

June 14, 1960

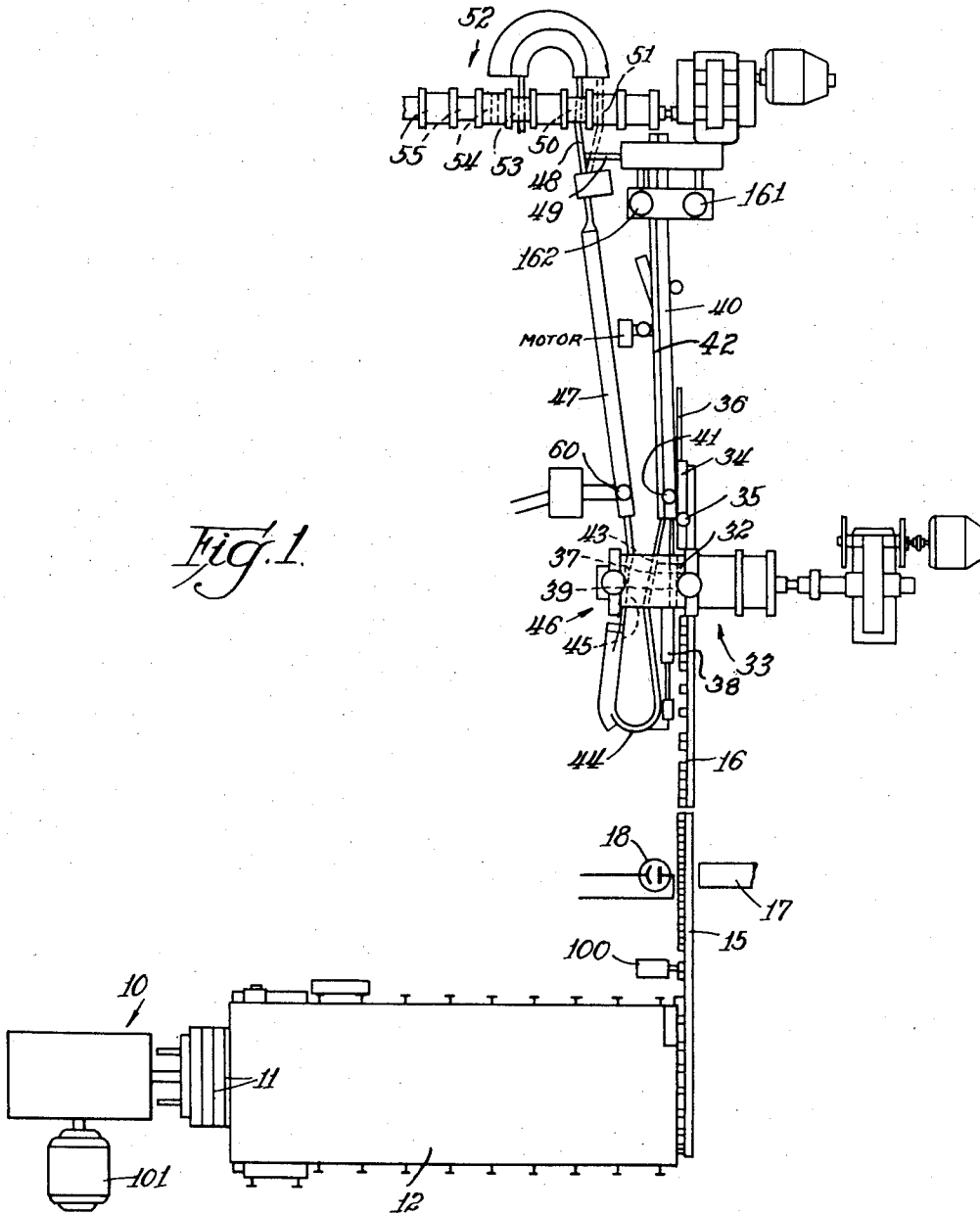
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2,941,126

