TECHNICAL NOTES.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 64.

N.A.C.A. RECORDING AIR SPEED METER.

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SUMMARY.

A new type of recording air speed meter is described which was designed by the technical staff of the National Advisory Committee for Aeronautics. The instrument consists essentially of a tight metal diaphragm of high natural period which is acted upon by the pressure difference of a pitot-static head. The resulting deflection of this diaphragm is recorded optically on a moving film. A number of records taken by the instrument are shown.

INTRODUCTION.

Air speed in flight has been recorded almost exclusively in France and in this country by the Toussaint-Lepère air speed meter which consists of a recording pen operated by a spring loaded bellows. For very accurate work this instrument has a considerable amount of friction and its natural frequency is so low that it can not be used to record rapid changes in air speed, such as bumps in flight or pulsations in the wind tunnel. The British have constructed a successful recording air speed meter in combination with their Mark II accelerometer, which is of a higher frequency and with less friction than the Toussaint-Lepere instrument.

The N.A.C.A. air speed meter (Fig. 3) was designed with the idea of producing an instrument for recording the absolute air speed in flight with great accuracy and at the same time to have such a high natural frequency that it could be used to study the structure of rapidly changing air flow. As this instrument is of general usefulness in recording pressure difference it was thought that a complete description would be of interest.

DIAPHRAGM CAPSULE.

The pressure difference to be measured is transmitted to either side of a steel diaphragm which is rigidly clamped at the edges between the halves of a circular capsule. As an unstretched diaphragm - due to a trace of concavity which can not be removed - has two points of equilibrium at zero pressure, it was found necessary to warm the diaphragm before clamping in order that it might be normally under a slight tension. It is also essential that the material of the capsule and the diaphragm have the same coefficient of expansion, otherwise the sensitivity will change with the temperature. This capsule and diaphragm is shown in Figs. 1 and 2.

A hardened steel screw passes through the center of the diaphragm and rests against the polished back of the mirror staff. This staff is mounted in a highly polished conical steel socket and is held against the diaphragm screw by a light hair spring. A plane silvered mirror 4 mm. square and .2 mm. in thickness is cemented to the staff. The deflections of the diaphragm are thus converted into a rotary motion of the mirror with very slight friction. The natural frequency of the diaphragm and mirror is about the same as that of a telephone diaphragm - 2000 vibrations per second. This frequency could be made even higher than this if it were desired to use the instrument for studying high pitch sound waves.

OPTICAL SYSTEM

The lamp consists of a special 3.8 volt bulb made especially for this work by the General Electric Company to give a true line source. The light from this lamp passes through a lens to the mirror from which it is reflected back through the same lens to the film as described more in detail in N.A.C.A. Technical Note No. 22. In this instrument the lens was a simple one but better results would be obtained by using a corrected photographic objective.

THE FILM DRUM.

The film is contained in interchangeable daylight loading drums revolving once in two minutes, a detailed description of which is given in N.A.C.A. Technical Note No. 22.

THE DRIVING MOTOR.

The film is moved by an electric motor connected to the drum by a worm drive. This motor was developed, after a considerable amount of experimental work, as the most satisfactory means of driving a drum at a relatively high speed. This motor is of the direct current, series type and is held at constant speed by means of a governor as shown in Fig. 4. This governor will hold the speed to within ±2% of constant for considerable changes in voltage and load. The motor runs on 8 volts, normally taking 1.6 amperes and will reach its normal speed in less than one-half second after closing the switch, with a starting current of 4 1/2 amperes.

PRECISION OF THE INSTRUMENT.

The width of the line traced by this instrument is rather great, 0.010 of an inch, due to the poor quality of the lens. If readings are taken on one edge of the line the sharpness is sufficient to read within 1/1000 of an inch, which will give a precision of 1% when the deflection is only 1/10 of an inch.

In order to determine the hysteresis of this instrument its readings were compared with those of a water column when the pressure was increased and decreased. The difference between ascending and descending curves was nowhere greater than 2% of the maximum reading, and this would undoubtedly be greatly reduced under the condition of vibration which exists on the airplane. For the sake of comparison a similar run was made on a Toussaint-Lepère air speed meter with the pen resting on the paper in a normal manner. In this case the corresponding hysteresis error was 26% of its maximum reading. The two sets of curves are plotted in Fig. 5.

