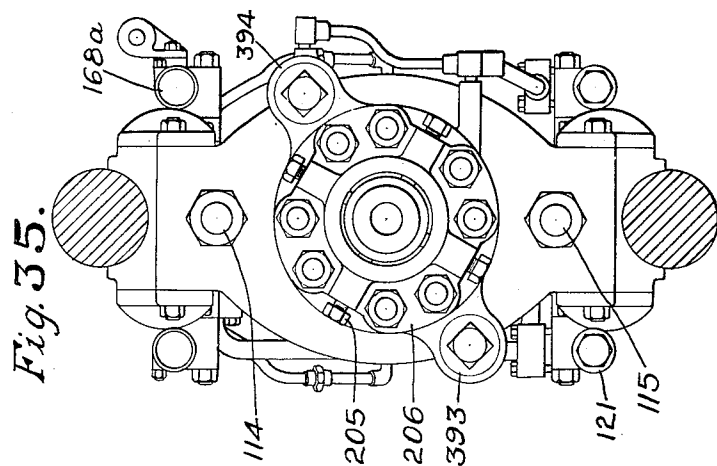
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 20



INVENTOR
David L. Summey
BY *Paul H. Rice*
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

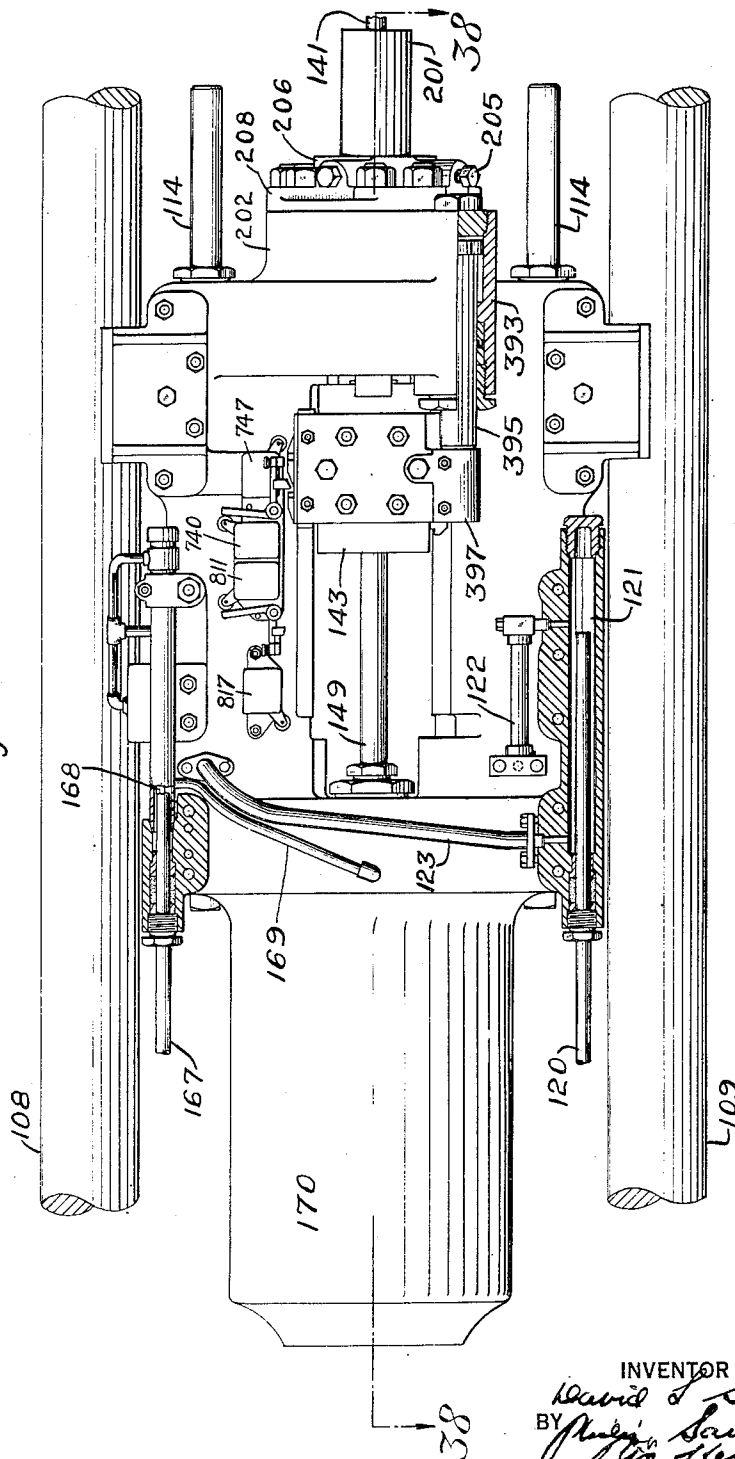
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 21

Fig. 36.



INVENTOR
David L. Summey
 BY *Philip S. Sawyer*
His Attorney
 HIS ATTORNEYS.

July 1, 1930.

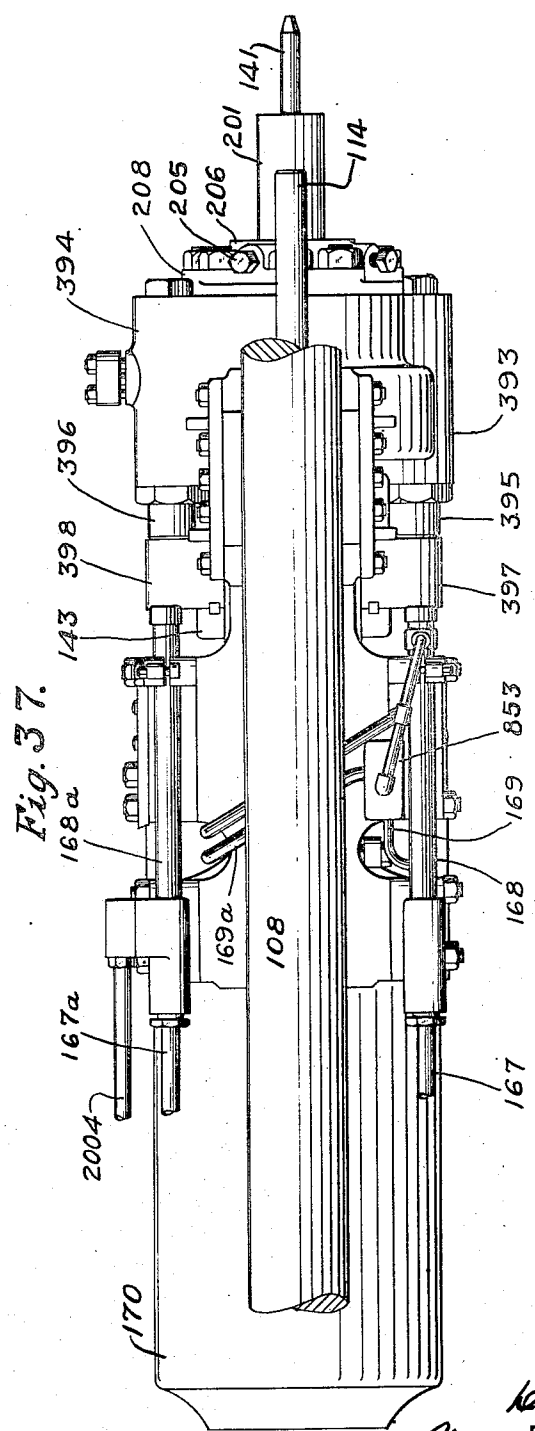
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 22



INVENTOR
David L. Summey
BY *Charles Lawrence & Co.*
HIS ATTORNEYS.

July 1, 1930.

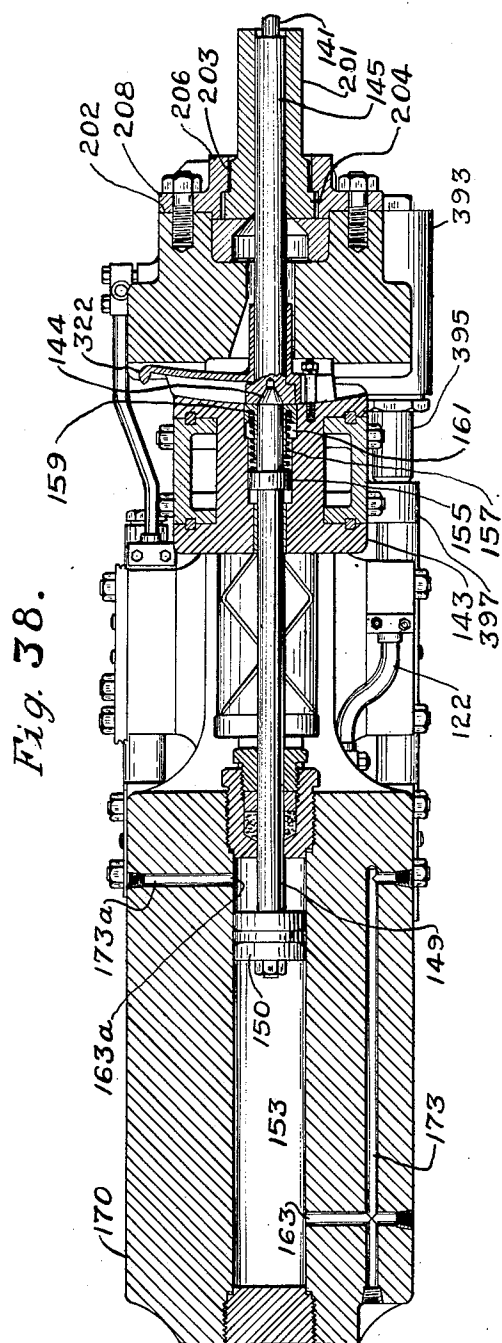
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Filed Feb. 20, 1928

50 Sheets-Sheet 23



INVENTOR
David J. Summey
BY
Richard Sawyer Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

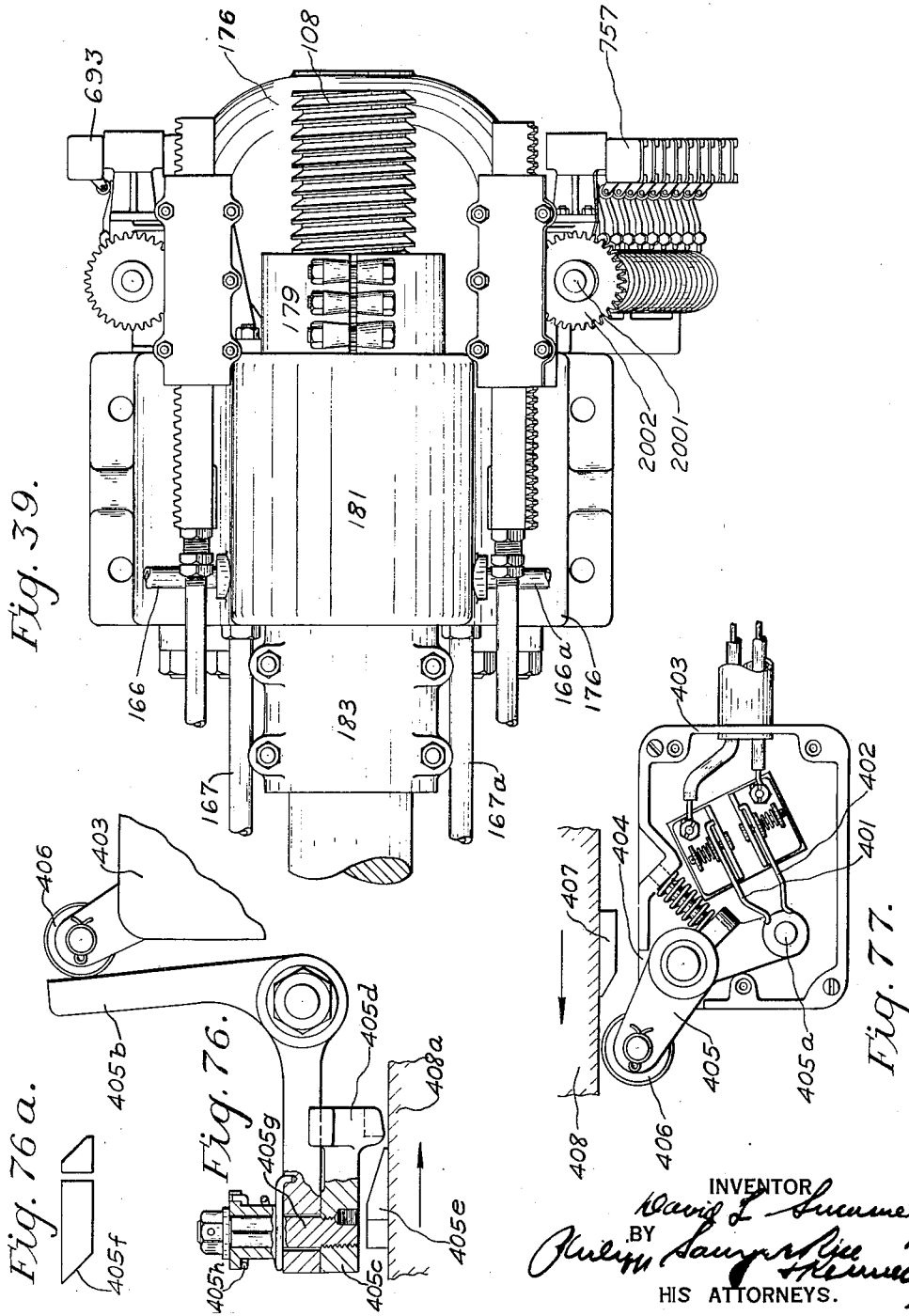
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 24



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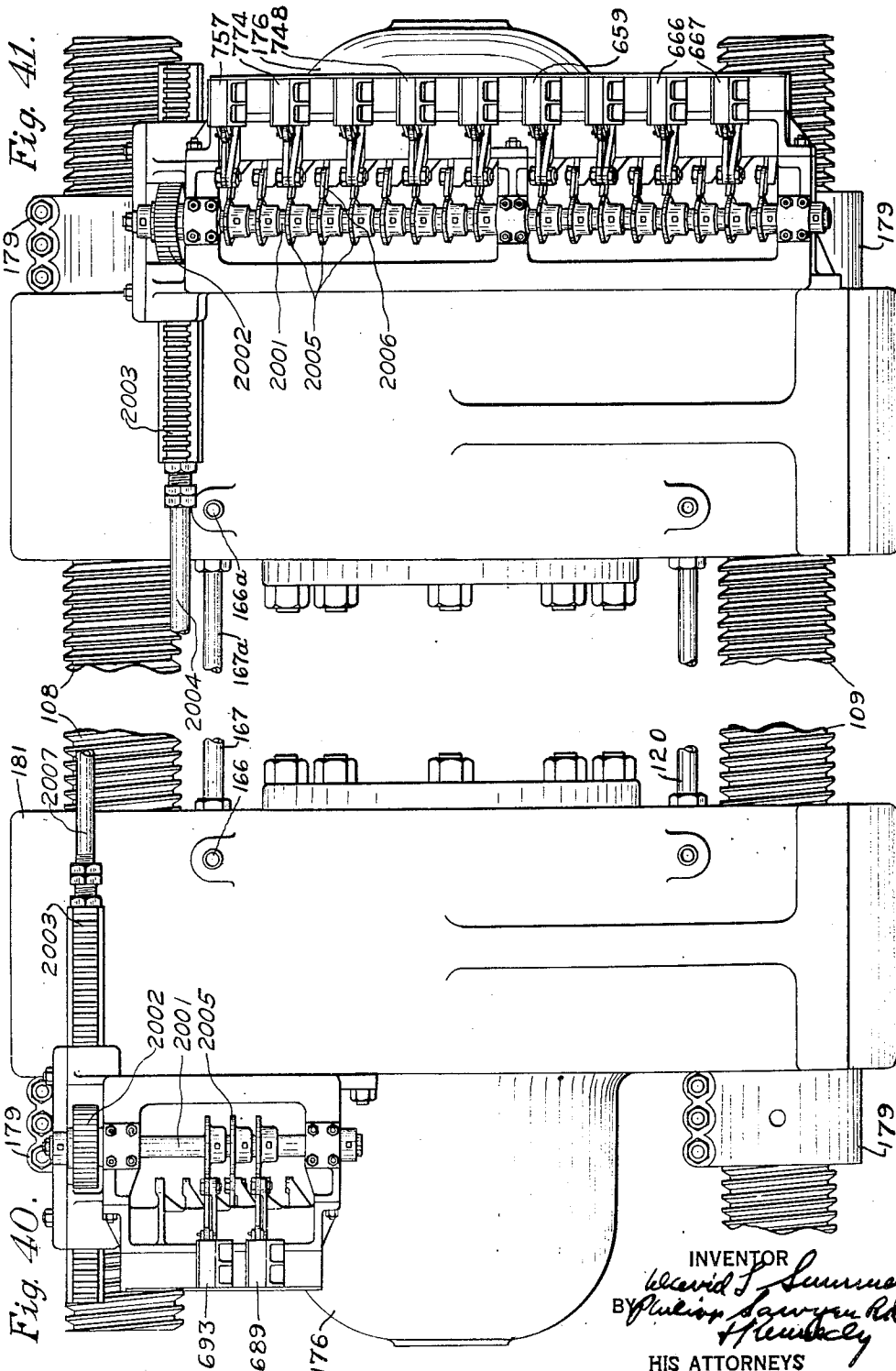
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 25



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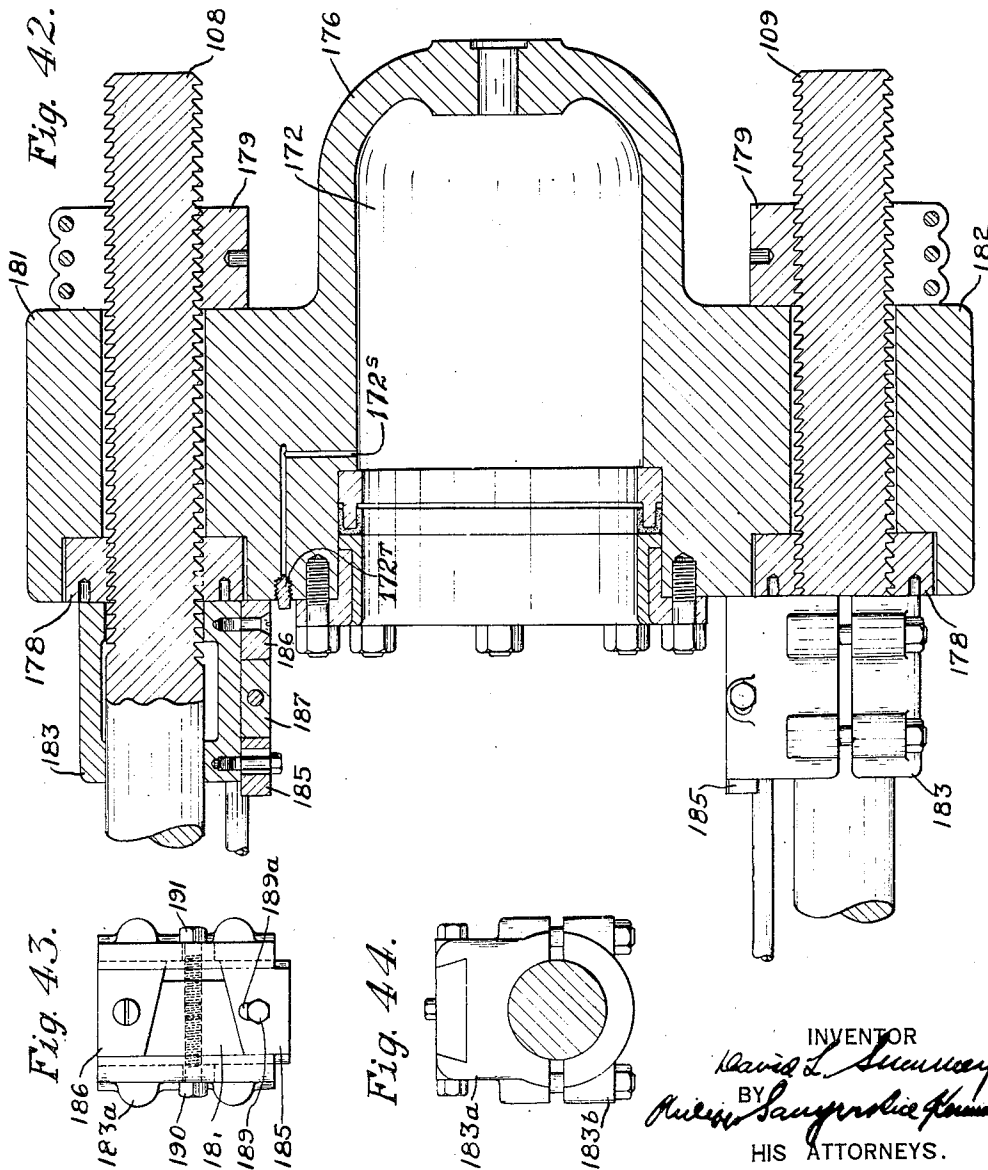
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Filed Feb. 20, 1928

50 Sheets-Sheet 26



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D. L. SUMMEY

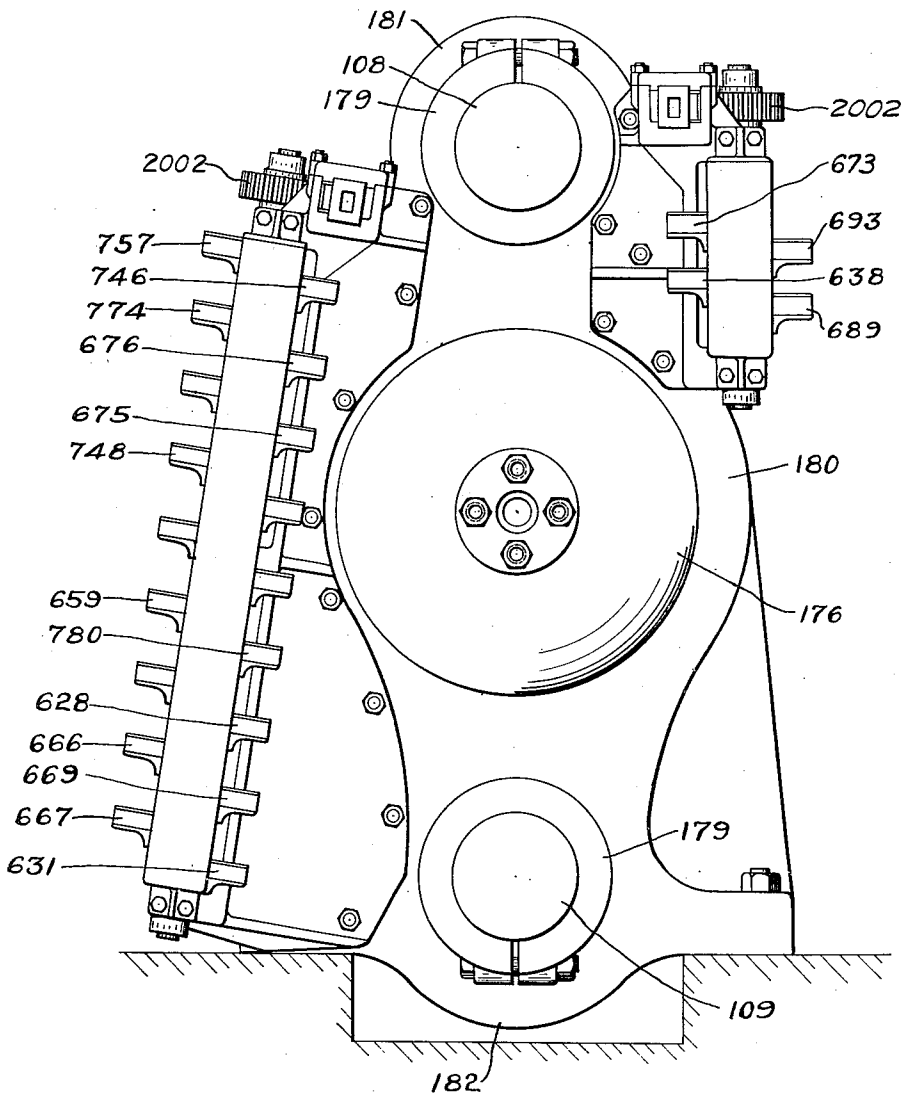
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METAL EXTRUDING APPARATUS

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50 Sheets-Sheet 27

Fig. 45.



INVENTOR
David L. Summey
William Sangrethie Kennedy
HIS ATTORNEYS.

July 1, 1930.

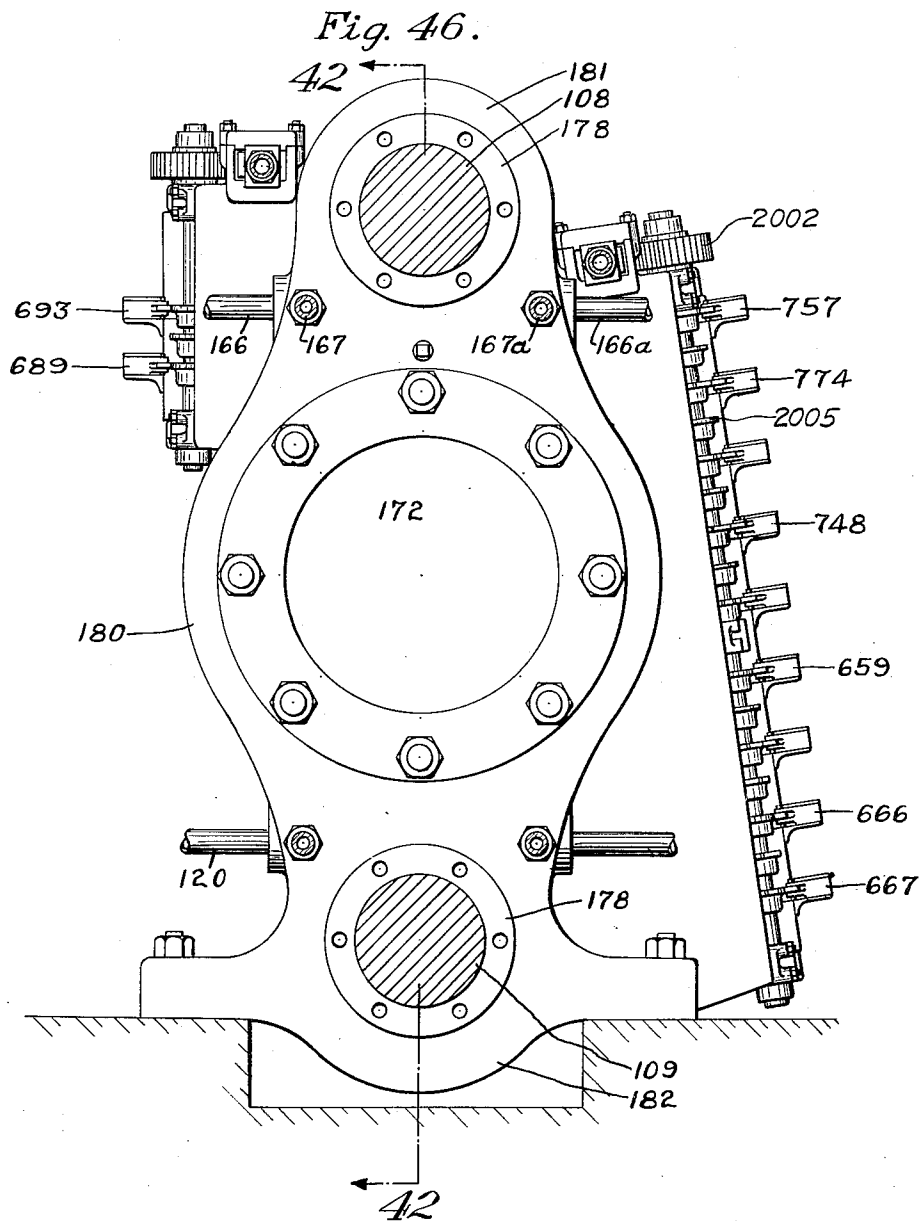
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 28



INVENTOR
David L. Summey
Philip S. Sargent & Sons
HIS ATTORNEYS

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 29

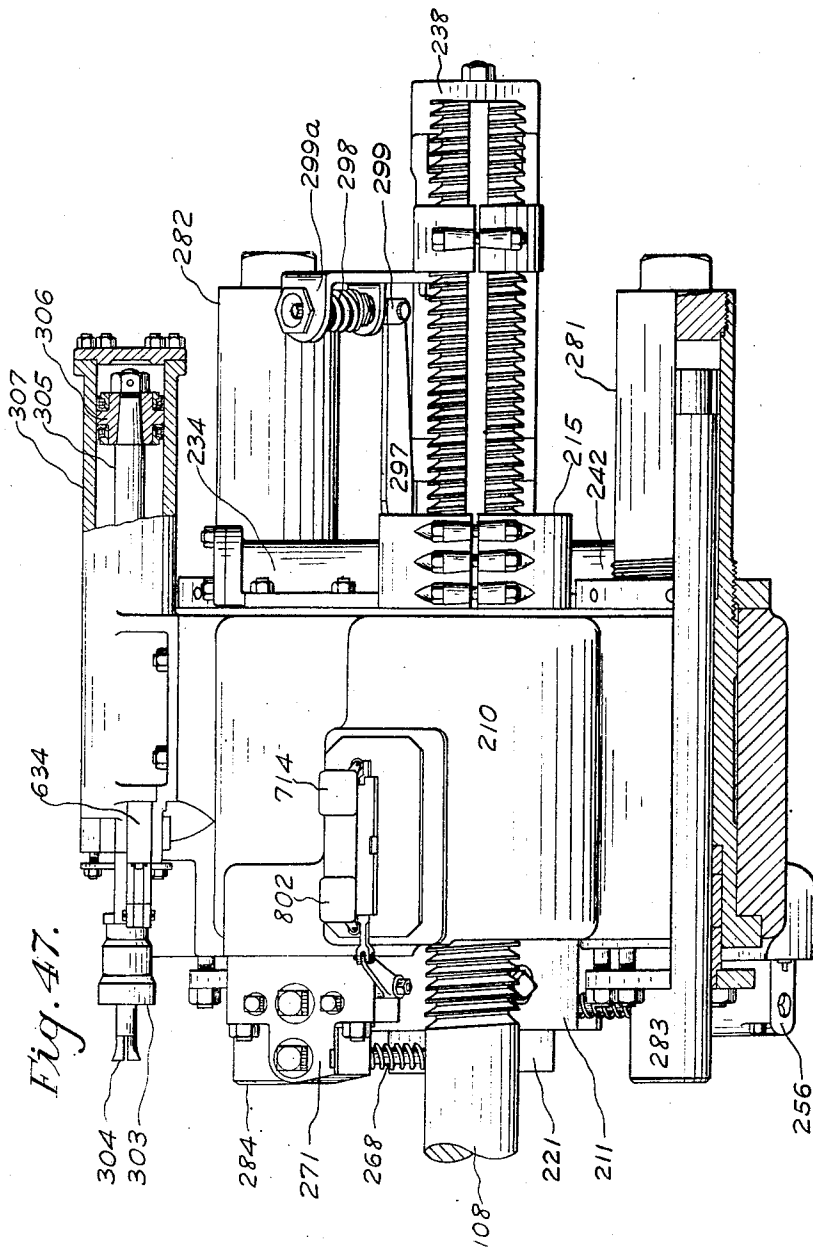


Fig. 47.

INVENTOR
David L. Summey
BY
William Sawyer & Co. Kennedy
HIS ATTORNEYS.

July 1, 1930.

