AP1234E

CHAPTER V —

GEE — ARI 5083

AL1 TO AP1234E —

USE OF GEE WITH THE UNIVERSAL INDICATOR , TYPE 2

GEE H Mk II — ARI 5685

~~CHAPTER V~~ AP1234E

GEE—A.R.I. 5083

Introduction

1. Accurate navigation by day and night under conditions of radio and radar silence, in indifferent weather, by unlimited numbers of aircraft flying under conditions when tactical considerations may prevent straight and level flying, calls for a fixing aid which can be operated quickly and simply.

2. Gee is a radar aid designed to meet such a requirement.

3. Historically, it is of interest to recall that it was evolved by British scientists to meet the needs of the Royal Air Force at a time when both Bomber and Coastal Commands were faced by serious navigational problems. It became operational about the time that the great "thousand-bomber" raids commenced in 1942, and when the Battle of the Bay of Biscay was reaching its maximum intensity. It is not too much to claim that it played as important a role in the success of the campaigns of that period as any other single factor. It was the first serious effort to provide the navigator with a rapid means of determination of position, and seldom has any one invention so faithfully and quickly satisfied the requirements for which it was developed. It continues to provide one of the best navigational aids yet devised.

Principle

4. The time difference between the reception of pulses from ground transmitters, working in pairs, is measured in units on a cathode ray tube screen. Two or more Slave stations, working with a common Master station, constitute a chain. The time differences of signals from two pairs of stations are measured simultaneously, and when the readings are referred to precomputed lattices on a special chart, the two simultaneous position lines secured combine to give a fix.

Performance

5. Frequencies in the V.H.F. band (20 to 85 megacycles) are employed. These tend to travel in the same way as light, and the distances at which reception is possible are thus largely a function of height. At altitudes of about 2,000 ft., reception is normally possible over land and sea at distances of 250 miles from a Gee transmitter. This distance may be greatly reduced if high ground intervenes between the transmitter and the aircraft, and in fact the signals may be completely screened. At heights of 15,000 to 20,000 ft. reception is experienced up to about 400 miles. In each case it is to be noted that these distances apply to each transmitter. To secure a position line, an aircraft must be within range of two transmitters, and to secure fixes, within range of three stations, *i.e.*, a common Master and two Slaves.

6. Under certain favourable weather conditions (usually when a marked inversion is present) reception at greater distances is experienced, even at low altitudes. This arises because the waves tend to be carried round the surface of the earth in "ducts" created by the different temperature layers of the atmosphere.

7. Some sky wave reception has also been noted well in excess of normal ranges.

8. Both these phenomena are comparatively rare, however, and special provision is not made for their exploitation for navigational purposes outside normal ranges.

9. The use of Gee is not restricted by weather. Its performance is for all practical purpose identical by day and night.

10. Accuracy is of a high order. In the best areas of a Gee lattice it is measured in terms of hundreds of yards. At extreme range, the ellipse of probability around a fix is of the order of seven to eight miles long and two to three miles wide. The average Gee fix is accurate to two miles or better.

11. Elaborate training is not necessary to achieve facility in the use of the equipment, and an experienced and competent operator can secure and plot fixes with ease in under two minutes.

Measurement of Time Difference

12. The time difference between the reception of pulses is measured by presenting these as signals on the same linear time base. The Master or "A" station is made to transmit so that its pulses produce two sets of signals which appear on the time base always at the same fixed distance apart. For purposes of identification the second of these signals is duplicated to give what is called a "ghost" signal (fig. 1).

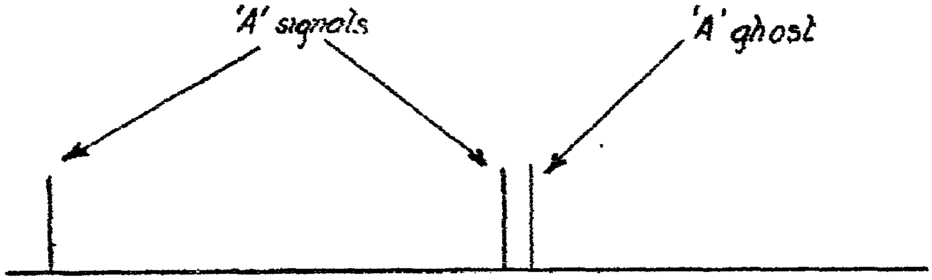


FIG. 1. Master Signals on Linear Time Base.

13. Transmissions from the first Slave or "B" station are so timed that the signals produced always appear on the time base between the two "A" signals. The signals from the second Slave or "C" station always appear behind the second "A" and "A ghost" signals. The complete time base thus presents the appearance shown at fig. 2 when signals from the Master and "B" and "C" Slaves are being received.

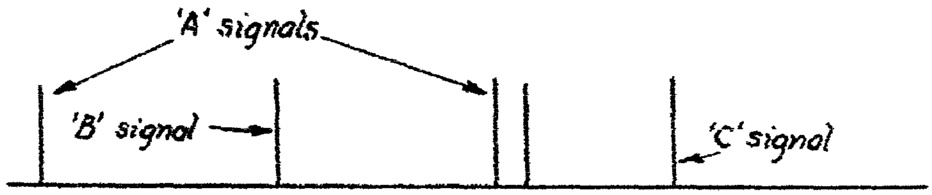


FIG. 2. "B" and "C" Slave Signals on Time Base.

14. It is found convenient to introduce a fourth ("D") Slave in several Gee chains. The signals from this are duplicated, separated by the same distance as the two "A" signals, and the delay is so arranged that one of these appears between the two "A" signals, and the other behind the second "A" and "A ghost." Each "D" signal has a "ghost" close up to it. The whole time base is split into two traces and these are presented one above the other. The traces are connected by fly-back traces, which are electrically blanked out and so are not visible.

15. The traces into which the time base is divided are equal in length to the distance between the two "A" signals. Hence at all times the first "A" signal appears either immediately above or below the second "A" signal with its attendant "ghost" signal alongside. Identification of the "A" signals from the Master station is thus immediately possible by inspection. Because of the delays introduced at the various Slave stations, it is clear that once the "A" signals are mounted on the left-hand edge of their respective traces, the "B" signal will appear on the same trace as the first "A" signal, with the "C" signal on the same trace as the "A" and "A ghost" signal. The "D" signals appear on both traces, one above the other.

16. Complete identification of all signals is rendered simple by this arrangement of the traces. By mounting the single "A" signal at the left of the upper trace, the "B" signal appears on the upper trace; the "A" and "A ghost" appear to the left of the lower trace and the "C"

signal is to the right of the "A ghost" on the lower trace. The "D" signal appears on both traces, and once the Master signals have been mounted on the left with the ghost on the lower trace, the complete picture is as shown at fig. 3.

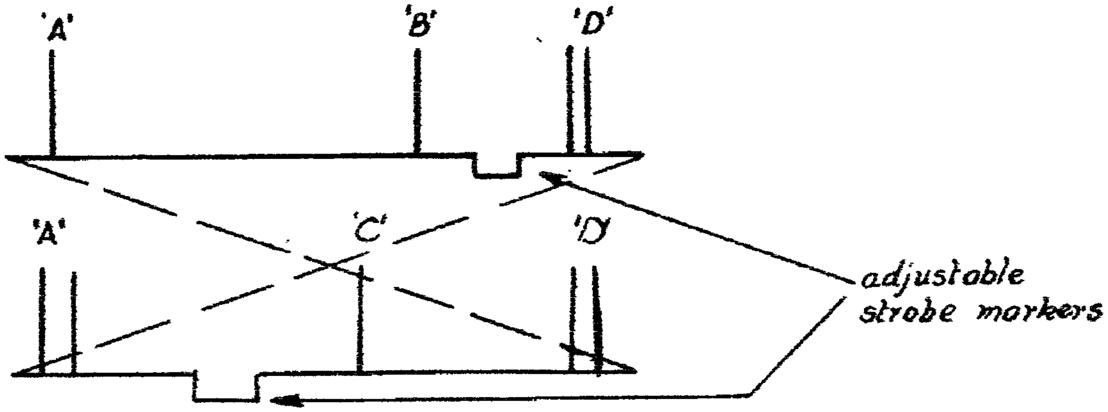


FIG. 3. Complete Display on Time Base.

17. On the main time base it is possible to read the time difference to the nearest unit (equal to 66·6 u-secs.). On the strobe time base measurement is carried out to the nearest 0·1 unit, and estimated to the nearest 0·01 unit.

18. Each trace is provided with a movable strobe marker. The left-hand section of each trace constitutes a fixed strobe. The movable markers are manipulated so that the Slave signals it is desired to use are mounted on them. At any one time, therefore, it is possible only to strobe the signals from two Slaves, *i.e.*, " B " or " D " on top, and " C " or " D " below. When strobed, the Slave signals appear on the underside of the trace. The combination of Slaves which can be used are " B " and " C," " B " and " D " or " C " and " D."

19. Each Gee chain operates on a different radio frequency. Once the equipment is set to the frequency of the chain it is desired to use, and the controls correctly set, signals from this chain appear on the traces on the screen, and are immediately ready for use.

The Equipment

20. Airborne Gee equipment is known as Airborne Radio Installation 5083. Mark II consists of an Indicator ; a Receiver incorporating an interchangeable radio frequency unit which can be changed in flight ; an alternator ; a voltage control panel where necessary ; an aerial and aerial loading unit (adjustable in flight for the various frequencies used), and the necessary wiring and cabling. The alternator and V.C.P. provide the necessary power supply—80 volts alternating current, with a power consumption of about 285 watts. The total weight of the installation including V.C.P. is approximately 100 lbs. The alternator, voltage control panel and wiring may also be used for Loran, and the Receiver and Indicator are mechanically interchangeable with the corresponding Loran units. Hence an aircraft wired for Gee can conveniently be converted for the use of Loran in place of Gee when this is desired.

21. The Indicator (fig. 4), which should be mounted in a position in the aircraft where it can be operated and read with ease by the navigator or other operator, incorporates the cathode ray tube, on which the signals are displayed and on which the time differences are measured (as described in detail at paras. 28–42 below), together with the controls necessary for the operation of the screen.

22. Once the receiver and aerial loading unit switches have been set to the appropriate position for the chain it is desired to use, signals from this pass into the Indicator and should appear on the traces. They will not necessarily remain stationary, owing to slight variation between the pulse recurrence frequency of the signals and the rate of formation of the traces. To bring them to rest, a calibrated Oscillator control is provided. This consists of two dials, of similar size, concentrically mounted. The rear dial provides coarse adjustment, and the front

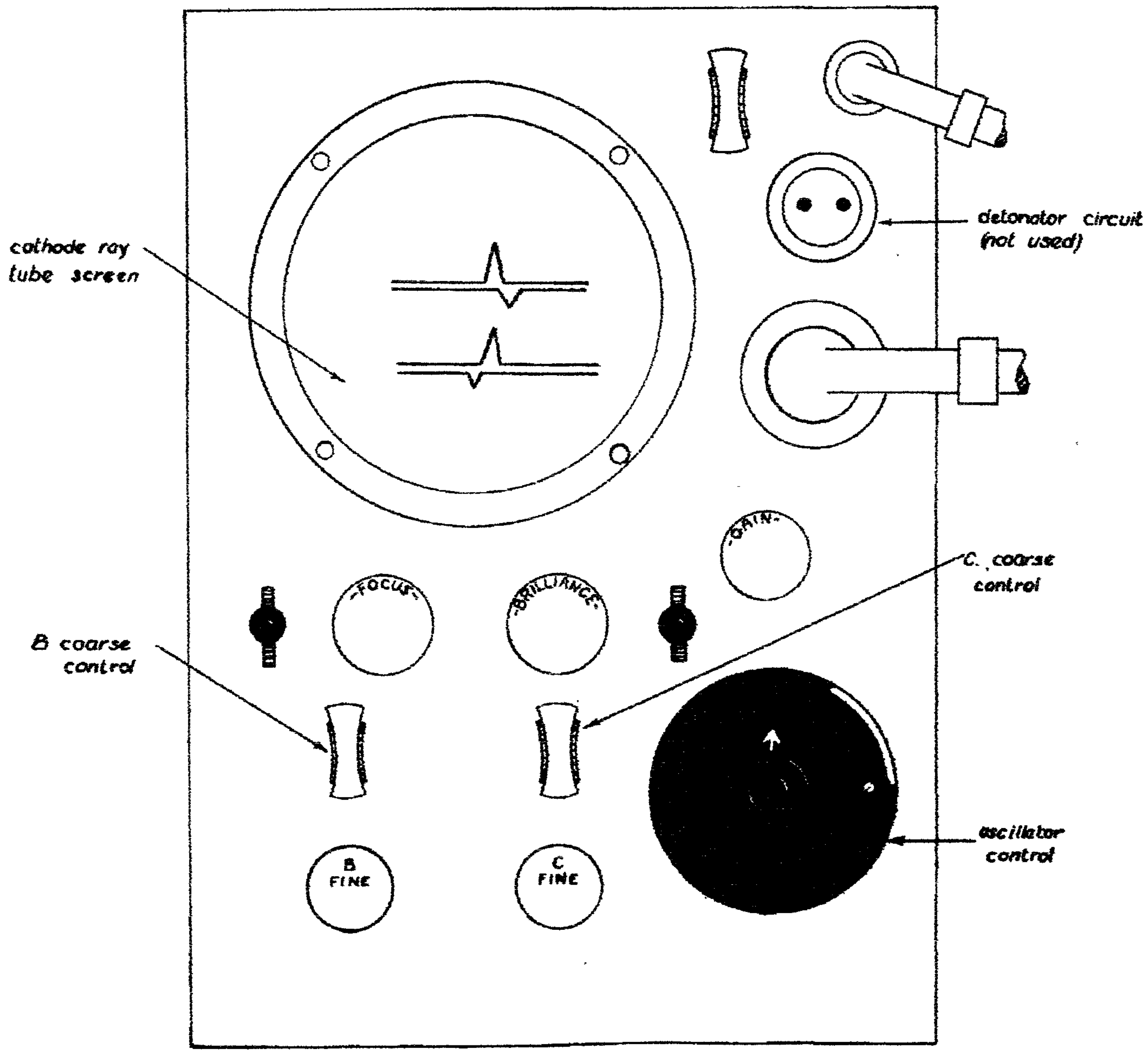


FIG. 4. Gee Indicator.

dial serves as a vernier control. Manipulation of this control brings the signals to rest. It is possible that signals from chains on neighbouring frequencies will break through and these may be drifting in relation to the signals from the required chain. In these circumstances care must be taken to bring to rest the correct signals (para. 44 below).

23. The Indicator is provided with a Brilliance control, with which to bring out the traces and signals on the screen, and adjust their brightness as required. To secure clear-cut, sharply defined traces, a Focus control is manipulated. Amplitude of the signals is regulated by a Gain control. The position of the strobe marker on the upper trace is regulated by the " B " strobe control, consisting of a click-stop coarse control, and immediately below it a fine control. Similar controls are provided for the strobe marker on the lower trace. Expansion of the time base is achieved by manipulation of a three-way tumbler switch on the left of the Indicator. In the lower position the main time base appears on the screen, together with the signals. The central position gives the strobe time base with signals, and the upper position the expanded strobe time base with signals. Once alignment has been effected, measurement of the time difference is

made possible by the provision of calibrated time bases. These appear on the screen when a two-way tumbler switch to the right of the Brilliance control is depressed. A two-way click-stop control at the upper right-hand corner of the Indicator controls the P.R.F. of the traces. Movement from the normal vertical position reduces the number of traces per second and permits the use of a longer trace when it is required to measure larger time intervals than is possible on the normal Gee time base. It will be noticed that, in this position, 30 instead of 25 Gee unit spaces appear on each trace. The switch has only a limited application, being left in the vertical position for the large majority of chains. It is used occasionally, however, for chains where a longer trace or a different P.R.F. is required (the only cases at the time of writing, January 1946, being those of the London and Tunisia Gee chains) and also in conjunction with developments of the Gee system. One point to notice in connection with the two chains mentioned above is that, although in theory the operator should count from 35 on the lower trace, counting is actually done in the conventional manner starting from 30, allowance having been made for this procedure in the lattice calculations.

