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THE RCAF
OBSERVER

Vol 5 No 4 October 1959

Volume 5 No4 October 1959

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The RCAF
OBSERVER
Incorporating the RCAF Navigation Bulletin
Founded 1949

FLYING SAFETY

A considerable amount of effort is being put into the promotion of flight safety in the RCAF today. "FLIGHT COMMENT", accident summaries, and posters continually remind aircrew of the need for conscious safety habits. Undoubtedly these measures are potent in reducing air accidents, but are they sufficiently broad in scope?

A close examination of flight safety literature reveals that only matters of primary concern to pilots, or to all aircrew in general, are touched upon. If any material has been directed solely to the safe practice of observer trades, it has been so infrequent that it is forgotten.

The neglect of observer trades in the flight safety programme of the RCAF provokes this question as a possible explanation: has the performance of observers been such that no safety programme is required? Certainly not! Within the past few years, several cases of observer malpractice have become well known. That all were not directly responsible for serious accidents can be attributed only to very good fortune. Obviously, then, the need exists for some programme of promoting safety in the observer trades.

The primary accent in a flight safety programme properly belongs to pilots, and if the programme were to include the observer specialties, much of the impact would be lost to pilots. However,the general safety habits are common to all crew members: adequate pre-flight planning, alertness and double-checking in the air, and a sound knowledge of equipment and techniques. The requirement, then, is for constant reminders of how these general principles can be applied to specific aspects of observers' flying duties.

The first concern of the RCAF OBSERVER is the specialized observer fields. Since this publication is available to all aircrew in the RCAF, what better medium is there for stressing flight safety to observers? Future issues will contain such material, the object being to improve the conduct of observer trades in the RCAF. The degree of improvement rests with the individual, for in the final analysis the success of any flying safety programme depends entirely on YOU.

SCATTER PROPAGATION

by
F/O DK Schneider
Central Navigation School

In recent years, the radio frequency spectrum has become more and more crowded, particularly in the lower and medium frequencies used for long range communication. Although the use of single sideband transmission will undoubtedly alleviate this situation somewhat, congestion is bound to continue in these frequencies.

Canada, because of her geography, possesses special problems in communication. The great distances can be traversed by lower frequencies, but there are still many difficulties, such as the common HF "blackouts" in the Arctic regions. Obviously, there is a need for an improved method of communication.

A very promising answer to these difficulties seems to be scatter propagation, which allows the use of VHF and UHF for long range transmission. Since the higher frequencies are not subject to "blackouts", this means of transmission is particularly suited to Canadian needs. Although scatter techniques have not yet been fully developed, gratifying success has been achieved in producing reliable, trans-horizon communication at higher frequencies.

Theory

The range of transmission of radio waves depends upon several factors, not the least of which are attenuation and reflection from the ionosphere. A radio wave radiated by an antenna is attenuated because its energy expands in all directions rather than just the direction in which reception is desired, and because some of its energy is absorbed by the earth. The amount of energy absorbed by the earth increases with frequency, until at VHF and above, transmission distances are only slightly greater than the optical line of sight.

When radio waves below VHF are radiated into the atmosphere, they are reflected back to earth to a large extent by the ionized layers of the ionosphere. At frequencies of VHF and higher, radio waves are absorbed rather than reflected by these layers.

Because of the high attenuation and the absence of reflection from the ionosphere, higher frequencies were not used for long range communication. In recent years, however, experiments have revealed a scattering phenomenon associated with certain high frequency transmissions, and have proven that this scattering can be used to increase greatly the range of high frequency transmission. Three separate techniques have been developed, each of which will be described briefly.

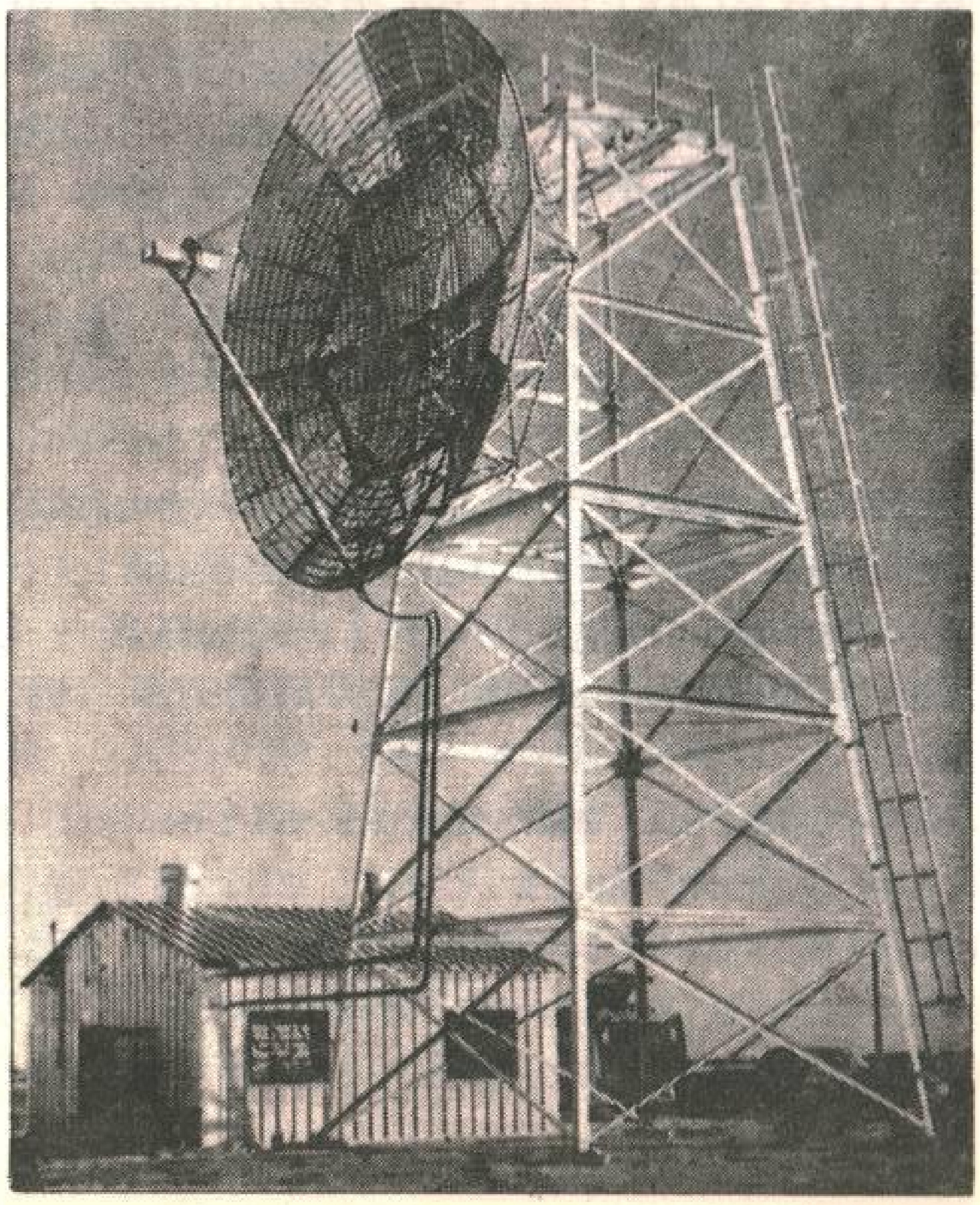


Figure 1

A 28 Foot Parabolic
Scatter Antenna

Tropospheric Scatter

When a high frequency signal from a sufficiently powerful transmitter is beamed at a very low angle into the troposphere, it is scattered in all directions, but the largest portion is scattered in the forward direction. A highly sensitive receiver placed in line with the direction of the transmitted energy can receive a signal which is sufficiently consistent for reliable communication. The mechanism by which scattering takes place is not really known, but appears to be the result of variations in the refractive index of the air due to changes in temperature, pressure, and moisture content.

Tropospheric scatter is usable for frequencies of 30 Mcs and above, but is most effective at UHF. The transmitter power output requirement is in the neighbourhood of 10 KW. To give the desired directivity, parabolic antenna reflectors with diameters of 28 to 60 feet are used (Figure 1). Because of the low angle of transmission, the maximum range for this type of system is 200-300 miles.

A particular problem associated with tropospheric scatter systems is fading, both short and long term. One type of such fading, called fast fading, takes place when two identical signals arrive at the receiver after having travelled paths that differ in distance by several wavelengths, so that they tend to cancel one another. This type of fading is also due to rapid fluctuations in the dielectric constant of the air. The effects of fading have been partially reduced by an automatic feature which reduces the bandwidth of the receiver during a period of fading, thus decreasing the noise level. Also, recent developments in the field of parametric amplifiers, which are noted for their extremely low noise level, are helping to extend the range and improve the reliability of scatter systems.

Another restriction imposed by scatter propagation is that amplitude modulation has not proven successful. However, frequency modulation has provided a transmission accuracy that compares very favourably with any other system.

To date, there are several thousand miles of tropospheric scatter circuits in North America, carrying every form of communication from teletype to television. With the technique still in its infancy, this is an indication of the great potential of scatter systems.

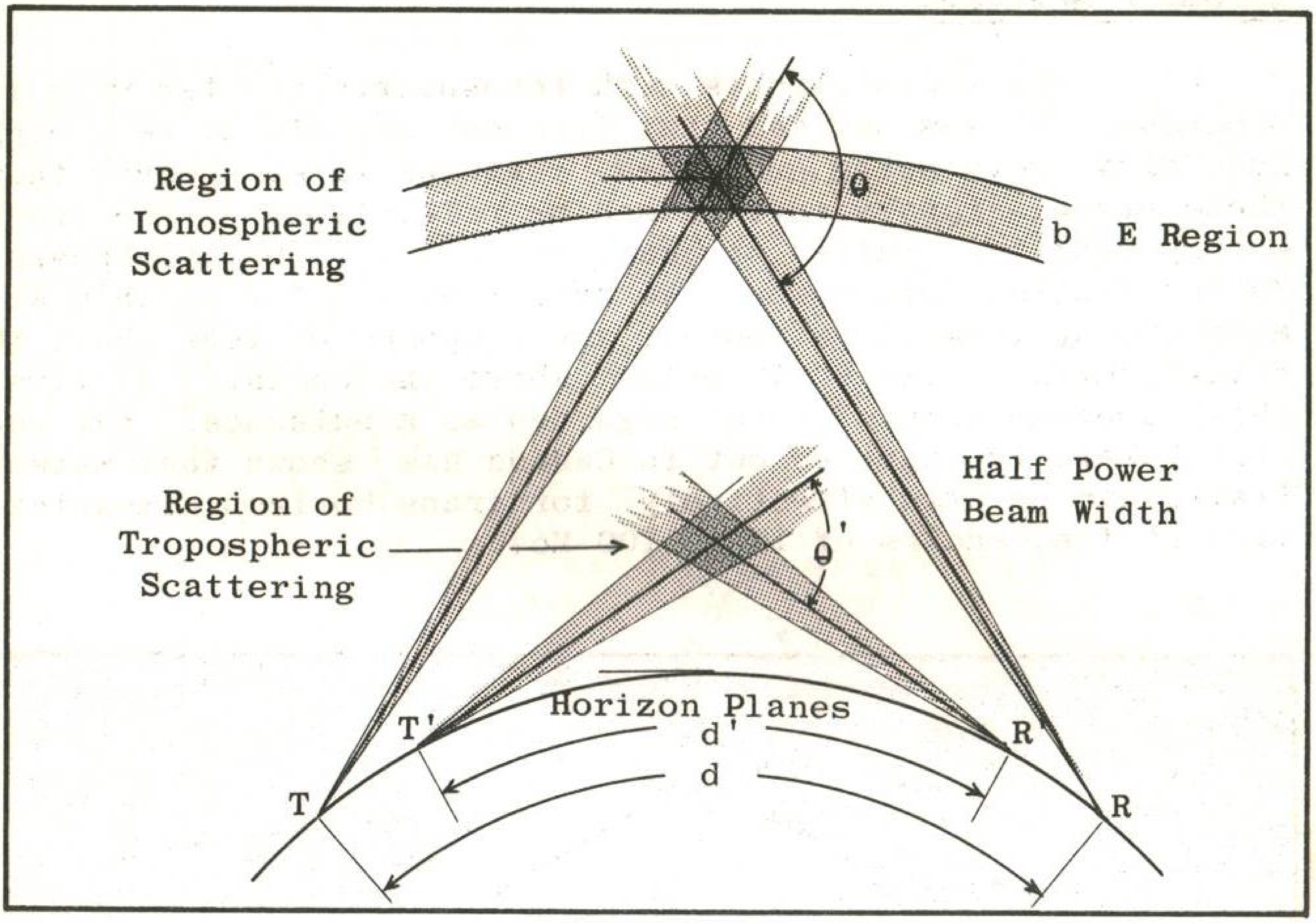


Figure 2 - Ionospheric and Tropospheric Scatter

Ionospheric Scatter

Ionospheric scattering of beamed radio waves in the 30 to 60 Mcs range occurs in much the same manner as the tropospheric phenomenon. Again, the cause is obscure but is thought to be due to irregularities in the degree of ionization of the E layer (Figure 2).

Because ranges of up to 1200 miles have been achieved with the ionospheric technique, it would appear to be superior to the tropospheric scatter system. Thus far, however, ionospheric systems have been incapable of carrying as much information as their shorter-range counterpart because narrower bandwidths must be used. A further disadvantage is that a more powerful transmitter (20-30 KW) and a larger antenna are required. Also, reliability suffers due to fluctuations in the height and general intensity of the ionized layer, and to multipath propagation. These difficulties have been partially resolved with an automatic request (ARQ) system, which makes the transmitter repeat automatically any portion of a message that is "garbled".

Meteoric Scatter

While experiments with ionospheric scatter were in progress, it was noticed that frequent signals of very high intensity were being received. It was later proven that these strong signals were caused by reflections of the radio energy from the trails of small meteors in the atmosphere. Meteor trails, formed when the meteor enters the earth's atmosphere at tremendous speeds, are composed of ions about 10 miles thick, some 60-70 miles above the earth. At first these "meteor bursts" were regarded as a nuisance, but research largely carried out in Canada has shown that meteor trails can be used effectively for trans-horizon communication at frequencies of 15 to 100 Mcs.

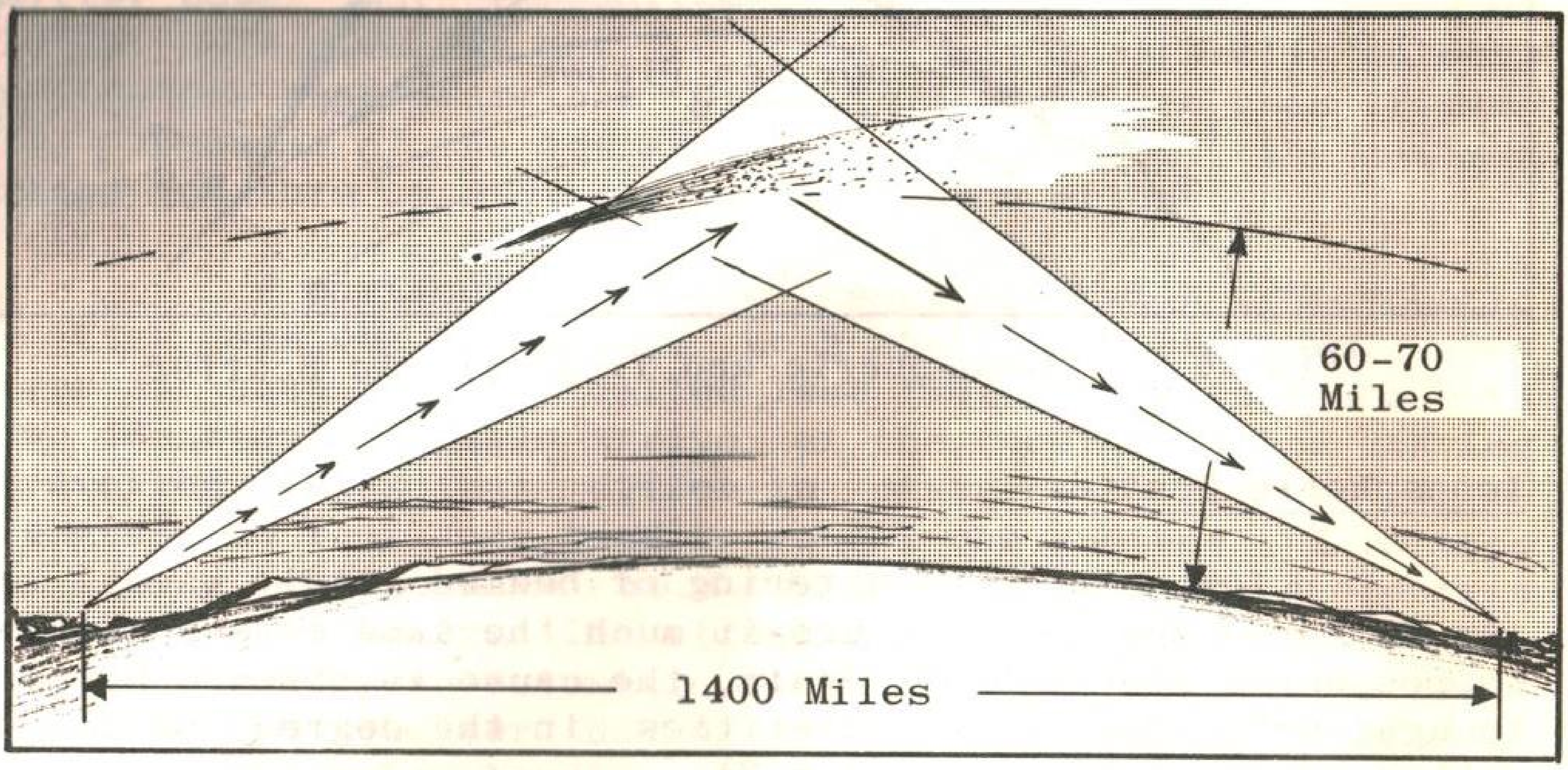


Figure 3 - Meteoric Scatter

The first to use this technique were scientists at the Radio Physics Laboratory in Ottawa. In a project code-named "Janet", they set up circuits which were designed to carry the equivalent of a continuous 60 word-per-minute, duplex teletype circuit. It was found that meteor trails were available for 5% of the time, so a sending rate of 1200 words per minute was necessary during transmission periods if an average rate of 60 words per minute was to be maintained. The system operated on a frequency of 40 megacycles with a power output of 500 watts, and showed an error rate of only 0.2% to 1%.

