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# THE NUS-3 UNSERVICED REMOTELY SUPPLIED AMPLIFYING STATION

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In 1954 Soviet industry began the series production of the NUS-3, unserviced, remotely-supplied amplifying station, developed upon order of the Ministry of Communications USSR. The present article gives the basic technical data of the NUS-3 station, examines the scheme, purpose, and area of use of this station, and describes the operation of its individual units.

## BASIC TECHNICAL DATA

The NUS-3 unattended, remotely-supplied amplifying station of the three-channel system of high-frequency telephony is designed for operation over copper and bimetallic open-wire circuits in the frequency spectrum adopted for the V-3 three-channel system (6.3-26.7 kc). The NUS-3 may be used both as a constantly operated intermediate amplifying station and as an auxiliary amplifying station operating temporarily under unfavorable meteorological conditions.

The NUS-3 may be powered remotely from an adjacent amplifying station or from local exchange sources of current. In the first case the NUS-3 is connected to the power circuit by transmission of the supply voltage in the conductor of the telephone circuit, whereby at the NUS-3 the amplifying equipment in both directions of transmission is connected at the same time. Upon disconnecting the NUS-3 amplifying equipment a bypass loop is created in its circuit, containing only K-5.7 filters and a filter equalizer FV (Figure 1).

In case the NUS-3 is used as an auxiliary amplifying station an arrangement is provided whereby, in accordance with previously chosen conditions, the station is automatically disconnected when line attenuation decreases to a point where operation of the station is no longer necessary.

If the NUS-3 is used as an attended intermediate station, it obtains its power from nearby sources: from a single plate battery or from two batteries (a filament battery and a plate battery).

The maximum gain of the NUS-3 station is the same as for the PV-3 intermediate amplifying stations and amounts to not less than 3.25 nepers (slope characteristic) for a frequency of 14.7 kc and not less than 5.5 nepers (slope characteristic) for a frequency of 26.7 kc. The rated sideband level at the output of the NUS-3 is 1.5 nepers. The automatic gain control with which the station is provided insures regulation of the gain over a range of not less than 1.5 nepers for the slope characteristic and 3.6 nepers for the flat characteristic.

The NUS-3 uses one type of vacuum tube, the total number of such tubes being 16. In order to reduce current requirements in remote supply the filaments of all tubes are connected in series in a single circuit. The total current in remote supply of the NUS-3 does not exceed 190 ma. The voltage applied to the NUS-3 in remote supply must lie within the

range of 160± 8 volts. The station is designed for operation at temperatures from -5 to + 40°C.

## LOCATION OF THE NUS-3 STATION ON TRUNK LINES

If the NUS-3 is used in constant operation as an amplifying station with remote supply, its gain will permit compensating for attenuation in the repeater section of a 4-mm copper circuit about 250 km in length with a distance of 20 cm between conductors under meteorological conditions of "25-mm icing". In this case from the amplifying station furnishing the voltage supply a standard 206-volt plate battery must be connected to the line (from the output of an SARN [automatic voltage regulator panel]).

In operation of the NUS-3 on 4-mm bimetallic circuits (with a copper layer of 0.4 mm) the greatest length of a repeater section, determining the gain of this station, is approximately 225 km. In order to provide remote supply over such a distance the feeding station must apply a stepped-up voltage of approximately 240 volts to the line.

In using the NUS-3 as an auxiliary amplifying station connected only under severe meteorological conditions, the greatest distance from the feeding PVS-3 station to the NUS-3 station will be 120-130 km. In this case, whether operating on copper or bimetallic circuits, the NUS-3 may be remotely fed from a standard 206-volt plate battery.

## BLOCK DIAGRAM OF THE NUS-3 STATION

The block diagram of the NUS-3 is given in Figure 1. The station is connected with the line through a protective unit consisting of SN-05 fuses, RA-350 and RB-280 dischargers, and a bleeding coil DK. After the protective devices the circuit contains the units for receiving the remote supply -- chokes Dr and DP, and buffer capacitors $C_1$ and $C_2$.

