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CITY TELEPHONE CIRCUITS BY TS. L. TARASOVA AND A. S. KORNEYEV
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Translation

Fundamentals of Telephony and the Multiplexing of City Telephone Circuits

By

Ts. L. Tarasova and A. S. Korneyev

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FUNDAMENTALS OF TELEPHONY AND THE MULTIPLEXING OF CITY TELEPHONE CIRCUITS

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CHAPTER 6. KRR-M MULTIPLEXING EQUIPMENT

[Text] 6.1. General Information

The KRR-M multiplexing equipment is a version of the KRR equipment. It is installed on the city and suburban telephone network and is designed for the formation of 30-frequency telephone channels on each connecting cable pair laid between two automatic telephone exchanges. The equipment permits not only economical use of the physical circuits of this cable, but it also insures the required norms with respect to attenuation of the signal on the local telephone communications networks. The equipment is used to multiplex the symmetric circuits with MKS cordel-styroflex insulation, and depending on its capacity (1.4 or 7 quads) it permits organization of 60, 240 or 420 channels respectively. The maximum communications range over the trunks formed by the KRR-M equipment is 80 km with six repeater sections with an average length of 13 km each.

The KRR-M equipment is a multichannel high-frequency telephony system with frequency division of the channels, and it operates as a single-cable, two-band system containing type A and B offices. The frequency band from 12 to 248 kilohertz is used to transmit the currents of the 30-channel group in the direction from office A to office B; from office B to office A, the 312 to 548 kilohertz band is used. The channels are amplitude-modulated; the effectively transmitted frequency band is 300 to 3400 hertz. Upper sideband frequency currents are used for transmission to the line. The lower sideband is suppressed during modulation of the phase difference circuit by no less than 25.2 decibels (2.9 Nepers) by comparison with the usable sideband. Such comparatively small suppression of the undesirable sideband currents prevents its use for transmitting currents of the adjacent channel with respect to spectrum as a result of the possibility of crosstalk between the channels. Therefore the width of one channel in the KRR-M equipment cannot be equal to the width of only one frequency sideband (approximately 4 kilohertz), and a frequency range equal to the width of two sidebands, that is, 8 kilohertz, is allotted in the linear spectrum for each channel. The channel carrier can be calculated by the formula $F_H=304+8n$, where n is the channel number, and it is equal to 312 kilohertz for the first channel, 320 for the second channel, and so on. The carrier frequency current on the transmitting side of the current is suppressed by no less than 14.8 decibels (1.7 Nepers) by the balancing converter circuit, and it is regenerated on the receiving end.

For transmission of the interaction signals there is a segregated signal channel 100 hertz wide. The average frequency of this channel of 3800 hertz is called the signal frequency. The current level of the signal channel is 5.22±1.74 decibels (0.6±0.2 Nepers) below the current level of the speaking channel.

In addition to individual frequency conversion which takes place on the transmitting and receiving end of each channel, the KRR-M equipment also has a group conversion stage by means of which the frequency spectrum from 312 to 548 kilohertz is converted to the spectrum from 12 to 248 kilohertz in the group transmission channel of office A and the 12-248 kilohertz spectrum is converted to 312-548 kilohertz spectrum in the group receiving channel of station B. These processes are realized by means of the 550 kilohertz group carrier frequency. After group conversion the channels at office A are inverted, that is, they are reversed with respect to their arrangement in the spectrum of office B. The frequency distribution of the 30 channels in the linear spectra of offices A and B is illustrated in Fig 6.1. The group carrier is not transmitted to the line.

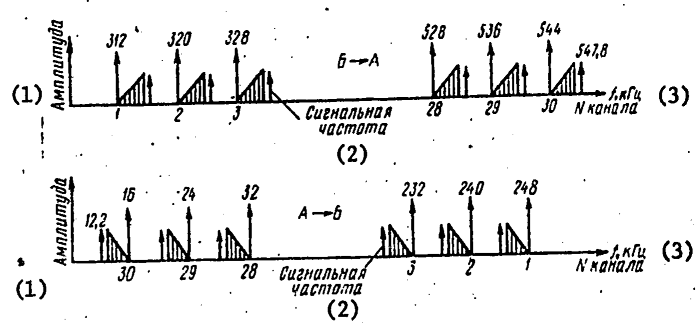

Figure 6.1. Frequency distribution of 30 channels in the linear transmission spectra of offices A and B

Key:
1. Amplitude
2. Signal frequency
3. f, kilohertz, N channels

The frequency of 8 kilohertz which is used to synchronize the generating equipment of both offices is transmitted over the group channel in the A→B direction together with the frequency band of 12-248 kilohertz.

The low-frequency terminals of the talking channel (the transmitter input and the receiver output) have a resistance of 600 ohms; the group channel junctions have a resistance of 75 ohms, and the wave impedance of the cable circuit in the operating frequency range of the equipment is 160 ohms.

In addition to the MKS cables, the KRR-M equipment can be used for operation over the TZ type cable with cordel-paper insulation and also for multiplexing the trunks of the radio relay systems.[1]

The multiplexing of the circuits of ordinary paired city telephone cables with paper insulation (type T cables) by the standard KRR-M equipment, with the construction of group equipment with respect to the two-band system and with an upper transmittable frequency of 548 kilohertz, does not appear to be possible as a result of the high attenuation constant and also insufficient protection against crosstalk of such cables on frequencies above 250 kilohertz. For multiplexing such circuits, the terminal group equipment is altered so that the operation is over a two-cable system with transmission of one frequency band from 12 to 248 kilohertz in both directions, and transistorized repeaters with a gain of 21.75 decibels (2.5 nepers) were used as the intermediate repeaters. These repeaters can be uncontrolled (NUP [uncontrolled repeater stations]) and installed in the cable manholes. This construction of the terminal and intermediate equipment permits multiplexing of a large number of type T cables previously laid in the city, and it does not require that the streets be torn up to lay new cables if the possibilities of the existing conduits have been exhausted.

It is inexpedient to use the KRR-M type equipment on the long-distance cable lines as a result of the wide frequency band allotted for one channel. The equipment requires the application of expensive quartz or magnetostrictive filters having steep attenuation buildup characteristics after the pass band in the individual channel equipment. These filters suppress the currents of the frequency sideband not used in the given channel by 50-60 decibels. This permits the use of this sideband to transmit the currents of the adjacent channel with respect to spectrum, limiting the spectrum of one channel to a width of 4 kilohertz. This construction of the individual units of the multiplexing system increases the cost of the terminal equipment, but it also lowers the cost of the intermediate equipment inasmuch as it does not require frequent installation of intermediate repeater stations along the communication line as when using the phase-difference system of suppressing one frequency sideband. The cost of the intermediate repeater stations is the most significant index of the total cost of the equipment installed on long main communication lines.

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[1]The trunk of a radio relay system is a wide-band radio channel which uses the frequency band and can combine a large number of channels and group channels formed by any multiplexing equipment. When using the KRR-M equipment the trunk of the radio relay system combines two group channels, that is, 60 channels.

6.2. Circuit Diagrams of the KRR-M on the City Telephone Trunks

The KRR-M equipment is installed on the trunks between the automatic telephone offices and also between the automatic telephone office and long-distance office. When organizing a trunk between two automatic offices the KRR-M equipment can be included in any selection stage between the IGI [I Group Selector] and the LI [connector] and on the trunk between an automatic office and a long-distance office, on any selection stage between IGIM and LIM.[1] The versions of the circuit diagrams of the multiplexing equipment between the IGI and IIGI selectors are presented in Fig 6.2.

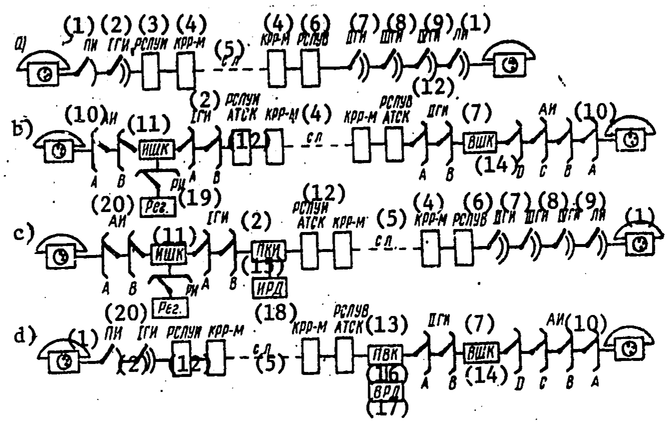

Figure 6.2. Various layouts for connecting the automatic offices of various systems through the KRR equipment channels

Key:

1. LI = connector
2. IGI = I group selector
3. RSLUI = outgoing multiplex trunk relay
4. KRR-M
5. SL = trunk
6. RSLUV = incoming multiplexed trunk relay group
7. IIGI = selector
8. IIIGI = selector
9. IVGI = selector
10. AI
11. IShK = outgoing plug connector
12. RSLUI ATSK = RSLUI for connection to the crossbar system
13. RSLUV ATSK = RSLUV for connection to the crossbar system
14. VShK = incoming plug connector
15. PKI = outgoing connection
16. PVK = incoming connection
17. VRD = incoming register
18. IRD = outgoing register
19. RI
20. Register

[1][Translator's note: M probably refers to long-distance GI and LI respectively.]

As the matching connector, outgoing and incoming multiplexed trunk relays are installed: RSLUI and RSLUV for matching with the ten-step equipment, RSLUI and RSLUV ATSK for matching with the crossbar system and RSLUIM and RSLUVM (RSLUIM and RSLUVM ATSK) on the trunks connecting with the long-distance office.

For connecting two ten-step systems (Fig 6.2a) the outgoing RSLUI is connected to the IGI selector bank, and the incoming RSLUV is connected to the IIGI wipers. When connecting two ATSK [crossbar systems] (Fig 6.2b) the outgoing system is connected to the IGI selector bank, and the incoming system is connected to the vertical of the IIGI selector. Figures 6.2c and d show the outgoing coupling from the crossbar system to the ten-step system and from the ten-step system to the crossbar system. In the former case, the outgoing RSLU [multiplexed trunk relay] is connected to the output of the outgoing connection PKI, and the incoming relay, to the IIGI selector wipers of the ten-step system. In the latter case, instead of the outgoing, the incoming connector PVK is installed on the cross-bar system. The PVK is connected to the incoming RSLU relay assembly. The PKI and PKV assemblies together with the outgoing and incoming registers IRD and VRD are needed for matched operation of the cross-bar system with the ten-step system.

The connections of the automatic offices and the long-distance offices do not differ theoretically from those presented with the exception of the fact that instead of the ordinary type GI group selectors, the long-distance selectors GIM are used, and when organizing the trunk between the selector and connector the relay assemblies RSLU are connected not to the LI [connector], but to the LIM [long-distance connector].

6.3. Composition of the Equipment and the Structural Peculiarities of the KRR-M Equipment

The KRR-M equipment includes the terminal and intermediate repeater bays. The former are called individual-group equipment bays and are made in two types: SIG-1M and SIG-30M, and the latter are called intermediate repeater bays SPU, which, depending on the type of feed, are also made in two types: SPU-2M with local feed and SPU-2D with remote feed. A S-0,9 ferroresonance voltage stabilizer is attached to each SIG-1M bay.

The external appearance of the KRR-M equipment bays is presented in Fig 6.3. In addition to the SIG-1M and the SIG-30M bays, the RSLU frames are installed in the terminal office. These frames contain plates with the trunk and differential system relays called the RSLU plates or the RSL-DS plates. In addition to the enumerated equipment, high-frequency cable boxes are installed at the terminal and tandem offices: one at the terminal office, and two at the tandem office. The boxes are made in two types: BM-2 for the four-quad 4x4 cables and BM-3 for the seven-quad 7x4 cables.

The amount of equipment required depends on the capacity of the multiplexed cable. When calculating the equipment for the terminal offices we begin with the fact that three SIG-30M bays can operate jointly with each SIG-1M bay. This set of equipment provides for the organization of 120 channels, for the repeating of which at the tandem office it is necessary to install two SPU-2M or SPU-2D bays, for each of them contains two repeater stations each. One cable pair is run to each repeater station, that is, 30 channels each. The number of trunk relay frames is selected calculating 20 RSLU relay assemblies or 30 RSLU ATSK assemblies for each frame. Fig 6.4 shows a simplified diagram of the required equipment for multiplexing four cable pairs for the case of coupling the KRR-M equipment to the ten-step system.

The SIG-1M and SIG-30M bays are put together as follows.

The SIG-1M bay contains 30-channel transceivers formed on the first cable pair; the group equipment is common to these 30 channels; the generating equipment for the 120 channels, that is, for four 30-channel systems; 120 static relays; electric power supply equipment; common signal, protective and input devices for the 120 channels.

The SIG-30M bay is auxiliary individual group equipment and it cannot be used independently without the SIG-1M bay, for there is no generating equipment or other common station equipment in it. The SIG-30M contains only 30 transceivers, the group equipment and power supplies common to them.

The switching of the SIG-1M and ISG-30M bays with the automatic office assemblies through the RSLU adapter is carried out as follows (see Fig 6.4 and 6.5). From the GI selector bank it goes through three wires a, b, c to each RSLU relay assembly; hence, after passing through the differential systems to the SIG-1M or SIG-30M bay it goes through six wires to each channel: two to transmission, two to reception of the talking channel and one each to transmission and reception of the signal channel (a ground is used as the second wire in the signal channel). From each SIG-1M or SIG-30M bay it goes to the high-frequency boxes over one pair each of the high-frequency cable. On passing through the repeater stations (if they exist), in the second terminal office this pair is run to the box in the same way, and hence to the SIG-1M or SIG-30M bays of the office. The difference lies only in the fact that whereas at the first terminal office the type A bays are installed (SIG-1M-A and SIG-30M-A), at the second terminal office type B bays are installed (SIG-1M-B and SIG-30M-B), and instead of the RSLUI, the RSLUV is installed. From the RSLUV assembly it goes through three wires a, b and c to the group selector wipers of the subsequent selection stage.

A characteristic feature of the design of the KRR-M equipment is the small size of the units, universality of their manufacture and simplicity of replacement. All the equipment is placed in the modules and plates and is installed on the bottoms of the bays insulated from the frame. The wiring of the bay is placed in the side panels of the frame and in the inside cavities of the bottom, from which it goes to special five-receptacle blocks which are fastened to the bottom. These same five-receptacle blocks fastened to the face panel are used to terminate the module installation.

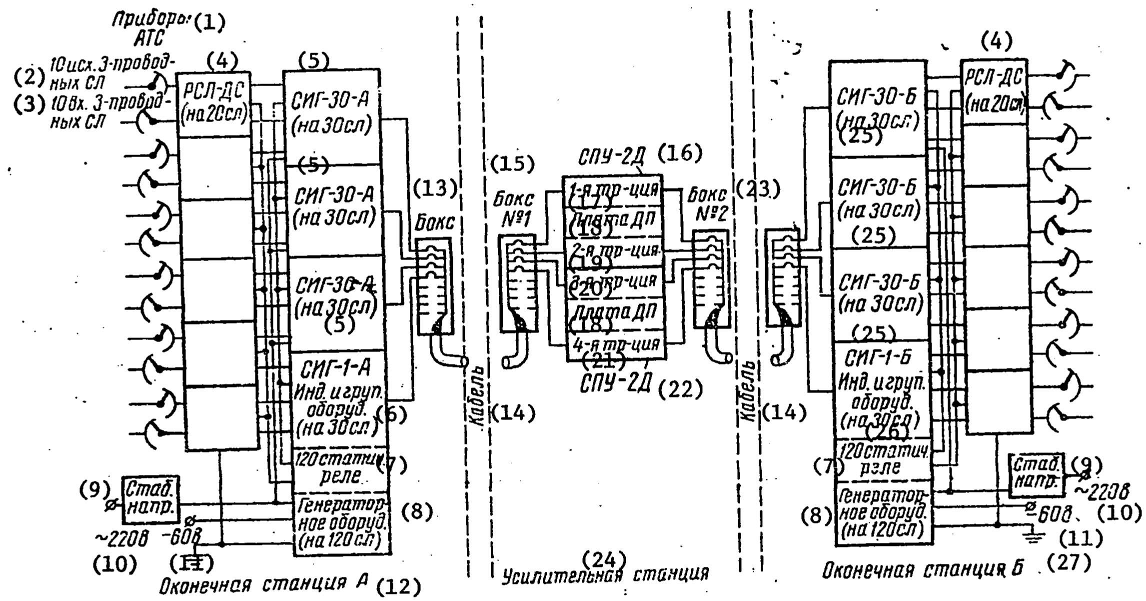

Figure 6.4. Simplified diagram of the equipment required to multiplex four cable circuits by KRR-M equipment

Key:

1. Automatic office assemblies
2. 10 outgoing 3-wire trunks
3. 10 incoming 3-wire trunks
4. RSL-DS [trunk and differential system relays] (for 20 trunks)
5. SIG-30-A (for 30 trunks)
6. SIG-1-A individual and group equipment (for 30 trunks)
7. 120 static relays
8. Generating equipment (for 120 trunks)
9. Stabilized voltage
10. ~220 volts
11. -60 volts
12. Terminal office A
13. Box
14. Cable
15. Box No 1
16. SPU-2D
17. 1st repeater station
18. DP plate
19. 2d repeater station
20. 3d repeater station
21. 4th repeater station
22. SPU-2D
23. Box No 2
24. Repeater station
25. SIG-30-B (for 30 trunks)
26. SIG-1-B individual and group equipment (for 30 trunks)
27. Terminal station B

For electrical connection of the module to the bays there are five-pronged jumpers. Some of the plates are connected by the same jumpers. All of the modules have shields. Modules of two types and sizes are used in the equipment: 75x190x246 mm^3 and 75x93x246 mm^3, which are installed three and six each on one tray respectively. In addition, on the SIG-1M bay there are plate blocks with nonstandard structural form. These are the static relay and input plates. These plates are connected to each other and to the outside mounting by wiring leads terminating in the 30-contact cut-in boxes. The same boxes are used to terminate the bay wiring of the circuits to which these plates are connected. The generating equipment is also made in the form of a plate -- the PITGO plate.

The transceiver module is built from printed circuitry and contains miniature parts. The amplifier, the modulators and the demodulator of the module are transistorized. Small elements are also used in other equipment junctions: ferrite-core armored inductance coils (OB-12, OB-20), transformers with Sh-type cores (OSh-0303; OSh-05075; OSh-0707; OSh-1215) and toroidal cores, semiconducting diodes and transistors, and the ULM, SP and other types of resistors.

In the group repeater and generating equipment modules, the 6Zh1P, 6P3S and 6P9 electronic tubes are used.

6.4. Principle of Formation of a Multichannel Signal and Transmission of It Over the Group Channels of the Terminal Offices

Each terminal office type A or B contains group and individual equipment (Fig 6.5). The individual equipment, that is, the equipment of each channel, includes the relay-switching circuitry with differential system (RSLU assembly), the individual frequency conversion devices (modulator and demodulator) placed in the ПП transceiver module (the receiver and transmitter are depicted separately in the figure) and the circuits providing for the transmission and reception of the control and interaction signals: static relays on transmission and the PSU control signal receiver on reception of the signal channel. The individual channel equipment and process of formation of the multichannel group signal are identical for offices A and B, and it takes place in the following way. For subscriber talking, the audio-frequency currents with a level of -13.05 decibels (-1.5 neper) go from the automatic office circuits through the RSLU assembly to the channel input. By using a differential system executed in the form of a bridge, to the different diagonals of which the channel transmitter and receiver are connected, the transition is made from the two-wire low-frequency channel to the four-wire channel of the multiplexing equipment. The carrier frequency F_{π} corresponding to the channel number is fed continuously from the generator equipment to the same modulator. As a result of modulation at the transmitter output, the upper sideband currents are formed (the lower sideband currents and the carrier are suppressed during the modulation process).

Inasmuch as the carriers are high-frequency oscillations from 312 to 544 kilohertz with an interval of 8 kilohertz, when talking over 30 channels the audio-frequencies from 0.3 to 3.4 kilohertz, modulating these carriers, are converted to the high-frequency spectrum from 312.3 to 547.4 kilohertz. Let us explain this in the example of calculating the sidebands of certain channels.

Channel No 1. The carrier F_{H1}=304+8·1=312 kilohertz. The upper sideband $F_{B\ b}$ is obtained as a result of addition of the carrier and the effectively transmitted voice frequency band 0.3 to 3.4 kilohertz. $F_{B\ b}$=312+(0.3-3.4)= 312.3 to 315.4 kilohertz.

Channel No 2. The carrier F_{H2}=304+8·2=320 kilohertz. The upper sideband $F_{B\ b}$=320+(0.3 to 3.4)=320.3 to 323.4 kilohertz.

Channel No 30. F_{H30}=304+8·30=544 kilohertz. F_{Bb}=544+(0.3 to 3.4)=544.3 to 547.4 kilohertz.

Thus, on the common input of the group equipment of the system a multichannel signal was formed which takes up the spectrum from 312.3 to 547.7 kilohertz, and considering a frequency of 3.8 kilohertz on which the interaction signals are transmitted, to 547.8 kilohertz or rounded from 312 to 548 kilohertz. The transmission level of this signal is -50.46 decibels (-5.8 nepers) on a resistance of 75 ohms.

The group channels of offices A and B are different in view of the fact that the KRR-M equipment operates by the two-band system.

The auxiliary repeater BY_{c2}[1] with average gain of 5.6 decibels (1.8 nepers) is at the transmission channel input of the A office. The purpose of the repeater is preamplification of the group signal to the level required for normal operation of the group frequency converter in this channel. The output level of the repeater is -32.5 decibels (-4.05 nepers). From the output of the auxiliary repeater the group signal goes to the D-552 low-frequency filter. The filter suppresses all the interference frequencies going beyond the limits of the operating spectrum of the equipment, by which overloading of the group converter is prevented. In the converter the frequency band of 312 to 548 kilohertz is shifted to the 12-248 kilohertz range using the 560 kilohertz group carrier.

The converter is assembled from diodes in a ring circuit. As a result of the simultaneous effect of the 312-548 kilohertz spectrum and the 560 kilohertz carrier, two modulation sidebands are formed:

upper sideband F_{Bb}=560+(312-548)=872-1108 kilohertz,
lower sideband F_{Hb}=560-(312-548)=12-248 kilohertz.

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[1] In Fig 6.5, the repeaters for the lower group of frequencies from 12 to 248 kilohertz have the index 1, and the upper group from 312 to 548 kilohertz, the index 2.

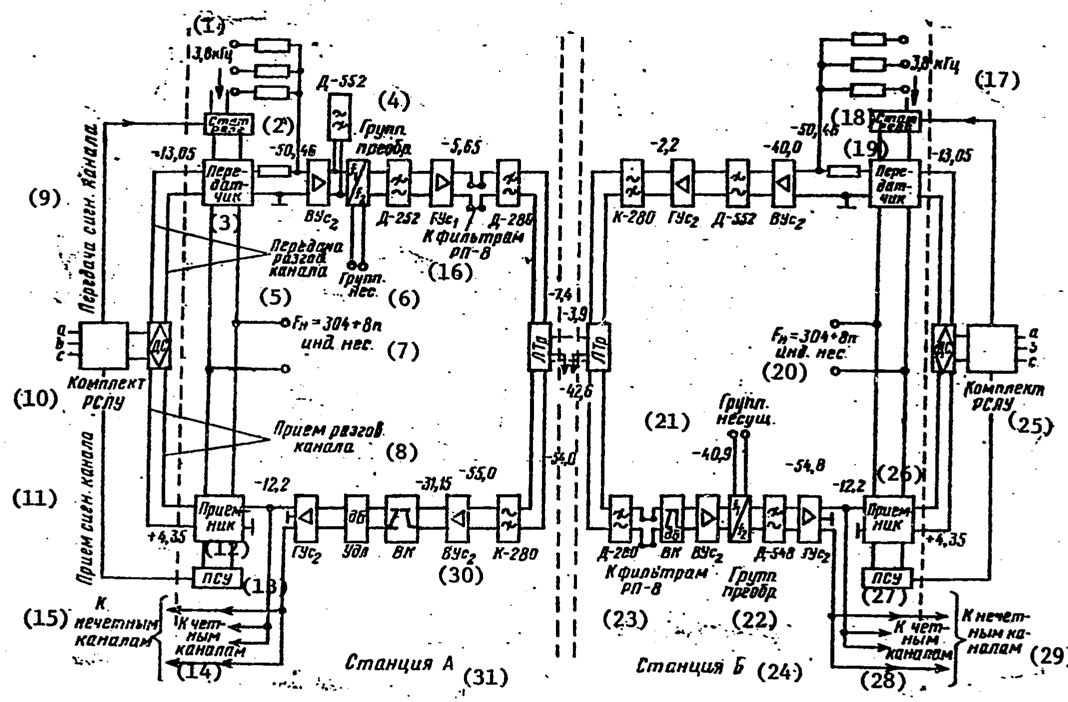


Figure 6.5. Structural diagram of the terminal offices of the KRR-M equipment

Key:

1 -- 3.8 kilohertz; 2 — static relay; 3 -- transmitter; 4 -- group converter; 5 -- talk channel transmitter; 6 — group carrier; 7 — individual carrier; 8 — talk channel receiver; 9 -- signal channel transmission; 10 -- RSLU relay assembly; 11 -- signal channel reception; 12 --receiver; 13 -- PSU; 14 -- to the even channels; 15 — to the odd channels; 16 -- to the RP-8 filters; 17 -- 3.8 kilohertz; 18 -- static relay; 19 -- transmitter; 20 -- individual carrier; 21 -- group carrier; 22 -- group converter; 23 -- to the RP8 filters; 24 -- office B; 25 -- RSLU relay assembly; 26 -- receiver; 27 -- PSU; 28 -- to the even channels; 29 -- to the odd channel; 30 -- auxiliary repeater; 31 — office A

Thus, a frequency spectrum of 12-248 kilohertz on which transmission is realized from the office A was obtained in the output of the group converter.

For suppression of the undesirable (in the given case upper) sideband and the remainder of the carrier, the D-252 filter is included after the converter. It passes the currents with a frequency above 252 kilohertz. The group repeater GY_{c1} with gain of 40.75 decibels (5.05 nepers) raises the signal level to -5.65 decibels (-0.65 nepers).

On the SIG-30A base the currents in the frequency band of 12-248 kilohertz then go through the D-280 routing filter and the line transformer to the line. The routing filter is used to separate the transmission and reception frequency band of the office, and the line transformer, to match the 75-ohm output of the filter to the 160-ohm input of the cable circuit and transition from the asymmetric filter circuit to the symmetric circuit of the two-wire line circuit.

The line transformer winding has a midpoint lead for organizing a phantom circuit linked between operators and for transmission of remote feed to the intermediate repeaters. The group signal in the lower frequency group of 12-248 kilohertz having a transmission level of -7.4 decibels (-0.85 nepers) is transmitted through the line transformer from the office A to office B. In this frequency group the carrier of each channel can be defined as [560-(304+8n)], and the currents of the channel itself have frequencies below the carrier.

Examples. The useful sideband of the first channel occupying the frequency band of 312-316 kilohertz at the input to the group channel will be transmitted over the line at frequencies of 560-(312-316), that is, from 244 to 248 kilohertz, and a frequency of 248 kilohertz will correspond to the 312 kilohertz carrier.

The 30th channel occupying the spectrum of 544-548 kilohertz is shifted to the 12-16 kilohertz range, and the 544 kilohertz carrier will correspond to 16 kilohertz.

In the SIG-1A bays, the P-8 rejector filter having an attenuation peak on a frequency of 8 kilohertz and operating in a pair with the П-8 filter (only the point of their connection is shown on the figure) is included at the output of the group repeater. These filters are needed for organizing a synchronizing channel, and they are considered in the section on the generating equipment of the terminal offices.

The purpose of the group receiving channel of office B consists in converting the signal in the 12-248 kilohertz spectrum arriving from the opposite office to the signal with 312-548 kilohertz spectrum, repeating of it, distribution with respect to the receivers of the 30 channels and compensation for the frequency-amplitude distortions.

A line transformer of the same purpose as at office A is included at the input of the channel. The current level at the input of the transformer is -42.6 decibels (-4.9 nepers). From the transformer output the group signal goes to the routing filter D-280 and, passing through the fork of the RP-8 filters (if it is the SIG-1M) or directly (if it is the SIG-30M), it goes to the BY_{c1} auxiliary repeater. The links of attenuation equalizers and attenuator are in the same module with the repeater. The operating principle of the equalizer BK (equalizing or correcting circuit) was investigated in Chaper 4. Here we shall only point out that out of the set of four links, one link BK is used to compensate for the distortions introduced by the two series-connected D-280 routing filters, one of which is at the output of the transmitting channel of the office A, and the other at the input of the receiving channel of office B; the other two compensate for distortions introduced by the cable network section, and the fourth element is an attenuator and is used for rough (stepped) adjustment of the level of the receiving signal. The smooth regulation of the level is realized by the variation in depth of the negative feedback of the repeaters (auxiliary and group) by means of the variable resistors, the shafts of which are led out to the front panel of the module. From the output of the BY_{c1} the multichannel signal in the 12-248 kilohertz spectrum with a level of -40.9 decibels (-4.7 nepers) goes to the group frequency converter, to which the group carrier frequency of 560 kilohertz is fed simultaneously from the generating equipment. As a result of conversion, two sidebands are obtained: the upper sideband 560+(12 to 248), that is, 572 to 808 kilohertz, and the lower sideband 560-(12 to 248), that is, 312 to 548 kilohertz. The D-548 filter which follows the grid converter suppresses all of the unnecessary conversion products, passing only the useful sideband from 312 to 548 kilohertz. The currents of these frequencies then go to the GY_{c2} group repeater where they are amplified to a level of -12.2 decibels (-1.4 nepers) required for operation of the receiver, and then they are distributed with respect to the receivers of the 30 channels. In order to increase the protection between channels, the output of the group receiving repeater is made in accordance with a differential circuit (the transformer with a midpoint) providing for the connection of two groups of 15 receivers each not connected to each other: the even and odd channels.

The band filter at the input of each receiver separates the frequency band of its channel from the group signal, which then is demodulated, being converted to a low-frequency signal from 0.3 to 3.4 kilohertz, it is amplified to a level of +4.35 decibels (+0.5 nepers), and from the output of the receiver it is routed through the RSLU relay assembly to the automatic office equipment.

The transmission channel of the office B differs from the transmission channel of office A in that the office B transmits a frequency band of 312 to 548 kilohertz formed directly in the transceiver models of the 30 channels in the direction of office A, and therefore it does not require group frequency conversion. The absence of a group converter excludes the necessity for the D-252 filter. The remaining elements of the group channels of the two offices are identical.

The group signal with a level of -50.46 decibels (-5.8 nepers) goes to the input of the auxiliary repeater. The repeater increases the signal level to -40 decibels (-4.6 nepers). The D-552 filter suppresses all of the frequency components above 552 kilohertz. The group repeater amplifies the signal, bringing it to a level of -2.2 decibels (-0.25 nepers).

On passing through the routing filter K-280 and the line transformer, the group signal, occupying the frequency spectrum from 312 to 548 kilohertz and having a transmission level of -3.9 decibels (-0.45 nepers) is transmitted over the line circuit to the office A.

The group signal occupying a spectrum of 312-548 kilohertz which can be distributed directly, without conversion, to the receivers of the 30 channels goes to the receiving channel of office A; the signal level at the input of the line transformer is equal to -54 decibels (-6.2 nepers). Only preamplification and further amplification of the signal by means of the auxiliary repeater BYc_2 and the group repeater GYc_2 and also the compensation for the frequency-amplitude distortions are carried out in this channel. The signal level at the input of the line transformer is -54 decibels (-6.2 nepers). Then passing through the K-280 routing filter, the group signal goes to the module containing the repeaters and equalizers. The links of equalizers are made up analogously to how this is done in the receiving channel of station B, but the parameters are different, for they are designed for another frequency band. The group repeater brings the receiving signal level to -12.2 decibels (-1.4 nepers), and distributes it with respect to two groups of receivers of the even and odd channels. Further processes are identical in both offices.

6.5. Signal Channel

In contrast to the nonmultiplex circuits, where the interaction signals are transmitted directly by battery power (direct current), the methods of signal transmission by audio-frequency currents are used in the multiplexing equipment. In the KRR-M equipment the segregated individual channel approximately 100 hertz wide located above the effectively transmitted frequency band of the speaking channel is available for this purpose. The average frequency of this channel -- the signal frequency -- is 3800 hertz.

For organization of the signal channel the transceiver module has circuits designed for signal frequency voltage input to the transmitting section and output of it from the receiving section of the channel. In each channel there is an electronic relay called a static relay which controls the operation of these circuits. The static relay is an electronic relay made from a low-frequency transistor in accordance with the single-stage amplification circuit with common emitter (Fig 6.6), and it is included between the 3800 hertz voltage source and the channel transmitter. Depending on the condiction of its circuitry, the static relay transmits or does not transmit signal frequency voltage to the channel. This occurs as follows: at the connection times when interaction signals are not transmitted over the channel, the transistor emitter circuit is broken by the contacts of the relays in the RSLU assembly (in the circuit these contacts are provisionally replaced by a group of control contacts p). In this case the stage is closed, and the signal frequency does not pass through it. In other connection phases when the channel is busy, a number is dialed, ring-off is being realized and the RSLU assembly circuits are adjusted to the corresponding states, the contacts of the relays of these assemblies close the positive feed circuit of the battery to the transistor emitter. Accordingly, the transistor is opened, and the signal frequency voltage amplified by it goes to the transceiver module. In the channel transmitter the signal frequency passes through the same modulation circuit as the talk signal, as a result of which the upper sideband frequency F_H+3.8 kilohertz is transmitted over the group channel to the opposite office.

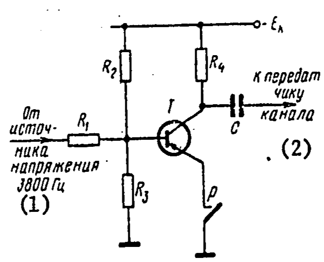


Figure 6.6. Static relay of the channel

Key:
1. From the 3800 hertz voltage source
2. To the channel transmitter

On the receiving end of the channel after demodulation the 3.8 kilohertz voltage goes to the control signal receiver PSU, where it is rectified, DC amplified and provides for operation of the servomechanism -- the relay in the RSLU assembly. This relay, on responding, adjusts the assembly circuitry so that the call, ring-off or other state is created. Thus, on the outgoing side of the channel, the DC pulses in the 3800 hertz signal frequency sending are converted by the static relay, and on the incoming side of the channel, on the contrary, the signal frequency is converted to DC pulses by means of the PSU [control signal receiver].

The use of the static relay insures reliable operation of the signal channel for it creates a large signal frequency level gradient in the open and closed state. With the static relay open, the current at the output of the PSU (the operating current of the PSU) $I_p=45\pm5$ milliamps, and with the static relay closed the quiescent current of the PSU I_π is no more than 0.5 milliamps.

There are 120 static relays in the SIG-1M bay on four plates of 30 each. The power is fed to the plates from a 24 or 60 volt station battery.

6.6. Channel Transceiver

General Information

The transceiver is the basic module of the individual channel equipment, and it is used for conversion of the talking and signal currents to high-frequency currents on the transmitting end of the channel and inverse conversion of the high-frequency spectrum to the currents of the initial voice frequencies, and the signal frequency sending to DC pulses on the receiving end of the channel.

Structurally, the transmitter and the receiver are made on separate plates using printed circuitry.

The structural diagram of the transceiver is depicted in Fig 6.7.

The basic assemblies of the transmitter (plate No 1) forming the talk channel are as follows: the UDl_1 attenuator, the Tp_1 input transformer, the D-3,4 filter, the ΦK_1, ΦK_2, ΦK_3 phase-shifting circuits, two modulators M_1 and M_2, the output transformer Tp_2 and attenuator UDl_2. For the signal channel there is an F-3,8 filter on the transmitter plate.

The receiver plate (plate No 2) contains the following: the band filter ПΦ, the demodulator DM, the band-elimination filter Z-8, the low-frequency amplifier UNCh loaded with respect to the talk channel on the D-3,4 filter, and with respect to the signal channel on the control signal receiver PSU. The latter consists of the signal frequency band filter Pf sign., the amplifier-detector Us-D and the trigger circuit. In addition, the receiver plate contains the voltage stabilizer Ct, from which the entire transceiver module except the PSU is fed.

The purpose of the individual assemblies and the operating principle of the module will be considered with respect to its schematic diagram presented in Fig 6.8.

Transmitter Plate

From the relay-switching circuit of the channel (the RSLU assembly) the speaking currents with a level of -13.0 decibels (-1.5 nepers) go to the transmitter input (terminals K_8-K_{10}). The input impedance of the transmitter equal to 600 ohms is created by means of the attenuator R_1, R_2, R_3, R_4; the attenuation of the attenuator is 3.48 decibels (0.4 nepers).

The symmetrizing transformer Tp_1 realizes the transition from the symmetric circuit of the attenuator to the asymmetric circuit of the filter and

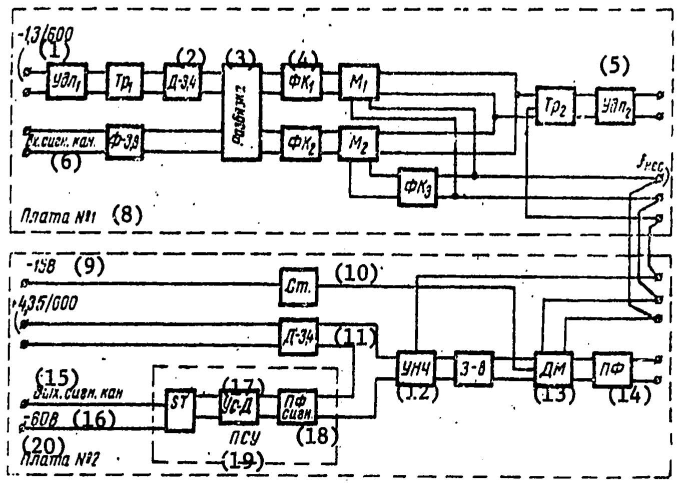


Figure 6.7. Structural diagram of the transceiver

Key:

1. UDl_1
2. D-3,4
3. Decoupling
4. FK
5. UDl_2
6. Input signal channel
7. $f_{carrier}$
8. Plate No 1
9. -15 volts
10. St.
11. D-3,4
12. UNCh
13. DM
14. PF band filter
15. Output signal channel
16. -60 volts
17. Us-D
18. Pf sign. [signal frequency band filter]
19. PSU
20. Plate No 2

eliminates direct coupling of the transmitter circuit to its output. A capacitor C_1 with a capacitance of 0.1 microfarads, the second plate of which is connected to the ground is connected to the midpoint of the primary winding of the transformer. The capacitor is used to suppress pulse interference penetrating the channel.

