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MEMORANDUM REPORT NO. 710/367

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CAST ARMOR REPORT NO. 11

INSPECTION OF HOMOGENEOUS CAST ARMOR

FEBRUARY 18, 1941

WATERTOWN ARSENAL
WATERTOWN, MASS.

RESTRICTED

Memorandum Report No. 710/367
Watertown Arsenal February 18, 1941

Cast Armor Report No. 11

INSPECTION OF HOMOGENEOUS CAST ARMOR

Subject

Radiographic Standards for Homogeneous Cast Armor

Object

The purpose of this investigation is
To develop radiographic standards for homogeneous cast armor.

Conclusions

(1) Porosity

For a given composition and heat treatment of homogeneous cast armor, unsoundness conditions including porosity lower its ballistic resistance. See Inclosure 1a.

Proposed standards for acceptable and unacceptable porosity conditions are illustrated in Figures 1 to 16, inclusive.

(2) Pipes

Piping in flanges is considered to be conducive to structural weakness. Where pipes occur in other than flange sections, they are considered as porosity.

Proposed standards for acceptable and unacceptable piping conditions are illustrated in

Contd

Figures 17 and 18.

(3) Tears

It is considered that tears behave much like porosity in reducing the ballistic resistance of homogeneous cast armor.

Proposed standards for acceptable and unacceptable tears are illustrated in Figures 21 to 25, inclusive.

(4) Cracks

It is considered that cracks in homogeneous cast armor are not acceptable. Figure 26 illustrates a radiograph of a crack in homogeneous cast armor.

(5) Proposed standards arranged to illustrate acceptable, borderline, and rejectable cases are shown in Figures 1 to 26, inclusive.

Inclosure 1

Discussion

(a) The ballistic resistance of homogeneous cast armor depends upon two factors, 1st, the intrinsic physical properties of the metal, and 2nd, the soundness of the metal. The intrinsic physical properties are considered to include the strength, ductility, and other physical properties that are characteristic of perfectly sound metal of a given composition and in a given physical condition. The soundness of metal is considered to connote its relative freedom from macroscopic defects, such as porosity,pipes, slag or other nonmetallic inclusions, tears and cracks.

Figure A illustrates unsoundness conditions in 5/8" cast armor which failed to pass ballistic tests. Similar cast armor that contained less porosity did pass. It is regarded that the rejected plate did not meet ballistic requirements because of the presence of excessive porosity.

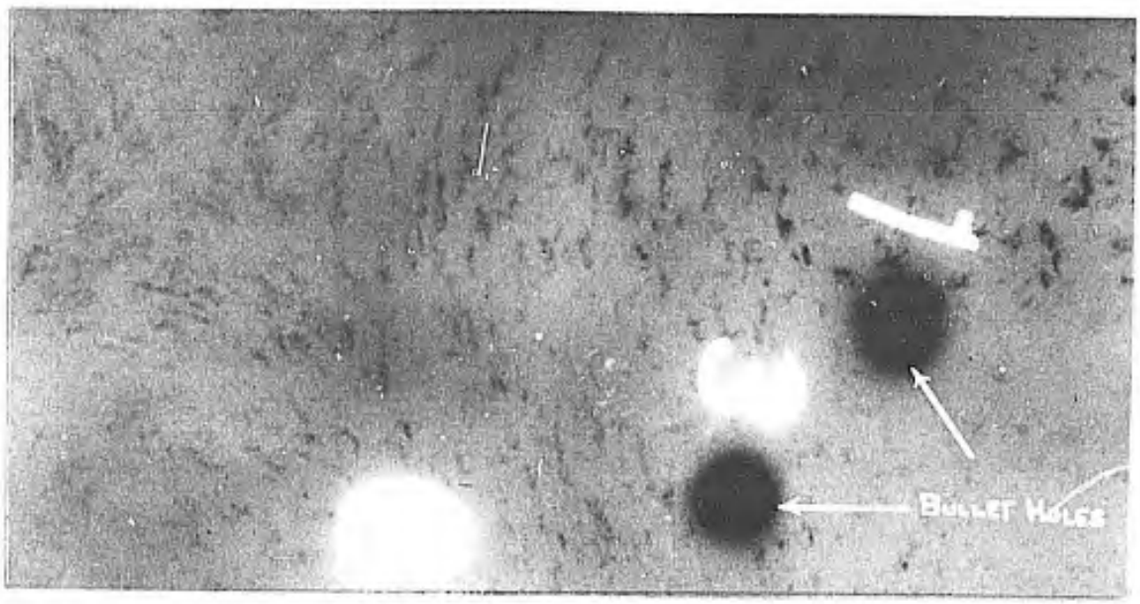

Fig. A

Unsoundness conditions that caused lowered ballistic resistance.

5/8" Homogeneous Cast Armor

This plate did not meet ballistic requirements. It is regarded that its failure in test was due to the presence of excessive porosity.

(b) If cast armor is to be judged by specified ballistic limits, it is possible that a very porous casting of one composition and heat treatment may have a ballistic resistance superior to another more sound casting of different composition and heat treatment. (See Figure 22). This distinction cannot be written into standards. However, since the amount and distribution of porosity are factors in the potential ballistic resistance, it is considered that all cast armor, regardless of composition and heat treatment, should be held to the same standards of soundness.

(c) The present report deals only with homogeneous cast armor. It is recognized that face hardened armor may have superior ballistic properties due to the effects of the hardened surface, and that such armor could meet the specified ballistic limit even though it contained much more porosity than homogeneous armor of similar composition. It is possible that different soundness standards should be set up for face hardened material. Such standards cannot be proposed at the present time because of lack of experimental data regarding the relative ballistic behavior of homogeneous and nonhomogeneous cast armor. The work of accumulating the necessary data is in progress, and a second report is expected to cover

the question of standards for nonhomogeneous armor.

(d) It is understood that an armor casting is rejectable if any part of it does not conform to the standards.

(e) It has been observed on occasions that, in regions of bad porosity, even though the ballistic resistance of the plate was relatively high, on impact a projectile carried out a section of the plate whose diameter was much larger than the diameter of the projectile itself.

Inclosure 2

Standards

Whenever possible, ballistic data were used in the selection of these standards. In the cases where such data were not available, estimates were made by comparison with radiographs for which the data were obtainable.

Ballistic data were available for the following standards: Figures, 5, 6, 7, 13, 14, 15, 16, 19, 20, 22, 23, 25 and 26.

In one case (Fig. 22), the cast armor just passed the specified ballistic limit, but was judged to be not acceptable. It is believed that in this case the bullets did not penetrate the worst part of the plate.

In all other cases, the cast armor marked acceptable passed the specified ballistic limit, and the unacceptable armor did not.

This effect is attributed to the weakness of the plate induced by the unsound condition.

Standards

(1) Porosity

Figure	Thickness	Condition
1	Any	Acceptable
2	3/8"	Acceptable
3	3/8"	Borderline not acceptable
4	3/8"	Not acceptable
5	3/8"	Not acceptable
6	1/2"	Borderline acceptable
7	1/2"	Borderline acceptable
8	5/8"	Acceptable
9	5/8"	Borderline acceptable
10	5/8"	Not acceptable
11	5/8"	Not acceptable
12	5/8"	Not acceptable
13	3/4"	Acceptable
14	3/4"	Acceptable
15	1"	Acceptable
16	2 3/4"	Acceptable

(2) Piping

17	3/8"	Borderline acceptable
18	5/8"	Borderline acceptable

Piping (contd.)

