Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 1

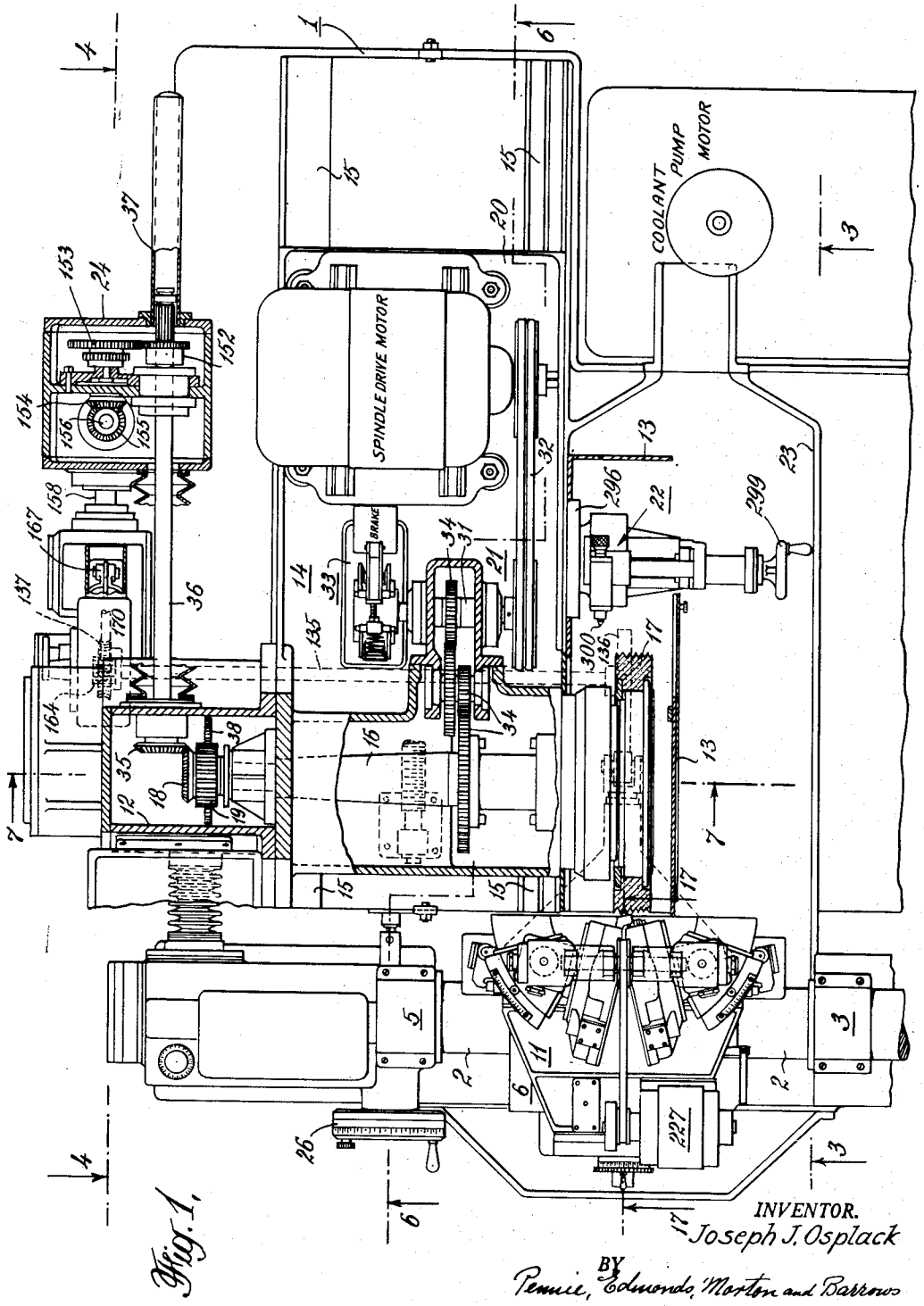


Fig. 1.

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 2

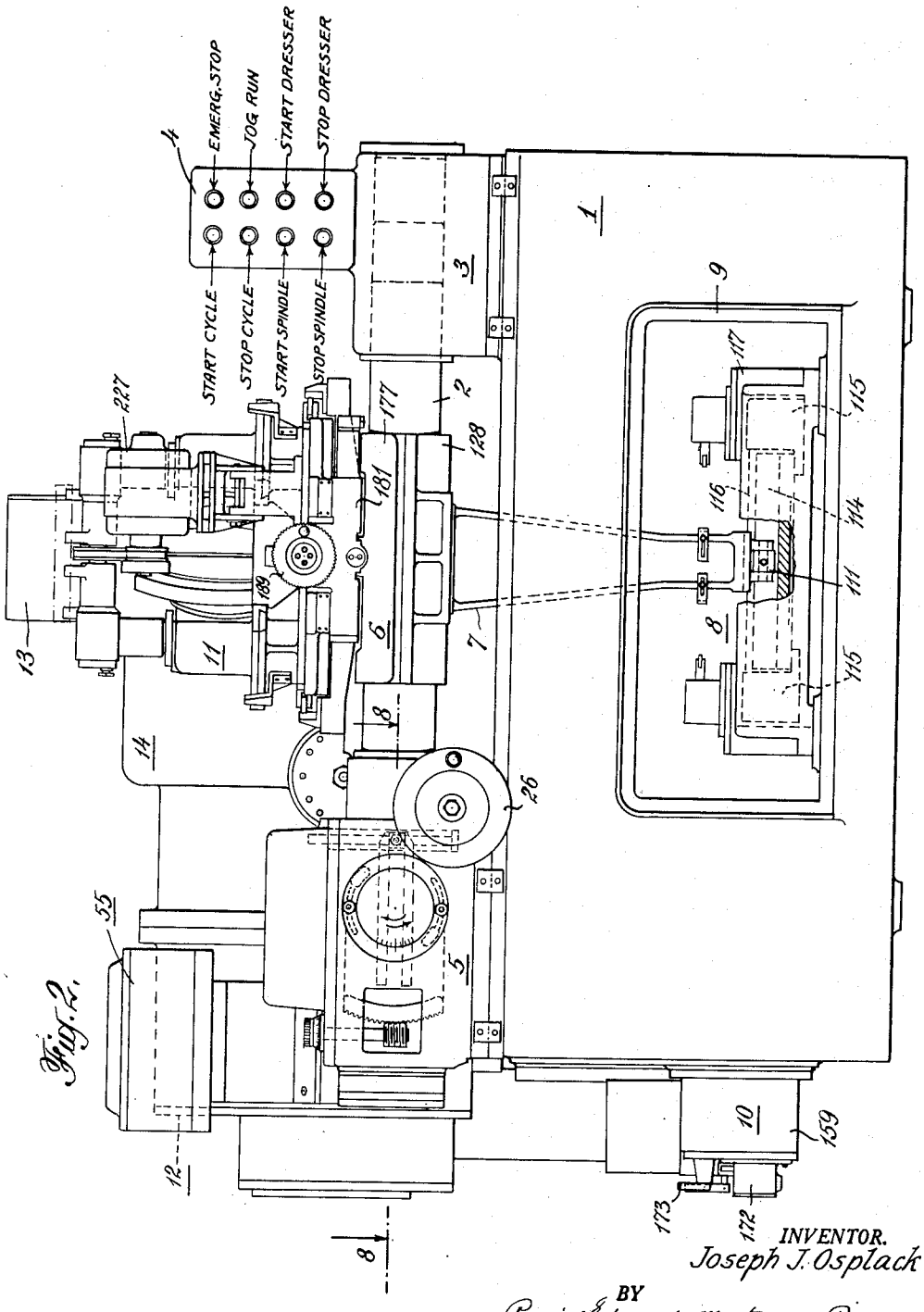


Fig. 2.

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 3

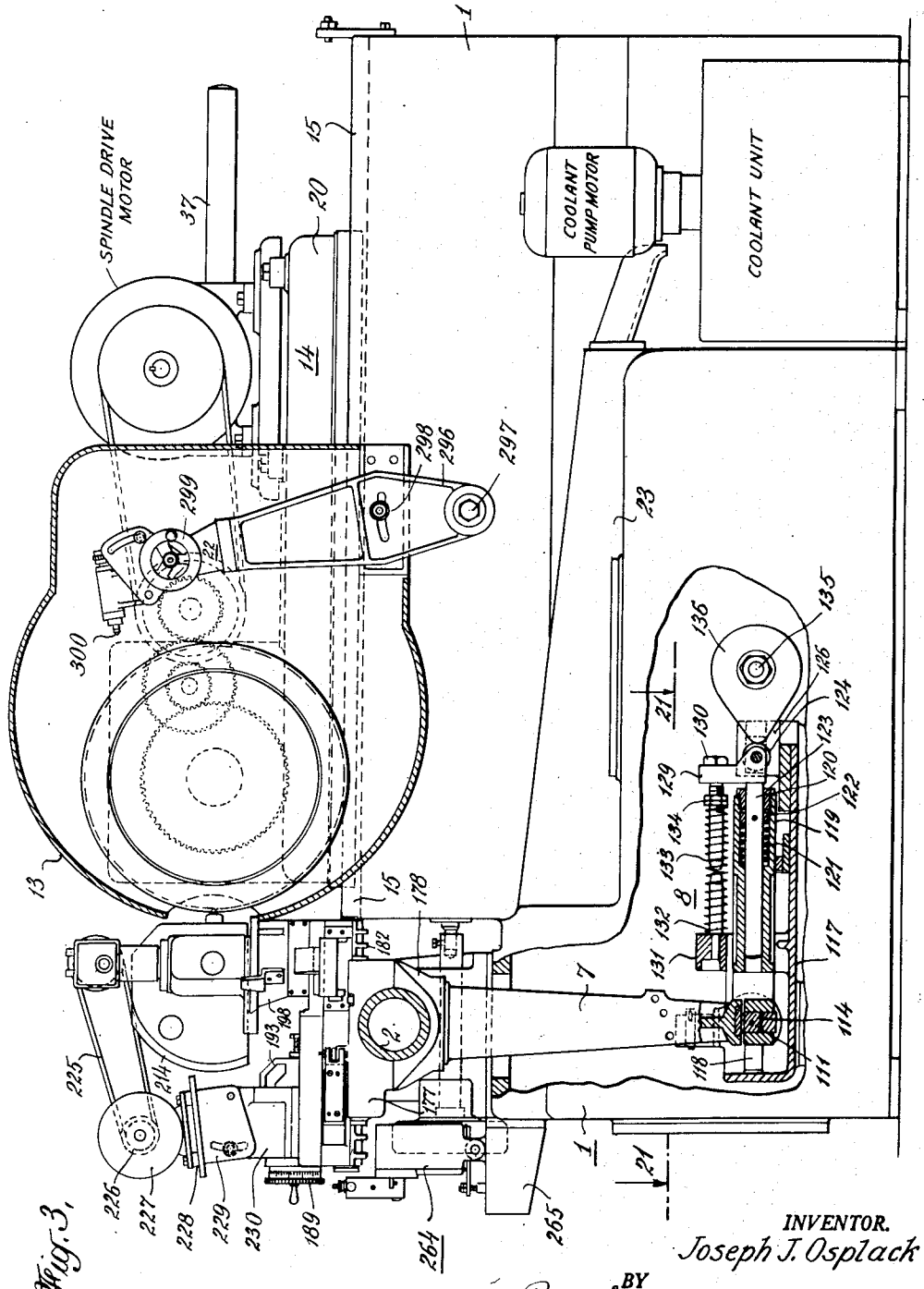


Fig. 3.

INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 4

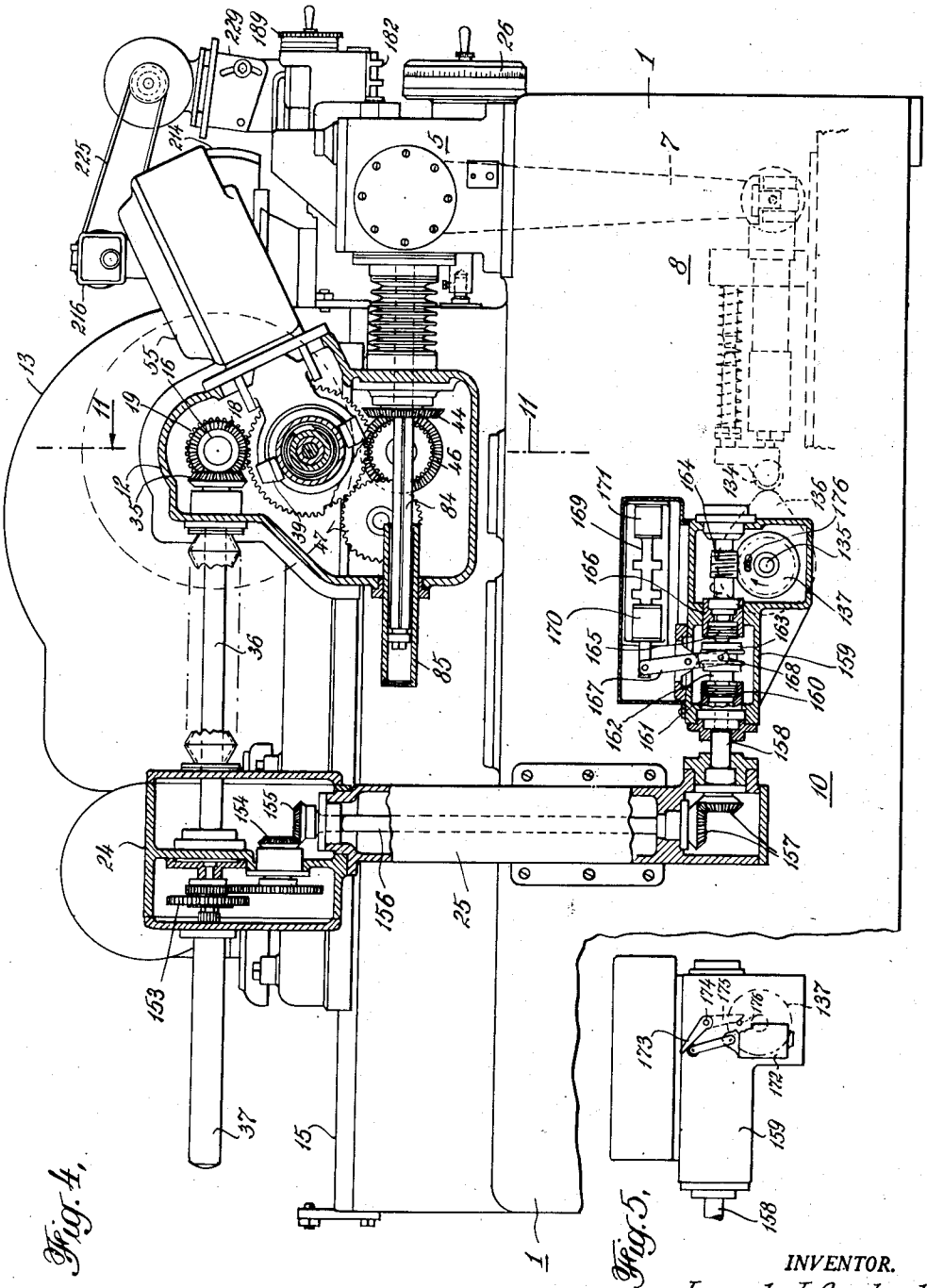


Fig. 4.

Fig. 5.

INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 5

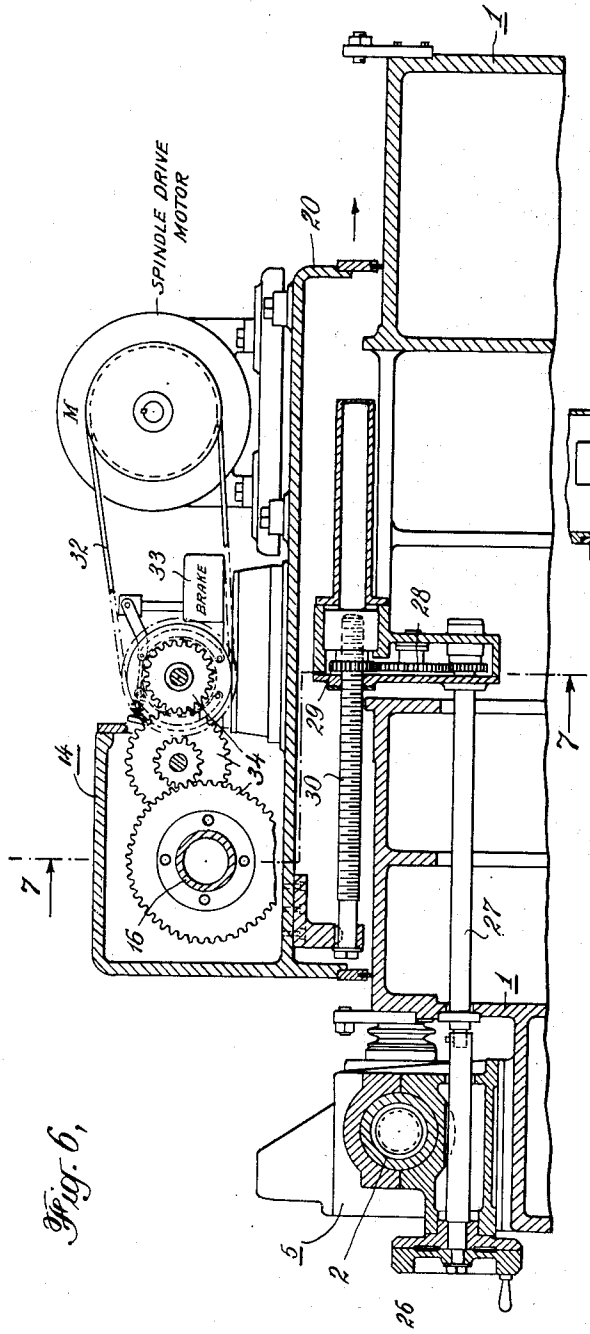


Fig. 6,

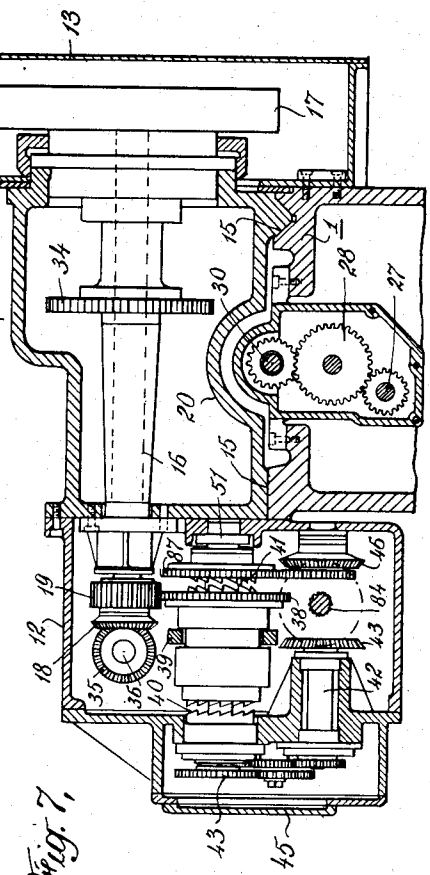


Fig. 7,

INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949

22 Sheets-Sheet 6

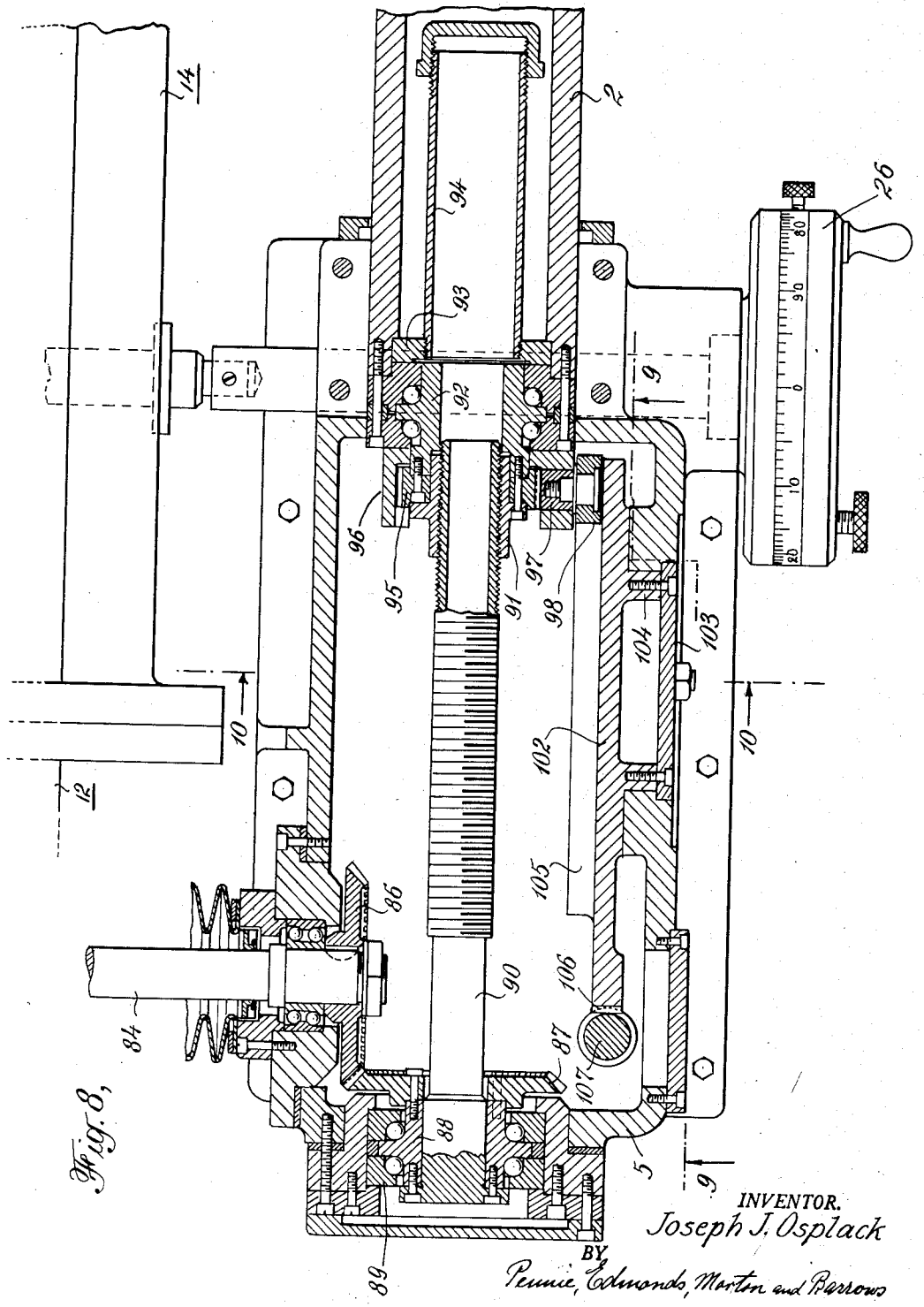


Fig. 8,

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 7

Fig. 10,

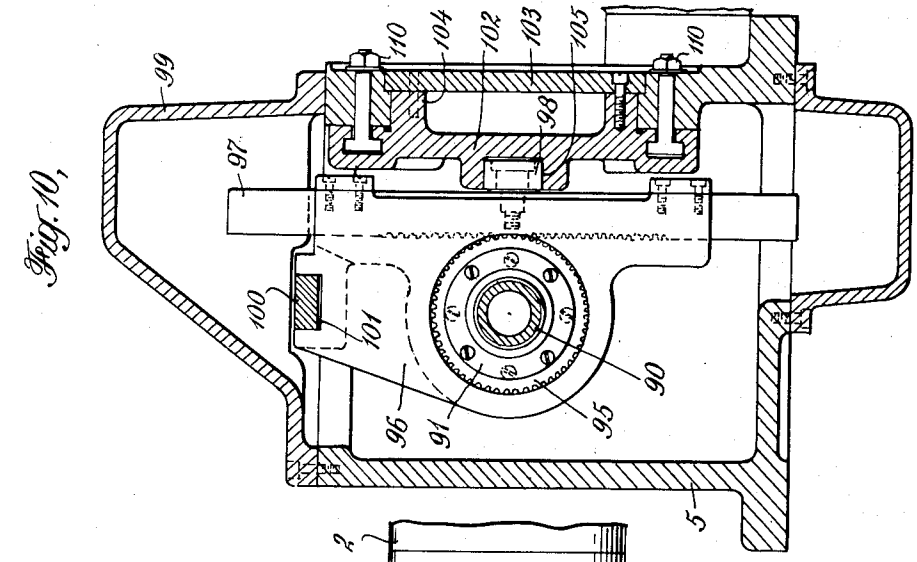
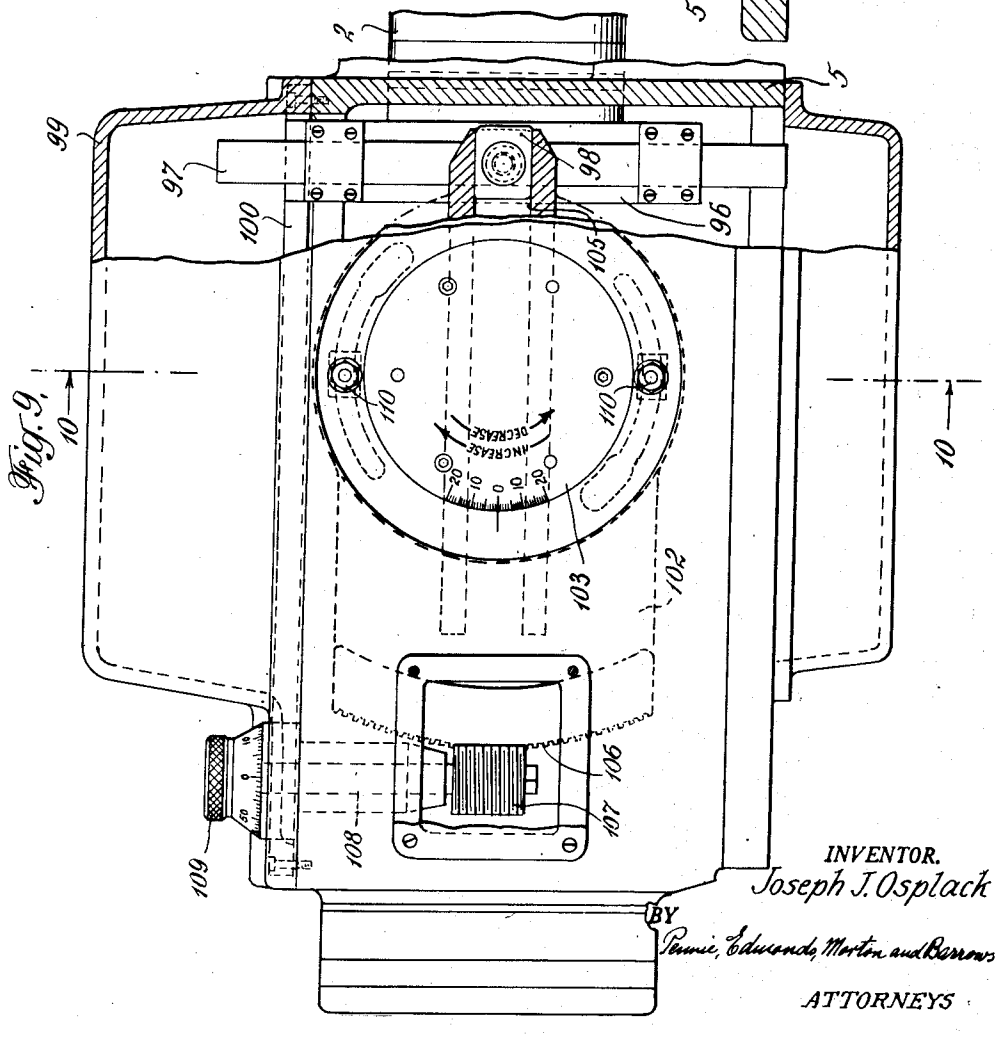


Fig. 9,



INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 8

Fig. 11,

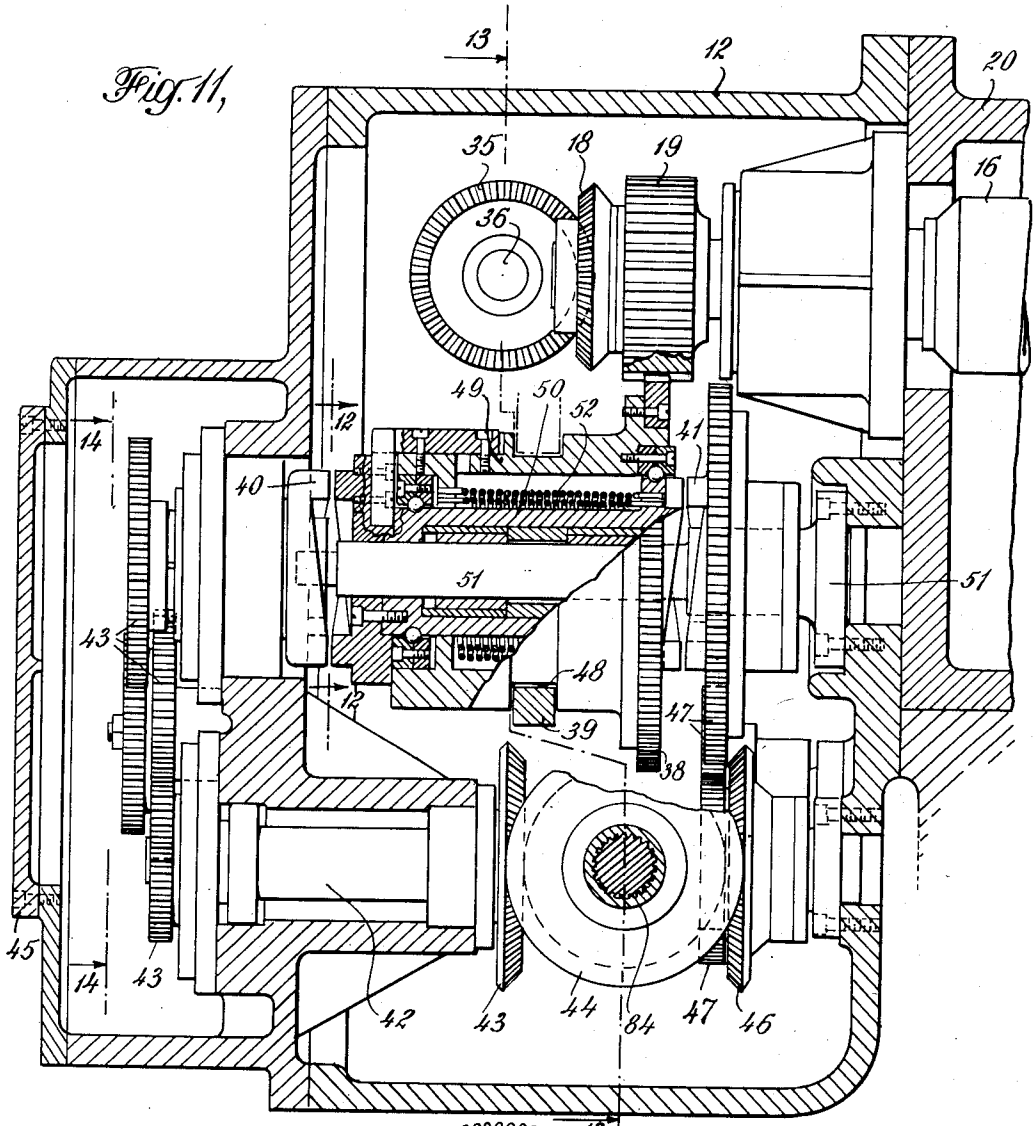
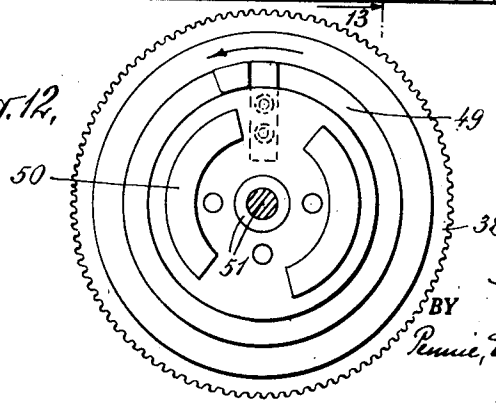


Fig. 12,



INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 9

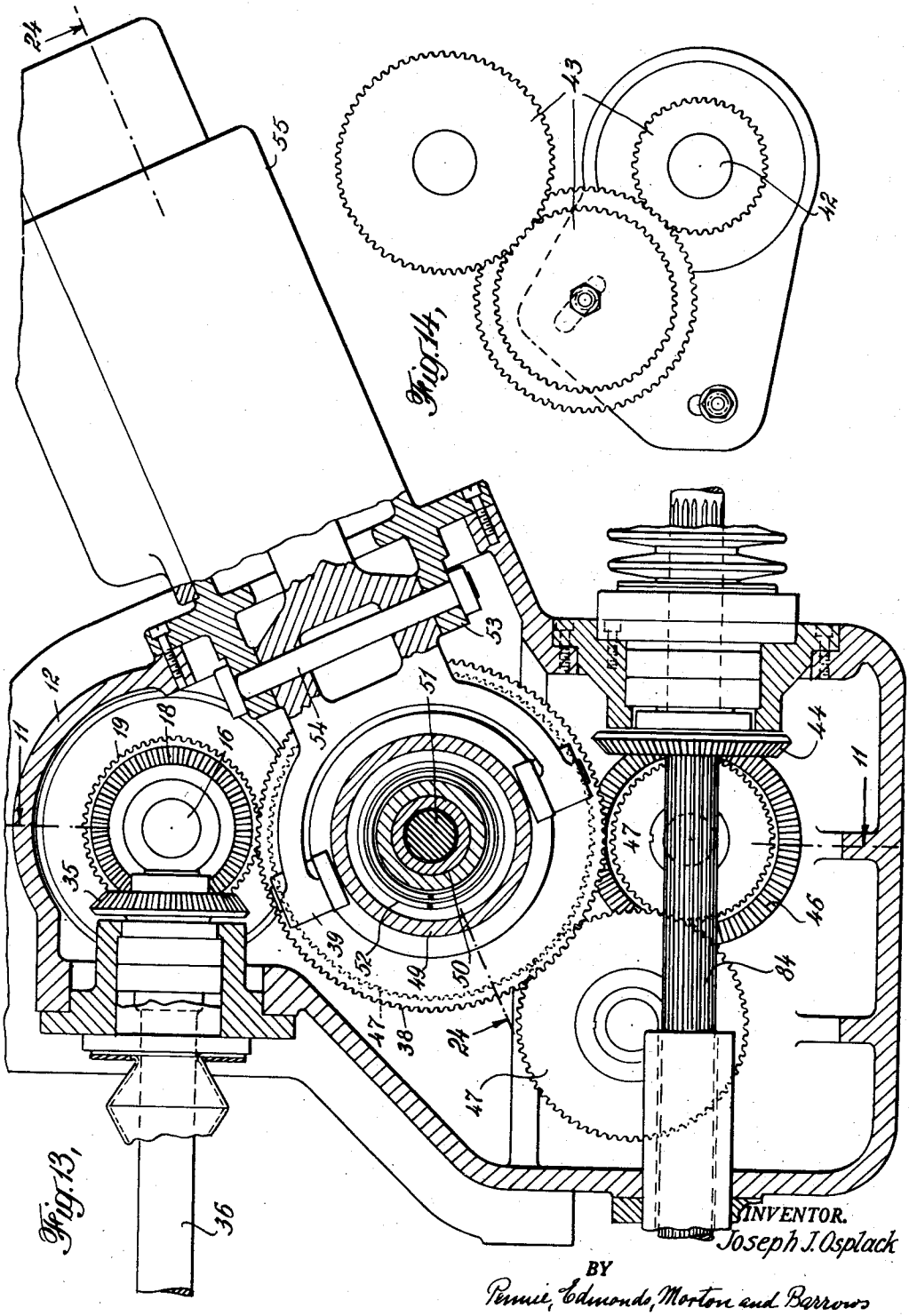


Fig. 14,

Fig. 13,

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949

22 Sheets-Sheet 10

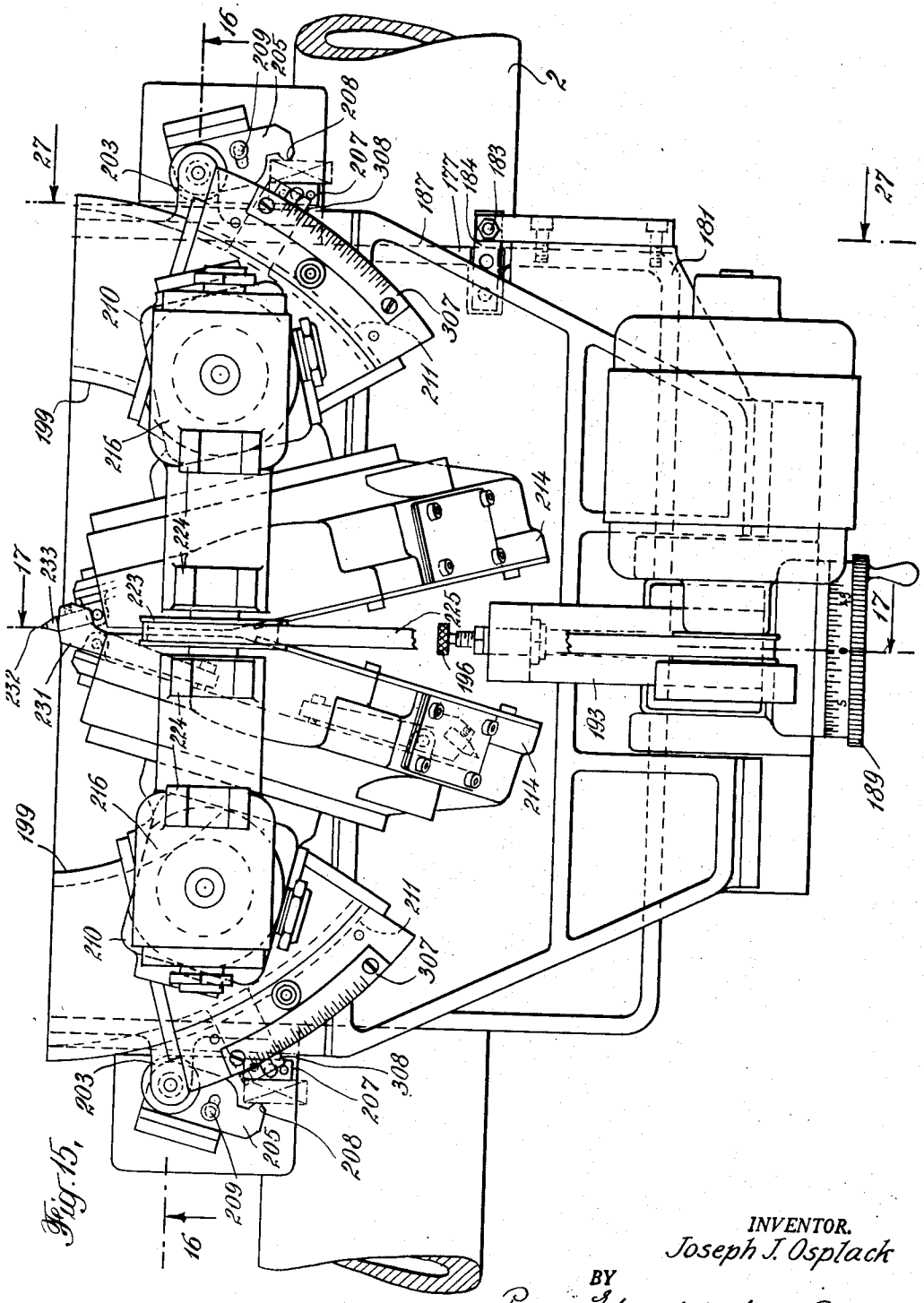


Fig. 15.