24. The radio frequency on which the required chain is operating is selected at the Receiver (fig. 5). The Receiver can, if necessary, be mounted some distance from the operator without undue inconvenience, provided it is accessible when it is necessary to change frequency. It must be mounted where the R/F unit can easily be extracted and replaced in flight, and in such a way that the tuning dial on certain types of R/F unit can be easily adjusted. Frequency selection on R/F units Types 24 and 25 is by means of a five-stud switch, and on Types 26 and 27 by means of a calibrated dial. In the case of these two latter types, having set the dial at the reading given at the briefing for selecting the required chain, some signals should be seen on the main time base on the Indicator unit. It is then necessary to adjust first the main tuning control (the calibrated dial) and secondly the fine tuning control (a second smaller knob) to obtain maximum size signals

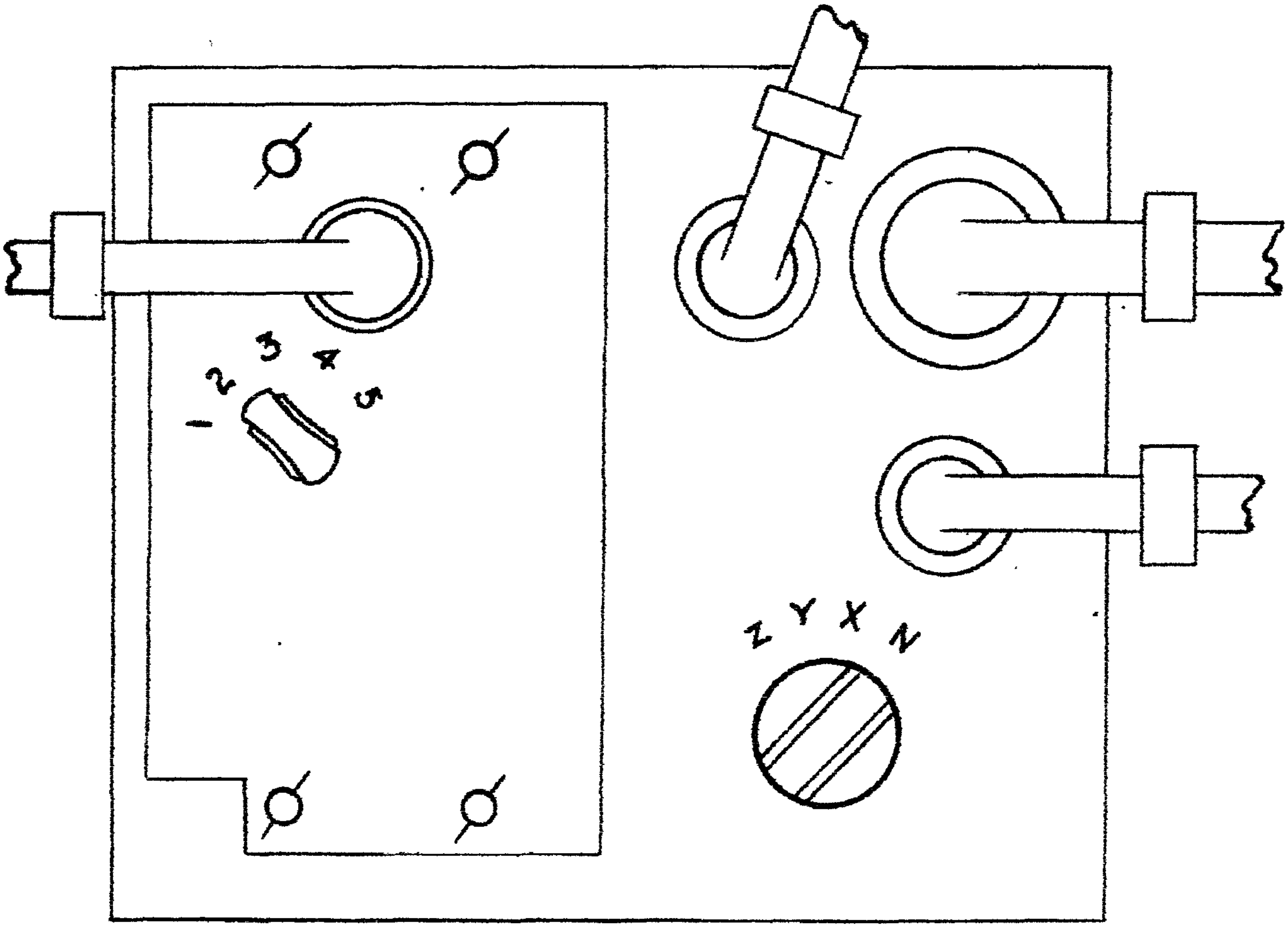


FIG. 5. Gee Receiver.

on the screen. The different units are used to cover different frequency bands (para. 43 below). An anti-jamming switch is provided with four positions, N, X, Y and Z. Under normal operating conditions this is kept at position " N." The R/F unit is secured by four quick-release bolts to facilitate removal.

25. The power supplies for the full equipment are controlled at the voltage control panel by an on-off switch. The V.C.P. can be mounted anywhere in the aircraft where access is possible immediately after take-off and just before landing.

26. Power is supplied by an alternator, driven by one of the aircraft's engines. It is not the concern of the Gee operator so long as it continues to function. If it ceases to function, lack of the necessary power will render the Gee equipment of no further use to him.

27. A whip aerial system is used, and this is connected to the equipment through an aerial loading unit. This should normally be a Type 51 which has an eight-stud switch marked 1–8 (the Types 2 and 2A with six positions are now obsolete and should not be used). The loading unit is set at the position appropriate to the frequency of the chain to be used. Details of the settings for this switch and for the R/F unit control are promulgated in connection with each Gee chain in operation, and should be secured at pre-flight briefings. The aerial loading unit should be positioned in the aircraft where the operator can conveniently adjust it whenever he resets the R/F unit control.

Operation

28. It has already been stated (para. 19) that when a particular radio frequency is selected, signals from the chain operating on that frequency will be seen on the Indicator screen. It is now necessary to consider this process of selection in greater detail, and to discuss the steps necessary to secure a reading. This section is not intended to indicate an operating procedure, which is outlined step by step at para. 42 below.

29. To detect the signals the main time base is used. The right-hand tumbler switch is set in its upper position, and the left-hand tumbler switch in the lowest position. The Brilliance, Focus and Gain controls are used to secure signals of the required intensity and amplitude. It does not follow that the signals will at first appear in their correct places on the trace. We have already seen (para. 16) that it is required to mount the single "A" signal on the left-hand side of the upper trace, with the "A" and "A ghost " immediately below it on the left of the lower trace. The Oscillator control is used to drift the signals along the traces until this position is reached, when they must be stopped by the same control. Rapid positioning is possible by using the rear (coarse) dial of the Oscillator control, and the front (fine) dial for finally ensuring that the "A" signals do not drift off the strobed sections of the traces. If they disappear to the left, or drift too far to the right, they will not appear on the strobe time base when this is used.

30. The Slave signals are next strobed, using the coarse controls for the upper and lower trace respectively to bring the strobe markers as near as possible to the Slave signals it is intended to use. With the respective fine controls the strobing is completed. Once strobed, the Slave signals appear on the underside of the trace (fig. 6).

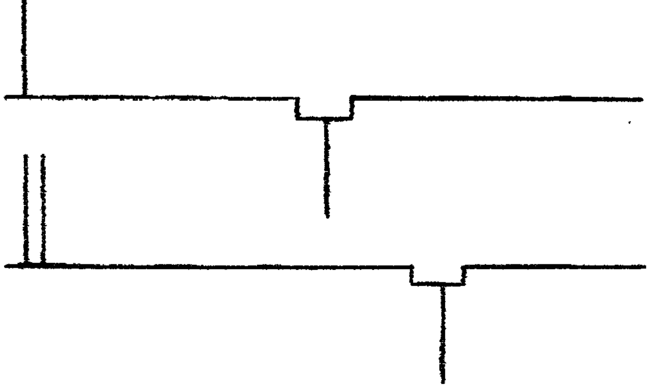


FIG. 6. Slave Signals Strobed.

31. If it is intended to use the " B " and " C " Slaves, the procedure is simple : their signals are strobed on the upper and lower traces respectively. If, however, the " D " Slave is to be used, this must be strobed on the trace which is not being used for the other Slave. Thus, when " B " and " D " are to be used, the " B " signal is strobed on the upper trace, and the " D " signal on the lower trace (fig. 7 (*a*)). When " C " and " D " signals are to be used, " D " is strobed on the upper trace, and " C " on the lower (fig. 7 (*b*)).

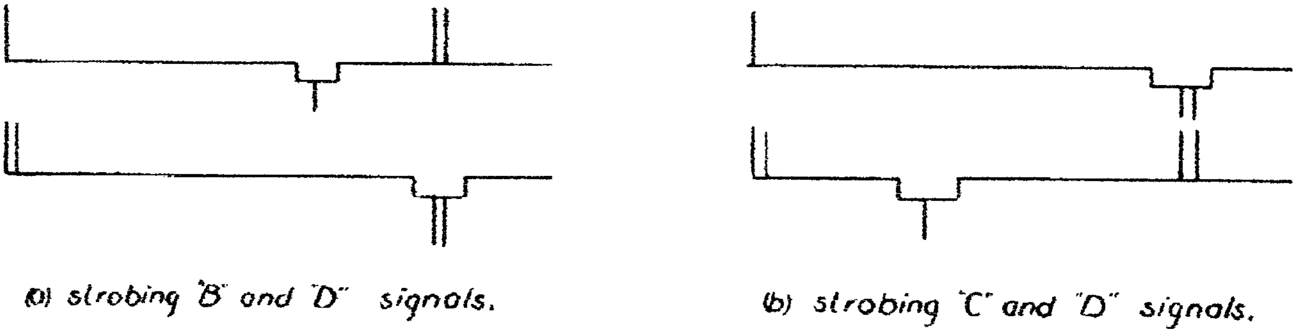


FIG. 7. Strobing Slave Signals.

32. Having strobed the Slave signals it is necessary to expand the time base to secure the precise alignment essential for accurate measurement of the time difference. The first stage is carried out on the strobe time base (the left-hand tumbler switch is placed in the mid position to secure this). The traces on the strobe time base are each split into two sections, one above the other and close together. The "A" signal in each case appears on the upper trace, with the strobed Slave underneath.

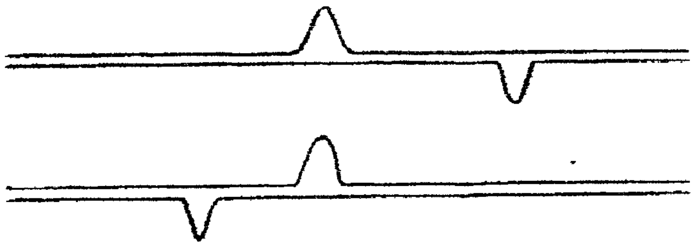


FIG. 8. Signals on Strobe Time Base.

33. Any tendency to drift is checked by the fine Oscillator control. The Fine " B " control is used to align the signals on the upper section of the trace ; the Fine " C " control to align those on the lower. Alignment is achieved by bringing the leading, *i.e.*, the *left-hand*, edge of the Slave signal directly into line with the left-hand edge of the Master signal. This is done with each Slave signal (fig. 9). In the general case, alignment can be effected with a reasonable degree of accuracy on this time base, but to check, and to ensure the best alignment when the highest possible standard of accuracy is required, the expanded strobe time base should be used. To employ this, the signals should be placed on the left of the strobe time base, using the Oscillator control first to

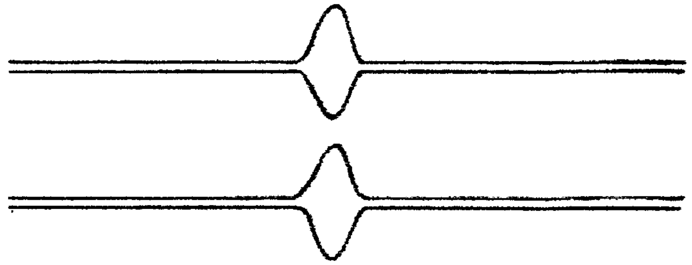


FIG. 9. Alignment of Signals.

move them and then to correct any drift. The left-hand tumbler switch is then placed in the upper position, and the expanded time base is brought into operation. Final alignment is then made by careful adjustment of the respective Fine controls.

34. The time at which exact alignment is achieved on both traces is the time of the resultant fix, and should be carefully noted. To secure fixes at exact times (such as an even minute), it may be found useful to note when there is 15 or 10 seconds to go to the minute, and by manipulating the Fine controls with each hand, keep the two Slave signals in alignment right up to the exact minute, clearing the signals at that time.

Reading Time Difference

35. Once the signals have been aligned they are no longer required, and all that is now necessary is to obtain the values of the readings from the Indicator unit. The signals are cleared from the screen and calibration pips are introduced on to the time base by depressing the tumbler switch on the right. It is to be noted that, once the signals have been cleared, neither of the Coarse or Fine controls should again be moved until the readings of time difference have been noted, and care should be taken that they are not touched accidentally. If they are moved, the position of the strobe markers will be moved, and erroneous readings will result.

36. Depressing the right-hand tumbler switch does not affect the action of the left-hand tumbler switch which continues to select the main time base, strobe time base or expanded strobe time base, although calibration pips not signals are now displayed in each case. The main time base appears as in fig. 10, the strobe markers still being visible on each trace. The upper side of the trace is calibrated in units, and every fifth unit is thickened and lengthened. Any calibration pip on the strobe marker is inverted, in the same way as the Slave signals. The number of units shown on each trace is 25. Five other units are represented by the invisible fly-backs (para. 14 above), and the full length of each trace plus fly-back is actually 30 units. It is desired to measure the distance from the Master signal to the Slaves. Since the Slave and Master signals have been placed the same distance from the beginning of their respective strobes, it is now only necessary to measure the distance between the strobes. Remembering that the "A" on the lower trace with its "A ghost" is simply a repetition of the Master signal, it will be seen that the distance to be measured on the upper trace must always lie between 0 and 25 units, while that on the lower trace must lie between 30 and 55 units. Values outside these ranges are not used in the system. The distance to the lower strobe marker consists of the number of units from the left of the lower trace to the leading edge of the marker, plus the length of the upper trace. A standard value of 30 must therefore be added to all readings taken on the lower trace. The time delay applicable to the "D" slave is always greater than 30 units; hence, although the "D" distance can be measured on either trace, depending on the one upon which it was strobed (para. 31 above), the standard value of 30 must always be added to the units counted.

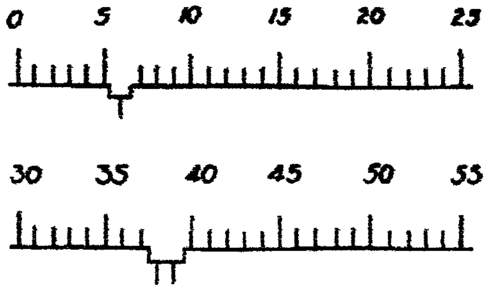


FIG. 10. Calibrated Main Time Base.

37. When the counting system is examined, however, it is found that, for technical reasons, the scale does not commence at the left-hand end of the Master strobe but from approximately the middle. The required reading must therefore be taken from a point on the Slave strobe which is the same distance from its left-hand end as the zero point of the scale is from the left-hand end of the Master strobe. The calibration of the strobe time base gives a picture as in fig. 11 (*a*); in this case the large calibration pips are a magnification of the whole numbers stroped on the main time base, and the small pips are extra calibrations, appearing only on the

strobe and expanded strobe time bases, representing 0·1 of a whole unit. Obviously the large calibration pips pointing upwards from the top and bottom pairs of traces are the zero point and the thirtieth calibration pip of the main scale; therefore, to fulfil the conditions of the last sentence but one, the reading must be taken from the expanded part of the scale immediately beneath the left-hand edge of these pips. The whole number calibration pips pointing downwards in each case may be easily identified by reference to the main time base. With regard to the interpolation for the second decimal place of the reading, it can be seen that this need not be done at the centre of the screen but can be estimated anywhere along the strobe time base since the spacings are all equal. In point of fact this interpolation *must* be done at some other point in view of the fact that the reference point is a wider calibration pip than the rest and tends to give slightly inaccurate second places of decimals. Since this is the case it can be readily appreciated that on the occasions when at extreme range or where great accuracy is required, the expanded strobe time base can be used to obtain a more accurate interpolation. This picture presents the left-hand ends of the strobes magnified a further five times as in fig. 11 (*b*).