Several records are shown (Fig. 6) which were taken on a JN4H airplane in flight and it will be noted that even the high period bumps are recorded. In Fig. 7 are shown several records taken by speaking into the back of the capsule with the same diaphragm setting but with the drum revolving at a much higher speed. It will be seen that the sound waves are recorded very sharply even though the instrument was not especially lightened for this type of work.

USES FOR THIS TYPE OF INSTRUMENT.

This instrument has been used successfully for recording the air speed in flight and for studying the flow in the wind tunnel, but by putting in other thicknesses of diaphragm it will be possible to use it for studying a large number of aeronautic and automotive problems. For example it could be used to study the pulsations of flow in an intake or exhaust manifold or the character of the sound emitted by various types of mufflers or the sound waves from a revolving propeller. For the latter uses this instrument has the advantage over a number of laboratory instruments designed for recording sound waves, in that it is portable and can be used under conditions of considerable vibration without having its readings affected.

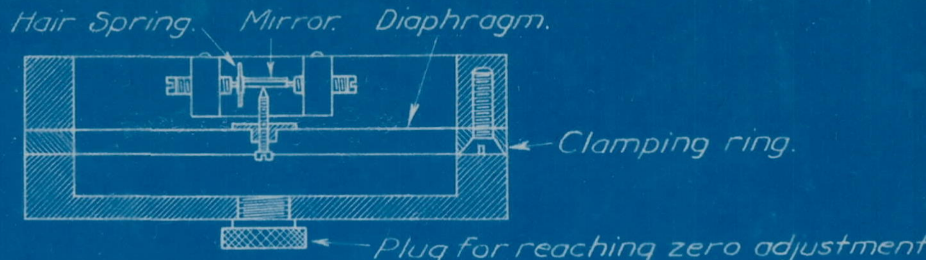

Fig. 2. Section of capsule.

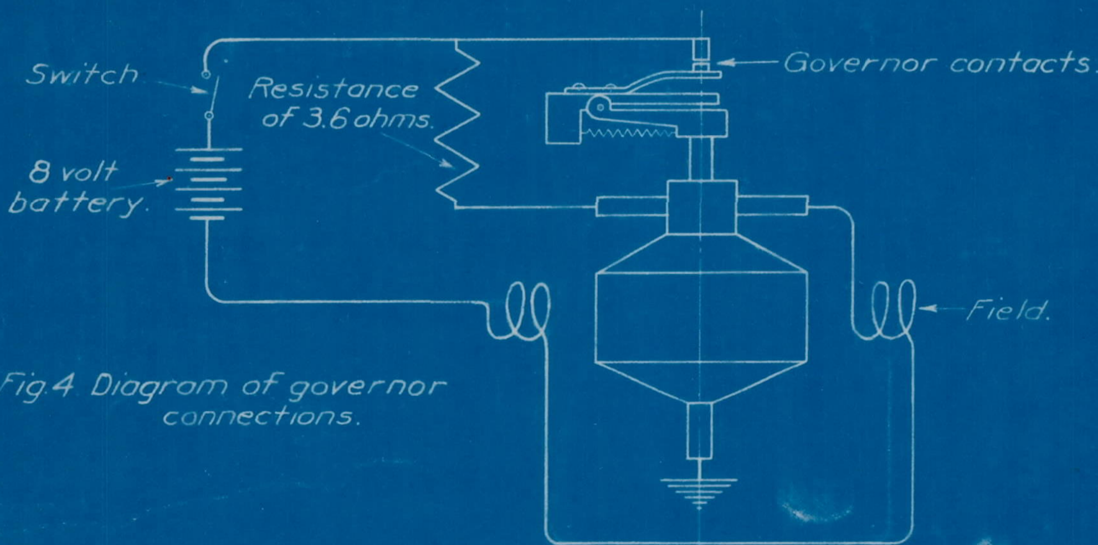

Fig. 4 Diagram of governor connections.

