PATENT SPECIFICATION

Application Date: June 11, 1919. No. 14,743/19. **150,103**

Complete Left: Dec. 11, 1919.

Complete Accepted: Sept. 2, 1920.

PROVISIONAL SPECIFICATION.

A Calculating Instrument for Aerial Navigation Purposes.

I, LEONARD CHARLES BYGRAVE, of 4, Beaumont Avenue, Richmond, Surrey, Captain in the Royal Air Force, do hereby declare the nature of this invention to be as follows:—

This invention relates to an instrument for facilitating calculations which have to be made for the purpose of aerial navigation.

The instrument according to the invention is shown in front and back views respectively in Figs. 1 and 2 of the accompanying drawings.

It consists of three circular discs A, B, C, and an arm D. The discs B and C are smaller than the disc A and are arranged concentrically therewith on opposite sides thereof. The discs B and C and the arm D are pivoted centrally to the disc A so as to be capable of rotation relatively thereto. The arm D is on the same side of the disc A as the disc B.

The part of the front side of the disc A which extends beyond the edge of the disc B is marked with compass bearings in the manner shown.

The disc B is marked with a number of lines parallel to a diameter, which is marked with an arrow, and with a number of circular arcs of the same radius as the disc, whose centres all lie on the diameter at equal intervals apart. The top part of the edge of the disc B near the arrow is marked with compass bearings, while the side parts of the edge and the diameter are marked with figures corresponding to the circular arcs, each of which represents a ground-speed.

The arm D has a straight edge passing over the centre of the disc B and its ends are formed so as to serve as pointers to be used in connection with the bearing marks on the disc A. The straight edge is marked on each side of the centre with a scale of wind-speeds and the arm is marked with arrows to indicate the direction of the wind.

This side of the instrument is used for solving directly vector problems involving wind-speed, air-speed and ground-speed, when the air-speed has some fixed value. In the instrument shown in the drawings this fixed value is 60 m.p.h., but the value will in general be chosen as that of the normal air-speed of the aircraft on which the instrument is to be used.

In such use of the instrument, the arrow on the diameter on the disc B gives on the bearing scale on the disc A the direction of the ground-speed, the magnitude of the ground-speed is given by the length of a line drawn parallel to this diameter to the upper edge of the disc B from the point on the arm D which represents the wind-speed, this arm being put with its edge in the direction of the wind, the air-speed is represented in magnitude and direction by the radius drawn to the point where the parallel line meets the edge of the disc, and the angle of drift of the aircraft is the angle between the diameter marked with the arrow and this radius. The compass course is given on the disc A by the end of the parallel line aforesaid.

An example of this use of the instrument is as follows:—

Find the speed and direction of the wind, when the compass course steered is 25°, the apparent drift of the ground from starboard to port, as obtained by

[*Price* 1/-]

a bearing-plate or drift-bar or otherwise, is 20°, and the measured ground-speed 70 m.p.h.

Set 25 on the bearing scale of the disc A opposite 20 on the left-hand side of the bearing scale of the disc B; turn the wind-speed pointer until its edge passes through the point where the parallel line on the disc B through the graduation 20 cuts the 70 circular arc. The wind-speed is then read off as 25 m.p.h. from W. by N.

The back part of the disc A which extends beyond the disc C and the edge of the disc C are both marked with similar logarithmic scales starting and ending at the same points and having 100 main divisions.

These scales are used in finding the time to cover a given distance at a given ground-speed and for similar calculations involving division or multiplication.

An example of such use is as follows:—

Find the time to cover 242 miles, when the ground-speed is 70 m.p.h.

Set 70 on the outer scale opposite 60 on the inner scale. Opposite 242 on the outer scale 207 minutes can be read off on the inner scale, which is the time required.

The same scales enable the solution of the vector problems to be obtained by using the front side of the instrument even when the air-speed of the aircraft differs from 60 m.p.h. For this purpose, it has only to be remembered that the corresponding sides of two vector triangles having the same angles are proportional one to the other.

The disc C is further provided with a circular slot E, the lower edge of which is provided with a scale of temperatures, while the disc A has a scale of heights which is seen through the slot in register with the temperature scale. These scales are such that the indicated air-speed at a given height and ground-temperature can be converted into the true air-speed, or *vice versâ*.

An example of the use of these scales is as follows:—

At 8,000 feet, what is the true air-speed corresponding to 81 m.p.h. indicated air-speed, the ground temperature being 100° F.?

