

RT 18, A RADIO-TELEPHONE WITH AMPLE FACILITIES FOR EXPANSION

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The RT 18 system combines the properties of a modern radio-telephone in respect of technical performance and the fulfilment of operational requirements with great versatility in application. To achieve this, the set was divided into sub-assemblies which can be combined in various ways to form different kinds of station. A comprehensive range of accessory elements enables it to be used for a variety of purposes.

IN the past numerous articles have appeared in this journal dealing with radio-telephone sets. The present article deals with a system of units—comprising the high-frequency and accessory elements—whose circuitry and constructional design allows them to be used for a wide range of applications. Radio-telephone sets for the transmission of a speech channel, or of information covering an equivalent bandwidth, have become essential in view of the present need for rationalization in industrial and power supply undertakings, and in public services. But their increasing distribution gives rise to new problems, in particular that of mutual interference. For this reason the requirements stipulated by the postal authorities—who bear the responsibility for undisturbed reception—are becoming increasingly stringent. On the other hand, owing to the demands of new applications, especially as regards reliability, the operational requirements are also being continually increased. This is obvious at once, when it is considered, for instance, what harm would be caused if a fault were to occur in a set used for data transmission in a power system or for the remote control of a locomotive.

When designing the new RT 18 system the above requirements were taken into consideration as far as possible. Among other things, the adoption of a building-block system allowed a wide range of combinations, and thus applications, to be achieved.

One property that all units have in common is the widest possible use of semiconductor elements, these being employed wherever technical and commercial reasons permit, and printed circuit modules. The first of these measures helps to enhance the reliability in two ways: on the one hand the useful life of semiconductor elements is considerably longer than that of tubes and relays while, on the other, their consumption and consequently the heat produced is only a fraction of what it used to be. Hence the temperature rise of the equipment is greatly reduced and the life of all other components indirectly prolonged. The use of printed circuits not only simplifies manufacture and maintenance of the sets, but also reduces the scatter in the performance figures from one set to another.

Transmitter-Receiver Sets

The RT 18 sets can operate in one of the four frequency bands 68–88 Mc/s, 146–174 Mc/s, 375–425 Mc/s and 450–470 Mc/s. The r.f. channel spacing in the two lower bands is 20 (25) or 50 kc/s, as required, while in the two upper bands it is 50 kc/s only. The transmitter and receiver can be used for simplex traffic, semi-duplex or duplex operation. In each case they may be operated at a number of preselected frequencies or pairs of frequencies, the maximum number of which is 8 in most cases, the extremes of which must be within 1 Mc/s of one another.

The method of modulation used in all sets is indirect frequency modulation (phase modulation). The transmission bandwidth corresponds to that of a telephony channel (300–3000 c/s, or 3400 c/s on request).

Either an a.c. or d.c. supply may be used. In the latter case the sets are designed for a supply voltage of 6, 12 or 24 V, the circuit of the power pack being so arranged that it can be changed at any time from 6 to 12 V or from 12 to 24 V, or vice versa. With appropriate supplementary elements the voltage range can be extended to 110 V. When fed from the mains the voltage range between 110 and 235 V, 50–60 c/s may be used.

In all wavebands and for all voltage variants the output power of the transmitter can always be one of two values: on d.c. 4–5 W or 15–20 W, on a.c. 4–5 W or 40–50 W.

The receivers are exclusively equipped with semiconductor elements and, in contrast to earlier models of radio-telephones, employ only single heterodyning.

Selectivity is assured by a highly stable filter with crystal resonance elements. By changing this filter, and by suitably matching the frequency swing and output, it is an easy matter to effect the change of channel spacing. The maximum sensitivity corresponds to that of good tube sets in all frequency bands. The low consumption of the receiver proper—only about 1 W—together with appropriate measures in the transmitter, enables the complete set to run at a very low power level when receiving. When battery-fed this is a prime consideration because transmitting times are generally very short, so that the average consumption is governed by the stand-by demand. In order to reduce the current consumption, highly stable quartz-crystal oscillators were developed, both for the transmitter and for the