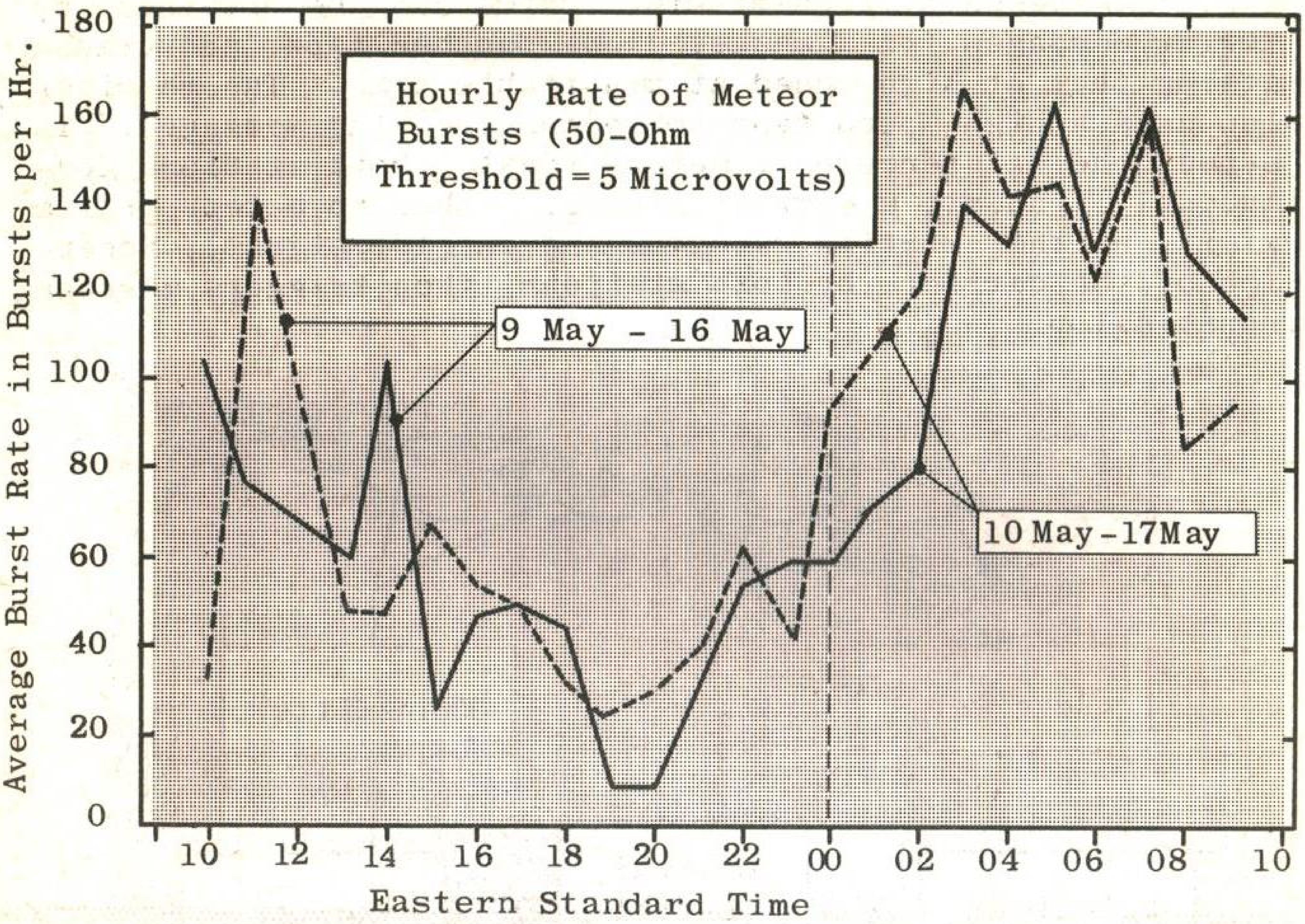


Figure 4

Meteor Strike Rate Variation (24 hours)

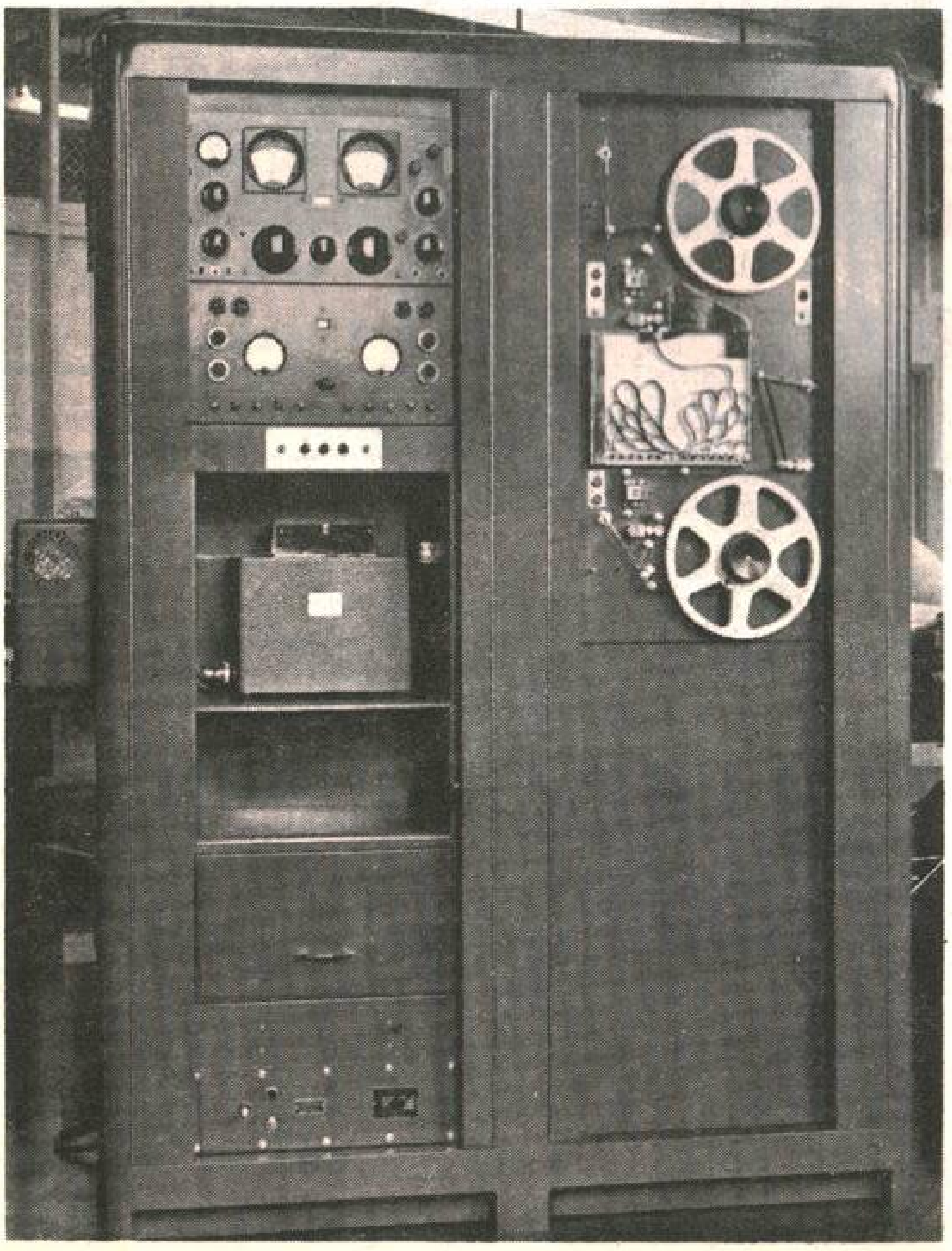


Figure 5

Magnetic Tape Message Storage Unit

Adequate transmission rates can be obtained by storing messages on a magnetic or punched tape, and transmitting them at high speed at a suitable time. The receiver also uses a high-speed tape to record incoming messages. To "sense" the existence of a meteor trail, both stations continuously transmit a carrier signal. When no meteor trails exist, neither station receives the carrier signal. Reception of the carrier by both stations then triggers message transmission.

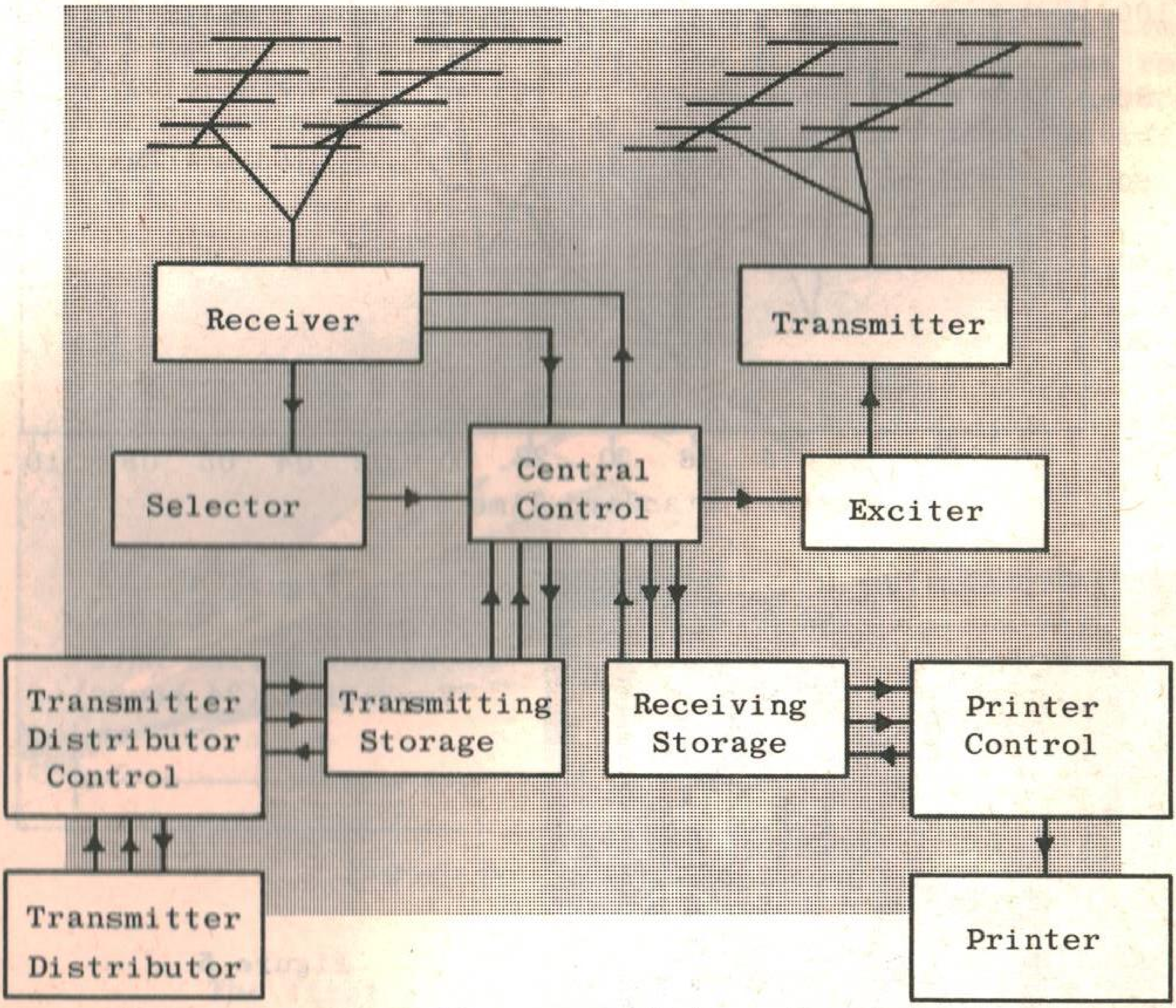


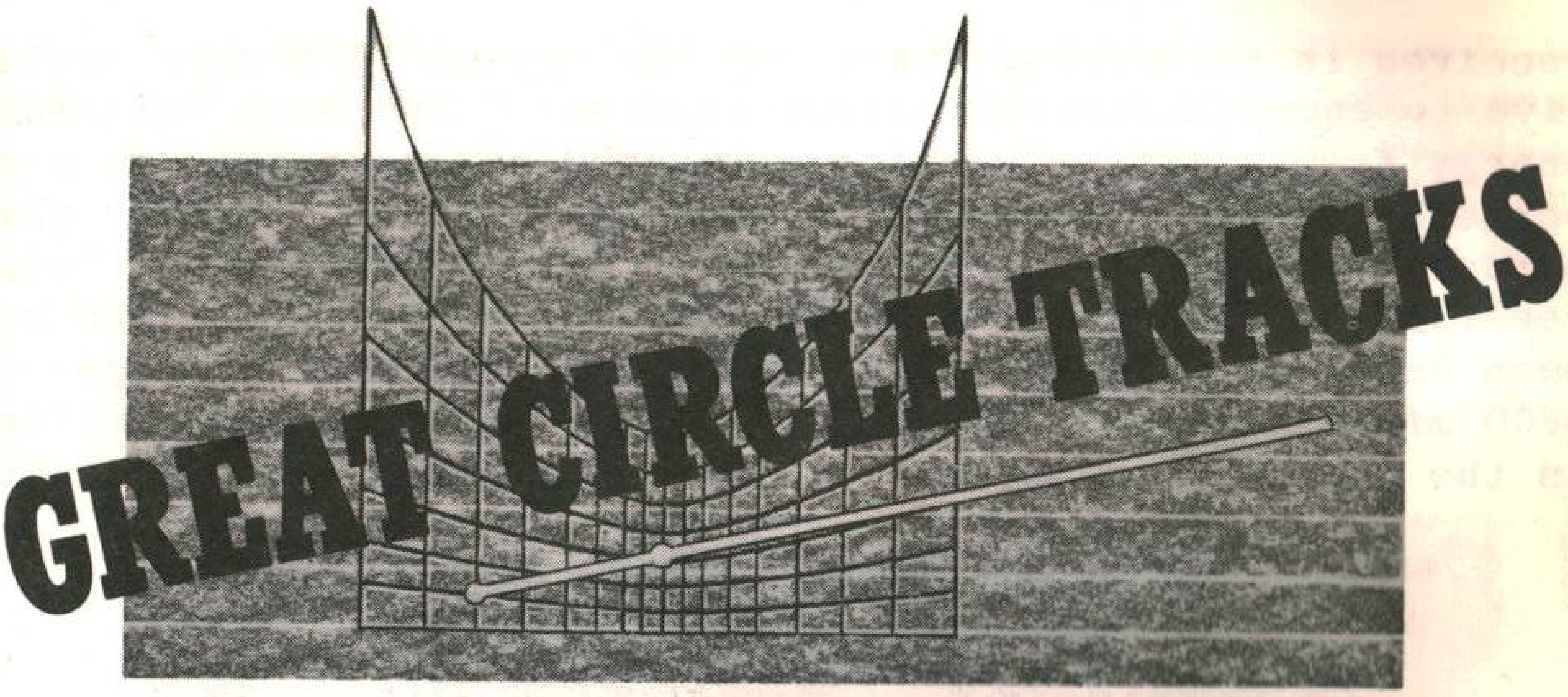
Figure 6 - Block Diagram of Meteor Burst System

The characteristics of a meteor burst system make it a useful partner for ionospheric scatter. It has comparable useful ranges, even with much smaller transmitter outputs, and although the system cannot be used continuously it does not suffer from the fluctuations in signal strength characteristic of ionospheric scatter, and is not limited to narrow-band applications. It has an advantage for military purposes in that the area where appreciable signals can be received is relatively small, so the system is highly resistive to enemy interception and jamming. The beam of radio energy from a meteor burst system need not be nearly as directional, and consequently a much smaller and simpler yagi array may be used for the antenna. Meteor scatter has successfully transmitted wide-band facsimile pictures, and has been used in ground-to-air communications over a range of 1200 miles. The only problem in ground-to-air communications is the design of a suitable antenna for high-speed aircraft.

Figure 7 - Aircraft Yagi Antenna for Meteoric Scatter

Conclusion

Several conclusions can be drawn from a consideration of the scatter techniques. Tropospheric scatter is superior to ionospheric in reliability, bandwidth, and frequency range, while the latter achieves greater range. The meteoric scatter system boasts a wider bandwidth and lower power requirement, yet the ionospheric technique is capable of a much higher data-handling rate. Thus each system has its own separate application, and the three techniques complement each other. Undoubtedly, all three forms of scatter propagation will become much more familiar to Canadians in the next few years.



GREAT CIRCLE TRACKS

ON ADMIRALTY CHART no5029

by
F/L DA Stonehouse
2 Air Observer School

Although denied categorically by RCAF Bulletin Number 26 (Map Projections), a simple and fool-proof method of tracing the great-circle path between any two points on the earth's surface is available to any navigator with a copy of Admiralty Chart 5029 and a modicum of patience. Since the requirement for such an operation occurs rarely in navigation at present, and almost never without considerable advance warning, both the chart and the patience can be obtained easily. With the increasing use of great-circle routes, however, the problem will arise with greater frequency.