Set 100 opposite 8 in the slot; then 95 is read off on the outer logarithmic scale against 81 on the inner scale. The required air-speed is 95 m.p.h.

The normal ground temperature is preferably marked in red on the temperature scale and is used in calculations when the actual ground temperature is not known.

The instrument is marked on both sides with lettering and arrows in order to make its use as simple as possible. Such marks are shown on the drawings.

Dated the 3rd day of June, 1919.

L. C. BYGRAVE.

COMPLETE SPECIFICATION.

A Calculating Instrument for Aerial Navigation Purposes.

I, LEONARD CHARLES BYGRAVE, of 4, Beaumont Avenue, Richmond, Surrey, Captain in the Royal Air Force, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to an instrument for solving plane triangles having one side of unit length and particularly suitable for facilitating calculations which have to be made for the purpose of aerial navigation.

The instrument according to the invention comprises a disc graduated with a number of arcs of unit radius and a straight line cursor mounted rotatably on said disc so that the centres of the arcs and the pivot about which the cursor is rotated lie in a straight line. For use in aerial navigation, the instrument is adapted with further discs which rotate about said pivot and are graduated with special registrable marks as hereinafter particularly described and claimed.

The instrument in its complete form for use in aerial navigation is shown in the drawings left with my Provisional Specification.

It consists of three circular discs A, B, C, and an arm D. The discs B and C are smaller than the disc A and are arranged concentrically therewith on opposite sides thereof. The discs B and C and the arm D are pivoted centrally to the disc A so as to be capable of rotation relatively thereto. The arm D is on the same side of the disc A as the disc B.

The part of the front side of the disc

A which extends beyond the edge of the disc B is marked with compass bearings in the manner shown.

The disc B is marked with a number of lines parallel to a diameter, which is marked with an arrow, and with a number of arcs of the same radius as the disc, whose centres all lie on the diameter at equal intervals apart. The top part of the edge of the disc B near the arrow is marked with compass bearings, while the side parts of the edge and the diameter are marked with figures corresponding to the circular arcs, each of which represents a ground-speed.

The arm D has a straight edge passing over the centre of the disc B and its ends are formed so as to serve as pointers to be used in connection with the bearing marks on the disc A. The straight edge is marked on each side of the centre with a scale of wind-speeds and the arm is marked with arrows to indicate the direction of the wind.

This side of the instrument is used for solving directly vector problems involving wind-speed, air-speed and ground-speed, when the air-speed has some fixed value. In the instrument shown in the drawings this fixed value is 60 m.p.h., but the value will in general be chosen as that of the normal air-speed of the aircraft on which the instrument is to be used.

In such use of the instrument, the arrow on the diameter on the disc B gives on the bearing scale on the disc A the direction of the ground-speed, the magnitude of the ground-speed is given by the length of a line drawn parallel to this diameter to the upper edge of the disc B from the point on the arm D which represents the wind-speed, this arm being put with its edge in the direction of the wind, the air speed is represented in magnitude and direction by the radius drawn to the point where the parallel line meets the edge of the disc, and the angle of drift of the aircraft is the angle between the diameter marked with the arrow and this radius. The compass course is given on the disc A by the end of the parallel line aforesaid.

An example of this use of the instrument is as follows:—

Find the speed and direction of the wind, when the compass course steered is 25°, the apparent drift of the ground from starboard to port, as obtained by a bearing-plate or drift-bar or otherwise, is 20°, and the measured ground-speed 70 m.p.h.

Set 25 on the bearing scale of the disc A opposite 20 on the left-hand side of the bearing scale of the disc B; turn the wind-speed pointer until its edge passes through the point where the parallel line on the disc B through the graduation 20 cuts the 70 circular arc. The wind-speed is then read off as 25 m.p.h. from W. by N.

The back part of the disc A which extends beyond the disc C and the edge of the disc C are both marked with registrable similar logarithmic scales, for reading true air-speeds and indicated air-speeds respectively, starting and ending at the same points and having 100 main divisions.

These scales are used in finding the time to cover a given distance at a given ground-speed and for similar calculations involving division or multiplication.

An example of such use is as follows:—

Find the time to cover 242 miles, when the ground-speed is 70 m.p.h.

Set 70 on the outer scale opposite 60 on the inner scale. Opposite 242 on the outer scale 207 minutes can be read off on the inner scale, which is the time required.

The same scales enable the solution of the vector problems to be obtained by using the front side of the instrument even when the air-speed of the aircraft differs from 60 m.p.h. For this purpose, it has only to be remembered that the corresponding sides of two vector triangles having the same angles are proportional one to the other.

