1953 INSPECTION

HYDRODYNAMICS STOP

TALK ON DITCHING

By Edward L. Hoffman or Ellis E. McBride

The Hydrodynamics Research Division has two towing tanks. This is tank no. 2 and is 1800 feet long. Tank no. 1 is 2900 feet long, is located parallel to this tank and just beyond this wall. Each tank has a towing carriage that is used primarily in conducting research on water-based aircraft. In addition to the towing carriages we have catapult devices available so that free launched landing characteristics of airplanes may be studied. The presentation today will include a talk to bring you up to date on our ditching program and a talk on the application of hydro-skis to water-based aircraft.

Our ditching program is aimed primarily at evaluating the water landing characteristics of land planes. We obtain information on preferred ditching procedure, probable ditching behavior, expected damage to the airplane, and means for improving the behavior and minimizing the damage. This information is considered by the various agencies in preparation of ditching procedures and has had some influence on design and equipment requirements.

Information is accumulated on the ditching characteristics of the current airplane designs through model investigations if the designs are new or unusual and in this respect we have established a back log of ditching experience. At the same time we have conducted research on some basic configurations to help fill out and substantiate our knowledge. We also evaluate ditching characteristics by analysis if the designs are similar to configurations for which we have made model tests.

We will show motion pictures to illustrate some current airplane designs and their ditching behavior. The model ditchings to be presented were made in calm water. In rough-water ditchings made parallel to waves the same general type performance should be obtained. In rough-water ditchings made perpendicular to waves, more damage and violence of motion may occur, depending on the landing technique and size of the waves.

One of the current airplanes to be illustrated is the B-45. This was the first jet bomber that we tested. The big influence on the ditching of the B-45 was the weak bomb-bay doors. This is an old story for bombers but it's still true. The next movie shows a ditching of the B-45 ending in a dive caused by failure of the bomb-bay doors. Because of the weak bomb-bay doors, bomber ditchings are frequently violent in behavior and safe ditching stations are relatively few.

The ditching considerations for bombers are in sharp contrast with those for transport-type airplanes. The transport generally has no very weak part in the fuselage bottom to correspond to bomb-bay doors, consequently the damage is less and the behavior is much better. The next movie shows a ditching run of the Stratocruiser. The behavior of this airplane is typical for most transports and is relatively good. The transport illustrated is a double deck type and, consequently, affords unusually good ditching safety on the upper deck.

In keeping with our policy of investigating a variety of types and configurations we naturally included the F7U. Here is a picture of this unusual configuration. The next movie will show a ditching run of this model. As you see the behavior is good. The outstanding characteristic of this type airplane is a tendency to skip at the high landing speeds associated with a swept-wing fighter.

A new design as far as ditching is concerned is the B-47. The outstanding features are the swept-wing, the nacelle installation and the bicycle landing gear which necessitates doors in the fuselage here and here. The next movie is a ditching run of the B-47 and shows that it made very good ditchings. Notice that the nacelles, which were fastened at scale strength, broke off and didn't affect the ditching run. Here is the model used in these tests. From these tests and tests of the other swept-wing airplanes we have concluded that swept wings have little effect on ditching behavior other than aerodynamic influence on handling and landing characteristics. The nacelles in this particular case had little effect on behavior since they broke off but it is conceivable that such an installation could be detrimental if the nacelles dug in and were strong enough to withstand appreciable loads. Also, the bicycle landing gear necessitates doors in the fuselage bottom which from the ditching viewpoint are undesirable because the fuselage is flooded more easily. A contribution of the bicycle gear design favorable to ditching is a very strong fuselage structure.

In addition to the specific investigations we have also tested various ditching aids. A particularly effective type is the hydro-ski ditching aid. We will illustrate the effectiveness of this in the next movies. First, here is a typical ditching run of the Constellation without the hydro-ski aid. This behavior was fairly good but the airplane decelerates rapidly and would sustain some bottom damage. Now let's add a hydro-ski. This planing surface is shown here extended below the fuselage. If you want to go all out for a really good ditching this aid may be worth the weight penalty. Watch this next run when the ski is used. The advantages of the hydro-ski are obvious.

This ends the talk on ditching. Mr. Ramsen (or McGehee) will now tell you about the application of hydro-skis to water-based aircraft.

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HYDRODYNAMICS STOP

HYDRO-SKI TALK

By John A. Ramsen or John R. McGehee

With the appearance of jet engines an opportunity was presented to make some radical changes in designs for water-based airplanes. For example, in propeller-driven water-based airplanes, the hull had to be designed so as to keep the engines high enough to provide clearance between the propellers and the water. This in turn made the hull bulky and not conducive to high performance when airborne. For jet-powered airplanes, the need for propeller clearance was no longer present, permitting considerable reduction in hull height. To take full advantage of the new propulsion system, the entire problem of water-based aircraft was reexamined using as a starting point the type of airplane known to give good aerodynamic performance.

