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(54) DISTURBANCE-INSENSITIVE REGULATING UNIT INCORPORATING A STEPPING MOTOR

(71) We, TELEFONGYAR, a body corporate organised under the laws of Hungary, of 126–132 Hungaria korut, 1143 Budapest, Hungary, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to control circuits incorporating regulating units for installations which incorporate a stepping motor, wherein the regulating unit is insensitive to disturbances which occur in the control circuit. The regulating unit comprises a protective circuit which is given the task of distinguishing from the useful signal disturbances of a pulse-like character which appear in the control input and are superimposed on the control signal and ensuring that the stepping motor carries out steps exclusively to the desired number.

In the reception section of the regulating unit, there is always provided an amplitude control apparatus which is given the task of compensating for changes in amplitude which are caused by the effect of various external disturbing influences, more especially the action of weather, such as temperature changes, lightning etc., to keep the amplitude appearing at the output of the reception section constant with a reasonable approximation wherever possible. The apparatus used for this purpose is usually provided with electromechanical regulating elements. These regulating units have the advantageous property that they usually have a storage characteristic, and thus even when there is a possible failure in supply voltage they remain at the state at which they arrived because of the action of the last regulating signal or remain at the same state when there is a switching-off, and they do not cause any unexpected uncontrollable amplitude changes in the line.

The control systems mentioned are expected to meet many requirements, namely that in the case of signals occurring by chance—which may be amplitude signals, frequency signals or signals which occur at unforeseeable times generally of a pulse-like character—the circuit may neither control nor function. The control apparatus constructed in this way must have a high degree of operating reliability since in most cases they have to operate without any supervision, far from the maintenance centre; assuming a distant supply, there is also a requirement to have a low consumption of energy and a supply unit of simple construction.

These requirements cannot in any way be met to any satisfactory extent with the apparatus known at present in other words it is not possible to meet all these requirements. The known regulating units usually comprise drives with multi-phase servomotors which involve the considerable disadvantage that on the one hand they represent continual energy consumers and on the other hand they require special medium-frequency supply units since with the small motor dimensions a satisfactory regulating force can be produced only in this way. A medium-frequency supply constitutes a separate disturbance source since during the switching operation at the switching instants the upper harmonics of the medium-frequency signal also appear, and these are radiated as disturbances from the input lines. The advantage of the regulating units which comprise regulating elements with a servomotor consist in that these are less sensitive to disturbances of a pulse-like character, and the servomotor, as an element having a storage characteristic, is capable of ensuring that the control unit does not vary its position even if the supply voltage is switched off.

In amplitude control units of apparatus used in the transmission art, regulating units with a stepping motor drive are not normally used although this solution would appear to be obvious. This would appear to be because stepping motor drives are extremely sensitive to disturbances of a pulse-like character, and a control apparatus comprising such a regulating element might take up a completely uncontrollable situation in the event of a disturbance. The stepping motor drives when there has been a series of disturbance pulses of uncontrollable number, amplitude and time length, carry out steps of uncontrollable number and in an uncontrollable direction, and the action brought about in this way causes an unallowable disturbance at the reception section.

In order to make it possible to eliminate disturbances, many experiments have been carried out but these have been unsuccessful since neither the size nor the frequency and pulse length nor the repetition time could be predetermined, so that the use of conventional filters certainly did not seem to offer a satisfactory solution.

Solutions are known—one is described for example in German published specification 2,312,170—wherein disturbances are supposed to be eliminated by the arrangement in series of a monostable multivibrator and an AND-gate; but this solution is not suitable for eliminating chance disturbances since it is only possible thereby to eliminate the disturbing action of pulses with a specific length whose repetition time exceeds a specific repetition time. But with the problem which the invention tackles the disturbances do not have the aforesaid character and instead—as already mentioned—they are of random character so that the problem is extremely complicated.

The invention has as its object to develop a regulating unit with a stepping motor which is insensitive to pulse-like disturbances, independently of the type and the amplitude magnitude of the pulse. Irrespective of whether the pulse sequence is periodic or non-periodic and whether the repetition times of the pulses are optionally fixed, the regulating unit must allow the system to operate satisfactorily in the presence of disturbance signals.

