

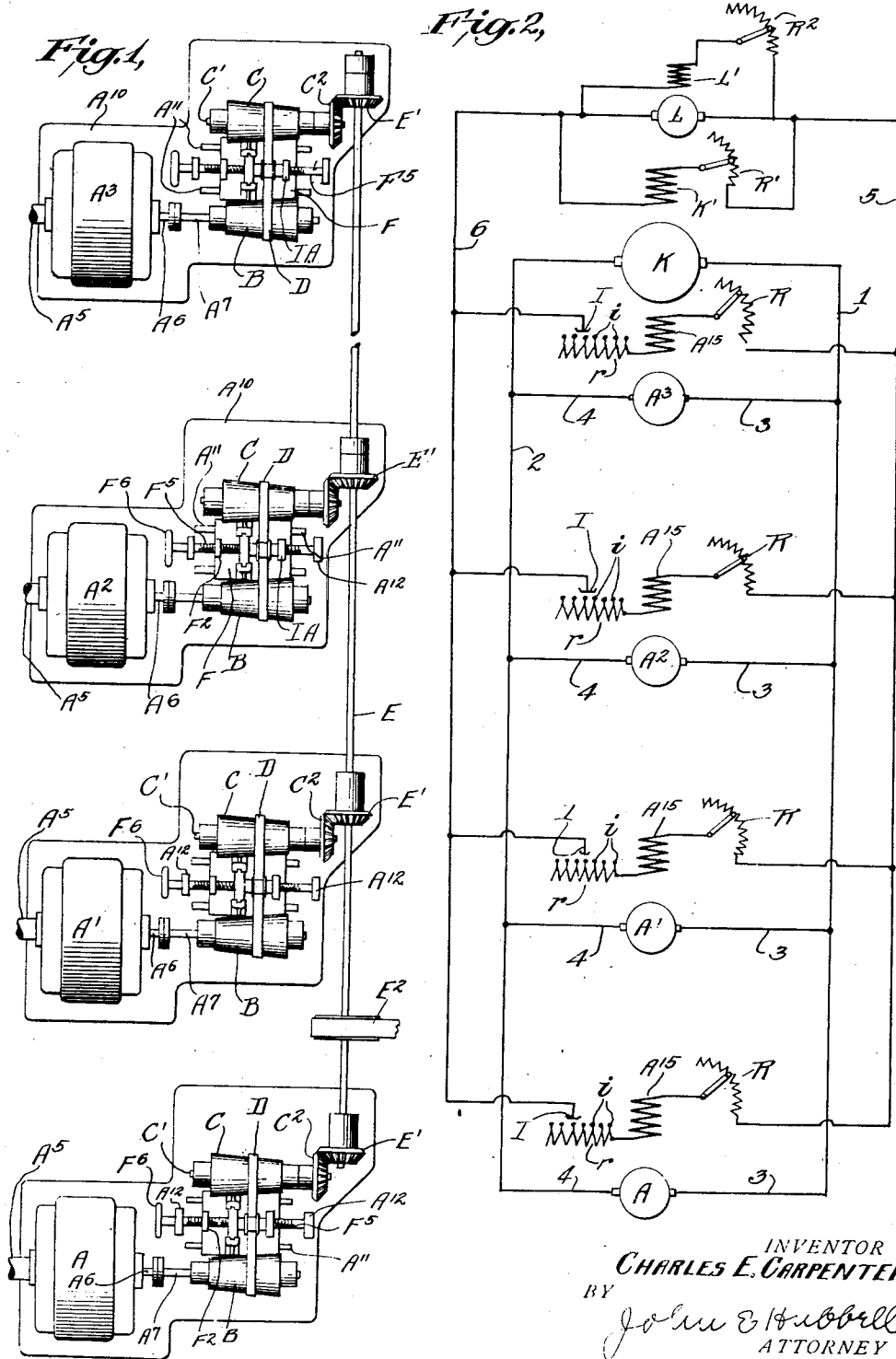
May 10, 1927.

C. E. CARPENTER

1,627,832

SPEED REGULATION

Original Filed Aug. 24, 1921 2 Sheets-Sheet 1



May 10, 1927.

