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ANTI-OSCILLATION MOUNT FOR BINOCULARS

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ANTI-OSCILLATION MOUNT FOR BINOCULARS

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FOREWORD

Under Project AC-26, Section 16.1 of NDRC has been engaged in a general study of night vision devices. Since magnification is an essential factor in any optical instrument capable of increasing range of visual detection, and since angular vibration limits the extent to which magnification can be used, it has been necessary to develop mounts which reduce vibration. Under Project NS-105, an anti-oscillation mount for shipborne binoculars is being developed.

The present report describes the development of anti-oscillation mounts for standard binoculars, intended for use by observers (not the pilot) in aircraft and by lookouts on ships.

Other developments of anti-oscillation mounts are described in the following reports:

University of Rochester
Section 16.1 Report No. 14
OSRD Report No. 1479

Eastman Kodak Company
Section 16.1 Report No. 63
OSRD Report No. 4444

The development of a more complicated gimbal mount for binoculars is described in the following reports:

University of Rochester
Section 16.1 Report No. 14
OSRD Report No. 1479

Eastman Kodak Company
Section 16.1 Report No. 63
OSRD Report No. 4444

A report is now being prepared by the Eastman Kodak Company on the development of an anti-oscillation mount in which a standard binocular is supported, at its center of gravity, by means of an inverted concave bakelite cone resting on a steel ball.

Tests of all of these mounts are now in progress.

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February 28, 1945

ANTI-OSCILLATION MOUNT FOR BINOCULARS

1. Statement of Problem

There is urgent need by the Army and the Navy for an anti-oscillation mount for binoculars to be used both in aircraft and on ships. Standard binoculars should be used if possible. The device should be easy to produce, and it should require the minimum of servicing to keep it in good operating condition.

2. Design of A.O. Mount

Previous tests of Torflex rubber bearings as a filtering means for rotational vibration has been made in preliminary work on a scanning device. These tests, fully covered in a report entitled PERISCOPIC SCANNING DEVICE (Section 16.1 Report No. 55, OSRD Report No. 4182) showed that excellent filtering action could be obtained by the use of properly designed rubber bearings. For this reason consideration was first given to Torflex bearings, but the difficulties encountered led to the development of an improved type of mounting called the Ball Type Mount. These two designs are fully discussed under (a) and (b) as follows:

(a) Internal Gimbal Mount. This design was a center of gravity unit with the binoculars carried on three shafts mounted on short sections of Torflex rubber bearings. These shafts comprised a gimbal system so compact as to fit between the two binocular halves. Damping was obtained by having a dry friction pad on a lever arm bear against a conical metal surface. An experimental unit was made wherein the binoculars were carried on a single cross shaft mounted on two rubber bearings, which give isolation in one axis only, namely, the horizontal transverse axis. The two bearings were 1/8" long - 5/16" ID x 5/8" OD #S-31620-R Torflex rubber bearings.

The test was made on the vibrating table shown in Fig. 3 of Section 16.1 Report No. 55 referred to above. The undamped natural frequency F_N of the binoculars was 210 cpm. This test showed the impracticability of using standard Torflex rubber bearings since even with bearings only 1/8" long the F_N was much too high to give good filtering action. It was thought that if pure gum rubber could be used the restoring force would be considerably lowered. However, the 1/8" long bearings were very fragile and had to be handled carefully to prevent the rubber and inner bushing from jumping out of the outer sleeve, since the rubber was under considerable compression. In previous tests on the scanning device where the length of the bearings was 1/2" or more this trouble was not so pronounced.

In this preliminary setup it was necessary to leave the interpupillary distance of the binoculars fixed after the unit was balanced, since any change in this distance materially changed the center of gravity and unbalanced the unit. It was found that the change in interpupillary distance from minimum to maximum width caused a shift of the center of gravity of approximately ± 9/16". A number of methods of compensating for this shift were considered, such as moving counterweights, etc., but no simple foolproof solution was found. For this reason it was decided to hang the two barrels of the binoculars on a plate using the same ears or brackets originally used but to separate them 2-9/16" which is the mean interpupillary distance. See Dwg. 71-A4. Thus mounted the center of gravity shifts less than ± 1/8" with maximum change in interpupillary distance which is not enough to disturb the proper functioning of the unit.

<u>(b) Ball Type A.O.Unit</u>. Simultaneously with the above work an entirely new design of A.O. unit was developed. This was a center of gravity unit wherein the three rubber bearing mounted axes needed for isolation in

all planes are replaced by a spherical bearing coated with rubber and enclosed by two metal hemispheres. For an assembly of this mount see Dwg. 71-A4. In the drawing 1 denotes the spherical bearing encased in rubber; 2 the dry frictional damping pad bearing against a concave spherical surface which provides damping in all modes of vibration; 3 the adjusting screw mechanism by which the interpupillary distance is changed, the screw mechanism being mounted on a plate which serves as a pendulum mount for the two binocular halves; 4 standard Bausch & Lomb 8 x 56 binoculars.

The first tests were made with a 1/2" diameter ball stud with a 1/8" thick pure gum rubber washer top and bottom in lieu of the vulcanized rubber on the ball stud. It was found that the restoring force with flat washers of pure gum rubber was sufficient to give an F_N of 200 cpm. If the washers were cut in the form of a cross  the restoring force could be lowered sufficiently to give an F_N of 150 cpm.

3. Construction and Testing of A.O. Unit for 8 x 56 Binocular Mount

A model unit constructed as shown in Dwg. 71-A4 was completed and tests went forward at once. A summary of these tests and further developments at that time are best described by extracts from Progress Report No. 4, as follows:

Tests of this model on a vibrating table and on mounts providing random vibration such as a camera tripod equipped with an eccentric motor and in the back of a moving truck indicated that isolation in three planes, namely, pitch, yaw and roll, was satisfactory. The dry frictional damping device provided sufficient damping for two modes of vibration, pitch and yaw, but insufficient damping for roll. The modification which was made on the binocular hinge in order to provide a method for changing the interpupillary distance without substantially altering the position of the center of gravity placed the center of gravity of the entire unit at some distance from the plane of the two optical axes of the binocular halves. For this reason roll is of more concern, and it became evident that both isolation and damping would be necessary.

Consideration was then given to mounting a second dry frictional damping device perpendicular to the damping device shown in Dwg. 71-A4, and further consideration resulted in a design of a single damping device combining the damping characteristics which would be achieved by two dampers placed perpendicularly. Such a design is similar to the device shown in Dwg. 71-A4 except that two dry friction pads were used instead of one. These two pads were placed approximately 3" apart (to yield equivalent leverage) on a yoke in a position comparable to that of the single pad damper shown in Dwg. 71-A4. These two pads bear against a section of a spherical surface.

Consideration was also given to the placement of a damping medium in the top half of the ball mount. Initial tests indicated that sufficient isolation and restoring force could be obtained by placing a rubber disc in the bottom half of the ball mount only. By placing a felt disc on the top half of the ball mount it was found that damping could be achieved. Further improvements were made by installing a circular phosphor bronze leaf type spring surrounding the top half of the ball encased in the sphere. This spring was attached rigidly to the ball stud supporting the binoculars and thus provided compression of the felt against the inner surface of the surrounding sphere. This spring is further beneficial inasmuch as it will provide compression at all times against the felt should the felt tend to take a set. Subsequent modification included the addition of a rubber disc between the upper half of the ball and the spring to provide more mechanical stability.

A special cone-shaped member has been added to the unit immediately above the sphere mount and serves as a stop for rotational motion of the binoculars.

The model, as just described, was tested under a variety of conditions, on a vibrating table, a vibrating tripod, and on a moving truck. At this time it became evident that a fixed head rest with eye pieces would be necessary for use with the mounted binoculars in order to maintain the placement of the observer's eyes in proper orientation with the eye pieces of the binoculars. Further improvement was noted when the base (5) on Dwg. 71-A4 was mounted on a shock absorbing mounting. This shock absorbing mount protects the instrument from sharp blows and aids somewhat in the filtering of undesirable vibration.

Acuity tests observing a line and letter chart reveal little if any loss of visual acuity between static and vibrating conditions when the 8 x 56 binoculars were mounted as shown in Dwg. 71-A5.

The unit was mounted on a shake table and vibrated for a total of sixteen hours to determine its mechanical life. Minor adjustments were necessary, but it is believed that the unit is in a satisfactory condition for preliminary shipboard tests. However it should be noted that the model in its present form has not been engineered for large scale production or for physical and mechanical stability which would be required in combat use.

Dwg. 71-A5 shows the design of the mount in its present form. The numbers on this drawing denote the following: 1, ball stud; 2, 1/8" medium hard felt; 3, interpupillary distance adjusting screw; 4, 8 x 56 binoculars; 5, pedestal base; 6, 1/8" pure gum rubber washer; 7, circular leaf type spring of .010" thick phosphor bronze; 8, pure gum rubber disc 1/16" thick; 9, black sponge rubber shock absorber 7/16" thick; and 10 and 11, shock absorbing base. The thickness of the base plate (5), together with the upper and lower sponge rubber discs, is such as to produce 1/8" compression of the rubber when the base is assembled. This supplied firm yet yielding support for the A.O. mount. Although it is true that lateral linear vibration will be converted into angular vibration since the center of gravity of the unit is above this base mount, this is more than offset by the cushioning effect of this type of base. These points are further discussed later in the report in Section 9 under the heading "Photographic Method of Testing A.O. Mount".

The following points should be noted in connection with this type mount inasmuch as the mount design is amenable to large modification to meet a wide variety of conditions:

1. The amount of damping available can be adjusted over a wide range within the sphere itself. If further damping is required than that which can be obtained within the ball mount, the external damping device could readily provide additional damping.

2. The isolation available by the use of the mount, as a function of the natural period of the unit can be adjusted over a wide range either by the addition of a weight as we have done, or by the adjustment of the sphere size to include more or less rubber. In one preliminary test, without damping, a natural period of approximately 50 cpm was obtained with the approximate mass distribution as now seen in the model itself.

3. It would be relatively easy to provide a mount of this sort with a means for adjusting the position of the ball stud with respect to the center of gravity.

4. By varying the ball and the sphere size, it is thought that this anti-oscillation mount is adaptable to a wide variety of installations.

As pointed out in the foregoing extract the need of a head rest to steady the observer's head and eyes was very necessary and considerable experimental work was done on the problem.

As shown in Dwg. 71-A5 the 8 x 56 binoculars were equipped with weights totaling approximately five pounds. This weight was added to increase the moment of inertia and thus lower the natural frequency. If the unit was to be used aboard ship the additional weight would not be objectionable, but for aircraft use as light a unit as possible is of course desirable. To this end the heavy weights as shown in Dwg. 71-A5 were removed from the binoculars and the bakelite objective guard rings were replaced with brass rings weighing approximately six ounces. This necessitated changing the amount of rubber and felt in the A.O. unit to keep the natural frequency as low as possible. With the light weights a natural frequency of 140 cpm was recorded, and if heavy weights were replaced a natural frequency of 96 cpm was possible. (See Figs. 1 and 2). Thus the same unit, by using either heavy or light weights, was applicable to shipboard or aircraft.

In order to check the effect of altering the interpupillary distance and adjusting the eye pieces for various foci, a number of tests were made. The curves resulting from these tests are shown in Figs. 2 and 3. The curves show that so little change takes place in the performance of the unit as to be negligible. Before making these tests considerable improvement in the means of laboratory testing the unit was made. The rigid vane, used in the early tests, carrying the aperture through which the beam of light was projected on a target was removed, and a small mirror was secured to the binocular unit near the center of gravity. A beam of light projected on this mirror was reflected to a distant scale on the wall and thus gave a measure of rotation only, which was what we desired to record. As soon as these tests were completed the unit was shipped to the Naval Air Base, Quonset, Rhode Island, for testing.

Reports of these tests indicated that the unit was unsatisfactory and further revisions of the design would be necessary. The preliminary model was returned to Hollywood where examination of the unit revealed that the mount had been forced and misaligned to such an extent that the characteristics of the anti-oscillation and damping units necessary for satisfactory operation of the unit were seriously impaired.

4. Design and Construction of Inverted Type A.O. Unit for Aircraft

Before undertaking design and construction of a final model, it seemed essential to obtain specific data regarding the use and application of the mount, particularly in regard to the type of aircraft and cockpit construction in which the installation would be made. To this end a trip was made to the Consolidated Aircraft Factory, San Diego, California, for the purpose of obtaining specific cockpit design information of a PBY patrol bomber in which it is understood the unit will be further tested.

As a result of this trip a first conclusion was reached that the installation of the mount for the anti-oscillation unit would involve an inverted yoke attached by a plate to structural ribs in the PBY cockpit. Some concern was felt regarding any installation of the unit involving permanent fixtures which would necessarily interfere with the primary function of the copilot during operations where complete freedom of view is necessary. Consideration was given, therefore, to a method of installation of the unit which would permit ease of immediate mounting and dismounting with a minimum of view obstruction during use of the unit. These considerations resulted in preliminary sketches of a design involving tripod legs fitted with rubber vacuum cups for attachment to the cockpit plastic roof. It was felt that such a design achieved the desired results of ease of mounting and dismounting and a minimum of view obstruction. The final design of this unit is shown in Dwg. 71-A8.

The design and construction of an alternate means of mounting in place of vacuum cups went forward at the same time. This was called a rigid bar mount and employed a 1/2" diameter steel bar secured at both ends to brackets mounted on two ribs of the aircraft cockpit roof. This construction also provided ease of mounting and dismounting inasmuch as the binoculars could be removed from the bar by loosening two knurled thumb screws. This construction is clearly shown in the drawing of the final design - Dwg. 71-A9.

In Fig. 9 a new type damping unit is shown. This is the result of an extensive research program covering a period of a number of months and running concurrently with the above described developments. It should be noted that in this design the damping means have been moved from the inside to the outside of the upper hemisphere. This was advantageous for the following reasons: (a) it allowed rubber to be placed above and below the center of the ball stud, thus providing a restoring force which was a couple and hence made the unit bore-sight better than the early model; (b) it permitted more rugged construction of the damping unit parts especially since the ball diameter was reduced from 1/2" to 3/8"; and (c) it made possible external adjustment of the damping force by raising or lowering the cone carrying the spring pressured brake shoes.

It was decided to make provision for units having three different restoring forces and hence three natural frequencies. This was done by making three units having undamped naturel frequencies of 100, 120 and 132 cpm, respectively. The different restoring forces were obtained by using varying shaped rubber washers and are referred to later as "light," "medium" and "heavy".

Laboratory tests were conducted on the binoculars mounted on the various units described above, the damping means being shown in Fig. 9, and the curves shown in Figs. 4, 5, 6, 7 and 8 were obtained. The curves are self-explanatory; however, the following points are of interest: Referring to Fig. 4 it will be noted that the dotted line showing the vibration transmission with the observer's head against the head rest was considerably below the solid line both at resonance and at velocities above 500 cpm. This is to be expected since the observer's head tended to steady the oscillation of the unit on the vacuum cups. Fig. 5 shows that the transmission of the ball type A.O. unit without pan and tilt head shock absorbing mount was .44 min. of arc in comparison with .22 min of arc as recorded in Fig. 4. These two curves are comparable since the same ball type unit was used for both, ie., the unit with medium restoring force (F_N = 120 cpm). We can also compare Fig. 8 with these two curves since that test was also on the same A.O. unit. In the latter case it should be noted that the transmission above 700 cpm is practically the same as shown in Fig. 4 in the solid line. This shows that the performance of the inverted unit, whether mounted on the vacuum cup feet or on the rigid bar mount, should be approximately equally good at high frequencies. The curve shown in Fig. 6 is comparable with the solid curve in Fig. 4 since all conditions are identical except that in Fig. 6 the unit was subjected to 1/32" translation in addition to 6.5 mins. rotation. Since our means of testing measures rotation only, and this test (Fig. 6) shows that the transmission was practically identical with that of Fig. 4, the conclusion could be drawn that the unit was well balanced. This is seen from the fact that any unbalance in a center of gravity unit will set up rotational forces which will materially increase the vibration transmission when the unit is subjected to translation as well as rotation. Now since the transmission in Fig. 6 shows no increase over that in Fig. 4 we may safely say that the unit is so well balanced that if it were subjected to translation only practically no rotation would take place in the binoculars.

The two curves shown in Fig. 7 give a comparison between two A.O. units, the light restoring force having a natural frequency of 100 cpm and the heavy 132 cpm, all other conditions being the same. It can be readily seen that the transmission at the higher frequencies is practically twice as great for the heavy as for the light. This is to be expected since theoretically the transmission should increase from 3.5% to 5.7% for a change in natural frequency from 140 to 176 cpm. If we check the performance of these mounts by calculating the magnification factor we find that the mounts are giving excellent filtering action. Let us take the performance of the mount as shown in Fig. 4 solid line. Now the magnification factor or efficiency is equal to the final amplitude divided by the impressed amplitude, that is,

Let A_I = Impressed Amplitude and A_F = Final Amplitude

then $E = \frac{A_F}{A_I}$

at resonance or 164 cpm

$$E = \frac{16}{6.5} = 2.48 \text{ or } 248\%$$

This shows very good damping.

Now at high frequencies, for example 840 cpm:

$$E = \frac{.44}{6.5} = .067 \text{ or } 6.7\%$$

This shows excellent filtering action since theoretically the best efficiency of this unit would be 4% where the ratio of impressed to natural frequencies is 840 to 164. This is shown by the formula:

$$\frac{A_F}{A_I} = \frac{1}{1 - \frac{(f)^2}{(n)^2}}$$

when n = natural frequency
f = forced frequency

Substituting the above values in the formula, we have:

$$\frac{(f)^2}{(n)^2} = \frac{(840)^2}{(164)^2} = 26.2$$

Then $\frac{A_F}{A_I} = \frac{1}{1-26.2} = \frac{1}{-25.2}$

The above minus sign denotes that the values are taken above the resonance point and can be disregarded.

$\therefore \frac{A_F}{A_I} = .4$ or E = 4%

The above formula is strictly true for systems having no damping, but gives a good measure of any system even where damping is present.

The value of the final amplitude at or near resonance in an undamped system can be obtained from this same formula, as follows:

At resonance the ratio $\frac{f^2}{n^2} = 1$

Hence $\frac{A_F}{A_I} = \frac{1}{1-1} = \frac{1}{0}$

$A_F = \infty A_I$

$\therefore A_F$ = infinity

This means that in a freely vibrating system with no damping, the final amplitude A_F would be very large at or near resonance.

5. Developments Preparatory to Flight Tests

While awaiting the flight tests work went forward on an improvement of the external damping unit described in Section 4. This device was an adjustable damping unit, the construction of which is clearly shown in Fig. 10, Dwg. 71-A8 and the pictures of the disassembled unit shown in Figs.25 and 26. It should be noted that the construction is very similar to the previous damping unit shown in Fig. 9 with the exception that the spring leaves of the Cardan hinge are now made straight instead of bent, and the spring pressure force is supplied by the coiled springs instead of the flat springs. The upper end of each coiled spring is nested in a recess in the spring washer and this washer can be moved vertically by adjusting the threaded adjustable nut, thus increasing or decreasing the pressure of the coiled springs on the friction plate and hence increasing or decreasing the damping of the unit.

While the adjustable damping device may not be necessary in a production model that was designed for one purpose only, it was felt that in an experimental model it would have considerable merit and this was substantiated in the tests both on aircraft and shipboard to be described later in the report.

Another new feature was the adjustable rotation stop. This new stop consists of a slidable curved section having a keylike projection to engage in the slotted skirt of the cone and secured by two screws in elongated holes. This construction allowed the clearance between the key and the slot to be equally divided and thus allow a minimum of rotational displacement without the hazard of the free member of the unit contacting the fixed member. This minimum freedom of rotation is important since the less allowable rotation of the ball stud the more certain is the unit to return to the center line or bore-sight. The new unit was tested both with chamois lining and felt lining as a friction medium. The tests using chamois showed entirely different results than those with felt in this regard: when using chamois the large amplitude oscillations were quickly damped out, but were followed by a series of very small vibrations at a high rate of speed seemingly with very little damping, evidently caused by the seizing of the chamois to the upper hemisphere. As soon as the chamois ceases to slide on the upper hemisphere the damping force falls to zero and additional restoring force from the resilient mounting of the damping ring tends to raise the natural frequency of the system and cause the unit to continue to vibrate. Now when the damping ring is more tightly fitted so that it is not as free to move as in the previous test, the small vibrations that occurred after the large swing were eliminated but the transmission at 800 cpm was considerably greater than in all previous tests using felt, and for this reason the use of chamois was discontinued. A series of tests was made to check the difference in damping for each 1/8 turn of the knurled adjustable nut. Since the nut has 40 threads per inch, each 1/8 turn represents approximately .003" change in the length of the coil springs. The tests were conducted as follows: The knurled nut was set at a position to give small damping, and this point was used as zero setting. Recording was made of natural frequency (F_N), approximate number of cycles for vibration to decay, and amplitude of travel of reflected light beam from mirror on unit. The results of the tests using the unit with medium restoring force, i.e. 120 cpm undamped natural frequency, were as follows:

Test No.	Turns of Nut	Natural Frequency c p m	Cycles Decay	Amplitude
1	0	136	5	7-3/8"
2	+1/8	140	4	4-1/2"
3	+1/4	140	3-1/2	3-1/2"
4	+3/8	152	2	2-3/4"
5	+1/2	168	1-1/2	2-5/8"
6	+5/8	180	1	2-1/2"
7	+3/4	180	1	2-5/8"
8	+1	200	1/2	2-9/16"

Further tests made on this unit showed no difference in the action of the damping device from that previously recorded in Figs.4 to 8 inclusive. However, the ease of varying the amount of damping was a very decided improvement and all the A.O. units were equipped with this type of damping device before making the flight tests.

6. Flight Tests of A.O. Mount for Binoculars

Before arranging for a flight test of the A.O. mounted binoculars, the unit was taken to Roosevelt Air Base, Terminal Island, San Pedro, California, and an installation test made on the PBY amphibian aircraft in which the flight tests were to be made. The anti-oscillation binocular unit was equipped with two means of attachment to the roof of the cockpit, the rigid bar type and the vacuum cup type. (Refer to Figs. 30 to 36 for photographs of finished units covering both types of installation). The forward bracket needed for the rigid bar type was installed on the cross member of the cockpit roof by removing two short standard machine screws and replacing same with longer screws. With minor modification the installation appeared to be satisfactory, and it was planned to make a flight test as soon as the ship was readied for flight. At this time the ship was grounded awaiting new parts.

As soon as the ship was available the unit was taken to San Pedro for a flight test. As stated above, the unit could be mounted either on the rigid bar support or by the alternate method consisting of adjustable length tripod legs, fitted with vacuum cups for attachment to the glass or plastic section of the cockpit roof. During the flight, lasting approximately one and one-half hours, both types of attachment to the plane were tested together with varying degrees of damping applied through the adjustable damping device. Visibility at the various altitudes summarized below was in all cases good.

The initial ground test of the unit consisted of observing objects while the plane was stationary with motors running at normal speed. Instructions concerning the use and function of the unit were given at this time. Summaries of this initial test, concurred in by all observers, are as follows:

1. By adjusting the damping to a proper amount an estimated 90% or more of the forced higher frequencies had been absorbed by the unit. This was easily apparent when the unit was partially grounded by locking the floating binoculars to the rigid mount.

2. Because of the large magnitude low frequency jerks and bounces induced by the motors it was necessary to employ a higher degree of damping than had been thought necessary from laboratory tests. Without the increased damping the binoculars tended to be in constant motion, making observation of any given object difficult. It was also visually apparent that too much damping soon tended to lock the floating binoculars and the unit, thus materially increasing the transmission of vibration into the binoculars. The naval lieutenants who observed this demonstration remarked that detail on distant objects was surprisingly good and that the unit provided a facility that would be useful in combat patrol flying. After these ground tests had indicated that the unit was performing satisfactorily, a takeoff was made at 12:45 p.m. During the flight runs were made at the following altitudes and with the air, ground and motor speeds as listed below:

Altitude	Air Speed	Ground Speed	Motor Speed
700 ft.	108 knots	124 m.p.h.	2100 r.p.m.
1500 ft.	80 knots	95 m.p.h.	2050 r.p.m.
3000 ft.	140 knots	161 m.p.h.	2300 r.p.m.
5000 ft.	110 knots	135 m.p.h.	2050 r.p.m.

The air was rough at all times during the flight which made the visual appraisal of the performance of the instrument somewhat less satisfactory than would have been the case had the air been smooth. No noticeable difference was apparent in the performance of the instrument at the various flying conditions listed above. It was noted that there was an optimum amount of damping for efficient operation of the unit in the air. Again, due to the large magnitude low frequency motions of the plane resulting from the rough air, it seemed necessary to increase the damping somewhat over that amount of damping which had been required in the ground test.

Comparisons were made of the rigid type bar mount and the vacuum cup mount. Because of the rough air the vacuum cup mount proved less satisfactory than the rigid bar mount due to the increased pressure necessary to hold the head against the head rest. This increased pressure of the head in the head rest resulted in motion of the entire binocular mount with relation to the cockpit roof. The rigid bar mount, on the other hand, permitted this increased pressure of the head without displacement of the entire unit.

After the damping had been adjusted, 90% or more of the high frequency vibration had apparently been removed. This permitted detailed observation of distant objects and was perhaps best demonstrated by the viewing of reflections from house windows. With the unit operating freely this reflection took on the form of a sharp distant outline. When the floating binoculars were locked to the aircraft cockpit mount attachment the reflection became a blurred pattern. The naval lieutenants remarked on this and indicated that they were able to observe distant objects with a high degree of accuracy of detail perception.

Tests with a dial indicator mounted on a mass of steel held in the hand gave some crude indication that the vibrations in the cockpit supports to which the binoculars were attached were of the order of magnitude of 10 to 20 thousandths of an inch.

The flight test indicated that minor modifications to the unit were required, including a stronger linkage between the scanning handle and the unit, and a stop to prevent clamping the binoculars to the head rest when decreasing the interpupillary distance. These modifications have been made.

7. Shipboard Model

Concurrent with the above developments, work was going forward on an anti-oscillation mount for United States Navy 7 x 50 binoculars for shipboard use. The binoculars in this model were mounted in the conventional manner, i.e., above the A.O. unit, not below as in the aircraft model. Also, the head rest was attached to the rigid side of the mount beyond the shock absorbing base instead of between the shock absorbing member and the A.O. unit. Experiments with some of the early mounts had shown the necessity for some kind of windshield, where the unit was to be used in the open, to prevent slow period oscillation caused by air disturbances, and this was incorporated in the design. This windshield was equipped with a glass window in the forward end which protected the binoculars from wind and spray. The window was easily removable for cleaning and inspection. Dwg. 71-All is an assembly of the completed model.

In the early discussions of the specifications of the model it was thought that a simple flange base should be provided for attachment to an alt-azimuth or similar mount already on board ship. However it was decided to make the model complete in itself and thus independent of any equipment which might or might not be found on board ship. To accomplish this a pan and tilt head as well as two control handles were designed as part of the model. However later specifications called for mounting the unit on Mark IV or Mark V surface alidade, so provision was made in the design for removal of the pan and tilt head if the alidade were used.

Dwg. 71-A11 and Figs. 27, 28 and 29 show the completed model and the adaptors for the various mountings.

The model was equipped with A.O. units having adjustable damping as shown in Fig. 10 identical with that described under Section 6. Adjustment for the head rest and for the interpupillary distance was provided. The last adjustment was different than the aircraft model, being accomplished by turning a knurled nut, shown between eye pieces, which actuated left and right hand screws. An indicator graduated from 60 to 70 mm was provided so that each operator could make the proper setting before attempting to use the binoculars. As soon as the unit was completed preliminary laboratory tests were made and the unit then taken to San Diego for the shipboard test described below. Further laboratory tests were made later and are fully described under Section 9 of this report.

8. Test of Shipboard Model of Anti-Oscillation Mounting for Binoculars

Arrangements were made to mount the shipboard A.O. unit on the destroyer U.S.S. Rowe for observation and test purposes. The Rowe was not equipped with a Mark IV or Mark V alidade; therefore provision was made on the lookout seat station, hereinafter described, for mounting the pan and tilt head of the A.O. unit. This work required some dismantling of the lookout seat equipment and some minor machine work which was performed in the machine shop aboard.

This work was done in the evening while the ship lay at anchor. The next morning the observers boarded the destroyer at 6:00 a.m. and proceeded out of the harbor to a point some sixty miles southwest of San Diego where the A.O. tests were performed.

The U.S.S. Rowe is a new destroyer of the 2100 ton class and was commissioned on March 13, 1944.

This ship was equipped with two three-bladed propellers which are generally operated at different speeds to avoid any beat frequency constancy which might be picked up by enemy detection devices. Listed in the table below are surface speeds and propeller shaft revolutions of the Rowe:

Surface Speed	Propeller Revolutions
5 knots	43 r.p.m.
10 knots	96 r.p.m.
15 knots	148 r.p.m.
25 knots	250 r.p.m.
35 knots	392 r.p.m.

There is a gear reduction between the engines and the propeller shafts, but this reduction was not stated.

The unit was mounted on one of the two lookout seats on the starboard side of the bridge deck. Both the port and starboard sides were equipped with two each of the lookout stations. These stations are normally manned by ship's personnel observing certain sections of the horizon through a pair of 7 x 50 binoculars rigidly mounted to the lookout seat. During the observation of the A.O. performance frequent comparisons were available through a rigidly mounted binocular on the conventional lookout seat and the A.O. mounted binoculars immediately adjacent thereto. Below is a log of the observations made throughout the day:

6:30 a.m. It was noted that the decrease in temperature during the night had caused an increase in damping which had been set at a medium level the night before. It was therefore necessary to reduce the damping one-half turn on the adjustable brass nut. Proceeding through the harbor at increased speeds from 5 to 10 knots, 43 to 96 propeller rpm, no perceivable vibration was noted on the bridge deck. After leaving the harbor it was noted that the ship rolled quite constantly by as much as 10° from normal at a frequency of 3.8 to 4 seconds per roll in what seemed to be a calm sea. The roll necessitated a constant motion of the tilt head to maintain the horizon in the middle of the binocular field. The pan and tilt head did not operate sufficiently smoothly to maintain constant horizon observation. Modifications of the existing tilt head must be made to provide this facility.

