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CANOPY BREAKER EXTENSION

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DATE	PAGES AFFECTED

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TEST OF EJECTION SEAT CANOPY BREAKER EXTENSION

1.0 PURPOSE

These tests were conducted to determine that the extension of the Canopy Breaker (RQ266) by 3.0 inches would not impair the ability of the Ejection System to catapult the pilot and seat through the canopy and provide zero speed-zero altitude escape.

2.0 EXTENT OF TEST

2.1 Previous tests have been conducted to qualify the Ejection System to zero-zero capability. (See SP-1496 and related movie, No. 336.) However, it is necessary to provide a three inch higher canopy breaker position to accommodate a tall pilot and an increased seat cushion thickness. The most difficult seat position for canopy breakage is as close to the canopy as possible. The seat travel is limited by a limit switch to 1/4 inch clearance between the rubber pad on the ram and the canopy glass. Thus the momentum of the seat is at its lowest when it contacts the glass.

2.2 Two tests were run. One test with the glass at ambient temperature (approximately 75°F) and one test with the glass chilled by dry ice to the lowest temperature obtainable.

2.3 A full pressure suit was put on the dummy for the first test to check the effect of the pressurized suit on the ejection and to check the possibility of suit damage.

3.0 TEST EQUIPMENT

3.1 Test Sled

This is a portion of cockpit mounted on a steel framework which has those parts of the fuselage, canopy, and seat pertinent to the test.

3.2 Seat

This seat is the same one used in a number of previous tests. It was repaired and modified to the new canopy breaker configuration. It is equipped with a recovery parachute in an effort to save the seat from damage. These tests emphasized this seat's affinity for asphalt. The result was an abnormal amount of repair necessary following the first test and retirement from active testing is indicated after the last test.

3.3 PYROTECHNICS

The pyrotechnic devices used were furnished from the customers stock. The ship portion of the Pyrotechnic System was not used. This included the Canopy Thrusters, the Internal Canopy Jettison, the External Canopy Jettison, and the Stick Stowage Systems.

The Seat System was activated by a pin fired initiator mounted on the steel frame of the sled and tripped by a long steel cable. This initiator fired through the seat disconnect into the seat portion of the Pyrotechnic System.

The Seat System was standard except for the omission of the "D" Ring, the shoulder reels were back and locked, inoperative lower line cutters on the drogue chute, and the "D" Ring cutter line was diverted to fire the added seat recovery chute gun.

3.4 Canopy

Two canopies were obtained and installed in the frames. One canopy had been rejected because of scratches suffered in polishing. There was no deterioration of strength.

3.5 Cameras

A total of thirteen cameras, eight fixed and five hand held, were used to record the tests. The pertinent still pictures are included herewith. The film from the various movie cameras has been edited into "Test of Extended Canopy Breaker on U-2R Escape System", film number 356, and is to be considered part of this report.

3.6 Cold Saddle & Dry Ice Box

This is a plywood box built to fit intimately over the canopy and hold the dry ice in such a position as to chill the canopy glass. The insulated ice box was used to transport the dry ice to the test site.

3.7 Instrumentation

Based on a review of report SP-1496, "Qualification Test of U-2R Escape System", dated 17 July 1969, there was no need to extensively instrument the current tests. This is substantiated by a study of the Strength-Temperature curve of the canopy material. This curve indicates that little strength is gained by decreasing the temperature below -20°F. For example, the ultimate tensile strength is 15,300

3.7 Instrumentation Cont'd

psi at -20°F and 16,200 psi at -60°F. This represents an increase of only 16.2/15.3 = 1.06 (6%). In loading the dry ice into the cold saddle, the same procedure was followed as in SP-1496, which gave three readings of -51°F, -61°F, and -68°F (average = 60°F) at time of removal of cold saddle. The elapsed time between removal and test was 1 minute and 15 seconds. The estimated surface temperature was -38°F and the internal temperature would be approximately -55°F.

In the current test the internal glass temperature is estimated to have been -50°F due to heat pickup being higher because the additional insulation wrapped around the canopy did not completely offset the 30 knot wind. This sets the glass strenth at 16,000 psi instead of 16,200 for a $\frac{16.0}{16.2} \cdot 100 = 99\%$ strength level.

3.8 Special

For the first test the dummy was dressed in a full pressure suit, S1010 PPA, and inflated to approximately 1 psig.

4.0 CONDUCT OF TEST

General: The following outline of the conduct of the test applies to both the ambient and the cold test. Exceptions are noted.

4.1 The seat was plumbed and the pyrotechnics added. The recovery chute was packed in the box below the seat with its gun packed. The dummy was strapped in. Photo No. 1.

4.2 The seat was loaded into the sled after the installation of the catapult. Photo No. 2.

4.3 The test sled was located on the test site so that the predicted seat impact point would be on sand to reduce damage to the seat. Photo No. 3.

4.4 The canopy was installed and locked down. Photo No. 3.

4.5 The cameras were located, power to run them provided, and loaded with film. Photo No. 4.

4.6 The pressure suit was inflated to approximately 1 psig.

4.7 The dummy initiator was replaced with a loaded one and the safety pin pulled to arm the initiator. Photo No. 5.

4.8 All personnel were cleared from the area and the count down started. The cameras began to run on the count of 2 and the initiator was fired on 0.

4.9 The cold test deviated from the above only in the loading of the dry ice into the cold saddle about 3 hours prior to the firing and five minutes prior to the firing time the insulation (tarps) were removed from the sled and the cold saddle removed from the canopy. Approximately one minute after the saddle removal the test was fired.