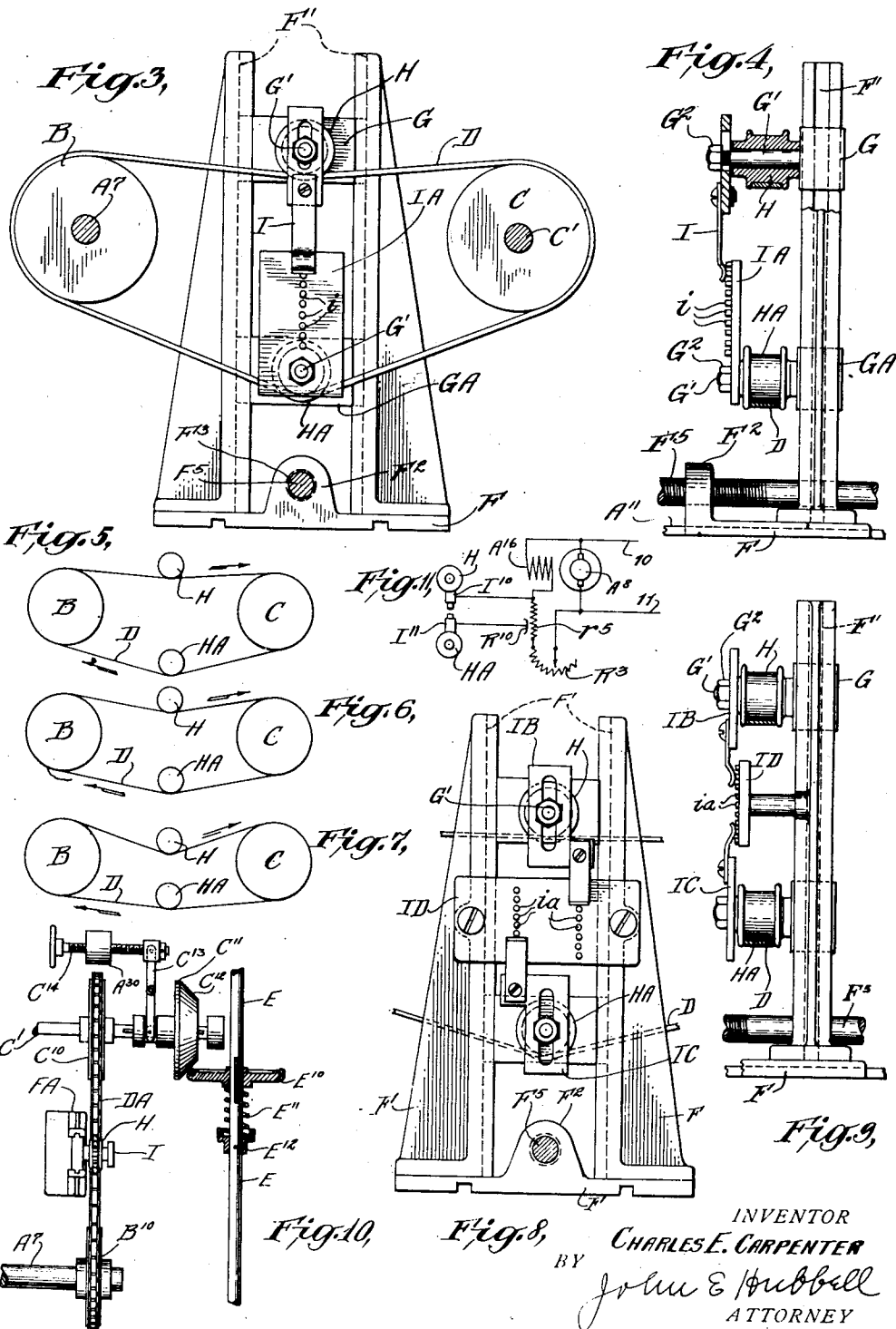
C. E. CARPENTER

1,627,832

SPEED REGULATION

Original Filed Aug. 24, 1921

2 Sheets-Sheet 2



INVENTOR

CHARLES E. CARPENTER

BY

John E. Hubbard
ATTORNEY

Patented May 10, 1927.

1,627,832

UNITED STATES PATENT OFFICE.

CHARLES E. CARPENTER, OF NEW YORK, N. Y.

SPEED REGULATION.

Application filed August 24, 1921, Serial No. 495,126. Renewed January 7, 1925.

The general object of my present invention is to provide improved means for maintaining a predetermined relation between the speeds of rotation of two shafts.