Here is a model (show model) of an airplane representative of high-speed designs which have given good aerodynamic performance. (Replace model) When water take-offs were attempted with this model, the resistance encountered was very high as shown on this first chart which is a plot of resistance against speed. The resistance on water shown here may be compared with the resistance of the same plane with wheels on a hard runway as shown by this curve. As a matter of fact the water resistance was so high that it exceeded the thrust of present designs. A typical thrust curve is shown here. This of course would make take-off impossible, for this speed (point to cross over) would be the top speed of such an airplane. If sufficient power were provided for take-off this power would be enough to make the airplane rise vertically.

Past experience has shown that the fuselage itself may be modified so that the resistance would remain in this region (refer to chart) below the thrust curve so that take-off would be possible. However, such modification of the fuselage would seriously compromise the aerodynamic performance.

This model (show model) was used in our preliminary investigations of hydro-skis which were begun in 1947. The hydro-skis are made by extending small portions of the fuselage like this (demonstrate). For those of you who are not familiar with hydro-skis, these lifting surfaces when extended below the fuselage support a water-based airplane during the high-speed part of the take-off and landing run. Thus the main body of the airplane is not subjected to the high water loads encountered at high speeds. Since the hydro-skis are retractable in flight, they would not compromise the aerodynamic performance.

The resistance characteristics of the arrangement with the hydro-skis included are shown in this next chart. In this region where the fuselage is running deeply in the water, the resistance rises rapidly as it did in the case of the fuselage alone. However, as the speed increases, the lift provided by the hydro-skis also increases until it is sufficient to raise the fuselage almost clear of the water as shown here. From this point on, the resistance decreases as the fuselage clears the water and the hydrodynamic load is carried entirely by the hydro-skis as shown here. Since the maximum resistance is less than the thrust, the airplane will take-off.

We will now see some motion pictures of this model landing as a free body in the river just outside this building. (Motion pictures - 2 landings - 1 min., 14 sec.) (1st landing) The model was launched from a catapult into the river. Stability is excellent; the model deviates very little from a straight course over the entire landing run. Near the end of the run the skis submerge and the airplane is supported by the buoyancy of the fuselage. (2nd landing) When the model lands on one ski, it rights itself and continues on a straight course. At the end of the run the ski again submerges at almost the same spot as in the previous run.

As you have seen, the landing problem with hydro-skis is a relatively simple one. For the take-off problem, however, the designer of a hydro-ski airplane needs information which will permit him to select the type of skis, their size, location and angle of attack so as to provide adequate stability characteristics and enough lift to support the airplane while keeping the resistance below the available thrust. In order to provide this information the NACA has investigated the characteristics of various types of skis and fuselages in combination. In addition, basic information on the characteristics of isolated skis of many types with various plan forms, bottom shapes, length-beam ratios, etc. has been obtained. As an illustration of the type of information available from the investigations with isolated skis and the way this information may be used by the designer we shall consider the relative merits of two simple surfaces. Since considerable data are available on the flat plate which is the classical base for comparison purposes, it will be used as the reference to which the characteristics of a surface curved to permit flush retraction into a streamline fuselage will be compared.

The next chart shows the lift for the two surfaces as a function of the angle of attack. The planing flat plate has good lift characteristics as shown by this line but when the surface is curved, the lift for a given angle of attack is reduced as shown by this line. The next chart shows the resistance for the flat plate and the same curved surface. It can be seen that for a given lift the resistance is increased in going from the flat plate to the curved surface. Information like that shown on these two charts has been obtained for many surfaces including some which are suitable for retraction into curved fuselages and yet have lift and resistance characteristics as good as or better than the flat plate.

Such information as this may be interpreted by the designer to enable him to select the size and type of ski necessary for his particular problem. For example, if the airplane engine had previously been selected so that the available thrust were known he would want to know the size of each type of ski which would enable him to keep the resistance at a value below this available thrust. For a given airplane the weight and therefore the lift required would be constant so that the aforementioned condition amounts to finding the relative sizes of the skis for a given lift-resistance ratio. The next chart compares the sizes of the flat plate and the curved ski shown on the previous charts which would give the same lift-resistance ratio. The size of the curved surface required (refer to chart) would be 40 percent greater than the size of the flat plate required (refer to chart).

On the other hand if it were possible to alter the thrust but the bottom area available for extension were fixed by the fuselage dimensions, the relative resistance for various types of skis having the same area would be an important item. The last chart shows the relative resistance which would be obtained with the two skis shown previously if the size were held constant. The resistance of the curved surface (refer to chart) is 25 percent greater than that of the flat plate.

