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DESCRIPTION OF THE END STATION OF THE THREE-CHANNEL EQUIPMENT TYPE V-3

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CHAPTER I

GENERAL DATA ON THE OV-3 EQUIPMENT

1. Purpose of the Equipment

The OV-3 equipment is a device for multiplex high-frequency telephony, designed for the purpose of increasing the carrying capacity of overhead communication lines made of nonferrous metals. When this equipment is used, a communication line will carry three additional channels in the frequency spectrum between 6.3 kc and 26.7 kc.

Besides the usual basic components required for transmission of three high-frequency channels, the equipment contains line filters DK-2.8 and DK-5.7 or balances BDK-2.8 and BDK-5.7.

These filtering components permit the creation of a tonal telephony channel in the spectrum from 0.3 to 2.4 kc and a photo-channel in the spectrum from 3.2 to 5.2 kc or, instead of these two channels, a broadcast channel in the spectrum from 0.15 to 5.0 kc. By means of the picard transformer, which is also part of the equipment, a telephone communication channel in spectrum up to 100 kc may also be formed.

2. Basic Equipment Data

The equipment operates on a "carrierless" principle. The equipment can send into the transmission line two different spectra of frequencies: either the main or the additional spectrum. The frequencies of these spectra are shown in Fig.1.

The additional spectrum is obtained from the main one by inverting the side frequencies of each channel. As a rule, the main spectrum is used; however, when two systems are operating on parallel circuits, one of the systems must be changed to the additional spectrum.

When the level fed into the commutator terminals is equal to the zero level,

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the side-frequency level at the line terminals of the intermediate and of the terminal equipment will be +2 nepers. At the same time, the level in the four-wire transit points of the end stations will be +0.5 neper at the receiving end and -1.5 nepers at the transmitting end. The amplification of the equipment is such that it will compensate for the damping occurring in a 450 km long transmission line made of copper wires of 4 mm diameter, with 20 cm distance between the wires and under weather conditions classified as "hoarfrost", d = 10 mm. At the highest transmitted frequency, the maximum amplification of the intermediate station will be 5.5 nepers, the minimum level at the input of the end station will be -4.5 nepers.

The equipment is provided with devices for automatic amplification adjustment, which compensate for the line damping variations that are caused by changes in atmospheric conditions. Besides the automatic amplification adjustment, a manual amplification adjustment is provided for; this ensures greater stability of the residual damping of channels in long communication lines and under difficult atmospheric conditions.

The equipment is designed so that it is possible to synchronize the carrier-frequency generator of one station by the carrier-frequency generator of the other station.

One of the three channels may be used for tonal telegraphy. To reduce the influence of telephone channels on the tonal telegraphy channel, some amplitude limiters are provided; these operate in the telephone channels.

The call in high-frequency channels is made by a 1000-cycle tone which is modulated by a frequency of 20 cps. The 1000-cycle frequency may be changed to a 500-cycle frequency, if necessary.

The tonal call device is connected to the two-wire part of the channel.

The end station is supported by two stands, each 2.5 m high and 650 mm wide; the intermediate station is supported by one stand of the same dimensions.

The station equipment is distributed on both sides of the stands; the compo-

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nents which require constant watching are on the face of the stand (these are the control elements and the components containing vacuum tubes). The components that do not require constant monitoring (mostly filters) are located on the back of the stand.

The equipment is constructed so that it may be disassembled, transported to its destination, and re-assembled there.

The equipment uses vacuum-tube types that are standard in wire-communication apparatus. When stabilized filament voltage is available, vacuum-tube types 10Zh12C (TO-1) and 10F12C (TO-2) are used; when a nonstabilized filament voltage is used, the vacuum-tube types 7Zh12C (TO-3) and 7F12C (TO-4) are employed.

In the latter case, the voltage is stabilized by means of separately-installed ballast tubes. Tubes of 7Zh12C type require 0.425B5.5-12 ballast; the 7P12C tubes require 0.85B5.5-12 ballast. Parameters of both the vacuum tubes and the ballasts will be found in the Table of Fig.2.

The equipment may use either direct current (220 v for plate circuits and 24 v for the filament and the signal circuits), or alternating current (both 127 v and 220 v). In the latter case, the power source should have a rectifier to provide direct-current voltages for the plate and the signal circuits and a step-down transformer for filament circuits*. The power requirements of the equipment will be found in the Table given in Fig.3.

3. Basic Diagram and Operating Principle of the End Station CV-3

A simplified block diagram of the end station (A) is given in Fig.4 and one for the end station (B), in Fig.5.

The equipment of the speech circuits of an end station consists of: the individual channel equipment, the group equipment, the line filters, and the balances.

* The power source may be ordered separately.

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The Individual Channel Equipment

The individual channel equipment has a double purpose: It permits changing over from a two-wire system of communication to a four-wire system and it converts the voice-frequency current into a high-frequency current (in the transmitting part of the station) and the high-frequency current into a voice-frequency current (in the receiving part of the station).

The voice-frequency currents, appearing at the commutator terminals "K", are conducted first to the extender of the two-wire transit TU, then to the differential system DS, and finally to the jacks of the four-wire transit. If the level at the commutator terminals is equal to zero level, the level at the jacks of the four-wire transit will be -1.5 nepers. From the jacks of the four-wire transit the currents will go to the limiter OGR and then to the transmitting system. The transmitting system consists of a modulator, a pass band filter, a leveler, and a band-filter transformer. The modulator changes the voice-frequencies into high frequencies. The pass band filter separates either the upper or the lower sideband of frequencies: depending on whether the equipment is operating in the main or in the additional spectrum. The output terminals of the band filters of the first and third channels are in parallel and are connected to one arm of the differential system; the output of the channel II band filter is connected to the other arm of the system. The function of the differential system is to prevent the occurrence of mutually shunting effect between the band filters of adjacent channels.

After passing the differential system, the high-frequency currents of all three channels enter the "group equipment" section.

In the receiving circuit, the three high-frequency currents enter the inputs of three parallel-connected receivers. Each receiver consists of an equalizer, a band filter, a demodulator, and a low-frequency filter. The frequencies of the given channel are separated by the band filter and are subsequently changed to voice frequencies by the action of the demodulator.

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The voice frequencies pass through the low-frequency filter of the receiver and into the low-frequency amplifier U.C.; then these frequencies pass through the jacks of the four-wire transit into the differential system and, finally, appear at the commutator terminals.

When the level at the commutator terminals of the transmitting station is zero, the level at the jacks of the four-wire transit of the receiving circuit will be equal to +0.5 neper, and the level at the commutator terminals of the receiving station will be equal to -0. [illegible] neper.

The equipment may be changed over to the four-wire method of operation by simply changing connections at the jacks of the four-wire transit and at the TT of the transmitting and of the receiving section. The damping in the extenders TT_2 and TT_3 of the four-wire transit is, respectively, TT_2 = 1.1 nepers and TT_3 = 0.[illegible] neper; at the same time, the levels in points "PER" (transmitter) and "Pr" (receiver) will be equal to -0.[illegible] neper.

The voice-frequency ringing device is wired into the two-wire part of the channel, between the two-wire transit extender and the differential system.

The diagrams in Figs. 4 and 5 represent the individual equipment of a single channel. Each end station contains three sets of individual channel equipment; the sets differ only in their band filters and their equalizers.

The Group Equipment

As seen from the Table in Fig. 1, the frequencies from 6.3 kc to 14.7 kc are used to transmit in the direction from A to B; the frequencies from 18.3 kc to 26.7 kc are used to transmit in the direction from B to A. In both the A and the B stations, the same frequency spectrum (6.3 kc to 14.7 kc) is furnished by the individual channel equipment of the end station; this means that the carrier frequencies arriving at the modulators of the first, second, and third channels of station A are the same as the carrier frequencies arriving at the modulators of these channels of

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station B. The band filters are also the same in both cases.

Upon leaving the individual channel equipment in station A, (Fig.4), the side frequencies of the three channels (located in the spectrum 6.3 kc to 14.7 kc) enter the group equipment. Here, they pass through the transmission amplifier Us.Per., through the directing filter D-16.4, through the line filter K-5.7, and then are fed into the line. The side frequency level of each channel (when the level at the commutator terminals is zero) is equal to +2 nepers.

The frequencies fed into the line from station B (Fig.5) should be in the spectrum of 18.3 kc to 26.7 kc. To obtain these frequencies, a group modulator, converting frequencies of 6.3 to 14.7 kc spectrum into the frequencies of 18.3 to 26.7 kc spectrum, is connected between the individual channel equipment and the transmission amplifier. The carrier frequency of the group modulation is 33 kc.

The band filters of the receiver are the same as the band filters of the transmitter, i.e., they all pass frequencies from 6.3 to 14.7 kc. The group equipment of station A, which receives from the line the upper spectrum of frequencies, must therefore have a frequency converter to change the frequencies of the 18.3 - 26.7 kc band to frequencies of the 6.3 - 14.7 kc band. In this case frequencies, received from the line, pass through the line filter K-5.7, through the directing filter DK-16.4, through the regulated artificial line RIL and into the group converter G.Pr. and the receiving amplifier Us.Pr.; after that, the frequencies of the 6.3 - - 14.7 kc spectrum enter the equalizers and the band filters of the channel receivers. Station B requires no group converter in the receiving circuit, since it receives from the line only the lower frequency spectrum.

In addition to the components discussed above, the group equipment includes a carrier-frequency generator and a means for amplification adjustment.

The Carrier-Frequency Generator

As seen from the preceding discussion, the operation of the equipment requires

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five carrier frequencies. These are: 6, 9, 12, and 33 kc when the main frequency spectrum is used, and 9, 12, 15, and 33 kc when the additional frequency spectrum is used. All mentioned frequencies are furnished by the carrier-frequency generator G.K. The oscillatory circuit of the generator is tuned to a frequency of 3 kc. The vacuum tube of the generator operates with a large cutoff, so that its plate current contains not only the main frequency of 3 kc but also the sharply-defined harmonics of this frequency. The second, third, fourth, and fifth harmonics, i.e., the frequencies 6, 9, 12, and 15 kc, are used as carrier frequencies of individual modulators: the eleventh harmonic (33 kc) is used as carrier frequency of the group modulator. The frequencies 6, 9, 12, and 15 kc are of a sufficient power and may be fed to the modulators directly; the 33-kc frequency is weaker and must therefore be passed through a pre-amplifier. All five frequencies are taken off the generator by means of suitable filters.

Modern equipment for high-frequency telephony is expected to satisfy rigid carrier-frequency stability requirements. In the equipment under discussion, these requirements are met by a quartz master oscillator which forms an integral part of the carrier-frequency generator. The frequency of the master oscillator is 9 kc, i.e., the same as the third harmonic of the frequency of the carrier generator - 3 kc. The 9-kc frequency is connected to the grid of the carrier-frequency oscillating tube to hold the frequency of that oscillator. In this fashion, the 3-kc frequency of the carrier-frequency generator is stabilized with sufficient accuracy.

Although the carrier-frequency generator is crystal-stabilized, a sufficiently high temperature differential may cause the carrier frequencies of end stations to differ slightly. To prevent such difference, provision is made for a continuous forced synchronization of the carrier frequencies of the B station by the carrier frequencies of the A station. This synchronization is achieved as follows:

To automatically adjust the amplification, a 9-kc control frequency is sent into the line by the station A. At the station B, this frequency is utilized for

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synchronizing the carrier frequencies. The 9 kc is filtered out by means of a narrow-band filter of the receiver ARU of the station B, is amplified and then fed to the grid of the vacuum tube of the carrier-frequency generator. In this case, the amplification takes place in the tube of the quartz oscillator, since due to the fact that forced synchronization is being used, this oscillator is not needed for operation of station B.

Automatic and Manual Amplification Regulation

The group-equipment section of the end station has means for automatic and for supplementary manual amplification regulation. These consist of a receiver for the control frequency of the automatic amplification regulator "Pr.ARU", of a receiver for sloping level regulation PNR, of a controlled artificial line RIL, and of a generator G-50 supplying 50-kc frequency.

The purpose of these devices is to compensate for the fluctuations of damping in the transmission line caused by variations in atmospheric conditions. Figure 6 shows graphs for the damping of overhead copper transmission lines, as a function of the line length and of the weather conditions. The curves in Fig.7 represent variations in the line damping with changes of the line length and of the weather; the changes of the latter being within the limits: "winter - dry" and "winter - hoarfrost" diameter = 10 mm. These curves show that, at higher frequencies the damping variations are greater and that the character of changes in the line damping is influenced by both the line length and by the weather conditions.

The curves of Fig.7 show also that, while the increase in line damping at weather conditions of "summer - wet" is approximately proportional to the frequency, the increase in damping at weather conditions "hoar-frost" occurs at a considerably higher rate than the increase in frequency. This fact causes considerable fluctuations in the residual damping of side channels in instances when only one control frequency is used for automatic level regulation. This is not the case in the

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equipment under discussion, since here the level is regulated by means of two control frequencies. One of these frequencies controls the operation of automatic level adjustment, the other permits application of periodic corrections (by means of the slanted level regulator) whenever a considerable slew is accumulated. Manual level adjustment is practically never required during the summer; however, in winter time, when wires are covered with hoar-frost, the automatic level adjustment alone is not satisfactory and must be supplemented by manual control of the level, by means of the slanted level regulator.

The level adjustment is achieved by means of the controlled artificial line RIL. A simplified skeleton diagram of the "RIL" is given in Fig.8. The RIL consists of two six-link artificial lines. (For simplicity, only three links are shown in Fig.8.) The damping in the links of the first artificial line is a function of the frequency; the damping in the links of the second line is not influenced by frequency changes. The magnitude of damping in both artificial lines is controlled by means of variable capacitors (capacitor K_1 in the first and capacitor K_2 in the second artificial line).

Each of these capacitors has seven stationary sections and one movable section. The stationary sections are located on a circle, each section occupying 1/8 of the circumference of the circle. The movable section is of the same size as the stationary sections and may be rotated to mesh with either the first or the seventh stationary sections, or (when left in an intermediate position) it may mesh partially with both these sections simultaneously. The connections between the stationary capacitor sections and the artificial line are shown in Fig.8.

The damping in the links of the second artificial line is independent of the frequency; therefore, when the movable section of the capacitor K_2 is moved from position 0 to position 60, the decrease in damping will be uniform for all frequencies (Fig.9b). In the links of the first artificial line, however, damping will decrease as the frequency is increased: since the stationary sections of the capacitor

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K_1 are connected to the links of this line across voltage dividers consisting of two series-connected resistors, moving the K_1 rotor from position 0 to position 60 will cause the damping in the RIL to diminish at high frequencies and to increase at low frequencies (Fig.9c).

When the rotors of both the K_1 and the K_2 are moved from position 0 to position 60 simultaneously, the damping in the RIL will change as depicted in Fig.9a, i.e., the higher the frequency, the greater will be the damping in the RIL. In this case the fluctuations in the damping of the RIL (Fig.9a) obey the same law that is obeyed by the variations in line damping under average atmospheric conditions.

The capacitors are designed so as to permit either a simultaneous or a separate rotation of both movable sections. If the variations in line damping caused by the variations in frequency do not agree with the average curves (this condition may be produced by hoar-frost or icing of wires), the residual damping curve will be skewed and the residual damping of side channels will change. This skew may be corrected by moving the rotor of the slant regulator. The rotors of the capacitors are rotated by an electric motor located on the plate which supports the RIL.

By means of cords and banana plugs, the capacitor rotors can be connected to corresponding jacks of KD and BUK-1 blocks.

When the control frequency of the automatic adjustment at the output of the amplifier is at a normal level, the motor does not operate and no adjustment occurs. As soon as the level of this frequency deviates from the normal, the motor is actuated and the damping of the RIL will be changed until the normal magnitude of the level is re-established. The direction of rotation of the motor will correspond to the direction of level deviation.

The motor is controlled as follows: The motor is equipped with two pairs of windings, supplied with a 50-cycle current; to stop the motor, the current in one pair of windings is reduced to zero; to reverse the direction of rotation, the current phase in one pair of the windings is changed by 180°.

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The motor is powered by a vacuum-tube generator for a frequency of 50 cps. One pair of windings is connected to the generator directly and the other, across an ARU receiver. The ARU receiver has a device that keeps the current in one pair of windings equal to zero as long as the control frequency remains at a normal level. When the control frequency level deviates from normal, this device will start the motor by supplying current of the proper phase and magnitude to one pair of windings. A simplified diagram of this device is given in Fig.10. The 50-cycle voltage is fed to the primary windings of the transformer T-1 of the differential system. One arm of this system contains the resistors R_2 and R_3, the other arm contains thermistor "Ter".

The thermistor is a resistor with a large temperature coefficient. In Fig.10b, the current and voltage in the thermistor is plotted against the resistance of the thermistor.

From the group amplifier, the control frequency passes into the narrow-band filter of the ARU receiver, is amplified, and fed to the thermistor. The T_1 transformer of the differential system is supplied with 50-cycle frequency. The 50-cycle voltage is taken off the secondary winding of the T_2 transformer, and is fed to the amplifier whose output is connected to the windings 3-4 of the motor.

When the level of the control frequency is normal, the differential system is at equilibrium, and no current flows through the windings 3-4 of the rotor. When the control-frequency level deviates from the normal level, the equilibrium in the differential system is destroyed; a 50-cycle current will begin to flow in the winding 3-4, which will cause rotation of the rotor. The direction of rotation will depend on whether the control-frequency level is above or below the normal level, since the voltages in the secondary of the T_2 transformer (that correspond to these two instances) have phase difference of 180°. Figure 10c shows the magnitude and the phase of the 50-cycle voltage in the winding 3-4 as a function of the current in the thermistor. The characteristic feature of this controlling system is the

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absence of relays.

The slant adjustment regulator is controlled by the slant adjustment receiver PNR. The second control frequency is taken off the output of the group amplifier by means of the narrow-band filter, and is then amplified and rectified.

The magnitude of the rectified current is characteristic for the slope of the residual damping curve; if an excessive slow is indicated, the slant is adjusted manually.

Besides its main purpose (counteracting the fluctuations of line damping) the RIL also has the function of a line equalizer. When the equipment is first installed, the ratio between levels is adjusted by means of the flat and the slanted regulators.

The frequency dependence of the line damping is compensated by setting the slant regulator accordingly. In this case, the possibility of separating the flat and the slant regulators simplifies installation of the equipment to a considerable extent; as shown in Fig.7, the variations in line damping with changes in the line length and the variations in line damping with changes in the weather conditions do not obey the same law. The initial installation of the equipment may be done without any measuring instruments, if the devices in the receivers for the automatic and the slant adjustment are set to zero position; this will correspond to the normal level (+0.3 to +0.4 neper) of the control frequencies at the input of the receiving group amplifier.

The ARU receiver contains a device that sends out an emergency signal when fluctuations of the control-frequency level are greater than 0.3 to 0.5 neper during a time period of 5 - 7 sec. The constantly operating equipment of the receivers for the automatic and for the slant adjustment provide a means for a continuous systematic control of the communication system.

Line Filters and Balance

Besides its main components, the end station also contains the line filters,

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DF-5.7 and DF-2.8. The filter DF-5.7 separates spectra of the three-channel equipment from that of the photo-channel. The voice channel of 0.3 to 2.4 kc and the photo-channel of 3.2 to 5.2 kc are connected to the line across the filters DF-5.7 and DF-2.8; without DF-2.8, the line may be used for the broadcast channel of 0.15 - - 5.0 kc. The balancing equipment of the duplex telephone amplifier consists of: the balance filters BF-2.8 and BF-5.7, the circuit-balancing Picard transformer, the balancing autotransformer, and the two-link circuit composed of resistances and capacitances.

The Line Autotransformer

When a city cable lead-in is accessible, the equipment is connected to it by means of its own line autotransformer.

This autotransformer is designed to work in the frequency range from 0.15 to 150 kc and to correlate resistances of 550 and [illegible] ohms.

Measuring Instruments

Two measuring instruments are supplied with the end-station equipment: a neper-meter and a tube tester. The neper-meter, consisting of a normal signal generator and a level indicator, permits measuring the residual damping of channels at a frequency of [illegible] c/s; the neper-meter is mounted on a stand. The portable tube tester consists of two instruments that make it possible to measure a) the plate current of any tube; b) the current in any filament circuit, supplied from a DC line; c) the deviation of the plate and the filament voltages from their nominal values when a battery or a rectifier power supply is used; d) activity or the emissivity of the vacuum-tube cathodes.

[illegible]. Basic Diagram of the Intermediate Station PV-3

A simplified skeleton diagram of the intermediate station PV-3 is given in

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Fig. 11.

When transmitting in the direction A-B, the circuit consists of: the line filter [illegible]-5.7, the directional filter [illegible]-16.4, the controlling artificial line RII, the group amplifier GUS, the directional filter D-16.4, and the line filter [illegible]-5.7.

When transmitting in the direction B-A, the circuit remains practically the same: it differs from the above only in the fact that the filters Y-16.4 are used instead of [illegible]-16.4 filters. In both cases, the Pr. ARU receiver for the control frequency of the automatic level adjustment and the PUR receiver for the control frequency of the slant regulator are connected in parallel with the output of the group amplifier. The motor of the ARU is powered from a 30-cycle frequency generator G-[illegible]. Besides its main components, the equipment of the intermediate station contains also line filters and balances. The purpose and operation of the intermediate station components are the same as those of their counterparts in the end station.

