EXAMINATION OF STRONTIUM-90 SOURCE CAPSULES FROM U. S. ARMY CALIBRATION DEVICES

OPERATIONS DIVISION

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Isotopes Technology

OAK RIDGE NATIONAL LABORATORY

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OAK RIDGE NATIONAL LABORATORY
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DEPARTMENT OF ENERGY

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EXAMINATION OF STRONTIUM-90 SOURCE CAPSULES FROM U. S. ARMY CALIBRATION DEVICES

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ABSTRACT

Twenty ^{90}Sr sources, removed from four of seven radiation Detector calibrator sets, were destructively tested for leaks and internal corrosion. One source was found to have a small hole in the window of the outer capsule that appeared to have been caused by electrical discharge during welding at the time of fabrication. None of the sources were found to be leaking ^{90}Sr. Test results, conclusions, and recommendations are reported.

INTRODUCTION

Seven detector calibrators (U.S. Army Radiac Calibrator Set, AN/UDM-2) were shipped to Oak Ridge National Laboratory (ORNL) from the Signal Corp Depot at Lexington, Kentucky for determination of the condition of the ^{90}Sr sources relative to deterioration during storage. Four of the seven sets, Serial Nos. 212, 276, 375, and 448, were selected at random and the sources removed for testing. Each calibrator set has a high and a low level radiation emission section for checking the operational reliability and calibration accuracy of various radiacmeters and radiac sets. Figure 1 is a photograph of the calibrator set in its case. The lefthand section is used for calibration of dose meters and contains four ^{90}Sr sources (one 20 microcurie source and three 25 millicurie sources). The righthand section is used for calibration of ratemeters and contains one 25 millicurie ^{90}Sr source. (The actual loading of the sources is greater than indicated; e.g., the 25 mCi is actually approximately 100 mCi.) Figure 2 is a photograph of the two sections after removal from their storage case. Figure 3 shows the disassembled sections with the sources removed.

A sketch of the encapsulated ^{90}Sr sources is shown in Figure 4. The sources are right circular cylinders and are doubly encapsulated in stainless steel with 10 mil windows which are brazed to a heavier stainless steel wall. The final closure of the source is by gas-tungsten arc welding. The outer capsule is threaded and screwed into the calibrator shields.

DISCUSSION

Upon arrival at Oak Ridge National Laboratory (ORNL) one of the seven calibrators was opened and examined to determine how it was assembled and how it should be disassembled to remove the sources. The chronology of events in the disassembly and inspection of four of the units, containing a total of twenty of the sources, is presented in Table 1.

The outer capsule of each source was visually inspected and photographed using a 100X magnification, leak tested, and smeared for transferrable activity. The outer capsule on one source was found to be leaking. This source had a hole burned in the outer window, apparently by electrical discharge, during the welding operation; however, the inner capsule was leak free and the source did not leak radioactivity. Three other sources also had arc burns (discoloration) on the outer windows but were free of leaks.

Some of the source windows were scratched and dented indicating they may have been handled roughly before being installed in the calibrator shields. Photographs of the outer windows of these sources are presented in Figures 5 through 24. Table 2 is a presentation of the observations and leak test results

Table 1. Army Strontium-90 Source Inspection Chronology of Events and Observations

Date	Activity	Observations
06/12/80	Received, removed sources, disassembled, and photographed one calibration set (212)	One source had obvious hole that was arc burned in window (SRB 1192)
06/19/80	Removed sources from additional calibration sets and identified and examined sources visually in hot cell. Photographed sources	See notes on each source presented in Table 2
06/27/80	Began leak testing outer capsules of sources. Hot water bubble test used	
06/30/80	Completed leak testing ^{90}Sr sources. Set up to remove window	Source SRB 1192 - outer capsule leaked at window - visible hole
07/01/80	Began removing outer capsule window of eight randomly selected ^{90}Sr sources. Smeared inside and outside of window. Smeared inner source and leak tested (hot water bubble test) inner source capsules	Smears on window <u>Outside</u> - 0 dpm to 2840 dpm <u>Inside</u> - 120 dpm to 118,000 dpm Smears on inner sources 0 dpm to 102,020 dpm. No leaks detected in any inner source capsule. Full data on smears taken is presented in Table 3
07/21/80	Visually examined inner capsules from the eight sources and photographed	
07/22/80	Opened inner capsules from four ^{90}Sr sources. Photographed front and back of window and inside capsules	Ceramic insert containing ^{90}Sr was intact and in good condition

Table 2. Army Strontium-90 Source Inspection Results

ORNL Source No.	Back Side of Source[a]	Window Side of Source	Mfg. Source No.	Results of Hot Water Leak Test
212-1	Red dot on weld	Arc hole in window - outer capsule	SRB 1192	Leaked - outer source window
212-2	Yellow dot on weld	Arc burn - no hole in window	SRS 325	No leak
212-3	Red dot on weld	Arc burn	SRB 1197	No leak - Bulge in window
212-4	Red dot on weld	Window slightly concave	SRB 1201	No leak
212-5	Red dot on weld	Window slightly concave	SRB 1196	No leak
276-1	Yellow dot-good weld	Good window-water spot on window	SRS 317	No leak
276-2	Red dot-good weld	Good window-very small bulge in window-does not appear to be from pressure	SRB 1126	No leak
276-3	Good weld-red dot	Very small concave-good window	SRB 1066	No leak
276-4	Red dot-good weld	Window slightly wrinkled-small arc burn	SRB 1067	No leak
276-5	Red dot-good weld	Window slightly concave-small dirt or grease spot on window	SRB 1068	No leak
375-1	Yellow dot-good weld	Window slightly wrinkled	SRS 1272	No leak
375-2	Red dot-weld rough at end	Window smooth except for small dent	SRB 1090	No leak
375-3	Red dot-bubble in weld (struck electrode)	Window smooth-very small concave	SRB 1030	No leak
375-4	Red dot-good weld	Slight wrinkling otherwise window perfect	SRB 1031	No leak
375-5	Red dot-good weld	Very small concave	SRB 1032	No leak
448-1	Red dot on weld-weld not smooth	Window concave-2 dents in window	SRB 487	No leak
448-2	Red dot-good weld	Window slightly concave small water spot in center	SRB 486	No leak
448-3	Red dot-good weld	Small arc burn-window wrinkled-slightly concave	SRB 485	No leak
448-4	Red dot-good weld	Window concave-has scratch mark-may have been done at ORNL	SRB 435	No leak
448-5	Yellow dot-good weld	Window slightly concave-wrinkled	SRS 155	No leak

[a]Red dot indicates a 25 mCi source; yellow dow indicates a 20 μCi source.

The windows on eight of the outer capsules were removed by machining off the brazed area. The front and back sides of three of these windows are shown in Figures 25 through 30. Each of the windows was smeared to determine the amount of transferrable activity on the outer surface and the inner surface (side toward the inner capsule). The windows were smeared over the entire surface using a Whatman 50 filter paper. The count rates determined for each of the smears taken on the windows are presented in Table 3.

Table 3. Smear Test Results for Army Strontium-90 Outer Capsule Windows and Inner Capsules

Source Identification	Outer Window (dpm)		Inner Source Capsule (dpm)
	Inside	Outside	
212-1	6,320	340	1,900
212-3	3,800	2,840	920
276-3	140	160	280
276-5	120	0	0
375-1	3,920	480	3,280
375-5	760	0	480
448-1	6,320	100	4,420
448-3	118,000	1,580	102,020

Photographs of the eight inner sources that were removed are shown in Figures 31 through 38. The arc burn on the window of source 212-1 is shown in Figure 31. All of the inner sources were leak tested and no leaks were detected. No significant structural faults were detected. Figures 39 through 42 are photographs of the inside cavity after removing the window from four of the outer source capsules. No observable damage or fabrication faults were noted.

The windows were removed from four of the inner sources. These windows are shown in Figures 43 through 46.

CONCLUSIONS AND RECOMMENDATIONS

With the exceptions of the one hole burned through an outer source window and obvious arc burns on three other sources, no structural failures were observed in the twenty sources examined. In no case was there evidence for the leakage of ^{90}Sr or indication of corrosion of the capsules or windows. The ceramic inserts were intact and were mechanically strong enough to resist breakage when dropped from a height of approximately 8 in.

We would expect the sources to be safe from loss of ^{90}Sr over the useful life of the units if they are maintained in the sealed case as it is now constructed and not subjected to a corrosive atmosphere such as salt water, etc. We recommend the source swipe schedule be maintained; a minimum of once each year; since 100% inspection of windows of all units in your possession might reveal one or more holes of the type observed in source SRB 1192. We believe, however, that with a doubly encapsulated source of the type examined there is a low probability of having a hole in both the inner and outer window of the same source. Further, the ceramic inserts that contain the ^{90}Sr fixed in an aluminum silicate ion exchanger insures against catastrophic failure of the source.

If sources of this design are required in the future, fabrication specifications should include consideration for elimination of the holes and arc burns of the type observed on the windows of the sources examined.

We did not consider it necessary to analyze the ^{90}Sr content of the sources or to make metallographic examinations of the inner windows since there was no observable evidence of corrosion.

Source window distortion is not a reliable indicator of source failure and the wrinkling and concavity is a consequence of the weld sealing of the source. Air in the source is heated during welding and after cooling a vacuum is produced that causes distortion in the 10-mil-thick window. This observation was confirmed in a conversation with one of the fabricators that produced the ^{90}Sr sources for the manufacturer of the calibrator sets.

