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THE HUNGARIAN TELECOMMUNICATION INDUSTRY: SELECTED BRANCHES 1/

Prepared by the
Hungarian Telecommunication Industry

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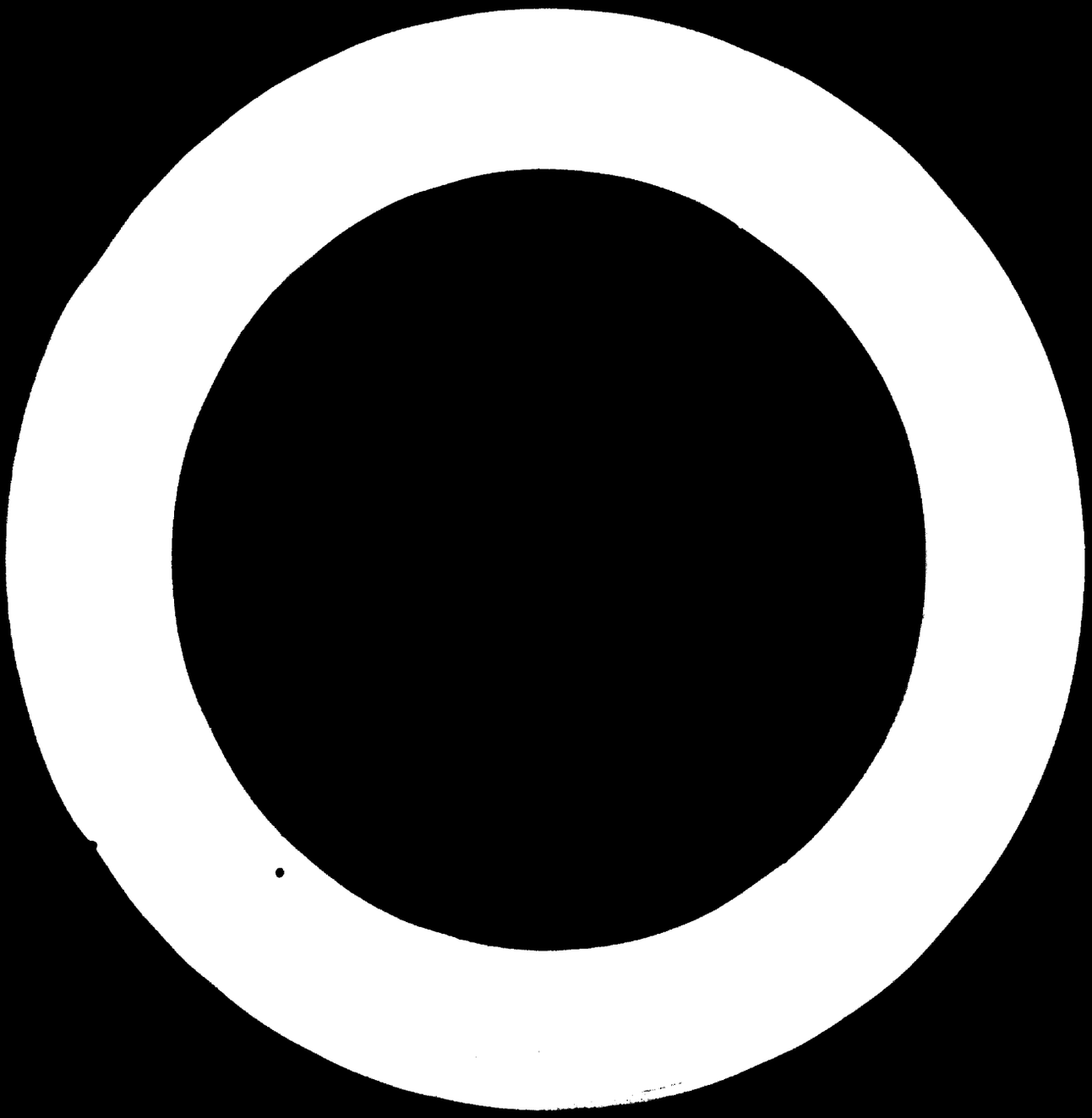

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INTRODUCTION

The Hungarian telecommunication industry prepared this background paper for the Consultative Meeting to be held in Budapest, 7-11 March 1977. The paper consists of a number of brief descriptions of the technologies of products now being manufactured in Hungary. This small sample of product technologies is expected to provide the participants of the meeting with some background before they visit plants and to offer a basis for discussions on possible industrial co-operation between Hungary and developing countries.

I. PRODUCTION OF TELEPHONE EXCHANGES IN HUNGARY

The invention of the telephone was commemorated all over the world in the last year. We, the workers and employees of the BHG Telecommunication Works celebrated already in 1974 the centenary of the foundation of our enterprise. Of course, it was at the beginning a small private workshop for the maintenance of contemporary telegraphic equipment. The development of telecommunication has been followed by the continuous growth of this industrial plant (incorporated into the famous Tungsram Works) which started at due time with the production of new telecommunication equipment such as telephones and manual telephone exchanges, repeaters and line fittings. The production of automatic telephone exchanges and radio receivers started in the 1920s followed by transmitters for radio broadcasting. The Works moved to its main plant under the name Standard Electric Co., as an ITT affiliate in 1938. In the 1940s it took up the production of carrier wave VHF and microwave equipment despite the force majeur compelling it to war production and after the war, reconstruction of the severely damaged Hungarian telecommunication network. By nationalization in 1949, the Works became independent. It has its present name since 1952.

Limiting the scope of this paper to telephone exchanges, we are proud in claiming that all telephone exchanges ever used in Hungary have been produced here except some foreign-made sample equipment. The first automatic system introduced was the Rotary system. The first public automatic exchange was inaugurated in 1928. The Rotary system has been used for decades, and its production is now being terminated. In 1956 a State decision was taken to introduce the crossbar techniques into Hungary. A genuine Hungarian crossbar switch has been patended followed by an assortment of crossbar and full relay PABXs.

At that time much experience and skill had been gained by the workers, many of whom already belonged to the second generation of the BHG worker "dynasties". So they mastered the not easy task of the introduction of all new production processes, including higher level of automatization. Since that time, they have produced some 740,000 lines of crossbar PABXs.

The family of crossbar PABXs produced by BHG Telecommunication Works consists of 4 types covering the capacity range from 20-2000 extensions. They are uniformly composed of the same Hungarian crossbar switch already mentioned and of the well-known flat type relay. Common control, uniform facilities and possibly the same or similar circuitry is used. This includes semiconductor diodes from the very beginning to simplify relay contact networks. A fully electronic control has been developed for the highest capacity PABXs (over 700 extensions) to provide the required call handling capacity of the common control.

A wire-spring relay has also been elaborated which is the main component of the full-relay PABXs ranging from 6 to 20 extensions. These form the RA family specified by the exclusive feature that an outgoing external communication can be "ordered", i.e. the user may push the earthing-button on the telephone set with depressed cradle. A ringing indicates immediately that a free outgoing line has been connected to the extension. As far as we know no other product offers this facility.

Tie-lines, in-dialling, toll restriction, etc. are the common facilities also offered by these two groups of PABXs.

Concurrently, or a little bit earlier, crossbar techniques have been introduced on another line. The USSR placed a long-term order for crossbar rural exchange according to its own design. Since 1965, we have produced more than 100,000 lines yearly of this type. This period witnessed the increase of the production to more than twice the earlier Rotary production, following an extended reconstruction of the producing plant. The mass production is highly mechanized or automated. Single-purpose machines and automatic test equipment took over the job of the earlier technologies.

The penetration of electronic control has continued in rural exchanges. A family of electronically controlled rural exchanges has been developed, using genuine Hungarian crossbar switches, wire-spring relay and third-generation semiconductor devices. This family has continued to practice common control by including a common processor accessed on a time-sharing basis, cover the capacities from 20 to 2,000 lines. A complete rural network on the Balaton lake has been in operation since 1966.

Another decisive step forward was the establishment of technical co-operation with LM Ericsson, Sweden, in the field of public crossbar exchanges. The well-proved AR system has been introduced together with an advanced technology, using pneumatic automation, computer-controlled testing etc. Based on this technique, the installation of public crossbar exchanges started in Hungary in 1969. This type of exchange increased up to now to the yearly production of 80,000 equivalent lines. A broad export market opened for our products. Almost 70% of the whole production is exported.

The export markets include Czechoslovakia, the German Democratic Republic, Poland and the USSR. PABXs are also exported to such developing countries as Algeria and Iraq. Greece and the United Kingdom of Great Britain and Northern Ireland have been customers for a long time. For the United Kingdom a specially developed private exchange (PAX) has been delivered, making it possible for enterprises owning plants all over the island to install a nation-wide private network.

The production capacity for AR type (public crossbar) exchanges is now devoted to furnishing equipment for Hungary, Czechoslovakia, the German Democratic Republic and Poland. The biggest job completed was the equipment of the 24,000 line Belváros exchange to serve downtown Budapest, replacing worn out Rotary equipment used since 1929. A dynamic reconstruction programme is under way to provide additional capacity to cover the needs of developing countries. First deliveries are expected in 1978.

Among crossbar public exchanges, ARF 102 type is intended for local exchanges, applicable as main, satelite, tandem and single exchange to serve any number of subscribers with a specific traffic up to 0.2 erl. Stage-by-stage control aided by MFC signalling is used. Other much-sought types are ARM 20 and ARM 50 transit exchanges for four-wire interconnexion of local and long-distance trunk lines. This system offers all facilities required in up-to-date automatic and semiautomatic long-distance service. Full availability of outgoing trunk groups, alternative routing, pad control, selection by analysing up to 5 digits and extended possibilities for interworking with other local, transit and rural systems are the main features of this system. Call-handling capacity surpasses 70,000 calls/hour (4,000 incoming multiple points).

The ARM systems / ARM 20 for medium and high capacities up to nearly 16,000 multiple points, ARM 503 for small capacities can be used at any level of the hierarchy in the national or even international network. A temporary international exchange was put into service in Prague in 1976. This system has been delivered for the national networks in Czechoslovakia, the German Democratic Republic and Hungary.

