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U.S. COAST GUARD
TESTING *and* DEVELOPMENT DIVISION

OFFICE OF ENGINEERING WASHINGTON, D.C.

REPORT

PROJECT REPORT

PROJECT 3941/02/01

CORROSION PROTECTION OF UNDERWATER BODY OF WAGB's

19 AUG 1965

UNITED STATES COAST GUARD

TESTING AND DEVELOPMENT DIVISION

PROJECT REPORT

Corrosion Protection of Underwater Body of WAGB's

by

LCDR E. L. PARKER, USCG

Date: SEP 14 1965

Approved: ______________________

C. E. McAULIFFE, CAPT, USCG
Chief, Testing and Development Division
U. S. Coast Guard Headquarters
Washington, D. C. 20226

ABSTRACT

This report summarizes the results of various test programs of corrosion protection used on the icebreaker hulls (WAGB). It discusses the present corrosion rates encountered with no corrosion protection and presents possible approaches to corrosion protection of the class ship.

1. BACKGROUND:

ETD Project J20/2-2 "Corrosion Test Underwater Body Steel Ship" was established in 1952 to determine whether the application of bottom paint to wind class icebreakers was economically justified. The project was based upon the fact that at that time the cost of bottom painting on icebreakers was running approximately 1½ times the cost of bottom painting on other vessels due to the removal of large amounts of paint incident to icebreaking and the practice of repainting after each ice season. From the standpoint of hull corrosion, basic corrosion theory showed the corrosion rate to be .005 inch per year and would incur no significant loss of hull strenght or integrity over the life of the hull. Pitting was of more direct concern than overall corrosion and theory indicated that on steel with mill scale thoroughly removed the ratio of depth of pits to overall corrosion tended to decrease with time so that the maximum rate of pitting would be on the order of .015 inches per year over a ten year period. Although painting tended to decrease the overall corrosion rate, the imperfections of any paint film tended to accelerate the rate of pitting by limiting the area and thus increasing the intensity of the corrosion process. It was further assumed that the need for antifouling paint was negated by the abravise action of the ice removing the fouling and the low rate and short season of fouling growth in the areas of operation and homeports of the icebreakers.

2. PROJECT GUIDELINES:

With the foregoing considerations as background, the project consisted of a thorough underwater body inspection of the three wind class icebreakers and the subsequent omission of bottom paint on the EASTWIND and WESTWIND. The NORTHWIND was to be the control ship and bottom painting was continued on her.

3. INITIAL INSPECTION:

a. WESTWIND. Inspection of WESTWIND during September, October 1952, at the Key Highway Yard, Bethlehem Shipbuilding Company, Baltimore, Maryland disclosed the following:

(1) General description. Hull was heavily fouled with marine growth. Approximately 50% of the underwater body below the 20 foot waterline covered with barnacles and grass. Much of the remaining area was lightly fouled or showed signs of barnacles having been recently rubbed off. Between the 20 and 25 foot waterline the hull was covered with a thick red rust. There was an antifouling paint of some type remaining on some of the bottom; however adhesion was poor and there was a loose scale under most of it.

(2) Description of the test areas.

a. Location, Frame 27, Stb'd, 2'6" above flat keel was covered with medium sized pits (average depth .035, width .06 to .15"). There were very deep pits along welds where hull plates were welded with butt seams or where clips had at one time been welded to the plates. (Photo #1)

b. Location, Frame 110½ Port, 10 feet out from center line. The area contained numerous large pits of fairly uniform size. (Average .25" diameter by .06" deep). (Photo #2)

c. Location, Frame 168 Port, 8 feet above flat keel. The area was very heavily pitted and appeared to be caused by cavitation. The area was rough and had many shallow pits or indentations 1/2" wide by 3/4" long. It also contained many tiny "pinhole" pits. (Photo #3)

d. Location, Frame 77 Stb'd, 16 foot waterline. The surface of the area was very rough and gave the appearance of having been heavily sandblasted. There were no smooth spots in the area. (Photo #4)

(3) Treatment. Underwater body scraped to remove fouling. Area in way of boottopping was sandblasted and given regular paint treatment.

b. EASTWIND. Inspection of EASTWIND during October 1952 at the South Boston Annex, Boston Naval Shipyard disclosed the following:

(1) General description. Approximately 3-5% of the old paint was still firmly adhering to the hull. It was located in the vicinity of the keel within 6 to 8 feet on either side. There was red rust between the 25 and 28 foot waterlines. In general below the 25 foot waterline the hull gave the appearance of having been recently sandblasted except for the location mentioned above. There was no fouling of any kind on the hull. Nineteen months previously the hull had been given a complete bottom paint job and when the hull was inspected 7 months later (12 previous to the above inspection) only 10 per cent of the bottom paint remained. At that time only the boottop area was painted.

(2) Description of the Test Area.

a. Location, Frame 28½ Stb'd, 2'6" above flat keel. Plating in general was smooth. There was light pitting throughout the area. (.060" diameter by .030" depth) (Photo #5)

b. Location, Frame 104 Port, 10' from center line of keel. Pitting consisted of a few wide flat pits. Large deep pits were found along butt welds similar to those found on WESTWIND. (.200" diameter by .040" depth) (Photo #6)

c. Location, Frame 169 Port, 9' above flat keel. There was paint adhering in this area. Pits appeared to be caused by cavitation. ($1\frac{1}{2}$ x 1" x .040" deep) (Photo #7)

d. Location, Frame 82 Stb'd, 22 foot waterline. Plating contained a few scattered pinhole pits. (.05" diameter x .020" depth) (Photo #8)

(3) Treatment. Underwater body scraped to remove fouling. Area in way of boottop sandblasted and painted.

c. NORTHWIND. Inspection of NORTHWIND during May 1953 at Todd's Shipyard, Seattle, Washington disclosed the following:

(1) General description. Plating was in good condition. No fouling was noted. About 10% of the bottom paint from the docking 5 months earlier was adhering. The paint adhering to the hull was in general located aft and below the stern tubes and in the vicinity of the bow tubes. Most of the hull was covered with a spongy red rust. There were no badly pitted areas observed. The welds did not show the heavy pitting seen on the other two ships.

(2) Description of Test Areas.

a. Location, Frame 24 Stb'd, 3 feet above keel. The plating fairly smooth. Only pitting a line of pits .030" to .080" wide, .010" to .012" deep about 4" long. (Photo #9)

b. Location, Frame 92 Port, 18 feet out from centerline. Pitting in the area was general with medium size shallow pits .010" to .025" diameter, .018 to .025" deep. (Photo #10)

c. Location, Frame 171 Port, 10 foot waterline. No pitting or other corrosion in evidence in the area. This was unusual since the other two ships were heavily corroded in this area. (Photo #11)

d. Location, Frame 88 Stb'd, 18 foot waterline. No pitting in this area. Surface of the plating was very rough. (Photo #12)

(3) Treatment. Sandblast and complete bottom job.

4. TWELVE MONTH INSPECTION:

Approximately one year after the initial inspection all three hulls were inspected. In general, the inspection disclosed no apparent change in the appearance of the hulls. In the case of the EASTWIND, approximately the same amount of old paint was still adhering. On NORTHWIND only 5% of the bottom paint was adhering from the May 1953 docking. Photos 13 through 17 show the areas on EASTWIND after one year without painting. Photos 18 through 21 show areas 1, 2 and 4 on NORTHWIND after one year. The paint in area 3 was still intact and was not removed for inspection. There were several areas of very thick rust bloom such as shown in Photo 19. At the time of the inspection, it was decided that these areas were not due to a specialized corrosion problem, but simply places that remained wet allowing a heavy bloom of rust to develop. When the bloom was wiped off there was no excessive or unusual pitting in the area. The NORTHWIND was given a complete bottom paint job in May 1954; EASTWIND and WESTWIND were left unpainted.

5. NAVY ICEBREAKERS:

Prior to the time of the second inspection on EASTWIND, the Navy had become interested in the condition of the welds on icebreakers since ATKA (AGB-1) was experiencing serious undercutting along the butt welds due to corrosion. It was theorized that the cause was due to the mill scale not being removed from the hull plating used in the construction of the ship. Tests had been conducted with samples of weld metal fastened to steel plates with and without mill scale. Under test conditions, with the sample fastened to clean steel the sample experienced a .80% weight loss; fastened to steel with mill scale, a 1.92% weight loss was experienced. The difference in potential measured between weld metal and base metal and between weld metal and mill scale was 80 mv. and 300 mv. respectively.

Enclosure 1 is a copy of the report of inspection by the Materials Laboratory, Boston Naval Shipyard. There was no noticeable undercutting of the welds on EASTWIND, nor on EDISTO (AGB-2) when inspected in October 1953.

6. PROJECT REVIEW:

In December 1955 the project was reviewed and the results of not painting were summarized by the following excerpt from the report of examination of the underwater body of EASTWIND during the October 1955 drydocking. The last bottom paint had been applied to EASTWIND in February 1951.

"The hull had the usual clean appearance. There was no fouling and practically no old paint adhering to the hull. There was a light layer of red rust caused by atmospheric corrosion since docking. Most of the hull appeared to be covered with a layer of hard scale about .010" thick. The pitting appeared to be the same as shown in the photographs taken during the 1953 docking. There were no extensively pitted areas, nor did the pitting in the welds appear to have increased since 1952 and 1953. The weld pitting is not nearly as deep as that first noticed on the WESTWIND in 1952".

At that time, it was decided to continue the procedure of not painting the underwater bodies of WAGB's as a permanent practice including the NORTHWIND. It is to be noted that reference is made to deep pitting of the welds on WESTWIND being observed as early as 1952.

7. CHRONOLOGICAL SUMMARY OF HULL CONDITIONS:

The following is a chronological summary of the condition and treatment of the underwater hulls of the WAGB's subsequent to 1955.

a. WESTWIND.

January 1955, Docking Report, "The reinforcing seam of the underwater plating completely erroded with pit holes extending approximately 1/8" into welded seams. Visual examination revealed no abnormal condition. Corrosion found consisted of scattered areas covering approximately 1/3 of the underwater plating particularly aft of frame 150. No painting since 1952".

April 1956, Docking Report indicated no change in condition of the hull. Hull not painted.

February 1957, Docking Report, "Extensive deep selective corrosion at plating welds noted. Depths up to 3/8" noted".

February 1957, Endorsement to Docking Report, "Hull plating appears to be satisfactory with no apparent corrosion due to unpainted condition. The shell butts and seams between the load waterline and bilge keel for the 3/5 length amidships shows extensive pitting and wasting away of the welds immediately adjacent to shell plates, leaving a slight ridge of weld material in the middle. Cause of the corrosion is not known but appears to result of dissimilarity between shell plating and weld material. A metallurgical study of this condition is warranted to develop proper welded techniques for this type hull. Welds in this area can now be considered 80% efficient".

November 1957, Enclosure 2 is a copy of a trip report regarding inspection of WESTWIND underwater body.

June 1958, Docking Report, "General corrosion of underwater body is extensive. Hull welds have been severely attacked but were built up with a 3/16" crown using 8016 electrodes after chipping down to sound metal. All welds below 28' waterline were chipped out to sound metal and rewelded."

April 1959, Docking Report, "Hull welds between keel plate and A strake both side deteriorated throughout length. Keel plate butt welds deteriorated. Weld around sea chests deteriorated. Pitting is noted over entire hull but particularly forward of frame 40 to a maximum depth of 1/4" and averaging 1/8" forward of frame 40. Pitting is noted in way of all old construction and staging brackets, to a depth of about 1/4". Chipped out to good metal and rewelded about 700 feet of welds as follows: Entire keel plate seam (port and starboard), all keel plate butts, boundary of B-1 and B-3 sea chests, and stem plate seams. Height of crown of weld metal 3/16" above base metal".

May 1959, District Endorsement to April docking report, "Plating shows pitting to be progressing at an accelerated rate while rewelded seams show no corrosion except on vertical seams (butts near stem). This is probably the result of some porosity in these overhead welds."

June 1960, Docking Report, "General condition of the underwater hull shows a large amount of corrosion and deterioration of the parent metal next to the welds. The entire underwater body is covered with a heavy spongy red oxide coating. Under this top layer is a grey oxide coating that appears to be heavier in the after body regions. Micrometer readings taken on sections of hull plate removed gives the average thickness of the oxide coating as .023" Maximum deterioration of the hull plating measured was in the region next to a weld, which was 1/4". Micrometer readings taken on the port side frames 29-39 between the 15-25 waterlines resulted in average plate thickness of 1.457". Audio readings were also taken at various locations over the hull; however readings were somewhat erratic. Maximum plate deterioration was .178" and minimum .10"."

March 1963, Docking Report, "The entire underwater hull is covered with a thick coating of corrosion. The corrosion appears to consist of three layers. The surface layer is grey, brittle and relatively hard Beneath the grey layer is a heavy, spongy, red coating. Under the spongy material the hull is covered with a thin black coating. In general the grey surface layer is intact only on the after 1/3 of the hull. The rest of the hull is covered with the red spongy material. Pitting was noted over the entire hull. Heaviest concentrations of pitting were noted forward of Frame 20 P. & S. between the keel and the 14' W.L. All pits are 1/4" to 3/8" in depth. Wasting to a depth of 1/4" to 3/8" in way of old construction and staging brackets in general throughout the underwater hull. Wasted patches approximately 1/4" deep were noted in several locations, particularly on the forward part of the hull. Hull welds show some deterioration throughout. Welds in way of old bilge block positions were wasted to depths of 3/8" to 1/2". Gouged out to solid metal and rewelded approximately 225 lineal feet of excessively deteriorated butt and seam welds. All new weld given 3/16" crown."

April 1965, Docking Report, "Entire bottom is covered with a layer of surface rust. In some areas, particularly around the stern counter, there was a spongy layer of iron oxide about 1/8" thick. Under the surface rust and spongy substance there was a thin layer of hard black coating. There was some pitting forward of frame 20 but no serious deterioration."

May 1965, District Endorsement to April's Docking Report, "The underwater body is pitted considerably and appears to be progressively worse than previous drydocking. The welds are now nobler than the hull plating and deterioration is occuring alongside the welds."

b. EASTWIND.

March 1956, Docking Report, "No bottom paint has been applied since February 1951. Hull plating corroded over 95% of area with pits as deep as 3/16" especially in weld and where temporary wedging brackets have been tacked on for plate assembly. No noticeable increase in corrosion since last drydocking."

August 1956, Docking Report, reports same conditions.

April 1957, Docking Report, "Bottom 98%-100% corroded. Some welds show signs of erosion; butts and seams may need building up at next docking."

October 1957, Docking Report, "Bottom has generally even corrosion with some pitting particularly at the ends. Welds are generally eroded slightly below the surface of the plating; but deeper on upper and lower seams of the "C" strake port side."

April 1959, Docking Report, "General plate corrosion most severe in A, B and C strakes bow to frame 48. Maximum depth about 1/8". Seams and butts spongy, maximum depth below plate level about 1/4". Seams and butts have eroded appearance, following welding bead contours. Plate corrosion from Frame 48 aft to 120 on A, B and C strakes uniform with little pitting and few scars. Pitting more general in D strakes. Extensive pitting prevalent aft of frame 120. Depth of pitting approximately 3/16"."

November 1959, Docking Report indicated same conditions.

August 1960, Docking Report, "Welded seam between A and B strake is eroded 3/8" deep from frames 50to 125 starboard side. Welded seam between B and C strakes is eroded 3/8" deep near sea chests and 1/4" deep elsewhere. Welded seams between C and D strakes are heavily pitted and eroded throughout the length of the ship. In general the horizontal seams below the waterline show more extensive pitting and erosion than vertical butts.

July 1961, Docking Report indicated no significant change.

January 1962, Docking Report, "All plating below the 20' WL is eroded and pitted extensively and deeply. As indicated by measurements around insert in D strake, Portside, Frame 25-27 showing thickness of 1.375" remaining of the 1.625" original plate. All welds in this area are corroded and porous to a depth of 1/4"-3/8" below the plate surface".

June 1963, Docking Report, One hundred and fifty audio gauge readings were taken on the starboard side and 50 were taken on the port side. These readings showed the corrosion at the operating waterline (D strake) averaged about 17% of the original plate thickness whereas the corrosion of the A, B and C strakes was on the order of 10 to 14%. Corrosion of the welds below the 25' WL was such that the weld surface was from 1/8" to 1/2" below the plate surface.

At this docking 2415' of plating weld was either arc-gouged or chipped out to good metal and rewelded. The areas covered:

(a) From keel to 21' WL, bow to frame 43
(b) From keel to 23' WL, frame 43 to 83 1/2
(c) From keel to 25' WL, frame 83 1/2 to 166 1/2

Radiographing of various locations showed no defects or differences in the weld where arc-gouging has been used in lieu of chipping.