Line-filter assembly DK-5.7 and DK-2.8 as well as the matching autotransformers AT used in the NUS-3 are similar to the corresponding units in the V-3 system.

The output of the K-5.7 relay in each direction of transmission is connected with the contacts of bypass-connector relay RV). If the supply is connected (that is, if the station is in operation), the RVO relay holds its armature in the drawn position, with the result that the output of the K-5.7 filter is connected to the taps of parallel connection of the directing filters DK-16.4. Upon connection of the supply this relay closes only after the total plate current drawn by the station reaches the normal value.

When the supply is disconnected the RV relay releases the armature, as a result of which the bypass circuit is connected. In this case the outputs of the K-5.7 relays are interconnected across filter equalizer PV. In bypass operation the station has an attenuation of 0.55 neper in the frequency range from 6.3 to 24.7 kc.

The output of the receiving filter in each direction of transmission is connected with the input of an adjustable artificial line arrangement RIL. The RIL equipment consists of artificial lines with sloped and flat regulation and a buffer-amplifier stage BUK. The BUK output of the lower group of frequencies is connected to line amplifier LUS. In the direction of the upper group of frequencies between the BUK output and the LUS input there is connected a K-24.0 filter limiting the upper frequency band.

The line amplifier has three stages of amplification, the output stage containing two tubes operating in parallel. The gain afforded by them in the frequency range of 6.3-26.7 kc is 6.6 nepers. The amplitude characteristic of the line amplifier is practically a straight line up to a level of 3 nepers at the output. In conjunction with this the rated sideband level of one channel is 1.5 nepers.

Connected in parallel with the output of the line amplifier is the pilot-frequency receiver PKCh, controlling operation of the ARU [automatic gain regulator] motor according to changes in the level of the pilot frequency. The level of each of the pilot frequencies at the output of the station is 0 nep. The 50-cycle current for the ARU motor is provided by a single-tube G-50 generator for each direction of transmission.

## TRANSMISSION AND RECEPTION OF THE REMOTE SUPPLY

Transmission and reception of the remote supply is achieved by a "two-wire-to-ground" arrangement. From the originating station the remote voltage is applied to the line across a transmission deck DP, containing the necessary regulating, monitoring, and signal instruments as well as a transmission coil DP. Through the mentioned instruments the positive side of the plate battery is connected to the center tap of coil DP, which is connected in parallel with the transmission circuit.

The NUS-3 has a similar receiving coil Dr. DP. Its center tap is connected with the winding of remote-feed relay RDP, in series with which a cold-cathode thyratron Tx-1 is connected. With the remote supply disconnected this thyratron prevents closing of relay RDP from telegraph signals, since a voltage of not less than 130 volts is required to fire the thyratron.

When the remote supply is fed to the line the thyratron fires, as a result of which relay RDP and connects the mid-point of coil Dr. DP with a load consisting of the filament, plate, and relay circuits.

The arrangement provides for application of the remote supply along both sections of the circuit adjacent to the NUS-3. One of the supplying stations is the principal station and the other is the standby. In case of interruption of the supply from the principal station the equipment of the NUS-3 automatically switches over to the standby station.

## SYSTEM OF AUTOMATIC LEVEL REGULATION

The ARU system consists of three units for each direction of transmission -- an adjustable artificial line RIL, a pilot-frequency receiver PKCh, and a G-50 generator. The principal function of the ARU consists in automatically adjusting the gain according to changes in the attenuation of the line. In addition, at the NUS-3 installation the ARU units automatically disconnect the station when the line attenuation decreases. This disconnection is preceded by a continuous drop in gain of the amplifier section of the station, continuing to the point where attenuation of the amplifying section is not equal to the attenuation of the bypass circuit.

The slope-regulating artificial line in the RIL arrangement (Figure 2) contains six sections which, across a special switching system with changeable terminals, is connected with stator sections 0-60 of the slope-regulating capacitor of the motor-capacitor block. The rotor of the slope-regulating capacitor is connected with a flat-regulation artificial line consisting of seven sections with their inputs connected to stator sections 60-0 of the flat-regulating capacitor. The output of the last (seventh) section connects with stator section -10 of this capacitor.