The invention therefore provides a regulating unit for amplitude control installations having a stepping motor as the regulating means, and a step reversing circuit for controlling the stepping direction of the motor wherein the control inputs of the step reversing circuit are connected to the outputs of a stepping direction evaluation circuit which receives an input control signal initiating operation of the motor, the signal input of the step reversing circuit is connected to the output of a controlled pulse generator and the output of the step reversing circuit is connected by means of at least one power switch to the excitation windings of the stepping motor, the outputs of the evaluation circuit are also connected to the inputs of an OR-gate, the output of the OR-gate is connected on the one hand to the input of a delay circuit, and on the other hand to the control input of a controlled rectangular-signal generator with an unequal mark/-space ratio waveform, the inverted output of the delay circuit is connected to one input of a NOR-gate, the output of the rectangular-signal generator is connected to the other input of the NOR-gate, and the output of the NOR-gate is connected to the control input of the controlled pulse generator.

The regulating unit according to the invention can also be arranged so that between the step reversing circuit and the power switch there is inserted a gate system whose enabling input is connected to the output of the rectangular-signal generator.

Hereinafter the invention is explained by way of example and in more detail with reference to the accompanying drawing, wherein:

Figure 1 shows a block diagram of the disturbance-insensitive regulating unit with stepping motor proposed by the present invention,

Figure 2 shows the signal shapes produced in the regulating unit according to the invention.

As Figure 1 shows, the signal input J of the regulating unit forms the input of the evaluation circuit 1. The signal, whose magnitude determines the number of steps of the stepping motor 17, or the controlled value to be set by the regulating element, arrives at the signal input J. In the evaluation circuit 1, the signal arriving at the signal input J is compared with a basic signal and in accordance with the result of the comparison issues a signal either to the right direction line 15 or the left direction line 16, whereupon because of the effect of the issued signal the stepping motor 17 carries out the necessary number of steps to the right or to the left respectively. The right direction line 15 and the left direction line 16 are connected to the control inputs of the reversing circuit 7. The control input of the reversing circuit 7 is connected to the output of a controlled pulse generator 6. The outputs of the reversing circuit 7 are connected by way of the gate system 8 to the power switches 9, the aforesaid power switches 9 operating the excitation coils 10 of the stepping motor 17. The right direction line 15 and the left direction line 16 are also connected to an OR-gate 5, the output of the OR-gate being connected on the one hand to the control input of a rectangular signal generator 2 which provides an output waveform having unequal mark and space portions and on the other hand to the input of a delay circuit 3. Preferably, the delay circuit 3 comprises a resistance 11, a capacitor 12, and an inverter 13. The inverted input of the delay circuit 3 is connected to one input of a NOR-gate 4, whereas the other input of the NOR-gate 4 is connected to the output of the rectangular-signal generator 2. The output of the rectangular-signal generator 2 is also connected with an enabling input of the gate system 8. The output of the NOR-gate 4 is connected to the control input of the pulse generator 6.

The rectangular-signal generator 2 supplies the signals "d" of Figure 2 and a division of the waveform can be made substantially into the portions consisting of the lengths of time t1 and t2. A signal will appear at the output of generator 2 only whilst a signal J is present at the control input. At the moment when the control signal is cancelled at the input the output signal also ceases, as is also shown in waveform "d" of Fig. 2.

This means that when the control signal appears again the rectangular-signal generator 2 starts its operating cycle from the beginning. The controlled pulse generator 6 produces the stepping pulses *f*, necessary for operating the stepping motor 17, as long as a signal is present at the control input J. Thus stepping pulses "f" are provided only in the conditions that the control signal J has a duration longer than the period t_1 and the NOR gate 4 is enabled during the period t_1.

After the cancelling of the signal at the control input J, at the most one error pulse can occur at the output of the pulse generator 6. The stepping pulses arriving at the signal input of the reversing circuit 7 are distributed in accordance with the signals *a*, *b* arriving at the control inputs and accordingly the stepping motor 17 carries out a rotational movement towards the right or towards the left.

