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The Argentine telecommunications networks *)

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SUMMARY

A description is given of the new telecommunication network which is now being built for the Argentine. When planning this network, it was necessary to compile a considerable amount of statistical data, so that calculations could be made of the probable traffic after a period of twenty years. With this information as a basis, the material required was determined and the country was divided into eleven zones, each with a centre station. Two of these zones cover Greater Buenos Aires (G.B.A.). For some time, a greater part of the traffic will be by radio, as in the inland suitable lines are not yet available. The plan comprises various networks, namely:

a. The National Telegraph Line Network. Any telegraph office can communicate directly with any other telegraph office, using teleprinters. Centre-stations will be provided with automatic telegraph exchanges. Keyboard selection of destination will be used. Multiple-tone telegraphy will be used to cover the greater distances, and d.c transmission for the shorter distances. In Buenos Aires there will be two exchanges exclusively for traffic of Great Buenos Aires.

b. The National Radio Network. During the period that the line network is being modernized, traffic in the national network will be carried out by radio, with B.A. as centre. Single-sideband equipment will be used for telephony and telegraphy, with frequency- or space diversity for the latter. As a measure for the prevention of mutilated teleprinter signals being passed through, use is made of T.O.R. epuipments. There are first-class and second-class stations. During night hours, traffic between second-class stations and B.A will take place via the first-class station in the zone of the second-class station. B.A. possesses an automatic telegraph exchange and a radio telephone exchange for handling traffic destined for B.A. or for transition of traffic between national stations.

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c. The Zonal Radio Networks. These networks deal with traffic within each separate zone only. Double-sideband equipment is used. Reperforating teleprinters are provided for telegraphy, and when atmospheric conditions are very unfavourable, hand morse keying will be used. Secrecy in telephony is obtained with renversor equipment. Each station will be fitted with a selective-calling device.

d. The Rural Radio Networks provide communication between the centre-station of each zone and villages of less importance in the particular zone. All traffic will be handled via the centre station. Telegraphy will be by hand morse only. For telephony, renversors will be fitted. Besides the fixed stations, mobile radio stations in special vans can be used as temporary stations and in case of emergency.

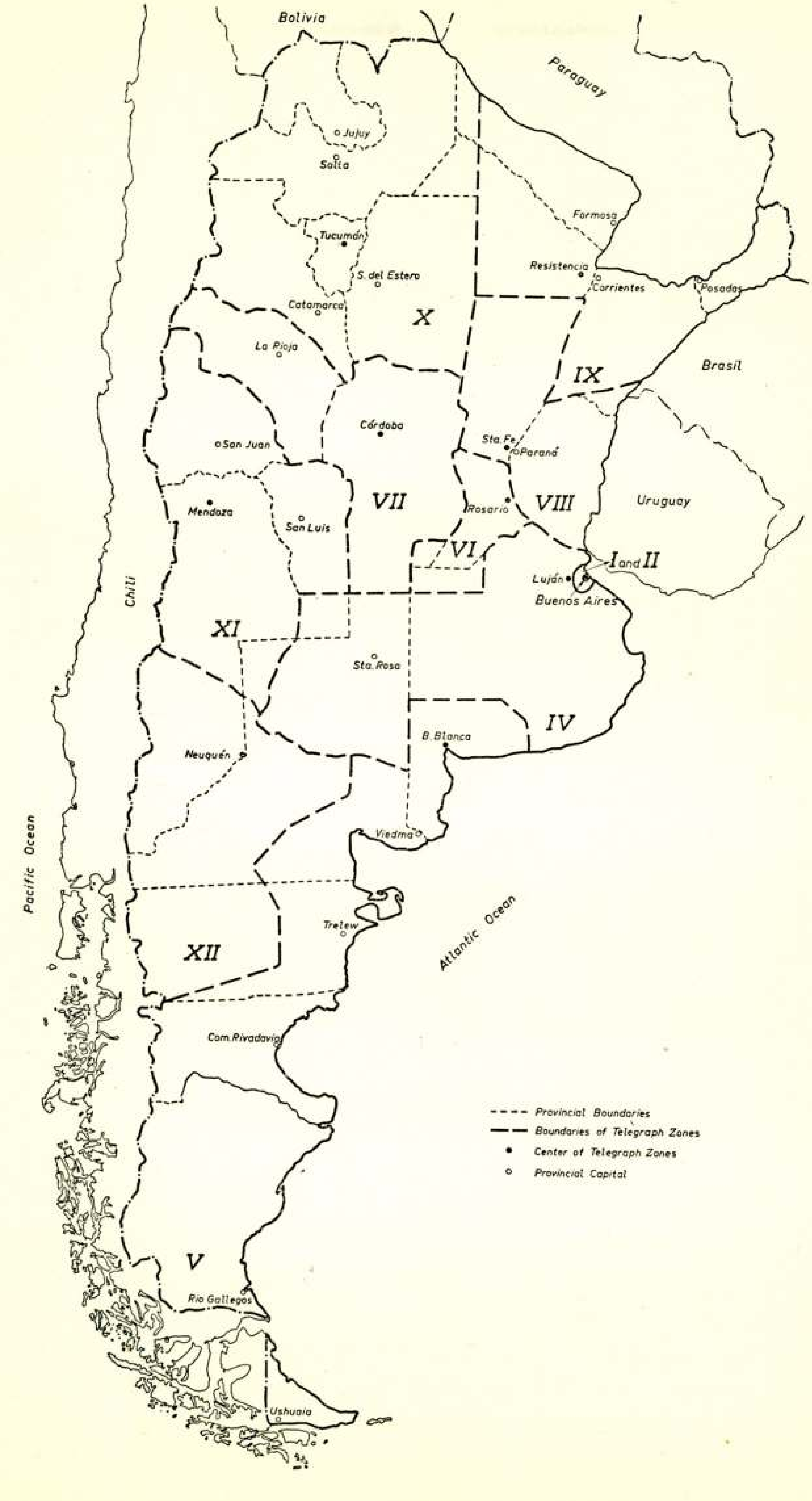
Further, there will be an international and a press radio service in B.A., and a mobile maritime service with B.A. as centre station. The maritime service also comprises a number of coastal and river stations.

1. *Introduction*

After two years of study, of planning and projecting, of calculation and consideration, in January 1952 H.E. the Argentine Minister of Post and Telecommunications (Correos y Telecomunicaciones) placed with Philips Telecommunication Industries at Hilversum and Philips Argentina S.A. at Buenos Aires contracts for the delivery and installation of the equipment and materials necessary for the execution of the first part of Argentine's future telecommunication networks.
It is here not the place to disclose in full detail the Plano Fundamental Telegrafico (Basic Telegraph Plan) and its subsidiaries, as elaborated by the Argentine Post Office engineers; but by courtesy of the technical Director of Telecommunications Prof. Ing. C. A. Costa, the principles and main considerations may be described here in such a way that the technicalities and merits can be appreciated.

2. *Statistics*

The 2 years of engineering work mentioned above, have been preceded by a considerable effort of a statistical nature, viz. the collection of sufficient traffic data. Not only were the numbers of telegrams sent by a number of existing telegraph offices counted, but their destinations were also ascertained. Further, in order to know what a "telegram" means as traffic load, the numbers of words of many thousands of telegrams were count-


Bolivia
Paraguay
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Formosa
Tucumán
Resistencia
Corrientes
Posadas
S. del Estero
Catamarca
X
La Rioja
IX
Brasil
Córdoba
San Juan
Sta. Fe
Paraná
VII
VIII
Rosario
Uruguay
Mendoza
San Luis
VI
I and II
Luján
Buenos Aires
Chili
XI
Sta. Rosa
IV
B. Blanca
Neuquén
Viedma
Pacific Ocean
Atlantic Ocean
Trelew
XII
Com. Rivadavia
V
Rio Gallegos
Ushuaia
Provincial Boundaries
Boundaries of Telegraph Zones
Center of Telegraph Zones
Provincial Capital

ed; this gave a "standard" telegram of 17 words, — excluding service indications. As a typical byproduct of this last count it was found that telegrams to Buenos Aires are on the average shorter than those from that city, — obviously the rural Argentinian is more frugal than his more urbane country-man. It was also found that Buenos Aires sent more telegrams to its suburbs — together with them forming Great Buenos Aires (GBA) — than it received from them; rather contrary to experience with comparable telephone traffic.

After preparatory work on samples, representative days and hours of traffic were fixed, and it was established that the peak-hour — normally late in the afternoon — has to deal with about 1/7-th of the 24-hours traffic. It is on peak-hour traffic of course that the amount of equipment has to be based.

Counts were then made of representative 24-hours traffic:

a. for each of the 40 biggest offices outside GBA:
   1. their total traffic,
   2. their traffic to Buenos Aires,
   3. their traffic to each of the 40 biggest offices,
   4. their traffic to each of 78 sample offices (sub b);

b. for each of further 78 sample offices outside GBA:
   1. their total traffic,
   2. their traffic to Buenos Aires.
   3. their traffic to each of the 78 offices,
   4. their traffic to each of the 40 biggest offices (sub a);

c. for GBA:
   the traffic of each office to each other office;

d. for Buenos Aires:
   the traffic to each of all offices outside GBA.

3. *Traffic calculations*

3.1. Zone boundaries

From the wealth of statistical information, the boundaries of the future telegraph zones — as distinct from the present telegraph districts — had first to be decided upon; in such a way that an optimum ratio of internal to total inland traffic is reached. An optimum ratio, and not the maximum ratio; the latter — being 1 — would be reached with the whole country as one big zone and its only exchange in Buenos Aires. All inland traffic would then be internal — as confined to one zone, but this solution is certainly not economical. Even when using tone-telegraphy, amplifiers would be wanted between the long distance offices and the exchange, and the number of telegraph circuit-miles (number of circuits times their length) would be excessive.

A number of test calculations on economics was thus made, the resulting zones — 2 in GBA and 9 in the rest of the country — are shown in figure 1. The arrangement of the 2 zones in GBA will be dealt with in detail in para. 5.2.

3.2. Traffic assessment

Then it was found that the sample offices mentioned above under 2b were far from evenly distributed over the zones, — which were not known when the samples had to be chosen. Even with an optimum distribution a number of 78:9 or about 9 sample offices per zone is rather small. Notwithstanding all the work mentioned under 2b, the total number of sample offices is only about 6 % of all the offices for which they stand, having — as was found later — about 21 % of their traffic.

Further counts of traffic were thus made after the zone boundaries had been established, viz. for Buenos Aires and for its suburbs; their traffic to each of the zones outside GBA being assessed. The figures mentioned under 2d were then correlated with the new ones, and from all the data then available the total traffic was first deduced.

The results are given in table I:

Table I

GBA	28.100
40 biggest offices	24.500
78 sample offices	5.900
all other offices	22.400
Total	80.900 telegrams/day

3.3 Traffic distribution

To arrive at the distribution of this traffic over the zones, and its division in internal and external traffic, quite some careful inter- and extra polation was wanted. The statistical figures gave then partly the distribution of the external traffic of the zones; the unknown distributions involved the "other offices" — and about 62 % of the traffic between the zones outside GBA.

They were found by treating the traffic of these offices as an "increase" of the traffic for which the distribution was known, — as indicated in para. 3.4 for the 20-years increase.

3.4 Future traffic

As the final plan is based on the traffic after 20 years, this future traffic had then to be assessed.

For the past 10 years revenue figures were available, from which the increase of traffic could be deduced for each telegraph district, — thereby taking into account service traffic. As a forecast is best made for big groups of traffic, the following 3 groups were considered:

a. GBA — with highly developed traffic,
b. the province of Buenos Aires and the Southern part of Santa Fé province — with rather well developed traffic,
c. the rest of the country.

In extrapolating the past rates of increase for a future 20 years, different saturation times were assumed for each of the groups by comparison with numbers of telephones installed, mains power consumed and other economic gauges.

As the outcome of these calculations and considerations, and also taking into account statistical figures for comparable other countries, a "20-year figure" of 5 telegrams per head of population per year was adopted. For the growth of the population in 20 years the figure (50 %) from the official statistical service was taken, and thus the total future daily traffic (after 20 years) was obtained. It amounts to 422.000 telegrams for a working day.

From the past 10-year increase figures per district such figures were deduced for the new zones, and based on these figures the division of the total future traffic over the zones was made. This way there resulted (different) increase factors per zone which must be credited with a good probability.

There was then left the problem of the future distribution of traffic between the zones, which gives rise to 10 second order equations with 10 unknowns, — the two zones of GBA for this purpose being taken as one. The positive real roots of these 10 equations were evaluated by a rapid iteration process.

Thus finally the 20-year traffic per zone, its division in internal and external traffic, and the distribution of the latter were found; these being all the data wanted for a proper dimensioning of the national line network and all its components, such as exchanges, trunk circuits and the like.

To give a general idea of the results and of the size of the traffic values involved, Table II may serve. It gives the traffic in Traffic Units (a T.U. equals 60 telegrams per peak hour). See para. 4.1. for the transmission speed.

Tabel II

Zones	GBA	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Total	410	119.1	47.7	31.3	125.8	52.2	46.3	73.1	70.6	29.1	1005.2
Internal	177.2	46.5	17.6	8.4	49.3	16.0	12.6	24.9	22.5	13.6	388.6
Internal %	43	26	37	27	40	30	27	34	32	47	38.7

It will be appreciated that the amount of work put into the traffic statistics and calculations was rather considerable. But as the dimensioning of exchanges (and trunk routes) is carried out with great exactness, using the probability calculus and carefully deciding upon types of grading, it was deemed justified and even necessary to aim at a high degree of exactness for the traffic figures, on which all further work must be based.

4. *The national line network*

4.1. Signalling method

It was decided to use tape-teleprinters with the 5 unit-code (plus start and stop pulses) on the whole network in order to avoid many trained morse-operators. Under the prevailing conditions the training of a limited number of more permanent technical staff for maintenance purposes was considered the better alternative; for the operation of the teleprinters every normal good typist can serve with not too much additional training. Thereby a high traffic speed can be obtained, this was fixed at 60 telegrams per hour sent and 70 telegrams per hour received. The difference between these figures is due to the necessary selecting time.

4.2. Telegraph Offices

Among the existing 1500 telegraph offices there are quite a number which will still have only a few telegrams per day after 20 years, and for such offices a teleprinter would not be an economic proposition, this apart of the extensive service scheme that would be required. To qualify for a teleprinter a minimum of about 15 telegrams per day was fixed, and in sparsely populated areas such teleprinter-offices will act as collecting and distributing centres. For these purposes they will use line telephony, existing morse circuits, and radio telephony and telegraphy on the new rural radio networks (see section 8).

Depending on the actual collection possibilities the minimum figure of 15 will be handled in a flexible way, but it can already be stated that about 400 teleprinter offices will be wanted outside Buenos Aires.

4.3. Exchanges

It was further decided to use automatic telegraph exchanges in the zone centres, so as to avoid errors due to human transit-handling and to increase the traffic speed. Each office will reach directly any other office in the country, — with one exception however.

As the number of (receiving) teleprinters per office must now be calculated on a probability basis, for the grade of service as used on telephone trunk lines the efficiency of the — per office — small number of "trunks" would be unacceptably low. The economy is restored by the introduction of an overflow, being a number of teleprinters — calculated for a high grade of service — which take the telegrams for offices to which all connections are found engaged. The final selectors of the exchanges select under those circumstances automatically an overflow position. The percentages of overflow were fixed according to a sliding scale, allowing the higher percentages to the smaller offices; as a result in the peak-hour about 6 % overflow may be expected, whereas outside the peak-hour this percentage will soon be negligeable. The overflow positions have a re-perforating attachment on their receiving teleprinters so as to eliminate possible human faults in the re-transmission; the operators at the overflow positions can see whether a wanted destination has a free connection.

As in this way there is no "lost" traffic to subscribers, for the calculation of the exchanges the Molina-Erlang formula can be applied.

4.4. Selection

For the selection of destination there is a choice between dial and keyboard, the latter was chosen for a number of reasons:

a. the destinations can be punched in the tapes of re-transmitting teleprinters, and also of transmitting heads and receive-send units of the radio network (see para. 6.2);

b. the selection pulses can pass through electronic re-generating amplifiers as may be wanted after transmission on long routes of open wire in the semi-tropical Northern part of the country;

c. the selection pulses can be guarded by TOR-equipment on the radio routes (see para. 6.3.);

d. the keyboard selection is quicker;

e. only one stringent requirement will be placed on the quality of the impulses, i.e., for the teleprinter code, and not for dialling.

These advantages fully justify the cost of the more complicated registers in the telegraph exchanges, as required by keyboard selection.

4.5. Transmission

For reasons of economy the use of multiple-tone telegraph equipment was indicated on this vast network with its big distances; only in the Buenos Aires area — and later in other bigger towns — single or double current d.c.-transmission will be used.

The choice between AM and FM was made in favour of FM, as this will be less sensitive to noise as is to be expected on open wire in the Northern semi-tropical part of the country, as well as along electric railways and in more built-in areas.

This reason is more stringent even for radio routes — as will be used initially on a rather big scale (see below); on such routes rapid level variations due to fading will also have to be met, and it will moreover be necessary to mark the disappearance of signal as a fault. All this indicates the use of FM, as a standard equipment for both radio and line.

The tone frequencies will be those as recommended by the CCIT, viz. the odd harmonics of 60 c/s from 420-3180 c/s. From these possible 24 frequencies normally, however, only 20 will be used, first divided in two groups of 10 each — with a spacing of two, then each group of 10 divided in 2 sub-groups of 5 each — with a spacing of one. The first division is made to allow for 10 frequencies in each direction on two-wire circuits; as the level of in- and outgoing frequencies may differ widely, a good separation is wanted to avoid cross-fire. The second division is needed on party lines (see below), in order to arrive at simple tone equipments in smaller offices. The small group of 5 will moreover permit an easy and still economic grouping of trunks at network junctions. The group spacing will thereby avoid too much distortion of signal, as would certainly result from a number of one-tone filters in series.

5. *The network in and around Buenos Aires*

5.1. General

This network will be realised in the first part of the execution, and has thus been elaborated in full detail.

Careful attention was thereby given to safety and security; these forbid to concentrate all the rather considerable traffic in one exchange only, although this might give the most economic solution. At first 3 exchanges were considered — and this explains the missing of Zone III in fig. 1; but finally it was decided to have 2 exchanges. They are both situated in Buenos Aires at a distance of some 3 miles.

The two exchanges will only handle traffic originating from or destined to GBA, as transit traffic will not enter the city. There is no need for this as all the telegraph exchanges in the country will be connected by a full-maze network, directly linking every exchange with every other one in the country for all the traffic to be interchanged.

5.2. Zone composition

The two zones of GBA are geographically intermixed to the maximum possible extent by distributing the telegraph offices of GBA as equally as possible over both exchanges with also a practically equal distribution of traffic load. Now every normal teleprinter can send as well as receive, but in automatic networks the number of receive connections is calculated on a probability basis; whereas send connections can be fully loaded. It is then found that except for offices with rather small traffic, separate send and receive connections will give the most economical solution.

The send connections of each office are as evenly as possible distributed over both exchanges, but for the receive connections such a division would lead to uneconomically small probability groups. These connections are thus kept together and go — geographically alternating — to one exchange only.

This with the exception of the Central Office with a very big group of connections for its own traffic, and for the connections to the radio exchange (see para. 6.2.).

5.3. Exchanges and interconnections

Both exchanges are equipped with fast motor driven switches. In comparison with telephone exchanges they have only a limited number of subscribers, but most of them with multiple connections, and all of them very busy ones. As a result the amount of switchgear is rather big. The number of registers with allotters c.s. is also considerable — but still comparatively small due to the high speed of the switches, resulting in short holding times. This is the more important as normally with a transmission speed of 60 telegrams per hour a telegram takes much less time than a telephone call. The exchanges are provided with overflow positions as described above.

The two exchanges are interconnected by a group of four-wire connections to allow a simple inter-transmission. The size of this group has been kept within limits as offices with double send connections — the majority — will only be allowed to pass traffic directly via the exchange to which the receive connections of the wanted office are connected.

As the address of handed-in telegrams must be coded anyhow, they can be sorted to the proper send position at the same time. This will not be necessary for the big traffic to the Central Office, — for final delivery or for radio-transit. These telegrams can moreover be used to equalize a temporary unbalance in the telegrams with GBA-destination. The Telegraph Offices are forced to follow the above arrangement as their input relay groups at the exchanges have been given a criterium that is recognized by the registers; as a result the exchange refuses to accept telegrams with "forbidden" destinations.

5.4. Transmission equipment

Initially teleprinter equipment will be installed for local traffic on a 10-year base and for traffic with the outlying zones on a 5-year base. This requires a total of 202 send teleprinters, 256 receive teleprinters and 46 send-receive teleprinters in the GBA area; distributed over 127 telegraph offices and using 2×108 tone frequencies. The exchanges will be equipped for 10-year traffic throughout.

Inside the town of Buenos Aires and with some Southern suburbs the transmission will be on single current d.c.-circuits, as the distances are relatively short and sufficient cable pairs are available. But for the other suburbs these conditions do not prevail, neither for Eva Peron (formerly La Plata) that is made to form part of the GBA network. Here tone-frequency connections will be used.

In total 39 offices are situated in 6 main directions, rather along railway lines. They will be served via circuits from both exchanges: their send connections evenly divided and the receive connections alternating along the route. Each wire pair will act as a party-line for maximum 10 connections; the offices are branched off from such a line at high impedance.

To avoid one-tone filters at too low frequencies, and to reduce anyhow the number of different ones — and of different tone oscillators —, these are only made for the middle group of 12(10) frequencies out of the 24(20) possible ones. The other frequencies are being obtained by group-modulation.

Thus along a party line the middle frequencies are directly sent or received, but after the tapping of 5 frequencies (send or receive) these are all used, and a group-modulator at that spot transforms then the outer frequencies to middle ones. In this way group-modulating equipment at each subsequent office is being avoided.

6. *The national radio network*

6.1. General

With the exception of GBA and its surroundings the present open wire telegraph network would need a rather considerable re-conditioning to bring it up to modern standards; with its many thousands of circuit-miles a big task. Instead, it has been decided to use in the future one network for both telephony and telegraphy, consisting of coaxial cable, multi-quad cable and open wire, — in this order from the centre outwards. The present growth of telegraph traffic as a result of the rapid development of the country does not permit, however, to wait with improvements until the new network will be realized; for this reason one will resort to radio which can give a quicker solution.

The traffic capacity of the national radio network will be 1/4th of the 20-year traffic, — the so-called 5-year traffic; this will also be sufficient to deal with urgent traffic in emergency cases after completion of the national line network. Radio will then be retained as a spare.

6.2. Radio telegraph exchange

Buenos Aires is the centre of the national radio network, with H.F. single side band connections with all provincial capitals and a few bigger towns inland. The actual transmitting and receiving stations lay on opposite sides outside the town, all traffic will be handled in the Central Office.

This handling is however not manual but fully automatic, and is catered for by a radio telegraph exchange in combination with a tape-relay system.

On the radio connections all traffic goes via pre-punched tape; at the outlying stations by means of keyboard-perforators and double transmission heads, — double so as not to lose time by the insertion of tapes. The transmission speed will be 160 telegrams per hour, so as to use to full capacity the rather costly radio circuits with their chain of equipment, — and moreover to save aether-space. The receive equipment is based on a reception speed of 170 telegrams/hour: the difference with the transmission speed being caused by the selection time.

Incoming circuits at the radio exchange — be it for outgoing traffic from GBA-offices via one of the line exchanges, or for incoming or transit radio traffic —, will by line finders or pre-selectors be connected to a free receive-send unit. Its receiving part performs the punching as necessary for outgoing traffic, and the tape provides storage for all traffic.

The punched holes are being controlled and after a telegram has been received the transmitter part sends it out after its associated line-selector has found a free connection in the wanted direction. The average holding time will be only about half a minute; when in abnormal cases — emergency or sudden crowding — a telegram has to wait for more than one minute, it will be passed on to one of 8 overflow positions in order to prevent a hold-up of following telegrams with different destinations on the same tape.

The distribution of incoming traffic to GBA offices goes via an outgoing line selector and a free junction to the wanted line-exchange, where one of a group of registers takes over the routing rather as for normal local traffic.

The use of tape-relay allows the combination of line and radio circuits, as now each radio circuit is complete in itself with a TOR-equipment at both ends — necessary for the automatic repetition of signals (for this TOR-equipment, see para. 6.3.).

From the beginning Rosario will be connected via lines; other stations inland may follow when their line connections are improved, and before the full national line network with its automatic exchanges comes into operation.

Such offices will then act as regional collecting and distributing centres, functions now already to be performed by the national radio stations. For this reason a rough analysis of the external traffic of these regions was made, rough because the regions are not too well defined and to a certain extent can be arranged with the existing line telegraph circuits in their neighbourhood, and in that of associated zonal and rural stations (see sections 7 and 8). Still an analysis apart from the general one was wanted, as obviously the external traffic of a region will pro rata be bigger than that of a bigger zone.

6.3. Telegraph equipment

On the radio path one channel of 3 kc/s bandwidth nominal and 300-2700 c/s actual will normally be available for telegraphy, allowing the use of maximum 18 tone-frequencies according to CCIT recommendations. As some smaller stations can do with a small telegraphy band and as the international frequency allocation goes by 5 kc/s, such stations will get 2 kc/s for telegraphy.

In total there will be 66 full duplex telegraph connections installed.

To counteract selective fading which might easily affect both the marking and spacing frequencies — being resp. plus and minus 35 c/s off the nominal frequency, or at 70 c/s distance — diversity will be used. On one busy route this is space diversity at both receiving sites, on the other routes the thereby necessary more expensive aerial and receiver arrangement can be saved by using frequency diversity, normally with 720 c/s spacing between the nominal frequencies. The available number of tone frequencies permits this.

Under adverse atmospheric conditions — as long periods of deep fading and/or heavy statics — a reliable reception of teleprinter signals with their short pulses of only 20 milliseconds would still not be assured, and — more serious — the automatic selection of destination might well be imperiled.

Therefore all telegraph circuits are moreover guarded by TOR-equipments. TOR signifies "Teleprinter On Radio", and means an equipment to detect and reject faulty teleprinter signals, asking — and giving — moreover an automatic repetition thereof. This kind of equipment has been developed by the Dutch Post Office; in close cooperation with this service an electronic execution was developed, specially suited for the present network with its medium distances.

It may be pointed out that TOR-equipment does not make the use of diversity superfluous, as repetition takes time and does mean loss of speed and thus of circuit efficiency. The present TOR uses a storage circuit to prevent the slipping through of faked signals, as may be produced by noise during fading periods. By increase of storage and thus of repetition time the security against this can be increased, — but at the cost of efficiency. This sets a practical limitation, and so normal precautions as diversity should not be neglected.

6.4. Telephone equipment

Although the radio network is primarily intended for telegraphy, it will also be used for telephony. As a matter of fact telephony will use the bigger part of the frequency bands, as in total there will be 34 radio telephone channels installed.

In Buenos Aires' Central Office two traffic control rooms will be equipped with manual exchanges, having access to the telephone exchanges of GBA, and to the long distance traffic room at Buenos Aires for line transit traffic. Radio transit on the network can also be performed.

At Buenos Aires all radio circuits terminate at radio telephone terminals with automatic level control and silencing devices to provide anti-singing. They will in groups of 6 be controlled centrally on a control desk in the technical control room.

At the stations inland for the bigger ones already available terminals will be used, the other ones will be provided with hand controlled speech-panels.

The levels on the circuits will be carefully controlled. Overloading of the transmitters will be prevented by compressor-amplifiers; the output from the receivers to the terminals will be passed through Alads (Automatic Level Adjusting Devices) only reacting to speech, to ascertain a proper average level at the terminals.

6.5. Radio equipment

To save on the number of transmitters, there will in Buenos Aires transmitting station be a number of them serving more than one outlying station, when these fall together in the beam of the (mostly) rhombic aerials with on the average 6 dB gain, — and when moreover their distances to Buenos Aires allow the use of the same frequency. The receivers at such commonly served stations will select the audio frequency band(s) intended for each of them.

There are further 3 cases where a for a national station qualifying town lies so near to another one that a completely separate equipment would not be justified. Such "twin" stations are interconnected by a VHF-link, to and from which the traffic is passed on without any handling. Four-channel carrier equipments are used for this purpose, with a bandwidth of 4 kc/s per channel and 6 kc/s channel spacing.

In total there will thus be in Buenos Aires 16 transmitters (excluding spares) to serve 30 outlying stations. With the exception of 2 off 5 kW peak transmitters they have all 10 kW peak power. They are equipped with 3 pre-tuned HF-units each, for day and night and eventually twilight. With an eye to the frequency-changes dictated by the sunspot cycle all coils are easily interchangeable. (The same applies to the receivers which have all pretuned HF-units.)

A final economy is obtained by dividing the national stations in first and second class stations, the first class ones with round the clock service and corresponding spare provisions, the second class ones for mainly day-time working and less spares. This with the exception of six of them which are self-supporting, i.e. they cannot rely on a neighbouring station, and are equipped accordingly. During the slack night hours these second-class stations will communicate with Buenos Aires via the first-class station in their area.

7. *The zonal radio networks*

Bigger towns in the area of a first class station which, at present, have inadequate line-communications, will also be given a radio connection to "their" first class station; together with the second class station(s) thus forming zonal radio networks. Buenos Aires itself will also be the centre of such a network.

In these networks 1 kW transmitters will be used; for telegraphy they can be keyed in A1 but also in F1 with a frequency shift adjustable between 100 and 1000 c/s, allowing simultaneous telephony with high power modulation.

Each network will have two operating frequencies, for transmission and reception by the centre, and for reception and transmission by the outlying stations, respectively. During night-hours a different set of frequencies will be used.

To allow direct communication between outlying stations, a calling outlying station can switch over to the centre's frequencies. All stations will have a selective tone-calling device, the transmitter being A2 modulated by its telephony modulator. The centre stations will thus have two pre-tuned HF-units installed, the outlying stations four. The respective receivers will be equally equipped. All HF tunings coils are easily replaceable with a view to the changes in frequency as required by the sunspot cycle.

For telegraphy, normally, reperforating teleprinters will be used, allowing a quick and faultless handling of transit telegrams in both directions. When atmospheric conditions are too bad for a teleprinter connection, hand morse keying and aural reception can be used. The telephone connections can be connected through via hand-controlled speech-panels; to ascertain a good degree of secrecy, on the zonal radio routes the speech-bands are inverted by means of renversor equipment.

The zonal networks have together 9 centres and 35 outlying stations. In total there will be installed 70 1 kW transmitters with associated receivers, calling devices, etc.

8. *The rural radio networks*

The economical value of many parts of the country far from Buenos Aires is such that good communications are warranted, also with an eye to further developments. Due to the big distances involved good line connections will take quite some time to materialise, so radio is the indicated way of communication for a number of years to come. It is provided in the form of rural networks, of which there are in total 11 with 64 outlying stations. Centre stations are always national stations; at Buenos Aires a rural centre station will also be installed.

Three networks will be provided with available 100 W-transmitters, all others with 75 W-transmitters. Each network has normally one set of 2 frequencies for day, another set for night operation. Each set gives a send and a receive frequency for the centre and vice versa for the outlying stations. In some cases, however, two sets of day-frequencies are used for the centre, in order to serve nearby and distant outlying stations. All traffic has to pass to — and through — the centre; all stations have a selective calling device so that only a wanted station will be called.

The stations can work A1 or A3, A1 with hand morse; for the outlying stations power is derived from motor driven AC-generators. For telephony secrecy renversors are provided.

There will moreover be 20 mobile rural stations, to serve for special conditions, to be used as a preliminary solution or during emergencies. They have each a "twin" 75 W transmitter (2 HF-units in one cabinet), and a receiver for 2 frequencies. The station complete with aerial masts (for transport in sections) and material, cables on drums and the like are installed in special vans on a truck chassis. For the power supply serves a motor driven AC-generator, mounted on a little trailer, which during use is put at a distance of 15 yards. The stations in the cars can be remotely controlled from a post office or similar building.

9. *International and press radio service*

The equipments for this service will be installed in Buenos Aires transmitting and receiving stations, and operated from the Central Office in Buenos Aires.

There will be installed 5 10-kW transmitters and 5 60-kW transmitters all working on high frequencies, in the beginning with A1 or F1 keying by high-speed morse transmitters (mostly with 100 Bauds) — from tapes pre-punched in the operating office. The transmitters are, however, suitable for low power and single sideband modulation, the first with 15 kW carrier power and the latter with 60 kW peak power.

At the receiving sites diversity reception will be used — with high-speed pen-recorders; transmitters and receivers will both work on rhombic aerials.

The 10-kW transmitters are of the separate HF-unit type and fitted with four HF-units each; the 60-kW stages — using separate 10-kW transmitters as pre-amplifier — can continuously be tuned in the frequency band of 6—27 Mc/s.

10. *Mobile maritime service*

The main station for this service is at Buenos Aires, the transmitters being operated from the receiving station. For the acceptance and distribution of telegrams this stations works as a telegraph office on the GBA line network.

For the passenger ships telephone service 2 radio telephone terminals will be installed in the receiving station.

Moreover, there are 3 first-class coastal stations, 7 second-class coastal stations and finally 8 river stations along rivers (and a lake) inland.

At Buenos Aires transmitting station there will be installed:

6 5-kW HF transmitters
3 10-kW HF transmitters
1 60-kW peak HF transmitter
2 5-kW MF transmitters

Each first-class station will have:

2 0,5-kW MF transmitters
1 1 -kW Multiple HF transmitter.

Each second-class station wil have:

2 0,5-kW MF transmitters
2 0,1-kW HF transmitters.

Each river station will have:

2 0,1-kW HF transmitters;
in addition 6 of them:
2 0,5-kW MF transmitters.

At all stations corresponding receiving equipment will be installed; especially at B.A. receiving station fitted with a good array of operating positions so as to ensure a really high-grade ship service.

11. *The telex network*

In Buenos Aires there will be installed an automatic exchange for the handling of private telegraph (telex) traffic. The exchange resembles in many respects the line telegraph exchange mentioned above; overflow positions are not provided however. When the connection to a wanted subscriber is not free, an engaged signal will be given to the calling subscriber.

The exchange will originally be equipped for 200 subscribers, with provisions for a possible extension to 900 in total. The subscribers use page-teleprinters with keyboard selection; they will be connected to the exchange via single- or double-current d.c.-circuits.

The operation in the GBA area is fully automatic; to reach subscribers in other towns those in GBA must resort to an operator who can make connections via telegraph circuits in the national radio network, — later on the national line network.

The charges for the service will be made in periods of 3 minutes, registered by counters. Trunk connections will be time-controlled by the operators.

12. *Miscellaneous equipment*

The traffic between the Central Office at Buenos Aires and its national transmitting and receiving stations goes over cable pairs, grouped in the channels that will be combined by the pre-modulators of the transmitters, resp. as they are obtained from the de-modulators following the receivers.

The operating and keying of the transmitters for the inland Press Service, for the Mobile Maritime Service and for Buenos Aires' zonal and rural stations is, however, performed via V.F.-telegraph connections, as is the passing-on of the received signals to — or via — the Central Office. For these purposes fully loaded 24-tone FM telegraph systems will be used, however in a one-sided execution as only one-way connections are wanted.

As a spare for the cables mentioned above, UHF-links will be provided between the Central Office and the transmitting resp. the receiving station. They use a 8-cm transmitter of about 10-W power, double frequency-modulated via a 24-channel carrier system.

