61-17

REMOTE-CONTROL AND REMOTE-SIGNAL SYSTEMS

By

V. S. Malov

FTD-TT- 61-17/1+2+4

UNEDITED ROUGH DRAFT TRANSLATION

REMOTE-CONTROL AND REMOTE-SIGNAL SYSTEMS

By V. S. Malov

English Pages: 24

Source: Gosudarstvennoye Energeticheskoye Izdatel'stvo Moscow-Leningrad 1960 pp. 66-88 (Chapter 4)

SC-950
SOV/ 5079

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION SERVICES BRANCH FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

FTD-TT- 61-17/1+2+4

Date 13 Feb. 1962

P

REMOTE-CONTROL AND REMOTE-SIGNAL SYSTEMS

V. S. Malov

4-1. General Information

Remote-control and remote-signal systems, as was explained earlier, accomplish the transmission of discrete information: control commands from manufacturing establishments and notices about changes in operation in these establishments*. In both remote control and remote signalling the task comes down to the formation, transmission and interpretation of an organic number of discrete signals corresponding to commands and notices. On the strength of this, the methods of constructing remote-control and remote-signal systems are analogous. In addition, the functions of remote control and remote signalling are usually performed by general establishments. Therefore, in the future, remote-control and remote-signal systems will be examined in general and only those elements peculiar to remote control and remote signalling will be isolated.

In general case a remote-control and remote-signal system may be represented by the block diagram in Fig. 32.

---

* The transmission of continuous commands (information) is carried out considerably more rarely (mainly in the control of moving objects). In mode of signal transmission these systems are similar to remote-measurement systems.

The sending of commands from the control point (CP) is carried out by action (by hand or from an appropriate pickup) on the individual command elements (unit 1). The command-signal formation unit 2 forms signals to be sent by communications channel to the execution point (EP). Here the signal is interpreted by a selecter 3, as a result of which the individual element of execution of the given command (unit 4) begins operation. The latter acts on the executing device 5 of the object of guidance and control (including or excluding the execution mechanism, change in its position, etc.).

Changes in the conditions of the object (change in the condition of equipment, attaining limited values of the controlling parameters, ets.), including those appearing as a result of command execution, are recorded at the EP by signalling transducers 6 (unit-contacts of mechanisms, contact measuring pickups, etc.). The signalling pickup turns on the corresponding individual signal-system element (unit 7). As a result the formation unit of the information signal 8 forms a signal and sends it along a communications channel to the CP. At the CP the received signal is interpreted by a selector 9, after which the signal-system execution element 10 corresponding to the given information starts operation and switches on the signal-system indicator 11 (usually a signal lamp).

In remote control as well as in remote signalling the fundamental functions of the system are: formation of a number of signals equal to the number of messages, transmission of the signal along a communications channel and interpretation of the signal for the purpose of switching on the execution element corresponding to the signal sent. The latter operation is called selection.

There are two different methods of forming and selecting signals:

1) each of the n elements of the signal is used for transmission of one of the m messages (m is the number of pulse-signal values). In this n independent messages may be sent in each signal, and the total number of possible messages is:

$$N = mn.$$

2) Signals are formed by combining all n elements of the signal at m values of the pulse sign, i.e., the messages are coded. In this the set of all n elements of the signal is used for the transmission of one message. The total number of possible messages $N = \varphi(n, m)$ is a function of the coding method selected. In the first case of signal formation the remote-control system is multichannel (n-channel), and in the second it is a single-channel system.

Let us call the selection in the first method of signal formation direct, and combined or code in the second.

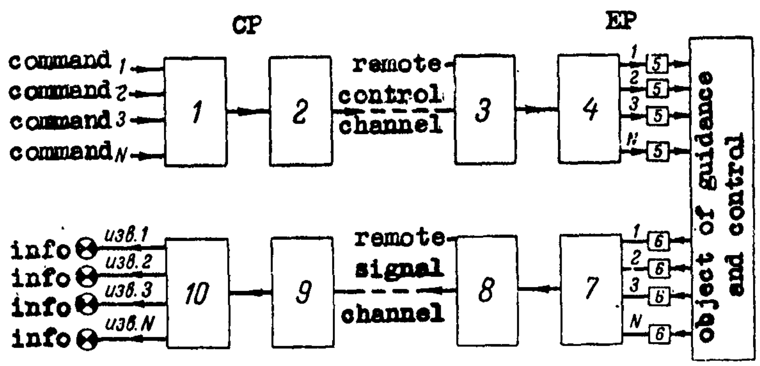

Fig. 32. General block diagram of a remote-control and remote-signal system.

1 - individual command elements; 2 - command signal formation unit; 3 - selecter; 4 - individual command-execution elements; 5 - execution device; 6 - signal-system pickup; 7 - individual signalling elements; 8 - information signal formation unit; 9 - selecter; 10 - individual signalling execution elements; 11 - signalling indicators.

In addition to the methods of selection examined, group choice is often used. In this the remote-control and remote-signal items are subdivided into groups and the selection operation is divided into two parts: a) the selection of a group to which the given item belongs and b) the selection of an item in the group. Sometimes the number of steps is increased, for example, a three-step choice is possible: group--subgroup--item.

In the case of direct selection, the group choice reduces the number of elements of the signal and, therefore, reduces redundancy.

Let N items be divided into g groups. Then the total number of signal ele-

$$n = n_1 + n_2 = g - \frac{N}{g} < N,$$

where n_1 is the number of elements of choice of the group; and n_2 is the number of elements of choice of an item in the group.

The minimum number of signal elements is obtained at

$$n_1 = n_2 \approx \sqrt{N},$$

i.e.,

$$n_1 = n_2 = \frac{n}{2}.$$

In multistep selection (l steps) this condition takes the form

$$n_1 = n_2 = \ldots = n_l \approx \sqrt[l]{N},$$

i.e.,

$$n_1 = n_2 = \ldots = n_l = \frac{n}{l}.$$

In combined choice the group selection does not reduce the number of signal elements, and for some types of codes it lengthens the signal. In similar cases group selection is used only for design considerations.