To give you a more graphic idea of the hydro-ski airplane and its operation we are going to demonstrate a take-off with a model of such an airplane. Three phases of the take-off will be demonstrated in three separate runs with the model. First we will see this phase (refer to second chart) where the load is carried principally by the fuselage. Second we will see this phase (refer to chart) where the bulk of the load has been transferred to the ski. And finally we will see a complete take-off in which the model will pass by during this phase (refer to chart) in which the entire hydrodynamic load is being supported by the hydro-ski. The model will be run free to pitch and free to rise (indicate with model) and will be powered by compressed air to simulate a jet power plant. The model which is similar to this one is attached to the towing carriage at your left.

The carriage will now start and you will see the model operating in the first phase which is essentially a displacement phase

(First model run). You may have noticed that no spray entered the ducts during this run. In early tests spray was observed to cling to the sides of the fuselage and to enter the ducts at these low speeds. Tests were conducted of various sizes of strips which indicated that the very small strips shown on this model (demonstrate) which would be only 3/4 inch wide full size, were effective in keeping the spray clear of the ducts. (Replace model). In the first run the resistance was due primarily to the fuselage and was rising rapidly as shown here (refer to chart). The carriage will now return and demonstrate the second or transition phase (refer to chart). (Second model run) In this run the resistance increased to a peak (refer to chart) and most of the load was transferred to the ski. The spray just at emergence does not enter the ducts but is directed to the side so that it causes no trouble. Next you will see the model make an unpiloted take-off, that is, the elevators will remain fixed throughout the run. By watching closely you will see the model pass through the two phases previously demonstrated and enter the final or planing phase (refer to chart) where it planes stably on the skis until take-off. The carriage will now return for this final run (third model run).

This ends the program of the Hydrodynamics Division.