The attenuation of the seventh section is inserted into the circuit with the automatic disconnection of the station, whereupon the amplifier section of the station introduces an attenuation equal to that of the bypass circuit. This is necessary in order that connection of the NUS-3 will not cause rapid changes in the residual attenuation of the channels. By changing the terminals the switching arrangement of the RIL unit permits connection of a different number of sections of the artificial line to the slope-regulating capacitor, thereby obtaining the same slope for the gain curve with different positions of the slope regulator.

If the flat regulator is set higher than the slope regulator, the terminals with the plus sign are selected; if the flat regulator is set lower than the slope regulator, the terminals with the minus sign are selected. After adjusting the regulators this permits matching similar scale divisions of the flat and slope regulators, according to the attenuation of the given line, without changing the frequency response for the gain established in the process of adjustment. This circumstance is of great importance in automatic disconnection of the NUS-3; if the scale divisions of the regulators are not matched, then one of the regulators will not be able to reach the extreme position (that is, the -10 position). The result will be that the attenuations of the amplifier section and of the bypass circuit will not be balanced, which causes rapid changes in the residual attenuation of the channels when the station is switched on and off.

The necessity for the described arrangement is due to the operating principle of the ARU system, in which both regulators are mechanically coupled under operating conditions.

By means of the switching arrangement the scale divisions of the regulators may be matched with an accuracy of ±5 divisions. The remaining difference in the positions of the regulators is balanced by an additional section (-10) of the slope-regulation capacitor, which is connected with variable voltage divider $R_4$ at the input of the RIL arrangement. This system permits additional continuous adjustment of attenuation in the RIL arrangement upon disconnecting the station.

For automatic disconnection of the NUS-3 the motor-capacitor block on the RIL deck is provided with a special cam on the same axis as the capacitor motors. Upon aligning the station it is set in a fixed position relative to the scale of the flat-regulation capacitor and is fastened in this position. The position of the cam depends on the ratio of the lengths of the repeater sections adjoining the NUS-3 and is determined according to a special chart.

In line with the cam is a group of contacts which close upon encountering the cam extension. Closing of the contact actuates an arrangement for automatic reduction of the station gain to zero. With this the ARU motors turn the regulators in the direction of decreased gain to their extreme position, after which the station is switched over to the bypass circuit.

Disconnection of the NUS-3 is controlled by means of automatic level regulators (Figure 3). The current of the pilot frequency, fed to the PKCh receiver, is amplified and applied to thermistor T, which is located in one of the arms of the ARU differential system. With the pilot frequency at the normal level the differential system is balanced and the current from the G-50 generator does not pass through it to the amplifier and on to the motor winding. If the level changes, then the resistance of the thermistor changes, as a result of which the 50-cycle

current appears at the amplifier input, the motor winding is fed, and the motor goes into operation.

In addition, the current of the pilot frequency is fed through a copper-oxide rectifier KV to a neper meter, indicating the level of the pilot frequency. The winding of ARU blocking relay $RB_1$ is connected in series with the meter.

The ARU system is blocked upon the disappearance or sharp reduction (by 1-1.5 nepers) of the level of the pilot-frequency current. Blocking of the ARU is achieved by three relays ($RB_1$, $RB_2$, $RB_3$) for each of the directions of transmission. With the pilot-frequency current at the normal level relay $RB_1$ holds its armature in the drawn position and its contacts shunt the winding of relay $RB_2$. Current then flows through the windings of relays RPN and $RB_3$. If the level of the pilot frequency drops sharply, relay $RB_1$ releases its armature and relay $RB_2$, being shunted, closes and opens the feed circuit for the 50-cycle current from the G-50 generator. Both windings of the motor are deprived of feed and the motor stops.