The determination of a great circle track is greatly simplified by a chart on which great circles are represented exactly by straight lines. This property is possessed by the gnomonic projection, which is the standard chart used by the RCAF for establishing great-circle tracks. This chart has, however, one important deficiency: the practical limit of the projection is 75° from the point of tangency. Since the earth, in common with most spherical objects, has a quadrant of 90°, the complete earth can be represented on a gnomonic projection only if two or more points of tangency are used. Admiralty Chart 5029 portrays a quadrant of the earth's surface on two separate charts, one a polar gnomonic, the other an equatorial gnomonic. From Figure 1, it can be seen that any two points within 150° change of longitude, and between 65° north or south of the equator,

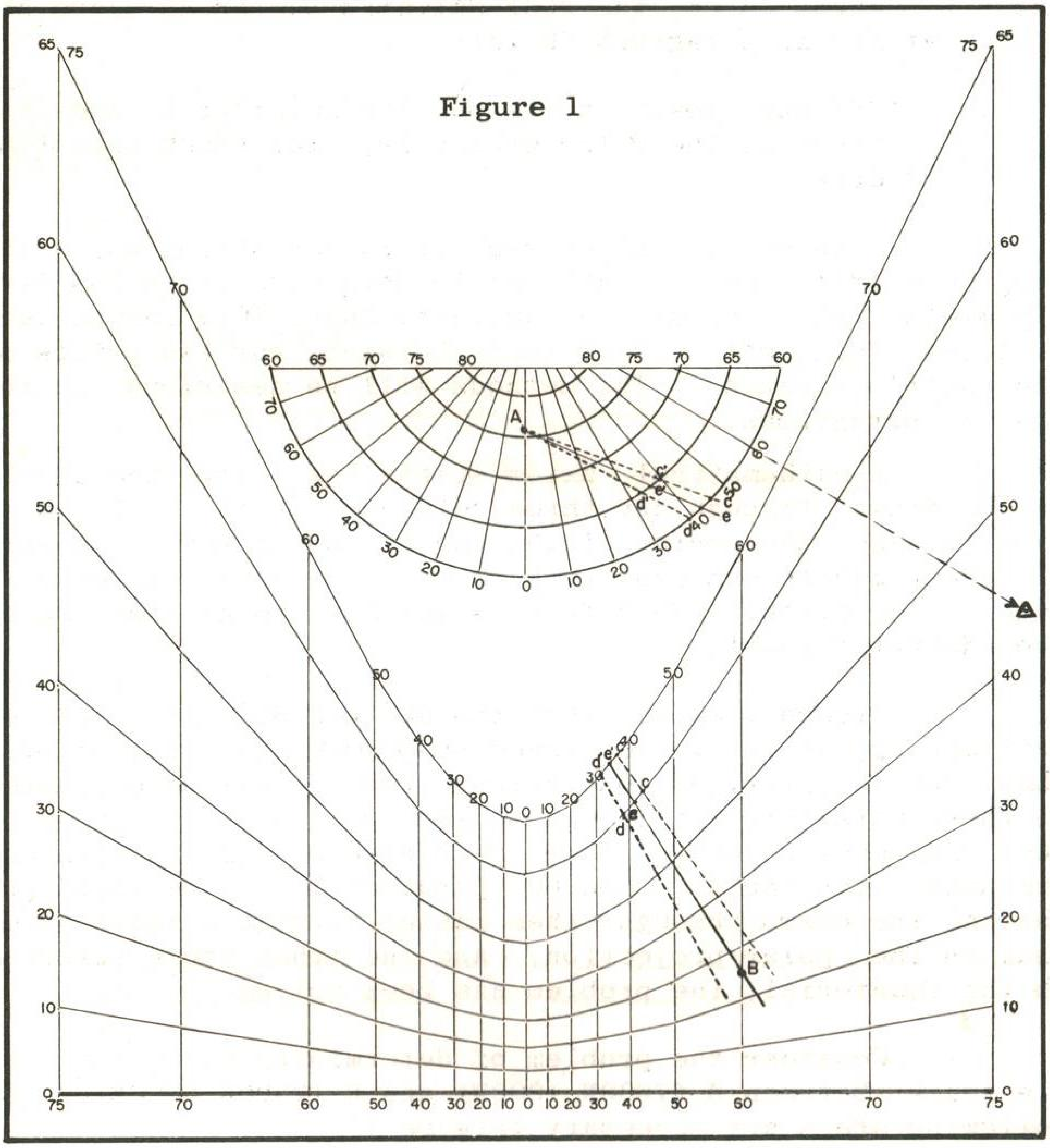


Figure 1

can be plotted quite simply on the equatorial gnomonic. Also, any two points which fall between 60° latitude and a pole can be dealt with easily. All that remains to complete the solution is the transfer of appropriately spaced coordinates to a conformal plotting chart.

What happens when one point of a route is on the equatorial portion, and the other on the polar segment of the chart? At this point reference texts are inclined to proceed happily to another topic, leaving the navigator with the impression that the problem is insoluble. One solution was suggested in the RCAF OBSERVER (Volume 3 Number 2) and later rejected. Also, the RCAF Bulletin Number 26 avers almost joyfully in paragraph 69 (d):

> "If one position is on the Equatorial and the other on the Polar graticule, the track cannot be drawn".

"Cannot" is, of course, a rather strong and challenging word in any context, but in this case it is positively misleading, because the Admiralty Chart 5029 can be used to locate the great circle track between any two points on the earth's surface. The methods will be described in the ensuing paragraphs.

A mathematical axiom states that only one circle can be drawn through any three points. Great circles must pass through the center of the earth (one point), so only one great circle can pass through any two points on the surface of the earth. This fact is the key to greater use of the Admiralty Chart.

Figure 1 shows that the 60° and 65° parallels of latitude appear on both the equatorial and polar projections. Thus from the previous conclusion, two specific coordinates on these parallels, although marked on the different projections, must be on the same great circle. If two such coordinates (on the 65° and 60° parallels) can be found so that a line drawn through them passes through a route terminal on the polar projection, and the other route terminal on the equatorial, the problem has been solved.

Consider the problem of determining the great circle track between A (7600N 1000W) and B (2500N 6000E). The following steps are necessary (Figure 1).

- Plot position A on the polar,and B on the equatorial projection of Admiralty Chart 5029.
- By visualizing B on an extension of the 60E meridian on the polar chart, estimate the approximate direction of the great circle track on the polar chart.
- Draw Ac' in the direction established above, cutting the 60N parallel at c, and the 65N parallel at c'.

- Plot the positions c and c' on the 60N and 65N parallels on the equatorial chart, and project a line through these positions towards B.

- Estimate a correction,and similarly construct Add' on both charts.

- Continue the process until Aee', passing through B , is established. This line is then the great circle track between A and B.

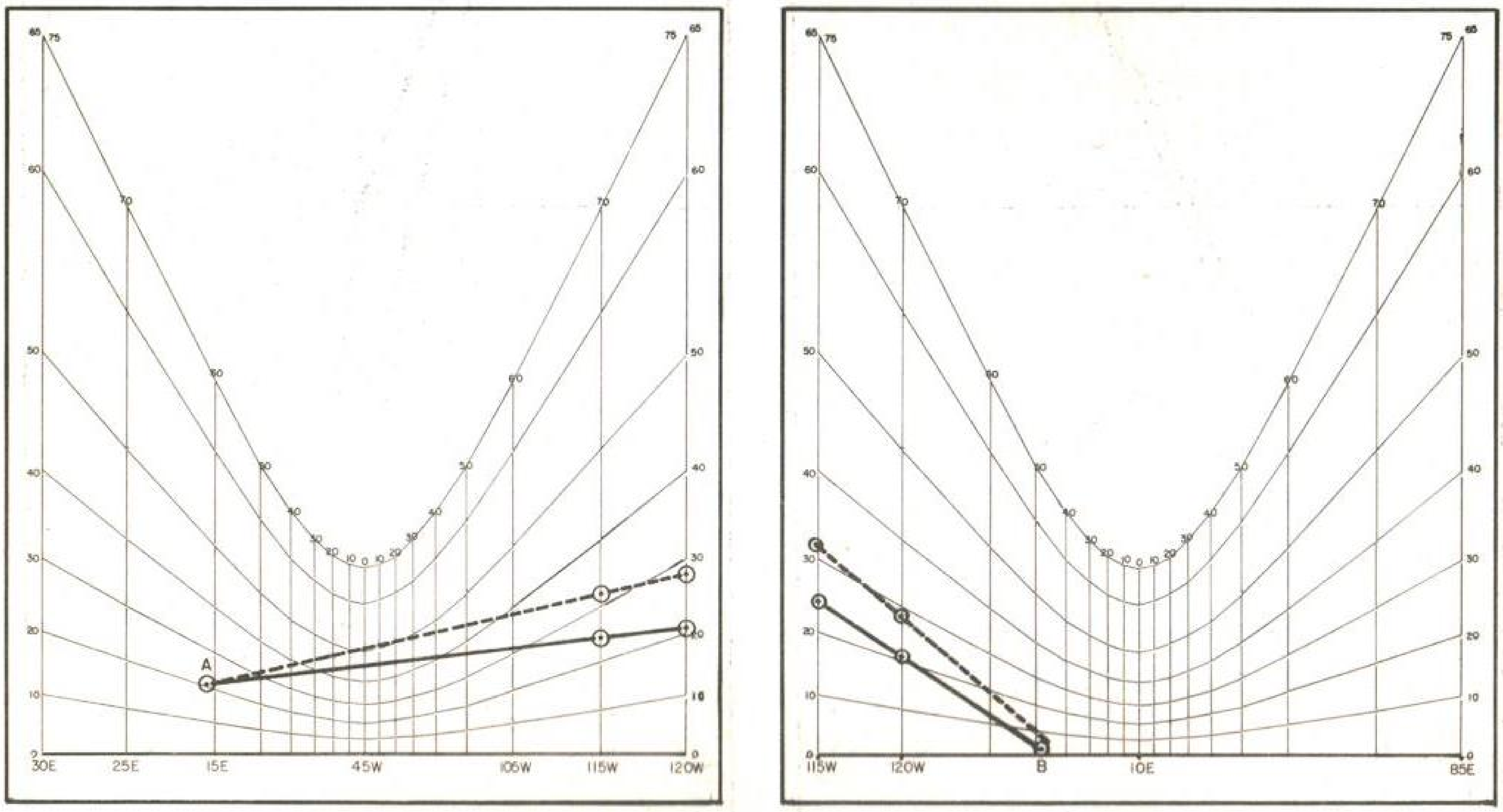


Figure 2

In the example used, it can be seen from Figure 1 that the great circle track crosses the 65°N parallel at about 35°15'E longitude. To check the track, this position was calculated mathematically to be 35°09'12"E. When the northern portion of the track was transferred to a polar stereographic projection, the initial great circle track measured 103°, compared with a mathematically-calculated value of 103°08'. The southern portion was plotted on a mercator chart, which gave a final great circle track of 164°, while the computed value was 164°56'. These small errors, 6' of longitude and 1° of track angle, are perfectly acceptable over the track distance of 3,659 nm. In fact, no greater accuracy can be expected in solutions to normal problems solved on the Admiralty Chart.

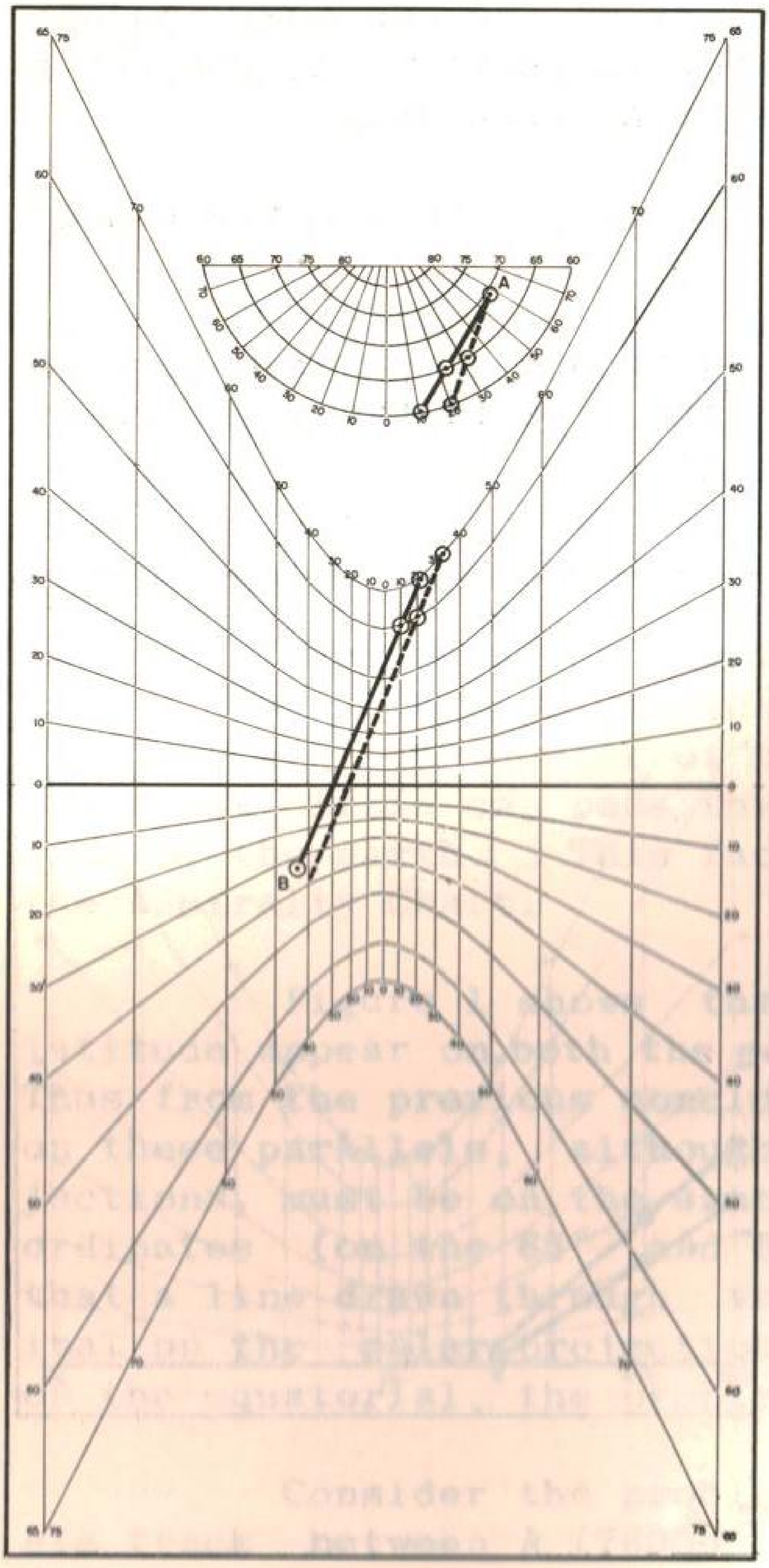


Figure 3

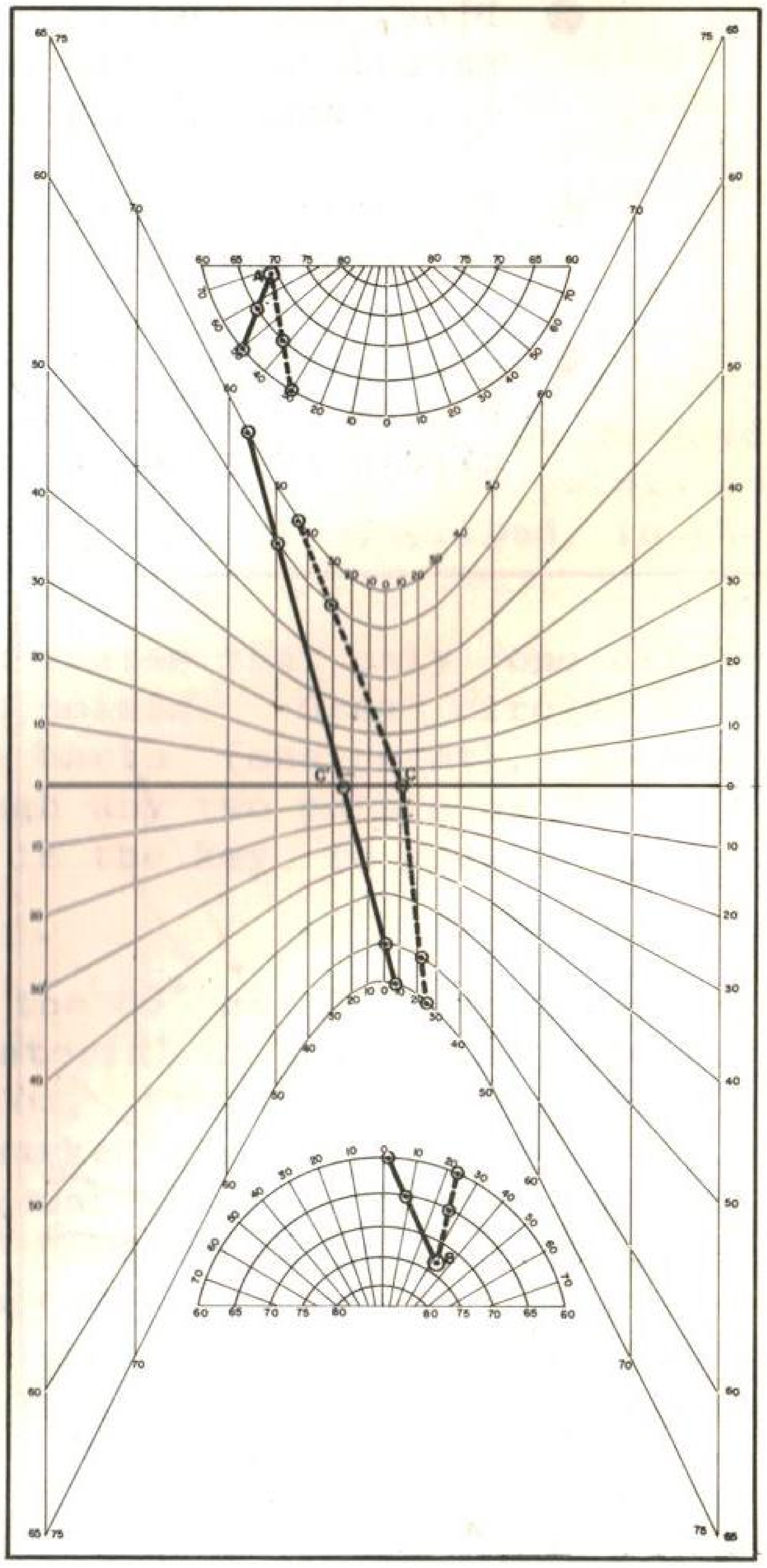


Figure 4

Another difficulty is presented by the longitude limit of 150° on the Admiralty Chart. However, a similar procedure can be used to locate the great circle track between two points whose longitude differs by more than 150°. As illustrated in Figure 2, two charts are used, with the meridians labelled so that a 5° or 10° overlap results. A trial-and-error operation will eventually produce two points on both charts on the great circle track between the route terminals.