The D-3,4 filter made up of the inductance coils L_1, L_3, L_4, L_5 and the capacitors C_3, C_4, C_5, C_6, C_7, C_8 and C_9 suppresses the components of the speaking signal with frequencies above 3.4 kilohertz. The speaking spectrum of the subscribers contains higher frequencies which on being transmitted through the speaking channel can cause incorrect operation of the signal channels of its own and the adjacent spectrum and also create interference in the adjacent speaking channels. Thus, a frequency of 3.8 kilohertz, passing through the D-3,4 filter of the transmitting end of the channel during talking, will be picked up as a signal frequency on the receiving end by the signal channel receiver. As a result, the relays in the RSLU

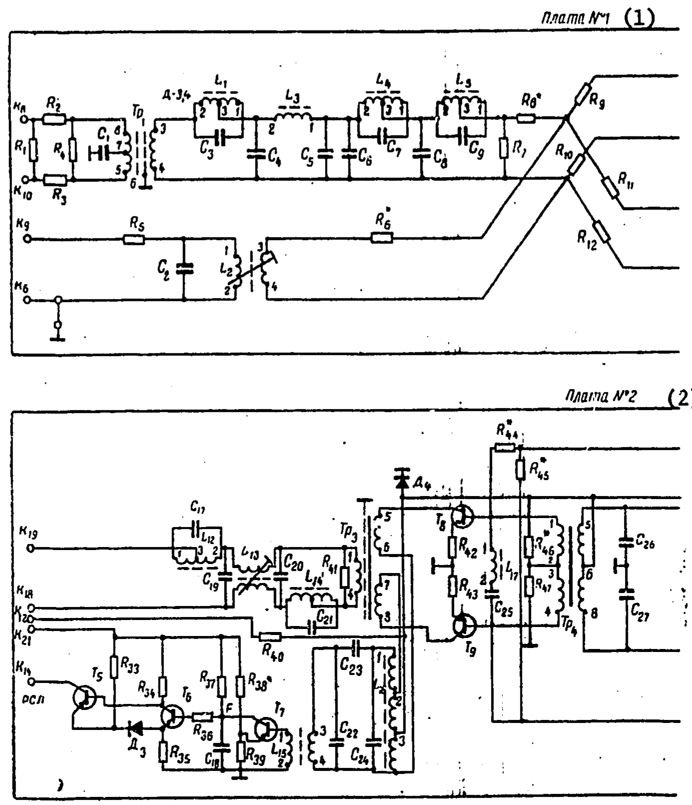
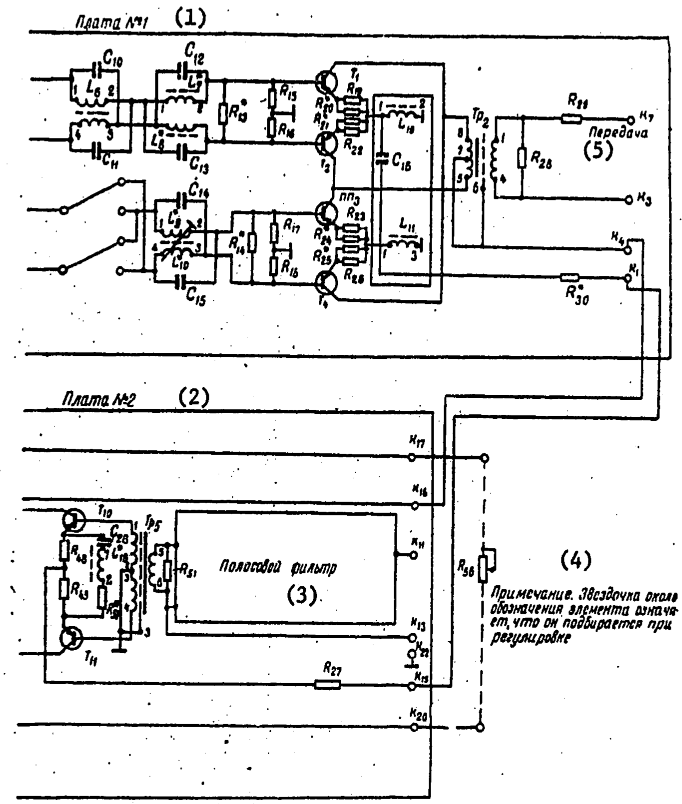


Figure 6.8. Schematic diagram of



a transceiver

Key:

1. Plate No 1
2. Plate No 2
3. Band filter
4. Note. The asterisk next to the designation of an element indicates that it is selected during adjustment
5. Transmission

assemblies will respond, and the subscriber will be sent a busy signal during the conversation. The currents with a frequency of 4.2 kilohertz, reaching the adjacent channel, after demodulation in it, will have a frequency of 3.8 kilohertz (8.0-4.2=3.8). This will be the cause for improper operation of the adjacent signal channel. In addition, the currents with frequencies above 4.2 kilohertz (frequencies to 12 kilohertz can be contained in the subscriber voices), getting into the adjacent speaking channels, after demodulation in them, will be converted to effectively transmitted frequency bands of these channels and cause interference in them.

In order to avoid the indicated interference in the adjacent signal and speaking channels, the D-3,4 filter has attenuation peaks on frequencies of 3.8 and 4.2 kilohertz, and at frequencies above 4.6 kilohertz its attenuation must also remain quite high. The frequency characteristic of the filter attenuation is presented in Fig 6.9. The attenuator R_7, R_8 and the decoupling resistors R_9-R_{12} are used to match the filter to the phase-difference circuit for suppressing one sideband.

The signal frequency current, passing through the static relay, reaches the input of the signal channel (the terminals K_9-K_6), where the Φ-3,8 band filter is included made up of the resonance circuit L_2C_2 and the resistor R_5. On a frequency of 3.8 kilohertz the circuit has current resonance and introduces minimum attenuation. From the frequency characteristic of the filter presented in Fig 6.10 it is obvious that on detuning the circuit, its attenuation increases sharply. The presence of the filter at the input of the signal channel decreases the interference in the adjacent channels on transmission of the number dialing pulses. The signal frequency pulses are not sinusoidal voltage of one frequency 3.8 kilohertz, but they contain a number of other frequency components, the voltages of which taken together could cause significant interference in the adjacent channel if they were not suppressed by the filter. In addition, the filter Φ-3,8 plays the role of a symmetrizing transformer providing for the transition from the asymmetric circuit of the static relay to the symmetric phase-difference circuit.

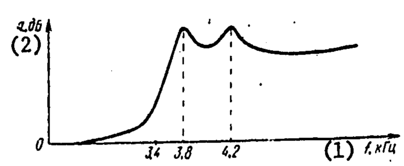


Figure 6.9. Frequency attenuation characteristic of the D-3,4 filter

Key:
1. f, kilohertz
2. a, decibels

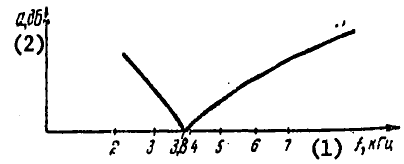


Figure 6.10. Frequency attenuation characteristic of the Φ-3,8 filter

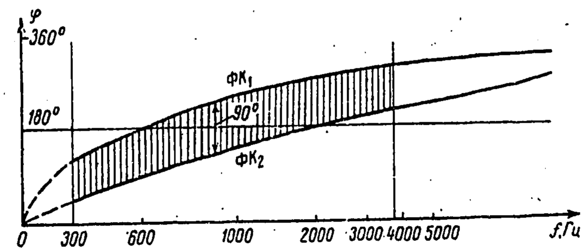
Key:
1. f, kilohertz
2. a, decibels

The signal frequency voltage is fed through the resistor R_6 to the phase-difference circuit. By the selection of this resistor the signal frequency level is set 5.21±1.74 decibels below the measuring level in the channel.

After the D-3,4 and Φ-3,8 filters the speaking and signal channels are joined together, and from there on they run through the same elements of the phase-difference circuit which is divided into two branches -- I and II -- by the decoupling made up of the resistors R_9, R_{10}, R_{11} and R_{12}.

The phase-difference circuit is used to convert the low-frequency signals to high-frequency oscillations containing only one modulation sideband, in the given case, the upper one. Let us remember that in the KRR equipment in order to decrease the cost of the terminal equipment, the channel transceivers do not contain complex, expensive filters which suppress the currents of the sideband not used in the given channel (and also other side conversion products), and the suppression of these currents is realized by the phase difference modulation circuit, the principle of which was investigated in Chapter 4. In contrast to the previously presented layout with one phase-shifting circuit $ΦK_1$, here in each branch of the circuit I and II there is a $ΦK_1$ and $ΦK_2$ circuit inasmuch as in practice it is impossible to create a circuit which will insure a single phase shift for a voltage of any frequency from 300 to 3800 hertz; the higher the current frequency, the greater the phase shift it acquires, on passing through the circuit, as is obvious from Fig 6.11. The required phase ratio between the currents reaching the modulators of branches I and II can be obtained only as the difference in the phase shifts created in each of the branches by the corresponding circuit $ΦK_1$ and $ΦK_2$. Here, as is obvious from the figure, the relative phase shift of 90° remains constant for the currents in the entire spectrum from 300 to 3800 hertz.

The phase shifting circuits $ΦK_1$ and $ΦK_2$ are sections made up of series and parallel-connected inductance coils and capacitors: L_6, C_{10}, C_{11}, L_7, L_8, C_{12}, C_{13}, L_9, C_{14}, C_{15}.



(1)

Figure 6.11. Relative phase shift between the branches of the phase-difference circuit

Key:
1. f, hertz

The ΦK_3 circuit is designed for creating a phase shift by 90° only for the current of one carrier frequency, and it is the section made up of the inductance coils L_{10}, L_{11} and the capacitor C_{16}. The circuit is included so that the carrier voltage reaches the modulator M_2 directly from the GIN [individual carrier generator?], that is, without a phase shift, and it reaches the modulator M_1 through the circuit. For introduction of identical attenuation by both branches of the circuit, there are resistors R_{13} and R_{14}, the ratings of which are selected.

The channel modulators are executed from the P416 high-frequency transistors in a balancing circuit which eliminates the carrier frequency current from the converted signal. In contrast to the balancing converter circuitry presented in Chapter 4, the differential input transformers are replaced by the resistors R_{15}, R_{16} and R_{17}, R_{18} by means of which grounded midpoints are formed. These same resistors connected in parallel to the high-resistance input circuitsof the transistorized modulators are the load for the phase-shifting circuits.

The low-frequency signal is fed to the transistor bases, and the carrier voltage to the emitters through the resistors R_{30} serving as the decoupling between the carrier circuits of the different channels fed from one GIN.

For temperature stabilization of the operating conditions of the modulators, the basic resistors R_{20}, R_{21}, R_{24}, R_{25} and the auxiliary resistors R_{19}, R_{22}, R_{23}, R_{26} are included in the emitter circuits of the transistors. By varying the ratings of the latter it is possible to regulate the amplification of the modulators by equalizing the attenuation of both branches of the phase-difference circuit.

The feed voltage of -9 volts is fed to the modulators through the midpoint of the output transformer Tp_2. The second terminal of the power supply is grounded. The transformer Tp_2 is simultaneously the load through which the converter currents of both modulators flow. Let us remember that the currents of the upper sidebands coincide with respect to phase and are added, and the currents of the lower sidebands are opposite in phase and are subtracted.

The degree of suppression of the lower sideband depends on the accuracy of achievement of the relative phase shift by 90° of the initial conversion products and also it depends on the equality of the attenuations in the branches of the phase difference circuit. Inasmuch as in the KRR equipment the goal was not stated of locating the adjacent channel in the spectrum of the suppressed sideband, in order to decrease the cost and simplify the individual equipment of the channels we are limited to suppression of the lower sideband by only 25.2 decibels (2.9 nepers), that is, attenuation of it by approximately 20 times by comparison with the useful sideband. This value is sufficient for the fluctuations of the useful signal level and, in the final analysis, the residual attenuation of the channel not to exceed ±0.43 decibels (±0.05 nepers).

The L-type attenuator R_{28}, R_{29} serving as the decoupling between the individual channels combined with respect to secondary winding of the output transformer and connected in parallel to the input of the group equipment of the system is included at the output of the circuit. For normal operation of the channels, the mutual coupling between them is small as a result of high output resistance of the collector circuits of the transistors, but if as a result of failure in any channel a short circuit appears in one modulator, then operation over all 30 channels becomes impossible. The R_{28}, R_{29} attenuator attenuates the coupling between the channels and simultaneously serves for establishment of the required magnitude of the output impedance of the plate.

The useful signal current level at the output of the transmitter with 30 parallel-included transmitters is equal to -50.46 decibels (-5.8 nepers) on a load resistance of 75 ohms.

The application of the phase-difference modulation circuit made it possible to standardize the transceiver module. The only replaceable assembly of the transmitter is the ΦK_3 phase-shifting circuit in the carrier circuit. All the remaining plate assemblies are identical for all 30 channels.

Channel Receiver

The high-frequency group signal occupying the frequency spectrum of 312-548 kilohertz and having a level of -12.2 decibels (-1.4 nepers) on a load of 75 ohms goes to the channel receiver. The ПФ (PF) band filter designed for separation of the currents of its own channel from the group signal is included at the input of the receiver (terminals K_{11}, K_{13}). The frequency damping characteristic of the filter does not have great steepness; its pass band is approximately 10 kilohertz. The basic purpose of the filter consists in limiting the power of the signals reaching the demodulator and capable of causing overloading of it and distortions in the channels.

Having such a wide pass band, the filter does not introduce sufficient attenuation for the currents of the near frequencies of the adjacent channels (the channel in the KRR equipment occupies a band 8 kilohertz wide). Therefore, in order to avoid crosstalk the channel receivers are separated into two groups -- even and odd. Inside each group the channel filters are connected in parallel, and the two groups are decoupled by means of a differential system included at the output of the group receiving amplifier (see Fig 6.28).

The band filter is the only assembly of the receiver which is different for each of the 30 channels, and it is executed structurally in the form of a separate removable plate element.

From the filter output the high-frequency signal goes to the demodulator, at the input of which the Tp_5 matching transformer is included. The demodulator is executed from two high-frequency transistors T_{10} and T_{11} with respect to the balancing circuit. The high-frequency signal which is subject to conversion is fed to the transistor bases; the carrier is fed to the emitter circuits, and the demodulated low-frequency signal is picked up from the collector circuits.

The resistors R_{48}, R_{49} in the emitter circuits have the same purpose as in the modulator circuit. The circuit C_{28}, L_{18}, R_{50} with voltage resonance on a frequency of 3.4 kilohertz is designed to decrease the negative feedback on the upper frequency of the speaking spectrum on which the demodulator creates reduced gain (in the transceiver modules of the KRR-M equipment the transistorized converters operate in a mode insuring not only signal conversion, but also signal amplification). The capacitors C_{26} and C_{27} in the output circuits of the transistor shunt the remains of the carrier and the upper sideband, and the useful demodulation products -- the lower sideband currents -- reach the demodulator load circuit through the transformer Tp_4. Power is fed through the midpoint of this transformer to the collector circuits of the transistors. The circuit L_{17}, C_{25} with voltage resonance on a frequency of 8 kilohertz is connected in parallel to the secondary winding of the transformer. This voltage is formed in the demodulator as the difference product between the remains of the carrier frequencies of the two adjacent channels and, on passing through the low-frequency amplifier UNCh, can cause crosstalk of the adjacent channel. The circuit prevents the currents of this frequency from reaching the input of the low-frequency amplifier. The circuit L_{17}, C_{25} jointly with the capacitors C_{26}, C_{27} form the band-elimination filter Z-8.

The low-frequency amplifier contains one amplification stage made from the transistors T_8, T_9 with respect to the two-cycle circuit. This type of circuit decreases the nonlinear distortions of the amplifier, as a result of which crossovers of the currents in the channels can appear along with false operation of the signal channel (sending of the busy signal during a conversation).

The resistors R_{46} and R_{47} create the required bias on the bases of the transistors, and the transistors R_{42} and R_{43} in the emitter circuits are used for stabilizing the amplification conditions. The collector circuits are fed through the midpoint of the primary winding of the output transformer Tp_3. The output level of the signal is regulated roughly (step regulation) by the aligning resistors R_{45} and R_{44} and the continuously variable resistance R_{56} included in parallel to the input of the amplifier and shunting it. The smaller this resistance, the smaller the gain of the amplifier. Here the resistor R_{44} does not permit complete shunting of the input of the amplifier or making its amplification extremely small, and the resistor R_{45} does not permit making it extremely large. The regulating resistance R_{56} equipped with an arm and dial is led out to the front panel of the unit and permits adjustment of the gain within the limits ± 4.35 decibels (± 0.5 nepers). Two loads are connected to the output of the low-frequency amplifier: the D-3,4 filter with respect to the speaking channel and the PF sign filter with respect to the signal channel.

The D-3,4 filter contains inductance coils of L_{12}, L_{13}, L_{14} and the capacitors C_{17}, C_{19}, C_{20}, C_{21} and, in contrast to the analogous filter installed on the plate of the transmitter, it is made by the symmetric scheme, for it is the last link of the receiver directly connected to the symmetric circuit of the RSLU assembly. The filter D-3,4 delays the currents with frequencies above 3.4 kilohertz, that is, the signal frequency current of its own channel and the currents of the adjacent channels having frequencies above 4.2 kilohertz at the demodulator output and this eliminates the interference and the noise in the channel. The signal level of the filter output is +4.35 decibels (+0.5 nepers) on a load of 600 ohms.

The control signal receiver is designed for receiving the signal frequency sending from the transmitting end of the channel and conversion of them to DC pulses required for operation of the relays (K or RZ) installed in the RSLU assemblies. The contacts of these relays create interaction signal transmission circuit to the automatic office devices. In order to insure reliable and stable operation of these relays, the current in their coils must either be completely absent (for example, on transmission of a conversation over the channel) orhave maximum value (for transmission of the interaction signals). Therefore the PSU must operate as a switch having only two states: closed-open; the transition from one state to another must take place not gradually, but discontinuously. The trigger circuit is most appropriate for the creation of such a regime.

The PSU contains the PF sign band filter made up of the coils L_{15}, L_{16}, the capacitors C_{22}, C_{23}, C_{24} and insuring its frequency selectivity, the detector amplifier based on the transistor T_7 and the trigger circuit executed from the transistors T_6, T_5. (The operating principle of the trigger circuit is investigated in Chapter 4.) A version of the asymmetric circuit -- a Schmidt trigger is used in the PSU of the transceiver module.

The trigger can be found in only one of two states: where the transistor T_6 is completely open, and the transistor T_5 is closed or when T_6 is closed and T_5 is completely open. Any other state is extremely unstable for it as a result of which it goes discontinuoutly from one state to another. This takes place as a result of positive feedback between the transistors through the resistor R_{35}. The feedback voltage developed on this resistor has always directed so that it decreases the negative potential of the base of the closing transistor and increases it on the base of the opening transistor.

In the initial state when the signal at the PSU input is absent or its voltage is less than the threshold voltage (the voltage drop on the resistor R_{39}), the transistor T_7 is blocked. The negative potential of the power supply is fed through the resistors R_{36} and R_{37} to the base of the transistor T_6. For such a low potential on the base the transistor T_6 is completely open and the current passing through it creates a voltage drop on R_{35} which closes the transistor T_5 through D_3, and the relay in the RSLU simply does not operate.

If the input voltage exceeds the threshold voltage, then in the negative halfperiod of this voltage the transistor T_7 opens, and the current in the circuit increases:

Plus, R_{39}, T_7, R_{37}, minus and the base potential of T_6 increases (it becomes less negative).

The transistor T_6 begins to close, and the resistance of its collector-emittor section increases. As a result, the negative potential of the base of the transistor T_5 increases, and the collector current begins to flow through it. Since the collector current of T_5 is much greater than the collector current of T_6, the voltage drop on the resistor R_{35} increases as a result of which T_6 closes even more and T_5 opens. This promotes a still greater increase in the collector current of the transistor T_5 and a voltage drop on R_{35}, and, consequently, more complete blocking of T_6. The process takes place in avalanche manner, as a result of which T_6 closes in practice discontinuously, and T_5 opens completely. The relay included at the output of PSU responds.

If the signal amplitude at the input of the receiver becomes less than the threshold value, then T_7 closes, and the base potential T_6 becomes more negative. T_6 begins to open from this, shunting the base circuit T_5, the collector current of which begins to decrease. The decrease in the current causes a reduction in the voltage on the resistor R_{35}, which promotes more complete blocking of T_6. The base circuit of T_5 is shunted more strongly, and the collector current of this transistor and the voltage drop on the resistor R_{35} decrease still more. The process, just as in the preceding case, builds up avalanche-like, as a result of which T_6 in practice opens discontinuously, and T_5 closes completely. The relay at the PSU output ais triggered, and the circuit goes to the initial state.

Thus, PSU has two stable states: open where the signal voltage at the input of the receiver exceeds the threshold voltage, and closed, where the signal at the input of the receiver is absent or its voltage is less than the threshold voltage. Correspondingly, the current in the relay winding with open receiver is equal to the operating current (and the relay operates), and with a closed receiver it is equal to the quiescent current (and the relay does not operate). This ch: acteristic of the trigger PSU permits us to obtain its highest noisepr . ess. Actually, the interference penetrating to the input of the receiver cannot cause false response of it (if the voltage of this interference is less than the threshold voltage).

The operating current of the PSU is 45±5 milliamps, the quiescent current does not exceed 0.5 milliamps. The PSU is fed from a separate voltage source of -60 volts in order not to create interference in the talk channels from the current pulses of the signal channel through the common power supply. The output transistor T_5 of the trigger circuit is fed from the automatic office battery through the relay circuit of the RSLU assembly. For stabilization of the feed voltage of the transistors on the receiver plate there is a D814B type silicon stabilitron, by means of which a constant voltage is maintained. The stabilization principle is illustrated in Fig 6.12. The circuit diagram of the stabilizer is presented in Fig 6.12a, and its volt-ampere characteristic is presented in Fig 6.12b.

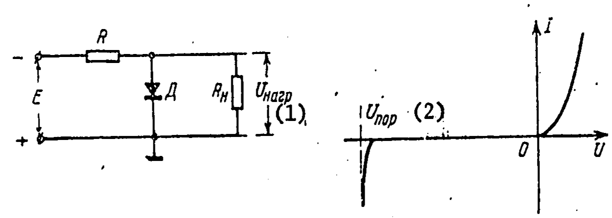


Figure 6.12. Voltage stabilization in the transceiver module

Key:

1. U_{load}
2. $U_{threshold}$

Under the effect of positive and small negative voltages the characteristic of this diode does not differ in any way from the analogous characteristics of ordinary silicon diodes. However, as soon as the negative voltage reaches the threshold value $U_{threshold}$, the current through the diode increases sharply as a result of a sharp decrease in its internal impedance which will become equal to 10-20 ohms.

As is obvious from the figure, the load resistance R_H is included parallel to the diode, and the ballast resistance R is connected in series to the voltage source E. For small values of E below the threshold, the current in practice does not flow through the diode, and all the voltage E is distributed between R_H and R. When the voltage on the stabilitron reaches the threshold value, with a further increase in it, the current through the stabilitron will increase sharply. This additional current causes an increase in the voltage drop on the ballast resistance R so that the voltage on the diode almost does not change, leaving it equal to the threshold voltage (in the given case 9 volts).

6.7. Generating Equipment

General Information

The generating equipment of the terminal office generates all the voltages required for operation of four KRR-M equipment systems: 30 individual carrier frequencies of the channels beginning with 312 to 544 kilohertz, every 8 kilohertz; the group carrier 560 kilohertz; the signal frequency 3.8 kilohertz and the synchronizing frequency 8 kilohertz. The equipment is constructed by the harmonic system with a reference frequency of 8 kilohertz.

The structural diagram of the generating equipment is presented in Fig 6.13. The reference frequency voltage selected by the master oscillator ZG with quartz stabilization goes through the differential transformer Tp_2 to the harmonic generator ΓΓ made up of two parts structurally executed in different modules: the power amplifiers Yc ΓΓ and the nonlinear system HC ΓΓ. The nonlinear system converts the sinusoidal current of reference frequency to the current having the form of the curve with sharp pointed pulses of positive and negative polarity. Such a current contains a large number of odd harmonics of the reference frequency.

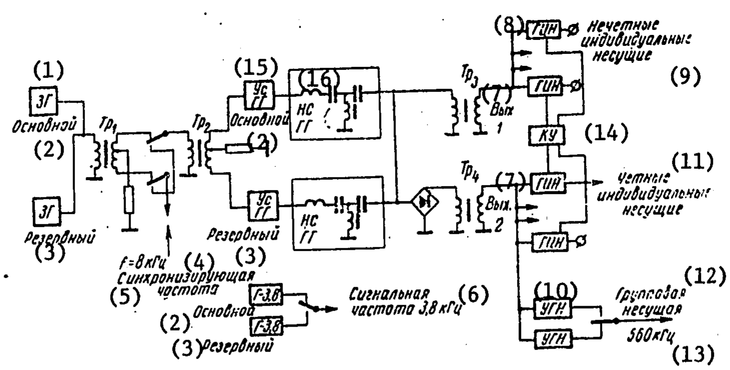


Figure 6.13. Structural diagram of the generating equipment

Key:

1 -- ZG = master oscillator; 2 -- basic; 3 -- reserve; 4 -- f=8 kilohertz; 5 -- synchronizing frequency; 6-- signal frequency 3.8 kilohertz; 7 -- output; 8 -- GIN = individual carrier generator; 9 -- odd individual carrier; 10 -- UGN = group carrier repeater; 11 -- even individual carriers; 12 -- group carrier; 13 -- 560 kilohertz; 14 -- monitor; 15 -- harmonic generator power amplifier; 16 -- harmonic generatornonlinear system

In order to obtain the even harmonics, the rectifying diode bridge is used at the output of which a train of one sign is formed containing only the even harmonics of the reference frequency.

Generators of the odd individual carrier frequencies are connected to the first output, and even to the second.

The reference frequency harmonics are separated by the narrow-band filters, they are amplified and are used to stabilize the individual carrier frequencies of the channels. These processes are realized in the individual carrier generators GIN. The GIN has two outputs: basic and monitor. From the basic output the carrier voltage goes to the transceiver module for realizing the modulation and demodulation processes, and from the monitor output, to the monitor module KY, by means of which the operation of the GIN is monitored. The GIN inputs are connected to the even and odd outputs of the harmonic generator in parallel 15 each. The basic and reserve group carrier amplifiers (560 kilohertz) YГH are also connected to the even output.

In addition to the enumerated equipment, the generating equipment of the terminal office includes two (basic and reserve) signal frequency 3.8 kilohertz generators and devices for transmitting and receiving the synchronizing frequency. Synchronization causes forced operation of the harmonic generators of different offices from the same reference frequency and it is carried out for exact coincidence of the carriers on the transmitting and receiving ends of the channel.

Master Oscillator

The master oscillator ZG (Fig 6.14) is executed from two 6Zh1P tubes. The generator or exciter of the autooscillations is the primary tube L_1. For stabilizing the frequency of these oscillations between the primary and secondary grids of the tube L_1 there is a quartz resonator KB with natural resonance frequency of 8 kilohertz. The load of the first stage of the generator is the oscillatory circuit LC_4 tuned to a frequency of 8 kilohertz. The voltage picked up from this circuit is fed to the controlling grid of the tube L_2. The second stage is a resonance voltage amplifier. The load of this stage is the parallel connected capacitor C_6 and the primary winding of the output transformer. For tuning the generator frequency there is a semivariable capacitor C_3. The output voltage is regulated by the potentiometer R_6. The rated magnitude of the voltage at the output of the module is 2.5 volts.

For reliable stabilization of the frequency of the generated oscillations a quartz resonator is placed in a thermostat with constant temperature of +50°C. The automatic maintenance of this temperature is realized by a heating coil (the heating element NE), the relays P_1 and P_2 and the thermocontactors TK_1, TK_2 (Fig 6.15). Until the temperature in the thermostat reaches 50°C, the transistor T is open, the relay P_1 operates and by its contact 3-4 closes the feed circuit of the heating coil.

When the temperature in the thermostat reaches 50°C, the mercury column of the thermocontactor TK_1 closes the feed circuit of +24 volts to the transistor base. The latter is blocked, the relay P_1 opens and breaks the coil feed circuit. When the temperature drops the heating element is again switched on. When the thermocontactor TK_1 fails, the thermocontactor TK_2 is switched on. It is designed to respond from a temperature of +60°C. The contacts of this thermocontactor close the operating circuit of the P_2 relay which switches off the heating element and creates an emergency signal at the SIG-1M bay.

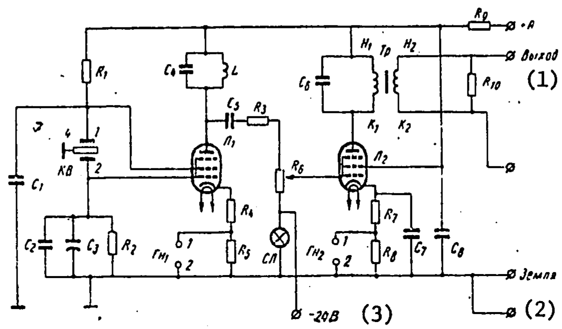


Figure 6.14. Master oscillator

Key:
1. Output
2. Ground
3. -24 volts

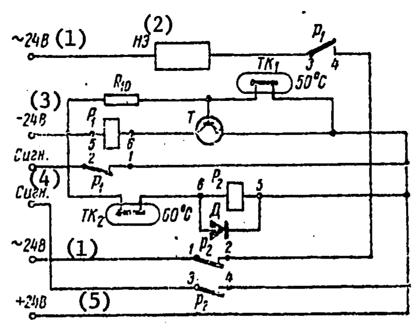


Figure 6.15. Circuit diagram of the thermocontactors and thermostat

Key:
1. ~24 volts
2. NE heating element
3. -24 volts
4. signal
5. +24 volts

The generating equipment includes two master oscillators: basic and reserve. Their outputs are connected in parallel to a common load. During operation of the basic generator the reserve generator is blocked by a negative voltage of -24 volts fed to the grid of the tube L_2 and simultaneously to the signal tube SL on the face panel of the unit. When this light burns it indicates that the module is not operating. On failure of the basic module, the blocking voltage is removed from the reserve module, and it automatically switches on.

The master oscillators are connected to the differential transformer Tp_1. The secondary winding of this transformer has a midpoint at which the ZG voltage is split into two outputs. The load of the first output is the transformer Tp_2 from which the voltage goes to the input of the harmonic generator of its own office. From the second output the voltage with a frequency of 8 kilohertz can be transmitted to the second office for synchronization of its generating equipment. The devices through which this voltage is transmitted form the synchronization channel.

Synchronization Channel

There are two methods of synchronizing the generating equipment of the terminal stations: 1) local or synchronization with respect to directions of operation and 2) general or centralized synchronization. Fig 6.16 shows the local synchronization system. The essence of it is that the master oscillator operates only at one of the terminal offices (office A). The voltage from this oscillator goes both to the harmonic generator amplifier of its office and along the synchronizing channel to the harmonic generator amplifier of the opposite office (office B).

Let us consider the synchronizing frequency transmission channel. At the transmitting office the 8 kilohertz reference frequency voltage reaches the differential transformer Tp_2. From the first output of this transformer the lock-on voltage is fed through the attenuator Udl_1 to the harmonic generator of its own office. The second output is connected through the attenuator Udl_2 to the band filter П-8. On passing through the filter, the 8 kilohertz voltage goes to the group channel and to the other with the high-frequency signal is transmitted through the routine filter D-280 and the line transformer to the line. This voltage goes through the line together with the group signal of office A (12-248 kilohertz). In the presence of repeater stations the synchronizing voltage passes through them, and it goes to the line transformer of the terminal office B, to the routing filter D-280, the band filter П-8 and the input transformer of the harmonic generator.

In order that the 8 kilohertz synchronizing frequency voltage designed for operation of the generating equipment not go together with the multichannel signal to the group receiving channel of the office and not cause overloading of it, the P-8 filter is installed (the band-elimination filter). The fork of the PП-8 filters is connected to the group channel between the D-280 filter and the group repeater.

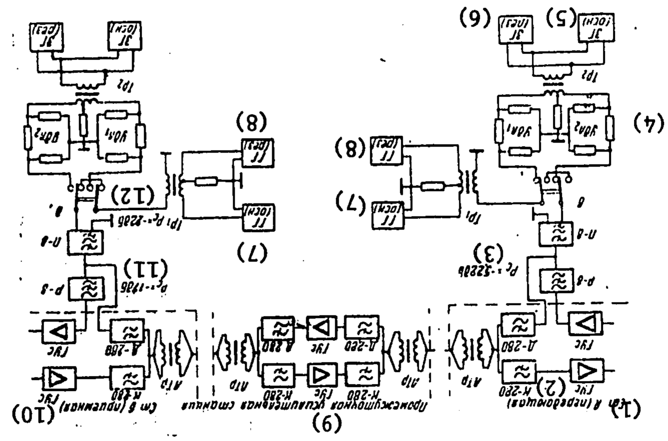


Figure 6.16.. Synchronization channel of the generating equipment

Key:

1. Office A (transmitting)
2. GUs = group repeater
3. P_c=-5.22 decibels
4. Udl_2 attenuator
5. ZG master oscillator (basic)
6. ZG master oscillator (reserve)
7. Harmonic generator (basic)
8. Harmonic generator (reserve)
9. Intermediate repeater
10. Office B (receiving)
11. P_c=-17 decibels
12. P_c=-22 decibels

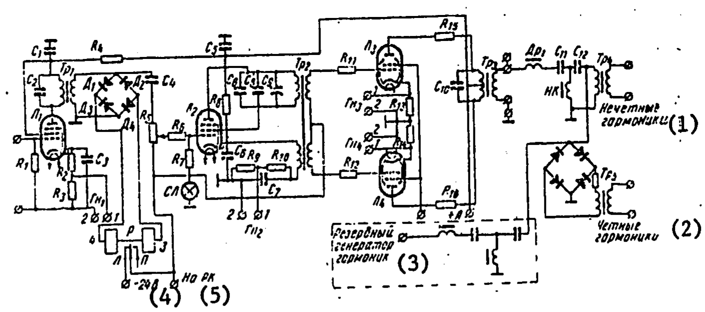


Figure 6.17. Harmonic generator

Key:

1. Odd harmonics
2. Even harmonics
3. Reserve harmonic generator
4. -24 volts
5. to PK

The attenuation of the attenuators Ud_1 and Ud_2 have a value insuring the required voltage for lock-on at the input of the harmonic generator independently of the method of supplying it: from the generator itself or over the synchronizing channel.

On the large city telephone networks a united centralized synchronization system has been organized which is set up so that the synchronizing voltage is generated by one generator and is distributed with respect to all points where the KRR equipment is installed. Special synchronization network units are installed here, by means of which the required parameters of this voltage are insured. The master oscillators of the bays of KRR equipment are not used in this case.

Harmonic Generator

The harmonic generator is a frequency multiplier which generates voltages with frequencies that are a multiple of the reference frequency of 8 kilohertz. The harmonic generator includes two modules: the amplifier module and the nonlinear system module. The purpose of the amplifier is to bring the reference voltage power to the required value for normal operation of the nonlinear system. The purpose of the nonlinear system is to insure the required shape of the output current.

The circuit diagram of the harmonic generator is presented in Fig 6.17. The amplifier is made in accordance with the three-stage circuit from two 6Zh1P tubes and two 6P3S tubes. The first stage based on the 6Zh1P tube operates as a resonance voltage amplifier. A small voltage is fed to the control grid of the tube L_1 from the master oscillator of its office or over the synchronizing channel. The anode load of this stage is an oscillatory circuit made up of the capacitor C_2 and the primary winding of the transformer Tp_1. On a frequency of 8 kilohertz, current resonance takes place in the circuit. The circuit resistance and the voltage drop on the circuit become maximal. This permits us to obtain the greatest gain only for 8 kilohertz voltage, which is especially significant when operating the harmonic generator from the voltage coming over the synchronizing channel. In this case, in addition to the 8 kilohertz frequency the incoming signal can also contain components with other frequencies. The resonance amplifier permits filtration of the 8 kilohertz voltage to remove the other frequency components.

The voltage amplified by the first tube is fed to the input of the second tube and simultaneously through the rectifying bridge to the polarized relay P. The relay in the operating state picks up the -24 volt locking voltage by its contacts from the controlling grids of the second and third stages and puts out the signal light on the panel of this module. In the absence of a master (synchronizing) voltage at the output of the first stage, the relay is tripped, and the module does not generate the characteristic voltage, the frequency of which in this case would be unstable.

Without an external signal the second tube, as indicated below, generates a voltage with a frequency corresponding to the parameters of its oscillatory circuit. Thus, the signal tube, on being put out, indicates the presence of a frequency of 8 kilohertz at the input of the module.

The second stage is also executed from the 6Zh1P tube and it operates in the generator mode with lock-on. The oscillatory circuit of this generator has a trimmer C_9. The resonance frequency of the circuit is close to 8 kilohertz. Under the effect of the external synchronizing voltage the frequency of the oscillation generated by the tube is stabilized, reaching the require value.

The third output stage is the resonance power amplifier executed from two 6P3S tubes by the two-cycle circuit. The variable resistor R_5 regulates the output level of the signal to the value required for operation of the nonlinear system. The basic element of the nonlinear system of the harmonic generator (Fig 6.18a) is the nonlinear coil HK, to which a powerful signal is fed from the output of the amplifier through the auxiliary filtering circuit Dp_{11}, C_{11}. The coil is wound on a ferrite ring having a rectangular hysteresis loop (Fig 6.18b). This nature of magnetization means that the saturation state of the core occurs not smoothly, but sharply, as soon as the current in the coil reaches the saturation current of i_H.

Inasmuch as the inductance of the coil L is defined as the variation of the magnetic flux per unit time $\Delta\Phi/\Delta t$, it will be the largest at those times when the core magnetization curve increases or decreases, that is, when the current still has not reached a value of i_H, for which the variation of the magnetic flux is stopped, and the inductance drops to zero. As a result of sharp transition of the core of the coil HK to the saturation state, its inductance will change just as sharply from the maximum value of L_0 to the minimum value L_H, and the resistance from Z_0 to Z_H differing from each other by no less than 1000 times.

The nonlinear system operates as follows. Until the reference signal current builds up, varying according to a sinusoidal law, the core is not saturated, the coil resistance HK is high, and the current does not in practice flow through it. At this time the capacitor C_{12} is charged. When the current reaches a value of i_H, the inductive resistance of the coil decreases sharply which in this case shunts the voltage source, and the charge capacitor C_{12} is discharged through the load Tp. The voltage of the discharge current is opposite to its direction when charging. Then with a decrease in the current the capacitor is again charged, and with a value of it equal to $-i_H$, it is again discharged in the opposite direction. As a result, the current pulses of positive and negative polarity flow through the load (Fig 6.18c). The circuit parameters are selected so that the capacitor discharge will take place very fast. The current pulse generation in the load is less than 2 microseconds for the pulse amplitude of 60 volts. This insures a large number of harmonics with slowly decreasing amplitude in the output current.

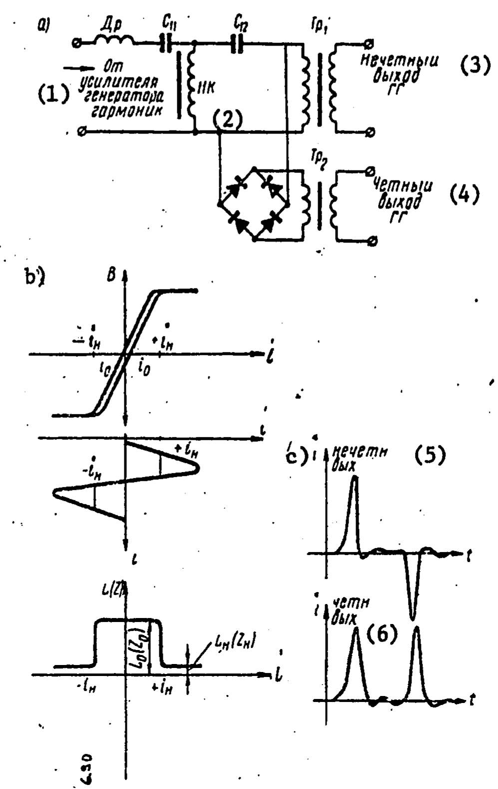


Figure 6.18. Nonlinear system of the harmonic generator and explanation of its operating principle

Key:

1. From the harmonic generator amplifier
2. HK nonlinear coil
3. Odd output of the harmonic generator
4. Even output of the harmonic generator
5. Odd output
6. Even output

It was indicated above that the current of this shape contains only the odd harmonics. In order to obtain even harmonics in the harmonic generator circuit there is a second, even output through the load bridge insuring double halfperiod rectification, and consequently, frequency doubling. The current at the bridge output has the shape of a unipolar curve containing only the even harmonics of the basic frequency of 8 kilohertz.