7:30 a.m. Speed 12 knots, 116 propeller rpm. A slight vibration was noticeable over and above the slow roll. This vibration was estimated to be of the order of 200 to 300 cpm but was insufficient in amplitude to cause any motion of the object field visually through the binoculars. The small amplitude vibration being introduced by the ship could be seen by comparing the dark surround of the binocular objective field with objects in the center of the field. This indicated that whatever vibration was being introduced to the binoculars was transformed into translation and hence was not affecting visual observation. It was not possible to detect any yawing of the ship.

9:30 a.m. Speed 11 knots, 106 propeller rpm. The vibration noted above became more pronounced at this speed. An estimate of the frequency of the vibration made with a stopwatch was 320 cpm with an amplitude of something less than .005". This estimate reveals an interesting correlation between the product of propeller shaft speed and number of blades in the propeller with the effective vibration introduced into the ship. As before, however, no motion of the object field through the A.O. mounted binoculars was apparent.

11:30 a.m. Speed 11 knots, 106 propeller rpm. Tests with increased and decreased damping indicated that the medium damping selected previously was optimum. With sufficient increase in damping vibration transmission into the binoculars became apparent, whereas insufficient damping caused the binoculars to be in constant motion about the center of gravity mount when the ship pitched and rolled.

1:30 p.m. Speed 15 knots, 148 propeller rpm. The amplitude of the vibration being introduced by the propellers increased somewhat and became sufficient so that the A.O. unit did not entirely remove all motion from the object field. A comparison of the A.O. and the rigidly mounted binoculars indicated, however, that at least 80%-90% of the vibration had been removed through the A.O. unit. About this time a strong head wind set in, estimated 15 to 20 mph. The shield as designed for the A.O. unit, however, seemed effective and no further apparent motion of the object field through the binoculars could be observed due to the wind.

4:00 p.m. Speed 25 knots, 250 propeller rpm, with a very strong head wind, estimated 25 to 30 mph. The vibration in the ship present at this speed was less than the vibration present at the 15 knot speed. The binoculars performed satisfactorily and their performance was not affected by the strong head wind. It was noted, however, that at this speed the rigidly mounted binoculars provided a jumpy object field and it was at this speed that the benefits of an A.O. mounted pair of binoculars became most apparent. In addition to the gain in image steadiness the shield and head rest of the A.O. unit made observation considerably easier than in the case of the rigidly mounted binoculars with neither shield nor head rest. It was during this series of observations at the higher speeds that several of the officers aboard ship commented upon the remarkable performance of the unit.

Immediately after the shipboard tests described in the above report the unit was put into the machine shop and the pan and tilt head remachined to operate very freely and smoothly. A rubber bumper was installed fore and aft on the tilt head since the unit now moved so freely when the brake was unlocked that if the control handles were released the unit would fall until it struck the base. In order to enable the unit to be mounted easily on the lookout, a further adaptor was made. This consisted of two round plates spread apart approximately $1\frac{1}{4}$" by four studs. The upper plate is machined to carry the pan and tilt head, and the lower plate has a large hole to fit over the main shaft of the lookout seat after the surface alidade is removed. The unit is shown mounted on this adaptor in Fig. 27, and the adaptor is shown unmounted in Fig. 29.

Provision is thus made to mount the unit in the following manner:

1. On central column of lookout seat.
2. On Mark IV surface alidade.
3. On Mark V surface alidade.
4. On bracket provided for Mark IV alidade.
5. On bracket provided for Mark V alidade.

A full set of laboratory tests were made of the unit, and it was then shipped east for testing.

9. Photographic Method of Testing A.O. Mounts

Before making the following series of tests a photographic method was developed which gave a permanent record of the performance of the A.O. unit while being tested on the vibrating table. This was accomplished by projecting a small spot of light onto the mirror fixed to the vibrating unit which in turn reflected the image onto a piece of film secured to a revolving drum. The 10" diameter drum was slowly turned by means of a geared motor at a peripheral speed of 3/4" per second. The exposed negative was then developed and printed and produced a clear sharp trace of the rotational vibrations of the unit. (See Figs. 12A to 24A inclusive for photographic traces). This photographic system was developed primarily for recording the vibrations and performance of the unit after it had been displaced from a neutral position by a transient force while mounted on both a vibrating and a stationary platform. However the new method gave so much more accurate results that it was decided to make all tests in this manner although it took considerably longer than the previous system described in the earlier part of this report.

In order to obtain the data for the curves shown in Figs. 12 to 24, the following steps were necessary: The developed negative was placed in an Eastman delineascope and the trace projected on a screen at such distance as to give a magnification of 21X. A piece of graph paper ruled 20 lines per inch or.050" per space was used as a measuring stick. The number of spaces displaced by the total height of the wave at three or four places was then read and recorded on the data sheet. See Fig. 11 for a typical sheet. Note the word "pitch" after the test number. This denotes the test was made with the binoculars rotating around their transverse horizontal axis. The word "roll" denotes rotation around the longitudinal horizontal axis, and the word "yaw" around the vertical axis.

Column (1) shows the mark or notched place in the film at time of making the exposure. Column (2) shows the cycles per minute of the vibrating table. Column (3) shows the number of spaces displaced by the wave at zero cpm and at various cpm as described above. Column (4) shows the ratio of final amplitude to impressed amplitude x 100 = $\frac{A_F}{A_I}$ x 100 which is the transmissibility or per cent transmission of the unit.

In this particular test it was not necessary to convert the data to an actual angle since we were interested only in a ratio of final to impressed angles. The data in Column (4) was plotted as the ordinates and that in Column (1) as the abscissae and a smooth curve drawn through the points. (See Fig. 12).

Most of the curves are self-explanatory; however, the following points should be noted: Referring to the shipboard model, rotating around the transverse horizontal axis, or pitch, (See Fig. 12) the curve shows that the unit was performing entirely satisfactorily since the damping is sufficient to keep the peak resonance value below 240%, which shows adequate damping at this frequency, and also that the transmission at the upper end of the curve at 900 cpm is approximately 4%, which shows excellent filtering action. Now if we compare Fig. 12, where the unit is mounted on the shock absorbing base, with Fig. 14, where the unit is mounted without the shock absorbing base, it should be noted that in Fig. 14, while the curve shows a transmission of less than 4% at 900 cpm, a study of the photographic traces of this test shows very peculiar characteristics. The curves at the upper frequencies are not smooth but are very irregular and particularly at 960 cpm the top of the curve consists of three small waves. In fact, the projected curve appeared thus

From this it can be seen that the small waves actually decreased the overall height of the main wave. It was noticeable on projection that a number of the curves at higher frequencies made without the base were noticeably jagged, irregular and not at all symmetrical. This condition is no doubt due to the fact that the vibrations of the lathe bed upon which the vibrating table was mounted are more likely to be carried through to the A.O. unit without the base than when the base is used. Although in this particular case the small vibrations tended to lower the peak of the curve; in other installations that might not be the case. This is also noted further on in the discussions of the inverted A.O. model. The test for longitudinal horizontal vibration or roll shown in Fig. 13 has approximately the same excellent values. Fig. 16 shows three curves of the effect of increase in damping on the per cent of transmission. At 940 cpm the transmission increased from 2% at the low value of damping to 10% at the higher value.

It should be noted that these values of damping, whether plus or minus, merely denote the position of the adjusting screw in relation to the arbitrary datum point marked zero. In other words the curve shows the results of turning the damping screws 1/2 turn or .012". The curve at 700 cpm rises more sharply, while that taken at 500 increases from 9% to 40%.

Fig. 15 shows the curve plotted from the photographic traces shown in Fig. 15A. This shows the failure of the unit (minutes of arc) to return to the center line or bore-sight when it was displaced by a transient force and allowed to vibrate to a rest position. The curve is very irregular and not at all conclusive for the following reasons: While great care was taken to displace the unit the same amount for each setting of the damping screw by moving it with a trigger against a fixed stop and then suddenly releasing the trigger, it must be understood that the unit does not vibrate exactly in one plane. In the above test any movement of the unit however slight in any other plane than that around the transverse horizontal axis (pitch) will have a decided influence on the final position of rest. In other words since the unit is not a single-degree-of-freedom system it can vibrate in a number of planes at the same time. Now suppose the unit is rotating around the vertical axis as well as pitching. In this case the unit will show a much better recovery than if it were <u>pitching</u> only. This can be explained by the fact that since only vertical displacements are recorded on the film we may actually have motion around the vertical axis after the recorded motion has ceased. Now motion of the unit in any plane means that sliding is taking place between the felt damping ring and the upper hemisphere (refer to Fig. 10); this means that <u>static</u> friction is not present. On the other hand, if the unit is vibrating in one plane only, for example pitch, and the vibrations become very small, a point will be reached where the friction force becomes greater than the restoring force and the felt seizes to the upper hemisphere. Let us call this the "sticking point" for want of a better name. Now as the damping force increases, the sticking point can move further and further away from the neutral position or center line. This means that the possibility that the unit will not return to the center line is greater for heavy damping than for light damping. To explore the theory still further another test was made where the damping was held constant but the amplitude of the initial displacement was varied. This means that the velocity of the unit varied as it passed through the sticking point. Velocity is very important for the test showed that at certain displacements the unit stopped at dead center, whereas at greater or lesser displacements considerable departure from the center line was recorded. However these tests were somewhat academic since in actual service (a) the mounting platform would always be vibrating, and (b) the transient force would never cause the unit to vibrate in one plane only. A test was conducted on the unit with the table vibrating at approximately 800 cpm and in this case the unit returned to dead center. (See Fig. 17 - Test 36).

The traces and curves of tests made on the aircraft model are shown in Figs. 18 to 24 and were conducted identically as those described above. Since we had two different methods of mounting the unit to the cockpit roof it was necessary to test both installations. Referring to Fig. 18, in which the inverted aircraft unit was hung from a sheet of glass secured to the vibrating table, it should be noted that the transmission was somewhat greater than that of the rigid bar mount shown in Fig. 19. At 900

cpm the former was 7% and the latter was 4%. In the test where the unit was mounted on the A.O. unit only, Fig. 20, the transmission of 900 cpm was approximately 5%. A study of the negative traces when projected on the screen showed that in the cases where the unit included the shock absorbing pan and tilt head the curves were much smoother than where the A.O. ball unit only was used. Note in Fig. 20 that at 820 cpm a point at 3.9% was shown which is actually lower than the theoretical value of 4.6%. This point was disregarded since the projected curve as noted above was distorted to the extent that the top of each wave was lowered considerably, in fact flattened by a small wave superimposed upon the main wave but out of phase with it. The wave when projected appeared thus 
This condition was similar to Fig. 14, as discussed above, but considerably more regular. This wave distortion could be due to the vibration of the lathe bed at certain speeds being carried through to the ball mount when no shock absorbing unit is used. In Fig. 21 the unit was mounted so that the binoculars pointed at right angles to the line of the table. This subjected the unit to a longitudinal rotation or roll. Excellent filtering action was recorded in this test, a value of 6.7% being recorded at 840 cpm. Fig. 22 shows the transmission curves at 500 cpm, 800 cpm and 1000 cpm for three degrees of damping. These have the same characteristics as those for the shipboard model but do not rise so abruptly. Figs. 23 and 24 show the same irregularities as discussed previously for the shipboard model. Tests 42 and 45, shown in Fig. 17, show recovery of the unit when the table was vibrating at 488, 660 and 856 cpm. In all cases the unit returned to dead center.

CONCLUSION

Two models of an anti-oscillation mount for binoculars have been made, a shipboard model and an aircraft model. Both of these models have been sent east for testing.

The laboratory tests show that the mounts eliminate approximately 95% of the impressed vibration. Preliminary field tests indicated that approximately 90% of the vibration was eliminated, but more extensive field tests by the Navy will no doubt provide more reliable data on their performance.

- LIST OF FIGURES AND DRAWINGS -

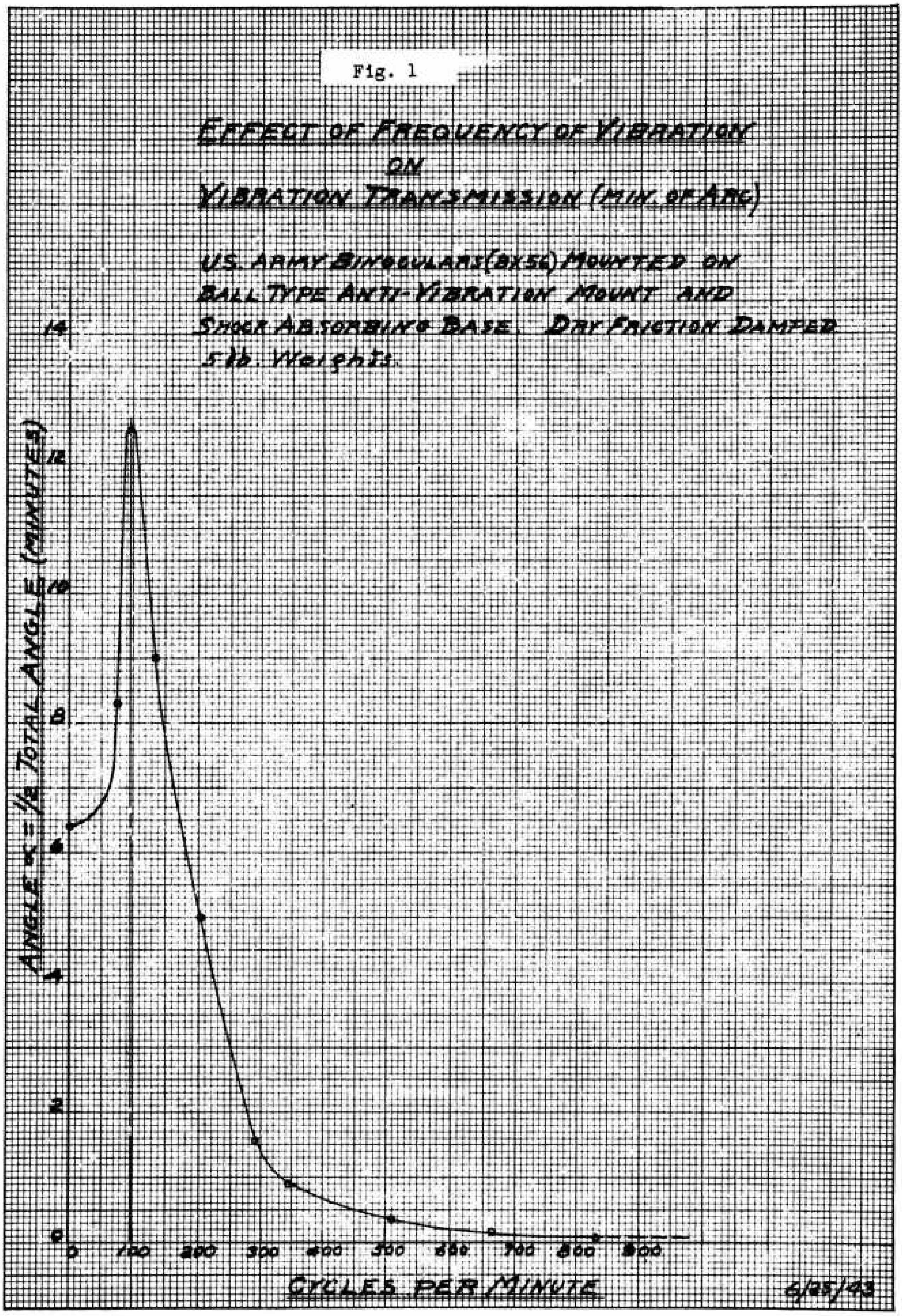


Fig. 1
EFFECT OF FREQUENCY OF VIBRATION
ON
VIBRATION TRANSMISSION (MIN. OF ARC)
U.S. ARMY BINOCULARS (8X56) MOUNTED ON
BALL TYPE ANTI-VIBRATION MOUNT AND
SHOCK ABSORBING BASE. DRY FRICTION DAMPED
5 lb. Weights.
ANGLE α = 1/2 TOTAL ANGLE (MINUTES)
0
2
4
6
8
10
12
14
0
100
200
300
400
500
600
700
800
900
CYCLES PER MINUTE
6/25/43

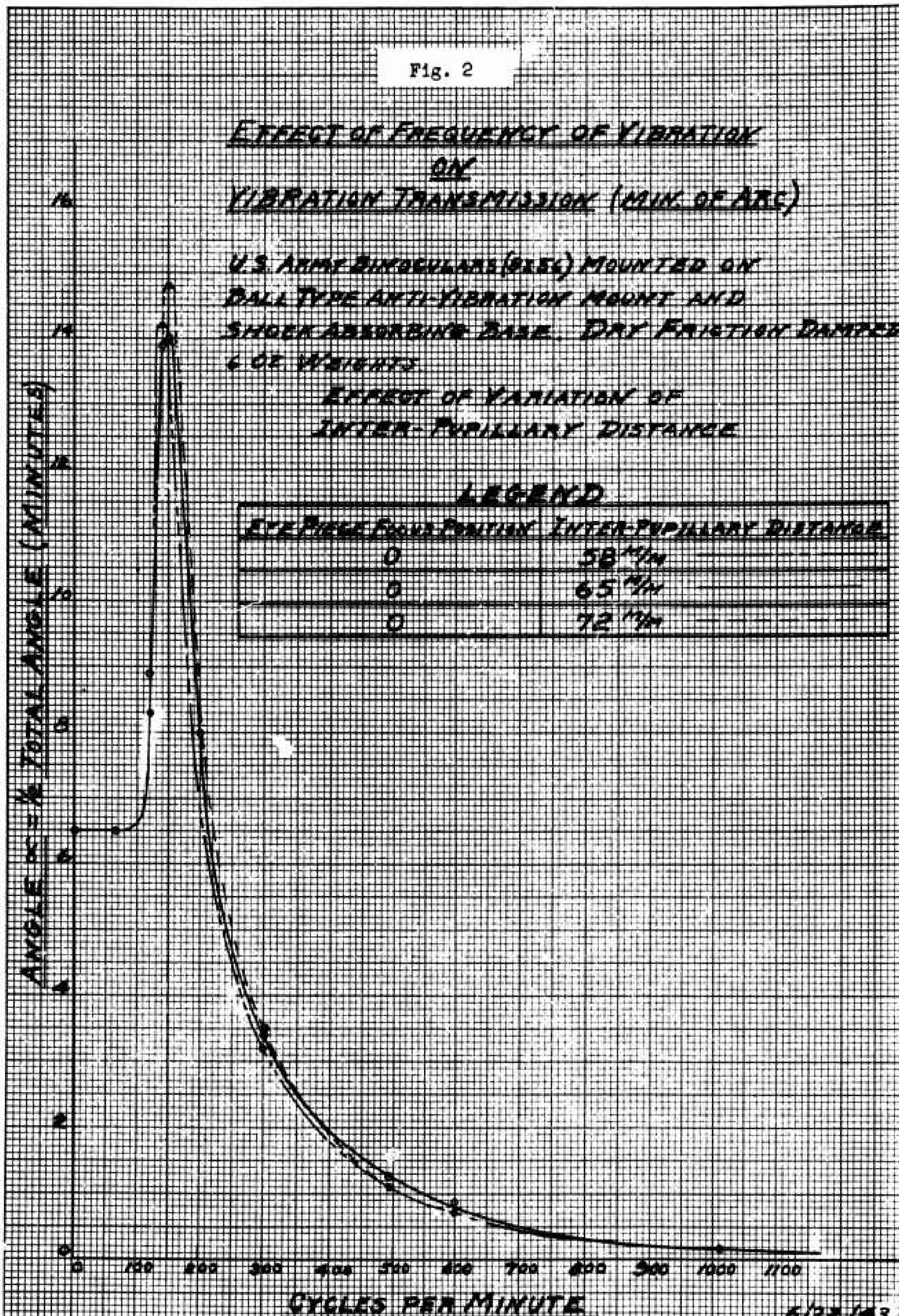
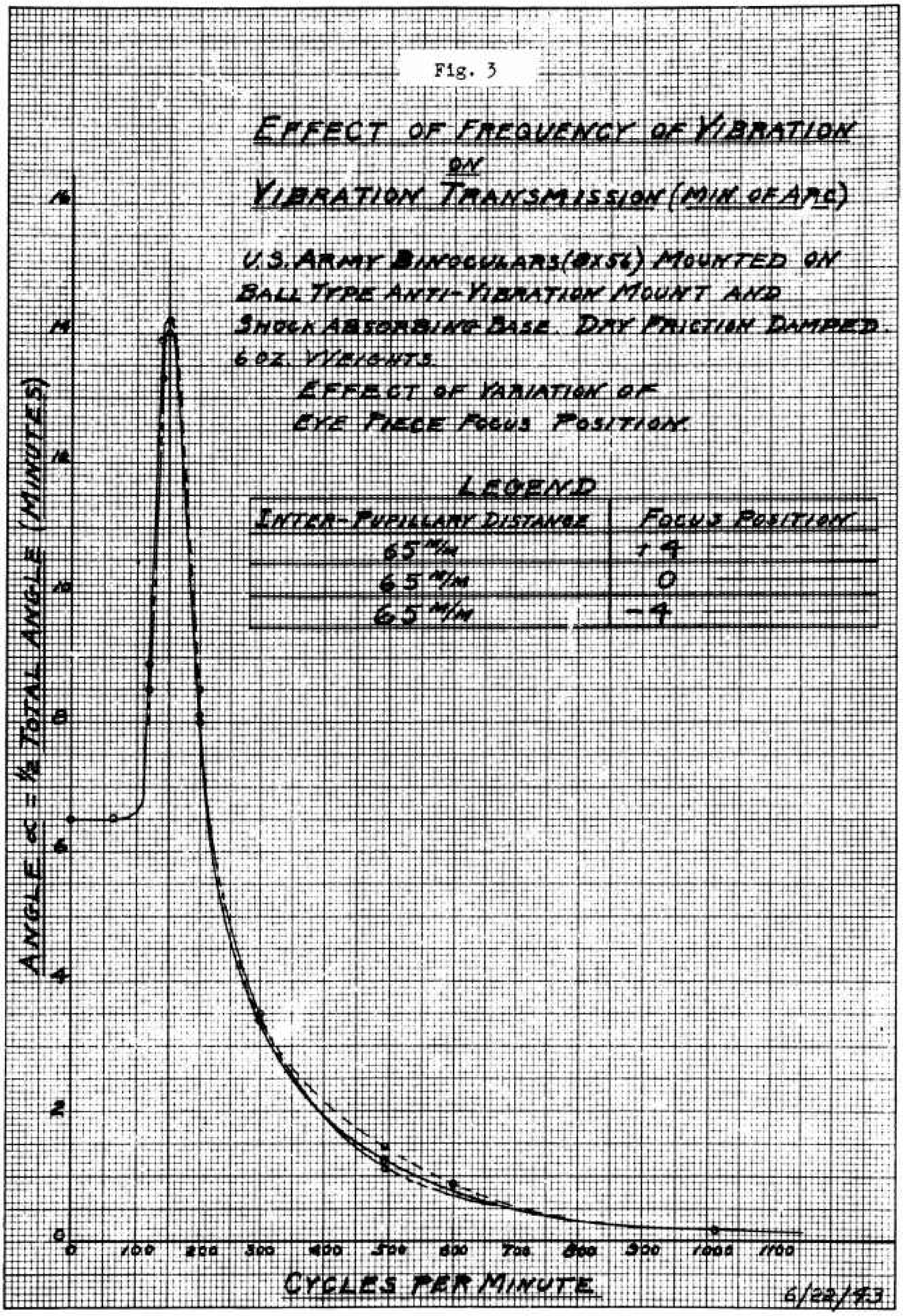


Fig. 2
EFFECT OF FREQUENCY OF VIBRATION
ON
VIBRATION TRANSMISSION (MIN. OF ARC)
U.S. ARMY BINOCULARS (6x30) MOUNTED ON
BALL TYPE ANTI-VIBRATION MOUNT AND
SHOCK ABSORBING BASE. DRY FRICTION DAMPED
6 OZ. WEIGHTS
EFFECT OF VARIATION OF
INTER-PUPILLARY DISTANCE
LEGEND
EYE PIECE FOCUS POSITION
INTER-PUPILLARY DISTANCE
0
58 M/M
0
65 M/M
0
72 M/M
ANGLE α = ½ TOTAL ANGLE (MINUTES)
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
700
800
900
1000
1100
CYCLES PER MINUTE
6/22/43


EFFECT OF FREQUENCY OF VIBRATION
ON
VIBRATION TRANSMISSION (MIN. OF ARC)
U.S. ARMY BINOCULARS (8X56) MOUNTED ON
BALL TYPE ANTI-VIBRATION MOUNT AND
SHOCK ABSORBING BASE. DRY FRICTION DAMPED.
6 OZ. WEIGHTS.
EFFECT OF VARIATION OF
EYE PIECE FOCUS POSITION.
LEGEND
INTER-PUPILLARY DISTANCE | FOCUS POSITION
65 M/M | +4
65 M/M | 0
65 M/M | -4
ANGLE α = ½ TOTAL ANGLE (MINUTES)
0
2
4
6
8
10
12
14
16
0
100
200
300
400
500
600
700
800
900
1000
1100
CYCLES PER MINUTE
6/22/43
Fig. 3

