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AUSTRALIAN DEVELOPMENTS OF REBECCA-EUREKA EQUIPMENT

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ABSTRACT

Rebecca-Eureka is a short-range homing system for aircraft, which was first developed in England. This paper gives a brief history of Rebecca-Eureka and a fairly detailed description of the Australian Rebecca Mk. IIB and Eureka Mk. II equipment.

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AUSTRALIAN DEVELOPMENTS OF REBECCA-EUREKA EQUIPMENT

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1 INTRODUCTION

During the last war the different models of Rebecca-Eureka equipment produced by Britain and America played a vital part in many operations. Its function was to enable aircraft fitted with Rebecca to home on to a Eureka ground beacon with continuous indication of range and heading relative to the beacon. Its main operational features were the security of operation and portability of the ground beacon (Eureka). Two men, or in the case of some models, one man, could comfortably carry the complete Eureka equipment, and it could be assembled and put in operation by one man in less than a minute after unpacking. The equipment was used in operations such as landing paratroops or dropping supplies, particularly at night or in uncertain locations, close-support bombing, guiding aircraft to beach-heads, and other forms of air-to-ground co-operation.

Eureka was widely used by underground forces in Europe, enabling supplies, arms, etc., to be dropped to them. In the invasion of Sicily and on D-Day extensive use was made of it. A common procedure was to land an advance party of paratroops equipped with one or more Eurekas, then about twenty minutes later the main force would arrive, guided by Rebeccas to the Eurekas.

In March 1944, it was decided, owing to the difficulty of obtaining British or American equipment, and the potential value of Rebecca-Eureka in the Pacific area, to produce Rebecca-Eureka equipment in Australia. The first production models were not complete until September 1945, about a month after the war ended. At least one of the Australian prototype Eurekas, however, was used operationally for supply dropping.

A feature of the Australian model, in particular Eureka, was its tropicalization: Eureka was required to withstand extreme tropical conditions of temperature and humidity for extended periods. It was also required to operate reliably after being dropped by parachute, or after being immersed in water, in case the parachute landed in a river. The prototypes adequately fulfilled all these requirements.

2 HISTORICAL DESCRIPTION

In order to place Rebecca-Eureka in perspective with other radar equipment a brief account of its development will be given, notwithstanding the fact that similar and more detailed accounts have already been published.

There are two main classes of radar, primary and secondary. Primary radar is normal radar in which a transmitter periodically radiates radio-frequency pulses from its aerial. Any objects in the path of the electromagnetic radiation will reflect some of the incident energy, portion of which will be picked up by the receiver as a series of radio-frequency pulses delayed by a certain time with respect to the transmitted pulses. This time delay represents the time taken for the electromagnetic wave (travelling at the velocity of light) to travel from the radar transmitter to the target and back to the radar receiver (12·2 micro-seconds per nautical mile between radar and target), plus any delays which occur in the receiver and display system. Thus with suitable timing circuits, the range of the target is known (relative to the velocity of light).

Secondary radar does not depend on reflections from the target; instead it uses pulses transmitted from a responder, or pulse repeater, situated on the target. These pulses are generally transmitted a short fixed time (order of one or two microseconds, representing unavoidable delays in the responder) after the reception of each of the pulses transmitted from the radar set, which in such a system is known as the interrogator.

The pulse transmitted by the responder need not necessarily be of the same radio frequency as the pulse transmitted by the interrogator (in Rebecca-Eureka the frequencies are different), but where the interrogator is a primary radar set with no auxiliary receiver and it is desired to have normal echoes displayed as well as the responder pulse, the responder must transmit on the same frequency.

If the responder pulse is coded, e.g. by switching off and on in a certain sequence (e.g. Morse code), or widening and shortening the pulses similarly, or any other device which produces an easily observed effect on the radar display, then it provides a means of identification. The first responders were fitted to aircraft for this purpose, in order to differentiate between friendly and enemy aircraft. Obviously no co-operation could be expected from the enemy, so responders were fitted in Allied aircraft which were likely to be flying in an area where, or at a time when, identification was desirable. This equipment, used in this way, was known as IFF (Identification, Friend or Foe).

The interrogator-responder system was next used with the responders situated at known points on the ground, then known as responder-beacons. Aircraft fitted with radar (Aircraft to Surface Vessel, ASV, and Aircraft Interception, AI, at that time) were then able to obtain range and bearing from the responder-beacon and so obtain their position with respect to it. Generally the beacons were placed at aerodromes and coded so that the pilot of an aircraft could identify the beacon at the aerodrome to which he wished to go, and home on to it.

The great value of the navigational facilities provided by this interrogator-responder system was appreciated and led to the development in England in 1941 of equipment independent of primary radar, known as Rebecca-Eureka Mk. I. This had the additional feature of separate frequency working with several channels. Rebecca was the interrogator and was carried in the aircraft and Eureka, the responder beacon, was situated on the ground.

In January 1943 investigations were begun in Australia on the use of Rebecca-Eureka in operations in New Guinea, where the homing facilities would be of service in jungle warfare for supply dropping, demarcation of bombing lines, etc. Experiments were made with experimental models of Rebecca and Eureka aimed at finding out what sort of homing accuracy was feasible, e.g. for supply dropping. The method of observation of minimum range was used and an average accuracy of $\pm$ 50 yards was obtained at about 500 ft. altitude.

In March 1944 it was decided to produce in Australia Rebecca and Eureka equipment comparable in performance with the British Rebecca Mk. IIB and Eureka Mk. II and with additional frequency facilities to enable ASV to interrogate Eureka, and Rebecca to interrogate ASV beacons. At that time most Australian aircraft, except fighters, were fitted with ASV. It was decided that signalling, probably by Alldis lamp, from the site of Eureka would be sufficient for location of the exact site provided the Rebecca-Eureka equipment enabled the aircraft to follow accurately a course passing over Eureka.

The Australian models were to be named after their British counterparts, viz. Rebecca Mk. IIB and Eureka Mk. II even though the frequency ranges were to be different. Previous Australian models were experimental forms of Rebecca and Eureka, which were used in flights on homing accuracy, and a Eureka Mk. I. As part of the programme for Rebecca Mk. IIB (Aust.) and Eureka Mk. II (Aust.) a Eureka Mk. I (Aust.) was developed and four models were made. This Eureka operated on 176 Mc/s only and was used in Royal Australian Air Force trials to test the performance of ASV against Eureka, especially in difficult terrain. It was found that the equipment operated satisfactorily in open country, but in mountainous regions the ground echoes at close range obscured the Eureka pulse on the ASV display. A remedy for this was to change the receiver frequency of ASV and the transmitting frequency of Eureka by a few megacycles. Another remedy was to increase the power of Eureka, but this would have been difficult. This result did not, however, change the programme, as the frequency adjustment could easily be made in all the equipment concerned without modification, if it were finally decided to be necessary, after trials on the production models.

Rebecca Mk. IIB (Aust.) was developed and manufactured by the Gramophone Co. in conjunction with the C.S.I.R. Radiophysics Laboratory. The Australian Rebecca was required to have two additional transmitter spot frequencies and three additional receiver frequencies in the Rebecca band. This meant that the Australian Rebecca would have six spot frequencies for both transmitting and receiving, one being 176 Mc/s and the other five being the Rebecca frequencies 214, 219, 224, 229, 234 Mc/s. The English Rebecca Mk. IIB had only three frequencies in the Rebecca band for transmitting and two for receiving.

Eureka Mk. II (Aust.) was developed in the Radiophysics Laboratory and six prototypes were made in the Laboratory workshops. The Australian Eureka Mk. II was required to have six spot frequencies for transmission and reception;

the English Eureka Mk. II having only five in each case. The additional frequency was 176 Mc/s. A feature of the equipment was the tropicalization, based on the sealing of the equipment and the tropicalization of the components in accordance with the latest information.

3 GENERAL DESCRIPTION

Rebecca and Eureka together constitute a short-range homing system for aircraft. The performance and the information provided enable an aircraft fitted with Rebecca to home from up to sixty miles, with the aircraft at a reasonable height (5000 feet) to any previously selected point on the ground, viz. the site of Eureka. Continuous indication is provided of the distance and heading of the aircraft relative to Eureka. In addition, the system had, at the time of development, a considerable degree of security.

Rebecca transmits radio-frequency pulses at approximately regular intervals. These are detected by the Eureka receiver, which produces corresponding video-frequency pulses, the leading edges of which are used to trigger the Eureka transmitter, which thus transmits radio-frequency pulses at a short, constant interval after the reception of the Rebecca pulses. These Eureka pulses are received by the Rebecca receiver. The Eureka transmitter is not normally operated on the same radio-frequency as the Rebecca transmitter, but the Eureka receiver and Rebecca transmitter must be tuned to the same frequency, and similarly the Rebecca receiver must be tuned to the frequency of the Eureka transmitter.

The time which elapses between the start of the transmission of the Rebecca pulse and the reception, at Rebecca, of the leading edge of the Eureka pulse, is measured by the timing circuits associated with Rebecca. This time interval is proportional to the distance between Rebecca and Eureka, with a small zero time interval corresponding to the sum of the delays in the circuits and aerial feeders. By suitable calibration of the timing circuits, observation of the Rebecca to Eureka distance can be made directly in miles.

The above description shows how the range information is obtained. The Rebecca timing device is the well-known radar system using a cathode-ray oscillograph with a time-base triggered simultaneously with the start of each transmitter pulse. The time-base voltage is applied to the vertical deflection plates, and the output of the receiver to the horizontal deflection plates. The pip corresponding to the Eureka pulse appears at a position on the time-base determined by the distance between Rebecca and Eureka. The screen of the cathode-ray tube is covered by a transparent scale graduated in nautical miles.

In addition to range information, indication is also provided of the heading of the aircraft relative to the bearing of the site of the Eureka which is being interrogated. This is accomplished as shown in Figure 1. There are two similar receiving aerials, one on the port side and one on the starboard side of the aircraft. Typical radiation diagrams of each aerial are shown in the figure. The receiver is switched, by a motor, at about twenty-five times per second, to each aerial alternately. The signal applied to the horizontal deflection plates of the cathode-ray tube is simultaneously switched from the right to the left deflection plates, so that when the receiver is connected to the port aerial the cathode-ray trace is deflected to the left, and vice versa.

By inspection of the radiation diagrams of the receiving aerials in Figure 1 (a), it can be seen that the "pips" on each side of the time-base line will be equal only when the received signal is arriving from straight ahead of the aircraft. The appearance of the Rebecca cathode-ray tube screen is shown in Figure 2 for two cases.