4-2. Some of the Most Important Connections and Units of Remote-Control Devices

The following are the fundamental functional connections and units of remote-control devices:

1. Pulse-sign forming devices.
2. Pulse-sign discriminators.
3. Coders } used in systems with combined selection.
4. Decoders }
5. Pulse generators } used in systems with time division.
6. Distributors }
7. Frequency selectors — used in systems with frequency division.
8. Trigger junctions — used in systems of intermittant action.
9. Output units of control and signalling.

From this list let us examine the coders, decoders and distributors, since they are the most characteristic and peculiar to remote-control devices.

Coders. Figure 33a gives the general circuit of a dual-code coder having multi-contact coding keys. The circuit was constructed for a three-element code ($n = 3$; $N = 8$). The buses z_a and z_b form circuits of the formation of the pulse-sign values "0" and "1". When one of the keys is pressed, code-pulse formation circuits are formed which correspond to the number of the coding key (1K—000, 2K—001, 3K—010, etc.).

In some cases, in order to decrease the number of key contacts, diode code circuits are used.

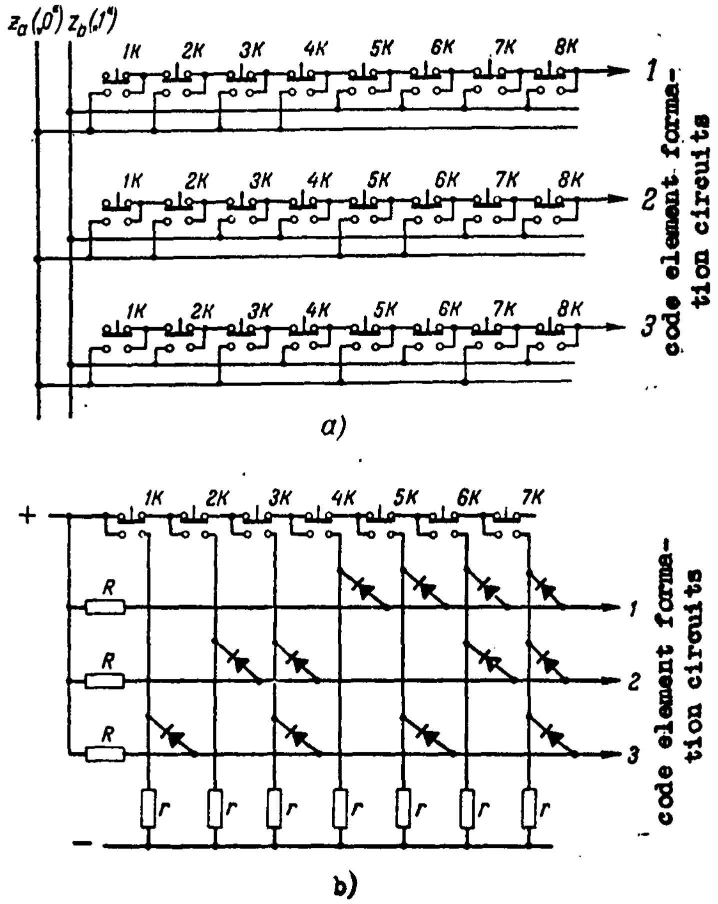

Fig. 33. Circuits of binary coders.
a - with multicontact coding keys; b - with diodes.

An example of this circuit for binary-code formation with signal transmission according to the presence or absence of a pulse is shown in Fig. 33b (the combination 000 is not used for signal transmission). In this case R ≫ r.

Coders for codes of other types are constructed in the same way.

Decoders. Most decoders use electromagnetic relays. In codes with m = 2 two relays are used for each signal element; they record the value of the pulse sign. The contacts of the recording relays form a decoding circuit. The most simple decoder circuit for a three-element binary code is shown in Fib. 34a. The indices of the recording relays correspond to the following system: the first figure indicates the number of the code element, and the second the value of the pulse sigh (0.1). For example, the relay of the third pulse, recording "0", is denoted by 30, while the relay of the same pulse, which records "L" is 31.

In contactless remote-control devices binary decoders based on lock-on circuits with two or more inputs are often used. The principle of their action was examined earlier. Figure 34 shows an example of a contactless decoder circuit for a code in one combination of the type C_5^2 (N = 0).

The recording elements are shown here conventionally as contacts of relays 11, 21, ..., 51, which when receiving a "unit", lock on the corresponding code element. In reality, the voltage is supplied to the horizontal buses by the contactless recording elements. Each output loop contains a diode lock-on circuit with two inputs. The resistors in the circuit are chosen form the condition R ≫ r. When two "units" enter the input of the corresponding lock-on circuit, a voltage is formed, since both diodes are cut off, for example, when relays 51 and 41 operate a voltage is formed at output 1.

Distributors. In relay-contact remote-control devices either telephone step-by-step switches—switches with step-by-step electromagnetic actuators—or relays serve as the distributors. The relays make up calculating circuits.

