COOK-OFF STUDIES ON AUXILIARY DETONATING FUZES MK 379 MOD 0 AND MK 384 MOD 0

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13. ABSTRACT

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(U) Two and one-half minutes after the start of the fire the Auxiliary Detonating Fuzes Mk 370 Mod 0 deflagrated. From a review of the data it is estimated that had the projectiles been loaded with Comp A-3 the fuzes would have initiated the reaction. However, tests of high explosive loaded projectiles would be required to determine the degree of violence of the final explosive event.

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NOLTR 71-54 20 April 1971

Cook-off Studies on Auxiliary Detonating Fuzes Mk 379 Mod 0 and Mk 384 Mod 0

(U) The work discussed in this document was supported by ORD TASK 341-136-092/5-U4728.

(U) This report is the second in a series of reports dealing with the response of ordnance items to flame engulfment. Future studies will assess the vulnerability of other ordnance items, and the means taken to extend their cook-off times.

GEORGE G. BALL
Captain, USN
Commander

ALBERT LIGHTBODY
By direction

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A. Background

During the last few years there have been instances on the deck of carriers (such as the FORRESTAL and ENTERPRISE) where a jet fuel fire has resulted in the cook-off of bombs and rockets. As a result of these catastrophies there has been a great deal of interest generated in the cook-off behavior of all ordnance items.

The cook-off characteristics of 5"/38 projectiles equipped with Mk 29 Point Detonating Fuzes and Auxiliary Detonating Fuzes Mk 379 Mod 0 and Mk 384 Mod 0 was therefore of interest. The Point Detonating Fuze Mk 29 is shown in Figure 1 (Reference 1). This type of fuze consists of basically an ogive and body, containing an interrupter and firing pin housing. In this test the nose detonator and relay detonator explosive mix were removed in order to evaluate the cook-off characteristics of the Auxiliary Detonating Fuzes Mk 379 Mod 0 and Mk 384 Mod 0. Table 1 gives the characteristics of the Fuze Mk 29.

The Auxiliary Detonating Fuze Mk 379 and Mk 384 are shown in Figures 2 and 3. Table 2 shows the main features of these auxiliary detonating fuzes. The Auxiliary Detonating Fuzes Mk 379 Mod 0 and Mk 384 Mod 0 are used in conjunction with a suitable mechanical time fuze, point detonating fuze (such as Mk 29), or a steel nose plug in 5"/38 projectiles. The Auxiliary Detonating Fuze Mk 384 is identical to the Mk 379 except for the 200 gm. booster. It is therefore possible by assembly of the booster to the Mk 384 to convert it to a Mk 379 Mod 0 Fuze. From a heat transfer point in the cook-off situation this is very important.

B. Experimental Arrangement

A flame envelopment test was run on four 5"/38 projectiles. Each projectile was equipped with Mk 29 Point Detonating Fuzes. Two of the projectiles were outfitted with Auxiliary Detonating Fuzes Mk 379 Mod 0 and two were outfitted with Auxiliary Detonating Fuzes Mk 384 Mod 0 (Figures 4 and 5). The projectiles were filled with sand as an inert simulant. The projectiles and fuzes were fitted with chromel alumel thermocouples to measure the thermal response of the system on heating. Figure 6 shows the thermocouple distribution in the 5"/38 projectiles and fuzes. In addition to these thermocouples, 8 thermocouples were mounted on the exterior of the projectiles in order to measure fire temperature. A Vidar Data Acquisition System was used to measure the thermocouple data. Up to 1000 three wire guarded data input channels can be scanned, and these data are measured and recorded on printed paper tape and magnetic tape. The system measures d.c. voltage between one microvolt and 200 millivolts which in this case can be translated to a temperature range between -30°F and +3000°F. These modes and ranges of measurement were remotely selected and were programmed in blocks of 10 for easy insertion into the computer. The usefulness of this system is its high degree of noise immunity from both common and normal mode interference. The system scanned at the rate of 5 pts/sec although faster scanning rates can be used.

Four 5"/38 inert projectiles were cooked-off in one pit. Each projectile was positioned approximately 36" from the surface of 2800 gallons of JP-4 fuel. A 35' x 35' x 1' enclosure (pit) was constructed from sand and polyethylene. The enclosure contained the fuel with two inches of water beneath the JP-4 to provide a level surface. The fuel was ignited with four thermite grenades modified with electric squibs. These were placed in four locations so as to initiate burning over the entire fuel surface, as rapidly as possible. In addition to the thermocouples measurements, two 16mm cameras were stationed 1500 feet from the pit to photograph any event occurring. The firing was viewed onclosed circuit television and a video tape recording was made of the shot.

C. Results and Conclusions

The atmospheric conditions were ideal for this experiment. The wind velocity was 0 knots and the visibility was unlimited. Figure 7 shows a typical test set up prior to ignition. Figures 8 through 15 show the fire temperature as a function of time. Two thermocouples were placed on the exterior skin of each projectile to record the fire temperature. The time to reach 1000°F was approximately four seconds. The average fire temperature was 1750 ± 100°F. The variation in fire temperature was small and engulfment of the projectiles in the fire was complete. The fire lasted for 17 minutes.

A slight popping sound was detected after the fire had burned for 2½ minutes. However, no visible observation was made to any burning or violent behavior. After reviewing the thermocouple data it was apparent that the projectiles equipped with the Mk 379 Auxiliary Detonating Fuze had deflagrated in 2½ minutes. Figures 16 - 19 and 20-- 23 are the temperature time plots of the projectiles which were outfitted with the Auxiliary Detonating Fuzes Mk 379. Both cooked-off in 2½ minutes. This time was arbitrarily taken as the time to reach 1000°F. The onset of the reaction took place in 2 minutes and 10 seconds. Even after burning, the thermocouples responded to record the fire temperatures. Figures 24 - 27 and 28 - 31 indicate the temperature on the Mk 384 Auxiliary Detonating Fuze. The thermocouples were placed toward the front of this live fuze to ascertain at what temperature cook-off occurred. From a review of these figures it is apparent that the heat transfer path occurs through the front of the projectile. Cook-off appears to have originated from heat entering the Mk 29 PDF, transferring to the Fuze Mk 379 and to the front of the adapter booster. The temperatures which were indicated on the bottom of the adapter booster were only slightly above room temperature when the reaction occurred. However, the temperature at the neck was 400°F. It is evident, therefore, that the heat was transferred from the Mk 29 Fuze to the auxiliary detonating fuze causing the reaction.

If the projectiles had been loaded with Comp A, would the Mk 379 Fuze have gone off first or would the explosive have gone off? Comp A is a mixture of 91% RDX and 9% wax. The cook-off temperature of Comp A was reported as being 356° (Reference 2). If we now look at Figures 32 - 39 which represent the interface temperature between the explosive and the steel, we observe the minimum cook-off time as being 3 minutes. It is estimated, therefore, that the tetryl in the adapter booster would have cooked-off before the main explosive charge.

A typical view of the test site after the reaction is shown in Figures 40 and 41. Representative case and fuze pieces are shown in Figure 42. It is apparent from the inflection point on Figures 24 - 27 that the aluminum employed in Auxiliary Detonating Fuzes Mk 379 and Mk 384 melted in approximately seven minutes.

From the remnants of the test (Figures 40 - 42) no detonation occurred, only a mild burning reaction. However, if the projectiles had been loaded with Comp A it is unknown if the projectiles would have responded in the same manner. The degree of violence of the reaction is quite complicated and is dependent upon the nature of the explosive break-up, degree of confinement and the strength of the steel at the time of the reaction.

D. Recommendations

It is recommended that an additional cook-off test be performed using an inert Mk 29 PDF and an Auxiliary Detonating Fuze Mk 379 fitted into an explosive loaded 5"/38 projectile. The cook-off time and nature of the reaction can therefore be determined.

REFERENCES

1. NAVORD OP 2215, First Edition, "Navy Gun-Type Information", March 1969.

2. National Northern NN-P-23, Gammel, H. P., "Properties of Explosives, Cook-off Studies; Initial Phase Report", October 1954.

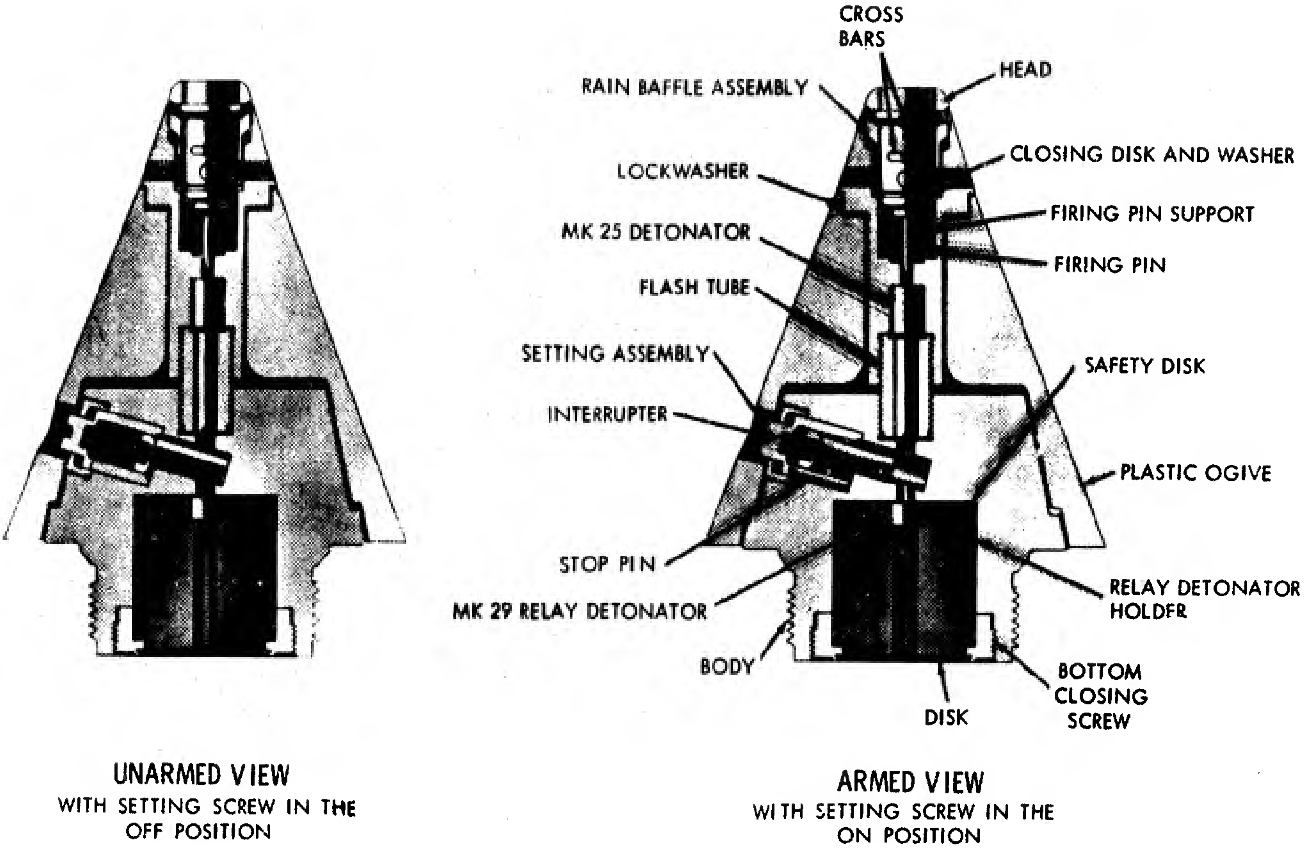

FIGURE 1 MK 29 POINT DETONATING FUZE ARMED AND UNARMED VIEW

TABLE 1

CHARACTERISTICS OF POINT DETONATING FUZE MK 29

NOMINAL WEIGHT (LBS.)	1.49
OVERALL LENGTH (IN.)	4.14
EXPLOSIVE COMPONENTS	
NOSE DETONATOR MK 25 MOD 0	LEAD AZIDE AND PRIMER MIX
RELAY DETONATOR MK 29 MOD 0	LEAD AZIDE

TABLE 2

AUXILIARY DETONATING FUZES MK 379 MOD 0 AND MK 384 MOD 0

MK	379	384
PROJECTILE USED IN	5"/38	5"/38 ILLUM.
NOMINAL WEIGHT (LB.)	1.5	1.0
OVERALL LENGTH (IN.)	5.8	2.2
EXPLOSIVE COMPONENTS		
DETONATOR MK 23	LEAD AZIDE	LEAD AZIDE
	TETRYL	TETRYL
	NOL PRIMER MIX	NOL PRIMER MIX
EXPLOSIVE LEAD	TETRYL	TETRYL
BOOSTER (GMS.)	TETRYL (200)	NONE

