

May 24, 1955

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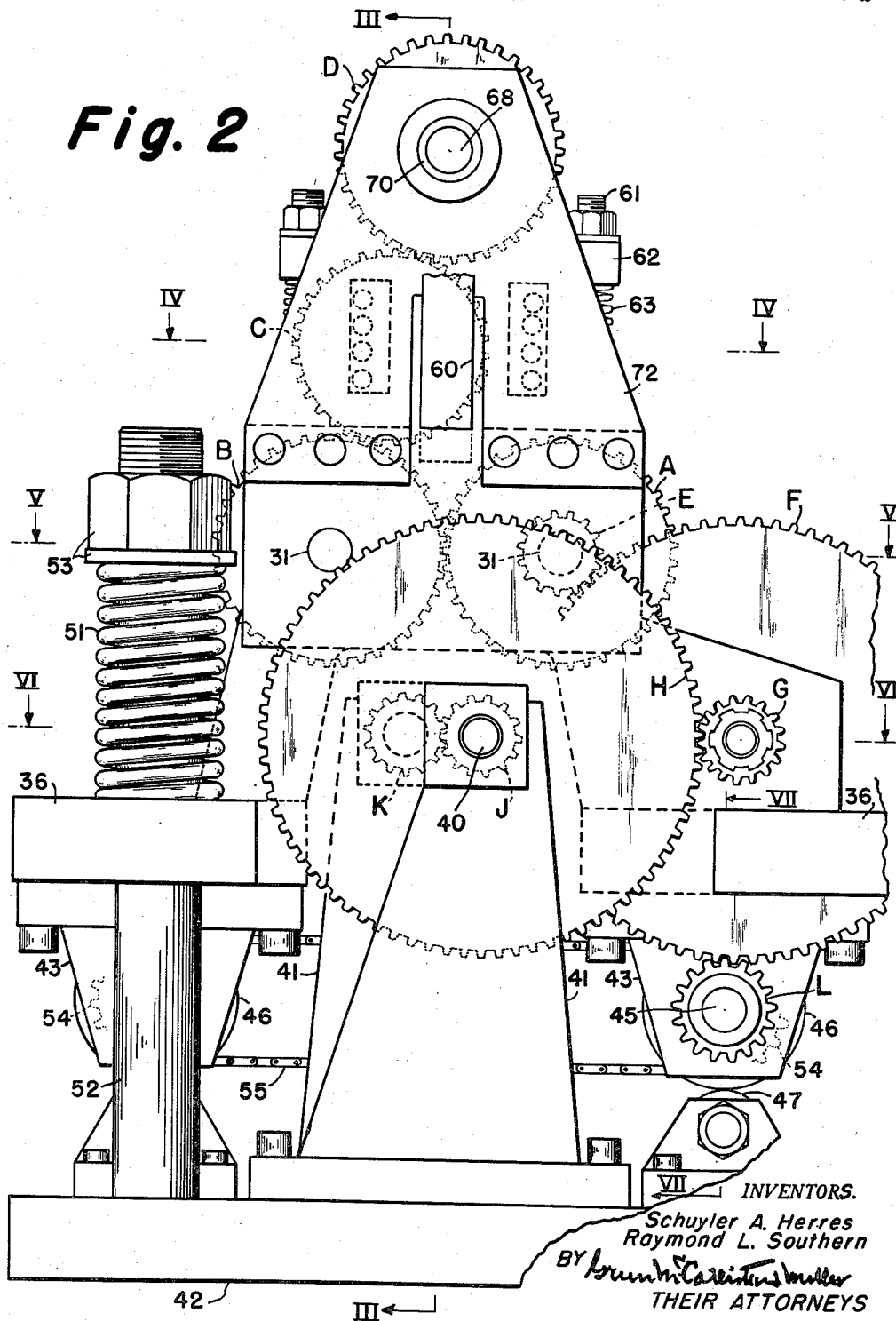
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APPARATUS FOR MAKING CONTINUOUS ELECTRODE STICKS

