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SPEED SYNCHRONIZATION OF INTERMITTENTLY OPERATED MACHINES

Filed July 5, 1929

2 Sheets-Sheet 1

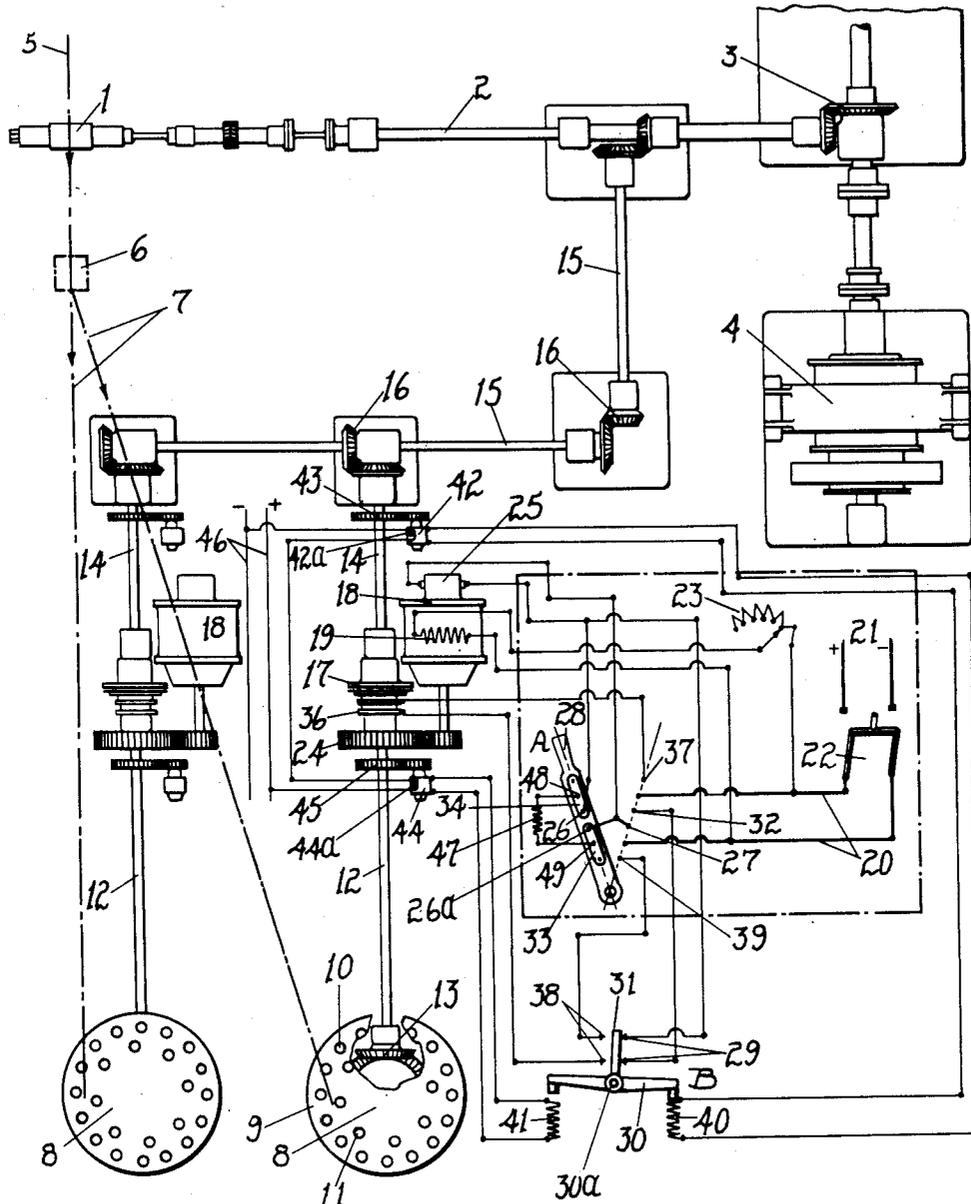


Fig. 1.

