ELECTRONICS LABORATORY • SYRACUSE, N.Y.

RADIOGRAPHIC TECHNIQUES FOR RELIABILITY SCREENING OF RELAYS

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NO. NAS8-20301
SEPTEMBER 30, 1966

PREPARED BY
SPECIALTY CONTROL DEPARTMENT, WAYNESBORO, VA.
AND
ELECTRONICS LABORATORY, SYRACUSE, N.Y.

GENERAL ELECTRIC

SPECIALTY CONTROL DEPARTMENT, WAYNESBORO, VIRGINIA

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CONTRACT FOR RADIOGRAPHIC TECHNIQUES FOR RELIABILITY

SCREENING OF RELAYS

CONTRACT NO. NAS8-20301

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Note: Copy of above to: Mr. Laurence Garrison, Contracting Officer
NASA, George C. Marshall Space Flight Center
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I. Recommendations:

1. Proposals submitted as required by contract:

a. "Proposed changes to MSFC-STD-355A, Standard Radiographic Inspection of Electronic Parts, dated September 29, 1966."

b. "Proposed Appendix - Hermetically Sealed Relays to MSFC-STD-355A, dated September 14, 1966."

Proposals were not included in this report, but were separately transmitted to customer.

2. Further work should be conducted in the use of 35 mm roll film on holding fixtures, film handling, and general automated component handling methods.

II. Conclusions:

1. Radiographic methods as performed in this contract can be successfully used to identify and locate certain defects that can occur in hermetically sealed relays. This includes metallic defects, such as:

Tramp Metal

Solder Balls

Weld Flash

Incomplete Assemblies

Extra Parts

Damaged Parts

Glass and ceramic parts were barely visible on x-ray film.

2. Radiographic inspection will not reveal the presence of low density contaminants or show defects in low density parts such as:

Dust

Organic Fibers

Epidermis

Flash from Molded Parts

Molded Part Configuration

3. Detection of contaminants, discrepant parts and assemblies depend on the internal structure of the relay. High density masses such as coils and heavy magnetic sections can blank all areas covered by their shadows and prevent effective inspection in one or more views.

4. Three views through the three co-ordinate axes are required to detect all defects. One or more of these may be unusable for relays with very high density sections.

5. X-ray was found to be particularly effective for examination of blind final assembly operations, such as internal welds from can to frame and seal-off hole soldering.

6. Test exposures with 35 mm roll film show better image quality in addition to faster component handling for automated processing. Improved image quality is attributed to the fact that exact source-to-film curvature correction is made for each component. Also, the film is positioned as near as possible to the component, and no film pack or backing is present to interfere with the x-ray beam.

7. When relays are subjected to an external solder process, i.e., solder sealing or lead tinning, care must be taken to note the location of external solder particles in order that these are not confused with internal defects.

III. Summary

In the x-raying of sealed relays the optimum exposure was found to be one which results in a density of the image of 2.0 and obtained at the lowest practical kilovoltage.

Comparable results were obtained using either a 36 or 48 inch target to film distance. The film size at 36 inches for reasons of distortion was limited to 4x17 and at 48 inches was limited to 6x17 inches with the 17 inch direction corrected for the proper radius of target to film distance.

Three views through the three co-ordinate axes are required to detect all defects, however, in some types of relays, one or more of the views will not necessarily be completely usable because the internal construction can be masked by coils or other relatively massive components.

Two types of penetrameters were used in the majority of exposures. One was the type illustrated in MSFC-STD-355A and the second was the actual case of the type relay being radiographed with an AWG #48 copper wire attached to the outside of the case. The former penetrameter was found to be more definitive.

Defects which could not be resolved by a radiographic examination were those where the internal implanted materials were of a light density such as hair, lint or insulation or where the internal discrepancies were masked by heavier sections of the internal construction.

Misaligned components and copper wires in excess of .002 of an inch in diameter were readily discernable.

The results of this program show that the x-raying of hermetically sealed relays is feasible and practical in locating certain types of defects which could affect the useful life of this device. However, because of its geometry, case thickness and composition and its internal construction, a visual inspection prior to final sealing is necessary.

IV. Purpose

The Materials & Processes Section of the Electronics Laboratory in conjunction with the Relay Operations of the Specialty Control Department of the General Electric Company undertook the program of evaluating radiographic techniques for the reliable screening of hermetically sealed relays under contract NAS 8-20301 for the George C. Marshall Space Flight Center, National Aeronautics and Space Administration at Huntsville, Alabama.

The purpose of this endeavor was to determine whether or not radiographic examination methods are practical in the non-destructive, 100% screening of hermetically sealed relays. If feasible, we would attempt to establish whether or not these methods will reliably reduce the margin of error in the sorting of rejectable components, and to develop practical test methods, procedures and acceptance criteria.

V. Introduction

The radiographic inspection of relays is similar to, but more involved than, the x-raying of semiconductors. This is principally true because of the number of individual components making up the internal structure and the physical rectangular dimensions of the case, some with mounting tabs, which places the device a marked distance away from the film.

The four relays on which this study was concentrated have the following three approximate nominal dimensions of case:

	Type	Height	Width	Thickness	Case Material
1	SAV	0.390	0.790	.008	Cu-Ni
2	SAF	0.885	0.800	.012	Cu-Ni
	SAM	"	"	"	"
3	SAH	0.810	1.00	.015	AISI 1010

Sketches and radiograph prints of the type relays tested are located in the appendix.

Penetrameters

Two types of penetrameters were utilized in the majority of exposures. One was the penetrameter depicted in MSFC-STD-355A and the second was the actual case of the relay being radiographed with an AWG size 48 copper wire attached to the outside of the case on the side away from the film.

Film

The film used in all the test exposures was a very fine grain, single emulsion film designated as Kodak R.

Processing

The exposed film was processed as recommended in the manufacturer's instructions.

X-Ray Equipment

The majority of the exposures were made using a General Electric

OX-175 unit with a 3.5 millimeter focal spot and a maximum of 175 kilovolts. Some tests were also made using a Norelco MG 150, with a 2.5 millimeter focal spot.

VI. Test Procedure

The test exposures were made by varying exposure time, kilovoltage, target to film distance and intensifying screens. The tabulation of the variables used is shown in the appendix.

Each type of relay with its mating penetrameter was exposed through each of their four sides and through the bottom with the pins up and with the pins next to the film. The exposures through the bottom were considerably longer to allow for penetration through the header. During these exposures the relays were placed directly under the target.

The test exposures were examined on an x-ray viewer at a magnification of 10 diameters. Density measurements were then made on a Densichron 2. The exposures which showed the best definition were used for the radiographing of the relays.

The first group of relays to be x-rayed consisted of 117 SAV units. To determine the maximum film size that could be utilized 5 rows of 15 relays each were placed on a 14"x17" film. The film was formed to fit either the 36" or 48" radius of the focal spot to film distance in the 17" direction.

A small number of relays were also deliberately tilted approximately 5^{o} to determine the feasibility of this method.

Seventy-one relays that had some type of defect implanted were radiographically inspected. Twenty-one others were a group of miscellaneous types, 363 were new relays out of current production, and 43 were relays manufactured by suppliers other than the General Electric Company.

The following relays contained deliberate defects and were x-rayed to determine if the defects could be resolved.

Serial Number	Relay Type	Type of Defect
1	SAF	Human Hair
2	SAF	Lint
3	SAF	Human Hair
4	SAF	Loose Tape Ends
5	SAV	Insulation Frayed on Black Coil Lead
6	SAF	Lint
7	SAF	Tape, Inserted in Gap
8	SAV	Contact Tip Bent to Header
9	SAM	Broken Ceramic Actuator
10	SAF	Loose Armature Shaft
11	SAF	" " "
12	SAF	" " "
13	SAF	" " "
14	SAM	Broken Actuator Actuator Lifter Not Properly Bent Coil Lead Touching Header
15	SAV	Stationary Tip Bent
16	SAV	Actuator Bead Rubbing Header Coil Lead Touching Edge of Contact
17	SAM	Coil Leads Not Welded to Pins
18	SAM	Coil Lead Burned Off - Weld Spatter
19	SAM	Display Sample
20	SAM	Shim Removed from Moveable Contact
21	SAF	Armature Return Spring Removed
22	SAV	Actuator Rod Rubbing Frame
23	SAH	Broken Ceramic Coil Spool Shims and Frame Spring Removed Armature Retaining Spring Not in Notch Broken Coil Lead to Header Weld
24	SAF	Actuator Bead Rubs Contact Coil Leads Not Welded to Pins Misaligned Stationary Contact

Serial Number	Relay Type	Type of Defect
25	SAF	0.015 Gap Between Frame and Spool Metallic Chips
26	SAV	Coil Lead Weld Broken Metallic Chips
27	SAF	Glass in Header with Frame Leg Welded
28	SAM	.005 Diameter Copper Wire
29	SAM	Coil Lead Smashed During Welding
30	SAV	Weld Spatter
31	SAV	Voids Along Welded Edge
32	SAV	"
33	SAV	"
34	SAV	"
35	SAV	"
36	SAV	"
37	SAE	Weld Spatter on Top of Frame
38	SAE	Can to Frame Weld at 30% Normal Cycle
39	SAF	"
40	SAF	"
41	SAF	"
42	SAF	"
43	SAF	"
44	SAF	"
45	SAF	Can to Frame Weld-Pressure-No Weld
46	SAF	"
47	SAF	"
48	SAF	"
49	SAF	Radiflow Leaker
50	SAF	"

Serial Number	Relay Type	Type of Defect
51	SAF	Radiflow Leaker
52	SAH	"
53	SAH	Corroded Frame Side Spring
54	SAH	Dead Spot
55	SAV	Weld Flash Frame to Bottom Plate
56	SAV	"
57	SAV	"
58	SAV	"
59	SAF	Can to Frame Weld-Pressure No Weld Current
60	SAF	"
61	SAF	"
62	SAF	Can to Frame Weld-Reduced Current (30% of Normal)
63	SAF	"
64	SAF	Can to Frame Weld-Normal Setting
65	SAF	"
66	SAF	"
67	SAF	Can to Frame Weld-Excessive Current
68	SAF	"
69	SAV	0.001"-0.002"-0.003"-0.004" Copper Wire
70	SAF	"
71	SAH	"

Also radiographed were the following quantities of sealed relays for a total of 427.

SAV	-	141		
SAF	-	99		
SAM	-	99		
SAH	-	24		
Miscellaneous	-	21	-	A to V
Potter-Brumfield	-	10	-	1P to 10P
Filtors Inc.	-	10	-	1F to 10F
Leach	-	10	-	1L to 10L
Struthers-Dunn	-	10	-	1S to 10S
Electro-Tec	-	3	-	1E to 3E

A representative number of the different type relays were radiographed using a Norelco MG 150 x-ray unit with a 2.5 mm focal spot. These exposures were made at 130 KV, 13.5 MA and at a 48 inch target to film distance. The film used was 35 mm Kodak "R". The resolution was superior to that of the flat film, one reason being that there is no cassette covering the film thus no material between the object and film. Photograph #3 shows a portion of the film.

VII. Discussion

Density

The optimum exposure which results in the best clarity of the image or the film is when the density is 2.0. A reliable and acceptable image can be obtained at density readings of 1.8 to 2.2. It is also necessary to obtain this value at the lowest practical kilovoltage.

Target to Film Distance

Tests were performed at 36 and 48 inch target-to-film distance at approximately the same film density. There appeared to be no difference in resolution or clarity of the images. The distortion measured according to MSFC-STD-355A was a maximum of 4.4% at 36 inches and 4.9% maximum at 48 inches using a curvature - corrected 17x4 inch film size.

Intensifying Screens

The use of screens at the higher KV did not noticeably improve the image.

Distortion

Using an entire 14x17 inch film corrected only in the 17" direction for the proper radius of target-to-film distance resulted in noticeable distortion of the relay image. At a 36 inch target-to-film distance only the center strip four inches wide was distortion-free, and at a 48 inch target-to-film distance this width was approximately six inches. Photographs 1 and 2 show this condition.

One test exposure was made at 48 inches utilizing units on the entire 14-17 inch film, corrected in the 17 inch diameter, and the penetrameter as per MSFC-STD-355A. There was noticeable distortion of the outer rows of relays even though the distortion percentages were as follows:

Penetrameter #3	Penetrameter #4
A - 5.4%	A - 5.0%
B - 7.7	B - 3.8
C - 0	C - 1.6
D - 1.7	D - 2.1

Exposure

The following settings were selected for the exposures of the various relays:

Type	Position	KV	MA	Time (sec.)	Distance (in.)
SAV	Side	90	8	125	36
"	Bottom	110	8	200	36
SAF	Side	110	8	125	36
"	Bottom	110	8	240	36
SAM	Side	110	8	125	36
"	Bottom	110	8	240	36
SAH	Side	110	8	125	36
"	Bottom	110	8	240	36

The 36 inch target-to-film distance was selected not only because there was no measurable difference in resolution between 36 and 48 inches but also because of the slightly smaller distortion value at the thirty-six inch level.

Penetrameters

Two types of penetrameters were used in the majority of exposures. The one described in MSFC-STD-355A and the second utilizing the can of the relays being radiographed with an AWG #48 (approximately .001") copper wire on the outside with the wire away from the film.

The former can be utilized if the film size is limited but the density of the device being x-rayed will not necessarily be identical to the penetrameter because of case material composition and thickness.

The latter penetrameter will have approximately the same density as the object being x-rayed, with some difference caused by the tolerance of the case thickness. The wire located on the outside of the case can be misleading. Tests made with the wire inside and outside the case showed that different exposures are necessary to discern the wire under each condition. A second test performed with varying lengths of .0012" diameter copper wire showed that when the wire length is shorter than 0.010" it is extremely difficult to resolve in the radiograph. If a relay then contains a particle which has a diameter of 0.001 of an inch and of a density comparable to copper it will be very difficult to discern.

Tilting

Deliberate tilting of the relays was tried in an attempt to show voids in the electron beam weld of the can to the header. This was not successful.

Implanted Defects

The materials (lint, hair, frayed insulation) implanted in the relays numbered #1 to #6 were not able to be resolved because of their light density. In relay #7 the tip alignment could not be resolved because of the diagonal direction of the armature which masks the gap.

Relays #39 to #48 and #59 to #68 were radiographed to determine the effects of varying the weld current on the top spot weld. The relays, where only pressure was applied without any current, were readily discernable. One of the two (#67) which had excessive current showed weld spatter. We did measure the effective weld bead on these relays with the following results:

Relay Number	Weld Condition	Effective Weld Length (inches)
39	Can to Frame Weld-30% Normal Current	.045
40	"	.045
41	"	.045
42	"	.045
43	"	.045
44	"	.045
45	Can to Frame Weld-Pressure-No Current	0
46	"	0
59	"	0
60	"	0
61	"	0
62	Can to Frame Weld-Reduced Current	.040
63	"	.042
64	Can to Frame Weld-Normal Current	.045
65	"	.045
66	"	.045
67	Can to Frame Weld-Excessive Current	.060
68	"	.060

These measurements show that the effective weld lengths are similar for normal currents and for settings up to 30% below normal. A definite increase in length was found when using excessive current.

The misaligned parts such as springs and contacts were readily resolved as was the weld spatter. The only defects that could not be resolved were primarily those that were of a light density or those masked by thicker sections in the internal structure of the relays.

These relays were also radiographed on the four sides and through the top both with the pins on and away from the film. This was done to determine if the defects located closer to the film would be more apparent. In each case the defect could be seen in views taken 180^{o} apart and there was also no apparent difference in making exposures either with the pins on or away from the film. We can conclude, therefore, that three views through the three coordinate axes are required to detect all defects, however, in some types of relays, one or more of the views will not necessarily be completely usable because the internal construction can be masked by coils or other relatively massive components.

The relays manufactured by suppliers other than General Electric were radiographed using the same established exposures with similar results. The exception was the devices from Electro-Tec. We were able to resolve the 0 and 90 degree views but the exposures through the top were unsuccessful because of high density or heavy sections in this area.

One time consuming portion of the evaluation of the relay radiographs is the presence of solder splatter on the outside of the case. Some provisions should be made to have the manufacturer either clean or mask these surfaces if a soldering operation is performed.

A tabulation of the defects found in all the radiographs can be found in the appendix. Photographs of typical defects with their corresponding radiograph prints are included as are radiograph prints of all the various types of relays tested. In some instances the defects in the photographs will not be readily apparent because of some loss of detail that naturally occurs in the reproduction process.

Of the sealed relays, the following quantities were considered to be discrepant.