When the level at the commutator terminal of the end station of the channel is zero, the level of side frequencies at the output of the intermediate station is [illegible] nepers. The working amplification in the intermediate station is 5.5 nepers at the highest frequency of the upper 26.4-kc group and 3.6 nepers at the highest frequency of the lower 16-kc group. The auxiliary equipment of the intermediate station (similar to that of the end station) consists of a stand-mounted level indicator and of a portable tube tester.

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CHAPTER II

BASIC DIAGRAM OF THE END STATION

Drawing No.P 131.00.20

1. The Transmitting Circuit

The end station may operate either as an A-station or as a B-station. In the former instance, the station will send into the line the lower frequency group of 6.3 - 15 kc and receive from the line the upper frequency group of 18.3 - 26.7 kc. In the latter case, the situation will be reversed; the upper frequency group will be sent and the lower frequency group will be received by the station. To change station operation from regime A to regime B, certain connections must be resoldered.

In the drawing No.P 131.00.20, the station components are connected to operate in regime B, and therefore this regime will be discussed first. The circuit of speech currents begins with the terminals IIID-1 and IIID-2 for the second channel, with the terminals IID-1 and IID-2 for the first channel, and with the terminals IVD-1 and IVD-2 for the third channel; these terminals are located at the lead-in comb of the individual equipment stand. The voice frequencies from a subscriber are received at these terminals. Behind these terminals, the circuit can be traced through the contacts of the dividing jacks "Comm." and "Lin.", the two-wire transit extender, the contacts of the call relay R_5, the differential system for connecting the voice-frequency ringing TDS, the contacts of the voice-call relay R_1, the STAT tacts of the dividing jacks "ISP.TV" and "DS", and through the terminals A_3 and B_3 of the differential system.

A copper oxide call relay R_2 is connected across the choke DR_3 to the contacts of the relay R_5 and to TV, in parallel with the main circuit; the purpose of this relay is to receive the inductor call from the commutator.

On leaving the differential system, the circuit goes through the 0.6 neper ex-

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tender to the transit jacks, thence to the transmission dividing jacks "Per" and into the modulator. The limiter may be either connected or disconnected by means provided for that purpose. When the limiter is connected, one of the telephone channels may be used for tonal telegraphy.

Behind the limiter, the circuit components on the modulator chassis include a set of extenders, a modulator, an equalizer, and a band filter. The level at the output of the station can be adjusted accurately by reconnecting the extenders. The summary damping of the extenders may be varied in the range of 0.0 to 0.6 neper, in steps of 0.1 neper. The ring-type modulator is assembled of copper oxide elements; the carrier frequency from the carrier-frequency generator enters the modulator at the terminals 7-8. The band filter, located immediately after the modulator, separates the side-frequency band at the output of the latter. If the main spectrum of frequencies is used, the upper sideband is separated, while the lower sideband is separated when the supplementary spectrum is used. The frequency bands enter the band filter through an equalizer.

The second-channel chassis contains, in addition, a block with a differential transformer "TF PER" to which the outputs of all three channels are connected.

After leaving the "TF PER", the circuit enters the chassis of the group frequency converter. This chassis holds the transformers that feed the control frequencies, the copper-oxide ring modulator, the extender, the band filter, and the amplifier of the group modulator. From the 33-kc amplifier "US-33", the 33-kc carrier frequency enters the terminals A_6-A_7 of the modulator. The band filter STAT PF-18-27 at the output of the modulator passes frequencies from 18.3 to 27 kc; only the lower frequency sideband will pass through this filter, the upper frequency sideband and the unbalanced remainder of the 33-kc carrier will be filtered out.

After leaving the group converter, the circuit goes through the transmission group amplifier, the directional filter K-16.4, the line filter K-5.7, and then through the line terminals IVG_2 and IVG_3 of the lead-in comb at the group-equipment stand.

Some of the K-5.7 filter elements are mounted on the chassis of the D-5.7 filter; this explains the somewhat peculiar appearance of connections between these two filters on the diagram. From the line end, these filters are connected in parallel.

When a city cable input is available, the equipment is connected to the line by means of the cable autotransformer "KT". In this case, the line is connected to the terminals IVD_2 and IVD_3 of the lead-in comb at the group-equipment stand and the terminals IVG_1 and IVG_2, IVG_3 and IVG_4 are connected by jumpers. The cable autotransformer is located on the chassis of the lead-in combs at the group-equipment stand.

A control-frequency inductor IKCh is connected to the output of the group amplifier; this inductor will send out an emergency signal if the transmitting group circuit fails to operate properly.

2. The Receiving Circuit

From the line, the high-frequency currents enter terminals IVG_2, IVD_3 of the lead-in comb at the group-equipment stand or, if the cable autotransformer is connected, the terminals IVD_2, IVD_3. The receiving circuit goes then through the line filter K-5.7 and through the directing filter D-16.4.

The controlling artificial line RIL is connected after the directional filter. As before, the RIL serves the following purposes:

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1. Compensation for line damping changes, caused by changes in the weather;

2. Establishing a proper (for the given amplification interval) magnitude and slope of the amplification frequency characteristic, when the equipment is connected to the line.

The flat adjustment and the slant adjustment regulators are mounted on the RIL chassis. Their functions were explained above. In addition, the RIL chassis car-

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ries also a single-stage amplifier BUK, which acts as a buffer between the flat adjustment regulator and the group amplifier. Its presence is necessary since the flat regulator cannot work into a low ohmic resistance. The RIL is followed by the group-reception amplifier Us.Pr., which is similar to the group-transmission amplifier. However, since the amplification required in this case should be lower than that in the transmission circuit, an extender is connected to the output of the Us.Pr. The other end of the extender is connected to the step-down transformer TP of the reception filters.

The purpose of this transformer is to match the 50-ohm resistance that follows. This resistance and the resistors that are connected in parallel with the inputs of the band filters create "L"-shaped extenders that prevent mutual shunting between the parallel-connected filters.

Further, the receiving circuit goes to the individual-equipment stand and enters the demodulator chassis. This chassis carries a band filter PF, an equalizer, a demodulator DM, and a low-frequency filter FPr. The band filter passes the same frequencies that are passed by the band filter in the transmission circuit of the given channel.

The band filter separates the frequency band that pertains to the given channel and feeds these frequencies first to the equalizer and then into the annular copper-oxide demodulator. The carrier frequency from the carrier-frequency generator enters the terminals 7,8 of the demodulator. The low-frequency filter will pass frequencies up to 2700 cps, but will filter out the frequencies of the upper sideband and unbalanced remainder of the carrier frequency.

The voice-frequency level at the output of the FNCh is -2.8 nepers; since this level should be +0.5 neper at the transit jacks, the FNCh is followed by a single-tube low-frequency amplifier UNCh. The amplification of this amplifier may be adjusted from 3 nepers to 3-4 nepers by means of a set of extenders and by a smooth regulator at the amplifier input. Provision is made for mounting the amplification

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regulator at the four-wire commutation support. In this case, the RU is connected to the amplifier by means of the pegs $IIIG_9$ and $IIIG_{10}$ of the lead-in comb at this support; at the terminal plate of UNCh-1, the jumpers between E_2-E_3 and E_4-E_5 should be removed and inserted between the terminals E_1-E_2 and E_5-E_6. The output of the UNCh is connected to the reception dividing jacks "Pr". From these jacks the circuit goes to the transit jacks and then, through extenders, into the differential system. The circuit between the differential system and the commutator terminal was discussed under the heading of "transmission circuit".

3. Changing the Operating Schedule of the Station; Changing from a Two-Wire to a Four-Wire Transmission

A station, operating as a B station, may be made to operate as an A station by moving the group converter from the transmission circuit to the receiving circuit, and by interchanging the filters K-16.4 and D-16.4. The interchange is made by re-soldering the connections at the lead-in combs of the chassis.

To shift the group converter into the receiving circuit, the following changes should be made in the connections at the lead-in comb of the converter: the jumpers between the pegs G_3-V_3, G_4-V_4, G_5-V_5, G_6-V_6, G_7-V_7, and G_8-V_8 should be removed; these jumpers should be inserted between the pegs V_2-B_1, V_2-B_2, V_3-B_3, V_4-B_4, V_5-B_5, V_6-B_6, V_7-B_7, and V_8-B_8.

On the RIL chassis, the jumpers between terminals B_2-B_3 and B_7-B_8 should be removed; these jumpers should be inserted between the terminals B_3-B_4, B_8-B_9, B_1-B_2, and B_6-B_7.

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The circuits connected to the terminals 3-4 and 7-8 of the filter DK-16.4 should be interchanged.

The change-over from a two-wire to a four-wire transmission is achieved by redistributing the jumpers in transit jacks, located in the commutation field at the individual-equipment stand.

4. Connecting the Spare Amplifier

If necessary, the transmission amplifier or the reception amplifier may be replaced by the spare amplifier. The connection is made by changing the positions of the jumpers at the spare amplifier terminal plate. If the transmission amplifier is being replaced, the control-frequency indicator IKCh should be disconnected from its output and connected to the output of the spare amplifier. To do so, the jumpers at the IKCh terminal plate are taken out of the 2-3 and 6-5 jacks and put into the 2-1 and 5-4 jacks.

5. Diagram of the Levels

A distribution diagram showing levels at the individual points of the end station is given in Fig.12.

6. Circuits Supplying the Carrier and Control Frequencies

The carrier and control frequencies are furnished and amplified by the quartz master oscillator KG, the carrier-frequency generator GEN.NES., and by the 33-kc amplifier which is equipped with a band filter F-33. The master oscillator and the carrier-frequency generator are mounted on one chassis, while the amplifier and the 33-kc filter are mounted on another chassis.

In a B station, the tube of the quartz oscillator operates as an amplifier tube; the voltage of the 9-kc control frequency, taken off the terminals 7-8 of the control-frequency receiver, is conducted to the grid of this tube. To chanSTATe tube from operating as a generator to operating as an amplifier, the jumpers at the terminal plate of the quartz oscillator should be redistributed. From the output terminals of band filters of the carrier-frequency generator, the carrier frequencies go to the terminals 7-8 of the modulators and demodulators. The levels of carrier frequencies at the terminals 7-8 are adjusted to be equal to -0.5 to -0.25 neper. The 9-kc and the 15-kc frequencies are also used as control frequencies;

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therefore they are led out of the B_1-B_2 terminals of the carrier-frequency generator and into the receiving circuit, across the terminals A_3-A_4 of the group converter. The level of the control frequencies at the entrance of the line should remain constant. Since the carrier-frequency generator does not stabilize the frequencies to a sufficient extent, an additional stabilization of the level is achieved by means of thermistors. The thermistors located on the chassis of the carrier-frequency generator, ensure practically constant level of the control frequencies. The level of the control frequencies at the entrance to the transmission circuit is equal to (5.8 to 5.9) neper. The 33-kc carrier frequency enters the A_6-A_7 terminals of the group modulator via the filter F-33 and the single-tube amplifier US-33. The level of the group carrier at the output of the US-33 is adjusted to be equal to -0.1 to +0.35 neper.

7. Level-Adjusting Circuits

The control-frequency receiver is connected to the terminals B_6-B_7, in parallel with the output of the receiving amplifier. The control-frequency receiver consists of the receiver for the automatic level adjustment Pr.ARU and the receiver for slanted (manual) level adjustment Pr.NRU. Narrow-band filters are connected to the outputs of both receivers. The Pr.ARU filter is tuned to 9 kc, and the Pr.NRU is tuned to 15 kc. Both the ARU motor (located on the RIL chassis) and the ARU receiver require a 50-cycle current for their operation. This current can be obtained from the station supply, but, to ensure continuous operation of the ARU in the case when the station 50-cycle voltage is interrupted, this current is furnished STAT 50-cycle vacuum-tube generator which is a permanent component of the station. From the terminals of the generator the 50-cycle voltage goes to the terminals 1-2 of the Pr.ARU and to the terminals A_2-A_3 of the RIL. Both receivers are provided with instruments that continuously measure the rectified control-frequency current. These instruments permit a continuous check of the operation of the transmission circuit.

If the pointers deflect beyond the limits of the colored center sector of the dial, an irregularity in the group circuit is indicated. Besides the permanently installed instrument, the ARU receiver has a signal device that sends out an emergency signal whenever the level of the 9-kc control frequency deviates from the normal level by more than 0.3 to 0.5 neper during a time interval of 5-7 sec. The operation of this device is discussed in the description of the operation of the control-frequency receiver.

8. Call Circuit

a) Sending a Call

A call current appearing at the commutator terminals $IIID_1$ - $IIID_2$ will actuate the call relay R_2 on the chassis of the receiver TV; this relay is connected in parallel to the speech circuit by means of a choke and a small full-wave copper-oxide rectifier. If a direct call current is used, the rectifier may be disconnected. The method of disconnecting is evident from the call-receiver diagram in the drawing No.135.40.87. Since the contacts of the relay R_2 are located in the supply circuit of the relay R_1, the latter is actuated and its contacts 12-13 and V_2-V_3 connect the channel to the output of the call generator GTV, which, as pointed out previously, supplies a 1000 - cycle frequency, modulated by 20 cps. The generator may be readjusted to provide a 500 - cycle frequency. The level of the modulated call voltage, at the points where the GTV is connected to the speech circuit, is equal to -1.1 neper. The output resistance of the GTV is 600 ohms so that the balance of the differential system is not disturbed when a call signal is sent out.

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When the relay R_1 is actuated, its contacts III_1-III_2 and III_3-III_4 will close. The first pair of contacts is in the circuit of the pilot light "Pos" (a call is being sent) at the signal panel; the second pair of contacts shorts out the input of the receiver TV, to prevent an unnecessary actuation of the latter.

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b) The Call Receiver

When a call is being received, the current of the 1000/20 or of the 500/20 call frequency passes (as all voice frequencies do) through the first differential system and into the differential system that actuates the tone-call receiver TDS; from the second winding of the transformer of this system the call enters the input of the tone-call receiver PTV.

The presence of call in this receiver actuates the relay R_6, whose contacts short the winding of the relay R_4 which, in the absence of call, was supplied across the resistor 4-5 and the fuse P35-2, and whose contacts III_1-III_2 were shunting the winding of the relay R_3.

When the relay R_6 is actuated, the R_4 relay drops out with a 400 - 450 msec delay.

The relay R_3 is actuated and grounds the winding of the relay R_5, which actuates this relay. Through its contacts 1-5 - 1-4 and V-5 - V-4, the relay R_5 sends voltage from the mechanical inductor to the commutator terminals $IIID_1$ and $IIID_2$; the contacts 1-1 - 1-2 connect a 600-ohm resistor on the equipment side. The contacts V-1 - V-2 of the same relay close the circuit of the pilot light "Pr" (a call being received) on the signal panel. The presence of two relays R_4 and R_3, one of which works by dropping in, the other by dropping out, permits to prevent the duration of call from varying. This question is discussed in greater detail in the description of the diagram of the tone-call receiver.

The purpose of the differential device TDS, through which the receiver T_{STAT} connected to the channel, is to prevent the receiver from being actuated by call currents coming from the commutator end, when a two-wire transit is used.

This question also is discussed at length in the description of the receiver TV.

9. Power Supply Circuits

The station is supplied either from direct-current sources of 24 and 220-volt voltage, or from an alternating-current source whose voltage is 127 or 220 volts.

When the station works on alternating current, it is provided with a power unit equipped with rectifiers to furnish the plate and the signal-circuit voltages; the filament voltages are obtained here by stepping down the line voltage. All supplied voltages are led to the individual-equipment stand and from there, by means of a stand-to-stand connecting cable, to the group-equipment stand. All supply wires are connected to bus bars and terminals on the plate where the fuse holders are mounted; this plate is protected by a housing.

When the bus-bar system of supply is used, the bus bars are connected to corresponding terminals in the fuse box by means of jumpers. Special jumpers are used to connect the bus bars of all posts in line.

When the station is operating on direct current, the 24-volt filament voltage is connected to the bus bars "ZM" and "-24". It is desirable to have a separate 24-volt source for supplying the signal circuits. This should be connected to the terminal "-24 sign." and to the terminal "+24", to which the filament circuit is also connected.

When no separate signal battery is available, the "-24" and the "-24 sign." terminals are connected by a jumper; in this case, however, the indicator of filament-voltage failure will not operate. The plate voltage is connected to the terminals "+220" and "ZM". The four jumpers on the fuse panel should be inserted into the jacks marked "=". When an alternating-current source is used, these jumpers should be in jacks marked "~" and, in addition, the voltage-connecting jumper STAT (see diagram of the power supply, drawing No.P 133.00.17) should be set to the position "127" or "220", to correspond to the voltage of the AC power line. This line is connected to the terminals "~" on the fuse panel.

A signal battery should be connected to the terminals "-24 sign." and "+24". If there is no signal battery, the terminal "-24 sign." should be connected to the terminal "-24 vypr"; the indicator of AC voltage failure at the stand is absent. The

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power pack is switched on by means of a tumbler switch on the face of the panel. The presence of AC voltage is indicated by a neon pilot light. The supply circuits are protected by fuses: The common circuits are protected by group fuses, and the circuits of individual blocks of equipment are protected by split fuses. P_1 and P_{20} are group fuses of DC circuits; fuses that protect the AC circuits are located on the power pack panel. The same split fuses are used for both the AC and the DC power source. The fuses are provided with means that indicate when they blow out. The fuses P_1 to P_{15} are in the plate circuits; P_{18} and P_{19} are in the circuit of the mechanical inductor; P_{20} to P_{38} are in the filament and in the signal circuits.

Filament Circuits of Tubes

Each filament circuit consists of a split fuse, a ballast tube (this may be absent if 10Zh12S and 10P12S tubes are used in the equipment), a quenching resistor, a jack for taking measurements, two series-connected tubes 10Zh12S, and one 10P12S tube in series with two parallel-connected 10P12S tubes. The filament-circuit diagrams of the end station are shown in Fig.13. The jacks, forming part of each circuit, are used for measuring the filament current and for interrupting a given circuit; a special blank plug is inserted into the jack to achieve the latter purpose. The jacks are located on corresponding panels.

The measurement of current is discussed under the heading "Measurements".

The plate voltages are connected to each component of the equipment across split fuses. The plate circuits of most of the elements are provided with protective filters consisting of a choke and a capacitor. Any plate voltage may be STAT moved from the panel by removing the corresponding split fuse.

10. Signal Circuits

The equipment is provided with means to signal the following occurences:

1. Blowing of any of the group fuses or split fuses;

2. Failure of the filament voltage (only when a separate signal battery is used);

3. Failure of the plate voltage;

4. Failure of the voice-current voltage;

5. Failure of the control frequencies at the output of the transmission group amplifier;

6. Fluctuation in the ARU control-frequency level at the output of the reception group amplifier, if the level changes by more than 0.3 to 0.5 neper and if the fluctuation persists for a time longer than 5 to 7 sec;

7. Limit of the automatic level adjustment;

8. Sending out or receiving a call on any channel;

9. Sending out a call from the voice-frequency ringing device or receiving a call from a disconnected direction, when a voice-frequency ringing device is being used;

10. Blocking of the ARU;

11. Changing from automatic adjustment of the slope of the frequency amplification characteristic to manual adjustment.

The signaling is achieved by means of commutator tubes mounted on the panels. In addition, when the cases 1-7 occur, a stand signal bulb OSL, (located at the fuse panel), will be lit, and a signal bell will ring. A spark quencher is connected into the circuit of the bell, to reduce noises in the channel. Closing of the bell circuit takes place simultaneously with the closing of the circuits of the ligSTAT bulbs of the corresponding transparent signs, namely: "PR" - fuses, "BAT" - battery voltages, "MI" - mechanical inductor, "KCh" - control frequencies. The circuits of the OSL bulb and of the bell are also closed in the case No.9, if a call is received at the PVU. In all other cases, no station-wide or row signaling will occur.

The lamps of the local and of the general signaling circuit will stay lit until the cause of the signal is removed. The bell and the transparent sign illuminators may be switched off by pushing the "Vykl.Zv." button on the signal panel. When the signal indicates an irregularity in the control channel, pushing this button will only silence the bell; the illuminator of the "KCh" transparent window will stay lit until the irregularity is corrected.

When the bell-silencing button is depressed, a signal lamp will light above this button; the lamp will stay lit until the cause of the signal is removed.

The signal circuit relays and most of the signal lamps for local signaling are located at the signal panel.

Signaling of failure of the filament voltage and of the call current is achieved by means of the relays RVT, RN, and RA; these relays drop out when the corresponding voltages disappear, and their contacts close the signal circuits. When the fuses burn out, the relay RRP is actuated. All named relays have four groups of contacts. The contacts II-1 and II-2 close the local signal circuits, the contacts II-3 and II-4 close the bell circuit, the contacts IV-1 and IV-2 close the circuit of OSL, and the contacts IV-3 and IV-4 close the circuits of the transparent sign illuminators. In the RRP relay, the function of the group II is performed by the group I, and the function of group IV is performed by the group V. The relay PB3 is blocked when the button "Vyk.Zv." is depressed, which interrupts the circuits of the bell and of the transparent window illuminators. A 50-ohm resistor is connected in series with the signal lamps of the local signal circuits; this reduces the voltage and prolongs the life of the lamps.

Some signal relays are located on the panels of the equipment correlated with their specific function, namely, on the panels of the control-frequency receiver and of the control-frequency indicator. Operation of these relays will be discussed when describing these panels.

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11. <u>Speak-Buzz Device and Commutation Field</u>

The end station is equipped with a speak-buzz device PVU, which is used for service calls and for checking the conditions of the communication channels.