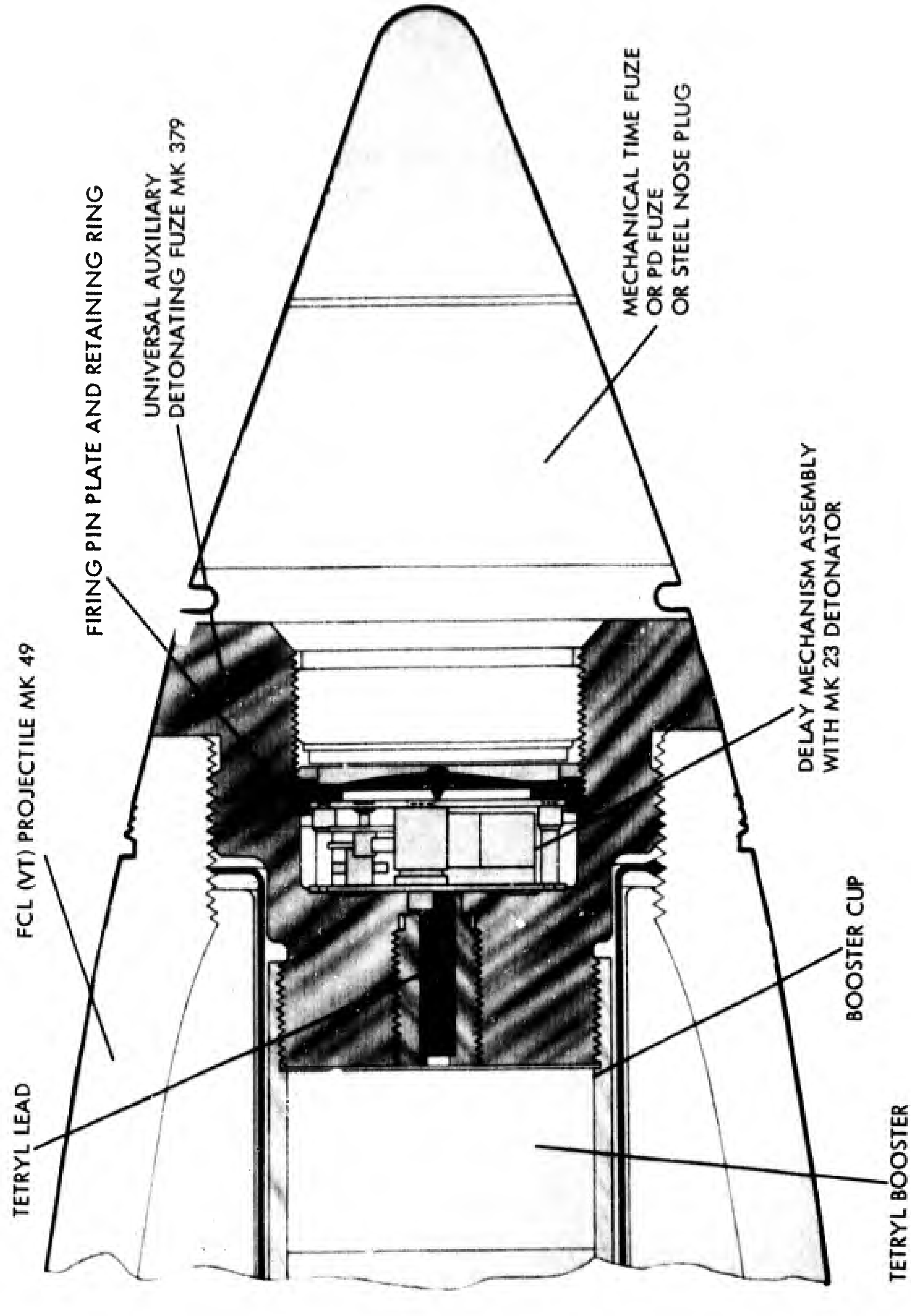

FIGURE 2. AUXILIARY DETONATING FUZE MK 379 MOD 0

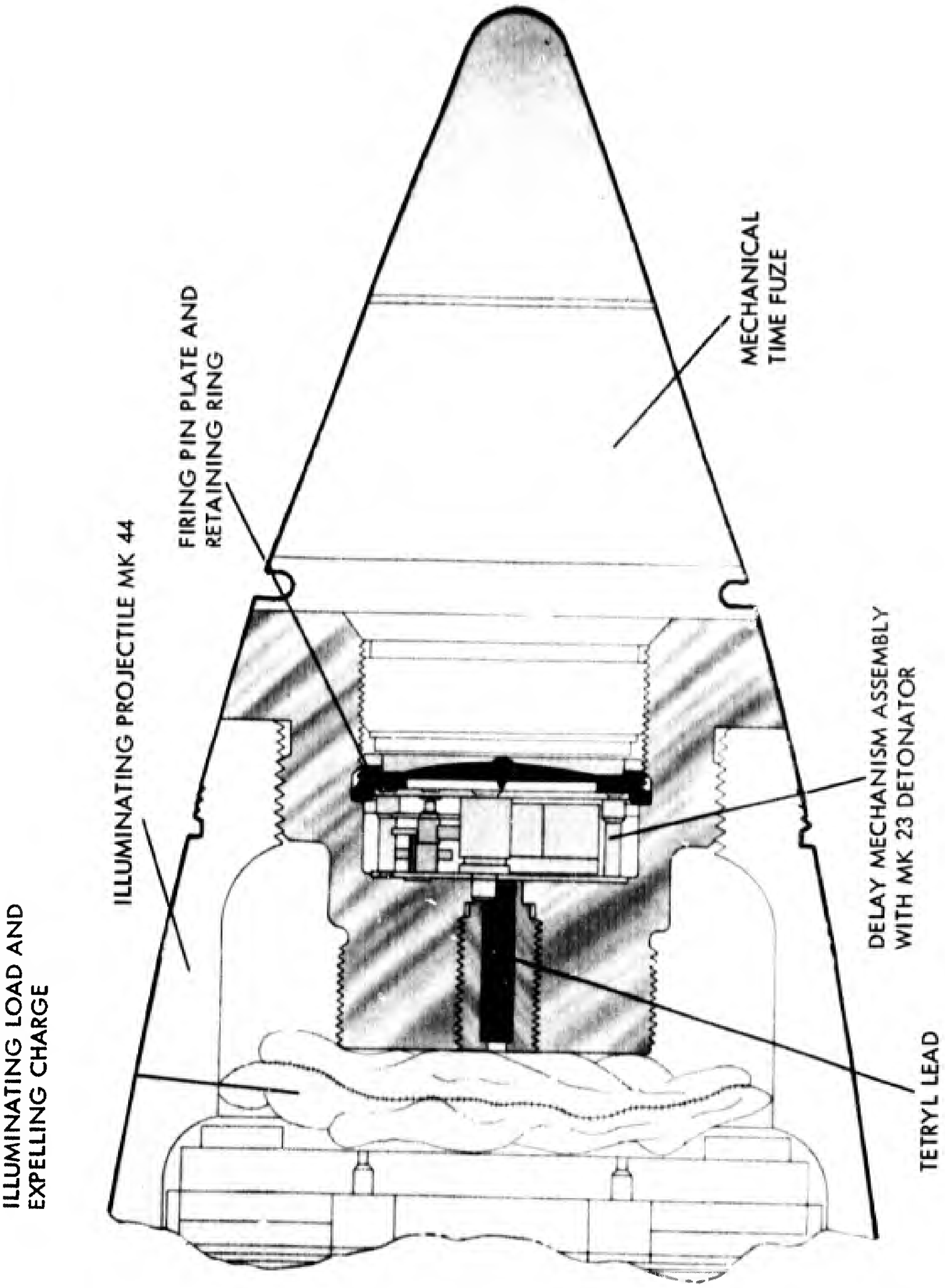

FIGURE 3 AUXILIARY DETONATING FUZE MK 384 MOD 0

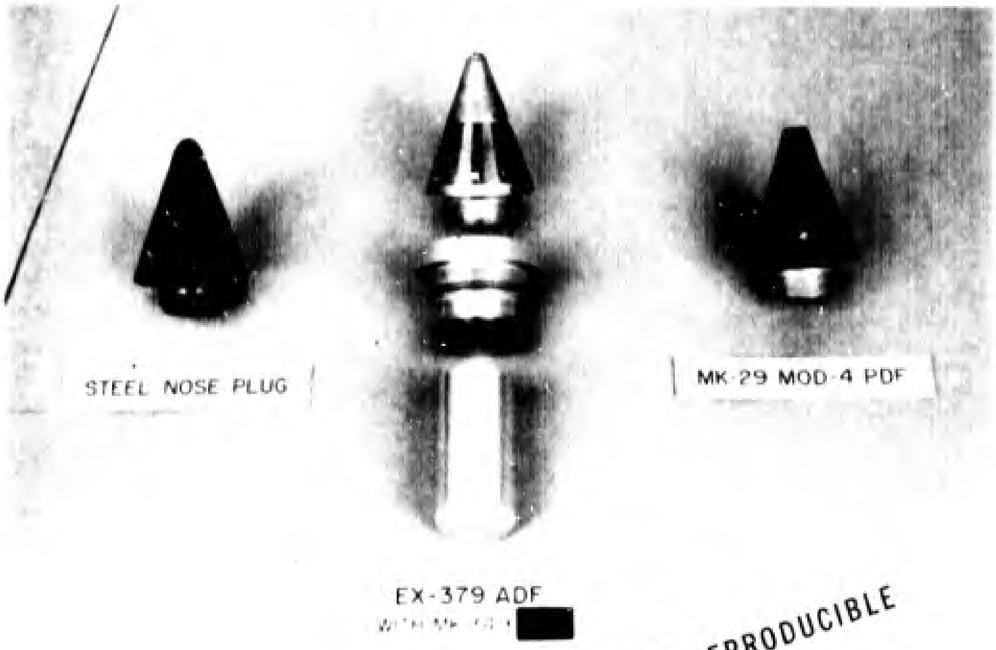

FIGURE 4 AUXILIARY DETONATING FUZE MK 379 WITH STEEL NOSE PLUG AND MK 29 MOD 4 PDF

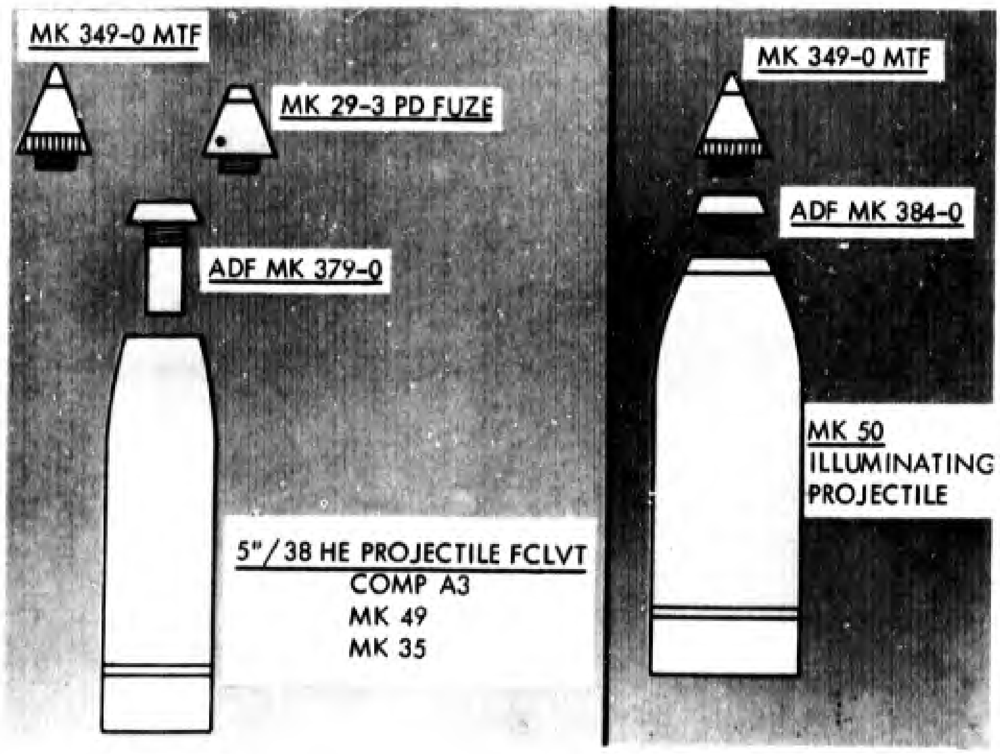

FIGURE 5 AUXILIARY DETONATING FUZES MK 379 MOD 0 AND MK 384 MOD 0 INSTALLED IN 5"/38 HE PROJECTILES AND ILLUMINATING PROJECTILE

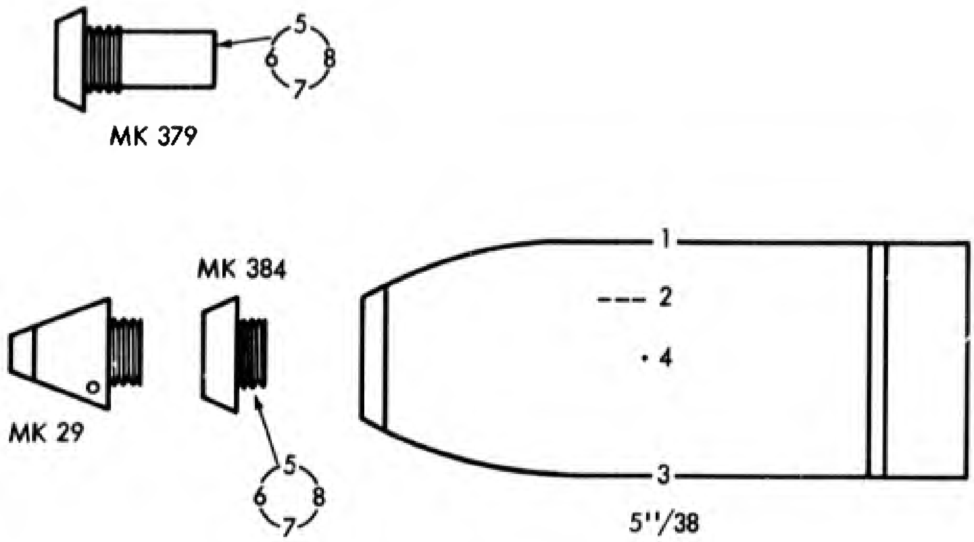

FIGURE 6 THERMOCOUPLE DISTRIBUTION IN 5''/38 AND AUXILIARY DETONATING FUZES MK 379 AND 384.

FIGURE 7 EXPERIMENTAL COOK-OFF ARRANGEMENT SHOWING POSITION OF PROJECTILES

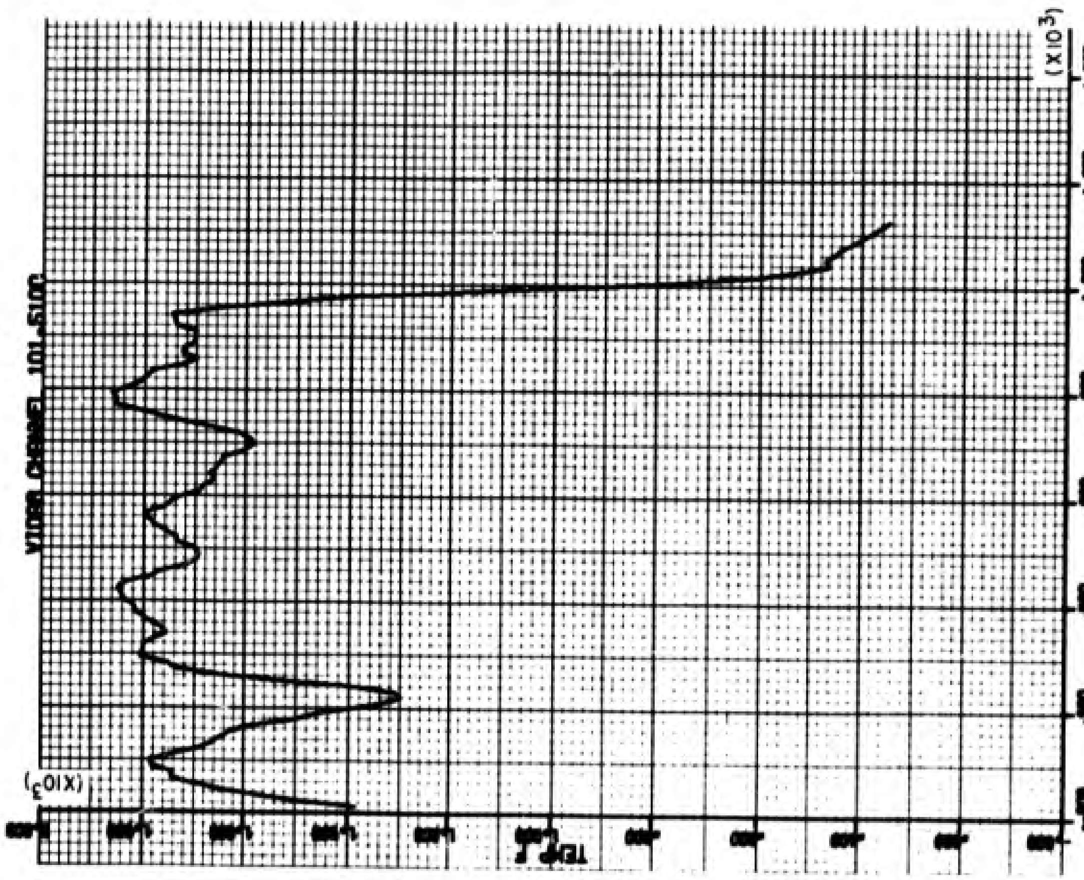

FIGURE 8 OUTSIDE FIRE TEMPERATURE (BOTTOM)

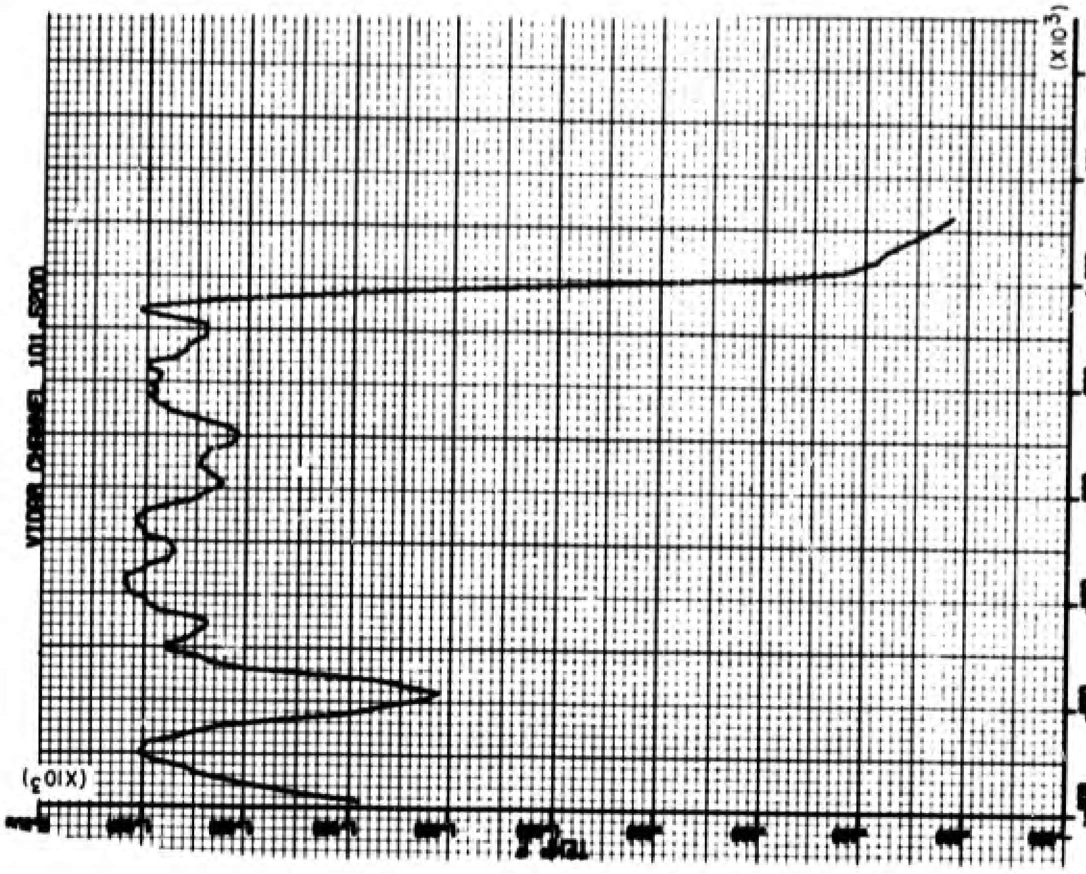

FIGURE 9 OUTSIDE FIRE TEMPERATURE (BOTTOM)

