United States Patent

[11] 3,601,263

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[45] Patented **Aug. 24, 1971**

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[54] **BILLET-HANDLING APPARATUS**
20 Claims, 31 Drawing Figs.

[52] **U.S. Cl.** ..... **214/1 QG,** 214/1 P, 214/7
[51] **Int. Cl.** **B65g 47/24**
[50] **Field of Search** ..... 214/1 R, 1 P, 1 PB, 1 Q, 1 QG; 198/33 AD

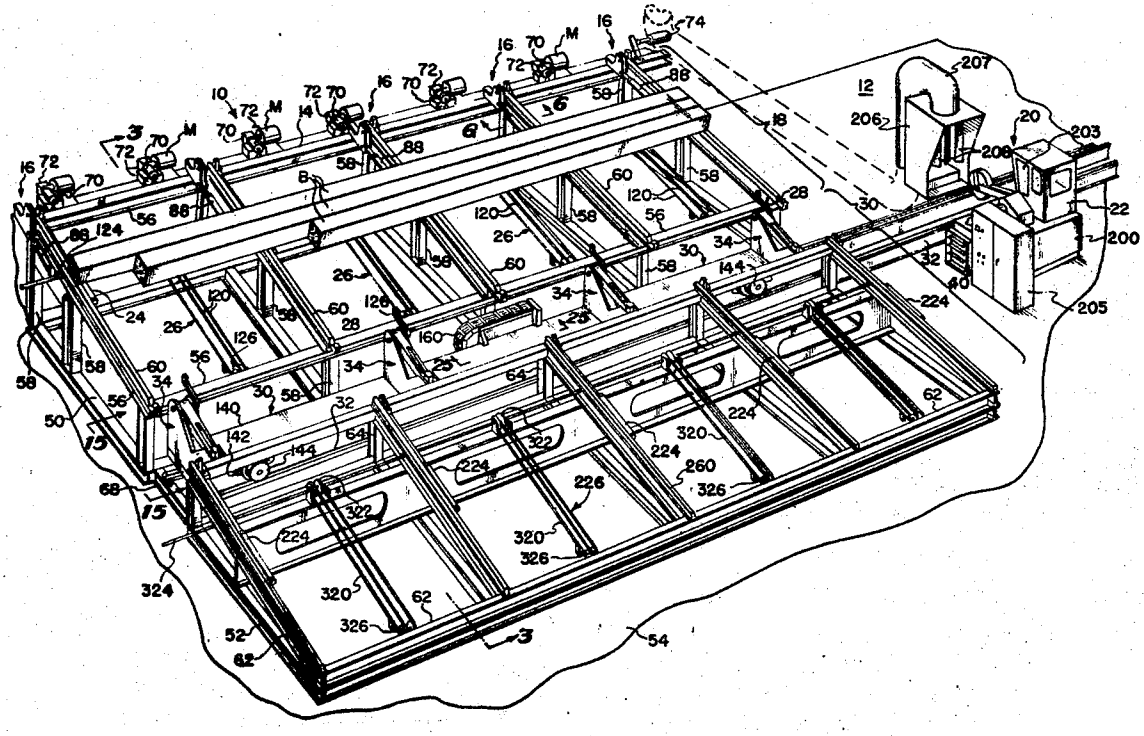
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Primary Examiner—Gerald M. Forlenza
Assistant Examiner—Frank E. Werner
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ABSTRACT: Billet handling and treating apparatus wherein successive billets emanating from a billet-spotting station are supplied to and stacked upon a charge table from which they are withdrawn, one at a time and deposited upon a manipulating car which conducts them to a grinding station for treatment. While the billets are being withdrawn from the stack, the charge table continues to be supplied with fresh billets which are formed into a reserve stack. When the original stack is exhausted, the reserve stack moves into position for withdrawal of the billets and the formation of another stack is initiated. Such billet stacking and withdrawal of billets is continuous so that at no time is there a lack of billets for the grinding operation.



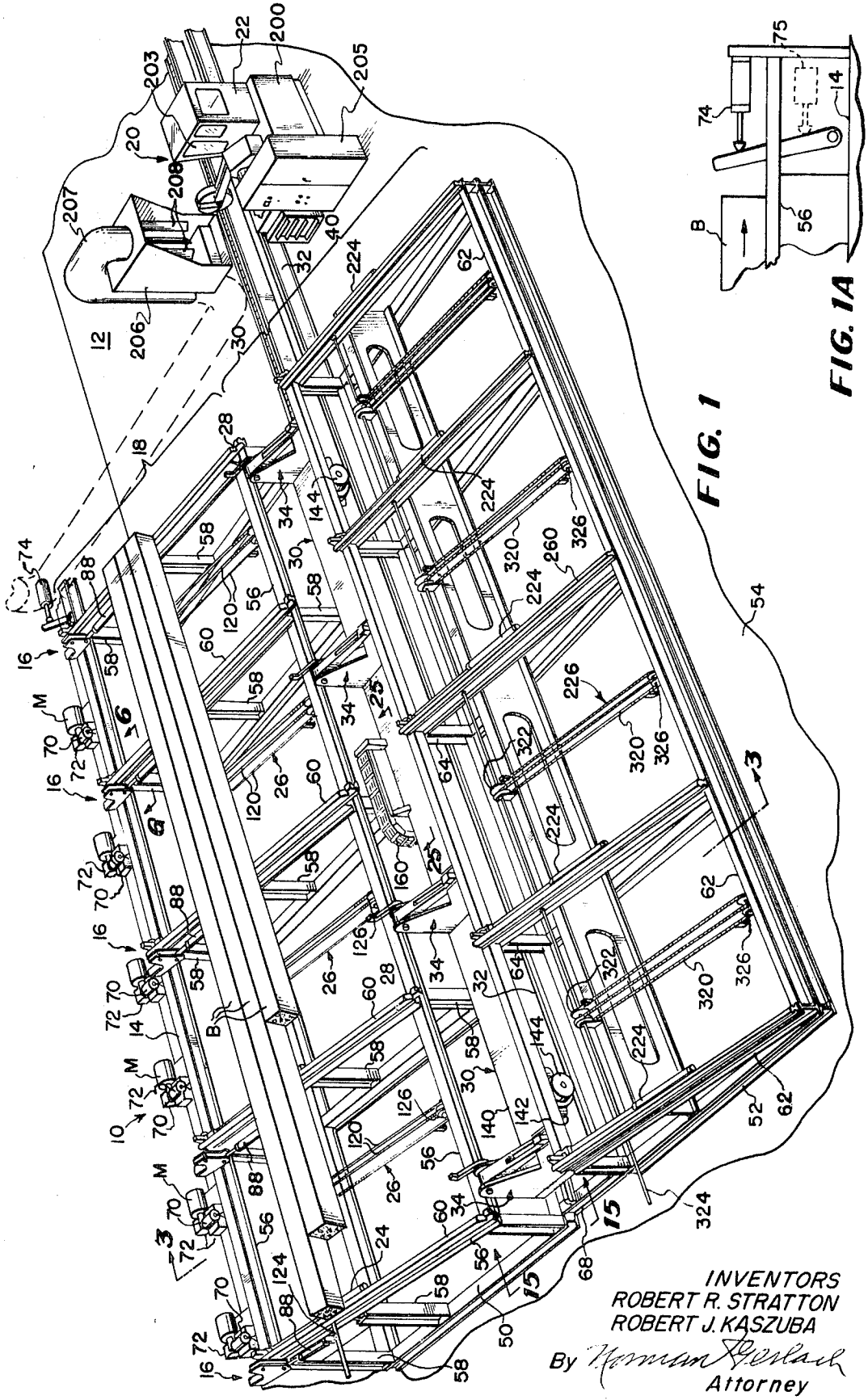


FIG. 1

FIG. 1A

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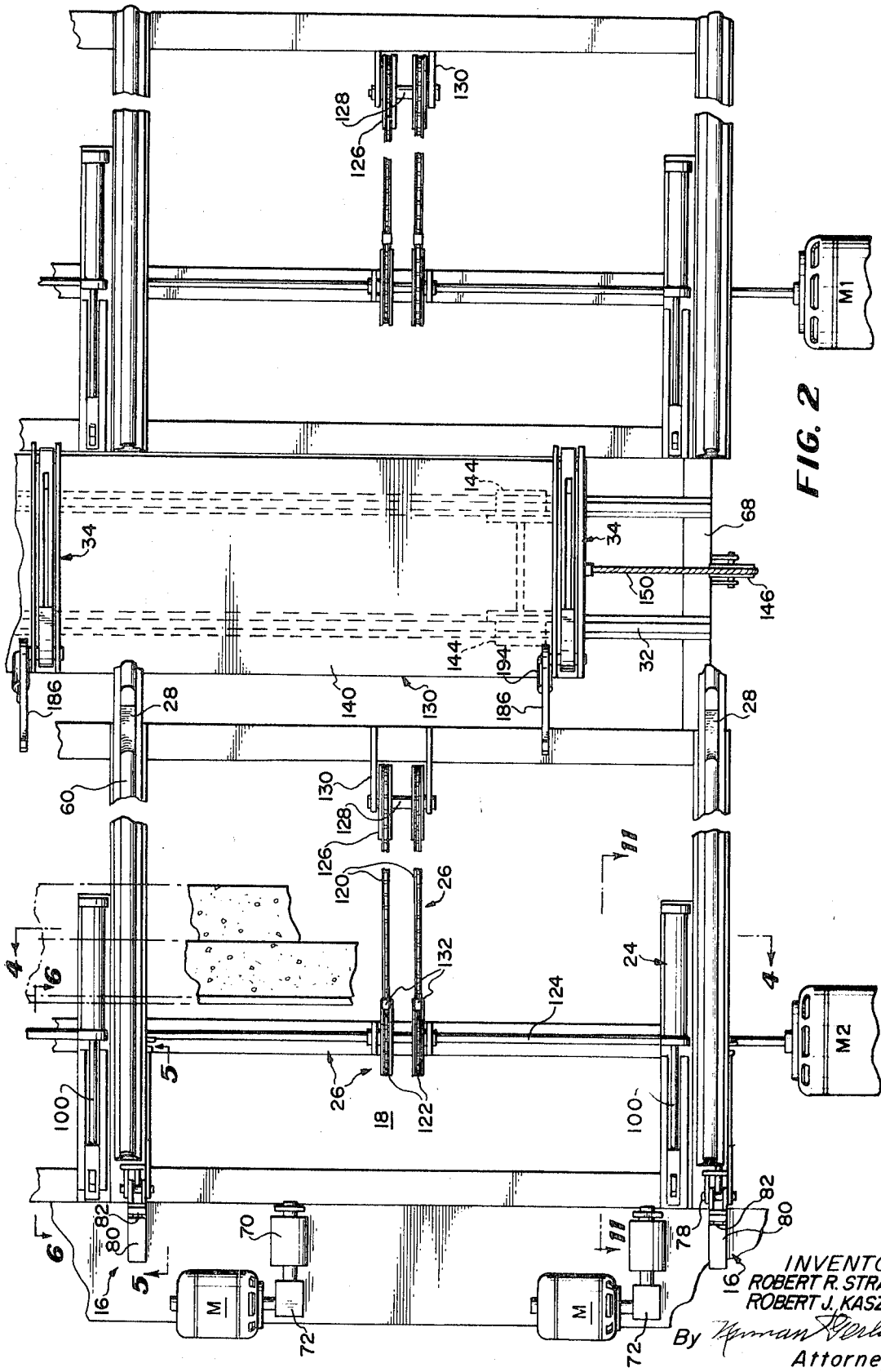


