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PNEUMATIC CONTROL SYSTEM

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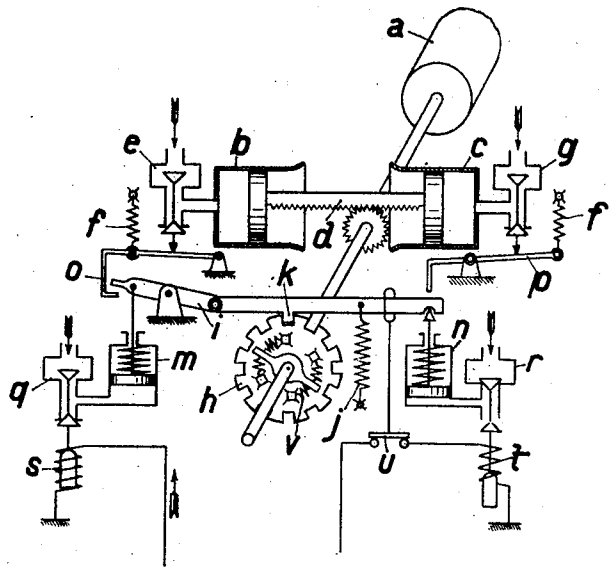

A. C. Couwenhoven

INVENTOR

By: Marks and Clerk
Attys

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ABRAHAM CORNELIS COUWENHOVEN, OF BADEN, SWITZERLAND, ASSIGNOR TO AKTIENGESELLSCHAFT BROWN, BOVERI AND CIE., OF BADEN, SWITZERLAND

PNEUMATIC CONTROL SYSTEM

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My invention relates to pneumatic control systems and it has particular relation to control systems for electric traction apparatus, and the like, wherein a control drum for establishing the various operating circuits is arranged to be moved between a plurality of positions by means of a pneumatic motor.

In the operation of such controllers it is important that the control drum be moved in definite steps corresponding to the different positions at which the drum establishes the various operating circuits. Where the drum is pneumatically controlled, as by means of a compressed air motor, difficulties are encountered in bringing the control drum into the exact control positions since, on the one hand, there is an elastic after effect of the confined air used to move the controller, and on the other hand, the inertia of the moving masses makes it difficult to bring them suddenly to a rest. As a result, the several controlling positions of the prior art controllers of the foregoing type could not be accurately fixed, thereby complicating the operation of the apparatus intended to be controlled thereby. According to the present invention the foregoing difficulties are eliminated by associating with the pneumatic motor apparatus, a mechanical locking device or detent so arranged as to positively mechanically lock the movement of the air motor and the associated control drum at the predetermined positions. The valves which control the flow of the operating pressure fluid into the pneumatic motor are directly controlled by the mechanical locking device so that, when the locking device has arrested the movement of the motor at a predetermined point corresponding to a control position of the control drum, the fluid pressure conditions in the motor are such as to maintain it in a stationary condition. This is secured by utilizing the locking device or detent itself for operating the control valves of the air motor.

My invention will be best understood from the accompanying drawing which is a diagrammatic view of the control system exemplifying my invention.

Although my invention is not limited thereto, it has been developed principally in connection with the railway control systems of the type such as described in Patent No. 1,323,301 of Paul L. Mardis. In such control systems the various circuits for operating the railway vehicle at a plurality of different speeds, according to the particular operating requirements, are established by means of a control drum arranged to be rotated in one direction or another direction by means of an air motor. The air motor is in turn controlled from an auxiliary controller actuated by the operator of the vehicle, the controller serving to suitably direct the flow of compressed air or other pressure fluid into the air motor in order to bring the operating mechanism thereof, with the associated control drum, into the desired operating position.

A system of this type arranged to embody my invention is diagrammatically illustrated in the drawing. The control drum which is to be moved between a plurality of control positions is indicated at *a* and is rotated by means of an air motor which comprises a pair of air or pressure fluid cylinders *b*, *c* with the associated pistons transmitting their movement to the control drum *a* by means of a rack and pinion gear *d*. The admission and escape of the compressed air into the cylinders or casings *b* and *c* of the air motor is controlled by a pair of main control valves *e* and *g*. The main valve *e* is commonly designated as the "off" valve while the other main valve *g* is commonly designated as the "on" valve for reasons explained hereinafter.

The two main valves *e* and *g* are held, by means of springs *f*, in the positions indicated in the drawing at which the compressed air is in communication with the two air cylinders *b* and *c*. Under this condition the air motor is stationary and the control drum is at rest. Releasing the spring *f* of the "on" valve *g* cuts the cylinder *c* off from the compressed air supply and the air confined in said cylinder is permitted to escape, causing clockwise rotation of the control drum *a*, which rotation is intended, in the present case, to represent control action for energizing the vehicle and raising the speed thereof. On the other hand release of the spring *f* in the

"off" valve *e* cuts the lefthand cylinder *b* off from the compressed air supply and the compressed air confined in the said cylinder is permitted to escape thereby moving the control drum counter clockwise towards the zero position at which the vehicle motors are de-energized.

