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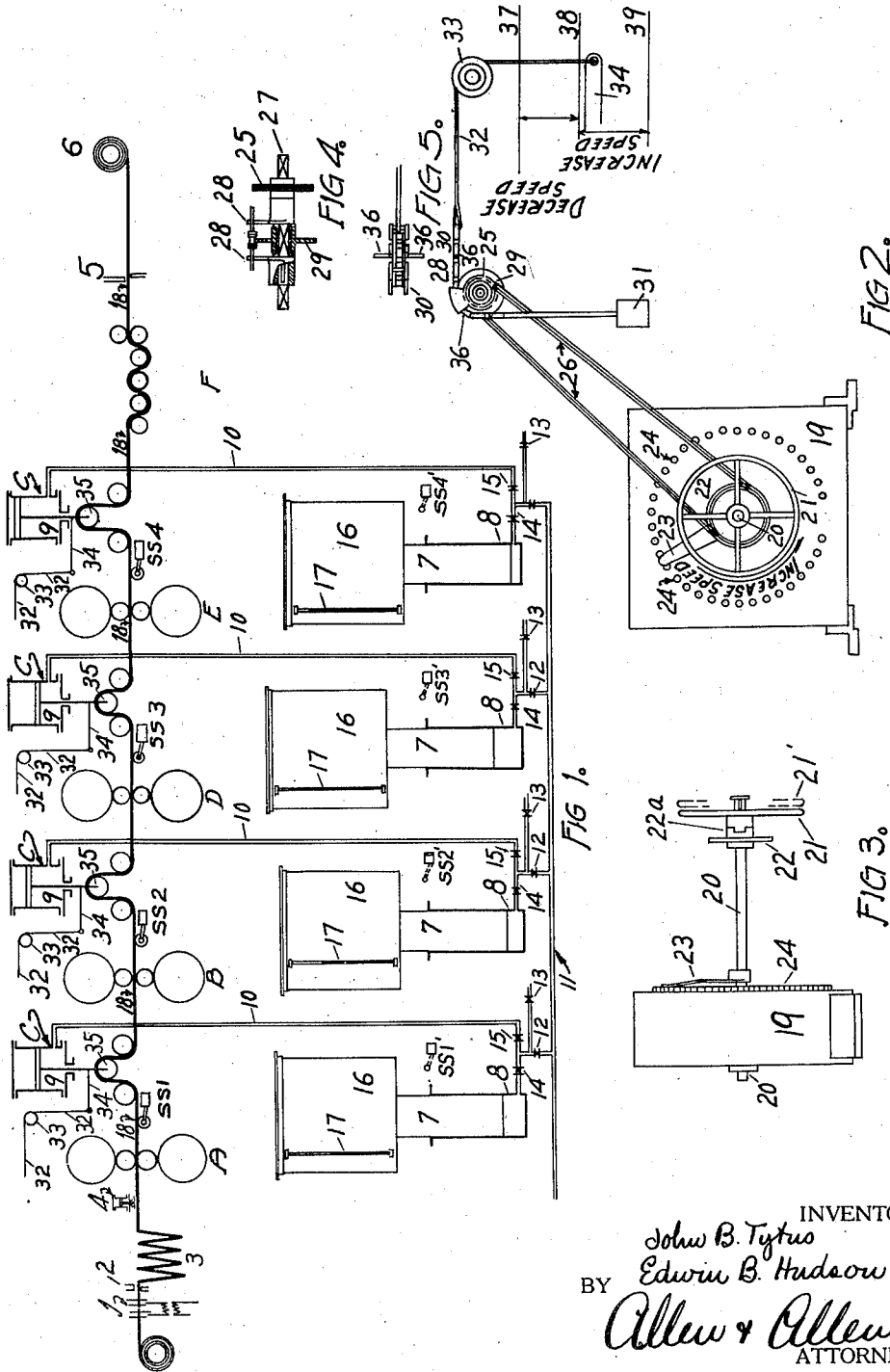
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CONTINUOUSLY TENSIONED TANDEM COLD MILL TRAIN