The filters of the odd generators of the individual carriers are connected to the odd output of the harmonic generator, and to the even, the filters of the even generators GIN and the filter UGN. From the circuit it is obvious that both outputs are connected to the various diagonals of the rectifying bridge. This decreases the mutual effect between the GIN, that is, it increases the protection between them. In the generating equipment of the office there are two harmonic generators: basic and reserve. On operation of one of them, the anode voltage is picked up automatically from the other.

Individual Carrier Generator -- GIN

The individual carrier generator (Fig 6.19) generates a voltage of individual carrier frequency required to feed the channel converters. A narrow-band filter tuned to a frequency of the corresponding harmonic of the reference frequency of 8 kilohertz is connected at the input of the GIN. From the filter output this voltage is fed through the matching transformer to the controlling grid of the 6Zh1P tube operating in the generator mode with lock-on. The magnitude of this voltage is sufficient for reliable lock-on of the GIN on drift of its natural frequency from the calculated one by ±2 kilohertz. The natural frequency of the generator is determined by the parameters of the oscillatory circuit made up of the capacitor C_3 and the primary winding of the transformer Tp_1. With respect to its effect the generator encompassed by the external voltage is equivalent to the narrow-band filter plus an amplifier. In order to decrease the effect of the load variation on the frequency stability of the GIN, the transformer is loaded on the attenuator R_4, R_5, R_6, R_8, R_{12} permitting regulation of the output voltage without variation of the output resistance of the generator. The variable resistor R_8 permits regulation of this voltage within the limits from 1.0 to 1.4 volts for a rated value of 1.2 volts.

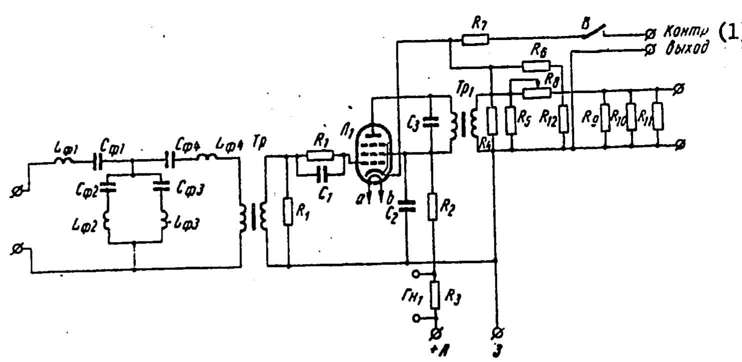


Figure 6.19. Individual carrier generator

Key:
1. Control

Each GIN is designed to feed the converters of four like channels: one based on the SIG-1M bay and three on the SIG-30M bays. During operation of all four systems of this equipment the resistors R_9, R_{10} and R_{11} are disconnected. For a load on a smaller number of converters one of the indicated resistors each is connected to the generator circuit instead of the missing KRR-M system.

In addition to the basic output, the GIN has a control output through the resistor R_7 and the toggle switch B. This output is connected to the monitor which signals when the GIN falls out of synch.

One GIN module has two generators -- even or odd channels with the exception of the generators of the 29th 30th channels which are placed in one module.

Group Carrier Repeater -- UGN

The group carrier repeater (Fig 6.20) is used for generation of the 70th harmonic of the reference frequency (560 kilohertz) from the even output of the harmonic generator and amplification of it to the required power.

At the repeater input for more reliable voltage filtering there are two sections of band filters analogous to the filters at the input of the GIN. The repeater is assembled as a two-stage circuit. The first stage is executed from the 6Zh1P tube by the resonance circuit. The anode load of this stage is the parallel circuit L, C_4 with resonance at frequencies of 560 kilohertz. The variable resistor R_3 is connected to the cathode circuit of the tube L_1 to regulate the output power of the repeater.

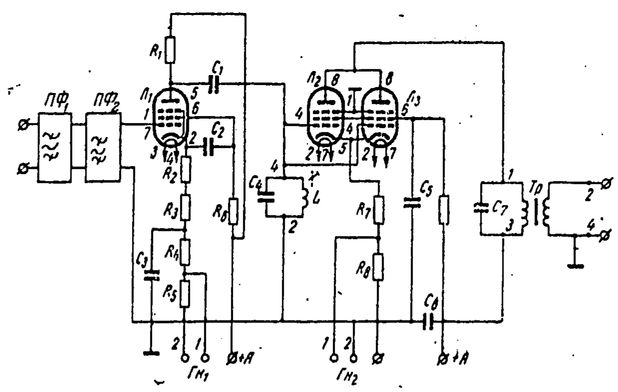


Figure 6.20. Group carrier repeater

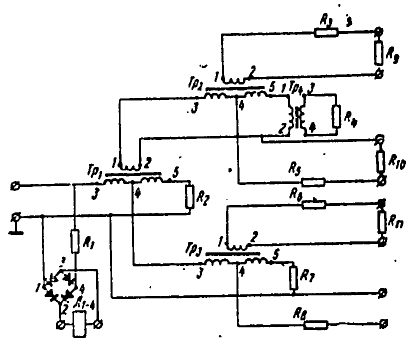


Figure 6.21. 560 kilohertz repeater differential system

The second stage -- the power amplifier -- is also executed by the resonance circuit from two 6P9 type tubes which are connected in parallel to increase the output power.

In order to avoid the transient effects between the group converters of different systems, the group carrier is not fed directly from the repeater to the group converters, but it is fed through the decoupling differential system (Fig 6.21). The differential system of the group carrier repeater is made up of three differential transformers Tp_1, Tp_2, Tp_3 which are structurally arranged in another module. The transformer Tp_1 separates the output of the receiver into two circuits connected to different diagonals of its bridge circuit. The transformers Tp_2 and Tp_3 divide each of these circuits again into two in like manner. As a result, four outputs well decoupled from each other are formed, from each of which the voltage is fed to its own group converter. The magnitude of this voltage is 1.2 volts, just as in the group converter itself. If only one system of the KRR-M equipment is in operation, the resistors R_9, R_{10}, R_{11} must be put in.

In the SIG-1 bay there are two UGN modules: basic and reserve. The outputs are connected in parallel to a common load. On operation of one of them, the anode voltage is automatically picked up from the other.

Generating Equipment Monitor

The monitor is used for continuous observation of the operation of the GIN and it signals if any of them drops out of synch. The control outputs of all of the individual carrier generators are connected through large decoupling resistances to the input of the monitor (Fig 6.22). The first stage executed from the 6Zh1P tube amplifies the entire complex input signal to a value at which the diode D_1 connected between the first and second stages will operate reliably as a nonlinear element. It is known that if the nonlinear element falls under the effect of voltages of different frequencies -- f_1, f_2, f_3,... -- then harmonics appear in the circuit from only initial frequencies of the type: $2f_1$, $2f_2$, $2f_3$,..., $3f_1$, $3f_2$, $3f_3$,..., $4f_1$, $4f_2$, $4f_3$ and also all possible combination frequencies, sum and difference, of the following type: $f_1 \pm f_2$, $f_1 \pm f_3$, $3f_1 \pm 2f_2$, $2f_1 \pm 3f_2$, and so on, which can be written in general form as $mf_a \pm nf_b$, where m and n are any integers, and f_a and f_b are any frequencies reaching the input of the module.

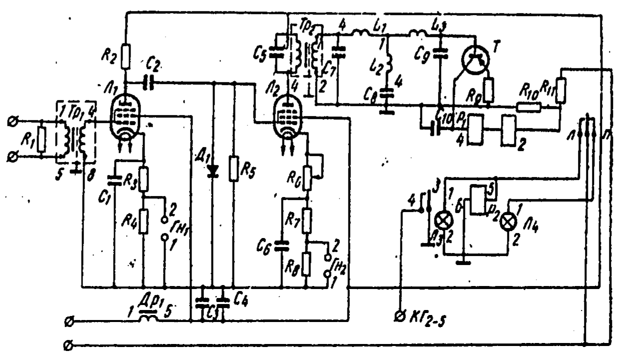


Figure 6.22. Monitor

All of these frequencies go to the second 6Zh1P tube for further amplification. For normal operation of the GIN, all of the frequencies generated by them are multiples of 8 kilohertz. In this case, among the entire set of frequencies fed to the tube L_2, none will occur which will be less than 8 kilohertz. Actually, any carrier, and more so the harmonics, will be greater than 8 kilohertz. Any summed combination frequency mf_a+nf_b will also be greater than 8 kilohertz. Only the combination frequency formed by the difference of two adjacent carriers will be equal to 8 kilohertz. This is the basis for the structure of the monitoring circuit.

The D-4,0 filter which passes currents with frequencies only up to 4 kilohertz is connected at the output of the second stage. During normal operation of all the GIN there will not be a single frequency which will pass through the filter. If any GIN falls out of synch., that is, begins to generate a frequency that is not a multiple of 8 kilohertz, then a difference combination frequency of less than 4 kilohertz will appear. The signal of this frequency will go through the D-4,0 filter, it will be rectified, amplified with respect to DC current by the transistorized stage and force the response of the polarized relay P_1. This relay closes the circuit of the relay P_2 by its contact, it switches on a red signal light and switches off a green signal light on the panel of the KY monitor module. The relay P_2 creates a general-bay emergency signal circuit.

Example, Let GIN No 3 begin to generate at 329 kilohertz instead of 328 kilohertz. Let us take two difference frequencies: F_3-F_2=329-320=9 kilohertz and F_2-F_1=320-312=8 kilohertz. These two combination frequencies create new frequencies: 9+8=17 and 9-8=1 kilohertz. The frequency of 1 kilohertz passes through the D-4,0 filter and the above-described signal response.

The GIN that has fallen out of synch must be disconnected from the transceivers. In order to find this GIN, it is necessary to disconnect the monitor outputs from the KY in the GIN modules until the red light goes out and the green light burns again.

Signal Frequency Generator

The signal frequency generator (Fig 6.23) is the only generator not connected with the harmonic system of the generating equipment, for the frequency of 3.8 is not a multiple of 8 kilohertz. The generator is made as a two-stage circuit.

The first stage based on the 6Zh1P tube operates as an autooscillation generator assembled by the three-point circuit. The oscillatory circuit C_1, C_2, C_{13}, L_1 is connected to the circuit between the control and screening grids of the tube. The midpoint of the circuit is connected to the cathode. These three electrodes play the role of the autooscillation exciter. The oscillations which occur are amplified then by the anode circuit of the tube loaded on the oscillatory circuit C_5, C_8, C_9 and the primary winding of the transformer Tp_1. This circuit, just as the first, is tuned to a frequency of 3.8 kilohertz.

The second stage -- a power amplifier -- is executed from two 6Zh1P tubes by the double-cycle circuit, as a result of which the characteristics of the amplifier are improved, and the nonlinear distortions are decreased. The two-cycle output requires complete symmetry of the circuit, and since in practice it is impossible to have entirely identical parameters of the two halves of the circuit, including two tubes, the halfwindings of the transformer and the other parts, additional measures are being taken to improve the amplifier characteristics. In parallel with the primary winding of the output transformer a circuit is included which is made up of the series-included inductance coil L_2 and capacitor C_{12}. This circuit with resonance voltages on the third harmonic of the basic oscillation has minimum resistance on it and shunts the output. The even harmonics are destroyed by the two-cycle circuit.

The capacitors C_{10}, C_{11} and the primary winding of the output transformer together make up a parallel circuit tuned to the basic signal frequency of 3.8 kilohertz at which the repeater also gives the greatest gain.

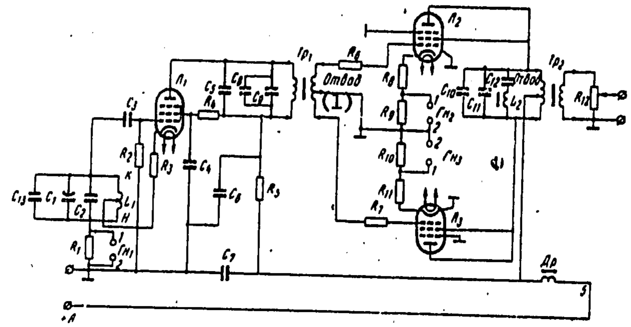


Figure 6.23. Signal frequency generator

Key:

1. Shunt

The output level of the generator is regulated by the potentiomer R_{12}. On a load of 16 ohms, the maximum voltage can be 3 volts. The signal frequency generator load is 120 static relays. The output power distribution of the generator between the static relays of the four systems of equipment is realized by decoupling resistors located in a separate module of the generating equipment.

Monitoring the Operation and Switching of the Generator Equipment Assemblies

For greater operating reliability all modules are redundant in the generating equipment except the GIN and the monitor. For automatic switching of the equipment from the basic to the reserve there are special relay assemblies connected with the signal system of the ISG-1M bay. The switching and signal elements are located on the protection and signal plates (the ZIS plate) and also directly in the generating equipment modules. The switching of the equipment from the reserve modules to the basic ones is done manually by using buttons also located on the ZIS plate. The switching from basic to reserve is automatic.

Let us consider the operation of the relay assemblies. The diagram of the relay assembly of the signal frequency generator is depicted in Fig 6.24. The assembly is made up of the $P_{G-3,8}$ polarized relay, two RPN type telephone relays: P_B and P_D, three signal lights, the button KH, the rectifier bridge BM and the diodes. The operation of the complex goes as follows. In the first step when the electric power is switched on, the voltage at the output of the generator of the signal part is insufficient for operation of the polarized relay $P_{G-3,8}$, the armature of which is on the right stop. The R-A contacts of the relay $P_{G-3,8}$ close the operating circuit of the relay P_B: "ground," armature A, right contact of the relay $P_{G-3,8}$ then

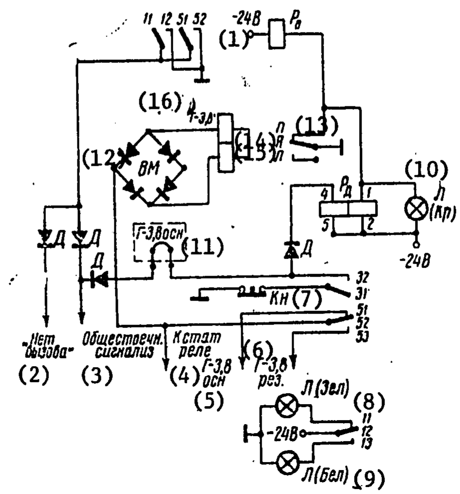


Figure 6.24. Relay switching complex of the G-3,8 kilohertz generator

Key:

1. -24 volts
2. No ring
3. General bay signal
4. To the static relay
5. G-3,8 basic
6. G-3,8 reserve
7. Button
8. Signal light (green) - L(Zel)
9. Signal light (white) - L(Bel)
10. Signal light (red) — L(Kr)
11. G-3,8 basic generator
12. Bridge rectifier
13. R - right
14. A - armature
15. L - left
16. $P_{G-3,8}$

parallel to the relays P_B and P_D, -24 volts. The red signal light L (Kr) lights simultaneously. The relay P_B closes the emergency signal circuit in the SIG-1M bay and the external "no ring" signal by its contacts 11-12 and 51-52.

The relay P_D, responding, closes the circuit of its restraining coil 4-5 by its contacts 31-32; by the contacts 52-53 it prepares the voltage feed circuit from the output of the reserve module to the load; by contacts 12-13 it closes the circuit to light the white signal light L(Bel).

In the second step of operation, the voltage at the output of the reserve module reaches the normal value. The polarized relay $P_{G-3,8}$ responds and switches the armature to the left contact. This brakes the circuit of the relay P_B, which, tripping its armature, removes the emergency general-bay signal and the "no ring" signal. In addition, the contacts of the relay $P_{G-3,8}$ brake the circuit of the tube L_1 and the operating winding of the relay P_D. However, this relay does not trip its armature, for its restraining coil remains under current.

In order to switch the load from the reserve generator to the basic generator it is necessary to press the button KH. Then the relay P_D is tripped, by its contacts it switches the load to the basic module and switches on the green light L (Zel).

If the basic generator G-3,8 fails during operation, the polarized relay $P_{G-3,8}$ is tripped which, throwing the armature to the right contact, creates the operating circuit of the relay P_D. The contacts 52-53 of the relay P_D connect the load to the output of the reserve module, and the contacts 12-13 connect the signal light L_3.

The relay P_B (emergency signal) does not succeed in responding in this case, for the relay $P_{G-3,8}$ immediately throws its armature as soon as voltage begins to go from the reserve module to the rectifying bridge. If the signal also drops on the reserve module output, then the contacts 11-12 and 51-52 of the relay P_B close the emergency signal circuit and the "no ring" signal.

The diode D_1 prevents response of the "no ring" signal from the voltage coming to the general bay signal over the other emergency signal circuits.

The operation of the relay assemblies of the harmonic generator and the group carrier repeater will be considered jointly.

These assemblies (Fig 6.25) include the polarized relay P_{UGN}; three RPN type relays: the $P_{\Gamma\Gamma}$ relay, the contacts of which connect +250 volts of anode voltage either to the basic or to the reserve harmonic generator; the relay P_B which switches +250 volts of anode voltage to the basic or the reserve module of the group carrier repeater, and the relay P_A which includes the emergency signal with respect to two lights for the harmonic generator and the group carrier repeater and two buttons.

Before the appearance of a voltage at the output of the harmonic generator and, consequently, the group carrier repeater module, the polarized relay P_{UGN} connected through the rectifying bridge to the outputs of the basic and reserve group carrier repeaters does not operate. The armature P_{UGN} is at the right contact, the operating windings of the relays P_A and P_B are deenergized, by the quiescent contacts 11-12 51-52 the relay P_A forms the general bay signal circuit, and also the operating winding circuit 1-2 of the relay $P_{\Gamma\Gamma}$.

The relay $P_{\Gamma\Gamma}$ responds and is blocked by its contact 31-32 forming the circuit for the winding 4-5; the contacts 52-53 are used to feed +250 volts to the anodes and the shielding grids of the tubes 6P3S of the output stage of the harmonic generator amplifier; the contacts 12-13 are used to include the tube L_1 of the harmonic generator complex.

Thus, in the first step the reserve harmonic generator amplifier is prepared for operation. From the two group carrier repeater modules, the reserve is also prepared for operation, for the quiescent contacts of the relay P_B are used to feed +250 volts to the anodes and the shielding grids of the tubes 6P9 of the output stage of the UGN [group carrier amplifier]. The operation of the reserve module is noted by the white light burning on the UGN complex.

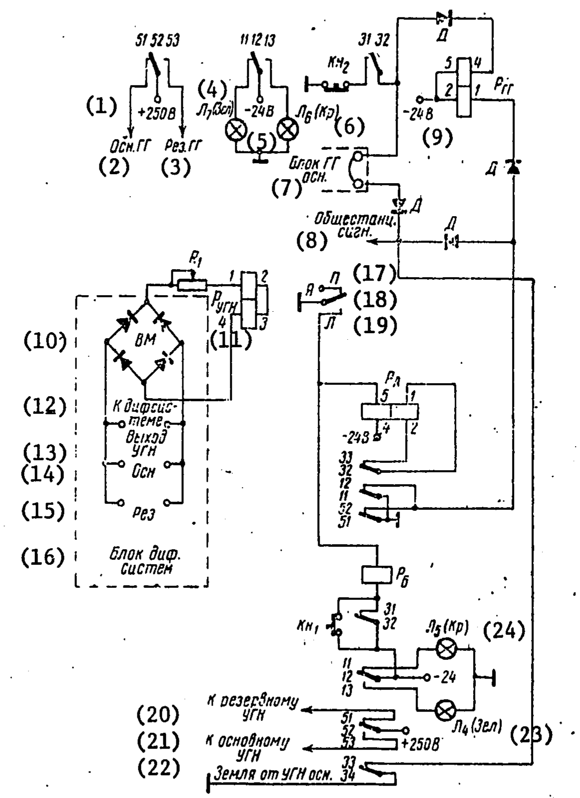


Figure 6.25. Relay assembly for switching the harmonic generator and the group carrier repeater

Key:

1 -- +250 volts; 2 -- Basic harmonic generator; 3 -- Reserve harmonic generator; 4 -- L_7(Zel) -- Green signal light; 5 -- -24 volts; 6 -- L_6(Kr) -- red signal light; 7 -- basic harmonic generator module; 8 --general office signal; 9 -- - 24 volts; 10 -- rectifying bridge; 11 --P_{UGN}; 12 -- To the differential system; 13 -- UGN output; 14 -- basic; 15 -- reserve; 16 -- differential system module; 17 -- right;18 -- armature; 19 -- left; 20 -- To the reserve UGN; 21 -- To the basic UGN; 22 -- Ground from the basic UGN; 23 -- Green signal light; 24 -- Red signal light

In the second step of operation after heating of the generator equipment tubes, the 70th harmonic goes from the output of the reserve harmonic generator, it is amplified by the reserve group carrier repeaters, and it is fed to the rectifying bridge. The polarized relay P_{UGN} responds, and it throws its armature to the left contact. The P_A relay circuit closes, and the P_B relay response circuit is prepared. The relay P_A responds, and by its contact 31-32 it short circuits its own winding 1-2, which slows the tripping; the contacts 11-12 and 51-52 break the emergency signal circuit and the circuit of the operating winding of the P_{GG} relay.

For conversion to the basic modules it is necessary to press the buttons KH_1 and KH_2. On pressing the button KH_1 the relay P_B responds and it is blocked by its own contacts 31-32; by the contacts 52-53 the anode voltage of +250 volts is fed to the basic module of the group carrier repeater, and by the contacts 13-12 the tube L_4 of the UGN complex is included.

When the button KH_2 is pressed, the relay P_{GG} trips, the contacts of which send +250 volts to power the tubes of the basic GG [harmonic generator] module, and the tube L_7 of the GG complex is switched on.

On failure of the basic harmonic generator, the group carrier amplifier simultaneously stops working. The relay P_{UGN} is tripped. The relay P_A is also tripped, but with a delay as a result of the shunt on its winding 1-2. This delay in tripping the relay P_A is needed so that in the case of accidental short-term surges of group carrier voltage its contacts will not switch.

The relay P_B also trips its armature, the anode voltage is switched to the reserve amplifier, and the light L5 of the UGN complex burns. The relay P_{GG} responds, switches the anode voltage to the reserve harmonic generator, the light L_6 burns, the general-bay emergency signal operates. The relay assembly operates analogously on failure of the group carrier repeater.

Thus, when there is a failure in the basic harmonic generator or the group carrier repeater the switching to the reserve module takes place jointly. In this case the lights L_6 and L_5 burn, and the general bay signal goes into operation.

When the harmonic generator stops operating as a result of damage to the ZG master oscillator modules or when the synchronizing frequency stops from the other office the signal lights burn on both of the harmonic generator modules, and the emergency signal responds.

The diagram of the relay assembly of the master oscillator is analogous to the diagram of the relay assembly of the signal frequency generator, and it is not described here.

6.8. Intermediate Repeater Stations

The intermediate repeater stations are installed to increase the communications range over the trunk and they are designed to compensate for attenuation and frequency-amplitude distortions introduced by the preceding section of the cable circuit.

The section of the cable circuit included between two adjacent repeater stations is called the repeater section. The length of a repeater section depends on the physical properties of the cable and the type of multiplexing equipment. When determining the admissible length of the repeater section we begin with the fact that its attenuation must be numerically equal to the gain of the repeater station. The latter is determined on the basis of the minimum and maximum transmission levels permissible in the circuit.

In the KRR-M equipment the difference between the maximum and minimum group signal levels can be 50.9 decibels (5.85 nepers) at the highest frequency of 548 kilohertz. This means that the gain of the repeating station and, consequently, the attenuation of the repeating section can also be 50.9 decibels. For the MKS type cable this corresponds to a length of 13 km.

The composition of the equipment installed at the tandem office is determined by its purpose -- compensation of the attenuation and the frequency-amplitude distortions introduced by the repeater section. For this purpose repeaters are used with a set of equalizing circuits. The KRR-M equipment is a two-band communications system; therefore the routing filters D-280 are installed at the repeater station. For matching the equipment of the tandem station with the cable circuit, line transformers are installed at the input and output of the station.

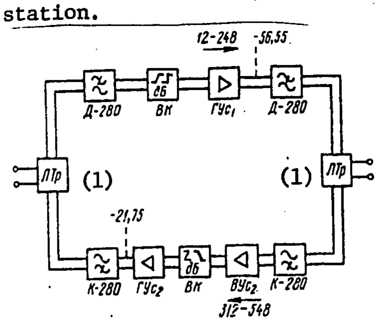


Figure 6.26. Structural diagram of the intermediate repeater station of the KRR-M equipment

Key:
1. Line transformer

The structural diagram of the repeater station is shown in Fig 6.26. In the direction of transmission of the lower frequency group (12-248 kilohertz) the group signal, passing through the line transformer LTp and the routing filter D-280, is amplified by the group repeater ΓYc1 and it is equalized by the set of equalizing circuit sections. By means of attenuators and continuous gain control the transmission level at the output of the group repeater is set equal to -6.65 decibels (-0.65 nepers). The routing filter D-280 and line transformer are included after the repeater, on passing through which the frequency spectrum of 12-248 kilohertz is transmitted to the next repeater section.

In the direction of transmission of the upper frequency group of 312-548 kilohertz, the schematic of the repeater station completely corresponds to the schematic of the receiving channel of the terminal office A. Between the routing filters K-280 at the input and output of the station a group repeater GYc2 and auxiliary repeater BYc2 are included. If the length of the trunk of the MKS type is less than 12.5 km, the auxiliary repeater can be left off. By using attenuators and continuous gain control the transmission level of this direction is fed equal to -21.75 decibels (-0.25 nepers).

For equalizing the frequency-amplitude distortions of the signal the spare parts kit for the intermediate station has elements of line equalizers for the frequency range of 12-248 kilohertz by 1.74, 3.48, 10.44, 13.82 decibels and for the frequency range of 312-548 kilohertz by 3.48, 5.65, 7.83 decibels.

Two repeater stations and a feed plate are installed on each bay of intermediate repeaters. The layout of the plate is considered below.

6.9. Group Channel Equipment

The group channels of the terminal offices of the KRR-M equipment contain the following: group and auxiliary repeaters, group converters, line transformers, group and routing filters. The intermediate repeater stations are made up of line transformers, routing filters, group and auxiliary repeaters.

All of the group equipment modules are four-terminal networks with input and output impedances of 75 ohms. The line transformers calculated for operation between loads of 75 and 160 ohms constitute an exception.

In the KRR-M equipment the group and auxiliary repeaters of two types are used: the lower frequency group GYc1 and BYc1 and the upper frequency group GYc2 and BYc2 designed to amplify the currents in the spectral from 12 to 248 kilohertz and from 312 to 548 kilohertz, respectively. The like repeaters for the lower and upper frequency groups do not differ from each other either in structural or in schematic respects. Only the ratings of the individual elements are different. All of the repeaters, with the exception of BYc1 are used at the type A and type B terminal offices and also at the intermediate repeater stations. The auxiliary repeater of the lower frequency group BYc1 is installed only at the type B terminal offices.

When using repeaters at the terminal offices the filaments of the repeater tubes are included in parallel, and when using this at the intermediate repeater stations the filaments of the repeater tubes of the two repeater stations (four group and two auxiliary) are connected in series.

The feed for the repeaters of the terminal offices is from the group equipment power pack PITGUc, and the intermediate stations, from the MP local power or DP remote power plate.

Let us consider the schematic diagram of the group repeater GYc1 at 12-248 kilohertz (Fig 6.27). The repeater is assembled by the three-stage circuit from four 6Zh1P tubes. At the input of the repeater is a step-up transformer with transformation coefficient of 1:7. Its purpose is to match the output of 30 channel transmitters with high-resistance input of the repeater tube. The required magnitude of the input impedance of the repeater of 75 ohms is achieved using the resistors R_{26}, R_1 included in parallel to the transformer windings. The repeater is assembled with respect to the rheostat-capacitive circuit (the repeater based on resistors). The individual elements of the stages have the following purpose: the resistor R_3 is the anode load of the first stage from which the amplified voltage is picked up and it is fed to the following stage (in the second stage the anode load is R_{10}). The resistor R_2 and the capacitor C_1 constitute the feed filter of the anode, and the resistor R_6 and the capacitor C_2, the feed filter of the shielded grid (in the second stage R_9, C_4 and R_{15}, C_6, respectively). The required magnitude of the feed voltages of the anodes and the shielded grids of the tubes L_1 and L_2 is insured by means of these resistors.

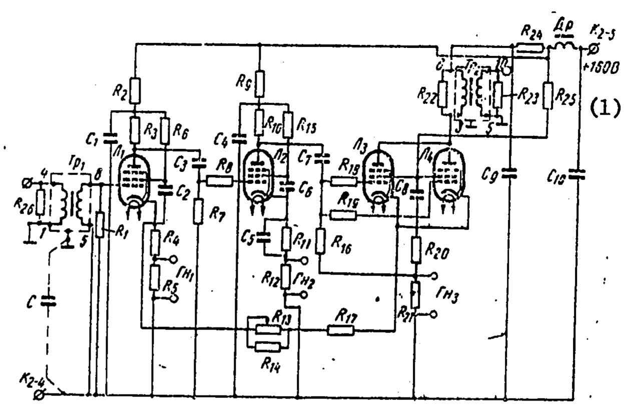


Figure 6.27. Group repeater for 12-248 kilohertz

Key:
1. +150 volts

The resistors R_4 and R_5 create automatic bias on the control grid of the tube L_1 and simultaneously negative current feedback in the first stage. Here a significant role is played by the resistor R_4, for R_5 has a small value and is used to measure the cathode current of the tube in the socket ΓH_1.

In the second stage for measuring the current in the socket ΓH_2 the resistor R_{12} is used; the automatic bias is provided by the resistor R_{11} which for the variable component of the current is shunted by the capacitance C_5, as a result of which the negative feedback is absent in this stage.

The capacitor C_3 between the first and second stages is separating; R_7 is the leakage resistance of the second stage.

The third stage — the power amplifier -- is made from two tubes included in parallel. Using the resistor R_{20}, a bias and negative current feedback are created automatically; the resistor R_{21} has small resistance and is used to measure the cathode current common to the tubes L_3 and L_4. The purpose of the remaining resistors and the capacitors is analogous to that described in the first two stages.

In addition to the individual negative feedback in the first and third stages, the amplifier is encompassed by common negative feedback, that is, the feedback from the output stage to the input stage. The common feedback circuit is formed by the Π-type four-terminal network made up of the resistors of the first (R_4, R_5) and the third (R_{20}, R_{21}) stages included in the cathode and connecting the resistors R_{13}, R_{14}, R_{15}.

It is possible to use the variable resistor R_{13} to smoothly regulate the gain of the amplifier by ± 4.35 decibels (0.5 nepers) with respect to its mean value of 49.5 decibels (5.7 nepers). The deep negative feedback stabilizes the gain and decreases the nonlinear distortions of the amplifier.

In order to match the output of the amplifier to the subsequent channel element (see Fig 6.5) a step-down transformer Tp_2 with transformation coefficient of 7:1 is used. By means of the resistors R_{22} and R_{23} the output impedance of the amplifier becomes equal to 75 ohms. The choke Dp, the resistor R_{24} and the capacitors C_9 and C_{10} are used as the feed filter.

The 12-248 kilohertz repeaters are installed both on the terminal equipment bays and at the intermediate repeater stations.

Fig 6.28 shows the diagram of a group repeater of the upper frequency group installed in the receiving channels of the terminal offices. The repeater has a differential output transformer permitting two outputs uncoupled from each other to be formed for the even and odd channels.

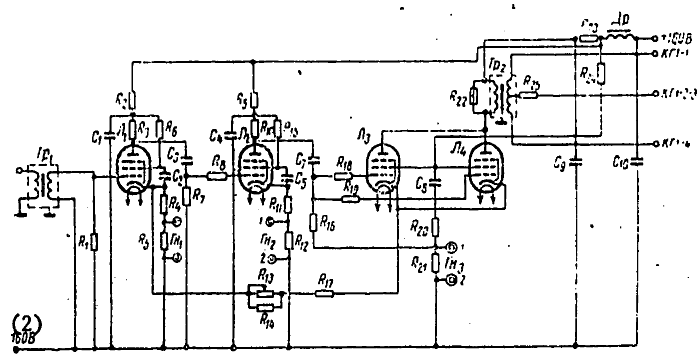


Figure 6.28. Group repeater for reception on 312-548 kilohertz

Key:
1. +160 volts
2. 160 volts

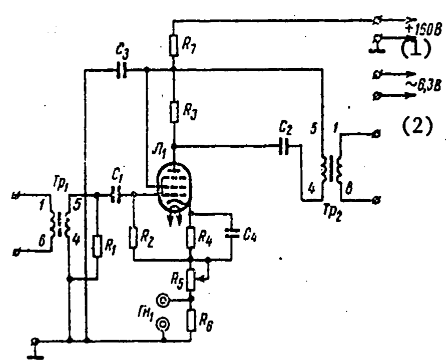


Figure 6.29. Auxiliary repeater

Key:
1. +160 volts
2. ~6.3 volts

The auxiliary repeater for the lower frequency group BYc_1 is executed by the single-stage circuit (Fig 6.29) from the 6Zh1P tube. The purpose of the individual elements of the repeater is analogous to that previously investigated. The maximum gain of the repeater is equal to 15.6 decibels (1.8 nepers) and is smoothly regulated by the variable resistor R_5 forming current feedback. The adjustment limits are +0.87 decibels (0.1 nepers). The diagram of the auxiliary repeater for the upper frequency group does not differ theoretically from that presented and is not considered here.

It was pointed out above that the group multichannel signal running through the communications channel undergoes different attenuation on different frequencies. The repeaters amplify all the frequencies identically, that is, they have planar gain control. This leads to the appearance of amplitude-frequency distortions of the signal. For correction of the distortions introduced by the cable network, the correcting four-terminal networks are connected in series to the repeater -- equalizers with frequency characteristics inverse to the characteristics of the cable network. The equalizers are made up of sections differing from each other by the steepness of the slope of the frequency characteristic and the frequency band. The sections of the equalizers are made of inductance coils of the OB-12 type, mica capacitors of the SSG and the SMGZ type and resistors of the BLL type with respect to the unbalanced circuit. The input and output impedances of the section are equal to 75 ohms. The sections of the equalizers enter into the composition of the group repeater modules. Thus, the equalizers of the upper group of channels enter into the set of modules containing the repeaters of the group of channels GYc_2 and BYc_2. The sections of these equalizers are made with obliqueness of the attenuation on the lower and upper frequencies (312 and 548 kilohertz) by Δa: 3.47 (0.4), 5.65 (0.65), 6.9 (0.8) and 8.7 decibels (1.0 nepers). For correction of distortions of the lower channel group (12-248 kilohertz), the set of sections for Δa is used: 3.47 (0.4), 10.4 (1.2), 12.2 (1.4), 13.9 (1.6) 17.4 decibels (2.0 nepers).

In the set of equalizers there are also sections designed to correct the distortions introduced by two series-connected routing filters DK-280, one of which is connected to the transmitting and the other at the receiving stations (for example, two filters of the D type or two filters of the K type). The sections of the equalizers are designed so that for any length of the repeater section the distortions introduced by the cable network are compensated by two sections, the distortions of the filters are compensated by a third section. The fourth section is an attenuator made up of only ohmic resistances and introducing identical attenuation on all frequencies. Step level control of the signal is accomplished by means of the attenuator. The required equalizer sections are selected when establishing the level diagram for the main line including the terminal and the intermediate repeater stations.

The DK-280 routing filters are used to separate the transmission and reception spectra of the upper and lower frequency groups. Both filters are made structurall in the form of a separate module.

Inasmuch as both filters are included on the line side in parallel, and the opposite signals have a large level gradient [for example, -7 decibels (-0.8 nepers) at the D-280 filter output and -53.9 decibels (-6.2 nepers) at the K-280 filter input], the filter characteristic must insure high protection from the crosstalk. Each filter must introduce no less than 60.8 decibels (7.0 nepers) of attenuation for the currents of the effectively transmitted band of the other filter (the D-280 filter in the 312-548 band, and K-280 in the 12-248 kilohertz band). On the frequencies of its effectively transmitted band the attenuation of each filter must not exceed 1.3 decibels (0.15 nepers).

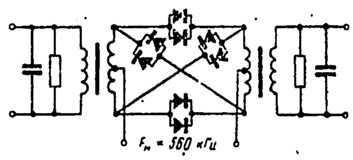


Figure 6.30. Group frequency converter

Key:

1. F_H=560 kilohertz

For limitation of the nonlinear distortions, air-gap coils are used in the filters. When tuning the filter circuits the coil inductance is regulated by introducing ferrite core.

The filter circuit is made up of shielded sections of the k and m type. The housing serves as the return wire and the common shield. The module is connected to the bottom by means of a maximum number of connecting blocks (6), some of which are connected in parallel. This block commutation permits inclusion of the assemblies of the equipment by rearranging the blocks without changing the intermodular wiring.

The group converters are installed at the terminal offices: in the transmission channel of office A and in the reception channel of office B. In the former case they realize the shift of the group spectrum of 312-548 kilohertz to the 12-248 kilohertz range, and in the latter case, vice versa. The group carrier is 560 kilohertz.

The converters are assembled in a ring circuit based on diodes of the D2V type, two diodes in each arm (Fig 6.30).

6.10. Electric Power Supply for the Equipment

Equipment Composition

The electric power supply of the KRR-M equipment comes from the 220 volt AC network. The power supply equipment is made up of converting transformers, rectifiers and filters. The following feed devices are installed in the SIG-1M terminal bay: the generating equipment feed plate (PITGO), the group equipment feed module (repeaters) of the 30-channel system (PITGU), the power pack for the individual equipment of the 30 channels (PITIO). In the SIG-30M bay there are group and individual equipment power packs. In addition, each SIG-1M bay is assigned a ferroresonance voltage stabilizer of the S-0,9 type, the power of which 0.9 kilowatts is sufficient for operation of one SIG-1M bay, three SIG-30M bays and the remote feed transmission plate. The latter is executed in the form of a separate device.

The intermediate repeaters can receive power either from a local source (SPU-2M) or remotely (SPU-2D). In the former case the local feed plate MP is installed, on the intermediate repeater bay; in the latter case, the remote feed plate DP.

The control signal receiver circuits PSU of the transceiver module are fed from the office battery at -60 ($^{+6}_{-2}$) volts.

Voltage Stabilization

During operation of the equipment the network voltage can vary with insignificant limits. In order that during this variation the voltage coming to the electric power units of the equipment remain in variant, a ferroresonance voltage stabilizer is installed to insure an output voltage within the limits of 215-220 volts.