Relay Type	Qty. Relays for X-ray Inspection	Qty. Relays found Discrepant *	Rejected Relays	
			Quantity	Reason
SAV	141	3	2	Foreign Material
SAM	99	4	2	Foreign Material
			1	Weld Flash
SAF	99	4	1	Foreign Material

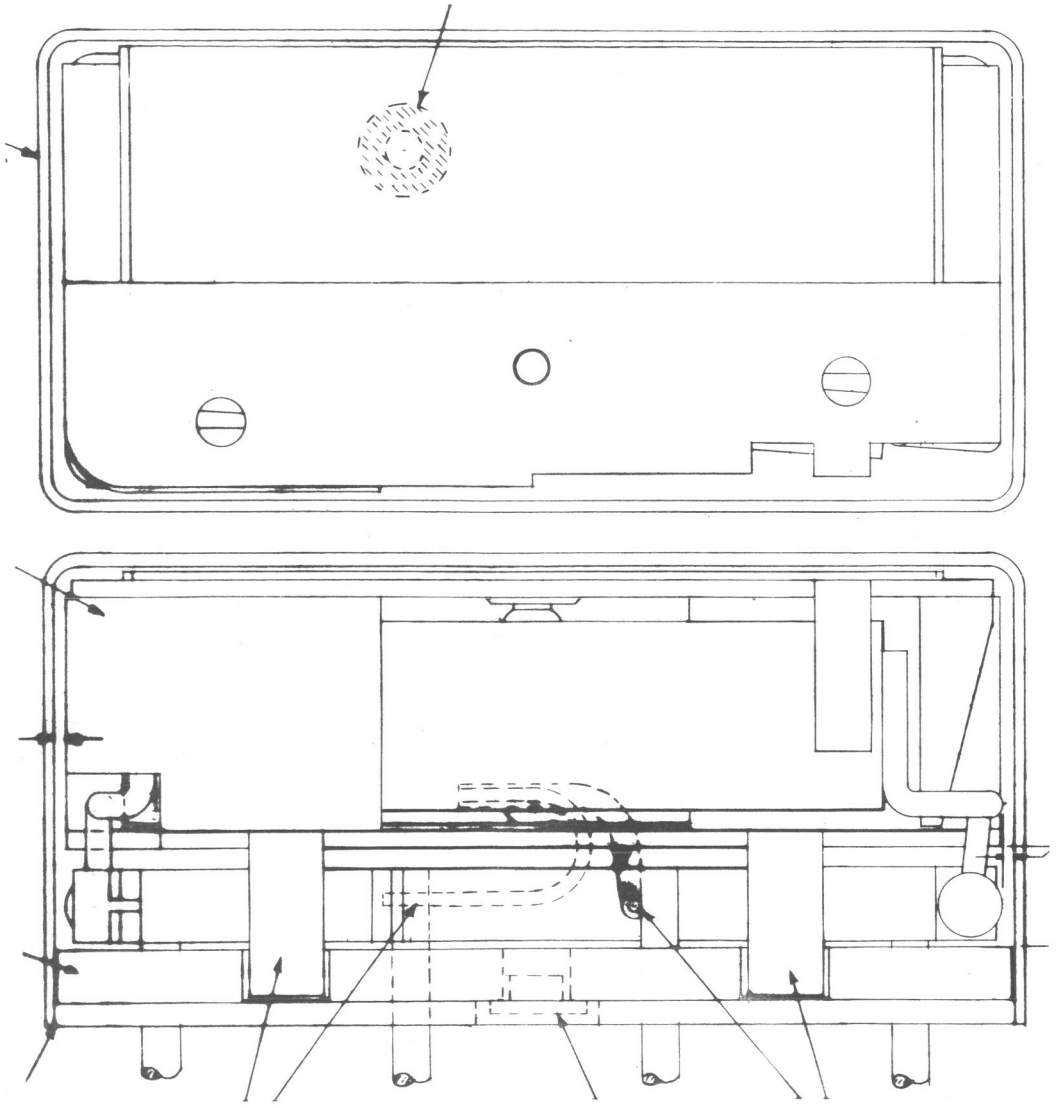
* Quantity of relays found discrepant by radiographic methods and confirmed after internal inspection.

Discrepant relays include; foreign material, non-uniform parts configuration, weld flash.

Recommendation for Future Work

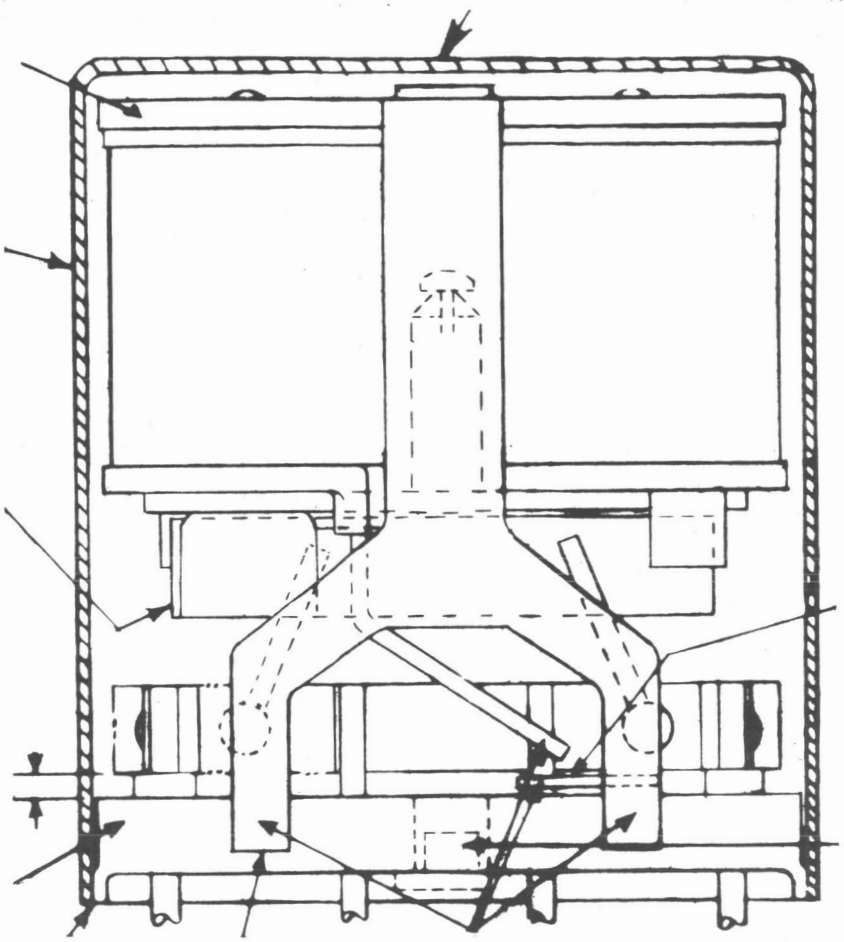
The elimination of distortion to the lowest possible value, is a necessity for the proper evaluation of relays. This can be accomplished to a value of less than 1% with superior resolution of the image by utilizing a method comparable to one which is now in the prototype stage at the Materials and Processes Laboratory.

The method employs an endless chain on which the devices are fixtured. The chain at the exposure station engages a doubly corrected track which forms the chain to the proper radius to coincide with the target-to-object distances in the longitudinal direction and also keeps the objects being radiographed normal to the x-ray beam in the vertical direction. This procedure practically eliminates all distortion and since 35 mm strip film is used without a cassette, improved resolution is also realized.



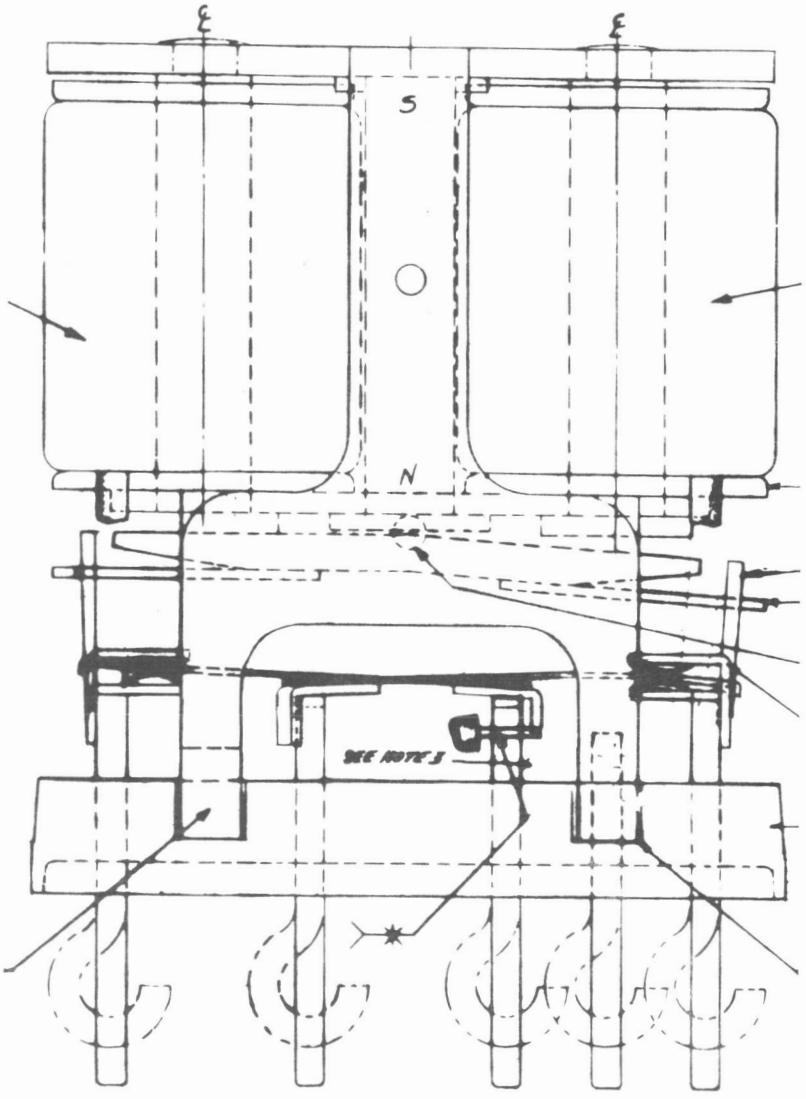
Sketch 1

SAV Type Relay



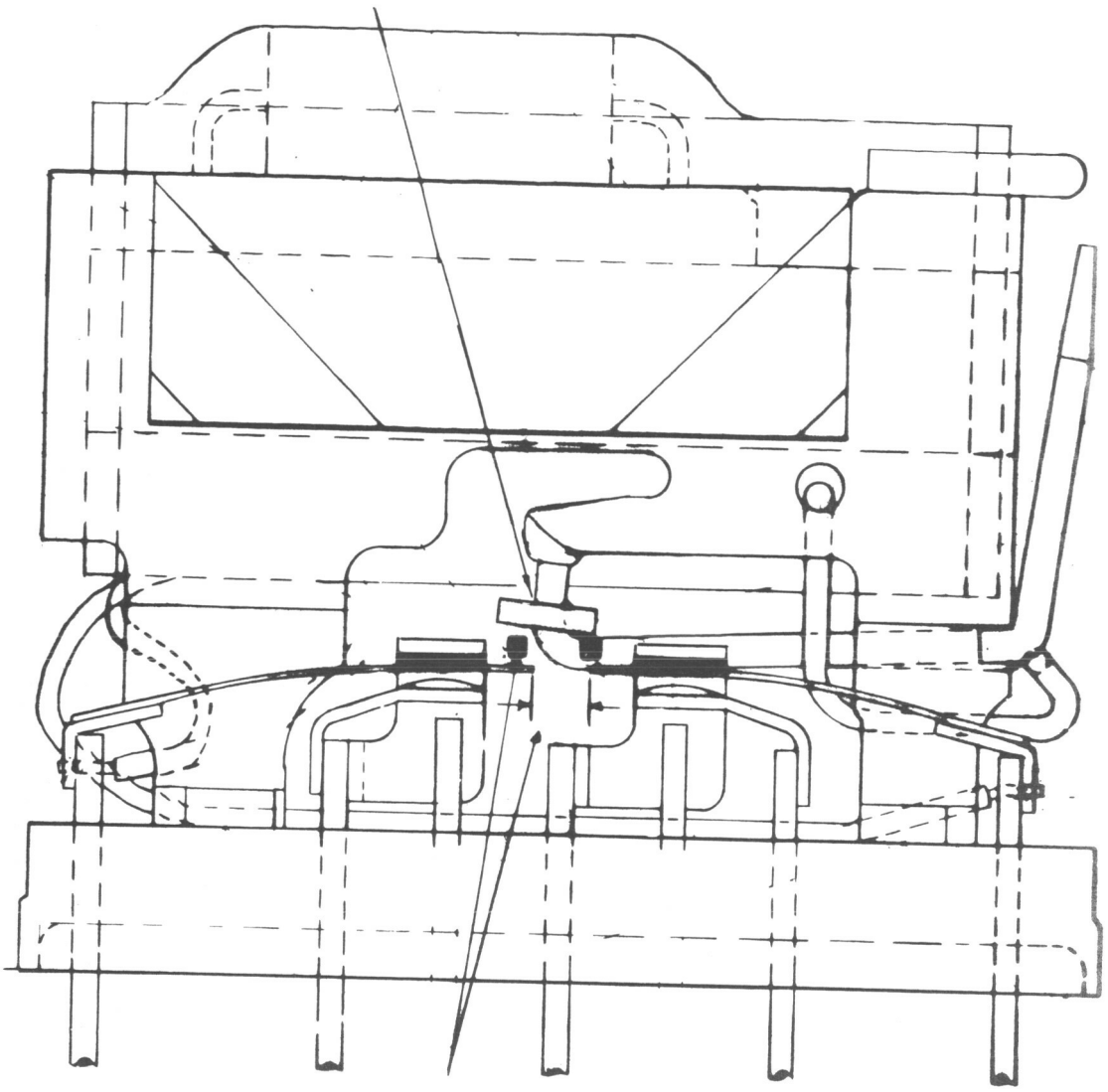
Sketch 2

SAF Type Relay



Sketch 3

SAM Type Relay



Sketch 4

SAH Type Relay

TEST EXPOSURES

8 MA	Exposure	Intensifying	36" Target to Film Distance Density		
KV	Time (Sec.)	Screens	SAV	SAF SAM	SAH
150	15				
150	25				
150	35		1.35		
150	40				
150	45		2.0	1.20	
150	50				
150	60			1.62	
150	65			2.01	
150	70				
150	75				
150	90			2.4	
150	120				
150	150				
150	180				
150	420				
150	600				
150	45	yes	2.01	1.48	
150	60	yes		2.02	
150	75	yes		2.5	
150	90	yes			
150	150	yes			
130	125				
130	240				

KV	Time (Sec.)	Screens	SAV	SAF SAM	SAH
110	80				1.5
110	100			1.3	
110	110			1.65	
110	120			1.82	2.02
110	125				2.16
110	130			2.05	
110	135				2.4
110	140			2.2	
110	145				
110	150			2.4	
110	155				
110	160				
110	165				
110	175				
110	185				
110	200				
110	240				
90	100				
90	120				
90	125				
90	130		2.05		
90	140		2.2	1.1	
90	150		2.4		
90	160		2.5	1.3	
90	170			1.65	
90	180			1.88	

KV	Time (Sec.)	Screens	SAV	SAF SAM	SAH
90	190			1.98	
90	200			2.11	
90	210			2.15	

8 MA

Exposure Intensifying

48" Target to Film Distance

Density

KV	Time (Sec.)	Screens	SAV	SAF SAM	SAH
150	50				
150	60				
150	70		1.56		
150	75				
150	80		1.79	1.20	
150	90		2.06	1.34	
150	110				
150	130				
150	150				
150	200				
150	300				
150	75	yes	1.9	1.3	
150	90	yes	2.3	1.55	
150	110	yes		2.02	
150	130	yes		2.4	
150	150	yes			
150	200	yes			
150	300	yes			

KV	Time (Sec.)	Screens	SAV	SAF SAM	SAH
110	130		1.8		
110	140		1.95		
110	150		2.15	1.2	
110	160		2.25	1.3	
110	180			1.5	
110	200			1.86	
110	210			1.90	
110	220			2.05	
110	230			2.08	
90	125				
90	135				
90	145				
90	150		1.3		
90	155				
90	160				
90	170		1.42		
90	180		1.5		
90	200		1.8		

COMPLETE EXPOSURE DATA

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
1	1 SAV	150-8-60 sec.	@ 36"	
	2	150-8-50 "	"	
2	3 SAV	150-8-40 "	" 36"	
3	1 SAV	150-8-35 "	" 36"	
	2	150-8-25 "	"	
	3	150-8-15 "	"	
4	SAV	150-8-180 "	" 36"	(Bottom exposure)
5	SAV & SAF	150-8-35 "	" 36"	(Built in defects 1-9)
6	SAV	150-8-45 "	" 36"	(Built in defects 5,8,15,16,22)
7	SAF	150-8-65 "	" 36"	(Sides #10-21)
		150-8-90 "	"	(Bottom)
7B	Repeat			
8	SAF	150-8-65 "	" 36"	(Sides)
		150-8-120 "	"	(Bottom)
9	SAF	1)110-8-80 "	" 36"	
		2)110-8-100 "	"	
		3)110-8-120 "	"	
		4)110-8-140 "	"	
		5) 90-8-100 "	"	

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
9(cont'd)		6) 90-8-120 sec.	@ 36"	
		7) 90-8-140 "	"	
		8) 90-8-160 "	"	
10	SAV & SAF	1)110-8-110 "	" 36"	
		2)110-8-120 "	"	
		3)110-8-130 "	"	
		4)110-8-140 "	"	
		5)110-8-150 "	"	
		6) 90-8-130 "	"	
		7) 90-8-140 "	"	
		8) 90-8-150 "	"	
		9) 90-8-160 "	"	
		10) 90-8-170 "	"	
11	SAV & SAF	1)110-8-130 "	" 48"	
		2)110-8-140 "	"	
		3)110-8-150 "	"	
		4)110-8-160 "	"	
		5)110-8-180 "	"	
		6) 90-8-150 "	"	
		7) 90-8-160 "	"	
		8) 90-8-170 "	"	
		9) 90-8-180 "	"	
		10) 90-8-200 "	"	
12	SAF	1) 90-8-180 "	" 36"	
		2) 90-8-190 "	"	

