No. 471537

GEORGE VI
~~EDWARD VIII~~

BY THE GRACE OF GOD

Of Great Britain, Ireland and the British Dominions beyond the Seas King, Defender of the Faith, Emperor of India: To all to whom these presents shall come greeting:

WHEREAS Carl Joseph Crane, a citizen of the United States of America, residing at 632-B, E. Street, Patterson Field, Fairfield, State of Ohio, United States of America, late of 1320 Farhills Avenue, Dayton, Ohio, United States of America, _____

hath declared that he has made application abroad for protection of his invention of Improvements in or relating to aerial flight instruments _____

and that the said invention was not in use within the United Kingdom of Great Britain and Northern Ireland, and the Isle of Man, by any other person before the date hereunder written of these presents to the best of his knowledge and belief:

AND WHEREAS the said applicant hath humbly prayed that a patent might be granted unto him in priority to other applicants for the sole use and advantage of his said invention:

AND WHEREAS the said applicant (hereinafter together with his executors, administrators, and assigns, or any of them, referred to as the said patentee) hath by and in his complete specification particularly described the nature of his invention:

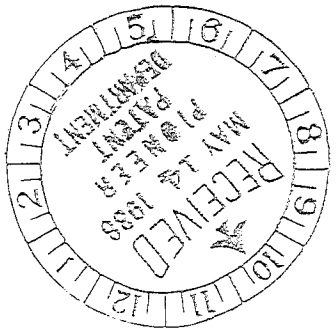
AND WHEREAS We, being willing to encourage all inventions which may be for the public good, are graciously pleased to condescend to his request:

KNOW YE, THEREFORE, that We, of our especial grace, certain knowledge, and mere motion do by these presents, for Us, our heirs and successors, give and grant unto the said patentee our especial license, full power, sole privilege, and authority, that the said patentee by himself, his agents or licensees, and no others, may at all times hereafter during the term of years herein mentioned, make, use, exercise, and vend the said invention within our United Kingdom of Great Britain and Northern Ireland, and the Isle of Man, in such manner as to him or them may seem meet, and that the said patentee shall have and enjoy the whole profit and advantage from time to time accruing by reason of the said invention during the term of sixteen years from the date hereunder written of these presents: AND to the end that the said patentee may have and enjoy the sole use and exercise and the full benefit of the said invention, We do by these presents for Us, our heirs and successors, strictly command all our subjects whatsoever within our United Kingdom of Great Britain and Northern Ireland, and the Isle of Man, that they do not at any time during the continuance of the said term of sixteen years either directly or indirectly make use of or put in practice the said invention, or any part of the same, nor in anywise imitate the same, nor make or cause to be made any addition thereto or subtraction therefrom, whereby to pretend themselves the inventors thereof, without the consent, license or agreement of the said patentee in writing under his hand and seal, on pain of incurring such penalties as may be justly inflicted on such offenders for their contempt of this our Royal command, and of being answerable to the patentee according to law for his damages thereby occasioned:

PROVIDED ALWAYS that these letters patent shall be revocable on any of the grounds from time to time by law prescribed as grounds for revoking letters patent granted by Us, and the same may be revoked and made void accordingly: PROVIDED ALSO, that if the said patentee shall not pay all fees by law required to be paid in respect of the grant of these letters patent, or in respect of any matter relating thereto at the time or times, and in manner for the time being by law provided; and also if the said patentee shall not supply or cause to be supplied, for our service all such articles of the said invention as may be required by the officers or commissioners administering any department of our service in such manner, at such times, and at and upon such reasonable prices and terms as shall be settled in manner for the time being by law provided, then, and in any of the said cases, these our letters patent, and all privileges and advantages whatever hereby granted shall determine and become void notwithstanding anything herein-before contained: PROVIDED ALSO that nothing herein contained shall prevent the granting of licenses in such manner and for such considerations as they may by law be granted: AND lastly, We do by these presents for Us, our heirs and successors, grant unto the said patentee that these our letters patent shall be construed in the most beneficial sense for the advantage of the said patentee.

IN WITNESS whereof We have caused these our letters to be made patent and to be sealed as of the sixth day of March one thousand nine hundred and thirty-five.

M. F. LINDLEY,



PATENT No. 471537

Carl Joseph Crane

Date of Patent 6 March 1935

Date of Sealing 2 DECEMBER 1937
(See Sections 26 and 27 of the Patents and Designs Acts, 1907 to 1932.)

NOTE.—The continuance of this Patent is conditional on the payment (by way of Patents Form No. 14) of the prescribed fees, which, under the Rules at present in force, are :—

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Before the expiration of the 4th year from the date of the patent (*and not from the date of sealing*) and in respect of the 5th year																	5	0	0
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One moiety only of these fees is payable if, and so long as, this Patent is indorsed "Licences of Right"—see Section 24 of the Acts.

As the payment of renewal fees is regulated by Act of Parliament, such fees cannot ordinarily be accepted a *single day* after the due date; but, if the payment has in fact been omitted, application may be made to the Comptroller, on Patents Form No. 15, for an enlargement of time to make such payment, and for this enlargement the fee payable is £2 for one month, £4 for two months, or £6 for three months, *but no enlargement can be allowed beyond three months.*

*** Patents Forms Nos. 14 and 15 may be purchased on personal application at the Inland Revenue Stamp Office (Room No. 28), Patent Office, 25, Southampton Buildings, London. W.C.2. Alternatively, they may be obtained at a few days' notice at any Money Order Office in Great Britain or Northern Ireland, upon prepayment of the value of the Stamp, or may be ordered by post from the Controller of Stamps, Bush House, South West Wing, Strand, London, W.C.2.

(R6615) Wt 15256/2723 3,000 7/36 H & Sr Gp 640

PATENT SPECIFICATION

Convention Date (United States): March 6, 1935.
Application Date (in United Kingdom): March 5, 1936.
Complete Specification Accepted: Sept. 6, 1937.

471,537
No. 6671/36.

COMPLETE SPECIFICATION

Improvements in or relating to Aerial Flight Instruments

I, CARL JOSEPH CRANE, a citizen of the United States of America, residing at 632-B, E. Street, Patterson Field, Fairfield, State of Ohio, United States of America, late of 1320, Farhills Avenue, Dayton, Ohio, United States of America, 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:—

The invention relates to improvements in instruments to facilitate aerial flight, particularly relating to an integrating device and co-related series of indicia in such unitary arrangements as will enable the proper control and flight of an aircraft by "blind" or "instrument" flying.

