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MAINTENANCE AND REPAIR OF RADIO-COMMUNICATION EQUIPMENT 1/

by

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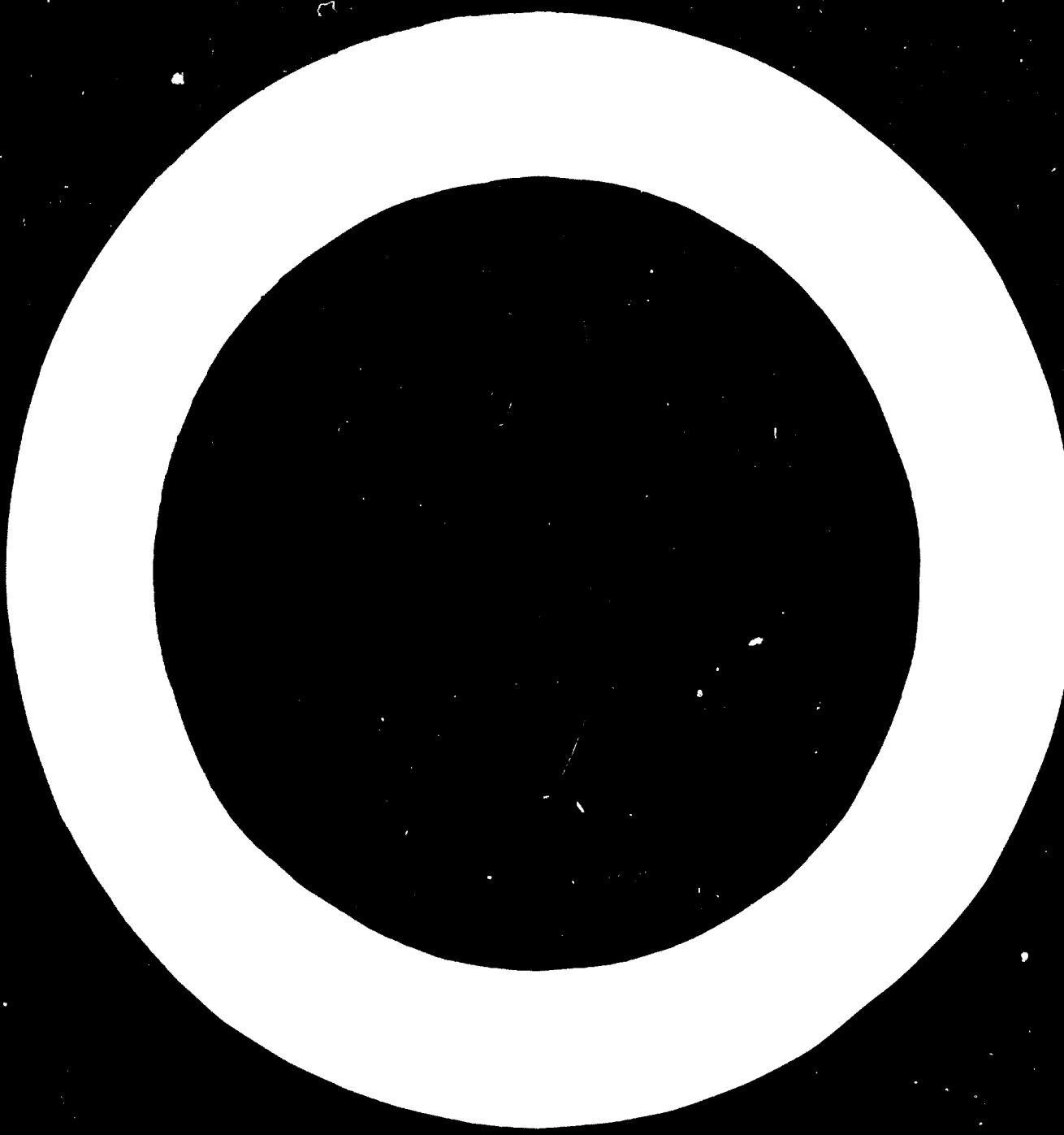


Introduction

Radio-relay lines is a means of communication in the Soviet Union. Together with cable lines they form an integrated far-flung inter-urban telephone, telegraph and TV network in the country. A large portion of TV channels and a certain part of inter-urban telephone and radio-broadcasting channels depend on radio-relay lines.

At present radio-relay and coaxial-cable lines make it possible to receive the Central TV programmes on a large area of the country and also to carry on an intensive exchange of TV programmes among the Soviet cities and with the "Intervision" and "Eurovision" network.

Thousands of kilometres of radio-relay lines have been erected along power-transmission lines, gas and oil pipelines and railroads to control their production processes. These lines of technological communication are often equipped by TV channels with a TV programme branched off to the relay stations along the line.

In the densely populated areas of the country line-of-sight radio repeaters are built, as a rule. Tropospheric communication radio-relay lines are built to establish communication in the hardly-accessible or scarcely populated areas, or short-wave radio communication channels are used for the purpose.

The radio-relay lines may be classified according to their application in the following way:

1. Large-capacity trunk lines. These lines, as a rule, are considerably long and are equipped with one or several telephone trunk lines and always by a TV trunk line.

2. Medium capacity lines meant for branching off trunk lines at certain directions where the need for communication is not likely to increase in future.

3. Small capacity radio-relay lines, with not more than 24 telephone channels, for local communication. Equipment with both frequency and time disconnection of channels is employed on these lines.

Since this report deals with the problems of servicing and repairing radio communication equipment, mention should be made first of the main rules of maintenance defined in the process of designing.

1. BASIC RULES OF MAINTAINING RADIO-RELAY LINES DETERMINED IN PROCESS OF DESIGNING

The principles and the scheme of maintaining each radio-relay line are determined in the process of designing. In the period when the direction of a line and the location of stations are determined special stress is laid on the approaches to the stations and also on power and water supply. Besides, when the places are chosen for the permanent-maintenance repeating stations (hub, main and terminal stations), the living conditions of the servicing personnel should be taken into account, as the proximity of schools, shops, cultural centres, etc.

A radio-relay line project also provides for the transport servicing of the line which includes the construction of garages and repair bases. At the same time the questions of administrative sub-division of the route into regions and sections is decided. The project also envisages the construction of houses for all these services.