Rural automatic is another field in which manual exchanges have finally been eliminated. System ARK 50 is produced for this purpose. In close co-operation with system ARM 20 or ARM 50, rural exchange type ARK, with a capacity of 30-4,000 subscribers, fitted with sophisticated remote testing and alarm transferring facilities operates unattended and can be maintained easily by a central staff. Several areas in Hungary and abroad are fitted or under installation with this kind of rural system. The application of the mentioned local, transit and rural systems is well elaborated. Owing to the full compatibility of these systems, and to the modular design, projecting a network is very easy and yields the maximum performance of the equipment. To obtain the economic optimum, the switching and transmission part of the network can be designed parallel with the aid of a computer.

The BHG Works employed some 6,000 workers in the mid-1960s, in Budapest. The further expansion of the producing capacity resulted in the subsequent erection of new plants in addition to the main plant. Now the Works is composed of 6 factories, 2 of them in Budapest. The total number of employees has increased to slightly over 9,000 while the productivity has almost doubled. This is helped by extended automation as the recent installation of a fully automatic finishing workshop (painting and galvanization). BHG research institute and training centre is being established.

The main task of the research institute is to develop a quasi-electronic switching system capable of covering all sizes and whiches applications may occur when executing switching jobs. The basic step has already been taken: a quasi-electronic PABX for 96-384 extensions with stored programme control will be put on field trial soon. The elaboration of a higher capacity (up to 4,000 extensions) PABX and fully electronic telex switching equipment is envisaged.

The engineers of the Works participate intensively in the work of the competent international organizations such as the Permanent Committee for Radioelectronics of CMEA and the relevant study groups of CCITT. This activity has contributed to the international recognition of the Works and enables the Works to observe the newest trends and developments.

The activity of the Works does not end when the ready-made equipment leaves the factories. Several hundred skilled workers and others stay home or abroad on many sites installing or supervising the installation of BHG-made exchanges. Advisory services and maintenance of equipment already installed are also provided to customers who need them. In this way, contact with customers never ceases.

II. VHF TECHNIQUES

The Budapest Radio Engineering Factory (BRG) has had for a long time four established product lines:

VHF radio equipment
Entertainment tape recorders
Professional multichannel tape recorders
Magnetic tape equipment for preparation and acquisition of data

Of these, the VHF radiotelephone line will be dealt with in this paper.

Of the above-mentioned product lines, the VHF radio equipment has been included in the BRG range for the longest time. Already in 1953, the year in which BRG was founded, VHF broadcast transmitters were manufactured, then, before long, VHF transceiver units. According to the state of the art at that time, these latter were, of course, electron valve equipment and the present modern equipment built of semiconductors and integrated circuits is a result of a gradual development work.

At present, all types of the basic equipment - hand-held, portable, vehicle-mounted and fixed-installation units - are manufactured. Concerning frequency band, equipment is available for all authorized VHF frequency bands, such as 80 MHz, 100 MHz, 160 MHz, 200 MHz, 300 MHz and 450 MHz, for all modes of operation. The technical characteristics of the equipment generally conform to those of units available in the world market, as well as to various postal and international standards and recommendations.

Besides the basic equipment, VHF applications have also been expanded to a large extent. To users' demand the various locally and remotely controlled VHF centres, control units with selective calling capabilities, industrial signalling networks and VHF radiotelephone networks of idle channel scanning capable of performing complex function have been developed.

For such communication networks, BRG also produces the various filters, antennas and antenna systems required. Thus, it is able to meet demand for the simplest single unit or for highly sophisticated VHF systems.

Radiotelephone equipment is manufactured at the BRG factory in Salgótarján. The factory capabilities ensure a high technical standard of the equipment production. Special attention is paid to the testing of parts, subunits and subassemblies; consequently, the end product also conforms to very stringent requirements. For example, piece-by-piece checking is

accomplished with the quartz crystals determining the frequency stability of the transceiver unit, which is also tested at the extreme temperature limits and is passed to assembling only if performance is satisfactory.

The individual circuit units are mounted on printed-circuit boards. Special care is exercised in the preparation of these PC boards, and also in the testing of the component parts to be mounted. The parts are soldered on the PC boards by means of an up-to-date wave-soldering machine. To test the circuit units, specific-purpose instruments are used. These specific-purpose measuring instruments are made in a separate BRG laboratory and the testing possibility with a specific-purpose instrument is already a development objective in the circuit design period. Thus the manufacture of larger lots is rendered possible and a uniform technical level is ensured.

Each aligned PC unit is subjected to cold-warm stress, and only thereafter does it proceed to the assembly section, where the units are assembled to form a complete item of equipment.

Of the circuit units, the so-called hybrid integrated circuits, which are made with thin- or thick-film technology should be mentioned. These integrated circuits have found application primarily in portable and mobile units where size reduction is essential. These circuits are partly assembled in a special plant section of BRG, where appropriate conditions are provided for the production of micro-circuits. Recently, the hybrid circuits have appeared not only in portable but in vehicle-mounted and fixed-installation equipment, too, especially for meeting the enhanced reliability requirements.

The final testing of the ready-assembled units takes place in separate premises, where, besides the specific-purpose instruments, special measuring gear is also available. The checking of compliance with the mechanical and climatic requirements is an integral part of the final tests. For this purpose each piece of basic equipment (transceiver, control unit) is subjected to a vibration and climatic stress test and it may be tested in a complete station configuration only after compliance with these requirements has been verified. In this latter test position the emphasis is laid on the test of the various features, and the equipment/station may be packed only after these functional tests have proved it satisfactory. On request, BRG puts the supplied communications network into operation and installs the antennas. As already mentioned, BRG produces for its units a complete range of antennas, in addition even antenna systems of special radiation-pattern to meet special requirements.

The Network Design Section of BRG can render assistance to the users by undertaking, if required, the overall design of the VHF system in question.

The VHF equipment of BRG is exported to many countries, and also sold on the domestic market. The foreign customers may be the end-users; in this case BRG supplies the equipment and the customer installs it. However, it is also feasible that the supervision of the installation and occasionally even the preparatory work (erection of antenna masts, installation of antennas, preparation of equipment sites) is performed by BRG experts. For some customers, this latter arrangement may be advantageous, since they are given a complete, commissioned communications network.

There is an evident need for making customers acquainted with the construction and operation of the equipment, which may be accomplished by using the BRG training facilities. The customer may, for example, send his technicians to BRG for a period of 3-4 weeks. They can follow in practice each technological phase of production, thereby acquiring the necessary knowledge about the equipment and its circuitry. For major customers, a BRG expert may stage on-site training on a limited scale. To maintain the satisfactory operation of equipment installed abroad, it is necessary to establish a repair service. BRG may help in providing this service with the necessary measuring instruments, even by supplying specific-purpose instruments.

As mentioned above, the foreign customers may be end-users; however, BRG may also grant a licence to a customer for the manufacture of some types of equipment. The introduction of the production, is, of course, a step-by-step process; first, it covers only a single equipment type, and even here, the assembly of subunits; then the scope of production may be gradually expanded.

Naturally, the case differs if the licence is restricted to a single user or if the production under licence is to be introduced in an existing or newly established factory. BRG can furnish a complete offer in both cases, which covers, besides a feasibility study, the required manufacturing equipment and tools, the recommended production area, the necessary staff, the requirements for test instruments etc. Thus, BRG is fully prepared to meet various user requirements for the supply of equipment or for the complex realisation of a communications network. In addition, BRG is prepared to lay the foundations of VHF technology in countries where it may be required, by granting manufacturing rights.

III ELECTROACOUSTICS

The particular features of the Hungarian electroacoustic industry's quick development are in brief the following:

(a) It engaged in research on telecommunications. The Hungarian results were published at the beginning of the 19th century and received international approval;

(b) It has disposed of its own research and development;

(c) It became specialized in complete professional systems.

It is engaged in research, developing, manufacturing, system-designing and installing work in the following lines:

Programme-making and transmitting systems, electroacoustic equipment of studios

Sound systems for covered and open-air areas and their electroacoustic equipment

Audio-visual systems for educational institutions

Glass technological equipment for chemical laboratories as well as for institutes of education

Furniture with built-in electroacoustical equipments

Besides the above-mentioned fields, BEAG (electroacoustical company) has joined the noise abatement programme, developing a module system of sound-absorbing panel elements.

BEAG, employing more than 3 000 workers, has its centre in Budapest, and specialized workshops in the country, whose productional activities are based on the resear h and development made n the centre. Owing to the relatively high number - 600 - of engineers and technicians, approximately 100 patents, which are protected by laws in the industrial countries of the world are put into practise of production more than 75 per cent.

The grouping within the individual lines - especially in the electroacoustical ones - is as follows:

I. Programme-making and transmitting systems, electroacoustic equipment of studios

Electroacoustic equipment of radio-studios, TV studios, sound-recording studios, record-copier-studios, film-studios and other studios

Some typical products

Mixing desks, 4-30 channel (mono, stereo) in portable and stabile construction

Announcing desks

Technical monitoring desks

Distribution commutating racks and tables

Line and power amplifier racks

Studio central desks

Studio microphones

Microphone stands

Monitoring loudspeakers

Volume indicators

The volume in production and trade of the studiotechnical equipment has reached and exceeded the level of some international companies. It delivers yearly not less than 8 - 10 complete sound systems for broadcast and TV Houses in the Soviet Union and in other countries. It issues the largest number of mixing desks in Europe. Besides the regular delivery at home, there is a large export to the Soviet Union; constant buyers are Bulgaria and Romania as well.

The factory has for years engaged in research and development in semi-automatic systems with computer control. The mass production of the studios has given the reason to use the group-elements of this product on the other fields, too, so has formed its second side face, the sound systems of opened and closed-space establishments.

II. Sound systems and electroacoustic equipment for open-air and covered areas

Electricacousitc equipment for cultural and educational institutions, sport establishments, national communal, political and scientific establishments, commercial and tourist establishments, industrial and agricultural establishments, sanitary institutions, establishments concerned with means of communication.

Some products.

Amplifier racks 5 x 200 W

Sound centre with amplifiers, record players, wireless

Microphone and line distributing blackboards and racks

Microphones, joint parts, cables; record-player and tape recorders in professional construction

Cabinet loudspeakers with volume control to information aim with transformer or without them, 05, to 3 W

High-power cabinet loudspeakersystems for large halls, theatres etc. up to 1.6 kW

Sound columns for closed and opened space 5 - 100 W

Horn loudspeakers for streets, squares, stations etc.