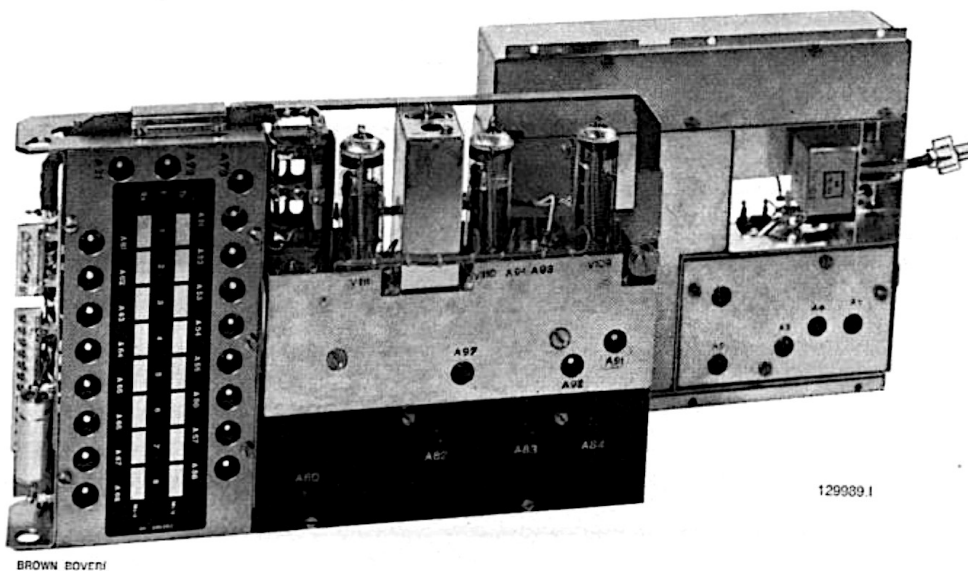


Fig. 1. – RT 18 sub-assemblies

Front: 5-W transmitter assembly
Rear: Receiver assembly

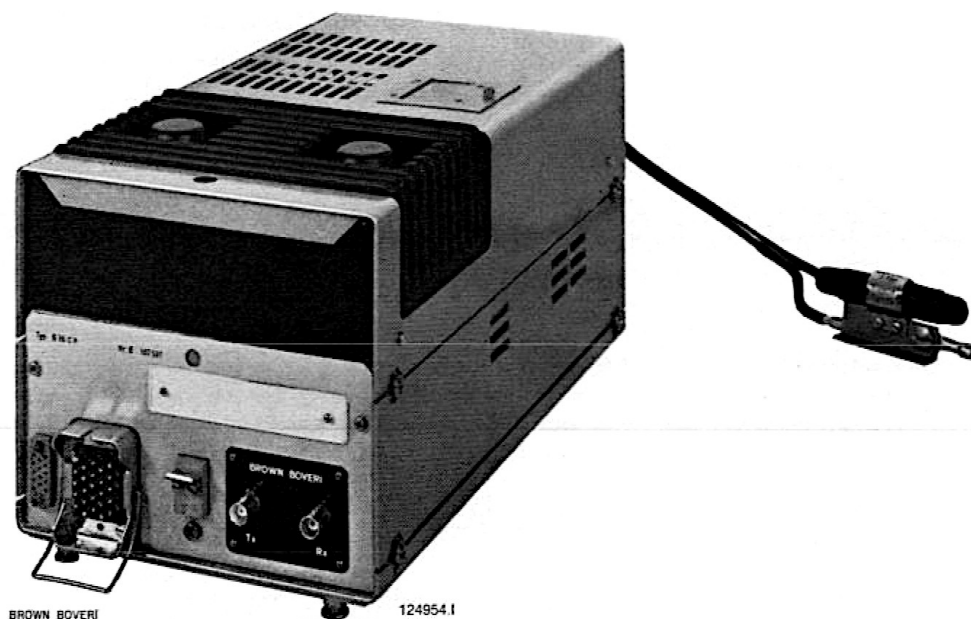


Fig. 2. – 5-W battery-fed transmitter-receiver set

The enclosure houses the assemblies of the receiver, the transmitter and the d.c. converter. At the front end are the test plug for the service instrument, the socket for the control cable and the two aerial sockets.

