

July 19, 1938.

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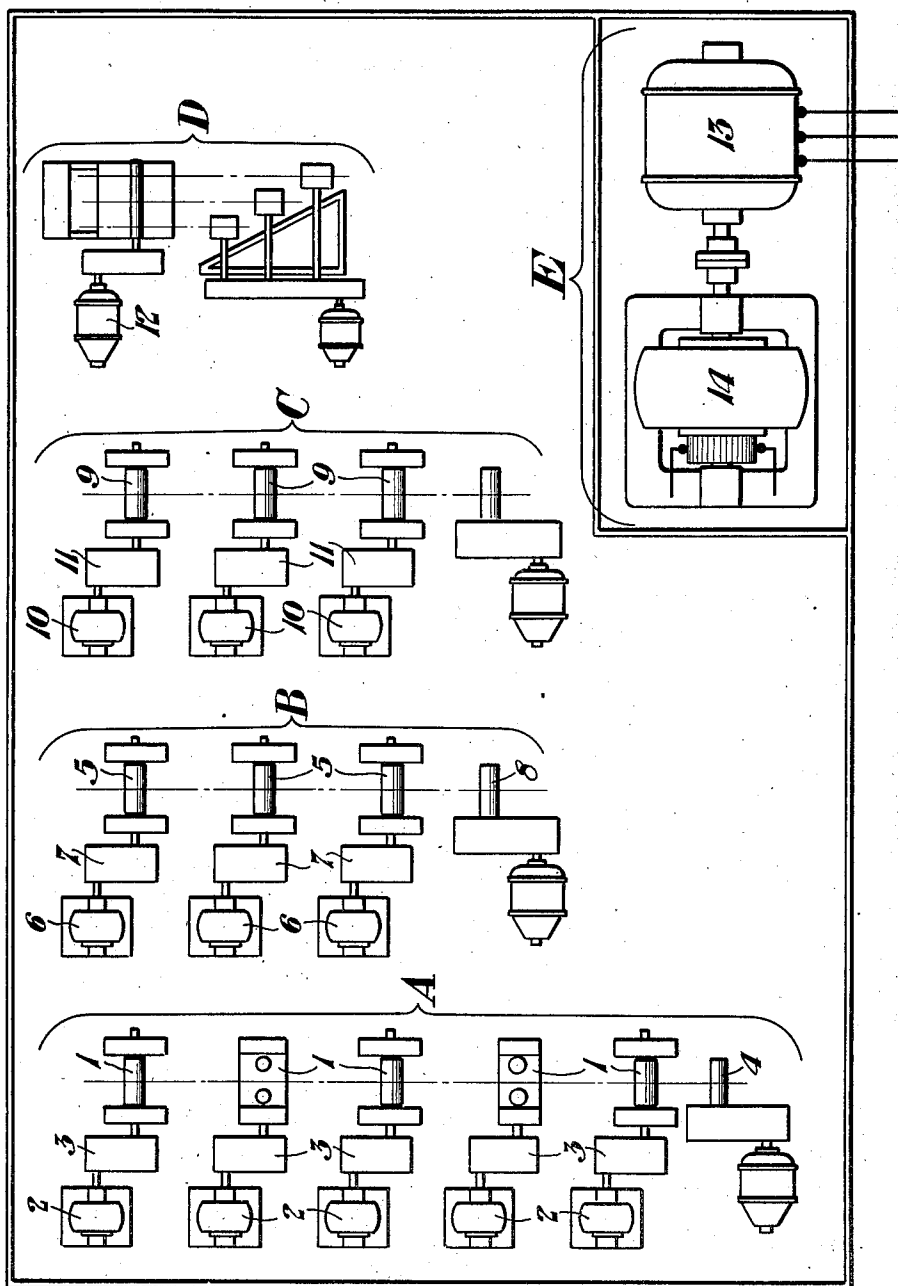
2,124,518

MILL DEPARTMENT CONTROL

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2 Sheets-Sheet 1

Fig. 1.