In accordance with the invention a turn indicating member is operated by a fluid flow means operated in response to the rate of turn of the aircraft on which the instrument is mounted, wherein the member indicates the amount of change of course, and furthermore which may also indicate the direction of turn and in addition the angular velocity of the turn.

The fluid flow means may conveniently constitute a turbine or impeller wheel on to which the fluid is directed in the form of a jet regulated by a vane, the angle of which may conveniently be controlled by a gyroscope responsive to the rate of turn of the aircraft.

In accordance with a further feature of the invention an instrument incorporating such a turn indicating unit is provided with a characteristic but artificial field of view that bears relative movement to angular deviations in aircraft flight about various axes, which will convey to the pilot a direction of turn, as well as the intensity and approximate magnitude of turn; stimulating him with a visual factor which will cause an elimination of the condition of vertigo to which he is subject in the absence of external visual reference when relying entirely on his instruments, as for instance when flying "blind".

It is possible by means of an instrument of this character to inhibit and counteract the illusion of turn in an opposite direction after turning movements, such as tail spin or spiral movement of an aircraft after completion, thus preventing the pilot from erroneously operating the aircraft controls, such as has many times resulted in a fatal second tail spin.

The improved turn indicator may be incorporated together with a bank indicator and a rise and fall indicator in such correlation that the pilot will receive a visual stimulus as a result of the movements of the aircraft to which these various devices are responsive which is similar to the normal flight stimulus.

In the accompanying drawings, wherein similar reference characters designate corresponding parts throughout the several views:—

Fig. 1 is a front view of an instrument according to the invention, which is demountable as a unit and is adapted to be mounted on the instrument board of any type of aircraft.

Fig. 2. is a vertical sectional view taken through the housing of the instrument, on the line 2—2 of Fig. 1 and showing certain operating mechanism therein in side elevation.

Figure 3 is a transverse vertical sectional view taken on the line 3—3 of Figure 2.

Figures 4 and 5 are fragmentary sectional side and plan views of the rise and fall indicator actuating mechanism.

Figure 6 is a detail sectional view of the suction relief valve.

Figure 7 is a fragmentary view of one of the gyroscope rotor mountings.

Figure 8 is a vertical sectional view through one of the gyroscope mountings.

Figure 9 is a front elevation of the turn indicating dial.

Figure 10 is a fragmentary detailed view of the rise and fall indicator yoke guide track, taken substantially on the line 10—10 of Figure 1.

Figure 11 is a front view of the bank indicator drive chain.

Figure 12 is a fragmentary view of the

impeller and its control vane, the view being taken substantially on the line 12—12 of Figure 2.

Figure 13 shows modified forms of control vanes.

Figure 14 is a fragmentary plan view of the impeller.

Figure 15 shows a series of modified forms of individual impeller blades.

Figure 16 is a detail view of the labyrinth packing.

In the drawings the letter A designates the instrument as a whole. The latter includes a primary casing B suitably provided for mounting on the instrument board of an airplane and a secondary casing C fitted into casing B and forming a part of the complete instrument.

The instrument itself is of a cylindrical form except as provided in the flat dome casing D which encloses the rise and fall mechanism and which forms an integral part of the casing B.

The indicating face of the instrument as shown in Figure 1 combines the various indicia for providing the airplane pilot with information of the turn, bank and climb and glide of the airplane to which the instrument may be attached. The indicator 1 for turn, the indicator 2 for bank and the indicator 3 for rise or fall are closely associated in the same field of view to provide the pilot with fatigue reducing means of flight control under conditions of blind flight. This close association of indication indicia in the same field of view also provides the pilot with a substantially identical visual stimulus as is obtained during normal clear weather flight and by means to be described later enables the pilot to inhibit the effects of vertigo which obtain during blind or instrument flight such as in fog.

The indicator 1 for turn is attached and fixed to its shaft 4 which is rotatably mounted in the bearings 5—5¹ of well known construction (such as friction reducing ball bearings). The bearing housing 6 is also provided with a close fitting labyrinth packing *b* to eliminate air leakage from or to the interior of the casing C, as shown in Figure 16. Attached to and fixed to the shaft 4 is a worm gear 7 which meshes with the worm 8 of the shaft 9. The worm shaft 9 mounted in a vertical manner is supported in pin type anti-friction bearings 10 and 11 in such a manner as to allow freedom of rotation in both directions. The bearings 10 and 11 are positioned in the extension arms 12 and 13 which form an integral part of the front cover 14 of the secondary casing C. Fixed to the shaft 9 is a disc 15 preferably constructed of thin gauge aluminum. This disc 15 is substantially circular in plan and rotates with the shaft 9 in such a manner that a portion of it occupies a position, as shown in Figure 2, between the poles of a permanent magnet 16 and spaced slightly therefrom, and in combination therewith forms a magnetic drag type of damper to prevent undesired overspeeding of the shaft 9, and to quickly reduce its speed when the force driving the shaft 9 has been removed. The magnet 16 is adjustably fixed to the gyroscope supporting bulkhead 16¹ extending transversely of the case C. Fixed to the shaft 9 near its upper extremity is an impeller 17 having a body 22 preferably constructed of some light alloy such as an alloy of magnesium. Disposed radially about the periphery of the impeller 17 are blades 18, constructed of some light material such as a magnesium alloy. They may be formed as an integral part of the impeller 17 if desired. The blades may be constructed in thin walled rectangular form 18 or 19, as shown in Figures 14 and 15, or of an inverted V-shape 20, or streamlined as shown at 21 in Figure 15. They may be fastened to or integrally moulded with the impeller body 22.

The impeller 17, in combination with its attached shaft and gearing to the turn indicator 1, forms torque amplifying means for transmitting the degree, speed and direction of rotation to the turn indicating element 1. In essential relation thereto and forming a part of the torque amplifying means is a vane 23 which is fixed to a yoke shaft 24 of the gyroscope 25. The gyroscope 25 together with its co-dependent bearings, yoke shaft, etcetera, is of the well-known type of spring centralized non-pendulous air spun gyroscope of two degrees of freedom, and is rotatably mounted in ball bearings 40 and 41 in the gimbal 42, as shown in Figures 2 and 7. The gimbal is mounted in ball bearings 43 and 44. All these bearings are of an adjustable type in order to secure the proper clearance for reduction of friction and ease of operation. The periphery of the gyroscope is provided with notched hopper recesses 45 for receiving the jet of air by which the gyroscope is rotated.