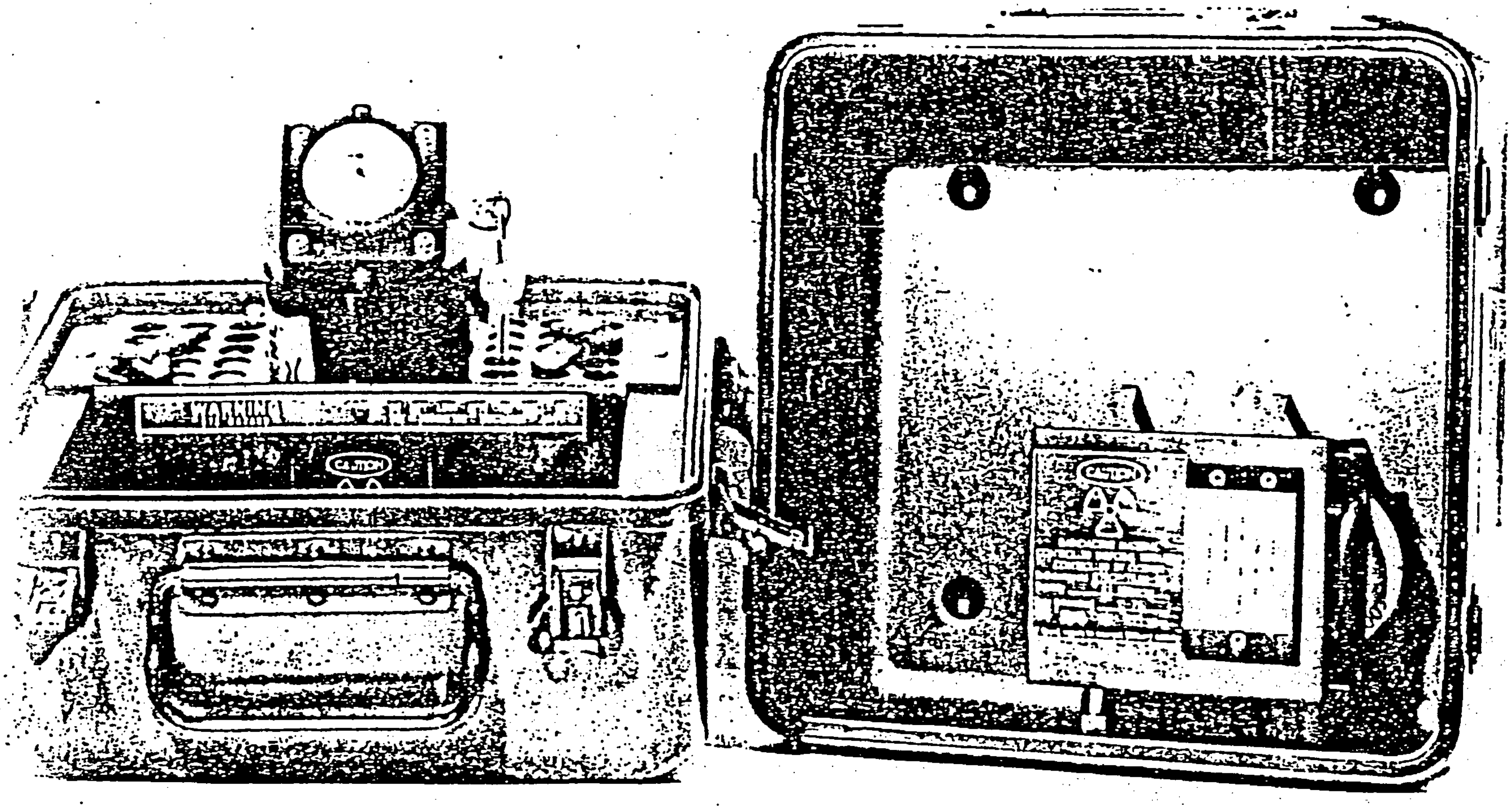


Fig. 1. U.S. Army Calibrator Set, Radiac AN/UDM-2

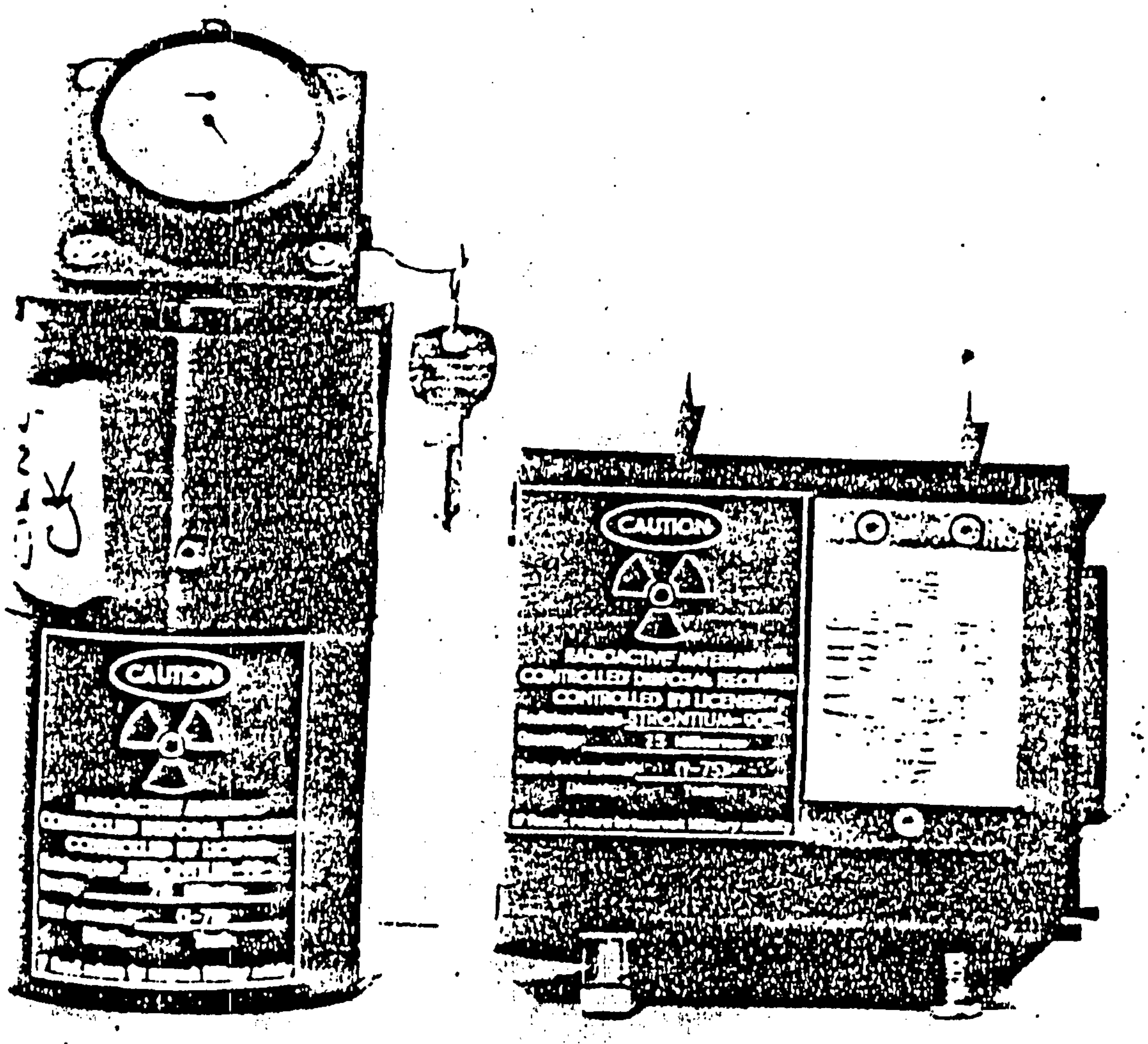


Fig. 2. Two Sections of U. S. Army Calibrator Set, Radiac AN/UDM-2

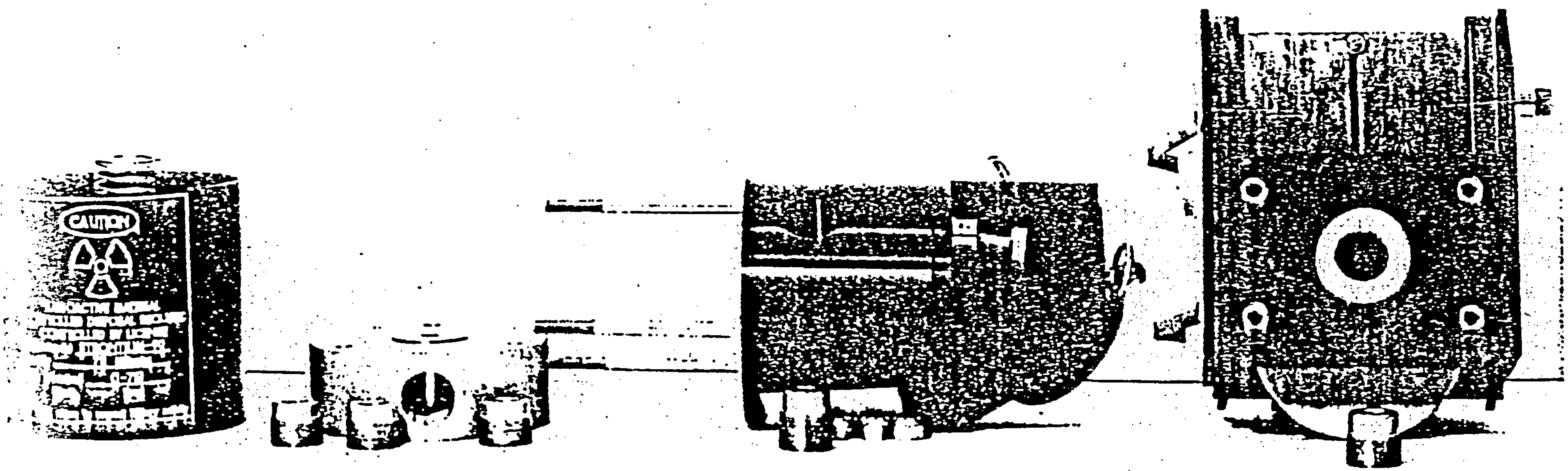


Fig. 3. Disassembled U. S. Army Calibrator Set, Radiac AN/UDM-2

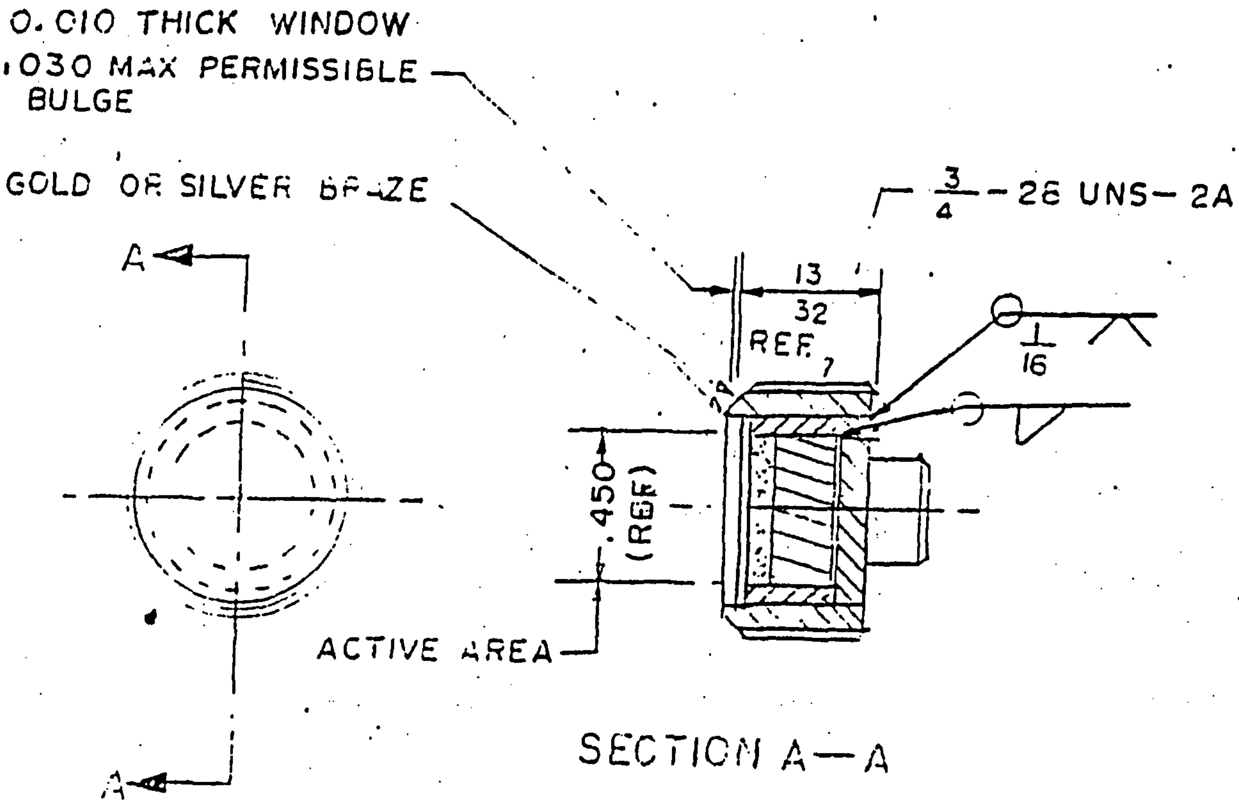


Fig. 4. Sketch of Strontium-90 Source Used in U. S. Army Calibrator Set, Radiac AN/UDM-2

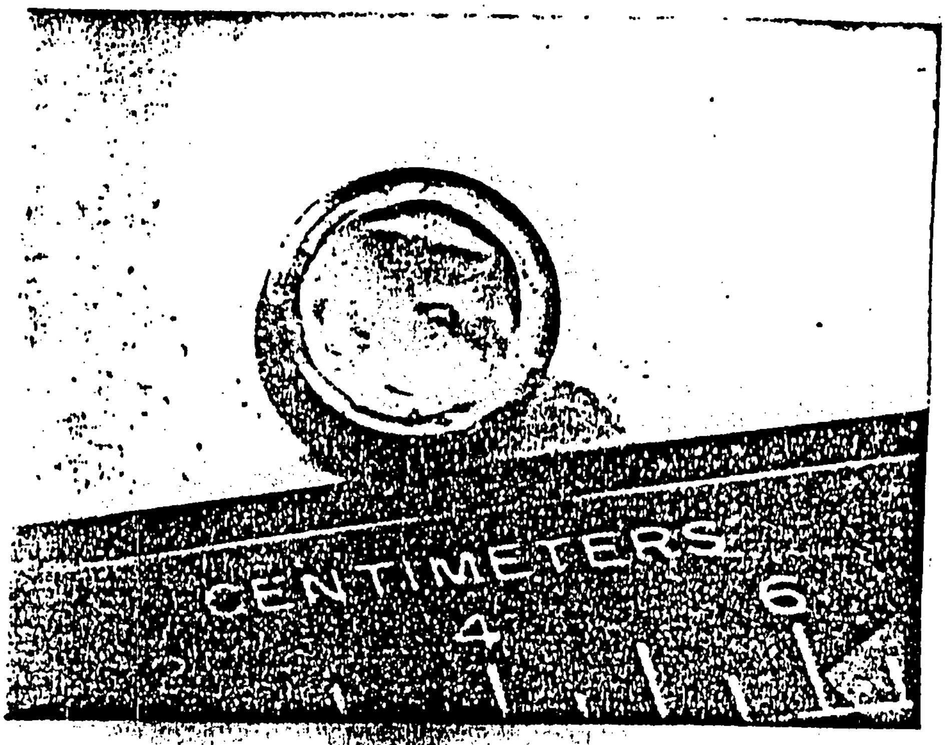
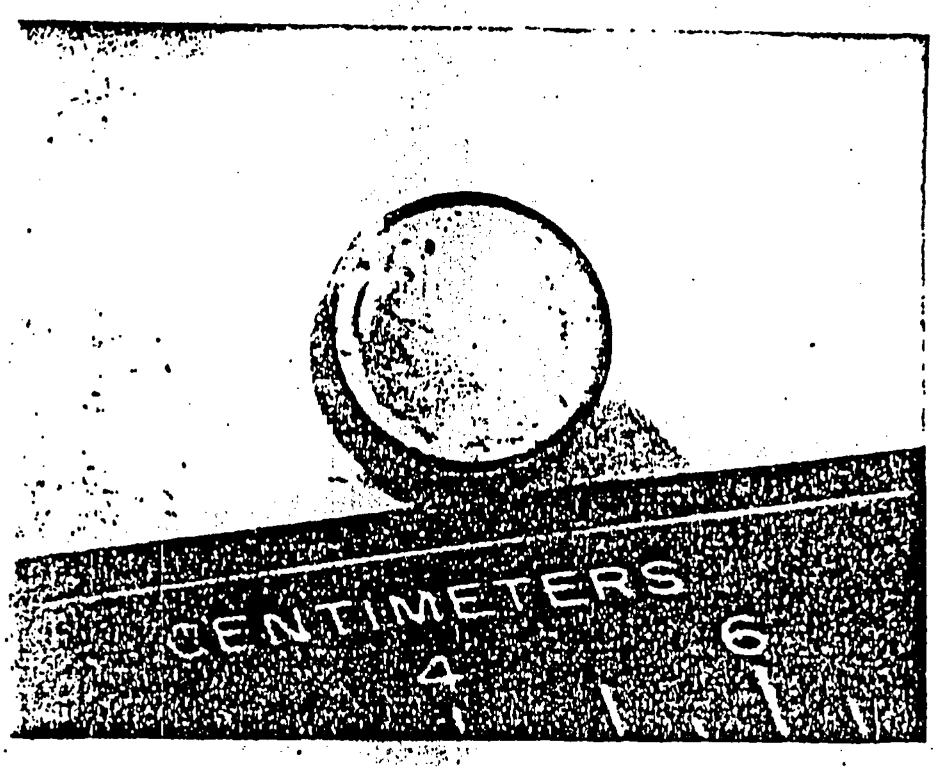


