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4000 Mc/s Radio Relay System for Broad-Band Long Haul Service

/Type GTT 4000/600/

by

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Summary

The equipment described forms a broadband multi-RF channel main line system for use in national and international telephone and television networks. The GTT 4000/600 type frequency modulated microwave radio system works in the 4000 Mc/s frequency band and may be used either with the normal or with the shifted frequency plan, recommended by CCIR.

Each broadband radio channel is designed to handle up to 600 telephobe circuits, or a television circuit for 625 line signal. A television sound channel /above the video band/ can also be handled.

Automatic switching from a regular to a protection channel is provided to assure service continuity in case of equipment trouble or fading. Should any of the regular channels fail, the protection channel stands, by to take over.

The power supply has also a stand-by equipment that automatically takes over in case of failure.

A narrow-band auxiliary radio channel provides order wire for maintenance, circuits for signalling as well as for controlling protection switching and for transmission and checking of alarm conditions. The intermediate stations may be used unattended.

Introduction

Broadband microwave radio links are equipments that can be conveniently interconnected in the international trunk networks and are suitable for the transmission of a

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large number of telephone channels as well as television programmes /image and sound/, e.g. in the framework of international programme exchange. Such a system will, of course, also lend itself to handling communication tasks of other nature.

In designing point-to-point radio systems it will prove expedient to keep to such design principles whose simpler or more complicated realisation is likely to meet the greatly differing requirements of the users. This consideration also holds good in the case of simpler equipment, which will then be easier to develop and expand.

The type of modulation to be used in a system is chosen to give the best compromise between noise and distortion performance on the one hand and practical design limitations on the other. In the broadband systems the phase modulation is suitable for converting a baseband signal to a modulated radio frequency one. The required characteristic lines between the frequency and phase modulation. In the case of transmission of multi-channel telephony or television signals, the practical solution is frequency modulation with preemphasis. High index frequency modulation is unsuitable, since it too trades bandwidth for noise performance. The compromise chosen in the CRT/4000/600 system is low deviation frequency modulation. This requires a relatively narrow band and will tolerate compression in the amplifiers. The optimum frequency deviation to be used is related to many factors, among which the more important are the transmitter power, the noise figure of the radio receiver, the system delay distortions, and the baseband signal to be transmitted.

The realisation of broad-band point-to-point systems is characterised by the type of repeater stations applied. Three general types of radio repeaters can be used. These are:

- baseband repeater, in which the signal is demodulated to baseband and remodulated on the radio frequency at each repeater,

- IF repeater, in which the modulated radio frequency signal is heterodyned to an intermediate frequency for amplification and equalisation and then heterodyned back to radio frequency without demodulation,

- RF repeater, in which the signal is amplified and radiated with only the frequency shift required for frogging. An RF repeater may be either a single radio channel repeater in which the radio channels are separated and amplified in individual amplifiers, or a multichannel repeater in which all radio channels in one direction are amplified in a single amplifier.

The baseband repeater provides the highest degree of route flexibility by making the baseband signal available at all repeater points along the route. However, in a long-haul system, the large number of modulators and demodulators connected in tandem would require each modulator to meet extremely stringent distortion requirements.

The multi-channel RF repeater is not suitable for applications where polarisation is used to separate the signals of adjacent radio channels. This leave only the single channel RF repeater and the IF repeater as possible choices.

The latter was chosen in the GTT 4000/600 system because of the greater ease of separating and equalising channels and of switching between working and protection channels. The use of IF-type repeaters leads to the use of the intermediate frequency as a common interconnection between the various parts of the system.

The development scheme has envisaged the elaboration of a common transmitter-receiver antenna system having in "go" and "return" direction three broad-band and one narrow-band RF-channels. By sitting two such equipments parallel the system can be extended in each transmission direction up to six broad-band RF channels.

As far as its history is concerned, early in 1961, a simpler version of the final system, known as GTT 4000/A

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type, was put in operation as part of an international main radio link. This version of the system is only suitable for the long-haul transmission of TV programmes /picture and sound/ in unidirectional reversible operation. The protection switching system of the equipment works on the "station switching" basis with the hot reserve type stand-by equipments.

With the GTT 4000/600 type equipment a national radio link is planned as part of an international main network, in the second half of 1962. The system to be installed will provide initially two working broad-band radio channels and one stand-by channel.

Contracts for the supply of microwave radio networks to provide long distance multicircuit telephone and television transmission links have been concluded with other countries.

General System Description

The GTT 4000/600 type broadband equipment is a multi-RF channel frequency modulated microwave radio relay system. The equipment is normally used to from a broadband main line system in national and international telephone and television networks which, when correctly planned and maintained, will provide an overall performance meeting both CCITT and CCIR recommendations.

Up to six broadband and two narrow-band /called auxiliary channels/ radio channels may be transmitted in each direction over any route.

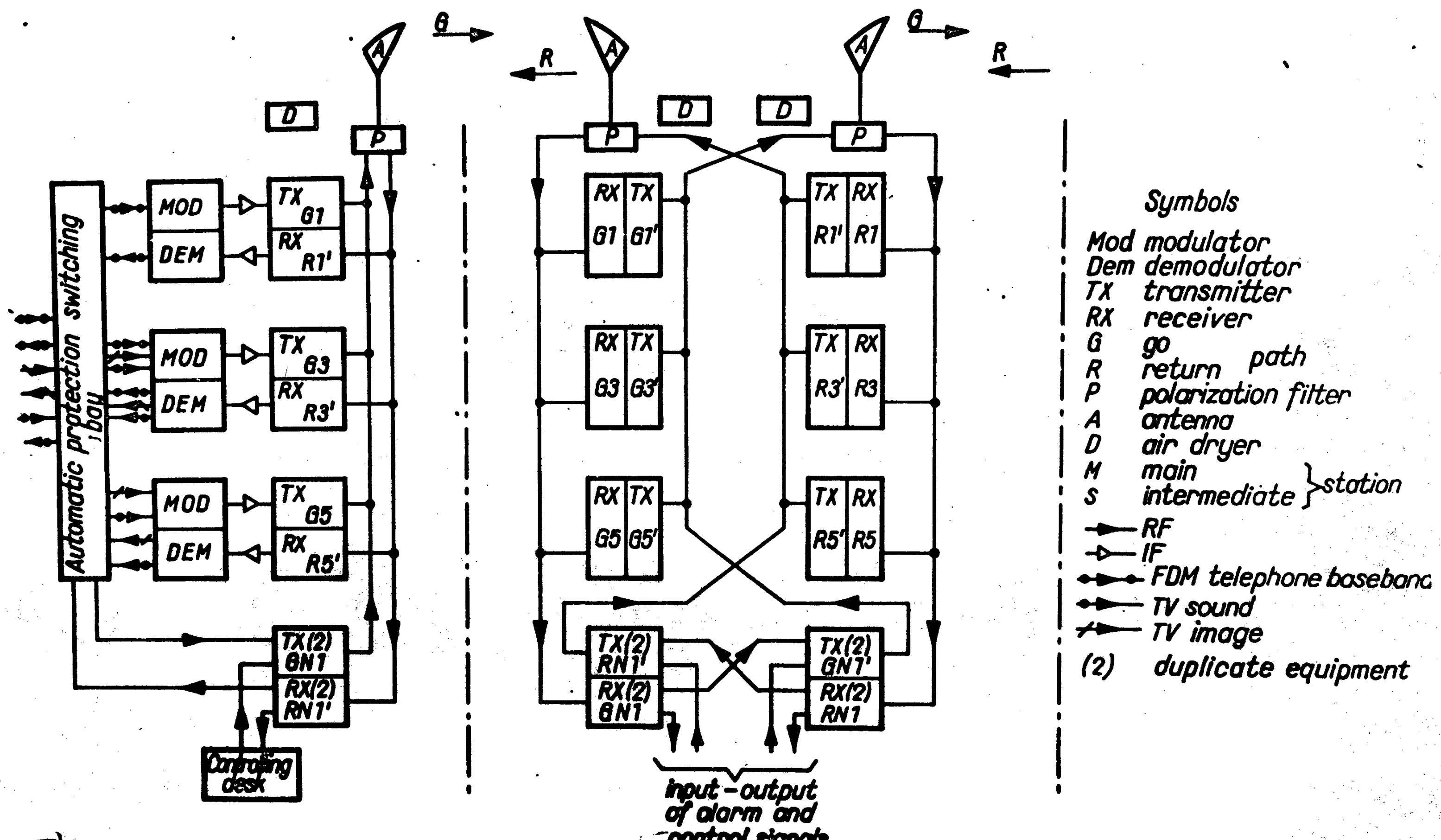
Each broadband radio channel is designed to handle up to 600 telephone circuits, each with a bandwidth of 300-3400 c/s and meeting CCITT/CCIR recommendations for long distance circuits, or a television circuit for 625 line /up to 6 Mc/s cutoff frequency/ signal. The possibility for coloured image transmission is also provided in the system. A television sound channel /above the video band/ can also be handled. The techniques employed make the system especially suitable for multichannel networks of increasing traffic requirements. Since the traffic carrying capacity is chiefly a result of the quality and not of the complexity of the circuits used the system will prove economical even if the present state of development calls only for a fraction of 600 telephone channels, whereas in case of TV transmission, image signals of less than 625 lines can also be handled.

