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Free-Flight Tun

TALK FOR 1949 INSPECTION

This is the free-flight-tunnel section of the stability research division. Since most of you are familiar with the operation of the tunnel from previous inspections, I shall not go into that. I would, however, like to remind you that in this tunnel we study the dynamic stability and controllability of airplanes by flying remotely-controlled scale models.

One of the big flying qualities problems being worked on at the present time is that of getting satisfactory Dutch roll stability in new high speed airplanes such as these shown in the photographs. Dutch roll is a combined rolling, yawing and sideslipping oscillation, a kind of wallowing motion, which has a relatively long period and generally occurs at low and moderate speeds. This oscillation can be calculated by known methods and the results of such calculations have been found to be in good agreement with flight test results.

We have here a chart illustrating the case of a hypothetical airplane having unsatisfactory Dutch roll stability. The chart shows the regions of satisfactory and unsatisfactory damping of the Dutch roll oscillation based on present Air Force and Navy flying qualities requirements. The green region represents period and damping characteristics which are considered satisfactory, whereas the red region represents unsatisfactory damping characteristics.

We know that, increasing the size of the vertical tail will increase the damping of the lateral oscillation. This change moves the airplane down in this direction on the chart. Although increasing the size of the vertical tail decreases the time required for the oscillation to damp to one-half amplitude, it also shortens the period of the oscillation so that the point representing the airplane damping moves down roughly parallel to the right side of the boundary between the satisfactory and unsatisfactory regions. Because of this simultaneous change of period and damping, it is often very difficult to make the damping of the lateral oscillation satisfactory by increasing the size of the vertical tail.

Reducing the dihedral angle of an airplane generally improves the damping of the lateral oscillation. This change moves the airplane down in this direction on the chart. Reducing the dihedral usually decreases the time to damp and causes only a slight reduction in period so that reducing the dihedral is a fairly effective means of improving the stability of the Dutch roll oscillation. In some cases, however, the dihedral angle cannot be reduced enough to make the damping of the oscillation satisfactory.

We also know that reducing the wing incidence or making it negative improves the stability of the Dutch roll oscillation. This change moves the airplane down in this direction on the chart. Here again we might find that practical considerations may prohibit reducing the wing incidence sufficiently to make the damping of the Dutch roll oscillation satisfactory.

In some cases, changing all three of these geometric factors simultaneously will not make the damping of the lateral oscillation satisfactory. In these cases it is necessary to resort to some artificial m eans of increasing the stability of the lateral oscillation. One relatively simple device for artificially increasing the stability of the oscillation is a rate-sensitive autopilot.

This model is equipped with a rate-sensitive autopilot to illustrate how such a device works. This autopilot consists of a rate gyro which is sensitive to a yawing velocity and controls the flow of air to a pneumatic servo mechanism which is linked to the rudder. Thus as the model yaws the rudder moves so as to oppose the yawing motion. You will note that the autopilot is sensitive to the rate of yawing and not to the angle of yaw. The rudder is deflected only when the model is yawing and is centered when the model is held at any angle of yaw. With this arrangement the autopilot increases the damping in yaw and therefore improves the damping of the lateral oscillation. For instance putting such an autopilot in our hypothetical airplane moves it down in this direction on the chart. It should be pointed out that a rate-sensitive autopilot can be made to move either the ailerons or rudder in response to either a rolling or yawing velocity.

We are going to show you a flight demonstration of the effect of rate-sensitive autopilot in increasing the stability of a lateral oscillation of a model in the tunnel. The flight model, which is a simplified research model, not a model of any proposed design, is equipped with an autopilot similar to the one in this model except that the rate gyro is mounted so that it is sensitive to rolling velocity and the servo moves the ailerons to oppose the rolling velocity. The pilot will take the model off and fly it for a while with the autopilot operating to demonstrate the good stability characteristics produced by the autopilot. Then the autopilot will be cut out to show the inherently low stability of the lateral oscillation which represents unsatisfactory behavior. A speaker in the tunnel will tell you when the autopilot is cut out and is switched back in. Now if you will step to the observation windows at the back of the room we will have the flight demonstration.

Now if any of you have any questions about the material presented or the operation of the tunnel I or any of these other members of the staff will be glad to try and answer them.