VARIABLE TIME INTERVAL SYSTEM

Filed Feb. 25, 1954

3 Sheets-Sheet 1



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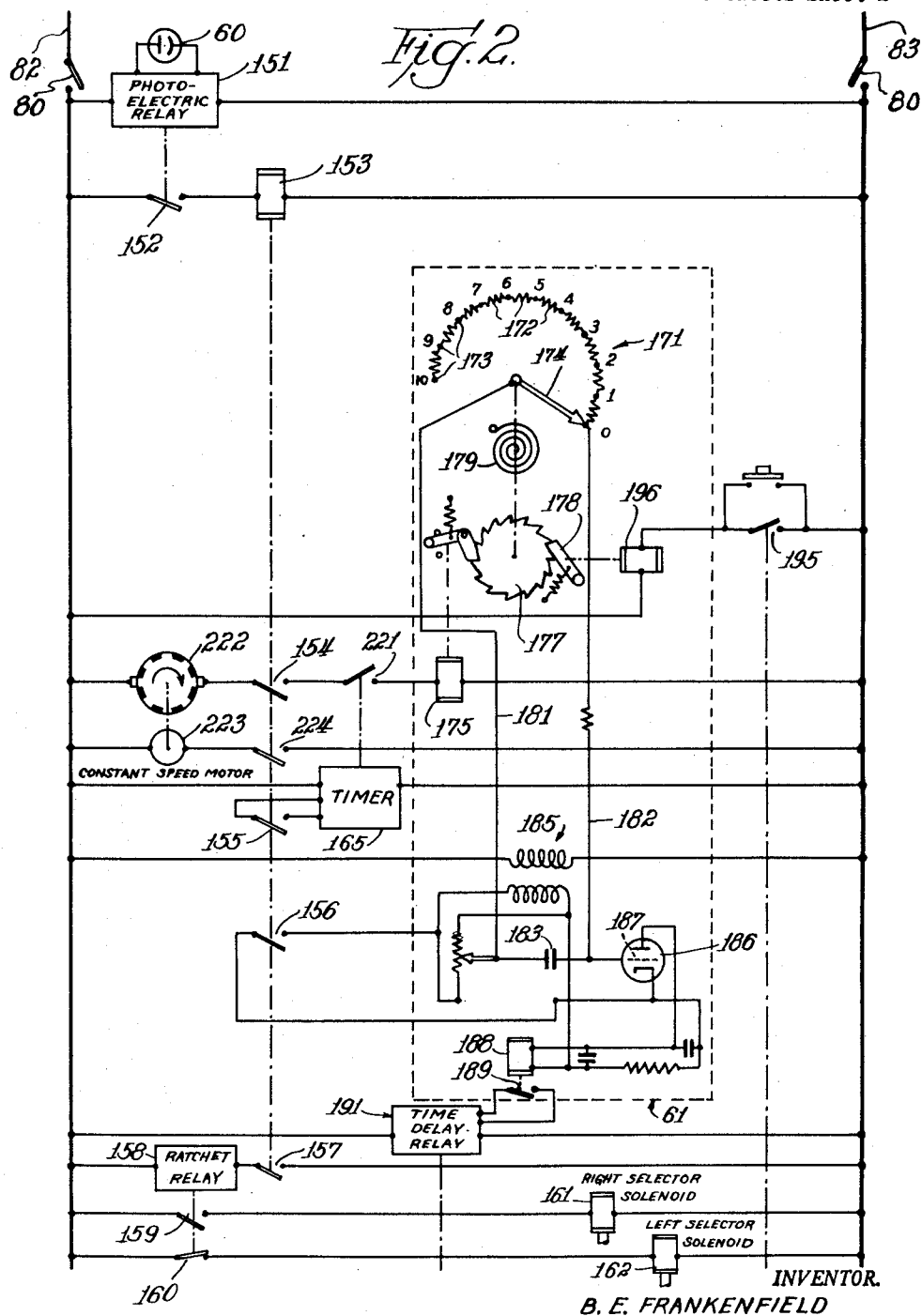
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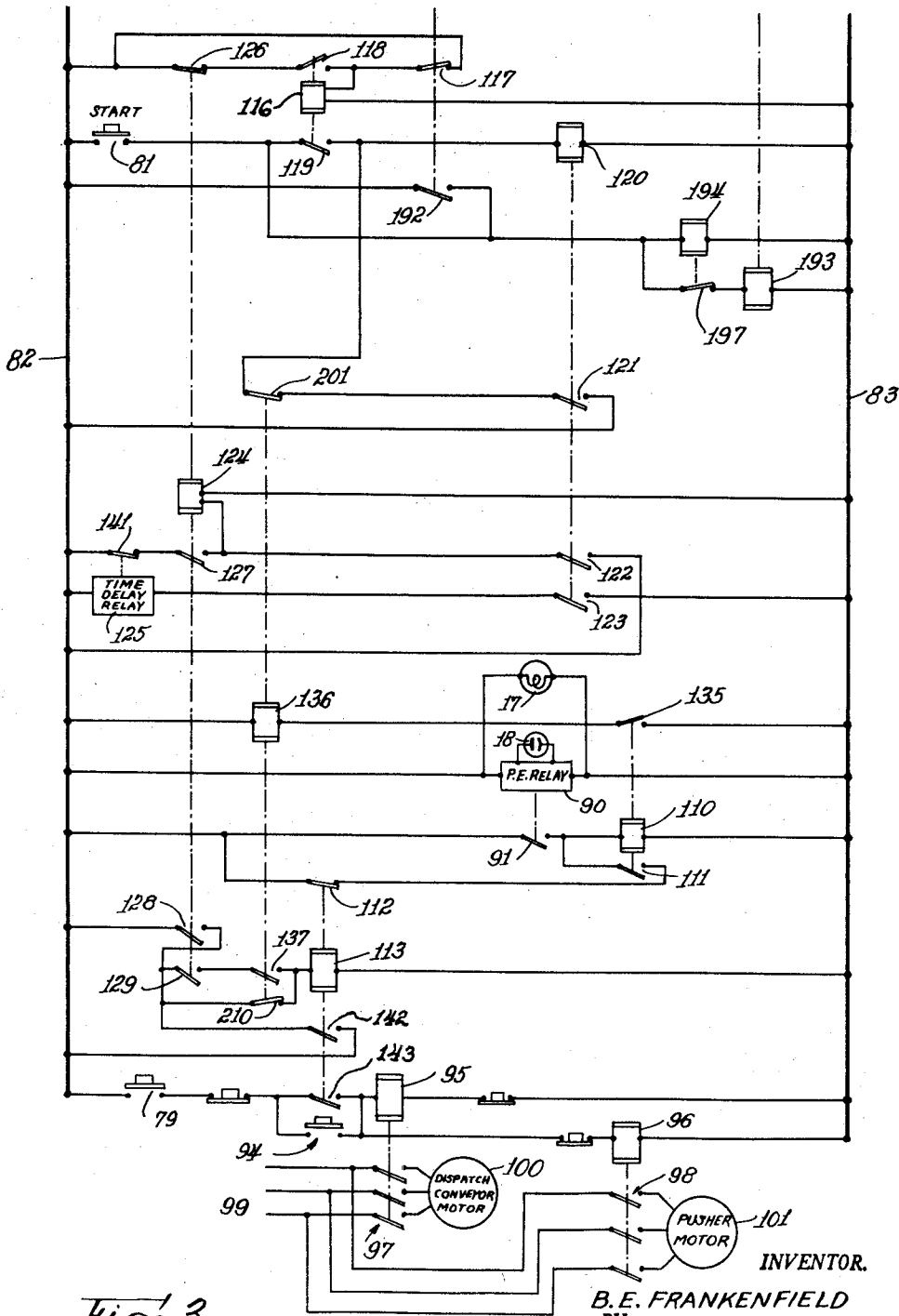


Fig. 3.