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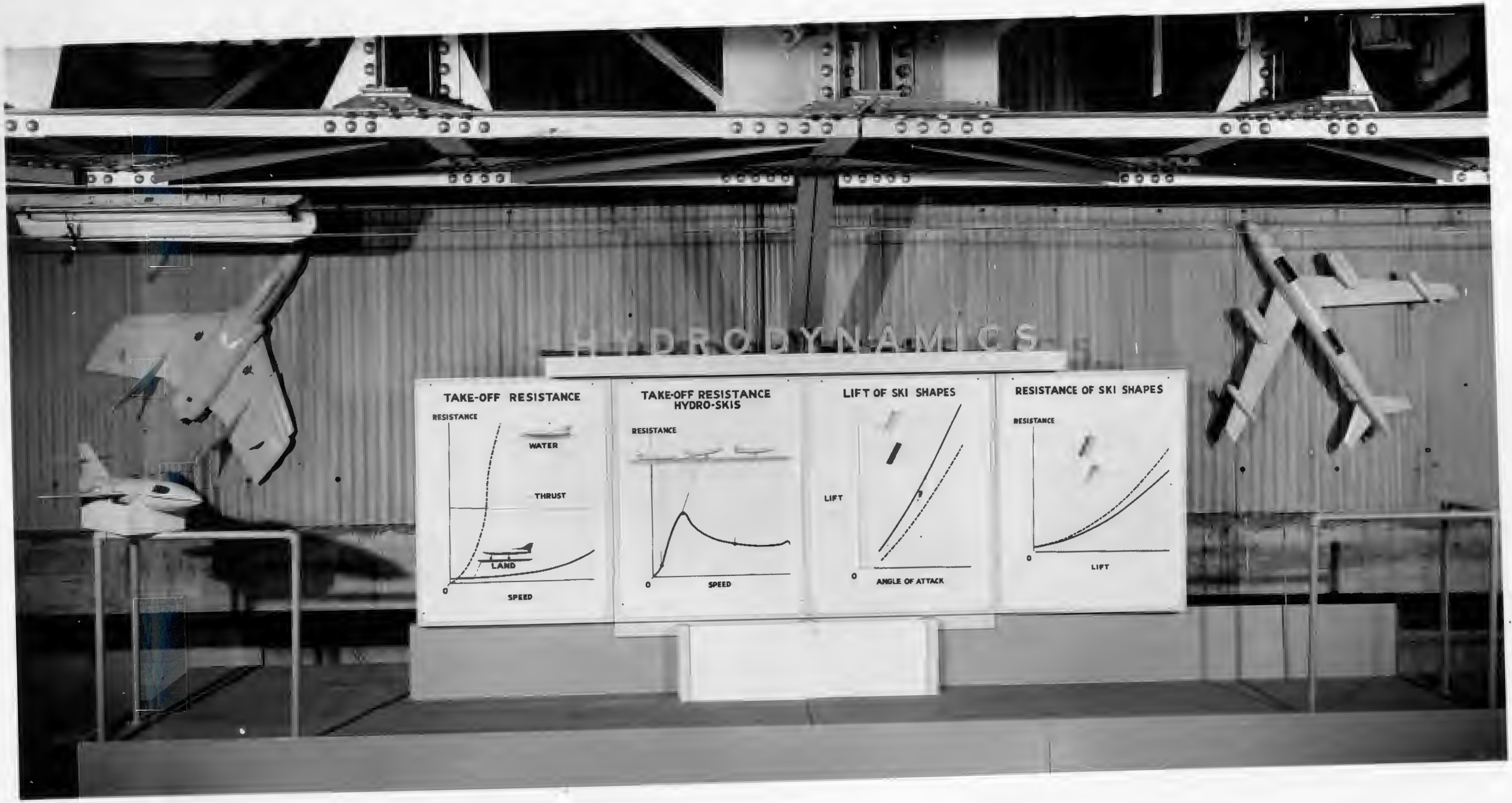
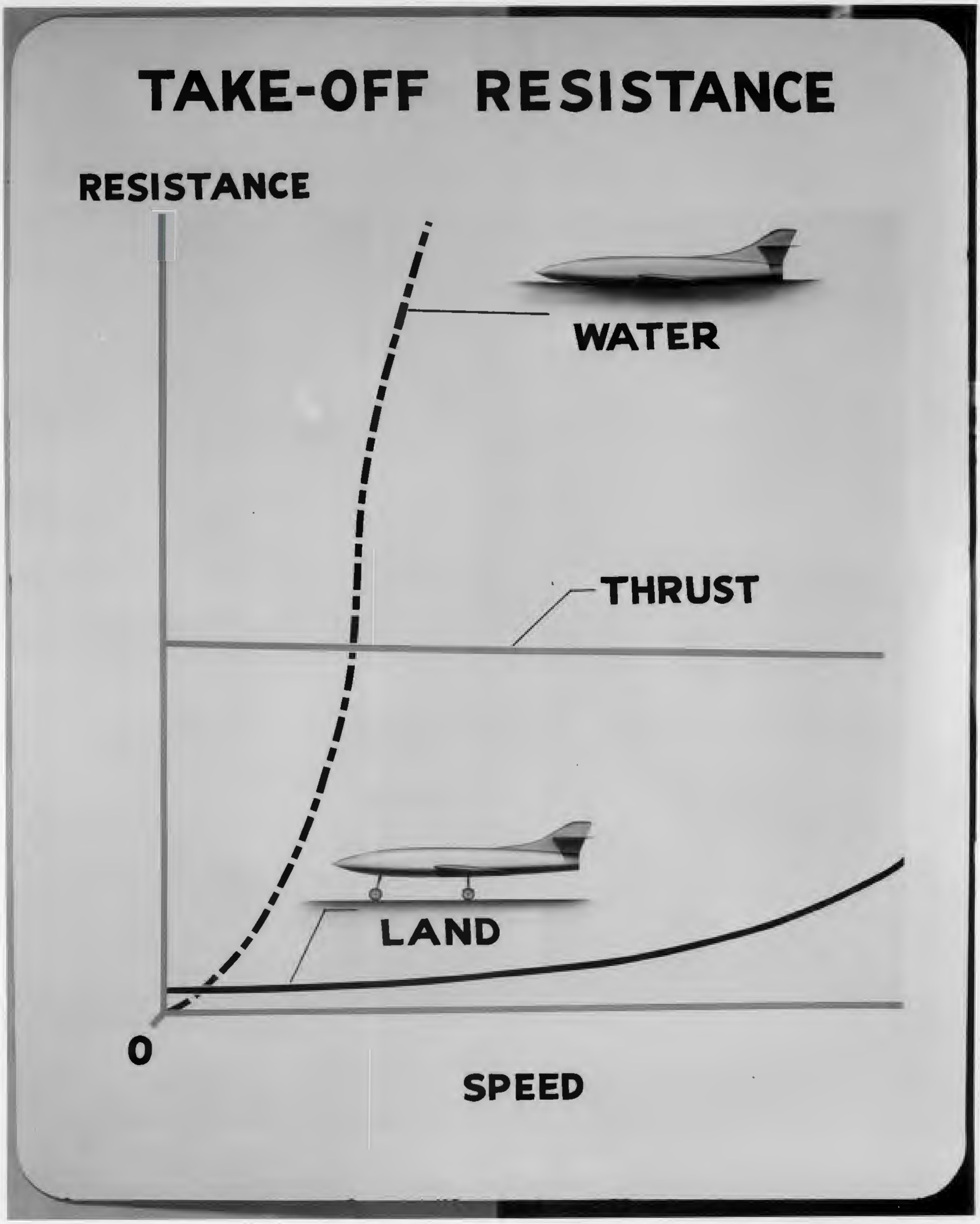