The disc C is further provided with a circular slot E, the lower edge of which is provided with a scale of temperatures, while the disc A has a scale of heights which is seen through the slot in register with the temperature scale. These scales are such that the indicated air-speed at a given height and ground-temperature can be converted into the true air-speed, or *vice versâ*.

An example of the use of these scales is as follows:—

At 8,000 feet, what is the true air-speed corresponding to 81 m.p.h. indicated air-speed, the ground temperature being 100° F.?

Set 100 opposite 8 in the slot; then 95 is read off on the outer logarithmic scale against 81 on the inner scale. The required air-speed is 95 m.p.h.

The normal ground temperature is preferably marked in red on the temperature scale and is used in calculations when the actual ground temperature is not known.

The instrument is marked on both

sides with lettering and arrows in order to make its use as simple as possible. Such marks are shown on the drawings.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A calculating instrument for solving plane triangles having one side of unit length comprising a disc graduated with a number of arcs of unit radius and a straight line cursor mounted rotatably on said disc so that the centres of the arcs and the pivot about which the cursor is rotated lie in a straight line, substantially as described.

2. A calculating instrument of the kind claimed in Claim 1, for aerial navigation purposes comprising a larger disc and a smaller disc pivoted at the centre and an arm mounted on the pivot, the larger disc being marked with compass bearings, the smaller disc being marked with parallel lines and arcs, and the arm being marked with a scale of wind-speeds, as described with reference to Fig. 1 of the accompanying drawings.

3. A calculating instrument according to Claim 2 comprising another smaller disc, this latter disc and the larger disc being marked with two similar registrable scales for reading indicated and true air-speeds respectively and with two other registrable scales for reading temperature and height, as described with reference to Fig. 2 of the accompanying drawings.

4. A calculating instrument for aerial navigation purposes comprising three circular discs and an arm pivoted together, two of the discs being smaller than the third and mounted on opposite sides thereof, the arm being formed with a straight edge and pointer ends, and the visible parts of the discs on both sides and the arm on one side being marked, substantially as shown in Figs. 1 and 2 of the accompanying drawings.

Dated the 11th day of December, 1919.

A. C. DAY,
Captain,
Agent for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1920

[This Drawing is a reproduction of the Original on a reduced scale.]