Filed Nov. 20, 1952

8 Sheets-Sheet 2

Fig. 2



May 24, 1955

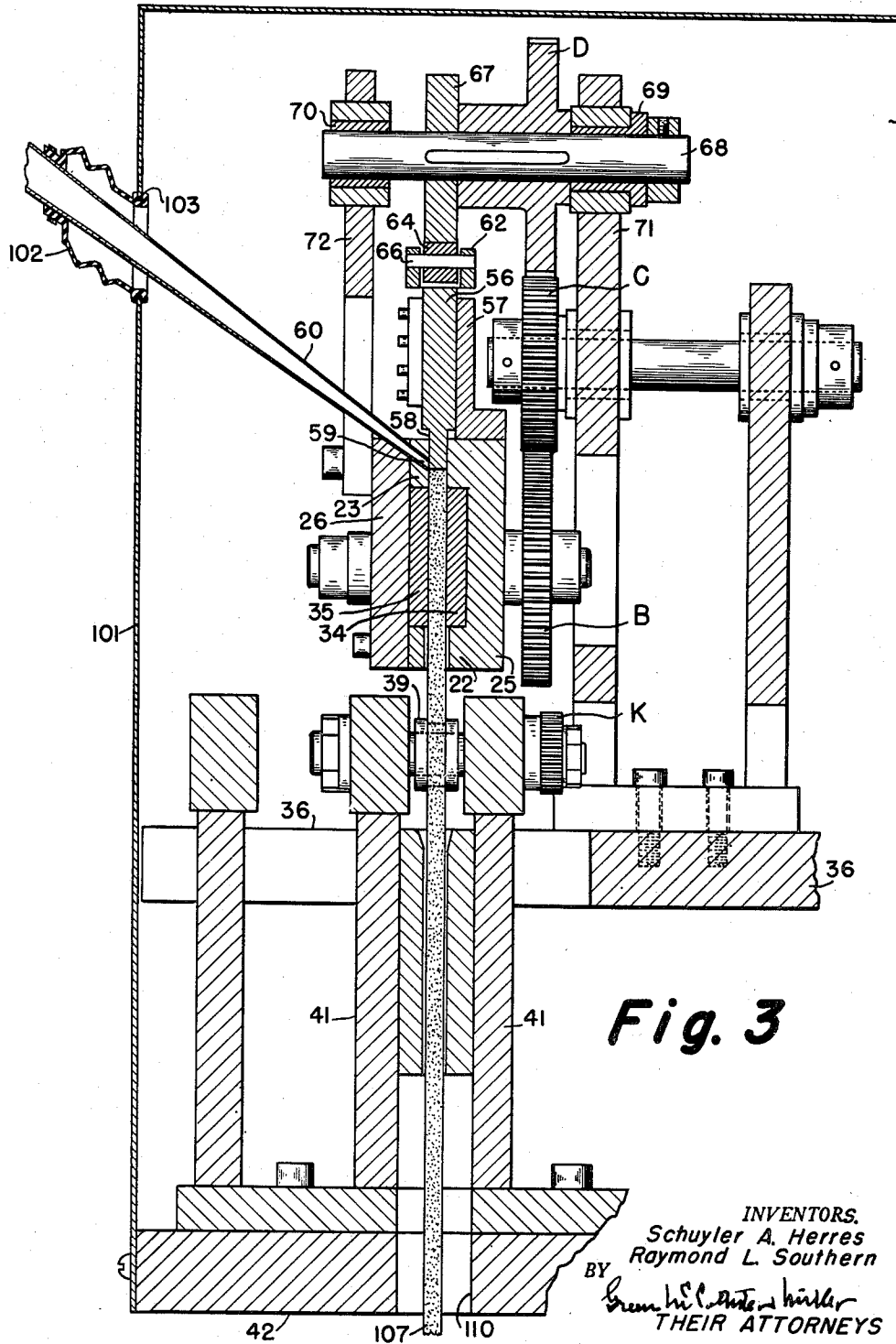
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Filed Nov. 20, 1952

