Oct. 12, 1943. E. O. CARMODY 2,331,304

WING LIFT AND AILERON ILLUSTRATOR

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Fig. 1.

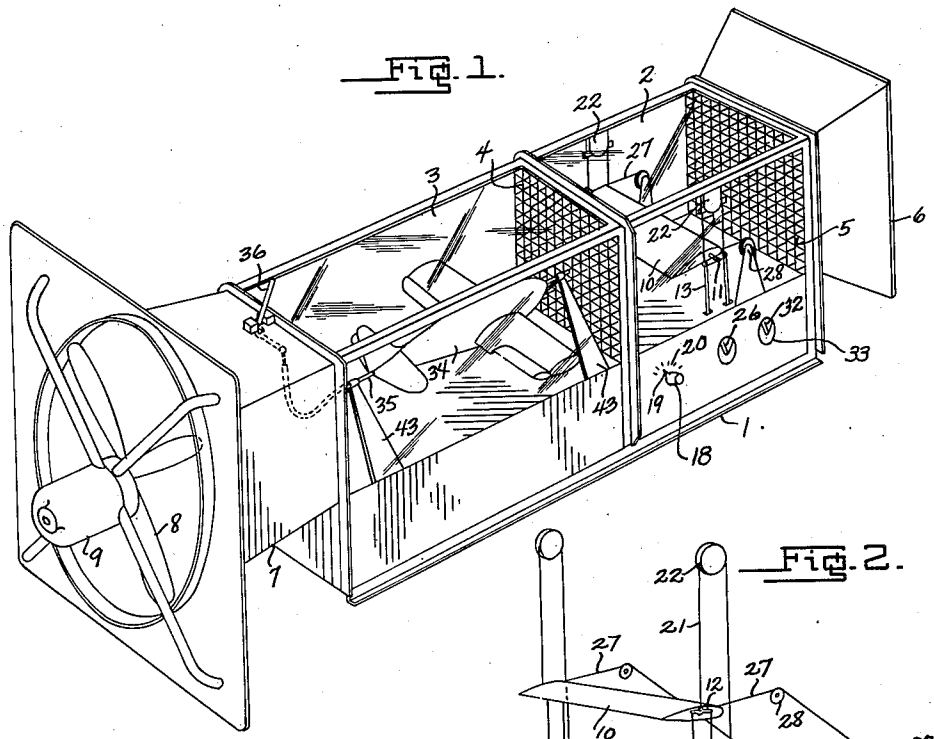


Fig. 2.

Fig. 3.

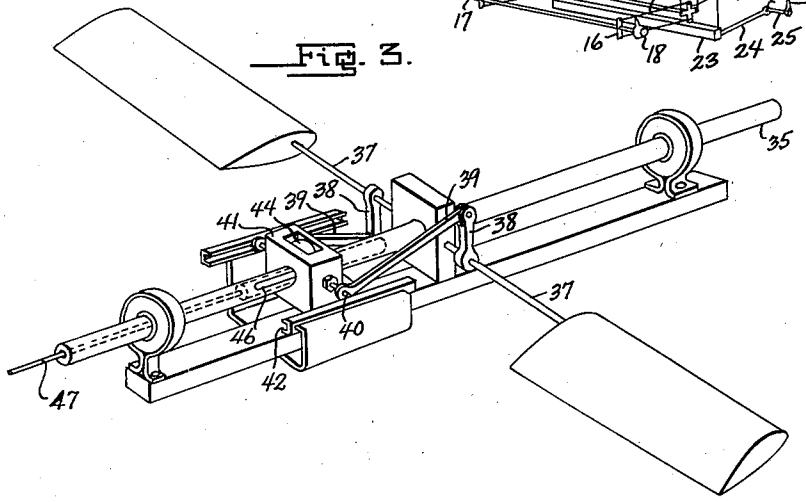


Fig. 5.

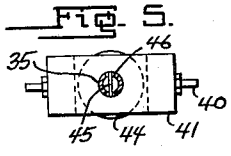
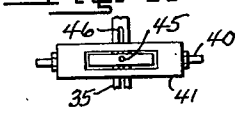


Fig. 4.



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Fig. 6.