The model used in this demonstration is not powered so it is flown in a glide. The operators are adjusting the tunnel angle to the glide angle at which the model is expected to fly. The airspeed is being brought up and at the proper airspeed the pilot will give up elevator control and the model will take off. Now the pilot gives up elevator. The model has taken off and is flying freely in the tunnel.

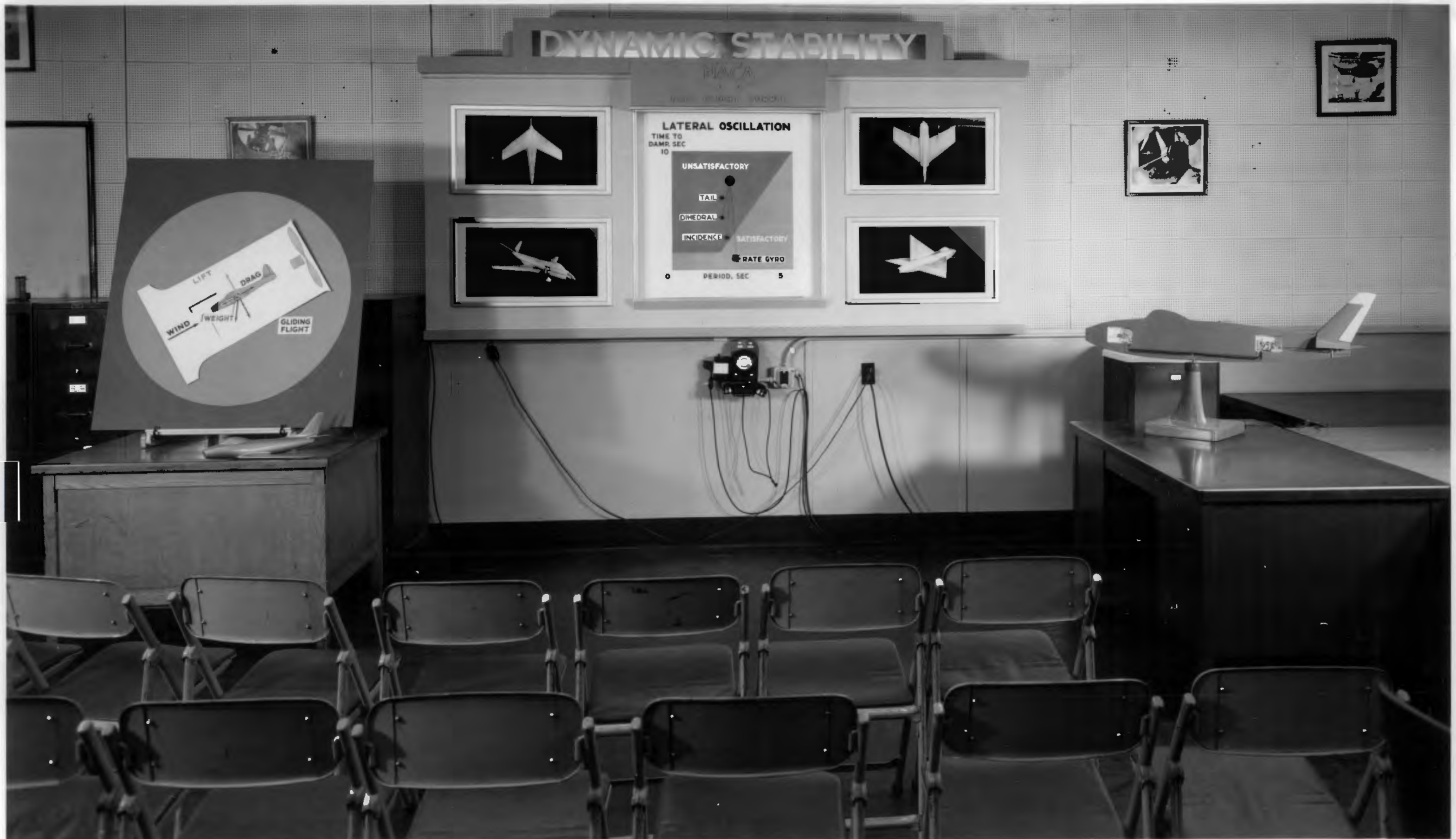
I would like to remind you that the rate gyro is operating and is applying aileron control to oppose rolling velocity. With a simple rate-sensitive autopilot like this the model has no sense of position in the tunnel so that it is necessary for the pilot to fly the model to keep it from bumping into the tunnel walls. With the rate gyro operating the lateral oscillation is so well damped that it is hardly noticeable. In this condition the model is easy to fly.

