SECTION 1

NZCAA PAMPHLET 25

(NOVEMBER 1968)

1. COMPASS COMPENSATION PROCEDURE

1.1 DOCUMENT INSPECTION

1.1.1 BEFORE SWINGING AND ADJUSTING AN AIRCRAFT'S MAGNETIC COMPASS IT IS ESSENTIAL TO INSPECT THE DOCUMENTATION REFERRING TO THE COMPASS HISTORY OF THE AIRCRAFT CONCERNED. SUCH HISTORY WILL BE RECORDED IN THE AIRCRAFT LOG BOOK AND IN THE COMPASS SWINGING RECORD BOOK. THE AIRCRAFT LOG BOOK CONTAINS DETAILS OF COMPASS SERVICEABILITY, REPLACEMENT AND PREVIOUS COMPASS SWINGS. THE LATTER NORMALLY CONSISTS OF THE DATE OF THE SWING PLUS A COPY OF THE RESIDUAL DEVIATIONS TOGETHER WITH THE SIGNATURE OF THE PERSON CERTIFYING THAT THE COMPASS HAS BEEN SWUNG AND CORRECTED. THE COMPASS SWINGING RECORD BOOK (OFTEN REFERRED TO AS COMPASS LOG BOOK) IS A RECORD OF THE DETAIL OF EACH SWING AND IS, IN EFFECT, THE WORK SHEET OF THE PERSON COMPENSATING THE COMPASS. IT CONTAINS DETAILS OF THE CO-EFFICIENTS FOUND AND THE EXTENT TO WHICH THEY WERE COMPENSATED.

1.1.2 IF THE COMPASS TO BE SWUNG IS A REPLACEMENT COMPASS THEN THE AIRCRAFT LOG BOOK WILL REVEAL THIS FACT AND THE PERSON CARRYING OUT THE SWING WILL THEN KNOW TO ZERO ALL THE CORRECTING DEVICES PRIOR TO COMMENCING THE SWING. IF THE SWING IS A ROUTINE, TIME DATED ONE THEN THE RESIDUAL DEVIATIONS OF PREVIOUS SWINGS SHOULD GIVE AN INDICATION OF THE DEVIATIONS LIKELY TO BE FOUND ON THIS PRESENT SWING.

1.2 PRE-TAXY ACTIONS

1.2.1 PRIOR TO TAXYING THE AIRCRAFT TO THE COMPASS SWINGING SITE ESTABLISH:

(A) THE SERVICEABILITY OF THE COMPASSES TO BE SWUNG (SEE PARAGRAPH 1.3);

(B) THE SERVICEABILITY OF THE LANDING COMPASS OR THE MEANS BY WHICH THE MAGNETIC HEADING OF THE AIRCRAFT WILL BE DEFINED, OR CONVERSELY THE CURRENCY OF THE MARKINGS ON THE COMPASS SWINGING BASE;

(C) THAT THE ASSISTANT WHO IS TO OPERATE THE LANDING COMPASS OR OTHER EQUIPMENT IS SUITABLY QUALIFIED OR BRIEFED AND THAT A READY MEANS OF COMMUNICATING INFORMATION BETWEEN THIS PERSON AND THE COMPASS ADJUSTER HAS BEEN ESTABLISHED;

(D) THAT THE COMPASS SWINGING SITE HAS BEEN CHECKED, OR IS KNOWN TO BE, FREE FROM ADVERSE MAGNETIC EFFECTS (SEE PARAGRAPH 1.4);

(E) COMMUNICATION WITH AIR TRAFFIC CONTROL OR OTHER AIRFIELD USERS IN ORDER NOT TO INTERFERE WITH FLYING ACTIVITIES.

1.3 COMPASS SERVICEABILITY CHECKS

1.3.1 DIRECT READING COMPASSES

(A) CHECK FOR EASE OF READING OF ALL NUMBERS AND OTHER GRADUATIONS.

(B) CHECK THAT THERE ARE NO BUBBLES IN THE LIQUID.

(C) CHECK THAT THE LIQUID IS NOT DISCOLOURED.

(D) CHECK THAT THE COMPASS IS SECURELY MOUNTED IN THE AIRCRAFT.

(E) CHECK THAT THERE IS NO EXTRANEOUS MAGNETIC MATERIAL IN THE VICINITY OF THE COMPASS INCLUDING MAGNETIC MATERIAL ON THE PERSONS CONDUCTING THE COMPASS SWING.

(F) CHECK THAT NO RECENT MODIFICATIONS IN THE VICINITY OF THE COMPASS COULD AFFECT IT. IT IS NECESSARY TO NOTE ANY ELECTRICAL WIRES WHICH MAY HAVE BEEN RE-ROUTED IN THE VICINITY OF THE COMPASS.

(G) SHOULD THE COMPASS SERVICEABILITY BE SUSPECT THE FOLLOWING ADDITIONAL CHECKS SHOULD BE CARRIED OUT:

(i) Pivot Friction Check

Deflect compass card approximately 10° and maintain it in this position for 30 seconds. Remove the deflecting agent and note the settling position of the card.

Repeat the procedure with deflection in the opposite direction.

The difference between the two settling positions should not exceed 2°. Do not tap the compass during the above test.

(ii) Damping Check

Deflect compass card 30° and hold it in this position for 30 seconds. Remove the deflecting agent and note the time taken for the card to return to 5° away from the equilibrium position. This time should be not more than 5 seconds nor less than 1 second and the overshoot past the equilibrium position should not exceed 15°. Repeat in the opposite direction.

1.3.2 Remote Reading Gyro-magnetic Compasses

1.3.2.1 As the procedure for checking these specialized types of compasses varies from type to type, it is recommended that the serviceability checks laid down by the manufacturers, or other competent authority, be adhered to in all cases.

1.4 Swinging Site

1.4.1 Sites on which compasses are swung must obviously be free of magnetic fields that will have varying influences on the earth's magnetic field at the site. To check that a proposed site, or to re-check an existing site, for freedom from unwanted magnetic fields, two suitable methods are given below (refer also to NZCAR, Part III, Leaflet A.5-1).

1.4.2 Distant Bearing Method

Select as a datum point a distant but clearly defined landmark (such as a church spire) about 10 miles from the site. Take bearings of this datum with a landing compass from different positions around the site, choosing the positions so that the whole area is covered. Compare the readings obtained. Within the limit of accuracy to which the compass can be read, the readings should be constant. If appreciable variations occur, the site is unsuitable.

1.4.3 Reciprocal Bearing Method

1.4.3.1 Two observers and two landing compasses are required. Stationing themselves 30 to 40 yards apart, each observer takes the bearing of the other. When sighting, the opposite compass, or the central leg of its supporting tripod (depending on the aspect) are suitable marks. The individual readings of each pair of bearings are then compared and they must, within fine limits, be reciprocal.

1.4.3.2 The two compasses must then be moved around the site and bearings taken at every 15 or 20 degrees and compared, successive stations being chosen in order to cover the whole site. The greatest care should be taken when reading the landing compasses. They should be read to the finest possible limits.

1.4.3.3 Provided that the bearings are consistently the reciprocals of each other within 1 degree, then the site is suitable.

1.5 Checks at Compass Swinging Site

1.5.1 It is essential to test if the aircraft compasses show a change of deviation when the control surfaces are moved, the engine power is increased so that the generators become operative or any radio or electrical equipment is turned on. If a deviation change does result, then the aircraft must be swung with the offending item approximating its normal cruise flight condition.

1.6 Method I - Coefficient Method

1.6.1 Correcting Swing

(a) Head aircraft approximately 000° compass. Obtain exact magnetic heading and note deviation.

(b) Head aircraft approximately 090° compass. Obtain exact magnetic heading and note deviation.

(c) Head aircraft approximately 180° compass. Obtain exact magnetic heading and note deviation.

Determine coefficient C: $\text{Coefficient C} = \frac{\text{Dev. N} - \text{Dev. S}}{2}$

Change the sign of C thus obtained and add it algebraically to the compass reading obtained in (c). Adjust the N - S (= C) corrector to make compass read the algebraic sum determined above.

(d) Head aircraft approximately 270° compass. Obtain exact magnetic heading and note deviation.

Determine coefficient B: $\text{Coefficient B} = \frac{\text{Dev. E} - \text{Dev. W}}{2}$

Change the sign of B thus obtained and add it algebraically to the compass reading obtained in (d). Adjust the E - W (= B) corrector to make compass read the algebraic sum determined above.

1.6.2 Check Swing

Note the deviation remaining on 270° and then head aircraft at 45° intervals from 270° noting the deviations on the remaining cardinal and quadrantal headings.

Determine coefficient A from -

$$\text{Coefficient A} = \frac{\text{Dev. on } (270 + 315 + 000 + 045 + 090 + 135 + 180 + 225)}{8}$$

Add this figure algebraically to the last reading obtained during the 8 point check swing and rotate compass mount to make compass read this algebraic sum.