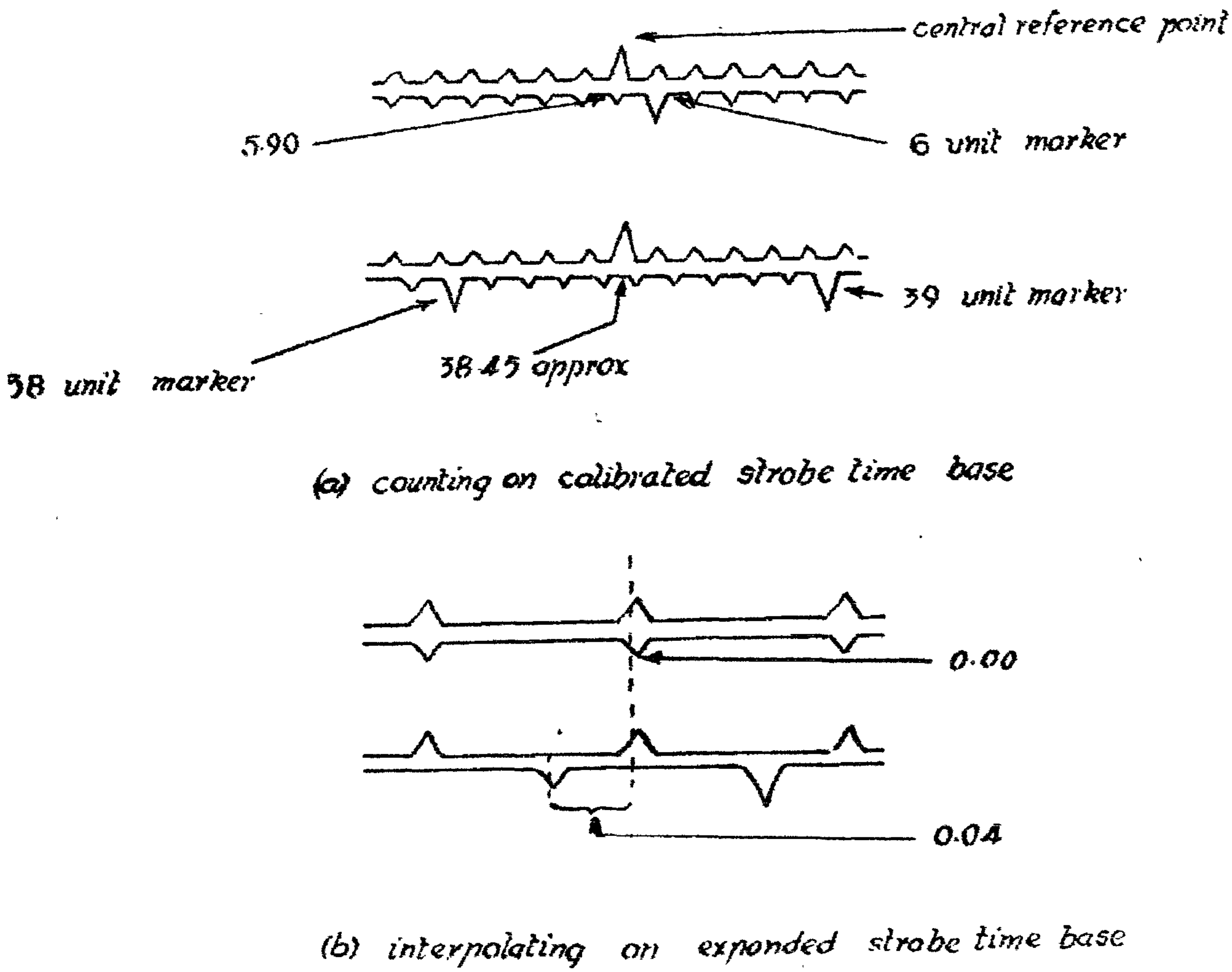


FIG. 11. Calibrated Strobe Time Bases.

38. It is now necessary to examine the method adopted in practice for obtaining the readings. Once the pulses have been aligned and the right-hand tumbler switch has been depressed (para. 35 above) the picture presented will (if high accuracy has been required) be that of the expanded strobe time base. Since the time base last in use during alignment is the one giving the highest order of accuracy, it will be found convenient to commence counting on that time base, and to go to the three time bases in reverse order obtaining the decimal places first and finding the whole numbers from the main time base last. Thus in fig. 11 (*b*) it can be seen that on the top trace, since the pips are vertically beneath each other, the second decimal place will be zero, whereas

on the bottom trace the top pips are displaced approximately four-tenths of the way between the lower pips giving a second decimal place reading of 4. The left-hand tumbler switch is now placed to its central position (fig. 11 (*a*)) thus selecting the strobe time base, and the reading can be seen to be just less than a whole number which we have yet to identify. Counting back from this number therefore it can be seen that the fraction of a unit will be approximately 0·90 (it will be appreciated from the observation on the expanded strobe time base that this is actually exactly 0·90) and the whole number will be one less than that which has been turned down on the strobe. Putting the left-hand tumbler switch to its "down" position displays the main time base (fig. 10) and it can be seen that the calibration pip turned down is the sixth ; thus the reading must be 5·90. The tumbler switch should now be placed back at its central position and the second reading taken. Counting from the left-hand pip which is pointing down, there are 4½ spaces between it and the reference point. From the previous inspection of the expanded strobe time base it is known that this must be 0·44. The tumbler switch is again depressed to its lowest position and, remembering that the calibration pip from which reckoning was made was the left-hand one of the two turned down, it can be seen from the main time base (fig. 10) that the correct reading in this case is 38·44.

39. The value of the readings on the two traces having been determined, it is necessary to find the final values with which to enter the lattice charts, to take into account which signals have been used. If the signal strobed on the upper trace was from the "B" Slave, then the value is correct at 5·90. If it was the "D" Slave, then 30 units must be added to give 35·90. The value of the reading on the lower trace is 38·44 irrespective of whether the "C" or "D" Slave was used.

40. With all the values finally determined the lattice chart for the appropriate chain is entered and position lines are plotted corresponding to the respective readings secured, giving a fix at their point of intersection. "B" lattice lines are printed in red, "C" in green, and "D" in purple (*see* chart opposite).

41. When described in detail this process necessarily appears somewhat elaborate and lengthy. In practice, the average operator can effect the process of alignment and counting in something like half a minute once he has gained facility.

Operating Drill

42. (*a*) *Switching On.* (*N.B.*—The equipment should be switched on only after take-off, and should be switched off before landing.)

(i) V.C.P.—power—on.

(ii) Receiver, anti-jamming switch at "N."

(iii) Receiver, R/F unit switch at appropriate setting for chain desired (Types 24 and 25) or appropriate dial setting (Types 26 and 27). In the latter case adjust main and fine tuning controls for maximum signals.

(iv) Aerial loading unit switch to appropriate setting.

(v) Set two-way click-stop control on upper right-hand corner of Indicator to appropriate position (para. 23).

(vi) After about five minutes (necessary for the equipment to reach operating temperature), turn up Brilliance control to bring out traces on screen ; adjust Focus for sharp, clearly defined traces.

(*b*) *To Secure a Fix.*

(i) Left-hand tumbler switch down ; right-hand tumbler switch level.

(ii) Adjust Gain control until "grass" just appears on traces or signals are easily seen.

(iii) With the Oscillator control, drift the signals along the traces until the single Master signal is at the extreme left of the upper trace ; stop them and check any tendency to drift with the Oscillator control.

(iv) With Coarse and Fine "B" controls, strobe the appropriate Slave signal on the upper trace ; with Coarse and Fine "C" controls, strobe that on the lower trace.

(v) Left-hand tumbler switch to central position.

(vi) With Fine controls bring upper and lower Slave signals into exact alignment directly under the Master signals, check drift with Oscillator control.

(vii) Check alignment on expanded strobe time base (left-hand tumbler switch up, adjust Fine controls if necessary).

(viii) Note time (this is the time of the resultant fix), and immediately depress the right-hand tumbler switch.

(ix) Read off and note the correct second decimal places.

(x) Left-hand tumbler switch central, read off and note the first decimal place of top reading ; left-hand tumbler switch down and note whole number of top reading (*see* para. 38 above) remembering to add 30 if the signal strobed was the " D " signal.

(xi) Repeat step (x) for lower reading remembering to add 30.

(xii) Enter chart with readings and plot the readings taken as position lines on or (when interpolation is necessary) between the lattice lines appropriate to the signals used (*i.e.*, " B " on the red lattice lines ; " C " on the green ; " D " on the purple). The intersection of the position lines is the required fix.

(*c*) *Homing* (paras. 50–61).

(i) Fly aircraft to point reasonably close to lattice line down which it is desired to home.

(ii) Left-hand tumbler switch down, right-hand tumbler switch down, set strobe markers to calibration units of point of homing.

(iii) Left-hand tumbler switch level, adjust Fine controls to give calibration readings for correct decimal places of point of homing (*N.B.* do *NOT* touch Coarse or Fine controls again till homing is completed, except to correct co-ordinate settings in para. 60).

(iv) Left-hand tumbler switch down, right-hand tumbler switch level, with the Oscillator control drift the signals along the traces until the single Master signal is at the extreme left of the upper trace ; stop them and check any tendency to drift with the Oscillator control.

(v) When the aircraft reaches such a position that the signal which has a constant value for the lattice line down which it is desired to home is within one Gee unit of the strobe marker value, raise left-hand tumbler switch to the central position.

(vi) Direct aircraft towards lattice homing line till appropriate signal is aligned with the Master signal on the strobe time base.

(vii) Turn on to a precalculated course to take aircraft down lattice homing line.

(viii) Make minor adjustments to course to maintain alignment of Master signal and signal of lattice homing line, and watch second signal appear on trace and approach the Master signal.

(ix) When both signals are in alignment with the Master signals, the homing point has been reached.

R/F Units

43. Reference has been made (paras. 24, 27) to the different types of R/F units in use. The frequency bands covered by these are :—

Type 24	.. ..	20 megacycles to 30 megacycles.
Type 25	.. ..	42 megacycles to 51 megacycles.
Type 26	.. ..	50 megacycles to 65 megacycles.
Type 27	.. ..	65 megacycles to 80 megacycles.

It will be noted that a frequency between 50 and 51 mc/s. can be received on a Type 25 or 26 R/F unit, whichever may be more convenient.

Breakthrough, Interference and Jamming

44. Although the difference between the radio frequencies used for the various chains is designed to separate them, it is possible for " breakthrough " to occur from another chain on an adjacent frequency when strong pulses from transmitters in that chain are being received.

Usually, however, these will be of smaller amplitude than those which are exactly on frequency; their appearance, especially on the strobe time base, will be somewhat "ragged," and they will probably drift when the signals it is required to use are brought to rest. The most effective means of ensuring that spurious breakthrough signals are not used in error is to keep a careful check on the D.R. position of the aircraft, based on previous fixes secured on signals which have been clearly identified. If ambiguity cannot be resolved by use of the D.R. position, a series of fixes should be obtained on one set of signals and the resultant T.M.G. and G/S compared with the D.R. If the wrong signals have been used, this should normally be revealed at once by this comparison. The signals which come up on the screen in positions corresponding to the Gee lattice co-ordinates for the D.R. position or which correspond to the D.R. track and G/S are clearly the genuine signals. A further method of checking the identity of a signal is to turn the R/F unit switch from position to position, at the same time observing the signal. The position which gives the largest signal is obviously indicative of the frequency of that signal, hence the chain to which it belongs.

45. In general, the Gee equipment is not liable to serious interference from other radio installations in the aircraft, nor is interference on the screen normally experienced from "precipitation static" when flying in rain or cloud. As range increases, and the Gain control is turned up to amplify the signals, the amount of "grass" on the trace grows until at extreme range it swamps out the signals. Towards extreme range, weak signals are still just visible on the screen through the grass. They may more readily be detected by swinging the Oscillator control backwards and forwards—if signals are present they may be detected moving through the grass, even though their amplitude is less than that of the grass. This movement becomes more apparent on the strobe time base, but as the signals are unlikely to be selected at random by the strobe markers, it is necessary first to set these (using the Coarse and Fine controls) to the Gee co-ordinates of the D.R. position, and operate the Oscillator control for maximum signal drift. If the signals are being received they pass through the strobed sections of the main time base, and so are brought on to the strobe time base, on the traces of which they appear as they sweep through it. Since they move quickly on the strobe time base, the Oscillator control must be operated promptly to stop the first signal detected, and to keep this on the trace. Once a signal has been detected, the fine Oscillator control should be swung to explore the immediate vicinity on both sides of the strobed sections for further signals. The "A" and "D" signals are at once identified by their characteristics, *i.e.*, the "A" by its position on the upper side of the traces and the "D" by its double signal. If only a single signal appears on the bottom half of either trace, and no other signal can be detected, it is possible that the "B" Slave has been strobed on the lower marker, or vice versa. In this case the main time base is used, the signal is identified on the strobe marker, and should be moved along the time base by means of the Oscillator control, until it is mounted on the other strobe marker. The strobe time base should then be searched as before for other signals. Once two signals have been identified, a position line can be obtained (paras. 62–66). D.R. co-ordinates change with time, and should be reset as necessary if the search for signals is prolonged.

46. Enemy interference usually takes the form of excessive noise on the traces, created in various ways. Eventually, at considerable distances from the Gee transmitters, this may obliterate the signals completely. Unless spurious pulses are created, however, and wrongly used in place of the genuine signals, accuracy is not interfered with. An experienced operator can often continue to read the signals after considerable interference has commenced, by keeping a close watch on the position of the signals, and detecting them as indicated at para. 45 above. The anti-jamming switch on the Receiver should also be tried in the position X, Y and Z—this operates filters which eliminate or reduce certain forms of interference. Details of counter measures, when operative, are stated at briefing.

Identification Blinking

47. To provide clear identification between different chains, where confusion might otherwise exist, the "A" ghost signal on certain chains is made to blink. Such blinking occurs at regular intervals (usually six seconds), and each chain where such identification is applied is given a definite number of times for the ghost to blink. The number is to be secured at pre-flight

briefing, together with other relevant information. Inspection of the "A" ghost signal then resolves any possibility of doubt as to which chain is being received.

Ragged Signals

48. Near the transmitters the signals on the strobe time base may become less sharply defined at their trailing edges, due to "echoes" trailing away to the right of the true signal. Provided the leading, left-hand, edge is used, however, results are not affected by this fact.

Charts

49. The normal presentation of Gee lattices is in the form of an overprint on Mercator and polyconic plotting charts, the scale in most general use being 1 : 1,000,000. Some sheets on a scale of 1 : 500,000 are also in existence. A separate series of charts is issued for each chain. Identification of the lattice lines to be used is usually provided by the standard colours—red for "B" signals, green for "C" and purple for "D." Sometimes, when green would be difficult to distinguish against a topographical background, the "C" lattice is printed in blue. The value of each lattice line is shown at intervals along the line, and in the margin.

Homing

50. Gee provides a valuable method of homing to any point within fixing range, and in the best areas is very accurate.

51. The simplest method of homing is to select from the chart the value of a lattice line which passes through the position to which it is desired to home. The value of the cross lattice line at the same point is also noted. The aircraft is flown by normal navigational methods towards the line down which it is intended to home. When reasonably close to this, the readings on the main time base should be correct to the nearest two units. By careful adjustment of the Fine control, using the calibrated time base, strobe time base and, where necessary, the expanded strobe time base, in each case with the right-hand tumbler switch down, the exact reading of the chosen line is set on the trace in use. At the same time, the exact value of the cross lattice at the homing point is set on the other trace. The right-hand switch is then raised, and the main time base examined to ensure that the "A" signals are correctly positioned on the left-hand side of the traces. The Slave signal for the lattice line down which it is intended to home should then appear on the appropriate strobe (fig. 12). The other Slave signal may not, if the aircraft is some distance from the homing point, yet appear on the other strobe, but as the aircraft approaches the homing point, it will approach this and will eventually appear on it. To ensure that the aircraft is flown down the intended homing path, the strobe time base is used. Course is continued until the Master and Slave signals come into exact alignment, whereupon the aircraft is turned on to a predetermined course which (after allowance for drift) will make good the track of the lattice homing line.

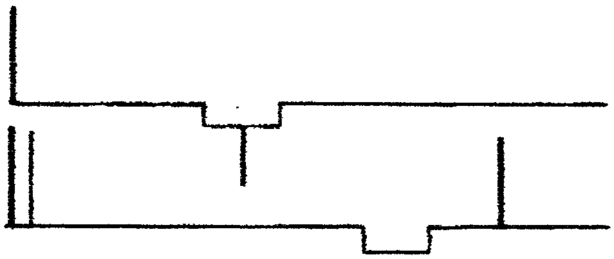


FIG. 12. Homing on a "B" Lattice Line.

52. If the aircraft deviates from the lattice line the signals drift apart. If the slave signal drifts to the left the aircraft is drifting into an area of lower readings, and vice versa. Examination of the chart will indicate in which way course should be altered.

53. As the aircraft approaches the homing point the other Slave signal approaches the strobe marker, and having reached this, appears on the strobe time base (fig. 13). It gradually moves along the trace as the point is approached until it becomes aligned with the Master. At this

point (provided the aircraft has been correctly steered along the homing lattice) the Gee co-ordinates recorded are those originally set on the calibrated time base, *i.e.*, of the homing point, and this is directly underneath the aircraft.