For convenience and to conform with the design of other pieces of standard long-distance communication equipment, the PVU is divided into separate panels: the microtelephone panel, the two-wire PVU panel, the four-wire PVU panel, and the control testing device KIU which is used to test the voice-frequency ringing device. All these panels and the commutation field (composed of separate panels with jacks) are located in the central part of the individual-equipment stand.

The principal wiring diagram of the station shows the PVU as separate squares; the connection of outside circuits to these squares is also shown. The principal wiring diagram of the PVU is shown in the drawing No.P 134.60.17. Most of the commutation field jacks are shown in the lower part of the station diagram; the commutation field jacks that belong to the transmission or to the reception circuits are shown in the corresponding parts of the diagram.

Each channel has the following dividing telephone jacks: the commutator-line jacks "COMM.-LIN." located immediately after the channel input terminal and serving the purpose of connecting the two-wire PVU to the channel; the jack "DT", used for the two-wire transit; the jack "ISP.TV.", used when the receiver TV is tested by means of the control testing device; two jacks "PER" in the transmission circuit of the four-wire part of the equipment and two jacks "PR" in the receiving circuit, both pairs serving the purpose of connecting the four-wire PVU when a four-wire transit connection or an external differential system is used.

The dividing jacks "TK" and "FK" are connected to, respectively, the vcSTAT channel and the photo-channel. When a broadcast channel is formed, the input is at the contacts IIB_1-IIB_2 of the lead-in comb. The jacks "UU" are connected to the input of the level indicator of the neper-meter; the jack "KIU" is connected to the output of the control testing device. The remaining jacks serve various other commutation purposes.

A two-wire PVU permits to send a call either into the line or into the commutator and conduct a conversation either in the direction of the line, or in the direction of the commutator, or in both directions simultaneously. The two-wire PVU is also a means for controlling the conversation and for connecting the normal generator or the level indicator to the channel. The two-wire PVU is plugged in by means of a double three-prong plug, inserted into the "COMM.-LIN." jacks of the corresponding channel.

The four-wire PVU is connected to the channel by means of two cables, each provided with two three-prong plugs. One plug is inserted into the transmission jacks, the other into the receiving jacks of the corresponding channel.

The four-wire PVU permits sending out calls in any direction, if a four-wire transit is used. In the case of an external differential system, a voice call will also be sent toward the commutator; leaving the differential system, the call acts upon the PTV which then sends an inductor current to the commutator.

In the case of a four-wire PVU the conversation may be conducted either separately toward the line and toward the commutator, or simultaneously in both directions. The four-wire PVU permits also a control of the transmission in both directions. Connecting the four-wire PVU will disconnect the two-wire PVU from the system. The elements of the four-wire PVU include an amplification stage that increases the loudness and the transient damping of the PVU circuit between the oppositely-directed transmission circuits. The four-wire PVU permits connecting the normal generator to the line transmission jack "PER" or to connect the level indicator to the line reception jack "Pr".

The control testing device serves the purpose of checking the good condition and the sensitivity of the tone-call receiver.

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For testing, the KIU jacks of the commutator field are connected to the "ISP.TV." jack by means of a two-wire cable. The PTV is tested by a fixed-period current which is sent by means of a telephone-type dialing apparatus, mounted on the KIU block.

12. Measurements

The residual damping of channels may be measured by means of the neper-meter mounted at the individual-equipment stand. The neper-meter consists of an 800-cycle frequency generator and of a copper-oxide level indicator.

The power source of the generator is controlled by a switch at the neper-meter panel.

The generator can provide the following fixed levels: -1.5; -0.7; 0.0; and +0.5 neper. The -1.5 and +0.5 neper levels are used for measurements in transmission and reception circuits of the four-wire system; the 0.0 neper level is used for measurements in the two-wire system.

The generator output may be taken off the jack at the neper-meter panel or from the jack at the PVU panel. Prior to using the generator, the level of its output should be checked by means of the copper-oxide level indicator; to do so, the rotary switch should be set to the position "REG.NG." and the zero level adjusted by means of the regulator.

The dial of the copper-oxide level indicator has the following ranges: -2.0 to 0.0 nepers and - 1.0 to +1.0 neper and 0 to +2.0 nepers, when the input resistance is 600 ohms: -0.5 to +1.5 nepers and +1.5 to +2.5 nepers, when the input resistance is 1000 ohms.

The main purpose of the copper-oxide level indicator is to measure the residual damping of the channels. In addition, the indicator may be used for measuring the level at other points of the equipment, where the level is not less than -2.0STAT nepers; this will include the station output, the output of the reception or transmission amplifier, and the control-frequency voltages at the modulators. The connections to the input of the level indicator may be made across the two-wire jack at the neper-meter panel, across the PVU, or across the "UU" jack at the commutation field. The level indicator can be used for measurements in the frequency range from 300 cps to 3 kc.

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The use of the neper-meter and of the station level indicator is facilitated by measurement jacks provided on most chassis with tubes. These include chassis of the reception and of the transmission amplifiers, of the RIL, UNCh, PTV, GTV, GEN, NES, US-33, G-50, and of the filter D-16.4.

A portable testing instrument of the IEL type is used for measuring currents and voltages in the equipment circuits and for testing the activity of the cathodes of tubes.

The portable testing instrument contains an ammeter with 0.15, 0.5, and 1.0 ampere ranges and a milliammeter whose range is 1.0 milliamp. In addition, the instrument contains variable resistors used for adjusting the filament voltage when the cathode activity is being measured. The ammeter is used for measuring the filament current; the plate voltage is measured by means of the milliammeter.

The instruments are connected to circuits being tested by means of cables attached to the instrument. The ammeter cable is provided with a three-wire plug that can be inserted into jacks of the measuring blocks of chassis with tubes.

The multiple switch of the portable testing instrument should be set to a suitable position, when the filament current, the plate current, and the cathode activity of the tubes are being measured. When the test-lead plug is inserted into the measurement jack of the circuit being tested, the ammeter will be in series with the circuit elements. The position of the switch indicates which range of the dial is to be read.

When the station is powered by alternating current, the portable testing instrument cannot be used for measuring filament currents.

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The milliammeter is connected to a cable ending in a two-prong plug; this is inserted into the one-wire jacks provided for the plate-current measurement and located at the measurement blocks of chassis. The readings of the milliammeter should be multiplied by a factor engraved next to each plate-current jack.

When the portable instrument is used in measuring the cathode activity of tubes, it is also connected by cables to the circuit being tested. In this case, the filament of the tube is supplied by a direct current or by a rectified current across an auxiliary circuit consisting of: the additional contact of the measurement jack, the sleeve of the jack, the body of the three-wire plug, the filament rheostat of the testing instrument, the ammeter, the neck of the plug, and the filament of the tube. It is possible to adjust the filament current while observing the changes in the plate current. A more detailed discussion of the cathode-activity measurements is given in the description of the portable testing instrument.

Filament voltages, plate voltages, and AC voltages may also be measured by means of the portable instrument.

In making these measurements, the milliammeter is connected to suitable jacks at the signal panel. The milliammeter reads "0.5" when the voltages being measured are at their normal level; this is achieved by suitably shunting the jacks and by use of additional resistors in the circuit being measured. When the voltage deviations are not greater than the allowed ±10% of the normal value, the milliammeter pointer should remain within the colored sector of the dial. A full-wave copper-oxide rectifier is provided for measuring AC voltages; this rectifier receives a 24-volt voltage from the power-pack transformer.

CHAPTER III

PRINCIPAL WIRING DIAGRAMS OF THE END-STATION COMPONENTS

1. Transmission Group Amplifier of the End Station

Note: It is forbidden to remove the tube grid while the equipment stand is switched on.

Principal wiring diagram No.P 135.41.16

The amplifier has three amplification stages. The first two are preamplification stages and use 10Zh12S or 7Zh12S tubes. The third (the output) stage uses 10P12S or 712SP tubes. The filament of the output-stage tube is in series with the parallel-connected filaments of the preamplifier tubes. A quenching resistor, located at the measurement block of the chassis, is connected in the common filament circuit. The plate voltage of the amplifier is delivered across a power-supply filter, consisting of the choke Dr 2 and of the capacitor C_{15}. The amplifier is provided with negative feedback. The feedback voltage is tapped from the R_{20} resistor, which is connected in the cathode circuit of the output tube and which is also connected to the winding of the output transformer T_2.

Due to this way of connecting the R_{20} resistor, the feedback will be influenced by both the voltage and the current. After being taken off the R_{20} resistor, the feedback voltage is distributed to all three amplification stages. The voltage enters the grid of the output stage tube directly; before entering the grid of the tube in the first preamplifier stage, this voltage passes through the voltage divider R_6-R_4; prior to arriving at the grid of the tube in the second preamplifier stage, the feedback voltage passes through the voltage divider R_{10}-R_7 and through the capacitor C_6.

The amplification may be adjusted within a 0.4 neper range by resoldering the connection at the D_1-D_6 terminals of the GUS-1 block. The output resistance of the amplifier may be adjusted by resoldering the connections at the B_1-B_4 terminals of the GUS-4 block. Adjusting the output resistance will not change the amplification of the amplifier. Both adjustments are made in the course of factory acceptance tests and should not be made under operating conditions.

The amplification of the amplifier is 11.5 nepers in absence of feedback; when feedback is present, this figure is reduced to 6.65 ± 0.05 nepers. The characteristic of the frequency dependence of amplification is shown in Fig.14; the amplitude characteristic and the clarity damping at the second and third harmonics are shown in Fig.15.

The input and output of the amplifier are provided with jacks for circuit connections. The connecting is done by means of jumpers.

The output transformer T_2 has a winding connected to the terminals B_6-B_7 of the comb; the control-frequency indicator IKCh may be connected to these terminals.

The filament voltage is measured at the jacks "US". The same jacks are used to turn off the filament voltage. The jacks L_1, L_2, and L_3 are used in measuring the plate voltages of the tubes. The jacks "VYKH" are used for measuring the level at the output of the amplifier.

2. Reception Group Amplifier

Principal wiring diagram No.135.41.16

The reception group amplifier does not differ from the transmission group amplifier.

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3. Reserve Group Amplifier

Principal wiring diagram No.131.41.17

In its main part, the reserve group amplifier does not differ from the transmission group amplifier. The only difference is in the commutation blocks of this amplifier; these are connected in a different way and have a greater number of jacks. The transmission of the reception group amplifiers may be replaced by the reserve amplifier without interrupting the communication, by simply inserting jumpers into the spare amplifier jacks that are marked with the symbols of the amplifier being replaced. When the reserve amplifier is connected to the circuit, the amplifier which is being replaced (and which, in this case, will be connected in parallel with the reserve amplifier) should be disconnected.

4. Control-Frequency Receiver

Principal wiring diagram No.135.40.98

The control-frequency receiver is composed of two independent elements; the control-frequency receiver for the automatic level adjustment Pr.ARU, and the receiver for slanted (manual) level adjustment PNR.

A. ARU Receiver

The ARU receiver is the controlling element of the automatic level adjustment; in addition, it furnishes a signal indicating that the control-frequency level of the ARU deviates more than 0.3 - 0.5 neper.

The terminals B_5-B_6 of the right-hand comb are connected to the output of the reception group amplifier. The terminals 1-2 of the left-hand comb are connected to the output of the 50-cycle generator. Before entering the grid of the tube L_2, the 9-kc control frequency passes through the narrow-band filter. The filter consists of two oscillatory circuits, L_1C_1 and L_2C_2, both tuned to a frequency of 9 kc.

The filter is designed as a sealed unit, with two trimmer capacitors, C'1 and C'2, attached to its cover. The curves of the relative damping of the filter are shown in Figs.16 and 16a.

The amplified control frequency passes through the transformer T_3 into a thermistor which, together with the resistor R_4, forms one arm of a differential system. The second arm of this differential system consists of the divided resistors R_1, R_2

and of the rheostat R_3. The values of R_1, R_2, and R_3 are so selected that, when the control frequency is at a normal level, the differential system is balanced with respect to the 50-cycle frequency and no 50-cycle voltage is present at the winding 2-4 of the transformer T_2, which is connected to center points of the differential system. A change in the control-frequency level will cause the resistance of the thermistor to change; this will destroy the balance of the differential system and, as a result, a 50-cycle voltage will appear in the winding 2-4 of the transformer T-2. This voltage goes to the grid of the same L_2 tube, where it is amplified. The amplified 50-cycle voltage is taken off the transformer T-4. The choke D_1 reduces the shunting effect of the differential system on the thermistor, at the control frequency. The function of the C_3 capacitor is to prevent shunting of the thermistor by the winding 1-5 of the transformer T_3, at the 50-cycle frequency. The capacitor C_1 shunts the transformer T-2 at the control frequency, so as to make the potential of point (1) of the narrow-band filter practically equal to zero (at the control frequency). The R_4 resistor prevents burn-out of the thermistor during accidental surges of the control-frequency level. The tube L_2 amplifies simultaneously two frequencies: the control frequency and the 50-cycle frequency. A highly stable amplification is required in the case of the former frequency; the amplification of the latter frequency does not have to be very stable. Therefore, the choke D-1 is connected in parallel with the feedback resistor R_5 in the cathode circuit of L_2: at a frequency of 50 cycles, this resistor is shunted by the choke.

The plate circuit of the tube L_2 contains three transformers: T-3, T-5 and T-4. The T-3 transformer supplies control frequency to the thermistor. The T-5 transformer has two functions: Its 6-10 winding supplies voltage to the copper-oxide rectifier K_1 which, after amplification, is used in a permanently connected device serving as the control-frequency level indicator; the winding 7-9 (for the case of the end station B) supplies a control-frequency voltage, to be used for the synchronization of carrier frequencies. After being amplified by the tube L_2, the

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50-cycle voltage goes through the transformer T-4 to the grid of the tube L_3. By means of a circuit composed of resistors R-10, R-11 and capacitors C_8, C_9, the phase of this voltage is shifted by 90^o with respect to the phase of the 50-cycle voltage which the motor receives directly from the generator of 50-cycle current. The transformer T-4 is shunted by the capacitor C_7, which is a control-frequency bypass. Since the power delivered by L_2 is not sufficient to operate the motor, a second amplification stage (using a tube of the 10P12S or 7P12S type) is provided.

From the A_3-A_4 output terminals of the ARU-6 block, the 50-cycle voltage goes through the contacts III-3 - III-4 of the relay R_1 to the terminals 3-4 of the input comb of the chassis; these are connected to one pair of the windings of the motor.

Operation of the ARU system is controlled by means of the relays R_1 and R_2. The relay R_2 is connected in parallel with the output terminals A_3-A_4, through a copper-oxide rectifier K_2. The relay R_1 is actuated by contacts III-1 and III-2 of the relay R_2. The actuating voltage of the relay R_2 is higher than the initial operating voltage which the motor receives from the terminals A_3-A_4. Smooth changes in level will not actuate the relay R_2 since, in this case, the level is quickly brought back to normal by the action of the motor. If, however, the level changes sharply by more than 0.3 - 0.5 neper, for a time longer than 5 - 7 sec, the action of the motor is too slow to return the level to normal and the relay R_2 is actuated. Level jumps lasting less than 5 - 7 sec are too short to change the resistance of the thermistor; the balance of the differential system remains practically undisturbed and the relay R_2 is not actuated. The relay R_2 will be actuated if the connection is interrupted because of faulty operation of the line or of the equipment, in which case the control frequency is absent: if the damping of the line changes abruptly, as is the case when, for instance, ice breaks off the line conductors; or if the mechanical components of the ARU fail to operate properly. In all these cases, the relay R_2 actuates the relay R_1, which then executes the following switch-

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ings: The contacts III-3 and III-4 disconnect the winding of the motor to prevent occurrence of a pseudo-adjustment; the contacts III-4 and III-5 connect the output of the amplifier to the resistor R-19 which is equivalent to the resistance of the motor windings; the contacts 1-1 and 1-2 connect a DC voltage to the disconnected motor winding, to brake the motor; the contacts V-3 and V-4 close the circuit of a signal lamp on the control panel of the chassis; the contacts V-1 and V-2, III-1 and III-2, 1-3 and 1-4 then close the circuits of the station-wide signal system. The KN_2 pushbutton is a means for blocking the ARU system. When depressed, this button actuates the relay R_1, which then breaks the motor circuit, disconnects the circuits of the stand-wide signal system, and lights the signal lamp on the control panel of the chassis.

A test instrument that has the function of a control-frequency level indicator may be used for adjusting the differential system during the initial installation of the equipment and for the periodic checkup, in which case the instrument is connected to the output of the amplifier in series with the winding of the relay R_2; this connection is made by depressing the pushbutton KN-1. When so connected, the instrument will indicate the presence of the 50-cycle voltage at the output of the amplifier; the differential system is then balanced by resoldering the connections on the resistors R_1 and R_2 and by adjusting the rheostat R_3 until a minimum instrument reading is obtained. The sensitivity of the ARU receiver is adjusted by resoldering the connections at the windings of the transformer T-7.

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B. NRU Receiver

The receiver for the slant level adjustment has the following elements: a 15-kc narrow-band filter, an amplification stage, a copper-oxide rectifier, and a milliammeter. The filter is connected across the transformer T_3; the winding taps of this transformer are used for adjusting the sensitivity of the circuit during the initial installation of the equipment. When the control frequencies are at a normal level, the pointer of the instrument is at the center of its scale, within the limits of the colored sector. A deflection of the pointer beyond the limits of this sector indicates a skew in the amplification curve of the group section of the circuit. In this case, an additional manual adjustment is required. No signaling is provided for this instance since, apparently, a skew of the curve is rare so that this phenomenon cannot be considered an emergency condition of the connection.

5. Regulating Artificial Line RIL

Principal wiring diagram No.P 134.20.40

The three main components mounted to the RIL chassis are: the artificial line for slanted adjustment, the artificial line for flat adjustment, and the buffer and amplifier stage BUK. The artificial line for slanted adjustment consists of six artificial line links, RIL-1 through RIL-6, connected to the reception circuit across the transformer TIL.

The output ends of the individual RIL links are provided with voltage dividers, through which these links are connected to 0.60 stator sections of the slanted adjustment capacitor; the output of the last link is directly connected to the capacitor section 60. From the output end, the characteristic resistance RIL links is equal to 2400 ohms. This resistance is matched to the resistance of the preceeding circuit element by means of the input transformer TIL.

The rotor of the slanted-adjustment capacitor is connected to the input of the flat-adjustment artificial line KD (a capacitor divider). This artificial line is assembled of capacitor links. Each link is connected to stator sections 0.60 of the flat-adjustment capacitor. The rotor of this capacitor is connected to the grid of the tube L_1 of the buffer and amplifies stage. Structurally, both adjustment capacitors and the motor are components of a single unit: the motor-capacitor block. The motor-capacitor block is connected to the circuit by means of two 16-contact strips. The capacitor rotors are connected to the circuit by inserting banana plugs into the proper jacks.

Thus, if necessary, the block may be removed from the chassis for repair, inspection, or testing.

The spare-parts set of the equipment contains two shielded cables with connected transition capacitors. When the motor-capacitor block is removed, the channel connections may be sustained by connecting the 16-contact strips to the corresponding jacks of the KD and the BUK-1 blocks by means of these cables; only the automatic adjustment facilities will be inoperative.

As pointed out on a previous occasion, during the normal operation of the ARU, the rotors of the flat-adjustment capacitor and of the slanted-adjustment capacitor are rotated by means of a motor. They may, however, be rotated manually, by means of two cranks at the face of the chassis, marked "Plosk.Reg." and "Nakl.Reg.".

The dials of the two capacitors are also located on the face of the chassis. Each dial has seven main divisions, marked 0, 10, 20, 30, 40, 50, and 60. Each main division is subdivided into five parts. The main divisions indicate the rotor position with respect to the stator sections. The subdivisions show the position of the rotor when it meshes with the two stator sections. The scales are read against the index line marked on the glass window. The position of the rotor of the flat-adjustment capacitor is read off the outer scale, and that of the flat-adjustment capacitor rotor is read off the inner scale. Setting 60 on the flat-adjustment scale corresponds to minimum damping of the RIL or to maximum station amplification; setting 60 on the slanted-adjustment scale corresponds to maximum slope of the STAT damping curve of the RIL. Normally, whether rotated by motor or by hand, both rotors rotate simultaneously. They may, however, be uncoupled; to do so, the upper knob "Plosk.Reg." should be pulled toward the operator. In this case, the contact group V of the capacitor is shorted, and the signal lamp "Pred.Reg." will light.

As mentioned above, the additional manual adjustment is required during the initial installation of the equipment and during the winter period, when the characteristics of changes in the line damping differ considerably from the average characteristic, and when a skew appears in the amplification curve of the group circuit. In such a case, it may happen that when the pointer of the ARU instrument (the left-hand instrument on the panel of the control-frequency receivers) is within the limits of the colored sector of its scale, the pointer of the slanted-adjustment receiver (the right-hand instrument) is out of the colored sector of its scale; this indicates that the skew of the control-frequency amplification is greater than 0.1 neper. To correct the situation, the ARU is blocked by depressing the button on the panel of the control-frequency receivers, and the flat-adjustment regulator is set so that the pointer of the slanted-adjustment instrument returns to the center of the scale. This, as a rule, will cause the automatic-adjustment pointer to move beyond the limits of the colored sector of its scale. The pointer is brought back to the neutral position by means of the slanted-adjustment regulator; after this, the ARU must be de-blocked. When either of the two rotors is in its extreme end position, a signal is emitted, and the motor is disconnected by means of the contacts of groups I, II, III, or IV.