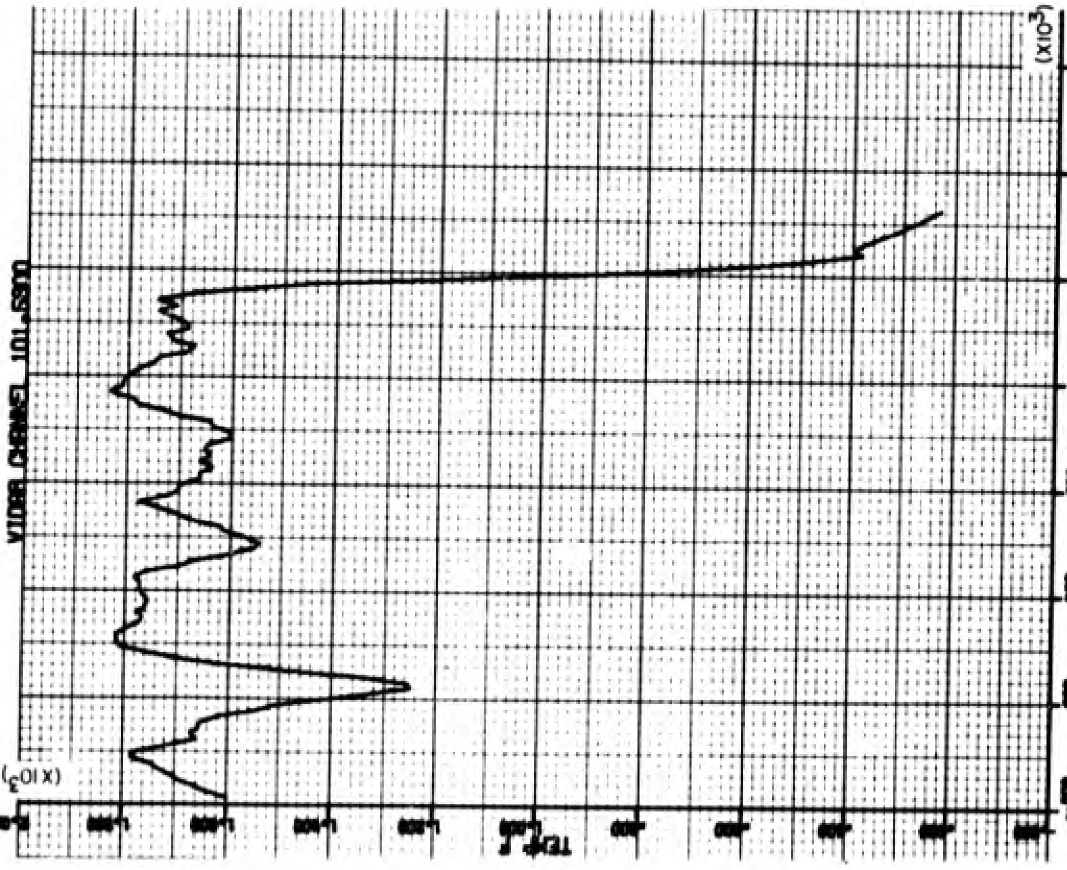

FIGURE 10 OUTSIDE FIRE TEMPERATURE (LEFT)

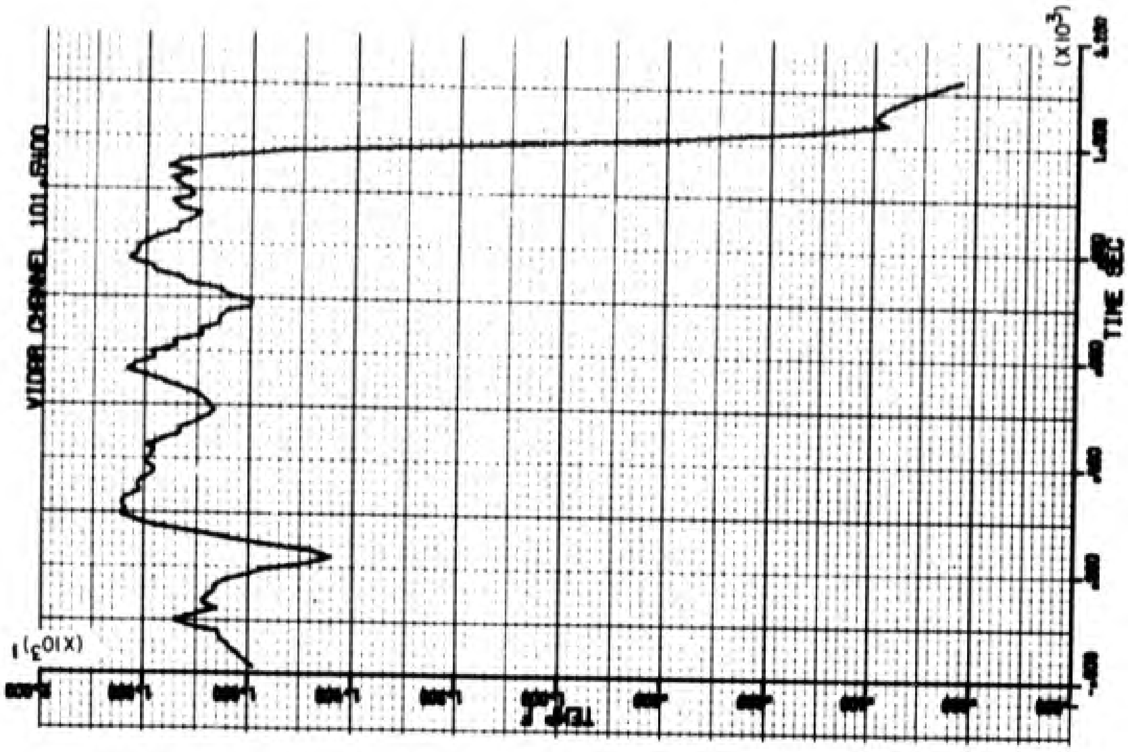

FIGURE 11 OUTSIDE FIRE TEMPERATURE (LEFT)

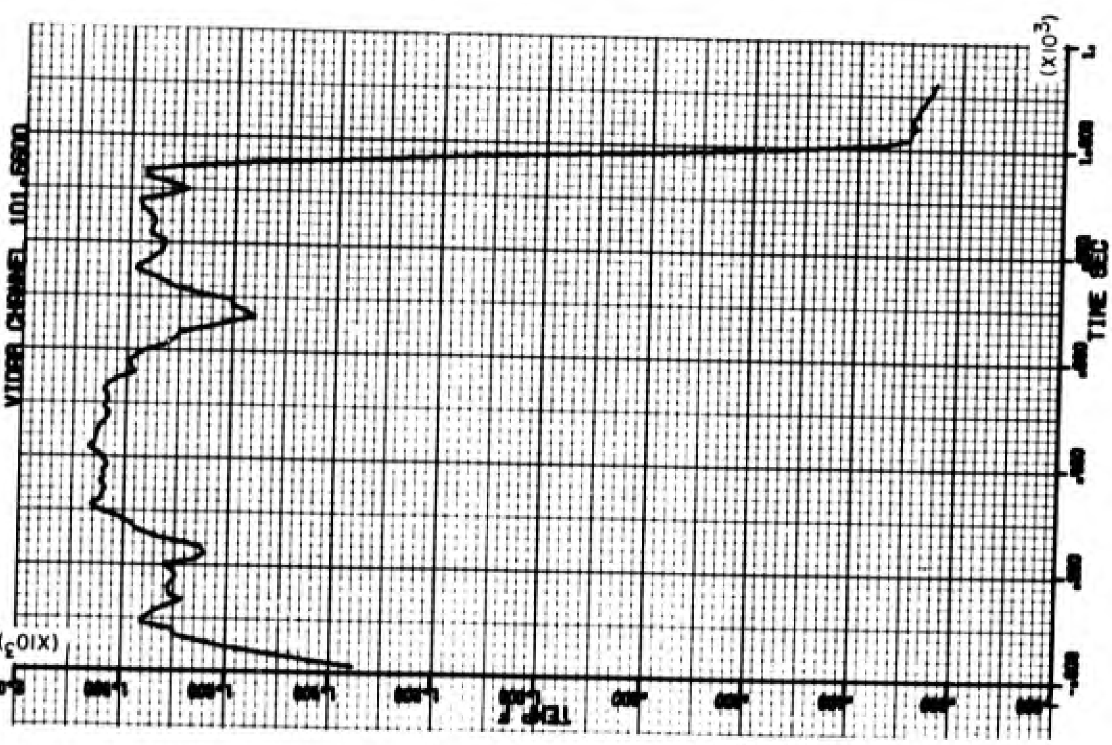

FIGURE 12 OUTSIDE FIRE TEMPERATURE (TOP)

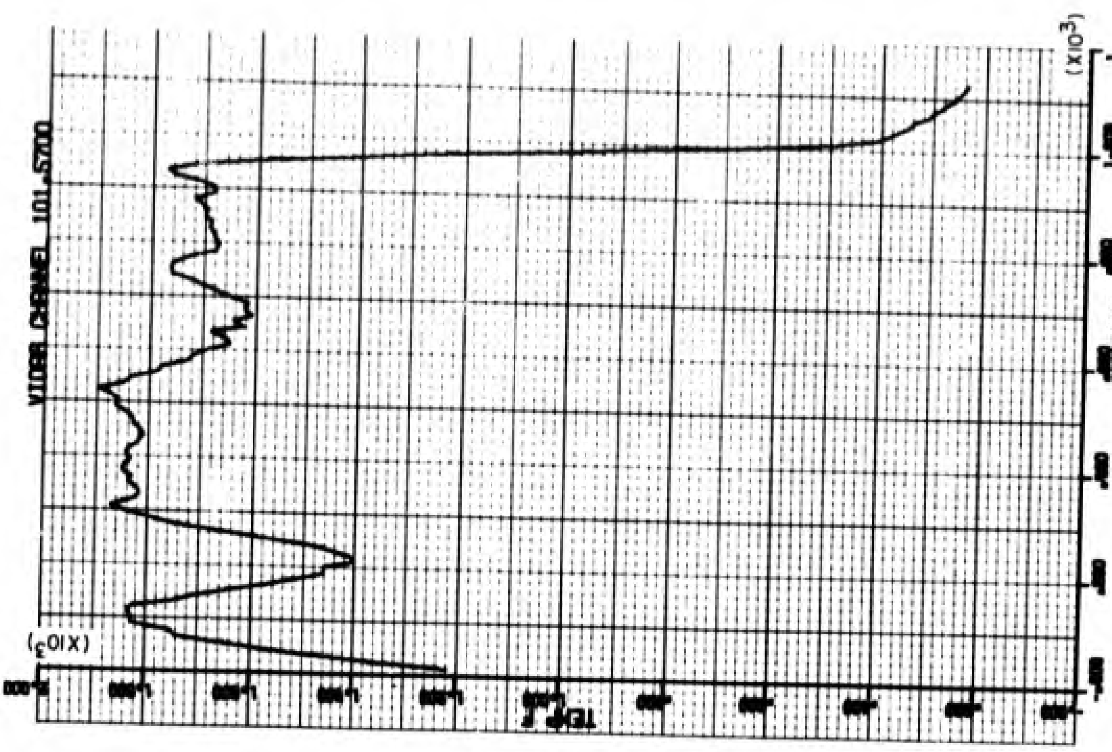

FIGURE 13 OUTSIDE FIRE TEMPERATURE (TOP)

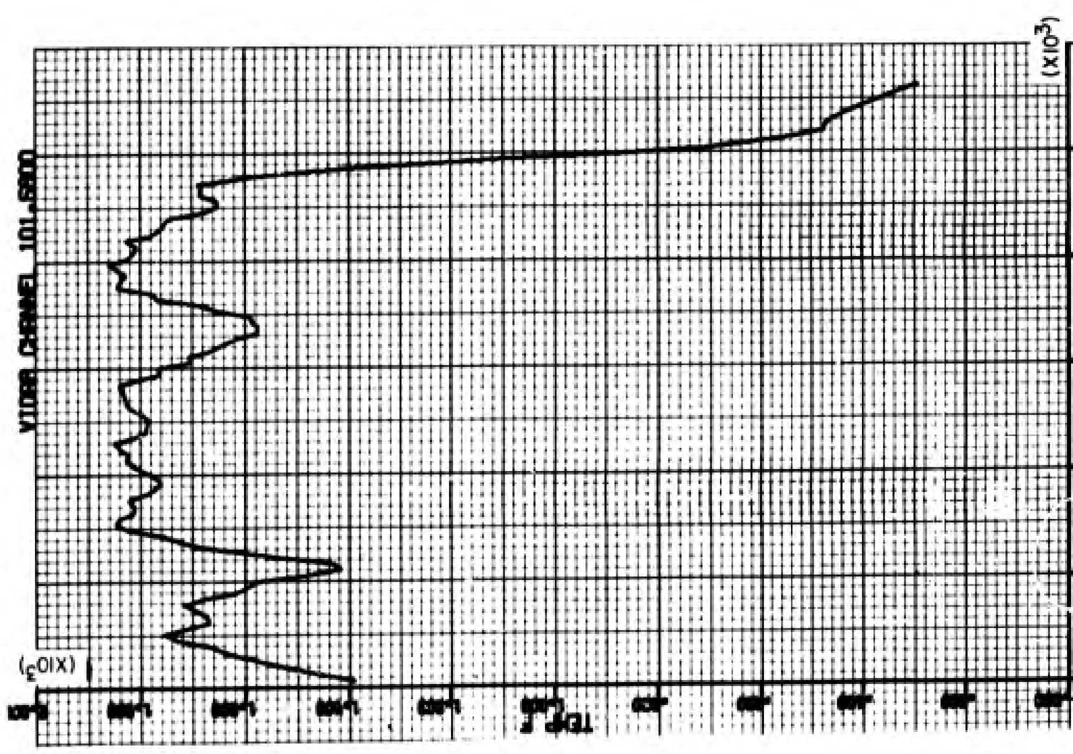

FIGURE 14 OUTSIDE FIRE TEMPERATURE (RIGHT)

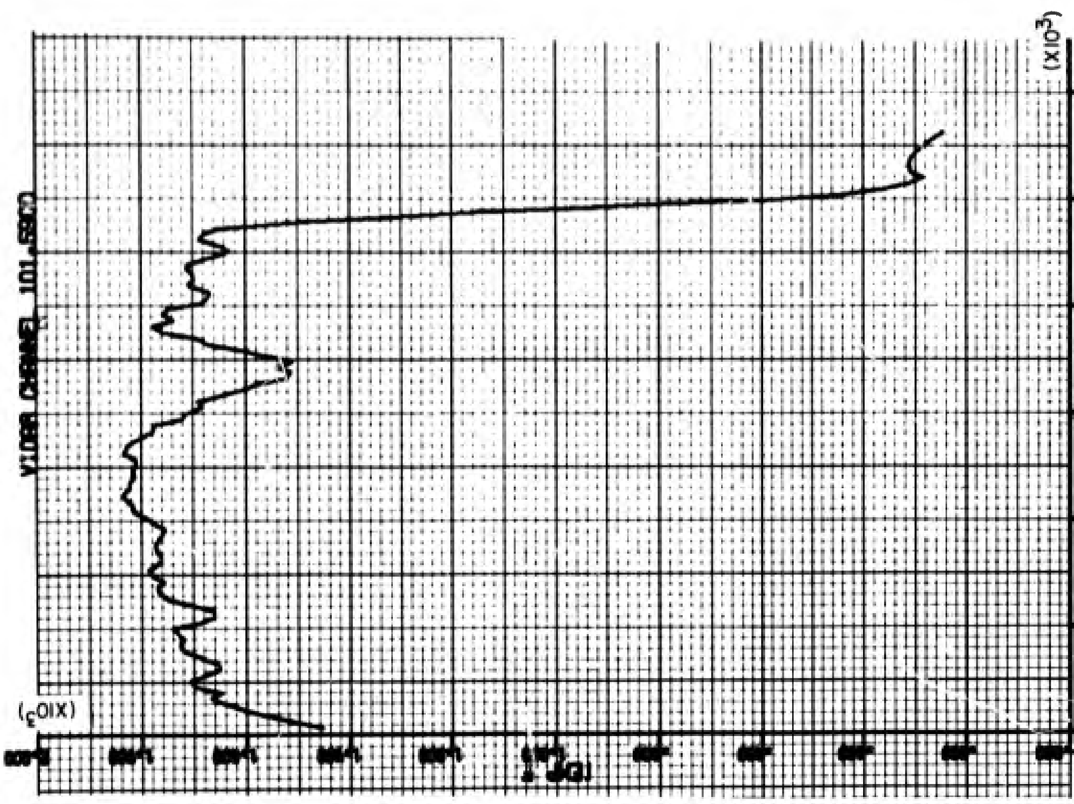

FIGURE 15 OUTSIDE FIRE TEMPERATURE (RIGHT)

