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AD NUMBER	
AD101615	
CLASSIFICATION CHANGES	
TO:	unclassified
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TO:	Approved for public release, distribution unlimited
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BOARD NUMBER 4 (7104 SU)
CONTINENTAL ARMY COMMAND
FORT BLISS, TEXAS

2 MAY 1956

/PAJ

ATBD-B GM 551

SUBJECT: LETTER REPORT OF TEST OF ACTIVE JAMMING AGAINST THE TYPE II
CORPORAL SYSTEM (FLIGHTS II U-13, II U-14)(C)

COMMANDING GENERAL
CONTINENTAL ARMY COMMAND
FORT MONROE, VIRGINIA
ATTN: ATDEV-4

FC

1. AUTHORITY.

A. TEST DIRECTIVE GM 551 (REFERENCE 2A BELOW) CONSTITUTES THE
AUTHORITY UNDER WHICH THIS TEST WAS CONDUCTED.

B. THE OVER-ALL PURPOSE OF THE USER TEST OF THE CORPORAL MISSILE
SYSTEM IS TO DETERMINE THE SUITABILITY OF THE SYSTEM FOR USE BY THE ARMY.
THE SPECIFIC PURPOSE OF THIS TEST WAS TO DETERMINE WHETHER OR NOT THE
CORPORAL MISSILE SYSTEM COULD BE EFFECTIVELY JAMMED DURING FLIGHT.

2. REFERENCES.

A. LETTER, ATDEV-9 471.94/150 (C)(20 SEP 51), OCAFF, 20 SEP
1951, SUBJECT: "ARMY FIELD FORCES USER TEST OF THE CORPORAL SURFACE-TO-
SURFACE MISSILE SYSTEM."

B. CONARC ENGINEER-USER CORPORAL MISSILE ECM TESTS, TEST PLAN
No EDL-T1, 15 JUNE 1955.

C. LETTER, ATBD-B 471.94/5, THIS BOARD, 21 DECEMBER 1955, SUBJECT:
"PRELIMINARY EVALUATION OF ACTIVE JAMMING AGAINST THE CORPORAL SYSTEM
(FLIGHTS II U-13, II U-14)(S)."

SPECIAL HANDLING REQUIRED
NOT RELEASABLE TO FOREIGN NATIONALS

CY NR 21 OF 80 CYS

EXCEPT *None*
BY AUTHORITY OF *Qua Bds, CONARC*
DATE 2 MAY 1956

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ATBD-B GM 551

SUBJECT: LETTER REPORT OF TEST OF ACTIVE JAMMING AGAINST THE TYPE II CORPORAL SYSTEM (FLIGHTS II U-13, II U-14)(C)

3. DESCRIPTION OF MATERIEL.

A. THE TYPE II CORPORAL MISSILE SYSTEM WAS USED DURING THESE TESTS. A DETAILED DESCRIPTION OF THE OPERATION OF THE MOST AFFECTED PORTIONS OF THE SYSTEM IS ATTACHED AS PART OF INCLOSURE NR 1.

B. ELECTRONIC DEFENSE LABORATORY (EDL) ELECTRONIC COUNTERMEASURES SYSTEM. THIS EQUIPMENT WAS DESIGNED AND FABRICATED BY EDL, AND WAS FIELD TESTED DURING THESE TESTS TO DETERMINE IF THE ECM BASIC PHILOSOPHY WAS SOUND. A DETAILED DESCRIPTION OF THIS EQUIPMENT IS ATTACHED AS PART OF INCLOSURE NR 1.

4. BACKGROUND. A DECISION WAS MADE THAT AN ABBREVIATED ECM TEST WOULD BE PERFORMED DURING THE FIRING PHASE OF THE CORPORAL USER TESTS. THE ELECTRONIC DEFENSE LABORATORY (EDL), MOUNTAIN VIEW, CALIFORNIA WAS SELECTED BY THE OFFICE OF THE CHIEF SIGNAL OFFICER, DEPARTMENT OF THE ARMY TO SUPPORT BOARD NR 4, CONARC IN THESE ECM TESTS. TO OBTAIN MORE VALID TEST RESULTS, IT WAS DECIDED TO ACTIVELY JAM THE MISSILE SYSTEM DURING A NORMAL FLIGHT RATHER THAN ATTEMPT TO JAM MISSILE COMPONENTS INSTALLED IN AN AIRCRAFT. EDL WAS TO PREPARE A LABORATORY MODEL OF INTERCEPT AND JAMMING EQUIPMENT BASED ON THE PHILOSOPHY DESCRIBED IN PARAGRAPH 3, INCLOSURE NR 1. TWO USER TYPE II CORPORAL MISSILES WERE TO BE JAMMED DURING FLIGHT TESTS.

5. SUMMARY OF TESTS.

A. CERTAIN ECM TERMS USED SUBSEQUENTLY IN THIS REPORT ARE DEFINED BELOW.

(1) SUCCESSFUL:

(A) SIGNIFICANT INCREASE IN ERROR OF MISSILE CAUSED BY CONFUSION OF GROUND STATION AND SPOOFING OF MISSILE.

(B) DENIAL OF ARMING COMMAND.

(2) ACTIVE ELECTRONIC COUNTERMEASURES--(ELECTRONIC JAMMING)-- THE DELIBERATE RADIATION, RERADIATION, OR REFLECTION OF ELECTROMAGNETIC SIGNALS WITH THE OBJECT OF IMPAIRING THE USE OF ELECTRONIC DEVICES BY THE ENEMY.

(3) PASSIVE ELECTRONIC COUNTERMEASURES--SEARCH FOR ELECTROMAGNETIC RADIATIONS TO DETERMINE EXISTENCE, SOURCE AND PERTINENT CHARACTERISTICS, INCLUDING THE COLLECTION AND TECHNICAL ANALYSIS OF RESULTANT ELECTRONIC INTERCEPT INFORMATION.

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ATBD-B GM 551

SUBJECT: LETTER REPORT OF TEST OF ACTIVE JAMMING AGAINST THE TYPE II CORPORAL SYSTEM (FLIGHTS II U-13, II U-14)(C)

B. THE INTERCEPT AND JAMMING OF CORPORAL User FLIGHT II U-13 (MISSILE NR 1627) WAS PERFORMED UNDER CONTROLLED CONDITIONS. THE CORPORAL GROUND STATION WAS EMPLACED IN THE ORO GRANDE CORPORAL FIRING AREA, WHITE SANDS PROVING GROUND, NEW MEXICO. STANDARD OPERATING PROCEDURES WERE FOLLOWED DURING CHECKOUT AND FIRING. THE MISSILE WAS FIRED AT 1130 HOURS, 8 DECEMBER 1955. THE INTERCEPT AND JAMMING EQUIPMENT, OPERATED BY EDL, WAS EMPLACED IN THE VICINITY OF HOLLOMAN AIR DEVELOPMENT CENTER (HADC) APPROXIMATELY 45 KILOMETERS (28 MILES) NNE OF THE LAUNCHING AREA. EDL INTERCEPTED THE MISSILE RADIATION AND THEN JAMMED THE RADAR GUIDANCE LINK. THE ACTION TAKEN WAS TO OVERRIDE THE LEGITIMATE COMMANDS IN AZIMUTH, GIVING THE MISSILE PREDOMINANTLY HARD GO LEFT COMMANDS, AND TO CAUSE ERRORS IN THE MISSILE POSITION MEASUREMENTS MADE BY THE CORPORAL GROUND GUIDANCE STATION. NO ACTION WAS TAKEN AGAINST THE MISSILE DOPPLER LINK. EDL WAS SUCCESSFUL IN THEIR ATTEMPT TO INTERCEPT AND JAM THE CORPORAL SYSTEM IN THIS FLIGHT.

C. THE INTERCEPT AND JAMMING OF CORPORAL User FLIGHT II U-14 (MISSILE NUMBER 1668) WAS ESSENTIALLY THE SAME AS FOR FLIGHT II U-13. THE MAJOR DIFFERENCE BETWEEN THE TWO FLIGHTS WAS THE INFORMATION EDL WAS ALLOWED TO KNOW PRIOR TO LAUNCHING OPERATIONS. INFORMATION FURNISHED EDL IS LISTED IN INCLOSURE NR 3. AN INFLIGHT MALFUNCTION OCCURRING IN THE CORPORAL MISSILE PREVENTED BOTH JAMMING AND COMMAND SIGNALS FROM AFFECTING THE MISSILE FLIGHT. DUE TO A MALFUNCTION OF THE JAMMER AUTOMATIC FREQUENCY CHANGING SERVO, EDL HAS CONSIDERABLE DIFFICULTY MAINTAINING "FREQUENCY LOCK." AGAIN, NO ACTION WAS TAKEN BY EDL TO INTERRUPT THE MISSILE-DOPPLER LINK. EDL WAS SUCCESSFUL IN THEIR ATTEMPT TO INTERCEPT AND JAM FLIGHT II U-14, BUT TO A LESSER DEGREE THAN WITH II U-13.

6. CONCLUSIONS.

A. THE CORPORAL TYPE II MISSILE SYSTEM IS VULNERABLE TO BOTH ACTIVE AND PASSIVE ELECTRONIC COUNTERMEASURES.

B. THE BASIC PHILOSOPHY OF EDL'S ECM SYSTEM IS SOUND.

C. THE APPLICATION OF CERTAIN PROCEDURAL CHANGES WILL ELIMINATE SOME OF THE EFFECTS OF ECM.

7. RECOMMENDATIONS. IT IS RECOMMENDED THAT:

A. TECHNIQUES BE DEVELOPED SUCH THAT THE FOLLOWING MAY BE ACCOMPLISHED:

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ATBD-B GM 551.

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- (1) ELIMINATION OF PRE-LAUNCH RADIATION.
- (2) TURN-ON OF RADAR HIGH VOLTAGE NOT EARLIER THAN $T + 10$ SECONDS.
- (3) CALIBRATION OF RADAR-LAUNCHER RANGE BE PERFORMED WITHOUT RADIATION.

B. CONTINUED EMPHASIS BE PLACED ON ECM, AND THAT TRAINING BE CONDUCTED IN SUCH A MANNER THAT THE EXISTING SECURITY DEVICES (CURRENTLY AVAILABLE IN THE MISSILE SYSTEM) LISTED BELOW ARE UTILIZED TO THE MAXIMUM EXTENT:

- (1) AZIMUTH COMMAND TERMINATION COUNTERS SET TO THE MINIMUM VALUE.
- (2) ALL RADIATION BE TERMINATED 10 SECONDS AFTER THE MISSILE RADIO BEACON IS DE-ENERGIZED AFTER RANGE CORRECTION TIME.
- (3) EXTREME CARE BE TAKEN IN ADJUSTING FREQUENCIES WITHIN THE SYSTEM IN ORDER THAT PEAK SIGNAL STRENGTH MAY BE RECEIVED.
- (4) VARY THE RADAR PRF (WITHIN THE CAPABILITY OF THE SYSTEM) BETWEEN MISSILE FIRINGS.
- (5) EXTREME CARE BE TAKEN WHEN ADJUSTING COINCIDENCE USING THE STANDARD DECODERS.

C. CONSIDERATION BE GIVEN TO MODIFICATION OF THE EXISTING CORPORAL TYPE II SYSTEM SO THAT:

- (1) "COMMANDS IN" ACTUATOR B-1 CAN BE RESET DURING ANY PORTION OF THE FLIGHT.
- (2) THE MISSILE TRANSPONDER SET AGC CHARACTERISTICS ARE IMPROVED SUCH THAT THE MINIMUM LEGITIMATE SIGNAL MAY BE ACTED UPON AND WEAKER JAMMING SIGNALS ELIMINATED.
- (3) THE SUSCEPTIBILITY TO WIDE PULSE JAMMING IS MINIMIZED.
- (4) HIGHER RADAR PRFs MAY BE UTILIZED (APPROXIMATELY 2000 PULSE GROUPS PER SECOND).

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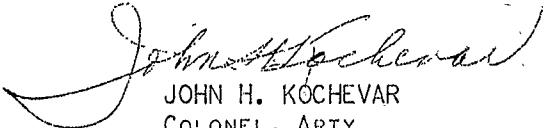
D. THE DEVELOPMENT AGENCY CONDUCT A STUDY OF THE SUSCEPTIBILITY OF FUTURE CORPORAL MISSILE SYSTEMS TO ECM.

