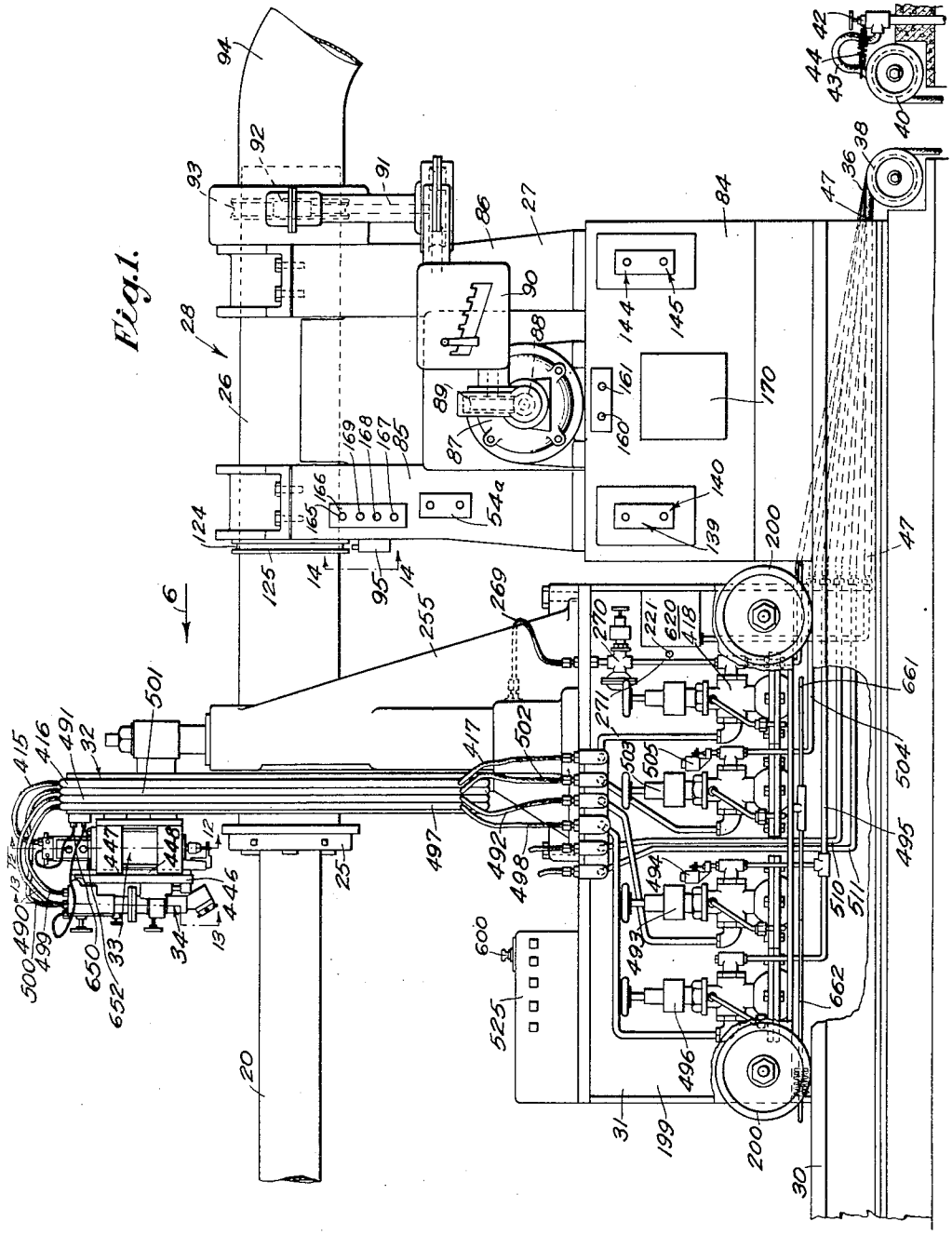
June 6, 1933. C. J. COBERLY 1,912,362

APPARATUS FOR CUTTING SLOTS IN PIPE

Filed Feb. 4, 1930 10 Sheets-Sheet 1

Fig. 1.



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APPARATUS FOR CUTTING SLOTS IN PIPE

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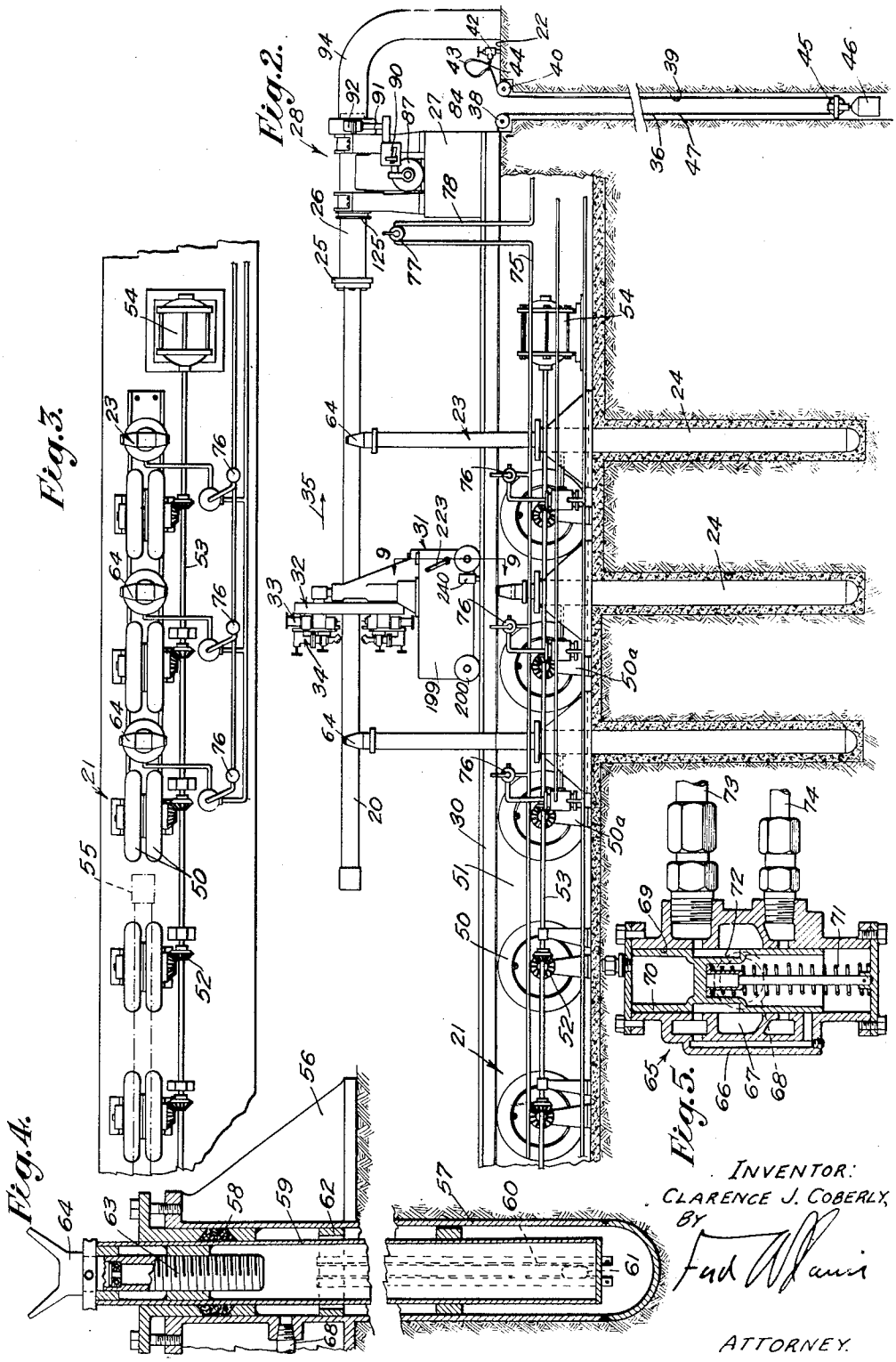


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

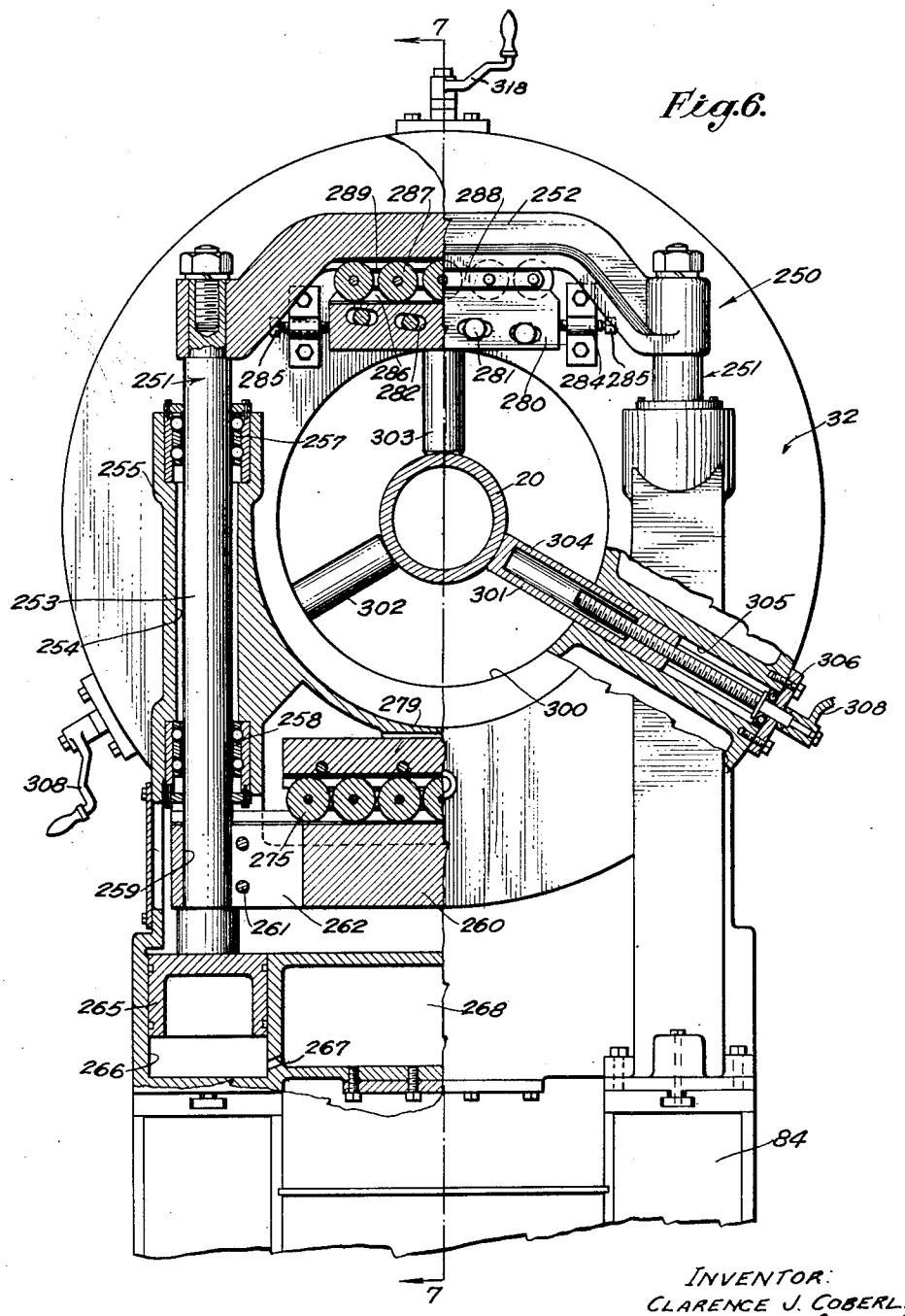
INVENTOR:
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APPARATUS FOR CUTTING SLOTS IN PIPE

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Fig.6.




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APPARATUS FOR CUTTING SLOTS IN PIPE

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Fig. 7.

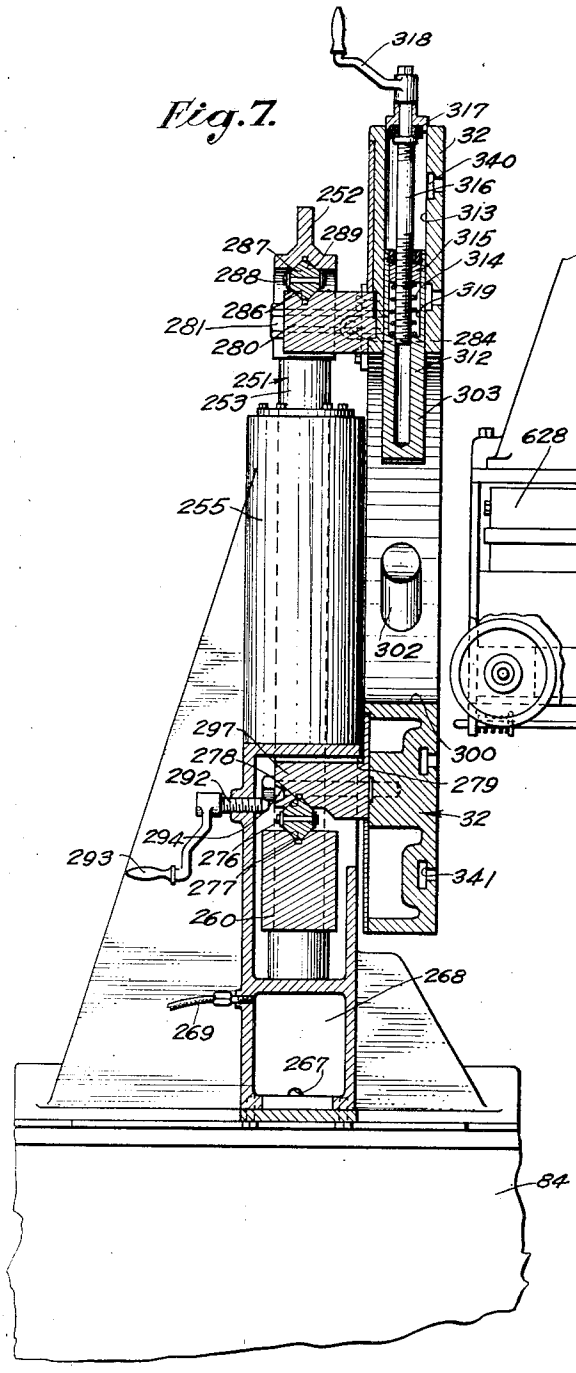
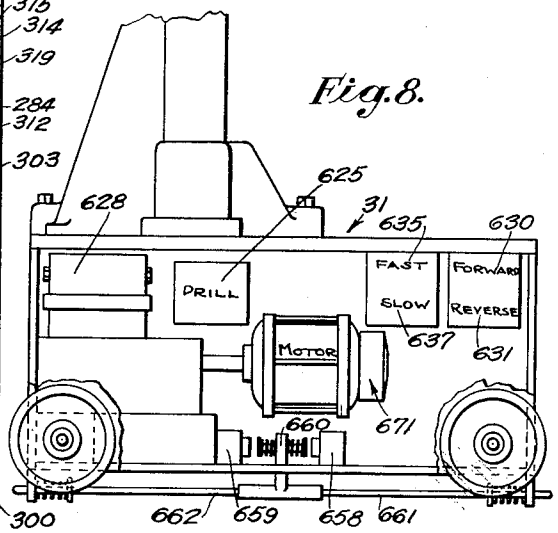



Fig. 8.