.7 Method II - Direct Correction

1.7.1 Correcting Swing

(a) Head aircraft approximately 000° compass. Obtain exact magnetic heading and adjust N - S (= C) corrector until compass reads correct heading.

(b) Head aircraft approximately 090° compass. Obtain exact magnetic heading and adjust E - W (= B) corrector until compass reads correct heading.

(c) Head aircraft approximately 180° compass. Obtain exact magnetic heading and note deviation. Adjust N - S corrector until deviation is reduced to 1/2 the value first obtained on 180°.

(D) HEAD AIRCRAFT APPROXIMATELY 270° COMPASS. OBTAIN EXACT MAGNETIC HEADING AND NOTE DEVIATION. ADJUST E - W CORRECTOR UNTIL DEVIATION IS REDUCED TO 1/2 THE VALUE FIRST OBTAINED ON 270°.

1.7.2 CHECK SWING

CARRY OUT A CHECK SWING EXACTLY AS FOR COEFFICIENT A IN PARAGRAPH 1.6.2.

1.8 FINAL CHECK ON ACCURACY OF SWING

1.8.1 THE RESIDUAL DEVIATIONS SHOULD DISCLOSE LITTLE OR NO COEFFICIENT A, B OR C PROVIDED EACH COEFFICIENT HAS BEEN REMOVED. ON SOME DIRECT READING COMPASS TYPES COEFFICIENT A CANNOT BE REMOVED AND OF COURSE, IN SUCH CASES, THIS WILL SHOW UP IN THE RESIDUAL DEVIATIONS. TO CHECK IF THERE IS LITTLE OR NO COEFFICIENT C REMAINING USE THE FORMULA -

$$\text{COEFFICIENT C} = \frac{\text{DEV. ON N} - \text{DEV. ON S}}{2}$$

TO CHECK THAT THERE IS LITTLE OR NO COEFFICIENT B REMAINING USE THE FORMULA -

$$\text{COEFFICIENT B} = \frac{\text{DEV. ON E} - \text{DEV. ON W}}{2}$$

1.8.2 IF THE ABOVE CHECKS OF COEFFICIENTS B AND C DISCLOSE LITTLE OR NO REMAINING COEFFICIENTS AND THE RESIDUAL DEVIATIONS CAN BE GRAPHED INTO A MORE OR LESS REGULAR CURVE THEN THE SWING CAN BE ACCEPTED AS REASONABLY ACCURATE. IF NO CORRECTIONS WERE MADE FOR COEFFICIENTS A, B OR C THEN THE RESIDUAL DEVIATIONS FROM THIS SWING SHOULD BEAR A RESEMBLANCE TO THOSE OBTAINED ON THE PREVIOUS SWING PROVIDED THERE WAS NO MAJOR EQUIPMENT CHANGE.

1.9 DOCUMENTATION (SEE ALSO NZCAR, PART III, LEAFLET A.5-1)

1.9.1 DEVIATION CARD

FOLLOWING A COMPASS SWING A RECORD OF DEVIATIONS REMAINING MUST BE MADE OUT AND PLACED IN THE AIRCRAFT. THIS RESIDUAL DEVIATION CARD MAY BE OF EITHER GRAPHICAL OR TABULAR FORM. SIGNATURE AND DATE MUST BE AFFIXED TO THE CARD.

1.9.2 AIRCRAFT LOG BOOK

CERTIFY IN THE AIRCRAFT LOG BOOK THAT THE COMPASS HAS BEEN SWUNG AND CORRECTED AND A DEVIATION CARD FITTED. A COPY OF THIS DEVIATION CARD IS ALSO TO BE PLACED IN THE LOG BOOK.

1.9.3 COMPASS SWINGING RECORD

IT IS REQUIRED THAT A PERMANENT RECORD BE KEPT OF COMPASS SWINGS UNDERTAKEN. FORM CA 2138 IS DESIGNED FOR THIS PURPOSE.

2. MAGNETISM AND COMPASSES

2.1 MAGNETS AND MAGNETISM

2.1.1 (A) MAGNETISM IS THE NAME GIVEN TO A PHENOMENON THE EXACT NATURE OF WHICH IS STILL VERY MUCH A MATTER OF SPECULATION. HOWEVER, THE EFFECTS OF MAGNETISM ARE WELL KNOWN. FOR THE PRACTICAL PURPOSE OF THIS PAMPHLET THE ESSENTIAL FACT IS THAT MAGNETISM IS CAPABLE OF EXERTING A MECHANICAL FORCE, WHICH LIKE ANY OTHER FORCE, HAS MAGNITUDE AND DIRECTION.

(B) MAGNETIC FORCE CAN BE EXERTED BY "MAGNETS" AND AN ELECTRIC CURRENT. AN AREA IN SPACE IN WHICH MAGNETIC INFLUENCE EXISTS, IS KNOWN AS A "MAGNETIC FIELD".

2.1.2 (A) A MAGNETIC FIELD CAN PRODUCE A FORCE ONLY IF IT HAS ANOTHER MAGNETIC FIELD WITH WHICH IT CAN REACT. IF THE SENSE OF THE FORCE IS SUCH THAT THE FIELDS TEND TO BE DRAWN TOWARDS EACH OTHER THEN A FORCE OF ATTRACTION IS SAID TO BE ACTING. CONVERSELY, IF THE FIELDS TEND TO BE PUSHED AWAY FROM EACH OTHER THEN A FORCE OF REPULSION IS SAID TO BE ACTING.

(B) AS STATED IN 2.1.1 MAGNETS AND ELECTRIC CURRENTS CAN EXERT FORCE DUE TO MAGNETISM AND THEREFORE IT FOLLOWS THAT THEY BOTH PRODUCE MAGNETIC FIELDS.

(C) A SELF-PRODUCED PICTURE OF THE FIELD OF A BAR MAGNET CAN EASILY BE OBTAINED BY SPRINKLING FINE IRON FILINGS OVER A PIECE OF PAPER AND THEN RESTING THE PAPER ON A BAR MAGNET. THIS METHOD CAN PRODUCE A PICTURE AS SHOWN BELOW:

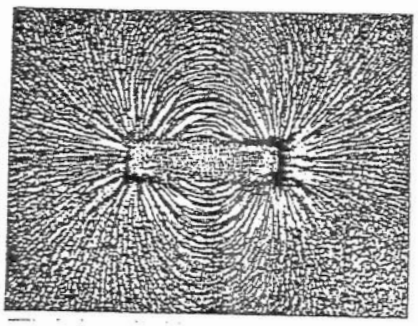

FIG.1

(D) IN A SIMILAR MANNER THE FIELD DUE TO AN ELECTRIC CURRENT CAN BE PRODUCED BY REPLACING THE BAR MAGNET WITH A CONDUCTOR PASSING NORMAL TO AND THROUGH THE PLANE OF THE PAPER. WHEN A CURRENT IS PASSED THROUGH THE CONDUCTOR A PICTURE AS SHOWN BELOW CAN BE PRODUCED:

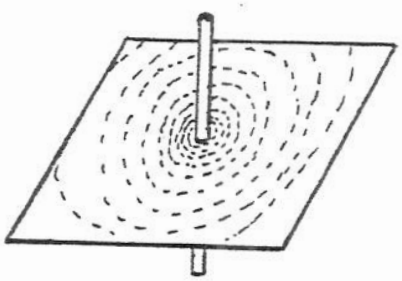

FIG.2

2.1.3 (A) A STUDY OF THE ABOVE PICTURES REVEALS SEVERAL FACTS. IN THE CASE OF THE BAR MAGNET THE IRON FILINGS HAVE BEEN SUBJECTED TO A FORCE THAT HAS MECHANICALLY ORIENTED THEM TO FORM A DEFINITE PATTERN. THIS PATTERN SHOWS LINES ALONG WHICH THE FILINGS LIE AND THESE LINES ARE TERMED "LINES OF FORCE". IT WILL BE NOTED THAT THERE IS A CONCENTRATION OF LINES AT THE ENDS OF THE MAGNET THIS CONCENTRATION BEING AN INDICATION THAT THE MAGNETIC FIELD IS DENSER AND HENCE STRONGER, IN THAT AREA.

(B) VERY NEAR THE ENDS OF THE MAGNET ARE TWO POINTS (AS SHOWN) WHICH ARE THE FOCI OF THE EMANATING PATTERN. THESE POINTS ARE THE "POLES" OF THE MAGNET, ALTHOUGH FOR MANY PRACTICAL PURPOSES THE ENDS OF THE MAGNET MAY BE ASSUMED TO BE ITS POLES.

(c) A FURTHER POINT TO BE OBSERVED IS THAT EACH AND EVERY LINE OF FORCE IS CONTINUOUS FROM POLE TO POLE - THOSE PASSING BEYOND THE FRAME OF THE ILLUSTRATION SHOULD ALSO BE FOUND TO BE CONTINUOUS - AND THROUGH THE SUBSTANCE OF THE MAGNET.

