REPORT No. 8.

GENERAL SPECIFICATIONS COVERING REQUIREMENTS OF AERONAUTIC INSTRUMENTS.

By The NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS.

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INTRODUCTION.

For the information of those concerned with the use or production of instruments used in the navigation and operation of aircraft, the following general list and specifications have been prepared with a view to indicating the lines on which development is required, and the restrictions and difficulties to be overcome in the design and construction of aeronautical instruments:

Barometer or altimeter.
Compass.
Air speed meter.
Inclinometer.
Drift meter.
Tachometer.
Oil gauge.
Oil pressure gauge.
Gasoline gauge.
Gasoline flow indicator.
Distance indicator.
Barograph.
Angle of attack indicator.
Radiator temperature indicator.
Gasoline feed system pressure indicator.
Sextant.
Airplane director.

GENERAL REQUIREMENTS.

All indicating instruments required in the navigation of aircraft should be as compact, rugged, and light as is consistent with accuracy, reliability and durability, and with ease of reading. Such instruments must be free from the influence of the following disturbing effects, excepting, of course, those effects on which they depend for their operation, viz, vibration, change of altitude and change of temperature.

BAROMETER OR ALTIMETER.

Barometers or altimeters must be sensitive and of open scale, and the lag in their operation should be the absolute minimum obtainable. When operating in a fog it is essential that the distance above the surface should be known within very close limits. Such instruments, of course, are dependent on barometric pressure and on varia-

tions of barometric pressure from the time of the start of a flight until the completion of a flight, which can not be provided for, but aside from this error their indications should be substantially accurate once they are adjusted at the point of departure. It is, therefore, necessary that the scale should be of equal divisions, as otherwise a change of zero to meet change of barometric height will introduce an error. Their location on the airplane must be carefully chosen so that their indications will not be influenced by the velocity pressures in flight.

COMPASS.

Compasses should have as high a directive force as is consistent with restricted dimensions. Provision should also be made in the compass mounting for compensating for the presence of magnetic material in the construction of the airplane, particularly compensation for heeling and dipping errors. In order that the directive force shall not be abnormally reduced by such compensation, it is, of course, desirable that the structure should avoid the use of magnetic materials in moving parts near the compass location, such as the control columns, shafts, and leads.

AIR SPEED METER.

An air speed meter should indicate reliably the speed through the air, and should be free from the effects of accelerations, as when the machine is banking strongly in a turn the effect of gravitation is augmented by the presence of the centrifugal force. As the sustaining power of an airplane is dependent upon the density of the atmosphere, it is considered that air speed meters which are dependent on the pressure due to velocity will be a safer form of indicator than a true anemometer type.

It is essential that the indicators shall be particularly sensitive and have an open scale reading at velocities approaching a stalling speed, which is the lower limit of safe flying speed. It is also necessary that they should indicate high speeds accurately, in order that excessive speed may be avoided when gliding. Excessive speed in gliding involves danger when a machine is brought up too sharply, as the combination of high speed and the maximum lift factor may readily stress the machine beyond safe limits. Also, when flying at high speed the angles of attack are small, and there is danger of the airplane entering a critical condition in which the flow of air may develop radical changes of state, and consequently great changes in the lifting power available. Air speed meters should be capable of calibration immediately prior to a flight. Air speed meters of the Pitot type dependent on a fluid are subject to gravitational errors when banking. They are also subject to error due to heeling or diving. Unless the leads from the Pitot tube to the indicating instruments are sufficiently large, there is also danger of a serious lag in indications.

INCLINOMETER.

Inclinometers of the pendulum or spirit-level type are inaccurate in the presence of accelerations and are only useful as a general check as to the attitude of the machine when flying in a fog. It is very desirable that an indicator free from these defects should be devel-

oped. A gyroscopic base line is considered desirable not only for purposes of indicating inclination but as affording a base line for sighting and for the use of instruments of navigation.

DRIFT METER.