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APPARATUS FOR CUTTING SLOTS IN PIPE

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Fig. 9.

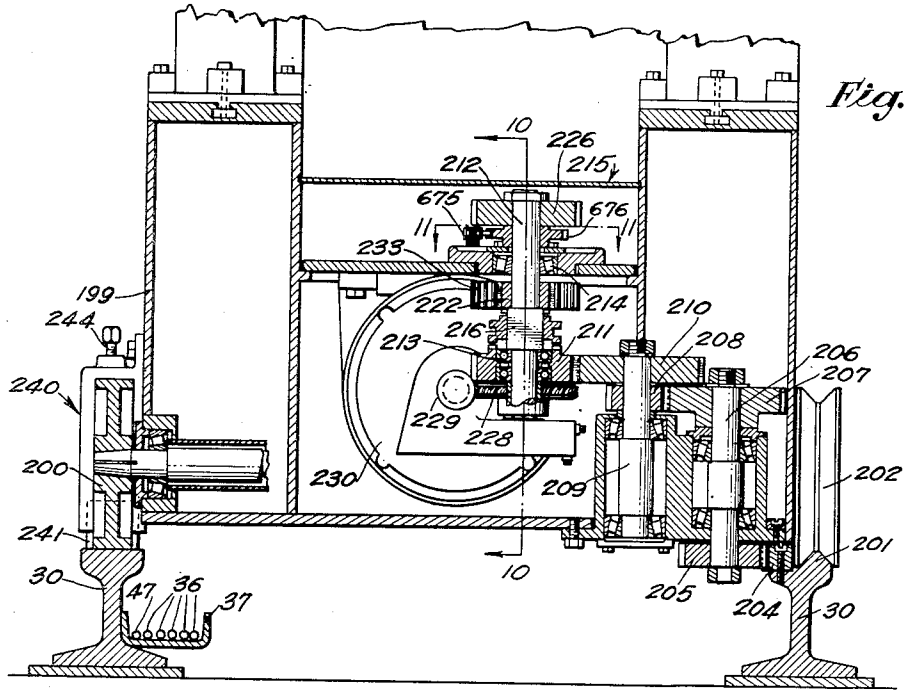



Fig. 10.

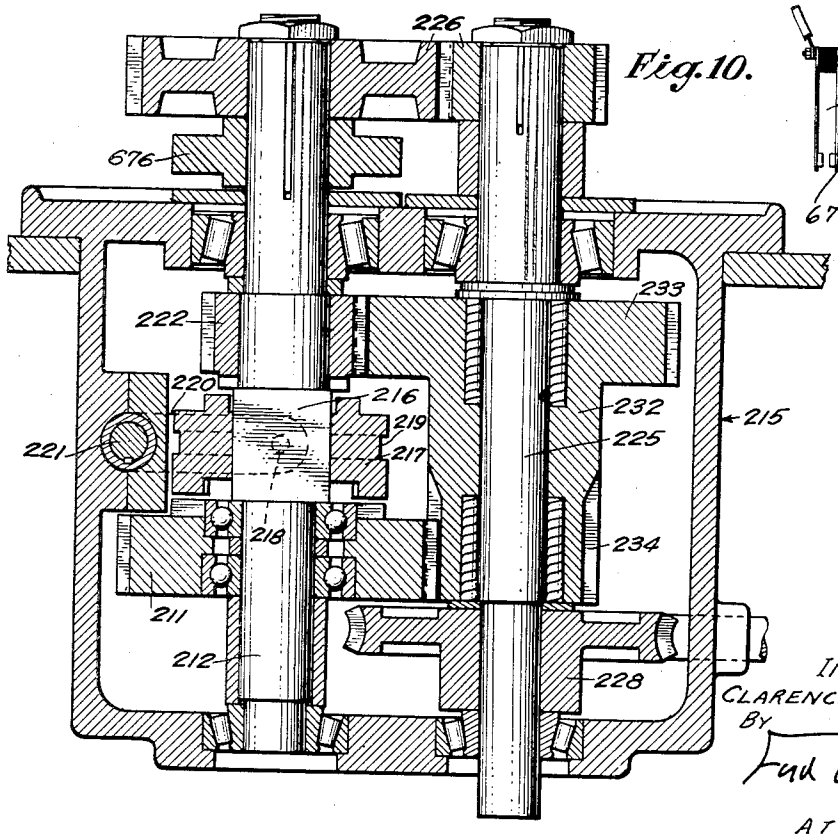
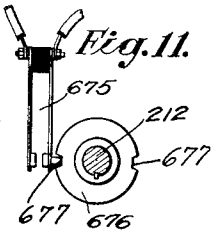



Fig. 11.




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APPARATUS FOR CUTTING SLOTS IN PIPE

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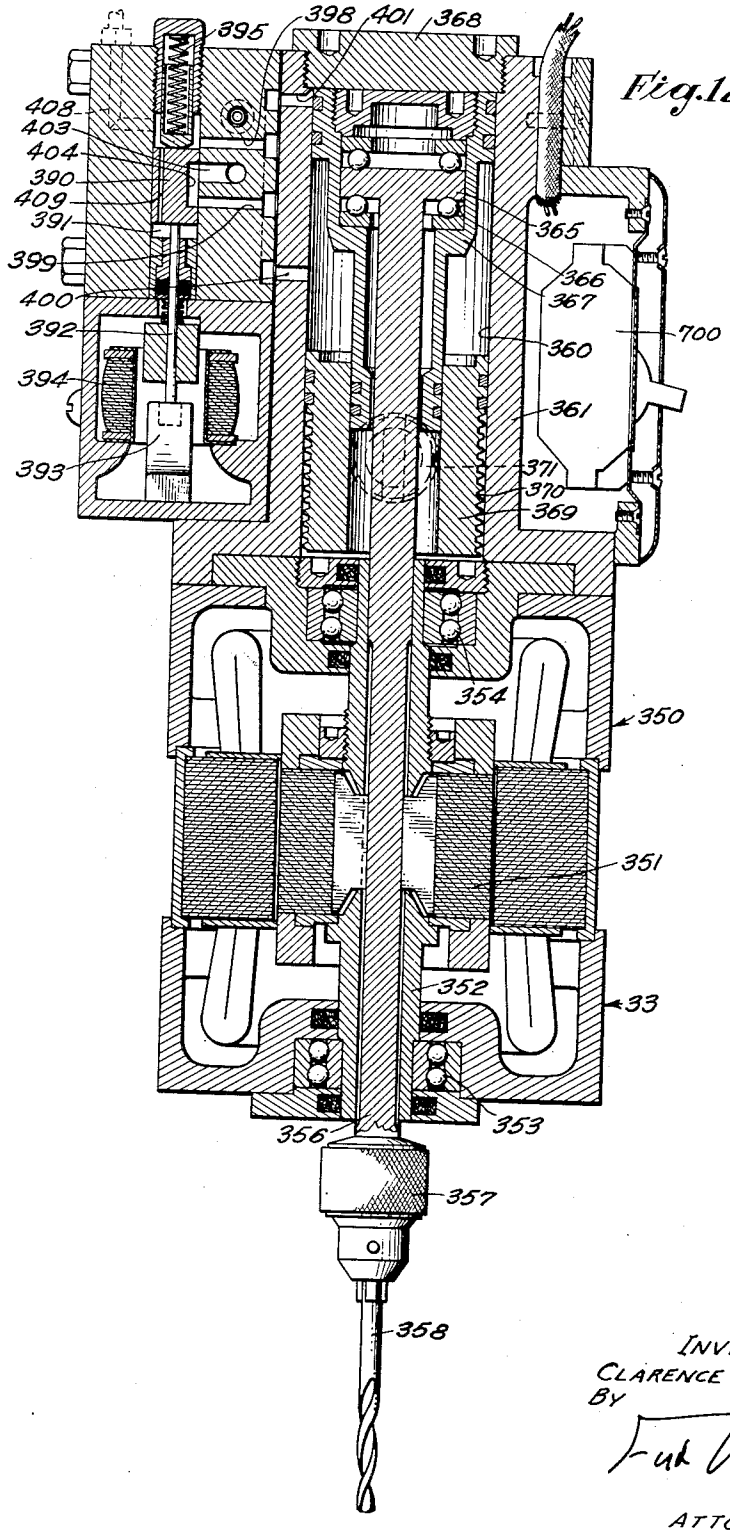



Fig. 12.

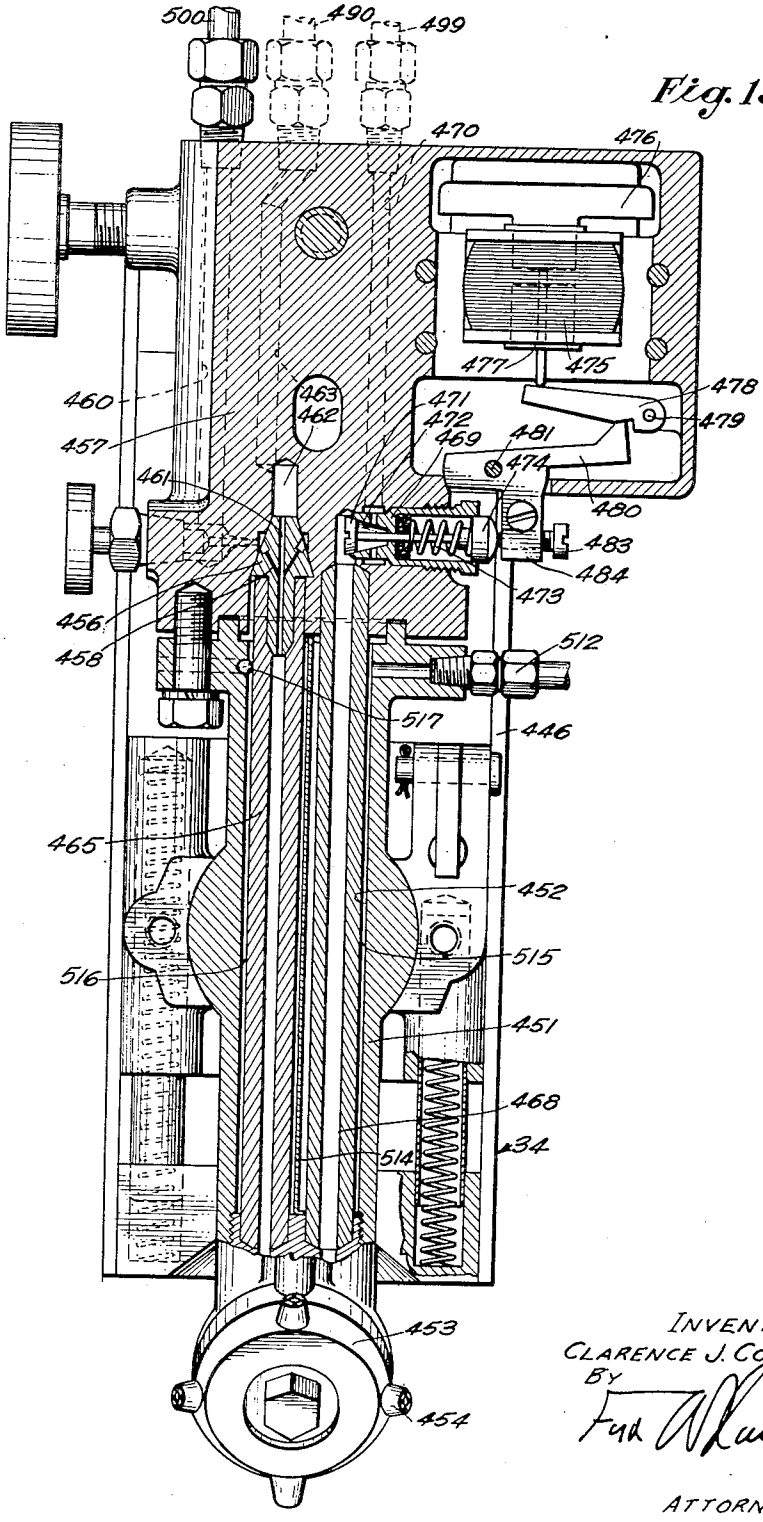
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APPARATUS FOR CUTTING SLOTS IN PIPE

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Fig. 13.




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APPARATUS FOR CUTTING SLOTS IN PIPE

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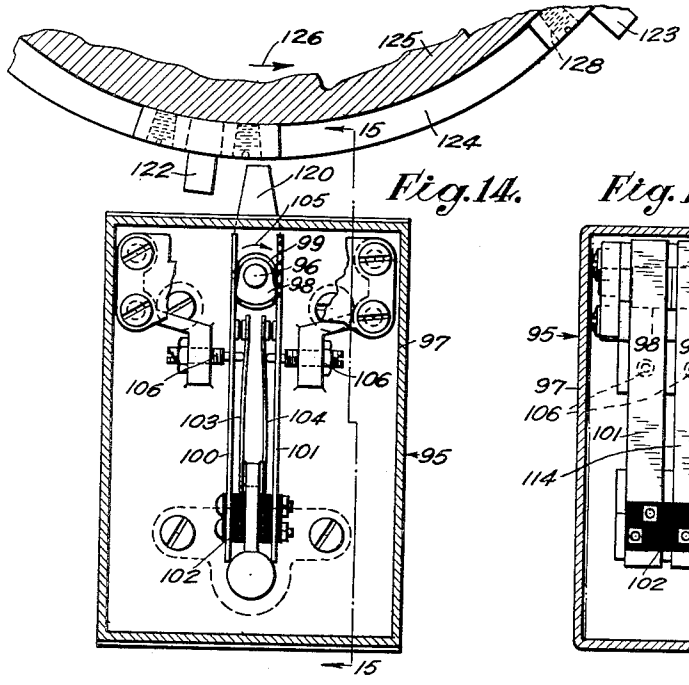



Fig. 14.