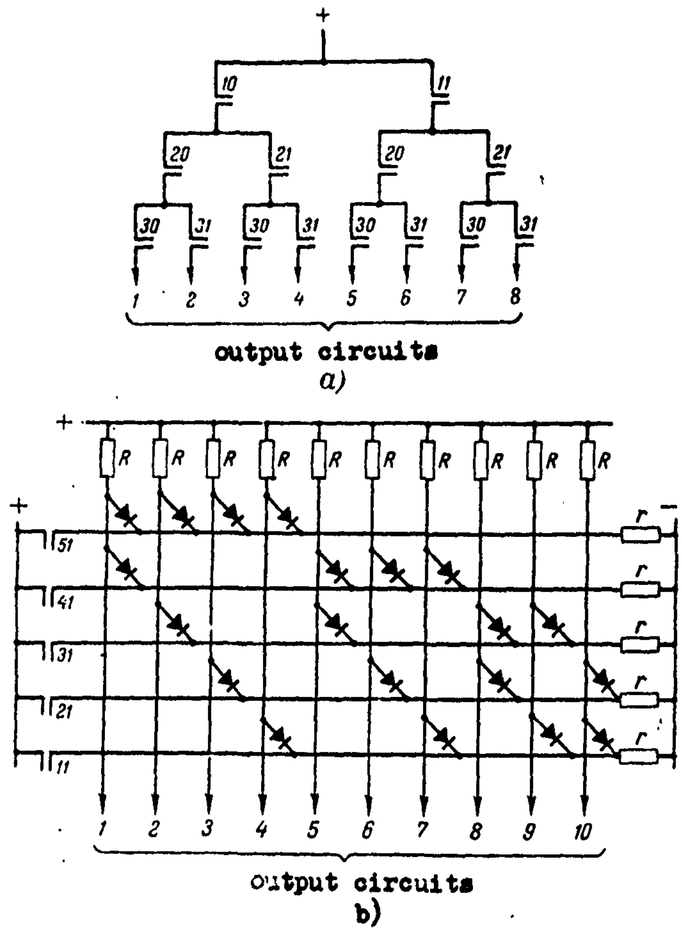

Fig. 34. Decoder circuits.

a - relay-contact binary decoder; b - binary matrix decoder of C_5^2 type code.

Two types of relay distributors are used: two-cycle and single-cycle. The first count off pulses and the intervals (pauses) between them, while the second count off only pulses (or only pauses).

Figure 35a shows the circuit of a two-cycle relay distributor. In this circuit, when the control relay P is switched periodically (i.e., when the relay is either open or closed) there occurs alternate switching on of the relay-counter C and switching off of the previous one in succession. The contacts of the relay C switch the corresponding transmission or reception circuits, (Fig. 35b).

The single-cycle distributor (Fig. 35c) has a more complicated circuit. The circuits of the relay-counter C are divided into odd and even. The division is accomplished using a two-coil relay (the coils are denoted by R_I and R_{II}). The relay R operates in two cycles: switched on during a odd pulse and the pause following it and switched off during an even pulse and pause. Because of the design of the circuit, the next relay C operates during the pause after the pulse to be counted off and switches off the previous one. Thus, the relays C switch on in numerical order. The number of switching circuits is equal to the number of pulses to be counted off.

From the number of contactless distributors, let us examine an electromagnetic circuit having a square hysteresis curve. These circuits, as relay circuits, are both single-cycle and two-cycle. Fig. 36a shows the circuit of a single-cycle distributor whose function is analogous to the relay distributor in Fig. 35a.

The cores of the electromagnets 1, 2, ..., n are made of permalloy or ferrite, which possesses a hysteresis curve nearly square in shape (Fig. 36c), This element is a passive memory cell with steady states "0" ($-B_r$) and "1" ($+B_r$). During magnetic polarity reversal of the core (transition from the state "1" t6 "0" by a negative magnetic field, or vice versa) a momentary voltage pulse is formed in the output winding. When a negative magnetizing field acts on a core in state "1" the core remains in this state and a small interference pulse is induced in the output winding, due to the fact that the hysteresis curve is not perfectly square.

The shifting of the core from the state "0" to "1" is usually called core "preparation" and magnetic polarity reversal from "1" to "0" is called "counting".

The operating principle of the circuit in Fig. 36a is the following: each core has four windings; a preparation winding w_1, a counter winding w_2, a transfer winding w_3 and an output winding w_4. In the starting position all cores except the first one are in the state "0". The first core is readied (transferred to "1") by pressing the button K_1 momentarily. Then switch K_2 shifts to the upper position and a counting pulse passes through all windings of the even cores. However, only core 1 was prepared; its polarity was reversed and an output pulse was formed in winding w_4. Simultaneously, a preparation pulse for the winding w_1 of core 2 is received from the winding w_4 of core 1. As a result, the latter core shifts to state "1".

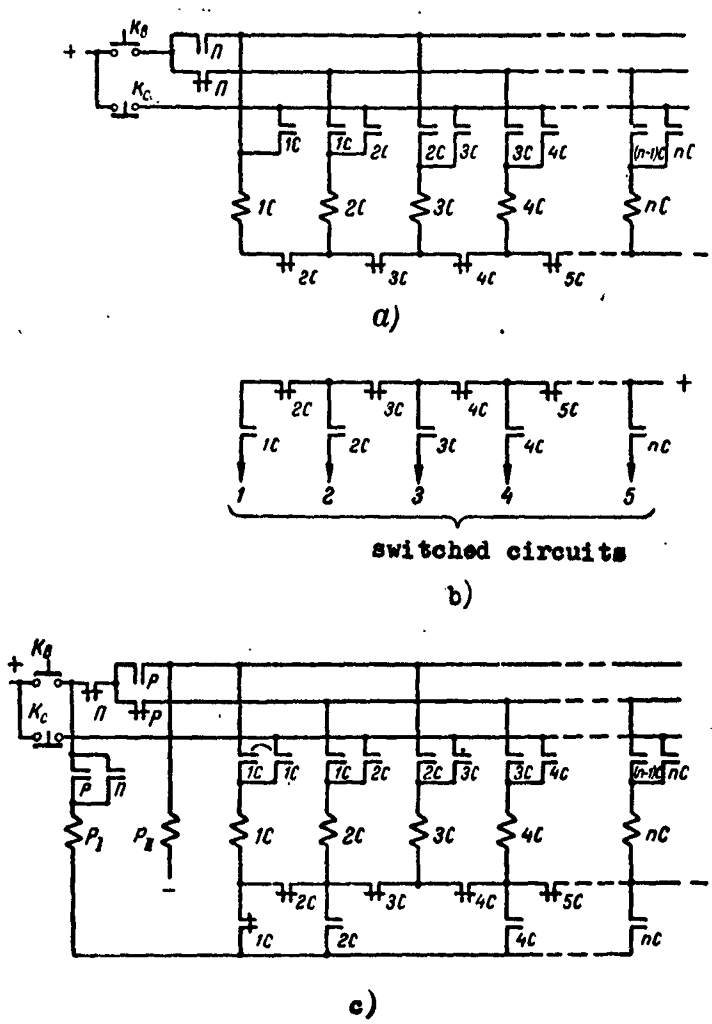

Fig. 35. Relay-distributor circuits.

a - two-cycle circuit; b - output circuits;
c - single-cycle circuit.