Figure	Thickness	Condition
19	2"	Acceptable
20	2 3/4"	Borderline not acceptable

(3) Tears

21	3/8"	Not acceptable
22	3/4"	Not acceptable
23	2"	Borderline not acceptable
24	2"	Not acceptable
25	2 3/4"	Acceptable

(4) Cracks

26	Any	Not acceptable

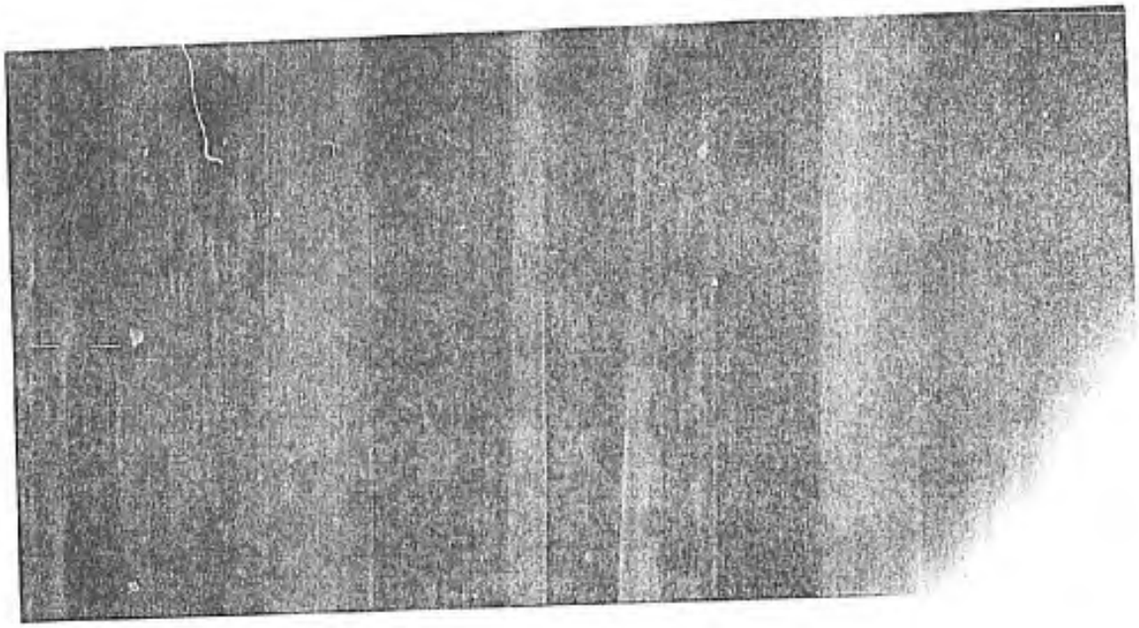

Fig. 1. SOUND METAL - Acceptable for all thicknesses of homogeneous cast armor.

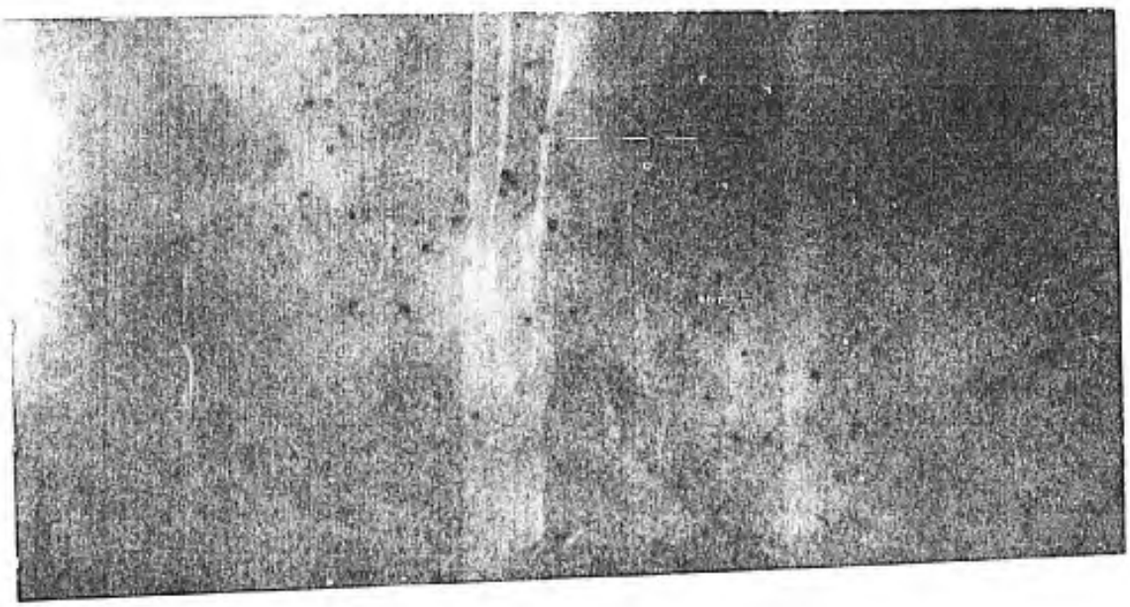

Fig. 2. POROSITY - 3/8" homogeneous cast armor. Acceptable.

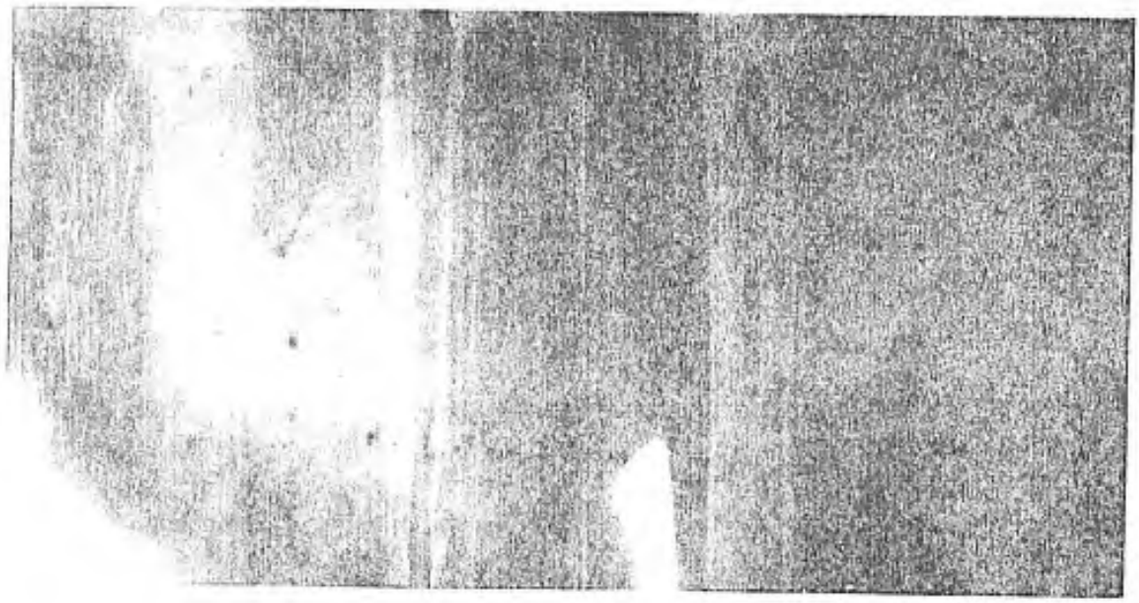

Fig. 3. POROSITY - 3/8" homogeneous cast armor. Borderline not acceptable.

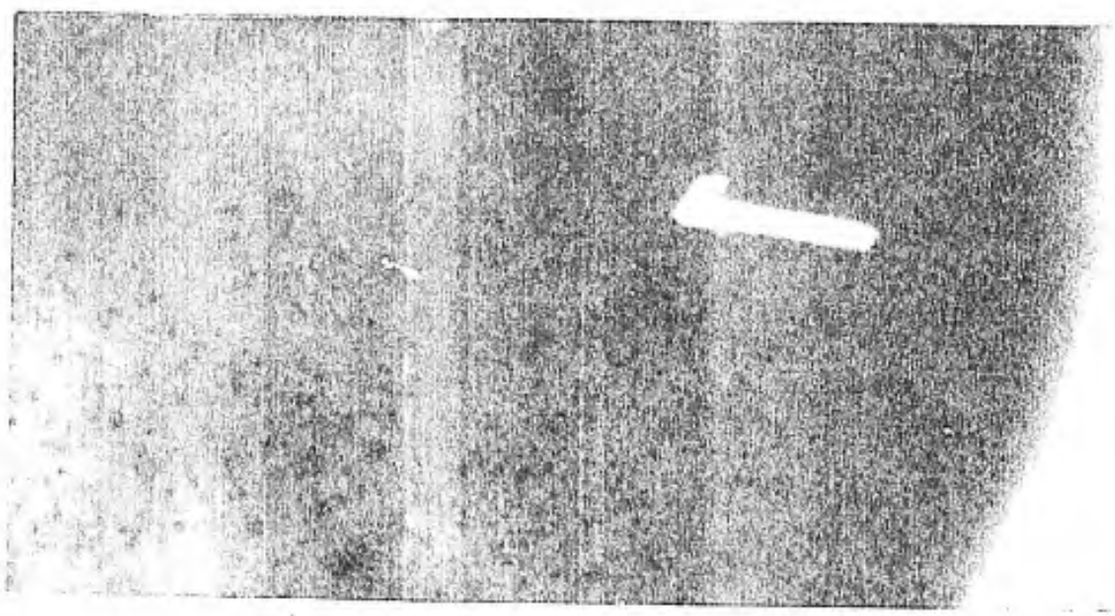

Fig. 4. POROSITY - 3/8" homogeneous cast armor. Not acceptable.