The effect of the ferroresonance stabilizer is based on the phenomena of magnetic saturation and voltage resonance, and it can be explained by Fig 6.31a. The stabilizer contains a transformer with a decreased core cross section, as a result of which the saturation mode is created in it. In this mode the inductance of the primary winding L_1 decreases sharply with an increase in current. Subsequently, the capacitor C is connected to the primary winding. The capacitance of this capacitor is selected so that for the greatest possible voltage in the network the circuit made up of the series-connected L_1 and C will have resonance on a frequency somewhat above the network frequency of 50 hertz. This frequency is defined by the formula $f_{res}=1/2\pi\sqrt{L_1C}$.

With a decrease in the network voltage, the current I_1 decreases, but the inductance L_1 increases, and the resonance frequency f_{res} is reduced and approaches 50 hertz. The resonance condition, as is known, is equality of the generator frequencies (in the given case the network) and the circuit f_{res}. Only in this case will the greatest current slow in the circuit. Thus, in response to the decrease in the input voltage, the inductance L_1 increases, and the resonance frequency decreases, approaching the network frequency, as a result of which the resistance of the circuit decreases, and the current I_1 increases.

With an increase in the input voltage the inductance L_1 decreases, and the resonance frequency increases and is removed still more from the network frequency. In turn, this will increase the circuit resistance and decrease the current I_1. The processes of decreasing and increasing the current mutually compensate for each other, as a result of which the invariant value of I_1 is maintained, and, consequently, the output voltage u_2 of the secondary winding is stabilized (Fig 6.31b).

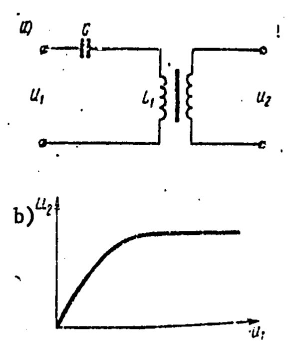


Figure 6.31. Explanation of the operating principle of a ferroresonance stabilizer

Along with the advantages of the ferroresonance stabilizersit is necessary to consider their basic disadvantages: the shape of the output voltage of the stabilizer as a result of its operation in the saturation mode is distorted, which leads to the appearance of harmonics of the network voltage frequency; near the stabilizers powerful variable magnetic fields occur which can create interference; large weight and size with significance power; high cost; great release of heat.

Generating Equipment Feed Plate (PITGO)

The generating equipment feed plate is designed to feed all of the generating modules of equipment. The schematic of a plate is presented in Fig 6.32. A power transformer is installed on the plate, the second winding of which is fed an AC voltage of 220 volts from the stabilizer. There are five secondary windings.

The first winding is used to obtain the AC voltage of 250 volts. This voltage is rectified by the rectifier (BY_1) assembled from silicon diodes, two in each arm of the bridge for high operating reliability. As a result of large scattering of the diode parameters, the diodes are shifted by resistors which equalize the return voltages between them. For smoothing the pulsations of the rectified current there is a two-section choke filter Dp_1; Dp_2; C_1-C_4. At the filter output 250 volts of DC voltage is formed which is required to feed the anode circuits and the shielded grids of the powerful 6P3S and 6P9 tubes of the output stages of the amplifier modules of the harmonic generator, the group carrier repeater and the signal frequency generator. The output voltage is regulated by the variable resistance R_1. The current in the load can reach 0.4 amps.

The second output winding is used to obtain an anode voltage of 160 volts required to feed the 6Zh1P tubes. The rectifying bridge BY_2 is assembled from the same silicon diodes as BY_1. The pulsations are smoothed by the two-section filter. The output voltage can be regulated smoothly by the resistance R_2. The normal load current is 0.35 amps.

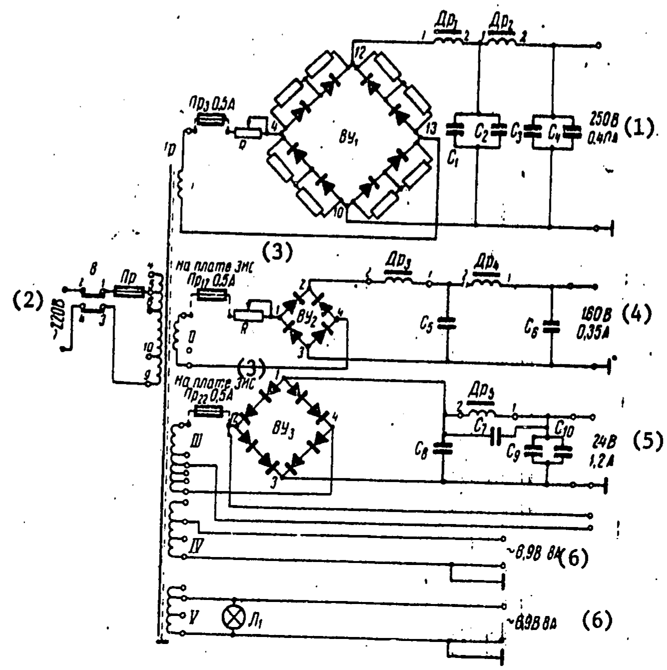


Figure 6.32. Generating equipment feed plate

Key:

1. 250 volts
2. ~220 volts
3. On the ZIS plate
4. 160 volts
5. 24 volts
6. ~6.9 volts, 8 amps

The third winding is used to obtain a DC voltage of 24 volts with a normal load current of 1.2 amps. This voltage is insured by the rectifier BY_3 -- the selenium column of the BM-16A2 type and the smoothing filter Dp_5, C_7-C_{10}, and it is used to feed the signal circuit of four 30-channel systems. On the same winding there is a lead from which the AC voltage of 24 volts is picked up to feed the heating elements of the thermostats of the master oscillators.

The fourth and fifth windings provide an AC filament voltage of 6.3 volts for the tubes of the basic and reserve modules of generator equipment. The load current of each output is 8 amps. A commutator tube L_1 is connected in parallel to one of the outputs for a control. From each plate output the voltage is fed through breakers located on the ZIS plate to the corresponding generating equipment modules and to the voltmeter which monitors all of the voltages generated by the electric power supply devices.

Group Equipment Power Pack of the 30-Channel System

The group equipment power pack is designed to feed group and auxiliary repeaters of the terminal stations. This pack is located both in the SIG-1M bay and in the SIG-30M bays. The diagram of the module is presented in Fig 6.33. The module generates 160 volts DC and 6.3 volts AC.

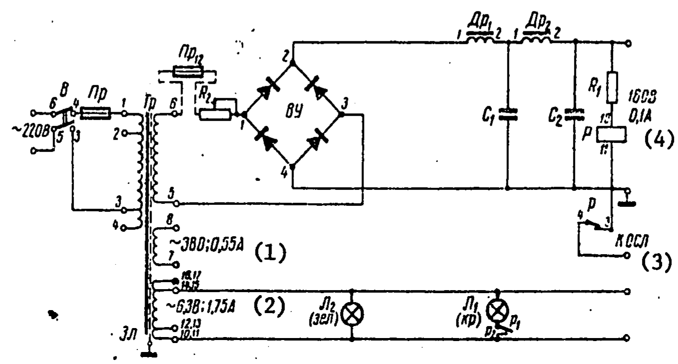


Figure 6.33. Group equipment power pack

Key:
1. ~38 volts, 0.55 amps
2. ~6.3 volts, 1.75 amps
3. To the OSL
4. 160 volts, 0.1 amps

The primary winding of the power transformer is fed from the 220 volt AC voltage stabilizer. There are three secondary windings. A voltage of 160 volts is picked up from the output of the first winding. This voltage is rectified by a silicon diode rectifying bridge, it is filtered by the two-section filter Dp_1, Dp_2, C_1, C_2, and it is fed to the anode and grid circuits of the 6Zh1P tubes. The voltage is regulated by the variable resistance R_2. The load current is 0.1 amps.

The secondary winding of the transformer insures that an AC voltage of 38 volts will be obtained, which is used in cases where the module is installed on the old-model bays (KRR).

From the output of the third winding 6.3 volts of AC voltage are obtained to feed the filament circuits of the group and auxiliary repeater tubes. The load current is 1.75 amps. The tube L_2 is included in parallel to this winding to signal normal operation of the module.

A control relay P is included at the output of the filter. During normal operation of the module it operates, receiving power from the rectifier through the additional resistance R_1. The contacts 1-2 of the relay P break the circuit of the signal tube L_1, and the contacts 3-4 open the general bay signal circuit.

If there is a failure in the module, for example, in the case of overheating of the breaker or in the absence of a rectified voltage, the relay P trips and its contacts include the corresponding signal.

Individual Equipment Power Pack

The individual equipment power pack (Fig 6.34) is designed to feed the modulators, the demodulators and the low-frequency amplifiers of the transceivers of the 30 channels. The module generates a 15 volt DC voltage with a normal load current of 0.8 amps. The module includes a transformer, a rectifying bridge based on silicon diodes and a smoothing filter.

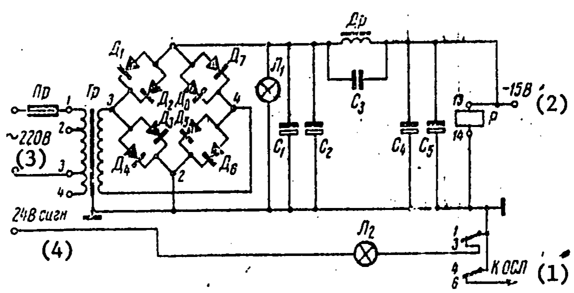


Figure 6.34. Individual equipment power pack

Key:
1. To the OSL
2. -15 volts
3. ~220 volts
4. 24 volt signal

The signal relay P is connected in parallel to the output. During the normal operation of the module this relay is under current and does not offer the possibility of formation of an emergency signal by the circuits. The tube L_1 burns on the panel of the module. When the output voltage drops, the relay is deenergized and tripped. The circuits of the signal tube L_2 are created from the 24 volt voltage fed from the PITGO plate an the module and the general bay signal.

Remote Power Transmission Plate

The remote power transmission plate (PDP) contains two identical rectifiers BY_1 and BY_2 (Fig 6.35), each of which provides two intermediate repeater stations with power.

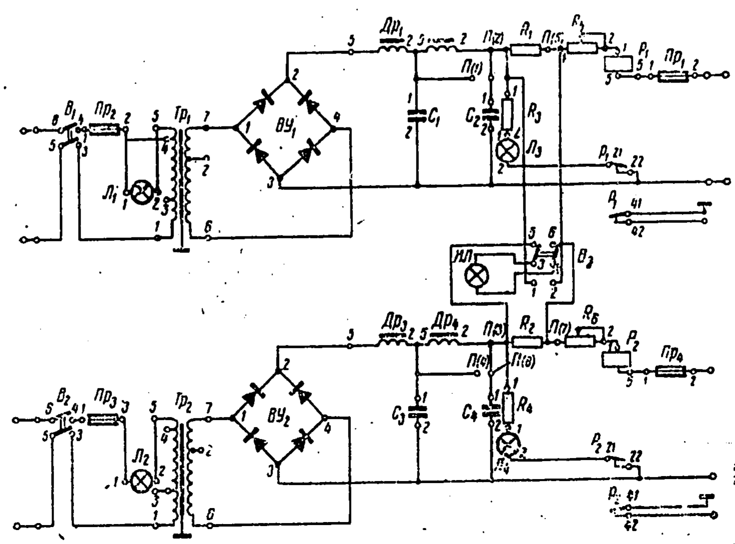


Figure 6.35. Remote power transmission plate

A voltage of 220 volts from the AC network is fed through a stabilizer to the primary windings of the power transformers Tp1 and Tp_2. The rectifying bridges assembled from silicon diodes are connected to the secondary windings of the transformers. The rectified voltage pulsations are smoothed by the two-section filters. A control milliammeter is connected to the resistors R_1 and R_2 included at the output of the filters using the toggle switch B. The resistors R_5 and R_6 are used to regulate the voltage of the plate. The maximum remote feed voltage is 270 volts for a current of 0.35 amps.

The tubes L_1 and L_2 signal the presence of an AC voltage at the plate input.

When the remote feed current drops, the relay $P_1(P_2)$ at the plate output trips, and by its contact it connects the ballast resistance R_3 or R_4 to the rectifier, it switches on the tube $L_3(L_4)$ and creates the general bay signal circuit.

The remote feed voltage is fed from each plate output to the midpoints of the line windings of the line transformers installed on two multiplexed circuits (Fig 6.36), and it is transmitted over the same pairs as the high-frequency signals. For prevention of crossover of the group signal currents from one circuit to the other through the remote feed devices the filters D-8 are connected to the midpoints of the transformers. For high-frequencies of the group signals these filters create a large resistance and insure the required protection between the circuits.

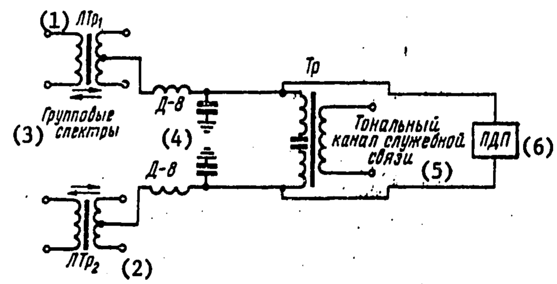


Figure 6.36. Connection of remote feed circuits and the link between operators to the line transformers

Key:

1. Line transformer - LTp_1
2. Line transformer - LTp_2
3. Group spectra
4. D-8
5. Audio-channel of the link between operators
6. PDP - remote power transmission plate

For organization of the low-frequency channel of the link between operators, the phantom transformer Tp is installed. The capacitor C connected in series with its winding does not permit closure to the direct current of the remote feed through the transformer.

For reception of remote feed of the unattended repeater stations in the SPU-2D bays remote feed reception plates are installed which are designed to feed two repeaters. The voltage at the plate output is 160 volts with a load current of 0.35 amps. This DC voltage is used both to feed the anode circuits and the filament circuits. Inasmuch as the filaments of all of the tubes of the two repeaters (a total of 18) are connected in series, the voltage required to feed them is $6.3 \cdot 18 = 113.4$ volts.

Local Feed Plate of the SPU-2M Bay

The MP local feed plate is installed on the SPU-2M intermediate repeater bays. The MP plate (Fig 6.37) is designed to feed two repeaters and operates from the 220 volt AC circuit. On the plate there is a ferro-resonance stabilizer formed by the choke Dp_1, the capacitor C_1 and C_2 of two microfarads each and the power transformer Tp_1. The rectifier is assembled from silicon diodes. After the two-section smoothing filer there is a relay P_1, the armature of which is pulled up during normal operation. By the contact 31-32 of this relay the repeater feed circuit is formed. The relay P_2 in the feed circuit also operates. After the resistor R_4 the rectifier voltage of 160 volts is fed to the anode circuits of two repeaters. For decoupling these circuits the voltage is fed to one of the feeders directly from the plate output, and to the other through two half-sections of the D-8 filter.

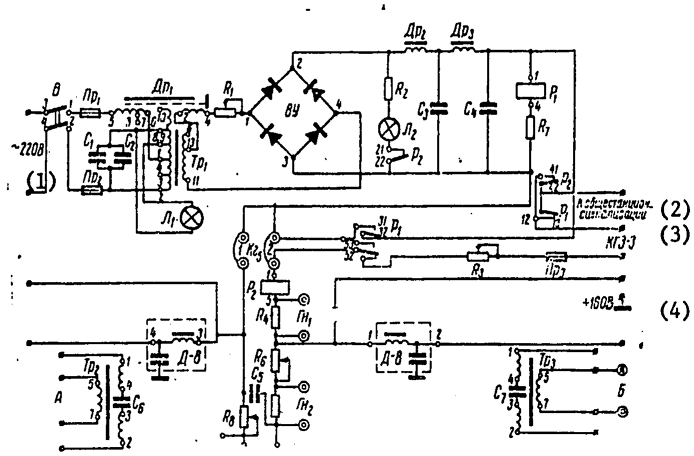


Figure 6.37. Local feed plate

Key:

1. ~220 volts
2. To the general-bay signal
3. KG3-3
4. +160 volts

The filament circuit formed from the series-connected filaments of all 18 tubes of the bay is connected in parallel through the resistors R_6 and R_5. The resistor R_6 is used to obtain a voltage of 6.3x18=113.4 volts.

The socket $ГН_1$ is used to measure the entire load current, and ГН2, to measure the current in the channel circuit.

There is a signal circuit on the plate. The tube L_1 signals the presence of a network voltage and the state of repair of the protectors Pr_1 and Pr_2. The relay P_1 connected in series to the load is under current in the operating state of the plate. When the load circuit is broken, the relay is released, the light L_2 burns and the general bay signal circuit is created.

The plate provides for automatic switching to reserve power and switching back to the base power. The reserve power can come from the DC battery, the positive terminal of which must be connected to the KG3-3 terminal. When the AC voltage drops, the relay P_1 releases, breaking the feed circuit from the rectifier and including the battery by the contact 51-52. If the battery voltage differs from 160 volts, the variable resistance R_3 is used to set the required amount. On appearance of a voltage at the output of the rectifier, automatic switching to this voltage takes place. In addition to the feed circuits, on the plate there are two phantom circuit transformers for the link between operators. If there is a transistorized repeater in the equipment of the link between operators, it receives power (-24 volts) through the resistor R_3.

Test Questions

1. What is the purpose and the basic technical specifications of the KRR-M equipment?

2. How are the channel frequencies distributed in the line spectra of offices A and B?

3. Enumerate the composition of the terminal and intermediate station equipment.

4. What is the purpose of the technical specifications of the individual equipment?

5. Explain the current transmission, the purpose of the assemblies and modules of transmitting and receiving channels of the type A and type B stations.

6. Explain the purpose, the basic technical specifications of the intermediate repeater station, its equipment composition and the current transmission of the signal of the upper and lower frequency groups.

7. Explain the purpose of the static relay, its operating principle and the basic characteristics of the signal channel.

8. Explain the structural diagram of the generating equipment of the terminal station, the purpose, the technical characteristics and the operating principle of all modules.

9. Explain the purpose, the composition of the equipment and the operating principle of the relay assemblies for switching the signal frequency generator, harmonic generator and group carrier repeater.

10. Give the equipment composition of the electric power supply devices, feed voltages used in the equipment and the peculiarities of obtaining them.

11. Explain the purpose, the electrical characteristics and the schematic of the transceiver module.

12. Explain the purpose and the frequency characteristic of the D-3,4 filter on the transmitter plate.

13. Explain the phase-difference circuit for suppression of the lower modulation sideband in the channel transmitter.

14. Explain the purpose, electrical characteristics and the schematic peculiarities of the basic receiver plate assemblies.

15. Explain the purpose, the electrical characteristics and the schematic peculiarities of the structure of the PSU.

16. Give the equipment composition of the group channels of the terminal and intermediate stations.

17. Explain the purpose, the basic electrical characteristics and the structural diagrams of the group and auxiliary repeaters, the group converters, and the routing filters.

CHAPTER 7. KRR-T (KAMA) EQUIPMENT

7.1. General Information

The KRR-M equipment has group, intermediate and generating equipment made from electronic tubes which is a serious deficiency, lowering its reliability. Therefore, in 1968-1970 a completely transistorized analog of the KRR-M equipment was developed — the KAMA equipment (the cable equipment multiplexing local automatic telephone exchanges) and the series output of this equipment was started.

The KAMA equipment, just as the KRR equipment, is designed to multiplex the trunks of the city and suburban telephone exchanges with 30 two-way telephone channels. The equipment is designed to multiplex symmetric cable pairs with cordel-styroflex insulation of the conductors (type MKS 7x4x1,2 and MKX 4x4x1,2) and also the single-quad cables with polyethylene insulation (type VTSP 1x4x1,2 or KSPV 1x4x0,9) with respect to the single-cable, two-band system in the spectrum to 548 kilohertz. The maximum communications range can reach 80 km with six repeater sections with an average length of 13 km each. Inasmuch as the same structural principles are used in KAMA equipment as in the KRR, the procedure for establishment of a subscriber connection over the trunks formed by the KAMA equipment channels is identical with that discussed earlier for the KRR equipment.

The distinction of the KAMA equipment from the KRR equipment is the following. In the KAMA equipment all of the group, generating and tandem equipment is built using transistors, automatic level control (ALC) and group channel monitoring devices which provide for determination of the damaged route and inclusion of a signal in the case of damage to the channel. In accordance with the standard requirements, in the KAMA equipment the frequency of the segregated signal channel has been changed from 3800 hertz to 3825 hertz; provision has been made for the possibility of synchronizing the generating equipment by an 8 kilohertz signal transmitted over the group channel of any 30-channel system and also from the general-station master oscillator or the synchronization network. In addition, in the KAMA equipment a device has been introduced for organizing the link between operators by a phantom circuit or a high-frequency channel, and the structural design of the equipment of the terminal and intermediate stations has been changed.

Inasmuch as the occupied frequency bands and the transmission levels are identical in the KAMA equipment and the KRR equipment, joint operation of the KAMA and KRR equipment on different pairs of the same cable is possible. However, the introduction of ALC and GCM [group channel monitoring] and also changing the signal channel frequency complicates the joint operation of the terminal offices of the KAMA equipment and the KRR-M equipment on one circuit. This type of inclusion (without ALC and GCM) is permitted only as an exception where in order to reduce the distortions of the transmitted number dialing pulses in this case it is recommended that a frequency of 3800 hertz be transmitted over the signal channel of the KAMA equipment (from the KRR equipment generator), and a frequency of 3825 hertz over the signal channel of the KRR equipment (from the generator of the KAMA equipment).

7.2. Equipment Composition and Structural Peculiarities

The composition of the terminal equipment of the KAMA equipment includes only one type of individual and group equipment bay SIG. The following are placed in this bay: three static relay modules CP; the line transformer module LTp; the DK-280 routing filter module; the transmission module of office A (at office B, the transmission module of office B); the reception module of office A (at office B, the reception module of office B); the D-552 filter module, the PП-8 synchronizing signal transmission module; the PIT power pack, the ALC and GCM module of office A (at office B, the ALC and GCM module of office B) and 30 transceiver modules.

The generating equipment of the KAMA equipment is segregated in a separate bay -- the generating equipment bay SGO which provides up to four SIG bays (120 channels) with carrier, control and signal frequencies. The SGO bay composition includes the following: the phantom transformer module ΦTp (nonremovable module); two PIT power packs; two ZG master oscillator modules (at office B, one module); the PY decoupling module, two GG harmonic generator modules; 16 GIN individual carrier frequency generator modules; two 296 kilohertz G-296 frequency generator modules; two 304 kilohertz GKCh control frequency generator modules; two 560 kilohertz UGN group carrier frequency repeater modules; two GTV (frequency 3825 hertz) ringer oscillator modules (in the KRR-M equipment these modules are called G-3,8), the KY monitoring module and two PVU-1 and PVU-2 speak-buzz key modules.

The equipment installed at the terminal offices also includes the remote power transmission bay SDP designed for four remote power circuits of 8 30-channel groups (with respect to a phantom circuit) and the common row bay ORS in which the following are placed: the row signal unit, the idle time counters for the system, auxiliary equipment and accessories.

The frames of all types of bays are identical, and they are in the form of a vertical welded frame 2600x500 mm in size. The modules are placed along the frame vertically on two sides in a single row on each side. There are no trays in the bay; the modules are inserted in the bay along special guides serving simultaneously for attachment of the modules and for attachment of the cable in the frame. The modules are connected to the frame by 5-pronged jumpers just as in the KRR equipment. All of the modules are made in two types of sizes: 98x88x245 mm and 198x88x245 mm with respect to one structural principle. The wiring of the modules is basically printed circuitry. The dimensions of the bay with the inserted modules (2600x250x240 mm) permit placement of 600 channels of KAMA equipment in a single row as opposed to 480 channels of KRR equipment.

The intermediate KAMA equipment is placed in the intermediate repeating bay SPU. The SPU is made in the form of a frame with attachments for fastening four sets of intermediate repeaters. Each of the assemblies provides for two-way repeating of 30 channels of KAMA equipment and it includes the following: two line transformer modules, two DK-280 filter modules, the lower group repeating module, the upper group repeating module, the power pack and ALC module installed in the middle repeating station in the B-A direction with communications length of more than 50 km.

For matching the KAMA equipment with the ten-step system or the crossbar system, the same RSLU relay assemblies are used as for matching the KRR equipment.

7.3. Construction of Group Channels of the Terminal Offices

Transmission Channel of Office A

The structural diagram of the group channel of office A of the KAMA equipment is shown in Fig 7.1.

The individual equipment of each office is made up of 30 transceivers (ПП). Carrier frequencies that are multiples of 8 kilohertz are fed to the ПП converters from the SGO bay. The carrier frequency of each channel, just as in the KRR equipment is determined by the formula $f_{carrier}=304+8n$ kilohertz where n is the channel number. As a result of conversion at the output of each channel upper modulation sidebands are formed; the lower sidebands are suppressed by no less than 25 decibels (2.9 nepers), and the carrier frequency, by no less than 14.8 decibels (1.7 nepers). The outputs of the transmitters of all 30 channels are connected in parallel; as a result a signal with a spectrum of 312-548 kilohertz is formed at the input of the group channel.

The group signal goes from the ПП modules to the D-552 module containing the D-552 low-frequency filter, the summing transformer Tp, the feed elements R_2, D_1 and C_1 of the 30 terminal stages of the transmitters and two attenuators Udl_1 and Udl_2 for input of the control frequency of 304 kilohertz to the group channel and the auxiliary frequency of 312 kilohertz. The D-552 filter limits the frequency of the group signal at the top (a frequency of 552 kilohertz), suppressing the side conversion products of the individual channel modulators. The summing transformer is used to combine the output of the 30 transmitters. The output impedance of the transmitters equal to 75 ohms is insured by the resistor R_3 which is connected to the secondary winding of the summing transformer.

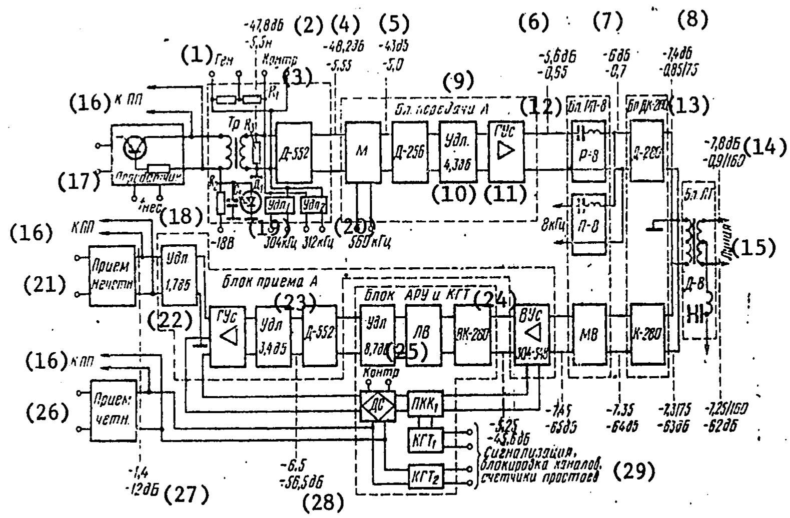


Figure 7.1. Structural diagram of the SIG-A office

Key:

1. GEN
2. -47.8 decibels, -5.5 nepers
3. Control
4. -48.2 decibels, -5.55 nepers
5. -43 decibels, -5.0 nepers
6. -5.6 decibels, -0.65 nepers
7. -6 decibels, -0.7 nepers
8. -7.4 decibels, -0.85/75 nepers
9. A transmission module
10. Udl. 4.3 decibel attenuator
11. GUs group repeater
12. PП-8 module
13. DK-200 module
14. -7.8 decibels
15. Line
16. To the ПП
17. Transmitter
18. $f_{carrier}$
19. Udl_1 attenuator
20. Udl_2 attenuator
21. Odd receiver
22. 1.7 decibel attenuator
23. A reception module
24. ALC and GCM module
25. 8.7 decibel attenuator
26. Even receiver
27. -12 decibels
28. -56.5 decibels
29. Signal unit, channel blocking, idle time counters

The "Gen" and the "Control" measuring sockets are used without disconnecting the modules. The measuring generator can be connected to the "Gen" sockets, and the selective level indicator can be connected to the "Control" sockets (by the high-resistance input) to measure the output levels of the transmitters and the control and auxiliary frequency levels.

The terminal stages of the transmitters are fed from the parametric voltage stabilizer consisting of the ballast resistor R_2 and stabilitron D_1. The stabilize voltage is equal to 9 volts. In order to avoid the appearance of crossovers with respect to the feed circuit, the stabilitron is further shunted by a capacitor C_1.

The measuring level of the transmitters and the input of the D-552 filter is -47.8 decibels (-5.5 nepers) on a 75 ohm load.

For automatic gain control of the group channel, a control frequency of 304 kilohertz is fed to the input of the D-552 filter through the Udl_1 attenuator. In order not to load the channel, this frequency is fed to its input with a level 8.7 decibels (1 neper) below the measuring frequency. In order to find the damaged line of the group channel, the 312 kilohertz auxiliary frequency is used. It is fed to the Udl_2 attenuator and if the group channel is in good working order it is not transmitted to the line. Thus, considering the control frequencies, the group equipment in the A-B direction must provide for transmission of the signals with a spectrum of 304-548 kilohertz.

From the output of the D-552 filter the group signal goes to the A transmission module containing the series-included group modulator M, the D-256 filter, the 4.3 decibel (0.5 neper) attenuator and the GUs group repeater. The input level of the module is -48.2 decibels (-5.55 nepers), the output level is -5.6 decibels (-0.65 nepers) on a load of 75 ohms.

The group modulator is executed from transistors, and it introduces a gain of 4.3-6.1 decibels (0.5-0.7 nepers). As a result of group conversion on a frequency of 560 kilohertz, the group signal of 304-548 kilohertz is converted to a spectrum of 12-256 kilohertz. In order to suppress the undesirable upper frequency sideband the D-256 filter is included after the modulator. The converted signal is amplified by the GUs group repeater. The amplification of the repeater is 43 decibels (5.0 nepers); the regulation limits are ±2.6 decibels (0.3 nepers). In order to reduce the excess gain, a 4.3 decibel (0.5 neper) attenuator is included at the input of the repeater.

From the group repeater output the signal goes to the band-elimination (rejector) filter P-8 which has maximum damping on a frequency of 8 kilohertz. The P-8 filter operates as a pair with the П-8 filter designed for transmission of a synchronizing frequency of 8 kilohertz to the line to the opposite terminal office.

The the signal goes to the DK-280 module. The fork of the DK-280 filters provides for the necessary protection between the transmission and reception channels of the terminal office [no less than 65 decibels (7.5 nepers)].

From the output of the D-280 filter the signal goes to the line transformer module. The line transformer is used to form a balanced (symmetric) line input circuit of the equipment and is designed for inclusion between loads of 75 ohms (on the office side) and 160 ohms (on the line side). The line winding of the transformer has midpoint lead-out for organizing the link between operators over phantom circuits and for remote feed of the repeaters of the intermediate repeater stations. In order to decrease the effect between the systems the D-8 filter is connected through the remote feed circuit to the midpoint of the line transformer. A 12-256 kilohertz group signal goes through the line transformer to the line with a level of -7.8 decibels (-0.9 nepers) on a load of 160 ohms.

Reception Channel of Office A

The reception channel must provide for amplification of the group signal with respect to 304-548 kilohertz and covering of the line attenuation to 60 decibels (6.9 nepers), which corresponds to attenuation of the line of maximum length (14.3 km) on a frequency of 548 kilohertz. If we consider that the transmission level of office B to the line is equal to -3 decibels (-0.35 nepers), the minimum reception level of the input of the line transformer of office A will be -62 decibels (-7.25 nepers). The signal level at the output of the group channel at the point of connection of the channel receivers is taken equal to -12.2 decibels (-1.4 nepers) on a load of 75 ohms.

The group signal at 304-548 kilohertz goes through the line transformer and the K-280 filter to the main equalizer MB. This equalizer is used to correct the residual errors of the line equalizers installed on the intermediate repeaters and also the distortions introduced by the office equipment included at the terminal office. The MB attenuation is about 1.7 decibels (0.2 nepers).

From the MB output the group signal goes to the A reception module made up of the auxiliary repeater VUs at 304-548 kilohertz, the 3.5 decibel (0.4 neper) attenuator, the GUs group repeater in the 1.7 decibel (0.2 neper) attenuator. The auxiliary upper group repeater VUs at 304-548 kilohertz is used for preamplification of the group signal. The average gain of the VUs is equal to 19 decibels (2.2 nepers), and by using the ALC circuits it can be regulated within the limits of ±7 decibels (0.8 nepers). The VK-280 equalizing circuit corrects the frequency characteristic of the two K-280 filters, one of which is in the office B transmission channel.

The line equalizer LV compensates for the amplitude-frequency distortions introduced by the preceding section of cable. The accuracy of the correction is ±0.9 decibels (0.1 nepers), and it is reached by means of two nonremovable variable equalizers, the resolderings in the circuit of which permit correction by steps of 1.7 decibels each (0.2 nepers). The Udl-8.7 decibel attenuator permits planar gain control of the channel in steps every 4.3 decibels (0.5 nepers).

The variable attenuators,VK-280, LV are structurally combined and together with the ALC devices are placed in the single ALC module.

From the output of the Udl-8.7 decibel attenuator the group signal goes to the D-552 filter designed to suppress the radio signals induced in the line. In order to obtain the required level diagram between the D-552 filter and the group repeater, a 3.5 decibel (0.4 neper) attenuator is included.

The group repeater amplifies the signal by 43 decibels (5.0 nepers). Channel receivers are connected to the output of the repeater. In order to increase the protection from the crosstalk between even and odd channels the GUs has two outputs: even and odd channels. The odd channel receivers are connected through the 1.7 decibel (0.2 neper) attenuator; the even channel receives are connected through the DS differential system which decouples the ALC devices and the individual channel receivers.

In order to monitor the reception level of any channel at the output of the group channel the "control" plug is provided. The control is exercised by means of a selective level indicator connected by the high-resistance input.

The ALC is realized by the PKK monitor channel receiver connected in parallel to the output of the group reception repeater. With variation of the level of the control frequency of the 304 kilohertz at the output of the GUs the receiver generates the corresponding signal to the regulating element located in the feedback circuit of the auxiliary repeater. As a result, the gain of the VUs varies to restoration of the normal reception level at the output of the group repeater.

For monitoring the group channel, finding the damaged line, signalling and blocking the channels, the receivers of the group channel control KGT_1 [GCM_1] and KGT_2 [GCM_2] are used.

Office B Transmission Channel

The structural diagram of the group channel of office B is shown in Fig 7.2.

The transmission channel is used for amplification and transmission of the group signal to the line with a spectrum of 304-548 kilohertz. In the B-A direction the group signal is not converted; therefore the B transmission module contains only the group repeater GUs with the average gain of 43 decibels (5.0 nepers). The D-552 filter module, the DK-280 module and the line transformer module execute the same functions as at office A.

The group signal measuring levels at the various points of the transmission channel are indicated in the diagram. At the GUs output the transmission level, just as in the KRR equipment is -2.2 decibels (-0.25 nepers) on a 75 ohm load; the signal goes to the line with a level of -3 decibels (-0.35 nepers) on a 160 ohm load.

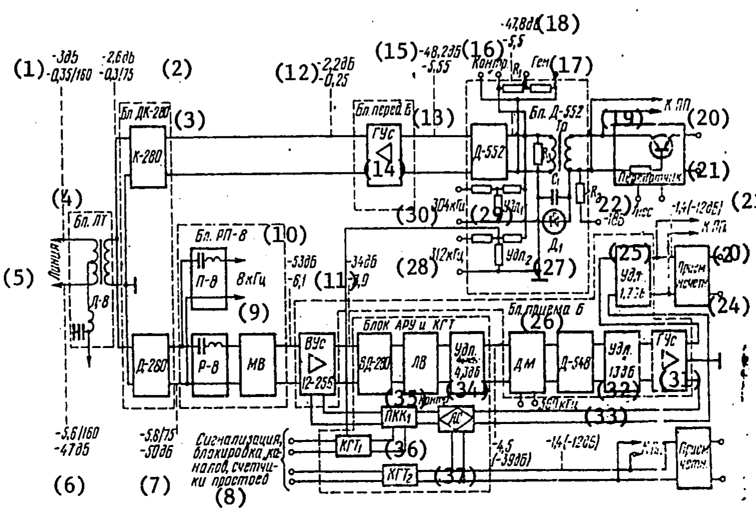


Figure 7.2. Structural diagram of the SIG-B station

Key:

1. -3 decibels
2. -2.6 decibels
3. DK-280 module
4. LT module
5. Line
6. -47 decibels
7. -50 decibels
8. Signal, channel blocking, idle time counter
9. 8 kilohertz
10. PП-8 module
11. -53 decibels
12. -2.2 decibels
13. B transmission module
14. GUs
15. -48.2 decibels
16. Control
17. Gen
18. -47.8 decibels
19. D-552 module
20. To the ПП
21. Transmitter
22. $f_{carrier}$
23. -1.4 (-12 decibels)
24. Odd receiver
25. 1.7 decibel attenuator Udl.
26. B reception module
27. Udl_2 attenuator
28. 312 kilohertz
29. Udl_1 attenuator
30. 304 kilohertz
31. GUs group repeater
32. Udl 13 decibel attenuator
33. 560 kilohertz
34. Udl 4.3 decibel attenuator
35. Control
36. $KGT_1 = GCM_1$
37. $KGT_2 = GCM_2$

Office B Reception Channel

The reception channel is used to receive the group signal with a spectrum of 12-256 kilohertz, conversion of it to the 304-548 kilohertz spectrum and amplification to a level of -12 decibels (-1.4 nepers) required for normal operation of the individual channel receivers. The minimum level of channel reception on a frequency of 248 kilohertz is -49 decibels (-5.6 nepers) on a 160 ohm load.

The group signal goes through the line transformer and D-280 filter to the PП-8 filter module. The rejector filter P-8 which has a maximum attenuation on a frequency of 8 kilohertz does not transmit the synchronizing frequency to the group channel. This frequency, which comes from the office A is separated by the П-8 band filter and goes to the generating equipment of office B. From the output of the rejector filter the group signal at 12-256 kilohertz goes through the main equalizer MB to the office B reception module. This module is made up of the auxiliary repe-ter VUs on 12-256 kilohertz, the demodulator DM, the D-548 filter, the Udl-13 decibel (1.5 neper) attenuator and the GUs group repeater.

The VUs introduces an average gain of 19 decibels (2.2 nepers) and it provides for automatic gain control within the limits of ±7 decibels (±0.8 nepers).

The VD-280 filter equalizer compensates for nonuniformity of the frequency characteristic of the two D-280 filters, one of which is located at office A. The LV line equalizer and the step attenuator compensate for the frequency-amplitude distortions introduced by the preceding section of MKS cable. Just as at office A, the correction is made by two variable equalizers permitting the magnitude to be altered by resoldering in steps every 1.7 decibels (0.2 nepers). The VD-280, LV and the variable attenuator are structurally combined with the ALC and they are placed in a single ALC module.

The group signal at 12-256 kilohertz goes to the input of the demodulator with a level of -39 decibels (-4.5 nepers). The D-548 filter is connected at the demodulator output. It transmits only the difference products of conversion, that is, frequencies of 304-548 kilohertz. In order to obtain the required level diagram, the 13 decibel (1.5 neper) attenuator is included between the filter and the GUs.

The DS differential system at the output of the GUs, the 1.7 decibel attenuator and also the ALC and GCM devices perform the same functions as at office A.