Filed July 21, 1933

2 Sheets-Sheet 1



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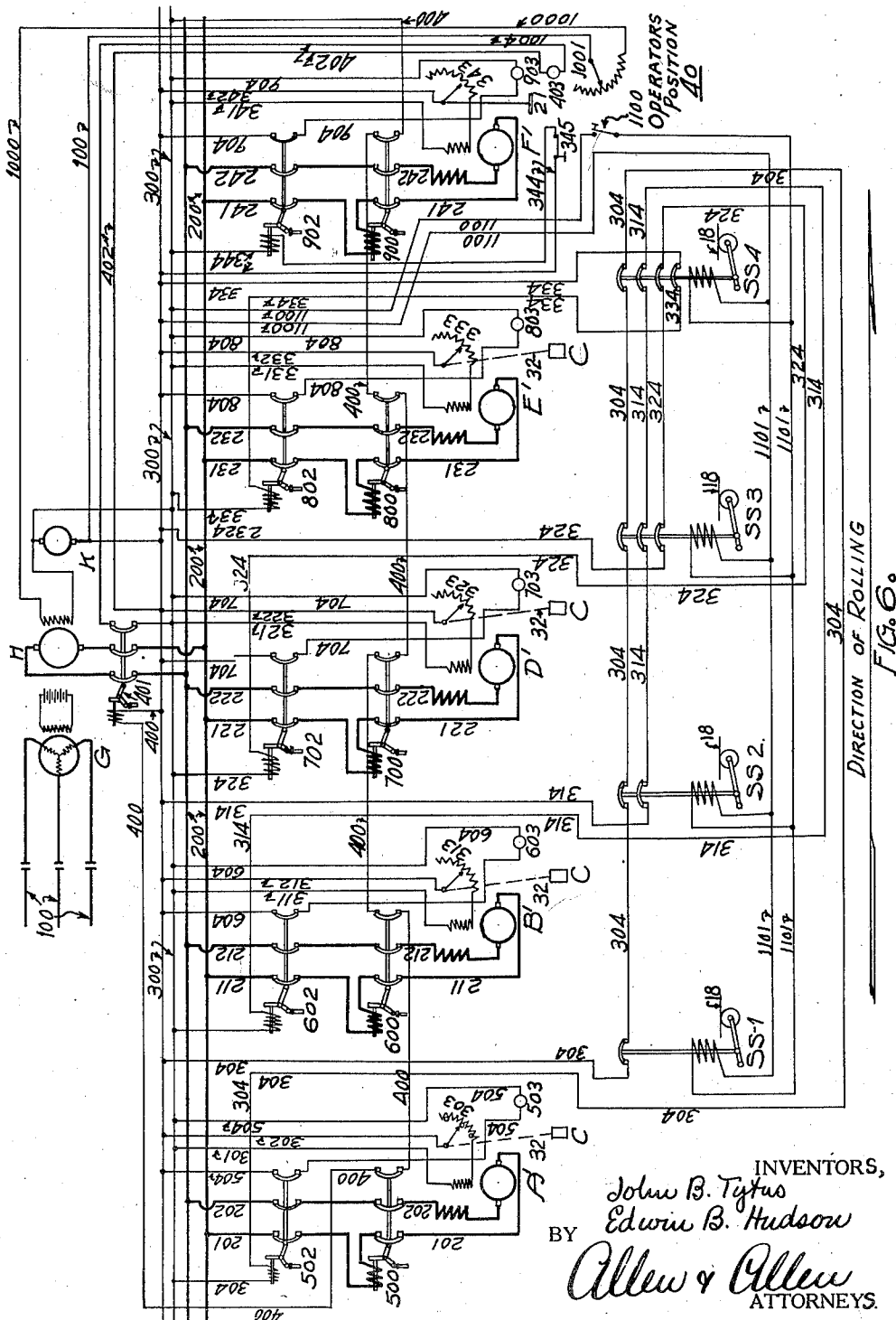
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UNITED STATES PATENT OFFICE

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CONTINUOUSLY TENSIONED TANDEM COLD
MILL TRAIN

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13 Claims. (Cl. 80—35)