In the presence of wind with a component across the line joining the aircraft and the site of Eureka the aircraft will follow a spiral course if it is continually pointed at Eureka. An experienced pilot, however, could approximately correct this by heading the aircraft to the appropriate side of the beacon, in other words maintaining a slightly greater signal on one side of the cathode-ray tube screen than on the other.

Security of operation is obtained mainly by separate frequency operation, which means that the Rebecca and Eureka transmitter frequencies are different, i.e. interrogation is performed on one radio frequency and response on another. (Another important advantage of separate frequency operation is the freedom from ground echoes on the Rebecca display.) In addition, both the transmitters and receivers of Rebecca and Eureka may be operated on any one of six spot frequencies each selected by a switch. These frequencies include five in the so-called Rebecca band 214 - 234 Mc/s and 176 Mc/s, the latter being the operating frequency of ASV. Thus Rebecca would be able to operate with Eureka in the Rebecca band and Eureka or ASV beacons on 176 Mc/s. Similarly Eureka could be used by ASV as well as Rebecca when on 176 Mc/s. When on 176 Mc/s with either Rebecca or Eureka same-frequency operation would be used, i.e. receiver and transmitter would operate on 176 Mc/s. Thus the number of channels available are 21, 20 of which are in the Rebecca band, excluding those with same-frequency operation, and one on 176 Mc/s. (The various frequencies were given code letters, A, B, C, D, E, P, corresponding to 214, 219, 224, 229, 234, 176 Mc/s respectively. The transmission frequencies of Eurekas were denoted by A', B', C', D', E', P'. Hence if channel B-E' were being used Rebecca would transmit on B and receive on E', and Eureka would receive on B and transmit on E'.)

The security of operation of Rebecca-Eureka was further increased by manual coding of Eureka.

The capacity of the system for one Eureka is determined by two factors, (i) the cluttering of the Rebecca display by unsynchronized pulses from Eureka due to other Rebeccas and (ii) the saturation of the beacon. The limiting factor to the capacity of a responder-beacon is generally the permissible mean dissipation in the transmitter tubes. To prevent this being exceeded it is normal to make the beacon inoperative(or paralyzed) for a short time after it has been triggered. This prevents the beacon's being triggered at more than a certain rate. It also means that the responding efficiency of the Eureka when being interrogated by a large number of Rebeccas will be reduced, i.e. each Rebecca will receive from the Eureka only synchronized pulses which are, over a period of time, a certain proportion of the number of pulses transmitted by the Rebecca.

The maximum ranges obtained with the Australian Rebecca Mk. IIB and Eureka Mk. II are shown in Figure 3. These results apply to the Rebecca band.

4 REBECCA Mk. IIB (Aust.)

Rebecca Mk. IIB (Aust.) is contained mainly in two units, shown in Figure 4, the receiver-transmitter unit and the indicator unit. The complete installation would include a transmitting aerial, two receiving aerials, power supply, power control box, and cabling.

A block diagram of the main units of Rebecca is shown in Figure 5. The cycle of operations, which recurs about 350 times per second, is initiated by the multivibrator, which triggers the transmitter and the time-base generator and simultaneously switches on the receiver local oscillator, whites in the cathode-ray tube, and supplies a suppression pulse to the IFF (if installed). The last three operations take slightly longer than the working range of the time base.

A pulse obtained from the transmitter modulator is delayed 2½ microseconds and used to generate a zero marker pulse which is mixed with the reveiver output and appears on the cathode-ray tube screen. This pulse indicates zero range when the aircraft is flying at an altitude of 500 feet.

The pulse from Eureka, responding to the Rebecca transmitter pulse, is picked up by the receiving aerials and fed to the receiver from the aerials, to which it is connected at the time, by the aerial switch. The radio-frequency pulse is amplified and detected in the receiver and the resulting video pulse applied to the right or left horizontal plate of the cathode-ray tube, depending on which aerial is connected.

4.1 Transmitter

Two VR135 ultra-high-frequency triodes are used in a push-pull oscillator circuit with transmission-line tuning in the plate circuit (see schematic diagram in Figure 6). Plate modulation is used, with a 2000-volt pulse of 2½ microseconds duration applied through a pulse transformer from the modulator.

The modulator consists of a resonantly charged pulse-forming line and a GL2050 thyratron. When the thyratron is triggered, by a pulse from the synchronizing multivibrator, the line is discharged by a 2½-microsecond current pulse through the primary of the pulse transformer.

Frequency switching is carried out by a turret which switches pre-adjusted capacity trimmers into the open end of the plate transmission line (Figure 7). In the Rebecca band the closed end of the transmission is short-circuited but on 176 Mc/s the short-circuit is removed leaving an inductance connected to the line, thus effectively lengthening it for the lower frequency.

Each trimmer condenser consists of a cylindrical borosilicate glass barrel, metallized on the outside at both ends, and open at one end. Snugly fitting brass caps are soldered to the ends and form the two condenser terminals. The outer condenser plate is formed by the end-cap over the closed end of the barrel and the metallizing at this end which covers approzimately five-sixteenths of an inch of the barrel length. The capacity variation is effected by means of a brass plunger which is made to slide along the inside of the barrel by turning a screw. The plunger has the form of an expansion ring and has sufficient friction against the glass to prevent it from turning.

The condensers are mounted on a polystyrene disk, and contact is made with the transmission line by means of knife contacts.

4.2 Receiver

A superheterodyne receiver is used, with one stage of radio-frequency amplification.

Incoming signals from the aerial, via the aerial switch, are fed to an RL37 (CV66) grounded-grid amplifier. This is followed by a tuned mixer (RL18). The intermediate-frequency (30 Mc/s) output is amplified in a five-stage stagger-tuned amplifier using EF50 pentode valves. The EA50 second detector is followed by an EF50 pulse amplifier, the output of which is fed to a 6SN7-GT cathode-follower mixer.

The gain of the receiver is controlled manually from the indicator unit by varying the cathode potentials of the first two stages of the intermediate-frequency amplifier.

The oscillator is switched on, for the duration of the time-base, by a positive square wave from the synchronizing multivibrator applied, through a radio-frequency decoupling circuit, to the oscillator grid.

Frequency switching is accomplished by switching pre-adjusted inductance trimmers into the oscillator and the tuned input circuit of the mixer. The tuning inductances, which are mounted on two polystyrene disks, are similar in construction to the trimmer condensers used in the transmitter. The glass barrel is, in this case, open at both ends, and the metallizing is only wide enough to permit the soldering of end caps to the barrel. The inductance of each coil is varied by means of the brass plunger sliding inside the barrel. Contact between trimmers and circuits is made by means of knife contacts.

The marker pulse generator, which is situated in the intermediate-frequency amplifier chassis, consists of an 884 thyratron and pulse-forming line. The 884 is triggered by a fraction of the transmitter-modulator pulse and produces a 3/4-microsecond pulse on one of the grids of the cathode-follower mixer, the output of which thus consists of the receiver output plus the marker pulse.

4.3 Indicator unit

The cathode-ray tube is a type of 5B1 (1802 P1), the screen of which is 5 inches in diameter. An edge-lit lucite screen is mounted in front of it, with the range markings engraved on it.

In addition to the cathode-ray tube with its electrode supply network and shift controls, the indicator unit contains the time-base generator and time-base amplifier, and the synchronziing multivibrator amplifier, and cathode follower.

In addition to shift, intensity and focus controls, the unit contains the gain control for the receiver, the "ON" and "OFF" push-buttons for the transmitter, and the range-changing switch.

The time-base generator is a simple resistance-capacitance charging circuit in which the resistances and capacitances are changed for each range. The condenser is alternately discharged and allowed to charge by electronically switching on and off an EF50 pentode which is connected across it. The working stroke of the time base takes place during each negative square wave, which is applied to the grid of the discharging pentode, from the synchronizing multivibrator. The working range of the time base is about 1/200 of the time constant, hence the time-base voltage is roughly linear with respect to time.

The time-base amplifier uses two EF50 pentodes in a push-pull cathode-coupled circuit.

4.4 Aerials

The transmitting aerial for Rebecca is generally a single quarter-wave spike mounted either on top of or underneath the nose of the aircraft. Occasionally a parasitic director or reflector element is added. When used over the range of frequencies 176 Mc/s to 234 Mc/s it must have broad-band properties.

The transmitting aerial is much the same on different types of aircraft, but the receiving aerials due to radiation diagram requirements, i.e. sharp cross-over straight ahead for direction-finding purposes and freedom from propeller flutter (fluctuation in gain due to the rotation of the propeller), vary with different types of aircraft. Some aircraft, such as Beauforts and Dakotas, are fitted with fuselage type aerials mounted just behind the nose; others, such as the Beaufighter, require wing-type aerials generally mounted on the underside of the main plane.

In addition, for use with Rebecca Mk. IIB (Aust.) the aerials are required to operate on 176 Mc/s as well as on the Rebecca band. The aerials must have satisfactory gain straight ahead, satisfactory cross-over of the two radiation diagrams, and freedom from lobes which might give false heading information on both 176 Mc/s and the Rebecca band. Rebecca aerials to cover this frequency range were developed, in Australia, only for the Beaufighter. The receiving aerials were wing-type aerials, a photograph of one of which is shown in Figure 8. An additional requirement, in the case of the Beaufighter, was that the presence of rockets on the underside of the wing should not affect the radiation diagram appreciably.

4.5 Operating characteristics

The main characteristics of the equipment are as follows:-

Transmitter frequency = one of six frequencies 176, 214, 219, 224, 229, 234 Mc/s selected by clicker switch.

Transmitter power output = 400 watts (peak)

Transmitter pulse length = 2·5 microseconds

Pulse repetition frequency = 350 p.p.s.

Receiver frequency = One of six frequencies 176, 214, 219, 224, 229, 234 Mc/s selected by clicker switch.

Receiver sensitivity= 10 microvolts (in 72 ohms) for signal = noise.

Receiver bandwidth = 1·8 Mc/s (overall - 3 db. down)

Receiver intermediate frequency = 30 Mc/s

Ranges = 4, 10, 40, 100 nautical miles

Power consumption = 150 VA (80 V, 1250 c/s)

Weight of receiver-transmitter unit = $32\frac{1}{2}$ lb.

Weight of indicator unit = 22 lb.

4.6 Construction

The receiver-transmitter unit consists of a main chassis and four sub-chassis - the transmitter unit, the radio-frequency unit, the intermediate-frequency channel and the power supply unit. The sub-chassis are plugged into the main chassis by means of strip-connectors which carry up to ten contacts. Such a construction facilitates maintenance (and production).

The indicator unit consists of a single chassis and front panel.

Components and materials were selected to give reliable performance under tropical conditions. All iron-cored transformers and chokes were hermetically sealed.