The switch-over of the contacts occurs when the spring (2) of one of the above contact groups is depressed by one of two cams located on the large drive gear of the capacitor. The contacts 1-2 break the circuit of the pilot light that signals blocking of the ARU [on the panel of KCh (control-frequency) receivers] and close the contacts 2-3-4. The contacts 2-3 close the circuit of the "PRED.REG." (limit of the adjustment) pilot light; the contacts 2-4 close the circuit of the relay R_1 on the control-frequencies receiver panel. When actuated, this relay stops the motor STAT connects the station-wide signal system. The station-wide signal may be switched off by depressing the "BLOKIR" button on the control-frequency receiver panel.

During the automatic level adjustment, the rotors of the capacitors rotate very slowly. A rotor will move from one extreme position to the other in 20 min. This will change the damping of the RIL at a rate of about 0.002 neper per second in the direction A-B, and at a rate of about 0.004 neper per second in the direction B-A; both given rates are for the middle frequency of the respective directions. The buffer and amplifier stage is a single-tube amplifier with a high ohmic input resistance. Besides its main function - that of matching the high-impedance circuit of the flat regulator to the low-impedance input circuit of the group amplifier - the BUK serves also the purpose of smoothing the amplitude distortions caused by the line and by the directional filters. When transmission takes place in the A-B direction, these distortions occur in the 6.3 - 15.0 kc frequency range; during transmission in the B-A direction, the distortions are in the 18.0 - 26.7 kc frequency range. The distortions are corrected by means of the inductances L_1 and L_2 and their respective capacitors, which are a part of the feedback circuit of the BUK tube. The LC circuits are connected across the autotransformers Dr1 and Dr2. The CL_1 circuit corrects distortions in the 6.3 - 10 kc range, that are due to the filter pair K-5.7; the CL_2 circuit corrects distortions in the 10 - 15 kc range, due to the filter pair D-16.4. When its capacitor is replaced by a smaller one, the same circuit is used for correcting distortions in the 18 - 26.7 kc range, due to the filter pair K-16.4. Parts of the R_7, R_8, R_9, and R_{10} resistors of the feedback circuit of the amplifier are shunted by these LC circuits, which creates a frequency dependence of the amplification of the amplifier. The elements of the LC-circuits are so selected, that the resulting frequency dependence of the amplification corresponds to the frequency dependence of the damping of the filters.

The correction is set by proper insertion of jumpers between the BUK-2 terminals.

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The circuit is provided with facilities for changing both the depth of correction and the slope of the correcting curve.

In the range 6.3 - 10 kc, the necessary steepness of the curve is obtained by installing a jumper between the terminal I_2 and one of the terminals of the row E_2-E_6; the maximum steepness of the curve is obtained when the terminals I_2 and E_6

are connected by a jumper.

Correspondingly, the depth of correction is selected by placing a jumper between a terminal of the row E and one of the terminals of rows D and G.

The maximum depth of correction is obtained when the jumper is connected to the D_1 terminal.

The correction in the frequency range 10 - 15 kc is adjusted in a similar fashion. In this case terminals of rows B and V, and of rows V and D-G are connected by jumpers; the former two rows are used in adjusting the steepness of correction, the latter in adjusting the correction depth. The terminals A_1 and A_2 should be shorted.

To apply corrections in the lower part of the 18 - 26.7 kc frequency range, the jumper between the terminals A_1 and A_2 is removed. To apply correction in the range of 23 - 26.7 kc, the jumpers should be inserted between the terminal I_2 and one of the row E terminals, and between the terminals of rows E and D, or E and G (depending on the required correction depth). No jumper is inserted between K_2 and K_3. Figure 17 shows correction curves obtained with various relative jumper positions.

When transmission is in the A-B direction, the amplification of BUK is greater than when transmitting in the B-A direction; this is achieved by disconnecting the R_5 resistor at the BUK-1 block.

6. Carrier-Frequency Generator

Principal wiring diagram No.135.80.25

The following components are mounted to the carrier-frequency generator chassis: the quartz master oscillator, the carrier-frequency generator, the band filters GF-6, GF-9, GF-12, and GF-15, and the control-frequency amplifiers SK-1 and SK-2.

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The Quartz Master Oscillator

The tube of the quartz master oscillator (KG) can work either as a generator or an amplifier. The desired operating regime is selected by inserting three jumpers into the "GEN" or into "US" jacks. When the jumpers are in the "GEN" jacks, the circuit operates as a generator. In this case, the electrode (2) of the quartz resonator KG is connected to the screen-grid of the tube, while the electrode (4) is connected to the control-grid of the tube, and the electrodes (6,8) to the cathode circuit of the tube. The quartz resonator oscillates at 9-kc frequency and is contained in a glass bulb with an octal base numbered 2, 4, 6, and 8, corresponding to the numbers of the base pins. The temperature coefficient of the quartz resonator frequency is 1×10^{-5} per $1^{\circ}C$.

The 9-kc voltage is taken off the secondary winding of the L_1, C_5 tuned circuit.

The magnitude of this voltage is regulated by changing the value of the resistance R_6, which has several taps for this purpose.

When the jumpers are in the "US" position, the tube operates as an amplifier. In this case, the quartz resonator is disconnected from the circuit. The amplifier input is connected to the winding of the transformer T_5 of the control-frequency receiver ARU. In addition, the resonant frequency of the tuned circuit in the plate circuit of the tube is adjusted to 9 kc by connecting the capacitance C_9. When the stage operates as a generator, this circuit is tuned to a frequency somewhat higher than 9 kc, to improve the excitation conditions. From the ARU receiver, the 9-kc frequency goes to the terminals B_7–B_8 of the input comb of the chassis. Since the filter of the ARU receiver does not completely remove the side frequencies, an additional filter circuit $L_2C_{10}C_{11}$ is provided at the input of the synchronization amplifier. The voltage at the amplifier output is adjusted by reconnecting the taps of the R_6 resistor.

Carrier-Frequency Generator

The operating regime of the carrier-frequency generator is so selected that its tube works with a large cutoff, so that the plate current appears as a series of short pulses. The cutoff angle of these pulses is approximately 35°; this is achieved by so selecting the components of the grid-leak that a large coupling factor and, correspondingly, a large negative bias value is obtained. When the generator operates under such conditions, the second to fifth harmonics of its fundamental frequency are powerful enough to be supplied directly to individual modulators. The fundamental frequency of the generator is 3 kc.

The frequency of the generator is accurately pre-set at the factory, by means of the capacitor C_5-C_7. The resistor R_2, in parallel with the circuit, determines the extent to which the frequency of the generator is covered by the master frequency. The synchronization is done by means of the 9-kc frequency, which is the third harmonic of the fundamental frequency of the generator. All carrier frequencies are taken off the generator by the primary of the transformer T_1. The primary is shunted by the L_1C_6 circuit, which is tuned to the fundamental frequency of the generator, i.e., to 3 kc. The output winding of the transformer T_1 is wired to the terminals B_2-B_3, which are connected to the band filters GF-6, GF-9, GF-12, and GF-15, through which the channel modulators and the control-frequency stabilizers are supplied. The second output winding of the transformer is connected to the terminals B_4-B_5 of the left-hand comb, to which the 33-kc filter and amplifier are connected.

The Carrier-Frequency Filters

The carrier-frequency filters are designed with a characteristic resistance of 50 ohms, which is approximately equal to the input resistance of two parallel-connected channel modulators, from where the carrier-frequency is supplied. The damping curves of these filters are plotted in Figs. 18 and 19. The resistors R_2 in the filters GF-9, GF-6, and GF-12 serve the purpose of quenching the power surplus. The tapped resistors R_{21} are used in adjusting the control-frequency voltage on the channel modulators to a required value. The R_3 resistor in the GF-6 filter is connected to the filter output by means of a jumper inserted between the terminals B_2-B_3; this resistor replaces the channel modulators, when the equipment is operating

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in the supplementary frequency spectrum. The resistor R_3 of the GF-15 filter serves the same purpose when operating in the main frequency spectrum.

The circuits that supply carrier-frequency to each of the channels are also connected to the corresponding "NES" jacks at the test block. To control the level of the carrier frequency, a level indicator may be connected to these jacks. If necessary, the carrier frequency of any channel can be removed by shorting its "NES" jacks with a jumper. Usually, this is required only when the modulators are to be balanced: The balancing process is rather difficult when all three carrier frequencies are present at the station output.

The Control-Frequency Stabilizers

These components are serving the purpose of stabilizing the level of the control frequencies. The voltage is stabilized by means of a thermistor connected in series with the resistor R_1. The thermistor-stabilized voltage goes through the extender R_2, R_3, R_4 to the terminals B_1-B_2 of the left-hand comb on the panel. The magnitude of the stabilized voltage can be adjusted by changing the value of the resistor R_4. Jacks at the GN block make it possible to disconnect one or both control frequencies, by altering the position of the jumpers. Disconnecting one of the frequencies is often necessary when the level of the other control frequency is being adjusted.

The input resistance of the stabilizers (from the end of the output terminals B_1-B_2) is 4000 ohms so that the damping of the circuit remains practically unchanged when the stabilizers are connected.

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7. The 33-Kilocycle Amplifier

Principal wiring diagram No.P 135.40.73

The 33-kc amplifier chassis contains both the 33-kc amplifier and the band filter GF-33.

The filter GF-33 will pass the eleventh harmonic of the basic frequency of the carrier-frequency generator but has a high damping at the frequency of adjacent harmonics. The damping curve of the filter is plotted in Fig.20. The input resistance of the filter at the 33-kc frequency is low (about 20 ohms), and therefore this filter is matched to the output of the carrier-frequency generator by means of the transformer T whose winding consists of only a few turns. The filter voltage is not taken off the load resistance but is tapped from the induction coil L_4, which is a part of the last link of the filter.

This voltage is conducted to the grid of the amplifier tube, type 10Zh12S. To obtain the required magnitude of the 33-kc voltage at the output of the amplifier, the amplification of the latter is adjusted by means of the feedback resistor R_5.

8. The Group Modulator

Principal wiring diagram No.136.20.25

The group-modulator chassis contains elements necessary for converting the lower frequency group into the higher frequency group and vice versa, depending on whether the chassis is connected to, respectively, the transmitting or the receiving circuit; in addition, the chassis carries blocks that contain a transformer for the control-frequency feed and a transformer, connected to the output of the band filters of the reception circuit and also a single-stage amplifier.

When the station operation is changed from regime A to regime B, the group converter should be disconnected from the reception circuit and connected to the transmission circuit; this is done by resoldering the connections at the terminals of the lead-in comb. The diagram shows connections of the end station, operating in regime B, i.e., the 6.3 - 15 kc frequencies are converted to 18 - 26.7 kc frequencies. In this case, filter PF-18-27 is connected after the modulator.

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To connect the group converter to the reception circuit of the station A, the jumpers should be removed from the terminals G_3-V_3, G_4-V_4, G_5-V_5, G_6-V_6, G_7-V_7, G_8-V_8; jumpers should be placed between the terminals B_1-V_1, B_2-V_2, B_3-V_3, B_4-V_4,

B_5-V_5, B_6-V_6, B_7-V_7, B_8-V_8.

In addition, the PF-18-27 filter at the output of the modulator is replaced by the D-15 filter.

In cases when the three-channel equipment is installed in a line that is already being used by a 12-channel system, the PF-18-27 filter is not required in the reception circuit. However, if the higher frequency spectrum is not being used and if interference, due to line disturbances in the 39 - 50 kc range, is present in the channels, the PF-18-27 filter may be used to remove that interference. In this case, the jumper V_3-B_3 should be removed, the jumpers G_5-B_3 and G_6-V_3 should be inserted, while V_4-B_4 should be grounded.

The modulator is of the copper-oxide type, connected in a ring. The 33-kc carrier-frequency voltage, measured at the terminals A_3-A_4 of the GM block, or at the terminals A_6-A_7 of the lead-in comb, is adjusted to 0.7 - 1.0 volt. The input resistance of the modulator, at the carrier frequency, is about 50 ohms. The damping of the modulator is 0.7 neper.

The damping curves of the filters D-15 and PF-18-27 are plotted in Figs.21 and 22. An 0.5 neper extender is connected between the filter and the modulator. This extender is necessary for improving the operating regime of the modulator.

A single-stage amplifier UGM, using the tube 10Zh12S, is provided to compensate for the damping caused by the filter and by the modulator. The total damping of the group-modulator chassis is equal to zero.

9. Low-Frequency Amplifier

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Principal wiring diagram No.138.20.02

The low-frequency amplifier chassis includes a differential system with extenders and the low-frequency amplifier of the receiving part of the channel.

The Differential System

The output of the differential system toward the commutator is wired to the terminals A_3-B_3, and its output toward the transmission line is wired to the terminals A_1-B_1. The balance of the differential system is connected to the terminals D_3-D_4 of the DS block. The balance is composed of the resistance R = 600 ohms; the capacitors $C_3 = 1\mu f$, $C_4 = 0.5\mu f$ which may be connected either in parallel or separately; the capacitors $C_5 = 0.01\mu f$, $C_6 = 0.02\mu f$ connected in parallel to the 600-ohm resistor. The balance is connected to the differential systems by means of jumpers between A_6 and D_4, and between A_1 and D_3. The capacitors are connected or disconnected by changing the positions of the jumpers at the block terminals.

An external balance may be connected by means of the terminals D_3-D_4 of the differential system, that are wired to the terminals A_7-B_7 of the comb of the chassis, which are connected to the pegs of the terminal block of the stand. From the commutator side, two capacitors, C_1 and C_1' each having a capacitance of $1\mu f$, are connected in series to the differential system. These capacitors prevent the call-relay from being shunted by the differential system. In the transmission circuit, the U_1 extender is followed by a matching transformer TRF whose function is to match the 300-ohm circuit of the middle point of the differential system to the 600-ohm circuit of the transmitting system. The transformer is wound on a toroidal core; together with the C_8-C_8' and C_7, C_7', C_7'' capacitors, this transformer acts as a high-frequency filter, whose cutoff frequency is 150 cycles. At 50 cps, the damping of this filter is about 4 nepers. The filter protects the transmission circuits from the inductor call current. Extender sets of 0.1, 0.2, and 0.3 neper are provided in the transmission and reception circuits of the differential system.

The characteristics of the differential system are plotted in Figs.23 STAT 24. Curve 1 in Fig.23 shows the frequency characteristic of the working damping of the differential system, measured in the direction of reception between the terminals D_5-D_6 and D_1-D_2, when the terminals A_1-B_1 and A_7-B_7 are connected to a 600-ohm load resistance. Curve 2 in Fig.23 shows the frequency dependence of the active damping of the differential system, in the direction of transmission from the terminals

D_1-D_2 to the terminals E_5-E_6 of the DS-1 block, when the terminals A_5-B_5 and A_7-B_7 are connected to a 600-ohm load. Figure 24 shows curves for the frequency dependence of the detuning damping. Curve 1 represents the case when the reception is directed from the terminals A_5-B_5, when the terminals A_3-B_3 and A_1-B_1 are connected to a 600-ohm load; curve 2 represents the case when the transmission is directed from the terminals A_3-B_3, when the terminals A_1-B_1, A_5-B_5 are connected to a 600-ohm load. In both cases, the balance side of the differential system (A_7-B_7) is connected to a 600-ohm load.

The Low-Frequency Amplifier

The low-frequency amplifier has only one stage and uses a 10Zh12S type tube. The input of the amplifier is connected to B_1 and B_2, while the output is connected to the terminals B_5-B_6 of the left-hand lead-in comb. The amplification is equal to 3.5 ± 0.05 nepers at 800 cps. The amplification at other frequencies of the frequency range of the amplifier does not differ from that at 800 cps by more than + 0.05 neper.

Besides its main function, the low-frequency amplifier serves the purpose of smoothing the voice frequency used for correcting the curve of the residual damping of the channel in the low voice-frequency range of 300 - 800 cycles and in the high voice-frequency range of 2000 - 2700 cycles.

The correction is achieved by means of resonant circuits connected in parallel to the resistor in the feedback circuit of the tube.

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The low-frequency range is corrected by means of the circuit consisting of the inductance L_1, the capacitance C_1, and the resistance R_4; the high-frequency range is corrected by a circuit consisting of L_2, C_2, and R_2.

The correction circuit permits changing both the depth of correction and the shape of the correcting curve. The slope of the curve is changed by means of resistors connected in series to the circuit (R_4 - for the lower frequencies, R_2 - for the higher frequencies); a minimum steepness of the curve is obtained when the full value of the resistor is used. The steepness is changed by inserting jumpers between the terminals of rows A_2 to A_5 (for the lower frequencies) and between the terminals I_2 to I_5 (for the upper frequencies).

The depth of correction is adjusted by suitable insertion of jumpers between one of terminals of the rows D_2-D_6 and G_2-G_6, and the terminals V_2-V_5 (for lower frequencies) or E_2-E_5 (for upper frequencies). Figure 25 shows the correcting curves that correspond to different jumper positions.

A smooth amplification regulator is connected at the input of the amplifier; by means of this regulator, the amplification can be adjusted within a 0.4-neper limit.

The A_9-B_9 terminals of the chassis are connected to the terminals of the lead-in comb of the stand, to facilitate connection of an external amplification regulator. When this regulator is connected, the jumpers between the E_2-E_3 and E_4-E_5 terminals of the UNCh block should be removed and inserted between the terminals E_1-E_2 and E_5-E_6 of the same block.

The amplitude characteristics of the UNCh, plotted as functions of the input level, are shown in Fig.26.

The filament of the UNCh tube is connected in series with the filament of the tone-call receiver tube of a given channel.

10. The Modulator

Principal wiring diagram No.136.20.23

The following elements are mounted on the modulator chassis: the limiter, the modulator, the equalizer, the band filter, and, in the case of a second-channel modulator, the band-filter transformer.

To accurately adjust the side-frequency level at the output of the station, the damping of the extender connected to the input of the modulator may be varied within the limits of 0.1 to 0.6 neper, by resoldering its connections.

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The modulator M is made of copper-oxide elements, connected in a ring. The potentiometer R_2, connected at the output side of the modulator, is used in balancing the carrier-frequency during factory calibration or, under field conditions, when the copper-oxide elements have to be replaced. Although the modulator is assembled from copper-oxide elements that are as uniform as possible, it is always necessary to additionally balance the carrier by means of the potentiometer R_2; this prevents the ARU from being influenced by the remainder of the unbalanced carrier frequency in the second channel. The level indicator of the neper-meter may be used in balancing. The level indicator is connected to the output of the group amplifier, and the balancing is done by adjusting the potentiometer until a minimum level reading is obtained; the control frequencies should be connected during the balancing process.

When the potentiometer is set to minimum, the level of the residual carrier frequency at the output of the group amplifier should be not greater than -1.5 neper. The carrier-frequency voltage at the terminals A_3-A_4 of the modulator is adjusted to 0.45 - 0.65 volts; the corresponding level should be -0.55 to +0.15 neper.

The extender R_1, connected between the modulator and the equalizer, improves the performance of the modulator.

The damping curve of the band filters is plotted in Fig.27. Distortions caused by filters in the marginal frequencies of their bands, are partly compensated by means of equalizers provided for that purpose. The characteristic of these equalizers is also shown in Fig.27.

An extender that is part of the equalizer permits to vary the correction depth within a 0.04-neper range. This is done by changing the position of the jumpers at the terminals of the equalizer blocks.

The distortions, caused by filters, are further compensated in the low-frequency amplifier.

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11. The Demodulator

Principal wiring diagram No.P 136.20.27

A band filter, an equalizer, a demodulator, and a low-frequency filter are mounted to the demodulator chassis.

Essentially, the demodulator chassis does not differ from the modulator chassis. The demodulator does not have a potentiometer for balancing the carrier frequency, since, in this case, no special requirements must be satisfied to ensure proper operation of the ARU; also, the unbalanced carrier frequency cannot go to the commutation terminals, since the path is blocked by the low-frequency filter that has a sufficiently high damping to stop the 6 and 9-kc carriers. The damping curve of this filter is plotted in Fig.28.

The carrier-frequency voltage at the input terminals A_3-A_4 is the same as in the case of the modulator, i.e. 0.45 to 0.65 volts.

12. Voice-Frequency Ringing Generator

Principal wiring diagram No.P 135.80.19

The voice-frequency ringing generator consists of a fundamental-frequency (1000 or 500 cps) generator and of a 20-cycle generator. The fundamental-frequency oscillatory circuit L_1-C_1C_2 is in the grid circuit of the tube L_1; the coupling winding of the inductance L_1 is connected across the resistor R_2, which is separate from the cathode circuit of the tube. The basic frequency is changed from 1000 cps to 500 cps when the capacitor C_1 is connected in parallel to the capacitor C_2. The fundamental frequency is tapped from the transformer T-2 in the plate circuit of the tube. When the frequency is changed to 500 cps, the capacitor C_5 should be connected parallel to the capacitor C_6.

The 20-cycle oscillatory circuit, consisting of the transformer T_1 and of the capacitor set C_7-C_{10}, is in the grid circuit of the tube L_2. The feedback winding of the transformer T_1 is connected across the resistor R_6, which is part of the cathode circuit of that tube.

The capacitor C_6-C_{10} set is used when the 20-cycle frequency is being adjusted at the factory. The taps E_6-E_4 of the feedback winding are used for adjusting the amount of feedback, which is also done at the factory. The grid of the tube L_2 receives the fundamental-frequency voltage from the secondary of the transformer T_2, which is connected in series with the 20-cycle oscillatory circuit. The generator regime of the tube L_2 is so selected that the pulses of its plate current have a 90° cutoff; the tube is open during one half-period of the 20-cycle frequency and is closed during the second half-period.