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
12(Cont'd)	SAF	3) 90-8-200 sec.	@ 36"	
		4) 90-8-210 "	"	
		5)110-8-200 "	" 48"	
		6)110-8-210 "	"	
		7)110-8-220 "	"	
		8)110-8-230 "	"	
	SAV	9) 90-8-130 "	" 36"	(Bottom)
		10) 90-8-160 "	"	
	SAF	11)110-8-130 "	"	(Bottom)
		12)110-8-160 "	"	
		13)110-8-200 "	"	
13	SAH	1)110-8-125 "	" 36"	
		2)110-8-150 "	"	
		3)110-8-175 "	"	
		4)110-8-200 "	"	
14	SAV & SAF	1)150-8-75 "	" 48"	(Screens)
		2)150-8-90 "	"	"
		3)150-8-110 "	"	"
		4)150-8-130 "	"	"
		5)150-8-150 "	"	"
		6)150-8-45 "	" 36"	"
		7)150-8-60 "	"	"
		8)150-8-75 "	"	"

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
15	SAV & SAF	9)150-8-70 sec.	@ 48"	
		10)150-8-80 "	"	
		11)150-8-90 "	"	
		12)150-8-35 "	" 36"	
		13)150-8-45 "	"	
		14)150-8-60 "	"	
16 A&B	SAF	1)150-8-35 "	" 36"	
		2)150-8-90 "	"	(Screens)
		3)150-8-150 "	"	"
		4)150-8-60 "	" 48"	
		5)150-8-75 "	"	
		6)150-8-200 "	"	(Screens)
		7)150-8-300 "	"	
		8)150-8-50 "	"	
Z	SAV	150-8-45 sec.	" 36"	#1501 - 1637
A	SAV	150-8-45 "	"	#5,8,15,16,22,26
B	SAF & SAM	150-8-65 "	" 36"	(Sides) #1,2,3,4,6,7,9,10
		150-8-90 "	"	(Bottom) 11,12,13
C	SAF & SAM	150-8-65 "	" 36"	(Sides) #14,17,18,20,21,24
		150-8-90 "	"	(Bottom) 25,27
C2	Repeat No's 25,26,28,29			

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
D	SAF & SAM	110-8-125 sec.	@ 36"	#37 to 48
E	SAV	90-8-125 "	" 36"	#30 to 36
F	SAF & SAH	110-8-125 "	" 36"	#23,49,50,51,52,53,54
G	SAV	90-8-125 "	" 36"	#55,56,57,58 #30 to 36 tilted
		90-8-200 "	"	1) Pins up - 27,30 2) Pins down - 27,30
		110-8-200 "	"	3) Pins up - 27,30 4) Pins down - 27,30
		110-8-240 "	"	5) Pins up - 27,30
H	SAV	110-8-140 "	" 48"	Distortion check
I	SAV	90-8-125 "	" 36"	(Sides) New #1-24
		110-8-200 "	"	(Bottom)
J	SAM	110-8-125 "	" 36"	(Sides) New #1-24
		110-8-240 "	"	(Bottom)
K	SAF	110-8-125 "	" 36"	(Sides) New #1-24
		110-8-240 "	"	(Bottom)
L-I	SAH	110-8-125 "	" 36"	(Sides) New 1-24
		110-8-240 "	"	(Bottom)
L-2	SAH	110-8-120 "	" 36"	(Sides)
		110-8-240 "	"	(Bottom)

TEST	TYPE	EXPOSURE	DISTANCE	REMARKS
M	Miscellaneous relays			
		110-8-125 sec.	@ 36"	(Sides) A to U
		110-8-240 "	"	(Bottom)
N	SAH	1)110-8-125 sec.	" 36"	
		2)110-8-135 "	"	
		3)110-8-145 "	"	
		4)110-8-155 "	"	
		5)110-8-165 "	"	
		6)110-8-175 "	"	
		7)110-8-185 "	"	
		8)110-8-200 "	"	
O	SAH	1) 90-8-125 "	" 48"	
		2) 90-8-135 "	"	
		3) 90-8-145 "	"	
		4) 90-8-155 "	"	
P	SAH	1)110-8-80 "	" 36"	
		2)110-8-100 "	"	
		3)110-8-110 "	"	
		4)110-8-120 "	"	
Q	SCW	110-8-120 "	" 36"	(Sides) #59 to 68
		110-8-240 "	"	(Bottom)
R	SAV	90-8-120 "	" 36"	- #1,2,3,4 mil Cu wire
	SAF & SAH	110-8-120 "	"	" "

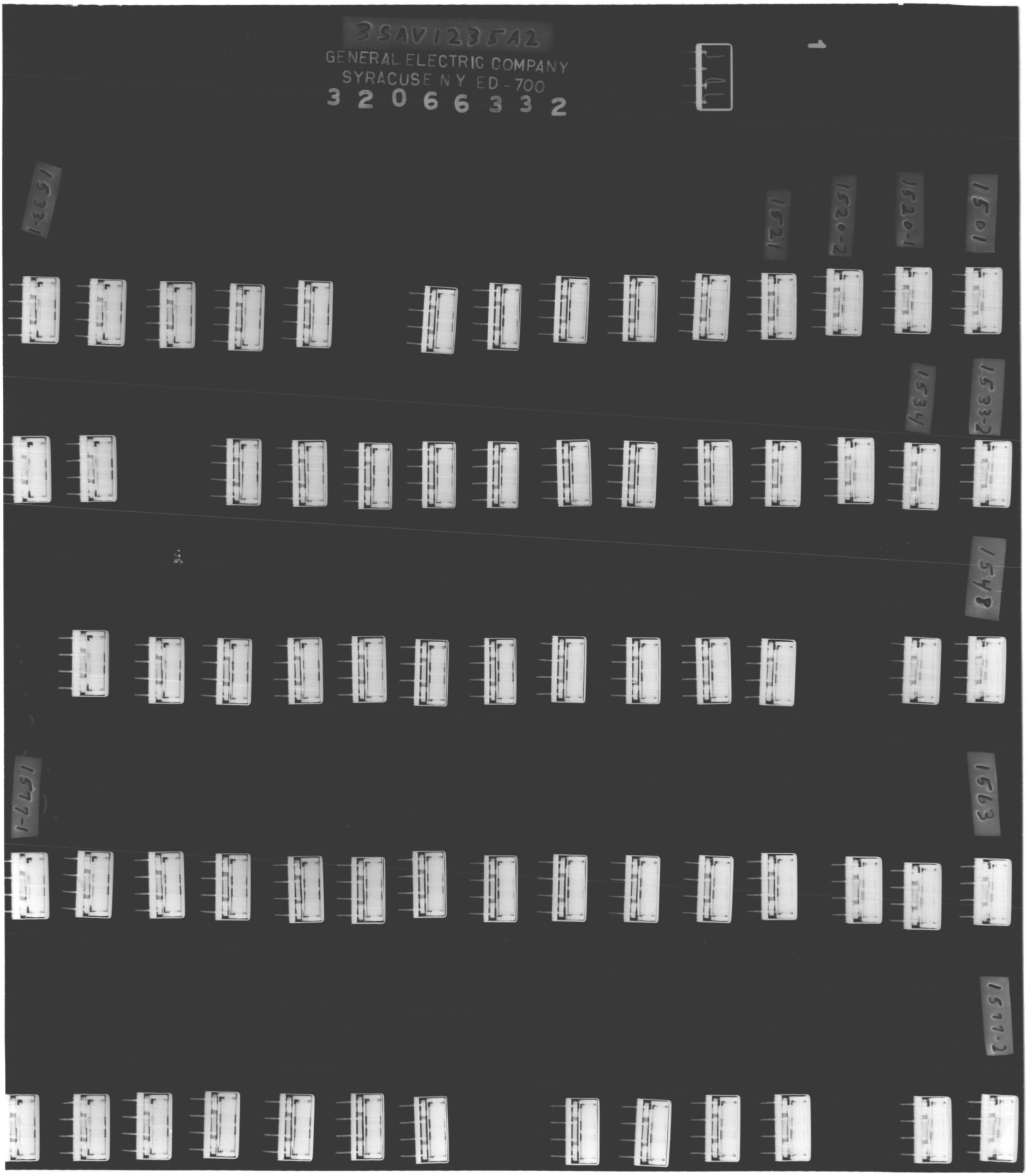
TEST	TYPE	EXPOSURE	DISTANCE		REMARKS
S	SAH	110-8-120 sec.	@ 36"	(Sides)	
		110-8-240 "	"	(Bottom)	#23,52,53,54
T	SAF	110-8-125 "	" 36"	(Sides)	New 1-75
		110-8-240 "	"	(Bottom)	
U	SAM	110-8-125 "	" 36"	(Sides)	New 1-75
		110-8-240 "	"	(Bottom)	
V	Potter-Brumfiel	110-8-125 "	" 36"	(Sides)	1P - 10P
		110-8-240 "	"	(Bottom)	
	Filters	110-8-125 "	" 36"	(Sides)	1F - 10F
		110-8-240 "	"	(Bottom)	
	Leach	90-8-125 "	" 36"	(Sides)	1L - 10L
		110-8-200 "	"	(Bottom)	
	Struthers-Dunn	90-8-125 "	" 36"	(Sides)	1S - 10S
		110-8-200 "	"	(Bottom)	
	Electro-Tec	150-8-420 "	" 36"	(Sides)	1E - 3E
		150-8-600 "	"	(Bottom)	Not discernable

Serial Number	Implanted Defect	Relay Type	Defect Noted in Radiograph
1	Human Hairs	SAF	None
2	Lint Ball	SAF	None
3	One Human Hair	SAF	None
4	Loose Tape End	SAF	None
5	Frayed Insulation or Coil Lead	SAV	None
6	Lint Ball	SAF	None
7	Tape in Gap	SAF	None
8	Tip Bent to Header	SAV	Tip Bent to Header
9	Broken Ceramic Actuator	SAM	Broken Ceramic Actuator
10	Loose Armature Shaft	SAF	None
11	"	SAF	None
12	"	SAF	None
13	"	SAF	None
14	Broken Actuator - Actuator Lifter not Properly Bent - Coil Lead Touching Header	SAM	Broken Actuator - Actuator Lifter not Properly Bent - Coil Lead Touching Header
15	Armature Return Spring Out of Line	SAV	Spring Out of Line
16	Actuator Bead Rubbing Header Coil Touching Edge of Moveable Contact	SAV	Bead Rubbing Header
17	Insulation Cut Short Coil Leads not Welded to Pins	SAM SAM	None Leads not Welded to Pins
18	Coil Lead Burned Off - Weld Spatter	SAM	Lead not Welded to Pin
19	Display Sample	SAM	
20	Shim Removed from Contact	SAM	None
21	Armature Return Spring Removed	SAF	None
22	Actuator Rod Rubbing Frame	SAV	None

Serial Number	Implanted Defect	Relay Type	Defect Noted in Radiograph
23	Broken Ceramic Coil Spool	SAH	Broken Ceramic Coil Spool
	Shims Removed		None
	Side Frame Spring Removed		None
	Deformed Moveable Contact		None
	Epoxy Particles		None
	Armature Retaining Spring not in Notch		Spring not in Notch
	Broken Coil Lead		None
24	Actuator Bead Rubbing Contact	SAF	Bead Rubbing Contact
	Coil Leads not Welded		None
	Misaligned Contact		Misaligned Contact
25	0.015 Gap Between Frame and Coil Spool	SAF	Gap
	Particles		Particles
26	Coil Lead Weld Broken	SAV	None
	Particles		Particles
27	Glass in Header with Frame Leg Welded	SAF	Leg Out of Line
28	.005 Copper Wire	SAM	Extra Copper Lead
29	Coil Lead Smashed - Weld Spatter	SAM	Metal Build-up on Post
30	Voids Along Electron Beam Weld	SAV	None
31	"	SAV	None
32	"	SAV	None
33	"	SAV	None
34	"	SAV	None
35	"	SAV	None
36	"	SAV	None
37	Weld Spatter on Top of Frame	SAE	Buildup on Top of Frame
38	"	SAE	"
39	Can to Frame Weld - 30% of Normal Current	SAF	None
40	"	SAF	None
41	"	SAF	None
42	"	SAF	None

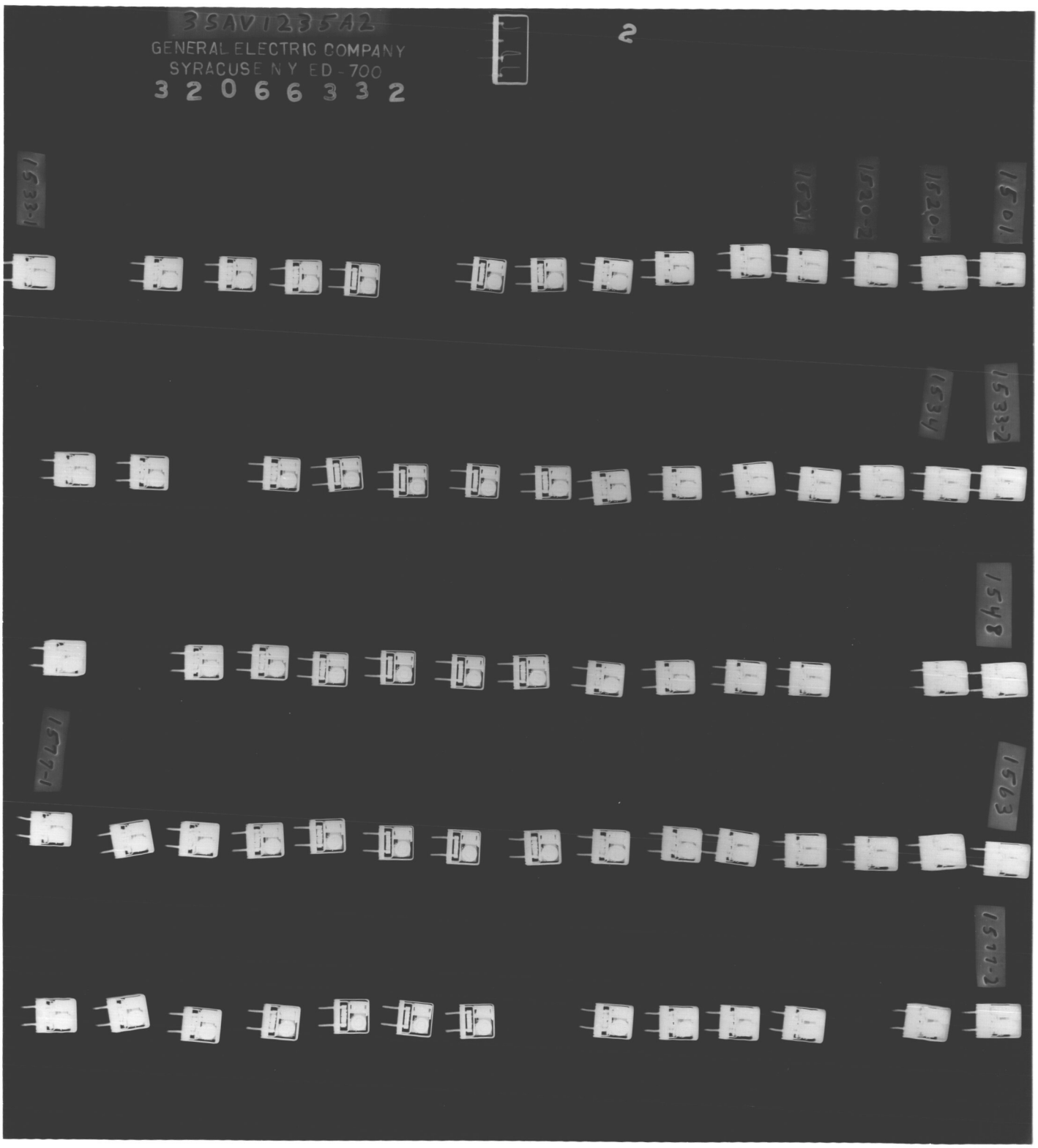
Serial Number	Implanted Defect	Relay Type	Defect Noted in Radiograph
43	Can to Frame Weld - 30% of Normal Current	SAF	None
44	"	SAF	None
45	Can to Frame Weld-Pressure with No Weld Current	SAF	No Weld
46	"	SAF	No Weld
47	"	SAF	No Weld
48	"	SAF	No Weld
49	Radiflow Leaker	SAF	None
50	"	SAF	None
51	"	SAF	None
52	"	SAH	None
53	Corroded Frame Side Spring	SAH	None
54	Dead Spot	SAH	None
55	Weld Flash Frame to Plate	SAV	None
56	"	SAV	None
57	"	SAV	None
58	"	SAV	None
59	Can to Frame Weld-Pressure with No Weld Current	SAF	No Weld
60	"	SAF	No Weld
61	"	SAF	No Weld
62	Can to Frame Weld-Reduced Current	SAF	None
63	"	SAF	None
64	Can to Frame Weld-Normal Current	SAF	None
65	"	SAF	None
66	"	SAF	None

Serial Number	Implanted Defect	Relay Type	Defect Noted in Radiograph
67	Can to Frame Weld-Excessive Current	SAF	Weld Spatter & Increased Weld Length
68	"	SAF	Increased Weld Length
69	.001-.002-.003-.004 Copper Wire	SAV	Readily Discern 3 Wires
70	"	SAF	Readily Discern 3 Wires
71	"	SAH	Readily Discern 3 Wires



Photograph 1

Reduced radiograph print showing distortion when full 14x17 inch film is used and corrected in 17 inch dimension - 0^{o} view.



Photograph 2

Reduced radiograph print showing distortion when full 14x17 inch film is used and corrected in 17 inch dimension - 90° view.

