FOR OFFICIAL USE ONLY

621 000

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Project NY 340 033-4

Technical Note N-360

CORROSION STUDIES ASSOCIATED WITH AN AIR BLAST CLOSURE UNIT

30 July 1959

by
C. V. Brouillette

CONTENTS

FIGURE LEGEND

Figure 1. Moving parts of Closure Unit before exposure, View 1.

Figure 2. Moving parts of Closure Unit before exposure, View 2.

Figure 3. Moving parts of Closure Unit before exposure, View 3.

Figure 4. Air Blast Closure Unit, assembled.

Figure 5. Closure Unit after 3 months exposure.

Figure 6. Example of special test panel.
A- Cd plated cotter pin; B- Unplated cotter pin;
b- Cd plate; d-2024 Al

Figure 7. Test panels on exposure rack.
a-Mild steel; b-Cd plate; c- 6061 Al; d- 2024 Al.

Figure 8. Test panels after 3 months exposure.
a- Mild steel; b- Cd plate; c- 6061 Al; d- 2024 Al.

Figure 9. Test springs in sheltered specimen holder, before exposure.

Figure 10. Test Springs in sheltered specimen holder, before exposure.

Figure 11. Test springs in unsheltered specimen holders, before exposure.

Figure 12. Exposure of Closure Unit and sheltered test springs.

Figure 13. Unsheltered test springs after 3 weeks exposure.

Figure 14. Sheltered test springs after 3 weeks exposure.

Figure 15. Sheltered test springs after 3 weeks exposure.

Figure 16. Moving parts of Closure Unit after 11 months exposure, View 1.

Figure 17. Moving parts of Closure Unit after 11 months exposure, View 2.

Figure 18. Moving parts of Closure Unit after 11 months exposure, View 3.

Figure 19. Special test panels after 9 months exposure.
a- Mild steel; b- Cd plate; c- 6061 Al; d- 2024 Al

Figure 20. Close-up of special test panels after 9 months exposure.
A- Cd plated cotter pins; B- Unplated cotter pins;
b- Cd plated; c- 6061 Al; d- 2024 Al.

Figure 21. Close-up of working parts of Closure Unit after 11 months exposure.

Figure 22. Test springs after 9 months exposure.

Figure 23. Test springs after 9 months exposure.

SUMMARY

CORROSION STUDIES ASSOCIATED WITH AN AIR BLAST CLOSURE UNIT

OBJECT OF PROJECT

To carry out a research and development program which will furnish methods, procedures, and plans for shelters of the Naval Shore Establishment in order to protect personnel, vital equipment and supplies from AW attack.

OBJECT OF SUBPROJECT

To determine the suitability of the materials of construction of air blast closure units after extended periods of exposure to atmospheric conditions.

OBJECT OF REPORT

To present the results of an eleven month exposure of an air blast closure unit (600 CFM Army Chemical Center Unit) to the marine atmosphere at Port Hueneme, and to make recommendations for changes in construction materials in order to reduce deterioration by corrosion and extend the operational life of the closure unit.

RESULTS

The closure unit was inoperable after eleven months exposure in a marine atmosphere because of the formation of corrosion products. Various operational parts of the closure unit were cemented together by these corrosion products and the tension of the various small steel control springs had been destroyed.

ABSTRACT

The efficient operation of a mechanical device is very dependent upon the ease of movement of its various working parts. Eleven months exposure of an air blast closure unit, fabricated from a combination of several different metals and alloys, resulted in the formation of a sufficient quantity of corrosion products to render the closure unit of doubtful operational value.

It is recommended that neoprene rubber gasketing be used throughout; that the louver door frame and support brackets be fabricated from 6061 Aluminum Alloy; that all pins be cadmium plated and coated with an inhibited soft grease such as AN-C-124a, AM3 Type II; and that all springs be heavily coated with the inhibited soft grease.

INTRODUCTION

An air blast closure unit was forwarded to The Naval Civil Engineering Laboratory for the purpose of determining the resistance of its materials of construction (and those of similar shelter components) towards corrosion.

Operation of this unit depends upon freedom of movement of all working parts after long periods of inactivity during atmospheric exposure under various climatic conditions.

The closure unit was designed for use inside a sheltered air vent where it would be subjected to atmospheric condensations associated with climatic temperature changes. Unsheltered exposure of the closure unit to the marine atmosphere 150 feet from the breakwater at Port Hueneme, California, was considered to be an accelerated corrosion test for this unit.

DESCRIPTION OF TEST

The moving components of the closure unit were disassembled and photographed in order to record their outward appearance prior to exposure to a corrosive atmosphere. The closure unit was reassembled and placed on exposure with the vent opening facing the breakwater to the south, approximately three feet from the ground and at a distance of approximately 150 feet from the ocean. The prevailing wind is westerly, but fine salt spray normally carries to the area where the closure unit was exposed.

Figures 1, 2. and 3, show the functional parts of the closure unit. The unit has two openings, one above the other, with duplicate parts as shown in the figures.

Figures 1 and 2 view the closure assembly from the inside. Figure 1 shows the doors closed and Figure 2 shows the doors open.

Figure 3 views the closure assembly from the outside with the doors closed. The linkages have been turned here to show the outer sides.

Figure 4 shows the assembled closure unit when placed on the atmospheric exposure rack.

Parts may be identified by the numbers placed on the figures.

Identifying Numbers:

1. Mild steel frame containing from 1 - 2 mils of enamel primer coating.
2. Foam rubber gasketing materials used as seals between the frame and the louver doors.
3. Louver doors fabricated from 2024 aluminum alloy.
4. Mild steel linkage, cadmium plated.
5. Linkage fabricated from 6061 aluminum alloy.
6. Lock lever fabricated from 6061 aluminum alloy.
7. Steel springs, uncoated, approximately 0.035 in. piano wire.
8. Round steel pins, (a) cadmium plated, (b) uncoated or plated. (Note one pin near identifying number 8b which was in bad condition as received).
9. Cotter pins, mild steel, uncoated.
10. Mild steel housing of closure unit containing 1 - 2 mils of primer coating.
11. U-shaped mild steel brackets or supports.

The small steel springs (Figures 1,2,3. Item 7) used in the closure unit did not contain a protective coating or plating. Because these springs are essential to proper functioning of the closure unit, tests were initiated to find a means to protect them from corrosion.

Test springs were formed from 0.033 inch piano wire and closely resembled the large spring in the closure unit in size and length. Forty springs were prepared and twenty of these were cadmium plated. A soft film inhibited grease (AN-C-124a - AM3 Type II) coating was applied to ten of the plated and ten of the unplated springs. The springs were then placed in specimen holders in such a way that five plated and five unplated test springs were in each of four specimen holders. One sheltered (Figure 9) specimen holder contained grease coated springs and one (Figure 10) contained ungreased springs. Greased and ungreased springs were also placed on unsheltered specimen holders. (Figure 11)

The supports for the springs were spaced on the specimen holder so that a tension was placed on the springs which approximated the tension on the larger spring in the closure unit. The hooks, or supports, for the springs were coated with paint. One end of the spring was electrically insulated by use of a plastic sleeve placed over the end of the springs in unsheltered exposure (Figure 11) and by use of a fiberglass rod for one support in the sheltered exposure (Figures 9 and 10). The unsheltered test specimens were placed on the atmospheric corrosion rack adjacent to the special metal test panels (Figure 7). The sheltered specimen holders were fastened to the side of the table which supported the air blast closure unit (Figure 12). The front cover of one sheltered specimen holder was partly removed for this picture to show the arrangement of the test springs. The sheltered specimen holders were open at the bottom thus permitting exposure to marine fog but giving protection from sun, rain and ocean spray.

Several different metals and alloys were used in contact with one another in the assembled closure unit. In the presence of condensed moisture, corrosion between dissimilar metals is accelerated. The corrosion products thus formed could interfere with proper operation of the closure unit. To study this effect, special test panels were designed. These test panels consisted of a 4" x 9" metal test panel which supported a 4" x 4" metal test panel (Figure 6). The smaller test panel is held in place on top of the 4" x 9" test panel by cadmium plated pins containing a cotter pin in each end. The two sizes of test panels were assembled in such a way that all combinations of mild steel, cadmium plated steel, 6061 aluminum alloy, and 2024 aluminum alloy were obtained. The assembled panels were placed on the atmospheric corrosion rack located near the corrosion test site used for the air blast closure unit, (Figure 7). In the vertical columns of Figure 7, the larger test panels (4" x 9") are, left to right: (a) mild steel, (b) cadmium plated steel, (c) 6061 aluminum alloy, and (d) 2024 aluminum alloy. The small test panels (4" x 4") are: bottom row, (a) mild steel, second row (b) cadmium plated steel, third row (c) 6061 aluminum alloy, and top row (d) 2024 aluminum alloy. Cadmium plated cotter pins were used in the pins on the left (Figure 6A) and plain mild steel cotter pins were used in the pins on the right (Figure 6B).

INITIAL TEST RESULTS

Closure Unit

Figure 5 shows the closure unit after exposure in a marine atmosphere for three months. The housing of the closure unit was coated with a thin olive drab enamel (1 - 2 mils) which would not be expected to protect steel in a marine atmosphere. This coating has failed after three months exposure and rust was formed over the whole housing and the steel frame (1). Inside the housing, water had collected to a depth of 1-1/2 inches from a rain that had occurred two days before inspection. Two weeks lapsed before it completely evaporated. Rust also occurred on the iron cotter pins (9), the steel springs (7), and the steel pins (8b). The steel springs showed the most severe rusting. The cadmium plated pins (8a) and the cadmium plated steel linkage (4) show no signs of corrosion attack. The 6061 aluminum alloy linkage (5) shows a slight amount of corrosion but the 2024 aluminum louver doors (3) are showing a considerable amount of aluminum salts and thus are rapidly pitting. The foam rubber gasketing material (2) was not resilient at the start of the test and does not appear to provide an air tight seal between the frame and the louver doors. However, dynamic air pressure tests on the sealing ability of this material, in place on the closure unit, were not made.

Test Specimens

No corrosion was observed on the cadmium plated panels after three weeks exposure. Very slight general attack appeared on the 6061 aluminum alloy and slight pitting attack appeared on the 2024 aluminum alloy. The mild steel shows normal rust over the whole surface of the panel (Figure 8).

Examination of the edges of the smaller (4" x 4") panels at the point of contact with the larger panels showed that some corrosion products had formed between the iron to iron panels (Figure 8, a-a). No corrosion which can be attributed to metal to metal contace was observed at this time between the remaining pairs of metal panels.

The uncoated iron cotter pins (right side of panels) were corroding rapidly but the cadmium plated cotter pins (left side of panels) showed no corrosion.

The condition of the test springs after three weeks of both unsheltered and sheltered exposure is shown in Figures 13, 14, and 15. Severe corrosion was observed on the bare steel springs in unsheltered exposure (Figure 13 - not greased - odd numbered). The corrosion of the springs in the sheltered exposure was considerably less (Figure 14). The bare steel springs containing the grease coating appeared to be protected satisfactorily in both types of exposure. Very slight corrosion attack was observed on the cadmium plated steel springs in unsheltered exposure (Figure 13 - not greased - even numbered), and no attack was observed on these springs in sheltered exposure (Figure 14). The greased cadmium springs showed no attack by corrosion in either type exposure.

FINAL TEST RESULTS

The closure unit was removed from continuous unsheltered exposure at Port Hueneme, California, after approximately eleven months. The test specimens and panels were removed after approximately nine months exposure.

Figures 16, 17, and 18, show the functional parts of the closure unit as they appeared at the end of the eleven months exposure to marine atmosphere at Port Hueneme. Figures 16 and 17 view the closure assembly from the inside. Figure 16 shows the louver doors closed and Figure 17 shows them open. Figure 18 views the closure assembly from the outside with the doors closed; the linkages have been turned over in order to view the convex or outer surface.

The foam gasketing material (2), Figures 16, 17, and 18, appeared to be a cellulose product and was in poor condition. After five months atmospheric exposure, a specimen of neoprene foamed rubber and a specimen of butyl foamed rubber were superior to the cellulose material in flexibility and resilience. The neoprene rubber was in better condition than the butyl rubber.