FIG. 2

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FIG. 3

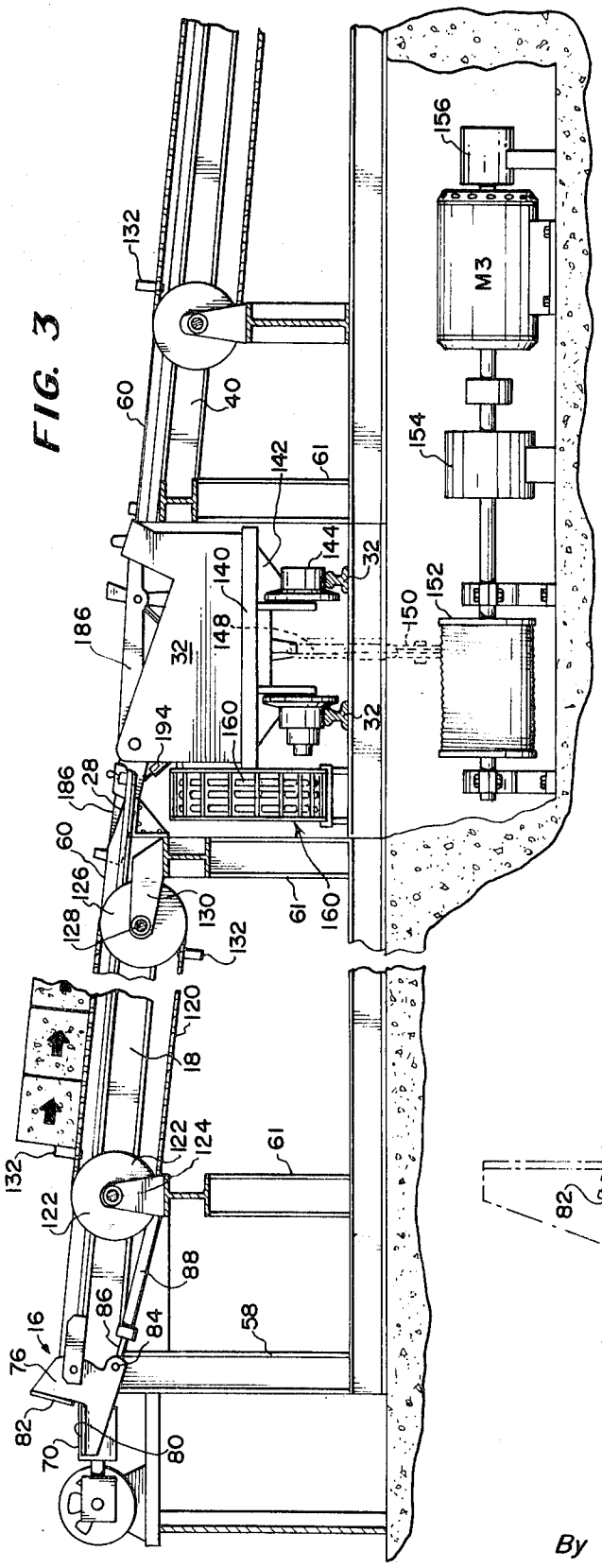


FIG. 9

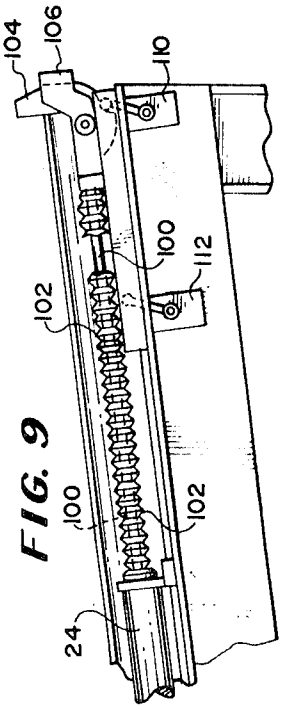
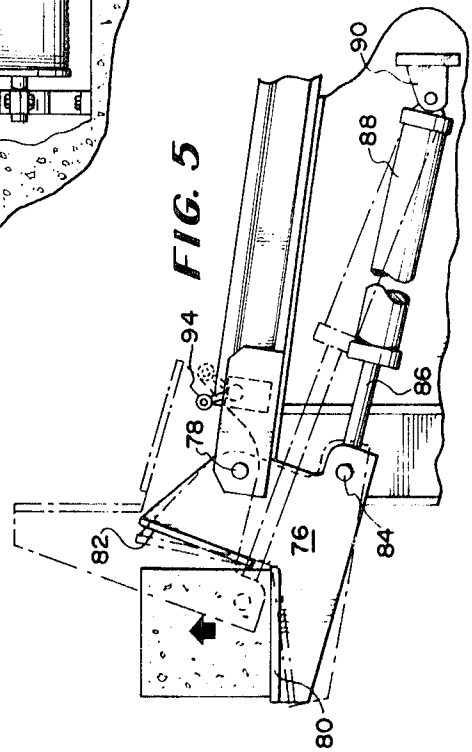


FIG. 5



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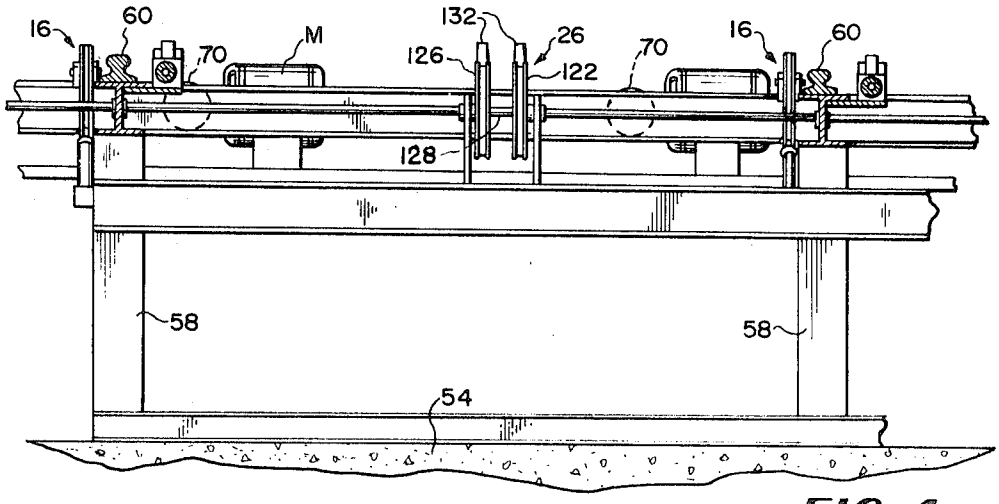


FIG. 4

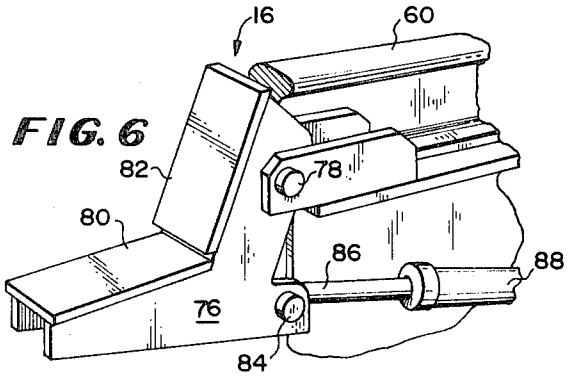


FIG. 6

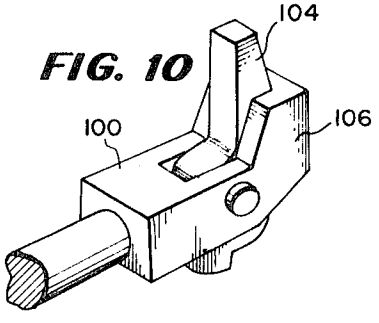


FIG. 10

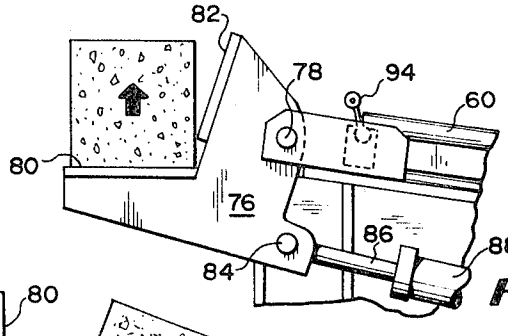


FIG. 7

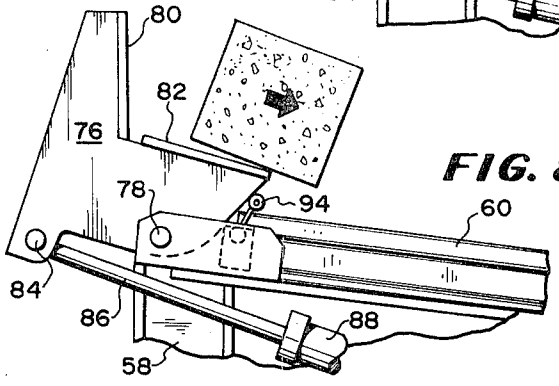


FIG. 8

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FIG. 11

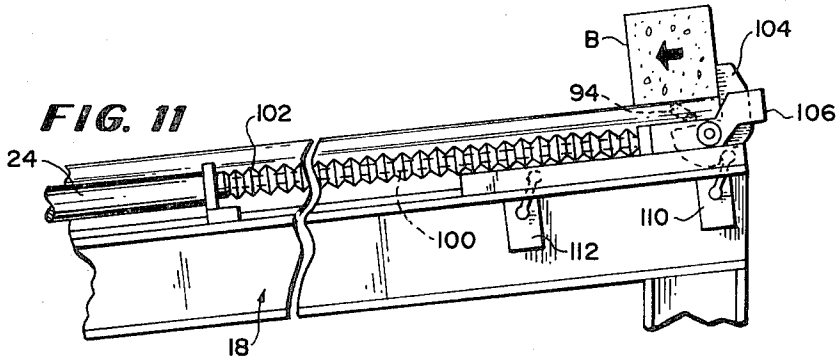


FIG. 12

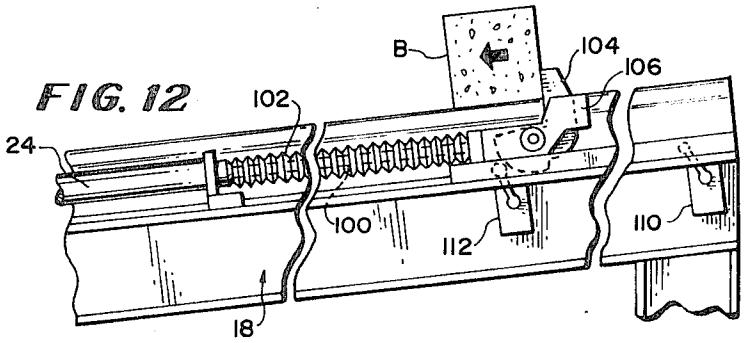


FIG. 13

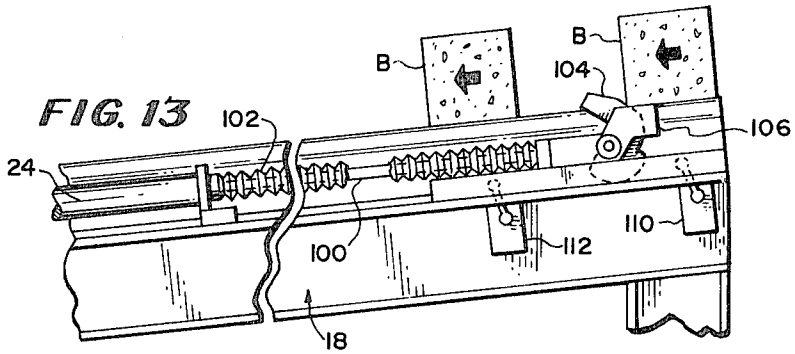
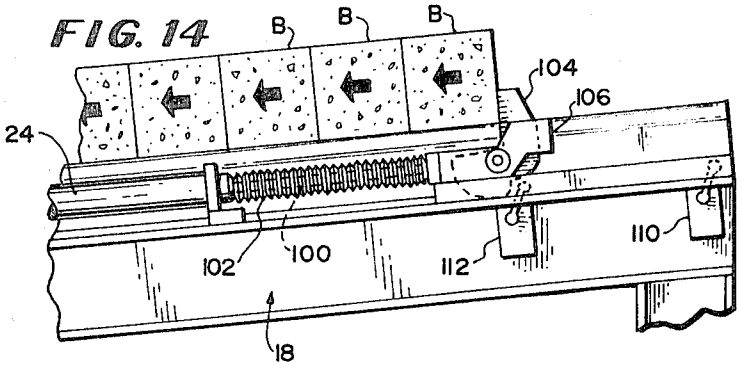


FIG. 14



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FIG. 15

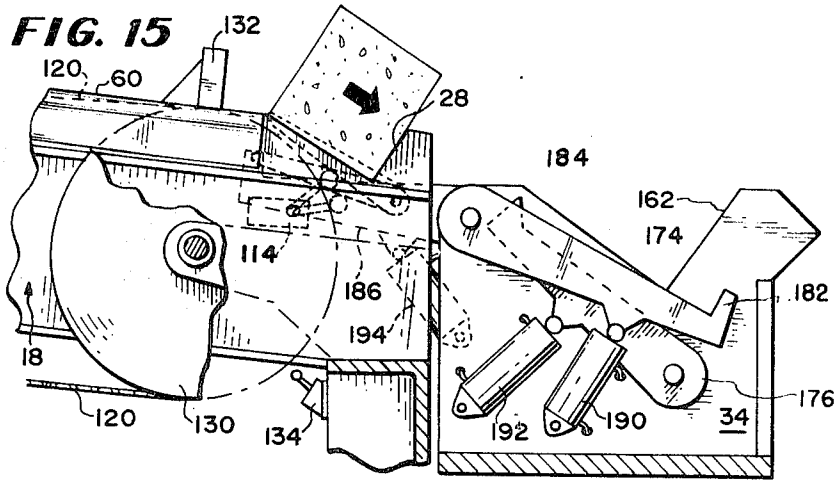
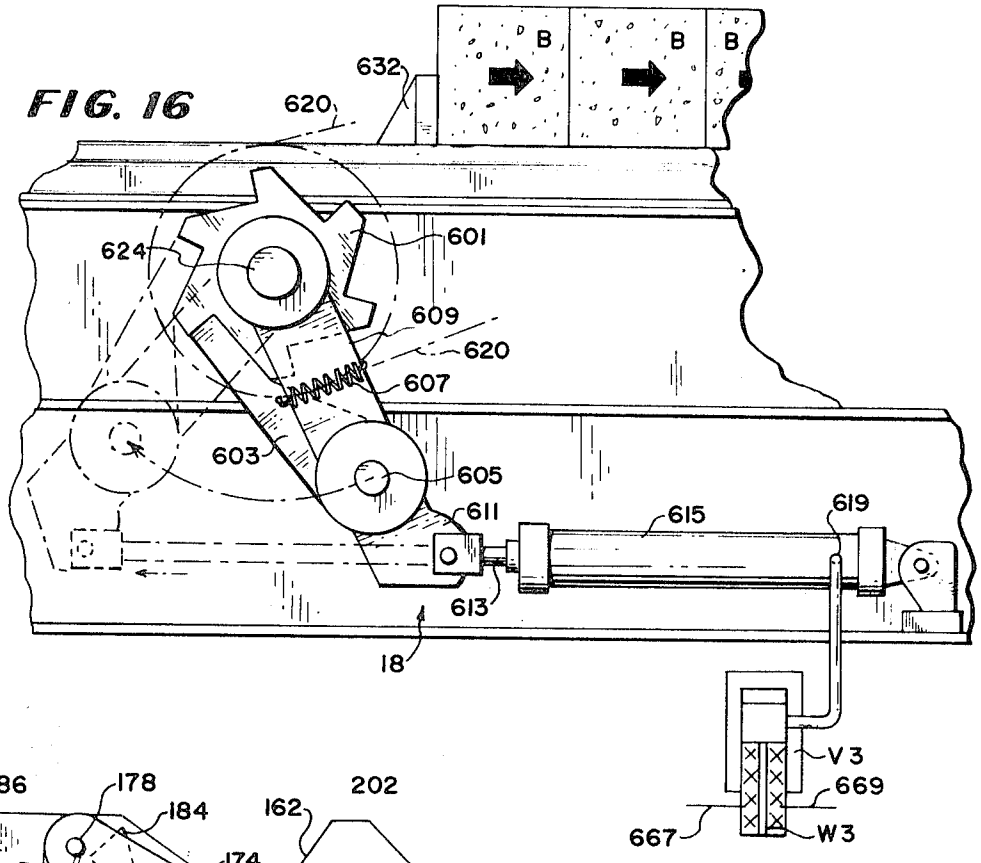