Now we will switch out the rate gyro. With the gyro out you can see a definite lateral oscillation. This oscillation is still stable but it is more lightly damped than when the gyro was in.

Now we will switch the rate gyro back in and you will notice how the model steadies down.

We will now land the model. To make a landing, the tunnel angle is reduced and the model drops to the floor of the tunnel.

This concludes our program in the free-flight tunnel.



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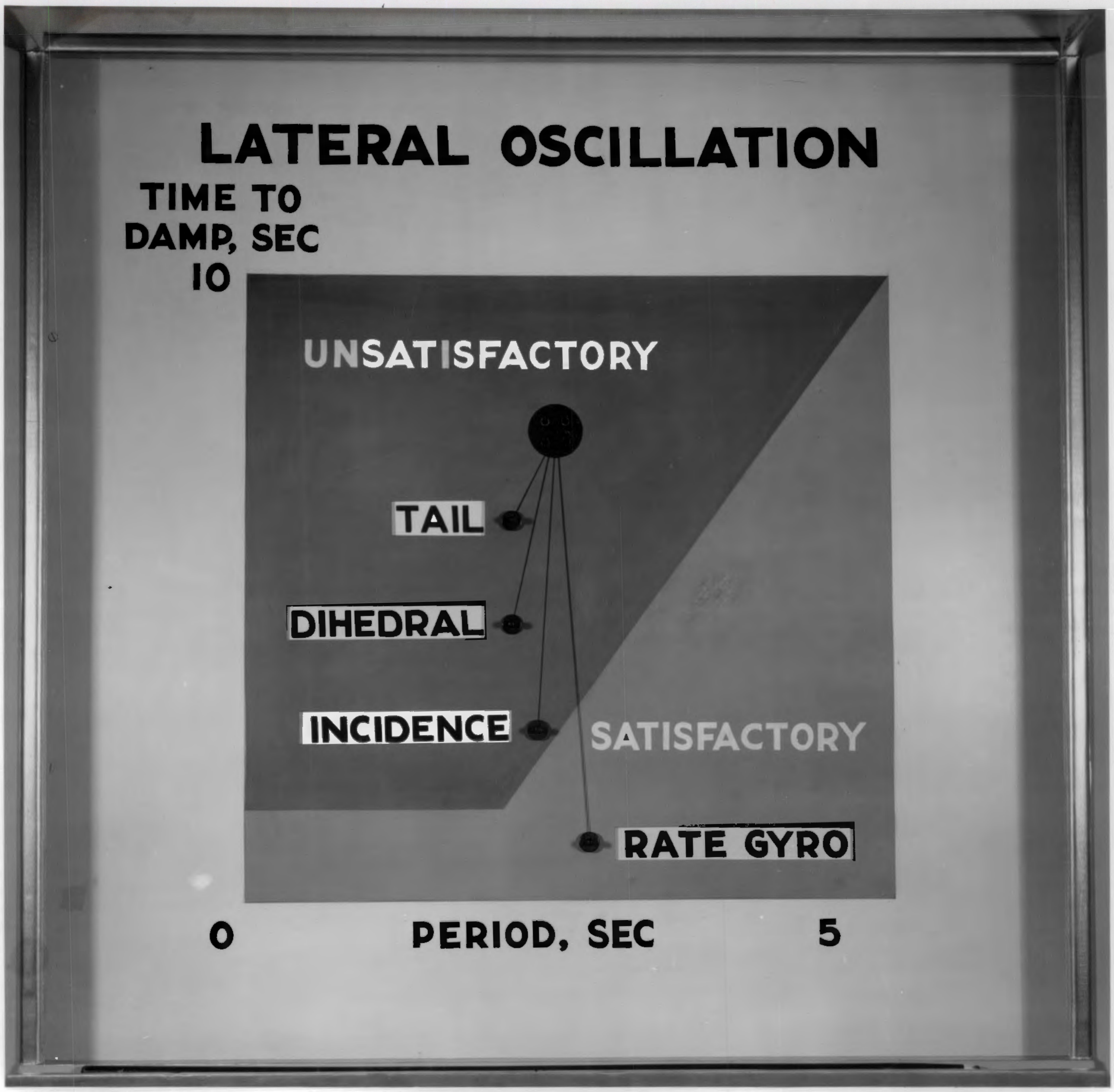