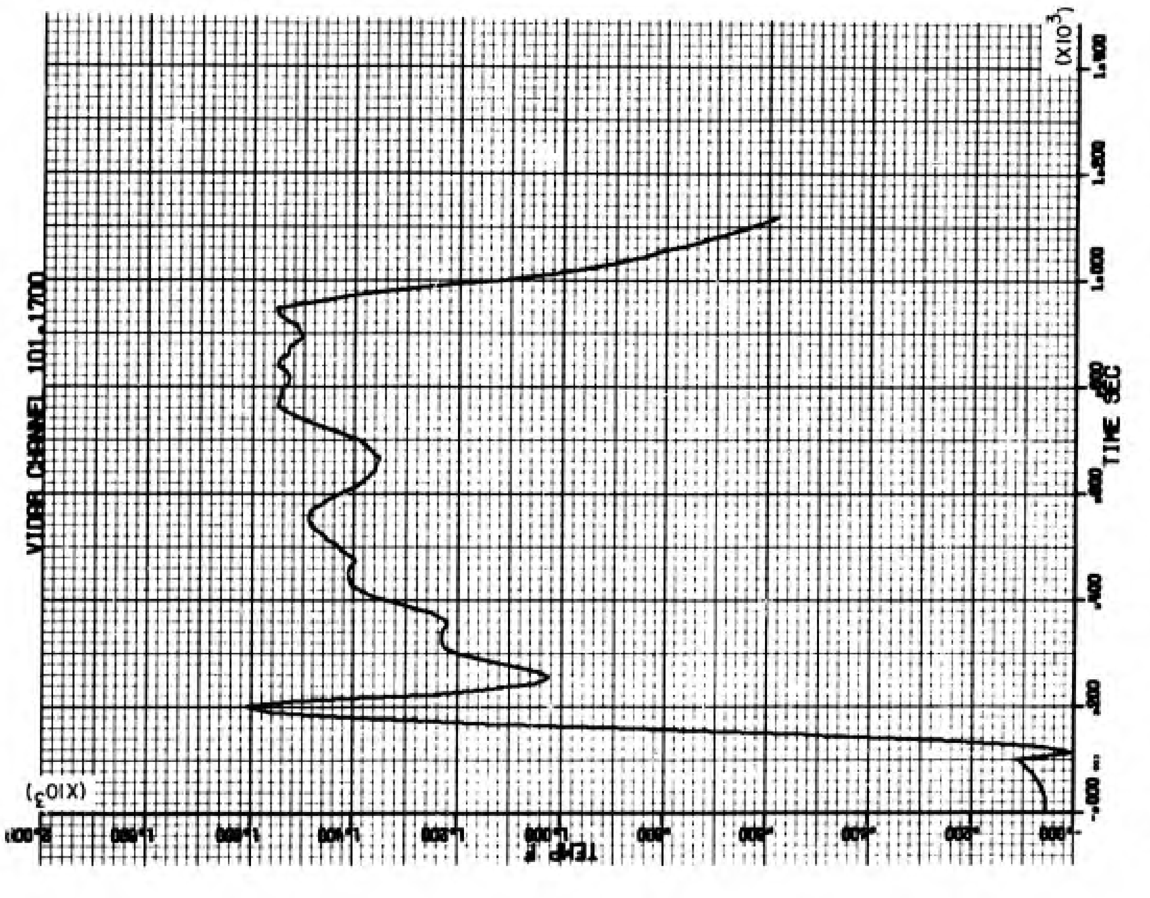

FIGURE 16 TIME TEMPERATURE PLOT OF THERMOCOUPLE (5) ON MK 379

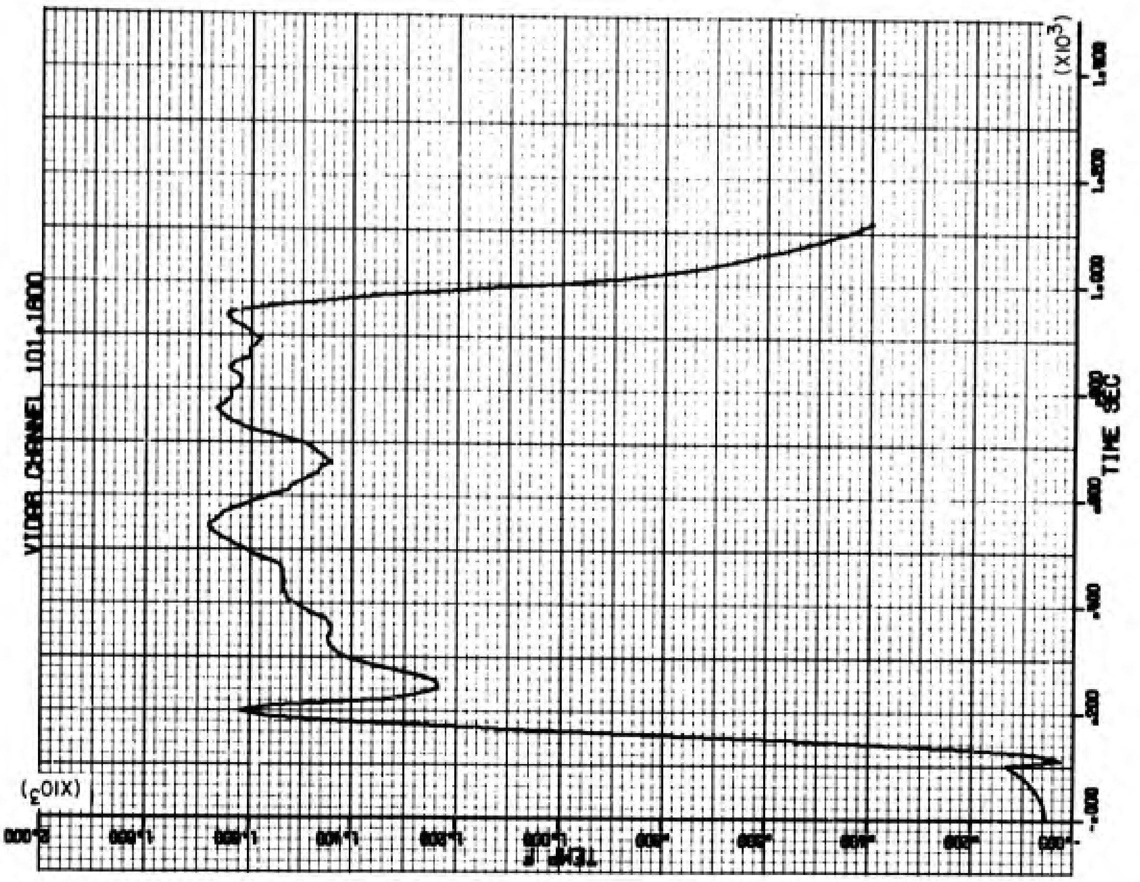

FIGURE 17 TIME TEMPERATURE PLOT OF THERMOCOUPLE (6) ON MK 379

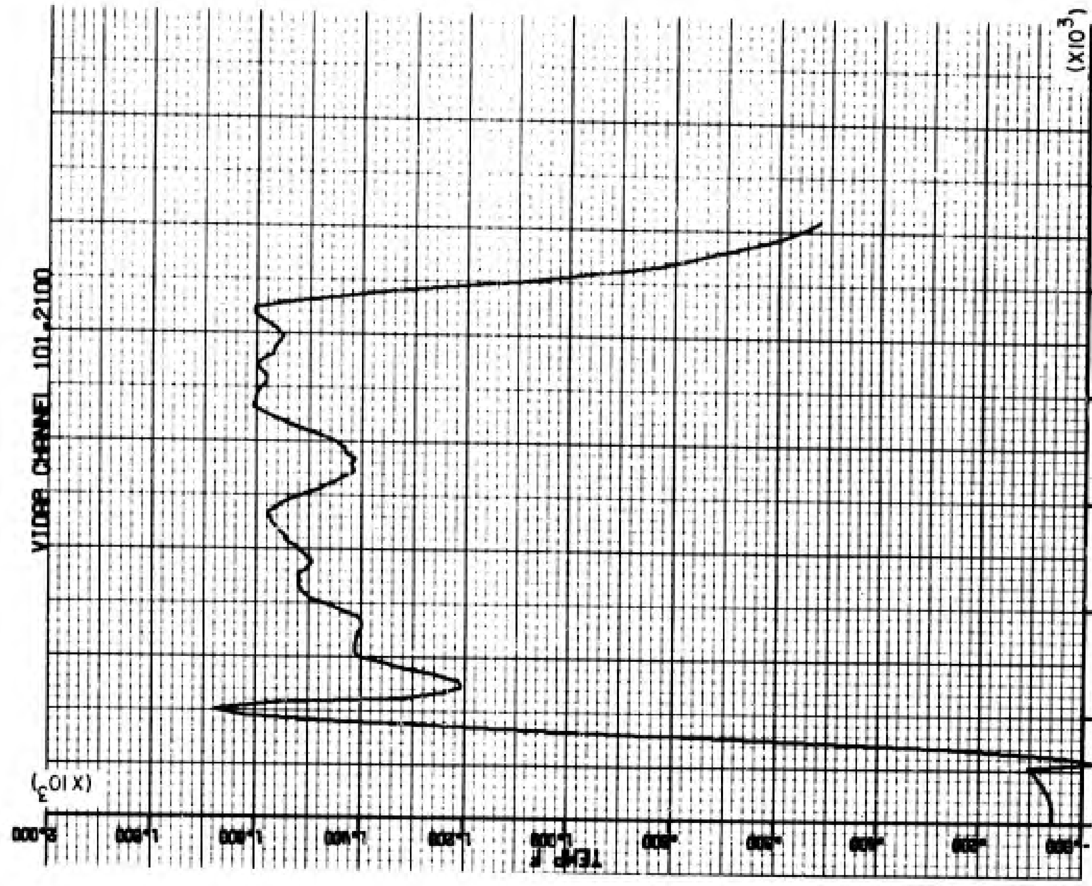

FIGURE 19 TIME TEMPERATURE PLOT OF THERMOCOUPLE (8) ON MK 379

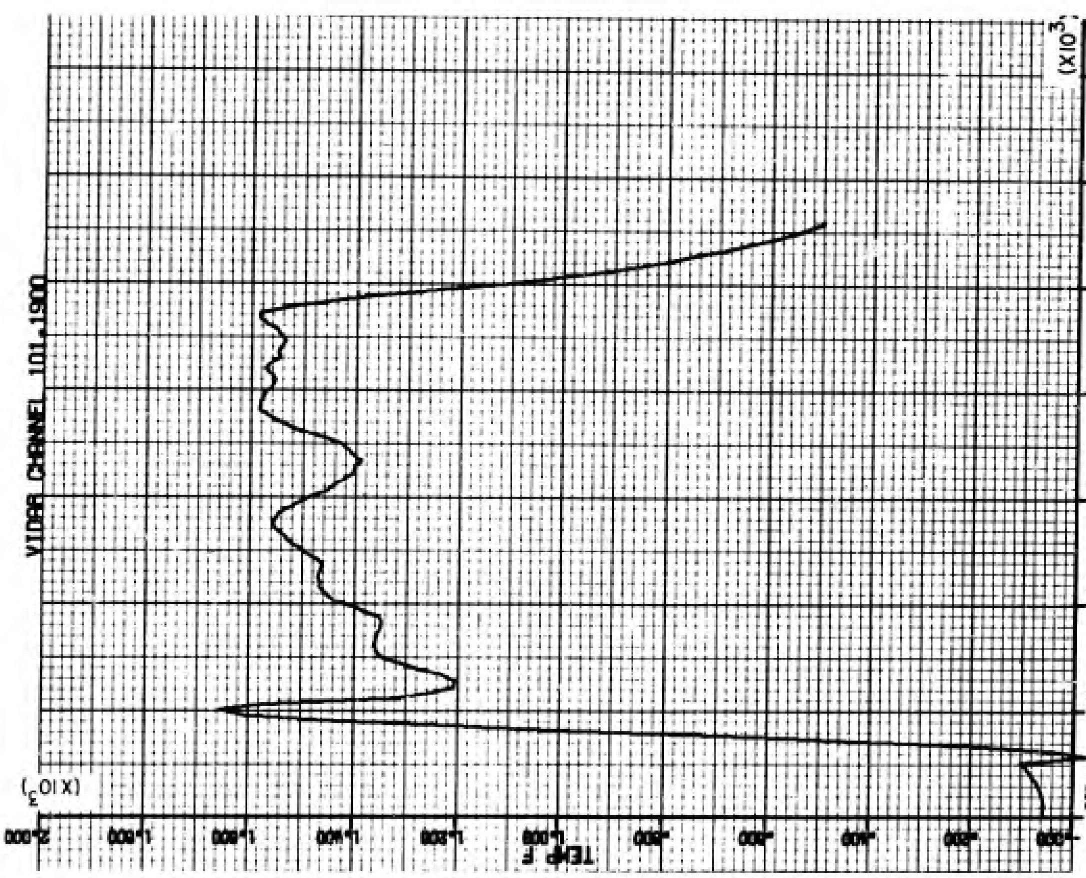

FIGURE 18 TIME TEMPERATURE PLOT OF THERMOCOUPLE (7) ON MK 379

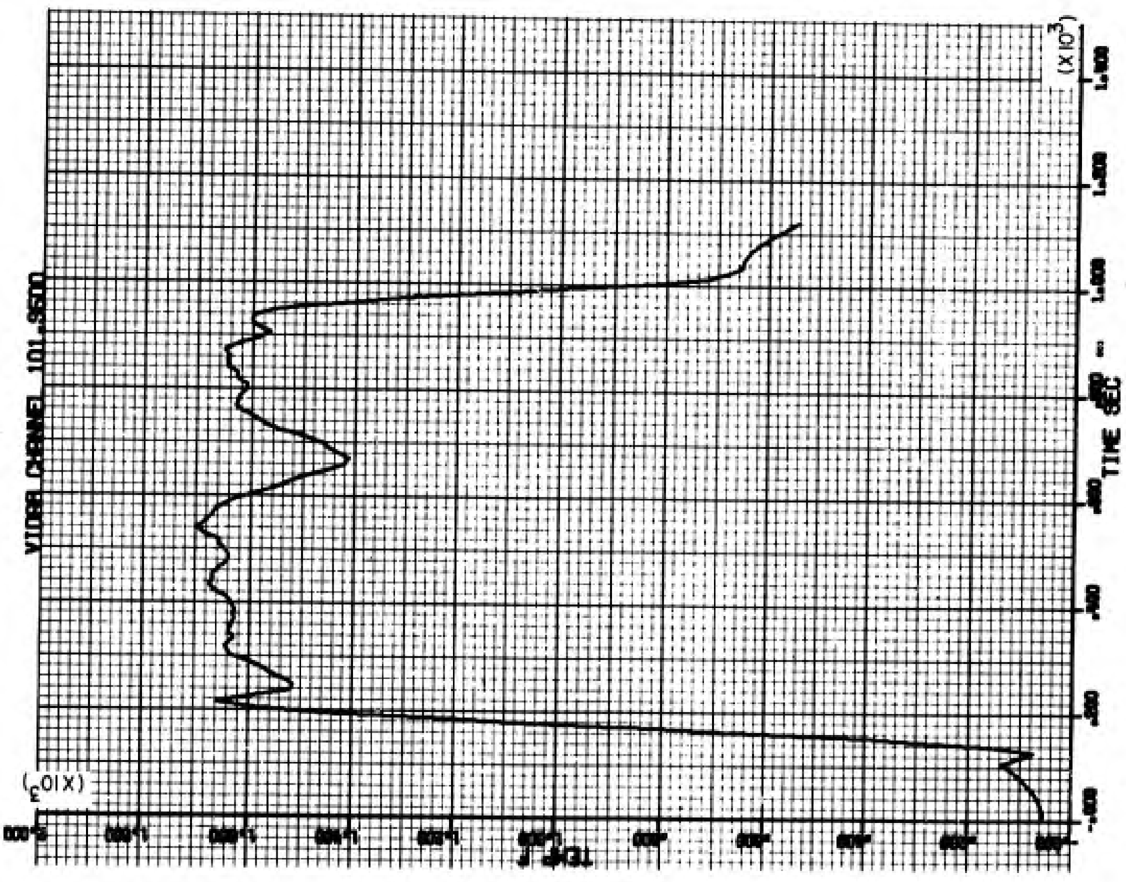

FIGURE 20 TIME TEMPERATURE PLOT OF THERMOCOUPLE (5) ON MK 379

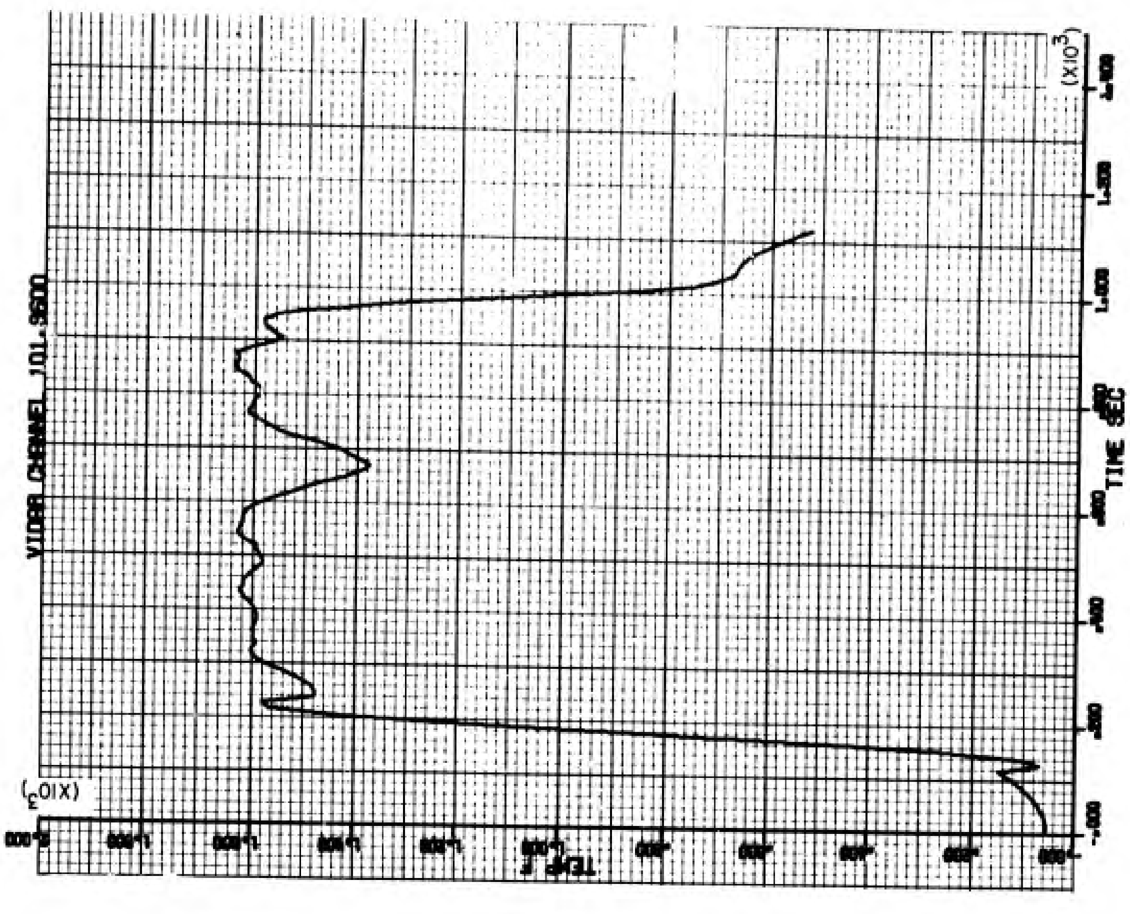