7.4. Intermediate Repeater Stations

With a trunk length of more than 13-14 km the terminal offices usually cannot compensate for attenuation of the section of cable. In order to increase the operating ring through the equipment, semiconductor intermediate repeater stations PUT are used.

The structural diagram of the PUT of the KAMA equipment appears in Fig 7.3.

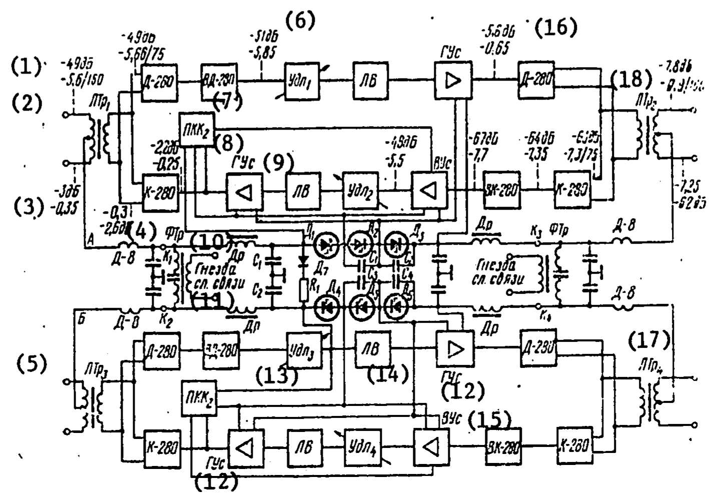


Figure 7.3. Structural diagram of an intermediate repeater station

Key:
1. -4.9 decibels
2. LTp_1 line transformer
3. -3 decibels
4. -2.6 decibels
5. LTp_3 line transformer
6. -51 decibels
7. VD-280
8. PKK_2
9. GUs
10. ΦTp phantom transformer
11. Plugs for the link between operators
12. GUs
13. Udl_3 attenuator
14. LV line equalizer
15. VUs
16. -5.6 decibels
17. LTp_4 line transformer
18. LTp_2 line transformer

The PUT contains the set of equipment which is used for two-way repeating of 30 channels. All of the PUT equipment is made up of modules analogous to the corresponding modules of the SIG terminal office of the KRR-M equipment and having the same purpose.

In the A-B direction the PUT covers the attenuation of 41 decibels (4.7 nepers). The minimum reception level at the input of the line transformer LTp_1 is -49 decibels (-5.6 nepers). The signal goes to the lower group amplification channel through the D-280 filter. The equalizer VD-280 compensates for distortions introduced by this filter. The correction of the distortions introduced by the preceding section of cable is accomplished by the variable attenuator Udl_1 and the variable line equalizer LV. Then the signal is fed to the input of the group repeater GUs and it is amplified to the level of -5.6 decibels (0.65 nepers). The amplified signal goes through the D-280 filter and the LTp_2 line transformer to the line with a level of -7.8 decibels (-0.9 nepers).

In the B-A direction the repeating covers attenuation of 60 decibels (6.9 nepers). The minimal level at the LTp_2 input will be -63 decibels (-7.25 nepers). The 304-548 kilohertz signal goes to the amplification channel of the upper frequency group through the line transformer and the K-280 filter. The VK-280 equalizer precompensates the distortions introduced by the K-280 filter, and then the signal is amplified by the auxiliary repeater VUs at 304-548 kilohertz. The variable attenuator Udl_2 and variable equalizer LV correct the frequency-amplitude distortions introduced by the preceding section of cable, after which the corrected signal is fed to the input of the group repeater GUs by which it is amplified to a level of -2.2 decibels (-0.25 nepers). Through the K-280 filter and the LTp_1 line transformer the group signal is fed to the line with a level of -3 decibels (-0.35 nepers).

With a communications length of more than 50 km at the middle repeater station in the amplification channel of the upper frequency group a control channel receiver PKK_2 is installed which realizes automatic gain control of the channel. The introduction of ALC in the B-A direction is explained by an inadmissible increase in noise level in the equipment channels on the long lines as a result of seasonal shift of the level diagram. Just as at the terminal office the PKK [control channel receiver] controls the gain of the auxiliary repeater in the case of variation in level of the control frequency of 304 kilohertz at the GUs output. The possible limits of variation of the repeater gain are ±7 decibels (±0.8 nepers) from the average gain of 19 decibels (2.2 nepers).

The second set of PUT equipment included between the line transformers LTp_3 and LTp_4 operates analogously, insuring two-way repeating of the second 30-channel group.

The repeaters of both assemblies permit remote feed from a DC power supply installed at the terminal office. The feed voltage of the repeater and PKK is received from individual stabilitrons D_1-D_3 (upper repeater) and D_4-D_6 (lower repeater) included in different conductors of the phantom circuit. The C_1-C_4 capacitors and the halfsections of the low-frequency filters Dp, C are the decoupling elements of the feed circuits.

7.5. Operating Principles of the ALC [automatic level control] and GCM [group channel monitor] of the KAMA Equipment

In order to improve the quality indexes of the channels and facilitate operation in the KAMA equipment provision is made for the installation of automatic level control (ALC) and a group channel monitor (GCM). In the equipment a frequency-dependent electric system for the ALC on one control frequency of 304 kilohertz is used. For the auxiliary circuits in the ALC and the GCM frequencies of 312 and 296 kilohertz are used.

Fig 7.4 shows the structural diagram explaining the operating principle of the ALC and the GCM of the KAMA equipment.

From the control frequency generators PKCh installed at the terminal offices, the control frequency of 304 kilohertz goes through the asymmetric attenuator Udl_1 in the D-552 filter module to the input of the group channel with a level 8.7 decibels (1 neper) below the measuring level. At the terminal offices, and with a communications length of more than 50 km and in the amplification channel of the upper frequency group of the middle intermediate repeater, the control frequency signal is isolated by the control channel receiver (PKK). At the terminal offices the PKK is connected to the output of the group channel.

Let us consider the operation of the PKK in the example of the office A for which the structural diagram of the receiver is shown in expanded form. At office B the receiver operates analogously. From the even channel output of the GUs the control frequency 304 kilohertz goes to the differential system, DS of the control channel receiver PKK_1 with a level of -21 decibels (-2.4 nepers). This frequency goes through the P-304 band filter to the modulator M with the carrier frequency 296 kilohertz. The difference conversion product gives a frequency of 8 kilohertz which goes through the Π-8 band filter to the $UKCh_1$ repeater. The amplified control frequency is fed to the regulating device PY_1. Here it is rectified and compared with the reference (standard) voltage. The result of the comparison is amplified by the DC amplifier and goes to the regulating element RE which controls the amplification of the auxiliary repeater.

A thermistor (thermal resistance type T8M), the resistance of which varies depending on the magnitude of the current flowing through it, is used as the regulating element. The thermistor is included in the negative feedback circuit of the VUs and shunts the frequency-dependent two-terminal network with respect to alternating current, varying the gain of the repeater. Thus, if the control frequency level at the output of the GUs decreases, in the PY_1 the difference between the reference voltage and the control signal voltage will lead to the fact that the current through the thermistor increases, and its resistance decreases. The shunting effect of the thermistor becomes stronger, the depth of negative feedback diminishes and the gain of the VUs increases. The normal control frequency level is restored at the output of the GUs. With an increase in control signal level at the output of the GUs the voltage difference of the control and reference signals leads to a decrease in current through the thermistor and an increase in its resistance. The depth of negative feedback of VUs increases, and its gain diminishes.

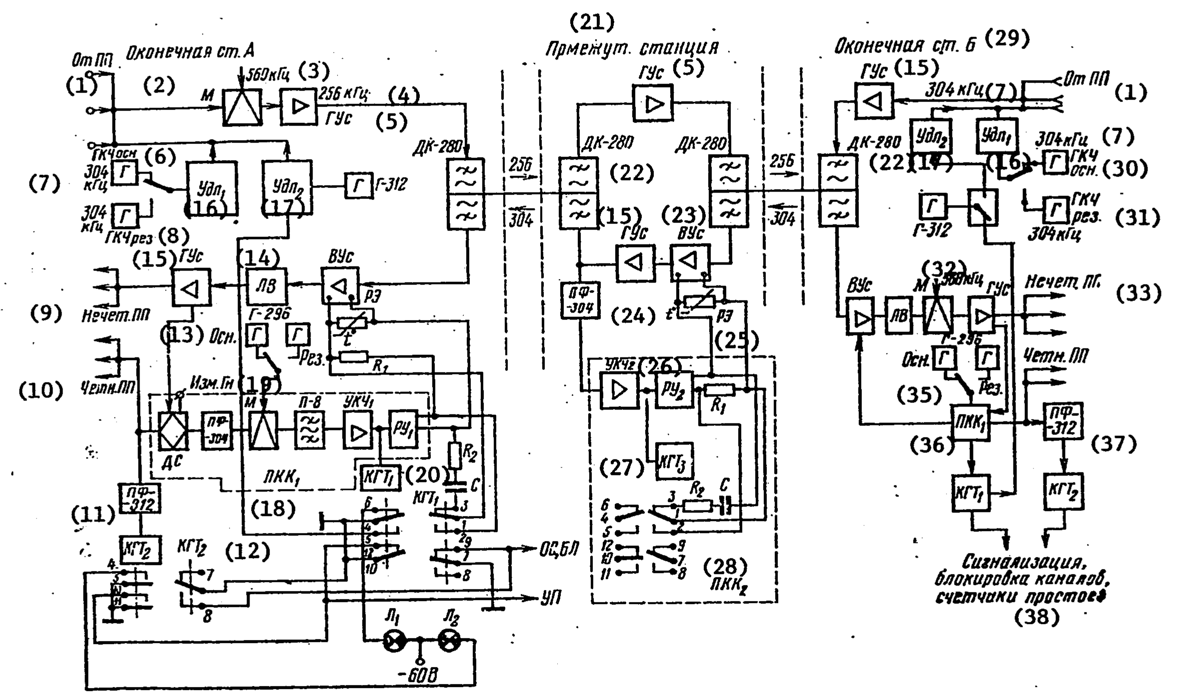


Figure 7.4. Structural diagram of the ALC and GCM

Key:

1 -- From the ПП; 2 -- Terminal office A; 3 -- 560 kilohertz; 4 -- 256 kilohertz; 5 -- GUs; 6 -- GKCh (basic); 7 -- 304 kilohertz; 8 --GKCh reserve; 9 -- odd ПП; 10 -- even ПП; 11 -- PF-312; 12 -- KGT_2 [GCM_2]; 13 -- basic; 14 -- LV; 15 -- GUs; 16 -- Udl_1 attenuator; 17 -- Udl_2 attenuator; 18 -- PKK_1; 19 --measuring generator; 20 -- KGT_1 [GCM_1]; 21 -- Intermediate station; 22 -- DK-280; 23 -- VUs; 24 -- PF-304; 25 -- RE; 26 -- $UKCh_2$; 27 -- KGT_3 [GCM_3]; 28 -- PKK_2; 29 -- Terminal office B; 30 -- GKCh basic; 31 -- GKCh reserve; 32 -- 560 kilohertz; 33 -- Odd ПП; 34 -- even ПП; 35 -- basic; 36 -- PKK_1; 37 -- PF-312; 38 -- signal, channel blocking, idle time counters

On variation of the level of the control frequency at the input of VUs by ±7 decibels (0.8 nepers) the ALC maintains the control frequency level at the GUs output with an accuracy of ±0.43 decibels (0.05 nepers), leaving the reception level of the 30 channels unchanged.

The ALC system is made not planar, but frequency-dependent, inasmuch asz the line losses depend on the channel frequency (number). For this purpose the feedback circuit of the VUs includes frequency-dependent two-terminal networks and the signals of frequency having greater attenuation are amplified more, and those having less attenuation are amplified less.

The ALC devices in the intermediate repeater station operate analogously. From the output of the upper group GUs the control frequency is separated by the PF-304 band filter of the control channel receiver PKK_2 and the amplified frequency goes to the input of the regulating device PY_2. Here the AC voltage is rectified and compared with the reference voltage, and the difference amplified by the DC amplifier is fed to the thermistor included in the negative feedback circuit of the VUs. Just as at the terminal office, the accuracy of maintaining the rated level of the control frequency at the output of the GUs of the intermediate station will be ±0.43 decibels with variation of the control frequency level at the input of the VUs by ±7 decibels.

At the intermediate stations where the ALC is not installed, a resistor is included in the negative feedback circuit of the VUs instead of the thermistor for which the gain of the amplifier is equal to a mean value of 19 decibels (2.2 nepers).

A control frequency of 304 kilohertz is also used to monitor the group channel. The control is realized by the KGT_1 [GCM_1] receiver connected to the output of the $UKCh_1$ of the control channel receiver PKK_1. In the presence of a 304 kilohertz frequency at the output of the $UKCh_1$ the GCM_1 receiver operates and by the 1-2 contact its relay connects the thermistor of the regulating element RE to the feedback circuit of the VUs. By the contacts 4-5, the Udl_2 attenuator is shunted through which the auxiliary frequency of 312 kilohertz is fed to the group channel, and the contacts 7-9, 4-6 and 10-12 break the signal, RSLU relay blocking and system idle time counter circuits.

When the control frequency level drops or is reduced by more than 3.5 decibels (0.4 nepers) at at the GCM_1 input the receiver relay releases, switching its contacts. As a result the resistor R_1 which limits the current through the RE is connected in series to the thermistor, and the R_2C circuit which shunts the thermistor with respect to alternating current is connected parallel to it. The resistancesof the resistor are selected so that an average gain of the VUs equal to 19 decibels (2.2 nepers) will be established on all frequencies of the band. The contacts of the released relay also close the local (the L_1 light lights up), row and general office signal (OS) circuits, the RSLU assembly circuits (BL), the system idle time counters (UP), and the circuit shunting the Udl_2 attenuator is opened.

The auxiliary frequency signal at 312 kilohertz goes to the group channel with a level equal to the measuring level. At the opposite terminal station this signal goes from the output of the GUs to the differential system of the PKK_1, and from the differential system filtered by the PF-312 filter, to the input of the GCM_2 receiver. The GCM_2 responds and by the contacts of its relay includes the local (the L_2 lights up), common row and general station signal, it blocks the channels and includes the system idle time counters of the opposite terminal office.

After recovery of the group channel at the GCM_1 input a signal appears with a control frequency of 304 kilohertz, and the receiver relay again responds, disconnecting the thermistor shunt, the signal, the blocking, the counters and shunting the Udl_2 attenuator. The frequency of 312 kilohertz ceases to go to the line, and the GCM_2 receiver relay of the opposite terminal office releases, disconnecting the signal, blocking and counters. The operating condition is restored.

Thus, by lighting the local signal lights the GCM_1 and GCM2 permit determination of the nature of the damage to the group channel. Thus, if the light L_1 is lit, then the incoming group channel is damaged; if L_2, the outgoing channel; if the lights L_1 are lit at both terminal offices, then the group channel is damaged in both directions.

At the intermediate station the control of the operating condition of the group channel is exercised by the GCM_3 receiver connected to the $UKCh_2$ output. In the presence of a 304 kilohertz frequency the servorelay of the receiver operates, connecting the thermistor to the feedback circuit of the auxiliary attenuator by its contacts. In the case of damage to the group channel or a reduction in level of the control frequency at the input of the GCM_3 by more than 3.5 decibels (0.4 nepers) the receiver relay releases. The shunts of the thermistor are connected, and the gain of the VUs is fixed in the middle position. The free relay contacts of the GCM_3 can be used for local (manned PUT) or remote (unattended PUT) signalling.

7.6. Group Repeaters of the KAMA Equipment

In the group channel of the KAMA equipment, an auxiliary repeater for the lower frequency group (VUs 12-256), an auxiliary repeater for the upper frequency group (VUs 304-548) and a group repeater, a single one for both frequency groups (GUs 12-548) are used. The VUs 12-256 is used only at the SIG-B terminal office; the remaining repeaters are used both at the terminal and at the intermediate stations. The repeaters of the KAMA equipment are made from transistors and are designed for inclusion between load resistances of 75 ohms. An 18 volt DC power supply is used to power the repeaters.

Fig 7.5 shows the schematic diagram of the auxiliary repeater of the upper frequency group. The repeater is designed for preamplification at the 304-548 kilohertz group signal, and it is a two-stage transistorized repeater with direct coupling with respect to direct current between the stages. Both stages of the amplifier are made from the P416 type transistors included above the circuit with common emitter (OE). In order to improve the signal/noise ratio at the input of the amplifier, the input circuit of the VUs is made in accordance with the transformer differential circuit (Tp_1, R_2) insuring the required input impedance of 75 ohms without using a shunt. The output impedance of the repeater (75 ohms) is determined by the shunt resistance R_8 and transformer Tp_2.

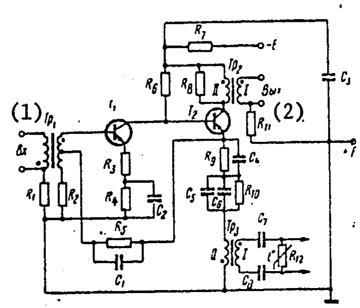


Figure 7.5. 304-548 kilohertz auxiliary repeater VUs

Key:
1. Input
2. Output

The first stage of the repeater is encompassed by local (resistor R_3) negative feedback and the entire amplifier is encompassed by general (the circuit R_5, C_1) negative feedback with respect to direct and alternating current. The correcting two-terminal network R_{10}, C_5, C_6, Tp_3, and R_{12} insuring the required frequency-dependent variation of the gain of the VUs on variation of the resistance of the thermistor R_{12}, is included in the feedback circuit of the second stage. The transformer Tp_3 matches the resistances of the thermistor with the correcting two-terminal network.

The operating conditions of the transistors are basically determined by the resistors R_2, R_4, R_5, R_6, R_9. The capacitors C_2 and C_4 are blocking, and C_7 and C_8 decouple the circuits of the VUs and the ALC with respect to direct current. In the feed circuit provision is made for a decoupling filter R_7, C_3. The average gain of the repeater with a thermistor resistance of 600 ohms is 19 decibels (2.2 nepers).

The auxiliary repeater of the lower group VUs 12-256 is designed for pre-amplification of the group signal of the lower frequency group. The circuitry of this repeater is analogous to the circuitry of the repeater VUs 304-548, and it differs from the latter only by the correcting two-terminal network in the feedback circuit of the second stage of the repeater which defines the frequency characteristic of the gain of the repeater on variation of the thermistor resistance. The average gain of the VUs 12-256 with a thermistor resistance of 600 ohms is also equal to 19 decibels (2.2 nepers).

Fig 7.6 shows the schematic diagram of the group repeater GUs 12-548. The repeater is designed for the basic amplification of the group signal in the upper or lower frequency group band, and it is a four-stage transistorized repeater with combined coupling between the stages. In the first two stages of the repeater made from the transistors T_1 and T_2 type P416A, direct DC coupling is used between the stages. The connection between the third (T_3 type P416A) and fourth (T4 type P609) stages is executed analogously. The coupling between the second and third stages is rheostat-capacitive (capacitor C_7). The application of combined coupling between the stages permits improvement of the phase characteristics of the multistage transistorized repeater and excludes the possibility of self-excitation of it.

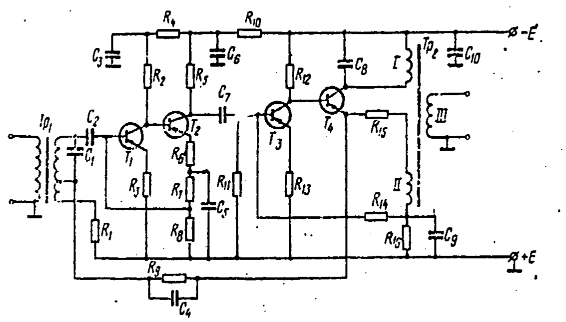


Figure 7.6. Group repeater GUs 12-548 kilohertz

All of the stages of the repeater are made in accordance with the circuit with common emitter, and they are encompassed by local (resistors R_3, R_6, R_{13}, R_{15}) and general (circuit R_9, C_4) negative feedback with respect to alternating current improving the frequency characteristics and the stability of the gain of the repeater. The last stage of the repeater is encompassed by negative feedback with respect to voltage (winding II of transformer Tp_2) which lowers the output impedance of the repeater to a value of 75 ohms. The input circuit of the GUs, just as of the auxiliary repeater, is made by the transformer differential circuit (Tp_1, R_1) permitting us to obtain input impedance of 75 ohms without the spplication of a shunt.

The operating conditions of the transistors T_1 and T_2 with respect to direct current are primarily determined by the resistors R_2, R_3, R_5, R_7, R_8, and the operating conditions of the transistors T_3 and T_4, by the resistors R_{11}, R_{12}, R_{13}, R_{14}, R_{16}. The capacitors C_5, C_9 are blocking;

C_2, C_7 are separating, and C_1, C_4, C_8 are correcting the frequency characteristic of the repeater. The feed circuit of the repeater includes the decoupling filters C_3, R_4; C_6, R_{10}, C_{10}.

The average gain of the repeater is 43 decibels (5.0 nepers). The repeater does not have a remote gain control. The gain control within the limits of $\pm$30 decibels ($\pm$0.3 nepers) is realized by resoldering the resistor R_3.

7.7. KAMA Transceiver

Transmitter Plate

The transmitter of the KAMA equipment is made analogously to the transmitter of the KRR-M equipment. A distinguishing feature of the transmitter is the fact that the phase-shift low-frequency six-terminal network is executed from RC-elements instead of LC-elements, and the modulator is replaced by a diode instead of transistor, but it is made from pairs of diodes not requiring selection. In addition, at the output of the transmitter an amplifying stage is included which permits the attenuation in the transmission channel to be reduced and it makes it possible to make the parallel operation of 30 transmitters independent, excluding mutual influence on each other.

The schematic diagram of the transmitter is shown in Fig 7.7. The speaking currents go to the input of the transmitter denoted by the terminals K_2, K_3 and through the symmetrizing transformer Tp_1 and the repeater based on the resistors R_1, R_3 they reach the input of the low-frequency filter D-3,4 (elements L_2-L_4, C_3-C_9). The attenuator matches the filter with the 600-ohm input of the transmitter and lowers the signal level at the input of the phase-difference circuit. The attenuation of the attenuator is 14 decibels (1.6 nepers); in this case the reflection coefficient of the input impedance of the transmitter decreases to 10%. The filter D-3,4 limits the speaking current band to a frequency of 3400 hertz and has an input impedance of 6 kilohms. In the attenuation band the attenuation of the filter does not drop below 35 decibels (4 nepers), and on frequencies of 3825, 4130 and 6000 hertz the filter introduces the maximum attenuations.

The signal frequency of 3825 hertz from the static relay module, analogous to the static relay of the KRR equipment goes to the terminals K_7, K_9. This frequency is also filtered by the band filter made up of the elements R_2, C_2, L_1 and it is fed through the resistor R_5 to the transmission channel after the filter D-3,4. By the resistor R_2, the signal frequency level at the input of the channel is set at 5.0$\pm$10 decibels (0.6$\pm$0.1 nepers) below the measuring level.

From the output of the D-3,4 filter the currents of speaking and signal frequencies go to the phase-difference circuit for suppressing the frequency sideband (FRS). As is known, the phase-difference circuit is made up of the phase-shifting, low-frequency six-terminal network (FSSh), two modulators, the carrier frequency phase shift circuit and the adder. In order to obtain a relative phase shift of 90° at the inputs of the modulators of the FRS, the initial low-frequency signal is first converted to two opposite-phase (that is, 180° out of phase relative to each other) voltages of equal amplitude. This is achieved by using a stage based on the transistor T_1 called a phase-inverse stage or invertor. The input impedance of the stage is equal to 6 kilohms; its operating conditions are determined by the divider R_4, R_5 and the resistor R_3 of the attenuator. The invertor load is made up of the resistors R_6 and R_7. Inasmuch as the signal phase in the collector circuit of the transistor differs by 180° from the signal phase in the emitter circuit, on the resistors R_6 and R_7, voltages occur, the relative phase shift between which is 180°. These voltages are fed to the RC phase-shifting element. The first element contains the resistors R_9, R_{11} and the capacitors C_{11}-C_{13}; the second element contains the resistors R_{10}, R_{12} and the capacitors C_{10}, C_{15}. The loads of the elements are the capacitors C_{14}, C_{16}, on the plates of which voltages occur which are 90° out of phase with each other. The error in the phase difference of the FSSh in the frequency spectrum of 300-3800 hertz does not exceed 2°, which permits suppression of the frequency sideband by no less than 30 decibels (3.5 nepers). The voltage amplitudes in the branches of the FSSh are equalized by the trimming resistor R_8 in the emitter circuit of the inverter.

The rated load resistance of the elements of the FSSh is equal to 15 kilohms. For matching such a high output impedance of the elements with small input impedance of the diode converters, each of the branches of the phase-difference circuit includes emitter repeaters executed from the transistors T_2 and T_3 (P416B type). The resistors R_{13}, R_{14}, R_{17}, R_{15}, R_{16}, R_{18} insure the operating conditions of the corresponding transistors. The currents of speaking and signal frequencies go through the separating capacitors C_{17}, C_{18} to the modulators of the phase-difference circuit branches.

Ring modulators executed from pairs of diodes of the GD-404AR type (the diodes D_2-D_5) not requiring selection are used in the transmitter of the KAMA equipment. The windings of the output transformer Tp_4 do not have midpoints; therefore the voltage of carrier frequency to the modulator diodes is fed to the midpoint of the capacitive dividers formed by the capacitors C_{24}, C_{25}, and C_{26}, C_{27}. Inasmuch as the pairs of diodes GD-404AR do not require selection, the degree of balancing of the converter (the degree of suppression of the current carrier is determined only by the asymmetry of the modulator circuit (for example, the halfwindings of the transformers Tp_2, Tp_3 are not identical, the capacitors C_{24}-C_{27} have scattering, and so on). When necessary the exact balancing of the converters is reached by installing additional trimming capacitances C_{20}, C_{21} and C_{22}, C_{23} parallel to the divider capacitors. The additional boundary of the residue of the carrier frequency is accomplished by the trimming resistors R_{21}-R_{24}.

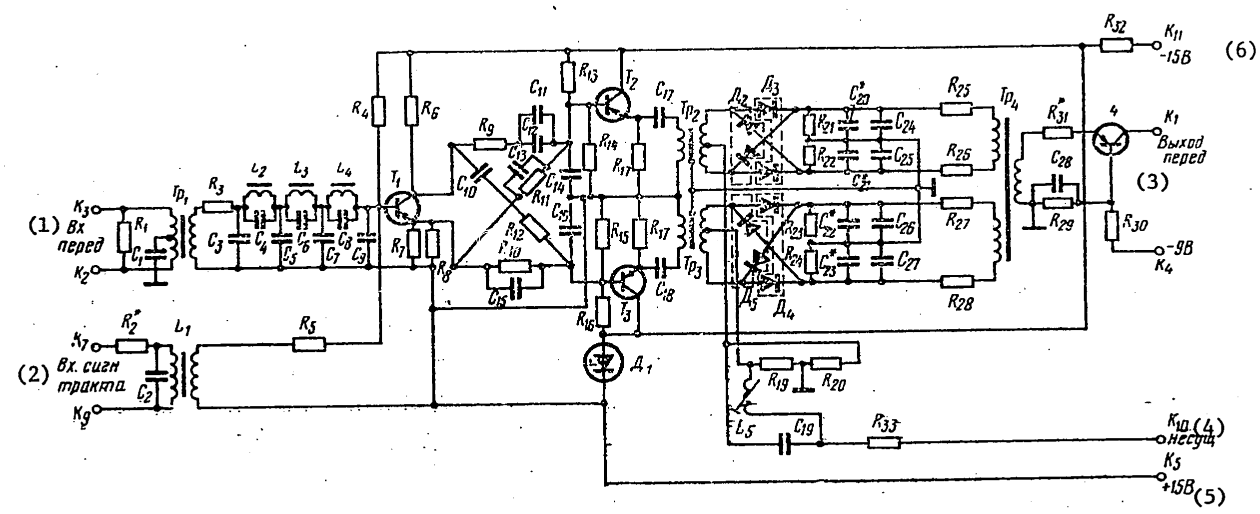


Figure 7.7. Transmitter of the KAMA equipment

Key:
1. Transmitter input
2. Signal channel input
3. Transmitter output
4. Carrier
5. +15 volts
6. -15 volts

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The carrier frequency phase shift circuit is executed from the elements L_5, C_{19} and it is used to obtain a relative phase difference of 90° between the carrier oscillations of the modulators of the phase-difference circuit. The coil L_5 can be used to regulate the degree of suppression of the undesirable sideband. In order to increase the stability of the degree of suppression for carrier level fluctuations the resistors R_{19}, R_{20} are used.

In the transformer Tp_4 the currents of the undesirable sidebands are suppressed, and the currents of the usable sidebands are summed and go to the output amplifying stage of the transmitter (T_4 type P416). The basic purpose of the terminal amplifier is to insure independent parallel operation of the transmitters of the 30 channels. For this purpose the stage is made from a transistor included according to the circuit with common base (OB), that is, by the circuit having small input and large output impedances. The collectors of the transistors of all 30 transmitters are joined together and connected to a common output (summing) transformer structurally located in the D-552 filter module.

In order to obtain a 75-ohm output of the transmitters, a shunt (a resistor R_3, see Figures 7.1, 7.2) is installed in the secondary winding of the summing transformer Tp. Inasmuch as the output impedance of one stage is several hundreds of kilohms, the load of the transmitters is determined only by the shunt resistance, which insures constancy of the output level independently of the number of simultaneously operating transmitters. The output level of the transmitter will be -47.3 decibels (-5.45 nepers) on a load of 75 ohms. The output level control within the limits of ± 1.7 decibels (± 0.2 nepers) is provided by the resistor R_{31}.

The feed of the collector circuits of the output stages is realized from a parametric voltage stabilizer located in the D-552 filter module. The resistors R_{29}-R_{31} insuring operating conditions of the output stage of the transmitter are installed there. The phase inverter and the emitter repeaters of the transmitter receive power from the parametric voltage stabilizer D_1, R_{32}. A stabilized voltage of 9 volts is fed from the stabilitron D_1 also to the receiver to feed the preliminary and terminal stages of the low-frequency amplifier. The feed to the divider R_{29}, R_{30} of the output stage of the transmitter comes from the parametric stabilizer located in the reception plate.

Receiver Plate

The channel receiver is executed in accordance with the structural diagram shown in Fig 7.8.

The distinguishing feature of the receiver is the absence of a band filter at its input, in connection with which summary signals come to the demodulator of each receiver immediately from the 30 channels. After the demodulation on the carrier frequency of the given channel the difference product of conversion of this channel is located in the frequency band of up to 4 kilohertz and it is separated from the converted signals of the remaining channels by the filter D-4,0. However, the useful signal level with this method of demodulation is very small and in order to obtain the required gain, the preamplifier PrUs is included in the receiver circuit after the transistor demodulator.

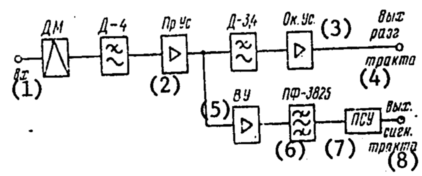

Figure 7.8. Structural diagram of the receiver of the KAMA equipment

Key:
1. Input
2. PrUs = preamplifier
3. Ok Us = terminal stage of the low-frequency amplifier
4. Output of the speaking channel
5. VU
6. PF-3825
7. PSU = control signal trigger receiver
8. Signal channel output

Another distinguishing feature of the receiver is the signal separation of the speaking and signal channels immediately after detection of them. The D-3,4 filter of the receiver is included before the terminal stage of the low-frequency amplifier OkUs and it does not pass the signal frequency to the input of the terminal amplifier. This excludes intelligible cross-talk with respect to the signal channel occurring when overloading the terminal repeater.

The schematic diagram of the receiver is presented in Fig 7.9.

The signals of all 30 channels go to the receiver input denoted by the terminals K_6, K_8. The L-type attenuator R_{20}, R_{21} which prevents overloading of the demodulator and lowers the group signal level at its input to -36 decibels (-4.1 nepers) is included at the input of the receiver. The demodulator DM of the receiver is made from the transistors T_4, T_5, type P416, and it introduces a voltage gain of no less than 17 decibels (2 nepers). The carrier frequency is fed to the emitter circuit of the transistors with a voltage of 1.2 volts. The resistors R_{17}, R_{18} included in the emitter circuits stabilize the demodulator parameters on variation of the temperature and fluctuations of the feed voltage.

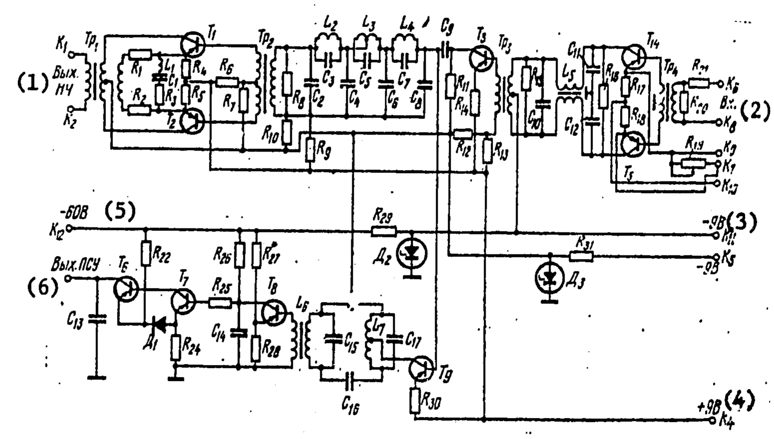

Figure 7.9. Receiver of the KAMA equipment

Key:

1. Low-frequency output
2. Input
3. -9 volts
4. +9 volts
5. -60 volts
6. PSU output

The demodulator load is the filter D-4 (L_5, C_{10}-C_{12}) which passes only the frequency band of its channel. The resistors R_{15}, R_{16} stabilize the input and output impedances of the filter equal to 11 kilohms. The filter attenuation on a frequency of 3400 hertz does not exceed 0.9 decibels (0.1 neper); on a frequency of 8 kilohertz it is more than 17 decibels (2 nepers).

The low-frequency preamplifier PrUs is executed from the transistor T_3, type MP41A, and it is loaded on the filter D-3,4 (L_2-L_4, C_2-C_8) providing for suppression of the products, the frequencies of which exceed 3400 hertz.

The operating conditions of the stage are standardized by the resistors R_{12}-R_{14}; the stage load is the resistor R_{11}.

The terminal repeater is executed by the two-cycle circuit based on the transistors T_1, T_2, type MP40, and it operates in the class A mode. In this mode both halfwaves of the signal are amplified; therefore, the total harmonic coefficient of this stage is minimal and does not exceed 1.5 %. The stages encompassed by negative feedback with respect to current (R_4, R_5) and voltage (the feedback winding of the transformer Tp_1 to the resistors R_1, R_2). The stage mode is stabilized by the resistors R_4-R_7.

The circuit L_1, C_1, R_3 included in the feedback circuit of the repeater is tuned to a frequency of 3,4 kilohertz, and it corrects the frequency characteristic of the channel in the upper frequency region. The depth of correction can be changed by the resistor R_3 if necessary.

The signal level at the output of the receiver is regulated within the limits of $+4.3 \pm 2.6$ decibels ($+0.5 \pm 0.3$ nepers) by the variable resistor type SP (R_{19}) included in the emitter circuit of the demodulator.

The signal frequency of 3825 hertz goes after amplification by the PrUs to the input of the auxiliary repeater VUs executed from the transistor T_9. The stage is made resonant for f=3825 hertz and introduces a gain only on this frequency. For other frequencies the circuitry of the stage is equivalent to the circuitry for including the transistor with OK and has a high input impedance not shunting the speaking frequency current. The stage mode is stabilized by the resistors R_9, R_{10}, R_{30}.

The auxiliary repeater operates in the limiting mode, which improves the operating reliability of the signal channel on fluctuation of the signal frequency level.

The load of the repeater is the band filter P-3825 (L_6, L_7, C_{15}-C_{17}) which separates the signal frequency of 3825 hertz and does not pass the currents of the remaining frequencies. The pass band of the filter is 150 hertz.

The trigger receiver of the control signals PSU (the transistors T_8, T_7, T_6, analogous to the PSU of the KRR-M equipment) is included at the filter output. The resistor R_{27} establishes the response threshold of the PSU. The operating current of the receiver is 45 ± 3 milliamps with a load of 1200 ohms. The PSU receives power from the 60 volt DC power supply. The feed goes to the demodulator from the same power supply through the parametric stabilizer R_{29}, D_2. The 9 volt stabilized voltage reaches the remaining assemblies of the receiver from the transmitter plate.

7.8. Generating Equipment

Structural Diagram of the Generating Equipment

Thirty individual carrier frequencies of the channels, the control frequency of 304 kilohertz, the auxiliary frequency of 296 kilohertz, the group carrier frequency of 560 kilohertz and signal frequency of 3825 hertz are needed for operation of the SIG bay of the KAMA equipment. The equipment for obtaining the indicated frequency designed to feed up to four SIG bays is located in the SGO bay, the functional diagram of which appears in Fig 7.10.

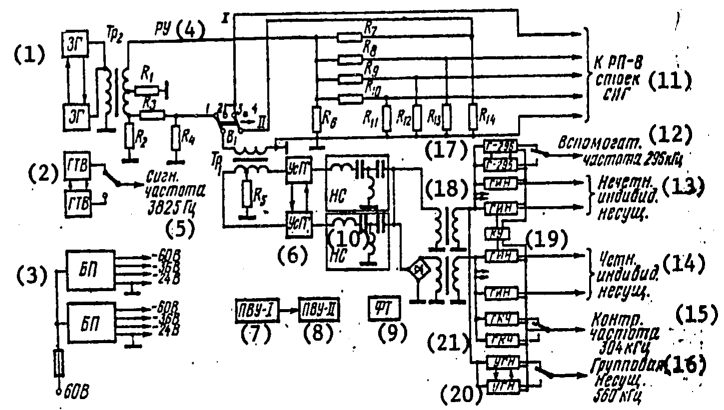

Figure 7.10. Functional diagram of the KAMA generating equipment

Key:

1. ZG = master oscillator
2. GTV= ringer oscillator
3. BP = power packs
4. RU
5. Signal frequency 3825 hertz
6. UsGG = resonance repeater
7. PVU-I = speak-buzz modules
8. PVU-II = speak-buzz modules
9. FT
10. NS
11. To the PП-8 of the SIG bays
12. Auxiliary frequency 295 kilohertz
13. Odd individual carriers
14. Even individual carriers
15. Control frequency 304 kilohertz
16. Group carrier 560 kilohertz
17. G-296
18. GIN - individual carrier generator
19. KU
20. UGN = group carrier frequency repeater
21. GKCh - control frequency generator

All of the frequencies with the exception of the frequency of 3825 hertz are multiples of 8 kilohertz, and a harmonic system with reference frequency of 8 kilohertz is used to obtain them. The latter is obtained from the master oscillator ZU module and goes to the decoupling module RU to the differential transformer Tp_2. The transformer has two outputs. Four attenuators which are parallel with respect to input -- R_7, R_{14}; R_8, R_{13}; R_9, R_{12}; R_{10}, R_{11} -- with an attenuation of 14.8 decibels (1.7 nepers) each are connected to one of them loaded on the resistor R_6. The signals from the outputs of the attenuators go to the PП-8 modules of the SIG bays and then to the line for synchronizing the opposite offices. The second output of the Tp_2 is connected through the attenuator R_2, R_3, R_4 with a total attenuation of 30 decibels (3.5 nepers) to the output differential system Tp_1. The outputs of this differential system are connected to the harmonic generator modules GG. The resistors R_1, R_5 are the balancing resistances of the differential systems.