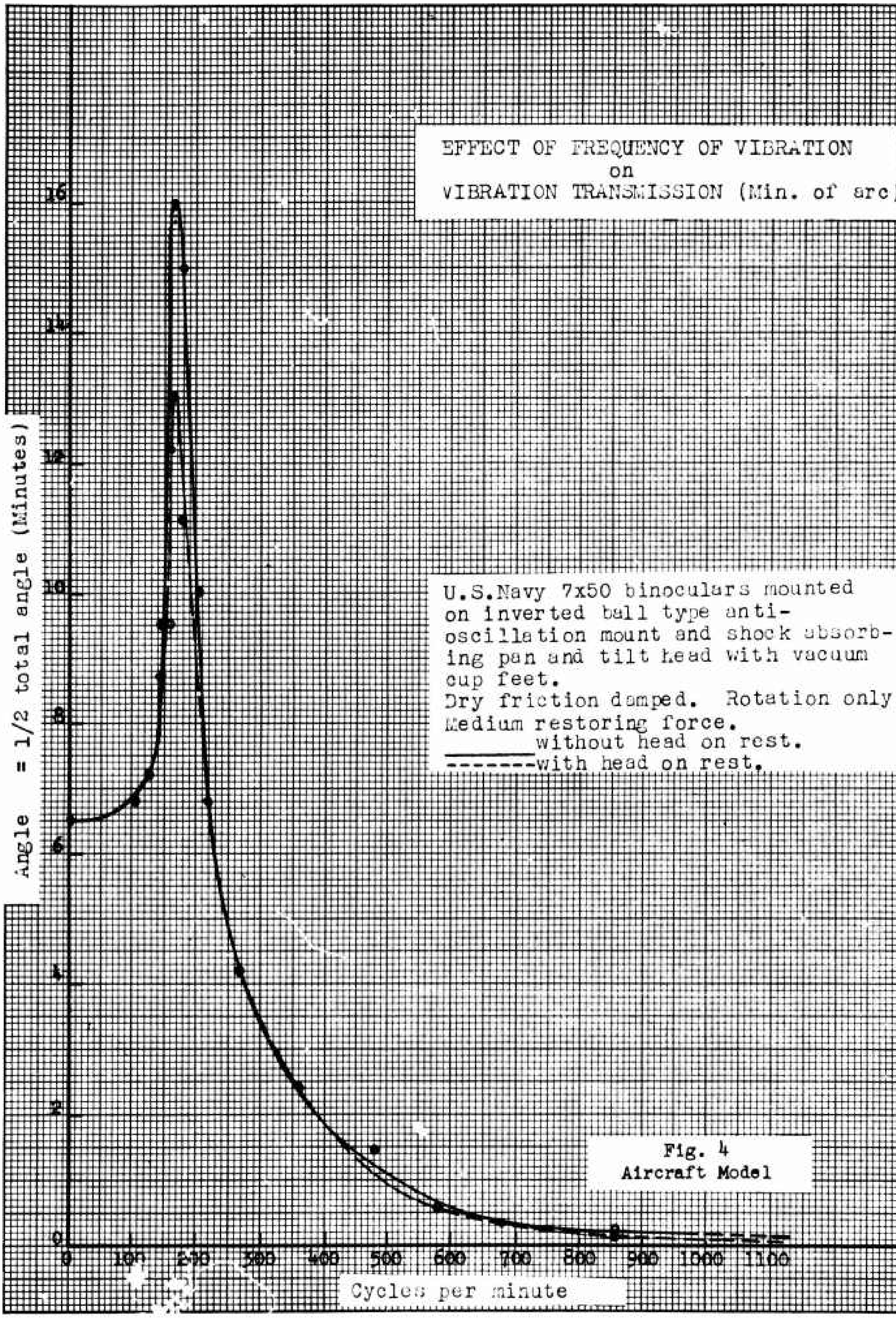


Fig. 4
Aircraft Model

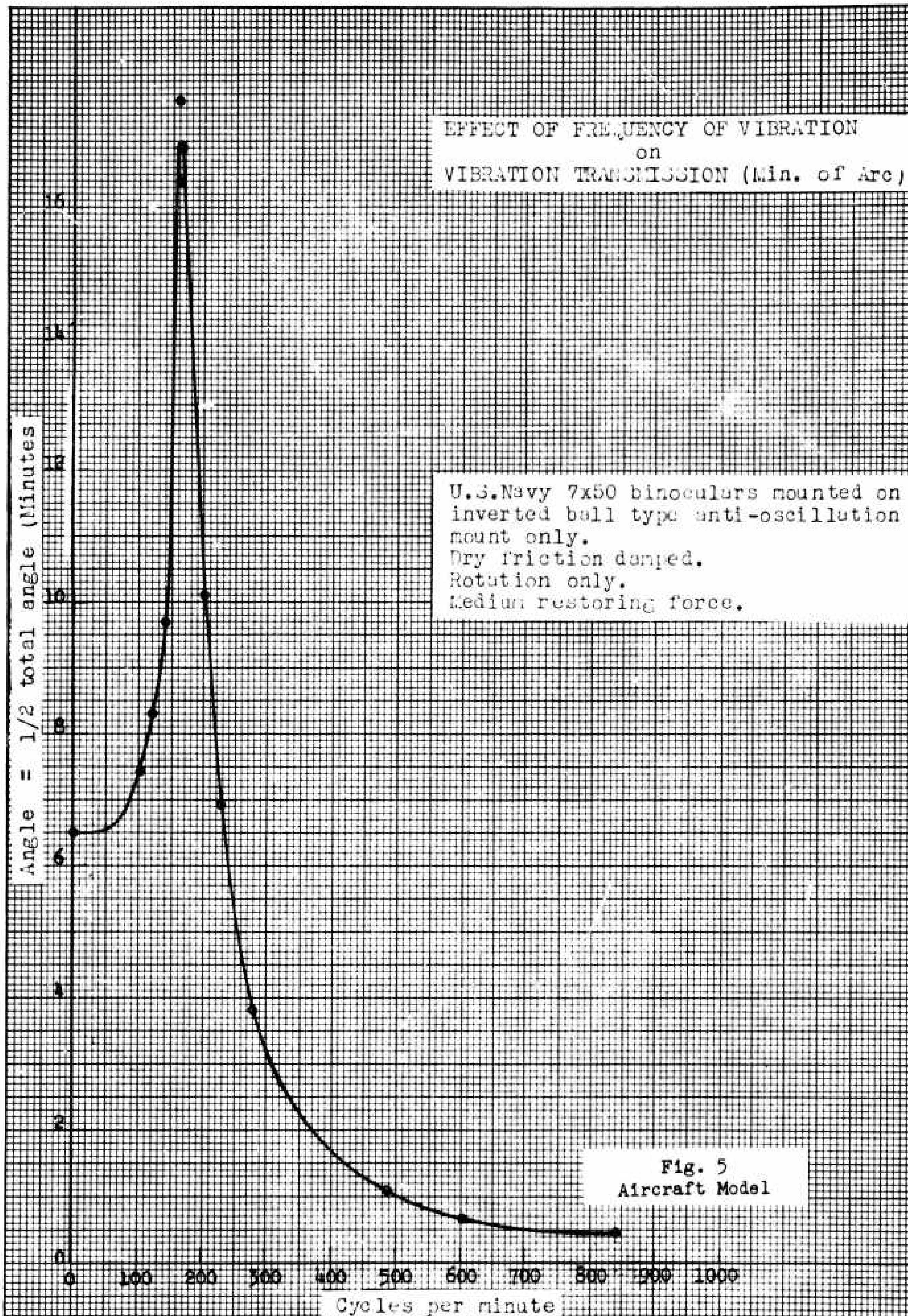


Fig. 5
Aircraft Model

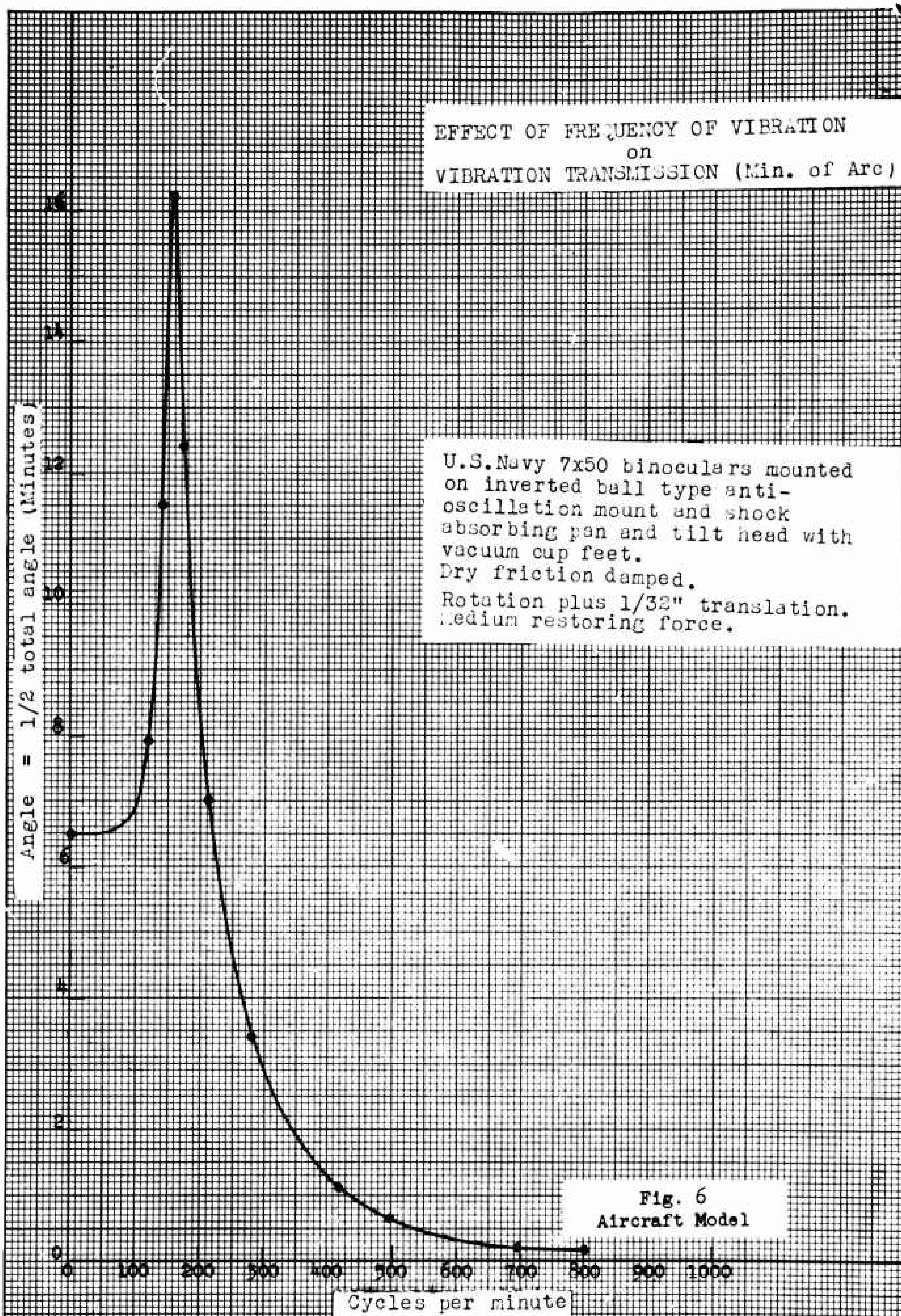


Fig. 6
Aircraft Model

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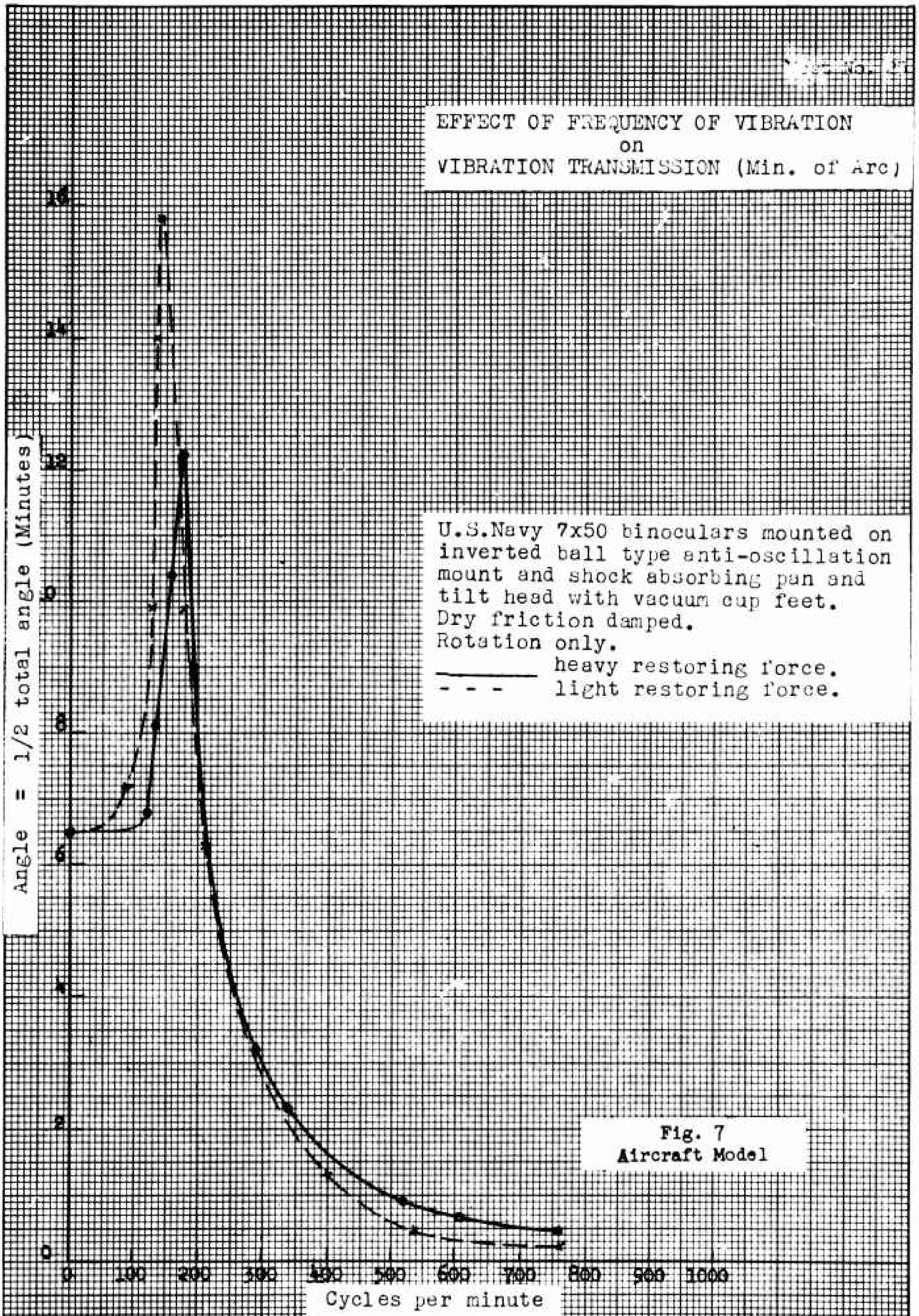

Fig. 7
Aircraft Model

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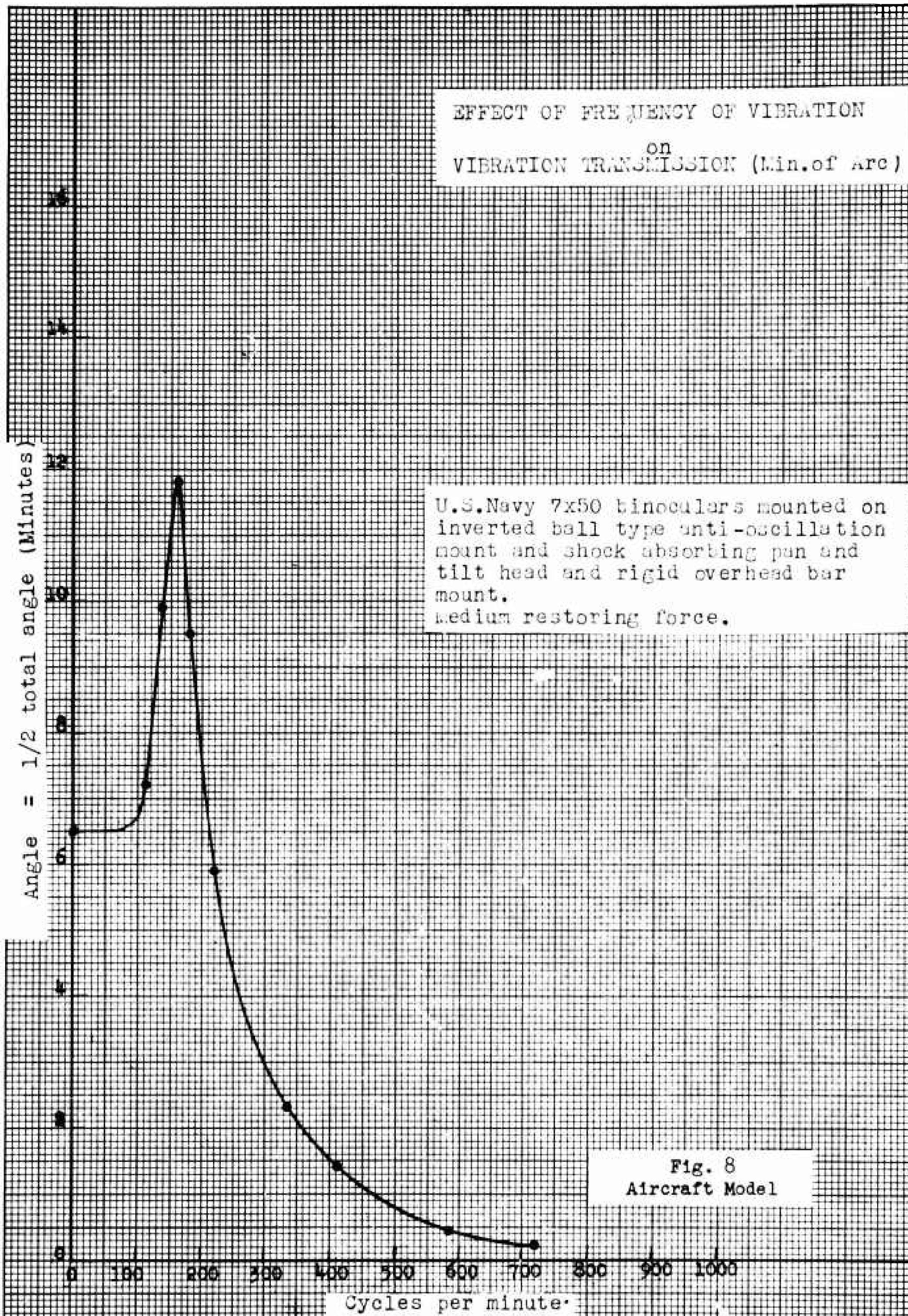
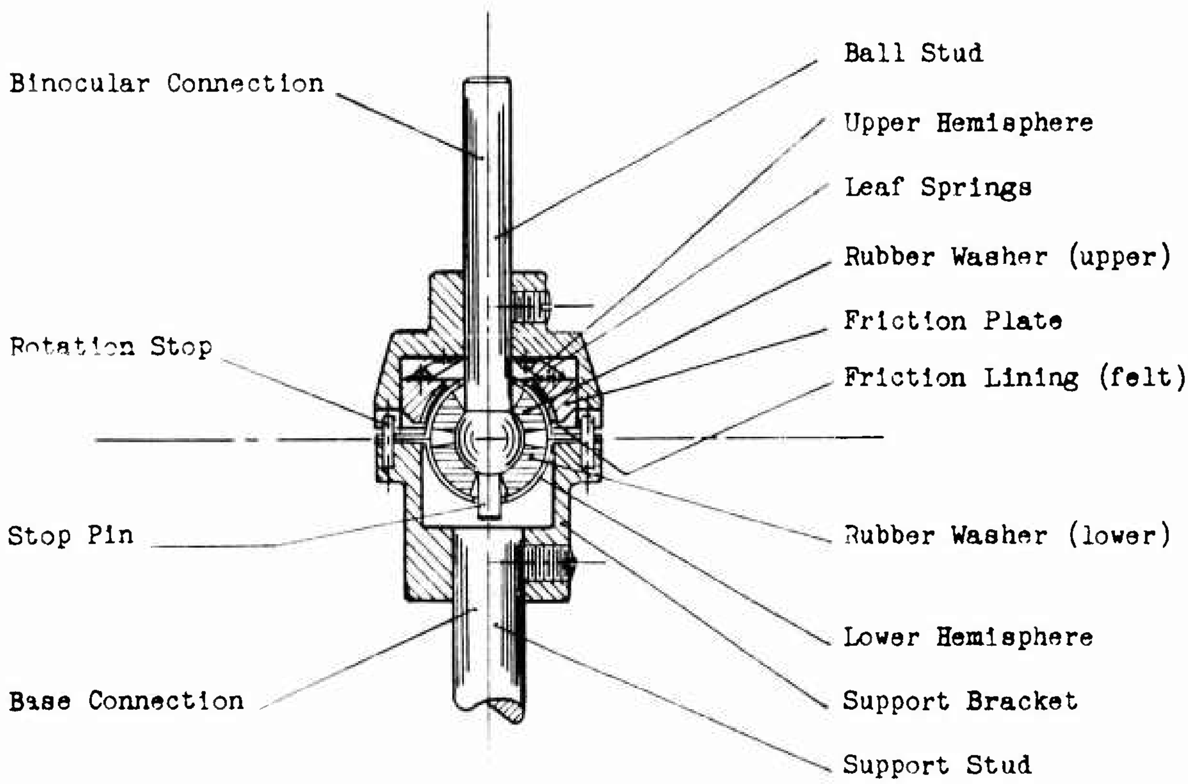
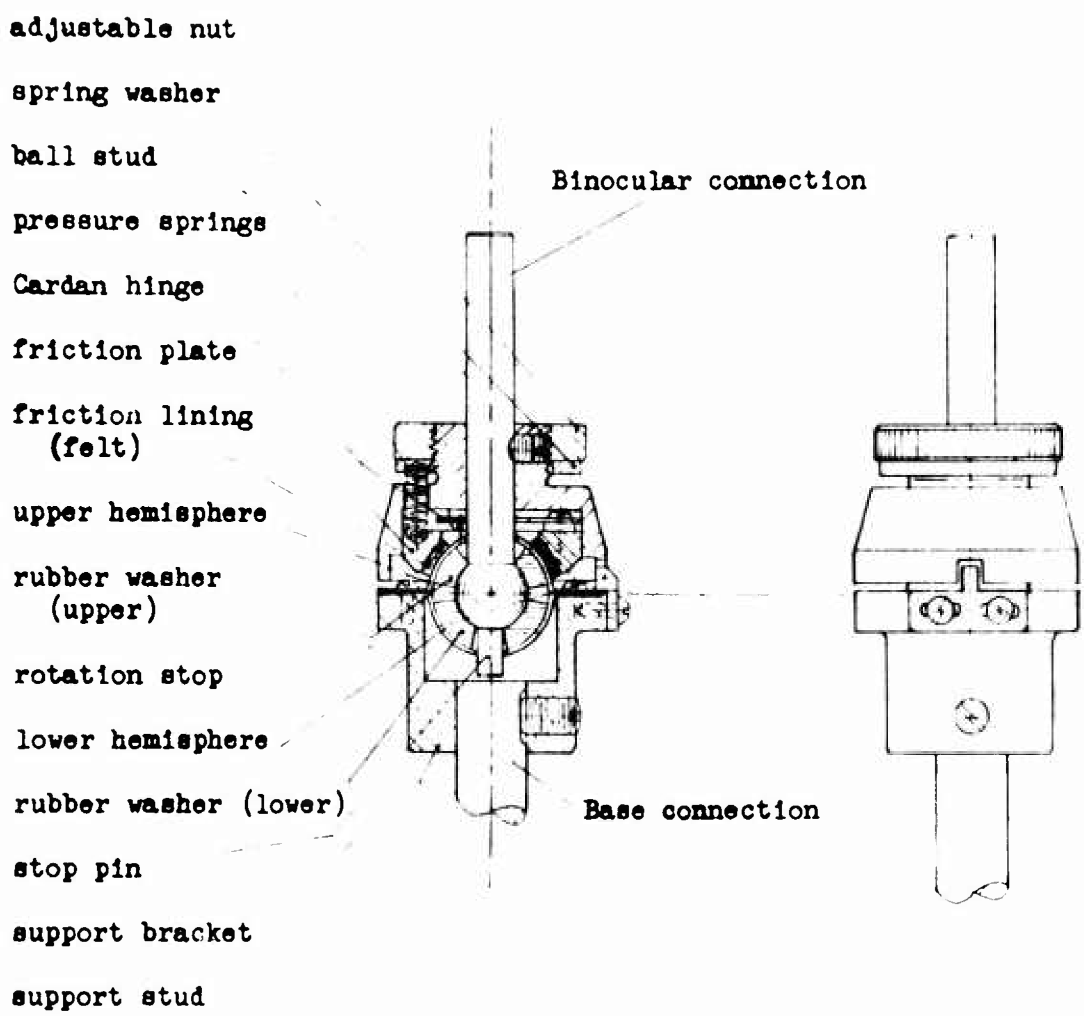


Fig. 8
Aircraft Model



Cross Section of A.O. Unit with External Damping
Fig. 9



Cross Section of A.O. Unit with Adjustable External Damping
Fig. 10

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Test No. 30
(Pitch)

DATA SHEET

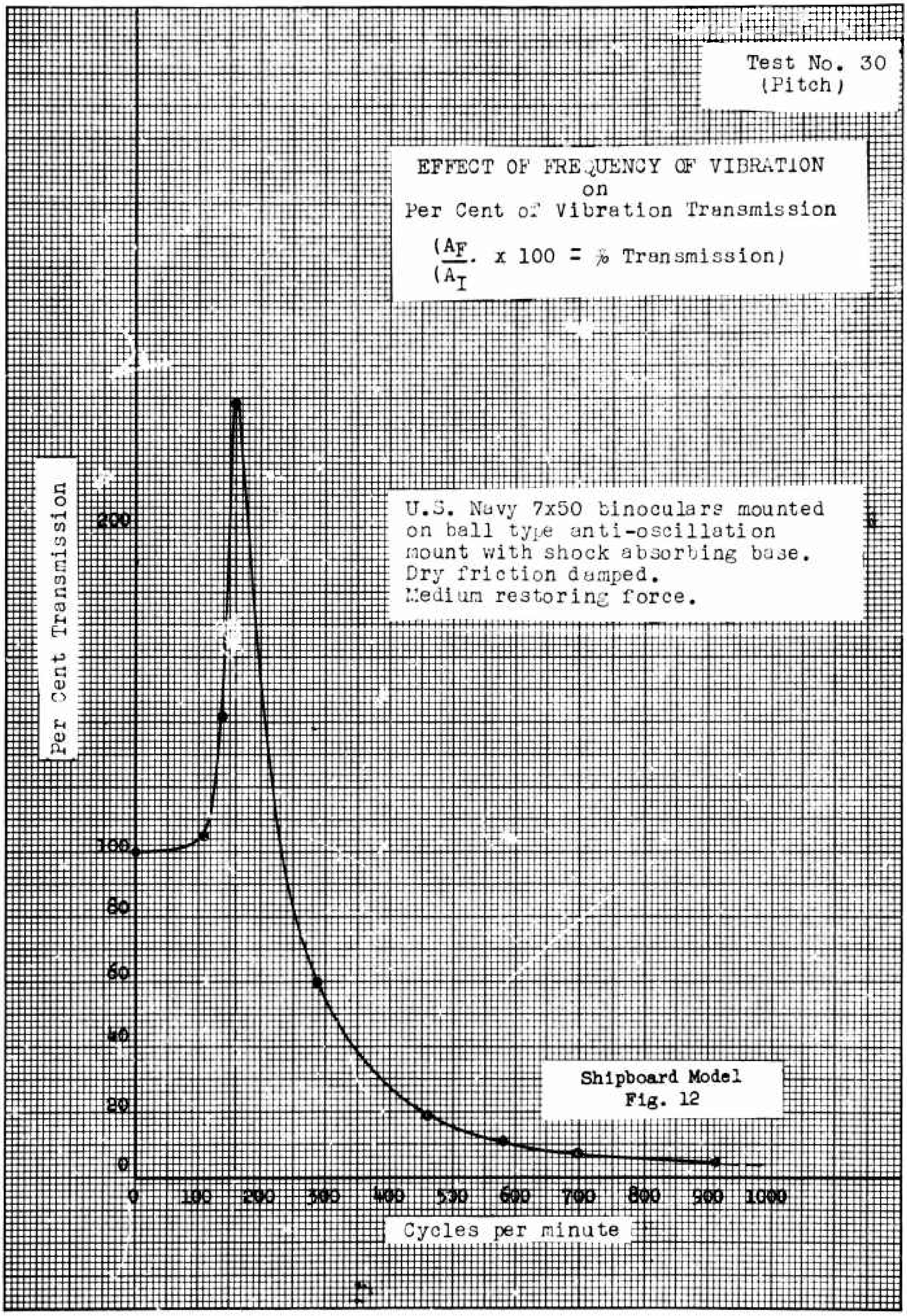
SHIPBOARD UNIT COMPLETE WITH SHOCK ABSORBING BASE
(7 x 50 Navy Binoculars)

SPECTRUM - 0 to 912 cpm
ACTUAL AMPLITUDE locked = 6.5 Minutes of Arc
PROJECTED AMPLITUDE locked = 45 = A_I

(1) Mark	(2) c.p.m.	(3) A_I = Amplitude Projected	(4) $\frac{A_F}{A_I}$ = % Transmission $\frac{(3)}{45}$ x 100
	0	45	100
1	912	(2 (2 (2 (2	4.4
2	700	(3.5 (3.5 (3.5 (3.0	7.5
3	580	(5 (5 (5 (5	11.1
4	460	(8 (9 (9 (8	18.9
5	288	(26 (27 (27 (28	60.1
6	160	(107 (108 (107 (107	238
7	108	(52 (52 (51 (52	105
8	140	(65 (63 (64 (64	142

Fig. 11

CONFIDENTIAL



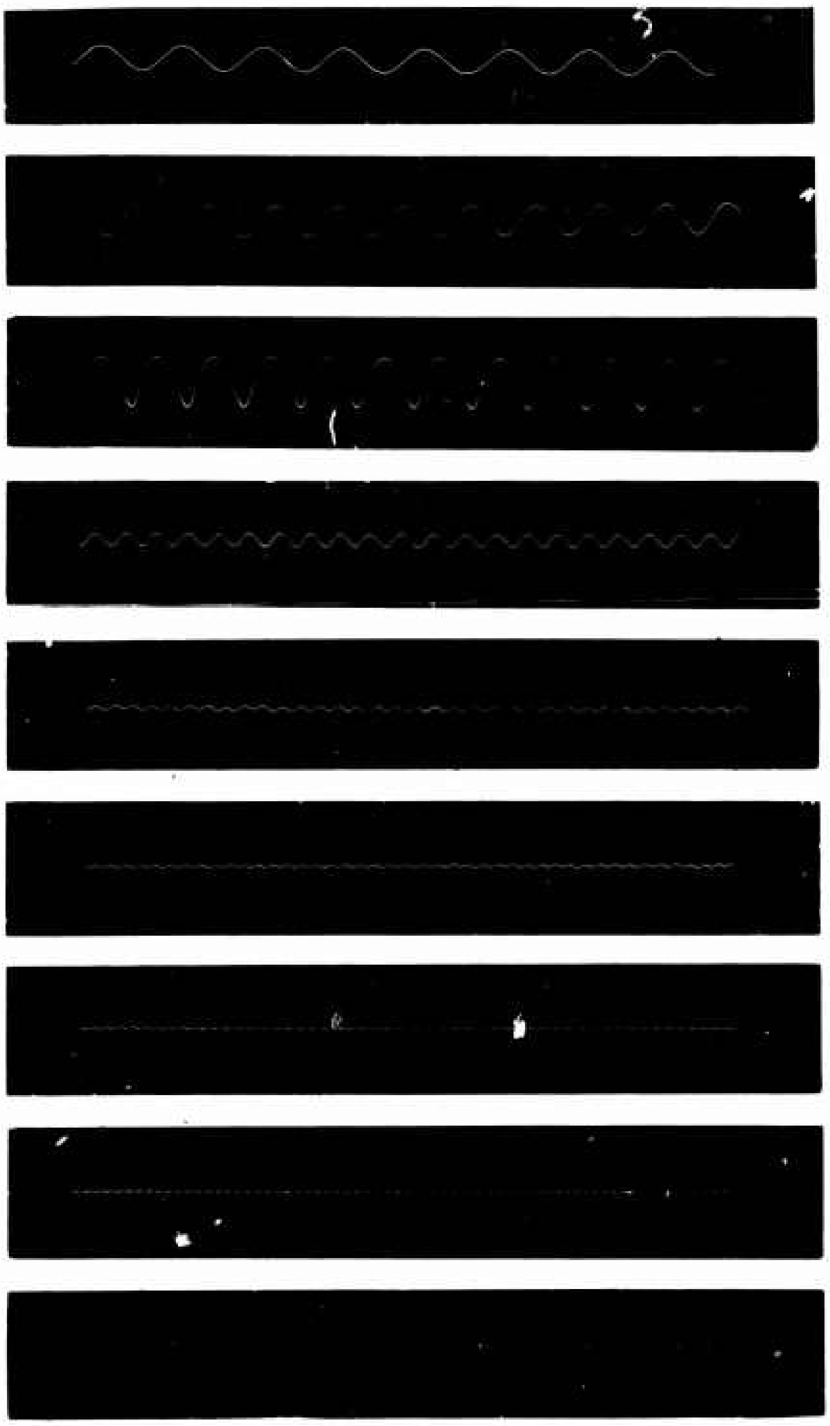
Shipboard Model
Fig. 12

Test No. 30
(Pitch)

CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITH SHOCK ABSORBING BASE
Rotation about Horizontal Transverse Axis
Medium Restoring Force



