Characteristics measured
under working conditions

Frequency band:
from 160 to 190 kc/s (present operating frequency 164 kc/s)

R.F. stability:
10^{-6}

Output power:
250 kW (carrier)

Efficiency:
54.1 % in carrier operation (Power factor 0.94)

A.F. input impedance:
600 ohms

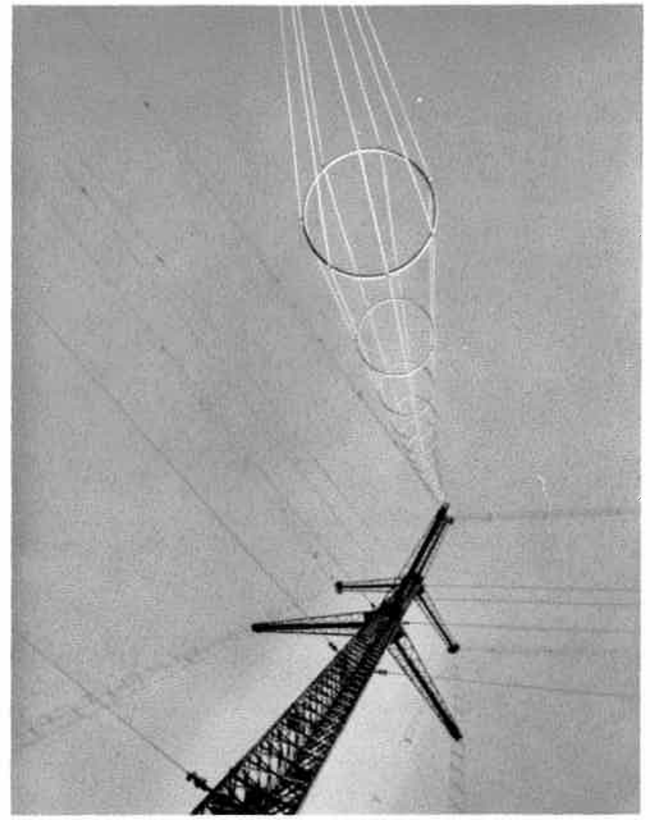
Input level:
0.775 V in 600 ohms,
for 100 % modulation at 1,000 c/s

Frequency response curve:
flat,
to within 1 dB from 100 to 8,000 c/s
2 dB from 30 to 10,000 c/s

Harmonic distortion:
less than 2 % from 30 to 4,000 c/s

Back-ground noise:
-61 dB with respect to a level corresponding to
100 % modulation depth at 1,000 c/s

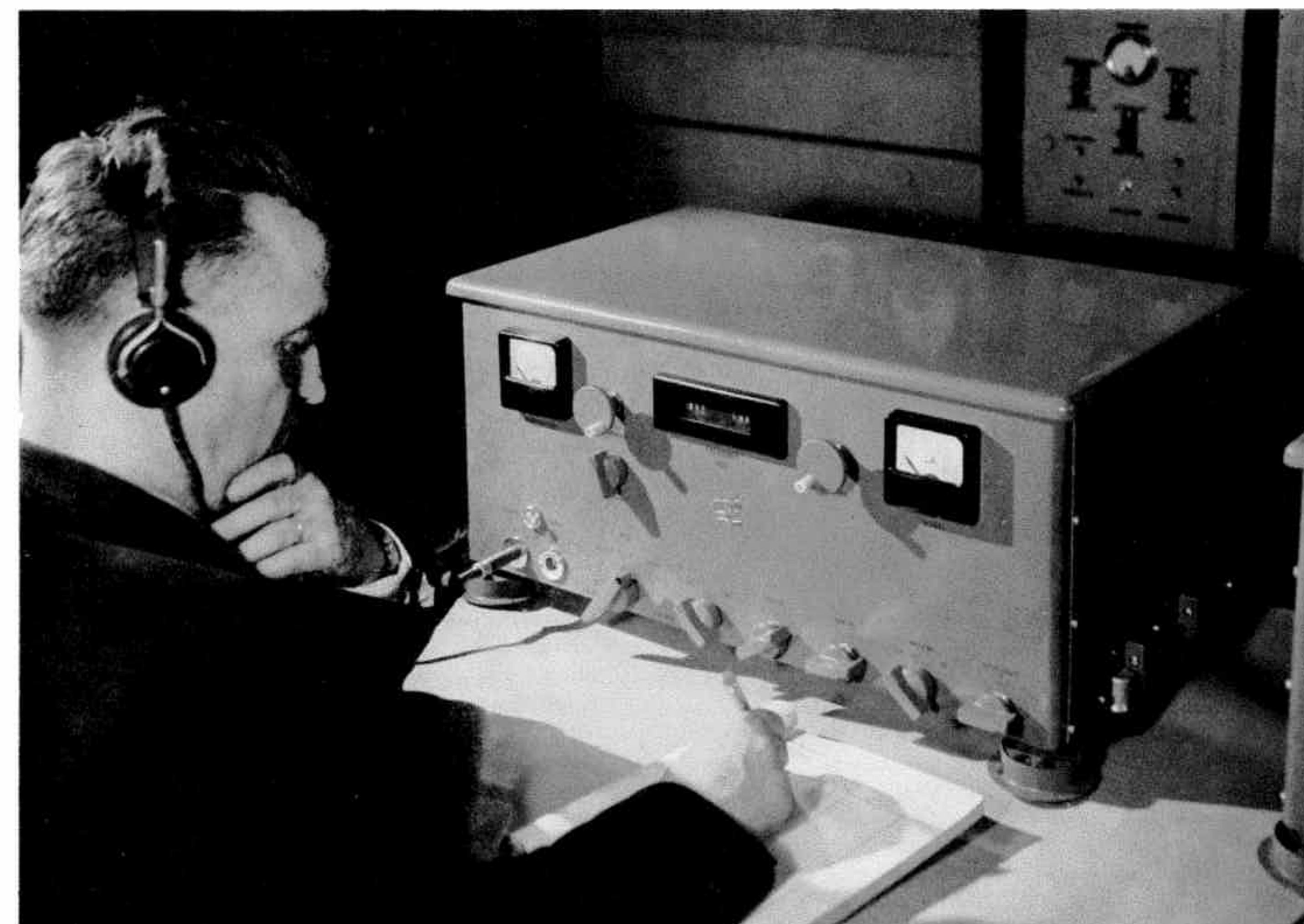
Drop in carrier:
3 %
between carrier operation and sustained modulation
of 100 % at 1,000 c/s



" French Industry is to be congratulated over this fine development and I would be the last to fail to include in these congratulations the engineers and technicians of all ranks, in the Administration as well as in Industry, who collaborated as a team and hand in hand in the execution of this very fine national undertaking ".

Extract from the speech by General Leschi, Director of the Technical Services of " Radiodiffusion et Television Françaises ", given out over the microphone on the 19th of October 1952, on the occasion of the opening of the Allouis transmitter.

THE "STABILIDYNE" RECEIVER
OPENS NEW FIELDS IN RADIOCOMMUNICATIONS



Introduction

It is well known that decametric waves provide long distance radio connections using quite moderate power at the transmitter.