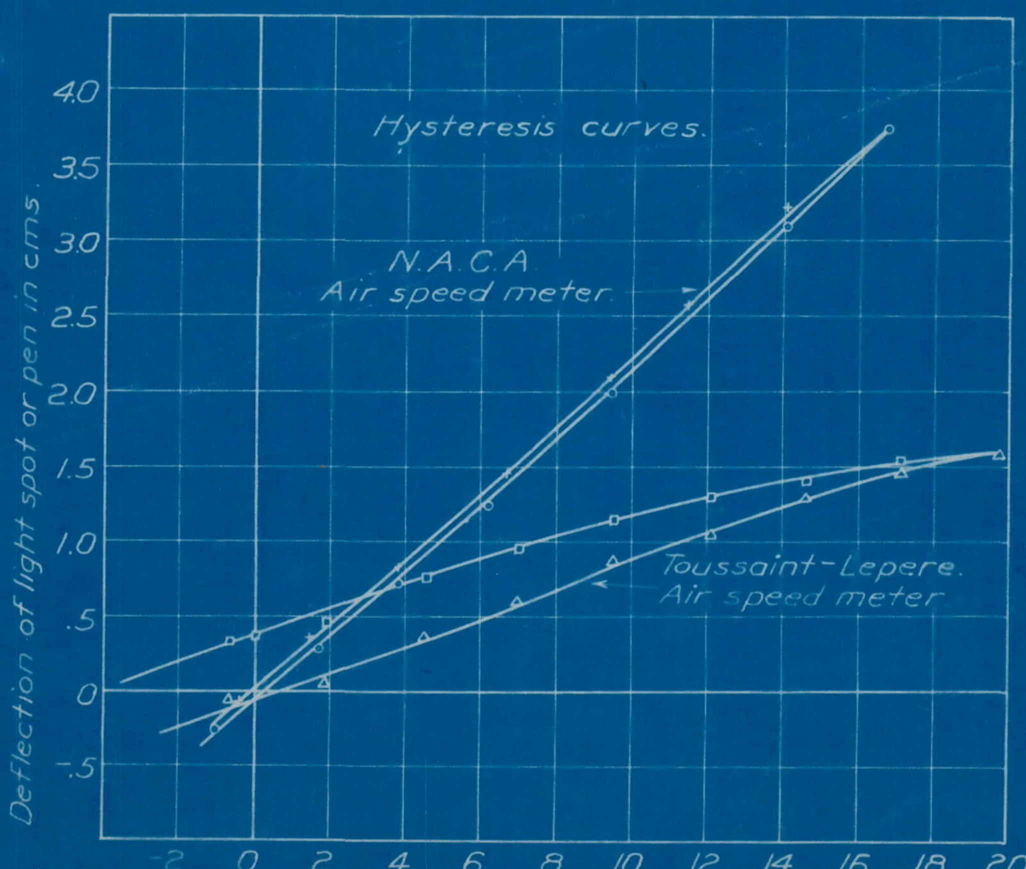

Fig. 5.