8 Sheets-Sheet 3



May 24, 1955

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8 Sheets-Sheet 4

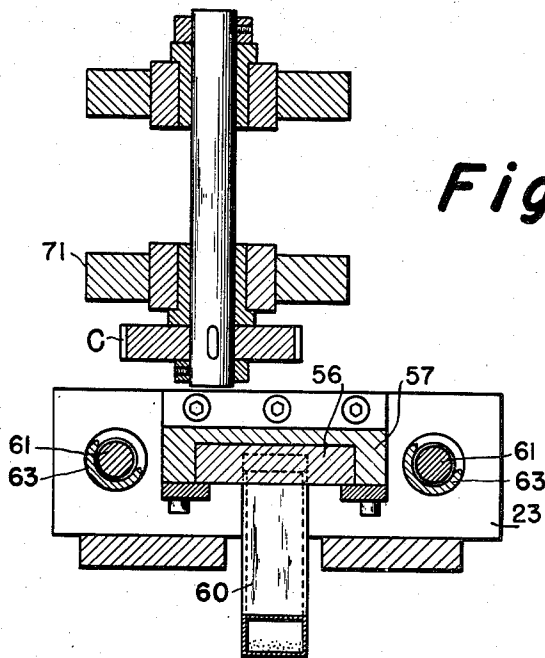


Fig. 4

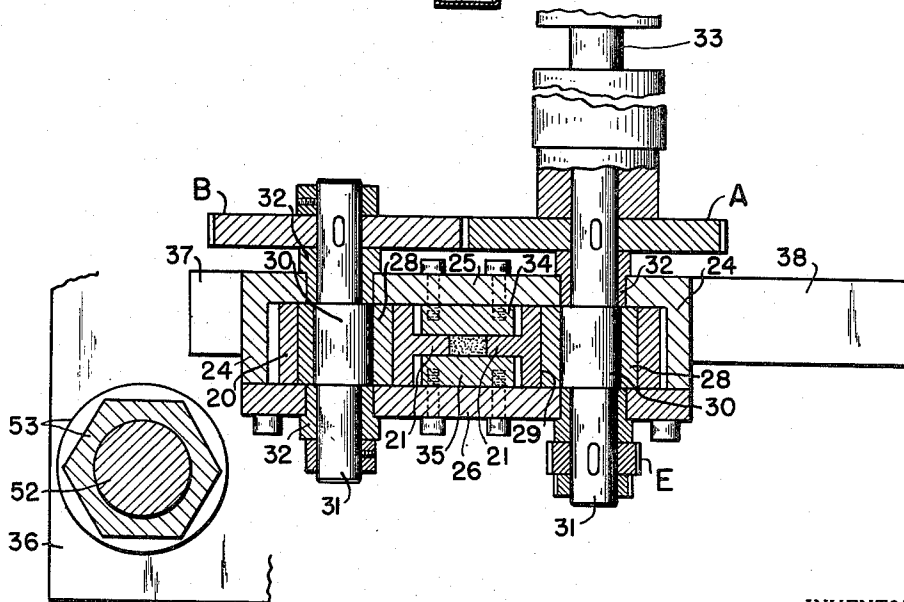


Fig. 5

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8 Sheets-Sheet 5

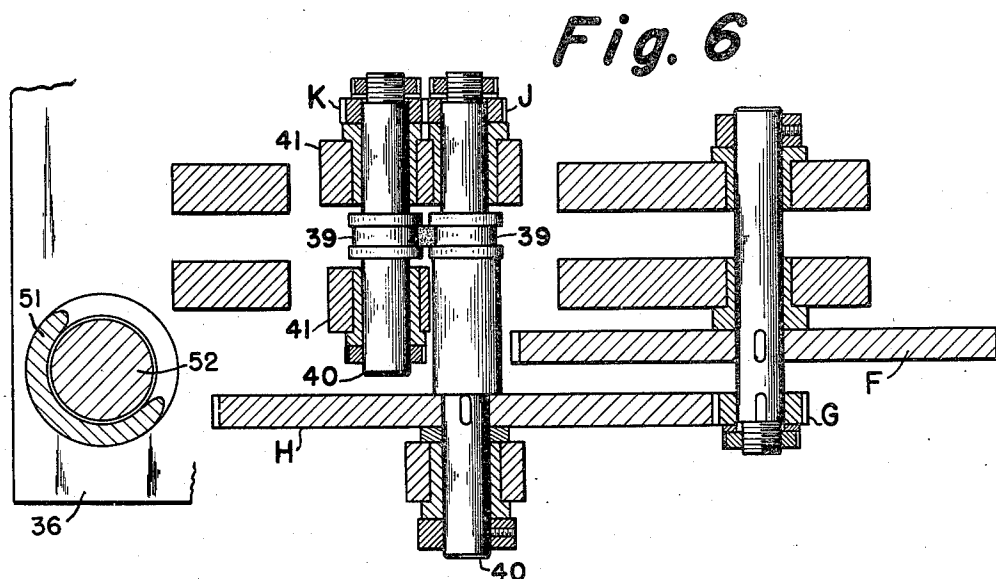
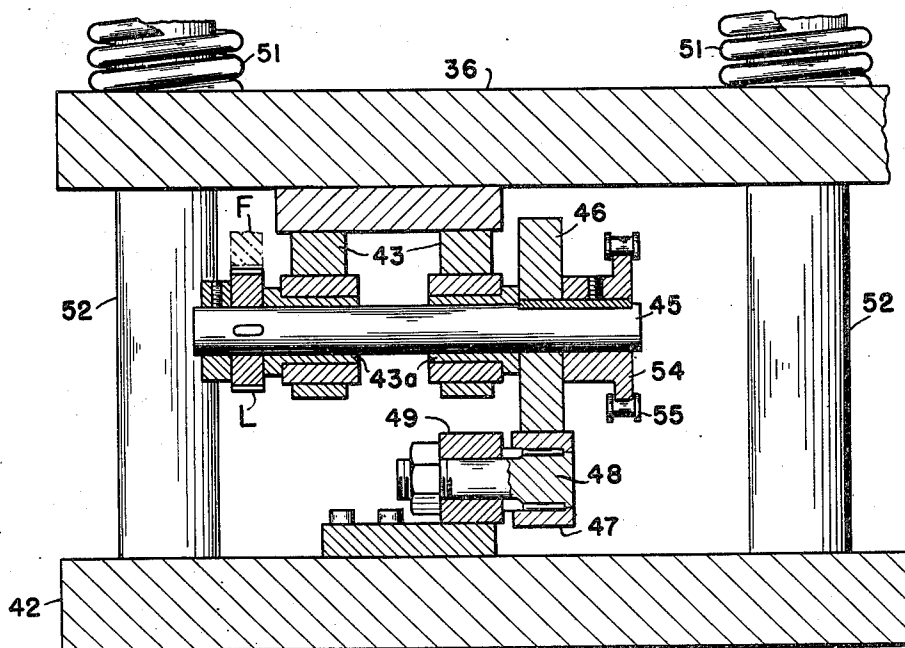


Fig. 7

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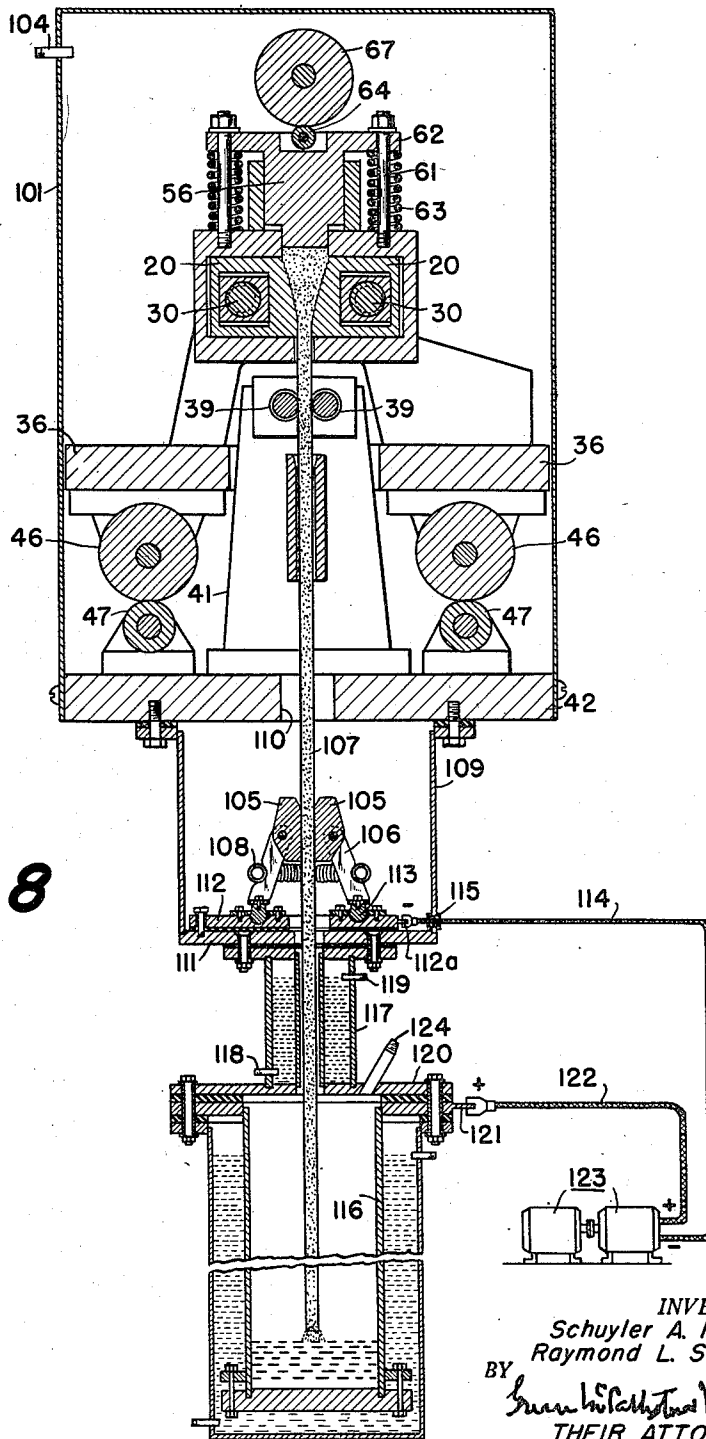
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APPARATUS FOR MAKING CONTINUOUS ELECTRODE STICKS