FIG. 16



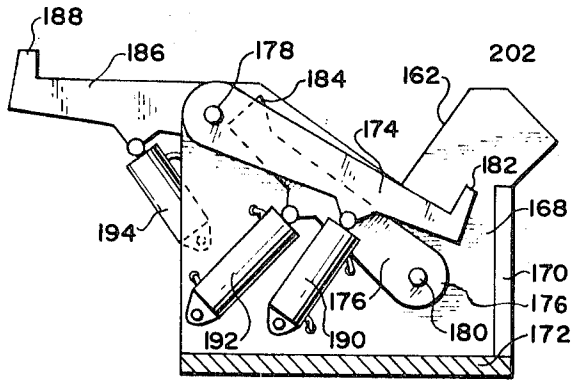


FIG. 17

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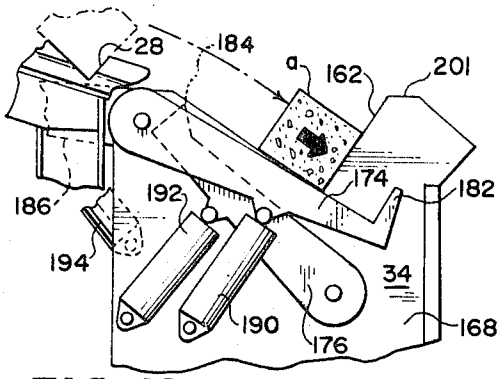


FIG. 18

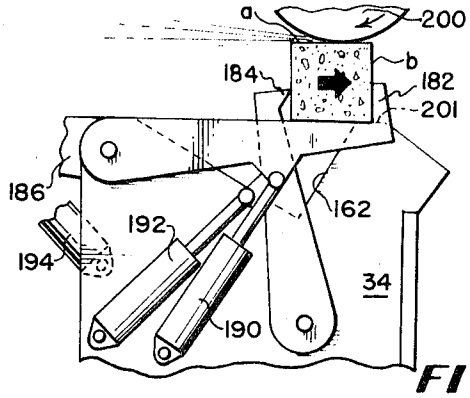


FIG. 19

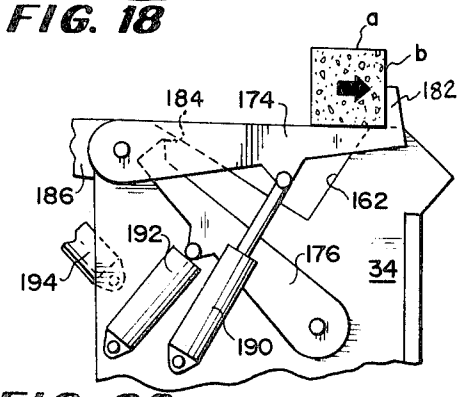


FIG. 20

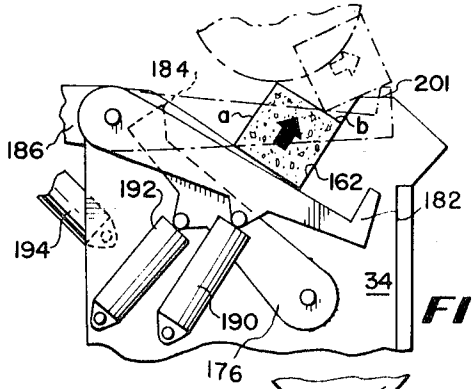


FIG. 21

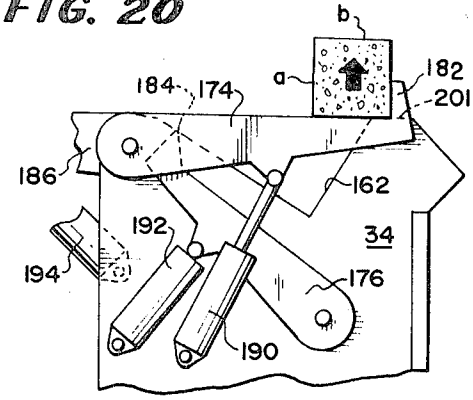


FIG. 22

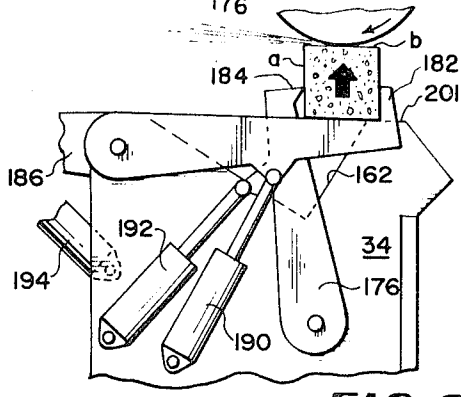


FIG. 23

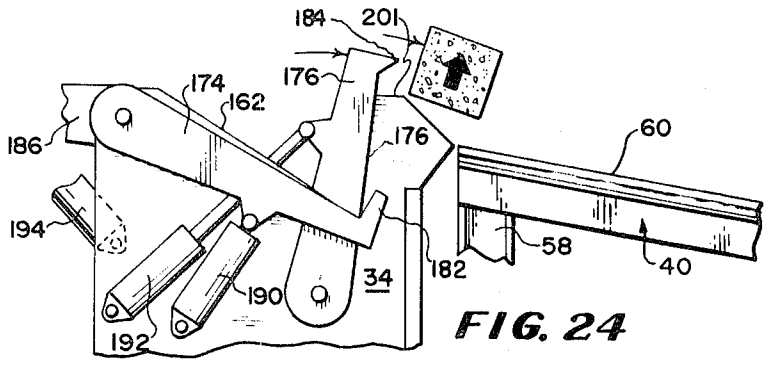


FIG. 24

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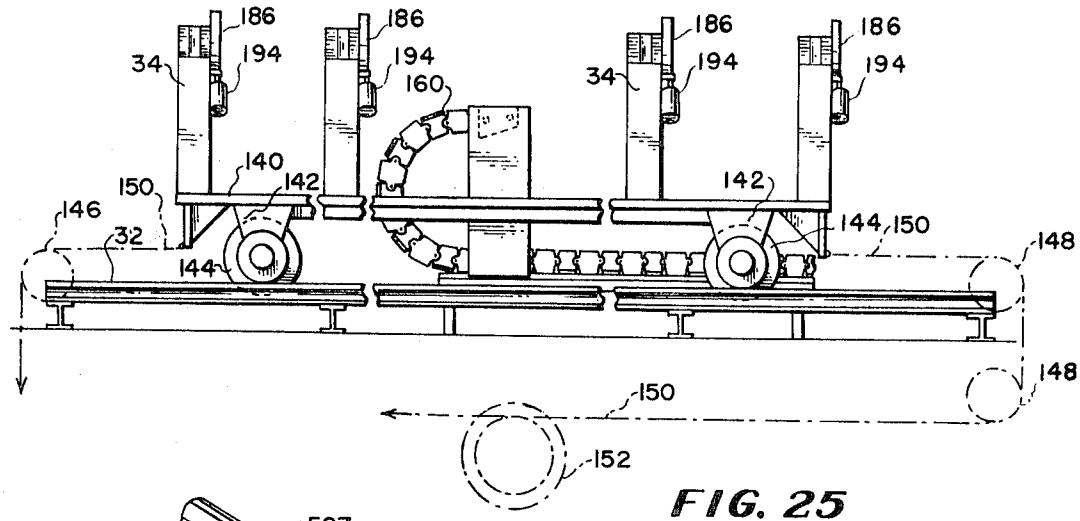


FIG. 25

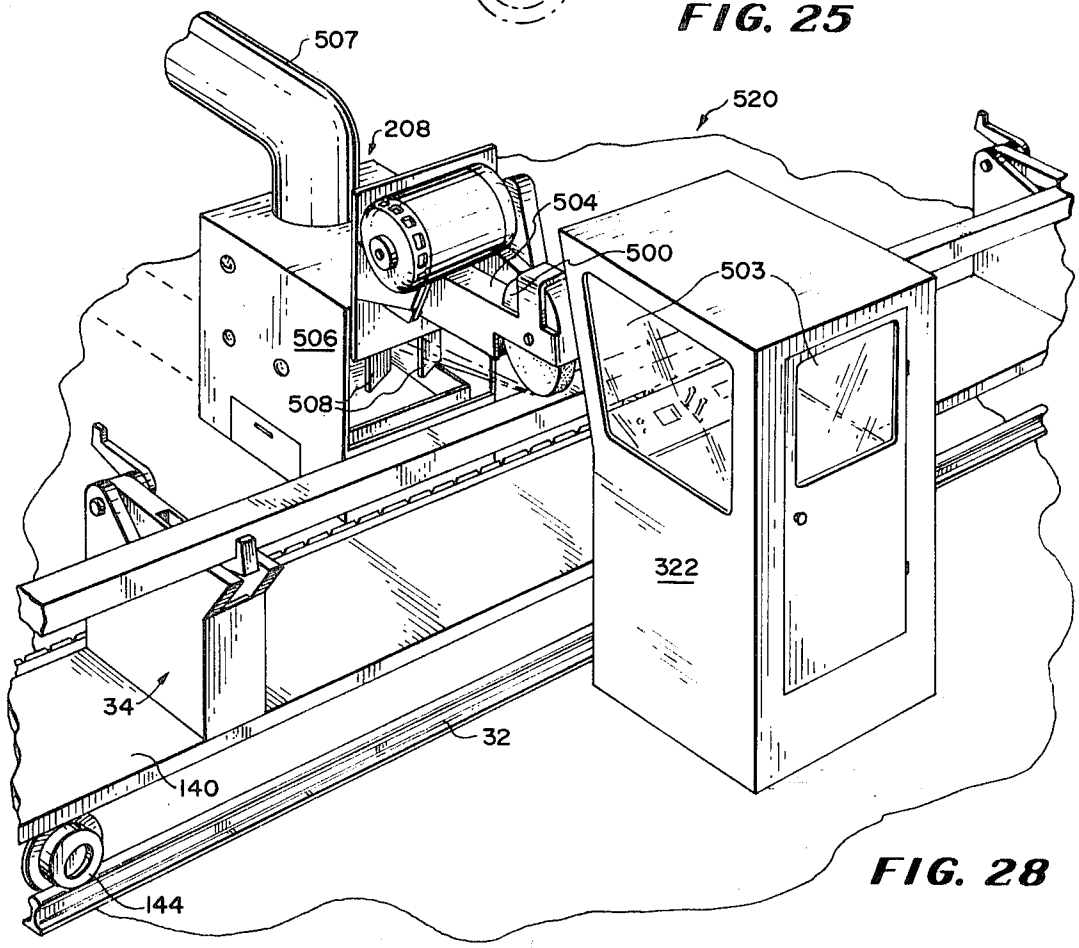


FIG. 28

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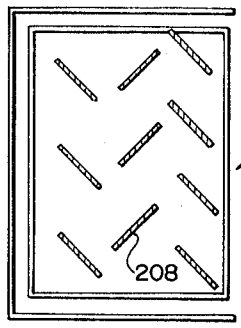