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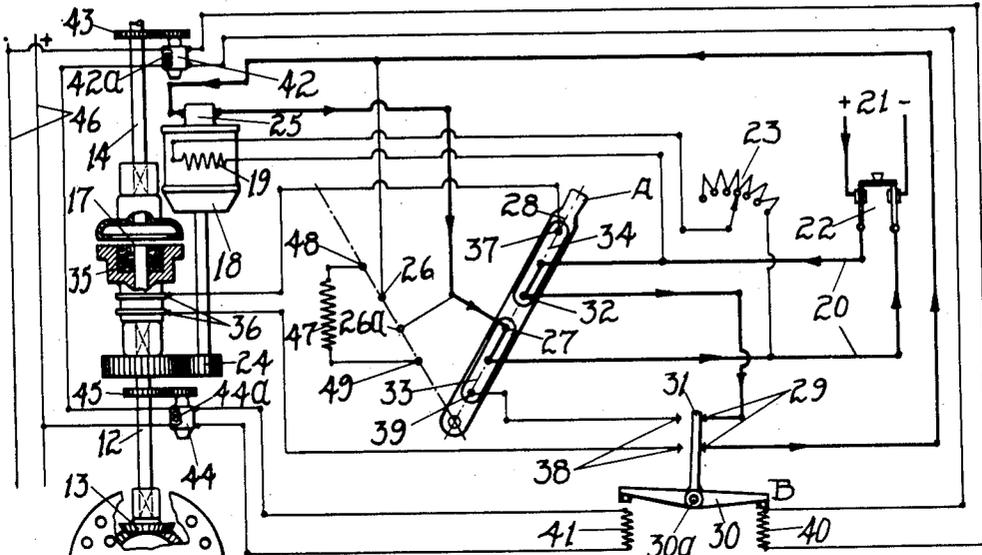


Fig. 2.

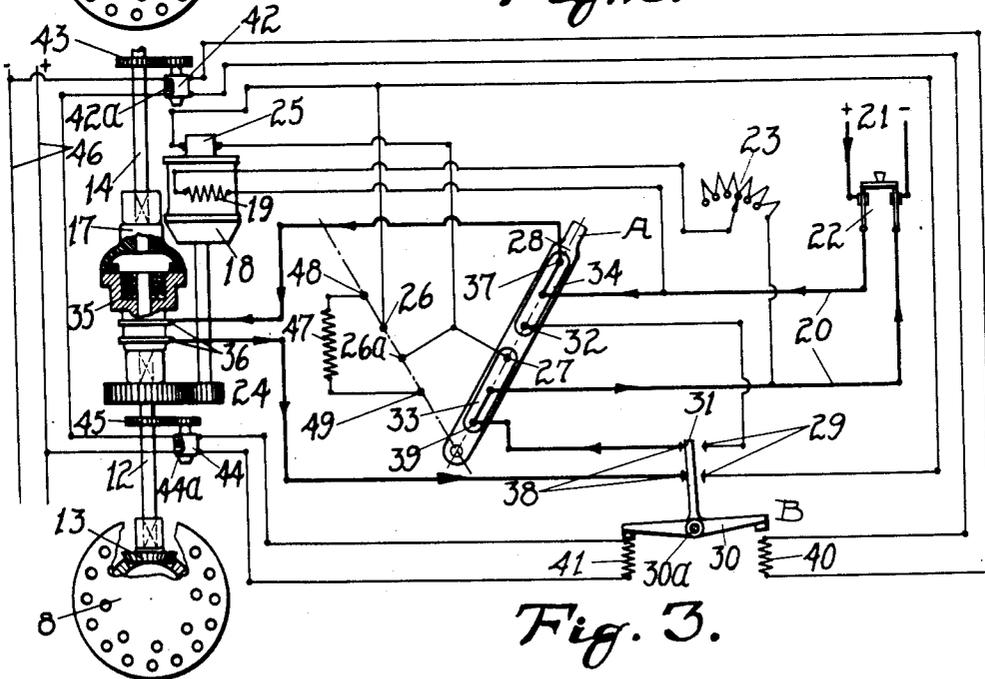


Fig. 3.