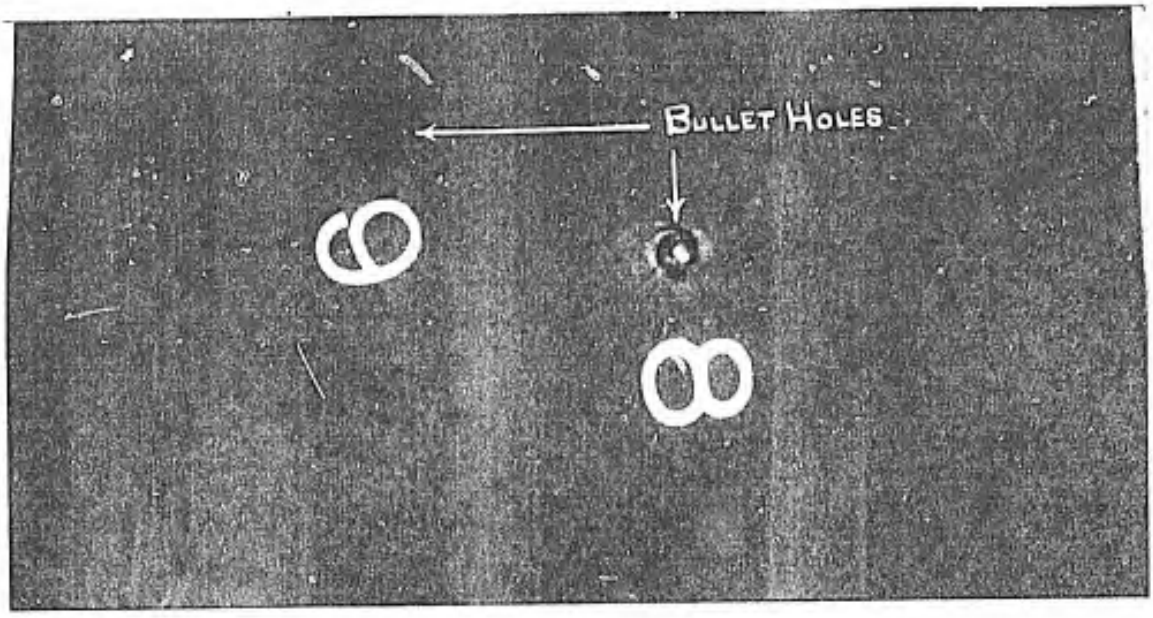

Fig. 5. POROSITY - 3/8" homogeneous cast armor. Not acceptable.

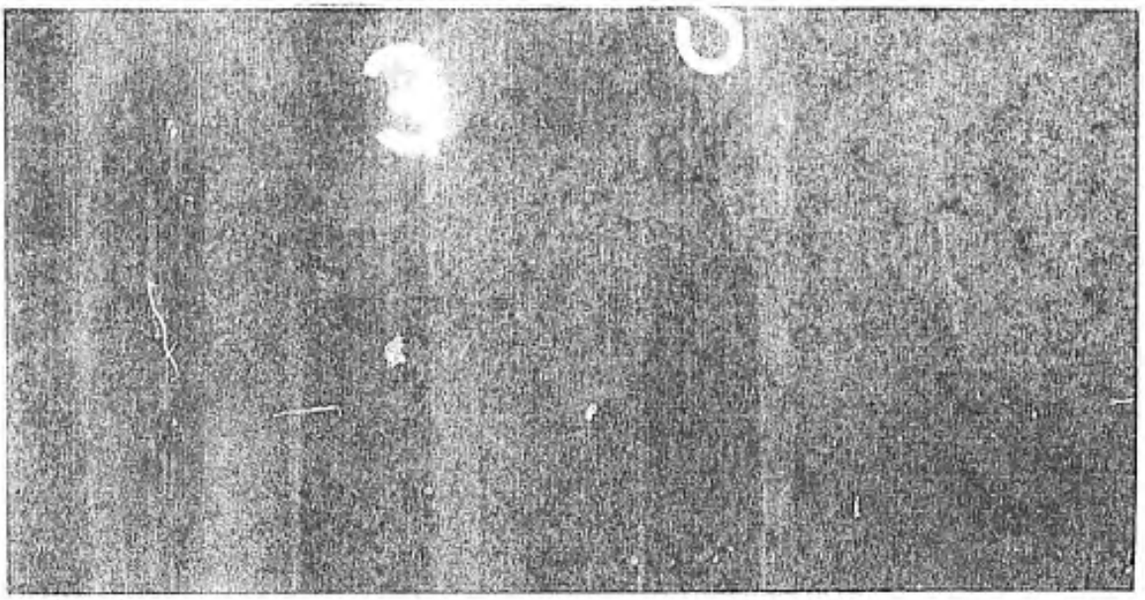

Fig. 6. POROSITY - 1/2" homogeneous cast armor. Borderline acceptable.

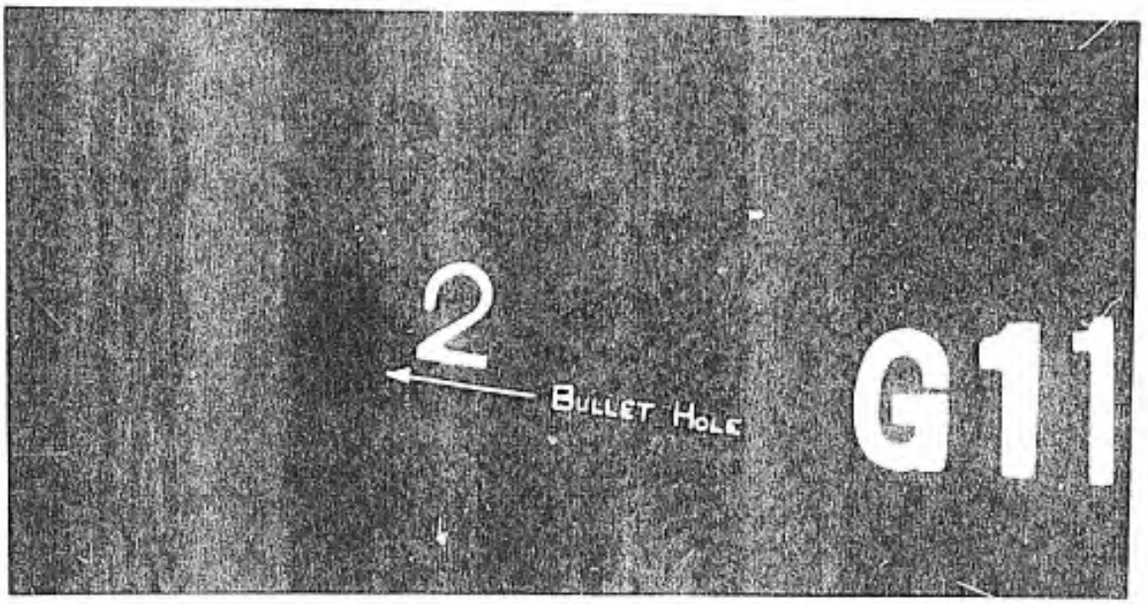

Fig. 7. POROSITY - 1/2" homogeneous cast armor. Borderline acceptable.