Fig. 3. — 20-W battery-fed transmitter-receiver set

Mounted on top of the receiver and 5-W transmitter is the final stage with d.c. converter for the entire transmitter. The converter for the receiver supply is at the rear of the set. In order to afford easy access to all parts for servicing, the 5-W transmitter and the output stage can be swung out.



local oscillator, thereby dispensing with the thermostats (with their relatively heavy current) that had been employed previously, even for the channel intervals 20 and 25 kc/s.

The transmitter is equipped with semiconductor elements in the a.f. stages and in the preliminary r.f. stages; tubes are only used in the power stages. In order to keep the current consumption on stand-by as low as possible, the filament heating of the tubes must not remain on when receiving. When directly or indirectly heated tubes are used, this involves a delay of a few seconds to enable the tubes to warm up, so that the set cannot transmit immediately. Consequently tubes with a special heating filament are used in the RT 18, the heating time of which averages between 250 and 300 ms, so that in practice the set is ready to start transmitting almost at once. As a result the transmitter may be switched off during waiting periods, without any operational disadvantages. To be able to provide all these variants as regards frequency, supply voltage, and output easily and with a minimum of elements, the circuits in the transmitter and receiver were combined into sub-assemblies (Fig. 1). A complete transmitter-receiver set consists of 3 to 4 such assemblies, which are accommodated in suitable enclosures. The basic elements are the receiver and the transmitter for an output of 4–5 W, each of which is mounted in its own chassis and housed in the case

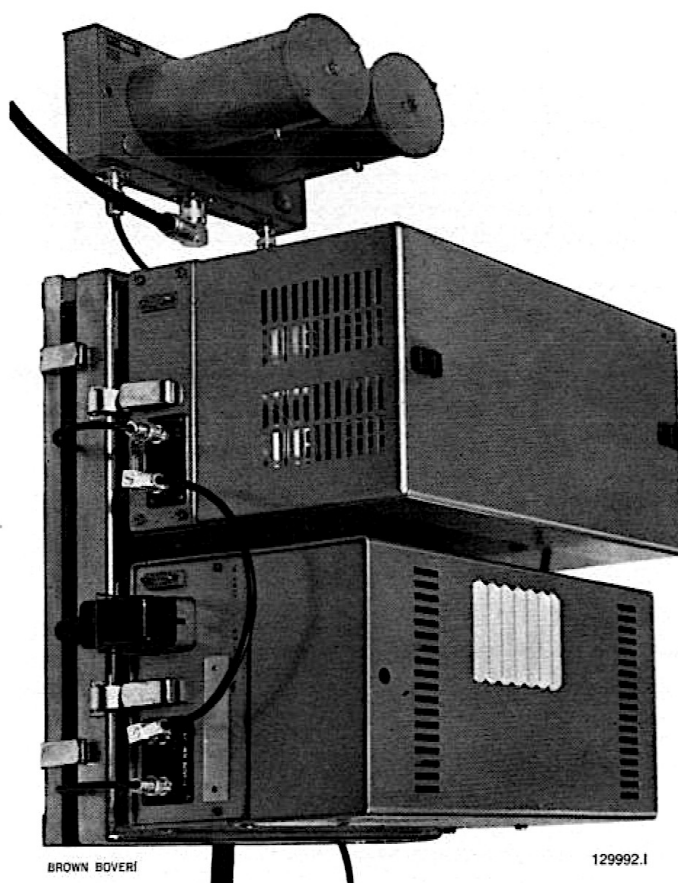


Fig. 4. — 5-W mains-fed transmitter-receiver set with 50-W final stage

Mounted on the hinged wall frame is the complete 5-W transmitter-receiver set (bottom). It can be operated on its own if desired. For an output power of 50 W the power stage mounted above it is required. For two-way traffic the duplexer mounted separately (top) allows the use of a single aerial common to the receiver and transmitter.