FIG. 27

FIG. 26

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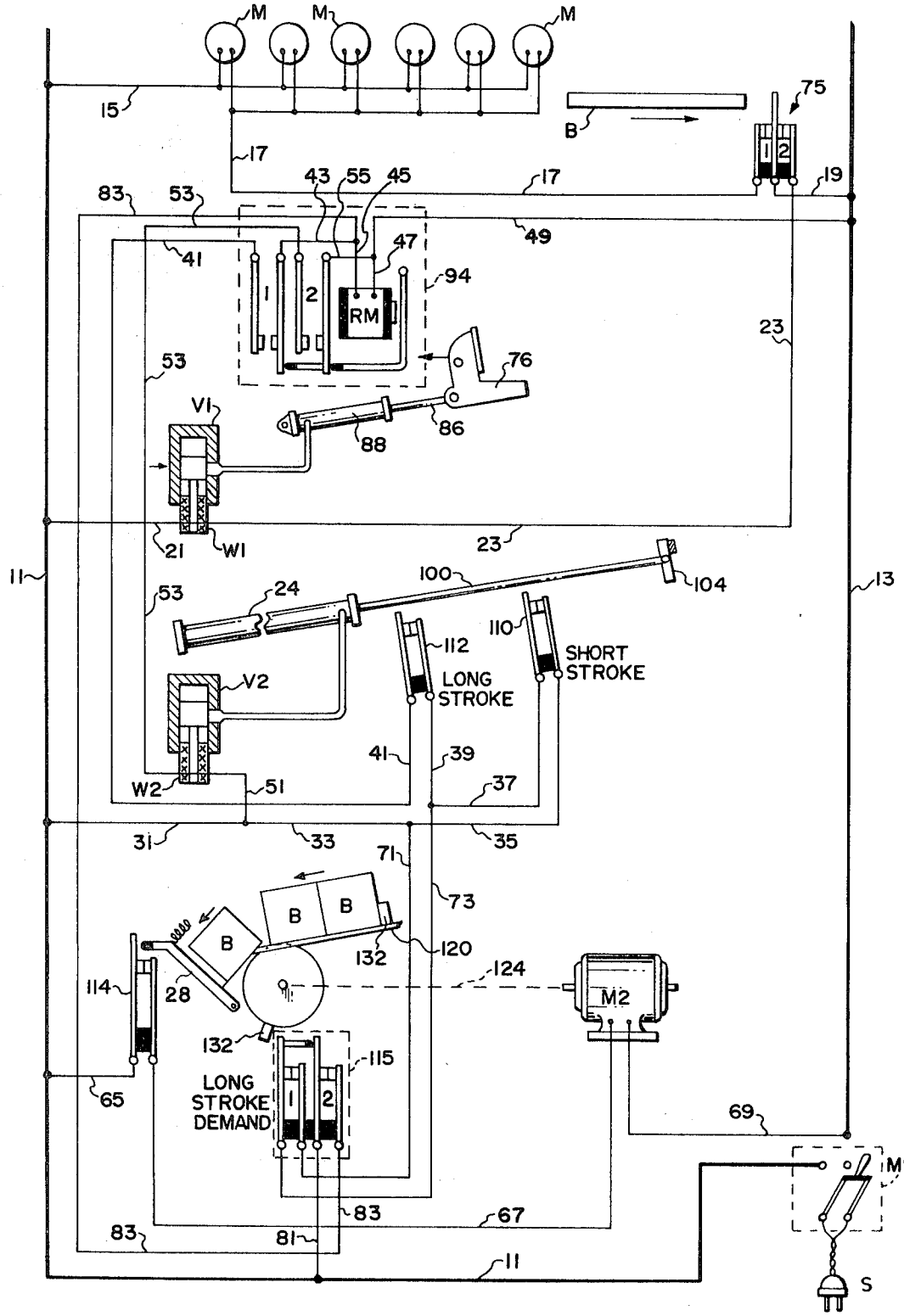
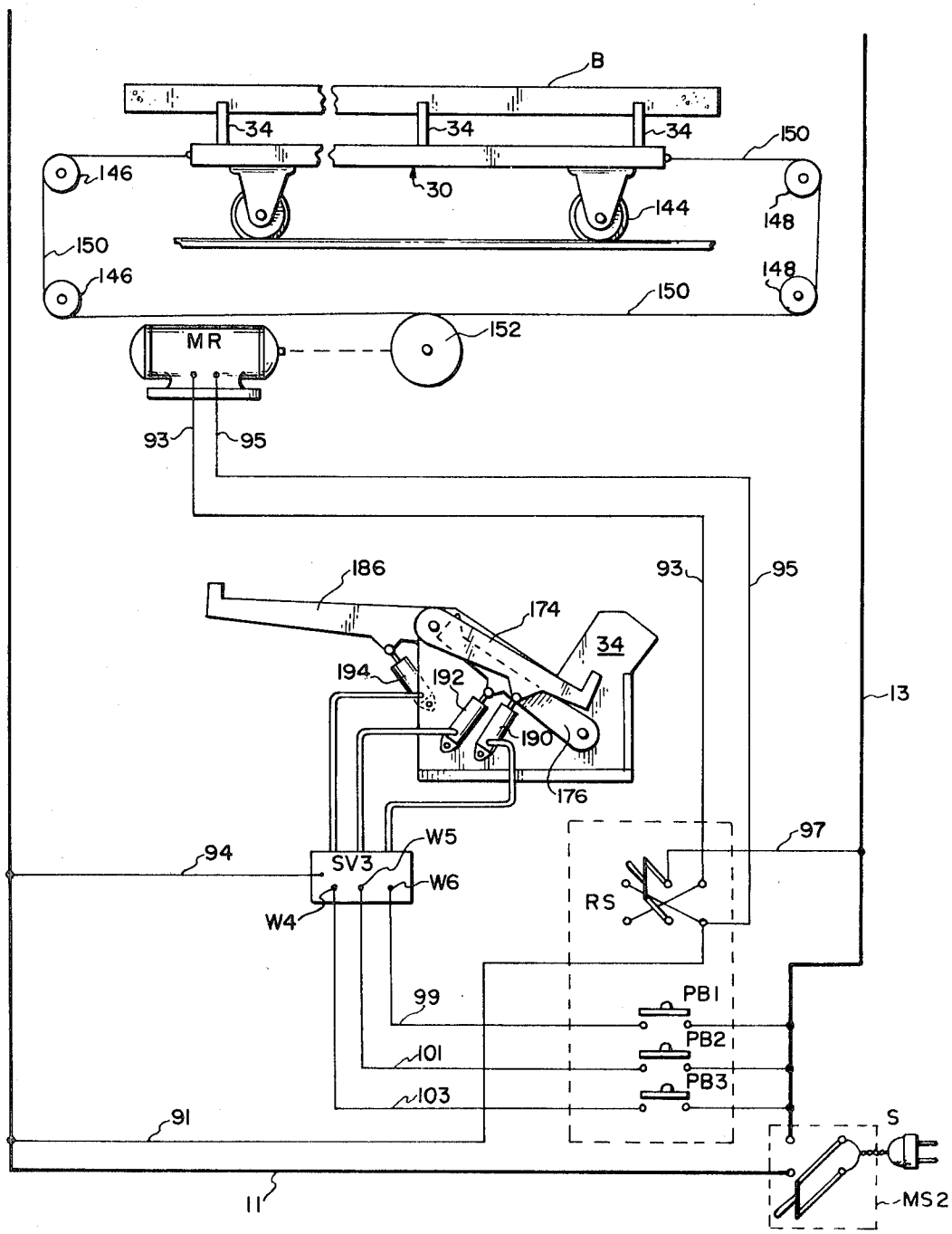


FIG. 29

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FIG. 30



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BILLET-HANDLING APPARATUS

The present invention relates to a billet-handling apparatus which is designed especially for use in a steel mill and by means of which steel billets, which have been examined for defects and marked accordingly for visual grinding to remove surface defects, are conducted from the examining location to a grinding station where they are operated upon to remove the defects and then are conducted to a region of discharge.

The preliminary examination of raw billets in a steel mill for the detection of surface defects and the spotting of such defects so that they will be more readily visible to an operator at a grinding station where the defects are removed has become a highly developed art involving such procedures as subjecting the billets to various liquid baths, the passing of electric current through the billets, magnetization of the billets and various other procedures which locate surface defects and identify them according to their character. Such procedures also include marking the billets with indicia so that the location and nature of the surface defects of the billets will become apparent to the operator of a grinding machine at a grinding station, it being understood that the operator may then more intelligently proceed to remove such surface defects in the marked billets. Among the defects ordinarily occurring on raw billets are the presence of surface scale (oxides), cracks, crevices, ridges and other high spots. One method of spotting surface defects on steel billets has been developed by Magnaflux Corporation of Chicago, Illinois and involves an apparatus which is manufactured and sold under the trade name "Magnaglo" and operates to discharge endwise onto a conveyor a succession of billets which have by various means been spotted for surface defects and then properly marked for subsequent surface grinding to remove the identified defects. The present invention relates specifically to billet-handling apparatus by means of which the thus discharged spotted and marked billets are received one at a time and in an endwise state on a takeoff conveyor and are then deposited singly and sidewise on the receiving end of a charge table where each thus deposited spotted and marked billet is periodically shifted forwardly along the table so that the successively received billets become stacked horizontally, i.e., closely nested in side-by-side relationship along the substantially horizontal plane of the charge table. After a given number of billets have become thus stacked on the charge table, the entire stack is shifted bodily as a unit forwards on the table thus bringing the leading billet in the stack into close proximity with an elongated manipulating car which is capable of receiving successive billets, one at a time, from the forward end of the charge table and travels endwise transversely of the charge table so as to transfer each billet which is deposited thereon from the charge table to a grinding station wherein it is operated upon to remove the surface defects which have previously been spotted by the "Magnaglo" or other defect-detecting apparatus.

The manipulating car is in the form of a shiftable bed which carries the billets, one at a time, endwise into the grinding station and beneath a rotating grinding wheel, the movements of the car being effected selectively under the control of the operator of the grinding apparatus who may shift the car in either direction, as required, to bring the spotted surface defects of each billet into register with the grinding wheel and who also has limited control over the grinding wheel so that he may take care of defects which are displaced from each other in the transverse direction of the billet being ground. The manipulating car also has associated with it mechanism whereby a billet may be turned about its longitudinal axis to cause the various side surfaces, as well as the various corner edges of a billet, to be presented for grinding by the grinding wheel at the grinding station.

After a given billet has been completely conditioned at the grinding station, the manipulating car is returned to its position of register with the forward end of the charge table and

the conditioned billet thereon is then deposited sidewise onto a discharge table where it is periodically moved forwards under the impetus of succeeding billet issuing from the manipulating car in order thus to create a horizontal stack of the conditioned billets. After stacking of a given number of the conditioned or ground billets, the entire stack is shifted bodily as a unit to bring the leading billet into register with the forward end of the discharge table, substantially in the same manner of billet movement along the charge table. From the discharge end of the discharge table, the conditioned billets may be withdrawn by various means having no relation to the present invention. For example, they may be picked off manually one at a time or a group of the billets may be hoisted from the discharge table by utilizing a magnetic hoist or the like. If desired, each stack of conditioned billets may be pushed off the end of the discharge table and onto a conveyor belt, onto a portable bin or container, or onto a work table where they may be strapped by a conventional hand or power-operated banding or strapping machine.

The novelty of the present invention resides not only in the overall combination of certain pieces of handling equipment whereby the raw but spotted and marked billets are successively withdrawn from the discharge conveyor of the "Magnaglo" or other billet-spotting apparatus, then conducted to the grinding station, then manipulated at the grinding station for billet-conditioning purposes, and finally conducted to a region of discharge, but also in various novel billet-handling subassemblies such as billet pickoff devices embodying billet-lifting, billet-tilting, billet-sliding and billet-tumbling mechanisms whereby each succeeding billet undergoing movement is transferred from one place to another, either by preserving its initial billet orientation or by changing such orientation. At the grinding station there is provided in associated relation with the manipulating car which supports the billets for grinding purposes novel means for selectively shifting the position of the billet undergoing treatment and for clamping the billet in a selected grinding position during the actual grinding operation.

At the grinding station, there is also provided novel means for collecting the products of abrasion in such manner that the discharge velocity of such products is abruptly reduced, thus allowing the coarse particles to settle and become separated from the fines.

The provision of a billet-handling apparatus of the character briefly outlined above constitutes the principal object of the present invention.

Numerous other objects and advantages of the invention not at this time enumerated will become readily apparent as the nature of the invention is better understood from a consideration of the following detailed description.

The invention consists in the several novel features which are hereinafter described and are more particularly defined by the claims at the conclusion hereof.

In the accompanying 11 sheets of drawings forming a part of this specification, two illustrated embodiments of the invention are illustrated.

In these drawings:

FIG. 1 is a top perspective view of a billet-handling apparatus embodying the principles of the present invention, such view showing the manner in which successive billets become stacked on the charge table of the apparatus;

FIG. 1*a* is an enlarged fragmentary detail view of a portion of the apparatus of FIG. 1, such view illustrating the nature of a combined shock absorber and limit switch mechanism which is employed in connection with the invention;

FIG. 2 is an enlarged fragmentary plan view of the apparatus of FIG. 1, such view omitting the grinding machine;

FIG. 3 is an enlarged transverse sectional view taken substantially on the vertical plane that is indicated by the line 3—3 of FIG. 1 and in the direction of the arrows;

FIG. 4 is a longitudinal sectional view taken substantially on the line 4—4 of FIG. 2;

FIG. 5 is an enlarged fragmentary side elevational view of a billet pickoff device which is associated with the receiving end of the charge table, the view being taken with the limits of the line 5—5 of FIG. 2 and in the direction of the arrows;

FIG. 6 is a perspective view of the device of FIG. 5;

FIGS. 7 and 8 are fragmentary side elevational views similar to FIG. 5 but illustrating schematically the manner in which the pickoff device functions to transfer a billet from the receiving conveyor to the charge table;

FIG. 9 is a fragmentary side elevational view similar to FIG. 5, taken within the limits of the line 9—9 of FIG. 2 and in the direction of the arrows and showing a billet-impelling assembly which is employed in connection with the invention;

FIG. 10 is an enlarged fragmentary side elevational view of a trip finger or dog which forms a component of the billet-impelling assembly of FIG. 9;

FIGS. 11 and 12 are fragmentary side elevational views similar to FIG. 9 but illustrating schematically the manner in which the billet-impelling mechanism of FIG. 9 effects a short stroke for billet-stacking purposes;

FIG. 13 is a fragmentary side elevational view similar to FIGS. 11 and 12 but illustrating the manner in which the billet-impelling mechanism effects its return stroke;

FIG. 14 is a fragmentary side elevational view similar to FIGS. 11, 12 and 13 but illustrating the manner in which the billet-impelling mechanism effects a long stroke for billet stack transfer purposes;

FIG. 15 is an enlarged fragmentary detail view of a portion of the structure of FIG. 3, the view being taken in the vicinity of the billet transfer region between the charge table and the manipulating car of the apparatus;

FIG. 16 is a fragmentary side elevational view of certain intermittently operable stack-feeding components which represent a modified form of the stack-feeding components of FIGS. 1 to 3, inclusive;

FIG. 17 is an enlarged fragmentary sectional view taken transversely through the manipulating car in the vicinity of a billet transfer mechanism or manipulator proper by means of which billets are successively withdrawn from the forward end of the charge table and deposited on the manipulating car, the view illustrating schematically the manner in which such transfer is effected;

FIGS. 18 and 19 are fragmentary sectional views similar to FIG. 17 but illustrating schematically the operation of certain billet-handling mechanism in raising a billet on the manipulating car into grinding position at the grinding station;

FIGS. 20 to 23, inclusive, are fragmentary sectional views similar to FIGS. 18 and 19 but illustrating schematically the manner in which the billet-handling mechanism is actuated to withdraw the billet from the grinding position of FIG. 19 and then manipulate the same throughout an angle of 90° for presentation of a different surface region to the rotary, power-driven grinding wheel of the grinding machine;

FIG. 24 is a fragmentary view similar to FIGS. 18 to 23, inclusive, but illustrating schematically the manner in which a conditioned or ground billet is discharged from the manipulating car to the discharge table of the billet-handling apparatus;

FIG. 25 is an enlarged longitudinal sectional view taken substantially on the vertical plane indicated by the line 25—25 of FIG. 1 and in the direction of the arrows, the view illustrating the reversible driving mechanism for the manipulating car;

FIG. 26 is a fragmentary perspective view of those parts of the apparatus that are in the vicinity of the grinding station;

FIG. 27 is a horizontal sectional view taken on the plane indicated by the line 27—27 of FIG. 26 and in the direction of the arrows;

FIG. 28 is a perspective view similar to FIG. 26 but showing a modified arrangement of the grinding station;

FIG. 29 is a circuit diagram of a particular control system which is used in connection with and forms part of the improved billet-handling apparatus; and

FIG. 30 is a circuit diagram of another control system of the apparatus.