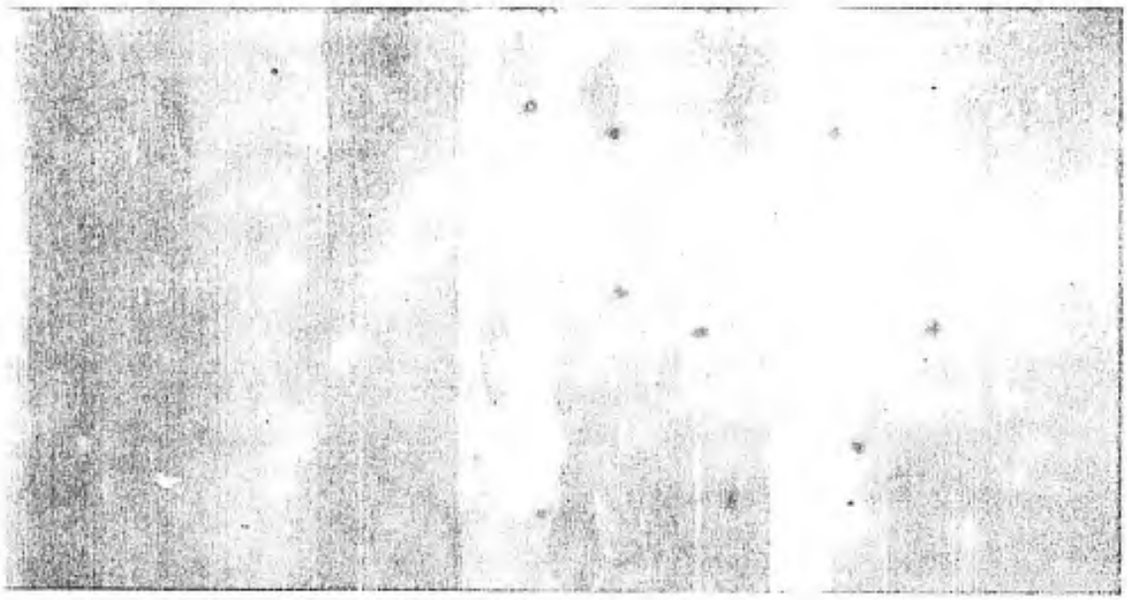

Fig. 8. POROSITY - 5/8" homogeneous cast armor. Acceptable.

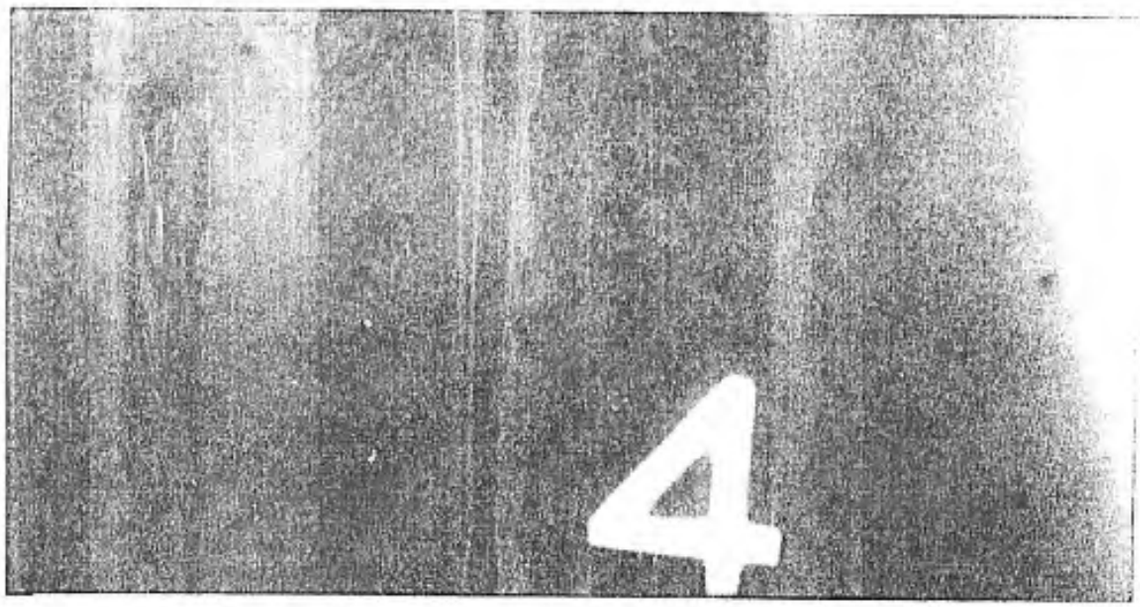

Fig. 9. POROSITY - 5/8" homogeneous cast armor. Borderline acceptable.

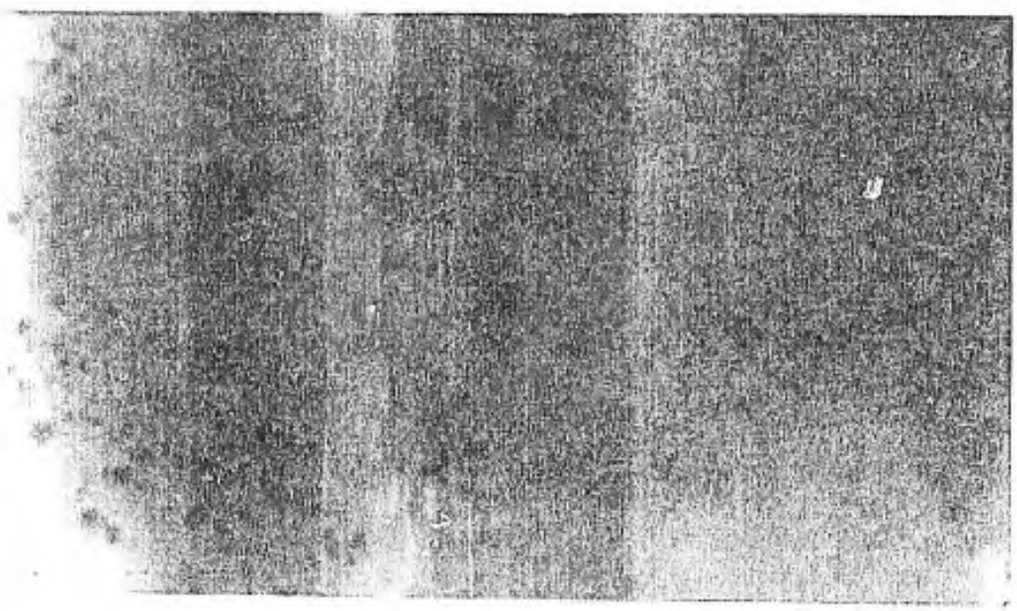

Fig. 10. POROSITY - 5/8" homogeneous cast armor. Not acceptable.