For the servicing of the equipment in the 9 zones inland there will be provided 9 service cars, one for each zone. In a body on a truck chassis they contain a very complete set of measuring equipment and instruments, together with a well assorted collection of spare parts. Small repairs can be performed in a little work-shop with a bench-vice and other tools. A small trailer can carry heavy equipments or spare parts.

For the service and maintenance of the equipment in the GBA-area an extensive set of measuring equipment is provided. For fixed control and monitoring points the necessary desks with equipments are provided, as well as the necessary operating desks.

Apart from the above mentioned power supplies for rural stations, 133 Dieselmotor driven a.c.-generators, with a total power of some 2250 KVA will be installed for various other stations.

The T.O.R. circuits for the Argentine radio-links *)

by W. Six **)

Lecture delivered for the Nederlands Radiogenootschap on December 17th, 1954.

1. *Introduction*

A national telegraph system which will link all parts of the country, has been planned for the Argentine. One section of this system is a radio network connecting Buenos Aires with the outlying stations. The centre of these radio links is an automatic telegraph exchange at Buenos Aires, which exchange includes a tape relay system. The radio communications are carried out on high frequencies and, generally, over long distances. It will, therefore, be clear that it is necessary to protect the coded messages and the selecting-code against errors due to fading and interference; otherwise, the probability for mutilation would be too high. For this reason, the radio links are guarded by T.O.R. circuits ***).

The T.O.R. equipment prevents faulty signals from being given through; if a signal is mutilated, it is rejected by the receiver and an automatic repetition takes place. The first equipment of this kind was developed by Dr H. C. A. van Duuren of the Dutch Post Office [1]) and has been in operation for several years; it is in operation on the international radio link Amsterdam-New York. Dr van Duuren's system was developed for a 4-channel multiplex system and works with a "3 out of 7" code. The 5-unit code taken from a normal tape is translated into a 3 out of 7 code. After reception, the 3 to 4 ratio of the units of a character is checked; thereupon the 3 out of 7 unit code is translated again into the 5-unit code, so that the conventional teleprinter can be used. This T.O.R. equipment is an electro-mechanical system.

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*) With kind permission of the Editor of Philips Communication News.

**) Philips Telecommunication Industries, Hilversum - Netherlands.

***) T.O.R. is the abbrevation of "Teletype On Radio".

[1]) H. C. A. van Duuren, Typendruktelegrafie over radioverbindingen (T.O.R.), Tijdschrift van het Nederlands Radiogenootschap XVI, 53—67, 1951.

In the Argentine project, one band of 300-2700 c/s on the radio-links is reserved for the telegraph channels. An 18-channel carrier system is used on this band, the channel spacing being 120 c/s. For this carrier system a new T.O.R. equipment has been developed by N.V. Philips' Telecommunicatie Industrie in close co-operation with the Dutch Post Office. In order to evade the rather elaborate translation from 5-unit code into 7-unit code and back again into 5-unit code, it was decided to use the normal 5-unit code and to check the form of the received signals. Furthermore, it was decided to develop an all-electronic circuit. In the electro-mechanical system, most of the switching is done by relays of which several have to work every 20 milliseconds, that is about 4 million times a day. Consequently, considerable maintenance is required for such a system. In the electronic circuit, most of the switching is done by means of cold-cathode tubes, which have a very long life, as will be explained later. For some special functions, vacuum tubes had to be used.

When using the 5-unit code, it is necessary to apply the frequency shift method of transmission, otherwise there is no possibility of checking the received signals. In the receiver it must be possible to distinguish between a mark, a space and fading. With an on-off-system there are only two situations, i.e. a signal giving a mark, or no signal giving a space, and thus the difference between a space and fading cannot be distinguished.

In the frequency shift system the frequency is shifted to one side for a mark and to the other side for a space. When fading occurs, no signal is obtained. In the discriminator of the receiver there are two filters, as shown in fig. 1. The shift is 35 c/s to either side of the centre frequency f_m. The signals passing through the filters are rectified, viz., the lower frequency f_1 to a plus and the higher frequency f_2 to a minus potential. When there is no signal or only the centre frequency, the discriminator gives zero potential.

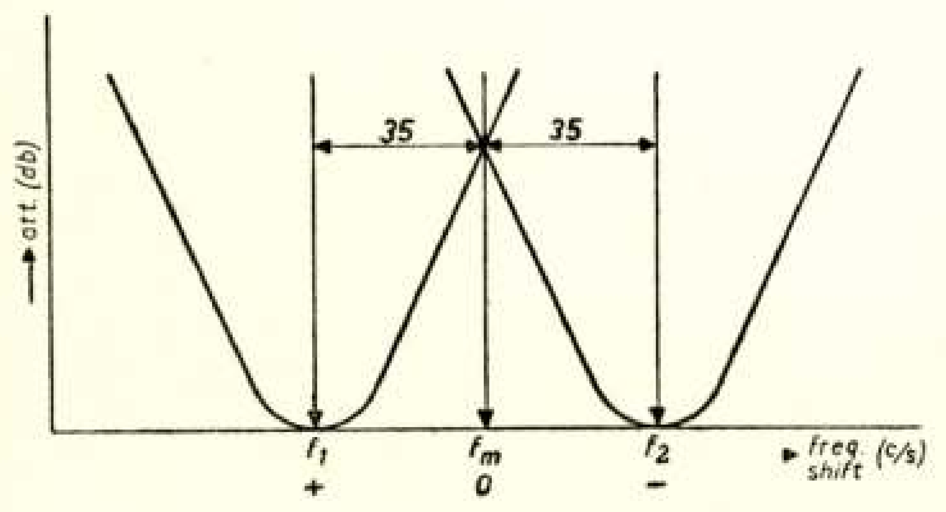

Fig. 1

Discriminator with a centre frequency f_m. A signal having a frequency f_1 is rectified to a plus potential, a signal having frequency f_2 to a minus potential, and a signal with a frequency f_m to zero potential.

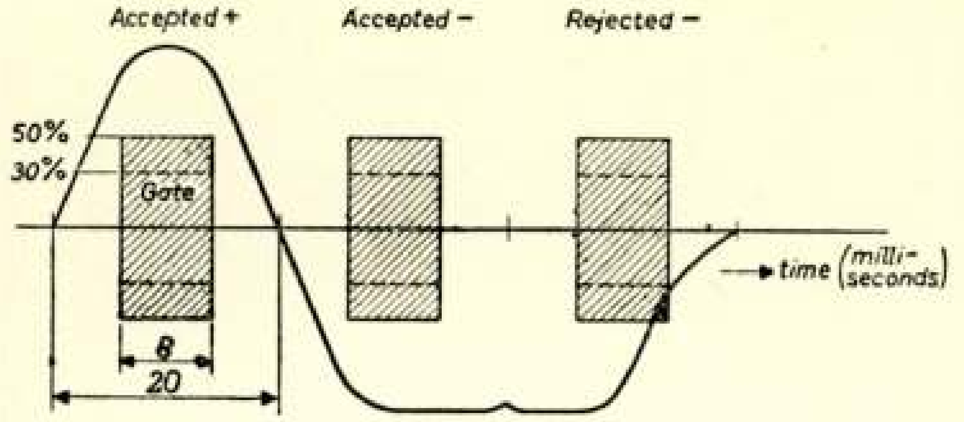

Fig. 2
Gate circuit in tester. From left to right are shown: an accepted plus, an accepted minus, and a rejected minus signal.

As already mentioned, the system works with the normal 5-unit code taken from a tape, to which a start- and a stop signal is added. The speed is 50 bauds; thus the duration of one unit is 20 milliseconds and that of a character 140 milliseconds. Therefore, the speed is about 428 letters per minute. Protection against faulty signals requires several operations, namely:

a. In the receiver the signals must be tested. This is done by a gate, as shown in fig. 2. The width of the gate is 8 milliseconds and the height is adjustable from 30 % to 50 % of the maximum signal. A mark must be above the threshold of the positive gate and a space below that of the negative gate. When the potential of a mark falls at any instant below the threshold of the gate, or the potential of a space rises above this threshold, the signal is rejected.

b. When a signal is rejected, reception is discontinued and a demand for repetition is sent to the transmitter over the return channel of the duplex system.

c. When the demand for repetition is received, the tape transmitter is stopped and the T.O.R. sender starts repeating a number of code elements. The number of elements that must be repeated depends on the propagation time from transmitter to receiver and back, including the propagation time of the cables and the filters in the system. Therefore, the sender needs a memory of as many elements as must be repeated.

d. The T.O.R. sender and receiver must run in synchronism with each other, so that the repeated elements link up with those elements already received before the demand for repetition was sent out. To secure synchronism, sender and receiver are fitted with a crystal oscillator of 60 kc/s. This frequency is divided by two multivibrators, first to 5 kc/s and then to 500 c/s. The latter frequency is divided to 50 c/s by means of a 10-counter. The counter gives impulses with a spacing of 20 milliseconds by which sender and receiver are governed. Phase synchronism is assured by a correction network in the receiver which will be explained later.

The demand for repetition is effected by giving zero potential to the modulator so that the centre frequency is sent out on the return channel. It will be clear that the telegram on the return path will then be mutilated. Therefore, repetition must always take place simultaneously on both channels of the duplex system.

The operation of the T.O.R. equipment will now be explained.

2. *The T.O.R. sender*

The block diagram of the T.O.R. sender is given in fig. 3. As already mentioned, the sender is governed by the 20-millisecond-spaced impulses from the 10-counter. In the 7-counter the 140-millisecond-spaced impulses required for each character, are formed.

The 10-counter, of which a description will be given in (5.2.), contains a set of 10 cold-cathode tubes of which only one is fired at a time. The counter is stepped forward under control of the 2-millisecond-spaced impulses derived from the 500 c/s frequency divider. Each tube, therefore, is fired during a period of 2 milliseconds only, at intervals of 20 milliseconds.

20-millisecond-spaced impulses may, therefore, be derived

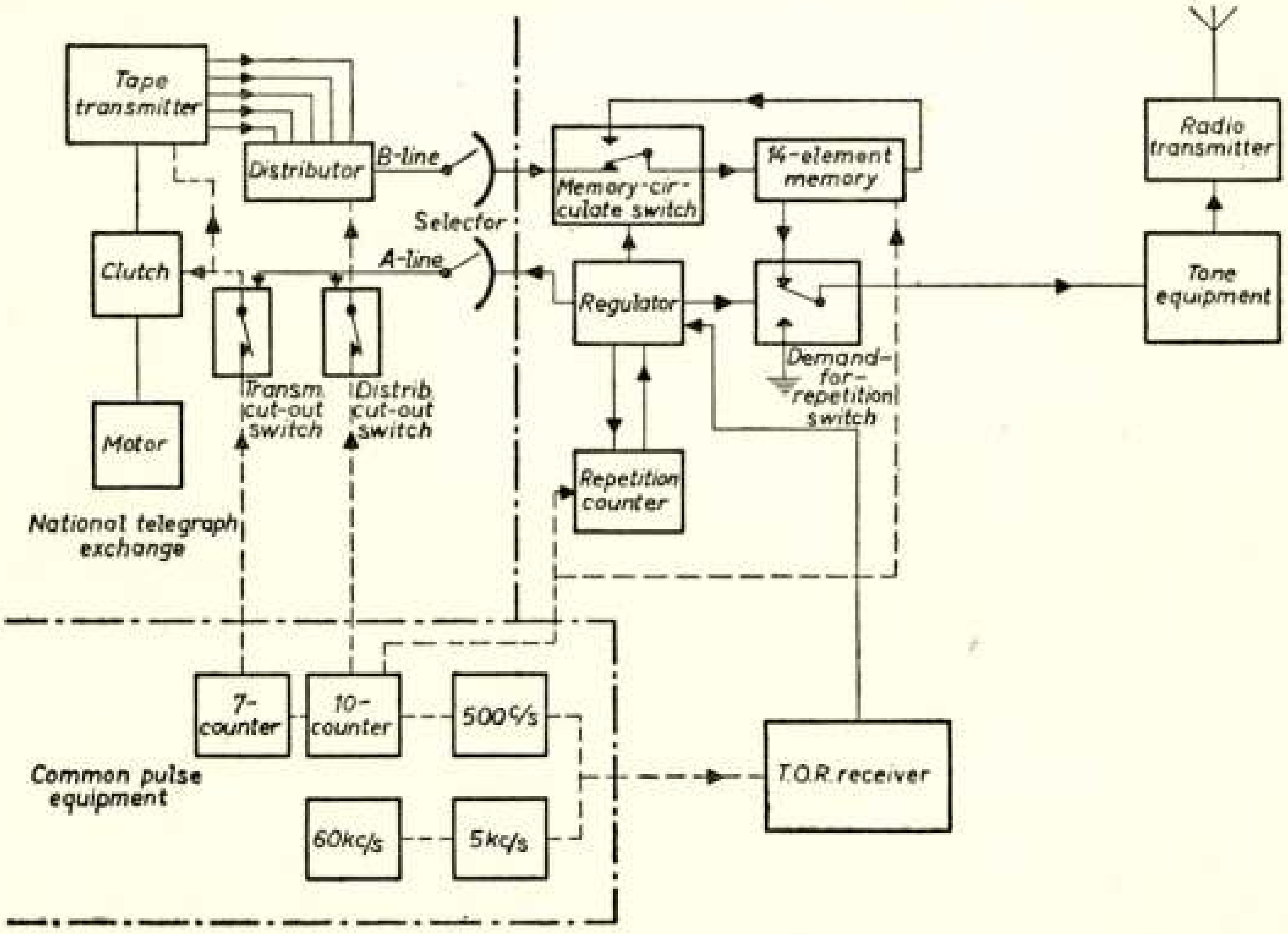

Fig. 3
Block diagram of the T.O.R. sender.

from each link of the ring counter, the time difference between the impulses being a multiple of 2 milliseconds. As shown in the diagram by the dotted lines, the 10-counter supplies stepping impulses to the different parts of the circuit. The phase of the impulses is chosen so that the stepping takes place in the correct sequence.

In Buenos Aires the 60 kc/s oscillator, the 5 kc/s and 500 c/s frequency dividers, the 10-counter and the 7-counter are common for all T.O.R. senders, whereas in the outlying stations, there is a common 60 kc/s oscillator and 5 kc/s frequency divider; but a 500 c/s divider, 10-counter and 7-counter are provided for each T.O.R. equipment. This is done because the receiver in an outlying station is synchronized with the sender in Buenos Aires. This synchronization takes place in the 500 c/s divider, as will be explained later. In an outlying station, the receiver and sender are in synchronism because both are governed by 20-millisecond-spaced impulses from the same 10 counter.

The receiver in Buenos Aires is synchronized with the sender in an outlying station. Therefore, there will be a phase difference between sender and receiver in Buenos Aires, depending on the propagation time between the two stations. Consequently, in Buenos Aires there is a separate 500 c/s divider and 10-counter for each receiver.

The 5-unit code information, read from the perforated tape by the sensing pins of the automatic tape transmitter, is transferred over 5 wires to the distributor, by means of the 140-millisecond-spaced stepping impulses. These stepping impulses are also sent to the clutch magnet of the tape transmitter. The result is that every 140 milliseconds this tape is advanced one character by the motor. In the distributor the start and stop elements are added to the 5-unit code. This distributor is a shift memory. It is stepped by 20-millisecond-spaced impulses, hence the elements of the code will be sent out in sequential form.

From the distributor the signals pass the selector in the National telegraph exchange and are led to the tone equipment, where they are modulated and passed on to the radio transmitter. They are also fed into the 14-element shift memory. Every signal element fed into the memory will be stepped through the 14 storage positions of the memory by the 20-millisecond-spaced impulses. After 280 milliseconds, an element will be stepped out of the memory and discarded.

When a demand for repetition from the outlying station enters the receiver – this demand for repetition being one element zero potential – the tester in the receiver responds to zero potential instead of to a plus or minus potential (mark or space); a signal is then sent to the regulator, switching it over. Simultaneously, the regulator passes signals to the transmitter cut-out switch, the distributor cut-out switch, the demand-repetition switch, the memory-circulate switch and the repetition counter. These signals cause the following operations to take place:

a. The transmitter cut-out switch is operated, and hence the 140-millisecond-spaced impulses to the sensing pins and to the clutch of the tape transmitter are interrupted, so that no further signals are transferred to the distributor and the transmitter is stopped.
b. The distributor cut-out switch is operated so that the 20-millisecond-spaced stepping impulses to the distributor are cut off. Consequently, the distributor stops and does not send out any further code elements.
c. The demand-repetition switch is activated only during one time-element of 20 milliseconds. Hence, one zero-potential element is sent out. This is done because, as already mentioned, the tester in the receiver cannot distinguish between a demand for a repetition and fading, or between a demand for a repetition and mutilation of the incoming signal due to other causes. If the signal is mutilated, a demand for repetition must be sent out. If, on the other hand, a demand for a repetition is made by the outlying station, it is not necessary to send out zero potential; but, as will be explained later, there is no objection to doing so.
d. The memory-circulate switch is operated by cutting off the sending path from the distributor and at the same time connecting the output of the memory to its input and to the tone equipment. The code elements stored in the 14-element memory will, therefore, start to circulate in this memory and at the same time are sent out.
e. The repetition counter is started and counts 14 time elements of 20 milliseconds each. When, after 280 milliseconds, this counter has completed its cycle, it will pass a signal back to the regulator which will then return to the normal positition, unless a "demand repetition signal" is still present. At the end of a repetition cycle the last 14 code elements will have been repeated (except the first one which is transmitted as zero potential by the demand-

repetition switch). The 14 elements stored in the memory then occupy exactly the same position in the memory as when the repetition started.

If the regulator cannot return to the normal position at the completion of the cycle of the repetition counter because a demand-repetition signal is still present at the receiver, the transmitter cut-out switch, the distributor cut-out switch and the memory-circulate switch will remain operated. The demand-repetition switch will again be operated for 20 milliseconds and the repetition counter will be started once more. Hence, the T.O.R. sender will repeat once more the same 14 code elements. If, however, no further request for repetition is received, the switches will be restored to their normal positions and the repetition counter will stop in the zero position. Normal transmission is then resumed. The distributor will again be stepped forward, controlled by the 20-millisecond-spaced impulses.

3. *The T.O.R. receiver*

The block diagram of the receiver is given in fig. 4. The signals picked up by the radio-receiver are passed through the tone equipment and are then split up into the 18 telegraph channels and converted into mark and space signals for each channel. The tone equipment delivers d.c. signals of the same

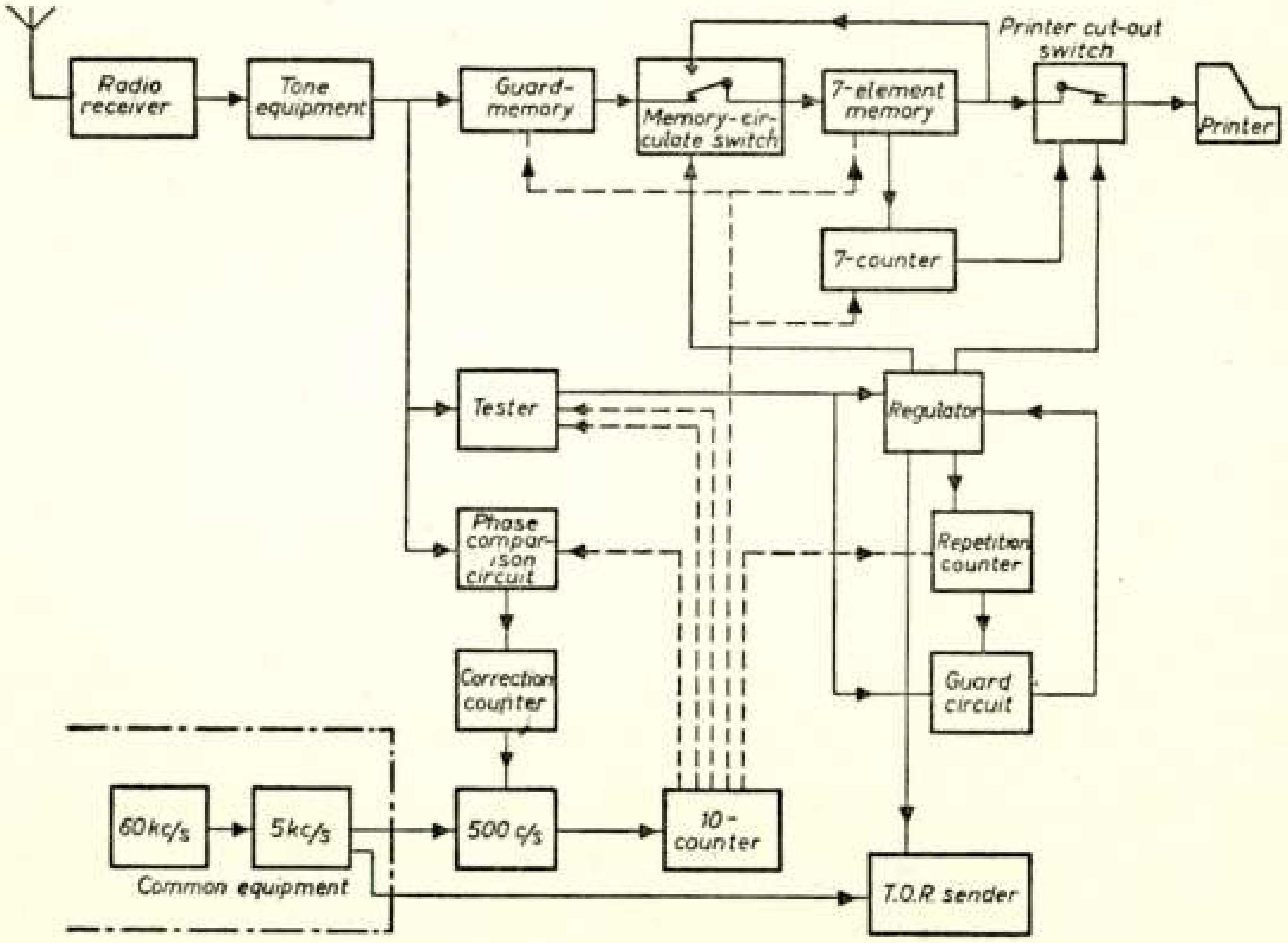

Fig. 4
Block diagram of the T.O.R. receiver.

impure form as those detected by the radio receiver to the T.O.R. receiver. The task of restoring these signals to their original square-wave form is left to the T.O.R. equipment. This is necessary in order to enable the T.O.R. to fulfil its main function of testing the signals as to whether their quality is sufficiently good for acceptance.

The received signals are passed through the guard-memory and the 7-element memory to the printer. The signals are stepped on through the memories by 20-millisecond-spaced impulses from the 10-counter. In the tester, all the incoming signals are tested for wave form, as has been described in the introduction. All positive signals must be above the positive threshold of the gate in the tester, and all negative signals below the negative threshold (see fig. 1).

As soon as a signal is rejected, the tester sends out a signal to the regulator, switching it over, and causing it to pass signals to the memory-circulate switch, the printer cut-off switch, the T.O.R. sender and repetition counter. These signals bring about the following changes in the circuit:

a. The memory-circulate switch is operated, disconnects the guard-memory from the 7-element memory and connects the input of the latter to its output. The code elements in the 7-element memory will, therefore, circulate during the time the regulator is off normal. At the same time, the code element that was stored in the guard-memory, as well as those elements that are received after the switch is opened, are lost.

b. The printer cut-off is biased, but it is not operated as long as the 7-counter is off normal. The reason for this is that each code element is checked individually; and if a unit is rejected, the connection is broken off in the middle of a character. The printer, however, will accept only complete characters. Since the 7-element memory always contains 7-code elements, it is possible to feed all the units of the character to the printer, provided the printer cut-off switch does not open before the character is completed. The 7-counter will only be stepped forward by the 20-millisecond-spaced impulses, when it has received a start impulse from the 7-element memory. This start impulse is produced by a change in the memory from a plus to a minus potential. This change from plus to minus always takes place between the stop element of one characte and the start element of the next one, because the storp element is always a plus, and the start element a minus signal. If, due to some reason or other, the 7-counter moves out of phase, it would be possible for the 7-counter to start in the middle of a character, as, in general, each character consists of a succession of changes from plus to minus potential, and vice versa, besides the changes occurring between the stop- and the start element. The 7-counter could be started in the middle of a character, but it cannot be re-started before it has completed its cycle. As long as different characters are received in succession, the 7-counter will, in general, not receive a starting impulse again after the completion of 7 elements, and thus the counter is gradually shifted until it is in phase with the end of the character, this being the only instance where there is always a potential change from plus to minus in in each character As the starting impulses normally arrive in regular succession at 140 millisecond intervals at the end of each character, impulses of 140 milliseconds can be derived from this counter, to operate the printer cut-off switch when it is biased by the regulator.

c. The sender gives a demand-repetition signal, as has been described in section 2.

d. The repetition counter is started and counts 14 time elements of 20 milliseconds each. When, after 280 milliseconds, this counter has completed its cycle, it will pass a signal back to the regulator through the guard circuit, unless one of the last 5 elements has been rejected by the tester; the regulator will then return to its normal position. The regulator should not return to normal if one of the last 5 elements is rejected, because at that moment these elements occupy the guard-memory and will be transferred to the 7-element memory when the memory-circulate switch switches over to normal. For this reason, the guard circuit is introduced, which only passes the signal from the repetition counter to the regulator if the last 5 elements have been accepted by the tester.

If the regulator cannot return to the normal position at the end of the cycle of the repetition counter because the incoming signals are still rejected by the tester, the memory-circulate switch and the printer cut-off switch remain operated; again a demand repetition signal is given by the sender and the repetition will be started once more. Therefore, during another 14 time elements of 20 millliseconds no new signal will be fed to the printer. During every period of 14 time elements, the 7-element memory circulates twice, and it is in exactly the same position at the end of this period as at the beginning. Generally, at the end of the period some of the code elements of the last character printed, are still present in the memory· Therefore, the printer cut-off switch is not closed before the 7-counter has completed its cycle, that is at the moment the starting element of the new character is transferred to the printer.

3.1. *The guard memory* (5-element memory)

In order to explain the function of the guard-memory the results of a period of fading, i.e., when no signal is received, must first be considered. In this case, there will sometimes be interference and there will always be noise. Now it would seem that, since the energy of random noise is distributed evenly over all frequencies, the energy passing through one of the two filters in the discriminator of the tone equipment (see fig. 2) would equal that passing through the other filter so that, after rectifying this noise, equal positive and negative potentials would be the result, their summation when connected in series yielding zero potential. This, however, is not true. The energy of random noise is equally distributed over all frequencies only when considering a long period; for a short period of 20 milliseconds it will be found that the energy is not equally distributed, and will sometimes pass through one filter of the discriminator, and sometimes through the other. Therefore, during a period of fading, noise produces plus and minus signals and these signals will reach the T.O.R. receiver.

Fig. 5 shows signals produced by noise during fading, compared with the time base of the 20-millisecond-spaced impulses. During each time interval of 20 milliseconds the signals are compared with the gate signal which is shown as a hatched block. Whether these signals will be accepted by the tester depends upon their form, and upon their periodicity. In general, there will be no phase synchronism between these signals and the 20-millisecond-spaced impulses in the receiver. Still, there is a certain probability that they will be accepted as correct signals, depending on the threshold of the tester. Experiments

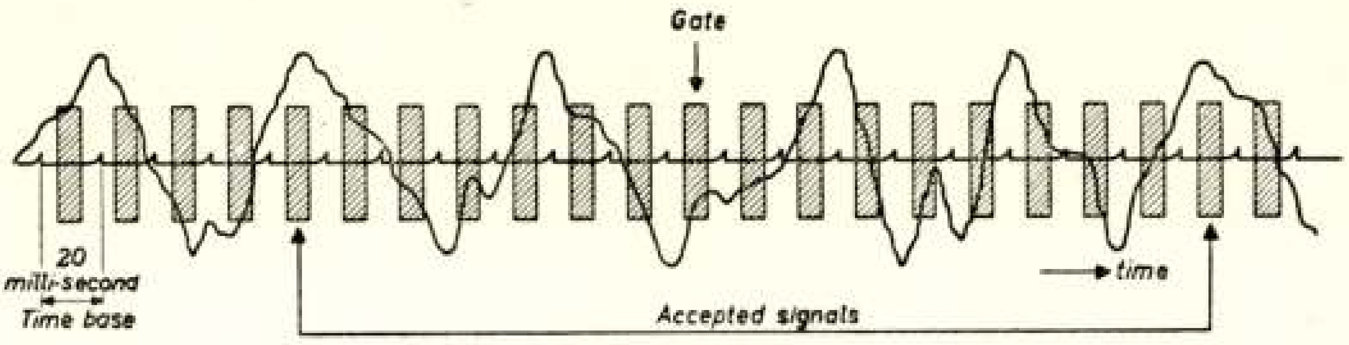

Fig. 5

Specimen of signals produced by noise; the 20-millisecond-spaced time-base impulses are shown by pips, and the tester gate by hatched blocks. Two elements are accepted by the tester.

have shown that the probability is about 0.05 when the threshold is adjusted to 50 %, and 0.1 when it is adjusted to 30 % of the maximum signal. Naturally, the probability that more than one signal will be accepted in succession is much lower; e.g., the probability that 5 units will be accepted in succession is $(0.05)^5 \sim 3 \times 10^{-7}$ for the 50 % threshold and 10^{-5} for the 30 % threshold. For this reason the guard-memory of 5 elements has been introduced. The code-elements are not transferred to the 7-element memory before ascertaining that the last 5 elements have been accepted as correct signals. As soon as the tester rejects one element, the 4 preceding elements are also rejected, by opening the memory-circulate switch. The probability that, during a period of fading, a signal will be accepted as a correct signal, is thus exceedingly small.

3.2. *The synchronization*

To synchronize the 20-millisecond-spaced impulses with the incoming signal, these impulses are compared with the transitions from plus to minus of the signals in the phase comparison circuit (fig. 4). If the 20-millisecond-spaced impulses are leading in phase with respect to the transitions, the phase-comparison circuit will pass a retarding signal to the correction counter (fig. 4), and, if the 20-millisecond-spaced impulses are lagging with respect to the transitions, an advancing signal will be given. The correction counter counts either the retarding or the advancing signals. The counter steps forward as long as there is a succession of either retarding or advancing signals, but it is put to zero each time there is a change from advance to retard, or vice versa. Each time the correction counter steps forward 9 steps, the synchronization signals are passed to the

500 c/s frequency divider, causing this divider to be retarded or advanced 0.2 milliseconds, i.e., by one cycle of the 5 kc/s divider. When this has been effected, the counter is brought back to zero.

The reason for introducing the correction counter is similar to that for introducing the guard-memory. As already mentioned, during periods of fading, signals will be produced by noise and, hence, there will be potential-transitions from plus to minus. When these transitions are compared with the 20-millisecond-spaced impulses, the comparison circuit will sometimes find them advanced and sometimes retarded. If the synchronization signals were passed directly to the 500 c/s divider, there would be a certain probability that, during a long fading period, the number of advances would exceed that of the retardations, or vice versa, to such an extent that the noise would bring the receiver out of synchronization. As the transitions produced by noise are erratic, the probability that 9 times in succession "advance" or 9 times in succession "retardation" would be found, is very small.

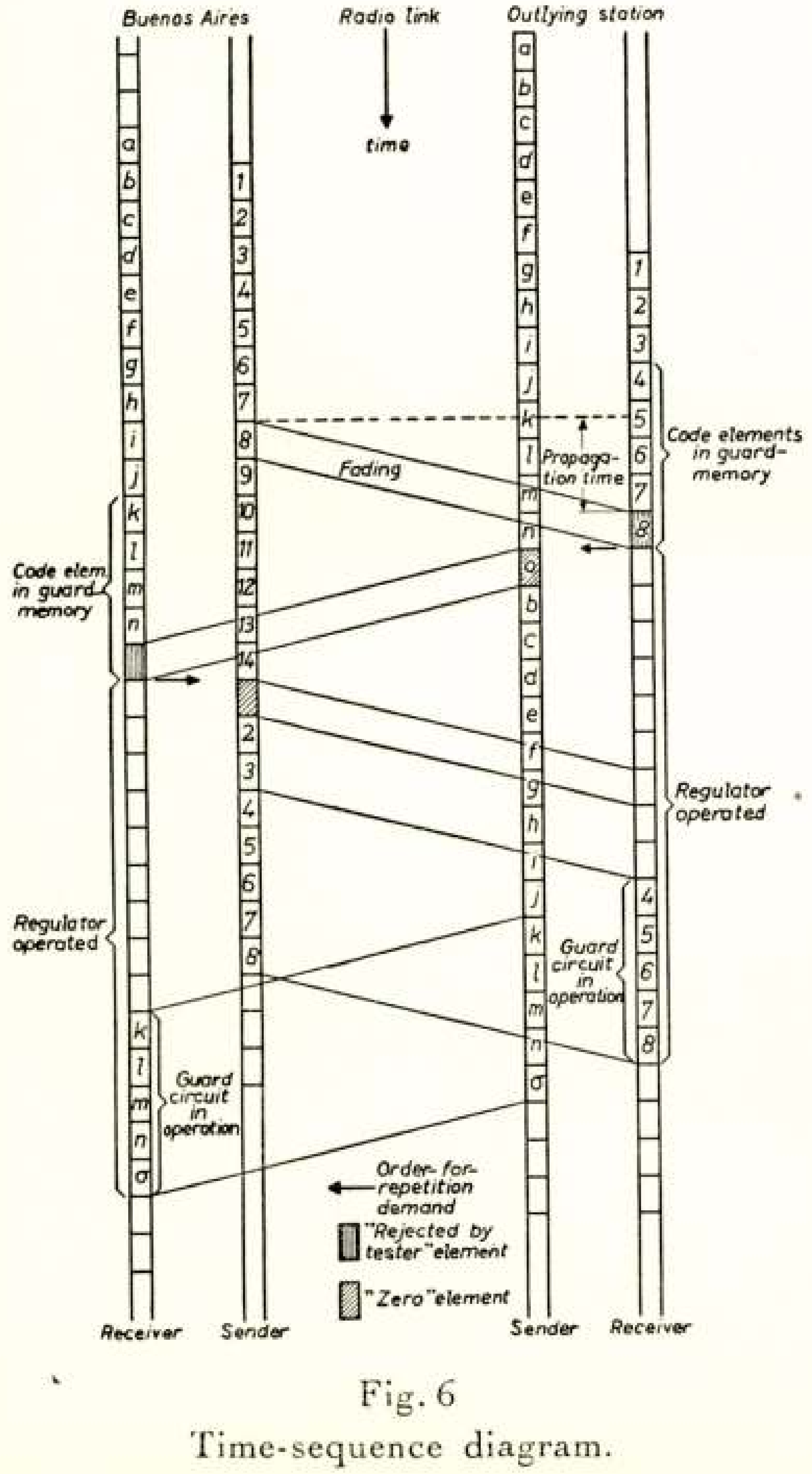

Fig. 6
Time-sequence diagram.

4. *The time sequence diagram*

In fig. 6, a time sequence diagram for a duplex connection between Buenos Aires and an outlying station is given, to make clear what happens during a repetition period. It is assumed that Buenos Aires sends the code elements, 1, 2, 3, 4, etc., and that at the same time the outlying station sends the elements a, b, c, d, etc. The elements sent from Buenos Aires are received in the outlying station after a certain propagation time. This transit time includes not only the propagation over the radio path, but also that over the cable circuits linking the radio transmitting and receiving sites with the telegraph operating equipment, and that through the filters of the tone- and radio equipment. In the diagram the total transit time has been assumed to be 50 milliseconds.