An experimental coating system was applied to the hull underwater body at this docking. The hull had been unpainted since February, 1951. The hull was prepared using a dry sandblast to give a commercial blast. The hull was then coated up to the top of the boottopping area as follows:

1. From midships forward, starboard, one coat of "CATHA-COAT", Formula 300 and one coat of Curing Solution.

2. From midships forward port, one coat of "CATHACOAT", Formula 303.

3. From midships aft, port and starboard, one coat of "CATHACOAT" Formula 302.

In addition the boottopping was painted with "DEVRAN" 201 and 209.

The foregoing was accomplished as part of ETD Project J20-1/2-31 "Zinc Silicate Paints WAGB's".

c. NORTHWIND

March 1956, Docking Report, "Moderate corrosion where bilge keels were removed."

October 1956, Docking Report, "Moderate corrosion where bilge keels removed. Corrosion over entire hull has increased considerably since last undocking. Underwater body painting is recommended".

October 1956, District Endorsement to Docking Report, "The remarks concerning corrosion of underwater body and painting thereof to possibly prevent furhter active corrosion in isolated pitted areas are not agreed with....."

February 1957, Docking Report, "Corrosion over entire hull as noted in October 1956 docking report. Hull shows an increase in corrosion over last docking. Underwater body has not been painted for last five dockings. Painting recommended at future docking."

November 1957, Docking Report, The following reference check spots were reported:

(1) Stb'd side, 6" up from keel weld, first butt weld aft of bow tube, weld in perfect shape, bead 5/32" above plating surface.

(2) Stb'd side, 20" up from keel weld, third butt weld from bow, pit 6/32" below plating.

(3) Stb'd side, 6' up from keel weld, 5th butt weld from bow, pit 1/4" below plating.

(4) Stb'd side, 2nd weld up from keel, 16" forward of stern frame good bead 6/32" high.

(5) Portside, 8' from keel 5th butt weld from bow, pit 6/32" below plating.

November 1957, Enclosure 4 is a copy of trip report covering inspection by headquarters personnel of same docking.

At this docking NORTHWIND was given a complete bottom paint job. Photos #22-28 show bottom prior to painting and Photos 29-33 after painting.

November 1958, Docking Report indicated 90% of AF paint remained. Days underway 58. Exposed area showed light corrosion.

June 1959, Docking Report indicated no AF paint remaining 60% of hull exposed to bare metal. Minor etching of hull plating throughout after underwater body. Areas of welding during construction appear to have corroded the worst.

March 1961, Docking Report, "Extensive pitting forward of port stern tube bossing. Not severe but should be inspected at all future dockings. Weld seams in after body pitted and corroded. Some pits 1/8" to 1/4" deep.

March 1963, Docking Report indicated same condition as existed in March 1961.

March 1964, Docking Report indicates no change in condition.

8. SUMMARY:

For the WESTWIND there is no record prior to 1952 as to the type of maintenance performed on the underwater body. The ship was beginning to show signs of deep pitting of plating and corrosion of the welds as early as 1952. The welds became progressively poorer until in 1958 it was necessary to commence a program of renewing the welds. Audio gauge readings taken in 1960 show the maximum plate deterioration to be .178". In 1959, an impressed current cathodic protection system was placed in operation aboard the WESTWIND during inport periods.

Prior to 1952, the EASTWIND had received routine bottom painting and at that time showed moderate corrosion with a few isolated deep pits particularly in the welds. These conditions remained relatively constant until 1957 when an increase in weld corrosion was reported. By 1959 the weld corrosion had progressed to the point that the welds were below the level of the shell plating by about 1/8" to 1/4". By 1962, the welds were corroded to a depth of 1/4" to 3/8" and shell plating showed losses as high as .250". In 1963, all welds below 21' W.L. were renewed and bottom painted with inorganic zinc silicate.

The NORTHWIND received routine bottom painting until 1954 and at that time moderate corrosion was reported. In 1957, based upon what appeared to be an increase in corrosion rate, the bottom was again painted. The bottom corrosion remained approximately the same until 1961 when some pitting in way of the welds was noted. This condition has remained constant to date.

9. CONCLUSIONS:

a. The corrosion rate experienced is in excess of that predicted by the theory presented in 1952. Theory said the corrosion rate would be .005 inches per year and pitting would be at a rate of .015 inches per year. If it is assumed that no protection has been provided over the life of these ships (20 years), the maximum general plate loss should not have exceeded .100 inches and pitting should not exceed .300 inches. The WESTWIND reported general plate losses as high as .178 inches in 1960 and the EASTWIND, .250 inches in 1963. Pits on all ships have been reported as high as .375 inches. (Note: This does not mean theory is wrong, but rather not all aspects of corrosion theory was considered.

The .005 inches per year rate is for steel in still or very slow moving water under natural conditions in the absence of a galvanic cell. There are a number of factors which can increase this rate considerably; at a water velocity of 10 fps the rate can be as high as 0.04 inches per year; a considerable amount of mill scale will cause pitting rates as high as 0.25 inches per year; increase in temperature will also increase the corrosion rate (e.g., the corrosion rate will be doubled by an increase in temperature from 50° to 80°F); steel suffers galvanic attack when in metallic contact with all copper alloys, nickel alloys, and stainless steel; and turbulence will increase the corrosion rate. Since all these conditions have existed during the life of these ships the higher corrosion rate is not unusual. Based upon measured losses, the corrosion rate varies between .013 and .022 inches depending upon the amount of protection assumed during the early life of the ships prior to 1952.

b. Standard bottom paints will not withstand ice operations. Example of this is the NORTHWIND, which received a complete bottom paint job in December 1952, five months later in May 1953 only 10 per cent of the bottom paint remained in way of the keel and under the stern tubes. Thus the amount of protection afforded by bottom paints will depend upon the time of application, i. e., if applied just before the ice operation and the ship is not docked immediately following very little protection will be afforded. On the other hand if painting is accomplished immediately following each ice operation, considerable protection will be afforded.

c. That fouling is not a problem as far as icebreaker performance is concerned.

d. The plate butt and seam welds are the most susceptible areas to corrosion attack. The procedure of chipping out or arc-gouging and rewelding provides temporary corrective action but is not permanent.

10. <u>POSSIBLE SOLUTIONS</u>:

a. No painting. Continue leaving the hull unpainted. If this procedure is followed, an additional ten year life will result in additional plate losses at the operating waterline of between .130 and .220 inches or a total loss of between 23 and 29 per cent. If an additional 15-year life is planned, the total loss would be between 27 and 36 per cent. In addition, it can be anticipated that the hulls will have to have the welds renewed at least once.

b. Painting (Anti Corrosive). Commence painting the underwater body using the standard bottom paint system exclusive of the antifouling paint on an annual basis. The painting is to be scheduled immediately following ice operations. Depending upon the extent of the ice operations this could provide as high as 80% protection. This would mean an annual drydocking with an estimated annual cost of $10,000 to $13,000 for sandblasting and $4,000 to $6,000 for painting. In off years, when drydocking for repair is not scheduled, there would be the additional cost of drydocking $6,000 to $7,000 and lay day costs. This would mean an average annual cost of $20,000.

c. Painting (Zinc Silicate). Commence painting the underwater body using inorganic zinc silicate coatings. Although these paints are susceptible to abrasive damage by the ice they will provide some protection due to their sacrificial nature, since the coating is anodic with respect to the base metal. Trial applications of this type coatings have been made on ATKA (AGB-3) by the Navy and on EASTWIND.

In the case of ATKA the application was made in January 1961 and inspected in February 1963. This application consisted of sandblasting to a "clean commercial dry sandblast" applying the zinc silicate coating and overcoating with one coat of Formula 117 (Pretreatment Wash Primer) followed by 2 coats of Formula 119 (Vinyl Red Lead). Inspection in 1963 showed the adhesion of the vinyl to be fair; adhesion of the zinc silicate to be good except that forward the zinc silicate had been abraded away. Areas where the overcoat was missing the zinc silicate showed a reduction in thickness (This is to be expected since it would be sacrificing to the bare steel).

EASTWIND was coated with three different systems of inorganic zinc silicate "CATHACOAT" 300, 302 and 303" in June 1963. These systems were given no overcoat and were applied over a "commercial sandblast". Inspection in June 1965 revealed little or no residual zinc coating remaining. However corrosion was described a light general rusting.

Although the paint system of ATKA appeared to be in better condition after the two year period, it is doubtful that the corrosion protection provided the hull was much greater than that afforded EASTWIND.

At the present time it would appear that painting with an inorganic zinc silicate system could be carried out on a biannual basis; particularly if the docking and painting is scheduled immediately following the second year's ice operation.

The cost for this system would be $10,000-$13,000 for biannual sandblasting, $7,000-$9,000 for zinc silicate application and $4,000 to $6,000 for overcoating if used. This would mean an average annual cost of $10,000 if zinc silicate only is used, $12,500 if overcoating is used.

The disadvantage of this system is the problems associated with application. The surface preparation as a minimum must be "clean commercial dry sandblast". No inhibitor or wash primer can be used to hold the prepared surface and the coating must be applied under dry conditions.

d. Cathodic Protection (Passive Installed) Hull attached anodes while feasible have the disadvantage of the hull attachment problem and current distribution , i.e. high current densities adjacent to the anodes but little protection at remote locations. The Canadian's achieved limited success on LABRADOR using a large number of magnesium anodes attached to the hull in way of the keel line in conjunction with anticorrosive hull painting. In the test application 30 (3" x 10" x 60") anodes were attached to the keel plus anodes installed in the ice chests. Inspection after one year of operation showed very little paint remaining and the condition of the hull depended upon the distance from the anodes. Based upon this test the National Research Establishment recommended that 50 anodes be installed, the hull be painted with anticorrosive and ice chests be fitted with anodes. This system would mean an average annual cost of approximately $26,000. Twenty thousand dollars for painting and $6,000 for anodes. The protection provided would be on the order 90 to 95%.

The part played by the paint may be questioned because of previous statements that paint will be removed by the ice. The reason for paint is that it will allow the hull to be rapidly polarized after undocking and the combination will provide the best protection until the paint is removed.

e. Cathodic Protection (Active Installed) This is not considered feasible since the hull must be penetrated to fit the active anodes. In addition, the need for anode shielding would present a problem in ice operation.

f. Cathodic Protection (Active Non-installed) An impressed current graphite anode system has been used by WESTWIND since 1959. This system consists basically of sixteen (8 each side) 3" by 60" graphite anodes weighing 25 pounds suspended over the side. The system is fed required current by two installed rectifiers. When the system was initially placed in operation the hull potential measured with reference to a silver -- silver chloride cell was on an average

-850 mv. A potential of -840 mv will normally afford 100% protection. The amount of protection afforded by the system will depend upon the amount of time it is used (inport only) and proper use. The initial cost of the WESTWIND system is 1959 was approximately $4,000. The power consumption is approximately 4 Kilowatts.

The system has the disadvantage of requiring care in mooring since the anode must be suspended over the side and it will not provide protection when underway.

ENCLOSURE (1)

C/O/P/Y

Materials Laboratory 13745
20 July 1965

MEMORANDUM FOR FILES

Subj: USCG EASTWIND - Condition of Underwater Hull-Corrosion as of This Date

1. On 15 July, 1953, Messrs. Lutts and Sadler of the Materials Laboratory inspected the underwater hull of the USCG EASTWIND in Dry Dock #4, South Boston.

2. The purpose of the inspection was to observe:

(a) Whether the electrically deposited welds joining the hull plating were corroded and eaten away below the level of the surrounding plates.

(b) Whether mill scale was present on the hull plates.

3. Prompting this inspection was a problem which had been assigned the Laboratory in connection with the USS ATKA where its electrically deposited weld metal joining the hull plating was found corroded and eaten away up to 1/4" below the level of the surrounding hull plating. According to Paul Ffield, in an article presented before the Naval Architects, attack of weld metal can be caused by the presence of mill scale on the surrounding plating.

4. Unfortunately the Laboratory did not determine whether the hull plating of the ATKA carried mill scale as the vessel left the shipyard before this point was established. It was thought that the findings in the case of the EASTWIND might be significant particularly if the two vessels were constructed at the same Shipyard. However, the Laboratory did take samples from the weld metal of the USS ATKA and from the H.T. steel shell plating and is attempting to duplicate with these samples the conditions of corrosion noted.

5. The results of the present inspection on the EASTWIND may be summarized as follows:

(a) The electrically deposited welds joining the hull plates are not corroded and eaten away below the level of the surrounding hull plating. There is occasional spotty needlelike attack in these welds, a condition not yet serious.

(b) No mill scale was present on the hull plating with the exception that the exposed flat keel, 18" wide, showed some mill scale. To confirm this latter observation, a small quantity of the scale was loosened by means of tapping by a hammer. These particles were strongly magnetic and readily picked up using a small magnet, indicating magnetic iron oxide.

(c) The hull plating which appears absolutely free from mill scale may have been pickled before constructing the vessel. The hull plating now shows 25% of its area protected in greater or lesser degree by paint. The exposed and bare areas of the hull plating are uniformly colored with red rust. A slight amount of needlelike pitting in the bare plating, inconsequential in effect, was observed. Areas at which clips were welded and subsequently removed were corroded to a depth from 1/8" to 1/4".

6. The impression was gained that overall condition of the bare portions of the hull was satisfactory and that continuance of bare hull status without paint protection was justified.

7. As to the help gained from this inspection in solving the ATKA problem, the present status is that here is an icebreaker free from all mill scale and largely free from paint with intact welds free from corrosion and undercutting. The obvious next step is to examine the ATKA upon her rescale on her underwater plating, thereby meeting the conditions stated by Ffield as common cause for corrosion and eating away of welds.

C. G. Lutts,
Materials Engineer.

ENCLOSURE (2) C/O/P/Y

ENE-2

Chief, Shipbuilding and Maintenance Branch 1 November 1957

WAGB Type Desk

Trip report; visit to the WESTWIND (WAGB 281) for conference re hull weld corrosion

1. Places visited - WESTWIND located in graving dock at Keystone Dry Dock and Ship Repair Company, Philadelphia, Pennsylvania, 30 October 1957.

2. Persons contacted:

Dr. T. P. May, International Nickel Company
Commander D. Hunt, USN, Bureau of Ships, Code 537
Mr. C. A. Loomis, Bureau of Ships, Code 597
Mr. I. D. Gessow, Bureau of Ships, Code 533F
Mr. L. M. Waldron, Naval Research Laboratory
Mr. H. D. Peterson, Naval Research Laboratory
Commander Shultz, Philadelphia Naval Shipyard
Mr. E. Franks, Philadelphia Naval Shipyard, Material Test Laboratory
Mr. J. O'Connor, Philadelphia Naval Shipyard, Material Test Laboratory
Mr. Thomas Grasson, Third Coast Guard District
Captain V. C. Gibson, Third Coast Guard District
Captain W. J. Conley, Commanding Officer, WESTWIND
Lieutenant Commander R. E. Williams, Testing and Development

3. The above party visually inspected the hull of the WESTWIND with particular regard to the corrosion which has attacked the welded joints in the underwater body. The deposited metal of all these welds has corroded away so that a groove exists along the joints. The depth varies somewhat from point to point over the surface of the hull; the seam between C and D strakes appears slightly deeper than other welds with depths of the order of 3/8 inch observed. The forward and midship areas of the underwater body appear somewhat worse than the after section of the ship. The surface of the deposited weld metal rem aining has a pitted or spongy appearance. Small areas of scale, believed to be mill scale in the inspection group, were observed on A strake plates about frame 30 P&S and frame 150 S. Moderate pitting has occurred in these areas, particularly about frame 30 S. The plating of this hull is HTS, Navy Department Specification 48-S-5, grade HT. Specified analysis is:

Carbon ----------------	.20 maximum
Manganese ------------	1.50 maximum
Phosphorus -----------	.04 maximum
Sulphur ---------------	.05 maximum
Silicon ---------------	.15 - .35
Copper ----------------	.35 maximum
Nickel ----------------	.25 maximum
Titanium --------------	.005 minimum

The welding was with mild steel rods under Bureau of Ships Specification 46E3 (INT), (AWS E 6010).

4. A general discussion followed with the following main points being made:

a. The corrosion is considered the result of galvanic action due to dissimilarity between weld metal and base plate. Although the weld is probably only slightly anodic to the base material, the area of the weld is so small in comparison to the plate area that a rather concentrated attack results. The absence of paint has permitted direct exposure of both electrodes to the electrolite, thus accelerating the action.