E. FUTURE MEDIUM AND LONG RANGE SURFACE-TO-SURFACE GUIDED MISSILE SYSTEMS BEING DEVELOPED USE A NON-RADIATING TYPE OF GUIDANCE SYSTEM.

F. THE PRESENT EDL DETECTION AND JAMMING SYSTEM BE MODIFIED, AS NECESSARY, AND A NEW PROTOTYPE SYSTEM BE CONSTRUCTED AND TESTED AGAINST COMMAND-TYPE SURFACE-TO-SURFACE MISSILE SYSTEMS.

✓ 5 INCLS

1. DESCRIPTION OF MATERIEL
2. PHOTOS OF EDL EQUIPMENT
3. DETAILS OF TEST
4. CHARTS OF REDUCED RECORDED DATA
5. PHOTOS OF RADAR RANGE SCOPE


JOHN H. KOHEVAR
COLONEL, ARTY
PRESIDENT

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BOARD NUMBER 4 (7104 SU)
CONTINENTAL ARMY COMMAND
FORT BLISS, TEXAS

/PAJ

DESCRIPTION OF MATERIEL

1. CORPORAL GROUND GUIDANCE STATION. THE GUIDANCE EQUIPMENT COMPRISES THOSE COMPONENTS USED IN THE CORPORAL SYSTEM FOR ELECTRONIC CONTROL OF THE MISSILE FROM THE TIME THE GROUND COMMANDS BEGIN TO OVERRIDE THE FLIGHT PROGRAMMER UNTIL FINAL RANGE CORRECTION. THE GROUND GUIDANCE EQUIPMENT NORMALLY CONSISTS OF THE RADAR SET AN/MPQ-25, THE RADIO SET (DOPPLER) AN/MRQ-7, AND THE COMPUTER GROUP AN/MSA-6.

A. RADAR SET AN/MPQ-25. RADAR SET AN/MPQ-25 INCLUDES RADAR SET GROUP OA-652/MPQ-25, OPTICAL TRACKER XM 3, AND ANTENNA GROUP AN-651/MPQ-25.

(1) THE RADAR SET IS INCLUDED IN THE CORPORAL MISSILE GUIDANCE SYSTEM TO MEASURE MISSILE POSITION CONTINUOUSLY AND TO TRANSMIT THE COMMANDS NECESSARY TO KEEP THE MISSILE ON THE PROPER HEADING TO THE TARGET. INFORMATION AS TO MISSILE RANGE, ELEVATION, AND AZIMUTH DEVIATION FROM THE CORRECT TRAJECTORY IS FED TO THE COMPUTER STATION WHERE THE COMMAND OUTPUT IS FORMULATED.

(2) CONICAL SCANNING PROVIDES A METHOD OF CAUSING THE ANTENNA TO FOLLOW THE TARGET AUTOMATICALLY. IN CONICAL SCANNING THE RF BEAM ROTATES ABOUT THE ELECTRICAL AXIS OF THE REFLECTOR AND AN ERROR VOLTAGE IS GENERATED TO CONTROL THE POSITION OF THE ANTENNA IN ELEVATION. THE ERROR SIGNAL WILL SHOW THE RELATIONSHIP OF THE MISSILE TO THE ANTENNA ELECTRICAL AXIS. THE ANGLE OF RADAR ANTENNA POSITION IN ELEVATION EQUALS ϕ , THE ANGLE OF ELEVATION OF THE MISSILE ABOVE THE HORIZONTAL PLANE AS MEASURED FROM THE RADAR SET. ROTATION OF THE ANTENNA IN ELEVATION MOVES THE ARMS OF THE ELEVATION POTENTIOMETER. THE COMPUTER RECEIVES VOLTAGES REPRESENTING $+\sin \phi$ AND $-\cos \phi$ FROM THE ELEVATION POTENTIOMETER.

(3) SINCE THE ANTENNA CANNOT BE MOVED IN AZIMUTH, THE AZIMUTH ERROR SIGNAL IS NOT USED FOR ANTENNA POSITIONING BUT IS SENT DIRECTLY TO THE COMPUTER STATION, WHERE A PROPORTIONATELY CORRECTIVE YAW COMMAND IS DETERMINED TO PUT THE MISSILE BACK ON A CORRECT HEADING TO THE TARGET BURST POINT.

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(4) IN AUTOMATIC OPERATION THE AZIMUTH AND ELEVATION ERROR SIGNALS DEVELOPED BY THE TRACKING SYSTEM HAVE A FREQUENCY OF APPROXIMATELY $25\frac{1}{2}$ CPS, WHICH IS THE FREQUENCY OF ROTATION OF THE CONICAL SCAN. THE REFERENCE SIGNALS FURNISH TO THE TRACKING SYSTEM A STANDARD WITH WHICH THE ERROR SIGNALS ARE COMPARED. IN AUTOMATIC TRACKING THE REFERENCE SIGNALS ARE SUPPLIED BY A TWO-PHASE GENERATOR, WHICH IS MOUNTED ON THE ANTENNA SHAFT AND IS DRIVEN BY THE SAME MOTOR WHICH DRIVES THE CONICAL SCAN.

(5) THE ERROR SIGNAL PRODUCED BY A PURE AZIMUTH POINTING ERROR IS EITHER IN PHASE OR 180 DEGREES OUT OF PHASE WITH THE AZIMUTH REFERENCE SIGNAL AND THE ERROR SIGNAL PRODUCED BY A PURE ELEVATION POINTING ERROR IS EITHER IN PHASE OR 180 DEGREES OUT OF PHASE WITH THE ELEVATION REFERENCE SIGNAL. THE AZIMUTH REFERENCE SIGNAL IS 90 DEGREES OUT OF PHASE WITH THE ELEVATION REFERENCE SIGNAL. THE FIELD WINDINGS OF THE REFERENCE GENERATOR MAY BE ROTATED TO ADJUST THE PHASE OF THE REFERENCE SIGNAL WITH RESPECT TO THE ANTENNA BEAM POSITION; THIS, IN EFFECT, ESTABLISHES THE PROPER RELATIONSHIP BETWEEN THE REFERENCE SIGNALS AND THE HORIZONTAL AND VERTICAL PLANE. THE ELEVATION TRACKING ERROR VOLTAGE (PROPORTIONAL TO THE AMOUNT OF PHASE SHIFT BETWEEN THE ELEVATION REFERENCE SIGNAL AND THE ELEVATION ERROR SIGNAL) IS PROPORTIONAL TO THE AMOUNT AND DIRECTION OF ANTENNA ELEVATION POINTING ERROR. THE AZIMUTH TRACKING ERROR VOLTAGE (PROPORTIONAL TO THE AMOUNT OF PHASE SHIFT BETWEEN THE AZIMUTH REFERENCE SIGNAL AND THE AZIMUTH ERROR SIGNAL) IS PROPORTIONAL TO THE AMOUNT AND DIRECTION OF MISSILE DEVIATION IN AZIMUTH FROM THE RADAR TARGET LINE.

(6) THE OPERATION OF THE INPUT CIRCUITS TO THE AUTOMATIC TRACKING UNIT (ELEVATION TRACKING) IS CONTROLLED BY A NARROW GATE FROM THE RANGE SYSTEM. GATED OPERATION OF THIS INPUT CIRCUITRY INSURES THAT ONLY SIGNALS ARRIVING WITHIN THE PERIOD OF THE NARROW GATE (EQUAL TO APPROXIMATELY 2,000 YARDS OF RANGE OR $\pm 1,000$ YARDS OF THE TARGET BEING TRACKED, AND ALSO EQUAL TO APPROXIMATELY 12.2μ SEC OF TIME) WILL ENTER THE AUTOMATIC TRACKING UNIT. DURING THE PERIOD OF THE NARROW GATE (APPROXIMATELY 12.2μ SEC) THE CONICAL SCAN WILL ROTATE APPROXIMATELY 2 MILS.

(7) THE GROUND RADAR STATION, AS PRESENTLY DESIGNED, OPERATES ON EITHER OF THREE PULSE RECURRENCE FREQUENCIES, 640, 731, OR 853 CPS. WHEN THE PULSE RECURRENCE FREQUENCY RECEIVED BY THE MISSILE DROPS TO 465 CPS, OR LOWER, INTERROGATION OF THE MISSILE TRANSPONDER STILL RESULTS; HOWEVER, NO PITCH OR YAW COMMANDS ORIGINATING OUTSIDE THE MISSILE WILL BE ACTED UPON BY THE MISSILE.

(8) IN ADDITION TO THE ABOVE, THE RADAR SET PROVIDES DATA FOR CONTINUOUS CORRECTION OF A PRESET PROPELLANT SHUTOFF TIME (A VITAL FUNCTION EFFECTING FINAL RANGE) BY DETERMINING PRECISE RANGE AND ELEVATION OF THE MISSILE DURING A SPECIFIED PORTION OF THE PERIOD OF POWERED FLIGHT.

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THE MISSILE POSITION MEASUREMENTS ARE SUPPLIED TO THE COMPUTER STATION WHERE A CORRECTION TO PRESET SHUTOFF TIME IS DETERMINED IF NECESSARY. AFTER SHUTOFF, THE RADAR SET TAKES ANOTHER PRECISE RANGE AND ELEVATION MEASUREMENT WHICH IS USED BY THE COMPUTER STATION TO DETERMINE A FINAL RANGE CORRECTION COMMAND TO BE TRANSMITTED TO THE MISSILE BY THE RADAR.

D. COMPUTER GROUP AN/MSA-6. COMPUTER GROUP AN/MSA-6 CONTAINS FACILITIES FOR COMPUTING DEVIATIONS OF THE PATH OF THE MISSILE FROM PRECALCULATED TRAJECTORY DATA AND FOR GENERATING CORRECTIVE COMMANDS, AS REQUIRED, TO BEING THE MISSILE ON COURSE SO AS TO ARRIVE AT THE TARGET BURST POINT. MISSILE AZIMUTH, ELEVATION, AND RANGE CORRECTION DATA ARE SUPPLIED BY THE RADAR SET, AND PRECISE RADIAL VELOCITY DATA IS FURNISHED BY THE DOPPLER STATION.

(1) A STANDARD TRAJECTORY IS COMPUTED FROM DATA SET INTO THE GUIDANCE SYSTEM PRIOR TO A MISSILE FIRING. COMMAND SIGNALS FOR CORRECTION OF MISSILE POSITION ARE COMPUTED BY COMPARING THE RADAR SET AND DOPPLER STATION DATA WITH COMPUTED STANDARD TRAJECTORY DATA. A MISSILE PROPELLANT SHUTOFF CORRECTION FACTOR IS COMPUTED IN THE COMPUTER STATION AND SUPPLIED TO THE DOPPLER STATION. ACCUMULATED IMPACT RANGE ERRORS OCCURRING AFTER PROPELLANT SHUTOFF ARE COMPUTED AND USED IN THE FORMATION OF A RANGE CORRECTION COMMAND. THE RANGE CORRECTION COMMAND, TRANSMITTED BY THE RADAR SET, PARTIALLY ARMS THE WARHEAD CARRIED BY THE MISSILE. IMPACT TIME OF THE MISSILE IS ALSO COMPUTED BY THE COMPUTER STATION AND IS USED TO TIME THE TRANSMISSION OF THE RANGE CORRECTION COMMAND.