Multichannel interconnection with cable systems or FDM channeling equipments is possible at modem /modulator-demodulator/ stations, i.e. stations comprising baseband interconnection points. This may be done either with the 600 channel part of the K-1920 and with the K-60 type Soviet channelling equipments simultaneously or with the baseband interconnection data recommended by CCIR.

The television programme may be readily dropped at any repeater station at IF without any deterioration of the "through" transmission. The dropped programme may be connected to the directly branching-off radio relay link /provided that the IFs of both systems are identical/, or by interconnecting a demodulating terminal equipment to a local transmitter. A TV programme or a TV reportage can readily be transmitted directly at IF by interconnecting a modulating equipment and disconnecting the main direction.

The simplified block diagram of the GTT 4000/600 system, equipped with odd numbered two-way radio channels, is shown in Fig. 1. Each broadband radio channel consists of a modulator, a microwave transmitter, one or more repeater, a microwave receiver and a demodulator. The modulator produces a 70 Mc/s signal which is frequency modulated by the incoming baseband signal. This FM signal is fed to a radio transmitter via 75 ohm coaxial cable. The radio transmitter heterodynes the IF signal to the desired microwave frequency and amplifies it for radiation to the next station. The radio receiver at the next station heterodynes the microwave frequency back to the 70 Mc/s intermediate frequency for amplification and equalisation. The output of the radio receiver may then be connected to another radio transmitter for transmission further down the route or may be connected

Fig.1.



Radio transmitting terminal
M

Radio repeater
S

FIG. 1

to a demodulator. The latter demodulates the signal and delivers the baseband signal to the terminating equipment.

As the system employs a 70 Mc/s intermediate frequency with a signal deviation meeting CCIR recommendations, the IF point thus permits interconnection with other SHF systems working on CCIR standards and likewise provides an IF switching point.

The protection switching system permits the replacement of a regular broadband radio channel by an equivalent stand-by or protection one. This is done automatically for equipment failures and for fades. It can be done manually to release the regular channel for maintenance. It is the purpose of the automatic protection switching system to ensure continuity of service over the GTT 4000/600 system.

The protection system prevents the occurrence of any signal loss in case of fading, and it will restore service a short time after transmission equipment has failed. Switching is done in switching sections. These usually contain a number of repeater stations and two radio terminal stations in which case the switching is normally done at baseband. When a channel has to be switched, it is replaced over the full length of the switching section by a protection channel. The automatic protection switching system is capable handling up to five regular channels with one protection channel.

Communication facilities between the various stations of the system are necessary for voice communications between maintainance personnel, transmission of alarm indications from unattended stations and operation of automatic protection switching. Narrow-band RF channels for the transmission of these signals within the frequency allocation of the GTT 4000/600 system have been designed. These channelx, called auxiliary channels, are provded as an integral part of the system, to carry maintenance circuits. The auxiliary channels must be protected against transmission failures due to equipment failure. To reduce interruptions of this nature to a minimum, stand-by equipments are provided with automatic change-over on the "equipment switching" base.

As a result of the design features referred to above a link of one two-way broadband radio channel may easily be extended in each transmission direction up to six broadband channels without disconnecting the traffic of the originally installed radio channels.

Radio Frequency and Polarization Plan

The GTT 4000/600 system works in the 3400-3900 Mc/s frequency band recommended by the Council of Mutual Economic Aid /CMEA 9th Section, Moscow, April 21-25. 1959/. On request the possibility for using the system in the 3800-4200 Mc/s band may also be included. In both frequency band either the normal or the shifted frequency plan recommended by CCIR /CCIR IXth Plenary Assembly, Los Angeles, 1959/ may be used. The centre frequencies of the normal and shifted frequency plans are respectively:

in the CMEA band: f_o = 3635 Mc/s f_o = 3649.5 Mc/s
in the CCIR Band: f_o = 3989 Mc/s f_o = 4003,5 Mc/s

The frequency allocation and polarization plan is shown in Fig. 2. "GO" and "RETURN" broadband radio channels, both up to six, and a pair of narrow-band radio channels are transmitted simultaneously, Frequencies 1...6 /or 1...6/ and 1'...6' /or 1'...6'/ carry broadband channels. Narrow-band radio channels are carried either by frequencies N1, N2 /or N1, N2/ and N1', N2' /or N1', N2'/, depending upon particular network planning requirements.

Interference between transmitters and receivers in the same station is minimized by grouping all the transmitters together in one half of the band and all the receivers together in one hald of the band and all the receivers together in the other half, as shown in Fig. 2. The channels are alternately horizontally and vertically polarized. Because of the good front-to-back ratio of the horn-reflector antenna, the same frequency can be used to transmit in both directions at each station, and the full band may be utilised in both directions. Each RF channel is carried alternately by two frequencies, viz. 1 and 1' etc. and N1 and N1' etc. As shown in Fig. 2, each channel is shifted