As the laws of propagation of these waves became better understood and forecast of reliable connections could be made with a higher degree of probability, their use over the last 30 years has shown a considerable advance. They enabled increasing needs of continental and inter-continental connections to be almost completely satisfied.

Progress recently made in the use of shorter waves, metric and centimetric, enables a part of the traffic to be passed over radio-links. But these very short waves, whose propagation is comparable to that of light rays, have a practical limit in range and will not entirely replace those of the decametric band, in many cases better able to ensure connections at medium and long range without the need for large installations.

The problem of setting up a maximum number of stations within that band becomes daily more acute. It frequently initiates research aiming principally at the narrowing of the band occupied by each transmission and its optimum utilisation, i. e. the transmission of the greatest possible " quantity of information ". But the result of this tendency is that, the waves of the various stations being closer together, the transmitters and receivers must be rigorously adjusted to the frequency assigned to them, under the penalty, for the former, of interfering with neighbouring waves and, for the latter, of receiving a transmission other than that intended for them.

The problem of frequency stability in permanent links has long been solved, by the use of piezo-electric quartz crystals at the transmitter as well as at the receiver.

The frequencies necessary for a reliable service, under various propagation conditions, having been allocated, it is then only necessary, in order to obtain the required stability, to fit each terminal station with a few crystals cut to suit these frequencies.

But difficulties arise as soon as *temporary connections* are being considered, this being particularly the case in most military applications in which frequencies cannot be fixed in advance and must be capable of being changed to suit the needs of the moment. Moreover because of their mobility, Armies and Navies in operations must have quickly available working links at all levels of command.

These conditions cause such network complications that certain stations are required to cater for forty distinct two-way connections, which means that each of them requires a complement of twenty four crystals. When, for technical or tactical reasons, the frequencies initially allowed for have to be changed, the crystals must be replaced *in every station* : supply delays so retard the operation that it is often necessary to set up mobile crystal-cutting workshops.

Besides the stabilised networks provided in the plan of Army operations, it is essential that receivers be allocated for *keeping watch* on foreign networks on any frequency in the band. Continuous exploration of this band must be possible; it is most important that such apparatus be provided with a tuning adjustment which can be read with sufficient precision to make it possible not only to keep watch but also to locate and identify any unknown transmissions. Generalised use of automatic high speed traffic imposes in addition that these receivers be sufficiently stable for recording by teletype all messages received.

Our company has carried out continuous research in that direction.

Encouraged by a Committee of the C.C.T.U. which met under the initiative of the French Navy with the particularly effective co-operation of the Technical Services of the three Arms and of the P.T.T., the company succeeded in developing on a new principle *equipment solving the problem*, in particular for connections of a temporary character. It is no exaggeration to say that, in this particular domain, apparatus based on this principle opens up a new era by the great flexibility which it offers while meeting the conditions of stability imposed by the latest International Conferences and those which can be anticipated from the next Conference.

The stability of the new equipment, in any frequency within the band, is comparable to that of quartz crystals.

The Stabilidyne thus provides a service equivalent to that of a receiver fitted with an infinite number of crystals. The only operation necessary, as simple as the dialling of a number on a telephone-dial, is the setting up on a *decimal counter* of the frequency of the wave to be received.

The advantages of quartz crystals are thus retained, but the attendant restrictions are completely eliminated.

The object of the pages which follow is to describe the means by which this advance has been made and the evolution which can be expected in radio-communications.

Mr. COLAS
Engineer, Receiving Equipment Branch

Evolution of stabilisation processes

From the earliest days of telecommunication on short waves, frequency stabilisation figured among the main difficulties to be overcome.

An important advance was at first made by means of master-oscillators at the transmitter, R.F. amplifiers, and, later, superheterodyne receivers at the receiving end, the increasing number of stations imposing a greater degree of selectivity.

Later, piezo-electric crystals appeared. Their use, generalised at the transmitter master oscillator as well as at the local oscillator of superheterodyne receivers, provided adequately stable connections. It was thus possible to utilise within the band a maximum number of connections, the sole limitation being that due to the band-width occupied by each transmission and the real selectivity, in transient conditions, of the receiver filter circuits. But the networks so established had lost all flexibility; it was therefore important to devise a process of stabilisation which, while maintaining the acquired reliability of the network, gave it back all the desirable flexibility. This has been obtained by the application of the " stabilidyne " principle.

Principle of the Stabilidyne

In a normal superheterodyne consisting essentially of a mixer, a local oscillator and an I.F. amplifier, the frequency of the oscillator is adjustable and the I.F. amplifier is tuned to a fixed frequency. Thus, to cover a continuous band from 2 to 30 Mc/s, with an I.F. fixed at 1 Mc/s, (1) the oscillator frequency must be continuously adjustable between 3 and 31 Mc/s. Instability of tuning is therefore almost entirely due to the local oscillator (see fig. 1).

There is another mode of operation in which the local oscillator is fixed and the I.F. variable. In this case, to cover the same band (2 — 30 Mc/s) with an I.F. varying continuously from 1 to 2 Mc/s, the frequency of the oscillator will need to be adjusted by successive 1 Mc/s jumps between 2 and 29 Mc/s, i.e. on 28 increasing fixed frequencies; continuous variation of the I.F., made at each jump, will provide full cover over the band (see fig. 2). If each one of those 28 fixed frequencies is stabilised by a separate crystal, instability of adjustment will bear only on the fraction corresponding to the variable I.F.

Relative to the first mode of operation (fig. 1) *stability will be improved from 1.5 to 28 times* depending on the particular point in the band.

In order to improve stability still further it is clear that the variable frequency must be reduced, the continuous variation of the amplifier must also be reduced and the number of successive jumps of the local oscillator frequency increased. Thus, with an I.F. varying from 100 to 200 kc/s, the frequency of the oscillator will have to be adjusted to 279 fixed successive values, in order to cover the 2 — 30 Mc/s band continuously. The stability so obtained will then be *from 10 to 100 times better*, according to the particular point in the band, than for the first mode of operation (see fig. 3). In the first example the 28 fixed frequencies can be stabilised by means of 28 crystals brought into use in turn.

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(1) Values given only for comparison with the following example (fig. 2).

In the designs already established on this principle, the number of crystals have been reduced by utilising their harmonics. Experience shows that it is possible to use as few as 14 crystals instead of 28; but the impossibility of adequately filtering the highest harmonics sets a limit in this direction.

Thus in an arrangement comprising four crystals operating on their harmonics 2, 5 and 7 very troublesome interference arises.

It was clearly impossible to apply the same circuit in the last example given, the 279 fixed frequencies could not be stabilised by 279 crystals, for reasons of size and cost.

