CHAPTER 34

TYPES OF A-M RECEIVERS

By I. C. HANSEN, Member I.R.E. (U.S.A.)

SECTION 1 : INTRODUCTION AND SIMPLE RECEIVERS

(i) Types of receivers (ii) Crystal sets (iii) Regenerative receivers (iv) Super-regenerative receivers (v) Tuned radio-frequency receivers.

(i) Types of receivers

Radio receivers may be divided into several categories as the following tabulation shows :—

(a) crystal
(b) regenerative
(c) superregenerative
(d) tuned-radio-frequency
(e) superheterodyne
(f) synchrodyne.

(ii) Crystal sets

The simplest type of receiver employs a crystal such as galena, plus a " catswhisker," for a detector. This, together with a suitable tuned circuit and a pair of headphones, forms a satisfactory local station receiving set. Its disadvantages are poor sensitivity and selectivity, together with low output. Modern developments have made available " fixed " germanium crystals which are being used satisfactorily as detectors. The transistor, or three element crystal, recently announced, offers the advantage of amplification as well as detection in the one unit.

(iii) Regenerative receivers

Higher sensitivity can be obtained by using a valve as a grid or plate circuit detector. Additional amplification can be obtained by means of reaction ; the feeding back of signal from plate to grid in the correct phase to aid the existing circuit gain. Oscillation will occur if too much feedback is used, hence the necessity for judicious use of the reaction control, particularly for speech modulated signals, which would otherwise be rendered unintelligible. When operated near the point of oscillation, i.e. at maximum sensitivity, the selectivity is such that serious side-band cutting occurs and distortion of the a-f signal results ; this is usually the limiting factor in the amount of feedback that can be successfully employed. As the input circuit is coupled directly to the aerial, should the circuit oscillate, radiation will occur with the risk of interference to other receivers operating nearby—hence the limited use of this circuit. An r-f stage between the aerial and detector assists in minimizing this trouble.

(iv) Superregenerative receivers (Fig. 34.1)

The superregenerative receiver is basically similar to the simpler detector with reaction. It, however, is adjusted to the threshold of oscillation so that an incoming signal will cause the circuit to oscillate. At this instant, a local "quench" oscillator, operating at a low radio frequency, damps out the oscillation, thus ensuring that the receiver is operating continuously at maximum sensitivity. The oscillator can be combined with the detector or it can be a separate valve. Although very sensitive, the superregenerative receiver has poor selectivity due to circuit loading. In addition, interference is also caused by radiation from the "quench" oscillator. It is used mainly for higher frequency work where fidelity is unimportant and high sensitivity from simple apparatus is required.

See also Chapter 27 Sect. 1(ii)F page 1087 for further information.

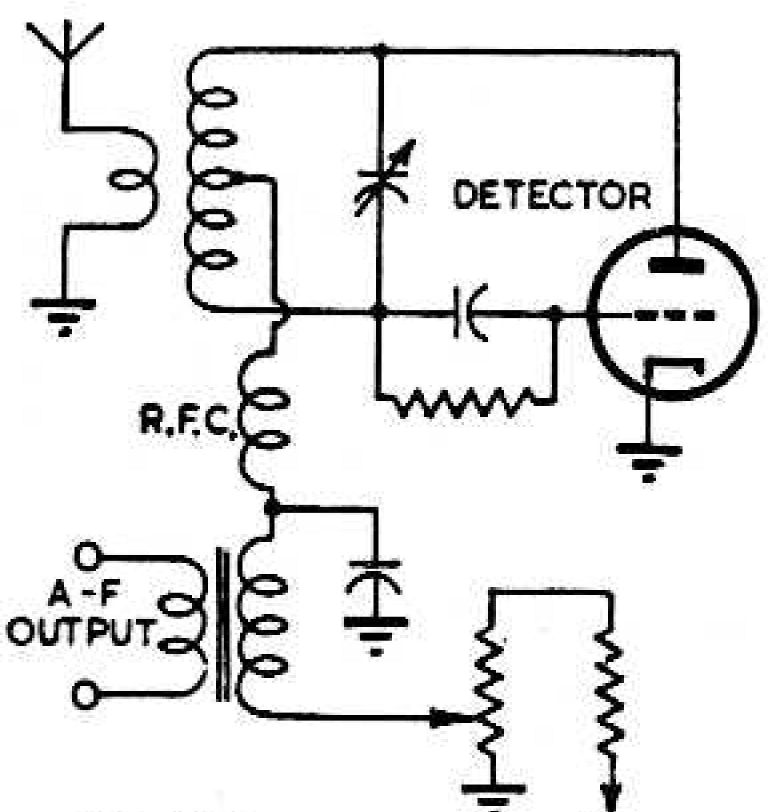

FIG. 34.1

Fig. 34.1. Self quenched superregenerative receiver incorporating linear reflex detector.