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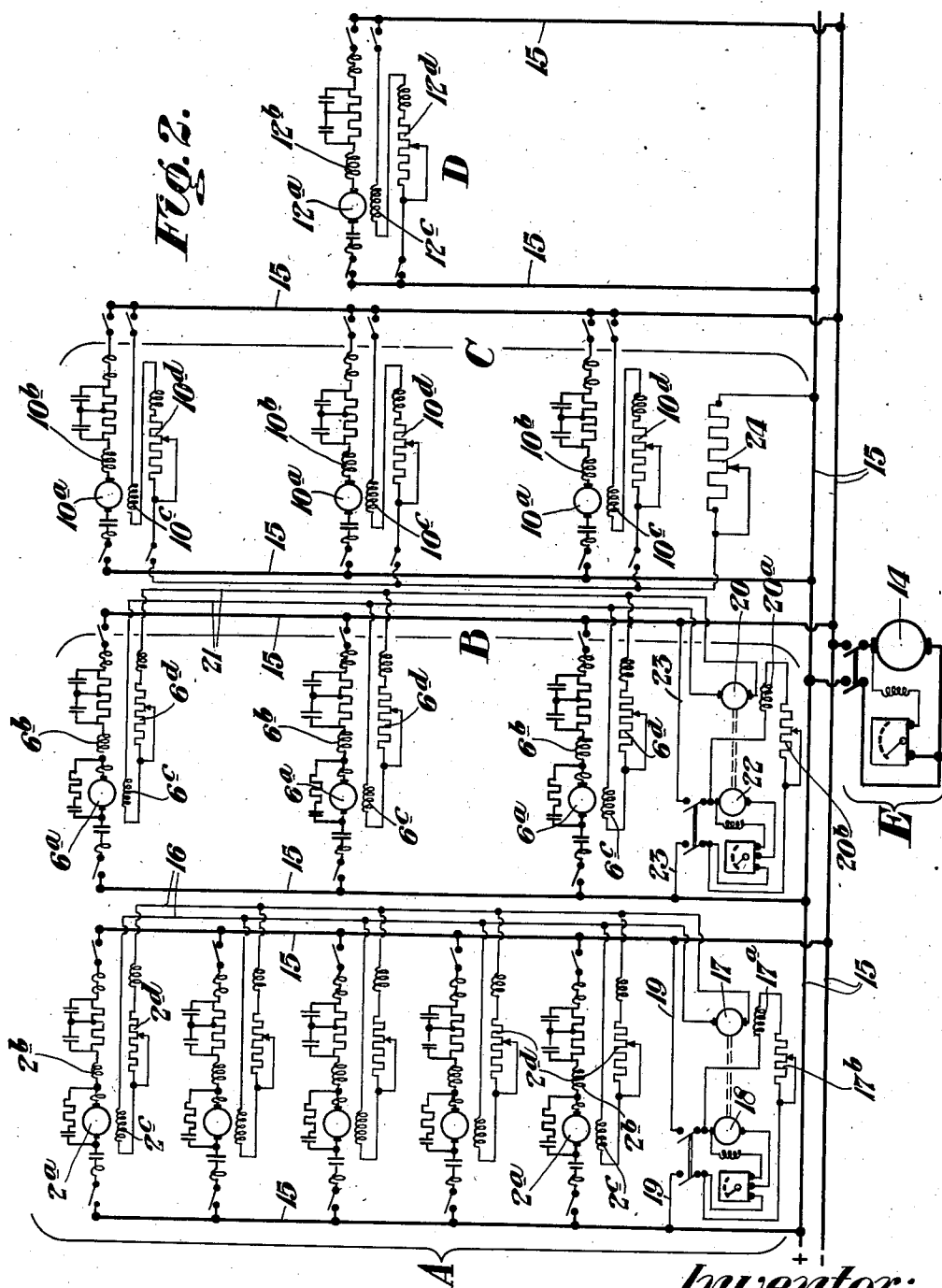
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MILL DEPARTMENT CONTROL

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2 Claims. (Cl. 80—31.1)

This invention is concerned with the operation of continuous mills of the type which includes a plurality of tandem roll-stands each provided with an electric driving motor, when they are included as a group of two or more in a mill department.

Such a mill may be used to reduce metal strip, the strip passing from one roll-stand to another in succession. It is obvious that each successive roll-stand must be run at a slightly higher speed to compensate for the elongation of the metal strip, the motors powering these stands being commonly provided with controlling rheostats to provide the required adjustments. The strip must be manually threaded through the various stands before rolling operations can commence. This requires the operation of the various stands at speeds that are sufficiently slow to prevent accidents. When the strip has once been threaded the speeds of all the roll-stands must be accelerated to normal rolling speeds which are considerably faster than the speeds required during threading. Obviously this acceleration must be accomplished so that the speed ratios between the various stands do not change. There are several ways of accomplishing what has just been described.