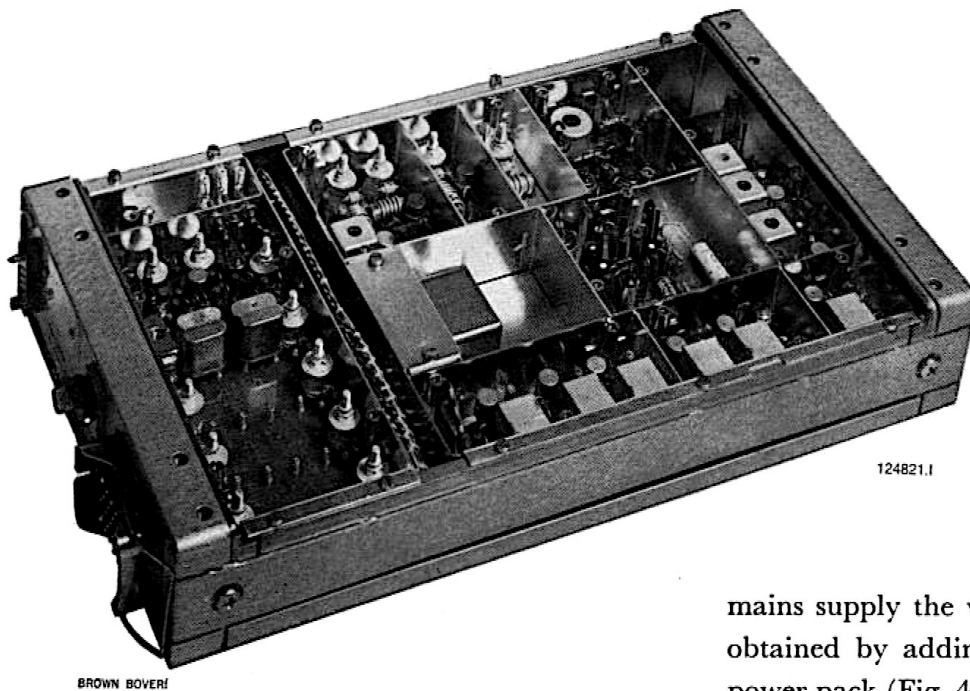


Fig. 5. – Supplementary receiver for use with the transmitter-receiver set

In this picture the screening hoods and the cover have been removed to show the two sub-assemblies: local oscillator (left) and receiver (right). In the latter the following can be recognized, from left to right: In the back row the r.f. amplifiers and muting circuit; in the middle row the i.f. filter and a.f. amplifier; in the front row the i.f. amplifier and crosswise on the right the demodulator.

of the 5-W set. If a mains or battery-fed power pack is added, this produces the 5-W set (Fig. 2 and 4). With battery feed the 15–20-W set is obtained by incorporating an output stage with power pack, additional to the basic unit, in which only the power pack for the receiver has to be added (Fig. 3). For

mains supply the variant with the higher output is obtained by adding an output stage with its own power pack (Fig. 4). Apart from these combinations, single transmitters or receivers can be supplied, the latter either for use as a separate monitoring receiver with its own power pack or as a supplementary receiver for transmitter-receiver combinations, in which case it does not require a separate power pack (Fig. 5). An example of this combination is the use for simplex traffic between a pair of mobile stations, each of which can operate in duplex with a base station. The most important combinations are illustrated schematically in Fig. 6.

All units may be mounted either on a horizontal frame or rack, or in a hinged wall-rack with vertical fixture. The battery-fed 5-W set can also be fitted beneath the dashboard of a vehicle.

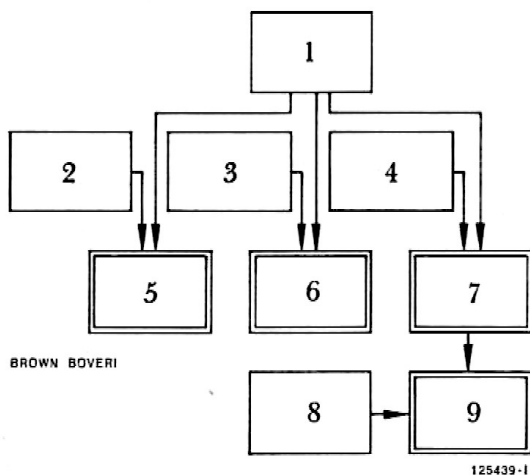


Fig. 6. – RT 18 station layout

The diagram shows an example of a combination of various elements.