(2) THE RANGE CORRECTION COMMAND ($\delta X_i = A\Delta R^1 + B \sin \beta + C \sin \beta + D$) IS COMPUTED NEAR MID-TRAJECTORY FROM ERRORS IN RADAR SLANT RANGE (ΔR), ELEVATION ANGLE ($\sin \beta$), RATE OF CHANGE OF ELEVATION ANGLE ($\sin \beta$) AND VARIOUS PRESET CONSTANTS. THE COMMAND IS COMPUTED WHEN THE MISSILE REACHES A PRECISE VELOCITY WHICH IS PRESET AND DETERMINED BY THE DOPPLER STATION. SLANT RANGE PROVIDED BY THE RADAR STATION IS OF TWO TYPES, ONE TYPE CONSISTS OF A CONTINUOUS MEASUREMENT OF THE DIFFERENCE (ΔR_0) BETWEEN MISSILE POSITION (R) AND A PRECALCULATED RANGE FOR MISSILE PROPELLANT SHUTOFF (R_0). THE OTHER TYPE OF INFORMATION CONSISTS OF A CONTINUOUS MEASUREMENT OF THE DIFFERENCE (ΔR_F) BETWEEN A GIVEN MISSILE POSITION (R), AFTER SHUTOFF, TO A PRECALCULATED RANGE AT WHICH FINAL RANGE CORRECTION VELOCITY WOULD NORMALLY BE REACHED (R_F). EACH OF THE TWO TYPES OF INFORMATION IS PRODUCED ONLY WHEN THE MISSILE IS WITHIN APPROXIMATELY 2,000 YARDS OF EACH PRECALCULATED RANGE. THE OUTPUT (EITHER R_0 OR R_F) IS IN THE FORM OF A DC VOLTAGE WHICH IS POSITIVE WHEN THE MISSILE IS APPROACHING THE PRECALCULATED RANGE, ZERO WHEN THE MISSILE IS AT THE PRECALCULATED RANGE AND NEGATIVE WHEN THE MISSILE IS BEYOND THE PRECALCULATED RANGE. THE OUTPUT VOLTAGE CHANGES CONTINUOUSLY SO THAT AT ANY POINT WITHIN THE RANGE SPAN IN WHICH MEASUREMENT IS MADE, THE VOLTAGE IS PROPORTIONAL TO THE DIFFERENCE BETWEEN ACTUAL RANGE AND

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GIVEN PRECALCULATED RANGE. THE PRESENT SCALE FACTOR FOR R_0 IS 300 YARDS PER VOLT AND FOR R_F , 230 YARDS PER VOLT. POSITIVE AND NEGATIVE VOLTAGE LIMITING NETWORKS IN THE RADAR STATION PREVENT R_0 AND R_F FROM REACHING VOLTAGE VALUES OF GREATER THAN ± 10 VOLTS.

(3) $\sin \beta$ IS A FUNCTION OF $+\sin \phi$ AND $-\cos \phi$ (ϕ = RADAR ELEVATION ANGLE) RECEIVED FROM THE RADAR STATION. $\sin \beta$ IS COMPUTED WITHIN THE RANGE CORRECTION COMPUTER.

(4) THE RANGE CORRECTION COMMAND CONSISTS OF A POLARITY PULSE OF ONE SECOND DURATION, THE POLARITY OF WHICH DETERMINES THE DIRECTION OF RANGE CORRECTION (GO LONG OR GO SHORT) FOLLOWED ONE SECOND LATER BY THE COMMAND PULSE WHOSE WIDTH DETERMINES THE AMOUNT OF RANGE CORRECTION. A SECOND FUNCTION OF THE POLARITY PULSE IS TO PARTIALLY ARM THE MISSILE.

(5) THE TIME ELAPSE BETWEEN TRANSMISSION OF THE RANGE CORRECTION POLARITY PULSE AND ARRIVAL OF THE MISSILE AT THE TARGET BURST POINT IS CRITICAL AND MUST EQUAL A PRECALCULATED TIME. THEREFORE ANY VARIATION IN THE TIME AT WHICH THE MISSILE REACHES RANGE CORRECTION VELOCITY AND THE PRECALCULATED TIME MUST BE COMPUTED AND USED TO TIME THE TRANSMISSION OF THE RANGE CORRECTION COMMAND. THIS IS THE SOLE FUNCTION OF THE TIME TO IMPACT COMPUTER. THE INPUT DATA TO THE TIME TO IMPACT COMPUTER IS THE SAME AS THAT FOR THE RANGE CORRECTION COMPUTER EXCEPT FOR THE PRECALCULATED CONSTANTS.

C. RADIO SET AN/MRQ-7. TOGETHER WITH THE RADAR SET AND THE COMPUTER GROUP, RADIO SET AN/MRQ-7 (DOPPLER) COMPLETES THE GUIDANCE STATION FOR THE CORPORAL MISSILE.

(1) THE DOPPLER STATION OPERATES AS AN INTEGRAL PART OF THE CORPORAL GUIDANCE STATION. ACCURATE MEASUREMENTS OF MISSILE RADIAL VELOCITY, COMMANDS, AND SIGNALS BASED ON THESE MEASUREMENTS ARE ACCOMPLISHED BY THE DOPPLER STATION.

(2) THE DOPPLER THEORY STATES THAT IF THERE IS A RELATIVE MOTION (VELOCITY) BETWEEN THE SOURCE OF THE WAVE MOTION AND THE OBSERVED WAVE MOTION, A CHANGE IN FREQUENCY OR PITCH OCCURS. THIS FREQUENCY CHANGE IS THE DOPPLER EFFECT, WHICH IS USED TO ACCURATELY MEASURE THE RADIAL VELOCITY OF THE CORPORAL MISSILE. THE DOPPLER STATION RF SIGNAL IS TRANSMITTED TO THE MISSILE RADIO BEACON WHERE IT IS AMPLIFIED, DOUBLED IN FREQUENCY AND RETRANSMITTED. THE DOUBLED RF SIGNAL CONTAINING THE DOPPLER FREQUENCY CHANGE IS RECEIVED AT THE GROUND DOPPLER STATION WHERE IT IS BEAT AGAINST TWICE THE GROUND DOPPLER TRANSMITTED FREQUENCY. THE FREQUENCY DIFFERENCE (BEAT FREQUENCY) IS A RESULT OF MISSILE RADIAL VELOCITY. WHEN THE RADIAL VELOCITY OF THE MISSILE AND THE RESULTANT DOPPLER BEAT FREQUENCY REACH A PREDETERMINED VALUE, A CODED SIGNAL MODULATES THE TRANSMITTER TO PROVIDE THE SHUTOFF COMMAND THAT INITIATES PROPELLANT SHUTOFF IN THE

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MISSILE. AT A LATER TIME, WHEN THE DOPPLER BEAT REACHES ANOTHER PRESET VALUE THE RANGE CORRECTION SIGNAL IS GENERATED. THIS SIGNAL IS RECEIVED BY THE COMPUTER STATION WHICH THEN DETERMINES THE VALUE OF RANGE CORRECTION COMMAND REQUIRED.

(3) IN ADDITION TO THE ABOVE, THE DOPPLER STATION TRANSMITS TO THE MISSILE, A DOPPLER WARHEAD ARMING COMMAND (CONTROLLED BY THE COMPUTER STATION).

2. CORPORAL MISSILE INTERNAL GUIDANCE SYSTEM. THE MISSILE INTERNAL GUIDANCE SYSTEM CONSISTS OF SEVERAL COMPONENTS INTERCONNECTED IN SUCH A MANNER THAT THE SYSTEM RECEIVES AND ACTS UPON VARIOUS SIGNALS FROM SEVERAL SOURCES DURING FLIGHT. A FEW MINUTES PRIOR TO TAKEOFF, A TEST IS ACCOMPLISHED DURING WHICH TIME THE GROUND RADAR RADIATES AND INTERROGATES THE TRANSPONDER SET (T S). SATISFACTORY COMPLETION OF THE "RADAR COMMAND LOOP TEST" INDICATES THAT THE RADAR-MISSILE COMMAND LINK IS FUNCTIONING PROPERLY. APPROXIMATELY FOUR SECONDS AFTER THE FIRING BUTTON ON THE FIRING PANEL IS DEPRESSED, THE ROCKET MOTOR HAS DEVELOPED SUFFICIENT THRUST TO CAUSE THE MISSILE TO RISE VERTICALLY FROM THE LAUNCHER. AT THIS TIME (T EQUALS 0 SECONDS) THE MASTER TIMER IN THE AUTOMATIC PILOT FLIGHT CONTROLLER (CONTROLLER) IS STARTED. DIRECTIONAL AND ATTITUDE STABILITY OF THE MISSILE IS MAINTAINED BY GYROSCOPIC SIGNALS FROM T EQUALS 0 UNTIL SHUTOFF. AT T PLUS 4 SECONDS, THE YAW PROGRAM SIGNALS WHICH HAVE BEEN PRESET IN THE CONTROLLER ARE COMBINED WITH THE GYRO SIGNALS, AND ARE SENT TO THE PROPER CHANNELS OF THE ELECTRONIC CONTROL AMPLIFIER (ECA). THE ECA THEN SENDS THE RESULTING SIGNALS TO THE NORTH AND SOUTH (YAW) SERVO MOTORS WHICH IN TURN ACTUATE THE NORTH AND SOUTH CONTROL SURFACES (FINS) AND PROGRAMMING IN YAW BEGINS. AT T PLUS 4.5 SECONDS, THE PITCH PROGRAM SIGNALS ARE INJECTED INTO THE SYSTEM THROUGH THE ECA TO ACTUATE THE EAST AND WEST (PITCH) FINS AND PITCH PROGRAMMING BEGINS. AT T PLUS 21 SECONDS, THE CONTROLLER CLOSES A SWITCH WHICH CAUSES ACTUATOR B-1 (COMMANDS IN) TO OPERATE. OPERATION OF B-1 ENABLES RADAR PITCH AND YAW COMMANDS FROM THE T S TO PASS THROUGH THE CONTROLLER TO THE ECA. THE FUNCTION OF THE T S IS TO RECEIVE THE CODED PULSE GROUPS FROM THE GROUND RADAR AND, IF THE FIRST THREE PULSES ARE CODED PROPERLY, TO EXTRACT INTELLIGENCE FROM THE FOURTH AND FIFTH PULSES AND TO TRANSMIT A TRACKING PULSE TO THE GROUND RADAR. THE INTELLIGENCE IS PLACED ON THE FOURTH AND FIFTH PULSES IN THE GROUND RADAR BY POSITION MODULATING THESE PULSES AT AN AUDIO RATE. POSITION MODULATION AT 75 CPS ON THE FOURTH (YAW) AND FIFTH (PITCH) PULSES WILL CAUSE THE MISSILE TO YAW LEFT AND PITCH DOWN THE MAXIMUM AMOUNT WHEREAS POSITION MODULATION OF THESE PULSES AT 105 CPS WILL CAUSE THE MISSILE TO YAW RIGHT AND PITCH UP THE MAXIMUM AMOUNT. POSITION MODULATION AT 90 CPS ON THE FOURTH AND FIFTH PULSES WILL CAUSE ZERO DEFLECTION ON THE FINS. THE POSITION MODULATION IS DETECTED BY DISCRIMINATORS IN THE T S, AND THE RESULTANT DC VOLTAGES ARE SENT TO THE CONTROLLER. MISSILE AUTOMATIC GAIN CONTROL (AGC) IS DETERMINED BY THE