Fig. 5. Source Number 212-1



[illegible]

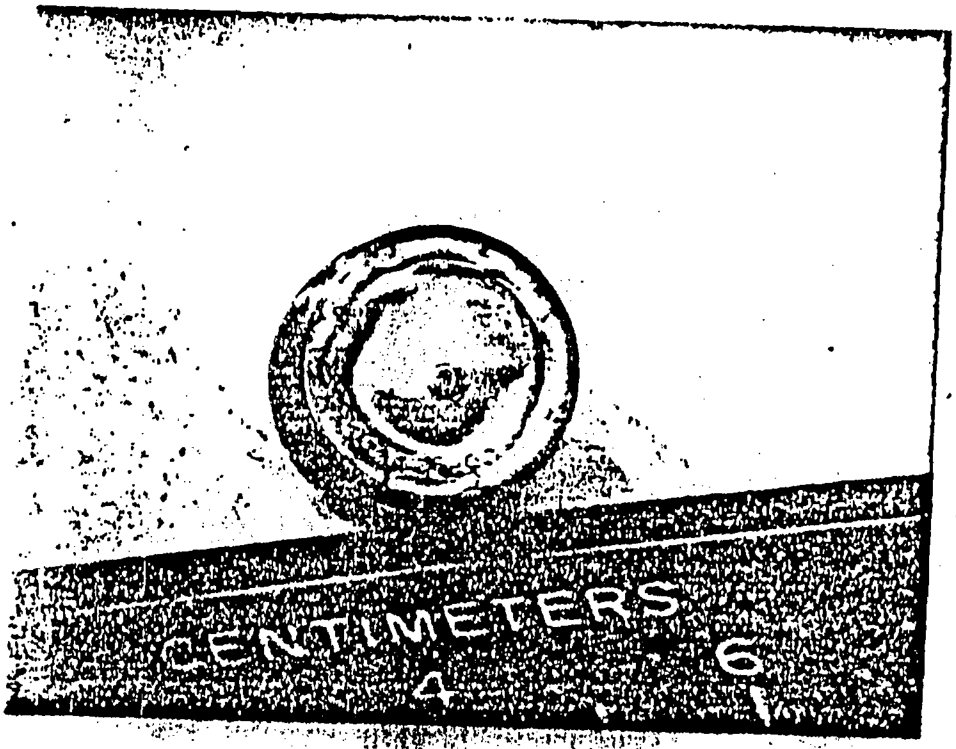


Fig. 7. Source Number 212-3

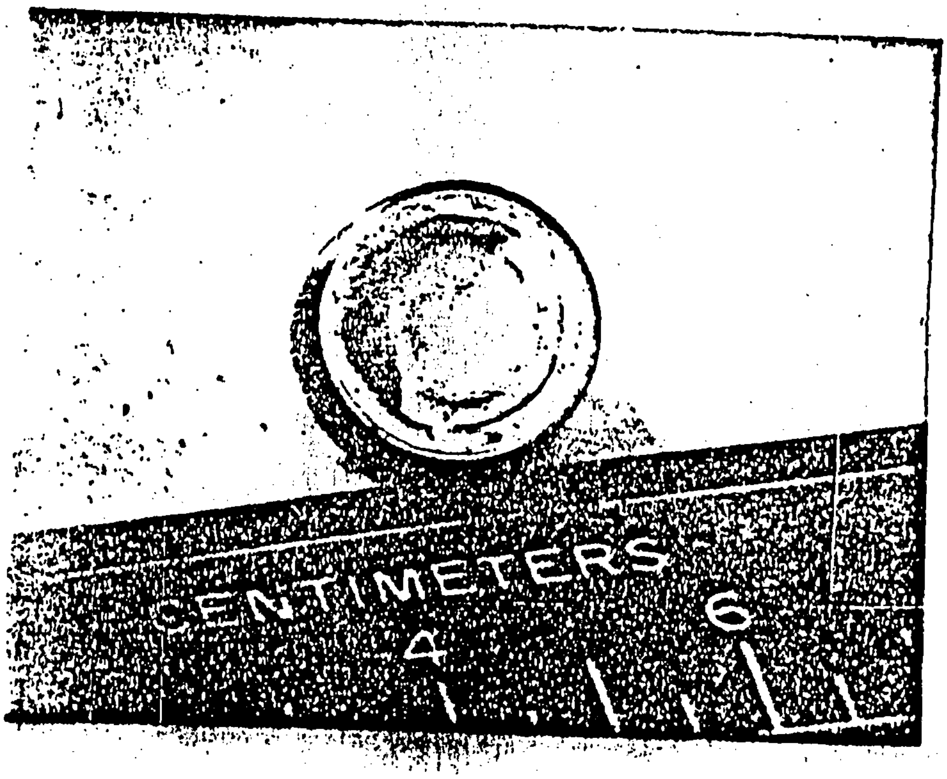


Fig. 8. Source Number 212-4

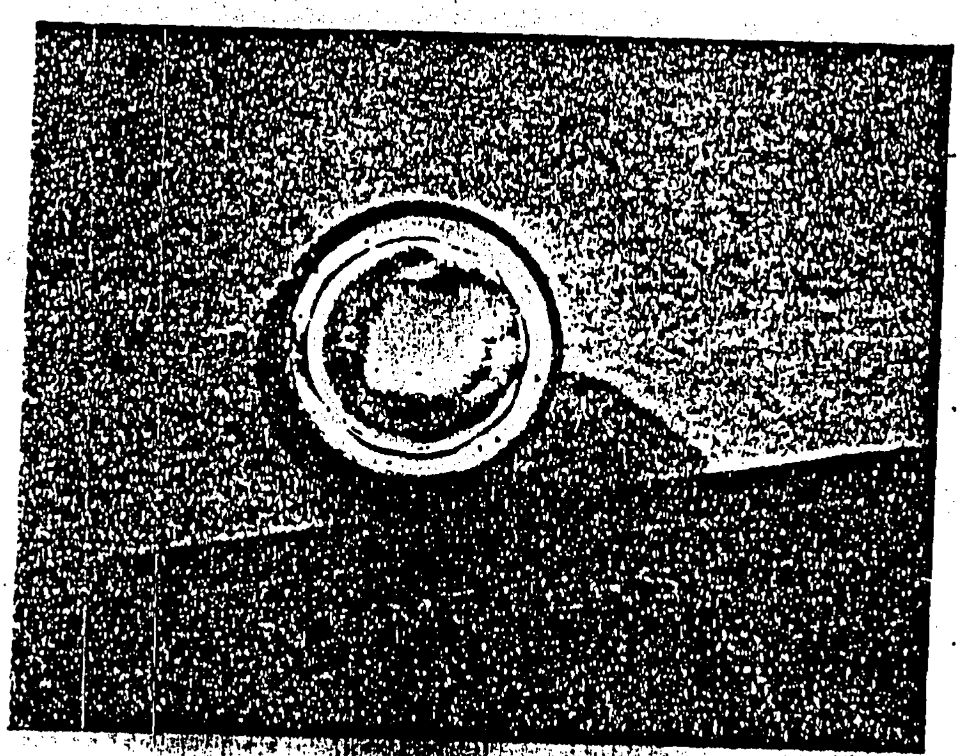
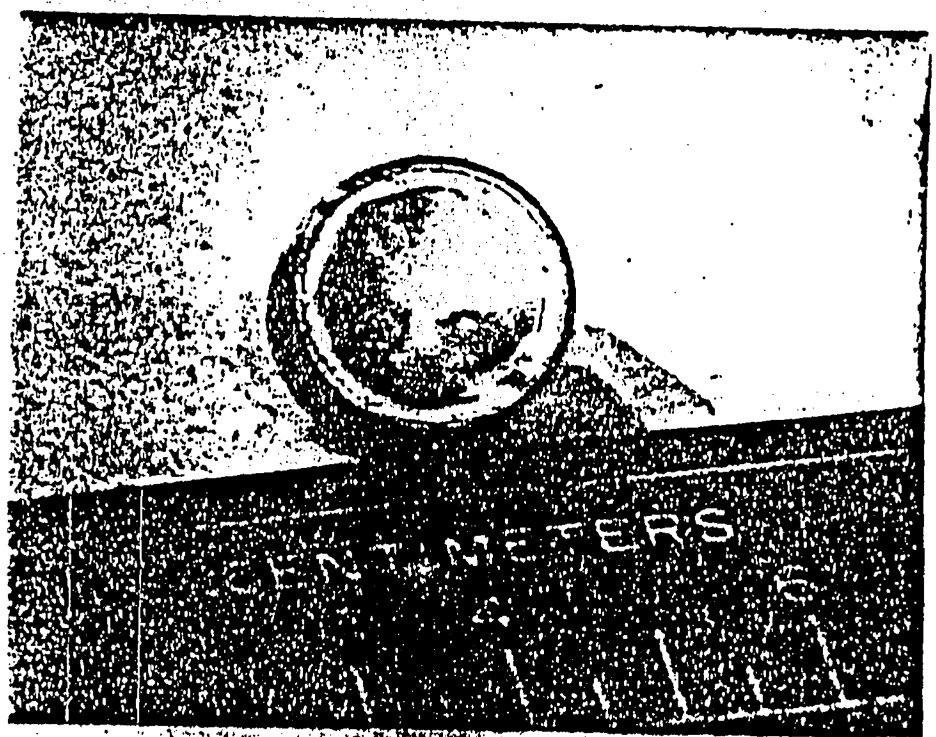