5 EUREKA Mk. II (Aust.)

The complete Eureka Mk. II (Aust.) equipment consists of the Eureka unit, together with a battery, aerial mast, two aerials (one for the Rebecca frequency band and one for 176 Mc/s), headphones, cables and carrying cases. The equipment is easily portable, the aerial mast and aerials breaking into small sections or folding, and the complete equipment, excluding carrying cases, weighing about 49 lb. The Eureka unit, a photograph of which is shown in Figure 9, weighs only 18 lb.

The equipment is extremely simple to operate. After it has been connected up and switched on, and the required receiver and transmitter frequencies have been selected by means of clicker switches, the equipment requires no attention. However, the operator, with the aid of a pair of headphones and a "test" push button on the Eureka unit, may check whether the equipment is operating satisfactorily, and also whether any Rebeccas are interrogating the Eureka. If coding is required, the operator uses the "code" push button in the same way as a Morse key. When the button is pressed the Eureka-transmitted pulse is increased considerably in length, this being observable on the Rebecca indicators.

5.1 Receiver

The receiver used is a separately-quenched super-regenerative type, similar to those used successfully in the English and American Eurekas and the ASV beacons. The main difficulty in the development of the Australian Eureka Mk. II was in meeting the requirement that the receiver operate on 176 Mc/s. as well as on the Rebecca band (214 - 234 Mc/s), by simple switching. This wide frequency range had not been covered previously. Some time was spent in endeavouring to obtain satisfactory operation by switching capacity trimmers, since these trimmers had been developed for Rebecca and were used in the Eureka transmitter. However, inductance switching had to be adopted, although it involved more difficulty in production. The receiver compartment with the inductance turret is shown in Figure 10 (a). The inductances were adjusted by movable slugs. In production the final design of the receiver proved to be extremely stable and reliable.

The super-regenerative oscillator employs an RL18 miniature triode (V2) connected in a Colpitts circuit (see Figure 11). This oscillator is quenched at 475 kc/s by a quench oscillator (V4) which uses an EF50 pentode. (Owing to limited supplies of miniature valves some large type valves had to be used.)

The output of the super-regenerative oscillator is rectified by a diode (V3) and amplified by a pulse amplifier (V8). This pulse amplifier is followed by a pentode (V9) operating as both a cathode follower and amplifier, the screen being used as the plate of the cathode follower. V9 is coupled back to V8 through C25 to form a flip-flop, or single-step multivibrator. The flip-flop is adjusted so that it does not trigger on the noise output of the receiver. The pulse output from the flip-flop is taken from the cathode follower and used to modulate the transmitter. The pulse length is increased when the code button is pushed, by increasing the appropriate time constant in the flip-flop.

The correct conditions for super-regeneration are obtained by adjustment of the bias on the super-regenerative oscillator. The bias is extremely critical and varies with any change in frequency, electrode voltages, heater voltage, or quench voltage amplitude. This is overcome by including an automatic gain stabilization (AGS) circuit, which operates on the noise output from the receiver and automatically adjusts the bias so that the noise level remains approximately constant. The operation of this circuit is most effective, as measurement of the receiver sensitivity over a range of battery voltage showed no change from 10•5 volts to over 13 volts. The AGS circuit consists of an amplifier (V7) tuned to 475 kc/s, followed by a diode (V6) and a DC amplifier (V5) the output of which is applied as bias to the grid of the super-regenerative oscillator.

The receiver is preceded by a grounded-grid triode (V1) buffer amplifier which is included mainly to prevent variable loading on the super-regenerative oscillator by the aerial and transmitter circuit, and also to prevent noise-modulated quench voltages getting into the aerial, causing interference to communication gear and reducing security.

5.2 Transmitter

The transmitter consists of two RL18 miniature triodes (V10 and V11) operating in push-pull, with crossed capacitive feedback, as a grid-modulated oscillator. The use of the feedback condensers is not usual in circuits of this kind at these frequencies, the feedback generally being obtained by means of the inter-electrode capacitances of the valves. However, to obtain satisfactory output over the frequency range 176 Mc/s to 234 Mc/s enabling frequency switching to be accomplished by switching capacity trimmers, with no adjustment of the output coupling circuit, this form of feedback had to be used.

In the quiescent state the oscillator valves are biased off on their grids by a negative voltage developed in the circuit of the quench oscillator. When the modulator is triggered this bias suddenly becomes positive for a time corresponding to the required transmitted pulse length.

Frequency switching is accomplished by switching preadjusted capacity trimmers, similar to those used in Rebecca, into the plate-tuned circuit. These trimmers are mounted between two polystyrene disks and contact with the circuit is made by means of knife contacts. Figure 10 (b) shows a photograph of the transmitter compartment with the frequency switching turret.

5.3 Power supply

The primary source of power is a 12-volt Ni-Fe battery, similar to that used with the British Eureka Mk. II. The equipment will operate continuously and satisfactorily on this battery for about seven hours. The current drain from the battery is 2·5 amp. at 12 volts. For converting 12 volts to the necessary H.T. a synchronous vibrator power supply is used.

5.4 Aerials

Common aerial working is used, i.e. the transmitter and receiver use the same aerial. The coaxial feeders to receiver and transmitter come to a junction with the aerial feeder, the cable length being such that minimum loss is suffered both in transmission and reception. This is achieved by deliberate mismatch so that looking at the junction from the aerial feeder the transmitter branch offers a much higher impedance than the receiver branch, and looking at the junction from the transmitter feeder the receiver branch offers a much higher impedance then the aerial feeder. The loss, either way, was reduced to less than 1 db. by this means.

Two different aerials are used, one for the Rebecca band and one for 176 Mc/s, each having the aerial feeder, junction box, and appropriate lengths of cable to transmitter and receiver. The Rebecca band aerial is a vertically-polarized quarter-wave spike with counterpoise elements (Figure 12) copied from the American AS-10 aerial for the American Eureka, AN/PPN-1. The radiation diagram is circular to within 1 db. and the gain is approximately equal to that of a half-wave dipole.

The aerial used on 176 Mc/s is of the horizontally-polarized crossed dipole type in which two half-wave dipoles are fed in quadrature. The gain of this aerial is about 4 db. down on a half-wave dipole, owing to the fact that it radiates almost equally in all directions as compared with the dough-nut shaped radiation diagram of a dipole. This was not regarded as serious, however, since ASV has higher transmitter power and receiver sensitivity than Rebecca. The cartwheel aerial, which is used in the ASV beacon, is horizontally polarized, has a circular horizontal radiation diagram, and has a gain approximately equal to a dipole, but it would be much more difficult to fold this type of aerial into a small space, for carrying, than it is for the crossed-dipole aerial.

5.5 Operating characteristics

The main characteristics of Eureka Mk. II (Aust.) are:-

Transmitter frequency = one of six frequencies 176, 214, 219, 224, 229, 234 Mc/s selected by a clicker switch

Transmitter power output = 8 watts (peak)

Transmitter pulse length = 8 microseconds - increasing to 18 microseconds on code

Receiver frequency = one of six frequencies 176, 214, 219, 224, 229, 234 Mc/s selected by a clicker switch.

Receiver sensitivity = { 150 microvolts for 100 per cent. triggering on Rebecca band
{ 200 microvolts for 100 per cent. triggering on 176 Mc/s.

Receiver bandwidth = 5 Mc/s (overall - 3 db. down)

Paralysis time = 100 microseconds

Delay, overall = 2 microseconds

Power consumption = 2·5 amp. at 12 volts (30 watts)

Weight of Eureka = 18 lb.

Weight of battery = 22 lb.

Weight of aerial system (mast, two aerials, cables) = 8 lb.

5.6 Construction

The receiver-transmitter and vibrator power supply units are contained in a sealed, aluminium, alloy box with dimensions 15 x 7¾ x 6½ inches; the units are mounted on the lid of the box which forms the control panel of the equipment. The main seal on the box is made by a Neoprene gasket inside the lid. The holding screws are screwed into blind rivet blocks attached to the box. The power socket connector and two coaxial socket connectors were modified, by the addition of Neoprene washers, to seal them effectively. The "test" and "code" push buttons are sealed by moulded Neoprene covers. The shafts of the frequency selector switches have Neoprene washers compressed into the shafts. The phone jack is contained in a small sealed can mounted on the back of the front panel.

A box containing $1\frac{1}{2}$ ounces of silica-gel is mounted inside the main box, and access to it is provided through a small cover plate. Actually it is desirable that this cover plate should be the weakest seal on the equipment so that any breathing which might occur will take place through the silica-gel.

In addition to the sealing of the box, all components were tropicalized according to the information available at the time of production.

All components, valves, etc., were mounted securely so that the equipment could withstand severe mechanical shocks, such as might be experienced when dropped by parachute.

6 ACKNOWLEDGEMENTS

Rebecca Mk. IIB (Aust.) was developed and produced by the Gramophone Co. Ltd., Homebush, under the direction of Mr. F. Canning, with Mr. B.F. Cooper, of the C.S.I.R. Radiophysics Laboratory, acting in an advisory capacity.

Eureka Mk. II (Aust.) was developed in the Radiophysics Laboratory, where six prototypes were made, and was produced by the Gramophone Co. The constructional design was supervised by Mr. R.C. Boothman, of the Gramophone Co., in order that the minimum difficulty would be encountered in production.