To secure positive stoppage of the control drum at the desired control positions and to avoid, what might be called, "blurred" action of the prior art arrangements of the foregoing character, the control drum *a* with the associated air motor is provided with a mechanical locking device so arranged as to cause said drum to stop only at predetermined fixed positions and to positively preclude stoppage of the drum at a point somewhat in advance or somewhat back of the desired control position. In the exemplification shown in the drawing the locking device is shown in the form of a ratchet wheel *h* having a number of notches corresponding to the steps of the controller. A detent arm with a detent *k* cooperates with the ratchet wheel *h* to either lock the same at the positions corresponding to the steps of the controller drum *a* or to release the same for movement by the compressed air motor. The lefthand end of the detent arm *k* is pivoted to a two-armed click lever *i* having a fixed fulcrum. The righthand end of the detent arm rests on a piston rod of an auxiliary air cylinder *n* while the lefthand arm of the lever *i* is actuated by the piston of a second auxiliary air cylinder *m*. Suitable stops on the lever *i* and detent *k* act upon the main valve control levers *o* and *p* in opposition to the springs *f* thereof in order to connect the cylinders *b* and *c*, respectively, either to the compressed air supply or to the atmosphere. The piston of the auxiliary air cylinder *m* is loaded with a spring to pull the left side of the lever *i* downwardly so as to cut off the main air cylinder *b* from the compressed air supply and connect it with the atmosphere, and at the same time to lift the detent arm *k*, thereby unlocking the ratchet wheel *h*. However, if compressed air is admitted to the auxiliary air cylinder *m*, by means of an auxiliary "off" valve *q*, the lever *i* is held in a raised position so that the cylinder *b* may communicate with the compressed air supply. The auxiliary "off" valve *q* may in turn be controlled by means of an electromagnetic coil *s* which is so arranged that, when said coil is energized, the valve *q* admits compressed air to the auxiliary cylinder *m*, holding the associated lever arm in a raised position, and, when said coil is de-energized, the auxiliary valve *q* cuts the air supply off from the auxiliary cylinder *m*, thereby leaving the loading spring free to pull the lever *i* downwardly and in turn cutting the compressed air supply off from the main cylinder *b*. The piston of the righthand auxiliary air cylinder *n* is also loaded and held in downward position and is similarly controlled by an auxiliary "on" valve *r* which is in turn actuated by an electromagnetic coil *t*. The auxiliary "on" valve *r* with the associated actuating coil *t* is so arranged that, when said coil *t* is de-energized, the compressed air supply to the auxiliary cylinder *n* is cut off so that the piston is held in the lowered position by the loading spring of the cylinder. If the actuating coil *t* is energized, the auxiliary "on" valve *r* admits compressed air to the cylinder *n*, raising the piston and therethrough the detent arm *k*, thereby unlocking the ratchet wheel *h* and also cutting off the compressed air supply from the righthand main cylinder *c* of the air motor.

The energization and de-energization of the electromagnetic coils *s* and *t*, by means of which the arms of the combined locking and main valve control mechanism are actuated, is suitably controlled by the operator depending on the position into which he desires the main control drum *a* to be brought. The details of this part of the mechanism do not constitute a part of my present invention and have accordingly not been illustrated. They are familiar to those skilled in the art.

The energizing circuit of the electromagnetic coil *t*, by means of which the auxiliary "on" valve *r* is controlled, includes an auxiliary switch *u* which is operated by the detent arm *k* so that when said arm is lifted, through the action of the piston in the righthand auxiliary cylinder *n*, the auxiliary switch is opened and the electromagnetic coil *t* is de-energized. Upon return of the piston in the valve cylinder *n* to the downward position and the subsequent lowering of the detent arm *k* when the detent drops into a notch of the ratchet wheel *h*, the auxiliary switch *u* is again closed, thereby reestablishing the circuit to the electromagnetic coil *t*.

The mechanical connection between the main control drum *a* and the ratchet wheel *h* includes a resilient coupling means, such as springs *v*, so arranged that when the detent arm *k* is momentarily lifted by the piston of the auxiliary cylinder *n*—and before said arm has time to follow the return movement of said piston, prompted by the de-energization of the magnetic coil *t* by reason of the interruption of the energizing circuit through the opening of the auxiliary switch *u*—a tooth of the ratchet wheel *h* will have run underneath the detent. Accordingly the detent will be held in raised position until it has reached the next notch on the ratchet wheel *h*, although the piston of the auxiliary cylinder *n* has, in the meanwhile, returned to its downward position. As long as the detent is in raised position, that is, until it drops into the next notch of the ratchet wheel, the main "on" valve *g* is held in its raised position connecting the righthand main cylinder

c with the compressed air supply and disconnecting it from the atmosphere.