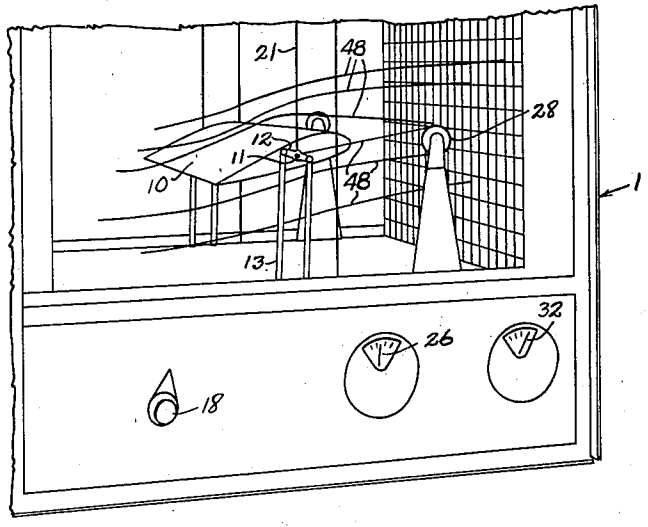
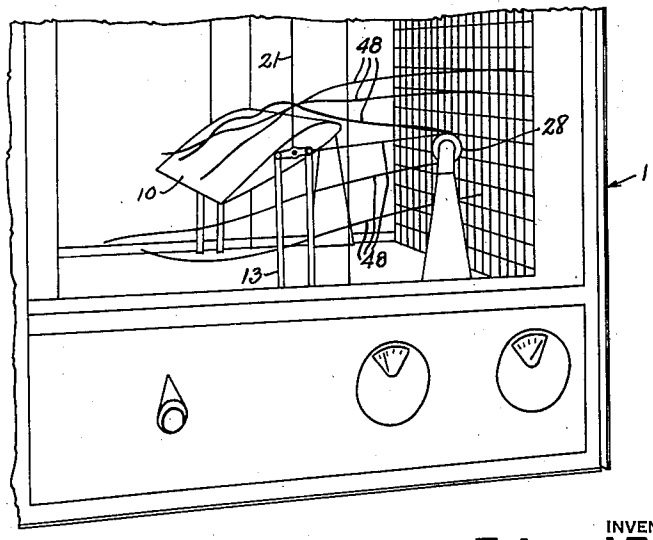


Fig. 7.



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2,331,304

WING LIFT AND AILERON ILLUSTRATOR

Edmund O. Carmody, United States Navy

Application December 26, 1942, Serial No. 470,270

7 Claims. (Cl. 35—12)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention pertains to aeronautics, particularly to apparatus used in connection with instructions in aeronautics, dynamic theory and practice in the art of flying. More specifically the present invention is a novel type of combined wind tunnel and model aircraft to illustrate the effects of aileron control and the causes of "stalling." Many students find it difficult to grasp the fact that in order to maintain a plane in a bank it is not necessary to keep the stick in the inclined position. Another thing that is sometimes difficult for the instructor to explain or the student to grasp is the effect of variation in the angle of attack of the airplane wing or its flying speed on the lift and drag characteristics, and the reasons therefor.

The object of this invention is to make a simple apparatus which will clearly illustrate the effects above referred to and will thus save time, effort and expense not only on the part of the instructor but also on the part of the students, and with better results in the proficiency of the class as a whole as well as a possibly considerable reduction in the number of students disqualified during the course.

More specifically the object is to illustrate the effects of aileron controls and the cause of stalling.

Other objects of the present disclosure will appear from the following description thereof taken in connection with the accompanying drawings, in which

Fig. 1 is a perspective view of an illustrative form of the present device;

Fig. 2 is a perspective of the airfoil and its connections mounted in one of the compartments of the device;

Fig. 3 is a perspective of the details of the control means for the ailerons of the airplane model in the other compartment of the device, and

Figs. 4 and 5 are details of the sliding connection between the manual control and the rotatable aileron controls.

Figs. 6 and 7 illustrate the yarn or strings fluttering in a manner to show two different results under conditions of smooth flow and vibration respectively.

Similar numerals will be used in designating the same parts in the several views of the drawings.