Fig. 9. Source Number 212-5



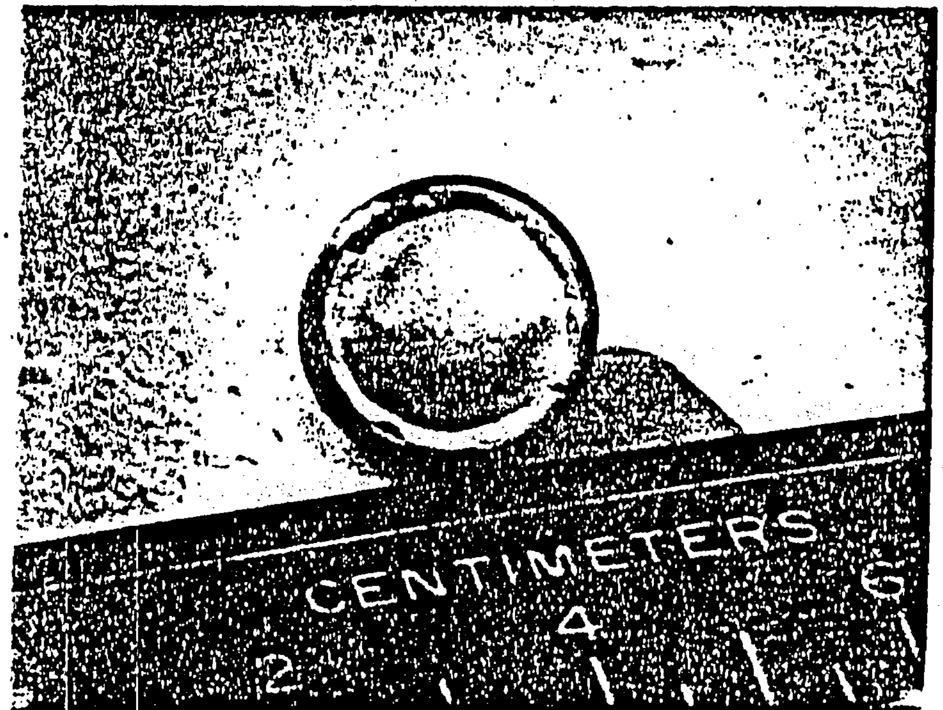


Fig. 11. Source Number 276-2

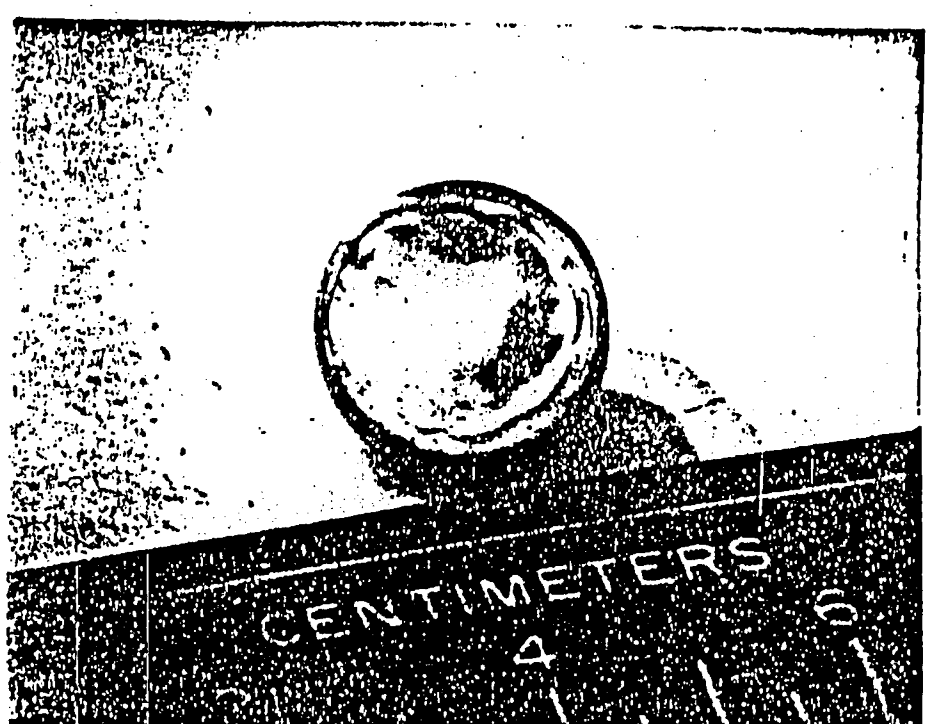


Fig. 12. Source Number 276-3

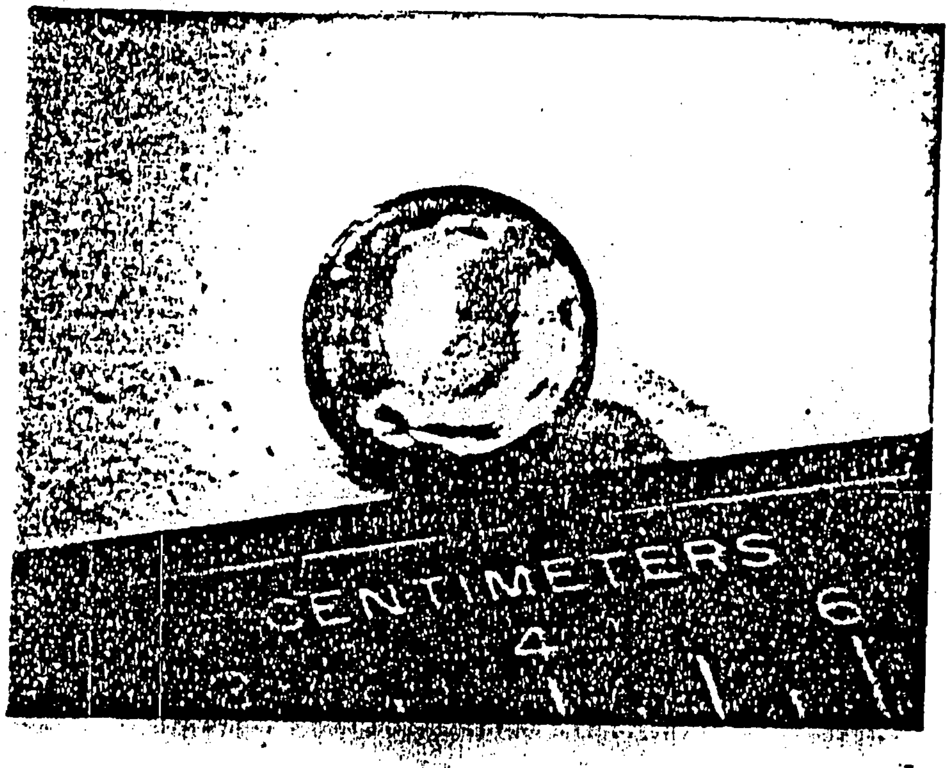


Fig. 13. Source-Number 376-4

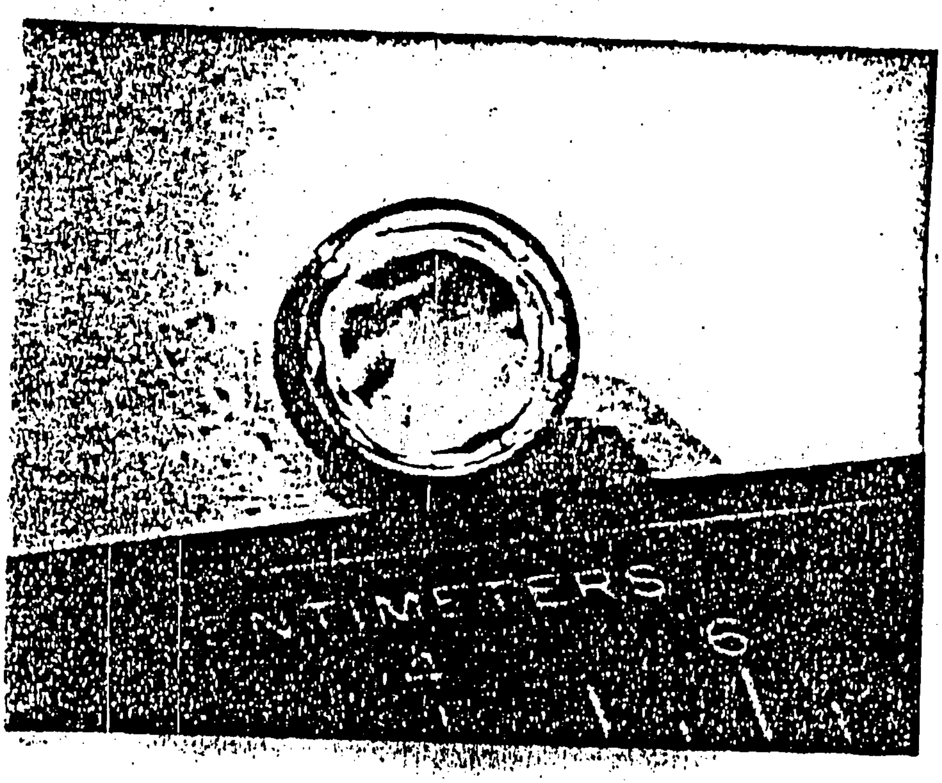


Fig. 14. Source Number 376-[illegible]