Our invention relates to the rolling of continuous metal pieces through tandem trains of cold mills, in which continuous, predetermined tensions are maintained on the entering and exit sides of the piece with respect at least to each pass, excepting the first. In an exemplary operation, metal strips of sheet width are welded together to form a continuous supply of metal. This continuous supply is sent serially through a plurality of cold rolling mills arranged in tandem. The continuous supply is tensioned constantly to predetermined degrees with respect to each pass, to which end it is necessary to provide a pulling device of a continuous type at least beyond the final mill in the train, and to provide tension controlling devices intermediate the several units in the train. The mills are arranged to exert upon the piece some tractive effort; but the use of tension makes possible a greater reduction of the piece per pass than could be made otherwise. It is not sufficient merely to measure the tension of the piece between passes and to endeavor to control the speeds of the several dynamic instrumentalities in the train, in accordance with such measurement of tension. It is necessary to provide intermediate the several dynamic instrumentalities means in which the continuous supply of metal may be taken up under a constantly applied and constantly predetermined static tension, a sufficient amount of the metal being so taken up to take care of sporadic irregularities in the rolling operation. When this is done, and when the speeds of the several dynamic instrumentalities are controlled in accordance with the length of the strip taken up by such static tension controlling devices, it is possible to maintain on the strip with respect to each pass, predetermined, constant tensions or differentials of tension. Reference is made to several copending applications which set forth various phases of and instrumentalities useful in carrying on the general process mentioned: An application in the name of Edwin B. Hudson, Ser. No. 602,883, filed April 4, 1932; an application of Edwin B. Hudson, Ser. No. 688,100, filed April 18, 1933; an application of Edwin B. Hudson, Ser. No. 688,101, filed April 18, 1933; and an application in the names of Tytus and Hudson, Ser. No. 670,930, filed May 13, 1933. In view of the reference herein made to these applications, a description of the general process or of specific processes, or of the several instrumentalities employed will not be made herein, excepting in connection with a description of an exemplary embodiment of this present invention, it being understood, however, that our invention is not restricted thereto. This invention relates to the electrical control of mills, arranged as indicated, for continuously rolling an endless supply of material. The

methods of rolling strip referred to require an automatic electrical control for their most effective operation. In preceding rolling operations, no necessity has arisen for such control because the sporadic irregularities in the rolling operation are not cumulative when rolling separate strips in lengths of 200 to 300 feet. However, when rolling a continuous supply of material, such sporadic irregularities in the rolling operation are preferably compensated for, as they occur, by means of an automatic speed regulation of the various dynamic instrumentalities of the mill train.

The sporadic irregularities may be caused by such conditions as the following:—

(1) Variation in gauge of the strip to be rolled. The gauge may vary throughout the length of the same coil to a slight degree, and the coils of strip which are welded end to end to form the continuous supply may vary somewhat in gauge.

(2) Variation in the drafts of the mills. It is desirable to provide an automatic control which is effective over a sufficient range so that any desired draft may be had on any particular mill. The range of such drafts may vary from zero to 50% or more.

(3) Variation in the adjustment of individual mills. In the operation of a mill train such as that referred to, it may be desirable to adjust the mill screw of some of the mills in order to redistribute the drafts, and to distribute work more effectively between the various mills. It is therefore highly desirable to provide an automatic electrical control which will readjust the speeds of the various units as such mill screw adjustments are made.

(4) Variation in actual or relative speed of individual units due to a change in the desired finished gauge. It is highly desirable to provide an automatic control system which will take care of these variations also to permit the flexible use of the mill train in the rolling of metal to different desired gauges, or in changing from one gauge to another.

The foregoing indicate certain objects of our invention.

It is a further object of our invention to provide a suitable electrical control having a wide range of overall speed control, such as a ratio of 1 to 100. The provision of means for a slow speed is highly desirable for the threading operation, whereas obviously relatively high overall speeds are highly desirable in production.

Another object of our invention is to provide electrical control in the nature of protection for each of the several motors of the mill train, so that all motors are stopped by an electrical overload. Still another object of our invention is the provision of means to stop motors in the train in the event of a breakage in the continuous sup-

ply of metal. Where the several automatic speed control devices are arranged to vary the speeds of preceding devices, one of our objects is to provide for the stoppage of all motors behind a break in the strip, while permitting all motors ahead of the breakage to continue running to discharge the leading portion of the broken strip from the mills.