The toggle switch B_1 is used to switch the external synchronization or synchronization mode from the local ZG master oscillator. In large telephone exchanges equipped with a single synchronization system, the reference frequency of 8 kilohertz goes to the RU module from the circuits of the synchronization network, and the ZG modules of the SGO bays are not used.

The harmonic generator is a frequency multiplier, and has two outputs: even and odd harmonics. The individual carrier frequency generators (GIN) of the even channels and the control frequency generator of 304 kilohertz (GKCh) are connected to the even harmonic output; the odd channel GIN, the auxiliary frequency generator of 296 kilohertz (G-296) and the group carrier frequency repeater (UGN) are connected to the odd harmonic output. The monitor (KU) is used to monitor the operation of the generators and the UGN. The signal frequency of 3825 hertz is generated by the ringer oscillator GTV. The frequency is used to feed the static relays of the SIG bays.

In the KAMA equipment provision is made for the organization of a link between operators for which two speak-buzz modules PVU-I and PVU-II are installed in the SGO bay. The link between operators can be formed over the high-frequency channel and over phantom circuits (the midpoints of the line transformers). For organization of the link between operators or with the phantom circuits, the phantom transformer module is used (FT).

The power for the generating equipment and the PVU modules comes from the BP power pack.

Master Oscillator

The master oscillator ZG (Fig 7.11) is made up of the two-stage repeater with transformer coupling between stages and bridge type feedback circuit. Both stages of the amplifier are made in accordance with the circuitry with common emitter. In the first stage the transistor T_2 (MP41) is used; in the second stage, T_3 (P214). The resistors R_3, R_4, R_6 and R_8, R_9, R_{10} stabilize the operating conditions of the corresponding transistors. In addition the resistor R_{10} not shunted by the capacitor creates negative feedback with respect to current improving the characteristics of the output stage.

The output transformer Tp_2 has three windings: winding I is connected to the collector T_3; winding II is the output winding, and winding III is connected to the feedback bridge diagonal. The feedback bridge is used to stabilize the frequency and level of the output signal of the generator. The high relative stability of the generation frequency (on the order of $3 \cdot 10^{-6}$) is achieved by including the quartz resonator KV in one arm of the bridge. This resonator operates with the series resonance frequency of 8000 hertz. It is possible to vary the generation frequency within small limits by the capacitors C_1, C_2.

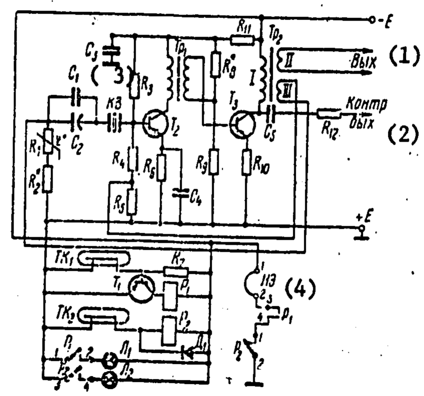

Figure 7.11. Master oscillator

Key:

1. Output
2. Control output
3. KV - quartz resonator
4. NE - heating element

The output signal level is stabilized by the thermistor R_1 included in the other arm of the bridge. The operating conditions of the thermistor with respect to the rate current are given by the resistor R_4 which together with the resistor R_5 forms the opposite arms of the feedback bridge. The generator output voltage equal to 1.25 ± 0.1 volts can be regulated by the resistor R_2.

In order to exclude the temperature effects on the generation frequency, the thermistor and quartz resonator are placed in a thermostat with a thermostating temperature of 50°C. The thermostating control circuit is made using the mercury thermocontactors TK.

On inclusion of the module, the negative potential of -60 volts is fed through the resistor R_7 to the base circuit of the T_1. The transistor is completely opened, the relay P_1 responds and by the contact 3-4 closes the heating element circuit NE, switching on the heating.

When the temperature in the thermostat reaches 50°C, the thermocontactor TK_1 shunts the bay circuit of the T_1. The transistor closes, and the relay P_1 esponds, opening the contact 3-4. The heating stops. After some reduction in temperature the TK_1 opens, T_1 opens and the relay P_1 again responds, switching on the heating. Then the process is repeated. The switching of the heating on and off is noted by the light L_1 (when the heating element NE operates the light burns).

If for any reason the heating is not shut off at 50°C, then when it reaches 60°C the thermocontactor TK_2 is included. The relay P_2 responds, the contact 1-2 disconnects the heating circuit. The circuit for the light L_2 is closed, and the emergency signal goes into operation.

Harmonic Generator

The harmonic generator GG is an 8 kilohertz frequency multiplier. It is made up of the resonance repeater UsGG and the nonlinear systems. In contrast to the KRR equipment where the UsGG for stabilizing the output level is made in the form of an autooscillator operating in the mode with locking, the UsGG of the KAMA equipment is made in the form of a resonance repeater with automatic gain control. The nonlinear system (NS) which loads the repeater is analogous to the NS of the KRR-M equipment.

The schematic diagram of the harmonic generator is shown in Fig 7.12.

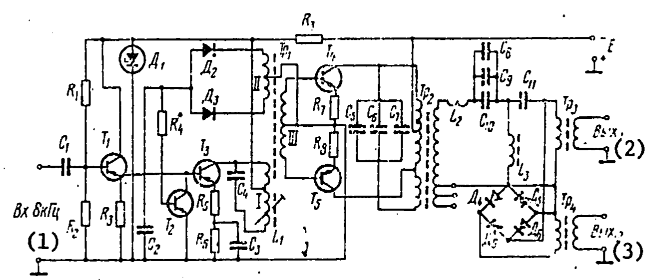

Figure 7.12. Harmonic Generator

Key:
1. 8 kilohertz input
2. $Output_1$
3. $Output_2$

The UsGG is made up of auxiliary repeater and the power amplifier. The auxiliary repeater is made two-stage. The transistor T_1 (type MP40) of the first stage of the amplifier is included in accordance with the circuit with common collector (OK), which makes it possible to obtain high input impedance of the amplifier required for matching to the decoupling module. The UsGG is connected to the latter through the separating capacitor C_1.

The second stage of the amplifier -- the resonance stage -- is executed from the transistor T_3 (MP41 type) included in accordance with the circuit with common emitter, and it is encompassed by local negative feedback (the resistor R_5). The coupling between the first and second stages is direct, and the operating conditions of the transistors are determined by the resistors R_1-R_3, R_5, R_6. The load of the second stage is the circuit formed by the inductance of the primary winding of the transformer Tp_1, the inductance coil L_1 and the capacitance C_4. The tuning frequency of the circuit is 8 kilohertz. The winding II is used for automatic gain control (AGC) of the auxiliary repeater. For this purpose the signal voltage induced in the winding II is rectified by the diodes D_2-D_3 and smoothed by the capacitor C_2. It is fed to the base of T_2. The negative control voltage with respect to the base of the T_2, depending on its magnitude, opens T_2 to a greater or lesser degree, shunting the input circuit of the second amplification stage. The limits of the automatic gain control are established by the resistor R_4.

For greater gain stability the auxiliary repeater is fed from a parametric voltage stabilizer R_9, D_1.

From the winding III of the transformer Tp_1 signal goes to the power amplifier -- the two-cycle output stage based on the transistors T_4, T_5 type P214. The transistors are included in accordance with the circuit with common emitter and they are encompassed by local negative feedback (the resistors R_7, R_8). The load of the terminal stage is a circuit formed by the primary winding Tp_2 and the capacitors C_5-C_7. By using the capacitors the circuit is tuned to a frequency of 8000 hertz.

The UsGG output is loaded on the nonlinear system made up of the circuit L_2, C_8-C_{10} tuned to 8 kilohertz, the nonlinear coil L_3, the capacitor C_{11}, the frequency doubler D_4-D_7 and the pulse transformers Tp_3, Tp_4. As a result of operation of the magnetic generator at the output of the Tp_3, a sign-variable pulse train is formed containing the odd harmonics of frequency 8 kilohertz. The even harmonics are obtained at the output of the Tp_4 after doubling the pulse repetition frequency.

The mutual protection of the even and odd outputs of the harmonic generator is no less than 26 decibels (3 nepers); the voltage of the harmonics used is about 150 millivolts.

The harmonic generator receives power from the 60 volt DC power supply.

Individual Carrier Frequency Generator

The individual carrier frequency generator (GIN) is designed to feed the individual channel converters of the SIG bays with carrier frequency currents. The schematic diagram of the generator is shown in Fig 7.13.

The GIN is made up of the band filter PF analogous to the GIN filter of the KRR equipment and the three-stage amplifier. The filter connected to the corresponding output of the GG separates the required harmonic of the 8 kilohertz reference signal required for synchronizing the GIN. However, the voltage of the separated harmonic (several tens of millivolts) is insufficient for direct synchronization of the generator. Therefore the first stage of the GIN plays the role of the synchronizing signal repeater.

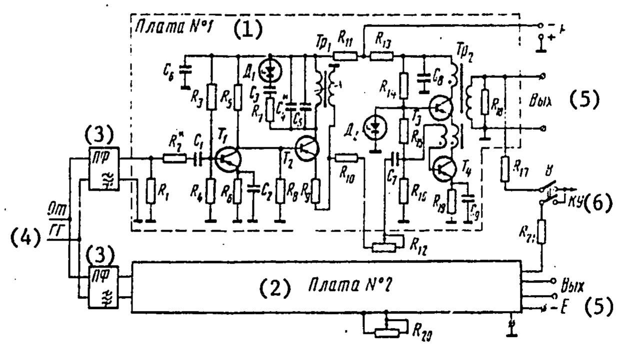

Figure 7.13. Individual carrier frequency generator

Key:

1. Plate No 1
2. Plate No 2
3. PF
4. From GG
5. Output
6. KU

The amplification stage is assembled from the transistor T_1, type P416, included in accordance with the circuit with common emitter. The resistor R_1 matches the input impedance of the stage to the output impedance of the filter, and jointly with the resistor R_2 forms the L-type attenuator which regulates the voltage of the segregated harmonic at the input of the amplifying stage. The operating conditions of the first stage with respect to direct current are insured by the resistors R_3, R_4, R_6. The capacitor C_2 is blocking.

The second stage (the transistor T_2, type P416) is an autooscillator operating in the mode with lock-on. The coupling between the first and second stages is direct. The autooscillator is assembled in accordance with the circuit with transformer feedback. The positive feedback voltage is picked up from the secondary winding of the transformer Tp_1 and is fed to the emitter circuit of T_2. The natural frequency of the autooscillator is determined by tuning the circuit made up of the primary winding Tp_1 and the capacitors C_4, C_5. For stabilization of the output level of the generator, the oscillatory circuit $Tp_1C_4C_5$ is shunted by the $D_1C_3R_7$ circuit. For positive halfperiods of the oscillations occurring in the circuit, the current goes through the stabilitron D_1, as a result of which a DC voltage is formed on the capacitor plates C_3 promoting symmetric restriction of the oscillations in the circuit and maintenance of their amplitudes on one level. With respect to direct current the circuit $D_1C_3R_7$ forms a parametric voltage stabilizer which stabilizes the voltage on the collectors of the transistors T_1 and T_2.

The resistors R_5, R_8, R_9 insure operating conditions of the autooscillator with respect to direct current. The relative lock-on band width is selected by the resistor R_2 such that the drift of the natural frequency of the autooscillator from the rated frequency by ± 3.5 to 4.5 kilohertz does not cause it to drop out of synch.

The output voltage of the autooscillator picked up from the feedback winding is fed through the resistor R_{10}, the potentiometer R_{12} and the dividing capacitor C_7 to the output stage (the transistors T_3 type MP40A and T_4 type P416) which is an oscillator with external excitation. The operating conditions of the transistors T_3 and T_4 with respect to direct current are insured by the resistors R_{14}, R_{15}, R_{16}, R_{19} and the stabilitron D_2. The capacitor C_3 is blocking. The output voltage equal to 1.2 ± 0.1 volts is regulated by the potentiometer R_{12}. The resistor R_{18} is a ballast resistor, and it is disconnected on connecting 3 and 4 SIG bays. The output signal goes through the resistor R_{17} and the toggle switch B to the KU module which monitors the synchrony of the GIN. The circuits R_{11}, C_6 and R_{13}, C_8 are feed filters. The feed of the module is from a 24 volt DC power supply.

Two generators (even and odd channels) are placed in one GIN module, excluding the GIN of the 29th and 30th channels which are placed in the same module.

Control and Auxiliary Frequency Generators (GKCh and G-296)

The control frequency generator GKCh is designed to feed the SIG bays with control frequency currents of 304 kilohertz, and the G-296 generator to feed the SIG bays with the auxiliary frequency currents of 296 kilohertz which is used as the carrier in the PKK_1.

The structural diagrams of the GKCh and G-296 do not differ from the structural diagram of the GIN. The differences in the schematic diagrams consist in the fact that the transistor of the first stage is connected to the GKCh and the G-296 with respect to the circuit with common base. This circuit diagram is simpler, it insures good matching with the input and filter and on the frequencies of the harmonics used introduces amplification with respect to voltage sufficient for reliable synchronization of the autooscillator. The output stage of the GKCh and the G-296 is made not from two transistors as in the GIN, but one transistor connected according to the circuit with common emitter. Here, in addition to the oscillation amplitude stabilization circuit in the autooscillator (the circuit D_1, C_3, R_7 in Fig 7.13) the GKCh has temperature stabilization of its operating conditions using a thermistor included in the base divider circuit of the output stage transistor. In the same generator, stepped regulation of the output voltage is used instead of continuous. As a result of the enumerated measures the relative stability of the output level of the GKCh does not exceed ± 0.03 nepers (0.3 decibels).

No increased requirements with respect to time and temperature stability are imposed on the G-296 generator, and therefore the corresponding stabilization circuits are excluded from the G-296.

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The rated output voltage of the GKCh and the G-296 generators will be 1.2 volts. The generator is fed from a 24 volt DC power supply.

Group Carrier Frequency Repeater

The group carrier frequency repeater UGN is designed to feed the group converters of the SIG bays with 560 kilohertz currents. In contrast to the KRR equipment, a frequency of 560 kilohertz in the UGN of the KAMA equipment is obtained by doubling the frequency of 280 kilohertz (the 35th harmonic of 8 kilohertz frequency). This is caused by an effort to simplify the structural design of the P-280 band filter included at the input of the amplifier (Fig 7.14).

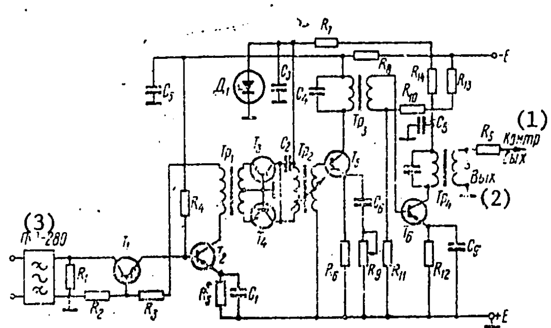

Figure 7.14. Group carrier frequency repeater

Key:
1. Control output
2. Output
3. PF-280 band filter

The repeater is connected to the odd output of the harmonic generator through the P-280 filter. The signal segreated by the filter is fed to the two-stage 280 kilohertz repeater. The first stage of the repeater is made from the MP40 transistor T_1 executed by the circuit with common base. This arrangement makes it possible to obtain a low input impedance of the stage required to match with the P-280 filter.

The first stage is directly connected with the second stage, the transistor T_2, type P416 of which is included in accordance with the circuit with common emitter. The resistors R_1-R_5 define the operating conditions of the two transistors with respect to direct current. The capacitor C_1 is blocking. The stage load is the transformer Tp_1, from the secondary winding of which the signal is fed to the frequency doubler.

The frequency doubler is made from the transistors T_3, T_4, type MP40 included in accordance with the circuit with common base. The transistors do not have bias on the emitters, and therefore they amplify only the positive halfwave of the signal. The transistors are opened alternately and in the common collector circuit the current has the shape of unipolar pulses (as for the two-halfperiod rectification). This signal contains even harmonics of 280 kilohertz frequency. The circuit made up of the primary winding Tp_2 and the capacitor C_2 is tuned to the second harmonic frequency -- the frequency of 560 kilohertz. With respet to direct current the multiplier receives power through the parametric voltage stabilizer R_7, D_1, C_3. Inasmuch as the feed voltage is fed to the transitor collectors through the multiplier circuit, the amplitude of the current oscillations at a frequency of 560 kilohertz in the circuit Tp_2, C_2 cannot exceed the voltages on the stabilitron, and the latter operates as an amplitude limiter. The signal voltage in the circuit remains unchanged even for voltage oscillations at the input of the module.

From the secondary winding of the Tp_2 the signal goes to the input of the 560 kilohertz repeater. The repeater is made two-stage; both transistors are included by the circuit with common emitter. The first stage based on the transistor T_5 (P416 type) does not have a bias on the base and amplifies only the negative halfwave of the signal. In the collector circuit of the transistor the current has the shape of unipolar pulses with repetition frequency of 560 kilohertz (just as for the single-halfperiod rectification), and it contains odd harmonics of this frequency. The resonance circuit made up of the primary winding Tp_3 and the capacitor C_4 is tuned to the primary harmonic and separates a frequency of 560 kilohertz for subsequent amplification of it. The R_6, C_6, R_9 are automatic bias elements. For varying R_9, it is possible to regulate the depth of negative feedback of the stage and the magnitude of the introduced amplification.

The output stage (T_6 type II608) operates in the line mode (it amplifies both halfwaves of the signal). The DC mode is given by the resistors R_{10}-R_{12}. The capacitor C_9 is blocking; R_8, C_5 and R_{13}, R_{14}, C_8 are the feed filters. The load of the terminal stage is a circuit made up of the primary winding of the output transformer Tp_4 and the capacitor C_7. The circuit is tuned to a frequency of 560 kilohertz. The secondary winding Tp_4 is the output winding. The signal voltage at the output of the amplifier will be 1.8 volts on a load of 25 ohms.

The amplifier is fed from the 60 volt DC power supply.

Monitoring

The monitor KU is designed to control the synchronization of the GIN, GKCh and G-296 modules. The schematic diagram of the KU is presented in Fig 7.15.

The control outputs of all the generators are connected to the input of the module. The group signal is amplified by the preamplifier based on the transistor T_1 (P416). The operating conditions of the transistor are given by the resistors R_6-R_9. The resistor R_5 plays the role of a shunt, insuring the required input impedance of KU (on the order of 10 ohms). The capacitory C_1 is separating, and C_3 is blocking.

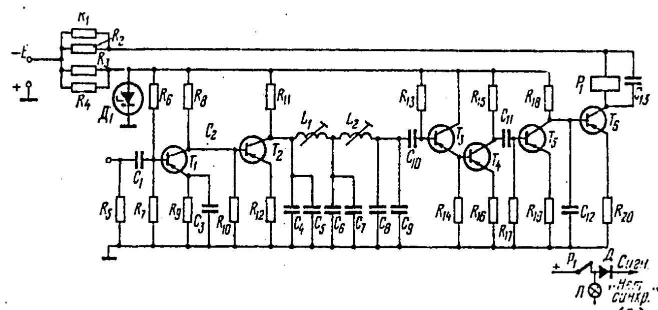
(1)

Figure 7.15. Monitor

Key:
1. "Out of synch" signal

The second stage based on the transistor T_2 (P416) operates in the nonlinear mode (there is no negative bias on the base) and is a detector. The detection mode is given by the resistors R_{10}-R_{12}. For synchronous operation of the control generators at the detector output all possible frequency fluctuations are formed which are multiples of 8 kilohertz. The detector load is the low-frequency filter D-4,0, made up of the elements C_4, C_5, L_1, C_6, C_7, L_2, C_8 and C_9. Since the cutoff frequency of the filter is 4.0 kilohertz, for synchronous operation of the controlled generators the voltage at the filter output is absent. When any generator falls out of synch its frequency varies and is not a multiple of 8 kilohertz. In this case, the difference product of conversion appears at the output of the detector in the pass band of the filter which goes through the separating capacitor C_{10} to the low-frequency amplifier (the MP40 type transistors T_3, T_4). In order to obtain a high input impedance required for matching with the filter, the first stage of the amplifier is made in accordance with the circuit with common collector The coupling between the first and second stages is direct. The operating conditions of the transistors are given by the resistors R_{13}-R_{16}.

The amplified signal is fed to the detector-amplifier (MP40 type T_5) and the switching circuit (T_6 type MP26). The capacitor C_{11} is separating. In the initial state, that is, in the absence of a signal, T_5 is blocked by a positive potential fed to the base of the transistor through the resistor R_{17}. Through the R_{18} the T_6 is fully opened and the relay P_1 responds. On appearance of a signal voltage at the base of the T_5 the transistor is opened by negative halfwaves of the input signal, and a pulsating current smoothed by the capacitor C_{12} flows in the collector circuit of the T_5. As the capacitor is discharged (through the open T_5) the negative potential of the base of T_6 decreases, and the transistor closes. The relay P_1 trips, switching on the emergency signal circuit.

The monitor receives the current from the DC 60 volt power supply. The amplifying stages KU are fed through a parametric voltage stabilizer R_3, R_4, D_1 and the last, switching stage, through the extinguishing resistors R_1, R_2. The capacitor C_{13} smooths the voltage pulsations occurring in the relay winding on switching the circuit.

Ringer Oscillator

The ringer oscillator GTV (Fig 7.16) is used to obtain a frequency of 3825 hertz which is used to feed the static relays of the SIG bays. The first stage based on the transistor T_1 (MP40) is the autooscillator executed by the differential bridge circuit. The L_1, C_2, C_3, C_4 circuit is tuned to a generation frequency of 3825 hertz. The resistors R_3, R_4 insure generation stability. In addition, these resistors jointly with the resistors R_1, R_2 create feed conditions of the autooscillator with respect to direct current. The capacitor C_1 is blocking, C_5 is dividing. Within the limits of ± 2 hertz the generation frequency can be varied by the trimmer C_3. The relative frequency stability of the oscillator will be $3 \cdot 10^{-3}$.

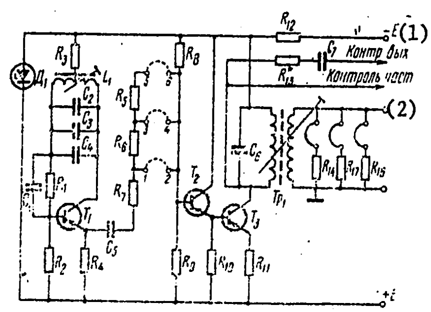

Figure 7.16. Ringer Oscillator

Key:

1. Control output
2. Control frequency

The signal of the autooscillator is amplified by a two-stage amplifier. In order to decrease the effect of the load on the oscillation frequency, the input impedance of the amplifier is made high-resistance. For this purpose the transistor T_2 (MP40) of the first stage of the amplifier is connected in accordance with the circuit with common collector. The first stage of the amplifier is loaded directly on the second, the transistor T_3 of which is connected in accordance with the circuit with common emitter. The operating conditions of the two stages with respect to direct current are insured by the resistors R_8-R_{11}. In addition, the resistor R_{11} creates negative feedback with respect to current which stabilizes the operation of the stage.

The amplifier load is the circuit formed by the inductance of the primary winding of the output transformer Tp_1 and the capacitor C_6. The circuit is tuned to a frequency of 3825 hertz. The secondary winding Tp_1 is the output winding. The resistors R_{14}-R_{16} are ballast resistors and are disconnected on connecting the second, third and fourth SIG bays. On a load of 62 ohms the output voltage of the oscillator is 200$\pm$13 millivolts. The step voltage regulation is accomplished by the divider R_5R_7. The oscillator has its own parametric voltage stabilizer $R_{12}D_1$ and is powered from a 60 volt DC power supply.

Monitoring the Operation and Switching the Assemblies of the SGO Bay

In the KAMA generating equipment the following modules are redundant: ZG, GG, GKCh, G-296, UGN and GTV. The modules operating in the basic mode or in reserve are equivalent; they do not differ with respect to electric circuitry or with respect to location in the frame of the bay. The monitoring of the state of repair and switching of the modules are accomplished by the PU switching circuits (Fig 7.17), the operating principle of which is the same in all modules.

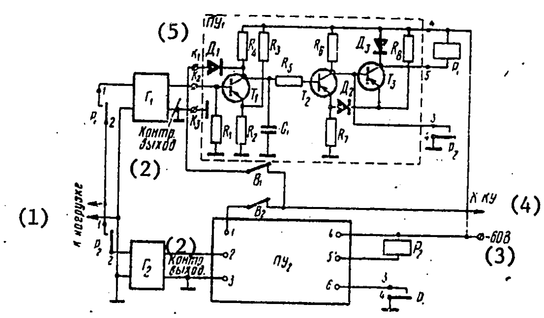

Figure 7.17. Switching circuit

Key:

1. To load
2. Control output
3. -60 volts
4. To the KU
5. PU_1 [switching circuit]

Each of the generators G_1 and G_2 has a switching circuit analogous to the PSU of the KRR-M equipment, to the terminals of which the control output of the corresponding generator is connected.

If the voltage at the input of the PU exceeds the threshold voltage ($U_{threshold}$), then T_1 is opened, and the trigger is in the state in which T_2 is closed, and T_3 is fully opened. The relay P_1 operates and by its contact 1-2 connects the basic output of the generator to load.

When the voltage drops or is diminished at the output of the generator to a value below threshold, T_1 closes, the trigger switches, and the relay P_1 is released, disconnecting the generator from the load. The collector potential of the first transistor, which is close to zero, with T_1 open becomes more negative. This potential is fed to the diode D_1 and the toggle switch B_1 to the monitor module where the circuit analogous to the PU includes the emergency signal.

The failed module is determined by the dropping of the emergency signal as a result of switching off the toggle switch B_1 or B_2.

In the case of simultaneous inclusion of the modules in a state of good repair, the generator at the output of which the voltage appears the faster is connected to the load first. If this generator is G_2, then the relay P_2 responds first and by the contacts 3-4 closes T_3, blocking the trigger of the first switching device in the nonoperating condition.

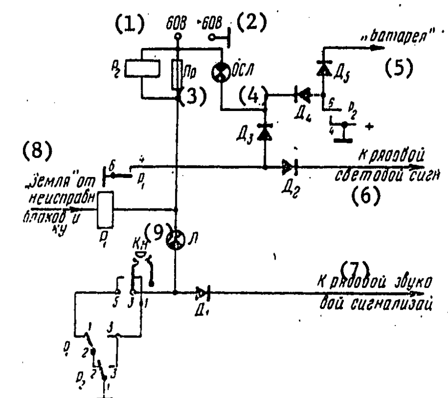

Figure 7.18. Signal circuit of the SGO bay

Key:
1. 60 volts
2. -60 volts
3. Pr
4. OSL
5. Battery
6. To the row light signal
7. To the row sound signal
8. Ground from the failed modules and KU
9. KH button

If the generator G_1 is excited first, then the relay P_1 responds and by the analogous contacts 3-4 blocks the trigger of the second PU. Thus, only one of the generators will always be connected to load.

The principle of the SGO bay signal system is explained in Fig 7.18.

When there is damage, the positive of the station battery is fed from the failed modules to the winding of the relay P_1 which responds. Through the circuit made up of the contacts 1-2 of the relay P_2, 2-3 of relay P_1, 1-3 of button KH, diode D_1, the positive is fed to the row sound signal system. Simultaneously the light L burns to signal that the bell has been switched on. On pressing the button KH the bell circuit opens and the tube L goes out. The row optical signal system is included as a result of feeding the positive through the contact 4-6 of the relay P_1 and diode D_2. A common bay light OSL is lit through the diode D_3.

If the damage is eliminated, then P_1 is released, and the OSL is extinguished. Through the closed contact 3-5 of the button KH, again the bell circuit is closed and the light L burns. The button KH is released, and the signal system returns to the initial state.

In case of burning of the common bay protector Pr, the relay P_2 responds. Through its contacts 1-3 the positive is fed to the bell circuit, and through contacts 4-6 and the diodes D_4 and D_5, to the OSL tube and the "battery" light of the row signal system.

7.9. Electric Power Supply for the KAMA Equipment

The electric power supply for the KAMA equipment comes from the station battery at 60 ($^{+6}_{-2}$) volts. The terminal offices are fed from the battery directly without application of the current converters and the extinguishing resistances. The required gradations of the feed voltages are obtained using the parametric voltage stabilizers included in series. For extinguishing the excess voltage, the current stabilizer is connected in series with the voltage stabilizers. This inclusion of the elements insures high efficiency of the power supplies and improves the stabilization coefficient of the output voltages.

The feed circuit of the SIG bay (Fig 7.19) contains the series-included parametric voltage stabilizers D_2-D_7 and the current stabilizer based on the transistors T_1 and T_2. The feed circuit elements form three groups of stabilizing feed voltages between which the entire load of the bay is distributed. The first two groups with 15 volts each are designed for a load current of 0.4 amps. The third feed group with a voltage of 18 volts is designed for the same load current. In addition, a number of circuits of the SIG bay are fed directly from the station battery for which the fourth feed voltage group of 60 volts is formed (not stabilized).

The parametric voltage stabilizer of each group is executed from two stabilitrons included in series, and it is used to stabilize the output voltage on variation of the station battery voltage and load current. In the first and second groups the stabilitrons D_2-D_5, type D815V are used with stabilization voltage of 7.5-8 volts. Thus, the stabilized voltage of each of these groups is 15 volts. In the third group the stabilitron D_6 type D815V and D_7 type D815G are included in series. The stabilitron D815G has a stabilization voltage of 10 volts; therefore the stabilized voltage of the third group is 18 volts.

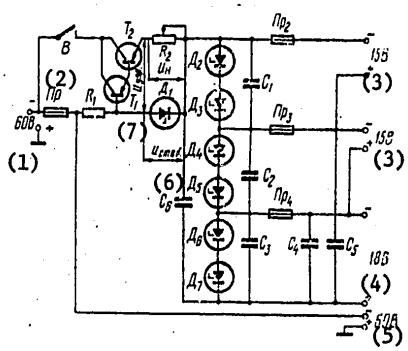

Figure 7.19. Feed plate of the SIG bay

Key:

1. 60 volts
2. Pr
3. 15 volts
4. 18 volts
5. 60 volts
6. U_{stab}
7. $U_{control}$

As a result of the application of the stabilitrons the independence of the load current of one output with respect to the load current of the other is insured. Thus, if the load current of the first output is absent, the entire current goes through the stabilitron, and the load current and voltage of the other outputs do not change. The capacitors C_1-C_3 eliminate the mutual effect of the outputs through the power supply. Simultaneously the positive leads of the first and second outputs with respect to alternating current (through C_4, C_5) are connected to the positive lead of the station battery.

The total voltage of the three successively formed groups of feed voltages will be 48 volts at the same time as the voltage of the station battery will be 60^{+6}_{-2} volts. In order that the excess voltage be extinguished and also the load current be stabilized, a current stabilizer is connected to the parametric voltage stabilizer circuit.

The current stabilizer is executed from transistors T_1 (P214) and T_2 (P201A). In practice the entire load current goes through the transistor T_2; therefore it is regulating. The magnitude of the current flowing through the transistor depends on the potential of the space: the more negative base potential decreases the transistor resistance at the same time as the less negative increases it. In order that the current intake by the feed circuit not depend on the load and the station battery voltage, the resistance of the regulating transistor is made controllable. This is achieved by using a matching transistor T_1, the DC mode of which is given by the resistors R_1, R_2 and the stabilitron D_1.

The emitter current of the transistor T_1 is the base current for T_2 and depends on the controlling voltage $U_{control}$, the negative of which is applied to the base of the T_1 transistor. The magnitude of the controlling voltage is determined by the difference between the voltage drop on the stabilitron U_{stab} and the voltage drop U_H from the load current on R_2, that is, $U_{control}=U_{stab}-U_H$. The voltage drop on the stabilitron (8 volts) does not depend on the load current and is strictly constant. The voltage drop on the resistor R_2, on the other hand, is directly dependent on the load current: it increases with an increase in load current and decreases when the load current decreases. Being the difference of two voltages, the controlling voltage decreases correspondingly (that is, it becomes less negative) with an increase in the load current, and it increases (that is, becomes more negative) with a decrease in it.

The stabilizer is designed for a defined load current; therefore the initial magnitude of the controlling voltage for a rated load current is given. On variation of the load current, for example, when it decreases, the voltage drop on the resistor R_2 decreases, which leads to an increase in the controlling voltage. With an increase in the load current, the emitter current of T_1 (or, what amounts to the same thing, the base current of T_2) increases, and the resistance of T_2 decreases. As a result the load current assumes the previous value. In the case of an increase in load current the magnitude of the controlling voltage and the emitter current of T_1 decrease, and the resistance of T_2 increases, lowering the magnitude of the current in the load to the initial value.

Thus, the current flowing through the resistor R_2 is kept invariant and equal to the rated value. The rated load current is established by the resistor R_2.

The electric power supply circuit of the SGO bay does not differ theoretically from the power supply circuit of the SIG bay, but it contains two groups of stabilized feed voltages, each of which is designed for a load current of 0.5 amps with a stabilization voltage of 24 volts. This voltage is obtained for three series-included D815V stabilitrons. The stabilizer analogous to the one installed in the feed plate of the SIG bay is used as the extinguishing resistance and the load current stabilizer.

In the remote electric power circuit of the intermediate repeater station (Fig 7.20) the feed circuits of the upper and lower repeater stations are connected to different leads of the phantom circuit. Three parametric voltage stabilizers each, forming three independent groups of feed voltages, are connected in series to each lead. The group with a voltage of 22 volts (the stabilitrons D_1 D_2, type D816A) is designed to feed the control channel receiver PKK. The other two groups each with a voltage of 18 volts (the stabilitrons D_2-D_5, type D815V), feed the repeaters of the upper and lower frequency groups of corresponding repeater stations separately. The capacitors C_3-C_6 are the decoupling elements excluding crosstalk between the repeaters. The elements Dr_1, C_1; Dr_2, C_2; Dr_3, C_7; Dr_4, C_8 form the half-sections of the low-frequency filters realizing additional filtration of interference in the feed circuit.

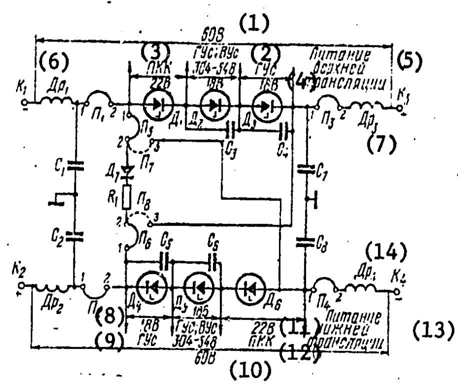

Figure 7.20. Feed circuit of an intermediate repeater station

Key:

1. 60 volts
2. GUs; VUs
3. PKK
4. GUs
5. Upper repeater feed
6. Dr_1
7. Dr_3
8. 18 volts
9. GUs; VUs
10. 60 volts
11. 22 volts
12. PKK
13. Lower repeater feed
14. Dr_4

The remote feed of the repeaters is through the midpoints of the line transformers of the multiplexed high-frequency cable pairs. The feed, as a rule, is organized by the "pair-pair" system. The feed by the "pair-ground" system is permitted only in an emergency, for as a result of significant potential difference between the ground points, stabilization of the feed voltages at the intermediate repeater stations is complicated.

When organizing the remote feed the terminals K_1-K_4 of the feed plate are connected through the filters D-8 to the midpoints of the line transformers (see Fig 7.3). The 320 volt DC voltage received from the 60 volt station battery using the transistorized current converters is used as the feed voltage source. With this voltage the remote feed system organized from the two terminal stations can feed up to 5NUP, that is, 10 repeater stations. In this case in the middle NUP the $П_2$ and $П_3$ jumpers are taken off, and the contacts 1-1 and 2-2 of the jumpers $П_2$ and $П_3$ are connected. It is also possible to take off the jumpers $П_1$ and $П_4$ and connect their contacts 1-1 and 2-2. In both cases each of the terminal offices feeds five repeater stations.

If the number of NUP does not exceed two, then the feed is organized only from one of the terminal offices. For this purpose, at the terminal office opposite to the feed a loop is made, that is, the terminals K_3 and K_4 are connected if the feed is from office A (the left) and the terminals K_1 and K_2 from office B (the right). The second terminal office remains in reserve in this case.

The remote feed system of the KAMA equipment provides for the possibility of determining the damaged section when a feed circuit breaks. For this purpose there is a D_7, R_1 circuit installed using the jumpers $П_5$, $П_6$ on each NUP from the feed office side. In the operating remote feed mode the diode D_7 (D226) is connected opposite to the feed voltage and has no effect on the operation of the plate. When a section of the feed circuit is damaged, the feeding terminal offices change the polarity of the feed voltage. In this case the diode in the NUP is included in the direct routing and by the magnitude of the remote feed current it is possible approximately to determine the location of the damage on the line.

With local feed the required gradations of feed voltages in each of the repeating stations are obtained directly from the 60 volt station battery by including the extinguishing resistances in series with the load.

Test Questions

1. What is the purpose and the basic differences of the KAMA equipment from the KRR-M equipment?

2. What modules enter into the terminal and intermediate station equipment?

3. Explain the current transmission and purpose of the assemblies of the transmitting and receiving channels of the terminal offices A and B.

4. Explain the structural diagram and purpose of the assemblies of the intermediate repeater station.

5. How do the ALC and the GCM operate at the terminal and intermediate stations?

6. Explain the purpose, technical specifications and the schematic peculiarities of the group and auxiliary repeaters.

7. List the structural characteristics of the channel transmitter and explain its operation.

8. Do the same for the channel receiver.

9. Explain the functional diagram of the generating equipment.

10. What are the structural characteristics and operating principles of the generating equipment modules?

11. How are the redundancy and the switching of the generating equipment modules accomplished?

12. How is the electric power supply set up for the terminal offices and the intermediate repeater stations?

CHAPTER 8. USE OF PULSE-CODE MODULATION IN MULTIPLEXING EQUIPMENT

8.1. Structural Characteristics of the PCM-TS Coupling Systems

A significant disadvantage of the multiplexing equipment constructed by the principle of frequency division of the signals is the fact that for effective use of it in the city telephone service it is necessary to lay a special cable with styroflex insulation of the MKS type conductors. In addition, in the telephone networks of large cities there are a large number of previously laid cables with paper insulation which have not been multiplexed at the present time. The KRR equipment is inefficiently used in such cables as a result of the low crosstalk attenuation between the pairs on the frequencies of the line spectrum of this equipment. In order to fall within the norm with respect to crosstalk attenuation, the length of the repeater section on low-frequency cables must be limited to 3-5 km and, in addition, the pairs suitable for multiplexing must be carefully selected. It is expedient to multiplex such cables using the IKM-VD [PCM-TS] equipment, the basis for the construction of which is the pulse-code modulation method and time sharing of the channels.

As is obvious, any type of information is transmitted over the line by electrical signals which constitute some amount of, for example, current or voltage which varies in time according to a defined law. With respect to their nature the signals can be analog and digital. An example of an analog signal (Fig 8.1a) is a voice signal in which the voltage or current varies continuously in accordance ... [original text discontinued at this point].