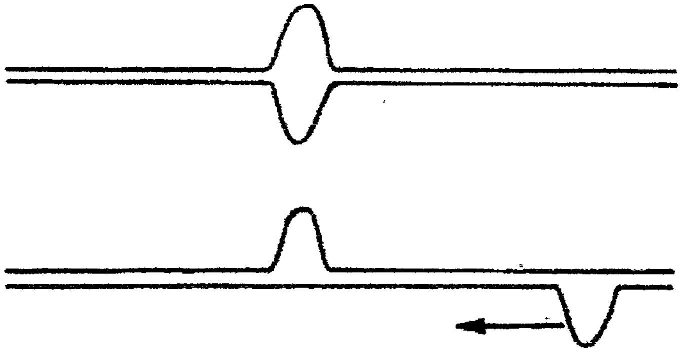


FIG. 13. Approach of Homing Point indicated by Drift of " C " Slave.

54. An alternative method of homing, which obviates the necessity for flying along one particular lattice line, consists of " across lattice homing." In this case the aircraft is flown by normal navigational methods until within such a distance of the homing point that when its co-ordinates are set on the calibrated time bases (as described at para. 51 above) both Slave signals are strobed. The appearance of the strobe time base is then similar to that shown at fig. 14. The object is to fly the aircraft so that both Slave signals converge towards the Masters, and once coincidence of all four is achieved the homing point is reached.

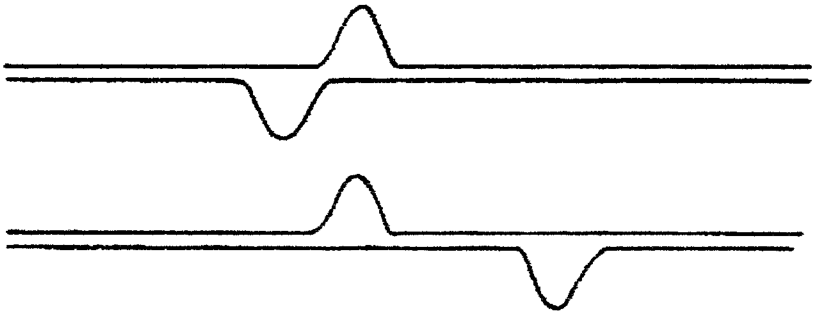


FIG. 14. Appearance of Strobe Time Base when Cross-lattice Homing.

55. Whether the Slave signals appear to the left or right of the Masters depends on the aircraft's position relative to the homing point on the Gee lattice. This is an important feature which is of considerable assistance to the homing procedure. Consider, for example, an aircraft using the " B " and " C " lattices for homing to a point T in fig. 15. Assume that the chart shows that the " B " readings to the north are less than at T, and that they increase on the south. Similarly, assume that the " C " readings are greater to the west and decrease to the east. When the aircraft is to the north of the point T, the " B " Slave signal appears to the *left* of the master signal, once the co-ordinates of T have been set on the Indicator. To the south the Slave signals appear on the *right* of the Master. Similarly, to the west, the " C " Slave appears to the *right* of the Master, and to the east, on the left. The appearance of the strobe time base thus indicates in which area the aircraft is situated when homing begins (fig. 15). In the north-east quadrant, where both lattice readings are less than at T, both Slaves appear to the left of the Master. In the north-west quadrant, the " B " Slave is to the left of the Master; the " C " Slave is to the right. In the south-west quadrant, both readings being higher, both Slaves are to the right, and in the south-east, the " B " Slave is on the right and the " C " signal on the left.

USE OF GEE WITH THE UNIVERSAL INDICATOR, TYPE 2

General

78. In certain installations (*e.g.* compound Gee/Gee H), Gee signals are displayed on the Universal Indicator, Type 2, described fully in paras. 26 to 29 of Chapter 11.

79. The differences between Gee operation on this and the normal Gee indicator are minor, viz. :—

(*a*) The two time bases may be vertical instead of horizontal.

(*b*) A slight difference exists in the method of reading time differences. This is described fully in para. 87.

Operating Drill

80. The operating drill is as follows :—

(*a*) Close switches on V.C.P. and Transmitter.

(*b*) Switch Function Switch to GEE.

(*c*) Anti-jamming switch to N.

(*d*) Check that correct R.F. Unit is in use.

(*e*) Selector switch on R.F. Unit to correct number.

(*f*) Aerial loading unit at correct position.

(*g*) Strobe switch to M, Main Time Base.

(*h*) Calibration pip key selecting signals.

(*j*) Adjust Brilliance and Focus as required.

The pulses from the ground stations A, A_G, B, C and D should now be visible on the time bases, and the navigator can proceed to take a fix.

Taking a Fix

81. Allow the pulses to drift on the Main Time Base until the A pulse falls on the A strobe at the lower end of the time base, with the identification pulse (A ghost) on the right hand trace. (If the time base is horizontal, A is placed on the bottom trace). Stop the pulses with the Crystal Frequency Control.

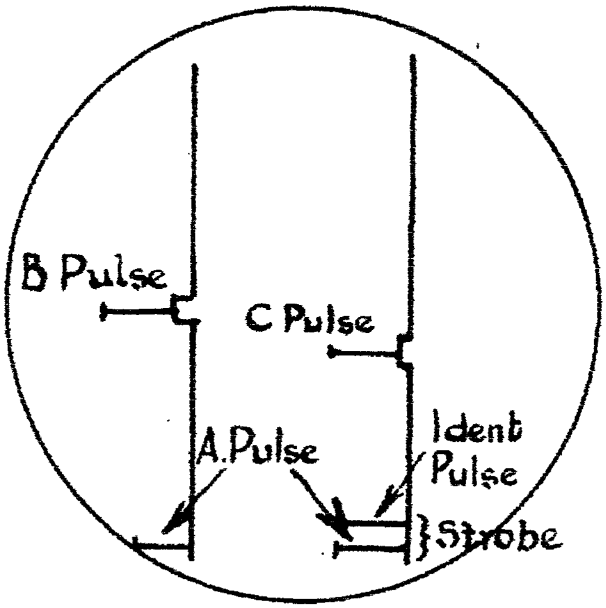


FIG. 22. Main Time Base on Universal Indicator.

82. Set the strobe to the 10 mile range and, by operation of the coarse and fine strobe controls, move the strobes over the appropriate pulses. In this installation the strobe markers are in pedestal form and the pulses are *not* inverted while on the strobes. Switch to Strobe Time Base, where the pulses should be visible. Use the B and C fine controls to align the respective pulses with the A pulses. The traces will now appear as shown in fig. 23.

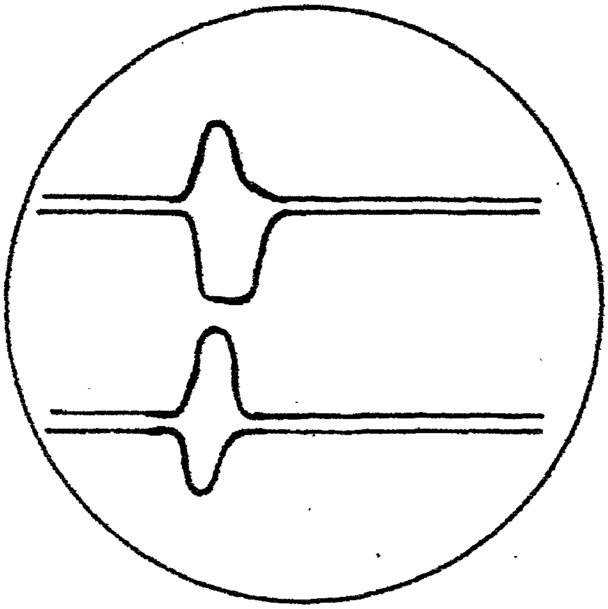


FIG. 23. Gee Strobe Time Base (10 m.).

83. If extreme accuracy is required, shift the pulses to the extreme left hand end of the 10 mile Strobe Time Base (bottom if vertical time bases) and switch to the 2 mile Strobe Time Base. Align the pulses accurately on this with the fine strobe controls (fig. 24).

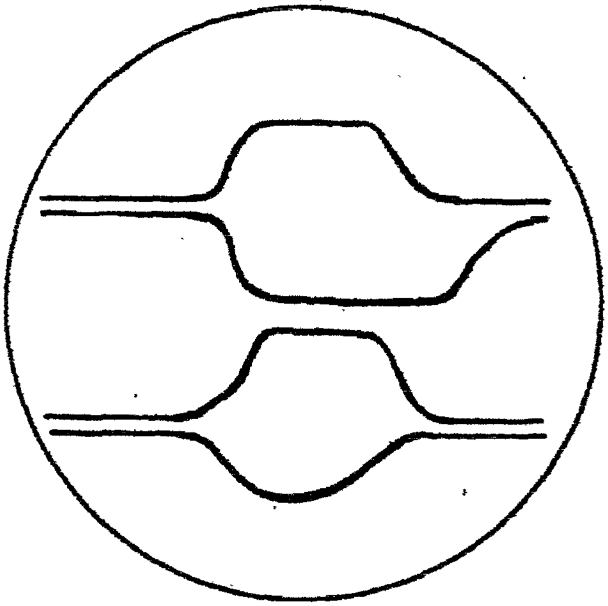
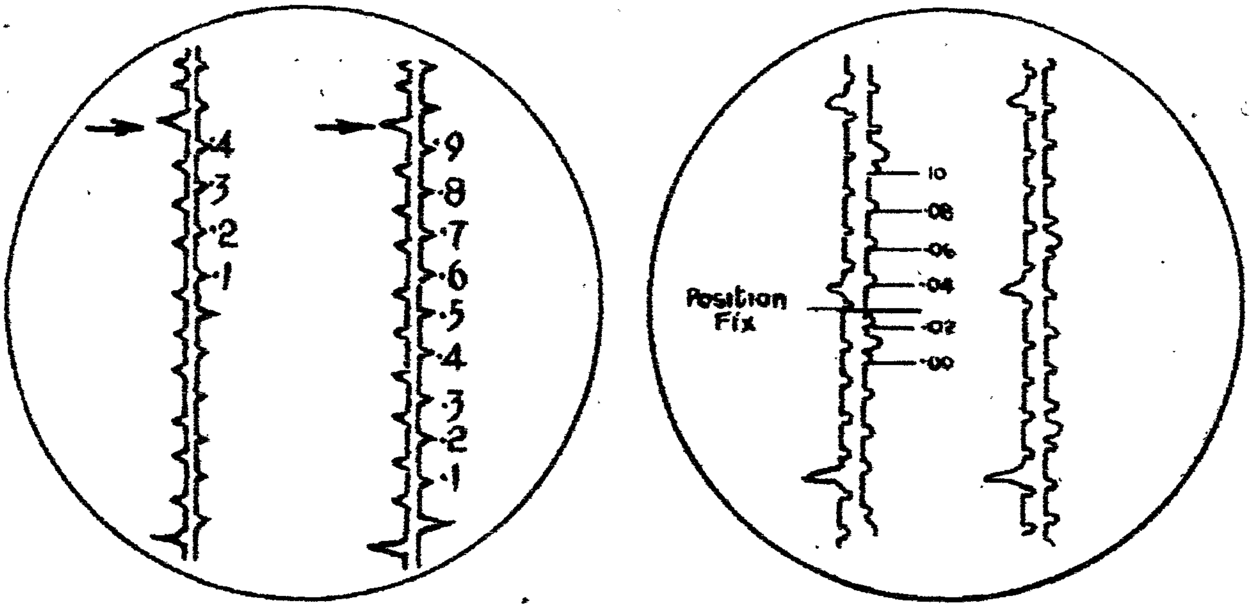


FIG. 24. Gee Strobe Time Base (2 m.).

84. Take the time and depress the Calibration Pip Key on Control Unit, Type 426. Time differences at the above time can then be read off as Gee Units.

85. The first and second decimal points are read off on 10 and 2 mile strobe positions respectively as in normal Gee operation. If the time base is vertical, the reference calibration mark is on the left (*see* fig. 25).

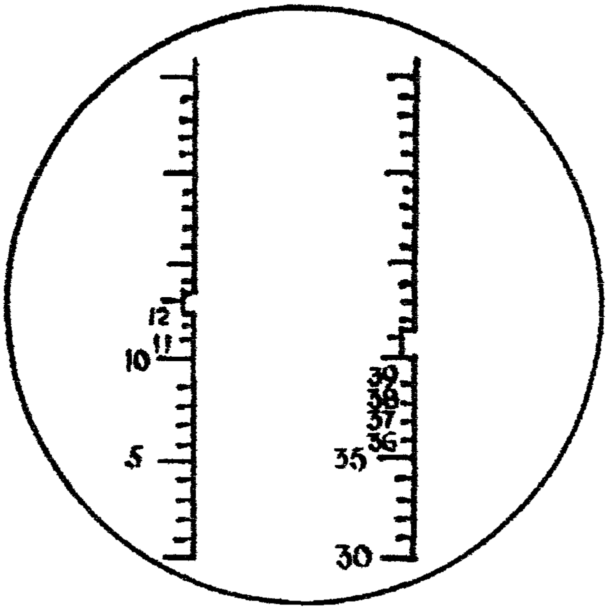


B = ·452 . C = ·942

FIG. 25. Method of Counting on 10 m. and 2 m. Strobe Time Bases.

86. Switch to Main Time Base, where the whole number reading is in a slightly different form from that obtained using Indicator, Type 62, on the normal Gee Mk. II.

87. Zero on the Universal Indicator, Type 2, is at the *start* of the A strobe. On the normal Indicator it is half to three-quarters of the way along it. Further, the calibration pips on U.I. Type 2, are *not* inverted by the strobe. Where the required whole number using the normal indicator was the one inverted by the strobe, in this instance it is the one *immediately in front of* the leading edge of the strobe marker (*see* fig. 26).



B = 12 C = 39

FIG. 26. Whole Number Reading on the Universal Indicator.

Homing

88. Homing can be carried out in the same manner as that described in paras. 50 to 61, bearing in mind the slightly different form of whole number reading mentioned in the previous paragraph.

50 Mile Strobe

89. The 50 mile Strobe position is useful on the Gee function for searching for ground transmitter pulses when they are difficult to see on the Main Time Base. With the strobe selector set to this position the entire Main Time Base can be scanned by the strobe, using the coarse control only.

Introduction

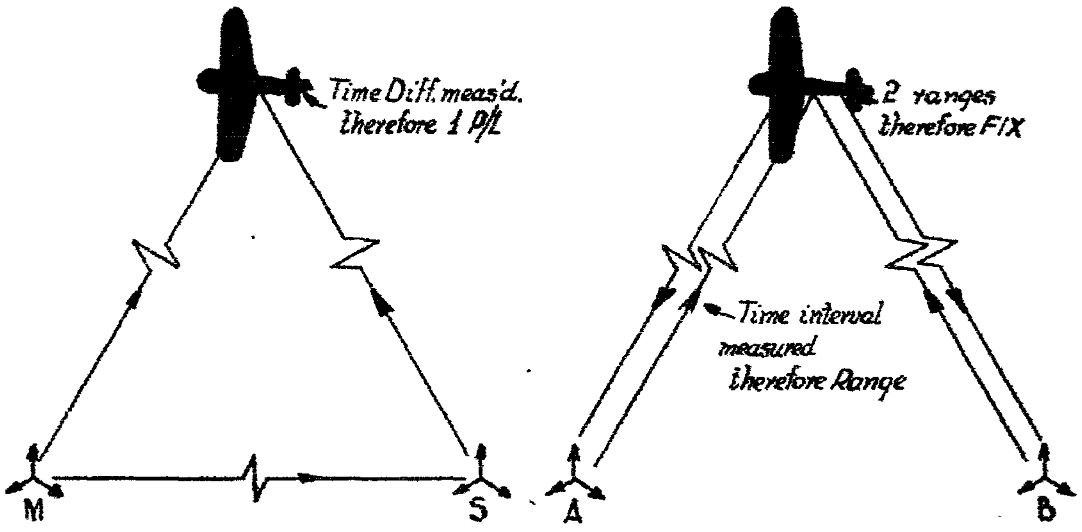
1. Gee H, Mk. II is an aircraft navigation equipment which provides medium range fixing of an accuracy sufficient for blind bombing. It also has a valuable application in Air Survey.

2. It is not a modified Gee equipment, although the information derived from its operation is displayed on the Universal Indicator, Type 2, which can also be used for Gee, Rebecca and Rebecca H. An integral part of the equipment is the Computor, Automatic, Type 56, or Gee H Mouse, which is an automatic blind bombing attachment designed for use with it.

3. The equipment is not suitable for pilot presentation or interpretation but requires a separate operator who is normally the navigator.

Principle—Time Measurement by Pulse Technique

4. The basic principle employed is the measurement of the time interval between two radio pulses. Unlike Gee, in which the time interval measured is that between the *reception* of pulses from two ground stations, Gee H measures the interval between *transmission* of a pulse by the aircraft and the reception of a " transponded " pulse from a ground beacon (fig. 1). As the speed of travel of radio waves is known, this time interval is directly proportional to range. Thus measurement of time interval is, in itself, measurement of range. By using two ground beacons, ranges from two known ground positions can be obtained and therefore a fix. In this respect, Gee H is similar in principle to the American Shoran equipment.