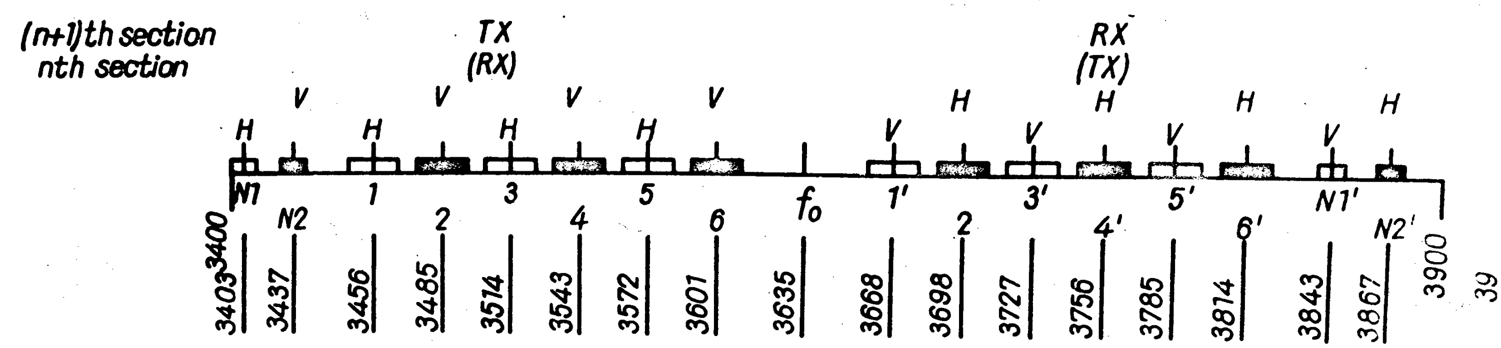


Fig.2·1·a
Normal frequency plan

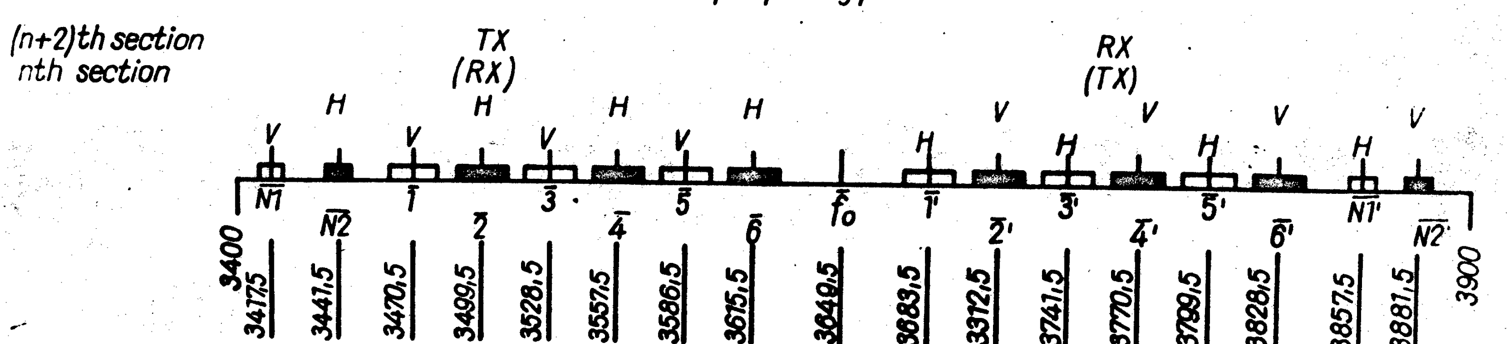


Fig.2.1.b
shifted frequency plan

FIG. 2

in frequency /or frogged/ by 213 Mc/s as it passes through a repeater station. Frequency frogging is necessary to prevent feedback from the repeater output into the input. A transmitter and a receiver are operated at the same frequency in the same station. Image frequency of each transmitter lies out of the working band.

According to a shifted frequency plan further six broad-band and two narrow-band RF channels can be transmitted in each direction crossing the main route or running parallel with it.

Three "GO" and three "RETURN" broad-band channels and a pair of narrow-band channels, all operating either at odd or even-number frequencies, are operated on the same antenna.

Baseband-FM converter /Modem/

As far as its modulation system is concerned the CTT 4000/600 system makes use of the frequency modulation in the broad-band RF channels; viz. FM with preemphasis both in the radio channels transmitting FMM telephone signal and TV picture signal, and double FM without preemphasis in the TV sound channel. The preemphasis characteristic is different in case of TP and TV transmission, respectively, both satisfying the recommendations of the CCIR /CEIR IXth Plenary Assembly, Los Angeles, 1959/.

The modem constitutes an important subsystem of the CTT 4000/600 radio system, as the link between the baseband signal and 70 Mc/s FM signal. The modulator converts the baseband signal into a frequency modulated signal centred at 70 Mc/s. The modulator uses a 4 KMc/s reflex klystron as a frequency modulator, the output of which is heterodyned down to 70 Mc/s by another 4 KMc/s reflex klystron. Automatic frequency control provides the required frequency stability.

The demodulator recovers the baseband signal from the FM signal. In the demodulator, an IF amplifier-limiter is followed by a balanced FM discriminator.

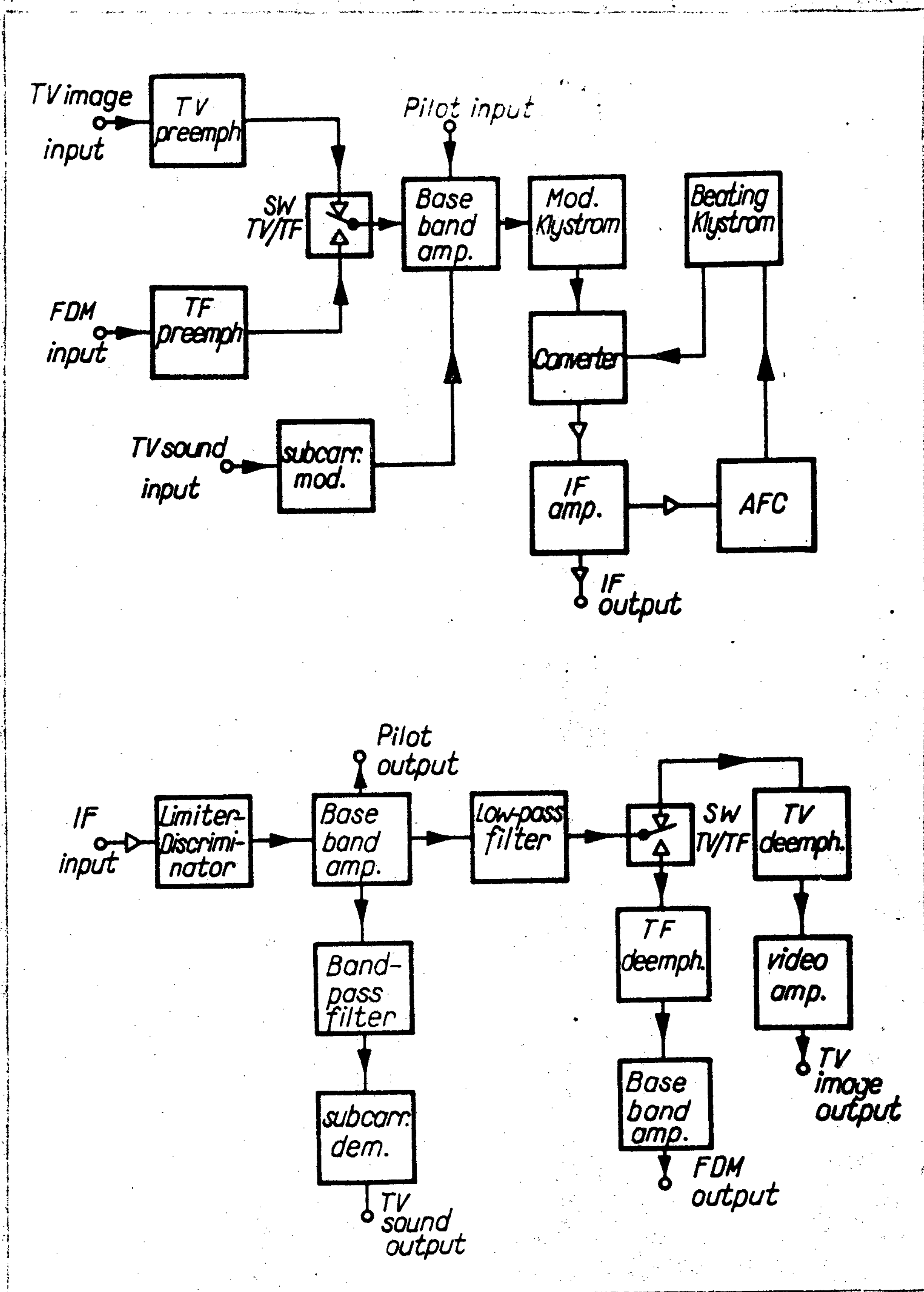

TV image input
TV preemph
Pilot input
SW TV/TF
Base band amp.
Mod. Klystrom
Beating Klystrom
FDM input
TF preemph
Converter
TV sound input
subcarr. mod.
IF amp.
AFC
IF output
Pilot output
IF input
Limiter-Discriminator
Base band amp.
Low-pass filter
SW TV/TF
TV deemph.
TF deemph.
video amp.
Band-pass filter
subcarr. dem.
TV sound output
Base band amp.
FDM output
TV image output

FIG. 3

In the modem appropriate amplification is provided at both the intermediate and baseband frequencies to permit interconnection with other parts of the system. Modulators and demodulators are required at the end of a route and at intermediate points where the baseband signal, or some portion of it, must be added or dropped.