Display for Hydrodynamics



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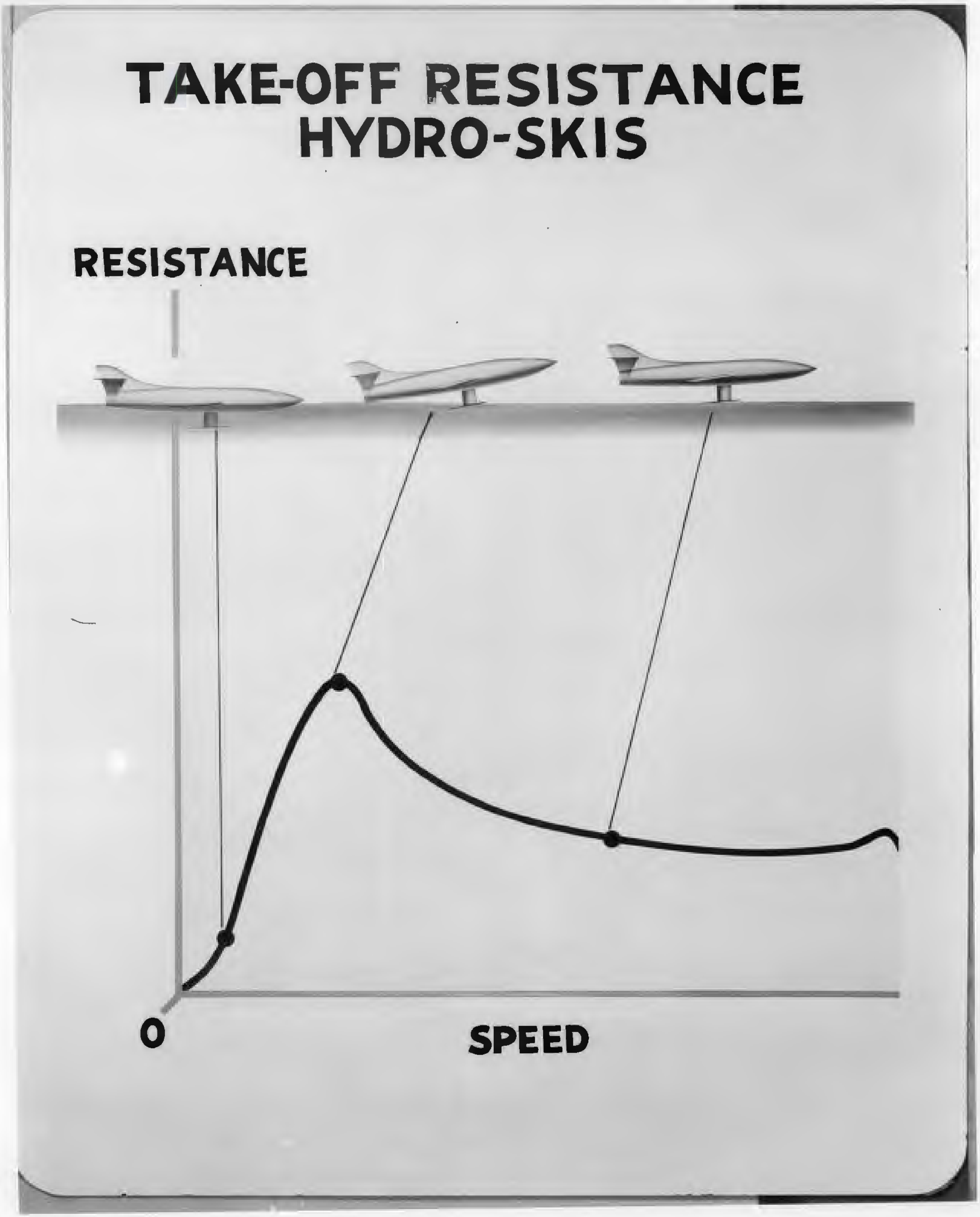