- 1 = 5-W transmitter-receiver
- 2 = Battery-fed power pack 6/12 or 12/24 V
- 3 = 20-W power stage and power pack 6/12 or 12/24 V
- 4 = Mains-fed power pack 110–250 V
- 5 = 5-W battery fed station
- 6 = 20-W battery fed station
- 7 = 5-W mains-fed station
- 8 = 50-W power stage and mains-fed power pack 110–250 V
- 9 = 50-W mains-fed station

Ancillary Elements

Although the transmitter-receiver combinations with their power packs form the backbone of a radio-telephone installation, they generally cannot fulfil the requirements of the particular application unless they are combined with certain ancillary devices. It is this wide range of ancillaries which makes the sets so versatile. For this reason a large number of such units was designed for use with the RT 18, their number being constantly increased to meet new requirements.

Most of these units are control and a.f. elements. The use of semiconductor elements is not solely restricted to those functions which used to be performed

by electron tubes, but also extends to the replacement of relays as far as possible; apart from reducing the consumption and the space required, it also eliminates components with moving parts subject to mechanical wear. These ancillaries can be divided up according to their respective field of application, as follows:

- a. Units for operation of the r.f. elements and for speech transmission (control units).
- b. Units for the selection of individual stations within a large group (selective calling devices).
- c. Units enabling the radio-telephone sets to be connected with the public or a private telephone network.
- d. Units for the remote control of a radio-telephone installation.
- e. Units to increase the security of radio-telephone links.
- f. Additional supply facilities.
- g. Devices for adapting to different means of mounting.
- h. Supplementary r.f. units.

The last two groups will not be discussed further. The constructional design of the ancillaries proceeded along two distinct lines. On the one hand ancillaries intended primarily or solely for mobile service were combined with the corresponding operating elements and housed in a single, compact enclosure. In contrast, ancillaries for fixed service—with the exception of the control units—were designed as plug-in printed-circuit modules conforming to the stand designs of the Brown Boveri electronic system. Depending on the number of these elements that are required, they are mounted in wall cabinets or in cubicles. While relying on the

same mechanical elements, this system is extremely adaptable to the requirements of a wide range of applications.

Control Units

This group, in addition to the control units proper, contains the handsets, loudspeakers with built-in amplifier, bell and buzzer units, and the like.

The simplest control unit for mobile service is fastened on the transmitter-receiver set, with which it form an integral, compact unit. If remote control is required, the unit type PS 11 (Fig. 7) is employed. It is used to switch the station on and off, being equipped with a telltale lamp; the various quartz-controlled r.f. channels can be selected, the volume of the loudspeaker varied in steps and reception at



Fig. 7. — RT 18 control units

The control unit type PS 11 (above) allows the transmitter-receiver set to be remote controlled over a cable. The control unit PS 21 (below) also contains a receiver for selective calling. Both are suitable for mounting in vehicles or for fixed installation. In the former case they are supplied with the separate handset and loudspeaker (as above), in the latter case they are combined in the telephone set HA 81 (as in the lower picture).

the opposite station monitored. By means of a simple additional unit, fixed stations can be called (in up to three different networks) from mobile stations. The loudspeaker with its built-in amplifier and the handset with its support are always mounted separately. The unit type PS 11 can also be used in fixed stations, in which case the loudspeaker and the handset can be mounted in an enclosure resembling a normal telephone unit.

The simplest fixed control unit is accommodated in the casing of an ordinary telephone set, in which the dial is replaced by the loudspeaker. For larger installations either the combination with the PS 11 mentioned above is used, or an adaptable master station with sets of push-buttons. With the latter version an extensive installation can be operated and supervised with ease.