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AMPLITUDE OF THE FOURTH AND FIFTH PULSES. AT T PLUS 31 SECONDS, THE CONTROLLER CLOSES A SWITCH WHICH OPERATES ACTUATOR B - 2 (GAIN UP). OPERATION OF B-2 INCREASES THE GAIN OF PITCH, YAW, AND ROLL SIGNALS. AT SOME TIME BETWEEN T PLUS 45 AND T PLUS 60 SECONDS (DEPENDENT UPON THE SETTING OF DOPPLER TIMER #1 OBTAINED FROM THE FIRING TABLES) THE CONTROLLER CLOSES A SWITCH WHICH ENERGIZES THE RADIO BEACON FOR A PERIOD OF 15 SECONDS. DURING THIS 15 SECONDS TIME, THE RADIAL VELOCITY OF THE MISSILE IS MEASURED BY THE GROUND RADIO SET. WHEN THE REQUIRED VELOCITY IS ATTAINED, THE GROUND RADIO SET SENDS A SHUTOFF SIGNAL WHICH IS RECEIVED AND RELAYED BY THE RADIO BEACON TO CAUSE PROPELLANT SHUTOFF. SATISFACTORY CLOSURE OF THE PROPELLANT VALVE CLOSES A SWITCH WHICH OPERATES ACTUATOR B-3 (CHANGE OVER). WHEN B-3 IS OPERATED, RADAR PITCH COMMANDS ARE TERMINATED (GROUNDED), AND STABILITY CONTROL IS SWITCHED FROM GYROSCOPES TO ACCELEROMETERS. SOME TIME BETWEEN T PLUS 96 AND T PLUS 114 SECONDS (DEPENDENT UPON THE SETTING OF DOPPLER TIMER #2 OBTAINED FROM THE FIRING TABLES) THE CONTROLLER ENERGIZES THE RADIO BEACON AGAIN FOR A PERIOD OF 35 SECONDS. THE VELOCITY OF THE MISSILE IS MEASURED AGAIN AND RANGE CORRECTION (RC) AND WARHEAD ARMING COMMANDS ARE TRANSMITTED TO THE MISSILE BY THE GROUND GUIDANCE STATION. AT T PLUS 100 SECONDS THE CONTROLLER CLOSES A SWITCH (COMMAND UNIT GATE) FOR 35 SECONDS WHICH WILL PERMIT THE RC COMMANDS TO BE RECEIVED BY THE SIGNAL DATA CONVERTER (SDC). THE COMMAND UNIT GATE BYPASSES THE COMMAND POTENTIOMETERS ASSOCIATED WITH ACTUATOR B-1. AT APPROXIMATELY T PLUS 104 SECONDS, THE CONTROLLER CLOSES A SWITCH WHICH "ARMS" THE MAGNETIC DISCRIMINATORS IN THE SDC ALLOWING THEM TO OPERATE ON THE RC COMMANDS. THE RC COMMAND MUST BE TRANSMITTED TO THE MISSILE BETWEEN T PLUS 104 AND T PLUS 132 SECONDS IF THE MISSILE IS TO RECEIVE IT. THE RC COMMAND IS MADE UP OF TWO PULSES (PITCH COMMANDS). THE FIRST PULSE IS ONE SECOND IN DURATION AND DETERMINES THE POLARITY (GO LONG OR GO SHORT) OF THE COMMAND. THE SECOND PULSE OCCURS ONE SECOND AFTER THE END OF THE FIRST PULSE AND DETERMINES THE MAGNITUDE OF THE RC MANEUVER (THIS COMMAND IS STORED ON THE MEMORY HELIPOT IN THE CONTROLLER TO BE USED LATER). WHEN THE FIRST PULSE OF THE RC COMMAND IS RECEIVED, THE SDC ACTIVATES A MAGNETIC CLUTCH IN THE CONTROLLER WHICH IN TURN CLOSES A SWITCH THAT STARTS TWO VEEDER ROOT COUNTERS - MANEUVER START AND AZIMUTH COMMAND TERMINATION. THESE TIMERS ARE PRESET TO PERFORM CERTAIN FUNCTIONS AT A CALCULATED TIME (20 SECONDS BEFORE IMPACT FOR MANEUVER START) AFTER RC COMMAND TRANSMISSION. WHEN THE MANEUVER START TIMER RUNS DOWN, A SWITCH IS CLOSED AND THE STORED RC COMMAND IN THE CONTROLLER IS APPLIED TO THE ERROR DETECTOR IN THE SDC. THE RC COMMAND LEAVES THE SDC AND PASSES BACK THROUGH THE CONTROLLER TO THE ECA AND CAUSES THE RC MANEUVER TO BEGIN. WHEN THE AZIMUTH COMMAND TERMINATION TIMER RUNS DOWN (ANY PRESET TIME AFTER RC COMMAND TRANSMISSION PLUS 10 SECONDS - DEPENDENT UPON EXPECTED COUNTERMEASURES ACTIVITY) A SWITCH IS CLOSED WHICH RESETS B-1 TO THE PREFLIGHT CONDITION THEREBY ALLOWING NO RADAR GUIDANCE COMMANDS TO PASS THROUGH THE CONTROLLER.

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3. ELECTRONIC DEFENSE LABORATORY'S ELECTRONIC COUNTERMEASURES SYSTEM. THE EDL EQUIPMENT BRIEFLY DESCRIBED BELOW IS HOUSED IN TWO SCR-584 RADAR VANS, AND, IN FACT, UTILIZES PORTIONS OF THE 584 RADAR EQUIPMENT. (SEE PHOTOS, INCLOSURE 2.) IT SHOULD BE EMPHASIZED THAT THIS EQUIPMENT REPRESENTS A LABORATORY MODEL ASSEMBLED FOR THE PURPOSE OF TESTING CERTAIN ECM CONCEPTS AND TECHNIQUES. AS SUCH IT SHOULD NOT BE CONSIDERED TO BE AN ECM PROTOTYPE SYSTEM SINCE NO ATTEMPT IS MADE TO ASSURE SATISFACTORY OPERATION UNDER CONDITIONS OTHER THAN THOSE EXISTING DURING THIS SERIES OF TESTS.

A. VERTICAL MOTION DETECTION SUB-SYSTEM (VMD). THE EDL SYSTEM INTERCEPTS AND RECOGNIZES THE CORPORAL MISSILE BY MAKING USE OF THE MOTION PARAMETER OF THE MISSILE BEACON (TRANSPONDER SET - TS) SIGNAL. THIS IS ACCOMPLISHED BY PERFORMING A FREQUENCY SEARCH IN CONJUNCTION WITH A FIXED ANTENNA CONFIGURATION WHICH ALLOWS THE ELEVATION ANGLE OF ALL SIGNALS OCCURRING BETWEEN 1° AND 60° ABOVE THE HORIZON TO BE MEASURED AND THE RESULTANT MEASURED ANGLE DISPLAYED VERSUS THE FREQUENCY AT WHICH THEY OCCUR. SUCCESSIVE DISPLAYS PERMIT THE SINGLING OUT OF ANY SIGNAL WHOSE ELEVATION ANGLE INCREASES WITH TIME AT A RATE CHARACTERISTIC OF A BALLISTIC MISSILE. PROPER FUNCTIONING OF THE VMD DEPENDS ONLY UPON KNOWING THE LAUNCHER AZIMUTH TO WITHIN $\pm 30^{\circ}$ AND THE TS FREQUENCY TO WITHIN ± 200 mc/s (FUTURE SYSTEMS WILL HAVE A GREATER FREQUENCY COVERAGE). THE OUTPUTS OF THIS SYSTEM ARE:

- (1) RECOGNITION OF THE EXISTENCE OF THE MISSILE.
- (2) AN ESTIMATE OF WHEN THE SIGNAL REACHES A PREDETERMINED ELEVATION ANGLE.
- (3) THE FREQUENCY BEING INTERCEPTED.

B. PASSIVE TRACK SUB-SYSTEM (PT). THE EDL SYSTEM ACQUIRES AND TRACKS THE MISSILE BY USING PASSIVE TRACKING TECHNIQUES ON THE TS RADIATIONS. THIS SUB-SYSTEM IS ACTIVATED WHEN THE "VMD RECOGNIZED" SIGNAL OBTAINS THE PREDETERMINED ELEVATION ANGLE. WITH THE PROPER FREQUENCY ALSO BEING TRANSFERRED FROM THE VMD, THE PASSIVE TRACKER SEARCHES RAPIDLY IN AZIMUTH UNTIL THE SAME SIGNAL IS DETECTED AND PASSIVE TRACK IS ESTABLISHED. DURING THE ACTIVE PHASE, THE RECEIVED SIGNALS ARE ANALYZED TO DETERMINE WHEN A CORRELATION EXISTS BETWEEN THE ACTIVE ECM AND THE RECEIVED SIGNALS. THE OUTPUTS OF THIS SYSTEM ARE:

- (1) CONTINUOUS AZIMUTH AND ELEVATION TO THE MISSILE.
- (2) CONTINUOUS MONITORING OF THE TS PRF.

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(3) 0.1 SECOND PULSE WHEN CORRELATION IS OBSERVED.

C. ACTIVE ECM SUB-SYSTEM (PULSE JAMMER).

(1) THE EDL SYSTEM SUPPLIES AN ACTIVE ECM ENVIRONMENT. THIS ENVIRONMENT TENDS TO DECEIVE THE MISSILE GUIDANCE SYSTEM BY:

(A) SUPPLYING ERRONEOUS COMMANDS AND

(B) CAUSING THE RESPONSE OF THE MISSILE TS TO BE ERRATIC TO THE GROUND GUIDANCE RADAR INTERROGATION.

(2) THE LATTER IN TURN WOULD CAUSE THE COMPUTER TO COMPUTE ERRONEOUS COMMANDS TO BE SENT TO THE MISSILE. THE EFFECTIVENESS OF THIS APPROACH WILL INCREASE AS MORE INFORMATION IS OBTAINED CONCERNING:

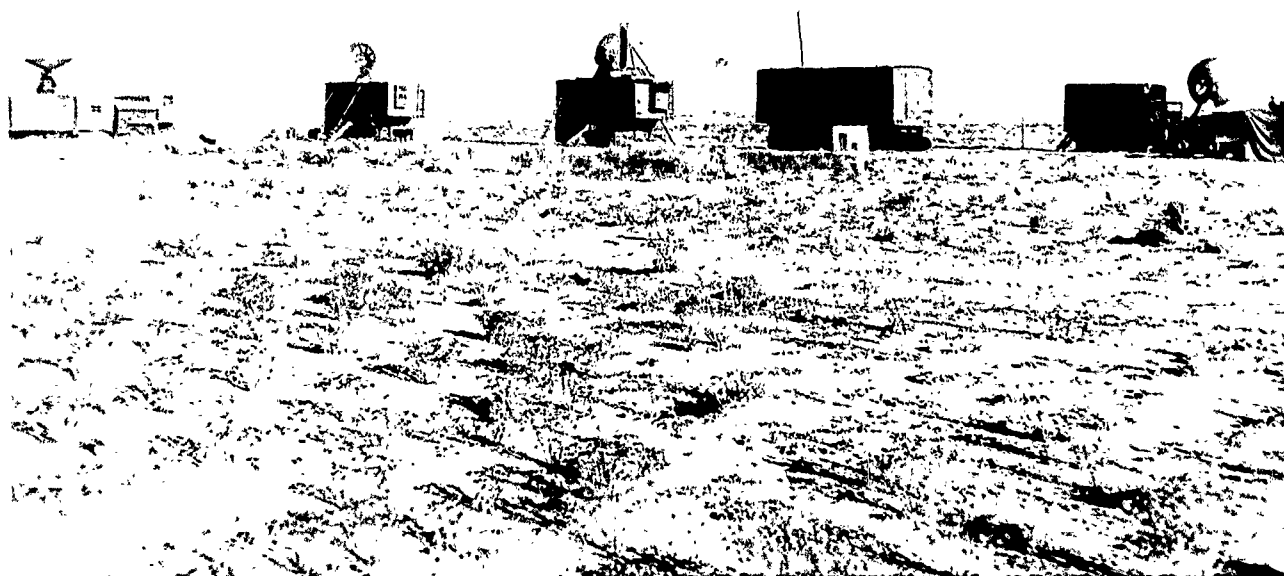
(A) THE LIMITS WITHIN WHICH ALL CORPORAL GUIDANCE RADAR TRANSMISSION CODES LIE.

(B) THE LIMITS WITHIN WHICH THE ACTUAL COMMAND PULSES ARE POSITION MODULATED, AND THE MODULATION FREQUENCY.

(C) THE CHARACTERISTICS OF THE GROUND GUIDANCE RADAR AND COMPUTER SYSTEM.

(3) THIS SUB-SYSTEM IS ALERTED WHEN THE MISSILE IS ACQUIRED BY THE PASSIVE TRACKER SYSTEM. THE HIGH GAIN TRANSMITTING ANTENNA IS POSITIONED BY THE PASSIVE TRACKING ANTENNA SYSTEM. THE OUTPUT FREQUENCY IS CAPABLE OF BEING SWEEPED OVER A 200 MC RANGE IN A 5 SECOND PERIOD AND THE SPACING OF THE INTERROGATION PULSES BEING TRANSMITTED ARE CHANGED RAPIDLY IN SUCH A WAY THAT ALL POSSIBLE CORPORAL PULSE CODES ARE TRANSMITTED SEVERAL TIMES IN A 0.25 SECOND INTERVAL. THE PASSIVE TRACKER ANALYSIS EQUIPMENT WOULD, WHEN THE ACTIVE ECM SIGNAL IS INTERROGATING THE TS, SEND A 0.1 SECOND PULSE TO STOP THE FREQUENCY SWEEP AND PULSE SPACING VARIATION. THEREAFTER, ANOTHER PULSE IS ADDED TO THE TRANSMITTER OUTPUT IN SUCH A WAY THAT THE MISSILE TS WILL RECEIVE INTERMITTENT FULL-LEFT COMMANDS. IN ADDITION, THE PRF OF THE OUTPUT SIGNAL IS ADJUSTED TO CAUSE THE RESPONSE OF THE MISSILE TS TO THE GUIDANCE RADAR SIGNAL TO VARY IN AMPLITUDE, THUS INTERFERING WITH THE TRACKING OF THE GUIDANCE RADAR AND WITH THE COMPUTATION OF TRAJECTORY ERRORS AND CORRECTIVE COMMANDS.