5.0 DISCUSSION

5.1 Ambient Temperature Test

This test, conducted 23 April 1970, successfully catapulted the seat through the canopy. See the series of photos taken at 20 frames per second on Page 7. Following is a discussion of pertinent photos.

5.1.1 Photo No. 3 illustrates the proximity of the canopy breaker and the dummy's helmet to the canopy. This is the uppermost position permitted by the limit switch in the seat raising circuit. The small ball tipped rod on the breaker is the feeler that opens the limit switch when the rubber pad is one quarter inch from the glass.

5.1.2 Photo No. 6 shows start of ejection. Note the compression of the rubber pad and the small ball snapping off the limit switch rod. The canopy frame has deflected off the cockpit pressure bulkhead by approximately an inch and a cloud of black smoke is coming up from the catapult initiator line where the male and female disconnect fittings have become unmated after 1 inch of travel.

5.1.3 Photo No. 7 (one twentieth of a second later) shows the initial fractures. Note how far the dummy's helmet is below the canopy breaker (compare to Photo No. 6). The seat is accelerating rapidly but the dummy is now being forced down into the cushion. Note that the visor on the helmet is very close to the edge of the glass. See the movies for more detailed information.

5.1.4 Photo No. 8 shows the dummy position one twentieth of a second later. Note his position relative to the canopy breaker is still the same as in Photo No. 7. Note the large piece of glass contacting the left knee.

5.1.5 Photo No. 9 shows the test to be a success. The seat has cleared the ship through the canopy, which was the purpose of the test. A subsequent malfunction of a portion of the ejection sequence detracted greatly from the glory of the test's success. This malfunction proved to be a well disguised blessing in that it happened in this test instead of in a more serious situation. (Personal chute deployment gun failed to fire.)

5.1.6 Photo Nos. 10 and 11 are left and right side views showing the total area cleared.

5.2 COLD CANOPY TEST

This test, conducted 6 May 1970, successfully catapulted the seat through the chilled canopy. Unfortunately, the Hulcher camera malfunctioned and photographs similar to Photos 6 through 9 are not available. However, the motion pictures are quite detailed. The results of the test are shown in Photo Nos. 12, 13, 14 and 15 which warrant the following discussion.

5.2.1 Photo No. 12 shows the left side of the canopy. The knee area is well cleared out but note the sharp point just forward of the seat tracks. Note melted frost.

5.2.2 Photos No. 13 and 14 again show good knee clearance and good glass clearing on the right side of the cockpit. Again you see the sharp point just forward of the tracks on the left side.

5.2.3 Photo No. 15 is a close up of the above mentioned point. A closer inspection of Photos 12, 13 and 14 shows a crack at the forward end of this large piece of glass. This allowed it to hinge outward and thus the sharp point did no serious damage to the dummy. However, there was a scuff mark on the left shoulder of the suit where the point contacted but did not tear the cloth.

6.0 CONCLUSIONS

The modified canopy breaker with the 3.0 inch vertical extension did not impair the ability of the catapult to force the pilot and seat through the canopy. The ambient temperature test was at 75°F approximately or an ultimate glass strength of 11,000 psi. The chilled canopy was estimated to be at -50°F or an ultimate strength of 16,000 psi.

There was no indication of stalling on the part of the catapult and the altitude of both tests were better than average height.

6.0 CONCLUSIONS Cont'd

The smaller contact surface of the modified canopy breaker cleared away less area and left more to be taken out by the seat and dummy than was true of the wider breaker of the tests of SP-1496. Admittedly, ejection through the canopy is a third stage emergency, but serious consideration must be given to the increased clearance obtained with a wider breaker.

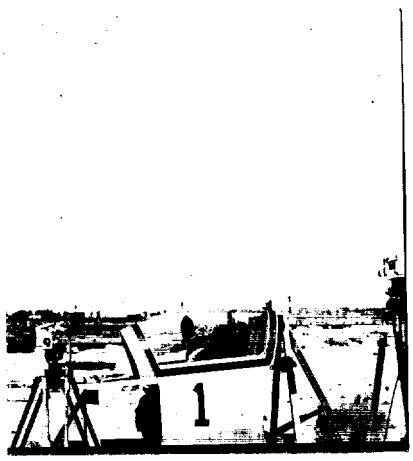
The added test of the inflated suit is considered successful in that two observers testified that the air was heard to escape from the suit after the unfortunate ground contact. It was "fortunate" that two cameramen were within a few feet of the dummy when he landed. There was a tear in the suit which is believed to have been caused by the broken leg received at the violent contact with the ground.

The added test of the thicker cushion was discussed above. The conclusion concerning this cushion is that it forces the pilot to sit higher and thus requires the higher canopy breaker. Study of the dummy's excursion during ejection indicates that as the seat accelerated the cushion allowed the pilot to remain relatively motionless until the seat had compressed the cushion. By this time, the seat has accelerated and catches the pilot with a high differential speed. It is questionable that there is an advantage to a soft cushion.

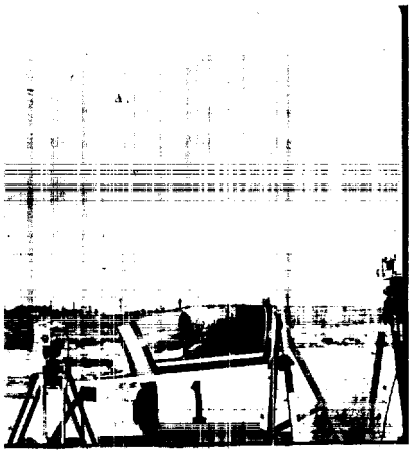
The cushion tested was 2 5/8 inches thicker than a standard cushion and 1 inch thicker than the one on which the design of the extended breaker was based. This means the pilot for which the breaker was intended will be 1 inch higher than the original proposed height.