There are two more odd situations which require special manipulation of the Admiralty Chart. One occurs when a track terminal is in a polar region, and the other in the equatorial region on the opposite side of the equator. In this case, the simplest method is to attach, upside down, the equatorial portion from another chart, and proceed as previously described (Figure 3).

A similar chart arrangement satisfies the other condition, which occurs when the route originates in one polar region, and terminates in the opposite polar region (Figure 4). This is the most difficult situation, requiring more trials and probably more errors before the required track can be determined. The procedure differs slightly from the previous examples:

- Join two Admiralty Charts at the equator.
- Plot the route terminals (A and B) in the polar segments.
- By visual inspection, select a point on the equator (C), which should fall near the great circle track.
- Using the trial-and-error method previously outlined, find the great circle tracks between A and C, and B and C.
- The two tracks found above will probably intersect at a slight angle at C. By estimation, choose another point (C') on the equator, and repeat the process; repetition of the entire operation will eventually determine a point on the equator through which the great circle tracks from A and B are coincident. This is the required great circle track between A and B.

Thus, by the use of a few simple expediencies, the Admiralty Chart 5029 can be used to find the great circle track between any two points on the earth's surface, with acceptable accuracy. Perhaps a more exact procedure could be devised, but it is doubtful that it would be any faster or simpler to apply. These methods make use of an existing chart which is available to any navigator: all that is required is a little practice.

SPECIALIST NAVIGATION COURSE


F/L DA Ruttan


S/L MG Reid


F/L EG Law

SEPT.-59 NO 12 JUNE-60


F/L EL Graham


Capt GA Schreiber


F/L W Colotelo

missile Guidance

part4

by
Flight Lieutenant GR Hunn
410 AW(F) Sqn

The emphasis placed on heavy calibre machine guns, cannon, and folding-fin rockets has probably tended to give the impression that air-to-air guided missiles are new, exciting, and different. Again, however, this is a misconception, because Germany entered this field during World War II. In fact, the German Air Force not only developed the X-4 missile, but also took measures to counter allied jamming of their command guidance.

German X-4 Missile

The X-4 (Figure 1) was a command guidance development to be launched by fighter aircraft. The missile was 78 inches long, had a 30 inch wing span, an effective range of 2,700 yards, and a speed of 560 mph at 21,000 feet. To eliminate the susceptibility of the radio command link to electronic countermeasures (ECM), wire links 12-18 kilometers long were devised.

The missile was released and controlled by the pilot of the fighter, using a visual sight. When the missile was fired, the gyro autopilot began operating, the warhead was armed, and flares were ignited at the wingtips of the

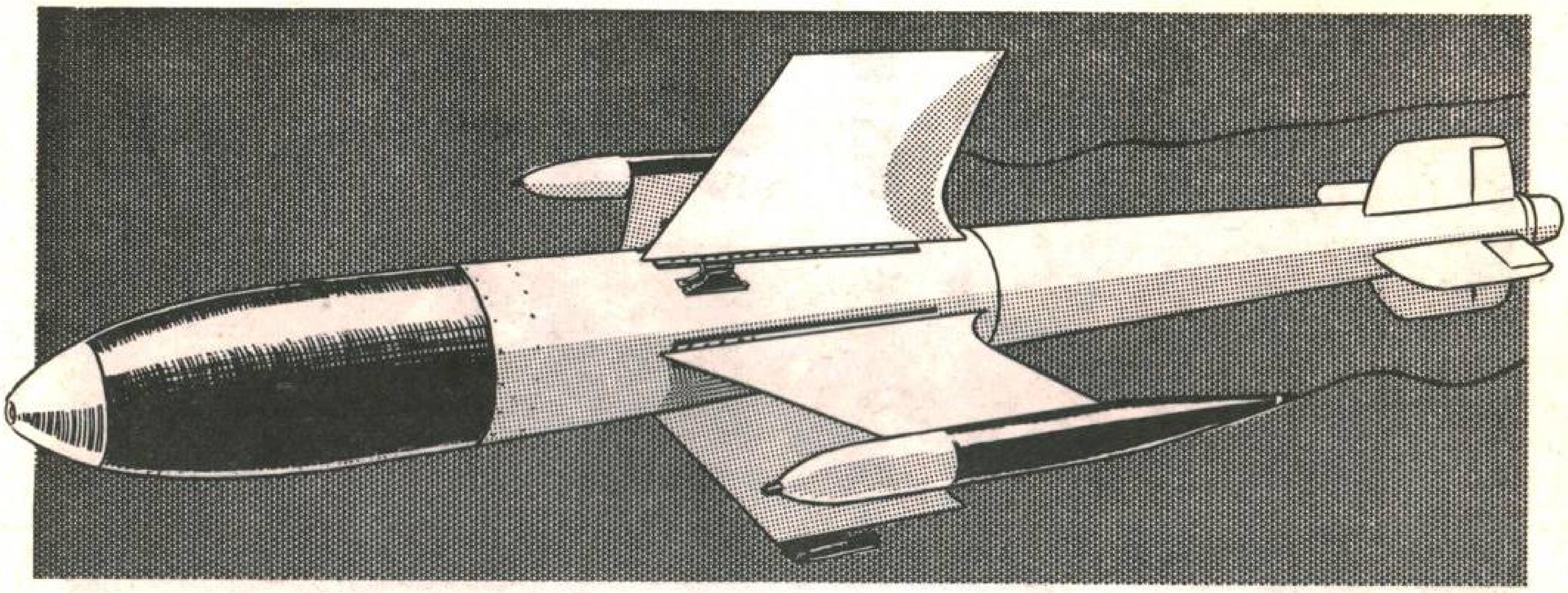


Figure 1 - German X-4 Air-to-Air Missile

projectile to facilitate visual tracking. The pilot steered the missile along the visual line-of-sight to the target using a joystick, similar to the Knuppel in the Burgund system, which transmitted the radio commands along the wire link(Figure 2). Two wire links were developed: the DORTMUND-DUISBURG, and the DUREN-DETMOLD systems.

The Dortmund-Duisburg wire link provided command transmission through two cables which connected the transmitting unit to the receiver in the missile. Movement of the joystick control modulated two audio frequencies which, when demodulated, actuated the pitch and yaw controls. The missile was rotated at 60 rpm to improve longitudinal stability, while a single gyro stabilized the vehicle along the line-of-flight. The gyro also oriented the pitch and yaw commands correctly.

The Duren-Detmold system used direct-current, with pitch commands changing the polarity of the voltage, while the current amplitude controlled yaw. If the wire broke,the missile continued to follow the last command received.

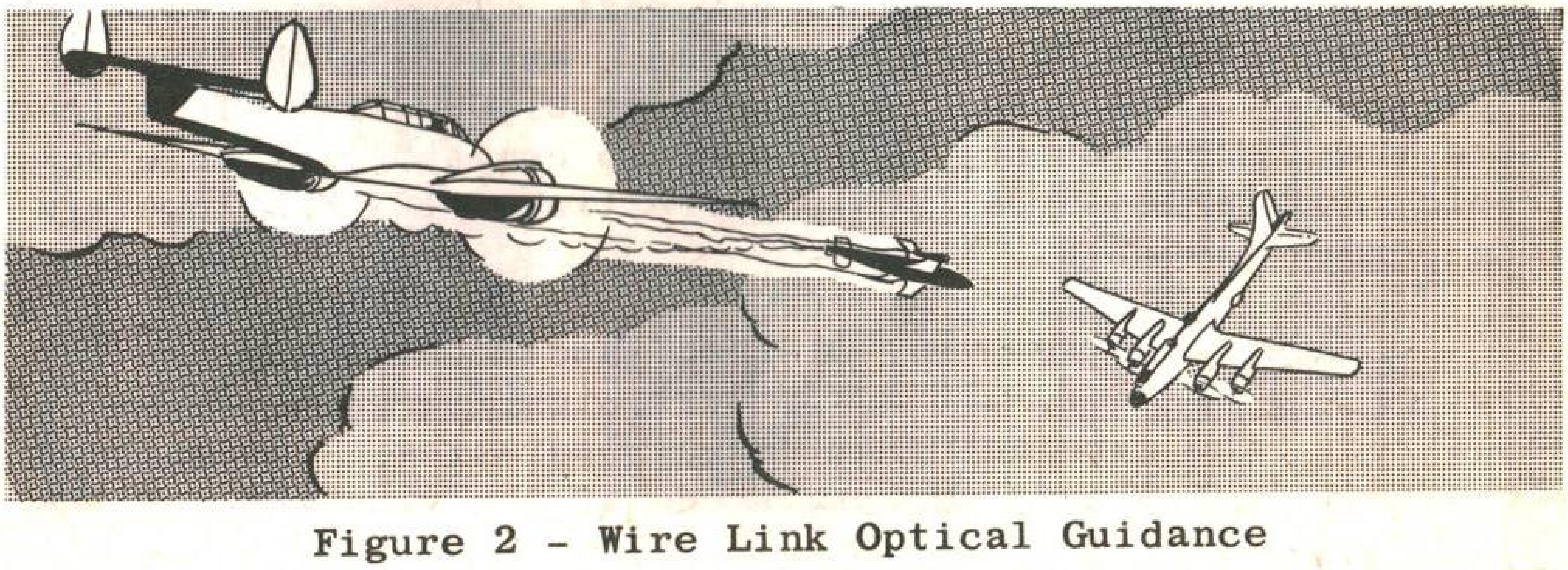


Figure 2 - Wire Link Optical Guidance

Command Guidance

When World War II closed, the Germans were testing an air-launched version of the Schmetterling missile, called the HS-117H, which was to be fired from large bomber aircraft. The missile had a horizontal range of 13,100 yards, and vertical coverage 16,000 feet above and below the launch aircraft.

Many problems exist with radio command guidance of air-to-air missiles, and the technique is not used, so far as is known, in modern missile systems. The principal problems encountered are tracking of both the target and missile, weight of components in the launch aircraft, and jamming: wire guidance is quite impractical for supersonic missiles.

Beam-Rider Guidance

The beam-rider guidance system has been discussed earlier in this series and will not be repeated. The principal limitation of the technique lies in the fact that the tracking/guiding radar beam must be pointed at the target throughout the missile's time-of-flight, which would restrict the manoeuvring of the fighter. The flight path of the launch aircraft should ensure that a minimum of lateral motion is required of the missile.

Active Homing Guidance

The three types of homing guidance are most suitable for air-to-air missiles. In the active-homing system the missile system is completely capable of an independent attack, once locked onto its target. The normal application is for the interceptor to detect and track the target, using the fire-control system, and solve the fire-control problem.

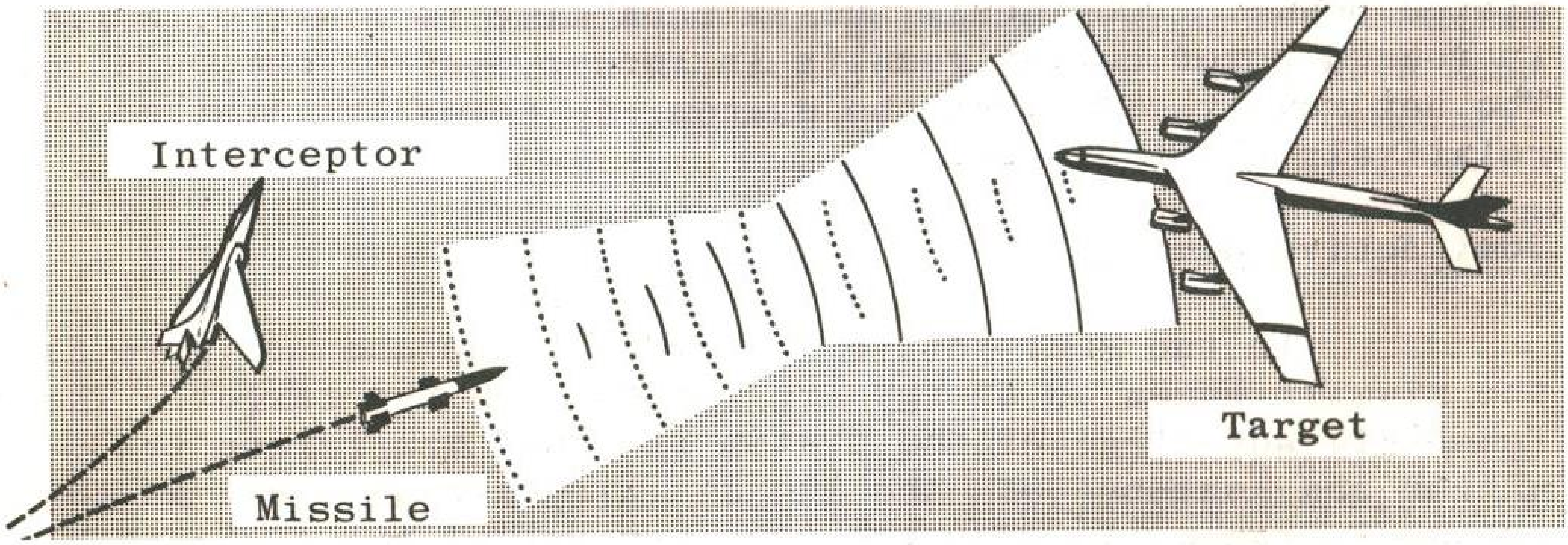


Figure 3 - Active Homing Missile

The interceptor is then flown so that the missile system seeks and locks-on to the target. After "lock-on", the missile may be launched, and the attack broken off (Figure 3).

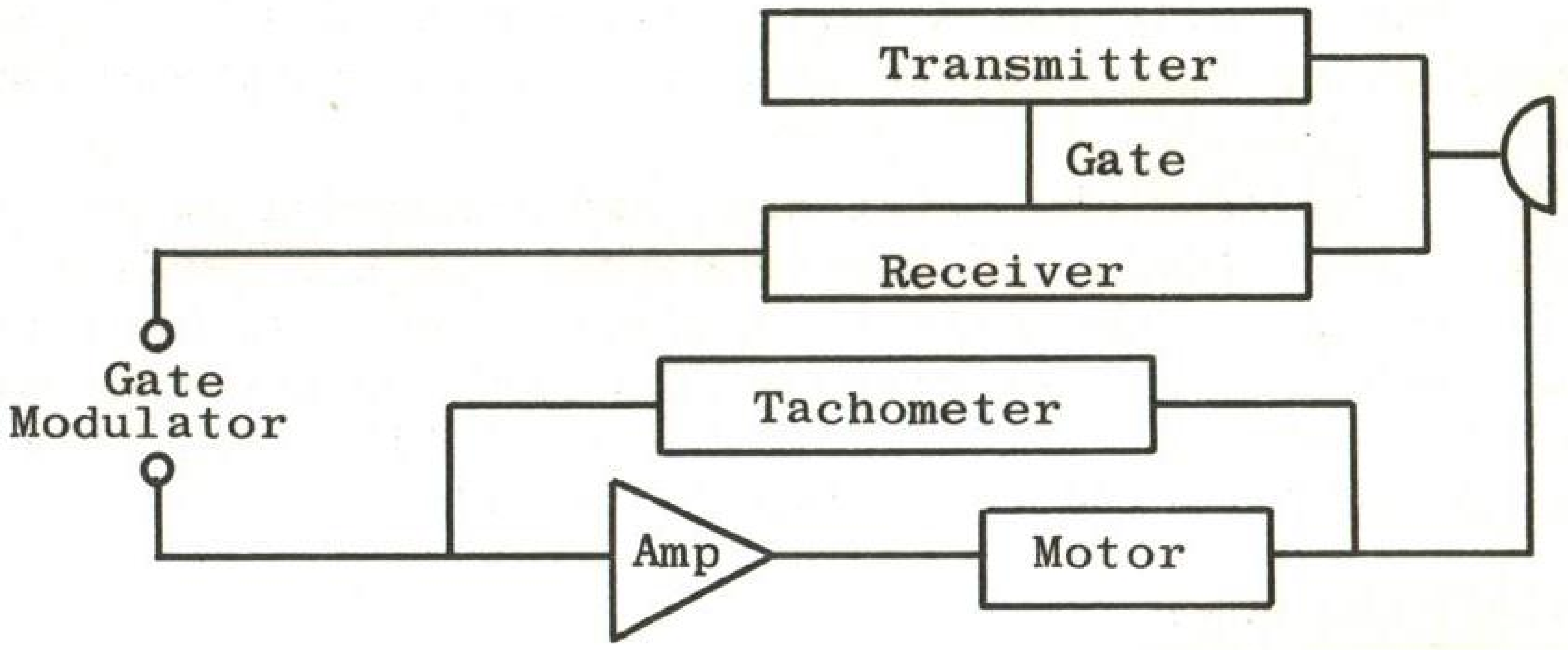


Figure 4 - Active Homing Tracking Loop

The diagram of the basic tracking loop of an active homing system is shown in Figure 4. The components are the transmitter, receiver, antenna, and antenna drive unit. To eliminate any extraneous targets the "gate" is used, which selects a target at a specific range, as instructed from the interceptor fire-control system prior to launching. The target is then maintained within the gate, and the azimuth and elevation error signals resolved.