Sound-absorbing modular units

III. Audiovisual systems for educational institutions (public, adult, special)

Some products

A-V audio-visual ground set, which is combined with diatape recorder and it performs the material

Teacher feedback equipment, measuring the effectiveness of the teaching

Programmed collective and individual teaching machines

Language laboratories

Individual and collective teaching equipment for hard-of-hearing students.

The company offers also its help in solving problems in the following fields:

Projecting new establishments

Reconstructing and completing existing studios

Participating in direction of mounting

Drilling operators, servicemen

Establishing of service stations

Buyers of Hungarian electroacoustic equipment include

Radio houses in the Soviet Union

Radio house of Havana, Cuba

Radio house of Cairo, Egypt

Radio house of Sofia, Bulgaria

Radio house of Bucharest, Romania

Sport stadium, Djakarta, Indonesia

Sport stadium, Tunis, Tunesia

Sport complex, Banica, Yugoslavia

Sport stadium, Algiers, Algeria

Sport complex, Bagdad, Iraq

Sport stadium, Leipzig, German Democratic Republic

Stadthalle, Karl Marx Stadt, German Democratic Republic

National Theatre, Weimar, German Democratic Republic

National theatre, Bucharest, Romania

Thomaskirche, Leipzig, German Democratic Republic

Teaching as well as public address systems of Karl Marx University, Leipzig, German Democratic Republic

Teaching Centres in Peru

Technical equipment for persons in teaching instruction

Hard-of-hearing persons in Czechoslovakia

Teaching as well as public address systems
of "Town of Physicians" near Moscow, USSR

The company is now producing electroacoustical equipment of the third generation, equipped with monolithically integrated semiconductor elements as well as some other types of second-generation silicon semiconductors. BEAG has its own electroacoustical research laboratory, three developing, constructing and technology departments, according to the three main fields of activity mentioned. It is to be noted that our products and our systems are compatible with the international standards as well as with international practise. Therefore our products are able to be used with other parts of systems manufactured by others.

IV. TETRA TRANSMISSION EQUIPMENT

Introduction

The manufacturing programme of Telefongyár (TERTA), Budapest, includes the following transmission equipment:

Voice-frequency (VF) equipment

Carrier telephone equipment for open-wire lines

Carrier telephone equipment for symmetrical cables

Carrier telephone equipment coaxial cables with small and normal diameter

Various multiplex equipment for radio-relay links

Pulse-code modulation (PCM) telephone equipment as well as telegraph and data transmission equipment compatible with PCM

VF telegraph transmission equipment

The main equipment and features of the systems given above are given below. Generally, it can be said that the systems comply fully with the relevant International Telegraph and Telephone Consultative Committee (CCITT) recommendations.

In addition, the more severe specifications required by specific geographic conditions for certain equipment are also satisfied, e.g., in the case of a particularly long connexion or in extreme climates.

Our equipment has two structural forms:

Cabinet-drawer design (mark S). This consists of a 2600 x 660 x 250 mm cabinet with cabling and drawers containing the functional circuit units in the supporting shelves of the cabinet. For the electrical connexion between the cabinet and the drawers short-circuiting plugs on the front are used. The station cabling is connected by soldering at the terminal strip on the upper cabinet part.

Uniform rack design (Sub-rack design type E2 mark K). This consists of a 2600 x 600 x 225-mm supporting rack frame and of sub-racks with one or several rows. The cabling between the rack and sub-racks and the station cabling is connected by plugging into the rack-side. The sub-racks form

complete, self-contained assemblies comprising plug-in printed circuit (PC) cards.

VF Systems

2/4 wire amplifiers with variable balancing network

2/4 wire terminating units with compromise or precisely adjustable balancing network

Ringing repeater (signalling tone receiver and sender)

Systems for open-wire lines

The 3-12 channel system meets CCITT recommendations G-361 A, B, and recommendation G.311, Fig. 3 variant, in respect both of the line-frequency band and the transmitting level and other principal parameters.

3-channel system, type BO-3

Cabinet for terminal stations. it is equipped with one or two terminal repeaters or with one terminal repeater and four frequency modulation (FM) telegraph channels. The repeater station can be of an attended or of a remotely-supervised dependent type. A variant for steel open-wire lines is also available.

12-channel system type, BO-12

Long-distance variant

The system parameters meet the requirements for both the 12,500-km reference circuit and extreme climates. The cabinet accomodates the equipment for one terminal station. An attended intermediate repeater equipment is also available.

Short-distance variant

Because of climatic effects or other disturbing influences the above system is completed with a remotely-supervised dependent repeater for shorter routes.

12-channel system, type BO-12 E2

The system with design E2 mentioned earlier is under development and would accomodate the equipment suitable for the long-distance (7500-km reference circuit) and normal (2500-km reference circuit) variants.

The terminal rack is equipped for four systems.

Also, a small rack equipped for one system would be manufactured (cabinet for wall mounting).

The rack for intermediate repeaters is equipped for three or four systems depending on the required services. The intermediate repeater would also be manufactured in a small rack for one system or in a cabinet for wall mounting.

Systems for symmetrical cables

Our manufacturing program includes a 12 channel system with a cabinet-drawer design which meets CCITT recommentation G.325, scheme 2, and recommendation G.326, "low-gain" variant, The 60-channel system is of E2 design and is in compliance with CCITT recommendation G.322, and within this, with the "low-gain" variant.

12-channel system, type BK-12

Small-station layout

The cabinet for terminal stations is completed with all the units of one system from the voice-frequency to the line-frequency band.

At the terminal station an additional through group filter rack can be used.

The cabinet for terminal stations can be equipped for one system and the equipment for attended, dependent stations for 8 systems.

Large-station layout

The variant comprising the following ensures a more economical layout for larger terminal stations:

VF terminating cabinet HZS-60/120

Channel-translating cabinet CMS-60, 5 primary groups

System-translating cabinet RMS-12, suitable for 10 systems
Through group filter cabinet GTS-12, for 6 systems, if required.

Line section equipment

Cabinet for attended intermediate repeater station FBK-12, can be equipped for 8 systems

Equipment for remotely-supervised dependent repeaters NBK-12 (can be equipped for 8 systems), accomodated in a hermetically closed steel container with cable tails.

Cable-termination cabinet KZS-12, can be equipped with cable heads containing 4 x 4 or 12 x 4 quads.

Service and power supply cabinet SZTS-12.

6/12-channel portable equipment, type BH-2

(See separate description)

60-channel system, type BK-60

The principal parameters of our system comply with the variants in CCITT recommendation G.322, scheme 2 and 2 bis and with the CCITT "low-gain" variant.

As regards the design, we are producing two different sorts: A special variant for cables with one quad and a normal variant for cables with several quads.

BK-60-2 system for one quad

Terminal-station equipment

The rack for terminal stations KMVK-60 is of combined design and contains the channel, group and system translating stages as well as the carrier supply and the group pilot regulating units. If required, the 2/4-wire hybrids can be accommodated in the separate rack HZS-60/120.

Line-section equipment

Combined repeater cabinet KES-60 containing the transmitting amplifiers for one quad, i.e. for two systems, and the receiving and line pilot regulating circuits (3 line pilots).

Equipment for remotely-supervised dependent repeater stations NBK-60-2, accommodated in hermetically closed, cylindrical steel containers with cable tails; the container can be directly buried.

Branching-type container through which one of the two 60-channel systems can be dropped off from the line section.

BK-60-3 system for several quads

Terminal-station equipment

According to the large-station layout principles the functionally identical equipment parts are accomodated in separate racks:

VF 2/4-wire terminating units (in a HZS 60/120 cabinet)

Channel translating equipment CMK-300 the rack comprising 25 primary groups the equipment contains electromechanical channel filters meeting the specifications of the Bundespost of the Federal Republic of Germany and employs 48 kHz premodulation

Group-translating sub-rack GMB-12/60-2; can be equipped for two systems

System-translating sub-rack RMB-60/60; can be equipped for 8 systems

Master oscillator sub-rack MOB-60; supplies the control and group pilot frequencies to the station

Group and supergroup pilot receiver sub-rack PVB-84/411; ensures central control for the group regulators accommodated in the rack.

The sub-racks referred to above can be accommodated in homogeneous racks or in common racks with combined layout (e.g., KMVK 12/60/60 combined translating and carrier supply rack).

Line section equipment

Combined repeater rack equipped for 8 systems KEK-60 (transmitting and receiving amplifiers, pilot regulators)

Equipment for remotely-supervised dependent repeater stations NBK-60-3; consists of an angular cast steel container with cable tails and can be equipped for 8 systems and placed in a man-hole

Cable-termination cabinet KZS 60-3; contains cable heads with 4 x 4 or 12 x 4 quads and a set of capacitors for cross-talk balancing

Separate equipment for cross-talk balancing AKB/F; contains a set of capacitors for cross-talk balancing and a phase shifter set in a closed container

Coaxial systems

Types BK-300, BK-300/G, BK-960 and BK-2700

Our system operating on CCITT normal and small diameter coaxial cables consists of 300-, 960- and 2700-channel complexes. The currently manufactured variant meets CCITT recommendations G.341, Fig. 1.a; G.343, Plan 1, G.338; G.344; and G.332, Plan 2.

The 300-channel system type BK-300/g suits special requirements and can be operated in a 7500-km reference circuit at a load higher than that recommended by CCITT (see below).

Terminal-station equipment

Common equipment

VF terminating cabinet HZS-60/120

Channel-translating rack CMK-300 (see above under BK-60-3 system)

Group-translating sub-rack GMB-12/60-5/-2/ equipped for 5 (2) secondary groups

Master osoillator sub-rack MOB-300/960/2700; for central supplying to the station the group pilot frequencies, the synchronizing frequencies and the 12- and 124- kHz control frequencies

Central pilot receiver sub-rack PVB-84/411; for checking the primary and secondary group pilots of the translating equipment mounted in the same rack

Through group and supergroup filter sub-racks TSB-G, -SG

Additional racks (Suite end-rack SLK, cable termination rack KVE, distributor rack NRK, power packs)

System-dependent equipment

300-channel system-translating sub-rack RMB-60/300

960-channel system translating sub-rack RMB-60/960

Super group translating sub-rack SGMB-60/15x60

2700-channel system translating sub-rack RMB-15x60/2700

The above sub-racks are manufactured in the uniform E2 design mentioned earlier and can be arranged in different locally required combinations composing homogeneous or combined racks in great variety.