The thicker cushion raises the pilot to the point where the shoulder straps of the parachute will bear on his shoulders. (See Photo No. 2.) The dummy had to be pushed down into the cushion to allow the chute to slip into its allotted space. Thus the dummy was carrying the weight of the chute on his shoulders.

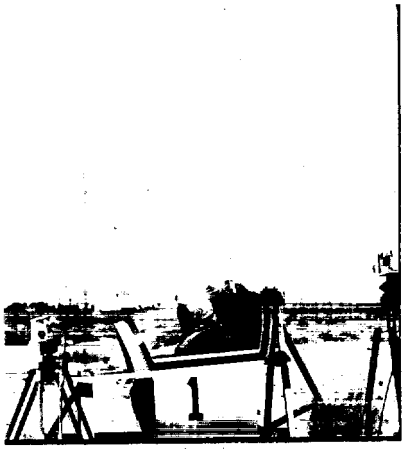
The thicker cushion must be carefully analyzed with reference to the short armed pilot being able to reach the "D" Ring when his suit is inflated. The same study must be made concerning the controls during suit inflation.



A

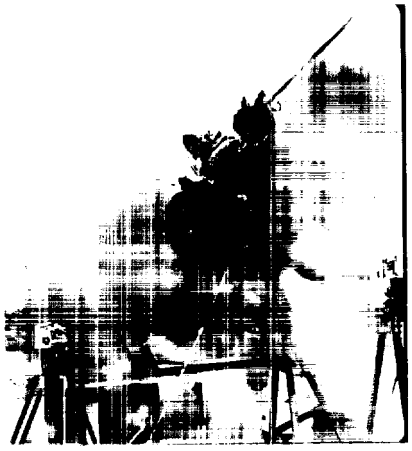


B



C

D



E

F

1. Prior to firing.
2. The initiator has fired the catapult and the seat has moved up to contact the glass. Note the black smoke from the initiator coming up the aft bulkhead. This occurs after the catapult moves the rocket up far enough to separate the mated connections of the initiator line.
3. The catapult has forced the Canopy Breaker through the canopy.
4. The pilot and seat are emerging through the canopy and the rocket has ignited.
5. The seat has cleared the tracks and the Seat Drogue Chute Gun has fired to deploy the stabilizing chute.
6. The test is successful.