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 11

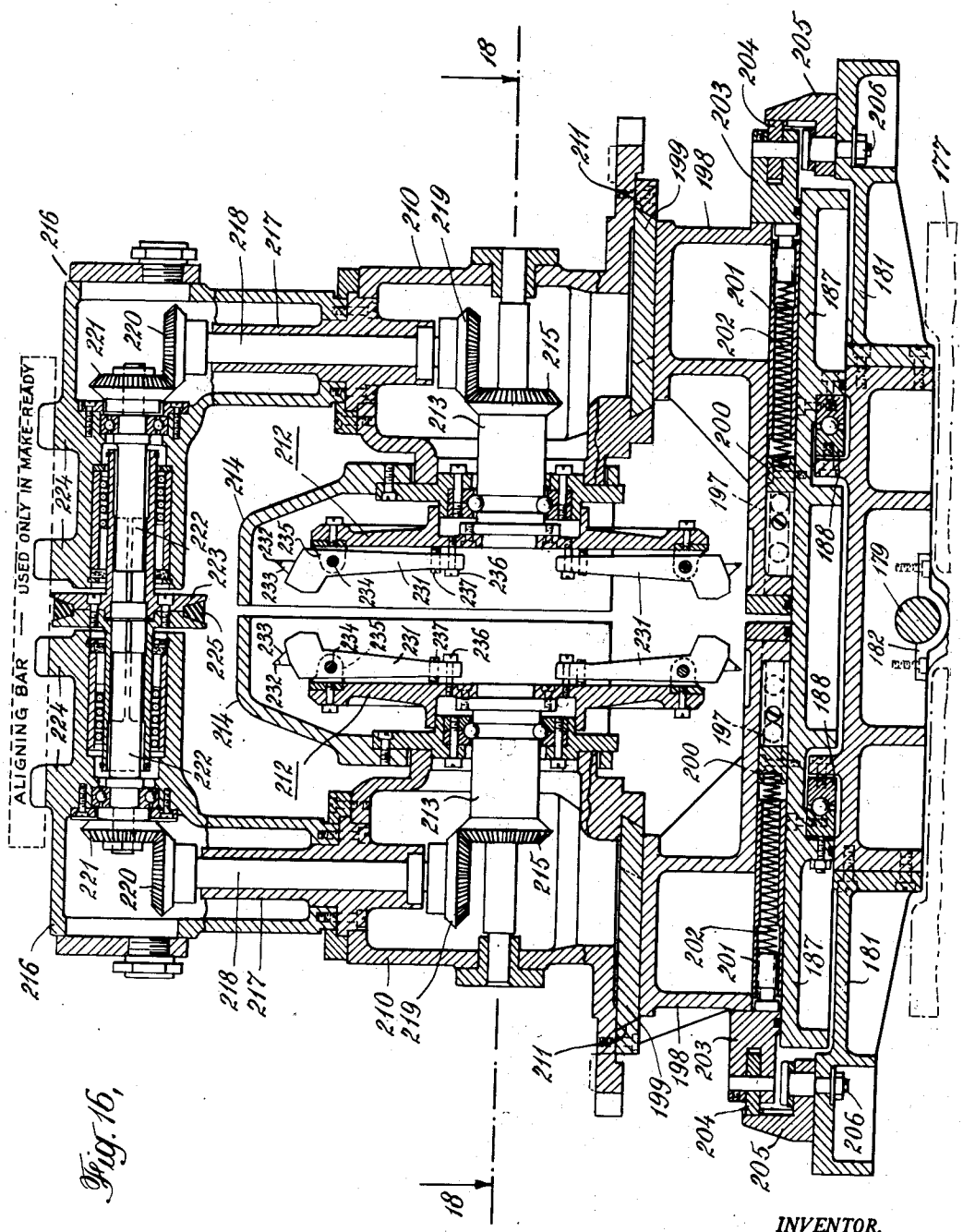


Fig. 16.

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

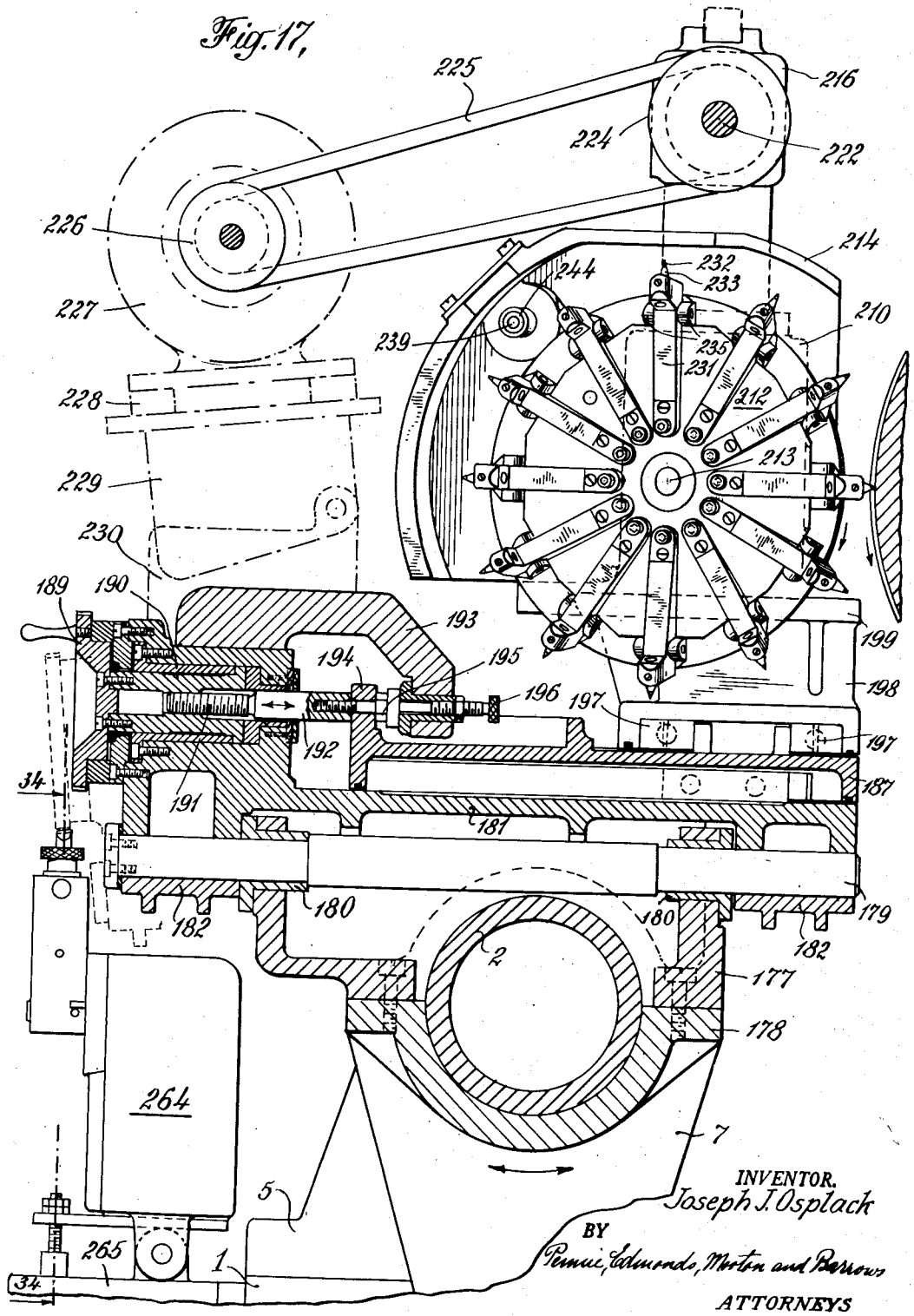
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 12

Fig. 17.

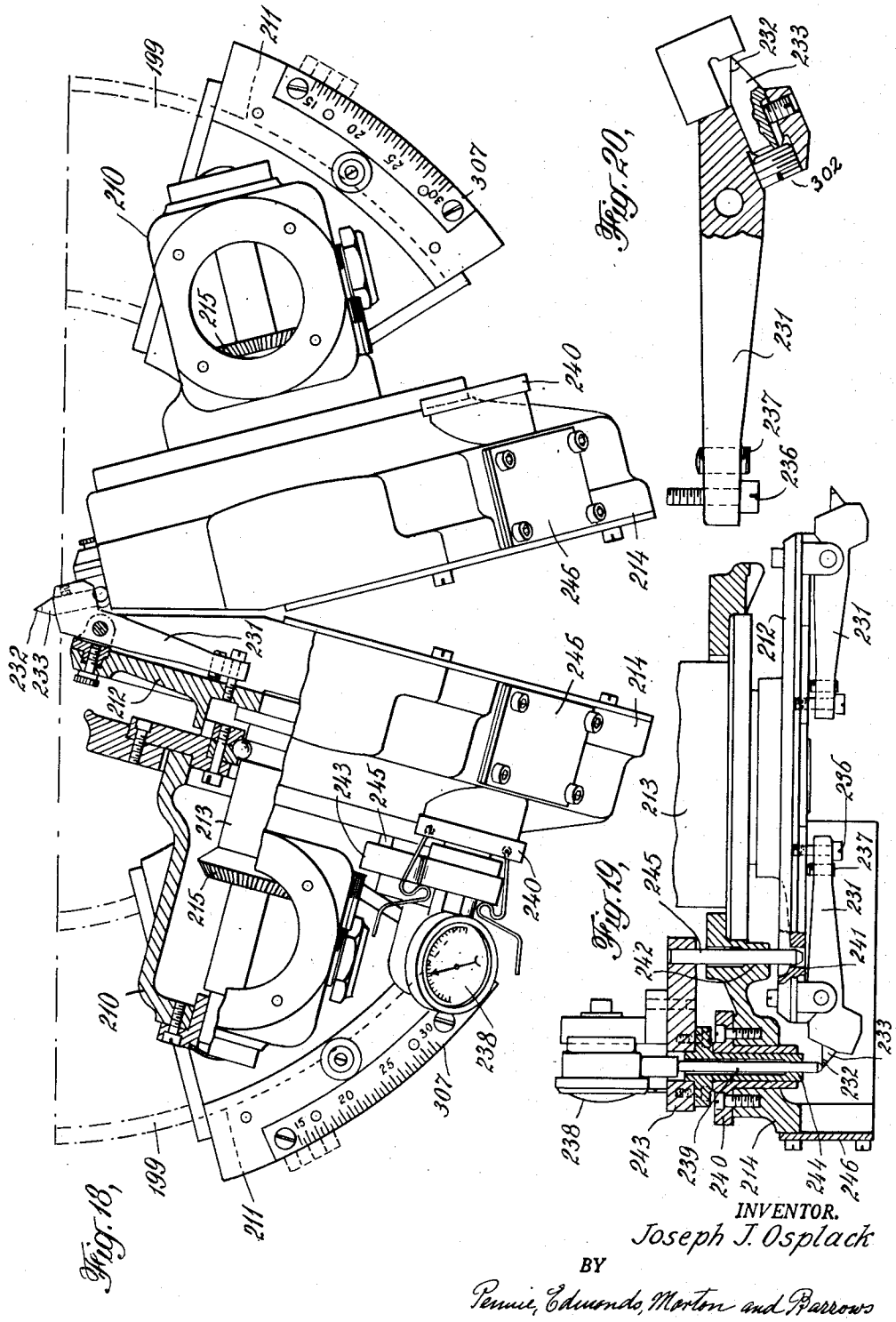


INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 13



INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 14

Fig. 21,

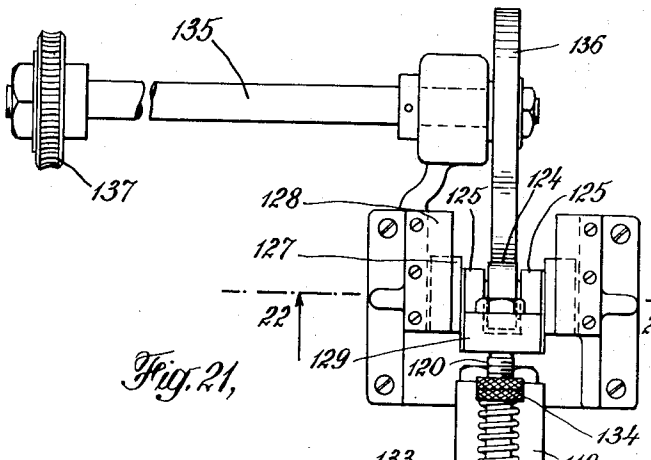


Fig. 22,

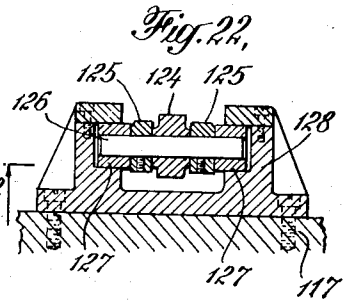
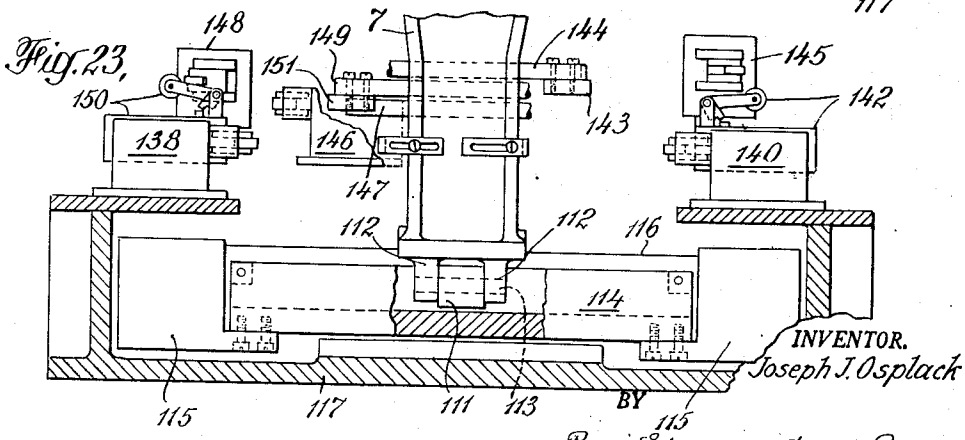


Fig. 23,



INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 15

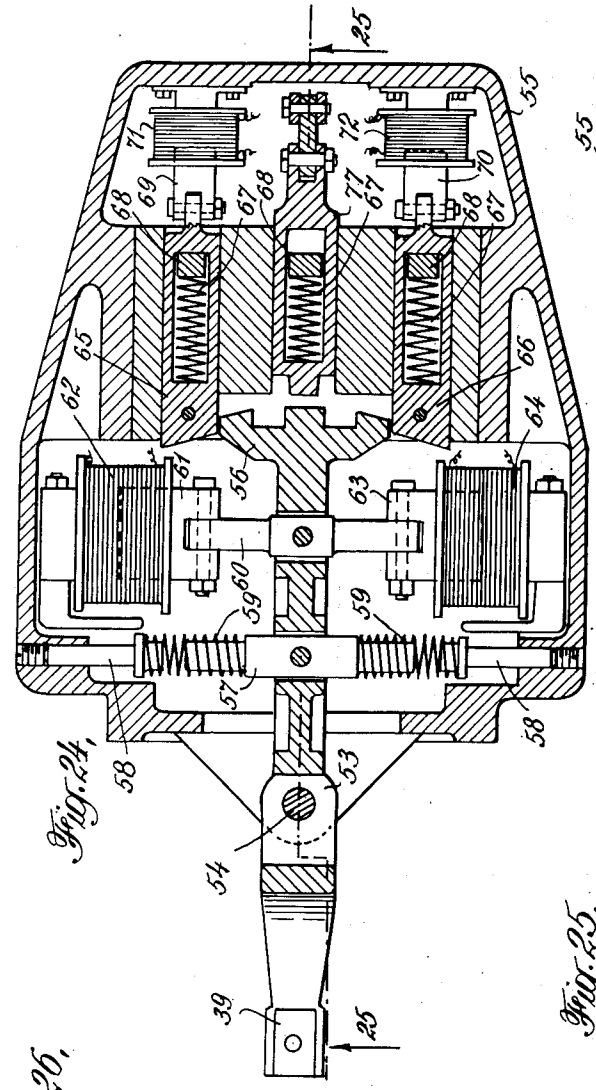


Fig. 24.

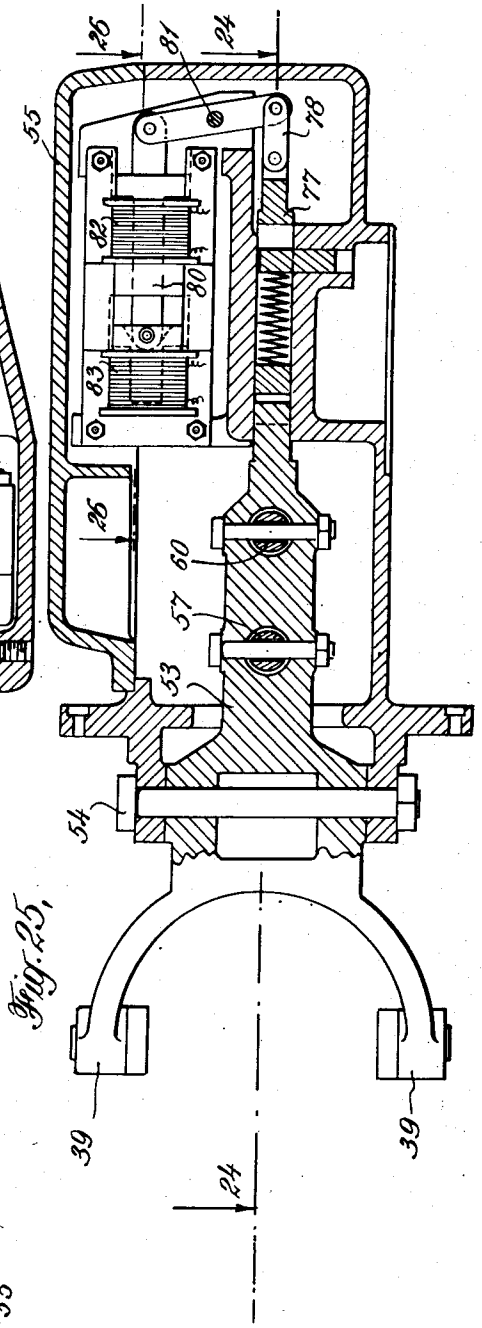


Fig. 25.

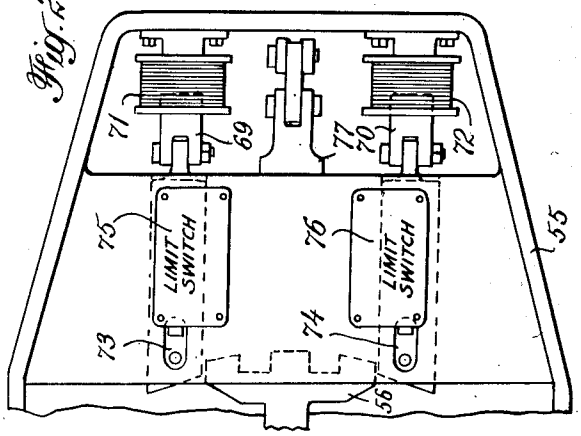


Fig. 26.