The presence of small areas of mill scale indicates that the plating was not de-scaled during construction of the vessel. Electrolytic action due to mill scale probably resulted in some damage to plate and weld material during early life of the ship. At this point insufficient scale remains to be a major factor. (Subsequent checking indicates that plating was pickled and flame scaled during construction of the vessel). The roughness of the surface of the weld is probably causing turbulence which is accelerating the corrosion.

b. Survey of the depth of the corroded grooves along the welds should be made with careful attention given to recording exact location measurements are made so that checks can be made at same points later. Use of a needle pointed depth micrometer was considered adequate for this purpose. Audio gauge or drill testing of plate areas away from weld was also suggested. The depth of the weld affected by the pitting or honeycombing can be definitely determined only by grinding out to sound metal. Bureau of Ships, Code 537, representatives felt that this might be appreciable and that the present weld surface presents a notch effect which also is a factor in reducing the strength of the welds. They considered that these factors combined with the loss of metal which has occurred are sufficient to definitely indicate repairs at first opportunity.

c. Satisfactory repair of the deteriorated joints can be obtained by the following procedure:

Grind out the surface of the grooves until sound metal is reached, removing all spongy or "honeycombed" material.

Visually inspect the prepared surface for cracks. Any cracks detected would be repaired in accordance with standard practice. Using a cladding technique (no weaving permitted) and a wandering sequence, build up the welds with type MIL 8016 rods under specification MIL-E-18038A. (This is a low hydrogen, nominal 1% nickel rod). Plating should be hand warm (60°-70°F.) before welding, preferably due to ambient temperatures but torches may be used if necessary.

d. It was recommended by Dr. May that test sections of repair be done at this time with the MIL 8016 rod and also with MIL 10015 rod (low hydrogen, nominal 1.60% nickel). The objective in using the alloy rod is to insure that the deposited metal is slightly cathodic to the base plate so that galvanic action of the type experienced with the mild steel weld material will not recur. It is estimated that the 8016 rod has sufficient alloying elements to accomplish this objective, but a trial of the two rods will provide a check.

e. Some type of protection from corrosion should be provided for the hull of these ships. The type of protection which should be used is largely a question of operating schedule and economics. Two systems are available - paint and cathodic protection. Cathodic protection of either sacrificial anode or impressed current types properly designed using available standards, information and equipment should produce satisfactory results without paint. A sacrificial anode system would require a considerable number of fairly large anodes if full protection of an unpainted hull is to be obtained. An impressed current system would require four or six anodes, plus current source and associated wiring. If the hull were painted the anode requirement would be considerably reduced. The question of paint should be seriously considered if operating schedules demand only one trip into the ice per year. Cathodic protection equipment would necessarily be of the suspended anode type, since hull attached anodes would be knocked off in the ice. Protection could not be afforded while in ice operations, and would probably not be practical when underway otherwise. Complete protection could be obtained when not underway. An impressed current system could build up a calcareous coating which might afford protection for a short time after current is out off, but this time is considered too short to be a factor in determining the type of protection to be installed.

5. Bureau of Ships representatives indicated that a written report of their opinions on this hull will be furnished.

6. Following actions are underway concerning this matter:

a. Approximately 150 feet of seam welding forward is to be repaired during current drydocking. Above procedure will be used and the two different rods recommended above will be employed. This work is being done with remaining funds set up for current availability.

b. A depth gauge survey of selected welds will be conducted by the ships officers, carefully recording locations, etc. Records will be attached to docking report.

c. Audio gauge readings of selected plates will be made and recorded as above. These readings are designed to check the average overall reductions in plating thickness for comparison with earlier estimates. There are some indications that these estimates are considerably in error. For example, two weld beads, belived made last year with stainless rod in connection with bilge keel repairs, now stand out from the hull in such manner as to make it appear that considerable reduction in thickness of the plate has occurred since the weld was made. Some check on this overall reduction is desired.

ELLIS L. PERRY

Copy to:
Dr. T. P. May
ETD Station 5-6

ENCLOSURE (3)

C/O/P/Y

ETD
CGTD J20/2-2
29 November 1957

FILE

LCDR R. E. WILLIAMS

NORTHWIND, hull inspection of

Ref: (a) CDR Perry (ENE) Report of 1 Nov 1957 re: WESTWIND

1. On 21 November NORTHWIND's hull was visually inspected by CDR E. L. Perry (ENE) and LCDR R. E. Williams (ETD), with particular attention of inspection being focused upon the condition of the underwater body welds. Comparison was made between NORTHWIND's condition and WESTWIND's condition as reported in reference (a).

2. Plating: Red rust covered the entire underwater body. A black scale was observed over the midship body between the 15' waterline and keel, both sides. Pitting of the plates was slight and spotty with no particular pattern apparent.

3. Welds: The deposited metal of the welds is beginning to corrode away in the same manner as has the WESTWIND's. This corrosion appears to be progressive with the most severe attack being at the bow below the 15' waterline. Traveling aft the degree of corrosion attack lessens until it tapers out at about frame 110. Similarly, traveling upward the visible corrosion attack lessens and tapers out at about the 20' waterline. At the 15' waterline, forward of midship's the reinforcing bead has disappeared and grooving has started. Below the 15' waterline, forward, grooving is more pronounced and is to about 3/16" maximum in depth. It is felt that the NORTHWIND would approach the WESTWIND's present condition if left unpainted for another three years.

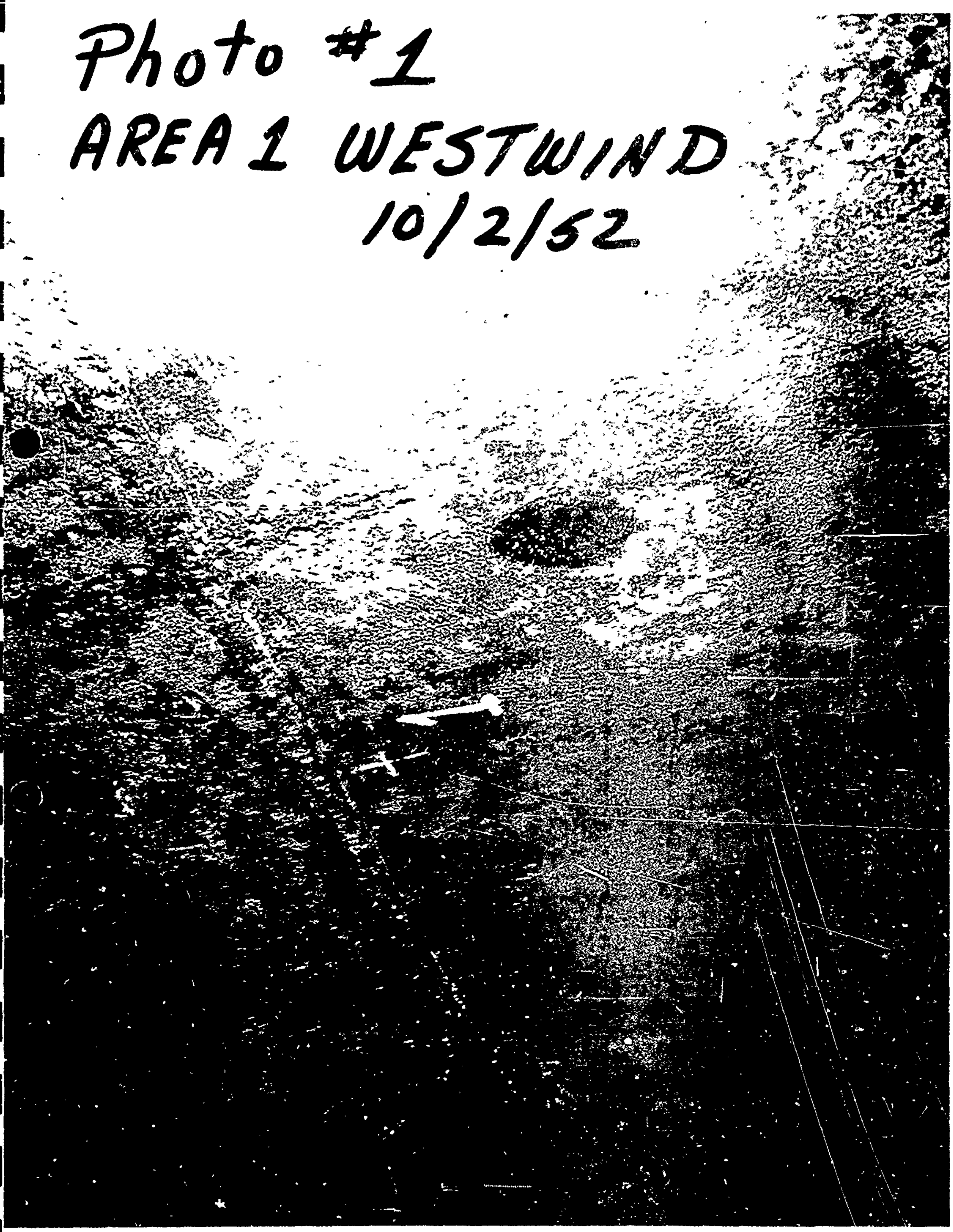
4. The ship's personnel were requested to take depth gauge readings of the welds, height readings of good welds and supporting photographs. Polaroid camera photographs taken by Headquarters' representatives are in CDR Perry's possession. The ship is being painted in the cold plastic system. The docking cost for labor and materials is approximately $7,500.

R. E. WILLIAMS

Copy to:
ENE

ENCLOSURE (4)

PHOTOGRAPHS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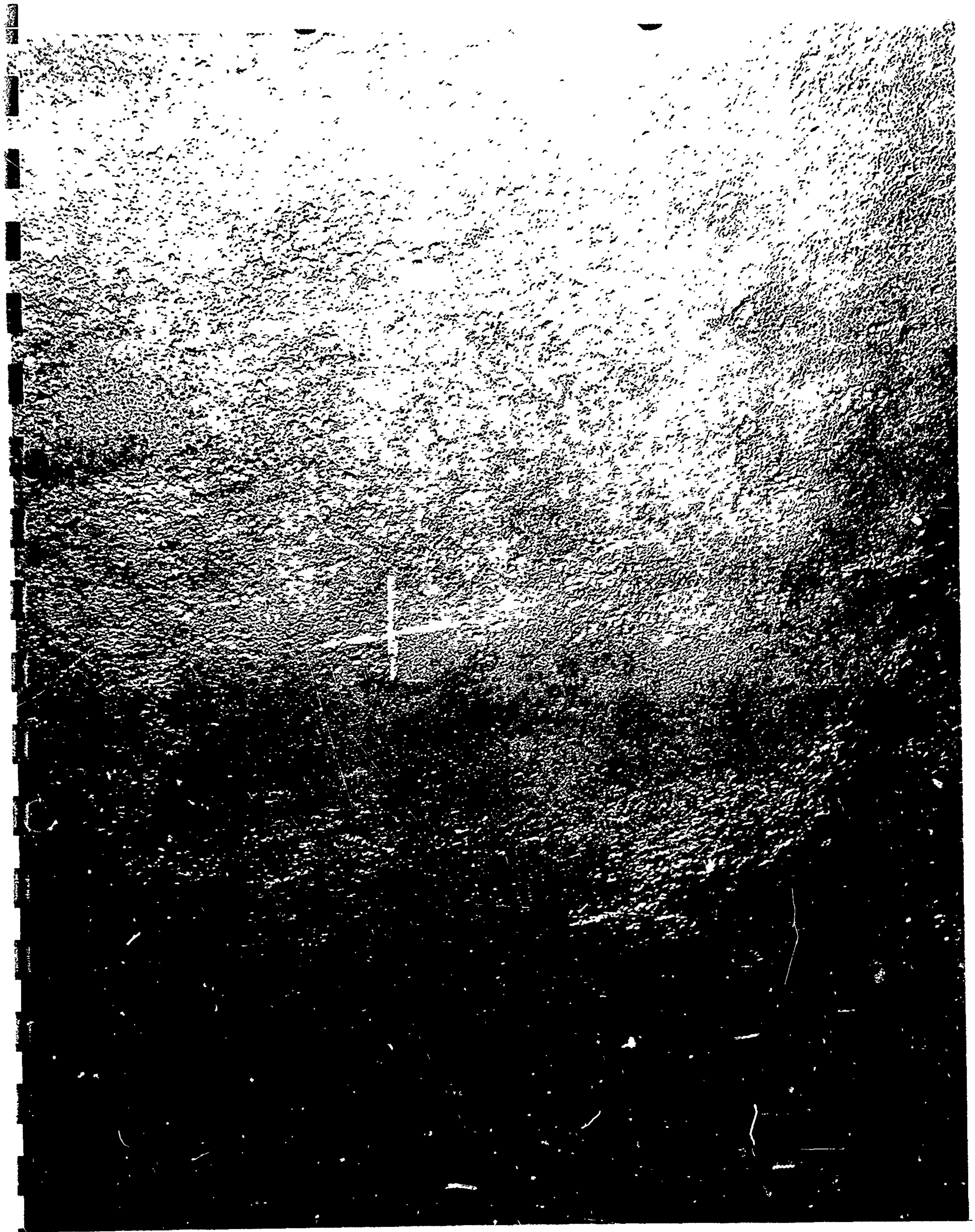