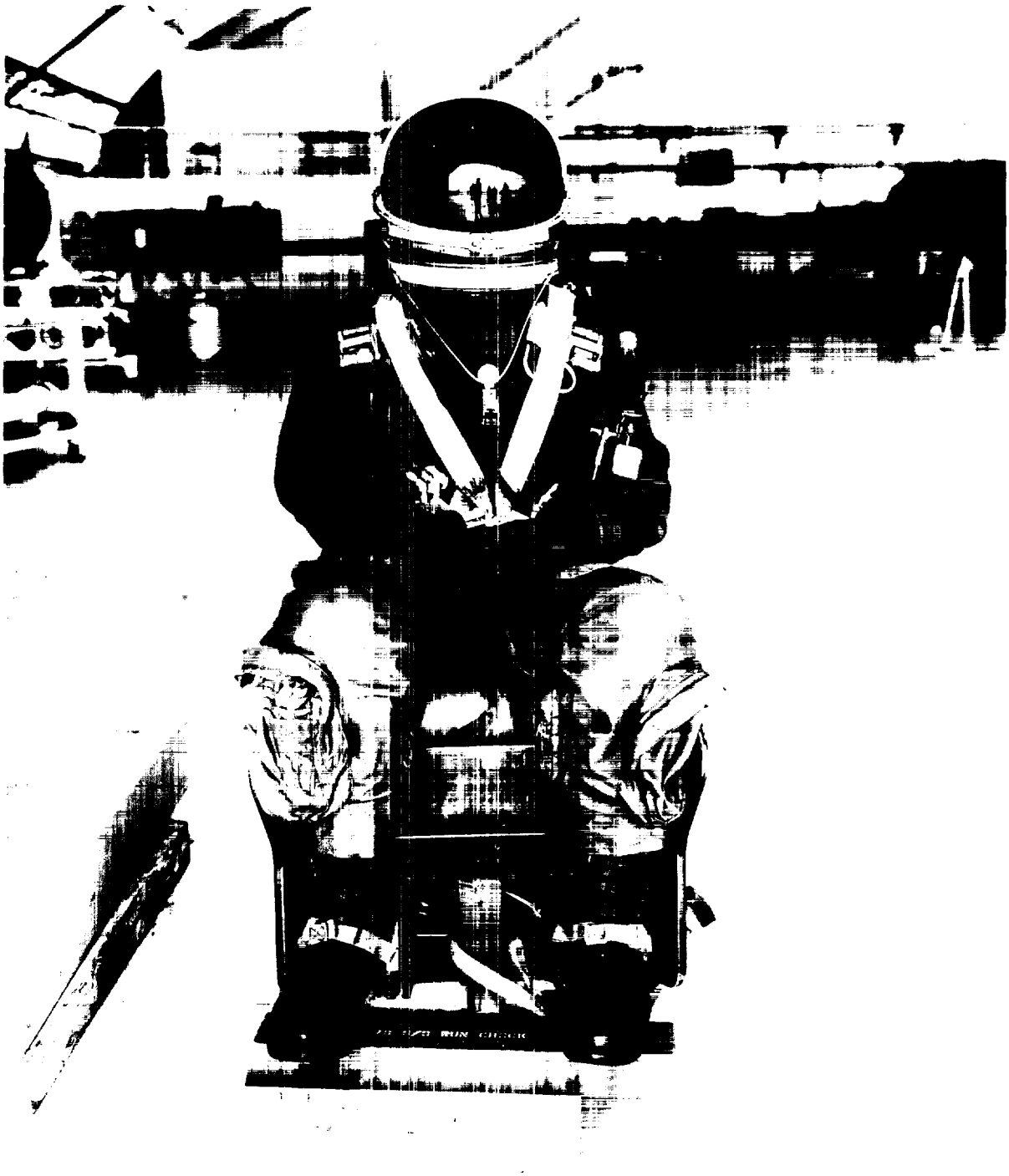


PHOTO NO. 1

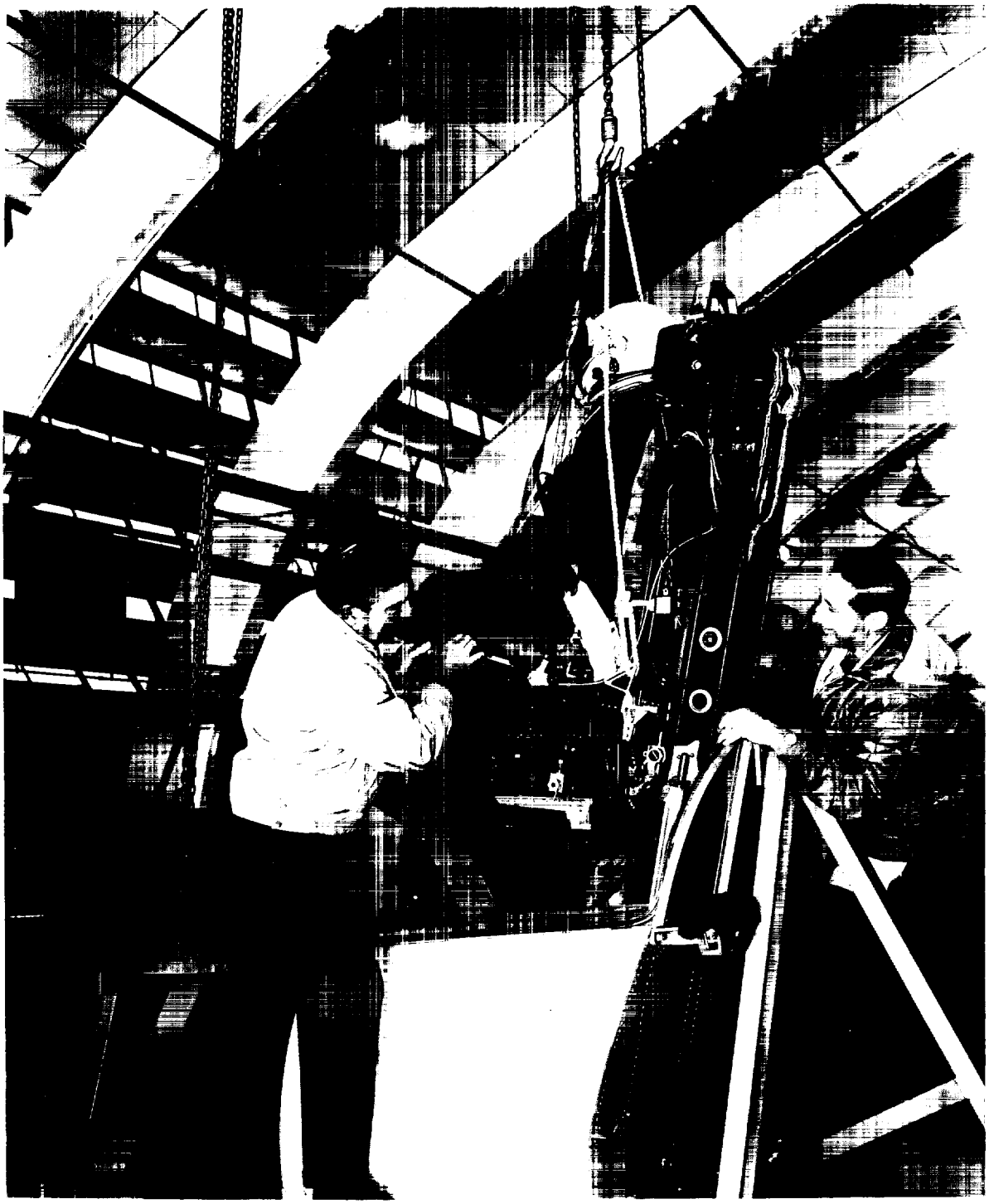


PHOTO NO. 2