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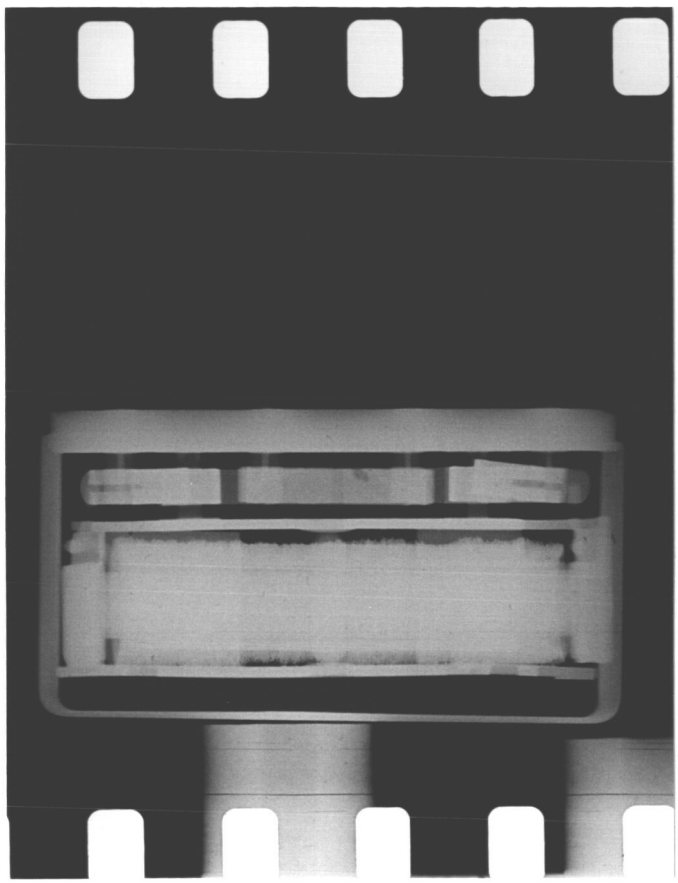

Photograph 3

Radiograph Print of 35 mm Film Strip

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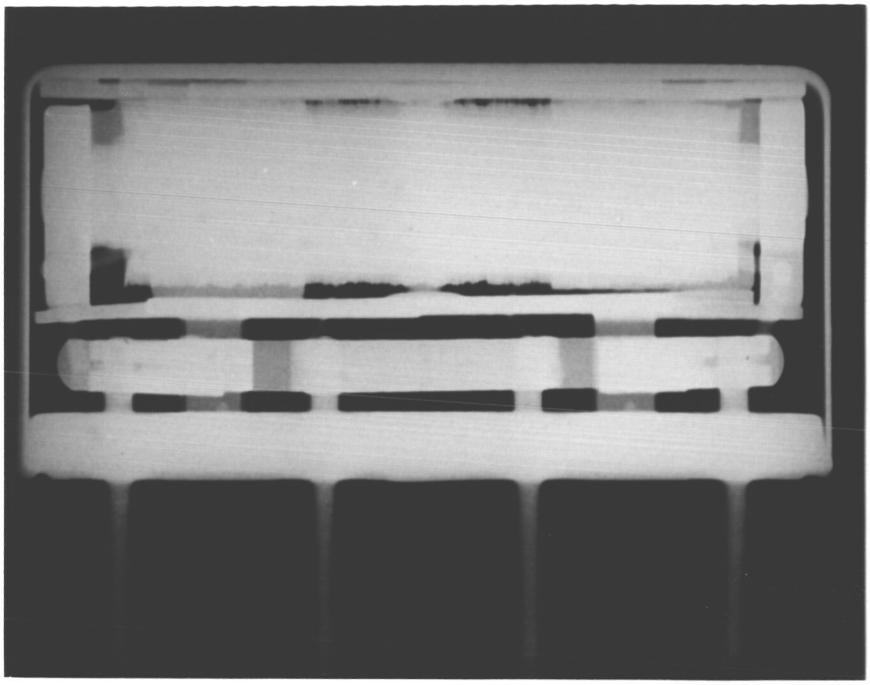
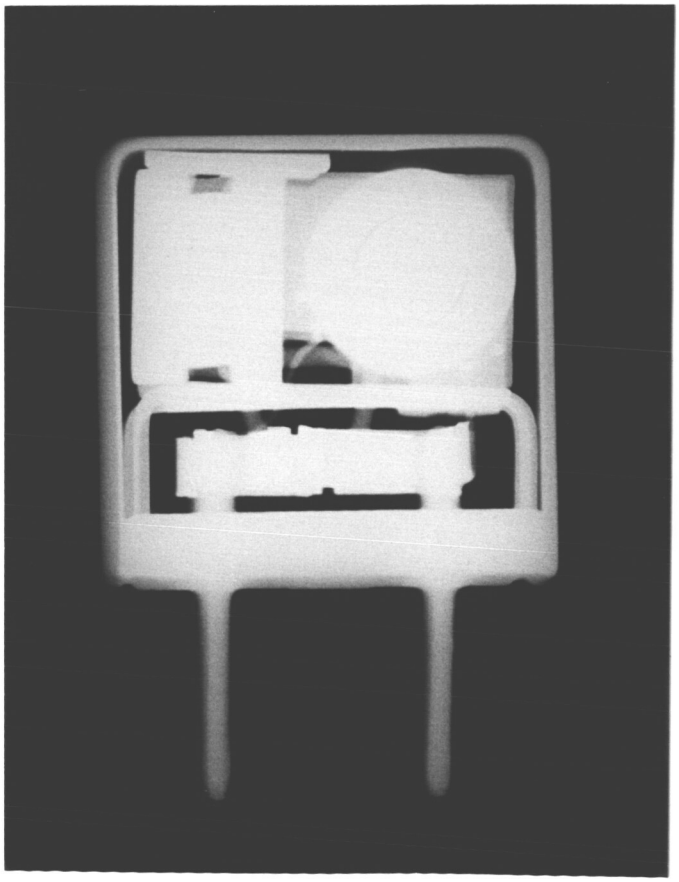


SAV

Radiograph Print

0° View



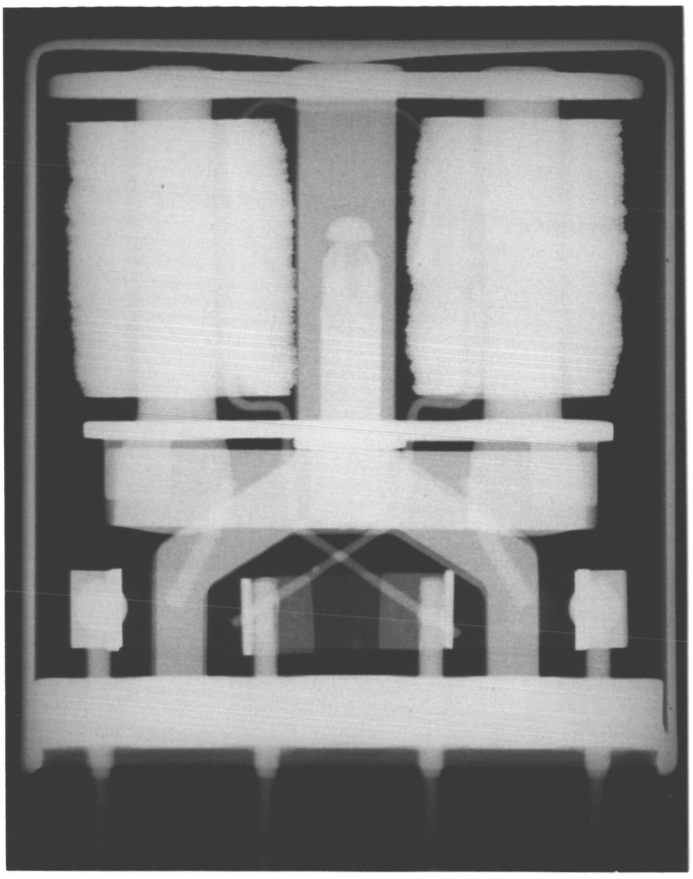
SAV

Radiograph Print

90° View

Photograph 4
Acceptable Relay

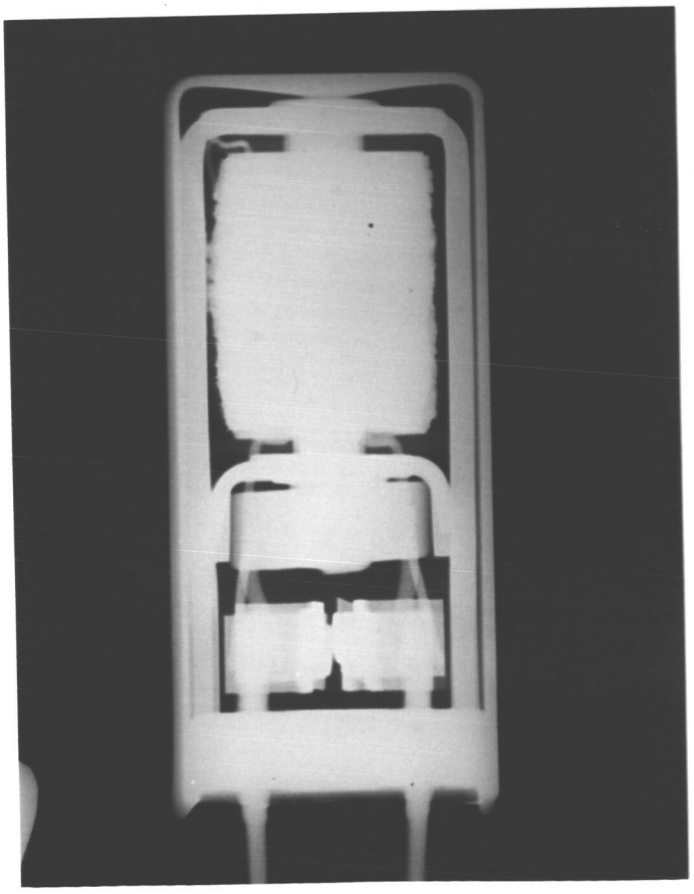
DATE: _____



SAF

Radiograph Print

0^{o} View



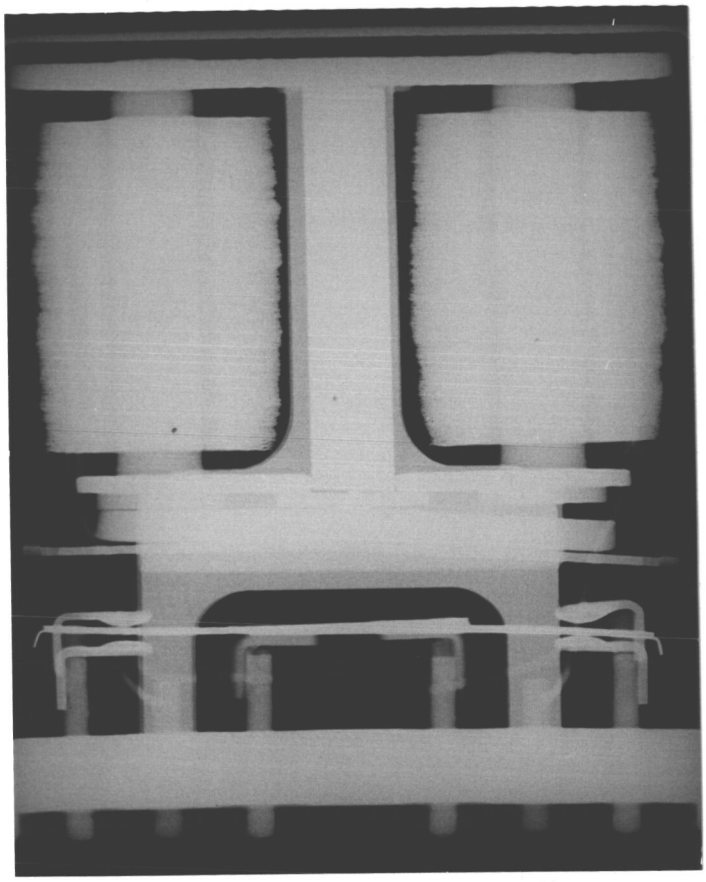
SAF

Radiograph Print

90^{o} View

Photograph 5
Acceptable Relay

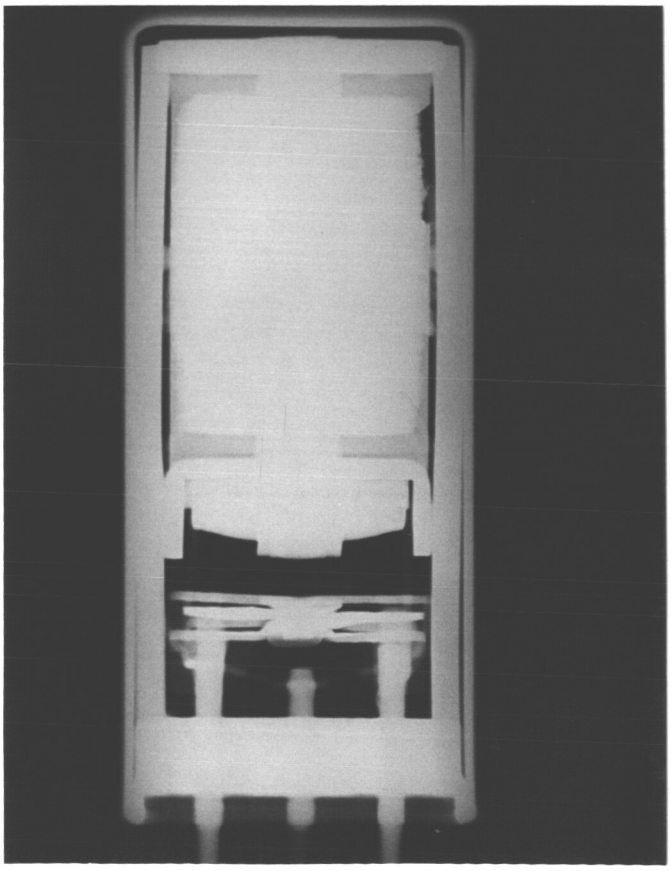
DATE: _____



SAM

Radiograph Print

0^{o} View



SAM

Radiograph Print

90^{o} View

Photograph 6
Acceptable Relay

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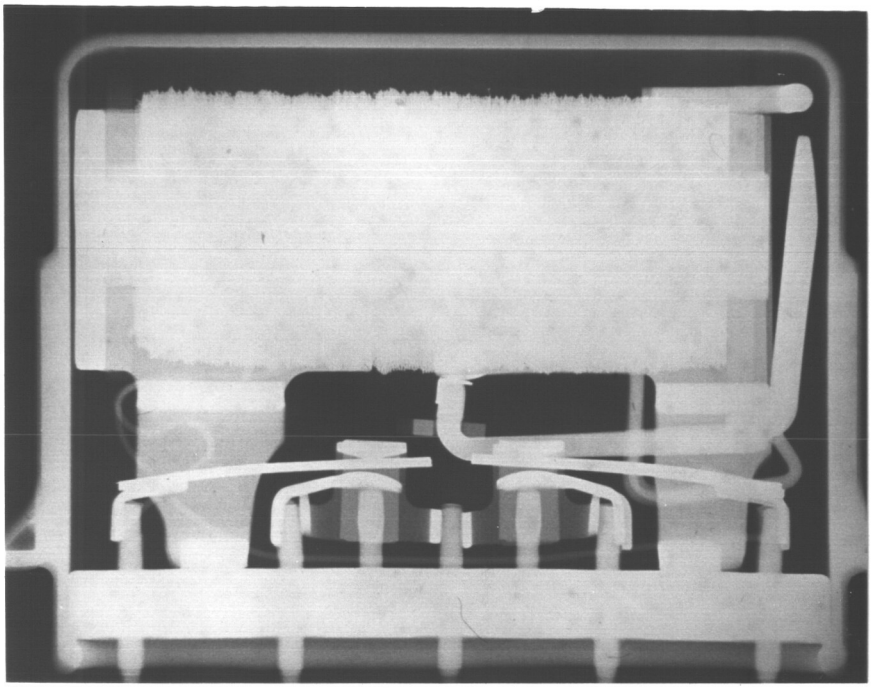
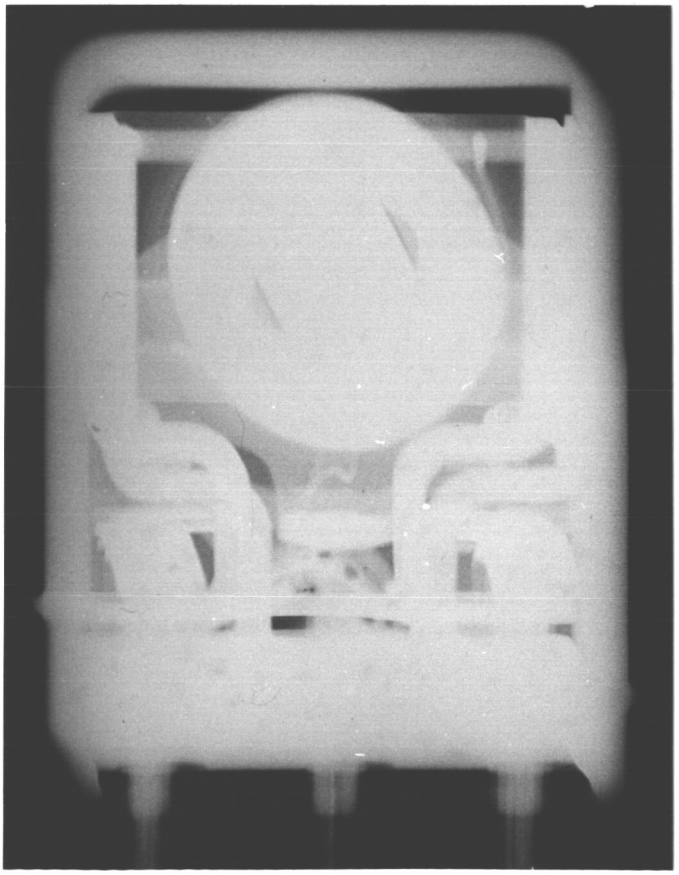