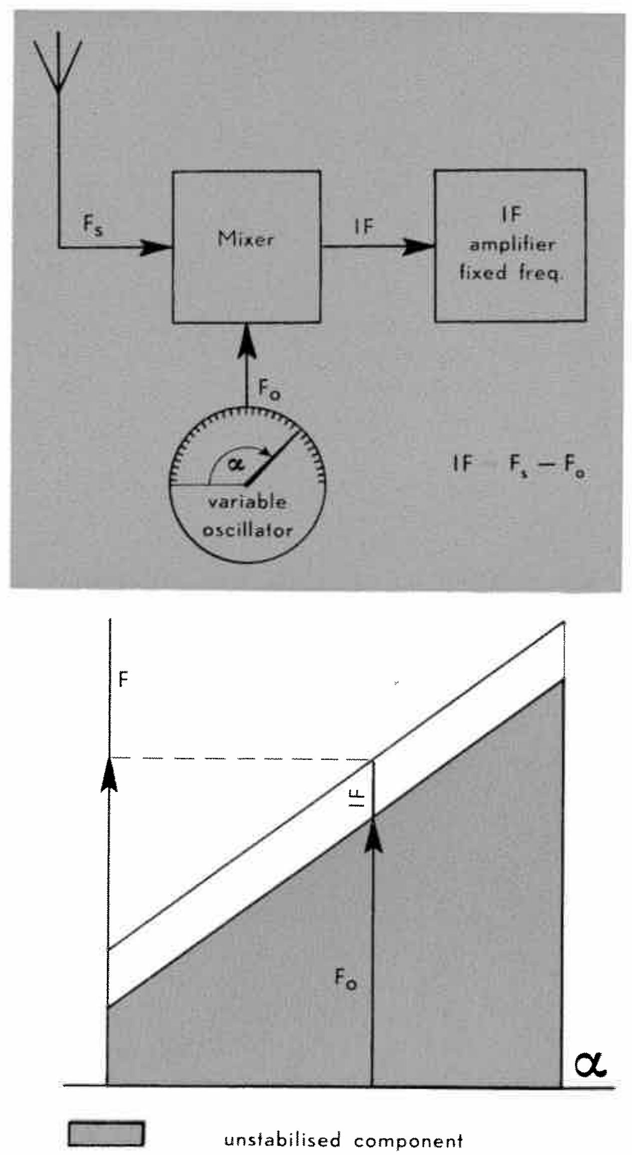


fig. 1

The stabilidyne principle uses a single 100 kc/s crystal with selection of 279 harmonics, stepped at intervals of 100 kc/s, without interference in reception.

This result is attained by the addition to the receiver described previously (fig. 3), of a superheterodyne circuit whose sole function is to select the frequencies; this is readily done by means of its I.F. filter, adjusted around 1000 kc/s, which satisfactorily eliminates frequencies of harmonics differing by 100 kc/s.

It is therefore possible to select the desired harmonic among the 279 useful ones and to convert it to a frequency of about 1000 kc/s by means of a suitable adjustment of the selection superheterodyne local oscillator, calibrated every 100 kc/s and adjusted to give maximum output level.

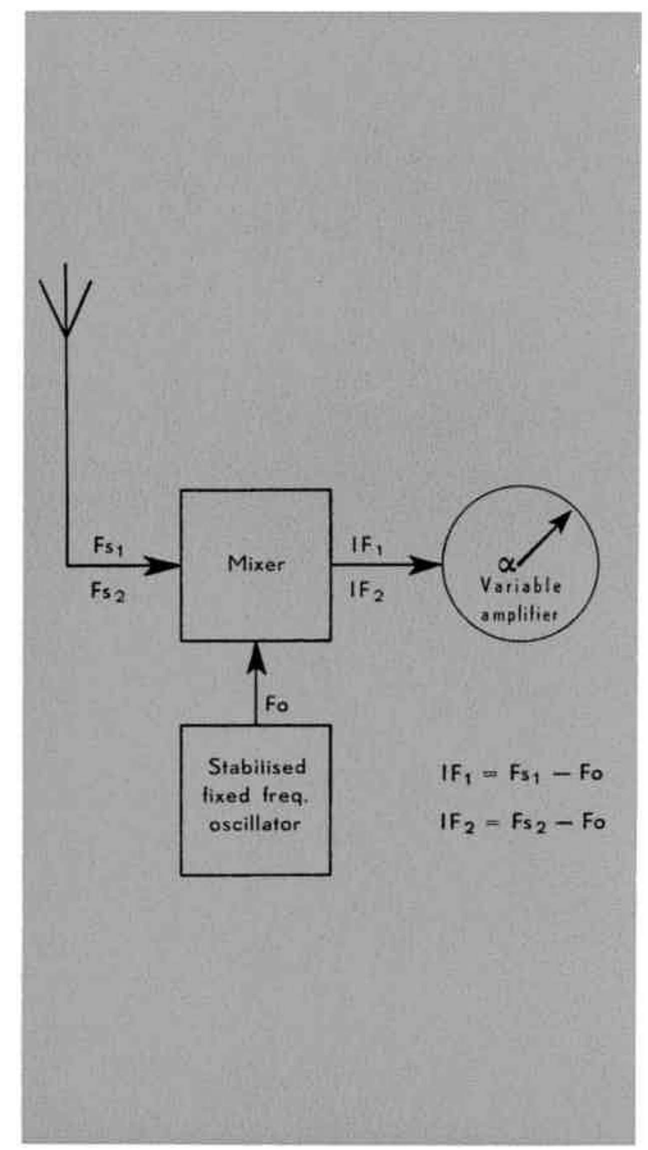
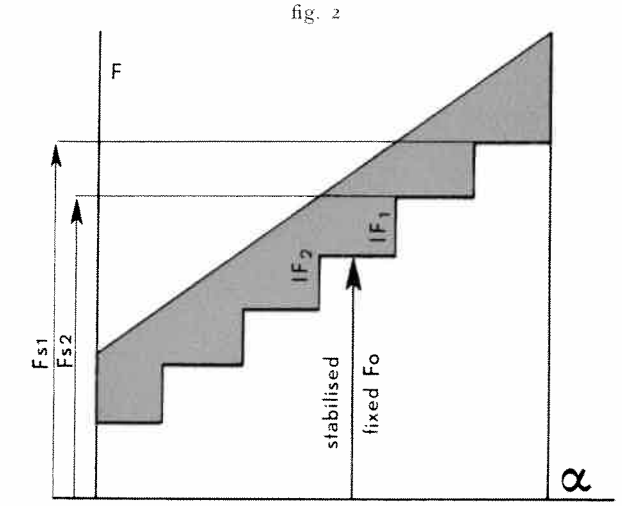