GENERAL DESCRIPTION

The billet-handling apparatus constituting the present invention is designed specifically for use in a steel mill or similar establishment and serves to conduct steel billets from an examining station where the billets are carefully examined for defects such as surface scale, cracks, crevices, high spots and other irregularities and also where such defects are spotted by suitable markings to enhance the visibility thereof, to a grinding station where the billets are operated upon by a grinding machine to remove the defects, after which the billets are conducted to a discharge region where they may be deposited on a takeoff conveyor or otherwise withdrawn from the apparatus. Insofar as this patent application is concerned, no novelty is claimed in connection with either the examining station or the grinding machine which conditions the billets by removing the spotted and marked surface defects therefrom. No disclosure is made of any specific examining equipment, the only reference to such equipment being in the form of a statement that the receiving conveyor of the billet-handling apparatus constituting the present invention is aligned with the discharge conveyor leading from the examining station to the end that there is continuity of movement of the billets from such examining station to the billet-handling apparatus. The two alternative disclosures which have been made in connection with the grinding station are purely exemplary disclosures, one such disclosure involving a grinding machine wherein the operator's cab faces in the direction of the boom which carries the rotary grinding wheel, and the other disclosure embodying a grinding machine wherein the operator's cab faces directly the distal or operative end of the boom in order that the operator may have a closer and better view of the grinding wheel. As between these two types of grinding machines, no difference in the operation of the billet-handling apparatus is involved.

BRIEF DESCRIPTION

Referring now to the drawings in detail and in particular to FIGS. 1 to 4, inclusive, the billet-handling apparatus constituting the present invention is designated in its entirety by the reference numeral 10, and it is adapted to be erected on the floor of a steel mill in the vicinity of a grinding station 12 and in an appropriate position where successive steel billets such as those indicated by the reference letter B may be received endwise on a takeoff or charge conveyor 14 from the discharge conveyor that is associated with a billet examining and treating station (not shown) at which the billets are examined for surface defects such as surface scale, cracks, high spots and other irregularities. After such defects have been located at the examining station, their visibility is enhanced by a conventional spotting or marking operation so that the operator at the grinding station 12 may more readily see them and manipulate the grinding machine accordingly.

From the charge conveyor 14 successive billets are deposited by a series of transfer or pickoff devices 16 which function simultaneously to deposit the billets, one at a time, onto the receiving end of a charge table which is indicated by the bracket 18 in FIG. 1. Substantially all of the functions performed by the billet-handling apparatus 10 are effected automatically but with a few functions taking place under control of the operator in the cab of the grinding machine at the grinding station 12, the grinding machine as a whole being designated by the reference numeral 20 and the cab thereof by the reference numeral 22. The control system whereby such automatic functions are initiated is disclosed in FIG. 29 and will be described in detail subsequently. The manually operable controls which are resorted to by the operator in the cab 22 of the grinding machine 20 are disclosed in FIG. 30 and likewise will be described hereafter.

Upon successive placement of the billets B sidewise on the receiving end of the charge table 18, several billet-stacking cylinders 24 are actuated to perform a short plunger stroke and serve to pull the billets, one at a time, from the extreme rear or receiving end of the charge table forwardly to stack the

billets in the generally horizontal but slightly inclined plane of the table, each freshly received billet serving to push the preceding billet forwards to produce a stack such as is shown by the three billets appearing in FIG. 1. After a predetermined number of billets have been thus stacked on the charge table 18 in the rear region thereof, the cylinders 24 are again actuated, this time to perform a long plunger stroke so that they now pull the entire stack of billets forwardly from the rear region of the charge table and position the stack on the forward region of the table where they overlie a series of chain conveyors 26 which operate intermittently under the control of certain limit switch mechanism to shift the stack of billets B periodically forwardly and cause the leading billet in the stack to slide from the forward edge of the charge table 18 into a charge table slot 28 (see FIG. 15) where it remains until the operator of the cab 22 signals for deposition thereof onto a traveling billet-receiving bed 30 (hereinafter referred to as the "manipulating car") which travels transversely of the apparatus 10 and conducts such billet to the grinding station 12 for presentation thereof to the grinding wheel of the grinding machine 20 in various selected positions of billet orientation. The manipulating car 30 rides on rails 32 (see FIGS. 2, 3 and 26) and, while it is at the grinding station, several billet manipulators 34 in series from function in a manner that will be made clear presently in connection with FIGS. 18 to 23, inclusive, to tumble the billet from one position to another for the purpose of presenting different side surfaces or corners of the billet to the grinding wheel for removal of surface defects. The manipulating car 30 is capable of being shifted endwise, i.e., transversely of the grinding station so that it may make various passes through the grinding station and beneath the grinding wheel of the grinding machine 20.

During the grinding operations on the billet B being conditioned or ground by the grinding machine 20, the billet remains supported within the confines of the manipulating car, and after the billet has been conditioned the manipulating car is returned to its position of register with the discharge end of the charge table 18. Thereafter, the same manipulators 34 which are employed for tumbling the billet at the grinding station are employed for lifting the billet out of the manipulating car and discharging the same sidewise onto the receiving end of a discharge table which is indicated by the bracket 40 in FIG. 1. The discharge table 40 is equipped with billet-stacking cylinders 224 which are identical with the billet-stacking cylinders 24 and serve the same function, namely, to pull the discharged conditioned or ground billets B into stacked relationship precisely as they were pulled on the charge table 18 by the cylinders 24, and then to shift the accumulated stack of billets forwards on the discharge table to a point of discharge.

THE APPARATUS FRAMEWORK

As best illustrated in FIG. 1, the framework of the billet-handling apparatus 10 is comprised of structural members which establish two base frames 50 and 52 which rest upon the foundation surface or floor 54 of the steel mill where the apparatus is installed. The base frame 50 is associated with the charge table 18, the latter being in the form of a rectangular frame 56 which directly overlies the base frame 50 and is supported in an elevated and slightly inclined position by means of various vertical posts 58. Wear bars or rails 60 extend in a fore and aft direction across the frame 56 and serve slidingly to support the various billets B thereon during movement thereof forwards along the charge table 18. The adjacent wear rails 60 preferably are equally spaced from each other and the number of such rails may vary according to the length of the longest billet which is to be accommodated by the apparatus, five such rails being disclosed herein for illustrative or exemplary purposes.

The base frame 52 is associated with the discharge table 40 which, likewise, is in the form of an inclined rectangular frame 62 which overlies the frame 52 and is supported on vertical posts 64. Wear rails 260, similar to the rails 60, extend along the frame 62. The inclination of the two frames 56 and 62 is similar so that these frames lie in a common inclined plane which establishes a forwardly and downwardly inclined path of movement for the billets B.

Short horizontal structural sections 68 serve to space the charge table framework from the discharge table framework and establish therebetween a clearance space for the manipulating car 30, this car, in the illustrated form of the invention, being slightly shorter in length than the length of the charge and discharge table frameworks.

THE CHARGE TABLE

(The Charge Conveyor)

Still referring to FIG. 1 wherein the details of the charge conveyor 14 are best illustrated, and additionally to FIGS. 2, 3 and 5, this charge conveyor consists of several motor-driven traction rollers 70 which are disposed in parallelism and, in addition, are aligned along the rear edge of the charge table 18, six such rollers being disclosed herein. Each roller is driven through a gear reducer 72 by an electric motor M, the latter being suitably mounted on the charge table framework of the apparatus. The various motors M are connected in a parallel electric circuit (see FIG. 29) for operation in unison. The rollers 70 constitute power rolls for impelling a billet B endwise and to the right along the rear edge of the charge table 18 and against a combined shock absorber and stop 74 at the right-hand rear corner of the charge table as viewed in FIG. 1, thus actuating a limit switch 75 (see FIG. 1*a*) which is effective to deenergize the various motors M and arrest further movement of the billet as will become clear subsequently when the circuit diagram of FIG. 30 is described. The travel of successive billets B by way of the motor-driven traction rollers 70 constituting the charge conveyor 14 is from left to right as viewed in FIG. 1.

(The Pickoff Devices)

The various pickoff devices 16 are associated with the charge conveyor 14, these devices being equally spaced along the rear edge of the charge table 18 and five such devices being illustrated in FIG. 1 although a greater or lesser number thereof may be employed if desired. Each pickoff device embodies a rocker element 76 (see FIGS. 6, 7 and 8) which is pivoted on a horizontal pin 78 for rocking movement between the position wherein it is shown in FIG. 6 and the position wherein it is shown in FIG. 8. The rocker element 76 is provided with a flat platelike shelf portion 80 which normally underlies a billet B on the charge conveyor 14. The rocker element 76 is further provided with a second flat platelike shelf portion 82 which extends at an obtuse angle to the shelf portion 80. The rocker element 76 is connected by a horizontal pin 84 to the outer or exposed end of plunger 86 which extends into and is slidable with respect to a fluid pressure cylinder 88, the latter being pivoted to a fixedly mounted bracket 90 (see FIG. 5) on a portion of the framework of the charge table 18. Normally, the plunger 86 assumes the retracted position in which it is shown in full lines in FIG. 6. In such position of the plunger 86, the shelf portion 80 of the rocker element 76 assumes an inclined position and is disposed below the level of a superjacent billet B on the rollers 70 of the charge conveyor 18 so as to afford a clearance whereby the billet may move freely along the conveyor without interference from the various rocker elements 66. At such a time as pressure fluid, either pneumatic or hydraulic, is supplied to the cylinder 88, the plunger 86 becomes extended from the cylinder and the rocker element 76 is rocked in a clockwise direction as viewed in FIG. 5 so that the shelf portion 80 engages the underneath side of the overlying or superjacent billet B and applies lifting force thereto as shown in full lines in FIG. 5 and in FIG. 7. Continued projection of the plunger 86 from the cylinder 88 as the result of the supply of fluid under pressure into said cylinder serves to tilt the rocker

element to the position wherein it is shown in broken lines in FIG. 5 and in full lines in FIG. 8, thus shifting the billet B thereon from the shelf portion 80 to the shelf portion 82, and since the terminal position of the rocker element 76 when the plunger 86 is fully extended is such that the shelf portion 82 is inclined as shown in FIG. 8, the billet will slide forwardly from the shelf portion 82 and be deposited on the charge table 18 near or adjacent to the rear edge of the latter. The placement of the billet B on the charge table is such that it is deposited within the reach of the billet stacking and advancing mechanism which includes the previously mentioned cylinders 24 and their adjuncts, the details of which will be set forth presently. It will be understood that the transfer of the billets from the charge conveyor 14 to the charge table 18 is effected by all of the fluid pressure cylinders 88 which are operated in unison both for plunger projecting and plunger retracting purposes.

In order to restore the rocker elements 76 to their original or initial position, a limit switch 94 is engaged by one of the rocker elements 76 when the latter reaches its billet-discharging position, actuation of this switch serving to restore the plungers 86 to their retracted positions within the cylinders 88 in a manner that will be set forth in detail subsequently in connection with the circuit diagram of FIG. 29.

THE BILLET STACKING AND ADVANCING MECHANISM

Still referring to FIGS. 1 to 3, inclusive, and, additionally, to FIGS. 9 to 14, inclusive, the previously mentioned billet-stacking cylinders 24 are adapted to be actuated either pneumatically or hydraulically in unison. Each cylinder 24 is fixedly secured in position on the framework of the charge table 18 alongside one of the wear rails 60 and is provided with a plunger 100 which preferably is covered with a collapsible protective sheathe or boot 102. At the outer or exposed end of the plunger 100 a tiltable pusher dog 104 is spring biased to a normally vertical position against a back stop 106 so that the pusher dog projects upwardly above the lowermost level of the billet B at the extreme rear end portion of the charge table 18 when the plunger 100 is fully extended from the cylinder 24. This extended position of the plunger 100 is its normal position so that when a billet is deposited on the rear end portion of the charge table 18 by the pickoff devices 16 as previously described, the dog 104 ordinarily will lie behind the newly deposited billet preparatory to impelling the billet forwardly on the charge table.

As previously set forth, the billet-stacking cylinders 24 are capable of performing either a short plunger stroke or a long plunger stroke, the short stroke serving to group the newly deposited billets into a stack on the charge table 18 and the long stoke serving to advance the stack bodily along the charge table in a forward direction.