In the case of strip hot-mills which are so large as to constitute a complete mill department the Ward-Leonard system is commonly used. In this system the power for the armatures and fields of the motors driving the various roll-stands is provided by a motor-generator set that receives its power from some outside source. This is economically practical because the demands of such a mill are so great. This motor-generator set does not supply power to any electrical equipment other than the mill motors. The speeds of the various motors are controlled by the individual rheostats with which they are equipped to effect the compensation required by the elongation of the work, and the speeds of all the motors may be simultaneously varied by varying the output of the motor-generator set, this being possible because there is no other electrical equipment to be affected. This system is also used in the case of the huge tandem cold-mills now used to produce very wide metal strip.

The above system is not suited for application to continuous mills such as are used, for instance, to cold-roll narrow metal strip. This product is commonly produced in what is called the cold-rolling department of a mill. These mills are naturally rather small, and a cold-rolling department therefore includes a number of such mills.

In addition, the department includes other electrical equipment. Each of these small mills is considered a unit and is of the type initially described. That is to say, each of these units includes a plurality of tandem roll-stands. Furthermore, these mills are operated as units, each working on separate lengths of strip.

It follows from the above that the Ward-Leonard system is not applicable as a medium of control for these mills, since its use would entail the provision of a motor-generator set for each of the units or mills, and this would necessitate such a large outlay of money as to be an economic impossibility. Furthermore, the other electrical equipment, such as collers, slitters, coiling machines, cranes and other devices powered by electrical motors, must be provided with suitable current and this would necessitate still another motor-generator set over and above those required for the various mills.

Because of the above described conditions prevailing in cold-rolling and other similar departments, including relatively large numbers of electrically powered units, a single large motor-generator set is provided that is of sufficient capacity to electrically power the entire department. It follows that the output of this motor-generator set cannot be varied as demanded by the Ward-Leonard system because this would not only control the speed of one mill but would also affect all of the other mills and electrical equipment included by the department.

Since all the mills in such departments are powered by the same motor-generator set, it is necessary to provide some means for simultaneously varying the speeds of the motors of each mill from threading to full rolling speeds without affecting the motors of the other mills. Heretofore, this has been sometimes done by providing a large heavy master rheostat for each of the mills. In each mill one of these master rheostats is in series with the shunt fields of the motors of that mill and with the rheostats which individually control the speeds of that mill's motors. This works satisfactorily when all of the roll stands in each of the mills are utilized during rolling. However, it is frequently necessary to use less than all of the stands included by one of these mills. In such instances the motors of some of the stands are disconnected, and this removes their individual rheostats from their normal series connection with their master rheostat.

Now, consequently, the settings for the threading and full rolling speeds of the master rheo-

stat are no longer the same, and accidents are very apt to occur in that the rollers may forget to adjust the resistance of the master rheostat to maintain the correct operating speed of the mill.

5 Sometimes casualties are suffered by the rollers, and it is even possible to put an entire mill out of operation. In spite of these defects this system now being described has been in common use in departments of the character under discussion.

10 The primary object of the present invention is to provide a control that is as fool-proof and operative as the Ward-Leonard system and which is at the same time sufficiently economical to permit its use in place of the system just described.

15 An example of how this is done in the case of the present invention is illustrated by the following drawings, in which:

Figure 1 is a plan schematically showing a conventional cold-rolling department such as produces cold-rolled steel strip, while Figure 2 is a wiring diagram schematically showing the application of the present invention to this department.

20 More specifically, the department illustrated by Figure 1 includes three cold-rolling mills A, B and C. Also, it includes a slitter D. The mill A consists of five tandem roll-stands 1, which are individually driven by electric motors 2 through the usual gear boxes 3. The mill is provided at one end with a coiler 4 that handles the work leaving the last stand in the usual manner. The operating requirements of this mill have already been generally outlined.

25 The mill B includes only three roll-stands 5, each individually driven by electric motors 6 through gear boxes 7. This mill is also provided with a coiler 8.

30 The mill C is exactly like the mill B, the roll-stands being numbered 9, the motors 10 and the gear boxes 11.

The slitter D is conventional and need not be described in detail excepting to mention that it is powered by an electric motor 12.

35 All of these mills are units in themselves, and the slitter D is also a unit. Each of these units is entirely independent of the others and must be operated and controlled independently. For reasons already described the department is provided with a single large motor-generator set E whose motor 13 is powered by a source outside of the department and whose generator 14 is of sufficient capacity to provide the power required by all of the mills and by the slitter. No other arrangement is economically practical.

40 The application of the principles of the present invention to the cold-rolling department represented by Figure 1 is shown by Figure 2. The generator 14 of the motor-generator set E is connected to power lines 15. These power lines power the various units in the department that are illustrated by Figure 1 as well as the other electrical equipment necessarily included by such a department but which is not illustrated.