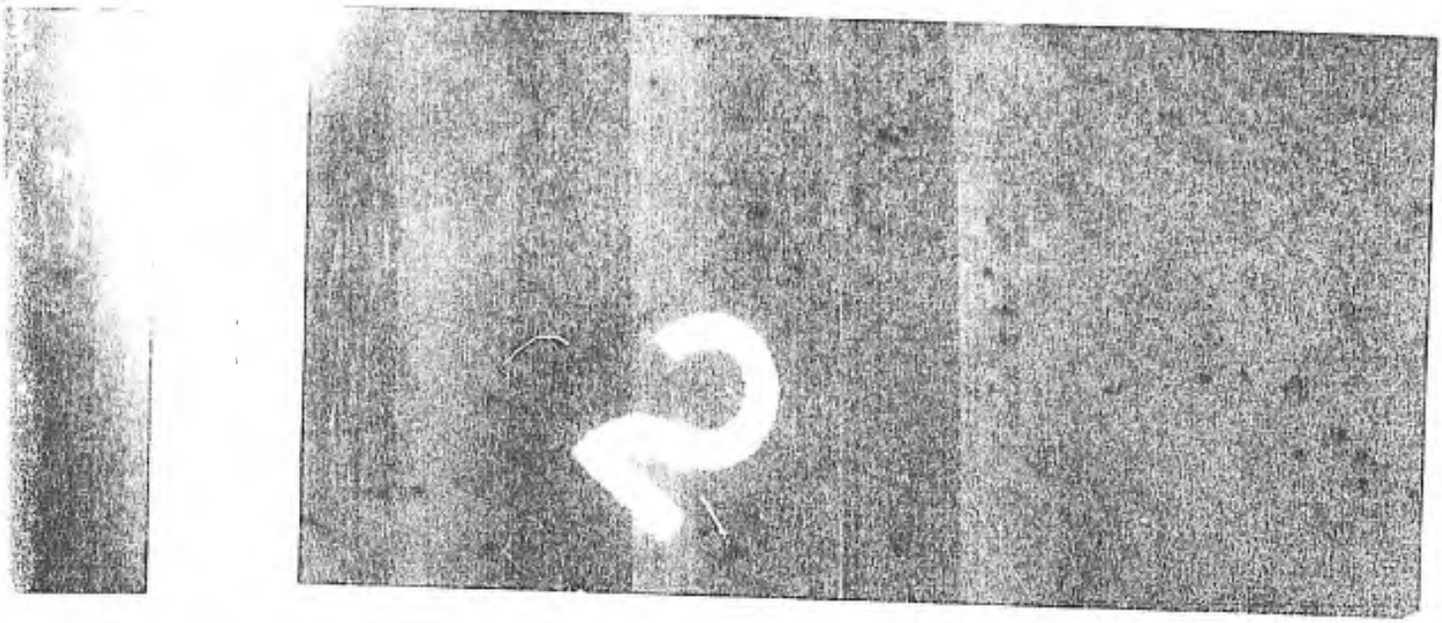

Fig. 11. POROSITY - 5/8" homogeneous cast armor.
Not acceptable.

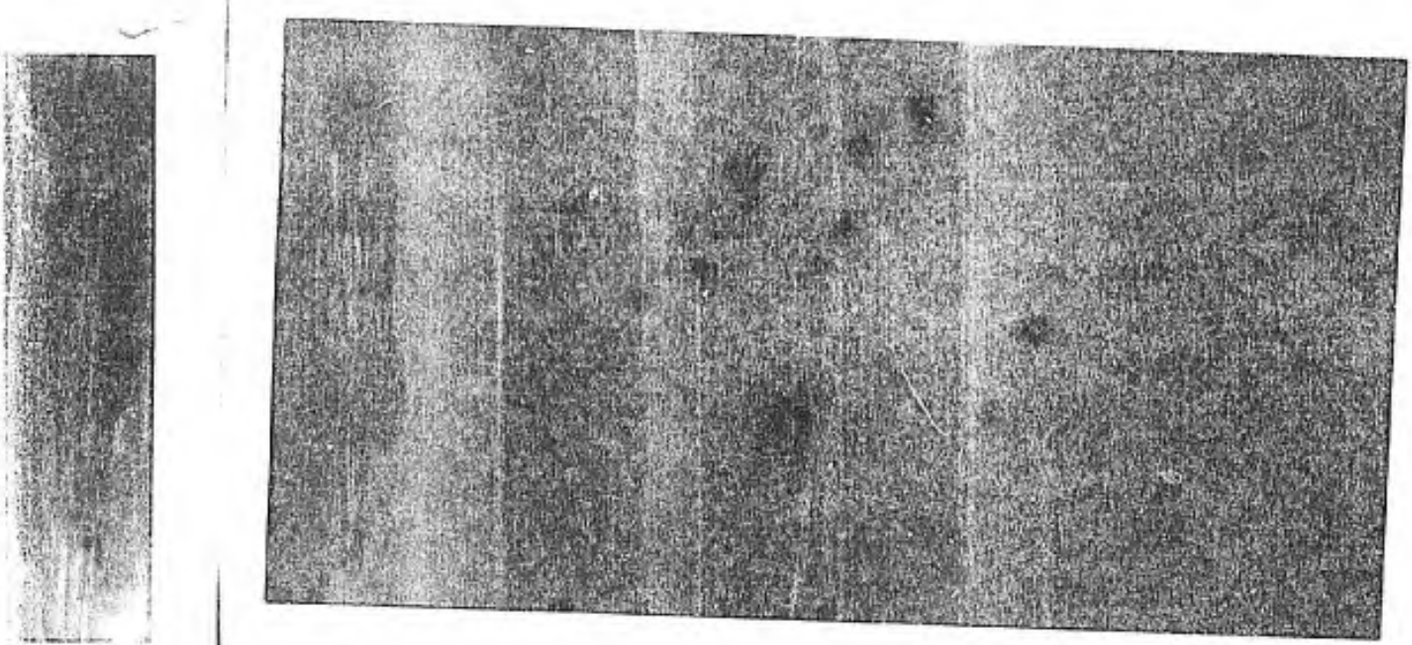

Fig. 12. POROSITY - 5/8" homogeneous cast armor.
Not acceptable.

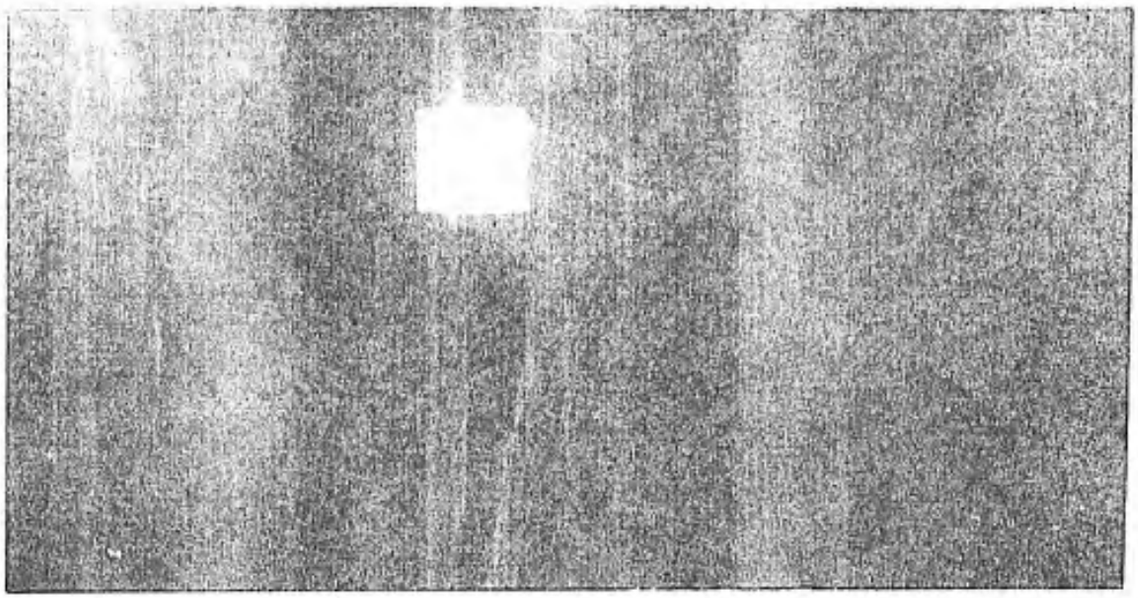

Fig. 13. POROSITY, TEARS, AND PIPES - 3/4" homogeneous cast armor. Acceptable.