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2,941,126

VARIABLE TIME INTERVAL SYSTEM

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3 Claims. (Cl. 317-142)

This invention relates to control systems and more particularly to a control system for delaying the initiation of one operation with respect to a preceding operation.

In the operation of metal rolling plants provided with a furnace, a roughing mill, an intermediate mill, a finishing mill, a conveyor for advancing billets from the furnace to the mill and a pusher for pushing billets from the furnace onto the conveyor, the billets are sometimes separated between the intermediate mill and the finishing mill in such a manner that alternate billets go through one series of passes of the finishing mill and the other billets go through another series of passes in the finishing mill. In the past, there has been no apparatus for automatically dispatching billets to the roughly mill so spaced that alternate billets are spaced a minimum safe distance apart and substantially no farther apart.

An object of the invention is to provide a new and improved control system in which the initiation of one operation is delayed a variable period of time dependent on the duration of a preceding operation.

Another object of the invention is to provide new and improved billet-dispatching systems for rolling mills.

A further object of the invention is to provide a billet-dispatching system wherein billets are fed automatically to a rolling mill as the mill needs the billets, the length of each billet to be fed to the mill being measured and the feeding of subsequent billets to the mill being controlled by the lengths of preceding billets.

A dispatching system for a rolling mill utilizing a specific embodiment of the invention may include a continuously operable delivery conveyor for feeding billets to a mill, a furnace, a dispatch conveyor for feeding billets from the furnace to the delivery conveyor and a pusher for pushing billets from the furnace to the dispatch conveyor. A photoelectric detecting device stops each billet at the delivery end of the dispatch conveyor. A second photoelectric detector actuated by a partially rolled billet going therepast and positioned in the mill, works in combination with a timing system to actuate, after a predetermined time delay, the dispatch conveyor to feed a billet from the delivery end thereof to the delivery conveyor when a preceding billet is at a predetermined point in the mill, and also to actuate the pusher to feed another billet to the dispatch conveyor. In this respect, according to the invention, the timing system includes means for measuring each billet in the mill as it is rolled and for delaying the dispatch of the secondly succeeding billet in accordance with the length of the billet being measured.

A complete understanding of the invention may be obtained from the following detailed description, when read in conjunction with the appended drawings, in which

Fig. 1 is a schematic, top plan view of an apparatus with which the invention may be utilized;

Fig. 2 is a diagrammatic view of a portion of a control circuit of the apparatus shown in Fig. 1, including that of the invention, and

Fig. 3 is a diagrammatic view of another portion of

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the control circuit, the top thereof fitting to the bottom of Fig. 2.

Referring now in detail to the drawings, there is shown in Fig. 1 an apparatus for dispatching billets 11 to a mill, dividing alternate billets in two paths and spacing the billets in each path a minimum distance apart regardless of variations in the lengths of the billets so that the full capacity of the mill is utilized. This apparatus includes a pusher 10 of a well known type for pushing the billets 11 of copper into and through a furnace 12, which heats the billets to a suitable temperature for rolling. When the pusher is actuated, it pushes one billet into the furnace and pushes a heated billet out of the furnace onto a dispatch conveyor 15, which moves the heated billet endwise toward a delivery conveyor 16. As the billet nears the end of the dispatch conveyor 15, it breaks a beam of light from a projector 17 to a photoelectric cell 18 of a well known type, which is responsive to blue light only, which, of course, is present in white light but not in red light from a heated billet, and the cell 18 causes the conveyor 15 to coast to a stop as the billet reaches a position clearing the beam of light at the end of the conveyor 15.