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8 Sheets-Sheet 6

Fig. 8



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2,708,770

APPARATUS FOR MAKING CONTINUOUS ELECTRODE STICKS

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8 Sheets-Sheet 7

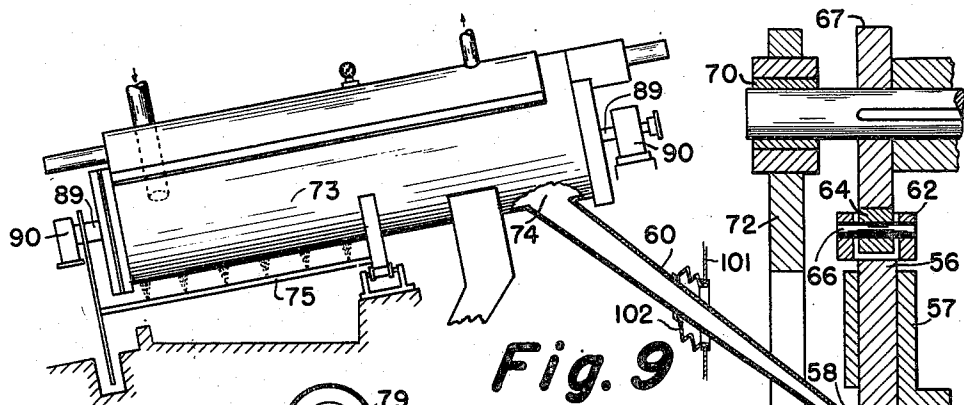


Fig. 9

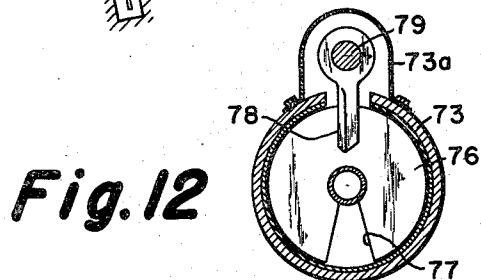


Fig. 12

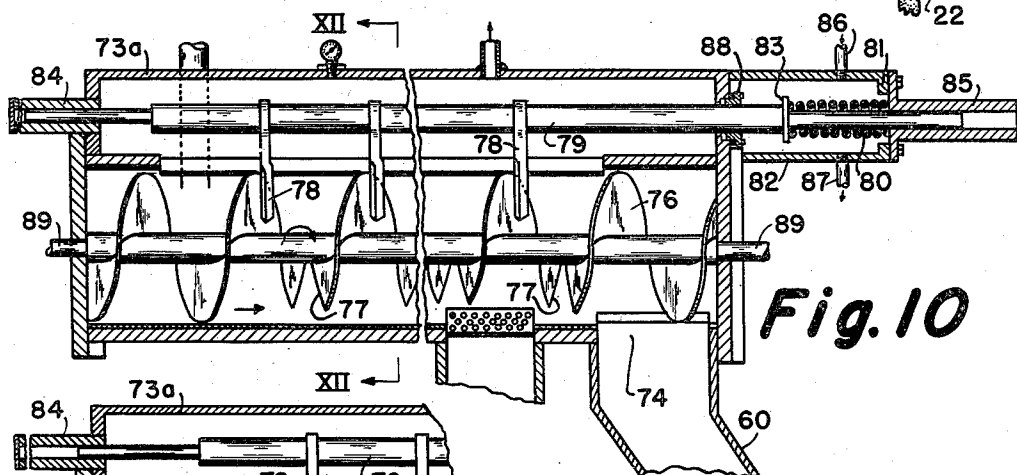


Fig. 10

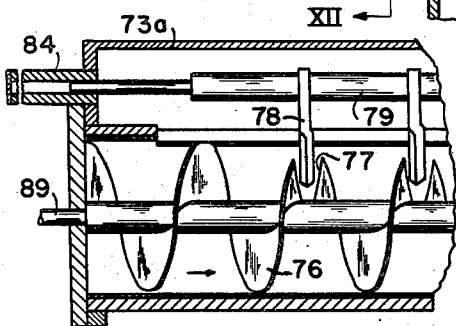


Fig. 11

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1

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APPARATUS FOR MAKING CONTINUOUS ELECTRODE STICKS

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Application November 20, 1952, Serial No. 321,628

10 Claims. (Cl. 18—12)

This invention relates to the making of ingots from consumable electrodes of difficultly reducible metal including titanium, to the making of metal sponge or powder of such metals and more particularly to apparatus for continuously forming electrode sticks from such sponge or powder.