Relay $RB_3$ serves to prevent blocking of the ARU upon connecting the station, when the regulators are in the -10 position and the pilot-frequency level at the LUS output is extremely low. This insures connection of the NUS-3 to the circuit regardless of the level of the pilot frequency.

With the level close to the rated value (after relay $RB_1$ has closed and the armature of relay $RB_2$ is released), relay $RB_3$ closes and prepares the circuit: blocking the ARU (by the contacts connected in the G-50 generator circuit in parallel with the contacts of relay $RB_2$), lowering the gain to zero (by the contacts in the balance circuit of thermistor BT), and disconnecting the station (by the contacts in the winding circuit of relay RVP).

Automatic lowering of the gain to zero and disconnection of the NUS-3 occur in the following manner. With a decrease in the attenuation of the line there comes a moment when the cams in the motor-capacitor blocks of both directions close their contact groups, shunting the winding of relay RPN. (Figure 3 shows only one relay RPN; actually, there are two -- one for each direction of transmission.) The latter releases its armature and its contacts open the balance circuit of thermistor BT, with the result that the regulators, independent of the pilot-frequency level, begin to turn in the direction of a decrease in gain. When they arrive at the extreme low position of -10, contacts in the motor-capacitor blocks close and current flows in relay RVP. This relay closes and breaks the tube filament circuit and the circuit of relay RVO, connecting the bypass circuit.

With the disappearance of the supply current, signal devices at the supply station operate, indicating that the NUS-3 has been automatically disconnected. Transmission of the remote supply is then discontinued.

If a standby supply is fed along a second repeater section, then upon disconnection of the NUS-3 the armature of a standy-supply blocking relay is drawn; this relay is fed from the standby side of the line (not shown in the diagram). In this case the signal devices at the standby station also go into operation and the station personnel disconnect the supply.

## LAYOUT OF THE NUS-3 STATION

All the basic equipment of the NUS-3 is placed in a moisture-proof cabinet (Figure 4) 1,670 mm high, 670 mm wide, and 545 mm deep. The weight of the cabinet is 340 kg. The cabinet is of all-welded construction over a frame of angular steel. Decks are fastened to the frame from two sides.

The cabinet has two doors, front and rear. The doors are provided with locks and rubber sealing strips. A window in the front door permits checking the operation of the ARU devices without opening the cabinet. The conductors are led in through collars with rubber gaskets at the top of the cabinet. On the outside left wall of the cabinet there is a TAU-1-MB handset for service calls.

The balancing equipment for the voice-frequency channel (consisting of two assemblies of balancing networks, filters, and transformers) is placed in a separate balance-filter rack (SBF). This is done because not all points at which NUS-3 stations are installed will also be equipped with voice-frequency amplifiers. The SBF rack has the following dimensions: 685 mm high, 671 mm wide, 426 mm deep.

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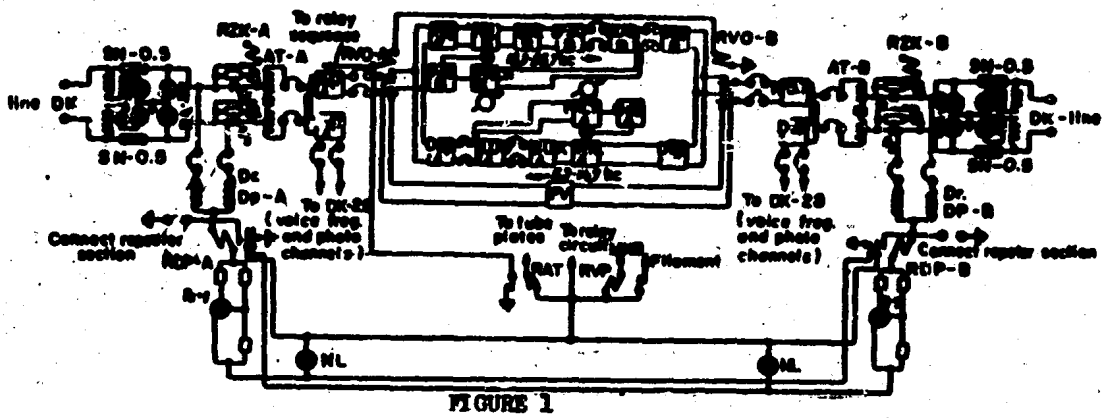