(v) Tuned-radio-frequency receivers (Fig. 34.2)

The simple receivers described above can give improved selectivity, sensitivity and output by the addition of radio frequency and audio frequency amplifier stages. Two or three r-f stages are commonly used ahead of the detector, which is usually of the plate detection or power-grid type. One or more a-f stages follow the detector depending upon the power output required. Such receivers are simple to design and construct for broadcast frequencies but present difficulties at higher frequencies. This is due to the risk of instability resulting from all the gain being achieved at the signal frequency. Tracking also becomes a problem as the frequency increases. In general, the defects of the tuned r-f receiver are variation of sensitivity and selectivity with frequency over the tuning range.

At broadcast frequencies, the circuit simplicity and ease of alignment are the main advantages.

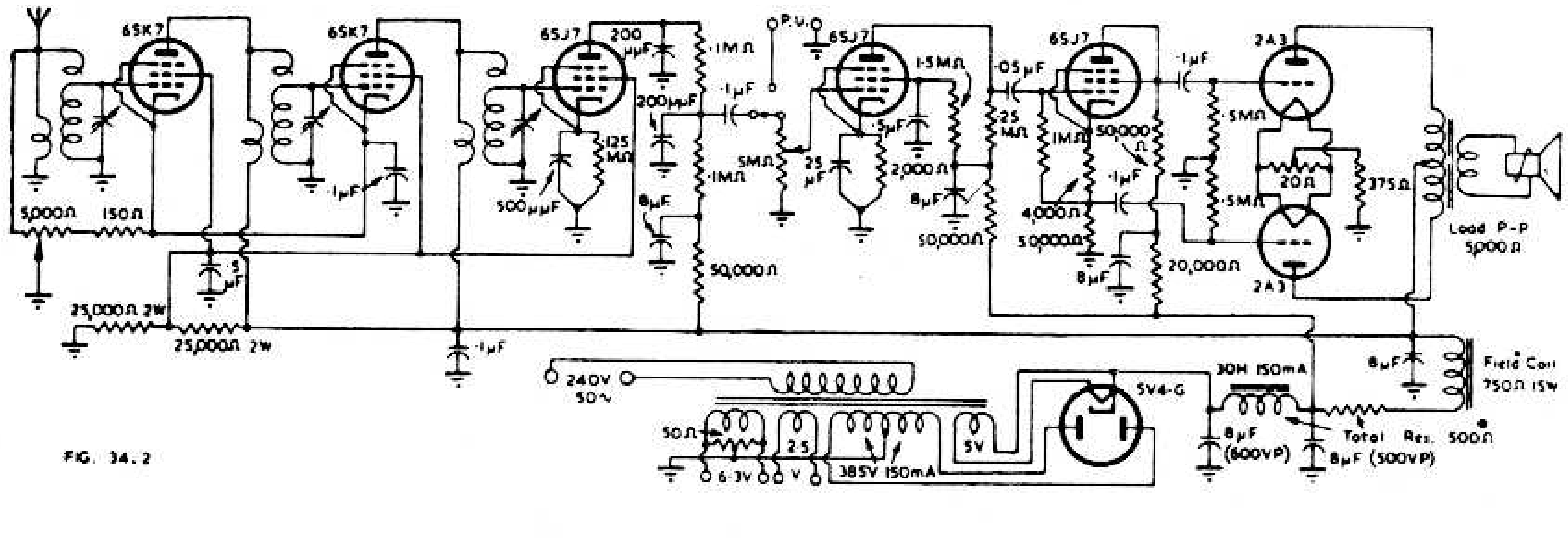

Fig. 34.2. Typical t.r.f. receiver

SECTION 2: THE SUPERHETERODYNE

The superheterodyne receiver as illustrated in Figs. 34.3 and 34.4, has several important advantages over other types of receivers. In the superheterodyne circuit, the incoming signal frequency is changed to a lower frequency, known as the intermediate frequency. The major part of the amplification then takes place at this frequency before detection in the normal manner. The typical superheterodyne tuner consists of several distinct sections. These are :—

(a) Preselector or r-f amplifier
(b) 1st detector or mixer
(c) Oscillator
(d) I-F amplifier
(e) 2nd detector.