Fig. 3. The block diagram of a modulator-demodulator is shown in Fig. 3.

In the modulator, the TV picture signal or FDM telephone signal, selected by baseband switch /SW-TV/TP/, is amplified by the baseband amplifier. In the case of TV programme transmission at this point a 8 Mc/s subcarrier, frequency modulated by TV sound signal, is added to the picture signal. The 8,5 Mc/s continuity pilot signal is added to the base-band signal too in each regular radio channel. The amplified baseband signal applied to the repeller of the modulated klystron, causes its frequency to vary around the centre frequency. The modulated signal is applied to the converter, where it is mixed with the frequency of the heating klystron. The output, a frequency modulated wave centred on 70 Mc/s, passes through an IF amplifier. The IF amplifier output is connected to the other parts of the system via coaxial cables.

To provide an input for the automatic frequency control /AFC/ circuit, a small fraction of the output from the IF amplifier is obstracted, and amplified. The resultant voltage from AFC circuit is applied to the heating klystron with proper polarity to reduce the average frequency error. Fig. 6. shows the used klystron modulator.

The demodulator accepts the 70 Mc/s FM signal and delivers the baseband signal. The FM input is applied to the demodulator by means of 75-ohm coaxial cable. The The IF amplifier-limiter suppresses any amplitude modulation of the input FM signal, which otherwise would cause unwanted distortion in the discriminator. In addition, the limiter action tends to maintain a constant input power for the discriminator circuit. The discriminator recovers

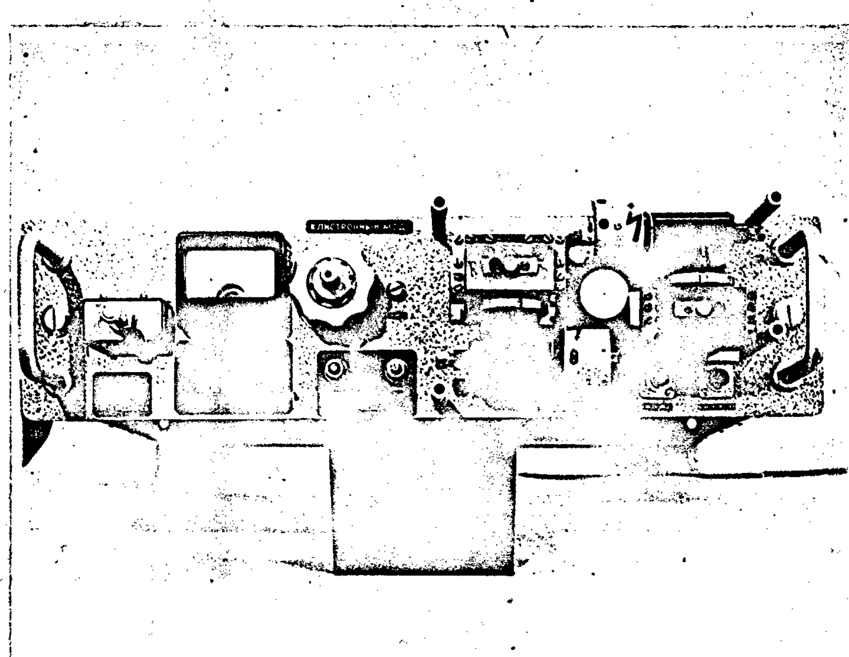


FIG. 6

the baseband signal from the FM wave, in two steps. First, networks which introduce amplitude slope across the IF band produce amplitude modulation, which is proportional to the frequency modulation of the input signal. Amplitude detectors then recover the baseband signal, which is subsequently amplified in the baseband amplifier.

The output signal of the baseband amplifier passes through a low-pass filter, which suppresses the TV sound subcarrier and continuity pilot signals. The baseband switch /SW- TV/TP/ selects the needed information. The output signal of the baseband switch, both TV picture signal and FDM telephone signal, passes through a de-emphasis network and an additional video amplifier to form the final output signal.

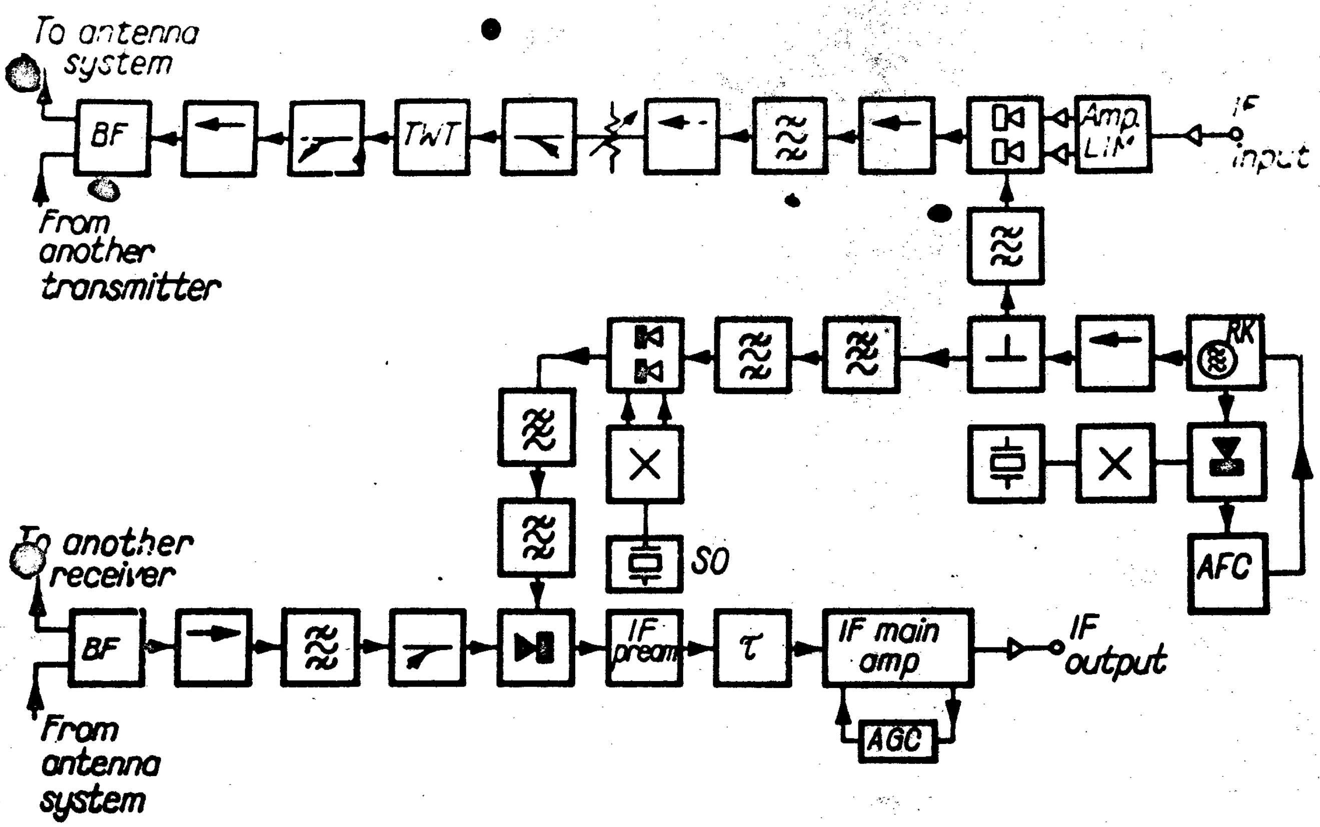
The frequency modulated subcarrier is applied through a band-pass filter to the subcarrier receiver, which as its output delivers the original sound signal.