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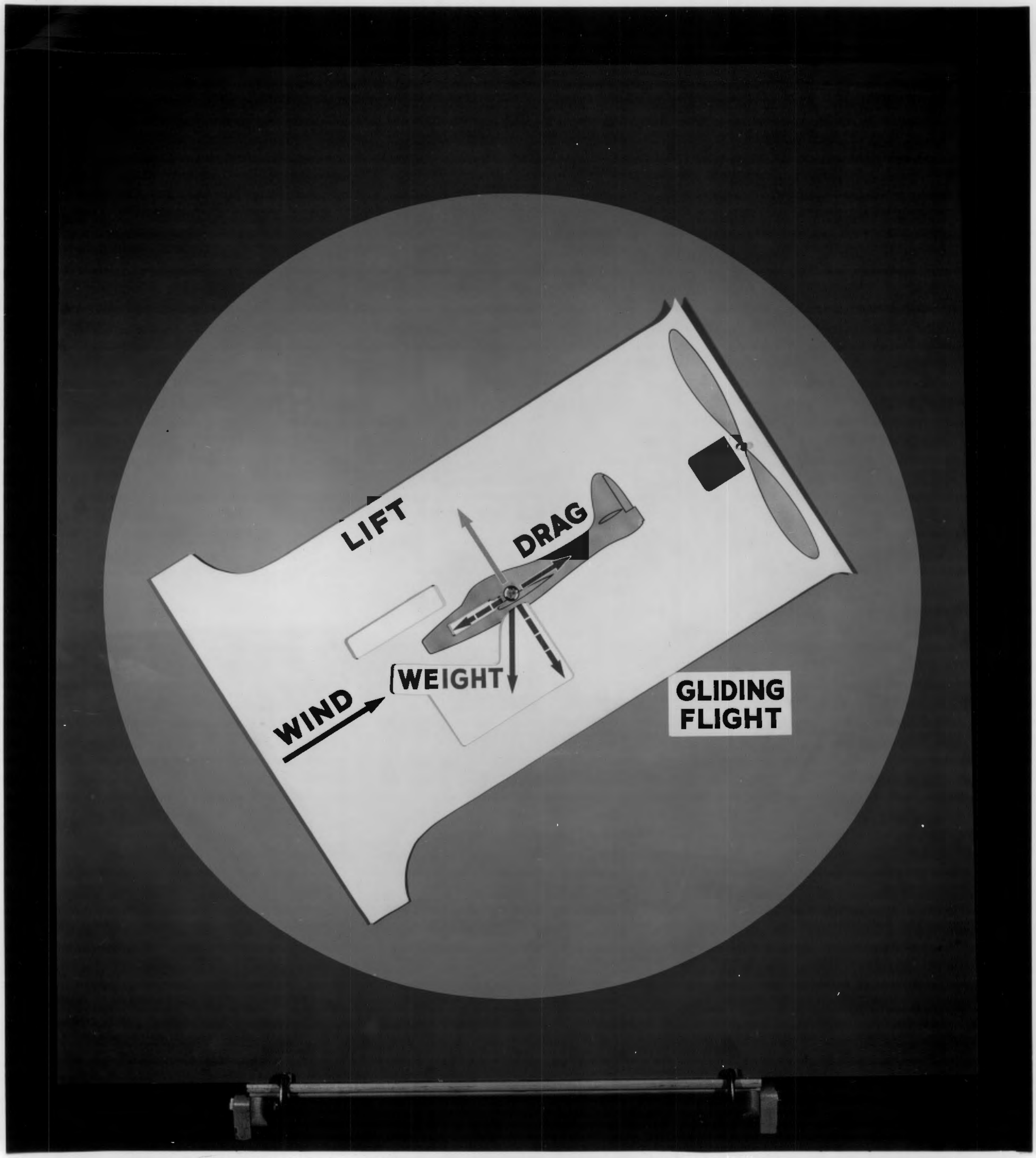