SAH

Radiograph Print

0^{o} View



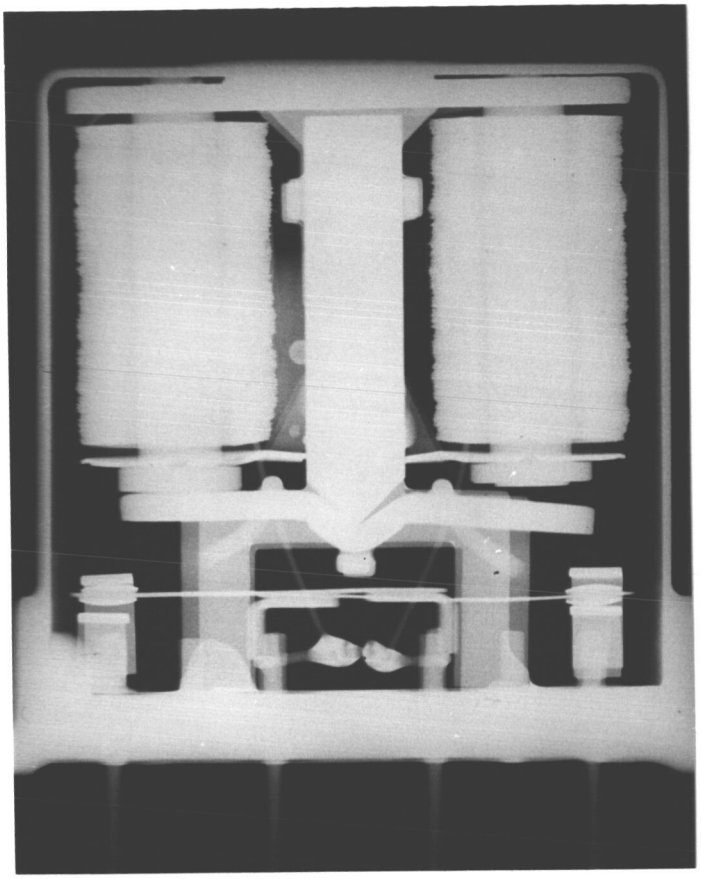
SAH

Radiograph Print

90^{o} View

Photograph 7
Acceptable Relay

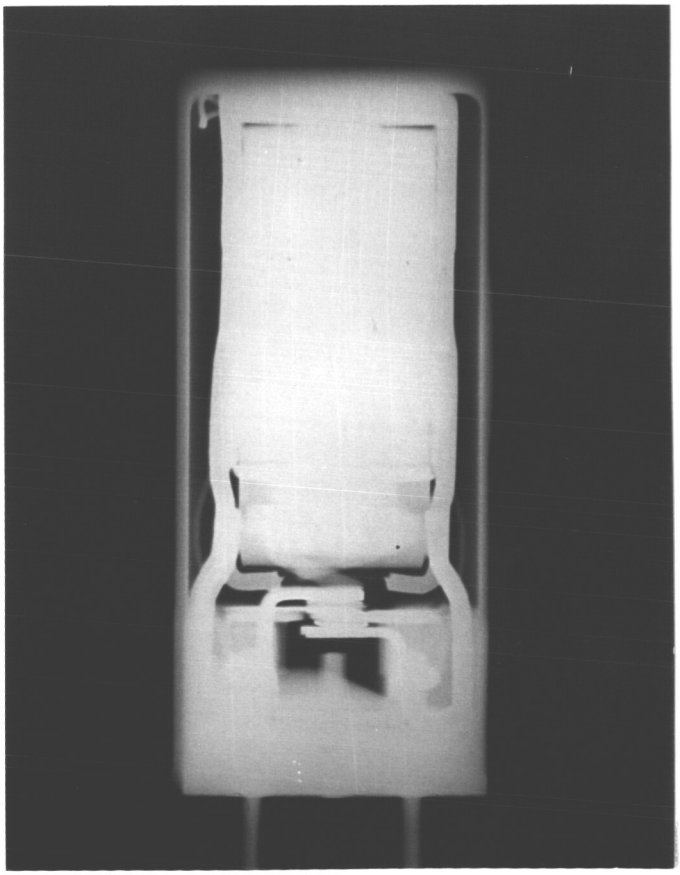
DATE: _____



Potter Brumfield

Radiograph Print

0^{o} View

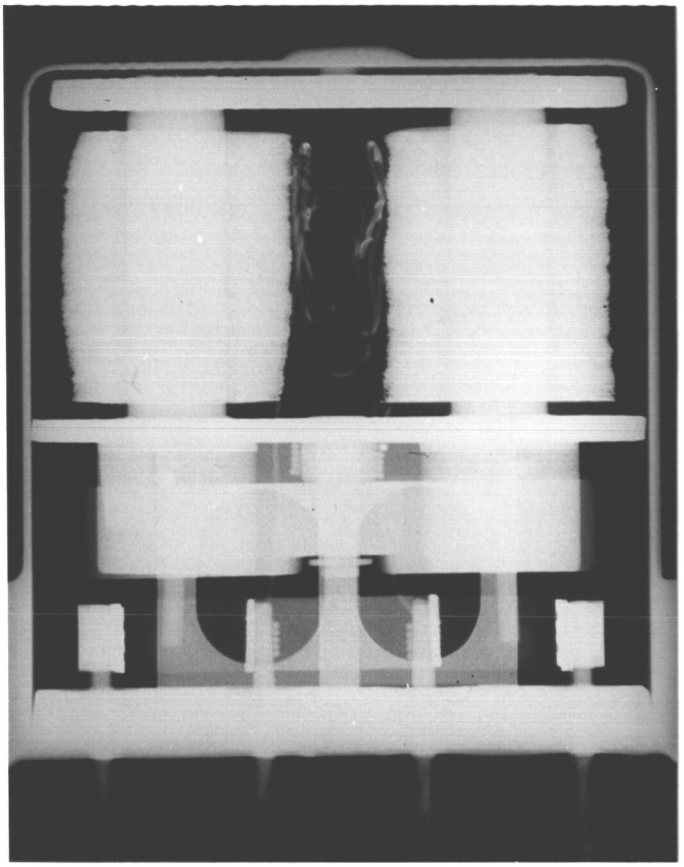


Potter Brumfield

Radiograph Print

90^{o} View

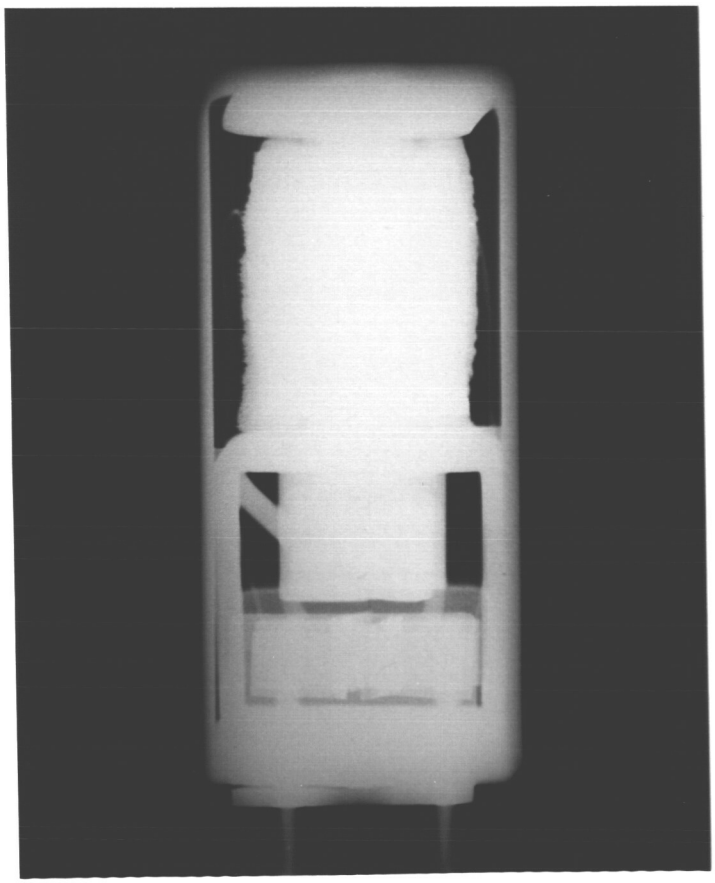
DATE: _____



Filtors Inc.

Radiograph Print

0^{o} View



Filtors Inc.

Radiograph Print

90^{o} View

DATE: _____

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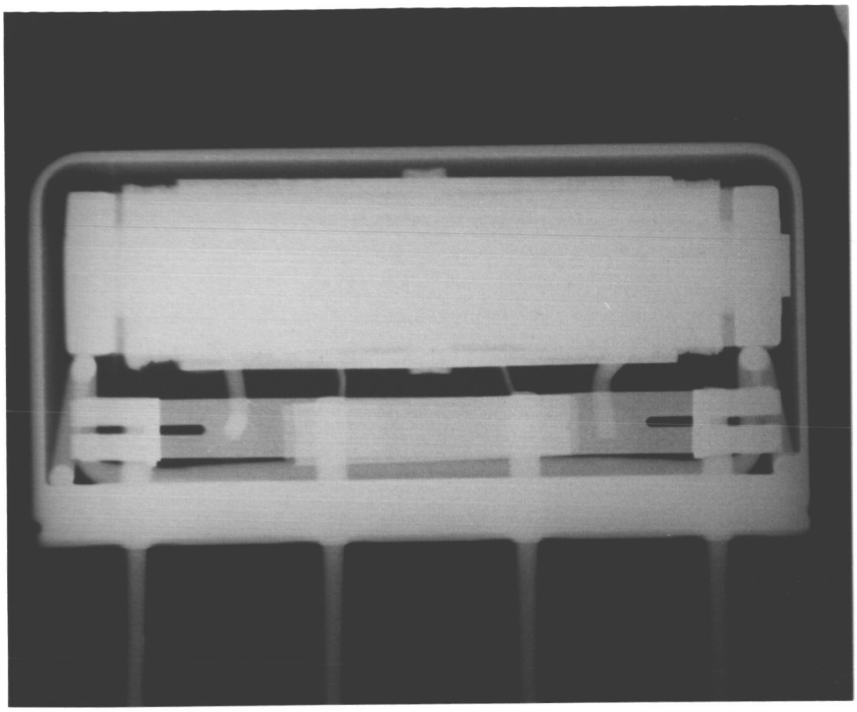
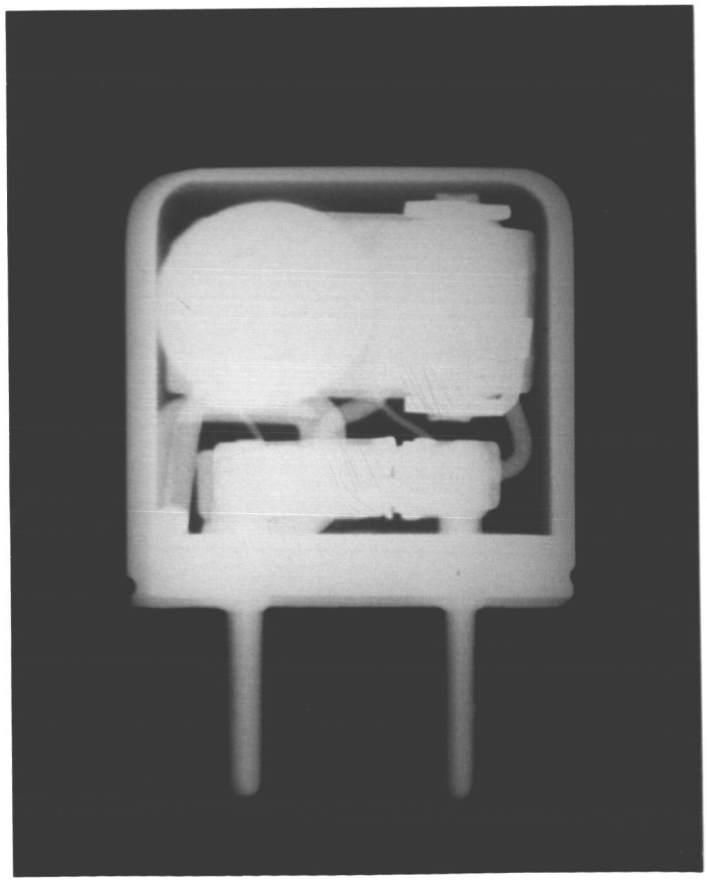


Leach

Radiograph Print

0^{o} View



Leach

Radiograph Print

90^{o} View

DATE: _____

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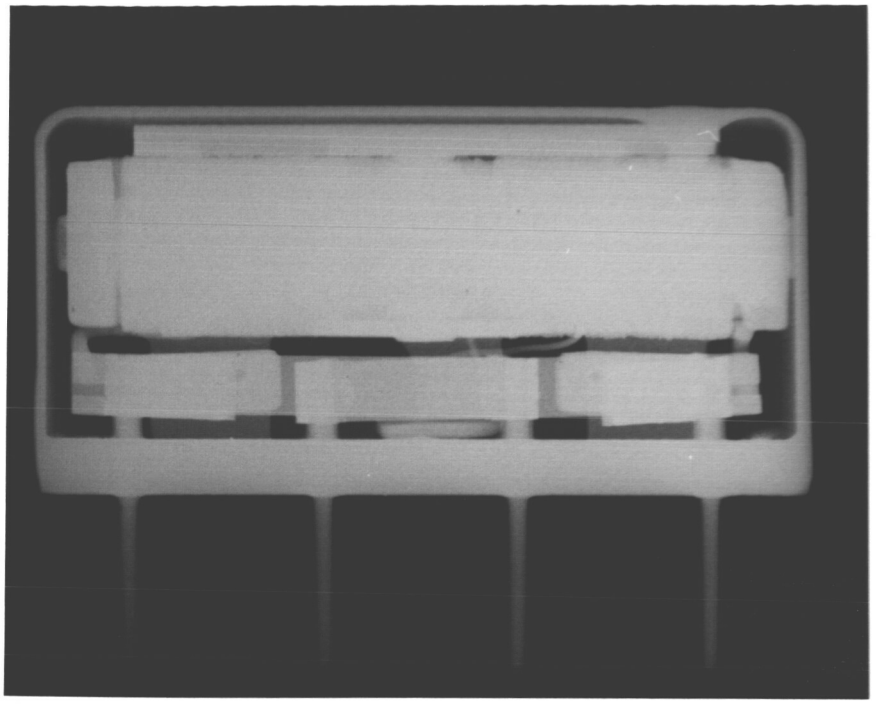
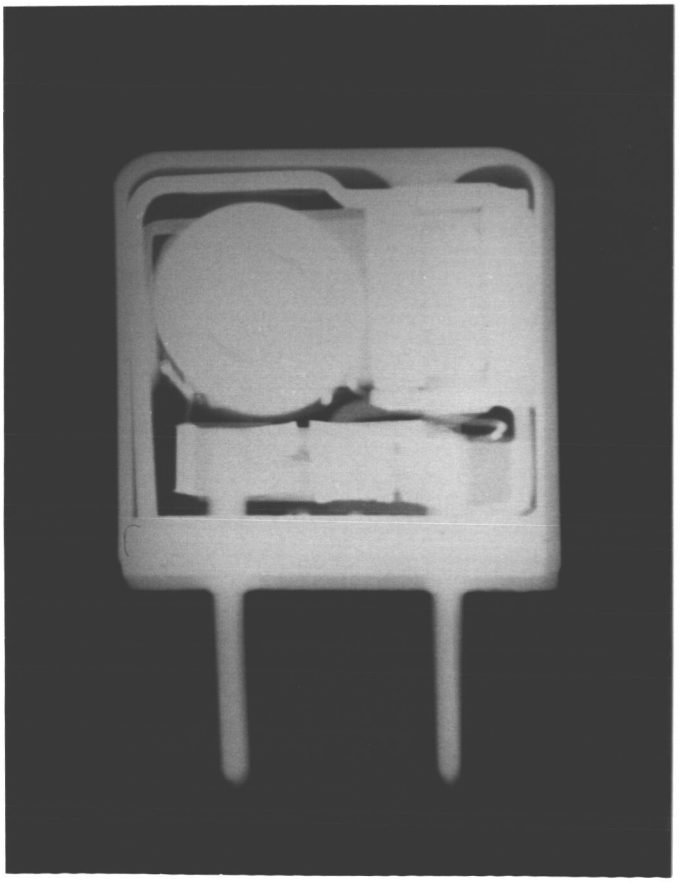