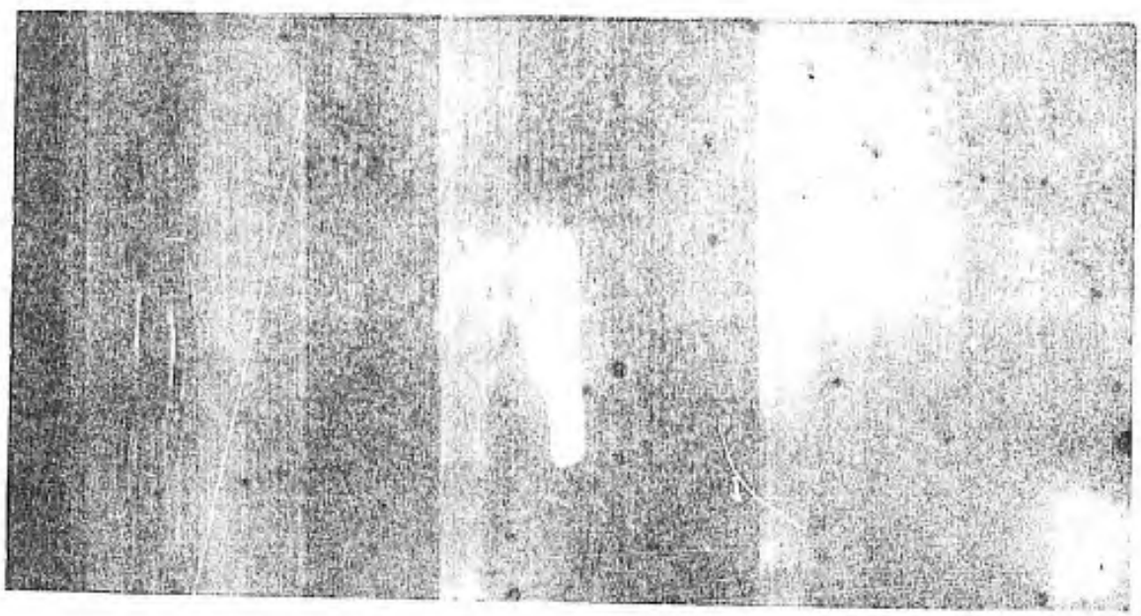

Fig. 14. POROSITY - 3/4" homogeneous cast armor. Acceptable.

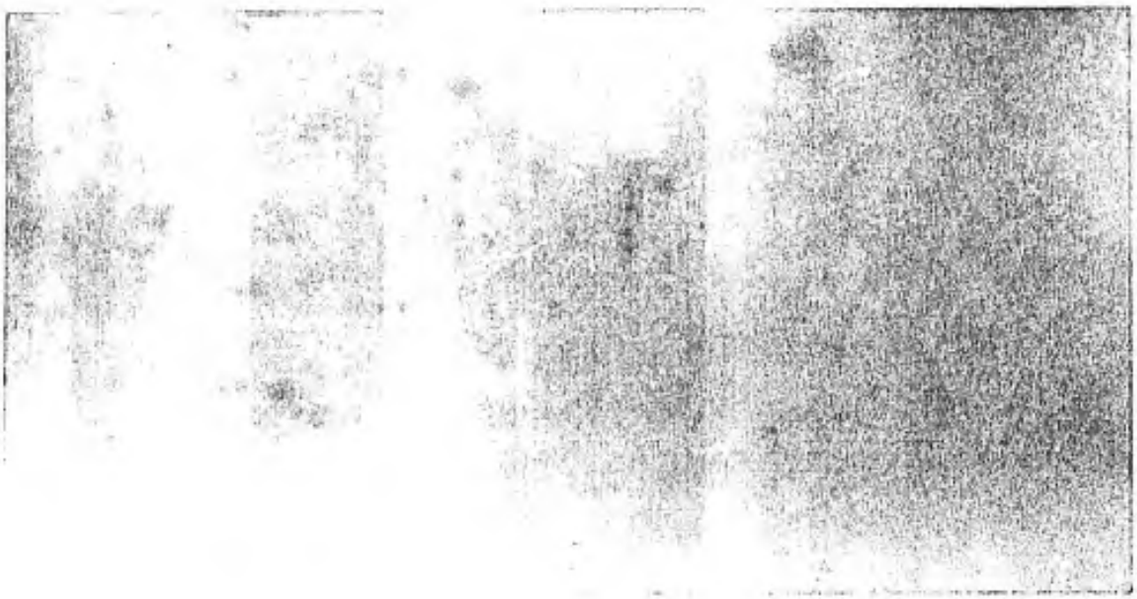

Fig. 15. POROSITY - 1" homogeneous cast armor. Acceptable.

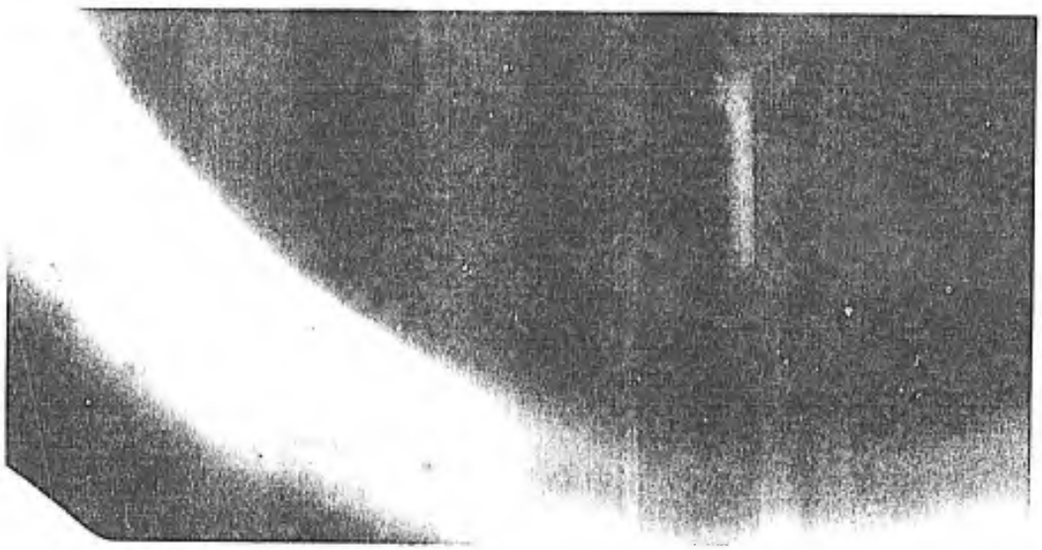

Fig. 17. PIPING - 3/8" homogeneous cast armor. Borderline acceptable when piping occurs only in flanges. Not acceptable when piping extends into other parts of the casting.

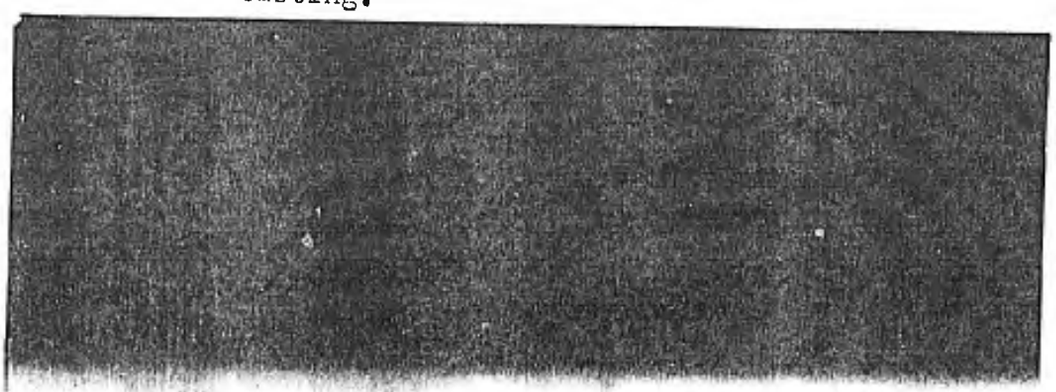

Fig. 18. PIPING - 5/8" homogeneous cast armor. Borderline acceptable when piping occurs only in flanges. Not acceptable when piping extends into other parts of the casting.