One object of this invention is to produce apparatus by means of which difficultly reducible metal such as titanium in sponge or powdered form can be progressively compacted into stick form suitable for use as a consumable electrode.

In an application filed by Schuyler A. Herres on February 8, 1951, and serially numbered 209,994, is disclosed a reaction tube or chamber in which metallic sponge or powder suitable for pressing into electrode sticks can be formed and a further object of this invention is to produce apparatus which can be combined with such a reaction chamber or tube so as to work in synchronism therewith in producing consumable electrodes from the product of such reaction chamber as such sponge or powder is formed.

In an application filed by Raymond L. Southern on February 20, 1951, serially numbered 211,887, now Pat. No. 2,662,104, the use of consumable electrodes in the manufacture of ingots is disclosed and a further object of this invention is to produce apparatus which can be combined with the device of said application of said Schuyler A. Herres and the electrode feeding and ingot forming device of said Southern application to produce an integrated apparatus for carrying on a continuous procedure from the making of the sponge to the making of the ingot.

Another object of this invention is to produce an integrated device in which the metallic sponge or powder compacting device of this invention is arranged so as to receive its supply of metallic sponge or powder from a reaction tube or chamber of the type disclosed in said Herres application 209,994, compacting the same continuously and in a step by step manner to the density desired in the consumable electrode and in continuously feeding such electrode to an electric arc furnace of the type disclosed in the said Southern application 211,887.

These and other objects which will be apparent to those skilled in this particular art, we attain by the method and device described in the specification and illustrated in the drawings accompanying and forming part of this application.

In the drawings:

Figure 1 is a view partially in front elevation and partially in section of the device or apparatus by means of which metal sponge or powder can be continuously converted into stick-like electrodes in accordance with this invention;

Fig. 2 is an elevational view of the device of Fig. 1 with parts omitted;

Fig. 3 is a sectional view taken on line III—III of Fig. 2;

2

Fig. 4 is a sectional view taken on line IV—IV of Fig. 2;

Fig. 5 is a sectional view taken on line V—V of Fig. 2;

Fig. 6 is a sectional view taken on line VI—VI of Fig. 2;

Fig. 7 is a sectional view taken on line VII—VII of Fig. 2;

Fig. 8 is a vertical sectional view in elevation embodying the electrode stick forming device or apparatus of Fig. 1—7 inclusive combined with an electric arc furnace for converting such stick to ingot form as disclosed in said Southern application;

Fig. 9 is a side view partially in elevation and partially in section of a reaction tube or tube-like chamber of the same general construction as disclosed in the two previously filed Herres applications serially numbered 109,885 and 209,994 and shows the same connected by a spout to the compression chamber of the compacting device of this application;

Fig. 10 is a central longitudinal sectional view on a somewhat enlarged scale of the reaction tube of Fig. 9;

Fig. 11 is a fragmentary sectional view of the left-hand end portion of the device of Fig. 10 with the screw conveyor turned forward 180° from the position shown in Fig. 10;

Fig. 12 is a sectional view taken on line XII—XII of Fig. 10;

Fig. 13 is a view similar to Fig. 5 and illustrates a modified form in which one wall of the compression chamber is arranged to yield under abnormal pressures in such chamber;

Fig. 14 is a side elevational view taken on line XIV—XIV of Fig. 13;

Fig. 15 is a sectional view taken on line XV—XV of Fig. 14; and

Fig. 16 is an enlarged fragmentary sectional view of a portion of the modified device of Figs. 13—15 inclusive.

The device of this invention for compacting metallic sponge or powder into stick form for use as a consumable electrode includes a pair of die members each comprising a block-like body portion 20 having a projecting fin-like portion 21 extending from the center of one end thereof with the distal end of said fin-like projection inclined and shaped to provide a series of shallow tread steps (see Fig. 1). Fins 21 extend vertically or at right angles to the path of movement of the die members. The die members are mounted for horizontal movement within an enclosing frame having a bottom 22, a top 23, end members 24 and side members 25 and 26 (see Fig. 5).

Each of the die members 20 is provided with a horizontal rectangular through opening 27 to receive a rectangular slide block 28. Block 28 has a sliding fit for up and down vertical movement within through opening 27, and clearance space above and below each block 28 is provided within its opening 27.

Each block 28 is provided with a horizontal circular through opening 29 for reception of a circular cam member 30 formed on a horizontal shaft 31. Each shaft 31 is journaled within suitable bearing bushings 32 secured within openings in side members 25 and 26.

One shaft 31, which serves as a drive shaft, has keyed thereon a gear A which meshes with a like gear B keyed to the other shaft 31. At the opposite end from gear A its shaft 31 is provided with a pinion gear E which is keyed in place. The shaft 31 which carries gear A and pinion E is coupled to the electric motor (not shown) for operating the device through a suitable reduction gear (not shown), the shaft of which is numbered 33 (Fig. 5). From Figs. 1 and 5, it will be apparent that as shafts 31 of gears A and B are rotated, the die members will be

3

simultaneously reciprocated horizontally in opposite directions.