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 16

Fig. 27,

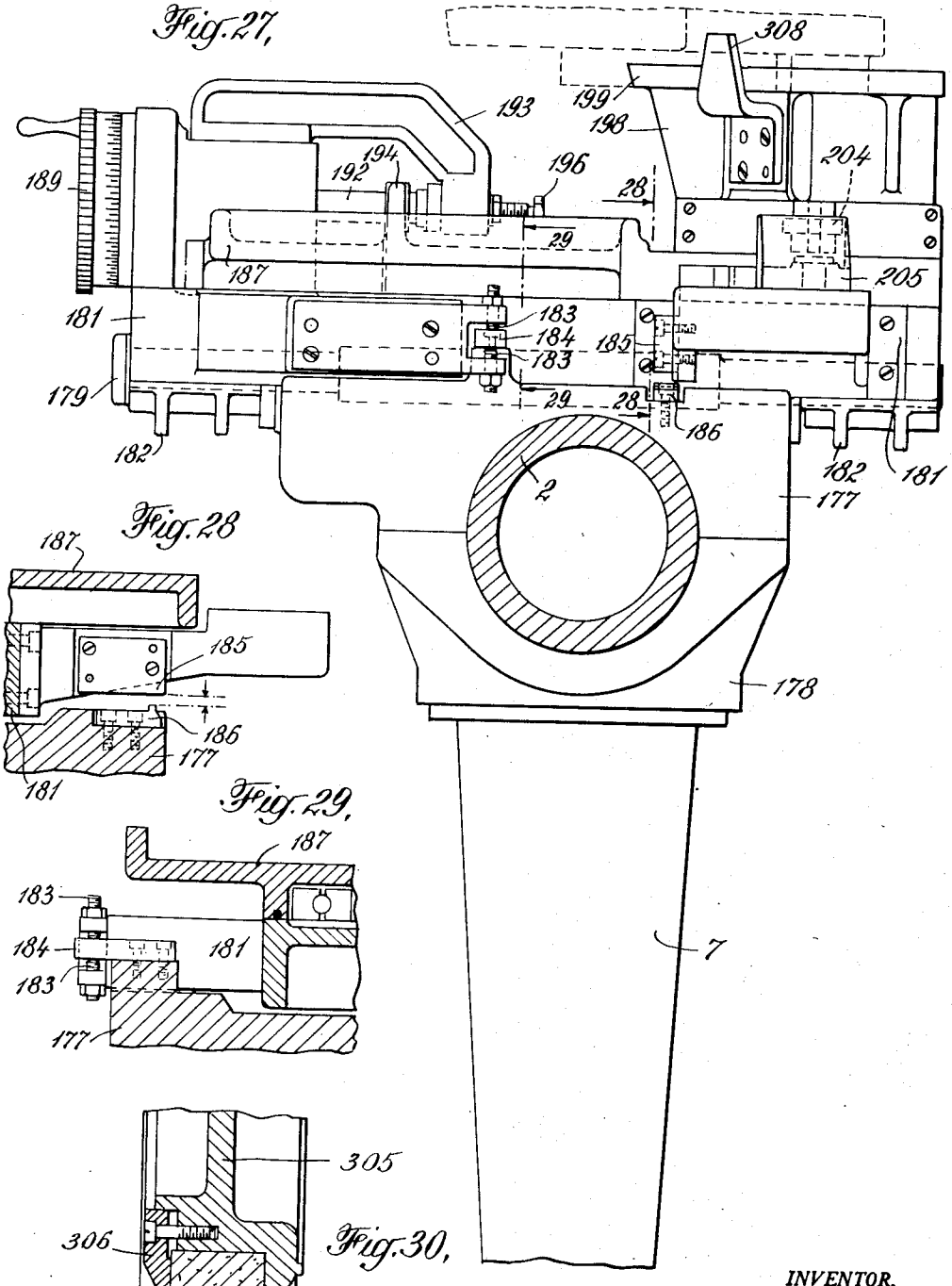


Fig. 28

Fig. 29,

Fig. 30,

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 17

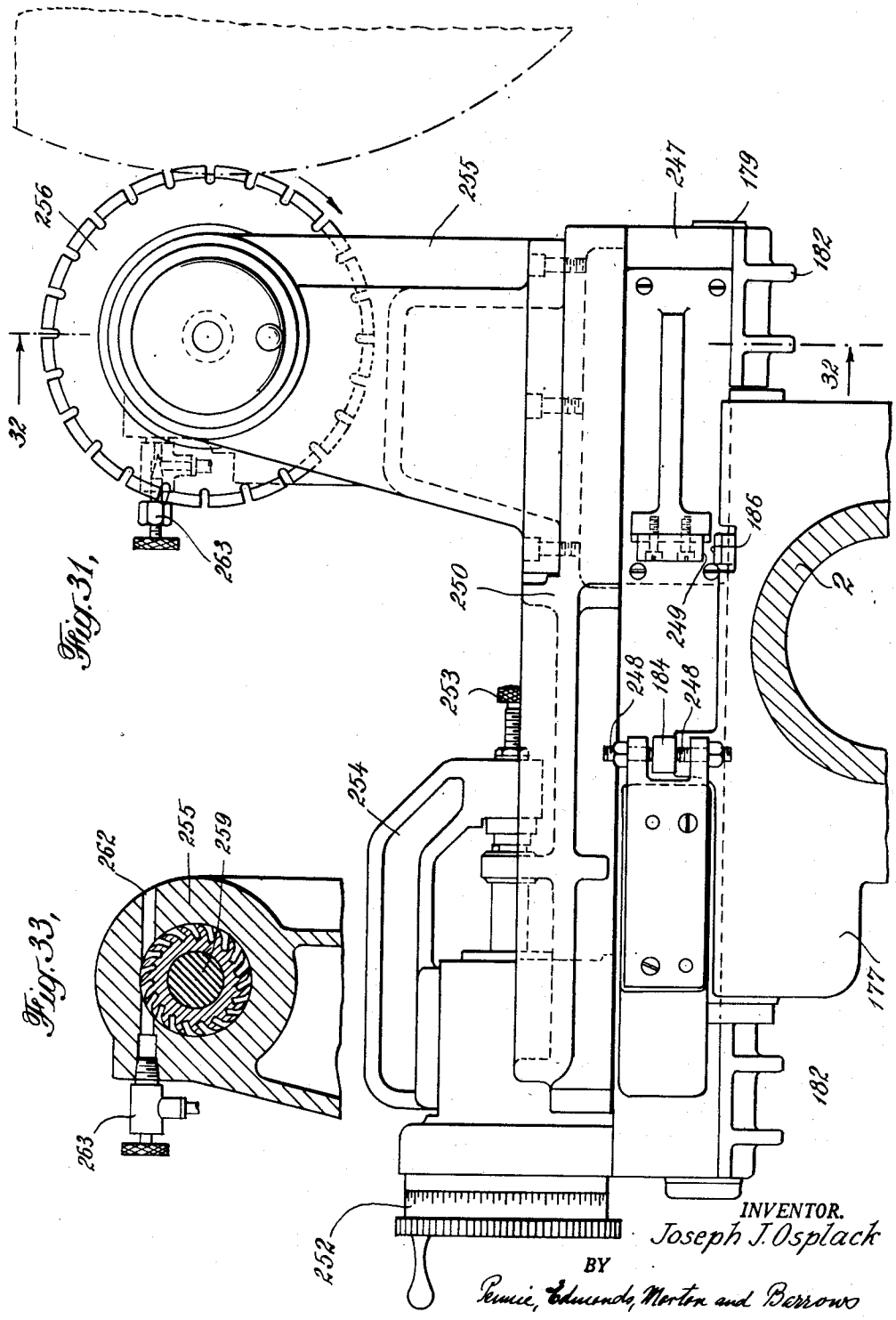


Fig. 31,

Fig. 33,

INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

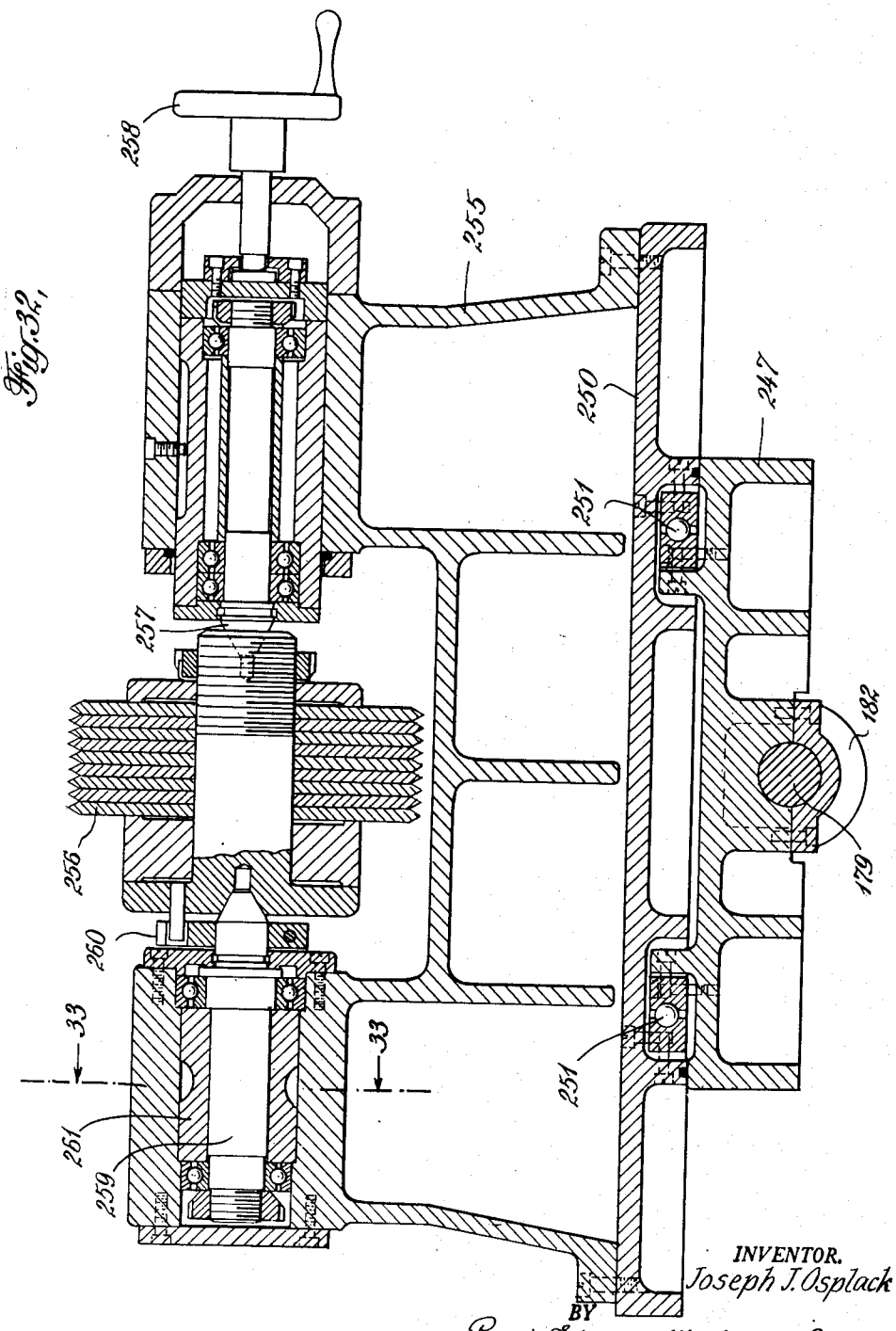
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 18

Fig. 32,



INVENTOR.
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows

ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 19

Fig. 34,

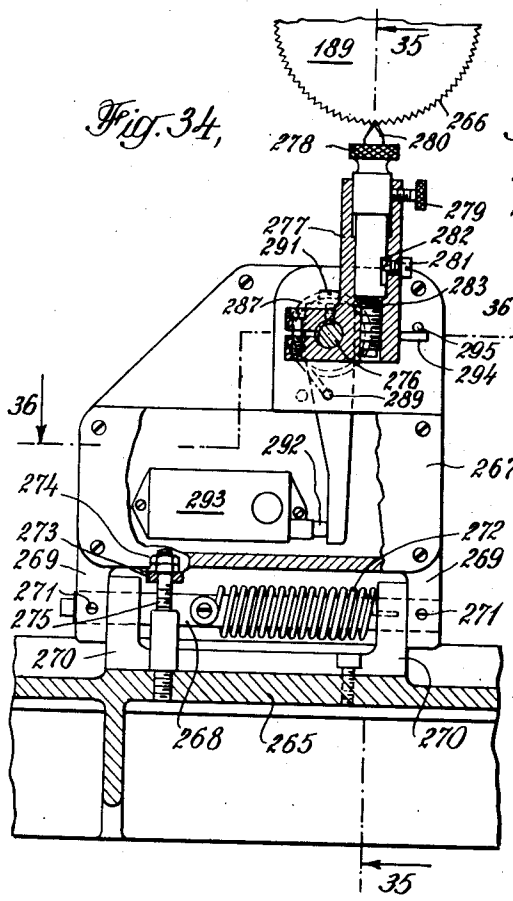


Fig. 35,

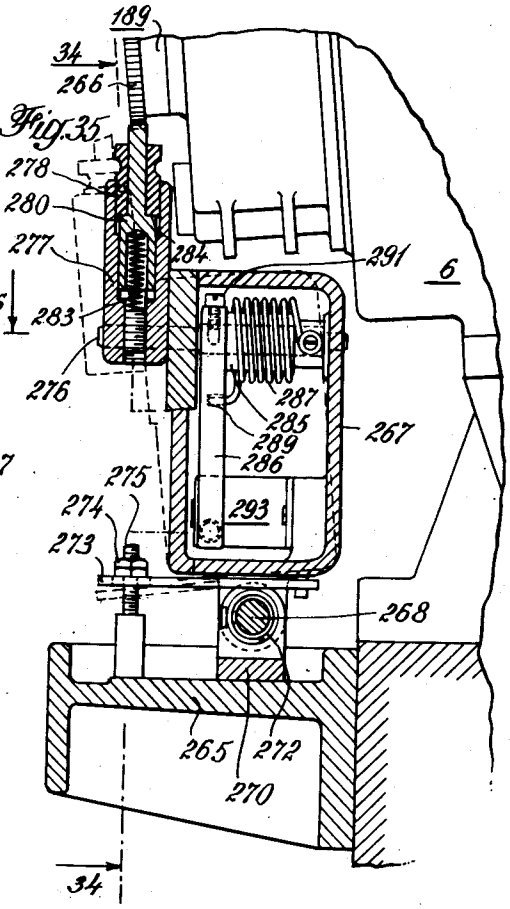


Fig. 36,

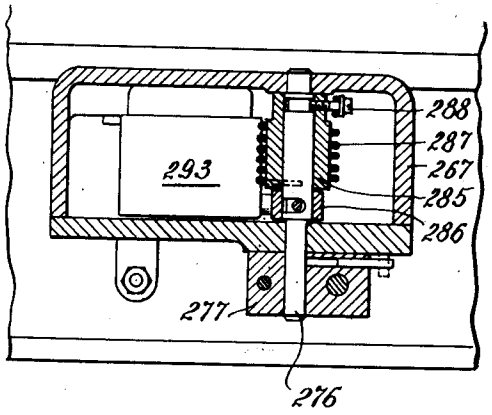
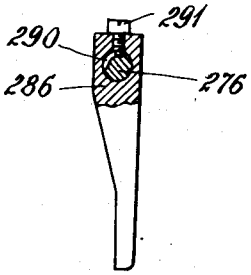


Fig. 37,



INVENTOR
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 20

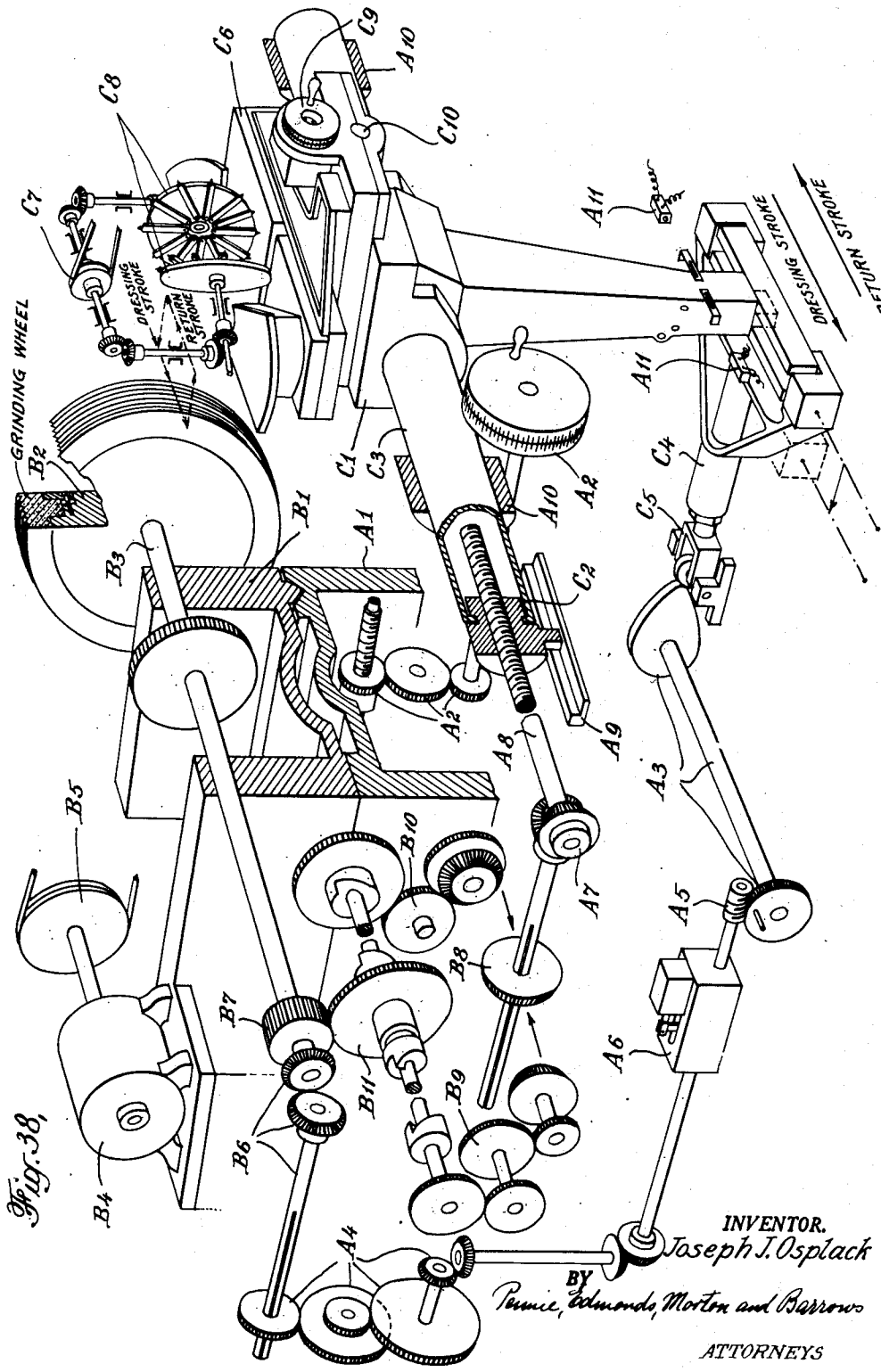


Fig. 38.

INVENTOR.
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949 22 Sheets-Sheet 21

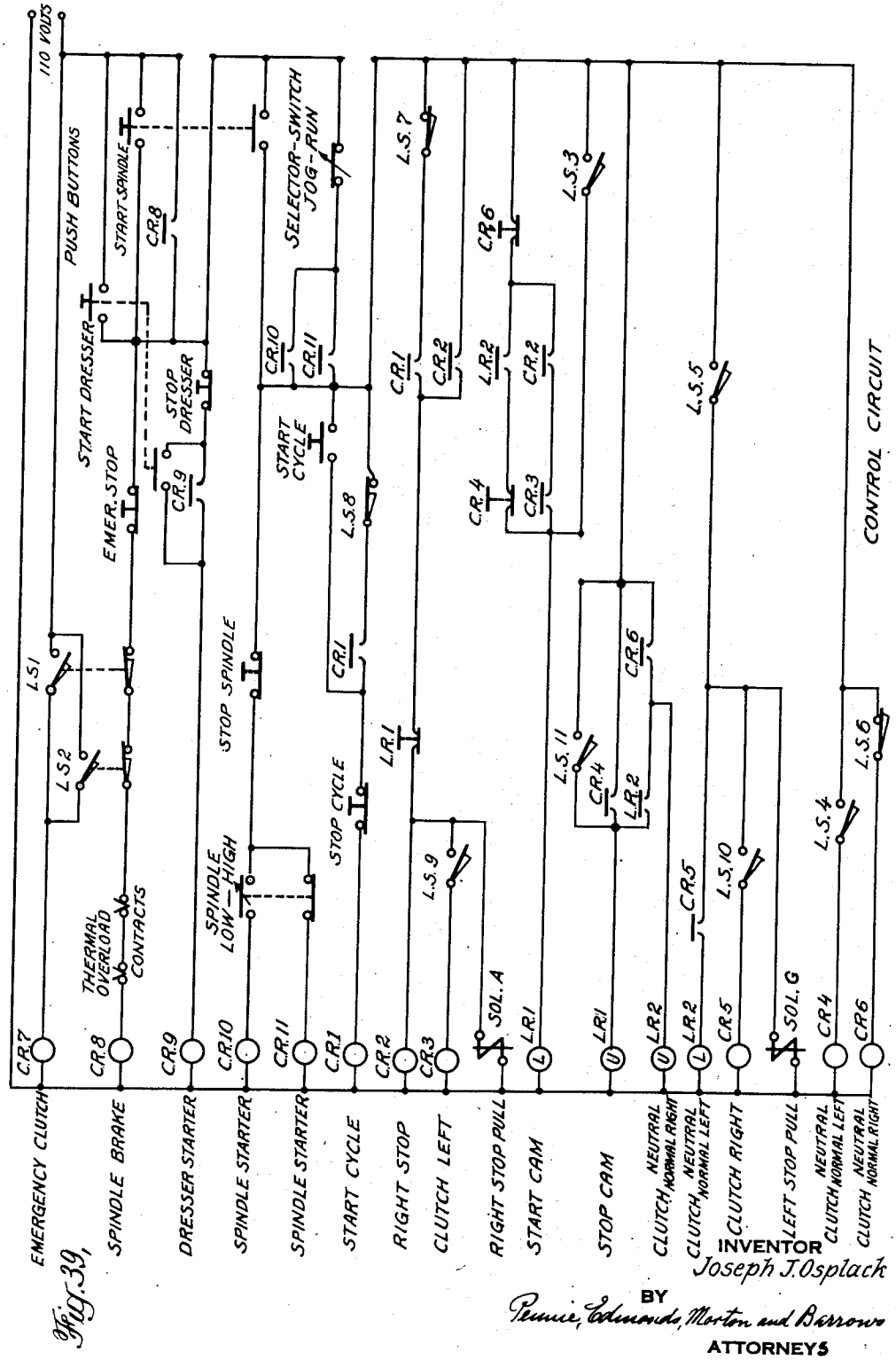


Fig. 39.