Line-section equipment

Two different types of line section equipment are available: one for terminal and attended intermediate repeater stations and one for remotely-supervised dependent repeater stations. As regards the structural design the equipment types are uniformly composed irrespective of the channel numbers.

Rack-mounted repeater for terminal and attended intermediate stations ETK-300, -960, -2700 containing:

In go-direction: stop filters, injection of line pilots, pre-emphasis, transmitting amplifier and dc power supply

In return-direction: a receiving line amplifier with automatic pilot regulating, de-emphasis, fix and variable line equalizers, adjusting and compensating pilot receivers and regulators, a frequency comparison pilot receiver, stop filters

The rack comprises a remote power supply, as well as a service channel and fault location circuits for servicing the line section

The rack-type ETK is manufactured in the uniform E2 design mentioned earlier and can be equipped for two systems.

Remotely-supervised dependent repeater station NBK-300, -960, -2700, containing:

In both directions: power-separttion and over-voltage proteotor devices, amplifiers and fault location circuits. In the 300- and 960- ohannel systems all of the amplifiers have an automatio pilot regulation while in the 2700 ohannel system, only every fourth of the amplifiers is adjustable and the others have a fixed gain.

The equipment consists of a corrosion-resistent cylindrical steel container with a hermetically closed cover and the container can be directly buried. For connecting the cables, cable tails are available. The use of over-pressure is possible. The container can accommodate six amplifiers for three connexions.

Combined radio-cable system type BM-300/C

Since this system type differs from the others, a brief description of its unparalleled features has been made separately.

Multiplex equipment for radio-relay links

The terminal multiplex equipment of the systems above can also be used for radio-relay links when inserting the matching units manufactured by TERTA in variants convenient for the frequency band and suitable for bridging various small distances between the multiplex and radio-relay equipment.

PCM systems and their supplementary equipment

The primary order PCM equipment, together with the supplimentary equipment, is already included in our manufacturing programme and the secondary order PCM equipment is in the experimental production stage. The primary system complies fully with CCITT recommendations G.711, 712 and 732.

Moreover, the matching units for signalling are suited to a great variety of different type exchanges ranging from the early rotary exchanges through cross-bar systems to the most up-to-date types of exchanges. From the line of the supplementary equipment the telegraph and data-multiplex systems compatible with PCM are still to be mentioned.

Equipment of a primary PCM system

Multiplex equipment type BD-30/32

Meets the above CCITT recommendations. The rack accommodates four systems. A line-terminating unit can also be placed in the rack.

Line-terminating unit

Can be accommodated in the above rack or in a separate rack. It is suitable for various types of cables or can be matched to radio-relay links in accordance with customer specified and CCITT recommended line code modifications.

Remotely-supervised dependent repeater station type NBD 30/32

Delivered in hermetically closed container and equipped to various degrees. The system has fault location circuits and various testing units in accordance with up-to-date demands.

Signalling matching equipment (translator)

The principal variants adapted to the technical requirements to be specified by authorities are as follows:

Signalling matching equipment with EM system

Electronic matching equipment with a central processor

Electronic matching equipment with a simple central control

The matching equipment can be accomodated in a rack alone (e.g., for 2 x 30 channels) or combined with PCM equimment in a common rack.

Telegraph/data transmission equipment compatible with PCM

The actual equipment group is avialable in two forms with different system engineering characteristics and in two different application variants:

With an internationally normalized 64 kbit/s interface for PCM systems

With a 64 kbit/s signal rate for direct line transmission

For telegraph transmission with simple sampling (without coding, with 31 telegraph channels, type TMB-31/32)

For transition coding normalized by CCITT (type TMB-240)

Note: Several variants of the different sub-multiplex equipment suitable for this type are under development.

VF telegraph equipment

The telegraph transmission system type BT-50/200, constructed in the uniform E2 design, ensures the transmission of telegraph channels with rates of 50, 100 and 200 bands and a quality required by the CCITT R series recommendations. The rack accommodates a maximum of 120 channels.

V. LIQUID-CRYSTAL DISPLAY

The manufacturing technology of liquid-crystal displays (LCDs) can be divided into four procedures:

Cleaning
Thin-film technique
Orientation
Mounting and sealing

In the following some solutions for these procedures will be outlined, as they have been worked out in our Institute in its laboratory production of liquid-crystal displays based on dynamic scattering.

Cleaning

The fabrication of liquid-crystal displays requires strict technological discipline and extreme cleanliness, not only of the environment (air, instruments etc.), but also of the applied substrate and other materials. The optical quality and reliability of liquid-crystal displays is basically determined by the effectiveness of the cleaning process.

Thin-film technique

After cleaning, the next most important operation is the formation of the glassy conducting layer. The surface resistance of the conducting layer should not be greater than 500 ohm, and its light transmittance must be good. The applied layer is tin dioxide with a few per cent antimony pentoxide. It is made by chemical layer deposition. The basic material is tin tetrachloride; out of this the tinoxide layer is developed by hydrolysis above 400°C:

$$SnCl_4 + 2H_2O \longrightarrow SnO_2 + 4HCl$$

After the deposition, the layer is heat-treated at 300-400°C to remove the traces of hydrogen chloride and to stabilize the layer. The pattern necessary for the display is made by photolithography adapted to the thin-film technique.

Orientation

The selection of the orientation depends on the mode of operation of the display. For displays working on the principle of dynamic scattering, the perpendicular orientation is used (the liquid crystal molecules are placed on the surface of the substrate perpendicularly). This orientation can be achieved by the deposition of an oriented chemisorbed layer. The orienting material is a silane molecule, which has one end of a long aliphatic carbon chain strongly attached to the surface of the substrate. The carbon chain perpendicular to the surface assures the orientation of the liquid-crystal molecules. The realization of the twisted nematic field effect mode of operation needs a parallel orientation. (molecules parallel to the surface of the substrate). The orientation is assured by a vacuum-evaporated silicon monoxide layer laid down at 10^{-5} torr The vacuum evaporation must be realized with a geometrical arrangement with the angle between the beam of vapour and the substrate is 5°-10°. The thickness of the layer is about 100 The assymmetrically shaped silicon monoxide molecules form parallel grooves that ensure the right orientation for the liquid crystal molecules.

Mounting and sealing

The mounting and sealing procedure depends on the required construction. In our Institute, the displays are first fabricated according to the special wishes of the precision engineering department. The thickness of the liquid crystal layer is 9-15μm The thickness and the sealing is ensured by a polyester layer. The polyester does not react with the liquid crystals. For filling with liquid crystal, there is a 1-mm hole on the display. (The glass substrate is punctured with an ultrasonic drilling machine before the conducting layer is formed.) After filling, the hole is closed mechanically with a tin alloy.

VI HYBRID INTEGRATED CIRCUITS

Integrated circuits exist in two basic technological variations. The generally known semiconductor integrated circuits are fabricated in great numbers and variety. Besides this, hybrid integrated circuits technology is first of all developed from the working processes of the passive elements, preferably to meet the users concrete requirements, in small series. Hybrid integrated circuits have in common that they are fabricated on some kind of insulator substrate, usually glass or ceramic. Semiconductor devices and capacitors are mounted and the ready-made circuits are encapsulated after measuring.

Every kind of technology exerts an influence on the increasing reliability and the decreasing dimensions of the integrated circuits, making possible the assembly of equipment with moduler elements. The hybrid circuits, representing about 15% of the market value of all the integrated circuits in those countries where the electronic industry is highly developed, have in turn been produced in two basic technological variations, thin-film and thick-film types. The thin-film hybrid integrated circuits, being a relatively smaller part of the hybrid circuits, are made up of conductor and resistor layers produced by vacuum operations such as cathode sputtering.

The thick-film technology has been more widely accepted. In this case, the conductor, resistor and dielectric layers and systems made up of them can be produced with viscous an thixotropic pastes screen printed on ceramic alumina (Al_2O_3) substrates.

The printed layers are burned in at high temperatures (800°- 1000°C). The thick-film technique is widely accepted because of its relatively low investment costs compared to other types of integrated circuit technology. The handling of the equipment is delicate, but it can be learned quickly. The requirements for environmental cleanliness are not extremely strict and are limited chiefly to the procedures of layer production (screen printing, burning-in and the auxiliary procedures), which form a small part of the whole process. The influence of the environment to the burned integrated networks is extremely small since the surface is protected by a glass layer. The procedures of mounting, measuring and packaging do not require special environment, only the usual conditions for precision equipment.

Thick-film resistors reach the quality of discrete metal layer resistors. They can be produced with a +20% tolerance without a subsequent adjustment and are made in the range from a few ohms to several tens of millions of ohms. The value of the printed resistors can be adjusted subsequently by sand blast or by laser trimming to +1%, in special cases to ±0.5%.

During trimming, the structure of the layer is damaged, which, however, does not influence the parameters of the resistance disadvantageously. The temperature coefficient of the resistors varies from 1×10^{-8} to 2.5×10^{-8} $(\text{deg C})^{-1}$, depending of the type of the applied pastes. The stability of the resistor is better than 1% during storage or loading. The noise factor is better than $1 \mu V/V$. The built-in resistors do not require any special covering. The aim of the applied covering is protection against mechanical and chemical damage.

The thick-film conductor systems are made up of alloys containing noble metals adhering firmly to an alumina ceramic substrate. They can be easily soldered and some types are of good bonding characters. The resistance of the layer is in the range $(2\text{-}100) \times 10^6$ ohm/cm^2 The conductor and resistor layers are completed with printed insulator layers having three fields of application. Between crossing wires, insulator layers can be made to assure a small capacitance together with good insulating properties. Capacitors of a dielectric constant of 10-500 and 2000 can also be made. Furthermore, covering and insulating layers can be produced in order to protect delicately printed systems.