108 cpm

140 cpm

160 cpm Peak

288 cpm

460 cpm

580 cpm

700 cpm

912 cpm

Impressed Amplitude

Shipboard Model
Fig. 12A

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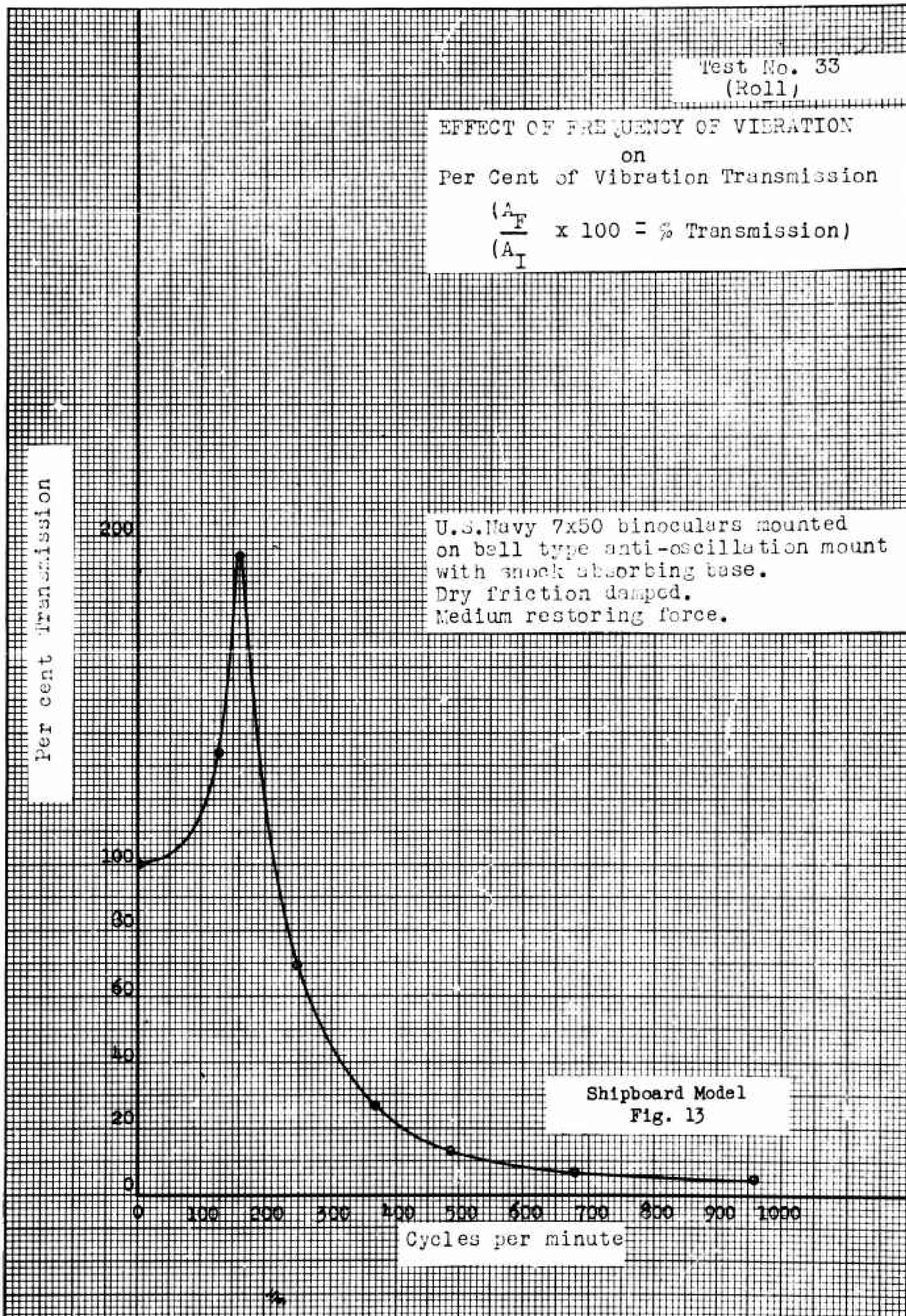


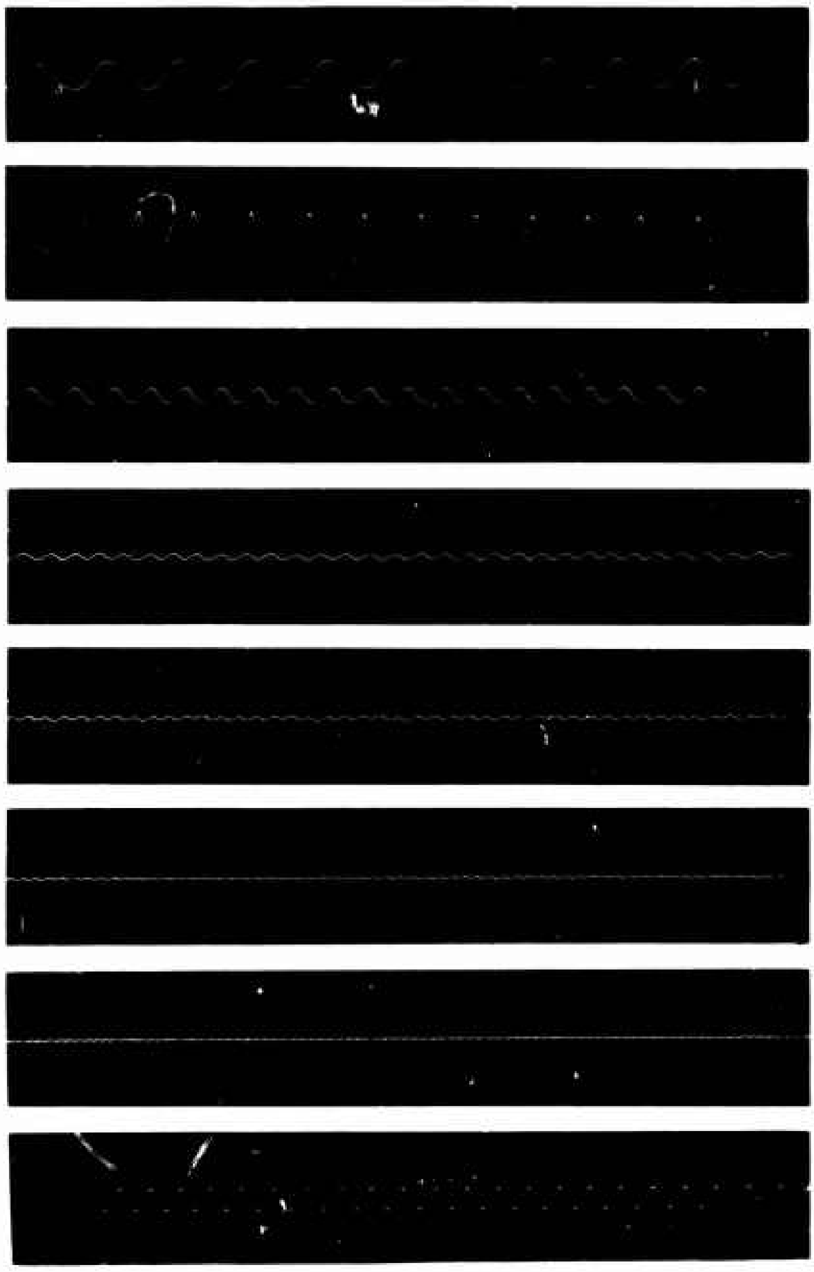
Shipboard Model
Fig. 13

Test No. 3*
(Roll)

PHOTOGRAPHIC TRACE

CONFIDENTIAL

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITHOUT SHOCK ABSORBING BASE
Rotation about Horizontal Longitudinal Axis
Medium Restoring Force



128 cpm

160 cpm Peak

248 cpm

368 cpm

488 cpm

680 cpm

960 cpm

Impressed Amplitude

Shipboard Model
Fig. 13A

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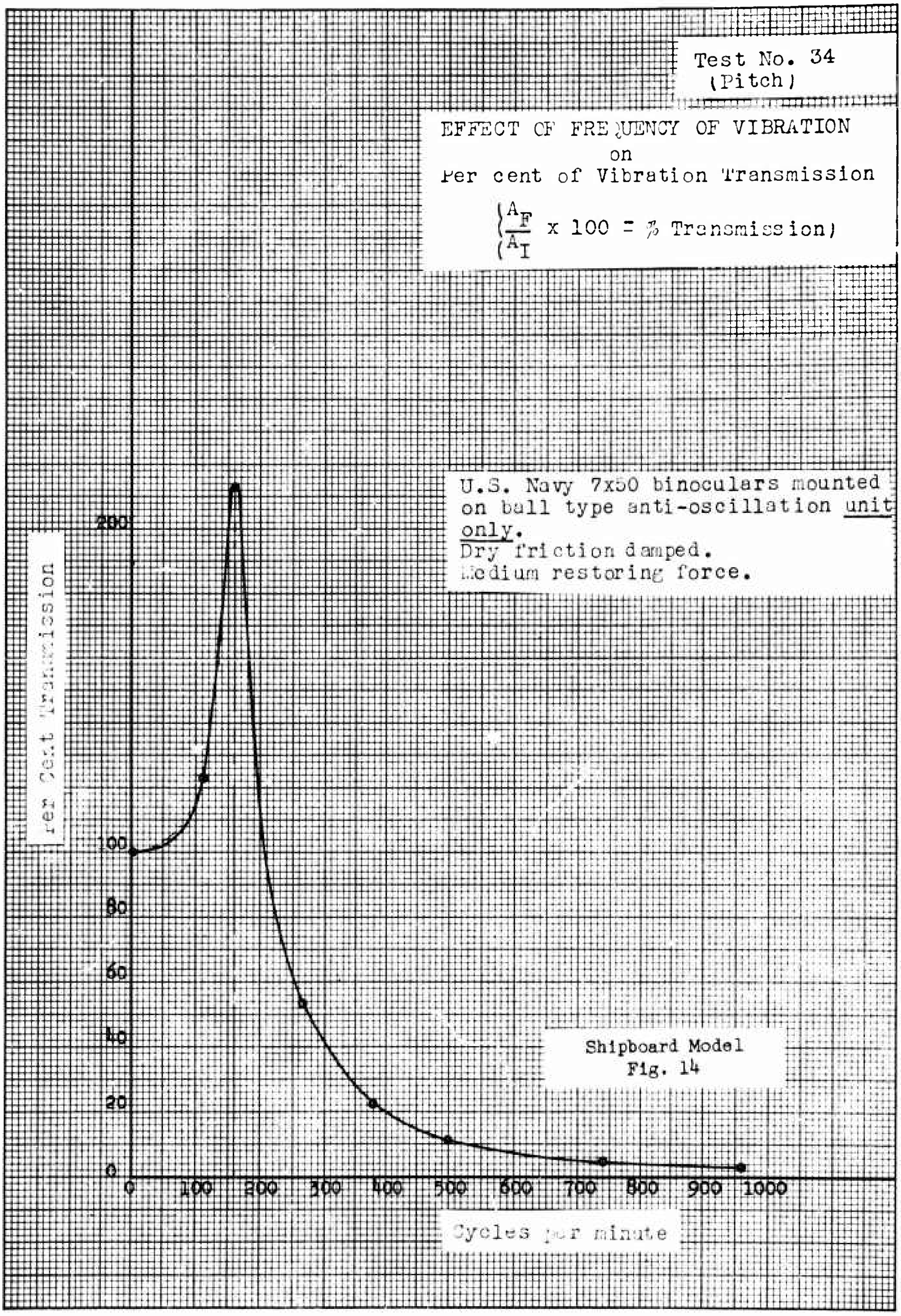


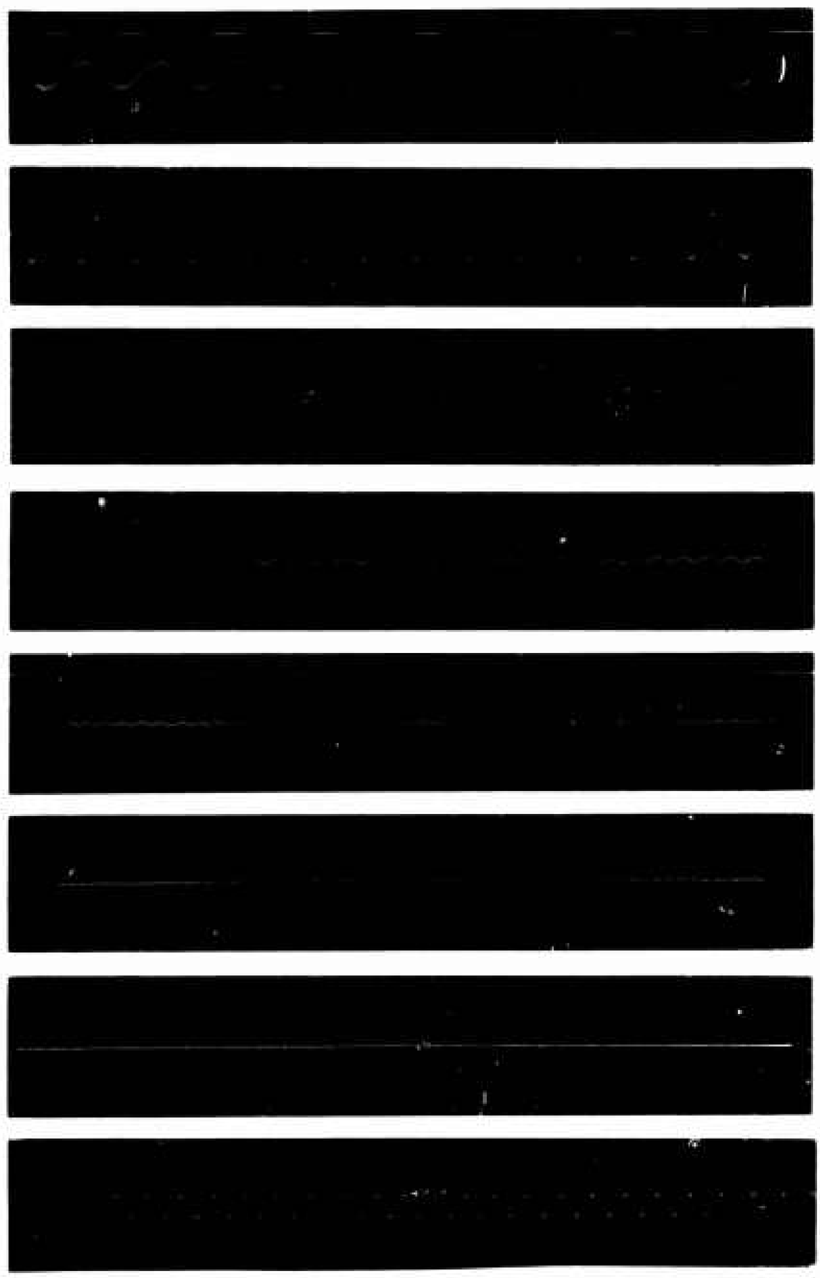
Shipboard Model
Fig. 14

Test No. 34
(Pitch)

CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITHOUT SHOCK ABSORBING BASE
Rotation about Horizontal Transverse Axis
Medium Restoring Force



112 cpm

160 cpm Peak

268 cpm

380 cpm

500 cpm

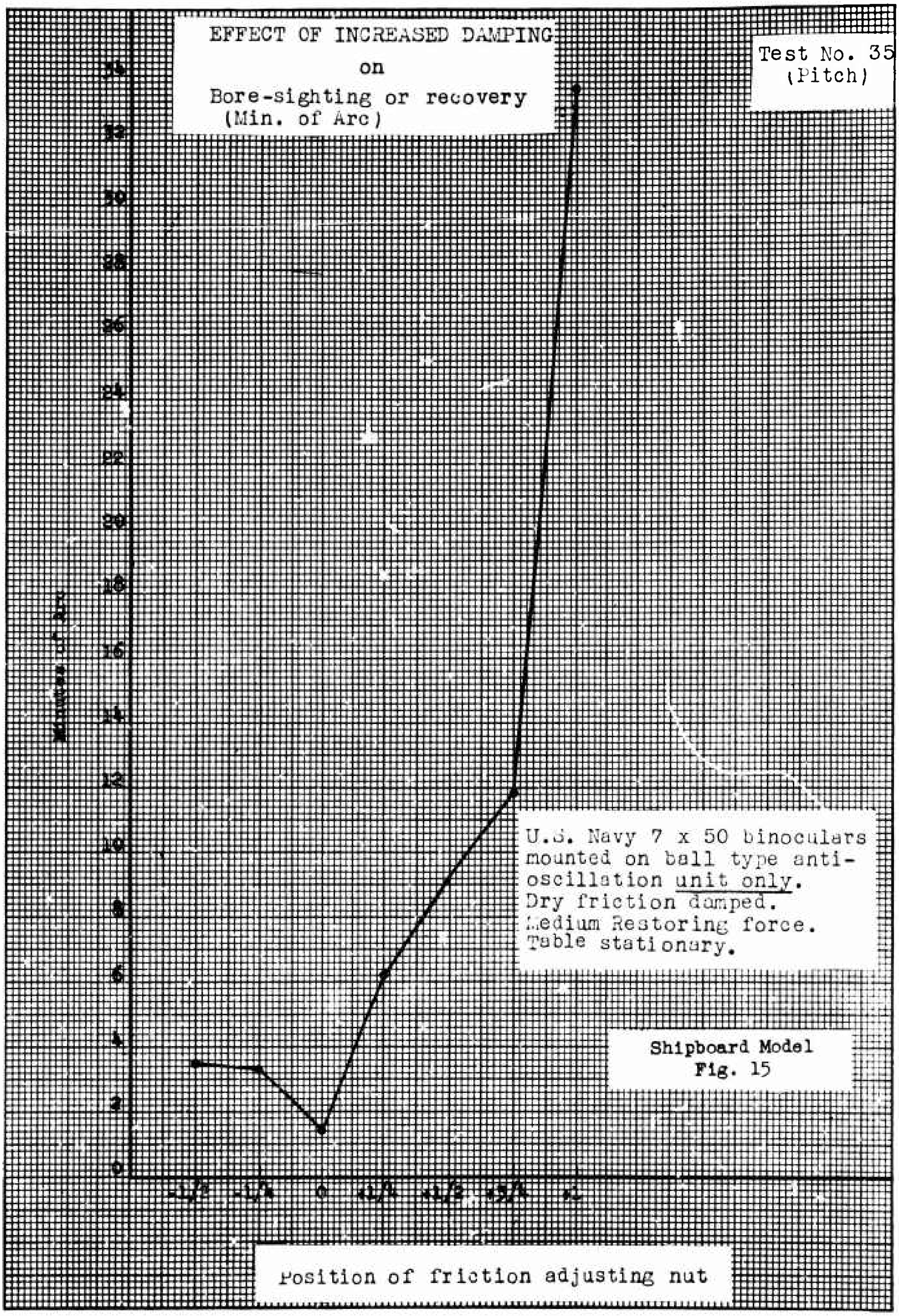
740 cpm

960 cpm

Impressed Amplitude

Shipboard Model
Fig. 14A

CONFIDENTIAL



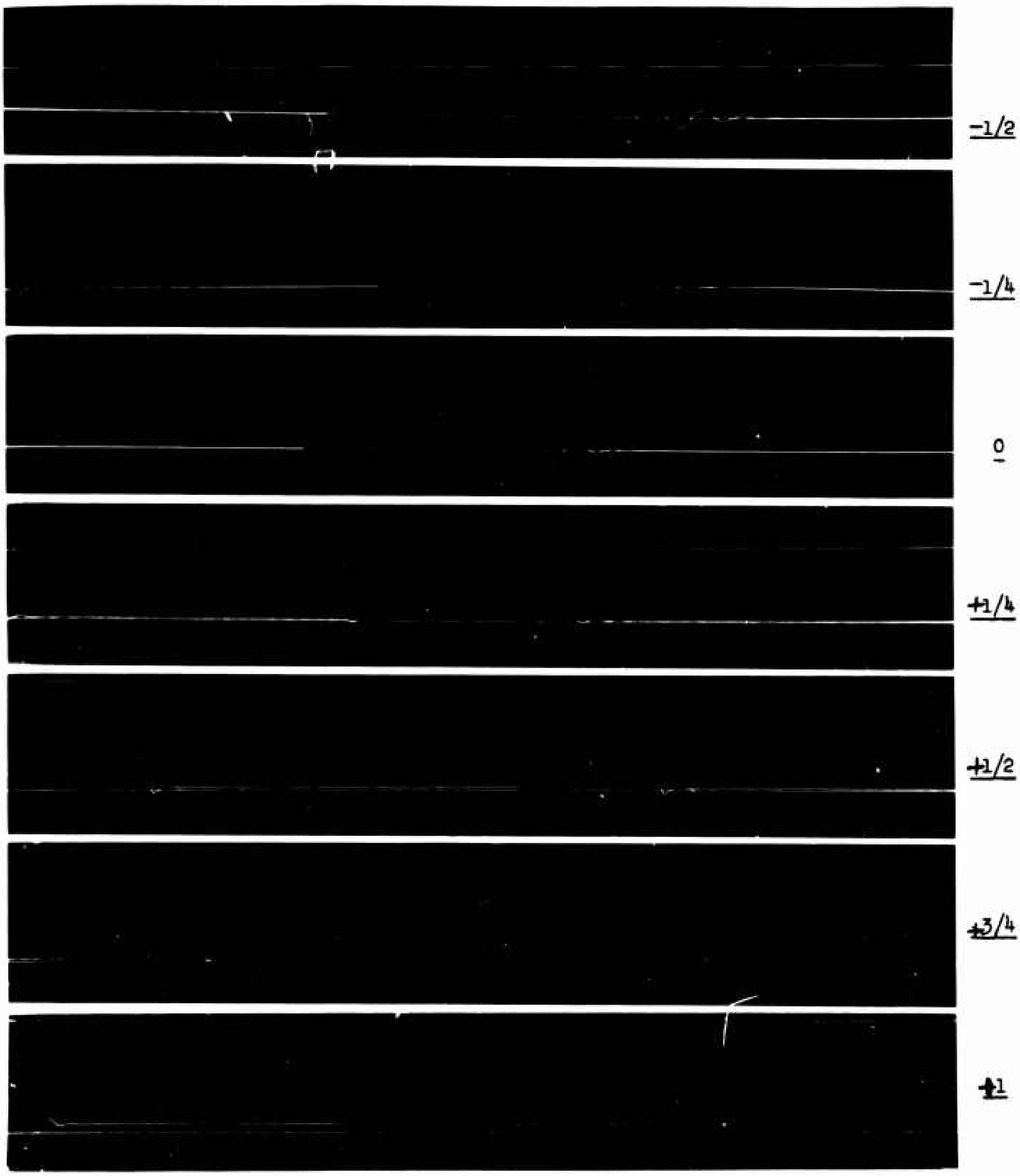
Shipboard Model
Fig. 15

PHOTOGRAPHIC TRACE

Test No. 35
(Pitch)

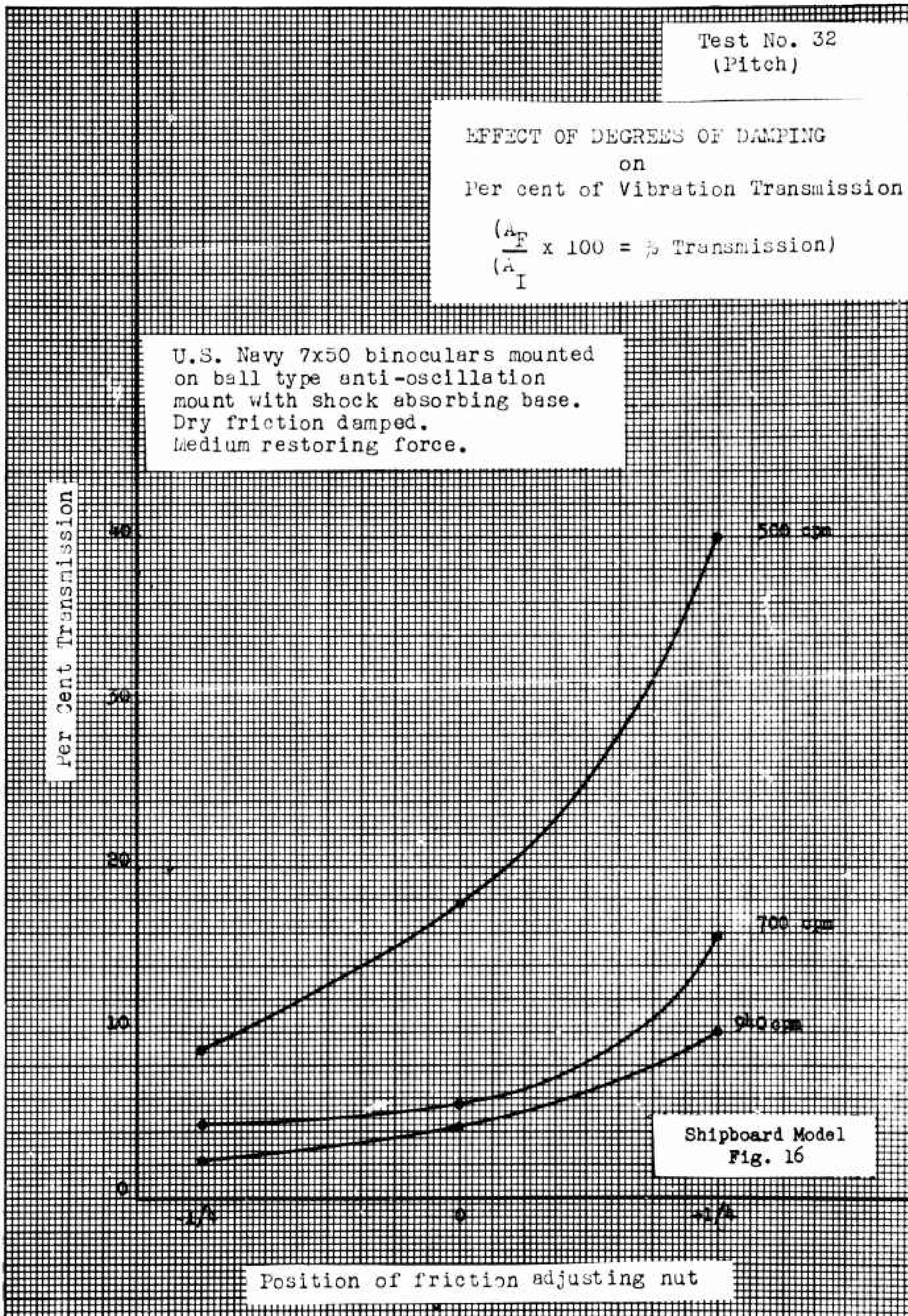
ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITHOUT SHOCK ABSORBING BASE
Rotation about Horizontal Transverse Axis
Medium Restoring Force

CONFIDENTIAL



Shipboard Model
Fig. 15A

CONFIDENTIAL



Shipboard Model
Fig. 16

Test No. 32
(Pitch)

PHOTOGRAPHIC TRACE

CONFIDENTIAL

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITHOUT SHOCK ABSORBING BASE
Rotation about Horizontal Transverse Axis
Medium Restoring Force

$-\frac{1}{4}$ 500

0 500

$+\frac{1}{4}$ 500

$-\frac{1}{4}$ 700

0 700

$+\frac{1}{4}$ 700

$-\frac{1}{4}$ 940

0 940

$+\frac{1}{4}$ 940

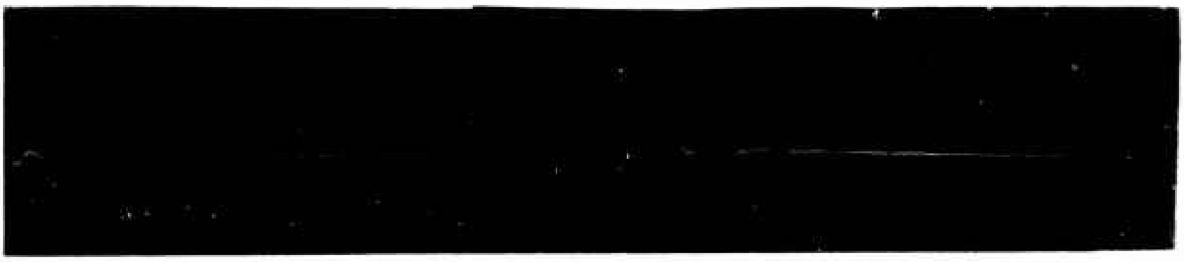
Shipboard Model
Fig. 16A

CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS WITHOUT SHOCK ABSORBING BASE
Rotation about Horizontal Transverse Axis
Medium Restoring Force

Test No. 36 (Pitch) - SHIPBOARD MODEL

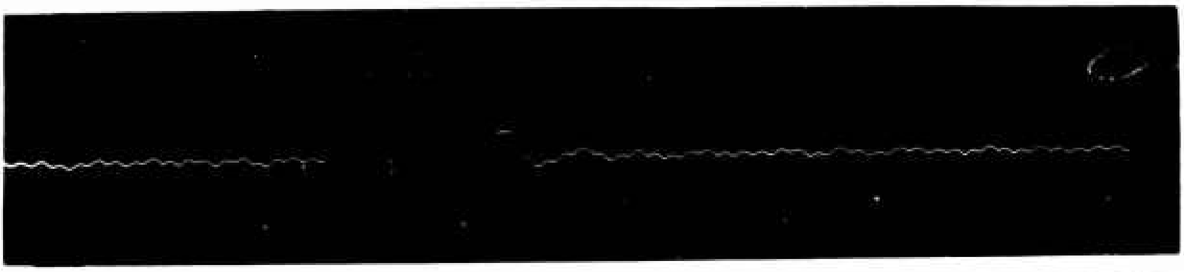


900 cpm

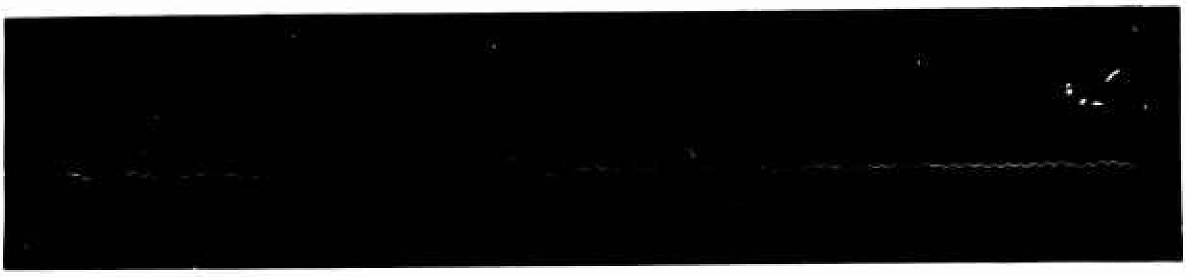
PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Mounted on A.O. Mount only
Rotation about Horizontal Transverse Axis
Medium Restoring Force

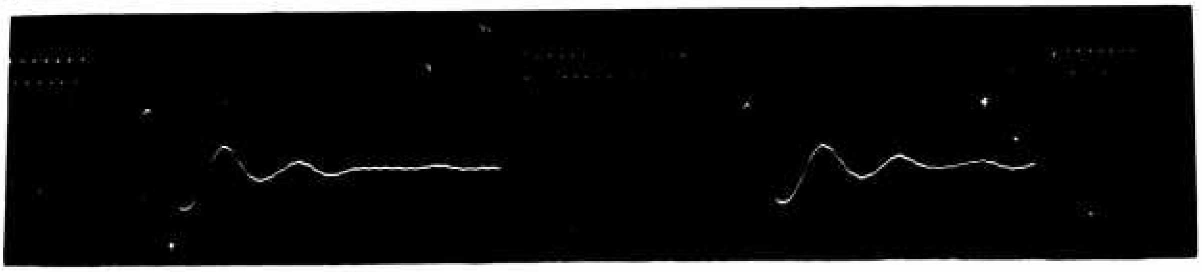
Test No. 42 (Pitch) AIRCRAFT INVERTED MODEL