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

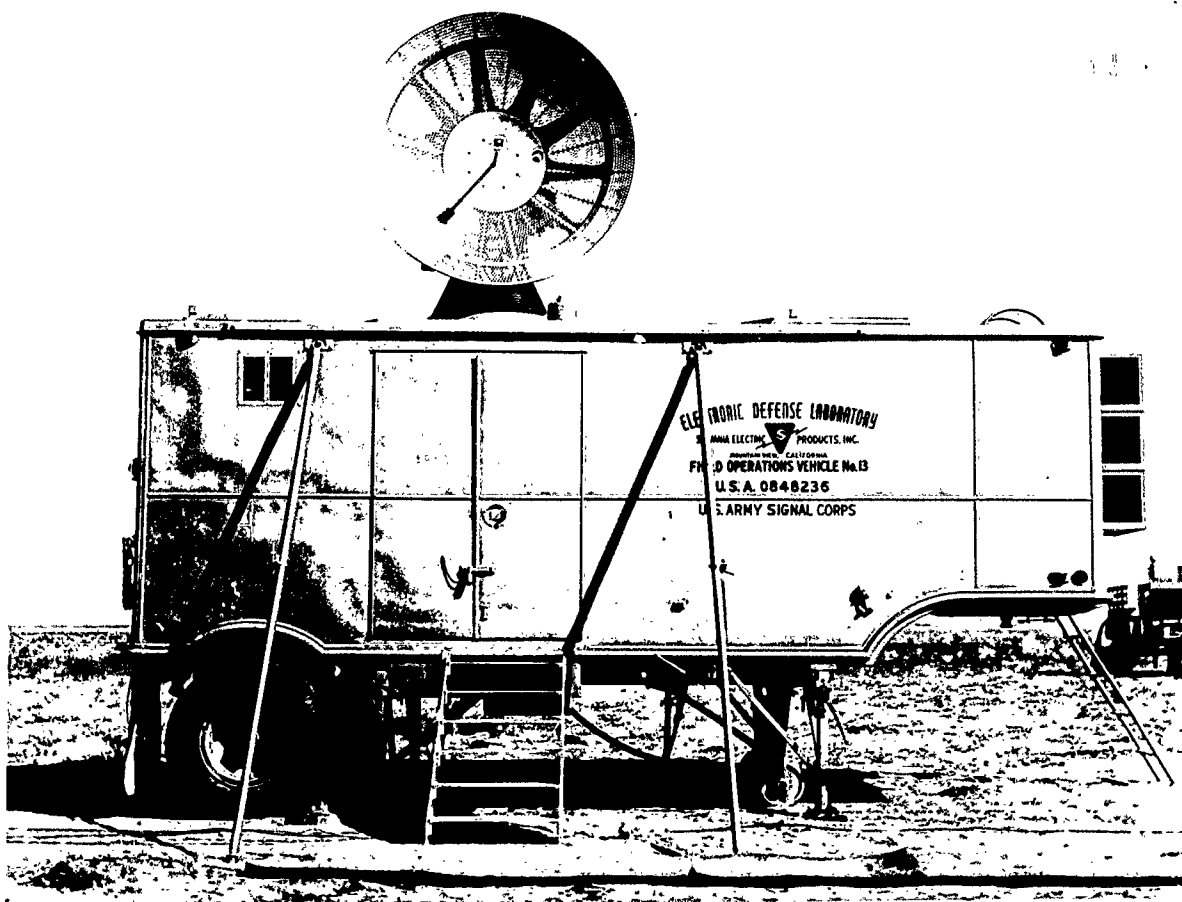
FORT BLISS, TEXAS
NEGATIVE NR GM 170-1

PHOTO NR 1--BOARD NR 4 AND EDL EQUIPMENTS EMPLACED NEAR HADC. LEFT TO
RIGHT: AN/MPQ-18 AND DATA DISPLAY UNIT, ECM PULSE JAMMER, 183.41
ECM INTERCEPT VAN (PASSIVE TRACKER AND VERTICAL MOTION
DETECTOR), LAB AND WORK VAN (EDL), SCATTER INTERCEPT EQUIP-
MENT (NOT USED IN THIS TEST).

INCLOSURE 2

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

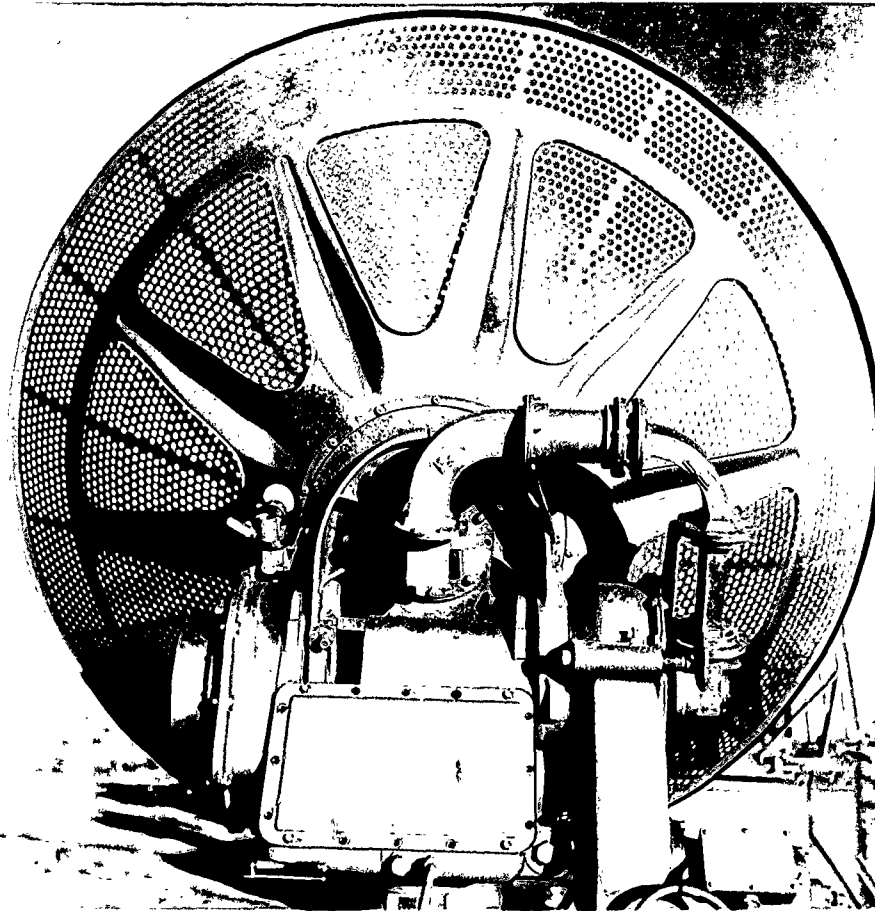
FORT BLISS, TEXAS
NEGATIVE NR GM 170-2

PHOTO NR 2--EDL PULSE JAMMER VAN.

INCLOSURE 2

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

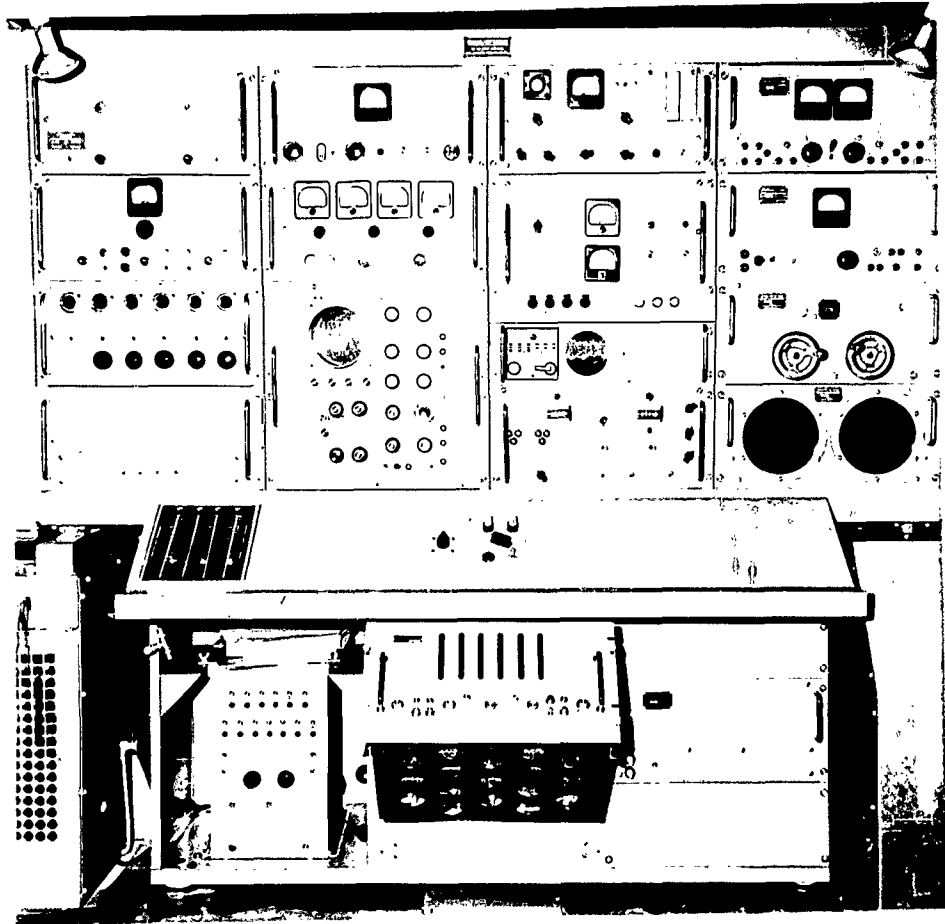
FORT BLISS, TEXAS
NEGATIVE NR GM 170-3

PHOTO NR 3--PULSE JAMMER ANTENNA.