Thus, during the first half-period of the 20-cycle oscillation, the fundamental frequency will be amplified by the tube; no fundamental frequency will be present at the output of the GTV during the second half-period.

As a result, the fundamental-frequency voltage at the output terminals 5-6 and 1-2 of the generator is modulated by the 20-cycle frequency. When a fundamental frequency of 500 cps rather than of 1000 cps is used, the capacitor C_{15} should be connected parallel to C_{16}, which is in parallel with the winding of the output transformer T_3.

The GTV has two outputs: a working output and a testing output. The power, available at the working output (terminals 5-6) is tapped across resistors located on the PTV chassis and is used to send the call through the channels. The test output (terminals 1-2) is connected to the control-testing system KIU.

The potentiometer R_8 in the working output circuit is the means for adjusting the output level. The resistance of the R_8 is low, which assures constancy of the output level in cases when the call is to be sent through several channels simultaneously. Even in the case when the call is sent through 16 channels at a time, the level does not drop more than 0.1 neper (as compared to the output level of a generator with no load).

Both the tubes L_1 and L_2 are of the 10Zh12S or of the 7Zh12S type. In contrast

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with the arrangement in other chassis, the ballast tube used with 7Zh12S tubes is mounted right on the chassis. This is necessary because of the possibility that the GTV chassis may sometimes be mounted at the TV stand. Figure 29 plots the generator output level as a function of the supply voltages and of the load. When the voltages and load vary within the technical specification limits, the frequency of the generator remains practically constant.

13. The Voice-Frequency Ringing Receiver

Principal wiring diagram No.P 135.40.84

The elements mounted to the voice-frequency ringing receiver chassis are: the receiver itself; the differential system for connecting the receiver; a series of relays that are part of the voice-frequency ringing circuit.

The receiver is connected to the two-wire circuit of a channel by means of a differential system, consisting of two resistors R_1 and R_2, both having a resistance of 10 ohms, and a transformer TDS.

The terminals A_{10}-B_{10} of the lead-in comb of the chassis are connected to the channel toward the commutator end; the terminals A_3-B_3 are connected to the channel toward the differential-system end.

Connecting the PTV to a channel does not increase the damping of the latter by more than 0.03 neper. Damping of the differential device through which the receiver is connected to a channel varies as a function of the direction of the received signal; signals received from the commutator end are damped 2.5 nepers more than those received from the differential-system end. When a two-wire transit is used, th situation makes it impossible to use the receiver at the transmitting station: The call would not pass through the receiver. From the terminals A_3-B_3 of the lead-in comb, voice-frequency signals go to the TDS and through its windings 4-2 and 7-9 — to the primary winding of the transformer T_1 of the receiver. When the call is sent by means of a DC current, the possibility of the calling relay being shunted by the windings of the TDS and of the transformer T_1 is prevented by the capacitor C_1, connected in series to the winding of the transformer T_1. The plate circuit of the receiver tube contains a resonant circuit, tuned to the fundamental frequency. The tuning may be changed from 500 cps to 1000 cps by disconnecting the winding II; to prevent changing of the sensitivity of the receiver, the jumper between the terminals D_2-A_3 should be removed and placed between the terminals D_3-A_3.

The amplified fundamental frequency (modulated by 20 cps) goes to the copper-oxide rectifier KM-1, where it is rectified. After rectification, the 20-cycle current passes through the transformer T_2, through the resonant circuits C_8-C_{11}, C_3-$C_{12}C_{14}$ (tuned to 20 cps), and into the copper-oxide rectifier KM-2, which is connected in parallel to the capacitors $C_{12}C_{14}$. From here, the rectified current passes into the winding of the relay R_6. In the circuit of the first rectifier KM-1, the R_7 resistor (shunted by the C_6 capacitor) is connected in series with the primary winding of the transformer T_2. The constant component of the current flowing in the circuit of KM-1 creates a voltage drop across R_7. The magnitude of this voltage depends on the strength of the call signal. This voltage shifts the working point of the copper-oxide rectifier KM-2, thus limiting the rectified current that passes through the winding of the relay R_6; such an arrangement permits keeping the required constant selectivity even during a considerable level fluctuation at the output of the receiver.

The sensitivity of the receiver is increased by using the telegraph relay R_6, of the RP-5 type, whose actuating current is 0.2 ma. The sensitivity of the receiver can be adjusted by varying the resistance of the feedback circuit; this is done by resoldering the connections between the terminals of the PTV-1 block. Maximum sensitivity is obtained when the terminals G_5-G_6 and G_1-G_2-G_4 are connected; in this position, the receiver will normally operate with the output level between -2.8 and -1.8 nepers.

When A_2-G_6, A_1-G_1, and G_2-G_3 are connected, the operating range of the receiver will be -2.2 to -0.5 nepers. This is a normal position. If the level at the point at which the receiver is connected is -1.1 neper with respect to the modulated current, a 1.1-neper sensitivity margin will be assured. Minimum sensitivity is obtained by connecting the terminals A_2-G_6 and A_1-G_1. In this position, the operating range of the receiver is -1.1 to 0 nepers.

The second capacitor C_4 in the plate circuit of the tube, the capacitor set C_8-C_{11}, the capacitor set C_{12}-C_{14}, and the taps of the choke T_3 are used in tuning the receiver at the factory. The curves in Fig.30 show the current in the winding of the relay R_6 as a function of the fundamental frequency and of the modulating frequency. The curves in Fig.31 show the dependence of the relay R_6 current on the level received from the terminals A_3-B_3 or from the terminals A_{10}-B_{10}, when the terminals A_3-B_3 are connected to a 600-ohm load resistance. The levels listed above and those found in Fig.29, are compiled relative to the modulated current (0.7 neper below the nonmodulated current).

The relays operate as follows: When a call signal is received, the R_6 relay is actuated; its contacts short-circuit the winding of the relay R_4, which then drops out, opening its contacts III-1 - III-2 that had been short-circuiting the winding of the relay R_3. When the relay R_3 is actuated in this fashion, the contacts III-1 and III-2 close the circuit actuating the relay R_5; the contacts 1-1 and 1-2 of the latter connect R_8 = 600 ohm into the differential system, while the contacts I-4 - I-5 and V-4 - V-5(across the resistors R_{12} and R_{13}) send a mechanical-inductor or a DC voltage to the commutator. In addition, the contacts V-1 - V-2 of the relay R_5 close the circuit of the pilot light "PR", located at the signal chassis. When a call toward the commutator is made by means of the mechanical inductor, the call voltage is connected to the terminals B_1-B_2; a DC call voltage will be connected to the terminals B_4-B_9.

The relays R_3 and R_4 drop out, with a 400 - 450 msec delay. Therefore, these relays will not be actuated by a pseudo-call of a duration less than 400 - 450 msec.

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In addition, this arrangement permits sustaining the duration of the call.

When a call is received from the commutator end, the relay R_2 (connected to the circuit across the choke DR_3 and the copper-oxide rectifier KM-3) is actuated. If calls are made by means of direct current, the KM-3 rectifier should be disconnected by placing jumpers between the terminals A_1-A_3, A_2-A_4 of the metering block. The contacts III-1, III-2 of the relay R_2 close the circuit of the winding of the relay R_1. When actuated in this fashion, the relay R_1 (by closing its contacts I-2, I-3 and V-2 - V-3) will connect the voice-frequency ringing generator to the differential system; the contacts III-3 - III-4 will short-circuit the input of the tone-call receiver to prevent reception of a pseudo-call; and, finally, the contacts III-1, III-2 will close the circuit of the pilot light "POS" at the signal panel.

Direct current may be used to send and to receive calls (with grounding) in the direction of the commutator. Either a two-wire (one wire for sending the call, the other for receiving), or a one-wire connection may be used.

For this purpose, the contacts of the relays R_2 and R_5 are connected to the terminals A_2 and B_6 of the chassis and then to the pegs $IIIB_9$ and $IIIB_{10}$ of the lead-in comb of the stand.

When a two-wire connection is used, the wire through which the call is sent from the commutator is connected to IIIB-9, the other wire is connected to IIIB-10.

When a call is received from the commutator, the terminal A_2 of the chassis becomes grounded, and the relay R_2 is actuated and sends the call along the previously described path.

When a call is received from the line, the R_5 relay is actuated (by the process described above) and its contacts III-2, III-3 connect the ground to the commutator.

In the case of a one-wire connection, the call current arrives at the peg $IIIB_{10}$ of the lead-in comb of the stand, then goes to the terminal B_6 of the PTV chassis, to the contacts III-2, III-1 of the relay R_5, and finally, across the terminals B_3 and A_2, to the relay R_1.

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A call, received from the line, follows the same path as in the case of a two-wire connection.

14. The Limiter

The limiter is located on the modulator chassis, and is built as a separate block. Its cover is provided with four jacks; two are marked TG - telegraph regime without limiter, the other two are marked TF - telephone regime with limiter. The input of the limiter is connected to the terminals of the lead-in comb, for connection to the channel. Essentially, this limiter is an artificial line, whose damping remains constant so long as the output level is below a certain value; above this certain value, the damping will increase with increase in level. The limitation threshold, i.e., the level value beyond which the damping will begin to increase, is equal to -0.7 neper, as measured at the output of the limiter. This corresponds to +0.8 neper at the commutator terminals of the equipment.

The damping is made dependent on the level changes by connecting copper-oxide elements in both the lateral and the transverse arms of the circuit. Across the resistors R_6 and R_5, these elements receive a constant bias from the B-battery. The elements in the transverse arm receive a negative bias, the elements of the lateral arm receive a positive bias. At low levels, the copper-oxide elements of the parallel arm offer a large resistance to the passage of speech currents, while the resistance of the series arm is low, resulting in a low damping of the system (about 0.15 neper). At levels greater than the limitation threshold, the resistance of the transverse-arm elements will drop sharply, while the resistance of the lateral-arm elements will increase, which in turn will increase the damping of the system. The circuit parameters and the operating states of the copper-oxide elements are so selected that the input resistance of the system is practically the same, at levels both greater and lower than the limitation threshold.

Due to the presence of the copper-oxide elements, some nonlinear distortions

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are produced by the limiter. When the level at the output of the limiter is -1.5 neper (zero level at the commutator terminals), the clear-factor of the limiter is not greater than 1%. However, at the level of -0.7 neper, the clear-factor increases to 5-6%.

When the limiter operates under telegraph conditions, the transverse-arm copper-oxide elements are disconnected and the resistor R_8 is connected across the elements of the lateral arm; under these conditions, damping of the limiter is not dependent on the level. The copper-oxide elements for the limiter are selected to be as uniform as possible; when it becomes necessary to replace these elements, the entire set should be replaced by a new set of four matched copper-oxide elements, found in the spare-parts kit. The characteristic of the limiter is shown in Fig.32.

15. The 50-Cycle Generator of the End Station

Principal wiring diagram No.P 135.80.23

The chassis of the 50-cycle generator of the end station carries two components: the generator of the 50-cycle frequency and the control-frequency indicator IKCh. As explained above, the 50-cycle generator is the power source of the ARU motor.

Obviously, a station AC source could be used for the same purpose. However, supplying the motor from a special vacuum-tube generator prevents the possibility of the ARU operation being interrupted when the station AC voltage is interrupted. The generator uses either a 10Zh12S or a 7Zh12S tube, and supplies about 0.5 watt of power, which amount is entirely sufficient for a steady operation of the motor. The frequency of the generator is factory-calibrated by means of the capacitors C_4, C_5, C_6.

The control-frequency indicator is used in checking the transmitting group circuit of the end station for proper condition. If the group circuit is in order, the control frequency is present at the output of the transmitting group amplifier; when the control frequency is absent, a defective condition of this part of the end station can be assumed.

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The IKCh has an amplifier tube of the 10Zh12S type, whose plate circuit contains the transformer T_1. The secondary winding of this transformer works into a copper-oxide rectifier and the R_1 relay, which is of the RP-5 type. The grid of the tube is connected to the winding of the output transformer of the transmitting amplifier across the resistor R_1. When control frequency is present at the amplifier output, the relay R_1 is actuated and its contacts L-Ya close the circuit of the relay R_2. The contacts V-3, V-4 of this relay open, connecting the resistor R_4 into the cathode circuit of the tube. This causes the negative grid bias of the tube to increase considerably, which will prevent the appearance of grid currents in the tube; these currents are undesirable, in view of the fact that the tube is connected in parallel to the main transmission circuit. Despite increased bias, the relay R_1 will continue to operate so long as the level of the control frequency remains normal. If the control frequencies disappear, the relay R_1 will break the circuit of the R_2 relay, whose contacts will then close the circuit of a suitable indicator lamp at the signal panel.

When the main amplifier is replaced by a spare, the jumpers should be removed from the "OSN" jacks and inserted into the "REZ" jacks. The jacks are located at one of the blocks, inside the G-50 chassis housing.

16. The Power Supply

Principal wiring diagram No.P 133.00.17

To satisfy the AC requirement of the station, a power-pack is provided. This power source is assembled on a separate chassis, located in the upper part of the face of the stand.

The power source provides 24-volt AC voltage for the filament circuits, 220-volt rectified voltage for the plate circuits, 24-volt rectified voltage for the signal circuits, and 19-volt rectified voltage for the microphone. The station can be adapted to operate either from a DC or from an AC source, by changing the connections at the fuse panel.

The AC power line is connected to the terminals A_8-A_9 of the lead-in comb of the chassis. From here, the voltage goes to the fuses and contacts of a toggle switch.

From the tumbler contacts, one wire goes to the terminal (7) of the power transformer and the other, to the center-jack of a three-jack cluster by means of which the rectifier is set to correspond to the voltage of the power line. When the line voltage is 127 v, the jumper should be inserted into the jacks marked "~127"; if the line voltage is 220 v, the jumper should be moved to the jacks marked "~220". In the first case, the winding III is connected, while in the second case both the windings III and IV are connected. Further, the power circuit goes through the brushes of a device whose function is to compensate for the line-voltage fluctuations. The resistor R_1 (or R_2) is connected between the brushes, which prevents short-circuiting of the transformer windings during the time that the brushes change their positions. Line fluctuations of -20% to +10% can be compensated. The voltage-compensating device is controlled by means of a knob at the face of the panel.

The filament voltage is taken off the winding V; the winding II supplies voltage to the signal-circuit rectifier, and the plate-circuit rectifier receives its voltage from the winding I. All these windings have taps by means of which the voltages of individual circuits are adjusted while the power chassis is checked at the factory. It is not necessary to change the voltage adjustment under field operating conditions.

The plate voltage and the signal-circuit voltage are rectified by the full-wave selenium rectifiers BS_1 and BS_2. Both rectifiers are provided with filters, consisting of a choke and of electrolytic capacitors.

The rectifier is intended to work with the following rated current values.

The 24-volt AC voltage: I = 6 amp; the rectified 220-volt voltage: I = 200 ma; the rectified 24-volt voltage: I = 0.3 to 1.0 amp; the rectified 19-volt voltage: I = 20 ma.

When the current consumption is 300 ma, a 0.5% ripple is present in the 220-volt rectified voltage; the ripple of the 24-volt rectified voltage is 8% to 15%, depending on the current consumption which may vary from 0.3 to 1.0 amp.

The efficiency of the rectifier is 55%.

17. The Neper-Meter

Principal wiring diagram No.138.80.45

Two independent measuring instruments are mounted on the neper-meter chassis: a "normal" generator and a level indicator. These instruments permit periodic measurements of the residual damping of the channels and check tests of the levels throughout the equipment. Either a 10Zh12S or a 7Zh12S tube may be used in the generator; facilities are provided for adding a ballast tube, which is required in the latter case. When no ballast tube is needed, the terminals 7-8 of the lead-in comb are connected by a jumper. The supply circuit of the tube is controlled by the key K_5 at the face of the panel. The generator furnishes a fixed 800-cycle frequency. Power is taken off the output winding of the R.F. transformer L_1 through an extender U_1 whose damping is 1.0 neper and Z = 600 ohms. The presence of this extender assures constancy of the output resistance of the generator. When the generator is connected to a 600-ohm load, one of the three fixed levels (0.5, 0.0, or -1.5 neper) may be selected by means of the key K_1.

In addition, a -0.7 neper output level may be obtained by connecting the 1.2 neper extender U_2 (this is done by depressing the pushbutton marked "-0.7 nep."). The output of the generator is connected to the jack "VYKh.GN" at the face of the panel and also to the terminals 3-4 of the lead-in comb, through which the generator is connected to PVU. The fine adjustment of the output level is done by means of the potentiometer "REG.NG", using a level indicator. This adjustment should be made at the beginning of each measurement series.

The level indicator employs a simplified circuit and is essentially a copper-oxide full-wave rectifier connected to a meter of 100 μ amp sensitivity. The input resistance of the level indicator may be equal to 600 or 10,000 ohms.

Either of the two input resistances may be selected by means of the key K_4.

In the first instance (600 ohms) the rectifier is connected to the terminals 4-8 of the secondary winding of the transformer TR-1. In parallel with the primary winding is resistor R_{20}, which makes the total resistance of the indicator equal to 600 ohms. The points of the device is set to the end of the scale by means of the rheostat R_{23}. In the second instance, the rectifier is connected to the terminals 6-5 of the secondary of the transformer TR-1. The resistors R_{21} and R_{22}, connected in parallel to the primary winding, make the total resistance of the level indicator equal to 10,000 ohms. The pointer of the instrument is set to the end of the scale by means of the rheostat R_{18}.

The low-resistance input measuring ranges are: 0.0 to -2 nepers; +1.0 to -1.0 neper; and +2.0 to 0.0 neper. The high-resistance input measuring ranges are: +1.5 to -0.5 neper; and +3.5 to +0.5 neper. The ranges are switched by means of the key K_3. With the low-resistance input, the indicator may be used in the frequency range from 300 cps to 10,000 cps; with the high-resistance input, this range is 200 cps to 3000 cps. The measurement is ±0.05 neper.

18. Directional Filters DK-16.4

Principal wiring diagram No.P 135.01.11

The chassis of the directional filters carries the following elements: STAT filters DK-16.4 (blocks from NFD-1 to NFD-8); the filter K-16.4 (blocks from NFK-1 to NFK-5); and the circuit for parallel operation (blocks NFK-o and NFK-So).

The filters may be connected to the station circuit (from the parallel-connection end) by means of the dividing jacks located above the cover of the chassis.

The filters are of a special type: all inductance coils are wound on toroidal, magnetic material cores. To make nonlinear distortions as small as possible (which is especially important in the case of directional filters) the cores are made of high-permeability material with a low hysteresis loss. Because of these cores and also because of the properly-designed circuit, it was possible to obtain high clear-damping in the filters. The damping curves of the filters are shown in Fig.33.

19. Line Filters DK-2.8

Principal wiring diagram No.P 135.00.99

The chassis of the filters DK-2.8 contains the following elements: the filter D-2.8 (blocks D-2.8-1 to D-2.8-5); the filter K-2.8 (blocks K-2.8-1 to K-2.8-10); the parallel-operation circuit; the block K-2.8-0; and two relays, RSh-1 and RSh-2, used for switching the filters when a broadcast channel is formed. Both relays are actuated by depressing the "VKL.ShV" push-button. The contacts of the relay RSh-2 disconnect the filter DK-2.8; the contacts II-2, II-1 and II-4, II-3 of the RSh-1 connect the terminals 5-6 of the lead-in comb of the chassis to the terminals 7-8, thus creating a circuit that by-passes the filter DK-2.8.

The damping curves of the filters DK-2.8 are shown in Fig.34. The inductance coils of all filters are wound on toroidal cores, made of magnetic materials.

20. Line Filters DK-5.7

Principal wiring diagram No.P 135.01.22

No.P 135.01.20

The filters DK-5.7 are located on two chassis; the chassis diagrams are given in the above-mentioned drawings. In Fig.35 the filters D-5.7 and K-5.7 are shown together, to simplify the diagram. Each of these filters has one "K"-type link and one bridge link. In order to increase the clear-damping, some of the inductance coils of both filters are wound without magnetic cores. The coreless coils are L_1, L_2 coils of the filter D-5.7 and L_0, L_1, L_2, L_4 coils of the filter K-5.7. All coreless coils of each filter are located within one copper housing. All other coils are wound on toroidal magnetic cores. The damping curves of the filters are shown in Fig.36.

21. Balancing Filter BDK-2.8

Principal wiring diagram No.P 135.01.07

The balancing filter consists of the following components: Blocks BDK-2.8-5 to BDK-2.8-1 which reproduce the filter D-2.8; the block BDK-2.8-6 which repeats the circuit used for connecting in parallel the filters D-2.8, K-2.8; and the block BDK-2.8-0 which balances the filter K-2.8. The terminals of the left and of the right lead-in combs of the filter are connected to the terminals of the lead-in comb of the stand.

22. Balancing Filter BDK-5.7

Principal wiring diagram No.P 135.01.25

The blocks BDK-5.7-1 to BDK-5.7-6 of this filter reproduce the filter D-5.7; the block BDK-5.7-B balances the filter K-5.7. With one exception, all inductance coils are wound on toroidal magnetic cores. The coreless coil L_1 is located within a separate housing.