These and other objects of our invention which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, we accomplish by that certain construction and arrangement of parts of which we shall now describe an exemplary embodiment. Reference is made to the drawings, wherein Fig. 1 is a diagrammatic elevational view of an exemplary mill train embodying our invention.

Fig. 2 shows an arrangement of the rheostat control for the various motors of the mill train, this arrangement being such as to provide for the automatic speed control hereinabove mentioned.

Fig. 3 is a side elevation of a chain equipped.

Fig. 4 is a detailed showing of a portion of the mechanical connection between a tension control device and the rheostat of a mill motor.

Fig. 5 shows a portion of a chain equipped with a controlling pin and employed in connection with the mechanism of Fig. 4.

Fig. 6 is an electrical wiring diagram of the various controls employed in the practice of our invention.

The particular embodiment chosen by us for the purpose of an exemplary showing herein is a train of four tandem cold rolling mills indicated generally at A, B, D, and E in Fig. 1. These mills are of the four-high type having small driven working rolls. A pulling machine F is shown at the end of the train. This pulling machine is of the continuous type. We have indicated at C tension controlling devices located between each of the mills in the train, and between the last mill and the pulling machine F. These static tension controlling devices are capable of taking up and paying out the strip under a constant, predetermined static tension; and they are also so arranged as to control the speed either of the mill or pulling machine located immediately ahead of each tension device, or the mill located immediately preceding such device.

In order that the train may have a continuous supply of material for rolling, we provide ahead of the mill a welding device, indicated generally at 1, a flash cutter 2, and a looping device 3 to permit continuous feeding of the welded strip in spite of the discontinuous process of welding. Preferably also we provide a brake 4 ahead of the mill A to lay the strip before it enters this mill.

Beyond the pulling machine F, we may locate a shear 5, so that the finished band of metal may be cut apart, either into sheets or into useful lengths for coiling as at 6.

The instrumentalities thus far referred to do not require more detailed description, since they are set forth in one or more of the copending applications hereinabove referred to.

For the sake of an exemplary showing, we have indicated the static tensioning device C as being of the hydraulic type, in which the pull roll 35 is actuated by a piston 9 in a hydraulic cylinder. We have shown the several static tension devices, each provided with an accumulator having a piston 7 working in a cylinder 8, which is connected to the pressure cylinder of the static tension take-up device C by a pipe 10. The accumulators may be loaded by means of tanks 16, filled with liquid

to predetermined levels. As shown by gauges 17 the hydraulic systems may be filled by means of a supply line 11, supplying fluid under pressure from a hydraulic pump not shown, through valves 12. The drainage of the hydraulic system may be accomplished by means of valves 13. Valves 14 and 15 may be manipulated so as to place the pistons 7 of the various accumulators in correct positions with reference to the pistons 9 of the static tension devices when these devices are functioning properly. It will be understood that this arrangement of the static tension controlling mechanisms is exemplary only, and is set forth here as forming part of but one operative embodiment of our invention.

The apparatus thus far described is exemplary of a tandem cold mill system in which it is possible to roll strip material indicated at 18 in the form of a continuous supply without interruption, and under controlled and continuous tension with respect to each pass, whereby it is possible to secure a greater reduction in gauge for each mill than is possible without tension control, or with a tandem mill rolling separate strips. This is predicated on an automatic control of the several dynamic instrumentalities in the train exerted by the static tension take-up devices; and we will now describe an exemplary way in which this may be done. Figure 2 shows at 19 one of the mill motor rheostats used in this instance to control the speed of the mill motor immediately preceding one of the static tension devices C. The rheostat comprises the usual case containing resistances brought out to contact buttons 24, a shaft 20 bearing the contact arm 23, and a hand-wheel indicated at 21. It will be understood that a rotation of the shaft 20 in one direction decreases resistance in the mill motor circuit so as to increase the speed of the motor, while a rotation of the shaft 20 in the opposite direction acts to cut down the speed of the mill motor. For the automatic operation, a sprocket 22 is rotatably mounted upon the shaft 27, and is arranged to be driven by means hereinafter to be described, in accordance with the length of strip taken up in the static tension device C. The hand-wheel 21 and this sprocket are provided, respectively, with clutch members indicated at 22a. The hand-wheel 21 is slidably but non-rotatably mounted on the shaft 20. When the clutch parts are engaged as shown in Fig. 3, a rotation of the sprocket 22 will produce a rotation of the shaft 20. The hand-wheel may, however, be pulled outwardly to the position shown in dotted lines at 21'. When this is done, the sprocket 22 is disconnected from the shaft 20, and the rheostat may be manipulated or adjusted by the hand-wheel 21.