INVENTOR
Joseph J. Osplack

BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Nov. 17, 1953 J. J. OSPLACK 2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Filed Oct. 21, 1949

22 Sheets-Sheet 22

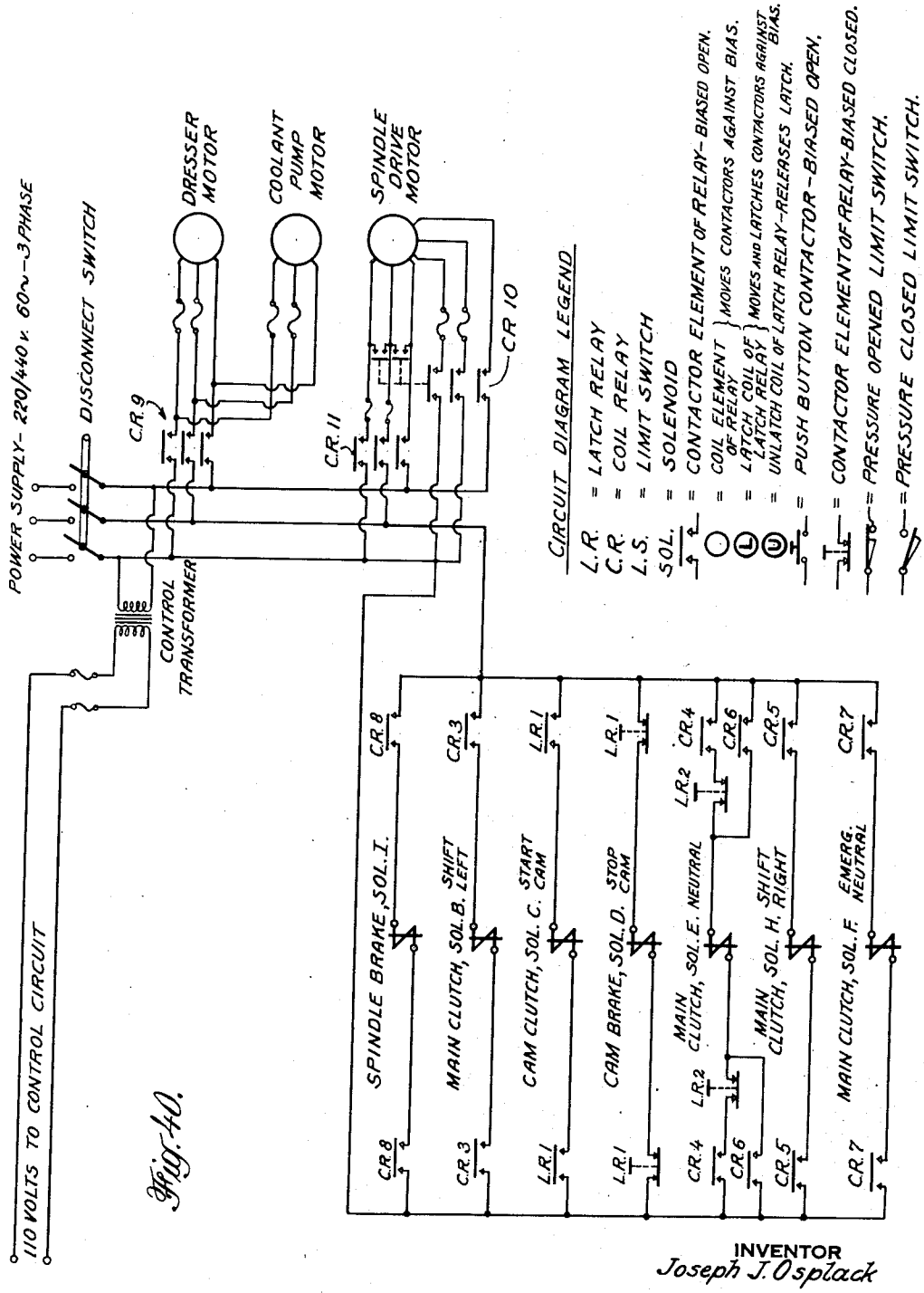


Fig. 40.

INVENTOR
Joseph J. Osplack
BY
Pennie, Edmonds, Morton and Barrows
ATTORNEYS

Patented Nov. 17, 1953

2,659,357

UNITED STATES PATENT OFFICE

2,659,357

METHOD AND APPARATUS FOR DRESSING HELICAL GRINDING WHEELS

Joseph J. Osplack, Detroit, Mich., assignor to Vinco Corporation, Detroit, Mich., a corporation of Michigan

Application October 21, 1949, Serial No. 122,686

12 Claims. (Cl. 125—11)

1

My invention relates to a method and apparatus for forming threads on the periphery of wide face grinding wheels and, especially, to a method and apparatus for dressing such threads with sufficient precision to enable them to be used in the hobbing grinding of gears.

Broadly speaking, the method of the invention is to move a rotating diamond support carrying a plurality of dressing diamonds to bring the diamonds rapidly successively into engagement with a rotating wheel to be dressed, the diamonds and the wheel surface having different linear speeds, while precisely controlling the relative axial and radial motions of the two rotating parts. Employment of this method will produce a greater precision in the resulting thread on the grinding wheel face than any method now known to me. Where the thread to be dressed is relatively coarse, a preliminary crushing step may be advantageously used to rough out the threads before dressing them to final form in order to conserve the precision dressing diamonds on the rotating diamond support.

In order advantageously to carry out the method of this invention, I have also invented an automatic machine for forming and dressing threads on grinding wheels capable of automatically carrying to completion a crushing stage, when required, and, upon resetting if a crushing stage has been employed, the final dressing stage. A machine according to my invention may be efficiently employed to form and dress hobbing grinding wheels at a rate sufficient to supply 75–100 gear hobbing grinders working at capacity.

In order to make more concrete the description of my method, I shall first proceed to a general description of the principles of construction and operation of automatic apparatus of my invention together with the governing theoretical considerations underlying the essential steps of my method. I shall then describe in detail the construction and operation of the preferred embodiment of my invention illustrated in the accompaning drawings, in which:

Fig. 1 is a partial plan view partially in section of an automatic dressing machine according to my invention;

Fig. 2 is a front view of a machine illustrated in Fig. 1 with certain parts omitted for clarity;

Fig. 3 is a transverse vertical section taken on the line 3—3 of Fig. 1;

Fig. 4 is a section taken on the line 4—4 of Fig. 1;

Fig. 5 is a detail showing the location of a switch controlling the multiple diamond wheel carriage motion;

2

Fig. 6 is a partial transverse vertical section taken on the line 6—6 of Fig. 1;

Fig. 7 is a partial longitudinal vertical section taken on the line 7—7 of Figs. 1 and 6;

Fig. 8 is a partial horizontal section on an enlarged scale taken on the line 8—8 of Fig. 2;

Fig. 9 is a longitudinal vertical section taken on the line 9—9 of Fig. 8;

Fig. 10 is a transverse vertical section taken on the line 10—10 of Figs. 8 and 9;

Fig. 11 is a vertical longitudinal section on an enlarged scale taken on the line 11—11 of Fig. 4;

Fig. 12 is a detailed axial view of the clutch taken on the line 12—12 of Fig. 11;

Fig. 13 is a transverse vertical section taken on the line 13—13 of Fig. 11;

Fig. 14 is an axial view of a change gear arrangement taken on the line 14—14 of Fig. 11;

Fig. 15 is a plan view showing in detail the multiple diamond supports;

Fig. 16 is a vertical longitudinal section taken on the line 16—16 of Fig. 15;

Fig. 17 is a transverse vertical section taken on the line 17—17 of Fig. 15, and on an enlarged scale on the line 17—17 of Fig. 1;

Fig. 18 is a horizontal plan view partially in section taken on the line 18—18 of Fig. 16;

Fig. 19 is a detailed view showing the arrangement for precision location of the diamond points by means of a dial micrometer;

Fig. 20 is a detailed view partially in section showing the arrangement for setting the location of the diamond points on their carrier arms;

Fig. 21 is a plan section of the dresser carriage motion limiting mechanism taken on the line 21—21 of Fig. 3;

Fig. 22 is a detailed cross-section taken on the line 22—22 of Fig. 21;

Fig. 23 is a front view partially in section of the switch arrangement illustrated in Fig. 21;

Fig. 24 is a section taken on a line 24—24 of Fig. 13, with certain parts omitted for clarity, to illustrate the shifting and locking solenoids;

Fig. 25 is a section taken on the line 25—25 of Fig. 24;

Fig. 26 is a section taken on the line 26—26 of Fig. 25;

Fig. 27 is an end view partially in section of the rotating diamond support carriage taken on the line 27—27 of Fig. 15 to illustrate the precision adjustment thereof;

Fig. 28 is a detailed cross-section taken on the line 28—28 of Fig. 27;

Fig. 29 is a detailed cross-section taken on the line 29—29 of Fig. 27;

Fig. 30 is a detailed cross-section through the periphery of a grinding wheel to be dressed;

Fig. 31 is an end view illustrating the mounting of a crusher wheel on the dresser carriage;

Fig. 32 is a cross-section taken on the line 32—32 of Fig. 31;

Fig. 33 is a cross-section taken on the line 33—33 of Fig. 32;

Fig. 34 is an end view of the dresser depth feed limit mechanism taken on the line 34—34 of Fig. 17;

Fig. 35 is a vertical section taken on the line 35—35 of Fig. 34;

Fig. 36 is a horizontal section taken on the line 36—36 of Fig. 34;

Fig. 37 is a detailed view of the switch operating finger shown in Fig. 34;

Fig. 38 is an exploded isometric schematic drawing showing the general principles of construction and operation of the machine;

Fig. 39 is a circuit diagram illustrating the control circuit; and

Fig. 40 is a circuit diagram illustrating the power supply circuit.

General principles of construction and operation

The general principles of the construction and operation of a machine according to my invention are best illustrated in Fig. 38, which shows schematically the essential elements in their mutual operating relationship. The following discussion of general principles is made solely with reference to the schematic showing of Fig. 38 and the reference numerals employed will not be used to designate parts of the assembled machine shown in the other drawings.

The purpose of the machine sketched in Fig. 38 is to form and accurately dress a thread on the operating face of a grinding wheel to be used in a hobbing gear grinding operation. All the parts of that machine can be conveniently considered as belonging to one of three groups—those mounted on the stationary machine base A1, each of which will be designated in this general discussion by an appropriate reference numeral preceded by the letter "A"; those mounted on and movable with the grinding wheel spindle slide B1, each of which will be designated in this general discussion by an appropriate reference numeral preceded by the letter "B"; and those mounted on and movable with the dresser carriage member C1, each of which will be designated in this general discussion by an appropriate reference numeral preceded by the letter "C."

Considering the dresser carriage C1 to be at the front of the machine illustrated in Fig. 38, the grinding wheel to be dressed is clamped about the periphery of a grinding wheel adapter disc B2 which is mounted at the right-hand end of grinding wheel spindle shaft B3. Spindle B3 is journalled horizontally and transversely in spindle slide B1. A driving motor B4 mounted on slide B1 drives spindle B3 through a train of gears and pulleys generally indicated as B5. At the left-hand end of spindle B3, a splined shaft driven from the spindle by a pair of bevel gears, all carried by spindle slide B1, affords a take-off drive generally designated B6 for a timed front-to-rear rocking motion imparted to carriage C1. Between spindle drive B5 and take-off drive B6, a wide-faced spur gear B7 is keyed to spindle B3.

An internally splined bevel gear B8 is mounted on spindle slide B1 to afford a drive take-off for a transverse reciprocating motion of dresser carriage C1. Power from wide-faced gear B7 is transmitted to bevel gear B8 through either of two gear trains generally designated B9 and B10 by the selective action of a sliding gear and clutch arrangement generally designated B11. Gear train B9 when engaged by sliding clutch B11 moved to the left in response to the action of a shifter mechanism (not shown), drives carriage C1 on the dressing stroke. Gear train B10, when alternately engaged by sliding clutch assembly B11 shifted to the right, drives carriage C1 on the return stroke.

Spindle slide B1 is mounted on the stationary base A1 of the machine by means of a conventional "flat" and V. The adjustment of spindle slide B1 on base A1 from front to rear of the machine, appropriately to position grinding wheels of various external diameters, is accomplished by means of a hand wheel and threaded shaft mechanism generally designated A2.

The delivery of the rocking motion to the dresser carriage C1 is accomplished by a rotatable cam assembly generally designated A3. Cam assembly A3 is powered from drive take-off B6 through a gear train generally designated A4 which drives a worm A5 through a control clutch mechanism A6.

The control clutch A6 is electrically operated from a pair of limit switches A11. The carriage transverse motion drive, taken off from gear B3, is delivered through a splined shaft and gear train assembly generally designated A7 which rotates a threaded shaft A8. The rotation of shaft A8 moves a carriage driving nut C2 transversely. Nut C2 is arranged to move carriage C1 with it in its transverse movements, the direction of these movements being determined by the direction of rotation of shaft A8, and hence by the setting of clutch B11. The exact relative movement rotationally between shaft A8 and nut C2 is controlled by adjustment of a sine bar A9. This sine bar acts to slow down or speed up the transmitted motion from gear train B9 when exact relative movements cannot be directly obtained by gearing. The exact transverse motion of carriage C1 is thus controlled by the gear train B9 and sine bar A9.

The carriage C1 is supported in stationary frame A1 on a carriage tube C3 which rests in bearings A10. Nut C2 is appropriately fastened to the left end of carriage tube C3 to leave the nut free to rotate about its axis, but fixed against relative axial movement with respect to the tube.

The lower end of carriage C1 engages in a yoke assembly C4 in which it is free to move transversely, but is held against relative front to rear movement. The rear end of yoke assembly C4 is fitted with a cam roller assembly C5 spring biased to engage the face of the cam A3. It is apparent that this arrangement permits cam A3 to adjust the front to rear rocking motion of carriage C1 in bearings A10 without interference with the transverse reciprocating motion imparted to that carriage by nut C2.

On top of carriage C1 is a dresser base assembly generally designated C6. This dresser base assembly carries a dresser driving motor (not shown in Fig. 38) which powers the dresser drive pulley and gear train generally designated C7. The dresser proper comprises a pair of multiple diamond carrying discs C8 each powered from gear train C7. These discs rotate in planes perpendicular to the dresser base and are provided with means for separately adjusting their mutual "toe in." Dresser base C6 is slidable from front to rear on carriage C1, this motion being con-

trolled by a dresser feed drive assembly generally designated C9. Dresser base C6 may also be tilted by means of an adjusting mechanism generally designated C10 about a horizontal axis running from front to rear of the machine in order to adjust for the "lead" angle of the thread being dressed on the grinding wheel.

From the generalities of construction just given, the method of operation of the machine can be readily understood. Let it be assumed that the grinding wheel to be dressed is one in which the threads have already been once cut or roughed out.

The pitch of the thread will determine the characteristics required for the gears in the train B9, which is in practice so arranged as to make the substitution of appropriate change gears easy. If the pitch of the thread is such that some standard set of change gears at B9 will not impart precisely the correct rate of linear motion to driving nut C2 through the rotation of threaded shaft A8, then a correcting component of rotation of nut C2 itself is provided for by an appropriate setting of sine bar A9.

The gears in train A4 must be appropriate for the width of face of the grinding wheel to be dressed. These gears are likewise in practice arranged to facilitate the substitution of appropriate change gear sets.

The ratio of spindle drive B5 is adjusted so that the peripheral speed of the grinding wheel is one half that of the diamonds on the dresser discs C8. By use of the hand wheel A2, the grinding wheel spindle slide B1 is brought forward toward carriage C1 so that the diamonds on the disc C8 are almost in contact with the face of the grinding wheel approximately at the right end of the dash-dotted line designated "dressing stroke" in Fig. 38 between grinding wheel and the discs C8.

As a starting point in describing the cycle, let us assume that the right-hand limit switch A11 has just been closed. This operates to cause clutch A8 to disengage, leaving cam roller C5 as shown on the high spot of cam A3. This places the upper part of carriage C1 carrying the dressing discs C8 fully forward toward the face of the grinding wheel. Conveniently, the right-hand limit switch A11 also operates an electromagnetic shifter to move clutch assembly B11 to the left. This sets in motion gear train B9, thus rotating threaded shaft A8 and moving the driving nut C2 and, hence, the whole carriage C1 in the direction of the arrow marked "dressing stroke."

Through the appropriate selection of change gears already described, the rate of travel of the carriage C1 is synchronized in accordance with the lead of the threads to be dressed on the grinding wheel. When the carriage C1 has progressed to the left fully across the face of the grinding wheel, thus completing a dressing stroke, contact will be made with the left-hand limit switch A11. The effect of this switch is to reengage clutch A6 for a period long enough to turn cam A3 from its position of high point contact of cam roller C5. The effect of this motion of cam A3 is to move the top of carriage C1 to the rear away from the face of the grinding wheel. The left-hand limit switch A11 is also conveniently arranged to activate an electromagnetic shifter (not shown in Fig. 38) for controlling clutch assembly B11. Clutch B11 is shifted first to a neutral position for a moment, and then to engage with gear train B10 which operates to reverse the rotation of threaded shaft A8 and cause driving nut C2 to move carriage C1 in the direction of the return stroke. By the completion of the return stroke, cam A3 has again come round to the high spot contact with cam roller C5 and right-end limit switch A11 is again activated. This cycle continues with the diamonds being fed into the dressing wheel by means of feed mechanism C9, which is preferably automatic in operation and self-limiting, until the threads on the grinding wheel are once more trued to specification.

Detailed construction.—Introduction

The mechanical details of the actual construction of a preferred embodiment of a machine according to my invention are illustrated in Figs. 1–37, inclusive; the electrical circuit diagrams for the control and power supply of this machine are illustrated in Figs. 39 and 40. The machine selected for illustration has for its purpose to put threads on the periphery of wide-faced grinding wheels. The machine is arranged not merely to dress threads to precision specifications with multiple diamond discs, but also to rough in, by means of steel crusher wheels, threads so coarse as to make their cutting entirely, by diamond pointed tools wasteful. The machine illustrated has been prepared to accommodate grinding wheels from a minimum diameter of 14" to a maximum diameter of 42", and in widths up to a maximum of 6½". The pitch capacity of the machine is for threads appropriate to cut gears from the very finest up to and including 4 diametral pitch.

In describing the actual machine constructed according to my invention in detail, parts embraced within the more generalized designations covered by the reference designations employed in Fig. 38 will be cross-referred by bracketed insertions to these reference designations where appropriate, but a new series of simple reference numerals will be used to designate the different parts of the machine shown in Figs. 1–37, inclusive, arranged consecutively in the order of their first occurrence in the description. In these figures the same part is always, of course, designated, by the same reference numeral. In order to clarify the mechanical illustrations (Figs. 1–37), many elements of the electrical power and control circuits have been omitted. These details are illustrated in Figs. 39 and 40 and a special reference system is employed in these two figures as hereinafter explained.

Detailed construction.—General layout

The machine is mounted (Fig. 2) on a base generally designated 1 [A1]. Horizontally supported on the base is a transversely slidable carriage support tube 2 [C3]. The tube 2 is supported above the base in appropriate bearings in a right-hand support housing generally designated 3, which also carries the control panel 4, and in a left-hand support housing generally designated 5, which also contains the final drive elements for imparting to tube 2 the precisely controlled transverse movement required to compensate for the lead of the thread being dressed by the machine.

A carriage generally designated 6 [C1] is mounted on the tube 2 between its right and left-hand supports with a downwardly extending arm 7 reaching to the lower portion of the base 1 where it is attached to a retract cam assembly generally designated 8 [A3, C4]. In Fig. 2 the

access opening 9 to the retract cam assembly 8 is shown with the protective cover removed and the retract cam assembly is indicated with a number of parts omitted for clarity. The retract cam clutch assembly generally designated 10 [A6] which in a manner to be explained hereafter controls the fore-and-aft motion imparted to the lower arm 7, is located at the left side of the machine generally in line with the bottom of the arm 7.

Clamped about the tube 2, the carriage 6 supports above the tube a complicated diamond dresser assembly generally designated 11 [C6, C7, C8]. The construction and operation of dresser assembly will be explained in detail hereafter, together with the description of an automatic dresser in-feed mechanism which has been omitted from Fig. 2 for greater clarity in showing the general layout of the machine. Above and behind left-hand tube support 5 in Fig. 2 can be seen the reversing gear housing generally designated 12, and extending above the diamond dresser assembly 11 can be seen the top of the grinding wheel guard 13.