Section (a) may or may not employ one or more r-f amplifiers. Its main functions are to improve the signal-to-noise ratio and to provide a sufficient degree of selectivity to avoid " double-spotting." This latter is the term applied to the reception of one station transmitting on a certain definite frequency, at more than one point on the tuning dial.

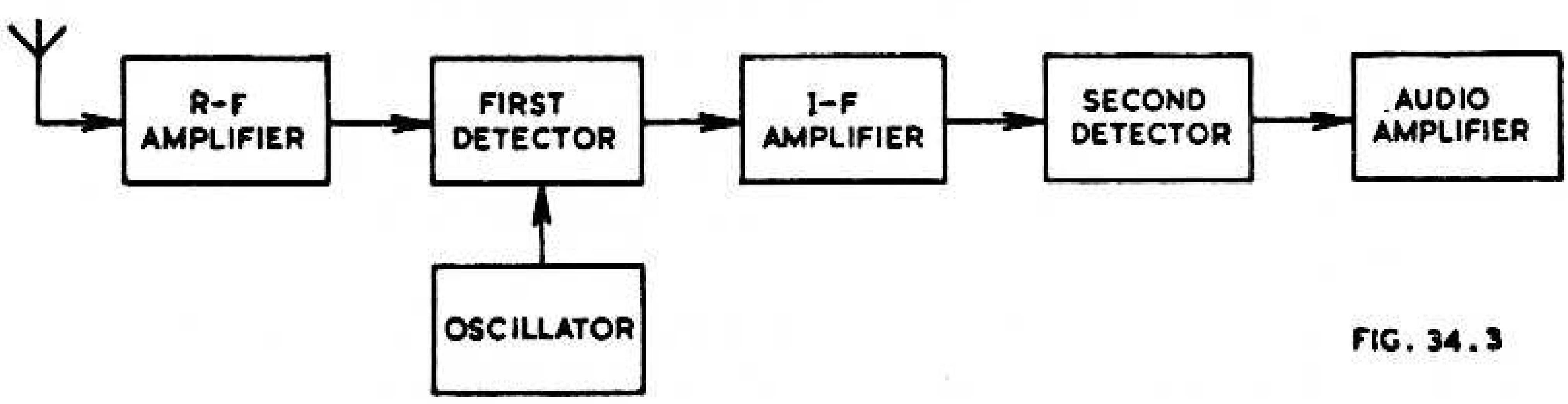

Fig. 34.3. Superheterodyne receiver—block diagram.

The first detector stage receives the modulated signal from the preselector and also an unmodulated signal from a local oscillator. These two r-f signals are arranged to differ by a constant frequency by suitable design of the preselector and oscillator tuning circuit constants. The output of the first detector is tuned to this difference frequency and as a result the original signals and their sum frequency are suppressed.

Various types of first detectors have been used, the most popular being the pentagrid and triode hexode converters (Refer Chapter 25). The tickler-feedback oscillator is very commonly used and optimum adjustment of this circuit minimizes harmonic production with its attendant whistles and spurious responses. It also ensures maximum conversion conductance from the first detector circuit and optimum signal-to-noise ratio.

The fixed frequency amplifier, called the intermediate frequency or i-f amplifier, usually consists of 1 stage, i.e. a valve and two i-f transformers, input and output.