When K_2 shifts to the lower position, the polarity of core 2 is reversed, i.e., it shifts to state "0", a pulse is formed in its winding w_4, and core 3 is readied. When K_2 is keyed repeatedly in a similar way, preparation and counting takes place at all remaining cores and output pulses are formed in their windings w_4 (Fig. 36b). If winding w_3 of coil n is connected to winding w_1 of coil 1, the distributor will operate continuously as a closed circuit.

In actual circuits the keys K_1 and K_2 shown in Fig. 36a are absent. The control of the distributor is accomplished by contactless elements.

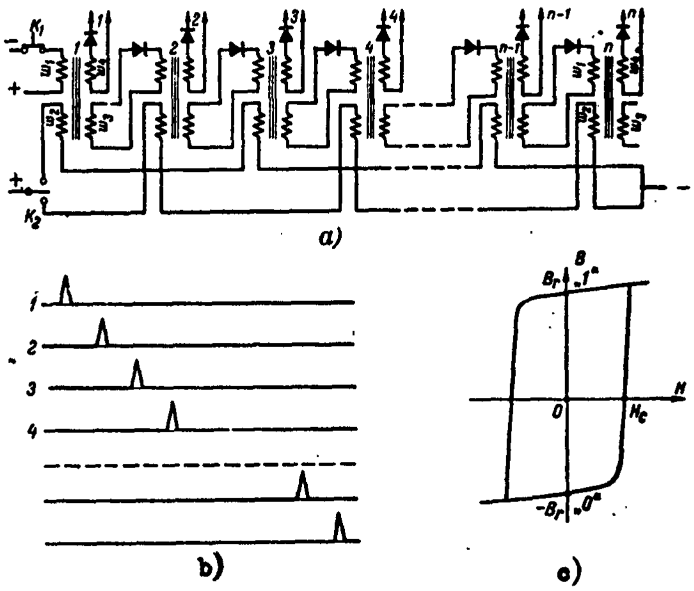

Fig. 36. An electromagnetic contactless distributor having a square hysteresis curve.

a - principal circuit; b - diagram of pulses in the output circuits; c - curve of coil magnetization.

4-3. Systems With Electrical Division (Multiwire).

Multiwire remote-control and remote-signal systems are improved types of remote-guidance systems. Usually they operate by direct selection. In order to reduce the number of connecting wires at a given number of commands and messages, several (2 to 4) pulse-sign values are used. The most customary pulse signs are polarity ($m = 2$) and magnitude (amplitude). Usually $m = 2$ is also taken for the magnitude sign. Using polarity and amplitude signs simultaneously, the total number of pulse sign values may be increased to $m = 4$.

An example of the schematic of linear circuits of this system is shown in Fig. 37. The circuit was made applicable to remote control and remote signalling of two-position object. The remote signalling of an object's position requires less current than remote control. A large instrument multiplier R_0 was put in the signalling-relay (CO, CB) circuit which signals the position of the item for this purpose. The position of the item is controlled by the unit-contacts 1B, 2B, ... To send a command by closing the contacts of key KU, the relay coil and the instrument multiplier are shunted by a low resistance R_s($R_s << R_0 + R_r$ is the resistance of the relay winding) and the current in the line is increased. The control relays (UB, UO) operate only at high current. The control and signalling circuits of the opposite positions ("switching on and off" and "switched off and on") are supplied by the positive and negative half-waves of a d. c. rectifier. Thus, four signals are transmitted by each wire: two commands and two notices.

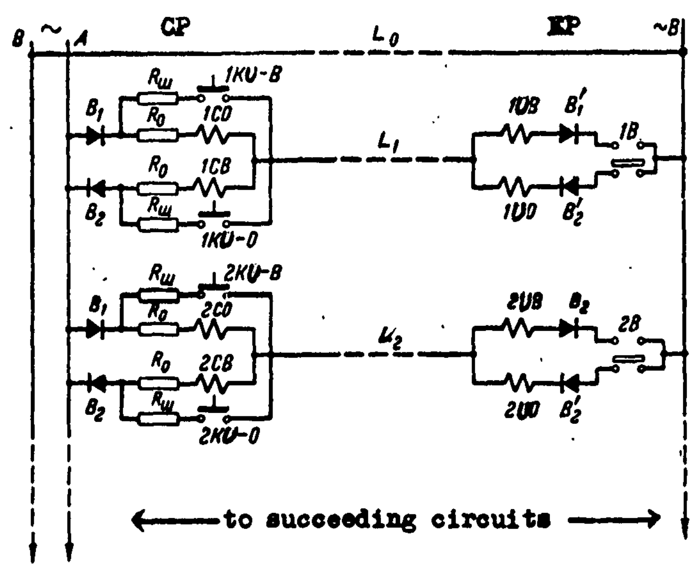

Fig. 37. Schematic of the linear circuits of a remote-control and remote-signal system.

KU—control key; CO—signalling relay of switched-off position; CB—signalling relay of switched-on position; UB—control relay switching-on; UO—control relay switching-off; 1B, 2B, ...—unit-contact of the execution mechanisms.

An increase in the number of wires in the communications line with an increase in the number of items of guidance and control makes multiwire systems uneconomic at distances in excess of 1 to 1.5 km.

4-4. Systems With Frequency Division.

Systems of this type are used mainly in the remote control of widely separated objects. The most simple version of this is a system with individual frequencies, i.e., with direct selection. Here each command or message corresponds to a definite frequency. Pulse signs are not used. Thus, the number of frequencies n is equal to the total number of commands (or messages) N.