The information-selecting baseband switches in the modulator and demodulator of the protection radio channel are automatically controlled by the automatic protection switching system.

In each modulator-demodulator of the broad-band RF channels is a local alarm system is provided.

Microwave Transmitter /TX/ - Receiver /RX/

Details of the GTT 4000/6000 transmitter-receiver are shown schematically in Fig. 4. At terminal stations the incoming 70 Mc/s FM signal first passes through amplifier-limiter, which is provided not only at the transmitting terminal, but at every repeater. This is done because it has been found essential to eliminate any amplitude modulation which would be converted to phase modulation by the traveling wave amplifier and appear as distortion that can not be compensated by equalization. The amplified and limited signal is fed



Symbols

high level / medium level / low level mixer

τ group delay time equalizer

attenuator

crystal oscillator

× multiplier

BF branching filter

TWT traveling wave tube

IF intermediate frequency

RK reflex klystron

SO shift oscillator

AGC automatic gain control

AFC automatic frequency control

LIM limiter

Amp. amplifier

ferrite isolator

band-pass filter

low-pass filter

directional coupler

⊥ power divider

FIG. 4

to the high-level mixer /transmitter converter/. This converter uses two germanium crystals in a balanced modulator circuit. The balanced circuit suppresses any amplitude modulation noise present on the local oscillator frequency input. We propose to come back later to the microwave carrier signal that is fed to the converter. The output signal from the modulator at transmitting frequency is passed through a band-pass filter and a microwave ferrite isolator. After selection of the appropriate sideband, the signal is applied to the transmitter amplifier. This TWT amplifier provides an output power of 5 watts. A second isolator is interposed between the amplifier and the branching filter /BF/ to minimize reflections into the traveling wave tube from impedance mismatches that cannot be avoided in practice. After this, the signal is fed to the channel separation network which combines it with the outputs of other transmitters for transmission to the antenna system.

In the receiver the incoming signal from the antenna waveguide system is selected by the channel separation network. After passing through an isolator the signal is further filtered by the channel bandpass filter and applied to the low-level mixer /receiver converter/. Here it is mixed with a beat oscillator frequency, to provide an intermediate frequency centered at 70 Mc/s.

The IF signal is amplified first by a low noise preamplifier of the cascode type and then by the IF main amplifier. Sufficient additional gain is available, as determined by the automatic gain control /AGC/ circuit, to keep the receiver output level constant over the 30 dB receiver input level range. Group delay equalization follows the IF preamplifier. All receivers have an equalizer which compensates for delay departures from ideal transmission for both the transmitter and receiver of the section.

In the repeater stations the transmitter frequency is gained from the receiver frequency with a frequency shift of 213 Mc/s. Therefore, the transmitter frequency stability on the repeater station depend only on the frequency stability of the shift oscillator /SO/.

The frequency of the reflex klystron /RK/ used as a transmitter local oscillator is stabilized. The transmitter local frequency is gained directly from the reflex klystron, while the receiver local frequency is produced by means of mixing the klystron and the 213 Mc/s shift frequency in the medium level mixer /shift convertor/.

Each transmitter-receiver of the broad-band RF channels is supplied with a local alarm system. The alarm circuit is controlled by the output level /level proportional to the output power of TWT amplifier/ and by the IF level /level proportional to the output voltage of the IF main amplifier./ The local alarm is given when there is a breakdown in the transmitter or receiver and it serves to localize the failure quickly by aid of the alarm panel and the measuring instruments panel of the bays. Local alarm is given by optical and audio signals.

Automatic Protection Switching System

The purpose of the automatic protection switching system is to ensure the continuity of service of the GTT 4000/600 system. The protection system prevents any signal loss in case of fading, and it will restore service a short time after transmission equipment has failed. The protection switching system permits the replacement of a regular radio channel by an equivalent stand-by or protection radio channel. Switching is done automatically in switching sections. When a channel has to be switched, it is replaced over the full length of the switching section by a protection channel. A switching section usually contains a number of repeater stations and a pair of terminal stations, or a terminal and a branching station. In the former case the switching is normally done at baseband, on both end of switching section, while on the branching station this is done on channels transmitting FDM telephone signal at baseband and on channels transmitting TV programme at IF. By use of automatic protection switching system, the over-all reliability of the CFT 4000/600 system is substantially improved. Switching at the end points of each switching section can be done manually to release the regular channel for maintenance purposes.

On the routes planned with three two-way broad-band radio channels, one protection channel permits to replace two regular channels, while on the fully planned routes /routes with six two-way broad-band radio channels/ one protection channel is capable handle five regular channels.

The priority possibility for any regular channel is provided in the automatic protection switching system.

The protection channel is always of the hot reserve type i.e. the stand-by channel is, like the regular channels, in switched-on position, only no traffic goes through it.

The continuity of service in each regular channel is monitored by a 0,5 Mc/s pilot signal and a noise-monitoring channel around it. The protection channel, when not carrying traffic, is monitored by the 8 Mc/s TV sound subcarrier as a pilot signal. In this case the stand-by channel does not carry 0,5 Mc/s continuity pilot signal. When the pilot level at the receiving end of a switching section falls below the prescribed value or the noise level /in the noise monitoring channel/ exceeds the prescribed value in any regular channel a remote-control process starts. If the protection channel is available for transmission, then at the transmitting end of the switching section the regular channel is bridged to the protection channel as a result of the remote-control process. When the 0,5 Mc/s pilot appears in the stand-by channel at the receiving end of this switching section, the traffic is switched-over from the regular to the stand-by channel. On this point, when the remote-control process is initiated, at the same time a gating process is applied to the next switching section. This results, that under the cut-off service time, due to the change-over process, on the next switching section the switching-over does not take place.

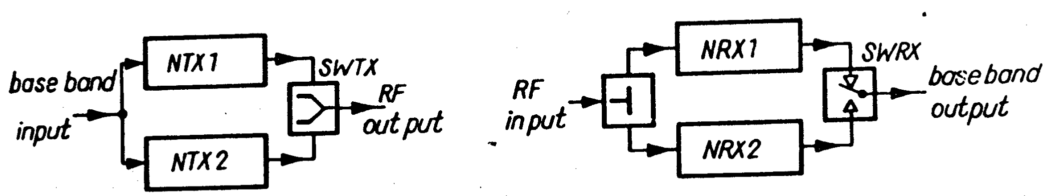
Both baseband and IF switches employed are of the vacuum-relay type. The circuits of the automatic protection switching system employ solid-state devices throughout.

Auxiliary /Narrow-Band/ Radio Channel

The operation and maintenance of the GTT 4000/600 radio relay system require communication facilities along the route, which can be used for the transmission of voice, protection switching and alarm signals. Special microwave narrow-band channels, referred to as the auxiliary radio channels have been designed for this purpose. The auxiliary channels share the antenna system of the broadband channels. The transmitting and receiving frequencies of these channels are allocated at the edges of the radio frequency band of the broad-band channels. The narrow-band radio channels employ frequency modulation with low modulation index and without preemphasis in the baseband.

The required reliability is achieved by providing an automatic protection switching system of the equipment switching type. A b block diagram is shown schematically in Fig. 5. Each regular transmitter and receiver is protected with a stand-by one. The stand-by equipments are of the hot reserve type. At each radio station, the baseband inputs of transmitters and microwave inputs of the receivers are connected in parallel. For the continuity of service both regular and stand-by equipments are monitored by a continuity pilot signal which is transmitted above the baseband. The pilot signal is suppressed and reinserted at each radio station.