The principal problems associated with this guidance system result from the necessity for keeping an air-launched vehicle down to manageable sizes. For example, range is a function of the area of the antenna and the transmitted power. Obviously the antenna size is limited, while increased power output results in longer, heavier components. The net result is that the system is normally limited to relatively short ranges.

Semi-Active Homing

In the semi-active guidance technique (Figure 5) the missile homes on energy reflected from the target. The immediate advantage of the system is that the larger transmitter and antenna of the launch aircraft provide an increase in range. In addition, the removal of the transmitter and its associated components from the missile results in a weight saving, and hence a smaller projectile.

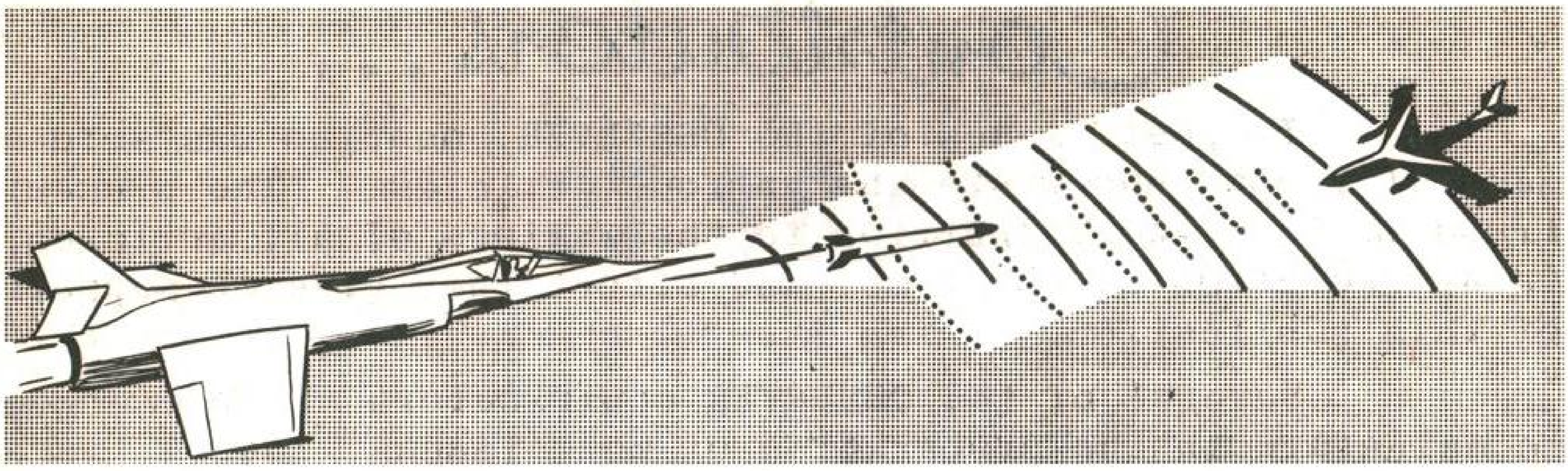


Figure 5 - Semi Active Guidance

Operation of the semi-active system before and after target acquisition is identical to that for its active counter-part, but the launch aircraft must ensure that the target is illuminated throughout the missile's flight, and again this could limit manoeuvrability.

Passive Homing

Of the three homing guidance systems, the passive technique requires the least equipment within the missile itself. The basic components of the system are the antenna or detector, the receiver, and the detector drive unit.

For example, in the infra-red or heat sensitive system,the amplitude of the received signals from four quadrants are compared to generate up/down and left/right guidance commands. If the missile is required to home on a radio frequency emission, such as from pulse-type radar, then direction finding by phase comparison would be possible.

The advantages of the passive homing technique are offset by the dependence of the guidance system on the emissions from the target. Obviously, the target must have some characteristic that distinguishes it from its surroundings. For this reason the aspect, background, and type of target, in addition to existing weather conditions,may all influence the effectiveness of the system.

Conclusion

This is the last of a series of four articles concerned with missile guidance. Of necessity, the descriptions of the various systems have been brief, but it is hoped that they have been sufficient to provide a background to this important and rapidly-developing aspect of modern weapons.

Contributors...

In past issues of the OBSERVER, mention was seldom made of those who wrote the various articles. The present trend is to give recognition to the writers of all articles, in appreciation of the time and effort they give in support of this publication.

Several of the OBSERVER contributors have emerged as mainstays in the preparation of most issues. Indeed, were it not for this reliable group of writers, the publication would have foundered many times. Future issues will introduce these staunch contributors to the readers and, it is hoped, convey some appreciation of their valuable assistance to the success of the RCAF OBSERVER.

F/L G.R. Hunn

Flight Lieutenant Graham Robert Hunn was born on December 19, 1931, in Birmingham, England.

Having moved to Canada following his education at King Edward's School in Birmingham, F/L Hunn took up residence with his parents in Toronto, where he was employed in the Canadian Bank of Commerce.

He enlisted in the RCAF in June, 1950, and received his Navigator's Wings at Summerside in June, 1951. Following completion of further training at the Operational Training Unit at Greenwood in December of the same year, he saw service with 404 (MR) Squadron there.

After serving at Summerside, in 1953 F/L Hunn was posted to the Central Navigation School at Winnipeg on the Specialist Navigation course. He was later employed on staff duties at that unit until June, 1956, when he took the Airborne Interception course at 2 Air Observer School.

Graduating at the top of his course at 3 AW(F) OTU in March of this year, F/L Hunn was transferred to 410 AW(F) Squadron in Ottawa where he now makes his home.

F/L Hunn has written more articles for the RCAF OBSERVER than any other contributor. This issue contains the last in a series of four articles by F/L Hunn, outlining missile guidance systems. Undoubtedly, more articles bearing his name will appear in the OBSERVER. That they will always be interesting and informative has been a foregone conclusion for some time.

37 SONI

8 Sep 59 - 18 Dec 59

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S/L HV Firneisz


F/L GE Conway-Brown


Capt ER Therkelsen


F/L PP Richardson


F/L HA Spikings


F/L GE Petzold


F/L CF Johns

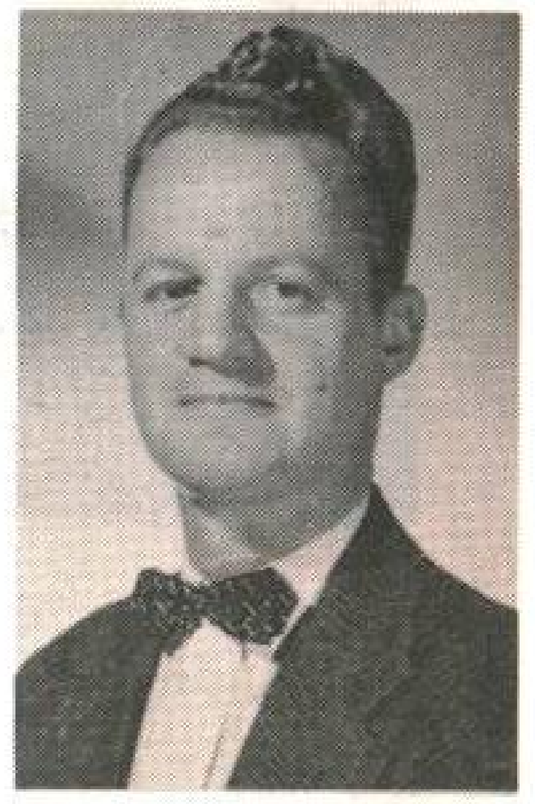

F/L WD Lyall


F/L JW Rodger


F/L RL Adamyk


F/L GW Patrick


F/O A McLellan


Mr. LC Oddy

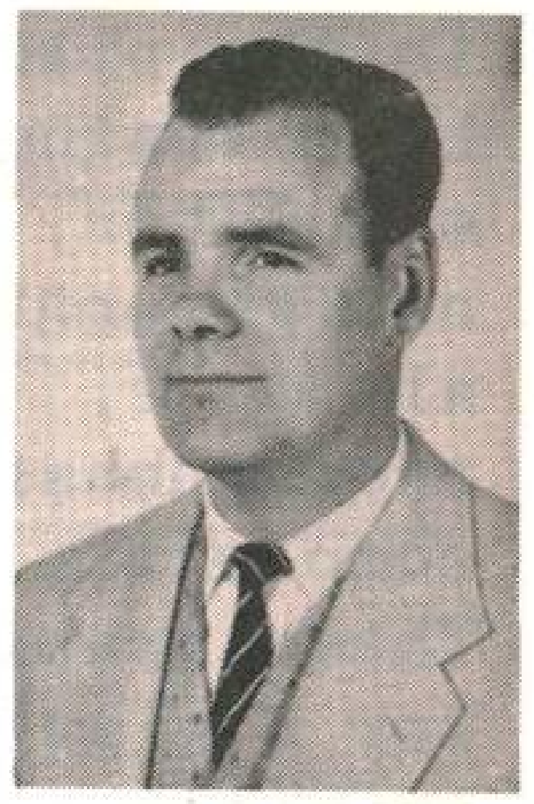

F/L LJ Rushcall


F/L CH Nason


F/O DK Schneider


F/O RJ Pearce


F/O JL Lefrancois

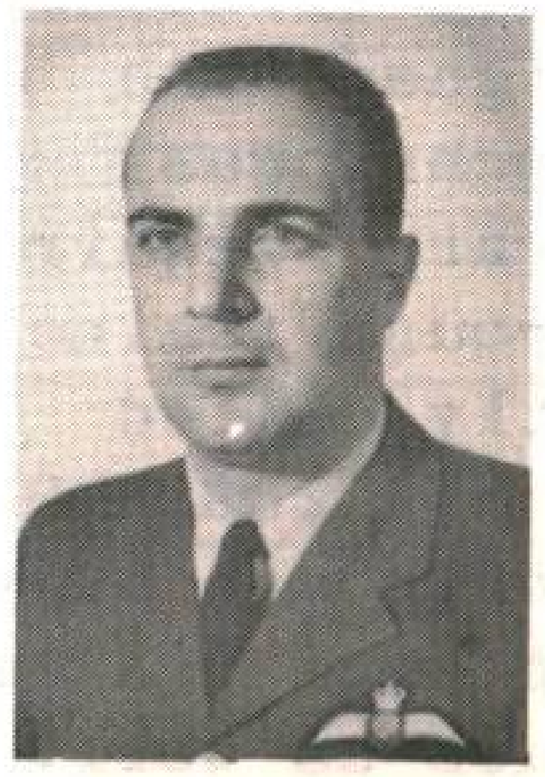

Mr. JT McBain


F/L KP LaRush


F/L HH Enns


F/L WA Gryba


F/L MS Slezak


F/O DJ Mulligan


F/O GH Montford

DR application trainer

INTRODUCTION

Over the past 50 years, many attempts have been made to simulate the aviator's problems in a ground trainer. In the pilot's field this goal has been achieved with the Link Trainer and its more modern counterparts. No flight simulator, however, had been designed for fully flexible navigator training. The great increase in aircraft speeds, altitude, and endurance in the past decade, together with the emphasis on cruise-control in jets, has led to greater complexity in many navigation procedures and techniques. These problems are so diverse that no one aircraft designed for navigation training can cope either practically or economically with the many conditions met today.

What, then, could be more suitable than a ground trainer designed with enough flexibility to simulate all navigation techniques? S/L G.C. Peek of the RCAF, considering contemporary requirements, has designed a very compact navigation ground trainer embodying great versatility. This trainer, aptly called the Deduced Reckoning Trainer, has been in use at 2 Air Observer School since 1957 and has proven its worth not only as an advanced and basic navigation trainer, but as a trainer for high-speed Airborne Interception techniques as well.

The DR Trainer, when coupled with the B-3 Drift Trainer, Radio Compass Trainer, Loran Trainer, Pressure Pattern Trainer, and Astro Trainer (all locally improvised) gives an added flexibility allowing any complex problem to be given the student, at a fraction of the cost of an air exercise required to present the same navigation problems.

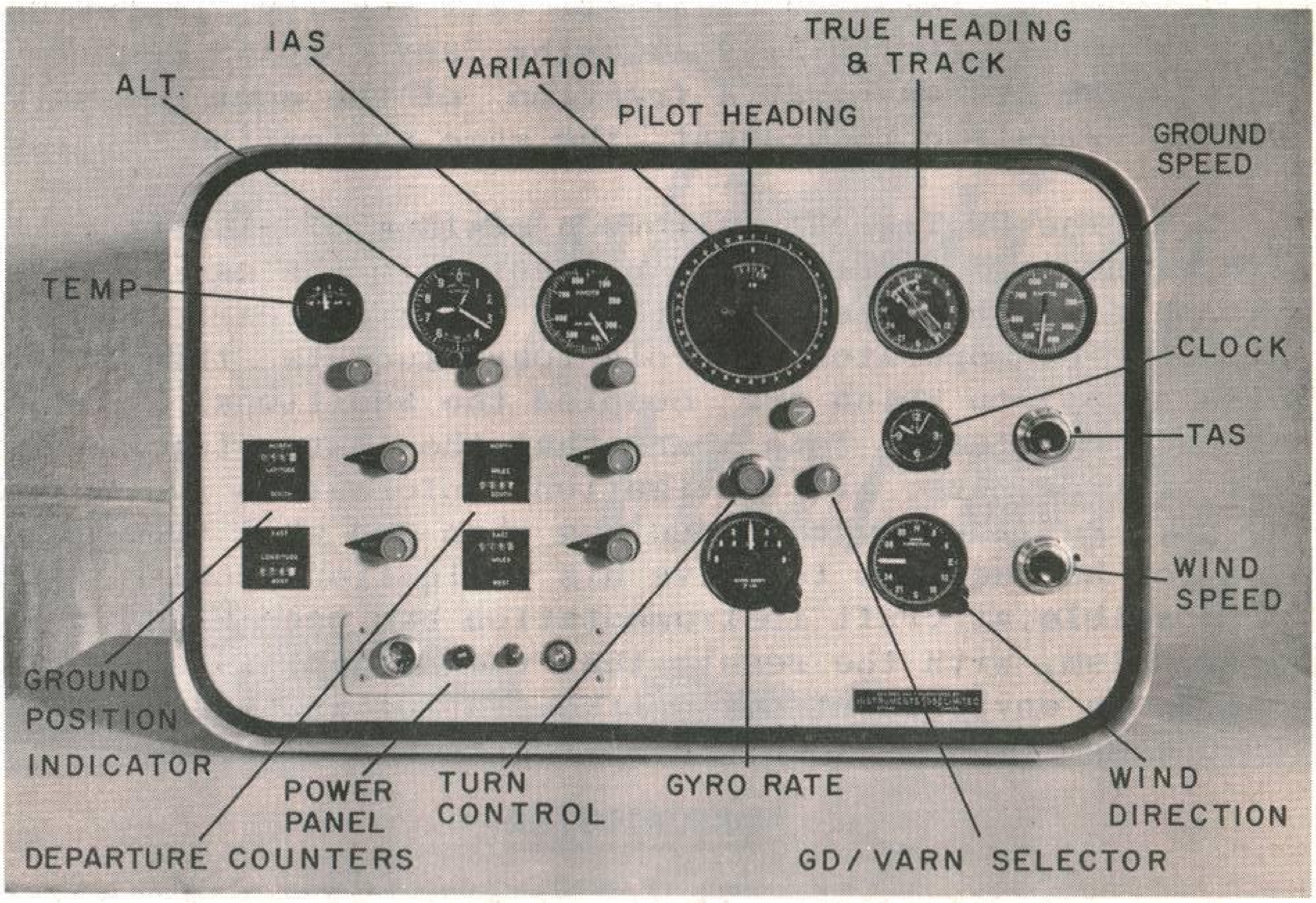
The DR Trainer allows a maximum of student initiative, since all problems are presented in the same time relationship as they are encountered in an air exercise. One instructor or operator controls four students through four DR Trainers, to which are coupled the additional trainers mentioned earlier. This means that the instructor has complete control over all navigation information fed to the student, yet the student decides when and what type of information he requires to solve his navigation problem. Wherever possible, aircraft instrumentation has been used to provide realism, with the result that the student is considered to be in an environment not unlike that of an aircraft navigation compartment, except for turbulence and noise.