FIGURE 21 TIME TEMPERATURE PLOT OF THERMOCOUPLE (6) ON MK 379

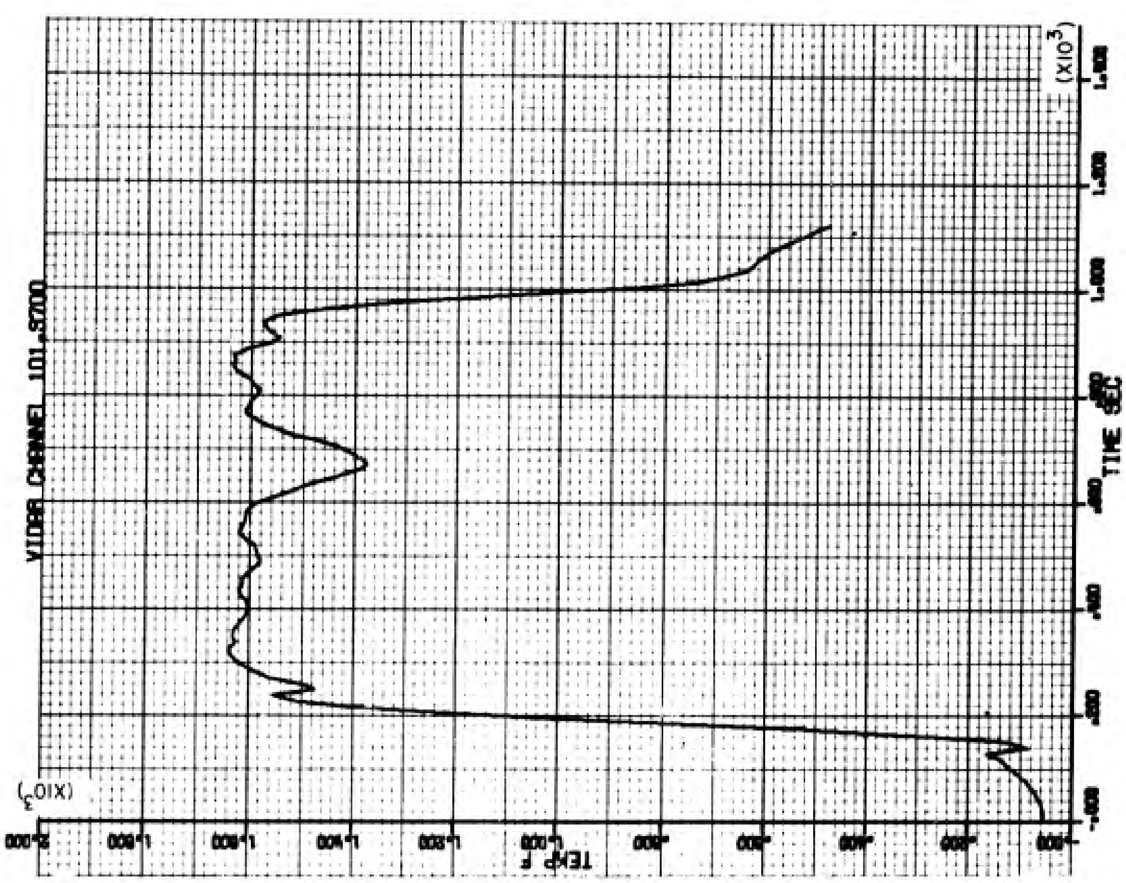

FIGURE 22 TIME TEMPERATURE PLOT OF THERMOCOUPLE (7) ON MK 379

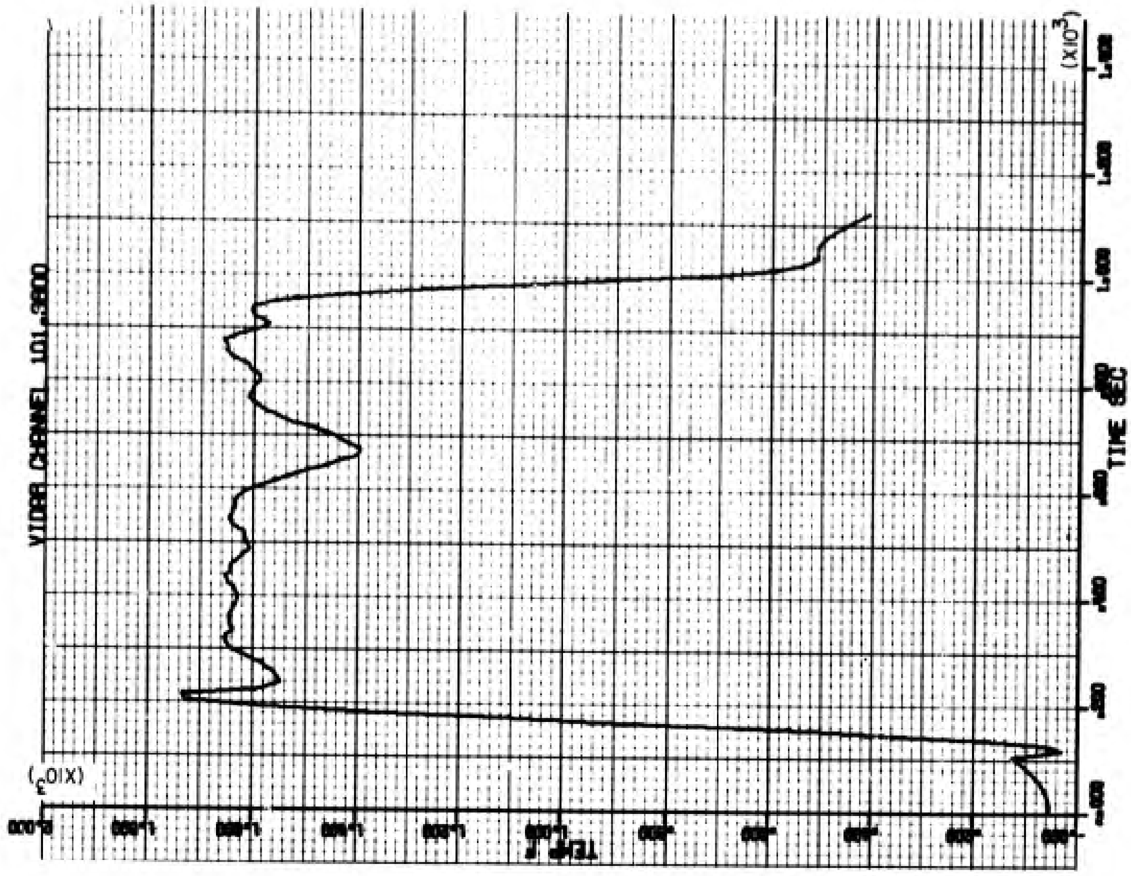

FIGURE 23 TIME TEMPERATURE PLOT OF THERMOCOUPLE (8) ON MK 379

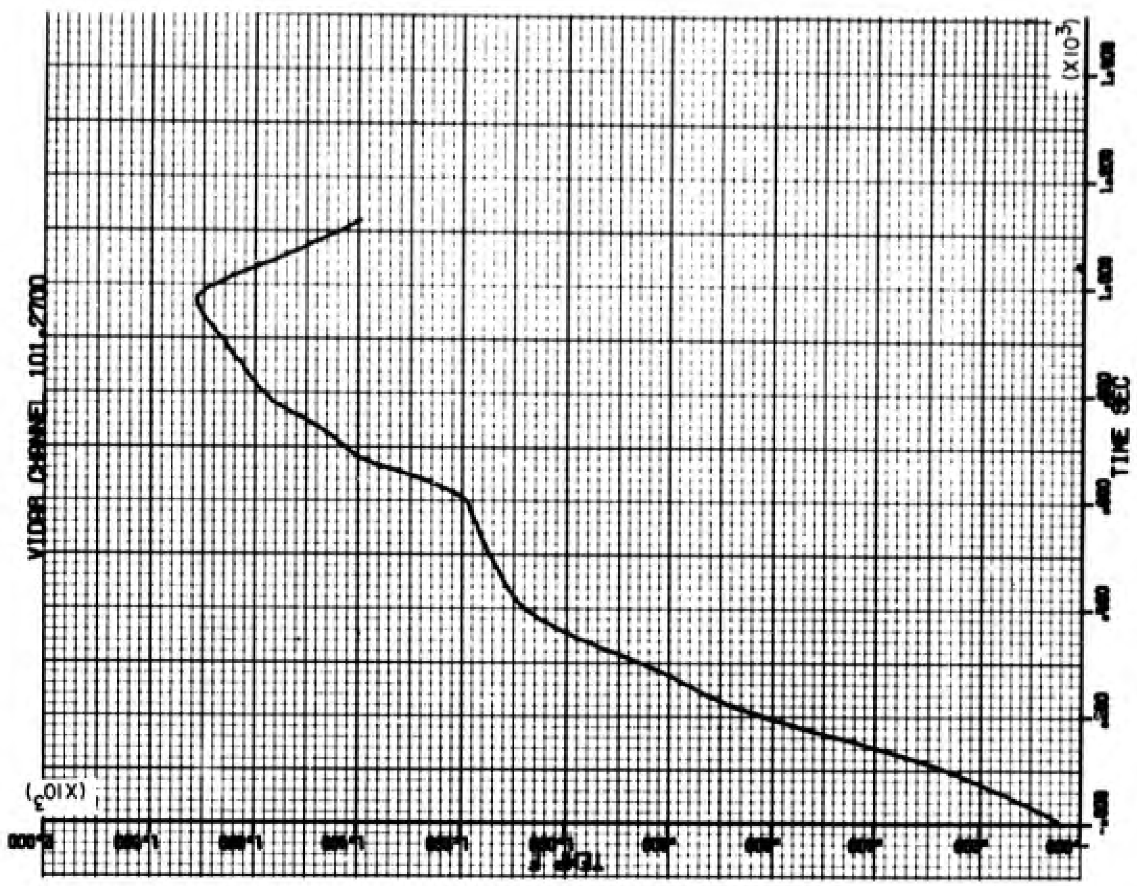

FIGURE 25 TIME TEMPERATURE PLOT OF THERMOCOUPLE (6) ON MK 384

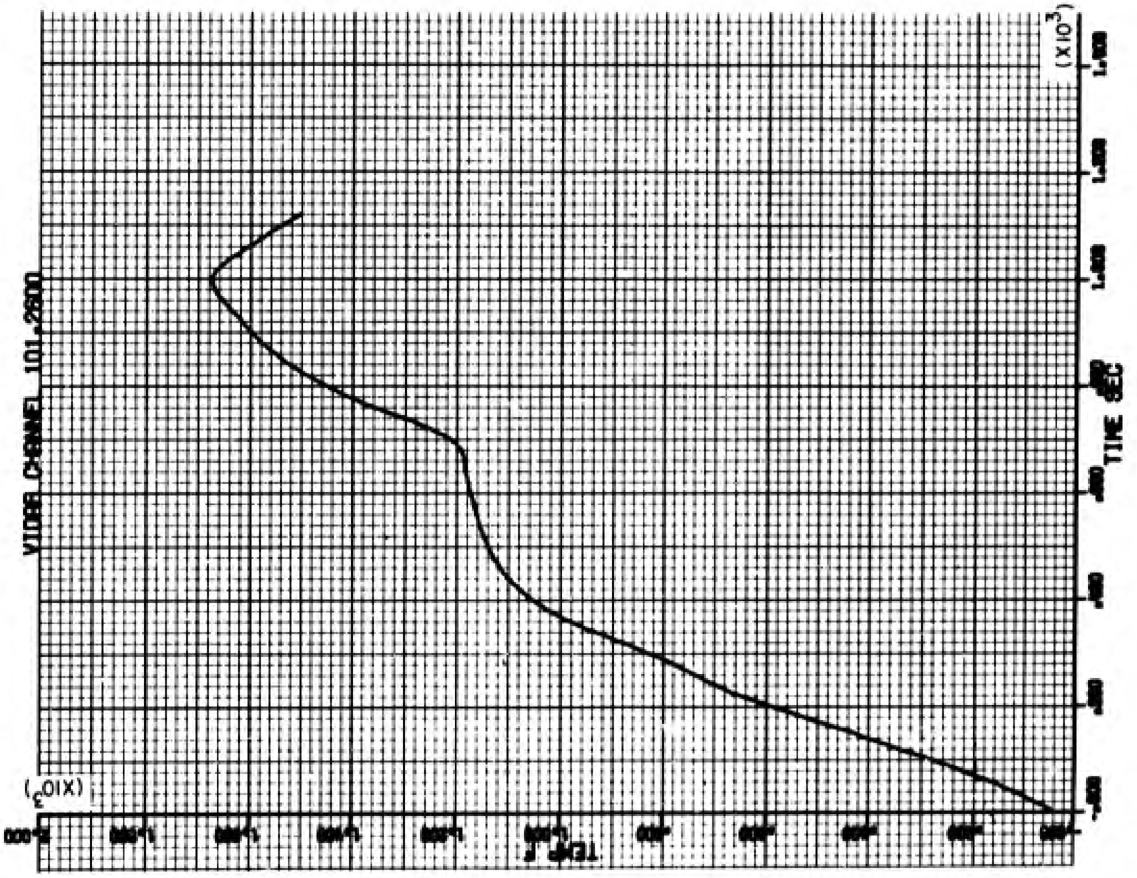

FIGURE 24 TIME TEMPERATURE PLOT OF THERMOCOUPLE (5) ON MK 384

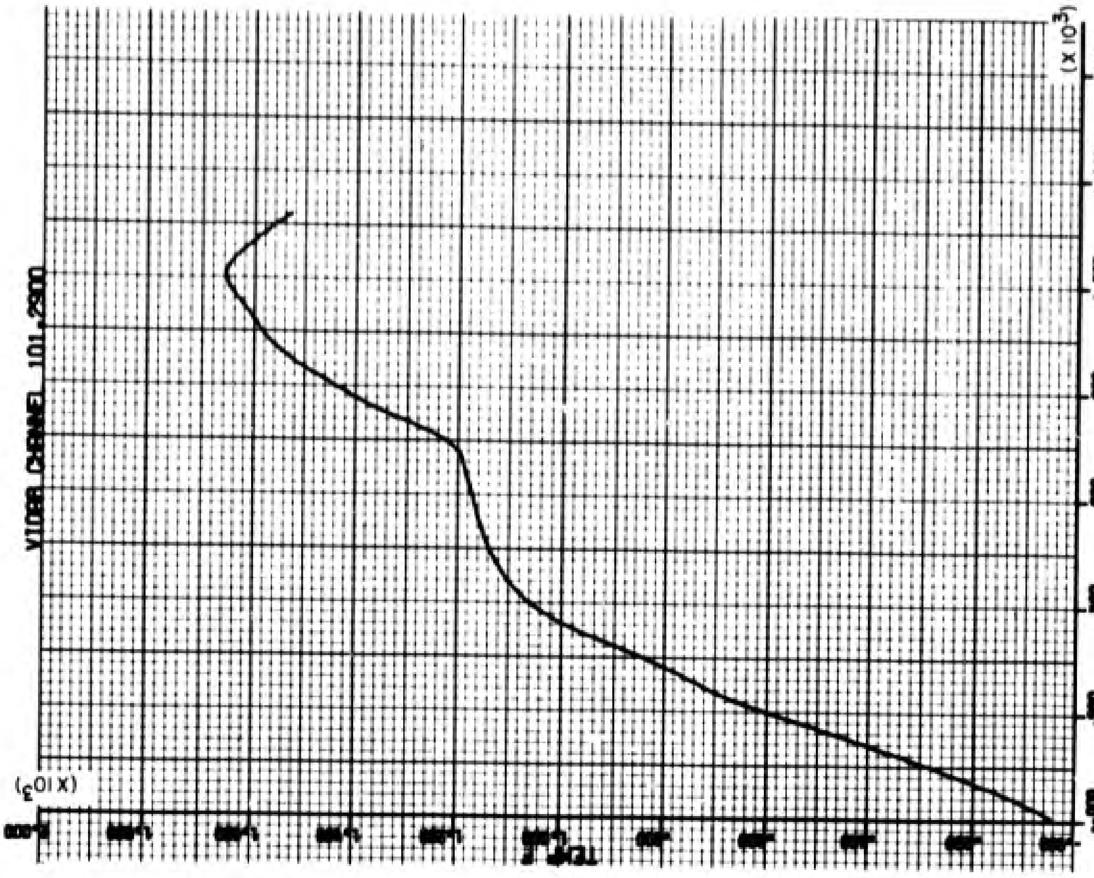

FIGURE 27 TIME TEMPERATURE PLOT OF THERMOCOUPLE (8) ON MK 384

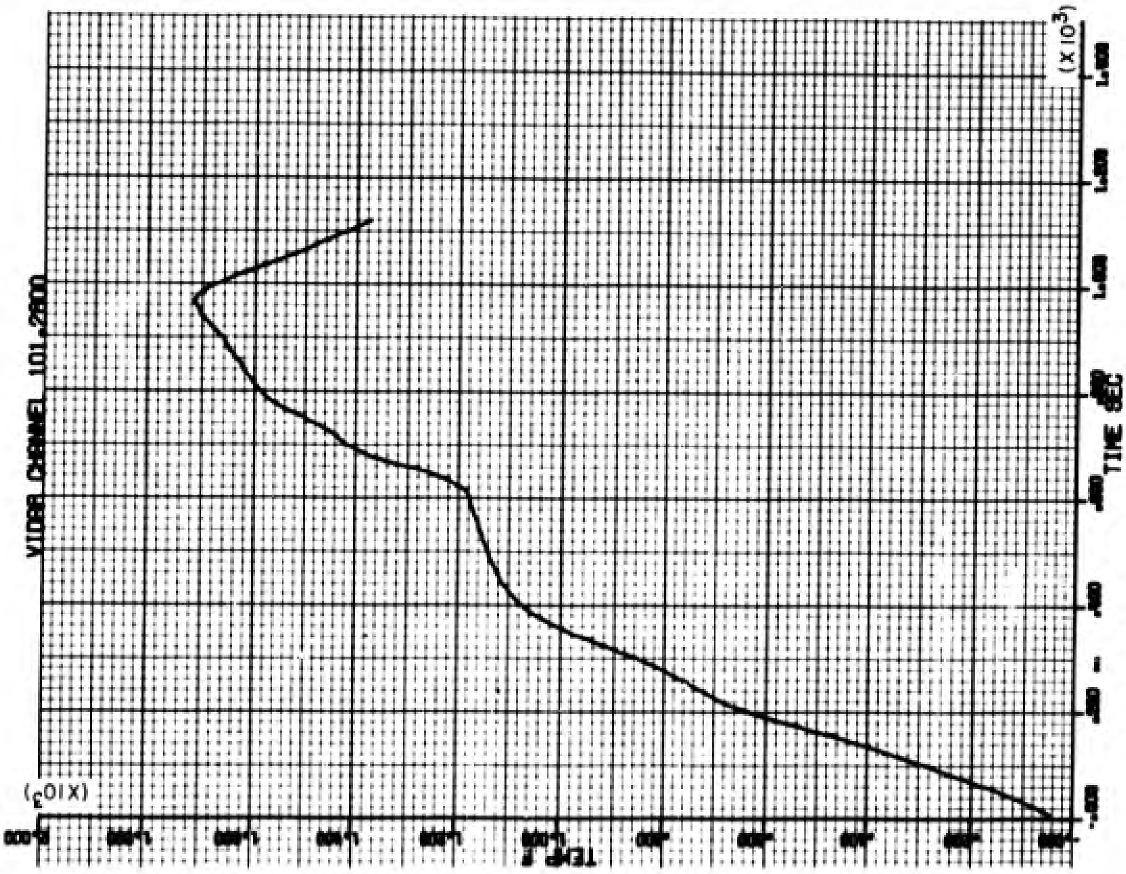