(D) IN THE CASE OF THE FIELD DUE TO THE ELECTRIC CURRENT SIMILARITIES TO THE BAR MAGNET FIELD ARE OBSERVABLE. THE LINES OF FORCE APPEAR AGAIN, THEY ARE MORE CONCENTRATED NEAR THE CONDUCTOR, HAVE A CIRCULAR PATTERN AND AGAIN ARE CONTINUOUS. AS THE FIELD IS CIRCULAR, NO POLES APPEAR.

2.1.4 (A) IT WAS STATED IN 2.1.3(A) THAT ".... THE IRON FILINGS HAVE BEEN SUBJECTED TO A FORCE THAT HAS MECHANICALLY ORIENTED THEM ...." AND IN 2.1.2(A) "... A MAGNETIC FIELD CAN PRODUCE A FORCE ONLY IF IT HAS ANOTHER MAGNETIC FIELD WITH WHICH IT CAN REACT". OBVIOUSLY THEN THE IRON FILINGS MUST THEMSELVES HAVE PRODUCED THEIR OWN MAGNETIC FIELDS TO REACT WITH THAT OF THE MAGNET - OR THAT OF THE ELECTRIC CURRENT.

(B) AS THE FILINGS HAVE PRODUCED A MAGNETIC FIELD THEY HAVE BECOME MAGNETS; IN FACT A SUBSTANCE WHICH, WHEN INFLUENCED BY A MAGNETIC FIELD BECOMES A MAGNET, IS A "MAGNETIC MATERIAL" THAT IS, IT CAN BE "MAGNETIZED".

(C) SEVERAL SUBSTANCES EXHIBIT MAGNETIC PROPERTIES BUT IRON AND MOST OF ITS ALLOYS EXHIBIT SUCH PROFOUND PROPERTIES THAT THEY ARE CLASSIFIED IN A CLASS OF THEIR OWN KNOWN AS "FERRO-MAGNETIC" SUBSTANCES. THERE IS A WIDE VARIATION OF PROPERTIES WITHIN THE GROUP RANGING FROM THE EXTREMELY "SOFT" MAGNETICALLY, TO THE EXTREMELY "HARD". A SOFT MAGNETIC MATERIAL IS ONE THAT IS HIGHLY SUSCEPTIBLE TO EVEN A COMPARATIVELY WEAK MAGNETIC FIELD, WHILST A MAGNETICALLY "HARD" MATERIAL HAS A LOW DEGREE OF SUSCEPTABILITY. CONVERSELY, A MAGNETICALLY SOFT MATERIAL WILL TEND TO LOSE NEARLY ALL OF ITS MAGNETISM WHEN THE MAGNETIZING FORCE IS REMOVED WHEREAS A HARD MATERIAL WILL NOT. IT IS OF THIS HARD MATERIAL THAT PERMANENT MAGNETS ARE MADE. EXAMPLES OF MAGNETICALLY HARD MATERIALS ARE TUNGSTEN, CHROME AND COBALT MAGNET STEELS, CAST STEEL, ALUMINIUM - COBALT - NICKEL - IRON ALLOYS (ALNICO, ALCOMAN) AND OF SOFT MATERIALS, PERMALLOY, NUMETAL, 50% COBALT IRON, 40% NICKEL IRON AND SOFT IRON.

2.1.5 (A) REVERTING TO PARAGRAPH 2.1.2 IT WAS STATED THAT REACTING MAGNETIC FIELDS CAN PRODUCE A FORCE EITHER OF ATTRACTION OR OF REPULSION.

(B) IF THE MATERIALS USED TO OBTAIN FIG.1 ARE SUPPLEMENTED WITH A SECOND BAR MAGNET IDENTICAL WITH THE FIRST, THE FOLLOWING PATTERNS CAN BE OBTAINED:

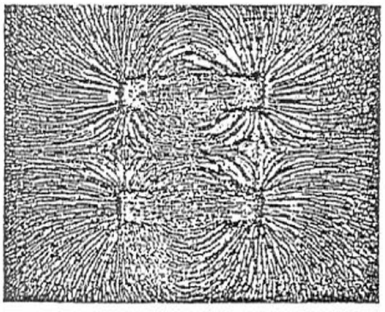

FIG.3

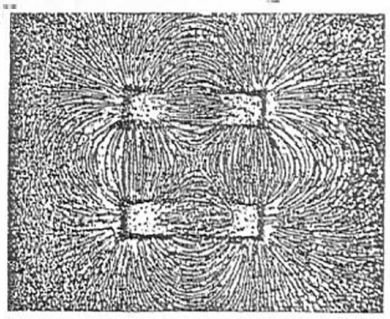

FIG.4

(C) ASSUMING THAT THE PATTERN OF FIG.3 WAS OBTAINED ON THE FIRST POSITIONING OF THE MAGNETS THEN BY TURNING ONE OF THE MAGNETS END FOR END, THE PATTERN OF FIG.4 WOULD APPEAR, AND VICE VERSA. AS ONLY ONE MAGNET WAS TURNED IT CAN BE INFERRED THAT THE TWO POLES OF A MAGNET HAVE DIFFERENT CHARACTERISTICS. THIS IS SO AND THE POLES OF ANY MAGNET ARE CALLED NORTH AND SOUTH RESPECTIVELY - GENERALLY ABBREVIATED TO N AND S. (THE RELATIONSHIP BETWEEN THIS TERMINOLOGY AND GEOGRAPHICAL NORTH AND SOUTH WILL BE SHOWN IN PARAGRAPH 2.2.) IT IS ASSUMED FOR CONVENTION, THAT LINES OF FORCE ARISE ON A NORTH POLE AND TERMINATE ON A SOUTH POLE. THE PATTERN OF FIG.3 WILL BE OBTAINED IF LIKE POLES OF THE MAGNETS ARE IN PROXIMITY, I.E. IF BOTH LEFT HAND POLES ARE N - OR BOTH S. IF UNLIKE POLES ARE IN PROXIMITY, ONE LEFT HAND POLE AN N AND ONE AN S, THEN THE PATTERN OF FIG.4 WILL OBTAIN.

(D) As stated earlier, each and every line of force is continuous and it can be seen from Figs.3 and 4 that this still occurs but in these cases the patterns of the lines have changed.

(E) In Fig.3 the lines of force due to each magnet show clearly but in the area between the magnets and in the extension to left and right of this area the pattern is flattened as if the fields were in compression and pushing against each other. It will be found that the fields ARE actually repelling each other and in the case of strong permanent magnets, with quite considerable force. The closer the magnets the greater will this force be.

(F) In Fig.4 the lines of force show a quite different pattern. In the same area as noted above the pattern is interwoven as if the fields were in tension and pulling towards each other, which in fact they are. In the case of strong magnets this force of attraction is considerable and again, increases with decreasing distance apart.

(G) From the foregoing it is readily deduced that LIKE poles REPEL and UNLIKE poles ATTRACT.

(H) Magnetic fields due to electric currents exhibit exactly the same properties of repulsion and attraction as those of bar magnets.

2.1.6 (A) To explain how the iron filings of paragraph 2.1.4 have become magnets, the "molecular theory of magnetisation" is convenient. This theory assumes a magnetic material is made up of "molecules" that are themselves minute permanent magnets with N and S poles. In the unmagnetised state it is assumed that the molecular magnets are so oriented that their N and S poles, by attration, form closed loops and hence produce no external magnetic field. See Fig.5.

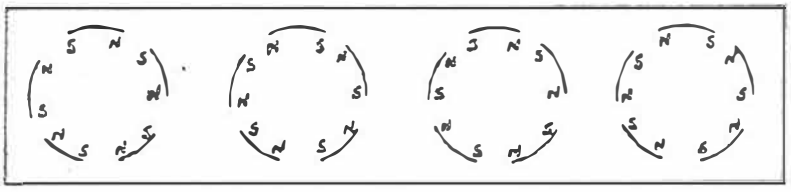

Fig.5

(B) However, when subject to the influence of a magnetic field, the molecular magnets, by attraction of the influencing field, re-orient themselves along the lines of force of that field. At the surface of the substance, adjacent to the influencing field will appear a pole of opposite polarity to that of the influencing field. Hence attraction will occur. At the opposite surface of the substance a pole of like polarity to that of the influencing field will appear. The substance is now a magnet, with poles and its own external magnetic field, due to these poles. See Fig.6.