Secured to side members 25 and 26 of the enclosing frame are members 34 and 35 (Figs. 3 and 5) which have smooth flat inner faces which serve as bearing surfaces for the sides of the fin-like portions 21 of the compacting die members. These flat surfaces in co-operation with the stepped inclined surfaces of such fin-like portions, form a compression chamber which decreases in cross section from its top to its bottom in a step-by-step manner.

In Fig. 1, shafts 31 are indicated by dotted circles which show that cams 28 have forced the die members to the limit of their outward movement away from the vertical center line of the compression chamber.

Top member 23 of the frame which encloses the die members is provided with a rectangular central opening which preferably corresponds in size and shape to the top of the compression chamber when the die members are moved to position where they are nearest to the vertical center line of the compression chamber and bottom member 22 of the enclosing frame has a rectangular central opening which is preferably slightly larger than the bottom of the compression chamber when the die members are in such position nearest the vertical center line of the compression chamber.

The enclosing frame for the die members is mounted a distance above a horizontal die member base 36 by means of spacer bracket-like legs 37 and 38.

Located a distance below and on opposite sides of the vertical center line of the compression chamber is a pair of pinch rolls 39—39. These are mounted on parallel horizontal shafts 40 shown by dotted circles in Fig. 1 and are geared together so as to rotate in opposite directions by pinion gears J and K; pinion J being mounted on the shaft which carries gear H (Figs. 2 and 6). Shafts 40 are journaled in bearings secured in position adjacent the top of a pair of upright support standards 41—41 (Figs. 1, 2, 3 and 6). These support standards are secured to bed plate 42 of the compacting device so that the vertical position of the axes of the pinch rolls is fixed.

Die member base 36 is provided with a central opening as shown in Fig. 1, and upwardly through which standards 41—41 extend. Base member 36 adjacent each of its four outer corners and extending downwardly therefrom is provided with a pair of hanger brackets 43. These brackets are provided with bearings 43a within which two parallel horizontal shafts 44 and 45 are journaled (Fig. 7). Each of these shafts at its opposite ends is provided with a cam 46 which is keyed thereto. Shaft 45 is provided with a pinion gear L which meshes with a gear wheel F (Figs. 2 and 7). Gear wheel F meshes with pinion E which is keyed to main drive shaft 31 of the device. Each cam 46 rests on a roller 47 the shaft 48 of which is secured within supports 49 which are bolted to the bed plate 42 of the machine (Figs. 1, 2 and 7).

Base member 36 which carries the downwardly extending hanger brackets 43 and is provided with bearings 43a within which shafts 44 and 45 of cam rollers 46 are journaled, is yieldingly forced downwardly by four compression springs 51, see Fig. 2, where one such spring is shown.

These compression springs 51 surround posts 52 secured to bed-plate 42 of the device or machine adjacent the four corners of such base in line with cams 46 and cam support rollers 47 and preferably as shown beyond or outside of the same.

Posts 52 extend upwardly through openings formed for that purpose in die member base 36. These compression springs which surround posts 52 are located between base 36 and a washer and nut 53 which confines each spring in place. This nut and washer 53 provide means for adjusting and evening up the four springs 51.

These compression spring and post combinations yieldingly hold cams 46 in contact with support rollers 47.

Shafts 44 and 45 to which cam rollers 46 are keyed are

4

provided with sprocket wheels 54, and shaft 44 is driven from shaft 45 by means of a sprocket chain 55 (Figs. 2 and 7).

The position of cams 46 on shafts 44 and 45 is so adjusted with relation to cams 30—30 on shafts 31 that die member base 36 and the housing for the die members reaches the limit of its upward movement as the die members reach the limit of their movement away from the vertical center line of the compression chamber, the position shown in Fig. 1.

In other words, cams 46 and 30 are so adjusted that the die members move apart or away from the vertical center line of the compression chamber during their upward movement with relation to the pinch rolls. The eccentricity of cams 46 with relation to shafts 44 and 45 is such that each upward movement of the die members occasioned by such cams will equal the vertical height of one of the steps making up the inclined series of steps of such die members.

A plunger 56 mounted for vertical sliding movement within a housing 57 secured to the top 23 of the die member enclosing frame is provided with a downwardly extending portion 58 for controlling the outlet port 59 of a conveyor spout 60 arranged to carry or convey comminuted or powdered metal sponge or finely divided titanium material from the source of supply of such material to be later described to the compression chamber of the compacting device of this invention (Fig. 9). Also secured to the top 23 of the die member enclosing frame are two vertically extending posts 61 and plunger 56 is provided with a horizontally extending cross arm 62 which has openings adjacent its opposite ends for slidably receiving such posts 61. Coil springs 63 located between the lower face of such cross arm and the top member 23 of the die member enclosing frame tend to yieldingly hold plunger 56 at the upper limit of its movement at which time outlet port 59 of the conveyor spout 60 is uncovered by downwardly extending part 58 of plunger 56 so that the space between the bottom of part 58 and the top of the partially compressed or compacted mass of material within the compression chamber will be filled with metallic material from such source of supply by way of conveyor spout 60.

A cam contact roller 64 located within and projecting above a centrally located pocket 65 in cross arm 62 is mounted for rotation on a pin 66 which spans said pocket and is secured within its opposite side portions. A roller cam 67 is keyed to shaft 68 to which gear wheel D is also keyed. Shaft 68 is journaled in bearings 69 and 70 secured to uprights 71 and 72 which form part of the frame of the device mounted on vertically movable base 36 which carries the die member enclosing frame.