5 My invention was primarily devised, and is especially adapted for use in controlling the speeds of a plurality of electric motors operated under the conditions existing in the case of a paper making machine in 10 which each of a plurality of rolls over which the web of paper stock passes is driven by an individual electric motor. In the operation of a paper making machine of this type, the web ordinarily changes in 15 length in its passage through the machine as the stock is converted from pulp into finished paper. Furthermore, the degree of elongation or, in some cases, contraction in length of the web, occurring at different 20 stages in the conversion of the pulp into finished paper varies with the conditions of operation. To avoid stretching and rupturing on the one hand, or undue festooning on the other hand, of the web portions extending between successive rolls, the speeds 25 of rotation of the different rolls must be very closely proportioned. With rolls of the same diameter driven by directly connected motors, the different motors must be 30 operated at different speeds but the difference in speeds is small. Furthermore, there must be a capacity for making small variations in the relative roll speeds in response to changes in operating conditions.

35 In utilizing the present invention to control the speeds of the different driving motors of a paper making machine of the type referred to above, or of any group of motors in which similar speed relations are 40 desired, I provide each of the motors to be controlled with an automatic controller comprising a pair of pulleys and a connecting belt, and I drive one pulley at a speed 45 which is the same as, or proportional to that of the motor, and drive the other pulley at the desired controlling speed, and associate with the belt, mechanism responsive to the changes in slack in one or both turns 50 or sides of the belt occurring on a variation in the relative speeds of the two pulleys, to adjust the speed of the motor as required to restore the desired speed relation. One pulley of each motor controlling 55 mechanism may be mounted directly on the shaft of the controlled motor and the other pulley may be driven by an individual syn-

chronous motor or other motor the speed of which may be regulated as desired, but in practice I prefer to mount the various control pulleys on, or to gear connect them 60 to a synchronizing shaft common to all of the motors regulated. This synchronizing shaft may be driven by one of the motors of the regulated group, or by an independent motor. The speed of travel of each belt 65 is thus a measure of the speed of the motor which it helps to control, and the relative speeds of the different motors may be varied by varying the relative belt speeds which can be accomplished in various ways. 70

My belt actuated control mechanism possesses the advantages of mechanical simplicity and reliability, and insures a very sensitive and positive speed control since a 75 departure in motor speed sufficient to effect a small portion of a revolution of one control pulley relative to the other will give a substantial movement to the control part or parts engaging the belt. Since the load transmitted by the control belt is small and 80 practically constant, narrow smooth belts may ordinarily be used without incurring trouble from belt slippage. In some cases I may use sprocket chains or the like as the control belts and pulleys in the form of 85 sprocket gears, thus eliminating all possibility of slippage.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to 90 and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have 95 illustrated and described preferred embodiments of my invention.

Of the drawings:

Fig. 1 is a diagrammatic plan view of 100 a group of motors having their speeds regulated in accordance with the present invention;

Fig. 2 is a diagram of the circuit connections which may be employed in connection with the apparatus shown in Fig. 1; 105

Fig. 3 is an elevation of a portion of the control mechanism employed in Fig. 1;

Fig. 4 is an elevation taken at right angles to Fig. 3 with parts broken away and in 110 section;

Figs. 5, 6 and 7 are diagrams illustrating

the changes in shape of the control belt resulting from changes in the relative speeds of the controller pulleys;

Fig. 8 is an elevation taken similar to Fig. 3 illustrating a modified form of control apparatus;

Fig. 9 is an elevation taken at right angles to Fig. 8;

Fig. 10 is a view illustrating a modification of the apparatus shown in Fig. 1; and

Fig. 11 is a diagrammatic representation of a modified form of control apparatus.

In the drawings, and referring first to the construction illustrated by Figs. 1 to 7 inclusive, A, A', A² and A³ represent motors, the power shafts A⁵ of which may be connected to the different rolls of a paper making machine, or to other devices which are to be driven in determined speed relations. To an extension A⁶ of each of the motor shafts is coupled a shaft A⁷ carrying a cone pulley B. Associated with each pulley B is an oppositely inclined cone pulley C, each pulley B and the corresponding pulley C being coupled by a narrow belt D. As shown in Fig. 1 the different pulleys C are each driven through a corresponding pair of beveled gears C² and E' from a common synchronizing shaft E which is driven at the desired speed which ordinarily should be capable of adjustment by any suitable driving means. As shown the shaft E is provided with a driving pulley E² through which the shaft E may be driven from a special motor or from an available line shaft or the like.