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UNITED STATES PATENT OFFICE

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SPEED SYNCHRONIZATION OF INTERMITTENTLY-OPERATED MACHINES

Application filed July 5, 1929. Serial No. 376,259.

The present invention, broadly considered, resides in a novel method and apparatus by which to put into action, from a condition of idleness or stoppage, any machine or the like whose working occurs intermittently or at intervals, and whose drive, for the entire duration of any working period, must be substantially synchronized with some other means or mechanism in practically continuous operation,—for example, a means used to secure delivery of stock or material to such intermittently-worked machine or machines.

A particular application of the invention, which is herein shown for illustrative purposes is in the driving of reels of the revolving or so-called pouring type, which are used for the coiling of hot metal rods, or other similar elongated products delivered at high speed.

It is necessary, as soon as one of these reels becomes filled, to switch the delivery of the stock to another adjacent reel, in order to take care of the substantially continuous delivery of said stock by the mill. This mode of operation requires the unfilled reel, in advance of any diversion of the stock thereto, to be started up from a non-revolving condition and accelerated to a speed which corresponds to the high delivery speed of the stock; only in this way can the reeling be properly started, and only by maintaining a close synchronization between reel speed and stock-delivery speed throughout the coiling operation, can a satisfactory coil be made.

The present invention insures the establishment and maintenance of such synchronization, by an arrangement of apparatus which permits the selected reel or other machine, in advance of its actual working, to be started independently, and accelerated until it is running in synchronism with the constantly-operated driving means which, in the case of reels, procures the delivery of the stock to be coiled thereon; thereafter, for the entire duration of the working period of the driven machine, such synchronism is maintained, as by automatically shifting the drive of said machine so started and accelerated to said constantly-operated driving means, so that, in the case for example of a reel, the coiling operation

can be inaugurated with absolute assurance of perfect synchronism between stock speed and reel speed from beginning to end. Other and further objects and advantages of the invention will be apparent from the following detailed description thereof, in connection with which reference is had to the accompanying drawings, wherein—

Fig. 1 is a plan view, partly diagrammatic, of my invention, and showing its application to a plurality of revoluble reels in operative relation to the finishing end of a rod mill, in conjunction with the accelerating and synchronizing devices for one of said reels.

Fig. 2 is a diagrammatic view of the accelerating and synchronizing apparatus of Fig. 1, and showing the condition of the parts when a reel is being accelerated.

Fig. 3 is a diagrammatic view similar to Fig. 2, and illustrating another condition of the parts, which is automatically established when the reel has been accelerated up to a speed corresponding to the stock-delivery speed.

Like reference characters refer to like parts in the different figures.

Referring first to Fig. 1, the finishing rolls of a rod mill are indicated at 1, the rolls being driven from a shaft 2 here shown as having a gear connection 3 with a driving motor or other prime mover 4. From the rolls 1, the elongated material 5, in the form of rods, bars or the like, passes to a suitable switch indicated diagrammatically at 6, which is selectively operable to direct the moving material through suitable reel delivery pipes 7, 7 to any one of a plurality of revoluble reels 8, 8, here shown as two in number. Each reel 8 is here shown as of the usual "pouring" type, with a rotatable table 9 which provides two series of concentric pins 10 and 11 between which the moving stock 5 is delivered from the pipe 7. Each reel table 9 is driven from a shaft 12 through suitable gearing 13.

According to my invention, the drive of shaft 12, when the material 5 is being coiled on the reel, is taken from the roll shaft 2, so as to maintain the reel speed in synchronism with the stock delivery speed, and to this end I have shown in alignment with the shaft 12

a constantly-rotating drive shaft 14 which is connected by means of countershafts 15, 15 and gearing 16, 16 with the shaft 2,—the gearing 13, 16, 16 being so proportioned that when the alined shafts 12 and 14 are clutched together, as hereinafter described, the surface speed of reel table 9, between the pins 10 and 11, will correspond to the delivery speed of the stock 5.