The 2024 aluminum alloy doors (3) showed very mild pitting over the entire surface, both on the inside and outside areas. These pits were covered with aluminum salts or corrosion products and were so shallow that their depth was not discernable with the eye. The strength of the louver doors would not be weakened as a result of this corrosion.

The 6061 aluminum alloy linkage (5) and lock or latch lever (6) were corroded in the same manner as the 2024 aluminum alloy doors. The larger pits on the linkage measured 0.0001 inch, but were only slightly discernable on the lock lever. The strength of the linkage and lock lever did not appear to be impaired.

The steel springs (7) were severly corroded. The spring tension was reduced to such an extent that the springs would not return to their original position after being very slightly extended.

The steel pins (8a), which were cadmium plated, were very slightly corroded. The steel pins (8b) containing no plating were corroded so badly that the lock lever (6) would not operate. The cadmium plated steel linkage (4) could be operated manually in either direction only with extreme difficulty. The unplated steel pins were reduced in diameter by approximately one-third by corrosion attack. Likewise, the steel cotter pins (9) and the unplated pins (8b) were cemented together by corrosion products so that the cotter pins could not be removed without breaking them apart.

The corrosion on the specially prepared metal test panels, Figures 19 and 20, was of the same severity as that which occurred on similar metal combinations of the closure unit. However, the contact between the large and small metal test panels did not result in increased corrosion products, and the small panel was easily lifted from the larger panel. Corrosion products were not sufficient in quantity to cause the two panels to become cemented together during the period of exposure (Figure 20). Possibly sufficient aeration was present to prevent a condition of prolonged dampness between the panels. As expected, the unplated steel panels (a) were severely corroded. The cadmium plated panels (b) were free of corrosion attack. The cadmium plating on the metal test panels measured 0.001 inches and is considered a heavy coating. The 6061 aluminum alloy (c) and the 2024 aluminum alloy (d), Figure 20, showed varying amounts of corrosion products over their entire surfaces. The quantity of corrosion products appeared to be slightly more on the 2024 aluminum alloy (d), than on the 6061 aluminum alloy (c). However, the pitting which occurred beneath the corrosion products appear to be insignificant in either case and was not measured.

In Figures 19 and 20 the cotter pins at the left (a) were cadmium plated and those on the right (b) were uncoated mild steel. The round steel pins which held the two metal panels together were cadmium plated and were not corroded. However, the steel cotter pins which were not cadmium plated (b) corroded so badly that they broke apart and could not be removed from the hole in the end of the round steel pins. The cadmium plated cotter pins (a) were corroded but could be loosened in the holes at the end of the round steel pins, yet they were sufficiently weakened by corrosion that they also broke apart upon being removed from the round steel pins.

Figure 21 shows the area of corrosion which resulted in severe damage to the working parts of the closure unit. As previously mentioned, the steel springs (7) were rusted so badly that they would not return to their normal contracted position after being removed from the unit. The two U-shaped brackets (11a, 11b) which support the cadmium plated steel linkage (4) and lock lever (6) were also severly corroded. The steel pins (8b) were cemented to these brackets by corrosion products. The corrosion products also caused the lock lever (6) and the cadmium plated steel linkage (4) to be so tightly bound in the brackets as to be inoperative.

The steel test springs, Figures 22 and 23, show the beneficial effect of a combination of cadmium plating and soft inhibited grease coating in marine atmospheric exposure (a,b, - even numbers). These springs were completely protected from corrosion in sheltered exposure (b), Figure 22, and only very slightly attacked in open exposure (a). The unplated steel springs which were grease coated were slightly corroded in sheltered exposure (b - odd numbers), Figure 22, and were severly corroded in open exposure (a - odd numbers). Corrosion was so severe on the ungreased springs in open exposure (a), Figure 23, that the cadmium plated springs could not be distinguished from the unplated springs. Corrosion was quite uniform and heavy on the sheltered unplated steel springs (b-odd numbers), Figure 23, which were not greased but appeared mostly at the ends of the cadmium plated springs in the same exposure (b-even numbers).

CONCLUSIONS

All moving parts of the closure unit fabricated from steel were badly corroded. The small steel springs were corroded so badly that they had lost their tension and were inoperative. Aluminum corrosion products appeared randomly over the surface of all aluminum parts and mild pitting occurred beneath the corrosion. The aluminum alloy 2024 was corroded slightly more than the 6061 aluminum alloy. However, the cadmium plate on the steel parts gave complete protection when a heavy cadmium plate was used. But, the plating on the cotter pins was not heavy enough to give good protection. As mentioned previously, the foam gasketing material was non-resilient, even at the beginning of the test, that it appeared to have no value as a seal between the louver doors and the door frame

RECOMMENDATIONS

The following changes are recommended to reduce the deterioration by corrosion to a minimum and to extend to a miximum the efficient operational life of the closure unit:

1. Use neoprene foam rubber for the gasketing material (2), Figures 1, 2, and 3.
2. Fabricate the louver frame, (1) Figures 1, 2, and 3, and brakets (11a, 11b) Figures 3 and 21, from 6061 aluminum alloy.
3. All supporting pins (8) and cotter pins (9), Figures 16, 17 and 18, should be heavily cadmium plated (0.001 inch) and grease coated with an inhibited soft grease such as AN-C-124a,AM3 Type II.
4. All metal springs should be coated with an inhibited soft grease such as AN-C-124A, AM3 Type II.

No changes are recommended in the existing aluminum alloy or cadmium plated parts. It is stressed that the cadmium coat should be heavy (0.001 inch).

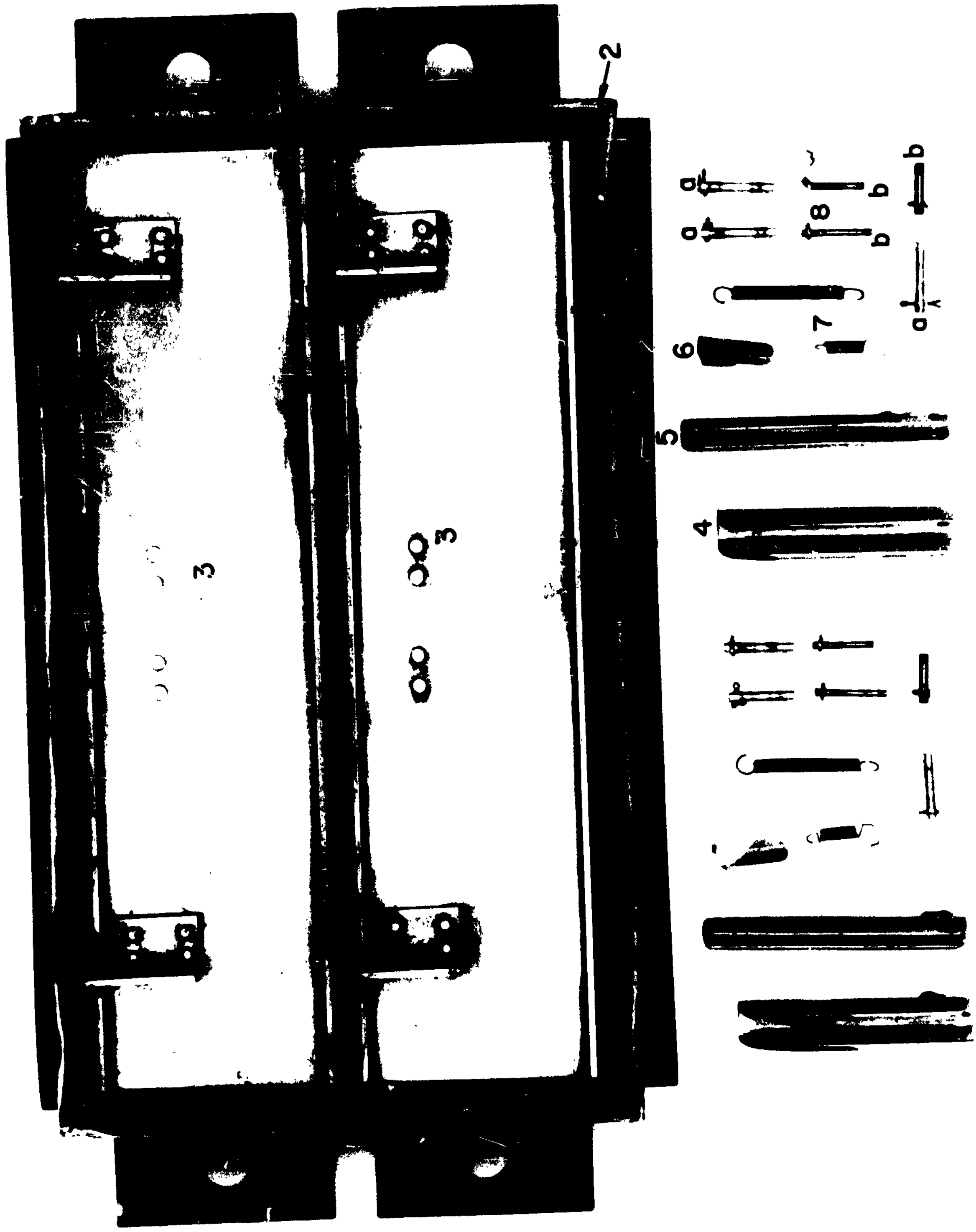


Figure 1. Moving parts of Closure Unit before exposure, View 1.

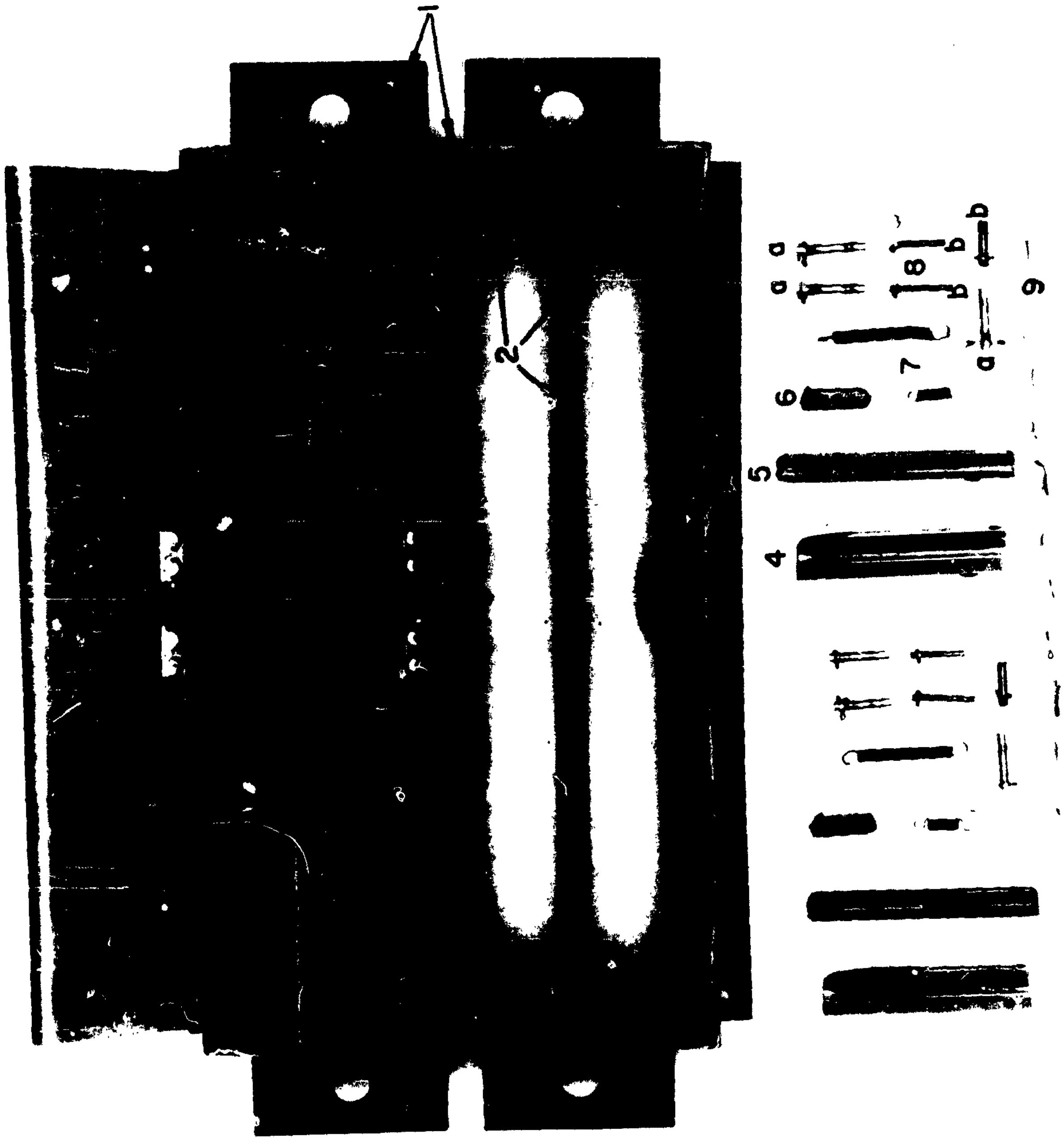


Figure 2. Moving parts of Closure Unit before exposure, View 2.