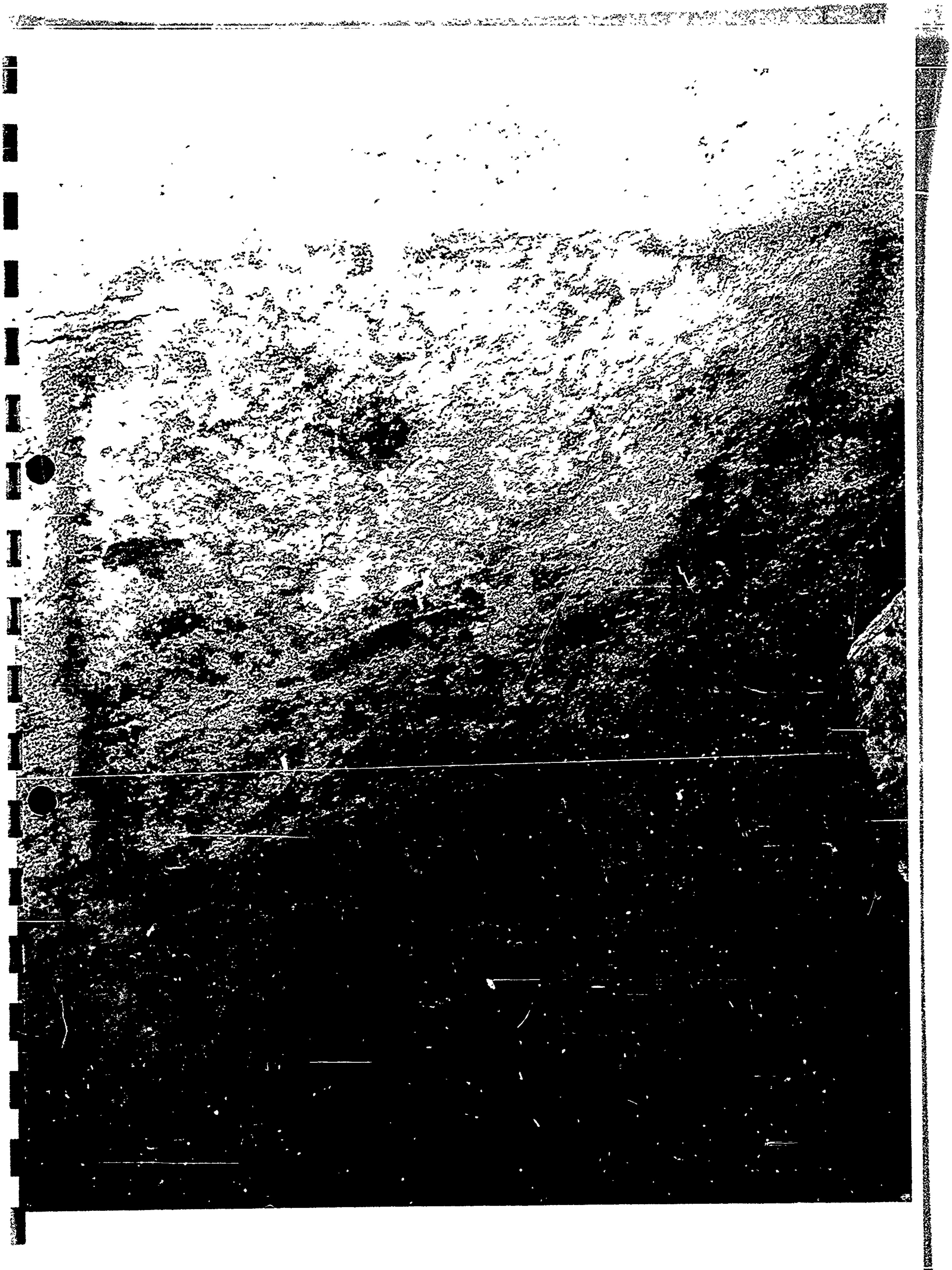

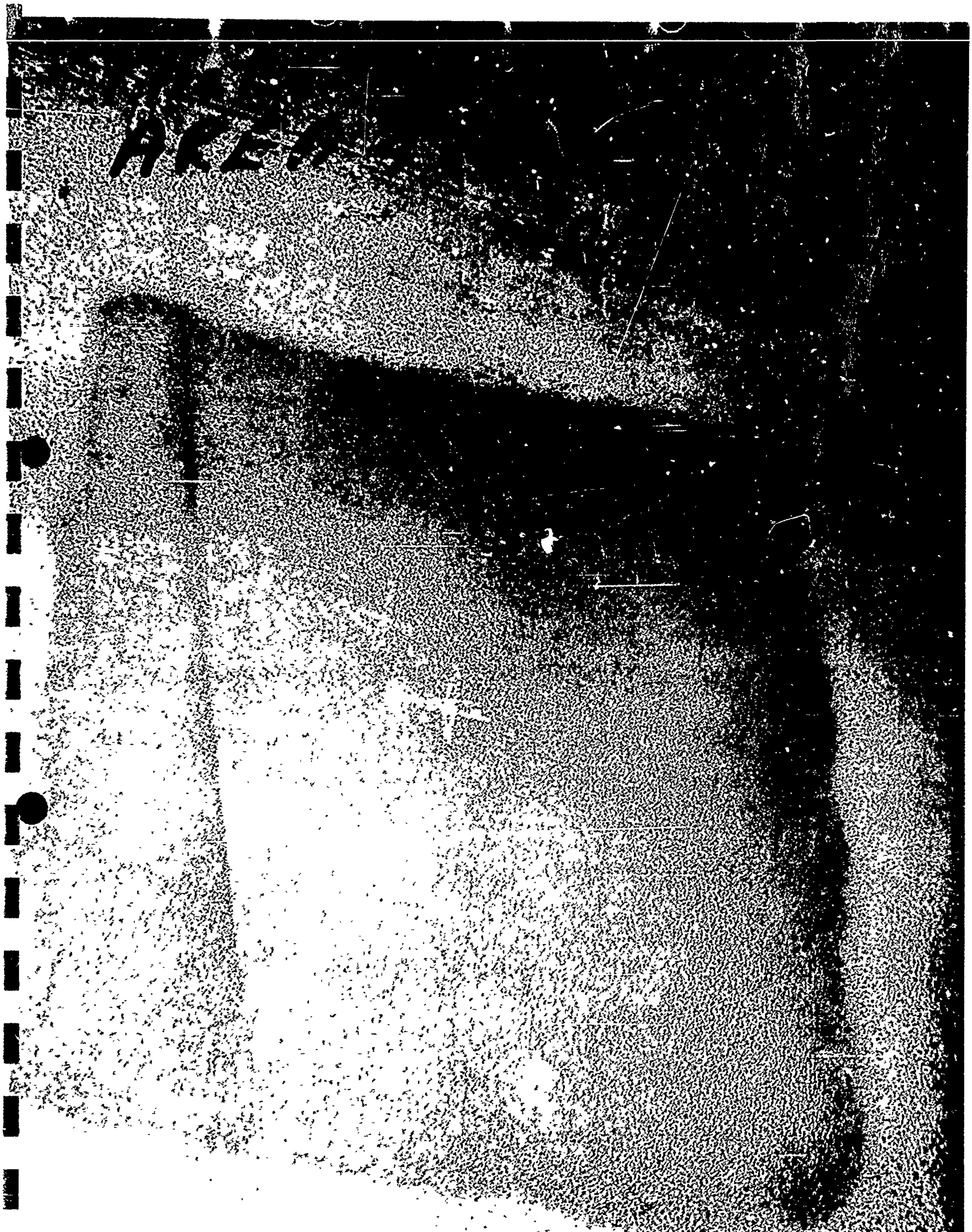

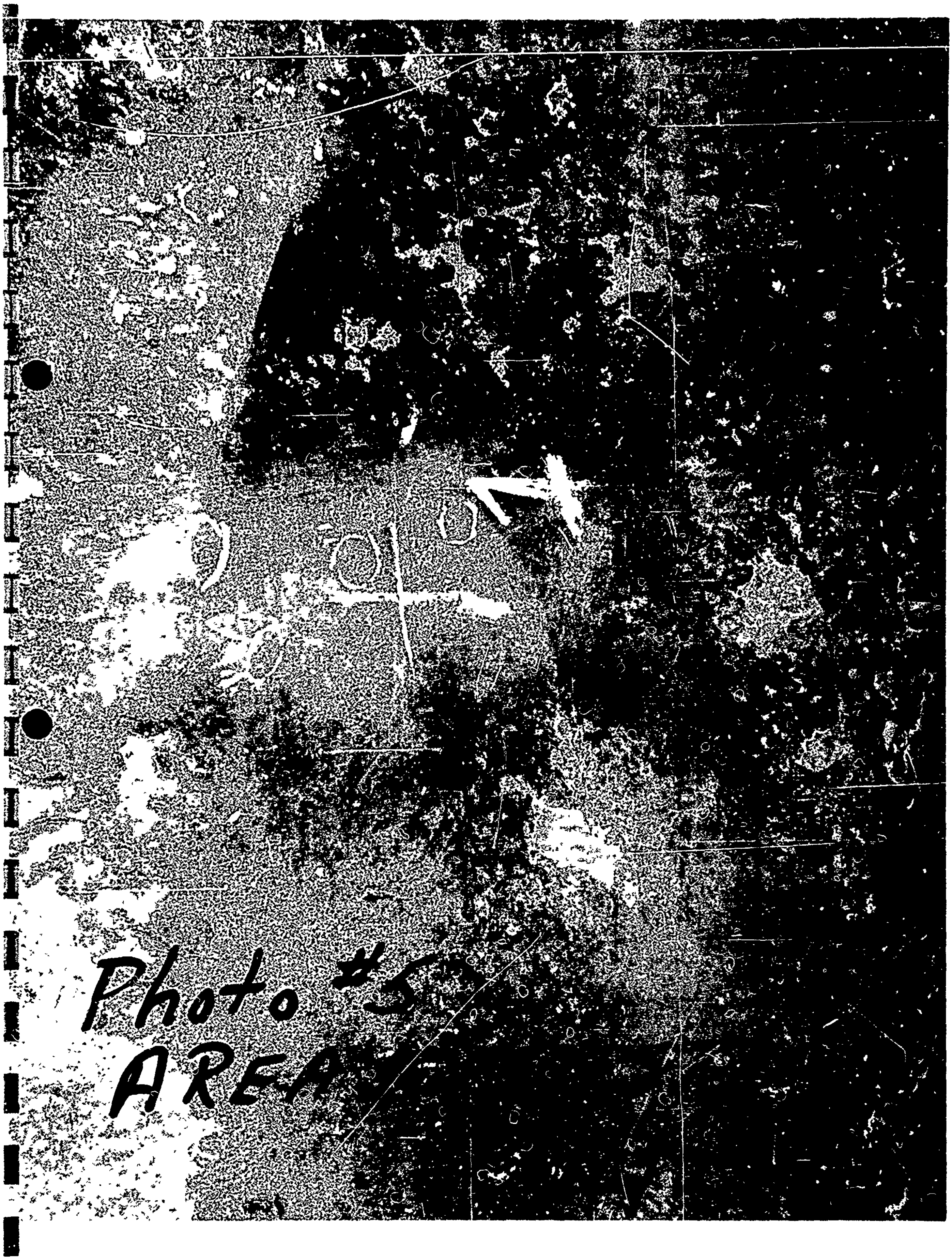
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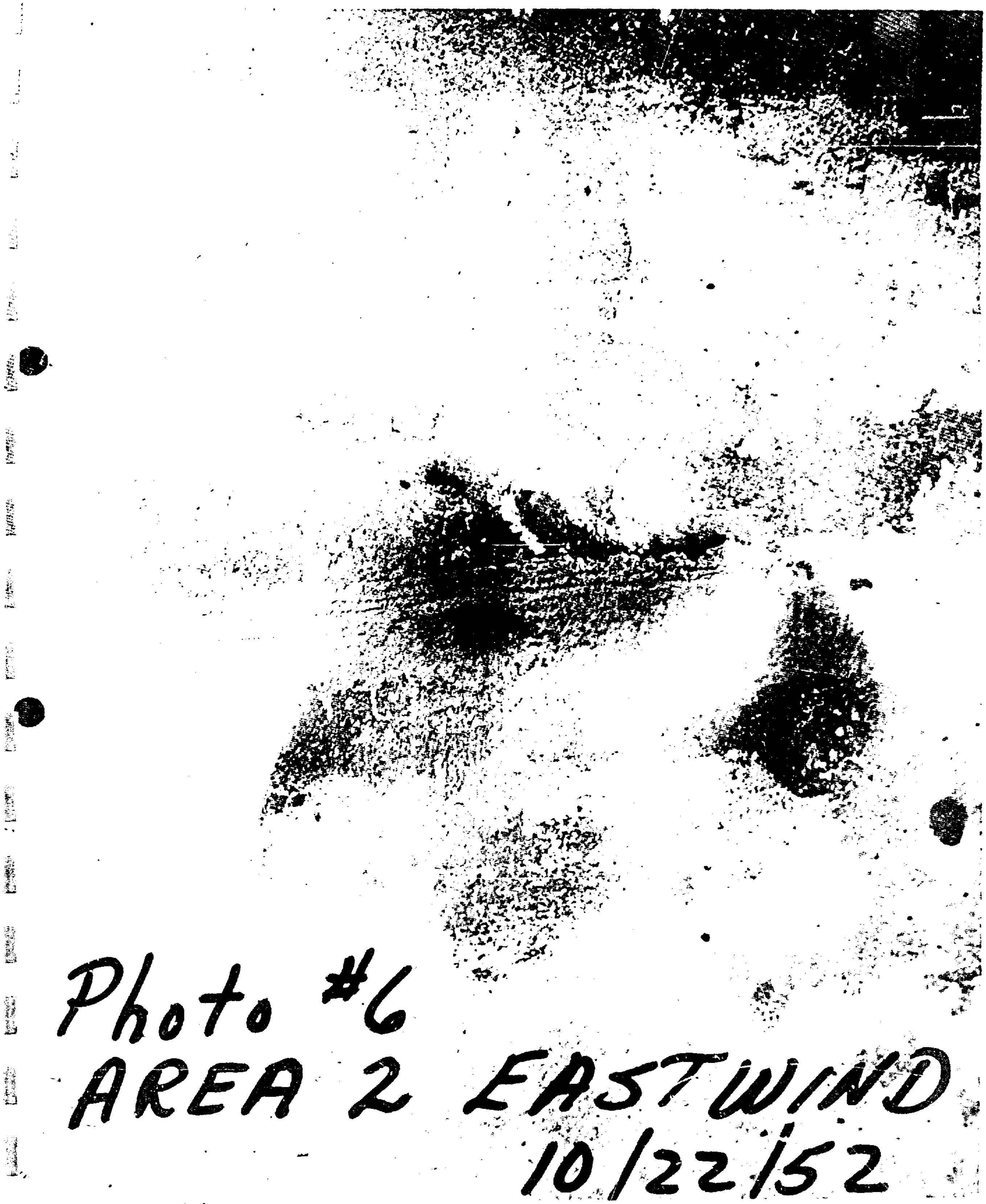
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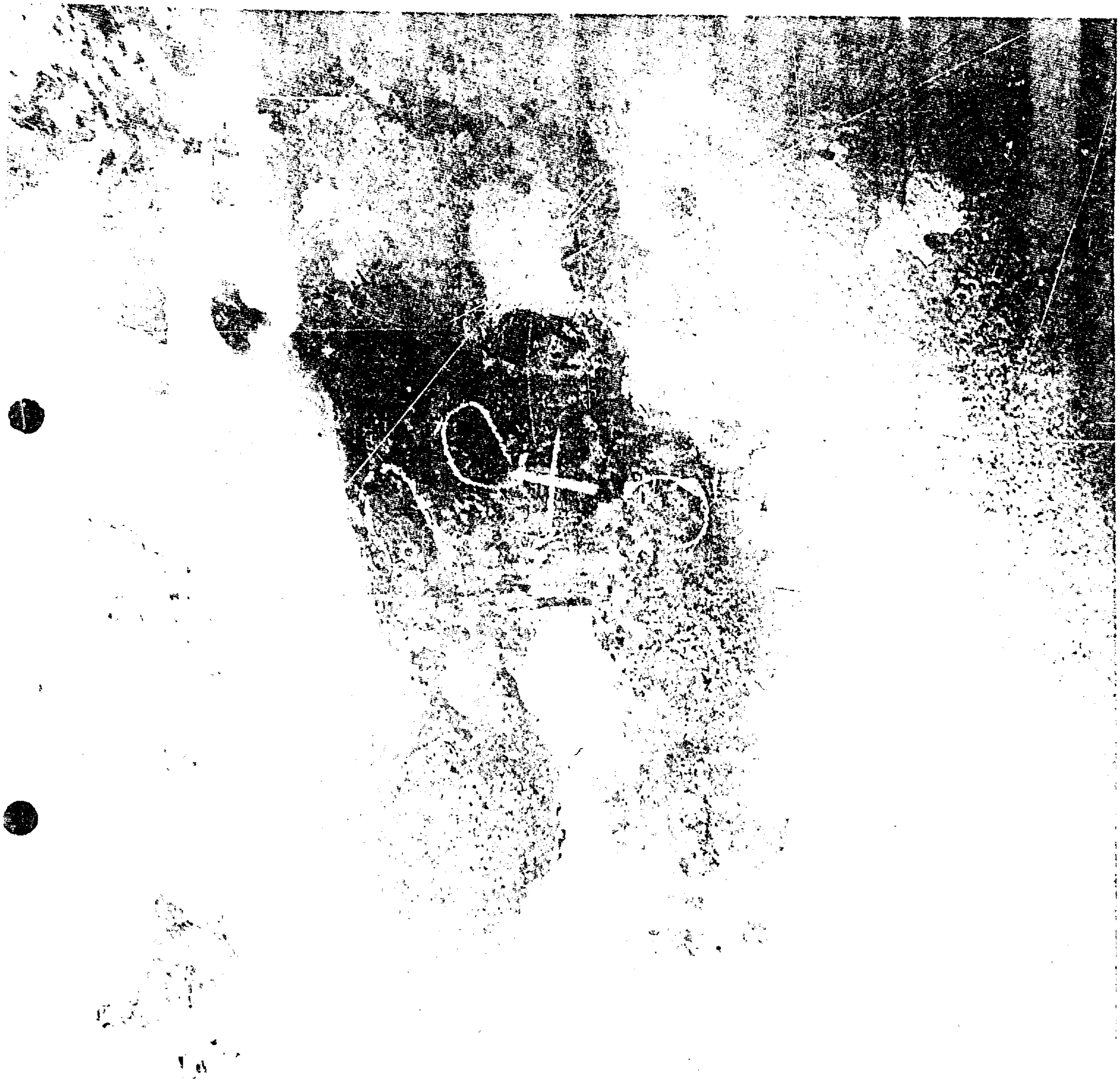