The sprocket 22 is connected by means of a chain 26 to a sprocket 25, non-rotatably mounted upon a shaft 27 shown in Fig. 4. A sprocket 29 is rotatably mounted on this shaft and carries a chain 30, to one end of which a weight 31 is attached. The other end of the chain is connected by means of a cable 32 passing over a sheave 33 to an arm 34 mounted for movement in connection with the movable roll 35 of the static tension take-up device. It will be clear that the movements of the movable roll of this device indicate the amount of strip taken up by the movable roll under static tension. Since the movable roll is driven upwardly in the embodiment shown, if it rises too far, this indicates that too much strip is being taken up by the device and necessitates either a diminution in the speed of the forego-

ing mill, or an increase in the speed of the succeeding mill, depending upon which mill is to be controlled thereby. Consequently if movements of the chain 30 are made to control movements of the mill motor rheostat 19, such speed control may be effected. It is advisable, however, to provide for some lost motion in this drive, so that there can be an intermediate zone in which sporadic movement of the tension take-up roller 35 will not directly affect a speed control. We accomplish this by mounting segmental members 28 non-rotatably upon the shaft 27, and by providing pins 36 extending beyond the edges of the chain 30, and adapted to contact these segmental members. When one of the pins strikes the segmental members, then the shaft 27 will be turned upon further movement of the chain; but until this happens there will be no movement of the shaft 27 because the sprocket 29 is rotatably mounted thereon. Two speed ranges are indicated in Fig. 2 at 37 to 38 for the decrease speed range, and 38, 39 for the increase speed range. By the construction shown in these several figures, the position of the roll 35 of the tension take-up device will act to increase or decrease the speed of the motor of the mill immediately preceding or immediately following the tension take-up device.

The instrumentalities so far described do not differ from certain of the instrumentalities described in the copending applications to which reference has been made; but they have been described here in order that the operation of our invention may be thoroughly understood.

Briefly, in the carrying out of our invention, we provide means for effecting an overall speed control of all of the dynamic instrumentalities in our mill train, irrespective of and without affecting the automatic speed control referred to. This enables us either to slow down our train for threading, or to speed it up after threading in order to bring it to the proper production speed. Essentially we do this by providing separate motors for each of the dynamic instrumentalities in the train, controlling these motors automatically as aforesaid, but also controlling them manually by varying concurrently the power supplied to each. A convenient method of doing this is by providing a generator driven by a motor connected to the power line, or by any other suitable prime mover, and then controlling the power output of the said generator by suitable means. We have shown in Fig. 6 the motor at G connected to a generator marked H. This generator supplies power to the several mill motors indicated at A¹, B¹, D¹, and E¹, in Fig. 6, and to the motor of the pulling device indicated at F¹. We have shown an excitor K for the field windings of the generator H, the said excitor being controlled by a suitable rheostat, or the like, 1001 located in a position of convenient access to the operator. The operator's position is shown at 40 in Figure 6. Standing in this position the operator can control the speed of the motor F¹ of the puller F by means of the hand-wheel 21 of the rheostat 343 of such motor. This rheostat is indicated diagrammatically in this figure at 343. A control of the speed of the motor F¹ will, in turn, control the speed of all of the other motors in the train, automatically through the action of the tension take-up devices C. Suitable trip breakers are provided for each of the motors indicated respectively at 502, 602, 702, 802, and 902. The controlling circuits for these breakers derive their power from power leads 300, as will be clear from