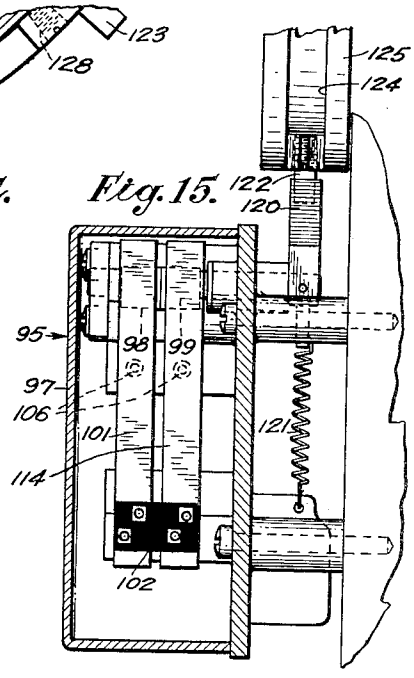
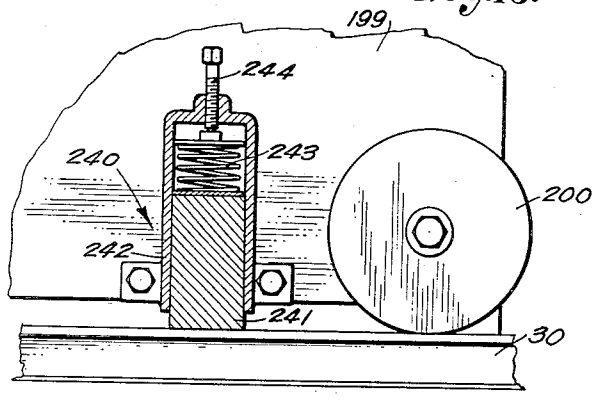



Fig. 15.

Fig. 16.




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June 6, 1933. C. J. COBERLY 1,912,362

APPARATUS FOR CUTTING SLOTS IN PIPE

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Fig. 17.

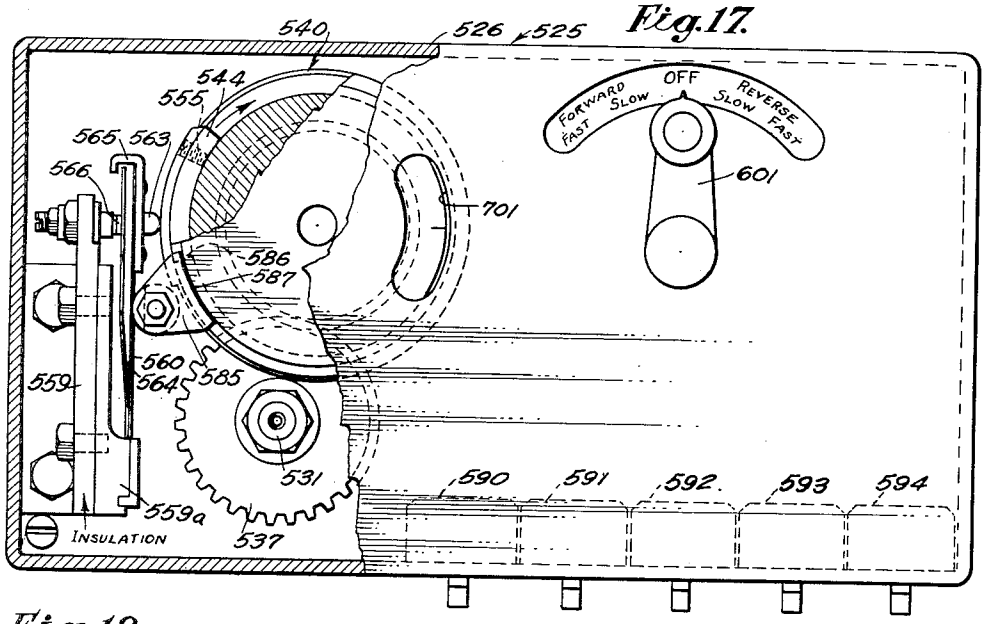
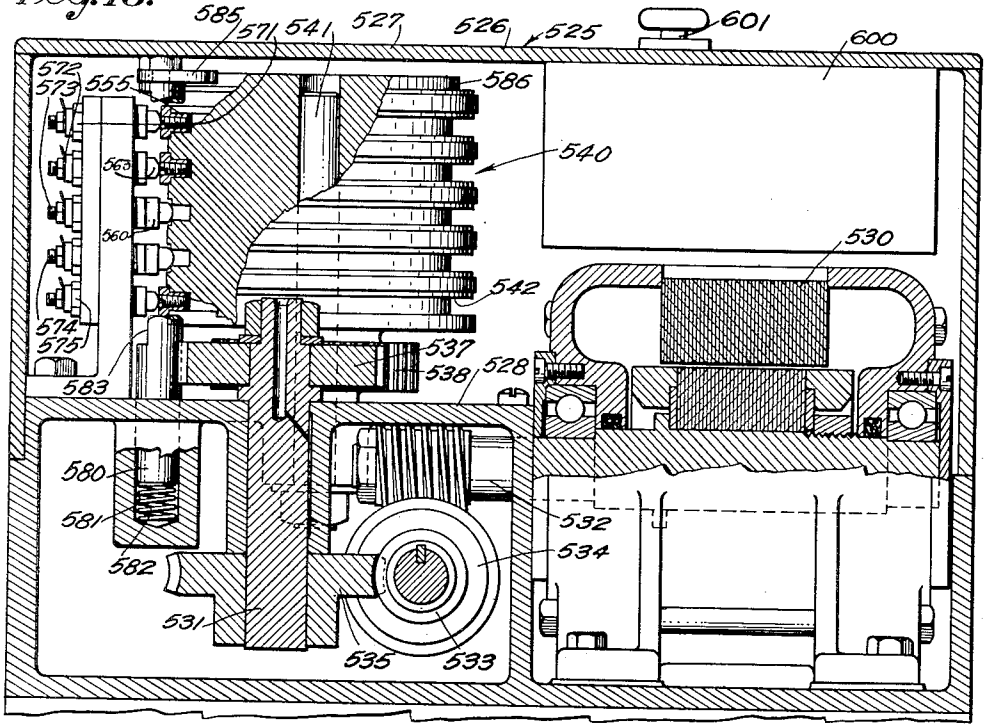



Fig. 18.




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APPARATUS FOR CUTTING SLOTS IN PIPE

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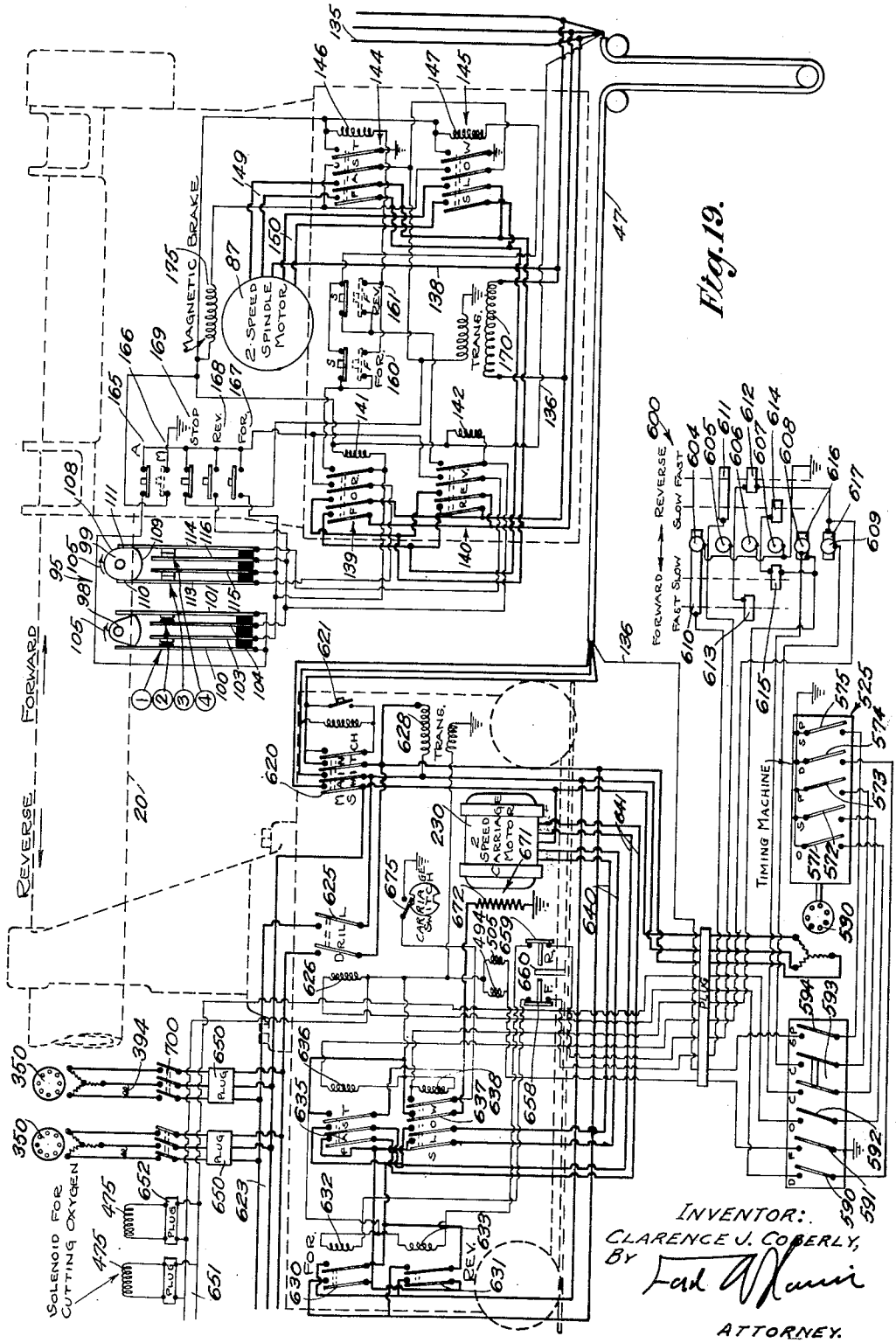



Fig. 19.

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Patented June 6, 1933 1,912,362

# UNITED STATES PATENT OFFICE

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## APPARATUS FOR CUTTING SLOTS IN PIPE

Application filed February 4, 1930. Serial No. 425,838.

This invention relates to the metal cutting art, and more particularly to a novel method and apparatus for cutting slots in a length of pipe or similar material, and is an improvement on the apparatus disclosed in my Patent No. 1,585,893, issued May 25, 1926.

In its preferred form, the present invention comprises a head including a spindle for controlling the angular position of the pipe, and a carriage movable along the pipe and supporting a plurality of drilling structures and a plurality of cutting torch structures disposed radially around the pipe. The drilling structures first penetrate the pipe after which the cutting flames from the torches are directed through the holes thus formed and the carriage is moved along the pipe, thus cutting a slot therein.

It is a general object of the present invention to provide an improved pipe-slotting machine of this type.

It should not be inferred, however, that this invention is limited only to pipe-perforating machines, for certain features thereof are not limited thereto but find utility in machines for otherwise processing pipe or other articles.

One of the important objects of the present invention lies in the provision of a novel handling apparatus, operated from the machine, for placing the pipe or other article in position in the machine without the use of cranes or other overhead lifting devices.

This I accomplish by the use of a plurality of hydraulically operated jacks, and it is an object of this invention to provide jacks which lift the pipe or other article into correct relationship relative to the machine and maintain this pipe or article in correct position during the processing thereof.

As the carriage moves along the pipe, it is necessary that these jacks be successively lowered, and it is another object of this invention to provide a plurality of jacks which may be operated simultaneously or individually.

Other objects of the invention lie in the novel apparatus for supplying the necessary gas and electricity to the carriage without the use of overhead hose and cables which are not only unsightly, but often become entangled and thereby incur the danger of being broken.

In my patent supra, I disclose an auxiliary pipe extending inside the free end of the pipe being perforated and which conducts the slag away from the jets. It is an object of the present invention to dispense with such an auxiliary pipe, thus saving large amounts of space previously necessary for the insertion and removal of the auxiliary pipe.

A further object of this invention is to provide a novel method of perforating a length of pipe by drawing a stream of air or other gas through the unperforated section of the pipe during the cutting process.

Not only does this stream of air collect and remove the slag, but it has a very desirable hardening action on the walls of the slot, and it is a further object of the invention to provide a novel method of hardening the walls of a perforation formed in a pipe, or other member, by drawing a stream of air, gas, or other fluid through this perforation during the cutting thereof by a cutting torch.

A further object of the invention is to provide a machine of the class described in which the sequence of events is controlled automatically, this sequence of events including not only the operation of the drills and torches, but also the movement of the carriage and the pipe.

A further object of the invention is to provide a machine in which various shapes of slots may be cut by relatively simple adjustments of the machine.

It sometimes occurs that one of the torch tips may become clogged, and a slot may thus be missed before the difficulty can be corrected. In returning for the purpose of correcting this defect, it is extremely desirable that the carriage be moved to the exact point at which the slot would otherwise have been started; in other words, to such a position that the torch is directed through the previously drilled hole. In accomplishing this end, I have devised a control system for the carriage which makes the distance between starting points of successive slots constant. This is

accomplished by providing means for automatically stopping the carriage only at certain predetermined positions, usually at one-half inch intervals or less.

It is an object of this invention to provide a novel control system for maintaining the distance between corresponding points of adjacent perforations constant.

A further object of the present invention is to provide a novel electric control system for the spindle which includes a single electric circuit connecting the carriage and the head.

A further object of the invention is to provide such a control system in which the desired spindle speed may be selected after which the electric circuit connecting the carriage to the head automatically controls the direction and speed of movement of the spindle.

Still another object of the invention is to provide a reversible electric drive means, the operation of which is controlled by the control circuit, this drive means being connected to the spindle for turning this spindle through an angle depending upon the position of a stop means which also acts to reverse the connections of the motor so that at a subsequent time the control circuit effects a movement of the spindle in an opposite direction.

Another object of the invention is to provide a novel floating support for the drill and torch structures whereby these structures are maintained a constant distance from the surface of the pipe regardless of irregularities or slight bends therein.

Other objects of the invention lie in the particular construction of certain of the elements and in certain combinations of elements, such, for instance, as the provision of a plurality of drills operated by individual motor means controlled by a single control means, and in the provision of a cutting torch in which the heating flame continuously acts to heat the metal while the cutting flame is controlled by manual or automatic means.

Other objects and advantages of the invention will be evident to those skilled in the art from the following description in which I shall point out in detail the novel features of my invention as applied to a pipe-slotting machine.

Referring to the drawings in which I have shown a preferred embodiment of my invention,—

Fig. 1 is a side elevational view of a portion of the machine of my invention, showing the carriage in its extreme forward position.

Fig. 2 is a general utility view showing the relationships between the various parts of my invention, and illustrates the carriage in working position.

Fig. 3 is a top view of the pipe-handling apparatus illustrated in Fig. 2.

Fig. 4 is a sectional view of a jack forming a part of the lifting means of my invention.