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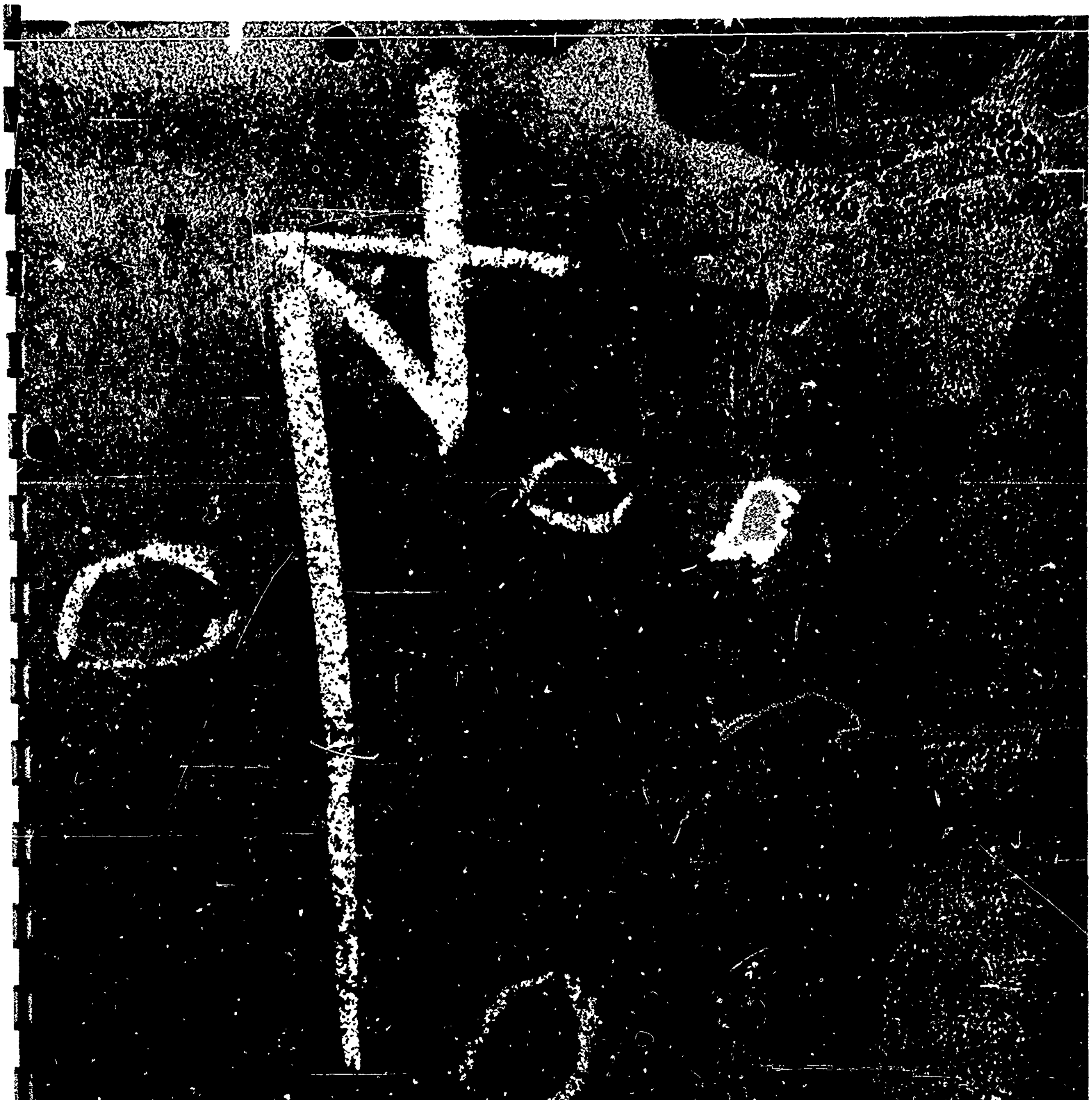N


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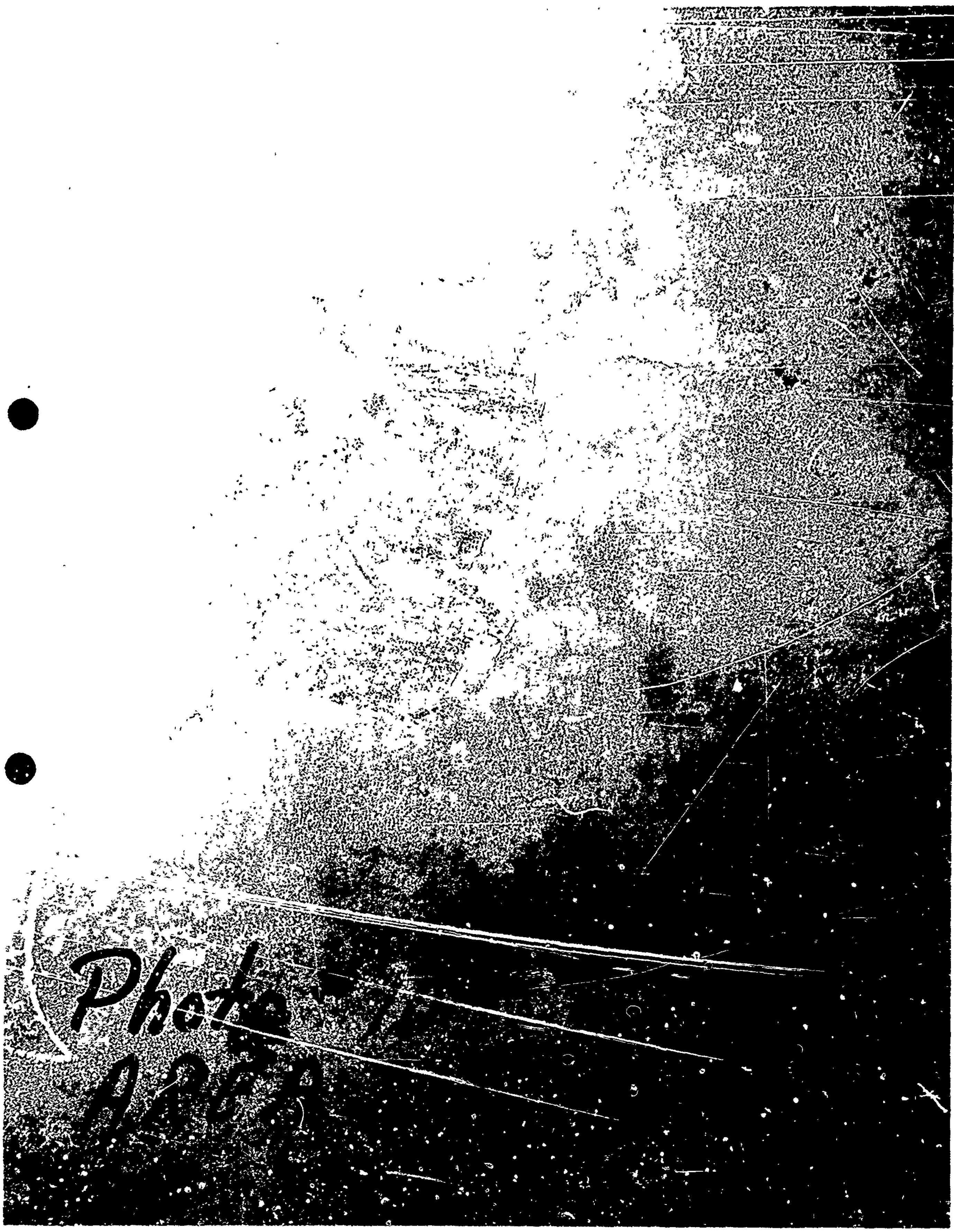
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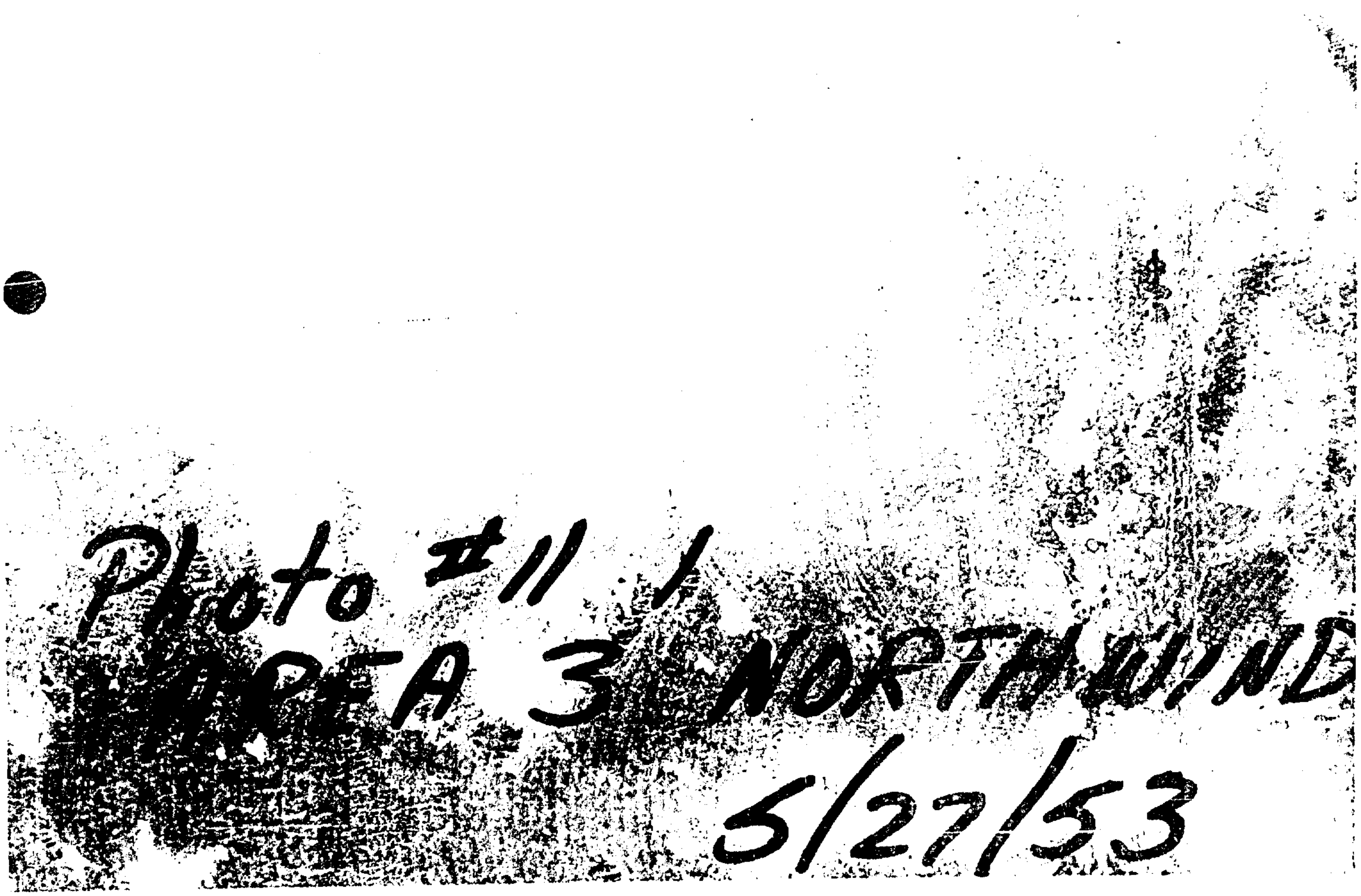
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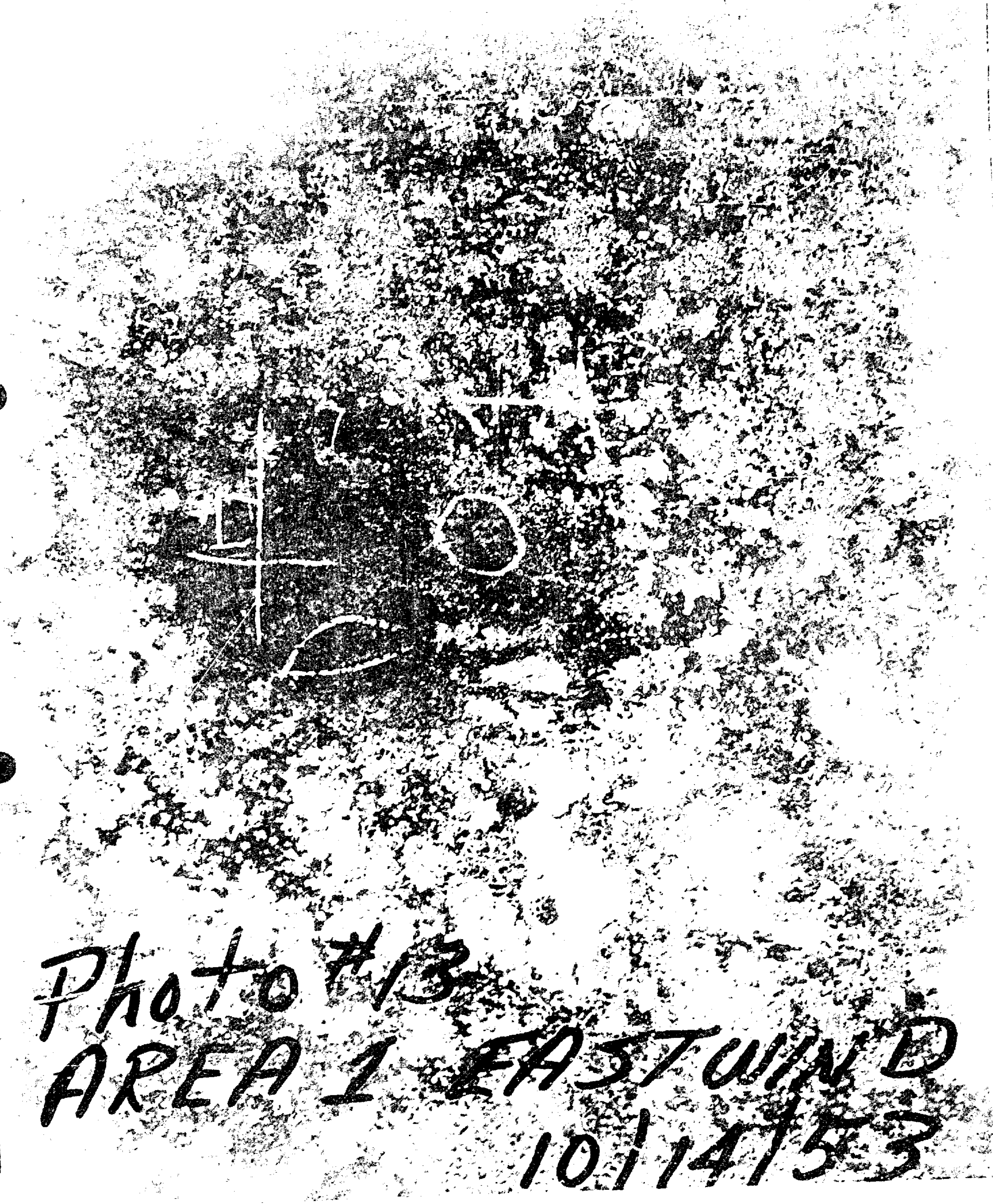
5/27/53

Photo #12
AREA 4 NORTHWIND
5/27/53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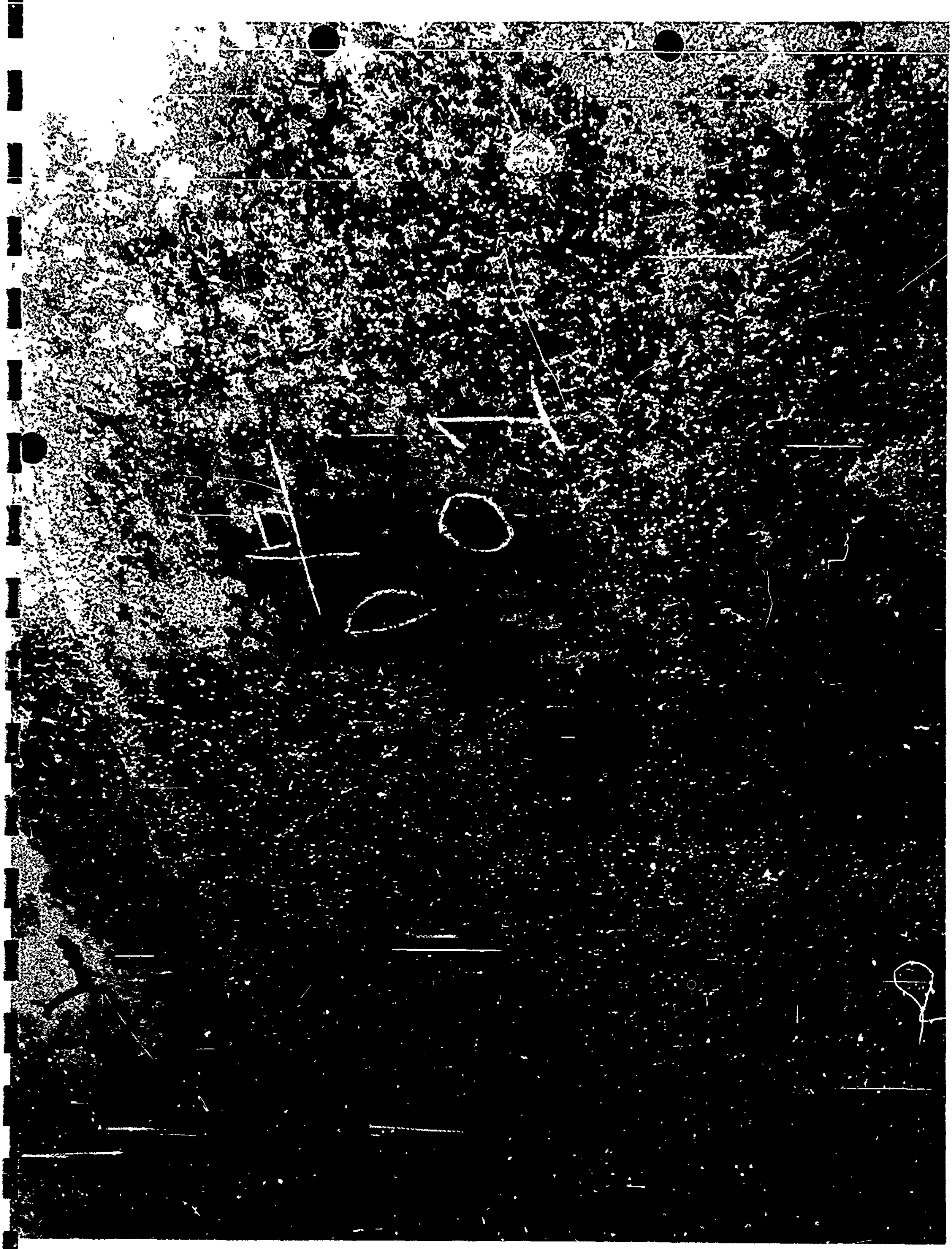