the diagram. By opening a switch 345, the trip breaker 902 for the motor F¹ can be tripped by power derived from the power lines 300, through leads 344 so as to stop the puller motor F¹. The trip breakers of the other motors in the train are arranged for actuation by means of switches hereinafter to be described, which switches are arranged to throw off the strip breakers. These switches are indicated at SS1, SS2, and etc. and are switches adapted to be maintained closed by the strip and to open automatically upon strip breakage. They may conveniently be in the form of switches having arms bearing against the strip itself, although they may likewise be arranged to be actuated by the static tension controlling devices, or by the accumulators connected therewith. The switch SS1, for example, makes or breaks the circuit represented by leads 304, which is the tripping circuit for the trip breaker 502 of the mill motor A¹. By following the leads 304, however, it will be seen that these leads go through switch mechanisms in connection with the devices SS2, SS3 and SS4. Should a breakage of the strip occur, say, at the switch SS3, this would not only trip the breaker 502 connected with the mill motor A¹, but also the breaker 602 (through a circuit represented by leads 314) connected with the mill motor B¹, and also the breaker 702 connected with mill motor D¹, through a circuit represented by the leads 324. In this way a breakage of the strip occurring at any particular point in the train is made immediately to stop all preceding motors; but it does not stop succeeding motors, because the circuits to such motors are not connected through preceding strip breakers. The switch mechanisms SS1 and etc. are, however, connected for magnetic operation through leads 1101 to a switch 1100 located at the operator's position 40. By closing this switch, all of the strip switches SS1, and etc. can be held by the operator in the closed position, while the mill train is being threaded. When the mill train has been threaded and placed in operation, then the strip 18 itself will act to maintain the switches SS1 and etc. closed until a breakage in such strip occurs.

As explained, a rheostat 1001 located in the operator's position controls, through leads 1000 and 1002, the excitor, from the excitor K to the generator H. When the mill train has been placed in operation, a variation of this excitor circuit will control the voltage applied by the generator H to all of the motors in the mill train, and consequently will control the overall speed of the mill train. The individual speed regulation of the several motors A¹, B¹, and etc. occurs automatically through the rheostats 300, 313, 323 and 333 (which will be understood as rheostats similar to the rheostat 19 in Fig. 2) by the several static tension devices C diagrammatically indicated in Fig. 6. The rheostat 343 of the puller motor F¹ will be controlled by the operator through the hand-wheel 21 thereof. Such control will be usually effective throughout the normal operating speed range of the mill train when it is running in production. A variation of the field strength of the generator H, whereby the overall speeds of all of the instrumentalities is controlled, may be used to vary speed in production, but is of particular value when lower speeds are required during the operation of threading the mills.

For the electrical protection of the various motors, we have provided circuit breakers indicated at 500, 600, 700, 800, and 900. These cir-

cuit breakers, each of the ordinary type, have overload protection; but they are also provided with additional contacts connected into a circuit represented by the leads 400 to trip a main circuit breaker 401, connected to the power leads from the generator H, should any of the circuit breakers 500, 600, etc. open, due to electrical overload.

In the event that a strip breaks in the mill, all mills or other dynamic devices behind the break are stopped, while all of the motors ahead of the break continue to run, removing the unbroken portion of the strip from the mills.

Preferably all of the trip breakers 502, 602, etc. are provided with additional contacts controlling indicator lines 503, 603, etc. located near the individual motors. There is also preferably an indicator light 403, connected to the main trip breaker 401, by circuit 402.

Thus by our invention we have provided a means for varying the overall speed of all of the dynamic instrumentalities in the mill train without affecting the automatic speed control. We have provided for the stoppage of the motors of all dynamic instrumentalities when an electrical overload trips the circuit breaker connected to any one of them. We have also provided means whereby a breakage of the strip will act to stop mills or other dynamic instrumentalities located ahead of the break in the train. It will be understood that the mechanism we have disclosed is exemplary only of our invention, and may be modified without departing from the spirit thereof. It will also be understood that instead of employing a series of mills and a final puller, pulling devices may be located between each of the mills in the train, and may be provided with motors as are the mill motors in the train.