488 cpm

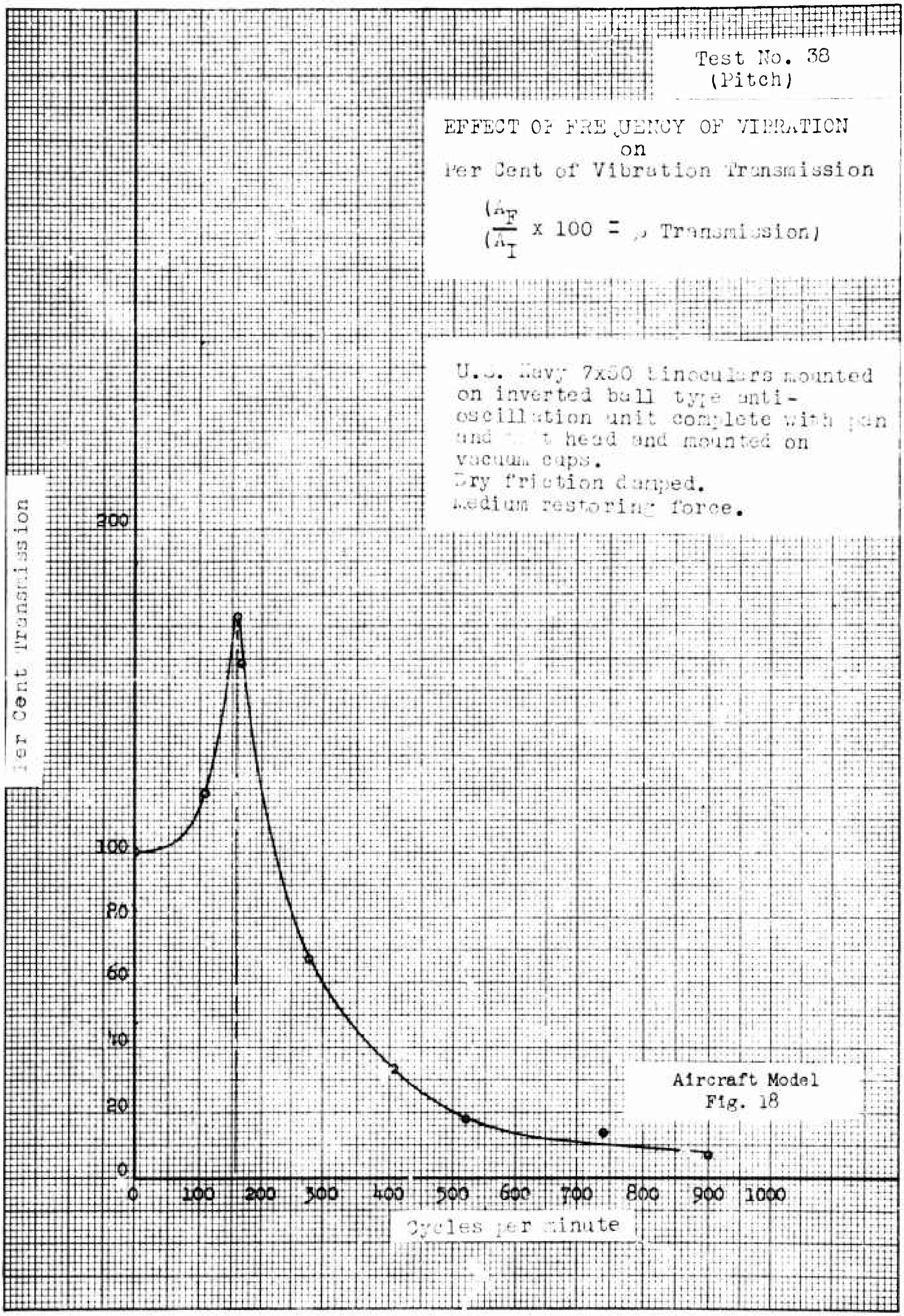


660 cpm



856 cpm

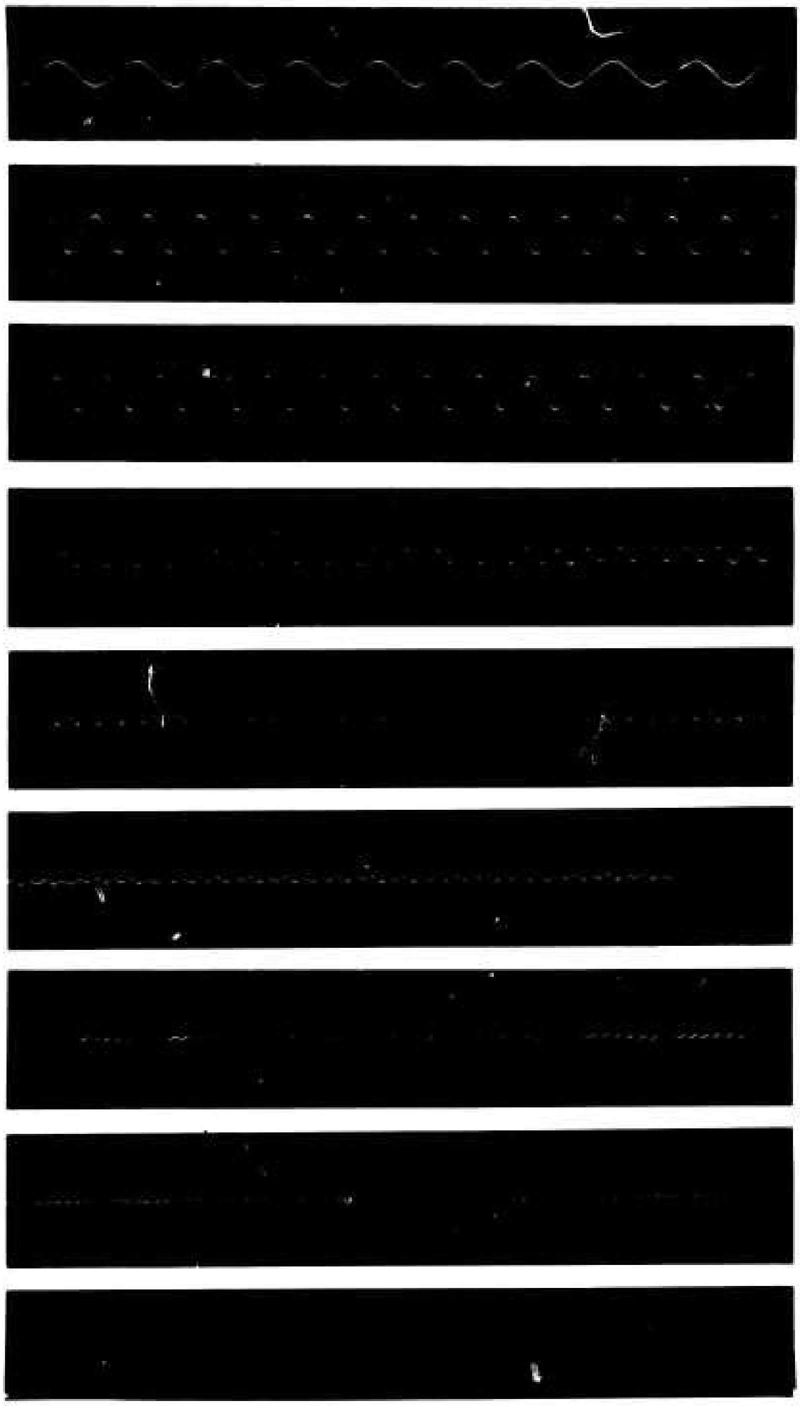
Fig. 17


Test No. 38
(Pitch)
EFFECT OF FREQUENCY OF VIBRATION
on
Per Cent of Vibration Transmission
$(\frac{A_F}{A_I} \times 100 = \%$ Transmission$)$
U.S. Navy 7x50 binoculars mounted
on inverted ball type anti-
oscillation unit complete with pan
and head and mounted on
vacuum caps.
Dry friction damped.
Medium restoring force.
Per Cent Transmission
200
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
1000
Cycles per minute
Aircraft Model
Fig. 18

Test No. 38
(Pitch)
CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Complete with pan and tilt head and mounted on vacuum cups
Rotation about Horizontal Transverse Axis
Medium Restoring Force



108 cpm

160 cpm Peak

165 cpm

280 cpm

408 cpm

520 cpm

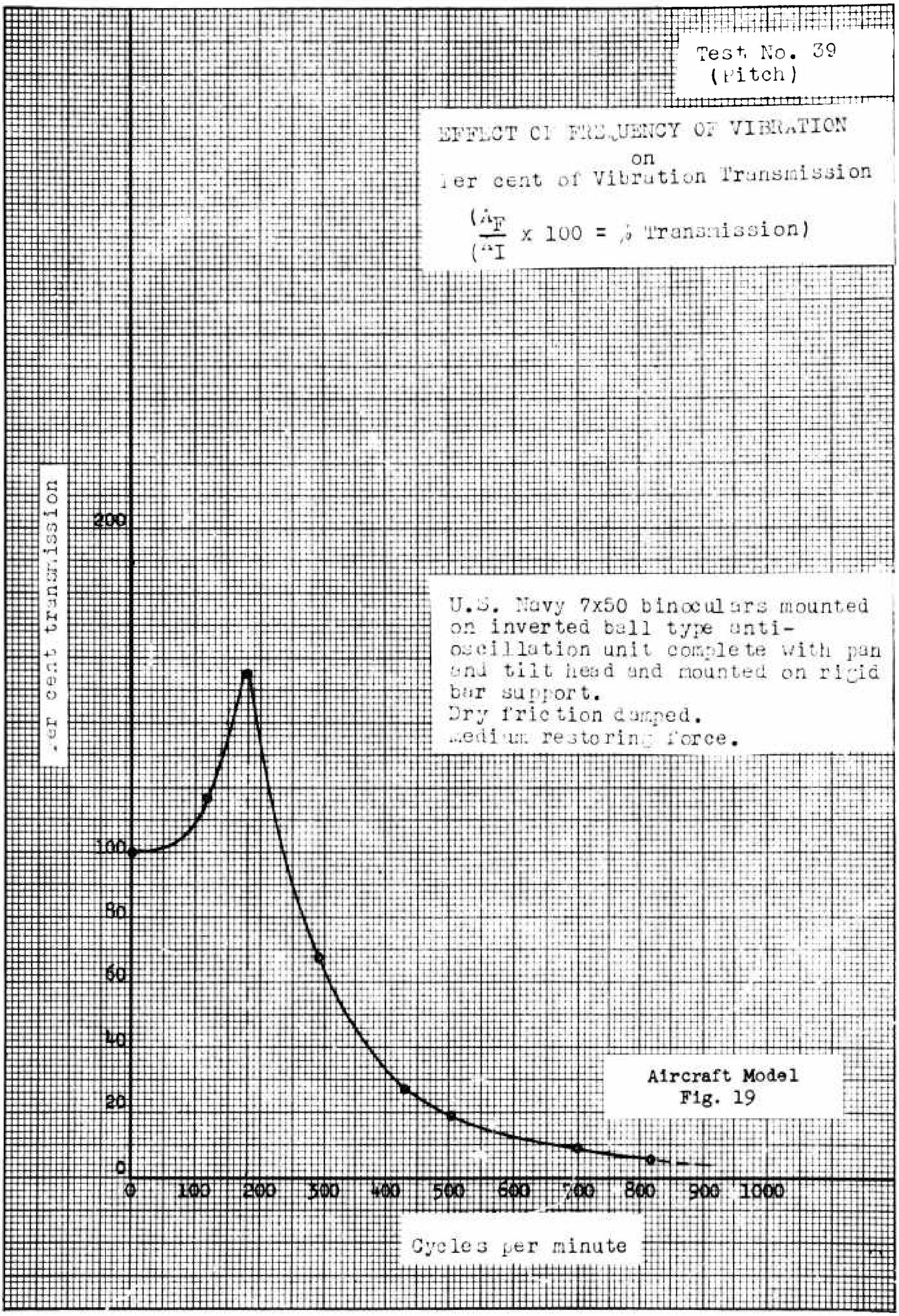
740 cpm

900 cpm

Impressed Amplitude

Aircraft Inverted Model
Fig. 18A

CONFIDENTIAL



Aircraft Model
Fig. 19

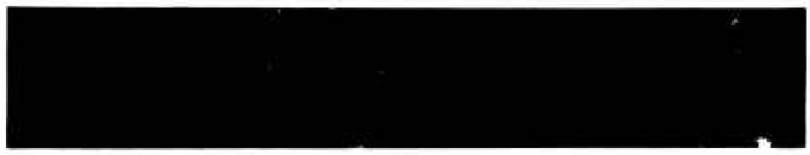
Test No. 39
(Pitch)
CONFIDENTIAL

PHOTOGRAPHIC TRACE

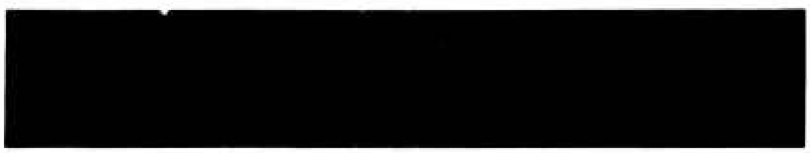
ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Mounted on AO Mount only
Complete with pan and tilt head and mounted on rigid bar support
Rotation about Horizontal Transverse Axis
Medium Restoring Force

120 cpm

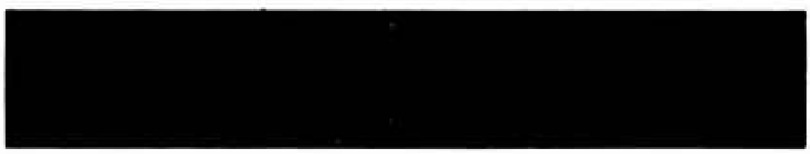
180 cpm Peak



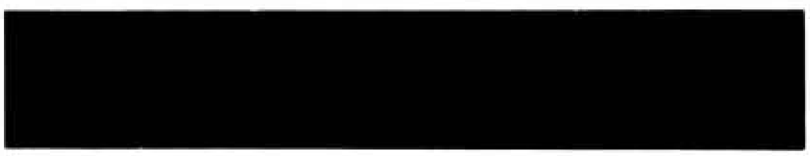
288 cpm



432 cpm

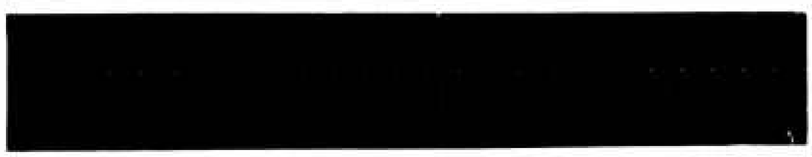


504 cpm



700 cpm

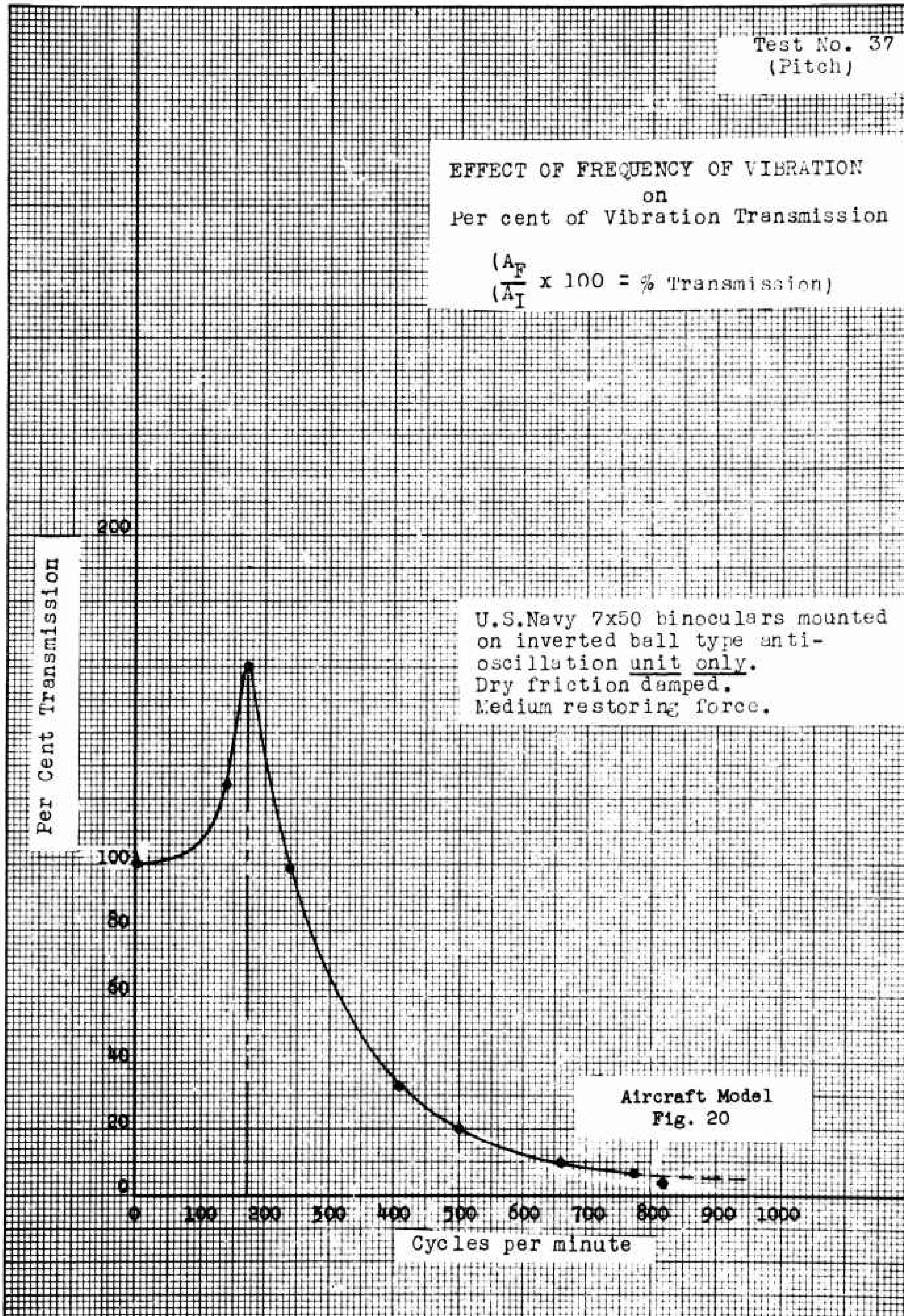
820 cpm



Impressed Amplitude

Aircraft Inverted Model
Fig. 19A

CONFIDENTIAL



Aircraft Model
Fig. 20

Test No. 37
(Pitch)

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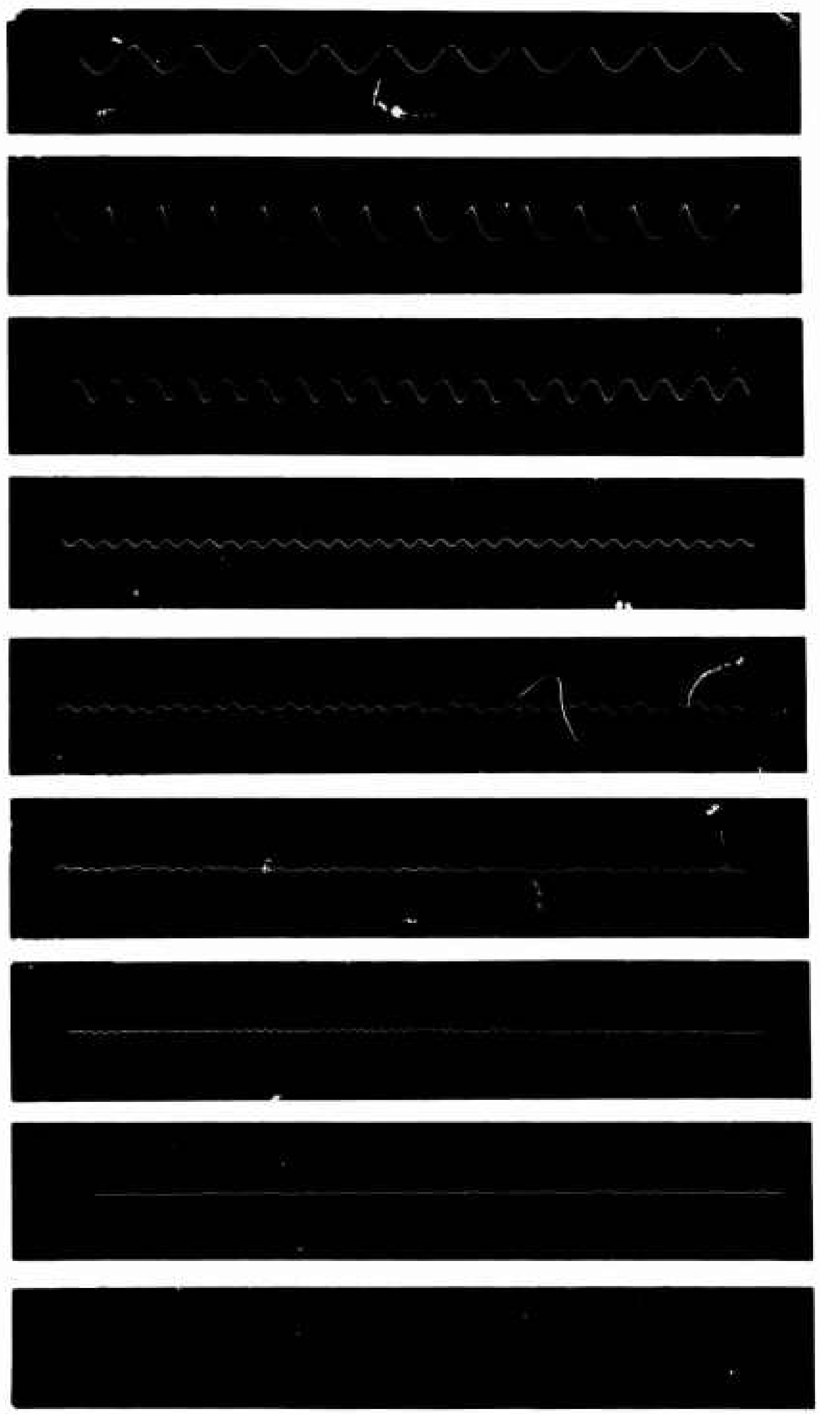
PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Mounted on A.O. Mount only
Rotation about Horizontal Transverse Axis
Medium Restoring Force



136 cpm

172 cpm Peak

240 cpm

408 cpm

500 cpm

660 cpm

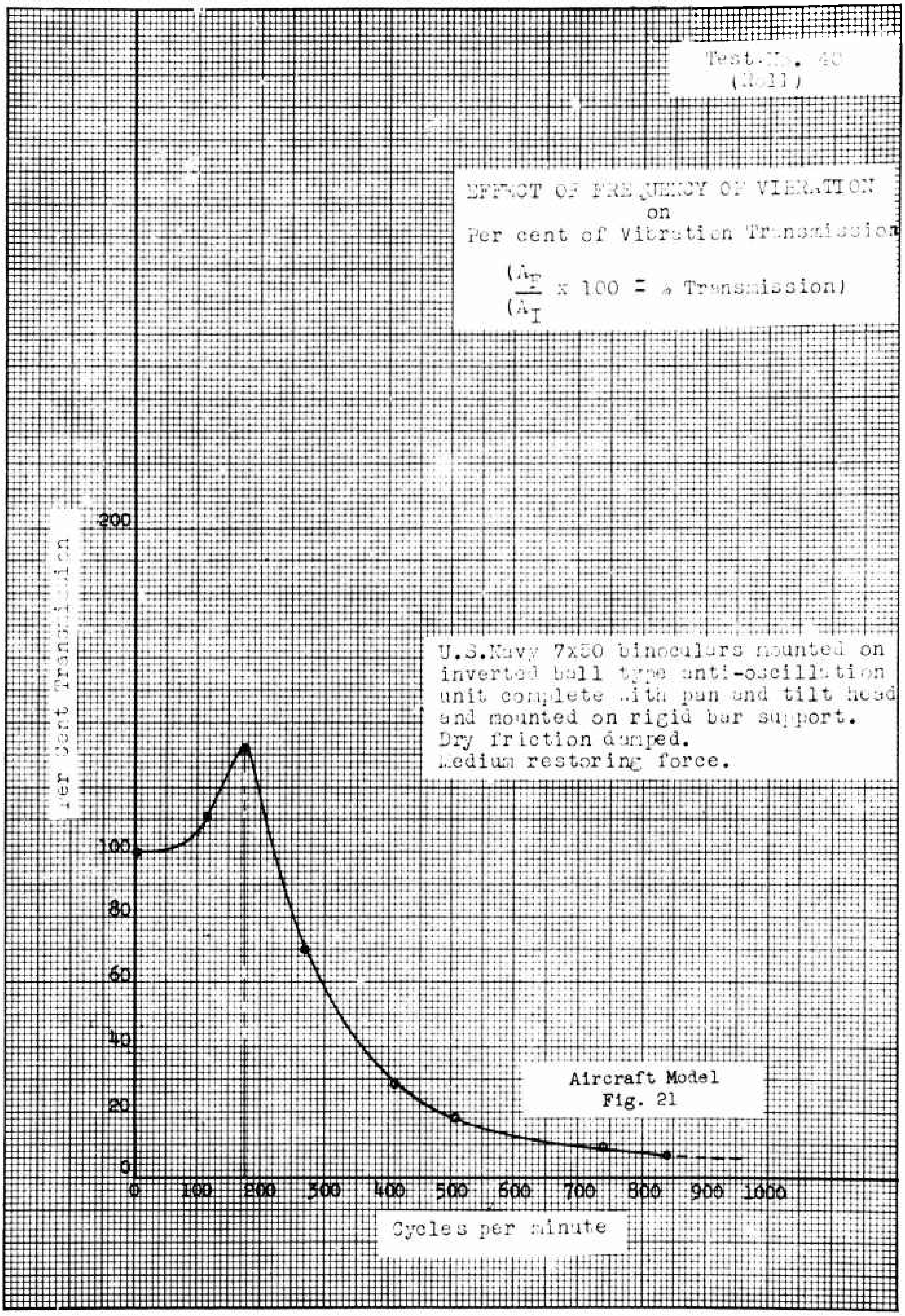
772 cpm

820 cpm

Impressed Amplitude

CONFIDENTIAL

Aircraft Inverted Model
Fig. 20A



Aircraft Model
Fig. 21

Test No. 40
(Roll)

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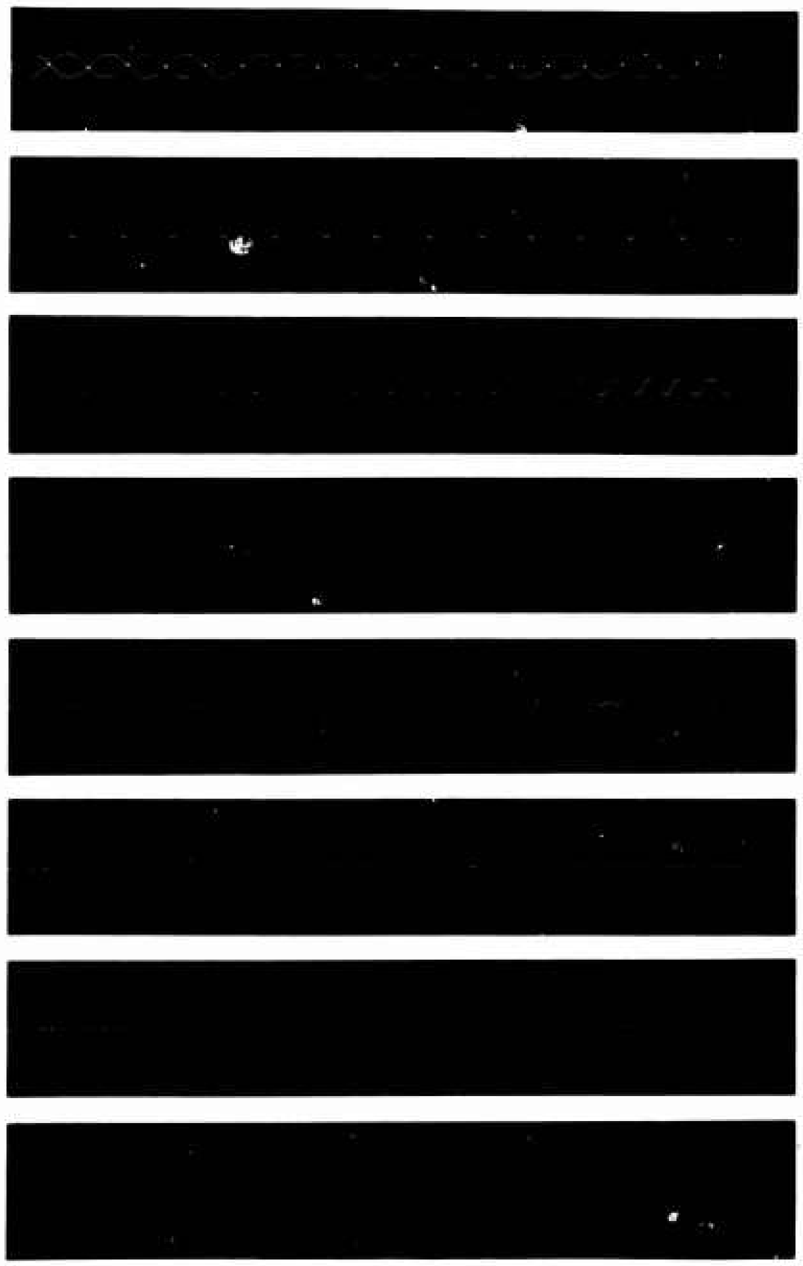
PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Complete with pan and tilt head and mounted on rigid bar support
Rotation about Horizontal Longitudinal Axis
Medium Restoring Force