Recently, besides the conductor systems of noble metal-based conductor pastes, nickel- and copper-based pastes have been proposed; for these burning-in requires a nitrogen atmosphere. Noble-metal systems to be burned-in in air are under development. By means of properly formed and deposited conductor and insulator layers, multilayer conductor networks can be produced which perform the function of a multilayer printed circuit board of smaller dimensions. Encapsulated or non-encapsulated semiconductor integrated circuits, transistors and diodes of subminiature or chip-type ceramic, and tantal capacitors can be mounted incorporated in printed and burned networks, depending on demand. This technology allows the combination of most different integrated circuits and special elements. The mounted circuits can be adjusted for the output parameters by means of varying the values in the printed state by the subsequent adjusting of some selected parameters.

The realization of the circuit covering to protect against external effects can be chosen within wide limits to meet the requirements of the user.

Thick-film hybrid integrated circuits can be applied in all fields of electronics, from resistor networks of average complexity or of high accuracy to large-scale integrated circuits. Different circuits can be economically realized in small series as well. Thick-film technology is suitable for manufacturing other electronic devices, among which displays operating on the principle of gas discharge should be emphasized.

The development of the technology made the elaboration of different measuring instruments and technological equipment necessary. The serial production of numerous modern equipment has been realized, for example, thick-film technology measuring instruments of general purpose and computer-aided equipment.

VII. COMPUTER-AIDED DESIGN AND MANUFACTURING OF ELECTRONIC CIRCUITS - THE AUTER SYSTEM

Background

The use of computers in the design, manufacturing and testing of up-to-date electronic circuits and systems is a basic trend in the electronic industry. This kind of automatic system containing computers, NC machines, automatic manufacturing and test equipment, has been developed and is used in large electronic laboratories. The specially designed operating systems and the computer-aided design applications programmes together with the hardware elements comprise the complete know-how for the design and manufacuuring of electronic circuits.

These CAD systems are highly independent of the actual technology or they can be matched quite easily for specified technological equipment. They are independent also of special application e.g. computing equipment, telecommunication systems, electronic measuring instruments, industrial control systems, medical electronics).

Since more than a decade, intensive research and development have been carried out in this field by TKI. The result of this activity is the AUTER system solving the design, manufacturing and testing problems in an integral system. The AUTER system is used for printed circuit board and integrated circuit technologies.

The AUTER system - in the hand of a designer - is a tool for solving the algorithmizable problems of the electronic circuit design process starting from the specification and terminating at the production testing. The result of the design process, on the other hand, is a production documentation appropriate also for serial production.

The main parts of the AUTER system are as follows:

Modeling of devices and simulation of electronic circuits and systems, as well as the design of circuits for standard functions (e.g. filters)

The layout design of printed circuit boards and integrated circuits

The control of the manufacturing and testing equipment

The standards of the technologies, the parameters of the electronic devices (electrical and geometrical data) and the standards of the documentation are stored in a data bank. These data will be automatically used during the design process. Most of the hardware equipment of the computing system - except the universal larger computer - are the products of the Hungarian electronic industry. They are operating in TKI in an integrated system. Some important features of the AUTER system are described below.

The main characteristics of the AUTER system

The elements of the AUTER system are CAD programme systems, which:

(a) Are user-oriented (i.e. no programming knowledge of the user is required; effective interaction between user and computer guarantees effective use of the system);

(b) Help the user in the whole design process, starting with the specification and terminating at the generation of manufacturing documents or at the experimental (prototype) production;

(c) Cover the design process of devices, circuits and systems as well;

(d) Are matched to the up-to-date (third and fourth generation) technologies.

The purpose of the AUTER system is to solve automatically all of the algoritmizable design phases that do not require intuitive decisions of the engineer. Thus, the AUTER system helps to increase the effectiveness of engineering. The elements of the AUTER system adopt themselves to the up-to-date technology (production equipment and production lines with or without NC control, automatic measuring and testing instruments etc.), and to the automatic testing capabilities and equipment for printed circuit boards and integrated circuits. The AUTER system is implemented on several computer configurations including alphanumeric and graphic terminals. The AUTER system makes possible to check the specification of devices, circuits and systems before realisation (simulation program systems), and increases the speed and effectiveness of printed circuit board and integrated circuit design (layout design and documentation program systems). Thus, by the use of the system, considerable decrease in total development time and cost can be achieved in the design and manufacturing of electronic and microwave circuits, devices and systems, including telecommunication, teleprocessing and computing systems.

The design process can be divided into three main sections: electrical design (design of the circuit schematic topology and parameter values), layout design (design of circuit geometry), and documentation and prototype production (generation of the documents for production of the circuit verified by prototype production).

During the electrical design phase, the designer's purpose is to determine or adjust the parameters of the network for ensuring the specification. This task is helped by modelling program systems, model data banks and simulation program systems.

The layout design starts with the electrical circuit schematics. On the basis of the selected type of the realization and the type of technology, the result is the layout (geometry) of the circuit (for printed circuit boards, integrated circuits and complex units containing printed circuit boards the geometrical parameters are the component arrangements, wiring etc.).

In the documentation phase, starting with the results of the electrical and layout design phase, the results are the documentation materials (containing alphanumeric and graphic documents, master films, rubylith masks, NC tapes for controlling the production and test equipments). Using these documents the prototype manufacturing and testing of the circuits check the quality of the documentation.

In accordance with the purposes of the AUTER system mentioned above, the main elements and services of the system are as follows (in parentheses: the name of the appropriate program system element): checking the specification for analog circuits (simulation).

DC, AC, noise and tolerance analysis of linear circuits, taking into account the effects of the temperature as well (ANAL-7,6,11)

Distortion analysis of circuits with small non-linearities (ANAL-11)

DC, transient and spectral analysis of nonlinear circuits (ANAL-3,8)

Analysis of nonlinear circuits under periodic excitations (ANAL-12)

Simulation of analog systems (ANAL-16)

Simulation of digital circuits and systems (ANAL-17)

Modelling and model data bank of semiconductor devices: discrete diodes, transistors, special semiconductor devices and functional units, analog and digital integrated circuits, building elements - cells - of integrate circuits (DATBK: a program for data handling)

The AUTER system is developed by TKI in co-operation with other Hungarian laboratories /SzTAKI, MIKI, HIKI, SzKI, KFKI etc. Here, only the results of TKI are listed.

Modelling and model data bank of microwave passive devices (FINDIF, CSATER)

Layout design (arrangement, path routing) and documentation (master films, assembly drawings, NC tapes for drilling etc.) of analog and digital-printed circuit boards; double-sided (KONSTR-4) and multi-layer (KONSTR-6) printed circuit boards

Backboard wiring of complex units containing printed circuit boards and other cable connectors: design and documentation (KONSTR-5)

Documentation of electrical circuit schematics for circuits composed of discrete and integrated circuit elements (KONSTR-7)

Data bank for the layout design and documentation: discrete elements, electromechanical components, IC elements, standard PCB parameters, technological parameters etc.

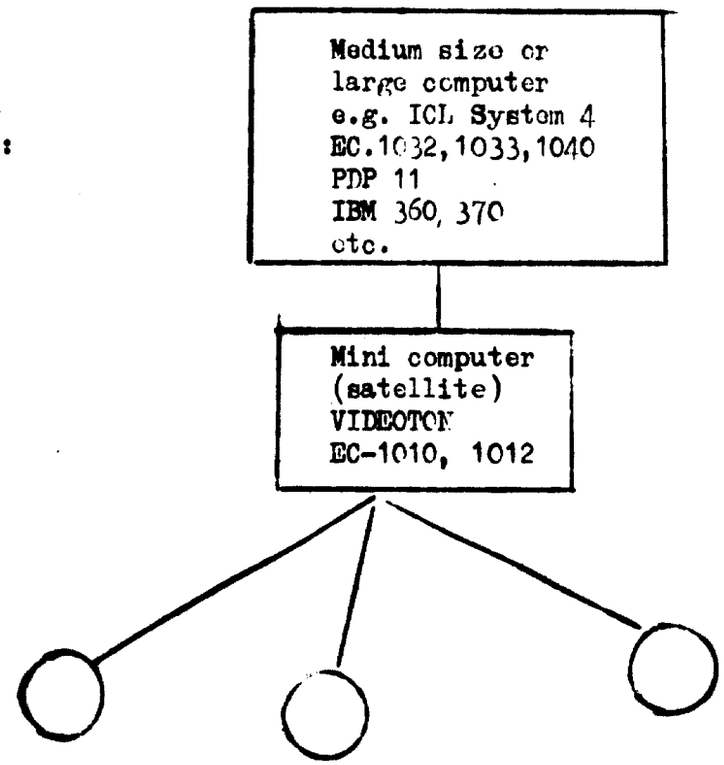
Generation of rubylith masks and documentation of monolythic (bipolar and MOS), hybrid (thick and thin film) and microwave integrated circuits; checking the mask layout data according to the electrical and technological prescriptions (design rules) (MASK-3)

Geometrical data bank of integrated circuit building elements ("cells") and standard details of integrated circuit layouts

On the basis of the AUTER system, a CAD service aids the design works of engineers of many laboratories. The service provides the designers with a background of thousands of circuit-design problems already solved recently in the TKI CAD service.

The hardware elements of the AUTER system

Computer hardware:



Off-line automata for documentation:	**Flat-bed plotters** e.g. Ferranti EP131	**COM Plotter** e.g. Ferranti EP240	**NC machines**
Prototype or serial production and testing:	**PCB** e.g.VIDEOTON EC-1010 controlled workshop for prototype production and testing (SzTAKI)	**Hybrid IC**	**Monolithic IC technology**

VIII. MEASURING GEAR SYSTEM OF TELEVISION RECEIVER PRODUCING FACTORIES

Television has become a subject of enormous development in the second half of the twentieth century; in the developed countries practically every family has its own television receiver. The second stage of the development is the possibility of introducing colour transmission systems. Although there are many colour television systems in the world, one thing is common to all, compatibility in the monochrome reception. Television can only come up to its task, when television broadcasting really exists in the given area: but suitable receivers are also necessary.

Opinions may differ on what is a receiver. One thing is fixed, the television receiver has to be produced cheaply and quickly. A reliable apparatus is needed, one that can be easily repaired in the case of breakdown.