This system has two principal drawbacks: a) a high number of frequencies used, which requires a wider working-frequency band, and b) a low noise stability, since interference at frequencies close to any of the working frequencies will lead to error.

Therefore, combined systems have gained considerably wider recognition. The codes C_n^2 are usually used in systems of this type, that is, codes with the parallel transmission of two signal frequencies at the total number of working frequencies n. The choice of this coding system is determined by two considerations. In the first place, the reduction of the number of possible frequency components during cross modulation is strived for: when there is a two-frequency signal the number of combined frequencies in the working-frequency band is minimal. In the second place, in two-frequency codes the decoding is very simple; the decoder is a combination of N lock-on circuits. In this one must reconcile the fact that at $n > 5$ combination by two increases redundancy (in comparison with the optimum combination; for example, for an even n—$C_n^{n/2}$).

The working frequencies, as a rule, are in the voice range.

The most important elements of systems with frequency division are the frequency selectors and oscillators.

Either electrical resonance (electrical selectors) or mechanical resonance (electromechanical selectors) is used as the frequency selectors. The most simple electrical selector is a series or parallel tuned circuit, sometimes in conjunction with an amplifier (Fig. 38).

Due to the insufficient selectivity of the tuned circuit, band filters are used. For comparison, Fig. 9 shows the frequency characteristics of a tuned circuit and a two-section band filter (type m and k sections) in which inductance coils with the same Q-factor are used. The advantages of the band filter are obvious. In practice, band filters are made with a pass band of 50 to 60 cps and more.

Tuning-fork (Fig. 40a) and reed (Fig. 40b) resonance selectors are among the electromechanical selectors used. In both cases the Q-factor of the oscillatory system is high (about 1,000), owing to which the pass band is extremely narrow ($\sim 0.1\%\ f_{res}$). This increases intolerably the voltage-build-up time at the output of the oscillator and requires highly stable tuning of both the selector and the oscillator.

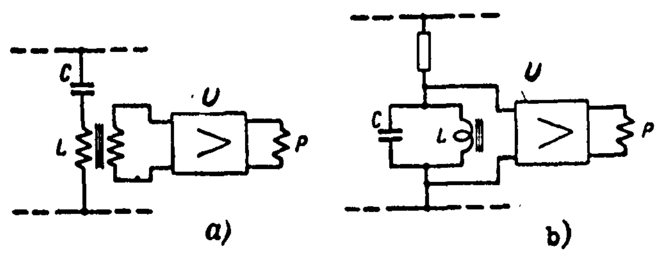

Fig. 38. The use of series (a) and parallel (b) tuned circuits as frequency selectors.

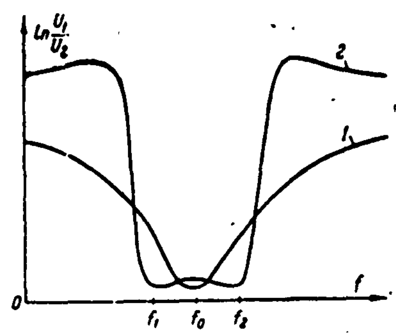

Fig. 39. The frequency characteristics of the tuned circuit (1) and band filter (2).

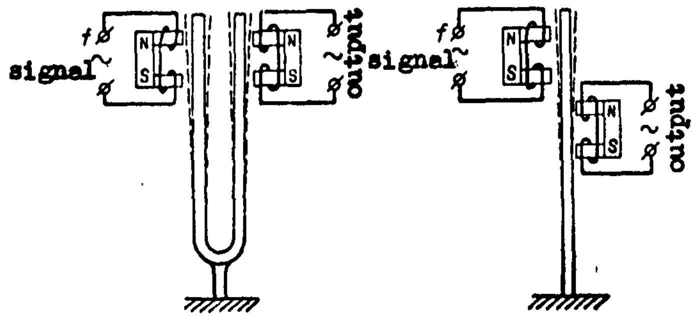

Fig. 40. Electromagnetic resonance selectors.
a - tuning fork; b - reed.

When mechanical oscillations are used for excitation and removal of the signal of polarized electromagnetic systems (Fig. 40), the latter exert a damping effect. As a result, the pass band is widened to 1% f_{res}.

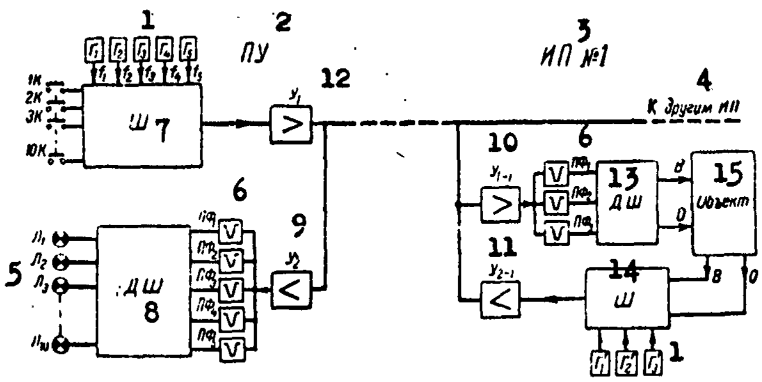

Fig. 41. Block diagram of a remote-control and remote-signal system having frequency division and combined selection.

G - audio-frequency oscillator; c - coder; A - amplifier; BF - band filter; D - decoder ; K - control key; L - signal lamp.

1) 0; 2) CP; 3) EP No. 1; 4) to other EP; 5) L; 6) BF; 7) C; 8) D; 9) A_2; 10) A_{1-1}; 11) A_{2-1}; 12) A_1; 13) D; 14) C; 15) object.

Together with these simpler electromechanical selectors, there are in use more complicated systems with several degrees of freedom. The frequency characteristics of these selectors are similar to those of the band filters.