fig. 2 and 3

fig. 2



unstabilised component

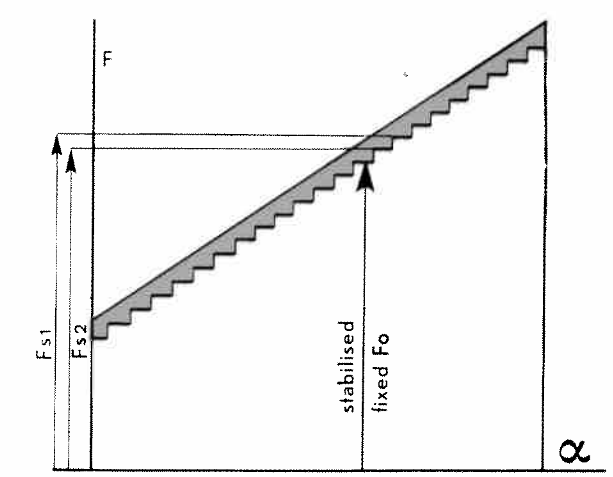
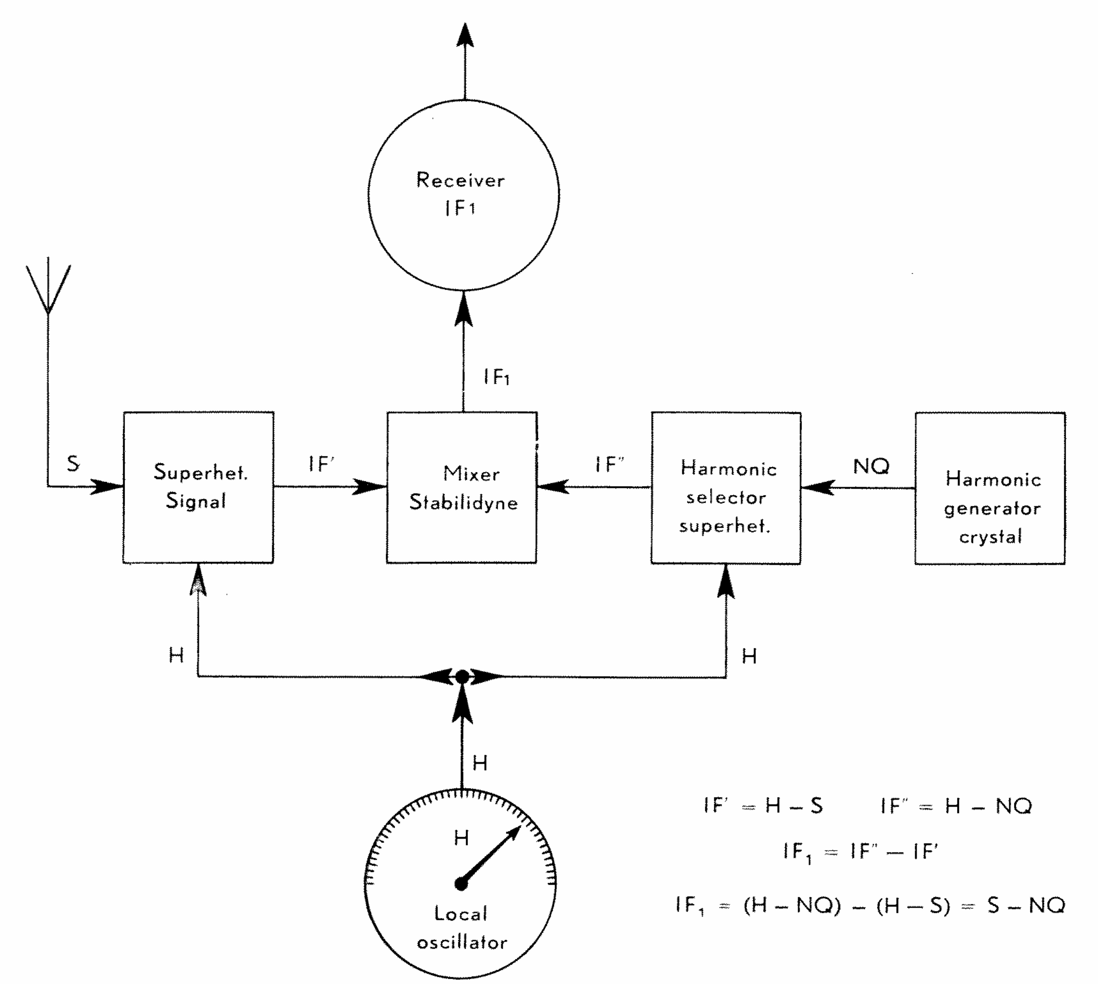


fig. 3

STABILIDYNE PRINCIPLE



Frequency IF1 provided by the stabilidyne mixer, is the difference between the signal frequency and the frequency of a crystal harmonic. It is independent of the frequency of the local oscillator H.

fig. 4

This wide band oscillator is unstable, but its variations are neutralised by the following process which is the basis of the stabilidyne principle. *The oscillator is common to the selection superheterodyne and to an input superheterodyne receiving the signal from the antenna,* and is tuned to the harmonic closest to the signal. The frequency arising from the signal thus differs at the most by 100 kc/s from the frequency due to the harmonic, since all harmonics are spaced 100 kc/s apart and the nearest harmonic has been selected. The two resulting frequencies are passed on to a third frequency changer. The frequency issuing from this frequency changer is therefore between 0 and 100 kc/s (1) and quite independent of the variations of the common oscillator. *These variations acting simultaneously on the two resultant frequencies the interval between them remains rigorously unchanged. (See fig. 4.)*

It only remains to receive the 100 kc/s band by means of a continuously variable receiver calibrated from 0 to 100 kc/s.

The harmonic selection oscillator is calibrated in hundreds of kilocycles from 2 to 30 Mc/s and the continuously variable receiver in kilocycles and hundreds of cycles from 0 to 100 kc/s. Each of the tuning controls of these two components drives a decimal counter. By placing these two counters alongside one another — that of the oscillator on the left and that of the receiver on the right — a number is set up representing the exact frequency to which the apparatus is tuned.

(1) In order not to complicate the description the nearest harmonic has been chosen. In actual practice, the selected harmonic is displaced by 200 kc/s in order to obtain a final frequency always contained between 200 et 300 kc/s, this band being more easily filtered and amplified.

General applications of the "Stabilidyne" principle

The principle previously described, in which one crystal provides an unlimited number of stable frequencies in a continuous band and which indicates the adjustment of any one of them on the decimal counter, can be applied in several ways.

Its first application to a mass production receiver is in respect of *short wave reception* in the band 2 to 30 Mc/s. This application is not restrictive and it is obvious that the same advantages can be secured for any other band by an appropriate choice of the crystal frequencies and of the various conversions.

A second application of the principle concerns transmission, either by reversing the arrangement to cause it to operate as an R.F. generator, or by using indirectly a receiver built on the principle described to monitor and regulate the frequency of a master-oscillator.

Stabilidyne master oscillators, having the same properties as the receivers, have also been developed. Their frequency stability is sufficiently good for successive multiplications as generally employed in transmission technique. The master oscillator needs cover only a reduced band thus being simpler in construction; the total band to be covered by the transmitter is obtained by frequency multiplication.

A third application of the same principle concerns *wavemeters.* These take the form of juxtaposition of several stabilidynes, connected in cascade; they provide accurate measurements of the frequency of signals from near-by or distant stations, as well as means for reading such frequency on a decimal counter, calibrated in cycles per second. This application can cover the range from 10 kc/s to 150 Mc/s. Small wavemeters of this kind have been developed for the band 2 to 30 Mc/s.

Special application
of the "Stabilidyne" principle to reception. Fixed watch.