If, for instance. code element 8 is mutilated by fading or interference, this element will be rejected by the receiver in the outlying station and the elements 4, 5, 6 and 7 in the guard-memory will be lost. The regulator gives the command to ask for repetition, on which command one element "zero potential" is sent instead of the code-element 0. After another 50 milliseconds the demand for repetition is received in Buenos Aires. Then first the demand for repetition is given and, after that, the sender in Buenos Aires repeats the last 13 elements, starting with element 2. In this case the demand for repetition has no effect because the regulator in the receiver in the outlying station is already operating at the moment the demand for repetition is received and the guard circuit is not yet in operation. At the moment that the repeated element 4 enters the guard-memory, the guard circuit is operated, and if the repeated elements 4, 5, 6, 7 and 8 are accepted by the tester, the regulator is put to the normal position while the element 4 is transferred to the 7-element memory and will be passed to the printer. In the same way the sender in the outlying station repeats the last 13 elements, starting with the code-element b.

In the diagram, the propagation time has been assumed to be 50 milliseconds. Under certain circumstances, for instance, for transmissions over a long distance, this time may be longer. Further, it is possible to give more than one zero element for repetition demand, in order to have still greater security, or to extend the guard-memory to more than 5 elements. The diagram shows that a 2-element period (elements 2 and 3) remains for these purposes. If more than this is needed, either the number of elements in the sender memory must be increased by seven, or the 14 elements of the memory must be repeated twice.

5. *The cold-cathode gas-discharge tubes*

As already mentioned, the T.O.R. equipment is an all-electronic device. Most of the switching is done by cold-cathode gas-discharge tubes. For this purpose, a special tube has been developed in the Scientific Research Laboratory of the N.V. Philips' Gloeilampenfabrieken at Eindhoven [2]). This is a gas-filled tube with three or four electrodes (Z 500 T with 3 electrodes, and Z 501 T with 4 electrodes) (fig. 7), i.e., a cathode, an anode and one or two trigger anodes. The cathode consists of a nickel plate covered with a layer of activated bariumoxyde;

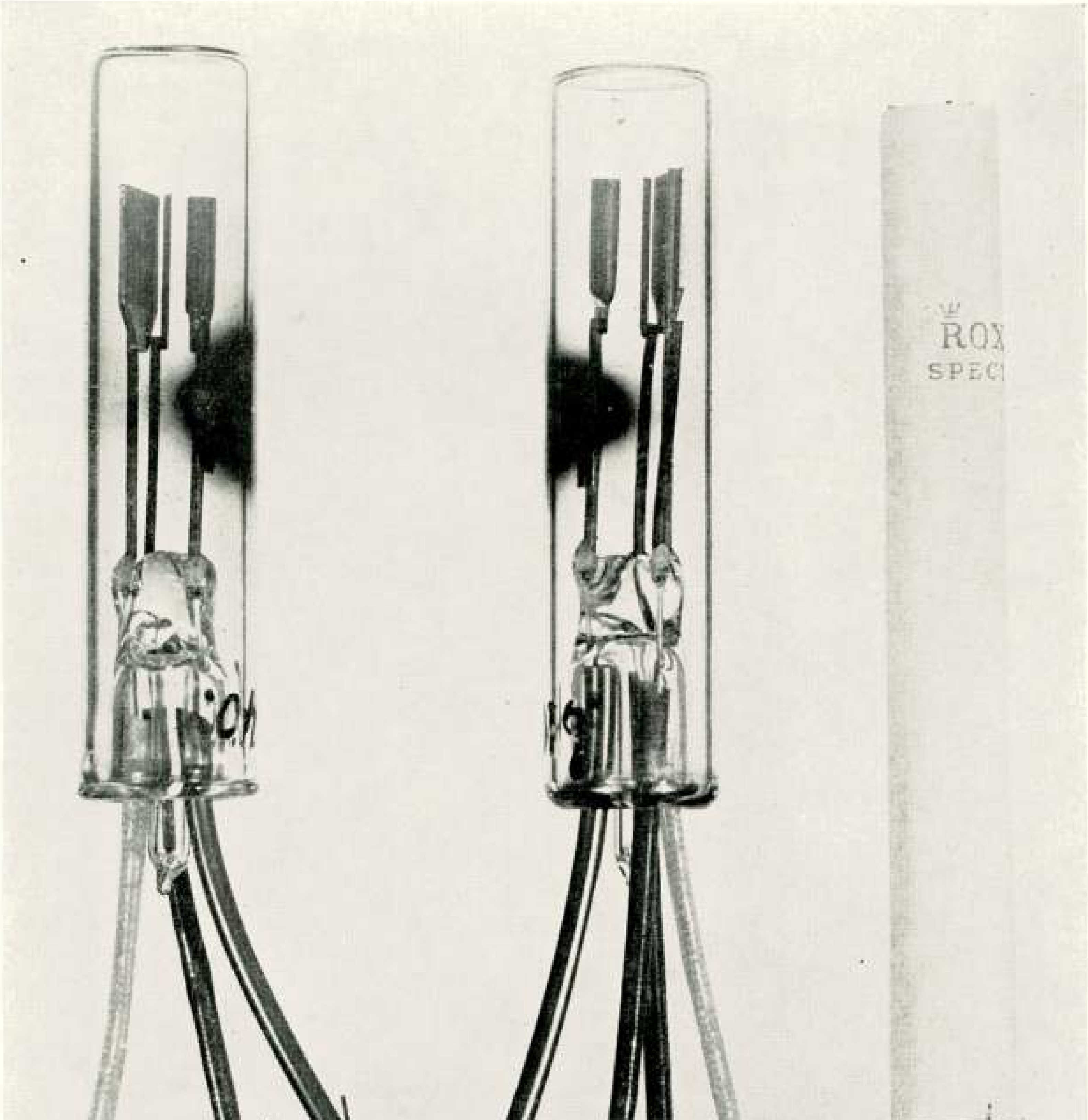

Fig. 7
The cold-cathode tubes Z 500 T with one trigger anode, and Z 501 T with two trigger anodes.

[2]) W. Six, Cold-cathode gas-filled tubes as circuit elements in automatic telephony, Communication News XIV, 58—69, 1954.

the anode is a nickel tube, and the trigger anodes are nickel wires; the gas is argon. The distances between the electrodes are chosen so that the breakdown voltage Vt between trigger anode and cathode is 70 volts, and the breakdown voltage V_a between anode and cathode is higher than 180 volts. The sustaining-voltage is 60 volts. When a discharge takes place between the trigger anode and the cathode, the gas in the tube is ionized, thereby decreasing the breakdown voltage of the main discharge gap. If, for instance, the breakdown voltage between anode and cathode is 160 volts, no ignition will take place in this discharge path, unless the gas is previously ionized by a discharge in the trigger gap and a current i_t of more than 30 microamperes flows in this gap. It may be added that the current i_t need flow for a short time only, since, as soon as firing has occurred in the main path, current continues to flow when t_i is zero.

Ionization and de-ionization of the gas is not instantaneous. The time needed for a breakdown is called the ionization time and is of the order of 100 microseconds. The time needed for de-ionization of the gas is called the restoring time and is about 250 microseconds. This means that for firing the main path the current in the trigger gap must flow for at least 100 microseconds; and that, if the discharge in the main path is extinguished, for instance by decreasing the voltage between anode and cathode below the sustaining voltage, the tube will breakdown again if, within 250 microseconds, this voltage is increased again to 160 volts.

The data for this tube are:

Breakdown voltage V_a of main gap: >180 volts.
Breakdown voltage of trigger gap: 66 to 74 volts.
Sustaining voltage: 54 to 66 volts.
Current i_t in trigger gap for which V_a is decreased to 130 volts: <100 microamp.
Normal anode current at which the cathode is fully covered with glow discharge: 6 mA.
Ionization time: approx. 100 microseconds.
Restoring time: approx. 250 microseconds.
Average life of tube when operated with normal anode current of 6 mA: 13.000 hours. At currents lower than 6 mA the life of the tube is inversely proportional to the current, and since the tubes are mostly run at a current of 2.5 mA, the average

life would be 30.000 hours. Most of the tubes, however, are fired for short periods only. For instance, each tube in a 10-counter is fired one tenth of the time the counter circulates; the average life of these tubes will thus be 300.000 hours, i.e., about 40 years, when the counter circulates continuously.

4.1. *Switching by means of cold-cathode tubes*

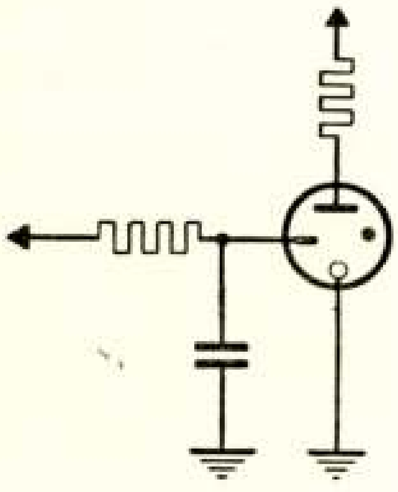

Fig. 8
Circuit of a cold-cathode tube; the current for initiating the the main discharge is supplied by the condenser across the trigger gap.

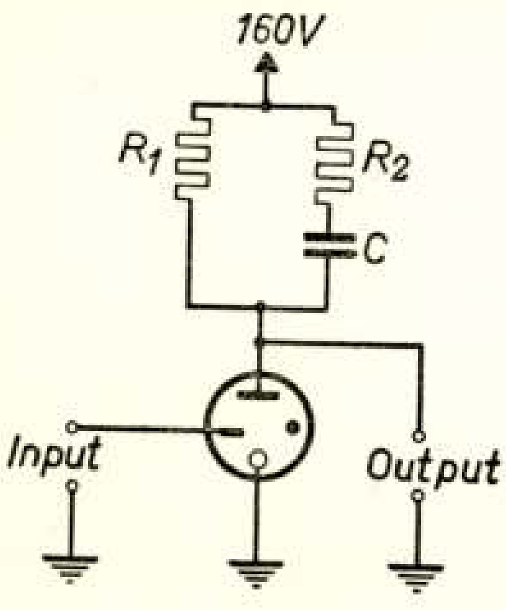

Fig. 9
Self-quenching circuit

We have seen in the preceding section that the main path of a cold-cathode tube can be fired by applying a specific voltage to the trigger anode. As shown in fig. 8, it is necessary to put a resistance in series with the discharge path, to limit the current. This resistance may be put either in series with the anode or in series with the cathode. The voltage drop across the resistance can be used to bias the trigger anode of another tube or for giving it an impulse. If the resistance is in series with the cathode, a positive impulse is obtained; if it is in series with the anode, a negative impulse.

As already mentioned, the current in the trigger gap must reach a certain value and then continue to flow for a certain time. Therefore, it is advantageous to switch a small condenser across the trigger gap as shown in fig. 8. In this case, the energy required for firing the tube is very low since, as soon as the trigger discharge occurs, the current is increased by the condenser discharge.

Once the main path of a tube is fired, the current flowing through this path is no longer dependent on the tension on the trigger anode. Therefore, the tube cannot be extinguished by reducing the voltage on the trigger anode, but only by reducing the tension between anode and cathode below the sustaining voltage, either by giving a positive impulse to the anode or a negative impulse to the cathode.

If, for instance, a resistance common to two tubes is placed in the anode circuit, one tube can be extinguished by firing the other. In this case however alternately one or the other of the tubes would be in operation; consequently, the life-time of the tubes would be considerably shortened. To prevent continuous operation, the so-called monostable multivibrator or self-quenching circuit is often used.

As shown in fig. 9, a tube can be connected in such a way that firing takes place by giving the trigger anode a sufficiently high potential; then, after a certain time, depending on the time-constant of the circuit, the tube will automatically extinguish. As long as there is a sufficiently high voltage on the trigger anode, the tube will periodically fire and extinguish. If, however, the voltage is taken off the trigger anode, the tube will remain extinguished. Hence, if one impulse of sufficient duration is applied to the trigger, one impulse will be obtained at the output of the circuit *).

In fig. 9, a positive impulse on the trigger anode results in a negative impulse at the output. If, however, the resistances R_1, R_2 and the condenser C are connected in series with the cathode, then a positive impulse at the input results in a positive impulse at the output. By applying either the negative impulse at the output of the self-quenching circuit to the anode of another tube, or the positive impulse to its cathode, the latter tube can be extinguished. To show in greater detail how circuits using cold-cathode tubes are built up, two circuits used in the T.O.R. equipment will now be given, namely, the 10-counter and the distributor.

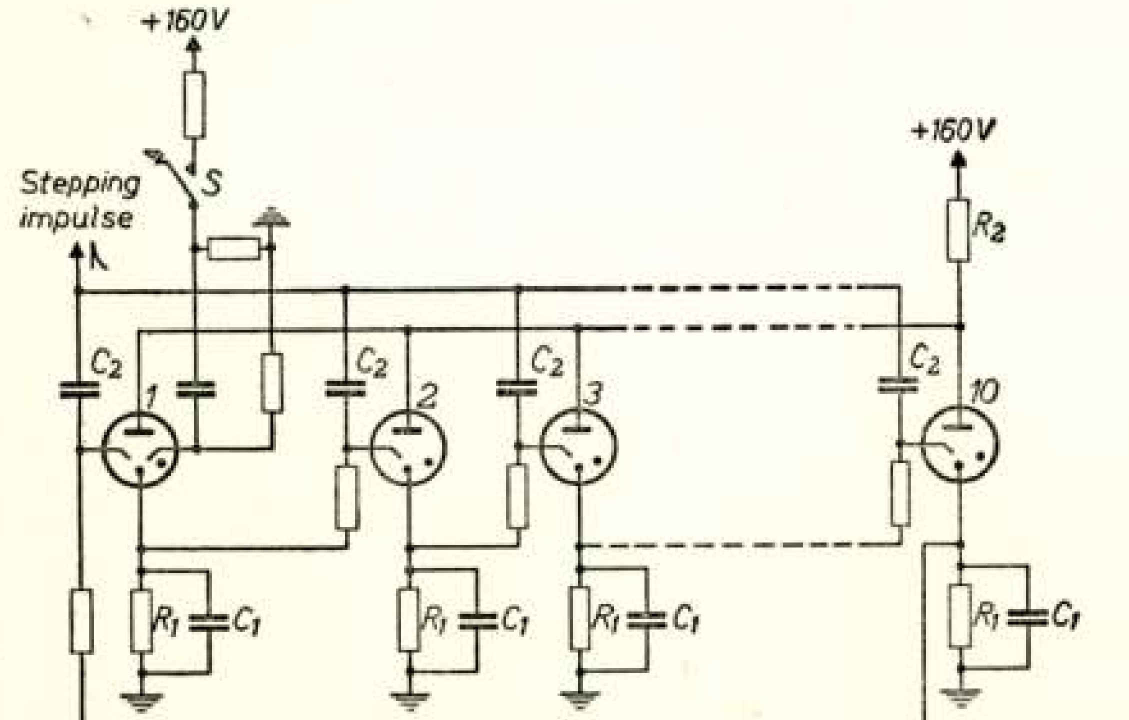

Fig. 10
Circuit diagram of the 10-counter.

5.2. *The 10-counter*

The circuit of the 10-counter is shown in fig. 10. When the starting knob is pressed, the 10-counter is started by switch S, which is closed for a short time only. When S is closed, tube 1 fires. Resis-

*) The functioning of this circuit is explained on p. 62 of the article cited in footnote 2.

tors R_1 are connected in series with the cathodes of all tubes, and, in addition, a common resistor R_2 is put in series with the anodes. The stepping impulses are fed, via condenser C_2, to the trigger anodes of all tubes. The amplitudes of the impulses are not sufficiently great to cause a breakdown of the paths between the trigger anodes and the cathodes, unless the trigger anodes are biased.

When tube 1 is fired, the trigger anode of tube 2 is biased by the voltage drop of about 60 volts across the cathode resistor R_1 of tube 1. Therefore, the first impulse fires tube 2. At the moment that tube 2 fires, the voltage drop across resistor R_2 increases from about 40 volts to 100 volts. Hence, the tension on the anode of tube 1 will be 60 volts and the tension on the cathode is temporarily kept at about 60 volts, due to the charge on condenser C_1. The voltage between anode and cathode of tube 1 decreases to zero so that this tube extinguishes. Now, the trigger anode of tube 3 is biased, and the second impulse will fire this tube and extinguish tube 2. In this way, each successive tube is fired by each successive impulse and the previous tube extinguished. When tube 10 fires, i.e., at the tenth impulse, the trigger anode of tube 1 is again biased and at the next impulse this tube fires again; and so on. From the cathodes of the tubes the 20-millisecond-spaced impulses, by which the T.O R. system is governed, can be derived; the cathodes of the tubes give 20-millisecond-spaced impulses, there being a time difference of 2 milliseconds for each successive tube.

5.3. *The distributor*

Fig. 11 gives the circuit diagram of the distributor. In the distributor the code elements are read from the tape by means of the sensing-pin contacts K_1, K_2 etc. Each unit of the distributor consists of two tubes A and B. Tubes $1B$ to $6B$ contain the code elements; $1A$ to $6A$ are quenching-tubes which are used to extinguish the tubes $1B$ to $6B$ if necessary, when the distributor steps forward.

When a mark is read from the tape the tube is not fired, whereas, when a space is read it is fired. Every 140 milliseconds the read-in impulses are given to the trigger anodes of tubes B, via condensers C_2. Whether these tubes are fired depends on the position of the contacts K. When a contact K

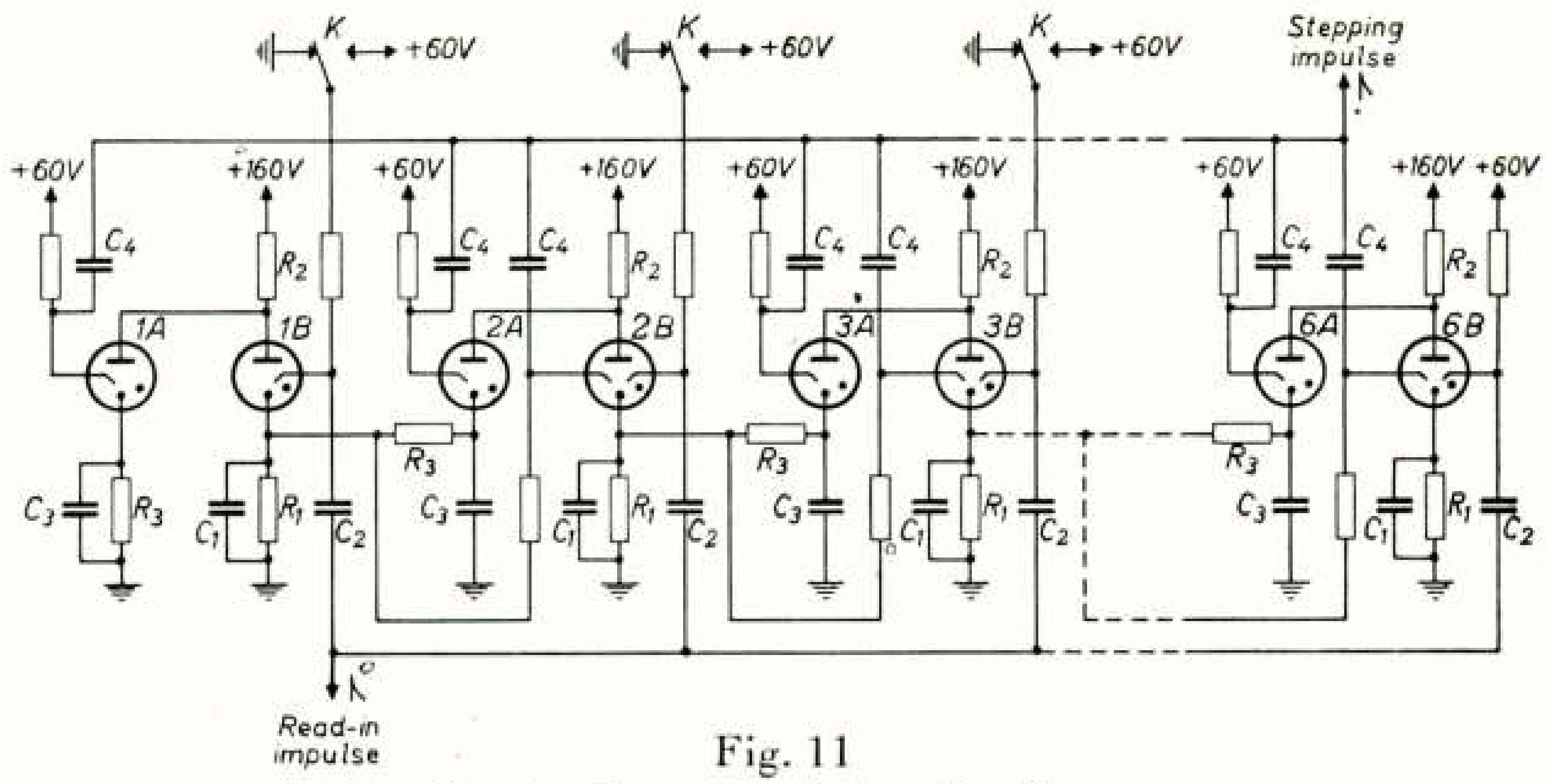

Fig. 11
Circuit diagram of the distributor.

is connected to earth, the corresponding tube B is not biased, whereas, when a contact K is switched over to 60 volts, the corresponding tube is biased, except tube $6B$ which is always biased. Now, when a mark is read from the tape, contact K is at zero potential, and when a space is read, K is connected to 60 volts. Therefore, when a space is read, the tube is fired by the read-in impulses, and when a mark is read the tube is not fired. As tube $6B$ gives the start element which is not read from the tape but is added in the distributor, it is always fired by the read-in impulse.

After the code elements have been fed to the memory, they are stepped forward by the stepping impulses, which, via the condensers C_3, are applied to the trigger anodes of all the tubes A and B, except $1B$. Again, whether these tubes are fired, depends on whether they are biased. If, for instance, tube $1B$ but not $2B$ is fired, the next stepping impulse must fire $2B$. In this case, the trigger anode of $2B$ is biased by the voltage drop across resistor R_1, and it is fired by the stepping-impulse. The trigger anode of the quenching-tube $2A$ is not biased because the cathode of this tube is connected to the cathode of tube $1B$. Hence, the trigger anode and cathode of $1A$ are both at 60 volts and this tube cannot be fired by the stepping-impulse. On the other hand, if tube $2B$ is fired and $1B$ is not, the next stepping-impulse must extinguish $2B$; the trigger anode of $2A$ is now biased and it will be fired by the stepping-impulse. Since the tubes $2A$ and $2B$ have a common resistor R_2 in the anode circuit, $2B$ will be extinguished when $2A$ fires. The circuit of tube $2A$ is self-quenching because there is a resistor

R_2 of low value in the anode circuit, and a resistor R_3 of high value (in series with R_1) bridged by the condenser C_3, in series with the cathode. Tube 1*B* must always be extinguished by the first stepping-impulse because there is no tube preceding it; therefore, the stepping-impulses are not fed to this tube.

From the foregoing it follows that certain code elements which are read from the tape, can be fed simultaneously to the distributor and that, if the distributor is stepped forward by impulses, the code elements appear as sequential impulses at the cathode of tube 6*B*.

6. *Construction of the T.O.R. equipment*

Certain parts of the circuit are combined to form units containing 14 cold-cathode tubes plus a number of vacuum tubes

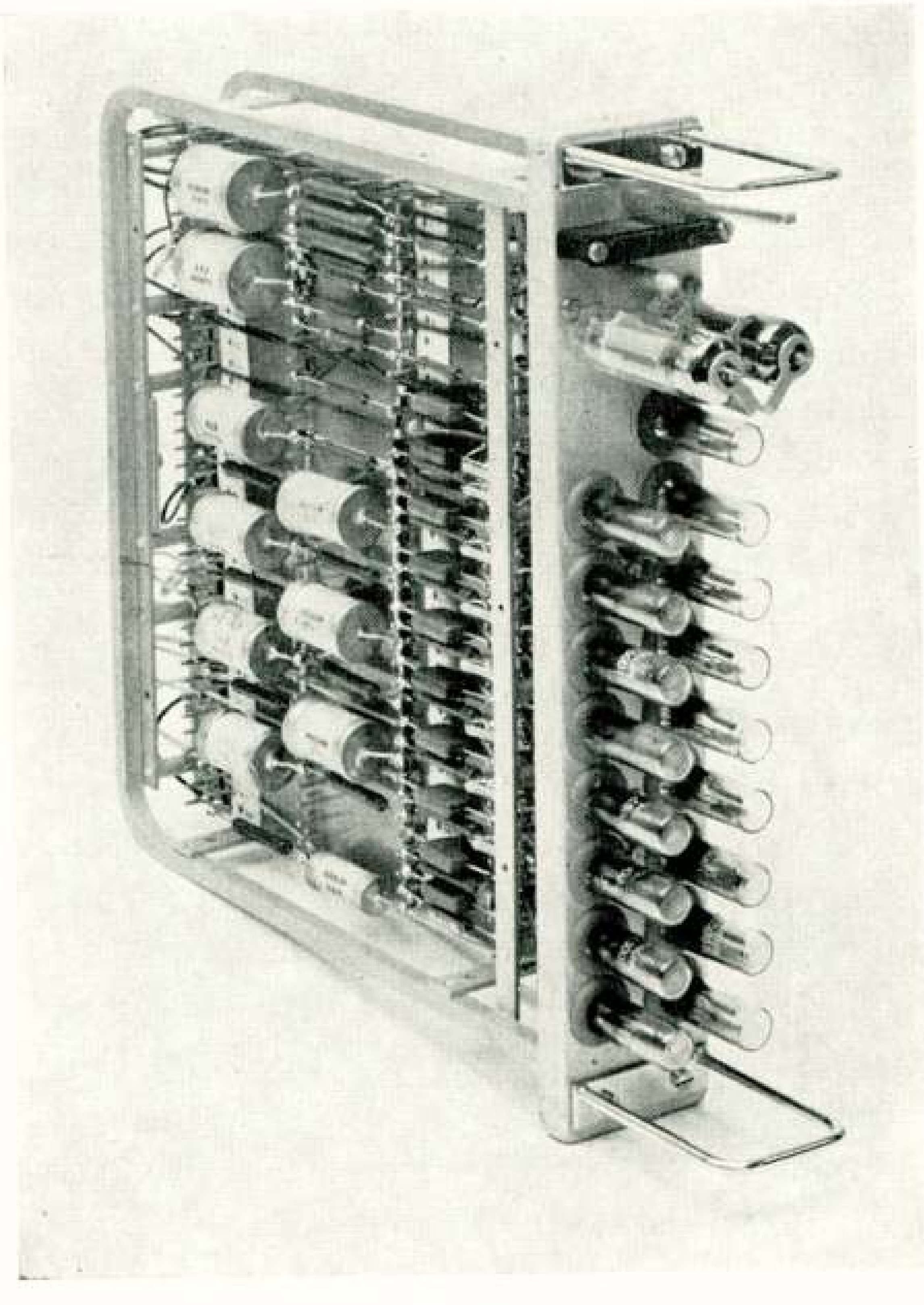

Fig. 12
A unit of the T.O.R. equipment.

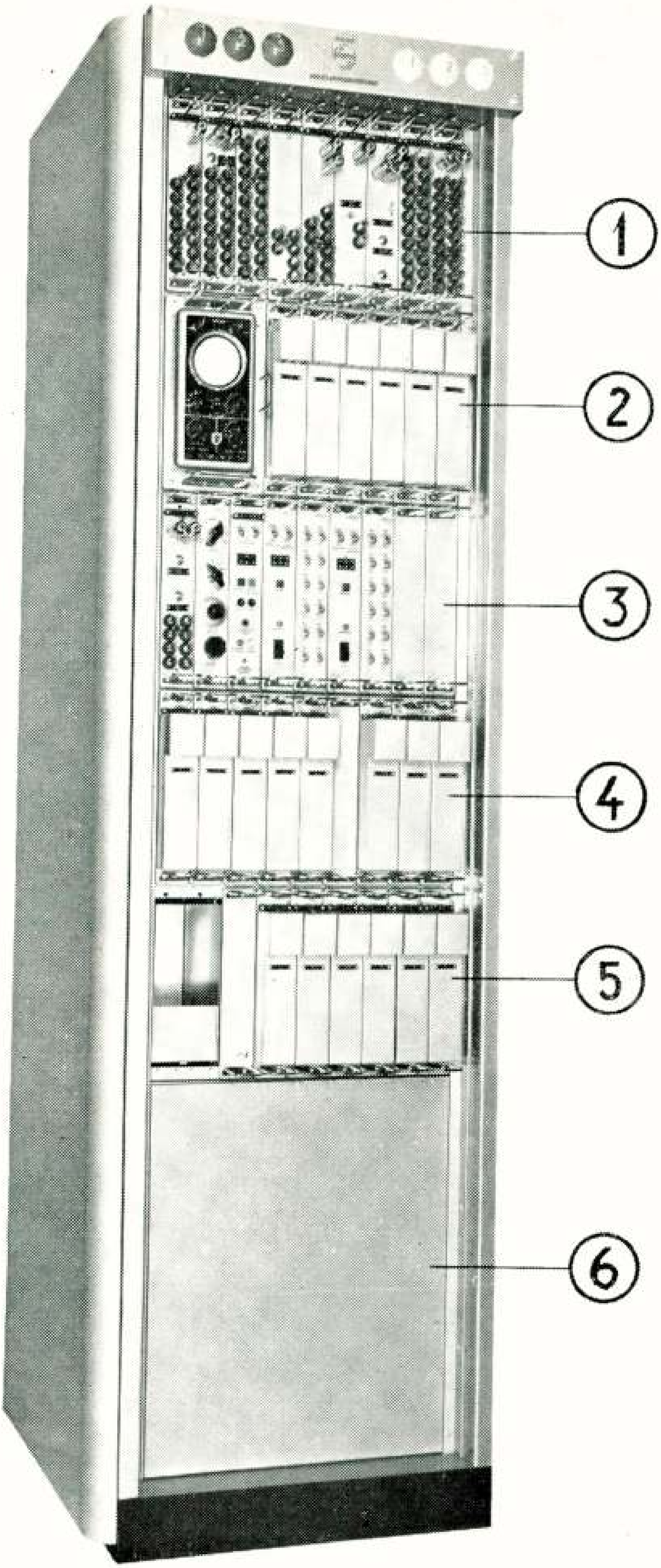

Fig. 13

Cabinet for 3 T.O.R. equipments of which two are mounted. The power supply unit is mounted at the rear of the cabinet. 1 and 2 are the receiver and sender panels, respectively, of T.O.R. I, which incorporates an oscilloscope and an oscillator common to the whole bay (from the receiver units the covers are removed). 3 is a measuring and servicing panel. 4 and 5 are the receiver and sender panels, respectively, of T.O.R. II. 6 is spare room in which a third T.O.R. equipment can be mounted.

not exceeding 4; when there are no vacuum tubes the maximum number of cold-cathode tubes is 20. The cold-cathode tubes protrude from the front of the unit and are mounted in rubber rings, so as to protect them against shock. They are soldered-in, because, as their life is comparable with that of other components, there is no need for replacement. The other components are mounted on an insulation plate; connections with the wiring are made by contacts at the rear of the unit when it is placed in the panel. In fig. 12 a unit is shown.

The T.O.R. equipment consists of two panels, one for the sender and one for the receiver; the units are placed in these panels like books on a shelf. Three T.O.R. equipments can be mounted in a cabinet together with a measuring- and servicing panel, as shown in fig. 13. In the back of the cabinet the power supply, the fuses and some of the supervisory lamps are mounted.

7. *Results*

Numerous tests have been made with the T.O.R. equipment on a radio-link Eindhoven-Hilversum. The test circuit has been operated for periods of 5 minutes without the T.O.R. equipment and 5 minutes with the T.O.R. equipment, alternately, for several months. The following results were obtained:
Without T.O.R., 8 % of the received characters were mutilated, whereas with T.O.R., only 4×10^{-5} of the received characters were faulty and the efficiency of the connection was 86 %, meaning that 14 % of the time was used for repetition. These figures show that when using the T.O.R. equipment, the mutilated characters were a factor of 2000 less in number than when the T.O.R. equipment was omitted.

SUMMARY

For the Argentine radio-links an all-electronic T.O.R. circuit has been developed. This T.O.R. equipment guards the telegraph channels on the radio-links against faulty signals produced by fading and interference, by automatically repeating the mutilated signals. The received code-elements are tested and if they are rejected, a „demand-for-repetition signal" is sent back to the T.O.R. sender, which then repeats a number of code elements. For the majority of the switching-elements in the electronic circuits, use has been made of a small cold-cathode trigger tube. Switching by means of these tubes is explained. A description is given of some of the circuits used in this T.O.R. equipment.

A radio test circuit between Hilversum and Eindhoven has shown that, when a T.O.R. equipment was inserted in the connection, the mutilated characters were a factor of 2000 less in number than when the T.O.R. equipment was omitted.

RÉSUMÉ

Un équipement de TOR (radiotélégraphie à téléimprimeurs) entièrement électronique a été étudié pour le réseau radioélectrique argentin. Au moyen d'un procédé de répétition automatique des signaux mutilés, cet équipement TOR protège les liaisons télégraphiques du réseau radioélectrique contre les faux signaux qui peuvent être produits par des fadings et des interférences. Le circuit fait le test de chacun des éléments de code qui arrivent et si un élément est refusé, un critère de demande de répétition est envoyé au TOR de la station distante, qui répète alors un certain nombre d'éléments de code. Pour la plupart des fonctions de commutation l'équipement utilise un tube à cathode froide. Suit une description de quelques-uns des circuits qui constituent cet équipement TOR. Une liaison d'essai entre Hilversum et Eindhoven a montré qu'avec l'intercalation d'un équipement TOR le nombre des caractères mutilés était 2000 fois inférieur au nombre de mutilations enregistré sur la même liaison sans équipement TOR.

ZUSAMMENFASSUNG

Für die argentinischen Funkverbindungen ist eine vollelektronische T.O.R.-Schaltung entwickelt worden. Durch automatische Wiederholung der verstümmelten Signale schützt die T.O.R.-Apparatur die Telegraphenkanäle der Funkverbindungen vor falschen Signalen, die durch Schwund und andere Störungen hervorgerufen werden. Die empfangenen Code-Elemente (Stromschritte) werden geprüft. Sind Sie verstümmelt, so wird ein „um Wiederholung bittendes" Signal (ein sog. „demand-for-repetition signal") zum T.O.R.-Sender zurückgegeben, der dann eine Anzahl Schritte wiederholt. Für den grössten Teil der Schaltelemente in den Röhrenschaltungen ist eine kleine Trigger-Röhre mit kalter Kathode verwendet worden. Das Schalten mit Hilfe dieser Röhre wird erklärt. Weiter werden einige der in dieser T.O.R.-Apparatur verwendeten Kreise beschrieben. Eine Funkprobeverbindung zwischen Hilversum und Eindhoven hat gezeigt, dass, wenn eine T.O.R.-Anlage in der Verbindung vorgesehen wurde, die verstümmelten Buchstaben der Zahl nach um einen Faktor 2000 weniger waren als wenn die T.O.R.-Apparatur fortgelassen wurde.