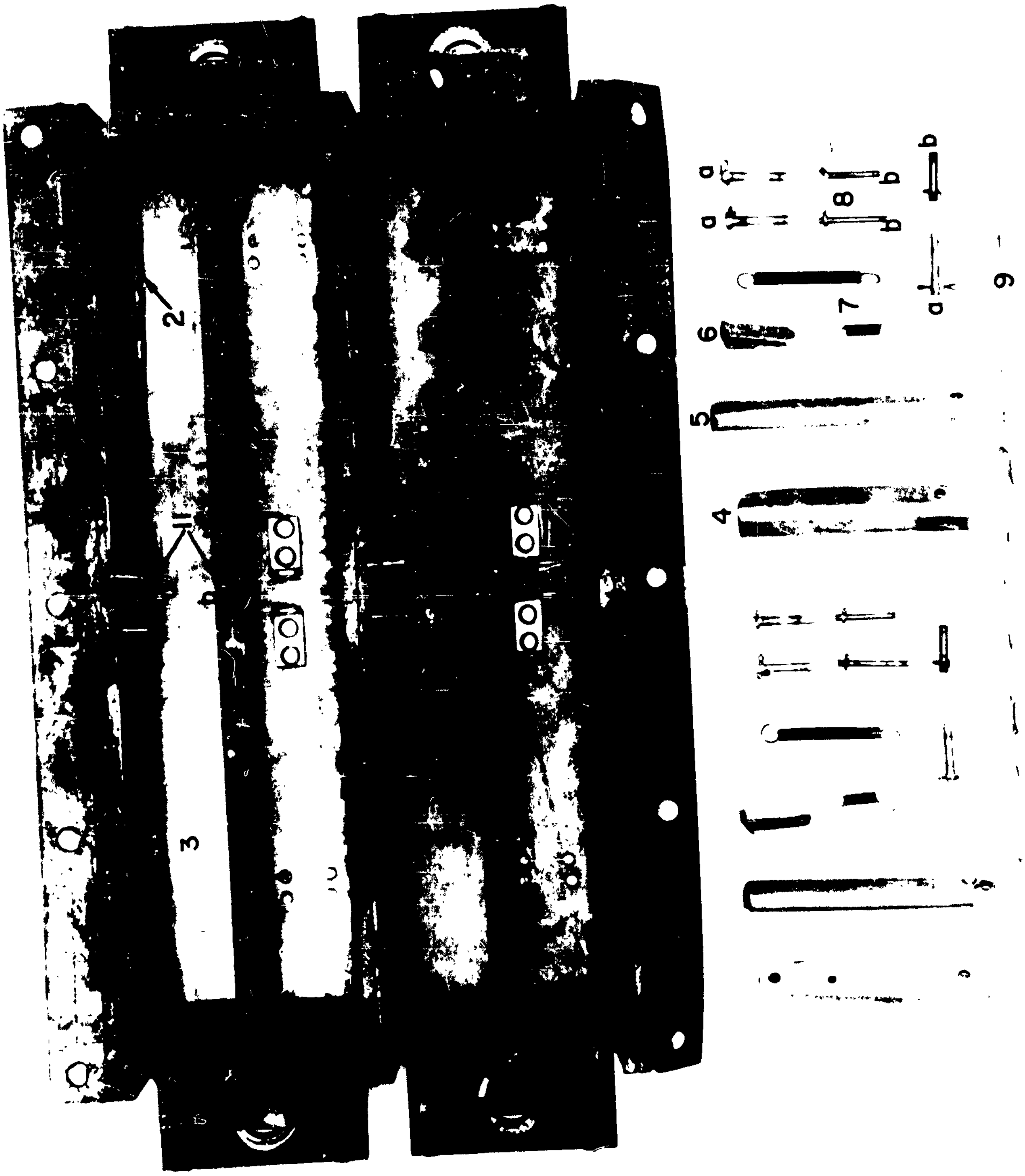


Figure 3. Moving parts of Closure Unit before exposure, View 3.

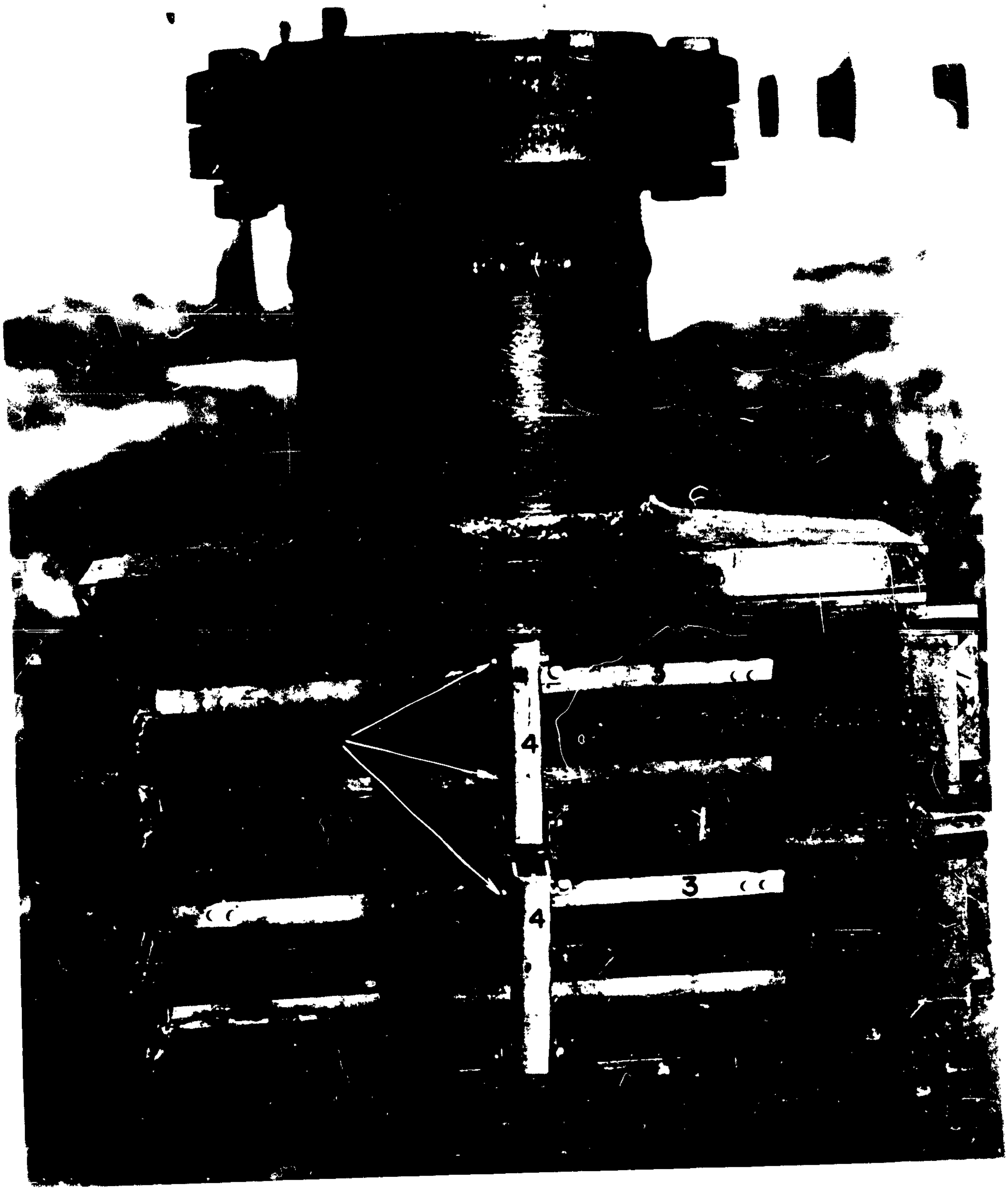


Figure 4. Air Blast Closure Unit, assembled.

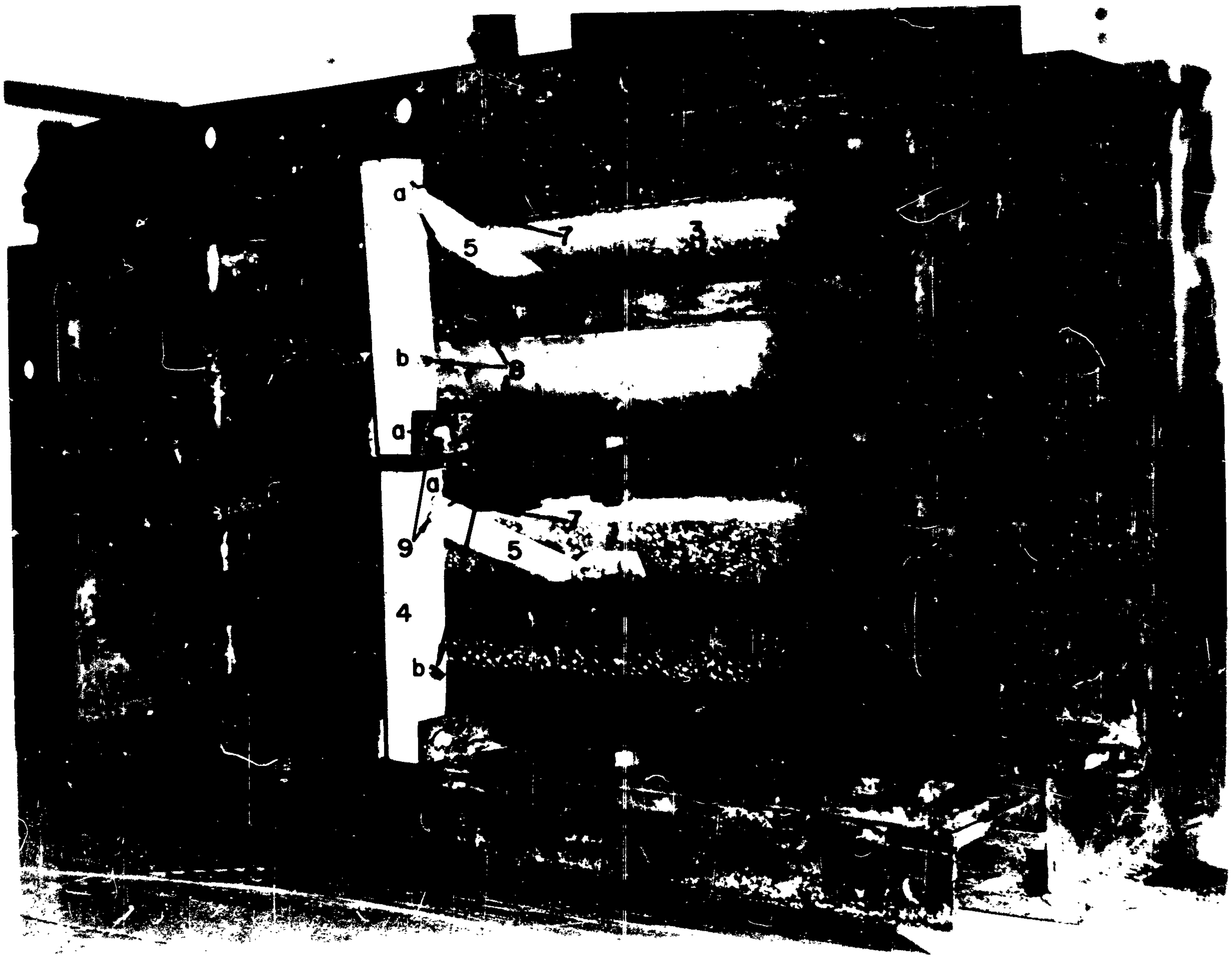


Figure 5.   Closure Unit after 3 month exposure.