The billet is fed from the dispatch conveyor 15 to the conveyor 16, and the conveyor 16 feeds the billet through a first pass 32 of a roughing rolling mill 33. The billet drops from the first pass to a guideway 34, and the light therefrom impinges on a photoelectric cell 35 to actuate a pusher 36 to feed the billet through a second pass 37, which rolls the reduced billet and feeds it to a reversing guide 38 to a third pass 39. The third pass 39 advances the billet therethrough onto a tilting shelf 40, and the billet actuates a photoelectric cell 41 to tip the shelf 40 by a well known mechanism (not shown) to drop the billet onto a conveyor 42, which feeds the elongated billet back through a fourth pass 43 of an intermediate mill 46 to a guide 44. The guide 44 reverses the billet back to a fifth pass 45, which advances and reduces the billet to rod form and feeds it along a guide 47 to a pivotal selector guide 48. The guide 48 may be held by a pneumatic piston 49 either in a position guiding the reduced billet to a pass 50 or a pass 51 of a finishing mill 52. The passes 50 and 51 feed to passes 53 and 54, respectively, which advance the further reduced rods to subsequent passes 55, the increased length of the billets requiring two series of passes to keep up with the roughing mill 33 and the intermediate mill 46.

As the billet moves from the fifth pass 45 along the guide 47, light therefrom actuates a photoelectric cell 60, which starts the pusher 10 and the dispatch conveyor 15, measures the billet going therepast and sets an adjustable timer 61 to control the dispatch of the secondly succeeding billet. The conveyor 15, after a predetermined delay, feeds another billet to the delivery conveyor 16, and the pusher 10 pushes another heated billet out of the furnace 12 onto the conveyor 15, which feeds it to the light-responsive tube 18, which stops the billet at the end of the conveyor 15.

To automatically feed the billets 11 (Fig. 1) through the furnace 12 to and through the rolling mill, switches 79, 80 and 81 (Figs. 2 and 3) are closed. The switch 80 supplies power from conductors 82 and 83 of a powerline to a control circuit. The projector 17 is energized to actuate a photoelectric relay 90 of a well known type to keep open contacts 91, which are open when there is no power on the relay 90 and also when the cell 18 receives light, but are closed when the beam from the projector 17 is cut off from the cell 18 by a billet. The switch 79 is set closed and a momentary switch 94 is held closed to actuate relays 95 and 96 to close contacts 97 and 98 in a powerline 99 to energize a motor 100 driving the dispatch conveyor 15 and a motor 101 actuat-

ing the pusher 10. The pusher 10 (Fig. 1) pushes the first heated billet from the furnace 12 onto the dispatch conveyor 15, and the switch 94 is held closed as the first billet travels past the photoelectric cell 18 to the delivery conveyor 16, which is running continuously and feeds the billet to the first pass.

The pusher 10 and the dispatch conveyor 15 then advance a second billet, and as it passes the cell 18, the cell 18 is darkened to actuate the relay 90 to close the contacts 91 while the billet is going past the cell 18, and the switch 94 is released to stop the billet at the end of the conveyor 15. Momentary closing of the contacts 91 actuate a relay 110, which locks itself in through holding contacts 111 and contacts 112 of a conveyor actuating relay 113. When the switch 80 was closed, a relay 116 pulled up through contacts 117, locked itself in through holding contacts 118 and closed contacts 119 so that, when the starting switch 81 was closed momentarily, a relay 120 was actuated. The relay 120 closed holding contacts 121 and contacts 122 and 123 to lock itself in and actuate a relay 124 and a resetting time delay relay 125. The relay 124 opened contacts 126, and closed contacts 127, 128 and 129. The relay 110 also closed contacts 135 to actuate a relay 136 to close contacts 137. By the time the second billet comes to rest on the conveyor 15 at the dispatching station, the time delay relay 125 has timed out to open contacts 141 to drop out the relay 124 to open the contacts 128 and 129 so that closing of the contacts 137 merely sets up the circuit to the relay 113, which includes holding contacts 142 and contacts 143 for actuating the motors 100 and 101.