(Short Stroke Billet Stacking)

Considering now the operation of only one of the various billet-stacking cylinders 24, short stroke billet stacking is effected under the control of the deposition of a billet B on the rear end portion of the charge table 18 by the pickoff devices 16 one of which strikes the limit switch 94 each time a billet is transferred from the charge conveyor 14 to the table. As will be described subsequently when the operation of the billet-handling apparatus is set forth in connection with circuit diagrams of FIGS. 29 and 30, actuation of the limit switch 94 initiates retraction of the plunger 100 into the cylinder 24, thus causing the pusher dog 104 to engage and impel the newly deposited billet B on the charge table 18 forwards along the wear rails 60 until such time as the pusher dog 104 engages a limit switch 110 which terminates the operation of the cylinder 24 and restores the plunger 100 to its fully projected position. This movement of the pusher dog 104 shifts the billet B from the position wherein it is shown in FIG. 11 to the position wherein it is shown in FIG. 12, the billet being thus left in this latter position while the pusher dog 104 is returned to its initial position as as to be able to engage the next succeeding billet B which is deposited on the charge table 18 by the pickoff devices 16. In moving to its initial position the dog 104, as soon as it engages the newly deposited billet B, is deflected by the latter as shown in FIG. 13 so that it may pass beneath such billet and then pop up again on the other side of the billet preparatory to impelling such billet forwardly during the next succeeding stroke of the plunger 100. The limit switch 110 is positioned so that it is engaged by the pusher dog 104 after the plunger 100 has performed a relatively short stroke, thus advancing the billet B on the table a commensurately short distance. As successive billets are advanced by the pusher dog upon repeated short strokes of the plunger 100, each newly deposited billet engages the next preceding billet and pushes it forwards, thus progressively building up a stack of the billets in the rear region or portion of the charge table 18. The stacking area of the charge table is, in effect, a storage area where billets may accumulate and be held in reserve when the demand for billets at the grinding station 12 is not great and the call for billets is less frequent than the rate of deposition of billets on the charge table from the charge conveyor 14.

All of the billet-stacking cylinders 24 operate simultaneously as described above and it is contemplated that only one cylinder need have the limit switch 110 associated with it.

(Long stroke Stack Advancing)

After a predetermined number of billets B have been thus stacked on the rear region of the charge table 18, means are provided for imparting a long stroke to the plungers 100 which then operate to shift the entire stack of billets forwards in the manner illustrated in FIG. 14. As will be described in connection with the circuit diagram of FIG. 29, initiation of the long stoke to each plunger 100 is effected only at such time as there is an absence of a billet in the aforesaid charge table slot 28. Considering now only one of the billet-slacking cylinders, in order to effect the long stroke of the plunger 100 and the pusher dog 104, means are provided for bridging or shorting out the limit switch 110 so that when this switch is engaged by the pusher dog 104, it will be without function, and in such an instance, the pusher dog will travel beyond said limit switch and engage a second limit switch 112 (the long stroke switch) as shown in FIG. 12, such second limit switch serving to terminate maximum retractile motion of the plunger 100 and the pusher dog 104 and then restore them to their fully projected position. The plunger and the pusher dog, in thus traveling throughout a long stroke, pull all of the accumulated billets B, i.e., the entire stack of billets, forwards on the wear rails 60 and thus position the stack in overlying relationship with respect to the chain conveyors 26 of the charge table 18. During such shifting of the stack of billets, and as the plunger 100 approaches its fully retracted position, the leading billet B in the stack is deposited in the charge table slot 28, thus depressing a limit switch 114 and restoring control of the cylinder 24 to its short stroke operation since the overriding control of the limit switch 112 is no longer effective. At this time, a resumption of placement of billets B on the rear region or portion of the charge table 18 will take place under the control of the cylinders 88 and the pickoff devices 16 while the chain conveyors 26 are operated intermittently to feed billets successively into the charge table slot 28 at a rate commensurate with their removal from said slot for placement on the manipulating car 30.

(The Chain Conveyors)

The chain conveyor 26 is best illustrated in FIG. 1 to 4, inclusive, and FIGS. 15 and 16 and consist of a plurality of pairs of endless conveyor chains 120 which extend around drive sprockets 122. The latter are fixedly mounted on a common drive shaft 124 which extends completely and transversely across the charge table 18, overhangs one edge of the table as

shown in FIG. 1, and is operatively connected to an electric motor M2 so as to be driven thereby when the motor is energized. The chains 120 also extend around idler sprockets 126 which are mounted on short shafts 128. The latter are rotatably supported in brackets 130 which are carried by the upper frame 56 of the framework of the charge table 18. The motor M2 is adapted to be energized in a selective manner to cause intermittent shifting of the stack of billets under the control of the chains 120. Accordingly, each pair of chains is provided with billet-impelling dogs 132, the dogs being arranged in side-by-side pairs and there being two such pairs of dogs for each pair of chain. During passage of the dogs along the upper reaches of the chains as shown in FIG. 3, the stack of billets B is shifted forwards by the dogs, an increment of stack movement taking place each time a billet is withdrawn from the charge table slot 28 and deposited on the manipulating car 30 as will be made clear when the operation of the apparatus is set forth more in detail hereafter.

At such time as the last billet B in the stack has been withdrawn from the charge table slot 28 (see FIG. 15), one of the impelling dogs 132 is free to move past the slot 28 and engage a trip switch 134 which initiates the long stroke of the plunger 100 as also will be described subsequently.

The plungers 100 and their associated pusher dogs 104 operate simultaneously and under the control of a single limit switch 110 and a single limit switch 112.

THE MANIPULATING CAR

Referring now to FIGS. 1 to 3, inclusive, and also FIGS. 18 to 24, inclusive, the manipulating car 30 is of elongated design and comprises a flat rectangular platform 140 having an undercarriage 142 with carrying wheels 144 which travel on the previously mentioned rails 32. Supported on the platform 140 in spaced relationship are the previously mentioned billet manipulators 34 (see also FIGS. 25, 26 and 29).

The manipulating car 30 is capable of being driven in either direction under the control of the operator in the cab 22 of the grinding machine 20. Accordingly and as shown in FIGS. 25 and 30 of the drawings, cooperating pairs of pulleys 146 and 148 are disposed adjacent to the opposite ends of the rails 32, and a drive chain 150 has its opposite end secured to the opposite ends of the manipulating car 30 and its medial region wrapped with a large number of turns around a drum 152 (see also FIG. 3) which is adapted to be driven in either direction by an electric motor M3. The latter operates through a gear reduction device 154 and is provided with magnetic braking means 156. As will be described in greater detail presently when the operation of the billet-handling apparatus is described, the motor M3 is operable under the control of a reversing switch RS (see FIG. 30). In order to handle the electrical circuit wires as well as the fluid pressure lines which are associated with the manipulating car 30, a conventional flexible conduit carrier 160 (see FIG. 25) may be employed. Various forms of flexible conduit carriers are available for wire and line carrying purposes, and for exemplary reasons herein, a conventional "Gleason Track" is disclosed, such equipment being manufactured and sold by Mayville Products Corp. of Mayville, Wisconsin 53050, under the trade name of "Gleason Track," this equipment being widely used in industry.

(The Billet Manipulators)

The nature and operation of the billet manipulators 34 are shown in FIGS. 18 to 24, inclusive. In the normal position of the manipulating car 30, the operator in the cab 22 of the grinding machine 20 maintains the manipulating car in side-to-edge register with the forward edge of the charge table 18 as shown in FIGS. 1 to 3, inclusive, and also in FIG. 15. Assuming for purposes of discussion that the stack of billets B has been advanced by the cylinders 24 which perform their long stoke for this purpose so that a billet is present in the charge table slot 28, automatic means are set into operation to remove such billet and deposit the same in a billet-receiving slot 162 in the manipulating car. Actually, the slot 28 at the front portion of the charge table 18 is in the form of a series of troughs which are formed at the forward ends of the various wear rails 60 as best illustrated in FIG. 15. Similarly, the billet-receiving slot 162 in the manipulating car is in the form of a series of similar troughs which are formed in the bodies of the individual manipulators 34. As clearly shown in FIGS. 15, 17 and 26, each manipulator 34 is in the form of a narrow boxlike casing having a relatively deep pocket 164 therein, the pocket being defined by sidewalls 166 and 168, a front wall 170 (see FIG. 15) and a bottom wall 172. The troughs which form the billet-receiving slot 162 are in the nature of notches in the upper portions of the sidewalls 166 and 168 of the boxlike casings of the manipulators 34. Disposed within each pocket 164 and pivoted for swinging movement therein are a billet-lifting arm 174 and a billet clamping and ejecting arm 176, the arms being pivoted for swinging movement about the axes of respective horizontal pins 178 and 180. The distal end of the billet-lifting arm 174 is provided with an upstanding hooklike protuberance 182 while the distal end of the billet clamping and ejecting arm 176 is provided with a pointed billet-engaging prong 184. A third arm 186 is pivoted with a hooklike protuberance 188 which is similar to the protuberance 182 on the billet-lifting arm 174. The third arm 186 constitutes a billet transfer arm and projects outwardly of the pocket 164 and is adapted to underlie a billet B which is disposed in the charge table slot 28. The billet-lifting arm 174 is provided with a longitudinal slot 189 therein (see FIG. 26) through which the clamping and ejecting arm 176 may project when this latter arm is raised to billet-clamping position.

The three arms 174, 176 and 186 are operable under the control of respective cylinder and plunger devices 190, 192 and 194. The arm 186 and its cylinder and plunger device 194 are disposed outside of the pocket 164, said arm and device being disposed alongside the sidewall 168. The cylinder and plunger devices 190 and 192 are disposed within the confines of the pocket 164. The various cylinder and plunger devices are operable under the control of the operator in the cab 22 of the grinding machine 20 in a manner that will become clear subsequently when the nature of the circuit diagram of FIG. 30 is set forth.

When a billet B is to be transferred from the charge table slot 28 (see FIGS. 15, 17 and 18) to the manipulating car slot 162, fluid under pressure is supplied to the cylinder and plunger device 194, thus causing the arm 186 to swing upwardly and in a clockwise direction so as to lift the billet B from the charge table slot 28 and by a sliding action cause said billet to be deposited in the billet-receiving slot 162 where it assumes the position shown in FIG. 18 of the drawings. Thereafter, the manipulating car 30 is caused to ride endwise on the rails 32 (see FIGS. 1, 3 and 26) so as to bring it and the billet B thereon to the grinding station 12 where the billet may be operated upon by the grinding machine 20.

(The Grinding Operation)

The nature of the grinding machine 20 will be set forth subsequently but for purposes of discussing the operation of the manipulators 34 in presenting different surfaces of the billet B on the manipulating car 30 to the grinding element of the machine, it is deemed sufficient to state at this time that the grinding element is in the form of a rotary wheel 200 (see FIG. 26) which rotates at a relatively high speed about a horizontal axis.

Assuming now that a billet B is disposed in the billet-receiving slot 162 in the manipulating car 30 as shown in FIG. 18, and considering the operation of only one of the manipulators 34, if the uppermost corner of the billet B is to be ground, the manipulating car will be conducted to the grinding station and then the grinding wheel 200 will be lowered upon the billet without altering its position within said billet-receiving slot 112. However, if the side surface labeled *a* in FIG. 18 is initially to be operated upon, the cylinder and plunger devices

190 and 192 will be actuated substantially in unison so that the billet-lifting arm 174 will swing to a substantially horizontal position and lift the billet B from the billet-receiving slot 162 on the manipulating car 30 and place it in the raised position in which it is shown in FIG. 19, while at the same time the billet clamping and ejecting arm 176 will swing forwardly against one side of the billet and clamp it firmly against the hooklike protuberance 182. The billet B will thus be held securely in proper grinding position for operation by the wheel 200 on the surface *a*. As is customary in connection with many conventional grinding machines where the work traverses the grinding wheel, during the grinding operation, the operator in the cab will manipulate his controls so as to cause the manipulating car 30 to move in one direction or the other in order to move the billet B beneath the grinding wheel and cause the spotted defects to move into register with the wheel.

After the surface *a* has been conditioned by proper grinding, if the operator desires to condition the surface labeled *b*, he will raise the grinding wheel 200 and then cause pressure fluid to be discontinued from the cylinder and plunger device 192 so as to retract the billet clamping and ejecting arm 176, thus causing the various manipulator elements to assume the positions in which they are shown in FIG. 20. Thereafter, pressure fluid may be discontinued from the cylinder and plunger device 190 so as to lower the billet-lifting arm 174, whereupon one corner edge of the billet B will bear against a pair of flats 201 which are formed on the upper edges of the sidewalls 166 and 168 and the billet will "tumble" into the slot 162 and assume the position wherein it is shown in FIG. 21. Thereafter, the previously described sequential operation of the cylinder and plunger devices 190 and 192 will serve again to raise and clamp the billet in the position in which it is shown in FIG. 23 with the side B thereof presented upwardly for grinding purposes. If the corner edge of the billet which intervenes between the sides *a* and *b* is to be treated by the grinding wheel 200, the grinding wheel may be lowered upon the corner edge while the billet B rests in the billet-receiving slot 162 in the manipulating car 30 as shown in dotted lines in FIG. 21. The remaining sides or edges of the billet may be selectively positioned for grinding by a judicious manipulation of the usual controls in the operator's cab 22, the billet B tumbling in a clockwise direction each time a positional change is effected.

After the various surfaces and corner edges of the billet B have been conditioned by the grinding wheel 200 of the machine 20, the billet may be ejected by bringing the manipulating car 30 to its initial position of register with the charge table slot 28 where the billet will register with the rear edge of the discharge table 40 (see FIG. 1 and 3). At this time, the cylinder and plunger device 190 will remain deenergized while pressure fluid will be supplied to the cylinder and plunger device 192 to cause the billet clamping and ejecting arm 176 to pass upwardly through the slot 189 in the billet-lifting arm 174 and forcibly push the billet B over the flats 201 and onto the discharge table 40.