In view of the extent of experience and the state and length of approaches it has been decided that one repair base on the route is able to service two or three repeating stations without stationary repair facilities of their own (non-serviced stations) in each direction from it, as the time of reaching such a station from a repair base should not exceed 2.5 hours.

Though constant presence of the technical personnel at the "non-serviced" stations is not envisaged, however, a small dwelling house, water supplies, etc. should be at every non-serviced intermediate station. During the adjustment period the visiting experts stay in that house and during the servicing period the house is used for creating the necessary conditions for the arriving repair teams. The expenditures on the construction of these houses account for an insignificant part of the whole cost of the line and are well justified by the conditions they provide for making good repair.

An establishment which in future should carry out the servicing of a given line is determined in the process of designing. According to the existing regulations, the general guidance of the technical maintenance of the radio-relay communication lines is exercised in the

Soviet Union by the Ministry of Communication with specialized departments under its direct control. These departments are responsible for the technical maintenance of the sections of radio-relay communication trunk lines assigned to them. Each such specialized department, according to specific conditions, ensures the technical guidance of the maintenance at a section of a radio-relay line or several lines with their total length ranging from 2 to 3.5 thousand kilometres. The section serviced by a specialized department, in its turn, is divided into smaller sections, from 500 to 700 km, which are maintained by the technical servicing regions. The maintenance personnel at radio relay (repeating) stations is directly subordinated to the region authorities, the latter being under a department's control. Fig. 1. shows the pattern of the department and regional services. It should be also noted that a considerable number of the specialized departments are engaged in the servicing of cable communication lines, apart from radio-relay lines. Such a combination is believed to be expedient and economical for organizational reasons.

Repair bases are set up to carry out emergency repairs or preventive maintenance at the non-serviced radio-relay stations along the route. A repair base consists of technical premises, a garage for two or three automobiles and a dwelling house for 8-10 flats. The technical premises include a radio workshop, a machine shop and a store-room. In some cases all the rooms of the repair base are housed in one building together with a garage. As a rule, the bases are located on the territory of radio-relay stations, preferably at hub or auxiliary stations which is convenient in that the problems of water and power supply, the telephone communication between the base and the line, and other problems can be solved easier that way. In some cases the bases are housed together with the administrative offices of regions and departments.

According to its functions the technical personnel may be subdivided, conditionally, into two groups: one performing the operations directly at the repeating stations, i.e. has to travel along the route, while the other works in the shops of this or other base.

The major task of the first group is trouble-shooting at the non-serviced stations of a radio-relay line and also all kinds of the preventive overhaul and repair of not interchangeable equipment units,

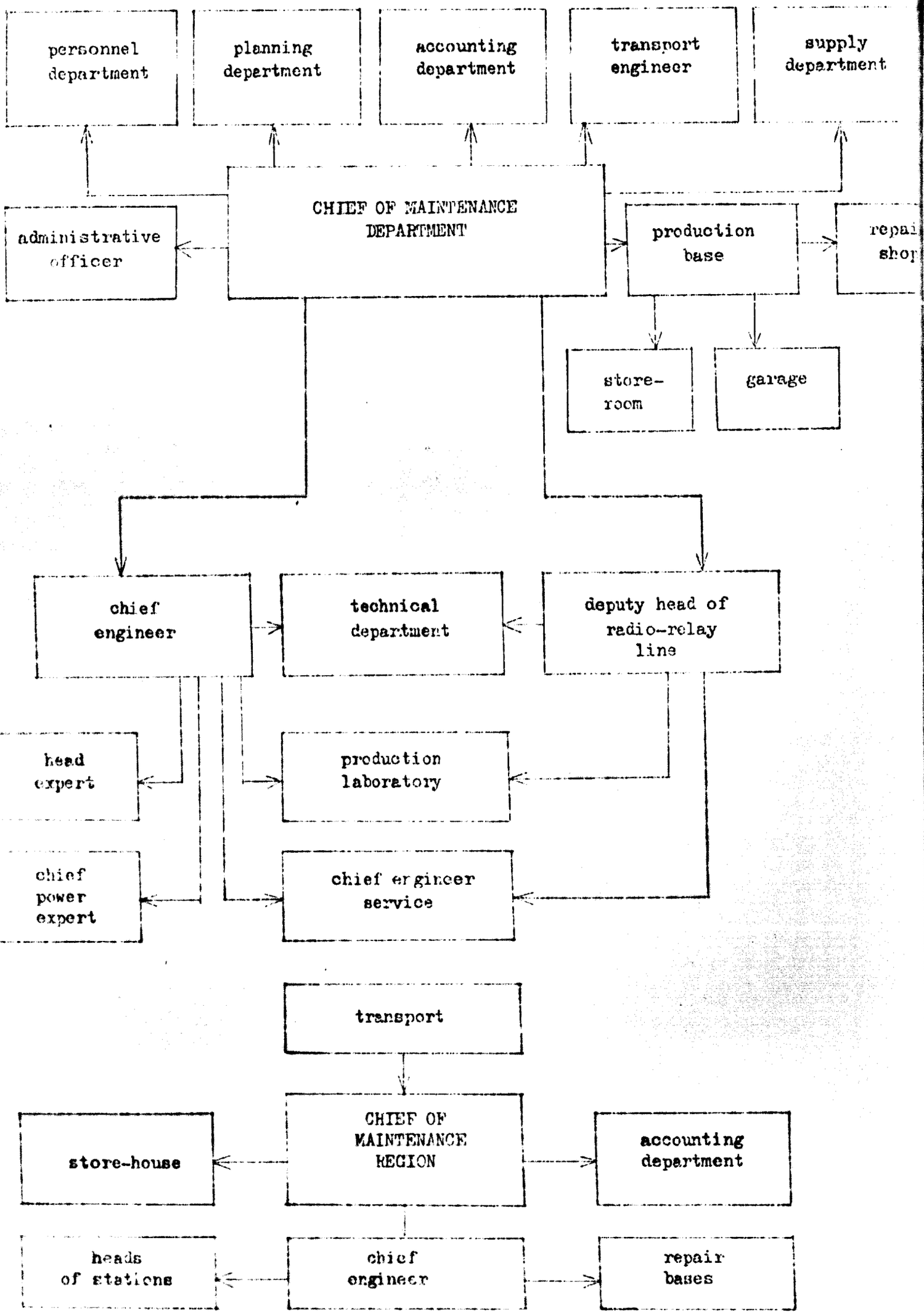

personnel department
planning department
accounting department
transport engineer
supply department
CHIEF OF MAINTENANCE DEPARTMENT
administrative officer
production base
repai
sho
store-room
garage
chief engineer
technical department
deputy head of radio-relay line
head expert
production laboratory
chief power expert
chief engineer service
transport
CHIEF OF MAINTENANCE REGION
store-house
accounting department
heads of stations
chief engineer
repair bases