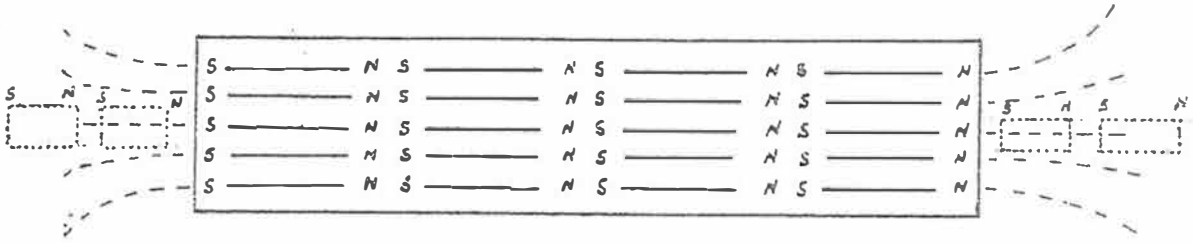

Fig.6

(c) Similarly each iron filing has become a small magnet, aligned with the direction of the influencing field in its vicinity. The molecular theory is supported by the fact that if a bar magnet is cut into smaller and smaller pieces each piece will be found to be a complete magnet. Conversely if additional bars of iron are placed as shown dotted in Fig.6, they will also be found to be magnets.

2.1.7 Summarizing

(A) Magnetism can produce a magnetic field in space. Magnetic fields interact and in so doing give rise to a mechanical force that has magnitude, direction and sense. If the sense of the force is such that the fields tend to be drawn together a force of attraction is said to exist whilst if the fields tend to be pushed apart a force of repulsion occurs.

(B) Magnetic fields emanate from magnets and electric currents. A bar magnet has at one end a North pole and at the other a South pole. Lines of force are assumed to arise from a N pole and terminate on a S pole and are always continuous. Like poles repel and unlike poles attract.

(c) Ferrous substances are magnetic. Soft magnetic substances magnetize and demagnetize easily, hard magnetic materials do not.

(D) The molecular theory of magnetization suggests that magnetic substances contain numerous minute molecular magnets that are aligned by a magnetizing field to produce poles, and consequently an external field.

3. PRINCIPLES OF COMPENSATION

3.1 Preliminary

3.1.1 (A) In an area where the only magnetic directive force acting is the earth's field, a compass needle will align with the magnetic meridian at that place.

(B) If, however, the earth's field has been distorted as almost invariably it will be both in and in the near vicinity of, an aircraft, then a compass needle in the aircraft will align with a resultant directive force.

(c) Compass compensation is aimed at producing, at the compass, a resultant directive force whose direction is as nearly as practicable the same as that of the magnetic meridian outside the aircraft.

3.1.2 (A) As noted above compass compensation is the application of forces. Although these forces are due to magnetism certain facts regarding force itself need appreciation.

(B) A force is completely defined by its magnitude, direction, sense and point of application. Furthermore a force can be resolved into a number of other forces of such magnitudes and directions that their overall and final effect is the same as that of the original single force.

(c) For example, if a force AB as shown by the vector in Fig.7 is referred to the three mutually perpendicular axes, it can be resolved into the separate forces AX, AY and AZ acting at a right angle to each other.

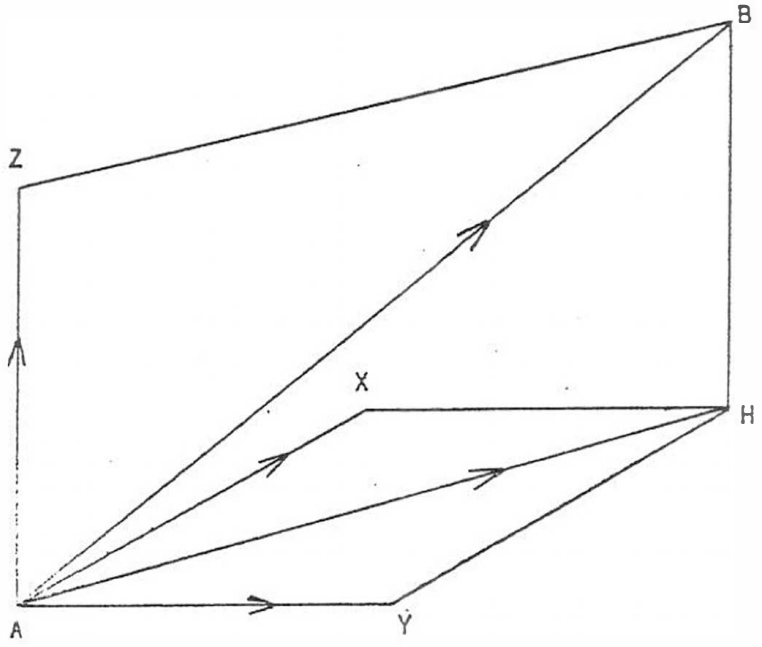

FIG.7

3.1.3 (A) IN AN AIRCRAFT THE RESULTANT DIRECTIVE FORCE AT THE COMPASS POSITION IS DUE TO (A) THE EARTH'S MAGNETIC FIELD, AND (B) MAGNETISM WITHIN THE AIRCRAFT. THE AIRCRAFT MAGNETISM CAN BE CLASSIFIED AS "HARD IRON" OR "PERMANENT"; "SOFT IRON" OR "TEMPORARY" AND "SUB-PERMANENT".

(B) HARD IRON MAGNETISM REFERS TO MAGNETICALLY HARD MATERIALS, THAT IS, THOSE MATERIALS WHICH ARE NOT EASILY MAGNETIZED BUT WHICH CONVERSELY ARE NOT READILY DEMAGNETIZED. EXAMPLES OF MAGNETICALLY HARD MATERIALS ARE CAST STEEL AND MANY ALLOY STEELS. IT MAY BE NOTED HERE THAT MAGNETISM DUE TO ELECTRIC CURRENT MAY BE CLASSIFIED AS HARD IRON. HOWEVER, BY OBSERVING COMPARATIVELY SIMPLE PRECAUTIONS INTERFERENCE TO COMPASSES BY ELECTRIC CURRENTS WILL NOT OCCUR.

(C) SOFT IRON MAGNETISM REFERS TO MAGNETICALLY SOFT MATERIALS, THAT IS, THOSE THAT ARE VERY EASILY MAGNETIZED AND DEMAGNETIZED. THE POLARITY AND STRENGTH OF A SOFT IRON MAGNET IS DEPENDENT ON THE DIRECTION AND STRENGTH RESPECTIVELY, OF THE MAGNETIZING FORCE.

(D) SUB-PERMAMENT MAGNETISM REFERS TO MATERIALS THAT CANNOT BE CLASSIFIED AS EITHER HARD OR SOFT. THEY CAN BECOME MAGNETIZED BY VIBRATION WITHIN A MAGNETIC FIELD SUCH AS BEING FLOWN ON A CONSTANT HEADING FOR A LENGTHY PERIOD. THEIR MAGNETISM WILL DISAPPEAR WITH THE PASSAGE OF TIME. AS SUCH MAGNETISM IS UNPREDICTABLE IT WILL NOT BE STUDIED FURTHER. HOWEVER, IT SHOULD BE BORNE IN MIND THAT CHANGES OF COMPASS DEVIATION DURING FLIGHT CAN BE DUE TO SUB-PERMANENT MAGNETISM.

2 ANALYSIS OF THE EARTH'S DIRECTIVE FORCE

3.2.1 (A) REFERRING TO FIG.7, IF THE VECTOR AB REPRESENTS THE TOTAL DIRECTIVE FORCE DUE ONLY TO THE EARTH'S MAGNETIC FIELD AT A POINT, THEN THIS FORCE HAS BEEN RESOLVED INTO THREE FORCES, AZ ACTING IN A VERTICAL PLANE, AND AX AND AY ACTING IN THE HORIZONTAL PLANE. THE RESULTANT OF AX AND AY IS AH AND IT IS THIS RESULTANT FORCE WHICH ACTS ON A COMPASS NEEDLE TO GIVE DIRECTION IN THE HORIZONTAL PLANE.

(B) THE COMPASS NEEDLE WILL ALIGN WITH THIS RESULTANT AND THUS BE ALIGNED WITH THE MAGNETIC MERIDIAN, THAT IS, THE NORTH SEEKING (RED) POLE OF THE COMPASS NEEDLE WILL POINT TO MAGNETIC NORTH.

(C) FORCE AZ OBVIOUSLY DOES NOT AFFECT THE DIRECTION OF THE HORIZONTAL COMPASS NEEDLE AS THIS FORCE ACTS IN A VERTICAL PLANE.

3.2.2 (A) LET THE THREE RESOLVED FORCES OF THE EARTH'S TOTAL DIRECTIVE FORCE BE X, Y AND Z, AND BE RELATED TO AN AIRCRAFT BY THE FOLLOWING CONVENTION:

X – ACTING TOWARDS THE AIRCRAFT HEAD, THE SENSE BEING THEN POSITIVE;

Y – ACTING TO STARBOARD, THE SENSE THEN BEING POSITIVE;

Z – ACTING VERTICALLY AND IF DOWNWARDS BEING THEN OF POSITIVE SENSE.