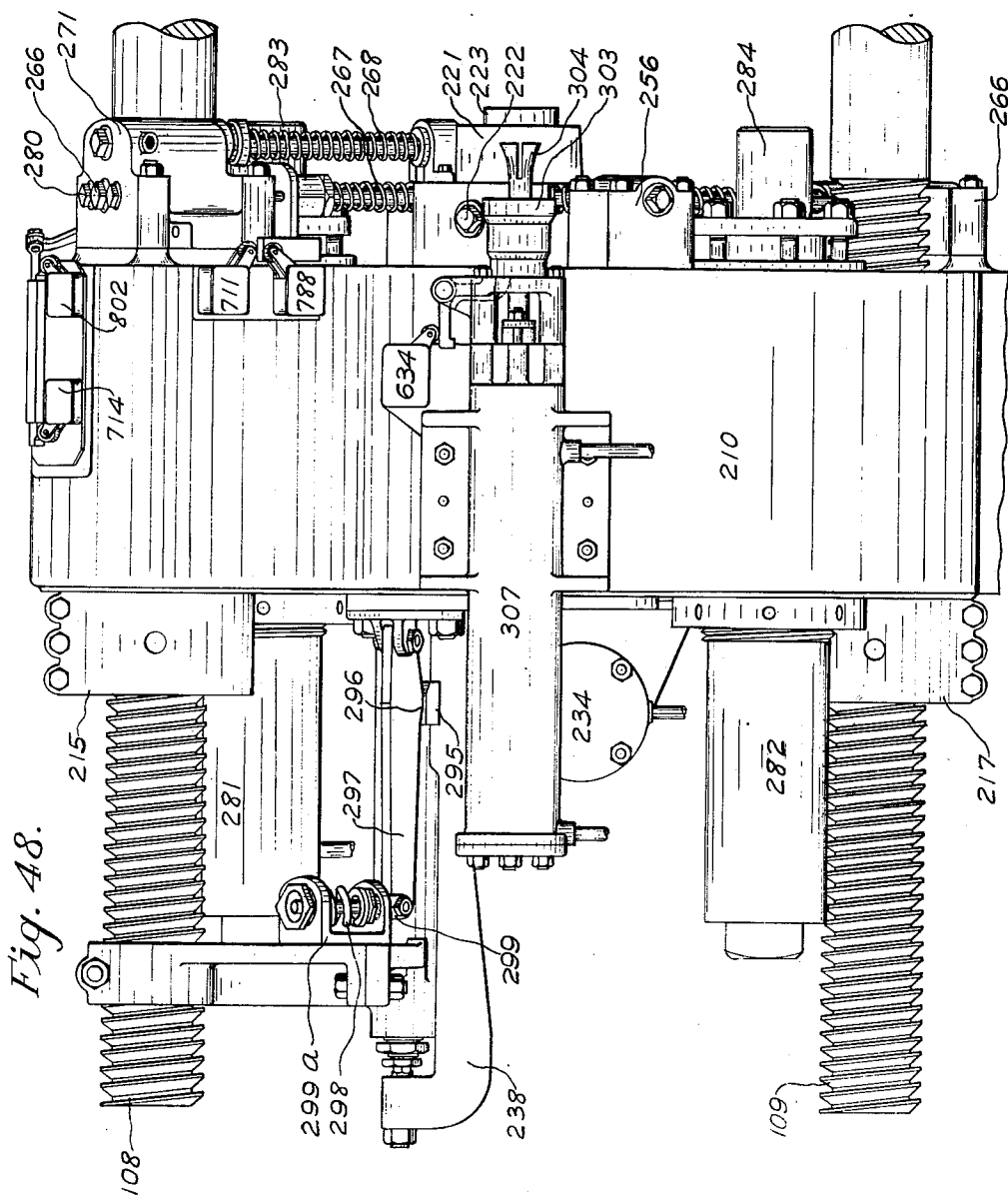
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 30



INVENTOR
David L. Summey
BY
Arthur Lawry Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

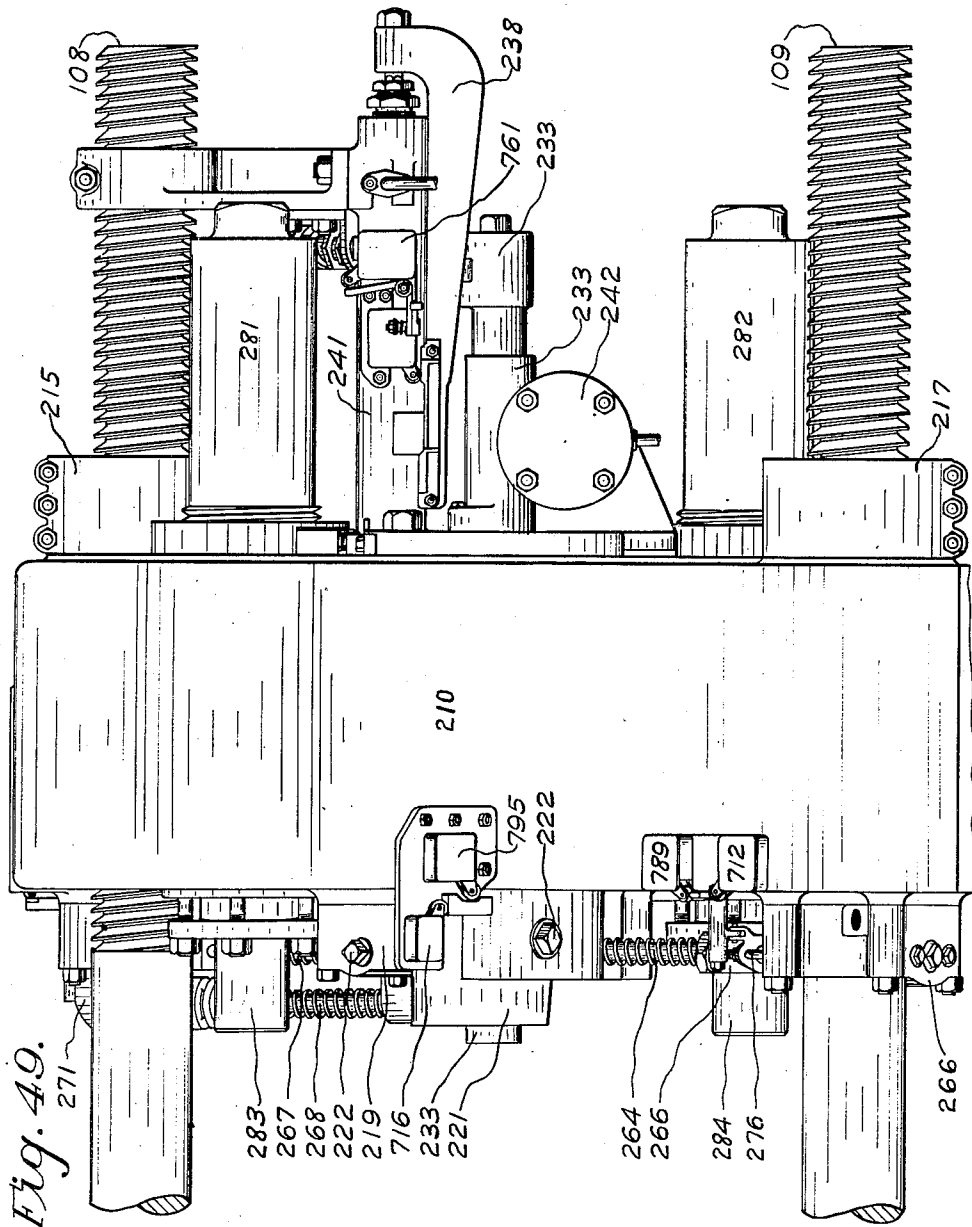
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 31



INVENTOR
David L. Summey
BY *Julian Lawrence R. Kunkley*
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 32

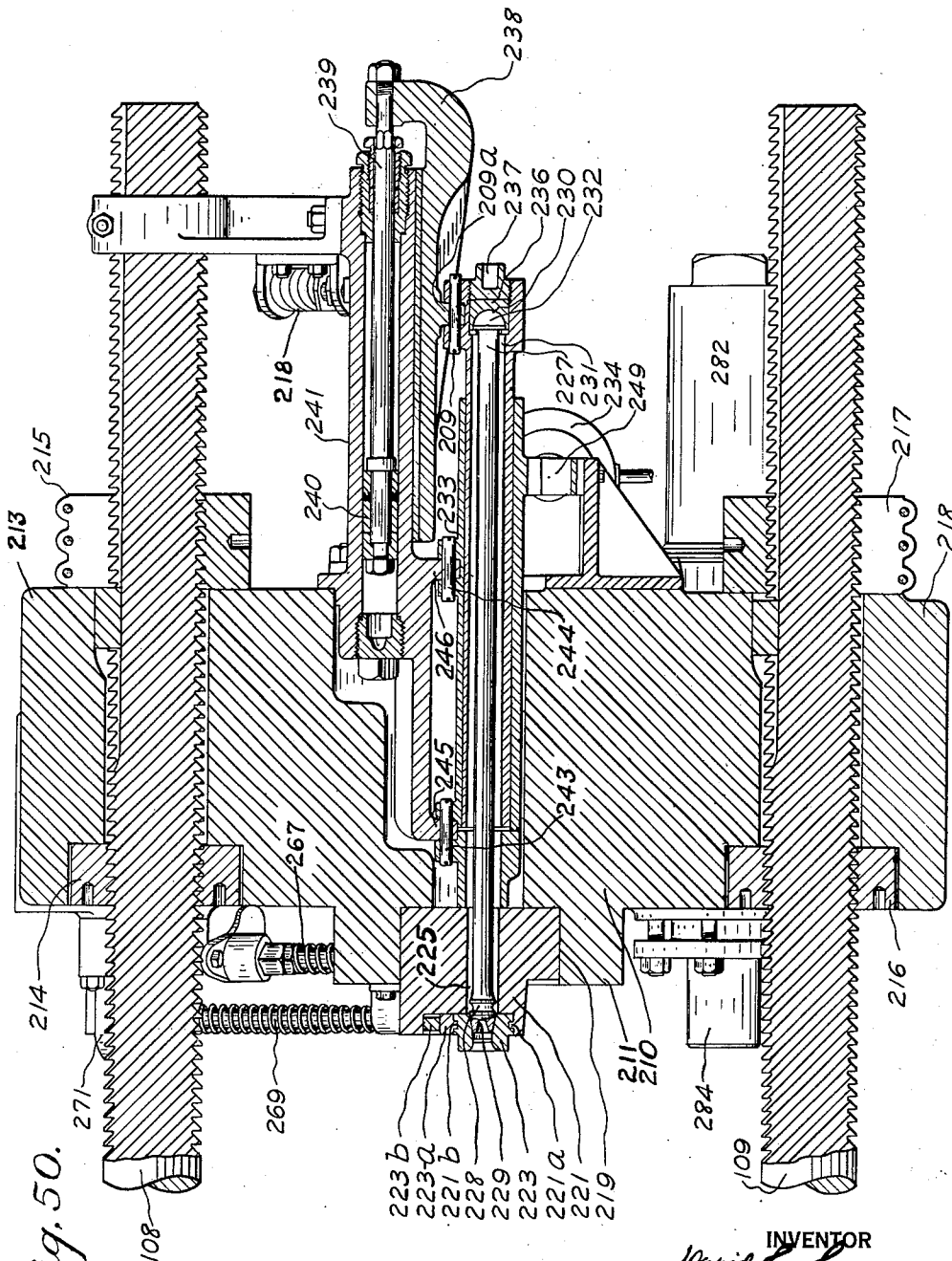


Fig. 50.

INVENTOR
David L. Summey
 BY
William Sawyer Rice, Harold
 HIS ATTORNEYS.

July 1, 1930.

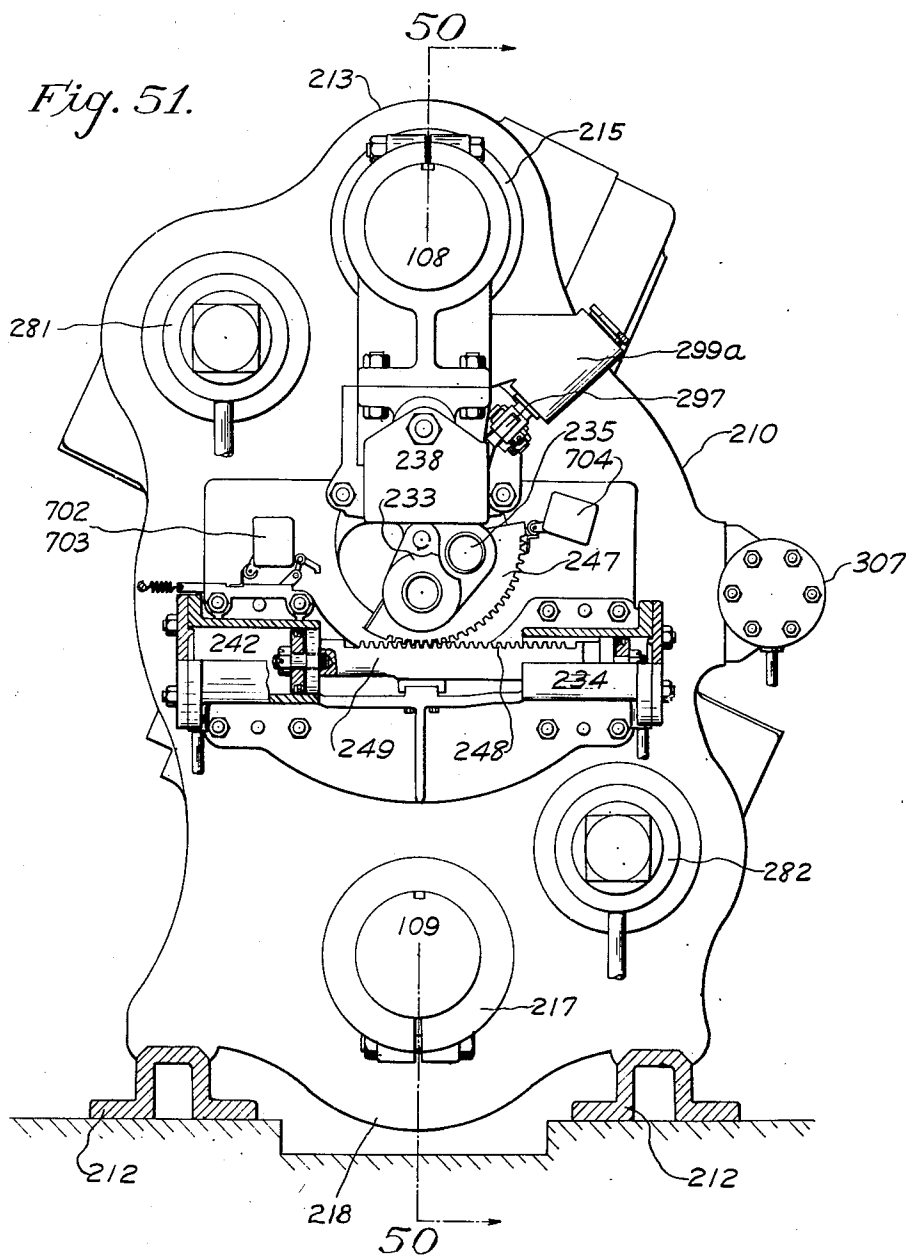
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 33



INVENTOR
David L. Summey
BY *Philip Sargent Rice Kennedy*
HIS ATTORNEYS.

July 1, 1930.

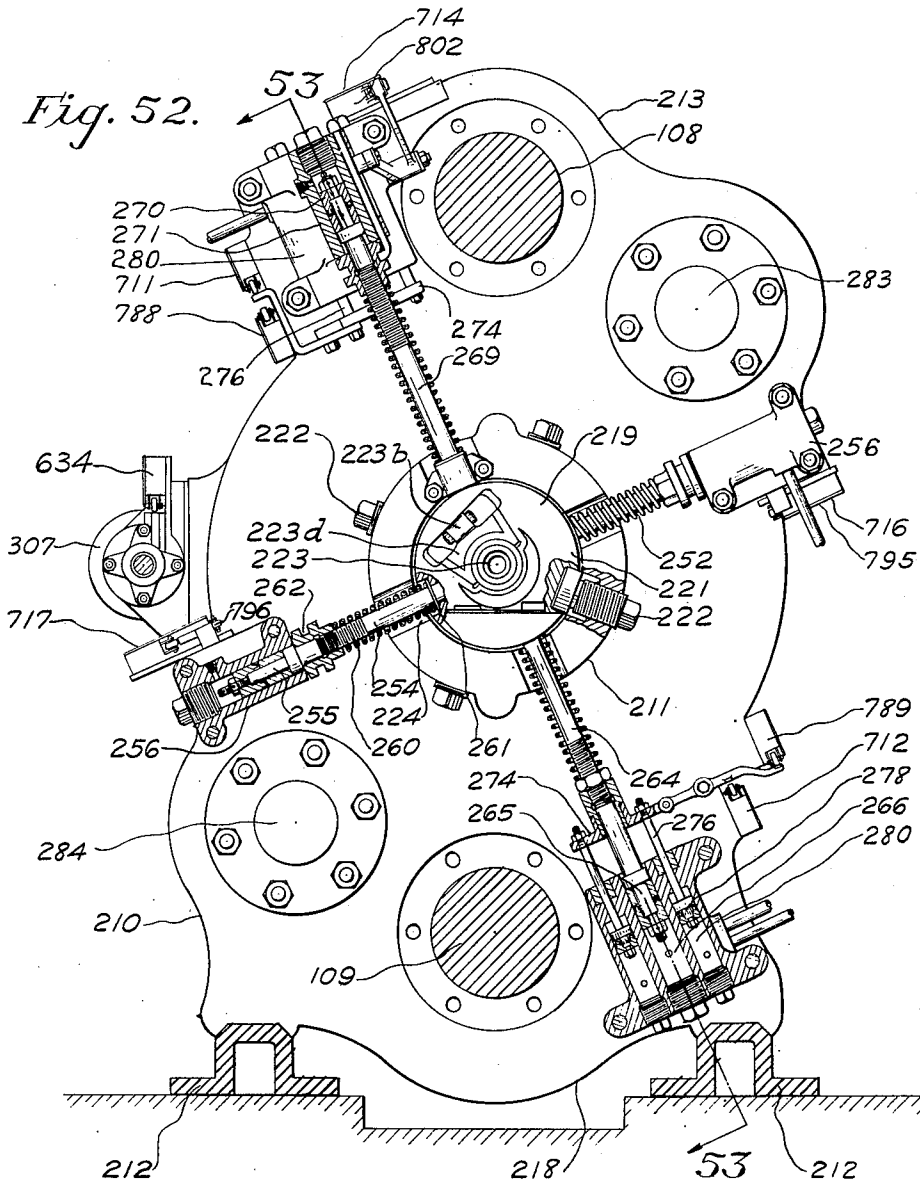
D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 34



INVENTOR
David L. Samurey
BY Philip Sawyer & Co. Keeney
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 35

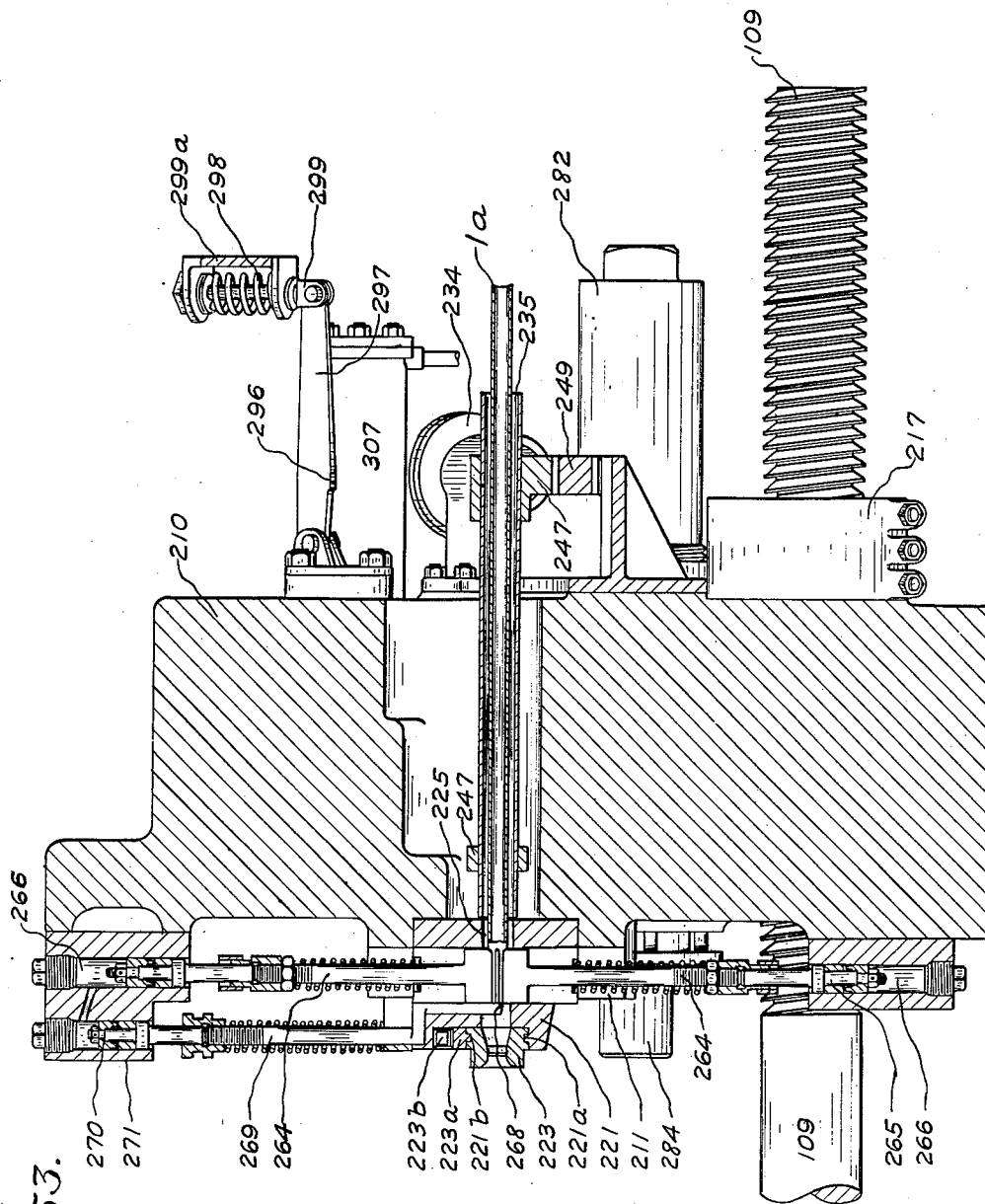


Fig. 53.

INVENTOR
D. L. Summey
 BY *Richard L. Summey*
 HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 36

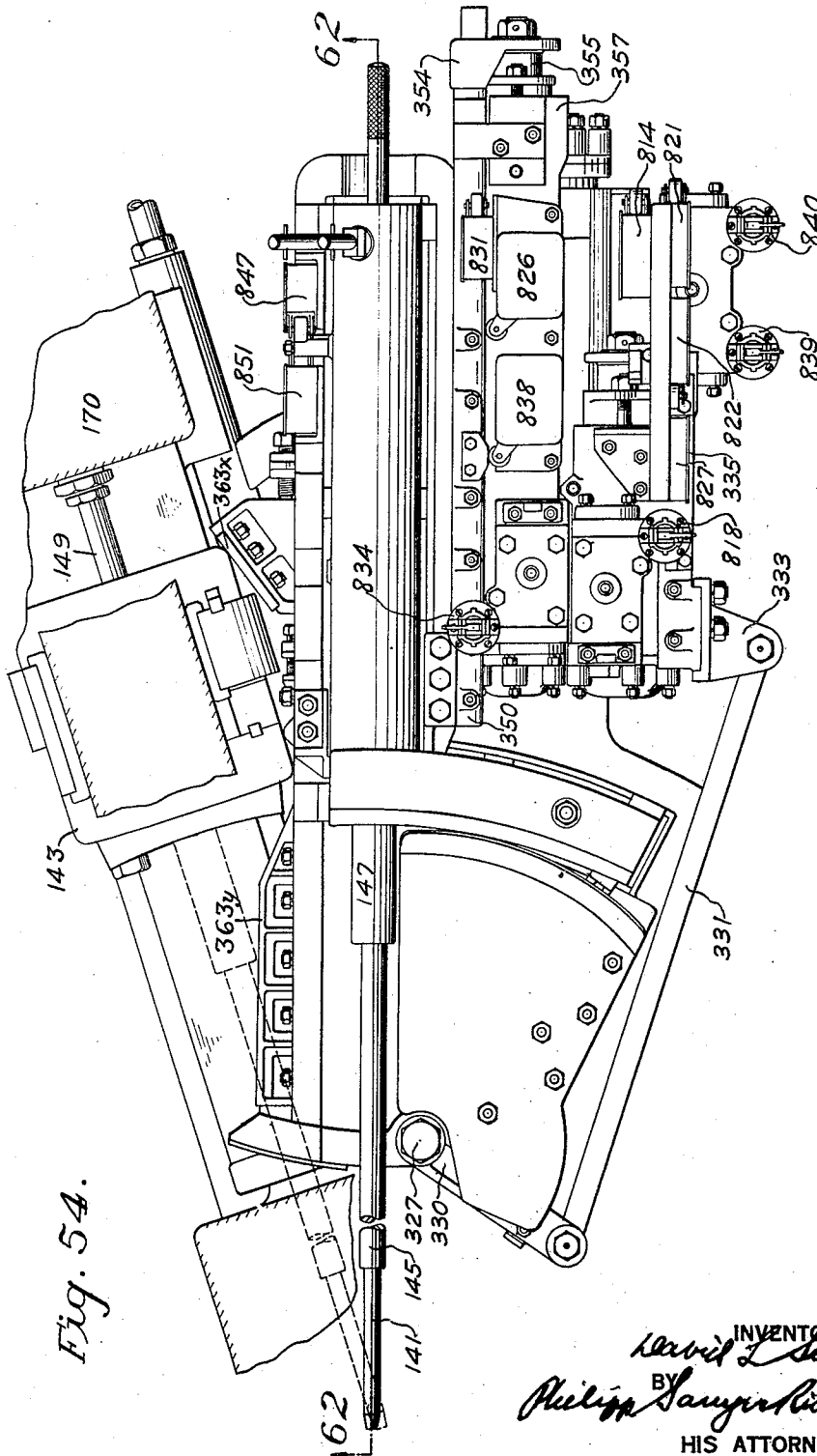


Fig. 54.

INVENTOR
Herbert L. Summey
BY *Philip Sanger & Howard*
HIS ATTORNEYS.

July 1, 1930.

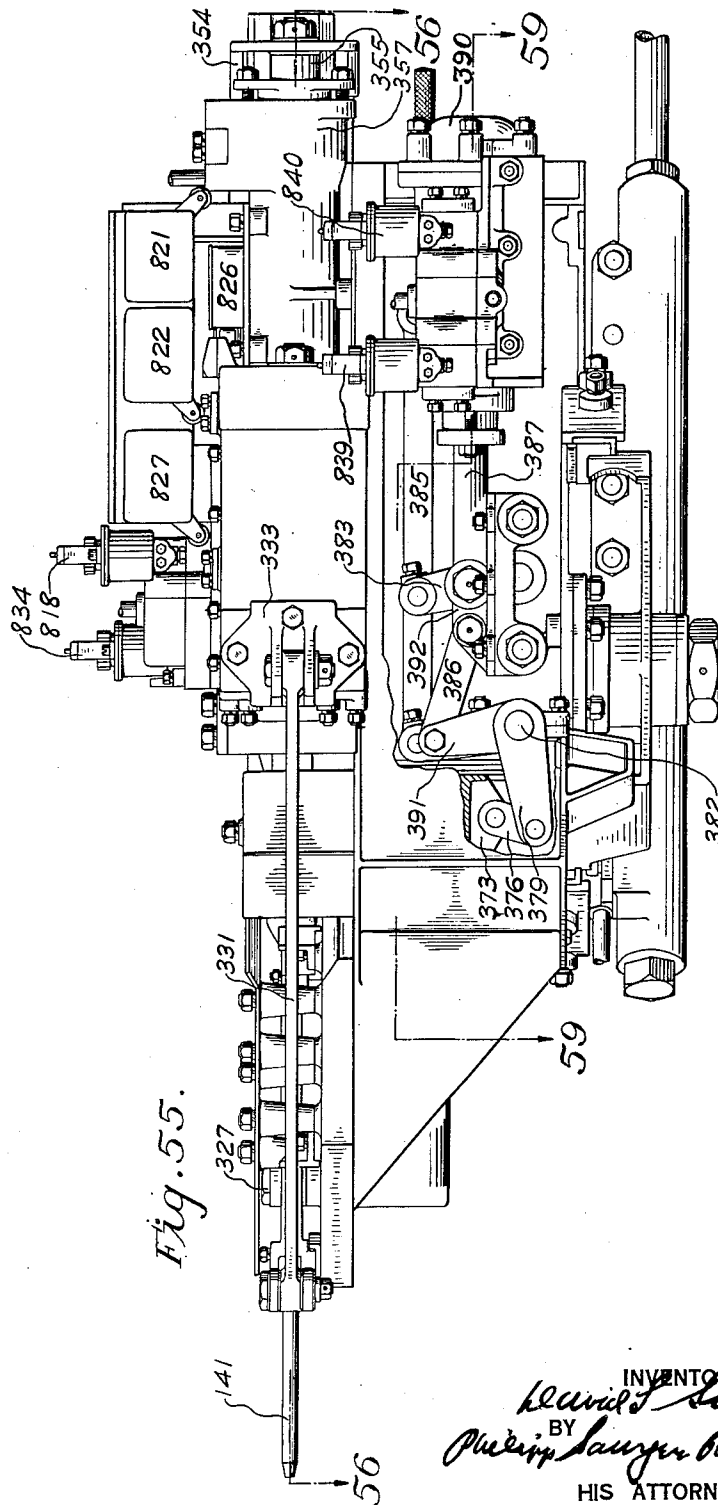
D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 37



July 1, 1930.

D. L. SUMMEY

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Filed Feb. 20, 1928

50 Sheets-Sheet 38

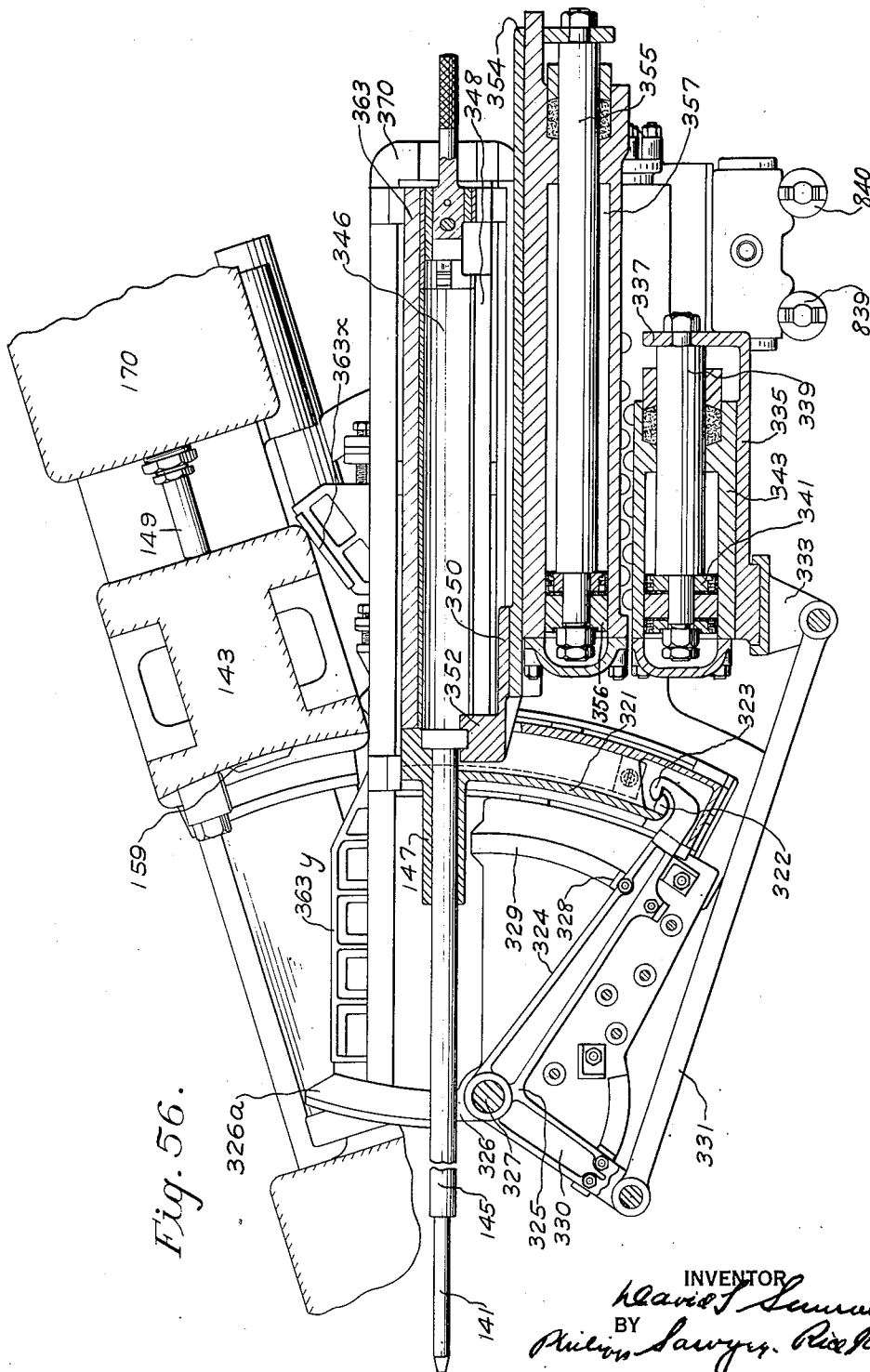


Fig. 56.