When the first billet is advanced by the intermediate mill at a predetermined rate of speed through the fifth pass 45, light therefrom impinges on the cell 60 as the entire length of the billet goes therepast. The cell 60 actuates a conventional photoelectric relay 151 to close contacts 152 concurrently with the illumination of the cell 60 so that a relay 153 is actuated concurrently with this illumination, the time of illumination being proportional to the length of the billet since the speed of the billet is fixed by the fifth pass. The relay 153 immediately closes contacts 154, 155, 156 and 157. The contacts 157 actuate a ratchet relay 158 to reverse the conditions of contacts 159 and 160 thereof to reverse valve-controlling solenoids 161 and 162 to shift the guide, 48. The relay 158 shifts the contacts 159 and 160 as it is energized each time, but doesn't affect these contacts as it is deenergized. The closing of contacts 155 and 156 simultaneously start a measuring timer 165 of standard design and constant time delay and the delay control timer 61, which always times out substantially before the timer 165 does so.

The timer 61 includes a selector switch 171 having resistors 172 connected in series by contacts 173 and a contactor 174 designed to engage the contacts 173. Each time a stepping relay 175 is energized, it moves the contactor 174 in a counterclockwise direction, as viewed in Fig. 2, to the next contact 173 through a ratchet wheel 177 against the action of a spring 179. A latch 178 holds the wheel in its stepped positions. The contactor 174, conductors 181 and 182, a capacitor 183, and whatever of the resistors 172 that are connected to the capacitor, form a resistance-capacitance network having a fixed time constant for each setting of the contactor 174. Thus, for a predetermined period of time, depending on the setting of the contactor 174, after the contacts 156 are closed to energize a transformer 185, the resistance-capacitance network makes a vacuum tube 186 non-conductive, and, after that time, makes the tube 186 conductive by raising the potential on a grid 187 thereof to actuate a relay 188 to close contacts 189. The contacts 189 start a standard timer 191, which, after a predetermined time, opens the contacts 117 and closes contacts 192 and holds them in this condition until reset by opening of the contacts 189. The contacts 192 actuate sequentially a relay 193 and a

relay 194, which is a slow pickup relay. The relay 193 closes contacts 195 to actuate a relay 196 to withdraw the latch 178 to reset the contactor 174 to the "O" contact 173. The relay 194 then opens contacts 197 to drop out the relays 193 and 196. The value of the resistors 172 may be such that the time of delay each imparts to the timer 61 is a multiple of the time between pulses from the commutator 222.

The opening of the contacts 117 does not affect the relay 116 at this time since it is locked in through the contacts 118. Closure of the contacts 192 also actuates the relay 120 to close contacts 121, 122 and 123, the contacts 121 locking in the relay 120 to hold the "call" for a billet if one is not at the delivery end of the dispatch conveyor 15. The contacts 122 actuate the relay 124 to open the contacts 126 to drop out the relay 116 to reset the circuit for another "call." The relay 124 also closes contacts 128 and 129 to set up the circuit to the relay 113, if a billet is not on the delivery end of the conveyor 15, or to actuate the relay 113, if a billet is on the delivery end of the conveyor 15 causing the contacts 137 to be closed. When the relay 113 is actuated, it opens the contacts 112, closes holding contacts 142 to lock itself in, and closes contacts 143 to the dispatch conveyor motor 100 and the pusher motor 101. The dispatch conveyor 15 then sends the billet on the delivery end thereof to the roughing mill and the pusher 10 and the conveyor 15 bring another billet to the delivery end of the conveyor 15. The speed of the pusher 10 and the conveyor 15 are such, as compared with the time required for the billet sent to the roughing mill to reach the fifth pass, that the billet on the conveyor 15 ordinarily comes to a rest at the end thereof substantially before the immediately preceding billet arrives at the fifth pass.