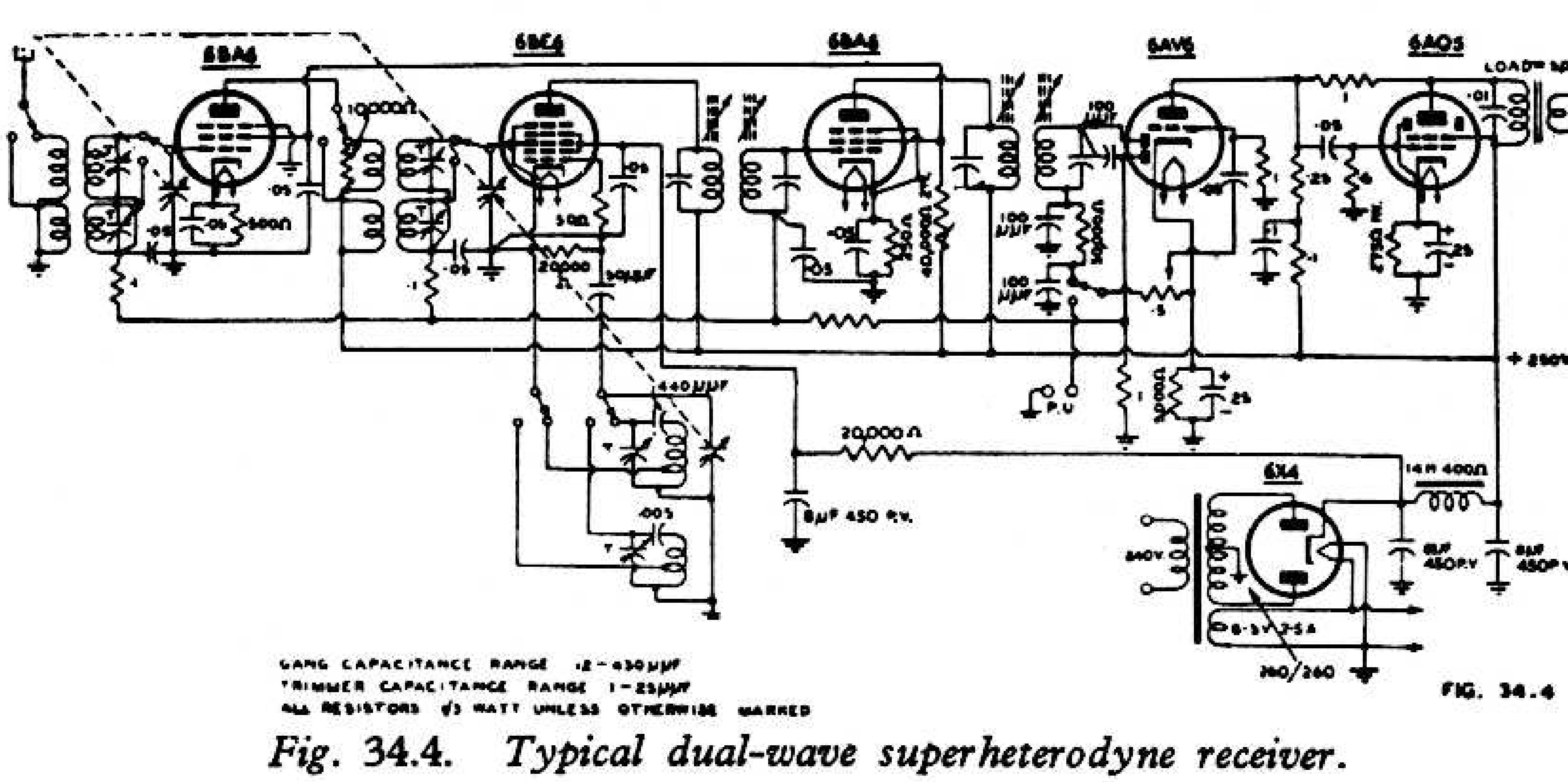

Fig. 34.4. Typical dual-wave superheterodyne receiver.

In wide band and communication receivers, two or more stages are commonly used. The intermediate frequency in general use is 455 Kc/s. Earlier receivers used 175 Kc/s but with the appearance of powdered iron cores and the development of high slope amplifier valves, the previous objection to the use of higher intermediate frequencies, i.e. lower gain, was nullified.

The higher i-f now in use considerably reduces the incidence of " double-spotting " i.e. the reception of the same station at two points on the receiving dial, one removed from the other by twice the intermediate frequency. Thus with an intermediate frequency of 455 Kc/s the first " double-spot " would be at 1460 Kc/s, which is near the upper limit of the broadcast band if this is taken as from 550 to 1600 Kc/s.

As most of the receiver amplification occurs at the intermediate frequency, which is fixed in frequency, the overall gain does not change appreciably with signal tuning. Similarly the selectivity remains approximately constant as this is largely predetermined by the i-f channel.

From the i-f amplifier the signal passes into a second detector stage where the audio frequency modulation is separated from the carrier and then amplified in the normal manner by a conventional a-f amplifier. If, as is usual, a diode detector is employed, the rectified carrier provides a direct voltage which can be used for various control purposes. The principal use is for automatic volume control, or, more exactly, automatic gain control. In this circuit the negative direct voltage, which increases with an increase in signal, is applied through suitable decoupling networks to the r-f, i-f and first detector grids as required. This overcomes, to a considerable degree, the effect known as " fading."

For the reception of continuous wave code signals another oscillator is necessary. The output from this is fed into the second detector and adjusted to give a suitable audio difference frequency, say 1000 c/s, when beating with the incoming code signals.