Turning now to Figs. 1, 3, and 4, the grinding wheel spindle slide assembly generally designated 14 [B elements] is supported on the frame 1 by a conventional flat-and-V trackway 15 [A1] extending to the rear of tube 2. The central element of the spindle drive assembly is the grinding wheel spindle 16 [B3] itself. Spindle 16 is parallel to tube 2. On the right end of the spindle is the grinding wheel 17 [B2] to be dressed; on its left end, two gears, a bevel gear 18 [B6] and a wide face spur gear 19 [B7], from which the motions of the dressing diamonds with respect to the rotation of the grinding wheel are precisely synchronized.

A spindle drive motor [B4] is mounted on the rear of spindle slide base member 20 [B1] and drives the spindle 16 through a belt-and-gearing train generally designated 21 [B5].

To the right of trackway 15 and to the rear of grinding wheel 17 an outside diameter dressing assembly generally designated 22 is mounted on base 1 above a coolant collection and drain pan 23 and inside wheel guard B. To the left of trackway 15, the retract cam drive change gears [A4] are supported in a housing 24 which is fastened to the base 1 by attachment to a vertical shaft housing 25. Also to the left of trackway 15, but carried by the spindle slide assembly 14, is the housing 12 for the reversing gear train [B3, B9, B10, B11]. A hand wheel 26 [A2] is located on the front of the machine to control the front to rear motion of the spindle slide assembly on trackway 15.

Detailed construction.—Spindle drive assembly

The spindle drive assembly generally designated 14 is best understood in detail by reference to Figs. 1, 3, 4, 6 and 7 for the more general features of its construction and to Figs. 11, 12, 13, 14, 24, 25 and 26 for details of the clutch and shifter mechanism of the reversing gear.

Spindle drive assembly 14 is slidably supported on machine base 1 by means of a slide base member 20 which rides on trackway 15. As shown especially in Fig. 6, the front-to-rear positioning of base member 20 is controlled by means of hand wheel 26 which is fastened to the front end of a shaft 27 journalled in base 1. At the rear of shaft 27 is a gear train 28 driven by rotation of that shaft and driving a positioning nut 29, the elements of gear train 28 and nut 29 being journalled in base 1. Nut 29 engages, and by its rotation advances or retracts, a threaded shaft 30 affixed to slide base member 20.

The spindle drive motor is bolted directly to spindle slide base 20 and drives spindle 16 through a belt-and-gearing train generally designated 21. In train 21, a countershaft 31 is driven at its right end from the motor by a belt and pulley arrangement 32 and at its left end is fitted an electrically controlled brake mechanism generally designated 33. The first element of a gear train 34 is fastened on shaft 31 between the pulley arrangement 32 and the brake mechanism 33. Through train 34 the motor and the brake mechanism positively control the rotation of spindle 16.

Grinding wheel 17 is mounted overhung at the right end of spindle 16 inside wheel guard 13 which is fastened to machine base 1.

The two gears 18 and 19 are mounted overhung at the left-hand end of spindle 16. These gears, from which the synchronized motions of the diamond dresser assembly are driven, are contained within reversing gear housing 12 which is bolted to, and moves with, spindle slide base 20.

As can be seen especially in Fig. 1, bevel gear 18 at the extreme left of spindle 16 meshes with another bevel gear 35 which is mounted on the front end of a long shaft 36, the front portion of which is journalled and supported in housing 12. The rear end of shaft 36 is supported and slidably journalled in a rearward extending support tube 37 affixed to change gear housing 24 which, in turn, is affixed to the base 1. The rear portion of shaft 36 is splined in order axially slidably to engage, but positively to rotate, a driving element of the change gears in housing 24, as explained in more detail hereafter.

Wide faced spur gear 19 is mounted near the left end of spindle 16, just to the right of gear 18, and meshes with a narrow faced spur gear 38. Gear 38 is journalled in housing 12 to be axially slidable parallel to the axis of spindle 16 by means of the fork 39 of a shifter mechanism, to be described later so as to engage alternately left-hand tooth clutch 40 or right-hand tooth clutch 41 without loss of driving mesh with gear 19.

As shown in Fig. 11, when the left-hand clutch 40 is engaged, a countershaft 42 parallel to the axis of spindle 16 is driven through change gear train 43. On the right-hand end of countershaft 42 is a bevel gear 43 meshed with a bevel gear 44. All these elements are journalled in reverse gear housing 12, access to change gears 43 being provided by a movable cover plate 45. Bevel gear 44 is internally splined to drive a spline shaft to be referred to later.

When the right-hand clutch 41 is engaged, a third bevel gear 46 is driven through gear train 47. These elements are also journalled in housing 12 and gear 46 meshes with gear 44.

The shifter fork 39 engages a circumferential groove 48 around the outer surface of a hollow barrel member 49 to which gear 38, in the form of a ring gear is attached. Outer barrel member 49 is journalled about inner barrel member 50 which, in turn, is journalled on a fixed stub shaft 51. The driving elements of clutches 40 and 41 are attached to the inner barrel member 50 and the two barrel members 49 and 50 are so keyed together that axial movement imparted to the outer barrel by shifter fork 39 is directly imparted to the inner barrel, but a spring cushioning device generally indicated at 52 serves to cushion the coupling of the rotational drive of the outer barrel to the inner barrel.

As shown in Figs. 24, 25 and 26, the shifter fork 39 is formed at the rear end of a pivoted shifting lever 53. Lever 53 is pivoted about a pin 54 to a shifter housing 55 which is fastened to, and extends forward and up from, reversing gear housing 12. The front end of lever 53 terminates in a twin notch latch portion 56 inside shifter housing 55.

A pivoted double-end spring guide member 57 passes through and is pinned to shifter lever 53 between its pivot 54 and latch end 56. A pair of stationary spring guide members 58 are fastened, one in each wall of housing 55 in line with and opposite the two ends of pivoted spring guide 57. A pair of coil springs 59 are inserted, one between each stationary guide 58 and the opposite end of pivoted guide 57. The effect of springs 59 is thus to bias lever 53 about pivot pin 54 to a central position in which shifter fork 39 is in the neutral position with both clutches 40 and 41 disengaged.

A pivoted thrust link 60 passes through and is pinned to shifter lever 53 between spring guide 57 and latch end 56. The right end of link 60 is fastened to a movable core member 61 of a solenoid 62 and the left-hand end of link 60 is fastened to a movable core member 63 of a solenoid 64.

To the right and left of latch end 56 are slidable shifter stops 65 and 66 respectively. These stops are slidably mounted in apertures in the housing 55 and are broached to receive coil springs 67 which cooperate with demountable stop members 68 to urge the slidable stops 65 and 66 rearward into the position illustrated in Fig. 24, in which stops 65 and 66 serve to lock shifter lever 53 in the neutral position. At their front ends slidable stops 65 and 66 are fastened to movable cores 69 and 70 respectively of the solenoids 71 and 72 respectively. As shown in Fig. 26, limit switch operating members 73 and 74 are fastened to slidable stops 65 and 66, respectively, to operate limit switches 75 and 76, respectively, in a manner to be explained later.

A shifter lever latch detent 77 is slidably mounted in an aperture in housing 55 parallel to and midway between slidable stops 65 and 66. Detent 77 is broached to receive a third coil spring 67 which cooperates with a third demountable stop member 68 to urge the detent 77 rearward to engage the latch end of shifter lever 53. In Fig. 24 detent 77 is shown in the retracted position. To effect this retraction, a toggle link 78 connects the front end of detent 77 through rocker links 79 to an articulated twin tandem movable core member 80. A fixed pivot 81 provides a fulcrum about which rocker links 79 transform a rearward motion of core 80 to a forward motion of toggle 78 and detent 77. The tandem movable core 80 is disposed to be activated by either of two solenoids 82 and 83, which are, respectively, the normal and emergency clutch neutralizing solenoids. It will be observed that, if detent 77 is not held retracted by a rearward positioning of core 80, it will lock shifter lever 53 into either its left or right positions as soon as that lever is moved into one of them.

Detailed construction.—Carriage tube transverse motion final drive

Turning now to Figs. 2, 4, 8, 9, and 10, the final drive elements for imparting and regulating the transverse (or lead and return) motion to tube 2 are mounted in or affixed to left-hand support housing 5 on the machine base 1. Bevel gear 44, which is driven from spindle 16 in a timed relation dependent upon the ratios selected for change gear train 43, engages with its internal splines an externally splined shaft 84. As particularly illustrated in Fig. 8, the front end of shaft 84 is journalled in support housing 5 and extends rearward through bevel gear 44, with which it is in splined engagement, to be axially slidably supported and radially journalled at the rear in an extension tube 85 fastened on reverse gear housing 12.

To the front end of shaft 84 there is affixed a bevel gear 86 which meshes with another bevel gear 87. Bevel gear 87 is fastened to the inner race member 88 of a thrust-and-radial-load ball bearing 89 mounted in the left-hand end of housing 5. Extending to the right, back through gear 87 and inner race 88 to which it is bolted, is a threaded shaft 90, the axis of which is coincident with the axis of carriage support tube 2.

The right-hand end of shaft 90 is threaded into a nut 91. Nut 91 is bolted to the inner race 92 of a thrust-and-radial-load ball bearing 93 which is bolted in turn to the left-hand end of carriage support tube 2. A cover tube 94 is fastened extending to the right from bearing 93 within carriage support tube 2 to receive and protect the right end of threaded shaft 90 when rotation of that shaft draws nut 91 and hence tube 2 to the left.

A ring gear 95 is bolted about the inner race 92, concentric with and surrounding nut 91. A trackway support structure 96 also surrounds ring gear 95 and engages the outer barrel of inner race 92 in a sleeve bearing fit. Trackway structure 96 is fastened rigidly neither to the inner nor the outer race of bearing 93. A vertically slidable rack 97 is carried in a vertical trackway on the front of support 96 engaging the teeth of gear 95. A slide block 98 is pivotably pinned to the center of rack 97 so that any up or down motion imparted to block 98 will cause a corresponding rotation of nut 91 through interaction of rack 97 and gear 95. A cap 99 on housing 5 affords a space for upward movement of rack 97. Contained within cap 99 and fastened to housing 5 parallel to the axis of carriage support tube 2 is a guide bar 100 engaging a groove 101 in the top of track support structure 96. The interaction of bar 100 and groove 101 prevents any rotary motion of support 96 about the axis of tube 2.

A sine bar member generally designated 102 is supported on the front wall of housing 5 by means of a graduated circular face plate 103 bolted to and slightly overlapping a circular boss 104. On the rear face of member 102 is a groove 105 forming the sine bar proper and engaging slide block 98. At the left end of member 102 is a segmental gear 106 engaging a worm 107 which is fastened to the lower end of a shaft 108 journalled in housing 5. At the upper end of shaft 108 and protruding from the top of casing 5 is a graduated dial knob 109. Face plate 103 is graduated in degrees, plus and minus, from a zero setting. Knob 109 is graduated into sixty equal "minute" divisions and the ratio of worm 107 and rack 106 are such that one turn of knob 109 moves member 102 through one degree. The angular position of member 102 about the axis of boss 104, which axis intersects the center line of sine bar groove 105, is set by loosening clamping bolts 110, turning knob 109 to produce the appropriate setting, and then retightening the clamping bolts. A zero-zero setting of knob 109 and plate 103 brings sine bar groove 105 exactly parallel with the axis of tube 2.

Detailed construction.—Retract cam assembly

Turning now to Figs. 2, 3, 21, 22 and 23, the lower end of carriage arm 7 is attached to a retract cam assembly generally designated 8. A slide block 111 is pivoted between two lugs 112 directly at the bottom of arm 7 about a pin 113 whose axis is parallel to the axis of tube 2. Block 111 slides in a track 114 formed between two front fork extensions 115 of a yoke 116. Track 114 and block 111 cooperate to impart to the bottom of arm 7 fore-and-aft motion of yoke 116 without interference with the transverse motion imparted to tube 2 by nut 91.

Bolted to the main base 1 of the machine is a cam assembly support frame 117. Projecting rearward from the front web of frame 117 are yoke locating pins 118 which cooperate with the front faces of fork extensions 115 precisely to locate the forward position of yoke 116. To the rear, yoke 116 terminates in a tubular portion 119 into which is inserted a cam roller mounting plunger 120. A rear portion of tube 119 is enlarged to receive a coil spring 121 surrounding plunger 120. A collar 122 fastened about plunger 120 contains spring 121 between the forward end of the enlarged portion of tube 119 and the shoulder the collar forms with the plunger. A threaded bushing 123 screwed into the rear opening of tube 119 to the rear of collar 122 limits the rearward travel of plunger 120. The rearward end of plunger 120 carries a cam roller 124. The roller 124 is journalled in a fork 125 formed in the end of plunger 120 upon a pin 126 whose axis is parallel to the axis of tube 2. Pin 126 extends to the right and left of yoke 125 to accommodate pivoted slide blocks 127 which are guided in a front to rear trackway 128 affixed to support 117.

Cam roller mounting fork 125 includes an upwardly extending bracket portion 129. A spring guide rod 130 extends forward from bracket 129 parallel to tube 119 and directly over it. A fixed cross member 131 is fastened to support 117 above yoke 116 to the rear of its front fork extensions 115. A short spring guide rod 132 is fastened to cross member 131 extending rearward therefrom coaxial with guide rod 130. A coil spring 133 is mounted on the guides 130 and 132 between the rear face of cross member 131 and the front face of an adjusting nut 134 which engages a rearward threaded portion of guide 130.

A shaft 135 is journalled fixed to the machine base 1 parallel to the axis of tube 2 and to the rear of cam roller 124. The axis of shaft 135 and cam roller mounting plunger 120 intersect. A one-lobe cam 136 is fastened to shaft 135 to be in contact with cam roller 124. Shaft 135 is driven through a worm wheel 137 well to the left of cam 136 in a manner to be explained later.

The relative proportioning and positioning of the parts of the retract cam assembly just described is such that when cam roller 124 is riding the high point of cam 135, as shown in Figs. 3 and 21, the front faces of yoke fork extensions 115 are firmly pressed into contact with locating pins 118 with spring 121 subjected to a slight compression and spring 133 to a considerable compression. As cam 136 turns away from this high point contact, the first effect of the combined spring compressions is to cause cam roller mounting plunger 120 to move to the rear until collar 122 contacts bushing 123 and thereafter spring 133 alone expanding between cross member 131 and nut 134 causes yoke 116 to move to the rear bringing with it fork 115 and hence slide block 111 and the bottom of arm 7.

In addition to the parts of the retract cam assembly just described, support 117 carries a plurality of limit switches actuated by adjustably positioned fingers attached to arm 7, which control the operating cycle of the machine in a manner to be explained later. These switches are and their actuating fingers may be cataloged as follows:

Snap-lock limit switch 138 closed by deep finger 139 to prevent overtravel of tube 2 to the left;

Snap-lock limit switch 140 closed by deep finger 141 to prevent overtravel of tube 2 to the right;

Microswitch 142 closed when depressed by undershoe 143 on finger 144 initiating the reversal of travel from right to left;

Snap-lock limit switch 145 closed when in contact with finger 144 controlling action of cam 136;

Snap-lock limit switch 146 closed when in contact with finger 147 controlling the action of cam 136;

Snap-lock limit switch 148 closed when in contact with finger 149 controlling the action of shifter 39; and

Microswitch 150 closed when depressed by undershoe 151 on finger 149 initiating the reversal of travel from left to right.

Detailed construction.—Retract cam drive

Turning now to Figs. 1, 2, 4 and 5, the drive for retract cam 136 is taken from grinding wheel spindle 16 through bevel gears 18 and 35 which drive splined shaft 36. Shaft 36 passes through retract cam drive change gear housing 24. Gear 152 journalled in housing 24 is internally splined to engage shaft 36. Gear 152 is the first element of a set of change gears 153 which drive a bevel gear 154 also journalled in housing 24 about an axis parallel to shaft 36. Gear 154 meshes with another bevel gear 155 at the top of a vertical shaft 156 which is journalled in vertical shaft housing 25 through which the drive taken off spindle 16 is transmitted to the lower part of the machine.

At the bottom of shaft 156 a pair of bevel gears 157 transmits the drive to a forward extending stub shaft 158 parallel to shaft 36. The forward end of shaft 158 is journalled in a retract cam clutch housing 159 and is coupled to the driving element 160 of a multiple disc clutch 161. The driven element of 161 is coupled to a shaft 162. Shaft 162 is coaxial with and extends forward from shaft 158. A grooved pressure collar 163 is journalled about shaft 162 and arranged so that a rearward pressure on it forces the driving and driven elements of clutch 161 into frictional engagement.

Shaft 162 extends forward in housing 159 to carry worm 164. Worm wheel 137 at the left end of shaft 135 is also located within housing 159 in mesh with worm 164.

Intermediate pressure collar 163 and worm 164, shaft 162 carries the rotating elements of a multiple disc brake 165, the static elements of which are fastened to a stationary collar 166. The disc clutch 161 and disc brake 165 are so positioned and proportioned that axial movement imparted to pressure collar 163 tending to press one into engagement, disengages the other. The effect of engaging brake 165 is to apply a braking force to shaft 162 and hence, through worm and worm

wheel 164 and 137, to shaft 135 and the retract cam 136. Conversely, the effect of releasing brake 165 and engaging clutch 161 is to transmit to shaft 135 a drive timed in relationship to the drive of spindle 15 according to the selected ratio of the change gear set 153.

The position of pressure collar 163 is controlled by a clutch operating lever 167, the lower part of which terminates in a fork 168 engaging the groove of collar 163. Lever 167 is pivoted to casing 159 a short distance above fork 168 and the upper end of lever 167 is pinned to the tandem double-acting movable core member 169. Two solenoids, 170 and 171, are arranged to cooperate with core 169 to control clutch 161 and brake 165. Solenoid 170 when activated tends to move core 169 to the left thus forcing pressure collar 163 to the right, disengaging clutch 161 and applying brake 165. Solenoid 171, on the other hand, when activated tends to move core 169 to the right thus forcing pressure collar 163 to the left, releasing brake 165 and engaging clutch 161 to couple retract cam 136 to its drive.

The operation of solenoids 170 and 172 is controlled in part, as will be explained later, by a limit switch 172 mounted outside clutch housing 159, near the end of shaft 135. Limit switch 172 is closed by pressure of a finger 173. Finger 173 is fastened to the left-hand end of a shaft 174 journalled in the left end wall of housing 159. Within housing 159, a second finger 175 is fastened to the right end of shaft 174. Finger 175 is arranged to contact a leftward protruding pin 176 on the left face near the periphery of worm wheel 137. The relative angular position of pin 176 and the high point of cam 136 on shaft 135 is such that, when the high point of cam 136 is in contact with cam roller 124, pin 176, through interaction with fingers 173 and 175, has closed limit switch 172.

Detailed construction.—Diamond dresser assembly

As previously explained, the actual dressing of threads on the face of the rotating grinding wheel 17 is accomplished by the action of a multiplicity of diamonds. The diamonds themselves are rotating, driven by a separate motor from that driving the grinding wheel spindle. The assembly of parts necessary accurately to position and to drive the multiplicity of dressing diamonds is carried on, and moves with, the carriage generally designated 6.

Turning now especially to Figs. 1, 2, 3, 4, 15, 16, 17, 18, 19, 20, 27, 28 and 29, the carriage 6 is clamped to carriage tube 2 by upper and lower tube gripping portions 177 and 178. The downward extending arm 7 is fastened to lower portion 178. Upper portion 177 supports the diamond dresser assembly proper.

In a manner best shown in Figs. 2, 16, 17 and 27, a fore-and-aft horizontal dresser base supporting shaft 179 is journalled in sleeve bearings 180 in the front and rear webs of the upper tube gripping portion 177. Shaft 179 protrudes both front and rear beyond upper gripping portion 177 and to these front and rear extensions a dresser assembly base member 181 is clamped by means of two removable cap portions 182. By means of this arrangement the plane of dresser base 181 may be tilted with respect to the axis of tube 2 accurately to set off an angle corresponding to the helix angle of the thread to be dressed on wheel 17. The exact set of this angle is determined (Fig. 29) by the adjustment of positioning screws 183 which are carried by dresser base 181 and which grip between them a positioning stop 184 carried by upper gripping member 177. The correctness of the adjustment thus achieved is gauged by use of a Johansson block (Fig. 28) between gauging points 185 and 186 precisely located on dresser base 181 and on upper gripping portion 177, respectively.