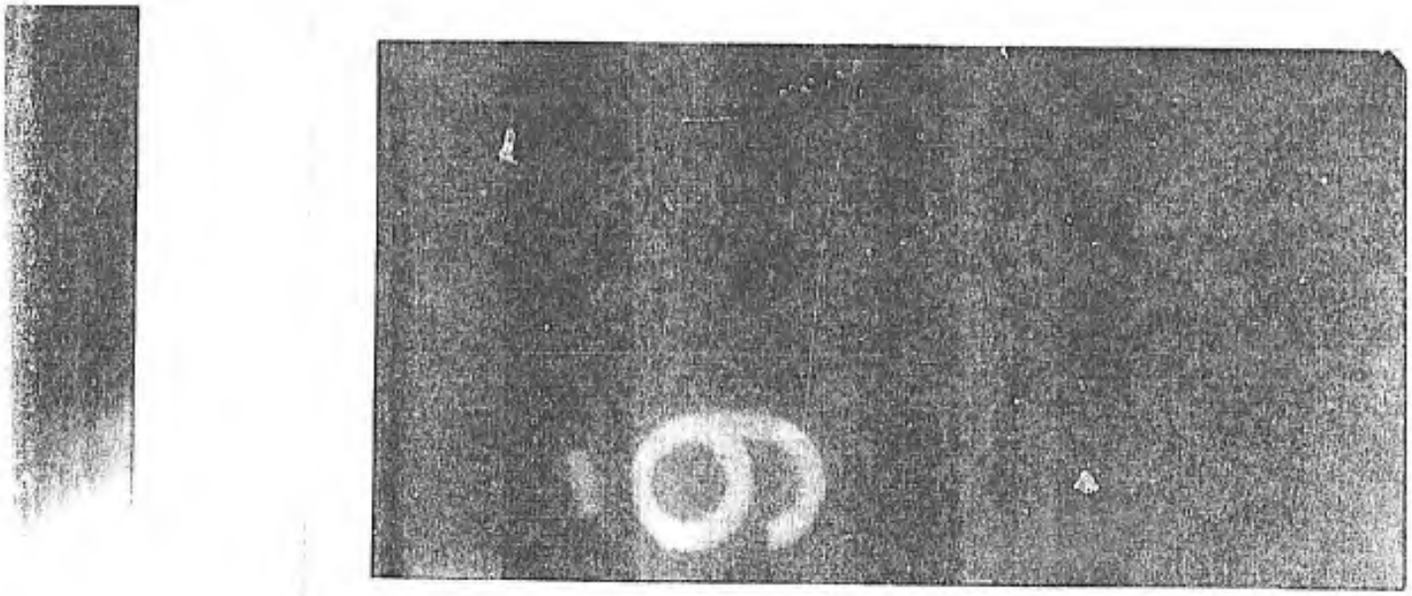

Fig. 19. PIPING OR TEAR OR BOTH - 2" homogeneous cast armor. Acceptable.

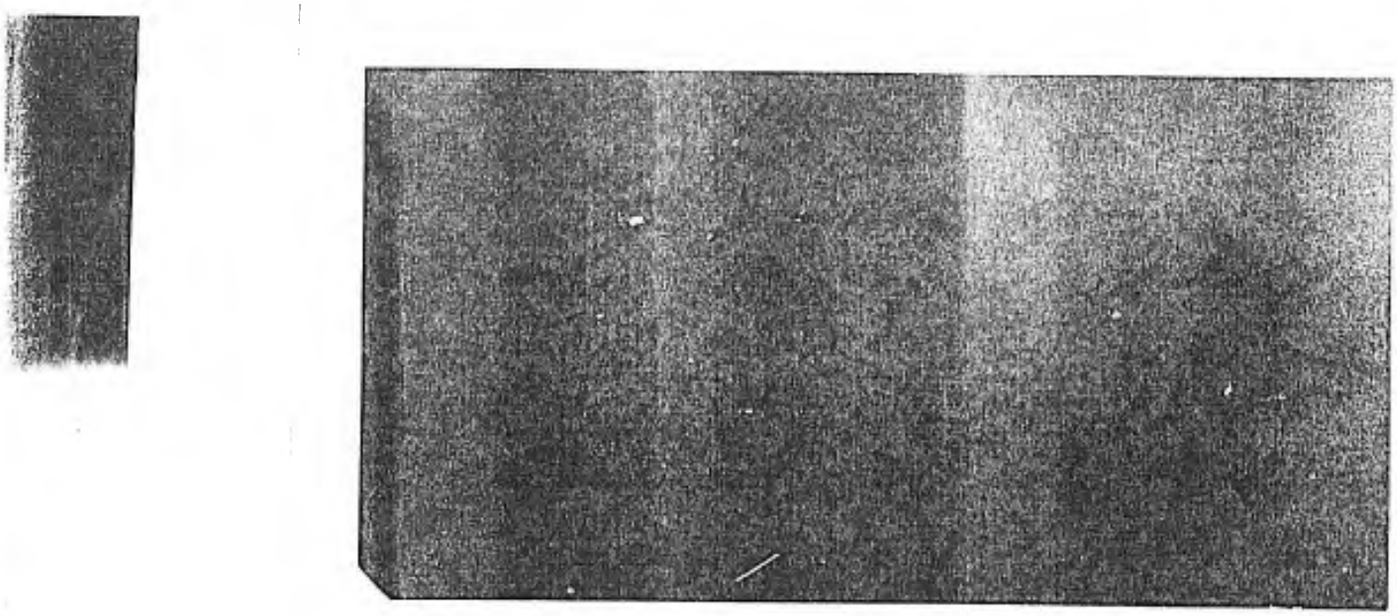

Fig. 20. PIPING OR TEAR OR BOTH - 2 3/4" homogeneous cast armor. Borderline not acceptable.

Fig. 21. TEAR - 3/8" homogeneous cast armor. Not acceptable when tear extends from flange to other parts of the casting.

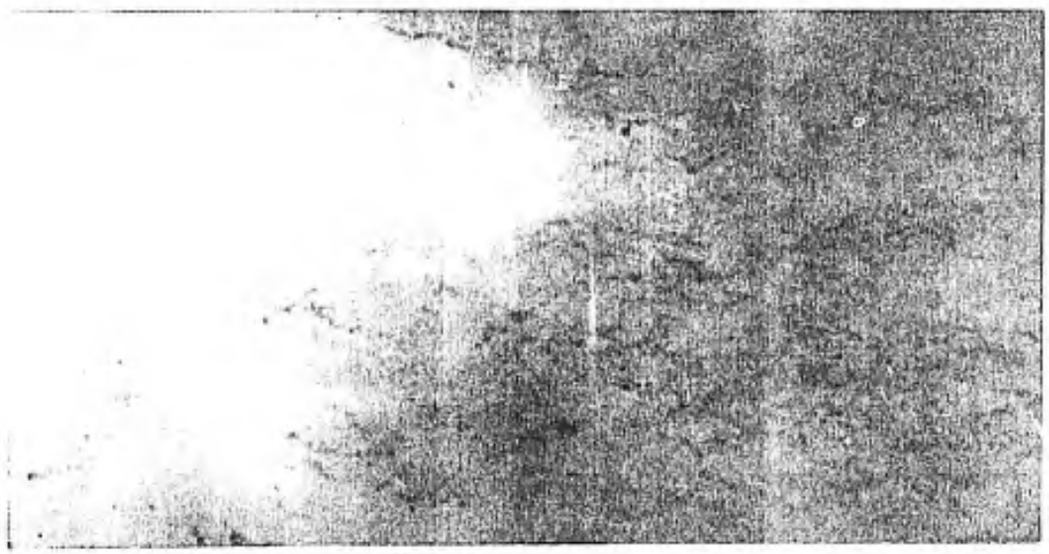

Fig. 22. TEAR - 3/4" homogeneous cast armor. Not acceptable.

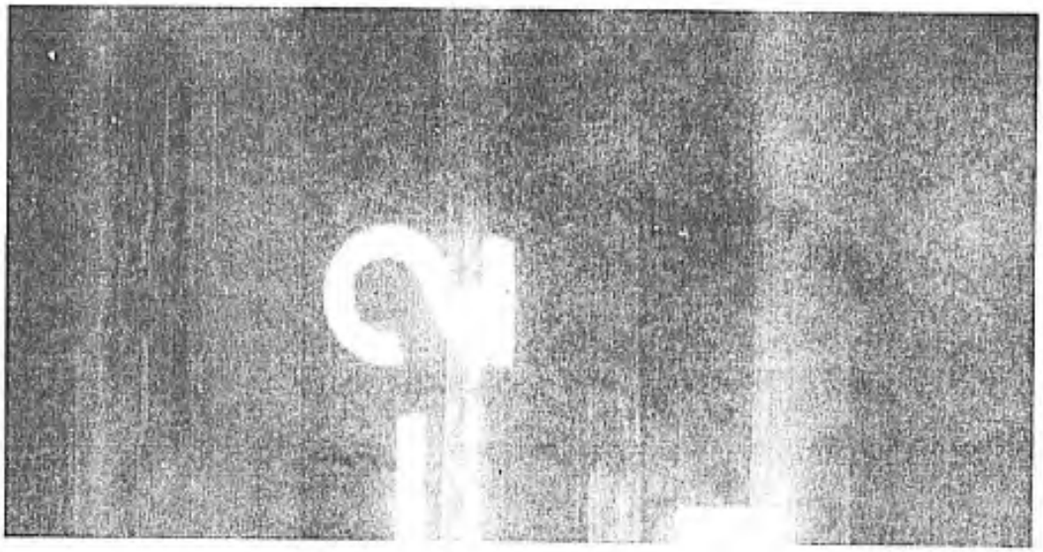

Fig. 23. TEAR - 2" homogeneous cast armor. Borderline acceptable.