Calling Devices

In addition to ordinary loudspeaker calling, mention may be made of tone-controlled loudspeaker calling. In this case the loudspeaker of the mobile station is blocked and is only switched on for the duration of the message by a tone emitted by the fixed station. This tone is usually the same for all vehicles of the mobile network. The corresponding call receiver can be incorporated in the control unit PS 11.

If a particular vehicle has to be called, one of the selective call systems can be adopted. The individual numbers 1 to 0 are allocated tone frequencies. When the network does not contain more than 10 vehicles, only one tone is emitted by the fixed transmitter; if there are more than 10 vehicles, two tone frequencies are emitted, corresponding to a two-digit number. When the signal has been received by the desired mobile station, a bell sounds, the mobile transmitter is briefly switched (acknowledging the call), possibly modulated with an acknowledgement tone, and finally a lamp lights up to indicate that the station has been called, should the operators not be momentarily present. All these functions are performed by the call signal receiver, automatically and entirely by electronic means. Further facilities can be provided for grouping vehicles for calling purposes, as well as for conference calls. The corres-

ponding equipment in the vehicle stations is combined with the control elements, forming a control unit type PS 21. This unit, like the PS 11, can also be used for fixed stations (Fig. 7). In the fixed station a manual or automatic ringing unit provides a simple means of selecting the desired vehicle. Other ancillaries permit the creation of "blocked" systems, in which only the calling or called vehicle can communicate with the fixed station, the others being blocked to prevent listening in.

Interconnection with a Telephone Network

If mobile units are manually connected with a telephone network, the base station can be equipped with the interconnection unit PT 11 together with a fixed control unit and an ordinary telephone set.

In the case of mobile networks which are automatically connected with a telephone network, the system of pulse ringing is used. Here each vehicle is equipped with a special control unit as well as the automatic ancillary unit, the other party being dialled in the normal way (Fig. 8).

The need for two fixed telephone subscribers to be linked by radio may arise if at least one of these stations is situated in a region where a wire link is out of the question for topographical or financial reasons. To enable such stations to be connected to the public system, a radio subscriber link can be supplied. This allows calls to be made (including working out charges and recording) in the normal manner by untrained subscribers.

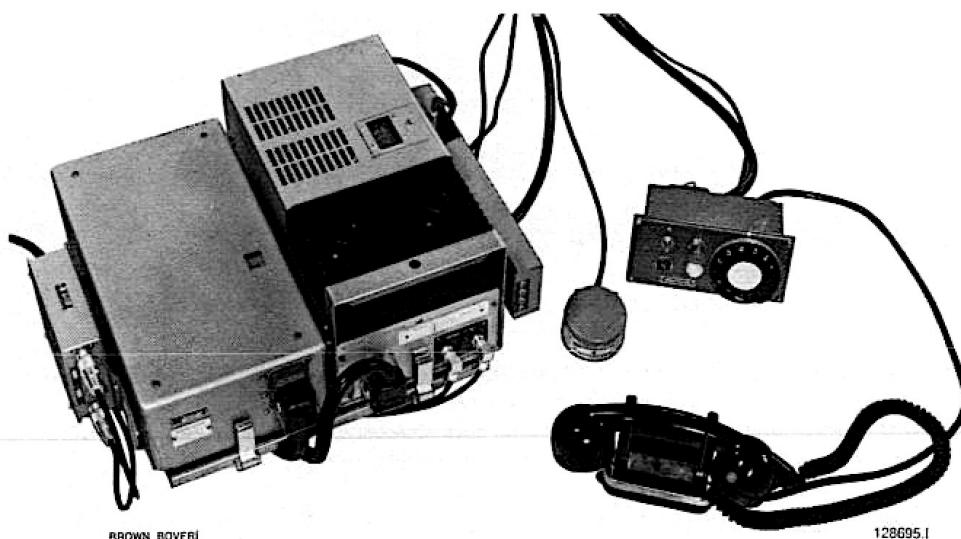
Remote Control Equipment

Apart from permitting signal transmission, this equipment enables a radio station to be controlled and monitored from a remote point over a wire or radio link. This may be necessary when unattended radio equipment is not located at the same place as the control equipment, as may sometimes be the case when propagation conditions at the latter point are unfavourable.