A dresser infeed slide 187 is mounted on the base 181. A fore-and-aft ball bearing track 188 guides slide 187 in its front to rear motion on dresser base 181. This front to rear motion is controlled precisely by a graduated hand wheel 189 which is journalled in base 181. The rotation of hand wheel 189 turns nut portion 190 of the shaft through which the hand wheel is journalled in the dresser base. Nut 190 engages a threaded portion 191 of a shaft 192 fastened to the front of dresser feed slide 187. Threaded portion 191 has a left-hand thread in order that a clockwise motion of hand wheel 189 may serve to move slide 187 to the rear feeding the dresser into the work. An overhanging bracket member 193 fastened to dresser base 181 reaches to the rear of the front web 194 of slide 187 to serve as a stop limiting the extent of the dresser infeed. To regulate the limit of infeed, the rear face of bolt 195 is machined to provide a gauging point on the rear of front web 194. An adjustable stop screw 196 is threaded from the rear to the front of the stop portion of bracket 193. Screw 196 and bolt head 195 provide a gap in which an appropriate Johansson block can be inserted.

On the rear portion of the upper surface of slide 187 are located a pair of transverse ball bearing tracks 197 upon which are slidably mounted a pair of dresser pads 198, each with its upper portion formed as an arcuate dove tail 199. A pair of stop blocks 200 are bolted to dresser feed slide 187, one extending up into the base portion of each dresser pad 198. Extending outward to the left and right of left and right stop blocks 200, respectively, are spring guide tubes 201 each containing a compression spring 202. The springs 202, through compression between stop block 200 and a cam support block 203 bolted to the outside of each dresser pad 198, tend to force the dresser pads apart along transverse track 197.

A pivoted cam roller 204 is arranged to rotate about a vertical axis in each cam support block 203. As shown especially in Figs. 15, 16 and 27, the outward motion of each dresser pad 198 under the influence of spring 202 is contained by the engagement of its cam roller 204 with an inner cam surface on a corresponding adjustable sine bar stop block 205. Sine bar blocks 205 are pivoted to dresser base 181 about bolts 206. The angular adjustment of the cam surface of each block 205 about its bolt 206 is accomplished by the insertion of an appropriate Johansson block between a corresponding locating stop 207 precisely positioned on dresser base 181 and a positioning point 208 precisely machined on the block 205 with respect to its cam surface. The adjustment of blocks 205 so achieved is locked by clamping action of clamp bolts 209.

The two arcuate dove tails 199 are machined as arcs of a true circle which, when the dresser pads 198 are so positioned on track 197, will have a common center. That center is located slightly to the rear of the dresser assembly, its location being a point on an imaginary perpendicular line that would be tangent to grinding wheel 17 at a point within it where the sides of the thread being dressed on it would intersect.

A bearing and drive housing 210 is mounted upon each of these arcuate dove tails 199 by means of a corresponding arcuate slideway 211 in its base. A diamond carrier disc 212 is fastened to the inner end of a horizontal shaft 213 journalled in each housing 210. Each disc 212 is protected by a heavy guard member 214 fastened to the corresponding housing 210. Each shaft 213 is located tangent to a circle concentric with the circle of which the corresponding track 211 is a part. On the inner end of each shaft 213 is a bevel gear 215. To the top of each housing 210 there is pivoted and clamped an L-shaped shaft-and-gearing housing 216. Fastened within each housing 216 is a vertical bearing tube 217. Journalled in each bearing 217 is a vertical shaft 218. At the bottom of each shaft 218 is a bevel gear 219 in mesh with the corresponding bevel gear 215 within the corresponding housing 216. At the top of each shaft 218 is a bevel gear 220. Each bevel gear 220 is in mesh with an outwardly facing bevel gear 221. Each bevel gear 221 is mounted on the outward end of an inwardly extending short shaft 222 which runs horizontally within the horizontal portion of each L-shaped housing 216. At the inner end of each shaft 222 there is slidably carried half of a V-belt pulley 223, the two halves being bolted together. On the top of the horizontal portion of each L-shaped housing 216 are a pair of aligning bar receiving rests 224. As indicated in Fig. 16, these rests accommodate an aligning bar to maintain the horizontal portions of housing 216, and thus the two shafts 222, in alignment during an adjustment of the position of housings 210 when housings 210 are necessarily unclamped. The aligning bar is removed when housings 210 have been reclamped to housings 210 and the machine is in use.

Pulley 223 is driven by a V-belt 225 from a motor pulley 226 on the driving shaft of a motor 227. Motor 227 is mounted, through a rubber mounting 228, on an intermediate motor support 229 adjustably pivoted to motor mounting block 230. Block 230 is fastened to and moves with feed slide 187.

As best shown in Fig. 17, a dozen radially-arranged, equally-spaced diamond tool holders 231 are fastened to the inner face of each diamond carrier disc 212. Each tool holder 231 is roughly L-shaped and carries a diamond point 232 on a dressing tool 233 mounted in the toe of its foot portion. All the diamond points 232 lie on a circle about the axis of shaft 213. Each tool holder 231 is fastened to a disc 212 by means of a pin 234 passing through its long leg near the heel and through a pair of lugs 235 on the inner face of the disc. A hold-down screw 236 passes through the long leg of each holder 231 and is threaded into disc 212 near the center thereof. The exact angular position of holder 231 about its mounting pivot 234 is assured by a pressure screw 237 threaded through holder 231 adjacent, and parallel, to screw 236, the end of which presses against the face of disc 212.

As can be seen especially in Figs. 15 and 18, the two opposite discs 212 are so adjusted with respect to one another about the axis of their corresponding mounting shafts 213 that the fingers 231 on the face of one disc appear opposite the interstices between the similar fingers 231 on the face of the other disc.

Turning now to Figs. 18 and 19, we see that each guard 214 is arranged to receive a dial micrometer 238 to indicate precisely the departure from a predetermined zero position of the inner end of an indicator rod 239. A bushed opening 240 extends horizontally through each guard 214 with its axis intersecting the circle upon which the corresponding diamond points 232 are to lie. Underlying the long leg of each diamond holder 231 is a disc locating hole 241 bored in the supporting disc 212. An access hole 242 is cut through each guard 214 to be in line with a locating hole 241 when its corresponding diamond point 232 lies on the axis of bushed opening 240. The dial micrometer 238 is mounted on a plate 243 with its indicator rod 239 supported in a bearing tube 244 the outside diameter of which corresponds with the inside diameter of opening 240. A disc locating pin 245 is also mounted on plate 243 parallel to indicator rod 239 and appropriately spaced from it to engage a disc locating hole 241 through aperture hole 242. The entire dial micrometer assembly on plate 243 is removed from the machine after the precise location of each diamond tip 232 is achieved. Easy access to the points of contact between the tip of indicator rod 239 and successive diamond points 232 is provided by a cover plate 246 on the upper front face of each guard 214.

Detailed construction.—Crusher assembly

Referring to Fig. 27, it will be observed that, if caps 182 are removed from beneath shaft 178, the entire dresser assembly can be lifted from the carriage 6. When threading a hitherto unthreaded grinding wheel, it is advantageous to substitute for the dresser assembly a crusher assembly in order to avoid needless wear on the diamonds caused by a roughing-in operation.

Referring now to Figs. 31, 32 and 33, a crusher assembly is shown attached to the upper gripping portion 177 of the carriage 6 by clamping a crusher base member 247 to the front and rear extensions of shaft 178 using caps 182. As in the case of dresser base 181, the plane of crusher base 247 is tiltable with respect to the axis of tube 2 to an angle to correspond with the helix angle of the thread to be dressed on wheel 17, the exact set of this angle is determined by adjustment of positioning screws 248 carried by crusher base 247 which grip between them the positioning stop 184 carried by upper gripping member 177, and the correctness of adjustment is measured by a Johansson block between gauging points 249 and 196 precisely located on crusher base 247 and upper gripping portion 177, respectively.

A crusher infeed slide 250 is mounted on base 247 on a fore-and-aft ball bearing track 251. As in the case of the front-to-rear motion of dresser slide 187, the front-to-rear motion of crusher slide 250 is controlled precisely by a graduated hand wheel 252 which operates in the manner already described in connection with hand wheel 189. Likewise, the infeed limit is determined by an adjustable stop screw 253 threaded from the rear to the front of a stop portion of a bracket 254 exactly as the similar stop screw 153 mounted in a similar bracket 153 limits the infeed of the dresser slide 187.

Bolted to the rear of crusher slide 250 is a transverse head-and-tail stock mounting 255 in which a multiple steel disc crusher tool 256 is rotated. A ball bearing tail stock spindle 257 is mounted in the right-hand portion of mounting 255 retractable by means of a hand wheel 258. A ball bearing head stock spindle 259 is mounted in the left-hand portion of mounting 255. A face plate 260 engages a pin in crusher tool 256 mounted between spindles 257 and 259 to afford

a positive drive for the tool from the head stock spindle. An air turbine rotor sleeve 261 is fastened about the body of spindle 259 with its buckets intersecting an air passage 262 through the left portion of mounting 255. A source of compressed air is coupled to passage 262 through a control valve 263.

Detailed construction.—Automatic dresser infeed

Turning now to Figs. 3 and 17, there is shown in outline and properly positioned an automatic dresser infeed assembly generally designated 264 supported on machine base 1 by means of a mounting bracket 265. This feed assembly is illustrated in detail in Figs. 34, 35, 36 and 37 and is omitted from the other figures for clarity. Feed assembly 264 is positioned, as shown especially in Fig. 17, to operate hand wheel 189 only when carriage 6 is retracted to its return stroke position as shown in dotted lines.

Turning now to Figs. 34 to 37, inclusive, it will be seen that the outer periphery of hand wheel 189 is toothed to form a ratchet wheel 266. An infeed assembly housing 267 is pinned to the top of a bracket 265 by means of a pivot pin 268 parallel to the axis of tube 2. The bracket 265 is rigidly fastened to the front of the base 1 in a position generally below the location of hand wheel 189. Pin 268 passes through a pair of lugs 269 on the bottom of the housing and a pair of lugs 270 on the top of the bracket, the lugs and pin so engaging each other as to hold the housing 267 against translatory motion relative to bracket 265. Pin 268 is locked to lugs 269 by set screws 271. A torsion spring 272 fastened to pin 268 and to one of the lugs 270 is biased to rotate pin 268 in a clockwise direction, viewed from the right. This rotation brings a stop arm 273 on housing 267 into contact with stop nuts 274 on a stop stud 275 carried by bracket 265. As shown in Fig. 35, stop nuts 274 may be screwed down to retract housing 267 to the disengage position shown in the dotted line. It will be understood that in Fig. 35, the carriage 6 is shown in its retracted return stroke position.

In the upper part of housing 267, a pawl pivot pin 276 is journalled with its axis in a plane perpendicular to the axis of tube 2. A pawl block 277 is fastened to a front extension of pin 276. A pawl bushing 278 is threaded in the top of block 277 and a set screw 279 is provided to lock the depth setting of the bushing in the block. A pawl 280 inserted within pawl block 277 is slidable therein with a range of travel limited by interaction of screw 281 in slot 282. A pawl spring 283 urges pawl 280 upward in block 277, the uppermost position of pawl 280 being determined by the engagement between its shoulder 284 and bushing 278. In operation, the adjustment of pawl bushing 278 controls the number of notches in ratchet wheel 266 that will be turned off by engagement with pawl 280 on a single pass of carriage 6 on a return stroke. The greater the extension of pawl 280 from pawl block 277, the coarser will be the feed it imparts to the dresser.

A spring bushing 285 surrounds pin 276 within housing 267 adjacent to the rear wall thereof. A trip lever 286 is mounted on shaft 276 between bushing 285 and the front wall of housing 267. A torsion spring 287 surrounds bushing 285. The rear end of torsion spring 287 is locked through bushing 285 to shaft 276 by means of set screw 288. The front end of spring 287 is inserted into a hole 289 in trip lever 286. As shown in Fig. 37, shaft 276 has a recess 290 where it passes through trip lever 286 and a stop screw 291 threaded into lever 286 enters recess 290, but does not engage shaft 276. Recess 290 covers only a portion of the circumference of shaft 276. The lower end of trip lever 286 engages the push rod 292 of a limit switch 293 within housing 267. The force exerted by spring 287 and the angular relations of trip lever 286 and pawl block 277 to the recess 290 on shaft 276 are so selected that stop 294 on pawl block 277 is brought into engagement with stop 295 on housing 267 without tripping limit switch 293. Moreover, so long as hand wheel 189 is free to turn, the dresser slide infeed not having reached its limit, spring 287 is effective to cause pawl 280 to remain in the vertical position and operate ratchet wheel 266 without tripping switch 293. When, however, hand wheel 189 can no longer turn, the engagement of pawl 280 with ratchet 266 will turn pawl block 277 and pin 276 against the force of spring 287 until the edge of the recess 290 engages the stop screw 291 and thus causes trip lever 286 to activate limit switch 293.

Detailed construction.—Miscellaneous mechanical features

The elements of the coolant circuit which is conventional are not shown in detail other than the coolant collecting and drain pan 23 and the coolant pump motor shown in Figs. 1 and 3. It is required merely that an adequate supply of coolant be delivered to the work being done on grinding wheel 17 as needed.

For truing the outside diameter of a grinding wheel without operating carriage 6, a conventional non-rotating diamond dresser assembly generally designated 22 is provided within the dresser guard 13. This assembly is supported on a mounting arm 296 which is pivoted to machine base 1 about a pivot bolt 297 and locked in any selected position by means of a clamp bolt 298. On the top of arm 296 is a conventional slide-and-lead screw dressing tool feed arrangement controlled by a hand wheel 299 for drawing a single dressing diamond 300 transversely across the face of the grinding wheel 17.

As shown in Fig. 20, each diamond tool holder 231 carries a diamond point 232 on a dressing tool 233 slidably mounted in a hole through the toe of its foot portion. The extension of diamond point 232 from the sole of the foot portion of holder 231 is adjusted by means of a special gauging jig. The setting of each dresser tool 233 thus measured is fixed by means of a set screw 302.

As shown in Fig. 30, the grinding wheel is advantageously formed as an abrasive rim 303 bearing the face 304 to be threaded fastened by means of a clamp ring 306 about an adaptor disc 305 which is mounted on spindle 15.

As shown in Figs. 15 and 27, the upper surface of the base of each diamond drive housing 210 is advantageously provided with a graduated segment 307 to cooperate with an index mark on a bracket 308 fastened to the corresponding dresser pad 198.

Detailed construction.—Power and control circuits

Turning now to Figs. 39 and 40, there are diagrammed, respectively, the control and power circuits to be applied to the machine just described. Basically, the power circuit shown in Fig. 40 includes the power supply main, the heavy electrical load elements of the machine,

and the several contactors which must be closed in order for power to be supplied to those elements; the control circuit shown in Fig. 39, the interconnection of the manually, mechanically and electrically operated switches and relay devices which close the contactors in Fig. 40. Since all the wiring and many of the electrical devices have been omitted from the figures illustrating the mechanical arrangement of the machine, another system of reference numerals and legends will be employed to make the two circuit diagrams easier to follow. In the following cross-reference table each element indicated on the circuit diagrams (Figs. 39 and 40) is listed, together with the reference numeral under which the corresponding element appears in the drawings of the machine itself (Figs. 1–37, inclusive). In the table, the circuit diagram designation appears first followed by the corresponding mechanical figures reference numeral in brackets:

CR 1—[—]	LR 1—[—]	LS 10—[76]
CR 2—[—]	LR 2—[—]	LS 11—[172]
CR 3—[—]	LS 1—[138]	SOL A—[71]
CR 4—[—]	LS 2—[140]	SOL B—[62]
CR 5—[—]	LS 3—[146]	SOL C—[171]
CR 6—[—]	LS 4—[148]	SOL D—[170]
CR 7—[—]	LS 5—[150]	SOL E—[82]
CR 8—[—]	LS 6—[145]	SOL F—[83]
CR 9—[—]	LS 7—[142]	SOL G—[72]
CR 10—[—]	LS 8—[293]	SOL H—[64]
CR 11—[—]	LS 9—[75]	SOL I—[a part of 33]

The two diagrams, Figs. 39 and 40, are to be read together. All elements are shown in the position which they would assume at the end of a normal automatically controlled dressing cycle, with power supply off.

The source of power supply is conveniently a 220–440 volt, 60-cycle, 3-phase main from which the whole machine may be cut off by a multi-pole disconnect switch. This can be conveniently supplied at 440 volts to the dresser motor, the coolant pump motor and the spindle drive motor and at 220 volts to the more heavily loaded solenoids. A control transformer is conveniently employed to reduce the higher voltage to 110 volts for operation of the control circuit, including relay coils and lightly loaded solenoids.

Coil relays, of which there are eleven, designated CR 1 to CR 11, inclusive, are relays through the coil element of which control current must be passing in order to keep its contactor element or elements in the "against bias" position. Some coil relay contactors are biased closed; others, open.

Latch relays, of which there are two designated LR 1 and LR 2, are relays which, through activation of a "latch" coil thereof, move the contactor elements associated with the relay to the "against bias" position in which they remain latched after deactivation of the latch coil of the relay until unlatched by activation of an "unlatch" coil thereof.

Limit switches, of which there are eleven, designated LS 1 to LS 11, inclusive, are electrical switches operated by mechanical contact with moving parts of the machine to open or close one or more control circuits.

Solenoids, of which there are nine, designated SOL A to SOL I, inclusive, are electromagnetic devices for applying force to a mechanical control element of the machine.

Detailed operation.—Positions and settings of elements at beginning of normal dressing cycle

In the following description of the relative positions and settings of the elements of the machine at the beginning of a normal dressing cycle it is assumed that the machine has just completed dressing a grinding wheel 17, that the machine cycle has been stopped following the opening of limit switch 293 [LS 8] (Fig. 34) and that the power supply disconnect switch (Fig. 40) has been opened. It is further assumed that the machine operator will proceed directly to the finish dressing of another grinding wheel to be threaded to the same specifications as the wheel just completed.

The machine is in the position it reaches at the end of its right normal coast travel. In this position cam roller 124 is riding the low part of retract cam 136 and the dressing diamonds are therefore withdrawn from the dressing position. Downward-extending arm 7 of carriage 6 (Fig. 21) is, thus, in the position in which finger 144 closes limit switch 145 [LS 5] and undershoe 143 on that finger closes limit switch 142 [LS 7]. There has, of course, been no over-run and, therefore, right safety limit switch 140 [LS 2] has not been touched by deep finger 141. The completion of the right travel of carriage 6 has carried ratchet wheel 266 past pawl 280 (Fig. 34) thus permitting the normal bias to close limit switch 293 [LS 8].

The spindle drive motor (Fig. 1) is, of course, deenergized. A grinding wheel 17 to be dressed is fastened to spindle 16 (Fig. 1). Dresser slide 187 is retracted by means of hand wheel 189 (Fig. 17) and the machine is again ready to be put in operation.

The spindle drive assembly 14 has, of course, already been positioned front to rear (Fig. 3) according to the outside diameter of the grinding wheel 17 by adjustment of the hand wheel 28. The power disconnect switch being open (Fig. 40), the solenoid [SOL I] of the electrically controlled spindle brake mechanism 33 (Fig. 1) is deactivated. Only power or circuit failure, the operation of overload circuit breakers, the closing limit switches 138 [LS 1] or 140 [LS 2] by over-run of carriage 6, or manual operation of the emergency stop push button can deactivate SOL I when the power disconnect switch is closed. Also since the power disconnect switch is open, the solenoid 170 [SOL D] which sets the retract cam braking clutch 165 (Fig. 4) is deenergized. The normal end of cycle position of the control circuit elements is such, however, that closing the power disconnect switch will, of itself, as explained later, energize SOL D.

The gears in train 34 (Fig. 6) are, of course, already appropriately selected in accordance with the outside diameter of grinding wheel 17 to provide the proper relative peripheral speeds between that wheel and the diamonds on rotating discs 212.

The clutch shifter fork 39 (Fig. 7) is in the neutral position; thus neither clutch 40 nor 41 are engaged. Solenoids 62 [SOL B], 64 [SOL H], 71 [SOL A] and 72 [SOL G] are all deenergized and right and left shifter stops 65 and 66 are, therefore, in their biased-rearward position engaging latch portion 56 of shifting lever 53 (Fig. 24). The change gears 43 (Fig. 7) are, of course, appropriately selected to provide a rotation rate for threaded shaft 90 (Fig. 8) corresponding to the lead of the thread to be dressed on the grinding wheel 17. In conjunction with the selection of these change gears, the angular setting of sine bar 105 (Fig. 9) has likewise been adjusted to correspond to the lead for the threads to be dressed upon grinding wheel 17.