THE DISCHARGE TABLE

The discharge table 40 is substantially identical with the charge table 18 except for the absence of a charge conveyor at its receiving end, the billets B being received directly from the manipulating car 30 as previously described. Additionally, at the discharge end of the discharge table 40 no billet-receiving slot, such as the slot 28, is provided, the billets being either pushed from the table and collected in a bin, on a conveyor or otherwise removed from said discharge table. The latter is provided with short and long stroke billet and stack impelling cylinders 224, a chain conveyor 226 and numerous other functional devices and adjuncts which correspond to similar devices and adjuncts present in connection with the charge table 18. Therefore, in order to avoid needless repetition of description, similar reference numerals but of a higher order have been applied to the corresponding parts as between the disclosures of the discharge table 40 and the charge table 18.

THE GRINDING MACHINE

Although the billet-handling apparatus of the present invention is capable of use with any conventional grinding machine which may be positioned at the grinding station 12, a preferred form of grinding machine is shown in FIGS. 1, 26 and 27 which is identified by the reference numeral 20. This machine is possessed of several advantageous features which render the same particularly useful in connection with the present billet-handling apparatus. Briefly, the grinding machine 20 embodies a base 202 on which the previously mentioned cab 22 is disposed. The viewing windows, several of which are indicated by the reference numeral 203, give a direct view of the entire billet-handling apparatus and the front window affords a close view of the billet B undergoing grinding. The grinding wheel 200 is carried at the distal end of a boom 204. A cabinet 205 for various electrical relay mechanisms and other control devices, and a swarf collector unit 206 are other adjuncts which are illustrated in FIGS. 26 and 27. The swarf collector 206 is in the form of a sheet metal structure the open side of which faces the cab 22. The products of abrasion are forcibly drawn through the open side of the swarf collector and into the said collector by suction which is induced in a stack 207 by a remote blower (not shown). Series of staggered baffles 208 which are disposed in plural rows with the individual baffles in the adjacent rows being disposed at an angle of 90° from each other serve as impact members against which the heavier particles impinge with the particles "bouncing" from one baffle to another until their velocity is reduced to a point where they fall to the bottom of the swarf collector 206. The fines are drawn through the stack 190 and then discharged.

In FIG. 28, a modified form of grinding machine 320 is shown. In such machine, the cab 322 opposes the boom 504 and the grinding wheel 500 on opposite sides of the rails 32 which support the manipulating car 30.

CIRCUIT DIAGRAM AND MODE OF OPERATION OF THE APPARATUS

A consideration of the circuit diagram of FIG. 29 with selective reference to various other views of the drawings will suffice largely for an understanding of the operation of the billet-handling apparatus 10 which, by a "stay full" operation as previously described, automatically transfers billets successively from the billet-spotting station to the manipulating car 30 and also, after conditioning of the billets at the grinding station 12, receives billets successively from the manipulating car and transfers them onto the discharge table 40 for ultimate discharge as desired.

Considering now FIG. 29 in conjunction with FIG. 1, closure of the master switch MS supplies electrical current from suitable source S, which may be a conventional power line, to one conductor 11 of the power line where it is available for energization of the various electrical instrumentalities which are associated with the billet-handling apparatus 10. The master switch MS also connects the other conductor 13 of the power line to the source S.

When no billet B is present on the charge conveyor 14, the number 1 contacts of the aforementioned limit switch 75 assume their normally closed condition so that a circuit exists from the line 11 through a lead 15, the motors M which are connected in parallel relationship, as previously described, a lead 17, the number 1 contacts of the limit switch 75 (now closed), and a lead 19 back to the conductor 13 of the power line. Energization of the motors M serves to rotate the traction rollers 70 of the charge conveyor 14, thus advancing the billet B endwise until it engages the limit switch 75 and reverses the number 1 and the number 2 contacts thereof. Opening of the number 1 contacts deenergizes the motors M while closure of the number 2 contacts establishes a circuit through the winding *w*1 of a solenoid-actuated control valve V1, the circuit extending from the conductor 11, through a lead 21, the winding *w*1, a lead 23, the number 2 contacts of the limit switch 75 (now closed), and the lead 19 back to the conductor 13. Ener-

gization of the control valve V1 supplies motive fluid, which may be either pneumatic or hydraulic, to the cylinder **88** so as to project the plunger **86** thereof and tilt the rocker element **76**, thus transferring the billet B on the charge conveyor **14** to the rear end of the charge table **18** in the manner previously described.

As soon as the billet B is lifted by the rocker element **76** from the charge conveyor **14**, the limit switch **75** is disengaged by the billet so that the number **1** and number **2** contacts of this switch become reversed and assume their normal condition wherein the number **1** contacts thereof become closed to impel a succeeding billet along the charge conveyor **14**, while the number **2** contacts become open to deenergize the winding *w*1 of the valve V1 and restore the rocker element **76** to its normal position for passage of the succeeding billet thereover.

Upon deposition of the billet B on the charge table **18**, the limit switch **94** is actuated (see FIG. **11**), thus closing the normally open number **1** and number **2** contacts of this switch. Closure of the number **1** contacts of the limit switch **94** establishes a locking circuit for a relay magnet RM which, when energized, maintains both of said contacts closed. This locking circuit extends from the conductor **11**, through leads **31**, **33**, **35**, the normally closed contacts of the short stroke limit switch **110**, leads **37**, **39**, the normally closed contacts of the long stroke limit switch **112**, a lead **41**, the number **1** contacts of the relay magnet RM, leads **43**, **45**, the relay magnet RM, and leads **47** and **49** to the conductor **13**. Closure of the number **2** contacts of the relay magnet RM establishes a circuit extending from the conductor **11**, through the lead **31** and a lead **51**, the winding *w*2 of a control valve V2, a lead **53**, the number **2** contacts of the relay magnet RM, a lead **55** and the lead **49** back to the conductor **13**. Energization of the winding *w*2 actuates the solenoid valve V2, thus supplying pressure fluid to the cylinder **24** so as to retract the plunger **100**, whereupon the pusher dog **104** on the distal end of said plunger is drawn forwardly along the charge table **18** so as to impel the freshly deposited billet B forwards. At a predetermined distance from the rear end of the charge table, the pusher dog **104** engages the limit switch **110** and opens the contacts thereof, such opening of these contacts serving to open the previously mentioned locking circuit for the magnet RM, thereby deenergizing this magnet and causing the number **1** and number **2** contacts thereof to become open. Opening of the number **2** contacts of the magnet RM causes deenergization of the winding of *w*2 of the valve V2 which then discontinues the supply of pressure fluid to the cylinder **24** so that the plunger **100** will become restored to its projected position, the billet B being left on the charge table **18** in the vicinity of the limit switch **110**. This limited movement of said plunger **100** in advancing the billet B is referred to herein as the "short stroke" of the plunger, and the limit switch **110** being referred to as the "short stroke" limit switch.

As the plunger **100** and pusher dog **104** approach the limit of their return movement, said pusher dog is deflected as shown in FIG. **13** so that it passes beneath the freshly deposited billet B, the billet transfer mechanism including the limit switch and relay magnet RM having been actuated during the short stroke of the plunger so that this mechanism has had ample time to supply a fresh billet B to the charge table **18** while the preceding billet B was being shifted forwards along the charge table. As previously described, each billet B which is acted on by a short plunger stroke is caused to move forwards, thus pushing whatever preceding billets may be present on the charge table **18** and accumulating such billets in the form of a substantially horizontal stack of billets as shown in FIG. **3**.

After a given number of billets B have been stacked on the charge table **18**, the plunger **100** is caused to perform a "long stroke" in order to shift the accumulated stack forwards on the charge table **18** and into overlying relationship with respect to the chain conveyors **26** which then shift the stack further forwards until the leading billet in the stack is pushed into the charge table slot **28**. However, the performance of the long plunger stroke is not a function of the number of billets in the stack. It is, however, a function of billet demand which arises when a preceding stack of billets has been exhausted due to removal of the last billet in the stack from the charge table slot **28** and deposition thereof on the manipulating car **30**. Energization of the chain impelling motor M2 takes place only when there is no billet B in the charge table slot **28** so that the contacts of the limit switch **114** remain closed and establish a circuit through the motor M2. This circuit extends from the conductor **11**, through a lead **65**, the contacts of the limit switch **114**, a lead **67**, the motor M2, and a lead **69** back to the conductor **13**. Each time a billet is withdrawn from the charge table slot **28**, the contacts of the limit switch **114** become closed so that the chain conveyors will impel the stack forwards and cause the leading billet in the stack to become deposited in the charge table slot **28**, thus terminating movement of the chain conveyors. Finally, when the stack has been depleted and the last billet in the stack has been removed from the charge table slot **28**, the impelling dogs **132** on the chains **120** are free to pass around the idler sprockets **126** and engage the trip switch **115**.

As soon as the impelling dogs **132** engage the trip switch **115**, the normally open number **1** contacts of this switch become closed. These latter contacts are bridging contacts which, when closed, bridge or bypass the short stroke contacts of the limit switch **110**, the bypass circuit extending from the lead **35** to the lead **37** and embodying two leads **71** and **73** both of which extend from the number **1** contacts of the limit switch **114** so that when these latter contacts are closed, opening of the contacts of the short stroke limit switch **110** is without function. In such an instance, the pusher dog **104** will move past the limit switch **110** and proceed to the long stroke limit switch **112** so as to open the contacts thereof and interrupt the previously mentioned locking circuit through the relay magnet RM, thereby restoring the plunger **100** and the pusher dog **104** to their normal projected positions preparatory to resuming a series of short strokes to accumulate a succeeding stack of billets on the charge table.

As previously stated, during performance of the long stroke of the plunger **100** and the pusher dog **104**, the accumulated stack of billets B is shifted bodily as a unit forwards on the charge table **18** so that it overlies the chain conveyors **26** which then proceed to advance the stack bodily until the leading billet in the stack falls into the charge table slot **28**, after which it serves to advance the stack, one billet width at a time, as each billet is withdrawn from said charge table slot **28** and deposited on the manipulating car **30**. Upon withdrawal of each billet B from the charge table slot **28**, the associated billet-impelling dogs **132** on the chains **120** push the stack forwards, thus depositing the leading billet in such slot until the entire stock is exhausted.

In order to initiate movement of the plungers **100** and the pusher dogs **104** for performance of the long stroke, engagement of the trip switch **115** by one of the billet-impelling dogs **132** also closes the number **2** contacts of the switch, thus energizing the relay magnet RM by means of a circuit which extends from the conductor **11**, through a lead **81**, the number **2** contacts of the switch **115**, a lead **83**, the lead **45**, the relay magnet RM and the leads **47**, **49** back to the conductor **13**. Energization of the magnet RM closes the number **1** and number **2** contacts thereof, thus energizing the winding *w*1 of the valve V1 through circuits previously described in connection with the short stroke of the plungers **100**. This time, however, the short stroke contacts **110** are bridged by the number **1** contacts of the trip switch **115** (now closed as previously described) so that the operative pusher dog **104** will bypass the short stroke limit switch **110** and proceed to the long stroke limit switch **112**, thus opening the contacts thereof and discontinuing the locking circuit for the relay magnet RM in order to allow the plungers **100** with their pusher dogs **104** to return to their projected position. During this long stroke of the plungers and their associated pusher dogs a fresh stack of billets is brought over the charge chain conveyors **26** which

then proceed to feed the billets B, one at a time, to the charge table slot **28** in the manner previously described.

The circuit diagram of FIG. **30** discloses the control instrumentalities which are available to the operator of the grinding machine **20** for actuating the manipulators **34** on the manipulating car **30**, and also for causing the manipulating car to traverse the grinding wheel **200** in either direction.

In order to shift the position of the manipulating car **30** in either direction, the previously mentioned reversing switch RS is provided and is disposed in the circuit for the reversible motor MR. This circuit, considering rotation of the motor in one direction to rotate the drum **152** in a counterclockwise direction so as to cause the manipulating car **30** to travel on the rails **32** from its position of registry with the charge table **18** to the grinding station **12**, extends from the conductor **11**, through a lead **91**, the reversing switch RS, a lead **93**, the motor MR, a lead **95**, the reversing switch RS and a lead **97** to the conductor **13**. Upon reversing of the switch RS, the path of travel of current through this circuit will extend through the motor MR in the opposite direction, thus reversing the direction of movement of the manipulator car **30** on the rails **32**.

It has previously been set forth how actuation of the cylinder and plunger devices **190**, **192** and **194** in a selective manner may be effected to present various side surfaces or corner edges of a billet B to the grinding wheel **200** for conditioning purposes. Each of these cylinder and plunger devices is operatively connected to a three-way solenoid-actuated directional control valve SV3 having three separate windings, the terminals for which are shown in FIG. **30**. Individual pushbuttons PB1, PB2 and PB3 are disposed in the control cab **22** of the grinding machine for energizing the three windings in a selective manner. The solenoid windings for the valve SV3 are designated by the reference indicia *44*, *w5* and *w6*, these windings, when energized, serving to supply pressure fluid to the cylinders **194**, **192** and **190**, respectively, by means of simple circuits involving the common lead **94** which connects the three windings to the conductor **11**, and leads **99**, **101** and **103** which connect the individual windings to the conductor **13** through the medium of the pushbuttons PB1, PB2 and PB3.

After a given billet has been conditioned at the grinding station **12**, the operator will cause the manipulating car **30** to be returned to its initial position of register with the discharge end of the charge table **18** where it also will move into register with the receiving end of the discharge table **40**. Since this latter table is equipped with mechanism and controls substantially identical with the billet-handling mechanism that is associated with the charge table **18** and with the control mechanism of FIG. **29**, including pickoff devices and actuating cylinders therefor, long and short stroke cylinder and plunger devices, etc., it is deemed unnecessary herein to enter into a detailed description of the movement of the deposited billets on the discharge table **40** or to illustrate the control circuitry which would be substantially identical with that disclosed in FIG. **29**.