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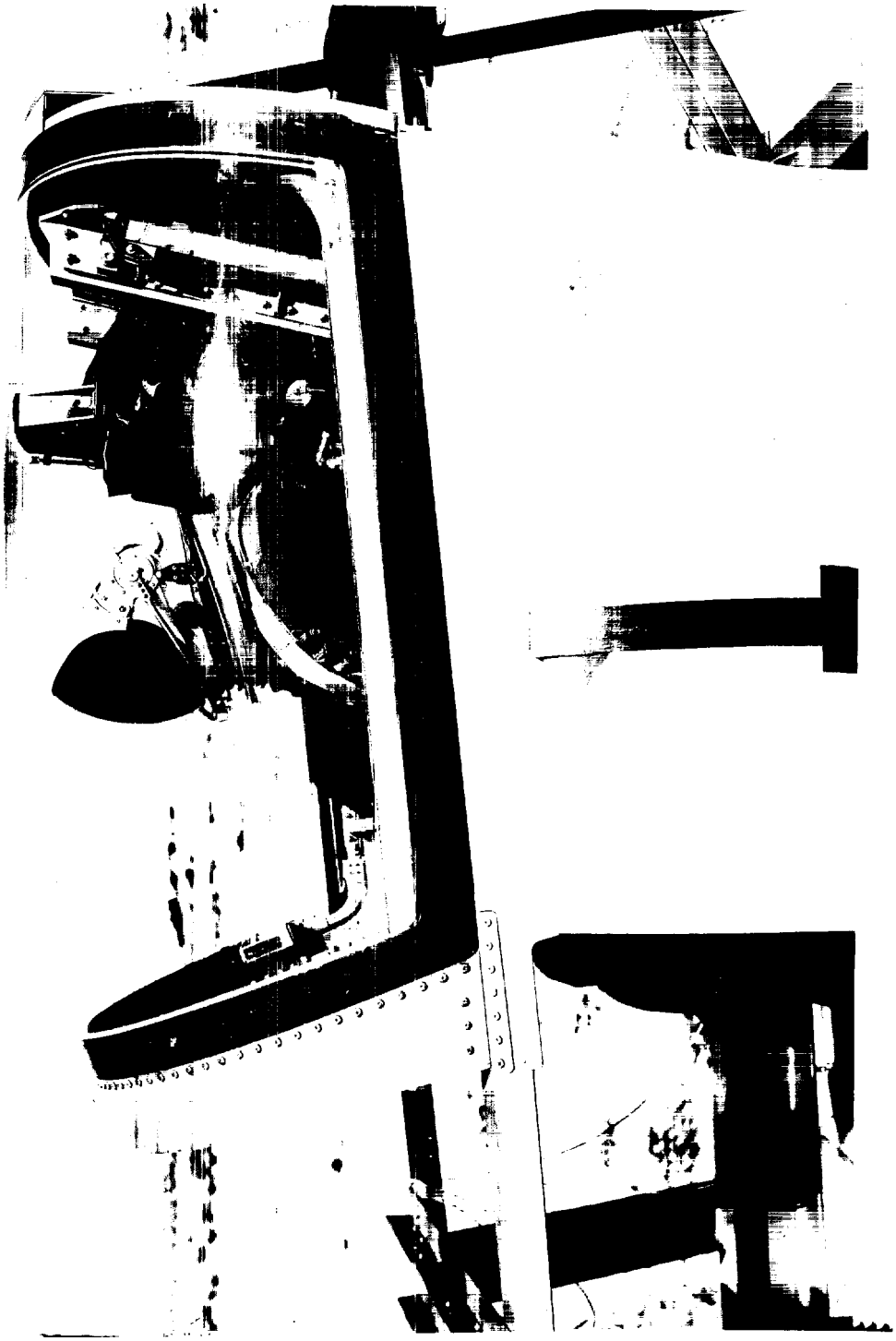
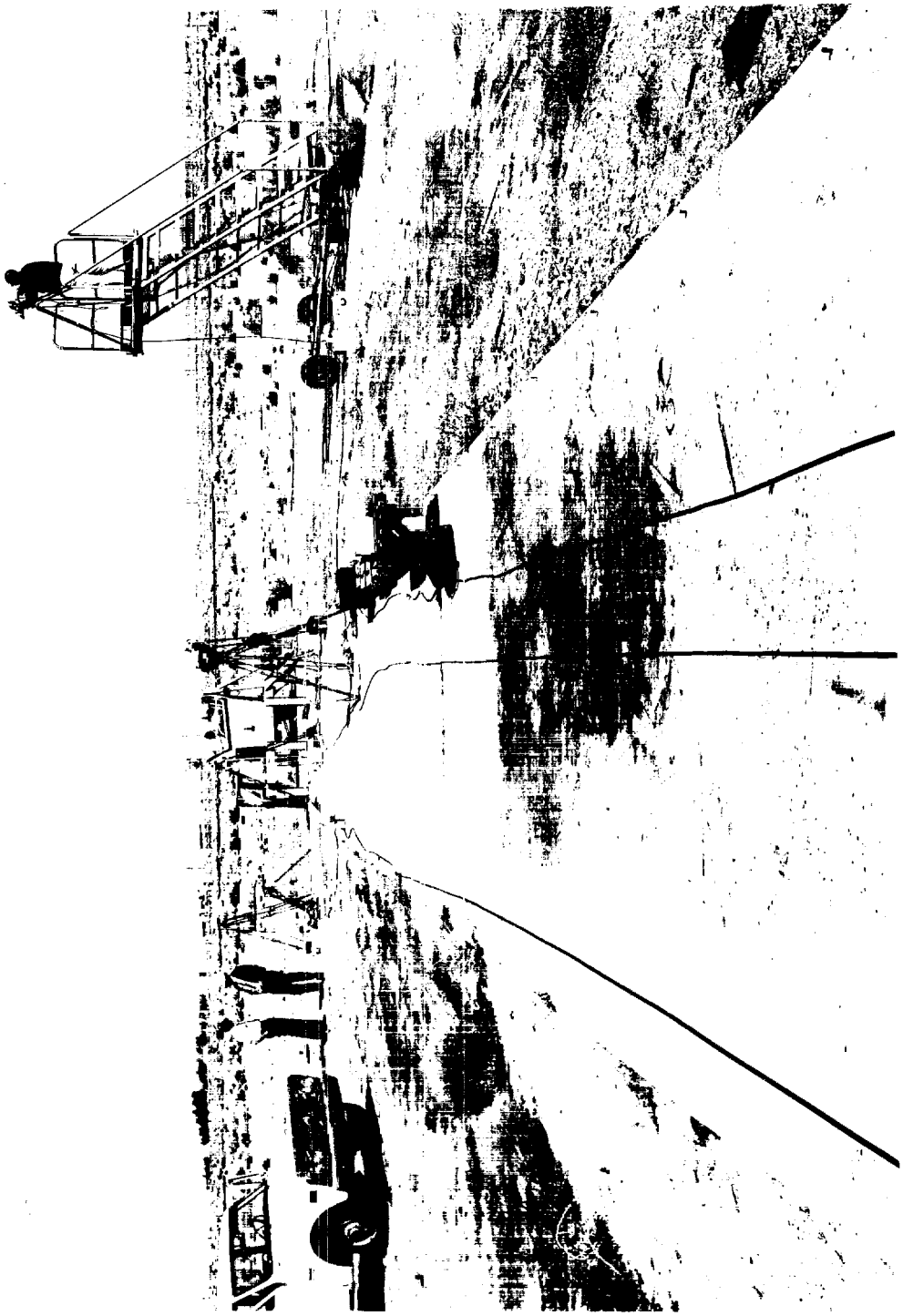