If there is a wire link between the control point and the radio station, e.g. a two-wire telephone line, the units for d.c. remote control will be used. With the full complement these units can perform the following tasks: Switching on the radio station, keying the

Fig. 8. — RT 18 with pulse dialling unit

The transmitter-receiver set is mounted together with the automatic ancillary unit RY 54 on the base-frame, which also carries the duplexer (left) and the distributor (right). Separate elements are the buzzer, the control unit and the handset.



transmitter, selecting one of two r.f. channels, indication of the operational state of the muting circuit, indication that the supply to the radio station has failed and changing over to the emergency supply, if possible.

If the number of commands that can be transmitted by the d.c. remote control system does not meet the operational requirements, or if there is no wire link between the two stations, a.f. remote control will have to be employed, in the first case augmenting the d.c. system, and in the second acting as an independent system. Using ten frequencies in the voice-frequency range it can emit ten separate commands. These may be combined in pairs (e.g. first command—transmitter keyed, second command—transmitter not keyed) or, from three commands onward, combined to form a selection system (e.g. three commands, each of which causes a different directional aerial to be connected to the transmitter receiver set). The fact that the command has been carried out is indicated audibly and visually. If selective ringing is required at the same time, this equipment can also be used for this, though a code frequency is required to ensure that there is a clear distinction between the two functions.

A further ancillary unit in this group enables an unattended relay station to be remote controlled by radio from a control centre.¹

¹ I. VANDEWALLE: The new radio network of the Vaud Cantonal Police. Brown Boveri Rev. 1965, Vol. 52, No. 4, p. 449-56.

Equipment to Improve the Reliability of Radio-Telephone Systems

In addition to the various monitoring and fault-indication devices, this group contains the ancillary unit for diversity reception. It enables a receiver that is momentarily capable of reception to be selected from a group of receivers. This group may contain from 2 to 6 receivers, which may either receive their signal voltage from separate aerials (space diversity) or, less likely, which operate at different frequencies (frequency diversity). In either case this device appreciably reduces the interruptions in reception due to fading, both as regards their persistence and duration. In the basic model of the unit the choice of receiver, when several are serviceable at the given moment, is arbitrary. By means of a further supplementary device it is possible to ensure that the "best" is always selected, i.e. the receiver with the best signal-to-noise ratio. The switching operation is performed so rapidly that not only speech, but even a data transmission is not affected. Fig. 9 illustrates a device for use with two receivers.

Power Packs

In this group are the power packs supplying the power for fixed ancillary units, should these not be supplied from the radio set, owing to the need to mount them separately, or on account of their unusually large number. (The mobile ancillaries are