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 39

Fig. 57.

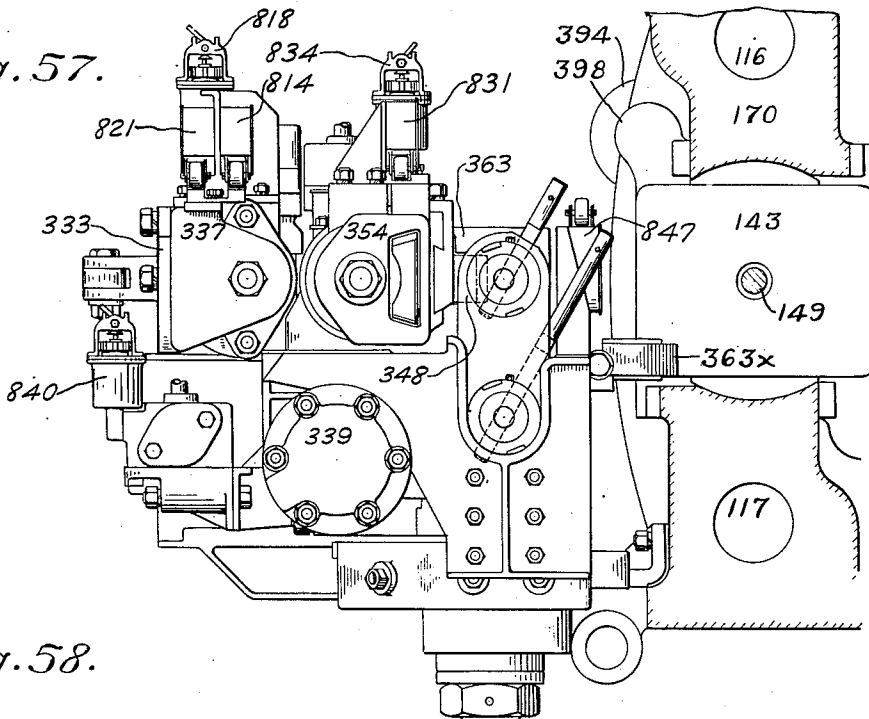
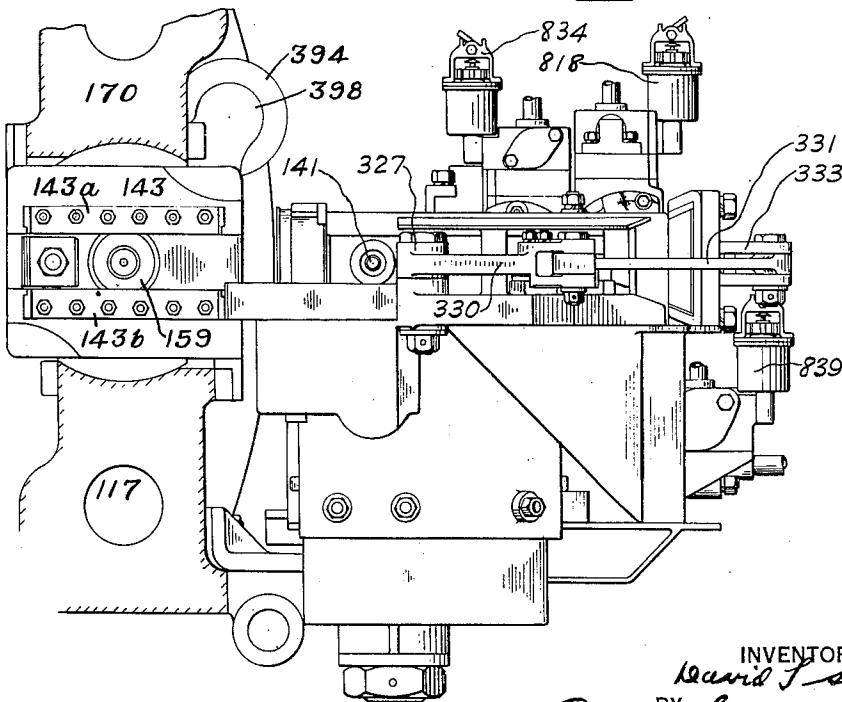


Fig. 58.



INVENTOR
David L. Summey
BY *Charles Sawyer Rice*
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

1,768,866

METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 40

Fig. 59.

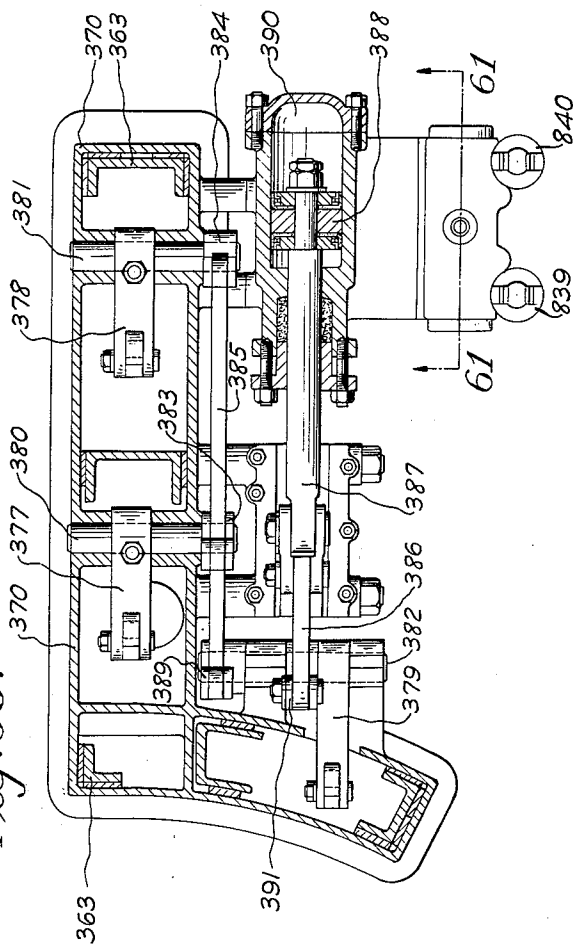


Fig. 61.

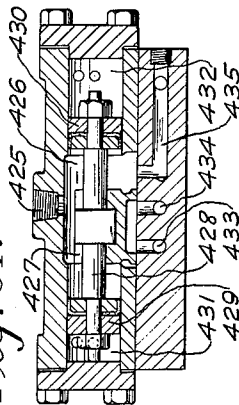
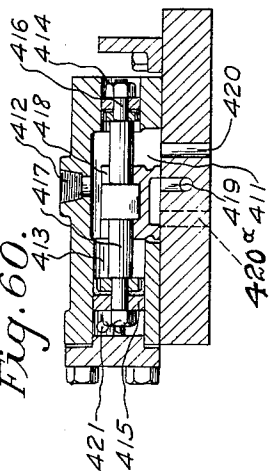


Fig. 60.



INVENTOR
David L. Summey
BY
Philip S. Summey & Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

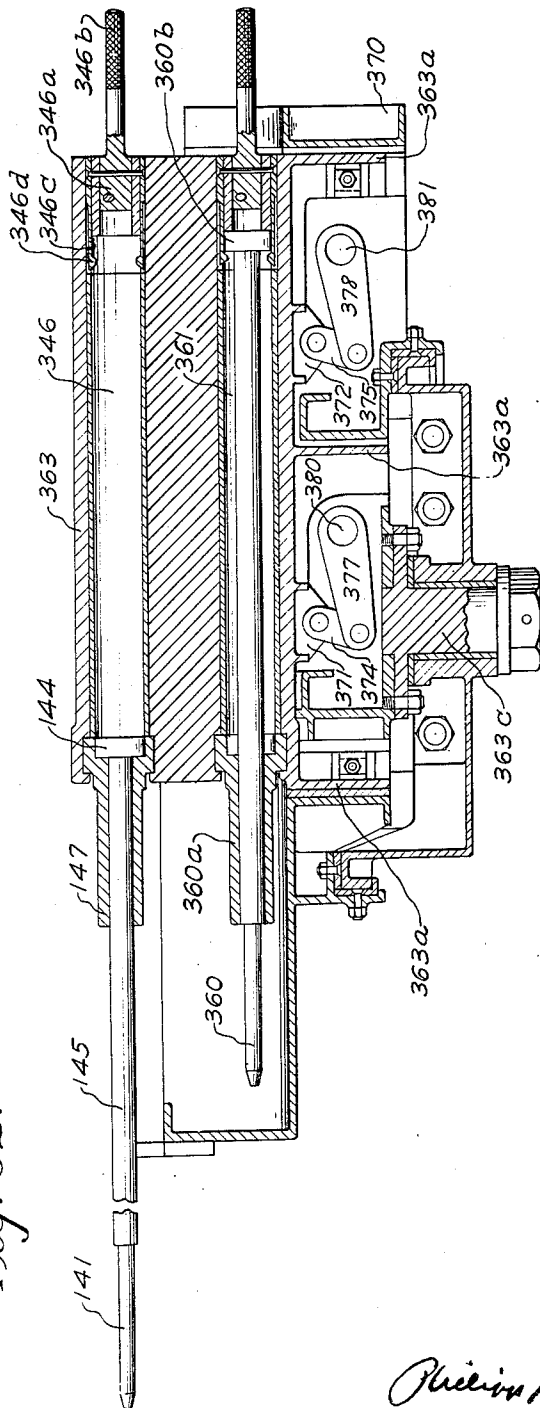
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 41

Fig. 62.



INVENTOR
David L. Summey
BY
Phillip Saenger Rice Kennedy
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

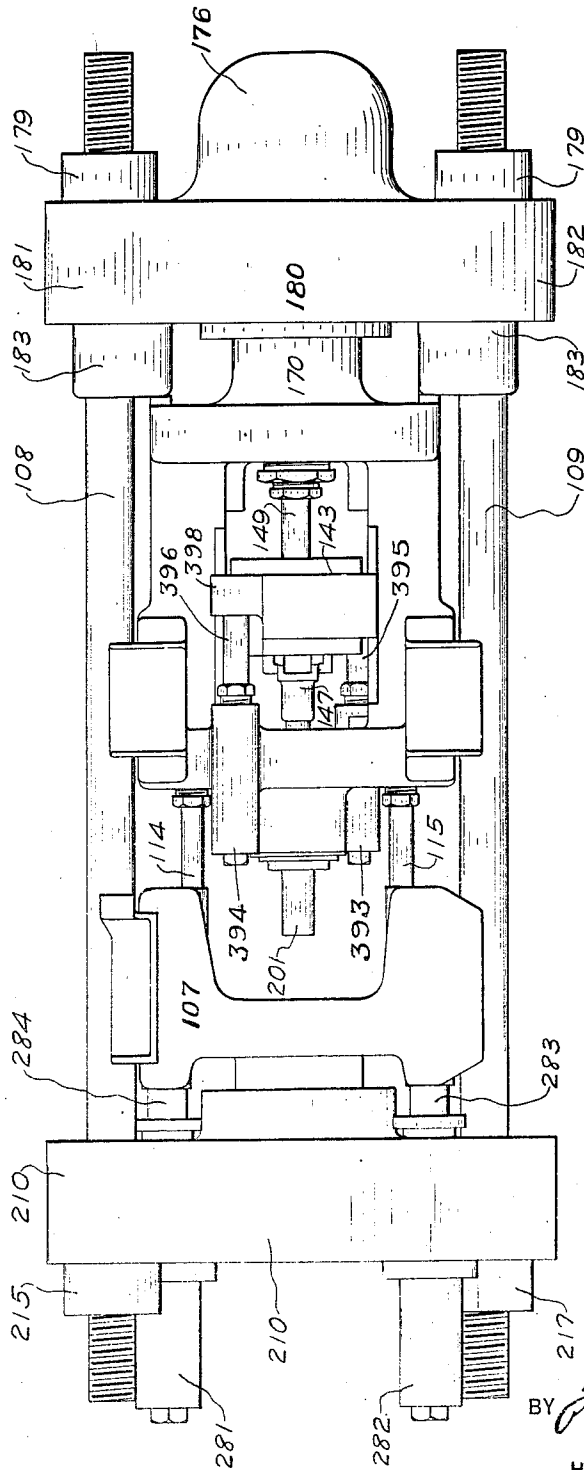
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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 42

Fig. 63.



INVENTOR
D. L. Summey
BY *William Lawrence*
His Attorney
HIS ATTORNEYS

July 1, 1930.

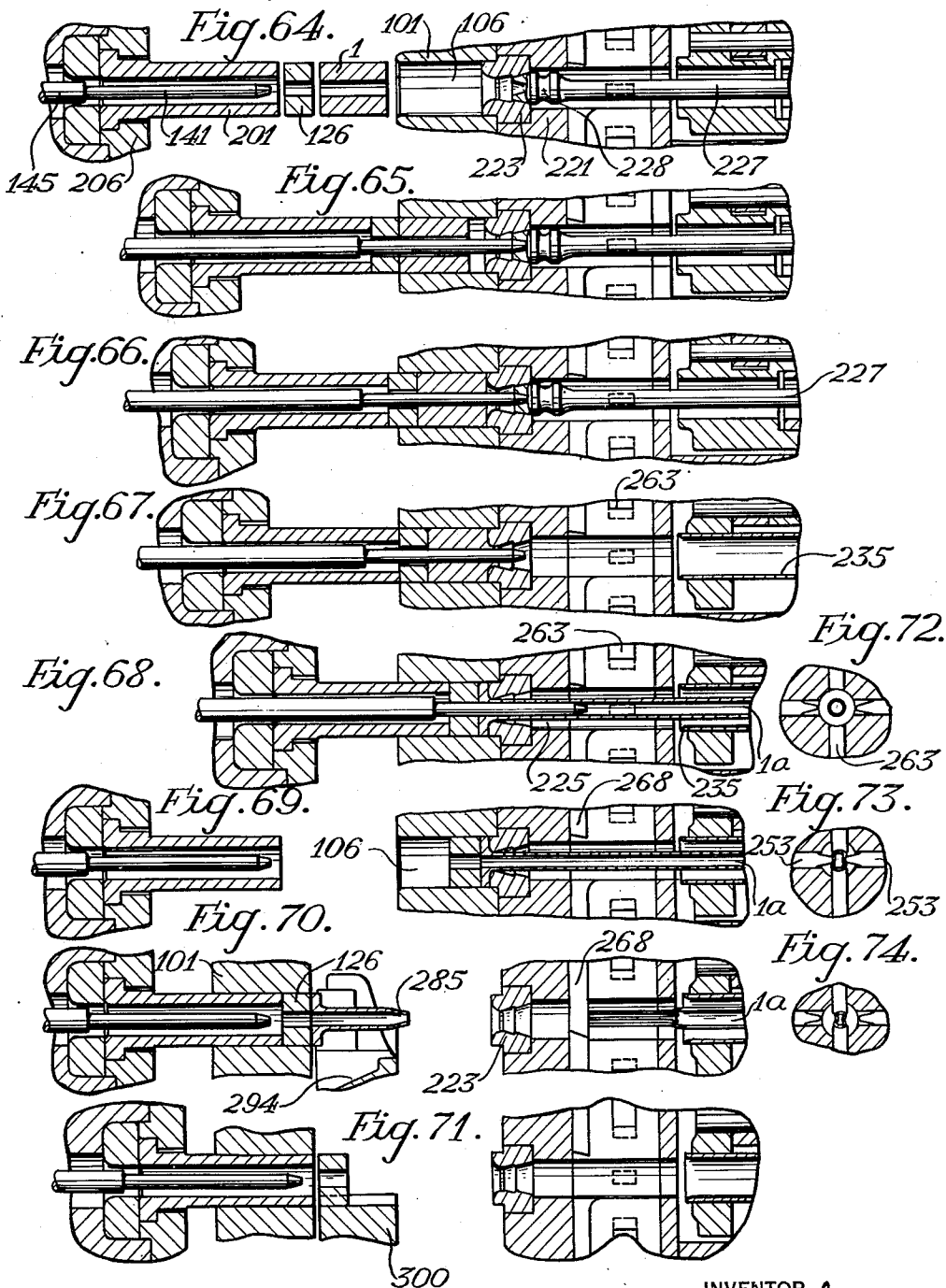
D. L. SUMMEY

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Filed Feb. 20, 1928

50 Sheets-Sheet 43



INVENTOR
D. L. Summey
BY
Kenneth S. Kennedy
HIS ATTORNEYS.

July 1, 1930.

D. L. SUMMEY

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Filed Feb. 20, 1928

50 Sheets-Sheet 44

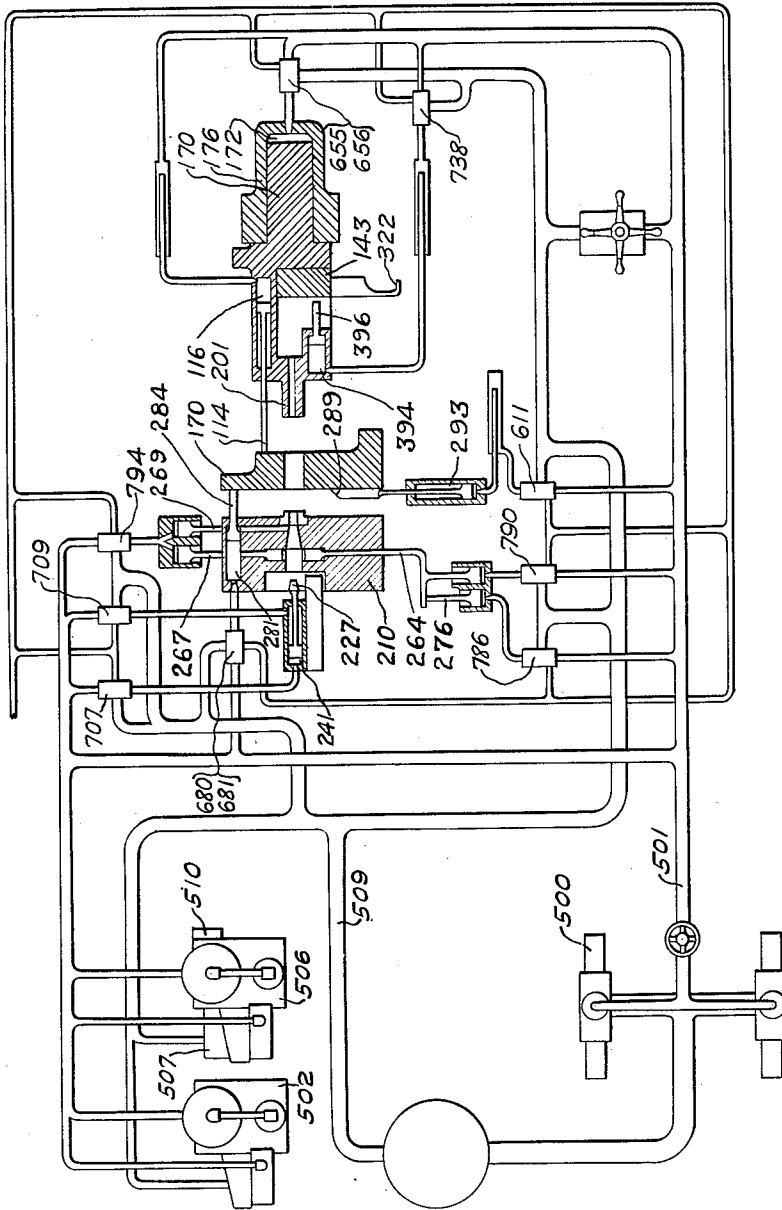


Fig. 75.

INVENTOR
David L. Summey
BY
Oliver S. Sawyer & Co.
HIS ATTORNEYS

July 1, 1930.

D. L. SUMMEY

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

50 Sheets-Sheet 45

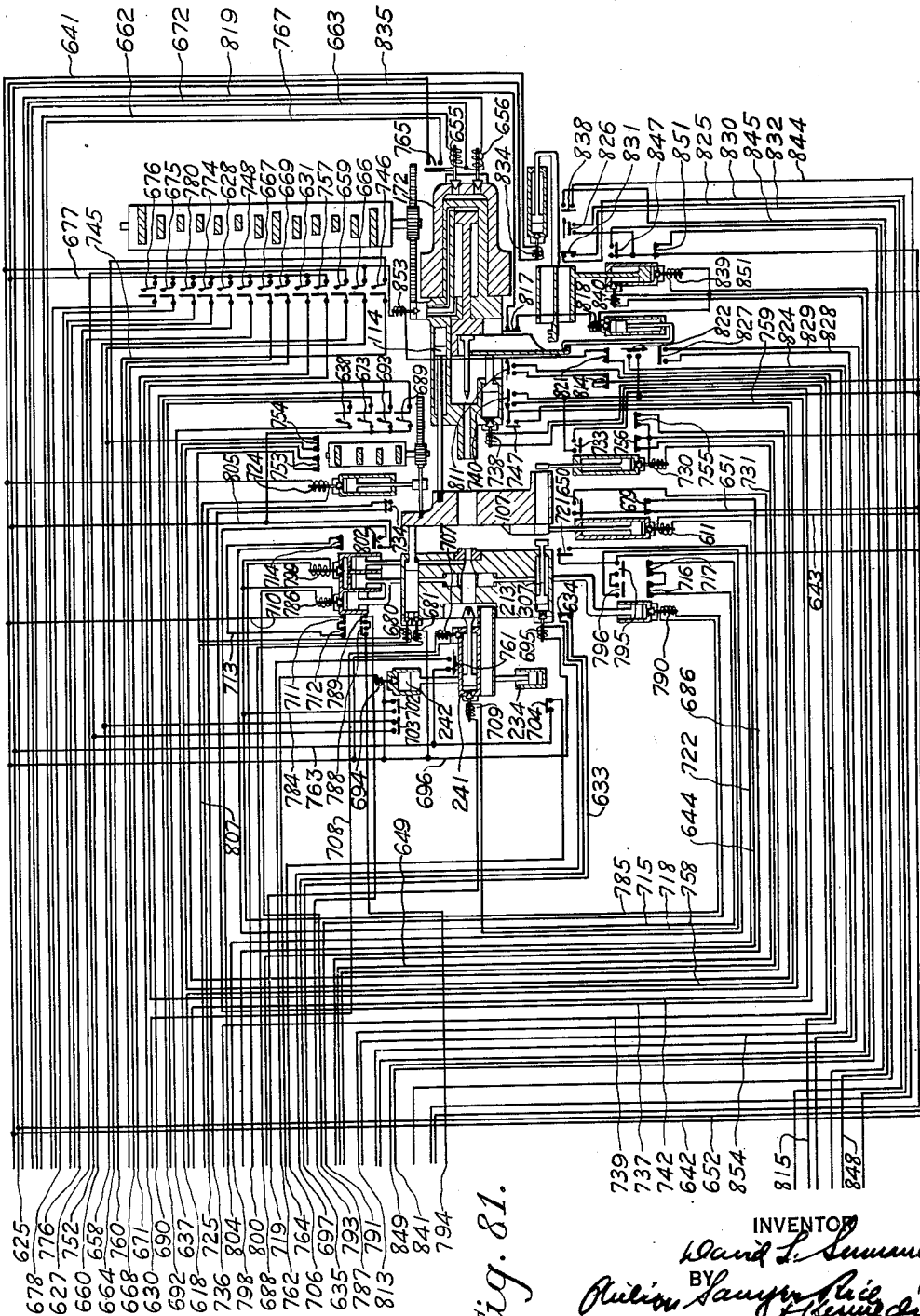


Fig. 81.

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METAL EXTRUDING APPARATUS

Filed Feb. 20, 1928

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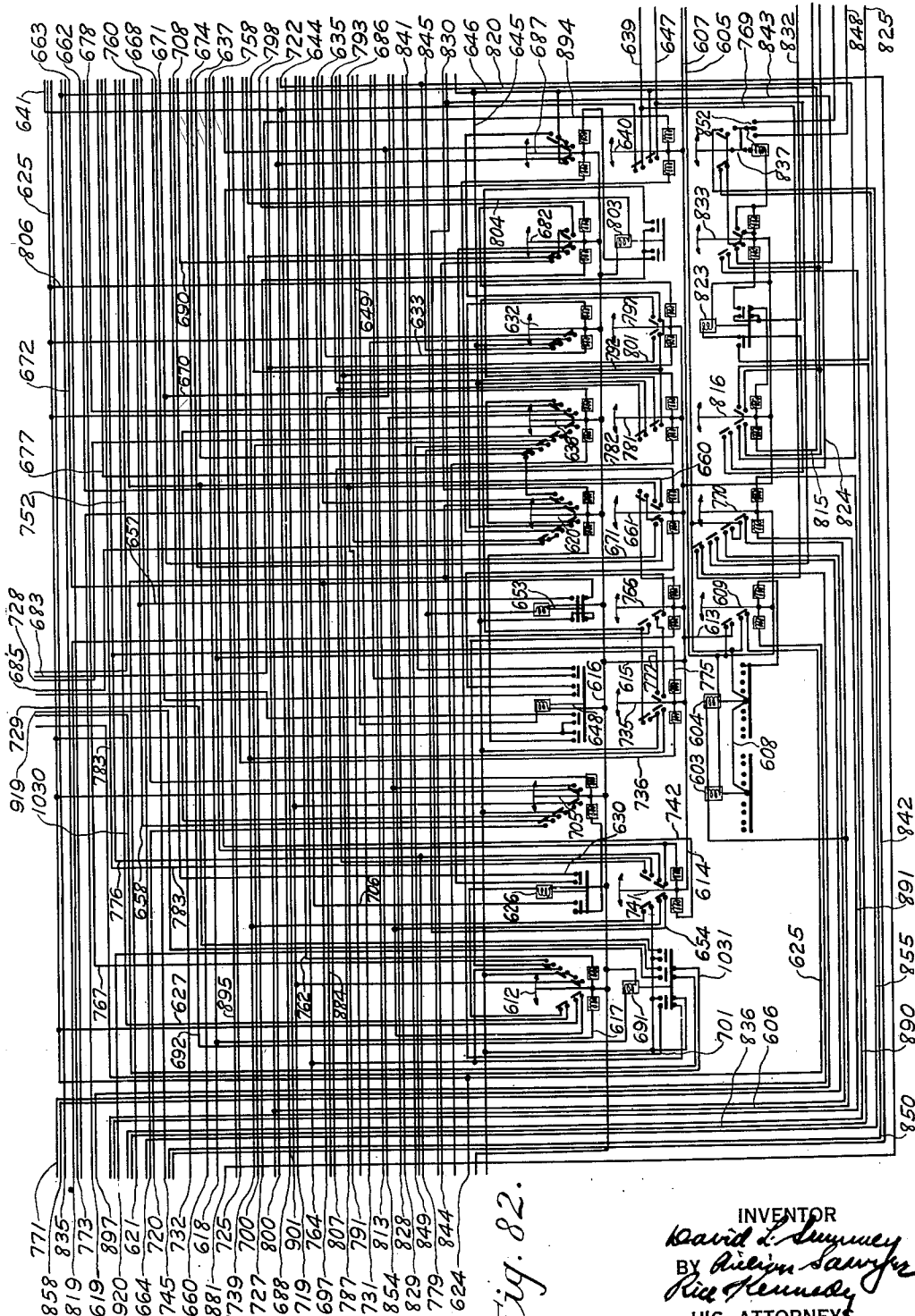


Fig. 82.