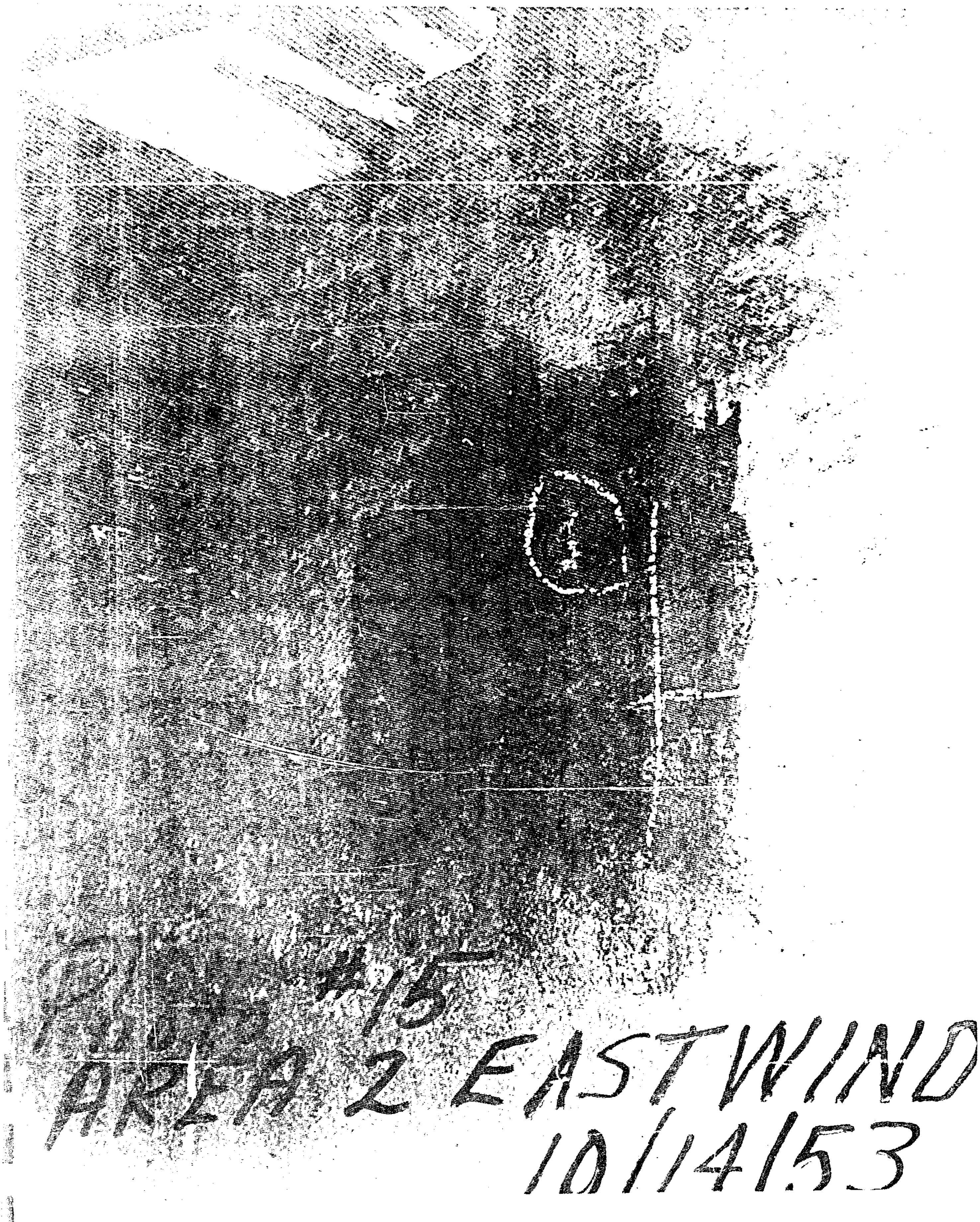
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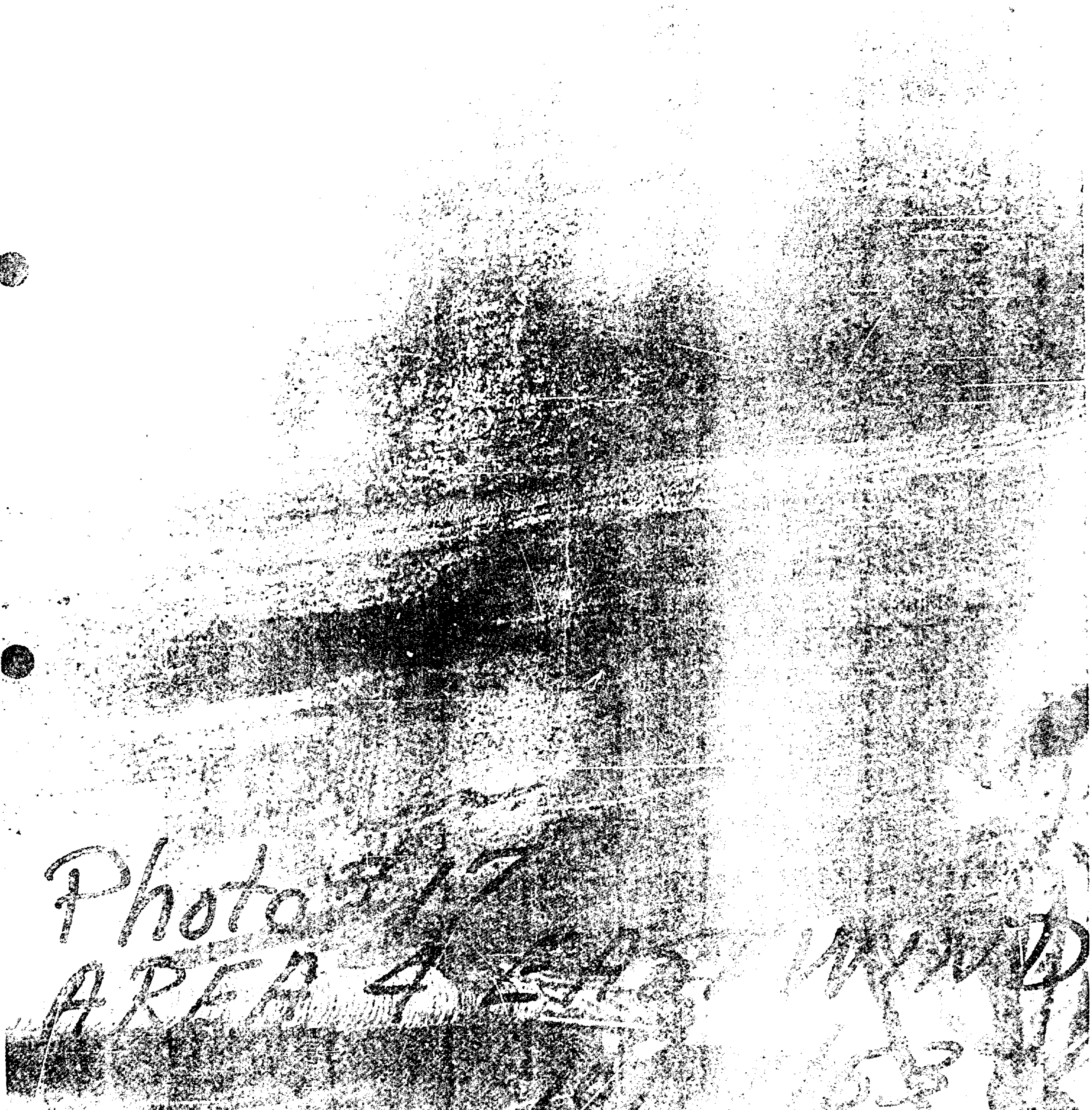
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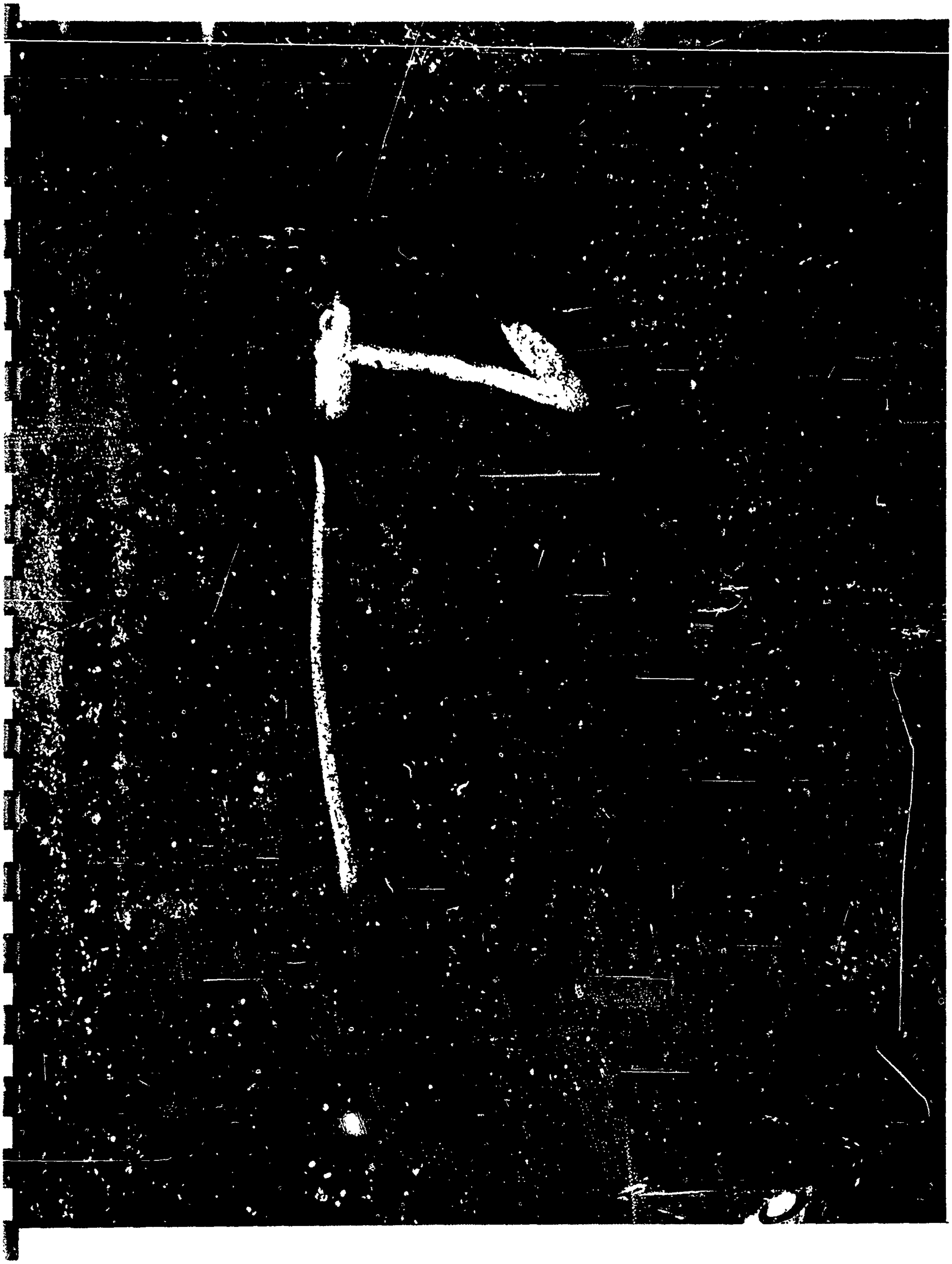