INCLOSURE 2

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

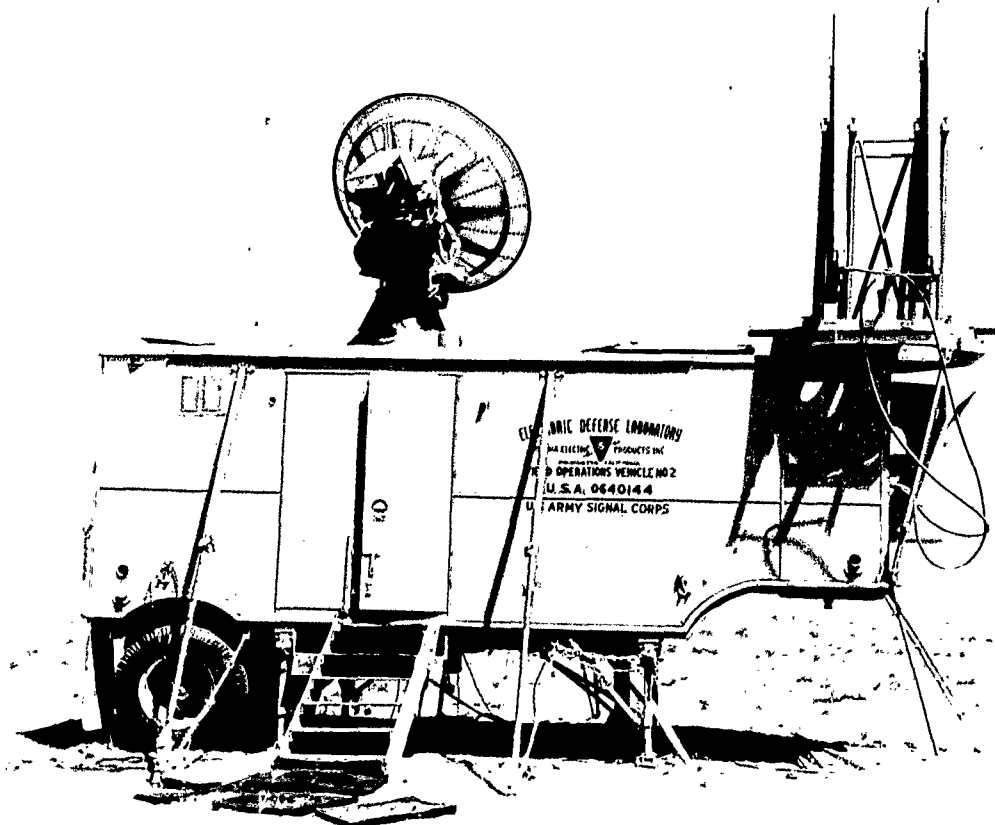
FORT BLISS, TEXAS
NEGATIVE NR GM 170-4

PHOTO NR 4--PULSE JAMMER CONSOLE

INCLOSURE 2

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

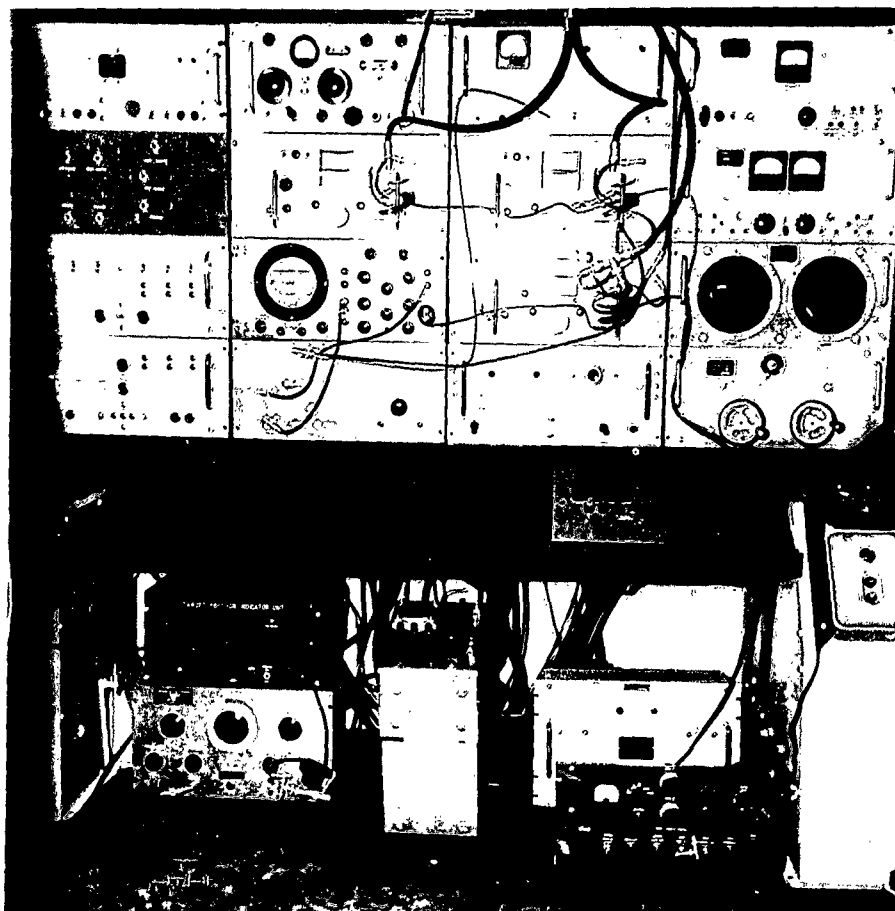
FORT BLISS, TEXAS
NEGATIVE NR GM 170-5

PHOTO NR 5--EDL INTERCEPT VAN (PASSIVE TRACK ANTENNA ON LEFT, VMD ANTENNA ARRAY
ON RIGHT).

INCLOSURE 2

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

FORT BLISS, TEXAS
NEGATIVE NR GM 170-6

PHOTO NR 6--INTERCEPT VAN CONSOLE.

INCLOSURE 2

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BOARD NUMBER 4 (7104 SU)
CONTINENTAL ARMY COMMAND
FORT BLISS, TEXAS

/PAJ

DETAILS OF TEST

1. MISSILE FIRING II U-13.

A. PURPOSE. THE PURPOSE OF THIS TEST WAS TO:

(1) DETERMINE WHETHER OR NOT THE CORPORAL MISSILE COULD BE "CAPTURED" AND COMMANDED INFLIGHT BY CERTAIN EDL JAMMING EQUIPMENT OPERATING UNDER OPTIMUM JAMMING CONDITIONS.

(2) DETERMINE THE EFFECTS OF THIS JAMMING ON THE GROUND GUIDANCE STATION (GGS).

(3) DETERMINE THE EFFECTS OF THIS JAMMING ON THE MISSILE.

(4) DETERMINE THE EASE WITH WHICH THIS JAMMING MAY BE ACCOMPLISHED.

(5) PROVIDE A MEANS OF FIELD TESTING EDL JAMMING EQUIPMENT AND TECHNIQUES.

B. CONDUCT OF TEST. THIS TEST WAS CONDUCTED UNDER OPTIMUM JAMMING CONDITIONS IN THAT EDL KNEW THE FOLLOWING:

(1) THE EXACT PULSE RECURRENCE FREQUENCY (PRF) OF THE RADAR TRANSMITTER.

(2) THE EXACT FREQUENCIES OF THE MISSILE AND RADAR SET.

(3) THE EXACT TIME OF LAUNCHING.

(4) THE CODE USED IN THE TRANSPONDER SET.

ALL OTHER CONDITIONS MAY BE CONSIDERED AS STANDARD. RANGE SILENCE WAS MAINTAINED ON THE RADAR AND RADAR IMAGE FREQUENCIES. VOICE COMMUNICATION WAS MAINTAINED BETWEEN THE EDL SITE NEAR HADC AND THE ORO GRANDE CORPORAL FIRING AREA IN THE EVENT EITHER PARTY NEEDED TO "HOLD" THE FIRING.

INCLOSURE 3

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C. RESULTS OF TEST. THE FOLLOWING IS A CHRONOLOGICAL SEQUENCE OF EVENTS INCLUDING THE ACTION TAKEN BY EDL AND SUBSEQUENT EFFECTS IN THE GROUND GUIDANCE STATION AND THE MISSILE.

(1) X-5 MINUTES. THE GROUND RADAR BEGINS TO RADIATE TO THE MISSILE AND CONTINUES RADIATION UNTIL IMPACT. THE TRANSPONDER SET (TS) IN THE MISSILE REPLIES TO THE CODED PULSE GROUPS SENT FROM THE RADAR. EDL INTERCEPTS RADIATION EMITTED BY THE GROUND RADAR BUT TAKES NO ACTIVE ACTION.

(2) T + 4.7 SECONDS.

(A) EDL DETERMINES THE FREQUENCY OF THE TS USING THE VMD.

(B) GGG. NO EFFECTS ARE NOTED.

(C) MISSILE. CONTINUES ALONG NORMAL PROGRAMMED TRAJECTORY.

(3) T + 5.5 SECONDS.

(A) EDL. PASSIVE TRACKER (PT) GOES INTO "AUTOMATIC TRACK" AND REMAINS IN AUTOMATIC UNTIL IMPACT. PT DATA IS NOT YET USEABLE.

(B) GGG. NORMAL OPERATION IS NOTED.

(C) MISSILE. CONTINUES NORMAL PROGRAMMING.

(4) T + 6.3 SECONDS.

(A) EDL PT LOCKS ON THE FREQUENCY OF THE TS.

(B) GGG. NO CHANGES FROM NORMAL OPERATION ARE NOTED.

(C) MISSILE. CONTINUES NORMAL PROGRAMMING.

(5) T + 20 SECONDS.

(A) EDL. PT DATA BECOMES SMOOTH.

(B) GGG. NO CHANGES IN NORMAL OPERATION ARE NOTED.

(C) MISSILE. CONTINUES NORMAL FLIGHT.

(6) T + 21 SECONDS.

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(A) EDL. PT ANTENNA NOW TRACKING MISSILE WITHIN ± 10 MILS. DATA SENT TO THE PULSE JAMMER BUT NO ATTEMPT TO JAM IS MADE.

(B) GGG. NO CHANGES ARE NOTED FROM NORMAL OPERATION.

(C) MISSILE. RESPONDS NORMALLY TO ALL COMMANDS.

(7) T + 38.3 SECONDS.

(A) EDL. PULSE JAMMER IS ENERGIZED. JAMMING BEGINS WITH A "CODE PROBE" OF THREE PULSES AT A PRF OF 2201.5 PULSE GROUPS PER SECOND. IMMEDIATE CODE LOCK IS OBTAINED AND IS INDICATED BY AN INCREASE IN TRANSPONDER RESPONSE. (SEE INCLOSURE 4, CHART 1, GRAPH B1-4.)

(B) GGG. NO EFFECT IS NOTED.

(C) MISSILE. NO ABNORMAL EFFECTS OTHER THAN AN INCREASE IN TRANSPONDER RESPONSE.

(8) T + 38.35 SECONDS.

(A) EDL. JAMMING WITH GROUPS OF THREE PULSES CONTINUES.

(B) GGG. RADAR AGC AND AZIMUTH ANGULAR ERROR VOLTAGE BEGIN TO FLUCTUATE AT APPROXIMATELY 4.1 CPS RATE. THE AUTOMATIC-AIDED RELAY IN THE RADAR RANGE TRACKING SYSTEM BEGINS TO CHATTER AT 4.1 CPS. ERRONEOUS AZIMUTH COMMANDS ARE GENERATED AS A RESULT OF THIS TYPE OF JAMMING (SEE INCLOSURE 4, CHART 1, GRAPH C1-4, CHART 3, GRAPH C1-6 AND INCLOSURE 5, PHOTOS D1-1 AND D1-2).

(C) MISSILE. NO ADDITIONAL EFFECTS ARE NOTED.

(9) T + 40.2 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUE.

(B) GGG. NO CHANGE IN RECORDED INDICATIONS.

(C) MISSILE. FINS BEGIN TO RESPOND TO ERRONEOUS COMMANDS RECEIVED FROM THE GGG.

(10) T + 41.5 SECONDS.

(A) EDL RECORDED TRANSPONDER RESPONSE AND CODE PROBE INDICATIONS BECOME INTERMITTENT (SEE INCLOSURE 4, CHART 1, GRAPHS B1-4 AND A1-1).

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(B) GGs. NO CHANGES IN RECORDED INDICATIONS.

(C) MISSILES. NO CHANGE IN RECORDED INDICATIONS.

(11) T + 45.8 SECONDS.

(A) EDL. JAMMER PRF IS SHIFTED TO 1475 PULSE GROUPS PER SECOND, AND A FOURTH PULSE IS ADDED TO THE GROUP. THE FOURTH PULSE IS POSITION MODULATED AT 72 CPS SO AS TO GIVE THE MISSILE A "GO LEFT" COMMAND. INTERMITTENT JAMMING AND PROBING CONTINUES.

(B) GGs. RADAR AGC BEGINS TO OSCILLATE AT APPROXIMATELY 10.2 CPS. THE AUTOMATIC-AIDED RELAY IN THE RADAR RANGE TRACKING SYSTEM BEGINS TO CHATTER AT APPROXIMATELY 10.2 CPS. AZIMUTH ANGULAR ERROR VOLTAGE CONTINUES TO BE ERRATIC PRODUCING ERRATIC AND ERRONEOUS AZIMUTH COMMANDS.

(C) MISSILE. RECORDED MISSILE AGC INCREASES APPROXIMATELY 3DB INDICATING THAT THE ADDITIONAL JAMMING PULSE IS BEING RECEIVED.

(12) T + 46.15 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUES.

(B) GGs. NO CHANGE IN RECORDED INDICATIONS.

(C) MISSILE. INDICATION OF A TRANSIENT APPEARS ON THE NORTH AND SOUTH (YAW) FINS.

(13) T + 46.6 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUES.

(B) GGs. NO CHANGE IN RECORDED INDICATIONS.

(C) MISSILE. NORTH AND SOUTH FINS MOVE TO HARD GO LEFT POSITION AND BECOME ERRATIC FOLLOWING NO SET PATTERN.

(14) T + 48.5 SECONDS.

(A) EDL. JAMMING WITH FOUR PULSE GROUPS CONTINUES (SEE INCLOSURE 4, CHART 1, GRAPH A1-1).