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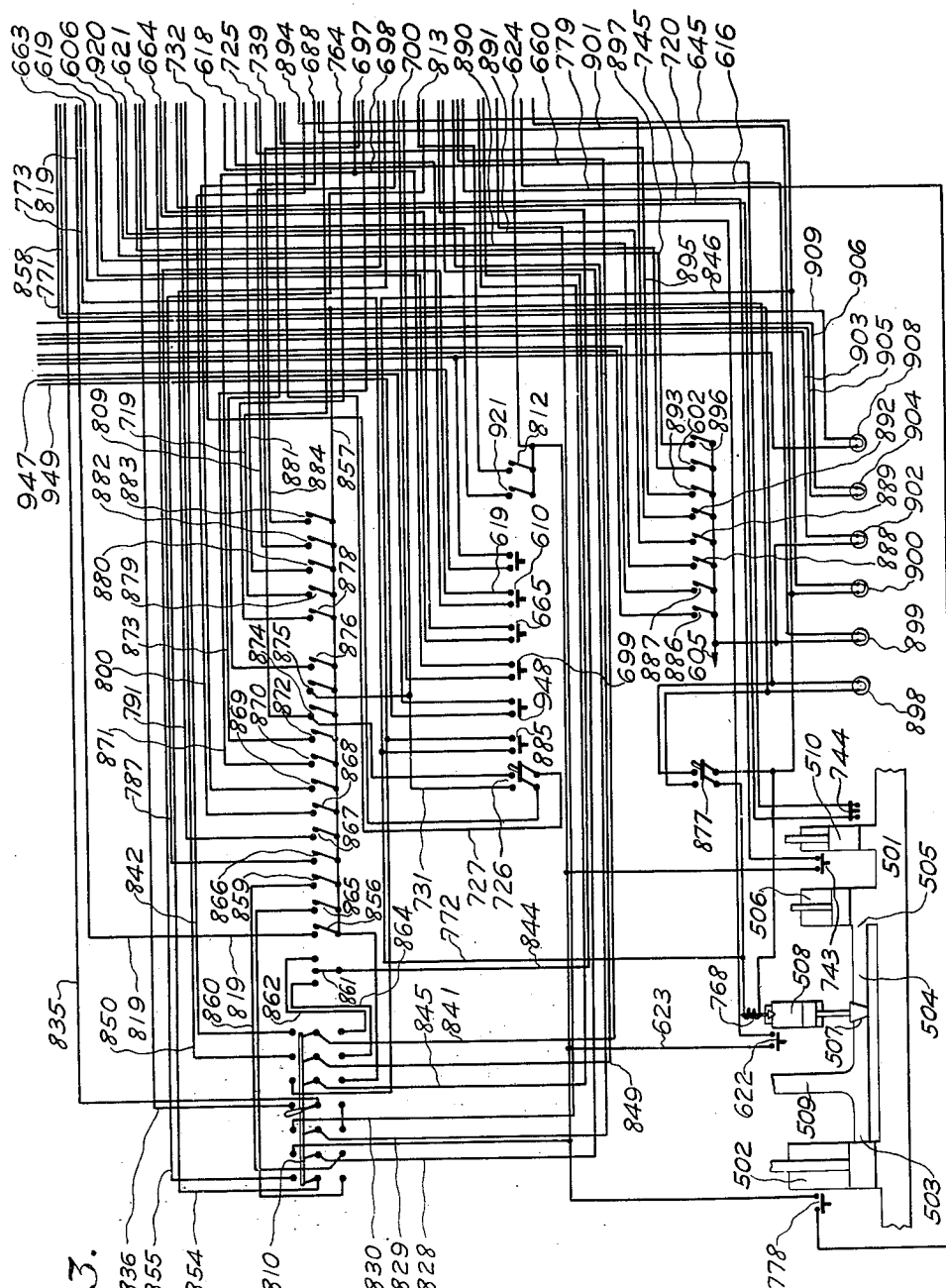
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METAL EXTRUDING APPARATUS

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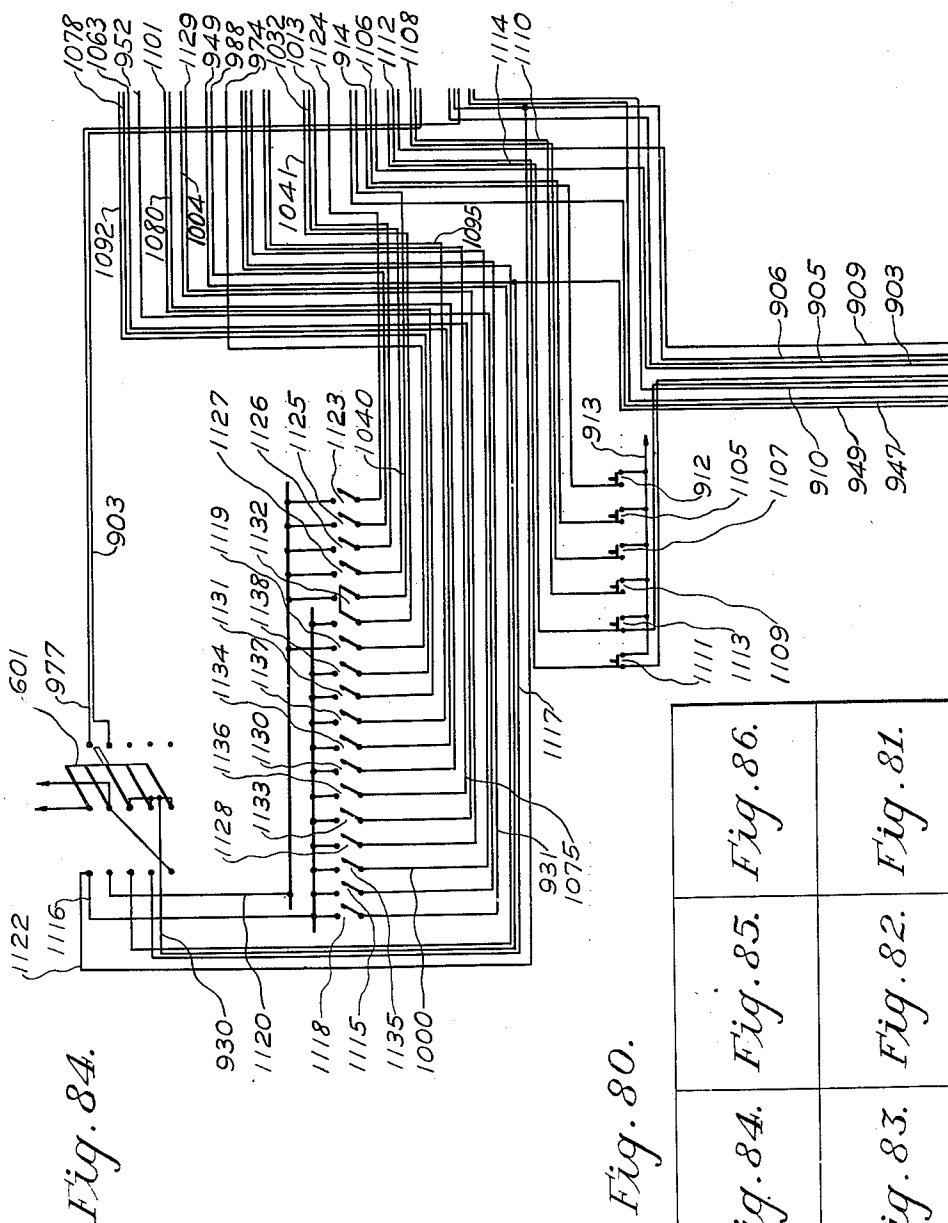


Fig. 84.

Fig. 84.	Fig. 85.	Fig. 86.
Fig. 83.	Fig. 82.	Fig. 81.

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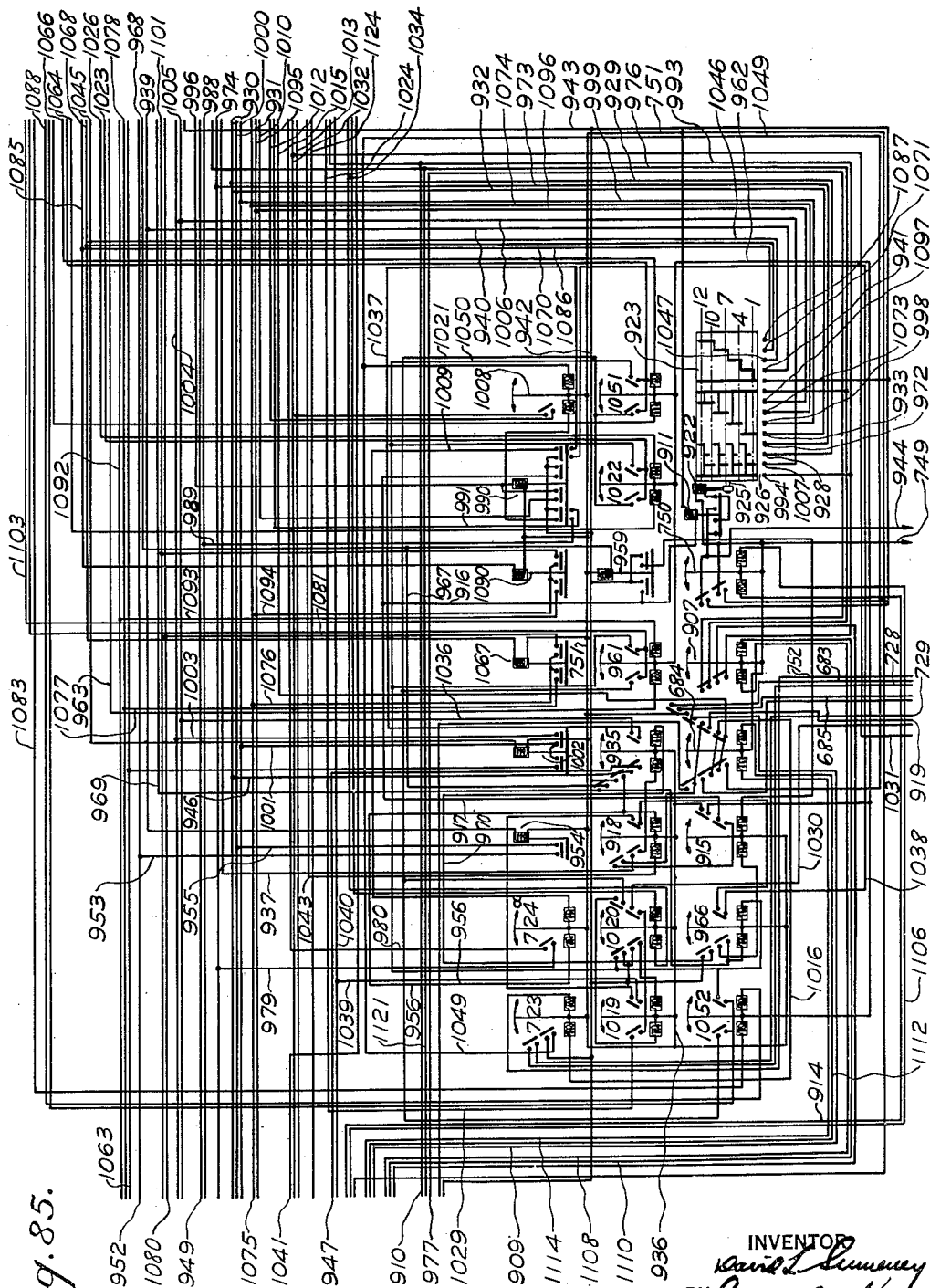
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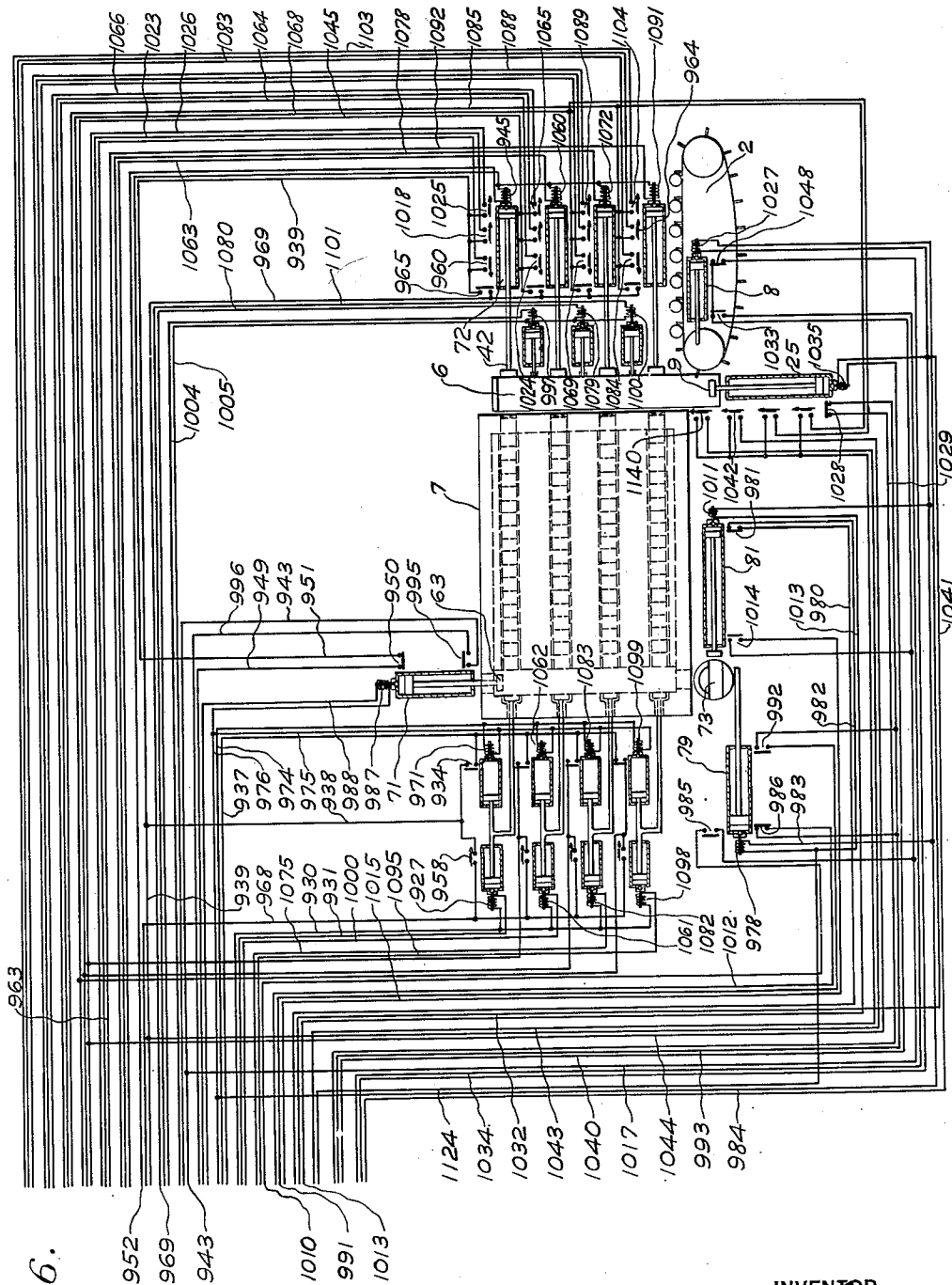
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50 Sheets-Sheet 50



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METAL-EXTRUDING APPARATUS

Application filed February 20, 1928. Serial No. 255,644.

This invention relates to metal extruding apparatus.

Metal tubes, such as brass tubing and piping, have been formed by drawing and by the so-called Mannesman process. Both of these methods are expensive, involving considerable time and labor.

It is an object of the invention to provide an apparatus capable of forming metal tubes, such as brass tubing and piping, by extrusion, economically and efficiently.

Extrusion presses operated by fluid pressure are known. Such presses require considerable manual labor, including a control operator, and one or more billet feeders for supplying cold billets to a furnace and transferring hot billets to the press. Moreover, the speed and alertness required in operating the control valves makes it necessary to relieve the control operator at least hourly and makes it difficult to obtain and keep competent operators.

It is a further object of the invention to provide apparatus for extruding metal, and particularly tubes, such that the complete cycle of heating, feeding and extruding a billet is automatic.

With these general objects, and others not specifically mentioned, in view, the invention consists in the features, combinations, details of construction and arrangements of parts which will first be described in connection with the accompanying drawings and then more particularly pointed out.

In the drawings:

Figure 1 is a plan view of apparatus constructed in accordance with the invention;

Figure 2 is a view of the same in side elevation;

Figure 3 is a view in end elevation showing the charging end of the furnace and the rear end of the press;

Figure 4 is a similar view of the other end of the apparatus;

Figure 5 is a sectional view taken on the line 5—5 of Fig. 7;

Figure 6 is a sectional view taken on the line 6—6 of Fig. 7;

Figure 7 is a plan view (enlarged over

Fig. 1) showing the charging end of the furnace;

Figure 8 is a sectional view taken on the line 8—8 of Fig. 7;

Figure 9 is a view in end elevation, with parts in section (enlarged over Fig. 3) of the charging end of the furnace;

Figure 10 is a sectional view taken on the line 10—10 of Fig. 7;

Figure 11 is a view partly in plan and partly in horizontal section (enlarged over Fig. 1) of the discharge end of the furnace;

Figure 12 is a sectional view taken on the broken line 12—12 of Fig. 11;

Figure 13 is a sectional view taken on the line 13—13 of Fig. 11;

Figure 13^a is a sectional view taken on the line 13^a—13^a of Fig. 13;

Figure 14 is a view in end elevation (enlarged) of the discharge end of the furnace;

Figure 15 is a view partly in elevation and partly in section of billet transfer mechanism;

Figure 16 is a sectional view (enlarged) taken on the line 16—16 of Fig. 18;

Figure 16^a is a sectional view taken on the line 16^a—16^a of Fig. 16;

Figure 17 is a sectional view taken on the line 17—17 of Fig. 15;

Figure 18 is a plan view (with parts in section) of billet transfer mechanism;

Figure 19 is a view of the same in end elevation;

Figures 20 and 21 are views in side elevation (enlarged over Figs. 1—3) of part of the press, showing the billet container unit from opposite sides;

Figure 22 is a sectional view taken on the line 22—22 of Fig. 25;

Figure 23 is an end elevation, with parts in section of this container unit;

Figure 24 is a detail sectional view taken on the line 24—24 of Fig. 22;

Figure 25 is an end elevation with parts in section, showing the other end of the container unit;

Figure 26 is a plan view of the parts shown in Fig. 20;

Figure 27 is a sectional view taken on the line 27—27 of Fig. 26;

Figure 28 is a sectional view taken on the line 28—28 of Fig. 27;

5 Figure 29 is a sectional view taken on the line 29—29 of Fig. 33;

Figures 30 and 31 are detail views showing part of Fig. 29 with the parts in different positions;

10 Figure 32 is a view in side elevation of the main ram unit with its cylinder removed;

Figure 33 is a view of the same in end elevation, with parts in section;

15 Figure 34 is a sectional view taken on the line 34—34 of Fig. 32;

Figure 35 is a view similar to Fig. 33, showing the other end of the main ram unit;

20 Figure 36 is a view similar to Fig. 32 showing the other side of the main ram unit;

Figure 37 is a plan view of the main ram unit;

Figure 38 is a sectional view taken on the line 38—38 of Fig. 36;

25 Figure 39 is a plan view of one portion of the press;

Figures 40 and 41 are views of the same in side elevation, taken on opposite sides;

30 Figure 42 is a sectional view taken on the line 42—42 of Fig. 46;

Figure 43 is a detail view showing part of Fig. 42 in plan;

Figure 44 is a view of the same in end elevation with parts in section;

35 Figure 45 is a view in end elevation of that portion of the press shown in Fig. 39;

Figure 46 is a sectional view through the press showing the other end of the same portion in elevation;

40 Figure 47 is a plan view of the other portion of the press, with parts in section;

Figures 48 and 49 are views in side elevation, from opposite sides, of the parts shown in Fig. 47;

45 Figure 50 is a sectional view taken on the line 50—50 of Fig. 51;

Figure 51 is a view in end elevation of that portion of the press shown in Fig. 47, with parts in section;

50 Figure 52 is a view in end elevation of the other end of the same portion, with parts in section, looking toward the right in Fig. 53;

55 Figure 53 is a sectional view taken on the line 53—53 of Fig. 52;

Figure 54 is a plan view of part of the press, showing the mandrel exchange;

Figure 55 is a view of the same in side elevation;

60 Figure 56 is a sectional view taken on the line 56—56 of Fig. 55;

Figures 57, 58 are end views of the same from opposite ends;

65 Figure 59 is a sectional view taken on the broken line 59—59 of Fig. 55;

Figures 60 and 61 are explanatory views showing, in section, two types of air control valves;

Figure 62 is a sectional view taken on the line 62—62 of Fig. 54;

70 Figure 63 is a diagrammatic view of the press in side elevation to show the relation of the parts;

Figures 64—74 are explanatory views showing schematically the progressive operation of the press;

75 Figure 75 is a diagrammatic view of part of the fluid pressure system;

Figure 76 is a detail view showing one form of switch-operating mechanism;

80 Figure 76^a is a further detail of the same;

Figure 77 is a detail view showing another form of switch-operating mechanism and a switch;

85 Figure 78 is a detail view showing in side elevation, with parts in section, a pressure control device;

Figure 79 is an end view of the same, with parts in section;

90 Figure 80 is a chart showing the relation of Figs. 81—86; and

Figures 81—86 are wiring diagrams.

While many features of the invention are capable of a wide range of uses, the drawings illustrate, by way of example, an extrusion press for extruding hot billets into the form of tubes; a furnace for heating the billets; transfer means for delivering a hot billet from the furnace to the press; and automatic means for causing operation of the various parts in a predetermined cycle. In this exemplification, the various movements are effected by fluid pressure power units, either air or water, and these power units are so controlled that the apparatus functions automatically, each step being dependent on the successful completion of one or more preceding steps, from the placing of a cold billet in a magazine to the completion of an extruded tube.

110 The present apparatus is designed particularly for extruding tubes of non-ferrous metals or alloys. The billets may be formed in any suitable manner. For example, they may be formed from lengths of cast cylindrical stock slightly oversize as to diameter. The stock is cut to convenient lengths, turned to proper diameter, and centrally bored for receiving a mandrel.

120 For convenience, the mechanical features of the furnace and press will first be described, apart from the automatic control.

Referring to the drawings, there is provided means for heating billets and this may conveniently be an electric furnace capable of such heat control as to make possible uniform heating of successive billets. In the present embodiment the furnace is illustrated more or less conventionally and comprises a housing 7, enclosing a furnace 130

chamber 7^a. This chamber may be heated in any suitable manner, for example, by electric resistors such as are described in applicant's copending application filed June 5, 1926, Serial No. 113,852. On Fig. 12 are indicated resistor coils 7^b and additional coils 7^c are indicated in Fig. 13. The temperature may be controlled in any suitable manner. Extending lengthwise of this furnace are a plurality of billet paths, in this instance four, formed by troughs 29 (Figs. 1, 11-13) of a suitable material, for example, nickel chromium alloy. The billets 1 here provided for are short lengths of cylindrical stock and the troughs 29 are arranged to receive and guide the billets in sidewise movement. That is, the billets lie transversely in their passage through the furnace. At the entrance end, the furnace has a plurality of inwardly swinging self-closing hinged doors 31 (Figs. 8 and 9), one door being provided for each path.

There is provided means for feeding billets to the furnace paths in predetermined order, for example, to the several paths in rotation. This may be accomplished by individual infeed pushers for the various paths and means for positioning the billets for these pushers. Although capable of various constructions, in that here shown as an example, in line with the four billet troughs 29 are four infeed pushers 42, 43, 44 and 45 (Figs. 6-8). These pushers are formed as parts of piston rods of fluid pressure units 39, 40, 41, 46 (Figs. 1, 6-8).

These fluid pressure units, as well as others herein referred to, comprise cylinders and pistons of suitable construction and are connected in the pressure line in any suitable manner. That end of the cylinder opposite the larger piston area is connected through suitable valve means by which that end of the cylinder may be put under pressure or exhaust. This may be termed the variable pressure end of the cylinder. The other end has a direct connection with the pressure line and may be termed the constant return pressure end. Owing to the piston differential, when the variable pressure end of the cylinder is connected in the pressure line the piston is advanced against the ineffective constant pressure. When the variable pressure end is connected with exhaust the constant pressure becomes effective and the piston is automatically returned. Throughout this description of the furnace and press the fluid pressure units referred to are of this type unless otherwise noted. The piping arrangement, the valves, and the control of the various units are hereinafter referred to. The later description also points out which of the units are air operated and which are water operated. For convenience of description, however, these features are, for the present, ignored and the fluid pres-

sure units considered merely in their roles of power means for moving the various parts.

As an infeed pusher advances under pressure it pushes the waiting billet, positioned as later described, through the swinging door into the corresponding furnace path. By the force of this advance stroke acting on the new billet all the preceding billets in that path are pushed ahead one step. Assuming the path to be full, this discharges the leading billet as hereinafter described. As the infeed pusher withdraws, the door swings shut to close the entrance.

While the billet positioning means may vary, it may include a delivery pusher working past the furnace doors and selective stop means for automatically determining which furnace path is to receive a billet. Although capable of various constructions, in the present embodiment, extending across the entrance end of the furnace is a delivery groove 6 (Figs. 1-3, 7-8) arranged to receive the billets endwise. Paralleling this transverse groove is a delivery push rod 9 (Figs. 9, 10). This push rod has a rack 11 meshing with a gear 13 mounted on a shaft 15. Motion is imparted to this shaft by means of a pinion 19 mounted on the shaft and meshing with a vertical rack 17. This rack is formed as part of a piston rod 21 having, at one end, a piston 23 working in a fluid pressure cylinder 25 and, at its other end, a piston 24 working in a fluid pressure cylinder 26. These two cylinders and pistons form, in effect, the usual fluid pressure unit. That is, cylinder 25, which is the larger in cross section, is connected, at its upper end, either with the pressure line or exhaust. Cylinder 26 is direct-connected, at its lower end, with the pressure line. When cylinder 25 is under pressure, rod 21 is forced downwardly due to the differential between the piston areas. This down stroke of rod 21 causes push rod 9 to advance along the groove 6 to push a billet, supplied as later described, across the delivery end of the furnace. The push rod is withdrawn by the upstroke of piston rod 21 under the constant pressure of cylinder 26, cylinder 25 being at exhaust.

While the selective stop means may vary, in the embodiment here shown as an example, below groove 6, and in front of the far side of the first three doors, are stops 33, 34, 35 (Figs. 1, 8 and 9) slidable in the floor of the groove. When one of these stops is elevated it projects upwardly into the groove and so into the path of the billet being delivered along the groove. As shown, these stops are mounted on duplicate piston rods 37 working in the cylinders of fluid pressure units 38. When one of these stops is advanced it determines the stroke of push rod 9 and positions the delivered

billet in front of the corresponding door and in line with the corresponding infeed pusher. For the fourth door, that is, the last one counting from the delivery pusher, a permanent stop 36 is provided. When all the movable stops are retracted the delivery pusher makes a full stroke and the billet is positioned in front of the last door.

The automatic control of these stops is hereinafter described. While the furnace paths may receive billets in any predetermined order, in the present embodiment billets are fed to the four paths in rotation.

There is provided means for supplying billets to the delivery push rod and in structures embodying the invention to the best advantage this supply means is in the nature of a billet magazine capable of holding an excess supply.

Although capable of various constructions, in that here illustrated as an example, extending at right angles to groove 6 are a plurality of supply units, in this instance three (Figs. 1-3 and 7). Each unit comprises an endless chain 3 having a number of spaced billet-propelling arms 5 and arranged to receive the billets crosswise. The chains pass over suitable sprockets, 4^a and 4^b, those at the forward end (Fig. 5) being keyed to a drive shaft 4. To give the supply means a step-by-step motion, as here shown, keyed to shaft 4 is a ratchet 8^c, the teeth of which are engaged by a pawl 8^a mounted on a toothed sector 8^b. This sector is pivoted on shaft 4 and meshes with a rack 8^b formed as an extension of a piston rod 8^a working in the cylinder of a fluid pressure unit 8. Operation of this unit causes the shaft 4, and consequently the supply chains, to be moved ahead one step.

In order that only one billet at a time will be supplied to delivery groove 6, the arms 5 on the several chains are staggered, with relation to each other. The chains being filled with billets in any suitable manner, as by an attendant, upon each forward step of shaft 4 one billet is brought into a position where it may roll into delivery groove 6 (Fig. 5), the several chains supplying billets in rotation. The supply means described makes it possible for the attendant to load up billets for a considerable run without regard to the timing of the other parts. The chains are in the nature of a magazine and may be extended in length to give as large a waiting supply as may be desired.

In the present embodiment the hot billets are discharged from the furnace paths by the insertion of a cold billet. That is, every time a cold billet is inserted, the leading hot billet of that path (assuming the path to be full) is discharged by the movement of the entire line of billets under the force of the infeed pusher. There is provided means

for controlling the movement of the billets at the discharge end of the furnace. As here shown as an example, at the discharge end, each trough 29 has an upward incline 29^a (Fig. 13) up which the billets ride. Extending across the discharge ends of the several paths, and located below the crests of these inclines, is a discharge groove 47 arranged to receive the billets endwise. Co-operating with each discharge incline is a billet hold back arranged to hold the leading billet at the crest of the incline, in order to keep the line of billets intact, prevent discharge of more than one billet, and, upon withdrawal, to control the billet to some extent in its movement into the discharge groove. As here shown as an example, each billet hold-back comprises a channel-like element 50 reciprocating in guides 50^a, 51 (Fig. 13).

To operate the billet hold-back, its rear end, which extends outside the furnace, is formed with a rack 53 (Figs. 13, 14) meshing with a pinion 54 mounted on a shaft 55. Also mounted on this shaft is a gear 56 (Fig. 13^a) meshing with vertical rack 57. Rack 57 is formed as part of a double ended piston rod 58 the pistons of which work in fluid pressure cylinders 59, 60. These units are like the units 25, 26 previously described, except that both cylinders are valve-controlled.

For the advance of an infeed pusher to insert a billet, the billet hold-back for that row is advanced by the down stroke of piston rod 58. This positions the holder (Fig. 13) to engage the leading billet, now on the crest of the incline.

There is provided means for causing the hold-back 50 to be withdrawn upon the arrival of a billet in a predetermined position. This may be accomplished by a detector actuated by the billet as it approaches contact with hold-back 50. Although capable of various constructions, in that here illustrated as an example, a billet detector comprises a billet engaging head 48 on a rod 49 which passes rearwardly through hold-back 50, being slidable in ribs in the latter. The head of the hold-back is recessed or cut away (Fig. 11) to receive detector head 48 but normally the detector head is held slightly advanced by a coiled spring 52 confined between part of rod 49 and part of hold-back 50. When the hold-back is advanced as above described the detector moves forward with it, its head 48 being slightly in advance of the end of the hold-back. As the leading hot billet is pushed up to the crest of incline 29^a by the insertion of the cold billet, it engages detector head 48 and rod 49 is thrust back against its spring, head 48 being received by the recess in the end of hold-back 50 (Fig. 13). This movement of rod 49 operates a control mechanism, as later de-

scribed, to cause reversal of piston rod 58 and consequent withdrawal of hold-back 50. As later described, the infeed pusher is withdrawn before the hold-back withdraws.

As a result, pressure on the line of billets is removed while the hold-back is still holding the leading billet at the crest of the incline. When, therefore, the hold-back is withdrawn, the leading billet is free to roll into discharge groove 47 but only that one billet will leave the path. As soon as the hold-back leaves the billet, detector rod 49 is free to take its normal relative position again under expansion of spring 52.

There is provided means for discharging a billet from the furnace. This may include a discharge pusher working along groove 47. Although capable of various constructions, in that here illustrated as an example, a discharge pusher is mounted on a rod 64 having a rack portion 65 (Fig. 12) meshing with a pinion 66 mounted on a shaft 67. Also mounted on this shaft is a gear 68 meshing with the teeth of a rack 69 formed on a piston rod 70. The piston of this rod works in the cylinder of a fluid pressure unit 71. After a billet has been moved into groove 47, and under a control hereinafter described, piston rod 70 is caused to make its down stroke, thus advancing pusher 63 along groove 47 and through a tubular extension 47^a passing through the furnace wall. This stroke of the pusher discharges the billet from the furnace.

In the present embodiment it is desired to move the discharged billet along a path at right angles to its path of discharge and there is provided means for turning the discharged billet through an angle of 90°. Although capable of various constructions, in that here shown as an example, adjacent the discharge end of extension 47^a is a turntable 73 (Figs. 11, 12) formed to provide a seat for the billet. The discharge stroke of pusher 63 deposits the billet onto this seat. Extending downwardly from the turntable is a shaft 75 journaled in a support 74 (Figs. 12, 16). Mounted on this shaft is a pinion 76 meshing with a rack 77. This rack is formed on the piston rod 78 of a fluid pressure unit 79 (Fig. 15). Operation of this unit gives the turntable a quarter turn after receiving a billet (Fig. 12) and later reverses it to billet-receiving position (Fig. 11).

The turntable has a side wall 73^a which, when the turntable is in the position of Fig. 12, closes the end of extension 47^a to prevent loss of heat.

In connection with the extrusion press hereinafter described, there is provided means for positioning a hot billet to be received by the container of the press. Although capable of various constructions, in that here shown as an example, from the

turntable the billet is moved along a guideway 82 (Figs. 15, 17, 18) by a transfer pusher 80 (Fig. 1) formed on the piston rod of a fluid pressure unit 81. The advance stroke of this pusher transfers the billet endwise onto the holder 84 of a press feed slide 83 (Figs. 1, 18, 19). The holder has a spring-pressed pivoted finger 85 (Fig. 19) to retain the billet in place in the holder. The holder 84 is given a slanting upward movement to position the billet in line with the press container. To this end, as shown, the holder is mounted on a suitably guided oblique drive rod 86 having rack teeth 87 meshing with a pinion 93 on a shaft 92. Also mounted on this shaft is a pinion 91 meshing with a rack 90 formed on the piston rod 89 of a fluid pressure unit 88. The advance stroke of piston rod 89 causes holder 84 to be moved obliquely upward to place the billet endwise in line with the press container, the stroke of rod 86 governing the billet position.

As is later more fully described, there is provided automatic control means for supplying a hot billet to the press and a cold billet to the furnace, when the press parts are in a predetermined position. With the apparatus above described and with the control means hereinafter described, and assuming a cold billet to be positioned by permanent stop 36, the supply of a hot billet to the press is started by the advance of the 4th hold-back. The corresponding infeed pusher then advances and feeds the waiting billet into the furnace, thereby forcing out the leading hot billet into discharge groove 47 (it being assumed that the paths are full). The discharge pusher then discharges the hot billet onto the turntable, which makes its quarter turn, and the billet is transferred to holder 84 which carries it to the press. The supply of a cold billet to the furnace is started by the advance stroke of fluid pressure unit 8. This causes shaft 4 to advance one step and one of the three chains 3 deposits a billet in delivery groove 6. Delivery pusher 9 then advances and moves the billet along the groove until stopped.

The next time the press calls for a hot billet the cycle is the same except that the hot billet is charged from the first path and the next cold billet is supplied to the second path.

The extrusion press here illustrated as an example is designed for extruding tubes but it will be understood that many features of the invention are applicable to other forms of extrusion presses, e. g. for rods.