New mobile and auxiliary equipment, produced by Philips Telecommunication Industries

by D. J. Braak *)

Lecture delivered for the Nederlands Radiogenootschap on December 17th 1954

SUMMARY

The need for a portable transmitter-receiver in the P.T.I. production program led to the development of a 5 channel FM packset, operating primarily in the 80 and 160 Mc/s bands, and on request in the 40 Mc/s band.

In actual networks a number of auxiliary equipments have been found necessary, to be used with the mobile and fixed stations SRR 296 and SFR 296.

The most important of these apparatus will be described in this article.

1. *Introduction*

The mobile radio equipment now in production at Philips Telecommunication Industries consists of the mobile transmitter receiver SRR 296 and fixed station SFR 296, already described in this periodical [1]) and the packset SDR 314, of which a short description will be given in the first part of this article. For use with the mobile radio equipment a number of auxiliary apparatus have been developed primarily for facilitating the building of complete networks. The most important items will be described in the second part of this article.

2. *The packset SDR 314*

2.1. General requirements

The primary requirement to this type is to provide telephone communication on a simple basis over a distance of at least 1 km in densely built areas between two of these sets, when carried on the back. This has turned out to be possible when using FM, a frequency around 160 Mc/s, a transmitter power

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*) Philips Telecommunication Industries, Hilversum - Netherlands.

[1]) Tijdschr. Ned. Radiogenootsch. 19, (1954), 139.

of 200 mW and a receiver sensitivity of 1 μV on the aerial for a 12 dB signal to noise ratio.

Further requirements are: splashproof case; immersion proof headset and microphone; use of a normal 6 V motorcycle type accumulator in acid proof compartment; operating time at least 8 hours when 20 % transmitting and 80 % receiving.

Furthermore a built-in loudspeaker for low power (100 mW) and up to five crystal controlled transmitting and receiving frequencies are specified.

The controls are restricted to an on-off switch at the side of the lower compartment and a frequency channel selecting switch on the upper lid.

2.2. Electrical requirements

As said before a signal of 1 μV on the receiver terminals, frequency modulated with 10 kc/s swing at 1000 c/s modulating frequency has to provide a signal to noise ratio of 12 dB.

Further specifications of the receiver are: selectivity 80 dB for 60 kc detuning; spurious response attenuation at least 60 dB; image response: at least 50 dB; A.F. response: deviations from a 6 dB/octave de-emphasis curve not more than +1 to −6 dB between 300 and 3000 c/s.

The transmitter requirements besides that of 0,2 W output power are: 6 dB/octave pre-emphasis audio response, and 50 dB spurious radiation attenuation.

The current consumption from the 6 V accumulator is restricted to 1,5 A at reception and 2,0 A at transmission.

2.3. Mechanical requirements

The set has to be able to withstand rough treatment, rain, standing in water up to 5 cm, spilling of acid from the accumulator in its compartment.

The sets undergo a bump test of 1000 bumps with max. acceleration of 4 g.

2.4. General construction

Fig. 1 shows the set, with built-in loudspeaker in the middle of the upper lid. The plastic cover adds some directivity for the higher audio frequencies. On the upper left is the squelch control, the screwdriver setting axis being covered by a nut. In this particular set the frequency setting switch, which is

Fig. 1
Packset SDR 314, with immersion proof microphone

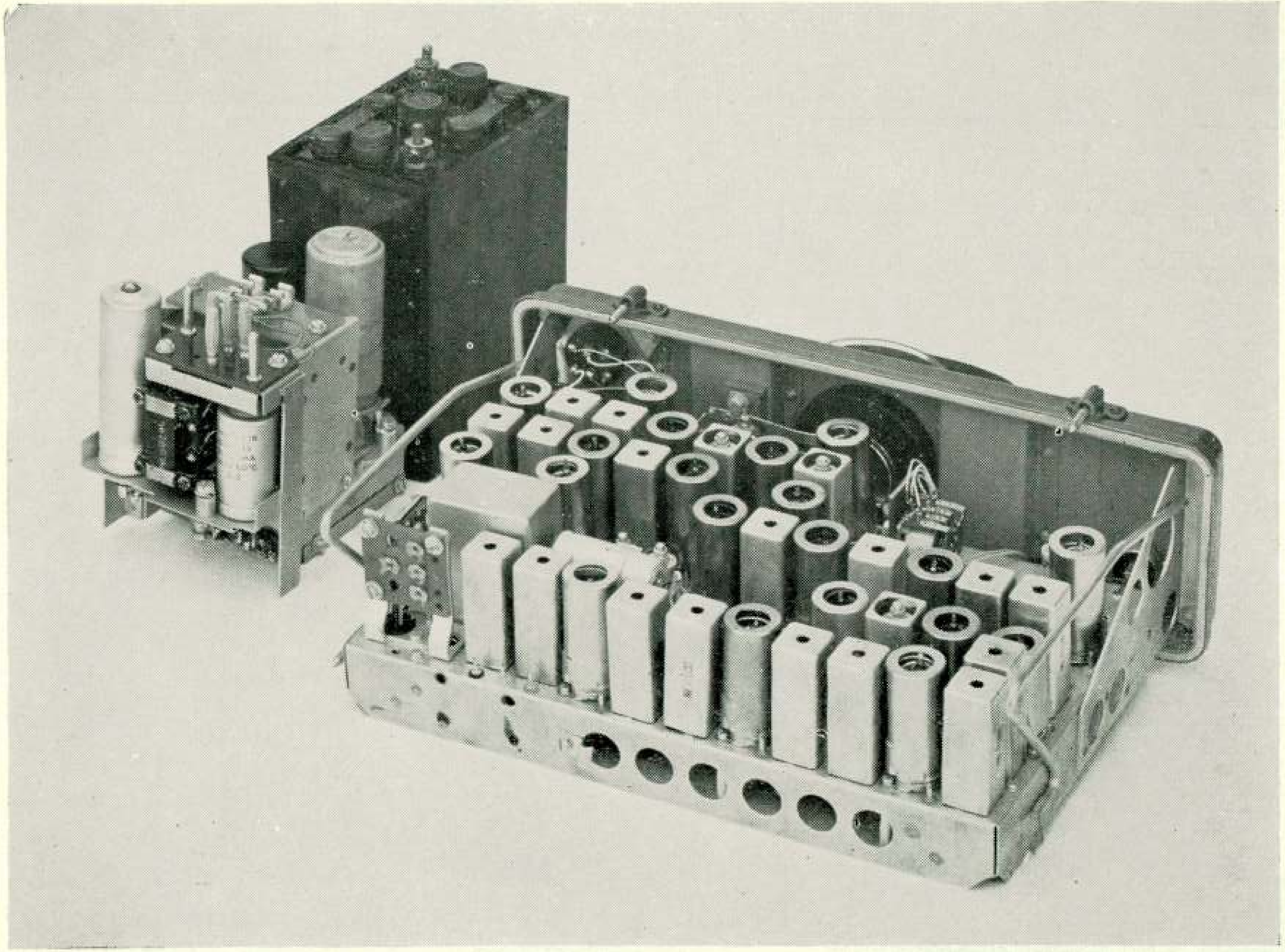


Fig. 2

Packset SDR 314; left to right: vibrator power supply unit, motorcycle type accumulator and transmitter-receiver chassis situated behind the squelch control has been left out. The upper lid is fitted upon the box in such a way that the box is hermetically closed.

The upper box contains the transmitter and receiver; the lower box houses the accumulator (left part) and the vibrator power supply (right part).

In fig. 2 are shown from left to right: vibrator power supply, accumulator and transmitter-receiver chassis (for one frequency channel).

The upper box is fitted on the lower one by snap fasteners, the vibrator compartment being then hermetically sealed off from the accumulator compartment.

2.5. Electrical arrangement

2.5.1. Receiver

Owing to the requirements for selectivity and spurious responses the receiver has to be a double conversion superheterodyne. To obtain adequate sensitivity, a R.F. stage with valve EF 95 had to be used, as at the time of development of this set no directly heated R.F. valves were available to give sufficiently high amplification at 160 Mc/s.

The rest of the valves in the receiver are of the 1,4 V battery types with miniature 7 pin base (DF 91 etc.) and the following stages are used: 1st mixer, 1st I.F. amplifier (7 Mc/s), 2nd mixer and 4 I.F. amplifiers on 1,5 Mc/s, the last of which acts as a limiter.

The discriminator has been equipped with germanium diodes OA 71; as output valve the transmitter power valve EF 95 is used.

A squelch circuit consisting of a noise amplifier and rectifier is incorporated.

To change the receiver from the 80 Mc/s band to the 160 Mc/s band only 3 coils need to be changed.

2.5.2. Transmitter

To facilitate changing from the 80 to the 160 Mc/s band and eventually to the 40 Mc/s band the oscillator frequency has been chosen in the 2,5 Mc/s region and the multiplication is thus 16 times for the 40 Mc/s band, 32 times for the 80 Mc/s band and 64 times for the 160 Mc/s band. Of course the modulating voltage attenuation or the sensitivity of the modulator have to be chosen accordingly.

The phase modulation is obtained by changing the phase-angle of a tuned circuit by a germanium diode in series with a capacitor. On the germanium diode not only an oscillator voltage is working, but also an A.F. voltage from the microphone. The A.F. voltage acts as a delay voltage for the rectifying diode, so that the R.F. current through the diode under certain conditions can be a linear function of the A.F. voltage. The phase modulation which can be obtained in this way exceeds 0,5 radian with sufficiently low distortion.

The modulation process takes place on a low voltage level, so that a R.F. amplifier precedes the multiplying chain. A maximum of 6 doublers (160 Mc/s band) follows after which a valve EF 95 acts as a power amplifier. As already stated, this valve is used also as an audio power amplifier, delivering about 100 mW to the loudspeaker.

2.5.3. Power supply unit

In this unit the normal Philips AP 6000 car radio vibrator is employed, but for the rectification a bridge circuit selenium rectifier is used. In this way we obtain 150 V for the output stage of the transmitter and 75 V for all other stages, by using a centertap on the transformer secondary. The directly heated 1,4 V filaments are connected to the 6 V battery in series of 4.

The transmit-receive relay also switches the directly heated filaments of transmitter and receiver on and off, so that the consumption remains comparatively low.

For some applications of this set under circumstances of high ambient noise, a separate loudspeaker box incorporating a transistor power amplifier is used, which delivers 1 Watt to the loudspeaker and consumes 6 V 0,4 A in the speech peaks.

Mechanical particulars

The set consists of two welded aluminium cases. As a bottom of the upper compartment the same aluminium pressing is used as for the top. It is point welded into the upper compartment. The sealing is assured by several coats of a resilient type of synthetic lacquer. When the upper part is placed upon the lower one, three guiding pins assure alignment of the power supply connectors between upper and lower parts.

For carrying the set on the back, a set of canvas straps is available, which can be fitted to rings on the upper part and holes in the braces on the lower part; these being also used to fix a canvas strap to distribute the pressure of the set evenly.

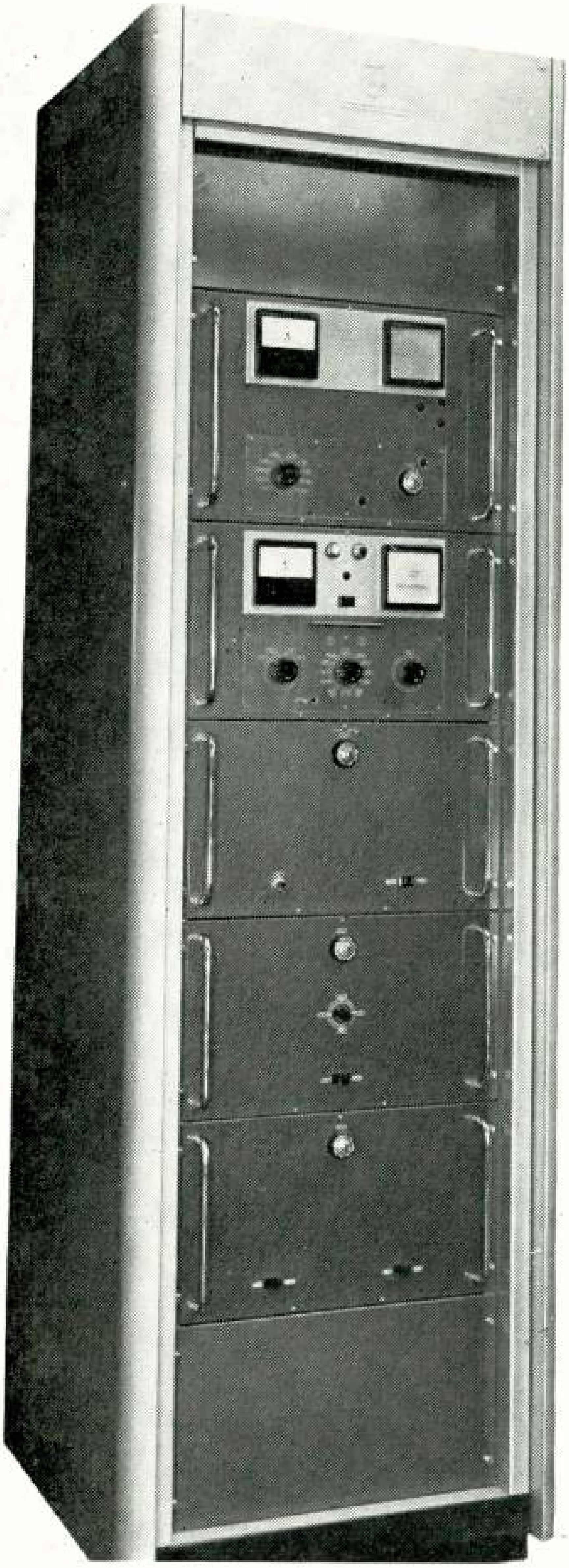


Fig. 3

250 Watt fixed station. Top to bottom:

1. 250 W power amplifier
2. 50 W fixed transmitter and receiver
3. Relay panel for remote control
4. Screen grid supply, negative bias supply for final amplifier and 600 Volt supply for driver
5. 2000 Volt anode supply for power amplifier

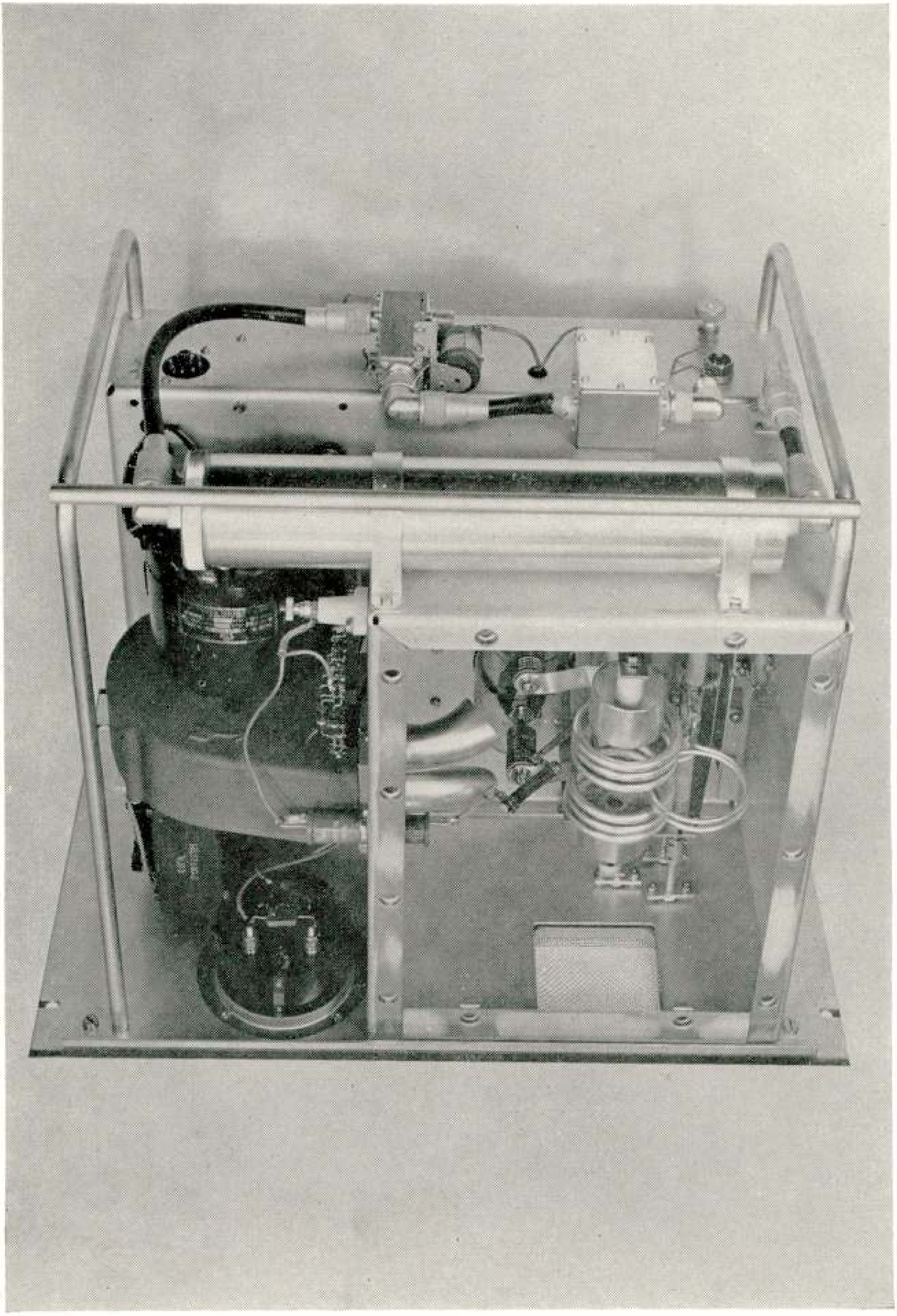


Fig. 4

250 Watt power amplifier for 80 Mc/s band

In cylindrical container; harmonic suppression filter

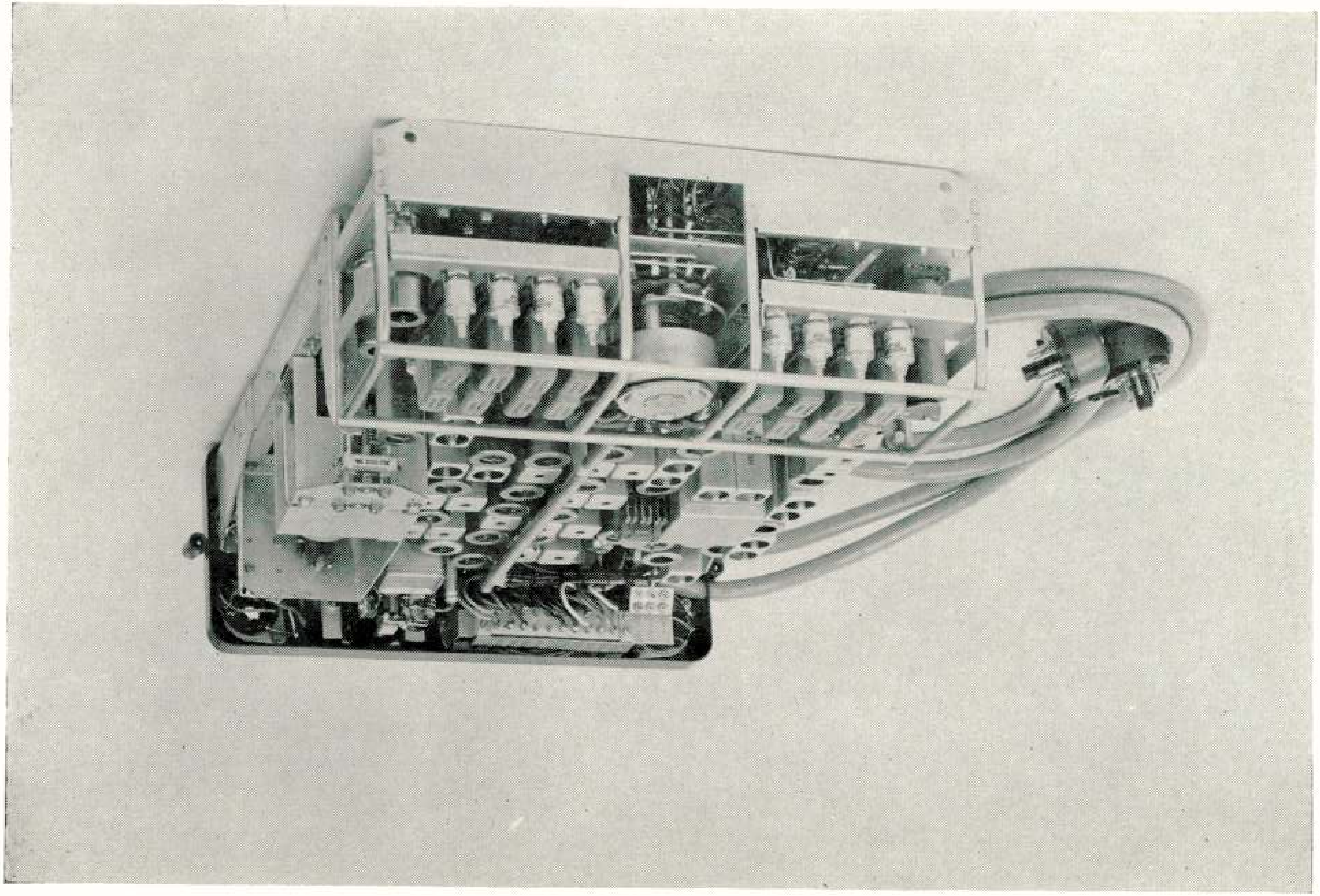


Fig. 5
8 frequencies mobile station with tone-operated switching of loudspeaker
The stepping switch which selects the wanted pair of crystals is in direct view

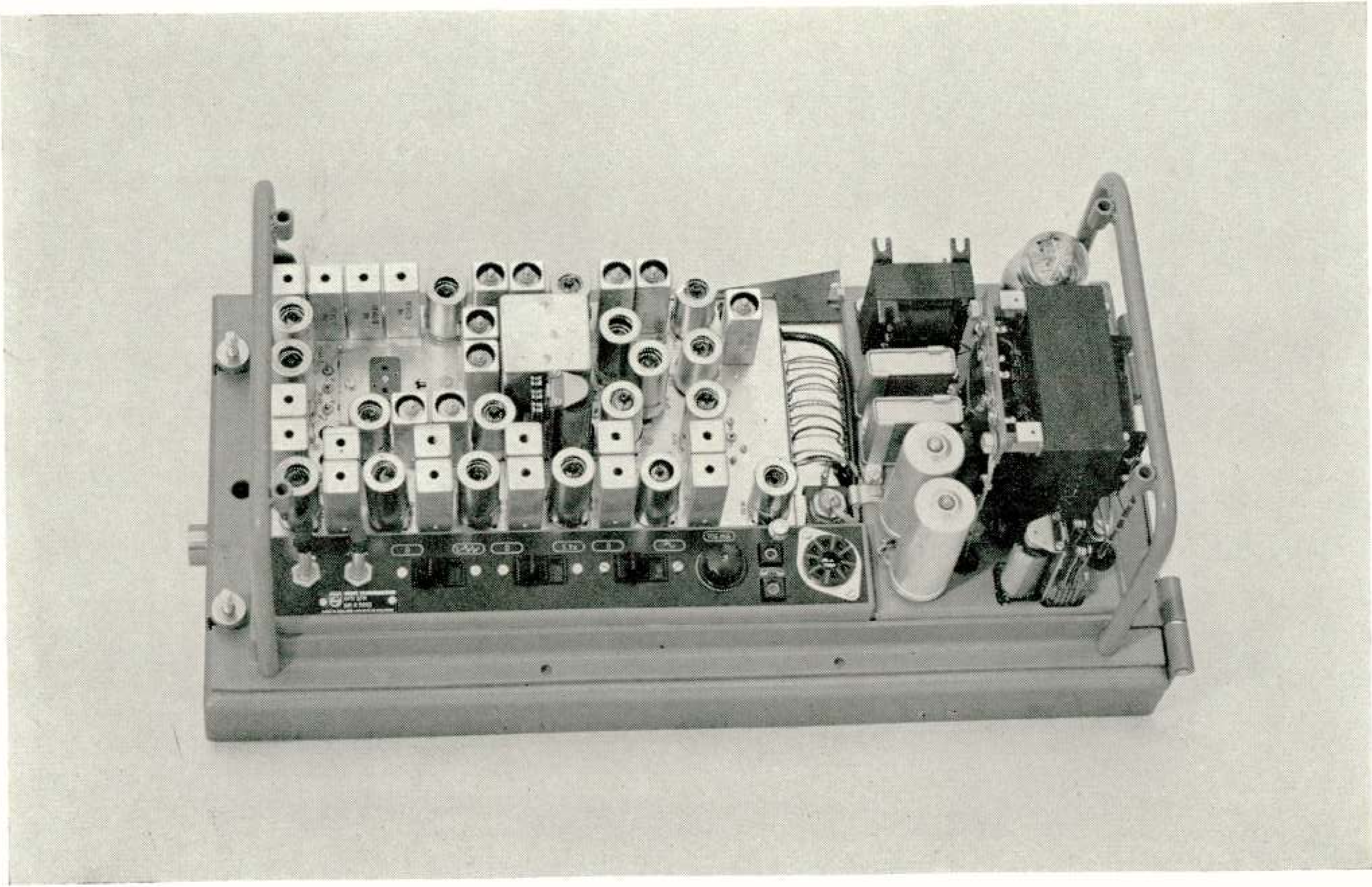


Fig. 6
Fixed station receiver for remote locations

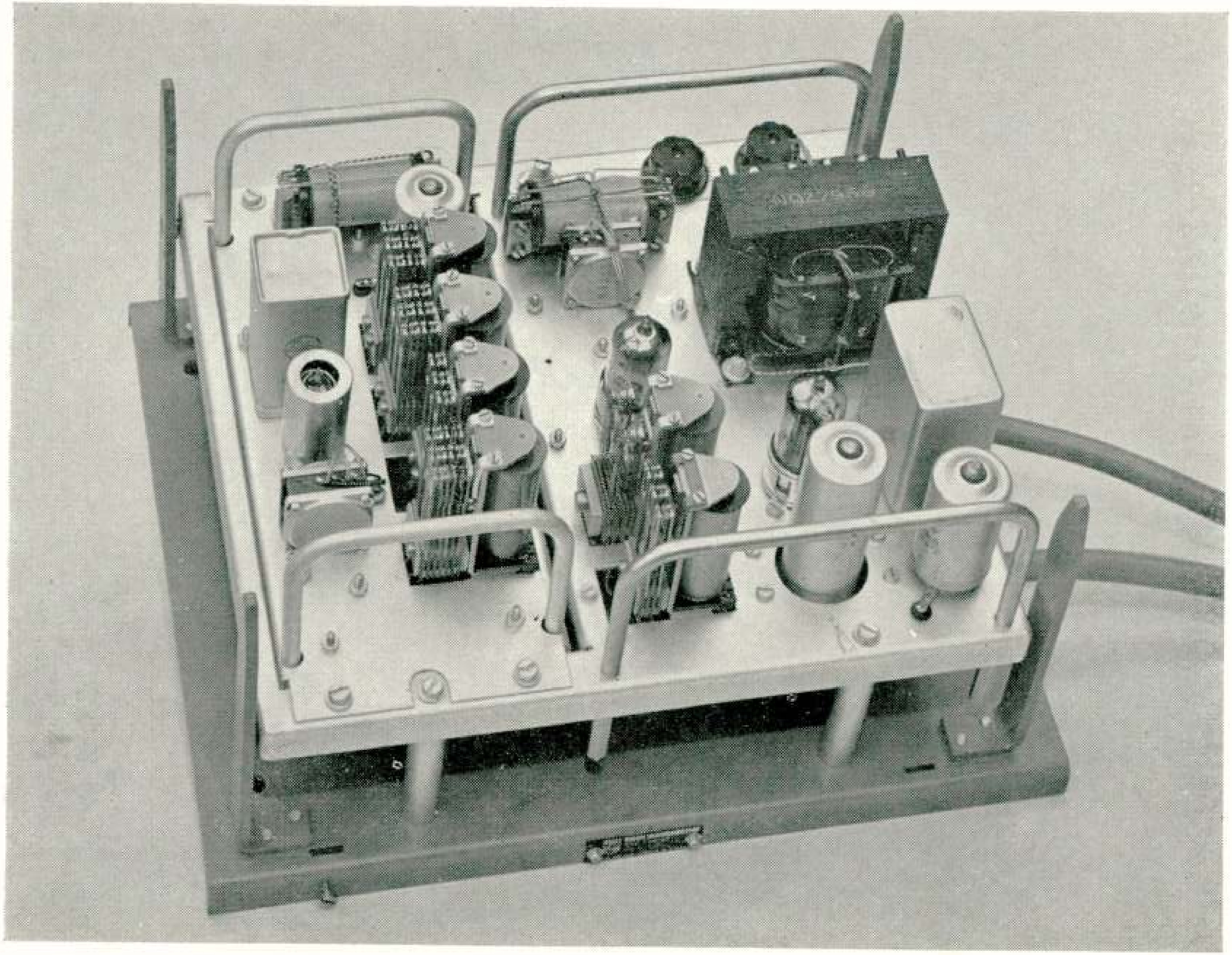


Fig. 7
Calling tone receiver and oscillator for switching mobile station loudspeaker off and on.

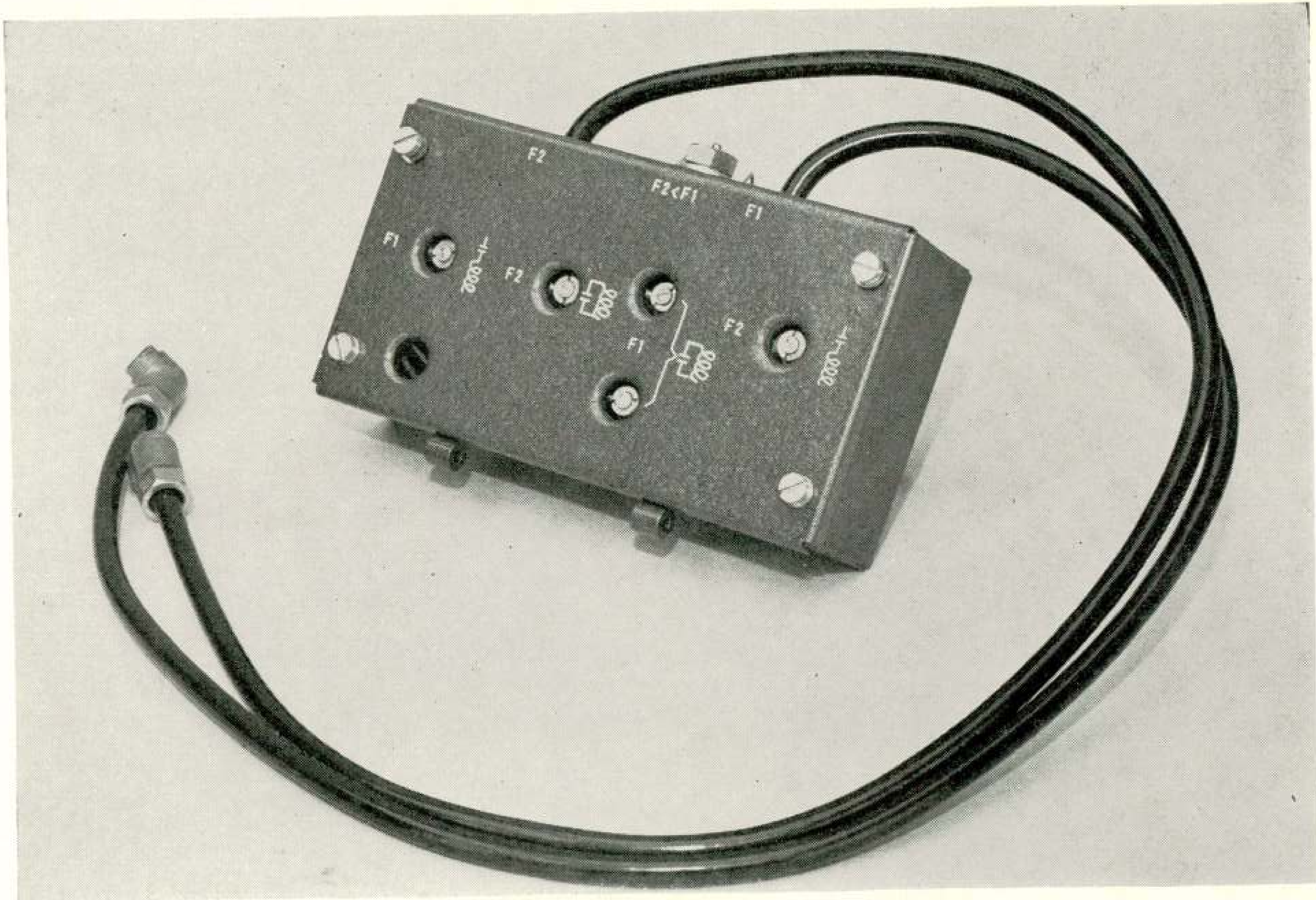


Fig. 8
Duplex filter (for simultaneous transmission and reception on a single antenna)

3. *Auxiliary apparatus to be used with mobile and fixed stations SRR 296 and SFR 296*

3.1. Power supply unit for 600 V 200 mA; to be used as an anode voltage source for obtaining 50—60 W output from a fixed station SFR 296, which normally delivers 15—20 W.

3.2. A 250 W amplifier with associated anode, screen grid and grid potential supplies equipped with two valves QB 3/300. This amplifier can be driven by a SFR 296, delivering 20 W for the 40 and 80 Mc/s bands, and needs about 40 W driving power for the 160 Mc/s band, in which case the driving stage has to be equipped with the anode supply unit mentioned under 3.1.

3.3. In fig. 3 a cabinet is shown in which are situated sliding 19 inch panels containing from top to bottom:

a. 250 W power amplifier with blower and measuring instrument (3.2.). By setting the associated switch this meter can be used to indicate grid voltage, screen grid voltage, anode voltage, cathode current of valve 1 and 2; and in still another position can be connected to a rectifier which is connected to the antenna cable, for tuning purposes.
b. SFR 296 fixed station, used as a driver for the power amplifier.
c. Relay panel for remote control.
d. Screen grid and grid supplies for power amplifier and 600 V anode supply for final amplifier of SFR 296.
e. 2500 V anode supply for power amplifier.

The cabinet has been equipped with microswitches to ascertain safety of maintenance.

Fig 4 gives a view of the tank circuit, output coupling coil and harmonic suppression filter.

3.4. A crystal switching unit for up to 8 transmitting and receiving channels. This unit can be built together with the standard chassis of the mobile station SRR 296 in the manner shown in figure 5. The switching is done by the Ledex stepping switch in the centre of the unit. Some relays are added to reduce the number of control wires to 3.

This chassis is also equipped with a tone-operated relay to connect or disconnect the loudspeaker. In this way the fixed station operator can make audible only the calls to the mobile stations. The mobile operator for whom the call is intended then flips a switch so that he can hear the conversation. Thus the others are not bothered by conversations not intended for them.

3.5. For use in areas from where the low-powered mobile units are not received well enough at the fixed station, a fixed receiver has been constructed which can be installed in such areas. The signals can be conveyed by line or by radiolink to the fixed station, where a combining unit selects the stronger signal.