13 Said stock delivery speed is so high, that it manifestly would be impractical, with a reel 8 at rest (following its stoppage for the removal of a coil therefrom) to clutch together the two alined shafts 12 and 14, the one stationary and the other rotating at high speed. Accordingly, to meet the requirement that each reel 8, in advance of any passage of the stock thereto, must be started up from rest and accelerated to the delivery speed of said stock, this invention contemplates an improved method and arrangement of apparatus whereby, at the will of an operator, any reel 8 may be started up and accelerated by means of an independent prime mover, until its shaft 12 reaches the speed of the rotating shaft 14, and then when the shafts 12 and 14 are in exact synchronism, a magnetic clutch 17 operates automatically to connect said shafts 12 and 14, so that the coiling of material on said reel can be inaugurated.

For thus starting and accelerating each reel, independently of its mill-driven shaft 14, a separate prime mover 18, preferably in the form of an electric motor of the direct current type is provided; said motor 18 has, as here shown, a field winding 19 connected in shunt across supply mains 20 adapted to be energized from a suitable source 21 of electrical energy, through the closing of a knife switch 22. An adjustable rheostat 23 of the usual type is connected in the circuit of the field 19 whereby the speed of the motor 18 may be varied, for a purpose to be hereinafter described. The shaft of the accelerating motor 18 is connected by gearing 24 to the reel shaft 12 so that when the motor 18 is connected to the source 21, the reel will be accelerated from rest and brought up to a speed determined by the operating speed of the motor 18 for a given setting of its field rheostat 23.

One terminal of the armature 25 of the motor 18 is connected in parallel to the separate stationary contacts 26a and 27 of a control switch A providing a handle 28 shown in the "off" position in Fig. 1. The other terminal of the motor armature 25 is connected in parallel to a third switch contact 26 and to one of a pair of spaced contacts 29 of a relay B which provides a pivoted armature 30 carrying a contact arm 31 which normally bridges the gap between the contacts 29. The other contact 29 is connected to a stationary contact 32 forming part of the switch A, and

when the switch arm 28 is thrown from the "off" position of Fig. 1 to the "on" position of Fig. 2, contact plates 33 and 34 carried by the switch arm 28 are adapted to connect the contacts 27 and 32, respectively, to the supply mains 20, thereby causing current to be supplied to the armature 25 of the motor 18, as indicated by the heavy circuit lines and arrows in Fig. 2. When this occurs, the motor 18 starts, and with it, through gearing 24, the associated reel 8, and as said motor picks up speed, the reel shaft 12 accelerates, until it finally attains a speed equal to or slightly above that of the shaft 14, whereupon, as hereinafter described, the clutch 17 is automatically thrown in to establish a driving connection between shafts 12 and 14, and to disconnect the reel accelerating motor 18 from the supply mains 20.

For purposes of illustration, the clutch 17 which is interposed between the reel shaft 12 and the mill driven shaft 14, is shown as providing a winding 35 carried by one clutch element which when energized is adapted to attract the other clutch element and establish a driving connection between the shafts 12 and 14. Current is adapted to be supplied to the winding 35 through slip rings 36, one of which is connected to a contact 37 adapted to be engaged by the segment 34 of the switch arm 28 when the latter is moved to the "on" position to connect one slip ring 36 to the positive side of the source 21. The other slip ring 36 is connected to one of a pair of spaced contacts 38 forming part of the relay B, the contacts 38 being separated when the relay contact arm 31 is in engagement with the contacts 29 controlling the circuit to the reel motor 18. The other relay contact 38 is connected to a stationary contact 39 of the control switch that is engaged by the switch segment 33 when the arm 28 is in the "on" position so as to connect the relay contact 38 to the minus side of the source 21. Therefore, when the motor 18 is operating through the circuit shown in Fig. 2, the circuit of the magnetic clutch winding 35 is open at the gap between the contacts 38 of the relay B, the functioning of which to cause automatic operation of the clutch 17 will next be described.