Fig. 5 is a pneumatically operated valve structure for controlling the operation of the jack shown in Fig. 4.

Fig. 6 is a view, partially in section, of the carriage structure of my invention and is taken in the direction of the arrows 6 of Fig. 1.

Fig. 7 is a sectional view of the carriage structure taken as indicated by the line 7—7 of Fig. 6.

Fig. 8 is a side view of the lower portion of the carriage structure with the cover removed.

Fig. 9 is a sectional view of the carriage driving mechanism and is taken as indicated by the line 9—9 or Fig. 2.

Fig. 10 is a sectional view taken on the line 10—10 of Fig. 9.

Fig. 11 is a view taken on the line 11—11 of Fig. 9 and illustrates the carriage switch.

Fig. 12 is a sectional view of the drilling structure of my invention taken on the line 12—12 of Fig. 1.

Fig. 13 is a sectional view of the torch structure of my invention taken on the line 13—13 of Fig. 1.

Fig. 14 is a view of the directional switch and is taken as indicated by the numeral 14—14 of Fig. 1.

Fig. 15 is a sectional view taken as indicated by the line 15—15 of Fig. 14.

Fig. 16 is a sectional view of a braking means for the carriage structure.

Fig. 17 is a top view of the timing machine of my invention, a portion of the cover thereof being broken away.

Fig. 18 is a side view, partially in section, of the timing machine illustrated in Fig. 17.

Fig. 19 is a general wiring diagram of a portion of the electrical connections utilized in my apparatus.

### *Machine in general*

Referring particularly to Fig. 2, the form of machine shown in the drawings is adapted to perforate a length of pipe 20 which is moved toward the machine on a conveying system 21 positioned below the floor level 22. An elevating system 23 is then utilized for moving the pipe vertically upward into a working position shown in Fig. 2, this elevating system being formed of a plurality of hydraulically operated jacks 24. When in this position, the pipe may be moved into a chuck 25 secured to a spindle 26 rotatably mounted in a head 27 and cooperating therewith in defining a head structure 28. The spindle 26 is adapted to turn the pipe 20 through a given angle, moving this pipe first in one direction and then in the other, as will be hereinafter described.

Mounted substantially at the floor level 22, and extending parallel to the axis of the pipe

20 are rails 30 along which a carriage structure 31 moves, this structure including a face plate 32 on which is secured a plurality of drilling structures 33 and a plurality of cutting torch structures 34. During the cutting of the slots in the pipe 20 the carriage structure moves in a forward direction indicated by the arrow 35 of Fig. 2 and the drilling structures 33 drill a series of holes through the pipe, after which the carriage advances until the cutting torch structures 34 lie adjacent these holes, whereupon a stream of cutting oxygen is forced through these holes and the carriage 31 is moved in a direction of the arrow 35 to cut a longitudinal slot in the pipe 20. When the desired length of slot has been cut, the stream of cutting oxygen is removed, new holes are drilled and the sequence of operations is repeated. It is usually desirable to stagger the slots formed in the pipe, and for this reason it becomes necessary to turn the pipe 20 by means of the spindle 26 between successive drilling operations.

The necessary air, oxygen, acetylene, and water are supplied to the carriage through a plurality of hose 36 resting in a guide means formed by a channel 37 secured to one of the rails 30, as best shown in Fig. 9, and extending over a plurality of sheaves 38 and into a well 39 where they form a loop, the free end of the hose extending upward through the well and over a plurality of sheaves 40, these hose being connected to individual supply means 42. A loop 43 is formed in each hose between the sheaves 40 and the supply means 42, there being a spring 44 across this loop. The hose are held taut by sheaves 45 pivotally secured to a weight 46 in the well, this weight rising and lowering as the carriage moves along the track. Any difference in length between the hose is taken care of by the spring 44. These hose are paralleled by four-conductor electric cable 47, this cable being for the purpose of supplying electrical energy to the carriage.

*Pipe-handling apparatus*

The pipe-handling system of my invention is specifically described in my co-pending application entitled "Apparatus for handling pipe", Serial No. 425,836, filed February 4, 1930, now Patent No. 1,861,113. One form of this apparatus is, however, diagrammatically shown in Figs. 2 to 5 inclusive so that its cooperation with the remainder of the apparatus will be apparent. Referring particularly to Fig. 2, it will be apparent that the conveyor system 21 forming a part of the pipe-handling system comprises a number of pairs of pneumatically tired wheels 50 rotatably mounted in standards 50*a* disposed in spaced relationship in a pit 51, each of these pairs of wheels being simultaneously driven through beveled gears 52 which are in turn driven by a shaft 53 to one end of which a motor 54 is connected. The forward or reverse rotation of this motor is controlled by a switch 54*a* on the head 27. The energization of the motor 54 simultaneously turns all of the wheels, so that by placing a pipe on the wheels, as indicated by dotted lines 55 of Fig. 3, this pipe may move along the length of the pipe 20 into a position below that shown in Fig. 2.

Three jacks 24 have been shown, these jacks being positioned between the pairs of wheels 50, the details of the jacks being best shown in Fig. 4 wherein is illustrated a base structure 56 from which a barrel 57 extends downward into the ground. The lower end of this barrel is closed and the upper end provides a suitable packing 58 for a hollow piston 59 adapted to slide vertically therein, the barrel 57 providing guides 60 between which a pin 61 of the piston 59 may slide. The piston 59 is illustrated in its lowermost position and the uppermost position thereof is determined by an engagement between the pin 61 and a ring 62 which is secured to the inner surface of the barrel 57 and adapted to journal the piston 59.

Threadedly retained in the upper end of the piston 59 is a sleeve 63 in which the shank of a pipe-supporting head 64 journals, this head being shaped in the form of a Y. When slotting pipe of small diameter it is necessary that the head 64 be raised relative to the piston 59, so that when the pin 61 engages the ring 62 the pipe will be axially aligned with the spindle 26. This adjustment is accomplished by turning the sleeve 63.

The jacks 24 are hydraulically operated and are individually controlled by pneumatically operated valve structures 65 which control the supply of water to the interior of the barrel 57. Each valve structure 65 provides a body 66 in which is formed a central chamber 67 communicating with its corresponding jack through a pipe 68. Adapted to slide in a bore 69 of the body 66 is a piston 70 which is resiliently retained in upper position by a spring 71, and which provides a pocket 72 so positioned as to connect the chamber 67 with a water outlet pipe 73 when the piston is in an upper position, and to connect this chamber with a water inlet pipe 74 when in a lower position. Water is thus supplied to or exhausted from the jack, depending upon whether the piston 70 is in a downward or an upward position, thus controlling the vertical position of the pipe.

The piston 70 is moved downward against the action of the spring 71 by air pressure supplied to the bore 69 above the piston from an air line 75, this pressure being controlled by an individual three-way valve 76 which is manually operable to either supply air to the valve structure from the air line 75, or to exhaust the air from the valve structure through this valve. One of these three-way

valves is provided for each of the valve structures 65 for individually controlling the jack associated therewith. In addition the air line 75 is provided with a three-way valve 77 positioned adjacent the head 27 for simultaneously controlling all of the jacks 24, this valve controlling the supply of air from an air supply pipe 78 to the air line 75. In the normal operation of the device, the three-way valves 76 are so turned that air is simultaneously supplied to the valve structures 65 when the valve 77 is opened, thus moving the pipe 20 vertically through the operation of the three jacks 24 shown. When, however, the carriage structure is moving along the rails 30, it becomes necessary to operate the jacks 24 individually, so that these jacks may be lowered out of the path of travel of the carriage structure and again be raised into supporting relationship with the pipe. The valves 76 make this individual operation possible.

*Head and spindle structure*

The details of this structure are best shown in Figs. 1, 2, 14, and 15. Referring particularly to Fig. 2, the head 27 provides a base 84 which is secured to a suitable foundation adjacent the well 39 and provides end posts 85 and 86 which extend upward and provide journal boxes at their upper ends for journalling the spindle 26. This spindle is rotated by a spindle motor 87 mounted between the end posts 85 and 86, this motor being provided with a worm 88 which meshes with a worm gear 89 secured to a drive shaft of a quick-change gear box 90. On the driving shaft of this gear box is mounted a worm which is meshed with a worm gear mounted on a vertical shaft 91, the upper end of which carries a worm 92 meshed with a worm gear 93 mounted directly on the spindle 26. The worm 92 thus provides a drive means for the spindle, and the speed of this drive means may be controlled by the gear box 90. In addition, I prefer to utilize a two-speed reversible motor 87 whereby further speed variations may be accomplished, as well as a change in direction of rotation of the spindle.

The spindle 26 extends a distance beyond the end post 85, and the chuck 25 mounted thereon at this end is of any suitable design which will retain the pipe 20 in axial alignment with the spindle 26. Furthermore, the spindle is hollow, the interior thereof communicating with the interior of the pipe 20, and also with a suction pipe 94 secured to the head 27 and extending to the suction-end of a suitable blower, not shown, so that a strong stream of air is drawn through the unperforated portion of the pipe 20, through the spindle, and through the suction pipe 94, for the purpose of hardening the walls of the perforations, and also conducting slag therefrom, as will be more fully explained hereinafter.

Mounted on the end post 85 is a directional switch 95 which cooperates with the spindle-control system, to be hereinafter described, in controlling the amount and direction of rotation of the spindle 26. The details of this switch are best shown in Figs. 14, 15, and 19, which illustrate a horizontal shaft 96 pivoted in the walls of a box 97 which encloses the directional switch 95. Mounted on the shaft 96 in spaced relationship are cams 98 and 99, the shapes of which are best shown in Fig. 19. The cam 98 is in the shape of a bell pivoted about an axis near the upper end thereof, the lower edges of this cam being respectively contacted by spring arms 100 and 101 which are mounted in an insulating structure 102. This insulating structure also mounts spring contacts 103 and 104 which are electrically disconnected from the spring arms 100 and 101 when the cam 98 is in a neutral position, shown in Figs. 14 and 19. When, however, the shaft 96 is rotated as indicated by the arrow 105 of Figs. 14 and 19, the spring arm 101 moves into engagement with the spring contact 104, while the spring arm 100 moves still farther away from the spring contact 103. When the shaft is rotated in an opposite direction, however, the members 100 and 103 come into engagement, and the members 101 and 104 remain separated. A suitable adjusting means 106 is provided for each spring contact, this adjusting means extending through an opening in the adjacent spring arm and contacting the spring contact to determine the outermost position thereof.

For the purpose of brevity, the spring arm 100 and spring contact 103 will hereinafter be described as contacts 1 of the directional switch, while the corresponding spring arm 101 and spring contact 104 will be termed contacts 2 of the directional switch.

The cam 99 is of slightly different shape, and provides an upper circular portion 108 concentric with the axis of rotation of the shaft 96, and a lower eccentric portion 109 joined thereto by substantially flat side surfaces 110 and 111. Respectively engaging these side surfaces are spring arms 113 and 114 which when the cam 99 is in its neutral position shown in Figs. 14 and 19 are in electrical contact with spring contacts 115 and 116. For the purpose of brevity, the spring arm 113 and spring contact 115 will be hereinafter referred to as contacts 3 of the directional switch, while the spring arm 114 and spring contact 116 will be hereinafter termed contacts 4 of the directional switch.

The cam 99 is so designed that when the shaft 96 is turned in the direction indicated by the arrow 105, the lower eccentric portion 109 thereof opens the contacts 3, the contacts 4 remaining closed due to the fact that the

spring arm 114 engages the upper circular portion 108 of the cam and is not moved outward thereby. When, however, the shaft is rotated in an opposite direction, the contacts 4 open and the contacts 3 remain closed in the same manner as previously described.

The pivoting of the shaft 96 is accomplished by a tab 120 directly connected thereto and normally extending upward under the action of a spring 121. Thus any sideward force exerted on the tab 120 will turn the shaft 96, but when this force is removed the shaft and its associated cams will return to a neutral position. Such a force is exerted on the tab 120 by stops 122 and 123 which are adjustably positioned in an annular channel 124 formed in an annular ring 125 secured to the spindle 26. Thus when the spindle 26 is rotating in a direction indicated by the arrow 126 of Fig. 14, the stop 122 will turn the shaft 96 as indicated by the arrow 105, while if the spindle is moved in an opposite direction the stop 123 will engage the tab 120 to move the shaft 96 in an opposite direction.

The stops 122 and 123 are preferably retained in the channel 124 by tapered set screws 128 which act to spread split end portions of the stops into clamping engagement with the walls of the annular channel 124 when these set screws are threaded inward.

*Spindle control system*

The electrical means for controlling the spindle are best shown in Fig. 19, taken in conjunction with Fig. 1, the switches shown in Fig. 19 being shown approximately in the positions which they occupy on the head structure of the machine. Referring particularly to Fig. 19, the cable 47 extending downward into the well 39 and to the carriage structure 31 comprises four conductors, three of which carry power from a three-phase supply line 135 to the carriage controls, as will be explained in detail hereinafter, and the fourth conductor being a control wire 136 extending between the carriage and the head. The spindle control system to be hereinafter described is controlled by the grounding of this control wire, this grounding controlling the direction of rotation of the spindle motor 87 through the directional switch 95.

Referring particularly to Fig. 19, one terminal of the spindle motor 87 is connected to a conductor of the supply circuit 135 through a conductor 138, the two remaining conductors of this supply circuit being connected to the line side of a "forward" contactor 139 and a "reverse" contactor 140, the closing of which are respectively controlled by the energization of solenoids 141 and 142. The contactors 139 and 140 are of the interlocked type, so that the closing of one precludes the closing of the other until the first one is opened.

The load side of each of these contactors is connected to the line side of a pair of contactors controlling the speed of the motor 87, these contactors being hereinafter referred to as a "fast" contactor 144 and a "slow" contactor 145, the closing of these contactors being respectively controlled by the energization of solenoids 146 and 147. The load side of the contactor 144 is connected to a circuit 149 which, when energized, cooperates with the conductor 138 in supplying current through that winding of the spindle motor which makes this motor turn over at high speed. Similarly, the load side of the "slow" contactor 145 is connected to a circuit 150, the energization of which moves the motor 87 at low speed. The contactors 144 and 145 are also of the interlocked type so that only one of these contactors can be closed at any particular time.

It will be noted from Fig. 19 that the conductor which is connected to blade 1 of the "reverse" contactor 140 extends to blade 2 of the "forward" contactor 139, and that blade 2 of the "reverse" contactor is connected to blade 1 of the "forward" contactor. Thus, assuming that the "fast" contactor 144 is closed, the energization of the solenoid 141 of the "forward" contactor 139 will send current through the circuit 149 in a given direction, while if the "reverse" contactor 140 is closed by an energization of the solenoid 142, this current in the circuit 149 will flow in an opposite direction. Inasmuch as the reversing of any two supply conductors will reverse a three-phase induction motor, it follows that the energization of the solenoids 141 and 142 controls the direction of rotation of the spindle motor 87, and that the energization of the solenoids 146 and 147 controls the speed at which the spindle motor turns.