As shown in fig. 6 the receiver turns on hinges to facilitate maintenance so that the lower part can be inspected and repaired.

3.6. Remote control desk set to be used with fixed stations, for distances up to 100 meters. The connecting cable has 8 wires.

3.7. Tone oscillator unit for tone calling from the mobile to the fixed stations, with associated tone receiver for use in the fixed stations. This tone receiver, together with a tone oscillator unit to provide the connecting and disconnecting of the mobile loudspeaker, is illustrated in fig. 7.

3.8. Remote control deskset, relay box and line connection box for controlling a fixed station over a 2 wire telephone line. The relay box which is situated at the remote position, contains a hybrid circuit, so that duplex operation is possible.

The desk-telephone is equipped with a switch giving the possibility to connect the radio circuit to the telephone line, to use the handset as a normal telephone, or to connect it to the radio circuit.

3.9. Teletype adapter unit.

This gives the possibility to transmit and receive teletype messages over fixed stations.

An audio subcarrier of about 3000 c/s is shifted $\pm$ 120 c/s in accordance to the 5 unit code transmitted.

At reception a bandpass filter restricts the input to the audio limiter to the essential bandwidth, and a discriminator following the limiter actuates a polar relay which switches the input to the printer.

By using low pass filters in the microphone and telephone circuits simultaneous telephone and teleprinter service can be provided.

Circuits for frequency generators

by L. R. Bourgonjon *)

Lecture delivered for the Nederlands Radiogenootschap on December 17th, 1954.

SUMMARY

Present day intensive use of radio equipment calls for higher demands on frequency stability. When great stability must be combined with variation in frequency, it is necessary to use a system for frequency synthesis. A survey of two different systems for frequency synthesis is given, one system using a mixer stage, the other employing a control loop with phase discriminator. To economize on crystals, in both systems an IGO (Impulse Governed Oscillator) may be used.

The block diagram of a multi-channel transmitter-receiver in the 100-156 Mc/s frequency band is shown.

1. *Introduction*

The present-day intensive use of the available frequency ranges, together with the utilization of higher frequencies, calls for constantly increasing frequency stability in telecommunication equipment.

In the frequency range up to about 20 Mc/s, the H.F. range, the difference in frequency between the various transmitters is determined by the system of modulation employed and there is no question of any regular distribution; for communication systems on higher frequencies it is customary to operate on a large number of fixed frequencies with fixed channel spacing.

This equipment often takes the form of a combined transmitting and receiving installation, in which the frequency-determining part, the frequency generator, is in common use for transmitter and receiver.

In aviation it is customary to work for short distance communication in the 100-150 Mc/s frequency range (the VHF range) with a channel spacing of 90 kc/s (Europe) or 100 kc/s (USA). In future the 225-400 Mc/s frequency range (the UHF range) with a 100 kc/s channel spacing is going to be employed

*) Philips Telecommunication Industries, Hilversum - Netherlands.

for this purpose, 1750 channels being available in this range. This means, however, that the frequency stability of the equipment must be about 25.10^{-6}.
For equipment used in military aircraft, very large fluctuations in the ambient temperature, air pressure and the occurence of mechanical vibrations must also be reckoned with.

As long as the equipment is used on one fixed frequency only, the crystal-controlled oscillator is completely satisfactory, for an oscillator of this type will meet practically any requirements for frequency stability.

If, however, continuous tuning or a great many frequencies are required, the crystal-controlled oscillator cannot be used without further measures being taken. Since the normal types of variable L.C. oscillators generally cannot be used for reasons of frequency stability, only a system of *frequency synthesis*, will meet the requirements.

2. *Frequency synthesis with mixer circuits*

The simplest circuit for a frequency generator with frequency synthesis is a mixer circuit, in which the frequency of a crystal-controlled oscillator (selectable) is mixed with the frequency of a continuously variable oscillator, working on a rather low frequency, the interpolation oscillator (IPO), which bridges the gaps between the frequencies of the various crystal-controlled oscillators (see fig. 1). The right choice of the various frequencies and the required filters, in conjunction with one or more multiplier stages, permits a continuously variable frequency generator to be realised, which will meet the requirements for frequency stability in the HF range.

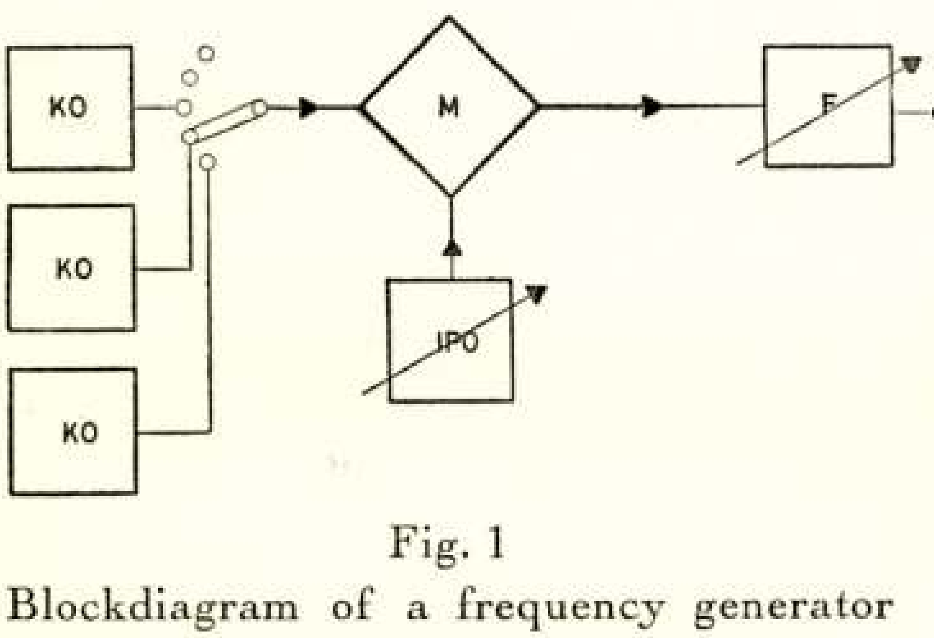


Fig. 1
Blockdiagram of a frequency generator with mixer circuit
KO — crystal controlled oscillator
IPO — interpolation oscillator
M — mixer stage
F — filter

An objection against the use of this circuit is the large number of crystals involved.

The number of required crystals may be reduced to one by replacing the many crystal-controlled os-

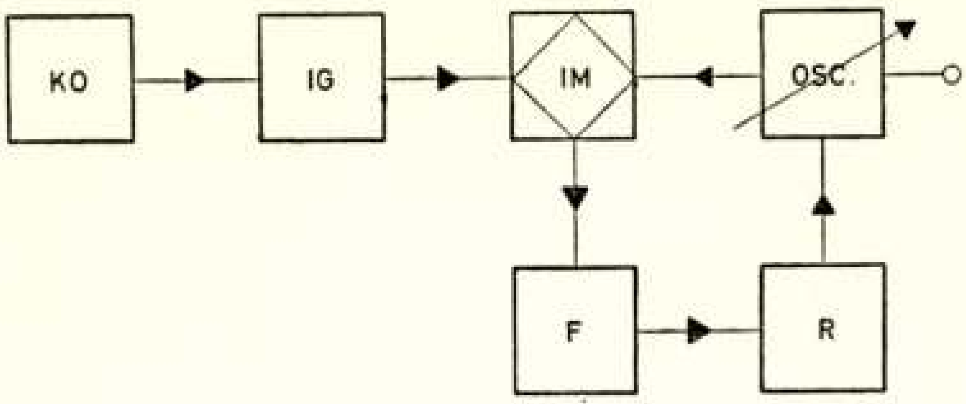


Fig. 2

Blockdiagram of an Impulse Governed Oscillator

KO — crystal controlled oscillator
IM — impulse mixer stage
Osc — oscillator
IG — impulse oscillator
F — filter
R — reactance circuit

cillators in the above design by a single Impulse Governed Oscillator (IGO circuit, see fig. 2).

When using an IGO circuit it is possible to synchronize an oscillator frequency with an arbitrary multiple of a reference frequency, multiples up to about 100 being feasible.

The block diagram for a frequency generator of this type is shown in fig. 3. Based upon this circuit, both complete transmitters and single exciter stages have been developed, which are continuously tunable over the 1.5-16 Mc/s range and have a frequency stability comparable with that of a crystal-controlled transmitter. The frequency steps of the IGO are 50 kc/s, the interpolation oscillator can be tuned from 300 kc/s through 350 kc/s. The basic range of the circuit is 1.5-4 Mc/s, which is extended to 16 Mc/s by the use of one or two doubler stages.

The highest frequency that can be realised with IGO circuits employing normal type tubes is determined by the minimum attainable duration of the required impulses. This limit lies at about 10 Mc/s for practical use. When the IGO system is to be used for the generation of much higher frequencies, a special tube E80T, must be used, the impulses being obtained by the deflection of the ribbon shaped electron beam through a slot in the anode.

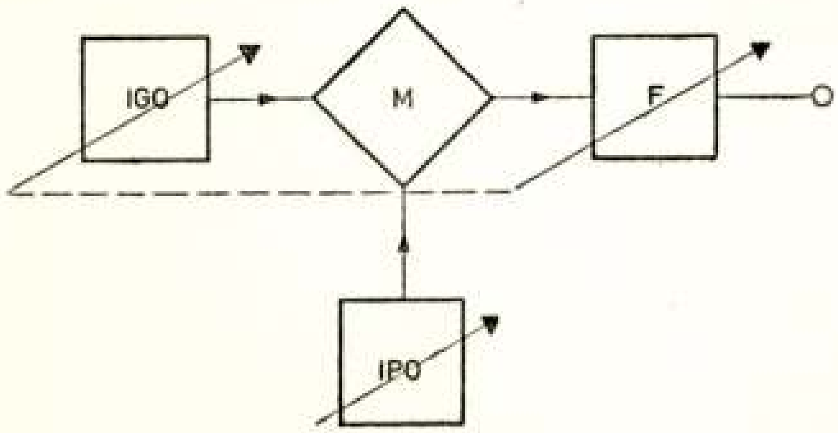


Fig. 3

Block diagram of a frequency generator with I.G.O.

IGO — impulse governed oscillator
IPO — interpolation oscillator
M — mixer stage
F — filter

The essential limitation of these circuits for frequency synthesis is determined by the unwanted mixing products. For, apart from the required mixing product, the mixer stage produces mixing products of a higher order which may enter under circumstances into the pass band of the filters and will effect interfering frequencies ("whistles").

These unwanted mixing products may be reduced to a minimum by the suitable choice of the basic frequencies, but this choice will often conflict with other considerations which govern the design. Circuits for higher frequencies soon meet with great difficulties where the suppression of interfering frequencies is concerned, as it is customary nowadays to insist on suppressing these frequencies down to a level of −80 dB or better.

3. *Frequency synthesis with control circuits*

A fundamentally different circuit, which has the restriction mentioned above to a lesser degree is represented by fig. 4. In this circuit the oscillator is synchronized with the sum (or difference) frequency of the IGO and the IPO with the help of a reactance circuit (R). Full synchronizing is achieved by employing a phase discriminator in the control loop.

The great advantage of this circuit lies in the direct generation of the required frequency, which to a large extent reduces the production of unwanted frequencies, so that stringent requirements in this connection can be met. A further advantage, particularly when employing the circuit as an exciter stage in a transmitter, is the rather high power produced by the variable oscillator, requiring few amplifier stages in the transmitter.

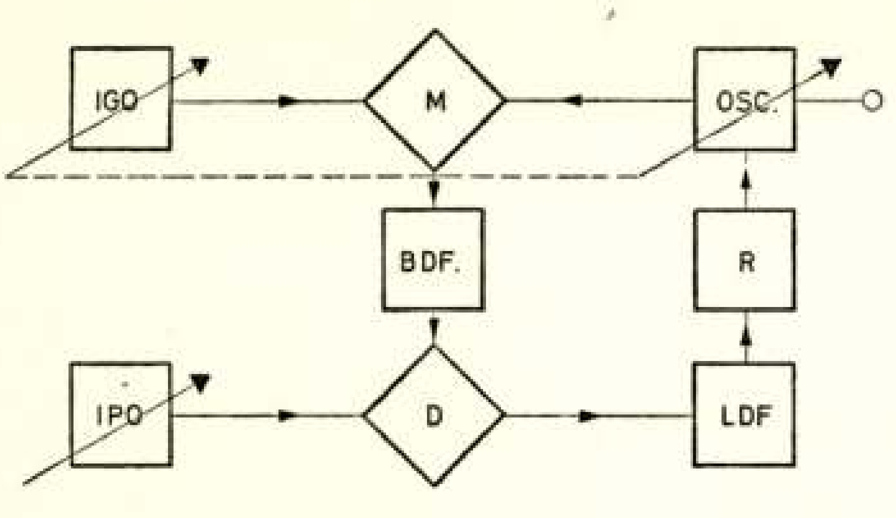


Fig. 4

Block diagram of a frequency generator with control circuit

IGO — impulse governed oscillator
IPO — interpolation oscillator
D — phase discriminator
R — reactance circuit
M — mixer stage
BDF — bandpassfilter
LDF — low pass filter
OSC — oscillator

One complication caused by circuits of this kind is that the control loop can only adjust itself to synchronism, when the oscillator frequency is brought near the wanted frequency.

A special hunting circuit or an additional frequency discriminator must be fitted for this purpose.

If a multi-channel system with constant channel spacing should be required instead of a continuously variable oscillator, the interpolation oscillator may be replaced by an oscillator that is variable in (fine) steps. If necessitated by the frequency stability required, a second IGO circuit may be used for the purpose. In this manner a frequency synthesis in steps of two kinds, i.e. coarse and fine, is achieved.

Based upon the above, a mobile transmitting-receiving equipment has been developed for operation in the 25-41 Mc/s frequency range with a channel spacing of 50 kc/s. The required frequency is generated with the help of a control loop, as shown in fig. 4, in which the frequencies of the two IGO's corresponding with steps of 500 kc/s and 50 kc/s in the final frequency, are synthesized.

Adjustment in steps of two kinds (coarse and fine) is no longer sufficient for operation in a larger number of channels on higher frequencies. Frequency adjustment in decimal steps is required for convenient frequency selection and logical design of the frequency generator. This means ten 100 kc/s, ten 1 Mc/s and six 10 Mc/s steps for a frequency generator for the 100-156 Mc/s range, with 100 kc/s channel spacing.

Fig. 5 shows the block diagram of an installation of this kind for the frequency range mentioned above, with frequency selection in three steps. The fine adjustment in a 1 Mc/s range is designed as a continuously variable oscillator which will permit adaptation to a 90 kc/s or 100 kc/s channel spacing.

The circuit comprises several control loops, the auxiliary loop synthesizing the fine steps (in this case a continuously variable interpolation oscillator) with the 10 Mc/s steps. A type E80T tube is employed for this purpose. This tube is excited by the 10 Mc/s signal derived from a 1 Mc/s crystal followed by a multiplier stage.

The frequencies produced in this manner are further synthesized in the main loop with the 1 Mc/s steps, also in a type E80T tube. In this way the frequency required for the 1st mixer stage of the receiver is attained. To excite the transmitter this frequency must be decreased by the 1st intermediate frequency (11.5 Mc/s). Again a control loop is used. Fig. 6 shows the various frequencies in the circuit.

A 10 Mc/s frequency is required for the 2nd mixer tube in the receiver. This 10 Mc/s frequency is already present in the exciter stage. The installation contains only 2 crystals in all.

Development in this field is in full swing. Various manufacturers are still perfecting the different systems, both mixer circuits and control loops being used, while rather many crys-

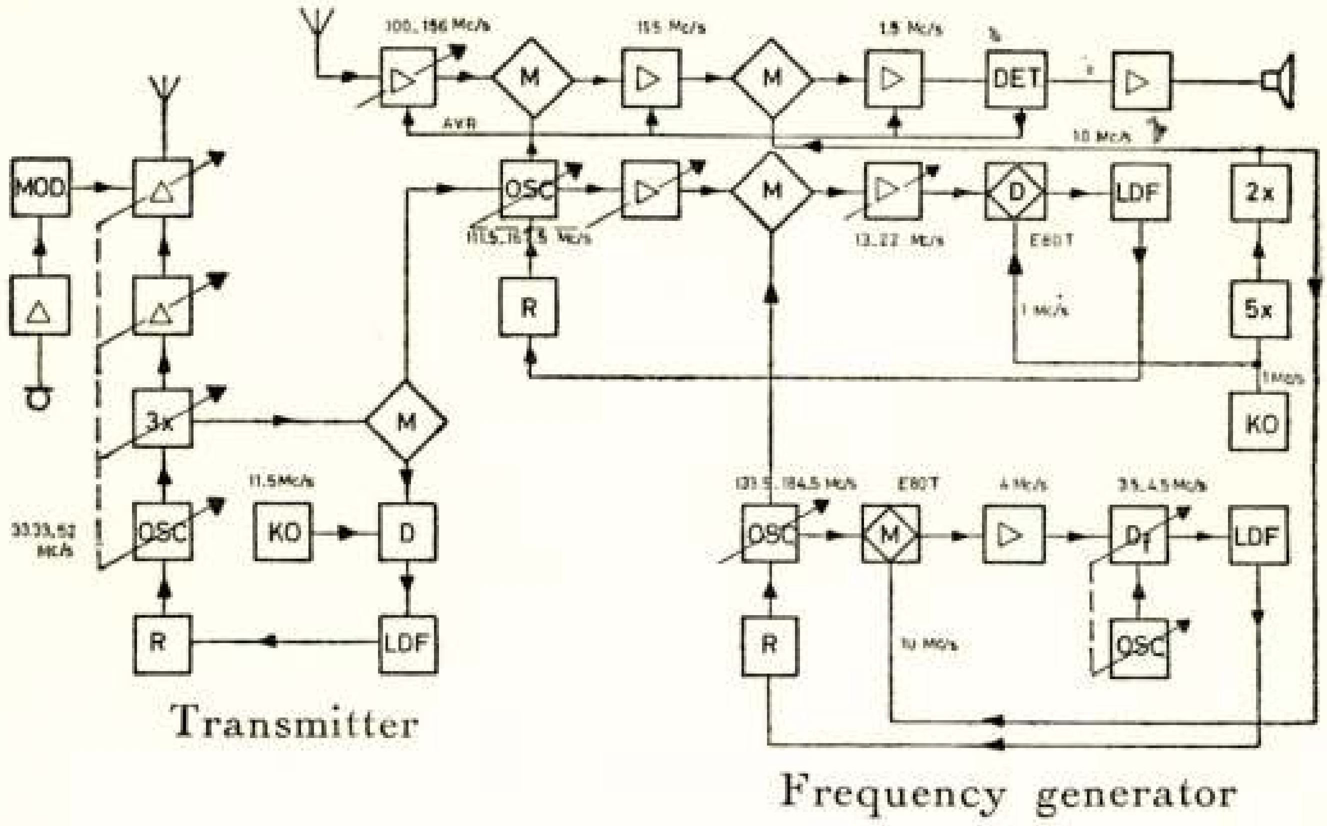


Fig. 5

Block diagram of a transmitting receiving installation for 100-156 Mc/s.

M — mixer stage
D — phase discriminator
LDF — low pass filter
MOD — modulator for amplitude modulation
DET — detector
KO — crystal controlled oscillator
OSC — oscillator
DF — combined frequency and phase discriminator
R — reactance circuit
AVR — automatic gain control

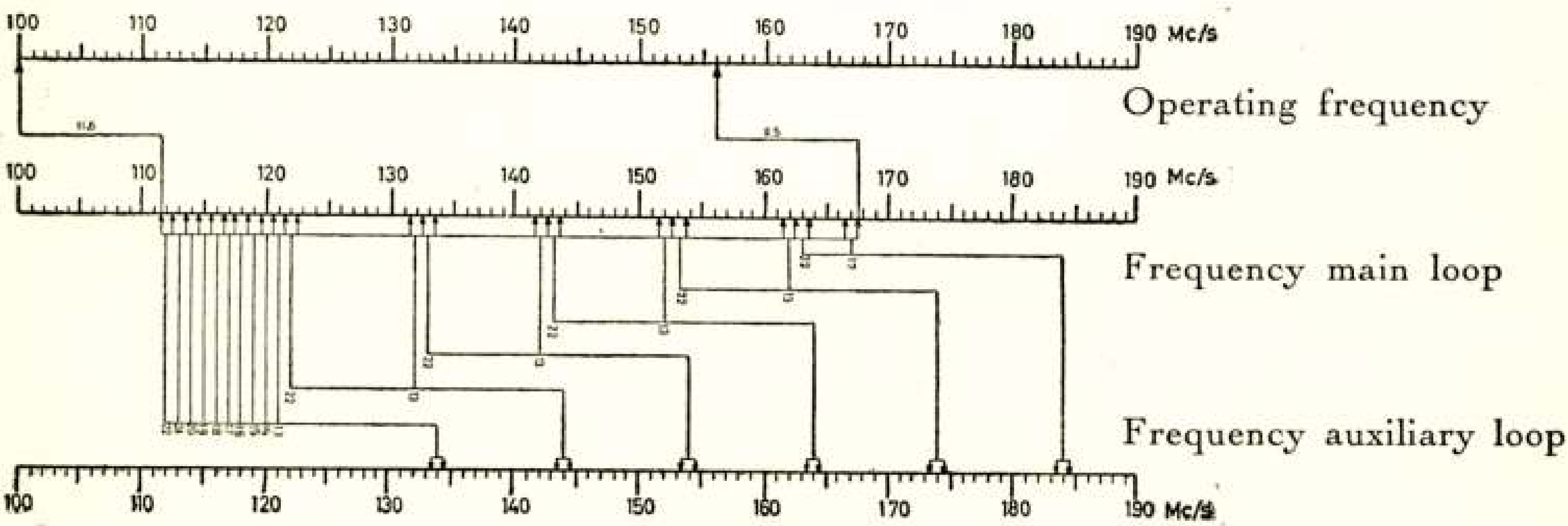


Fig. 6

Frequency diagram of a transmitting receiving installation for 100-156 Mc/s.

tals are necessary in most cases. The future will have to show which system is to be preferred. The author, however, is of the opinion that our circuits, using IGO principles and control loops and only a few crystals, have distinct advantages.

Literature

E. H. Hugenholtz: De impuls gestuurde oscillator en zijn toepassingen (The impulse governed oscillator and its applications). NRG Bulletin, Vol. XII no. 3, May 1947, page 89.

E. H. Hugenholtz: Impulse governed oscillator, A system for frequency stabilization. Philips Techn. Rev. 14, no. 5, 1952/53.

J. Bruysten, H. Groendijk, M. R. Mantz: The E80T beam deflection tube. Electronic application Bulletin, Vol. 13, no. 11/12, Nov./Dec. 1952.

H. J. Finden: Developments in Frequency Synthesis. Electronic Engineering, May 1953.

G. J. Camfield: A frequency-generator system for VHF communication equipment. Proc. I.E.E. Part III, March 1954, page 85.

Radio link operating in 4000 Mc/s band, for television and multi-channel telephony

by H. C. Bennebroek Evertsz *)

Lecture delivered for the Nederlands Radiogenootschap on December 17th, 1954.

SUMMARY

A Philips link equipment of new design is discussed. It comprises heterodyne repeater stations and is equipped with SHF triode amplifiers.

1. *Introduction*

The January 1954 issue of the "Tijdschrift van het Nederlands Radiogenootschap" (vol. 19 no. 1, p.p. 25—42) contained an extensive description of the 3,5 cm and 37 cm link equipments which are in production at the moment. A new equipment has since been developed working in the 3800-4200 Mc/s band. The Philips triode, EC 56, has made it possible to mix and amplify signals at these frequencies. The laboratory model of this equipment is now under test on a radio link between Hilversum and Huizen in the centre of Holland, with one repeater station at Laren. Some details of the antenna systems, the receivers and the transmitters, used for this link, are given below.

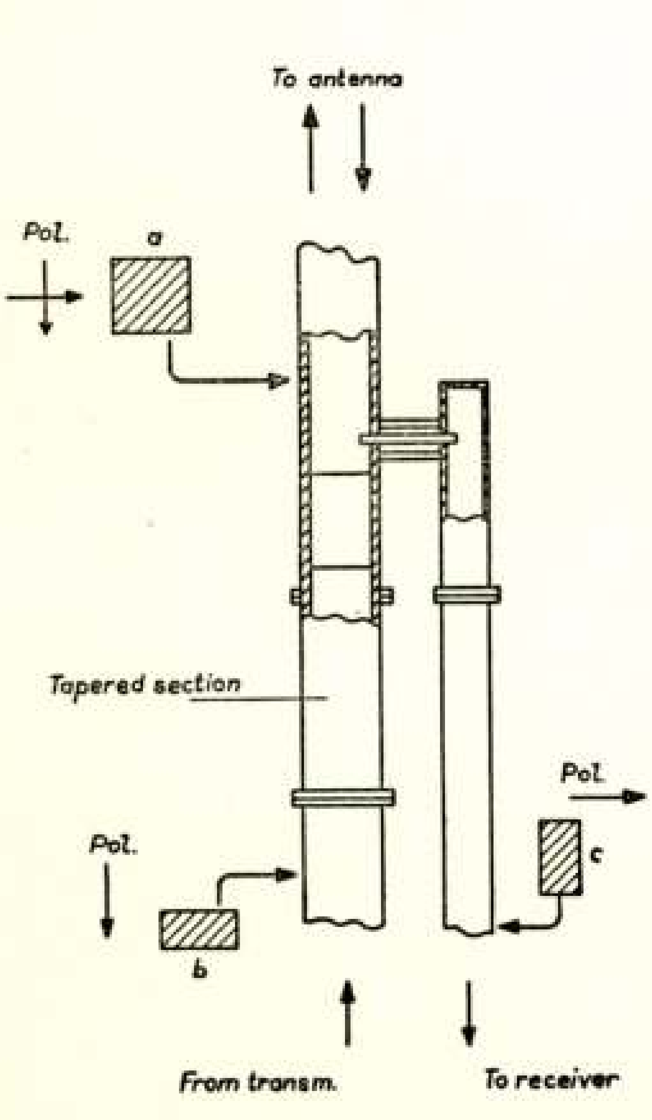


Fig. 1
The antenna polarization filter

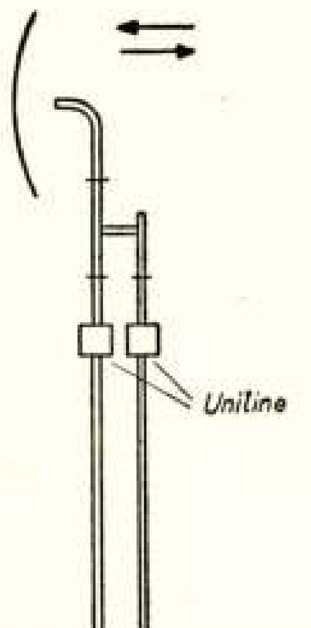
2. *Antenna system*

This consists of a parabolic dish having a diameter of 3,25 meters, illuminated by a square waveguide in two polarization planes which are at right angles. This waveguide changes into two rectangular waveguides near the reflector in the antenna tower. Fig. 1 shows the polarization filter.

*) Philips Telecommunication Industries, Hilversum - Netherlands.

The rectangular waveguides contain so-called "unilines" at both ends which enable the waveguides to be terminated so as to cause minimum reflection, irrespective of the matching conditions of the transmitter, receiver or antenna. As the intermodulation due to phase non-linearity (time-of-travel distortion) is proportional to the product of the reflection coefficients at both ends of the feeders, the insertion of "unilines" permits the use of very long feeders, before this form of intermodulation distortion becomes intolerable. Hence the electronic part of the equipment may be fitted near the base of the antenna tower, which will reduce the cost of installation and make servicing easier. In addition, waveguide change-over switches may be fitted in the repeater station between the "unilines" and the transmitter or receiver, without causing mismatch. The equipment thus becomes reversible and may be used for multi-channel telephony or for conveying television signal over two wide-band channels in one direction.

The type of "unilines" employed consists of



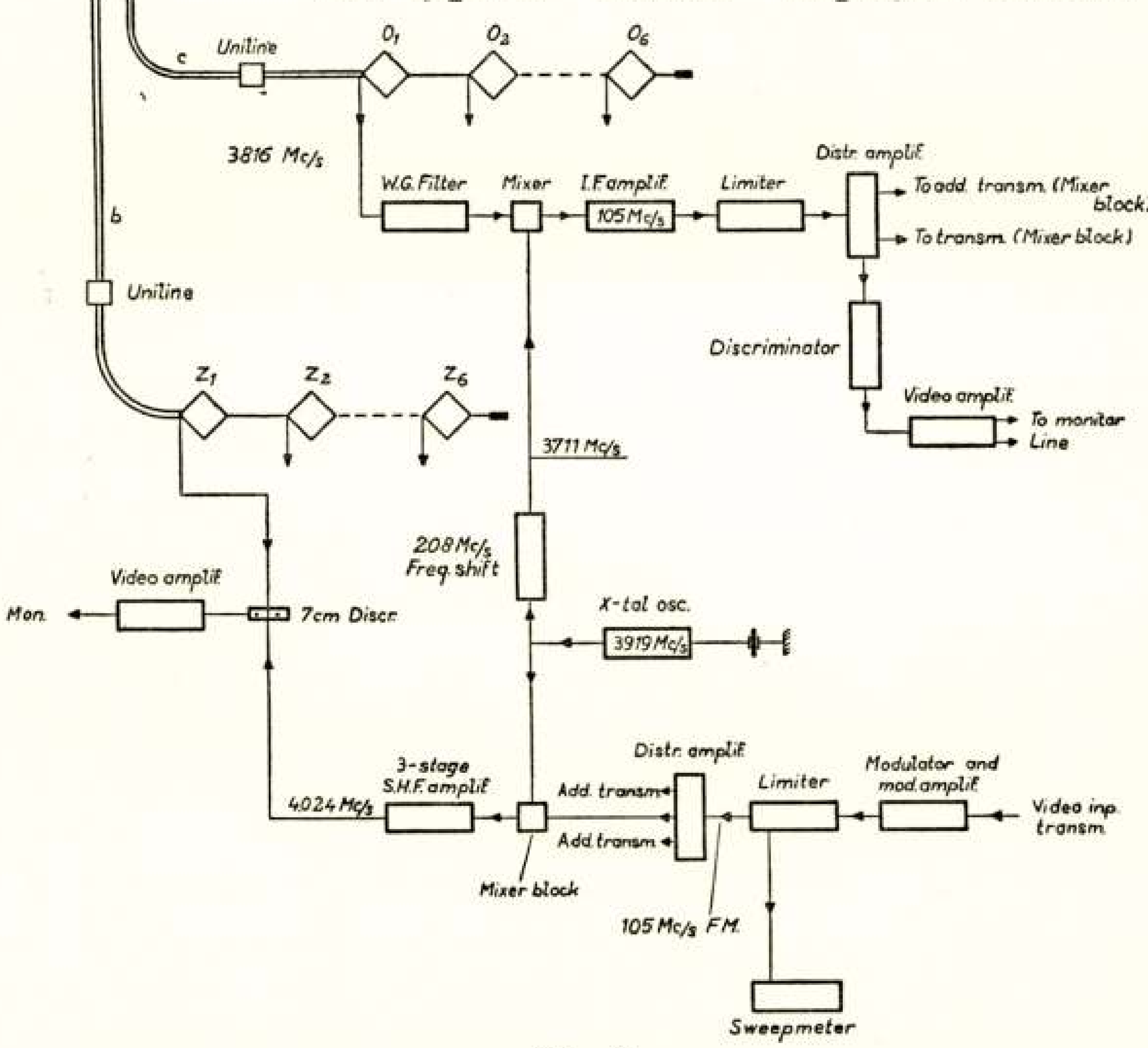


Fig. 2

The general schedule of the equipment for television a small sheet of ferrite fitted in the waveguide at a spot where the H-vector of the travelling wavefront produces a circular rotating field.

A magnetic field set up at right angles to the waveguide produces ferro-magnetic resonance in the ferrite sheet, but only for one direction of travel. Thus energy transmission through the waveguide is only possible in one direction.

Up to 6 branching filters $O_1 \ldots O_6$ and $Z_1 \ldots Z_6$ (fig. 2) may be coupled to the transmitting and receiving waveguides *b* and *c*, behind the lowermost "unilines", suitable for connecting 6 wide-band channels in both directions.

3. *General lay-out of the equipment*

Fig. 2 gives the general schedule of the equipment for television purposes. Fig. 3 gives an idea of the construction of the cabinet, containing the receiver and transmitting units.

4. *Receiver section*

Each receiver input has a waveguide bandpass filter. The spacing between the centre frequencies of the receivers is 32 Mc/s, as recommended by the CCIR. When the crosstalk attenuation between waveguides *b* and *c* (fig. 1) is 30 dB, the branching filter and the waveguide filter should attenuate the rejected band by about 90 dB.

The waveguide filter is followed by the balanced crystal mixer and the I.F. amplifier (see fig. 2). The latter is equipped with E180F tubes ($S = 15\,mA/V$), has a bandwidth of 30 Mc/s and a response curve which is flat within tenths of dB; the centre frequency is 105 Mc/s. The total gain is 85 dB minus 6 dB conversion loss (fig. 4).

The signal is then passed on to a distribution amplifier to obtain three independent I.F. output circuits. One output is connected to the limiter stages and the discriminator of the receiver, the second output to the transmitter, and the third to an additional transmitter when this must also be modulated.

The mixer frequency for the receiver is produced in the frequency shift chassis, where the signal of the crystal-controlled SHF oscillator is mixed with a 208 Mc/s signal which is also generated by an oscillator with quartz control (fig. 5).