The term "static tension devices" as used hereinafter in the claims should be construed to mean devices operating to maintain a substantially invariable tension in the strip or rolling piece irrespective of the variations in the elongation thereof or variations in the length thereof between dynamic instrumentalities.

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

1. In a rolling mechanism the combination of interspaced driven mills, a pulling device located between said mills, and static tension maintaining devices located between each mill and said pulling device, each said static tension device adapted to control the speed of an adjacent mill, or pulling device respectively and means irrespective of said automatic control for varying the overall speed of each of said mills and said puller concurrently.

2. In a rolling mechanism the combination of interspaced driven mills forming a tandem train, at least one pulling device located at the end of said train, static tension devices located between each mill and each adjacent mill or puller, each of said static tension devices adapted to control the speed of an adjacent mill or pulling device, and means irrespective of said control for varying the overall speeds of each of said mills and pulling devices concurrently.

3. In a rolling mechanism the combination of interspaced driven mills forming a tandem train, at least one pulling device located at the end of said train, static tension devices located between each mill and each adjacent mill or puller, each of said static tension devices adapted to control the speed of an adjacent mill or pulling device,

and means irrespective of said control for varying the overall speeds of each of said mills and pulling devices concurrently, said means comprising a generator connected to supply power to said several mills and pulling devices, and means for controlling the voltage of the power so applied.

4. In a rolling mechanism the combination of interspaced driven mills forming a tandem train, at least one pulling device located at the end of said train, static tension devices located between each mill and each adjacent mill or puller, each of said static tension devices adapted to control the speed of an adjacent mill or pulling device, and means irrespective of said control for varying the overall speeds of each of said mills and pulling devices concurrently, said means comprising a generator connected to supply power to said several mills and pulling devices, and means for controlling the voltage of the power so applied, said means comprising means for controlling the field strength of said generator.

5. In a rolling mechanism the combination of interspaced driven mills forming a tandem train, at least one pulling device located at the end of said train, static tension devices located between each mill and each adjacent mill or puller, each of said static tension devices adapted to control the speed of an adjacent mill or pulling device, and means irrespective of said control for varying the overall speeds of each of said mills and pulling devices concurrently, said means comprising a generator connected to supply power to said several mills and pulling devices, means for controlling the voltage of the power so applied, and means for stopping all of said mills and pullers upon an electrical overload of any one of them.

6. In a metal rolling device including dynamic instrumentalities, a train of tandem cold mills, a pulling machine located at the end of said train, static tension devices located between each of said mills and between the final mill and said pulling device, said static tension devices arranged to take up, under a predetermined force, a portion of a continuous strip fed through said train, means for causing said static tension take-up devices to control the speed of an adjacent dynamic instrumentality in said train, means for simultaneously controlling the overall speed of each of said dynamic instrumentalities in said train, irrespective of said automatic speed control, said means comprising a generator connected to supply power to said several dynamic instrumentalities, means for controlling the voltage of the power so supplied, and means for stopping all of said dynamic instrumentalities behind a breakage in the strip in the direction of travel of the sheet upon the occurrence of such breakage.

7. In a metal rolling device including dynamic instrumentalities, a train of tandem cold mills, a pulling machine located at the end of said train, static tension devices located between each of said mills and between the final mill and said pulling device, said static tension devices arranged to take up, under a predetermined force, a portion of a continuous strip fed through said train, means for causing said static tension take-up devices to control the speed of an adjacent dynamic instrumentality in said train, means for simultaneously controlling the overall speed of each of said dynamic instrumentalities in said train, irrespective of said automatic speed control, said means comprising a generator connected to supply power to said several dynamic instru-

mentalities, means for controlling the voltage of the power so supplied, and means for stopping all of said dynamic instrumentalities behind a breakage in the strip in the direction of travel of the sheet upon the occurrence of such breakage, said means comprising switching means for each of said instrumentalities arranged to be actuated by the tension in said strip, said switches so connected together that the tripping of any one thereof will trip all switches in the train ahead of said one.