MODIFIED CHAIN CONVEYOR DRIVE

In FIG. **16**, a modified form of conveyor chain drive mechanism which is capable of replacing the motor M2 of FIG. 2 for the purpose of intermittently advancing the conveyor chains **120** is shown. This mechanism assumes the form of a ratchet and pawl device wherein a ratchet wheel **601** cooperates with a pawl **603**, the ratchet wheel being mounted on the drive shaft **624** for the various conveyor chains **120**. The pawl is mounted for swinging movement on a fixed shaft **605** and is normally held in engagement with the ratchet wheel **601** by a spring **607** which is connected at its ends to the pawl **603** and an anchor bar **609**. The pawl **603** is provided with an extension **611** which is pivotally connected to a spring-loaded plunger **613** which is associated with a cylinder **615**. The latter carries a piston **617** which reciprocates in the cylinder **615** under the control of the selective admission of pressure fluid to the cylinder through a port **619** on one side of the piston **617**. Pressure fluid may be supplied to the cylinder **615** by means of a solenoid-actuated control valve V3 which is similar to the valves V1 and V2 and has a solenoid winding *w3* from which there extend leads **667** and **669** which may constitute circuit wires corresponding to the leads **67** and **69** of FIG. **29**, the winding *w3* being substituted in the circuitry of FIG. **29** in place of the motor M2.

When the above-mentioned substitution of the winding *w3* of the valve V3 for the motor M2 is made, each energization of the winding *w3* will have the same effect as energization of the motor M2, the pawl **603** serving to actuate the ratchet wheel **601** thus to advance the billets B which are contained in a stack of billets on the conveyor chains **620** by an increment of motion substantially equal to the width of a single billet.

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification as various changes in the details of construction may be resorted to without departing from the spirit or scope of the invention. For example, although the various control cylinders **24**, **88**, **190**, **192**, **194** and **615** have been disclosed as being provided with spring-biased plungers and are of the single-acting type in order that they may be actuated by simple solenoid-actuated valves which likewise are of the single-acting type, such disclosure is in the interest of simplicity. In actual practice, if desired, dual-acting cylinders and directional control valves, therefore, may be employed and appropriate relay circuitry devised to yield the necessary sequential operation of the various instrumentalities. Additionally, in the circuit diagram of FIG. **29**, although the operation of the apparatus has been set forth in terms of the functioning of a single fluid pressure cylinder **88** and a single billet-stacking cylinder **24**, it will be understood that such description also is in the interest of simplicity and that the multiple cylinders **88** and **24** that are associated with the charge table **18** are actuated in unison under the control of common valves V1 and V2 or of multiple valves having solenoid windings which are connected in electrical parallel. Irrespective, however, of the particular electrical and fluid circuitry employed, the essential features of the invention are at all times preserved.

Having thus described the invention what we claim as new and desire to secure by Letters Patent is:

1. In an apparatus for handling and treating elongated billets while conducting them from a spotting station to a grinding station for presentation of different sides thereof to a grinding wheel and for thereafter conducting the treated billets to a region of discharge, in combination, a charge table having a rear billet-receiving end and a front billet discharge end and adapted to receive successive billets thereon for sidewise sliding movement forwards from said rear end to said front end, an elongated manipulating car mounted for tractional movement in the transverse direction of the charge table and in opposite directions between a first position wherein it is disposed alongside and in close proximity to and register with the front end of the charge table and a second position wherein it is projected endwise out of the lateral confines of the charge table and into said grinding station, means for depositing successive billets onto said charge table at the rear end thereof, means automatically effective upon such deposition of each billet for impelling the same sidewise and forwards on the charge table a distance equal to at least the width of a billet whereby any preceding billets on said charge table are shifted sidewise and forwards by the last deposited billet, thus progressively establishing s substantially horizontal stack of contiguous billets on the charge table, means effective after a predetermined number of billets have thus been stacked on the charge table for shifting the entire stack bodily as a unit forwards on said charge table a distance equal to at least the width of the stack, means engageable with the trailing billet of the thus shifted stack for further shifting the stack forwards until the leading billet thereof closely approaches the forward end of the charge table, means for removing the leading billet of the

further shifted stack from the charge table and depositing the same on the manipulating car when the latter is in its first position for subsequent transfer to the grinding station when the manipulating car moves to its second position, and means for selectively moving said manipulating car in opposite directions.

2. In an apparatus for handling and treating elongated billets, the combination set forth in claim 1, wherein said means for depositing successive billets onto the charge table comprises a charge conveyor including a series of traction rollers disposed in transverse alignment along the rear end of the charge table, an electric motor for driving each roller, said rollers being adapted to impel successive billets endwise thereover, a normally energized electric circuit common to said motors and including a limit switch positioned in the path of movement of the billets on said roller and effective when a billet moves into register with the rear end of the charge table to deenergize said circuit, and a series of billet transfer devices operable under the control of said limit switch for engaging each billet as it moves into register with the rear end of the charge table and placing the same on the charge table.

3. In an apparatus for handling and treating elongated billets, the combination set forth in claim 2, wherein each billet transfer device comprises a tiltable rocker element having a first shelf portion normally underlying the billet on the charge conveyor and a second shelf portion disposed at an obtuse angle with respect to the first shelf portion, said rocker element being effective when rotated in one direction through an angle of approximately 90° to transfer the billet from the first shelf portion to the second shelf portion for sliding movement from the latter shelf portion onto the charge table, and means operable under the control of said limit switch for rotating said rocker element.

4. In apparatus for handling and treating elongated billets, the combination set forth in claim 3, wherein said means for rotating said rocker element comprises a lift cylinder having a plunger operatively connected to the rocker element, and a normally deenergized solenoid-actuated valve effective when energized to supply pressure fluid to said cylinder to project the plunger and effect rotation of the rocker element, said valve being energizeable under the control of said limit switch.

5. In an apparatus for handling and treating elongated billets, the combination set forth in claim 2, wherein said means for impelling said billets on the charge table to produce a stack of billets comprises a series of billet stacking cylinders having plungers provided with billet-impelling dogs on the distal ends thereof and effective when pressure fluid is supplied to the cylinders to engage each freshly deposited billet on the charge table and impel the same forwards, together with any preceding billets which may have been deposited on said charge table.

6. In an apparatus for handling and treating elongated billets, the combination set forth in claim 5, wherein the means engageable with the trailing billet of the contiguous stacked billets comprises said billet-stacking cylinders, together with selectively operable means for limiting the effective stroke of the plungers associated therewith to a short plunger stroke for billet-stacking purposes and a full stroke for stack-impelling purposes.

7. In an apparatus for handling and treating elongated billets, the combination set forth in claim 2, wherein said means engageable with the trailing billet of the contiguous stacked billets comprises a series of stack-impelling cylinders having plungers provided with stack-impelling dogs on the distal ends thereof and effective when pressure fluid is supplied to the cylinders to engage the trailing billet of the stack of billets and impel the same forwards, thus shifting the entire stack of billets forwardly.

8. In an apparatus for handling and treating elongated billets, the combination set forth in claim 2, wherein the means for further shifting the stack forwardly comprises a chain conveyor including endless chains which underlie the stack after initial forward shifting thereof, a billet-engaging dog on each chain and engageable with the trailing billet in the stack, an electric conveyor motor for driving said chain conveyor to urge the stack forwards, a normally closed electric circuit for said conveyor motor, and means effective each time a leading billet in the stack closely approaches the forward end of the charge table for opening said latter electric circuit.

9. In an apparatus for handling and treating elongated billets, the combination set forth in claim 8 and including, additionally, means effective when the last billet in a given further shifted stack has been removed from the charge table and deposited on the manipulating car for actuating said stack-shifting means to bring a fresh stack of billets into position for further shifting thereof.

10. In an apparatus for handling and treating elongated billets, the combination set forth in claim 1, wherein the means for further shifting the stack forwardly comprises a chain conveyor including endless chains which underlie the stack after the initial forward shifting thereof, a billet-engaging dog on each chain and engageable with the trailing billet in the stack, and means for driving said conveyor to urge the stack forwardly.

11. In an apparatus for handling and treating elongated billets, the combination set forth in claim 1, wherein the means for removing the leading billet of the further shifted stack from the charge table and depositing the same on the manipulating car is disposed on the manipulating car.

12. In an apparatus for handling and treating elongated billets, the combination set forth in claim 1, wherein the means for removing the leading billet of the further shifted stack from the charge table and depositing the same on the manipulating car comprises a series of billet transfer arms carried by the manipulating car and mounted for swinging movement about a common horizontal axis, said arms normally underlying said leading billet on the charge table when the manipulating car is in its first position of register with the latter and being operable upon swinging movement thereof about said horizontal axis to raise said leading billet in the stack from the charge table and, by a sliding operation, shift the same from the charge table onto the manipulating car.

13. In an apparatus for handling and treating elongated billets, the combination set forth in claim 1, wherein the means for removing the leading billet of the further shifted stack from the charge table and depositing the same on the manipulating car comprises a series of manipulators mounted on said manipulating car, each manipulator comprising a body portion providing a trough for reception therein of the billets removed from said stack on the charge table, a billet transfer arm pivoted to said body portion for swinging movement about a horizontal axis and normally underlying the leading billet in the stack on the charge table when the manipulator car is in its first position, said arm being operable upon swinging movement about said axis to raise said leading billet from the charge table and slide the same into said trough.

14. In an apparatus for handling and treating elongated billets, the combination set forth in claim 13 and including, additionally, a billet-lifting arm and a billet-clamping arm pivoted to said body portion for swinging movement about respective horizontal axes, said two latter arms normally underlying said trough, said billet-lifting arm being operable when actuated to engage and raise a billet from said trough and maintain the same at an effective grinding position, said clamping arm being operable when actuated to engage the thus raised billet and, in combination with said lifting arm, clamp the same in said grinding position, and means for selectively actuating said lifting and clamping arms.

15. In an apparatus for handling and treating elongated billets, the combination set forth in claim 14, wherein said billet lifting arm is provided with a protuberance on its distal end and against which the clamping arm, when actuated, impels the billet by a sliding action.

16. In an apparatus for handling and treating elongated billets, the combination set forth in claim 15, wherein said billet-clamping arm, when actuated, is yieldingly urged against the

billet which has been raised to a grinding position by the billet-lifting arm, and the grinding position of the billet is above the level of the trough, whereby, when the clamping arm is actuated and the lifting arm is restored to its normal position, the clamping arm functions as an eject arm to discharge the raised billet from the manipulating car.

17. In an apparatus for handling and treating elongated billets, the combination set forth in claim 15, wherein said trough is of V-shape configuration and is provided with a first forwardly and upwardly inclined side and a second rearwardly and upwardly inclined side disposed substantially at a right angle to the first side, the billet-lifting arm upon actuation thereof, in the case of billets which are of rectangular cross section, serving to support one side of the billet in a substantially horizontal position to the end that the opposite side is presented to the grinding wheel for grinding purposes while a corner edge of the billet overhangs the forward edge of the slot to the end that when the billet-lifting arm is restored to its normal position underlying the trough, the billet will fall under the influence of gravity into the trough and, due to its overlying position with respect to the edge of the trough, be rotated through an angle of 90° and assume a reoriented position within the trough.

18. In an apparatus for handling and treating elongated steel billets while conducting them from a spotting station to a grinding station for presentation of different sides thereof to a grinding wheel and for thereafter conducting the treated billets to a discharge region, in combination, a charge table having a rear billet-receiving end and a front billet discharge end and adapted to receive successive billets thereon for sidewise sliding movement forwardly from said rear end to said front end, a discharge table positioned forwardly of and spaced from the charge table, said discharge table having a rear billet-receiving end and a front billet discharge end, an elongated manipulating car mounted for tractional movement in the transverse direction of the charge table and discharge table and in opposite directions between a first position wherein it is disposed between the front end of the charge table and the rear end of the discharge table, and a second position wherein it is projected endwise out of the lateral confines of said tables and into said grinding station, means for depositing successive billets onto said charge table at the rear end thereof, means automatically effective upon such deposition of each billet for impelling the same sidewise and forwardly on the table a distance equal to at least the width of a billet whereby any preceding billets on the charge table are shifted sidewise and forwardly by the last-deposited billet, thus establishing a substantially horizontal stack of contiguous billets on the charge table, means effective after a predetermined number of billets have thus been stacked on the charge table for shifting the entire stack bodily as a unit forwardly a distance equal to at least the width of the stack, means engageable with the trailing billet of the thus shifted stack for further shifting the stack forwardly until the leading billet thereof closely approaches the forward end of the charge table, means on the manipulating car and effective when the latter is in its first position for removing the leading billet of the further shifted stack from the charge table and depositing the same on the manipulating car for subsequent transfer to the grinding station when the car moves to its second position, means on the manipulating car and effective when the latter is in its first position for removing a treated billet therefrom and depositing the same on the rear end of the discharge table, billet-stacking and stack-shifting means on the discharge table identical to the billet-stacking and stack-shifting means on the charge table, and means for moving said manipulating car selectively in opposite directions.

19. In an apparatus for handling and treating elongated billets as set forth in claim 18, wherein said means for depositing successive billets onto said charge table comprises a charge conveyor including a series of traction rollers disposed in transverse alignment along the rear end of the table, an electric motor for driving each roller, said rollers being adapted to impel successive billets endwise thereover, a normally energized electric circuit common to said motors and including a limit switch positioned in the path of movement of the billets on said rollers and effective when a billet moves into register with the rear end of the charge table to deenergize said circuit, and a series of billet transfer devices operable under the control of said limit switch for engaging each billet as it moves into register with the rear end of the charge table and placing the same on the latter.

20. In an apparatus for handling and treating elongated billets, the combination set forth in claim 19, wherein each billet transfer device comprises a tiltable rocker element having a first shelf portion normally underlying the billet on said charge conveyor and a second shelf portion disposed at an obtuse angle with respect to the first shelf portion, said rocker element being effective when rotated in one direction through an angle of approximately 90° to transfer the billet from the first shelf portion to the second shelf portion for sliding movement from the latter shelf portion onto the charge table, and means operable under the control of said limit switch for rotating said rocker element.