Fig. 1

since the interchangeable units are repaired at the workshops of a base. To carry out its mission, the first group is given a specially equipped automobile for the purpose. It has, for instance, shock-absorbing devices for carrying measuring instruments, spare equipment units, spare radio valves, semi-conductor instruments, various spare parts, tools and all sorts of other accessories. The mobile (or travelling) group includes: a radio engineer who is the leader of the group, an automation engineer, a senior power technician, and several other technicians. A travelling repair team is comprised of specialists experienced enough in their job. The senior power technician is responsible for the work of the whole equipment of diesel generators, transformer sub-stations, and guaranteed power supply sources. The automation engineer is responsible for the good functioning of all the distance-control and signalling devices at a non-serviced station and the section at which there are stations having a common automation system. A travelling group may include other specialists (as a locksmith, or a welder) to perform scheduled maintenance. All the members of a travelling group, live, as a rule, on the premises of a base and, if necessary, can reach the place of trouble fast. The group also includes stands-in who work all the time in the shops and join the group if any of its members falls ill.

As it has been mentioned above, no repair of interchangeable equipment units is done on the spot but in the workshops of a base. To do the repairs and the adjustment of the units the shops are provided with special tools, devices, stands, and measuring instruments. The stands are used for the adjustment of the equipment units. Racks or equipment units adapted mechanically and electrically for being connected to the necessary measuring instruments and providing an easy access to all the regulation elements in the units which are to be adjusted may be used for the adjustment purposes.

Below is the list of the main repair bases used by the shops and travelling groups.

Channels of telephone communication between a base and the nearest serviced station and also for the management of the technical servicing region are designed for an efficient control over the work at the repair bases.

2. PERSONNEL TRAINING FOR SERVICING RADIO-RELAY LINES

According to the missions performed, the technical personnel is sub-divided into maintenance and control categories. The first one is occupied with the problems of equipment maintenance, or, in other words, it performs a round-the-clock duty at those radio-relay stations which are to be serviced. Such stations include, in the main, the terminal and hub ones. The group (or the shift) includes an engineer who acts as its chief and two or three technicians, depending upon the amount of the equipment installed at the station. At the communication routes of less importance the group (shift) may be headed by a person with secondary technical education provided he is experienced enough in the job. Each of the shifts remains on duty for six hours and is responsible for the normal functioning of not only the stations it services but also the section of automatically controlled radio-relay stations assigned to it.

The second category of control (non-shift) personnel includes a chief engineer who is the head of the station and trunk-line engineers who are the staff members only at the main stations. The staff of the trunk-line engineers is selected in such a way that there would be one engineer per every TV and telephone trunk line and per every communication route with the length of the section being no less than 500 km. The main task of trunk-line engineers is to maintain the electric properties of the trunk lines of the radio-relay lines within the set norms, to analyse the work of the equipment at each separate station and along the TV and telephone lines as a whole, and to carry out the electric measurements of the trunk lines. In cases when the apparatus of telephone trunk-line multiplexing are placed in one technical building with the equipment of the hub and terminal repeating stations, their servicing is exercised by one separate group of personnel subordinate directly to the management of the technical servicing region. And if a small number of telephone channels (12-24) is assigned for a radio-relay station out of the whole lot the servicing of the equipment is performed by the shift and staff personnel of the radio-relay station.

The above principles of servicing refer, in the main, to the line-of-sight relay repeaters supplied with the most up-to-date Soviet-made equipment. The intermediate relay repeaters of tropospheric

communication and the station equipped with older apparatuses, or the stations with new equipment but situated in the regions of the country which are difficult to access are, as a rule, serviced (have permanent maintenance). The personnel at these stations and composition of the shifts are determined by the concrete servicing conditions at a given station. The staff of tropospheric communication stations include additional members for auxiliary servicing: cooks, diesel-engine operators, medical personnel, power experts, and so on. The servicing of such stations is performed by an "expeditional" method i.e. the technical personnel goes to the station for two weeks or more. These stations have all the necessary conditions for a long stay of the technical personnel there.

Since the Ministry of Communication possesses a great amount of all sorts of technical means, our higher and secondary technical education establishments (communication institutes and technical schools) train experts with a broad field of specialization. The servicing establishments of radio-relay lines are staffed mainly by the specialists who have graduated from a "Radio communication and Broadcasting" faculty at an institute or a technical school which trains specialists for radio and TV centers, radio communication and radio-broadcasting enterprises and corresponding research institutes. Upon graduating from an educational establishment the specialists coming to the place of their assigned job should undergo practical training there to work properly. Various forms of additional training are organized for the young specialists, to keep their professional level up to the mark. Their primary task is to master in detail the equipment used there. The practical study of the problem is going on in the laboratories of an enterprise where special stands imitating a radio-relay line are used. This enables them to study the equipment and the methods of measurement most efficiently. The theoretical study of the principles and the specific features of the equipment installed at radio-relay communication lines is carried out at the short-term courses set up at a department. The lectures at the courses are delivered by the most competent specialists.

Apart from the young specialists, the technical training at the department involves the whole personnel. There exists a practice of

training through reading lectures on communication channels, and also TV channels within the limits of one line or a whole network of TV channels. The reader speaks from a studio of a TV center or a video-telephone station. At present this method of technical training has become most widespread. It makes it possible to invite the best specialists from research institutes or enterprises to deliver the lectures. To illustrate, lectures on various theoretical problems of radio-relay communication, and on new equipment are delivered from Moscow twice a month through the TV channels of the radio-relay network. The lecturers are the most competent instructors of higher educational establishments or researchers.

The training at the center or at enterprises is planned beforehand. The plan includes the most topical subjects or those which turned to be poorly mastered (which was revealed at a preceding exam). Every year the knowledge of the equipment by the whole technical personnel servicing radio-relay lines is checked upon by a commission headed by the chief engineers of the regions together with the chief engineers and leaders of the repair bases. This measure facilitates a better mastering and servicing of the whole equipment and installations by the personnel.

