SECTION 5

INSTRUMENTS

Chapter 5.1 Instrument Repairs

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INSTRUMENT REPAIRS

General

The repair and adjustment of flying instruments is a matter for an Instrument Repair Laboratory, in general, since a fairly large quantity of test equipment is required. However, there are a few simple checks that can be carried out with relatively uncomplisated apparatus. These checks can be used to indicate whether or not the instrument is serviceable. If the instrument is shown to be unserviceable, then it can be returned to an Instrument Laboratory for attention.

The failure in flight of, say, an altimeter in a powered aeroplane can well result in the machine flying into a mountain, with the loss of all on board. The same is not true of the failure in flight of the altimeter of a glider. In this case, the flight may well come to an earlier landing than the pilot had anticipated, but this is the worst that can be expected. In fact it can be said that, apart from the A.S.I., the instruments in a glider are not directly a safety matter. The A.S.I. is excepted from this, since it is clearly essential, if the machine is to be operated within its speed limitations, that the A.S.I. really does give a correct reading throughout the permitted speed range of the machine. Possibly we could also include, to a minor extent, the Altimeter, since we do rely on this instrument to indicate the various levels of Controlled Airspace. To this end, it is particularly important that the millibar subscale is correctly set with regard to the main movement of the instrument.

Blind-Flying Instruments

Artificial Horizons are specialist jobs. They really can only be checked, repaired and overhauled in an Instrument Laboratory. The same is true of the **Turn and Slip Indicator**, except that it is quite a simple job to desensitize one of these instruments for glider use. Normally, these instruments are designed for use in powered aircraft, and if they are fitted into gliders with no modification, it is found that they are far too sensitive; i.e., they indicate full scale turn when the glider is performing a fairly gentle turn. Though there is no generally agreed standard for gliders, what is needed is an instrument which indicates full scale turn at a rate of turn which is greater than is ever likely to be used for circling. This means desensitizing the instrument, and is quite easily carried out. The Turn and Slip Indicators used in gliders are nearly all electric, and are driven from dry batteries. They consist of a gyro, with its axis athwartships in the glider, and the cage carrying the gyro is pivotted in the fore and aft direction. The cage is restrained by a spring, and the process of desensitizing the instrument simply consists of increasing the tension of this spring. The manner of accomplishing this varies with different types of instrument, but is usually obvious when the case of the instrument is opened.

Altimeters

To check an altimeter does require an altitude chamber and some means of exhausting the air from it. Provided that this equipment is available, with a mercury manometer to measure the pressure in the altitude chamber, the actual process of checking the altimeter is quite straightforward. Place the instrument in the altitude chamber and check the error against the mercury manometer up to the full scale reading of the altimeter. The permissible error varies with the type of instrument.

When satisfied that the movement of the instruments is accurate to within the permitted limits, the next step is to check that the millibar subscale is correctly set. In all altimeters, there is a small screw near the subscale setting knob, and this enables the connection between the movement and the subscale to be disconnected. To set the subscale; set the movement of the altimeter to read zero feet, with the connection between the movement and the subscale disconnected. Now set the millibar to read the actual ambient pressure, and, finally, reconnect the subscale to the movement without altering the setting of either.

Air Speed Indicators

The A.S.I. is the one instrument in a glider which does bear directly on its safety in flight. This is because the A.S.I. is the only indication that the pilot has of his actual speed and, unless the indications of the A.S.I. are correct, it is quite possible that he may exceed the speed limitations of the glider unwittingly. The dangers of this do not need elaborating.

It is perfectly simple to check an A.S.I. against a water manometer, and it ought not to be too difficult for any repairer to make up his own manometer. All that is needed is a pair of glass tubes connected to form a U tube manometer, and suitable rubber tubing to connect the A.S.I. to one limb, and some form of applying pressure to the limb. A scale behind the U tube completes the apparatus. The scale may be made up using the law that the pressure in lb./sq. feet equals $\frac{1}{2} \times$ density in slugs $\times$ velocity^2 in ft./sec. This is $\frac{1}{2} \times \cdot 00237 \times V^2 \times 12/62{\cdot}4$ when translated into inches of water. As an example, let V equal 40 kts. This is 67·5 ft./sec. Then the pressure in inches of water for this speed is $\frac{1}{2} \times \cdot 00237 \times 67{\cdot}5^2 \times 12/62{\cdot}4$, and this works out to 1·04 inches of water. Substituting other values for V, it is quite easy to build up a scale. In general, it is as well to construct a manometer capable of measuring up to about 150 kts. or more, since we now have gliders with permitted speeds of this order.

Strictly speaking, the formula $\frac{1}{2} \times$ density $\times V^2$ is not quite accurate, but for the speeds that we are concerned with, the error is negligible. When testing an A.S.I., there should not be appreciable friction in the movement, that is to say that the reading should be sensibly the same whether made on a rising, or falling, sequence. To be acceptable, the maximum error must not exceed 2 knots.

Compasses

All compasses are fitted with some sort of adjustment, or corrector, to reduce the deviation to a minimum. This is sometimes a small box in which magnets can be inserted, but more usually these days the corrector consists of a mechanism by which two pairs of magnets can be rotated by a key so as to cancel each other out, or to work together. One pair work in the North-South direction and the other pair in the East-West. Compasses should be adjusted periodically and the deviation recorded on a deviation card which is displayed in the cockpit beside the compass. This process is known as "Swinging the Compass".