(*a*) Gee. (*b*) Gee H.

FIG. 1. Illustration of Principles.

5. The major differences between the Gee and Gee H systems are :—

(*a*) With Gee, the stations are inter-dependent, the slave stations being dependent upon the master. With Gee H, the ground stations are independent of each other.

(*b*) With Gee, no transmission from the aircraft is necessary, whilst with Gee H, the aircraft does transmit.

(*c*) Three ground stations are necessary to obtain a fix with Gee, but only two with Gee H (*see* fig. 1).

The Lattice

6. As the principle of the system results in measurement of range, the lattice produced by Gee H is in the form of families of concentric circles centred on the ground beacon positions.

7. In 1/15,000th of a second a radio pulse travels 12·4 miles. Thus, if an aircraft is 6·2 (12·4 ÷ 2) miles from a responder beacon, the time of travel of a pulse from aircraft to beacon plus the time of travel of the " transponded " pulse back to the aircraft, will be 1/15,000th/second. This period of time has been arbitrarily selected as the basis of measurement and is known as one Gee H unit. *1 Gee H unit = 6·2 miles.*

8. Each circle in the lattice has a value in Gee H units, corresponding to its distance from the ground station. The delay at the ground beacon between reception of a pulse and transmission of the "transponded" pulse is taken into account in constructing the lattice. Ignoring this allowance for the moment, the circle at distance 18·6 miles from the beacon position would be labelled 3 Gee H units ; the circle at distance 19·22 miles, 3·1 Gee H units, etc.

9. The effect of the delay between reception and transmission of pulses at the ground station, is to displace the range circles a distance of about ·1 miles towards the station, as stated above. Thus the 3 Gee H unit circle is at 18·5 miles range, etc.

10. The appearance of the Gee H lattice is as shown in fig. 2. Ambiguity due to the range circles cutting in two places is resolved from consideration of D.R. position. At ranges where D.R. position may be considerably in error, the ambiguous positions will be far apart.

PERFORMANCE

Range

11. The frequencies employed are from 20 to 80 Mc/s. Normally, a lower frequency is used for the aircraft than for the ground transmitter. Thus the power developed, less in the aircraft than in the ground transmitter, is offset by the longer range attainable with lower frequency. The peak power output of the aircraft transmitter is 20 kilowatts. The range scale normally in use is 0–48 Gee H units, or about 0–250 nautical miles, but triggering of ground stations does occur at greater ranges than this and the time base *can* be extended to 0–95 Gee H units. The limiting factor for the ground to air path is the power of the ground transmissions ; under normal conditions the maximum range is about 300 nautical miles.

Accuracy

12. The accuracy of measurement of range depends simply on the accuracy of pulse timing and measurement, and is independent of range itself. Time delay at the beacons is monitored to within extremely accurate limits and taken into account when producing the lattice (para. 8). Strobed time bases are used for measurement of range, so that the accuracy of ranging depends solely on the accuracy with which strobes can be lined up and readings made.

13. Reading can be carried out to ·002 Gee H units, which is equal to 22 yards. Thus the accuracy to which range can be determined is ± 22 yards. This accuracy is constant for all ranges.

14. Fixing accuracy, however, does vary with range, decreasing as the angle of cut of the position circles becomes greater or less than 90°. Fixing accuracy is maximum at a distance from the centre of the base line equal to half the length of the base line (angle of cut 90°). At this range maximum error will be about 40 yards.

15. For ranges less than or greater than that stated above, accuracy decreases. Representative figures, taking a base line 100 miles in length are :—

	Range	*Fixing Accuracy*
For longer or shorter base lines these ranges will vary in proportion	100 n. miles	50 yds.
	130 n. miles	75 yds.
	180 n. miles	100 yds.
	230 n. miles	125 yds.
	280 n. miles	150 yds.

Thus if an accuracy of 50–75 yards is acceptable for blind bombing, Gee H Mk. II satisfies this requirement at ranges of up to 130 n. miles, this range directly decreasing or increasing with length of base line.

Serviceability

16. Serviceability of the airborne equipment is high, whilst the ground equipment is frequently serviced and continually monitored so that unserviceability is an unusual occurrence.

Height

17. The equipment is designed to operate at heights of up to 35,000 feet.

Capacity

18. It is obvious that the beacons cannot respond to more than one aircraft at any instant and, in fact, it takes the beacon about 100 μsecs to receive a pulse, transpond and then recover preparatory to dealing with another pulse. The P.R.F. of the airborne Gee H transmitter is 100. In other words, in each second the beacon has to handle 100 pulses from each aircraft. Simple arithmetic will show that if one aircraft occupies 100×100 μsecs of the beacon's time in each second, then the number of aircraft which can be handled is limited to $\frac{1{,}000{,}000\ \mu\text{secs}}{100 \times 100}$ or 100, but in practice this figure is found to be 70 or 80. In order that an aircraft can distinguish the responses to its own transmissions, the P.R.F. is jittered or changed automatically, which results in only the wanted pulses being stationary on the screen.

THE EQUIPMENT

Composition of the Equipment

19. The airborne equipment comprises :—

(*a*) Receiver.

(*b*) Transmitter.

(*c*) Universal Indicator, Type 2.

(*d*) Voltage Control Panel.

(*e*) Gee H Mouse.

(*f*) Aerials.

The total weight of the installation is approximately 225 lbs.

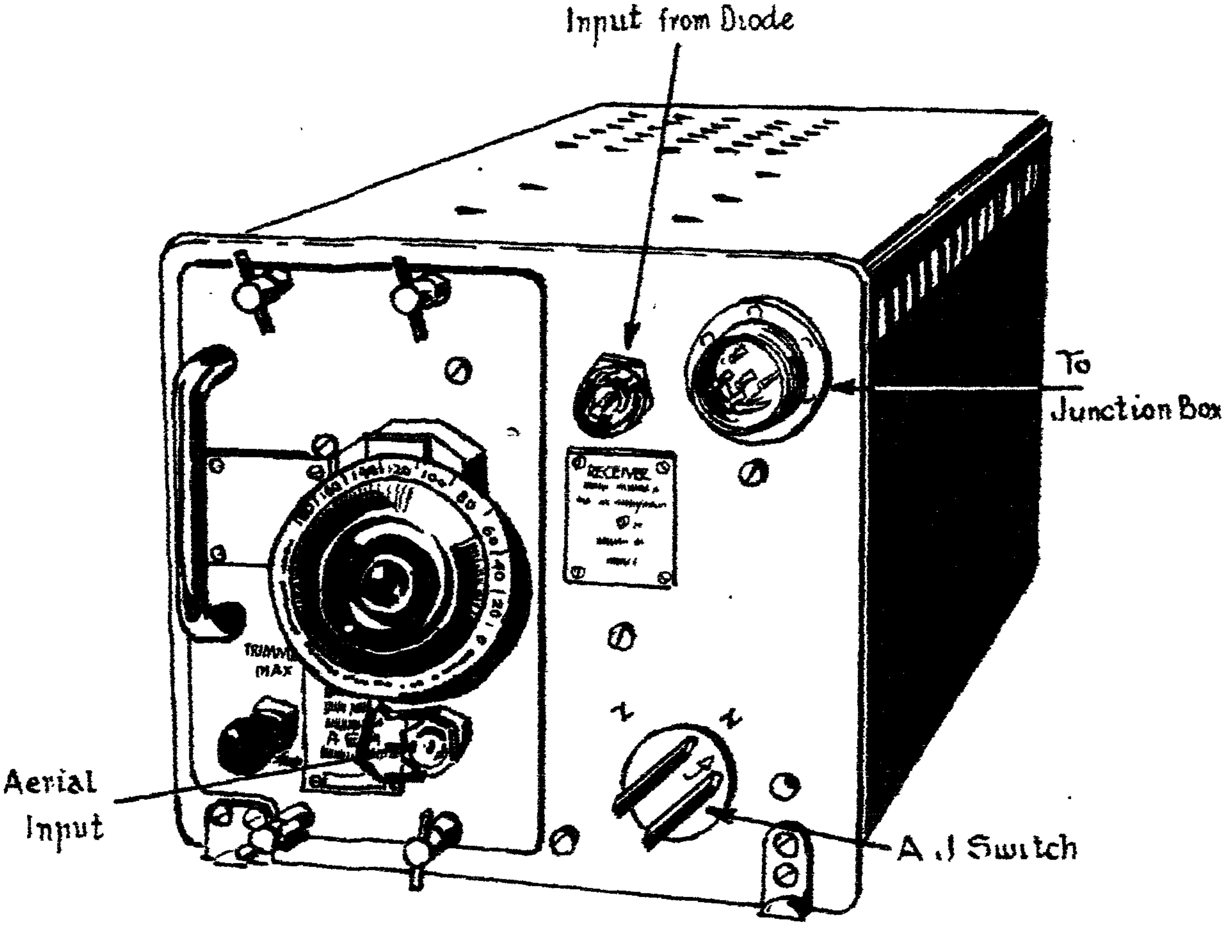


FIG. 3. The Receiver, R.3582B.

20. The receiver (fig. 3) employs a superheterodyne circuit, amplifying signals received from the ground beacons and passing them to the indicator. Provision is made for all frequencies on the 20 to 80 Mc/s band by readily interchangeable R.F. units (fig. 4), similar to those employed in Gee Mk. II. Four R.F. units are supplied, viz :—

(*a*) *Type* 24. 20–30 Mc/s.

(*b*) *Type* 25. 40–50 Mc/s.

(*c*) *Type* 26. 50–65 Mc/s.

(*d*) *Type* 27. 65–80 Mc/s.

21. Types 24 and 25 incorporate five-position selector switches for tuning to any one of five selected frequencies in their respective bands. Types 26 and 27 incorporate continuously variable tuning so that any frequency in their respective bands can be employed.

22. An anti-jamming switch is provided (*see* fig. 3). It has two positions, N and Z. Position N is used when no jamming, or C.W. jamming, is experienced, while Z is selected in other cases of jamming.

23. There are three sockets on the face of the receiver, viz :—

(*a*) The aerial input socket (on interchangeable R.F. unit).

(*b*) A six pin socket through which passes power to the receiver, and receiver output to the indicator.

(*c*) Transmitter pulse input socket.

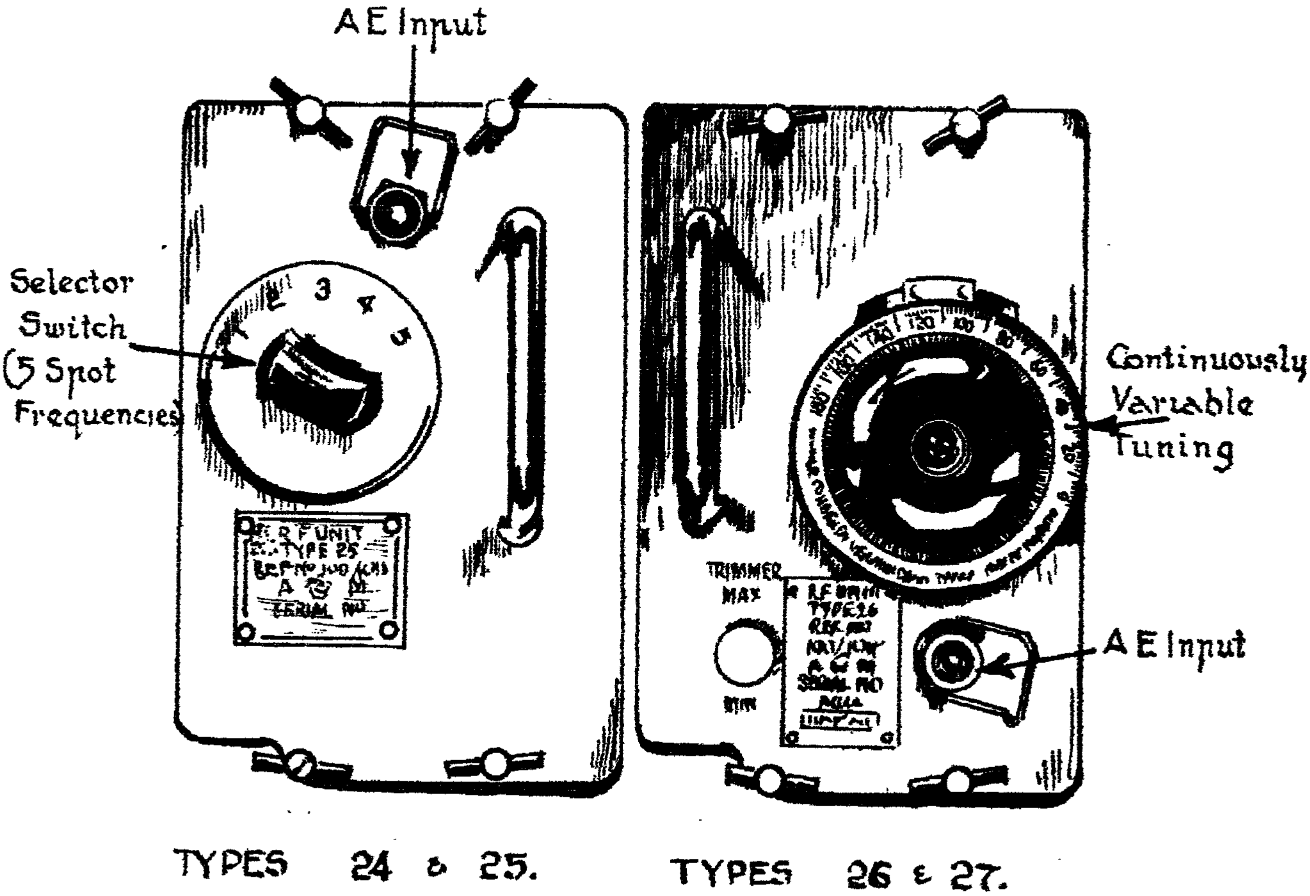


FIG. 4. R.F. Units.

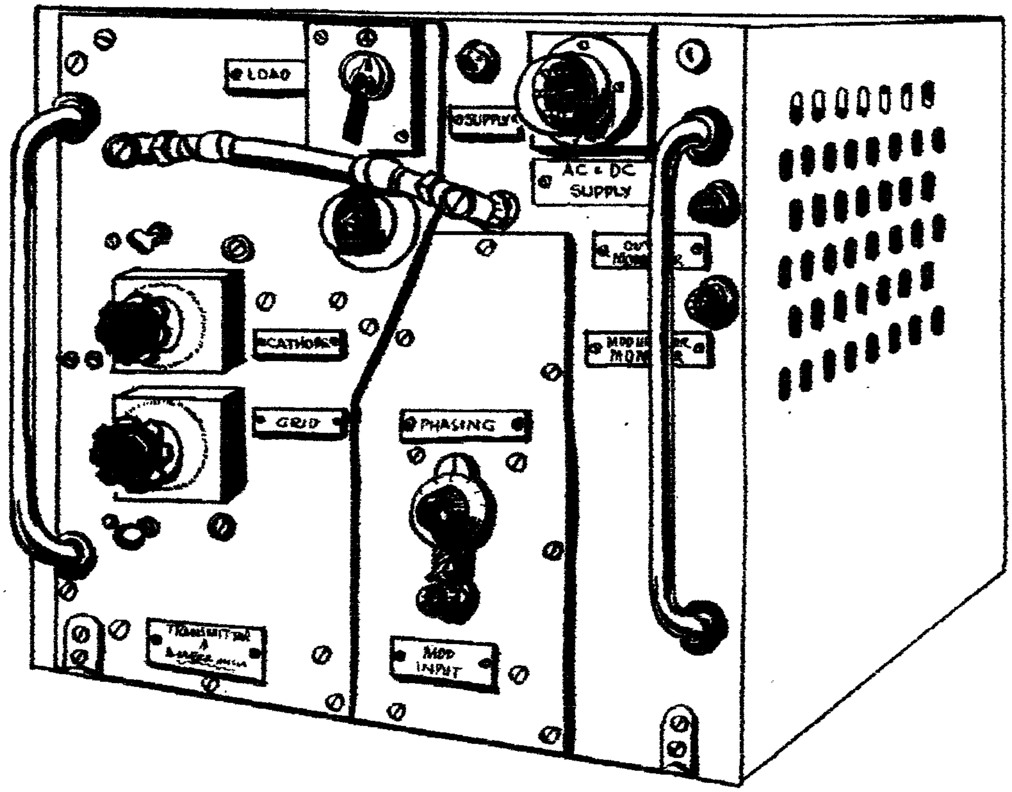


FIG. 5. The Transmitter.