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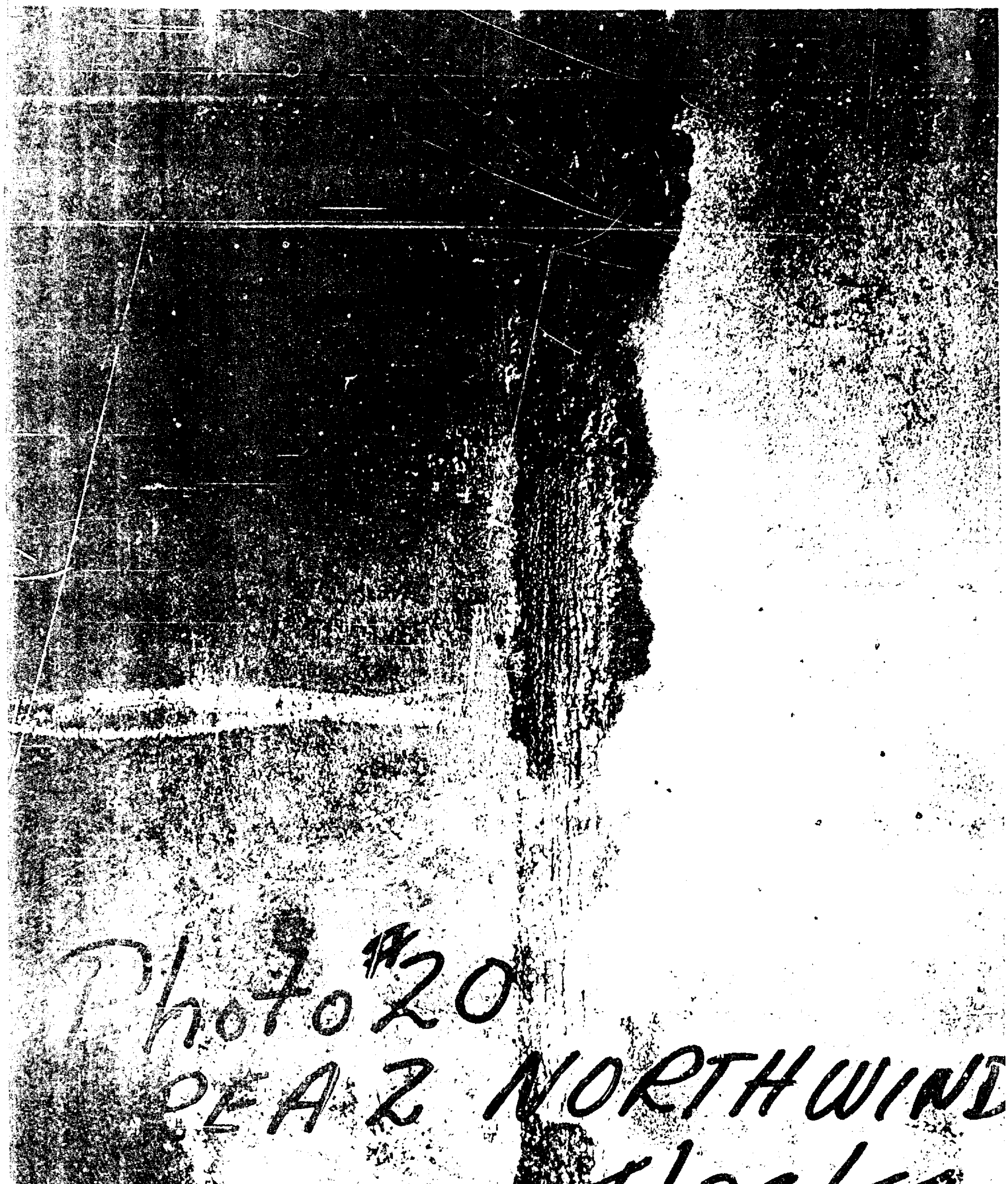
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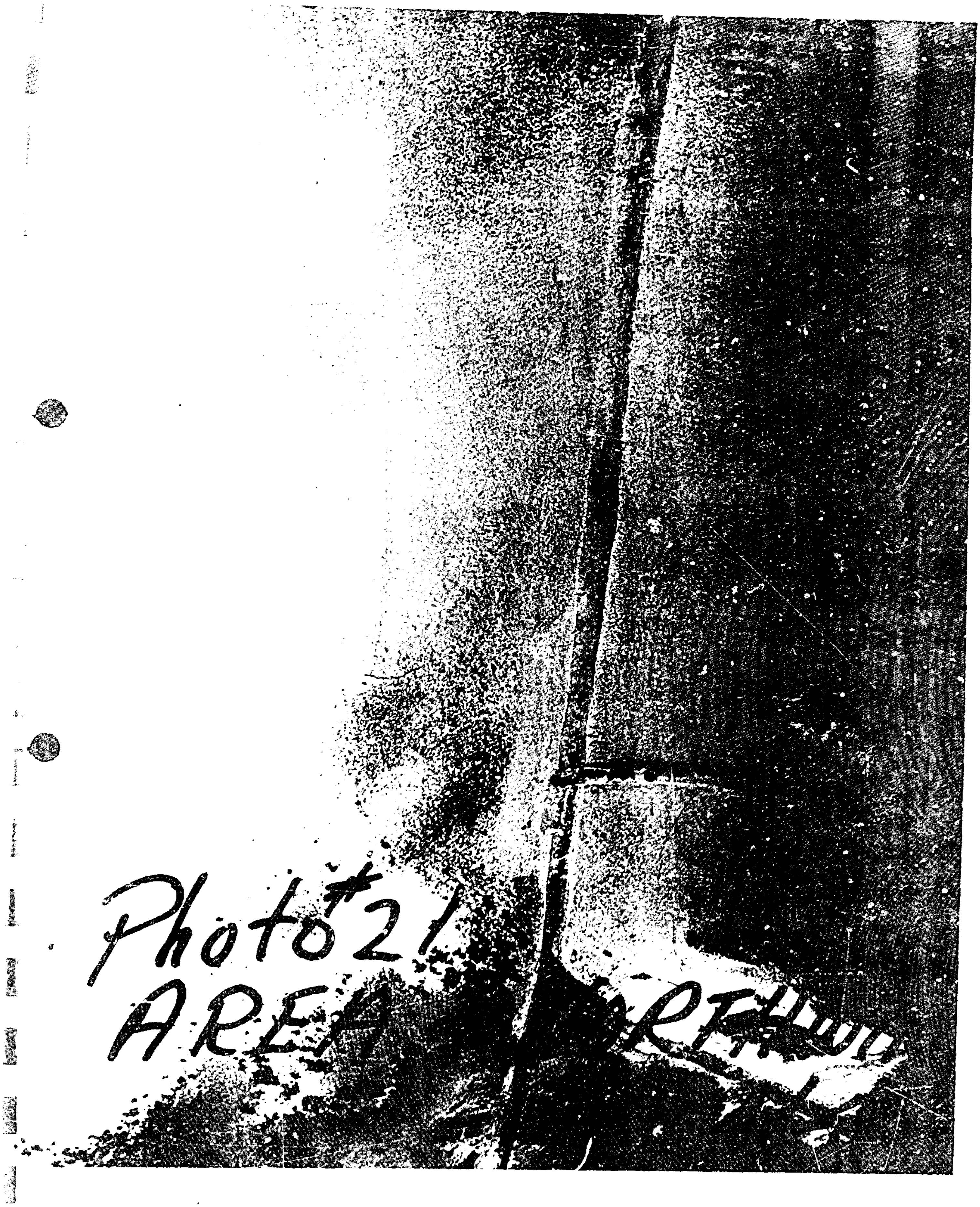
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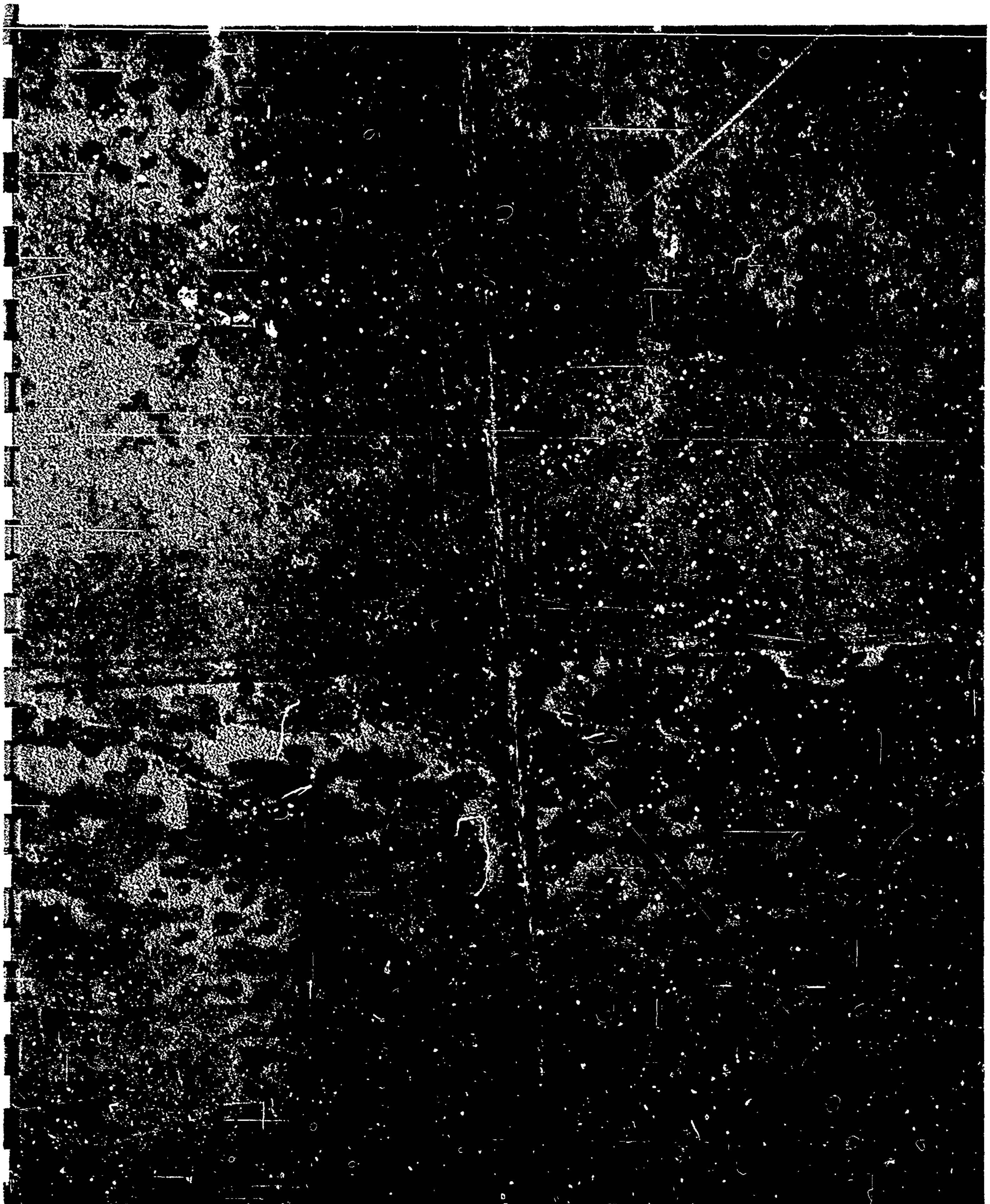

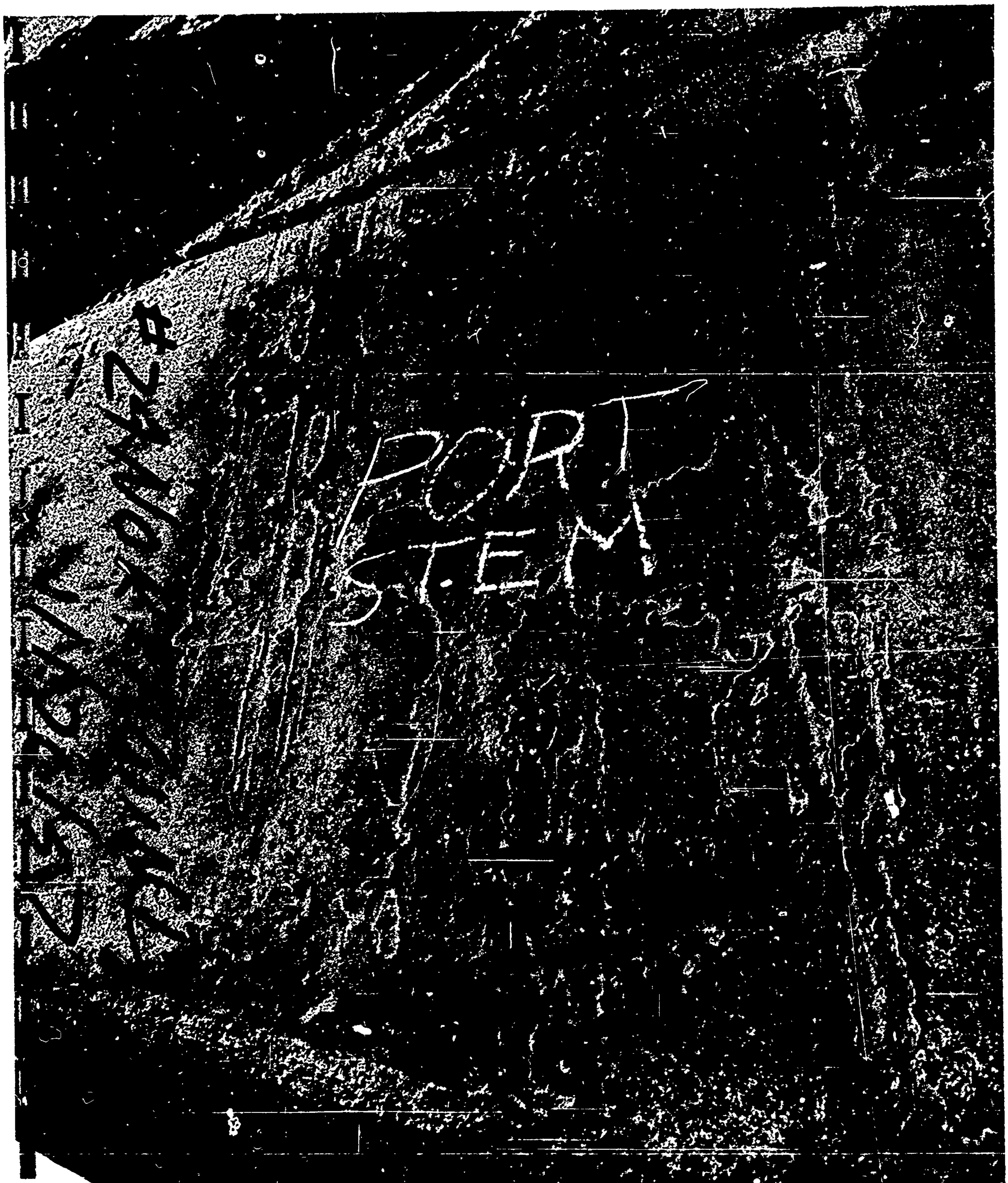
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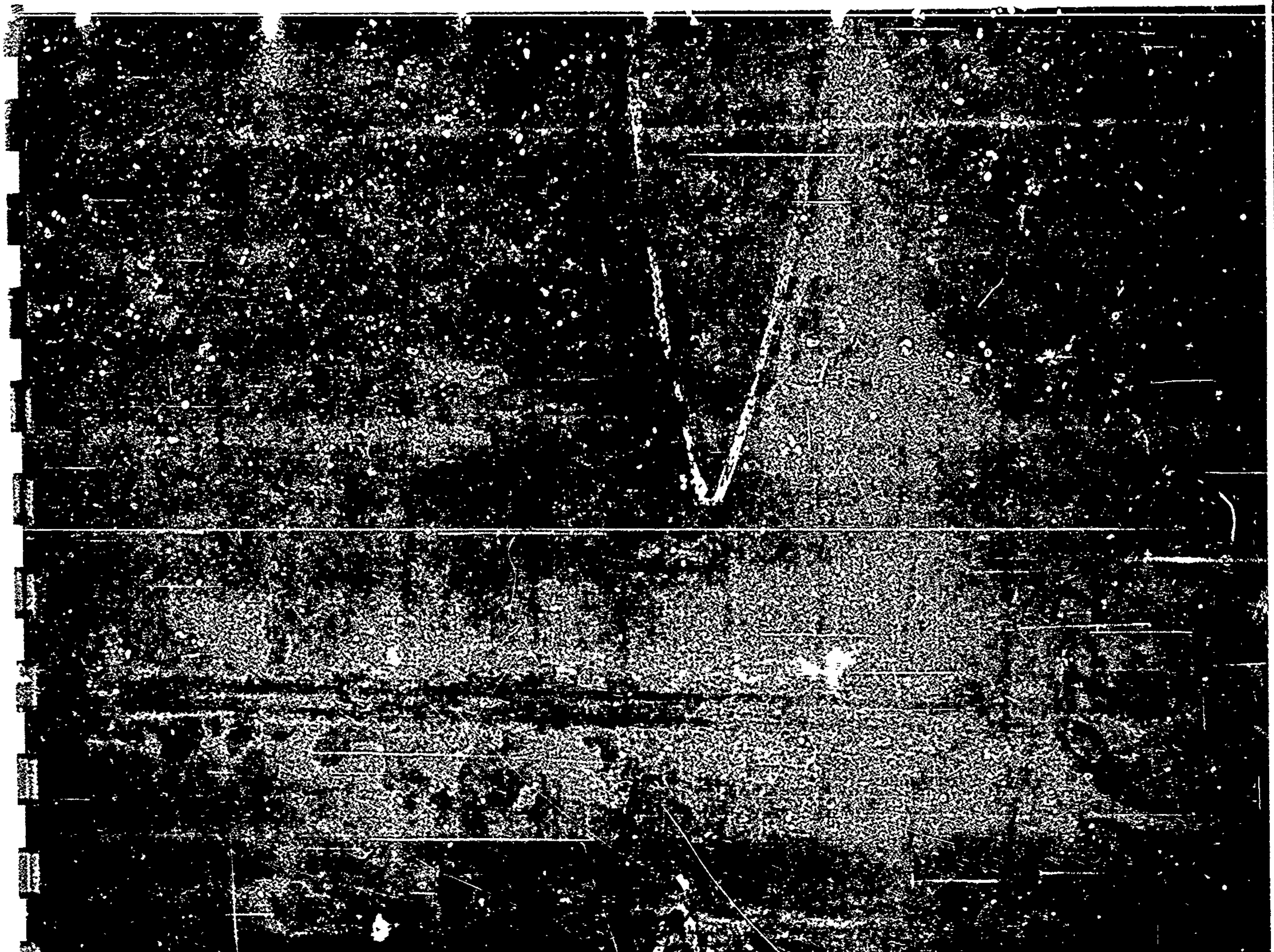