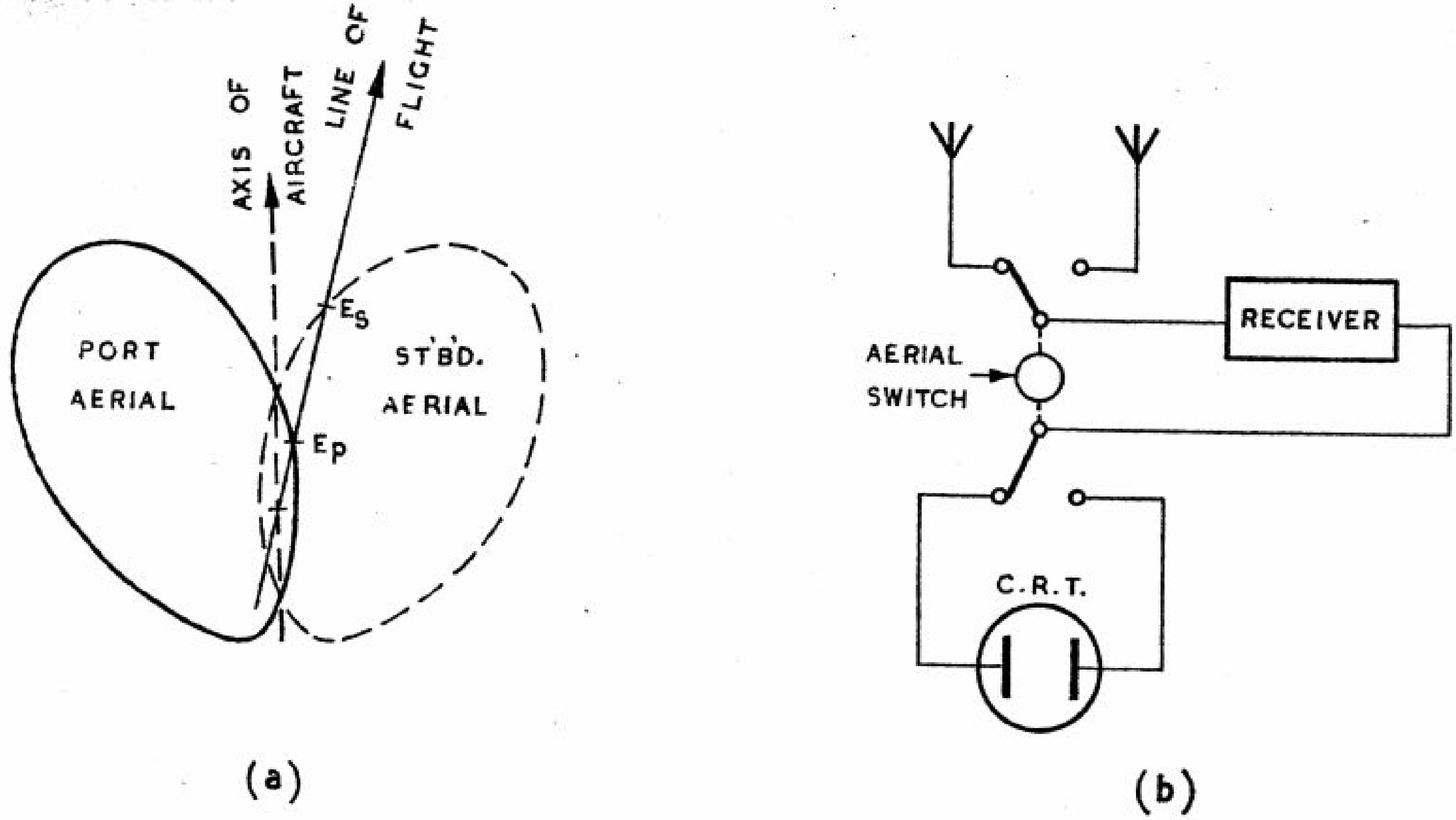
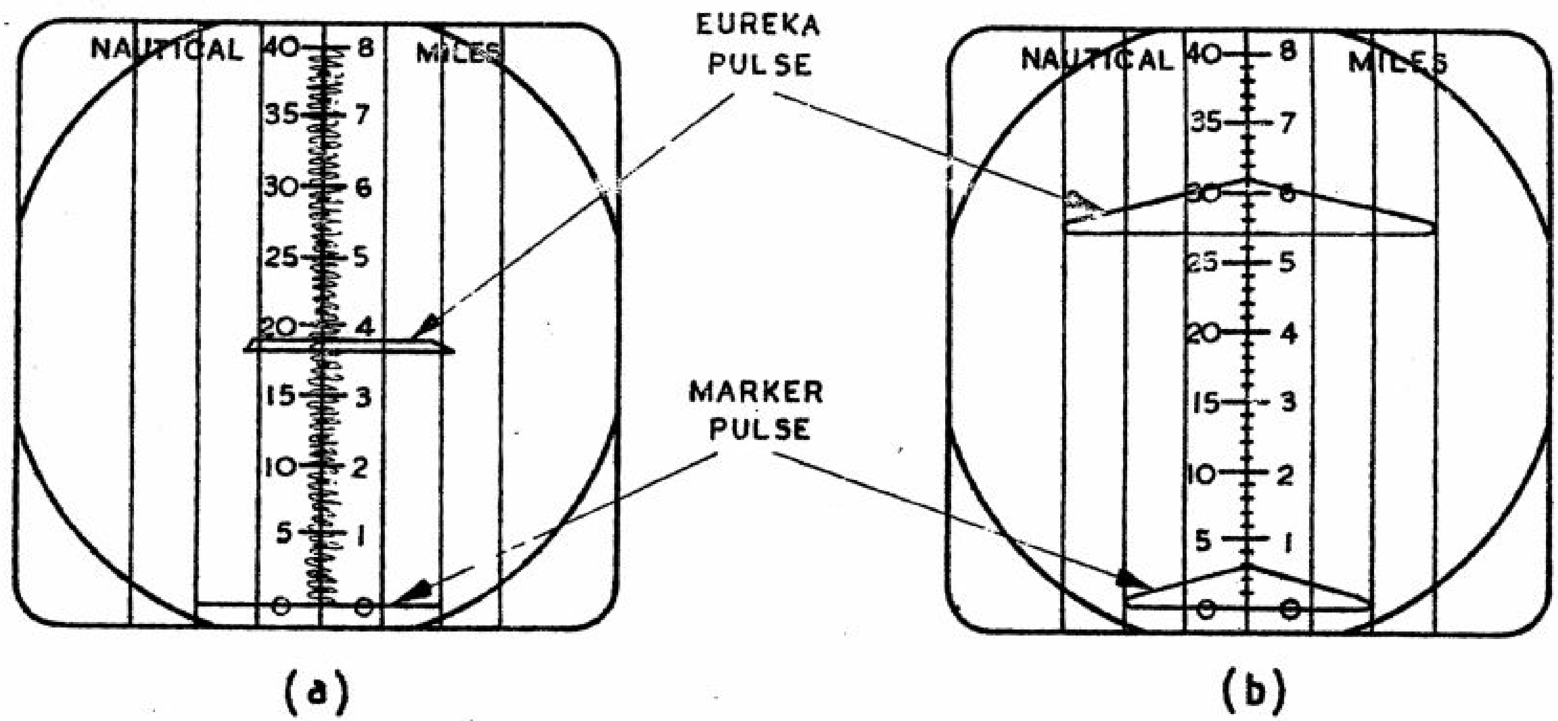


FIG. I.

METHOD OF D/FING USED IN REBECCA.



(a) 100 miles scale. Eureka 36 miles away on starboard side.

(b) 10 miles scale. Eureka 5·4 miles away straight ahead.

FIG. 2.

APPEARANCE OF REBECCA DISPLAY.

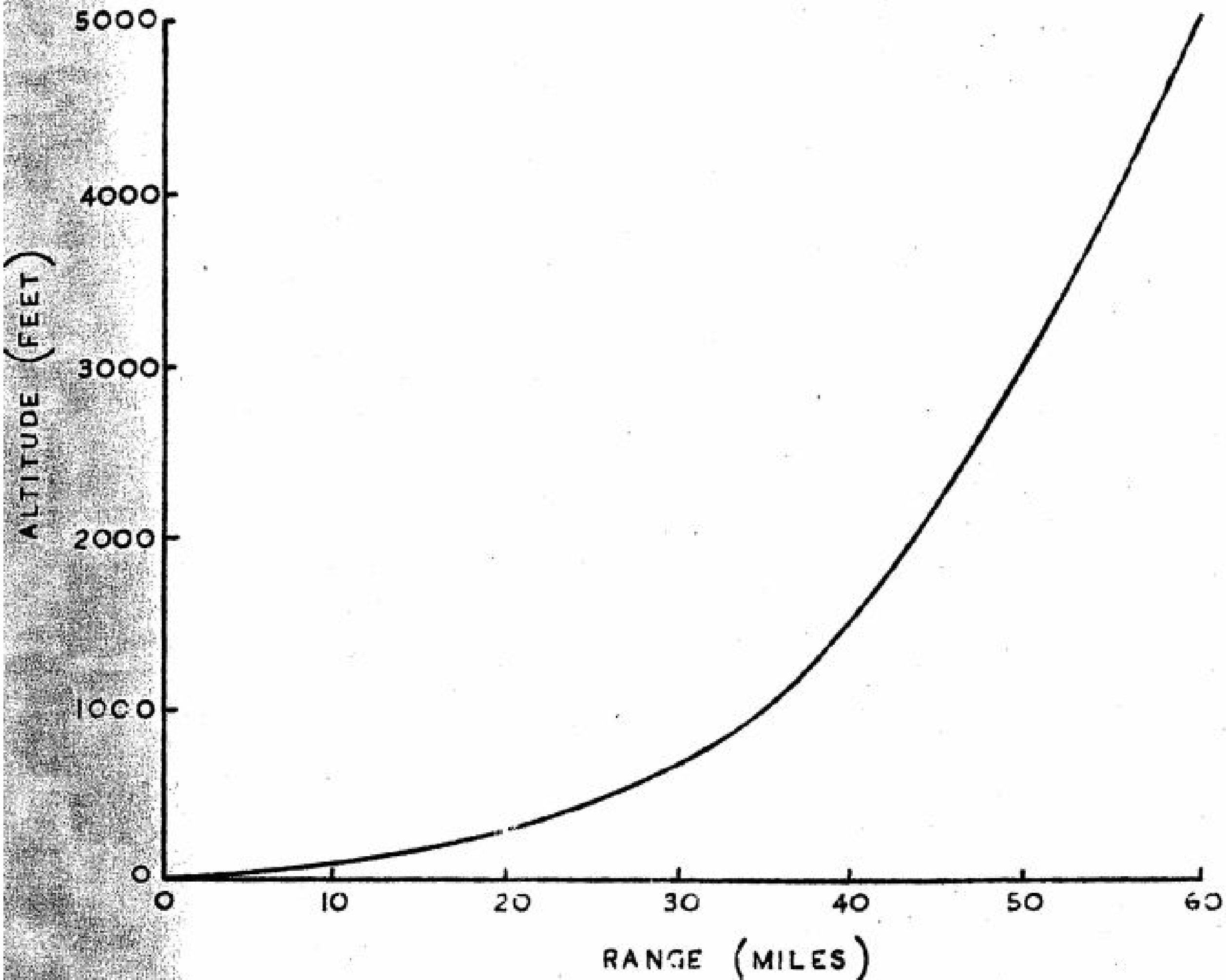


FIG. 3.

MAXIMUM RANGE OF REBECCA-EUREKA (AUST.)