Drift meters are of two types—one designed for the purpose of indicating leeway over the surface for use in connection with navigation, and the other more properly termed "side slip indicator" for the purpose of indicating whether or not the machine is flying square to the wind. The latter designation is considered preferable for indicating the attitude of the machine. For navigating over the ground the course is readily determined by ascertaining the apparent motion of objects on the surface, and the same method is available for navigating over the water, provided there is a definite object on which to sight. One type of drift meter indicates by the streaking of waves across the objective glass of the instrument as apparent drift, but as the particles of the waves themselves which indicate this streaking have a velocity of their own, such indications are subject to error. If the surface wind direction or velocity were known, correction might be made, but when flying at an altitude of several thousand feet it is very likely that the airplane itself may be in an entirely different current of air than that present at the surface. In addition to this, tidal currents may also affect the velocity of the water particles. Two forms of side slip indicators exist, the simplest form being that of the well-known string or pennant, but the latter can not be used satisfactorily in the wake of a tractor propeller. The other type consists of a very sensitive pendulum which indicates whether or not lateral accelerations are present, as will be the case for a machine which is not properly balanced laterally, but such an instrument is subject to the defect that if the machine is side slipping laterally at a constant speed, lateral acceleration is no longer present. It can only be depended on to indicate initial disturbances.

TACHOMETER.

Tachometers should be absolute in their indications, and if electrical should not be subject to disturbances in the conductivity of circuits from any cause, or to deterioration of magnetism of a permanent magnet.

OIL GAUGE.

Oil gauges must definitely indicate the amount of oil present in the crank case.

OIL-PRESSURE GAUGE.

Oil-pressure gauges must accurately indicate the pressure in the oil system and should also indicate that the flow of oil is undisturbed.

GASOLINE GAUGE.

Gasoline gauges should indicate the amount of gasoline available in the main tanks, and should not depend on the visibility of gasoline in a glass tube, as, due to the transparency of gasoline, a full tank and an empty tank would give the same indications. Mechanical indicators are considered preferable.

GASOLINE-FLOW INDICATOR.

Gasoline-flow indicators should depend on mechanical means of indicating that the gasoline is being supplied from the main tanks to the service tanks.

DISTANCE INDICATOR.

For navigation at sea or over unknown country, it is desirable that a record of distance flown through the air should be available. If it were not for the fact that the slip of the propeller depends largely on the load of the machine, and whether or not the machine is climbing or gliding, an engine counter would serve this purpose, but it is considered preferable to have a counter or recorder actuated by an anemometer for this purpose. In either case, actual distance over the surface will require correction for the wind velocity and direction.

BAROGRAPH.

Barographs are subject to the same general specifications as altimeters.

ANGLE OF ATTACK INDICATOR.

An angle of attack indicator should be dead beat, free from the effects of gravitation, and accurately respond to and indicate any change of the direction of flow of air to the supporting surfaces. It should be light, rugged, and its indications should be clearly legible to the pilot. It should be designed for attachment in advance of the wings on a tractor biplane and clear of the influence of the propeller or the body.

RADIATOR TEMPERATURE INDICATOR.

A radiator temperature indicator should be readily inserted in the top of the radiator and should clearly indicate the best operating temperatures. The thermometer should conform to best practice, and the entire instrument be sufficiently rugged to withstand reasonable vibration and shock.

GASOLINE FEED SYSTEM PRESSURE INDICATOR.

Where the gasoline feed is not gravitational, the indications of the pressure available must be accurate. The gasoline feed system pressure indicator must not be affected by vibration or change of temperature. It must have a good scale and a dead-beat action.

SEXTANT.

Sextants should be as light and small as possible commensurate with proper accuracy. A sextant for measuring the altitude of a heavenly body above a horizontal plane without the use of the sea horizon or an artificial horizon would be most desirable.

AIRPLANE DIRECTOR.

An airplane director for the mechanical solution of the course and distance made good, based on the course and speed of the aeroplane and the force and direction of the wind, is a desirable development.