(B) FIG.7 CAN THEN BE REDRAWN AS SHOWN BELOW:

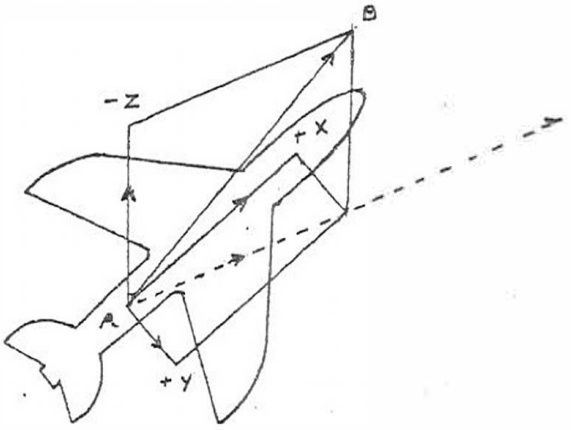

FIG.8

(C) IN FIG.8, FORCE Z IS SHOWN ACTING UPWARDS. THIS IS BECAUSE IN THE SOUTHERN HEMISPHERE THE ANGLE OF DIP OF THE EARTH'S FIELD IS SUCH THAT THE NORTH SEEKING (RED) POLE OF THE COMPASS NEEDLE IS BEING SUBJECTED TO A FORCE ACTING UPWARDS FROM THE HORIZONTAL. HENCE THE SENSE OF Z IS NEGATIVE IN SOUTHERN LATITUDES.

3.2.3 THE EFFECT OF FORCE Z IS SUCH THAT IT WOULD, UNLESS COUNTERACTED, CAUSE THE COMPASS NEEDLE TO BE INCLINED AT AN ANGLE TO THE HORIZONTAL (THIS EFFECT IS OF COURSE ZERO AT THE MAGNETIC EQUATOR AND MAXIMUM AT THE MAGNETIC POLES). TO COUNTERACT FORCE Z, THE COMPASS NEEDLE AND ITS ATTACHED CARD ETC. ARE PIVOTED VERTICALLY ABOVE THEIR RESULTANT C. OF G. HENCE AS THE NEEDLE SYSTEM TENDS TO BECOME INCLINED TO THE HORIZONTAL DUE TO Z, ITS C. OF G. LINE TO THE PIVOT MOVES AWAY FROM THE VERTICAL AND GRAVITATIONAL FORCE EXERTS A RESTORING COUPLE. THIS ARRANGEMENT ALLOWS THE SYSTEM TO REMAIN NEARLY HORIZONTAL UP TO LATITUDE 70°N OR S, APPROXIMATELY.

3.3 ANALYSIS OF AIRCRAFT PERMANENT MAGNETISM

3.3.1 REFERRING TO THE AIRCRAFT PERMANENT MAGNETISM NOTED IN PARAGRAPH 3.1.3 IT SHOULD BE BORNE IN MIND THAT THIS MAGNETISM IS FAIRLY CONSTANT REGARDLESS OF AIRCRAFT HEADING, POSITION, ETC. THE RESULTANT FORCE OF THE PERMANENT MAGNETISM CAN ALSO BE RESOLVED INTO THREE COMPONENT FORCES ACTING AS SHOWN IN FIG.9.

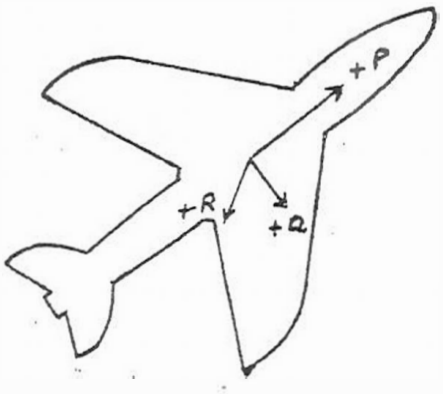

FIG.9

P – ACTING FORE AND AFT AND POSITIVE IF FORWARD.

Q – ACTING ATHWARTHSHIPS AND POSITIVE IF TO STARBOARD.

R – ACTING VERTICALLY AND POSITIVE IF DOWNWARDS.

3.3.2 THE MAGNETIC FORCES SO FAR CONSIDERED ACTING AT THE COMPASS POSITION CAN BE CONVENIENTLY COMBINED:

HORIZONTAL FORCES

+X; +P – ACTING FORWARD.

+Y; +Q – ACTING TO STARBOARD.

VERTICAL FORCES

+Z; +R – ACTING DOWNWARDS.

3.4 ANALYSIS OF "SOFT IRON" (TEMPORARY) MAGNETISM

3.4.1 (A) IT WAS STATED IN PARAGRAPH 3.1.3 THAT "SOFT IRON" MAGNETISM IS ASSOCIATED WITH MATERIALS THAT ARE EASILY MAGNETIZED. HENCE, SOFT IRON MATERIAL IN AN AIRCRAFT WILL BECOME MAGNETIZED BY THE INFLUENCES OF MAGNETIC FIELDS SURROUNDING IT. THE MOST IMPORTANT OF THESE FIELDS IS THAT OF THE EARTH.

(B) THE VARIOUSLY DISPOSED ITEMS OF SOFT IRON IN AN AIRCRAFT WILL, UNDER THE INFLUENCE OF THE EARTH'S MAGNETIC FIELD, BECOME TEMPORARY MAGNETS. THEIR POLARITIES WILL DEPEND ON THEIR SHAPES AND THEIR ORIENTATION IN THE EARTH'S FIELD. THEIR STRENGTHS WILL DEPEND ON THEIR MAGNETIC CHARACTERISTICS AND THE STRENGTH OF THE EARTH'S FIELD. AS THESE MAGNETS ARE SOFT IRON AND THUS EASILY MAGNETIZED AND DEMAGNETIZED, THEIR POLARITIES AND STRENGTHS WILL CHANGE WITH CHANGES OF THE AIRCRAFT'S HEADING, ATTITUDE AND POSITION.

3.4.2 (A) THE THREE RESOLVED COMPONENTS OF THE EARTH'S FIELD, X, Y AND Z WILL EACH CAUSE MAGNETIZING OF SOFT IRON COMPONENTS. COMPONENT X, FOR INSTANCE, WILL MAGNETIZE SOFT IRON MATERIALS WHICH WILL THEN PRODUCE A RESULTANT FIELD FROM THEIR MAGNETISM.

(B) THE RESULTANT FORCE OF THIS FIELD CAN BE RESOLVED INTO THREE COMPONENTS AS BEFORE – ONE ACTING VERTICALLY, ONE ACTING FORE AND AFT HORIZONTALLY AND ONE ACTING HORIZONTALLY ATHWARTSHIPS. AS THE STRENGTHS OF THESE COMPONENTS IS A FUNCTION OF THAT COMPONENT OF THE EARTH'S FIELD THAT INDUCED THE SOFT IRON MAGNETISM THE RESOLVED SOFT IRON FORCE IS ALWAYS IDENTIFIED WITH THAT COMPONENT OF THE EARTH'S FIELD THAT INDUCED IT.

(c) Similarly, components Y and Z of the earth's field will cause each three more resolved soft iron components giving a total of nine. By convention the soft iron components are:

Due to Horizontal (X and Y) components of earth's field –

+ aX : acting forward.

+ dX : acting to starboard.

+ gX : acting downwards.

+ bY : acting forward.

+ eY : acting to starboard.

+ hY : acting downwards.

Due to Vertical (Z) component of earth's field –

+ cZ : acting forward.

+ fZ : acting to starboard.

+ kZ : acting downwards.

(d) For convenience the 9 components can be considered as being due to 9 soft iron "rods" having length but negligible area. The rods are thus capable of being magnetized longitudinally only.

3.4.3 (a) Assuming that X', Y' and Z' represent respectively the <u>total</u> in-line magnetic forces fore and aft horizontal, athwarthships horizontal, and vertical in an aircraft, then:

		<u>Earth</u>		<u>Hard Iron</u>		<u>Soft Iron</u>
X'	=	X	+	P	+	aX + bY + cZ
Y'	=	Y	+	Q	+	dX + eY + fZ
Z'	=	Z	+	R	+	gX + hY + kZ

(b) Of the above forces, those due to the earth's field are directive forces, whilst those due to hard and soft iron magnetism are <u>deviating</u> forces. The prime concern of compass compensation is dealing with the deviating forces.

(c) As only those deviating forces acting in the horizontal plane give directional effects on the compass, (i.e. deviations), then those forces acting only in the vertical plane need not be considered in a study of deviations.

(d) The horizontal deviating forces can conveniently be grouped on the basis of their similar effects on the compass, as follows:

(i) P and cZ.

(ii) Q and fZ.

(iii) aX and eY.

(iv) bY and dX.

3.5 Effects of Deivating Forces on the Compass Needle

3.5.1 (A) In studying the effects of the various forces acting on the compass needle it is convenient to postulate an "isolated pole" that is, a magnetic pole that is purely North (Blue) with no attached South (Red), and vice versa. An isolated North pole will be attractive to the North seeking (Red) end of the compass needle whilst conversely an isolated South pole will repel the North seeking end of the compass needle. It should be noted that the North seeking end of a compass needle is known by convention as the red end.

(B) To differentiate between isolated poles due to hard iron and those due to soft iron, such poles will be shown as O for hard iron and □ for soft iron.