Change-over from regular to stand-by at the outputs of the transmitters is done by means of electromagnetically



power divider
RF switch
base band switch

NTX1 regular narrow-band transmitter
NRX1 regular narrow-band receiver
NTX2 Stand-bay narrow-band transmitter
NRX2 Stand-bay narrow-band receiver

FIG. 5

controlled microwave switches /SWTX/. The switches employed at the outputs of receivers are vacuum relay type baseband switches /SWBX/.

At each station it is necessary to recover the baseband signal, so that specific signals can be added or removed.

The narrow-band transmitters operate without radio frequency amplification and employ reflex klystrons as transmitting tubes.

The narrow-band receivers, are of in principle the same type as those of broad-band channels, except, that the local frequency is fed to the low-level mixer directly from a reflex klystron. The frequency of the narrow-band transmitter is not stabilised, but the receiver local oscillator is controlled by the automatic frequency control circuit.

Each narrow-band transmitter-receiver uses a local alarm system similar to the broad-band transmitter receiver.

<u>[illegible] and Remote Control System</u>

In connection with system maintenance three telephone channels are used for conversations between the various stations. One connects all the stations along a section of the radio route with the associated alarm centre. Known as the "radio order circuit", this circuit is essentially a party line which permits an individual in one station to talk with an individual at any of the other stations in the section. Two additional voice circuits are provided over much longer sections of the radio route, but only selected stations are connected.

A planned radio route can be divided into sections by means of main stations or so called alarm centers. The intermediate stations, planned between main stations may be unattended. The alarm and control system is capable to handle 10 unattended stations from a main station.

These are usually arranged so that not more than 5 stations are located on either side of the main station.

The protection switching system of the broad-band radio channels requires transmission facilities for a total of five tones in each direction along the radio route. Each direction permits transmission from the receiving end to the transmitting end of a switching section. Tones at 19,5, 21,5, 23,5 25,5 and 27,5 KHz, called "express signals", are used for five regular channels. When the tone corresponding to a particular channel is received at the transmitting end of the section, the signal on the regular channel is transferred to the stand-by channel. When transmission on the regular channel returns to normal, the procedure is reversed.

The circuits of the auxiliary channel systems are entirely transistorized.

Antenna Waveguide System

The antenna-waveguide system consists of the antennas, waveguide feeders, polarization filters, ferrite isolators, flexible waveguide sections, waveguide-antenna measuring equipment and other waveguide elements needed to connect the antenna with the channel branching filters.

Fig.7. Along main routes horn paraboloid aerials /Fig. 7./, 5,50 m in height, 3,80 m in width and 3,80 m in depth are employed. In addition, 3 m dia. paraboloid aerials are available for dropping and inserting wide-band services to from by-routes. Both aerial types are of an aluminium alloy and are designed for pressurized service.

The feeder from within the station to the antenna feed consists of square waveguide with 9x20 mm cross-section /for short feeders/, or of 70 mm dia. round waveguide for long feeders.

The waveguide feeders and aerials are maintained with a pressure of dry air. The pressurized air is derived from an air dryer.

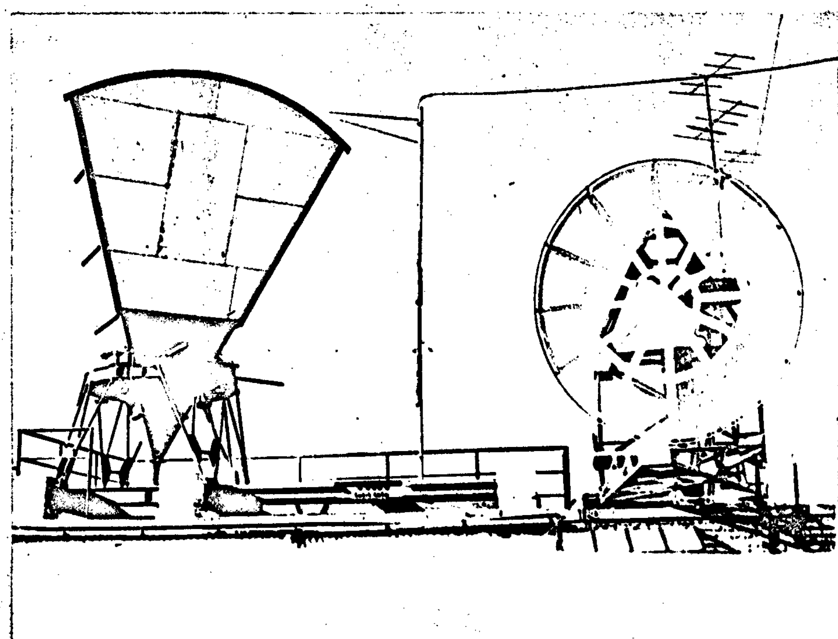


FIG. 7

Mechanical Arrangements and Bay Construction

All bays used in CCC 4000/600 system, except the control desk, are identical: 2,10 m high, 0,75 m wide and 0,65 m deep. The control desk is 1,20 m high, 1,66 m wide and 1,06 m deep. The main bays used are as follows:

- Broad-band RF bay, comprising a broad-band transmitter, a broad-band receiver, the microwave component parts and the channel separation filters for the appropriate transmitter-receiver frequencies. All electronic circuits excepted the reflex klystron in the RF bays, are accommodated in cases of half depth and 15 or 35 cm high. The waveguide assembly occupies the rear half of an RF bay.

- Modem bay accommodating one modulator and one demodulator for a broadband RF channel.

- Three variants of narrow-band RF bays are employed, viz.:

Narrow-band RF bay for terminal station, comprising two narrow-band transmitters and receivers /regular and stand-by/, the microwave components, as well as the telesignalisation circuits.

Narrow-band RF bay for repeater station TF type, from point of view of the transmitter-receiver accommodating the same circuits and components as does the bay for terminal station, and the engineers' order wire channel circuits.

Narrow-band RF bay for repeater station TR type, comprising transmitter-receiver and microwave component as before, as well as telesignalisation circuits.

- The control desk containing the voice circuits of service telephone channels with hand sets, as well as the adjustable elements and alarm indicators /lamps/ of the alarm, control and protection switching system.

- There are two main types of protection switching bays, viz.:

- IS-bay for terminal station, baseband type, containing pilot generators, pilot and noise monitors, logic