Struthers-Dunn

Radiograph Print

0^{o} View

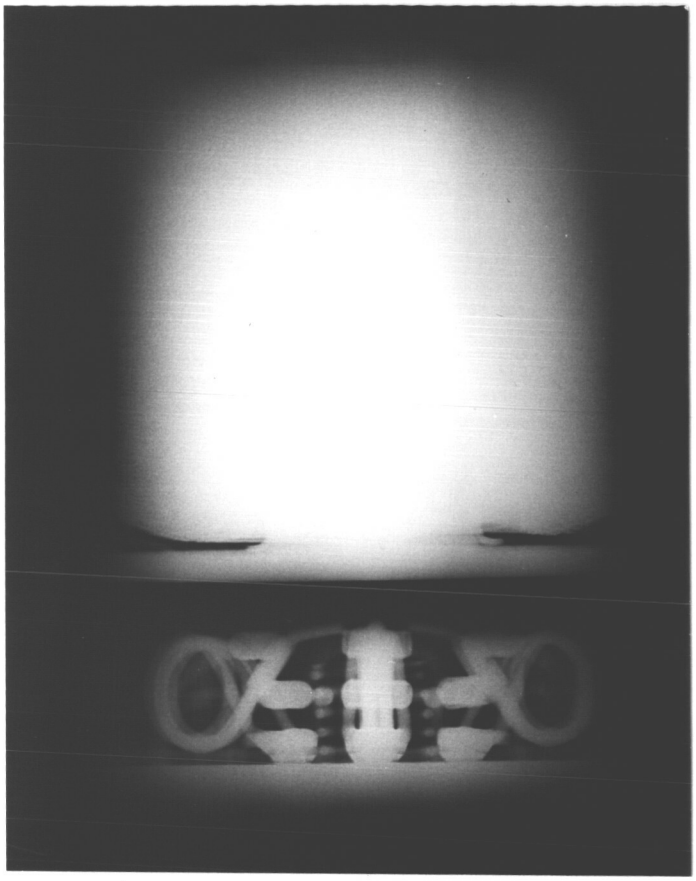


Struthers-Dunn

Radiograph Print

90^{o} View

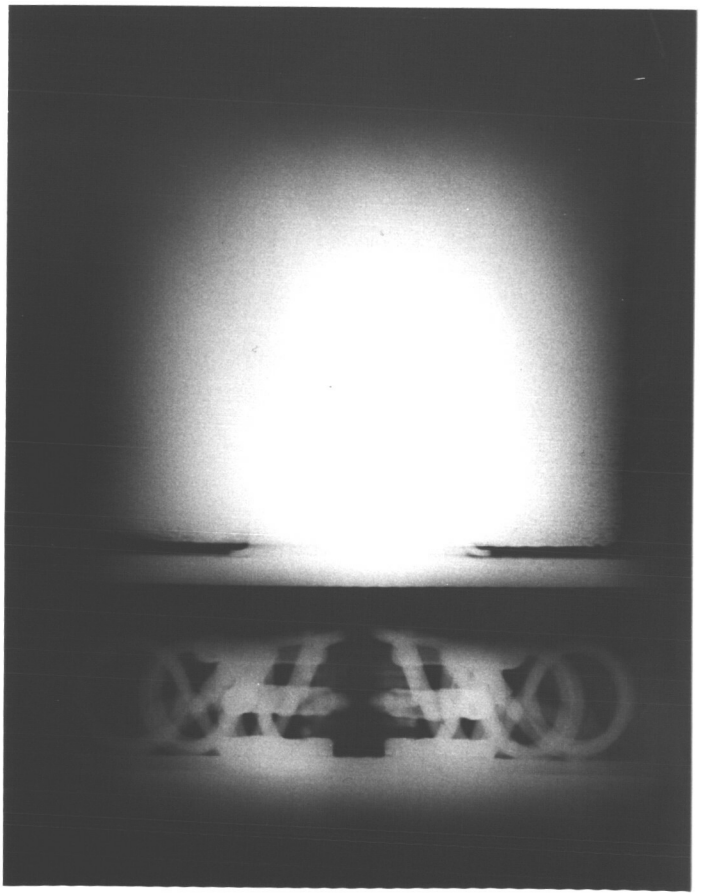
DATE: _____



Electro Tec

Radiograph Print

0^{o} View



Electro Tec

Radiographic Print

90^{o} View

DATE: _____

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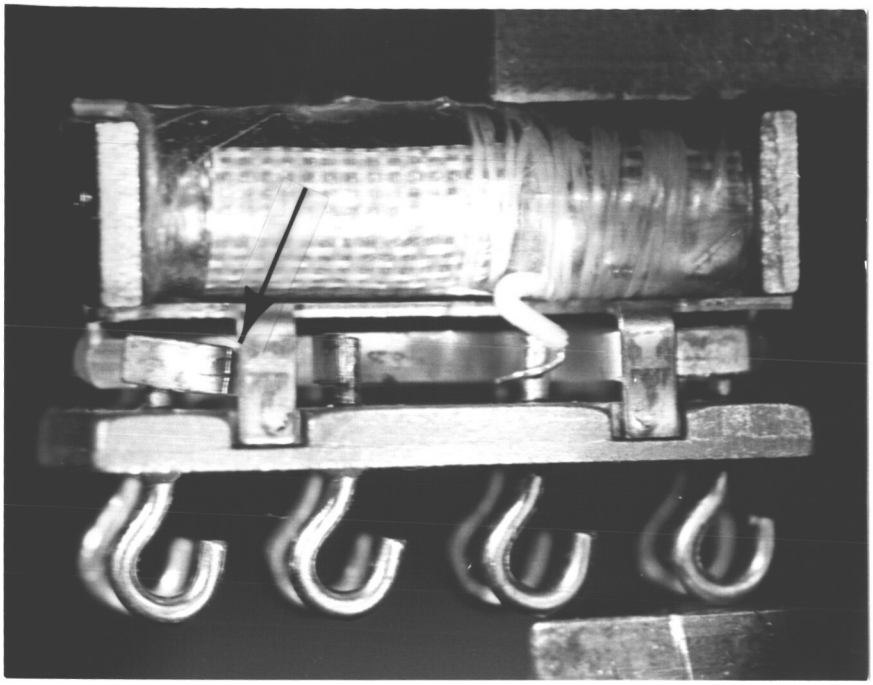
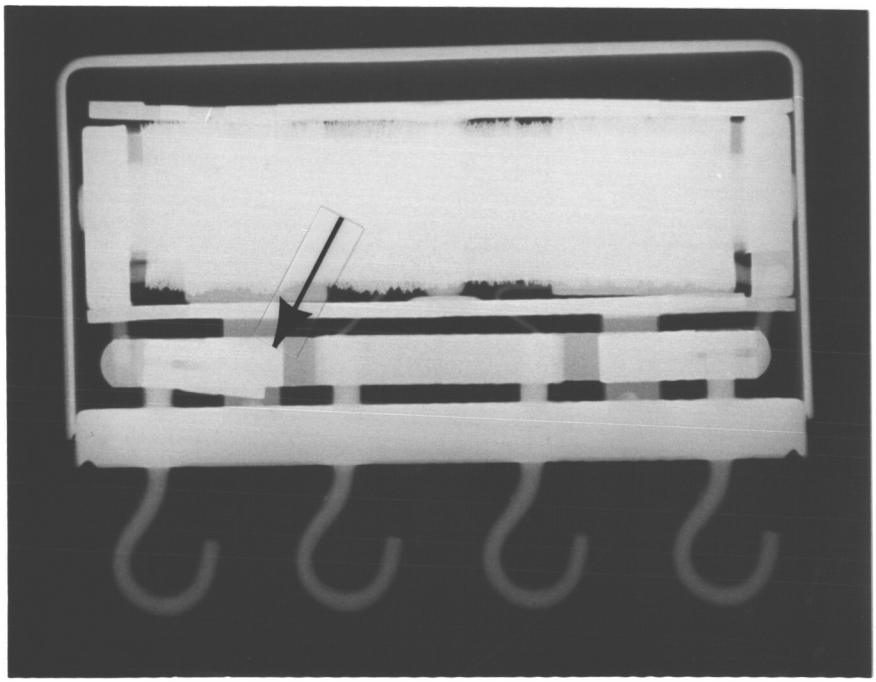


RELAY #8

SAV

Contact Tip
Bent to Header



RELAY #8

SAV

Radiograph Print
of
Above Misalignment

DATE: _____

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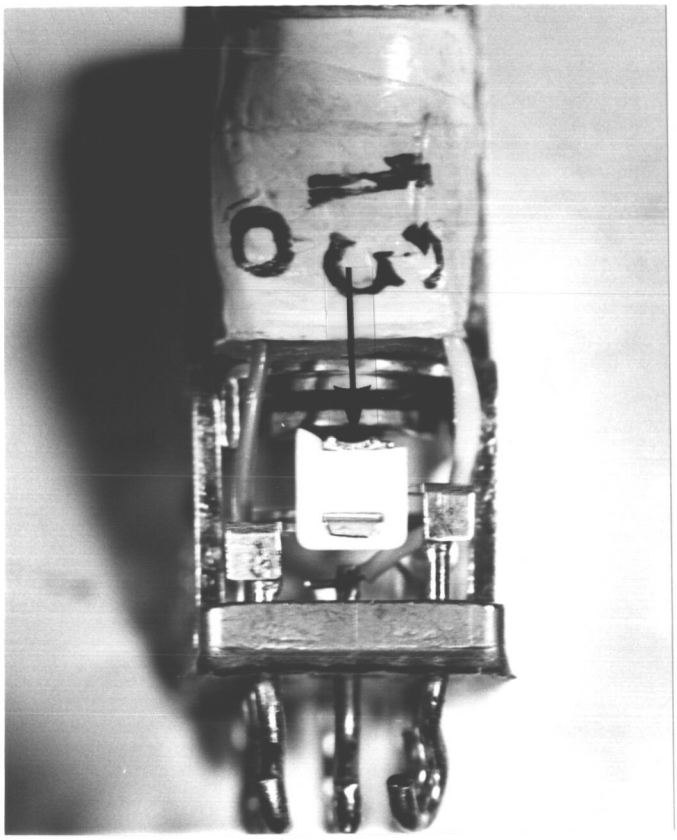
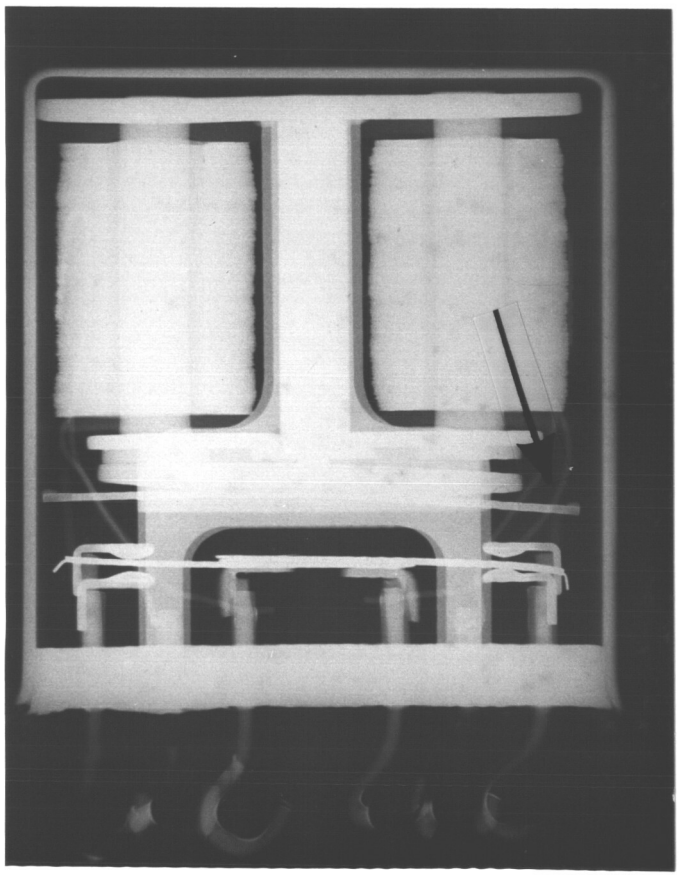


RELAY #9

SAM

Broken Ceramic
Actuator

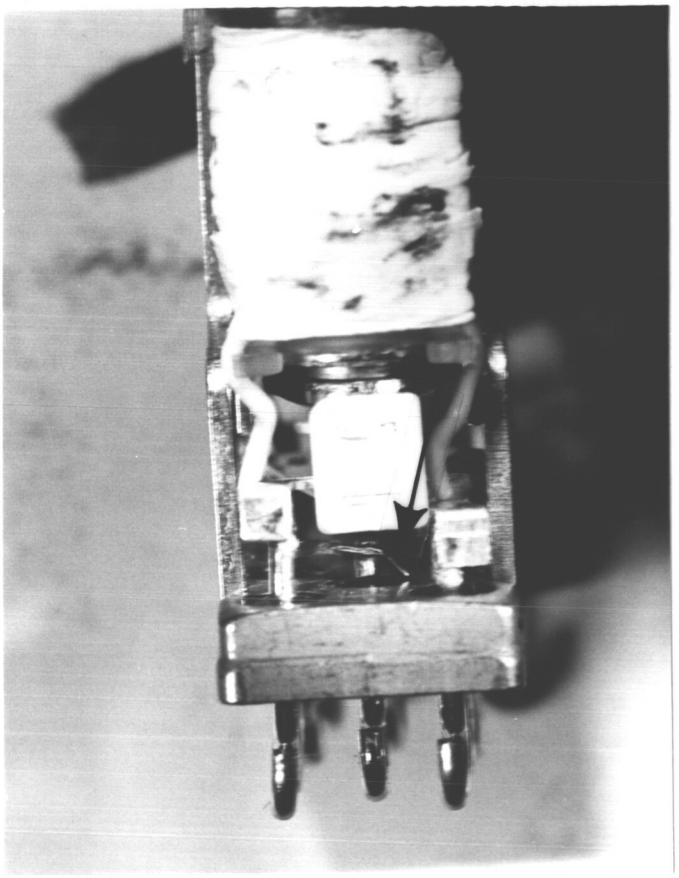


RELAY #9

SAM

Radiograph Print
Broken Ceramic
Actuator

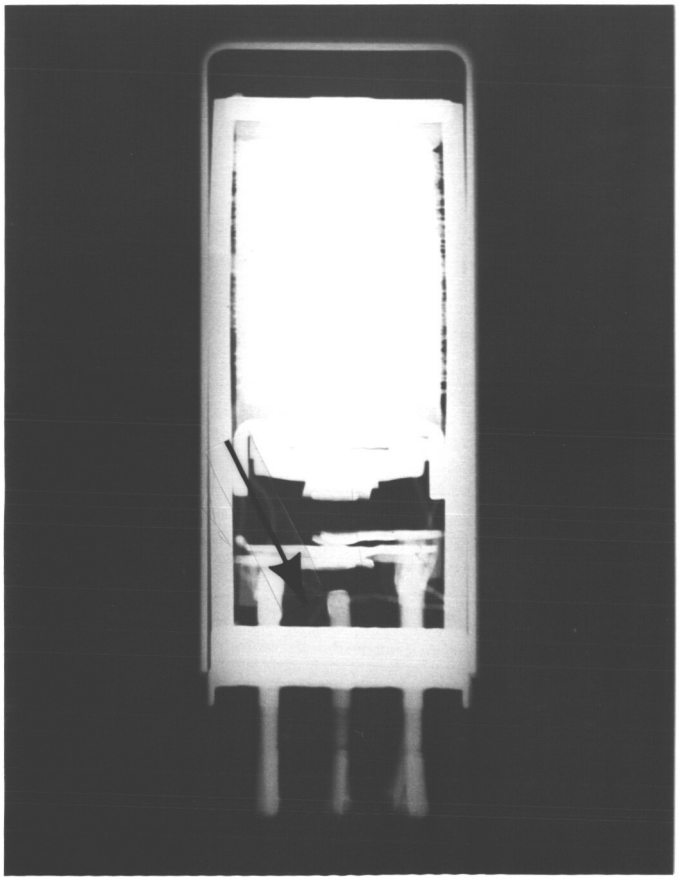
DATE: _____



Relay #14

SAM

Coil Lead Touching
Header



Relay #14

SAM

Radiograph Print of
Above Condition

DATE: _____

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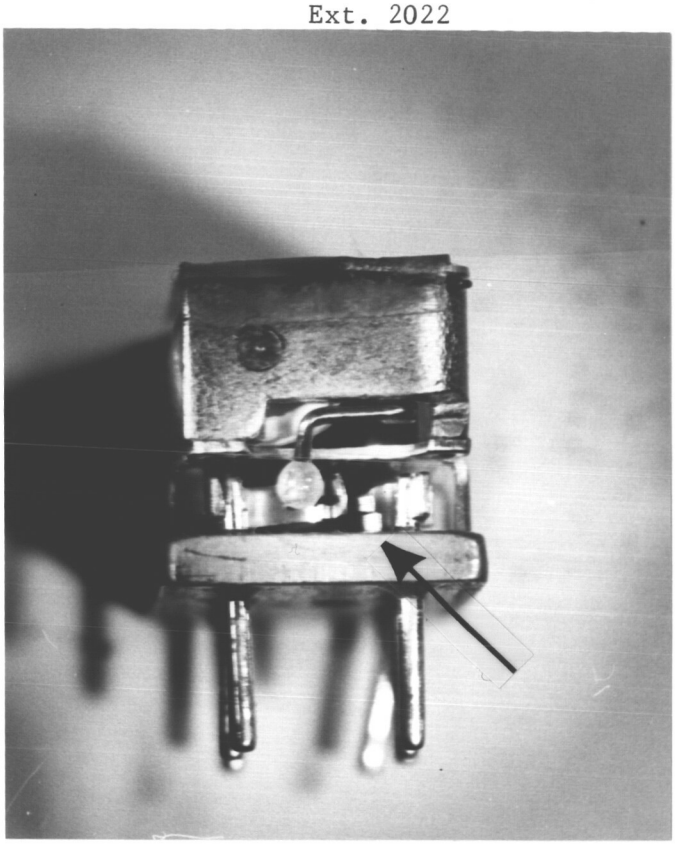
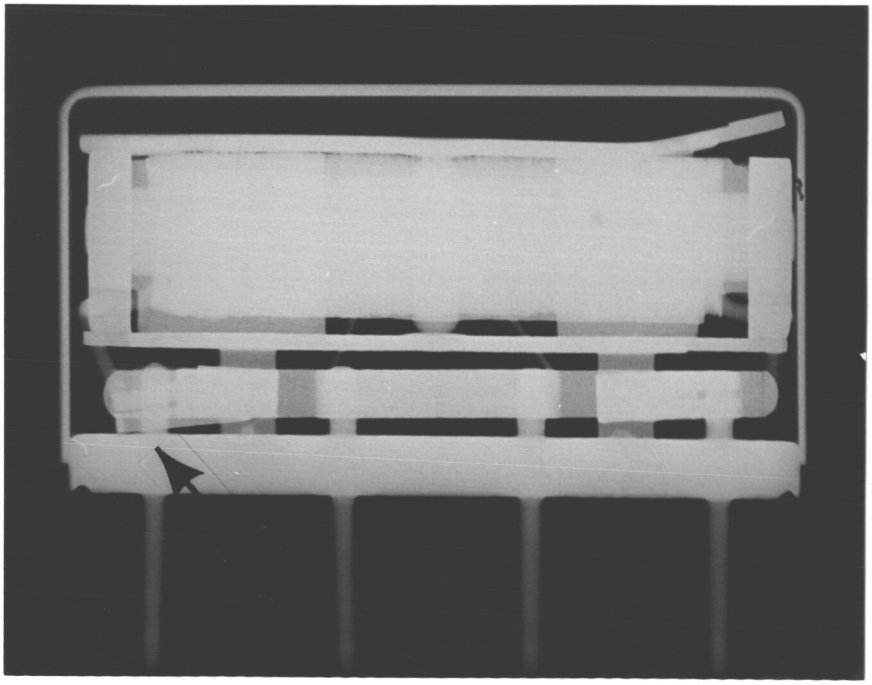