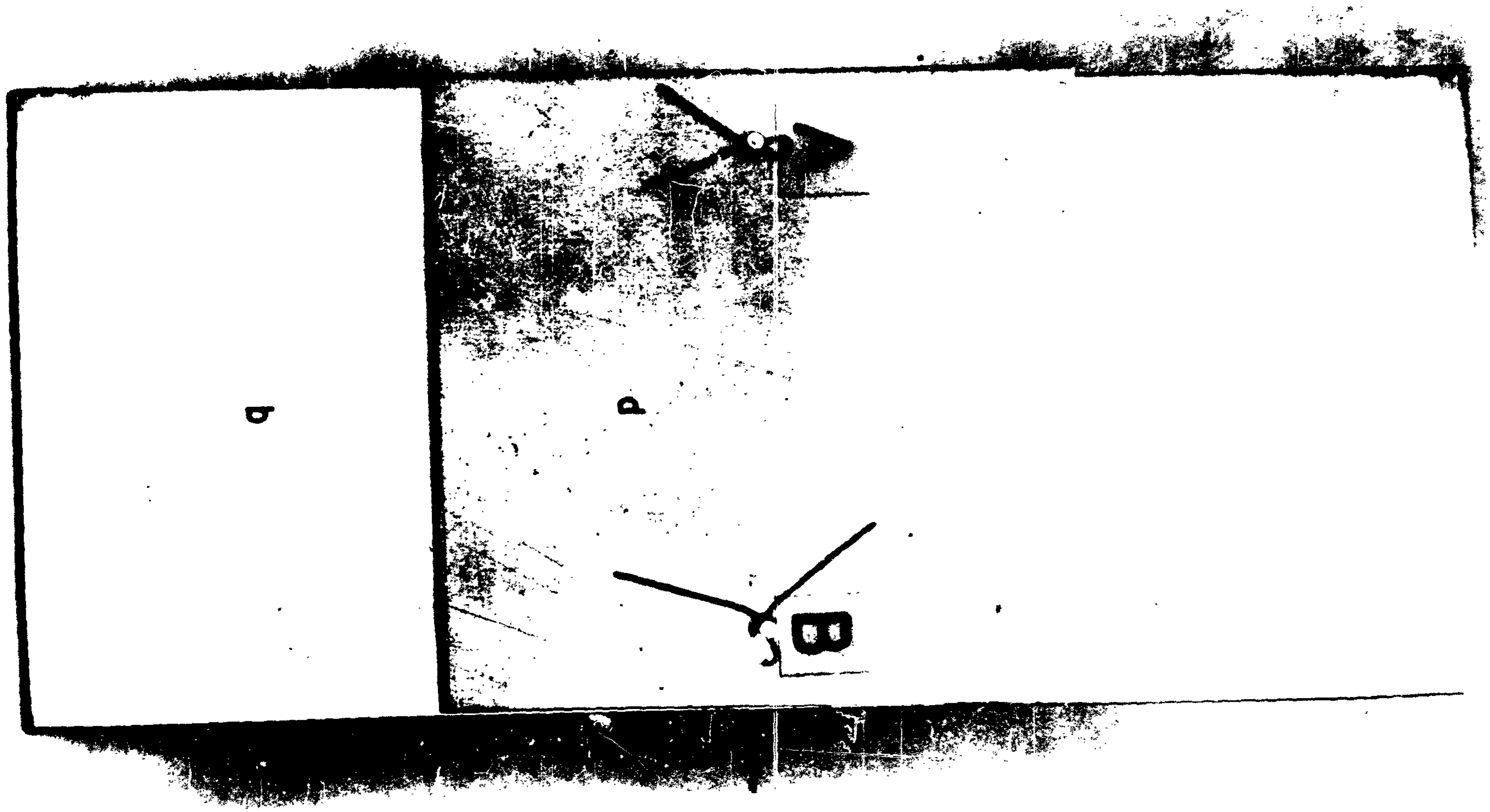


Figure 6. Example of special test panel. A–Cd plated cotter pin; B–Unplated cotter pin; b–Cd plate; d– 2024 Al.

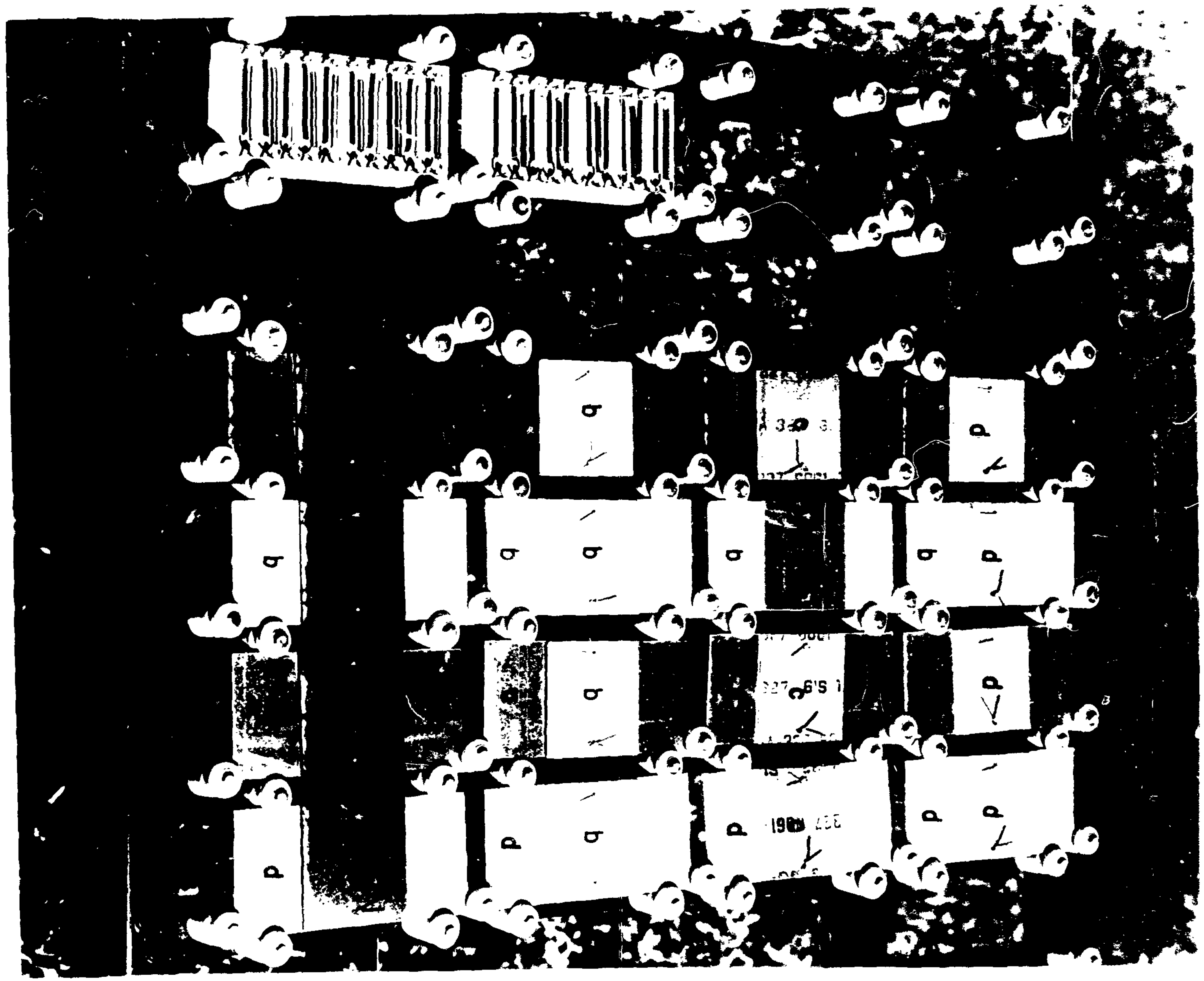


Figure 7. Test panels on exposure rack. a- Mild steel; b- Cd plate; c- 6061 Al; d- 2024 Al.

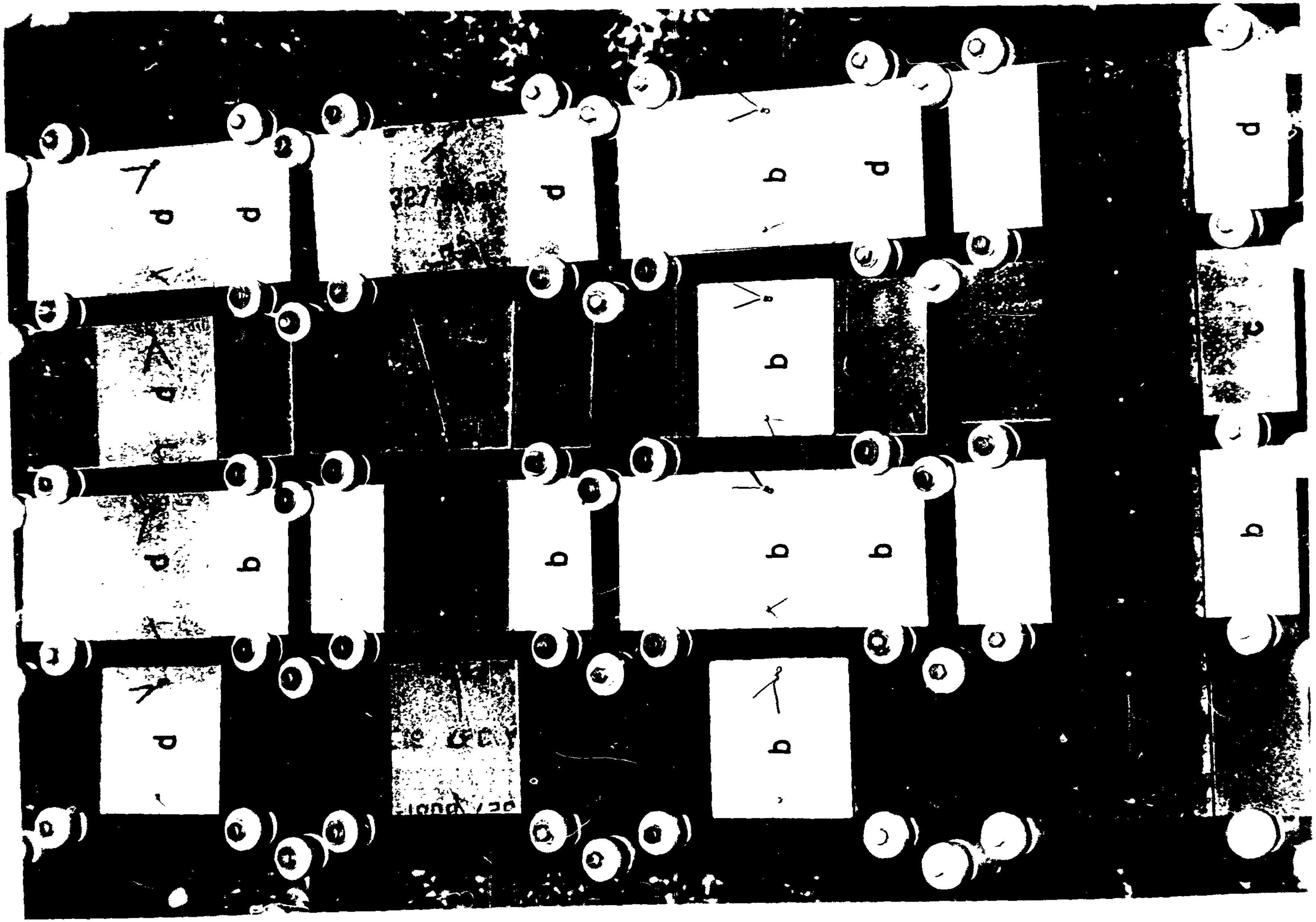
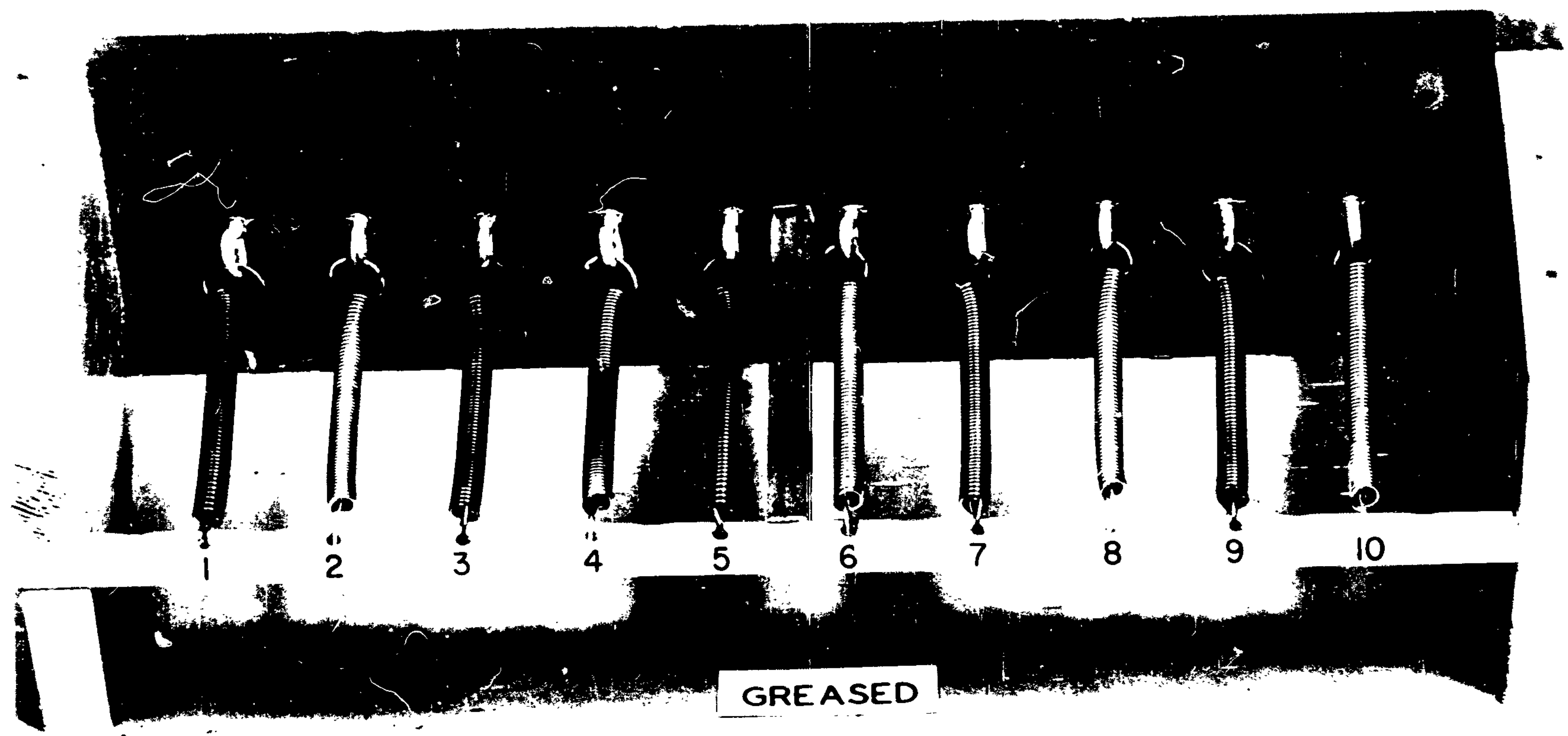