(B) GGs. THE AUTOMATIC-AIDED RELAY IN THE RADAR RANGE TRACKING SYSTEM GOES TO AUTOMATIC AND REMAINS IN AUTOMATIC UNTIL APPROXIMATELY T + 53 SECONDS. THIS INDICATES THAT THE RETURN SIGNAL FROM THE MISSILE BECAME STRONGER; HOWEVER, CHANGES IN 150 SINE BETA BECOME MORE ERRATIC CAUSING MORE ERRATIC (POSSIBLY ERRONEOUS) ELEVATION COMMANDS TO BE GENERATED (SEE INCLOSURE 4, CHART 4, GRAPH C1-7).

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(c) MISSILE. NO CHANGE IN RECORDED INDICATIONS IS NOTED.

(15) T + 52 SECONDS.

(A) EDL. INTERMITTENT PROBE AND JAM CONTINUES.

(B) GGS. INDICATIONS ARE PRESENT OF THE RADAR ANTENNA SLEWING IN ELEVATION. AZIMUTH ERROR VOLTAGE MEASURED BY THE GROUND STATION IS NEAR ZERO (DOVAP DATA SHOWS THE MISSILE TO BE 28 METERS TO THE LEFT OF THE TARGET LINE). A DECREASE IN RECEIVED SIGNAL STRENGTH IS NOTED PROBABLY CAUSED EITHER BY OPERATOR CONFUSION IN TRYING TO MAINTAIN THE TARGET OR BY A POOR RETURN SIGNAL AS A RESULT OF JAMMING.

(c) MISSILE. FINS CONTINUE TO BE ERRATIC AND RESPOND PREDOMINANTLY TO GO LEFT (SEE INCLOSURE 4, CHART 3, GRAPHS B1-6 AND B1-7). TRANSPONDER RESPONSE LEVELS OFF AT APPROXIMATELY 1100 PULSES PER SECOND.

(16) T + 62.8 SECONDS.

(A) EDL. INTERMITTENT PROBING AND JAMMING CONTINUES WITH MORE JAM TIME AS OPPOSED TO PROBING TIME. TRANSPONDER RESPONSE REMAINS STEADY AT APPROXIMATELY 620 PULSES PER SECOND WITH OCCASIONAL DROPS TO APPROXIMATELY 200 PULSES PER SECOND. PT RECEIVER AGC GOOD AND STEADY (INCLOSURE 4, CHART 1, GRAPH B1-4; CHART 5, GRAPH A1-2).

(B) GGS. AZIMUTH ERROR VOLTAGE INDICATES THE MISSILE APPROXIMATELY 30 MILS (M) TO THE LEFT OF THE TARGET LINE (DOVAP DATA PLACES THE MISSILE 299 METERS TO THE LEFT OR APPROXIMATELY 12.7 M). RADAR WAS SWITCHED FROM "AUTOMATIC" TO "REMOTE" AT T + 58.62 SECONDS AS CONSIDERABLE DIFFICULTY WAS ENCOUNTERED TRYING TO TRACK THE RETURN PULSE. THIS SWITCHING TO TRACKER CONTROL CAUSED SATURATED GO RIGHT COMMANDS TO BE GENERATED. RADAR AGC IS VERY POOR (SEE INCLOSURE 4, CHART 1, GRAPH C1-4; CHART 3, GRAPH C1-6; CHART 5, GRAPH C1-5).

(c) MISSILE. YAW FINS OSCILLATING VIOLENTLY AT A RANDOM RATE IN RESPONSE TO COMMANDS OF OPPOSITE POLARITY FROM TWO SEPARATE SOURCES.

(17) T + 72 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUES OR RECORDED INDICATIONS.

(B) GGS. RADAR IS IN REMOTE AND AGC IS VERY POOR (SEE INCLOSURE 4, CHART 5, GRAPH C1-5 AND INCLOSURE 5, PHOTOS D1-3 AND D1-1).

(c) MISSILE. DURING PERIODS OF JAMMING, THE YAW FINS ASSUME A HARD GO LEFT POSITION WHEREAS DURING PERIODS OF PROBING THE FINS OSCILLATE VIOLENTLY (ALMOST FROM STOP TO STOP) AT APPROXIMATELY 5 CPS.

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(18) T + 78.6 SECONDS.

(A) EDL. TRANSPONDER RESPONSE BECOMES HIGHER (APPROXIMATELY 1100 PULSES PER SECOND), AND MORE JAMMING TIME THAN PROBING TIME IS NOTED. AVERAGE RECEIVED SIGNAL STRENGTH (AGC INDICATION) IS VERY GOOD (SEE INCLOSURE 4, CHART 1, GRAPHS B1-4 AND A1-1; CHART 5, GRAPH A1-2).

(B) GGS. AZIMUTH ERROR VOLTAGE INDICATES THAT THE MISSILE IS APPROXIMATELY 34.4 μ TO THE LEFT OF THE TARGET LINE (DOVAP DATA PLACES THE MISSILE APPROXIMATELY 23.9 μ LEFT).

(C) MISSILE. YAW FINS PREDOMINANTLY ASSUME A GO LEFT POSITION.

(19) T + 104.5 SECONDS.

(A) EDL. JAMMING IS CONSTANT WITH NO PROBING SIGNALS BEING SENT. GOOD RETURN SIGNAL LEVEL AND HIGH TRANSPONDER RESPONSE IS INDICATED (SEE INCLOSURE 4, CHART 1, GRAPHS A1-1 AND B1-4; CHART 5, GRAPHS A1-2).

(B) GGS. RADAR IS STILL IN "REMOTE," BUT A POOR RETURN PULSE IS BEING RECEIVED. AZIMUTH COMMANDS REMAIN SATURATED TO GO RIGHT (SEE INCLOSURE 4, CHART 3, GRAPH C1-6).

(C) MISSILE. PREDOMINATE HARD GO LEFT COMMANDS BEING RECEIVED. SIGNAL DATA CONVERTER IS TRIGGERED BY A SIGNAL RECEIVED IN THE PITCH CHANNEL (SEE INCLOSURE 4, CHART 2, GRAPH B1-1). THIS SIGNAL WAS NOT TRANSMITTED BY THE GROUND GUIDANCE STATION.

(20) T + 107.5 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUE OR RECORDED INDICATIONS.

(B) GGS. AZIMUTH ERROR VOLTAGE NOW INDICATES THAT THE MISSILE IS APPROXIMATELY 38.2 μ TO THE LEFT OF THE TARGET LINE (DOVAP DATA PLACES THE MISSILE APPROXIMATELY 37.1 μ LEFT OF THE TARGET LINE).

(C) MISSILE. RESPONDS TO HARD GO LEFT COMMANDS (SEE INCLOSURE 4, CHART 3, GRAPH B1-6).

(21) T + 114.54 SECONDS.

(A) EDL. NO CHANGE IN JAMMING TECHNIQUE (SEE INCLOSURE 4, CHART 1, GRAPHS A1-1 AND B1-4; CHART 5, GRAPH A1-2).

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(b) GGS. XM-3 TRACKER LOSES THE TARGET, AND THE ON TARGET LIGHT GOES OFF (SEE INCLOSURE 4, CHART 2, GRAPH C1-3).

(c) MISSILE. YAW FINS REMAIN AT HARD GO LEFT POSITION.

(22) T + 115.12 SECONDS.

(a) EDL. NO CHANGE.

(b) GGS. RADAR IS SWITCHED FROM "REMOTE" TO "AUTOMATIC." AZIMUTH COMMANDS CHANGE FROM SATURATED GO RIGHT TO SATURATED GO LEFT. RADAR HAS ESSENTIALLY NO RETURN SIGNAL TO TRACK (SEE INCLOSURE 4, CHART 2, GRAPH C1-3; CHART 3, GRAPH C1-6; CHART 5, GRAPH C1-5).

(c) MISSILE. NO CHANGE IS NOTED IN YAW FIN POSITIONS. AGC BEGINS TO RISE (SEE INCLOSURE 4, CHART 5, GRAPH B1-5).

(23) T + 120.1 SECONDS.

(a) EDL. BORESIGHT CAMERA RECORD REVEALS THAT THE PT IS TRACKING THE MISSILE WITHIN ± 2 MILS.

(b) GGS. RADAR IS SWITCHED FROM "AUTOMATIC" TO "REMOTE" (XM-3 TRACKER IS NOT ON TARGET) AND AZIMUTH COMMANDS CHANGE FROM SATURATED GO LEFT TO SATURATED GO RIGHT .3 SECONDS LATER. AZIMUTH COMMANDS REMAIN SATURATED GO RIGHT FOR THE REMAINDER OF THE FLIGHT (SEE INCLOSURE 4, CHART 2, GRAPH C1-3; CHART 3, GRAPH C1-6).

(c) MISSILE. YAW FIN RESPONSE BEGINS TO FORM A SYSTEMATIC PATTERN OF HARD GO LEFT DEFLECTION FOR A PERIOD OF APPROXIMATELY FIVE SECONDS FOLLOWED BY AN APPROXIMATE ONE AND ONE-HALF SECOND PERIOD OF OSCILLATIONS AROUND ZERO DEGREES DEFLECTION. THIS PATTERN CONTINUES UNTIL APPROXIMATELY T + 170.5 SECONDS. AGC BECOMES STEADY AFTER INCREASING APPROXIMATELY 3 DB (SEE INCLOSURE 4, CHART 3, GRAPHS B1-6 AND B1-7; CHART 5, GRAPH B1-5).

(24) T + 122.7 SECONDS.

(a) EDL. TRANSPONDER RESPONSE CHANGES FROM 1100 PULSES PER SECOND TO APPROXIMATELY 731 (PRF OF RADAR) PULSES PER SECOND. PT RECEIVER AGC BEGINS TO DECREASE (SEE INCLOSURE 4, CHART 1, GRAPH B1-4; CHART 5, GRAPH A1-2).

(b) GGS. RADAR REMAINS IN "REMOTE" BEING CONTROLLED BY THE XM-3 TRACKER WHICH IS NOT ON TARGET. AZIMUTH COMMANDS REMAIN SATURATED GO RIGHT.

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(c) MISSILE. NO CHANGES IN RECORDED INDICATIONS.

(25) T + 130.8 SECONDS.

(A) EDL. TRANSPONDER RESPONSE IS STEADY AT APPROXIMATELY 1100 PULSES PER SECOND. PT RECEIVER AGC STILL DECREASING. NO CHANGE IN JAMMING TECHNIQUE IS MADE.

(B) GGs. RADAR IS SWITCHED FROM "REMOTE" TO "MANUAL" AND REPORTS "TARGET LOST." AZIMUTH COMMANDS REMAIN SATURATED GO RIGHT. (SEE INCLOSURE 4, CHART 2, GRAPH C1-3; CHART 1, GRAPH C1-4).

(c) MISSILE. NO CHANGES IN RECORDED INDICATIONS ARE NOTED.

(26) T + 146.7 SECONDS.

(A) EDL. PT RECEIVER AGC IS VERY LOW. TRANSPONDER RESPONSE IS APPROXIMATELY 600 PULSES PER SECOND (SEE INCLOSURE 4, CHART 5, GRAPH A1-2; CHART 1, GRAPH B1-4).

(B) GGs. OFF TARGET.

(c) MISSILE. NO CHANGE IN RECORDED INDICATION. CONTINUES TO FOLLOW PATTERN DESCRIBED AT T + 120.1 SECONDS.

(27) T + 148.3 SECONDS.

(A) EDL. RETURN SIGNAL LEVEL (AGC) HIGHER AND STEADY PROBABLY DUE TO RETUNING THE LOCAL OSCILLATOR IN THE PT RECEIVER (SEE INCLOSURE 4, CHART 5, GRAPH A1-2).

(B) GGs. OFF TARGET.

(c) MISSILE. NO CHANGE.

(28) T + 163.5 SECONDS.

(A) EDL. RETURN SIGNAL LEVEL (AGC) BEGINS TO DECREASE SLOWLY. TRANSPONDER RESPONSE CHANGES FROM 1100 PPS TO 731 PPS. (SEE INCLOSURE 4, CHART 5, GRAPH A1-2; CHART 1, GRAPH B1-4.)

(B) GGs. OFF TARGET.

(c) MISSILE. NO CHANGE.

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(29) T + 170.5 SECONDS.

(A) EDL. NO CHANGE IN RECORDED INDICATIONS.

(B) GGS. OFF TARGET.

(C) MISSILE. YAW FINS BEGIN TO FLUCTUATE INTERMITTENTLY WITH THE PERIOD BETWEEN FLUCTUATIONS DECREASING (SEE INCLOSURE 4, CHART 3, GRAPHS B1-6 AND B1-7).