The advantages of the superheterodyne over the tuned-radio-frequency receiver are :—

(a) more uniform sensitivity and selectivity over the tuning range,

(b) stability is greater, as the major part of the amplification takes place at a low radio frequency,

(c) the i-f amplifier can be designed for minimum sideband cutting, while preserving reasonable gain,

(d) greater selectivity.

It should be noted that the superheterodyne contains more tuned circuits than the t.r.f. receiver, but fewer tuned circuits are continuously variable.

See References (B).

SECTION 3 : THE SYNCHRODYNE

A newer type of receiver is the " synchrodyne " (Fig. 34.5). In this design, selectivity is obtained without resort to tuned circuits or band-pass filters. The block diagram of Fig. 34.5 will facilitate the understanding of the operation of this circuit which requires no tuning circuits other than that of the oscillator. Here, the desired incoming modulated signal is heterodyned with a local unmodulated signal of the same carrier fiequency. The output from the detector, consisting of the required modulation plus unwanted higher frequency components from stations operating on adjacent channels, is then fed to an a-f amplifier through a low-pass filter.

This simple filter can readily be designed to cut off sharply at any requisite point whereas the usual superheterodyne band-pass filters require many elements and generally reduce the response at a considerably lower frequency than that desirable for optimum results.

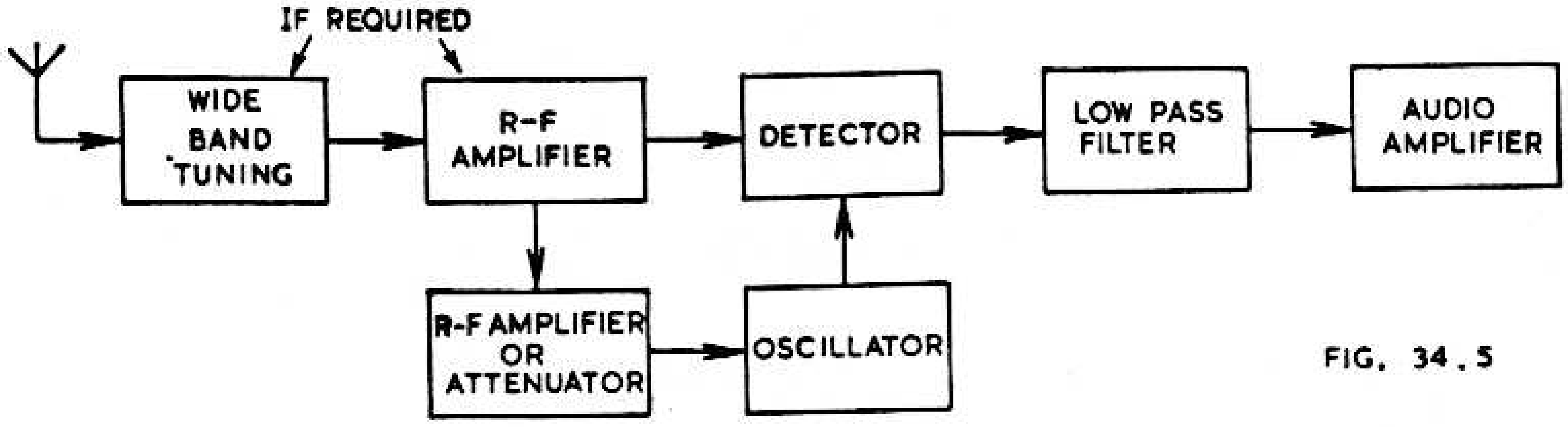

Fig. 34.5. *Synchrodyne receiver—block diagram.*

The selectivity of the synchrodyne depends upon the oscillator circuit and a restriction of the frequency band there does not affect the a-f response.

To avoid beats in the output signal the local oscllator must be synchronized or " locked " with the wanted carrier. One advantage of this receiver is that it is either correctly tuned or not tuned at all. Distorted output due to mistuning is thus impossible. The only effect of altering the oscillator tuning within the synchronizing range is to change the volume level.

If necessary, a broad-band r-f amplifier can precede the detector to avoid strong stations overloading the receiver. As in the typical superhet, a.v c. voltage derived from the detector output can be used for gain control.

The main disadvantage of this receiver is that loud heterodyne whistles are heard when tuning in a station. This defect can be readily overcome by the use of push-button tuning, and hence the synchrodyne is likely to be most popular for high-quality local-station reception.

See References (C).

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Additional references will be found in the Supplement commencing on page 1475.