There is provided a billet container movable longitudinally of the axis of the press. As here shown as an example (Figs. 20 et seq.), sliding between press tie rods 108, 109 is a U-shaped container cross head 107, 130

its arms serving as long bearing guides (Fig. 20). This cross head has an open ended cylindrical container sleeve 102 (Fig. 22) forming a container chamber 106 for the billet. This sleeve has a collar-like portion 103 between end portions 104, 105 and is held in place by cylindrical nuts 112, 113, which firmly fit the end portions of the sleeve and are threaded into the cross head bore in the manner illustrated in Fig. 22. The cross head has adjustable bearing pieces 110, 111 (Figs. 22, 24) for taking up wear in order to keep the container on the proper center line.

While the container cross head may be moved in any suitable manner, as here shown as an example, it is moved forward, i. e. toward the die or in the direction of extrusion, by piston rods 114, 115 (Figs. 29, 63), the free ends of which abut the cross head. These pistons work in the fluid pressure cylinders 116, 117 under constant pressure. The cross head is moved back in the opposite direction by means of piston rods 283, 284 (Figs. 47 and 63) working in the cylinders of fluid pressure units 281, 282 and also arranged to abut the cross head. It will be noted that piston rods 114, 115 are of smaller diameter than piston rods 283, 284. Consequently the constant pressure of units 116, 117 is effective only when units 281, 282 are at exhaust.

As appears in Fig. 29 cylinders 116, 117 are formed in the main ram 170, later more fully referred to. As this ram reciprocates, the cylinders, of course, move with it. There is provided means for delivering pressure fluid to these cylinders without the use of flexible pipes. This may be accomplished by telescoping conduits. As here shown as an example, (Figs. 35, 36) a stationary pipe 120, adapted for connection in the pressure line, extends through a suitable packing into a cylinder or conduit 121 carried by the main ram and which telescopes the pipe as the main ram moves. Cylinder 121 is connected with pressure fluid cylinder 117 by a pipe 122 and with pressure fluid cylinder 116 by a pipe 123 both of which pipes are carried by the ram. With this construction flow of pressure fluid is not interfered with by the movement of the ram.

For the reception of the billet the container is advanced and the main ram withdrawn. With the parts in this position a billet is brought into line between container and ram as above described. In order to avoid having the extruding plunger make direct contact with the billet, a dummy block is used. There is provided means for positioning a dummy block 126 behind the billet. This dummy block is of the same diameter as, but shorter than, the billet. In the present embodiment, a seat 128 (Fig. 25) for the dummy block is carried on a

slide 127. This slide is formed on a piston rod 129 the piston 130 of which operates in a pressure fluid cylinder 131. When the slide is withdrawn, seat 128 is located just below the mouth of a chute 133. A dummy block supplied to this receptacle, as later described, slides down the chute onto the seat for transfer to position in line with the billet.

Upon the advance stroke of piston rod 129, seat 128 is moved obliquely upwardly to position the dummy block behind the billet.

There is provided a mandrel for cooperating with the extrusion die in the formation of tubes and in structures embodying the invention to what is now considered the best advantage the mandrel is carried by the main plunger but is movable independently thereof. This mandrel, in the present embodiment, is utilized to hold the billet and dummy block in place so that holder 84 and slide 127 may be withdrawn out of the way. Although capable of various constructions, in that here shown as an example, an extrusion mandrel 141 (Fig. 29) is threaded into the end of a mandrel extension rod 145 slidable in the forward end of the main plunger 170. This extension rod is connected with a cross head 143 slidable in a suitable opening in the main ram. To this end, the inner end of extension rod 145 has a head 144 which seats in a mandrel carrier block 147. This block, later more fully described, has a sleeve portion, as appears in Fig. 29, embracing the inner end of extension rod 145. As later described, block 147 is slidable sidewise, that is, to and from the plane of Fig. 29 to remove the mandrel. It is held to the cross head 143 as respects forward and back movement, i. e. along the axis of extrusion, by upper and lower guides 143^a, 143^b, which are bolted to the forward end of the crosshead and take over suitable shoulders on block 147, as shown in Fig. 29. Extending into an internal bore 161 in cross head 143 is the end of a piston rod 149 the piston 150 of which works in a fluid pressure cylinder 153 formed in the main ram 170. The forward end of this piston rod is tapered to take into a tapered recess in the head of extension rod 145. When piston rod 149 is advanced, it pushes rod 145 forward to advance the mandrel, cross head 143 being moved forward by the engagement of block 147 with guides 143^a, 143^b. The reverse movement of the mandrel is later described.

Since cylinder 153 is formed in the main ram, means is provided for supplying pressure fluid regardless of ram movement. This may be accomplished by telescoping conduits. In the exemplification here illustrated, cylinder 153 is arranged to have a variable pressure at each end. Pressure fluid, e. g. air, is admitted to one end of the

cylinder through an inlet port 163 (Fig. 38) which communicates with a pipe 169 (Figs. 36, 37) leading to a valve unit 853 on the main ram. This valve unit is connected with a pipe or conduit 168 carried by the ram and telescoping over a stationary pipe 167 as the ram moves. Pipe 167 is tapped into a stationary casting 181 (Fig. 40), later referred to, and communicates with a tapped hole 166 connected to the pressure line. The other end of cylinder 153 receives air through a port 163^A (Fig. 38) at the end of a bore 173^A in the main ram. This bore communicates through a pipe 169^A (Fig. 32) with valve unit 853, (Fig. 37). This valve unit is of any suitable construction, such as those elsewhere described, to connect either pipe 169^A or pipe 169 with the pressure source, the other pipe being connected to exhaust.

Fig. 32 shows supplemental telescoping conduits 167^A, 168^A, normally idle, which may be connected up if it is desired to connect one end of cylinder 153 for constant return pressure.

After the billet and dummy block, which are centrally pierced (Fig. 64) have been positioned as above described, the mandrel is advanced and threaded through them. This supports the billet and dummy block and thus permits holder 84 and slide 127 to withdraw out of the way, Figs. 19, 25.

The main ram 170, which carries the extruding plunger, as later described, is, in effect, a large piston rod working in a fluid pressure cylinder 172 (Fig. 42). This cylinder is formed within a large casting comprising a rearwardly extending cylindrical portion 176, a wide central portion 180, and narrower upper and lower wing portions 181, 182. This casting is securely but adjustably anchored to tie rods 108, 109. To this end, as here shown, the ends of the tie rods are screw-threaded and pass loosely through bores in the wing portions of the casting. At the front side, the wing portion 181 is recessed to receive a countersunk nut 178 threaded onto the tie rod and at the rear side is a split nut 179. Duplicate nuts are provided on the lower tie rod. These nuts adjustably anchor the casting to the tie rods.

The rear portion of the main ram 170, that is, the right hand end as viewed in Fig. 29, works in the cylinder 172 as a piston and the ram is advanced by the variable, i. e. valve controlled, pressure in this cylinder. The forward portion of the ram has bearing members 170^a, 170^b, riding on tie rods 108, 109, to guide the ram in its movement. In the present embodiment, the extrusion plunger is removably and adjustably mounted on the main ram. To this end, as shown, extruding plunger 201 (Fig. 29), tubular to accommodate the mandrel, is secured to the forward end of ram 170.

The inner end of plunger 201 has a plurality of stepped shoulders or collars 203, 204. Fitting over these stepped shoulders with a loose fit is a retaining ring 206. This ring is bolted to the annular front end of plunger 170. The inner rim of ring 206 takes into a recess formed in the end of the ram, as appears in Fig. 29. Threaded through equally spaced radial holes in retaining ring 206 (Fig. 35) are a plurality of adjusting screws 205. The ends of these screws bear against the peripheral surface of shoulder 203 on the plunger. With the construction described the extruding plunger is held on the center line and its position may be trued by the adjusting screws. Between the inner end of the plunger 201 and the ram is a pressure-transmitting ring 208 (Fig. 29) of hardened steel.

In the present embodiment the billet and dummy block are inserted in the container chamber by a preliminary advance of the main ram. This takes place after or partly simultaneously with the advance of the mandrel. The preliminary stroke is sufficient to push the billet and dummy block, now strung on the mandrel, into the container chamber. Fig. 64 illustrates the parts with the billet and dummy block held by the holder 84 and slide 127 (not shown). Fig. 65 shows the mandrel advanced through the dummy block and billet. The main ram is advancing and the extrusion plunger has already inserted the billet. In Fig. 66 the advancing ram has partly inserted the dummy block.

The metal of the hot billet in the container chamber is extruded by the ram, through a die. While the extrusion die and its associated parts may vary in construction, in the embodiment here illustrated as an example, a die holder 221 (Figs. 48-52), having a bore 225, is mounted in a recess in the face of a large casting 210. This casting rests loosely on floor rails 212 to accommodate expansion and contraction of the tie rods and other parts. The casting is generally cylindrical, with upper and lower wing portions 213, 218, bored to receive the tie rods 108, 109. The casting is adjustably secured to the tie rods by countersunk nuts 214, 216, and split nuts 215, 217, like the nuts 178, 179, above described.

Removably secured in the die holder is an extrusion die 223 having the proper bore to give the extruded tube the desired outside diameter. The inside diameter is, of course, governed by the mandrel. As shown, the die (Figs. 50, 52) seats in a recess in the face of holder 221 and has a suitable groove interlocking with an arcuate tongue 221^a on the lower wall of the recess. Above the die is a removable wedge shaped piece 223^a seating in the recess of holder 221 and

having an arcuate tongue 221^b which forms a continuation of tongue 221^a to take into the groove of the die. Locking piece 223^a is normally held in position by a locking pin 223^b. Upon removal of this pin, piece 223^a may be lifted away and the die removed.

Means is provided for adjustably centering the die. To this end, as here shown, die block 221 is loosely mounted within a boss 211 (Figs. 50, 52) on the casting 210. Threaded through this boss are a plurality of micrometer adjusting screws 222 bearing against the periphery of holder 221. By manipulation of these screws, the holder 221, and hence the die, may be properly centered, and retained.

The invention in its entirety includes means for centering the mandrel and in structures embodying the invention to what is now considered the best advantage, the mandrel is first centered by a centering tool and thereafter is held by a preliminary upset of the billet. The mandrel centering tool may conveniently be mounted so as to be interchangeable with an extrusion guide conduit. Although capable of various constructions, in that here shown as an example, the centering tool is a rod 227 (Fig. 50) having a conical head 228 arranged to fit into the conical discharge mouth of the die bore. This head has a tapered recess 229 to take over the tapered end of the mandrel 141. Rod 227 is connected, at its other end, with a reciprocating sleeve 231 to have a certain amount of universal play. To this end, as shown, the inner end of rod 227 has a rounded head 232 which is confined in the socket 230 of a shouldered socket piece 236 held to the sleeve by an end nut 237.

To advance and withdraw the mandrel centering rod 227, sleeve 231 is slidable endwise in a pivoted carrier 233. To reciprocate the sleeve, it is connected, as here shown, by a connection later described, with a slide 238 somewhat like an inverted planer slide. The hooked end of this slide is connected with the end of a piston rod 239, the piston 240 of which works in a fluid pressure cylinder 241, valve controlled at each end.

The centering rod being advanced to the position shown in Fig. 50, its head fits in the die bore whereby it is accurately centered. Any necessary play is taken up by the ball and socket connection described. When the mandrel is advanced, as above described, its tapered end takes into the tapered recess in the head of centered rod 227, whereby the mandrel is accurately centered with respect to the die. This contact, of course, stops the mandrel.

With the mandrel thus definitely held in centered position, the main ram is advanced to cause a preliminary upset of the metal of the billet sufficient to cause the metal to

fill out the container chamber and flow into the annular space between the end of the mandrel and the die bore. As a result, the upset metal grips the mandrel and holds it in its centered position so that the centering rod 227 may be withdrawn. This preliminary or upsetting advance of the main ram may conveniently be the same advance that inserts the billet, as previously referred to. Referring back to Figs. 65, 66, these figures represent the preliminary stroke of the ram, with the extruding plunger pushing the billet and dummy block into the container chamber. The mandrel is shown centered by centering rod 227. Fig. 67 represents the position of the parts at the end of this preliminary advance of the main ram. Extruding plunger 201 has upset the billet sufficiently for the metal to grip the mandrel and mandrel centerer 227 has been withdrawn. The method of controlling the stroke of this preliminary advance is hereinafter described.

There is provided means for preventing retractive movement of the centering rod 227 during the preliminary upset of the billet above described. To this end, as here shown, on the upper face of slide 238 is a brake block 295 (Fig. 48) adapted to engage a braking surface 296 formed on the underside of a pivoted lever 297. The free end of this lever is connected by a link 299 with a spring 298 secured to a bracket 299^a. Should slide 238 have a tendency to move, during the preliminary upset, such movement is prevented by the braking action of lever 297 spring-pressed against block 295.

There is provided a guide conduit for the extruded tube and in structures embodying the invention to what is now considered the best advantage, this guide conduit is mounted on a carrier which also carries the mandrel centering tool and is movable across the axis of the die to position these elements alternately. Although capable of various constructions, in that here shown as an example, a swinging carrier 233 (Figs. 50, 51) carries a guide conduit or tube 235. The sleeve 231 of the mandrel centering tool is slidable in this carrier, the sleeve and conduit being disposed on different radii. Carrier 233 is pivoted by pins 243, 244, to lugs 245, 246, on an extension of the casting forming cylinder 241. To accord with the pivotal movement of the carrier, sleeve 231 of the mandrel centering unit is pivotally connected to slide 238 by a pin 209 passing through a lug 209^a on the slide. To swing the carrier on its pivot, the lower part of the carrier has a gear sector 247 (Fig. 51) meshing with a rack 248 on a double pistoned piston rod 249. The left hand piston, as viewed in Fig. 51, which is the larger, works in a variable pressure fluid cylinder 242. 13

The other piston works in a constant pressure cylinder 234.

After the preliminary advance of the main ram and withdrawal of the centering tool 227, piston rod 249 is moved to the left (as viewed in Fig. 51.) This swings carrier 233 on its pivot to move the mandrel centering unit out of line and substitute guide conduit 235. In this position, as represented in Fig. 67, the conduit adjoins the end of the bore through the die carrier to receive the emerging extruded product.

The main ram is now advanced into the container on its extruding stroke, whereby the metal of the billet is extruded in the form of a tube 1^a. This tube passes out through bore 225 in the die holder and is received by guide conduit 235 (Fig. 68). In the present embodiment, the main ram is given its preliminary stroke under relatively low pressure and its extruding stroke under high pressure. Pressure regulating valves are known and means for an automatic pressure change is disclosed in applicant's co-pending application Serial No. 94,334, filed March 12, 1926.

After the mandrel centering tool is withdrawn, and upon the extrusion stroke of the main ram, the mandrel is carried forward to substantially the position represented in Fig. 68. This movement is due in part to the continued stroke of piston rod 149 (Fig. 29) and part to the advancing movement of the main ram which, as above described, carries the entire mandrel unit.

As soon as the extrusion operation is completed pressure is taken off the main ram and the mandrel is withdrawn.

In the present embodiment this mandrel withdrawal is effected in part by the piston rod 149, previously described but there is provided auxiliary means for giving additional force at the first part of the stroke. As elsewhere pointed out, unit 150, 153 is an air unit and the auxiliary means makes use of water pressure to insure the mandrel being freed from the billet stump. As here shown as an example, on the forward or die end of the main ram (Figs. 32, 36) are two fluid pressure units 393, 394 having piston rods 395, 396, arranged to abut bosses 397, 398 on mandrel cross head 143. These units are now placed under pressure to push back the mandrel cross head. At the same time cylinder 153 is placed under return pressure to withdraw piston rod 149. This results in a backward movement of the mandrel unit.

The parts are so arranged that the mandrel may be freed from piston rod 149 on this back stroke. As here illustrated as an example, the piston rod 149 has a collar 155 located in the inner space 161 in cross head 143. When the parts are advanced (Fig. 29) this collar is spaced from the end wall of space 161. At some point in the back stroke

of the mandrel unit, the piston rod makes a differential movement, until collar 155 engages this end wall, thereby withdrawing its tapered end from the inner end of extension rod 145. The auxiliary units are used to free the mandrel from the stump. Thereafter the crosshead is pulled back by the engagement of collar 155, on piston rod 149, with the cross head. In either case the cross head movement withdraws the mandrel by the connection above described.

Means is provided for latching the mandrel extension rod to hold it on the center line during this withdrawing movement. As shown, slidable in the inner space of cross head 143 is a grooved ring 159 pressed outwardly by a spring 157 bearing against collar 155. As appears in Fig. 31 this latching ring bears against the unit comprising block 147 and head 144 and counteracts any tendency of this unit to move sidewise, during withdrawal. This latching force, however, is not sufficient to interfere with the positive sidewise pull on the block 147 later referred to. As appears in Fig. 30, when the mandrel unit is removed, as later described, the latching ring projects slightly beyond the face of the cross head. It is displaced inwardly against its spring by the act of replacing a mandrel. To limit the extent of projecting movement of ring 159, rod 149 carries a double ended stop pin 164 which takes into slots 165 formed in ring 159.

During this withdrawal of the mandrel the main ram is withdrawn. In the present embodiment this results from placing cylinder 172 at exhaust. Referring to Fig. 29, the main ram carries cylinders 116, 117, for the container advancing piston rods 114, 115. These rods, as above described, were advanced to move the container unit up against die-back casting 210 (Fig. 63). When the main ram was advanced, cylinders 116, 117 were telescoped over their piston rods due to the great pressure differential between these cylinders and ram cylinder 172. When cylinder 172 is placed at exhaust, the constant pressure in cylinders 116, 117, becomes effective. Since piston rods 114, 115 cannot advance because they abut the container, backed by casting 210, cylinders 116, 117, and consequently the main ram, move back.

There is provided means for delivering an extruded tube having one end pointed for threading into a draw die. This may be accomplished by crushing in the tube at the trailing end just in advance of the point where the tube is to be cut from the stump, whereby the tube has the proper point at the cut end. Although capable of various constructions in that here shown as an example, mounted on the die-back casting 210 are two pair of pointing tools equally spaced about the die axis (Figs. 52, 53). One pair

which may be termed indenting tools comprises two diametrically located heads 253 formed to indent the extruded tube along a portion of its length. These indenting heads are carried on piston rods 254, the pistons 255 of which work in fluid pressure cylinders 256 mounted on the casting 210. The tools work through suitable radial openings 224 formed in boss 211 and die holder 221. Spaced 90° from these tools are two diametrically opposed gripping and crushing tools. These comprise heads 263 formed to correspond to the curvature of the extruded tube. The heads are mounted on piston rods 264, the pistons 265 of which work in fluid pressure cylinders 266. These tools also work through suitable radial openings like openings 224.

For the pointing operation heads 263 are first advanced to function as grippers to hold the extruded tube and prevent distortion of the metal outwardly under the force of the indenting tools. To this end, supplemental advancing means is provided to give these tools 263 the proper stroke, i. e. a stroke less than the full stroke of piston rods 264 for the crushing function. For this purpose, as shown, each rod 264 is connected to a cross head 274. This cross head is mounted on a pair of small piston rods 276, the pistons of which work in fluid pressure cylinders 280 formed in the casting of cylinder 266. The advance stroke of piston rods 276 moves tools 263 into gripping contact with the extruded tube (Fig. 72). While the extruded tube is so held, the indenting tools 253 are advanced to form elongated indentations in the tube (Fig. 73). Tools 253 are then withdrawn and tools 263, now functioning as crushers, are further advanced by their main pistons 265. This crushes in the tube walls, as illustrated in Fig. 74.

Following the pointing operation the extruded tube is severed from the sprue. To this end, as here shown as an example (Figs. 52, 53, 69, 70) a shearing tool or cutter 268 is carried by a rod 269 connected with a piston 270 which works in a fluid pressure cylinder 271 mounted on casting 210. The cutting unit is mounted just in front of one of the crushing tool units, that is, between the back of the die and the crusher unit (Fig. 53). This brings the line of cut at approximately the trailing end of the pointed portion of the tube. Advance of cutter 268, the tube being still gripped by the crushing tools, severs the tube (Fig. 70) which may be removed in any suitable manner. The cut end, as the tube is delivered from the press, is already pointed for threading into a draw die. The crushing tools are then withdrawn. In order to make sure of the proper withdrawal, each of the four pointing tools has a return spring 260. These springs are coiled about the tool rods and are

confined between washers 261 on block 219 and nuts 262 on the rods.

The cutting operation leaves a waste stump 285 comprising an unextruded sprue and a short length of tube left in the die.

In the present embodiment the stump is withdrawn from the die and ejected from the container by a back movement of the container. To this end, following the cutting operation described, the container unit is moved back, away from the die, by means of piston rods 283, 284 (Figs. 47-63) already described. This back stroke of the container unit withdraws the stump from the die and then brings the dummy block against the end of the withdrawn extrusion plunger 201 to expel the stump from the container chamber (Fig. 70).

In the present embodiment, the parts are so arranged that at the end of this back stroke of the container the stump is out of the container chamber and the joint between the stump and dummy block is substantially in the plane of the face of the container. To this end, means is provided for adjustably controlling the back stroke of the main ram so that the stump will have the position just referred to (Fig. 70). This may be accomplished by adjustable stops for engagement by the ram unit. As here shown as an example (Figs. 42, 43, 44), mounted on the tie rods just in advance of the main ram cylinder casting 180 are stops 183. Each stop comprises upper and lower saddle elements 183^a, 183^b, bolted together about the tie rod. The abutment portion of the stop comprises a three-piece plate carried by saddle element 183^a. The middle piece 187 of the three is wedge-shaped and the end pieces 185, 186, are formed to provide a wedge-shaped slot, as appears in Fig. 43. As shown, rear end piece 186 is secured in place and front end piece 185 is adjustably held in place by a lock bolt 189, working in a slot 189^a. Adjustment is made by moving the wedge-shaped piece 187 in or out, whereby the abutment piece 185 is moved backward or forward, sliding in a dove tailed groove in the saddle member, to have an adjusted stopping position. The wedge-shaped piece is moved by adjusting screws 190, 191, going through the saddle and threaded into the wedge from opposite sides in the manner of micrometer screws.

When the ram unit is moved back it engages stop plates 185 and its position at the end of the stroke is definitely fixed.

There is provided means for separating the stump from the dummy block in the event that they become "frozen" together during extrusion. Although capable of various constructions, in that here shown as an example, a cut-off 287 (Fig. 23) carries a knife-like element 289 and is mounted on a transverse slide 290. This slide is con-

nected with a piston rod 291, the piston 292 of which works in a fluid pressure cylinder 293. Upon advance of slide 290 across the axis of the press, the knife 289 wipes across the face of the container and knocks or cuts off the stump 285 (Fig. 70) which falls into a pocket 294 (Fig. 23).

This pocket has a slanting floor and is open at the back. When the slide is advanced, as just described, crosshead casting 107 serves as a back or closure for the pocket. But upon return of the slide to its original position (Fig. 23) the pocket is carried beyond its back wall and the stump slides out of the pocket and out of the press, e. g. onto the floor.

In the present embodiment the dummy block is carried away by this same operation of the slide 290. To this end, as soon as the knife has knocked off the stump, in the left hand movement of the slide (Fig. 23) the main ram is advanced sufficiently to kick out the dummy block from the container. The dummy block is received by a holder 300 carried by slide 290. The main ram is at once placed at exhaust and again returns to withdrawn position by pressure in cylinders 116, 117, as previously described.

Since the slide 290 is carried by the container cross head and since the latter moves back and forth along the axis of the press, there is provided telescoping means for supplying pressure fluid, in this case water, to cylinders 293. To this end, as here shown as an example (Fig. 23) fluid is supplied to the variable pressure end of the cylinder through a conduit 293^a connecting with a pipe 293^b leading to a coupling 293^c. This coupling is connected by a pipe 293^d (Fig. 20) which passes into a stuffing box 293^e bolted to the tie rod 109. Tapped into this stuffing box is a pipe 293^f supported by a bracket 293^g. Pipe 293^f telescopes inside of pipe 293^f as the container cross head reciprocates. In the side of stuffing box 293^e is a tapped hole 293^h which may be connected with the pressure line in any suitable manner. The constant return pressure end of cylinder 293 receives pressure fluid, through a bore 293ⁱ (Fig. 23) communicating through a suitable bore (not shown) with a pipe 293^k (Fig. 21) leading to a coupling 293^l. Leading from this coupling is a pipe 293^m passing into stuffing box 293ⁿ. Also tapped into this stuffing box is a pipe 293^o within which the pipe 293^m telescopes. Fluid is supplied to the stuffing box through a bore 293^p which may be directly connected in any suitable manner to the pressure line.

After the dummy block is removed from the container it is reconditioned for further use. To this end, there is provided means for trimming the bore and the outer surface of the block. Although capable of various constructions, in that here shown as an ex-

ample, upon the return stroke of slide 290, the dummy block is brought into line (Figs. 27, 28) with a conduit 301 leading to a trimmer 302. This trimmer has a bore 310 provided with a bell mouth for reception of the block. Located in equally spaced radial openings in the trimmer housing 302 are three spring-pressed slidable holders 314 carrying trimming knives 317. As appears in Fig. 28, these knives 317 are so arranged as to form a complete circular cutting edge for trimming the outside of the dummy block, the springs serving to position the knives so as to project normally into the bore 310.

The dummy block is pushed through this trimmer by a combined pusher and scraper. This element comprises a head 303 (Figs. 47, 48) mounted on a piston rod 305, the piston 306 of which works in a pressure fluid cylinder 307 carried by die-back casting 210. On the head 303 is mounted a scraping device 304 comprising a flaring tube split in two directions at right angles to each other and formed with a knife-edge rim. This scraping tool is of a size to pass through the bore of the dummy block when collapsed inwardly. As piston rod 305 is advanced, the rim of scraper 304 engages the dummy block and pushes it forward until the block enters the bell mouth of the trimmer device (Fig. 27). The resistance of the spring-pressed knife holders 314 is sufficient to stop the dummy block temporarily, whereupon the scraper device 304 enters the bell mouthed bore of the dummy block and scrapes the same clean in its passage through the same. By the time the rim of scraper 304 has passed through the bore, head 303 engages the trailing end of the block and forces it forward. The dummy block being forced against the holders 314 spreads the same apart so that the leading end of the dummy block can clear the trimming knives. By the time this takes place the trailing end of the dummy block has entered an enlarged chamber 312 formed around the trimmer bore. The knife holders 314 being no longer held back close in under the force of their springs and knives 317 are thus held against the outer periphery of the block. As the block moves forward it is scraped clean by the knives, the scrap being received in chamber 312 from which it can pass out through an opening 313. The continued stroke of piston rod 305 pushes the dummy block on until it makes contact with the far wall of chute 133. The piston rod is then withdrawn to free the scraper from the dummy block. Means is provided for preventing the block from following the scraper back. As shown, three spring-pressed latches 315 are spaced at equal intervals around the bore of the trimmer just inside the mouth of chute 133. As the dummy block moves into the mouth of

the chute these latches are forced back against their springs but as the dummy block passes they drop down in behind the latter to prevent it from moving back with the scraper head. As the scraper moves back any scrap metal, e. g. a ring of scrap, is retained in enlarged chamber 312 by contact with the shoulders of knife holders 314 at the wall of the chamber.

The dummy block meanwhile has slid down chute 133 into pocket 128 for subsequent delivery to the press.

There is provided latching means for holding the dummy block to its seat. This comprises, as shown, a pivoted latch 137 having a heel 137^a and mounted on an L-shaped slide 137^f which is secured to piston rod 129. In the position of Fig. 25, the latch is held raised by a lever 137^b bearing against a stop 137^c on cylinder 131. As soon as piston rod 129 starts forward, lever 137^b moves away from its stop whereby the spring 137^d pulls down the latch until its heel 137^a engages the dummy block to hold it in its seat. This holds the dummy block to its seat on its travel to the press. The latch, however, in the Fig. 25 position acts to hold the dummy block from bouncing out of its seat after it comes down the chute. The mouth of the chute also prevents the dummy block from moving endwise in its seat. As the dummy block is moved into position on the line of the container chamber, a projection 137^e on the latch rides over extrusion plunger 201 and raises the latch so that the dummy block is free to be moved into the container as previously described.

Since the dummy block feed unit is carried by the container cross head, which reciprocates on the axis of the press, telescoping means is provided for delivering pressure fluid, in this case air, to cylinder 131. As here shown as an example, the variable pressure end of this cylinder is connected by a pipe 131^a (Fig. 25) with a double coupling 131^b (Fig. 20). The complete piping is not shown and may be of any suitable arrangement. From the coupling a pipe 131^c leads to a double stuffing box 131^d. Also tapped into this stuffing box is a pipe 131^e within which pipe 131^c telescopes. The stuffing box and pipe 131^e are mounted on tie rod 108. Air is supplied to the stuffing box through a bore 131^f connected with the pressure line in any suitable manner. Air is delivered to the constant return end of cylinder 131 by a pipe 131^g leading to the other half of coupling 131^b. From this half of the coupling a pipe 131^h leads to the other half of stuffing box 131^d and telescopes within a pipe 131ⁱ. A bore 131^k in the stuffing box is directly connected with the pressure line in any suitable manner.

Meanwhile the container unit has been advanced into original position against the

die unit. As it takes this position, swinging carrier 233 is swung on its pivot to move guide conduit 235 out of line and replace the mandrel centering tool in line. The mandrel centering rod 227 is then advanced into centering position as previously described. The parts are now in a position for the next cycle.

Figs. 64-74 illustrate diagrammatically the successive steps of the extrusion press. In Fig. 64 the mandrel centering tool is in centering position and the billet and dummy block are in position for insertion in the container. In Fig. 65 the mandrel has been advanced to support the dummy block and billet and the slides (not shown) have withdrawn. The mandrel has advanced into the mouth of the die and is centered by the centering tool. The ram has advanced to insert the billet and dummy block in the container. In Fig. 67 the ram has given the billet its preliminary upset to grip the mandrel, the centering tool has been removed and the guide conduit is in receiving position. In Fig. 68 the billet has been extruded into a tube. In Figs. 69 and 73 the ram and mandrel have been withdrawn and the pointing tools have indented the trailing end of the tube. In Figs. 70 and 74 the crushing tools have completed the pointed formation of the end of the tube; the cutter has severed the tube from the stump; the container has been moved back to eject the stump beyond the face of the container; and (in dotted lines) the stump has been separated from the dummy block. In Fig. 71 the ram has advanced slightly to eject the dummy block, which is being carried away to the trimmer. To complete the cycle the dummy block is trimmed and returned to its slide; the ram is again withdrawn; the container is advanced against the die; the guide conduit is removed and the centering tool substituted; and the dummy block and a new billet are moved into position. This returns the parts to the position of Fig. 64.

Provision is made for bleeding the main ram cylinder of entrapped air. As here shown as an example, a bore 172^a (Fig. 42) leads from cylinder to atmosphere. This bore is normally closed by a plug 172^b. In case the water system is drained, for repairs or the like, upon resumption of water flow, air may become trapped in cylinder 172 and interfere with proper operation. This air can be bled out by removing plug 172^b.

The invention in its entirety includes means for removing and replacing a mandrel. This may be accomplished by a mandrel exchange device carrying a plurality of mandrels into which the withdrawn mandrel may be transferred and from which a substitute mandrel may be inserted. In the present embodiment the exchange device has capacity for two mandrels so that one may

cool while the other is in use. Although capable of various constructions, in that here shown as an example, block 147 has an arcuate extension 321 extending outwardly (Fig. 56) to the side of the main ram. At its end this extension has a hook 322 adapted to be engaged by a hook 323 on the end of one arm 324 of a bell crank lever pivoted at 327 on the frame 326 of the exchange device which is carried by the main plunger. The other arm 330 of the bell crank is pivoted to a link 331 pivotally connected to a bracket 333. This bracket is mounted on an L-shaped slide 335, the short leg 337 of which is secured to a piston rod 339. This rod is on a piston 341 working in a fluid pressure cylinder 343.

The mandrel unit having been withdrawn so that the mandrel clears extrusion ram 201 (Fig. 29) piston 341 is moved to the left (as viewed in Fig. 56). During the withdrawal of the mandrel, hook 322 is engaged by hook 323. By this movement of piston 341, block 347 is drawn outwardly to the position of Fig. 56, carrying with it the mandrel extension rod and mandrel. During this removal operation the forward end of the mandrel unit rests on an arcuate support 326^a.