The armature 30 of the relay B projects equally on opposite sides of its pivot 30a and these portions of the armature 30 are under the influence of coils 40 and 41 symmetrically disposed with respect to the pivot 30a. The terminals of the right hand coil 40 are connected to the terminals of what is commonly known as a tachometer generator 42, the shaft of which is connected to the mill driven shaft 14 through gearing 43. The other coil 41 of the relay B is connected to the terminals of a second tachometer generator 44, the shaft of which is connected to the reel shaft 12 through gearing 45 having exactly the same ratio as the gearing 43 of generator 42. The

tachometer generators 42 and 44 are exact duplicates, both electrically and mechanically, and the field windings 42a and 44a of these generators are connected in series across a constant voltage source represented by the mains 46. Consequently, when the reel shaft 12 and the mill shaft 14 are separately driven, the generators 44 and 42 will energize the relay coils 41 and 40, respectively, in direct proportion to the speeds of the shafts 12 and 14, and should the shaft 12 be driven at the same speed as the shaft 14, it necessarily follows that the relay coil 41 will have exactly the same excitation as the coil 40. It is also apparent that should the shaft 14 be driven from the mill motor 4 when the motor 18 is not driving the shaft 12, the separate excitation of the relay coil 40 by the generator 42 will hold the armature 30 of the relay B in the position shown in Fig. 1, in which position the relay contact arm 31 bridges the gap between the spaced stationary contacts 29 in the circuit of the motor 18. This is the normal position of the armature 30 of relay B when the reel 8 under consideration is out of operation and the mill is delivering stock to another reel.

As previously pointed out, when the arm 28 of the control switch A is in the "off" position, as shown in Fig. 1, there is a break in the circuit of the motor 18 between the switch contact 32 and the positive supply main 20 and there also is a break in the energizing circuit of the clutch 17 between one of the contacts 38 of the relay B which is connected to the switch contact 39 and the negative supply main 20. Therefore, with the handle 28 in the "off" position neither the motor 18 nor the clutch 17 can be energized. In the "off" position of the switch A however, the terminals of the motor armature 25 are connected across a resistance 47 by the engagement of the switch contact segments 33 and 34 with stationary contacts 48 and 49 between which the resistance 47 is connected and with contacts 26 and 26a connected to the armature 25. In other words, with the switch arm 28 in the "off" position the armature of the motor 18 is connected directly across a resistance, so that any rotation of the shaft of motor 18 by reason of its connection with the reel shaft 12 will result in a regenerative braking effect, the purpose of which will be hereinafter described.

The control switch A is preferably located at a point adjacent to the reels 8, as in an operator's pulpit indicated diagrammatically by the dot and dash lines in Fig. 1, and there is also mounted in the operator's pulpit the adjustable rheostat 23 for the field 19 of the reel motor 18. The various settings of this rheostat 23 to obtain different speeds of the motor 18 are so calibrated that the operator is able to determine for a given setting of the rheostat at just what speed the

reel motor 18 will operate. There is also available to the operator a tachometer driven from the mill motor 4 adapted to indicate the speed of that motor, and the operator will be provided with a chart showing the relation between the speeds of the reel motor 18 and of the mill motor 4 whereby the operator can determine the speed at which the reel motor 18 should be driven in order to accelerate the reel table shaft 12 to the speed at which the shaft 14 will be driven for a given speed of the mill motor 4.

In order to coil a rod on a given reel, the operator first observes the speed at which the mill motor 4 is operating and then sets the rheostat 23 of the motor 18 of the reel selected for forming the next coil to give the proper reel motor speed. The operator then throws the handle 28 of the switch A to the "on" position, as indicated in Fig. 2, whereupon the circuit of the motor 18 is completed as indicated by the heavy circuit lines and arrows. The motor 18 thereupon accelerates the reel shaft 12 and when the speed of the shaft 12 attains a speed equal to or slightly more than that of the shaft 14 then being driven from the mill motor 4, the excitations of the relay coils 40 and 41 by the tachometer generators 42 and 44 have practically the same value. When this condition is attained, the armature 30 of the relay B is subjected to a sufficient pull on the left hand side of its pivot 30a to cause the armature to assume a reverse position from that shown in Fig. 2, as shown in Fig. 3, thereby causing the contact arm 31 to leave the contacts 29 and to bridge the gap between the contacts 38. When this occurs, the motor 18 is disconnected from the supply mains 20, while the circuit of the winding 35 of the magnetic clutch 17 is completed, as indicated by the heavy circuit lines and arrows in Fig. 3. As a result, the reel shaft 12 now becomes clutched to the driving shaft 14, and is driven from the mill motor 4, thereby insuring that the surface speed of the reel table 9 between the pins 10 and 11 will exactly correspond to the delivery speed of the stock when the operator directs the next length of material to the selected reel by means of the switch 6. This automatic synchronization of a selected reel leaves the operator free to observe the actual formation or removal of a coil on another reel, and his entire attention can be concentrated upon operation of the rod switch 6 at the proper time, with absolute assurance that the selected reel has already been accelerated to the proper coiling speed, and is being driven in synchronism with the mill when the material arrives at the reel.