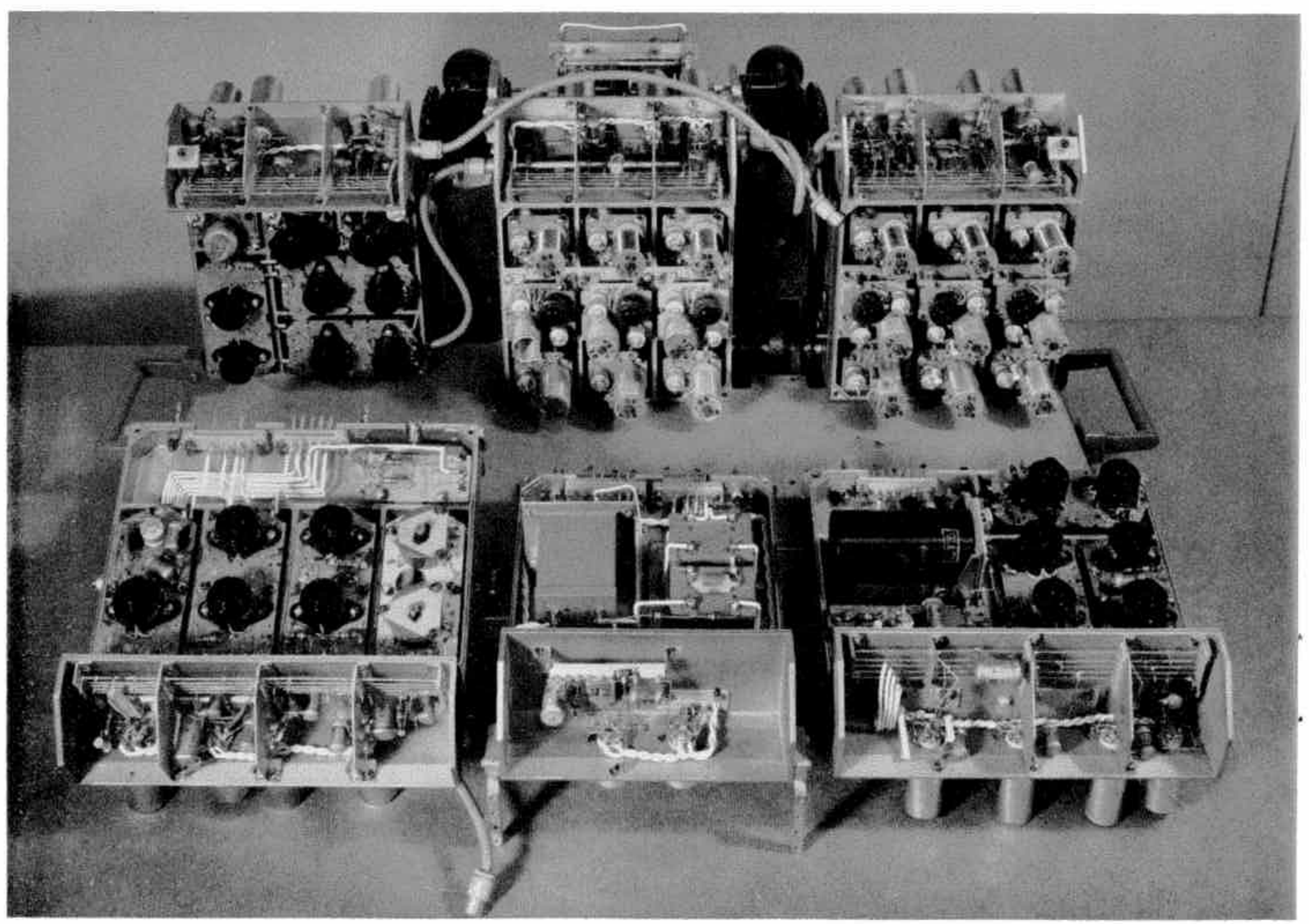
The new system will develop its full potentialities when stations fitted with stabilidyne receivers are also equipped with transmitters working on the same principle.

The important advantages which could be expected from the new possibilities, at first offered for receivers alone, appeared from the moment the first stabilidyne receivers were brought into use. The novelty of a tuning system, set up numerically on a decimal counter to within a few tens of cycles, completely changes traffic outlook.

Formerly, in order to set up a connection, the operator had to search for his correspondent who was required to transmit throughout the tuning process. With the stabilidyne receiver this search is completely done away with. It is only necessary for the operator to set up the frequency of his correspondent before any transmission at all is made by the latter and to wait: he is sure to receive the first signal sent on this frequency. *No preliminaries are required.*

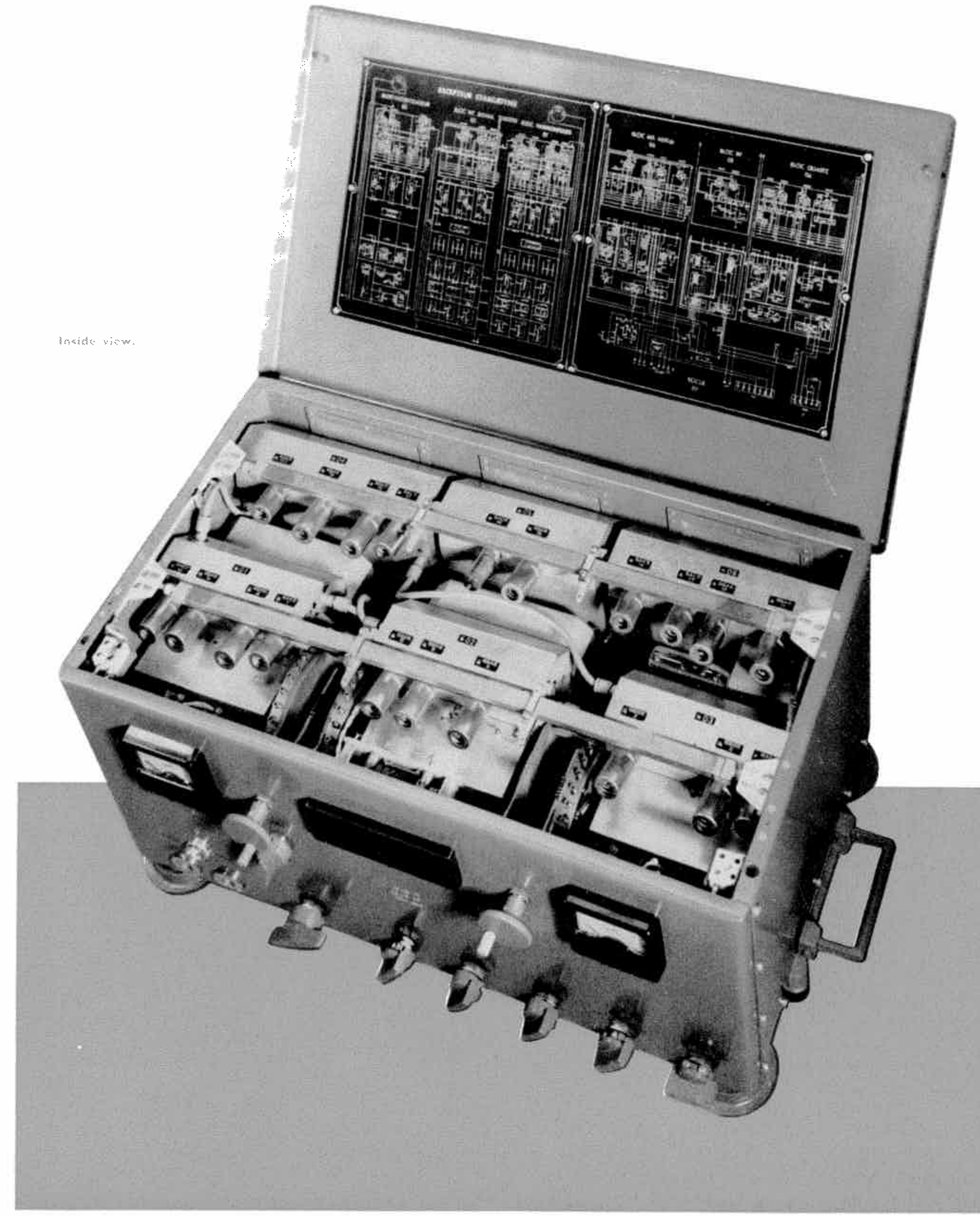
Communication programmes have been followed, with complete success, with this mode of operation. For instance, in the course of sea trials the 40 stations of a plan set up before the exercise were obtained on the frequencies and at the times previously fixed; no readjustment was found necessary to the tuning of a receiver *whose counter was set up before any transmission had taken place.*