To fulfil the above requirements, a technological system, modern and well constructed, is necessary, but this technological system needs also a measuring system. In the early periods of manufacturing television receivers the system of the individual measuring instruments is used, i.e. in this case on the bench of each worker there are standing the measuring instruments necessary for producing the measuring signals and enabling the display of the measured results.

This method is disadvantageous, at first in the relation of the costs. Clearly a complicated instrument is more expensive than a measuring system, which includes the complicated parts only once or several times at a central place and cheap indicators are set up on the measuring benches. The individual measuring system has some other disadvantages, e.g. technical supervision is complicated, the energy consumption is greater, a large store is requested for the repair materials, more place is needed, and so on.

The advantages of the central television measuring system can be indicated by the following example:

Let us assume the forming of a measuring working-place for adjusting the IF. section of the television receiver. The minimum demand is a good-quality sweeper, which gives adequate level in the IF band, and delivers possibilities for marking the characteristic frequencies. The costs can be assumed as follows:

Individual sweeper, without indicator: x
Indicator: y
Central equipment, with distribution system and accessories: k
Indicator: y

Since indicators are necessary in both cases their cost can be disregarded in the estimation. Costs of the solution with individual equipment:

$a = nx$

where n is the number of the working places

Costs of the central equipment: $a' = k$

The central equipment is advantageous, when

$nx > k$

respectively

$k/x > n$

It means that the ratio of the central and individual equipment costs equals the number of working places. If the number of working places feedable from one central equipment is - according to the reality - 300, it means that the ratio of the costs of the central and individual equipment can be the same, i.e. 300 by identical cost factors. In real situations, the central system is advantageous when there are more than 10 working places.

The co-operative Híradástechnika in Budapest fulfils all demands of the producers of television receivers in respect of technological measuring and testing systems, further in respect of instruments and equipment requested for servicing purposes. The technological system of the factory instruments is based on the central system, but deviates from this principle when the wanted technical characteristics cannot be realized in the central system.

The steps of manufacturing a television receiver can be as follows:

Setting into operation
Tuner adjustment
IF section adjustment
Adjustment of the video and colour parts

Setting into operation itself needs no measuring instruments, only indicators for rather indicating and not measuring voltages, currents, and resistance. Some of the working places need an oscilloscope too.

With this set of equipment each step can be performed between the first switching-on and having the lighting raster on the picture tube.

The adjustment of the tuner needs much effort because several channels have to be adjusted, the transmission characteristics tuned up, the gain and input impedance measured and the accurate frequency of the oscillator checked. Because of the multiple tasks and of the high frequencies (up to 1,000 MHz), the central solution for this task is not advantageous because of the cable network, which cannot transfer the sweep signals to the individual working places within the strict tolerances.

The tuner adjusting equipment of Híradástechnika, called Crom, satisfies all the tuner adjustment and measurement demands in individual layout. The essential in this is the following: the oscillator voltage from the tuner under test gets into a mixer stage which shifts this with the value of the used intermediate frequency. This frequency after regeneration gives the centre frequency which will be swept and as input signal given to the input of the tuner under test. So frequency response and gain can be measured. The equipment is automated in that it produces automatically the optimum centre frequency of the sweeper from the set oscillator frequencies by shifting these with the frequency of the IF. In this way, the sweeper is not to be set by changing the tuner oscillator frequencies: the oscillator frequency can be measured. Also the tuner input impedance, which is the input impedance of the whole receiver, is swept by the automatic sweeps in the given band and can be displayed on the indicator. Furthermore the equipment enables the gain and the regulation properties to be measured. The operating of this equipment needs no skilled worker. In technical respects, it is interesting that the indicating picture tube is not of more beams: it works on the point-raster principle. So there is a possibility to display an unlimited number of events (beams), with individually set brilliance.

The equipment Signal is of central system. In the central part the equipment generates the swept IF signal (according to the optional standard), the sweep signals of small deviation requested for measuring the SECAM colour system-receivers for adjusting the colour discriminators, furthermore the video sweep, necessary for adjusting the video parts. These signals can be transmitted to the working places over a switching and distributing cable system.

The feeding of the HF signals to the individual working places is done from directional couplers, so defects at the working place do not affect the parameters of the entire system.

The sweeper gives the sweep signal during the forward period, but the frequency markers can be mixed in during fly-back. The amplitude of the pulse markers can be set individually, so a possibility exists for not only setting the corner frequencies of the transmission characteristics, but also for measuring the amplitude. The adjustment of the IF section is easy, no scale or other is required, the measured curve must only be brought into covering with the marker pulses. The receiver so adjusted has to be controlled, and the operation of the whole set is measured. For this purpose, the Central Measuring and Controlling System is used, which is a central television transmitter system. It can be split into three parts, as video signal sources, by which the HF-transmitters can be modulated and the control system used for checking the system parameters.

In a maximum layout this equipment includes 10 monochrome and colour video signal sources, which can be switched to the transmitters in any combination. In the standard layout there are 16 transmitters, but this number can be enlarged. The transmitter operates with up-to-date PLL-system oscillators, resulting in costs savings, higher stability and greater versatility. This enables, for example, the simultaneous transmission of signals of different television standards. The control instruments are vision and sound demodulators standardized in the transmitter techniques, colour and monochrome picture monitors with studio-quality parameters, oscilloscope, control audio amplifier, noise meter, and so on. It is a great advantage of the equipment system, that it can be ordered in optional configuration, e.g. with only an HF-channel. . In this case the electronic test pattern generator is an optimum signal source because it delivers practically all the measuring signals in one picture, e.g. an electronically produced circle, without lincarity error, too. The latest innovation is the so-called word-inserter, which electronically inserts the number of the channel for the easiest identification of the received channel, especially necessary for testing receivers with touch control.

This equipment in its full layout enables all the measurements on the television receivers (geometrical and luminance linearity, pulse transmission, pulse tilts, clamping static and dynamic convergence, white balance, and so on). The measuring signal can be used generally for visual evaluation: the quality parameters are professional, so the colour encoders are of studio quality, the specification of the channel transmitters is identical to that of the television transmitters, and so on.

The signals can be transmitted as video signals or as HF-signals to the working place. For the demands of the service shops the co-operative Hiradastechnika offers a wide scale of instruments. The television complex generator gives monochrome and colour signals in all of the VHF and UHF channels, the television tester with very small dimensions delivers simple signals for the in situ repairs of television receivers.

IX. STUDIO TAPE RECORDERS

After the Second World War, a basic change took place in recording techniques. Magnetic recorders developed and perfected before the war became industrial products and their quality increased rapidly. Improvement was possible because industry started to produce magnetic tapes of increasing quality. The improvement of recorders and tapes is still going on.

In Hungary, the advantages of magnetic recording became obvious rather early. In the early 1950s the laboratories of the Hungarian Radio started developing a recorder of their own. Recorder production was transferred to Mechanikai Laboratórium (ML) in 1954 and in spite of a provisional interruption, development and production have been carried out there ever since.

The successful beginning (1955-1958) was followed by a sudden stop affecting both quality and reliability. This was due to some administrative measures resulting in the subsequent transfer of the production of tape recorders from factory to factory four times between 1959 and 1962. Development suffered a loss of four years' time, and the succeeding producers found it difficult to continue to improve technology. ML regained production rights in 1963. Since that time the development of recorders has steadily increased and passed beyond expectations.

Many parameters of a studio recorder are identical with those of a domestic one. There are, of course, parameters usually not referred to when considering a domestic appliance. Parameters of a studio recorder are, however, weighted on a tacit understanding, by a reliability factory, and a long-term constancy of parameters of each appliance is guaranteed by the manufacturer.

Let us examine how quality and reliability of studio tape recorders produced in Hungary have improved in the past 20 years as shown by parameters such as:

Design principles, facilities
Stability and accuracy of tape driving
Volume range
Frequency response
Distortion

Four types of recorders were subjected to examination. Development having taken place for the past years can easily be assessed by considering recorders

SM - 4/56
STM - 10
STM - 200 /210/
STM - 500/510/
SM 4 / 56 type studio tape recorder

1. The appliance was developed in the laboratories of the Hungarian Radio, improved and manufactured by ML.

Speed of tape driving - 76.2 and 38.1 cm/s (early variants)
38.1 and 19.05 cm/s (later variants)

Equipped with vacuum-tube amplifiers
Direct operation by push buttons connected to Bowden cables
Sound-axis provided by the main shaft of a hysteresis synchronous motor
One single high-voltage relay used
No remote control except prepared distance start of play-back or recording
Tape drive, when switched in, speeds up at a rather low ratio as main drive starts only when a definite operation is switched. This makes construction simple but it is a disadvantage in operation.
There is no tape tension control. The energy orginating in the tape changes at a ratio of 1 to 2.5, approximately (80-200g) when coil diameter is 290 mm

This has several disadvantages such as:

Distortion towards the end of the coil

Relatively big difference in speed between the beginning and the end of the tape (slip)

Different high frequency response at the beginning and the end of the tape

More wear of reproducing head

The last factor was important because in the 1950s reproducing heads were made of permalloy, which is magnetically soft and has little resistance to abrasion.

The appliance can easily be serviced. Both amplifiers and trolley can be removed and are accessible from both sides. The recorder is reliable, mainly because of its simplicity. It can be mended easily, even without taking it to a special workshop.

2. The use of direct tape drive (by the main shaft of a hysteresis synchronous motor) is simple and highly reliable. Unfortunately, it does not provide sufficient stability in tape driving. Distortion is ± 0.15% at a speed of 76.2 cm/s and ± 0.2% at a speed of 38.1 cm/s. The accuracy of tape speed depends on, and is related to, frequency stability of mains voltage.

3. Volume range is specified as ≥ 50 dB. This value is due to the sum of noise produced by the amplifiers and the premagnetized tape.

The vacuum-tube amplifiers caused problems and affected that parameter of the appliance negatively. The low-noise penthode used in the input stage became noisy for several reasons (e.g. owing to a leakage on the cathode filament).