Figure 8. Test panels after 3 month exposure. a- Mild steel; b- Cd plate; c- 6061 Al; d- 2024 Al.


1
2
3
4
5
6
7
8
9
10
GREASED

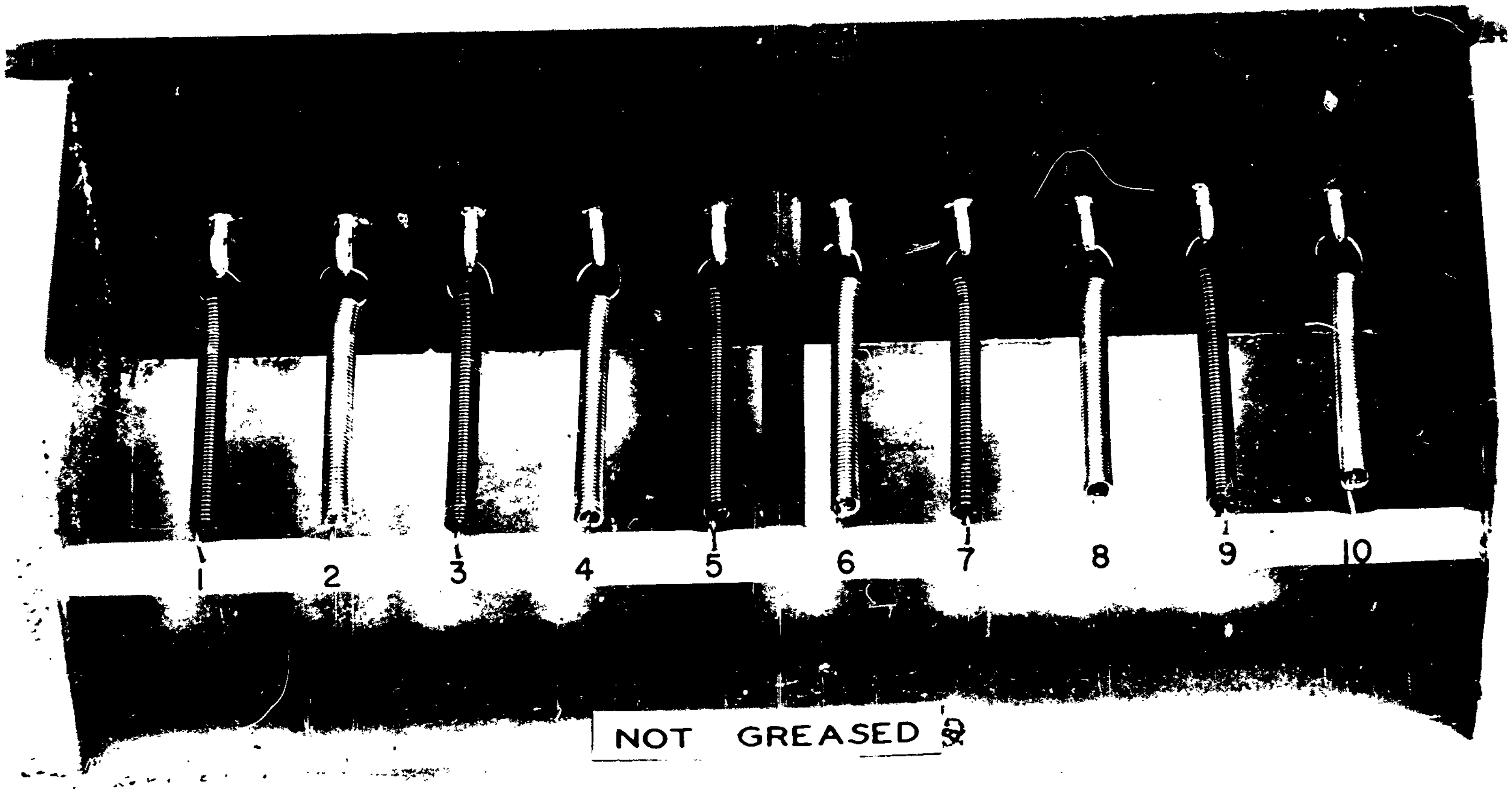


Figure 10. Test springs in sheltered specimen holder, before exposure.

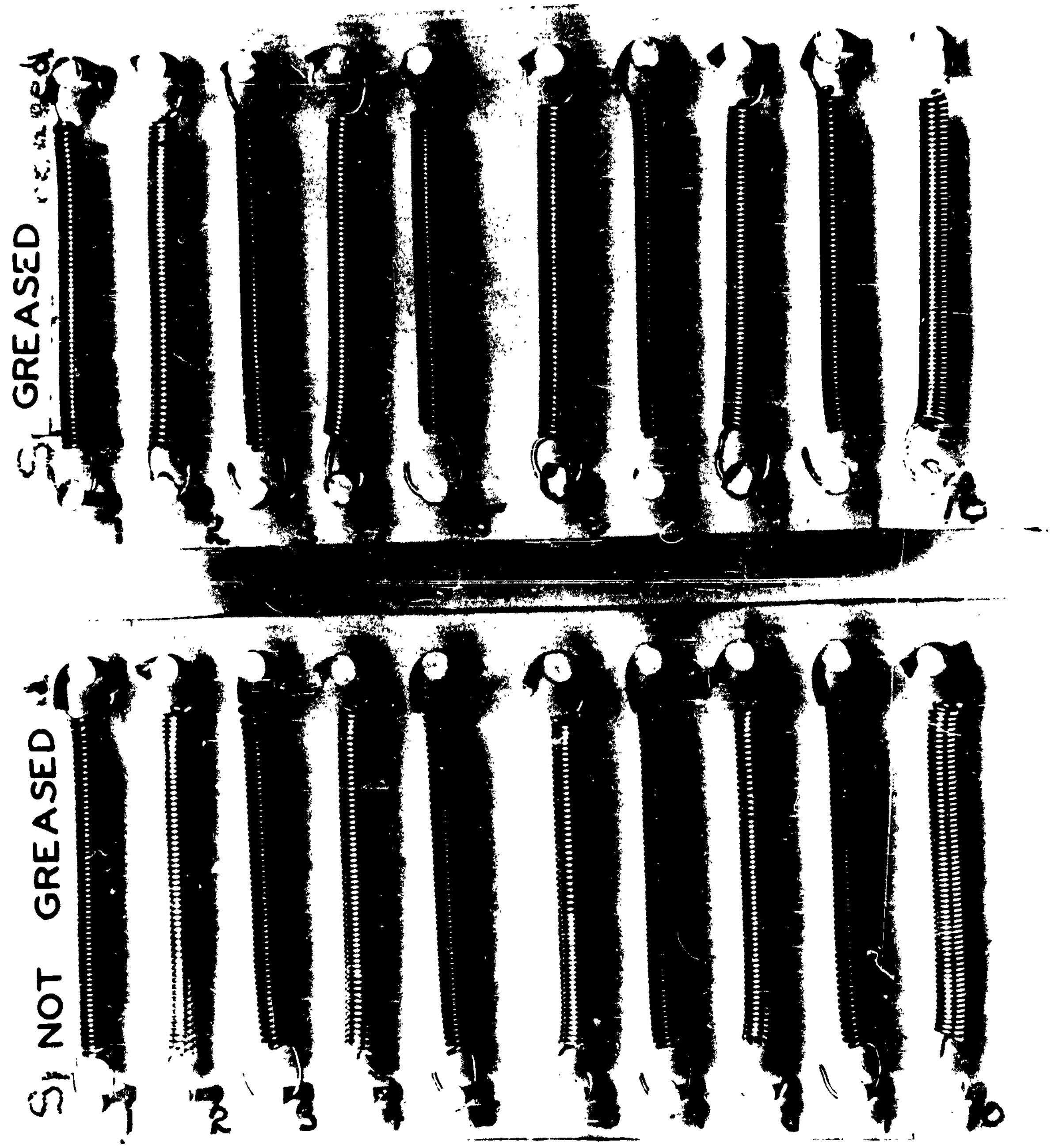


Figure 11. Test springs in unsheltered specimen holders, before exposure.

Figure 12. Exposure of Closure Unit and sheltered test springs.