FIGURE 26 TIME TEMPERATURE PLOT OF THERMOCOUPLE (7) ON MK 384

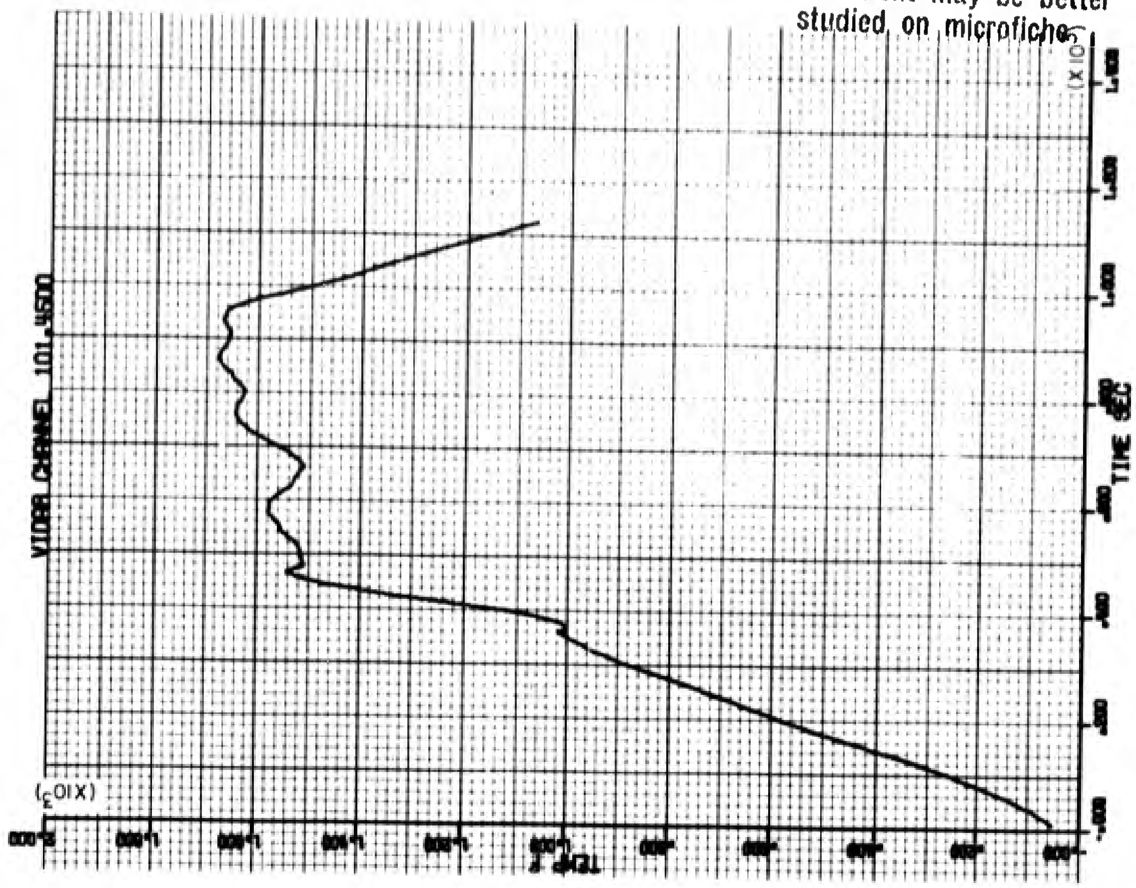

FIGURE 29 TIME TEMPERATURE PLOT OF THERMOCOUPLE (6) ON MK 384

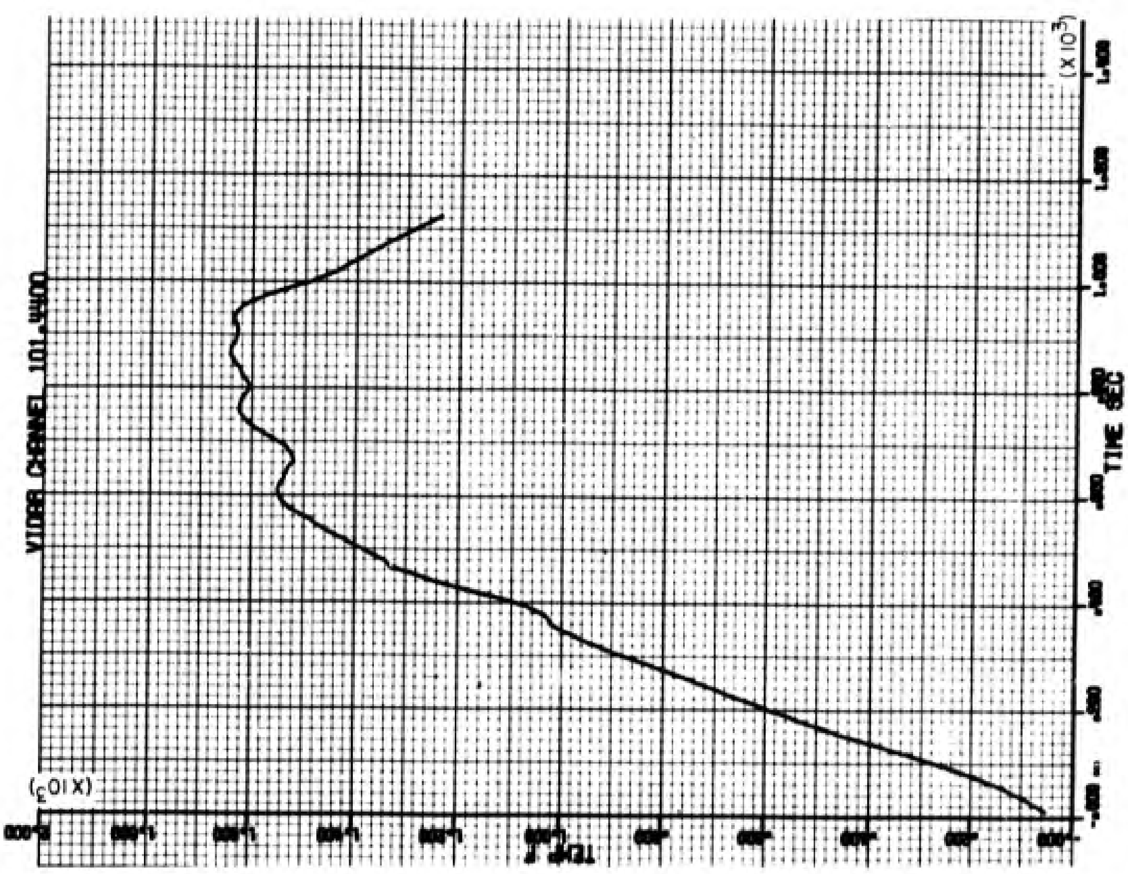

FIGURE 28 TIME TEMPERATURE PLOT OF THERMOCOUPLE (5) ON MK 384

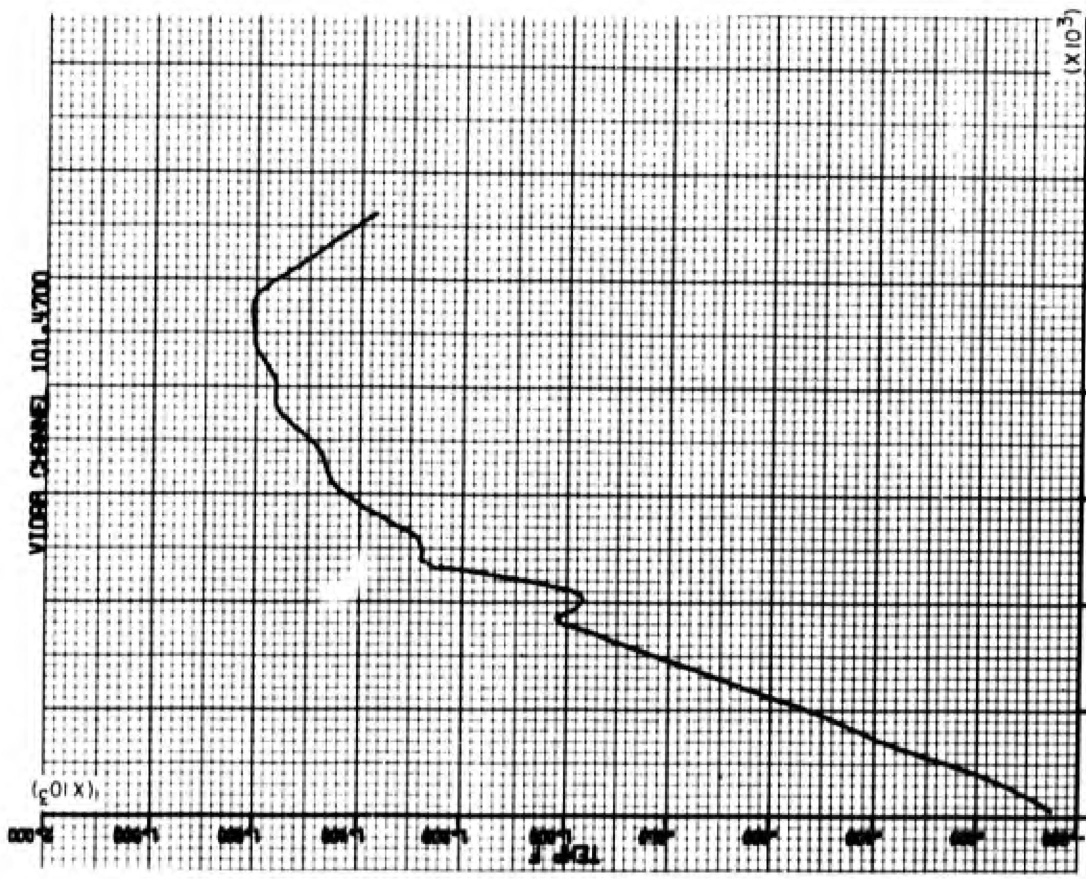

FIGURE 30 TIME TEMPERATURE PLOT OF THERMOCOUPLE (7) ON MK 384

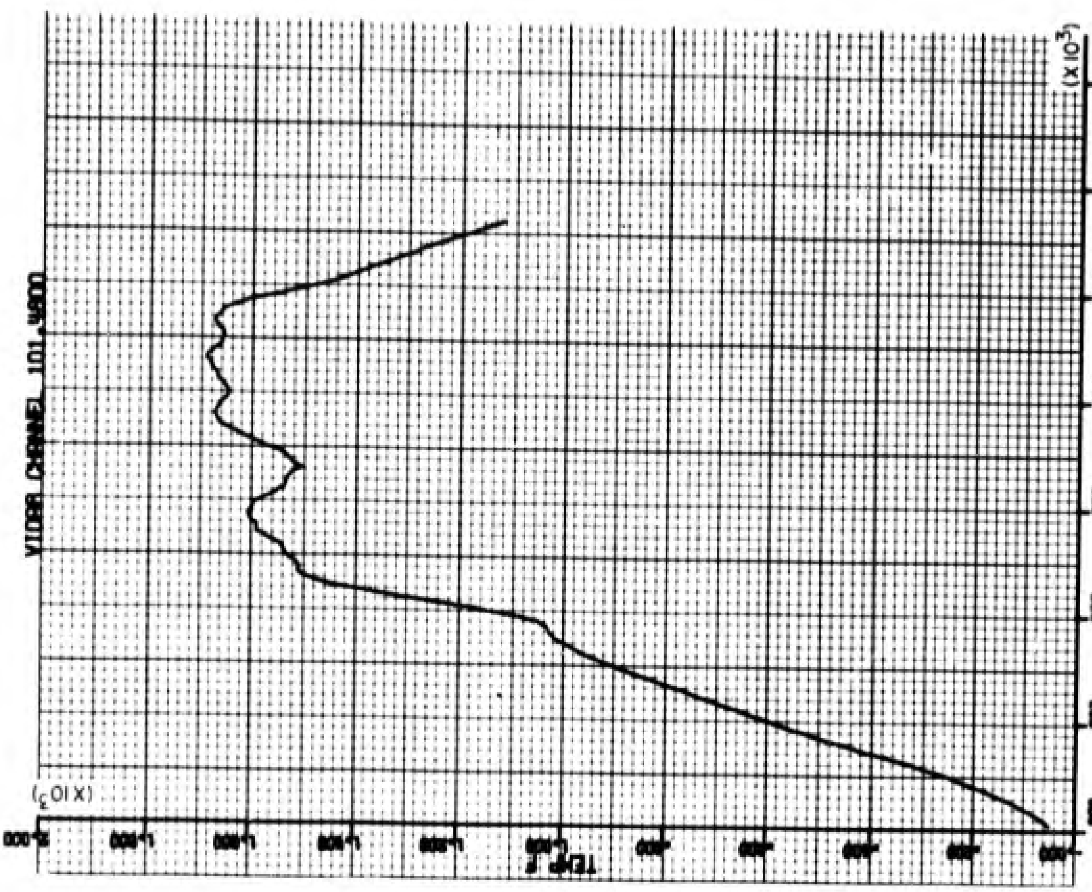

FIGURE 31 TIME TEMPERATURE PLOT OF THERMOCOUPLE (8) ON MK 384

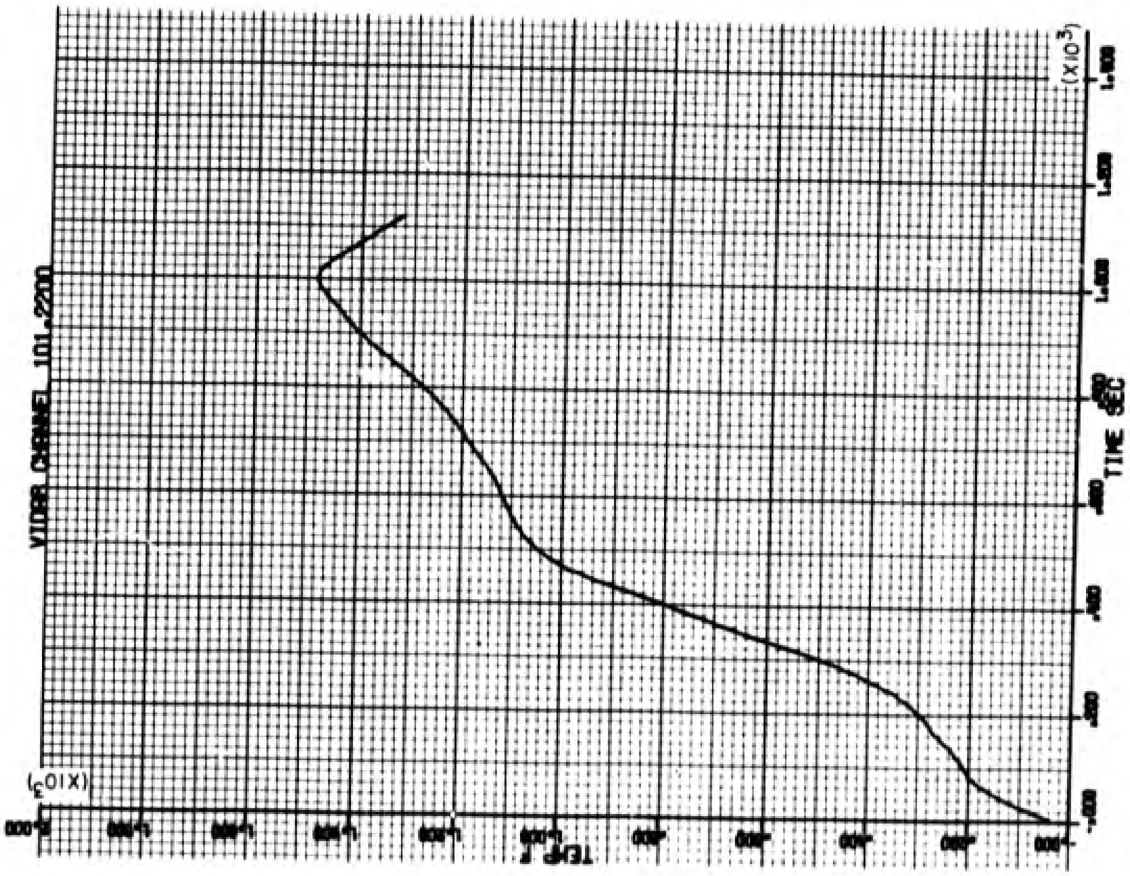

FIGURE 32 TIME TEMPERATURE PLOT OF THERMOCOUPLE (1) AT INTERFACE BETWEEN THE SAND AND STEEL