The vane 23 is positioned in what is essentially a centralized vertical location beneath a fluid jet 26 and constitutes the means whereby the movement of the gyroscope 25 is transmitted in amplified degree to the turn indicating element 1. When no condition of turn of the airplane exists it should be evident that the gyroscope 25 is in a centralized position, as shown, being restrained in this centralized position by a centralizing spring 27 of cantilever leaf construction.

When the airplane to which the instrument is attached effects a turn there is an immediate precession of the gyroscope about its axis, the amount of precession depending upon the rate of turn, and the direction of precession dependent upon the direction of turn. Assuming that the gyroscope is rotated in the direction of the arrow, then for a right turn the induced precession will be such as to cause the axis of the vane 23 to be displaced in a direction of the line bb^1 of Figure 12. The air which is constantly flowing from the jet 26 over the vane 23 will be deflected by an angular setting of the vane and effect rotation of the impeller 17 in a direction and at a rate substantially proportional to the direction and rate of turn of the aircraft. Since this turn, however small, requires time to complete, the total angular rotation of the impeller and its connected indicator for turn, in degrees is substantially proportional to the degree of turn of the airplane. It is this inherent quality of the torque amplifying mechanism that in fact reduces the whole to an integrator of turn.

It should be apparent that the control vane 23 may assume a plurality of angular settings between stops and between the position lines aa^1 and bb^1 of Figure 12 as indicative thereof. For each of these angular settings there is a definite characteristic air flow from the jet 26 over the vane 23, and onto the impeller 17 which is productive of special and definite rates of turn of the impeller and connecting linkages. If desired, other forms of vanes 23^1 and 23^{11}, shown in Figure 13 may be used in lieu of the vane 23.

The air impinging on the impeller 17 and for driving the rotors of the gyroscope, is drawn into the secondary casing by means of suction pump or venturi tube of any satisfactory design. The source of suction is connected to a fitting 28 which is integrally formed with the rear cover 29 of the secondary casing C. To replace the air withdrawn from the secondary casing, air enters the casing through a screened inlet 30 thence passing through a channel 31 which forms an integrally moulded portion of the secondary casing. From this air duct or channel 31 another jet 32 supplies air to the gyroscope rotor wheel 25. It should be apparent that since the volume of air and pressure thereof passing over the impeller and driving the gyroscope rotor must be mutually related in quantity to control the related speed of the gyroscope and the speed of the impeller, it is important that the air jets 32 and 26 be closely associated as shown. Again since the volume of air and pressure thereof passing through the channel 31 must remain substantially constant, a pressure relief valve 33 is mounted in the back cover 29 of the secondary casing C to maintain at all times a substantially constant suction in the casing. This pressure relief valve, also shown in Figure 6, consists essentially of a spring loaded washer 34 of fibre or other similar material, forming a closure to the recessed cut 35 which is open to atmospheric pressure. The threaded pin 36 with head 37 serves as an adjustable keeper for the spring 38; the knob or nut 39 is used to vary the tension in the spring 38, thereby controlling the suction within the casing. Increasing the spring tension serves to be productive of a higher vacuum within the casing, while lower spring tension produces the opposite effect.

It should now be obvious that if under operating conditions, the present improved instrument be subjected to turning movements such as when properly installed in an airplane during flight, a clockwise motion of the indicator 1 for turn will result during left turns, visually producing in the correlated field of view with the bank indicator 2 an apparent turn to the left as is normally seen by the pilot of the airplane during normal flight. The opposite obtains for a right turn wherein the indicator for turn rotates counter clockwise visually producing in the correlated field of view with miniature airplane banking indicator an apparent turn to the right, since the detail markings engraved on the turn indicator have now a relative motion past the " nose " of the miniature airplane index from the right to the left. The detail markings 53 on the turn dial represent a simulated cloud effect portrayed in numerals which divide the turn indicating face into a number of equal divisions, while the detail markings 54 represent substantially the number of degrees of turn actually swept through during a turn, such markings being the equivalent of those found on the conventional compass card. The index 55 serves as a " lubber's line " for reading off the degree markings. The index 55 is in fact a pointer formed by an upward extending portion of the semi-circular disc portion 56 of a false wall or bulkhead 56^1. This wall 56^1 is an integral portion of the primary case B. The portion 56 masks the lower portion of the turn indicating disc from the pilot's field of view. The upper edge $57--57^1$ of the masking portion 56 is preferably straight, as shown in Figure 1, and that portion of it visible to the pilot has delineated thereon characteristic mark-

ings representative of a cloud field as viewed from the air.

The indicating member or disc 1 will be rotated in a direction depending upon the direction of turn of the airplane and by an amount depending upon the angle turned through. If the rate of turn is quick the disc will rotate faster than if the rate of turn is slow. Therefore the speed of movement of the disc gives the pilot an indication of the angular velocity of turn. This velocity is not indicated numerally or in degrees but is nevertheless a true indication of velocity. A similar indication would, of course, be received by the pilot if he were to regard the external field of view from the airplane.