The Transmitter

24. The transmitter (T.1629) (fig. 5) consists of a modulator and a transmitter contained in one case. The frequency coverage is 20 to 80 Mc/s and is readily adjustable to any frequency in this range by means of the three controls on the front of the unit. However, it is *most important* that frequency be set accurately, if the ground beacons are to pick up aircraft transmissions efficiently. This precludes changing frequency in the air. Further, any but small frequency changes necessitate a change in aerial also, rendering even more impracticable the changing of frequency in flight.

25. On the face of this unit is mounted the supply switch which controls the power supply for the entire installation.

The Universal Indicator, Type 2

26. This unit can be used as an indicator for Gee, Gee H, Rebecca, and Rebecca H functions. In effect it is a single unit, but for purposes of installation, convenience and simplicity of control, it has been split into three sub-units, viz :—

(*a*) Strobe Unit, Type 61.

(*b*) Control Unit, Type 426.

(*c*) Indicator Unit, Type 166.

27. *Strobe Unit, Type* 61. This unit contains that part of the Universal Indicator which need not be accessible in flight. On it are pre-set controls for repetition frequencies, calibration pips, etc.

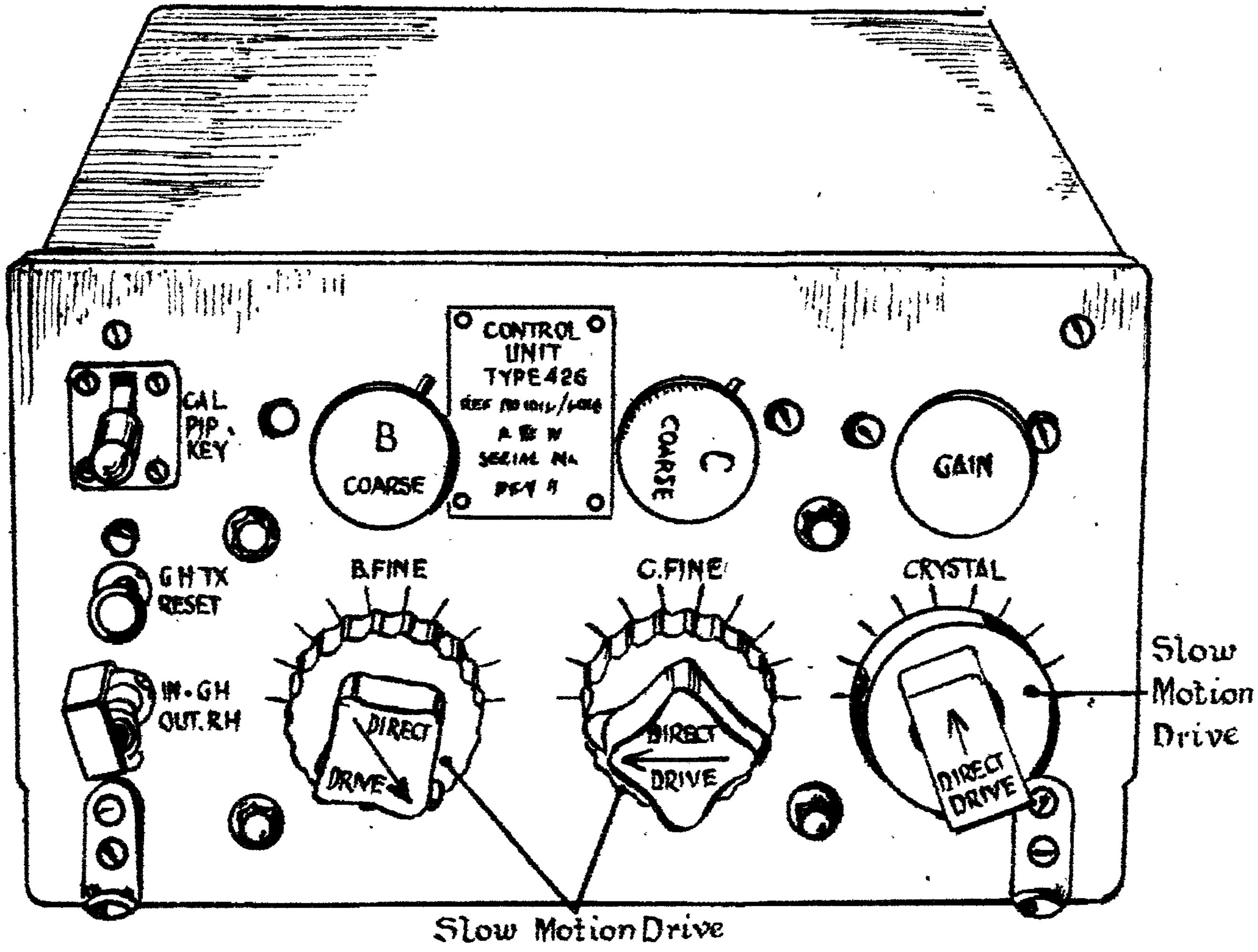


FIG. 6. Control Unit, Type 426.

28. *Control Unit, Type* 426. This unit (fig. 6) is installed in the aircraft close to the Indicating Unit, Type 166, and, with the latter, carries all the controls which are navigator-operated. The controls on the face of this unit are as follows :—

(*a*) Calibration Pip key.
(*b*) Gee H transmitter reset button.
(*c*) Gee H/Rebecca H selector button.
(*d*) B Strobe Coarse control.
(*e*) B Strobe Fine control.
(*f*) C Strobe Coarse control.
(*g*) C Strobe Fine control.
(*h*) Receiver Gain control.
(*j*) Crystal Frequency control.

29. *Indicator Unit, Type* 166. The following controls are mounted on the face of this unit (fig. 7) :—

(*a*) Range switch for strobe time bases.
(*b*) Function switch.
(*c*) Strobe switch.
(*d*) Test button.
(*e*) Line spacing control.
(*f*) Strobe spacing control (pre-set).
(*g*) Brilliance control.
(*h*) Astigmatism control (pre-set).
(*j*) Focus control.

Also on the face of this unit are two sockets for power, output, etc. leads.

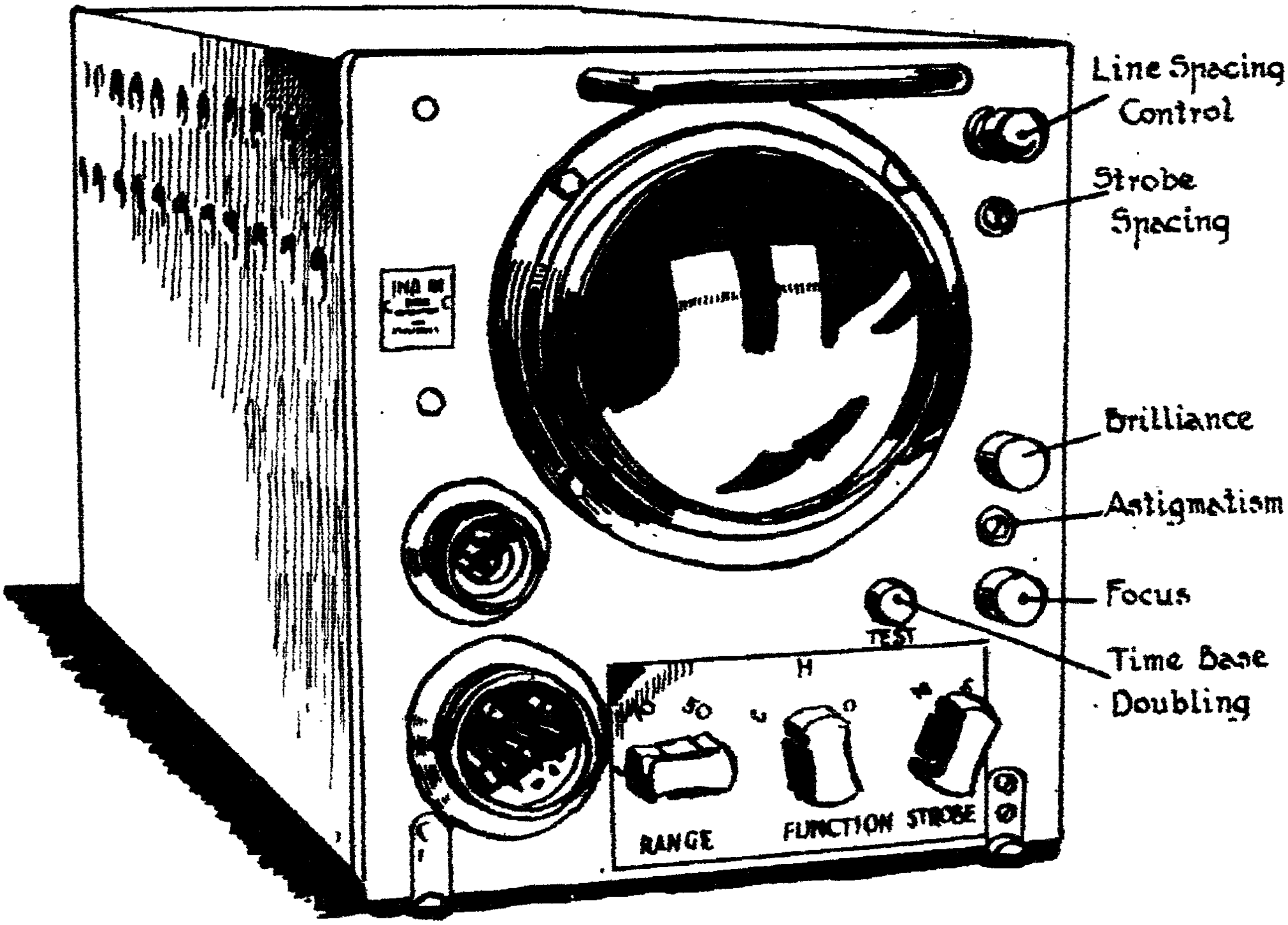


FIG. 7. Indicator, Type 166.

Voltage Control Panel

30. This panel (fig. 8) regulates or distributes the necessary A.C. and D.C. supplies from the aircraft generator and batteries. On it is an on/off switch and, inside the cover, a fuse.

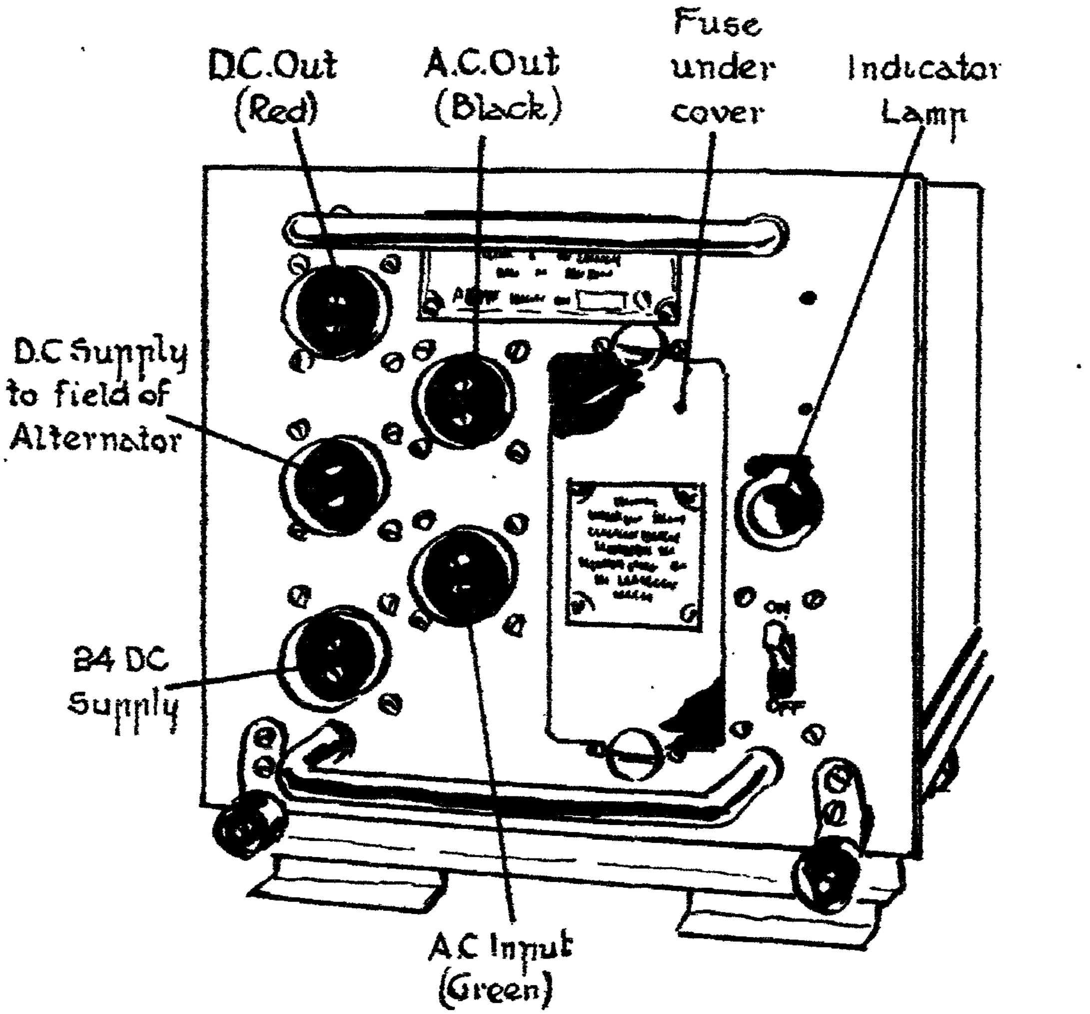


FIG. 8. Voltage Control Panel, Type 5.

Gee H Mouse

31. Otherwise known as the Computor, Automatic, Type 56, the Gee H Mouse is an automatic device which facilitates the use of Gee H Mk. II, as a blind bombing aid. It takes account of time of bomb fall and aircraft speed, and operates the bomb release.

32. The section of the unit of interest to the navigator is the Control Unit, Type 522 (fig. 9), containing :—

(*a*) Master switch.

(*b*) Reset button.

(*c*) Setting knob.

(*d*) Bomb release switch.

(*e*) Camera release switch.

A full description of the principle and operation of " Mouse " is given in paras. 69–74.

The Aerials

33. Two aerials are used, one for receiving and the other for transmitting. The receiving aerial is used for the whole frequency range of 20 to 80 Mc/s. by means of an aerial loading unit, Type 51. This aerial serves both Gee and Gee H. The Gee H transmitting aerial, as mentioned in para. 24, must be changed for any change in frequency. Ten different screw-in aerials are available for this purpose.

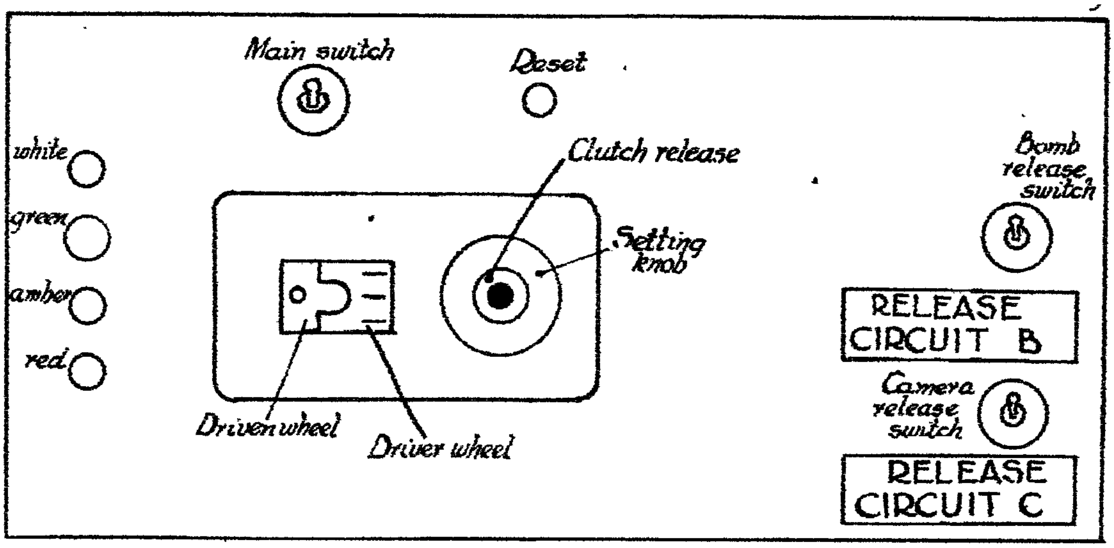


FIG. 9. Control Unit, Type 522.

Function of the Controls

34. *Indicator, Type* 166. The functions of the controls on the Indicator are listed below :—

(*a*) *Strobe Spacing.* This is a pre-set control, by means of which the strobe time base for Rebecca H is made symmetrical with respect to the scale engraved on the screen.

(*b*) *Astigmatism.* This is a pre-set control, adjusted in conjunction with focus to give best trace definition.