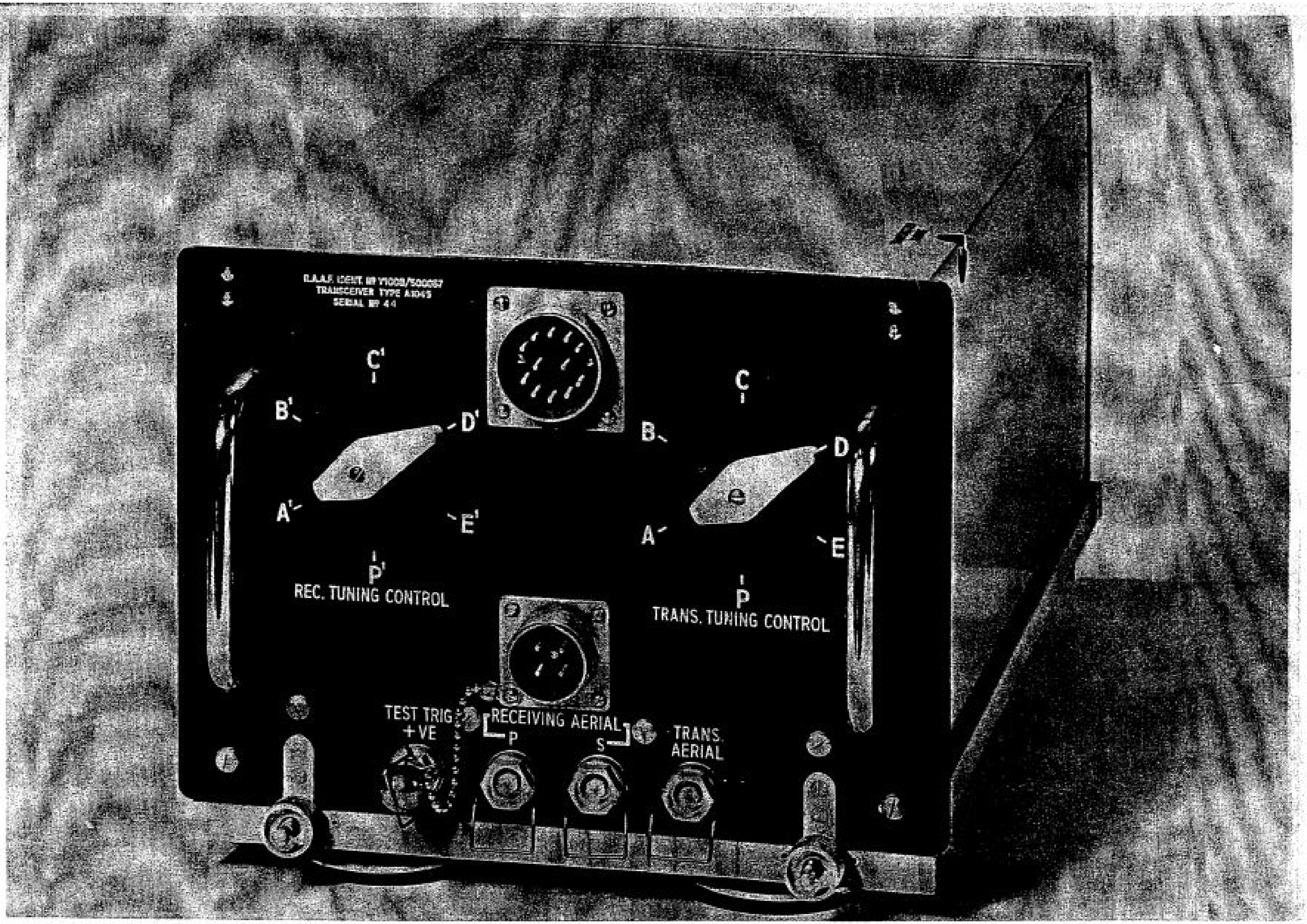


FIG. 4(a) REBECCA MK IIB (AUST.); RECEIVER-TRANSMITTER UNIT

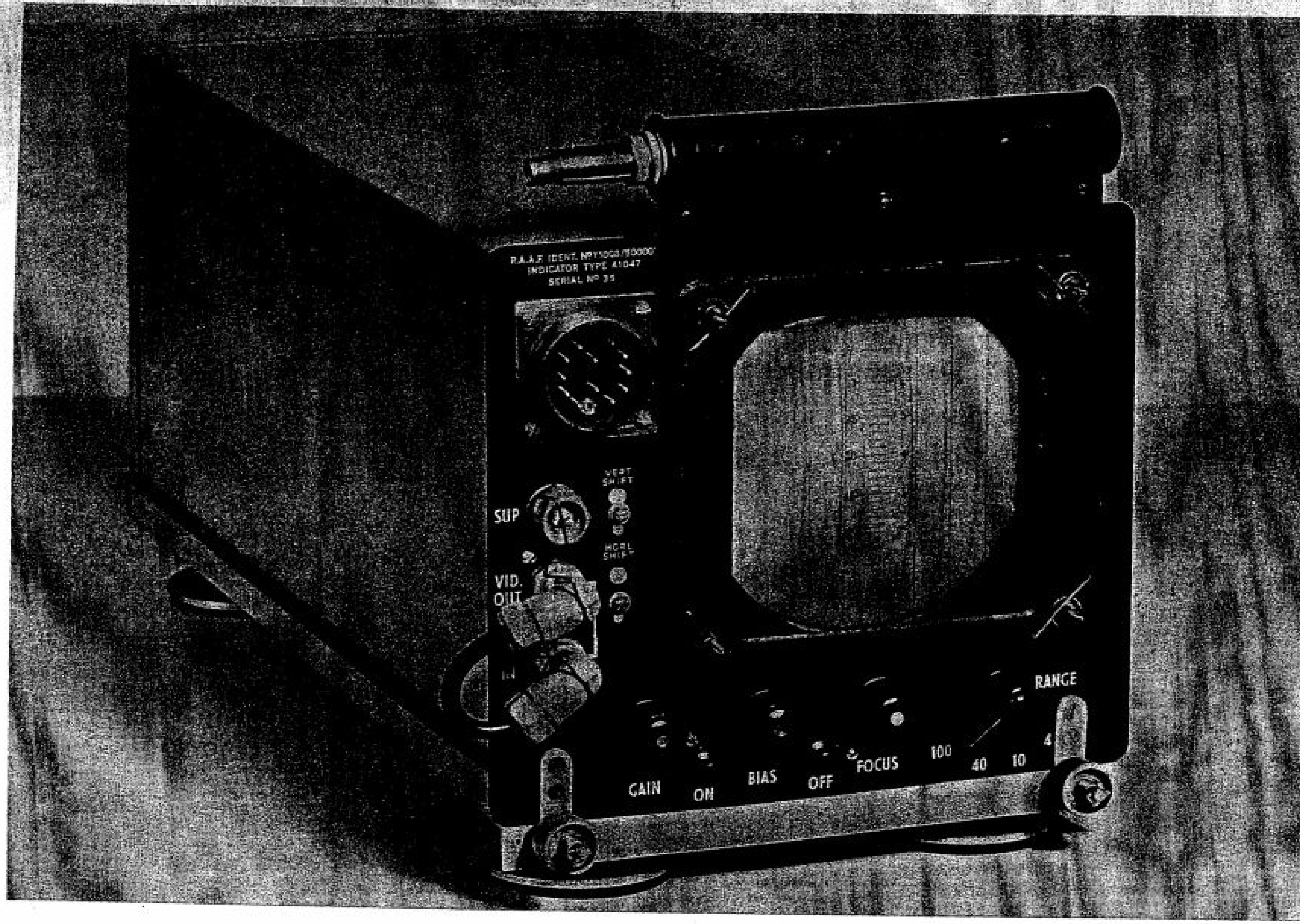


FIG. 4 (b) REBECCA MK IIB (AUST.); INDICATOR UNIT

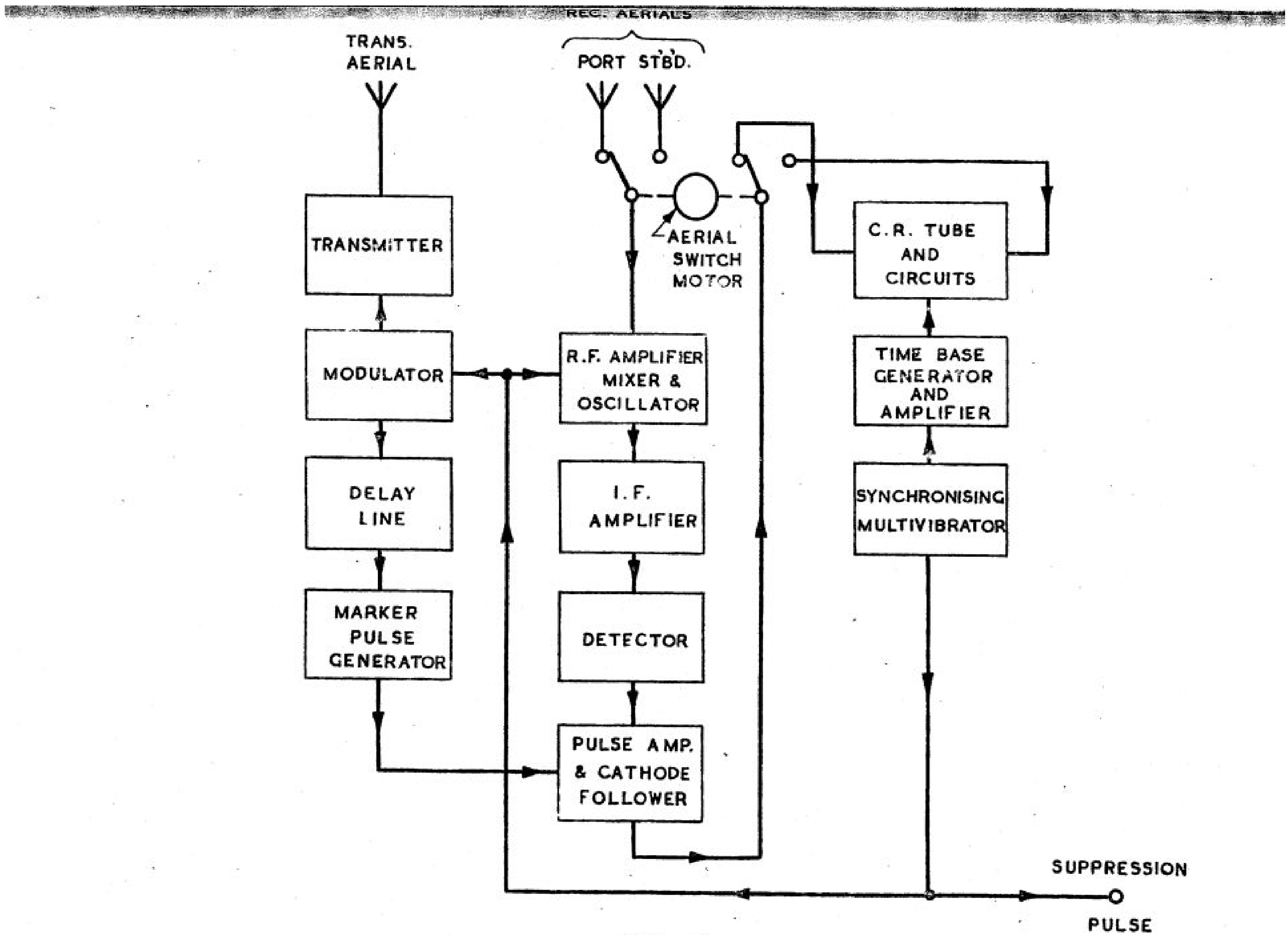


FIG. 5.