Since the carriage 6 is in its normal extreme

right position all the elements of the carriage tube transverse motion final drive will be in substantially the position shown in Fig. 8.

The change gears 153 (Fig. 4) are, likewise, already appropriately selected to synchronize the rotation of retract cam 136 with the rotation of threaded shaft 90. Since the carriage 6 is in its retracted position, lower arm 7 will not be in the position illustrated in Fig. 4, but the clutch operating lever 167 will be in the position shown in that figure.

Both the dresser drive motor 227 and the coolant pump motor (Fig. 1) are, of course, deenergized.

Detailed operation.—Movement of parts during a complete normal dressing cycle

To follow the ensuing description, both Figs. 39 and 40 should be referred to throughout. Specific reference will be made to other figures as necessary.

To start the cycle, the operator first connects in the power supply by closing the power disconnect switch. Because the termination of the previous cycle has left latch relay LR 1 unlatched, SOL D [170] is forthwith energized applying pressure to cam brake 165. All other solenoids and motors remain deenergized and at rest.

The operator now depresses the push button marked "Start Dresser." This energizes the coil of dresser starter relay CR 9. The contactors associated with CR 9 are biased open and are, therefore, closed by the activation of this relay. The closing of the CR 9 contactors starts the dresser motor and the coolant pump motor and closes a control circuit through CR 9 coil, so that the release of the "Start Dresser" push button does not stop the dresser and coolant pump motors. Depressing the "Start Dresser" push button also energizes the coil of spindle brake relay CR 8. The contactors associated with CR 8 are biased open and are, therefore, closed by the activation of this relay. The closing of the CR 8 contactors energizes SOL I, releasing the spindle brake 33, and also closes a control circuit through CR 8 coil so that the release of the "Start Dresser" push button does not cause the spindle brake to set.

The operator next verifies the position of the "Jog-Run" selector switch, which should be turned to "Run" as shown, and the position of the "High-Low" spindle speed switch, which will normally be set at "High" as shown when a finish dressing operation is in progress and at "Low" when a crushing operation is in progress.

The operator now depresses the push button marked "Start Spindle." This energizes the coil of spindle motor high speed starter relay CR 11. The contactors associated with CR11 are biased open and are, therefore, closed by the activation of this relay. The closing of the CR 11 contactors starts the spindle drive motor and closes a control circuit through CR 11 coil, so that the release of the "Start Spindle" button does not stop the spindle drive motor. Since LS 6 [145] is closed, the coil of relay CR 6 will be energized by depressing the "Start Spindle" button and kept energized by the closing of the CR 11 contactors. The contactors associated with CR 6 include contactors for energizing SOL E [82], which is the normal clutch neutralizing solenoid and operates to move shifter lever latching detent 77 forward against its bias. These solenoid-energizing contactors (Fig. 40) are biased open. Also associated with CR 6 are two sets of control circuit contactors (Fig. 39), one of which is biased open and the other biased closed. The biased open contactors which are closed by the energizing of CR 6 energize the "unlatch" coil of LR 2. This effects no change as this "unlatch" had already been energized by the closing of LS 6 at the conclusion of the preceding cycle and the contactors associated with LR 2 already released to their bias. The biased closed contactors which are opened by the energizing of CR 6 open a circuit which is to be closed later by the opening of LS 6.

The operator now depresses the push button marked "Start Cycle." This energizes the coil of CR 1. The contactors associated with CR 1 are all in the control circuit and biased open. Since LS 7 and LS 8 are closed, the closing of the contactors associated with CR 1 establishes a control circuit through the coil of CR 1 and LS 8, assuring that these contactors remain closed when the "Start Cycle" button is released until the cycle ends normally by the opening of LS 8, or is ended manually by depressing the "Stop Cycle" button or by the activation of an emergency control. The closing of the CR 1 contactors also closes a circuit through LS 7, the biased closed contactors associated with latch relay LR 1 which was unlatched at the end of the previous cycle, and, in parallel, through the coil of CR 2 and through SOL A [71]. This solenoid retracts the right shifter lever stop 65 (Fig. 24) closing LS 9 [75]. The energizing of CR 2 closes the biased open contactors associated with it which are all in the control circuit. The closing of the CR 2 contactors closes a circuit energizing CR 2 which by-passes the CR 1 contactors and LS 7, but still includes the biased closed contactors of LR 1. The closing of LS 9 energizes the coil of relay CR 3. The biased open contactors associated with CR 3 are closed to energize SOL B [62], shifting thrust link 60 (Fig. 24) to the right and hence engaging left-hand clutch 40 (Fig. 7) which commences the motion of carriage 6 to the left (Fig. 8). The automatic cycle has begun.

The beginning of the dressing stroke (travel to the left) of the carriage 6 opens limit switch 142 [LS 7]. As already explained the energizing of CR 2 has closed a circuit by-passing LS 7. The carriage 6 continues its left travel and opens limite switch 145 [LS 6].

The opening of LS 6 deenergizes the coil of CR 6 thereby restoring the associated contactors to their respective biased open and biased closed positions. The opening of the biased open contactors deenergizes solenoid 82 [SOL E] controlling the shifter lever latching detent 77 and permits the force of spring 67 to force detent 77 into engagement with the latch portion 56 of shifting lever 53 which is still being held in position to engage clutch 40 by energization of solenoid 62 [SOL B]. Simultaneously, the closing of the biased closed contactors associated with CR 6 closes a control circuit through the latch coil of LR 1 and the biased open contactors associated with CR 2 and CR 3, both of which are energized. The energization of the latch coil of LR 1 closes and latches closed the biased open contactors and opens and latches open the biased closed contactors associated with that relay. The opening of the biased closed LR 1 contactors deenergizes SOL D [170]. The deenergizing of solenoid 170 releases the retract cam braking clutch 165. Simultaneously the same biased closed contactors deenergize the

coils of CR 2 and CR 3, thus opening the biased open contactors associated with each of them. Opening of the CR 3 contactors deenergizes SOL B [62] which, but for the latching of the detent 77, would permit the main clutch to return to neutral. The opening of the CR 3 contactors also opens a number of control circuits including the control circuit just closed through the latch coil of LR 1, but, because of the latch arrangement of this relay, the deenergizing of this coil does not affect the position of its associated contactors. The opening of the biased closed contactors associated with LR 1 also deenergizes SOL A [71]. This permits right stop plunger 65 to be released to the control of spring 67 urging it rearward, but, inasmuch as the latch end 56 of shifter lever 53 is held to the right by its engagement with detent 77, right stop plunger 65 comes to rest against the front face of latch end 58 ready to complete its rearward motion when shifter lever 53 is again moved out of the left travel position. The deenergizing of solenoid 71 [SOL A] also opens limit switch 75 [LS 9]. Simultaneously the closing of the biased open contactors associated with LR 1 energizes SOL C [171]. This engages retract cam driving clutch 151.

Cam 136 (Figs. 4 and 5) starts rotating and carriage 6 moves into depth in doing so closing momentarily limit switch 172 [LS 11]. The momentary closing of LS 11 momentarily energizes the unlatch coil of LR 1 thereby releasing the associated contactors to their biased position. This deenergizes SOL C and energizes SOL D releasing the retract cam from its drive and setting the retract cam braking clutch. The position of limit switch 172 in relation to the angular position of cam 136 on shaft 135 is such that the cam is now stopped with the cam follower 124 riding the high point of the cam. This movement of the LR 1 contactors in the control circuits does not at this time close or open any such circuits, but merely sets them up for subsequent opening or closing. The carriage 6 thus continues its left travel uninterrupted and in the in-depth position.

The continuing left travel of carriage 6 in the in-depth position eventually brings finger 147 on arm 7 (Fig. 23) into contact with limit switch 146 [LS 3] The closing of LS 3 completes the dressing stroke by closing a circuit which commences the rotation of retract cam 136 although the carriage 6 continues to travel to the left. This closing of LS 3, referring to Fig. 39, energizes the latch coil of LR 1 which in turn, by deenergizing SOL D and energizing SOL C, releases the retract cam driving clutch. As soon as the retracting of the dresser begins, LS 3 opens, deenergizing the latch coil of LR 1 which, as we have seen before, does not affect the position of its latched contactors. The dresser continuing its travel left as it is moved out by rotation of cam 136 until finger 149 closes limit switch 148 [LS 4]. The closing of LS 4 energizes the coil of CR 4. Because the previous circuit has left the contactors of LR 2 in their biased position, the closing of CR 4 energizes SOL E [82]. The energizing of solenoid 82 (Fig. 25) causes the retraction of detent 77 from its engagement with the latch end of shifter fork 53 thus permitting coil springs 59 to return that lever to its neutral position. The movement of latch end 56 to the neutral position permits the complete movement of right stop plunger 65 to the rear under the influence of spring 67. The carriage drive is thus disengaged, but the rotating parts are not braked and the carriage continues a left coast travel. The energizing of the coil of CR 4 also in the control circuits opens a biased closed contactor in an alternate circuit through the latch coil LR 1 and closes a circuit through the unlatch coil of that relay. This restores the LR 1 contactors to their biased position in which SOL C is deenergized and SOL D is energized and the retract cam driving clutch is released and braking clutch set. It will be observed that between the closing of LS 3 initiating the retracting motion of the carriage by rotation of cam 136 and the closing of LS 4 which stops this motion as just described the time interval is controlled by the rate of left motion of carriage 6. It is for this reason that the change gears 153 controlling the rate of rotation of cam 136 must be selected properly to synchronize with the change gears 43 controlling the rate of rotation of carriage driving shaft 90.

The continuing coast travel of carriage 6 to the left now closes limit switch 150 [LS 5]. The closing of LS 5 energizes SOL G [72]. The energizing of solenoid 72 withdraws a left stop plunger 66 against bias spring 67 and closes limit switch 76 [LS 10]. The closing of LS 10 energizes the coil of CR 5 thus energizing SOL H [64]. The energizing of solenoid 64 shifts shifter lever 53 to engage dresser return drive clutch 41. Simultaneously the closing of contactors associated with CR 5 in the control circuit energizes the latch coil of LR 2 thus latching closed the bias open contactors associated with that relay and latching open the biased closed contactors. The opening of the biased closed LR 2 contactors deenergizes SOL E [82] thereby permitting detent 77 to reengage in latch portion 56 of shifter lever 53 notwithstanding that CR 4 continues to be energized. As a result of the engagement of return travel clutch 41 the carriage 6 now starts right (return stroke) travel. This opens LS 5 thereby deenergizing SOL G [72] releasing left stop plunger 66 to the control of spring 67 which urges it forward to contact the rear face of latch portion 56 of lever 53 where it will remain so long as that latch portion is held by solenoid 64 [SOL H] in the return stroke clutch engaging position. The release of plunger 66 opens limit switch 76 [LS 10]. The opening of LS 5 also deenergizes CR 5 and thereby deenergizes both the latch coil of LR 2 and SOL H. The engagement of detent 77 in the latch portion 56 of shifter lever 53 prevents the deenergizing of SOL H from permitting the shifter fork to return to neutral position. The dresser continues its travel to the right opening of LS 4 [148].

The opening of LS 4 deenergizes CR 4. This in turns opens the circuit through the unlatch coil of LR 1 and closes a circuit through the latch coil of LR 1. The newly closed circuit includes the biased closed contactors of CR 4 and the biased open contactors of LR 2 which have previously been latched closed. As before the energizing of latch coil LR 1 releases the retract cam brake and sets the retract cam clutch. The cam 136 starts rotating and the dresser continues its right travel. The cam follower 124 commences this period on the low part of cam 136 and the motion of the cam during this return stroke is stopped before the cam follower reaches the raised portion of the cam. The dresser thus being in its fully retracted position the return stroke motion causes ratchet wheel 266 to en-

gage pawl 280 (Figs. 34–37). Until the machine reaches the end of a cycle, each engagement of pawl 280 with ratchet wheel 266 will effect merely a predetermined increment of infeed of dresser slide 187.

As the carriage 6 nears the end of its travel right it closes limit switch 145 [LS 6]. The closing of LS 6 energizes the coil of CR 6 opening the biased closed contactors associated with it and closing the biased open contactors. The closing of the biased open contactors of CR 6 energizes SOL E [82]. The energizing of solenoid 82 which draws detent 77 from engagement in the latch end of shifter lever 53 permitting the spring bias to restore that lever to neutral. The restoration of the lever 53 to neutral permits the spring bias of left stop plunger 66 to thrust that plunger to its rearmost position locking the lever in neutral. Simultaneously the opening of the biased closed CR 6 contactors opens a circuit through the latch coil of LR 1 and closes a circuit through the unlatch coil of LR 1 with the effect already repeatedly discussed of deenergizing SOL C and energizing SOL D thereby releasing the retract cam driving clutch and setting the retract cam braking clutch. As previously explained the cam follower 124 has not yet begun to climb the raised portion of cam 136. Likewise as previously explained the shifting of the dresser drive clutch into neutral is not associated with any braking action and the carriage 6 continues its coast travel to the right. It will be especially noted that the closing of CR 6 energizes the unlatch coil of LR 2 restoring the contactors associated with that relay to their biased position.

As the dresser continues its coast travel right it closes LS 7. It will be observed that the closing of LS 7 brings all the parts into the position which they occupied after the "Start Cycle" push button had been depressed and accordingly the dresser recommences its dressing stroke.

The dressing stroke and return stroke pattern just described will be repeated automatically until the dresser infeed slide 187 reaches the limit of its rearward travel as set by the position of stops 195 and 196. As already explained, when the stops come into engagement, it is no longer possible for pawl 280 to rotate ratchet wheel 266 and the engagement of pawl 280 with that wheel on the return stroke of the carriage will, therefore, open limit switch 293 [LS 8]. The opening of LS 8 deenergizes the coil of CR 1 so that the closing of LS 7 can no longer effect the energization of CR 2 and the dresser transverse motion will stop upon the completion of that return stroke.

Detailed description.—Operation of manual and automatic emergency controls

If, for any reason, it is desired to stop the dressing cycle prior to the opening of LS 8, depressing the Stop Cycle push button will deenergize CR 1 and will, therefore, have precisely the same effect on the continuing of the cycle as the opening of LS 8, i. e. the carriage motion will stop at the end of the next return stroke.

If, for any reason, it is desired completely to deenergize the machine, it is necessary only to press the Emergency Stop. This will deenergize CR 8 coil, the opening of whose associated contactors deenergizes all control circuits except the emergency clutch neutral circuit through the coil of CR 7, and all power circuits except that controlled by CR 7. Especially, SOL I [33] is deenergized and spindle brake 33 is thereby set.

If the carriage overruns the limits of coast travel set by limit switches 142 and 150, either limit switch 140 or 138 [LS 2 or 1] will be contacted. Contacting either LS 1 or LS 2 will have the effect of pressing the Emergency Stop plus the effect of activating CR 7. This energizes SOL F [83]. Solenoid 83 operates to withdraw detent 77 from the latch portion 56 of shifter lever 53 thus returning the main clutch to neutral.

To jog or "inch" the machine the Jog-Run switch is set to the Jog position and the Start Spindle and Start Cycle buttons are held depressed until the required movements are completed.

Having now described my invention in detail and explained the principle thereof in general and in terms of the best mode in which I contemplate applying that principle, I do not wish to be limited to the details of the construction disclosed for which many equivalent details will suggest themselves to those skilled in the art. Instead I claim and seek to protect by Letters Patent the new method and apparatus particularly pointed out and distinctly claimed in the appended claims.

I claim:

1. The method of dressing threads on the circumferential face of an abrasive wheel which includes repeated cycles including the steps of bringing a rotating circular series of discrete diamond-pointed cutting tools into contact with a point on said face while simultaneously rotating said wheel in the direction to produce peripheral motion thereof in the same direction as, but at a rate substantially less than, the peripheral motion of said series and moving said series axially of said wheel across said face at a rate equal to one lead of the thread to be dressed thereon for each revolution thereof and between each of said cycles moving the point of contact of said series with said wheel a predetermined distance from the greatest diameter thereof inwardly along the specification surface of the thread to be dressed thereon.

2. The method of dressing threads on the circumferential face of an abrasive wheel which includes repeated cycles including the steps of simultaneously bringing each of two rotating circular series of discrete diamond-pointed cutting tools into contact with a separate point on said face while simultaneously rotating said wheel in the direction to produce peripheral motion thereof in the same direction as, but at a rate substantially less than, the peripheral motion of said series and moving said series axially of said wheel across said face at a rate equal to one lead of the thread to be dressed thereon for each revolution thereof, and between each of said cycles moving the point of contact of one of said series with said wheel a predetermined distance from the greatest diameter thereof inwardly along the specification surface of one flank of the thread to be dressed thereon while similarly moving the point of contact of the other of said series with said wheel along the specification surface of the other flank of said thread.

3. The method of claim 2 in which the two thread flank surfaces in contact with the two series are surfaces on the opposite sides of the same inter-thread space.

4. Apparatus for dressing threads on the circumferential face of an abrasive wheel including a power-rotatable abrasive-wheel spindle, an independently-power-rotatable dressing-tool carrier disk, a plurality of diamond-pointed dressing

tools of bell-crank form pivoted about axes substantially perpendicular to radii of said disc adjacent the outer circumference and on one face thereof, said bell-cranks being disposed with their inner arms substantially radial to said disc and their outer arms substantially parallel to the axis of said disc, a diamond point on the outer face of each of said outer arms, means operably connected to said tools for adjusting the displacement of the inner arms thereof from said disc whereby said points can be set in a circle concentric with and in a plane perpendicular to said disc and of a radius greater than said disc, a carriage bearing said disc and movable parallel to the axis of said spindle, a power drive operably connected to said carriage, and means interconnecting said drive and said spindle in predetermined timed relation.

5. Apparatus according to claim 4 in which the power drive connected to the carriage includes means for producing a double motion of said carriage, one, a motion along a line parallel to the spindle axis and the other, a rocking motion about said line.

6. Apparatus according to claim 5 in which the means interconnecting the drive and the spindle includes means for timing the rocking motion in relation to the parallel motion so that motion of the carriage parallel to the spindle axis in one direction carries the disc rocked to a position relatively near to said axis and in the other direction carries said disc rocked to a position relatively away from said axis.

7. Apparatus according to claim 4 in which the disc is mounted on the carriage on a slide movable relative to the carriage in a direction perpendicular to the axis of the spindle.

8. Apparatus according to claim 7 in which the motion of the slide is controlled by a lead screw operatively engaging the carriage.

9. Apparatus according to claim 8 including a wheel operatively connected to the lead screw and means fixed in space engaging said wheel once during each cycle of carriage motion whereby the advance of the lead screw mechanism is controlled by motion of the carriage.

10. Apparatus according to claim 4 in which the disc is mounted on the carriage on a base member movable relative to the carriage in a direction to alter the angular relationship of the disc axis to the spindle axis.

11. As a sub-combination, a grinding wheel dresser device comprising a dressing-tool carrier disc, a plurality of diamond-pointed dressing tools of bell-crank form pivoted about axes substantially perpendicular to radii of said disc adjacent the outer circumference and on one face thereof, said bell-cranks being disposed with their inner arms substantially radial to said disc and their outer arms substantially parallel to the axis of said disc, a diamond point on the outer face of each of said outer arms, and means operably connected to said tools for adjusting the displacement of the inner arms thereof from said disc whereby said points can be set in a circle concentric with and in a plane perpendicular to said disc and of a radius greater than said disc.

12. Abrasive-wheel dressing apparatus including a pair of supports, a device according to claim 11 mounted in each of said supports to rotate about the disc axis, a common power source operably connected to and capable of rotating the discs of each of said devices in synchronism, and guides for said supports so arranged that said devices are movable along converging paths to cause the point circles of said discs to intersect in a common point, the axes of rotation of said devices lie in a single plane, and the angular relation between said axes is adjustable.

JOSEPH J. OSPLACK.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
153,568	Husbands	July 28, 1874
1,051,483	Bryant	Jan. 28, 1913
1,097,222	Grannis	May 19, 1914
1,161,242	Noyes	Nov. 23, 1915
1,501,230	Olson	July 15, 1924
1,588,928	Wirrer	June 15, 1926
1,624,868	Hanson	Apr. 12, 1927
1,701,675	Hoagland	Feb. 12, 1929
1,773,386	Burgess	Aug. 19, 1930
1,946,888	Tougas	Feb. 13, 1934
2,347,283	Ross	Apr. 25, 1944
2,380,286	Bauer	July 10, 1945
2,388,064	Markus	Oct. 30, 1945
2,391,979	Kershaw	Jan. 1, 1946
2,482,785	Lohutko	Sept. 27, 1949