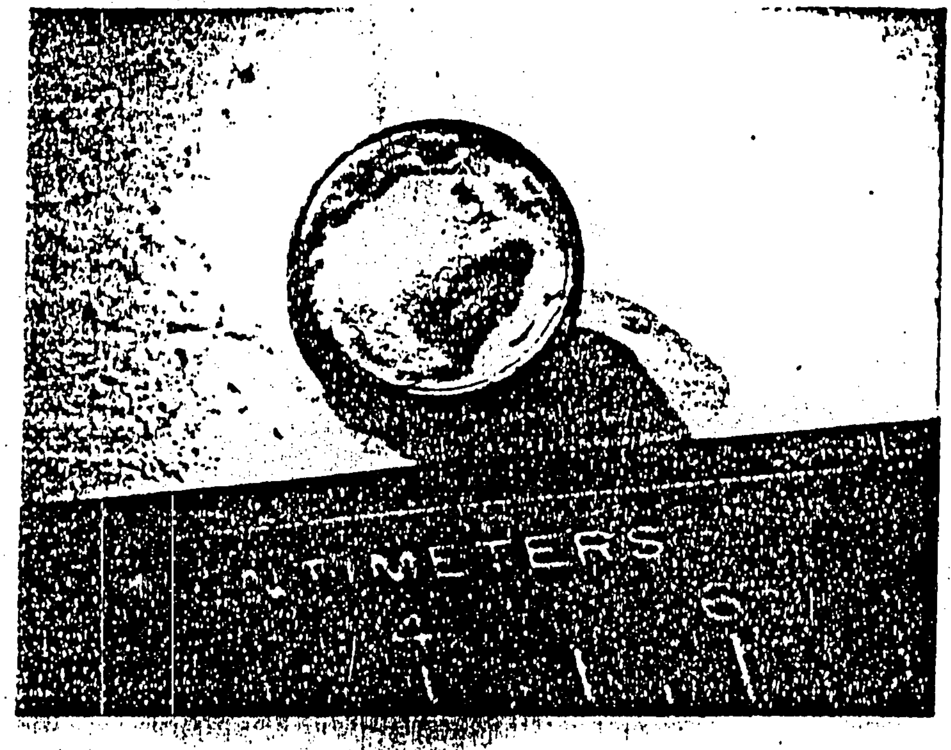


Fig. 15. Source Number 375-1

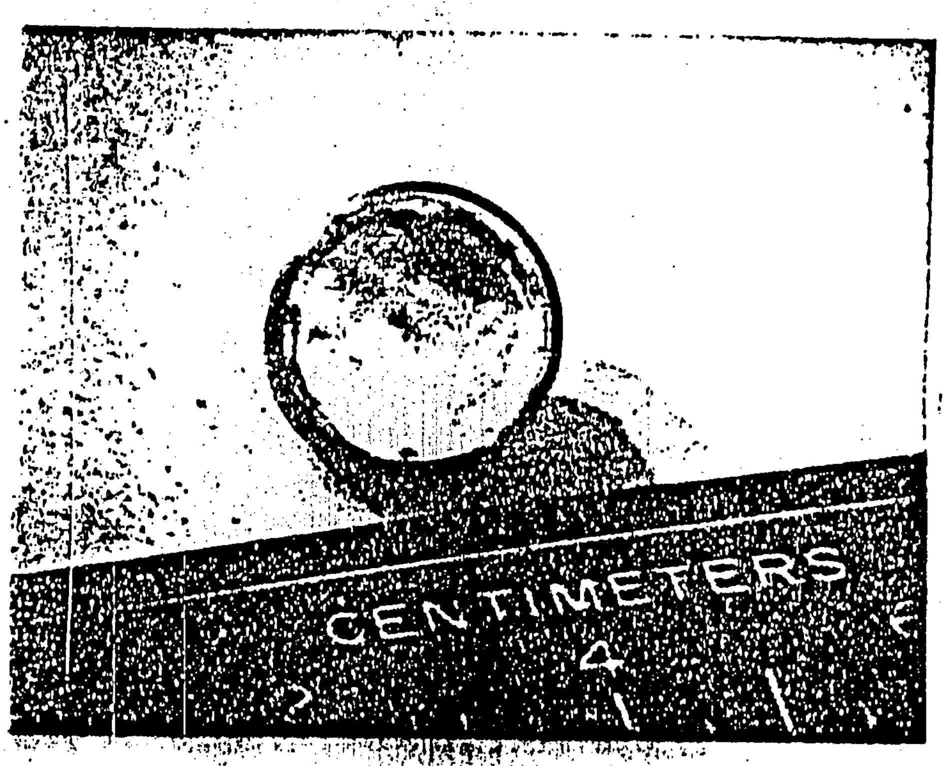


Fig. 16. Source Number 375-2

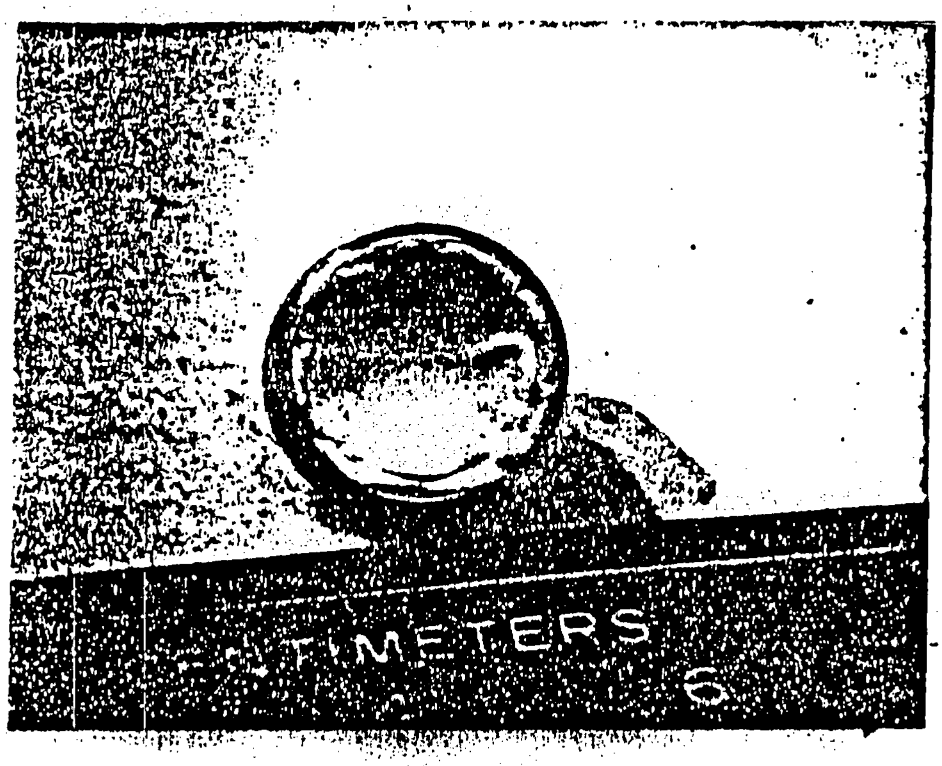


Fig. 17. Source Number 375-3

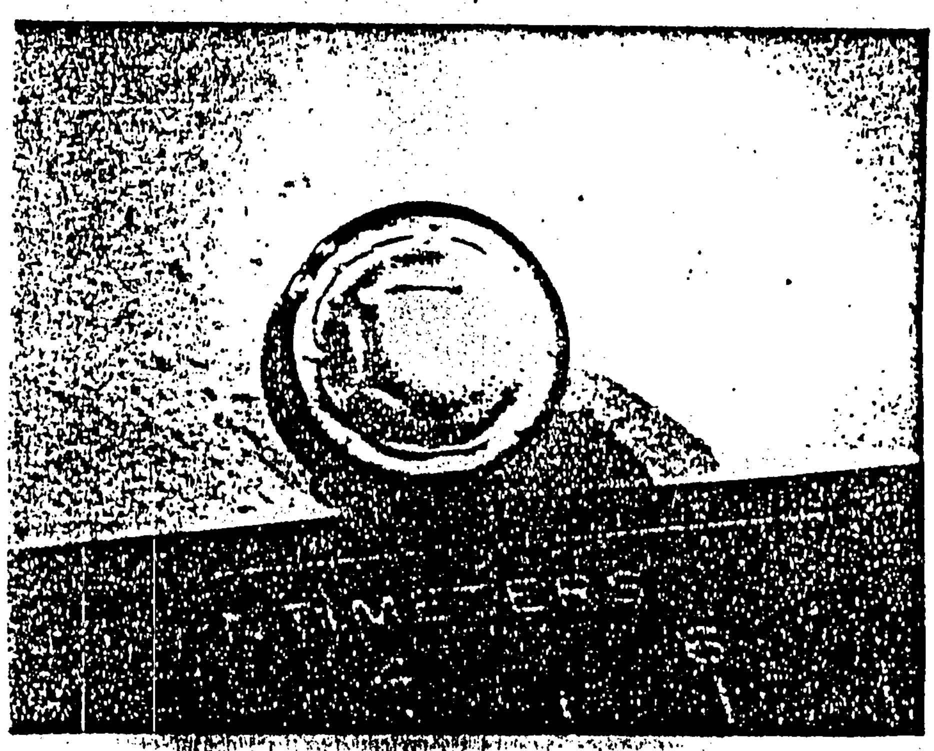


Fig. 18. Source Number 375-4

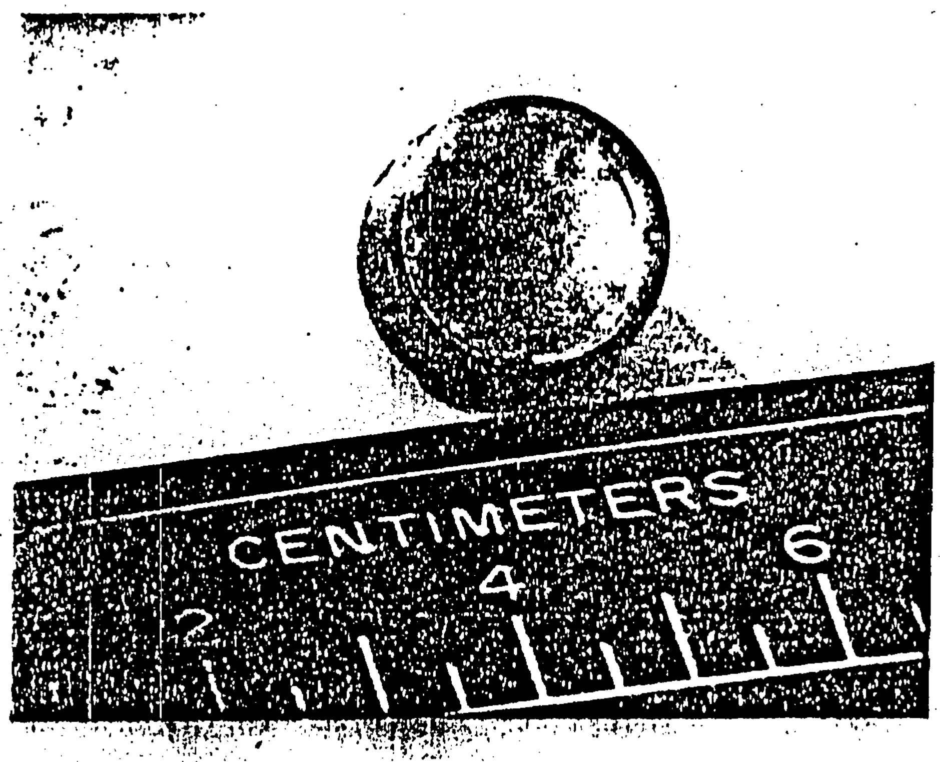


Fig. 19. Source Number 375-5

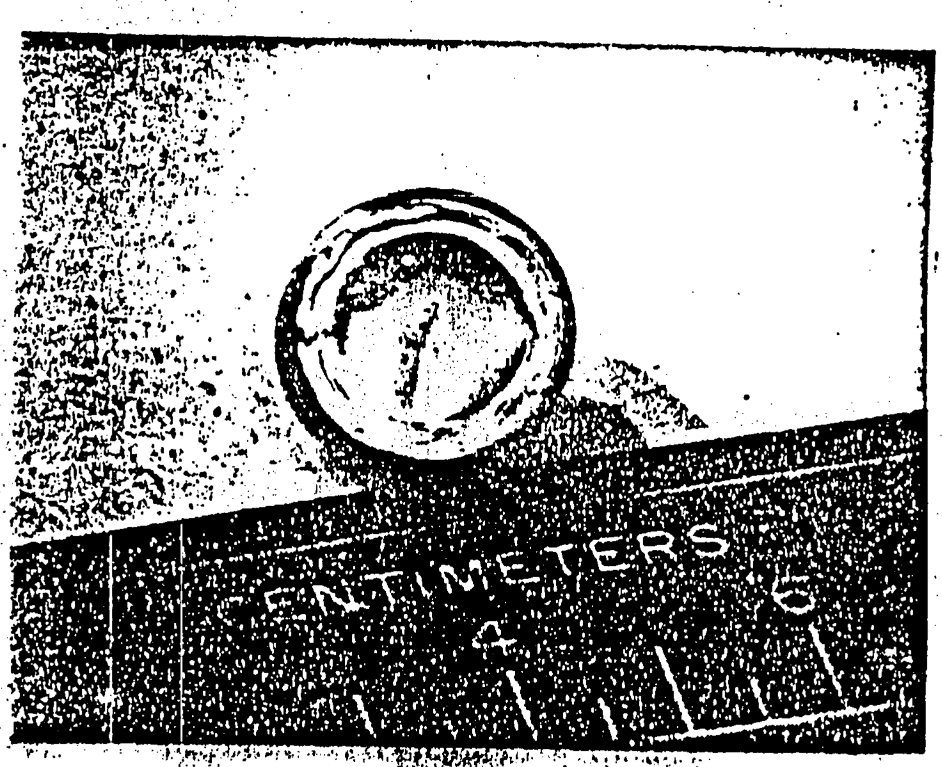


Fig. 20. Source Number 448-1

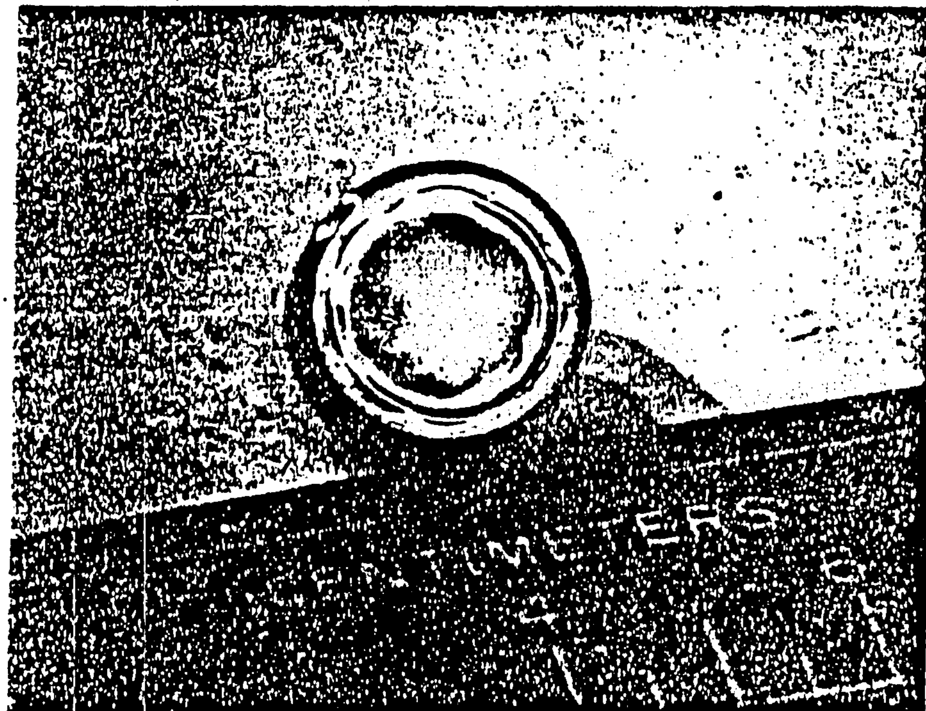
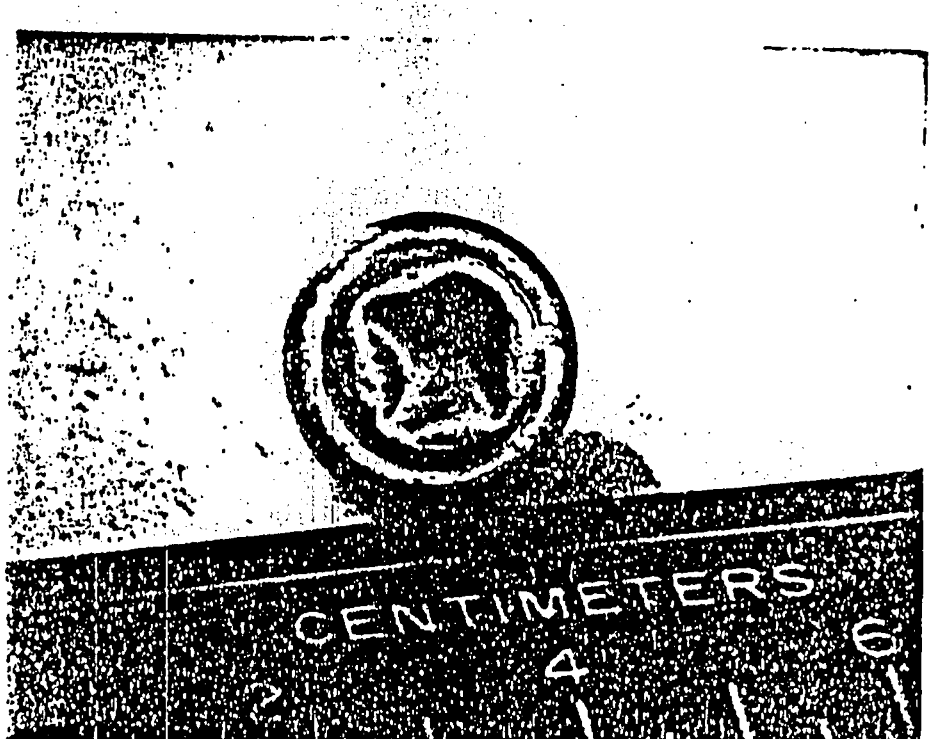