RELAY #15

SAV

Stationary Contact Tip
Bent Down to Header



RELAY #15

SAV

Radiograph Print
of Side View of
Above Misalignment

DATE: _____

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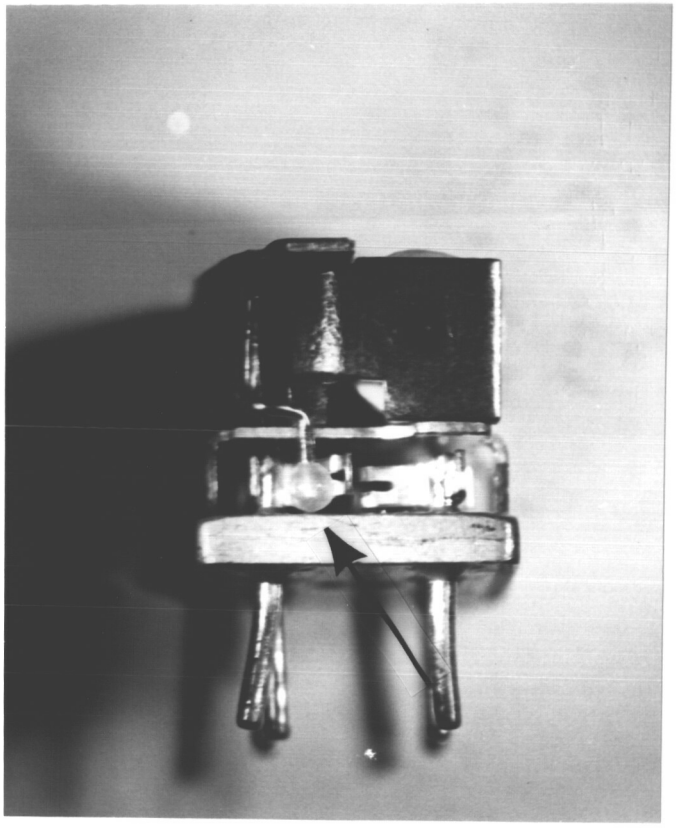
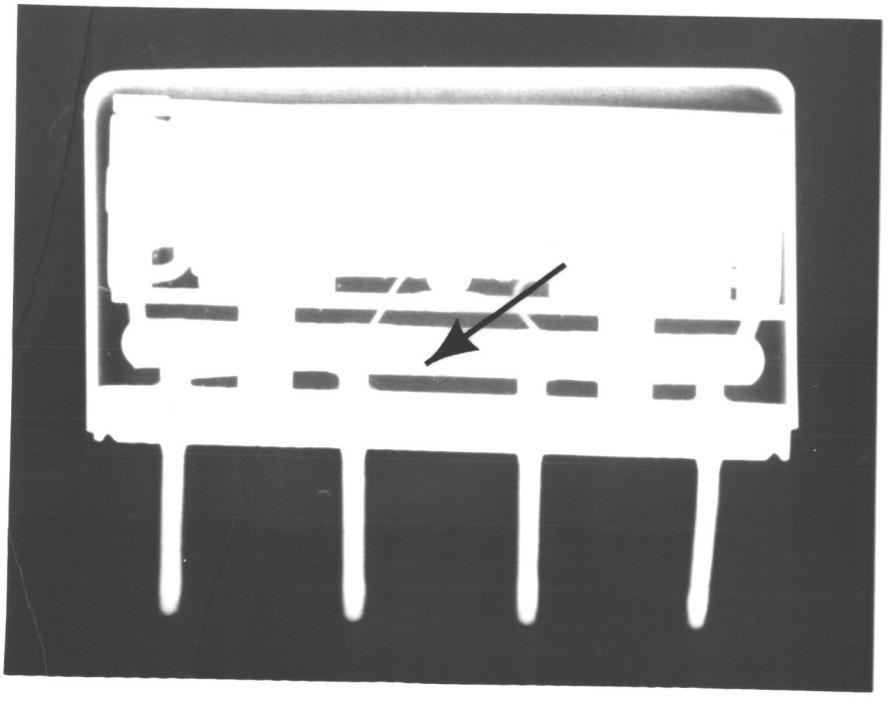
Electronics Park
Ext. 2022