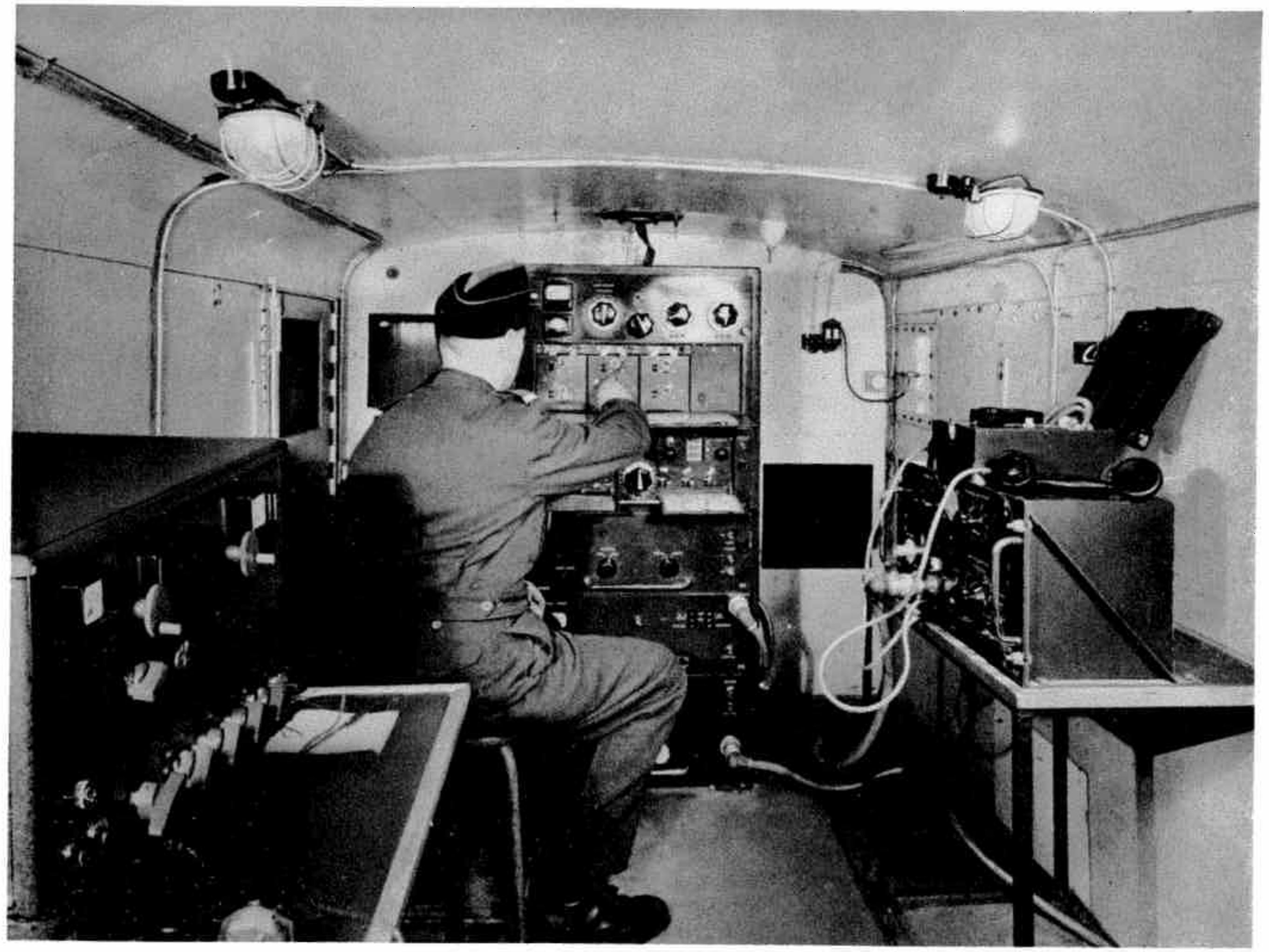
The classical picture of the radio operator, head-set on his ears searching for his correspondent among neighbouring transmissions, has thus become out of date. This specialist is now replaced by a simple attendant capable of setting a number on a counter.



General view of units making up the stabilidyne receiver.

Inside view.





Utilisation of stabilidyne receiver in a vehicle.

Military applications

This simplification in setting up a connection is of first importance in certain military applications. The saving of time reduces the duration of a transmission, to a strict minimum and hence the risk of its being picked up and its message read by the enemy; there is the further advantage that it is possible to transmit a message by a series of short transmissions on pre-determined frequencies whose sequence can be instantly changed.

The stabilidyne receiver is very useful under "watch" conditions because of the facility it provides of continuous exploration of the band and accurate measurement of the frequency of a station picked up.

A transmitting station fitted with a crystal stabiliser, whose tuning it is difficult to change is therefore liable to be permanently watched from the moment its frequency has been measured and set up on the counter of a stabilidyne receiver.

In view of these advantages, which can in due course, be still further enhanced, this new type of receiver meets the stringent and varied needs of Armies engaged in operations. It is designed to satisfy the needs of the service at sea and in the field. The distribution of the various components in separate blocks facilitates dismantling and eases maintenance. Thus, installation of this apparatus in the transmitter rooms of a warship, in the cabin of a radio van or even carried externally in its transport case, raises no particular difficulties. The equipment is fully tropicalised.

Frequency-shift reception

Another application of the stabilidyne receiver with its stability of tuning, is recording by teletype of telegraphic messages transmitted by frequency-shift. In this mode of transmission, the tuning of the receiver must remain rigidly set to the mean frequency of the transmission. Signals are transmitted by a shift of the emitted frequency of the order of 300 c/s on either side of the mean frequency; it is therefore essential to keep the tuning set accurately on this frequency.