Closely associated in the same field of view with the turn indicator disc 1 is the indicator for bank or banking index 2, positioned in front of the upper portion of the turn indicator disc. It is mounted on a shaft 58 running in bearings 59 and 60, the former set in the bulkhead 56, by means of studs 62. The banking index 2 is capable of rotation on its shaft 58 both clockwise and counter clockwise to a substantial amount of 90 degrees in either direction. Attached to the shaft 58 on the banking indicator and forming an integral part thereof is a sprocket 63 which engages an endless chain 64 which in turn engages a sprocket 65 of a shaft 66. The shaft 66 is rotatably mounted in bearings 67 and 68 of conventional nature, the latter being provided with labyrinth packing, similar to that shown in Figure 16, to prevent the influx of air into the secondary casing at the location of said bearing. Attached to the rearward extenson of the shaft 66 is a gear segment 69, the teeth of which engage the teeth of a gear segment 70, the latter segment being fixed to and mounted upon a shaft 71 extending forwardly from and connected to the gyroscope gimbal 72. The gyroscope 46 with its bearing, etcetera, is similar in construction to the gyroscope 25, having two degrees of freedom but no spring centralizing means, and being provided with a pendulum 47 rigidly fixed to the gimbal 72. Attached to the pendulum 47 is a piston rod 49 of a dashpot 50 of well known and conventional construction. A needle valve 51 is provided for the dashpot in order to obtain varying degree of damping. A needle valve jet 52 supplies air for driving the gyroscope 46 and is integrally formed as a part of the cover plate 29 of the secondary casing C. It should be apparent that any rotation of the gimbal shaft 71 imparts, through the linkages just described, a rotation of the shaft 58 of the banking indicator 2, but, as is quite evident in a counter direction. Therefore, if the case of the instrument is banked or tilted to the left without accompanying turn in that direction, the pendulum 47 will effect a clockwise rotation of the gyroscope gimbal 72 in relation to the instrument casing. This displacement results in a counter clockwise rotation of the shaft 58 of the banking indicator 2, producing in fact a depressing of the left wing 2^1 of the index to indicate a tilt to the left or a condition of left bank. The reverse action holds for a tilt to the right as in a right side slip and is productive of an indication of right bank. Since a right or left bank or tilt unaccompanied by turn does not produce precession in the gyroscope, the latter in no manner affects the indication just described. However, should a bank turn be executed the case of the instrument and therefore the pendulum 47, is subject to the resultant of the force of gravity and centrifugal force. Therefore, the pendulum 47 would assume the "apparent vertical" and there would be no causative force to cause rotation of the gimbal 72 and its mechanically related structure and consequently no indication of bank. The precession of the gyroscope 46 however, prevents the pendulum 47 assuming the "apparent vertical" during a bank turn so that there is in fact a rotation of the gimbal 72 which is transmitted through the mechanism and productive of an indication of bank while turning in degree substantial to that actually obtained by the airplane to which the instrument is attached.

It should be apparent that while the gyroscope 25 which through improved means actuates the turn indicating disc is undamped and non-pendulous, the gyroscope 46 is damped and is pendulous, making the latter sensitive to the effects of gravitational force, centrifugal force or combinations thereof, as well as to turning motions or various combinations of all three, thereby producing in the indicator for bank substantially precise indications representative of the actual deviations of the airplane to which it is attached about its longitudinal axis.

Closely associated in the same field of view with the banking indicator 2 and the turning indicator 1, is the indicator for rise or fall 3 hereinafter referred to as the horizon bar. The horizon bar is preferably positioned in front of the turn indicating disc and its plane of vertical travel substantially parallel to but to the rear of the plane of the banking indicator 2. The horizon bar 3 is provided, as will be seen, with mechanism to cause the bar

to rise when the airplane to which the present improved instrument is attached, is losing atmospheric pressure altitude. A rise of the airplane through successively decreased air pressure layers will cause a fall of the horizon bar. The change either upwardly or downwardly of the horizon bar from its neutral position as shown in Figure 1, is an indication, respectively, of fall and rise of the airplane. In ordinary clear weather flight this impression, or visual stimulus is substantially identical with that received by an airplane pilot when the nose of the airplane appears above the true horizon during climb or gain in altitude and below it during glide or loss of altitude. The horizon bar, both visible portion 3 and hidden portion 3^1, is preferably constructed of some light material such as a magnesium alloy. It has an arc shaped body with its lower opposite ends provided with pointer like bars extending toward each other. They are substantially parallel to the lateral axis of the instrument, in the same plane and spaced at their proximate ends. The arc shaped body of the horizon bar 3 is centrally pivoted to the rocker arm 73 by a pin 74, as shown in Figure 2. To constrain the movement of the horizon bar to substantially vertical travel, the lower right and left extremities of the horizon bar are provided with wafer rollers 75 and 75^1 constructed of thin steel, running in grooved tracks 76 and 76^1; the latter preferably being constructed of tempered glass to reduce friction. The wafer rollers are rotatably mounted on the extremities of the horizon bar on pin type bearings 77, as shown in Figure 10. The rear grooved tracks are counter-sunk into the bulkhead 56 and cemented thereto, while the forward tracks 76^1 are mounted in brackets 78, which in turn are suitably fastened to the bulkhead 56^1 by means of screws 79. It is apparent from the foregoing that the horizon bar suspended at the pivot 74 is constrained to movement in substantially a vertical plane. Extending slightly to the left near the lower left wafer roller 75, a portion of the horizon bar forms an index 80 which in fact is an indicator for reading off the indicated rate of climb from a scale suitably delineated on the mask 81 formed of paper or the like and secured to the rear of the bezel glass closure 82 of the primary case. The bezel glass closure 82 which in fact forms an air tight transparent closure for the front of the primary case is held securely in place by the snap ring 83^1.

The rocker arm 73 is pivoted on a pin 83 and together with the suspended horizon bar is statically balanced about the fulcrum 83, in order that the system will not be adversely affected by the accelerations accompanying flights through rough air. A fulcrum post 84 is provided with knife edges 85 and 86, forming a supporting point for the fulcrum post by receiving therebetween a portion of a bi-metallic temperature compensated adjustment bar 87. The latter of articulated formation is supported by a pin bearing 88. The upwardly extending portion of the adjustment bar 87 is positioned between a spring 89 to the rear and a pin 90 to the front. The pin 90 is threaded where it passes through the dome casing D and is provided with a knurled knob 91, by means of which the position of the fulcrum 83 may be changed. This will alter the neutral position of the horizon bar. It is well-known that instruments which include pressure operated cellular elements, as is true of the present preferred embodiment, are subject to slight errors due to drift; the setting knob 91 is therefore provided to re-set the horizon bar should an error become apparent.

A forked end 92 of the rocker arm 73 slidably engages a cam or eccentric 93 which is rotatably mounted on a shaft 94. The eccentric 93 is limited in rotation to 90 degrees in either direction from the neutral position shown in Figure 4. Attached to the eccentric and fixed thereto is a pinion 95 that is capable likewise of a total rotation of 180 degrees. Clockwise rotation of the eccentric and its attached pinion is stopped when the cammed slot 96 (shown in Figure 4) engages the pin 97 while counter clockwise rotation is stopped when the cammed slot 98 engages the pin 99, in spite of additional rotation of an eccentric drive sector 100. The eccentric drive sector has a pinion 101 keyed therewith which engages the teeth of the power sector 102, the latter being rotatably mounted on a shaft 103, and spring constrained to a neutral position (shown in Figure 4) by the coil spring 104. Rotation of the power sector is the result of expansion or contraction of the diaphragm cell 105 and its connecting tappet 106; the latter being of roller type in the preferred embodiment and rotatably mounted on a pivot 107 in the diaphargm stud 108. The latter forms an integral part of the diaphragm 105 as by being welded or soldered thereto. The diaphragm together with its threaded hollow outlet 109 and the capillary leak tube 110 form an assembly well known as the capillary leak type of statoscope.