3.5.2 Effect of Component P

(A) Assuming that P is +ve then its effect is that of an isolated Ⓑ pole forward of the compass and on the fore and aft line. The deviating effect of +P through the cardinals and quadrantals will be as shown in Fig.10.

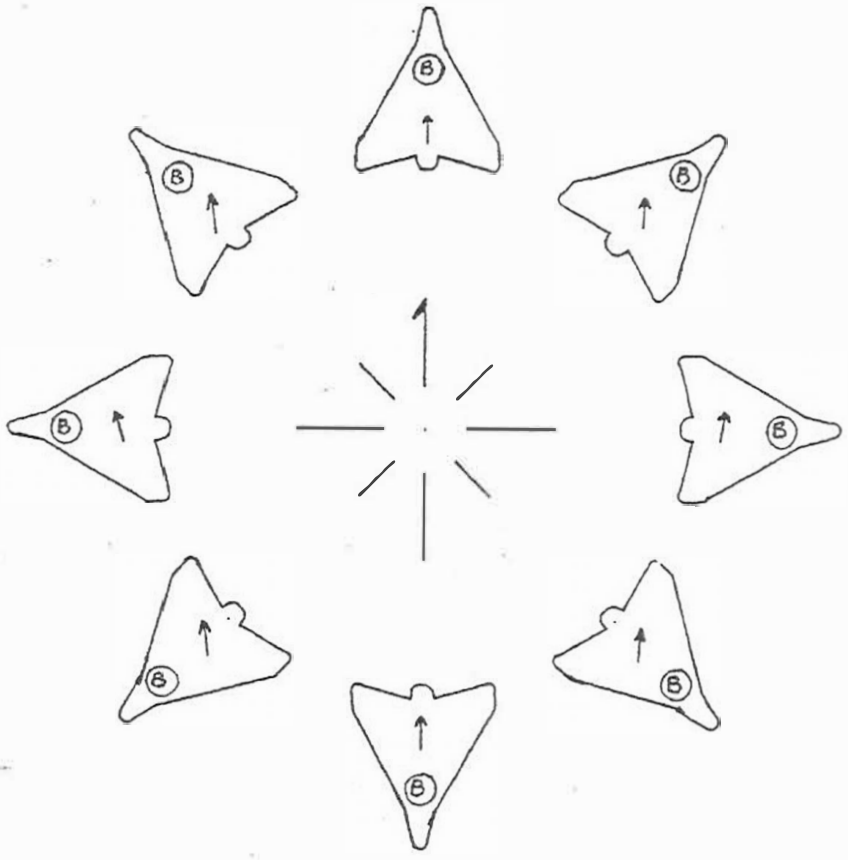

Fig.10

(B) ON 000° AND 180° HEADINGS THE EFFECT OF +P, DEVIATIONWISE, IS ZERO, WHILST ON 090° AND 270° IT IS MAXIMUM WITH INTERMEDIATE VALUES ON THE QUADRANTALS. THE DEVIATION IS OF COURSE DUE TO THE ATTRACTIVE FORCE OF (B) UPON THE NORTH SEEKING END OF THE COMPASS NEEDLE.

(C) ON 000° AND 180°, (B) ACTS IN LINE WITH THE MERIDIAN AIDING THE EARTH'S DIRECTIVE FORCE ON 000° AND OPPOSING IT ON 180°.

(D) ON EASTERLY HEADINGS, +P HAS, BY ATTRACTING THE COMPASS NEEDLE TO THE EAST OF THE MERIDIAN, CAUSED THE COMPASS TO READ LOW AND THUS GIVEN EASTERLY (OR POSITIVE) DEVIATION. ON WESTERLY HEADINGS +P HAS ATTRACTED THE NEEDLE TO THE WEST OF THE MERIDIAN THEREBY CAUSING WESTERLY (OR NEGATIVE) DEVIATION.

(E) HAD THE HARD IRON MAGNETISM BEEN SUCH THAT -P OBTAINED, THIS WOULD BE EQUIVALENT TO AN ISOLATED (B) POLE AFT OF THE COMPASS AND UNDER THIS CONDITION THE DEVIATIONS WOULD BE WESTERLY (-) ON EASTERLY HEADINGS AND EASTERLY (+) ON WESTERLY HEADINGS.

(F) GRAPHS OF THE DEVIATIONS DUE TO +P AND -P ARE SHOWN IN FIGS.11(A) AND 11(B) RESPECTIVELY.

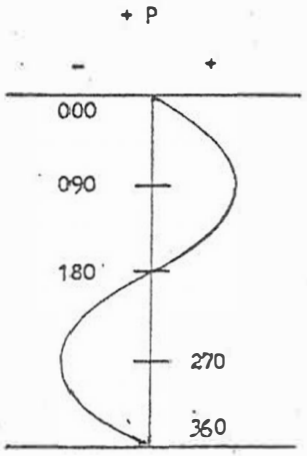

FIG.11(A)

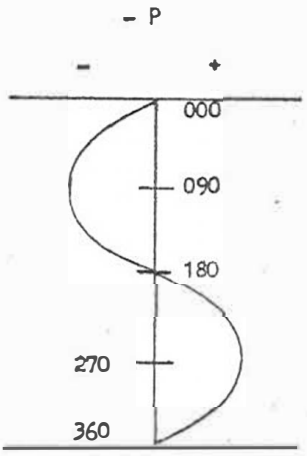

FIG.11(B)

IT WILL BE NOTED THAT THE DEVIATION CURVES ARE SINUSOIDAL IN FORM.

3.5.3 EFFECT OF COMPONENT cZ

(A) IT WILL BE RECALLED THAT cZ IS THAT COMPONENT OF THE AIRCRAFT'S SOFT IRON MAGNETISM INDUCED BY THE VERTICAL COMPONENT, Z, OF THE EARTH'S FIELD, AND ACTING ALONG THE FORE AND AFT HORIZONTAL LINE. cZ IS POSITIVE IF IT IS EQUIVALENT TO AN ISOLATED [B] POLE FORWARD AND AN ISOLATED [R] POLE AFT, OF THE COMPASS. IF THESE [B] AND [R] POLES ARE REVERSED IN POSITION THEN cZ WILL BE NEGATIVE.

(B) A LITTLE CONSIDERATION WILL SHOW THAT THE DEVIATING EFFECT OF + cZ WILL BE SIMILAR TO +P AND -cZ TO -P. IF cZ AND P ARE OF THE SAME SIGN THEIR EFFECTS WILL BE ADDITIVE, WHEREAS IF THEY ARE OF DIFFERENT SIGN, THEIR EFFECTS WILL BE SUBTRACTIVE. THIS IS SHOWN GRAPHICALLY IN FIGS.12(A) AND 12(B).

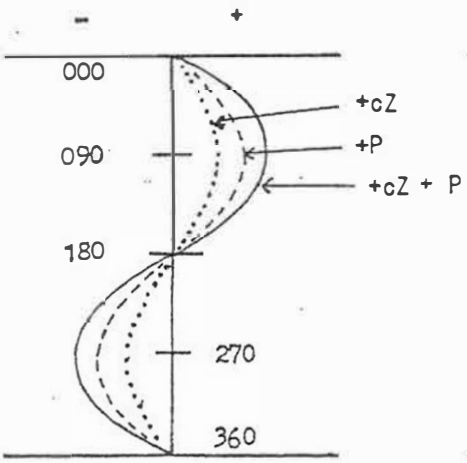

FIG.12(A)

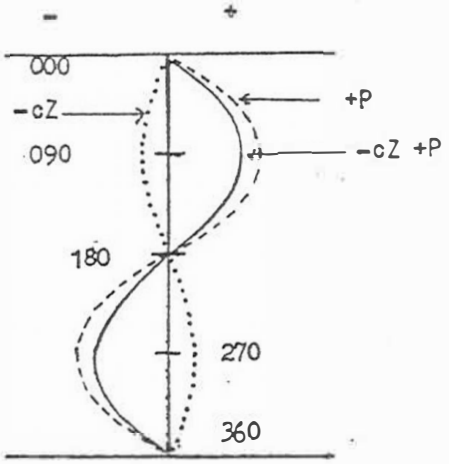

FIG.12(B)

AGAIN IT WILL BE NOTED THAT THE DEVIATION CURVES OF cZ AND OF P $\pm$ cZ ARE SINUSOIDAL.

3.5.4 (A) REFERRING TO THE SINUSOIDAL CURVES OBTAINED IN THE GRAPHS OF P AND cZ, THE SINE OF ANY ANGLE IT WILL BE RECALLED, VARIES FROM A MINIMUM VALUE OF 0 AT 0°, TO A MAXIMUM OF 1 AT 90°, TO A MINIMUM OF 0 AGAIN AT 180°, A MAXIMUM AGAIN OF -1 AT 270° AND 0 AGAIN AT 360° (000°).