The speed of each of the motors A, A', A² and A³ is regulated by the corresponding belt D through mechanism comprising a frame F mounted on the motor bed plate A¹⁰ and adjustable along bed plate guides A¹¹ in a direction parallel to the axes of the corresponding pulleys B and C. This adjustment is effected with the apparatus shown by means of an adjusting screw F⁵ journaled in brackets A¹² projecting from the bed plate A¹⁰ and provided with a hand wheel F⁶. The screw passes through a threaded opening formed in a web portion F² of the frame F. The frame F is formed with a guideway F' for vertically movable cross heads G and GA. The cross head G carries a stud shaft G' upon which is journaled a flanged idler pulley H which rests upon the upper turn of the belt D, and the cross head GA carries a similar stud G' supporting an idler HA resting upon the lower portion of the belt D. Associated with the idlers H and HA are electric contact devices I and IA, respectively, the relative movements of which, as the relative amounts of slack in the two turns of the belt vary, directly or indirectly adjust the circuit connections of the controlled motor to thereby regulate its speed. As shown in Figs. 3 and 4, the contact device I comprises a slotted

arm having a spring contact finger and adjustably clamped by the nut G² to the end of the stud G' for the idler H. The contact device IA is secured to the supporting stud shaft G' for the idler HA and is provided with a plurality of contact studs *i* one or another of which is engaged by the contact finger I according to the distance between the axes of the idlers H and HA.

In the contemplated mode of operation of the apparatus shown in Figs. 1 to 7, the direction of the belt travel is that indicated by the arrows in Figs. 5, 6 and 7, and the normal conditions of each controlled belt D, when the proper speed relation between the corresponding pulleys B and C exist, will be that illustrated in Fig. 6 in which there is about the same degree of dip or slack in each turn of the belt D. On a decrease in the speed of the motor pulley B relative to the control pulley C, the upper turn of the belt tightens and the lower turn acquires more slack. The effect of this is to move the idlers H and HA apart into the positions shown in Fig. 5, whereupon the contact devices I and IA will adjust the electrical connections for the motor to increase the speed of the latter and restore the condition illustrated in Fig. 6. When, on the other hand, the pulley B is turning too rapidly relative to the control pulley C, more slack is given to the upper portion of the belt and the lower portion is tightened, and the idlers H and HA move toward one another into the positions shown in Fig. 7 with a corresponding adjustment of the contacts I and IA and a resultant decrease in motor speed.

It will be understood, of course, that the contacts adjusted by the idlers H and HA may adjust motor circuits, or motor circuit controlling relays in any of the various ways commonly employed to adjust the speed of electric motors. In the arrangement shown diagrammatically by way of example in Fig. 2, the various motors A, A', A² and A³ are direct current motors having their armatures connected by leads 3 and 4 to supply conductors 1 and 2 connected in turn to the brushes of the generator K. The latter has its field winding K' energized by a separate exciter L which also supplies current for energizing the field windings A¹⁵ of the motors A, A', A² and A³. The exciter L is shunt wound and regulating rheostats R' and R² are placed in the field circuits of the generator K and exciter L respectively.

The field circuit for each of the motors A, A', A² and A³ includes in series with the field winding A¹⁵ a hand operated rheostat R, the contact finger I, and more or less of a resistance *r* which is connected at intervals to the contact studs *i* of the controller contact member IA, so that when the idlers H and HA are spread apart more of the resist-

ance r is cut into circuit, the motor field current is correspondingly reduced, and the motor speeded up, an opposite effect being produced when the idlers H and HA approach one another. It will be understood, of course, that in practice the various rheostats R, R' and R² are adjusted to supply approximately the proper amount of electric energy to each of the motors A, A', A² and A³, to enable the latter to carry its load at the proper speed, and the automatic control mechanism are then called upon to effect only the slight variations in motor field strength required to maintain the exact speed relation desired between each motor and its control pulley C. When the speed of the paper making machine as a whole is to be varied, as it may be by adjustment of the rheostat R', the speed of rotation of the shaft E is correspondingly varied. When it is desired to vary the relative speed of any of the controlled motors, and the others, this is effected by rotating the threaded shaft F² of the said one motor to shift the corresponding belt D axially of the cone pulleys C and B in one direction or the other.