As Figure 2 shows for example there is present at the right direction line 15 the signal "a" which represents a relatively long-duration logical level L. Of course in this case there is present at the left direction line 16 the signal "b" which indicates in practice the absence of a signal (logical level is equal to zero). The aforesaid signal "a" on the one hand determines the function of the reversing circuit 7, and on the other hand the signal passes by way of the OR-gate 5 to the control input of the rectangular-signal generator 2 and to the control input of the delay circuit 3. Under the action of this control signal there appears at the output of the rectangular-signal generator 2, in accordance with the regeneration time of the generator, within a short time a logical level L such as is to be seen at the signal "d". At the input of the delay circuit 3 there is present the signal "c" and at the outlet the logical level 0 occurs at the output after a period of time Δt since the output is inverted (see signal c1 in Figure 2). As a result there appears at the output of the NOR-gate 4 the signal "e" where the logical level L appears only at the beginning of time t2. During the period of time which elapses up to this instant the protective circuit determines whether the signal appearing at input J is in fact an operating signal or a disturbance signal. This is done as follows. If it is a pulse-like disturbance, the rectangular-signal generator 2 starts another cycle of operation but if a useful signal is never provided, i.e. the duration of time t1 of the input signal is never reached, signals are not issued at the output of the pulse generator 6.

The delay time Δt of the delay circuit 3 must be longer than the longest of the switching times of the gate circuits present in the apparatus and of the rectangular-signal generator 2, whereas on the other hand it must be shorter than the longer period t1 of the rectangular-signal generator 2. The logical levels L appearing at the output of the NOR-gate 4, of duration t2, control the pulse generator 6. These control signals are designated as "e" in Fig. 2. This also shows that one false pulse can occur here.

The signals corresponding to the control input appear at the output of the pulse generator 6; such a signal is for example the signal "f" shown in Fig. 2. The signal of the controlled pulse generator 6 passes through the reversing circuit 7, the gate system 8 and the power switches 9, which transmit to the excitation windings 10 the power signals necessary for operating the stepping motor 17. The aforesaid false pulse is produced for example when the signal "a" in Fig. 2, is longer than the period of time n. (t1 + t2). The gate system which is enabled by the signal "d" is given the task of eliminating the faulty pulse. As Fig. 2 shows, the signal "g" which appears at the output of the gate system 8 does not contain the faulty pulse, thus preventing a faulty step at the stepping motor.

Form the foregoing it will be clear that within the circuit arrangement according to the present invention no faulty steps occur in spite of pulse-like disturbances appearing at the input. This fact can be proved by tests, since it has not been found possible to produce a pulse resulting in a faulty step. In extreme cases when oscillations comparable with the period of the signal generator 2 were produced, there was at the most a ± 1 faulty step, although the period time of the oscillation was so long that it had a magnitude comparable with the time t1. In practice this faulty step can be regarded as equal to nil, since the regulating unit comprehends the entire control range with 300 steps of the stepping motor.

Using regulating units according to the invention, with a stepping motor, it is possible to meet all the requirements which are expected of an amplitude control apparatus used in the transmission art. The apparatus does not require special supply, it can be operated from the simple direct current supply unit of the circuit, it is not sensitive to pulse-like disturbances, and it can be kept in operation with a motor of small dimensions. The apparatus has available a storage characteristic since after steps have been carried out the stepping motor remains in its existing state even after the electrical current circuit has been switched off. With an integrated construction, the working life is substantially unlimited; fault-free operation makes it possible to use it at places without inspection, and production is simple and inexpensive.