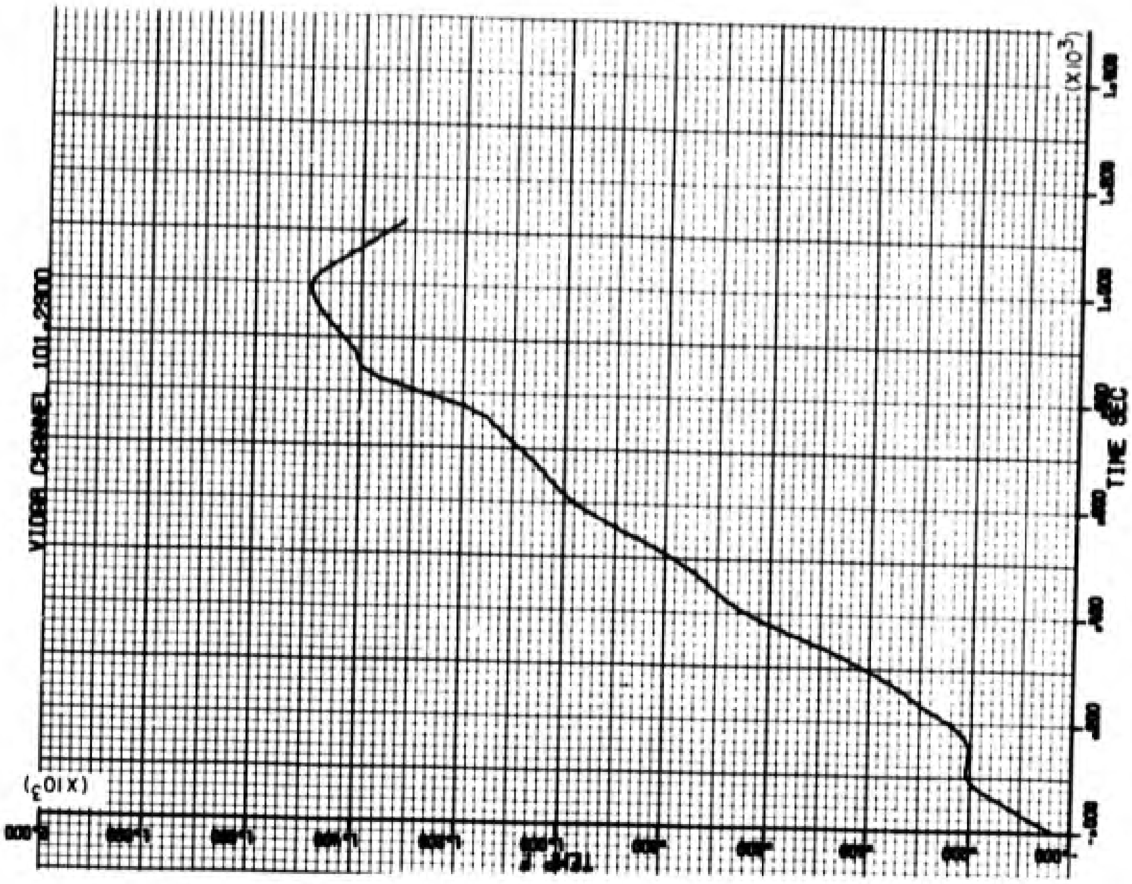

FIGURE 33 TIME TEMPERATURE PLOT OF THERMOCOUPLE (2) AT INTERFACE BETWEEN THE SAND AND STEEL

Details of illustrations in
this document may be better
studied on microfiche

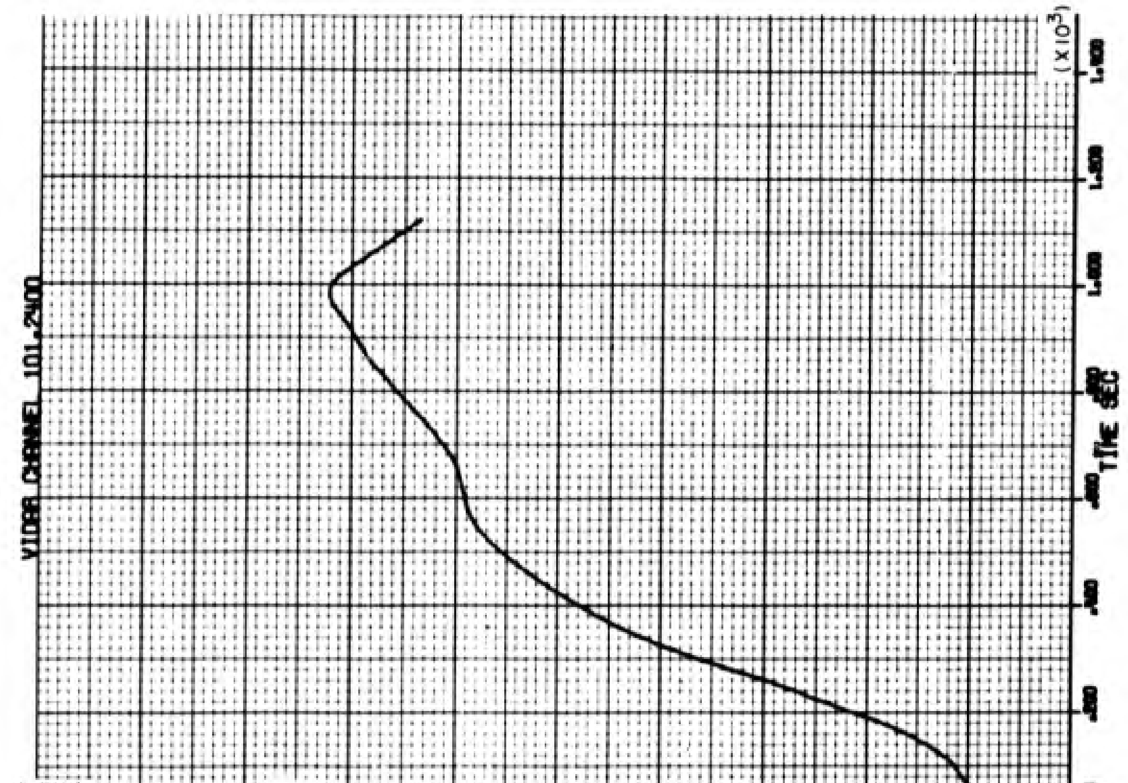

FIGURE 34 TIME TEMPERATURE PLOT OF THERMOCOUPLE (3) AT INTERFACE BETWEEN SAND AND STEEL

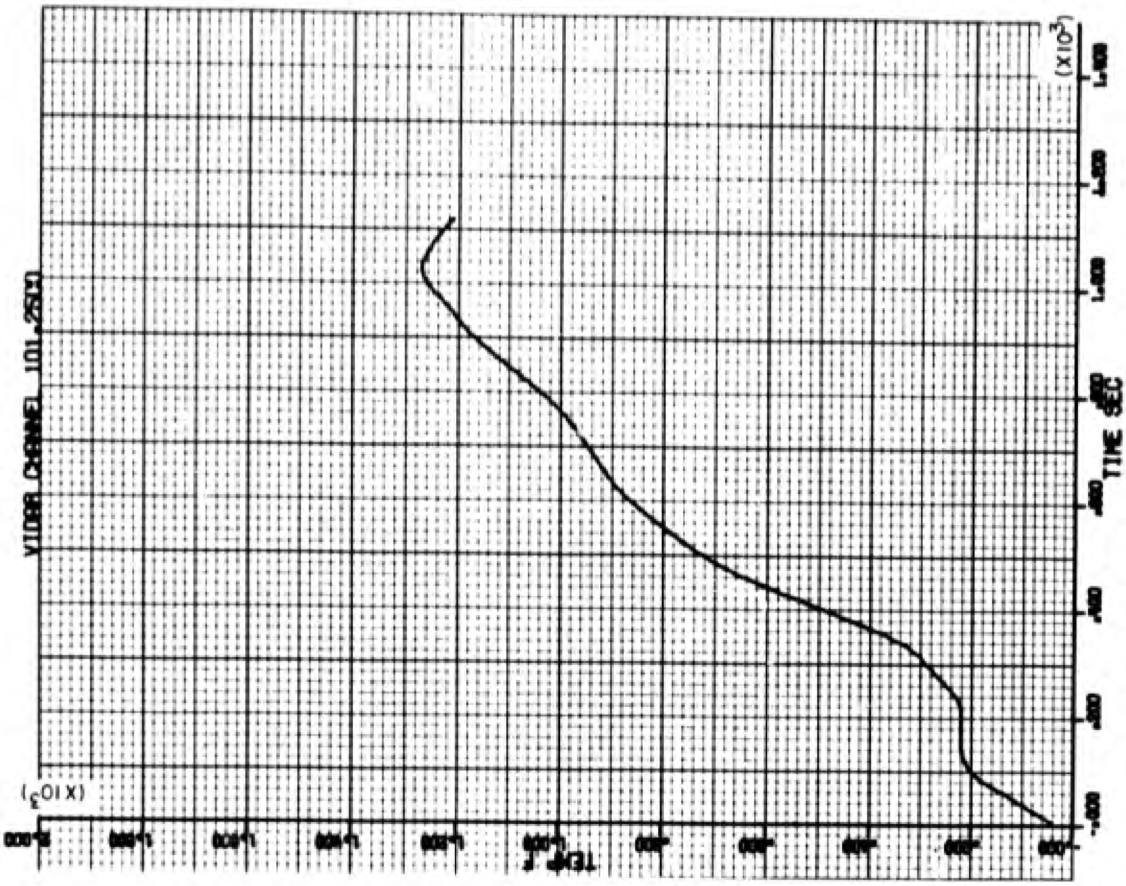

FIGURE 35 TIME TEMPERATURE PLOT OF THERMOCOUPLE (4) AT INTERFACE BETWEEN SAND AND STEEL

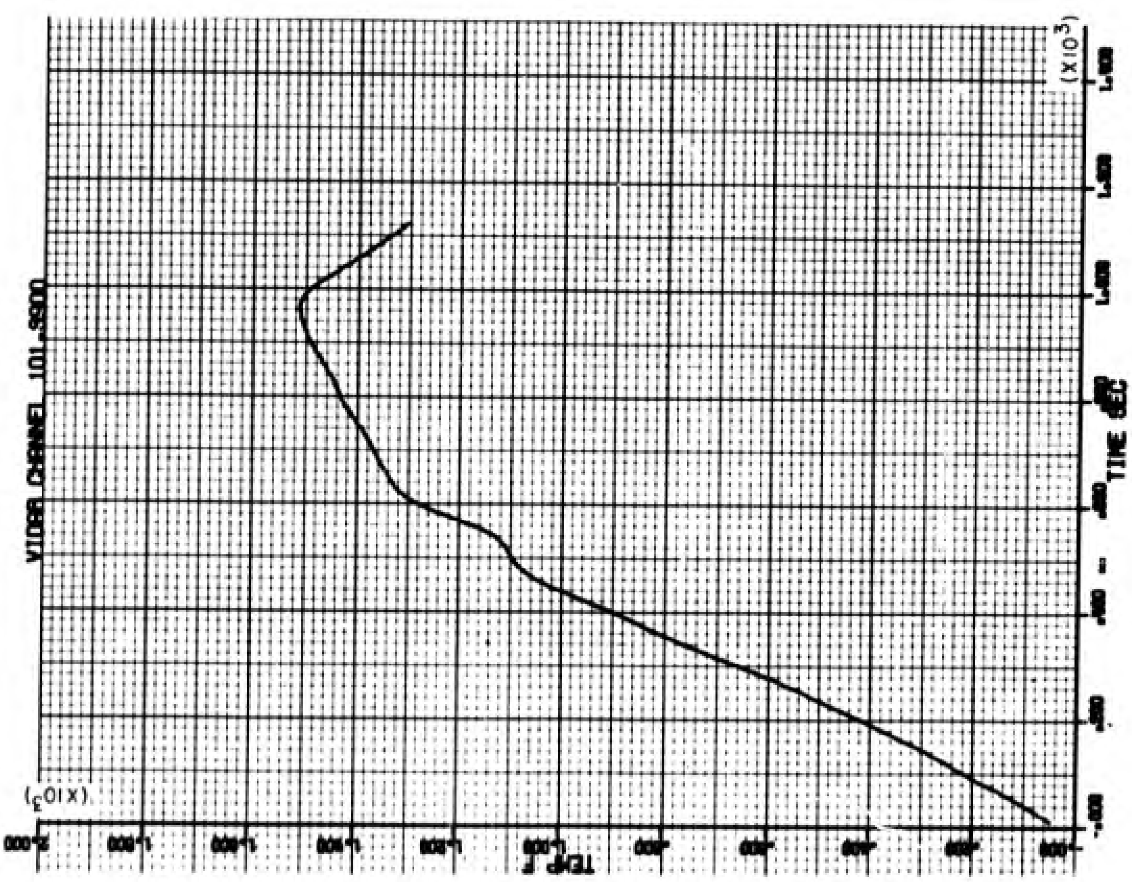