BLOCK DIAGRAM OF REBECCA Mk. II B (AUST.)

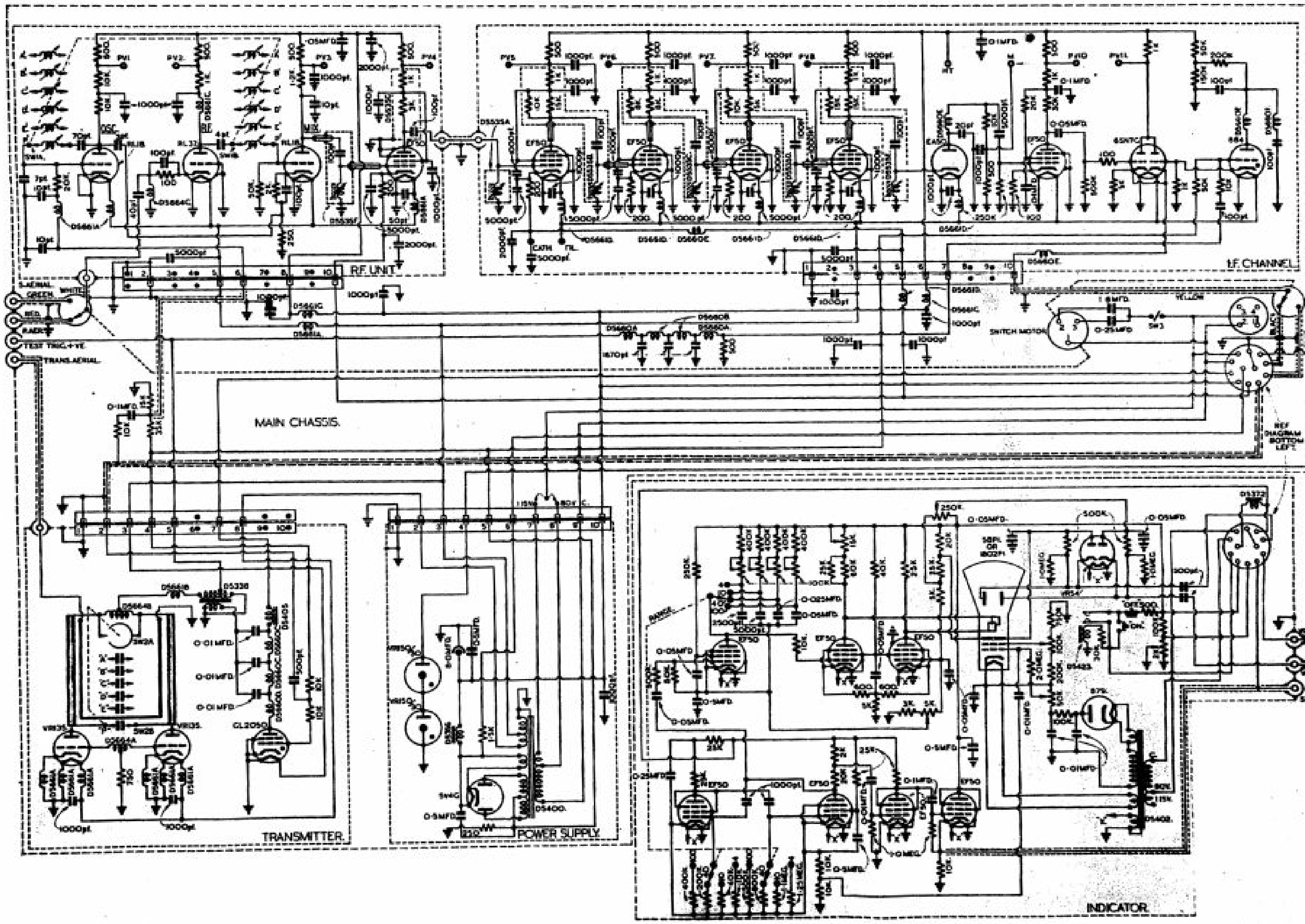


FIG. 6 SCHEMATIC DIAGRAM OF REBECCA MK II B (AUST.)