DESCRIPTION

The Operational limits, tolerances, and power requirements for the DR Trainer are:

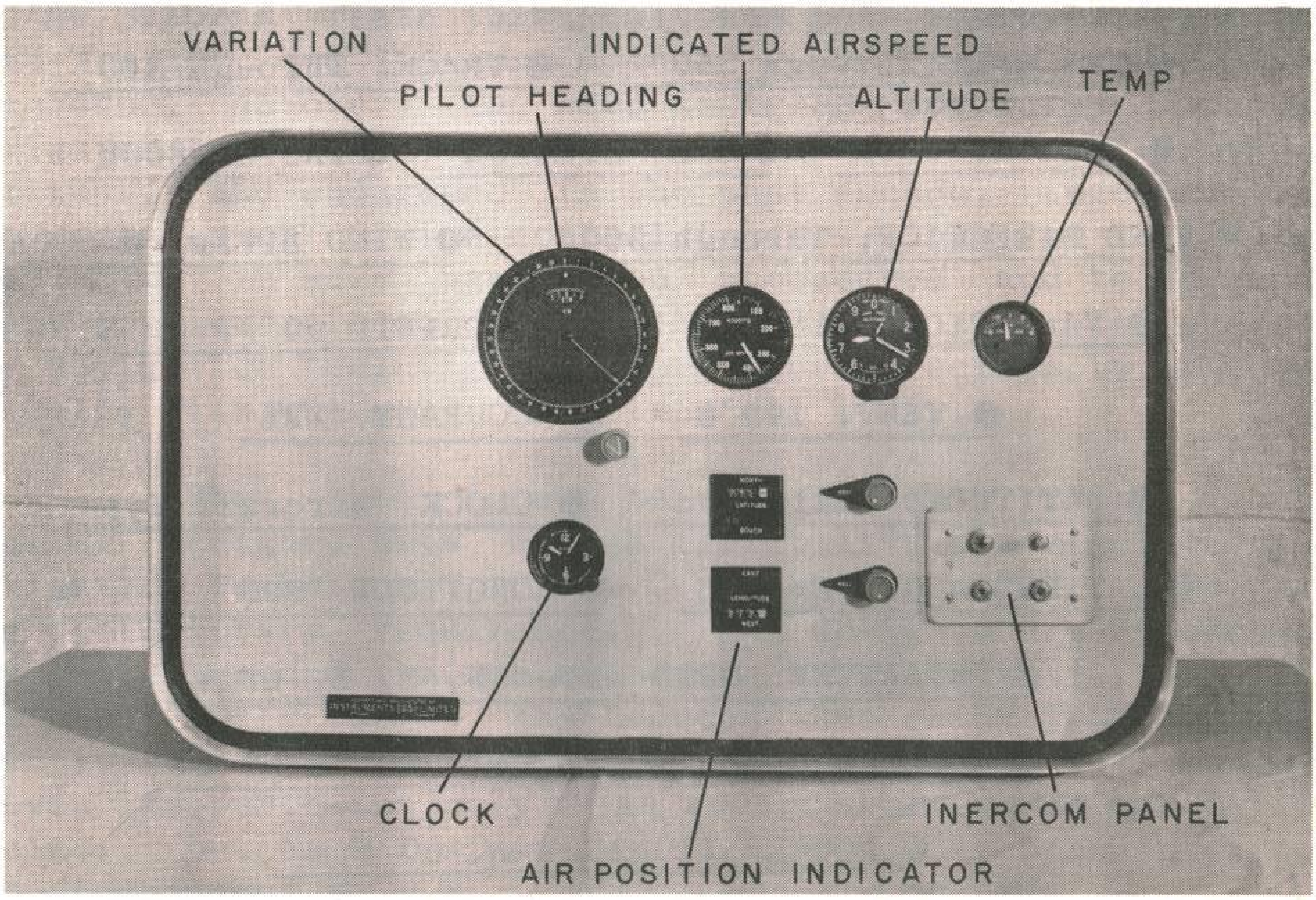
- HEADING: Through 360°
- TRACK: Through 360°
- TAS: 80-600K
- G/S: 80-800K
- IAS: 0-800K
- WIND DIRECTION: Through 360°
- WIND SPEED: 0-200K
- VARIATION: ±180°
- GYRO DRIFT: 90° P or S
- TEMP: ±45°C
- ACCURACY: ±2%
- ALTITUDE: Unlimited
- CLOCK: Aircraft Type
- LATITUDE: 999°N or S
- LONGITUDE: 999° E or W
- DEPARTURE: 9999 Miles N, S, E, or W
- MAXIMUM OPERATIONAL LAT: 80° N or S
- POWER: 110-120V AC 60 cps
- WEIGHT: 144 Lbs
- SIZE: 31" x 20" x 15"

OPERATOR'S PANEL



(FIG. I.)

STUDENT'S PANEL



(FIG. 2)

The DR Trainer is essentially an analogue computer with one programme. The initial input information consists of: True Airspeed (TAS), Pilot Heading, Magnetic Variation or Gyro Drift, and Wind Speed and Direction (W/V). The initial Ground and Air Positions, set on the GPI, API, and Departure Counters, can also be considered as input information.

The output data is in the form of continuous Ground and Air Positions. In addition, there are a number of computed values visible only to the machine operator. These are: True Heading, True Track, Groundspeed, Drift, and Deflection due to gyro precession. Of the above values, only Pilot Heading, Air Position, IAS, Temperature, and Altitude are continuously visible to the student, while all other values are available either through deduction or from the associated trainers. Figures 1 and 2 show the disposition and method of presentation of data on the operator's and student's side of the machine.

OPERATION

To simplify the illustration of data flow within the trainer, Figure 3 shows the various components grouped according to their use. All data transfers or connections in the trainer are completely mechanical, consisting of solid or flexible shafting and gears. A number of universals, differentials, mechanical clutches, irreversible links, resolvers, and specialized friction brakes are incorporated, but only a few of these are illustrated as examples. In the case of the GPI, there are 32 matings or passes between the motor and the final output. This example shows the need for fine-tolerance machining and careful calibration of the various components during manufacture.

Grid Quiz

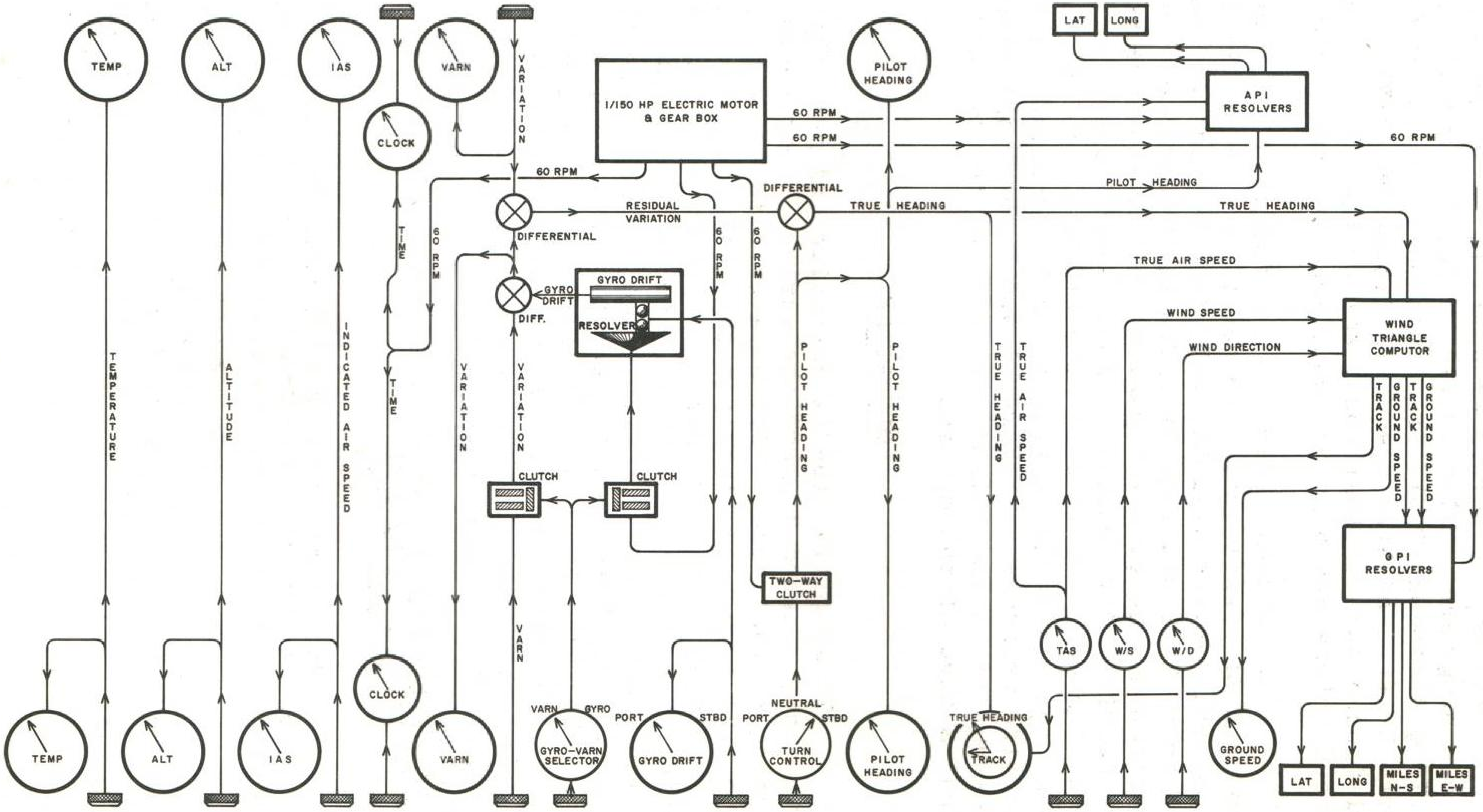
When using a Polar Stereographic chart or a curved grid Lambert Conformal, with Greenwich as the reference meridian, the formula for determining Grid Heading is:

$$GH = TH \begin{array}{l} + \text{ West Long} \\ - \text{ East Long} \end{array}$$

This formula applies to the northern hemisphere. Would it be correct for similar charts of the south polar regions?

DR APPLICATION TRAINER (SCHEMATIC)

STUDENT'S SIDE



NOTE: ALL LINKAGE AND TRANSMISSION SYSTEMS IN THIS TRAINER ARE MECHANICAL. WHERE FEASABLE THIS SCHEMATIC IS ALSO DIAGRAMMATIC.

OPERATOR'S SIDE

FIGURE 3

From the operator's side (Figure 3), it can be seen that when Temperature, Altitude, and IAS are set by the operator, a direct drive gives the same readings on identical instruments on the student's side of the machine. It is also apparent that settings on these three instruments will have no effect on the remainder of the trainer. They are provided to give realism to an exercise, and to allow a student to calculate his TAS and True Altitude from readings set by the operator.

As shown, the clocks are independently resettable yet obtain their torque from the trainer motor. This means that they will remain synchronized once they are set. The time ratio is 1:1, in that 1 hour of Civil time equals 1 hour of trainer time. This feature allows the machine to be stopped and restarted at any time during an exercise, without disturbing the time relationship of either the clocks or the problem set into the trainer.

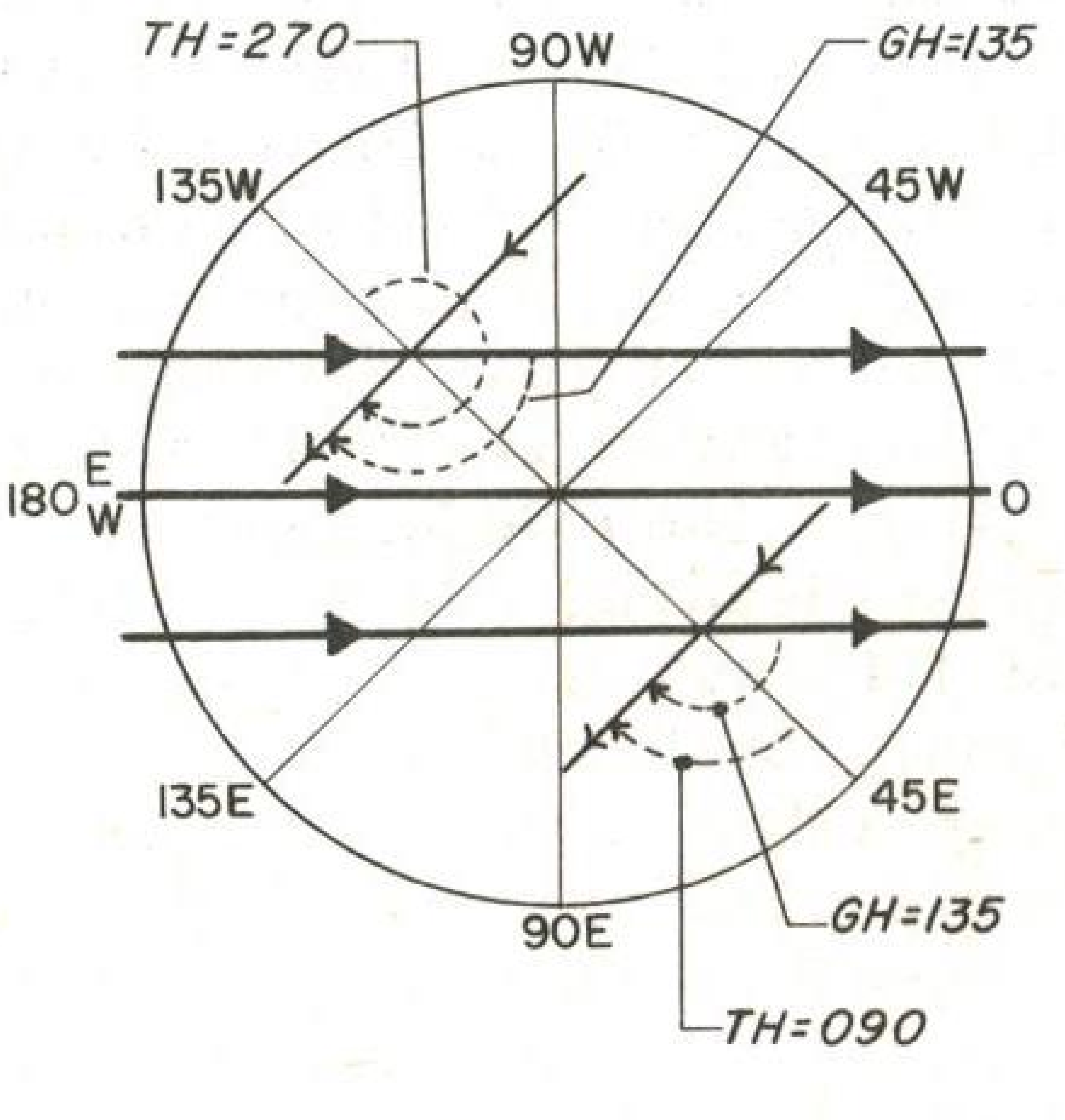
The heading group which consists of Pilot Heading, Variation, Gyro Drift, True Heading, and True Track has been broken down in Figure 3 into separate indicators for ease of illustrating information flow. From Figures 1 and 2, it can be seen that Pilot Heading and Variation are actually on the same indicator, displayed exactly as they are in an aircraft-installed, CL-2 Master Indicator. Depending on the exercise, the operator selects either Gyro Drift or Variation, using the 2-way selector just to the lower left of the clock. If he selects Variation, then variation may be set into both sides of the trainer. If he selects Gyro, a rate-controlled gyro is clutched in and feeds an error to the heading system, dependent on the rate and direction (P or S) selected by the operator. When the operator sets Variation into the trainer, he is actually introducing an error which is corrected only if the student alters heading or sets his own Variation to the same value. If the student's variation is at 0° and the operator has set on local variation, then dependent on the exercise, the CL-2 will read Compass Heading and the combined TH and TTr indicator will read TRUE values. If the student sets in the correct variation, both the CL-2 and the combined TH-TTr indicator will read TRUE values. Close inspection of the heading group in Figure 3 will show how this variation/gyro system operates. The Turn Control alters the Pilot Heading (consequently TH, TTr, and the azimuth to the various resolvers) at 3°/sec P or S, while internal computers automatically change all values which are affected by a heading change. From the heading group, TH is fed to the

Wind Triangle Computer for processing, while Pilot Heading is fed to the student's API (Figure 3). It can be seen that if the student has not set correct variation on his side of the trainer, his API will be fed something other than TH. Since student variation and operator variation are combined through a differential, this error will be carried on to the Wind Triangle Computer, eventually affecting the GPI. This situation in the DR trainer corresponds exactly to the phenomena that would be experienced in an air exercise if variation is incorrectly set on the VSC of the compass system.

The Wind Triangle Computer receives its information from a setting group consisting of three dials and knobs (Figure 1 - lower right corner). These settings of TAS, Wind Speed, and Wind Direction are made by the operator and not disclosed to the student. The fourth value, TH, completes the input required by the computer to give the desired output. The outputs of Track and Groundspeed are delivered to the GPI resolvers, which convert these values into Latitude and Longitude as well as Departure. The True Track is also fed to the combined TH-TTr indicator. A visual comparison of the TH and TTr pointers on this indicator will give the operator an immediate Drift reading. The Wind Triangle Computer also delivers G/S to the G/S indicator, so that the operator may take direct readings.

grid quiz (cont'd from p.169)

No!



Consider the diagram: the direction of Grid North continues around the earth, so that on the chart of the southern polar regions the direction of GN appears to be reversed. Also, the longitudes appear as the reverse of those on a north polar chart. Inspection of the heading examples will show that:

$$GH = TH \begin{array}{l} - \text{West Long} \\ + \text{East Long} \end{array}$$

Thus in the formula the application of longitude is reversed in the southern hemisphere!

The student's API resolves Pilot Heading and TAS from the operator's TAS setting, and displays the student's air position in Latitude and Longitude.

All position indicators are readily reset by depressing and turning the knobs adjacent to each set of counters.

The intercom system is similar to those used in aircraft, with both the operator and the student using standard microphones and head-sets. The operator has a five-position intercom unit, allowing him to operate four trainers and to converse with four students individually or collectively. A two-way aural and visual "call" system is also incorporated.

The Trainer power supply is controlled by the operator with a toggle switch on each trainer. The intercom power and volume is controlled by switches on the intercom selector box.

APPLICATION

In a typical trainer exercise at 2 AOS, 16 DR Trainers are used in banks of 4. One or two instructors are assigned to each bank, depending on whether the exercise being run involves enough astro work to warrant two operators. This arrangement means that only four to eight instructors are required for each four-hour exercise for 16 students. Since these exercises accomplish nearly the same aim as an air exercise,the economy in aircraft and man hours proves to be most attractive. Figure 4 shows a general view of part of the trainer room at 2 AOS.

Basic students receive four of these exercises in ascending order of difficulty, programmed so that a trainer exercise is given one or two days before each assessed air exercise. This arrangement brings to light any faults in procedure a student might commit,and gives him time to study so as to improve these procedures before putting them to use in the air.