(B) COMPARING THE CURVES OF +cZ + P IN FIG.12(A) AND -cZ + P IN FIG.12(B), IT CAN BE SEEN THAT ALTHOUGH BOTH CURVES ARE OF IDENTICAL FORM, THEIR MAGNITUDES ARE DIFFERENT. IF FOR EXAMPLE THE RESULTANT DEVIATION ON MAGNETIC HEADING 090° IN FIG.12(A) IS $+5^{\circ}$, BUT IN FIG.12(B) IT IS $+3^{\circ}$ THEN, AS SIN 90° IS ALWAYS 1, TO OBTAIN A VALUE OF $+5^{\circ}$ IN FIG.12(A) THE DEVIATION ON 090° MUST BE 5° SIN 90°. THAT IS, TO OBTAIN, IN DEGREES, THE ACTUAL DEVIATION ON ANY HEADING, CAUSED BY P AND cZ, THE SINE OF THE HEADING ANGLE IS MULTIPLIED BY SOME FIGURE.

(C) THIS FIGURE IS THUS A COEFFICIENT AND IN THE CASE OF P AND cZ THE COEFFICIENT IS, TO MAKE IT GENERAL, NOMINATED, B. THIS COEFFICIENT B HAS A VALUE GOVERNED BY THE MAGNETIC STRENGTHS AND SIGNS OF P AND cZ AND REPRESENTS THE MAXIMUM DEVIATION THESE FORCES PRODUCE. IN FIG.12(A) COEFFICIENT B HAS A VALUE OF $+5^{\circ}$ WHILST IN FIG.12(B) ITS VALUE IS $+3^{\circ}$. HAD THE DEVIATIONS ON 090° BEEN NEGATIVE OR WESTERLY IN FIG.12(A) AND 12(B), THEN THE COEFFICIENT WOULD HAVE ALSO BEEN NEGATIVE.

(D) ON MAGNETIC HEADING 045° IN FIG.12(A) THE DEVIATION DUE TO P AND cZ WILL BE 5° SIN 45°, $= 5^{\circ} \times 0.7 = 3.5^{\circ}$, AND SO ON THROUGH OUT THE 360 DEGREES.

3.5.5 (A) REFERRING AGAIN TO FIG.12(A) IT WILL BE SEEN THAT THE DEVIATION ON 090° IS $+5^{\circ}$ BUT ON 270° IT IS -5°. IF THE DEVIATION WAS DUE TO HARD IRON EFFECTS (P) ONLY THEN FIG.10 WILL SHOW HOW THIS REVERSAL OF SIGN HAS OCCURRED. ON 090° THE ISOLATED POLE (B) IS TO THE RIGHT, OR EAST OF THE RED POLE OF THE COMPASS NEEDLE WHEREAS ON 270° (B) IS TO THE LEFT, OR WEST OF THE NEEDLE. HENCE THE DIRECTION, AND THEREFORE THE SIGN, OF THE DEVIATION HAS CHANGED ON 270°.

(B) REMEMBER ALSO THAT SIN $270^{\circ} = -1$. THE EFFECT OF P + cZ HAS THE SAME REACTION ON THE COMPASS NEEDLE WHEN THE RESULTANT GIVES AN ISOLATED BLUE POLE FORWARD. TO CALCULATE COEFFICIENT B, OBTAIN THE DEVIATION ON 090° ADD IT ALGEBRAICALLY TO THE DEVIATION ON 270° WITH THE SIGN OF THE LATTER DEVIATION CHANGED (SIN $270^{\circ} = -1$) AND DIVIDE THE RESULT BY 2. HENCE -

$$\text{COEFFICIENT B} = \frac{\text{DEV. ON E} - \text{DEV. ON W}}{2}$$

FROM FIG.12(A) : COEFFICIENT B $= \frac{+5^0 - (-5^0)}{2}$

$= \frac{+5^0 + 5^0}{2} = +5^0$

THIS METHOD OF CALCULATING COEFFICIENT B CANCELS OUT ANY EFFECT WHICH COEFFICIENT A MAY HAVE HAD ON THE FIGURES CONCERNED.

NOTE THAT IN METHOD 2 OF PARAGRAPH 1.7, BY REMOVING ALL B ON EAST AND HALF OF IT ON WEST THE SAME RESULT HAS BEEN ACHIEVED AS BY USING THE COEFFICIENT METHOD.

3.5.6 EFFECT OF COMPONENT Q

(A) ASSUMING Q IS POSITIVE THEN ITS EFFECT IS THAT OF AN ISOLATED (B) POLE TO STARBOARD OF THE COMPASS. THE DEVIATING EFFECT OF +Q THROUGH THE CARDINALS AND QUADRANTALS WILL BE AS SHOWN IN FIG.13.

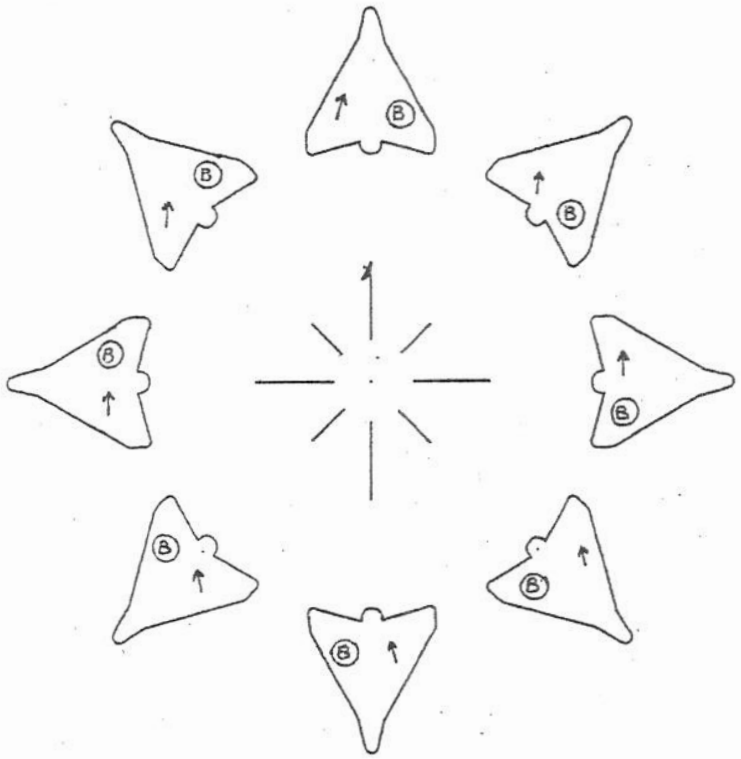

FIG.13

3.5.11 If now the effect of A is corrected by rotating the compass bowl, the effect of B corrected by adjusting the E - W corrector, the effect of C corrected by adjusting the N - S corrector, then the only deviating forces left are those due to D and E. As these are normally not corrected in an aircraft, the final deviation card in the aircraft is a record of the deviation present due to D and E. If the deviation due to A, B and C is removed from Fig.15 the final deviations present will be as shown in Fig.16.

RESIDUAL DEVIATIONS

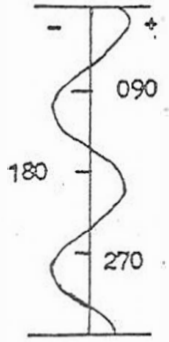

Fig.16

3.5.12 In correcting for coefficients B and C by adjusting the corrector magnets, magnetic fields have been introduced acting at the compass position. The resultant force of these fields is such that it opposes and neutralizes the deviating force that gave rise to coefficients B and C.

3.5.13 (a) If, following correction for coefficients A, B and C, it is found that large residual deviations are present, these will be due to soft iron magnetism. Action will then have to be taken to locate the offending material and prevent it from influencing the compass.

(b) Coefficients D and E are calculated thus:

$$D = \frac{(\text{Dev.NE} - \text{Dev.SE} + \text{Dev.SW} - \text{Dev.NW})}{4}$$

$$E = \frac{(\text{Dev.N} - \text{Dev.E} + \text{Dev.S} - \text{Dev.W})}{4}$$

SPECIMEN OF COMPLETED FORM

(REFER PART B, PARA 1.9, PAGE 13)

A/C REGISTRATION ZK— ABC
A/C TYPE Cessna 180 REASON Routine
COMPASS E2
SER. Nr 1347 DATE 2/4/68
BASE Nowra
Signature: J. Doe LIC. Nr 123

APP. HDG	COMP. HDG	MAG. HDG	DEV.
N	003	359	-4
E	085	091	+6
S	170	178	+8
W	265	267	+2

$C = \frac{(-4)_N \cdot (+8)_S}{2} - \frac{-12}{2} = -6$

MCR 176

$B = \frac{(+6)_E \cdot (+2)_W}{2} - \frac{+4}{2} = +2$

MCR 263

			RES. DEVS
NW	316	317	+1	-2
N	358	000	+2	-1
NE	042	047	+5	+2
E	089	093	+4	+1
SE	134	135	+1	-2
S	177	179	+2	-1
SW	220	225	+5	+2
W	269	273	+4	+1

$A = \frac{+24}{8} = +3$

FOR	STEER
000	001
045	043
090	089
135	137
180	181
225	223
270	269
315	317

NOTE—1. MCR = MAKE COMPASS READ
2. REASON = e.g. ENGINE CHANGE; ROUTINE; ETC.