As the relay 113 is actuated, it drops out the relay 110 to drop out the relay 136 to drop out the relay 120 by opening contacts 201. The relay 136 also closes contacts 210 before opening contacts 137 thereof so that the relay 113 remains energized until a billet is fed from the furnace 12 to the conveyor 15 and comes to the cell 18. The darkening of the cell 18 actuates the relay 90 to actuate the relay 136 through the relay 110, and the relay 136 deenergizes the relay 113 to stop the motors 100 and 101, to time delay relay 125 having dropped out the relay 124 after just sufficient time for the billet on the delivery end of the conveyor 15 to have been advanced from the conveyor 15.

The photoelectric cell 60 is actuated by each billet coming from the fifth pass, each billet being advanced at a constant speed for the entire length thereof, and actuates the relay 153 for that time, which is proportional to the length of the billet. The timer 165 is set for the time a billet of the shortest length would take in passing the cell 60, and closes contacts 221 at the end of that time. For a billet of the shortest length, the timer 165 closes the contacts 221 as the relay 153 drops out so that the relay 175 is not actuated.

For a billet heavier than minimum (and therefore longer when rolled than one of minimum length), the timer 165 closes contacts 221 while the billet still holds the relay 153 in, and the relay 175 is pulsed through a commutator 222 driven by a constant speed motor 223 energized through contacts 224. The number of pulses is proportional to the excess length of the billet over the minimum, such a billet actuating the relays 151 and 153 longer than one of minimum length. The timer 61 has already actuated the timer 191 to dispatch the next billet and has been reset before the timer 165 closes the contacts 221 so that the timer 61 is being set for the second or alternate billet behind that actuating the cell 60.

On each pulse of the relay 175, it steps another resistor 172 into the resistance-capacitance network of the timer 61 to increase the time delay before the relay 188 is actuated to so adjust the time that the second

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succeeding billet will be a minimum distance behind the billet energizing the cell 60. The setting of the relay 191 is such as to keep a billet secondly succeeding one of minimum length just the minimum distance behind that billet of minimum length, and the time delay of the timer 61 is always added to the time delay of the timer 191, the delay of the timer 61 being zero when the contactor 174 engages the number "0" contact 173.

Operation

Assuming one billet to be approaching the fifth pass 45 and another to have arrived at the delivery end of the conveyor 15, the latter billet already momentarily actuated the photoelectric relay 90 to momentarily close the contacts 91 which actuated the relay 110 to actuate the relay 136 to drop out the relay 113 to stop the conveyor motor 100 and the pusher motor 101 and lock the relay 110 in. The circuit to the conveyor and pusher starting relay 113 then is set up for actuating the relay 113 when the contacts 128 and 129 are closed. As the billet approaching the fifth pass 45 travels through the fifth pass, it actuates the photoelectric cell 60 to actuate the relays 151 and 153. The relay 153 actuates the relay 158 to reverse the conditions of the contacts 159 and 160 to change the selector guide, closes the contacts 155 to start the standard timer 165 and closes the contacts 156 to the variable timer 61, which then starts timing.

After a predetermined period of time has elapsed dependent on the setting of the contactor 174, the timer 61 times out to actuate the relay 188 which starts the standard timer 191. A predetermined period of time after the timer 191 has been started, it opens contacts 117 to prepare for resetting the relay 116, and also closes the contacts 192 to actuate the relays 120, 193 and 194. Actuation of the relay 193 closes the contacts 195 to release the latch 178 to reset the selector switch 171 before the timer 165 times out. Actuation of the relay 120 actuates the relay 124 through contacts 122, and actuation of the relay 124 closes the contacts 128 and 129 to actuate the relay 113 to start the conveyor motor 100 and the pusher 101 to feed a billet on the delivery end of the conveyor 15 to the conveyor 16, which feeds it into the roughing mill and brings another billet from the furnace to the delivery end of the conveyor.