To explain the operation of the foregoing system, let us assume the entire control system at rest, that is, that the main control drum has been brought to a definite operating position and is to be held therein. Under such conditions the several valves and the parts of the system will be in the positions indicated in the drawing, both main air cylinders b and c being in communication with the compressed air supply and, therefore, in a state of equilibrium. At the same time the detent k holds the ratchet wheel h in locked position, the "off" coil s is energized and the "on" coil t de-energized. If the operator now desires to move the main control drum forwardly to one of the higher speed positions, in the present case in clockwise direction, he energizes the circuit of the "on" coil t. The "on" coil will thereupon cause the auxiliary "on" valve r to admit compressed air to the auxiliary "on" cylinder n, lifting the detent arm from the notch in the ratchet wheel h. The detent arm will in turn act upon the main valve control lever p thereby opening the outlet of the main "on" valve g and cutting the air supply off from the main cylinder c. Consequently, the air in the lefthand main cylinder b will force the rack d to the right, thus rotating the main drum a in clockwise direction.

Disregarding, for the moment, the absence of the auxiliary switch u in the energizing circuit of the "on" coil t, the drum will continue to move until it has reached the position desired by the operator at which time the circuit of the "on" coil t will be de-energized. The auxiliary "on" valve r will thereupon drop into the position shown in the drawing, releasing the compressed air from the auxiliary cylinder n and leaving the detent k free to drop downwardly to engage the next notch of the ratchet wheel, thus mechanically locking the drum a at the exact control position into which it was desired to bring the same. At the same time the righthand valve lever p is released, the main "on" valve g is thrown back into the position shown in the drawing, reestablishing the compressed air supply to the cylinder c. Since the two main cylinders b and c are now again under equal air pressure, the rack d will no longer be under unbalanced pressure and equilibrium will be reestablished.

In many cases, as when the controller is advanced over a number of speed steps by a single setting of the controller by the operator, it is important that the individual control steps shall be carried out distinctly. That is, it is often desired that the controller shall move from step to step and its movement be momentarily arrested at the end of each step, and then proceed as if the operator actually intended movement over single steps only. A distinct feature of the present invention is an arrangement for such controller operation and it is to this end that I have provided the auxiliary switch u in the energizing circuit of the "on" coil t of the controller. In operation, with the switch u arranged as shown in the drawing and described hereinabove, the energizing circuit of the "on" coil t is interrupted each time the detent k is lifted by the piston of the right-hand auxiliary cylinder n from a notch of the ratchet wheel h. The de-energization of the "on" coil t immediately releases the air from the cylinder n causing its piston to return to its zero position, in which it is shown in the drawing. In the meantime, the detent k has seated upon one of the teeth of the ratchet wheel h and is thus held in lifted position until said wheel has moved by a whole tooth corresponding to a full step of the controller at which time the detent moves into locking position in the next succeeding notch under the action of spring j. At the end of the step, when the detent drops back into the next notch, the energizing circuit of the "on" coil t is again completed and, if this position does not correspond to that set by the operator, the cycle of operations recommences, the switch u being closed again and the magnet t energized thereby moving the rachet wheel h and the controller a by another step, and so on, until the desired position is reached. To move the main control drum a in the opposite direction, in the present case toward the zero position of the drum, the "off" coil s is de-energized. This releases the compressed air from the auxiliary "off" cylinder m thereby bringing the lefthand arm of the lever i to downward position. As a consequence, the righthand arm of the lever i will lift the detent k from the ratchet wheel, leaving the main drum a free to rotate, and, at the same time, the lefthand arm of said lever i will force the main controlling lever o of the main valve downwardly, cutting the compressed air supply off from the left-hand main cylinder b and connecting it to the exhaust. Consequently, the air in the cylinder c will force the rack d to the left and this lefthand movement will continue until the piston has moved through its full stroke or until the magnet coil s is again energized. In the latter case the lever i is set free to return to its former position, as shown in the drawing, which action does not take place, however, until the detent has come opposite a notch in the ratchet wheel h at which point the ratchet wheel and the drum are locked and the main valve e again brought to the position at which air equilibrium in the two cylinders b and c is reestablished. The foregoing arrangement, whereby the "off" coil s must be held energized during the entire forward movement or while the control drum occupies any of the forward positions, is very advantageous since it insures that, upon fail-

ure of the control-current supply, or any other accident of such nature, the detent *k* will be mechanically raised from the ratchet wheel *h* and the entire mechanism positively returned into its zero position.