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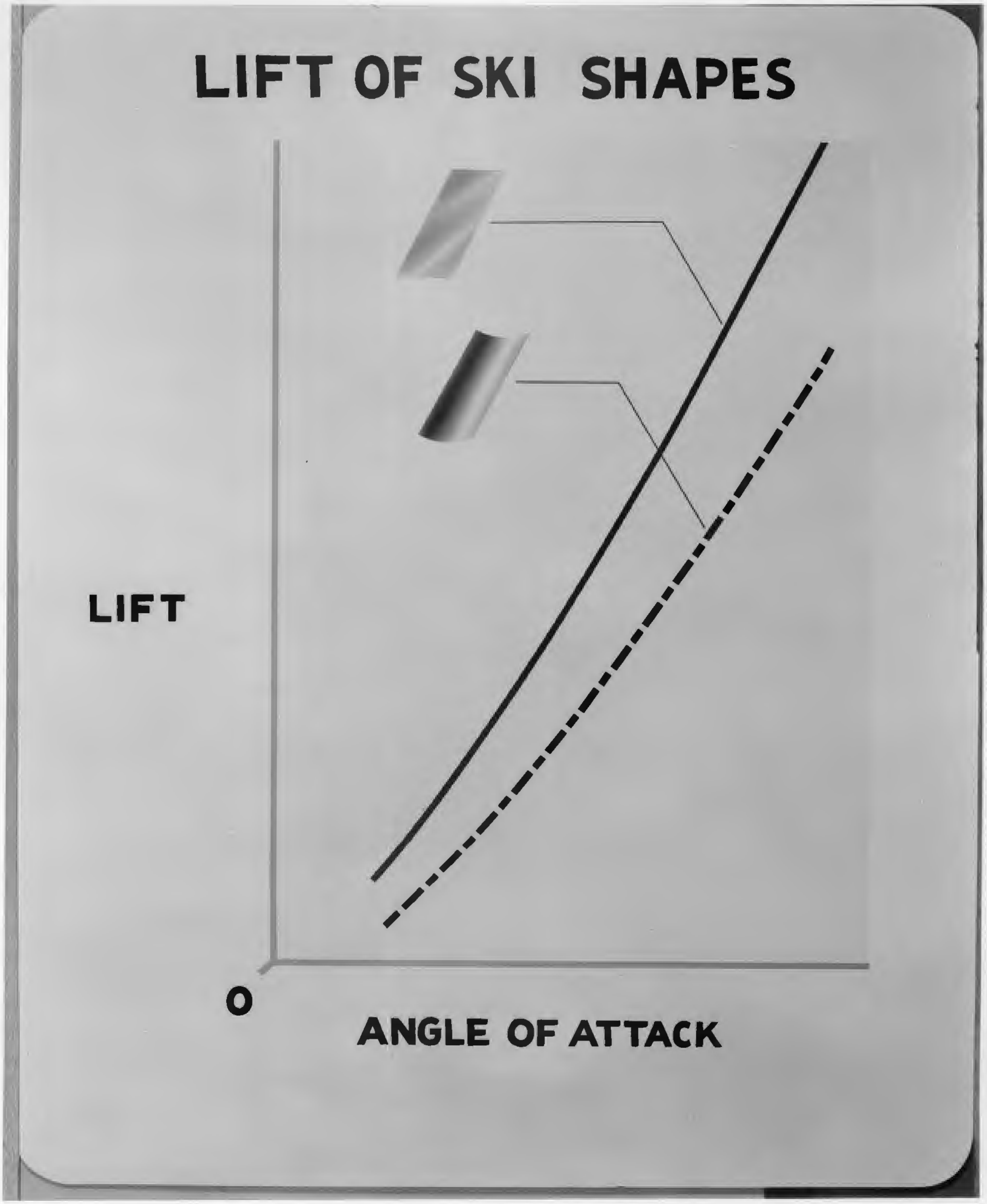
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