8. In a metal rolling device including dynamic instrumentalities, a train of tandem cold mills, a pulling machine located at the end of said train, static tension devices located between each of said mills and between the final mill and said pulling device, said static tension devices arranged to take up, under a predetermined force, a portion of a continuous strip fed through said train, means for causing said static tension take-up devices to control the speed of an adjacent dynamic instrumentality in said train, means for simultaneously controlling the overall speed of each of said dynamic instrumentalities in said train, irrespective of said automatic speed control, said means comprising a generator connected to supply power to said several dynamic instrumentalities, means for controlling the voltage of the power so supplied, and means for stopping all of said dynamic instrumentalities ahead of a breakage in the strip, upon the occurrence of such breakage, said means comprising switching means for each of said instrumentalities arranged to be actuated by the tension in said strip, said switches so connected together that the tripping of any one thereof will trip all switches in the train ahead of said one, and means for setting all of said instrumentalities during the threading operation.

9. In a rolling apparatus including dynamic instrumentalities, the combination of a train of tandem mills, means located at least beyond the final mill for exerting continuous tension upon a continuous strip passing through said mills, means located between all of the dynamic instrumentalities in said train for taking up said strip under a constant, predetermined static tension, means for automatically controlling the speeds of said several instrumentalities in accordance with the length of strip so taken up, means for stopping said instrumentalities upon a release of said tension, and means for rendering said last mentioned means inoperative during the threading of said train.

10. In a rolling apparatus including dynamic instrumentalities, a train of tandem cold mills, means for exerting a pull continuously on a continuous strip passing through said train and located at least beyond the final mill therein, each of said dynamic instrumentalities being provided with a separate electric motor, circuit breakers attached to each of said motors, a main circuit breaker, contacts connected to each of the other circuit breakers for tripping said main circuit breaker, supplementary circuit breakers attached to each of said motors, and means for selectively tripping said last mentioned circuit breakers upon the occurrence of a break in said strip.

11. In a rolling apparatus including dynamic instrumentalities, a train of tandem cold mills, means for exerting a pull continuously on a con-

tinuous strip passing through said train and located at least beyond the final mill therein, each of said dynamic instrumentalities being provided with a separate electric motor, mutually interconnected, circuit breakers for tripping said main circuit breaker, supplementary circuit breakers attached to each of said motors, means for selectively tripping said last mentioned circuit breakers upon the occurrence of a break in said strip, said last mentioned means comprising strip actuated switches, means for causing each of said switches to break the circuit of each preceding switch, means for rendering said switches inoperative, and means for simultaneously varying the voltage of current applied to each of said motors.

12. In a rolling apparatus including dynamic instrumentalities, a train of tandem cold mills, means for exerting a pull continuously on a continuous strip passing through said train and located at least beyond the final mill therein, each of said dynamic instrumentalities being provided with a separate electric motor, mutually interconnected, circuit breakers for tripping said main circuit breaker, supplementary circuit breakers attached to each of said motors, means for selectively tripping said last mentioned circuit breakers upon the occurrence of a break in said strip, said last mentioned means comprising strip actuated switches, means for causing each of said switches to break the circuit of each preceding switch, means for rendering said switches inoperative, means for simultaneously varying the voltage of current applied to each of said motors, said last mentioned means comprising a generator, means for driving said generator, and means for varying the field strength of said generator.

13. In a rolling apparatus including dynamic instrumentalities, a train of tandem cold mills, means for exerting a pull continuously on a continuous strip passing through said train and located at least beyond the final mill therein, each of said dynamic instrumentalities being provided with a separate electric motor, mutually interconnected, circuit breakers for tripping said main circuit breaker, supplementary circuit breakers attached to each of said motors, means for selectively tripping said last mentioned circuit breakers upon the occurrence of a break in said strip, said last mentioned means comprising strip actuated switches, means for causing each of said switches to break the circuit of each preceding switch, means for rendering said switches inoperative, means for simultaneously varying the voltage of current applied to each of said motors, said last mentioned means comprising a generator, means for driving said generator, means for varying the field strength of said generator, means for taking up said strip under a predetermined static tension between each of said dynamic instrumentalities, and means for causing said last mentioned means to effect automatically a control of the speed of an adjacent dynamic instrumentality, and means for manually controlling the speed of one of said instrumentalities which, through said automatic speed control, will control the speed of all of said other dynamic instrumentalities.

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