The valve units *q* and *r* and the respective operating electro-responsive coils or elements *s* and *t* therefor constitute means common to the fluid motor and the holding or locking means *k*—*h* for controlling or governing the same, each of such units comprising, as shown, fluid inlet and outlet valves which are opened and closed respectively upon excitation of the associated operating coil and which are closed and opened respectively upon deenergization of the latter. The arrangement, accordingly, is such that upon energization of each of the controlling or governing devices *q*—*s* and *r*—*t* release of the holding means *k*—*h* and forward movement or operation of the motor is effected, while upon maintenance of energization of device *q*—*s* and deenergization of device *r*—*t* application of the holding means and non-operating or balanced-pressure condition of the motor is effected, while upon deenergization of each of the controlling devices release of the holding means and reverse movement or operation of the motor is effected.

While I have described a specific form of my invention, it is not limited to the details shown and described, such as electromagnetic control of the mechanical locking device, etc., but is susceptible of many other modifications that will suggest themselves to those skilled in the art.

I claim as my invention:

1. In a controller system, a control member, a pressure fluid motor mechanism for moving said control member between a plurality of control positions, pressure fluid valve means controlling the movement of said pressure fluid motor mechanism, a mechanical locking device for arresting the movement of said pressure fluid motor mechanism, means actuated by said locking device to control said valve means, and means for effecting locking and unlocking action of said locking device.

2. In a control apparatus, a control member, a pressure fluid motor mechanism for moving said control member to a plurality of definite control positions, pressure fluid valve means controlling the movement of said motor mechanism, a mechanical locking device for arresting the movement of said control member in the predetermined positions, said mechanical locking device controlling said valve means to cause movement of said controller when in unlocked position, and means for unlocking or locking said locking device to control the movement of said controller member.

3. In a control apparatus, a control member, a fluid-pressure motor device for moving said control member to a plurality of predetermined positions, a mechanical locking device for locking said control member in the predetermined control positions independently of operation action of said motor, means actuated by said locking device for controlling the supply of fluid to and the exhaust of fluid from said motor in response respectively to unlocking and locking action of said device, and means for controlling said locking device.

4. In a control apparatus, a control member, a motor for moving said control member through a plurality of steps to assume a plurality of distinct control positions, a mechanical locking device for mechanically locking said control member in any of the positions, means for energizing or de-energizing said motor in response to unlocking or locking action respectively of said device, means for holding said device in unlocked or locked position to control the movement of said control member, and means for causing step-by-step movement of said controller when controlled to move through a plurality of steps, said last-named means comprising means responsive to the initiation of a control step movement for causing said locking device to return to the locked position at the end of said step and responsive to the return of said locking device to the locked position for unlocking it to cause the following control step movement.

5. Apparatus as defined by claim 2 wherein the locking device comprises a member having a plurality of notches and a detent arranged to engage said notches and characterized by two sets of means for effecting movement of said detent out of operative relation with respect to said notched member, one set of such means causing movement of the control member in one direction and the other set of such means causing movement of the control member in the opposite direction.

6. Apparatus as defined by claim 2 characterized by two sets of independently operable actuating means for said locking device each operable to effect unlocking action of the latter, one set of such means being operable to initiate operation of such apparatus in one direction and the other set of such means being operable to initiate operation of such apparatus in the opposite direction.

7. Apparatus as defined by claim 2 wherein the locking device comprises a member having a plurality of notches, and a detent for engaging said notches to lock said device, said detent being arranged to be pivoted at two points, and characterized by means for pivoting said detent at one point to unlock the same and produce movement of the control member in one direction, and means for pivoting said detent at another point to un-

lock the same and produce movement of said control member in another direction.

8. In a control apparatus, a control member, a pressure fluid motor for moving said control member through a plurality of control steps to assume a plurality of distinct control positions, a mechanical locking device for arresting the movement of said control member in any of the control positions, means actuated by said locking device and responsive to locking and unlocking action thereof to control the movement of said motor, means operable to impart unlocking movement of said locking device and operable to control step-by-step operating movement of said control member with a distinct stop momentarily arresting such movement at the end of each step, and means operable to impart unlocking movement of said locking device and to control continuous return movement of said control member.

9. In a control apparatus, a control member having a zero position, a pressure fluid motor for moving said control member from its zero position through a plurality of control steps to assume a plurality of distinct control positions and to return the same to its zero position, a mechanical locking device for arresting the movement of said control member in any of the control positions, means actuated by said locking device and responsive to locking and unlocking actions thereof to control the movement of said motor, control means operative to impart unlocking movement to said locking device, and operative to initiate movement of said control member away from the zero position, control means operative to cause movement of said control member to its zero position, and energy supply means for operating each said control means, the last said control means being operative to initiate operation of said control member to return to its zero position upon failure of said energy supply means.

In testimony whereof I have signed my name to this specification.

ABRAHAM CORNELIS COUWENHOVEN.