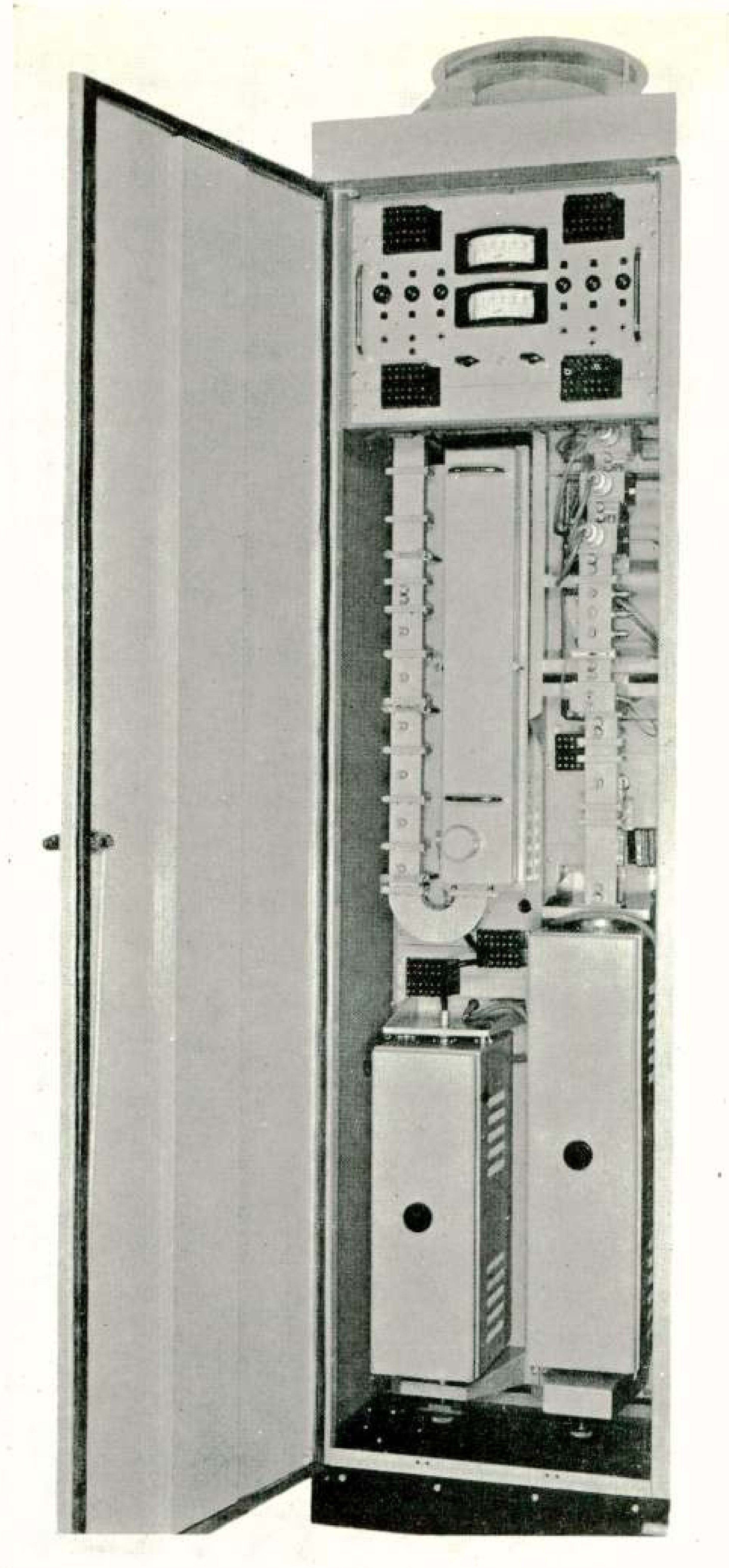


Fig. 3

Front view of transmitter-receiver cabinet of the 4000 Mc/s link equipment. To the left the receiver section comprising at the top the waveguide bandfilter, the crystal mixer and the I.F amplifier, at the bottom the frequency shift oscillator. To the right the transmittter section comprising at the top the SHF amplifier with

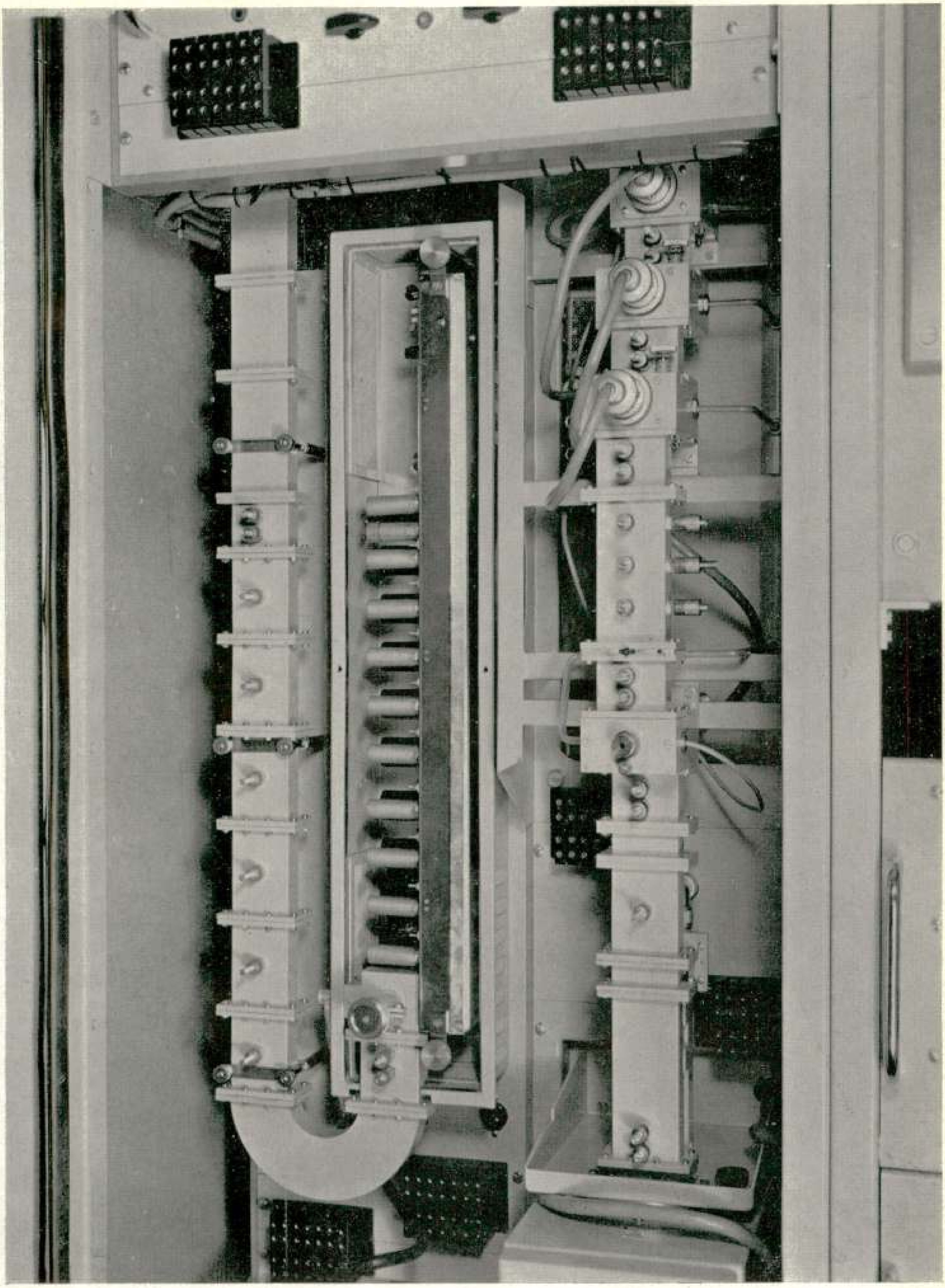


Fig. 4
To the left the waveguide bandfilter, the crystal mixer and the I.F. amplifier of the receiver section. To the right the SHF amplifier and the transmitter modulator, transmitter section.

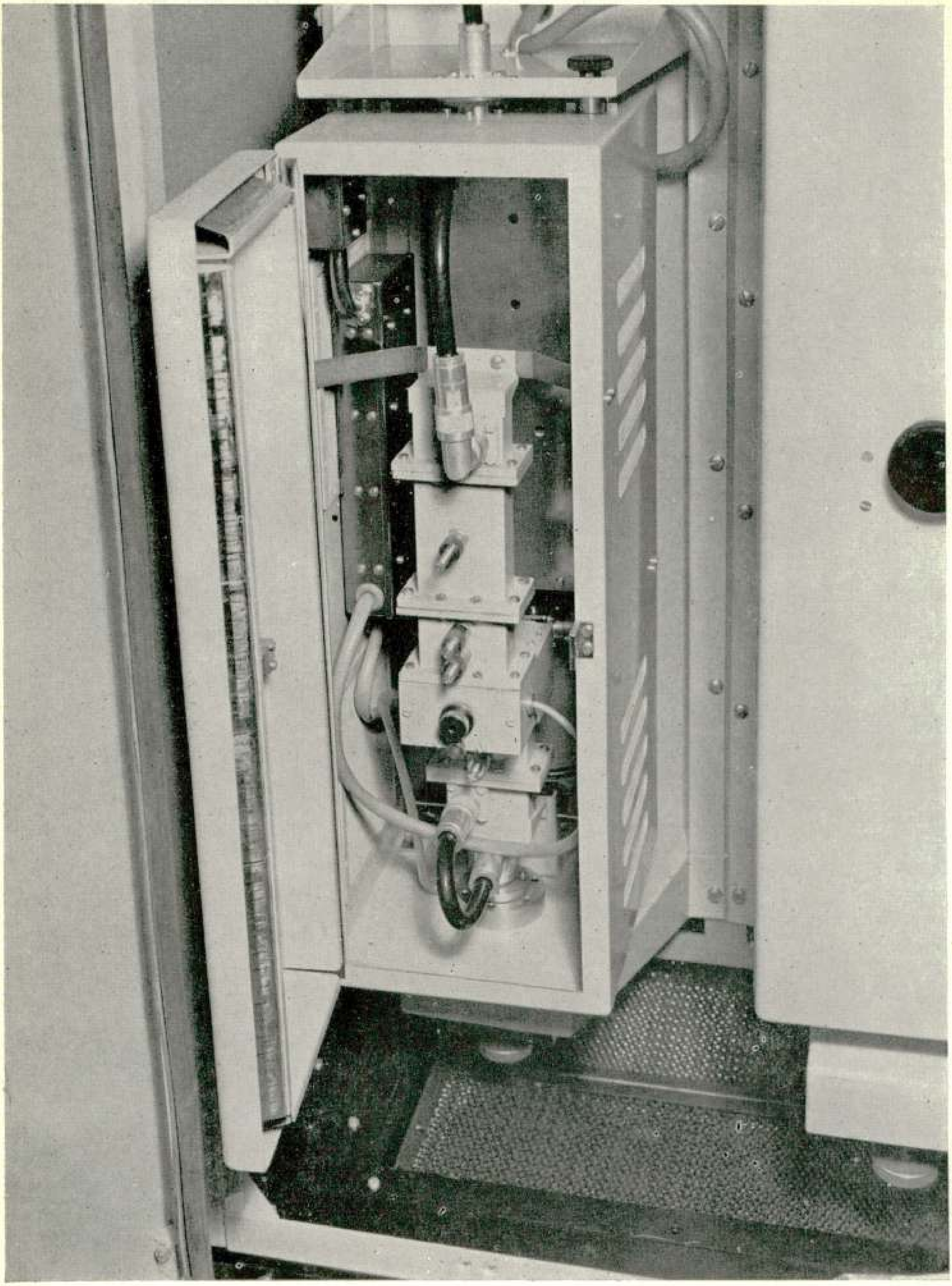


Fig. 5
Frequency shift oscillator. Visible on the picture is the mixer stage, where the signal of the crystal-controlled SHF oscillator is mixed with a 208 Mc/s signal.

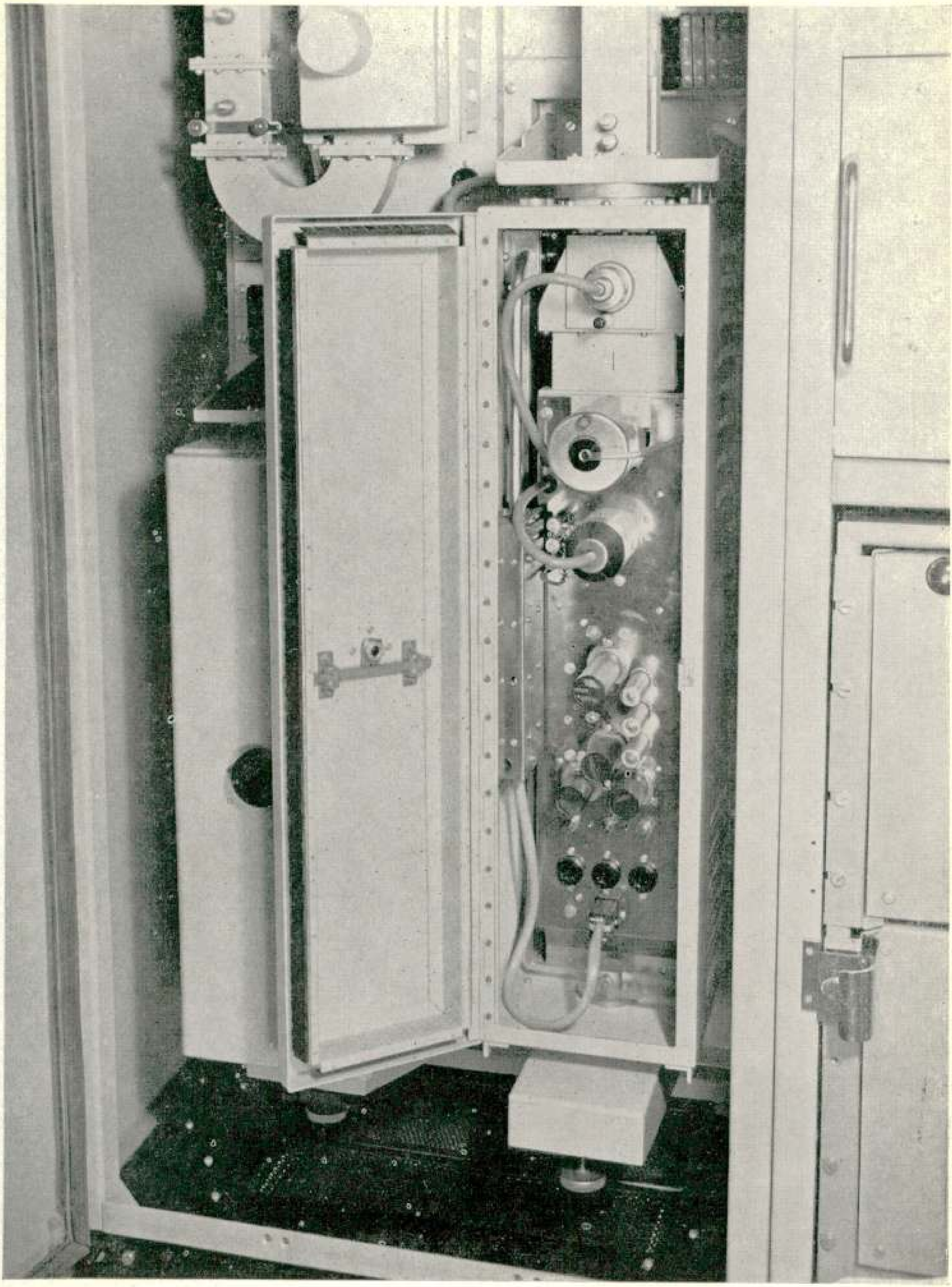


Fig. 6
Crystal-controlled 4000 Mc/s oscillator. At the lower part of the picture the 21 Mc/s crystal with multipliers of convential design, at the upper part the multipliers with coaxial- and waveguide circuits,

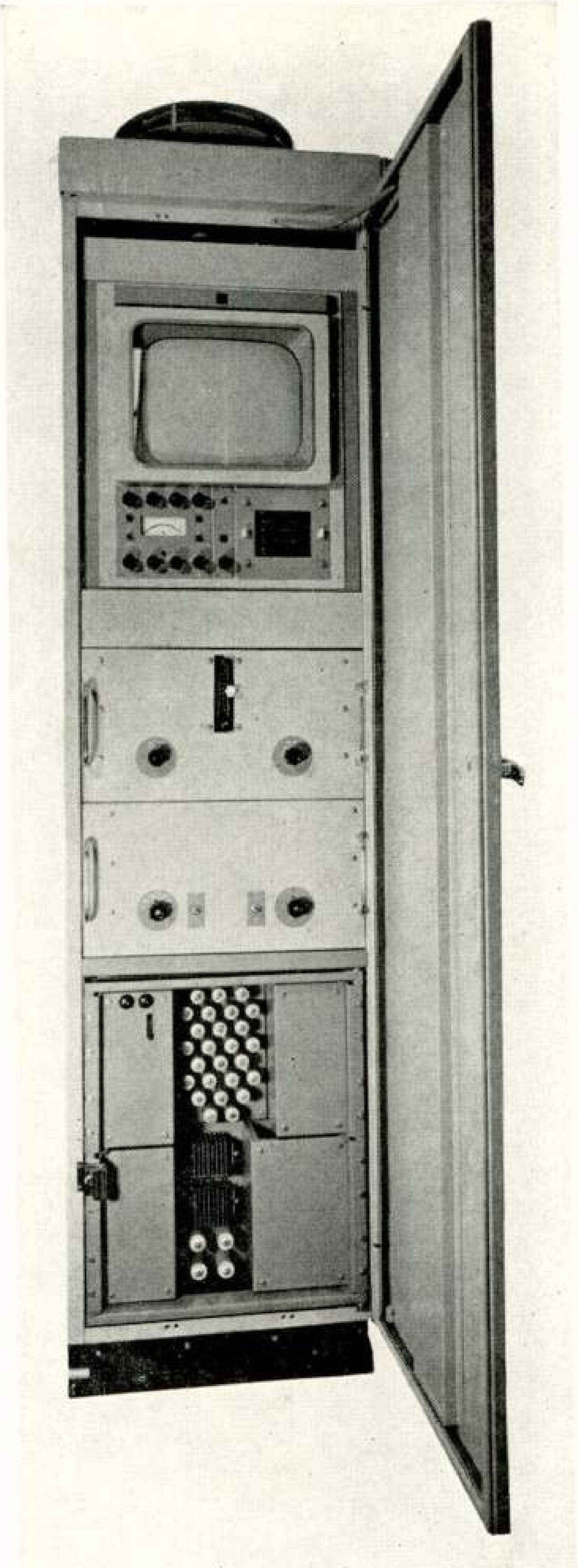


Fig. 7
The monitor and test cabinet of the 4000 Mc/s link equipment as supplied for TV. At the top of the monitor receiver, at the centre the test panel and the modulator, at the bottom the power supply section.

5. *Transmitter section*

The transmitter comprises a crystal-controlled SHF oscillator, a mixer stage, a three-stage SHF amplifier, a modulator, a modulation amplifier with limiter and a video amplifier (see fig. 2).

The SHF oscillator is equipped with an overtone crystal, frequency approx. 21 Mc/s. This frequency is multiplied by ten in the conventional way in a circuit using E180F and QQE03-12 tubes, then tripled twice by EC 56 tubes with coaxial circuits, and finally doubled by one EC 56 tube in a waveguide circuit. The output is approx. 200 mW (fig. 6).

The modulator is a 52.5 Mc/s oscillator with a reactance tube in a special circuit, giving a very linear frequency modulation characteristic. The F.M. signal is doubled in frequency, amplified, limited and finally mixed with the SHF oscillator signal. One sideband of the product of mixing is then passed on to the SHF amplifier, the other sideband being reflected by a band rejection filter. The output of the SHF amplifier is approximately 1.5 W (fig. 4 upper right side).

6. *Monitor*

Fig. 7 shows the front side of the monitor-test equipment for television. For telephony purposes some chassis are to be changed, the monitor and the sweep measuring device into a modulation control panel and the adequate modulator.

7. *Transmitting and receiving frequencies*

The location of the 6 wide-band channels in the 3800-4200

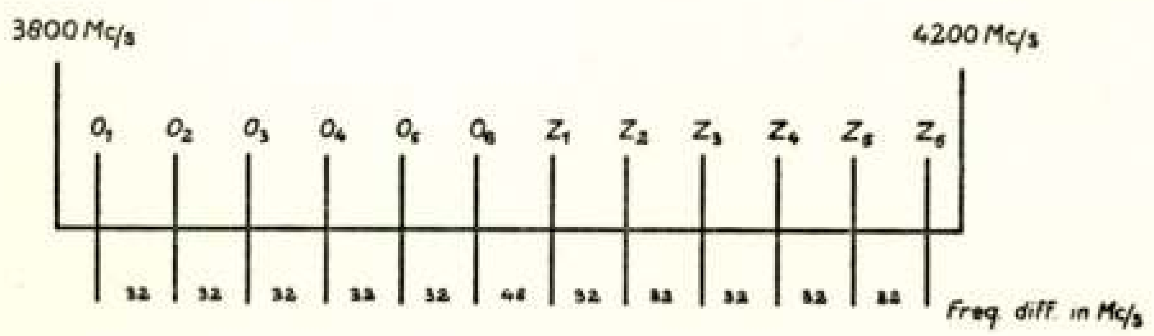


Fig. 8a

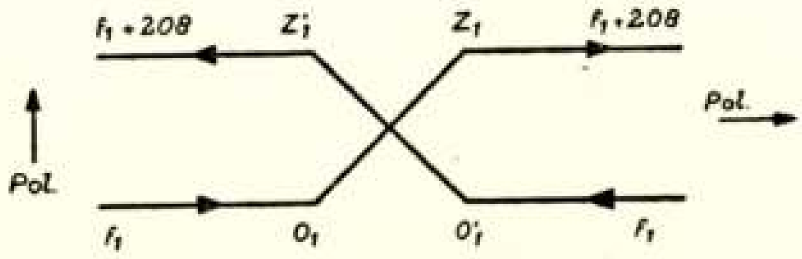


Fig. 8b

Mc/s band has been selected in accordance with the recommendations of the CCIR (see fig. 8a). The frequency allocation plan for one wide-band channel for duplex working in a relay station is shown in fig. 8b.

For the successive hops, the polarization is alternatively horizontal and vertical.

8. *Characteristics*

The table on pag. 193 shows the chief characteristics of the 37 cm link transmitter for outside television broadcasts, the 3.2 cm semi-mobile link transmitter equipment for television, and the 7.5 cm link transmitter for television and multi-channel telephony.

This table also gives a good survey of the possibilities offered by the various types of equipment.

Type of Link Transmitter	37 cm for TV	3.2 cm for TV	7.5 cm for 240-channel tel.	7.5 cm for TV
Transmitter level	30 dBm	+ 25 dBm	+ 32 dBm	+ 32 dBm
2 × aerial gain	36 dB	+ 76 dB	+ 80 dB	+ 80 dB
Attenuation by receiver and transmitter waveguide	– 5 dB for 2 × 30 m cable		– 3 dB for 2 × 50 m waveguide – 2 dB for 4 "unilines"	– 3 dB for 2 × 50 m waveguide – 2 dB for 4 "unilines"
Transmitter atten. free space	– 118 dB for 20 km	– 147 dB for 50 km	– 139 dB for 50 km	– 139 dB for 50 km
Receiver level	– 57 dBm	– 46 dBm	– 32 dBm	– 32 dBm
Thermal noise	– 101 dBm over band of 20 Mc/s width	– 101 dBm over band of 20 Mc/s width	– 101 dBm over band of 20 Mc/s width	– 101 dBm over band of 20 Mc/s width
Noise figure	+ 12 dB	+ 18 dB	+ 13 dB	+ 13 dB
Modulation improvement factor	– 1.5 dB [1] (p.t.p. sweep 8 M/cs	– 6 dB [1] (p.t.p. sweep 12 Mc/s)	for tel. – 32 dB [1] (r.m.s. sweep 0.5 Mc/s)	– 6 dB [1] (p.t.p. sweep 12 Mc/s)
Sweep reduction factor	0 – for TV	0 – for TV	+ 10 dB for tel.	0 – for TV
Total thermal noise level	– 90.5 dBm	– 89 dBm	– 110 dBm	– 94 dBm
S/N due to thermal noise, per hop	33.5 dB $\frac{\text{r.m.s.}}{\text{r.m.s.}}$ =	43 dB $\frac{\text{r.m.s.}}{\text{r.m.s.}}$ =	for telephony: 78 dB in the worst	62 dB $\frac{\text{r.m.s.}}{\text{r.m.s.}}$ =

Automatic Tuning of Transmitters

by W. L. Vervest *)

Lecture delivered for the Nederlands Radiogenootschap on December 17th 1954

SUMMARY

The Philips Instantuner is a device for automatically resetting a tuning element in any one of twelve preset positions. When several tuning elements are used, which is normally the case, a corresponding number of instantuners is required. Remote control of radio equipment is then limited to a simple manipulation. Manual tuning is also possible in any position by pressing a push-button mounted in a special vernier knob. The presetting procedure is very easy. Changing from one preset frequency to another (automatic tuning) is accomplished in 1—3 seconds for small transmitters, e.g. aircraft transmitters, and in 2—10 seconds for larger transmitters, e.g. broadcast transmitters.

Each instantuner is built as a separate unit, designed for universal application. It consists of a blocking-mechanism and a torque-limiting clutch. The blocking-mechanism contains twelve pawls and pawlrings, so that the main shaft can be blocked in any one of twelve preset positions.

Owing to the use of the special torque-limiting clutch a resetting accuracy of $\pm 0{,}01°$ can be achieved. This clutch releases the driven spindle of a tuning element from the driving-motor, as soon as the preset position is reached.

The torque-limiting clutch

This clutch forms a link between the driving shaft and the blocking unit. The primary gear of the clutch is coupled to a driving mechanism and the secondary gear is connected to the blocking unit, both gears forming a part of this clutch.

When the torque on the secondary gear exceeds an oppositely directed torque exerted on it by a powerful spring fitted in the torque-limiting clutch, the secondary gear stops and the connection between this and the primary gear is entirely released. But the torque of the spring continues to act upon the secondary gear in the original direction of rotation of this gear.

As soon as the load on the secondary gear becomes less than the torque exerted on it by the spring, this gear is again coupled to the primary gear.

*) Philips' Telecommunication Industries, Hilversum, Netherlands.

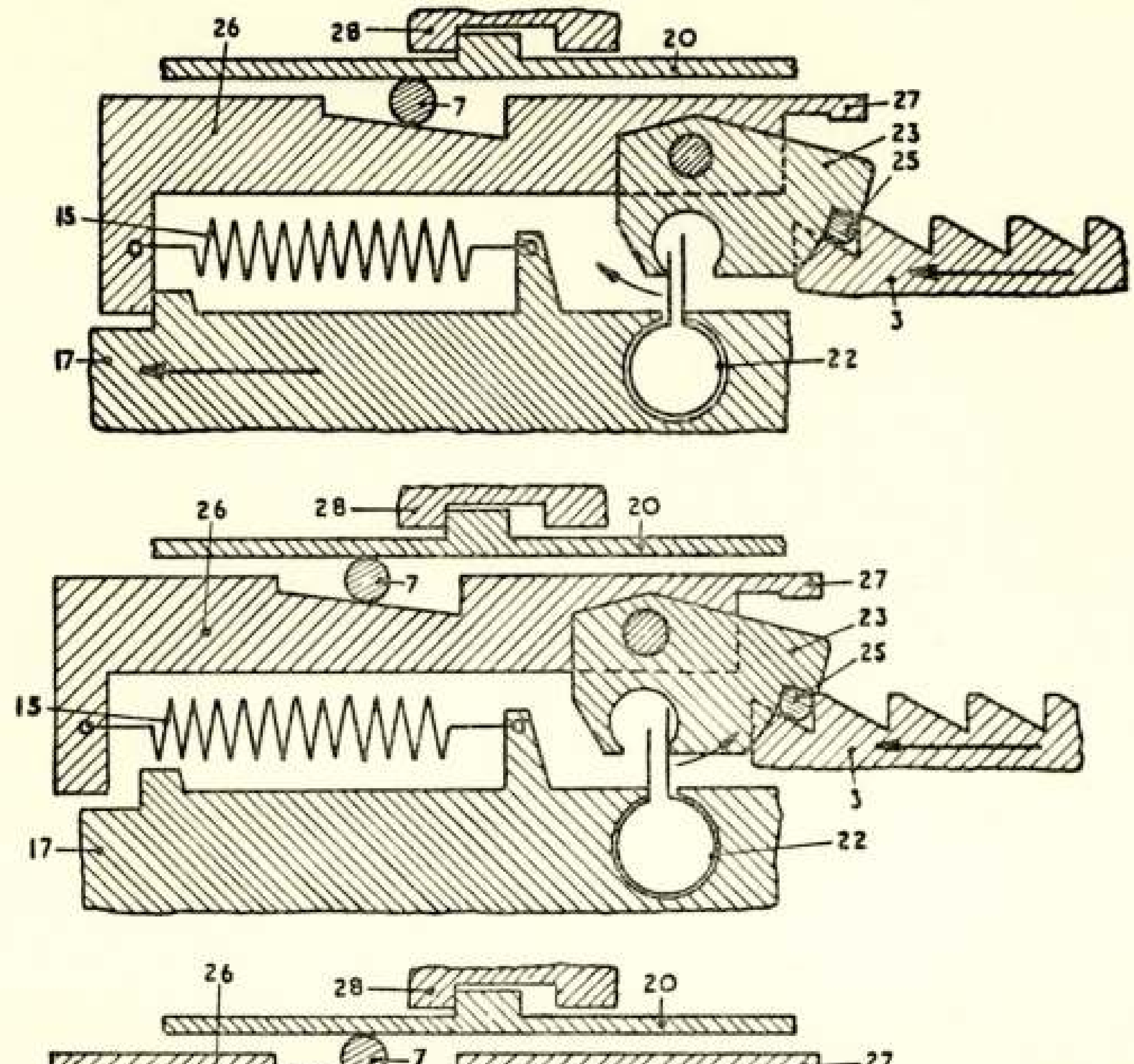


Fig. 1
Four phases of the torque-limiting clutch in action. The drawings show sliding spindles. In case of rotating spindles the same principles apply.

It will be assumed in the following description for the sake of simplicity, that sliding spindles are used. Generally, rotating spindles and gears are used.

In fig. 1a, (3) represents the primary gear which is coupled to disc (26) by means of pawl (23) and roller (25). As long as pawl (23) is kept in position, the primary gear (3) and disc (26) make the same sliding movement when the primary gear is moved in the direction of the arrow. The movement of disc (26) is transferred to the secondary gear (17) which is connected to disc (26) by means of the spring (15). During this sliding movement the pawl (23) and consequently the roller (25) are pressed into the teeth of the primary ratchet (3) and held there by the action of spring (22) which tends to rotate pawl (23) in a direction as shown by the arrow. It is assumed that the torque which is transferred is smaller than the oppositely directed torque exerted by spring (15) upon disc (26). When this is not the case or when the secondary gear (17) is stopped, disc (26) moves to the left with respect to the secondary gear (17) under the influence of the driving torque of the primary gear (3), thus stretching the spring (15).

At a certain instant the pressure of spring (22) changes its position (fig. 1b). The pressure on pawl (23) is now directed in such a way that it tends to sever the connection between the primary gear (3) and disc (26).

In case of further relative displacement of (17) and (26) the ends of the spring (22) come together and now exert such a pressure on pawl (23) that the latter, via roller (25) leaves the teeth of the primary gear (3) thus releasing this gear from disc (26) (fig. 1c). Spring (22) now forces pawl (23) upwards against stop (27). As soon as the connection between primary gear (3) and disc (26) is severed the latter is pulled to the right under the influence of the loaded spring (15). However, this movement is limited by the clamping roller (7). Under the influence of spring (15) and the limiting action of roller (7) the disc (26) is clamped in the housing (20). The housing can make only a slight movement to the right, with respect to stop (28). This movement which takes place through the action of a powerful spring (15), may be used to operate a contact which interrupts the electrical circuit of the driving motor.

In fig. 1d is shown disc (26) after being stopped by the housing (20). Spring (15) eliminates the play in the mechanism coupled to the secondary gear.

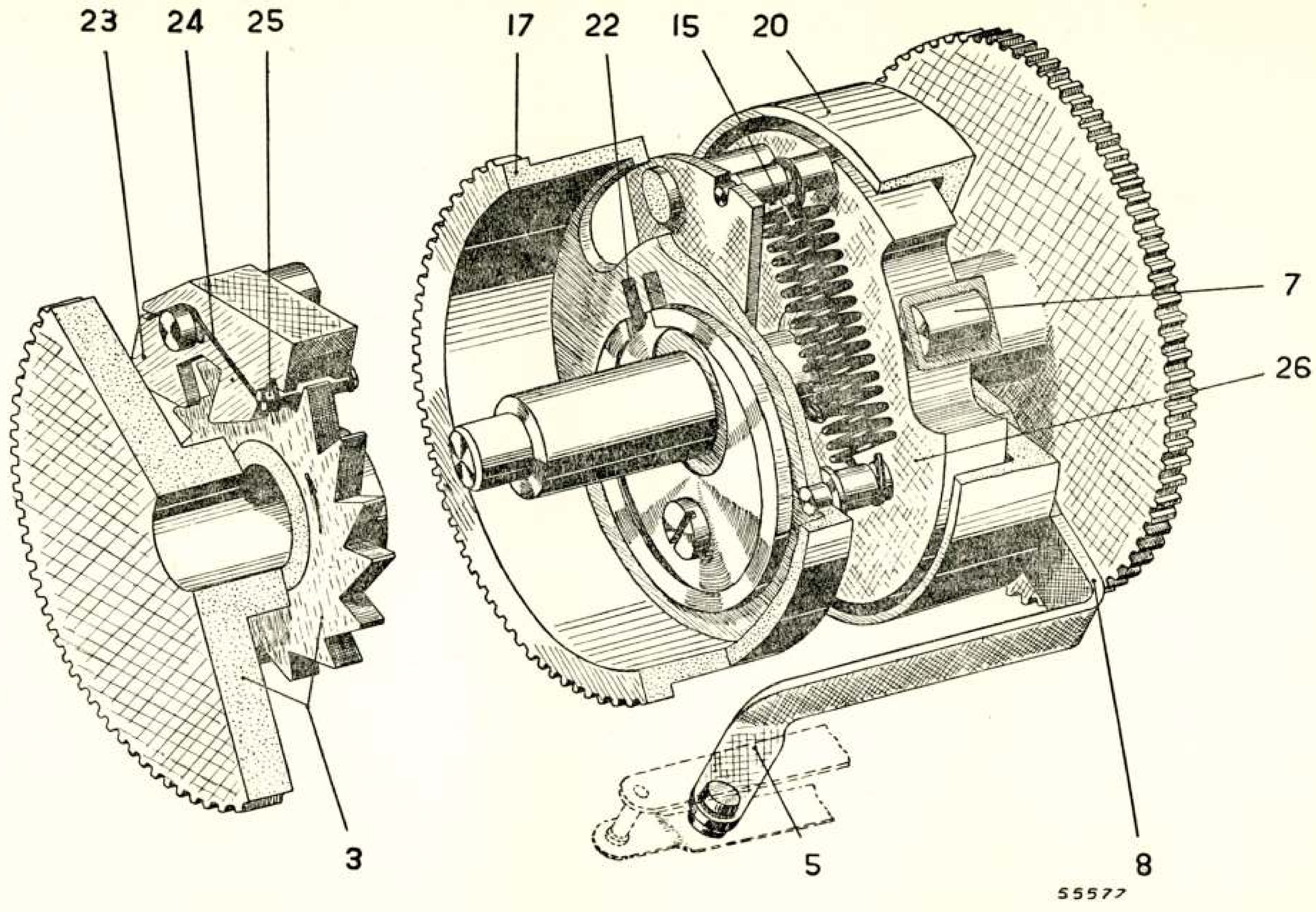


Fig. 2
Perspective sectional drawing of the torque-limiting clutch. The primary [gear with its associated roll-pawl are shown dismantled

Further reference will be made to this later on. When the load which is applied to the secondary gear (17), decreases and reaches a value that is lower than the oppositely directed torque exerted by spring (15), the secondary gear (17) moves to the left under the influence of spring (15) and consequently the pressure of spring (22) on pawl (23) changes its position and direction as a result of which pawl (23), together with roller (25), is pressed into the teeth of the primary gear (3) so that the connection between (3) and (26) is restored.

Finally, the secondary gear (17) and disc (26) are reengaged under the influence of spring (15) and the initial position illustrated in fig. 1a is reached again. The housing (20) is moved to the left by the action of a weak spring, which is now possible since (17), (15) and (26) are moved now as one unit to the left by the primary gear (3) via roller (25) and pawl (23), thus disengaging roller (7) and housing (20). The contacts actuated by the latter revert to the initial position.