When the coiling of a given length of the material on the selected reel is completed, the operator throws the control switch arm 28 for this particular reel to the "off" position. In the meantime, before the coiling

on the above described reel is completed, he has performed exactly the same sequence of operations as described above with respect to another similarly-equipped and driven reel 8, to start and speed up the latter, in readiness for diversion to it of the closely-following next length of material delivered by the mill.

When its control handle 28 is thrown to the "off" position, as shown in Fig. 1, the first reel table 8 with the complete coil thereon is quickly brought to rest by the regenerative braking effect which results from the connections thereupon established. As previously pointed out, moving the arm 28 to the "off" position disconnects the winding 35 of the magnetic clutch from the supply mains 20 thereby breaking the coupling between the reel shaft 12 and the mill driven shaft 14, and at the same time connecting the resistance 47 directly across the terminals of the armature 25 of the reel motor 18. Consequently, continued rotation of this filled reel 8 causes its motor 18 to act as a generator, and since the resistance 47 is connected directly across the armature 25, a braking effect will be applied to the shaft 12 which will bring the reel table 8 quickly to rest. The completed coil may then be removed from the reel by any suitable means, leaving the reel in readiness for forming another coil when its control handle 28 is again moved to the "on" position.

I claim:

1. In apparatus of the class described, a revoluble reel for the coiling of stock as delivered by a rolling mill or the like, a motor independent of the drive of said mill, for starting said reel, preparatory to a coiling operation thereon, and accelerating it to a predetermined speed, corresponding to the delivery speed of the stock, and clutch means responsive to the reel's attainment of said predetermined speed for synchronizing the drive of the reel with the drive of said mill.

2. In apparatus of the class described, a revoluble reel for the coiling of stock as delivered by a rolling mill or the like, a motor independent of the drive of said mill, for starting said reel, preparatory to a coiling operation thereon, and accelerating it to a predetermined speed, corresponding to the delivery speed of the stock, and means responsive to the reel's attainment of said predetermined speed for connecting it to the drive of said mill, and for discontinuing its operation by said motor.

3. In apparatus of the class described, a revoluble reel for the coiling of stock as delivered by a rolling mill or the like, a motor independent of the drive of said mill, for starting said reel, preparatory to a coiling operation thereon, and accelerating it to a predetermined speed, corresponding to the delivery speed of the stock, and means respon-

sive to the reel's attainment of said predetermined speed for connecting it to the drive of said mill, and for discontinuing the supply of current to said motor.

4. In apparatus of the class described, a revoluble reel for the coiling of stock as delivered by a rolling mill or the like, an electric motor independent of the drive of said mill, for starting and accelerating said reel, preparatory to a coiling operation thereon, clutching means between said reel and the drive of said mill, and means responsive to acceleration of said reel by said motor for operating said clutch means to connect said reel with the drive of said mill.

5. In apparatus of the class described, a revoluble reel for the coiling of stock as delivered by a rolling mill or the like, an electric motor connected to said reel for starting and accelerating it preparatory to a coiling operation thereon, a magnetic clutch interposed between said reel and the drive of said mill, and means responsive to acceleration of said reel by said electric motor for simultaneously energizing said magnetic clutch and deenergizing said motor.

6. The combination with means for delivering stock to be coiled, of a plurality of revoluble reels adapted for the coiling of said stock, a motor associated with each reel and operable to start and accelerate the same while the stock is coiling on another reel, and clutch means responsive to a selected reel's attainment of the stock speed for synchronizing the drive of said reel with said stock-delivery means.