The device as a whole is illustrated in Fig. 1, wherein the base 1 has two compartments 2 and 3 mounted thereon in the form of a conduit with a screen 4 between them. The conduit has transparent sides and top. The forward end of the conduit has a screen 5 and funnel inlet 6, mounted thereon. At the rear end of the conduit is a funnel shaped cowling 7 at the end of which is mounted a fan 8 driven by a motor 9. In the forward compartment an airfoil 10 is mounted on a shaft 11 having arms 12 extending in line with the airfoil and pivoted at their ends to pairs of vertical bars 13 which extend downward through the bottom of the conduit into the base, where each pair is pivotally connected to two opposite arms of vertical cross member 14. The other two arms of these cross-members are connected by horizontally extending bars 15 which are pivotally connected to said arms at one end and also pivotally connected to a pair of arms 17 at the other end, the arms 16 being mounted on a shaft 17 to which a control knob 18 is attached on the outside of the base. The knob has a pointer 19 working across a dial 20 to indicate the relative position of the airfoil with respect to the air stream in the conduit. These bars and cross arms constitute a floating device attached to the airfoil which is hung by means of strings 21, attached to the ends of shaft 11 and passed over pulleys 22 and down through the floor of the conduit into the base of the device where they are tied to a counterweight bar 23 and also by means of arms 24 to a shaft 25 mounted in the base and extending outside for connection of a pointer 26 to indicate on a dial on the outside of the base the lift of the airfoil, the force of the lift being counterbalanced by a mechanism 49 while the counterweight bar 23 is merely to balance the weight of the airfoil. In order to show the drag characteristics of the airfoil under any particular conditions the shaft 11 is also connected by strings 27 passed over pulleys 28 and tied to the ends of arms 29 on the shaft 30 which extends outside of the base to receive a pointer 32 indicating the drag on a dial 33. A counterweight 31 mounted on the shaft 30 is used to counterbalance the drag of the airfoil, the dial being calibrated to show relative drag. In either of these indicators on the outside of the base it is not important to show the exact drag or lift but merely the relative values thereof under different conditions of air speed and angle of attack.

In the rear compartment of the conduit, an aircraft model 34 is mounted rotatably on a horizontal hollow shaft 35 which runs fore and aft through the longitudinal axis of the model and which is rigidly mounted on standards 43 at its

front and rear so that the model may rotate in response to manipulation of the aileron controls, the ailerons being connected by a mechanism later to be defined to a wire 47 which is run inside the shaft on which the model is mounted and extends to the top of the cowling at the rear of the conduit where it is connected to a miniature control stick 36 by a bell-crank arrangement. The ailerons are connected to the control stick by means of a mechanism consisting of shafts 37, 37 integral therewith respectively and having arms 38, 38 extending in opposite directions from the axis of said shafts and having links 39, 39 pivotally connected thereto at one end and pivoted at their other ends to pins 40 mounted on opposite sides of a block 41. The outer ends of pins 40 are mounted to slide in horizontal groove members 42 mounted in the frame of the model. The block 41 is bored to fit loosely over the shaft 35 inside the model and has a cut-out portion therein for the insertion of a collar 44 which is also bored to loosely fit over this shaft and to slide therealong in response to the axial movements of the block. A pin 45 is passed through this collar and through a slot 46 in the shaft and to it is connected the end of the control wire 47 which passes out through the rear end of the shaft and through a flexible hose to the underside of the top of the cowling 7 where it is connected to a bellcrank connection to be operated by the control stick 36 for moving the control wire axially so as to manipulate the ailerons through the device just described in response to the corresponding movements of control stick 36. The model has nonfriction bearings by means of which it is mounted to turn on shaft 35, at least one of which is a thrust bearing to keep the model from sliding along the shaft 35.

The screens 4 and 5 are made of parallel flutes directed in line with the conduit so as to straighten out the flow of air to the conduit and eliminate any possible eddy currents which might otherwise occur as the result of outside disturbances as the air passes into one compartment and then into the other.

A series of bright colored yarn or strings 48 may be attached to the screen 5 at intervals for the purpose of showing the course of the air stream through the first compartment to enable the student to better visualize the effects of varying the attitude of the airfoil on the surrounding air stream. Short strands of the yarn may be attached directly to the surface of the airfoil at various suitable points. In operating the present device the fan 8 is started and by manipulating the controls 18 and 36 the effects mentioned above may be observed through the transparent walls of the conduit. The effect of varying flying speed may be simulated by varying the speed of the fan.

Fig. 6 shows the air currents flowing smoothly over the surfaces of the airfoil. In Fig. 7 the angle of attack has been increased to the point of breaking up this smooth flow on the upper surface, at the particular air speed, and the broken currents are irregular and cause the wing to flutter or vibrate. If the angle is not reduced immediately, the lift drops suddenly and the drag increases. The angle corresponding to maximum lift at any particular air speed will be noted to be just below this critical angle where the current begins to break away from the upper surface. This critical angle is also found to be smaller with increasing air speeds. Furthermore, it will be found that for any air speed, the angle for maximum lift to drag ratio is slightly less than that for maximum lift.