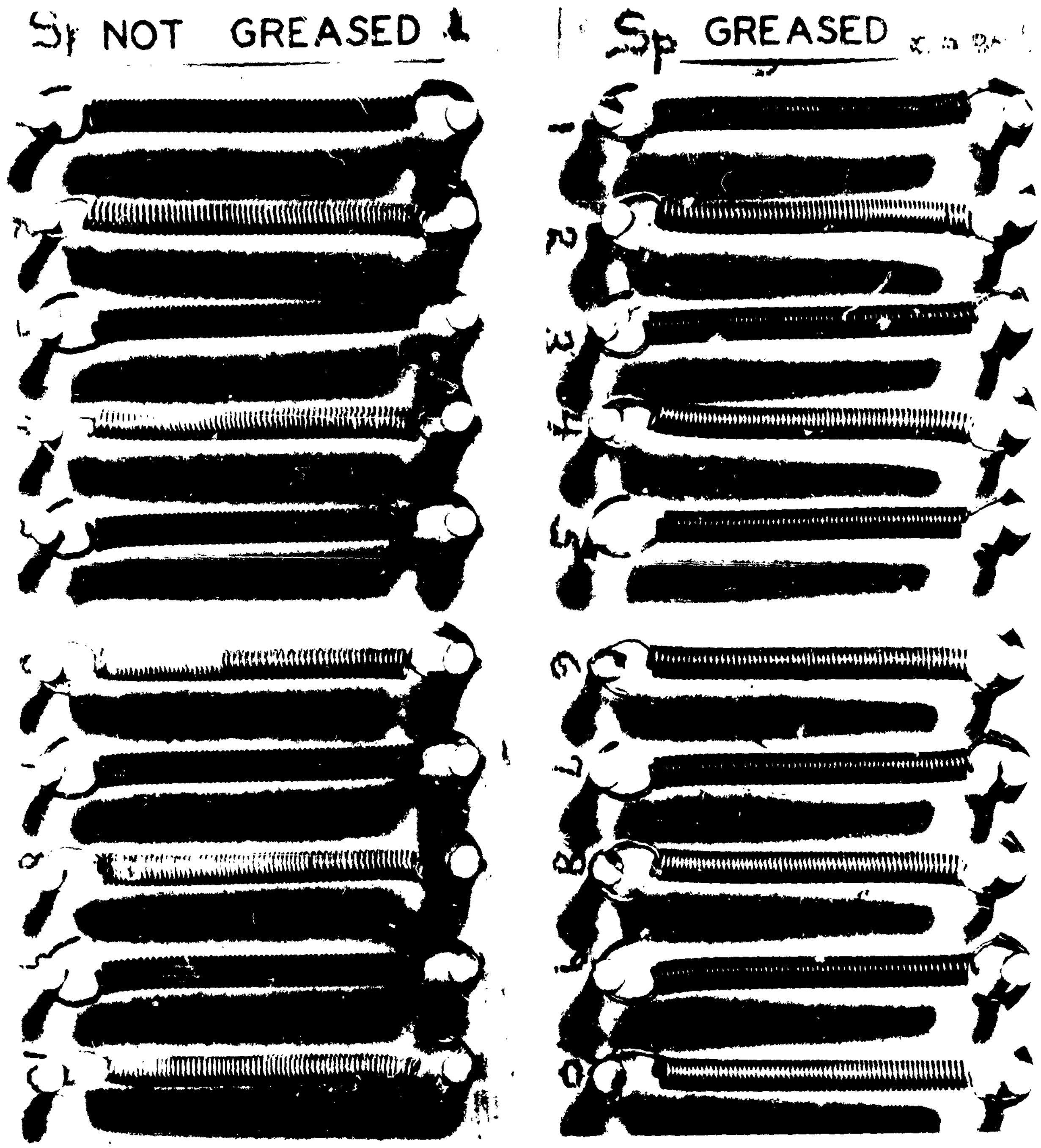


Figure 13. Unsheltered test springs after 3 weeks exposure.

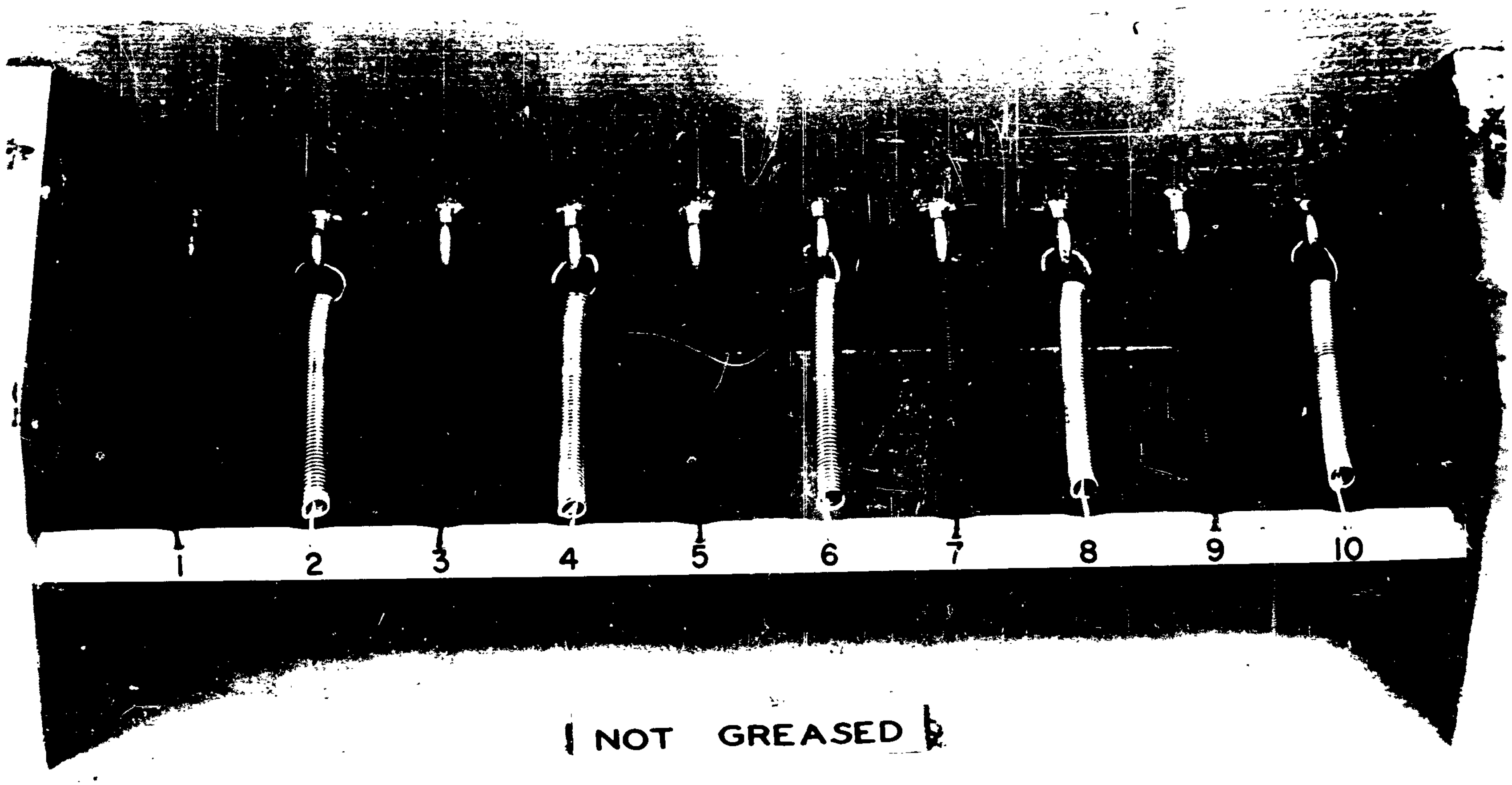


Figure 14. Sheltered test springs after 3 weeks exposure.

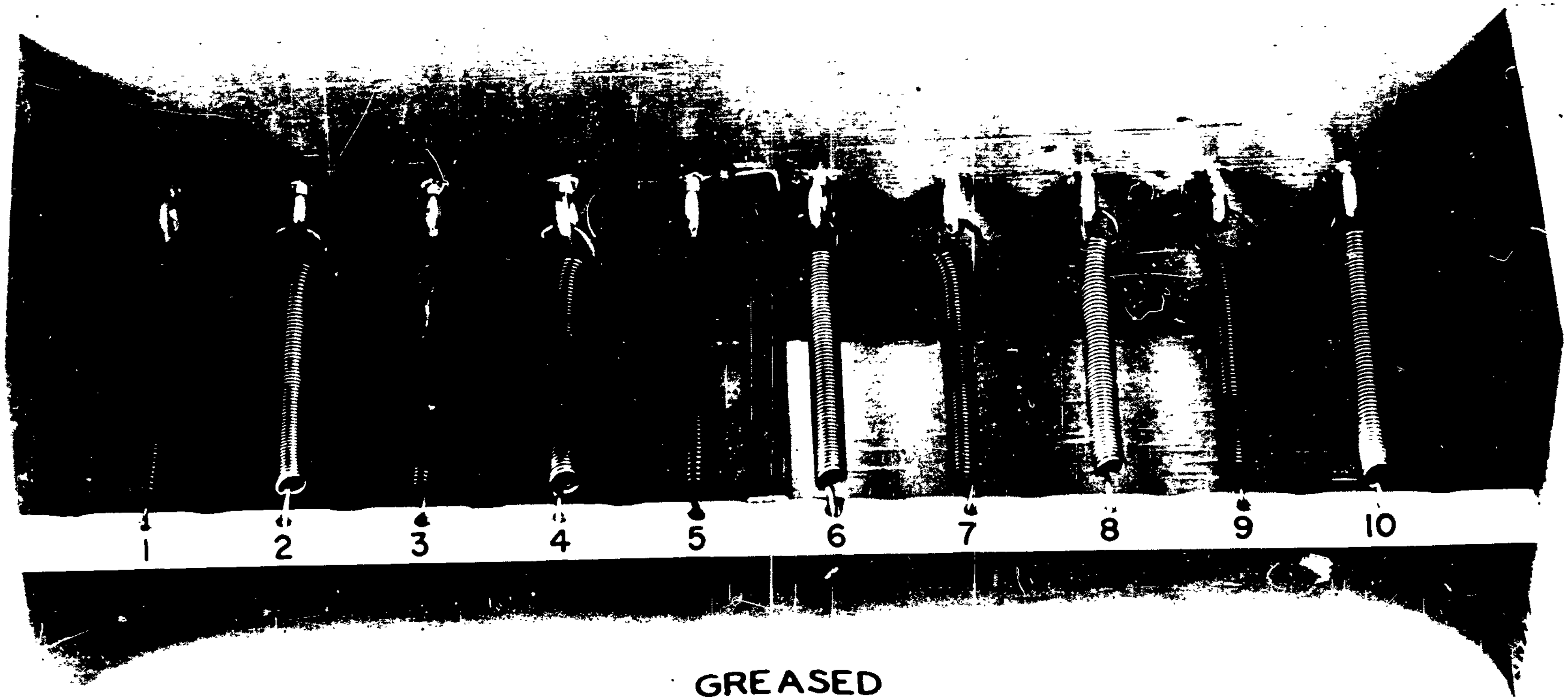


Figure 15. Sheltered test springs after 3 weeks exposure.