The solenoids 141, 142, 146, and 147 are connected to a pair of selector switches respectively termed a "forward" selector switch 160 and a "reverse" selector switch 161. The selector switches are diagrammatically illustrated as being of the disc or pallet type, and each is provided with a pallet switch, when in an upper "slow" position shorts a pair of contacts, and when moved into a lower or "fast" position shorts another pair of contacts. The position of the pallets of the selector switches 160 and 161 controls the energization of the solenoids 146 and 147. Thus, if it is desired that the spindle move forward at slow speed and reversed at fast speed, the pallet of the switch 160 will be thrown upward and that of the switch 161 will be thrown downward. The effect of these switches will be apparent from a detailed description of the operation of the control system.

The solenoids 141, 142, 146 and 147 are also connected to a series of spindle control

switches mounted on the end post 85. For the purpose of distinction and clearness, I have designated these spindle control switches by names indicative of their function, thus the upper of these switches has been termed an "automatic" spindle control switch 165 and comprises a pair of contacts shunted by a suitable pallet. This pallet may be moved away from these contacts and into shorting engagement with contacts of a "manual" spindle control switch 166 illustrated immediately therebelow, the position of this pallet determining whether the spindle is turned automatically or whether it may be manually controlled by the closing of "forward" and "reverse" spindle control switches 167 and 168. The current passing through the solenoids of the contactors passes through a "stop" spindle control switch 169 which is normally closed, but which may be opened whether it is desired to stop a spindle for any reason.

A transformer 170 is utilized for supplying low potential current to the solenoids of the contactors, the primary of this transformer being connected across one phase of the supply circuit 135, one terminal of the secondary being grounded, the other terminal extending to the "stop" spindle control switch and to blades 3 of the contactors 144 and 145. The remaining connections are clearly shown in Fig. 19, power conductors being indicated by heavy lines, and control conductors by light lines. I prefer to utilize a magnetic brake 175 on the spindle motor 87, this brake being of the type that locks as soon as the current supply to the motor is cut off, and releases as soon as the current is turned on. This permits a quick stopping of the spindle so as to prevent an overrunning thereof when the desired angular position has been reached.

Assuming that the spindle has been moving in a forward direction, as indicated by the arrow 126 of Fig. 14, and that the shaft 96 of the directional switch 95 has been turned by engagement with the stop 122 in a direction indicated by the arrow 105 of Figs. 14 and 19, the contacts 1 and 3 of the directional switch 95 will be opened and contacts 2 and 4 thereof will be closed, as previously described. Assuming now that the pallets of the selector switches 160 and 161 are in an upper position, as shown in Fig. 19, the grounding of the control wire 136 at the carriage, or at any point, will complete a circuit from the transformer through ground, the control wire 136, the solenoid 142 of the "reverse" contactor, contacts 2 of the directional switch, the "automatic" spindle control switch 165, the "stop" control switch 169, and to the secondary of the transformer 170. This closes the "reverse" contactor 140 which in turn completes a circuit from the grounded terminal of the transformer through the control wire 136, the solenoid 147 of the "slow" contactor, the "reverse" selector switch 161, blade 4 of the "reverse" contactor 140, the contacts 2 of the directional switch, the "automatic" spindle control switch 165, the "stop" spindle control switch 169, and thence to the transformer. This energizes the motor 87 and simultaneously releases the magnetic brake, the circuit through the solenoid 175 of this brake including blade 3 of the "slow" contactor 145.

It is only necessary to momentarily ground the control wire 136, for the "reverse" and "slow" contactors 140 and 145 are self-energizing when once closed, the holding circuit of the former being from the transformer through ground to grounded blade 4 of the "slow" contactor 145, through the solenoid 142 of the "reverse" contactor 140, contacts 4 of the directional switch, blade 3 of the "reverse" contactor 140, and returning to the transformer through the "stop" control switch 169, while the holding circuit of the latter includes grounded blade 4 of the contactor 144, the solenoid 147 of the "slow" contactor, the "reverse" selector switch 161, blade 4 of the "reverse" contactor 140, contacts 4 of the directional switch, blade 3 of the "reverse" contactor, returning to the transformer through the "stop" spindle control switch.

At this time the spindle is moving in a direction opposite to that indicated by the arrow 126 of Fig. 14, thus allowing the stop 122 to disengage the tab 120, and allowing the cams to be thrown into neutral position by the spring 121. When this occurs, contacts 4 remain closed and contacts 1 remain open, the only change being in contacts 3 and 2, the former being closed and the latter being opened by this movement into a neutral position. These contacts, however, have no effect on the reverse movement of the spindle which continues until the stop 123 comes into engagement with the tab 120 and rotates the shaft 96 in a direction opposite to that shown by the arrow 105. When this occurs, contacts 4 of the directional switch are opened, thus immediately stopping the spindle motor 87 by de-energizing the solenoids 142 and 147 and 175, and the contacts 1 are closed, the contacts 3 remaining closed and the contacts 2 remaining opened. The spindle thus remains stationary at this point during the perforating operation.

When the control wire 136 is subsequently regrounded, current passes from the transformer through the control wire 136, the solenoid 141 of the "forward" contactor 139, contacts 1 of the directional switch, the "automatic" spindle control switch 165, returning to the transformer through the "stop" control switch 169. The energization of the solenoid 141 closes the "forward" contact

139 and completes a circuit from the transformer through the control wire 136, the solenoid 147 of the "slow" contactor 145, the "forward" selector switch, blade 4 of the "forward" contactor 139, the contacts 1 of the directional switch, and returning to the transformer through the "automatic" and "stop" spindle control switches.

Once the "slow" contactor 147 is thus closed, it remains closed, the holding circuit thereof including grounded blade 4 thereof, the solenoid 147 of the "slow" contactor, the "forward" selector switch, blade 4 of the "forward" contactor 139, the contacts 3 of the directional switch, the blade 3 of the "forward" contactor 139, the current returning to the transformer through the "stop" control switch. A similar holding circuit is completed through the solenoid 141 of the "forward" contactor and includes contacts 3 of the directional switch, blade 3 of the "forward" contactor 139, and the "stop" spindle control switch.

This moves the spindle in a forward direction, and returns the cams of the directional switch to a neutral position at which time contacts 2 open and contacts 4 close, this opening and closing having no immediate effect on the rotation of the pipe which continues until the stop 122 engages the tab 120 to move the directional switch into such a position that the forward movement of the spindle is arrested.

The setting of the selector switches 160 and 161 determines whether the "fast" or the "slow" contactors 144 or 145 are to be energized after the closing of either the "forward" or "reverse" contactors 139 and 140, as will be readily apparent.

It will be furthermore apparent that successive groundings of the control wire 136 will control the forward and reverse movements of the spindle and that the control circuit formed by this control wire and the ground may be utilized for controlling the operation of the spindle from the carriage.

Should manual operation of the spindle motor 87 be desired, the operator moves the pallet of the "automatic" spindle control switch downward and into engagement with the contacts of the manual control switch 166. If it is then desired to move the spindle in a forward direction, the "forward" spindle control switch 167 is depressed until the desired amount of movement has taken place, the closing of this switch completing a circuit from the transformer, through ground to the "manual" spindle control switch 166, and through the solenoid 141 of the "forward" contactor 139, the current returning to the transformer through the now closed "forward" spindle control switch 167, and the "stop" spindle control switch 169. This completes another circuit from the transformer through the ground to the "manual" spindle control switch 166, through whichever of the solenoids 146 or 147 has been previously selected by the "forward" selector switch 160, the current passing through blade 4 of the "forward" contactor 139, through the "forward" control switch, and through the "stop spindle control switch 169 to the transformer. This, of course, energizes the spindle motor 87.

Similarly, the manual closing of the "reverse" spindle control switch 168 will rotate the spindle in a reverse direction during the period that it is depressed.

*Carriage structure*

The carriage structure provides a body 199 to which a pair of flat-surfaced wheels 200 are rotatably secured, these wheels rolling on one of the rails 30 provided with a flat surface. The other of the rails 30 provides a guiding bead 201 which fits a pair of grooved wheels 202 rotatably secured to the body 199. This latter rail is provided with a rack gear 204 secured thereto along its length and best shown in Fig. 9. The teeth on this rack are meshed with a pinion 205 mounted on a shaft 206 extending vertically and journalled in the body 199. The upper end of the shaft 206 carries a gear 207 which is meshed with a pinion 208 mounted on an auxiliary shaft 209 also extending vertically and being suitably journalled in the body 199. The extreme upper end of this shaft carries a gear 210 which is intermeshed with a floating gear 211 rotatably mounted on a shaft 212 which is in turn journalled in bearings 213 and 214 in the body 199.

The gear 211 and the shaft 212 form a part of a transmission 215 which may be of any well-known construction, but it is preferably formed as best illustrated in Figs. 9 and 10. In this form of the invention, the shaft 212 is formed with a squared portion 216 on which a collar 217 may slide longitudinally under the action of a pair of pins 218 engaging in an annular channel 219 formed around this collar, the pins 218 being mounted in an arm 220 secured to a shaft 221 which extends forward through the body 199 as indicated in Figs. 1 and 2, this shaft being provided with a lever 223 for shifting the collar upward and downward. The lower end of the collar provides a clutch means which cooperates with a similar clutch means formed on the upper end of the floating gear 211 when the collar is in a lower position, thereby drivably connecting the shaft 212 and the floating gear 211. The upper end of the collar provides a clutch means which, when the collar is in an upper position, cooperates with a similar clutch means formed on the lower end of a floating gear 222 rotatably mounted on the shaft 212, so that when the collar is in an

upper position the gear 222 is non-rotatably connected to the shaft 212.

Another shaft 225 is journalled in the body 199 in a manner similar to the shaft 212 and extends parallel thereto, the upper ends of the shafts 225 and 212 being interconnected through a pair of change gears 226 in a well-known manner. Near the lower end of the shaft 225 is keyed a worm gear 228 which is meshed with a worm 229 mounted on the shaft of a carriage motor 230. An idler 232 is rotatably mounted on the shaft 225 and provides an upper gear 233 which is meshed with the gear 222, and a lower gear 234 which is meshed with the floating gear 211.

When the collar 217 is in a lower position the motor drives through the worm gear 228, the shaft 225, the change gears 226, the floating gear 211, and through the gear train to the rack 204. When this collar is moved into an upper position, the motor drives through the shaft 225 and the gears 226, as previously described, through the gear 222, the idler 232, through the floating gear 211, and thence through the gear train shown in Fig. 9. The speed of movement of the carriage may thus be changed by moving the lever 223 or by changing the change gears 226. In addition, I prefer to utilize the motor 230 which is of the multi-speed type and which is reversible for a purpose to be hereinafter described.

Mounted on each side of the carriage body 199 is a brake means 240, best shown in Fig. 16 as comprising a block of material 241, preferably made of lignum vitæ, which is slidable in a shell 242 and which is resiliently held in engagement with the rail immediately therebelow by a compression spring 243. The pressure on this spring is controlled by a bolt 244 threaded through the top wall of the shell 242. These brake means prevent the carriage from being moved along the rails due to the pull exerted thereon by the hose 36 and cable 47 and the weight 46 associated therewith, and also prevent any backlash existing in the transmission 215 and its associated gear train from affecting the accurate operation of the switch means controlling the accurate positioning of the carriage structure and which will be hereinafter more fully described.

*Face plate mounting*

The face plate 32 is mounted in floating relationship relative to the carriage structure 31 in a manner best shown in Figs. 1, 6 and 7. Referring to these figures, I have designated the floating arrangement for supporting the face plate by the numeral 250 which includes a frame 251 vertically movable relative to the carriage body 199. This frame 251 is composed of a yoke 252, to the ends of which are connected vertical columns 253 which are cylindrical in shape and which extend through openings 254 formed in a cast superstructure 255 forming a part of the carriage structure and bolted to the upper portion of the carriage body 199. The columns 253 are vertically journalled in the openings 254 by upper and lower bearings 257 and 258, best shown in Fig. 6, and the lower ends thereof extend through cylindrical openings 259 formed in a block 260 extending between the two columns and forming a part of the frame 251. The block 260 may be secured to the columns 253 by any suitable means such, for instance, as bolts 261 extending across a slot 262 communicating with the cylindrical opening 259 and extending a distance toward the center of the block 260, so that the bolts 261 may draw the walls of this slot closer together, thus clamping the vertical columns in the cylindrical openings 259.

The extreme lower end of the vertical columns 253 are formed in the shape of pistons 265 which are adapted to vertically slide in cylinders 266 formed in the superstructure 255. Compressed air is supplied to these cylinders through passages 267 communicating with a storage chamber 268 formed in the superstructure 255. The pressure of the air in the storage chamber 268 is maintained constant through a hose 269, best shown in Fig. 1, which communicates with a pressure regulator 270 to which air is supplied through an air line 271 connected to one of the hose 36 extending downward in the well 39.

The face plate 32 is horizontally movable in the frame 251, this being accomplished by a series of lower rolls 275 formed as best illustrated in Fig. 7, and rotatably secured in a retainer 276. These rolls engage the walls of a V-shaped channel 277 formed in the block 260, and the upper surfaces thereof roll in a similar V-shaped channel 278 formed in the lower surface of a transverse member 279 which is suitably bolted to the face plate 32, as best shown in Fig. 7.

A similar transverse member 280 is adjustably secured to the upper portion of the face plate 32 by a plurality of bolts 281, each of which extends through an elongated opening 282, the longitudinal axis of which is inclined, as best shown in Fig. 6, so that by moving the transverse member 280 to the left, as indicated in Fig. 6, this member will be moved upward and toward the yoke 252, while an opposite movement will cause the space between the yoke 252 and the member 280 to be increased. This movement of the member 280 is effected through an adjusting means 284 clamped to the face plate 32 at opposite ends of the transverse member 280 and providing adjusting screws 285 which engage the ends of the member 280. The upper surface of this member 280 provides a V-shaped channel 286 in which a plurality of

rolls 287 rests, these rolls having surfaces shaped to correspond to the shape of the channel 286 and being rotatably mounted in a retainer 288. The lower surface of the yoke 252 provides a similar V-shaped channel 289 in which the rolls 287 may roll. Thus, when the rolls 275 and 287 are in place, the transverse member 280 may be so positioned that no play in a vertical direction exists between the frame 251 and the face plate 32.

The face plate is thus mounted so as to be moved in its own plane in any direction relative to the carriage, any horizontal component of this movement being permitted by the rolls 275 and 287, and any vertical component of this movement being permitted by the vertical movement of the frame 251.