3. BRIEF SPECIFICATIONS OF RADIO-RELAY EQUIPMENT

The radio-relay equipment used in this country is sub-divided into two main types according to the difference in wave propagation: the line-of-sight equipment (or quazi-optical visibility equipment, to be more precise), and the equipment used on the lines where the long-distance tropospheric wave propagation effect is employed. The latter type gives us an opportunity to carry on only the transmissions along 60-channel telephone communication lines with the distance between repeating stations being around 300-400 km. The designing of the tropospheric communication equipment for the transmission along 120 telephone channels is nearing completion at present. A new kind of radio-relay communication with the use of the Earth artificial satellites has been used widely in recent years. Thus, in April 1965 the Soviet Union made a successful launching of the Molnia-1 satellite meant for

TV and multi-channel telephone communication between Moscow and Vladivostok which is intensively at work now.

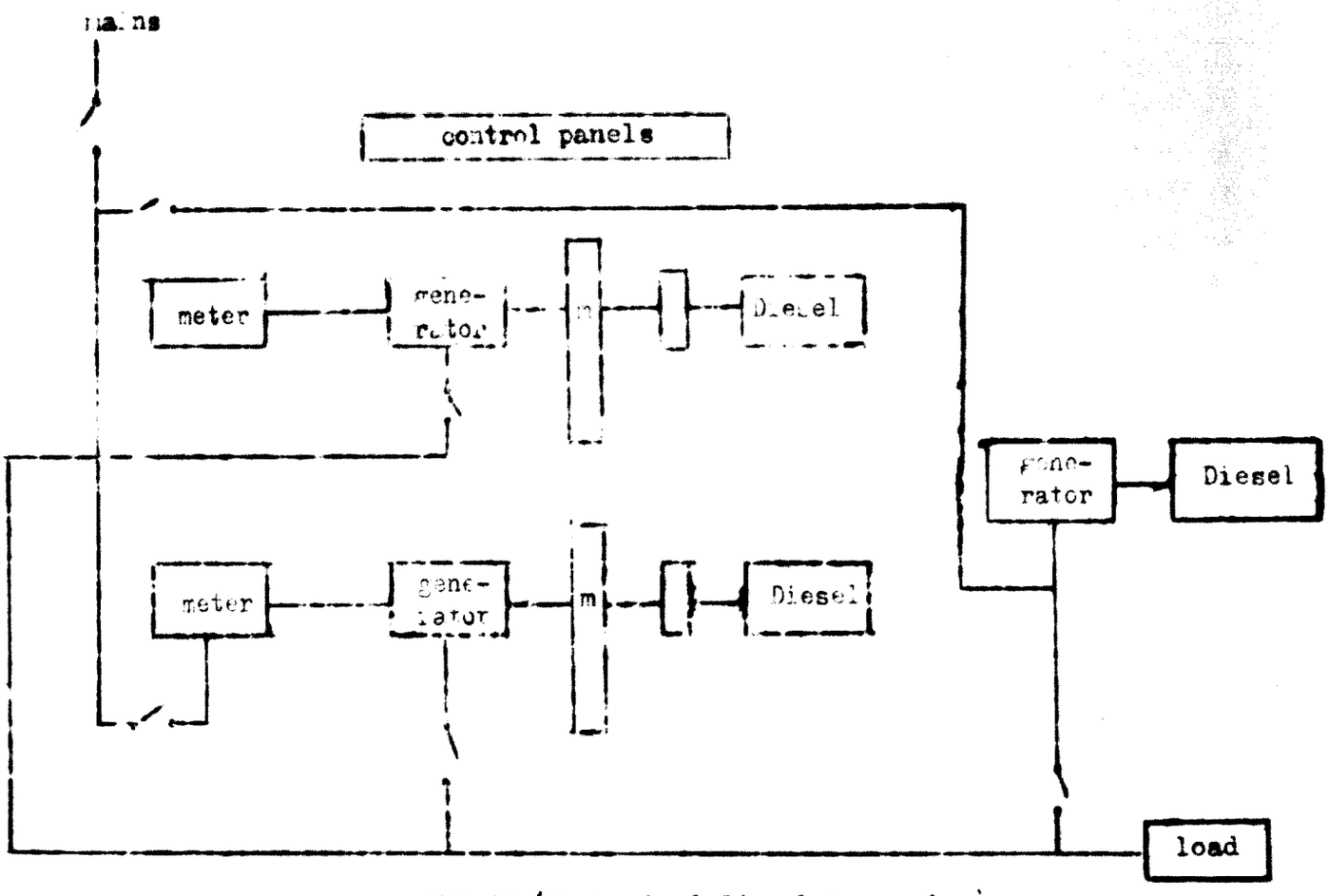
In the Soviet Union mainly the equipment produced in this country and also that manufactured by the Hungarian "Budavox" association is used at the radio-relay lines. The Budavox association supplies to the Soviet Union the equipment of the GTT 4,000/600 and RR-28 types. The latter is the small-capacity radio-relay equipment (i.e. with a small number of channels) having pulse-phase modulation, now widely used in the construction of radio-relay communication lines along railways, oil and gas pipelines and for carrying on telephone communication inside a region. In 1969 Hungary started to supply the trunk-line radio-relay equipment of the "Druzhba" type developed on the basis of bilateral technical co-operation between Hungary and the Soviet Union. The table given below contains the brief technical specifications of the radio-relay equipment which at present is installed on the lines or whose series production is planned to begin in the near future.

A proper supply of electric power to the station is of much importance for ensuring the set reliability and authenticity of radio-relay communication channels. It is seen from the list of the main specifications of radio-relay equipment given below that all the equipment used on the lines is designed for the power supply from a.c. sources which is accounted for by the fact that many electrovacuum instruments installed in the equipment (as ceramet triodes, klystron, travelling-wave valves) require a comparatively high voltage which can be obtained only through transforming low voltage and rectifying high a.c. voltage.