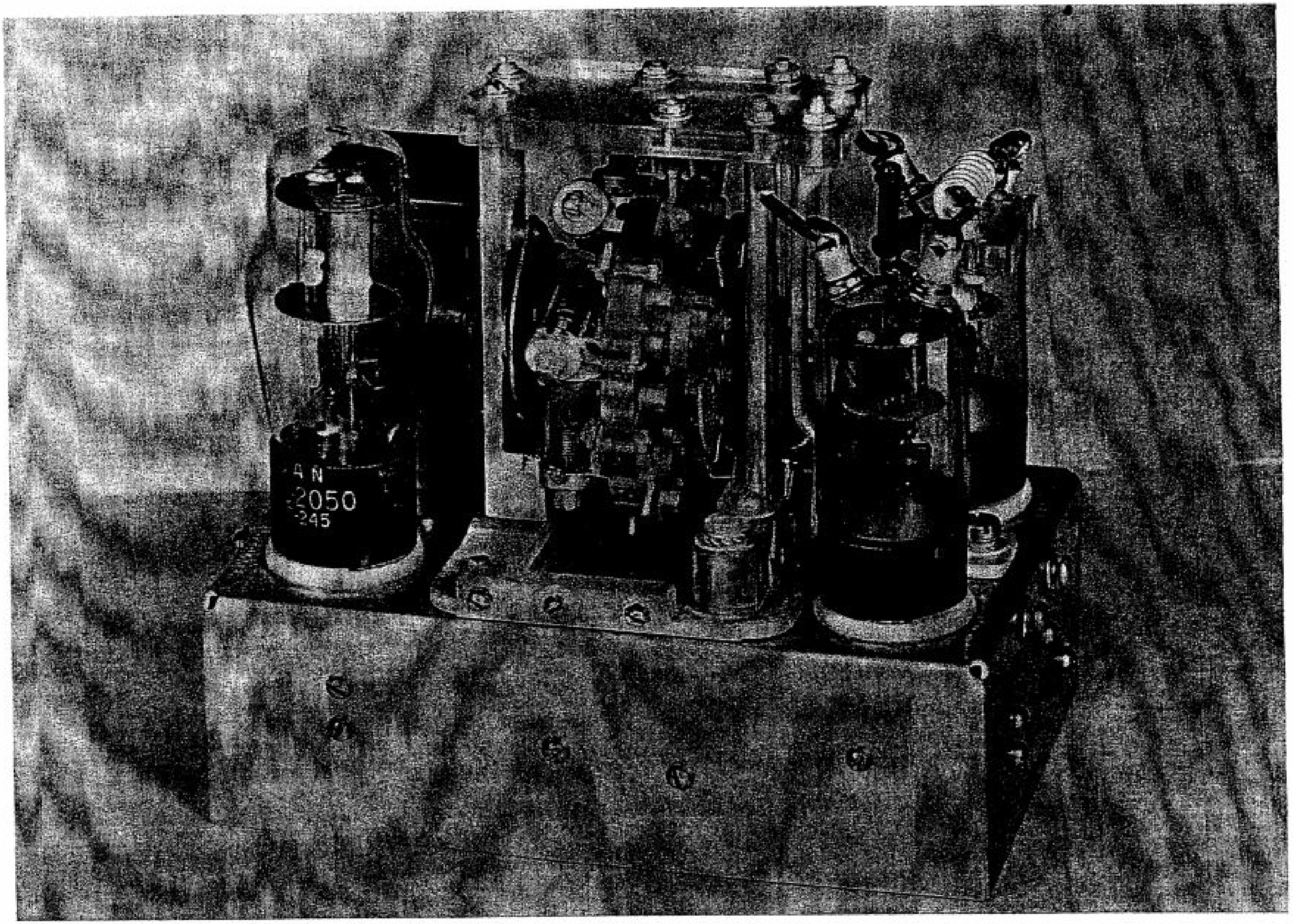


FIG. 7 REBECCA TRANSMITTER SUB-CHASSIS SHOWING TUNING TURRET

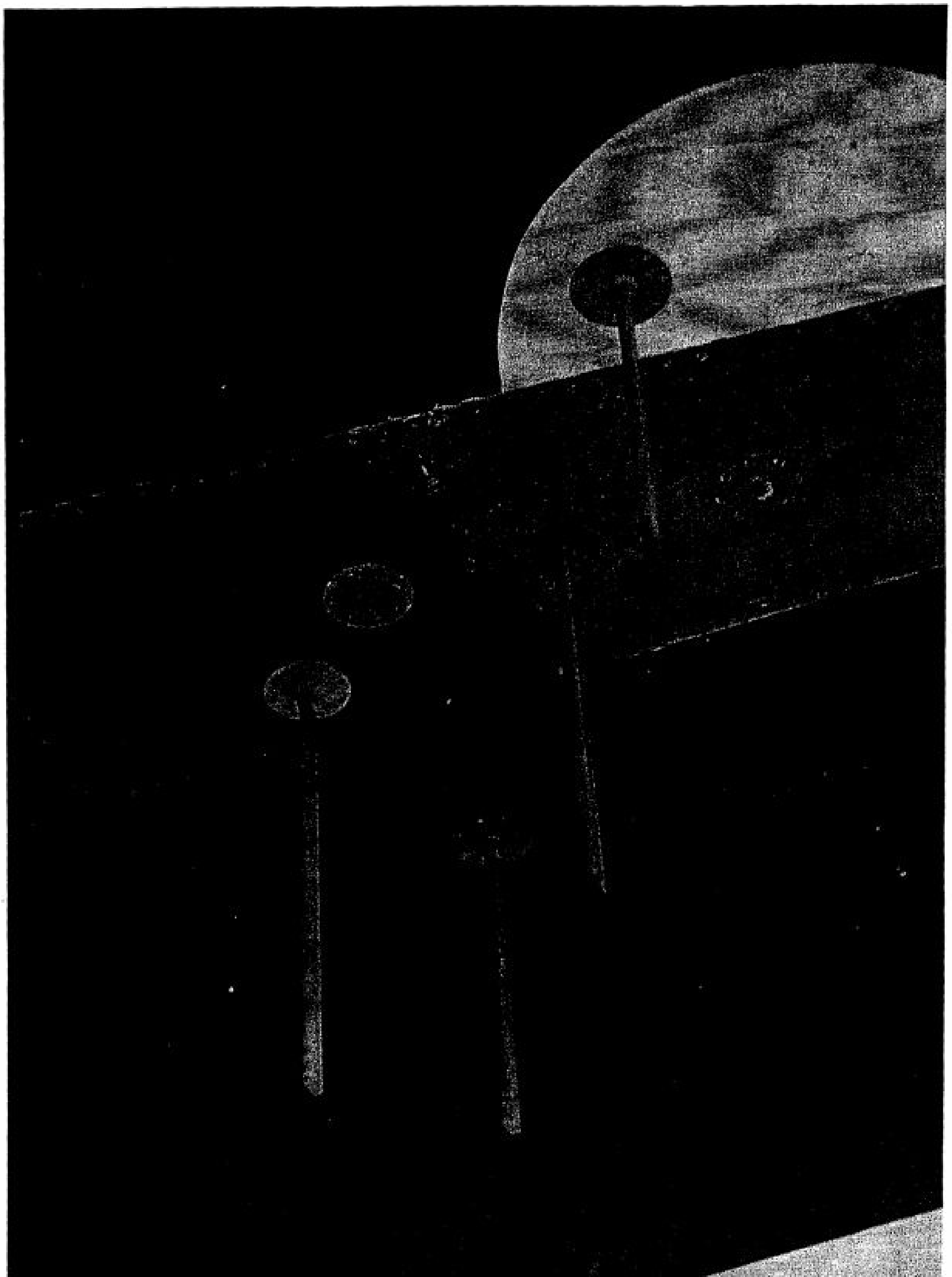


FIG.8 REBECCA RECEIVING AERIAL ON BEAUFIGHTER

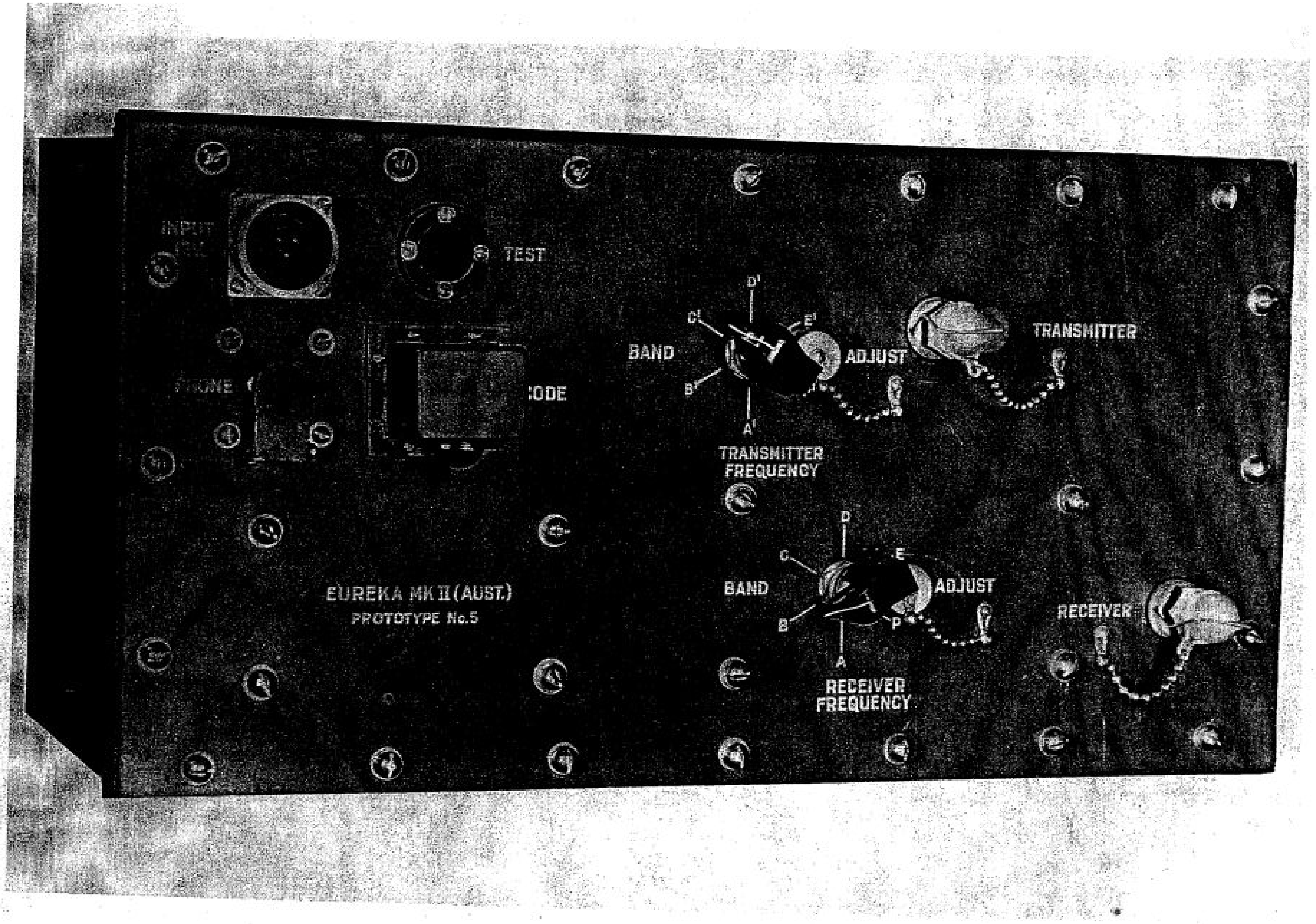


FIG.9 EUREKA MK II (AUST.)