WHAT WE CLAIM IS:—

1. A regulating unit for amplitude control installations having a stepping motor as the regulating means, and a step reversing circuit for controlling the stepping direction of the motor wherein the control inputs of the step reversing circuit are connected to the outputs of a stepping direction evaluation circuit which receives an input control signal initiating operation of the motor, the signal input of the step reversing circuit is connected to the output of a controlled pulse generator and the output of the step reversing circuit is connected by means of at least one power switch to the excitation windings of the stepping motor, the outputs of the evaluation circuit are also connected to the inputs of an OR-gate, the output of the OR-gate is connected on the one hand to the input of a delay circuit, and on the other hand to the control input of a controlled rectangular-signal generator with an unequal mark/space ratio waveform, the inverted output of the delay circuit is connected to one input of a NOR-gate, the output of the rectangular-signal generator is connected to the other input of the NOR-gate, and the output of the NOR-gate is connected to the control input of the controlled pulse generator.

2. A regulating unit according to Claim 1, wherein between the step reversing circuit and the power switches there is arranged a gate having an enabling input which is connected to the output of the rectangular-signal generator.

3. A regulating unit according to Claim 1 or Claim 2, wherein the delay circuit comprises an RC delay circuit coupled to an inverter.

4. A disturbance-insensitive regulating unit for amplitude control installations substantially as described herein with reference to the accompanying drawing.

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1598734 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

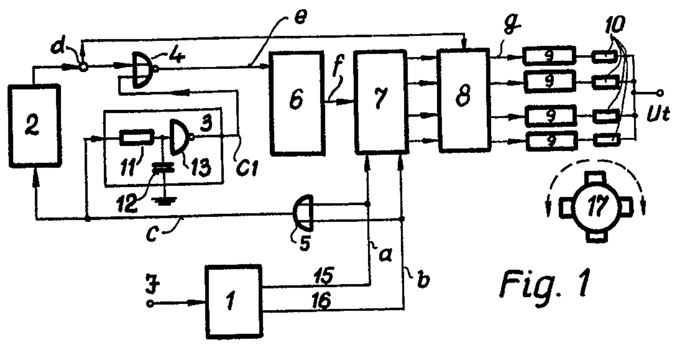

Fig. 1

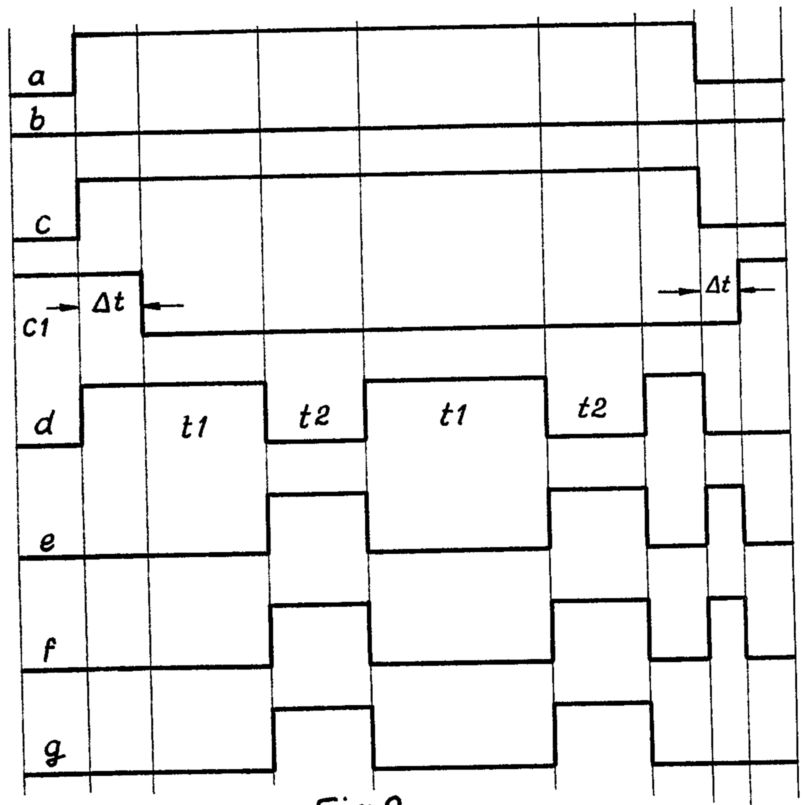

Fig. 2