45 It is to be understood that practically all of the motors used in such a department are intended for D. C. current and include shunt-field windings. Generally the motors of a continuous mill of the type under discussion are compound wound since this provides for smoother rolling operations. Therefore, the wiring diagram shows all of the motors as being compound wound.

50 In the case of the mill A the armatures and series-field windings 2^a and 2^b of all of the motors 2 are directly connected to the power lines 15.

The shunt-fields 2^c of these motors are provided with controlling rheostats 2^d so that their strength can be varied. Before the present invention these shunt-fields were energized by the lines 15 through a master rheostat connected in series with all of the shunt fields, the shunt fields themselves being connected in parallel relative to each other and the only way of simultaneously varying the speeds of all of the motors together was by means of that master rheostat. The disadvantages of this procedure have already been discussed.

5 In the present instance, however, the shunt-fields 2^c are connected by lines 16 to a generator 17 that is part of a small motor-generator set whose motor 18 is connected through lines 19 to the lines 15 so as to receive power from the motor-generator set that powers the entire department. The generator 17 is provided with a field winding 17^a that is energized by the lines 19 through a rheostat 17^b. This motor-generator set just described is of approximately no greater capacity than is required to properly energize all of the shunt-field windings 2^c of the motors 2. In other words, it is a very small affair as compared to the set powering the entire department and is consequently much less expensive. Furthermore, it is to be noted that this motor-generator set is entirely independent of the set powering the entire department so far as the operation of the latter is concerned. That is to say, variations in the output of the generator 17 cannot possibly affect the output of the generator 14. If this were not so all of the other electrical equipment in the department would be affected.

10 In the case of the mill B the armature and series-field windings 6^a and 6^b of the motor 6 are all directly energized by the generator 14 through the lines 15. This unit is likewise provided with a small motor-generator set whose generator 20 energizes the shunt-field windings 6^c of the motor 6 through lines 21, the shunt-field rheostats 6^d of these motors 6 serving as controls. The motor 22 of this little motor generator-set is powered by the lines 15 through lines 23 and the field 20^a of the generator of this set is energized by these lines 23 through a rheostat 20^b.

15 The operation of these two mills will now be described, it being kept in mind that they are two different units entirely independent of one another.

20 To effect threading of the mill A the rheostat 17^b is adjusted so as to increase the strength of the field 17^a of the generator 17. This causes the motors 2 to operate at sufficiently slow speeds to permit manual threading of the various roll-stands of this mill. When this is completed the rheostats 2^d are adjusted to obtain the proper speed ratios between the various motors powering the various stands so as to compensate for the elongation of the work. As soon as this is done the rheostat 17^b is operated to decrease the field strength of the generator 17, whereupon the motors accelerate to full rolling speeds. The mill A may now be considered as operating at full speed.

25 Turning now to the mill B, let it be assumed that the rheostat 20^b is used to produce sufficiently low speeds to permit manual threading of this mill as was done in the case of the mill A. After threading, the rheostat 6^d may be adjusted to compensate for the elongation of the strip. At this point it is desirable to accelerate the mill B to full rolling speed. This is done by operation 30

of the rheostat 20^b in the same manner as was done to accelerate the mill A.

Now it is to be noted that the acceleration of the mill B cannot in any way affect the operation of the mill A or any of the other electrical equipment included by this department. The generator 20 of the small motor-generator set that energizes the shunt-fields 6^c of the motors 6 is entirely independent of the generator 14 of the motor-generator set E.

It can now be appreciated that the mills A and B are each provided with a suitable electrical control which permits these mills to be operatively independent of one another and which at the same time does not involve the great expense of the Ward-Leonard system. The motor-generator sets consisting of the motors 18 and 22 and the generators 17 and 20 are sufficiently small to render the control economically practical. Upkeep is inexpensive and no electrical complications are involved.

Now in the case of the mill C the armatures 10^a, and series-fields 10^b of the various roll-stand motors 10, are all directly connected to the power lines 15. The shunt-fields 10^c and individual rheostats 10^d of the various motors 10, are connected to the power lines 15 through a master rheostat 24.

To operate the mill C it is necessary to adjust the rheostat 24 to obtain the slow speeds that permit threading, the rheostats 10^d being adjusted to compensate for the elongation of the work and the rheostat 24 then set to accelerate the mill. This provides for reasonably good operation so long as all three of the roll stands of the mill C are used. However, it is often desirable to use less than all of these roll stands, and it is then necessary to eliminate one of the motors 10. This removes the rheostat 10^d of that motor and the motor itself from the circuit, and the settings of the rheostat 24 are then no longer an indication of the speed of the mill.