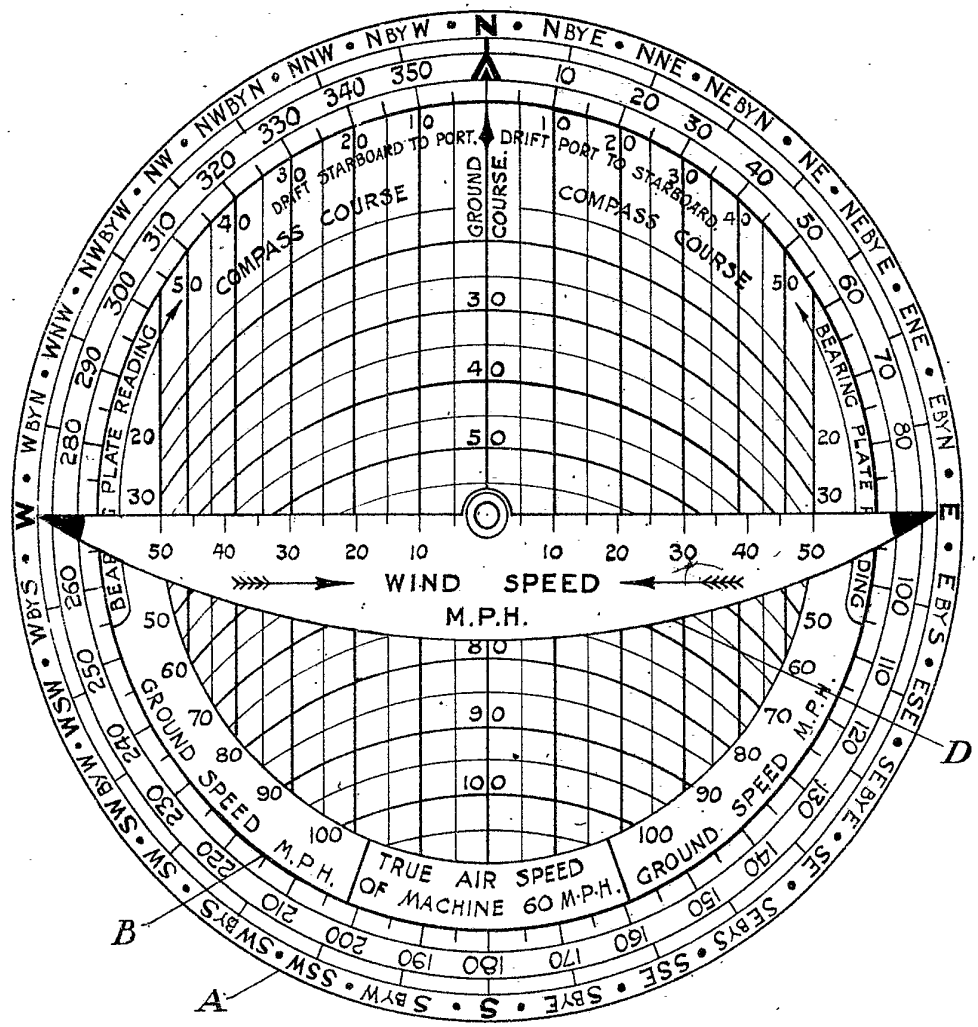

Fig 1.

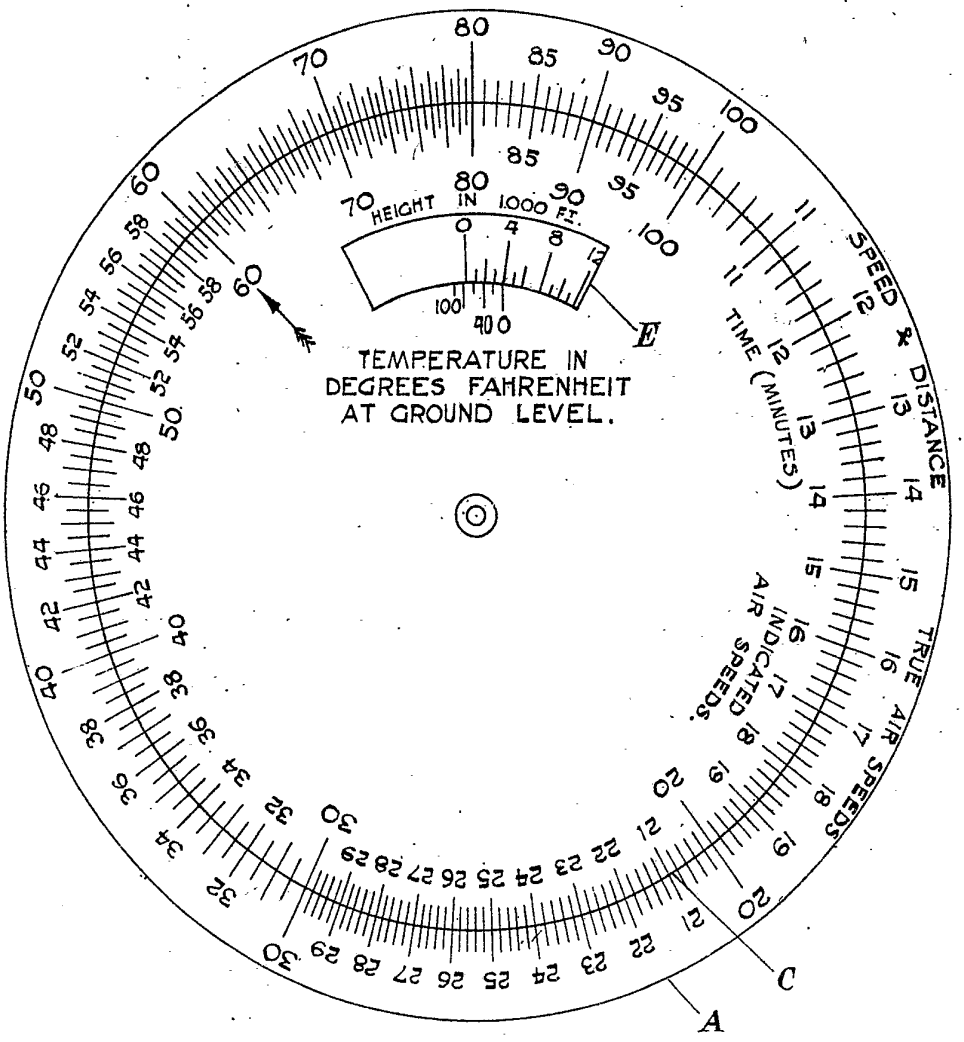

Fig 2.

Malby & Sons, Photo-Litho