PHOTO NO. 3



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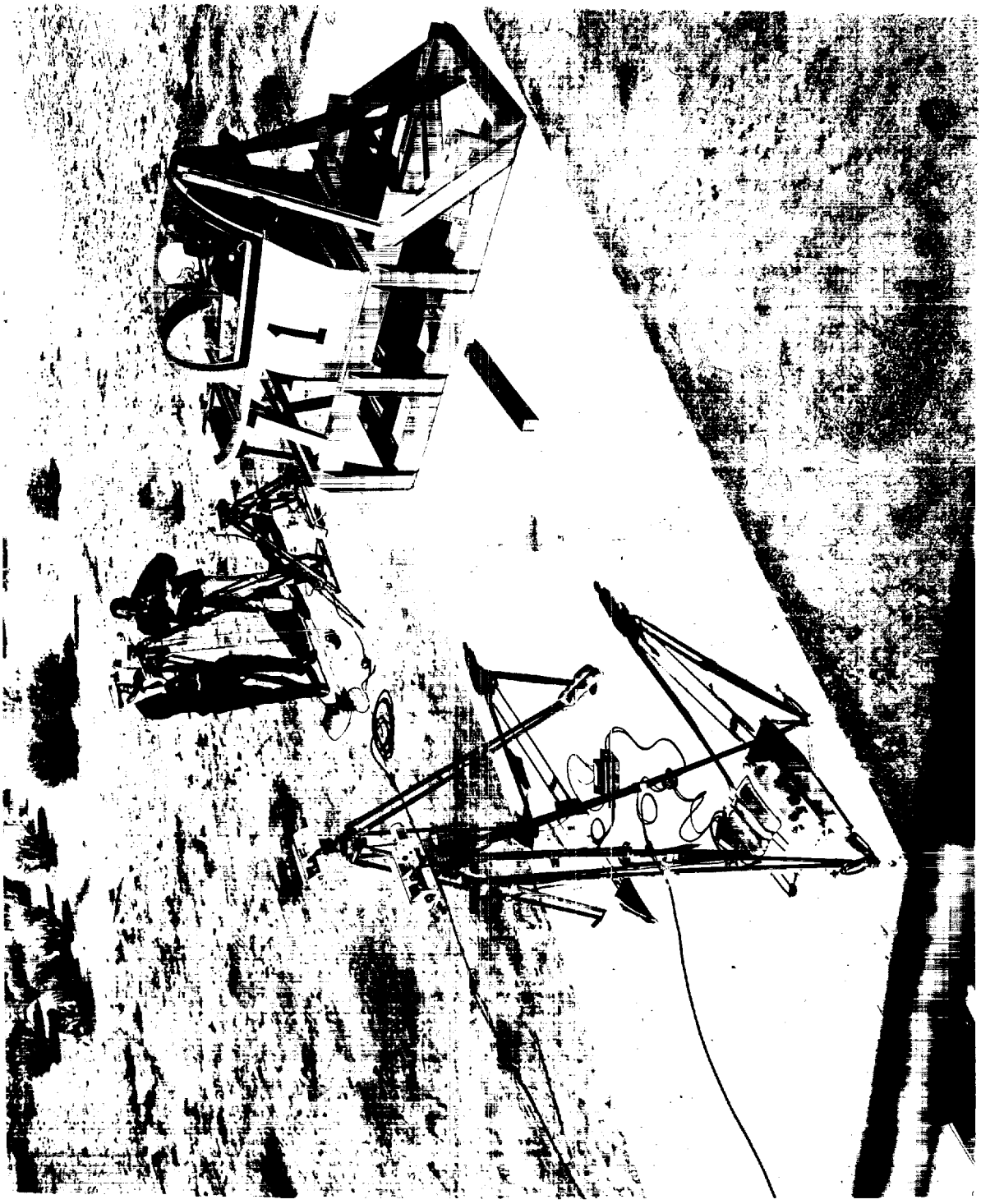