Owing to physical characteristics of magnetic scanning by moving elements, the reproducing head gives lower voltage towards low frequencies. The output voltage of the head is

$$U_{out} = -w \frac{d \cdot \Phi}{d_t} \cdot 10^{-8} V$$

The value of d_t is proportionate to the growth of wave length and U_{out} tend to reach 0. This means in practice that the sensibility of the play-back amplifier of a studio recorder is between 50 and 100 microvolts at frequencies below 50 c/s.

Hum sensibility is increased by the high input impedance of vacuum tubes. This parameter is decisively influenced by the noise of the premagnetized tape, resulting from two factors:

Characteristics of the tape
Characteristics of the appliance

The latter one being examined with SM 4 / 56 the following factors should be considered:

(a) The distortion of premagnetizing current is of some percentage. Tape noise is increased by distorted premagnetizing current containing d.c. component. A better value cannot be reached owing to the low Q of the reproducing heads made of laminated permalloy.

(b) The fineness of the part of reproducing heads directly touching the tape strongly affects tape noise. In a tape running on an unequal surface, premagnetizing field strength changes periodically. This fluctuation of field strength causes tape noise of low periodicity. With SM 4 /56 the reproducing head made of laminated permalloy cannot be polished up to have superfinished surface because it is too soft.

(c) It is also due to the heads used that the frequency of premagnetizing owing to bad Q. This results in a disadvantage, as premagnetizing can mix new sounds in the audible range with harmonics of high-pitched sounds, and the new sounds are recorded as well.

(d) The large slit width of old tapes and reproducing heads requires relatively big high elevation in the amplifiers, which leads to an increase of noise. In studio techniques this is one of the parameters that has seemingly not improved significantly for the last 20 years. Transmission range of SM 4 / 56 comprises 40 to 15,000 c/s. Most up-to-date recorders do not provide much larger frequency ranges either.

The improvement of this parameter can, however, be assessed by other features:

(a) Tape speed was reduced from 76 cm/s to 19.05;

(b) Recently developed tapes require smaller high elevation. So does the reduction of the slit of the reproducing head.

With SM 4 / 56 band width of the reproducing head was 10 µm. Amplitude contraction caused by the finite slit-width of a reproducing head at a definite frequency can be determined as

$$20 \log \frac{\sin \alpha}{\alpha} \qquad \alpha = \frac{\pi \cdot r}{\lambda}$$

where

r = slit width

λ = wave length

The table below indicates high-elevation ratio at 16 ko/s relative to some speed and slit-width values:

TAPE SPEED / SLIT WIDTH	3 µ	10 µ
76.2 cm/s	0,06 dB	0,8 dB
38.1 cm/s	0,2 dB	2,7 dB
19.05 cm/s	1 dB	15 dB

As a conclusion it can be stated that frequency range of SM 4/56 is fairly identical with that of present day recorders. The same range was, however, recorded at speed values of 76.2 and 38.1 cm/s with bigger high elevation than that today. The disadvantage of this phenomenon does not affect this parameter, but rather volume range and distortion are affected.

Economic effect of high tape speed--76.2 and 38.1 cm/s-- is a consumption of tape two or three times larger than with modern recorders.

In studio techniques non-linear distortion of a one kc/s signal recorded and played back is measured or indicated as required. This parameter is of great significance in recording techniques. By the time a record is broadcast on radio[1/] it is reproduced or translated many times, and distortion can accumulate. Therefore, it is desirable that master tapes should have minimum distortion.

SM 4/56 has a distortion ratio of 2% specified by recording tape. But it must be noted that the distortion caused by the amplifiers of SM 4/56 represents only some tenth of 1% of noise over the whole range of transmission. The 2% distortion was mainly due to the tape. Naturally tape quality has improved since the 1950s and SM 4/56 can be specified more favourably if a modern tape is used.

STM 10 type
STUDIO TAPE RECORDER

1. The recorder provides two speeds: 38.1 cm/s and 19.05 cm/s

The trolley is controlled by a logical control device with relays. This makes operation easy. The operator is not supposed to make big efforts when specific operations are to be switched by push buttons. With SM 4/56 a push button was pressed by one to two kilograms power and passed a 20 -30 mm way. Mechanical elements (brakes, rubber rolls) are operated by electromagnets. The trolley is controlled by relays, and remote control is also provided for. A new Hungarian patent was first applied here; the optional use of tapes coiled with interior or exterior magnetic layers. Speed up of tape drive is high, owing to the rubber roll which presses the tape to the rotating sound axis. It has vacuum-tube amplifiers. The trolley cannot be turned out as with SM 4/56, but it can be lifted. The amplifiers can be drawn out and are interchangeable. The trolley controlled by relays, makes operation easy, provides a wide range of facilities, but relay defects which occur from time to time affect reliability negatively.

1/ Or recorded on a disc.

The appliance can be serviced easily. All electric units are changeable. The changeability of the trolley - as compared with the previous type - was not justified sufficiently.

2. To provide the steadiness of tape driving, the sound axis is attached to the main shaft of the motor through a mechanical filter. The mechanic filter comprises a bulky flywheel and rubber friction. This made it possible to reach a distortion ratio $\leq$ 0,15% at 38,1 cm/s and $\leq$ 0,25% at 19,05 cm/s respectively.

The accuracy of tape speed is determined by the accuracy of the frequency of the mains voltage. There is no tape-tension control in the appliance. As a consequence the same disadvantage appears as in SM 4/56.

3. Volume range is by 2 dB better than that of SM 4/56 (52 dB). The vacuum-tube amplifiers are rather sensitive to hum. Features mentioned in items SM 4/56 - 3(a, b, c) are valid for STM 10 as well.

4. Frequency band is unchanged but tape speed is lower:

38.1 and 19.05 cm/s -- 40-15,000 c/s. Its Telefunken type reproducing heads are made of permalloy. The slit width of the head is 6-7 µm. That is why there is no need to have a big high-elevation in the output amplifiers in spite of lower speed (better noise ratio).

5. This parameter as with SM 4/56 depends on the type of tape used. Specified value is of 2%.

STM 200 type
STUDIO TAPE RECORDER

1. This device was developed at ML in 1963/64.

As to solutions of design, this equipment was much more advanced as compared with former ones. While in previous models designers tried, with more or less success, to adopt solutions existing in actual foreign makes, they embodied quite a number of original and ingenious solutions in the STM 200. These solutions are now protected by patents in a number of European countries. One of the most significant technical innovations was the facility to build up the trolley as a mechanical block unit (7 main units), each of which constitutes an independent unit and can be readily removed from the device. The advantages of this feature appear in favour of both manufacturer and end-user.

The quality of the high-precision trolley improves in the course of the production, if the mechanical units are measured independent of the trolley by means of single-purpose instruments, rather than if measured in an assembled trolley. From the point of view of the end-user, the readily interchangeable units improve the reliability and permit easier servicing. The trolley is controlled by logical control circuits with relays. The advanced quality in the control unit is characterized by:

The number of relay contacts is reduced to 20 - 30% of the usual;
Relays contain only main contacts, all relays are similar (4 x a);
Relays are provided with plug connectors and are interchangeable.

The breakdown ratio of main contacts is better by a factor of 10 than that of break contacts or switching contacts.

The service life of the few UK made (Hamlin type) reed relays built in the trolley of the device amounts to 10^7 - 10^8 switching (20 - 30 years).

In this device tubes are replaced by semi-conductor elements (transistors and diodes). This alone results in a sudden improvement in operational safety.

A uniform tension of the section of the tape before the sound axis is performed through electronic control. The entirely new electronic control system (ML patent) contributes to a great extent to the stability and good values of certain parameters, e.g.

Uniformity of tape tension
Distortion
Frequency response
Slip of the tape

The operation switch is the most stressed unit of theetape recorder. The contact elements hare are reed cartridges actuated through a permanent magnet (operational safety). Similar reed contacts perform the switchover of the required corrections in the amplifiers when changing the speed. Based on the experience of the past 10 years it can be laid down as a fact that as few as some 10 of the built-in cartridges amounting to approximately 100,000 became defective.

Remote control is available within the entire range of operations. This was the first model of domestic make adopting ferrite play-back and recording heads (Philips). The service life of these heads is by a magnitude longer than that of the conventional ones. Through their application it was possible to secure unchanged parameters of the device for 4 - 5,000 hours of operation. (With Permalloy heads readjustment was necessary every 200 hours and replacement after approximately 1,000 hours.) Both mechanical and electrical servicing of model STM-200 is very easy.

Operational safety is also very good, which is mostly due to the simple and well-reasoned design and to the purposeful selection of high-grade components (ferrite heads, Papst motors, reed relays, transistors etc.).

2. The design of the main motor unit as compared with the previous model STM-10 turned out much more successful.

The joint of the inertia mass and the hysteresis synchronous motor does not permit any slip. The accuracy of the bearing supports and of the sound axis, and the very high quality driving motor results in a very reduced distortion. With 30 - 40% of the series-produced devices the value of distortion is less than 0.03% at 38.1 cm/s.

The factory warrants a distortion ratio of

$\leq 0.05\%$ at 38.1 cm/s
$\leq 0.1\%$ at 19.05 cm/s

The main motor unit requires hardly any maintenance, has high operational safety. The above-mentioned parameters are warranted even after many thousand service hours. The accuracy of tape speed is determined, the same as in previously specified models, by the accuracy of frequency of the mains voltage.

3. As to the volume range of the equipment, the development is colossal. High impedance electron tubes in the input stage do not cause trouble any more. The preamplifier constituted of low-noise transistors /f $\leq$ 1 - 1,5 dB/ results in a signal/noise ratio better than 76 dB. As compared with the specified value of 68 dB, this represents a very considerable reserve. The volume range of the device is now determined to a great extent by the noise of the tape. The combined integrated signal/noise ratio is better than 62 dB, which means an improvement by 10 dB as compared with model SM4/56. The improvement in the signal/noise ratio of amplifiers amounts at least to 16-17 dB.

The following features also contribute to the improvement of the signal/ noise ratio (see points 3/a and b concerning SM4/56.):

(a) The high quality ("Q") of the ferrite recording heads permits the realization of a low distortion of the premagnetizing current;

(b) The special ferrite material of the heads is polished for high lustre and keeps this finish for a long time;

(c) The small slit width of the reproducing heads (3 /um) and the up-to-date tapes require less high-elevation.