Figure 41 shows the block diagram of a remote-control and remote-signal system having frequency division and combined selection (code C_5^2). This system is made for dispersed, two-position objects. From the control point CP, the switching signal of the objective is sent when the key K is pressed. As a result, two oscillators are connected to the amplifier A_1 and a two-frequency signal enters the line. At the execution point EP, band filters BF are set up which pass determined frequencies. When the corresponding two-frequency combination is received, the command sent is decoded and the object receives the control pulse.

The remote signal of the object's position is sent automatically when it is switched. During the course of a given time interval two oscillators are connected to the transmission amplifier A_{2-1}, forming a two-frequency signal combination. At the CP the received signal is separated by the band filters BF and interpreted by the decoder D; a signal relay operates at the output of the decoder and the signal lamp of the 0-th position of the object is switched on.

4-5. Systems Having Time Division.

Systems having time division pertain to a category of the most universal remote-control systems for concentrated objects. There are a considerable number of modifications of systems of this type. The distinguishing features of the system are: synchronization, a selection method (direct or combined), a pulse sign form, and also a means of transmitting signals (intermittent* or continuous, cyclic transmission). Until recently, systems with episodic signal transmission and stepped synchronization have been used almost exclusively. This solution was determined first of all by the properties of the apparatus to be used: electromechanical apparatus (electromagnetic relays and step-by-step selection) was used.

* In intermittent transmission, signals are sent only in one switching cycle in case new information is formed or a command sent.

The life of electromechanical apparatus is limited to a maximum number of operations, therefore, continuous (cyclic) operation cannot be allowed.

The introduction into remote-control technology of new contactless components—semiconductors and magnetic pulse components—has removed these limitations and increased the number of possible engineering solutions.

Let us first examine systems with intermittent signal transmission. The simplest of these systems with time division are those having direct selection. These are called distributor systems.

Transmission at each distributor step of an individual signal is characteristic of systems of this type. In step-by-step synchronization, each pulse acts as an information carrier as well as a distributor synchronization pulse. Pulse signs having two values (the pulse duration or the interval between pulses or polarity) are usually used. One of the two pulse-sign values is active (1) and is used for the transmission of a command or notice; the switching of the distributor is accomplished at active as well as passive (0) pulse-sign values. An example of a pulse diagram in a communications channel using polarity pulse-signs is shown in Fig. 42. Active negative pulses transmit the corresponding information signals (No. 4 and No. 6) and serve simultaneously as a synchronizer. The positive pulses are passive and are intended only for synchronization.

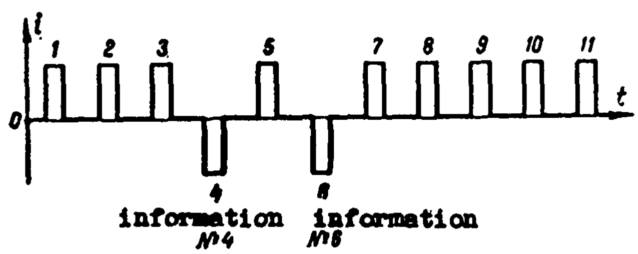

Fig. 42. Signal diagram of a distributor system with polarity pulse-signs.

The total number of messages here is equal to the number of pulses, and, therefore, to the number of steps of distribution. It is obvious that the interference stability of this system is not high, since the distortion of any pulse will lead to error; to the formation of a false signal during transition of a passive pulse into an active one or to a signal not being formed. The distribution principle is used only in remote signalling, since in this case the result of signal distortion is less dangerous, and to transmit several messages in one cycle is very tempting.

In remote control only one command is sent per cycle. This makes it possible to detect signal distortion. This method of transmission does not correspond to direct selection and in essence denotes the use of coded signals of the type C_n^1. In this case redundancy is inexcusably high since $C_n^1 < C_n^{n/2}$ (the latter code type in a single combination has minimum redundancy).

Figure 43a shows the block diagram of a remote-control—remote-signalling system of intermittent action, explaining the functions and structure of the device. The transmission of a command from the control point CP is accomplished by switching on the appropriate command key 1KU, 2KU, ... and momentarily pressing the starting button SB. The latter switches on the trigger element T_1 and thereby the pulse generator GP_1. The pulse generator controls the switching of the distributor D_1 in addition to sending pulses in the line for controlling the distributor D_2 at the EP. As a result, both distributors have synchronized switching for all practical purposes (more accurately, D_2 lags behind D_1 for the time required to transmit the pulse along the communications channel). The distributors alternately connect the corresponding control key KU and the execution circuits to the communications channel. When one of the control keys is pressed, the pulse-sign value is changed by the pulse-sign forming device PSF_1 and a pulse with an active pulse-sign value is sent.

At the EP this pulse is detected by the pulse-sign discriminator PSD_2. As a result, at a given step a circuit is formed for the operation in the unit U_2 of the output control element corresponding to the transmitted command. The command is executed after checking the correctness of the signal reception, accomplished by the shield S_2. The principles of accomplishing this protection will be explained later (§ 4-6).

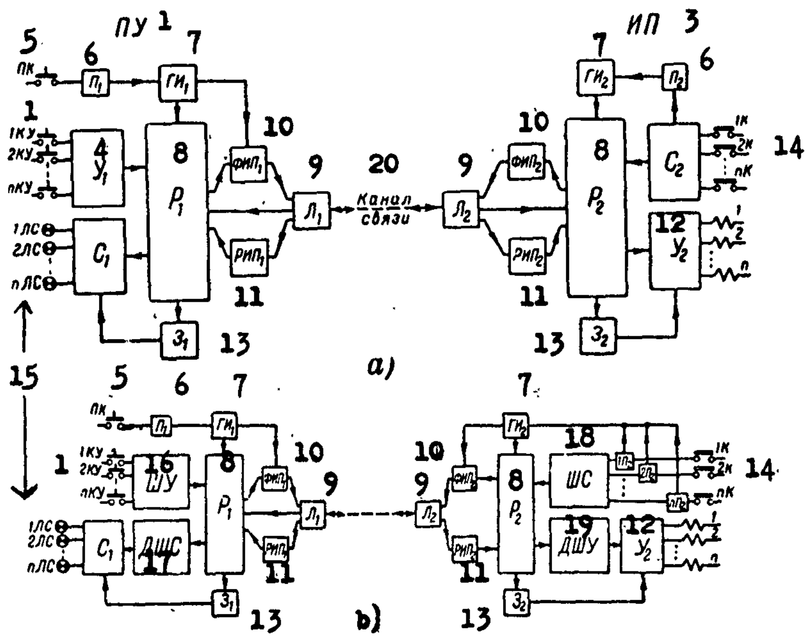

Fig. 43. Blockdiagram of remote-control—remote-signal systems having time division.