(*c*) *Brilliance.* Operation of this control varies the grid potential of the C.R.T. and thus the intensity of the electron beam.

(*d*) *Focus.* Operation of this control varies the potential on the second anode of the C.R.T. thus focusing the electron beam.

(*e*) *Function.* This is a three position switch which, when set at the desired position (Gee, H, or Rebecca), switches in the appropriate receiver, etc., and feeds the appropriate signals to the indicator screen.

(*f*) *Line Spacing Control.* Operation of this control varies the spacing between time bases to suit the navigator's requirements.

(*g*) *Strobe Switch.* This switch has two positions, selecting either main or strobe time bases.

(*h*) *Range Switch.* This is a four-position switch with which the desired length of strobe time base is selected. The positions of the switch are 2, 10, 50 and 150 miles.

(*j*) *Test Button.* This is used for checking and inspection purposes. It is also known an the time base doubler switch. When pressed, the time base appears as shown is fig. 10 below. When the equipment is correctly set up the step should appear at the 29th calibration pip on the main Gee time base.

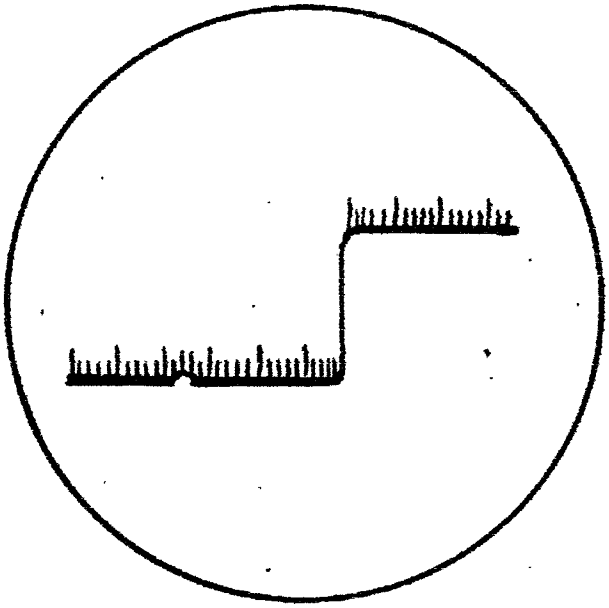


FIG. 10. Effect of Test Button.

35. *Control Unit, Type* 426. The following are the controls contained in this Control Unit :—

(*a*) *Receiver Gain.* This control varies the signal amplitude fed from the Gee H receiver to the indicator ; if Rebecca is installed, the control serves the same purpose for this function.

(*b*) *Gee H/Rebecca H Selector Button.* When the function switch (para. 34 (*e*)) is set to H, operation of this button selects the required H function. Button *in* selects Gee H and *out* selects Rebecca H.

(*c*) *Crystal Frequency Control.* Use of this control has the effect of varying slightly the time base recurrence rate and thus the position of pulses on the time base. On the Gee function, pulses are moved to their correct positions on the time base and halted, there by operation of this control.

(*d*) *B Coarse Strobe Control.* With this control the B strobe is moved along the left hand or top time base, in jumps.

(*e*) *B Fine Strobe Control.* With this control the B strobe is moved smoothly along the time base for the distance between the coarse jumps. The control incorporates a direct and a slow motion drive.

(*f*) *C Coarse and Fine Strobe Controls.* These controls have the same function for the C strobe as the B controls have for the B strobe.

(*g*) *Calibration Pip Key.* This control selects either calibration pips or signals for display on the time base.

(*h*) *Gee H Transmitter Reset Button.* There is an overload circuit in the Gee H transmitter, and if it trips it can be reset by pressing this button. When the button is depressed the transmitter is off ; thus, if doubt exists as to the authenticity of any pulse, operation of this button will resolve the doubt. If the pulse is spurious, it will not disappear when the button is depressed, switching the transmitter off.

OPERATION

Introduction to Operation

36. A.R.I. 5685 is built up around the Universal Indicator, Type 2, and Gee H is only one of the facilities offered by the installation. Provision is made for working with Gee and Rebecca, and their respective H systems, although normally Gee and Gee H are the only two facilities available with the installation.

37. The equipment is designed with the intention that Gee shall be used for normal navigation purposes and Gee H only when the highest possible fixing accuracy is required, *e.g.* during a bombing run. The Universal Indicator, Type 2 is not installed when Gee alone is available, but where it *is*, it serves the dual function.

38. The following paragraphs describe the operation of the equipment as Gee H. Operation as Gee is described in paras. 78 to 89 of Chapter 5. Operation as Rebecca is not described.

General Operation

39. The aircraft transmits pulses and these pulses, when received by a ground beacon tuned to the correct frequency, trigger the ground beacon, which retransmits pulses to the aircraft.

40. Two time bases appear on the C.R.T., and the local or aircraft pulse will appear at the left hand end of each of these. If the time bases are vertical the local pulse appears at the bottom of them.

41. When the two beacons of the H chain respond, both beacon responses will appear as pulses on both traces. The method of distinguishing between them is described in para. 59. The appearance of the Indicator is as shown in fig. 11.

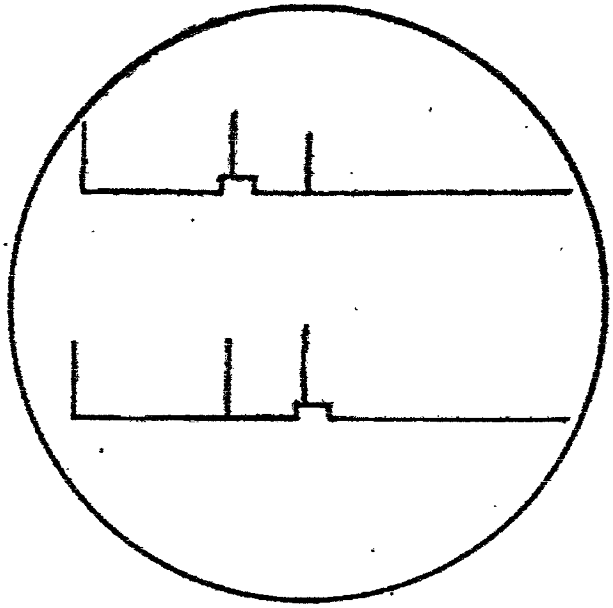


FIG. 11. H Main Time Base.

42. Reference to para. 4, describing the principle of Gee H, will show that it is required to measure the time difference between the local pulses and the received beacon pulses. As in Gee, Mk. II, a system of strobing is employed to enable the navigator to measure these time intervals accurately.

43. The local pulse is locked to the time base in Gee H, time of commencement of the time base and transmission of a pulse being synchronised. Beacon responses appear along the time base at distances commensurate with their range.

44. Two strobes are provided on each time base :—

(*a*) The A strobe, which is at the extreme bottom or left hand end of the time base and is not marked.

(*b*) The B and C strobes on the left and right hand strobe time bases respectively.

The length of these strobes is determined by the position of the strobe selector switch. They may be 2, 10 or 50 miles in length, the 150 mile strobe being non-operative for Gee and Gee H. The strobe visible on the main time base is the 10 mile strobe.

45. These strobes are used in exactly the same way as are the strobes in Gee, enabling the operator to line up the pulses accurately and thus determine time difference (Chapter 5 of this Section).

Switching On

46. There are only three switches controlling power supplies to the installation, procedure for switching on being as follows :—

(*a*) Close the switch on the V.C.P., Type 5.

(*b*) Close the switch on the Transmitter, Type T.1629.

(*c*) Power is supplied to the desired units by switching the function switch on the Indicator, Type 166 to the appropriate position.

Operating Drill

47. To employ the installation as Gee H, the operating drill is as follows :—

(*a*) Close switches on V.C.P. and transmitter.

(*b*) Check that correct R.F. unit is installed.

(*c*) Place R.F. unit selector switch to correct setting.

(*d*) Place aerial loading unit, Type 51, to required setting.

(*e*) Switch anti-jamming switch to N.

(*f*) Switch function switch to H.

(*g*) Depress Gee H/Rebecca H button.

(*h*) Set strobe switch to M (Main Time Base).

(*j*) Set calibration pip key to obtain signals.

(*k*) Adjust brilliance and focus as required.

(*l*) Adjust line spacing control as desired.

(*m*) Switch to Gee function and halt pulses with crystal frequency control ; switch back to H. This is essential if maximum accuracy is to be obtained as it has the effect of correctly setting the crystal oscillator, which provides the calibration pips.

48. The local pulses and the received beacon pulses should now be visible on the time base ; the local pulses will be at the bottom of the trace or at the left, depending on the orientation of the tube. The beacon pulses will be at distances up or along the time bases commensurate with their range. The navigator can now take a fix.

Taking a Fix

49. As stated above, the local or transmitter pulses will appear at the extreme left end of both time bases. When both ground beacons are responding, both beacon pulses will be visible on each trace. The strobes are placed on these by means of the strobe controls and the picture should then appear as in fig. 11.

50. Switch to strobe time base, where the pulses should be visible. Use the B and C fine controls to align the respective pulses with the A pulses. The traces will now appear as shown in Fig. 12.

51. When extreme accuracy is required, shift the pulses to the extreme left hand end of the 10 m. strobe time base (bottom if vertical time bases) and switch to the 2 m. strobe time base. Align the pulses accurately on this time base with the fine strobe controls (fig. 13).

52. As soon as the pulses are lined up on the strobe time base, take the time and switch the calibration pip key to give calibration pips.

53. Reading of the second and first decimal points is carried out on the 2 m. and 10 m. strobe time bases, as for Gee, Mk II (*see* Chapter 5). Whole numbers are read as shown in fig. 14, the number *before* the front edge of the strobe marker being taken.

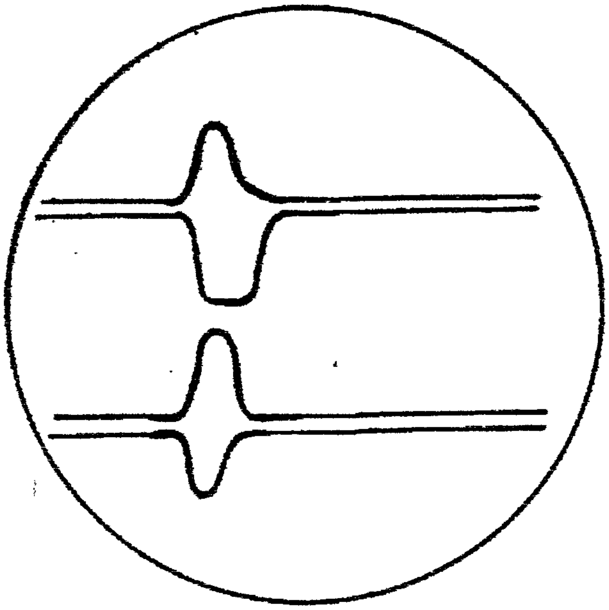


FIG. 12. Strobe Time Base (10 m).

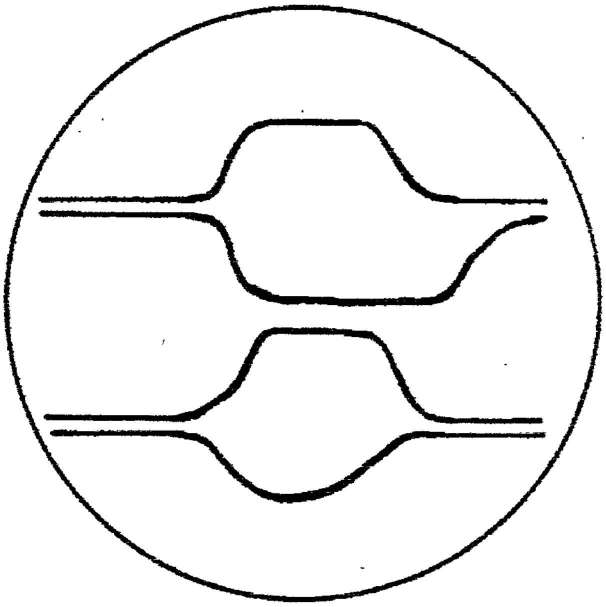


FIG. 13. Strobe Time Base (2 m).

54. The time base velocity is increased for the duration of the strobe markers, while on the main time base the calibration pips are closely spaced. If difficulty in reading the whole number is experienced, switch to the 50 mile strobe time base. A major calibration pip will be visible on the expanded portion and the desired whole number can be obtained by counting back from this.

Homing

55. Homing can be carried out either :—

(*a*) Along a line of constant range.

(*b*) Along a line of constant range difference (hyperbolic).

The two methods are described below.

56. *Range Homing*. For the first method the procedure is as for Gee ; the strobes are set to the required fix and the aircraft is then directed so that one pulse is brought into line. The aircraft is then flown so that this pulse is maintained in alignment (*i.e.* at a constant range from one beacon) until the other pulse also comes into line. This method of homing on Gee is described in paras. 50–61 of Chapter 5 of this Section, and is the same for Gee H.

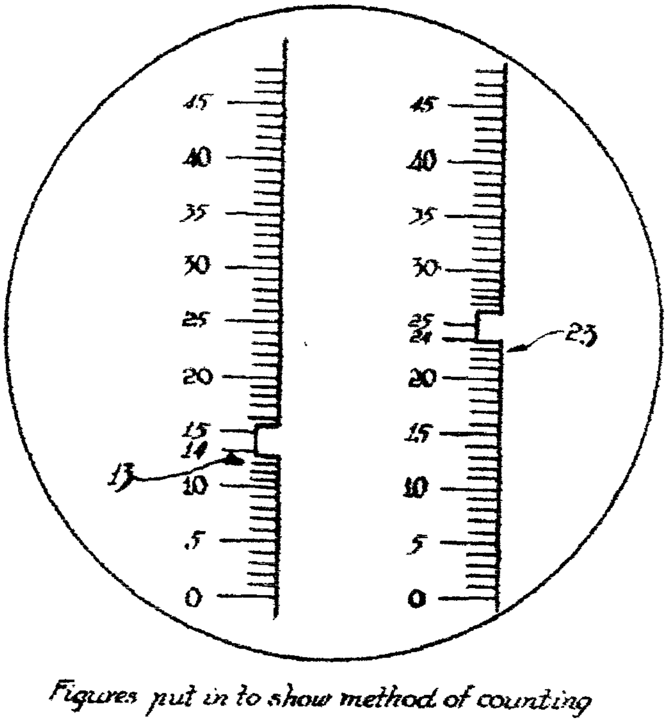


Fig. 14. Whole Number Reading.

57. *Hyperbolic Homing*. The second method is the more accurate of the two, though rather more difficult in practice. It is carried out as follows :—

(*a*) Calculate range *difference* at desired homing point (*e.g.* 8.2 Gee H units).

(*b*) On main time base, place strobe marker beneath one beacon response.

(*c*) Reduce line spacing to zero. The picture will now appear as in fig. 15.

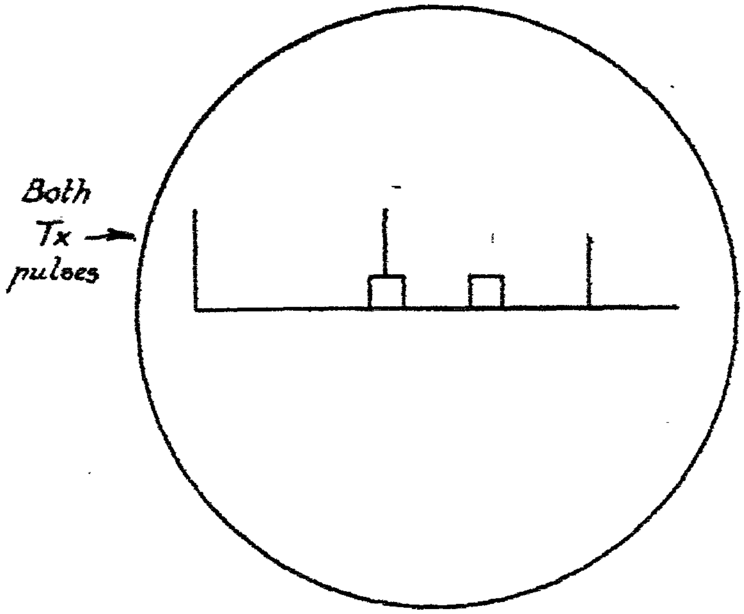


Fig. 15. Hyperbolic Homing.

(*d*) Shift other strobe to a distance 8·2 Gee H units away from the first one.

(*e*) Direct aircraft so that second signal moves on to second strobe marker. Aircraft is now on the line of constant range difference which passes through the homing point.

(*f*) Direct aircraft so that the two beacon pulses are aligned on the 10 m. strobe time base.

(*g*) Set strobes to co-ordinates of the homing point.