Fig. 2 illustrates the torque-limiting clutch in its practical form. The numbers in the figure correspond to those in the preceding description.

The small spring (24) ensures that the roller (25) is pushed back against pawl (23) after the latter has left the primary ratchet (3).

A lever (8) is mounted on the housing (20) and serves to actuate the contacts shown when moving through a narrow angle as has been described above.

The blocking unit

The blocking mechanism of the instantuner contains a number of pawl rings (12) and pawls (18) (see fig. 3). The pawl ring assembly mounted on the main shaft consists of 12 pawl-rings which can be rotated around the bearing rings. The pawl-rings are separated from each other by spacer rings (11).

In order to couple the spacer rings to the main shaft, the assembly formed by these rings and the bearing rings is compressed between a shoulder on the shaft and a nut. The forces which develop when the mechanism is stopped, are thus no longer capable of displacing the spacer rings with respect to the shaft. The nut is at the same time the rear pressure ring for the pawl-ring assembly.

When the flap (1) on the knob of the main shaft is pressed

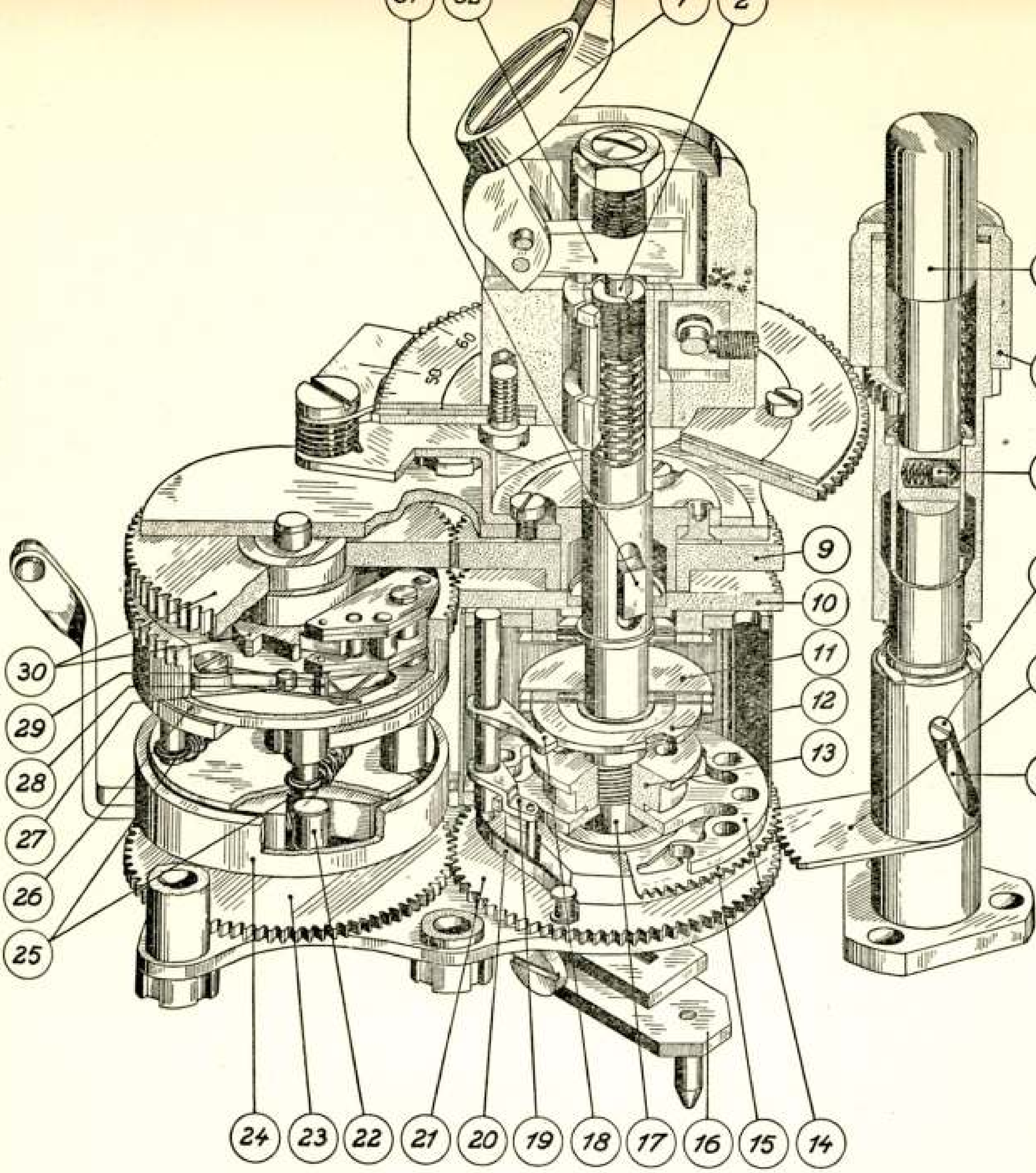


Fig. 3

Perspective sectional drawing of the instantuner with manually operated slow-motion drive.

1 = flap
2 = pressure pin
3 = push-button manual tuning
4 = knob of slow-motion drive
5 = ball catch
6 = pin
7 = gear-wheel sector
8 = slanting slot
9 = intermediate wheel of position train
10 = pressure gear wheel
11 = spacer rings
12 = pawlrings
13 = rear pressure-ring
14 = cage cheeks
15 = manual-operation disk
16 = coupling to tuning element
17 = main shaft
18 = pawls
19 = pawl-lifting lever
20 = spring on selector wheel
21 = selector wheel
22 = clamping roller of freewheel
23 = intermediate wheel of selector train
24 = house of freewheel
25 = springs of torque-limiting clutch
26 = secondary wheel of clutch
27 = hairpin spring
28 = lifting pin of roller pawl
29 = roller pawl
30 = primary wheel with associated ratchet of clutch
31 = pressure key
32 = tapered key

home, pressure is exerted on the pawl-rings and the associated spacer rings, by a sliding tapered pin mounted in the knob. The force is transferred to the pressure gearwheel at the front of the assembly via a pin and a pressure block (32), through the hollow main shaft. The pawl-rings and the space-rings are compressed between the rear pressure-ring (13) and the pressure gear-wheel (10), and in this way they constitute an integral unit with the main shaft. When the flap at the front is opened, the compressive force is removed and the pawl-rings can be rotated on the shaft. The pawls, each with a pawl-lifting lever, are mounted on 12 pawl spindles. The pawl spindles are evenly distributed around the main shaft and are borne by two cage cheeks (14).

The selector wheel (21), which turns freely on the main shaft, and by means of which one of the pawls is selected, is provided with a collar. The pins attached to the lifting-levers (19) rest on this collar. In this position of the lifting-lever, the head of a pawl does not engage its pawlring; it is held a little distance away from the pawl-ring, far enough to clear the point where its diameter is greatest. The collar has a V-shaped notch in which a lifting-pin can be depressed by a spring enabling one of the operating levers to make a pawl engage the associate pawl-ring. After rotating, the main shaft is arrested by this section of the pawl-ring device, whilst the remaining eleven pawls stay clear of their pawl-rings. Selecting a new position, therefore, entails rotating the selector wheel through an angle of 30° or a multiple of 30°.

The pin of the lifting-lever associated with the engaged pawl is then forced upwards on the slope of the V-shaped notch. The pawl is thus automatically released by the motor, whilst the pawl selected next is now in the position to arrest the main shaft. The direction of rotation of the selector wheel is is always the same and independent of the direction of rotation of the selector switch.

The instantuner

The instantuner is suitable for one direction of rotation and two or more units can be coupled by using intermediate gears. The blocking-mechanism and the torque-limiting clutch, are built as a unit and mounted between two endplates. In fig. 3 intermediate gear (9) is coupled to the primary gear (30) and can rotate freely on the mainshaft (17). The gear (23)

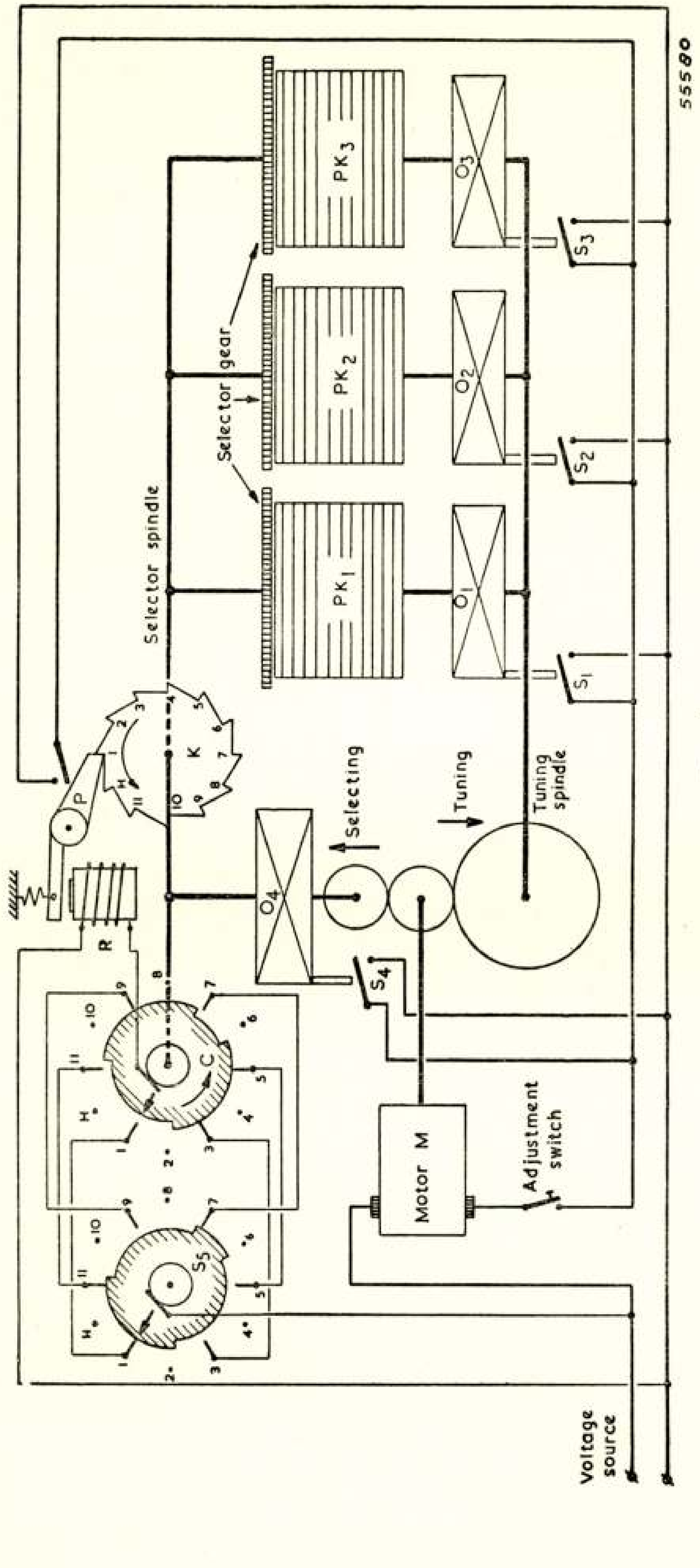


Fig. 4

Functional diagram of the complete tuning mechanism with three coupled instantuners. S_5 represents the remote control switch, which is electrically connected to the click-knob mechanism by means of 7 wires.

is coupled to selector gear (21) and can rotate freely on the supporting spindle of the torque-limiting clutch.

It will be clear that when a second instantuner is coupled to that shown in fig. 3, the direction of rotation of the primary gear (30) and the primary gear of this second instantuner is the same owing to the presence of intermediate gear (9). The second instantuner, however, differs from the unit shown in fig. 3, since the secondary gear of the second unit may not be coupled to gear (10) of the instantuner illustrated.

Furthermore the selector gear (21) of the instantuner shown in fig. 3 and the selector gear of the coupled unit have the same direction of rotation owing to the presence of intermediate gear (23).

Therefore it is possible to couple directly all the tuning elements by means of instantuners on the front panel of a transmitter. All instantuners are mounted on a solid common frontplate by fixing screws and can be easily replaced.

The instantuner and the torque-limiting clutch are held together by end plates.

Combination and control of instantuners

In fig. 4 is shown the functional diagram of a complete tuning device consisting of three instantuners.

The driving motor M drives the selector gears of the instantuners PK_1, PK_2 and PK_3 via a torque-limiting clutch O_4. On the selector spindle are also mounted a collector C and a ratchet gear K. The same motor also drives the central spindles of the instantuners PK_1, PK_2 and PK_3 via the torque limiting clutches O_1, O_2 and O_3 and a step-down gearing.

It is assumed that the system is at rest after having selected a desired preset position of the tuning elements, the torque-limiting clutches O_1, O_2 and O_3 having released the instantuners from the driving-mechanism.

During this action the contacts S_1, S_2 and S_3 have been opened and thus the motor circuit is broken.

Changing-over to other frequencies

When it is desired to change over to another frequency it is only necessary to operate the selector switch by bringing it in the position corresponding to the desired preset position of the tuning element. If for instance S_5 in fig. 4 is turned from position 1 to 2, current flows via collector C thus energising the electromagnet R which releases pawl P from the ratchet K

which is rigidly mounted on the selector spindle. Consequently the secondary gear of the torque-limiting clutch O_4 is no longer blocked and the coupling springs restore the connection between the selector spindle and the driving-mechanism. The contact S_4 which is operated through the action of O_4, as already described above, now closes the motor circuit after the motor has been started by closing the contact on ratchet pawl P. The motor turns the selector gears from position 1 in position 2.

As already stated, as soon as the selector gears leave position 1, all the pawls engaged, are lifted and the main shafts are no longer blocked.

Consequently the torque-limiting clutches O_1 ,O_2 and O_3 are able to restore the connection between the main shafts and the driving-mechanism. As a result, each of the contacts S_1, S_2 and S_3 closes the motorcircuit. All the torque-limiting clutches are now engaged.

As shown in fig. 4 the collector C is mounted on the selector spindle. This collector is designed in such a way that just before the selector spindle reaches position 2 the electrical circuit of the electromagnet R is interrupted, which permits the spring-loaded pawl P to engage the ratchet K so that the selector spindle is accurately stopped in the desired position.

The torque-limiting clutch O_4 permits the selector spindle to be stopped while the motor keeps running.

When the clutch O_4 releases the selector spindle from the driving-mechanism contact S_4 opens.

However, the electrical circuit of the motor remains closed via the contacts S_1, S_2 and S_3 which have been closed in the meantime.

The required pawls are now set.

When the tuning-elements have reached the desired position the main shafts are blocked, as a result of which the torque limiting clutches O_1, O_2 and O_3 release these shafts from the driving-mechanism and open the contacts S_1, S_2 and S_3. Since these contacts are connected in parallel, the motor is switched off by the last contact to be opened, thus ending the tuning cycle. As stated before, the spring torque remains on the main shafts and eliminates the play in the mechanism giving the high resetting accuracy of the intantuner.

The tuning elements must not be fitted with stops which limit the angle of rotation, since the instantuner mechanism rotates in one direction only.

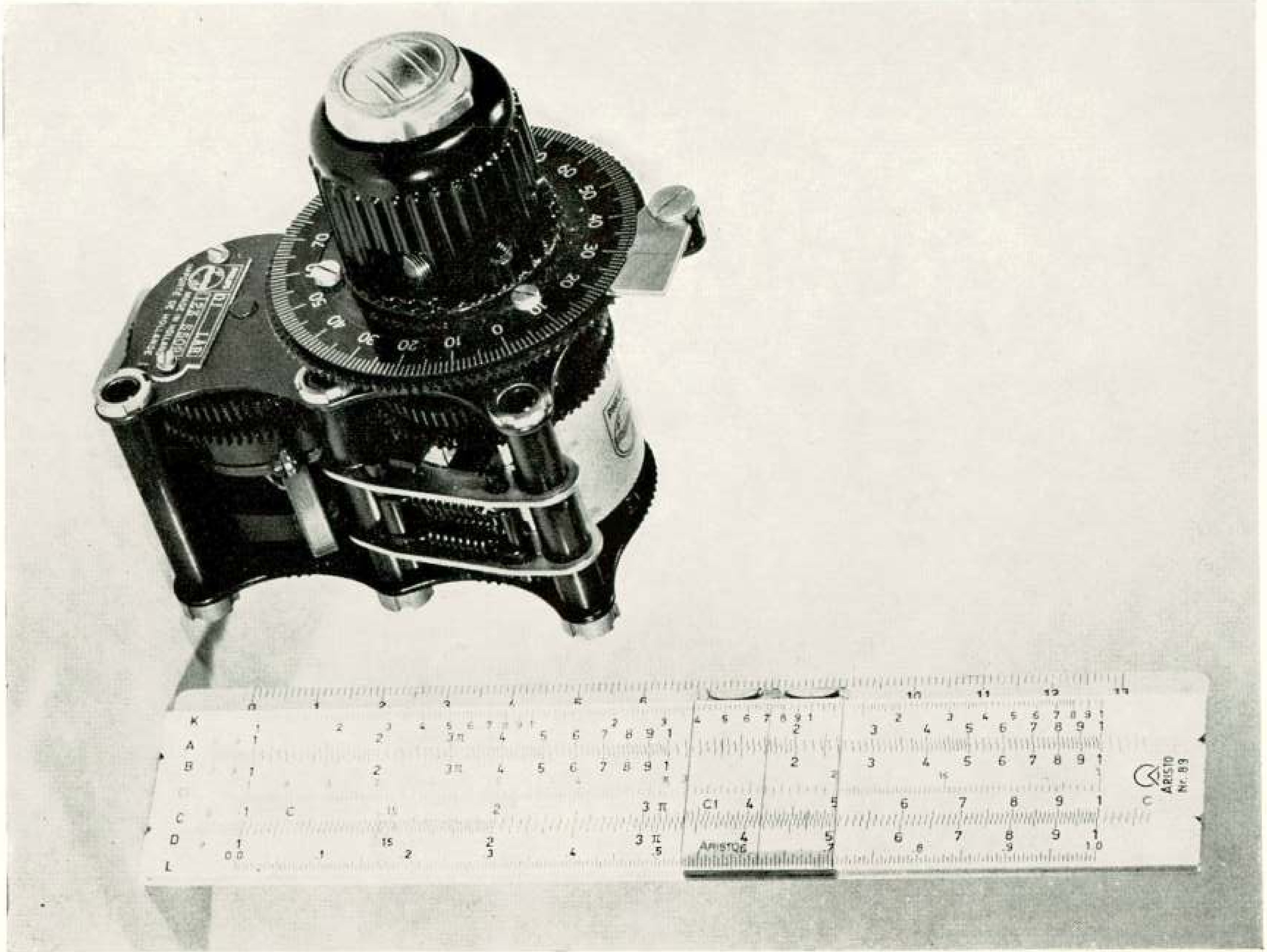


Fig. 5
Photograph of an instantuner, designed for aircraft transmitters and suitable for a transmitted torque of max. 0.3 Nm.

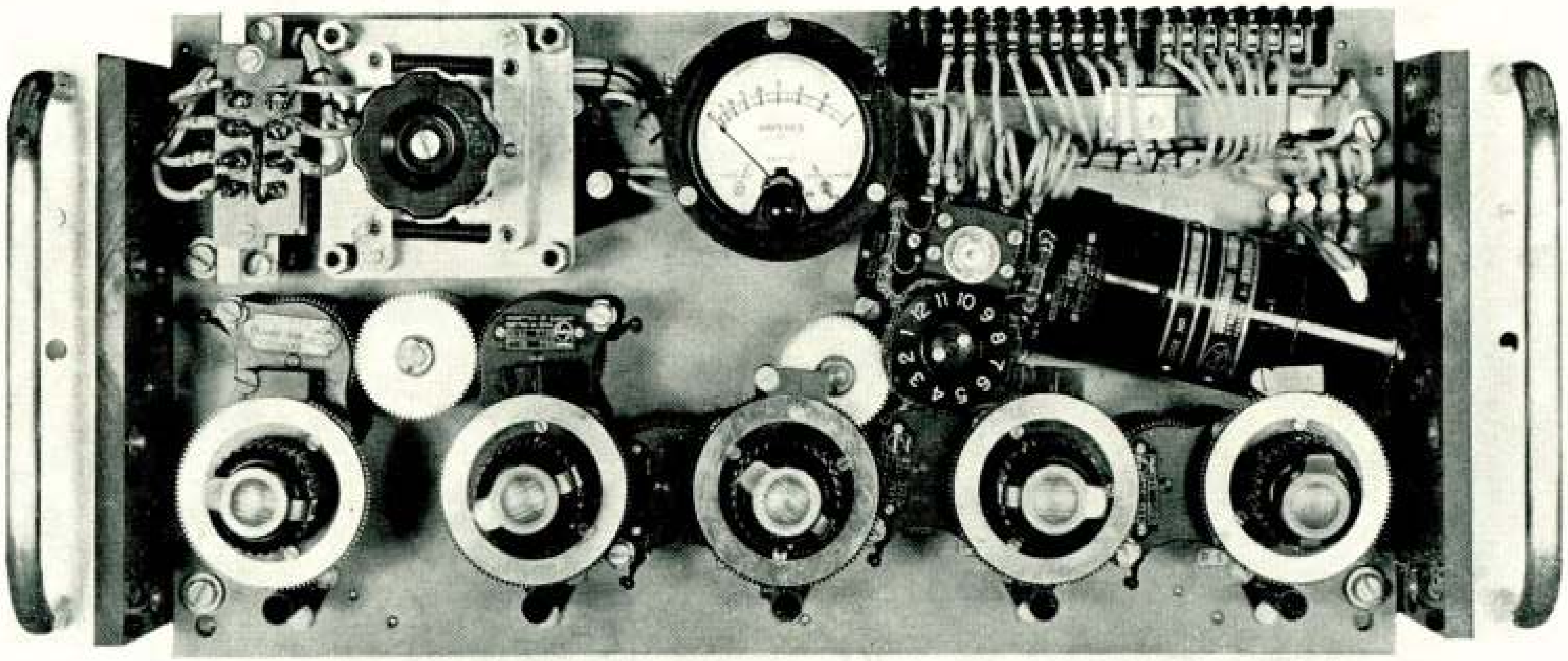


Fig. 6
Application of a number of instantuners with central drive-mechanism on the front panel of a transmitter.

General outline of the development of transmitters for television and frequency modulation

by P. W. L. v. Iterson and H. A. Teunissen *)

Lecture delivered for the Nederlands Radiogenootschap on December 17th 1954

1. *Introduction*

During the post-war years Philips Telecommunication Industries have developed a range of TV and FM transmitters, together with aerials and accessory equipment. These transmitters are to be employed in the Netherlands TV and FM project. The requirements to be met by these transmitters have been laid down in the CCIR recommendations, in addition to which every PTT Administration has its own regulations. In a number of cases these requirements are in fact surpassed. The following frequency ranges were laid down:

41 — 68 Mc/s,	band I	Television broadcasting
87.5—100 Mc/s,	band II	Sound broadcasting (usually FM)
174 —220 Mc/s,	band III	Television broadcasting.

The Netherlands television transmitter at Lopik operates in band I (61—68 Mc/s), all other transmitters in the Netherlands being planned to operate in band III.

The majority of TV stations in Europe have adopted the 625 line system and use FM for sound. The sound transmitters work on a frequency which is 5.5 Mc/s higher than the video carrier frequency.

2. *Power*

A range of transmitters with the following powers has been developed:

Video	Sound
Band I	
50 W drives 500 W	10 W → 100 or 250 W
50 W → 500 W → 5 kW	10 W → 250 W → 1 or 3 kW
50 W → 500 W → 5 kW → 25 kW**)	10 W → 250 W → 5 kW

*) Philips Telecommunication Industries, Hilversum - Netherlands.

**) Under development for Lopik.

Video	Sound
Band III	
50 W → 500 W	10 W → 100 or 250 W
50 W → 500 W → 5 kW	10 W → 250 W → 1 or 3 kW
Band II	
	10 W → 50 W *)
	10 W → 250 W
	10 W → 250 W → 5 kW
	10 W → 250 W → 10 kW

3. *Tubes*

The higher frequencies and the relatively high powers used necessitated the development of new types of output tubes. It proved possible to construct air-cooled tetrodes with an anode dissipation of 2.5 kW, i.e. type QBL 5/3500.

The use of tetrodes has the following advantages over the use of triodes:

a. low grid current, so small driver stage
b. high efficiency, because a fairly large driver stage can usually be omitted (e.g. an overall efficiency of 60 % for a 10 kW FM transmitter)
c. efficient and simple neutralizing, without the use of a grounded-grid circuit with its low efficiency
d. stabilizing the anode voltage of the RF output stage in the TV video transmitter to absorb mains voltage surges is not necessary
e. low grid current, so small video modulator for TV video transmitter.

4. *Design*

All transmitters are housed in separate, identical cabinets, thus permitting the installation to be extended in a simple manner. An example of this is the 5 kW T.V. transmitter. The 500 W preliminary stage is housed in a single cabinet and drives the 5 kW video output stage direct via a coaxial conductor. The 5 kW output stage has a separate power supply and modulator cabinet. This design permits a rapid change-over from the output stage to the preliminary stage, should the

*) Intended for FM link transmitter networks.

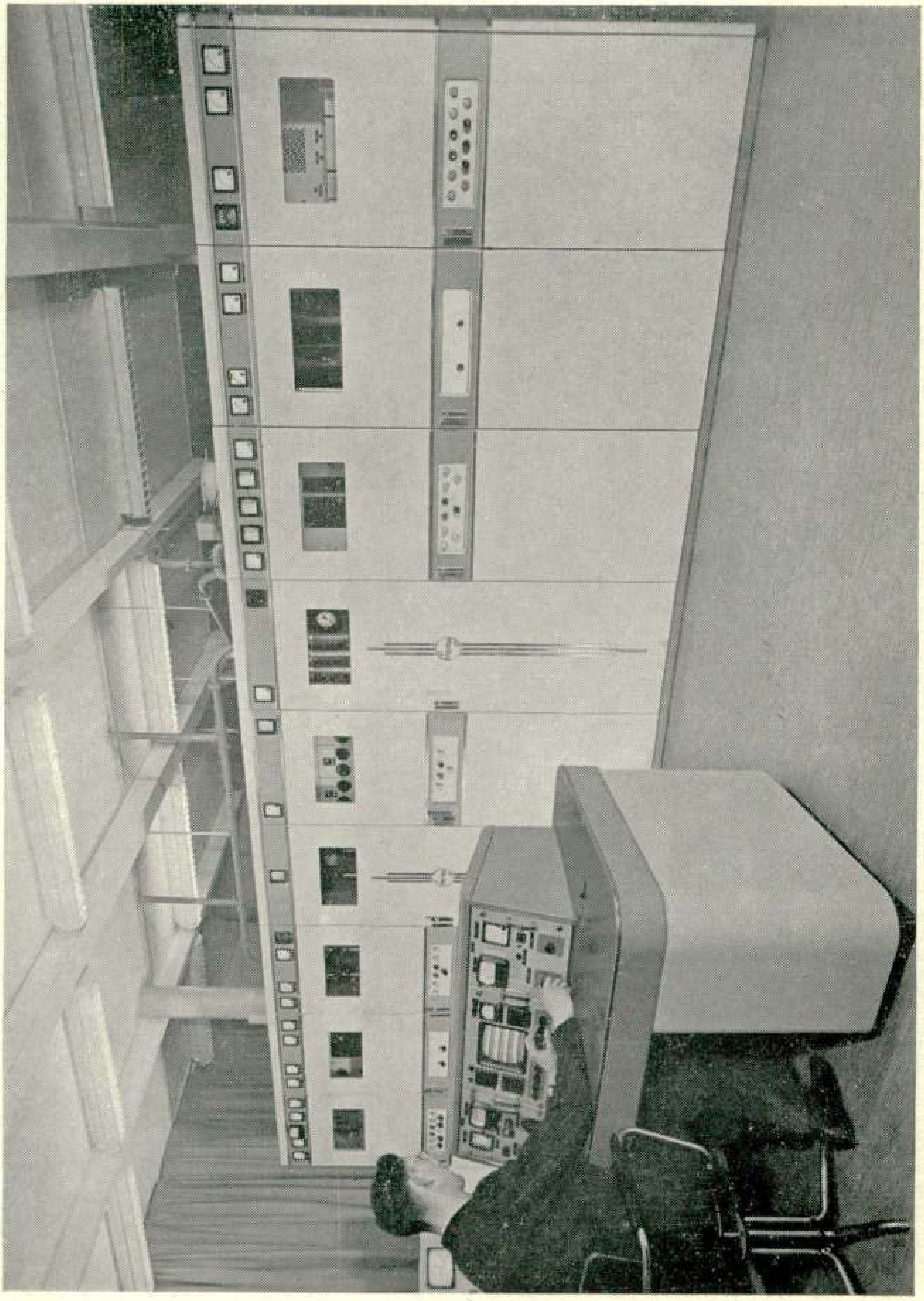


Fig. 1
5 kW TV video transmitter and 3 kW FM sound transmitter, band I.

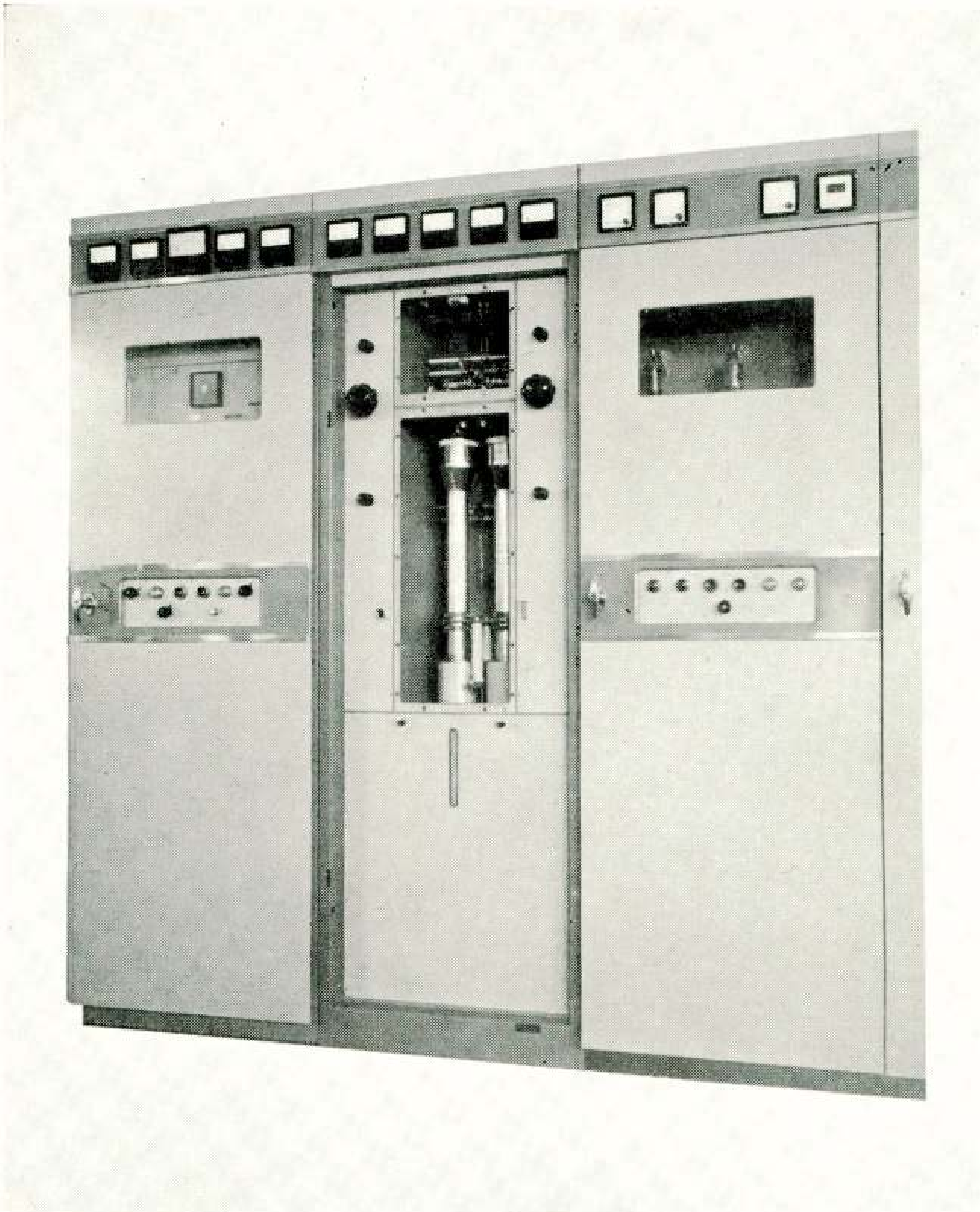


Fig. 2
5 kW FM sound transmitter, band II.

power stage develop a fault. It also permits changing over from the preliminary stage in operation to the stand-by preliminary stage, if a fault develops in the former.

Wherever space permitted, use was made of flat, vertical mounting plates, and chassis extending on telescopic runners were used in all other cases. Fig. 1 shows the front panels of the cabinets, mentioned above, six in number from the right.

Fig. 2 shows a 5 kW FM transmitter for band II. The left-hand cabinet contains the 250 W preliminary stage, the 10 W driver stage and the power supply unit. The centre cabinet houses the 5 kW output stage. The copper slug grid tuning circuit is visible at the very top. The right-hand cabinet accommodates the HT supply unit for the 5 kW output stage.

5. *Power supply*

All transmitters up to 1 kW are fed from single phase, 220 V $\pm$ 5 % AC mains, the transmitters with higher power being supplied from a 3-phase, 380 V $\pm$ 5 % mains. The normal mains frequency is 50 c/s and it is a simple matter to adapt the transmitter to 60 c/s mains.

5.1. Heater supply

The requirement with respect to hum to be met by TV video transmitters is only −45 db, a requirement that can easily be met by employing a Scott circuit or a slightly variable 3-phase mains supply (for 3 tubes in parallel), even with large directly heated filaments.

All tubes in FM transmitters with single phase supply are DC fed, including the indirectly heated tubes in the exciter. In particular the first tubes in the exciter (oscillator tube etc.) very soon give rise to FM hum, the requirement to be met being −65 db. The requirement for AM hum is −60 db, and this is easily met with the DC fed heaters, provided the other electrode voltages are sufficiently smoothed.

The heater rectifier consists of a transformer, a selenium rectifier and a choke. In the larger FM transmitters with 3-phase supply, only the heaters of the output tubes are Scott connected and AC fed, yet the hum requirements are met.

5.2. HT supply

The power supply units employed in the FM transmitters are of conventional design. Nearly all power supply units for the TV transmitters must be stabilized electronically, for the human eye is highly sensitive to small and rapid variations of the video signal amplitude. The RF signal amplitude corresponding to the black level must therefore be independent of mains voltage surges and also of the picture contents. This implies that the stabilizing factor be high and the internal resistance low (between 0 and 5 Mc/s).

Since the RF output tubes in the video transmitters up to 5 kW are tetrodes, it is not necessary to stabilize the anode voltage, provided they are not driven to maximum anode voltage.

The RF output tube in the 25 kW video transmitter is a triode, however, and the transmitter will therefore have a feedback circuit. The use of electrolytic capacitors has been avoided for all transmitters, the more reliable paper capacitors being used throughout. All transformers and chokes are housed in closed cans, an ambient temperature of 40 °C has been taken into account.