As can be seen if the airplane to which the instrument is attached effects a climb,

the reduced atmospheric pressure encountered will first be effective on the exterior of the diaphragm since time is required for sufficient air to escape through the capillary tube 110. Should this climb be constant there will be a continuous escape of air through the capillary tube 110, as air friction in the tube prevents instantaneous equalization of pressure between the interior and exterior of the diaphragm. This very inequality of pressure will produce an expansion of the diaphragm and, through the linkage described above a lowering of the horizon bar 3 to indicate a climb of constant value. The reverse is true for a loss of pressure altitude which is accompanied by a collapsing of the diaphragm with attendant rise of the horizon bar to indicate a glide. It should be pointed out here that for optimum results the threaded connection 109 should be connected to a separate capacity in the form of a thermally sealed tank of air under atmospheric pressure. Likewise for optimum results the threaded connection 111 should be connected to a static air pressure line located in the airflow about the airplane.

The diaphragm together with its connecting linkages exclusive of the horizon bar 3, is mounted for support to the cover 112 of the dome casing D which forms an airtight closure for this the upper part of the primary casing. The cover 112 is recessed and fixed into the dome casing D being fastened thereto by means of machine screws or the like.

It should now be apparent that the primary casing in combination with its integrally moulded casing encloses the mechanisms for rise and fall together with the banking indicator. It also forms the base shell for the mounting of the instrument to the instrument panel by means of the lugs 113. The front bezel glass closure 82 with its attached mask 81 also provides a mount for the steel ball in glass tube inclinometer 114 of well-known design and construction, the latter unit being cemented to the inner surface of the bezel glass for visible reference by the pilot.

The secondary casing C together with its front cover 14 and rear cover 29, constitutes a unitary element which may be withdrawn intact from the primary casing B after disconnecting the chain 64 from the pulley 65. This secondary casing is provided with dowels 115 and 116 (see Figure 2) which accurately position the front of the casing within the primary casing to provide accurate register. Screws 117 fasten the rear cover of the secondary casing to the shell of the primary casing combining the whole into one unified and compact instrument in the preferred embodiment.

It should now be apparent that there is grouped in closely associated field of view, and normally related apportionment, indicia of turn, bank and climb or glide in such manner as to provide, by visual reference thereof, an efficient designation of aircraft operation, based on vertigo and fatigue reducing factors, the present improved and preferred arrangement embodying a very material simplification of mechanism and increase in reliability of operation.

Various changes in the shape, size, and arrangement of parts are possible within the ambit of the invention.

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.—An aircraft instrument comprising a turn indicating member actuated by fluid flow means operated in response to the rate of turn of the aircraft on which the instrument is mounted wherein the member indicates the amount of change of course.

2.—An aircraft instrument comprising a turn indicating member actuated by fluid flow means operated in response to the rate of turn of the aircraft on which the instrument is mounted wherein the member indicates the amount of change of course and the direction of turn.

3.—An aircraft instrument comprising a turn indicating member actuated by fluid flow means operated in response to the rate of turn of the aircraft on which the instrument is mounted wherein the member indicates the direction and angular velocity of turn and the amount of change of course.

4.—An aircraft instrument according to any of the preceding claims wherein the fluid flow means is controlled by a gyroscope responsive to the rate of turn of the aircraft.

5.—An aircraft instrument according to any of the preceding claims wherein the fluid flow means comprises a turbine or impeller wheel.

6.—An aircraft instrument according to claim 5 wherein the impingement of the fluid on the turbine wheel is controlled in response to the rate of turn of the aircraft.

7.—An aircraft instrument according to claim 6 wherein the fluid is directed onto the turbine in the form of a jet and the jet is regulated in response to the rate of turn of the aircraft.

8.—An aircraft instrument according

to claim 7 wherein the jet is regulated by a vane, the angle of which is regulated in response to the rate of turn of the aircraft.

9.—An aircraft instrument according to claim 8 wherein the vane is attached to a gimbal ring of the gyroscope.

10.—An aircraft instrument according to any of claims 6—9 wherein the turbine is braked.

11.—An aircraft instrument according to claim 10 wherein the braking of the turbine is effected by a magnet or magnets between the poles of which a disc connected to the turbine wheel is disposed for rotation with the turbine wheel.

12.—An aircraft instrument according to any of claims 5 to 11, wherein the turbine is disposed in a sealed case from which the air is exhausted and to which air is admitted in a jet directed against the turbine.

13.—An aircraft instrument according to any of the preceding claims, wherein the turn indicating member is associated with a bank indicating member and/or a horizon indicating member disposed in the same field of view of the pilot.

14.—An aircraft instrument according to any of the preceding claims including an aircraft simulating element adapted to move angularly about a horizontal axis under the impulsion of means responsive to banking of the aircraft.

15.—An aircraft instrument according to claim 14, wherein the means responsive to the banking of the aircraft which actuates the aircraft simulating element comprises a pendulous gyroscope.

16.—An aircraft instrument according to claim 14 or 15, wherein a horizon simulating element is actuated so as to move towards and away from the aircraft simulating element according respectively as the aircraft ascends or descends.

17.—An aircraft instrument according to any of claims 14—16, wherein the wings of the aircraft simulating element are parallel to a horizon simulating element when the aircraft is in normal straight flight.

18.—An aircraft instrument according to any of the preceding claims including a horizontally disposed element simulating the horizon line, the turn indicating member having a face over which said element is movable upward and downward.

19.—An aircraft instrument according to any of the preceding claims, wherein the turn indicating member has a face constituting an artificial field of view.

20.—An aircraft instrument according to any of the claims 16—19, wherein the turn indicating member, the horizon simulating element and the aircraft simulating element are disposed together in the same field of view of the pilot so as to give by their conjoint movement a unitary indication portraying the attitude and movement of the aircraft.