FIGURE 36 TIME TEMPERATURE PLOT OF THERMOCOUPLE (1) AT INTERFACE BETWEEN SAND AND STEEL

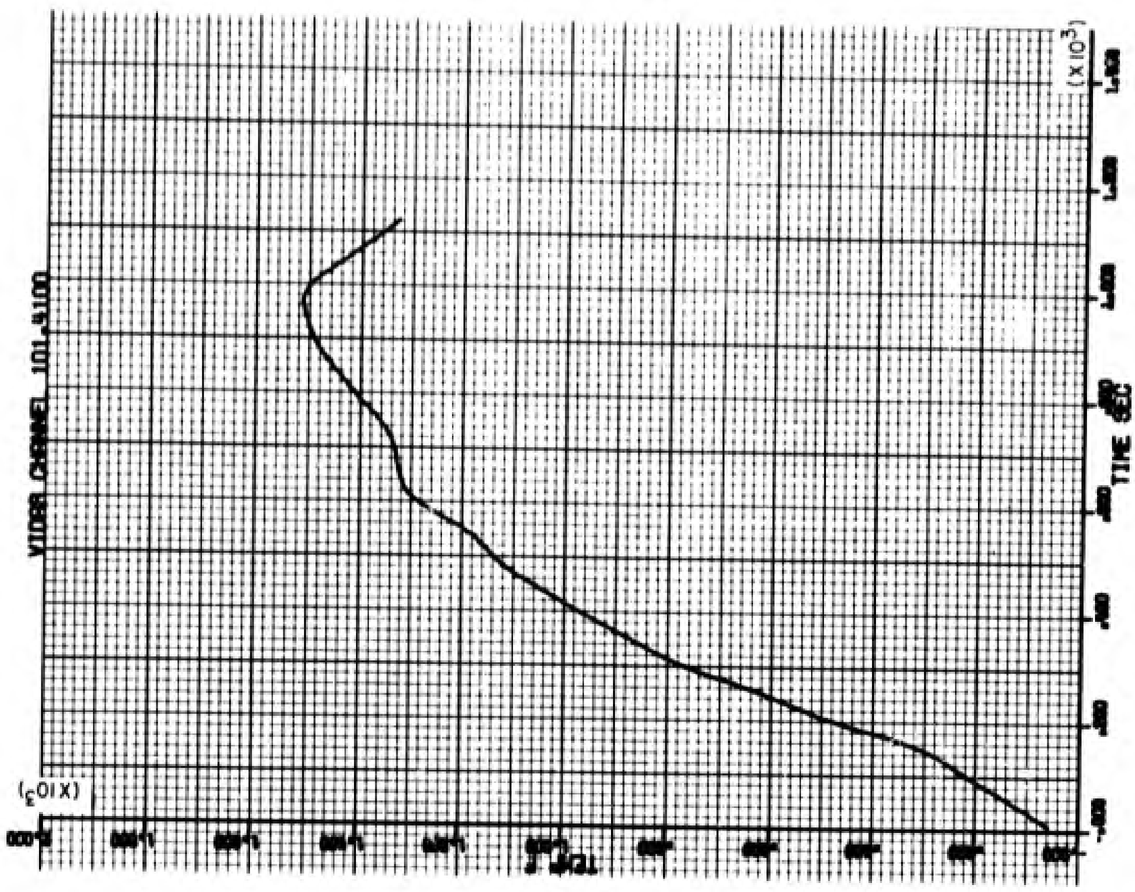

FIGURE 37 TIME TEMPERATURE PLOT OF THERMOCOUPLE (2) AT INTERFACE BETWEEN SAND AND STEEL

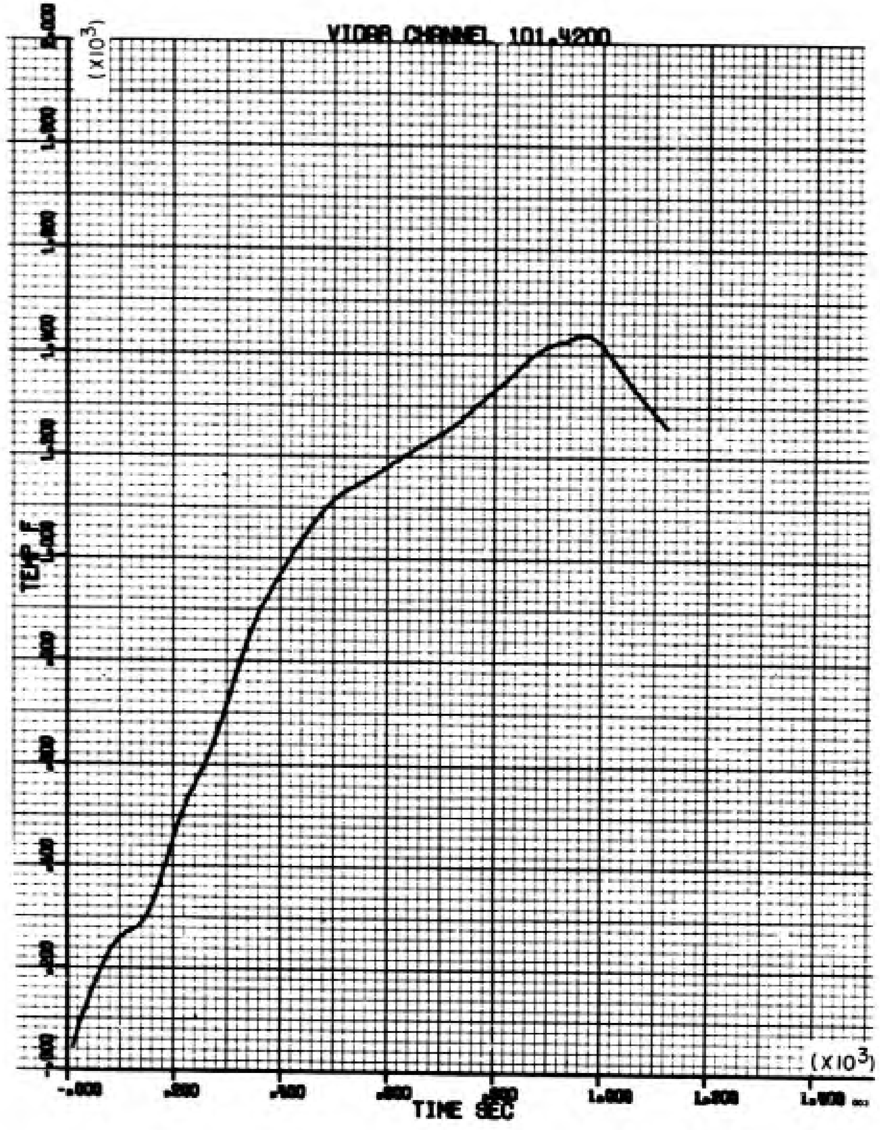

FIGURE 38 TIME TEMPERATURE PLOT OF THERMOCOUPLE (3) AT INTERFACE BETWEEN SAND AND STEEL

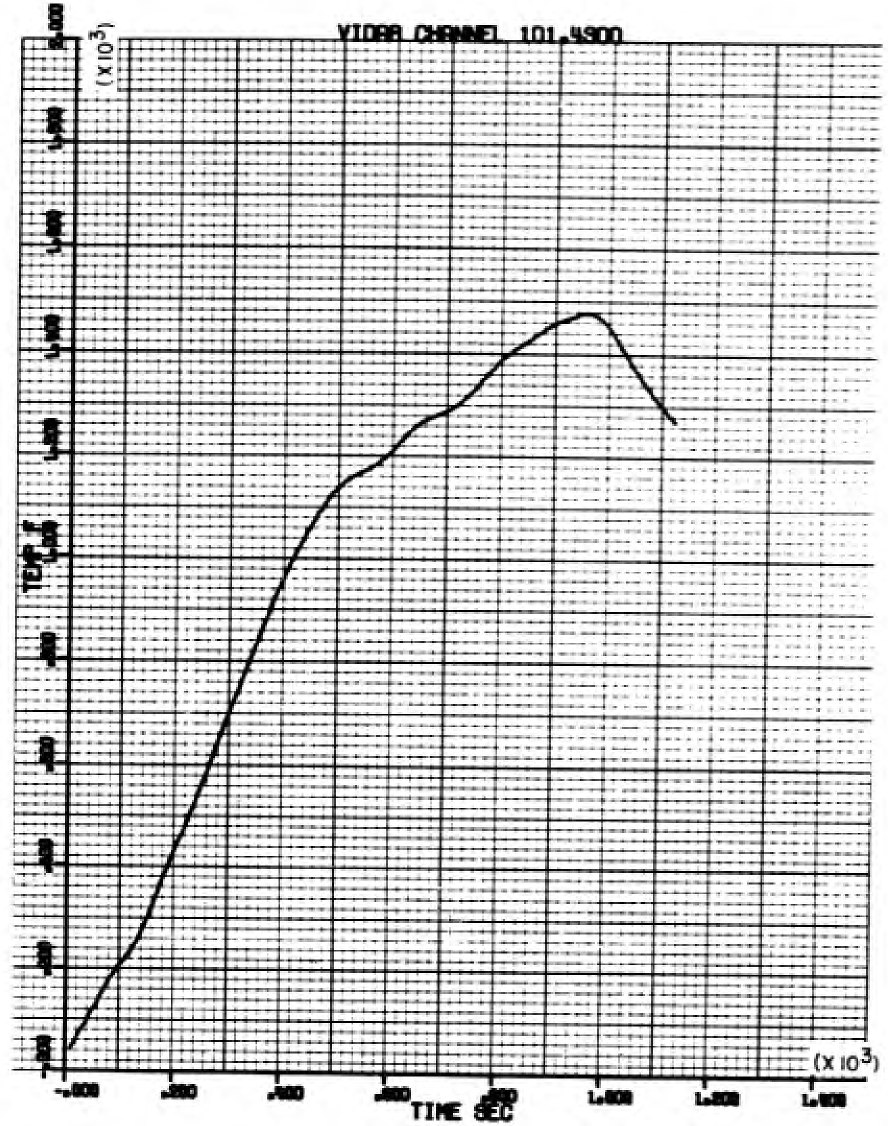

FIGURE 39 TIME TEMPERATURE PLOT OF THERMOCOUPLE (4) AT INTERFACE BETWEEN SAND AND STEEL

FIGURE 40 TEST SITE AFTER TEST

FIGURE 41 CLOSE-UP OF PROJECTILE AFTER TEST

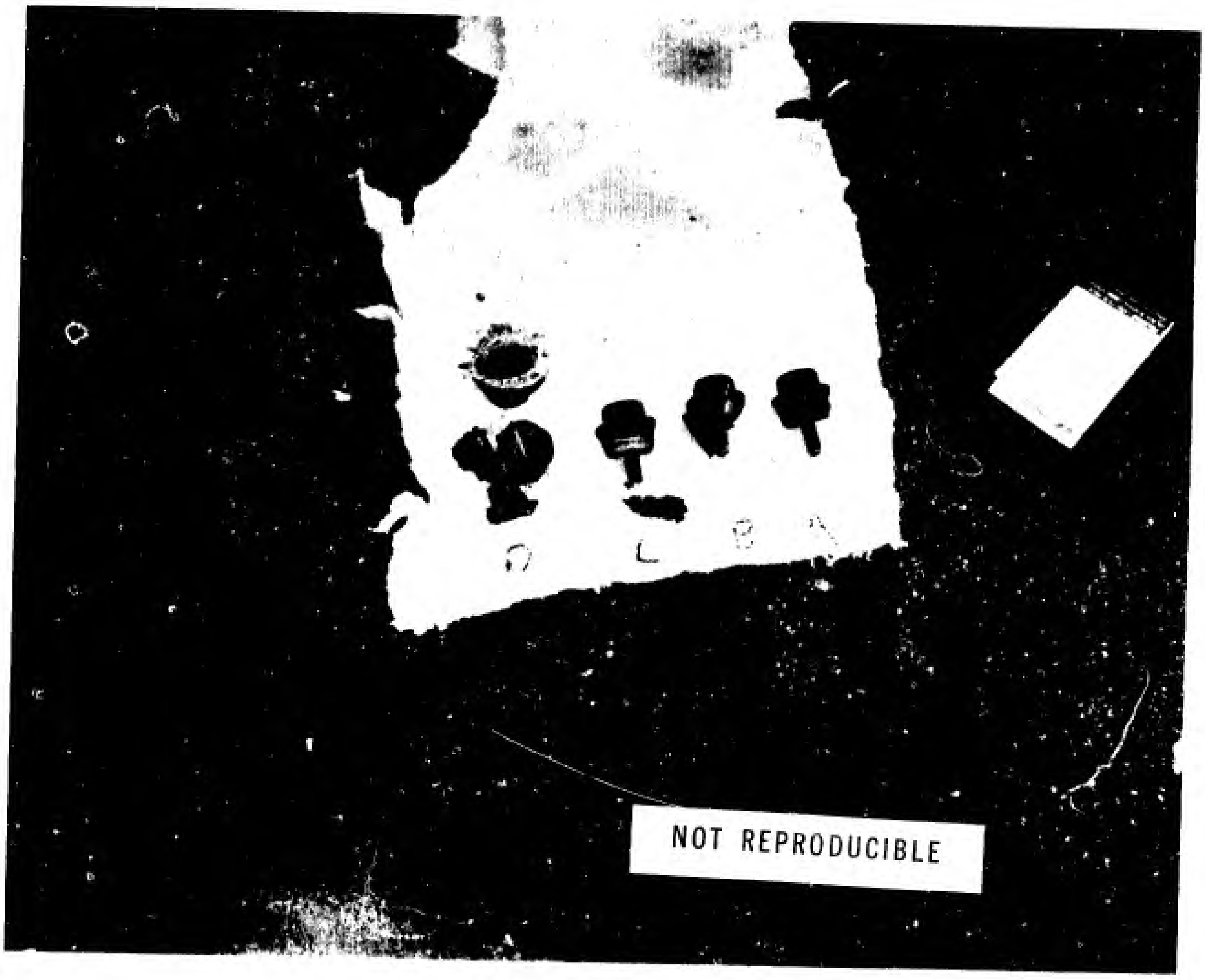

FIGURE 42 FUZE REMNANTS AFTER TEST