The designers of radio-relay repeating stations try to supply them with power coming from two independent sources, i.e. they envisage the construction, where it is economically reasonable, of two independent power-transmission lines. However, the feeding of power to a station by two independent sources in some cases does not yet solve the problem of a steady power supply. During violent storms - in case power is fed to the stations through overhead power transmission lines - both lines may often get de-energized. For that purpose automated diesel generators are installed at the stations regarding concrete conditions. The experience of servicing the first repeating stations has shown that voltage stability plays no mean role in ensuring the set authenticity at their telegraph

Nos	basic specifications	types of equipment							
		for trunk lines of communication					for inter-regional communication lines		
		R-600	R-600M	R-6002M	GTT-4,000 600	"Voskhod"	"Druzhba"	RM-28	container
1.	Frequency range	3400-3900	3400-3900	3400-3900	3400-3900	3400-3900	5600-6200	1650-2000	390-470
2.	Channel capacity								
	a. telephone channel	600	600	600	600	1920	1920	24	6
	b. TV								
	1. video-channel	1 dupl.	1 dupl.	1 dupl.	1 dupl.	1 dupl.	1 dupl.	-	-
	2. sound channel	1 dupl.	1 dupl.	1 dupl.	1 dupl.	4 dupl.	4 dupl.	-	-
3.	Maximum number of high-frequency channels	2(2+1)	2(2+1)	2(2+1)	2(2+1)	8 or 3+1 6+2		1	12
4.	Kind of modulation	frequency modulation	fm	fm	fm	fm	fm	pulse-phase mod.	fm
5.	Type of antenna	horn-type	horn-type	horn	horn	twin reflector or horn-type	horn	horn	cophase 8-element
6.	Capacity of transmitter watts	2	2	5	5	10	10	18	1.5
7.	Reserve system	regional	regional	regional	regional	station spanned rec.	regional	station	station
8.	Organization of service channel	separate trunk	separate trunk	separate trunk	separate trunk	telephone trunk	separate trunk	telephone trunk	trunk-line
9.	Power supply	220v	220v	220v	220v	220v	220v	220v	24v
10.	Producer	USSR	USSR	USSR	Hungary	USSR	Hungary	Hungary	USSR
11.	Produced since	-	1964	1966	1964	1970	1969	1969	1970

channels; and it is not the slow alterations in the voltage of the current fed there but the sharp reductions which the electronic stabilizer is unable to compensate that are most dangerous. This voltage instability is often takes place in industrial areas with their huge power consumers switching on now and again. The sharp voltage reductions at repeating stations is compensated with the help of motor generators with inertia flywheels, which makes the power supply to the equipment independent of the power mains when necessary. Converters of direct current into alternating current which receive a.c. voltage from a storage battery and get an additional charge from a rectifier connected to the external power-supply network are used for the very same purpose. The role of the damping element in the system is played by the storage battery. There are two types of guaranteed power-supply installations used currently in the radio-relay network: diesel-generators with inertia flywheels and motor-generators also with inertia flywheels. Below are the schematic diagrams of these installations and their properties.



MDG-20 (Mechanical Diesel Generator)

The operation of the 20 kw guaranteed power supply device (MDG-20) depends on the principle of mechanical connection with the Diesel. The installation contains:

a) one or two units with a flywheel (depending on the conditions of the station's electric power supply), each consisting of an asynchronous motor, a synchronous generator, a flywheel, an electromagnetic coupling and an automated Diesel rated at 40 hp;

b) an automated Diesel generator installation ADG-48 with a 80 hp Diesel;

c) unit and Diesel generator control panels.

The ADG-24 Diesel generator with a 40 hp Diesel can be used as an auxiliary Diesel generator. But in this case the power rating of the guaranteed power supply device with a flywheel decreases down to 15 kw. The load is applied to the terminals of the generator of one of the flywheel units. The second unit is in reserve.

The initial starting of the flywheel unit to the speed of 250-300 rpm is done by the Diesel starter. Further increase in rpm to the nominal figure is effected by means of the Diesel with the electromagnetic coupling engaged. If there is voltage on the station's input after the starting is completed, the unit's asynchronous motor is plugged into the mains, the coupling disconnects the Diesel, the latter comes to a standstill and the load receives its voltage from the generator. If an outer source trouble occurs, a pulse is generated instantly for the starting of the flywheel unit Diesel and the auxiliary Diesel generator. Before the Diesel is started, the load gets its voltage on account of the flywheel's energy. Given below are the basic specifications of the unit's components.

MDG-20 BASIC SPECIFICATIONS

1. **Diesel**
   a) power rating--40 hp
   b) nominal rpm--1,450
   c) cooling--water-air (radiator)
   d) voltage--40 v

2. **Coupling--electromagnetic**

3. Inertia flywheel:

a) weight--1,520 kg

b) radius--520 mm

4. A.C. Generator

a) power rating--23 kw

b) rmp--1,450

c) voltage--220/380 v

d) phase conjugation YΔ

5. A.C. Generator

a) power rating--24 kw

b) voltage--400 v

c) type of current--three-phase, A.C., f=50 c/s

d) phase conjugation: star with a neutral terminal

All the elements of the unit are mounted on a common frame placed on shock absorbers. The installation total weight is 3,600 kg. Overall dimensions:

length--4,280 mm

width--1,216 mm

height (without shock absorbers)--1,615 mm

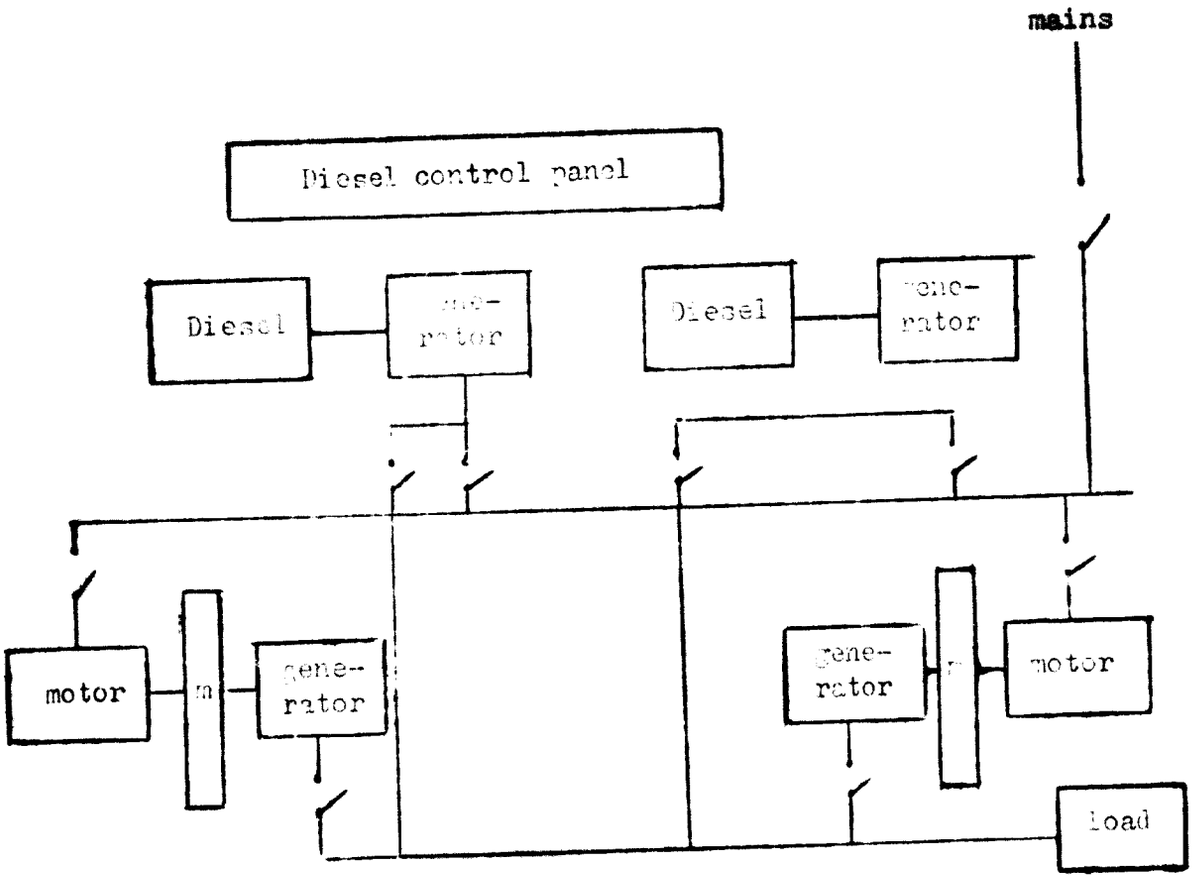
The second type of the guaranteed power supply unit consists of an electric motor, an inertia flywheel and an A.C. generator. Such installations come in two modifications with a 20-kw generator and with a 7.5-kw generator, which are named AGM-20 and AGM-7.5 respectively.

The guaranteed power supply unit rated at 7.5 kw and 20 kw (AGM-7.5; AGM-20) consists of:

a) depending on the power supply conditions, one or two flywheel units are mounted, each with an asynchronous motor, a three-phase synchronous generator and a flywheel;

b) two or three automated Diesel generator units;

c) control panel



AGH-7.5 and AGH-20.

The starting and running up of the flywheel unit is effected by the asynchronous motor which has a phase rotor for increasing the starting torque and for lowering the starting current. If there is voltage from the outer source, the flywheel unit operates from the mains. In case of trouble with the outer source, a pulse is generated for the starting of two reserve automated Diesel generators simultaneously, with the first Diesel, that has picked up the necessary r.p.m., taking up the load, and the second one coming to a standstill. AGH-7.5 and AGH-20 basic technical characteristics follow below.

Depending on the outer source reliability, two or three Diesel generators can be installed at the stations utilizing motor-generators with inertia flywheels.

Nos.	Basic characteristics	AGI-20	AGI-7.5
1.	Electric motors:		
	a) voltage	400	380/220
	b) type of current	three-phase A.C.	three-phase A.C.
	c) r.p.m.	1,420	1,420
	d) power rating, kw	20	7.5
2.	Generator		
	a) voltage	400	380/220
	b) type of current	three-phase A.C.	three-phase A.C.
	c) r.p.m.	1,500	1,500
	d) power rating, kw	24	15
3.	Weight of flywheel, kg	1,520	740
4.	Radius of flywheel, mm	160	610
5.	Weight of installation, kg	3,000	1,850
6.	Overall dimensions of the installation, mm	length 2,970	length 2,225
		width 1,216	width 1,350
		height 1,080	height 1,310

5. TELEPHONE CHANNEL MULTIPLEXING EQUIPMENT

To multiplex radio-relay lines use is made mostly of the cable line multiplexing equipment which employs the channel mode separation principle. The line spectrum obtained on the equipment output occupies a 4 x n--wide frequency band, with n indicating the number of channels made. The spectrum of the type K-24 and K-60 channel-making equipment, designed for multiplexing symmetric cables, occupies the following band:

K-24 -- 12-108 Kc/s

K-60 -- 12-252 Kc/s

The line spectrum of the equipment used on coaxial cables should be:

for the type K-300-channel system -- 60-1,300 Kc/s

for the type K-1920-channel system -- 312-8,500 Kc/s

In case of multiplexing a comparatively small number of channels use is made at radio relay lines of the equipment employing the principle of temporary channel separation.

6. CHARACTERISTICS OF MEASURING INSTRUMENTS TO MAINTAIN RADIO-RELAY LINES

One of the main demands placed upon the relay lines is the high efficiency of uninterrupted reliable operation which can be secured by reducing in radio communication the number and duration of interruptions necessary for the preventive maintenance of equipment, its repair and measurements. The curtailment of such idling is largely conditioned by the rational solution of control and measurement questions. Control over the state of equipment can be done through various measurements. The measurements used today can be divided into two types:

1. Uninterrupted control.
2. Prophylactic measurements.

In the process of radio communication uninterrupted control is effected over the channel main parameters and information transmitted to obtain data on the quality of communication and find out what measures must be taken in case of a deviation. Such control, as a rule, is done by apparatus or devices built in the equipment proper. Experience shows it is efficient to continuously control the level pattern and the level of summary noises (neat plus nonlinear) in telephone trunks.

In telephone trunks continuous control is usually conducted over the level pattern and, by means of test-line signals fed in the trunk input, over the transmission pattern, frequency and transitional characteristics, and nonlinearity. Control of the level pattern in both trunks (telephone and TV) is done by measuring, at the point of reception, the special sinusoid voltage of a pilot tone applied to the trunk input. As to the frequency, the pilot tone is higher than the operating band.