21. An aircraft instrument according to any of claims 15—20, wherein the gyroscope responsive to the rate of turn and/or the gyroscope responsive to bank are/is disposed in the sealed case and are/is operated by an air stream admitted thereto.

22.—An aircraft instrument according to any of the preceding claims wherein the turn indicating member is disposed in a housing having a masked face provided with a semi-circular opening disclosing an upper segment of the member, the lower edge of which opening is horizontal when the aircraft is in normal straight flight.

23.—An aircraft instrument according to claim 22, wherein the housing supports the means by which the horizon simulating element is actuated and is formed to detachably receive the sealed case.

24.—An aircraft instrument according to any of the preceding claims, comprising a rotatable disc-like element positioned in a vertical plane and rotatable about a horizontal axis, means responsive to turning of the aircraft for actuating a turbine to rotate said disc counter clockwise for a right turn and clockwise for a left turn, a horizontally disposed element simulating the horizon line and movable upward and downward across the face of said disc-like element, means for actuating said horizon simulating element whereby said element moves downward for an upward movement of the aircraft, and upward for a downward movement of the aircraft, an indicating element simulating an aircraft having its wings normally parallel to said horizon simulating element and adapted to move angularly about a horizontal axis, and means responsive to banking of the craft for actuating said aircraft simulating element so that its position with respect to the horizon simulating element corresponds exactly to the bank of the aircraft, said disc-like element, said horizon simulating element and said aircraft simulating element providing by their conjoint movement a unitary indication portraying the exact attitude and movement of the aircraft.

25.—An aircraft instrument substantially as described with reference to the accompanying drawings.

Dated this 5th day of March, 1936.

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Fig. 1

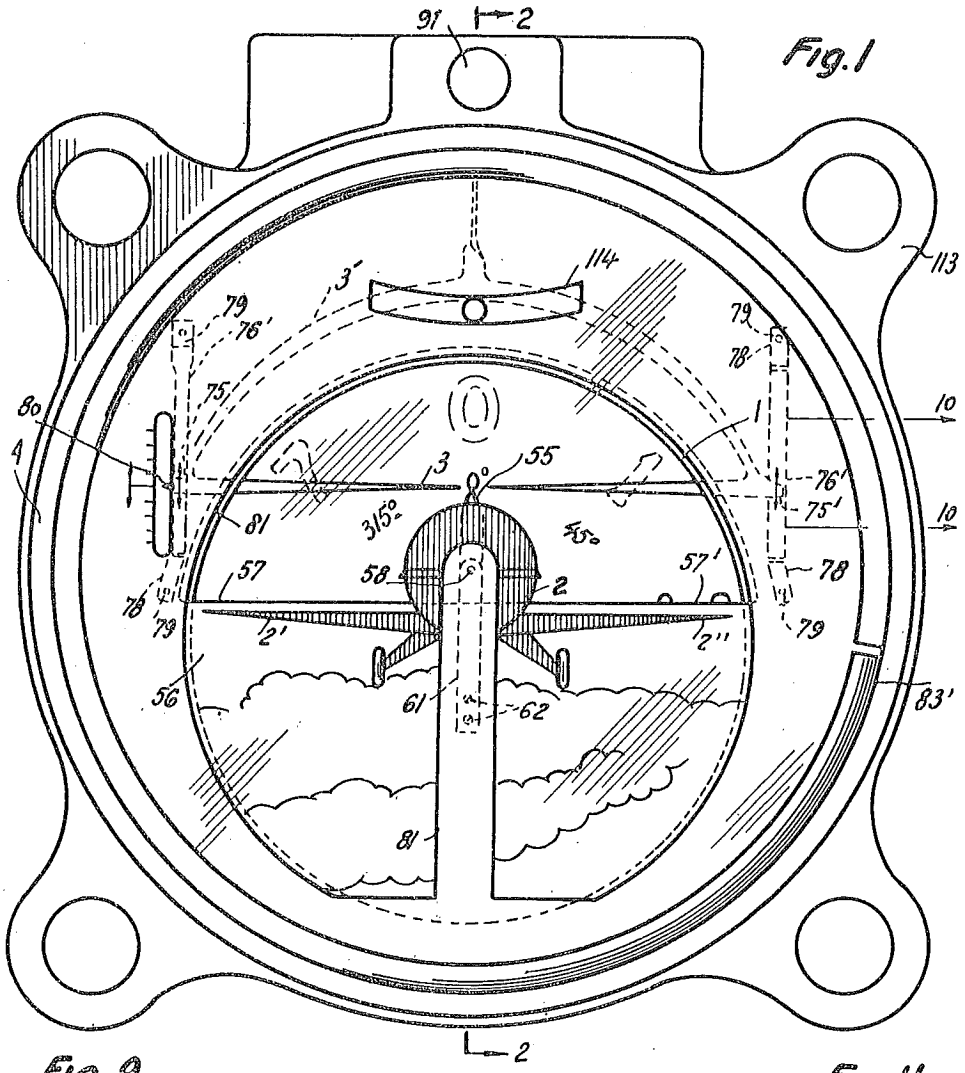


Fig. 9

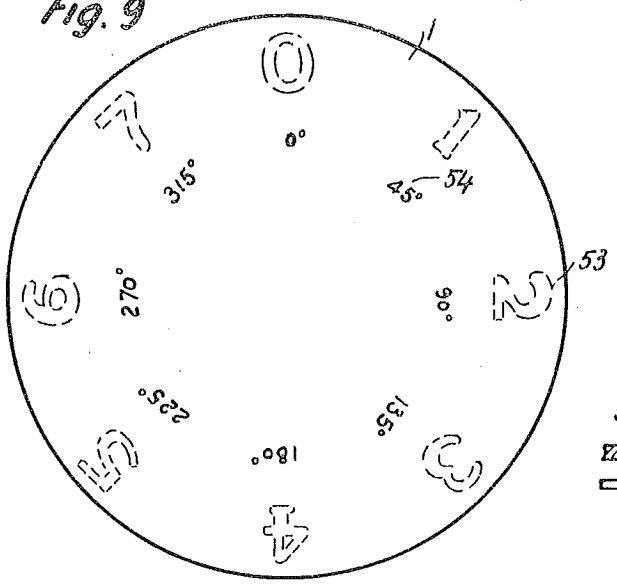
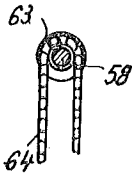