a - distributor system; b - combined system; KU - command key; SB - starting button; U_1 - individual command elements; T - trigger element; GP - pulse generator; D - distributor; L - line junction; PSF - pulse-sign forming device; PSD - pulse-sign discriminator; U_2 - individual command-execution elements; S - shield; K - unit-contact of the execution mechanism; C_2 - individual signalling elements; C_1 - individual signalling execution elements; SL - signal lamp; CC - command coder; CI - information-signalling coder; CD - command decoder; DI - information-signalling decoder.

1) CP; 2) KU; 3) EP; 4) U_1; 5) SB; 6) T; 7) GP; 8) D; 9) L; 10) PSF; 11) PSD; 12) U_2; 13) S; 14) K; 15) SL; 16) CC; 17) CI; 18) CD; 19) DI; 20) commo channel.

Remote-signal transmission is accomplished in the same way. The automatic starting of the devices (T_2, GP_2) is carried out when the unit-contact controlling the position of the objective of the signalling is switched. At the CP, the signalling output elements corresponding to pulse reception with active pulse-sign values operates in the signalling unit C_1, and the signal lamps SL are turned on. It should be noted that in the remote-signal transmission cycle, caused by a change in the state of one of the objects to be controlled, the state of not only that object but all other objects will be signalled. At the same time, all signals except the one not carrying information will therefore cause redundancy.

The line junctions L_1 and L_2 serve to separate the local and line circuits, and in addition, they are used for amplification and formation of the pulses.

Combined systems to a considerable extent repeat the structure and mechanism of the signal transmission of distributor systems, but are supplemented by coders CC and CI and decoders CD and DI in command and message transmission and reception cycles (Fig. 43b).

In recent years a number of remote-control systems with cyclic signal-transmission have been built. Contactless components are used in these systems; this makes possible continuous operation of the devices, since the life of contactless components is for all practical purposes not a function of their wear. These systems usually have distributor (direct) selection.

In the most simple remote-control systems having cyclic signal transmission, calculated at comparatively short transmission distances, synchronization of the sending and receiving distributors is accomplished from a general a. c. power-supply circuit of industrial frequency. Switching takes place once or twice per cycle of the industrial frequency. The simplified block diagram of this system of unilateral action and the diagram of the pulses in the line are shown in Fig. 44a and b. The diagram is set up for sending command No. 2.

The transmitting distributor D_I is made as a ring circuit and operates continuously, accomplishing one step per half cycle of the current. The receiving distributor D_{II} is connected as an open ring and stops after n steps. The repetitive switching cycle of D_{II} begins after reception of the synchronizing (starting) pulse C, which is to be sent in the beginning of the cycle of D_I. The synchronizing pulse differs from the other pulses (in the present case, by polarity). On the receiving side the synchronizing pulse is separated by the discriminator PSD. In this distributor control circuit, random disturbance of the synchronized switching of the distributors is corrected after each cycle.

Control-signal transmission is carried out according to whether or not the next pulse is present in the line. In the present case (sending command No. 2) only pulse 2 enters the line. In the receiver, the operation of the individual control element (D_1, D_2, ...) takes place when the pulse from the corresponding cell of distributor P_{II} agrees in time with the signal pulse entering from the line.

The circuit in Fig. 44a is intended only to illustrate the basic principle of the action of similar devices and does not contain a number of essential connections which ensure the necessary interference stability of the remote-control system.

The transmission distance for these systems is limited by the presence of a overall synchronous electrical supply and also by the stability of the phase shift angle between the voltages in the current supplies of the transmitting and receiving devices. The reliable action of the system is ensured at a phase difference not exceeding $\pm$ 45 to 90°.

Regarding this, the most universal devices are those having cyclic action, local pulse generators and cyclic synchronization (Fig. 44c). The frequencies of the generators G_1 and G_2 are approximately equal. The synchronization of generator G_2 is accomplished once per cycle by a synchronizing pulse. The frequency stability of the generators must be sufficiently high, in order that the phase difference between G_1 and G_2 not exceed the allowable number of parts of the cycle.