DATE: 2/4/68 Signature: J. Doe LIC. Nr 123

FOLD HERE

FOR	STEER
000	001
045	043
090	089
135	137
180	181
225	223
270	269
315	317

EXPIRY: 2/4/69

COMPASS SWING
AIRCRAFT LOG BOOK CERTIFICATE

A/C REGISTRATION ZK— ABC
TYPE Cessna 180 SER. Nr 1347
COMPASS E2
BASE Nowra
REASON Routine
Signature: J. Doe
DATE 2/4/68 LIC. Nr 123
EXPIRY: 2/4/69

FOR	STEER
000	001
045	043
090	089
135	137
180	181
225	223
270	269
315	317

(B) ON 000° AND 180° HEADINGS THE EFFECT OF +Q, DEVIATION-WISE IS MAXIMUM, WHILST ON 090° AND 270° IT IS ZERO WITH INTERMEDIATE VALUES ON THE QUADRANTALS. ON NORTHERLY HEADINGS +Q WILL GIVE EASTERLY, OR POSITIVE DEVIATIONS WHILST ON SOUTHERLY HEADINGS IT WILL GIVE WESTERLY, OR NEGATIVE ONES. A -C WOULD OF COURSE GIVE THE REVERSE OF THIS.

3.5.7 EFFECT OF COMPONENT fZ

(A) IF fZ IS +, ITS EFFECT IS THAT OF AN ISOLATED B POLE TO STARBOARD OF THE COMPASS AND THIS EFFECT WILL OBVIOUSLY BE SIMILAR TO +Q. FIG.14(A) AND 14(B) SHOW GRAPHICALLY THE EFFECTS OF +Q + fZ AND -Q + fZ RESPECTIVELY.

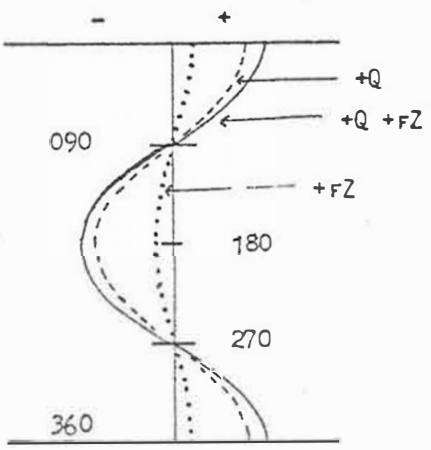

FIG.14(A)

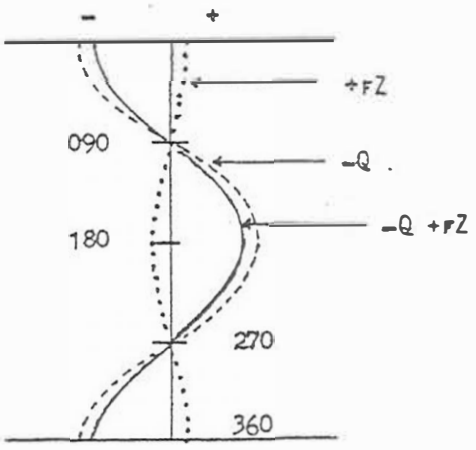

FIG.14(B)

(B) THE DEVIATION CURVES IN THE ABOVE FIGURES ARE A FUNCTION OF THE COSINE OF THE HEADING ANGLE AND THE ACTUAL VALUE, IN DEGREES, OF THE DEVIATION ON ANY HEADING IS GIVEN IN THIS CASE (Q AND fZ) BY THE PRODUCT OF THE COSINE OF THE HEADING ANGLE AND A COEFFICIENT. THIS COEFFICIENT IS NOMINATED C. COEFFICIENT C IS CALCULATED FROM:

$$\text{COEFFICIENT C} = \frac{\text{DEV. ON N} - \text{DEV. ON S}}{2}$$

THIS METHOD CANCELS OUT ANY COEFFICIENT A WHICH MAY HAVE BEEN PRESENT.

3.5.8 EFFECT OF COMPONENTS aX AND eY

THE RESOLVED SOFT IRON COMPONENTS aX AND eY WILL GIVE RISE TO DEVIATIONS WHICH ARE MAXIMUM ON QUADRANTAL AND ZERO ON CARDINAL HEADINGS. THE COEFFICIENT ASSOCIATED WITH THIS MAGNETISM IS CALLED COEFFICIENT D.

3.5.9 EFFECT OF COMPONENTS bY AND dX

(A) THESE COMPONENTS CAN GIVE RISE TO SOMEWHAT COMPLICATED DEVIATIONS IN THAT THEY MAY CONSIST OF A PORTION THAT IS CONSTANT ON ALL HEADINGS, AND A PORTION THAT VARIES AS THE COSINE OF TWICE THE HEADING ANGLE. THE COEFFICIENT ASSOCIATED WITH THE VARIABLE DEVIATION IS COEFFICIENT E AND THAT ASSOCIATED WITH THE CONSTANT PORTION IS COEFFICIENT A.

(B) HOWEVER, COEFFICIENT A MAY NOT ONLY BE DUE TO SOFT IRON MAGNETISM BUT ALSO TO OTHER CAUSES SUCH AS THE COMPASS CARD BEING DISPLACED RELATIVE TO THE MAGNET SYSTEM, INCORRECT ALIGNMENT OF THE COMPASS WITH THE FORE AND AFT AXIS OF THE AIRCRAFT, CHANGE OF VARIATION SINCE CALIBRATION WHEN A COMPASS BASE IS USED FOR SWINGING.

(c) Coefficient A due to soft iron magnetism is known as "Real A", and that due to other causes is called "Apparent A". In practice it is impossible to differentiate between the two and correction is made for "Coefficient A". Its value is calculated by:

$$\text{Coefficient A} = \frac{1}{8}\ (\text{Dev.N} + \text{Dev.NE} + \text{Dev.E} + \text{Dev.SE} + \text{Dev.S} + \text{Dev.SW} + \text{Dev.W} + \text{Dev.NW})$$

+A gives Easterly or + deviation, whilst −A gives Westerly or − deviation.

3.5.10 Combined Effect of Deviating Forces

(A) The components of the various deviating forces can be grouped according to their effects on the compass needle as −

(I) (1) bY and dX of form $E \cos 2\theta$
(2) bY and dX " " A

(II) P and cZ of form $B \sin \theta$

(III) Q and fZ " " $C \cos \theta$

(IV) aX and eY of form $D \sin 2\theta$

Where θ is the compass heading angle and A, B, C, D and E are the coefficients representing the magnitudes of the deviations caused by their associated components.

(B) The combined effect of these forces is shown graphically in Fig.15(F). Graphs of the individual deviations shown in Fig.15(A), (B), (C), (D), (E) are combined in (F). For convenience positive coefficients have been assumed.

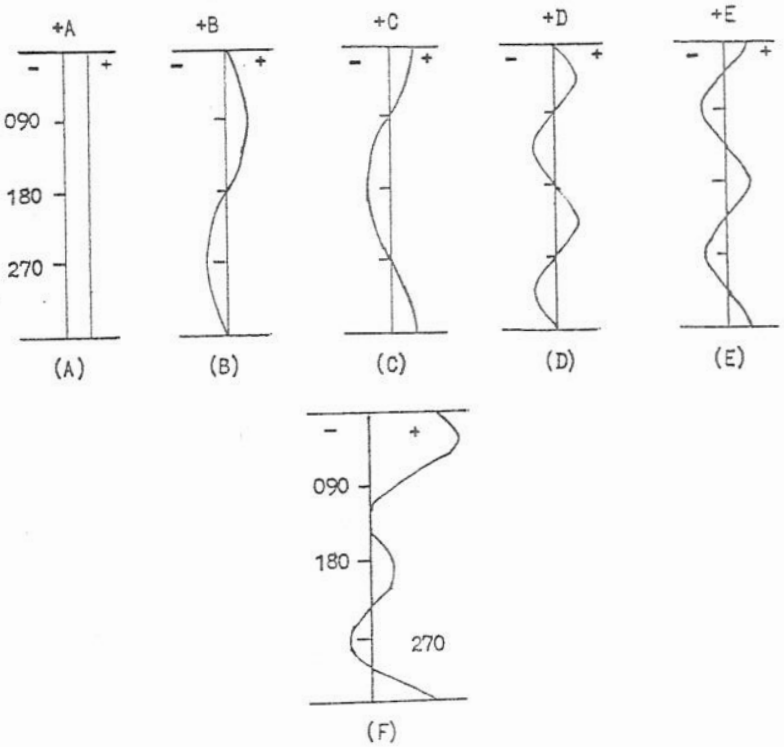

Fig.15