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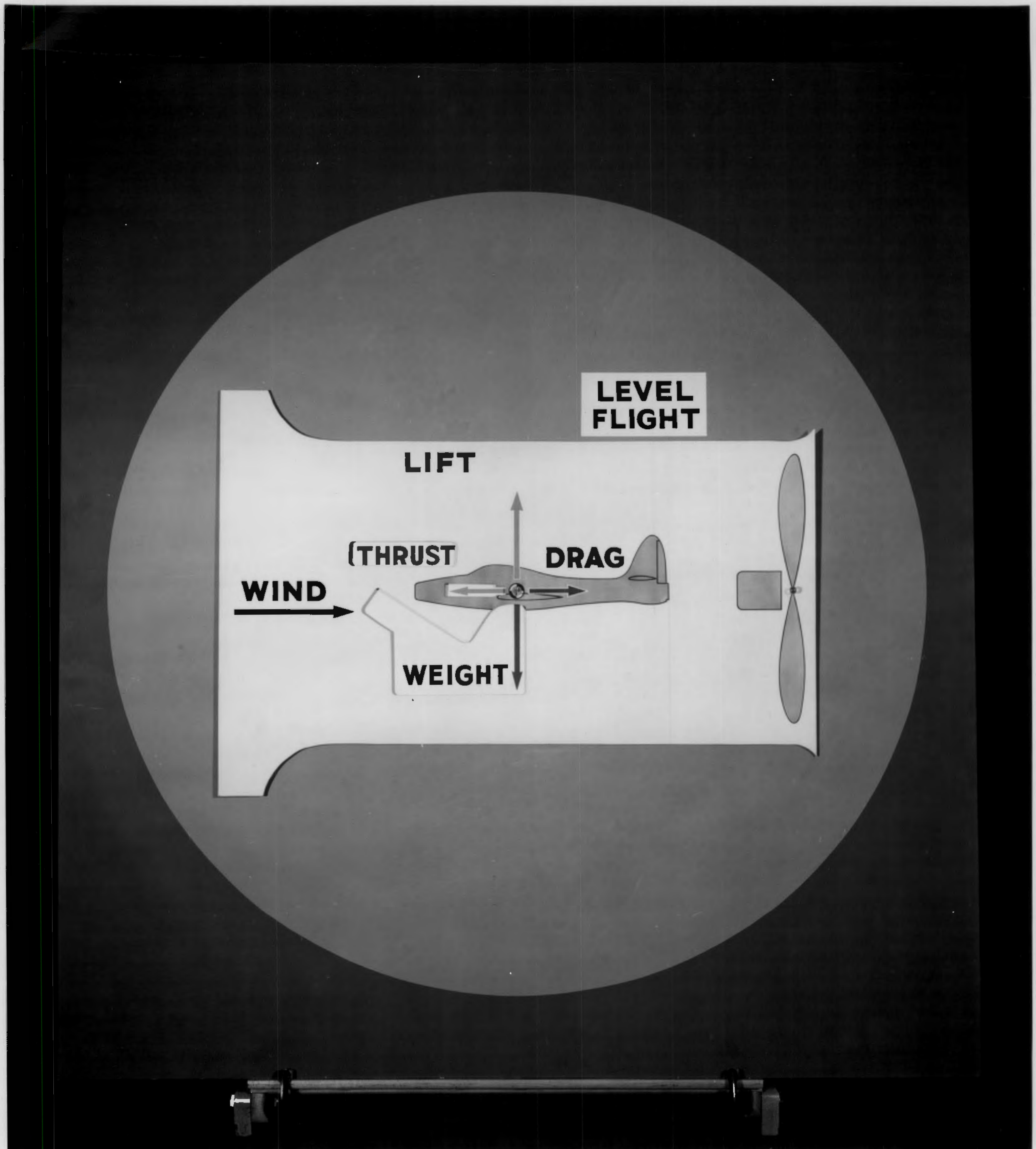

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