116 cpm

176 cpm Peak

272 cpm

412 cpm

508 cpm

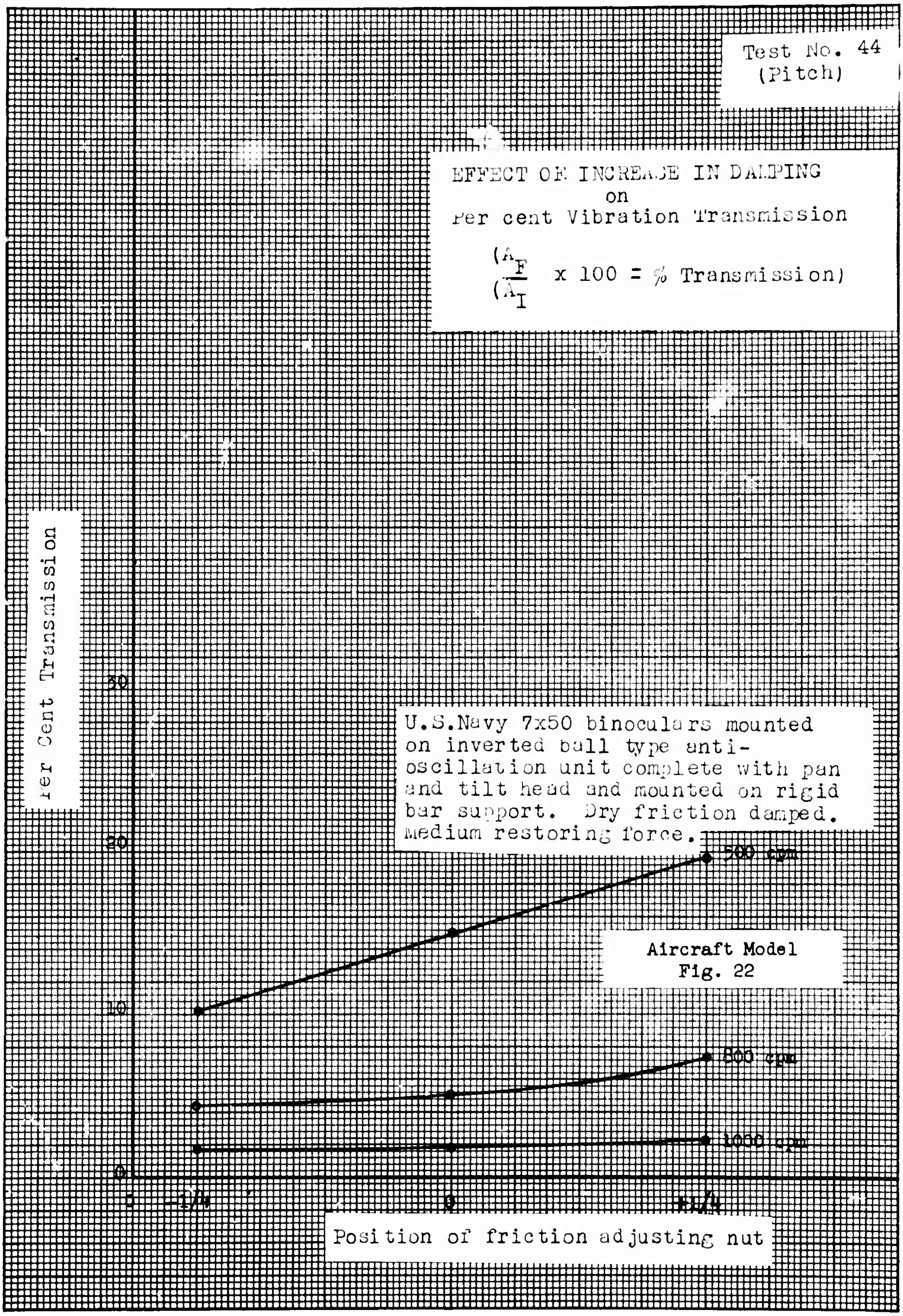
740 cpm

840 cpm

Impressed Amplitude

Aircraft Inverted Model
Fig. 21A

CONFIDENTIAL



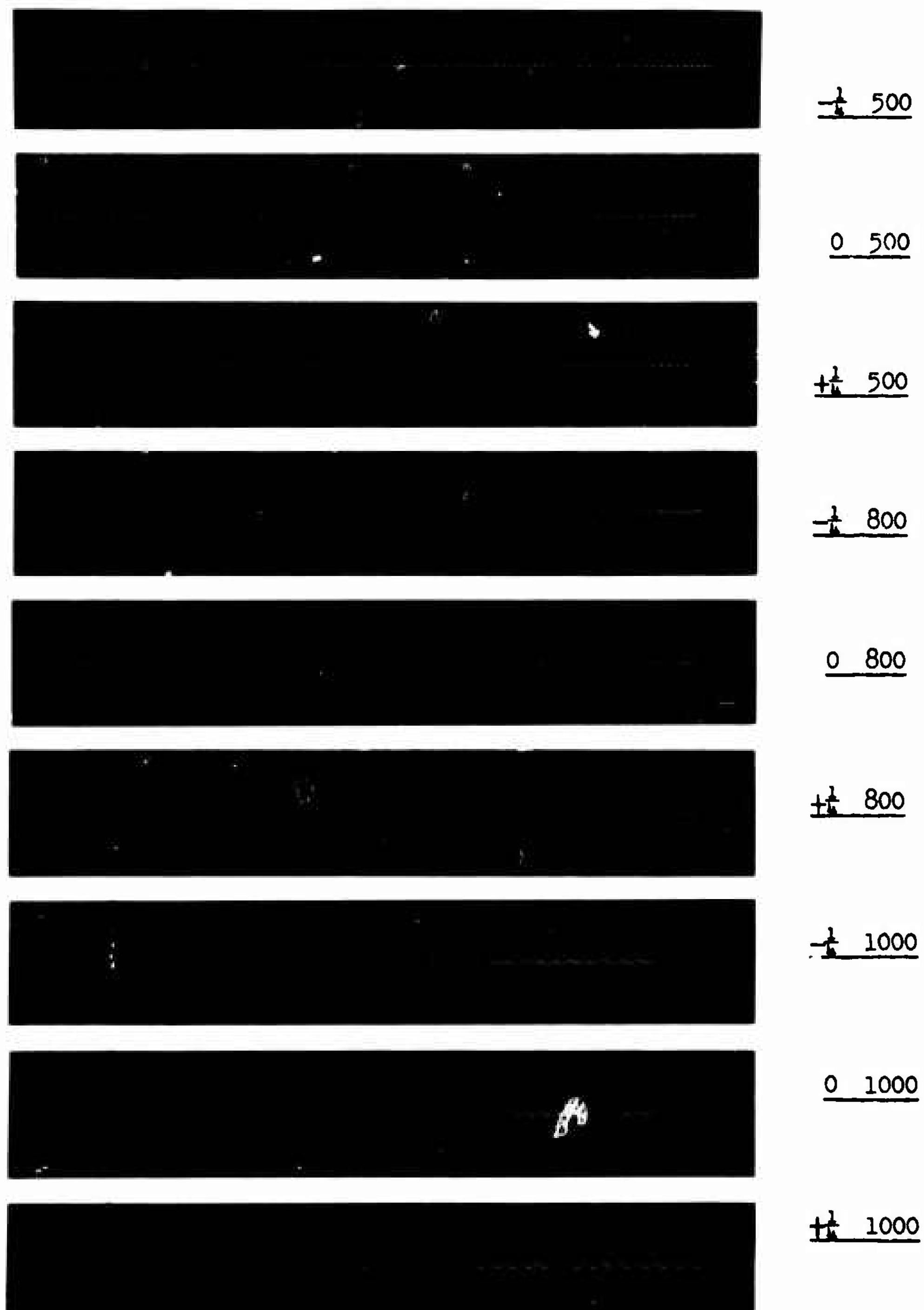
Aircraft Model
Fig. 22

Test No. 44
(Pitch)

CONFIDENTIAL

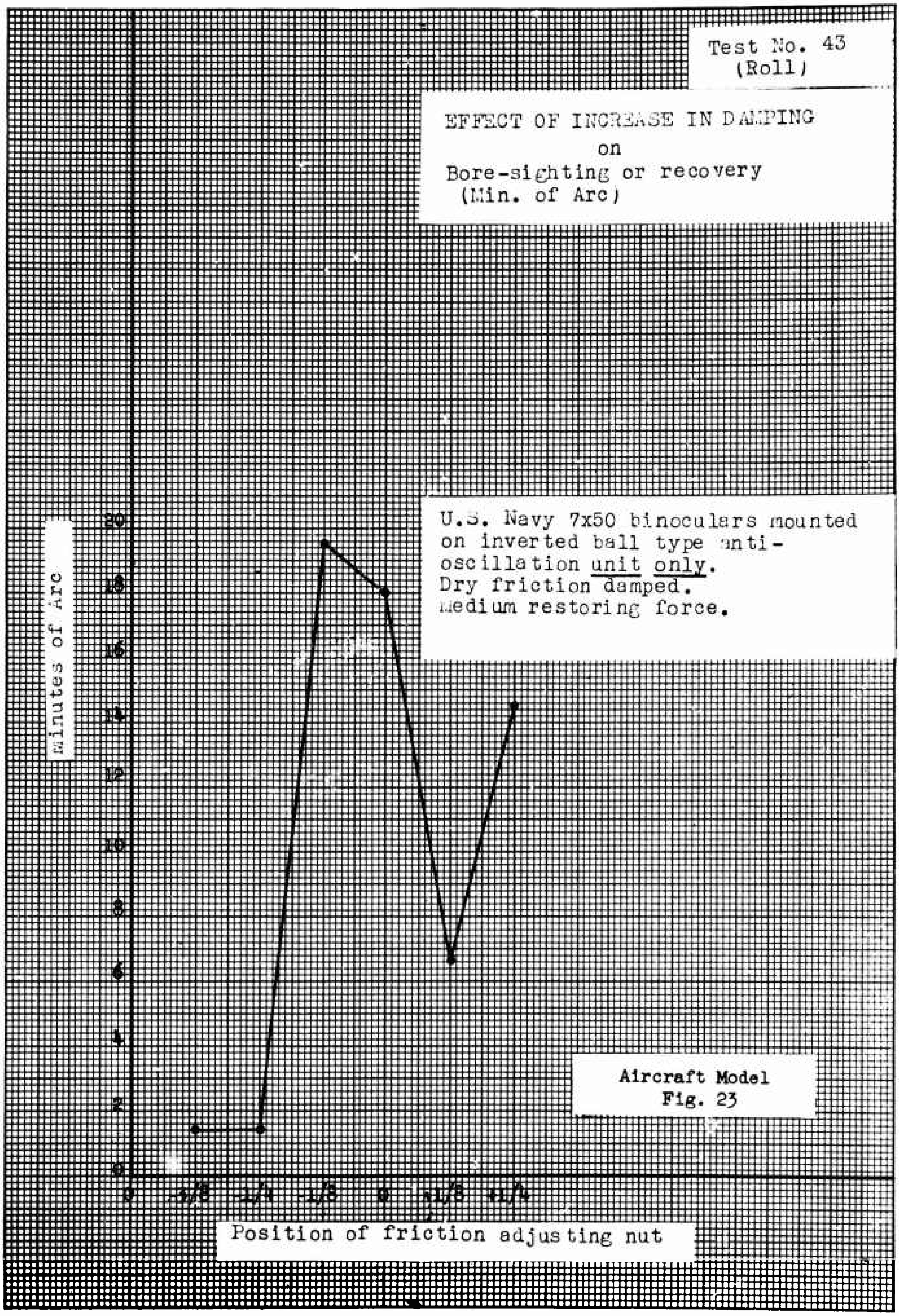
PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Complete with Pan and Tilt Head and Mounted on Rigid Bar Support
Rotation about Horizontal Transverse Axis
Medium Restoring Force



Aircraft Inverted Model
Fig. 22A

CONFIDENTIAL

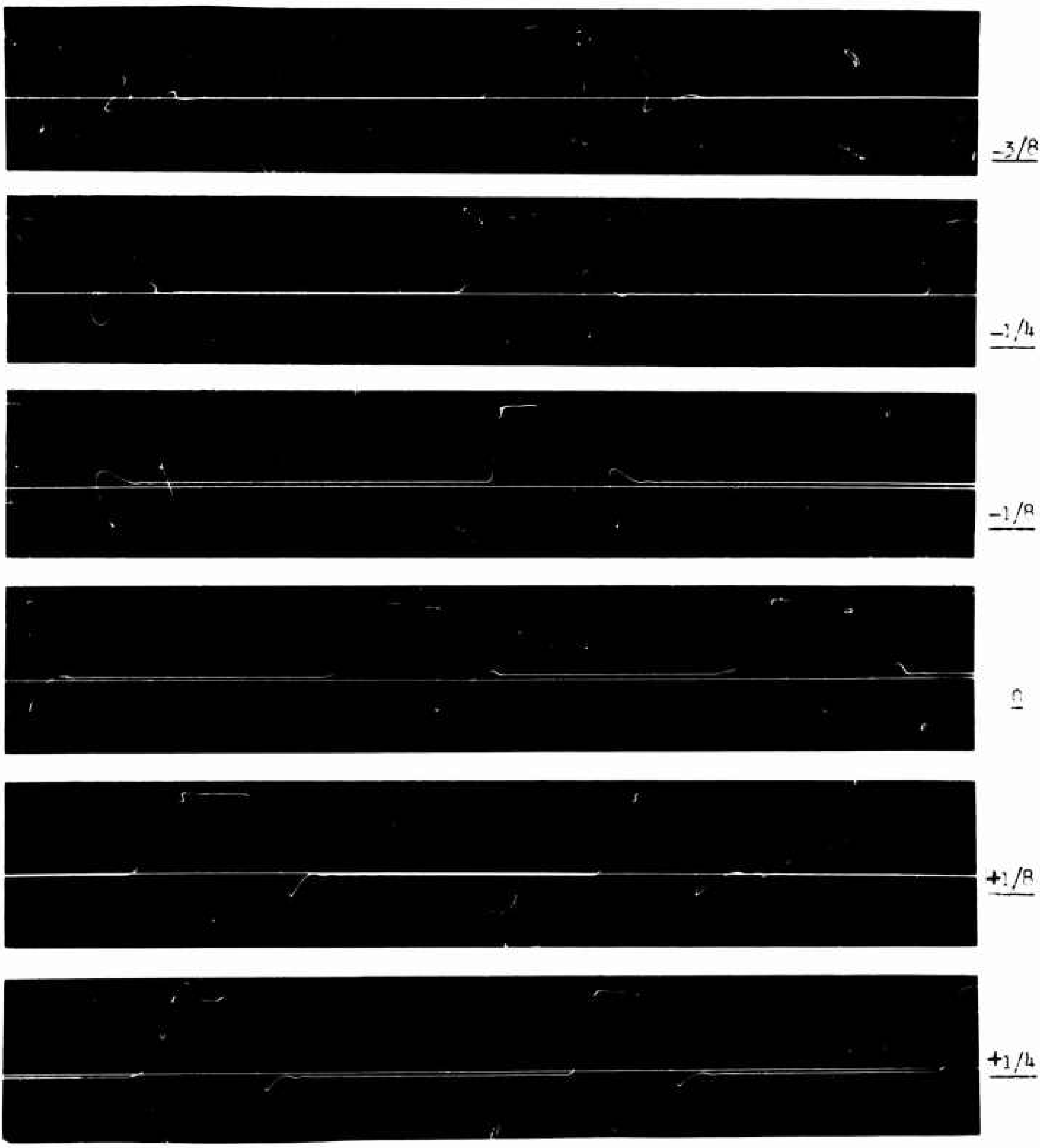

Test No. 43
(Roll)
EFFECT OF INCREASE IN DAMPING
on
Bore-sighting or recovery
(Min. of Arc)
U.S. Navy 7x50 binoculars mounted
on inverted ball type anti-
oscillation unit only.
Dry friction damped.
Medium restoring force.
Minutes of Arc
Aircraft Model
Fig. 23
Position of friction adjusting nut

Test No. 43
(Roll)

CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Mounted on A.O. Mount only
Rotation about Horizontal Longitudinal Axis
Medium Restoring Force



Aircraft Inverted Model
Fig. 23A

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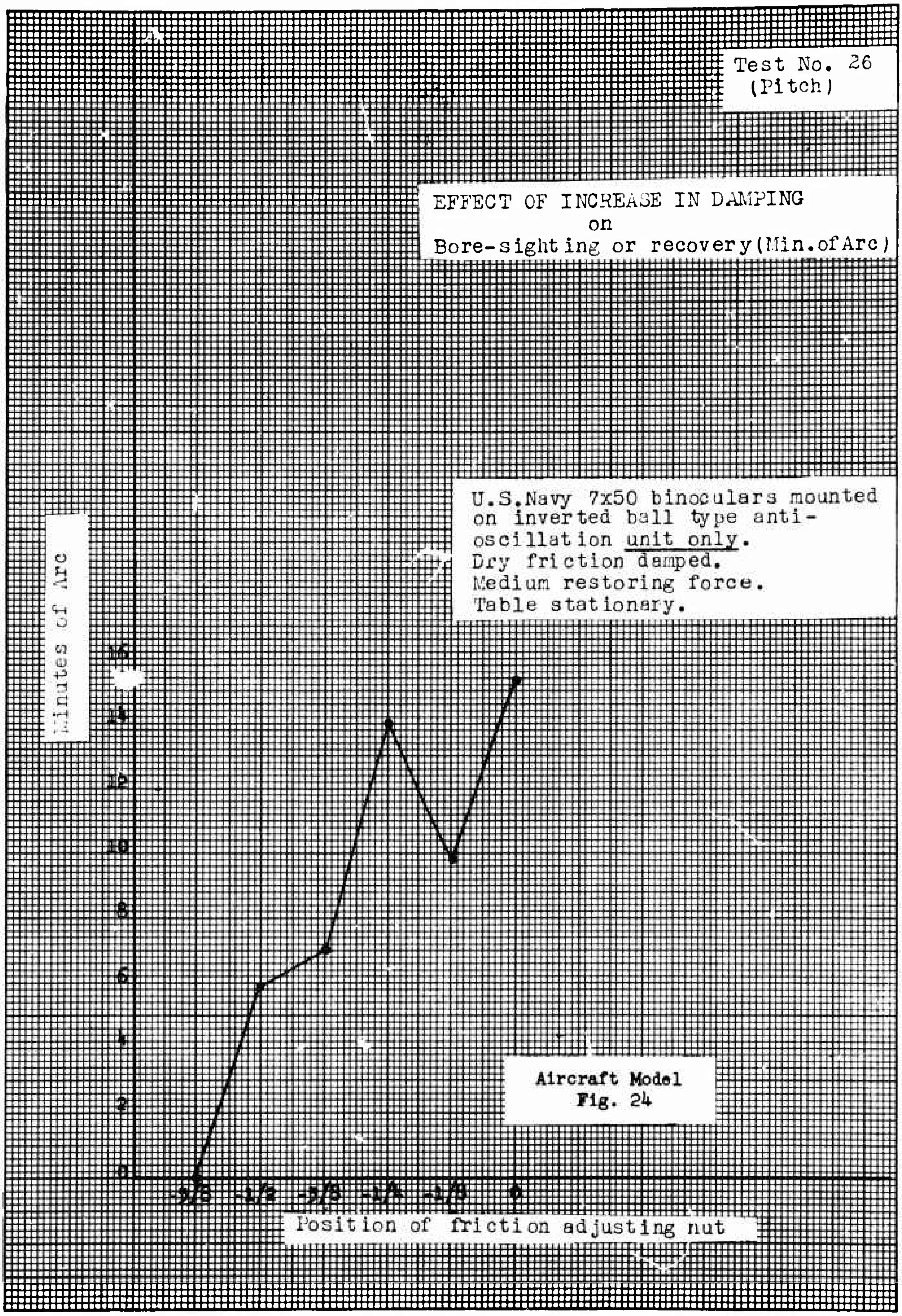
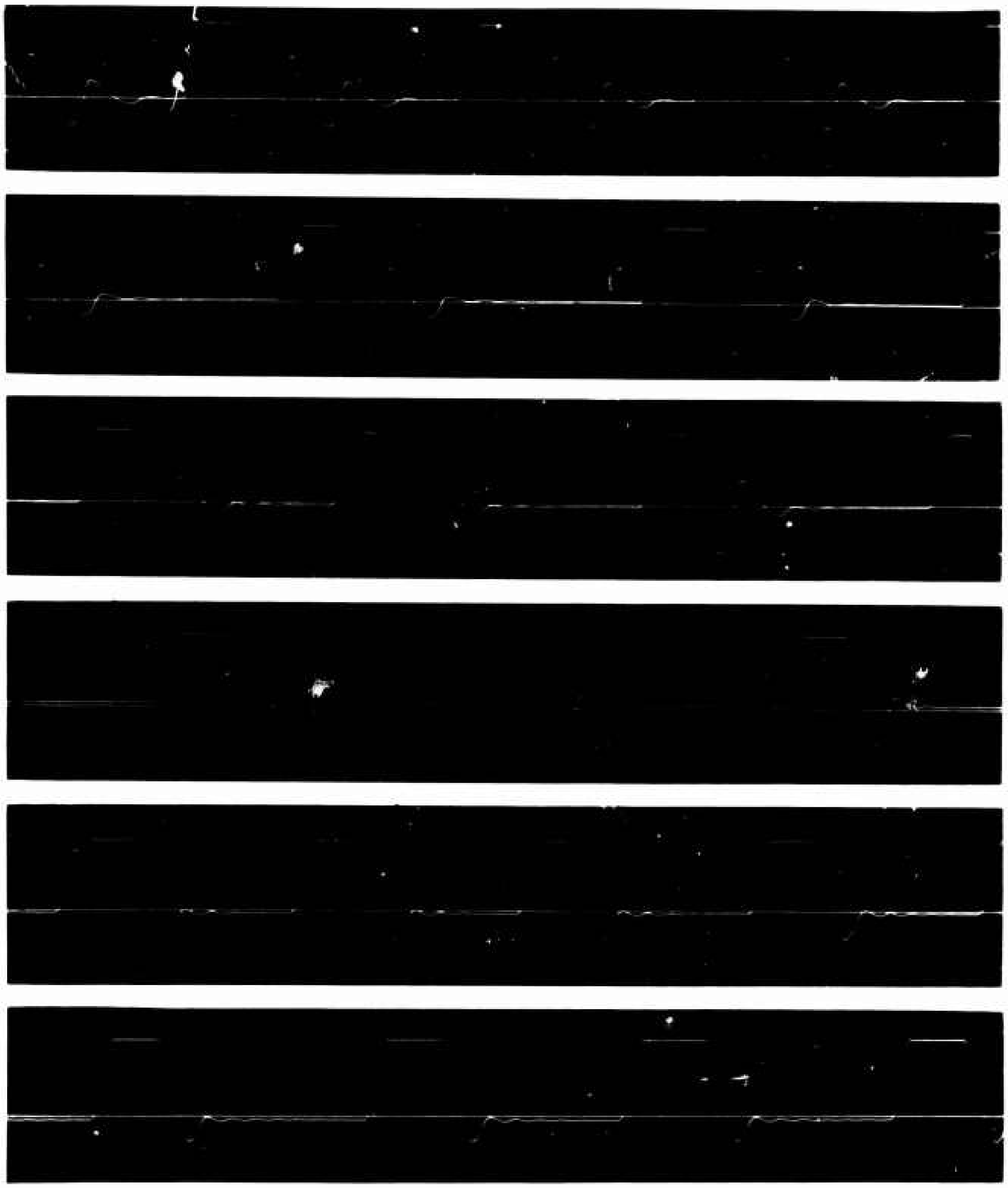


Aircraft Model
Fig. 24

Test No. 26
(Pitch)
CONFIDENTIAL

PHOTOGRAPHIC TRACE

ANTI-OSCILLATION MOUNT FOR U.S. NAVY 7 x 50 BINOCULARS
Mounted on A.O. Mount only - Table Stationary
Rotation about Horizontal Transverse Axis
Medium Restoring Force