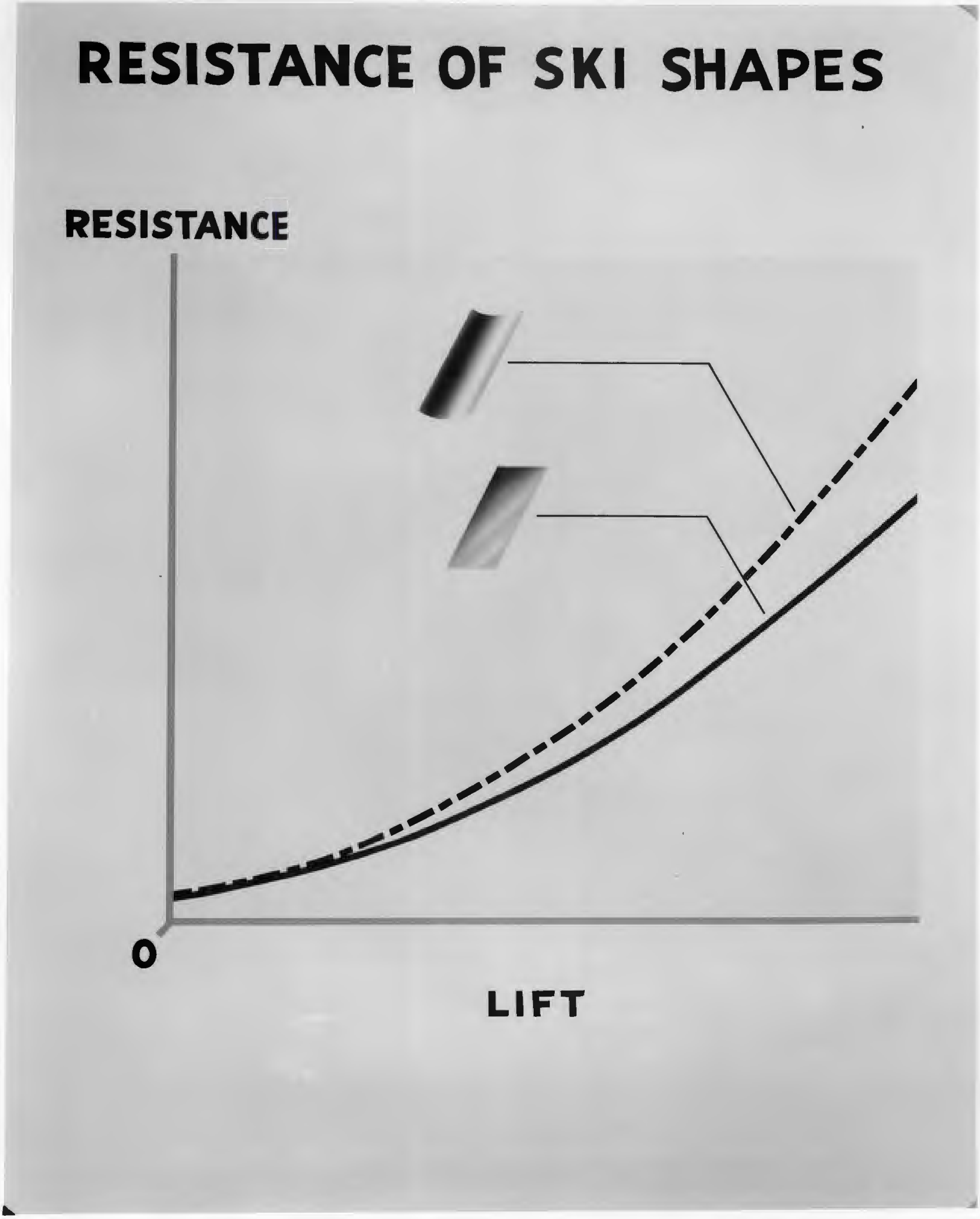
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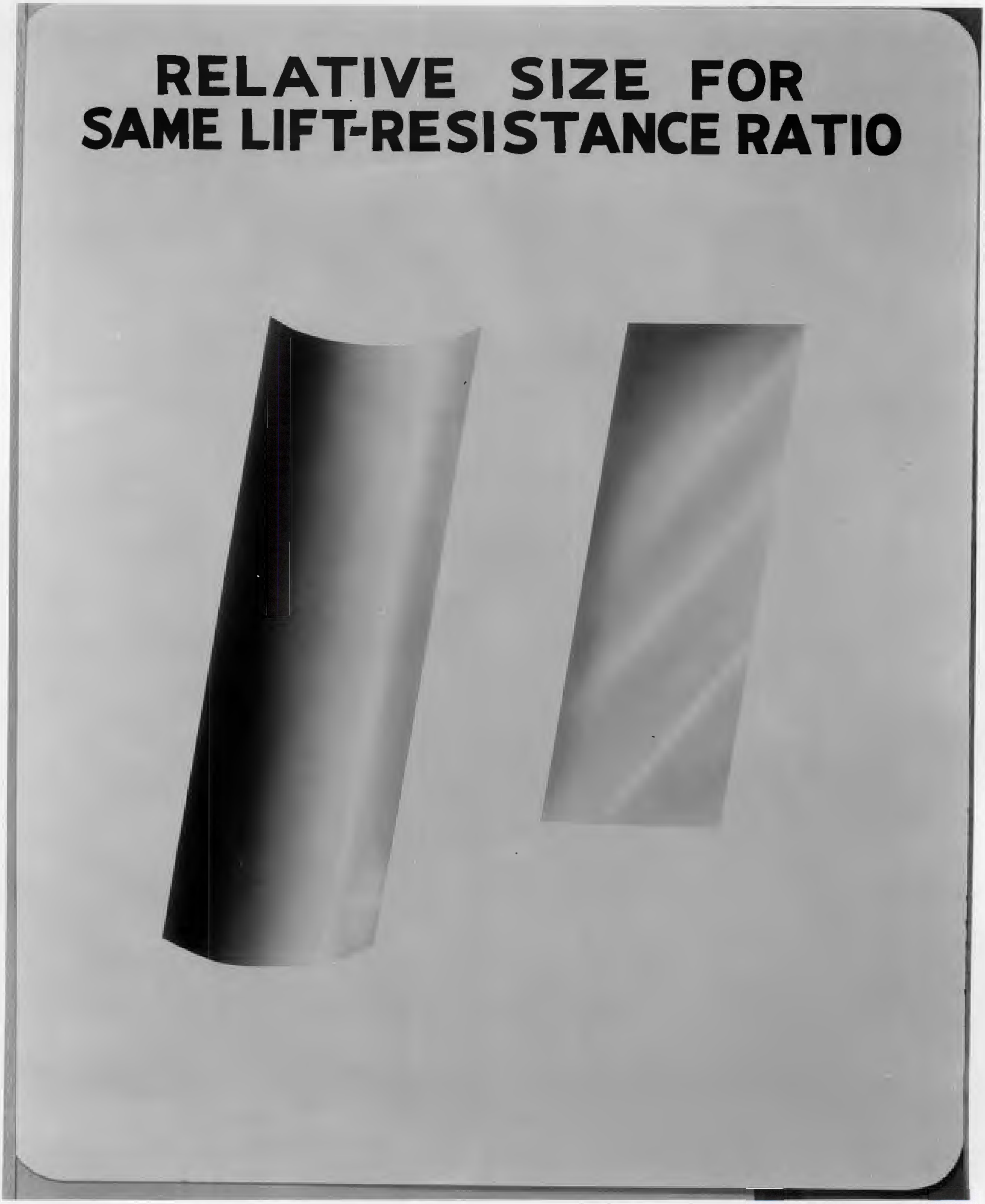