Gear wheel D is driven by gear wheel A by way of gear wheel B and idler gear wheel C. Gear wheels A and B are keyed to shafts 31—31 which operate the die members through cams 30—30, and since gear wheel D is keyed to the same shaft 68 as cam roller 67 and gear wheel D is driven by idler gear wheel C which meshes with gear wheel B, cam roller 67 will be so adjusted with relation to shaft 68 that downwardly extending portion 58 of plunger 56 is caused to block off outlet port or opening 59 of conveyor spout 60 when the die members have been moved to a position where they are nearest the vertical center line of the compression chamber. Cam roller 67 moves plunger 56 downwardly in opposition to springs 63 and with relation to the die member enclosing frame as well as with relation to the die members.

The source of supply of the material to be compressed or compacted into electrode stick form can be a suitable hopper such as disclosed as an alternate arrangement in said Herres application Serial No. 209,994, but it preferably takes the form of a tube-like reaction chamber as disclosed in said application. Said reaction chamber has a discharge spout 60 terminating in outlet opening 59 at

5

its lower end which is controlled by downwardly extending portion 58 of plunger 56.

Such an arrangement is disclosed in Figs. 9-12 inclusive and as in said application, comprises a tube-like reaction chamber here numbered 73 which is inclined upwardly at about a 10° slope from its entrance or inlet end to the entrance 74 of the conveyor spout 60. Into this tube-like reaction chamber which is hermetically sealed, molten reducing metal such as magnesium or sodium in the proper amounts is introduced together with a halide such as titanium tetrachloride. An exothermic reaction within chamber 73 is initiated by heating the chamber and its contents to a reaction temperature by means of a series of burners 75. After the reaction is started, the tube-like chamber is cooled and maintained at a temperature within a range of from about 1475° F. to about 1650° F., all as disclosed in said Herres application 209,994.

The spiral screw 76 which agitates the materials and aids in completing the reaction differs from that shown in said application in that a segmented screw is substituted for the solid screw of said application. In this segmented screw, a pie-shaped piece is cut out of each blade convolution or turn as at 77. A number of finger-like scrapers 78 depending from a rod 79 are arranged to bear against the forward faces of the convolutions of the screw and are yieldingly held in contact therewith by means of a coil spring 80. Spring 80 surrounds a reduced end portion of rod 79, is located between end 81 of a spring housing 82 and a collar 83 located on rod 79 at the inner end of such reduced portion, and is mounted so as to slide within bearings 84 and 85 which project from opposite ends of the tube-like chamber in axial alignment with rod 79.

Since it is necessary to maintain spring 80 cool for the purpose of keeping its temper, we provide spring housing 83 with an inlet 86 and an outlet 87 so that a constant stream of cooling fluid (gaseous) can be passed through housing 82. A stuffing box 88 is provided between the interior of spring housing 82 and the interior of the upper extension 73a of the tube-like reaction chamber for preventing any of the spring cooling fluid from entering the tube-like reaction chamber should such fluid be injurious to the titanium values within the reaction chamber.

Shaft 89 of screw 76 which is journaled within suitable bearings located within pillow-blocks 90 is driven by a suitable motor (not shown) through a reduction gear (not shown) and under the control of a device which will cause it to operate in synchronism with the compacting device.

In the modification shown in Figs. 13-16 inclusive, side member 26 of the die member enclosure frame is modified so as to provide a pocket for receiving a member 91 which takes the place of member 35 and has a smooth, flat inner face that forms a bearing surface for the side of the fin-like portions 21 opposite member 34.

Member 91 is provided with side wings or flanges 92 which are held in contact with shoulders 93 formed in the walls of its pocket as shown in Fig. 13, by means of a series of springs 94, which surround locating members 95 projecting outwardly from wall 96 of member 91 which is the wall opposite that which forms the bearing surface for fin-like portions 21 of the compacting die members.

Springs 94 which surround the locating projections 95 are located between the outer wall of member 91 and a backing member 97 which contacts said springs and is provided with depressions adapted to accommodate locating projections 95.

A cover 98 for the pocket of member 91 is bolted in place by bolts 99. A series of spring adjustment screws 100 are threaded through cover 98 and bear against backing member 97 opposite springs 94. These spring adjustment screws are provided with lock nuts as shown

6

in Figs. 13 and 15 and since the pressure within the compression chamber of the compacting device during its compacting strokes equals about 14 tons per square inch, springs 94 are preferably of the type disclosed in United States Patent 2,224,969 of December 17, 1940, and marketed by Hubbard and Company, Pittsburgh, Pennsylvania, as Hubbard Super Service Alloy Spring Washers. Adjustment screws 100 are so adjusted as to keep member 91 at the inner limit of its travel as shown in Figures 13 and 14 until the pressure in the compression chamber of the compacting device exceeds 14 tons per square inch when springs 100 will allow member 91 to move slightly or enough to relieve the excess pressure and permit the compacting jaws 21 to complete their immediate compacting stroke. When the excess pressure is relieved, member 91 will immediately and automatically return to normal position; each relief movement of member 91 need be but a few thousandths of an inch.

In order to accommodate the increased thickness of the parts including member 91, springs 94, backing member 97 and spring adjustment screws 100, it will be necessary to lengthen shaft 31 which carries pinion E as well as some of the other shafts, for example, the shafts that carry gear H and pinion G.

The compacting device is enclosed within a casing 101 which is secured to the bed plate 42 of the device. An opening is provided in one wall thereof to accommodate spout 60 (Fig. 3) and a flexible bellows-like member 102 secured to the spout 60 and to the walls of said opening as at 103, prevents the escape of the atmosphere within the casing through the opening for spout 60. Casing 101 which encloses the compacting device is provided with an inlet 104 adapted to be connected to a source of supply of a gas which is inert to titanium such as argon gas, helium, etc.