After the mandrel unit has thus been removed from the press it is placed in a cooling chamber and a cool mandrel substituted. To this end, as here shown, the mandrel exchange includes a housing 363 having capacity for a plurality of mandrels and having means whereby any one of the mandrels may be brought in line with the position of Fig. 56. This may be conveniently accomplished by a housing having a plurality of mandrel chambers, the housing having an indexing movement to place the desired chamber in the position referred to. In the present embodiment the housing has two mandrel chambers 346 and 361 (Fig. 62) located one above the other and the housing is indexed up or down to position the proper chamber.

Assuming the parts to be in the position of Figs. 56 and 62, the housing 363 is down and mandrel 141 has been removed from the press and is in line with chamber 346. As the mandrel unit takes the removed position the head 144 of extension rod 145 takes into a recess in a hook block 352 mounted on an L-shaped slide 354. The short leg of this slide is secured to the end of a piston rod 355 the piston 356 of which works in a fluid pressure cylinder 357. Upon movement of piston 356 to the right (as viewed in Fig. 56) slide hook 352 draws the mandrel extension rod and mandrel into chamber 346. Housing 363 has a slot 348 to accommodate the slide hook 350.

Housing 363 is now raised to move this cooling chamber out of line and bring the other chamber with its cool mandrel into

line. To this end, as here shown as an example, housing 363 has a depending skirt portion 363^a adapted to have a sliding bearing in a box-like frame 370 forming part of the mandrel exchange unit (Fig. 62). The housing has a three point link suspension. Pivoted to lugs 371, 372 and 373 (Figs. 55, 62, 59) on housing 363 are links 374, 375, 376 respectively. These links are mounted respectively on rocker arms 377, 378, 379, in turn mounted on rock shafts 380, 381, 382. Rock shafts 380, 381 are rocked from shaft 382. To this end, mounted on shafts 380, 381, are rocker arms or levers 383, 384 pivoted to a link 385. This link is pivotally connected to a rocker lever 389 mounted on rock shaft 382. This latter shaft is rocked by a rocker lever 391 mounted thereon and pivoted to a link 386 connected by a cross head 392 with a piston rod 387. This rod is on a piston 388 working in a fluid pressure cylinder 390 valve controlled at each end. When piston 383 is moved to the right (as viewed in Fig. 59) the three rock shafts are rocked clockwise (as viewed in Fig. 62), thus elevating housing 363. Reverse of piston 388 reverses the parts and lowers the housing.

As shown in Fig. 62, in the lower cooling chamber is a substitute mandrel unit 360 including block 360^a that is a duplicate of block 147. When housing 363 is elevated, the hot mandrel unit is brought out of line and the cool mandrel unit brought into line. This automatically places head 360^b of the substitute cool mandrel into the grip of hook 352 which is, as above described, at the end of its stroke opposite the position of Fig. 56. Similarly, substitute block 360^a is brought into the position formerly occupied by block 147, with its hooked end hooked into hook 323 of lever 324.

Upon reversal of piston 356, slide 354 moves to the left (as viewed in Fig. 56) and advances the substitute mandrel unit into the position formerly occupied by the hot mandrel unit (Fig. 56). Piston 341 is now given its reverse stroke and by a reverse movement of bell crank lever 324, 330 substitute block 360^a, carrying substitute mandrel 360, is moved into the press to the operative position of Fig. 29. On the next extrusion cycle, therefore, the substitute cool mandrel is used.

Meanwhile the first mandrel is cooling. If desired, the withdrawn mandrel may be subjected to a cooling medium, e. g. a blast of cool air, in any suitable manner.

After the next extrusion the operation of exchanging mandrels is the same except that the hot mandrel is received in the lower chamber (housing 363 being elevated) and the housing is then lowered to bring the cooler mandrel into line.

In the present embodiment the mandrel exchange is moved into and out of exchange

ing position and this movement is dependent on the position of mandrel cross head 143. To this end, as here shown as an example, the entire mandrel exchange unit is mounted on a trunnion 363^c (Fig. 62) journaled in and carried by the main plunger 170. On the exchange is a cam track 363^x (Fig. 56) arranged to be engaged by the rear corner of cross head 143 as the latter moves back to withdraw the mandrel from extrusion position. This engagement swings the mandrel exchange unit into exchange position (Fig. 56). The unit also has a cam track 363^y arranged to be engaged by a front corner of cross head 143. When the cross head is advanced to insert the mandrel in extrusion position, this engagement swings the exchange unit in the opposite direction, i. e. counter clockwise as viewed in Fig. 56. The exchange unit is thus moved out of the way of the other parts for the extrusion operation.

There is provided means for conveniently removing a mandrel unit in case of wear or the like. This may be accomplished by removable elements which receive the mandrel unit while in the cooling chamber. Although capable of various constructions, in that here shown as an example (Fig. 62) the rear end of each cooling chamber of the mandrel exchange is normally closed by a removable element comprising a plug 346^a, pinned into the open mouth of the chamber, and a handle 346^b. Carried by the plug are two leaf springs 346^c. The ends of these springs extend into the chamber beyond the plug and terminate in oppositely facing lugs 346^d. These lugs extend into the path of head 144 (or 360^b) on the mandrel extension rod. When the mandrel unit is drawn into the cooling chamber, as above described, the head spreads the springs and passes the lugs which then drop in behind the head. In this position, as shown in the lower chamber Fig. 62, the mandrel unit is latched in place during the movement of the cooling housing. When the mandrel is drawn forward again, for reinsertion in the press, the head simply wipes over lugs 346^d to spread the same.

To remove a mandrel from the apparatus, the pin which holds plug 346^a in place is removed. The plug element is then grasped by handle 346^b and withdrawn. The two springs, with their lugs engaging the head of the mandrel unit, serve in the nature of a pair of tongs that draw the mandrel extension rod and mandrel out of the cooling chamber. A new mandrel unit is substituted by reversing the steps just described.

The invention in its entirety includes means for automatically effecting the operation of the various fluid pressure units whereby each succeeding machine operation is dependent for its initiation upon the com-

pletion of a preceding operation or operations. This may be accomplished, generally speaking, by control valves for the pressure units, which valves are, in turn, automatically controlled by electric circuits. While such valves and their controlling circuits may vary in construction and arrangement, a suitable form of valve and a suitable electric control are disclosed in a copending application filed March 12, 1926, Serial No. 94334. For convenience, an example of one of these valve units is shown in Fig. 60. This valve comprises a valve chamber 411 having an inlet 412 connected with a pressure line, e. g. compressed air. The valve chamber has two cylindrical extensions 413, 414 of different diameter, the smaller one being opened to atmosphere and the larger one closed. In these extensions work pistons 415, 416 are carried on a piston rod 417. Mounted on this piston rod is a D-slide valve 418. Opening out of the valve chamber 411 is an exhaust passage 419 leading to atmosphere and a passage 420 adapted for connection with the variable pressure end of an air-operated power cylinder. Under what may be termed normal conditions, the pressure in the valve chamber holds the D-slide valve moved to the left, as viewed in Fig. 60. In this position passage 420 connects the controlled cylinder with the pressure line to advance the piston of the controlled unit. The D-slide valve is moved in the opposite direction by admitting air pressure, as by a by-pass, through a passage 421, into the closed extension 413. When this takes place the D-valve is moved to the right, due to the piston differential, and the D-valve spans passages 419, 420. This connects the controlled cylinder with exhaust so that the piston of the unit moves back under its constant return pressure as previously described. When the passage 421 is again closed, the D-valve moves back to the left under chamber pressure.

As is more fully described in the application referred to, the admission of air via passage 421 is controlled by a solenoid-operated valve which connects the cylindrical extension either with the pressure line or exhaust. The circuit of the latter is controlled by a switch suitably placed to be actuated by some predetermined operation or at some predetermined time. A closed circuit may result in a closed solenoid valve or vice versa, according to the desired arrangement. These valve units may be termed, for convenience, magnetic valves.

For some purposes it is desired to operate the power unit in both directions by variable pressure. In that case, each end of the cylinder has one of these valve units, one end of the cylinder being at exhaust while the other end is connected with the pressure line.

In the following description of the automatic operation, the several air power units are referred to as being actuated by opening valve number so-and-so. It is to be understood that the word "valve" in this connection is intended to cover the complete unit including the D-slide valve and its controlling solenoid-operated valve, or some equivalent construction. In the drawings the reference numerals have been applied, for convenience, to the solenoid of the valve unit. Unless otherwise specified, an energized circuit for the solenoid is referred to as "opening" the valve. This means that the D-valve is in such position as to connect the controlled cylinder to main line pressure. Conversely, a "closed" valve, upon breaking of the circuit, means a D-valve in such position that the controlled end of the cylinder is at exhaust.

In the case of hydraulic power units, that is, units in which the machine part is actuated by water pressure, the controlled end of the cylinder, as described in the application referred to, has associated therewith a water inlet valve and a water exhaust valve, both of the poppet type. These water valves are actuated by pistons working in air cylinders, the air supply being controlled by magnet valves of the type illustrated in Fig. 60. In such cases valve chamber 411 has a third passage 420^a, indicated in dotted lines in Fig. 60, and adapted for connection with the air cylinder in place of a constant return connection. The D-slide valve, in such case, connects either end of the controlled cylinder with the pressure line, the other end being at exhaust. When the D-valve is in one position the water valve is opened, in the other position it is closed.

In the case of such hydraulic units, reference to an "open" valve means a D-valve in such position that the controlled hydraulic valve is open, be it the inlet or exhaust valve. Similarly a "closed valve" means a D-valve in such position that the controlled hydraulic valve is closed.

The application referred to discloses also a hydraulic unit in which both water valves are controlled from a common magnetic valve. In such case the air passages of the D-valve are cross-connected to the opposite ends of the air cylinders of the hydraulic inlet and exhaust valves. That is, in one position of the D-valve, one end of the air cylinder for the inlet valve and the opposite end of the air cylinder for the exhaust valve are connected with main line pressure, the other ends of the two cylinders being connected with exhaust.

In such cases reference to an "open valve" means a D-valve in such position that the hydraulic inlet valve is open and the exhaust valve closed so that the hydraulic cylinder is under pressure. A "closed valve" means

a D-valve in such position that the inlet valve is closed and the exhaust valve open.

The piping diagram shows the units actuated by water power. Where only one "valve" is referred to in the case of a hydraulic unit, it is to be understood that it is of the cross-connected type just described.

The units not shown in this diagram are, in the present embodiment, air operated.

For certain uses some modification of the D-valve unit may be desirable. For example, in the case of the unit (cylinder 390) for holding mandrel exchange housing 363 raised or lowered, a control valve such as illustrated in Fig. 61 is used. This may be termed a "stay-put" valve. This unit has a valve chamber 426 connected with the pressure line by an inlet 425. In the valve chamber is a D-slide valve 427 mounted on a piston rod 428 having pistons 429, 430 working in cylindrical extensions 431, 432. These extensions are of the same diameter and are both closed to atmosphere. Opening out of the valve chamber are three passages. Passages 433 and 435 are connected with opposite ends of cylinder 390 and passage 434 to exhaust, e. g. atmosphere. The D-valve is arranged to span either of passages 433, 435 and exhaust passage 434 so that one end of cylinder 390 is receiving pressure and the other end is at exhaust.

Extensions 431, 432 both have air inlet passages like passages 421, each being controlled by a solenoid-operated valve. The D-valve is moved by admitting air to one of the cylindrical extensions, the other being at exhaust. Assuming the valve to be in the position of Fig. 61 it will stay put in that position even if the air pressure for right hand extension 432 is cut off, as by the closing of the solenoid-operated valve. It will remain in this position until pressure is admitted to the end of extension 431. Similarly, when moved to the right it will remain there until pressure is again admitted to extension 432, even though extension 431 is at exhaust.

The solenoid-operated valves may be conveniently controlled by having the coils in D. C. lines, in which are contactors or relays having their coils in A. C. lines. These latter may be controlled by one or more switches operated by the movement of some part of the apparatus. While these switches may be of any suitable construction Fig. 77 illustrates a convenient example. As shown, a housing 403 encloses a pair of contacts 401, 402 normally separated. Pivoted to housing 403 is an operating lever 405 its outer end projecting through a slot 404. This lever is spring-held in normal position, i. e. the position of Fig. 77. When the lever is moved on its pivot, a conductor pin 405^a, mounted on its inner end, is inserted be-

tween the contacts to bridge the same and close the circuit. If it is desired to have a normally closed circuit, the switch contact arms may be arranged to be normally in contact with pin 405^a, this contact being broken, on actuation of the lever, to open the circuit.

The several switches hereinafter referred to may conveniently be operated by means of cam elements carried by or moved by various parts of the apparatus. These cam elements act directly, or through an intermediate lever, on a roller 406 (Fig. 77) carried on the switch operating lever and which may be considered typical. By the formation and location of the cams and the arrangement of the switches, the desired time, type and duration of switch contact may be obtained to effect the circuit conditions hereinafter described. The type of actuation depends on the circuit condition desired and the character of the actuating part. For example, Fig. 77 illustrates a typical example of instances where it is desired to operate a switch as some moving part completes a stroke, the switch being held in actuated position until the moving part withdraws. As here shown, roller 406 is arranged to engage a cam 407 on a moving part 408. When the latter moves in the direction of the arrow of Fig. 77, the roller rides up the cam thus closing (or opening) the switch. The cam has a high on which the roll remains until the part typified by 408 is withdrawn.

Fig. 76 illustrates an example of instances where it is desired to operate a switch on relative movement of the parts in one direction only. The switch lever roller is engaged by a bell crank lever 405^b. Connected by a pin 405^a to one arm of this bell crank is a lever 405^c carrying a cam engager 405^d. This latter is arranged for contacting with a cam 405^e on a moving part of the apparatus 408^a. When the latter moves in the direction of the arrow in Fig. 76, engager 405^d slides up cam 405^e and the bell crank is swung on its pivot to actuate the switch lever. As the cam passes by, the lever swings back under its own weight. When part 408^a reverses its stroke, a bevel 405^f (Fig. 76^a) on the cam engages a like bevel on cam engager 405^d and swings lever 405^c on pin 405^a without affecting the bell crank so that the switch is not operated. As the cam passes by, lever 405^c is returned to normal position by a spring 405^b.

It will be apparent from the description of the circuits hereinafter which switches are operated by machine parts such as typified by parts 408, 408^a and the several cams are not specifically referred to. Given the desired circuit conditions and the moving part involved it will be understood that the

switch and cam may be arranged in any suitable manner.

In the present embodiment of the invention certain parts of the press, namely the main ram and the container crosshead, control the operation of a plurality of switches. There is provided means for operating a group of switches in timed relation with the movement of these units. This may be accomplished by grouping a number of switches and grouping the actuating cams on a drum that is rotated by the movement of machine part in question. To this end, as here shown (Figs. 40, 41, 45, 46), at the rear of the press, carried by the main ram cylinder casting, is journaled a drum shaft 2001 having a gear 2002 meshing with a rack 2003. This rack is connected by a tubular link 2004 with the main ram unit (Fig. 37). Also mounted on the drum shaft are a number of cams 2005 engaged by pivoted wipers 2006 which in turn engage the rollers (like roller 406 of the typical switch of Fig. 77) of a number of switches elsewhere referred to. As the main ram moves, the drum and its cams are rotated to actuate the switches. By the arrangement of the high points of the cams and by the relation of switches and their wipers to the drum, the various switches are made to open or close at the proper time with relation to the ram movement to effect the circuit conditions hereinafter described.

A similar grouped set is mounted on the opposite side of the main ram cylinder casting, its rack being connected by a tubular link 2007 with the container crosshead (Fig. 26). The switches of this set are actuated in timed relation with the container movement to effect the circuit conditions hereinafter described.

Links 2004, 2007 are tubular to serve as conduits for carrying wires to various parts of the apparatus.

In the embodiment of the invention here illustrated as an example, the solenoid coils of the various magnetic valves are included in circuits of a D. C. system. These circuits are controlled by make and break devices. For the automatic operation the make and break devices are relays or contactors comprising a coil, a core and a contact bar, the several contact bars having various contact terminals. Two types of contactors are here illustrated. In one a single lifting solenoid is used to raise a contact bar; in the other a pair of oppositely disposed solenoids move a contact bar into contact with one or another set of terminals depending on which solenoid is energized. The several contactors may be conveniently collected on a panel board.

The coils of the contactors are included in circuits of an A. C. system and these

circuits are controlled by the switches above referred to and hereinafter mentioned.

The circuits controlling the several magnetic valves also have hand switches, which may be collected on a panel board, to enable an operator to control the various operations of the apparatus manually in case of an emergency and causing the parts to move into the initial position above referred to.

The wiring diagram is shown in Figs. 81—86 with these figures arranged in accordance with the chart of Figure 80. In the wiring diagram the several switches are shown and arranged diagrammatically. They are, however, in most cases, illustrated in the apparatus drawings.

In describing the automatic operation of the apparatus it is assumed that the several furnace paths are filled with billets. In starting, this may be done by hand. Thereafter the paths are kept full automatically. It is also assumed that a cold billet is positioned by permanent stop 36 in front of the last, or 4th, furnace door. It is further assumed that the press parts are in the position in which an extruded tube has been pointed and cut, the container is away from the die, and the main ram is withdrawn (Fig. 70). The press parts may be brought to this position by manual control of the circuits and valves. As presently described, the automatic operation, in starting a run, is put into effect by means of certain hand switches. Thereafter the apparatus functions through successive cycles automatically without cessation, until stopped.

For the automatic operation, a double-throw hand switch 601 (Fig. 84) is closed to the right to connect up the current sources. The next step is to place all the controlling contactors in what may be termed an initial or normal setting. This setting is controlled by closing two contactors 603, 604. To this end, the desired operating coil of each of the several contactors is connected by means of a suitable conductor to one of a plurality of contacts 608 on contactors 603, 604. To simplify the diagram only one of the contacts is shown connected, namely, that connected with the right hand coil of contactor 609.

Contactors 603, 604 are closed by closing a hand switch 602 in a circuit including one side of the A. C. source on conductor 605, conductor 606, the coils of contactors 603, 604 in parallel, to the other side of the A. C. source on conductor 607.

The various contactors being thus placed in their normal or initial setting, the automatic operation is started by preparing circuits for opening control valve 611 of cylinder 293 to start slide 290 to the left, as viewed in Fig. 23. This is accomplished by closing hand switch 610. As a result, con-

tactor 612 is moved to the left by the completion of the following circuit—from one side of the A. C. source on conductor 607, upper left contacts of contactor 609, which is moved to the left in its initial setting, conductors 613, 614, 615, 616, to the left magnet of contactor 612, conductors 617, 618, contacts of hand switch 610, conductor 619, lower right contacts of contactor 620, which is normally to the right, conductor 621, contacts of switch 622 on the pressure control device (later described) and which is assumed to be closed at this time, conductors 623, 624, 625, to the other side of the A. C. source on conductor 605 through the lower left contacts of contactor 609. Contactor 626 now moves upward to close its contacts, being energized in a circuit which extends from one side of the A. C. source on conductors 607 and 616, previously traced, through the lifting magnet of contactor 626, upper left contacts of contactor 612, conductor 627, switch 628, which was closed by the withdrawal of the main ram, conductors 625, 677 to the other side of the A. C. source on conductor 605 through the lower contacts of contactor 609. Contactor 636 thereupon is energized to close its left contacts in a circuit also extending from one side of the A. C. source on conductor 616, through the left magnet of contactor 636, upper contacts of contactor 626, conductor 630, switch 631, also closed by the ram withdrawal, to the other side of the A. C. source over conductors 625, 677 as previously traced. Contactor 632 is energized to move toward the left in a circuit extending from one side of the A. C. source on conductor 616 through the left magnet of contactor 632, conductor 633, through the contacts of switch 634 on the trimmer and which, in normal position, is closed, conductor 635, upper right contacts of contactor 620, which is moved to this position initially, uppermost left contacts of contactor 636, conductor 637, contacts of switch 638, controlled by the container and which is closed with the container moved away from the die, conductor 618, closed hand switch 610, conductor 619, lower right contacts of contactor 620, conductor 621, contacts of switch 622, conductor 623 to the other side of the A. C. source on conductor 624 as previously traced.

This movement of contactor 632 prepares a circuit for energizing the coil of magnetic valve 611, traceable from one side of the D. C. source on conductor 639 to the upper left contacts of contactor 640, moved initially to the left, over conductors 641, 642 and 643, through the coil of the valve 611, conductor 644, upper left contacts of contactor 632, conductors 645, 646, lower left contacts of contactor 640 to the other side of the D. C. source on conductor 647. Valve 611, thus opened, controls the admission of water into

cylinder 293 and slide 290 is advanced to knock or cut the stump off as hereinbefore described.

This movement of slide 290 closes a switch 650 to control the advance of the main ram for ejecting the dummy block. The lifting magnet of contactor 648 is now energized to close its contacts, the circuit extending from conductor 616 through the magnet, conductor 649, through the contacts of closed switch 650, conductors 651, 652, to the other side of the A. C. source on conductor 625. The closure of the contacts of contactor 648 effects the energization of the lifting magnet of contactor 653 in a circuit extending from conductor 616, through the magnet of contactor 653, conductor 654, next to the upper left contacts of contactor 636, right closed contacts of contactor 648, lower left contacts of contactor 632, to the other side of the A. C. source on conductor 625, as above traced. The closure of the contacts of contactor 648 also moves contactor 620 to the left over the following circuit—from one side of the A. C. source on conductor 616, left magnet of contactor 620, left contacts of contactor 648 to the other side of the source on conductor 625. The magnetic valve for intake valve 655 of cylinder 172 is now actuated, by a circuit extending from one side of the D. C. source on conductor 647, conductors 646, 645, upper contacts of contactor 653, conductors 657, 658, through the contact of switch 659, controlled by the main ram and which is closed with the ram in this position, conductor 660, lower right contacts of contactor 661, which is initially to the right, conductor 662 through the operating coil of valve 655, conductor 663 and emergency switch 665, (which is normally closed), conductor 664, through the contacts of switch 666 closed with the ram in its present position, to the other side of the D. C. source on conductor 641. The circuit for the operating coil of exhaust valve 656, as will later appear, is traceable through the lower contacts of contactor 653 and valve 656 is, therefore, closed, since the lower contacts of this contactor are open.

Valve 655, upon opening, admits pressure fluid into the main ram cylinder 172 advancing ram 170 to eject the dummy block, as above described.

As soon as the dummy block has been ejected from the container chamber, the ram is withdrawn again. To this end, upon the ejecting stroke of the ram, switch 667 is closed to effect closing of inlet valve 655 and opening of exhaust valve 656 of the main ram unit. On the closure of switch 667 contactor 661 is moved to the left in a circuit which extends from one side of the A. C. source, on conductor 607, left contacts of contactor 609, conductors 613, 614, through the left magnet of contactor 661,

inner right contacts of contactor 648, conductor 668, switch 667, to the other side of the source over conductor 625. Contactor 661 moves to the left, breaking its right hand contacts and therefore breaking the circuit controlling the operating coil of valve 655, which was traced through the right contacts of this contactor. Thereupon this valve closes. A circuit is completed for moving contactor 636 to the right, extending from conductor 616, right magnet of contactor 636, conductors 670, 671, left contacts of contactor 661, conductor 674, switch 673 which is closed with the container in this position, to conductor 625. Contactor 636 may also be swung to the right upon the closure of switch 669 which takes place upon further movement of the ram past switch 667, if the ram over-travels and carries the container with it, opening switch 673. The energizing circuit for contactor 636 then passes through the magnet of the contactor, conductors 670, 671, switch 669 to conductor 625. Upon the breaking of the left contacts of contactor 636 the circuit through the magnet of contactor 653 is opened, causing this contactor to fall, opening its upper contacts and closing its lower contacts, thereby again breaking the circuit through the operating coil of valve 655, which circuit, it will be remembered, passed through the upper contacts of this contactor. The circuit for exhaust valve 656 is now closed—the latter circuit being traceable from conductor 647, contactor 640, conductors 646, 645, lower contacts of contactor 653, conductor 672, operating coil of valve 656 to conductor 663, and back to conductor 641 as previously traced for intake valve 655. Upon closing of exhaust valve 656, the ram moves back under the constant pressure of cylinders 116, 117. This movement of the ram effects return of slide 290 to normal position by causing valve 611 for cylinder 293 to close. To this end, as the ram moves back it closes, in passing, switches 675, 676. The closure of switch 675 causes contactor 661 to move to the right, the circuit for this contactor extending from conductor 614 through the right magnet of contactor 661, conductor 677, through the contacts of switch 675, to the other side of the line on conductor 625. Closure of switch 676, completes a circuit to move contactor 632 to the right, this circuit extending from one side of the A. C. line on conductor 616, through the right magnet of contactor 632, lower left contacts of contactor 620, upper right contacts of contactor 636, conductor 678, through the contacts of switch 676 to the other side of the line over conductor 625. This opens the circuit of the operating coil of valve 611 whereupon this valve closes and slide 290 is returned to normal position under the constant pressure in cylinder 293

(Fig. 23), as above described. The return of the stump cutoff effects the opening of switch 650, which was closed upon its forward advance, opening the circuit to contactor 648 which thereupon falls, opening its contacts.

As the ram reaches its withdrawn position, switches 675 and 676 are opened and switch 631, also mounted to be controlled by the ram, is closed, whereupon contactor 636 is returned to the left over a circuit which extends from one side of the A. C. source on conductor 616, left magnet of contactor 636, right contacts of contactor 626, conductor 630, contacts of switch 631, to the other side of the line on conductor 625.

The return of slide 290 effects advance of the container unit to its normal position against the die by closing magnetic valve 680 for the intake of cylinders 281, 282 and opening magnetic valve 681 for the exhaust of these cylinders. To this end, return of the slide to normal position closes switch 679. As a result, contactor 682, initially to the right, is moved to the left, its energizing circuit extending from one side of the current source on conductor 616, through the left magnet of contactor 682, conductor 683, uppermost right contacts of contactor 684, conductor 685, upper left contacts of contactor 620, conductor 686, contacts of switch 679 to the other side of the line on conductors 651, 652, 625. The closure of switch 679 also moves contactor 687 to the left in a circuit which extends from one side of the line on conductor 616 through the left magnet of contactor 687, middle left contacts of contactor 620, over conductor 686 as traced with respect to contactor 682. Contactor 687, upon closing its left contacts, opens at its right contacts, the circuit controlling the operating coil of the intake valve 680, causing this valve to close, and closes at its left contacts, the circuit controlling exhaust valve 681, causing this valve to open. This latter circuit extends from one side of the D. C. source on conductor 641, conductor 696 through the operating coil of valve 681, conductor 688, left contacts of contactor 687, conductor 646, left contacts of contactor 640 to the other side of the line on conductor 647. Thereupon the container crosshead is moved forward to its normal position against the die by piston rods 114, 115 actuated by the constant pressure in cylinders 116, 117, as above described.

The container unit, upon moving toward the die, passes and closes switch 689, whereupon contactor 620 is moved to close its right contacts, its circuit being traced from one side of the A. C. line on conductor 616, right magnet of contactor 620, upper left contacts of contactor 682, conductor 690,

contacts of switch 689 to the other side of the line on conductor 625.

The movement of the container unit into normal position effects movements of swinging carrier 233 to remove the guide tube and bring the mandrel centering unit into line; advance of the piston rod 305 of the dummy block pusher-scraper; and insertion of a cold billet into the furnace with the consequent discharge of a hot billet. To this end, upon the end of the advance stroke of the container unit, switch 693 is closed. As a result, contactor 691, normally down, is energized to close its upper and open its lower contacts, its circuit extending from one side of the A. C. line on conductor 616, through the magnet of contactor 691, conductor 692, contacts of switch 693, to the other side of the line on conductor 625. Upon the opening of the lower contacts of contactor 691, the circuit for the magnetic valve 694 of cylinder 242 for carrier 233, which circuit extends over conductor 764 through the lower contacts of contactor 691, is opened. This opens valve 694, this being one of the units elsewhere referred to in which an open circuit opens the valve. By the pressure admitted to cylinder 242 the carrier is swung on its pivot to move guide conduit 235 out of line and place the mandrel-centering unit in line (Fig. 51).

The closure of the upper contacts of contactor 691 also opens valve 695 for cylinder 307 of the dummy block trimmer unit, to admit air thereto, the circuit extending from one side of the D. C. source on conductor 641, conductor 696, operating coil of valve 695, conductors 697, 698, hand switch 699, conductor 700, lower left contacts of contactor 682, conductor 701, upper left contacts of contactor 691, to the other side of the line, as previously traced, over conductors 645 and 646. Thereupon piston rod 305 advances to push the dummy block through the trimmer.

The closure of the upper contacts of contactor 691 also closes a circuit for feeding a billet into the furnace, as hereinafter described.

The movement of carrier 233 just described effects advance of the mandrel-centering rod to centering position. To this end, upon the swinging movement of carrier 233, switches 702 and 703 are opened and switch 704 is closed. The closure of switch 704 moves contactor 705 to the left from its normal right hand position, the energizing circuit therefor extending from conductor 616, left magnet of contactor 705, upper closed contacts of contactor 626, conductor 706, contacts of switch 704 to the other side of the line on conductor 625. Valve 707 controlling the cylinder 241, which controls the lengthwise movement of the centering tool, is closed, its operating coil being ener-

gized in a circuit which extends from one side of the line on conductor 641, conductor 696, through the operating coil of valve 707, conductor 708, left contacts of contactor 705 to the other side of the line on conductors 645, 646. Unlike the majority of the magnetic valves, this valve 707 is of the type in which an energized solenoid means a closed valve, as is more fully explained in the co-
 pending application referred to. At the same time valve 709, controlling the other side of cylinder 241 is opened, its coil being energized in a circuit which extends from one side of the line on conductor 641, conductor 710, contacts of switches 711, 712, conductor 713, contacts of switch 714, conductor 715, contacts of switches 716, 717, conductor 718, operating coil of valve 709, conductor 719, left contacts of contactor 705 to the other side of the line on conductors 645, 646. Under these conditions, i. e. with the closure of valve 707 and the opening of valve 709, the centering tool is moved towards the die into centering position.

Meanwhile the dummy block pusher has pushed the dummy block through the trimmer and the completion of the advance stroke effects its withdrawal by closing switch 721. The closure of switch 721 causes contactor 682 to be moved to the right, the energizing circuit being traced from conductor 616, right magnet of contactor 682, conductor 722, switch 721 to conductors 652, 625. As contactor 682 moves to the right it breaks the circuit to the operating coil of valve 695, which extends through the left contacts of the contactor, causing this valve to close. Thereupon the piston 305 is reversed under constant return pressure in cylinder 307. The advance stroke of the dummy block pusher also closes switch 634.

The press feed slide and the dummy block feed slide are now operated to place a billet and dummy block in line with the container. To this end, valve 724 for cylinder 88 of the billet slide is opened by completion of a circuit extending from conductor 641, operating coil of valve 724, conductor 725, hand switch 726, which is closed normally, conductor 727, left contact of contactor 636, conductor 728, left contacts of contactor 723, which is moved to the left, as later described in connection with the furnace, conductor 729, upper contacts of contactor 691, to conductors 645, 646. At the same time, valve 730 for cylinder 131 of the dummy block slide 127 is opened through an energizing circuit traced from conductors 641 and 642 through the operating coil of the valve 730, conductor 731, hand switch 726, conductor 732, left contacts of contactor 636, over conductor 728 as traced for the coil of valve 724.

This movement of the billet and dummy block slides effects advance of the mandrel

by closing switches 733, 734. As a result, contactor 735 (normally right) now moves left in a circuit traced from the A. C. source on contactor 609, conductors 613, 614 through the left magnet of contactor 735, conductor 736, switch 734, conductor 737, switch 733, to the other side of the line, on conductors 652 and 625. The closure of the contactor 735 to the left causes magnetic valve 738 to close the inlet and open the exhaust of cylinders 393, 394. The circuit for valve 738 extends over conductors 641, 642, operating coil of the valve, conductor 739, through the left contacts of contactor 735 to conductor 645. Thereupon mandrel 141 is moved forward under fluid pressure in cylinder 153 threading through the billet and dummy block until it engages the centering tool 229. The controlling valve 853 for this cylinder is opened as later described in connection with the automatic exchange of mandrels.