Prophylactic measurements are repeatedly made to check the equipment and trunks in compliance with the passport norms. As for their character, the prophylactic measurements can be divided into station and linear. For station measurements sets of measuring instruments are needed which help control the parameters of transceivers, modulators, demodulators and other auxiliary equipment. As to their equipment, the telephone and TV trunks of radio relay lines are distinguished for their output devices, therefore various sets of measuring instruments are used for linear measurements.

For station measurements of transceivers the following devices are required:

1. Meters of amplitude-frequency characteristics and of group time of delay for the spectrum of intermediate frequency and the spectrum of high frequencies.

2. White noise generator for measuring the noise factor of receivers.

3. Reflector meter for checking the matching of coaxial cables and wave guide elements.

4. Wave metres for measuring high frequencies and intermediate frequency.

5. Generators of standard signals.

6. Meters of the power of transmitters.

For linear measurements and the measurements of modulators and demodulators the following measuring instruments are needed:

1. Meter of differential distortions (amplification, phase).

2. Meter of frequency characteristics and of group time of delay for the low spectrum of group frequencies.

3. Spectrum analyzer.

4. Microvoltmeter with a set of filters.

The four types of devices mentioned above are required for measuring the trunks used both in telephone communication and TV broadcasting. However, for checking the level of noises in telephone communication a meter of transitional interferences should be added up, and for measuring TV broadcasting a special set of instruments is needed. Depending on the purpose of measurements, all the above measuring instruments are manufactured for various limits and ranges of frequencies to be measured.

So far, all measuring instruments for station and linear measurements consist of separate devices. Some of them have been developed especially for measuring a certain type of equipment, while others are multi-purpose instruments. At present, measuring racks are being developed so as to conduct a complex of measurements. Thus, measuring racks

are expected to be made for the measurement of the needed parameters of transceivers; measurement of modulators and demodulators; linear measurement of telephone trunks. For conducting all kinds of TV trunk linear measurements the industry has evolved a set of special measuring instruments ensuring:

a) generation of TV test signals

b) measurement of residual fading

c) measurement of intermediate characteristics within a long space of time

d) measurement of nonlinear distortions of image signal and sound accompaniment

e) measurement of nonlinear distortions of synchroimpulses

f) measurement of fluctuating noises and periodic video and sound interference

g) measurement of emplitude characteristics along the video and sound spectrum

h) generation of sound frequencies.

All the afore-mentioned principles of measurement are referred mainly to radio relay lines of large and medium capacity. The electric control principles of the equipment at the radio-relay lines of small capacity are somewhat different. As a matter of fact, the transceiving equipment of these lines have small dimensions, thus it can be easily replaced in case of need. This obviates various measurements at intermediate stations.

The repair and measurement of the equipment of the radio-relay lines with a small number of trunks is made in workshops. As is clear from Section 4 radio relay lines with a small number of trunks are fitted out with two types of equipment--PM-28 apparatus of Hungarian origin and home-made "Container" installation. The PM-28 apparatus is fitted out with the measuring instruments of its own envisaged in the firm's delivery. For measurements at radio relay lines provided with the "Container" installation the following devices are required:

1. Meter of transmitter power for the frequencies of 390-470 megacycles. The highest level of measurements is 5 Kw and the lowest, 0.5 kw with an error of 20 per cent.

2. Meter of noise coefficient for the frequency range of 390-470 megacycles, ensuring the receiver noise measurement with an error of not more than 2 d.b. within the range of 3-20 "kt" units.

3. Meter of matching for the frequency range of 390-470 megacycles, measuring, with an error of 10 per cent, travelling wave coefficient from 0.9 to 0.5.

4. Meter of amplitude-frequency characteristics for the frequency range of 7-9 m.c. with a sweeping band of 0.05--1 m.c., with the highest output level being 0.2 v and the lowest, 1 millivolt, and the irregularity ranging from 0.3 to 3 d.b. The sensitivity of the meter indicator is no less than 10 millivolts with the possibility of its decreasing by 40 d.b.

5. Meter of differential amplification distortions. The range is 7-9 megacycles. The lowest limit of measurement is 0.1 per cent with the deviation of $\pm$ 30 Kc/s, the error being not more than 0.03 per cent. The limit of such measurement is 0.3--100 m/sec.

6. Meter of transconductance. The range is 7-9 m.c. The limit of measurements of modulator transconductance is 50-200 $\frac{Kc/s}{v}$. The limit of measurements of demodulator transconductance is 10-100$\frac{v}{m.c.}$.

7. Generator of standard frequencies for the range of 390-470 megacycles.

8. Wavemeter for the frequency range of 390-470 megacycles.

9. Meter of transitional interferences with the noise frequency band of 4.6 - 32 Kc/s and with 3 channel being measured. The meter input and output resistance 135 and 600 ohms. The level of device noises is 1 and the error of measurements, $\leq$ 2 d.b.

The workshops of repair bases are fitted out with all types and sets of measuring instruments to measure and tune a certain type of equipment in operation. Thus, the workshops must have sets of devices for measuring transceivers, modulators and demodulators, auxiliary automatic and telesignalisation equipment, TV and telephone trunks. Besides, each repair base has devices for measuring the heterogenity of wave guiding routes, the antenna amplification coefficient, and appliances for antenna adjusting. The workshops of the bases are fitted out with the necessary machine tools, gas-electric welders, etc.

7. ORGANIZATION OF RADIO-RELAY LINES MAINTENANCE AND ORDER OF EQUIPMENT OPERATION

All repair work and preventive maintenance of the equipment, excluding breakdowns, is carried out in accordance with the plans elaborated beforehand and approved by the chief district engineer of technical maintenance. The plans are compiled for monthly and quarterly periods. In compiling such plans the following factors should be taken into consideration: the "Rules of technical maintenance of radio relay lines", time intervals in inspection and repair, experience accumulated during the period of operation, and the results of the dependability analysis. At the serviced stations teams of repair bases fulfil out the most difficult and responsible operations, for the rest of the planned repair work and all kinds of changes in the station are carried out by these stations' technicians on their own.

To enhance the responsibility for the equipment maintenance of the serviced stations the duties to maintain all equipment and apparatus are divided among the station's staff. Systematic control of their work and its quality is effected by the station's chief.

The inspection and repair of non-serviced stations call for the well-organized order and efficient utilization of the work of the repair bases' technicians, strict responsibility of every person for a proper performance of his job.