7. The combination with means for delivering stock to be coiled, of a plurality of revoluble reels adapted for the coiling of said stock, a motor associated with each reel and operable to start and accelerate the same while the stock is coiling on another reel, and means responsive to a selected reel's attainment of the stock speed for shifting the drive of said reel from its motor to said stock-delivery means, and for discontinuing the supply of current to its motor.

8. The combination with means for delivering stock to be coiled, of a plurality of revoluble reels adapted for the coiling of said stock, a motor associated with each reel and operable to start and accelerate the same while the stock is coiling on another reel, and means responsive to a selected reel's attainment of the stock speed for opening the circuit of its associated motor, and shifting its drive from said motor to said stock-delivery means.

9. The combination with means for delivering stock to be coiled, of a plurality of revoluble reels adapted for the coiling of said stock, a motor associated with each reel and operable to start and accelerate the same while the stock is coiling on another reel, and means responsive to a selected reel's attain-

ment of the stock-delivery speed for opening the circuit of its associated motor, and for simultaneously connecting said selected reel to said stock-delivery means.

7 10. The combination with delivery means for stock to be coiled, of a revoluble reel for the coiling of such stock, an electric starting and accelerating motor operatively connected to said reel, means responsive to said
10 reel's acceleration by said motor for procuring the drive of said reel by said stock-delivery means, and means responsive to said
15 reel's disconnection from said stock-delivery means, for imposing, through said motor, a regenerative braking effect on said reel, to quickly bring it to rest.

11. The combination with a delivery means for stock to be coiled, of a revoluble reel for coiling said stock, an electric motor operatively connected to said reel, for starting and accelerating it while the stock is coiling on another reel, means for automatically opening the circuit of said motor when the reel attains the stock-delivery speed, means operable automatically to connect said reel to
25 said stock-delivery means, for rotation in synchronism therewith during the coiling operation, when said stock-delivery speed is attained, and means responsive to the disconnection of said reel from said stock-delivery
30 means, at the completion of the coiling operation, for imposing on said reel, through said motor, a regenerative braking effect, to bring said reel to rest.

35 12. The combination with delivery means for stock to be coiled, of a revoluble reel for the coiling of said stock, an electric motor operatively connected to said reel, for starting and accelerating it while the stock is
40 coiling on another reel, clutching means between said reel and said stock-delivery means, means responsive to said reel's attainment of stock-delivery speed for operating said clutching means to drive said reel, during the
45 coiling operation thereon, from said stock-delivery means, and means responsive to unclutching of said reel from said stock-delivery means, at the completion of the coiling operation, for imposing on said reel, through
50 said motor, a regenerative braking effect, to bring said reel to rest.

13. The combination with delivery means for stock to be coiled, of a revoluble reel for the coiling of said stock, an electric motor
55 operatively connected to said reel for starting and accelerating it while the stock is coiling on another reel, a magnetic clutch interposed between said reel and said stock-delivery means, means responsive to said reel's attainment of stock-delivery speed for simultaneously energizing said magnetic clutch and deenergizing said motor, whereby said
60 reel, for the coiling operation thereon, is driven by said stock-delivery means, and means responsive to the deenergization of

said magnetic clutch, in disconnecting said reel from said stock-delivery means at the completion of the coiling operation, for imposing on said reel, through said motor, a regenerative braking effect, to bring said reel
70 to rest.

14. The combination with delivery means for stock to be coiled, of a revoluble reel for the coiling of said stock, an electric motor operatively connected to said reel, a control
75 device for starting said motor, to accelerate said reel while the stock is coiling on another reel, means operable without movement of said control device from its starting position for shifting the drive of said reel to said
80 stock-delivery means and for opening the circuit of said motor, when the stock-delivery speed is attained, whereby the drive of said reel, during the ensuing coiling operation thereon, is maintained in synchronism with
85 the delivery of the stock by said stock-delivery means, and means responsive to movement of said control device to an inoperative position for disconnecting said reel from said stock-delivery means at the completion of
90 said coiling operation.