4. The transmission range of the device comprises 30 - 16,000 c/s. (At a speed of 19.05 cm/s as well.)

5. With up-to-date tapes (e.g. BASF LR-56, AGFA PER-555, 525) the low distortion (0.1 - 0.15%) of the amplifiers is well utilizable. In the case of using such tapes and standard tape magnetization a non-linear distortion can be reached below 1%. (The specified value is still 2%.)

STM-500 type
STUDIO TAPE RECORDER

By the time a number of protypes have been built as yet by ML, series production has not yet been started and development work is still going on. Development work was based on three fundamental conceptions:

Solutions of the design of the well-approved model STM-200 should be utilised;

Electronic components had undergone meanwhile very considerable progress, which should be adopted in the new equipment;

As many mechanical structural elements as possible should be replaced by electronics (with a view to improving operational safety).

Designers have built up the control unit of the trolley of elements of TTL logical integrated circuits.

This solution offers an optimum of the control of the trolley:

(a) False switching is completely excluded;

(b) Individual operations can be programmed;

(c) No relays are needed;

(d) Maximum oprrational safety is provided

For switching on and controlling of motors, magnets, amplifiers, correction is performed by transistors, triacs, diodes and reed cartridges. Thus the device does not contain wearing electric switching elements.

The mechanical block system well approved in model STM-200, as well as the solution of the control of tape tension has been adopted here as well.

Tape tension control is extended here also to the section of the tape after the sound axle, which has a favourable effect upon the distortion and slip parameters. From the point of view of operational safety, it is essential that mechanical vibration damper elements (pneumatic pump in STM-200) be replaced by electronic dampers.

Amplifiers are built up of elements of integrated circuits and low-noise silicon transistors.

For the first time with this equipment the very high precision, digital signalling electronic "tape length time" indicator has been adopted.

Servicing the equipment is very easy (interchangeable mechanical and electrical components). On the other hand, the intricacy of circuits will set strict requirements against maintenance instruments.

1. The characteristic feature of tape driving systems used up to now was that the accuracy of the tape speed was determined by the accuracy of the frequency of the mains voltage (synchronous motors). In extreme cases the fault might have reached 1-2%.

In Model STM-510 a special electronic unit provides for keeping the motor speed at the exact value. Specified speed tolerance is better than $10^{-5}/C^{\circ}$. This means an improvement by several magnitudes as compared with the previous device. Distortion of the device amounts to 0.04% at 38.1 cm/s and 0.06% at 19.05 cm/s.

2. There is no improvement regarding volume range as compared with Model STM-200, since this is limited so far by the noise of the tape. Specified combined signal/noise ratio is 63 dB at a tape speed of 30.1 cm/s and 62 dB at 19.05 cm/s. The noise level of amplifiers is identical with that of Model STM-200. What has been said in this relation is valid for this case as well, with the exception that the amplifiers of Model STM-510 are executed with integrated circuits and silicon transistors.

3. The transmission range is identical with that of Model STM-200, comprising 30 - 16,000 c/s. Tolerance range, however, is somewhat stricter.

4. Data are similar as quoted under point 5. regarding STM-200.

Recapitulating the foregoing, the investigation of the qualitative development experienced during the last 20 years, and of the reliability of the equipment has been performed analysing the solutions of design of four different models and of four selected parameters of the same.

It can be stated that greatest progress is observable in respect of the design of the devices, their solutions and execution. They became easier to be attended, the range of operations was expanded. The usual mechanical actuating and control elements were mostly replaced by electronic components. Consequently, the probability of breakdowns of mechanical parts has been reduced to a minimum.

The introduction of ferrite heads was of great significance, resulted in a sudden improvement of operational safety, and quality was improved as well.

The trolley with a completely electronic control "knows" much more, beyond comparison, and has higher operational safety than those controlled by relays. On the other hand, its intricate build-up required more qualified maintenance staff.

The distortion parameter has improved fivefold (0.2 - 0.04%). It is notable, however, that the method of measurement of distortion also has changed in the meantime. Initially distortion measurement had been performed in the linear frequency range between 0.2 and 50 c/s, later by means of a standardized instrument of non-linear characteristics within the range of 0.2 - 200 c/s (hearing - correct method of measurement). The accuracy of tape speed had been initially proportional to the variations of the mains frequency (max. fault 1 - 2%). Today the speed of the motor has a crystal oscillator stability ($10^{-5}/C^{\circ}$). In spite of this, the high accuracy can be utilized but to a fraction, since the actual speed of the tape is susceptible to slip along the entire reel length owing to the friction of the rubber roll against the sound axle (in fact an accuracy of 0.03 - 0.1 . 10^{-3} is available).

Already in Model STM-200 a tape driving mechanism could be designed, which had a very good operational safety (3 - 5 years). The very high speed stability ($10^{-5}/C^{\circ}$) of the sound axle in STM-500 requires on the other hand rather intricate electronics.

As to the improvement of the volume range of the equipment, a most important part is played by modern transistors and integrated circuits. The improvement in the signal/noise ratio of the amplifiers amounts at least to 16 dB. The introduction of semi-conductors had a great significance in respect of increased operational safety as well.

The frequency response parameter has apparently not changed very much during these 20 years. The tolerance range became somewhat stricter, on the other hand the tape speed was reduced from 76.02 cm/s to 19.05.

The improvement in the field of non-linear distortion can be attributed almost totally to the tapes used. However, distortion orginates even now mostly from the non-linearity of the tapes rather than that of the amplifiers. What development can be foreseen for the future concerning quality and reliability?

It may sound strange, but should be said that for the sake of one main objective, the automation of studios, a further improvement of certain qualitative features (frequency response, volume range, distortions etc.) will be dispensed with for the time being. A fundamental condition of automation is, namely, the tape carrying cassette (e.g. NART, Philips, Unisette etc.). The cassette will almost in every case interfere with the parameters connected with a uniform tape speed (distortion etc.). On the other hand, the control signals indispensable for the control of automatic equipment take the place of useful information on a part of the tape and consequently the signal/noise ratio is reduced.

Even through the application of the most up-to-date noise attenuation electronics only the losses can be regained, especially if the tape width is reduced at the same time (e.g. in the case of the Philips Contact Cassette from 6.25 mm to 3.81 mm).

A further improvement of reliability is to be expected as a consequence of the integration of electronic elements and of a further eclipsing of mechanical functions in favour of electronics. A very good example of this development is the new ML device, the Model STM-500.

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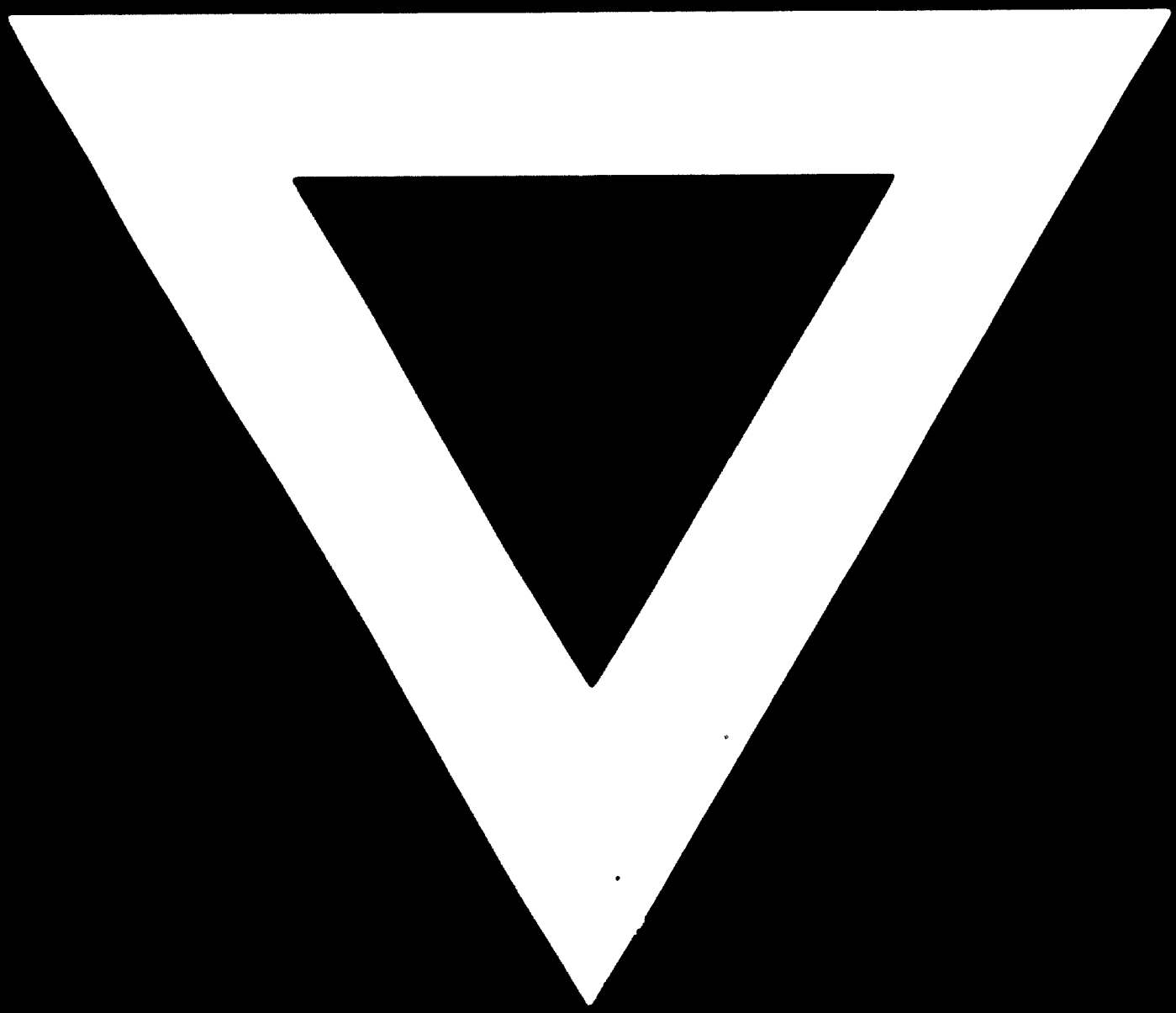

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