It is to be understood that the controller elements of these rheostats are marked to indicate threading and full rolling speeds, and are relied upon by the rollers during the operation of the mill. Therefore, unless a suitable additional resistance is put into the circuit by means of the master rheostat to take the place of the omitted equipment, the rollers cannot properly operate the mill. As previously mentioned, it frequently happens that carelessness in this respect leads to serious accidents.

The armature 12^a, series-field 12^b and shunt-field 12^c of the slitter's motor 12 are shown as being connected to the power lines 15 in the usual manner. This motor is included simply to illustrate the fact that the cold-rolling department not only includes a number of mills but also other electrical equipment.

The mill C is included partly to emphasize the fact that the department includes a number of unit mills and partly to illustrate the deficiencies of the old arrangement. The outputs of the little motor-generator sets that are used to energize the shunt-windings of their motors are relatively constant regardless of the number of shunt-fields energized so long as the outputs of these sets are sufficient to properly energize all of the shunt fields of the motors in each instance.

Although the various units have been described as being connected directly to the power lines 15, it is to be appreciated that the branches of these power lines leading to these units do not necessarily have the carrying capacity of the power

lines themselves, since the latter must carry power to all of the electrical equipment of the entire department.

In spite of the advanced state of the electrical control art there is no instance known to the present inventor where a plurality of motors which must be speeded or slowed in unison have been controlled by means of a small motor-generator set which energizes the shunt-fields of these motors and which is entirely independent of the main power source which powers the armature circuits of the motors. So far as is known, the Ward-Leonard system is the only fool-proof control, while the rheostat control illustrated in the case of the mill C is the only control sufficiently inexpensive to be used in a cold-rolling or similar department. As a matter of fact, the average control used in conjunction with a small mill unit having tandem roll-stands consists simply of the rheostats which control the shunt-fields of these motors, no master rheostat being used because of the dangers involved. Hence a length of strip is frequently almost completely rolled before the shunt-field rheostats can be juggled to positions which provide for full rolling speeds and at the same time compensate for the elongation of the work.

There are, of course, variations of the Ward-Leonard system which include a motor-generator set that powers the armature circuits of a series of mills and which is provided with a field exciting motor-generator set which is relatively small and which in some instances energizes the shunt-fields of the motors. This cannot be used in a cold-rolling department for the reason that any variation in the output of the exciting motor-generator set not only varies the shunt-fields of the motors but varies the field of the generator of the motor-generator set that is powering the entire mill. This obviously varies the output of the motor-generator set, and if this set were used to power an entire cold-rolling department, which is the only economically possible arrangement, all of the other electrical equipment of the department would be affected and the entire department thrown into confusion.

I claim:

1. In a mill department, a continuous mill including a plurality of tandem roll-stands each provided with an electric driving motor having a shunt-field winding, other electrical equipment operatively independent of said mill and said motors, a motor-generator set of sufficient capacity to electrically power said motors and said other equipment, power lines arranged to carry the output of said motor-generator set to the armature windings of said motors and to said other electrical equipment that is operatively independent of said motors, whereby variations in the output of said motor-generator set will affect said motors and said other electrical equipment as well, a motor-generator set of approximately no greater capacity than is required to properly energize the said shunt-field windings of said motors, means for electrically connecting the motor of the second named motor-generator set to said power lines, said second named motor-generator set being otherwise entirely independent of the first named motor-generator set, electric lines arranged to carry the output of said second named motor-generator set to said shunt-field windings of said motors, variable resistances arranged in said lines so as to individually control the energizing current supplied each of said shunt-field windings of said motors, and means

for varying the output of said second named motor-generator set, whereby the speeds of said motors may be simultaneously varied without substantially affecting their respective speed ratios and without materially affecting said other electrical equipment or said first named motor-generator set.

2. A method of controlling the speeds of a plurality of tandem roll-stands driven by electric motors having shunt-field windings and powered by a source that also powers other electrical equipment whereby its output cannot be varied without affecting the latter, said shunt-field windings being each provided with variable re-

sistances, said method including powering the armatures of said motor directly by said source, energizing said shunt-field windings through said resistances by means of a second source whose output may be varied without materially affecting the output of the first named source, varying said resistances to obtain the speed ratios between said motors required for the proper operation of said roll-stands and varying the output of said second source as required to cause said motors to drive said roll-stands at slow or threading speeds and to subsequently accelerate so as to drive said roll-stands at fast or rolling speeds.

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