-5/8

-1/2

-3/8

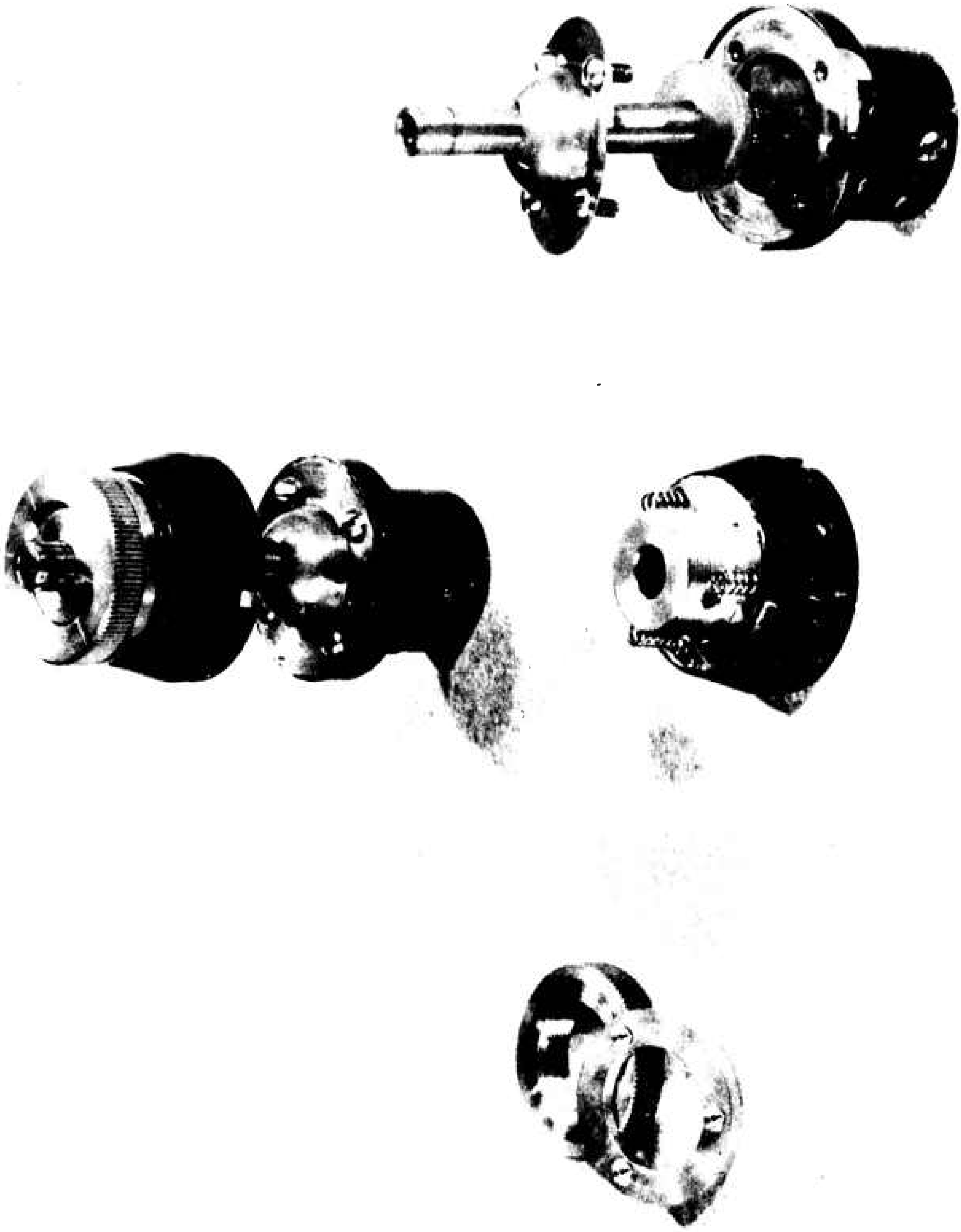
-1/4

-1/8

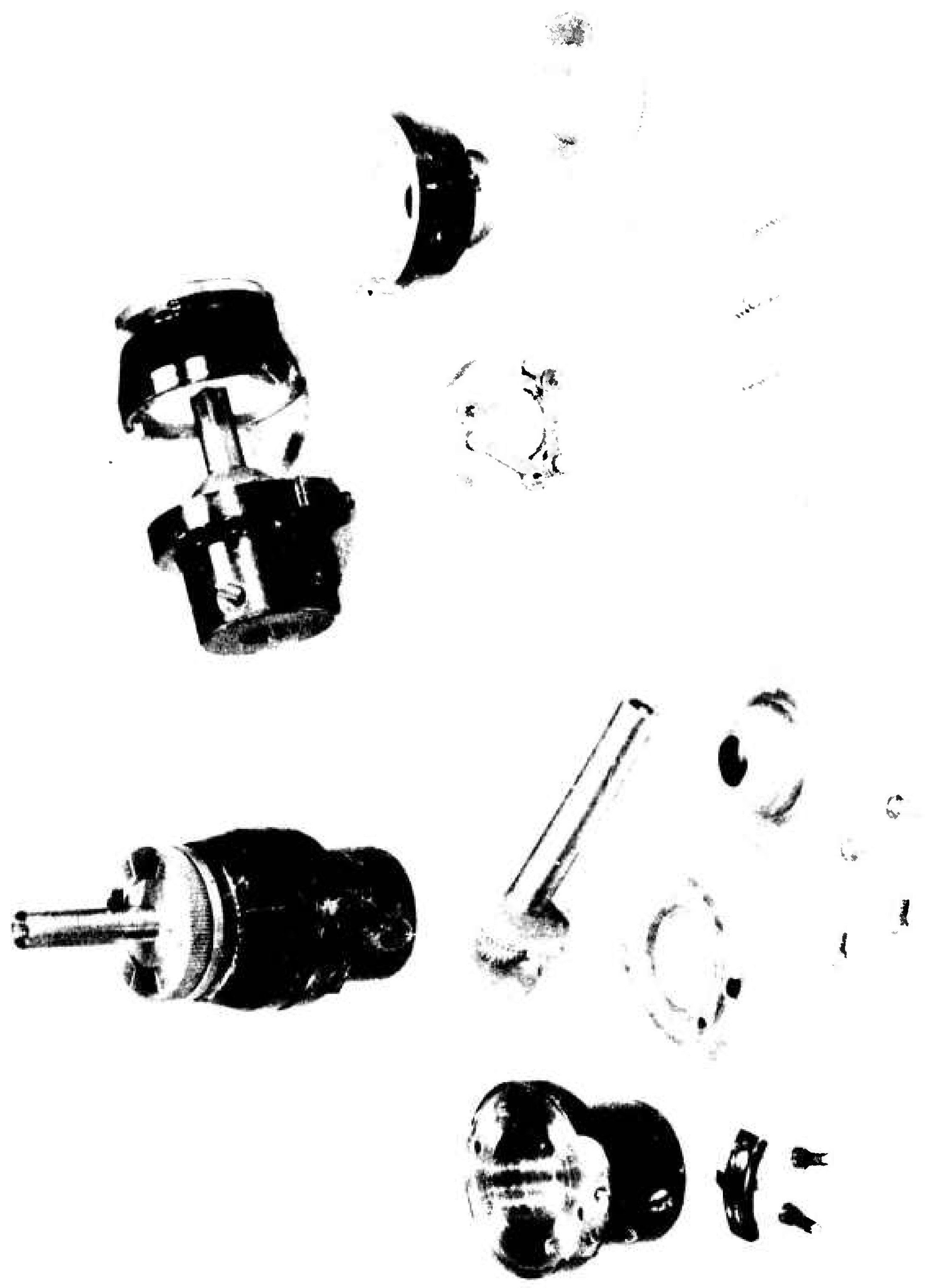
0

Aircraft Inverted Model
Fig. 24A

CONFIDENTIAL



Disassembled A.O. Unit
Fig. 25



Disassembled A.O. Unit
Fig. 26

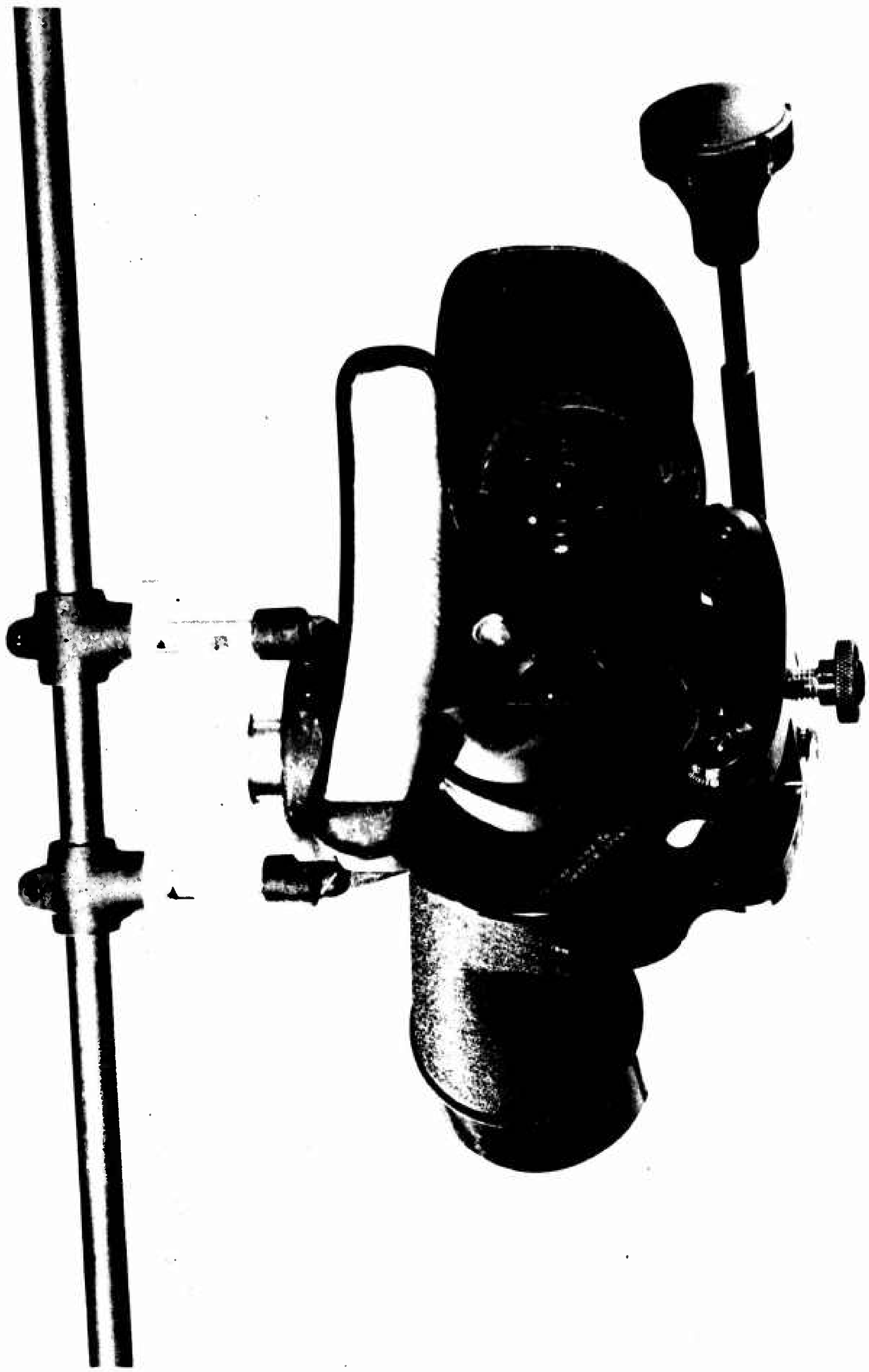
Shipboard Model
Fig. 27

Shipboard Model
Fig. 28

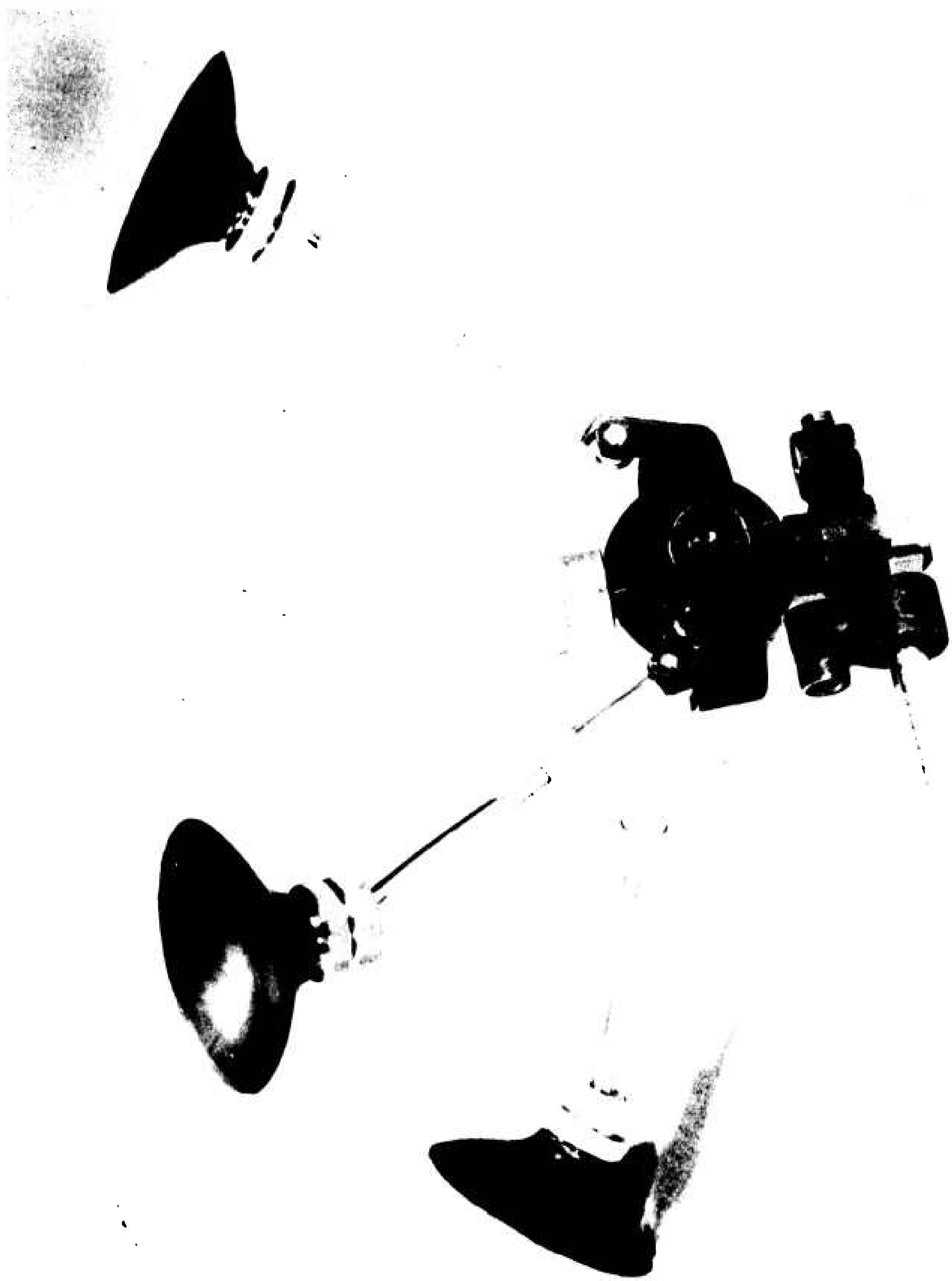
Shipboard Model with Mounting Brackets
Fig. 29

Aircraft Model in Case
Fig. 30

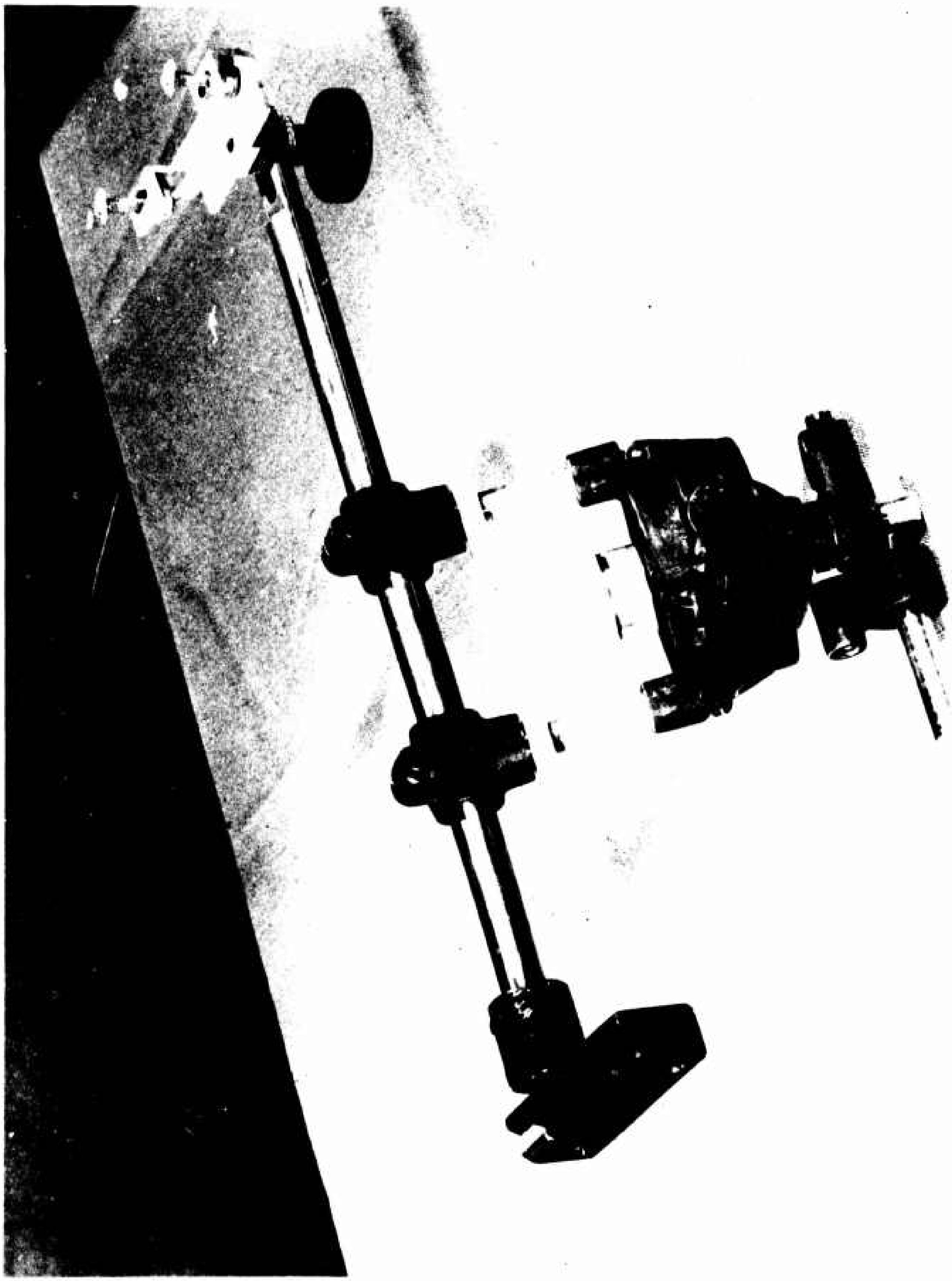
Aircraft Model - Vacuum Cup Mount
Fig. 32



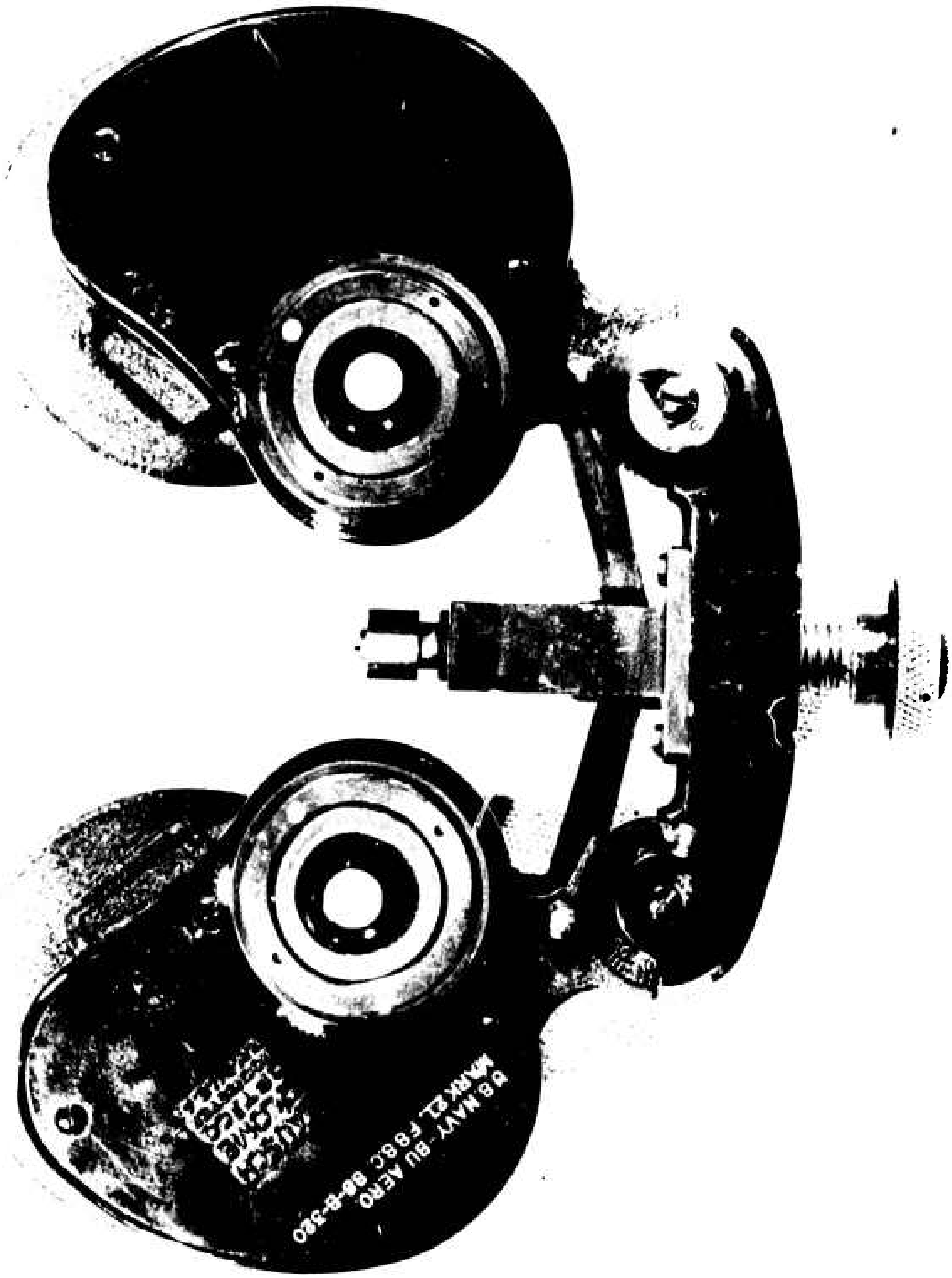
Aircraft Model - Rigid Bar Mount
Fig. 34



Aircraft Model - Sub-assemblies
Fig. 35



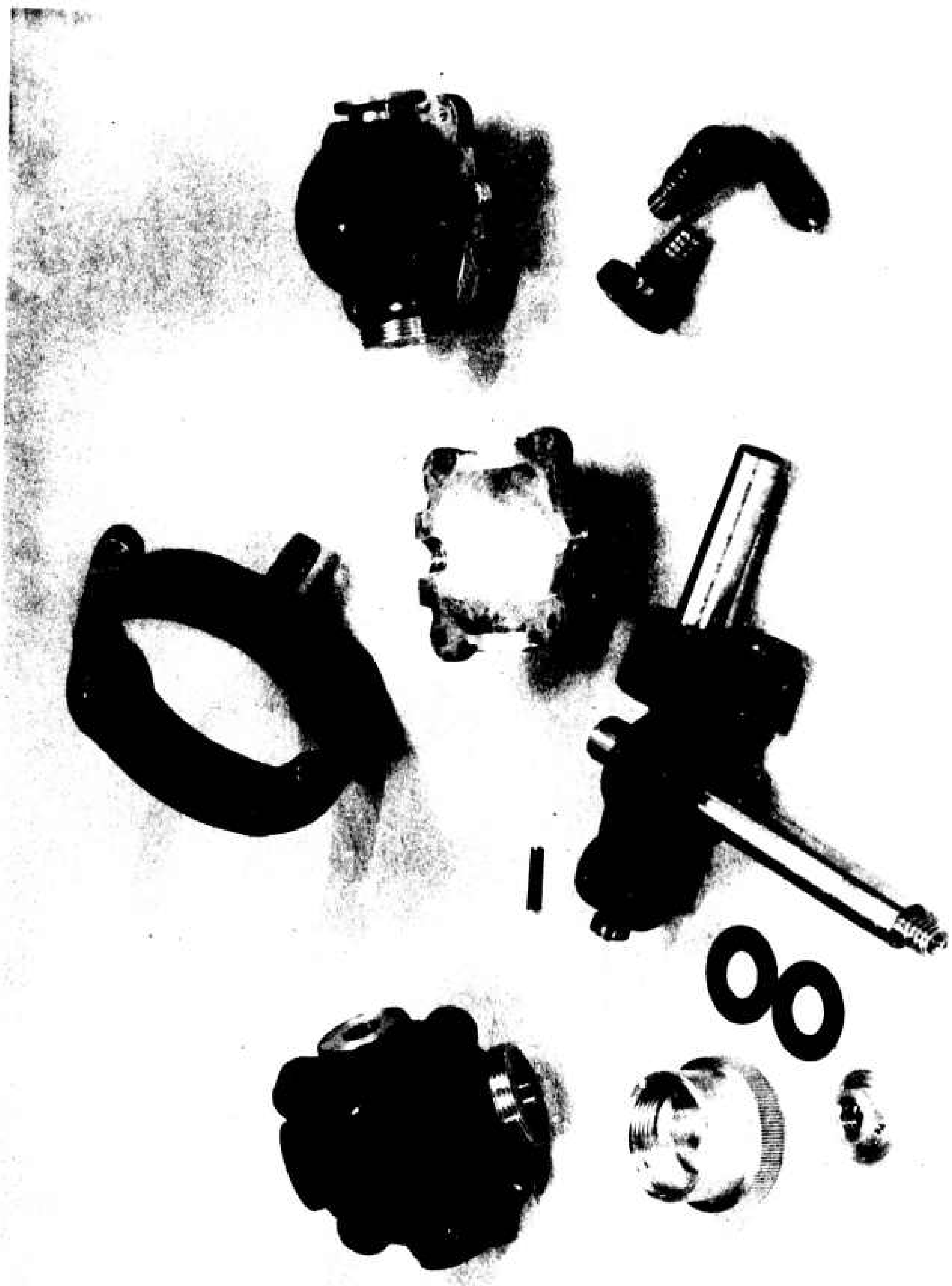
Aircraft Model - Sub-assemblies
Fig. 36



Aircraft Model - Sub-assemblies
Fig. 37

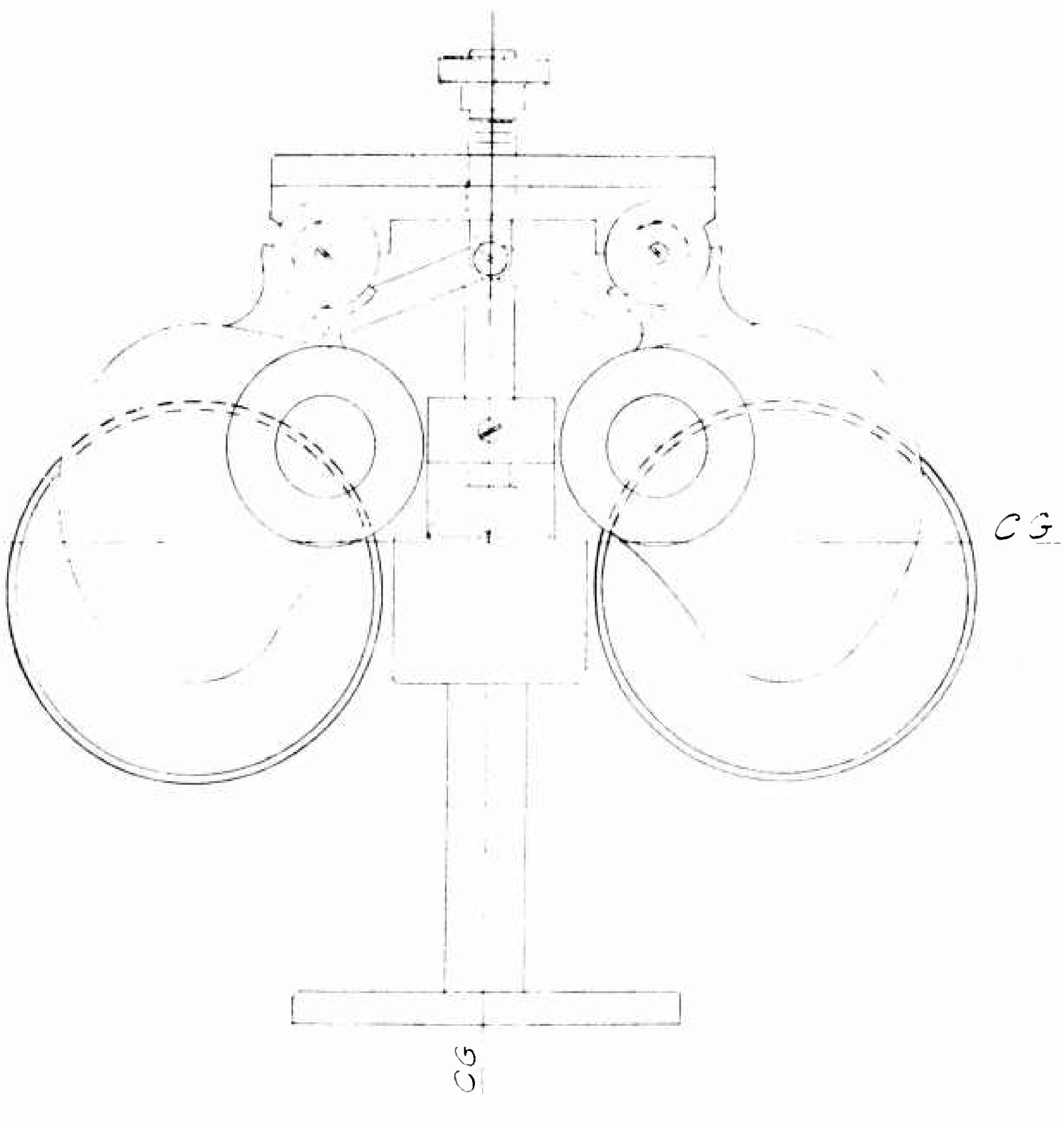
Aircraft Model - Sub-assemblies
Fig. 38

Aircraft Model - Sub-assemblies
Fig. 39

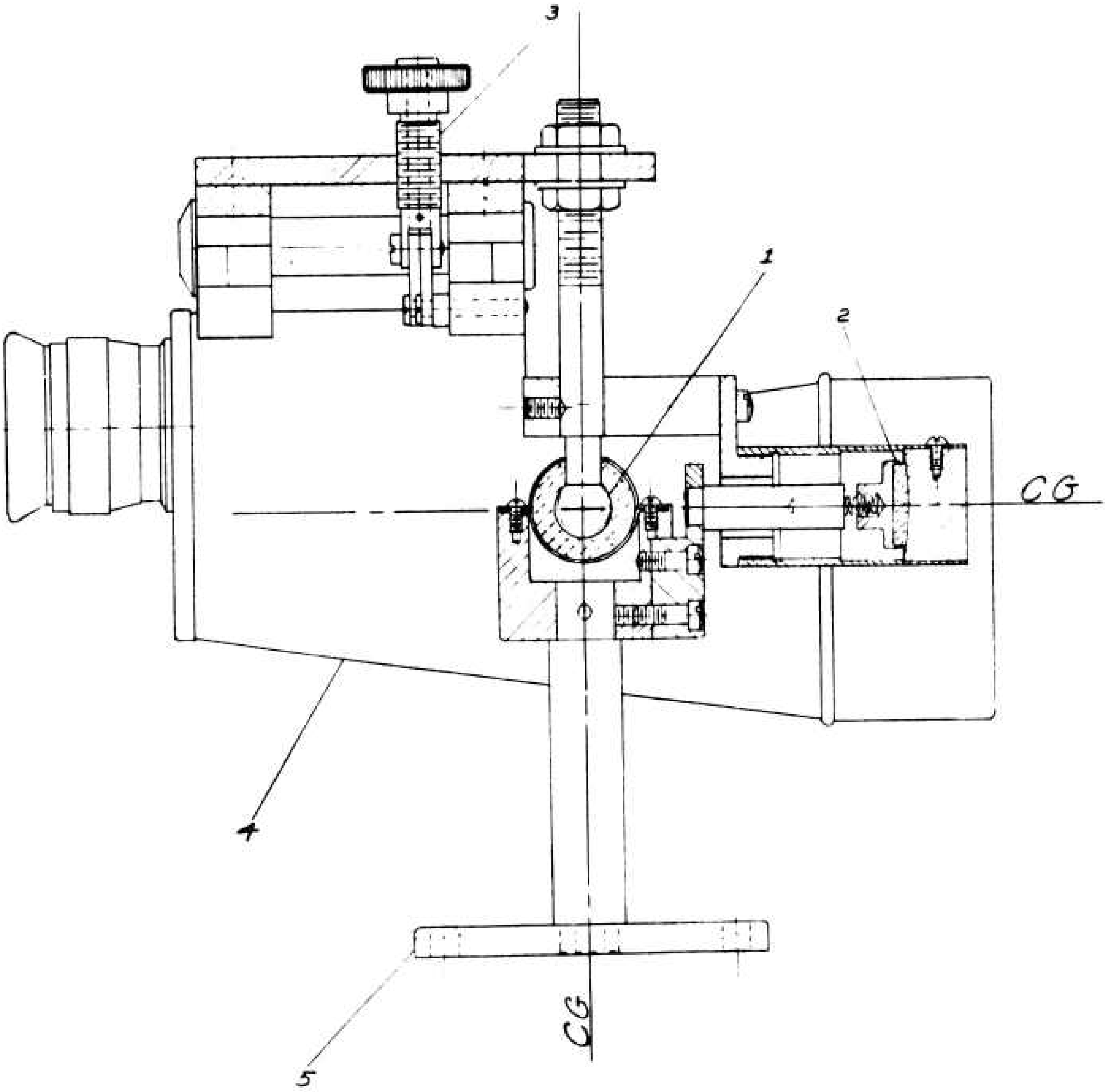


Aircraft Model - Disassembled Pan and Tilt Head
Fig. 40

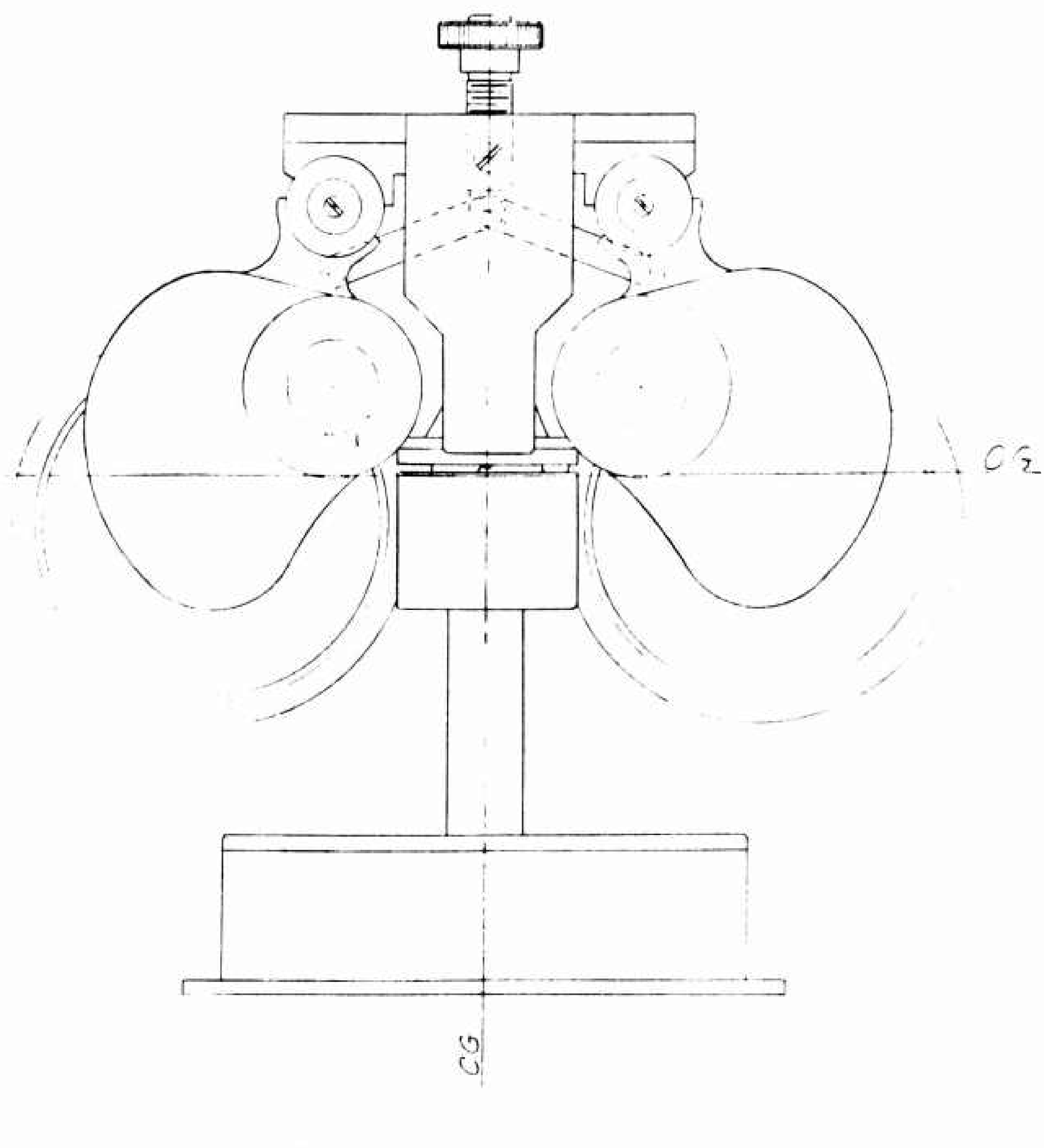
Aircraft Model - Disassembled Head Rest
Fig. 41