It is desirable to provide a locking means acting between the superstructure 255 and the face plate 32 for the purpose of clamping these structures together when adjustments are being made. Such a clamping means is illustrated in Fig. 7 as comprising a screw 292 threaded into the superstructure 255 and being turned by a crank 293. The inner end of this screw is beveled as indicated in Fig. 7 and is adapted to fit in a socket 294 formed in a transverse member 297, thus preventing any floating action between the face plate and the superstructure while the screw engages.

It is very desirable to maintain the drill structures 33 and the torch structures 34 a constant distance from the periphery of the pipe 20. It is in this capacity that the floating action of the face plate 32 is of extreme importance, for it is seldom possible to find a length of pipe that is exactly straight. I thus provide a centering means for maintaining the face plate concentric with the axis of the pipe, regardless of whether or not this pipe is slightly out of alignment, this centering means being best shown in Figs. 6 and 7. From these figures it will be apparent that the face plate is provided with an opening 300 through which the length of pipe 20 extends, this opening being of sufficient diameter so that the face plate may move over the chuck 25 and into a position shown in Fig. 1 for a purpose to be hereinafter described.

The centering means of my invention comprises three adjustable centering members numbered respectively 301, 302 and 303 which extend radially into the opening 300 and into engagement with the surface of the pipe 20. The centering members 301 and 302 are in the form of plungers through which screws 304 pass, these plungers being slidable in radial passages 305 of the face plate. Each screw 304 is journalled in a thrust bearing 306 positioned inside the radial passages 305, and a crank 308 is secured to the outer end thereof. Thus by turning the cranks 308, the centering members 301 may be moved radially into the opening 300. The ends of these members may be shaped to approximately conform to the contour of the surface of the pipe 20, as indicated in Fig. 6, and a suitable guide means is preferably provided for preventing any rotation of the centering member 301 in the passage 305.

The centering member 303 is of slightly different construction, as shown best in Fig. 7, and provides a plunger 312 slidable in a vertical passage 313. A resilient downward pressure is exerted on the centering member 303 by means of a compression spring 314 which is compressed between a shoulder of the centering member and a collar 315 which is threaded to a screw 316, this screw being journalled in a thrust bearing 317 and being provided with a crank 318. The collar 315 slides in a passage 319 of the centering member 303, this centering member being preferably provided with guide means for preventing a rotation thereof in the passage 313. Thus by turning the crank 318, the resilient downward pressure of the centering member 303 on the upper surface of the pipe 20 may be readily varied.

By resiliently mounting one of the centering members, I accomplish several important results, the foremost of which are the elimination of play between the centering means and the pipe as the carriage is moved along, and making it possible to hold pipes which are not exactly circular. Similarly, the spring 314 acts in conjunction with the air pressure in the cylinders 266 to move the frame 251 upward, and in the operation of my device, I usually prefer to adjust the pressure regulator 270 so that the pressure in the cylinders 266 substantially balances the weight of the face plate and its attachments, thus allowing the spring 314 to be utilized only for the purpose of maintaining the pipe in contact with the centering members 301 and 302, although obviously this spring also acts to compensate for any deficiency of pressure in the cylinders 266. It is not necessary, however, to resiliently mount but one of these centering members, for if desired they may all be thus mounted to give a resilient centering action.

*Drill structure*

The details of the drill structures 33 of my invention are fully illustrated and described in my copending application entitled "Drill structure", Serial No. 425,837, filed February 4, 1930, the present application disclosing, in Fig. 12, only those features which are of importance in combination with the remainder of the machine.

A number of these drill structures are secured to the front surface of the face plate 32 by means of bolts extending through a portion of the base of the drill structure and being threadedly received by squared washers 340 disposed in annular T-shaped grooves

341 formed in the face plate 32 so that the angular position of each drill structure may be readily varied.

Referring particularly to Fig. 12, each drill structure is provided with its own individual motor 350, the rotor 351 of which is mounted on a sleeve structure 352 which is in turn rotatably mounted in bearings 353 and 354 of the motor shell. Extending through this sleeve structure 352 and splined thereto is a spindle 356, the lower end of which carries a chuck 357 for clamping a drill 358, the upper end of this spindle extending axially into a cylindrical bore 360 formed in a head 361 secured to the upper end of the motor 350. The upper end of the spindle 356 provides a flat plate 365 which is journalled in a cavity 366 of a piston structure 367 slidable in fluid-tight relationship with the walls of the cylindrical bore 360. The means for journalling this flat plate 365 relative to the piston structure 367 comprises a pair of thrust bearings, so that when the piston is moved downward, and the motor is energized, the drill pressure will be controlled by the amount of pressure forcing the piston structure 367 downward.

The retracted position of the spindle is determined by engagement between the piston structure and a cap 368 closing the end of the cylindrical bore 360, and the advanced position of the spindle 356 is controlled by the position of a stop member 369 adjustably positioned in the bore 360 and in the path of travel of the piston structure 367, the adjustment of the stop member 369 being effected by the interengagement of threads 370 on the periphery of the stop member 369 and threads on a plug 371 extending into the cylindrical bore 360.

The spindle 356 is both advanced and retracted through pneumatic means electrically controlled from a remote point. This is accomplished by means of a slide valve 390 which is slidable in a valve chamber 391 under the action of a plunger 392 connected thereto and to an armature 393 which is moved upward when a solenoid 394 is energized. The slide valve 390 is resiliently held in a lower position by a spring 395, this spring being compressed when the solenoid 394 is energized. Upper and lower air passages 398 and 399 communicate with opposite ends of the valve chamber 391 and also communicate respectively with the lower and upper ends of the cylindrical bore 360 through passages 400 and 401. Formed between the passages 398 and 399 is an exhaust passage 403 which is in communication with the passage 399 through a pocket 404 on the slide valve 390 when this slide valve is in a lower position. When the slide valve is moved into an upward position the pocket 404 connects the exhaust passage 403 with the upper air passage 398.

A supply of compressed air is delivered to the valve chamber through a passage indicated by dotted lines 408 of Fig. 12, and this air may reach the lower portion of the chamber 391 through a passage 409 formed through the slide valve.

Thus, when the slide valve is in a position shown in Fig. 12, the compressed air supplied to the valve chamber 391 is delivered to the cylindrical bore 360 at a point below the piston structure through the passages 398 and 400, thus exerting an upward pressure on the piston to hold the spindle in withdrawn position. At this time the upper end of the cylindrical bore communicates with the exhaust passage 403 through the passages 401 and 399, and the pocket 404. If, now, the solenoid 394 is energized, the valve member moves upward and compressed air may flow through the passage 409 to the lower part of the valve chamber 391 and through the passages 399 and 400 to the upper end of the cylindrical bore, thus exerting a downward force on the piston and moving the spindle downward. The compressed air previously retained below the piston is exhausted through the passages 401, 398, and the pocket 404 which at this time connects the passage 398 and the exhaust passage 403.

The amount of downward pressure on the spindle is controlled by the pressure of the air, and when the drill has penetrated the pipe, the piston structure 367 continues to move downward until it engages the stop member 369. Upon de-energization of the solenoid 394 the supply of compressed gas is again transferred to the lower portion of the cylindrical bore, and the spindle is withdrawn by the upward pressure exerted on this piston structure.

The passage 408 receives air through a hose 415 best shown in Fig. 1 and which is in turn connected to an air manifold 416 which extends around the face plate 32 and which is adapted to supply each of the drill structures with compressed air. The manifold 416 is in communication with the air line 271 through a flexible hose 417 and a pressure regulator 418, the setting of this regulator determining the rate of advancement of the drills 358.

*Torch structure*

The torch structure of my invention is shown in detail in my patent Serial No. 425,839, filed February 4, 1930, now Patent No. 1,872,408 and in Fig. 13 I have shown only the main features thereof. Referring to this figure, the torch structure comprises a base 446 which is shown as being secured directly to one of the drill structures 33, as best shown in Figs. 1 and 2, though a spacer may be inserted therebetween as will be hereinafter described. This securing means is preferably adjustable to allow ad-

justment of the radial position of the torch structure relative to the drill structure, and in its preferred form comprises radially extending dovetailed openings 447 formed on the drill structure and in which a dovetailed tongue 448 formed on the base 446 extends, suitable clamping means being provided for controlling the relative positions of the torch and drill structures.

Suitably mounted on the base 446 in a manner to provide universal adjustment, as described in my copending application supra, is a torch body 451 which provides a longitudinal opening 452 therein. A turret head 453 is rotatably mounted on the lower end of the torch body 451 and provides a plurality of tips 454, the details of this turret head being shown in my application supra and in my Patent No. 1,639,328, granted August 16, 1927. Suffice it to say, that only the lowermost tip 454 is in use at any one time and that when in operation this jet first supplies a heating gas to the pipe followed by a stream of cutting oxygen.

The heating gas utilized is a mixture of oxygen and acetylene which are intermixed in a mixing member 456 mounted in a cavity of a head 457 secured to the torch body 451. The mixing member 456 provides converging passages 458 which are in communication with an acetylene passage 460 formed through the head. A longitudinal passage 461 is formed through the mixing member 456 and is supplied with low-pressure oxygen from a chamber 462 which communicates with a passage 463. The mixed gases pass downward through a pipe 465 extending through the opening 452 and are transmitted to the lowermost tip 454 where they are lighted to form a heating flame.

Subsequently, this lowermost tip is supplied with a jet of cutting oxygen, this high-pressure oxygen passing through a pipe 468 also extending through the opening 452 and communicating with a high-pressure oxygen valve 469 to which oxygen is supplied through a passage 470. The valve 469 comprises a valve head 471 normally held in engagement with a seat 472 by a compression spring 473 which acts against a plunger 474.

This valve is electrically controlled from a remote point, this control being effected through a solenoid 475 which, when energized, lowers an armature 476 carrying a pin 477 which acts to pivot a linkage member 478 about a pin 479 and thus pivot a bell crank 480 about a pin 481. At this time an adjusting screw 483 threaded through an arm 484 of the bell crank comes into engagement with the head 474, thus compressing the spring 473 and moving the valve head 471 away from the seat 472. The spring 473 closes the valve 470 as soon as the solenoid 475 is de-energized.

Referring now to Fig. 1, low-pressure oxygen is supplied to the passage 463 through a hose 490 which communicates with a manifold 491 supplying low-pressure oxygen to each of the cutting torches. This manifold is supplied with low-pressure oxygen through a flexible hose 492 which is in communication with a pressure regulator 493. A magnetic valve 494, similar in construction to the magnetic valve on the torch structure 34, controls the supply of high-pressure oxygen to the pressure regulator 493 from a high-pressure oxygen line 495 connecting to one of the hose 36. This high-pressure oxygen line 495 also connects to a pressure regulator 496 which communicates with a manifold 497 through a flexible hose 498, this high-pressure oxygen being supplied from the manifold 497 to the passage 470 through a hose 499.

Similarly, acetylene is supplied to the passage 460 through a hose 500 which connects to a manifold 501 which is supplied with acetylene from a hose 502 communicating with a pressure regulator 503. The acetylene gas is supplied thereto through an acetylene line 504 in which a magnetic valve 505 is placed, this valve being of a type similar to the valve 494 and being adapted to open when the solenoid thereof is energized.

Two of the hose 36 are utilized for the purpose of supplying and withdrawing cooling water to the torch structures. These hose respectively communicate with pipes 510 and 511, the former being connected to a fitting 512 communicating with the opening 452 of the torch body 451, as shown in Fig. 13. The interior of this opening is divided by a baffle 514 into an inlet chamber 515 which communicates with the fitting 512 and an outlet chamber 516 which communicates through a passage 517 with an outlet fitting. The water entering the inlet chamber 515 through the fitting 512 moves downward around the pipe 468 and through cooling water passages formed adjacent the turret head 453 so that the water moves in heat-transferring relationship with this turret head and thence into the outlet chamber 516. From here the water passes through the passage 517 and through the outlet fitting communicating therewith and to the next torch structure. Thus the water passes in succession through each of the torch structures and returns through the pipe 511.

*Control system for carriage, drills and torches*

The control system for the carriage and its associated drills and torches is arranged for automatic or manual operation, as desired. In effecting this type of control I utilize a timing machine 525 of novel construction which is mounted on the body 199 of the carriage structure. As best shown in Figs. 1, 17, and 18, this timing machine is enclosed in a box 526 provided with a hinged cover 527 and including a shelf 528. A motor 530

is mounted in the box 526 and drives a vertical shaft 531 extending through the shelf 528 by means of worms 532 and 533 respectively meshed with worm gears 534 and 535, the latter worm gear being secured to the shaft 531. The upper end of the shaft 531 carries a change gear 537. A gear 538 meshes with the change gear 537 and is secured to the lower end of a cam assembly 540, this cam assembly and the gear 538 being rotatably mounted on a stationary shaft 541 extending upward from the shelf 528.

The cam assembly 540 is in the form of a unitary drum having five annular channels 542 cut therein in each of which a cam 544 may be adjustably positioned. Each cam is clamped in place in its respective channel by means of a tapered set screw 555 threaded into each end of the cam member, these ends being split so that as the tapered screw 555 is screwed inward the cam expands into tight engagement with the walls of the channel in which it is positioned.

Extending upward from the shelf 528 and to one side of the cam assembly 540 is a bracket 559 formed of insulating material and carrying a plate 559*a* to which five spring arms 560 are mounted. Each of the spring arms 560 extends adjacent the mouth of one of the channels 542, as best shown in Fig. 18, and includes a follower 563 which is adapted to engage the cam 544 thereadjacent, the spring arms 560 retaining the followers 563 in resilient engagement therewith, and moving these followers into engagement with the walls of the channels 542 after the cams 544 have passed thereby. A contact arm 564 is mounted adjacent each of the spring arms 560 and the end thereof is retained in a hook member 565 so as to prevent unlimited movement of the free end of the spring contact relative to the spring arm 560. When the follower 563 rests on the surface of its cam 544, the spring contact 564 is in engagement with a contact 566 which is adjustably mounted in the insulated bracket 559, each of the contacts 566 being thus insulated from each other. The five contact arms 564 and their respective spring arms 560 and contacts 566 form five timing machine switches numbered respectively 571 to 575 inclusive. No insulation is placed between the contact arms 564 and the plate 559*a*, so that all of these contact arms are electrically connected together and are grounded to the carriage structure 31.

The position and length of the cams 544 on the cam assembly 540 determine the sequence of operations of the machine, and it is desirable to use a different cam assembly for each different set-up. For this reason it is desirable to make the cam assembly 540 easily replaceable. It is likewise desirable when removing the cam assembly 540 from the timing machine that means be provided for moving the followers 563 away from the cam assembly so as to not interfere with the removal thereof. Such a means is provided in the form of a shaft 580 which is vertically slidable in a bore 581 in which a spring 582 is compressed, this spring tending to force the shaft 580 upward. This shaft is provided with a flat side 583 which extends adjacent all of the spring arms 560 and faces these spring arms during the normal operation of the timing machine. When, however, the shaft 580 is turned about its axis, the bottom wall of the flat side 583 engages each of the spring arms 560 and moves the followers 563 away from the cam assembly 540.