23. The Call System and the Commutation Field

Principal wiring diagram No.P 134.60.17

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The Two-Wire PVU

The two-wire PVU is connected to the channel by means of a double three-wire plug, through the "LIN.COMM." jacks of the two-wire PVU block. The PVU may be connected either in the direction of the line or in the direction of the commutator, by placing the key K_1 in a corresponding position. The call is sent by depressing the key K_2 toward the "VYZOV" position. This creates a circuit consisting of: the split fuses MI, the terminal A_6 of the micro-telephone block, a section of the resistor R_1, the contacts of the keys K_2, K_1, and K_3, the contacts of the "LINIYA" jack, the connecting cable, and, finally, the channel input. The return path of the circuit may be traced through: the "LINIYA" jack, the contacts of the three above keys, and the terminal A_7 of the two-wire PVU. Depressing the key K_2 will actuate the relay R_3, which is connected to the resistor R_1 through a copper-oxide rectifier. This relay closes the circuit of the "POS.VYZ" signal lamp. To send a call toward the commutator, the key K_1 is set to the position "KOMM". When the key K_2 is depressed, a circuit differing from the one described above only in having a series-resistor R_3, will be created. When the key K_1 is in the position "RAZG.LIN" or "RAZG.KOMM", or when the key K_2 is in the position "OBShch.RAZG" (this corresponds to the two-way call circuit), the R_2 relay is actuated. The contacts I-1, I-2 will close the microphone supply circuit, and the contacts V-1, V-2 will connect the microphone (across the contacts of the keys K_2 and K_1) to the corresponding jacks of the PVU. In addition, this relay will switch the telephone from "control" to "conversation".

When the PVU is connected from the line end or from the commutator end, the disconnected end is loaded with a resistor R_1 = 600 ohms and a capacitance of $C_1 = 1\mu f$; in parallel to these, the relay R_1 is connected, across a copper-oxide rectifier. This relay is actuated when a call is received; its contacts send a 24-volt voltage into the winding of the relay R_4 which receives +24 v across the contacts of the key K_1. The contacts V_1-V_2 of this relay close the circuit of the "PR.VYZ" signal lamp and of the station-wide signal circuit. The circuits will open when the key [illegible] STAT moved to another position.

When the keys are in their center positions, the telephone receiver, across the transformer TR, is connected in parallel to the call circuit, for monitoring. The normal generator or the level indicator of the neper-meter may be connected to the "LINIYA" jacks by means of the key K_3.

The Four-Wire PVU

The four-wire PVU is connected to the channel by means of two cables, each having two double three-wire plugs. One cable connects the jacks "PER" at the four-wire PVU block with the jacks "PER" of the commutation field of one of the channels; the other cable is used for connecting the "PR" jacks of the two equipment pieces. To make a call in the direction of the line or in the direction of the commutator, the key K_2 is depressed. When a call is sent toward the station, depressing the key will close the circuit that goes through the terminals B_7-B_8 (to which the tone-call generator is connected), through the contacts 9-10 of the key K_2, through the extenders U_1, U_2, through the contacts 15-16 and 7-8 of K_2, through the contacts of K_1, through the "PER.LIN" jack, and finally through the connecting cable and into the "PER" jack of the channel.

When a call is sent toward the commutator, the signal originating in the tone-call generator goes through the same terminals B_7-B_8, through the contacts 1-2 of K_2, through the extender U_1 and the contacts 3-4 and 11-12 of K_2, through the "PRIYEM.COMM" jack, through the connecting cable and into the "PER" jack of the channel. After passing the differential system, the call current will act on the tone-call receiver, which then will connect the mechanical inductor to the commutator. In a four-wire transit, the tone call from the "PR" jack is sent into the transmission circuit of the second end station.

When a plug is inserted into the "PER" or "PRIEM" jacks, the relay R_1 is actuated; its contacts V_1-V_2 close the filament circuit of the amplifier tube, connect the telephone receiver to the output transformer T_3 of the amplifier, and connect the microphone to the input of the extender U_3. The amplifier tube is of the heater type, with about 30-40 sec warm-up time, and therefore the four-wire PVU (when the plugs are inserted into the above jacks) will not be ready for use until this time is over and the tube has warmed up.

When the line is used for conversation, the key K_4 should be in the "RAZG" position. The contacts 14-15 of the key will close the microphone supply circuit, the contacts 3-4 and 17-18 will shunt the resistors R_5 and R_6; the contacts 19-20 will connect the microphone circuit (through the extender U_3) to the differential transformer T_1. Through the transformer T_1, the speech currents of this circuit will go to the contacts 7-8 and 21-22 of the key K_3, and into the "PER.COM" jack; through the transformer T_2, these currents will go to the contacts 2-3 and 16-17 of the key K_3, to the contacts 2-3 and 8-9 of the key K_1, and into the "LINIYA PRIEM" jack. Thus, speech currents will be simultaneously conducted in both directions of transmission. Incoming speech currents will to through the transformers T_1 and T_2 to the grid of the amplifier tube; the plate circuit of this tube is connected to the telephone receiver across the transformer T_3.

The differential transformer T_1 separates the opposite-direction transmissions, and also reduces the loudness of the outgoing call as heard at the sending station.

In case a separate call (toward the line or toward the commutator) is to be sent, the key K_3 should be set to the proper position. The contacts of this key will disconnect the unused transmitting direction and charge it into the resistors R_3 and R_4, of 600 ohms each. The amplifier tube is required for increasing the loudness and for balancing the differential system.

When the keys K_2 and K_4 are in their center positions, both directions are monitored. In this case, speech currents pass through the resistors R_5, R_6, the transformers T_1, T_2, into the amplifier and then into the telephone receiver.

The Control Testing Device

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The device is used for checking the performance of the tone-call receivers. The terminals B_7-B_8 of the KIU receive voltage from the voice-frequency ringing generator. This voltage goes through the resistors R_1 and R_2 to the key K_2. The function of this key is to vary the testing level at the "KIU" jack at the commutation field. When the key K_2 is in its center position, the level will be at its normal magnitude of 1.1 nepers. When the key is shifted upward, the level will increase by 1.0 neper; moving the key downward will reduce the level by 0.7 neper. When the key K_1 is in the "TV" position, the TV generator is connected to the "KIU" jack. In the position of the key K_1 "TV MN", the generator is connected to the "KIU" jack of the spring-relay R, operated by means of the dialing mechanism. Depending on the number dialed, the duration of the signal sent by the dialing mechanism may vary from 0.1 to 1.0 sec.

To check the PTV of its own station, the "KIU" jack is connected by a cord with the "ISP.TV" jack of the corresponding channel. The receiver should operate when the level is at its normal value, as well as when it is higher or lower than normal. During the test, the "LIN" jack of the channel whose receiver is being tested should be connected with the jack marked "600 ohm".

In testing by means of the dialing mechanism, the PTV receiver should not operate when "1" or "2" is dialed; the receiver should, however, operate when "3" or any higher number is dialed.

The PTV of the opposite station is tested by means of the two-wire PVU which, in this case, should be connected to the jacks "DS" and "ISP.TV". In addition, the "KONTR" button at the KIU panel should be depressed for the duration of the test call.

24. The Lead-In Combs

The lead-in panel of the No.1 stand carries four 60-contact combs and also the channel extenders of the station. The interstand cable is connected to the fSTAT comb; the circuits of the first channel are connected to the second comb and those of the second channel, to the third comb; the circuits of the third channel are connected to the fourth comb. The types of circuits connected to the terminals of the lead-in combs of the stand No.1 are listed in the Table given in Fig.37.

The lead-in panel of the No.2 stand carries two 50-contact combs, and also the line and the balancing autotransformers, together with the capacitor sets. The right-hand comb is used for connecting the external and the line circuits; the interstand cable is connected to the left-hand comb. The circuits connected to the terminals of the lead-in combs of the No.2 stand, are listed in the Table given in Fig.38.

The cable autotransformer is connected by wiring to the terminals IVG_2-IVG_1 and the terminals IVG_3-IVG_4. The frequency characteristics of the operating attenuation and of the reflectance of the autotransformer (when connected to a 550-ohm and to a 140-ohm load) are given in Fig.40.

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CHAPTER IV

INSTALLATION OF THE EQUIPMENT. INSTALLATION TESTS AND MEASUREMENTS

1. Installation and Wiring

The stands of the end station are erected in accordance with the general drawing No.P 330.00.56. The first stand is at the left and the second stand, at the right side.

The stands are attached to the floor by means of bolts set in concrete blocks. They are also fastened to the wall or to the next row of equipment by means of steel-angles. In addition, the stands are bolted together at the base, and their upper parts are interconnected with straps.

Panels that were removed to facilitate transportation of the equipment, should be mounted in their proper place in accordance with the drawings No.P 330.00.54 and No.P 330.00.55. The installation panels should be connected as indicated in the stand assembly diagrams, drawings No.131.00.21 and No.P 131.00.23. The wires of the interpanel connecting cable are spaced to fit their respective terminals, which simplifies the wiring. The interstand cable is also constructed in this fashion.

If the stand is the last or the first in a row, its open side should be covered by protective plates (see general view, drawing No.P 330.00.56). Instead of the upper plate, a signal transparency panel may be installed.

The transparency panel is connected to the corresponding terminals of the lead-in comb of either stand, in accordance with the diagram of drawing No.131.00.20.

After the panels and the interstand cable are connected, the wiring should be tested by ringing the station components.

If the wiring is found to be correct, the supply lines may be connected to the stand No.1. The "-24 v" and "ground" are connected to bus bars and all other supply voltages, to terminal blocks at the fuse panel.

The wires to be attached to the terminal blocks are provided with lugs that fit under the nuts of the terminal posts.

2. Preparing the Equipment for Connection to the Line

While connecting the equipment to the line, the following procedure must be used:

1. Install the tubes 10Zh12S and 10P12S (if the filament voltage is stabilized) or the tubes 7Zh12S and 7P12S (if the voltage is not stabilized). Also, in the case of nonstabilized filament voltage, install a ballast tube 0.425B5.5-12 for 7Zh12S tubes or a ballast tube 0.85B5.5-12 for 7P12S tubes. All ballast tubes, except those used in the PTV, GTV, and GNCh, must be installed on the ballast chassis.

If the filament voltage is not stabilized and ballast tubes must be used, remove the connections between the terminals A_1-B_1 to A_8-B_8 of the right-side lead-in comb on the ballast panel, and also between the terminals A_3-A_5 of the lead-in combs on the PTV and GTV panels and the terminals 7-8 of the lead-in comb of the nepermeter. The location of the tubes and ballasts is shown in the filament circuit diagram, Fig.13.

2. Mount the quartz resonator at the KG-1 block on the chassis of the carrier-frequency generator. The jumpers in the quartz oscillator blocks of both stations should be in the position "GEN". Until final adjustment of the control-frequency levels of the A-B direction is completed, the station B generator should operate independently of the station A generator, and its frequency should be controlled by the quartz resonator of the B station.

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3. Install thermistors on the chassis of the carrier-frequency generator and on the chassis of the control-frequency receiver. The TP-2/0.5 thermistors are installed in SK_1 and SK_2 blocks on the GN chassis. A T-2/2 thermistor should be mounted to the ARU-2 block of the PKCh chassis.

4. Connect the voltage supply lines.

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5. Install group fuses and split fuses, first in the filament circuits and then in the plate and signal circuits. Consult Fig.52 for establishing the jumper positions.

6. Test the filament and plate circuits of all tubes by measuring their filament and emission currents. Use the portable measuring instrument IEL-4 for this purpose. Compare the instrument readings with the data listed in the Fig.41 Table. If there is a considerable difference between a measured value and the tabulated counterpart, find and correct the cause of this discrepancy.

7. Adjust the filament currents of all tubes (see Fig.13).

This adjustment is possible only if the mean filament voltage of the given station is known beforehand. The filament voltages are measured by means of a portable 0-30 v voltmeter, connected to the "+24" and "-24" terminals of the fuse panel. The current adjustment should be performed as follows:

First case: the filament voltage is stabilized.

a) Measure the current in the given filament circuit by means of the portable instrument IEL-4.

b) Measure the filament voltage at the stand (within an accuracy of 0.1 v) by means of the portable instrument and calculate the difference between this voltage and the mean filament voltage of the given station.

c) Using the Table of Fig.41, find the filament current value that should correspond to this calculated difference between the measured and the mean filament voltage. Regulate the filament current produced by changes STATthe value of the quenching resistor, mounted to the test block. Change the position of the sliding contact of the quenching resistor at the test block of the chassis until the filament current is equal to the tabular value. Re-tighten the slide of quenching resistor.

d) The filament current should be within 0.29 - 0.35 amp for the 10Zh12S tubes and 0.58 - 0.70 amp for the 10P12S tubes.

Second case: the filament voltage is not stabilized.

a) In parallel with the ballast of the circuit to be adjusted, connect a second 0 - 15 v portable voltmeter to the terminals of the ballast-tube panel of the PTV, GTV, or of the neper-meter (see Fig.13).

b) Within a 0.1 v accuracy, measure the voltage at the stand; calculate the difference between the measured value and the mean filament voltage of the given station.

c) Adjust the ballast-tube voltage until it is equal to 8.75 + ΔV, where ΔV is the difference between the measured and the mean filament voltage. If the measured voltage is greater than the mean value, ΔV should be taken with the "plus" sign; if the voltage is less than the mean value, ΔV should be taken with the "minus" sign. The ballast-tube voltage is adjusted by means of the quenching resistor, located at the test block of the chassis.

8. Measure the emission currents and the cathode activity of the tubes.

The emission currents and activities are measured after the filament current of a given tube is adjusted. The measurements should be made in accordance with the instructions found in Appendix No.2.

9. Adjust the power supply.

This adjustment is necessary for the following reasons:

The power supply is factory-calibrated so that, at normal load, a 220 v rectified voltage corresponds to a 24 v filament voltage. However, under operating conditions, the mean filament voltage may be not equal to 24 v; therefore, when a DC power supply is replaced by an AC supply, the tubes may happen to be operating under abnormal supply conditions. If the mean filament voltage of a given station is within the 23.5 - 24.5 v range, the power supply does not have to be adjusted; if the mean voltage does not fall within the mentioned limits, adjustment is necessary.

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The adjustment should be made in accordance with the following procedure:

a) Change to AC power supply. To do so: install group fuses on the power-supply panel; on the same panel, move the jumpers to the jacks marked "~"; set the voltage selector to the "127" or "220" position, to correspond to the voltage of the power line; switch the system on by means of the toggle switch.

b) Using the portable IEL-4 instrument, measure the voltage at the "Anod" jacks. Adjust the regulator on the power-supply panel until the pointer of the instrument is at "0.5"; this will correspond to a 220 v plate voltage.

c) Measure the voltage at the "~" jacks and compare it with the mean voltage obtained when the station is operating on a DC supply. If the two values differ by more than 5%, the positions of the jumpers between the terminals of row A of the left-side lead-in comb of the power-supply panel should be changed. The positions of the jumpers are given in the basic diagram of the power supply, drawing No.P 133.00.17. When a jumper is moved to the next terminal, the voltage will change by 5%.

10. Check the performance of the signal circuits.

a) Test the signal system for blown fuses. Closing of the signal contact of any fuse should light up the "PRED" lamp on the signal panel and the light bulb of the "PR" transparency; it also should ring the signal bell.

b) Test the signal system of the battery-voltage failure, by removing the fuses P_1 and P_2, one at a time. In both cases, the "BAT" transparency should be illuminated, the bell should ring, and the signal lamps "ANOD" or "NAKAL" (respectively) should light up. In a similar fashion, the circuit which signals failure of the mechanical-inductor voltage is tested. In this case, removing the fuse P_{18} or P_{19} should light the "MI" signal on the signal panel and on the transparency panel; the bell should also ring.

c) Test the signal system of the adjustment limits on the RIL chassis, by moving the RIL capacitors (by means of the "PLOSK.REG." knob) first to one and then to the other extreme position.

In both instances the "PRED.REG." lamp at the RIL panel and the "KCh" transparency should light up, and the bell should ring. When the slant-adjustment capacitor is disconnected from the motor drive, the "PRED.REG." signal on the RIL panel should light. Depressing the "BLOKIR" button should light a signal on the PKCh panel. Whenever the transparency signals are illuminated, the general-signal lamp OSL should also light. When the transparencies and the bell are disconnected by means of the "VYKL.ZV." knob, the "VYKL.ZV." lamp should light; the OSL lamp should stay lit. In the case of the circuit signalizing failure of the control frequency, only the circuit of the signal bell but not that of the "KCh" transparency is interrupted when the "VYKL.ZV." button is depressed.

11. Check whether the operating regime of the station corresponds to the direction of communication. If the given end station is transmitting southward or eastward, the station should operate as an A station, i.e., the lower frequency group 6.3 - 15 kc should be sent into the line. If the station is transmitting northward or westward, it should operate in a B regime, i.e., the upper frequency group should be sent into the line.

If the operating regime of the station does not correspond to the above conditions, the connections should be changed to remedy the situation.

12. Make certain that the station is operating in the required regime: either in the main or in the supplementary frequency spectrum. The operating regime of the station may be selected by changing the connections at the blocks GF-6, GF-9, GF-12, and GF-15 on the chassis of the carrier-frequency generator. When the main spectrum of frequencies is used, the terminals E_2-E_3 of these blocks are connected. When the E_2-E_1 terminals are joined, the station will operate in the supplementary frequency spectrum.

13. Check the carrier-frequency voltages at the modulators, demodulators, and at the group converter.

The level of the carrier frequency fed to the modulators and demodulators is measured at the left-side test block of the carrier-frequency generator panel; the

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level of frequency supplied to the group modulator is measured at the test block of the US-33 chassis.

The carrier-frequency voltage at the modulator and demodulator should be 0.46 - 0.65 v (-0.55 to -0.2 neper); the modulator carrier-frequency voltage of the group modulator should be 0.7 - 1.0 v (-0.1 to +0.35 neper). The voltages can be measured by means of the level indicator of the neper-meter.

14. Check the level of the unbalanced carrier frequencies.

The measurements can be performed by means of the level indicator of the neper-meter (600-ohm input), connected to the jacks at the panel of the filters DK-16.4.

Prior to measurement, the control frequencies should be disconnected. This is done by setting the jumpers at the carrier-generator block to the position "VYKL".

The carrier-frequency level at the terminals IVG_2-IVG_3 should be not less than -2.0 neper. A higher level would require balancing of the modulators. When one modulator is being balanced, the carrier frequencies should be removed from the other two modulators, by short-circuiting the proper jacks at the left test block of the carrier-frequency generator. The balancing is performed by means of a potentiometer located at the test block of the modulator; the potentiometer is adjusted until a minimum level (read on the level indicator) is attained.

15. Measure the control-frequency levels.

The measuring instrument should be connected to the jacks located on the panel of the directional filters DK-16.4. When the level of one control frequency is being measured, the other control frequency should be switched off. The levels of both control frequencies should be within +0.4 to +0.6 neper limits. If the control-frequency levels are beyond these limits, they must be adjusted. The adjustment is made by changing the connections between the terminals A_2-A_5 of the blocks SK-1 and SK-2.

16. Measure the output level of the side frequency in each channel.

For convenience, this level may be measured at the jacks of the DK-16.4 panel instead of at the output terminals of the stand. The output terminals IVG_2-IVG_3 should be connected to a 600-ohm load. One of the connecting lines SL-9 - SL-12 and the 600-ohm resistor (wired to the "600-ohm" jack of the commutation field) are used for this purpose. In addition, high-resistance input of the level indicator should be used.

When a zero-level 800-cycle frequency is connected to the "LIN" jack of a channel, the level of the side frequency at the jacks of the filter DK-16.4 should be $+2.05 \pm 0.1$ neper. The side-frequency level in the first channel of the lower band should be 0.15 neper higher than the side-frequency levels of other channels (thus the transmission damping of the filter K-5.7 is being taken into consideration).

17. Measure the output level of the tone-call at the jacks of the filter DK-16.4 of each channel.

In order to send a tone-call along a channel, the commutator terminals must receive a mechanical-inductor voltage, or else the armature of the relay R_1 at the TV-receiver chassis must be moved by hand. The level of the side frequency of a tone-call, as measured at the jacks in the filter DK-16.4, should be +1.25 to +1.45 nepers.

18. Check the performance of the tone-call receivers of all three channels, in accordance with the procedure discussed in Section 13, Chapter III.

3. Measurement of the Circuit Parameters

Before the final connections to the long-distance line are made, the main parameters of the circuit, whose carrying capacity is to be increased by the equip STAT should be measured. These parameters are: insulation resistance between wires and also between each wire and ground; circuit resistance; resistance of each wire; asymmetry of the circuit and the operating damping of the amplifier section in both directions of communication.

The frequency dependence of the circuit damping should be uniform.

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The B-3 equipment cannot be used in lines whose damping curve has an undulating shape, several maximums, or sharp breaks. Such shape of the damping curve is indicative of distortions due to detuning between the resistance of the circuit and that of the cable inserts, or to absorption in parallel circuits. The causes of distortions should be found and corrected before the equipment is connected to the line.

4. Adjustments to be Made After the Equipment is Connected to the Line

I. Adjusting the Control Frequencies in the Direction A-B and Testing the Performance of the ARU

1. Check the control-frequency levels at the jacks on the panel of the filters D-16.4 when the station is under line load. The level of each control frequency should be from +0.4 to +0.6 neper.

Before measurement, disconnect the control frequencies and measure the interference level at the jacks of the filter DK-16.4. This level should be not greater than -1.5 neper.

2. Block the ARU by pushing the "BLOKIR" button on the PKCh panel and set the flat and the slanted regulator of the RIL to the "0" position; this will correspond to maximum damping of the flat regulator and to minimum steepness of the slant-regulator curve.