A series of four slide blocks 105 preferably formed of copper, are substituted for contact rolls 55 of said Southern application 211,887. Slide blocks 105 are pivotally mounted on the distal ends of support arms 106 and are held in contact with the four sides of the electrode stick 107 by a spring 108 which encircles arms 106 and takes the place of spring 53 of said Southern application.

A housing 109 is secured to the underside of bed plate 42 of the compacting device and since it is in open communication with enclosing casing 101 for the compacting device by opening 110 at the center of bed plate 42, this housing 109 is also filled with the same atmosphere as housing 101.

Housing 109 is provided with a relatively heavy floor 111 which is preferably weld united to its side walls and forms a support for the base member 112 for the pivotal mounting portions 113 of the four arms 106 which carry contact blocks 105. Base 112 is preferably formed of copper and is electrically insulated from floor 111. Current of one potential (negative) is supplied to base member 112 by a supply line 114 which passes through an insulating bushing 115 in the side wall of housing 109 and is connected to a projecting lug 112a of base 112.

Housing 109, as well as the compacting device and its housing 101 is supported from the smelting furnace or crucible 116 by means of an annular water cooled spacer member 117. This spacer member is provided with water inlet 118 and water outlet 119 and with a central through passage which is preferably circular in cross section and with a diameter slightly greater than the greatest diagonal dimension of the electrode stick which is fed downwardly therethrough and into the smelting furnace or crucible 116.

Crucible or smelting furnace 116 is preferably of the same construction as that in said Southern application 211,887. The crucible proper is water jacketed and insulated from its top portion 120 which is connected as at 121 to the positive pole (by line 122) of a suitable motor generator set 123. Top 120 of the crucible or smelting

furnace 116 is provided with an outlet pipe 124 which serves as an outlet for the combined structure disclosed in Figure 8; embodying the complete apparatus except for the reaction chamber or device of Figures 9-12 inclusive.

The inert gas entering inlet pipe 104 adjacent the upper end of housing 101 for the compacting device flows into housing 109 through opening 110 in bed plate 42 of the compacting device, passes from housing 109 down through the central opening in spacer member 117 around the electrode stick and into crucible or smelting furnace 116. From such crucible or smelting furnace, it flows through outlet pipe 124. A constant slow moving stream of inert gas preferably fills the different compartments of the integrated device and passes out through outlet pipe 124; it being understood that the integrated device has been evacuated before the inert gas is fed into the same.

What we claim is:

1. In apparatus for making electrode sticks in a continuous manner from sponge or finely divided difficultly reducible metallic material including titanium, the combination of a pair of compacting members mounted for horizontal reciprocation between the parallel smooth flat surfaces of a pair of side members, such compacting members having opposed inclined stepped faces, the space bounded by such inclined stepped faces and the flat faces of said side members forming a compression chamber which diminishes in cross section from its top to its bottom in a step by step manner, means for effecting simultaneous reciprocation of said compacting members horizontally in opposite directions toward and from the vertical center line of such compression chamber, means for simultaneously raising and lowering said pair of compacting members in synchronism with such horizontal reciprocations, means for supplying to said compression chamber the material to be compacted to stick form, and means below said compression chamber for gripping the formed stick and moving the same downward in synchronism with the downward movements of said compacting members; the up and down movements of the compacting members being adjusted with relation to their horizontal reciprocations so that as said compacting members reach the limit of their outward or relief movements away from said vertical center line, they also reach the limit of one of their upward movements, and reach the limit of one of their inward or compacting movements toward such center line as they reach the limit of one of their downward movements.

2. A structure as defined in claim 1, in which the means for effecting simultaneous reciprocations of the compacting members in opposite directions comprises cam-like members.

3. A structure as defined in claim 1, in which the means for simultaneously raising and lowering the compacting members comprises cam-like members and rollers having fixed axes.

4. A structure as defined in claim 1, in which the means below the compression chamber for gripping the formed stick and moving the same downward comprises pinch rolls.

5. A structure as defined in claim 4, in which the vertical position of the pinch rolls is fixed and the compacting members are moved both horizontally and vertically with relation to such pinch rolls.

6. A structure as defined in claim 4, in which the means for supplying to the compression chamber the material to be compacted to stick form takes the form of a chute leading from a source of supply of such material and in which such chute is blocked off from the compression chamber during inward and downward movements of the compacting members.

7. A structure as defined in claim 6, in which the member blocking off the chute is movable with relation to the compacting members, but in synchronism with their movements.

8. A structure as defined in claim 1 in which said means for simultaneously raising and lowering said pair of compacting members in synchronism with such horizontal reciprocations has operating elements to raise and lower the compacting members a distance equal to the vertical height of one of the steps of the opposed inclined faces of said compacting members.

9. Apparatus for making electrode sticks in a continuous manner from sponge or finely divided difficultly reducible metallic material including titanium which comprises, side support members, a pair of compacting members operatively positioned for opposing reciprocation between said side members to compact the material into stick form, said compacting members having opposed stepped faces defining a compression chamber which diminishes in cross section in a step by step manner, means operatively connected for moving said compacting members toward and away from each other and transversely of the compression chamber and for simultaneously moving said compacting members longitudinally with respect to the compression chamber, and means for supplying the compression chamber with material to be compacted to stick form.

10. Apparatus as defined in claim 9 wherein, means is positioned for gripping the formed stick and moving it from the compression chamber in synchronism with the longitudinal movement of said compacting members.

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