The technicians of repair bases who inspect and repair non-serviced radio-relay stations are responsible for their techniques and uninterrupted operation. The repair of the stations is permissible only in case of a disorder in a non-interchangeable unit of the equipment. The removable components and units are mainly repaired at workshops. Such a procedure of repair work is conditioned by the fact that the travelling teams of repair bases have at their disposal the necessary number of various removable units and components, and on finding a fault in a unit they replace the latter.

As is known, the repair work can be planned in the cases when, by means of statistics or calculation, the operation resources of equipment and its units are determined. There are a comparatively small number of such units at the radio-relay lines. Referred to such units are guaranteed power supply devices (Diesels, generators, motor-generators, accumulators,

elevating mechanisms (lifts), antenna foundations (masts, towers), structural erections (buildings, radio equipment booths). Among radio-relay equipment, service life is fixed only for electronic devices. Therefore, the main task of the travelling team is technical inspection at the stations.

The inspection is carried out in accordance with the assignment given beforehand and taking into account that every unit of the station is subjected to regular inspection.

To exemplify this we offer the time intervals in inspection of the main equipment of the station where the type P-600 apparatus are installed.

1. ANTENNA--WAVE GUIDING ROUTE

a) Outside inspection of the route	once a month
b) Inspection of mechanical fixing	once a month
c) Inspection of air-tightness	once a quarter
d) Measurement of reflection coefficient	once a quarter

2. MAST STRUCTURES

a) Inspection of verticality	twice a year
b) Inspection of guy tension	once a year
c) Inspection of foundations	twice a year
d) Inspection of mast welded seams and other metal structures	twice a year

3. ELEVATING MECHANISMS

a) Inspection of elevating cables	once a month
b) Inspection of electric motors	once a year
c) Inspection of winches, units, doors	once a quarter
d) Technical inspection of the lift by the commission	once a year

4. RADIO TECHNICAL EQUIPMENT

a) Inspection of the correspondence to the nominal of radio valve and semi-conductor current	once a month
b) Inspection of threshold devices of "power" and "carrier" indicators	once a month
c) Inspection of value of voltage generated by amplifiers	once a month

d) Inspection of passage of TV signals and commands	once a month
e) Inspection of forced cooling devices	once a month
f) Inspection of the correspondence to the passport of transceiving sets.	once a month

5. POWER GENERATING EQUIPMENT

a) Heat inspection of contacts of contacts of heavy current circuits	once a quarter
b) Inspection of water level in the Diesel cooling system and of operation of signal transducers	once a month
c) The same kind of inspection in lubricating system	once a month
d) Inspection of Diesel starting system	once a month
e) Lubrication of motor-generator bearings	once a quarter
f) Cleaning of collectors	once a quarter
g) Inspection of ventilation system and Diesel fuel pumping	once a month

The greater portion of the above-mentioned operations is effected without interrupting the station's operation therefore special attention is paid to observing labour protection measures whose violation can cause the injury of the maintenance personnel and damage to the equipment.

Emergency repair is done in all cases of disorder when the immediate repair of equipment is required. The travelling repair team receives the signal to go to the place of trouble from the technicians of the central or auxiliary station or from one of the chiefs of the district. Emergency trucks of the repair base are kept in constant readiness. Before departure to put things in order the team leader specifies the character of the trouble through TV signals he receives. He also makes suppositions about the place and character of the trouble by summing up the TV signals. As a result lacking instruments needed for the repair are added to the equipment of the emergency trucks and, if need be, additional maintenance workers can be called to the place of repair. The calling at any time of the sufficient number of workers of the travelling repair team is done in accordance with a schedule prepared in advance taking into consideration the actual situation and technical possibilities.

Having come to the damaged station the group reports its arrival and starts trouble shooting only after getting permission. When the repair is over every disorder is thoroughly analysed on the spot to find out its causes, and corresponding documents are filled.

Of great importance for increasing the dependability and quality of radio-relay lines operation is properly organized analytical work in every link of the operation process.

In compliance with the established order, the analysis of work of the preceding month and quarter is done by a technical maintenance district. Later, the maintenance department compiles an analysis, drawing on the data of districts' analyses. The summary analysis of all radio-relay lines operation for the preceding quarter, on the basis of the data of departments, is done by the USSR Ministry of Communication head enterprise entrusted with the operative-technical guidance of operation of the entire radio-relay network.

The form and order of the analysis is regulated by the instruction which helps sum up the data obtained from the subordinated organizations.

The purpose of the analysis is to spot the unreliable units in the equipment and find the causes of temporary instability. Two kinds of analysis are compiled at every radio-relay line and its district: analysis of the causes of idling and analysis of qualitative indices. The principle of compiling the analysis of the idling causes consists in systematizing the damages of every unit.

Experience shows that all interruptions in communication at radio-relay lines can be summed as follows:

faults in radio equipment; faults in electric power supply devices; fadings; violations of technical maintenance rules.

The first two reasons as a whole can be divided, in the process of the analysis, according to separate units and components of the equipment. Thus, failures of radio equipment operation are divided, during the analysis, into failures of transceivers, service communication devices, control and signalization automatic devices, modulators and demodulators.

Thanks to the fact that data on the causes of idling are collected from all relay lines it is quite possible, while summing up the reasons,

to determine units and components marked by potential unreliability and take necessary measures to prevent damages or emergencies.

In analysing interruptions in radio communication because of fadings, it is feasible to find out the points of lines subjected to these phenomena and to take steps to eliminate such phenomena. The analysis of violations of the technical maintenance rules helps discover and systematize the most common mistakes and miscalculations of the maintenance personnel and to take measures to prevent them.

The analysis of the qualitative indices of radio relay lines operation is made to reveal the causes of temporary instability. The original material for such an analysis is the data on the results of the measurements made, which are to be compared with the previous measurements and data of the electric passport for a given line and its district.

This kind of analysis is used not only for finding the optimal solutions of maintenance questions but also for developing new specimens of equipment and for modernizing the existing types of equipment.

To systematize various measurements made at radio-relay lines, special instructions have been elaborated on each type of measurement, which determine the procedure and method of measuring, and the order of processing the data. The instruction define precisely parameters to be checked up, list measuring instruments, methods of their connecting to the controlled circuits and contain forms of accountability.

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