FIGURE 1

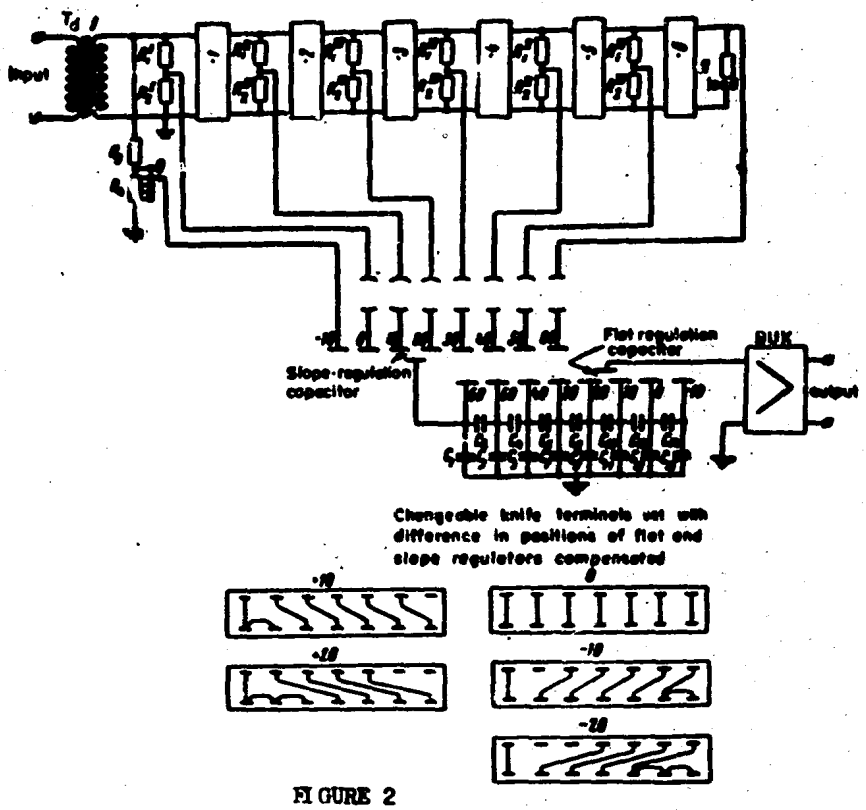

FIGURE 2

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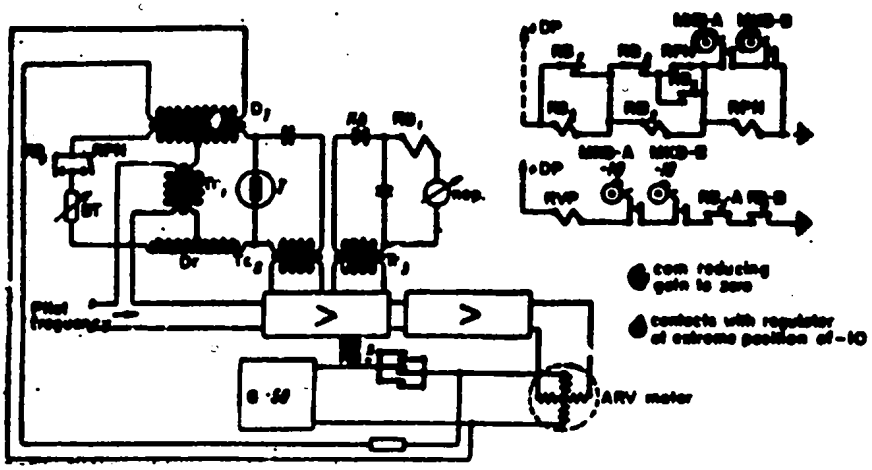


FIGURE 3

FIGURE 4

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