PHOTO NO. 5

6

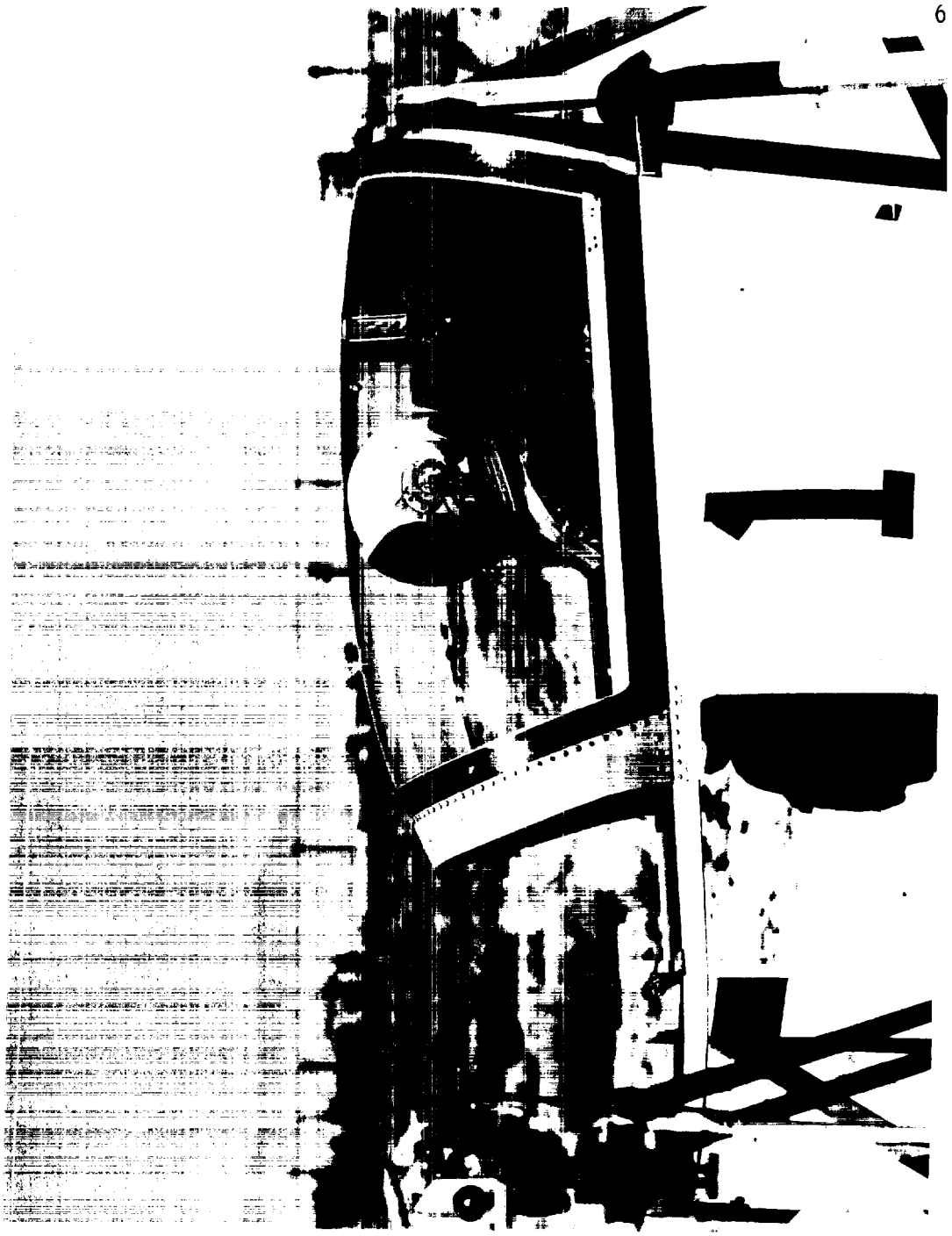

PHOTO NO. 6

PHOTO NO. 7

8

PHOTO NO. 8

PHOTO NO. 9

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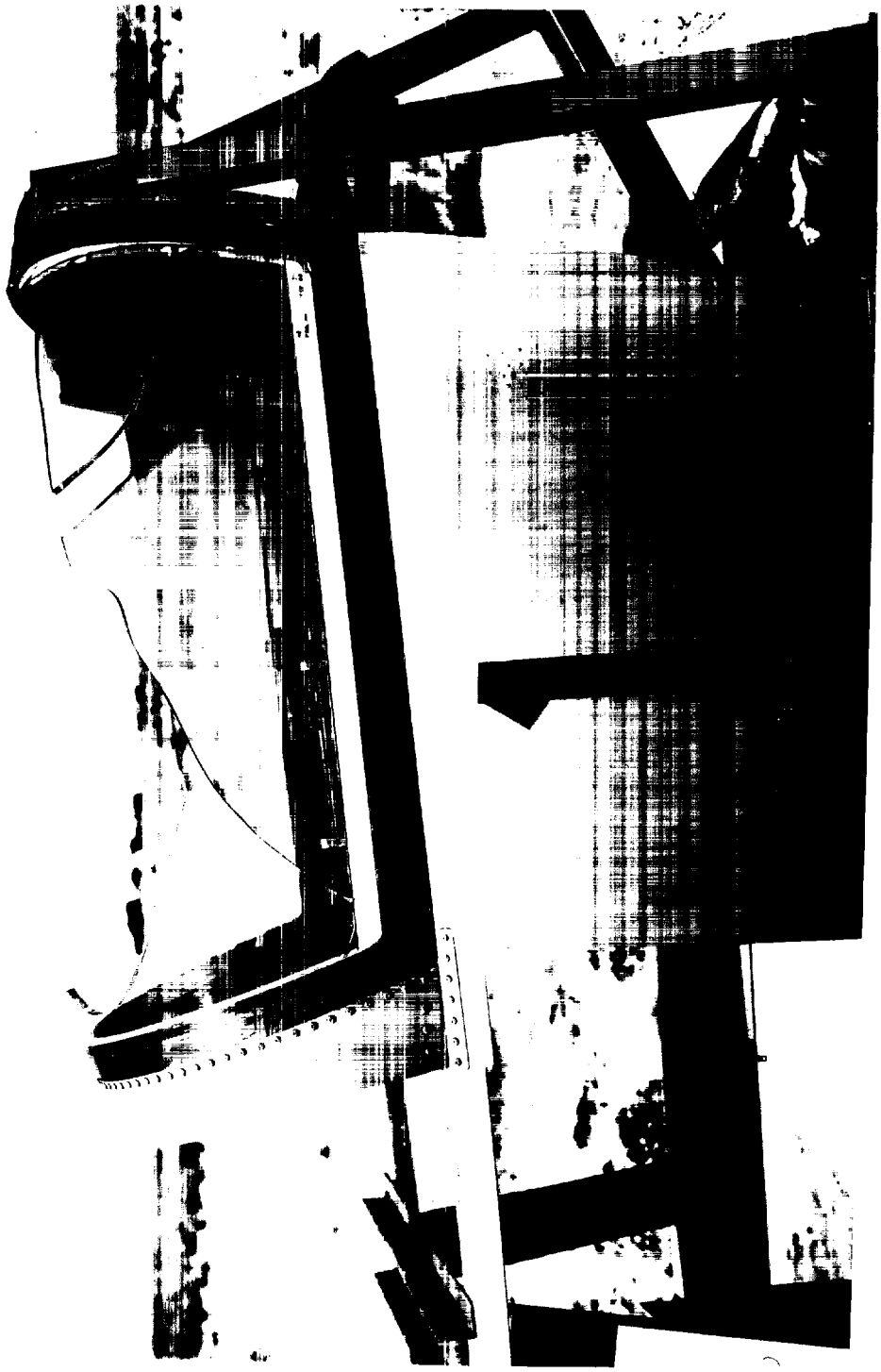