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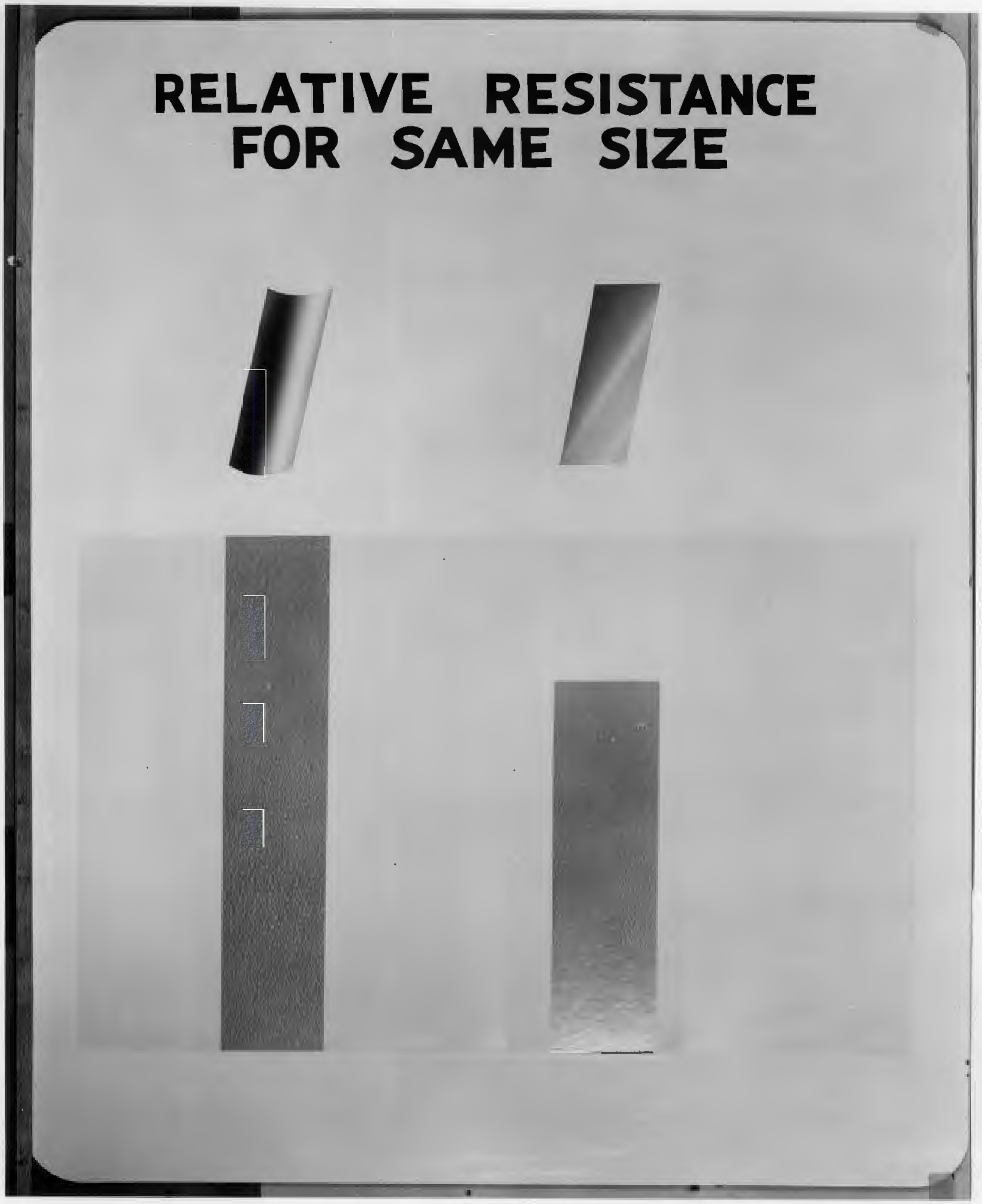

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