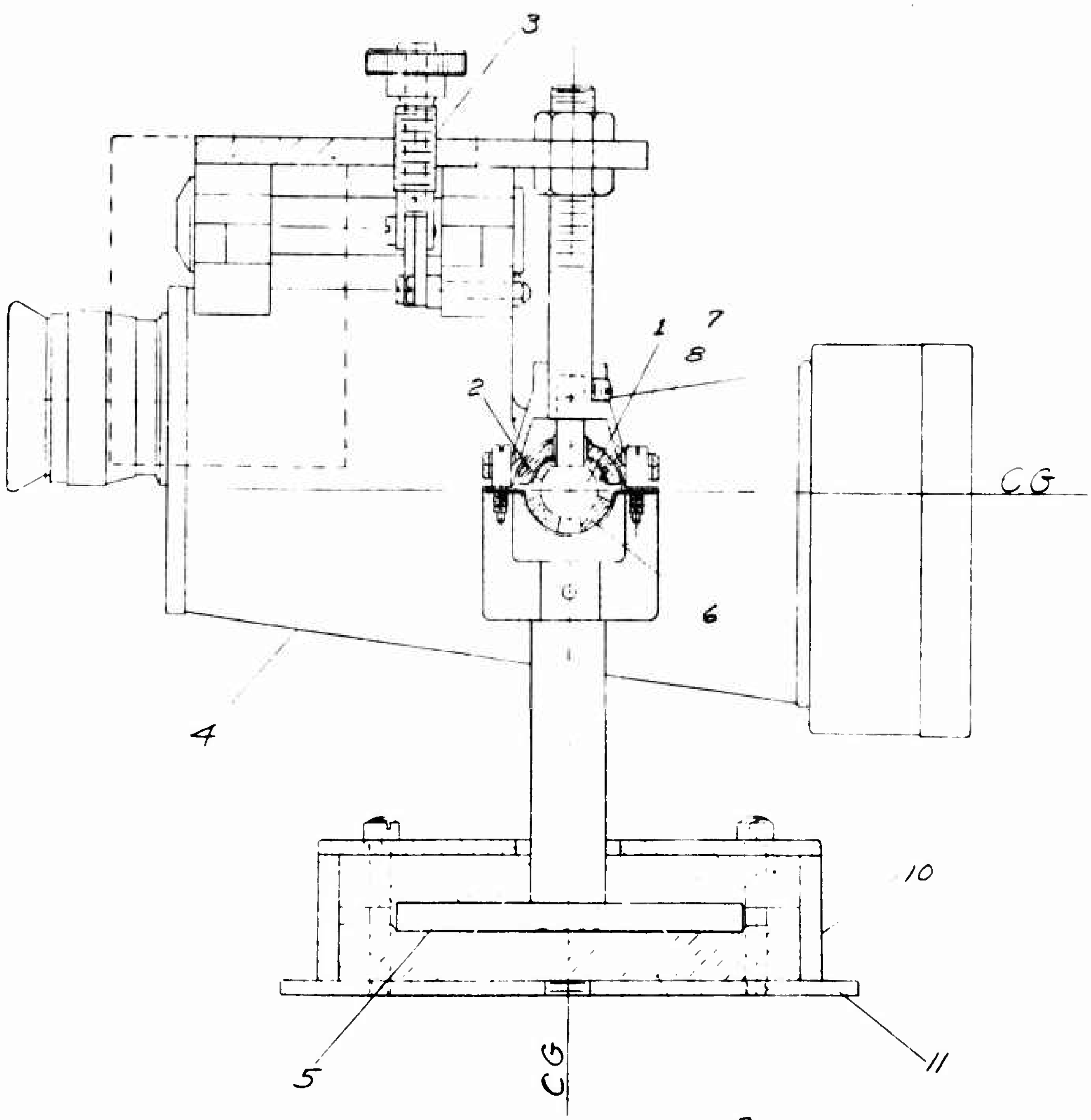
Anti-Oscillation Mount
Dwg. No. 71-A4



Anti-Oscillation Mount
Dwg. No. 71-A4



Anti-Oscillation Mount with Shock Absorbing Base
Dwg. No. 71-A5



Anti-Oscillation Mount with Shock Absorbing Base
Dwg. No. 71-A5

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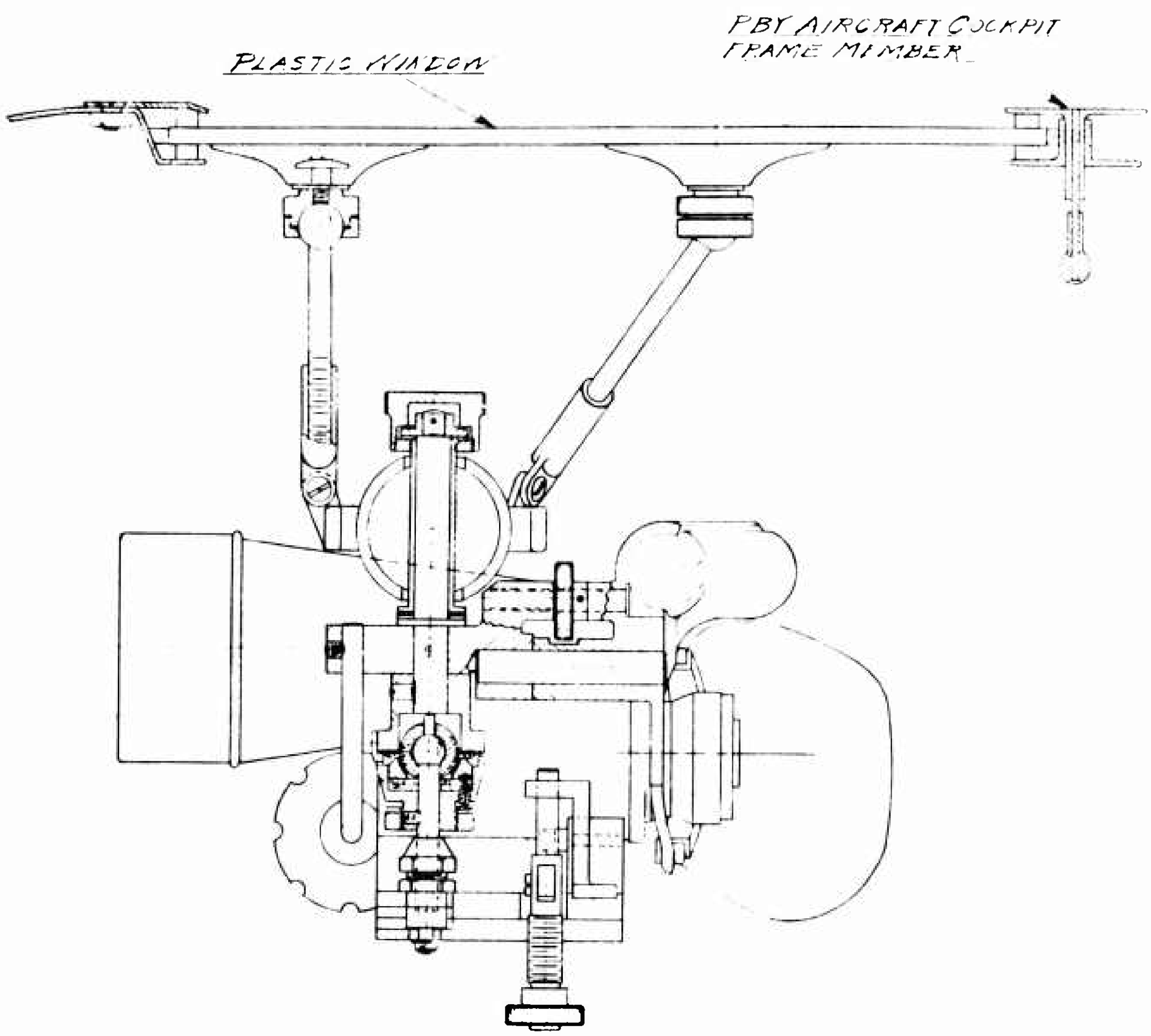

Aircraft Inverted Model - Vacuum Cup Mount
Dwg. No. 71-A8

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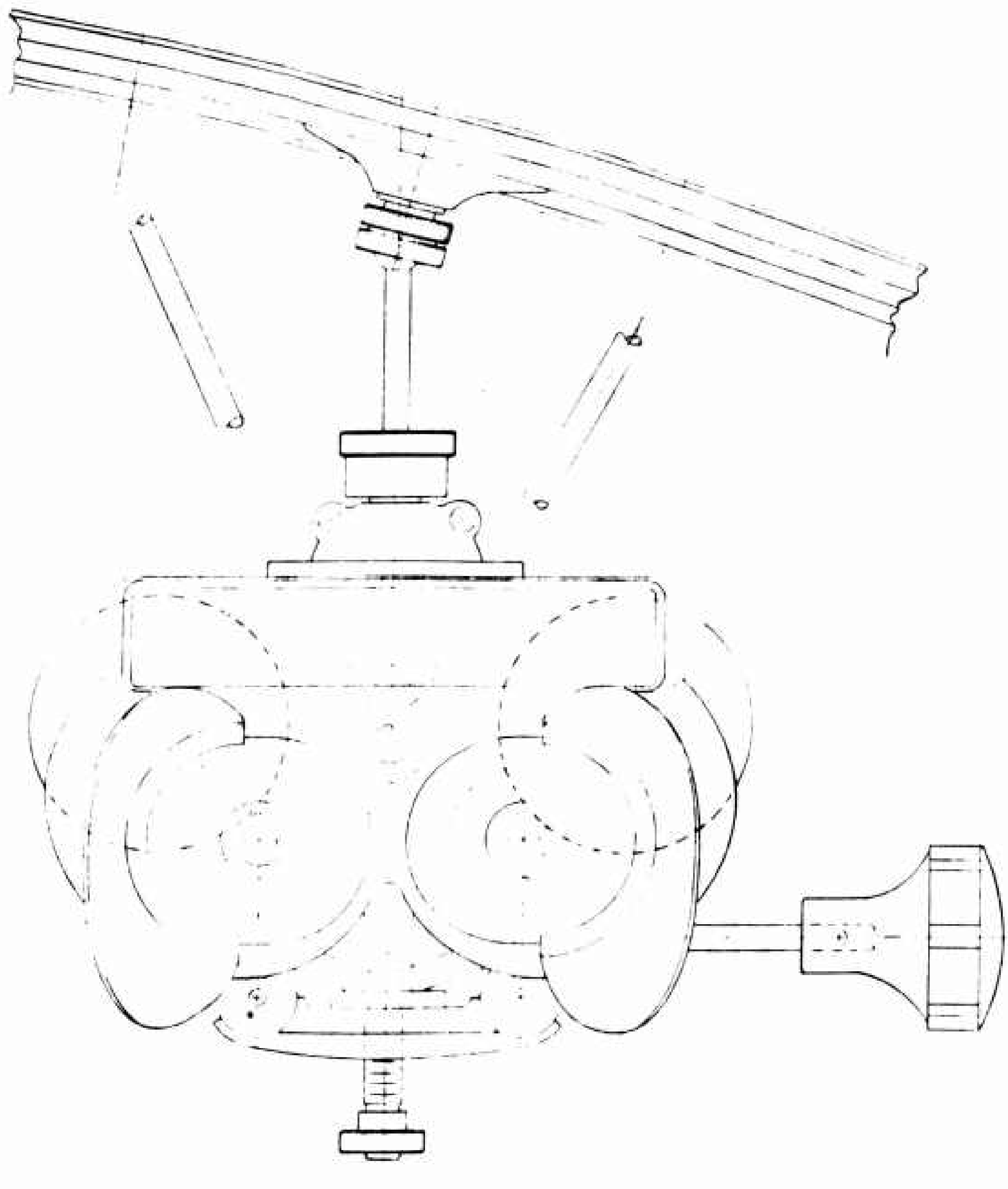
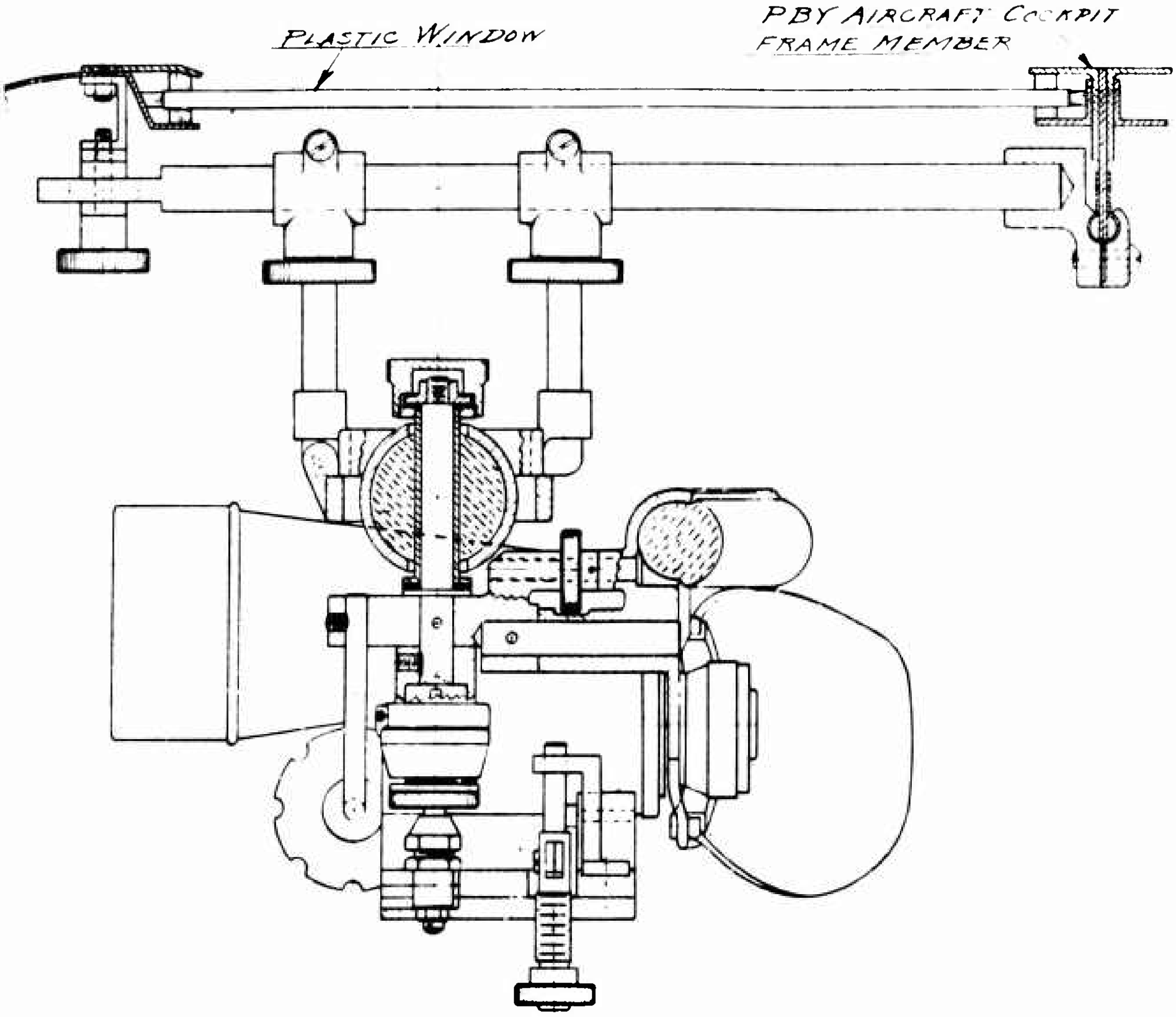


Aircraft Inverted Model - Vacuum Cup Mount
Dwg. No. 71-A8

CONFIDENTIAL



Aircraft Inverted Model - Rigid Bar Mount
Dwg. No. 71-A9

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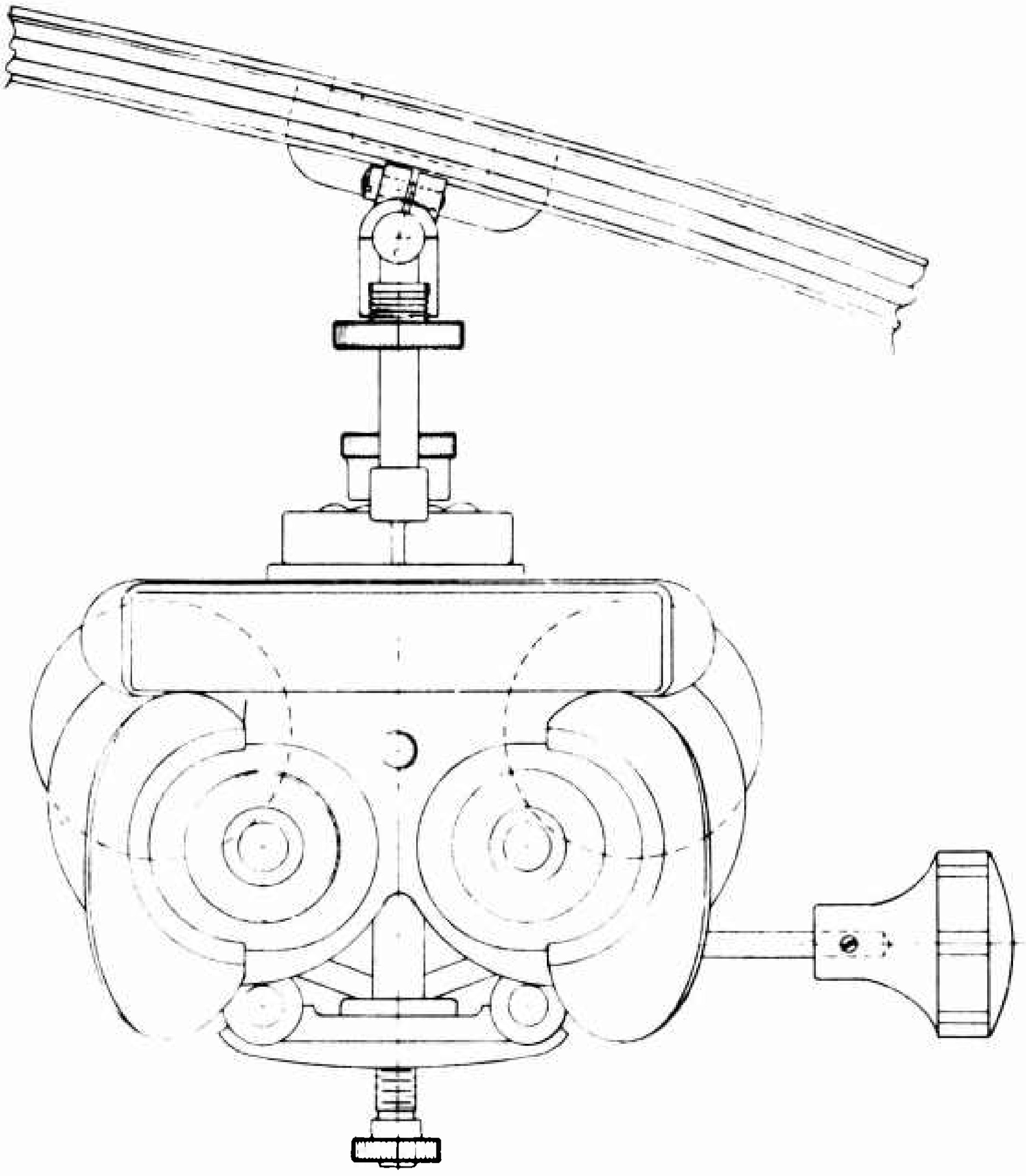
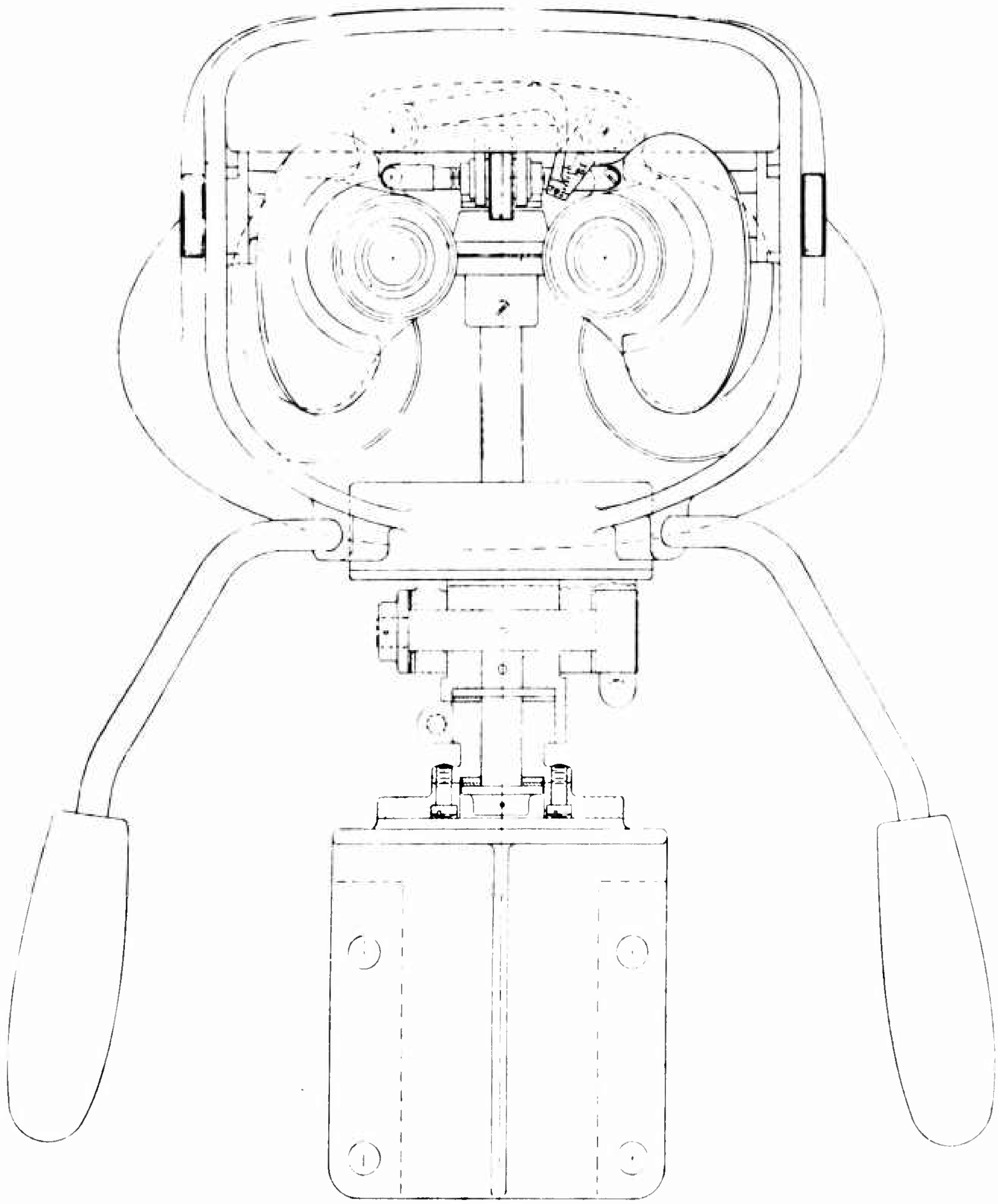


Aircraft Inverted Model - Rigid Bar Mount
Dwg. No. 71-A9

CONFIDENTIAL



Shipboard Model
Dwg. No. 71-A11

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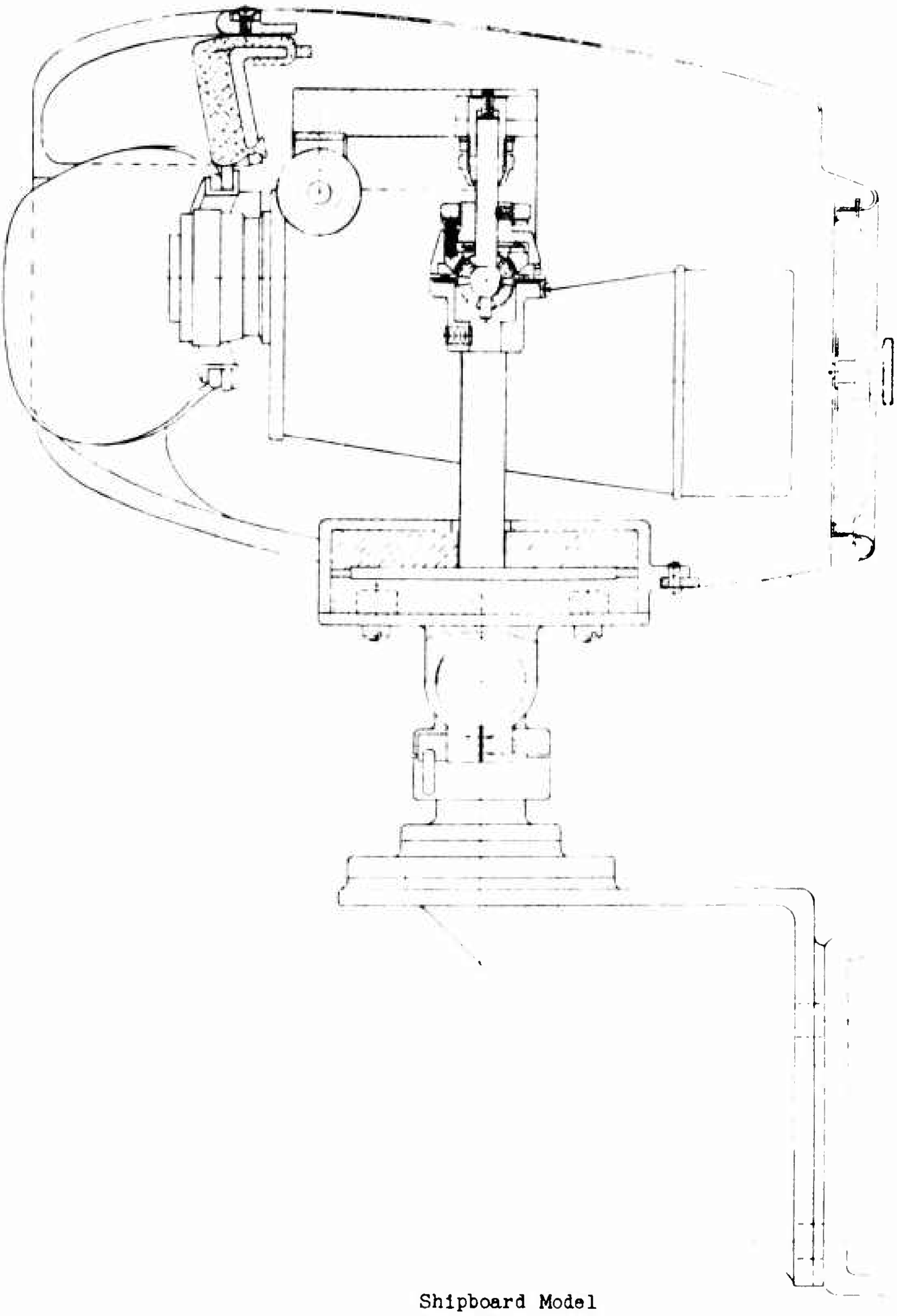
[redacted]



Shipboard Model
Dwg. No. 71-A11

[redacted]

TSDIO FORM OD 0 (80 FC2 47)

Technicolor Motion Picture Corp.

AUTHOR(S)

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DIVISION: Ordnance and Armament (22)
SECTION: Fire Control (4)
CROSS REFERENCES: Mounts, Telescope (65243)

C-22-4-12

ATI- 18080

ORIG. AGENCY NUMBER

O.S.R.D.- 4185

REVISION

AMER. TITLE: Anti-oscillation mount for binoculars

FORG'N. TITLE:

ORIGINATING AGENCY: O.S.R.D., N.D.R.C., Sec. 16.1, Washington, D. C.

TRANSLATION:

COUNTRY	LANGUAGE	FORG'N.CLASS	U. S.CLASS.	DATE	PAGES	ILLUS.	FEATURES
U.S.	Eng.		Confd'l	Feb'45	88	63	photos,tables,graphs,drwgs

ABSTRACT

Description is given of development of antioscillation mounts for standard binoculars intended for use by observers in aircraft and lookouts on ships. Laboratory tests indicate that mounts eliminate approximately 95 percent of the impressed vibration. Preliminary field tests showed that approximately 90 percent of vibration was eliminated.

265650

T-2, HQ., AIR MATERIEL COMMAND — AIR TECHNICAL INDEX — WRIGHT FIELD, OHIO, USAAF

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UNCLASSIFIED per Authority of OSRD List #26, Dated 17-21 June 1946

~~AD-B808 573~~

(2) P 13/5

(23) *Mounts Binoculars

(23) Antioscillation