This movement of the mandrel controls the preliminary advance of the main ram to insert the billet and dummy block in the container chamber and give the billet its preliminary upset. To this end, the advance of the mandrel closes switch 740, whereupon contactor 741 is moved to the left, its circuit being traced from the A. C. source on conductor 614, left magnet of contactor 741, conductor 742, contacts of switch 740, to the other side of the line on conductors 652 and 625. Contactor 653 is now energized to close its upper contacts, its energizing circuit extending from conductor 616, through the magnet of contactor 653, conductor 654, left contacts of contactor 741, left contacts of contactor 612 (which was moved left to start slide 290 towards the center), to the other side of the line on conductor 625. The circuit for exhaust valve 656 is therefore opened and that for inlet valve 655 closed, whereupon valve 656 closes and valve 655 opens, starting the main ram forward as previously described.

Meanwhile the mandrel has moved fully forward, opening switches 740 and 747.

The start of this advance of the ram effects withdrawal of the billet and dummy block slides by closing switch 748. Thereupon contactor 723 is moved to the right, its circuit extending from one side of the A. C. source on conductor 749, left contacts of contactor 750 which, as will later appear, has been moved to its left hand position, conductor 751, through the right magnet of contactor 723, conductor 752, switch 748, to the other side of the line on conductor 625. Valves 724 and 730 controlling the billet and dummy block slides 83, 127, respectively, now close because their energizing circuits, which were traceable through the left contacts of contactor 723, are opened upon movement of contactor 723 to the right. Thereupon both of these slides are with-

drawn under constant pressure in cylinders 88, 131 (Figs. 19 and 25). Switches 733, 734 are opened by this movement of the slides.

Further advance of the ram closes switch 669 and opens switch 748, the closure of switch 669 causing contactor 636 to move to the right in a circuit traceable from conductor 616 through the right magnet of contactor 636, conductors 670, 671, contacts of switch 669 to conductor 625.

Continuing, the ram opens switches 666 and 669 before which time the dummy block and billet slides 127 and 83 have moved fully back, closing switches 753, 754, 755 and 756.

Provision is made for stopping the ram if the dummy block and billet slides fail to retract properly, and to this end, unless the billet and dummy block slides move sufficiently far back to close switches 754 and 755, the ram will stop as soon as it opens switch 666 because the circuit for valve 656 controlling the ram passes through switches 754 and 755.

Switch 628 is now opened by the ram, breaking the circuit through the magnet of contactor 626, which thereupon lowers, switch 757, also controlled by the ram, being closed by continued movement of the ram.

In order to be sure that the mandrel has been fully advanced before extrusion begins, the mandrel unit, in moving forward, as above noted, is arranged to open normally closed switch 747 at the same time that the ram closes switch 757, thus preventing the energization of the right magnets of contactors 741 and 735, which contactors, upon moving to the right, would reverse the ram and mandrel. In this connection it is to be noted that the energizing circuit for the right magnet of contactor 741 is traceable from conductor 614, through the magnet of contactor 741, conductor 758, contacts of switch 747, conductor 759, contacts of switch 757 to conductor 625, and that the circuit for the right magnet of contactor 735 passes through the right contact of contactor 741.

Means is provided for automatically limiting the extent of this preliminary stroke of the main ram and in constructions embodying the invention to the best advantage this limitation is dependent on main ram pressure so that the ram will not upset the billet sufficiently to extrude the same. As here shown as an example, associated with the main water line is a valve chest 510 (Figs. 78, 79) its valve chamber 511 being connected through an inlet 512 with the water line. Working in the valve chamber is a piston rod 513 which abuts a crosshead 515 sliding on rods 516, 517. Extending upwardly from the crosshead is a rod 518 carrying an arm 519 normally engaging spring-held, switch-operating lever 520.

Movement of the piston rod 513 is opposed by a spring 521 confined between crosshead 515 and an adjustable abutment 515^a. By adjustment of the latter the opposing force of spring 521 may be given various predetermined values. Lever 520 controls switches 743, 744 in such manner that when the lever is held up by its spring, switch 743 is closed and switch 744 is open. Switch 743 is in a series interlock with switch 746 controlling the centering tool withdrawal and switch 744 is in a parallel interlock with switch 659 controlling the main ram inlet valve. As soon as inlet valve 655 of the main ram unit is opened, as described, to advance the ram, the hydraulic pressure in the main line drops. As a result, rod 518 is moved down by spring 521, arm 519 actuating switch lever 520 to open switch 743 and close switch 744. As the ram reaches the point where it starts to upset the billet, the resistance starts to build up the main line pressure. When this pressure reaches a predetermined point, piston rod 513 raises crosshead 515 and rod 518 against the pressure of spring 521, thus permitting switch lever 520 to reverse. This closes switch 743 and opens switch 744. Opening of switch 744 breaks the circuit for inlet valve 655 of the main ram, switch 659 having been opened by the ram unit in passing. Consequently the ram stops. It does not withdraw, however, because its exhaust valve is still closed.

This movement of the ram also closes switch 746 and opens switch 757.

This movement and stopping of the ram effects the withdrawal of the mandrel centering tool, the mandrel now being held in centered position by the upset metal. To this end, closing of switch 743, as just described, causes contactor 705 to move to the right by closing a circuit extending from one side of the line on conductor 616, through the right magnet of contactor 705, conductor 760, contacts of switch 746, which closes immediately before the billet is upset, conductor 745, contacts of switch 743, to the other side of the line on conductors 624, 625. Contactor 705, upon moving to the right, breaks the circuit controlling valve 707, causing this valve to open, and breaks the circuit to valve 709 causing this valve to close. This reverses cylinder 241 and the centering tool is withdrawn from centering position.

With a valve control at each end of cylinder 241 two objects are accomplished. By placing the cylinder under exhaust for withdrawal of the centering tool a quicker withdrawal is effected than if the cylinder were under constant return pressure. This insures removal of the centering tool before any extrusion can take place. Also, by having the cylinder at exhaust when the centering tool is in centering position there is

provided a strong net pressure to resist any tendency of the centering tool to be pushed away during upsetting of the billet.

If switch 744 should fail to open, the circuit to valve 655 will be broken by contactor 705 moving to the right upon the closure of switch 743, above described, since the circuit through the operating coil of valve 655 extends from conductor 663, as previously traced, through the operating coil of the valve, conductor 662, lower right contacts of contactor 661, conductor 660, contacts of switch 744, conductor 720, upper left contacts of contactor 705, conductors 658, 657, upper contacts of contactor 653 as previously traced to conductor 645.

Withdrawal of the centering tool effects reverse swing of carrier 233 to move the tool out of line and put guide conduit 235 in line. To this end, the centering tool, upon its back stroke, passes and closes switch 761 which causes contactor 612 to move to the right by closing a circuit extending from conductor 616, right magnet of contactor 612, conductor 762, switch 761, to the other side of the line on conductors 763 and 625. This movement of contactor 612 closes a circuit for valve 694 extending from conductor 641, conductor 696, coil of valve 694, conductor 764, right contacts of contactor 612, to conductors 645, 646. Thereupon valve 694 closes and carrier 233 is given a reverse swing under constant pressure in cylinder 234 to place guide conduit 235 in line. It is noted that this unit is one of those, elsewhere referred to, in which a closed circuit closes the valve rather than opens it.

Closing of switch 761 and the subsequent movement of contactor to the right also opens valve 709 by closing a circuit extending from conductors 641 and 710, through contacts of switches 711 and 712, conductor 713, closed switch 714, conductor 715, closed switches 716, 717, conductor 718, the coil of valve 709, conductor 719, right contacts of contactor 612 to conductors 645, 646. Upon opening of valve 709, pressure fluid is admitted to the right end of cylinder 241 (as viewed in Fig. 50) for advancing the centering tool in the next cycle. It is meanwhile ineffective against the pressure in the other end of the cylinder, valve 707 being still open.

Switch 761 is opened by the continued withdrawal stroke of the centering tool.

The swing of carrier 233 just described effects the advance of the main ram for the extrusion operation. To this end, the carrier, in the movement referred to, opens switch 704 and at the end of its movement closes switches 702, 703.

The closure of switch 703 completes a circuit extending from the current source on conductor 641, contacts of switch 666, conductor 664, contacts of hand switch 665

(which is normally closed), conductor 663, operating coil of valve 655, conductor 662, right contacts of contactor 661, conductor 660, contacts of switch 659, conductors 658, 657, upper contacts of contactor 653 to conductors 645, 646. This opens valve 655 again and the main ram starts forward on its extrusion stroke.

In the present embodiment, the above described operations are carried out under relatively low water pressure. For the extrusion stroke of the ram, however, relatively high water pressure is utilized. The pressure control is here indicated diagrammatically but is more fully shown and described in the copending application referred to. Referring more particularly to Figs. 75 and 83, leading from the pressure side of a pump unit 500 is the main water pressure line 501. Associated with the main line is a piston-like relief valve 502 controlling a port 503 in a pipe 504 leading to the exhaust line 509. Also associated with the main line is a second relief valve 506 controlling a port 505 in a pipe 504. Between these two relief valves is a valve 507 controlling flow through pipe 504. Relief valve 502 is set to open upon an excess main line pressure above a high maximum and relief valve 506 is set to open upon an excess over a low maximum. When the system is under low pressure, control valve 507 is open. If the low maximum is exceeded relief valve 506 opens and the main line is thus opened to exhaust via pipe 504. To place the system at high pressure, valve 507 is closed, thus cutting off port 505 from exhaust even though relief valve 506 may open. If the maximum high pressure is exceeded, relief valve 502 opens to connect the main line with exhaust.

Valve 507 is operated by a fluid pressure unit controlled by a magnetic valve unit 768. This valve is energized to open and admit pressure to the cylinder to close valve 507 upon opening of valve 655 to start the ram. To this end, the movement of inlet valve unit 655 in opening closes switch 765 causing contactor 766 to move from its normal right hand position to the left. The circuit for this contactor extends from conductors 613, 614, left magnet of contactor 766, upper right contacts of contactor 612, conductor 767, contacts of switch 765, to conductor 625. The closure of contactor 766 to the left completes the circuit for energizing valve 768, the circuit extending from conductor 639, uppermost contacts of contactor 640, normally in its left hand position, conductor 901, operating coil of valve 768, conductors 772, 773, contacts of contactor 766, upper left contacts of contactor 735, to conductors 645, 646.

The ram now completes its advance under high pressure and extrudes the billet through the die into the form of a tube

which passes out through guide conduit 235 as above described.

The completion of the extrusion stroke of the ram effects cutting off the high pressure, the return of the mandrel and the return of the ram itself. To this end, the ram, at the end of its stroke closes switch 774. This moves contactor 735 to the right, its circuit extending from conductor 614 through its right magnet, conductors 775, 776, switch 774, to conductor 625.

Contactor 735, upon breaking its left contacts, breaks the circuit controlling valve 768. As a result, valve 507 is opened to place the system under low pressure. This movement of the valve closes switch 622, previously referred to as being closed when the system is under low pressure. Upon closing of this switch contactor 741 moves to the right, the circuit extending from conductor 614, through the right magnet of contactor 741, conductors 758, 777, right contacts of contactor 735, left contacts of contactor 766, conductor 621, contacts of switch 622, to the other side of the line on conductors 623, 624, 625. If the pressure during the extrusion operation exceeds the predetermined value, the high pressure relief valve 502 opens to relieve the pressure and, in opening, closes switch 778 before switch 774 closes. In such case the circuit for the right magnet of contactor 735 is traceable over conductors 775, 776, 779, contacts of switch 778 to conductors 624, 625.

Upon moving to the right, contactor 741 opens the circuit for valve 738, which reverses the condition of cylinders 393, 394, whereupon the mandrel unit starts back.

Contactor 741 also opens the circuit energizing contactor 653 which falls back, closing the circuit to exhaust valve 656 and opening the circuit of inlet valve 655, whereupon the ram also starts back under the constant pressure in cylinders 116, 117. Switch 774 is opened by the start of the ram withdrawal.

Withdrawal of the main ram effects operation of the pointing tools. To this end, as the ram moves back it passes and closes switch 780, which, in turn, moves contactor 781 from its normal right hand position to the left, the circuit for this contactor extending from conductor 614 through its left magnet, conductor 782, right contacts of contactor 741, conductor 783, contacts of switch 780 to conductor 625. This closes a circuit from conductors 641, 696, contacts of switch 702, conductors 784, 785, operating coil of valve 786, conductor 787, left contacts of contactor 781, to conductors 645, 646. The valve 786, being opened admits fluid pressure to cylinders 280, whereby the gripping tools 263, 264 are advanced to grip the extruded tube, as before described.

Tools 263, 264, upon moving inwardly,

close switches 788 and 789 and these switches, upon closing, complete a circuit to open valve 790, which circuit extends from conductor 641, conductor 696, through the contacts of switch 702, conductors 784, 785, operating coil of valve 790, conductors 791, 792, left contacts of contactor 781, conductor 793, contacts of switches 789 and 788, conductor 794 to conductor 646. Valve 790, upon opening, causes the pointers 253 to move toward the extruded tube to indent its walls. The movement of the pointers causes switches 717, 716, 712, 711, to open to prevent any possibility of the centering tool moving in during the pointing operation. When the pointers have reached the end of their stroke, switches 795 and 796 are closed, causing contactor 797 to move to the left, this circuit extending from conductor 614 through its left magnet, conductor 798, switches 796 and 795 to conductors 652, 625.

The movement of contactor 797 to the left prepares the circuit for opening valve 799 for cylinders 265, 266, of the crushing tools 263 and cylinder 271 of the shears 268. The circuit for valve 799 extends from conductors 641, 696, contacts of switch 702, conductor 784, operating coil of valve 799, conductors 800, 801, left contacts of contactor 797, left contacts of contactor 781, conductor 793, contacts of switches 789 and 788, conductor 794 to conductor 646. Upon opening of valve 799 tools 263 are further moved in under pressure in their main cylinders to perform their crushing operation and shears 268 move down to cut off the finished tube from the stump.

This movement effects the withdrawal of the pointing tools and the withdrawal of the container unit away from the die by closing switch 802, whereupon contactor 803 is raised to close its contacts in a circuit extending from conductor 616, through the magnet of contactor 803, conductor 804, contacts of switch 802, to conductors 805, 625. Contactor 687 now moves to the right, its circuit being completed from conductor 616, right magnet of the contactor, through the closed contacts of contactor 803 to conductors 806, 625, whereupon valve 680 is opened and valve 681 is closed starting the movement of the container away from the die under the control of rods 283, 284, in cylinders 281 and 282. The circuit for energizing the operating coil of valve 680 extends from conductor 646 through the right contacts of contactor 687, conductor 807, operating coil of inlet valve 680, contacts of switch 753, contacts of switch 756 to conductors 642, 641; and the circuit to exhaust valve 681 which was traced through the left contacts of contactor 687 is broken. Switch 693 is opened by the movement of the container away from the die, causing the magnet of contactor 691 to become deenergized,

opening its upper contacts and closing its lower contacts.

At the same time that contactor 803 causes contactor 687 to swing to the right, the closing of its contacts also energizes the magnet of contactor 781, causing it to move to the right, the circuit for this contactor extending from its magnet through the upper contacts of contactor 803 to conductor 625. Thereupon the circuit controlling valves 786, 790, 799 is opened, closing these valves, whereupon the pointers and shears withdraw. The shears unit, in retracting, closes switch 714 and opens switch 802 causing contactor 803 to become de-energized. Switches 788, 789 and 795, 796 are also opened and switches 717, 716, 712 and 711 are closed.

The container unit in moving away from the die passes and closes switch 689, completing an energizing circuit for contactor 797 which causes this contactor to be moved to the right. This circuit extends from conductor 614, right magnet of contactor 797, through the right contacts of contactor 682; conductor 690 through the contacts of switch 689 to conductor 625 as previously traced. The energizing circuit previously traced for valve 768 is again established, closing this valve, thus causing valve 507 to close and build up the high pressure for the purpose of ejecting the stump from the container on the next cycle, as above described.

Upon continued withdrawal of the container, switch 689 is opened and switches 638 and 673 are closed, whereupon contactor 766 moves to the right, by a circuit extending from conductor 614, right magnet of contactor 766, upper right contacts of contactor 661, conductor 674, switch 673 to conductor 625, opening valve 768, thus placing the press in condition for a new cycle. Switch 638 is used as an interlock for the start of the cycle, being closed to energize contactor 332 to the left. Slide 290 now moves in again to knock off the stump and the above described cycle is repeated. Automatic operation continues as long as the starting switches remain in running position.

In the above description of the automatic press cycle the mandrel exchange device was omitted. This device may be included in the automatic cycle or not, as may be desired. If it is cut out, the same mandrel is used over and over. If it is to be included, the controlling circuits are cut in by moving a double-throw hand switch 810 (Fig. 83) to the upper of its two positions. Thereafter the exchange unit is controlled by the mandrel unit. As the latter withdraws after an extrusion operation, it passes and closes switch 811, completing a circuit from conductors 625, 624, cutout switch 812, conductor 813, contacts of switch 811, contacts of

switch 814 which is closed at this time, conductor 815, left magnet of contactor 816 to conductor 614. Contactor 816 now swings to the left, closing its left contacts to prepare a circuit for the exchange apparatus.

By this time the mandrel unit has closed switch 817, whereupon a circuit is completed for closing the valve 818 controlling cylinder 343, this being another instance of a closed circuit closing the valve. This circuit extends from conductors 641, 642, operating coil of valve 818, contacts of switch 817, conductors 819, 820, left contacts of contactor 816 to conductor 646. Valve 818 is thereupon closed to put cylinder 343 under constant pressure and piston rod 339 is operated to swing bell crank 324, 330, thus removing the hot mandrel unit from press position to the position of Fig. 56. This stroke of piston rod 339 opens switches 814 and 821, preventing further operation of the mandrel control until the new mandrel is in place. At the same time, switch 822 is closed by the piston rod, completing a circuit for contactor 823 which extends from conductors 625, 652, contacts of switch 822, conductor 824, left contacts of contactor 816, magnet of contactor 823, to conductor 614. Contactor 823 closes, through its own contacts, a holding circuit for itself which circuit extends from its magnet through its upper closed contacts, conductor 825, contacts of switch 826 to conductor 652.

As the piston rod reaches the end of its stroke, switch 827 is closed, whereupon a circuit is established from conductors 625, 624, contacts of hand switch 810, conductor 828, contacts of switch 827, conductor 829, other contacts of switch 810, conductor 830, contacts of switch 831, conductor 832, upper contacts of contactor 823, left magnet of contactor 833 to conductor 614. Contactor 833 is energized in this circuit and swings to the left, establishing a circuit extending from conductor 641, operating coil of valve 834, conductor 835, upper contacts of hand switch 810, conductor 836, left contacts of contactor 833 to conductor 646. Valve 834 being thus opened, admits pressure to cylinder 357 and the advance of piston rod 355 draws the mandrel into the cooling chamber. During this movement, switches 831 and 826 are opened and at the end of the stroke switch 838 is closed and switch 826 is closed. The momentary opening of switch 826 breaks the holding circuit for contactor 823, which drops and the closing of switch 838 prepares a circuit for raising or lowering the cooling housing, depending on which chamber the cool mandrel is in.

The direction of movement depends upon the position of contactor 837, valve 839 or 840 being operated, as the contactor is to the right or left respectively. Let it be assumed that contactor 837 is in the right hand posi-

tion, that is, that the cool mandrel is in the lower chamber. It is, therefore, necessary to raise the housing. With contactor 837 to the right and contactor 833 to the left, the closure of switch 838 establishes a circuit extending from direct current on conductor 642, operating coil of valve 839, conductor 841, contacts of hand switch 810, conductor 842, right contacts of contactor 837, left contacts of contactor 833, conductors 843, 844, contacts of switch 838, conductor 845, contacts of hand switch 810 to conductors 846, 645. Pressure fluid is thereupon admitted to the left end of elevating cylinder 390 as viewed in Fig. 59 and the housing is raised, as hereinbefore described. As soon as the housing is completely raised, switch 847 is closed, establishing a circuit for contactor 837 for moving this contactor to the left so that, upon the completion of the next extrusion operation, the housing may be lowered to bring the upper mandrel into position. This circuit is traced from conductor 652, contacts of switch 847, conductor 848, contacts of double-throw switch 852, controlled from contactor 837, operating magnet of contactor 837, right magnet of contactor 833 to conductor 614, thus moving contactor 833 to the right.

Upon the next cycle, when the closing of switch 838 causes contactor 833 to be moved to the left, a circuit is closed to energize valve 840, whereupon pressure is admitted to the other end of cylinder 390 and the housing is moved downwardly. This circuit extends from conductors 641, 642, coil of valve 840, conductor 849, contacts of switch 810, conductor 850, left contacts of contactor 837, left contacts of contactor 833, conductors 843, 844, contacts of switch 838, conductor 845, contacts of switch 810 to conductors 846, 645. When the housing has been completely lowered, switch 851 is closed, moving contactor 837 to the right. The energizing circuit for this contactor extends from conductors 625, 652, contacts of switch 847, conductor 848, contacts of double-throw switch 852, controlled from contactor 837, magnet of contactor 837, right magnet of contactor 833, to conductor 614.

In either case, the housing movement positions a cool mandrel which is then moved outwardly from the cooling chamber into its block. The movement of contactor 837 at the end of either stroke of the housing unit causes contactor 833 to swing to the right, opening its left contacts and thus opening the circuit for the coil of valve 839 or 840, as the case may be. The housing, however, remains in its position even with valve 839 (or 840) de-energized because, as previously described, the D-slide valves for these units are of the stay-put type.

This movement of contactor 833 also breaks the circuit for valve 834 so that pis-

ton rod 355 reverses, under constant pressure in cylinder 357, to push the cool mandrel out of the cooling chamber into its block. This movement closes switch 831, completing a circuit through the right magnet of contactor 816. This circuit extends from conductor 614, right magnet of contactor 816, lower contacts of contactor 823, conductor 832, contacts of switch 831, conductor 830, contacts of hand switch 810, conductor 829, contacts of switch 827, conductor 828, contacts of hand switch 810, to conductor 624. Contactor 816 swings to the right upon energization in this circuit and opens, at its left contacts, the energizing circuit for the operating coil of valve 818, which valve opens, whereupon piston rod 339 reverses under pressure admitted to cylinder 343 to reverse bell crank 330, 324 and insert the cool mandrel in the press.

As soon as the mandrel is positioned, switch 821 is closed, completing a circuit extending from conductor 641, through operating coil of valve 853, above referred to, contacts of switch 821, conductor 854, contacts of hand switch 810, conductor 855, right contacts of contactor 816 to conductor 646. Valve 853 being opened, the mandrel is moved forward as above described.

Referring now to the furnace operation, the furnace cycle for supplying a hot billet is started, as previously described, by the closing of contactor 691 upon movement of the container unit up to the die. It is assumed that the furnace is full of billets and that a cold billet is waiting in front of the last furnace door, against permanent stop 36.

With the closure of contactor 691, as above described, a circuit is completed for the contactor 911 controlling the operating magnet of furnace current source controller 923, presently described, which circuit extends from one side of the line on conductor 749, lower left contacts of contactor 750 which was moved to the left at the beginning of the operation by the closure of hand switch 912 (the circuit for the left magnet extending from conductor 913 over conductor 914 and back to conductor 749), conductor 751, magnet of contactor 911, conductors 916, 917, right contacts of contactor 915, the normal position of which is to the right, left contacts of contactor 918, right contacts of contactor 684, conductor 919, upper right contacts of contactor 691, conductor 920, hand switch 921, conductor 624, to the other side of the line on conductor 625. The energization of contactor 911 completes a circuit through its contacts for energizing controller-moving magnet 922, whereupon the controller 923 is moved to position 1. This circuit extends from conductor 944, upper contacts of contactor 911, magnet 922, to conductor 749.

While the controller 923 may be of any desired construction which will make the contacts as shown, it conveniently comprises a shaft 924 magnetically driven in a step-by-step manner by means of magnet 922. Mounted on shaft 924 is a plurality of cam discs 925 adapted for closing a number of contacts 926. The shaft may be arranged to take any desired number of steps. In this case each step represents one-twelfth of a complete revolution of the shaft. There are, therefore, 12 steps, representing 4 cycles, one for each of the four furnace lines, the controller moving through three steps for each cycle.

Movement of the controller into position 1 effects the advance of billet holder 50 for the last furnace path. To this end, contactor 954 is raised by a circuit extending from conductor 751, magnet of contactor 954, conductor 940 to controller contact 941 in position 1. This energizes valve 927 controlling cylinder 60 of the last path by a circuit extending from contact 928 of the controller in position 1, conductors 929, 930, operating coil of valve 927, conductors 931, 932 to the other side of the line on controller contact 933. Valve 927 being opened, first holder 50 is advanced.

This movement effects insertion of the waiting cold billet. To this end, upon the end of the stroke of holder 50, switch 934 is closed. This causes contactor 935 to move from its normal right hand position to the left, its circuit being traced from one side of the line on conductor 751, conductor 936, left magnet of contactor 935, left contacts of contactor 918, normally in its left hand position, conductor 937, contact of switch 934, conductors 938, 939, 940 to the other side of the line through contact 941 of the controller. Contactor 918 now moves to the right in a circuit traceable from one side of the line to conductors 751 and 936, right magnet of contactor 918, left contacts of contactor 935 to the other side of the line over conductors 942, 943, contactor 750 to conductor 944. Contactor 935 also completes a circuit controlling valve 945 for cylinder 39 of infeed pusher 42 of the last furnace path. This circuit extends from contact 928 on the controller, conductors 929, 930, 946, lower left contacts of contactor 935, conductor 947, contacts of hand switch 948 now closed, conductor 949, contacts of switch 950 on the hot billet discharger which is closed at this time; conductor 951, operating coil of valve 945, conductors 952, 953, upper contacts of contactor 954 which is normally energized, to the other side of the line at controller contact 933, over conductors 955, 931, 932. Opening of valve 945 admits pressure to cylinder 39 causing the cold billet to be pushed into the furnace.

The movement of contactor 935 to the left

also moves contactor 724 to the left in a circuit extending from conductor 936, left magnet of contactor 724, conductor 956, left contacts of contactor 935 to the other side of the line, over conductors 942, 943, 944 as previously traced.

Infeed pusher 42, on this stroke, passes and closes switch 960, whereupon contactor 961 moves to the left in a circuit extending from conductor 936, upper right contacts of contactor 915, conductor 962, left magnet of contactor 961, conductor 963, contacts of switch 960, to the other side of the line over conductors 939, 940, to controller contact 941.

Provision is made for causing the infeed pusher to be withdrawn while holder 50 is still advanced so that not more than one hot billet will be pushed into discharge trough 47 by the feeding stroke of the pusher. To this end, valve 945 is de-energized prior to operation of cylinders 59, 60.

As the leading hot billet is pushed, by insertion of the cold billet, against detector 48 the consequent back movement of rod 49 closes switch 958. The end of the feeding stroke of pusher 42 closes switch 965 for that path.

Closing of switch 958 causes contactor 966 to move to the left by a circuit extending from one side of the line on conductor 751, left magnet of contactor 966, left contacts of contactor 935, conductors 967, 968, switch 958, conductors 938, 939, 940, to the other side of the line on controller contact 941. Contactor 966, upon moving to the left causes contactor 915 to move to the left by a circuit extending from conductor 751, left magnet of contactor 915, left contacts of contactor 966, conductor 969, switch 965, just closed, to the other side of the line on controller contact 941 over conductors 939, 940. Contactor 966 also causes contactor 935 to move to the right by a circuit extending from conductor 751 through the right magnet of contactor 935, conductor 970 and left contacts of contactor 966, to the other side of the line over conductors 942, 943, 944.

By this movement of contactor 935 the energizing circuit for valve 945 is broken and infeed pusher 42 is withdrawn under return pressure in cylinder 39.

Meantime, the closing of switch 958 has closed a circuit for contactor 959 extending from conductor 751, through the magnet of contactor 959, conductor 968, switch 958, conductors 938, 939, 940, to controller contact 941. As presently described this movement of contactor 959 effects withdrawal of holder 50. To delay such withdrawal until the infeed pusher has been withdrawn, contactor 959 is given a delayed action. This may be accomplished by a dash-pot or other braking device. As a re-

sult, contactor 966 moves left, as just described, before contactor 959 closes.

The closing or lift of contactor 959 effects movement of controller 923 to position 2, the circuit for its magnet 911 extending from conductor 751, magnet 911, through the upper contacts of contactor 959, to conductors 942, 943. As the controller leaves position 1 it breaks the circuit energizing the operating coil of valve 927 for cylinder 60, closing this valve and placing the cylinder at exhaust, and, when the controller reaches position 2, it closes the circuit for energizing the operating coil of valve 971 for cylinder 59, opening this valve. This circuit extends from controller contact 972, through conductors 973, 974, operating coil of valve 971, conductors 975, 976, upper left contacts of contactor 907, conductor 977 to current controlling switch 601. The closure of contactor 959 also moves contactor 915 to the right through its upper contacts. Upon closing of valve 927 and opening of valve 971, rack 57 is moved upwardly to withdraw the holder, whereby the leading hot billet is lowered into the discharge groove, as described.

Movement of the controller to position 2 also causes movement of the turntable 73 to billet-receiving position. To this end a circuit is closed through the coil of valve 978 controlling cylinder 79. This circuit extends from contact 972 of the controller in position 2, through conductors 973, 974, 979, left contacts of contactor 724^a, conductor 980, contacts of switch 981, operating coil of valve 978, to the other side of the line on conductor 977 at the contacts of switch 601 over conductor 983, 984, 976 and contactor 907. Valve 978 being opened, pressure fluid is admitted to cylinder 79 to turn the turntable from the position of Fig. 12 to billet-receiving position. During this movement, the turntable unit closes switch 985 and opens switch 986.

Operation of the turntable effects discharge of the billet from the furnace. At the end of its movement, it closes switch 992 closing a circuit from conductor 977, through contactor 907, conductor 976, coil of valve 987, conductors 988, 989, lower contacts of contactor 990 (normally down) conductor 991, contacts of switch 992, conductor 993, to the other side of the line over conductor 903 to switch 601 over conductor 907. This opens valve 987 and admits pressure fluid to cylinder 71. This, in turn, causes advance of the discharge pusher 63 to push the billet out of the furnace onto the turntable.

Movement of the discharge unit opens switch 950 and, when it has reached the end of its stroke, it closes switch 995. Thereupon contactor 990 is energized to open its lower contacts and to close its upper contacts in a circuit extending from conductor 944 through the contacts of contactor 750, con-

ductor 943, contacts of switch 995, conductor 996, magnet of contactor 990 to the other side of the line on conductor 751. The closure of the upper contacts of contactor 990 moves the controller into position 3, the circuit for the magnet 911 of the latter being traceable from conductor 751, magnet 911, conductor 916, through the upper right contacts of contactor 990 to conductor 942. Upon the movement of the controller out of position 2 contactor 954 becomes de-energized and falls and, upon the movement of the controller to position 3 a circuit is completed for energizing contactor 1002 to lift and close its upper contacts. This circuit extends from conductor 751, magnet of contactor 1002, conductor 1045, 1046, to controller contact 1047 in position 3.

The closure of contactor 990 also sets billet stop 35 for the third furnace path by opening valve 997, admitting fluid to cylinder 38 of that path. The circuit for the operating coil of this valve extending from contact 998 of the controller in position 3, conductors 999, 1000, 1001, upper contacts of contactor 1002, conductors 1003, 1004, operating coil of valve 997, conductors 1005, 1006, to the other side of the line on controller contact 1007.

Contactor 990, upon moving, breaks its lower contact, thereby breaking the circuit to the operating coil of valve 987, which causes this valve to close, whereupon the discharge pusher is withdrawn under constant pressure in cylinder 71. This closing of the upper contacts of contactor 990 also effects return of the turntable to the position of Fig. 12. To this end, contactor 724^a moves to the right, its circuit extending from conductor 751, right magnet of contactor 724^a, conductor 1009, upper contacts of contactor 990, to conductors 942, 943. Contactor 724^a, upon opening its left contacts, opens the circuit to the operating coil of turntable cylinder valve 978, which closes, whereupon the turntable is moved back under constant pressure in cylinder 79. During this movement it opens switch 992. Contactor 1008 is now moved to the left, its circuit extending from conductor 751, left magnet of contactor 1008, upper contacts of contactor 990 to conductors 942, 943, it being noted that contactor 990, upon energizing, is held up in a circuit extending through its own upper contacts, conductor 1010, and through the contacts of switch 985 to conductor 943.