(*h*) Switch to strobe time base (50 m. or 10 m. depending on range) and direct aircraft so that the beacon pulses remain aligned and move along the time base into alignment with the transmitter pulse.

(*j*) When all three pulses are aligned on the 2 m. strobe time base, the desired homing point has been reached. The picture will now be as shown in fig. 16.

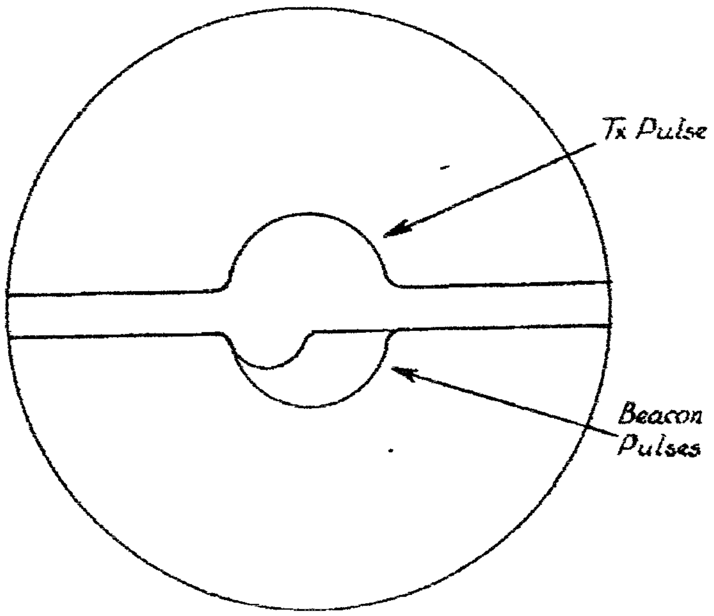


FIG. 16. Completed Hyperbolic Approach.

58. The hyperbolic method is only suitable for approaches made from the opposite side of the homing point towards the beacon. Otherwise it will not be possible to watch the beacon pulses moving into line with the transmitted pulses and so direct the aircraft. The reason for this is that the transmitted pulses are at the start of the strobe time bases.

Identification of Stations

59. Ground beacons are identified by blinking of the pulses, the transmission being interrupted in the form of morse letters. Coding may also be carried out in the form of periodic sideways jumps of the response on the trace from one beacon, this being known as the I or interrupted beacon and the other, the U or uninterrupted beacon.

Special Points for Manipulation

60. The crystal oscillator provides the calibration pips; therefore, for maximum accuracy it is essential that this oscillator be on the correct frequency. This is done by halting the pulses on the Gee function by means of the crystal oscillator control and leaving the control on this setting for Gee H working. After setting it do *NOT* touch it again.

61. The orientation of the tube for vertical or horizontal time bases is a matter of choice for individual operators. The leads to the C.R.T. are of sufficient length to allow turning the tube into either of the above positions. Most operators prefer horizontal time bases.

Blind Bombing Procedures

62. The systems of blind bombing using Gee H are both, in essence, timing systems, the timing being carried out with reference to Gee H fixes on the bombing run. These fixes are known as " *Warning Points* ". Two procedures are in use as follows :—

(*a*) *Warning Point System.* In this system the timing is done manually.

(*b*) *Mouse System.* In this system the timing is done automatically by the Computor, Automatic, Type 56.

Warning Point System

63. This is the system of blind bombing adopted when Mouse is not installed, *i.e.* in Gee H, Mk. II, installation A.R.I. 5597. It involves the use of three points (*see* fig. 17).

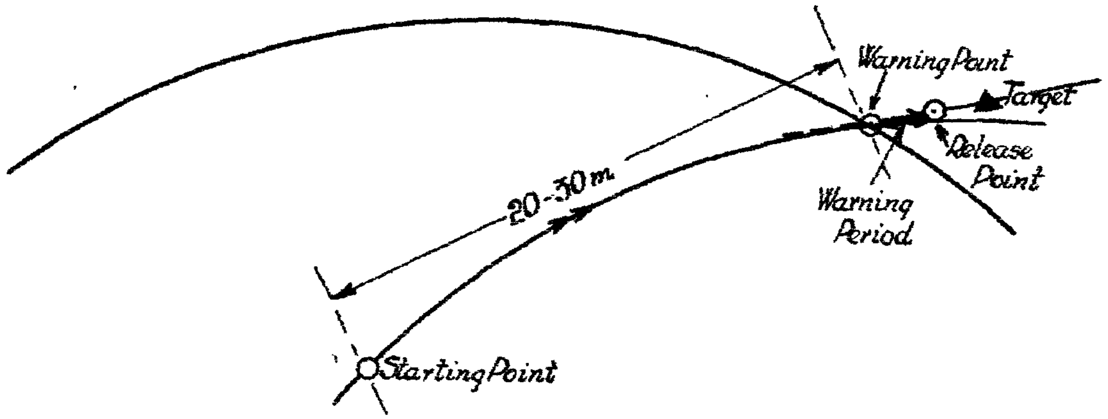


FIG. 17. Warning Point System.

These points are :—

(*a*) Starting point.

(*b*) Warning point.

(*c*) Release point.

64. The starting and warning points are about 20 or 30 miles apart on a Gee H range circle, and the warning point is calculated so that the tangent to the range circle at this point is the required tracking line for bombing. The starting point is 20 or 30 miles away from the warning point, which allows the navigator time to settle accurately on his Gee H range circle approach to the target.

65. *Starting Point.* This point is reached by Gee and D.R. navigation. Every effort should be made to reach it accurately, as it is from here that the Gee H approach to the target is made.

66. *Warning Point.* The co-ordinates of the warning point are set on the Gee H Indicator. It is essential that the aircraft arrive at this point, not only as a position, but also on the correct Gee H tracking circle. The co-ordinates of this point are calculated before flight from a knowledge of :—

(*a*) Maximum ground speed.

(*b*) Maximum height.

(*c*) Bomb ballistics.

67. *Release Point.* This is a point along the tangent to the Gee H circle at the warning point, and will be reached some seconds after the warning point. This delay is referred to as the warning period, and depends on the divergence of actual height and ground speed from the figures used in calculation of the warning point. Tables are provided which give the warning period in seconds.

68. *The Procedure.* Information as to positions of starting point, best height and air speed, etc. are supplied to the navigator at briefing. It is the crew's job to carry out the procedure as follows :—

(*a*) To reach the starting point.

(*b*) To maintain the required Gee H track between starting and warning points by reference to the indicator, and to determine the required heading for bomb release from consideration of drift experienced.

(*c*) To reach the warning point at the correct height and air speed and *on the correct heading*.

(*d*) To fly *straight and level* during the warning period.

(*e*) To extract the correct warning period from the tables and to release the bombs exactly on the expiration of this period.

The Mouse System

69. The Mouse System employs two warning points, both of which lie on the Gee H approach circle to the target and are calculated from a consideration of height, ground speed and time of bomb fall (T.B.F.). The timing is done automatically by the device known as the Gee H Mouse.

Principle of Mouse

70. The system is in essence a stop watch. Knowing the time of bomb fall, and with fixing facilities on the approach to the target, accurate bombing can be carried out simply by accurate timing of T.B.F. and the run between fixes on the approach path.

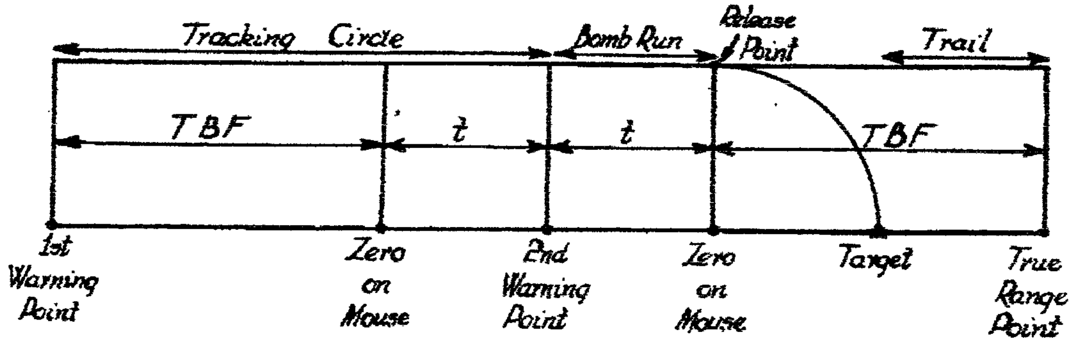


FIG. 18. Principle of Gee H Mouse.

71. The warning points are spaced so that the distance between them is equal to the distance between the second warning point and the true range point (position of aircraft when the bomb strikes the target). Thus, if the time of the bomb fall is known, the point of release will be at a time from the second warning point equal to :—

Time to fly between warning points — T.B.F.

Mouse employs this principle. The aircraft is navigated first by Gee and then by Gee H to reach the first warning point. Time of bomb fall is calculated by the navigator and set on the stop watch (Mouse) backwards from zero.

72. As the aircraft passes over the first warning point, the Mouse is set in operation. The stop watch then moves forward to zero as the aircraft moves along the tracking circle. The watch continues moving forward until the second warning point, where it is halted and reversed by the navigator. The time it indicates at this point is :—

Time to run between warning points — T.B.F. (t).

This is the time required to fly from the second warning point to the release point. Operation is automatic from the second warning point after the Mouse is reversed ; as the stop watch passes through zero, the bombs are automatically released.

73. The warning points are calculated on the ground and are selected with allowance made for the forecast wind over the target. Between warning points the aircraft is guided along the Gee H tracking circle and from the second warning point to the release point it flies a track tangential to the tracking circle at the second warning point (fig. 19).

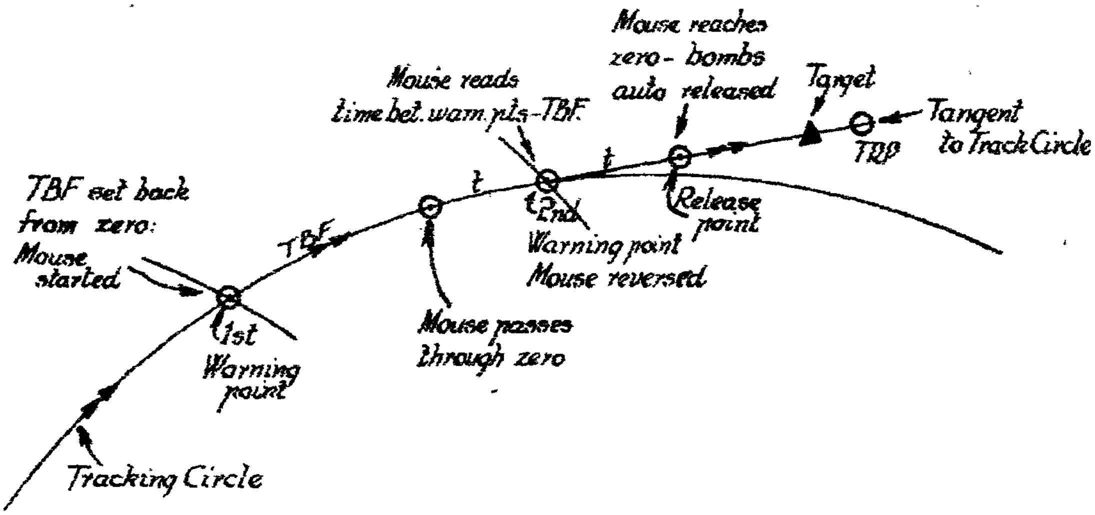


FIG. 19. Mouse Approach and Bombing.

Instructions for Use of Mouse

74. The practical operation of Mouse in order to achieve the result described above is as follows :—

(*a*) Switch Master Switch on Control Unit, Type 522, ON (*see* fig. 9).

(*b*) Ensure that bomb release and camera arming switches are ON.

(*c*) Operate reset button to ensure that Mouse is ready for operation ; no signal lamps should be lit.

(*d*) Set T.B.F. by means of setting knob and lock the clutch release.

(*e*) When the aircraft reaches the first warning point, depress the bomb release switch. This starts the stop watch ; the white signal light should light.

(*f*) As the stop watch passes through zero, the green warning lamp should light. Until this occurs, it is ineffectual to depress the bomb release switch a second time.

(*g*) When the aircraft reaches the second warning point, depress the bomb release switch for the second time. This halts and reverses the stop watch. The amber signal lamp should light.

(*h*) Mouse will now run backwards to zero and the bombs will be released automatically when it reaches zero. At this point, the red signal lamp should light.

Special Precautions

75. The normal function of Gee H is as a bombing aid, and it is most important that the beacons should not be overloaded when using the system for bombing. Therefore, Gee H should only be used for the *actual bombing run.*

76. A small error in the setting of co-ordinates will produce larger and larger errors as range increases. Therefore, co-ordinates should be accurately set on the indicator by using the 2 m. strobe time base *and* the setting frequently checked. It is also essential if the co-ordinates are to be set accurately that the crystal oscillator, which provides the calibration pips, be correctly adjusted by halting the pulses on the Gee function.

77. Bombing on the correct track is most essential ; a small error in heading is far more serious than a small displacement from track. Therefore :—

(*a*) While on the approach circle, determine as accurately as possible the heading required to make good a track tangential to the circle at the second warning point. Make every endeavour to arrive at the second warning point on this heading, so allowing the pilot to fly straight and level during the warning period.

(*b*) Ensure that the aircraft is on the correct heading at the time of bomb release.

78. Because the angle of cut between the position circles is acute at the warning points (normally about 30°), it is better that both beacon pulses be displaced in the same direction from the transmitter pulses than if one were lined up and the other displaced. In the former case, the error is in effect the shorter side of a triangle, while in the latter the error is equal to the longer side (*see* fig. 20).

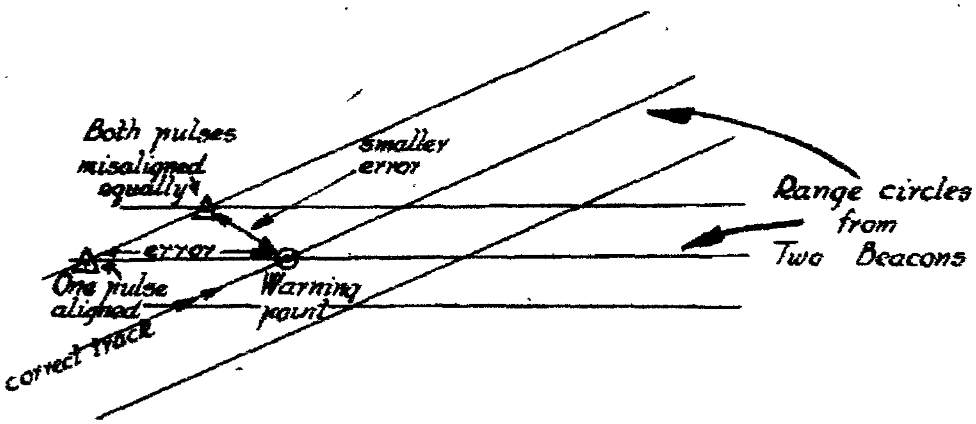


FIG. 20. Displacement from Warning Points.

79. It is thus obvious that it is better to have the beacon pulses aligned *one with the other*, even though they may be out of alignment with the transmitter pulses, than it is to have one beacon pulse aligned with the transmitter pulse, and the other displaced.

Security and Jamming

80. Installation A.R.I. 5685 is not seriously affected by interference from other installations in the aircraft, nor does precipitation static produce any considerable effect. As range is increased and the Gain control advanced, the amount of " grass " on the screen grows until it eventually swamps the signals. They may, however, still be detected by strobing the section of the Main Time Base where they are expected to be from a consideration of D.R. position, and searching the strobed position for signals.

81. As the Gee H system demands aircraft transmission, a loss of security is inevitable. However, use of the equipment for the actual bombing approach and run only, counteracts this to some extent. By the time the aircraft has commenced its run, its presence and target will in any case probably be well known to the enemy. Use at any time other than for actual bombing, however, is a serious security breach and should be avoided except in emergency.

82. Jamming usually takes the form of excessive and erratic noise on the traces, obliterating signals at extreme range. However, as long as the signals can still be seen, no loss of accuracy results from this jamming. Reading of signals through considerable jamming may be achieved by judicious use of strobe time bases as mentioned in para. 80, and in para. 45 of Chapter 5 of this Section. Deception pulses may be created by an enemy ; but it is most unlikely that they would provide a series of readings of the order expected, and detection of them would, as a result, be easy.

Fault Finding

83. The serviceability of the installation should, given adequate ground maintenance, be good. In the event of failure in the air the following checks should be carried out :—

(*a*) Check that the correct operating drill has been followed.

(*b*) Check main fuse.

(*c*) Check fuse in V.C.P., Type 5.

(*d*) Check security of all leads.

84. If these checks produce no results, the equipment should be reported as unserviceable, a description of the symptoms experienced being given to the maintenance team.