It is, of course, desirable that this shaft 580 be not turned during the operation of the cam assembly, and for this purpose I secure a plate 585 to the upper end thereof, this plate extending into an annular notch 586 and providing an annular surface 587 extending adjacent the inner wall of this notch to prevent any rotation of the shaft 580 when the plate is in a position shown in Fig. 17. This is the normal position of this plate during the operation of the machine, the shaft being held downward against the action of the spring 582 by engagement between the top of the shaft and the hinged cover 527. When, however, the cover 527 is raised the spring 582 forces the shaft 580 a distance upward and moves the plate 585 out of the annular notch 586, thus permitting this plate and its associated shaft to be turned to disengage the followers 563 from the cam assembly.

Also mounted in the box 526 are five manual control switches numbered respectively 590, 591, 592, 593, and 594, each of these switches having an operating lever extending outside the box to permit manual operation thereof. These switches are all of the single-pole type with the exception of the switch 593 which, as indicated in Fig. 19, is of the two-pole type. As will be noted from this figure, the two poles of this switch are respectively connected to the switches 572 and 573 on the timing machine, the switch 590 being connected to the switch 574 thereof and the switch 594 being connected to the switch 575 thereof. The switch 591 is grounded, so that with the exception of this switch 591 the manual control switches are wired in series with the switches of the timing machine.

Also mounted in the box 526 is a controller 600 which is operated by an arm 601 extending above the cover 527, the controller 600 being secured to the lower surface of this cover. This controller may be of any conventional type and provides an arm 601 shown in Fig. 17, which may be moved to the left to control the forward movement of the carriage motor 230 and moved to the right to control the reverse movement thereof. Two speeds are provided, so that when the controller is in the first position from neutral, the motor

is turning slowly, and when turned to the second position the motor is turning rapidly.

Such a controller is shown diagrammatically in Fig. 19 as comprising a plurality of primary contacts respectively numbered 604, 605, 606, 607, 608, and 609, and a plurality of secondary contacts numbered respectively 610, 611, 612, 613, 614, 615, 616, and 617. As diagrammatically shown the primary contacts are movable relative to the secondary contacts, although obviously either set of contacts might be moved relative to the other. Considering the primary contacts as being movable, I have illustrated the secondary contacts as being in the form of segments, the segment 610 extending through the neutral position and through the first and second positions for forward movement. The segment 611 extends through the first and second positions for reverse movement, while the segments 613 and 612 are respectively positioned in the second position for forward and reverse movement. So also, the segments 615 and 614 are respectively positioned in the first position for forward and reverse movement, the segments 616 and 617 being in the neutral position. As will be seen from Fig. 19, the primary contacts 604 to 607 are grounded to the carriage, the remaining connections being clearly shown in Fig. 19.

The switch means for controlling the movement of the carriage and the operation of the drills and torches are diagrammatically illustrated in Fig. 19 in the approximate positions they occupy on the carriage structure. Referring to this figure, the three supply conductors which extend through the cable 47 are connected to a main switch 620 which is of the solenoid-operated type and which is closed by a push-button 621 in a well-known manner.

The load side of one terminal of this switch is directly connected to the neutral wire of a drill bus 623 and also to the neutral wire extending to the carriage motor 230 as well as one terminal of the motor 530 of the timing machine, this motor being of the three-phase type. The other two terminals of the main switch are connected to the drill bus 623 through a drill switch 625 having a solenoid 626 controlling the closing thereof, these terminals of the main switch being also connected to the other two terminals of the motor 530 and to the primary of a transformer 628, one terminal of the secondary of which is grounded to the carriage.

The closing of the main switch also supplies current to interlocked "forward" and "reverse" switches 630 and 631 respectively operated by solenoids 632 and 633, it being noticed that the load terminals of these switches are reversed relative to each other. The line terminals of these switches are connected to the load side of a "fast" switch 635 controlled by a solenoid 636 and to the load side of a "slow" switch 637 controlled by a solenoid 638, the load sides of the "fast" and "slow" switches being respectively connected to circuits 641 and 640 of the motor 230, the energization of the former circuit rotating the motor at high speed, and the energization of the latter rotating the motor at slow speed.

The drill bus 623 is in the form of a cable positioned on the face plate, and provides a number of receptacles wired in parallel and to which the three-phase drill motors 350 may be connected through suitable plugs 650, as diagrammatically shown in Fig. 19. The solenoid 394 of each drill structure is connected across one phase of the motor so that when the motor is energized the solenoid 394 is simultaneously energized.

Also mounted on the face plate is a cable forming a torch bus 651 to which is wired a plurality of jacks adapted to receive plugs 652 which are respectively connected to the solenoids 475 of the drill structure so that when the torch bus is energized, the high pressure oxygen valves 469 are opened. One terminal of this torch bus extends to the ungrounded secondary terminal of the transformer and the other extends to the manual control switch 592.

Wired in the circuits of the solenoid 632 and 633 of the "forward" and "reverse" switches 630 and 631 are "forward" and "reverse" bumper switches 658 and 659 which are diagrammatically shown as being of the pallet type and being normally closed by spring means. These switches are adapted to be operated by an arm 660, best shown in Figs. 8 and 19, and which is secured to "forward" and "reverse" bumpers 661 and 662 which are slidably journalled below the carriage body 199, as best shown in Figs. 1 and 8. These bumpers have transverse portions which extend between the rails 30 a distance beyond the ends of the carriage, so that if the carriage should be moved against any projection, such, for instance, as one of the jacks 24, the holding solenoids of either the "forward" or "reverse" switches 630 and 631 would be de-energized, depending upon the direction of movement of the carriage to immediately stop the carriage.

The carriage motor 230 is also provided with a magnetic brake of the type which is released when the motor is energized and which quickly stops the motor when de-energized, this magnetic brake being operated by a solenoid 672, diagrammatically shown in Fig. 19 as being connected between ground and to blade 3 of the "slow" switch 637.

Blade 4 of the "slow" switch 637 is connected to one terminal of a carriage switch 675, the other terminal of which is grounded. This carriage switch is operated by a cam 676 having one or more notches 677 formed in the periphery thereof so that when one

of these notches comes opposite the blade of the switch 675 this switch opens. The details of the switch 675 are best shown in Fig. 11, and the cam 676 thereof is mounted on the shaft 212 of the transmission 215, as best shown in Figs. 9 and 10. It will thus be apparent that the angular movement of the cam 676 is a function of the amount of movement of the carriage, and the purpose of this switch is to stop the carriage at any one of a large number of positions, these positions being equally spaced. The spacing of these positions is determined by the number of notches formed in the cam 676 and the gear ratio between this cam and the rack 204 through which the carriage is driven. In the usual run of work, it is only necessary to stop the carriage at positions spaced one-half inch apart.

The utility of being able to stop the carriage at predetermined positions will be apparent when considering the difficulty which would otherwise be encountered should one of the torches fail to function, thus requiring a return of the carriage to this position for the purpose of correcting this error. It is, of course, necessary that the torch flame be directed through the hole previously drilled, and it is a function of the spacing switch 675 to automatically stop the carriage at the exact position when once the carriage has been moved into the approximate vicinity by means of the controller 600, thus making it unnecessary to position the cams 544 with extreme accuracy. This will be more apparent from the following description of the operation of the carriage control system.

When it is desired to manually move the carriage along the tracks, this is accomplished by turning the controller 600 to the left or to the right, depending upon whether a forward or reverse movement is to take place. Before tracing through these circuits, however, it is well to note that when the controller is in a neutral position a circuit is completed from the transformer through ground to the contact 604 of the controller, thence through the segment 610, the "forward" bumper switch 658, the solenoid 632 of the "forward" switch 630, and thence to the other terminal of the transformer so that the "forward" switch 630 is at this time closed. If, now, the controller is moved into the first "forward" position, the contacts 604 to 609 may be considered as moving leftward, thus completing a circuit from the transformer through ground to the contact 607, thence through the segment 615, through the solenoid 638 of the "slow" switch and to the transformer; thus closing the switch 637 and energizing the circuit 640 of the carriage motor. A further movement of the controller into the second "forward" position would break this circuit through the solenoids 638 of the "slow" switch and would close a new circuit through the solenoid 636 of the "fast" switch 635, this circuit being completed through the contact 606 and the segment 613 of the controller.

Similarly, if the controller is moved into its first reverse position, the circuit through the solenoid 632 of the "forward" switch 630 will be broken when the contact 604 leaves the segment 610 and the new circuit will be completed through the contact 605 and the segment 611, through the "reverse" bumper switch 659, and the solenoid 633 of the "reverse" switch 631, thus energizing the "reverse" switch. Simultaneously, the circuit is completed through the contact 607 and the segment 614, through the solenoid 638 of the "slow" switch 637, thus closing this switch and energizing the circuit 640 to move the carriage motor in a slow speed in a reverse direction. Further movement of the controller into its second reverse position breaks the circuit through the solenoid 638 and completes a new circuit through the solenoid 636 of the "fast" switch 635, this circuit also including the contact 606 and the segment 612 of the controller.

It will be noted that any time the "slow" switch 637 is closed a circuit is completed from the grounded terminal of the transformer through the carriage switch 675 if closed, through blade 4 of the "slow" switch 637, and through the solenoid 638 thereof. Thus, if the carriage were being moved either forward or reverse at slow speed, and the controller 600 were moved to a neutral position in the approximate vicinity that the carriage is to be stopped, the carriage switch 675 would maintain the current through the solenoid 638 of the "slow" switch until such a time as the cam 676 opened this switch, at which time the carriage would be in the exact desired position. If the carriage is moving in a reverse direction this movement of the controller 600 into neutral position will open the "reverse" switch 631 and close the "forward" switch 630, thus moving the carriage forward until the carriage switch 675 opens, but if the carriage was previously moving in a forward direction this forward movement will continue until stopped by the carriage switch 675.

The timing machine 525 is only utilized on the forward movement of the carriage; in other words, during the cutting operations and when the carriage is moved toward the head. It is within the function of the timing machine to move the carriage forward either at slow or fast speed, thus when the controller is in neutral position, as it invariably is when the timing machine is in operation, a closing of the switch 572 of the timing machine will send current from the grounded terminal of the transformer, through this switch to the manual control switch 593, through the contact 608 and the segment

616 of the controller, and thence through the solenoid 638 of the "slow" switch 637, as previously described. Should the timing machine open the switch 572 when the carriage switch 675 is closed the movement of the carriage will continue until this spacing switch opens, as previously described. If, however, the timing machine closes the switch 573, a circuit is completed from the transformer through this switch through the switch 593, the contact 609 and segment 617 of the controller, and through the solenoid 636 of the "fast" switch 635. This circuit is not changed by the opening or the closing of the carriage switch 675 so that the carriage will continue to move forward until the switch 573 of the timing machine is opened. Only one of the switches 572 and 573 are ordinarily used on a given job, and the desirability of the use of the spacing switch 675 ordinarily dictates the use of the switch 572 for controlling the forward movement of the carriage. However, on certain jobs it is desirable to use these switches 573 and 572 in succession, the former advancing the carriage at high speed to a point within a fraction of an inch of the desired stopping point and the latter slowly advancing the carriage until stopped by the spacing switch 675.

Whenever the timing machine closes the switch 574 a circuit is completed from the ground terminal of the transformer through this switch through the manual control switch 590, and through the solenoid 626 of the drill switch 625. This energizes the drill bus 623 and sets all of the motors 350 into operation. The energization of this bus simultaneously energizes each of the solenoids 394 so that not only are the drills controlled through the action of the drill motors 350, but they are advanced due to air pressure supplied to the piston of the drill structure when the solenoid 394 is energized.

When the manual control switch 591 is closed a circuit is completed from the ground terminal of the transformer through this switch, through the solenoids of the magnetic valves 494 and 505 controlling the supply of low-pressure oxygen and acetylene to their respective manifolds 491 and 501, and then to the other terminal of the transformer 628. Thus, whenever this manual control switch 591 is closed the heating jets issuing from the lowermost tips of each of the cutting torches may be lighted and continue to heat the pipe throughout the cutting operation thereof unless the manual control switch 591 is opened in the meantime.

When the timing machine closes the switch 571, a circuit is completed from the ground terminal of the transformer through this switch and through the manual control switch 592, and thence through the torch bus 651 to the other terminal of the transformer. This energizes the torch bus and simultaneously energizes each of the solenoids 475 of the torch structures connected thereto, thus opening the high-pressure oxygen line and allowing the cutting action to take place.

Similarly, when the timing machine closes the switch 575 a circuit is completed from ground through this switch, through the manual control switch 594, and through the control wire 136 running to the spindle. As previously described, each time this control is grounded the spindle starts to move from its maximum position toward its other maximum position so that the momentary closing of the switch 575 of the timing switch sets the spindle control system into operation as previously described.

If it is desired to operate the drills or torches independently of each other, this may be accomplished by closing the switches of the timing machine, and by individually closing the manual control switches 590, 592, and 594 in the desired sequence. Furthermore, if it is desired to operate any of the drills individually, or if it is desired not to operate one or more drills, this may be readily accomplished by means of a switch 700 positioned in the circuit of each motor between the plug 650 and the windings of the motor, the position of this switch being best shown in Fig. 12.

The contacts 608, 609, 616 and 617 of the controller 600 permit direct shifting from automatic to manual operation of the carriage, for if the controller is moved from its neutral position, the circuits controlled by switches 572 and 573 of the timing machine are broken, thus rendering the timing machine inoperative to move the carriage until the controller is again moved to neutral position.

*General operation*

It will be readily apparent to those skilled in the art that the flexibility of the control system of my invention permits any desired sequence of events, but for the purpose of clearness, I shall describe in general two desirable sequences of events without in any way limiting myself thereto. The sequence of events is, of course, controlled by the cam assembly of the timing machine, while the cutting speed is controlled by the timing machine, by the position of the handle 223 controlling the gears of the transmission, and by the change gears 226. Similarly, the speed at which the different events take place may be changed by means of the change gear 537 of the timing machine in combination with the gear 538.

Assuming now that a length of pipe has been placed on the wheels of the conveyor system and that the carriage has been moved toward the head so that the chuck 25 and a portion of the spindle 26 extend through the

opening 300 of the face plate, as shown in Fig. 1, the conveyor switch 54*a* on the head is closed, thus moving this pipe along the conveyor system toward the head until the forward end of this pipe lies near the carriage structure 31. The valve 77 is then opened and the three jacks simultaneously rise, thus elevating the pipe into a correct axial position, as previously described. The carriage is then manually moved in a reverse direction by means of the controller 600 until the end of the pipe 20 extends through the opening 300 of the face plate. At this time the centering members are moved into engagement with the pipe and sufficient tension is utilized on the upper of these members to act as a clamping means so that when the carriage is again moved forward, the pipe will be slid along the jacks 24 and into the chuck 25 where it is then clamped.