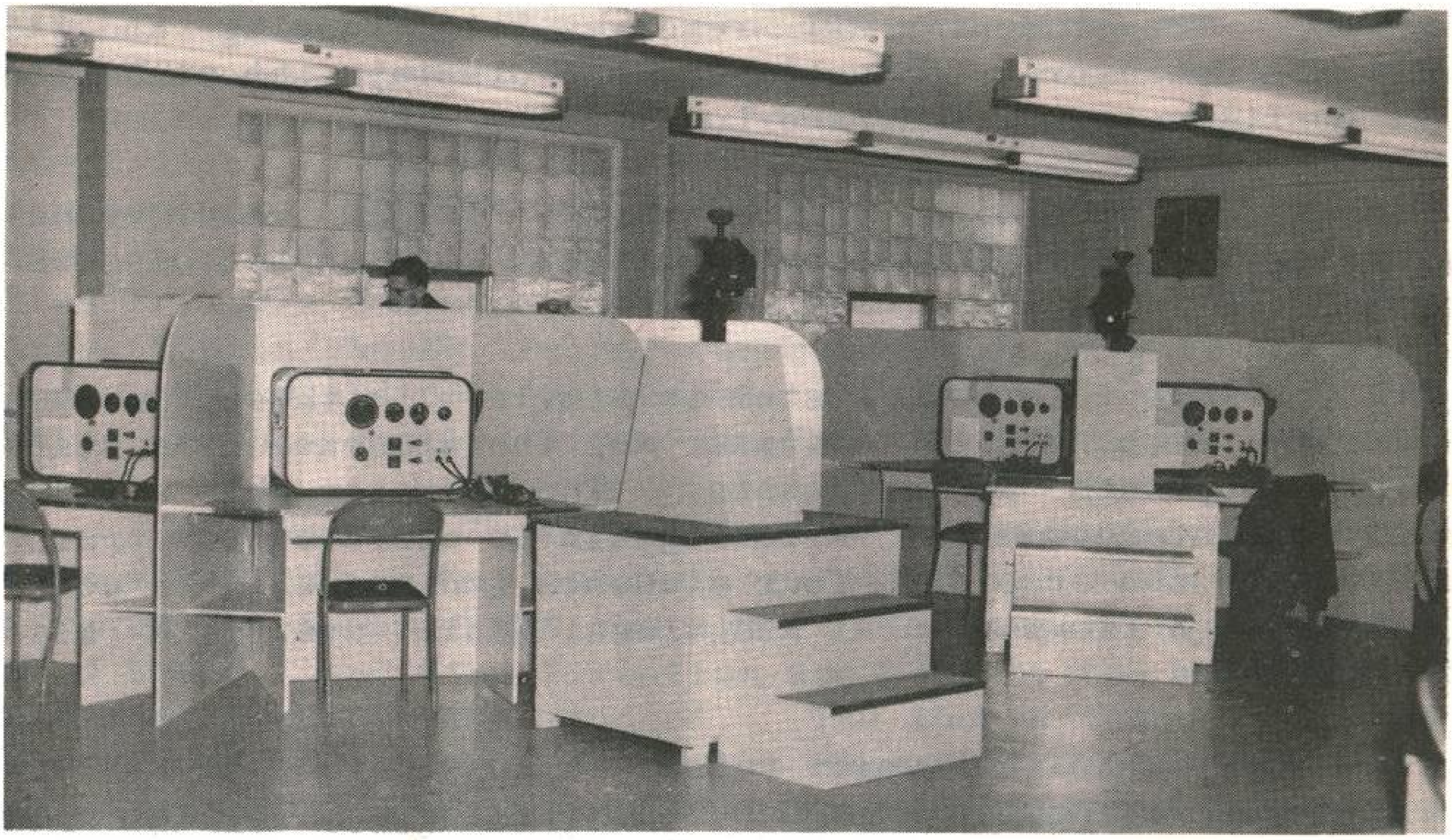


Figure 4 - DR Trainers at 2 AOS

Applied Long Range Navigation students carry out an additional 11 trips on the trainers, with each exercise presenting a different technique or set of procedures. Some examples of advanced exercises are the Night Astro, Pressure Pattern, Tactical, Grid Gyro and Limited Aids exercises. These exercises are carried out and assessed just before the air trip, demonstrating the same techniques to be employed in the air.

To illustrate how a trainer exercise is organized and carried out, a sample briefing for exercise number 110 is shown as appendices A and B. Appendix A is given the student, and he is allowed 50 minutes to draw up a flight plan and make general preparations for the trip. Besides the general trainer rules posted on each machine, appendix A is all the student needs to arrive at his trainer fully prepared for the exercise.

Appendix B contains the special instructions required by the operator to prepare the trainers for the student. To facilitate speed in plotting and the use of a radio bearing plotter, the operator's charts are covered with acetate,which also allows him to make entries in grease pencil, thus conserving charts. He is supplied with one of these charts per student, so that a separate plot may be kept for each.

The average exercise duration of three hours, combined with quick trainer turn-around, allows the easy completion of 32 exercises per working day. It takes an experienced operator approximately six minutes to set up a bank of four machines.

The assessment of trainer trips is given the same attention as an air exercise,using the same proformas, marking techniques, and nearly the same mark breakdown. Marking these trips, however, becomes an easy task for the assessor with experience, because of his knowledge of the routes and conditions of the exercise. The total time required on the syllabus for each exercise is five hours, including the preparation, assessment or analyzing time.

Figure 5 shows an operator's position with three of the four trainers visible, along with (left to right) the Radio Compass Trainer Monitor, B-3 Drift Trainer Control,and Intercom Control Unit. As shown, the operator is supplied with a standard headset and an "open" boom-microphone,allowing him full use of both hands for trainer manipulation while conversing with any of the four students. The console design gives the operator instant access to all trainers, both primary and auxiliary, as well as ample table space for charts and equipment. In addition, this design provides compactness and isolation of information(such as W/Vs) which might compromise an exercise.

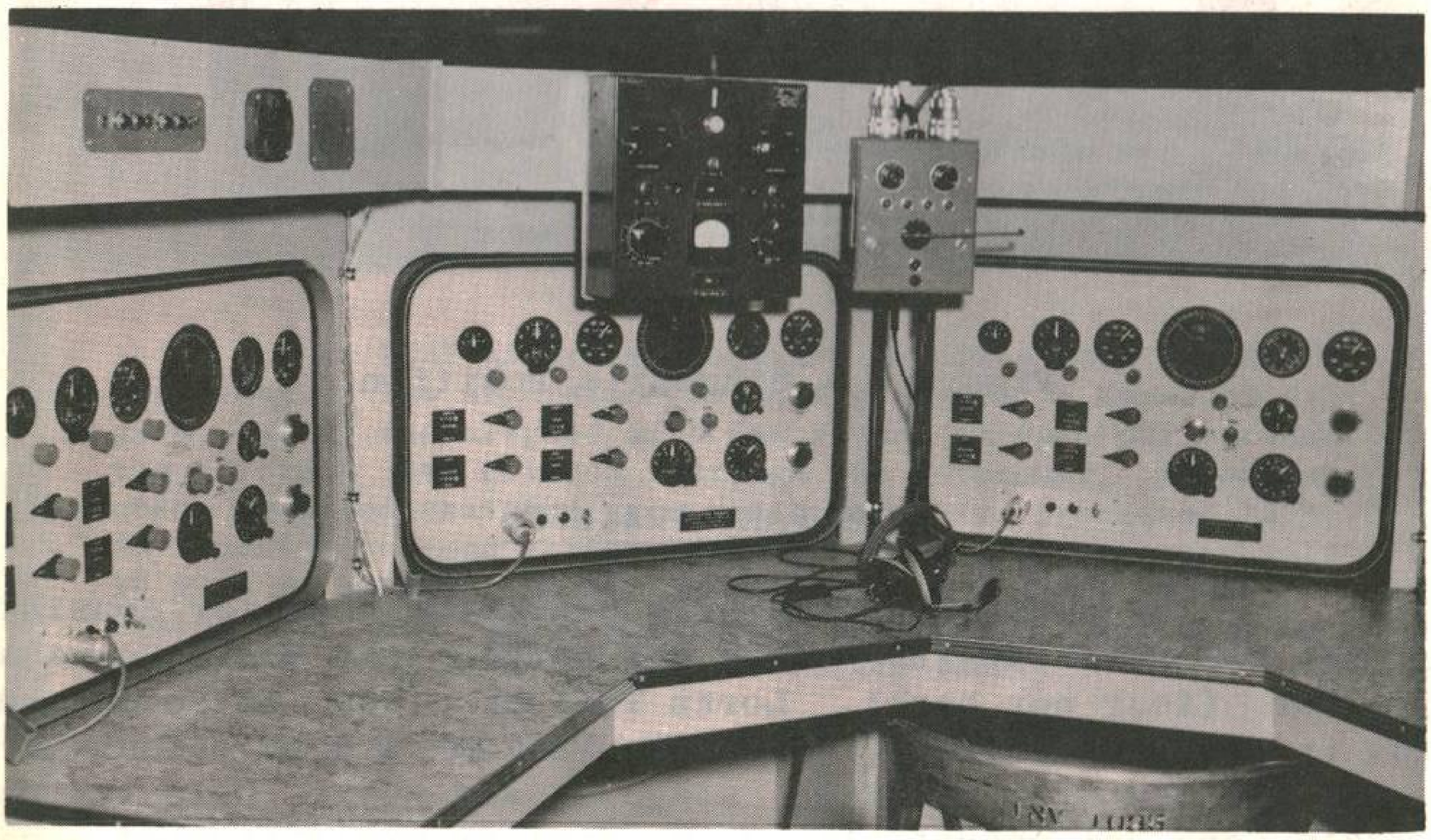


Figure 5 - Operator's Position

Figure 6 portrays one of the four student positions in each bank. In addition to the DR Trainer, the student's Radio Compass Control box and repeater, aircraft-type intercom jack-box, a Quadrantal Correction card, Compass Deviation card, and general trainer instructions are shown. The student is isolated from his companions, and has intercom connection only with the operator. In the upper right corner of the trainer a one-way chute for passing message chits to the operator is provided. All information requested by the student is done so by chit, while the operator returns required data either by intercom or by setting it on an auxiliary trainer for the student to obtain by observation or manipulation.

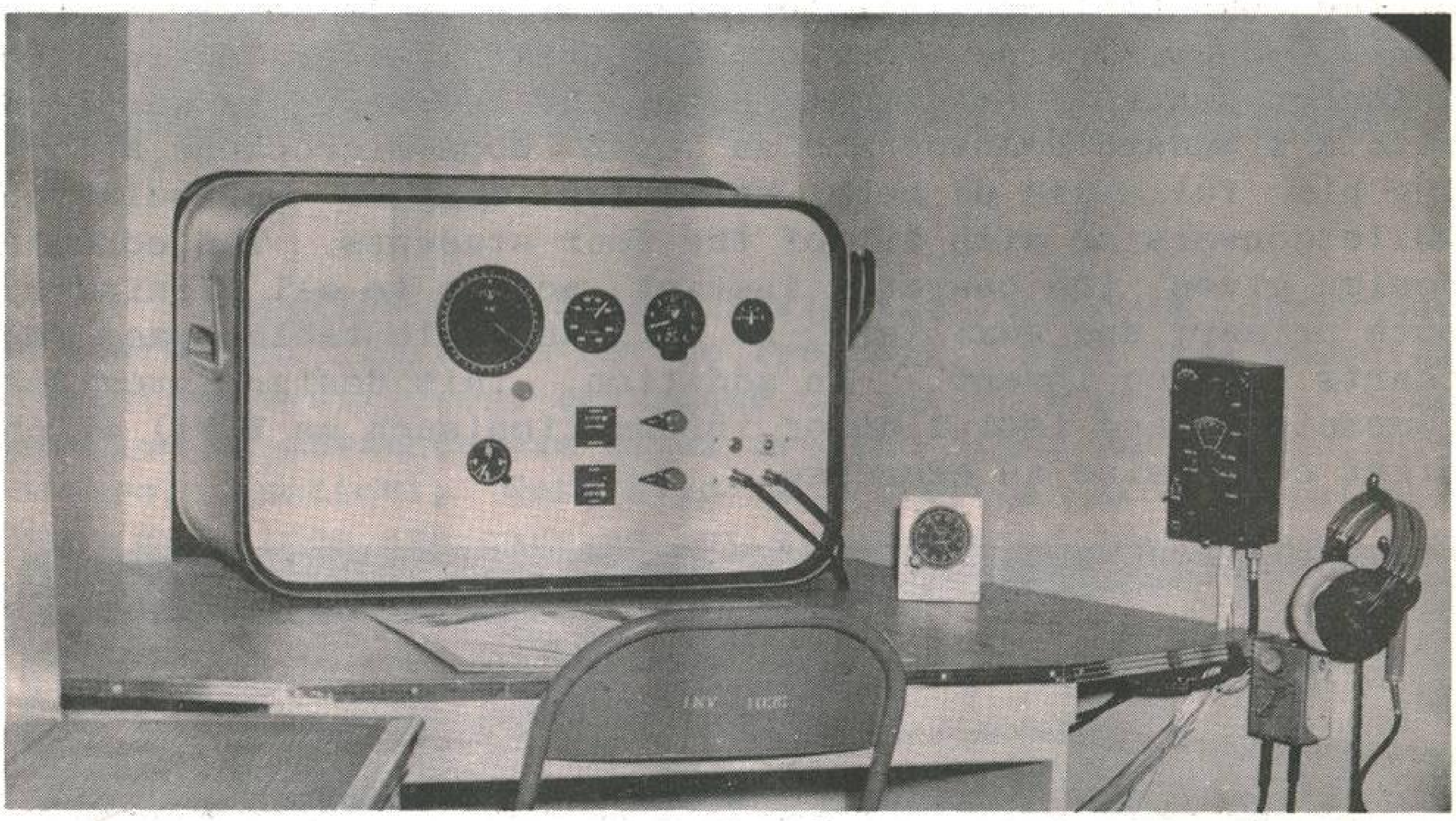


Figure 6 - Student's Position

AUXILIARY TRAINERS

The auxiliary trainers mentioned earlier consist of the B-3 Drift Trainer (one per bank), the Radio Compass Trainer (four per bank), Loran Trainer (four per bank and now in prototype stage), Pressure Pattern Trainer (four per bank and now in prototype stage), and Astro Calculation Curves (one per operator). These devices are described more fully in the following paragraphs.

B-3 Drift Trainer

The B-3 Drift Trainer is a modified version of the older Mk II Drift Trainers. These consist of a rotatable table, upon which is mounted two spools containing a tape of coloured ground panorama. The table device is enclosed below a B-3 driftmeter, which has been modified so that only the tape appears in the field of view. The drift is varied by rotating the table, and the G/S by varying the speed of the tape across the spools. The settings of Drift and G/S are made on a control box located at the operator's position (Figure 5).

Radio Compass Trainer

The Radio Compass Trainer is a locally-designed system composed mainly of control units and indicators. Each student position is equipped with an indicator, and a control unit on which the LOOP and COMPASS control positions have been deactivated. The operator has two control units, each of which can be selected to control one or two student installations. A sense antenna enables the student to tune to local broadcast stations, a radio range station, and several beacons which have been given call signs corresponding to actual radio aids along the student's track. When a student has correctly tuned to a station, the operator uses the LOOP control to set the correct bearing on the indicator. The bearing is determined by the operator from the GPI position in relation to the chart position of the radio aid.

ANOTHER CHECK

An RCAF aircraft departed Resolute Bay bound for Mould Bay. The aircraft was equipped with a Kearfott N-1 gyro, which was aligned with the runway on take-off. When the aircraft had climbed through the overcast, a heading check revealed that the gyro had apparently precessed 12°S. An immediate second check produced a value of approximately 10°P. An examination of the periscopic sextant mount revealed that the rubber shock-seal had failed, allowing the entire inner azimuth assembly to rotate freely.

WATCH FOR FAILURE OF THIS SEAL IN PRE-FLIGHT CHECKS

Loran Trainer

The Loran Trainer, which will be used on advanced exercises, will provide each student with an actual indicator. The student's set will be a repeater of the operator's master indicator, upon which the operator will be able to set any desired reading. The reading will be obtained by plotting the GPI position on a standard Loran chart. As far as the student is concerned, the operation will be exactly as it is in an aircraft. The APN-4 Loran set will be used until the APN-70 becomes available.

Pressure Pattern Trainer

The Pressure Pattern Trainer is simply a mock-up of a Radar Altimeter, visible to both the student and the operator. It is used in conjunction with the trainer pressure altimeter to obtain "d" factors. The operator sets on a radar altitude which will give the student a pressure pattern position line falling through the GPI position.

Astro Calculation Curves

Obviously, it would be impossible for one operator to calculate observed altitudes for four students during an astro exercise, if the normal method of sight reduction were used. To improve the speed of such calculations, sets of curves were developed, one for the sun, and another for preselected stars. In both cases, the GPI position is used to determine the exact LHA and Latitude. With these arguments, the operator enters the curves and extracts the observed altitude directly, so that he must apply only sextant correction, dome refraction, and atmospheric refraction in reverse before passing the reading to the student. With additional tables of GHAs for the sun and stars, an experienced operator can determine an observed altitude is less than half a minute. The student, on the other hand, must perform exactly the same calculations and apply the same corrections as he would in an air exercise, except that he does not actually use a sextant.