Fig. 11



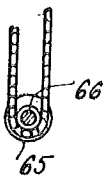


Fig. 10

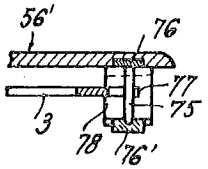
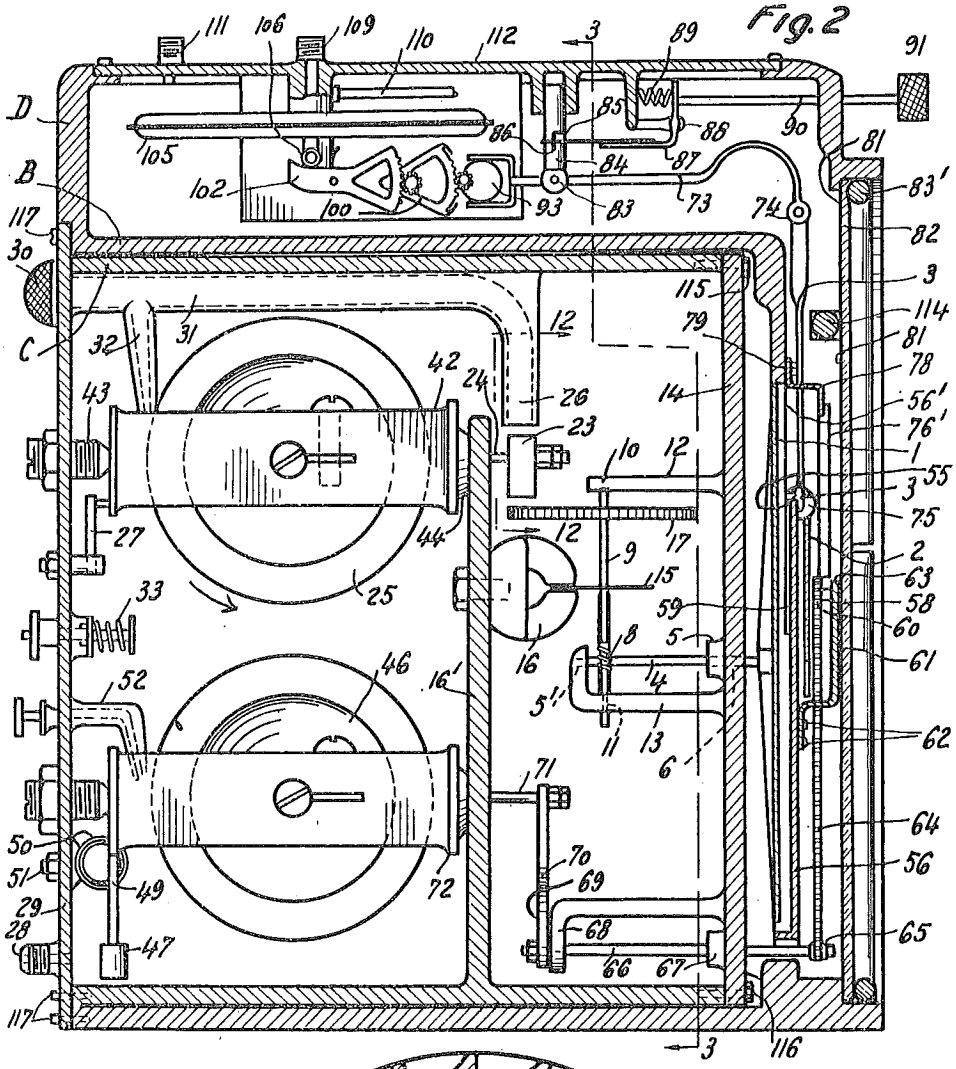


Fig. 2



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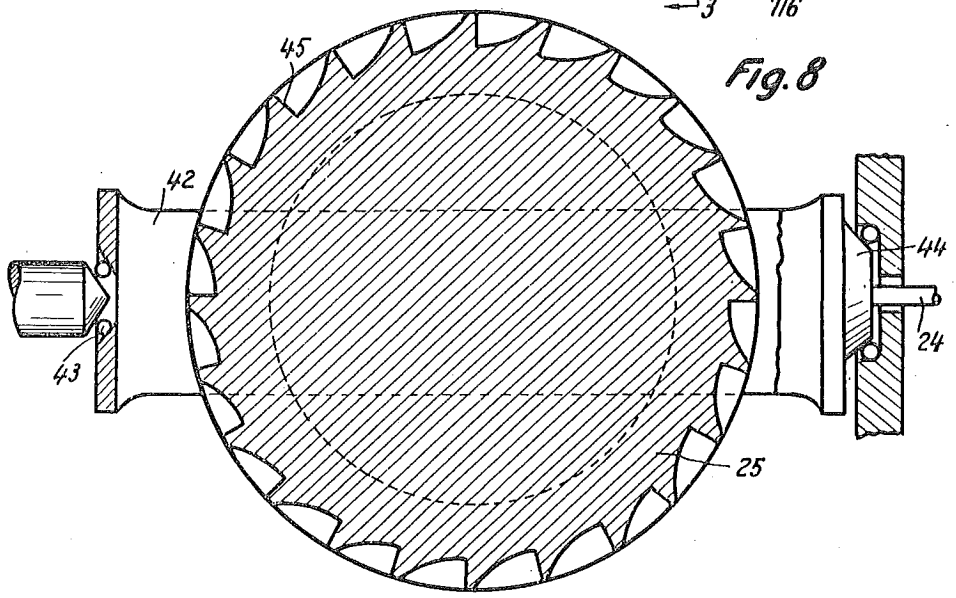