Fig. 21. Source Number 448-2



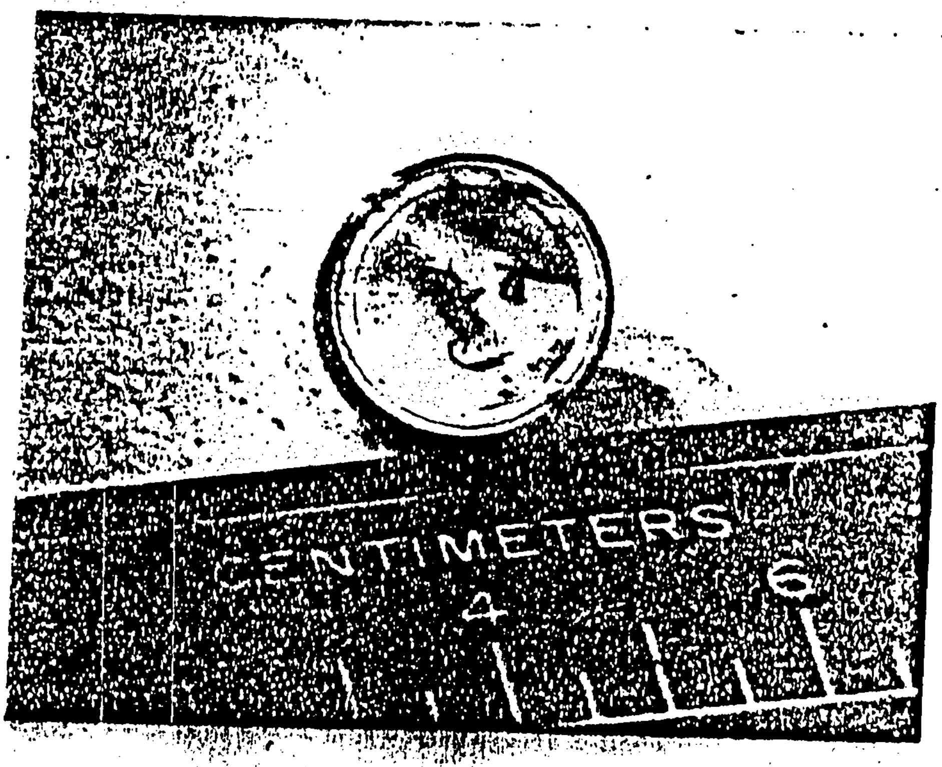


Fig. 23. Source Number 448-4

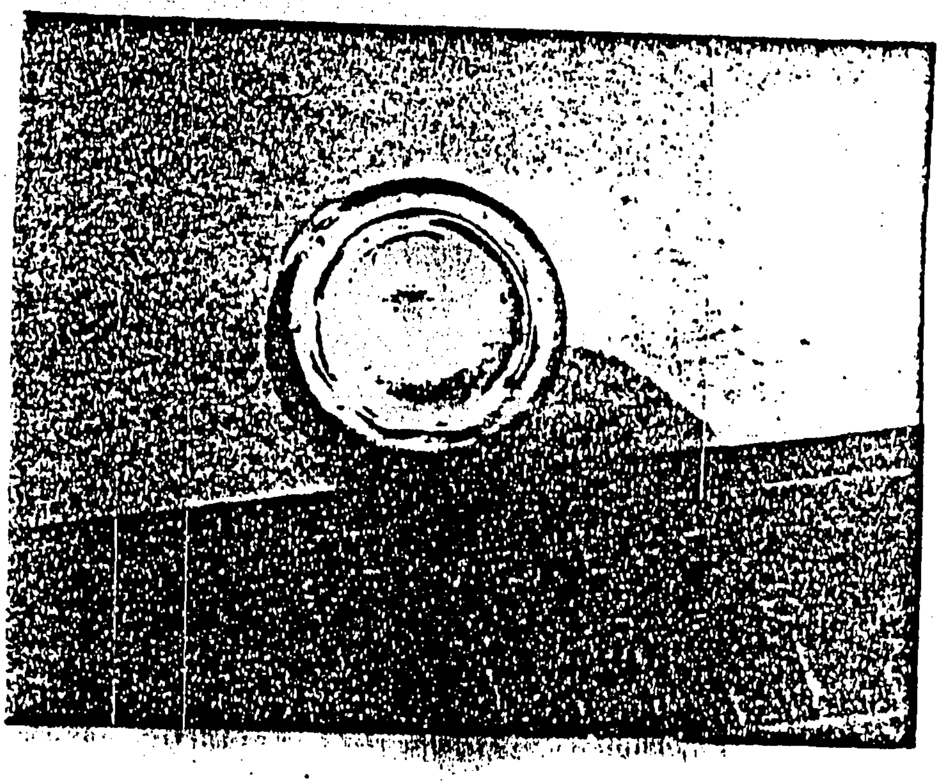


Fig. 24. Source Number 448-5

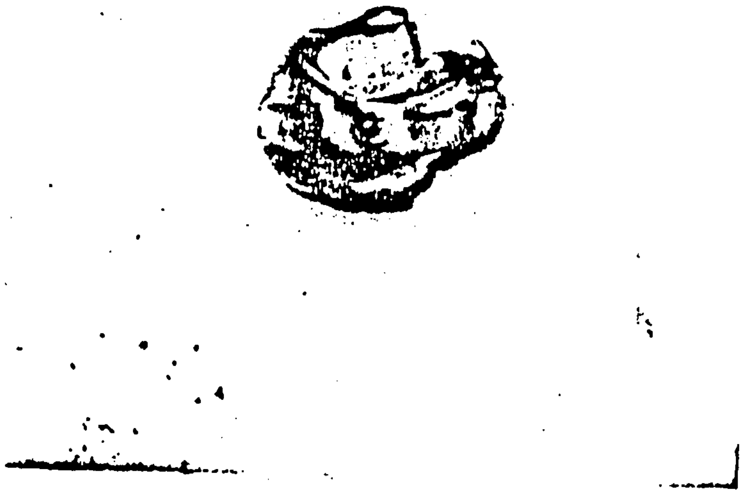


Fig. 25. Outside of Outer Source Window (212-1)

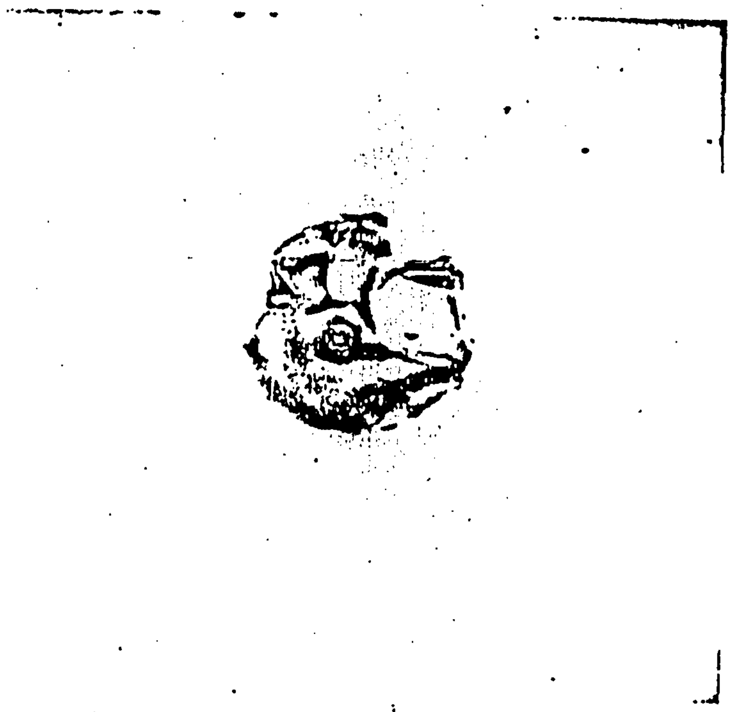


Fig. 26. Inside of Outer Source Window (212-1)

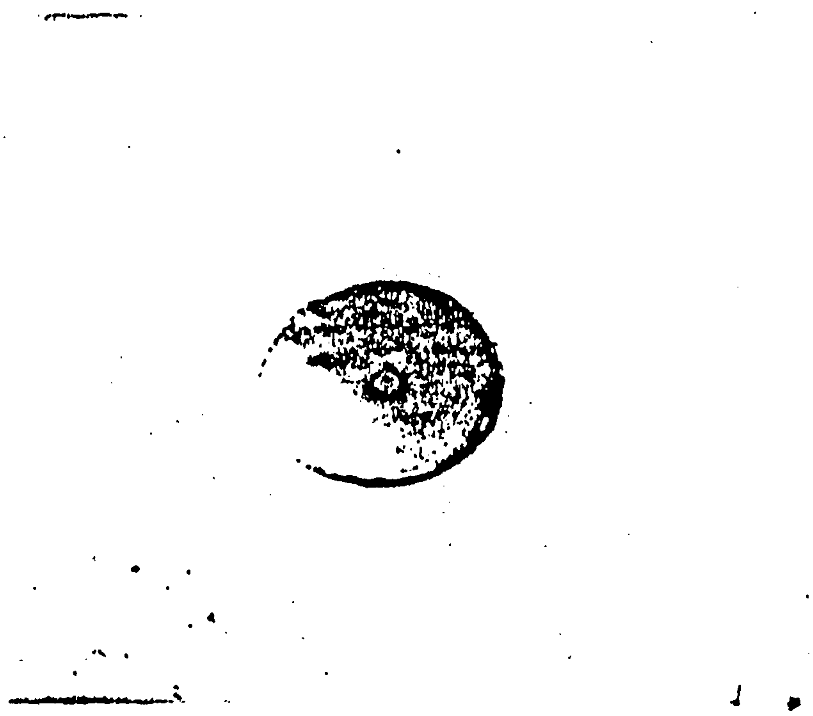


Fig. 27. Outside of Outer Source Window (212-3)

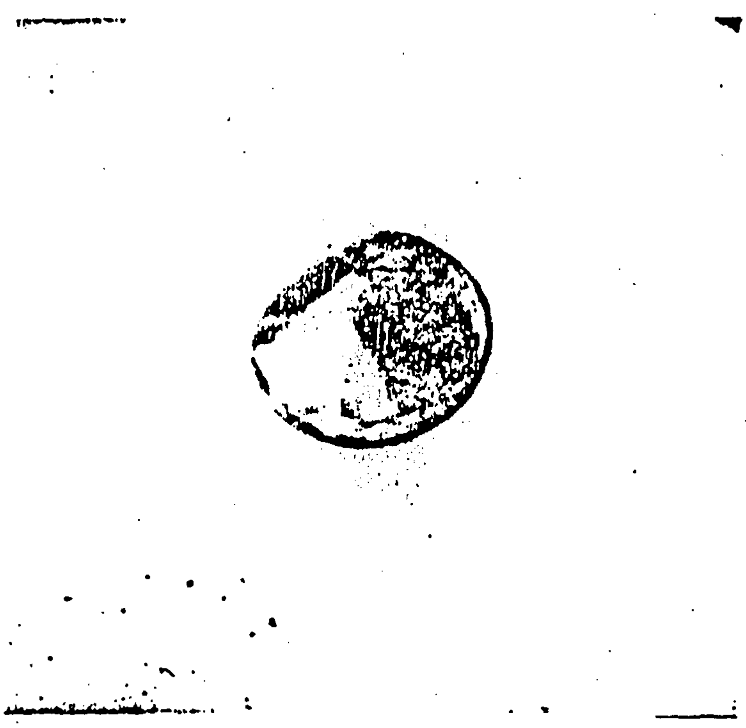


Fig. 29. Outside of Outer Source Window (276-3)

Fig. 30. Inside of Outer Source Window (276-3)