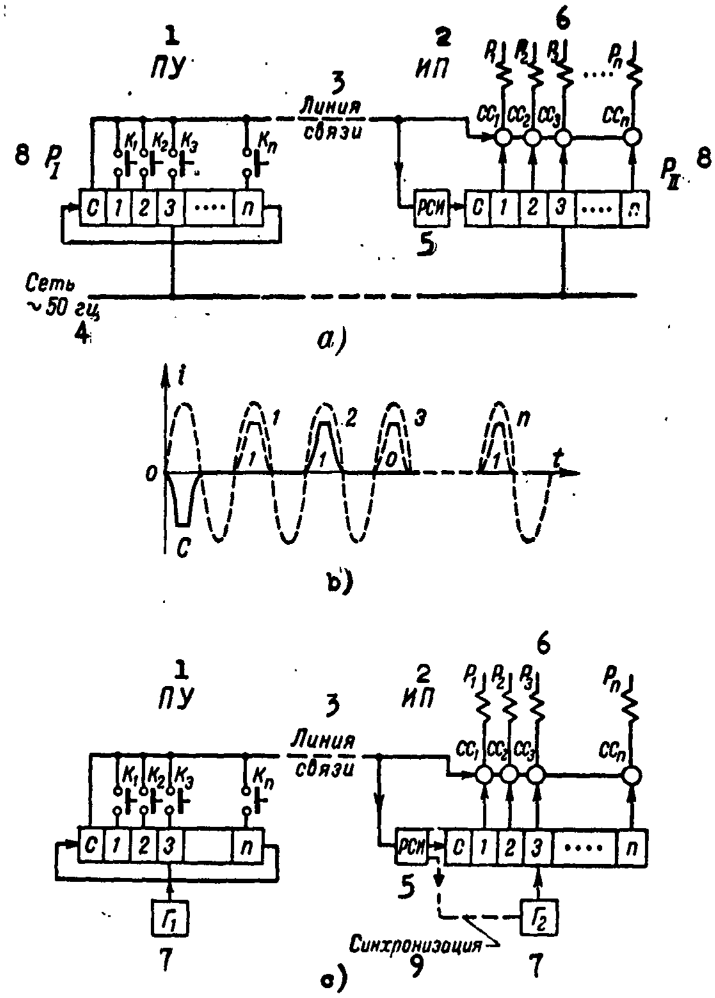

Fig. 44. Cyclic remote-control systems.

a - simplified block diagram of a system with a synchronized overall circuit; b - diagram of pulses in the communications line; c - simplified block diagram of a system with a local pulse generator; D_I and D_{II} - distributors; K_1, K_2 - command keys; CC_1, CC_2, ... - lock-on circuits; R_1, R_2, ... - execution relays; SPD - synchronizing pulse discriminator; G_1, G_2 - oscillators.

1) CP; 2) EP; 3) commo line; 4) ~50 cpp circuit; 5) SPD; 6) R; 7) G; 8) D; 9) synchronization.

4-6. Shielding from the Execution of Distorted Signals.

The interference stability of a remote-control system cannot be absolute: there always exists a certain probability of incorrect signal interpretation, caused by interference distortion. The higher the interference stability of the system the lower this probability will be. However, even a low probability of distorted-signal execution is undesirable since it can lead to serious aftereffects for the installation to be controlled.

Therefore, the receiving parts of remote-control devices are equipped with shielded components and junctions, which are intended to increase the interference stability of the system. It is obvious that shielding will not improve the inherent capabilities of the signal system itself.

With the exception of code reception with distortion correction, the shielding is constructed on the principle of locking out distorted signals.

The most satisfactory shield in unit signals is numerical, i.e., based on the number of signal elements. In systems with time division this shielding simultaneously controlls the synchronization of distributor switching in the course of a cycle.

In combined systems with codes having error detection, the functions of shielding are carried out by the decoder. In order to achieve code-shielding properties, the decoder circuits chosen must react to active ("1") as well as passive ("0") pulse-sign values of all code elements. For example, in a contact decoder, the circuit of selection for a given code is made up of the series connection of normally closed contacts corresponding to "zero", and normally closed contacts for "one".

In some code systems (in particular, in systems with frequency division) the transmission of passive elements, as a rule, is not carried out. In this case the control of the correctness of signal reception is accomplished by calculating the number of received signal elements ("ones"), which is possible in codes of the type C_n^k, etc.

Many other methods of shielding are used.

BIBLIOGRAPHY

1. B. K. Shchukin, Osnovy Tekhniki Teleupravleniya, Gosenergoizdat, 1946.
2. B. I. Domanskiy, Vvedeniye v Avtomatiku i Telemekhaniku, Gosenergoizdat, 1950.
3. V. I. Siforov, S. A. Drobov, Ya. D. Shirman and N. A. Zheleznov, Teoriya Impul'snoy Radiosvyazi, Izdaniye LK VVIA, 1951.
4. S. Gol'dman, Garmonicheskiy Analiz, Modulatsiya i Shumy, Izd. Inostrannoy Literatury, 1951.
5. G. M. Zhdanov, Teleizmereniye, Gosenergoizdat, Part I, 1951, Part II, 1952.
6. A. A. Kharkevich, Spektry i Analiz, Gostekhizdat, 1957.
7. O. A. Goryainov and R. L. Raynes, Teleupravleniye, Gosenergoizdat, 1955.
8. A. A. Kharkevich, Ocherki Obshchey Teorii Svyazi, Gostekhizdat, 1955.
9. V. S. Malov, Telemekhanika v Energeticheskikh Sistemakh, Vtoroye Izdaniye, Gosenergoizdat, 1955.
10. Tekhnika Peredachi Rezul'tatov Izmereniya po Radio, Sbornik Perevodov, Voyenizdat, 1955.
11. Telemekhanizatsiya v Narodnom Khozyaystve, Sbornik, Izd. AN SSSR, 1956.
12. S. Goldman, Teuriya Informatsii, Izd. Inostrannoy Literatury, 1957.
13. Upravleniye i Izmereniye na Passtoyanii, Sborink Perevodov, Izd. Inostrannoy Literatury, 1957.
14. M. H. Nickols and L. L. Rauch, Radiotelemetry, Izd. Inostrannoy Literatury, 1958.
15. A. V. Fremke, Teleizmereniya, Gosenergoizdat, 1958.
16. S. A. Ginzburg, I. Ya. Lekhtman and V. S. Malov, Osnovy Avtomatiki i Telemekhaniki, Vtoroye Izdaniye, Gosenergoizdat, 1959.
17. Tekhnika Peredachi Izmereniy po Radio s Raket i Snaryadov, Sbornik Perevodov, Voeynizdat, 1959.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE	Nr. Copies
HEADQUARTERS USAF	
AFCIN-3D2	1
OTHER AGENCIES	
CIA	1
NSA	2
AID	2
OTS	2
AEC	2
PWS	1
PGE	1
RAND	1

MAJOR AIR COMMANDS	Nr. Copies
AFSC	
SCFTR	1
ARO	1
ASTIA	10
TD-Bla	3
RADC (RAY)	1
SSD (SSF)	1
BSD (BSF)	1
ASD (DCF)	1
ESD (ESY)	1
AFMTC (MTW)	1
APGC (PGF)	1
AEDC (AEY)	1
AFSWC (SWY)	1