The carriage is then moved toward a position near the free end of the pipe 20, the jacks being successively lowered and again raised to permit this movement of the carriage, and the drills and torches are then properly adjusted as to position and the timing machine is then set into operation. During this time the timing machine may be in operation provided the manual control switches 590 to 594 are opened. These manual control switches are now closed and the heating flames are lighted. The first operation of the timing machine is to close the switch 574 which operates the drills as previously described. This is, of course, done during the time that the carriage is not moving along the tracks. In other words, the switches 572 and 573 of the timing machine are open. After drilling is complete the switch 574 opens and the drills are withdrawn after which the switch 572 closes and the carriage moves forward until this switch and the carriage switch 575 both open, at which time the tips of the torches are directly adjacent the holes previously drilled. The heating flames then act to heat the surrounding metal and when the necessary temperature has been reached the timing machine closes the switch 571, thus opening the oxygen valves of the torches and sending a cutting stream of oxygen therethrough. Almost simultaneously, the timing machine closes the switch 572 and the carriage moves forward, thus cutting the slot in the pipe. The opening of the switch 572 stops the carriage unless the spacing switch 675 is not open, in which event the movement continues until this spacing switch opens. The timing machine momentarily closes the switch 575 which moves the spindle from one extreme position into the other at a position determined by the setting of the "forward" and "reverse" selector switches 160 and 161. Subsequently, the sequence is repeated and a new series of slots is thus formed in spaced relationship with the slots first formed and also in staggered relationship relative thereto.

It is, however, usually desirable to space the drill and torch structures at such distances that the drills may be forming a new series of holes during the time that the heating flames are preparing the walls of the previously drilled holes for the cutting action of the oxygen stream. This spacing may be varied to compensate for different desired center-to-center spacings of slots, by the insertion of a spaced of suitable size between the torch and drill structures, this spacer having a tongue formed on one side and a groove formed on the other, this tongue and groove being similar to the tongue 448 and groove 447. No spacer is shown in Fig. 1, the set-up there shown being used on the shortest center-to-center spacing usually required.

It is desirable to have made up a number of the cam assemblies 540 to correspond to different standard lengths and spacings of slots. These different cam assemblies preferably bear marks on their upper faces which may be seen through a window 701 formed in the cover 527 of the timing machine so that the operator may know the exact act in the sequence which is being performed.

During the time that the slots are being formed, a high velocity stream of air is drawn through the spindle and through the pipe. It is not necessary to cap the end of the pipe when the carriage is working near this end, nor at any other time, for I have found that the stream of air is drawn through only the slots being cut and those slots which lie close thereto. Usually, the slots formed in a two-foot length of pipe are sufficient to pass the incoming air without any of this air being drawn through the end of the pipe. This stream of air or other gas is very important to this invention inasmuch as it tends to harden the walls of the slots as they are formed and also carries away any slag which would otherwise be deposited inside the pipe. Another very important use of this stream of air is to deflect the streams of cutting oxygen after they reach the interior of the pipe. If this is not done and a pair of torches are disposed in axial alignment on opposite sides of the pipe the jet from one will tend to throw slag into the other jet, thus clogging it.

With the machine of my invention it is possible not only to cut longitudinal slots as described, but also to cut slots which are transverse of the pipe. Such transverse slots may be cut by simply changing the sequence of operations of the timing machine, and rotating the pipe during the time that the cutting jets pass therethrough rather than moving the carriage longitudinally along the pipe at this time. The cutting speed on such transverse slots is controlled by the setting

of the gear box 90, and the speed of the motor 87.

Similarly, it is possible to cut helical slots with my machine, this being accomplished by rotating the spindle at the same time that the carriage is advancing and during the time that the cutting jet of oxygen passes through the pipe. The angle of this helix is, of course, determined by the relative speeds of advancement of the carriage and rotation of the spindle 26. Various other shapes of slots may be secured by different speeds of rotation of the spindle 26 and advancement of the carriage structure 31.

While I have shown and described my invention as being applicable in cutting slots in pipe, it should be understood that various other cutting operations could be performed, thereby such as the mere drilling of holes. Furthermore, the apparatus is not limited to use in processing pipe, the drill structure, for instance, being adapted to drill a series of holes in any cylindrical piece of metal. Other details, such as the pipe-handling system are also not limited to use with my machine. The appended claims should therefore not be interpreted as being limited thereto.

Various changes and modifications too numerous to specifically mention, may be made without departing from the spirit of this invention, and it should be understood that the invention should not be limited to the particular structure shown and described.

I claim as my invention:

1. In a machine for perforating a pipe, the combination of: a spindle including a passage therein; means for retaining said pipe in alignment with said passage of said spindle; means for successively penetrating said pipe; and suction means for drawing a stream of gas through said passage, said stream removing any material removed during said penetrating of said pipe.

2. In a pipe-slotting machine, the combination of: means for supporting a length of pipe; a carriage movable longitudinally along said pipe; means independent of said pipe for guiding said carriage whereby said carriage moves longitudinally in a given path; a cutting means; means for mounting said cutting means in floating relationship with said carriage; and means contacting said pipe at a position spaced longitudinally from the zone of action of said cutting means for maintaining a given portion of said cutting means at a constant distance from the surface of said pipe as it is moved longitudinally therealong.

3. In a pipe-slotting machine, the combination of: means for supporting a length of pipe; a carriage movable along said pipe; means independent of said pipe for guiding said carriage; a face plate mounted in floating relationship with said carriage; a cutting torch carried by said face plate and directed toward said pipe; and guide means acting between said face plate and said pipe for maintaining said cutting torch a constant distance from the surface of said pipe as it is moved longitudinally therealong.

4. In a pipe-slotting machine, the combination of: means for supporting a length of pipe; a carriage movable along said pipe; means independent of said pipe for guiding said carriage; a frame mounted in said carriage to move in a given direction in a plane substantially perpendicular to the axis of said length of pipe; a face plate mounted in said frame to move in a given direction substantially at right angles to the direction of movement of said frame relative to said carriage and in a plane substantially parallel to said first-named plane; a cutting means carried by said face plate; and centering means acting between said face plate and said pipe for maintaining a given portion of said cutting means at a constant distance from the surface of said pipe as it is moved therealong.

5. In combination in a machine for processing a length of material: a face plate providing an opening through which said material passes; means for moving said face plate along said length of material; means carried by said face plate for processing said material during a movement of said face plate therealong; a pair of centering members mounted in said face plate and extending into said opening and into centering engagement with said length of material; and another centering means resiliently mounted in said face plate and engaging said length of material.

6. In combination in a machine for processing a length of material: a face plate providing an opening through which said length of material passes; means for moving said face plate along said length of material; means carried by said face plate for processing said material during a movement of said face plate therealong; resiliently mounted means extending from said face plate and into engagement with said length of material; and counterbalance means acting in conjunction with said resiliently mounted means for substantially counterbalancing the weight of said face plate and the processing means supported thereby.

7. In a pipe perforating machine, the combination of: a head; a spindle journalled in said head and extending forward therefrom; a chuck means mounted on the forward end of said spindle and adapted to receive one end of the pipe in clamping relationship; and a carriage structure movable longitudinally with respect to said pipe and providing an opening through which said pipe extends during the processing thereof, said opening being of sufficient diameter to

pass said chuck means and at least a portion of said spindle when said carriage structure is moved close to said head, thereby permitting vertical movement of said pipe into alignment with said chuck means without interference with said carriage structure.

8. In a pipe perforating machine, the combination of: a head; a spindle journalled in said head and extending forward therefrom; a chuck means mounted on the forward end of said spindle and adapted to receive one end of the pipe in clamping relationship; a carriage structure movable longitudinally with respect to said pipe and providing an opening through which said pipe extends during the processing thereof, said opening being of sufficient diameter to pass said chuck means and at least a portion of said spindle when said carriage structure is moved close to said head, thereby permitting vertical movement of said pipe into alignment with said chuck means without interference with said carriage structure; and clamping means associated with said carriage structure for clamping said carriage structure and said pipe whereby a movement of said carriage moves said pipe with respect to said chuck means after said pipe is in alignment with said chuck means.

9. In combination: a plurality of jacks for supporting a length of material; a carriage adapted to move along said material; means carried by said carriage for processing said material; and means for lowering from the path of travel of said carriage any of said jack means when said carriage reaches that portion of said material supported thereby, said means controlling the subsequent reraising thereof when said carriage has moved therepast.

10. In a machine for processing a material comprising: track means, there being a well formed in the ground at one end of said track means; means for supporting a length of said material above said track means; carriage means movable along said track means; processing means mounted on said carriage means; and means in the form of one or more flexible members connected to said carriage means for effecting the operation of said processing means, said flexible members extending downward in said well to form a loop, the position of which changes when said carriage is moved along said track means.

11. In a machine for processing a material comprising: track means, there being a well formed in the ground at one end of said track means; means for supporting a length of said material above said track means; carriage means movable along said track means; processing means mounted on said carriage means; means in the form of one or more flexible members connected to said carriage means for effecting the operation of said processing means, said flexible members extending downward in said well to form a loop the position of which changes when said carriage is moved along said track means; and guide means extending parallel to said track means for supporting that portion of said flexible members between said carriage and said well.

12. In a machine for perforating a length of pipe, the combination of: a head structure; control means on said head structure for changing the angular position of said length of pipe; carriage means movable along said length of pipe; perforating means carried by said carriage and including a drill means and a cutting means; switch means on said carriage and controlling the action of said perforating means and the movement of said carriage means; and timing means mounted on said carriage to move therewith for controlling said switch means and said control means thereby controlling the movement of said carriage and the angular position of said length of pipe and the operation of said perforating means.

13. In a machine for perforating pipe, the combination of: a head; a spindle rotatively mounted in said head; drive means for rotating said spindle; and switch means operated as a function of the angular position of said spindle and cooperating with said drive means for controlling the direction of movement of said spindle.

14. In a machine for perforating pipe, the combination of: a head; a spindle rotatively mounted in said head; drive means for rotating said spindle; a control circuit adapted to control the movement of said drive means; and means operative as a function of the angular position of said spindle for reversing said drive means upon successive energizations of said control circuit.

15. In a machine for perforating pipe, the combination of: a head; a spindle rotatively mounted in said head; a reversible electric motor for rotating said spindle; forward and reverse contactors for controlling the direction of rotation of said motor; a control circuit for controlling the operation of said contactors from a remote point; and switch means operative as a function of the angular position of said spindle for selecting which of said contactors is operated upon a subsequent energization of said control circuit.

16. In a machine for perforating pipe, the combination of: a head; a spindle rotatively mounted in said head; multi-speed drive means for said spindle; selector means for determining the speed of rotation of said drive means; and means operative as a function of the angular position of said spindle for determining the direction of rotation of said spindle.

17. In combination: a carriage structure; drive means for said carriage structure; manually operated control means for con-

trolling said drive means to move said carriage into the approximate desired position; and means operated in response to the position of said carriage for further moving said carriage after said manually operated means has been moved into a neutral position until said carriage reaches the exact desired position.

18. In a machine for perforating a length of pipe, the combination of: a supporting means for supporting said pipe, the interior of said pipe being unobstructed; perforating means movable relative to said pipe and cutting said pipe starting at one end and ending at the other, said one end of said pipe being open; and suction means communicating with said other end of said pipe and drawing a stream of gas through the unperforated section of said pipe, said gas entering said pipe through the perforations already formed and through said one end of said pipe which is open.

19. In a machine for forming perforations in a length of pipe, the combination of: a face plate; a drill means on one side of said face plate for drilling a hole through said pipe; a cutting torch on said one side of said face plate and directed toward said pipe; means for spacing said cutting torch and said drill means a distance apart along said pipe a distance equal to the desired spacing of corresponding portions of two perforations; means for securing said face plate, said drill means and said cutting torch together; means for simultaneously actuating said drill and said cutting torch to simultaneously drill a hole in said pipe and heat the area around a hole previously drilled; means for forming a cutting jet from said cutting torch after said drill means has completed its operation, said cutting jet extending through the hole the area around which was previously heated; and means for relatively moving said cutting torch and said pipe to form a slot therein.

20. In a pipe slotting machine for slotting a length of pipe, the combination of: carriage means movable longitudinally with respect to said pipe; a plurality of cutting means disposed around said pipe; means for mounting said cutting means in floating relationship with respect to said carriage to move in all directions in a plane substantially perpendicular to the axis of said pipe; and guide means acting between said last-named means and said pipe for maintaining said cutting means spaced from the surface of said pipe a constant distance as said carriage means moves longitudinally with respect to said pipe.

21. In a pipe slotting machine, the combination of: a carriage body; a frame movable with respect to said body and including a pair of columns vertically slidable in said carriage body; a face plate adjacent said frame and vertically movable therewith; guide means slidably mounting said face plate with respect to said frame to move horizontally therein; and centering means for maintaining said face plate centralized with respect to said pipe as said carriage is moved longitudinally along said pipe.

22. A combination as defined in claim 21 including piston means formed by the lower end of said columns and in which said carriage body includes cylinders in which said piston means may slide, and including means for maintaining a pressure in said cylinders to at least partially balance the weight supported by said frame.

23. In a machine for processing a length of material, the combination of: a head; a spindle rotatably mounted in said head and attached to one end of said length of material; electric drive means for rotating said spindle; a carriage movable longitudinally with respect to said length of material; control means on said carriage; a single control circuit operatively associated with said control means and extending to said head; and means for operatively connecting said drive means and said control circuit to operate said drive means in opposite directions upon successive energizations of said control circuit.

24. A combination as defined in claim 11 in which said switch means includes a directional switch and a stop means engageable with said directional switch when said spindle has reached a desired angular position to interrupt the current to said drive means to stop said spindle.

25. A combination as defined in claim 11 in which said switch means includes a directional switch and a pair of adjustable stops engageable with said directional switch when said spindle is in desired extreme angular positions, said directional switch including contacts opening upon engagement between said directional switch and one of said stops to stop said drive means, said directional switch including contacts controlling the connections to said drive means upon said engagement whereby subsequent energization of said drive means will operate said drive means to turn said spindle in a reverse direction.

26. A combination as defined in claim 9 including a drive means for moving said carriage, means associated with said drive means for stopping the movement of said carriage, and a bumper on said carriage operatively connected to said last-named means and positioned to engage any one of said jacks that has not been lowered from the path of travel of said carriage to stop the movement of said carriage upon engagement of said bumper and such jack.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 28th day of January, 1930.

CLARENCE J. COBERLY.