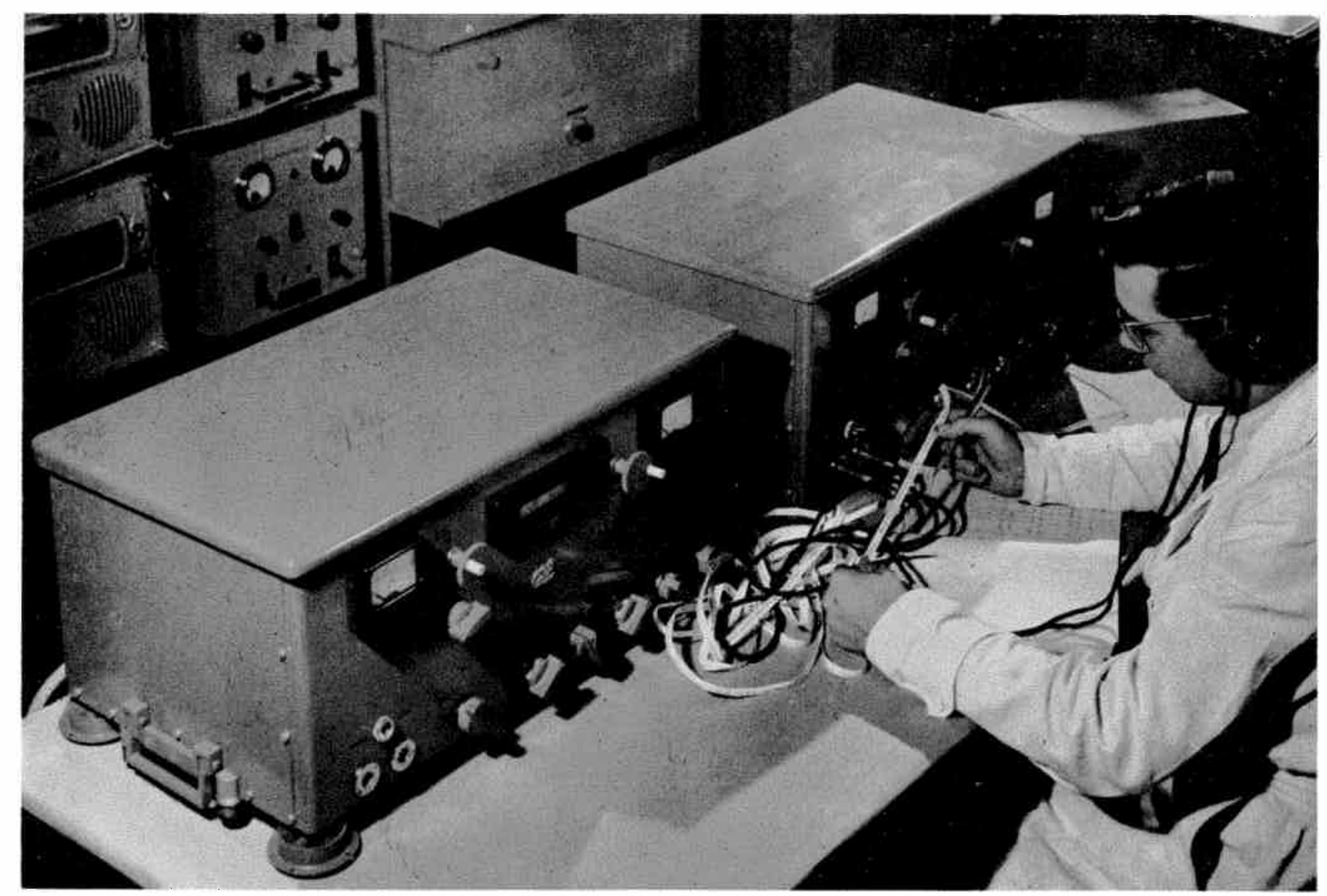
At that time correct performance had been obtained only by means of crystal stabilised receivers. It was therefore possible to record messages only from known stations and necessary to have at hand corresponding crystals to fit the receivers engaged in each connection.

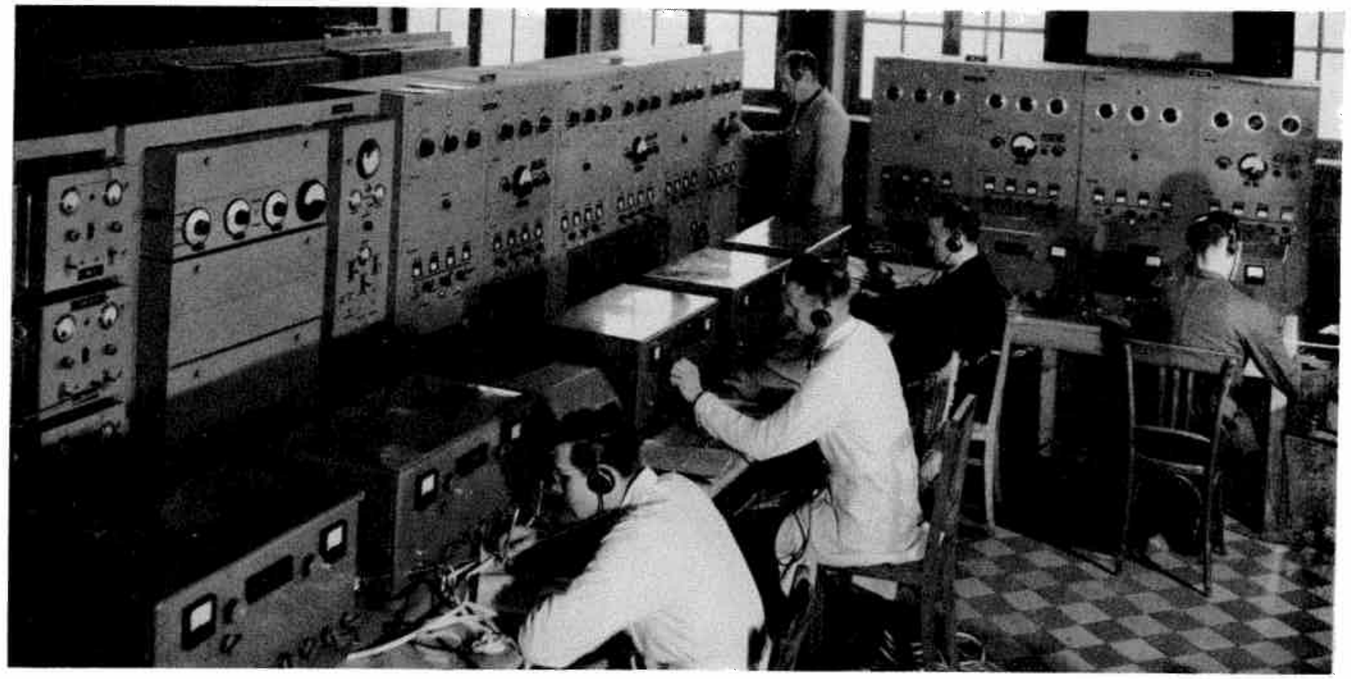
If a message on a new frequency had to be recorded a normal continuously tuned receiver had to be made use of; it was not infrequently the case that in spite of the care taken by the operator, frequency drift in this apparatus caused up to 70 errors per page. This was particularly serious in the case of cyphered messages.