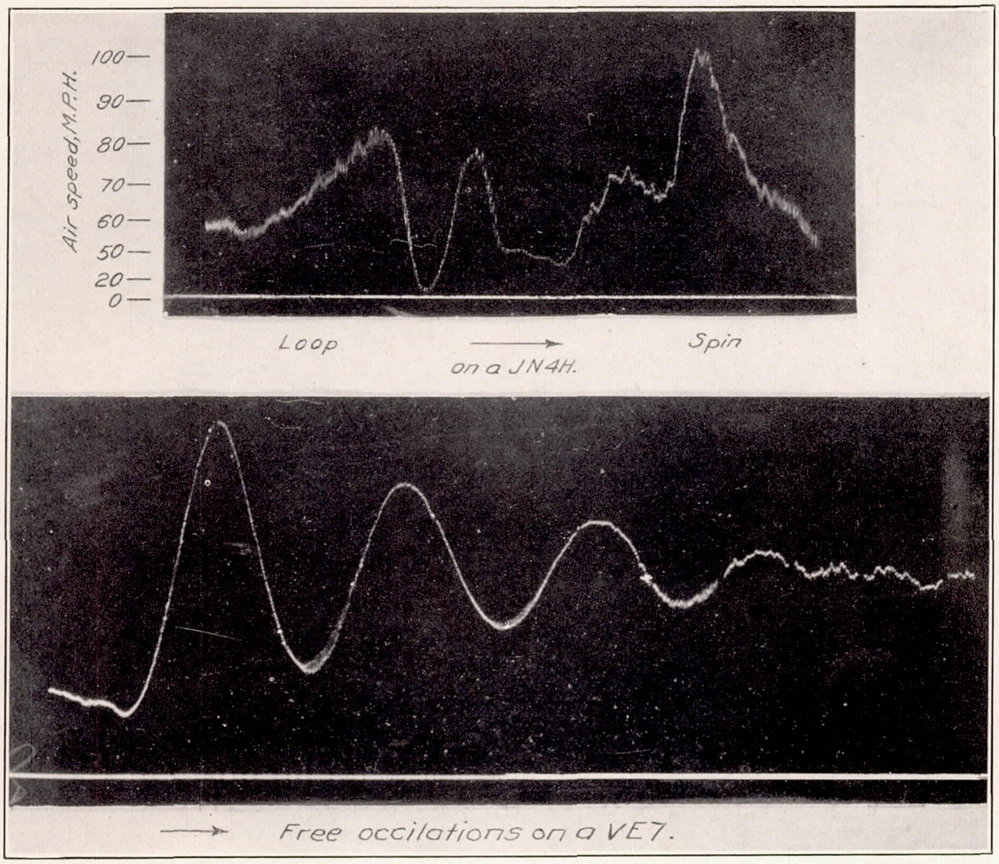

FIG. 6.—SOME RECORDS ON FREE FLIGHT. ONE INCH HORIZONTALLY CORRESPONDS TO 12 SECONDS.

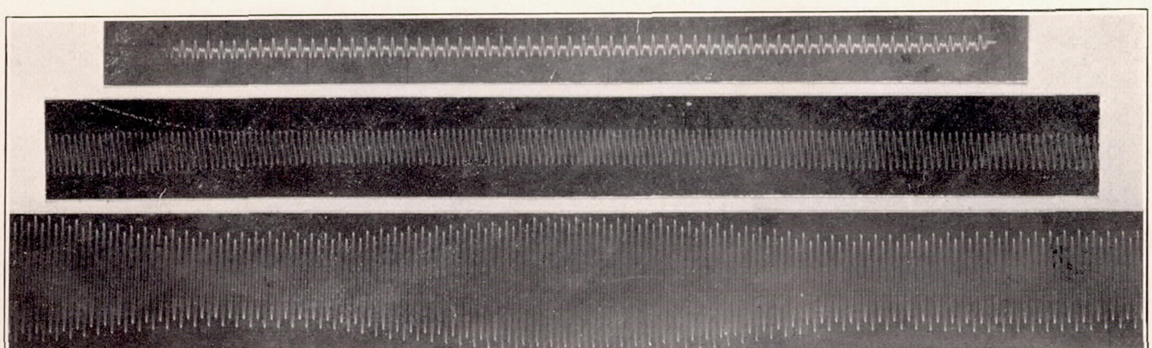

FIG. 7—SOUND WAVES PRODUCED BY THE HUMAN VOICE. ONE INCH HORIZONTALLY CORRESPONDS TO .048 SECONDS.

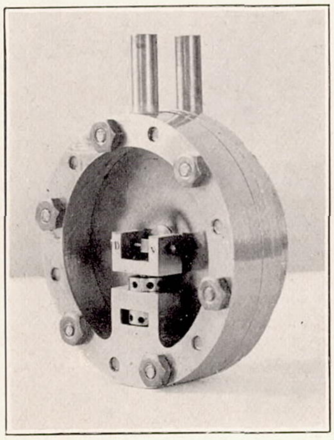

FIG. 1.—CAPSULE AND DIAPHRAGM.

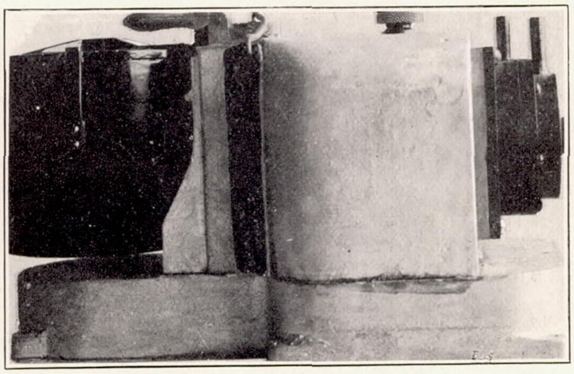

FIG. 3.—THE N. A. C. A. RECORDING AIR SPEED METER.