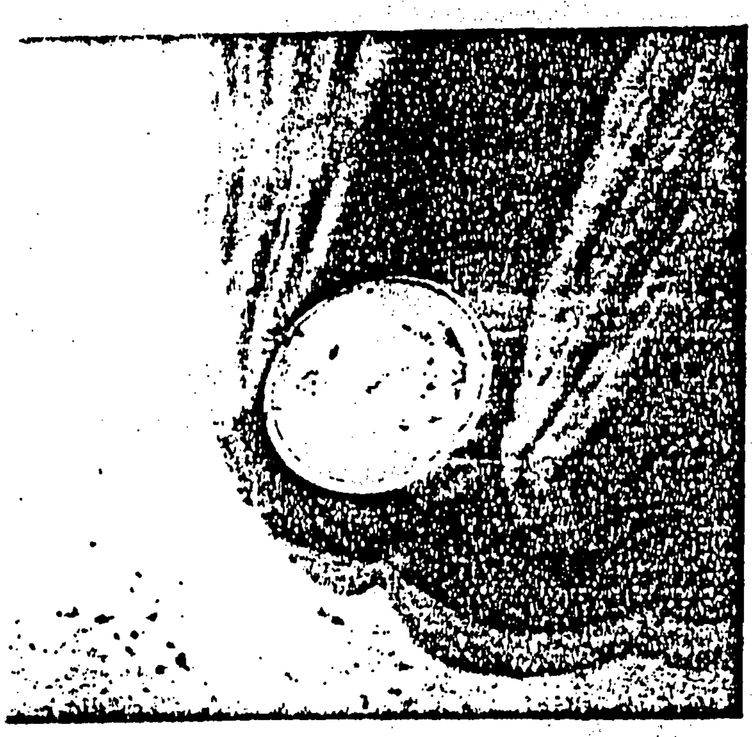
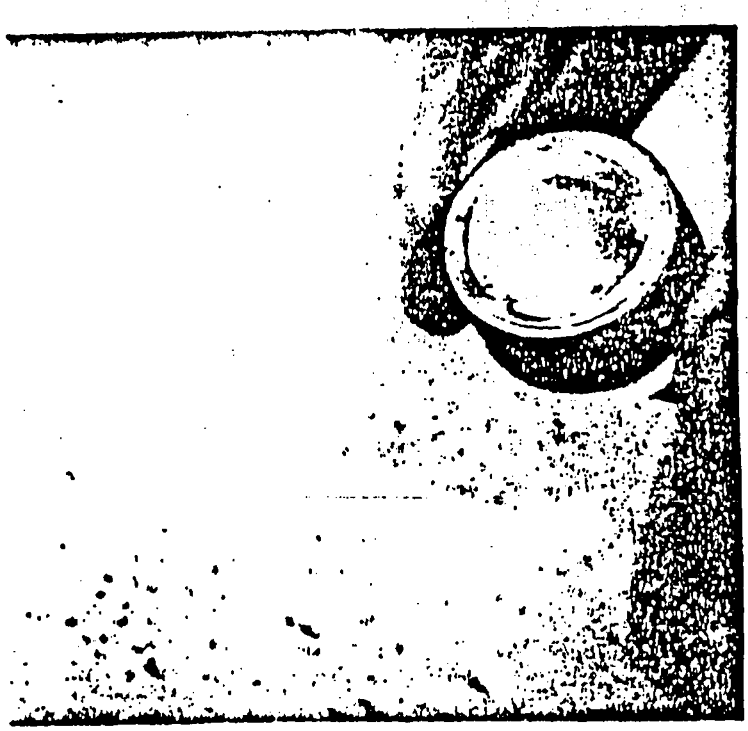


Fig. 31. Inner Source (212-1)



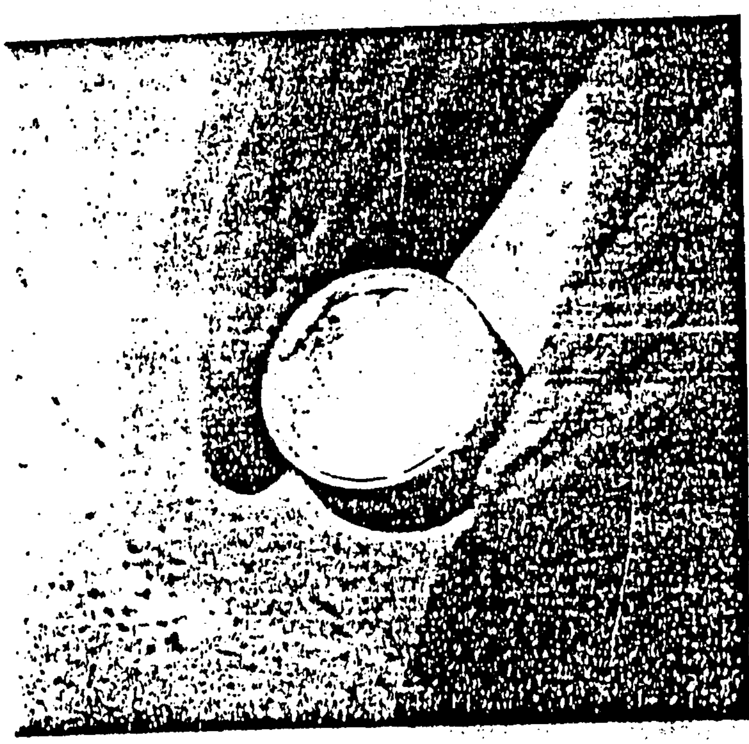


Fig. 33. Inner Source (276-3)

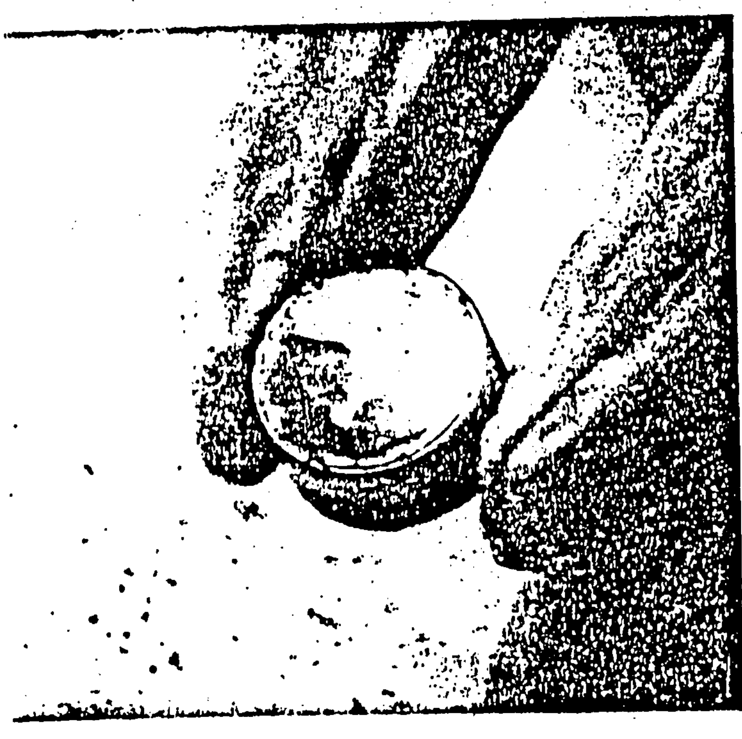


Fig. 34. Inner Source (276-5)

Fig. 35. Inner Source (375-1)

Fig. 36. Inner Source (375-2)

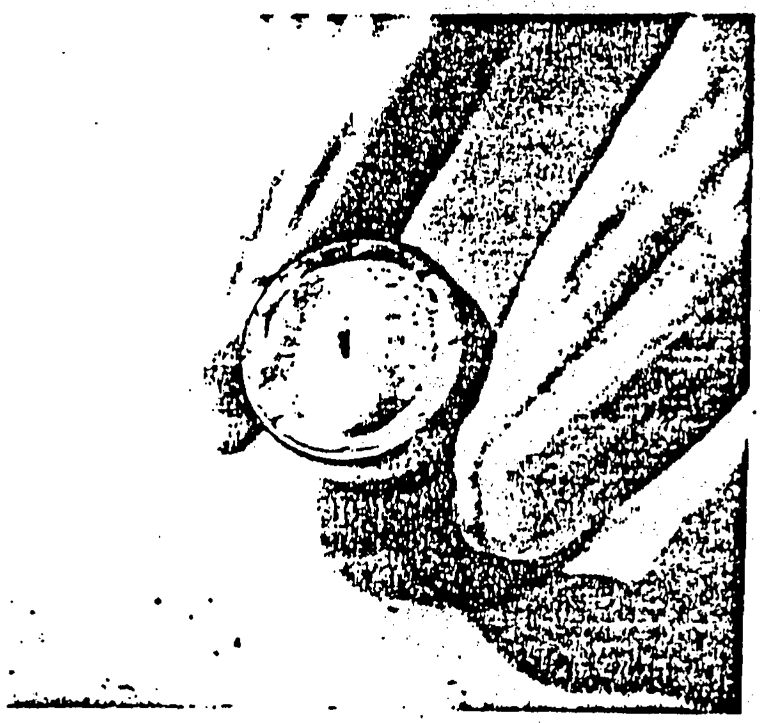


Fig. 37. Inner Source (448-1)

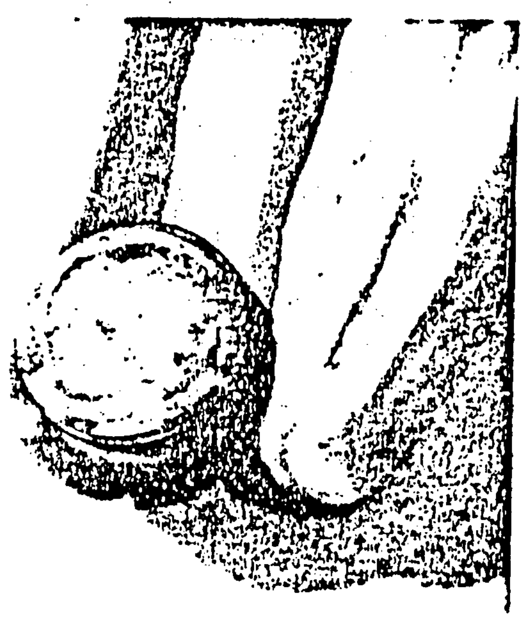


Fig. 38. Inner Source (448-3)

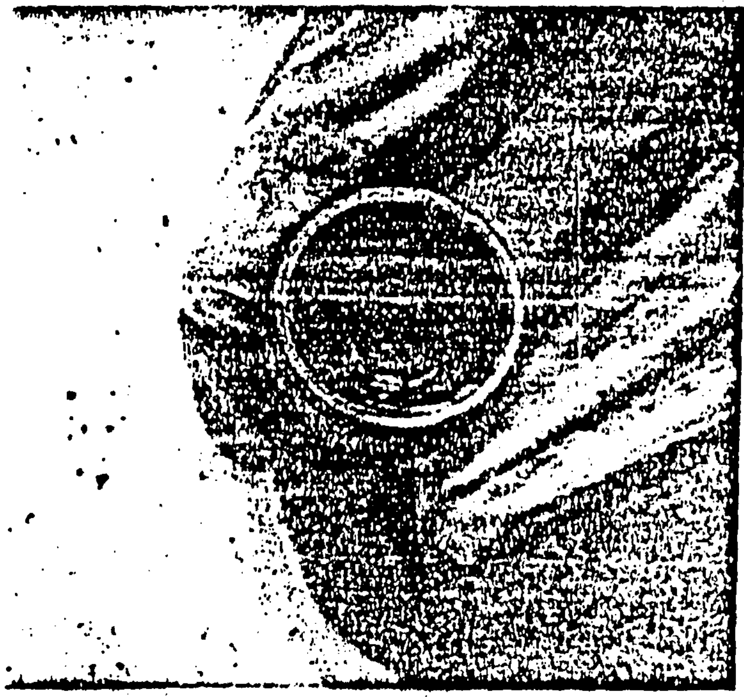


Fig. 39. Inside Outer Source Capsule (212-1)

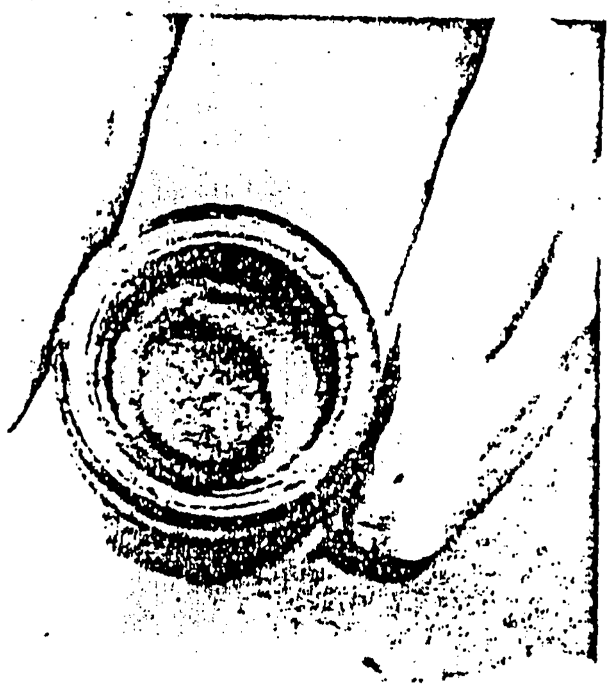


Fig. 40. Inside Outer Source Capsule [illegible]

Fig. 41. Inside Outer Source Capsule (375-1)