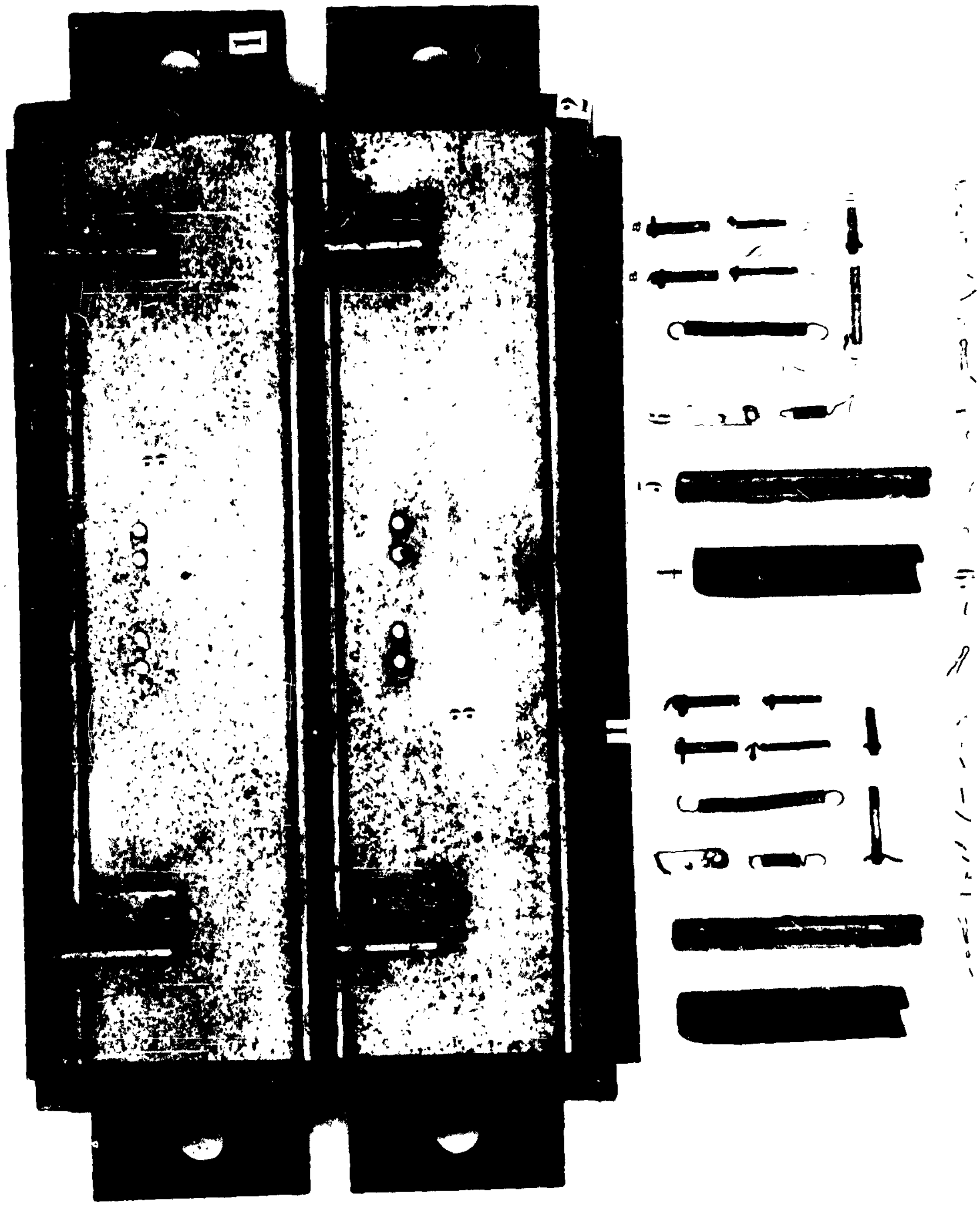


Figure 16. Moving parts of Closure Unit after 11 months exposure, View 1.

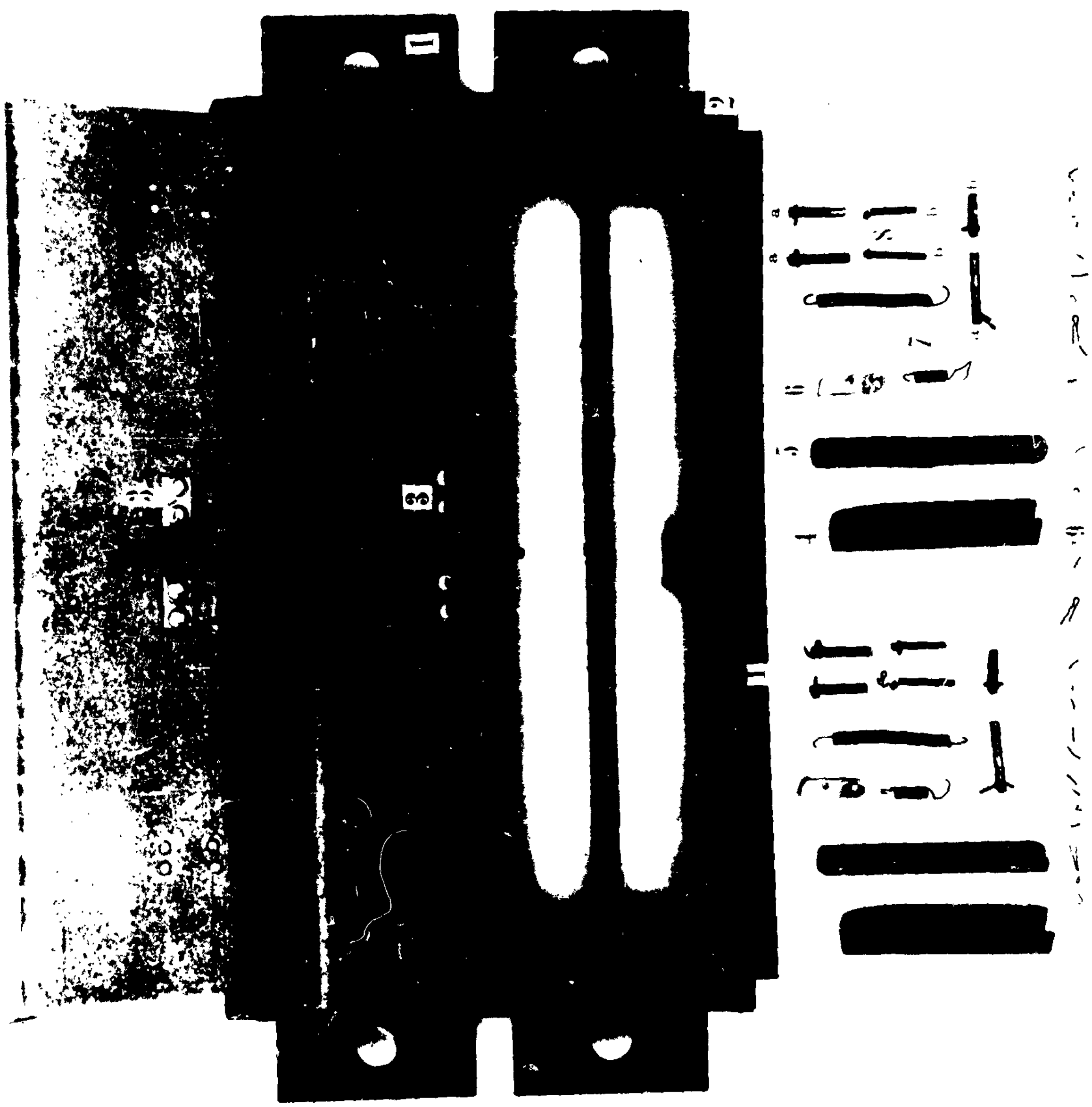


Figure 17. Moving parts of Closure Unit after 11 months exposure, View 2.

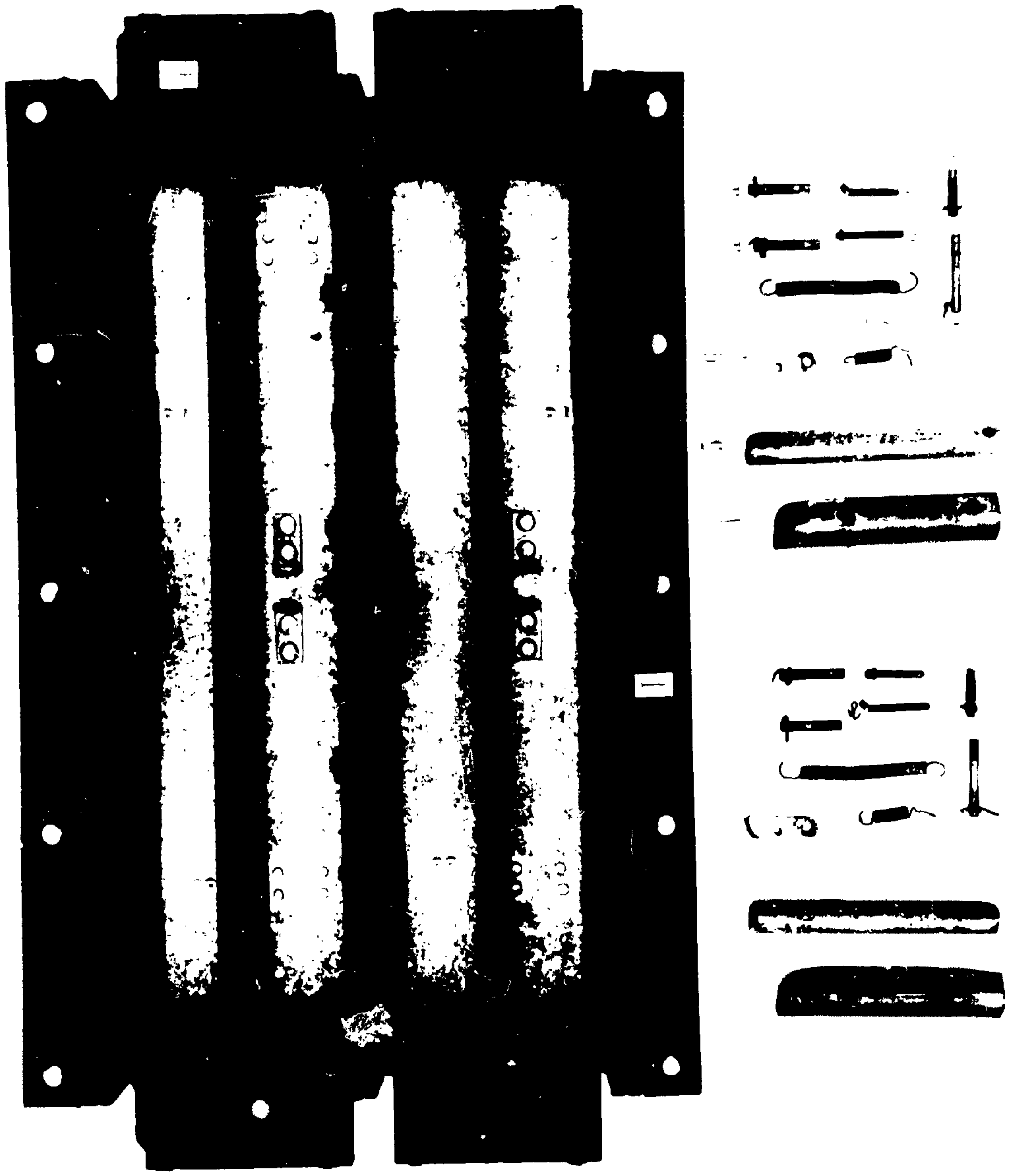


Figure 18. Moving parts of Closure Unit after 11 months exposure, View 3.

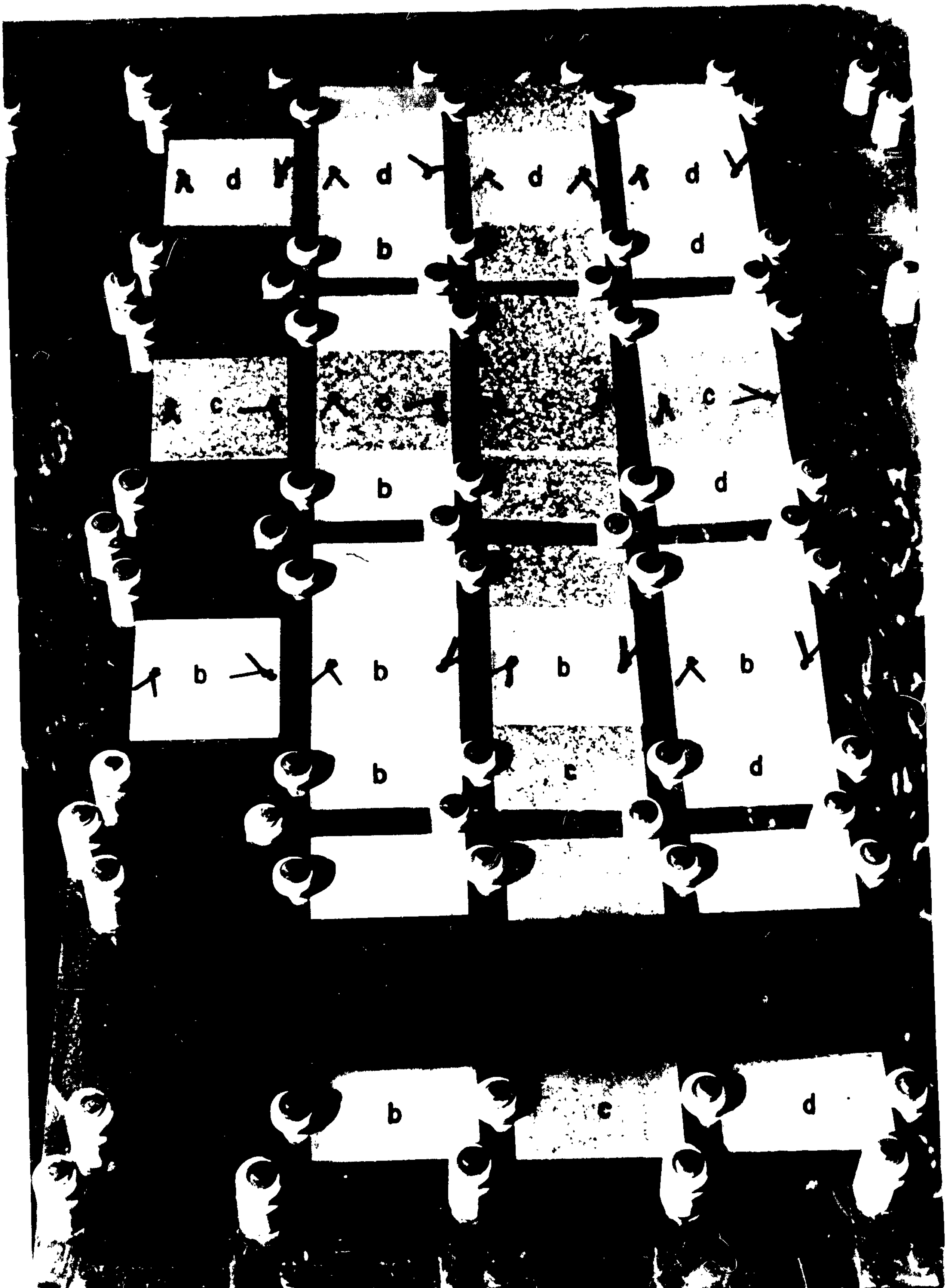


Figure 19. Special test panels after 9 months exposure.
a- Mild steel; b- Cd plate; c- 6061 Al; d- 2024Al.