3. Adjust the control-frequency levels at the output of all intermediate stations (starting with the first station) and at the output of the reception amplifier of the B station. The sequence of adjustment should be the same in intermediate stations and in the end station.

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The adjustment is made as follows:

First, by simultaneously rotating both RIL regulators, bring the pointer of the right-side instrument on the panel of the control-frequency receivers (the 15-kc control frequency) to the colored segment of the dial.

4. Decouple the regulators. Rotating the slant-regulator alone, then the flat-

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regulator alone, bring the pointers of both instruments to the position "O" at the center of the colored segment of their dials. Couple the regulators.

5. Measure the level of each control frequency. The intermediate-station levels should be measured at the jacks on the panel DK-16.4 of the A side, while the end-station levels should be measured at the "VYKH" jacks of the reception amplifier. When the level of one control frequency is being measured, the other control frequency must be disconnected from the end station. Both control-frequency levels of the intermediate station must fall within the +0.4 to +0.6 neper range; the 9-kc level of the end station must also be in this range, but the level of the 15-kc frequency of that station may be 0.15 neper higher than this. If the measured level is outside of the indicated range, it should be adjusted by means of the RIL; in this case, the sensitivity of the receiver must also be adjusted. To adjust the sensitivity, change the connections at the TUF block of the PKCh panel until the pointer of the instrument returns to the colored segment of the dial. The sensitivity will increase by 0.2 neper, if the wire leading to the terminals G_1-G_5 or B_1-B_5 is removed from a lower-numbered terminal and connected to a higher-numbered terminal; the sensitivity will decrease by 0.1 neper, if the wire leading to the terminals B_2-B_4 or A_2-A_4 is removed from a lower-numbered terminal and connected to a higher-numbered terminal. After the sensitivity of the receiver is adjusted, the RIL must be regulated again until the pointer of the PKCh instrument is in the "O" position. It is not recommended to check the sensitivity before two hours are elapsed from the time when the stand was connected to the line.

6. Check the control-frequency receiver of the ARU for balance, by means of the STAT "PROV.BAL." knob located at the left side of the panel of the KCh receivers. When this button is depressed, the pointer of the instrument of the ARU should be at the beginning of the scale. The receiver must be balanced if the pointer comes to rest more than 2-3 mm away from the beginning of the scale. The balancing is done by means of the potentiometer at the ARU block of the PKCh panel. Balancing of the

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receiver is considered satisfactory if the pointer is within 2-3 mm from the beginning of the scale.

7. Test the performance of the ARU by using the following procedure: Remove the blocking of the ARU and, by turning the "PLOSK.REG." knob, bring the pointers of the instruments on the PKCh panel to the edges of the colored segment of their dials. The ARU should begin to operate, which will be indicated by the fact that the capacitor knobs are slowly rotating; this motion will return the instrument pointers to the center of the colored segments of their dials. The procedure must be repeated twice, moving the pointers first to one and then to the other end of the colored sectors.

8. Test the performance of the ARU signal system.

By changing the damping of the RIL, move the pointer of the ARU instrument on the PKCh panel to read +0.2. Wait 5.7 sec; the ARU signal system should not start to operate until this time is over. Repeat the procedure, by setting the pointer at -0.2. The signal system should become operative when the damping is changed, so that the instrument reads +0.3 to +0.5 neper or -0.3 to -0.5 neper.

9. Place the jumpers on the panel of the carrier-frequency generator of station B in the position "US". Repeat the control-frequency level test.

II. Measuring the Residual Damping in All Channels and Checking the Diagram of Levels in the A-B Direction of Transmission

While performing these measurements, disconnect the other transmission direction by removing the jumpers from the "PER" jacks of the four-wire transit of station B.

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The residual damping of the channels must be regulated in the following sequence:

At the station A, feed the zero level from the generator of the neper-meter to the first channel, into the "LIN" jack. Measure the level at the following points: transit jacks "PER" of station A; jacks at DK-16.4 of station A; "LIN-A" jacks of the commutation fields of all intermediate stations; output of the reception group amplifier of station B; transit jacks of the receiving part of the channel of station B; "LIN" jack of the given channel at station B. The level of the side frequency at the jacks DK-16.4 of the end station A and of all intermediate stations should be +1.95 to +2.15 nepers; at the output of the reception amplifier in station B, this level should be +1.8 to +2.0 nepers. When the amplification regulator of the UNCh is in the position "5", the voice-frequency level should be: -1.6 to -1.4 neper in the transmission transit jacks; +0.4 to +0.6 neper in the reception transit jacks; -0.9 to -0.7 neper in the "LIN" jacks of the channel.

In a similar fashion, the residual damping of the channels is measured and the level diagram is checked for the direction B-A. The direction A-B of transmission should be disconnected during the test. When the residual damping measurements are completed, the connections of both transmission directions should be restored.

III. Testing the Stability of the Channels

At both end stations, remove the load from the commutator terminals of the channel being tested. Set the level indicator to the "-0.5 to 1.5" range and connect the high-resistance input of the instrument to the "LINIYA" jack of the station which will be adjusted. All other channels must be connected to 600-ohm loads. Disconnect the motor drive on the RIL panel and slowly rotate the flat-regulator knob in the direction of increasing calibration numbers until an abrupt movement of the pointer of the level indicator is observed.

Reverse the direction of rotation of the amplification regulator, to find the position when the generation loss occurs. Leave the regulator in this position, STAT measure the residual damping of the channel. The difference between this reading and -0.8 neper will give the stability margin of the channel. This margin should be -0.6 neper or higher. When the stability test of all channels is completed, return the flat-regulator to its original position, i.e., one at which the pointer of the ARU instrument will return to the "0" mark. If the stability margin of a channel happens to be lower than 0.6 neper, the frequency dependence of the residual damping of the channel will have to be measured.

IV. Testing the Tone-Call in All Channels

Perform the following tests:

1. Test the performance of the TV receivers receiving tone-calls from the generator of the station; conduct the test at normal,reduced, and increased signal level.

2. Test the performance of the TV receivers receiving a normal-level pulse of a fixed duration from the generator of the station.

3. Test the performance of the TV receivers of the opposite station.

V. Supplementary Tests and Measurements

The above-described tests and measurements are mandatory and can be performed by means of testing devices forming a component part of the equipment. If additional testing instruments are available, it is recommended that the following supplementary tests be made:

1. Determine the frequency dependence of the amplification of the group equipment in the frequency range of 6.3 - 15 kc, for both directions of communication.

2. Determine the frequency dependence of the residual damping of all channels.

3. Measure the amplitude characteristic of the channels.

The test should be conducted in accordance with the conventional diagrams for measuring the working amplification and the operational damping. In the group-amplification circuits, the amplification in the direction A-B should be measured at the input of the transmission amplifier of station A and at the output of the reception amplifier of station B; the measurements in the direction B-A should be made at the input of the group converter of station B (jacks "Vkh.GT" on the left-side test block of the panel, with the jumpers removed), and at the output of the reception amplifier of station A.

Figures 43 and 45 show frequency characteristics and amplitude characteristics of the channels.

Figure 44 shows typical characteristics of the group equipment. The frequency characteristic of the intermediate-station amplification (both before and after it has been smoothed by the correcting circuits of the BUK) is plotted in Fig.46. The frequency characteristic of the group section of both end stations has a similar slope.

Figure 47 shows the frequency dependence of the RIL damping for the case when the capacitors of both the flat and the slanted adjustment are rotated simultaneously.

Figure 48 shows the changes in the RIL damping as a function of the position of the flat-adjustment capacitor only; in Fig.49, these changes are plotted as a function of the position of the slant-adjustment capacitor.

All above curves are for the A-B direction of communication. The corresponding curves for the B-A direction will have the same shapes, but will be parallel-shifted by 0.4 neper upward with respect to the curves for the A-B direction. The shift is caused by the resistor R_5, which is connected across the output transformer of the BUK.

CHAPTER V

MAINTENANCE TESTING OF THE EQUIPMENT

1. Tube Maintenance

The quality of performance of the equipment is, to a large extent, determined by its tubes. One damaged tube in the main part of the equipment will disrupt operation on all three channels; for this reason, the operation of the tubes should be closely controlled. The present equipment uses new types of tubes, designed especially for long-distance wire communication systems. Although under normal conditions the life of these tubes is very long, 5000 hrs or more, they still require systematic maintenance testing.

a) The service life of tubes will be much shorter, if the filament voltage is too high; therefore the filament-voltage sources must be closely controlled.

As was pointed out on a previous occasion, when the equipment is being installed, the mean filament voltage of a given station must be known beforehand; the initial adjustments of the filament-circuit voltages are made on the basis of this mean value. If, for instance, these adjustments are based on a voltage value that is lower than the actual mean filament voltage, the filaments of the tubes and ballasts will be almost continuously overheated; this will greatly reduce their service life. If the mean filament voltage of the station changes for any reason, all filament circuits of the equipment should be re-adjusted. These re-adjustments do not disrupt the operation of the equipment in the least, since they are made by merely changing the resistances of the quenching resistors in the filament circuits; this is easily done without disturbing the operation of the filament circuits. In making these adjustments, connect a voltmeter across the quenching resistor and, by moving the slide of the resistor, change the voltage drop in accordance with the known change of the mean filament voltage.

If one or more tubes have to be replaced, adjust the filament circuits in accordance with the procedure outlined in Chapter IV, Section 2, Cases 1 and 2.

b) As a rule, a tube will break down not only when its filament is burned out, but also when it loses emission; therefore, the emission of tubes must be periodically tested. The emission current of tubes should be checked daily. Should the emission current of any tube start differing from the specified values, the cathode activity of this tube must be tested (see procedure for measuring cathode activity). In addition, the cathode activity of all tubes must be measured once a week. Tubes with an abnormally low cathode activity must be replaced. The cathode activity is tested without interrupting the operation of the equipment.

2. Testing the Distribution of Levels in Group Equipment

A systematic control of the control-frequency level is necessary for maintaining a proper level distribution in the group-equipment circuits. The ARU circuit is not provided with means for signaling irregularities in the operation of the slant-adjustment; under adverse atmospheric conditions, the performance of the slant adjustment must therefore be controlled by means of the slant-adjustment instrument on the PKCh panel.

It is recommended that the level of the ARU control frequencies at the jacks of the filters DK-16.4 of the transmitting end station and of intermediate stations, and at the "VYKH" jacks of the reception amplifier of the end station be checked once a month. This level should not deviate from the originally set value by more than 0.1 neper in the case of the transmitting side of the end station, or by more than 0.4 neper in the case of the intermediate stations and of the reception side of the end station. When the control frequencies are at a normal level, the pointer of the PKCh instrument will stay within the colored segment of the dial. If the pointer goes beyond the limits of the colored segment, the tuning of the narrow-band filter of the PKCh must be tested. The testing and re-tuning of this filter are performed as follows: Slowly change the capacitance of one trimmer at the narrow-band filter block, until a maximum reading is obtained at the PKCh instrument; repeat this step by changing the capacitance of the second trimmer. The tuning should be done with utmost accuracy. If the pointer of the PKCh instrument stays out of the colored segment of the dial even after the narrow-band filter is re-tuned, the sensitivity of the receiver must be adjusted by changing the connections at the TUF block.

Other measurements required for maintenance of the equipment (such as measurements of residual damping of channels, etc.), must be performed in accordance with the pertaining maintenance instructions.

APPENDIX No.1

BASIC ASSEMBLY DIAGRAM OF INTERMEDIATE STATION

Drawing No.P 131.20.11

1. The Main Route

a) Communication Direction A-B

The line coming from the side of the end station A is connected to the terminals IG_2-IG_3 at the lead-in comb of the stand; if a city cable input is used, the connection is made via the matching autotransformer AT. The line is then connected to the terminals ID_2-ID_3; the IG_1-IG_2 and IG_3-IG_4 terminals are connected by jumpers.

Further, the circuit goes to the points of parallel connections of the filters D-5.7B and K-5.7B (one of the coils of the K-5.7 filter is located on the chassis of the filter D-5.7 so that the diagram of connections between these filters has a somewhat unusual appearance). The output of the filter K-5.7B is wired to the "LIN-B" jacks located in the commutation field. From the points of parallel connections of the filters D-16.4B and K-16.4B, the circuit goes through the filter D-16.4B and then into the regulating artificial line RIL-A. As explained on a previous occasion, the RIL has the following functions:

1. Compensation for the variations in line damping, caused by changes of weather.

2. Establishing magnitude and slope of the frequency characteristic of stSTATn amplification in accordance with the requirements of a given amplification interval (during initial installation of the equipment).

The RIL panel is provided with a flat and a slanted amplification regulator; the functions of these regulators were described in one of the preceding Sections. In addition, a single-stage amplifier BUK is also mounted on the RIL chassis; the

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BUK acts as a buffer between the flat regulator and the group amplifier. Its presence is necessitated by the fact that the flat regulator cannot work directly into the low-resistance input of the group amplifier.

The RIL stage is followed by the group amplifier US-A, which has the function of sustaining a required transmission level at the line terminals. The US-A is followed by the directional filter D-16.4A. From the points of parallel connections of the filters D-16.4A and K-16.4A, the circuit goes through the terminals 5-6 of the directional filter panel to the dividing jacks "LIN-A", located at the commutation field. Further, the circuit goes through the line filter K-5.7 to the terminals IVG_2-IVG_3 at the lead-in comb of the stand. This end of the circuit is also provided with a cable autotransformer AT. If it becomes necessary to connect this transformer, the terminals IVG_1-IVG_2 and IVG_3-IVG_4 are joined by jumpers, and the line from the direction of station B is then connected to the terminals IVD_2-IVD_3.

b) Communication Direction B-A

The circuit of the communication direction B-A is analogous to that of the direction A-B with one exception: facilities are provided for connecting the filter D-30 between the RIL and the group amplifier US-B.

This filter is required when the present equipment is to be used in lines already utilized for operation of a 12-channel equipment.

2. Connecting the Spare Amplifier

The intermediate station is provided with a spare amplifier US.REZ. which, if necessary, can be used for replacing the main amplifier of either direction; the replacement is performed without interrupting the communication. When the spare amplifier is to be connected, the position of the jumpers at the terminal blocks of both the spare and the main amplifier should be altered. First, the jumpers at the spare block of the amplifier must be inserted into the jacks "US-A" or "US-B", (depending

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on which amplifier is being replaced). Then, the jumpers that connect the main amplifier to the circuit are removed.

3. The Level Diagram

The distribution diagram of the levels at individual points of the intermediate stations is shown in Fig.12a. The side-frequency levels are denoted by a continuous line, the dotted line indicates distribution of control-frequency levels.

4. The Circuits For Level Adjustment

In parallel with the output of each group amplifier, a control-frequency receiver is connected to the terminals B_2-B_5. The control-frequency receiver consists of a receiver for automatic level adjustment (Pr.ARU) and of a receiver for slanted (manual) level adjustment (Pr.NR). The control-frequency receivers operating in the communication directions A-B and B-A differ only in the narrow-band filters connected to their outputs. These filters are tuned to frequencies of 9 kc and 15 kc for the A-B direction, and to 18 or 24 kc for the B-A direction.

The 9-kc and the 24-kc frequencies are used for the automatic level adjustment; the 15- and 18-kc frequencies are used in the manual level adjustment. The ARU receiver and the ARU motor (located on the RIL chassis) require a 50-cycle AC current for their operation. This current could be obtained from a station source; however, in order that the ARU will continue to operate during breakdowns of the station voltage, each station is equipped with a separate vacuum-tube 50-cycle generator for each direction of communication. The 50-cycle voltage, delivered by the generator, goes to the terminals 1-2 of the Pr.ARU and to the terminals 3-4 of the RIL. Both control-frequency receivers are provided with permanently-connected instruments for measuring the rectified control-frequency current. These instruments permit a constant control of the level of communication. When communication in one direction is interrupted, the pointers of the instruments of the control-frequency receiver, op-

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erating in this direction, will move to the beginning of their respective dials. If the instrument pointers are outside of the colored sector of the dial, an insufficient compensation of line damping is indicated. In addition to the permanently-connected instrument, the ARU receiver is equipped with a signal device that sends out an emergency signal whenever the level of the 9-kc or of the 24-kc frequency deviates by more than 0.3 neper from a normal value for a time period longer than 5 or 7 sec. The operation of this signal device was explained in the description of the control-frequency receiver circuit.

5. <u>The Tone Channel, the Phototelegraphy Channel, and the Broadcast Channel</u>

The circuit of the voice-frequency channel that enters from the direction of the line A, takes the following route: line terminals IVG_2-IVG_3; filter D-5.7A; contacts IV_1-IV_2 and IV_3-IV_4 of the RSh_2-A relay; input of the filter D-2.8A; contacts II_1-II_2 and II_3-II_4 of the relay RSh_2-A; Picard transformer LT; contacts I-2, I-1 and contacts V_2-V_1 of the relay $RShB_2$; dividing jacks "TK-A" and the terminals IVB_2-IVB_3 of the lead-in comb of the stand.

The circuit of the phototelegraphy channel follows an analogous route to the filter K-2.8A; from here, it goes through the dividing jacks "FK" to the terminals IVB_7-IVB_8 of the lead-in comb of the stand.

When a broadcast channel is formed, the tone channel and the phototelegraphy channels must be excluded. Each side is switched by means of the three relays: RSh_1, RSh_2, and RShV. When the pushbutton "ShV" is depressed, the relays RSh_1 and RSh_2 (located on the signal panel) are actuated. The contacts of these relays will disconnect the filters D-2.8 and K-2.8 and will connect the output of the filter D-5.7 to the output of the "LT" transformer. In addition, the relay RShV is also actuated; the contacts I-2, I-3 and V_2-V_3 of that relay will connect the output of the line transformer to the terminals of the lead-in combs of the broadcast channel (IVB_9-IVB_{10} for the A line, I B_9-IB_{10} for the B line). When the broadcast channel is connected, the "Vkl.ShV" signal lamp will light on the signal panel. The line filters at the other end of the station (from the side of line B) are connected in the same way as the line filters from the side of line A.

The balance device of the duplex telephone amplifier of a voice-frequency telephony channel consists of a balancing line transformer BLT, of balancing filters BDK-2.8 and BDK-5.7, of a balancing auto-transformer, and of a two-link circuit consisting of several resistors and capacitors. The balancing autotransformer or balancing coil is connected only when a line autotransformer is being used. There are two sets of balances; one set (for line A) is wired to the terminals IVG_5–IVG_6 of the lead-in comb of the stand, the other set (for line B) is wired to the terminals IG_5–IG_6. The balancing filters BDK-2.8 and BDK-5.7 are mounted on separate panels; the BLT is mounted on the BDK-2.8 panel; the balancing cable autotransformers and balancing coils are located on the panel of balancing lines.

6. The Power Supply Circuits

The station may be powered either by a DC source capable of delivering 24 and 220 volts, or by an AC source having either 127 v or 220 v voltage. To utilize the latter source, the station is provided with a supply unit which rectifies the AC current to supply plate circuits of the equipment and lowers the voltage to be used in the filament circuits of the tubes. The electric power line is connected to bus bars and terminals located under the housing of the fuse panel.

When using a DC source, the 24-volt voltage for the filament circuits, is connected to bus bars marked "+24" (ground) and "-24". It is recommended that a separate 24-volt source be used for supplying the signal circuit; the source must be connected to the terminal "-24 SIGN" and to the common grounded bus bar. If no separate signal battery is available, the "-24 SIGN" terminal should be connected to the terminal "-24" by means of a jumper. In this case, the signal system for filament-voltage failure will be inoperative.

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The plate voltage is connected to the terminal "+220" and to the grounded bus bar. The four jumpers on the fuse panel must be inserted into the jacks marked "=".

When an AC, rather than a DC source is used, the said jumpers should be moved to the jacks marked "~" and, in addition, the voltage regulator on the power-supply panel should be set to the position "127" or "220", as the case may be. The AC voltage is connected to the terminals "~" on the fuse panel. Also, a signal battery should be connected to the terminals marked "24 SIGN" and "+24". If such a battery is not available, the terminal "-24 SIGN" is connected to the terminal "24 VYPR"; in this case, the signal system for AC voltage failure (at the given stand) is inoperative. The power supply is controlled by means of a toggle switch located at the face of the panel. When the AC voltage is on, a neon indicator lamp will light.

The supply circuits are protected by fuses; group fuses protect the common circuits, and split fuses protect the circuits of individual equipment sections. The fuses P_1 and P_{16} on the fuse panel are group fuses for DC circuits. The group fuses of the AC circuits are located on the power-supply chassis. The same split fuses are used for AC and DC. The fuses P_3 to P_{11} protect the plate circuits, while the filament circuits are protected by the fuses P_{18} to P_{27}; the fuses P_{14} and P_{15} are in the mechanical inductor circuit; the signal circuits and the PVU are protected by the fuses P_2, P_{17}, P_{28}, and P_{29}. All fuses are provided with contacts that signal their burn-out.

Filament Circuits of Tubes

Each filament circuit consists of a split fuse, a ballast (which is disconnected when the equipment uses tubes 10Zh12S and 10P12S), a quenching resistor, a test jack, two series-connected 10Zh12S tubes, and one 10P12S tube, in series with two parallel-connected 10Zh12S tubes. The test jack is used in measuring the filament current; this jack also acts as a circuit-breaker, when a blank plug is inserted. The jacks are located on each individual panel. The method of measuring the filament current

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was described in the "Measurements" Section.

The plate voltage reaches individual components of the equipment via corresponding split fuses. A protective filter, consisting of a choke and a capacitor is included in the plate circuits of most of the chassis. To break a plate circuit, its split fuse must be removed from the holder.