In the same conditions, replacing the conventional receiver by a stabilidyne ensures correct performance, giving to any frequency in the band the same degree of reliability as in the case of a fixed frequency crystal receiver.

The advantage of fitting stabilidyne receivers in a traffic centre ensuring connections of a temporary nature is readily appreciated. A special application where this equipment surpasses any other system is watch-keeping and recording in traffic monitoring Stations set up for recording and identifying transmissions from a variety of sources.

Teletype frequency shift reception.





Traffic room fitted with stabilidyne receivers.

High performance exploitation

Although the performance of the stabilidyne receiver is comparable for sensitivity and selectivity to that of other receivers of the same class, but unstabilised, extended statistical trials made on long distance links, under difficult propagation conditions, have shown that reception was markedly superior from the double point of view of traffic regularity and quality of reception.

Besides easy tuning provided by setting up the frequency enabling the required station to be found instantly, another explanation of this superiority lies in the very high degree of instantaneous stability which gives the received tone perfect " readability ".

It was very quickly apparent that it would be valuable to fit " stabilidynes " in traffic centres providing fixed connections and at present fitted with crystal controlled receivers. These are allocated each to a single connection and it is not always easy and sometimes impossible to tune them to different frequencies; this necessitates the provision of a relatively large amount of emergency equipment to remedy immediately any accidental defect. Their replacement by stabilidyne receivers makes for great flexibility since each receiver can be allocated at will to one or the other of the connections maintained by the centre, permutation of the antennae being provided by a selector/distributor.

Further, stabilidyne receivers are particularly useful for double or triple-diversity working, frequently employed in radio Centres. It would also be possible to construct a special stabilidyne to provide two or three distinct amplification chains and one single harmonics channel. However, users generally prefer to have separate standard equipment which can be switched in or out as required. Each receiver is provided with the necessary connecting points for this mode of operation.

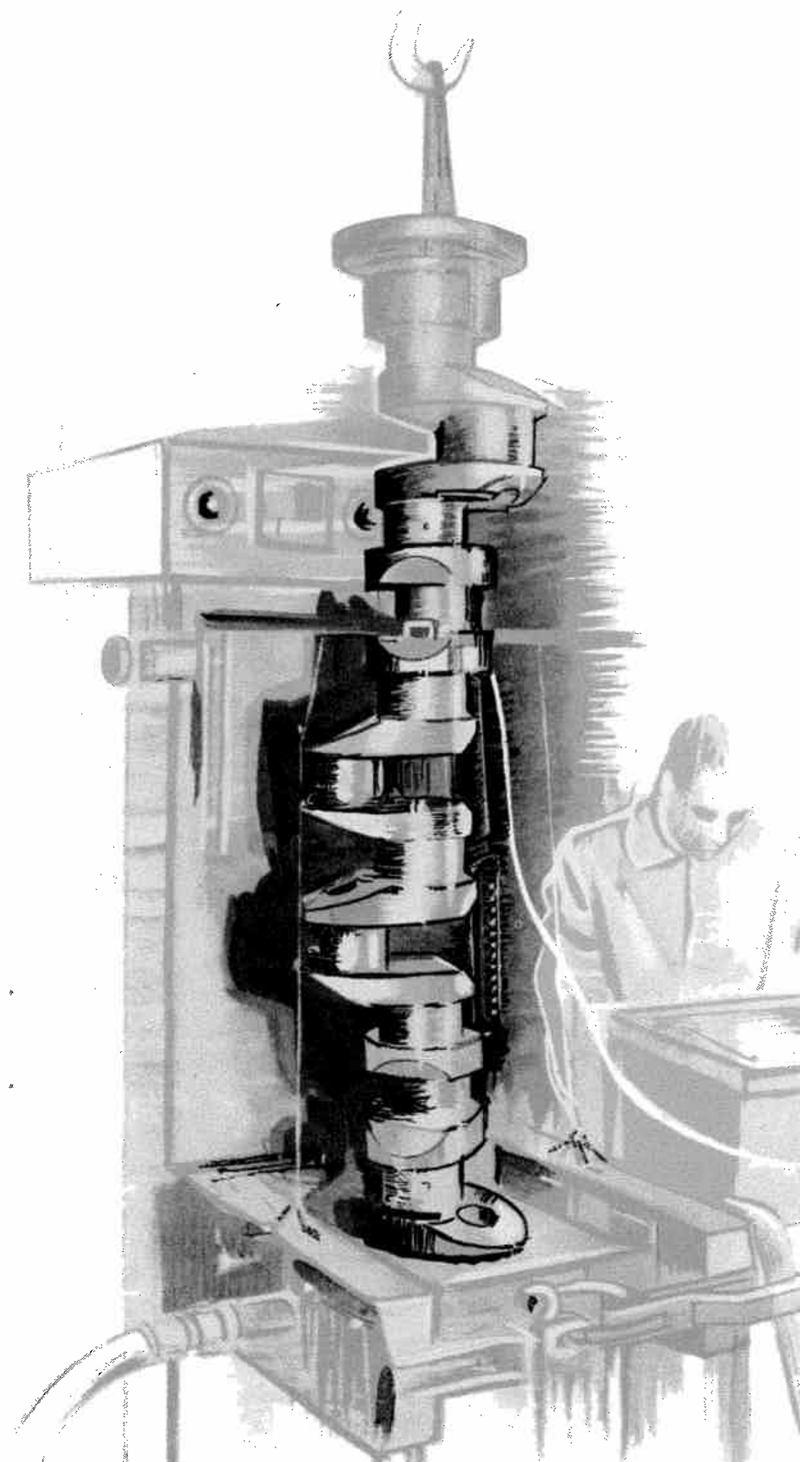
Finally, it should be noted that the constructional technique of the stabilidyne ensures that its performance characteristics are maintained under the most strenuous conditions of use (temperature, humidity, shocks, mains variations, etc...). Moreover, systematic use of very moderate voltages for the anode supplies ensures that tubes and components have unusually long life.

Conclusion

The " stabilidyne " has many uses and it provides, in various forms, several types of apparatus. The great advantages it offers, more particularly in respect of temporary connections, permit the anticipation of a profound change in the character of radio traffic.

STEL

C E L E B R A T E S A M I L L I O N O P E R A T I N G H O U R S O F H I G H F R E Q U E N C Y G E N E R A T O R S



The management and staff of STEL (Société de Traitements Électrolytiques et Électrothermiques) have recently celebrated the first million operating hours of high frequency generators installed in French industry. The "HF" department of STEL, created in 1945 for the construction of industrial equipment for high frequency treatment, has already installed more than 500 plants in France, representing a total power output of 3,000 kW, nearly the same power used by the Radiodiffusion Française.

Although the principles of heating by high frequency current have been known for a long while, it was only after the second world war that this technique was effectively developed. In fact, because of its military importance, the SFR, during the occupation, continued research which had already been undertaken on a large scale, and which had resulted already in the construction of a 100 kW plant. This plant was operated in the cellars of the factory at Levallois during the occupation.