In Fig. 11 I have illustrated by way of example an arrangement in which the motor speed is regulated, not by a step by step variation of the resistance in the field winding current, but by alternately cutting into and out of the motor field circuit a resistance of such magnitude that when included in the field circuit the motor will tend to run at a speed above that desired, and when cut out of the field circuit the motor will tend to run at a speed below that desired. The controlled motor A² shown in Fig. 11 has its armature connected between supply conductors 10 and 11, and has its field winding A¹⁶ connected in shunt to the armature in a circuit including a hand operated rheostat R² and an automatic controller resistance r^2 . One terminal of the last mentioned resistance is connected to a contact I¹⁰ carried by the controller idler pulley H, and the controller idler pulley HA carries a cooperating contact I¹¹ connected to the opposite terminal resistance r^2 or to an intermediate portion of the latter. Advantageously the connection between the contact I¹¹ and the resistance r^2 is made through a connector R¹⁰ which can be manually adjusted along the resistance r^2 to obtain the desired sensitiveness of regulation.

With the arrangement shown in Fig. 11 when the motor A² runs above speed the contacts I¹⁰ and I¹¹ are moved together by the resultant changes in belt slack and the corresponding portion of the resistance r^2 is short circuited to thereby increase the field strength and decrease the motor speed. When the motor slows down the contacts I¹⁰ and I¹¹ are separated and the motor field is correspondingly weakened thus reducing

the motor speed. In the practical operation of this sort of control apparatus, the contacts I¹⁰ and I¹¹ engage one another and separate at frequent intervals and the belt actuated controlling mechanism thus holds the motor speed at the desired mean between its maximum and minimum speeds.

A special advantage of my improved control mechanism arises from the fact that the control belts D have practically no load to transmit and hence the belts may be light in weight and narrow and without danger of belt slippage prejudicially affecting the desired speed control. The two idlers, H and HA balance one another so to speak, and thus maintain practically uniform tension on both turns of the belt under the normal condition of operation. It will be obvious, of course, that the greater the total amount of slack in the belt, the greater the range of relative movement of the idlers H and HA, and the smaller the changes in belt tension produced by a given relative movement of approach or separation of the idlers.

In the modification illustrated in Figs. 8 and 9, the idlers H and HA carry adjustable spring contact fingers IB and IC, respectively, each of which cooperates with a corresponding set of resistance studs ia carried by a rheostat element ID rigidly secured to the controller frame F. With the modification shown in Figs. 8 and 9 the idlers H and HA with their supporting parts and contacts may be counterparts so that each idler and the parts connected to it exactly balances the other.

While I prefer, in order to increase the range of movement of the control parts and to increase the number of steps by which the control resistance may be varied, to utilize the changes in slack in both parts of the belt, it is obvious, of course, that where conditions make this desirable, the slack variations in one part only of the belt may be utilized to control the motor speed. For example, with the apparatus shown in Figs. 8 and 9, the contact IC and cooperating studs ia may be omitted without any change in operation other than a decrease in the number of steps by which the controller resistance may be automatically adjusted.

In the modification shown in Figs. 8 and 9, the relative speed of the cone pulleys may be varied, as in the apparatus shown in Figs. 3 and 4, by the simple adjustment axially of the pulleys B and C of the frame F in which the idlers H and HA are mounted. This mode of varying the speed relation maintained between the synchronizing shaft E and the motor driven shaft A² over which the control belt of each controller runs is a very good one from a practical standpoint because of the ease and reliability of operation, and the relative simplicity of the mech-

anism required, but this variation in relative speed can obviously be obtained in other ways as shown for example in Fig. 10.

In Fig. 10 the control belt DA is shown as a sprocket chain and the pulleys over which it runs are sprocket wheels B¹⁰ and C¹⁰ carried by the shafts A' and C' respectively. The controller shaft C' is driven from the synchronizing shaft E by a variable speed gear which as shown comprises an element C¹¹ splined on the shaft C' and provided with a conical surface C¹² engaged by a friction driving wheel E¹⁰ splined on the shaft E. The member C¹⁰ can be axially adjusted along the shaft C' as by means of a lever C¹³ and a screw C¹⁴ threaded through the stationary abutment A³⁰. The friction driving wheel E¹⁰ is held against the conical surface C¹² in the different axial adjustments of the latter, by means of a spring E¹¹ acting between the wheel E¹⁰ and a collar E¹² secured to the shaft E. The idler actuated control mechanism responsive to changes in slack in the belt DA may be exactly like that shown in Figs. 3 and 4 except that in this case the frame FA in which the belt engaging idlers are mounted may be stationary.