7. Signal Circuits

An intermediate station is provided with means to signal the following events:

1. Burn-out of any of the group fuses or split fuses.

2. Filament-voltage failure.

3. Plate-voltage failure.

4. Failure of the call-current voltage.

5. Changes in level of the ARU control frequency at the output of the group amplifier of either communication directions; the changes are signaled whenever their magnitude is greater than 0.3 - 0.5 neper and their duration longer than 5-7 sec.

6. Instant at which the automatic level regulator approaches one of its deflection limits.

7. Blocking of the ARU.

8. Change from automatic to manual adjustment of the slope of the amplification-frequency characteristic.

The signaling is achieved by means of commutator bulbs located on panels. In addition, when cases 1-6 occur, a stand signal lamp "OSL" will be lit and a signal bell will ring. The closing of the signal-bell circuit occurs simultaneously with the closing of the circuits of the light bulbs of the corresponding transparent signs, namely: PR - for the fuses, BAT - for the battery voltage, MI - for the mechanical inductor, KCh - for the control frequency. In all other cases, the all-stand and the row (transparencies) signal system remains inoperative.

The lamps for local and for general signaling will stay lit until the cause of the signal is removed. The bell and the transparency illuminators may be switched off by depressing the "VYKL.ZV" button located on the signal panel. The button has no caging mechanism; when this button is depressed, the identically-marked lamp above will light and stay lit until the trouble is corrected.

The signal-circuit relays and most of the local signal lamps are located on the signal panel. Failure of the filament voltage and of the call current is signalized over the relays RVT, RN, and RA; these relays drop out whenever the corresponding voltages are interrupted and their contacts close the corresponding signal circuits. Burn-out of fuses is signaled by means of the relay RRP. Each of the named relays has four groups of contacts. The contacts II-1 and II-2 close the circuits of local signaling; the contacts II-3 and II-4 close the circuit of the signal bell; the contacts IV-1 and IV-3 close the circuit of the "OSL" bulb; the circuits of the transparency light bulbs are closed by the contacts IV-3 and IV-4*. The relays RBZ are blocked when the button "VYKL.ZV" is depressed; this closes the circuits of the signal bell and of all transparency illuminators. Several 50-ohm resistors are connected into the local signal circuits, to reduce their voltages and thus to increase the service life of the signal lamps.

Some of the signal relays are located on the control-frequency receivers chassis. These relays are discussed when describing the operation of components on whose panels they are located.

8. <u>The Voice-Frequency Ringing Device and the Commutation Field</u>

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The intermediate station is equipped with a two-wire voice-frequency ringing system, which is used for making service calls. The system is composed of two stan-

*The functions of the contact group II of the relay RRP are performed by the contacts of group I; those of group IV – by contacts of group V.

dard panels: a microtelephone panel and a panel of a two-wire PVU. The system and the commutation field (consisting of separate panels with jacks) are located at the center section of the stand.

On the general assembly diagram of the station, the PVU is represented by individual squares; the connections of outside circuits to these squares are also shown. The basic assembly diagram of the PVU is shown in drawing No.P 134.60.24. Most of the commutation-field jacks are shown in the lower part of the station diagram; other jacks are depicted as a part of circuits to which they belong.

The dividing jacks "TK" and "FK" of both the A and the B side are connected to, respectively, voice channel and photochannel. The jacks "LIN-A" and the "LIN-B" are connected to the input of the directional filters. The output of the level indicator is wired to the jacks marked "UU". The other jacks fulfill various commutation functions. The two-wire PVU permits to initiate a call and to monitor the tone-channel communications. The two-wire PVU is connected to the "TK" jacks and to the jacks of connecting lines by means of a four-wire plug.

9. Measurements

The transmission levels at various points of the communication circuit may be measured by means of the level indicator mounted to the station stand.

The level indicator is switched on by a switch at the UU panel. The input resistance of the indicator is 600 ohms when the lower jack is used; this input resistance is over 10,000 ohms when the upper jack (marked "VYSOKOOMN") is used. The total range covered by the level indicator is −6 to +4 nepers. By means of a rotary switch, this range may be covered in 2.0-neper steps. The frequency range of the indicator is 300 cps to 30 kc. The input of the level indicator is also wired to the jacks PVU and to "UU" of the commutation field. At these points, the input resistance of the instrument is 600 ohm, but may easily be changed to 10,000 ohms by simply inserting a blank plug into the "VYSOKOOMN" jack on the UU panel.

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The control-frequency level and the level of side frequencies at various points of the circuit may also be measured by means of the level indicator. To facilitate this measurement, most of the tube-containing stages (among these: US-A, US-B, RIL-A, RIL-B, and G-50) are provided with special test jacks. In addition, these measurements may also be made at the jacks "LIN-A" and "LIN-B". A portable test instrument, consisting of an ammeter (having 0.15, 0.5, and 1.0 amp ranges) and a microammeter (1.0 milliamp range), is provided for measuring the filament voltages, emission currents, and emf of the electric supply sources. The instrument also contains variable resistors for regulating the filament voltage when making cathode-activity measurements. The ammeter is used in filament-current measurements; the plate currents are measured by means of the milliammeter.

The test instruments are connected to the circuits by means of test leads provided for that purpose. The ammeter lead ends in a three-wire plug which can be inserted into the test jacks of the chassis containing vacuum tubes.

The portable instrument is provided with a switch which, by changing connections in the instrument circuit, makes it possible to use the instrument for either measuring the filament and plate currents or the cathode activity. In the former instance, the ammeter of the instrument is connected to the neck and head of the three-wire plug; when this plug is inserted into the test jack of the circuit to be tested, the ammeter is in series with the other circuit components. The value of the current is then read off the ammeter dial, in the range selected by the range switch. The portable instrument cannot be used for filament-current measurements when the station is operating on AC.

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The microammeter is wired to a two-wire cord, ending in a two-prong plug. In making measurements, this plug is inserted into one-wire jacks of the plate circuits. The numbers engraved above each of these jacks, are conversion factors; the reading of the microammeter must be multiplied by these factors.

In this instance, a cord with a three-wire plug on one end and with a two-prong plug at the other end must be used. The three-wire plug should be inserted into the jack "IZM" and the two-prong plug, into the test jacks of the plate circuit to be tested. The same test leads are used when the circuit of the test instrument is changed to suit the conditions under which the cathode activity must be measured. In this case a temporary circuit for supplying the filament of the tube with direct current and with rectified current is formed. This circuit consists of: additional contact of the test jack; body of the jack; body of the three-wire plug; filament voltage rheostat, located within the test instrument; ammeter; neck of the plug; and filament of the tube. Such arrangement permits simultaneous adjustment of the filament voltage and observation of the plate-current variations. The filament, the plate, and the AC voltages are also measured by means of the portable instrument. The instrument, in this case, is connected to suitable test jacks on the signal panel, and its microammeter is read. The "0.5" reading of the microammeter will correspond to normal values of all measured voltages; this is made possible by suitably shunting the test jacks and by inserting an additional resistor in the circuit being measured.

If the voltages of the electric supply sources deviate by not more than the allowed ±10% from their nominal normal values, the pointer of the microammeter should remain within the colored segment of the dial. A copper-oxide rectifier, located on the signal panel and supplied with 24-volt AC voltage from a power-transformer winding, is used in measuring AC voltages.

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APPENDIX No.2

THE IEL-4 VACUUM-TUBE TESTER

(Description of the Instrument and Operating Instructions)

I. Purpose of the Instrument

The vacuum-tube tester IEL-4 is a supplementary portable testing instrument to be used with the long-distance equipment; the instrument is intended for testing vacuum tubes under actual operating conditions. The instrument may be used in the following types of equipment: SUTU; V-3; NUS-3; V-12; K-12; TT-12/16, and others.

Since all necessary additional resistors, shunts, rectifiers, and other special devices are built right into the long-distance equipment parts, the following measurements may be made by means of the IEL-4 instrument:

1. Filament-current measurements in circuits, supplied by direct-current voltage.

2. Measurements of total filament voltage of tubes, supplied with either direct or alternating current.

3. Emission-current measurements.

4. Cathode-activity measurements.

5. Measurement of plate voltage, as delivered to the stand.

II. Technical Data

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The vacuum-tube tester is equipped with two magnetoelectric instruments:

1. An ammeter, to be used for measuring the filament currents. The instrument has three ranges:

from 0 to 100 ma

from 0 to 0.5 amp

from 0 to 1.0 amp

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2. A microammeter, to be used for all other measurements. The instrument has two main ranges:

from 0 to 1.0 ma

from 0 to 100%,

and a supplementary range, from 60 to 100%.

Test leads, provided with the instrument, are used in connecting it to the filament and plate circuits of the equipment.

III. Structural Data

The vacuum-tube tester IEL-4 consists of a metal box with a cover and with an internally-attached metal panel.

The following components and controls are located under the cover, on the metal panel; two measuring instruments; two rheostat knobs; a range switch; a switch for changing the circuit connections of the instrument.

Leads for connecting the tester to the test jacks of the equipment components are brought out through openings in the panel.

IV. Description of the Basic Diagram and of the Operating Principle of the Instrument

The basic diagram of the vacuum-tube tester is shown in the drawing No.P 133.80.53.

1. Measurements of Emission Currents of Vacuum Tubes; Measurements of the Emf of the Voltage Sources

To measure the emission currents and the voltages, the switch K_2 must be in "izm. toka i napr" (measuring current and voltage) position (Fig.No.1).

The measuring circuit which is formed when the switch K_2 is in this position consists of the microammeter "mA" (200 μ amp movement), and of a supplementary resistor R_{10} that brings the total resistance of the circuit to 2000 ohms. The dial of the microammeter is graduated from 0 to 1 ma.

By means of a test cord ending in a two-prong plug (distance between the prongs: 13 mm), which may be inserted into the test jacks of the long-distance equipment, the instrument is connected to low-ohmic resistors (shunts) of the tube circuits. As a rule, these resistors are between the ground and the cathode of a tube; the resistors carry the full emission current of the tube, equal to the sum of the plate and the screen-grid currents.

In some cases, when it is impossible to have shunt resistors in the cathode circuit, they are located in the plate circuit of the tube.

The emission current is determined by measuring the voltage drop on these shunt resistors.

The voltages of the supply sources are measured in a similar fashion and by means of the same microammeter. These measurements are facilitated by a marked sector and an index line on the dial of the instrument.

Because of the additional resistors and shunts incorporated into the test circuits of the long-distance equipment for this purpose, the pointer of the microammeter will remain at the center of the marked-off dial sector as long as the voltages being measured are at their normal values.

The limits of the sector correspond to a ±10% voltage fluctuation.

The measurement of the 24-volt AC voltage is facilitated by copper-oxide rectifiers in the test circuits of the long-distance equipment.

2. Measurement of the Filament Currents

The circuit for measuring the filament current is formed when the key K_2 is in the "izmer. toka i napr." (meas. curr. and voltg.) position (Fig.2). This circuit consists of the ammeter amp/ma, the range key K_1, and the ammeter shunts R_4, R_5, and R_6.

The R_4 shunt is connected for making measurements in the 100-ma range; the 0.5-amp range is covered by connecting the R_4 and R_5 shunts; all three shunts are

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used when making measurements in the 1.0-amp range.

The 0 - 100 ma scale is used for measuring the filament currents of the 12Zh1L and 10Zh1L tubes; the filament currents of the 10Zh12S and 7Zh12S tubes are measured with the 0 - 0.5 amp dial, while the 0 - 1.0 amp scale is used for measuring the current of the 10P12S and 7P12S tubes.

The test cord used in filament voltage measurements is connected to the neck and head of a three-wire plug (6.5 mm dia.); this plug fits the special jacks provided for the purpose of filament current measurements.

When the key K_2 is in the position "Vykl", the ammeter is shorted; this prevents an accidental breaking of a filament circuit while inserting the plug of the test lead into the jacks for the filament-current measurement.

3. Cathode-Activity Measurements

When the instrument is used for measuring the cathode-activity, the key K_2 should be in the "izm. akt. katoda" (meas. cath. activity) position (see Figs.3a and 3b).

As seen from the diagram in Fig.3a, the resistors R_3 and R_8, operating as voltage regulators, are in series with the ammeter. The pointer of the instrument is aligned with the 100% mark by means of the fine-tuning rheostat R_9 which is in series with the microammeter (Fig.3b).

In conducting cathode-activity measurements, the three-wire plug of the instrument is inserted into the filament test jack, while the two-prong plug is used for making connections with the plate circuit of the same tube. STAT

The cathode activity is measured by reading the relative (percent) changes in the plate current that correspond to a reduced filament current.

First, the filament current is adjusted to the nominal value by means of the rheostats R_3 and R_8, and the pointer is brought to the 100% mark by means of the rheostat R_9. Next, the filament current is given a predetermined decrement (again,

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by means of R_3 and R_8) and the corresponding plate current (in percent) is read.

V. Operating Instructions for the IEL-4 Instrument

1. Emission-Current Measurements

For making emission-current measurements, the instrument is connected to the corresponding jacks by means of the two-wire plug; the key K_2 should be in the "izm. toka i napr." position.

The microammeter reading, multiplied by the factor marked next to the test jack to which the instrument is connected, will give the omission current in milliamperes.

2. Filament Current Measurements

To measure the current in a filament circuit, the instrument is connected to a special test jack by means of the three-wire plug. The proper measurement range of "100 ma", "0.5 amp", or "1.0 amp" should be selected by means of the key K_1; the key K_2 should be in the "izm. toka i napr." position.

The current is read off the scale selected by the key K_1.

Note: the emission current and the filament current of a tube may be measured at the same time.

3. Cathode-Activity Measurements

To measure the cathode activity, the instrument is connected by means of the three-wire and the two-wire plugs, inserted into the corresponding test jacks of the equipment components.

Before connecting the instrument, set the "grub. reg. nakala" (coarse filament adjustment) to the mark 3-4. Set the key K_2 to the "izmer. akt. katoda" position; by means of both the "grub. reg. nakala" and the "plavn. reg. nakala" (continuous filament adjustment) rheostats, adjust the filament current to a value equal to the mean filament current for the given circuit.

After waiting not less than 3 min, bring the instrument pointer to the 100% division on the main scale, by means of the "ust. na 100 prots." (set to 100%) rheostat.

By means of the "plavn. reg. nakala" and the "grub. reg. nakala" rheostats, reduce the mean filament current to a value given in the description of the long-distance equipment.

Wait until the cathode is stabilized at the new temperature (not less than 3 min), then read the relative decrease of the cathode activity from the main scale. If it is impossible to set the instrument to 100% on the main scale, the 100% division of the auxiliary scale must be used.

In the latter case, the relative decrease in cathode activity should also be read off the auxiliary scale.

Note: All above measurements can be performed while the equipment is in operation; the test instruments cause no interference.

Test-Circuit Schematics

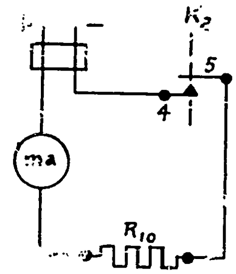

Fig.1

Circuit for Measuring the Emission Current and the Source Voltages

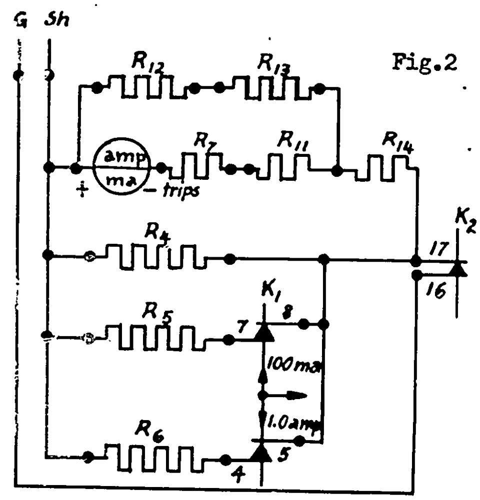

Fig.2

Circuit for Measuring the Filament Current

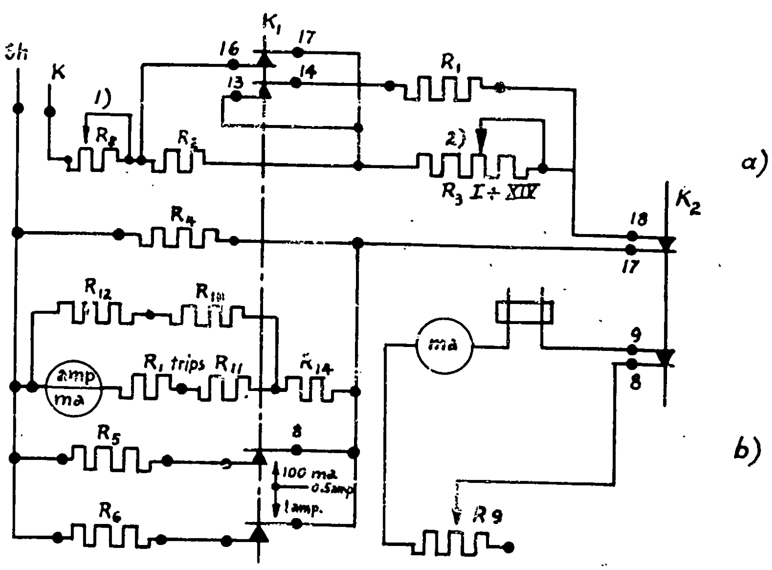

Fig.3

a)

b) STAT

Circuit for Measuring the Activity of a Cathode

1) plavn. reg. nak. (continuous filament adjustment); 2) grub. reg. nakala (coarse filament adjustment); 3) Ustanovka na 100% (set to 100%)

APPENDIX No.3

CONNECTING THE VOICE-FREQUENCY RINGING SYSTEM IN A FOUR-WIRE CIRCUIT

I. Connecting the GTV and the PTV to the Four-Wire Part of an End Station (with a Differential System)

1. Connecting the GTV

a) On the left-side of the PTV chassis, move the jumpers from the terminals A_2-A_3 and B_2-B_3 to, respectively, the terminals A_2-A_1 and B_2-B_1.

b) On the left-side comb of the PTV chassis, move the jumpers from the terminals A_5-A_4 and B_5-B_4 to, respectively, the terminals A_5-A_6 and B_5-B_6.

c) On the lead-in comb of the stand I, remove the jumpers joining the terminals III G_1-III G_3 and III G_2-III G_4.

d) On the lead-in comb No.1 of the stand, insert jumpers between the terminals III E_3-III G_3 and III E_3-III G_4; III E_1-III G_1 and III E_2-III G_2.

Note: The jumpers between the terminals V_3-V_5 and V_3-V_6 of the left-side comb of PTV chassis should be removed.

2. Connecting the PTV

a) On the left-side comb of the PTV chassis, remove the jumpers between the terminals V_9-A_9 and V_8-B_9.

b) On the left-side comb of the PTV chassis, place jumpers between the terminals V_{10}-B_9.

c) On the left-side comb of the PTV chassis, place jumpers between the terminals A_3-A_8 and B_3-B_8.

d) On the left-side comb of the PTV chassis, place jumpers between the terminals A_4-A_7 and V_4-V_7.

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e) On the No.1 lead-in comb of the stand, place jumpers between the terminals III V_9-III G_5 and III V_{10}-III G_6.

II. Connecting the GTV and the PTV to the Four-Wire Part of an End Station Whose Differential System is Disconnected

In this case the call may be sent by means of direct current only. There are two possibilities:

a) Two separate wires may be used, one for sending, the other for receiving the call. The call is sent by grounding the terminal III B_9 of the No.1 lead-in comb of the stand.

The incoming call will ground the III V 10 terminal of the No.1 lead-in comb of the stand.

b) A single wire may be used for sending and receiving the call. In this case, the terminals A_2-B_3 of the right-side comb of the PTV chassis should be connected by a jumper.

The call is sent out by grounding the terminal III B 10 on the No.1 lead-in comb of the stand.

An incoming signal will ground the same terminal.

1. Connecting the GTV

a) On the left-side comb of the PTV chassis, remove the jumpers joining the terminals A_4-A_5 and B_4-B_5.

b) On the left-side comb of the PTV chassis, place jumpers between the terminals A_5-A_6 and B_5-B_6.

c) On the No.1 lead-in comb of the stand, remove the jumpers joining the terminals III E_9-III D_9 and III E_{10}-III D_{10}.

d) On the No.1 lead-in comb of the stand, place jumpers between the terminals III E_9-III V_1 and III E_{10}-III V_2.

e) On the left-side comb of the PTV chassis, place jumpers between the terminals V_3-V_5 and V_4-V_6.

Note: The III E_1 and III E_2 terminals of the No.1 lead-in comb of the stand are assumed to be the transmission input terminals.

2. Connecting the PTV

a) On the left-side comb of the PTV chassis, remove the jumpers joining the terminals V_9-A_9 and V_8-B_9.

b) On the left-side comb of the PTV chassis, place jumpers between the terminals A_4-A_1 and B_4-B_1.

c) On the left-side comb of the PTV chassis, place jumpers between the terminals A_9-A_7 and B_9-B_7.

d) On the No.1 lead-in comb of the stand, place jumpers between the terminals III E_3-III V_5 and III E_4-III V_6.

Note: The terminals III V_9 and III V_{10} of the lead-in comb of the stand are assumed to be the reception output terminals.

The lead-in comb designations quoted in the present Chapter correspond to the second channel (comb III). The appropriate connections for the first and the third channels should be made on, respectively, the comb II and IV, in agreement with the procedure outlined above.

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