Before attempting to swing the compass, a few checks should be made. First, take a small piece of steel, and, bringing this close to the compass, deflect the needle some ten degrees or more. Remove the piece of steel and watch the behaviour of the needle. It should return to within one degree of its original position. A greater error than this indicates an unacceptable amount of friction and the compass should be sent for overhaul. Next, check the effect of switching on any of the electrics in the glider, blind flying instruments, radio, etc. If any of these have more than one degree change in the compass reading, efforts should be made, by repositioning the compass, or rerouting the cables, to reduce the effect to one degree. If this proves impossible, then the compass should really be swung twice; once with the offending electrics "on" and once with them "off", and the difference recorded.

To swing the compass proceed as follows: take the glider at least 100 yards from any buildings or vehicles, or in fact anything that could affect the earth's magnetic field. Now remove from your pockets any ferrous material, and examine the glider to make sure that no stray ferrous material is in the cockpit or anywhere in the glider where it could affect the compass. All stray ferrous material should be removed 100 yards away, but do see that the glider is in the "flight" state, i.e., tool kits and derigging tools must be in their usual positions as for flight, barograph in place, etc.

Some means of lining the glider up on the various points of the compass will be needed, and this can be a compass base marked out on the ground, if you have one, or more usually it is done by the use of a hand bearing compass. If using the hand bearing compass, sight over the fin to line the glider up, but keep the hand bearing compass at least 20 yards away from the glider at all times.

Whichever method is used to line the glider up, the next step is to line the machine up exactly on magnetic North, East, South and West, and to record the compass readings. Let us assume that these are N.015, E.097, S.186, W.285. Now the first thing to note is that we can eliminate a lot of this error simply by correcting the position of the lubber line of the compass relative to the centre line of the glider. Add up the total errors and divide by four. This gives us plus 15, plus 7, plus 6, plus 15, total 43, and this divided by four gives us 10·75, or about eleven. (Had any of the errors been less than the correct reading the error would have been minus instead of plus.) Therefore, if we loosen the compass mounting and rotate the whole compass eleven degrees anti-clockwise, so as to reduce all the readings by eleven degrees, we can reduce the errors to the following: N.004, E.086, S.175, W.274.

Now, using the North-South corrector, twist the key until the errors are a minimum on North and South. In the case above, we ought to be able to get the N. reading to about 359 while the South reading comes up to nearly 180. Next, using the East-West corrector, do the same on this key to reduce the East-West errors to a minimum. In this case above we ought to be able to get the readings down to 090 and 270.

Finally, set the machine up again on the compass base, or line it up with the hand bearing compass on North, North East, East, etc., all the way round the compass, and record the deviation on each reading. Make out a deviation card and mount this beside the compass in the cockpit. Make sure that you date, and sign, the deviation card.

The above case is perhaps a somewhat idealised one. It must be realised that the deviation is caused by many stray fields and that it is only an approximation to try to correct them out in the North-South and East-West directions. Correcting in the North-South direction will possibly have a very small effect in the East-West direction and *vice versa*, so on the final check it may be found that a second correction in one of the correctors is possible.

If the compass is of the old fashioned type with a corrector box below the magnet system, it may be found that the corrections have to be made by inserting small magnets into two small tubes, one fore and aft, and the other athwartships, but the effect is exactly the same as manipulating the key on the corrector. By the way, you must use the proper key for this job. These keys are specially made of non-magnetic material, and any attempt to adjust the correctors with any sort of tool is to invite trouble.

Treat compasses gently, and this really applies to all instruments. Compass pivots are very delicate, and if the fine points are damaged, the result soon shows up as increased friction.

Variometers

At the present time there are two basic types of variometer, the electric, and the mechanical. As regards the electric type, unless you happen to be an expert instrument mechanic, any malfunctions should be dealt with by the makers. The instruments are delicate affairs and are easily damaged. The Cook and the Crossfell are the two most widely known electric variometers. Mechanical variometers are of many types. In general, again, these should be overhauled when necessary by an instrument laboratory, as the movements are very delicate. However, there are a few troubles with these things that can be dealt with quite easily. The first enemy of all these instruments is damp. Sticking of the indicator, needle or pellet, is the first sign, and the instrument should be removed and placed in a dry, warm environment for a few days. Protect from dust, and frequently you will find that the trouble is cured.

All the mechanical variometers are simply flowmeters measuring the rate of flow of air into, or out of, a capacity. The flows are quite small, and therefore the instruments have to be very delicate, and care must be taken to prevent the ingress of dust into the mechanisms.

It is not at all a difficult matter to calibrate variometers, provided that you have an altitude chamber available. Put the variometer to be calibrated into the chamber and start up the evacuating pump. Adjust the rate until the variometer reads, say, 3 ft./sec., or 1 knot, or any suitable reading. Now, keeping the variometer indication constant, time the actual climb over a range of about 1,000 feet. Repeat this for other readings of the variometer. You then have a direct comparison between the variometer readings and the actual times of the climbs and descents. It is best to do this calibration repeatedly up and down, in the first two thousand feet of the "atmosphere" and not to try to calibrate the instrument at high altitudes. All variometers tend to read low, i.e., register less than the actual rate, the higher the actual altitude, and they are designed to read correctly at sea level. However, if you are in the habit of flying to great heights in a glider, it is not a bad plan to calibrate your variometer at several levels, say, sea level 10,000 feet, 20,000 feet, so that you do know what the readings actually mean at these heights.