Figure 20. Close-up of special test panels after 9 months exposure.
A- Cd plated cotter pins; B- Unplated cotter pins;
b- Cd plated; c- 6061 Al; d- 2024 Al.

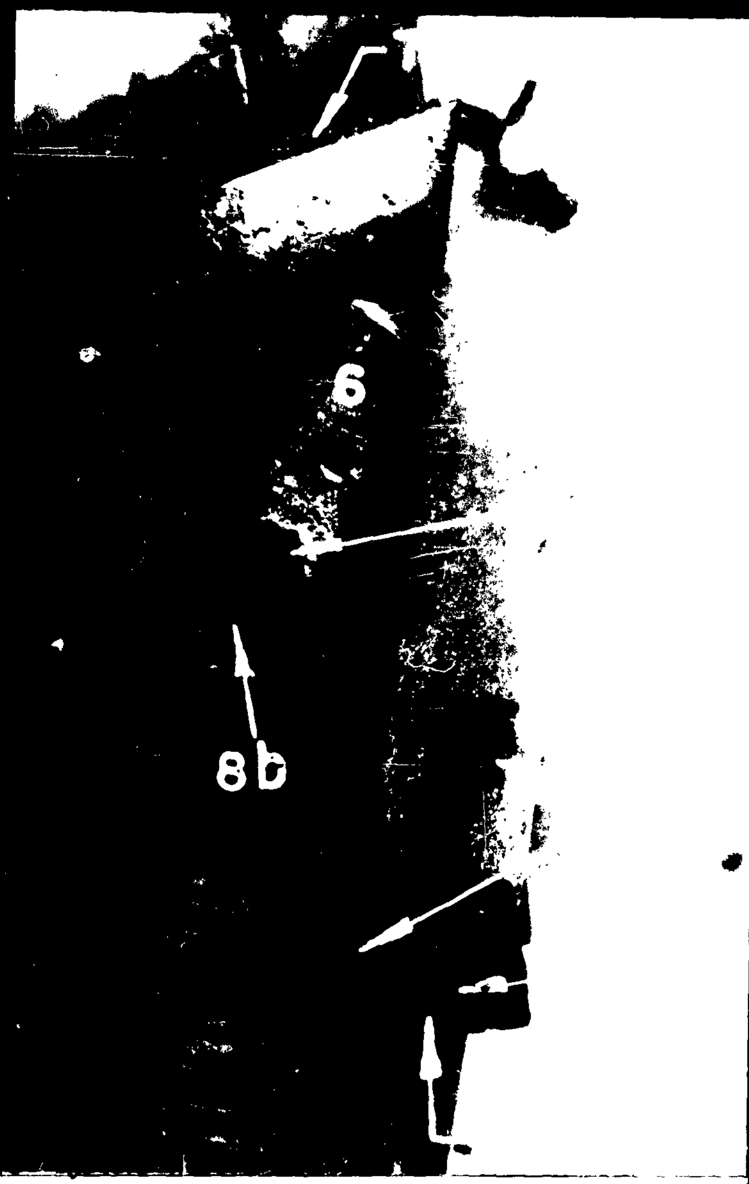


Figure 21. Close-up of working parts of Closure Unit after 11 months exposure.

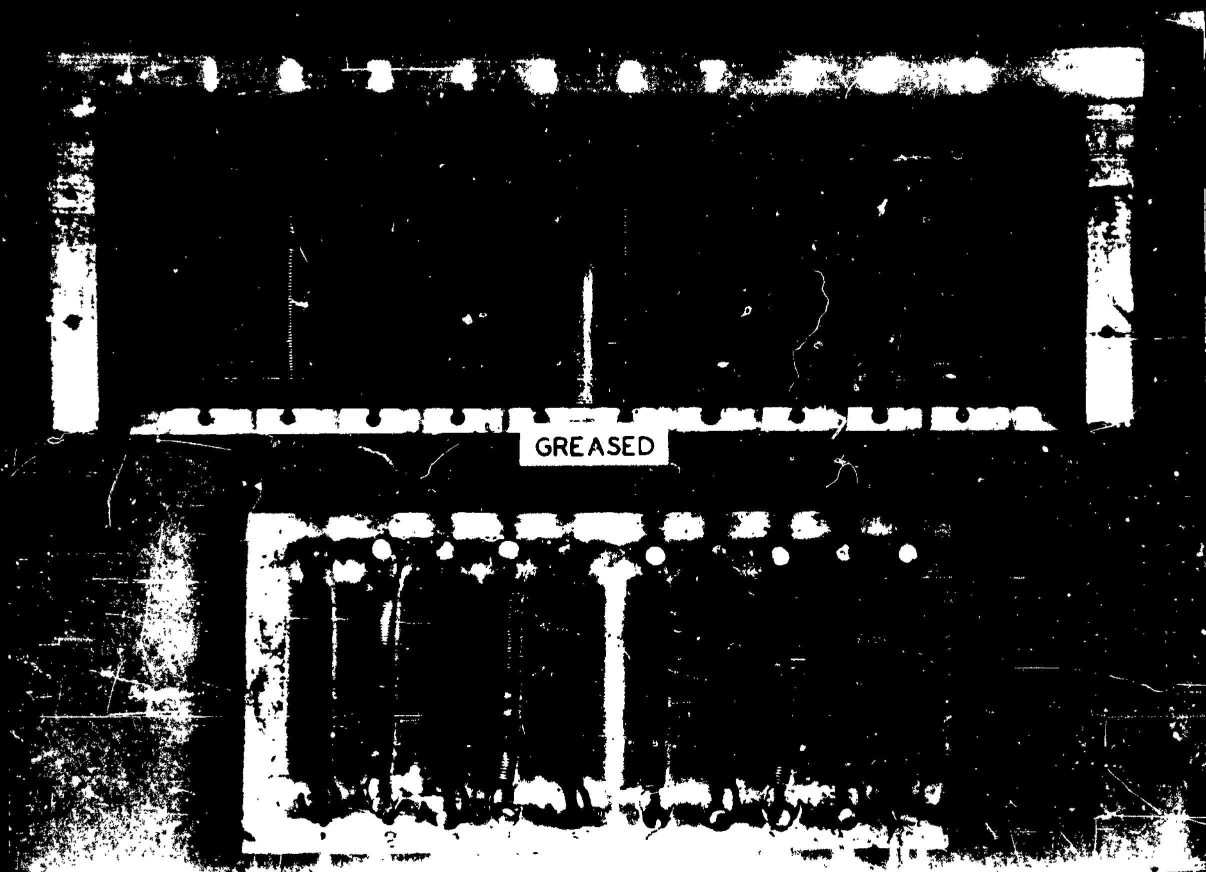


Figure 22. Test springs after 9 months exposure.

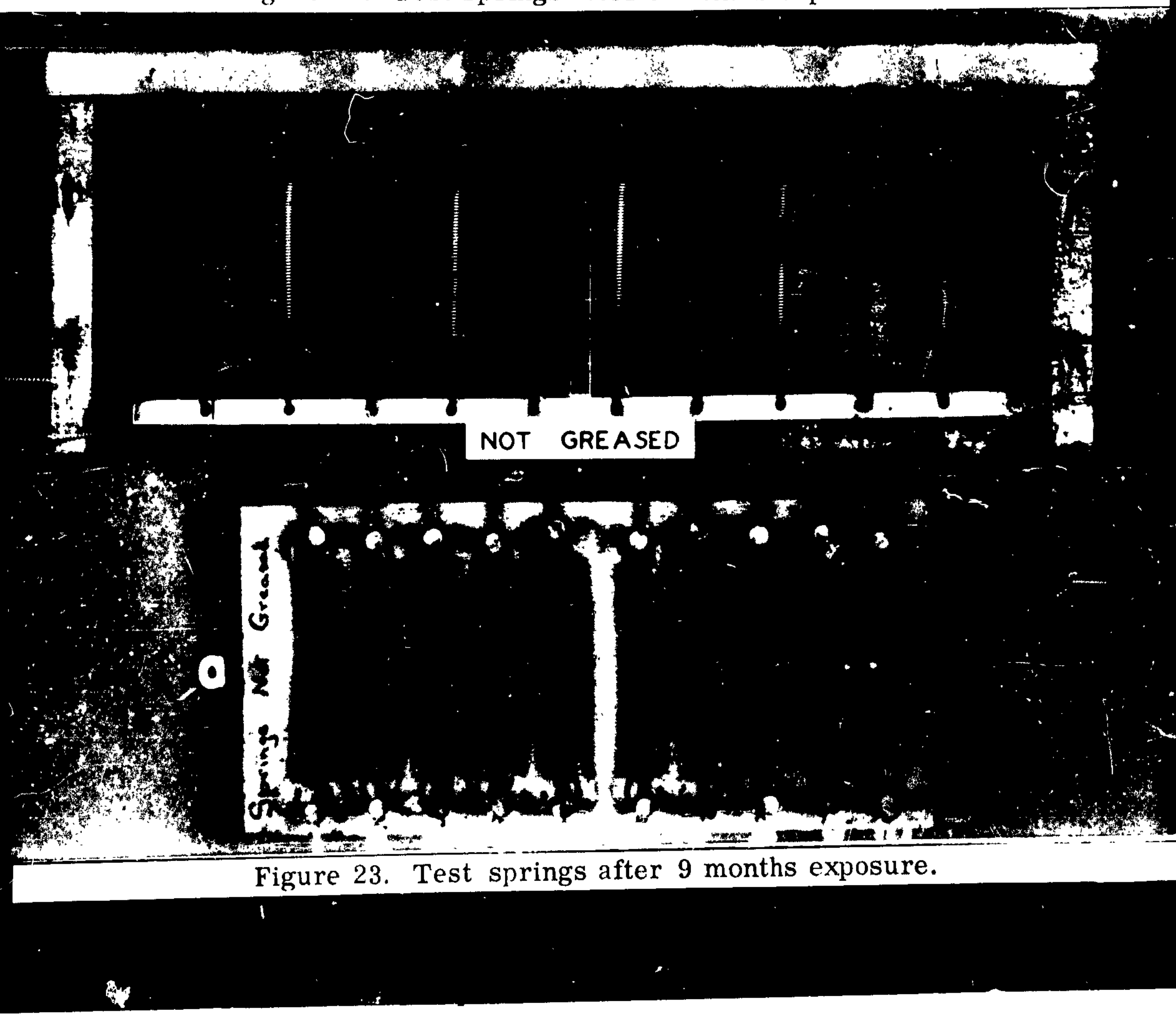


Figure 23. Test springs after 9 months exposure.