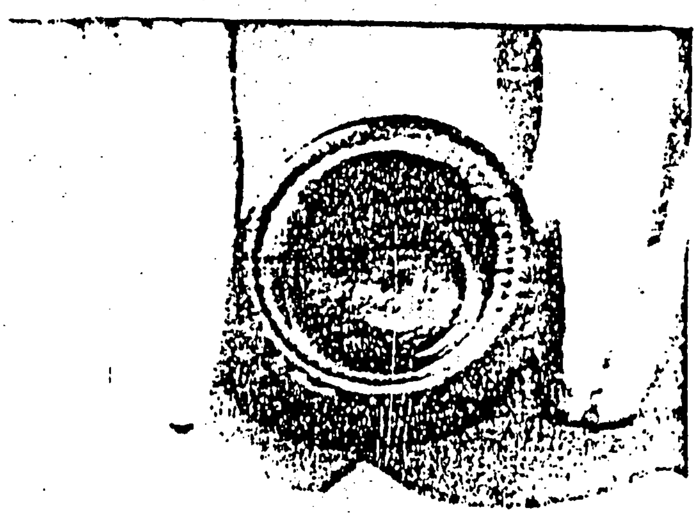


Fig. 42. Inside Outer Source Capsule (375-5)

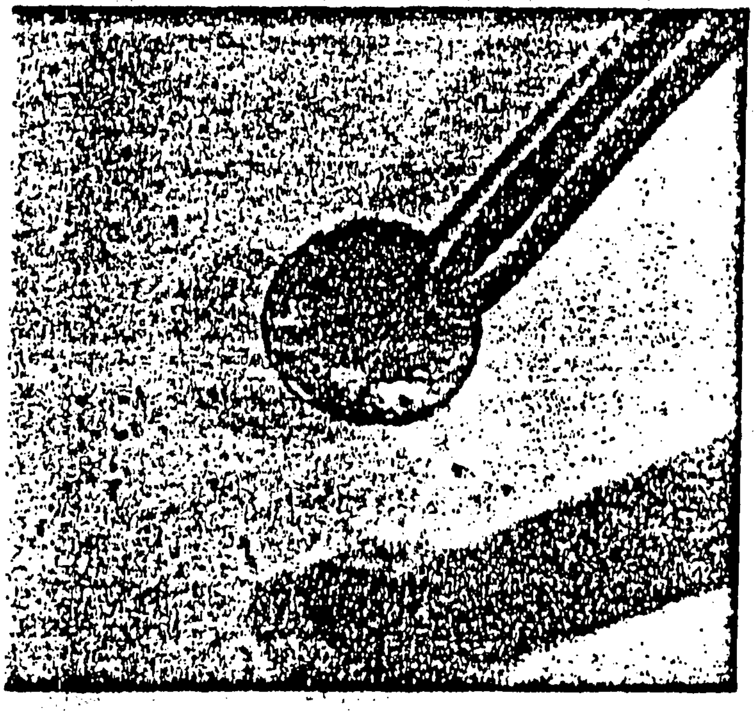


Fig. 43. Outside of Inner Source Window (212-1)

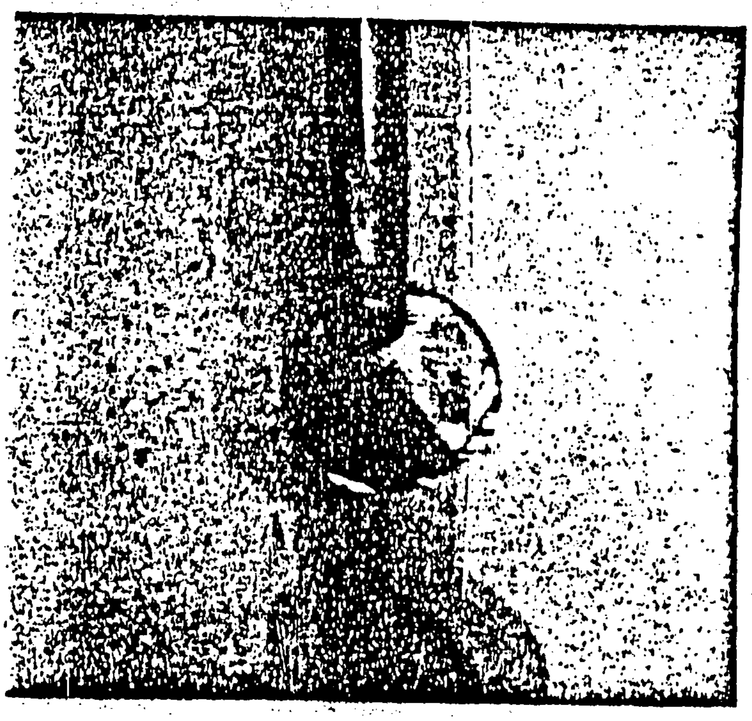


Fig. 44. Inside of Inner Source Window (212-1)

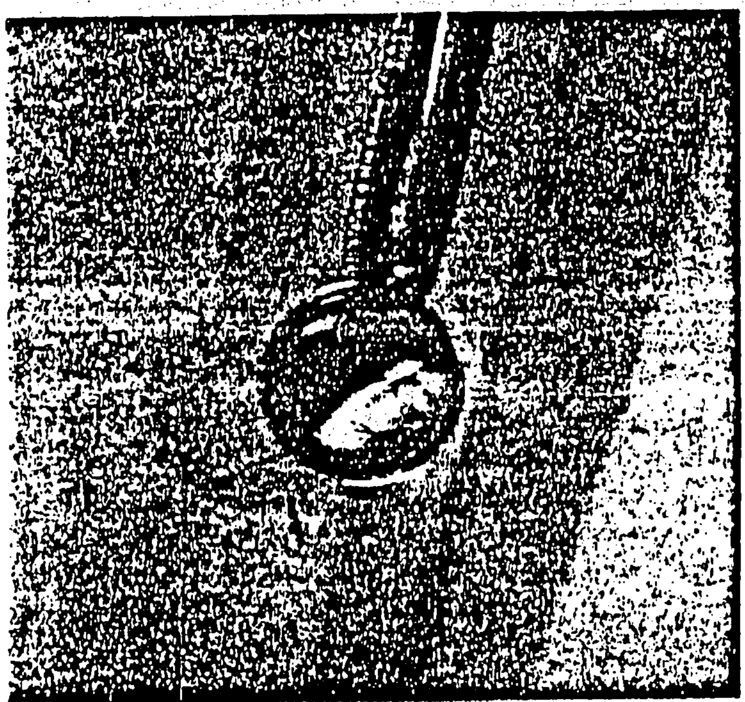


Fig. 45. Outside of Inner Source Window (375-1)

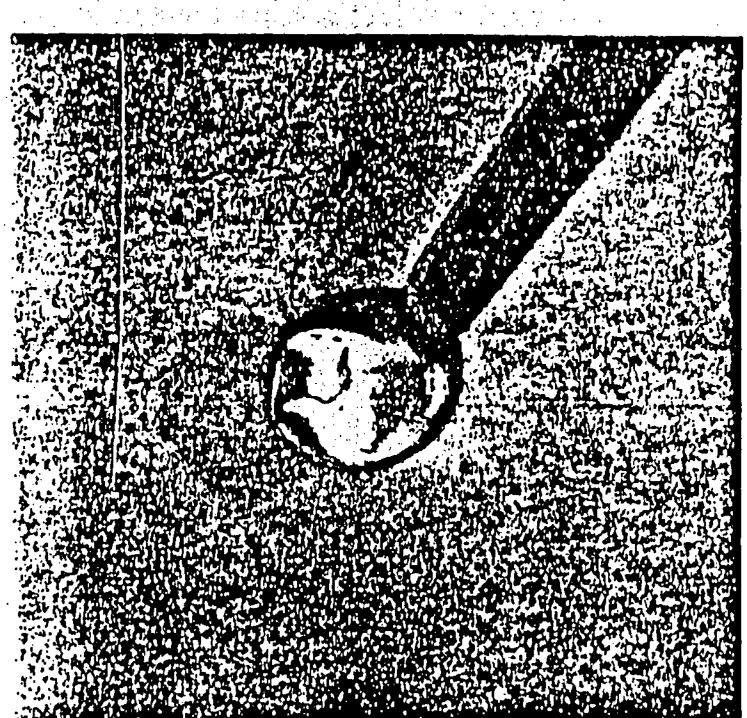


Fig. 46. Inside of Inner Source Window [illegible]

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE CORPORATION
NUCLEAR DIVISION

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37830

October 7, 1980

Mr. Richard G. Rast
Radiac Div.
Department of the Army
U.S. Army Combat Surveillance
and Target Acquisition Laboratory
Fort Monmouth, New Jersey 07703

Dear Mr. Rast:

Subject: Determination of Strontium-90 Activity in the Sources Removed from U.S. Army Calibration Devices

To clarify the statement in the introduction of the report "Examination of Strontium-90 Sources from U.S. Army Calibration Devices", August 1980; concerning the differences in strontium-90 content stated compared with the actual amount, additional assays were made as follows.

Two strontium-90 sources, one a nominal 25 mCi source and the other a nominal 20 μCi source, were dissolved and the resultant solutions assayed to determine the total strontium-90 present. The nominal 25 mCi source (ORNL Identification Number 212-1) contained 43.1 mCi on September 17, 1980. The nominal 20 μCi source (ORNL Identification Number 375-1) contained 123 μCi on September 29, 1980.

We have rewritten the affected pages of the report sent to you in August 1980. Please insert these pages in your copy of the report.

Very truly yours,

F. N. Case
Isotopes Technology
Operations Division

FNC:drw

Attachments

Incl 2

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OPERATIONS DIVISION

K. W. Haff and F. N. Case
Isotopes Technology

OAK RIDGE NATIONAL LABORATORY

Prepared for the U. S. Army under Interagency Agreement
DOE No. 40-1091-80, ARMY No. DAAB07-80-M-6486

Revised October 1, 1980

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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EXAMINATION OF STRONTIUM-90 SOURCE CAPSULES FROM U. S. ARMY CALIBRATION DEVICES

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ABSTRACT

Twenty ^{90}Sr sources, removed from four of seven radiation Detector calibrator sets, were destructively tested for leaks and internal corrosion. One source was found to have a small hole in the window of the outer capsule that appeared to have been caused by electrical discharge during welding at the time of fabrication. None of the sources were found to be leaking ^{90}Sr. Test results, conclusions, and recommendations are reported.

INTRODUCTION

Seven detector calibrators (U.S. Army Radiac Calibrator Set, AN/UDM-2) were shipped to Oak Ridge National Laboratory (ORNL) from the Signal Corp Depot at Lexington, Kentucky for determination of the condition of the ^{90}Sr sources relative to deterioration during storage. Four of the seven sets, Serial Nos. 212, 276, 375, and 448, were selected at random and the sources removed for testing. Each calibrator set has a high and a low level radiation emission section for checking the operational reliability and calibration accuracy of various radiacmeters and radiac sets. Figure 1 is a photograph of the calibrator set in its case. The lefthand section is used for calibration of dose meters and contains four ^{90}Sr sources (one 20 microcurie source and three 25 millicurie sources). The righthand section is used for calibration of ratemeters and contains one 25 millicurie ^{90}Sr source. (The actual loading of the sources is greater than indicated; e.g., a 25 mCi source was dissolved and the ^{90}Sr content was determined to be 43.1 mCi on September 17, 1980. Similarly a 20 μCi source was found to contain 123 μCi of ^{90}Sr on September 29, 1980. Figure 2 is a photograph of the two sections after removal from their storage case. Figure 3 shows the disassembled sections with the sources removed.

A sketch of the encapsulated ^{90}Sr sources is shown in Figure 4. The sources are right circular cylinders and are doubly encapsulated in stainless steel with 10 mil windows which are brazed to a heavier stainless steel wall. The final closure of the source is by gas-tungsten arc welding. The outer capsule is threaded and screwed into the calibrator shields.

DISCUSSION

Upon arrival at Oak Ridge National Laboratory (ORNL) one of the seven calibrators was opened and examined to determine how it was assembled and how it should be disassembled to remove the sources. The chronology of events in the disassembly and inspection of four of the units, containing a total of twenty of the sources, is presented in Table 1.

The outer capsule of each source was visually inspected and photographed using a 100X magnification, leak tested, and smeared for transferrable activity. The outer capsule on one source was found to be leaking. This source had a hole burned in the outer window, apparently by electrical discharge, during the welding operation; however, the inner capsule was leak free and the source did not leak radioactivity. Three other sources also had arc burns (discoloration) on the outer windows but were free of leaks.

If sources of this design are required in the future, fabrication specifications should include consideration for elimination of the holes and arc burns of the type observed on the windows of the sources examined.

We did not consider it necessary to make metallographic examination of the inner windows since there was no observable evidence of corrosion.

Source window distortion is not a reliable indicator of source failure and the wrinkling and concavity is a consequence of the weld sealing of the source. Air in the source is heated during welding and after cooling a vacuum is produced that causes distortion in the 10-mil-thick window. This observation was confirmed in a conversation with one of the fabricators that produced the ^{90}Sr sources for the manufacturer of the calibrator sets.