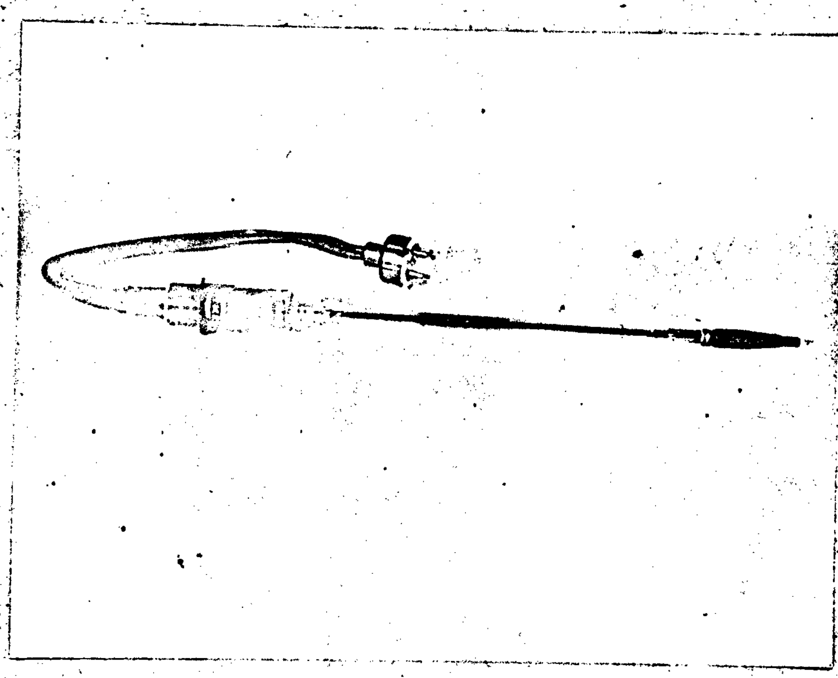


FIG. 8

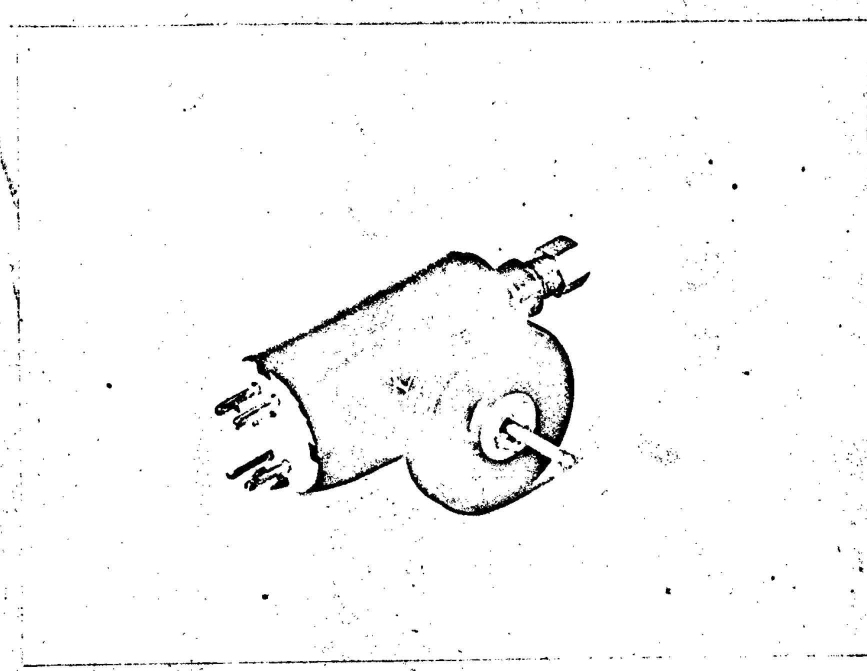


FIG. 9

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and controlling circuits with video-switches for all broad-band radio channels.

- IF-bay for main station, baseband-IF type, comprising the same circuits as bay for terminal station. The difference is in the switching. In the regular broad-band channels transmitting TV programme the switching-over takes place at IF, while in the rest regular channels this is done at baseband.

In all circuits of the GTT 4000/600 system tubes suitable for prolonged service are employed. The tubes used in non-microwave circuits are USSR-types, recommended by OIRT. The microwave tubes /MRO_3 type TWT - Fig. 8. -
Fig.8.
and MRO_2, MRO_3 type reflex klystron - Fig. 9. - / as well as some of the solid state devices used in the system have been developed in Hungary.
Fig.9.

A part of a repeater station installed with GTT
Fig. 10. 4000/600 equipments is shown in Fig. 10. The picture shows three broadband RF bays with two narrow-band RF bays. Special
Fig.11. microwave components such as ferrite isolators /Fig. 11./,
Fig.12. polarization filter /Fig. 12/, flexible waveguide section
Fig.13. /Fig. 13./, microwave switches, as well as special test equipments have also been developed.

Power Supply

The GTT 4000/600 system have been designed to operate on 220 ±5 V, 50 ±3 c/s three phase, AC mains. The AC power is distributed to the individual units of equipment where local rectifiers of various types, produce DC power of the required voltage and stability. Under commercial power failure conditions, emergency power is provided by single or multiple diesel engine-alternator sets. In case of failure these are automatically switched-on.

Summary of Data

1. General Specifications.

SHF frequency band: 3400-3900 Mc/s or 3800-4200 Mc/s

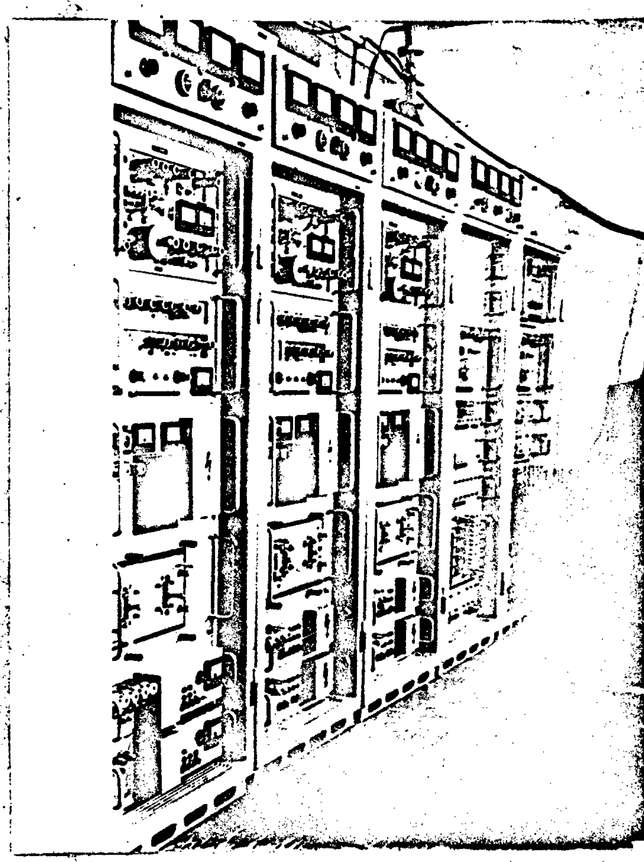

FIG. 10

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Radio channel capacity: up to six broad-band two-way and two-way narrow-band channels in each SHF frequency band.

Type of aerial: horn-paraboloid antenna

Aerial gain (relative to an isotropic source): 39 dB at 3635 Mc/s

Type of antenna feeder for bi-polarized signals:

- short feeders: square waveguide with 50x50 mm cross section
- long feeders: round waveguide with 70 mm dia.

1.1. Broad-band Radio Channels

Transmitter output power: 5 W

Receiver noise figure: 14 dB

Receiver AGC range: +5 dB to -25 dB relative to free space level

Receiver intermediate frequency: 70 Mc/s

Receiver IF impedance: 75 ohms unbalanced

Receiver IF bandwidth: ± 12 Mc/s between 1 dB points

Receiver IF levels:

- output of receiver: 1 V or 0,5 V
- input to transmitter or demodulator: 0,3 V

1.2. Narrow-band Radio Channels

Transmitter output power /minimum/: 250mW

Receiver noise figure: 14 dB

Receiver AGC range: +5 dB to -25 dB relative to free space level

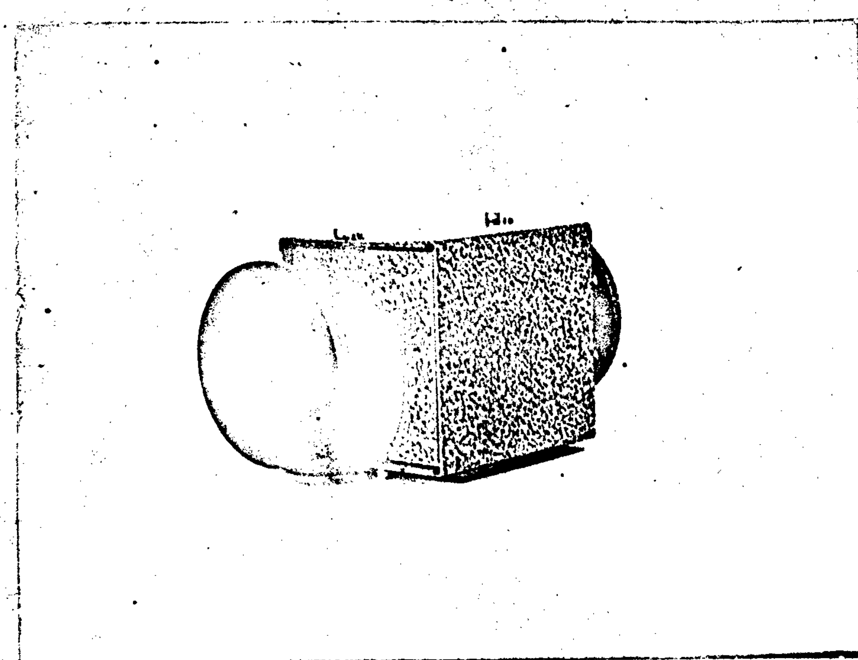
Receiver intermediate frequency: 40 Mc/s