PHOTO NO. 10

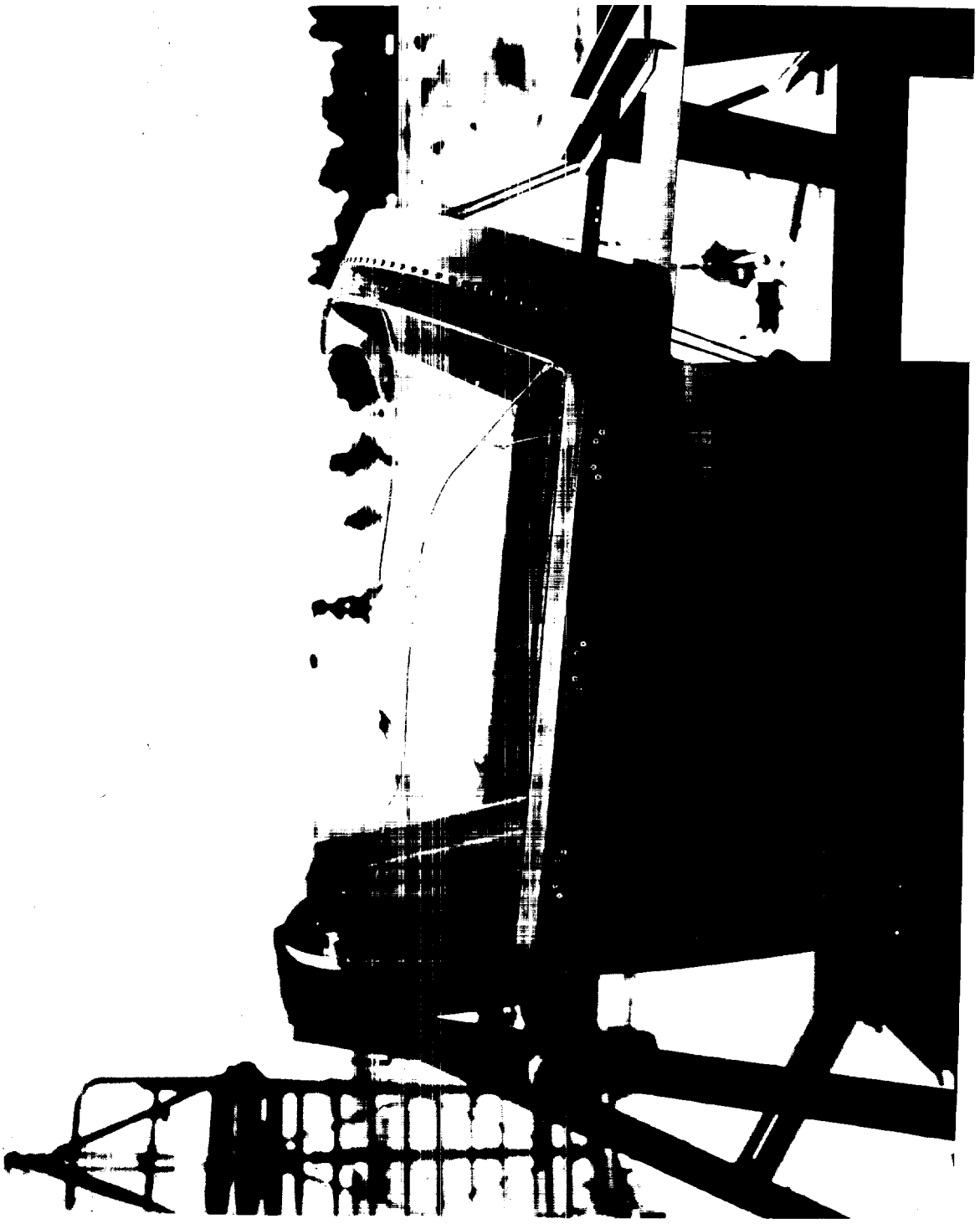

PHOTO NO. 11

PHOTO NO. 12

PHOTO NO. 13

PHOTO NO. 14

PHOTO NO. 15