The return of the turntable controls operation of the transfer pusher 80. To this end, as the turntable reaches its normal position, switch 985 is opened, breaking the holding circuit of contactor 990 and causing this contactor to fall. At the same time, switch 986 is closed and valve 1011, controlling the delivery pusher cylinder 81, is opened, an energizing circuit therefor being traceable

from controller contact 994, conductor 993, contacts of switch 986, conductor 1012, left contacts of contactor 1008, conductor 1013, operating coil of valve 1011, conductors 984, 976, to the other side of the line at contactor 907. Pressure fluid being thus admitted to cylinder 81, pusher 80 is advanced to transfer the billet to holder 84 of the press feed slide 83.

During this movement the pusher opens switch 981 and, at the end of its stroke, closes switch 1014. Contactor 723 now moves to the left in a circuit which extends from conductor 751, left magnet of contactor 723, conductor 1016, right contacts of contactor 684, conductor 1015, contacts of switch 1014, to the other side of the line on conductors 1017 and 943. Contactor 1008 is now energized to move to the right in a circuit traceable from conductor 751 right magnet of contactor 1008, conductor 1049 through the left contacts of contactor 723, to the other side of the line on conductor 943. This movement of contactor 1008 breaks the circuit for valve 1011 which closes and transfer pusher 80 withdraws under constant pressure in cylinder 81.

If the furnace is operating independently, contactor 684 is in its left hand position and the circuit for moving contactor 723 to the left is traceable through the left contacts of contactor 684.

The above described furnace operations, while necessarily described as successive, are more or less simultaneous. During this time, also, the discharged billet is being fed to the press.

The infeed pusher 42, upon its return movement, passes and closes switch 1018, whereupon contactor 1019 moves to the left in an energizing circuit from conductor 936, left magnet of contactor 1019, right contacts of contactor 1020, conductor 1021, left contacts of contactor 1022 (which was moved to the left upon the closure of switch 1024 by the previous withdrawal of pusher 43 of the third path), conductor 1023, contacts of switch 1018, conductors 939, 940, to the other side of the line on controller contact 941.

If pusher 43 had not caused contactor 1022 to move to the left by not closing its switch 1024 (corresponding to switch 960 for the last path) then switch 1018 will reset contactor 966 to the right because, by not closing switch 1024, there has been an indication that no billet is needed for the third line. The circuit for moving contactor 966 to the right extends from conductor 751, right magnet of contactor 966, conductor 1050, right contacts of contactor 1022, conductor 1023, contacts of switch 1018, conductors 939, 940, to controller contact 941.

Infeed pusher 42 continuing, passes and closes switch 1025 and opens switch 1018, whereupon contactor 1022 moves to the right

in a circuit traceable from conductor 936, right contacts of contactor 915, conductor 962, right magnet of contactor 1022, conductor 1026, contacts of switch 1025, to the other side of the line over conductors 939, 940, at controller contact 941.

The furnace now waits for the container 101 to move back from the die 221 after the extrusion operation. Thereupon contactor 691 is again released, dropping down, to effect feed of another billet. To this end, a circuit is closed through controller contact 994, conductor 993, contacts of switch 1028, conductor 1029, left contacts of contactor 1019 and right contacts of contactor 1020, conductor 1030, lower contacts of contactor 691, conductors 1031, 1032, operating coil of valve 1027, conductors 984, 976, to the other side of the line at contactor 907. Valve 1027 being thus opened admits fluid pressure to cylinder 8 and piston rod 8^a is advanced to move the billet supply chains ahead one step. This deposits a billet in groove 6.

The supply unit movement effects operation of the delivery pusher. To this end, the advance of piston rod 8^a closes switch 1033, whereupon contactor 1020 is moved to the left, its circuit extending from conductor 936, through its left magnet, conductor 1034, contacts of switch 1033, to the other side of the line on conductors 1017 and 943. Contactor 1020, upon moving to the left, causes contactors 1019 and 966 to move to the right, the circuit for contactor 1019 extending from conductor 936, right magnet of contactor 1019, left contacts of contactor 1020, to conductors 942, 943 and that for contactor 966 extending from conductor 751, through its right magnet, upper left contacts of contactor 1020 to conductors 942 and 943. Valve 1035 for cylinder 25 is now opened, its circuit extending from controller contact 1007, conductors 1006, 1005, 1036, right contacts of contactor 935, conductor 1037, lower contacts of contactor 990, conductor 1038, right contacts of contactor 966, right contacts of contactor 918, right contacts of contactor 1019, conductors 1039, 1040, operating coil of valve 1035, to conductors 984, 976. This admits fluid pressure to cylinder 25 and delivery pusher 9 moves forward, opening switch 1028, and pushing the new billet along the groove 6 until it is stopped by encountering stop 35 for the third furnace path.

If, while operating, billets are changed from smaller to larger size so that finally the length of the billet line becomes so great that the charging cylinder for the last line causes the billet holder to close switch 958 before switch 960 closes, then contactor 961 remains to the right. Then, when the infeed pusher for the first path passes switch 964, on its retracting stroke, it does not cause a billet to be delivered to the last path

since the circuit for moving contactor 1019 to the left will not be completed and therefore the circuit through the operating coil of valve 1027 will not be closed. Thus the conveyor will not take the necessary step to deliver a billet to groove 6 as hereinbefore described.

If while operating, billets are changed from larger to smaller size so that finally the length of billet line becomes so short that switch 965 is closed instead of switch 958, then it is necessary to feed more billets to the furnace to increase the line lengths sufficiently to cause the closure of switch 958.

Contactor 966 thereupon moves to the left in a circuit extending from conductor 751, left magnet of contactor 966, conductor 969, contacts of switch 965, conductors 939, 940, to controller contact 941. The movement of contactor 966 to the left effects the movement of contactor 915 to the left and contactor 935 to the right. The circuit for contactor 915 may be traced from conductor 751, left magnet of contactor 915, lower left contacts of contactor 966, over conductor 969 as traced for contactor 966 and the circuit for contactor 935 is completed from conductor 936, right magnet of contactor 935, conductor 970, upper left contact of contactor 966, conductors 942, 943.

The movement of contactor 935 to the right opens at its left contacts the energizing circuit for valve 945, controlling the infeed cylinder, withdrawing the pusher. Switch 1018 is now closed whereupon contactor 1019 moves left in a circuit traceable from conductor 936, left magnet of contactor 1019, right contacts of contactor 1020, conductor 1021, left contacts of contactor 1022, conductor 1023, contacts of switch 1018, conductors 939, 940 to controller contact 941.

The movement of contactor 1019 to the left now reestablishes the circuit for valve 1027 (previously traced) introducing another billet into groove 6. Contactor 915 will remain to the left during these billet feeding movements preventing the controller 923 from being moved to position 3. When upon the closure of switch 1140 on the forward stroke of pusher 9, contactor 918 is moved left and also preventing contactor 1022 from being moved to the right.

When the delivery pusher reaches the end of its stroke it closes switch 1042, moving contactor 918 to the left in a circuit extending from conductor 936, left magnet of contactor 918, conductor 1043, contacts of switch 1042, conductors 1044, 1045, 1046, to the other side of the line at controller contact 1047. Upon the movement of contactor 918 the circuit through the operating coil of valve 1035 is broken, closing this valve, whereupon the delivery pusher 9 is with-

drawn under constant return pressure in cylinder 25, leaving the billet in front of the door of the third furnace path for the next call of the press.

The furnace has now gone through one complete cycle using three positions of the controller. Since there are four furnace paths, there are four of these cycles and the next call of the press will move the controller to position 4, whereupon another cycle of operations similar to that above described will take place. The controller moves to position 7 for the third cycle and to position 10 for the fourth cycle, as will presently appear.

It is considered unnecessary to describe a complete cycle of operations for inserting billets into the third, second and first furnace paths, as the contactors involved are the same. However it is noted that infeed cylinder 40 for third infeed pusher 43 is controlled by valve 1060 and that the cylinders 60, 59 of third holder 50 are controlled by valves 1061, 1062. It is also noted that upon the controller moving into position 4 for the starting of the second cycle, contactor 1002 is energized instead of contactor 954. The circuit for contactor 1002 has already been described and it will be remembered that this contactor completed a circuit for the operating coil valve 997 controlling the billet stop for the second path. It also completes, through its other contacts, a circuit for energizing the operating coil of valve 1060. This circuit may be traced from conductor 951, operating coil of valve 1060 conductor 1063, left contacts of contactor 1002, conductor 1001, conductor 1000, conductor 999, to controller contact 998 in position 4. The circuit for valve 1061 extends from controller contact 998 in position 4, contactors 999, 1000, coil of valve 1061, conductors 930, 929, to controller contact 928 in position 4.

In the cycle of operations for the fourth or last billet path contactor 954 was de-energized upon the controller moving out of position 1. Likewise contactor 1002 becomes de-energized upon the controller moving out of position 4.

The circuit for valve 1062 which is opened to cause the return of third holder 50 may be traced from conductor 975, coil of valve 1062, conductor 974, conductor 973, to controller contact 972 with the controller in position 5.

When the infeed pusher 43 for the third path reaches the end of its stroke, it closes switch 1024 whereupon contactor 1022 moves to the left, this circuit extending from conductor 962 to the left magnet of contactor 1022, conductor 1064, contacts of switch 1024, conductors 1045, 1046, to controller contact 1047. This places this contactor in position for operation on the first suc-

ceeding cycle which involves the fourth or last furnace path. On its return movement from depositing a cold billet into the furnace, this infeed pusher closes switch 1065, whereupon contactor 1051 is moved to the right to perform the same function in the second cycle as performed by contactor 1022 in the first. The circuit for the right magnet of contactor 1051 extends from conductor 962, through its right magnet, conductor 1066, contacts of switch 1065, to conductor 1045.

With these exceptions the operation of the second cycle is the same as that for the first cycle, the controller moving into position 7 for the third cycle.

In the third cycle contactor 1067 is energized in place of contactor 1002 on the second cycle. The circuit for contactor 1067 extends from conductor 751, magnet of contactor 1067, conductors 1068 and 1070 to controller contact 1071 with the controller in position 7. Valve 1072 controlling cylinder 41 of infeed pusher 44 of the second path is opened by closing a circuit which extends from controller contact 1073, conductors 1074, 1075, 1076, upper contact of contactor 1067, conductors 1077, 1078, operating coil of valve 1072, conductor 951, contacts of switch 950, conductor 949, as previously traced for similar valves 945 and 1060. Valve 1079 controlling cylinder 38 for billet stop 34 is opened by a circuit which extends from common conductor 1005, operating coil of valve 1079, conductors 1080, 1081, upper contacts of contactor 1067, over conductors 1076, 1075, 1074 to controller contact 1073. Valve 1082 controlling second cylinder 60 is operated in a circuit extending from common conductor 930, operating coil of valve 1082, conductors 1075, 1074, to controller contact 1073, while the circuit for valve 1083 controlling second cylinder 59, extends from conductor 975, operating coil of valve 1083, to conductor 974. Contactor 1052 corresponding in function to contactors 1051 and 1022, is moved to the left in a circuit extending from conductor 962, through the left magnet of this contactor, conductor 1083, contacts of switch 1084 (corresponding to switch 960) conductors 1085 and 1086, to controller contact 1087. This contactor is moved to the right in a circuit traceable from conductor 962, right magnet of contactor 1052, conductor 1088, contacts of switch 1089 (corresponding to switch 1025) back to conductor 1068.

For the fourth cycle, the controller is moved to position 10 and contactor 1090 is energized, its circuit being completed from conductor 751, through its magnet, conductors 1085 and 1086, to controller 1087. Valve 1091 for cylinder 46 of first infeed pusher 45 is opened by a circuit extending from conductor 951, operating coil of valve

1091, conductors 1092, 1093, upper contacts of contactor 1090, conductors 1094, 1095, 1096, to controller contact 1097. The circuit for opening valve 1098, controlling first cylinder 60, extends over conductors 1096, 1095, operating coil of valve 1098, to conductor 930, while the circuit for the operating coil of valve 1099, controlling first cylinder 59, is the same as that traced for valve 1083. Valve 1100 controlling cylinder 38 of billet stop 33 is opened by a circuit traceable from conductor 1005, operating coil of valve 1100, conductors 1101, 1102, upper contacts of contactor 1090, over conductors 1094, 1095 and 1096 to controller contact 1097.

The circuit for operating contactor 961, corresponding to contactors 1022, 1051 and 1052, to move it to the left, extends from conductor 962, left magnet of contactor 961, conductor 963, contacts of switch 960, conductors 939, 940, to controller contact 941 and is moved to the right by means of a circuit traceable from conductor 962 to the right magnet of contactor 1103, contacts of switch 1104 (corresponding to switch 1025) conductors 1085, 1086, to controller contact 1087.

Provision is made for manually controlling the various operations. To this end, for each magnetic valve there is provided a hand switch connected in circuit with the operating coil of the valve.

For example, referring to the press, hand switch 866, when closed, establishes a circuit from conductor 857 through its contacts to conductor 787 leading to the operating coil of valve 786 so that this valve may be closed as desired. In like manner switch 867 connects conductor 857 to conductor 791 leading to the coil of valve 790; switch 868 to conductor 800 leading to the coil of valve 799; switch 869 to conductor 688 leading to the coil of valve 681; switch 870 to conductors 871 and 807 leading to the coil of valve 680; switch 872 to conductors 873 and 697 leading to the coil of valve 695; switch 874 to conductor 725 leading to the coil of valve 724; switch 875 to conductor 731 leading to the coil of valve 730; switch 876 to conductor 739 leading to the coil of valve 738; switch 877 to the coil of valve 768; through contactor 770, conductor 858, one pole of switch 877, valve 768, other pole of switch 877, conductor 771 to contactor 770; switch 878 to conductor 764 leading to the coil of valve 694; switch 879 to conductor 719 leading to the coil of valve 709; switch 880 to conductors 881 and 644 leading to the coil of valve 611; switch 882 to conductors 809, 662 leading to the coil of valve 655; switch 883 to conductors 884 and 672 leading to the coil of valve 656.

There is also provided an additional hand switch 885, closure of which completes a

circuit for energizing the operating coil of valve 768 controlling the high pressure valve cylinder 508. This circuit extends from conductors 646, 645, 846, contacts of switch 885, conductor 772, operating coil of valve 768, conductor 901 to conductors 641, 639, through the contacts of contactor 640.

The contactors controlling the supply of alternating and direct current for the various circuits may be individually moved to the right or left by means of hand switches conveniently located on this control board and shown schematically in Fig. 83. Switches 886 and 887 connect one side of the alternating current source on conductor 605 respectively to the left and right operating magnets of contactor 684 in the furnace control circuit for determining, as will hereinafter appear, the separate or joint operation of the furnace and press. There are also included switches 888 and 889 controlling, over conductors 890 and 891, respectively, the movement of direct current controlling contactor 770 to the right and left.

Switches 892 and 893 control over conductors 894 and 895 respectively, the right and left operating magnets of contactor 640, also controlling the direct current supply circuits and switch 896 over conductor 897 controls the left magnet of contactor 609, its right magnet being controlled through a contact on contactor 604.

There is provided means for setting the circuits so that the press and furnace will operate together, as above described, or independent of each other. As shown, this depends on the position of contactor 684, right hand position causing joint operation, left hand position causing independent operation.

For independent operation either hand switch 1113, at the furnace hand control station (later referred to), or hand switch 886 at the press hand control station is closed. Either causes contactor 684 to move to the left. Switch 1113 completes a circuit from one side of the A. C. line on conductor 913, switch 1113, conductor 1114, left magnet of contactor 684, conductor 749 to the other side of the line. Switch 886 completes a circuit from the A. C. line on conductor 605, switch 886, conductor 1114 and left magnet of contactor 684, as described.

For joint operation either hand switch 1111, at the furnace control station, or hand switch 887, at the press control station, is closed. Either moves contactor 684 to the right. Switch 1111 completes a circuit from conductor 749 to the right magnet of contactor 684, conductor 1112, switch 1111 to conductor 913. Switch 887 completes a circuit from conductor 605 through switch 887, conductor 1112, right magnet of contactor 684 to conductor 749.

For manual operation of the mandrel in-

terchange apparatus the operator at the control station opens hand switch 812 and closes double-throw hand switch 810 to its down position. In order to operate cylinder 343 to withdraw the mandrel from the press, the operator closes switch 856 completing a circuit which extends from conductors 641, 642, operating coil of valve 818, contacts of switch 817, closed with the mandrel in position in the press, conductor 819, contacts of switch 856, conductors 857, 858, left contacts of contactor 770 to conductor 647. Valve 818 closes to actuate cylinder 343 to remove the mandrel, as above described. The operator now closes hand switch 859 and, when the piston rod of cylinder 343 has fully completed its stroke, it causes switch 827 to close, completing a circuit for valve 834, which circuit may be traced from conductor 641, operating coil of valve 834, conductor 835, contacts of hand switch 810 in its downward position, conductor 829, contacts of switch 827, conductor 828, contacts of switch 810, conductor 860, contacts of switch 859, conductors 857, 858, left contacts of contactor 770 to conductor 647. When the piston rod of cylinder 356 controlled by valve 834, reaches its full open position, switch 838 closes and, upon the operation of double-throw hand switch 861 to the one side or the other by the operator, the cooling housing will be caused to move either up or down depending upon which mandrel is to be replaced. Let it be assumed that the housing is to move upwardly. The operator then closes double-throw switch 861 to the right causing the energization of the operating coil of valve 839. A circuit may now be traced from conductors 641 and 642, operating coil of valve 839, conductor 841, contacts of switch 810, conductor 862, right contacts of switch 861, conductor 844, contacts of switch 838, conductor 845, contacts of switch 810, conductors 857, 858, left contacts of contactor 770 to conductor 647.

The movement of the housing may be controlled by any suitable stop.

If it is assumed that the housing is already in its uppermost position and it is necessary to lower it, valve 840 must be operated. The operator then moves hand switch 861 to the left and a circuit for the coil of valve 840 is completed from conductors 641 and 642, operating coil of valve 840, conductor 849, contacts of switch 810, conductor 864, left contacts of switch 861, conductor 844, contacts of switch 838, conductor 845, contacts of switch 810, conductors 857, 858, left contacts of conductor 770 to conductor 647.

In either case, the operator now opens switch 859, which permits the piston rod of cylinder 357 to return under constant pressure. The piston rod of cylinder 343 is returned by opening switch 856 and hand switch 865 is then closed. This return move-

ment closes switch 821. Thereupon the coil of valve 853 is energized to carry the mandrel forward into the press. The circuit for energizing the coil of valve 853 may be traced from conductor 647, left contacts of contactor 770, conductors 858, 857, contacts of switch 865, contacts of switch 810, conductor 854, contacts of switch 821, operating coil of valve 853 to conductor 641.

In order to operate the furnace control circuit by hand, hand switch 601 is moved to the left, disconnecting the source of supply from conductors 903 and 977 leading to the automatic control and connecting it over a plurality of conductors to the hand switches.

In order to open valve 945 to insert a billet into the last path of the furnace, switch 1115 is closed, completing a circuit from one side of the line on hand switch 601, conductors 1116, contacts of hand switch 1115, conductor 952, operating coil of valve 945, to conductor 951, through switch 950, conductors 949, 1117, to the other side of the line at hand switch 601. At the same time switch 1118 is closed to open valve 927 which controls the movement of billet holder into the furnace to receive the hot billet. The closure of switch 1118 completes a circuit from conductor 1116, contacts of switch 1118, conductor 931, operating coil of valve 927, conductor 930, to the other side of the current source at the contacts of switch 601.

The billet holder is withdrawn by closing switch 1119, completing a circuit for the operating coil of valve 971 extending from current source at switch 601, conductor 1120, contacts of switch 1119, conductor 974, operating coil of valve 971, conductors 975, 976, 1121, 1122, to switch 601.

It is noted that the operating coils of valves 1062, 1083 and 1099 are included in parallel with the circuit for the operating coil of valve 971 so that, when switch 1119 is closed, these valves will be opened.

To swing the turntable into position to receive the hot billet, valve 978 is opened by closing switch 1123, completing a circuit from conductor 1120, contacts of switch 1123, conductor 1124, operating coil of valve 978, conductors 983, 984, 976, 1121 and 1122. Thereupon valve 987, controlling the discharge unit is opened under control of hand switch 1125 which, upon being closed, completes a circuit from conductor 1120, contacts of switch 1125, conductor 988, operating coil of valve 987, to conductor 976, thence back to switch 601 as before described. The billet having been deposited upon the turntable, the latter is turned back, under constant pressure, by opening switch 1125. Valve 1011 for the transfer unit is operated by closing switch 1126, which completes a circuit from conductor 1120 to the contacts of this switch, conductor 1013, operating coil

of valve 1011, conductor 984, thence back to switch 601 over conductor 976, as previously traced.

Valve 1027 for the supply unit is opened upon the closure of switch 1127 which completes a circuit from conductor 1120, to the contacts of switch 1127, conductor 1032, operating coil of valve 1027, back to switch 601, over conductors 984 and 976.

The billet stop for the proper line of the furnace may also be set by hand. For this purpose any one of valves 997, 1079 or 1100 is opened. For opening valve 997 hand switch 1128 is closed completing a circuit from conductor 1116, contacts of switch 1128, conductor 1004, operating coil of valve 997, conductors 1005, 1129, to switch 601. Valve 1079 is energized upon the closure of switch 1130 in a circuit extending from conductor 1116, through the contacts of switch 1130, conductor 1080, operating coil of valve 1079 to conductor 1005, and valve 1100 is opened upon the closure of switch 1131, its circuit extending from conductor 1116, contacts of switch 1131, conductor 1101, operating coil of valve 1100 to conductor 1005. Valve 1035 for the delivery pusher is opened by closing hand switch 1132, whereupon a circuit is established from conductor 1116 to one pole of switch 1132, conductor 1041, operating coil of valve 1035, conductor 1040, through the second pole of switch 1132 to conductor 1120.

For opening valve 1060 switch 1133 is closed, establishing a circuit from conductor 1116, contacts of switch 1133, conductor 1063, operating coil of valve 1060, to conductor 951, while the operating coil of valve 1072 is energized upon the closure of switch 1134 in a circuit extending from conductor 1116, contacts of switch 1134, conductor 1078, operating coil of valve 1072 to conductor 951.

Valve 1091 is opened upon the closure of switch 1138, this switch completing a circuit from conductor 1116, contacts of switch 1138, conductor 1092, operating coil of valve 1091 to conductor 951.

The valves for the billet holders for the second, third and fourth furnace lines may also be operated by hand, switch 1135 controlling valve 1061. The circuit for the coil of this valve extends from conductor 1116, contacts of switch 1135, conductor 1000, operating coil of valve 1061 to conductor 930. The coil of valve 1082 is energized upon the closure of switch 1136 in a circuit extending from conductor 1116, contacts of switch 1136, conductor 1075, operating coil of valve 1082 to conductor 930, while the coil of valve 1098 is energized upon the closure of switch 1137, the circuit extending from conductor 1116, contacts of switch 1137, conductor 1095, operating coil of valve 1098 to conductor 930.

It will be remembered that, at the beginning of the operation, hand switch 912 was closed to move contactor 750 to the left to connect current for supplying the various contacts. This contactor may be moved back to its right hand position, to stop the furnace, by closing hand switch 1105. The circuit for the right magnet of contactor 750 may now be traced from one side of the line on conductor 913, through the contacts of switch 1105, conductor 1106, right magnet of contactor 750 to the other side of the current source on conductor 749. Current controller contactor 907 is moved to the left to close its contacts by the closure of hand switch 1107, the energizing circuit extending from one side of current source on conductor 749, left magnet of contactor 907, conductor 1108, contactor switch 1107 to the other side of the current source on conductor 913. Switch 1109 is closed to move contactor 907 to the right, the circuit for the right magnet of this contactor being traceable from conductor 749, right magnet of contactor 907, conductor 1110, contacts of switch 1109 to conductor 913.

There is provided indicating means for showing various circuit conditions. In the present embodiment a series of pilot lamps are located at the switchboard. Lamp 898 indicates the fact that contactor 770 is in its left hand or "current on" position. The circuit for lamp 898 is traced from conductors 639 and 769, top left contacts of contactor 770, conductor 771, lamp 898, conductor 858, next to the top left contacts of contactor 770 to conductor 647. Therefore, when contactor 770 has closed its current feeding contacts, lamp 898 is illuminated.

Lamp 899 indicating the left hand position of alternating current controlling contactor 609 is illuminated in a circuit extending from conductor 605, lamp 899, conductors 616, 615, 614, 613, top left contacts of contactor 609 to conductor 607.

In like manner, lamp 900 is lighted when contactor 640 closes its left contacts, the circuit for this lamp being traceable from conductor 645, lamp 900, over conductors 901 and 641 to the top left contacts of contactor 640 thence to conductor 639.

Lamp 902 connects from conductor 605, over conductor 903 with the lower left contacts of contactor 750, to conductor 749, in the furnace control circuit to notify the operator that this contactor has closed its left contacts connecting alternating current to the furnace control circuit, while lamp 904 shows the closure of direct current controlling contactor 907 also in the furnace control circuit. The circuit for lamp 904 extends from the right contacts of switch 601, conductor 977, upper left contacts of contactor 907, conductors 976, 1121, 906, through lamp 904, conductors 905, 993, low-

er contacts of contactor 907, conductor 903 to the contacts of hand switch 601.

As before pointed out the furnace and press may be operated singly or in unison, either condition being effected by the closure of contactor 684 to the left for separate operation and to the right for joint operation. The circuit for lamp 908, which is traceable over conductor 944, top contacts of contactor 750, conductors 943, 942, 910, lamp 908, conductor 909, right contacts of contactor 684, conductor 751, lower contacts of contactor 750 to conductor 749 lights this lamp when the press and furnace are operating together, that is, with contactor 684 to the right.

With lamp 908 extinguished it is evident that the furnace and press are operating separately. If at any stage of the automatic operation of the furnace and the press it is desired to stop the operation of the latter, this may be accomplished by opening hand switch 921.

As above described, when the container reaches its position against the die in preparation for receiving a hot billet for an extrusion operation, contactor 691 is energized upon the closure of switch 693 whereupon a circuit is completed through the closed contacts of contactor 691 and of hand switch 921 for energizing the controlling magnet 911 of the furnace controller 923 to commence the furnace cycle of operations. The next operation of the press control circuit, namely, the advance of the billet slide with a hot billet, depends for its initiation upon the movement of contactor 723 to the left and contactor 723 is moved to the left upon the closure of switch 1014 by the hot billet transfer, the operation of which depends upon completion of progressive furnace operations initiated upon the movement of controller 923 above noted.

It is evident, therefore, that if the circuit for energizing the controller 923 is opened at the contacts of switch 921, none of the furnace operations will take place with the result that a hot billet will not be delivered to the billet slide by the hot billet transfer. The press container will, therefore, remain in its position against the die.

In the press above described, the billet was formed previous to use with a central bore for passage of the mandrel. With a slight modification of the control mechanism and wiring, the press may be used with solid billets, i. e. billets not previously pierced. In such cases, the mandrel centering tool is not used and to get greater power for the mandrel the mandrel fluid pressure unit is connected into the water line instead of being operated by air. The controlling circuits are so modified that the cycle is as follows—

The billet slide and dummy block slide operate as above described to position the dummy block and the billet. The mandrel is advanced sufficiently to thread through the dummy block and thereafter the mandrel and ram advance together, the end of the mandrel being kept flush with the face of the dummy block. This pushes the billet into the container and pushes the dummy block off the dummy block slide onto the billet slide whereupon the dummy block slide is withdrawn out of the way. Continued movement pushes the dummy block into the container whereupon the billet slide is withdrawn out of the way. This movement is continued until the billet has been upset sufficiently to cause it to fill the container chamber. Then the ram is stopped and the mandrel advanced alone, and pushed through the hot metal of the billet until its forward end enters the mouth of the die. By this preliminary upset of the metal the billet is so held that the mandrel passes through it on the center line. Thereafter the extrusion is the same as above described.

In the foregoing description of the automatic cycle, it is noted that the various switches and contactors are at some stage of the operation returned to their original settings to be ready for the next cycle, although such resetting is not, in all cases referred to specifically.

It is noted also that, except in certain instances, no reference is made to the control of the length of stroke of the various pressure units. It will be apparent that where stops are required to limit the stroke of a unit, any suitable form of stop may be provided. In the present embodiment, the container unit has no stop other than the die unit. On reverse it goes to the end of the piston's stroke. The ram has no stop for its forward stroke. All the other units have suitable stops for positively limiting the piston strokes.

What is claimed is:

1. In combination, an extrusion press, a billet heating furnace, and automatic means controlled by the press for supplying a billet from the furnace to the press.

2. In combination, an extrusion press, automatic means for operating the press parts through a predetermined cycle, a billet heating furnace, and automatic means for delivering cold billets to the furnace and supplying hot billets to the press.

3. In combination, an extrusion press comprising a billet container, a die and an extrusion ram, a billet heating furnace, means for moving billets through the furnace, and means for conveying a hot billet from the furnace to the press, the actions of said moving and conveying means being synchronized.

4. In combination, an extrusion press comprising a billet container, a die and an extrusion ram, a billet heating furnace, and automatic means dependent on a predetermined position of the press parts, for conveying a hot billet from the furnace to the press.

5. In combination, an extrusion press comprising a billet container, a die and an extrusion ram, a billet heating furnace, a billet magazine, and automatic means dependent on a predetermined position of the press parts for delivering a cold billet from the magazine to the furnace and for conveying a hot billet from the furnace to the press.

6. In combination, an extrusion press including a die, and a billet container movable toward and away from the die, a furnace for heating billets including billet charging and discharging means and means for supplying a discharged billet to the press, and automatic means controlled by the movement of said container to a position adjacent the die for operating said discharge means.

7. In combination, an extrusion press including a movable billet container and a die, a furnace including billet charging and discharging means, a slide for supplying a billet to the press, and automatic means controlled by the press for causing a billet to be discharged from the furnace to said slide and moved by said slide to the press.

8. In combination, an extrusion press, a slide for supplying a billet to the press, a slide for supplying a dummy block to the press, a furnace including billet-discharging means, automatic means controlled by the press for causing a billet to be discharged from the furnace to said billet slide, and automatic means controlled by such discharge for advancing said slides.

9. In combination, an extrusion press, a furnace including billet charging and discharging means, means including electric control circuits for causing an automatic operation of the press and furnace through a predetermined cycle, and means for changing such circuits to cause independent automatic cycles of the press and furnace.

10. In combination, an extrusion press, a furnace including billet charging and discharging means, means including electric control circuits for causing an automatic operation of the press and furnace through a predetermined cycle, and means for changing said circuits to stop said automatic cycle.

11. In combination, an extrusion press, a furnace including billet charging and discharging means, means including electric control circuits for causing an automatic operation of the press and furnace through a predetermined cycle, means for changing said circuits to stop said automatic cycle, and means for thereafter controlling said circuits manually to operate the press and furnace.

12. In combination, an extrusion press including a die and a movable billet container, a furnace for heating billets, a billet magazine, and automatic means controlled by the movement of the container away from the die for causing a billet to be delivered from said magazine to a position for insertion in the furnace.

13. In combination, an extrusion press including a die and a movable billet container, a furnace having a path along which billets may be pushed, the leading hot billet in said path being discharged from the path by the insertion of a cold billet, a billet magazine, automatic means controlled by the movement of the container away from the die for causing a billet to be delivered from the magazine to a position for insertion in the furnace, and automatic means controlled by the movement of the container into a position adjacent the die for inserting the positioned billet in the furnace and supplying the discharged billet to the press.

In testimony whereof, I have hereunto set my hand.

DAVID L. SUMMEY.