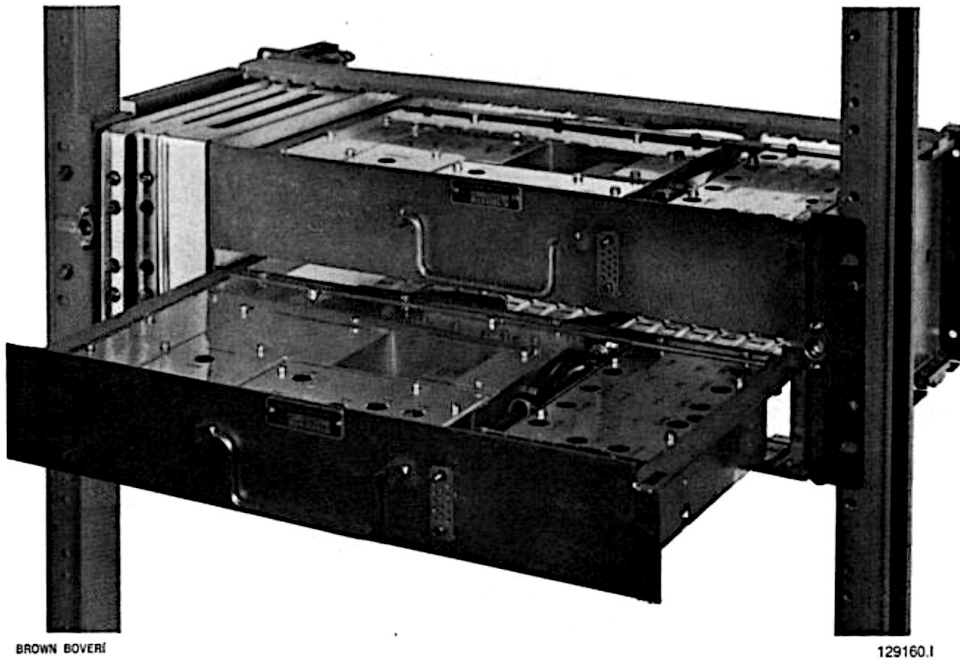


Fig. 9. - Diversity reception equipment for the RT 18 receivers

The two drawer units mounted in the frame each contain a receiver. On the left of these are the plug-in modules with the selector circuit and the monitoring lamps.

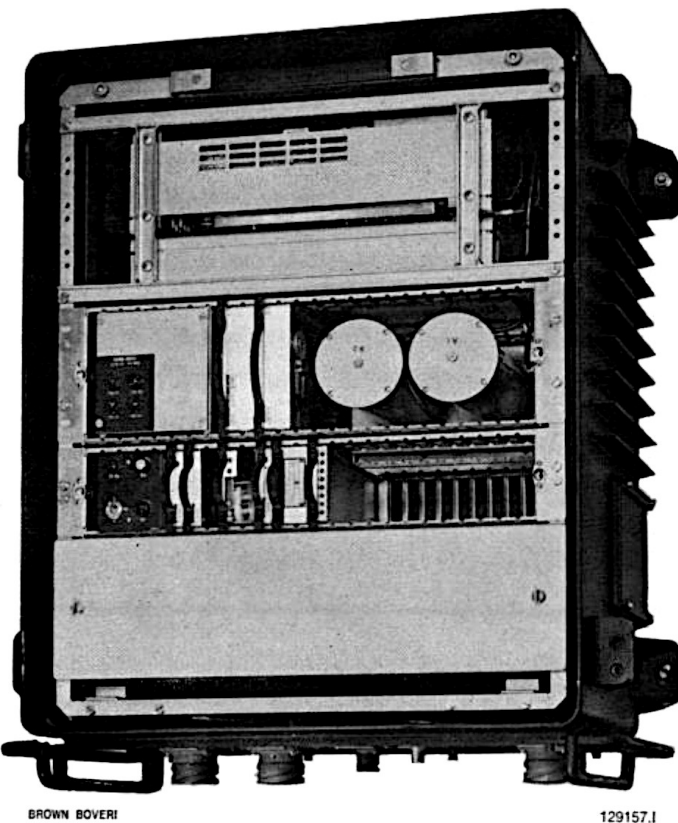


Fig. 10. - Transmitter-receiver set for the remote control of a shunting locomotive

The radio and ancillary units are accommodated in a totally enclosed cast-iron case, the hinged frame in which affords easy access. At the top is the 5-W transmitter-receiver set with an additional receiver; in the middle the transformer that converts the battery voltage 27-48 V to a stabilized voltage of 24 V, the call signal receivers and the duplexer. At the bottom are the remote-control receivers.

always fed from the power pack of the transmitter-receiver set.) The group also contains the various supplementary elements required for abnormal supply voltages. These include the devices which permit the basic set and the ancillaries to be fed from a d.c. source at a voltage between 28 and 110 V.

These are d.c. converters with two-step control. The supply current is switched on and off by semiconductor elements in such a way that a train of d.c. pulses is produced. The ratio of the on-time to the off-time is controlled so that the average power consumed always corresponds to the load on the transformer, regardless of the battery voltage. A storage element attends to the conversion of the output voltage, which is smoothed by filters. This arrangement operates at a remarkably high efficiency, without using any mechanically moved parts which would be subject to wear. A complete station for the remote control of locomotives with a supply voltage of 27-48 V can be seen in Fig. 10.

(KME)

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