RELAY #16

SAV

Actuator Bead
Rubbing Header

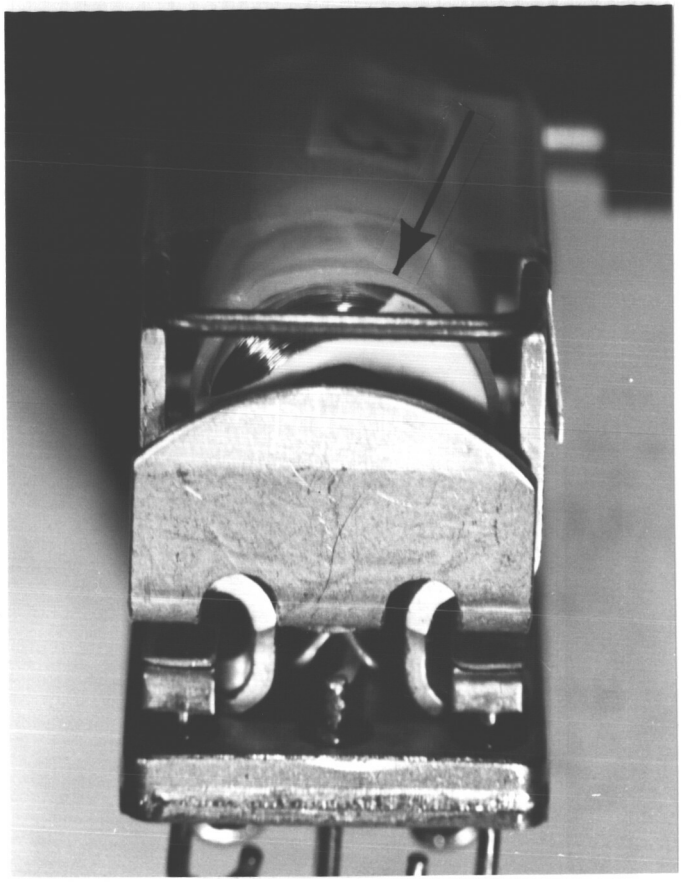


RELAY #16

SAV

Radiograph Print
of Above Condition

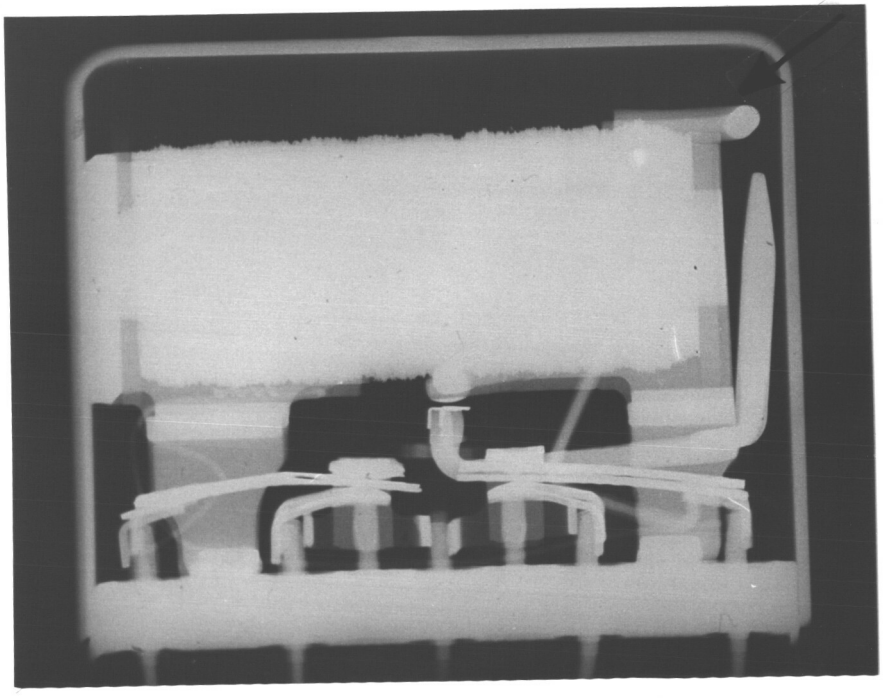
DATE: _____



RELAY #23

SAH

Broken Ceramic

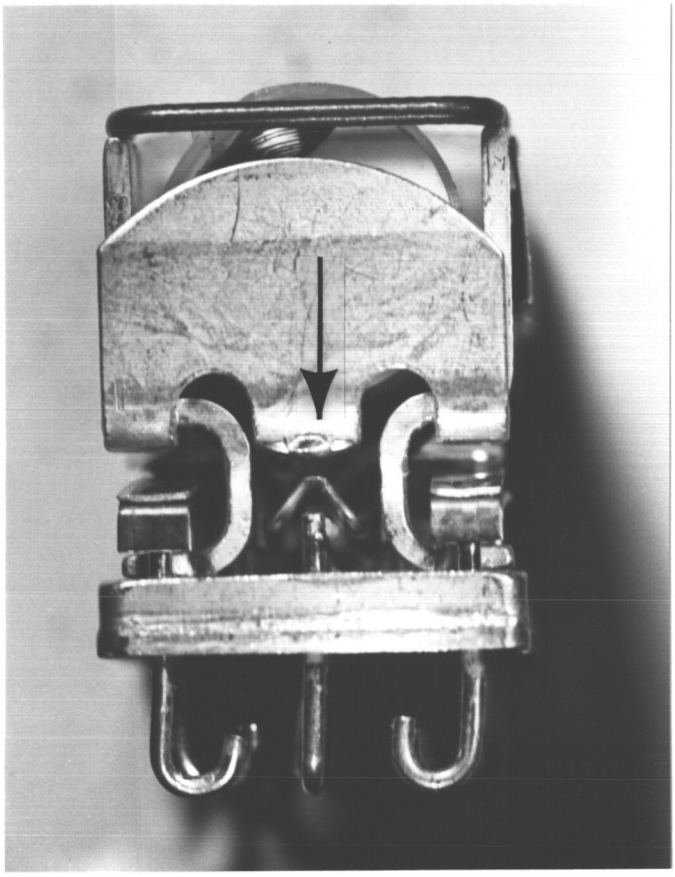


RELAY #23

SAH

Radiograph Print of
Above Condition

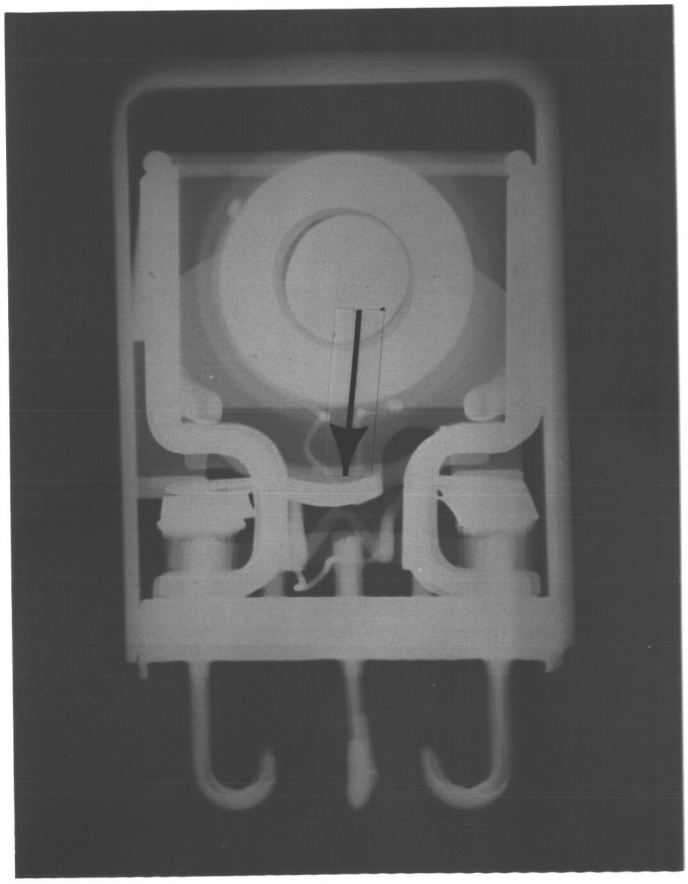
DATE: _____



Relay #23

SAH

Spring not in Notch

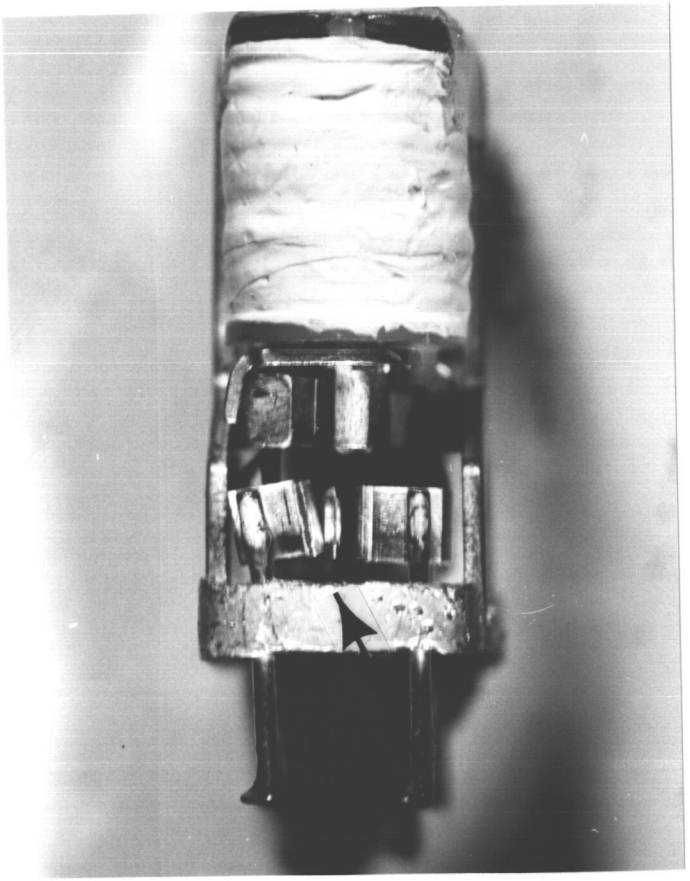


Relay #23

SAH

Radiograph Print of
Above Condition

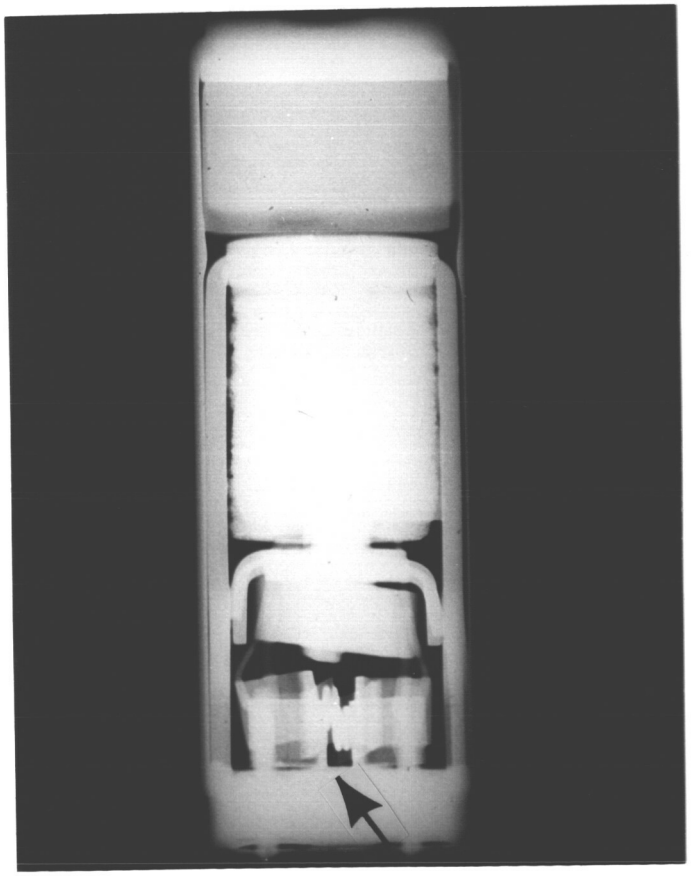
DATE: _____



Relay #24

SAF

Misaligned Contact



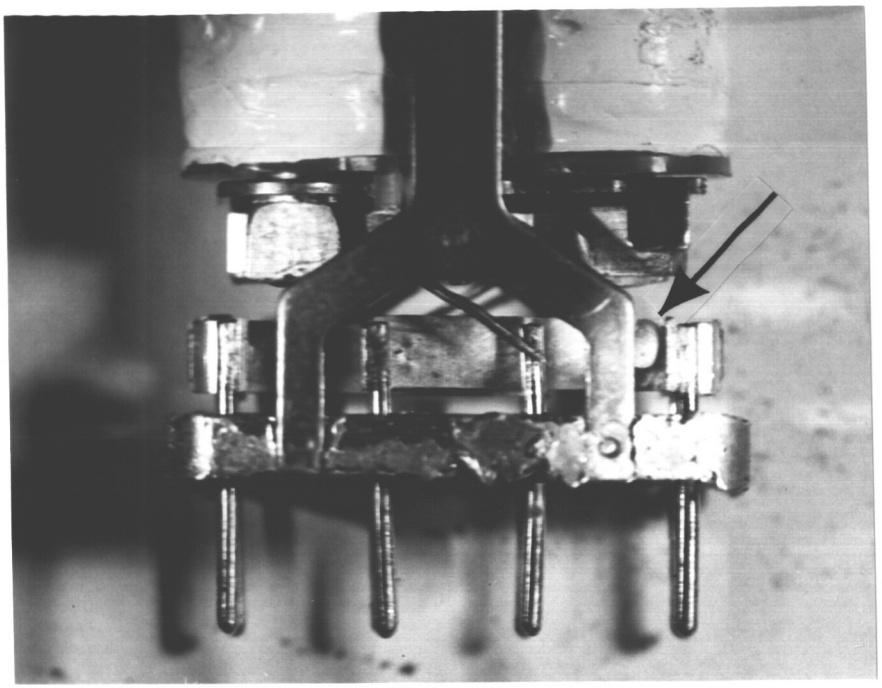
Relay #24

SAF

Radiograph Print
of Misaligned Contact

DATE: _____

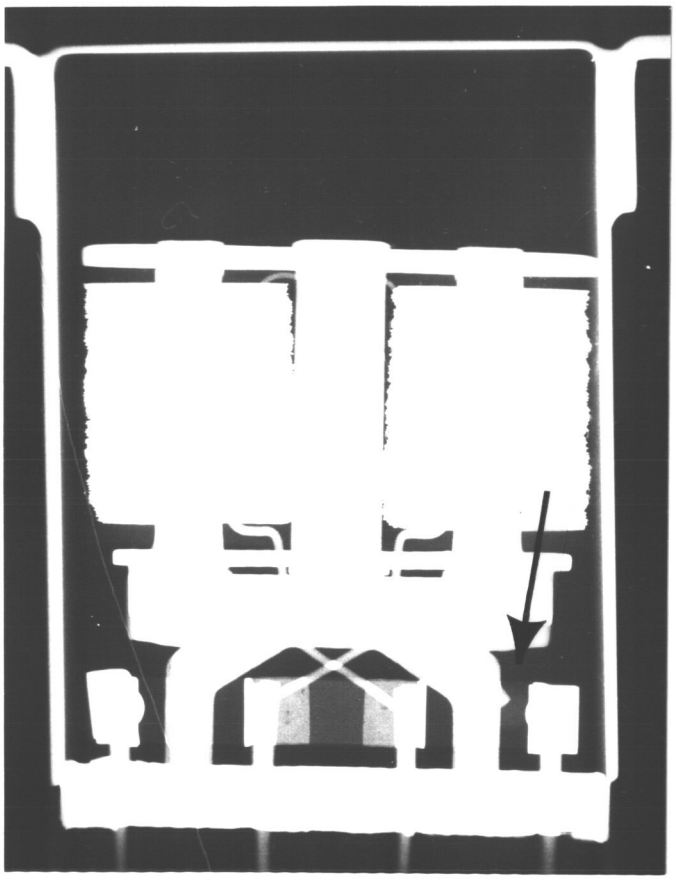
MATERIALS & PROCESSES LABORATORY
METALLOGRAPHIC SECTION
Room 108, Building 3
Electronics Park
Ext. 2022



Relay #24

SAF

Actuator Bead
Rubbing Contact



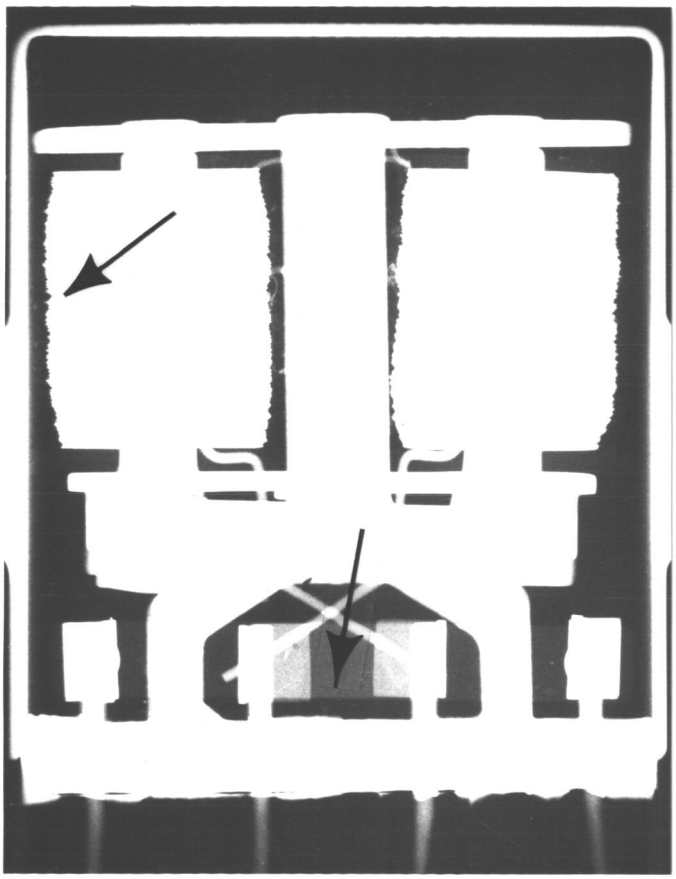
Relay #24

SAF

Radiograph Print
of Above Condition

DATE: _____

MATERIALS & PROCESSES LABORATORY
METALLOGRAPHIC SECTION
Room 108, Building 3
Electronics Park
Ext. 2022



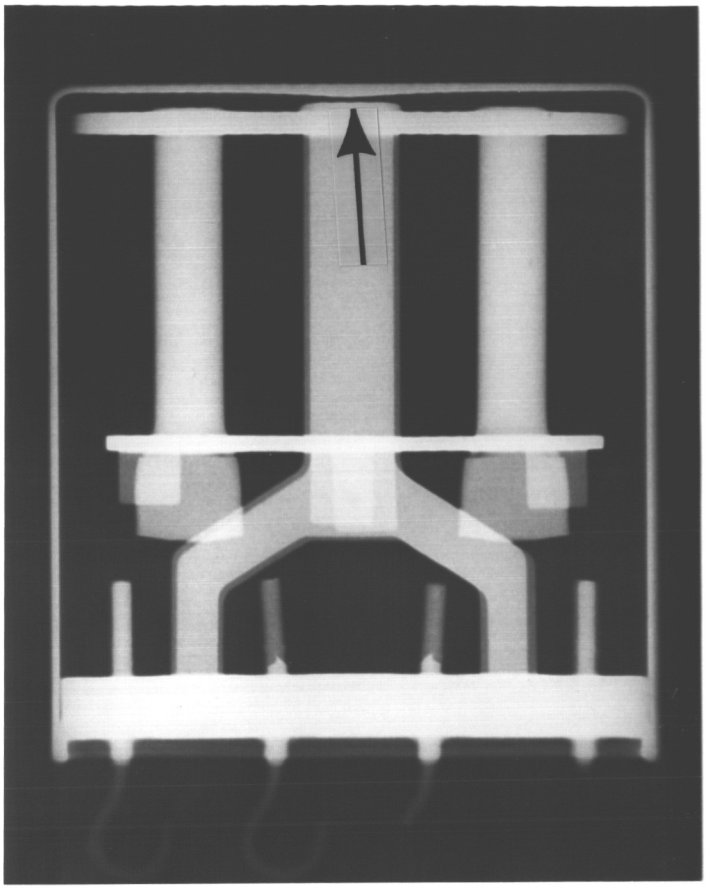
Relay #25

SAF

Radiograph Print

Metal Particles

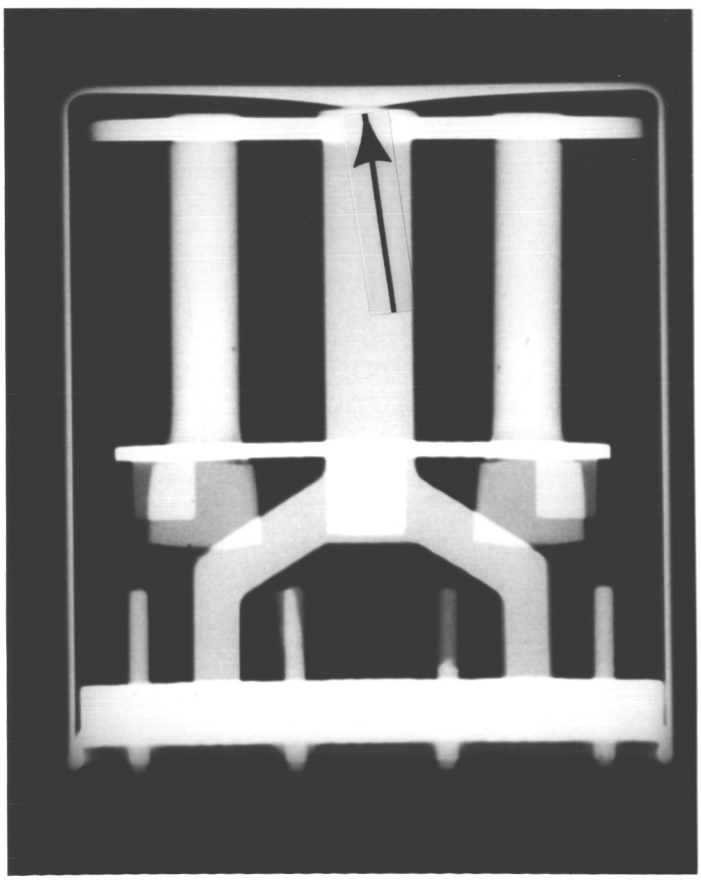
DATE: _____



Relay #59

SAF

Radiograph Print
Pressure - No weld
current.



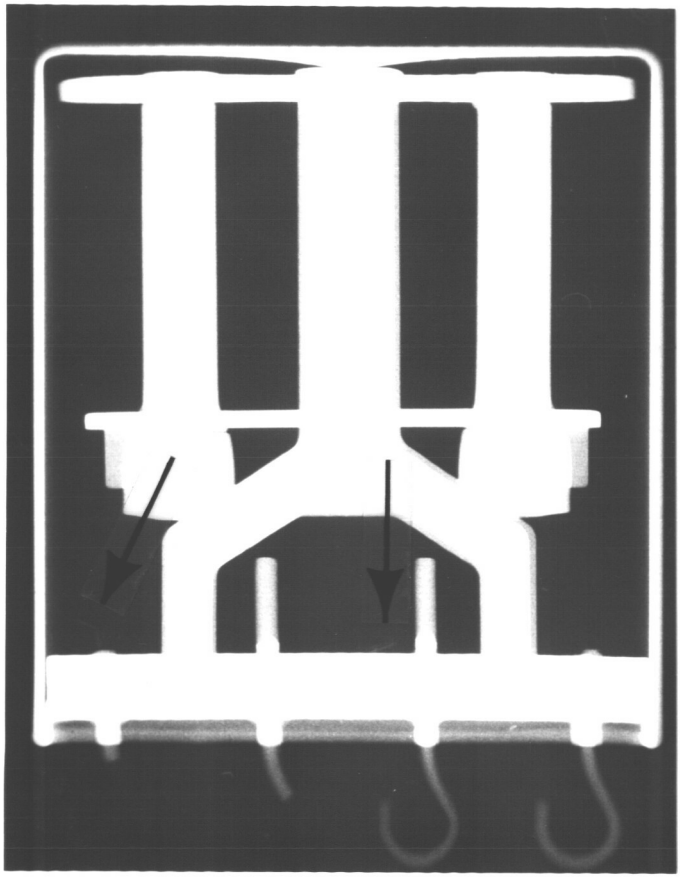
Relay #64

SAF

Radiograph Print
Pressure - Normal
current setting.

DATE: _____

MATERIALS & PROCESSES LABORATORY
METALLOGRAPHIC SECTION
Room 108, Building 3
Electronics Park
Ext. 2022



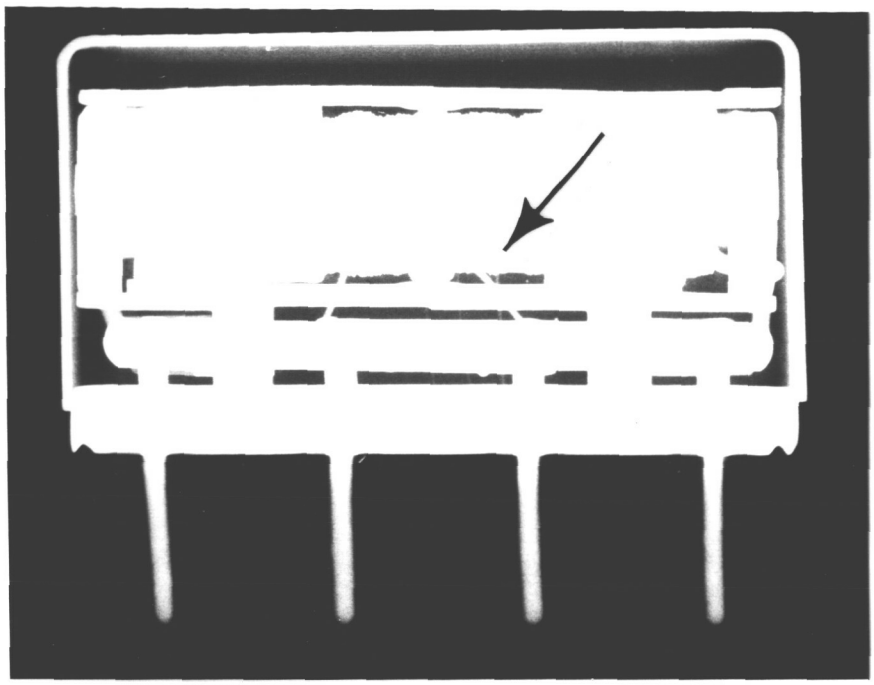
RELAY #67

SAF

Radiograph Print
Weld Splatter

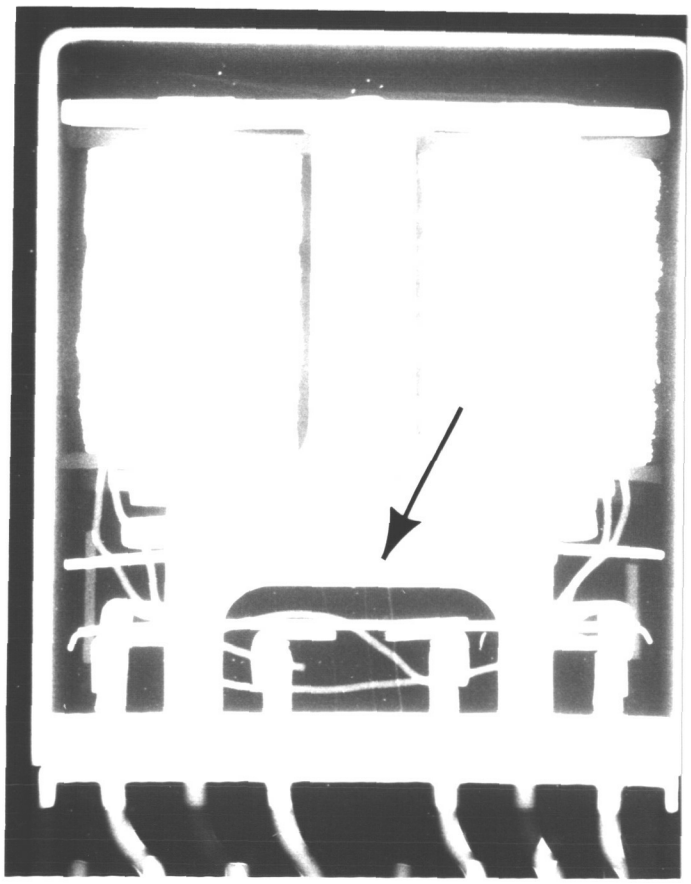
DATE: _____

MATERIALS & PROCESSES LABORATORY
METALLOGRAPHIC SECTION
Room 108, Building 3
Electronics Park
Ext. 2022



SAV

Radiograph Print
0.001"-0.002"-0.003"-
0.004" Copper Wire



SAF

Radiograph Print
0.001"-0.002"-0.003"-
0.004" Copper Wire