All transmitters are eminently suitable for use in tropical climates.

6. *Design of the RF circuits and method of bypassing*

For the larger tubes the RF anode circuits may be regarded as Lecher circuits where frequencies in band II and III are concerned. The same applies to the grid circuit of the 10 kW FM transmitter, incorporating 4 type QBL 5/3500 tubes, when used in band II.

For use in band III, it was necessary to lengthen the grid circuit by a $\frac{1}{4}\lambda$ open circuit, because the point of maximum current lies at the intake point of the tubes.

Fig. 3 illustrates the construction of the 5 kW TV video output stage for band III. The grid tuning circuit is seen in the upper section, the anode tuning circuit being shown below it. It is possible to make use of coils even in band III when less powerful tubes, e.g. up to 50 W (QQE 06/40), are employed. The tuning capacitance then consists merely of the tube and the parasitic capacitances with a series-capacitor, if any, to tune out the parasitic self-inductance. The circuit is tuned by means of 2 symmetrical, adjustable copper slugs in the coils.

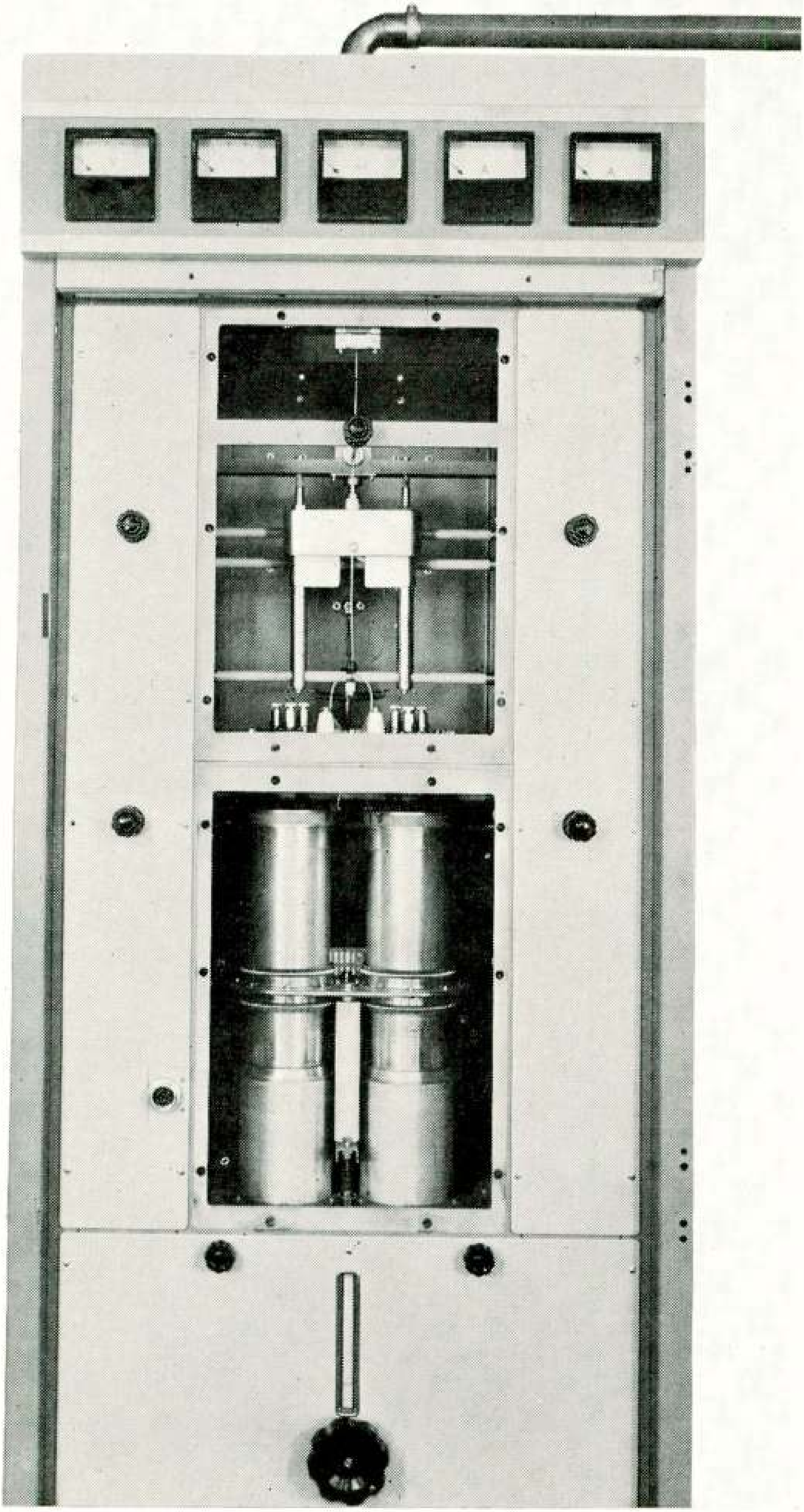


Fig. 3
Output stage 5 kW TV video transmitter, band III.

Coupling of the various cabinets is by means of coaxial cable for the low power transmitters and coaxial tubing for those of higher power. The outputs of the transmitters are usually balanced, the connection to the unbalanced circuit being made via $\frac{1}{4}\lambda$ loop or a balance-unbalance transformer (balun). This transformer is usually of the wideband type, capable of handling the entire frequency band. RF currents of high value flow through the shorting stub of the Lecher circuits and, consequently, the contacts must be well made. The shorting stub has a collar of sping contacts, and good contact is further ensured by an additional coil spring which keeps the spring contacts tight. The construction of the Lecher system is such that it can be moved in a vertical direction when the tubes require to be changed One electrode of the RF bypass capacitor is a metal plate, the other electrode being formed by the chassis. In view of the high temperatures, teflon is used as the dielectric. Both the heaters and the screengrids are RF bypassed by means of this capacitor, impedances of a sufficiently low value being thus obtained. A few paper capacitors are used to bypass the supply leads for video signals.

The circuits of RF output stages in video transmitters must be wideband. A slight drop in the frequency response curve is permissible since this results in higher efficiency and output power. This drop is easily corrected with the correction equipment before the video modulator.

7. *Frequency stability and the generation of frequency modulation*

The carrier frequency for the TV video transmitter is derived from a very stable crystal oscillator. The requirement to be met is: frequency deviation $\leq \pm 500$ c/s. The TV sound transmitter may be driven by the video transmitter oscillator by mixing the signal from the latter with a signal derived from a crystal oscillator (with about ten times lower frequency), or direct from a separate stable crystal oscillator which drives the frequency modulated exciter.

Frequency modulation in the FM exciters is accomplished in the following manner:

A type OA 71 germanium diode in series with a low value capacitor is shunted across part of the circuit of a coil oscillator. When the current flowing through the diode is varied, the impedance of the series capacitor and with it the frequency of the circuit varies. The current through the diode is then varied in AF rhythm. Naturally, the stability of the mid-frequency of the coil oscillator is insufficient and this frequency should be compared with the frequency of a crystal oscillator, which is 33 kc/s lower.

The difference frequency is generated in a hexode type mixer tube. A direct current, which drives the diode and thus keeps the difference frequency constant on the 33 kc/s discriminator frequency, is obtained via a limiter and a 33 kc/s frequency discriminator. Both the coil oscillator and the discriminator are temperature compensated. By the use of these a frequency stability of $\leq \pm 1000$ c/s can be achieved. The non-linear distortion for the entire transmitter when employing the method of modulation under discussion is $\leq 1\,\%$ between 30 and 15000 c/s, measured without de-emphasis network.

Synchronous AM	≤ -45 db (amplitude variation due to modulation)
FM noise	≤ -70 db, with pre- and de-emphasis network
FM hum	≤ -65 db, with pre- and de-emphasis network.

The FM exciters have their own built-in AF oscillator, which makes it possible to adjust the frequency deviation by means of the so-called "1st Bessel minimum".

8. *Amplitude modulation of the video transmitter*

The RF signal is multiplied and amplified between the crystal oscillator and the grid of the RF output tube, where modulation is accomplished. In television this is called high-power modulation. Contrary to high-power modulation, low power modulation is accomplished a few stages prior to the output stage. The amplifiers following the modulated stage must then be wideband linear (class B) amplifiers, giving rise to the understandable tuning difficulties. The modulator, however, can then be smaller. For powers up to 5 kW modulation is accomplished in the grid circuit of the output tube. The 25 kW transmitter consists of the 5 kW transmitter followed by a linear amplifier as otherwise the modulator would have to be very big indeed, particularly since the output tubes are triodes.

The video modulator of the 500 W transmitter and that of the 5 kW transmitter each comprise three amplifier stages only. The DC component is restored in a clamping circuit, operating on the back porch, in the grid circuit of the modulator output stage. Each line scanning period the back porch is brought to a fixed direct voltage level by means of clamp pulses derived from the trailing edge of the sync. pulse. The clamping circuit comprises 4 tubes and is connected direct with the input of the video modulator. This clamping circuit supplies very stable pulses, even in the presence of a good deal of noise and additional hum.

The grid of the RF output tube has a metallic connection with the anode of the modulator output tube via a video correction filter. The cathode of the RF output tube is thus at a high direct voltage, which gives the correct negative bias for this tube. With this method of DC restoration, the stability at black level is better than $\pm 2\%$ for mains fluctuations of $\pm 5\%$ and varying picture contents. The unmodulated RF preliminary stage must operate as a generator with a low internal resistance. For this purpose the grid circuit is damped with a low-inductance resistor. Variations in the grid current due to variations in the picture contents then have little influence on the amplitude of the RF signal.

The internal resistance of the modulator must also be low.

Both methods prevent deviations in linearity, and the nonlinearity of the entire transmitter is $\leq \pm 20\%$. The modulator output stage of the 5 kW video transmitter consists of 3 type QB 3.5/750 tubes with an anode resistance of 400 ohms, while the grid current of the RF output stage ($2 \times$ QBL 5/3500) is only about 30 mA mean current for a black picture.

9. *Vestigial sideband system for TV video transmitters*

In order to come up to the CCIR recommendations, which aim at the most favourable utilization of the available frequency spectrum, the lower sideband must be suppressed in accordance with a given curve. A vestigial sideband filter specially developed for this purpose is fitted at the output of the transmitter. The filter has both a high pass section and a low pass section. The power of the upper sideband passes through the high pass section and is applied to the aerial via a diplexer. The power of the lower sideband passes through the low pass section and is then dissipated in a 51.5 ohm resistor. The entire filter is constructed from coaxial tubing, tuning being effected by means of adjustable shorted tubing.

The losses in the filter give rise to so much heat, that the various elements, which may severely affect the tuning by their expansion, must be made of material with a low coëfficient of expansion, i.e. invar. Quite apart from this, it is still necessary to cool both the filter and the resistor by means of a blower.

The requirements met by the filter are:
Insertion loss for f_b = picture carrier ≤ 0.3 db,
Variation in loss between f_b and f_b + 5Mc/s $\leq$ 1 db,
Insertion loss f_b – 1.25 Mc/s and f_b – 5.5 Mc/s $\geq$ 20 db,
Standing wave ratio between f_b – 5 Mc/s and f_b + 5 Mc/s 1:1.15

10. *Diplexer*

The signals of the sound transmitter and the video transmitter can be led to a single aerial via a single feeder by the use of a diplexer. The diplexer prevents the video signals from penetrating into the sound transmitter, and vice versa.

It is a bridge type diplexer and also made of coaxial tubing, The filter must be wideband for the transmission of video signals. The power reflected by the various T stubs used is dissipated in resistors. The diplexer is also blower-cooled. Another type of diplexer has been developed, which permits the operation of two FM transmitters with a slight difference in frequency on one and the same aerial without interfering with one another.

The requirements met by the TV diplexer for use in band III are:

Insertion loss for picture carrier f_b	$\leq$ 0.1 db
Insertion loss for sound carrier	$\leq$ 0.3 db
Variations in loss between f_b – 1.5 Mc/s and f_b + 5 Mc/s	$\leq$ 3 db
Loss between video input and aerial output for f_b + 5.5 Mc/s	$\geq$ 29 db
Crosstalk attenuation from video to sound for f_b – 0.75 Mc/s to f_b + 6 Mc/s	$\geq$ 30 db
Standing wave ratio for video input	$\leq$ 1 : 1.1
Standing wave ratio for sound input	$\leq$ 1 : 1.3

11. *Harmonics and adjacent frequencies*

The adjacent frequencies have been successfully suppressed to very low values by making use of bandpass filters in the preliminary stages, if necessary, and by loop coupling (magnetic transfer only). Proper screening of the RF output stages prevents spurious radiation. The use of a high oscillator frequency

(5 – 10 Mc/s) is also advantageous. A harmonic suppression filter has been developed for use in FM transmitters. This filter suppresses the 2nd, 3rd and 4th harmonics to an adequate degree. Its properties are:

Maximum power: 10 kW

Standing wave ratio: better than 1:0.85 (Z_0 being 51.5 Ω)

Suppression: 60 db at resistance load.

Frequency: 87.5 – 108 Mc/s.

The use of this filter permits the suppression of the harmonics and adjacent frequencies to considerably less than 1 mW.

12. *Monitoring of transmitters*

An FM receiver is coupled with the output of the FM transmitters. This FM receiver is also entirely constructed of coaxial tubing and operates without thermionic tubes. A monitoring amplifier is connected with the receiver to permit a check on the properties of the transmitter. Reflectometers make it possible to measure both the forward power and the reflected power.

A picture monitoring receiver is coupled with the output of the video transmitters. The picture monitoring receiver for band I consists of coils and that for band III of tuned coaxial tubing. These receivers have a phase and amplitude curve corresponding with those of normal commercial receivers. The transmitters are aligned with the help of these monitoring receivers, a video sweep generator (0 – 10 Mc/s) and square wave signals (repetition frequency 312.5 kc/s). The various test signals are supplied by a separate test signal generator. The video transmitter is provided with several other monitoring points, e.g. in the modulator. Either a picture monitor or an oscilloscope may be connected to these points.

13. *Control desk TV transmitters*

The control desk contains two picture monitors for checking both the input and the output of the transmitter. The output of the stand-by link receiver may also be monitored.

The FM sound transmitter is checked with the help of a monitoring amplifier. The control desk has been kept as simple as possible, the more involved checks being made from the control cabinet. The various monitoring points are led out to this cabinet, which also has facilities for connecting the test signal generator etc.

14. *Video correction equipment*

The majority of the imperfections of the TV video transmitter can be corrected at video level at the transmitter input. To this end, a number of correction devices have been developed, which will also remedy any faults in the incoming video signal. The transmitter, particularly the RF output stage with the vestigial sideband filter and the monitoring receiver, has a fairly large phase error. This error is remedied with a phase correction filter. This is an all-pass network providing sufficient pre-correction to overcome the phase lag of the transmitter + monitoring receiver.

The RF output stage has a slight response drop for the higher video frequencies and a few small phase errors resulting from it. These can also be remedied by means of pre-correction. A phase and amplitude corrector, operating on the principle of the "derivative amplifier", has been developed for this purpose. The phase and amplitude corrector permits the addition of the 1st, 2nd and 3rd derivatives of the video signal, with such magnitude and polarity that the fault in the amplitude characteristic is removed. The proper phase pre-correction is accomplished automatically. The modulator and RF output tubes give rise to a few linearity errors, resulting in black and sync pulse compression. A stabilizing amplifier has been developed, the output sync. pulse of which is variable and which permits pre-correction of the linearity (gamma correction).

A white-clipper has been built into this stabilizing amplifier to prevent the transmitter from being modulated more than 90 %, since special requirements have to be met with regard to the use of the intercarrier sound receivers.

The stabilizing amplifier also remedies the following faults of the *incoming signal:* additive hum up to about 25 %, AF faults up to 25 % for 50 c/s square waves, too small a sync/signal ratio up to 5/95 %. It sometimes happens that the noise in poor link connections is excessively high, e.g. 20 %, while the sync. signal ratio has decreased to e.g. 5/95 %.

The use of the stabilizing amplifier then makes it possible to supply proper sync. pulses with a 40/60 % ratio, yet the "streakiness" due to noise is low.

The video voltages in this correction equipment are relatively low. The equipment is also used in link connections subjected to severely fluctuating mains voltages. For this purpose the psu's are electronically stabilized and have an extremely high stabilizing factor.

15. *Test signal generator for TV video transmitters*

A test signal generator has been developed suitable for testing the video transmitter. The test generator supplies the following signals mixed into the complete sync. signal:
50 c/s square wave synchronized with the frame frequency
62.5 kc/s square wave synchronized with the line scanning frequency
312.5 kc/s square wave synchronized with the line scanning frequency rise time $\leq$ 0.05 μsec
line saw tooth synchronized with the line scanning frequency.
This saw tooth can be varied with constant peak value in such a manner, that various picture contents are simulated.

A 4 Mc/s signal may be mixed in additively. When the signals have passed through the equipment under test, all frequencies lower than 4 Mc/s are filtered out. The linearity deviation can then be accurately measured and the gamma correction, for example, adjusted. Video sweep signal of 0—10 Mc/s $\pm$ 1 db with markers at 2.5-5- 7.5 and 10 Mc/s, and a repetition frequency of 50 c/s.

The sync. signals meet the CCIR recommendations and may either be free running with crystal control or mains synchronized.

16. *Aerials*

The choice of the right aerial makes it possible to acquire a high ERP on these short waves with restricted transmitter power. The aerial gain is obtained through focussing in the horizontal plane.

A super turnstile aerial has been developed for use in band I. A section of this type of aerial consists of two systems of vertically mounted dipoles, fed in such a way that the band width suffices for at least one channel. A number of these sections may be stacked. With 3 stacked sections the gain is about 3.5. The standing wave ratio is better than 1 : 1.1 for one channel. A helical aerial has been developed for use in band II. This aerial consists of a vertically placed cylinder, from the centre of which run two helices at a given spacing, one clockwise and the other anti-clockwise.

The aerial is centre-fed by means of a single feeder. These helical aerials may also be stacked to obtain a higher gain.

The gain of one section is about 5, the standing wave ratio being 1 : 1.1.

An aerial of the same type, having the same properties, has been developed for use in band III.

17. *Change-over in case of break-down*

TV transmitters are so intricate, that it has not been possible as yet to use them unattended. Therefore the transmitters have been provided with facilities for manual change-over to reduced-power operation, i.e. change-over to the preliminary stage. A manually operated coaxial switch for a power carrying capacity of 20 kW has been developed for this purpose. A motor-driven coaxial switch can be supplied for use with unattended FM transmitters. The transmitter may also be switched to a 5 kW or 20 kW water-cooled loading resistance.

Various FM transmitters will be supplied for use in unattended stations. Such a station will house two complete 5 kW FM transmitters to relay the Hilversum I and II programmes. Each transmitter has a 250 W stand-by preliminary stage. When the output stage develops a fault, a change-over to the 250 W preliminary stage is made. In the case of a fault developing in the preliminary stage in use, a change-over is made to the stand-by preliminary stage. The entire change-over procedure is effected automatically by means of a so-called robot. This robot consists of a number of relays, which are controlled by the output of the various reflectometers (output meters). A number of precautionary measures have been embodied in the robot — and in the transmitter proper — which prevent a change-over to the loading resistance from being made when the water-cooling is not on.

The robot itself may be controlled remotely, and it may be used to switch transmitters on or off remotely. The robot may be switched out of circuit and the various change-overs made remotely. The prevailing situation is shown by means of pilot lights. Five twin conductor wires are required for remote control. A single twin conductor wire suffices when a multiplexing circuit, operating on either direct current or voice frequency pulses, is used.

Boekbespreking

"A Treatise on Electricity and Magnetism", by James Clerk Maxwell. Unabridged Third Edition; Two volumes bound as one. Dover Publications, Inc. 1954, 1006 pag., 13 x 20 c.m., 122 fig. Prijs $ 4,95.

De "Dover Publications, Inc." liet een onveranderde afdruk verschijnen van het bekende en beroemde werk van James Clerk Maxwell: „A Treatise on Electricity and Magnetism". Het betreft de derde druk, zoals deze in 1891 verscheen.

Maxwell, die in 1879, op 48-jarige leeftijd, overleed heeft reeds het verschijnen van de tweede druk, die in 1881 van de pers kwam, niet meer beleefd.

Het mag wel als volmaakt overbodig, zelfs als ongepast worden beschouwd een bespreking aan dit werk te wijden.

Het ware te wensen, dat de heruitgave van dit grote werk van Maxwell, mede door de lage prijs, in handen zal komen van physici en ingenieurs. Het is schrijver dezer regelen bekend, dat er onder de laatsten velen zijn, die degenen onder hen, die de werken van Maxwell en van Heaviside bestuderen, als verloren voor het vak beschouwen.

Hiertegenover moge worden gesteld de uitspraak, die op de omslag van de nieuwe uitgaaf voorkomt: as an educator Maxwell contended that "science is most easily digested in its nascent state". Certainly his own original research papers make many of the ideas of electricity, magnetism, optics and mathematical physics clearer than the hundreds of secondary tests and treatises covering the same ground.

J. P. S.

NIEUWE UITGAVEN

De redactie ontving de volgende nieuwe uitgaven:
Computer Development (SEAC and DYSEAC) at the National Bureau of Standards.
Elsevier's Dictionary of Television, Radar and Antennas door W. E. Clason.
Deze uitgaven zullen in een der volgende nummers besproken worden.

FLUG-, WETTER-, UND ASTRO-FUNKORTUNGSTAGUNG

Van 1—4 Juni had te München de Funkortungstagung plaats in het Deutsches Museum.

De opkomst voor dit congres was groot, het deelnemerstal beliep boven de 700, van wie het merendeel uit Duitsland. Vele sprekers waren uitgenodigd om de drie dagen met een veertien lezingen per dag te vullen, over onderwerpen waarbij de electronica een grote rol speelt. We noemen hiervan onder meer automatisering van het vliegen, landen en plaats bepalen, uitbreiding van de grond-contrôle, weersbepaling door middel van radar etc.

Van Air France kwam een verslag over proeven genomen met semi-automatisch en volautomatisch aanvliegen op de landingsbaan. De apparaten hiervoor gebruikt, vergemakkelijken het landen voor de piloot aanmerkelijk en maken een nauwkeuriger koershouden mogelijk. Het bleek ook mogelijk om het landen zelf aan een electronisch apparaat over te laten. Om dit laatste aan alle eisen van veiligheid te laten voldoen wordt echter de installatie zo kostbaar, dat het de vraag is of dit economisch verantwoord is.

Société Radio Air gaf een overzicht van de ontwikkeling en mogelijkheden van het Radio WEB systeem voor plaatsbepalen. Met een systeem van vier zenders is het mogelijk om zowel in het vliegtuig als op de grond de plaats van het vliegtuig automatisch te bepalen en aan te geven op een kaart of een kathodestraalbuis. Het automatisch navigeren behoort hiermee ook tot de mogelijkheden.

Op London-Airport is een 8 mm Decca-radar geïnstalleerd om een overzicht te hebben van het vliegveld. Tijdens de voordracht over deze installatie werd een foto van het radarbeeld getoond. Het beeld is zo gedetailleerd, dat de vorm van een vliegtuig te herkennen is. De startbanen zijn duidelijk te zien, terwijl ook mensen en auto's door de sterkte van de echo's te onderscheiden zijn.

Bendix Aviation kwam met een beschrijving van een vliegtuig radar om centra van slecht weer op te vangen. Tevens geeft het radarscherm een beeld van de bodem waarover gevlogen wordt en de richting van Racon bakens. Het radarapparaat werkt zowel in de 3 als in de 5 cm band.

Compagnie Française Radioelectrique en Compagnie Generale de Telegraphie Sans Fils gaven in samenwerking met de Duitse en Franse posterijen een demonstratie van de overdracht van een radarbeeld via televisie van Parijs naar München. De bovengenoemde Maatschappijen hebben een „storage tube" ontwikkeld waarin het radarbeeld aan één zijde van een inwendig scherm opgebracht en aan de andere zijde voor het televisiebeeld afgetast wordt.

Prof. Meinke, Hoogleraar aan de Technische Hogeschool te München, ontwikkelde een storage tube, waarmee het mogelijk is om de bandbreedte, benodigd voor een radarbeeld, sterk te comprimeren. Tevens wordt bereikt, dat de signaalstoorverhouding aanzienlijk vergroot wordt.

De firma Pintsch gaf een demonstratie hoe met deze buis het radarbeeld met 6 kHz bandbreedte overgebracht kan worden.

Van de firma C. Plath kwam een beschrijving van een methode om peilingen met een kruisraam te verrichten bij het optreden van het nachteffect.

Van Nederlandse zijde werd door F. C. Bik van de K.L.M. een voordracht gehouden over „Barometrische navigatie bij transatlantische vluchten en contrôle daarop met behulp van electronische en astronomische plaatsbepaling."

Alle gehouden voordrachten zullen t.z.t. in druk verschijnen.

A. D.

JOURNÉES INTERNATIONALES DE CALCUL ANALOGIQUE TE BRUSSEL

Van 27 September tot 1 October 1955 zal in Brussel een Congres gehouden worden, gewijd aan de Analogiemachines, hun principes en wetenschappelijke en industriële toepassingen. Het Congres wordt georganiseerd door de S.I.T.E.L. (Société Belge des Ingénieurs des Télécommunications et d'Electronique) in samenwerking met enige andere Belgische Genootschappen.

Er zullen een 7-tal „Conférences" gehouden worden van ca 1 uur, alsmede een 50-tal „Communications" van ca 1 kwartier.

De „conférences zijn:

„Problèmes de simulation" (titre provisoire)
M. J. BRODIN (Laboratoire Central d'Armement - France)

„The mechanical differential analyser, recent development, applications"
M. S. EKELÖFF (Chalmers University of Technology - Sweden)

„Network Calculators" (provisional title)
M. E. L. HARDER (Westinghouse El. Corp. - U.S.A.)

„Resistance Network analogues"
M. G. LIEBMANN (Associated Electrical Industries - Great-Britain)

„La méthode d'analogie rhéoélectrique; ses possibilités et ses tendances"
M. L. MALAVARD (Université de Paris - France)

„Analyseurs différentiels électroniques" (titre provisoire)
M. F. H. RAYMOND (Société d'Electronique et d'Automatisme -France)

„Special Calculators" (provisional title)
M. H. WALLMANN (Chalmers University of Technology - Sweden)

Tijdens de conferentie zal een tentoonstelling gehouden worden van apparaten, die van belang zijn voor de gebruikers en constructeurs van analogiemachines.

Men kan zich tot 15 Augustus voor de Conferentie aanmelden. De inschrijvingskosten bedragen 300 Belgische francs. Men wende zich tot:

M. R. PERETZ, ingénieur A.I.Br., Secrétaire du Comité d'Organisation
50, avenue Fr. Roosevelt, Brussel.

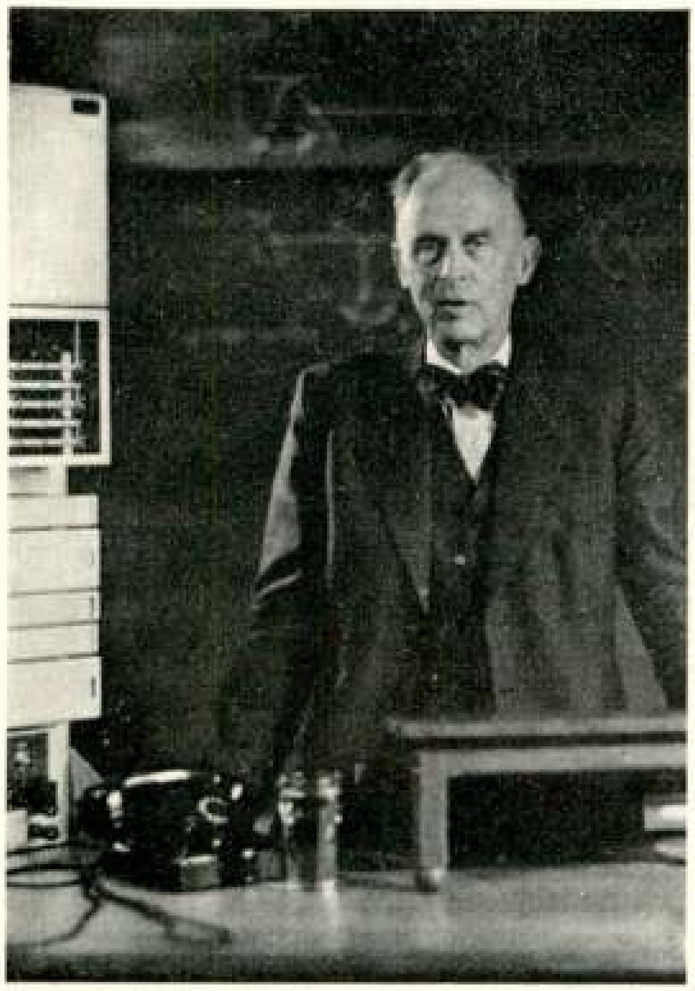
Uit het Nederlands Radiogenootschap

PERSONALIA

H. RENS †

Het Bestuur brengt met leedwezen ter kennis van de leden dat de Heer H. Rens, directeur van de Middelbaar Technische Radioschool te Hilversum, op 30 April j.l. is overleden. Namens het Nederlands Radiogenootschap werd de begrafenis te Hilversum bijgewoond door de voorzitter van de Examencommissie, Ir P. H. Boukema.

JUBILEUM VAN PROF. Dr Ir W. TH. BÄHLER



Op 20 Mei j.l. was het vijfentwintig jaar geleden, dat Prof. Bähler het hoogleraarsambt aan de Technische Hogeschool te Delft aanvaardde met zijn inaugurele oratie over „Automatische Telefonie".

Vele leerlingen, oud-assistenten, collega's, vrienden en belangstellenden waren tezamen in de grote collegezaal van het gebouw voor Technische Physica om getuige te zijn van en in te stemmen met de vriendelijke en van respect en waardering getuigende woorden, die tot de jubilerende hoogleraar en zijn echtgenote, in tegenwoordigheid van hun beide zoons en echtgenoten werden gericht.

De Voorzitter van de Afdeling voor Electrotecniek der Technische Hogeschool, Prof. Ir W. Fontein, richtte als eerste spreker het woord tot de jubilaris. Na de grote verdiensten van Prof. Bähler als docent en als vakman en zijn scherpe, speelse geest in het licht te hebben gesteld, bood Prof. Fontein, als voorzitter van het comité, dat de samenkomst voorbereidde, namens oud-leerlingen, collega's en vrienden de jubilaris mèt zijn gelukwensen, een fraai muziekinstrument, een cello aan. De President Curator der Technische Hogeschool reikte daarna, mèt vriendelijke en waarderende woorden, aan Prof. Bähler het bekende T.H.-symbool, de brandende fakkel, uit.

De president van de Electrotechnische Vereniging sprak namens de studenten en overhandigde een album met portretten van promovendi, oud-leerlingen, oud-assistenten enz.

De president van de raad van beheer van het Koninklijk Instituut van Ingenieurs, Dr L. Neher, sprak namens dit instituut en zegde hem o.m. dank voor het grote aandeel, dat hij nam bij het tot stand komen van de afdeling voor Electrotechniek van het instituut

Als laatste spreker trad Ir W. H. van Zoest, als oudste en eerste assistent van Prof. Bähler naar voren. Uit zijn woorden bleek duidelijk met hoe groot enthousiasme, nu vijfentwintig jaar geleden, de jonge docent Bähler met zijn eerste assistent en zijn trouwe medewerker L. S. van Wijk aan het werk zijn getogen. Hij bood Prof. Bähler aan het slot van zijn toespraak een strijkstok voor de cello en nog een album aan.

De hoogleraar betrok in zijn dankwoord allen, die hem hielpen en hem de gelegenheid gaven zijn onderwijstaak en onderzoekingen geheel zelfstandig te verrichten. Hij herdacht in het bijzonder wijlen Prof. Elias, die hem de Technische Hogeschool binnenleidde.

Een druk bezochte receptie, die de vele aanwezigen de gelegenheid bood de jubilerende hoogleraar en zijn echtgenote de hand te drukken, besloot de bijeenkomst.

J. P. S.

VERGADERINGEN

Sinds het verschijnen van het vorige nummer hadden de volgende vergaderingen plaats:

18 Mei te Den Haag. Spreker: Ir J. L. Bordewijk over: Faze-draainetwerken en enkele toepassingen daarvan in de transmissietechniek, en Ktz. b.d. J. Houtsmuller met als onderwerp: Propagatie eigenschappen van metergolven op niet te grote afstand van de zender.

17 Juni te Eindhoven. In samenwerking met de Geluidstichting werden op 17 Juni te Eindhoven lezingen en demonstraties betreffende magnetofoons gehouden.

Sprekers waren:

Dr W. K. Westmijze: Principe van de magnetische registratie.
Ir G. Bakos: Mechanische constructie van magnetofoons.
Dr J. J. Geluk: Gebruik en toepassing van magnetofoons.
Ir R. Vermeulen: Geluidsreproductie met magnetische registratie.

WERA EXAMENPRIJS

DE WERA examenprijs van het Wetenschappelijk Radiofonds Veder voor bijzondere prestaties bij het radiotechnicus examen is voor de voorjaarsexamens toegekend aan de Heer C. W. H. van Huystee, Paulus Potterlaan 13, Bilthoven.

NIEUWE LEDEN

Ir J. V. Bolier, v. Kretschmar van Veenlaan 96, Hilversum.
A. S. van den Bosch, Genemuidenstraat 189, Den Haag.
Dr B. G. Dammers, Valkenswaardseweg 25, Aalst N.B.
Ir A. Delsman, Laan van Vogelenzang 12, Hilversum.
Dr H. Groendijk, St. Jansweg 6, Eindhoven.
A. de Jong, Borneostraat 24, Den Haag.
Ir A. J. van der Ploeg, p.a. Thermion N.V., Lent (bij Nijmegen)
Ir K. Rodenhuis, Guido Gezellestraat 40, Eindhoven.
Dr J. G. van Wijngaarden, Griendstraat 47, Geldrop.

VOORGESTELDE LEDEN

Ir A. C. H. Borsboom, Graaf Florislaan 9, Hilversum. (PTI)
Ir A. Bijl, Frits Ruysstraat 20B, Rotterdam (O.). (Lab. Kon. Shell)
Ir L. Ongkiehong, Apollolaan 175[3], Amsterdam Z. (Lab. Kon. Shell)
Ir T. Poorter, Pieter Huyssensweg 20, Eindhoven. (Philips)
Ir G. Radstake, Piet Heinstraat 21, Den Haag. (PTT afd. O.T.)
Dipl. Ing. J. L. Roulet, Hertesprong 18, Eindhoven. (Philips)

NIEUWE ADRESSEN VAN LEDEN

Ir J. C. Buis, Diependaalse Drift 29, Hilversum.
Ir J. Domburg, Poirterslaan 13, Eindhoven.
Prof. dr C. J. Gorter, Burggravenlaan 3, Leiden.
Ir L. A. W. v. d. Lek, Laan van Nieuw Oost Einde, Voorburg.
Ir C. J. Pluygers, Sportlaan 710, Den Haag.
Dr P. Schagen, 5 Sylvan Way, Redhill, Surrey, Engeland.
Ir M. J. Vermeijden, Javalaan 38, Hilversum.
Ir Th. J. Weyers, Javalaan 40, Hilversum.