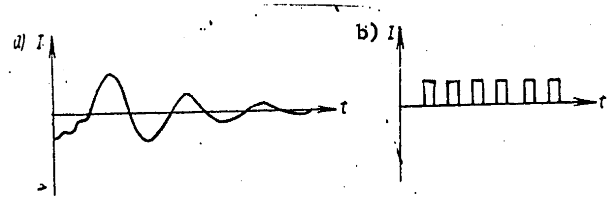

Figure 8.1. Analog and digital signals

CHAPTER 9. RELAY ASSEMBLIES OF MULTIPLEXED TRUNKS

9.1. General Information

The relay assemblies of multiplexed trunks together with the differential systems are an intermediate matching circuit which is included between the office devices of the automatic office and the low-frequency terminals of the channel formed by the KRR equipment. The assemblies are distinguished with respect to structural design and circuitry depending on where the multiplexing equipment is installed: between the automatic office or between the automatic and long distance offices and also depending on the automatic office system: 10-step or crossbar. In addition, assemblies installed on the outgoing or incoming sides of the channel are distinguished.

The relay assemblies are executed in the form of removable plates on separate frames making up the equipment of the terminal offices. The number of assemblies installed on one frame is 20 for the 10- step system (ATS-DSh) and 30 for the crossbar system (ATSK). A signal plate is also installed on the frame. The station conductors are connected to the assemblies on the frames.

The RSLU [multiplex trunk relay] assemblies are connected to the multiplexing channel equipment by the differential systems DS executed from resistors. The differential systems provide for the transition from the two-wire low-frequency channel to the four-wire channel of the KRR equipment.

The relay assembly is used to control the operation of the signal channel. In the corresponding connection phases, when the interaction signals must be transmitted over the high-frequency channel, defined relays of the assembly close the positive feed circuit of the battery with respect to the signal conductor of the relay assembly to the static relay of the channel. The static relay opens and transmits the signal current to the channel. In this case the duration and also the nature of arrival of the signal frequency in the channel correspond to this duration and nature of the positive feed through the relay contacts. For example, when dialing a number the signal frequency goes in the form of pulses repeating the pulsation of the positive feed on the signal line. At other connection times the signal frequency goes continuously or is absent in general.

On the receiving end of the channel, after demodulation and amplification, the signal frequency goes to the control signal receiver PSU where it is converted to a direct current and controls the operation of the relay K of the outgoing assembly or the relay RZ of the incoming assembly. These relays, in turn, adjust the circuits of the assemblies so that the direct current sendings reach the devices of the opposite automatic office exactly as the analogous signals were transmitted from the opposite automatic office.

When studying the circuitry of the RSLU assemblies it is recommended that the following principles be considered.

1. Each new connection phase differs from the preceding one by the state of the signal channel, that is, by the absence of a signal frequency, pulsation or continuous arrival of the signal frequency. There is no signal frequency in a free, good channel. From the time the channel becomes busy, the signal frequency sendings start, which become pulsating when the number is dialed. These sendings stop during a conversation. When either subscriber sends a ring-off, the signal frequency sendings are renewed to transmit the ring-off signal to the opposite office and initialize the assembly circuits.

2. The transmission of the signal frequency in one direction causes transmission of it in the opposite direction. The analogous situation occurs when it stops.

3. The interaction signals, on being transmitted over the signal channel, change the polarity on the speaking lines of the outgoing or incoming RSLU assembly. Then these signals are transmitted to the IGI selector or LI connector circuits, creating the speaking, ring-off or other condition in these circuits.

4. With positive battery feed to the static relay of the outgoing side of the channel the RZ relay in the incoming RSLU assembly responds first, and with positive feed to the static relay of the incoming side the relay K in the outgoing RSLU assembly responds first.

9.2. RSLU ATS-DSh [10-Step System Multiplexed Trunk Relay] Assemblies

The RSLUI [outgoing RSLU] and RSLUV [incoming RSLU] assemblies are installed on the high-frequency trunks formed by the KRR-M equipment between the automatic offices of the 10-step system (GATS-47 and GATS-54).

Fig 9.1 shows the structural diagram of the assembly. From the automatic office devices to the differential system of the assembly there are two wires a and b. From the differential system to the KRR-M channel to the transceiver there are four wires: two for transmission and two for reception. The third wire c is connected directly to the relay assembly connected to the multiplexing equipment by two wires. The signal frequency feed through the static relay SR to the channel is controlled by one of these wires, and the reception of the DC sendings from the signal channel receiver PSK to the relay K (RZ) of the RSLU assembly is controlled by the other.

The schematic diagrams of the assemblies are presented in Figures 9.2 and 9.3. In addition to the relay assembly and the differential system, each circuit includes three attenuators: Udl_1 and Udl_2 0.35 decibels (0.4 nepers); Udl_3 0.17 decibels (0.2 nepers) and two diodes. Using the attenuators, the required signal level is created in the channel and the diodes included opposite to each other play the role of the signal amplitude limiter, the operating principle of which can be explained by Fig 9.4. Two graphs are combined in the figure: 1) dependence of the resistance R of the diode on the voltage applied to it and 2) variation of the voltage in the time t. As is obvious from the figure, the higher the voltage is with respect to magnitude, the less the diode resistance. Therefore when the signal voltage is small (curve u_1), the resistance of the diodes is large (points 1-1), and they do not shunt the talk channel. When the signal voltage corresponds to the curve u_2, the diode resistance decreases sharply (points 2-2), and a large current branches through them. This limits the magnitude of the current coming into the channel, and destruction of the transceiver level diagram is prevented.

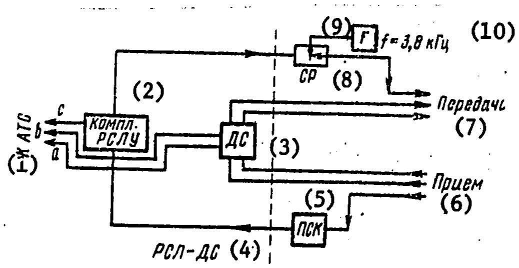

Figure 9.1. Structural diagram of the RSLU assembly

Key:

1. To the automatic office
2. RSLU assembly
3. DS
4. RSL-DS
5. PSK
6. Reception
7. Transmission
8. SR
9. G
10. f=3.8 kilohertz

The attenuations introduced by the RSLU assemblies into the 800 hertz channel are equal to 13 decibels (1.5 nepers) in the transmission direction (from point p_1-p_2 to points p_7, p_8) and 7.8 decibels (0.9 nepers) in the reception direction (from points p_9, p_{10} to points p_1, p_2).

Purpose of the Outgoing Assembly Relay. 0 — ring-off relay -- responds when the assembly is busy, holds for the entire time of the conversation and is released after the two-way ring-off;

I -- the pulse relay -- receives the dial pulses from the GI [selector] circuit and transmits them to the high-frequency channel;

S -- series relay -- responds on arrival at the first dial pulse and holds for the entire series of pulses, disconnects the separating capacitors C_8 and C_9 from the pulse circuit, excluding their effect on the operation of the pulse relay;

K -- control relay -- is included in the collector circuit of the output stage of the PSU and operates, receiving the control signals from the multiplexing equipment;

B -- auxiliary relay to the relay K;

RO -- when the assembly is busy it responds following the relay 0 and insures more reliable operation of the relay K to the completion of the establishment of the connection. For the time of the conversation it connects the resistor R_7-1500 parallel to the relay K, eliminating the possibility of its wearing out during the conversation and insuring its slow tripping at the end of the conversation;

OS -- relay for completion of establishment of connection -- responds when the called subscriber answers and holds for the entire conversation. It is released after two-way ring-off. Before the called subscriber answers it shunts the transmitting talk channel of the high-frequency channel, preventing the occurrence of generation in the unloaded channel on the subscriber line and telephone and protecting the channel from powerful pulses arising at the input of the differential system from charging and discharging of the separating capacitors during transmission of the number dialing pulses;

PK -- the channel damage relay -- provides for sending a "busy" signal to the subscriber when the channel fails and switches on the office signal;

SV -- interaction signal relay -- responds on ring-off both from the calling party's side and from the called subscriber's side.

Purpose of the incoming assembly relays. The RZ -- the busy relay -- is included in the collector circuit of the output transistor of the PSU and operates, on receiving control signals from the KRR equipment. It receives and transmits busy signals, dial pulses and all the interaction signals between IGI selector and LI connector in all steps of establishing a connection and ring-off;

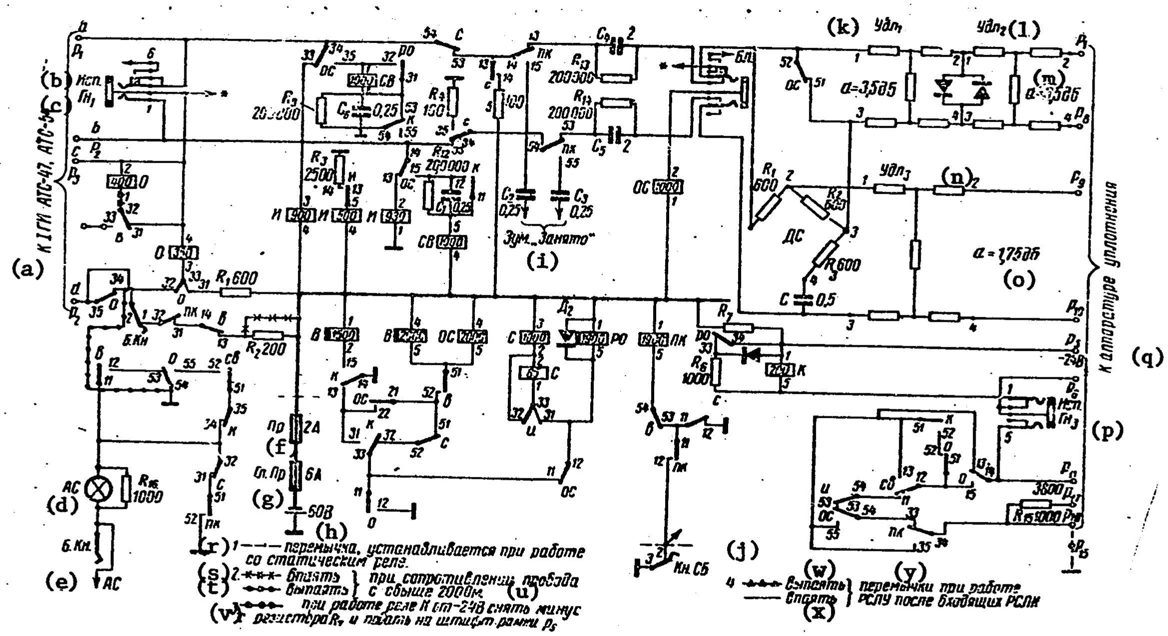

Figure 9.2. Outgoing RSLUI assembly for coupling to the ATS-DSh 10-step system

Key:

a -- To the IGI selector of ATS-47, ATS-54; b -- ISP.; c -- GN_1; d -- AS; e -- B. KN.; f -- Pr; g -- Gl. Pr; h -- 60 volts; i -- busy signal; j -- KN. SB; k -- Udl_1 attenuator; 1 -- Udl_2 attenuator; m -- 3.5 decibels; n -- Udl_3 attenuator; o -- 1.75 decibels; p -- Nsp. GN_3; q -- to the multiplexing equipment; r -- jumper is installed for operation with the static relay; s -- connected; t -- disconnected; u -- for a wire resistance of more than 200 ohms; v -- for operation of the relay K from -24 volts take the negative from the resistor R_7 and connect to the post of the frame P_5; w -- disconnect; x -- connect; y -- jumpers for operation of the RSLU after the incoming RSLU

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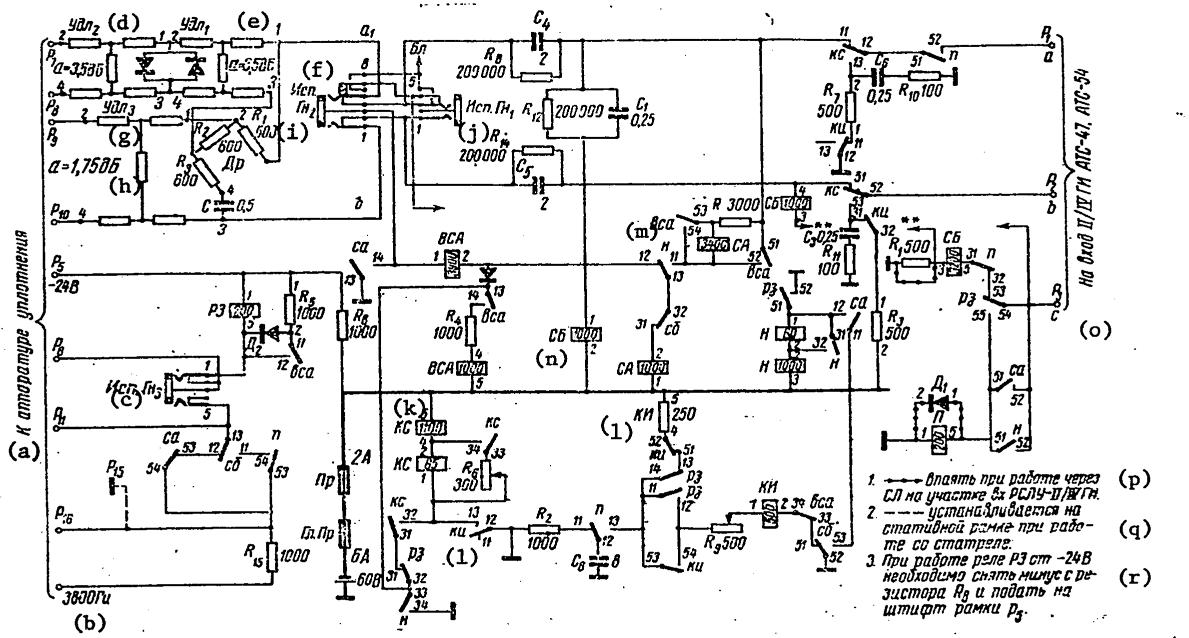

Figure 9.3. Incoming RSLUV assembly for coupling to the ATS-DSh 10-step system

Key:

a -- To the multiplexing equipment; b -- 3800 hertz; c -- ISP GN_3; d -- Udl_2 attenuator; e -- Udl_1 attenuator; f -- 3.5 decibels; g -- Udl_3 attenuator; h -- 1.75 decibels; i -- ISP. GN_2; j -- ISP. GN_1; k -- KS; l -- KI; m -- Vsa; n -- SB; o -- to the input of the II/IV GI selectors of the ATS-47, ATS-54; p -- connect for operation through the trunk in the input section of the RSLU-II/IV GI selector; q -- installed on the frame for operation with the static relay; r -- for operation of the RZ relay from -24 volts it is necessary to take the negative from the resistor R_8 and feed to the post of the frame P_5

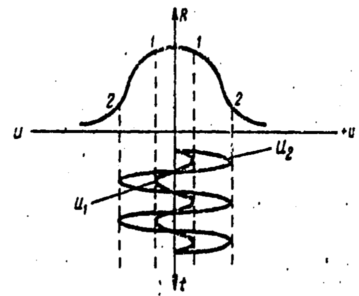

Figure 9.4. Explanation of the principle of limiting the current amplitude

N is the auxiliary relay for the RZ relay which responds at the time the assembly becomes busy and holds until the called subscriber answers;

P -- the test relay -- responds when the assembly is busy and holds until ring-off;

KI -- the pulse relay of the pulse corrector;

KS -- the series relay of the pulse corrector;

SA -- the signal relay of the line a -- receives the signal from the LI [connector] circuit that the subscriber has answered, holds the armature for the entire time of the conversation, transmits the ring-off signal of the called subscriber when he hangs up the phone last;

VSA -- auxiliary relay for the SA;

SB -- signal relay of line b -- controls the presence and the state of repair of the II/IVGI selector equipment over line c at the output of the incoming RSLU assembly. It receives the ring-off signal over line b from the LI circuit and transmits it in the direction of the outgoing automatic office when the called subscriber hangs up the phone first.

Initial State of the Assemblies. When the KRR-M equipment channel is in a state of good repair and II/IVGI selector in the incoming automatic office is also in good repair and is in the initial state, no relay is operating in the outgoing RSLU assembly, the positive feed of the battery is not fed over the signal line p_{11} to the static relay and, consequently, the signal frequency current is not transmitted in the direction of the incoming automatic office.

In the incoming assembly the relay SB is under current which receives the negative feed from the battery from the II/IVGI selector circuit over line b. The contact 12-13 of the relay SB breaks the signal conductor p_{11} as a result of which the positive feed is picked up from the standard relay, and the signal frequency current is not transmitted in the direction of the outgoing office.

If the II/IVGI selector in the incoming automatic office is damaged or removed, then the Sb relay trips the armature and closes the positive feed circuit to the static relay of the incoming side of the channel. The signal frequency current is transmitted over the high-frequency channel of the KRR equipment in the direction of the outgoing automatic office, and in the RSLUI assembly the relay K responds according to the following circuit:

1. The 60 volt negative terminal; the conductor p_5; the contact 1-5 of the relay K; the springs 1-2 of the test socket Gn_3; the wire p_6; the collector of the output ransistor of the PSU; the junctions: collector-base and base-emitter; the 60 volt positive terminal.

The relay B responds according to the following circuit following the relay K:

2. Positive terminal; contact 14-15 of the relay K; winding 1-2 of the relay B; negative terminal.

The possibility of a busy outgoing assembly is prevented by the contact 13-14 of the relay B, and the contact 11-12 closes the circuit for burning the tube AS of the frame and the individual tube of the assembly. By the signal received the service personnel of the outgoing automatic station communicate the presence of damage to the incoming automatic station.

Assembly Busy. When the RSLUI assembly is busy on the GI side the relay O responds overthe wire c by the following circuit:

3. The positive terminal from the GI circuit through the winding of the test relay; wire c; winding 4-3 of the relay O; contact 33-32 of the relay O; springs 2-1 of the blocking button BKn; contact 32-31 of the relay PK; contact 14-13 of the relay B, resistor R_2-200, negative terminal.

The relay O, responding,is blocked by its contact 33-31; the contact 14-15 closes the positive feed circuit to the static relay as a result of which the signal frequency current goes to the channel transmitter. In the transmitter the signal frequency modulates the carrier frequency of the channel, and in the form of the sideband it passes through the group equipment of the transmitting channel of the outgoing automatic station, then along the line, the group equipment of the receiving channel of the incoming automatic station, it is demodulated in the channel receiver and forces response of the relay RZ in the incoming RSLU assembly. The purpose of operation of the RZ relay is analogous to circuit 1 for operation of the relay K in the outgoing assembly.

The relay RZ, responding, creates by the contact 54-55 the operating circuit of the test relay П

4. Positive terminal; winding 1-5 of the relay II; contact 55-54 of the relay RZ, wire c, II/IVGI selector; relay O in the II/IVGI selector; negative terminal.

The relay SB trips its armature. The auxiliary relay H responds to the contact 11-12 of the relay RZ:

5. Positive terminal; contact 12-11 of relay RZ; windings 1-2 and 2-3 of relay H; negative terminal.

The relay H blocks the operating circuit of the relay P by the contact 51-52. This relay continues to hold its armature independently of the contacts of the RZ relay, and by the contact 31-32 shunts its low-resistance winding 1-2 and becomes delayed for releasing. Through the quiescent contacts 12-13 of the relay SB and 31-32 of the relay SA the positive feed goes to static relay, and the signal frequency is transmitted in the direction of the outgoing automatic office.

In the RSLUI assembly the relay K responds, then the relay B. The contact 14-13 of the relay B breaks the wire c, by which the busy state of the given assembly is noted. In the outgoing assembly the relay RO also responds by the following circuit:

6. Positive feed; contact 12-11 of the relay O; contact 11-12 of the relay OS; winding 5-1 of the relay RO; negative terminal.

By the contact 33-34 the relay RO disconnects the resistor R_7-1500 from the winding of the relay K, insuring more reliable operation of it for the time that the assembly is busy. Thus, a circular check takes place when the good channel is busy. If the high frequency channel has failed, then the signal frequency current does not go in the forward direction, and, consequently, also in the return direction or only in the return direction, and the relays K and B in the RSLUI assembly do not respond. When the first pulse of the number dialed by the subscriber arrives, the relay I responds over the following circuits:

7. Positive feed from IGI selector; wire a; contact 33-34 of the relay OS; winding 3-4 of the relay I; negative feed.

8. Negative feed from the IGI; wire b; contact 14-13 of the relay OS; winding 2-1 of the relay I, positive.

The contact 33-31 of the relay I closes the operating circuit of the relay S.

9. Positive; contact 12-11 of the relay O; 11-12 of relay OS; 31-33 of relay I; windings 1-2 and 2-3 of relay S; negative.

Through the operating contact of the relay S and the quiescent contact of the relay V the relay PK responds in the circuit 10.

10. Positive; contacts 12-11 of relay S; 43-54 of the relay V; winding 5-1 of the relay PK, negative.

After completion of dialing the first digit of the number the relay S releases, but the relay PK continues to hold its armature, for, responding, it was blocked by its contact 11-12, receiving the positive through the closed springs 3-2 of the SB button. The contacts 14-15 and 54-55 of the relay PK closes the feed circuit of the "busy" signal along the wires a and b in the direction of the calling subscriber, and the contact 51-52 of this relay closes the signal light circuit of AS:

1. Positive; contact 52-51 of the relay PK; 31-32 of the relay S; and in parallel the resistor R_{16}-1000; then negative through the springs of the button BL and the signal plate of the frame.

The subscriber, hearing the "busy" signal hangs up the phone. In the RSLUI assembly the relay O releases, and the relay PK remains under current.

The contact 31-32 of the relay PK opens the line c in the direction of IGI, by which the assembly is blocked from busy. In order to remove the block after eliminating the damage, the service personnel must press the button SB. Then the relay PK releases. The signal AS is extinguished, and the RSLU assembly is ready for the new busy, that is, the initial state of the assemblies is restored.

When the good channel is busy, in the RSLUI the relays O, RO; K, V are under current, and in the RSLUV, the relays RZ, N, P.

Dialing a Number. When dialing a number from the pulses relayed from IGI, in the outgoing assembly the relay I pulsates (circuit 7 and 8). The contact 53-54 of the relay I periodically breaks the sending of the signal frequency to the high-frequency channel, and the dial pulses are transmitted to the incoming assembly.

With the first dial pulse in the outgoing assembly with respect to circuit 9 the relay S responds. The contacts 33-34 and 53-54 disconnect the separating capacitors C_8, C_9 from the pulse relay at the time of dialing so that distortions are not introduced into operation. The contacts 13-14 and 34-35 of the relay S connect the resistors R_4 and R_5 to these capacitors. The capacitors are discharged through the resistors. This prevents false operation of the pulse relay after completion of relaying the pulses. On completion of the series the relay S is released.

In the incoming assembly in the cycle with the incoming pulses the relay RZ pulsates, where when the current pulse appears in the relay I and its contact 53-54 is open, the signal frequency sending to the incoming automatic office is broken. At this time, there is no pulse in the RZ relay, and it releases. Thus, the pulses received turn out to be inverted.

Since the pulse duration t_{pulse} is made up of the closing time t_c and the opening time t_o of the pulse circuit which are different (with a pulse coefficient K_{pulse}=1.6, t_o is greater than t_c by 1.6 times), then in the incoming assembly the ratio of t_o and t_c is disturbed with respect to the outgoing assembly. For correction of the pulses, a pulse corrector is introduced into the incoming assembly circuit. This corrector is made up of a capacitor C_6 with a capacitance of 8 microfarads, relays KI, KS and resistors. The operation of the corrector can be explained according to Figures 9.5 and 9.6 in which the basic electrical circuits characterizing the correction process and the time diagrams of the operation of the corrector are presented.

Let the subscriber dial the number 2. On first response of the relay I in the outgoing RSLUI relay assembly (Fig 9.5a and 9.6a) the contacts of relay I break the signa line to the high-frequency channel, as a result of which the relay RZ releases in the incoming RSLUV assembly (Figures 9.5b and 9.6b). The capacitor C_6 (Fig 9.5c) is discharged through the contact 13-14 of the relay RZ by the following circuit:

12. Positive; capacitor C_6; contacts 12-13 of the relay P; 14-13 of the relay RZ; 51-52 -of the relay KI; resistor KI-250; negative.

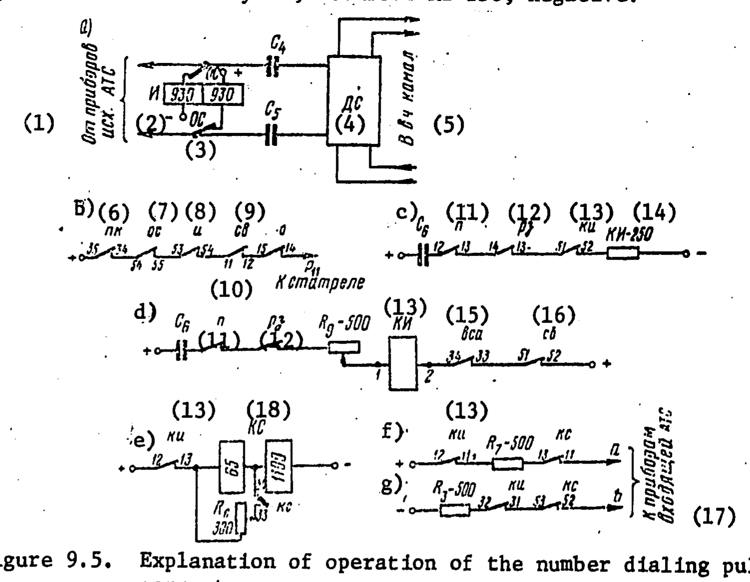

Figure 9.5. Explanation of operation of the number dialing pulse corrector

Key:

1 -- From the devices of the outgoing automatic office; 2 -- I; 3 -- OS; 4 -- DS; 5 -- to the high-frequency channel; 6 -- PK; 7 -- OS; 8 -- I; 9 — SV; 10 -- to the static relay; 11 -- P; 12 -- RZ; 13 -- KI; 14 -- KI-250; 15 -- Vsa; 16 -- SB; 17 -- to the incoming automatic office devices; 18 -- KS

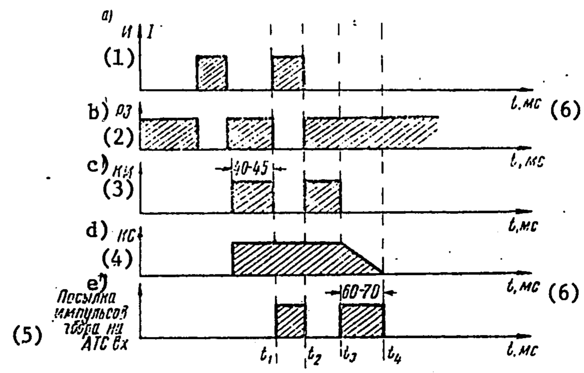

Figure 9.6. Time diagrams of the corrector

Key:
1. I
2. RZ
3. KI
4. KS
5. Sending dial pulses to the automatic office input
6. t, milliseconds

During subsequent releasing the relay I, the relay RZ responds and by its contacts creates the discharge circuit of the capacitor through the relay winding KI (Fig 9.5e). The relay KI responds (Fig 9.6c) and by its contacts creates the operating circuit of the relay KS (Fig 9.5e) which, responding, holds during the entire pulse series (Fig 9.6d).

On repeated response of the relay I in the RSLUI, the relay RZ in the RSLUV releases a second time, and again the capacitor discharges. The relay KS continues to hold through the quiescent contacts 31-32 of the relay RZ. Until the relay RZ is deenergized (t_1-t_2) the first dial pulse is transmitted in the direction of the incoming automatic office by the circuits presented in Fig 9.5 f and g.

Thus, the sending of the first pulse to the incoming automatic office (Fig 9.6e) takes place only after the second releasing of the relay RZ.

After repeated release of the relay I and response of the relay RZ the capacitor C_6 again discharges through the winding KI which, on responding, again cuts off the sending of the first pulse in the direction of the incoming automatic office. Here the relay KS continues to hold its armature through the operating contact 12-13 of the relay KI. After discharge of the capacitor (t_3) the relays KI and KS are released. During the delayed releasing of the relay KS to the time t_4 the second dial pulse is transmitted through the quiescent contacts of the relays KI and KS. Thus, the sending of the last pulse of each dial series depends on the release time of the relay KS which is regulated by the resistor R_6 and must be within the limits of 60-70 milliseconds.

Subscriber Answers. When the called subscriber answers, the poles of the line a switch in the LI connector, for which instead of the negative, the positive feed of the battery starts, and the insulation of the line b takes place from which the polarity is picked up. With this polarity on the subscriber lines in the RSLUV assembly the relay SA responds by the circuit:

17. Positive along the line a from LI; contacts 12-11 of relay KS; 31-32 of relay SA; winding 5-4 of relay SA; contact 11-13 of relay N; windings 2-1 of relay SA; negative.

The relay SA, responding, continues to hold the armature in the local circuit:

18. Positive; contact 32-31 of relay VSA; 31-33 of relay SA; winding 5-4 of relay SA; contact 11-13 of relay N; winding 2-1 of relay SA; negative.

The contact 53-54 of relay SA breaks the signal conductor and the sending of the signal frequency to the high-frequency channel stops. In the outgoing assembly the relay K releases and the relay OS responds by the following circuit:

19. Positive; contact 12-11 of relay O; 33-32 of relay K; 52-51 of relay S; 52-51 of relay V; winding 5-4 of relay S; winding 5-4 of relay V; relay OS; negative.

Relay V continues to hold in the same circuit.

By the contact 51-52 of relay OS, the shunt is moved from the speaking channel in the transmission direction. The contacts 14-15 and 34-35 of the relay OS switch the poles of the line a and insulate the line b in the direction of IGI. The contact 54-55 of the relay OS picks up a positive from the signal wire and stops sending the signal frequency in the direction of the incoming office. The contact 11-12 of the relay OS breaks the operating circuit of the relay RO, and it drops. The quiescent contact 33-34 of the relay RO connects the resistor R_7 in parallel with the winding of the relay K. The resistor R_7 prevents response of the relay K during the conversation.

In the incoming RSLU assembly the relays RZ and N release and the operating circuit of the relay VSA is created:

20. Positive; contact 13-14 of relay SA; winding 1-2 of relay VSA; contact 12-13 of relay N; 32-31 of relay SB; winding 2-1 of relay SA; negative.

In this circuit the relay VSA responds, and the relay SA continues to hold its armature.

After releasing the relays RZ and N, the test relay P of the assembly and the ring-off relay O of II/IVGI are blocked by the contact 51-52 of the relay SA. Thus, during the conversation in the outgoing assembly the relays O, V, OS are held, and in the incoming channel SA, VSA, P.

Ring-off from the Direction of the Calling Subscriber. If the calling subscriber hangs up the phone first, then a negative pulse will be fed to the line a from IGI. In the outgoing RSLU assembly the relay SV responds by the following circuit:

21. Negative over line a from IGI; contact 34-35 of relay OS; winding 1-2 of relay SV; contact 53-54 of relay K; positive.

The contact 12-13 of relay SV closes the signal line, and a signal frequency is sent in the direction of the incoming automatic office. In the incoming RSLU assembly the RZ relay responds, and after it the relay N. The contacts 13-11 of the relay N and 52-51 of relay VSA connect the thousand-ohm winding 1-2 of the relay SA with the negative at the end to the line a in the LI direction. Accordingly, the signal will be transmitted to the LI about ring-off on the part of the calling subscriber. The contact 33-34 of the relay N blocks the relay VSA.

When the called subscriber, having received the "busy" signal from the LI hangs up the phone, the poles of the lines in the LI reverse in the direction of the incoming assembly: line a is insulated, and the negative will be fed to the line b. For this polarity on the lines in the RSLUV the relay SA releases, and the relay SB responds according to the following circuit:

23. Positive; winding 3-4 of relay SB, contact 51-52 of relay KS; 51-52 of relay P; line b; negative from the LI.

The contact 13-11 of the relay SB closes the signal line, and the signal frequency goes in the direction of the outgoing automatic office. In the RSLUI assembly the relay K responds, and the contact 11-12 connects the negative to the line b in the direction of IGI through the winding 4-5 of the relay SV; and the contact 53-54 insulates the line a. For this polarity on the lines, IGI goes to ring-off and picks up the positive from the line c in the direction of the outgoing assembly where the relays O, OS and SV drop. The signal line is broken, and the sending of the signal frequency to the incoming automatic office stops.

In the RSLUV assembly the relays RZ, N and VSA drop. The positive is picked up from the line c in the direction II/IVGI, and all the devices of the incoming automatic office go to ring-off. The relay P drops, the relay SB is free of the negative with respect to line b and also drops.

After return of II/IVGI to the initial state the relay SB again responds, receiving the negative over the line c. The contacts13-11 of the relay SB and 54-53 of relay P break the current sending of signal frequency to the channel. In the RSLUI, the relays K and V drop. The RSLUI and the RSLUV assemblies reach the initial state.

Ring-off from the Direction of the Called Subscriber. If the called subscriber hangs up first, then a pole switch takes place on the lines in the GI direction so that the wire a is insulated, and a negative is fed to the line b. In the incoming assembly the relay SB responds according to the following circuit:

24. Negative from LI along the line b; line b in the RSLUV assembly; the contact 51-52 of the relay KS; winding 4-3 of the relay SB; positive.

The contact 31-32 of the relay SB breaks the operating circuit of the relay SA which slowly drops. The contact 11-13 of the relay SB closes the signal line in the direction of the high-frequency channel, and the signal frequency is transmitted to the outgoing automatic office. In the delayed release time of the relay SA the relay N responds by the following circuit:

25. Positive; contact 52-53 of relay SB; 11-12 of the relay SA; windings 1-2 and 2-3 of the relay N; negative.

The contact 51-52 of the relay N provides for holding the relay P in the RSLU assembly and the relay O in the II/IVGI with respect to the line c. The contact 33-34 of the relay N blocks the relay VSA.

From the sendings of signal freqqency in the RSLUI assembly the relay K responds, and the poles of the lines are switched in the IGI direction: the wire a is insulated, and the negative is fed to the wire b through the winding 4-5 of the relay SV. The relay SV responds in the circuit in series with the relay SB to the IGI.

The contact 12-13 of the relay SV closes the signal line and the signal frequency current goes in the direction of the incoming automatic office. In the RSLUV assembly the RZ relay responds, and the relay N continues to hold through the contact 51-52 of the relay RZ. The calling subscriber receives the "busy" signal from the LI circuit and hangs up the phone.

The instruments of the outgoing automatic office go to ring-off. In the RSLUI assembly the relays O, OS, SV release, and the sending of the signal frequency to the incoming automatic office stops. In the RSLUV assembly, the relays RZ, N and VSA are released, the delay circuit of the relay P of the assembly is disturbed, and the relay O in II/IVGI with respect to the line c. All of the devices of the incoming automatic office go to ring-off, reverse pole switching of the lines a and b takes place in the LI. In the incoming RSLU assembly the relay SB releases, and the signal line in the direction of the multiplexing equipment is closed through the quiescent contacts of the relays SA and SB.

When the II/IVGI instrument circuit reaches the initial state, again the relay SB responds with respect to the wire c and breaks the signal frequency sending to the outgoing automatic office. The relays K and V release in the RSLUI assembly, and the assembly will be ready for a new busy.

9.3. The RSLUM[1] Relay Assembly

The RSLUMI and RSLUMV outgoing and incoming relay assemblies are installed on the trunks between the automatic offices and the long distance offices. The outgoing RSLUM assembly is installed between the GIM and the input of the high-frequency channel formed by the KRR equipment. The incoming RSLUM assembly is installed between the output of the high-frequency channel of the KRR-M equipment and the II/IVGI input of the local automatic telephone office. The diagrams of the assemblies are presented in Figures 9.7 and 9.8.

Purpose of the Relays of the Outgoing Assembly. O -- ring-off relay -- responds when the assembly is busy, holds for the entire time of the conversation and releases after ring-off in the direction of the long distance telephone office;

I -- the pulse relay receives the number dialing pulses, the call and cut-off sendings from the GIM circuit and transmits them by a signal frequency current over the high-frequency channel;

K -- control relay -- connected to the collector circuit of the output stage of the PSU, receives the control signal with circular testing of the channel, and also the signals for establishing the connection with respect to the end of the dialing of the number, the answering and ring-off of the called subscriber;

V -- auxiliary relay -- operates when the assembly is busy after receiving the monitor signal and releases after ring-off from the direction of the long-distance office;

S -- the series relay -- responds on the first dial pulse and holds during the entire series of pulses. With its contacts it disconnects the separating capacitances from the pulse circuits so that these capacitances will not distort the shape of the pulses. It operates briefly after establishment of the connection, creating a circuit for response of the OS relay;

The OS relay is the relay for completion of establishment of the connection, it responds after establishment of the connection to the called subscriber;

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[1][Translator's note: M in this abbreviation and following abbreviations such as GIM refers to the long distance telephone office. Otherwise the abbreviations mean the same as already defined without the M.]

SV -- the interaction signal relay -- responds after completion of the establishment of the connection in the case where the called subscriber is free;

A -- after relay -- responds when the called subscriber answers and holds for the entire time of the conversation until the called subscriber hangs up the phone;

PK -- the channel damage relay -- responds after the long distance telephone operator dials the first number if the channel is damaged.

Purpose of the Incoming Assembly Relays. RZ is the busy relay which operates on receiving the control signals from the PSU of the transceiver module, it receives the number dialing pulses, the call, cut-off and ring-off sendings;

N -- auxiliary relay to RZ relay -- prepares the operating circuit of the KI relay;

KI -- pulse relay of the pulse corrector;

KS -- series relay of the pulse corrector -- responds for the first pulse of the KI relay and holds for the entire series of pulses formed by the corrector;

P -- test relay -- responds when the assembly is busy and holds until ring-off from the direction of the long distance office;

SB -- signal relay of line b -- receives signals over line b: completion of establishment of connection, "subscriber busy," "subscriber free," "subscriber answers," ring-off from the subscriber direction and it transmits these signals to the high-frequency channel in the GIM direction;

U -- holding relay -- operates in the initial state of the assembly, receiving the negative from the GIM circuit over the line c;

SA -- signal relay of the line a -- receives the signal of completion of establishment of the connection over line a in the case where the subscriber is free and also the answer and ring-off signals from the subscriber direction;

OT -- answer relay -- operates when the called subscriber answers, holds for the entire time of the conversation, releases on ring-off both from the subscriber direction and from the telephone operator of the long distance office.