As the timer 165 times out, it closes the contacts 221 to the stepping relay 175, and if the billet coming through the fifth pass 45 is longer than minimum, the timer 165 and the relay 153 are maintained actuated thereby, and the commutator 222 pulses the relay 175 a number of times proportional to the excess length of the billet to increase the time delay of the timer 61 proportionately to that excess length of the billet. Hence, the second succeeding billet behind the longer billet which is actuating the selector switch 171 will be delayed longer than if the billet actuating the switch 171 were of minimum length, and will not be dispatched immediately when the billet presently going through the roughing mill comes to the fifth pass and actuates the conveyor 15 to deliver that billet to the mill. Consequently, the alternate billets are maintained a safe distance apart as they go through the finishing mill, and also are dispatched as quickly from the conveyor 15 as may be safely done.

When the relay 113 is actuated, it drops out relays 110 and 136 to cause the relay 120 to be dropped out. The relay 120 starts the timer 125, which shortly thereafter opens contacts 141 to drop out the relay 124. As the billet clears the cell 60, the relay 153 is dropped out, and the timers 165 and 61, which resets the timer 191, as it is dropped out. The timer 191 now reenergizes the relay 116. Each billet going through the fifth pass 45 sequentially actuates the timer 61 to start the timer 191 to place the call for the next succeeding billet in accordance with the previous setting of the contactor 174, the

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relay 196 is actuated to reset the contactor 174 to zero, the timer 165 times out, and, if the billet at the fifth pass is greater than minimum, causes the commutator 222 to pulse the relay 175 to move the contactor 174 to bring in resistors 172 in accordance with the amount the billet is excessive in length. This new setting of the timer 61 controls the dispatch of the secondly succeeding billet to the mill.

Thus, the above-described apparatus keeps the billets a minimum distance apart regardless of variation in lengths thereof, and also keeps alternate billets as close together as possible since the pusher 10 and the conveyor 15 normally bring a billet to the delivery end of the conveyor 15 before the call for the billet is made at the fifth pass. That is, the billets are brought in less time to the discharge end of the conveyor 15 than it takes for the preceding billet to go through the roughing and the intermediate mills and call for the following billet. Since alternate billets are dispatched as closely together as possible, the capacity of the mill is maximum.

Certain features of the above-described apparatus are disclosed and claimed in copending application Serial No. 328,656, filed December 30, 1952, by J. F. Stoltz for "Conveyor systems," now Patent No. 2,790,530.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A system for initiating a second operation at a time interval after completion of a first operation, said time interval being responsive to the duration of the first operation, comprising means for sensing the duration of the first operation, means operated by the sensing means for forming pulses during said duration, a resistance-capacitance network including a variable resistance, means operated by the pulse forming means for varying the resistance in response to the number of pulses formed during said duration, a vacuum tube connected to the resistance-capacitance network, and a voltage supply connected to the resistance-capacitance network for controlling conduction of the tube through said network, said conduction of the tube controlling the initiation of the second operation.

2. A system for delaying a second operation an interval responsive to the duration of a preceding first operation, comprising means for sensing the duration of the first operation, means actuated by the sensing means for forming pulses at a predetermined rate during the duration of the first operation, a stepping relay connected to the pulse forming means, a variable resistance, means connected between the resistance and the stepping relay for varying the resistance value of said resistance in response to each pulse received by said relay, a capacitance connected in parallel with the variable resistance to form a resistance-capacitance network, a vacuum tube connected to the resistance-capacitance network, means connected to the vacuum tube for initiating the second operation in response to firing of the tube, and a voltage supply connected to the resistance-capacitance network for firing the tube.

3. A system for delaying the initiation of one operation in response to the duration of a prior operation, comprising means for sensing the duration of the prior operation, means operated by the sensing means for forming pulses during said duration, a variable resistance, means operated by the pulse forming means for increasing said resistance in response to each pulse so that the value of the resistance at the end of said prior operation is directly proportional to said duration, a capacitance connected in parallel with the resistance to form a resistance-capacitance network having a variable time con-

stant dependent upon said duration, a vacuum tube connected to the resistance-capacitance network, means operated by the vacuum tube for initiating said one operation, and a voltage supply connected to the resistance-capacitance network for controlling the tube through said network. 5

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