Two of the important features that should be thoroughly impressed on the new flier are the effect and manipulation of the aileron control and the reaction between an airfoil and the airstream under different conditions of angle of attack and air speed. These features are visibly and clearly illustrated in the model air tunnel of the present invention. This device gives the student the opportunity of actually manipulating the aileron controls and practicing placing the plane in a bank to any desired degree, learning always to return the stick to neutral position in order to maintain any particular degree of banking. It also serves to clearly illustrate, in a much shorter time and more impressively, the reaction between an airfoil and the airstream, than could be learned by lectures and sketches on the blackboard. The student can actually observe the airstream currents and their effects on any airfoil, such as the wing of a plane, by turning the control knob for varying the angle of attack or changing the speed of the airstream, and watching the relative effects on lift, drag and the air currents, noting also the all important characteristics of "stalling" and the vibrations occurring just before the stall. Having made these observations, he may more readily recognize the symptoms of an oncoming stall in actual flight, and can thus avoid possibly serious consequences by taking timely countermeasures. These observations will also impress him with the necessity of maintaining flying speed to avoid stalls in actual flight.

Thus it will be seen that a simple inexpensive device has been constructed which will save time and effort as well as expense in that it not only eliminates the necessity for the instructor or student to spend an excessive amount of time for instructions which would otherwise be necessary but also saves the use of expensive full scale equipment and the unnecessary hazards ordinarily submitted to in actual flying for this preliminary training.

Various modifications in size and form as well as arrangement may be made in this device without departing from the scope of the invention which is defined by the appended claims.

This invention may be made or used by or for the Government of the United States for governmental purposes without the payment to me of any royalties thereon or therefor.

What I claim is:

1. A wind tunnel mounted on a base having transparent sides and top, an airplane model rotatably mounted on its longitudinal axis therein for complete unobstructed rotation, aileron control means for said plane extended to the wall of the tunnel for operation by a stick on the outside thereof for instruction and practice purposes.

2. A wind tunnel mounted on a base having transparent sides and top, a sample airfoil mounted transversely on a horizontal shaft hung by strings tied to its ends and passing over pulleys at the top of the tunnel then down into the base to arms on a shaft which extends to the outside of the base and has a pointer on its end, a counterweight for balancing the weight of the airfoil connected to said strings in the base, means for turning said pointer shaft in response to the lift on the airfoil, and a scale on which said pointer indicates the amount of lift.

3. A wind tunnel mounted on a base having transparent sides and top, a sample airfoil mounted transversely on a horizontal shaft hung by strings tied to its ends and passing over pulleys at the top of the tunnel then down into the base to arms on a shaft which extends to the outside of the base and has a pointer on its end, a counterweight for balancing the weight of the airfoil connected to said strings in the base, means for turning said pointer shaft in response to the lift on the airfoil, a scale on which said pointer indicates the amount of lift, floating means for controlling the angle of attack of the airfoil by a knob on the base, and indicator means on the base connected to the airfoil for showing the amount of drag.

4. A wind tunnel having two compartments tandem with transparent walls, an airplane model mounted rotatably on its longitudinal axis in one compartment for complete unobstructed rotation, a typical wing floatingly mounted in the other compartment, a control stick on the outside of the wind tunnel for controlling the ailerons on the model airplane without restricting its rotary motion, a manual control for the angle of attack of said wing operated from the outside of the wind tunnel, means for indicating relative lift and drag of said wing, the compartments being separated by a screen for straightening out the airflow through the tunnel, another such screen at the inlet end of said tunnel, a suction fan at the other end of said tunnel, and means for controlling the speed of operation of said fan.

5. A wind tunnel having transparent walls, an airfoil hung therein in flying position, floating control means for varying the angle of attack of said airfoil, means for indicating the relative lift on said airfoil and means for indicating the relative drag on said airfoil.

6. A wind tunnel having transparent walls, an airfoil hung by strings loosely attached to the ends of a transverse shaft through the airfoil and passed over pulleys at the top of the tunnel and down through the base of the tunnel where they are fastened to a counterweight to balance the weight of the airfoil, indicator means responsive to the lift of the airfoil, another indicator means responsive to the drag of the airfoil, and floating connections from the airfoil to a manual control for adjusting the angle of attack of said airfoil.

7. A wind tunnel having transparent walls, an airfoil hung by strings loosely attached to the ends of a transverse shaft through the airfoil and passed over pulleys at the top of the tunnel and down through the base of the tunnel where they are fastened to a counterweight to balance the weight of the airfoil, indicator means responsive to the lift of the airfoil, another indicator means responsive to the drag of the airfoil, floating connections from the airfoil to a manual control for adjusting the angle of attack of said airfoil, and means for varying the air speed through the tunnel.

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