15. The combination with delivery means for stock to be coiled, of a revoluble reel for the coiling of said stock, an electric motor operatively connected to said reel, a control
95 device for starting said motor, to accelerate said reel while the stock is coiling on another reel, means operable without movement of said control device from its starting position for shifting the drive of said reel to said
100 stock-delivery means and for opening the circuit of said motor, when stock-delivery speed is attained, whereby the drive of said reel, during the ensuing coiling operation thereon, is maintained in synchronism with the
105 delivery of the stock by said stock-delivery means, and means responsive to movement of said control device to an inoperative position for disconnecting said reel from said stock-delivery means at the completion of said coiling
110 operation, and for imposing on said reel, through said motor, a regenerative braking effect, to bring said reel to rest.

16. The combination, with a delivery means for stock to be coiled, of a revoluble
115 reel for coiling said stock and adapted to receive its drive, during a coiling operation thereon, from said stock-delivery means, a driving means for said reel, independent of said stock-delivery means, to procure its
120 starting and acceleration while the stock is coiling on another reel, corresponding reel-driving members receiving rotation, respectively, from said stock-delivery means and from said independent means, and means responsive to speed-equality of said members
125 for shifting the drive of said reel from said independent means to said stock-delivery means.

17. The combination, with a delivery 130

means for stock to be coiled, of a revoluble reel for coiling said stock and adapted to receive its drive, during a coiling operation thereon, from said stock-delivery means, an independent driving means for said reel, unconnected with said stock-delivery means, to procure the starting and acceleration of said reel while the stock is coiling on another reel, a continuously-rotating reel-driving member receiving its rotation from said stock-delivery means, a corresponding member in the drive of said reel by said independent means, and means responsive to speed-equality of said members for shifting the drive of said reel from said independent means to said stock-delivery means.

18. The combination, with stock-delivery means, of a plurality of machines adapted for operation, selectively, on said stock, a driving means independent of said stock-delivery means, associated with each machine to start it, preparatory to a working operation thereof, and means responsive to acceleration of a selected machine by its starting driving means, for shifting its drive to said stock-delivery means.

19. The combination, with stock-delivery means, of a plurality of machines adapted for operation, selectively, on said stock, a driving means independent of said stock-delivery means, associated with each machine to start it, preparatory to a working operation thereof, and means responsive to acceleration of a selected machine by its starting driving means, for shifting its drive to said stock-delivery means, and for discontinuing the power supply to said starting driving means.

20. The combination, with an intermittently-worked machine, of a constantly-operated driving means for the actuation of said machine during its working periods, a motor unconnected with said constantly-operated driving means, for starting said machine, preparatory to each working operation thereof, means responsive to said machine's acceleration by said motor for procuring the drive of said machine from said constantly-operating driving means, and means responsive to said machine's disconnection from said constantly-operating driving means, at the finish of a working operation, for imposing on said machine, through said motor, a regenerative braking effect, to bring said machine to rest.

21. The combination, with an intermittently worked machine, of a constantly-operating driving means for the actuation of said machine during its working periods, a motor independent of said driving means for starting said machine, preparatory to a working period thereof, and for accelerating it to a predetermined speed corresponding to the speed of said driving means, and means responsive to said machine's attainment of said predetermined speed for connecting it to

said driving means and for discontinuing its operation by said motor.

22. The combination, with an intermittently-worked machine, of a constantly-operating driving means for the actuation of said machine during its working periods, a motor independent of said driving means for starting said machine preparatory to a working period thereof, and for accelerating it to a predetermined speed, corresponding to the speed of said driving means, a magnetic clutch interposed between said machine and said driving means, and means responsive to said acceleration of said machine by said motor for simultaneously energizing said magnetic clutch and deenergizing said motor.

23. The combination, with a plurality of intermittently worked machines, of a constantly-operating driving means for the actuation, selectively, of certain of said machines, during their working periods, a motor associated with each machine, for starting it, preparatory to a working period thereof, and for accelerating it to a predetermined speed corresponding to the speed of said driving means, and means responsive to a selected machine's attainment of said predetermined speed for shifting the drive of said machine from its motor to said driving means.

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