Initial State. In the initial state the signal frequency current is not transmitted over the channel. When the channel of the KRR equipment is not busy and the device of the automatic telephone office to which the

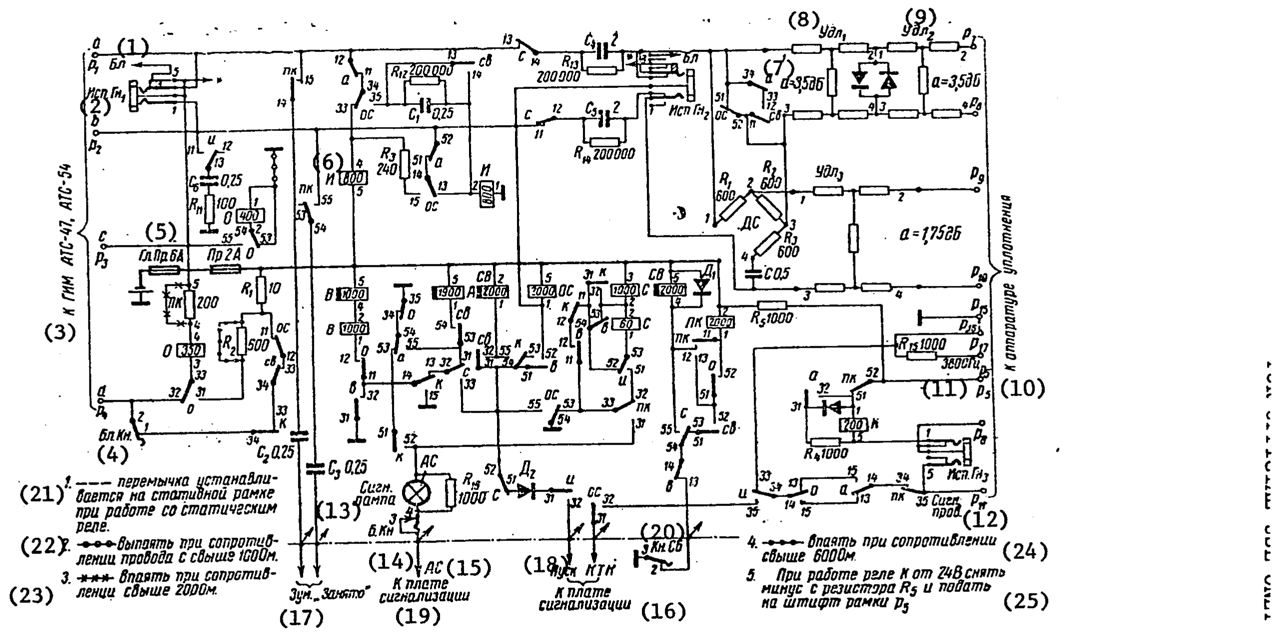

Figure 9.7. Outgoing RSLUM assembly

Key:

1 -- Bl; 2 -- Isp. Gn_1; 3 -- to the GIM of the ATS-47, ATS-54; 4 -- Bl. Kn; 5 -- Gl. Pr; 6 -- I; 7 -- a=3.5 decibels; 8 -- Udl_1 attenuator; 9 -- Udl_2 attenuator; 10 -- to the multiplexing equipment; 11 -- 3800 hertz; 12 -- signal lead; 13 -- signal light; 14 -- B. Kn; 15 -- AS; 16 -- to the signal plate; 17 -- busy signal; 18 -- start; 19 -- to the signal plate; 20 -- Kn. Sb; 21 -- jumper is installed on the frame during operation with the static relay; 22 -- disconnected for line resistance of more than 100 ohms; 23 -- connected for a resistance of more than 200 ohms; 24 -- connected for a resistance of more thaN 600 ohms; 25 -- for operation of the relay K from 24 volts take the negative from the resistor R_5 and feed to the post of the ring P_5

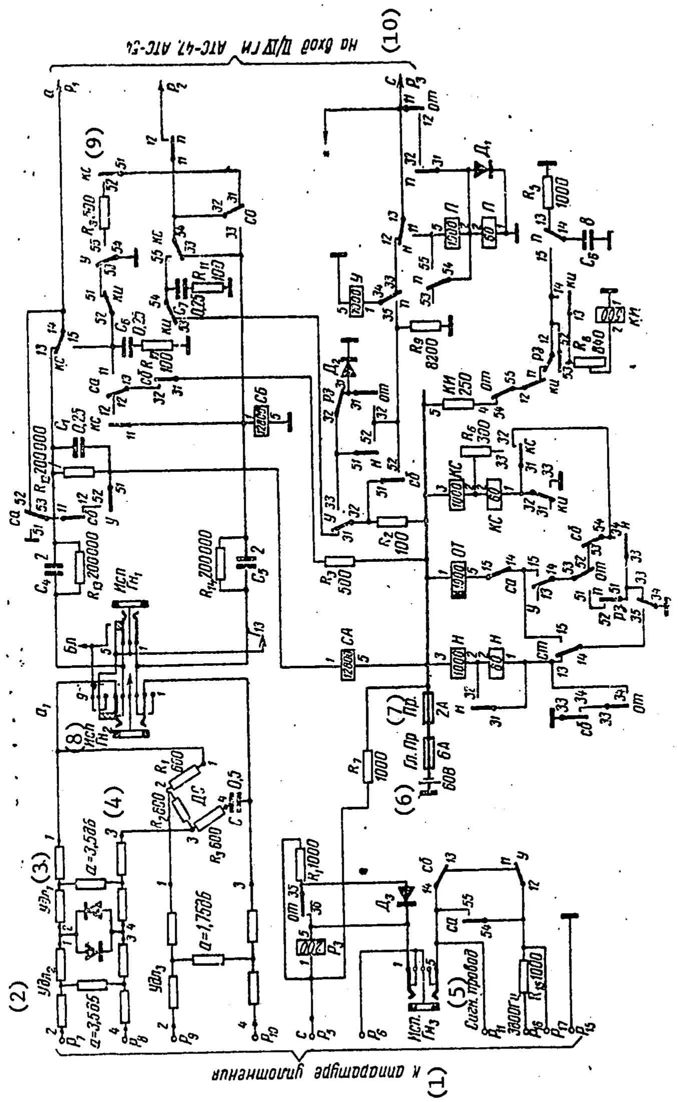

Figure 9.8. Incoming RSLUM assembly

Key:
1 -- to the multiplexing equipment; 2 -- Udl_2 attenuator; 3 -- Udl_1 attenuator; 4 -- 3.5 decibels; 5 -- signal lead; 6 -- Gl. Pr.; 7 -- Pr.; 8 -- Isp. Gn_2; 9 -- KS; 10 -- to the input II/IVGI ATS-47, ATS-54

wires a, b and c of the incoming assembly are connected, is good and is in the initial position, no relay operates in the outgoing assembly, and in the incoming assembly the relay U operates, receiving the negative from the II/IVGI circuit over the line c.

1. Positive; winding 5-1 of relay U; contact 32-31 of relay P; 12-13 of relay N; line c of the assembly; line c II/IVGI; negative.

The operating contact 11-12 of the relay U breaks the signal line, the signal frequency current does not go to the channel and in the outgoing assembly the relay K does not operate. The busy circuit of the outgoing assembly over line c is prepared through its quiescent contact 34-33. The signal frequency is also not transmitted in the direction of the incoming automatic office.

If the trunk (the channel of the KRR equipment) is damaged on the incoming automatic office, removed from the work area or left without ring-off II/IVGI, then the relay U in the RSLUMV assembly does not operate. The contact 11-12 of the relay U closes the signal line, as a result of which the signal frequency current goes to the channel. In the RSLUMI assembly the relay K responds and the contact 34-33 blocks the failed channel from busy from the GIM direction. The contact 51-52 of the relay K closes the signal tube circuit AS of the frame. After 1-2 minutes an individual signal appears of failure of the channel -- the AS tube burns.

Busy Assembly. The outgoing assembly and the high-frequency channel are occupied by line c from the GIM direction. In the RSLUM assembly the ring-off relay O operates which, on responding, is blocked by the contacts 31-33 and 54-55, and the contact 14-15 creates the circuit for sending the signal frequency to the channel.

In the incoming assembly the relay RZ operates, and through its contact 34-35, the relay N. The contact 12-13 of the relay N breaks the operating circuit of the relay U, and the contact 11-13 forms the operating circuit of the test relay P. The latter responds and is blocked on its 60-ohm winding. The relay U releases and the contact 11-12 forms the sending circuit of signal frequency in the direction of the long distance office. The relays K and V operate in the RSLUMI assembly.

In the busy state in the RSLUMI assembly the relays O, K and V are under current; and in the RSLUMV, the RZ, N and P.

Number Dialing. When the number is dialed the relay I pulses in the RSLUMI assembly. For the first dial pulse the series relay S responds and holds to the end of the series. Its contacts 11-12 and 13-14 disconnect the speaking line from the capacitors C_4 and C_5. For each response of the relay I in the RSLUMV assembly the RZ relay releases, after which the obtained pulses turn out to be inverted.

The correction of the pulses and their further transmission to the devices of the incoming automatic office take place analogously to how this was described in item 9.2.

On completion of the establishment of connection, three cases are possible:

1) The called subscriber is free;

2) The called subscriber is busy with a local connection;

3) The called subscriber is busy with a long distance connection.

Let us consider the operation of the assemblies in the enumerated cases.

Called Subscriber Free. After completion of establishment of the connection in the RSLUMV assembly the SB relay responds, receiving the negative over the wire b from the LIM circuit. The contact 13-14 of this relay breaks the signal line. In the RSLUMI assembly the relay K releases, the relay S responds, and then the relay OS. The latter, responding, closes its contact 54-55, through which it continues to hold after the conctact 53-54 breaks the operating circuit of the relay S. The contact 51-52 of the relay OS removes the shunt from the transmitting speaking channel of the multiplexing equipment.

In the RSLUMV after response of the relay SB with delay the relay U operates (the resistor R_0-8200 is included in parallel to its winding). The operating contacts 11-12 of the relay SB and 51-52 of the relay U create the operating circuit of the relay SA which receives a positive over the line a from the LIM circuit. The relay SA, responding, is blocked in the local circuit through its contact 51-53. The contact 54-55 of the relay SA closes the signal line in the high-frequency channel, and in the RSLUMI the relay K responds, through the contact of which 54-55 of the operating circuit of the relay SB is formed. The latter responds and is blocked. As a result of simultaneous operation of the relays OS and SV, the polarity on the subscriber line changes: the winding of the relay I with positive is connected to line a, and with negative to line b. With this polarity on the long distance switchboard the ring-off light of the cord burns signalling the operator that the subscriber is free. The operator sends the ring-off.

Called Subscriber Is Busy with a Local Connection. In this case in the incoming RSLUM assembly the relays SB and U respond, and relay SA does not operate, for the positive of the battery from the LIM circuit is not fed over the line a. The contacts 13-14 of the relay SB and 11-12 of relay U break the signal line and the positive feed to the static relay of the channel is stopped. In the outgoing RSLUM assembly, the relay K releases, the relays S and OS respond. The contact 54-53 of the relay OS breaks the operating circuit of the relay S, which releases. The winding of the relay I with battery negative is connected to the line b, and the line a is insulated, for the relay SV does not respond in case the called subscriber is busy, and its contact 13-14 remains open.

With this polarity on the lines in the IGIM direction on the long distance switchboard the ring-off light of the cord blinks. The telephone operator, receiving the signal that the subscriber is busy with a local connection, connects to the talking subscriber (by contact 51-52 of the relay OS the shunt is picked up from the transmitting channel, and the subscriber hears the telephone operator), warning the required subscriber of the forthcoming long distance call, and if he agrees, "through clearing" takes place by pressing the through clearing button. In the RSLUMI assembly the relay I responds, receiving the positive over the line b from the GIM circuit. Through the operating contact 31-32 of relay I a positive is fed to the pulse relay P located in the frame signal plate. The pulse relay responds, and by its contacts it sends a pulsating positive to the static relay. In the incoming RSLUM assembly the relays RZ and KI pulsate, the relay KS responds and by the contact 51-52 feeds the positive of the battery to the line b in the LIM. The relay SB in this case holds in the local circuit. The LIM circuit is switched so that the called subscriber is freed of the local connection and is held for the upcoming long distance connection.

If the subscriber hangs up after through clearing the operator rings him. In this case in the RSLUMI assembly, a negative goes over the line a from GIM, the relay I responds which by its contact 31-32 triggers the general frame pulse relay in the signal plate. In the RSLUMV assembly the relays RZ and KI pulsate, and to the completion of each sending the relay KS holds, through the operating contacts of which the battery negative is fed over the line a to the LIM. The LIM circuit provides for sending an inductor current to the subscriber telephone.

When the subscriber answers, the SB relay is released in the RSLUMV, for the battery negative feed stops over the line b from the LIM. The contact 11-12 of the relay SB breaks the operating circuit of the relay SA. The latter, on being released, breaks the signal line to the high-frequency channel.

In the RSLUMI assembly the relay K releases and the relay A responds. The polarity is picked up from the lines a and b. On the long distance switchboard the ring-off light of the cord pair lights. The contact 33-34 of the relay A picks up the shunt from the transmitting speaking channel, and the contact 13-14 breaks the signal line.

The relays RZ and N release in the RSLUMV circuit, but in the time of delayed release of the relay N, the relay OT responds, through the contact of which the relays U and P continue to hold.

During the conversation of the subscribers, the relays O, V, A, OS, SV operate in the RSLUMI, and the relays U, OT, P operate in the RSLUMV.

The sequence of processes occurring during the ring-off in the RSLUMI and the RSLUMV assemblies is the same as for the RSLUI and the RSLUV assemblies, and it is not considered here.

If the subscriber is busy with a long distance connection, the assemblies operate analogously to the case of busy with a local connection, but in addition to this a busy signal is sent from the LIM circuit.

9.4. Signal Plate of the RSLU-RSLUM Frame

Purpose of the Relay. The signal plate (Fig 9.9) contains the following relays:

AS -- the signal relay -- operates on signalling from the outgoing assembly of failure of the high-frequency channel, failure of the group selector at the opposite automatic office, delay of ring-off from the direction of the calling subscriber;

PS -- signal relay -- operates when the frame protector burns out;

PP -- signal relay -- operates when the individual protector burns out;

N and K -- time delay relays -- operate at the beginning and at the end of the time interval required for the appearance of a damaged signal on the frame, respectively;

Bl -- blocking relay for operation of the assembly -- responds when the plug is stuck in the test socket Isp. Gn_1 of the RSLUI assembly;

P -- pulse relay -- sends current pulses over the high-frequency signal channel to the incoming assembly for "cut-off."

Signalling Burnout of the Protectors. When the frame protector burns out the relay PS responds by both windings, receiving positive at the location of the short circuit and negative through the good frame protector. Responding, the relay PS is blocked by its contact 33-34, receiving the positive independently from the initial circuit. The contact 51-52 of the relay PS closes the row, section and group signal circuits and the PS tubes on the RSLU frame.

When the individual protector burns out on the frame of the outgoing assemblies the signal contact of the protector Pr closes the operating circuit of the relay PP. The contacts of the relay PP create the circuits for the row, section, group signalling and the tube PP on the RSLU frame.

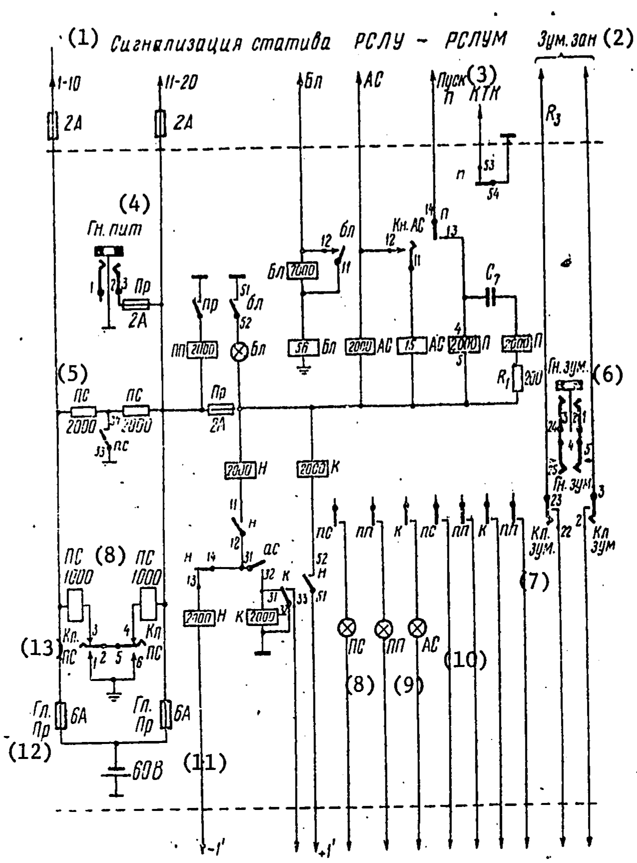

Figure 9.9. Signal plate of the RSLU-RSLUM frame

Key:

1. Signal system of RSLU-RSLUM frame
2. busy signal
3. Start
4. Gn. pit [power plug]
5. PS
6. Gn. Zum.
7. Kl. zum
8. PS
9. PP
10. AS
11. 60 volts
12. Gl. Pr
13. Kl. PS

Signalling Failure of the High-Frequency Channel or the II/IVGI Device at the Opposite Automatic Office. On failure of the high-frequency channel in the forward or return direction, absence or failure of II/IVGI at the counter automatic office, the signal frequency current is not transmitted to the outgoing automatic office. In the RSLUI assembly a positive appears on the AS line, as a result of which the relay AS in the signal plate responds.

1. Positive along the line AS from the RSLUI assembly; winding 2-1 of the relay AS; negative.

The contact 31-32 of the relay AS prepares the operating circuit of the relay N from the negative pulse of the 1-minute breaker 1':

2. Positive; contact 32-31 of the relay K; 32-31 of the relay AS; 14-13 of the relay N; winding 2-1 of the relay N; then the negative through the breaker of the SVU.

The relay N, responding, holds by the second winding through its contact 11-12 independently of the breaker. The contact 51-52 of the relay N connects the winding of the relay K to the wire over which the positive is fed also from the 1-minute breaker +1' from the SVU. On expiration of another minute, when a positive appears on the wire +1', the relay K responds by the circuit:

3. Positive through the one-minute breaker; contact 51-52 of the relay N; winding of the relay K-2000; negative.

By the contact 32-31 the relay K removes the shunt from the holding winding, and by the contacts 11-12 and 51-52 closes the circuits of the row or sectional signalling. On the frame the light AS burns. For discovery of the independent channel it is necessary to press the button AS on the frame. The button contacts connect the low-resistance winding AS-15 parallel to the winding of the relay AS-2000, and the individual light of the assembly burns.

The light AS burns on the frame of the outgoing RSLU even in the case where the individual protector burns out on the incoming side of the channel (in the RSLUV assembly). Then when the outgoing assembly is busy the signal frequency current goes in the forward direction. In the incoming assembly the relay RZ responds connected through the PSU of the channel. The relay N cannot respond as a result of absence of the protector. As a result, the signal frequency current does not go in the opposite direction. For the first dial pulse, positive appears on the AS line in the outgoing assembly. Further operation of the relay of the signal plate takes place analogously to what was described above.

Sending of Current Pulses over the High-Frequency Signal Channel to the Incoming Assembly. When the long distance telephone operator presses the "ring" button, the pulse relay P responds in the signal plate according to the following circuit:

4. The positive from the outgoing assembly; the start P line; contact 14-13 of the relay P; winding 4-5; negative.

The relay P breaks the line to the high-frequency signal channel by the contact 53-54, the sending of the signal frequency current in the forward direction is stopped, and the relay RZ is released in the incoming assembly.

The relay P, responding, is deenergized by its contact 13-14, and by the contact 53-54 closes the signal wire to the channel.

In the RSLUVM assembly the relay RZ responds. The quiescent contact 13-14 of the relay P again restores its operating circuit, and the process is repeated again.

Thus, the current pulses are sent through the contacts of the pulse relay to the incoming RSLUMV assembly during the entire time until the button is pressed on the long distance switchboard. As a result, the battery positive is fed over the line b in the LIM direction, the circuitry of which in this case insures "through clearing" of one subscriber and holding of the connection to the line of the subscriber required for the long distance conversation.

9.5. RSLU ATSK[1] Relay Assemblies

The RSLUI and the RSLUV ATSK relay assemblies are designed for matching the multiplexing equipment with the equipment of the crossbar system.

The diagrams of the assemblies are presented in Figures 9.10 and 9.11. The input of the outgoing RSLU assembly is connected to the field of the GI stage or to the connecting assembly, and the output of the assembly is connected to the multiplexing equipment. For connection to the GI field the assembly has seven lines: a, b, e, f -- speaking; d -- busy line; c -- line marking disconnection of the differential system; k -- test line. The assembly is connected to the multiplexing equipment by six lines: of them four are speaking, and there are one each for transmitting and receiving the control and interaction signals.

The incoming assembly is connected to the multiplexing equipment analogously and it is connected directly to the vertical of the GI module (for operation of the ATSK with the ATSK) or through a connecting assembly (for operation of the ATS-DSh 10-step system with the ATSK crossbar system). The purpose of the lines a, b, e, f, d, c and k is the same as for the outgoing assembly.

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[1] Crossbar system.

Purpose of the Relays of the Outgoing Assembly. 0 -- ring-off relay -- responds for busy and hold until the disconnect signal;

I -- pulse relay -- included in the lines a and b;

KI -- correct the dial pulses and transmit them over the signa line to the high-frequency channel;

S -- series -- responds for the first dial pulse and holds for the entire series of pulses, disconnects the separating capacitances from the pulse circuit;

K -- receiving relay -- receives the control and interaction signals over the signal line from the multiplexing equipment;

V -- auxiliary relay to the 0 relay -- operates after obtaining the signal frequency for busy incoming assembly, drops after ring-off from the calling subscriber side;

A -- answer relay -- operates if there is an answer, releases on ring-off from the direction of the called subscriber, insures switching of the pulse of the wires a and b in the direction of the automatic office for transmitting interaction signals;

PK -- blocking relay of the assembly in case of damage to the channel and auxiliary to the relay V, holds until the called subscriber answers;

SV -- signal relay -- receives the ring-off signal from the direction of the calling subscriber and transmits it over the signal line to the high-frequency channel;

DS -- relay for disconnecting the differential system -- responds when establishing a tandem connection through the high-frequency channel.

Purpose of the Relays of the Incoming Assembly. 0 -- ring-off -- responds when the assembly is busy and holds for the entire connection;

VO -- auxiliary relay to the relay 0;

RZ -- receiving relay -- receives the control and interaction signals over the signal line from the multiplexing equipment;

KI -- corrects the number dialing pulses and transmits them to the subsequent selection stage;

S -- series -- responds on the reception of the fist dial pulse and holds for the entire series of pulses;

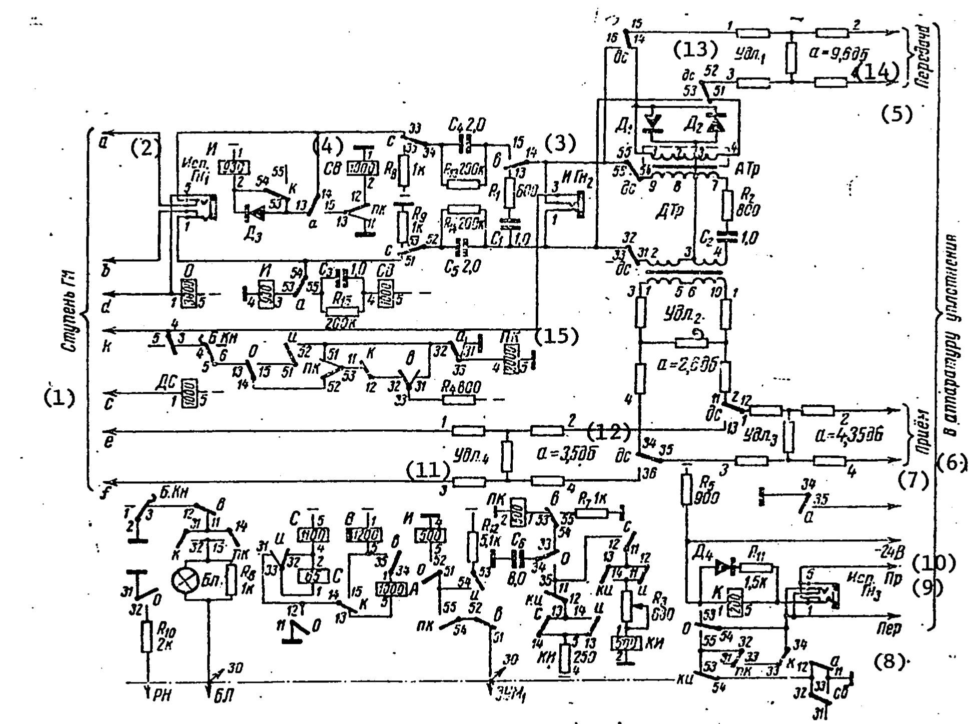

Figure 9.10. Outgoing RSLU ATSK assembly

Key:
1 -- GI stage; 2 -- Isp. Gn_1 test socket; 3 -- IGn_2; 4 -- SV; 5 -- transmission; 6 -- to the multiplexing equipment; 7 -- reception; 8 -- transmission; 9 -- reception; 10 -- -24 volts; 11 -- Udl_4 attenuator; 12 -- a=3.5 decibels; 13 -- Udl_1 attenuator; 14 -- a=9.6 decibels; 15 -- PK

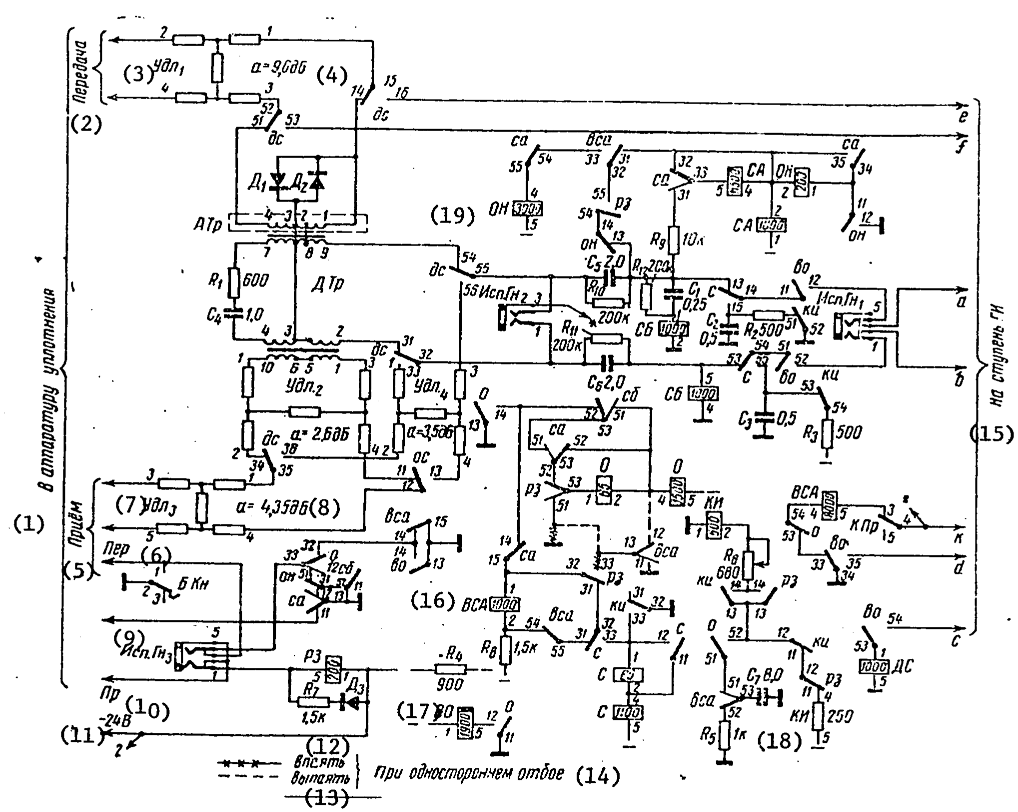

Figure 9.11. Incoming RSLU ATSK assembly

Key:

1 -- to the multiplexing equipment; 2 -- transmission; 3 -- Udl_1 attenuator; 4 -- a=9.6 decibels; 5 -- receiver; 6 -- transmission; 7 -- Udl_3 attenuator; 8 -- a=4.35 decibels; 9 -- Isp. Gn_3 test socket; 10 -- receiver; 11 -- -24 volts; 12 -- connect; 13 -- disconnect; 14 -- for one-way ring-off; 15 -- to the GI stage; 16 - VSA; 17 -- VO; 18 -- KI; 19 -- ON

SA -- signal -- receives the answer and ring-off signals of the called subscriber, transmits the ring-off signal of the calling subscriber;

VSA -- control relay -- operates in the initial state of the assembly by the line k, controlling the state of repair of the GI and the marker, releases when the assembly is busy;

DS -- relay for disconnection of the differential system -- responds when establishing the tandem connection through the multiplexing equipment channels.

Initial State. In the RSLUI all of the relays are deenergized, and in the RSLUV, the VSA relay under current, which indicates the state of good repair of the GI input attached to the given assembly.

When there is damage at the incoming end, the battery positive is fed to the signal line in the direction of the multiplexing equipment by the quiescent contact 14-15 of the relay VSA. In the RSLUI assembly the relay K responds, which by its contacts breaks the control circuit over the line k, blocking the assembly from busy and switches on the blocking signal of the assembly.

Busy Assembly. The test is made on the RSLUI assembly from the GI stage over the line k. The free and good assembly is denoted by the presence of a battery negative through 800 ohms with respect to the circuit:

Positive; test relay; line k of the marker of the GI stage; line to the RSLUI assembly; contact 5-6 BKn; 13-14 of relay O; 52-53 of relay PK; 11-12 of relay K; 32-33 of relay V; R_4-800; negative.

When the RSLUI is busy, the relay O operates, receiving the battery positive along the line d first from the ARB circuit, then from the IShK circuit. The contact 14-15 of the relay O breaks the negative feed circuit to the test line k, blocking the assembly from new busies, the contact 34-35 closes the charge circuit of the capacitor C_6 (8 microfarads), and contact 54-55 provides for sending the audio frequency current to the channel.

In the RSLUV assembly the relay RZ responds which by the contact 51-53 closes the operating circuit of the ring-off relay O. The latter, by contact 31-33, closes the circuit for sending the signal frequency in the opposite direction. The contact 53-54 of the relay O breaks the operating circuit of the relay VSA, but it continues to hold by its winding 1-2 through the contact 13-14 of the relay O, the relay VSA, the relay RZ. The contact 11-12 of the relay O closes the operating circuit of the relay VO which, on responding, by the contact 34-35 makes the marker GI busy, and the contact 51-52 and 11-12 connects the lines a and b. If the channel is good in both directions, then in the RSLUI the relay K responds and by the contact 14-15 closes the operating circuit of the relay V. The latter, by the contact 14-15, connects the speaking channel, and by the contact 31-33, closes the operating circuit of the PK relay.

In the busy state in the outgoing assembly the relays O, K, V, PK are under current, and in the incoming assembly, -VSA, RZ, O, VO.

If the high-frequency channel is failed, then the signal frequency does not go in the forward or return direction, and the relay K in the RSLUI does not respond. On arrival of the first pulse of the dialed number from the ARB (in the case where the coupling is realized from the crossbar to the 10-step system) the relay I responds and includes the series relay S. The contact 51-52 of the relay I creates the operating circuit of the relay PK, which, on responding, is blocked by its contact 51-53. The contacts 51-52 of the relay O and 54-55 of the relay PK connect the busy signal to the winding 5-4 of the relay I which is induced in the line windings of this relay and is transmitted to the calling subscriber. The contact 52-53 of the relay PK breaks the test circuit over the line k, and the contact 14-15 includes the signal of failure of the channel.

After ring-off of the calling subscriber the RSLUI remains blocked from the subsequent busies until the damage is eliminated.

The contact 32-33 of the relay PK closes the signal frequency current sending circuit to the channel in the forward direction. After elimination of the damage the signal frequency is transmitted in the return direction. In the RSLUI the relay K responds, the blocking circuit breaks for the relay PK which, releasing, disrupts the signal frequency sending the circuit in the forward direction, as a result of which the sending of the signal frequency in the return direction stops. The relay K releases, and the assembly returns to the initial state.

If a coupling is realized between the crossbar automatic office, then the information between the register of the outgoing automatic office and the marker of the incoming automatic office is transmitted by frequency code over the speaking lines. In the case of failure of the channel the register of the outgoing automatic office does not receive interrogation from the marker of the incoming automatic office about the output of the corresponding digit of the number and on expiration of the time delay frees the instruments participating in the connection. In the RSLUI assembly the relay O is released. Through the quiescent contactsz 33-34 of the relay O and 54-53 of the relay V in the discharge circuit of the capacitor C_6 (8 microfarads) the relay PK responds and is blocked by its contact 51-53. The contact 32-33 of the relay PK closes the signal frequency sending the circuit to the channel in the forward direction. Further operation of the circuit takes place analogously to that described.

Dialing the Number. On connection from the ATSK to the ATS-DSh the information is transmitted by the DC pulses over the lines a and b. Here the relay I pulsates in the RSLUI. With the first pulse the relay S responds, the contacts of which disconnect the separating the capacitors C_4 and C_5 from the pulse relay. The resistors R_8, R_9 are connected to the capacitors.

For the first release of the relay I in the capacitor discharge circuit C_6 (8 microfarads) the correcting relay KI responds. The time this relay is under current is determined by the discharge time of the capacitor C_6 and must be 40-45 milliseconds. This is achieved by regulating the resistor R_3-680 and varying the thickness of the stripped seal plate KI from 0.1 to 0.3 mm. The contact 53-54 of the relay KI periodically breaks the sending of the signal frequency current to the channel.

In the RSLUV the RZ relay pulsates. When it first releases the capacitor C_7 is charged (8 microfarads). On subsequent response of the RZ relay in the discharge circuit of the capacitor C_7 the relay KI responds. The time the relay KI is under current is determined by the discharge time of the capacitor C_7 and must be 40-45 milliseconds. This is achieved by regulating the resistor R_6-680 and varying the thickness of the stripped seal plate of the relay KI. The relay KI, responding, closes the operating circuit of the series relay S by the contact 32-33, which holds for the entire series of pulses. At the time of dropping of the KI relay the relay S holds through the contact 31-32 of the relay RZ and its contact 32-33. Through the quiescent contacts 51-52 and 53-54 the relay KI the corrected pulses are transmitted to the 10-step system devices.

On completion of dialing the relay S releases, and the relay RZ responds for a prolonged time. The ringing goes from the LI to the subscriber.

If the trunks are formed by two like ATSK, then the information about the dialed number is transmitted over the speaking lines by frequency code. The pulsed relay does not operate in this case. After completion of establishment of the connection the subscriber receives the ringing signal from the circuitry of the incoming trunk outlet VShK.

Subscriber Answers. When the called subscriber answers as a result of pole switching of the lines in the LI to the line a of the RSLUV the battery positive is fed. The relay ON responds and by the contact 51-52 opens the signal frequency sending circuit in the direction of the outgoing automatic office, by the contact 11-12 closes the operating circuit of the winding 1-2 of SA and the blocking circuit of winding 1-2 of relay ON until the relay SA responds.

In the RSLUI the relay K releases, but the relay V continues to hold the armature through its contact 34-35 in series with the relay A. In this circuit the relay A responds and by the contact 31-33 shunts the winding 4-5 of the relay PK which responds with delay. For the time of the delayed release of the relay PK the pure positive feed goes to the line a through the contact 11-13 of the relay PK, and after release of this relay the positive feed is through the winding 1-2 of the relay SV. The contact 11-12 of the relay A breaks the signal frequency sending circuit in the forward direction, as a result of which the relay RZ releases in the RSLUV, and then the VSA relay.

During the conversation in the RSLUI the relays O, V, A are under current, and in the RSLUV, the relays O, VO, SA.

Ring-off of the Calling Subscriber Direction. If the calling subscriber gives the ring-off first, then the battery negative is fed to the line a from the direction of the outgoing automatic office. In the RSLUI the relay SV responds, the contacts of which close the signal frequency sending circuit. As a result, the called subscriber receives the "busy" signal from the LI or the VShK circuit.

After ring-off of the called subscriber, the relay SA releases in the RSLUV, the relay SB responds which closes the signal frequency sending circuit in the opposite direction. The contact 14-15 of the relay SA creates the operating circuit of the relay VSA.

In the RSLUI the relay K responds which breaks the operating circuit of the relay A. The contact 14-15 of the relay A picks up the battery positive from the line a, as a result of which the preceding cord instruments are freed, and the contact 32-33 restores the operating circuit of the PK relay. In the RSLUI, the relay O also releases, then the relay V with delay and the operating circuit of the relay PK is broken. The contact 54-53 of the relay O breaks the signal frequency feed to the channel in the forward direction; in the RSLUV the relays RZ, SB, O, VO, VSA release. After freeing the GI, the operating circuit of the relay VSA is restored. The contact 14-15 of this relay stops the signal frequency sending to the channel in the return direction. In the RSLUI, K releases, and the assembly is ready for a new busy.

Ring-off from the Direction of the Called Subscriber. If the called subscriber rings off first, then in the LI or VShK the positive is picked up from the line a, and the negative is fed to the line b. In RSLUV the relay SA releases, and the relay SB responds. Through the contact 13-12 of the relay SA and 11-12 of the relay SB the signal frequency sending circuit in the return direction is created.

In the RSLUI, K responds and by the contact 13-14 breaks the operating circuit of the relay A. The relay A releases and by the contact 11-12 closes the signal frequency feed circuit to the channel; by the contact 32-33 the operating circuit of the relay PK is restored, and by the contact 54-53 and 13-14 the windings of the relay I are connected to the lines a and b. Simultaneously the "busy" signal is sent in the direction of the calling subscriber from the VShK or IGI. In the RSLUV the relay RZ responds, and then VSA.

After ring-off of the calling subscriber and release of the preceding cord devices, the line d is broken. In the RSLUI the relay O releases, then with delay V, and the operating circuit of the relay PK is broken. After releasing of the relay O, the signal frequency feed to the channel is stopped. In the RSLUV the relay RZ releases, then O, VO, VSA, and SB. The contacts of the relay VO break the GI holding circuit. After the release of the GI the relay VSA again responds, which breaks the signal frequency sending circuit in the return direction. In the RSLIU the relay K releases, and the assembly returns to the initial state.

Tandem Connection Over the High-Frequency Channel. If when establishing a tandem connection the RSLUI assembly is connected through the group selector stage to the RSLUV assembly, then a series circuit is created in the relay assemblies over the line c in which the relay DS of the outgoing and incoming assemblies respond. In the lines a, b, e, f the contacts of these relays disconnect the differential systems of the assemblies, and the speaking lines with a level at the commutation point of 3.47 decibels (0.4 nepers) are connected, that is, the four-line tandem is created.

In order to match the ATSK equipment of the long distance cord to the multiplexing equipment, the RSLUIM and the RSLUVM assemblies are used. The operation of these assemblies can be considered by the circuits for the RSLUMI and the RSLUMV and the RSLU ATSK assemblies.

Test Questions

1. What is the purpose and what are the types of RSLU assemblies?

2. Explain the structural diagram of the RSL-DS assembly.

3. Explain the process of the circular checking when the high frequency channel is busy by the circuits of the RSLU ATS-DSh assemblies.

4. Explain the operation of the RSLU ATS-DSh assemblies when a failed channel is busy.

5. Explain the process of transmission of the number dialing pulses over the high-frequency channel.

6. What is the purpose and what is the operating principle of the pulse corrector?

7. Explain the operation of the relay circuits when the called subscriber answers and the speaking condition of the assemblies.

8. Explain the sequence of the processes occurring in the relay assemblies if: 1) the calling subscriber rings off first; 2) the called subscriber rings off first.

9. How do the RSLUM assemblies operate when the good and failed channels are busy?

10. Explain the principle of the appearance of a signal at the long distance switchboard in cases where: the subscriber is free, busy with a local call, busy with a long distance call.

11. Explain the operation of the assembly during ring-off after a conversation has been held.

12. Explain the operation of the relay assemblies RSLU ATSK when the good and failed channels are busy.

13. Explain the operation of the assemblies when dialing a number.

14. Explain the operation of the relay circuit when the called subscriber answers and the speaking condition of the assemblies.

15. Explain the principle of establishing a tandem connection of automatic office over the high-frequency telephony channels.

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