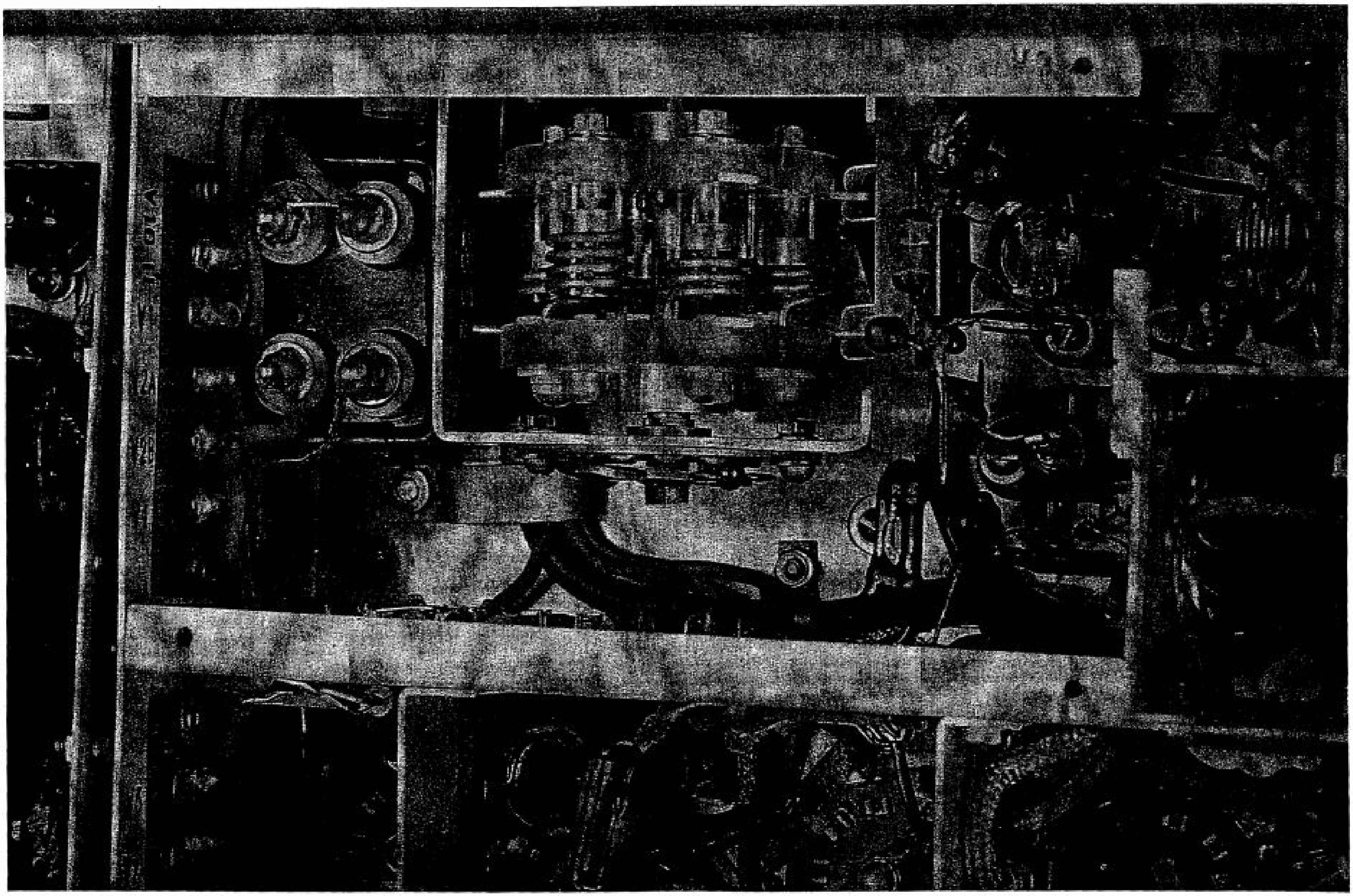


FIG. 10(a) RECEIVER - TUNING TURRET USED IN EUREKA

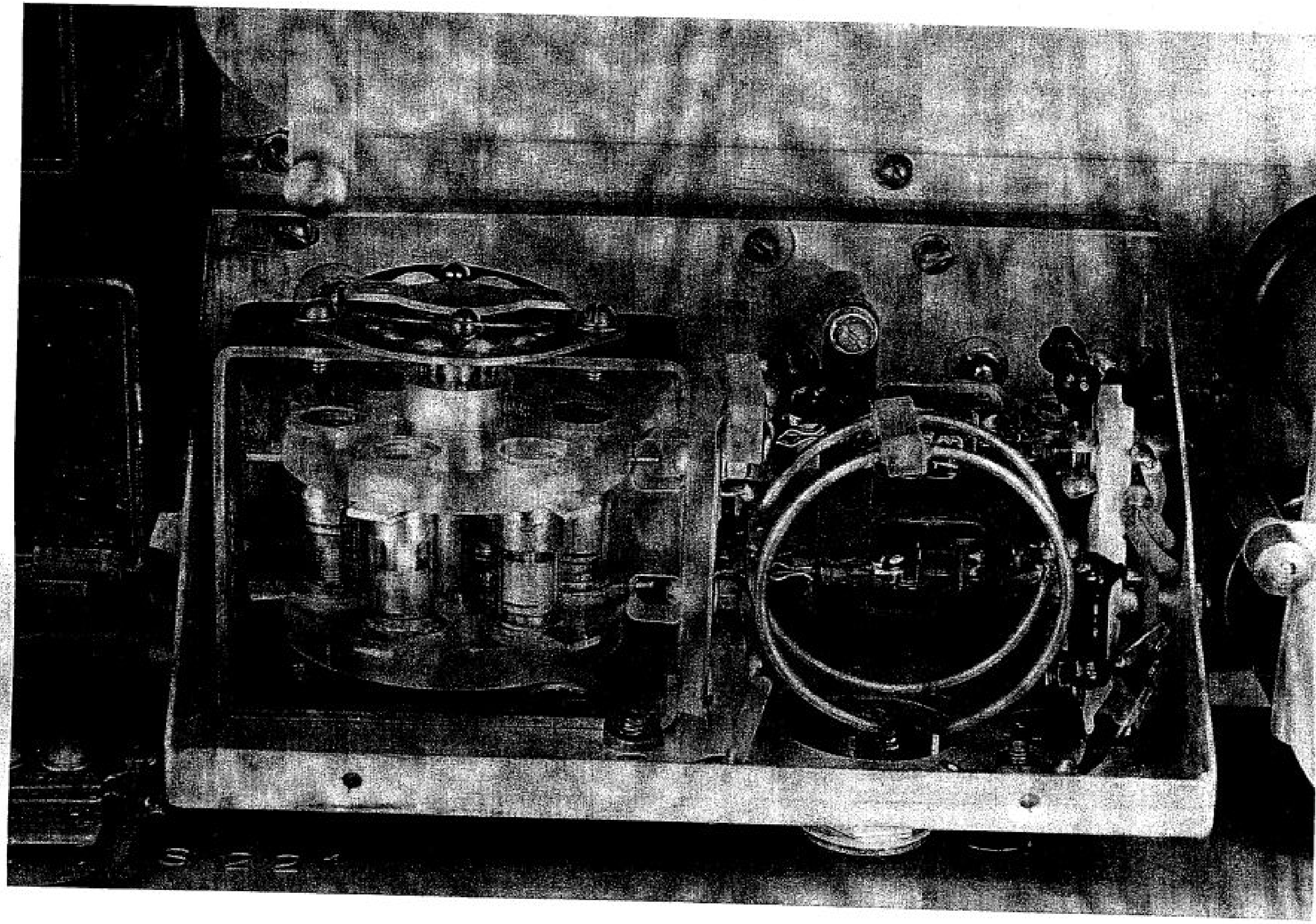


FIG. 10(b) TRANSMITTER – TUNING TURRET USED IN EUREKA

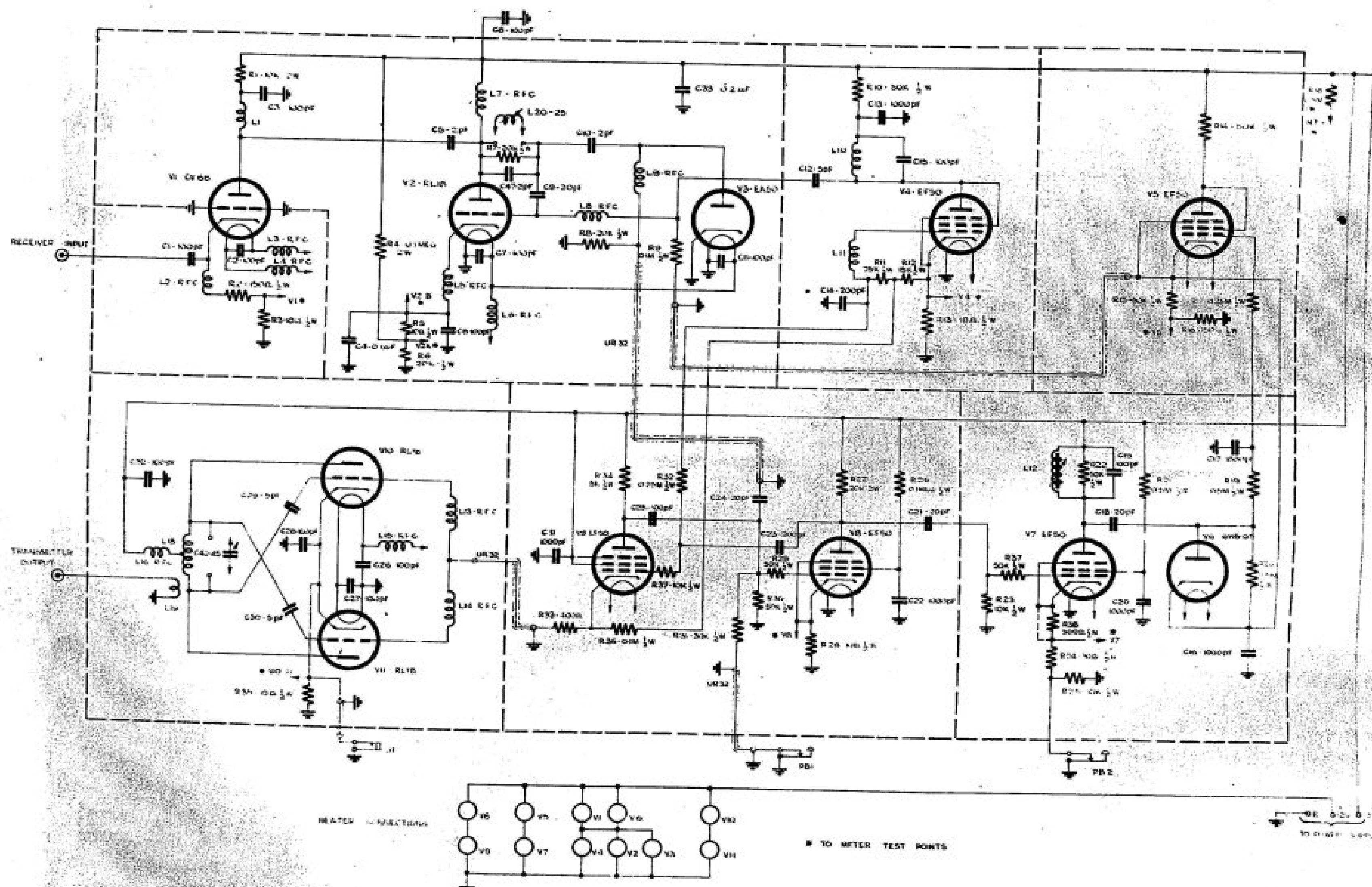


FIG.II SCHEMATIC DIAGRAM OF EUREKA MK II (AUST.)

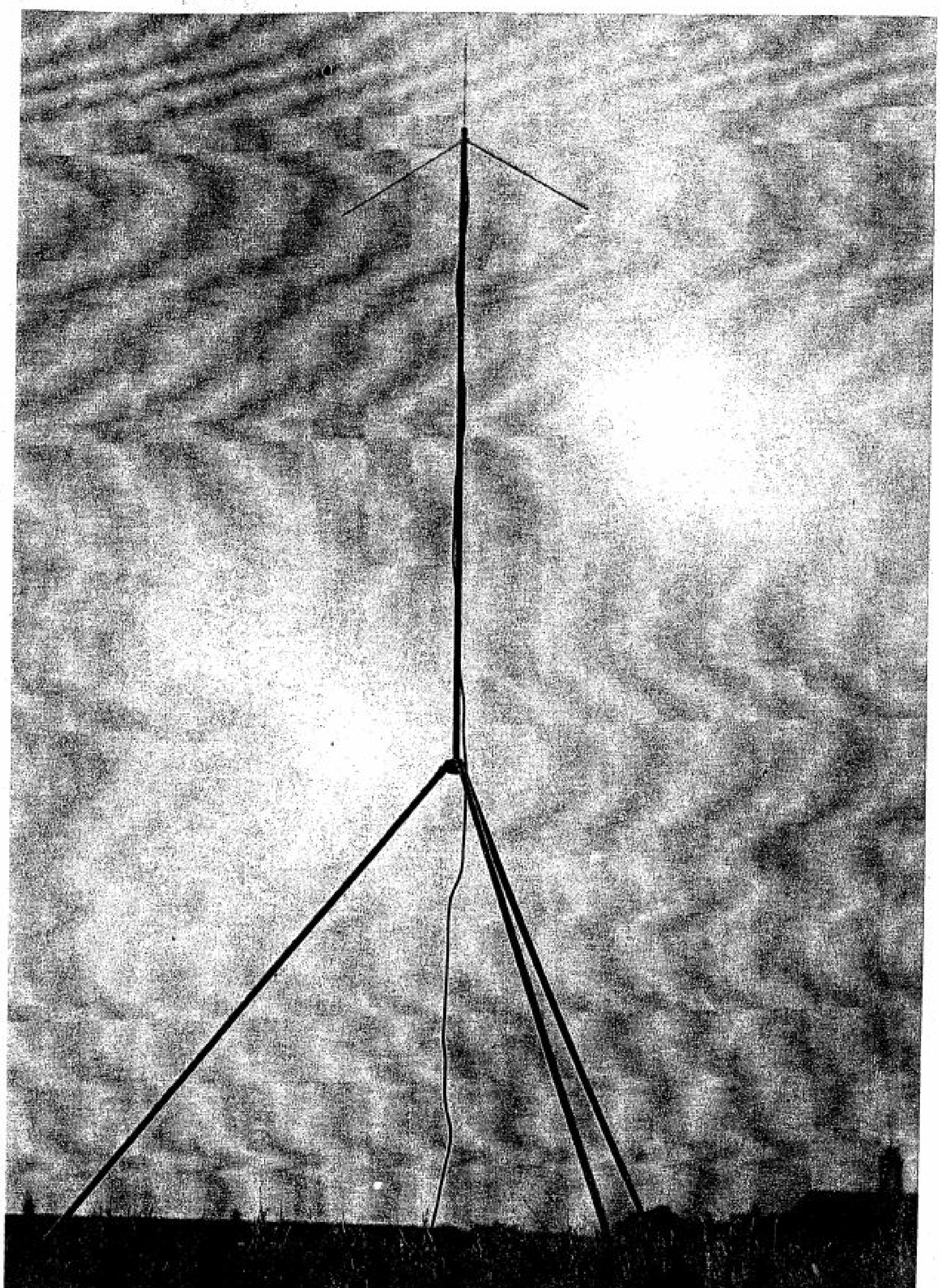


FIG.12 EUREKA AERIAL MAST