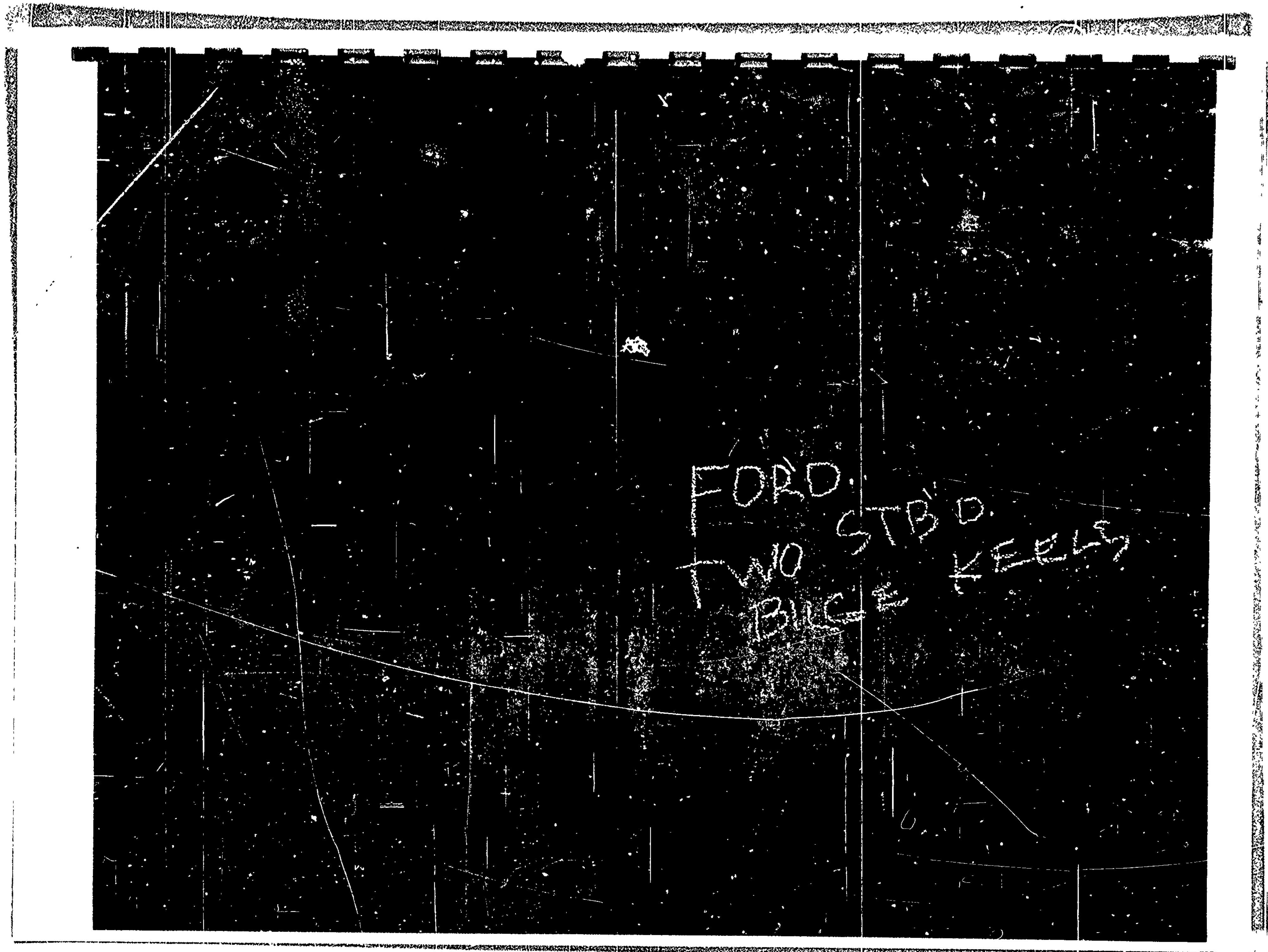
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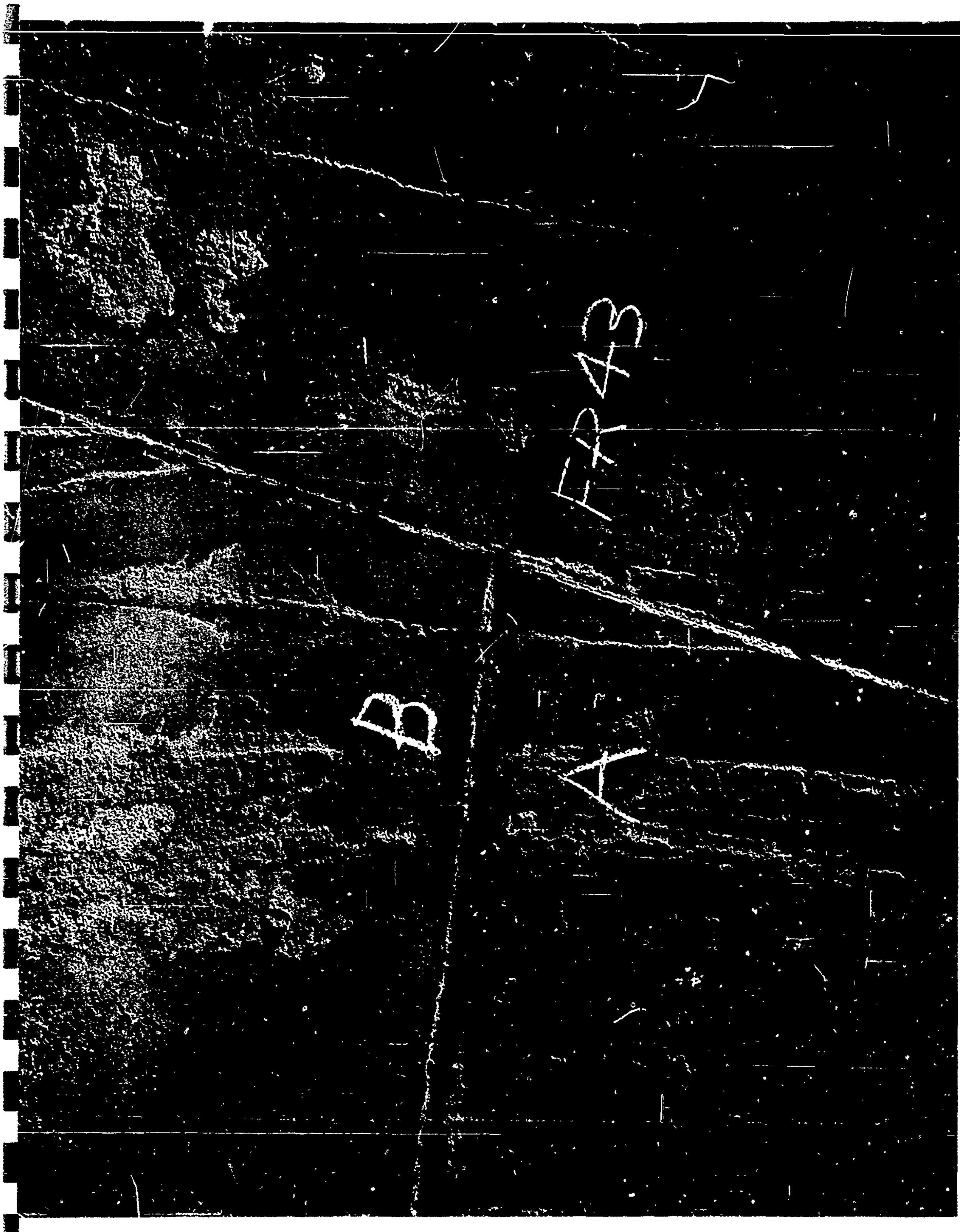
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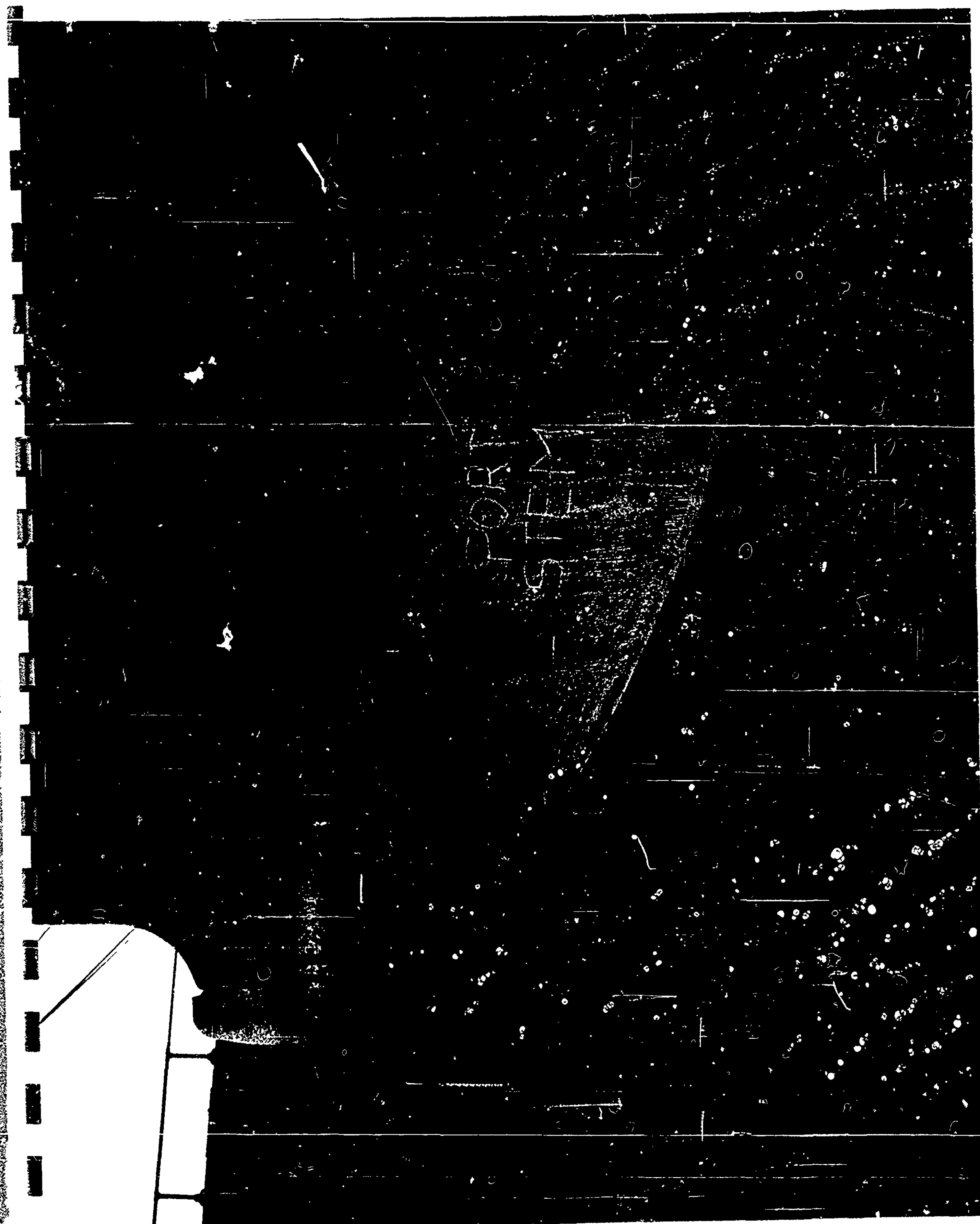

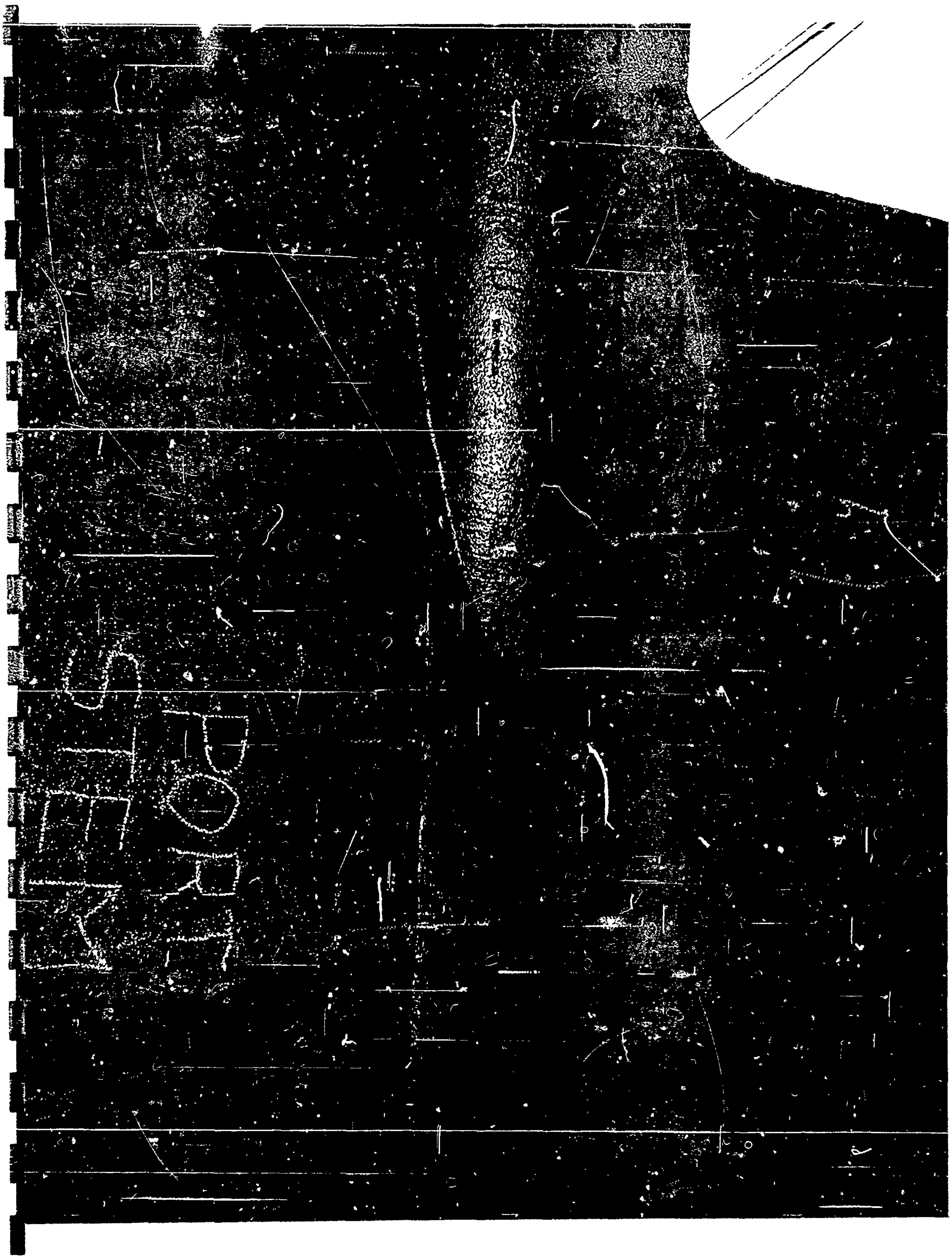

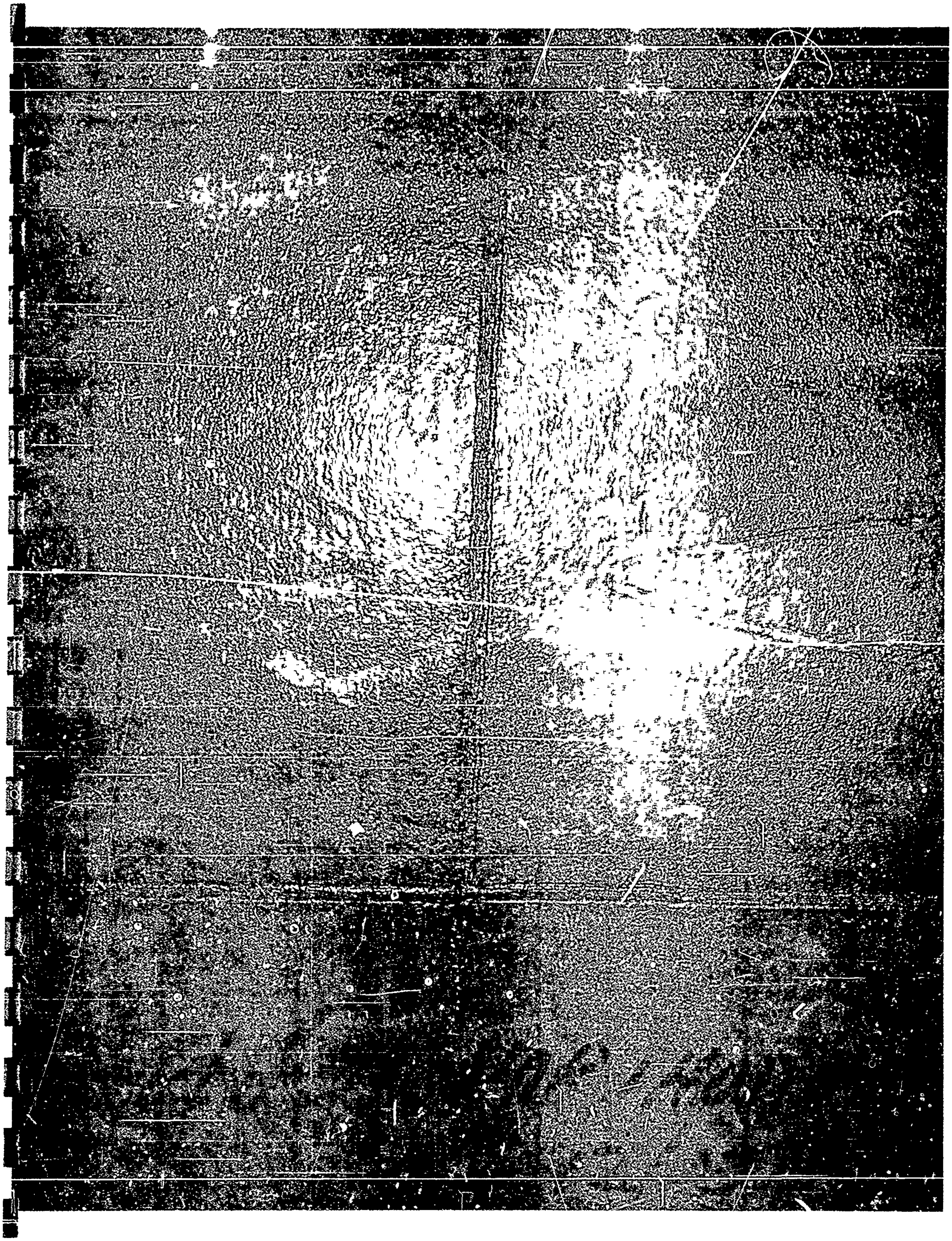

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