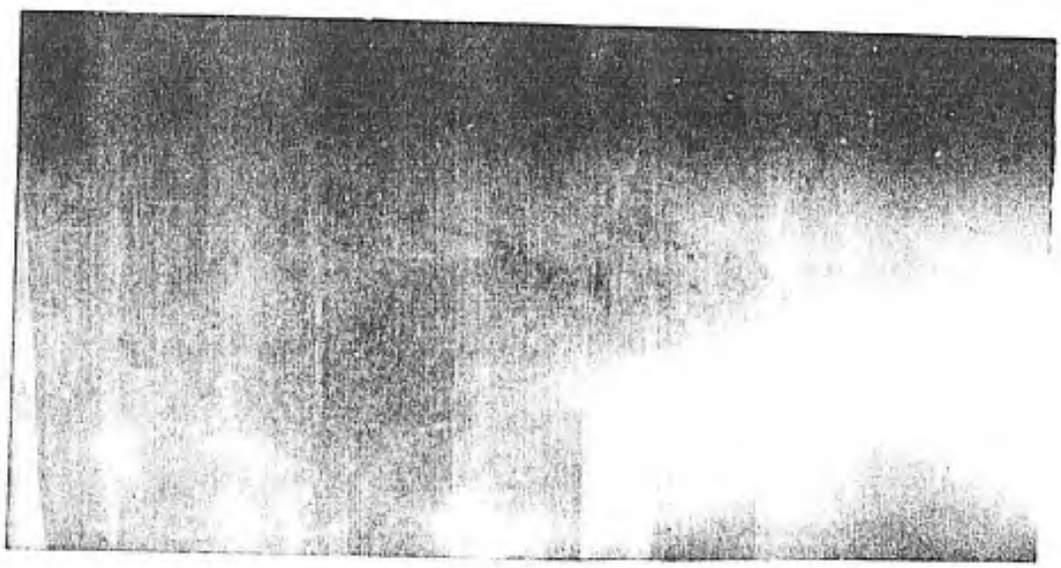

Fig. 24. TEAR - 2" homogeneous cast armor. Not acceptable.

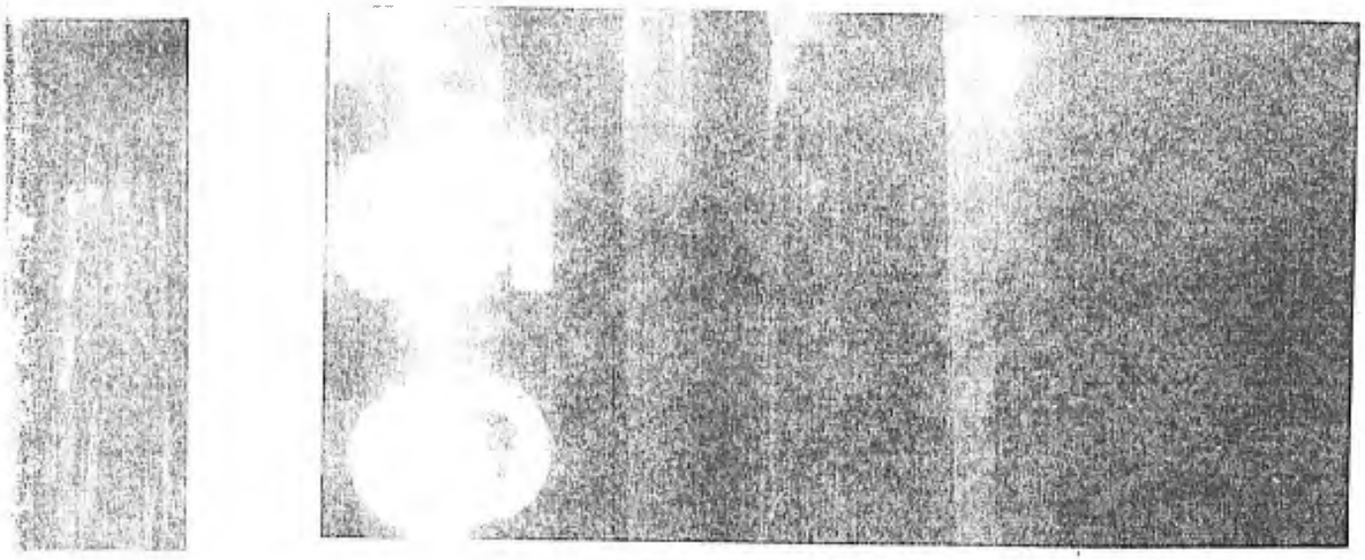

Fig. 25. TEAR - 2 3/4" homogeneous cast armor. Acceptable.

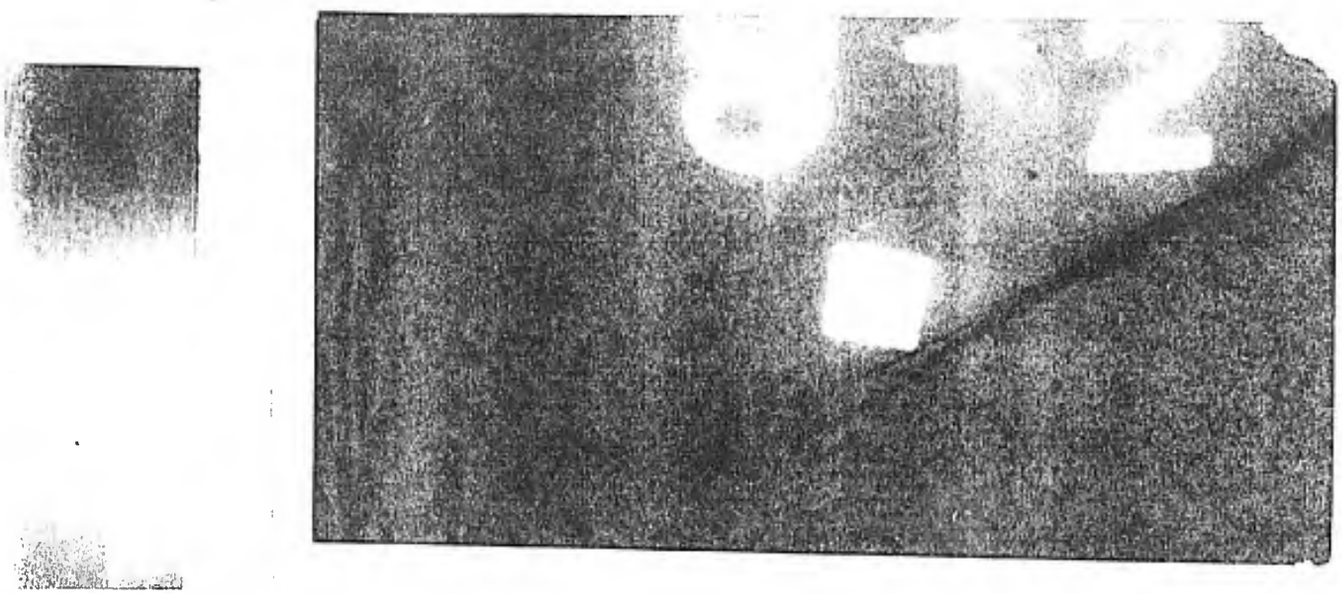

Fig. 26. CRACKS - No cracks are acceptable.