Where the adjustment in relative speed of the motor driven pulley over which the control belt runs and the synchronizing shaft is not obtained by an adjustment of the belt axially of the pulley as in Figs. 3 and 4, the control belt may be a sprocket chain, and the pulleys over which it runs may be sprocket wheels as shown in Fig. 10 thus eliminating all possibility of belt slippage. In general, however, since the control belts transmit no appreciable load, belt slippage will give no trouble when smooth belts are used, and in practice I would ordinarily prefer to use a smooth belt and simple flanged pulleys in lieu of the chain DA and wheels B¹⁰ and C¹⁰ in apparatus in which the adjustment in relative speed is effected as in Fig. 10.

While in accordance with the provisions of the statutes I have illustrated and described the best form of my present invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of my invention without departing from the spirit of my invention as set forth in the appended claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a system comprising a motor, a synchronizing shaft, a pulley driven by the motor, a pulley driven by the shaft, a belt looped about the pulleys, the improved means for maintaining a definite speed rela-

tion between the motor and shaft consisting of a motor speed regulator, and means controlled by variations in the length of said belt between given points, resulting from variations in the relative speeds of said pulleys, for adjusting said regulator as required.

2. In a system comprising a motor, a synchronizing shaft, a pulley driven by the motor, a pulley driven by the shaft, a belt looped about the pulleys, and a motor speed regulator, the improvement which consists in means actuated by variations in the relative pulls of the pulleys on the two sides of the belt loop for adjusting said regulator as required to maintain a definite speed relation between the motor and shaft.

3. In a system comprising a motor, a synchronizing shaft, a pulley driven by the motor, a pulley driven by the shaft, and a belt looped about said pulleys, the improved means for maintaining a definite speed relation between the motor and shaft, consisting of a speed regulator for said motor comprising a series of contact studs and a co-operating switch member, and idlers bearing on the two sides of the belt and effecting movements of the switch member over the contacts as the idlers assume different positions in response to changes in the relative lengths of the two sides of the belt loop as required to maintain a definite speed relation between the motor and shaft.

4. In a system comprising a motor, a synchronizing shaft, a pair of cone pulleys driven one by the motor and the other by the shaft, a belt looped about the pulleys, and a motor speed regulator, the improvement which consists in means actuated by variations in the relative lengths of the two sides of the belt loop for adjusting said regulator as required to maintain a definite speed relation between the motor and shaft.

5. In a system comprising a motor, a synchronizing shaft, a pair of cone pulleys driven one by the motor and the other by the shaft, and a belt connecting said pulleys, the improved means for maintaining different definite speed relations between the motor and shaft, comprising an idler pulley engaging the belt, a support on which said idler pulley is mounted with freedom to move as required to maintain engagement with the belt as the length of said belt between given points varies, means for adjusting said support to adjust the belt axially of the pulleys, and a motor speed regulator comprising a switch mechanism adjusted by the aforesaid movements of the idler as required to maintain a definite speed relation between the motor and shaft.

6. In a system comprising a motor, a synchronizing shaft, a pair of cone pulleys driven one by the motor and the other by the shaft, and a belt looped about the pulleys, the improvement which consists in a

support, a pair of idler pulleys engaging the two sides of the belt and mounted on said support with freedom for movements in response to variations in the relative lengths of the two sides of the belt loop, means for adjusting said support to thereby adjust the belt axially of the pulleys, and motor speed regulating provisions including an electrical switch mechanism mounted on said support and actuated by the movements of certain of said idlers.

7. In a system comprising a plurality of motors and a synchronizing shaft, the improved means for maintaining definite speed relations between the different motors and

said shaft consisting of an individual control device for each motor, which comprises a pulley driven by the motor, a pulley driven by the shaft, a belt connecting the pulleys, and means responsive to the variation in the relative lengths of the two sides of the belt loop for adjusting the speed of the corresponding motor as required to maintain a definite speed relation between the motor and shaft.

Signed at New York in the county of New York and State of New York this 23rd day of August, A. D. 1921.

CHARLES E. CARPENTER.