2. Baseband Interconnection Data

2.1. 600 channels baseband

Traffic frequency range:

- with K-60 and K-1920 type FDM channeling equipments: 12-252 Kc/s and 312-2596 Kc/s
- according to CCIR recommendations: 60-2596 Kc/s



- FIG. 11

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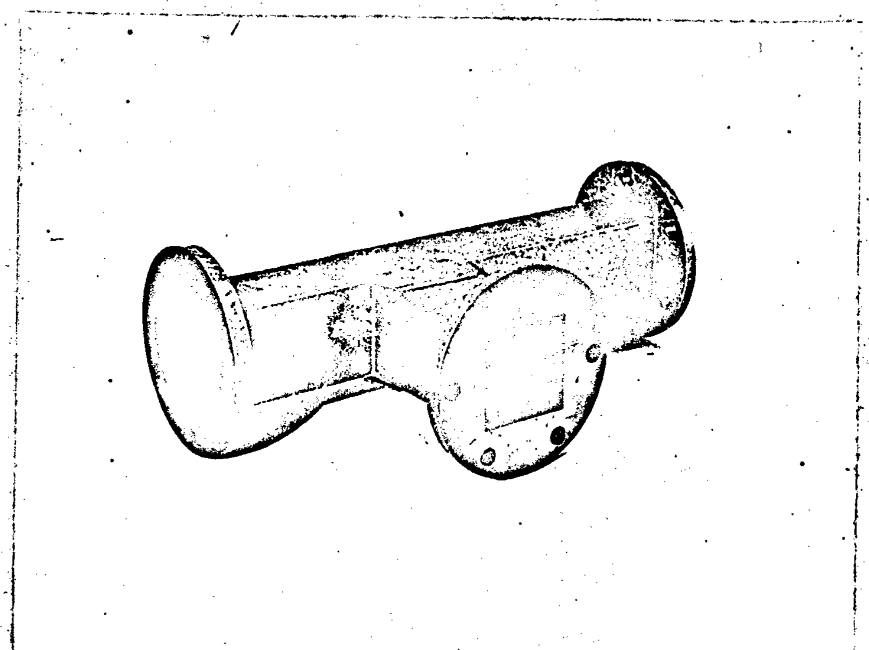

FIG. 12

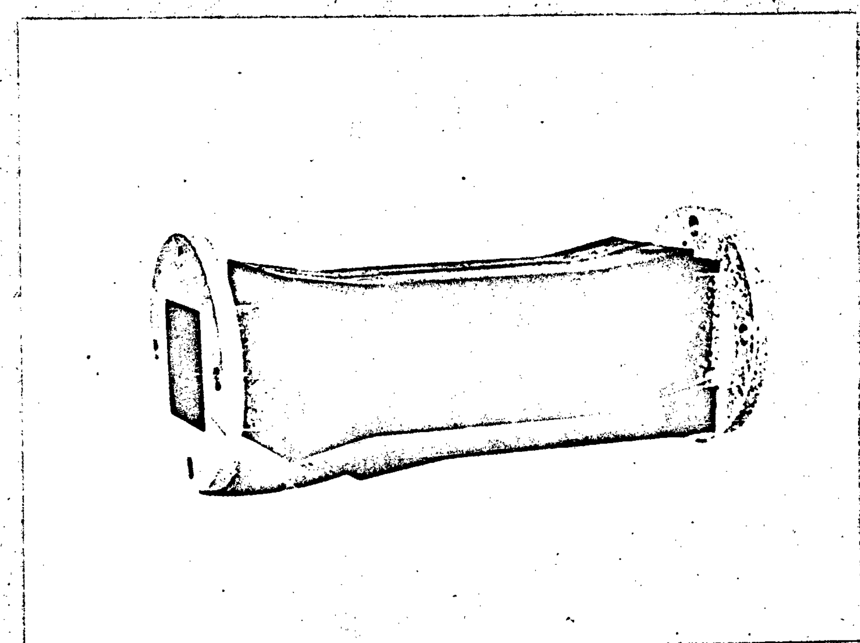

FIG. 13

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Input and output impedance:
- with K-60 and K-1920 type FDM channeling equipments: 135 ohms balanced and 75 ohms unbalanced,
- according to CCIR recommendations: 75 ohms unbalanced.

Input level:
- with K-60 and K-1920 type FDM channeling equipment: -1,85 nepers and -2,5 nepers
- according to CCIR recommendations: -15 dBm

Output level:
- with K-60 and K-1920 type FDM channeling equipments: -3,1 nepers and -2,2 nepers
- according to CCIR recommendations: -15 dBm

Preemphasis-deemphasis: CCIR, IXth Plenary Assembly, Los Angeles, 1959.

Test tone deviation in the 0 dB preemphasis channel: 200 Kc/s eff.

Pilot signal frequency: 8,5 Mc/s

Pilot deviation: 140 Kc/s eff.

2.2. TV image channel

Frequency range: 30 c/s to 6 Mc/s

Input and output level: 1 Vp-p

Input and output impedance: 75 ohms unbalanced

Polarity: white positive

Preemphasis-Deemphasis: CCIR IXth Plenary Assembly, Los Angeles, 1959

Frequency deviation at 0 dB preemphasis point: 8 Mc/s p-p

Pilot signal frequency: 8,5 Mc/s

Pilot deviation: 140 Kc/s eff.

2.3. TV sound channel.

Frequency range: 50 c/s to 10 Kc/s

Input, output level: 2,2 V rms.

Input and output impedance: 600 ohms balanced
Test tone deviation : ± 150 Kc/s
Subcarrier frequency: 8 Mc/s
Frequency deviation caused by subcarrier: ±750 Kc/s

3. Baseband data of narrow-band TF channels

3.1. Voice circuits

Frequency band of radio order circuits: 0,3-3,4 Kc/s
Signaling frequency of radio order circuits: 4 Kc/s
Subcarrier of express radio order circuits: 15 Kc/s
Baseband of 1th express radio order circuits: p,6 - 12.7 Kc/s
Baseband of 2th express radio order circuits17 Kc/s
Signaling tones of alarm and control system:
4,2; 4.4; 4.6; 4.8; 5; 5.25; 5.5; 5.75;
6; 6.3; 6.6; 6.9; 7.2 Kc/s
Tones of protection switching system:
19,5; 21.5; 23.5; 25.5; 27.5:Kc/s
Frequency of continuity pilot signal: 45 Kc/s

During 1963 the following CTT 4000/600 lines were put into operation:

"The Eastern Relay System" of the Hungarian Ministry of Post with automatic switching for 3 channels with an approx. length of 350 kmt.

For the Czehhoslovakian Ministry of Post one line for 3 channel operation and one line for 4 channel operation, both with automatic switching and with a length of approx. 350 km.

For the Soviet Ministry of Post 2 lines each for 3 channel operation with an automatic switching and for certain stations TV branching: Aggregate length approx. 550 km.