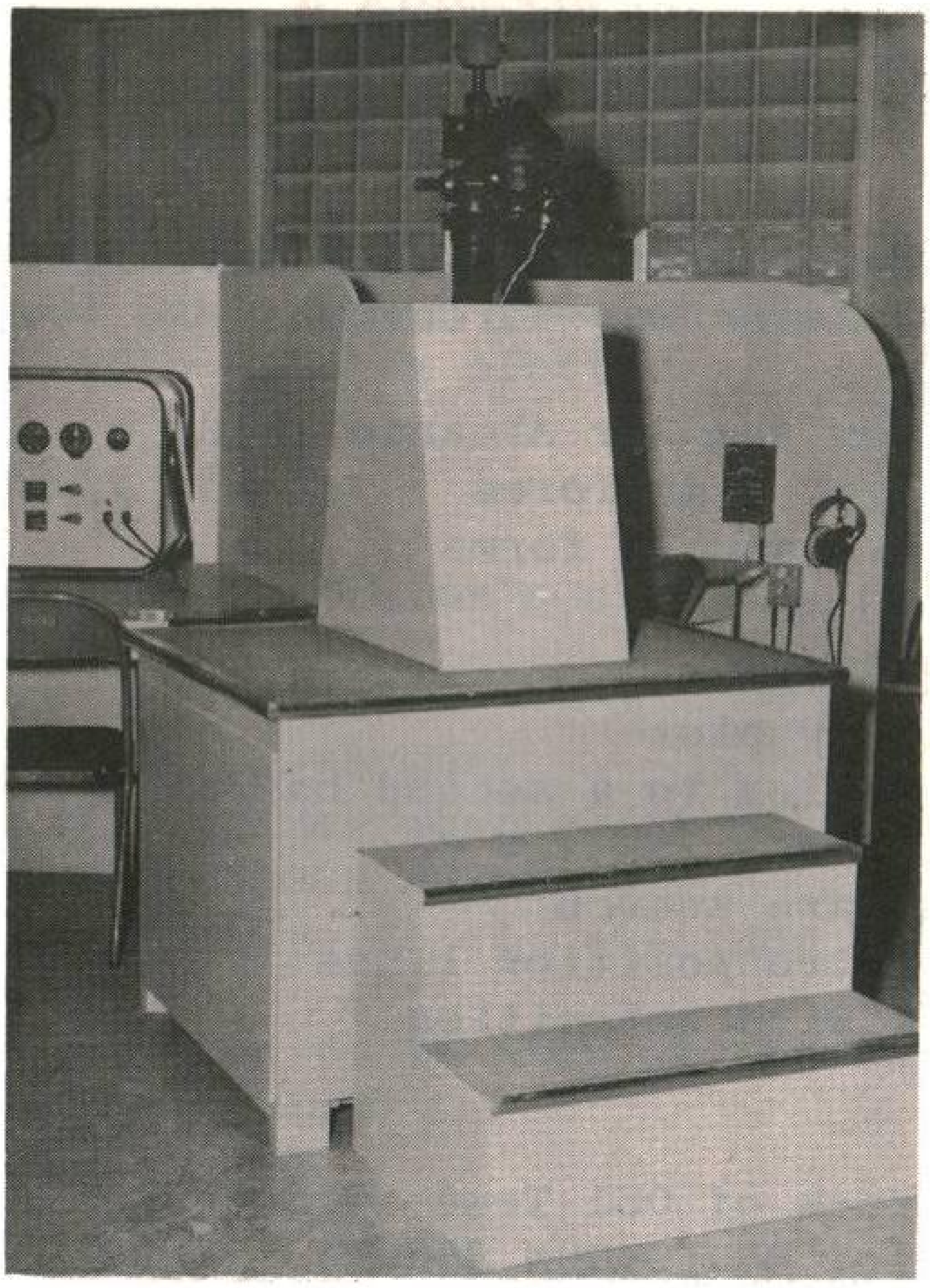


Figure 7 - Drift Trainer

Conclusion

From the foregoing description, it can be seen that the RCAF has obtained an easily-operated navigation simulator capable of presenting any navigation problem, requiring all the techniques in use today. The DR Application Trainer has proven itself compatible with the use of a large variety of auxiliary trainers, such as those used at 2 AOS. Its compactness and ready transportability, along with its many other advantages as a trainer, make it a desirable asset to any navigation training establishment.

In the 20 months these trainers have been employed by 2 AOS, they have proven themselves capable of better preparing both Basic and Applied students for their air exercises. They allow the student to complete an air exercise with more confidence and determination than ever before, armed with the knowledge that his techniques have been perfected on the ground. The trainer value, as mentioned earlier, can be directly reckoned in dollars, man and aircraft hours saved, as well as in a general improvement in student air marks.

APPENDIX A

DR TRAINER EXERCISE 110 STUDENT INSTRUCTIONS

Equipment

Computor, Protractor, Dividers, Straight Edge
1:1,000,000 James Bay Mercator
AP 3270 Vol 3
Extracts from the Air Almanac 1958
Log and flight plan forms
Message chits and PX forms

Navigation Techniques

Mechanical air plot
Radius of Action to a second base and revision
Interception
Relative square search
Radio and astro position lines
Multi-drift wind velocities

Route

Patrol a track of 081 True from base "A" (5300N 8630W) returning to "B" (5400N 8500W), three hours after setting heading from base.

General

Squadron - 2 AOS
Aircraft - Dakota DRT #__
Captain - Instructor
Date - 26 Jun 58
ETD - 1700Z (Set clocks to 1700)
Watch correct at 1600, rate zero

Met Information

1/180/30/+5
3/180/35/+3
5/160/40/+1

Requirements

20 points per hour, all aids except visual position lines, pinpoints or radar fixes.

Instructions

Do a complete flight plan and pre-flight plan of the Radius of Action. Set heading over base at 1700 at an altitude of 1000 feet at an RAS of 145. Cruise at 1000 feet at 145K.

Carry a mechanical air plot.

Radio Stations

ZM - 5400N 8500W
AW - 5256½N 8223½W
FG - 5349½N 7902W

APPENDIX B

OPERATOR'S INSTRUCTIONS

1 Lay out master charts, grease pencils, sun graphs (4800N-5500N), GHA Sun tables (26 Jun 58), astro correction card, and radio bearing plotter.

2 Test B3 Drift trainer.

3 Set up trainers (operator's side) as follows:

(a) switch on
(b) alter heading to 094
(c) shut off trainer when clock second hand is at "O"
(d) set GPI to 5300N 8630W
(e) set temperature to +5, altitude 1000 feet, RAS to 145
(f) set variation to 7W plus any deviation
(g) set clock to 1700
(h) set TAS at 145
(j) set W/V 220/20

4 Start trainers when individual students are ready and alter heading to the desired heading.

5 Change variation at every isogonal.

6 Pass the following Message from Base at 1800:

> MFB #1 - "Intercept a ship whose position at 1700 was 5140N 8000W, Track 344, Speed 24 Knots. If you do not see the ship on ETI carry out a relative square search using a visibility of five miles".

7 Tell student on ETI that the ship is not visible.

8 On the third leg of the search tell the student that he is over the ship and is to divert immediately to Fort George Radio. Pass student radar fix at this time.

9 Change W/V at ship to 315/40.

23 SORI

8 Sep 59 - 18 Dec 59

Back Row

F/O HL Turner F/O J Gridley F/O D Robinson
F/O J Barr F/O FF Herring

Front Row

F/O J Britney F/L LJ Rushcall (Course Director)
F/L VL Jarvis F/O AG Gosselin

4 SO(AI)I

8 Sep 59 - 18 Dec 59

Back Row

F/O DA Granoski, F/O FM Marsh, F/L GW Patrick(Course Director)
F/O BC MacDonald   F/L GA Cragg

Front Row

F/O DA Findlay   F/O WR Jackson   F/O T Sakamoto

Letters to the Editor

Dear Sir:

I was most interested in the article "RΘ in Jet Navigation" in the July issue of the RCAF OBSERVER.

It may be of interest to know that 410 Sqn uses a slight modification to the SOPs for local area operations, as suggested by F/O WS Nasi of this unit. If the variation setting control on the GSIC is left at zero, and magnetic winds and vectors are added, the result is a position given as a magnetic bearing and distance from the selected reference. This is a distinct advantage because the required data is presented in the form in which position is normally passed by GCI, thus eliminating the application of variation during the flight. The fact that the observer must think in terms of magnetic direction presents no problems, because one quickly readjusts to the technique.

A further point, that was omitted in the article, was the use of the RΘ in its intercept mode. Use of the RΘ as an intercept computer is not too satisfactory because of the increased workload and confusion factor resulting from revisions of target heading, speed, and particularly of position. Secondly, attempts to use the instrument for conversions can, under certain conditions, be quite complex. A final point is the lack of ground position, which can prove most embarassing when combined with radio failure. Use of the instrument in the suggested magnetic mode gives continuous ground position, in the desired coordinates, while providing a larger degree of tactical freedom, with only a slightly increased workload.

It is hoped that this modification to RΘ operation will be considered by other units, and that the ugly spectre "Navigators have always used true direction" will not be allowed to prejudice its usefulness.

G.R. Hunn F/L

410 AW (F) Sqn
RCAF Station Uplands

Dear Sir: Critical Point and PNR - Comet

Your July article regarding the calculation of a PNR was quite interesting; since you mention the Comet, I am outlining below our thoughts at 412 (T) Sqn.

First, I must disagree that the PNR should be calculated assuming an engine-loss; this encroaches on the purpose of a CP. I suggest that the CP and PNR should be worked out in the normal manner, and then a check made to ensure that sufficient fuel will remain at the CP to proceed or return with one engine out (this can indeed be critical with the C119). Thus the PNR can serve its other functions, such as an operational recall or the weather "clamping" at the destination.

In the case of the Comet it is not convenient to use a formula to determine the PNR, insomuch as air miles per gallon varies so much with weight and temperature. Until recently, the solution of both CP and PNR was done graphically on the How-goz-it. This method was unsatisfactory for several reasons, and the writer designed the attached graph to supply a very quick and completely accurate answer.

The graph is entered with the Wind Component for the first half of the flight; proceed up to the Wind Component for the second half of the flight, and read the percentage of the flight distance to the CP. Then carry on up or down to the diagonal line and read the percentage of the PLE that can be used outbound to the PNR. The whole operation takes less than a minute, since Wind Components are already available on the Comet Flight Plan.

It should be noted that:

(a) CP is calculated on 3 engines, PNR on 4.

(b) Since Flight Plan Time (which includes climb and descent) is used in establishing the PLE, variables of weight and temperature automatically are taken into account. The amount (Reserve Fuel - 7000 lbs) is calculated at a flat 6000 lbs/hr, since the aircraft will be very light when this is burned.

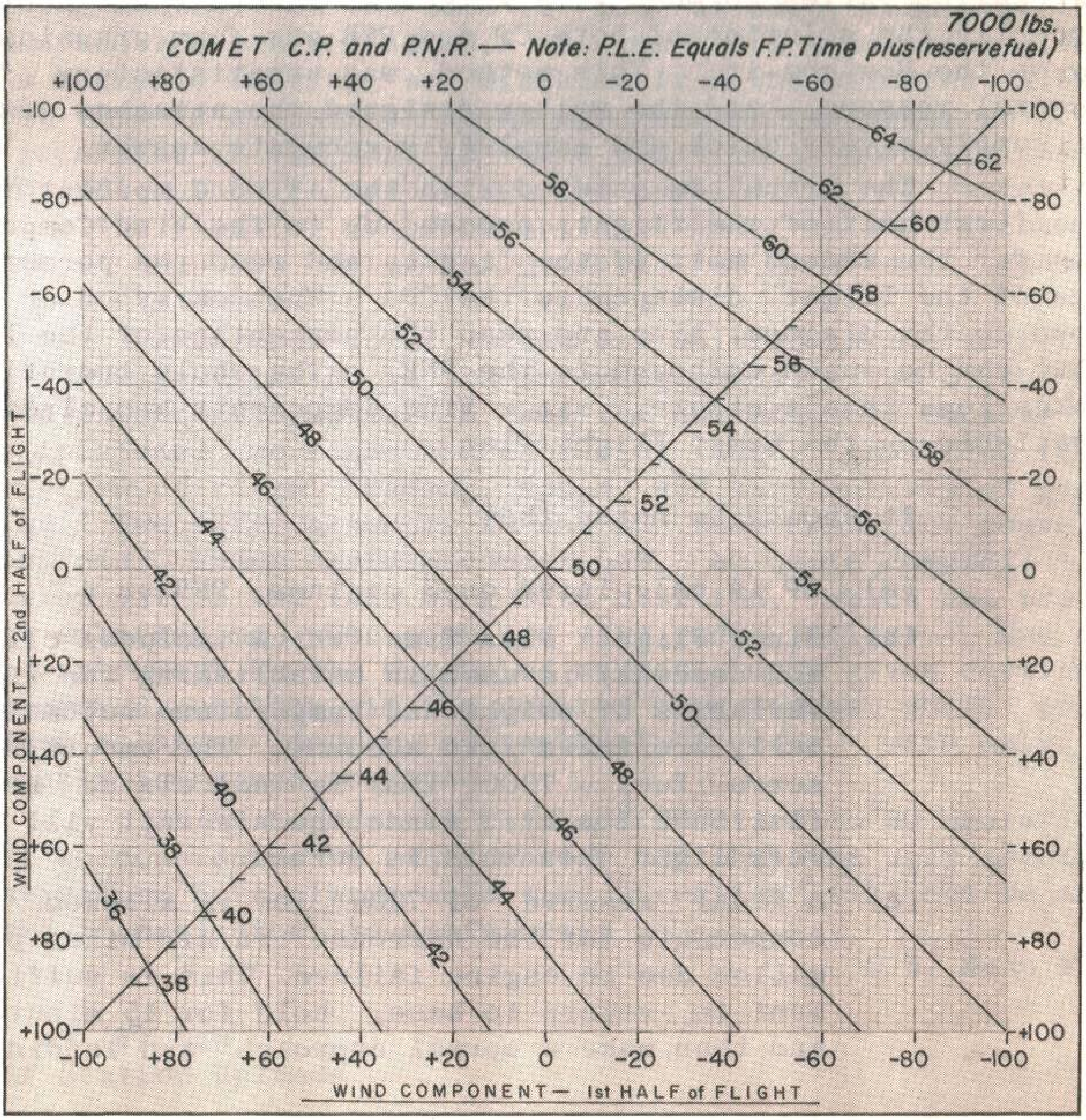
(c) A final reserve of 7000 lbs is allowed to compensate for the decrease in air miles per gallon due to engine failure. This is sufficient to return to base, hold for 15 minutes and then make a normal approach and landing, even if the engine is lost exactly at the PNR (a return under such circumstances would of course be made only if destination weather suddenly "clamped" as the engine failed).

(d) It is assumed that CP and PNR are close enough together to use the same Wind Component in both calculations; if they are indeed far apart, fuel problems cannot exist.

The graph has been used on operations and found to be a very satisfactory method, particularly from the speed and accuracy points of view.

H.G. Morson S/L

412 (T) Sqn
RCAF Station Uplands



Dear Sir:

In the article "PNR" by F/L MD Gates in the July 1959 OBSERVER, the author seems to have confused the purpose of the PNR with that of the Critical Point.

Referring to the Observer Training Manual, Volume 1, paragraph 111.44, the "Point of No Return is the point beyond which an aircraft cannot fly and still return to its starting point". The PNR is not intended to provide anything but a maximum range point at normal fuel consumption, and is calculated after the fuel requirement has been determined. Other conditions, such as engine failure and increased consumption, are arguments in Critical Point and fuel calculations.

Let us stray a bit and look at the second sentence in paragraph 111.44: "A knowledge of this point is particularly important in flights over areas where there are no alternates, such as trans-oceanic or Arctic flights". Now let's re-read that statement, think about it, and then refer to CAP 100, article 111.06, para (1). No alternates - no flight! Anyway, the point of departure could be used as an alternate,if weather permits and sufficient fuel is carried.

Since particular reference was made to the C119, let's examine the fuel regulations for this aircraft.

(a) Domestic (including Northern) Flights: the fuel required is the sum of:

Base to Destination - at normal consumption
Destination to Alternate - at normal consumption
Holding (45 mins) - at normal consumption
Taxi, runup and climb - 800 lbs

(b) Trans-Oceanic Flights (when more than 400 miles from the coast line)

● When the alternate is beyond the destination,the fuel required is the sum of:

Base to Critical point of entire flight (base - destination - alternate) at normal consumption

Critical point to alternate(through destination) at single engine consumption and reduced TAS

Reserve at alternate (30 mins single engine consumption = 875 lbs)

Taxi, runup and climb = 800 lbs

- When the alternate is between base and destination, the fuel required is the sum of:

  Base to CP (CP between base and destination) at normal consumption

  CP to alternate (through destination) at single engine consumption and reduced TAS

  Reserve at alternate (30 minutes single engine consumption = 875 lbs)

  Taxi, runup, and climb = 800 lbs

(The C119 normal consumption is 1500 lbs/hr, and single engine consumption is 1750 lbs/hr).

The author seems to be concerned about the safety of an aircraft attempting "a single-engine return from a normal PNR on a long over-water flight". If the PNR is beyond the CP, the persons responsible for the decision of returning to base deserve the consequences awaiting them. The decision to return to base or continue to destination or alternate in event of an engine failure is governed by the position of the critical point and not the PNR.

The formula ($X = \frac{PLE \times O \times H}{C_1H + C_2O}$) proposed in the article is a compromise between the PNR and the CP and fulfills the requirements of neither. A major drawback with this formula is that the 45 mins of fuel reserved for holding is lost in the calculation of the PLE, and would not be available on return. Also, the consumption may be higher than expected and might eliminate the 10% allowance in the PLE.

This formula may be of some use, however, if the point of safe return (PSR) is used instead of the PNR. The PLE for PSR is take-off fuel minus 10% minus 45 minutes of fuel at normal consumption, the latter being the fuel reserved for holding. This point is more realistic, since the fuel for holding is not available for flying to destination or alternate but must be reserved for holding at the alternate. The PSR has now replaced the PNR in Air Transport Command.

The PSR (or PNR) and CP have specific definitions and serve specific purposes, but fuel regulations are variable and take into account the type of aircraft, its capabilities, restrictions, use, and terrain over which it normally flies.

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SORRY!

.... that this issue of the "Observer" is so late. The addition of Observer Standards to CNS this past summer proved to be more than the Publications Section could bear. As a result, there will be no January '60 issue. We hope that additional staff will resolve our difficulties sufficiently for us to publish Volume VI Number I in April.

The Editor

The opinions expressed in the contributions to the RCAF OBSERVER are those of the writers and do not necessarily represent official RCAF views. The Editor reserves the right to make any editorial changes in manuscripts which he believes will improve the material without altering the intended meaning.

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