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Fig.3

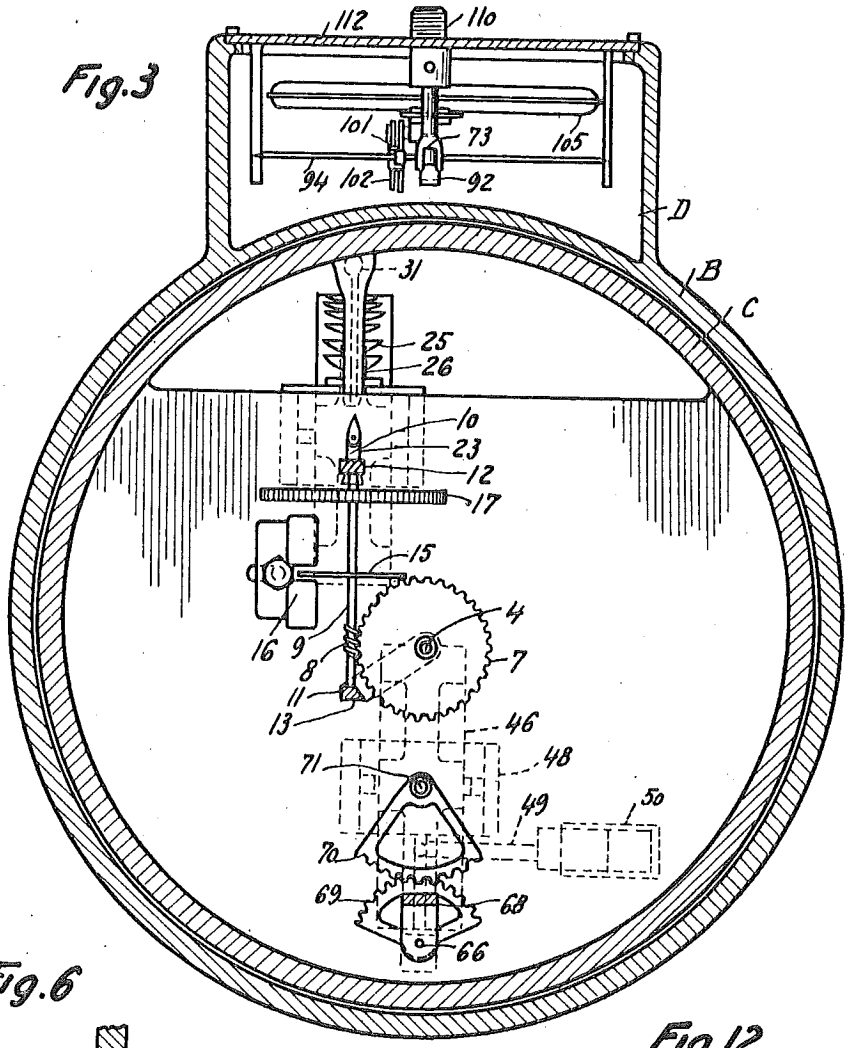


Fig.6

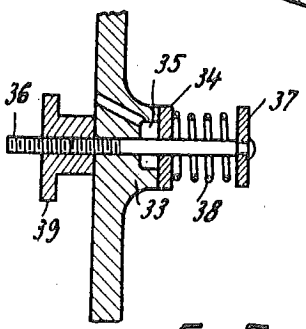


Fig.7

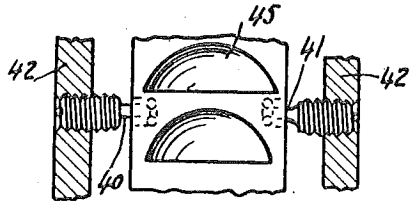
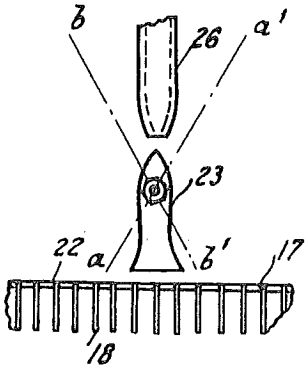


Fig.12



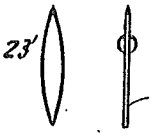


Fig.13

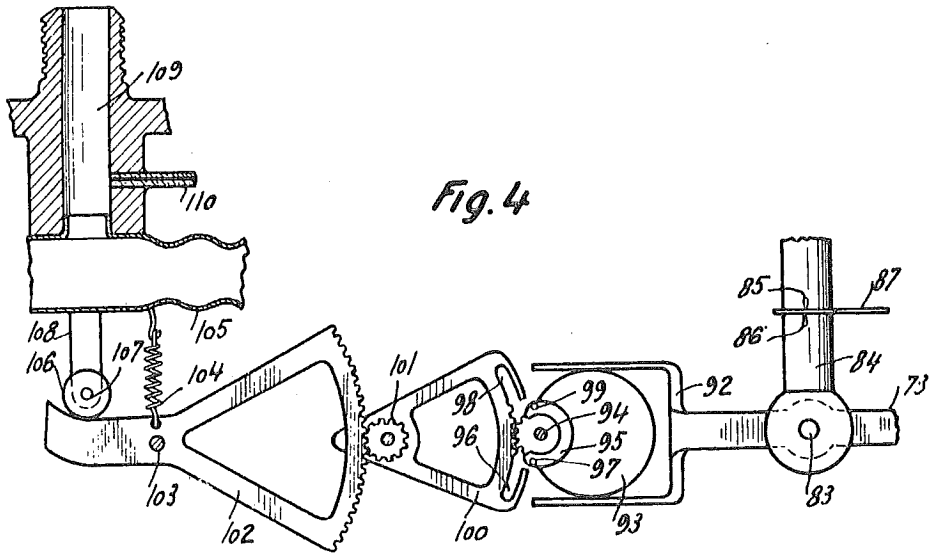


Fig. 4

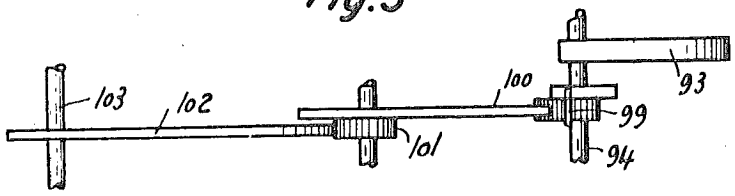


Fig. 5

Fig. 14

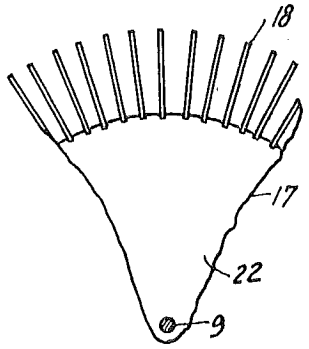


Fig. 15

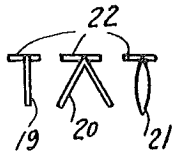
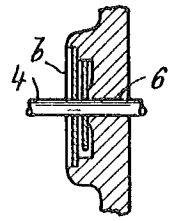


Fig. 16



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