(30) T + 206.5 SECONDS.

(A) EDL. PT RECEIVER AGC IS ERRATIC. PROBING SIGNALS ARE SENT BY THE JAMMER. TRANSPONDER RESPONSE CHANGES FROM APPROXIMATELY 1200 PPS TO APPROXIMATELY 100 PPS (SEE INCLOSURE 4, CHART 5, GRAPH A1-2; CHART 1, GRAPHS A1-1 AND B1-4).

(B) GGS. OFF TARGET.

(C) MISSILE. ALL FINS APPEAR TO BE COMPENSATING FOR ROLL.

(31) T + 209.0 SECONDS.

(A) EDL. JAMMING SIGNALS SENT BY JAMMER. TRANSPONDER RESPONSE CHANGES FROM 100 PPS TO APPROXIMATELY 1200 PPS. PT RECEIVER AGC VERY LOW (SEE INCLOSURE 4, CHART 1, GRAPHS A1-1 AND B1-4; CHART 5, GRAPHS A1-2).

(B) GGS. OFF TARGET.

(C) MISSILE. AGC VERY LOW (MORE THAN -30 DBM). ALL FINS SETTLE OUT WITH SMALL OSCILLATIONS BETWEEN ZERO AND 2 DEGREES DEFLECTION.

(32) T + 215.11 SECONDS. MISSILE IMPACT 7010 METERS LEFT; 7287 METERS OVER.

D. ANALYSIS OF RESULTS. REFERENCE TO PARAGRAPH 1c, THIS INCLOSURE, THE FOLLOWING ANALYSIS IS PRESENTED. TO FACILITATE RAPID CORRELATION BETWEEN EVENTS, REFERENCE WILL BE MADE TO T + TIMES.

(1) T + 38.35 SECONDS.

(A) THE FLUCTUATION OF GROUND RADAR AGC, AZIMUTH ANGULAR ERROR SIGNAL, AND ERRATIC OPERATION OF THE AUTO AIDED RELAY IS CAUSED BY

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THE INABILITY OF THE GROUND RADAR TO RECEIVE THE MISSILE TRANSPONDER PULSE FOR APPRECIABLE PERIODS OF TIME. RECURRENCE RATE OF THESE PERIODS IS ABOUT FIVE (5) CPS. FACTORS CONTRIBUTING TO THIS CONDITION ARE:

1. TRANSPONDER PULSE WIDTH.
2. TRANSPONDER RECOVERY TIME.
3. RATE AT WHICH THE TRANSPONDER IS BEING INTERROGATED.
4. PULSE RECURRENCE FREQUENCY OF THE GROUND RADAR.
5. WIDTH OF NARROW GATE WHICH GATES THE INPUT CIRCUITRY OF THE GROUND RADAR AUTOMATIC ELEVATION TRACKING UNIT.

(B) THE TRANSPONDER PULSE WIDTH (TRANSMISSION TIME) AND RECOVERY TIME ARE SUCH THAT WHEN THE TRANSPONDER IS INTERROGATED IT WILL TRANSMIT FOR A PERIOD OF 1.6 MICRO SECONDS AND CANNOT BE INTERROGATED AGAIN FOR APPROXIMATELY 400 MICRO SECONDS. THE RATE AT WHICH THE TRANSPONDER IS INTERROGATED IS A FUNCTION OF GROUND RADAR PULSE RECURRENCE FREQUENCY (APPROXIMATELY 731 CPS) AND EDL JAMMER PULSE RECURRENCE FREQUENCY (APPROXIMATELY 2201 CPS). JAMMER PRF IS THREE (3) TIMES THAT OF THE GROUND RADAR, PLUS APPROXIMATELY 5 CPS. THE TRANSPONDER IS INTERROGATED AT A FREQUENCY LOWER THAN THAT OF THE JAMMER PRF DUE TO DESIGN CHARACTERISTICS OF THE TRANSPONDER. A CONDITION WILL EXIST PERIODICALLY WHEN THE TRANSPONDER IS INTERROGATED BY THE JAMMER AND TWO OR THREE HUNDRED MICRO SECONDS LATER IT IS INTERROGATED BY THE GROUND RADAR. A DELAY LINE IN THE TRANSPONDER WHICH MUST BE ALLOWED TO CHARGE FOR APPROXIMATELY 400 MICRO SECONDS HAS NOT CHARGED SUFFICIENTLY TO PRODUCE A TRANSPONDER OUTPUT AS A RESULT OF THIS SECOND INTERROGATION. (NOTE BASE LINING IN PHOTOS D1-2, NRS 2 AND 3, INCLOSURE 5.) THE DELAY LINE BEGINS ANOTHER CHARGE CYCLE AND TWO OR THREE HUNDRED MICRO SECONDS LATER THE JAMMER AGAIN INTERROGATES THE TRANSPONDER (PERIOD OF JAMMER PRF IS APPROXIMATELY 450 μ SECONDS). AGAIN, THE DELAY LINE HAS NOT CHARGED SUFFICIENTLY TO PRODUCE A TRANSPONDER OUTPUT. THE NEXT TWO JAMMER PULSES WILL INTERROGATE THE TRANSPONDER AND A TRANSPONDER OUTPUT WILL RESULT. HOWEVER, APPROXIMATELY 200 MICRO SECONDS AFTER THE SECOND OF THESE TWO PULSES THE CORPORAL GROUND RADAR INTERROGATES THE TRANSPONDER AND THE SEQUENCE STARTS OVER AGAIN. IF THE JAMMER PRF WERE EXACTLY THREE TIMES THE GROUND RADAR PRF, THE SEQUENCE DESCRIBED ABOVE WOULD CONTINUE INDEFINITELY. UNDER THIS CONDITION THE GROUND RADAR WOULD NEVER RECEIVE A TRANSPONDER PULSE, AND THE EDL PASSIVE TRACK RECEIVER WOULD RECEIVE TRANSPONDER PULSES AT A FREQUENCY EQUAL TO $2/3$ THE JAMMER PRF. THE SEQUENCE IS SLOWLY CHANGING HOWEVER, SINCE THE JAMMER PRF IS EQUAL TO THREE TIMES THE GROUND RADAR PRF PLUS APPROXIMATELY 5 CPS. AFTER ABOUT $1/4$ SECOND THE TIME RELATIONSHIP BETWEEN THE JAMMER PRF AND THE GROUND RADAR PRF WILL HAVE CHANGED ENOUGH (400 μ SECONDS) TO ALLOW INTERROGATION OF THE TRANSPONDER BY THE GROUND RADAR BEFORE THE NEXT JAMMER INTERROGATION (450 μ SECONDS).

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(c) THE INPUT CIRCUITRY TO THE AZIMUTH AND ELEVATION TRACKING SYSTEM IS GATED TO INSURE THAT ONLY THOSE TRANSPONDER PULSES CAUSED BY GROUND RADAR INTERROGATION WILL ENTER THE AZIMUTH AND ELEVATION TRACKING SYSTEM (REFERENCE PARAGRAPH 1A, INCLOSURE 1, RADAR SET AN/MPQ-25). THIS GATE IS OPEN BETWEEN APPROXIMATELY 5 MICRO SECONDS BEFORE THE EXPECTED TRANSPONDER RETURN PULSE AND 5 MICRO SECONDS AFTER EXPECTED TRANSPONDER RETURN PULSE. IN THE EVENT A TRANSPONDER PULSE CAUSED BY JAMMER INTERROGATION ARRIVES AT THE INPUT OF THE AZIMUTH AND ELEVATION TRACKING UNIT AFTER THE GATE HAS OPENED UP AND BEFORE THE EXPECTED RETURN PULSE, SLANT RANGE MEASUREMENT IS AFFECTED, RANGE MEASUREMENT IS A FUNCTION OF TIME (SEE PHOTOS D 11-1, INCLOSURE 5), AND AZIMUTH AND ELEVATION DATA IS AFFECTED BECAUSE THE RADAR ANTENNA BEAM MAY BE DISPLACED FROM THE MISSILE (DUE TO CONICAL SCAN ROTATION) BY AS MUCH AS 1°. THESE ERRORS ARE SMALL HOWEVER, IN COMPARISON TO THE ERRORS CAUSED BY LOSS, AT THE GROUND RADAR, OF TRANSPONDER SIGNALS FOR RELATIVELY LONG PERIODS OF TIME. DURING THESE PERIODS NO ERROR SIGNAL IS PRESENT IN THE TRACKING SYSTEM AND ERROR MEASUREMENT VOLTAGE GOES TO ZERO. AS A RESULT AZIMUTH ANGULAR ERROR (θ), ELEVATION ERROR, ELEVATION COMMANDS, AND AZIMUTH COMMANDS INCREASE AND DECREASE SINUSOIDALLY AT APPROXIMATELY 4 CPS.

(d) ERRONEOUS COMMANDS DEVELOPED AS DESCRIBED ABOVE ARE TRANSMITTED TO AND ACTED UPON BY THE MISSILE.

(2) T + 45.8 SECONDS. CHANGING JAMMER PRF FROM APPROXIMATELY 2200 CPS TO APPROXIMATELY 1475 CPS CAUSED THE SAME RESULTS AS DISCUSSED ABOVE EXCEPT THAT THE FREQUENCY OF OSCILLATION IN RADAR AGC, AUTO-AIDED RELAY AND AZIMUTH ANGULAR ERROR IS NOW APPROXIMATELY 10 CPS (1475 CPS EQUALS TWICE RADAR PRF PLUS APPROXIMATELY 10 CPS). ADDITION OF A FOURTH PULSE TO THE JAMMER PULSE GROUP AT THIS TIME GIVES THE JAMMER THE ABILITY TO COMMAND THE MISSILE IN YAW (SEE PARAGRAPH 2, INCLOSURE 1 CORPORAL MISSILE INTERNAL GUIDANCE SYSTEM). THE "GO LEFT" COMMANDS SENT TO THE MISSILE BY THE JAMMER OVERRIDE ANY COMMANDS THE GROUND RADAR MIGHT DEVELOP TO CORRECT THIS CONDITION BECAUSE THE TRANSPONDER IS INTERROGATED BY THE JAMMER AT A MUCH GREATER RATE THAN BY THE GROUND RADAR (SEE DISCUSSION UNDER T + 38.35 SECONDS).

(3) T + 46.6 SECONDS. NORTH AND SOUTH FINS MOVE TO HARD GO LEFT POSITION BECAUSE OF JAMMER COMMANDS AND ARE SOMEWHAT ERRATIC SINCE GROUND RADAR COMMANDS TRY TO CORRECT THIS CONDITION FOR RELATIVELY SHORT PERIODS OF TIME.

(4) T + 48.5 SECONDS. THE STRONGER SIGNALS RECEIVED BY THE GROUND RADAR MAKE TRACKING LESS DIFFICULT. HOWEVER, THE RECEIVED SIGNAL IS NOT AT THE EXPECTED TIME AND ERRORS ARE CAUSED BY DISPLACEMENT OF THE RADAR ANTENNA BEAM FROM THE MISSILE DUE TO CONICAL SCAN (SEE DISCUSSION UNDER T + 38.35 SECONDS).

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(5) T + 104.5 SECONDS. THE RANGE CORRECTION POLARITY PULSE RECEIVED BY THE MISSILE IS BELIEVED TO HAVE BEEN CAUSED BY THE 5TH GROUND RADAR PULSE BEING IN COINCIDENCE WITH THE FOURTH JAMMER PULSE. THE FOURTH JAMMER PULSE WAS MODULATED AT 72 CPS YAW COMMAND CAUSING A POSITIVE POLARITY PULSE. THIS POLARITY PULSE STARTED THE TIMERS WHICH TERMINATE AZIMUTH COMMAND AND CAUSE RANGE CORRECTION MANEUVER START.

(6) T + 130.8 SECONDS. SWITCHING THE GROUND RADAR TO "MANUAL" CAUSED ERRONEOUS COMMANDS TO BE SENT TO THE MISSILE. ORDINARILY THE PRF WOULD HAVE BEEN DROPPED OUT PRIOR TO THIS, PREVENTING THE MISSILE FROM RECEIVING THESE COMMANDS. HOWEVER, UNDER CONDITIONS OF JAMMING SUCH AS EXISTED AT THIS TIME, THE FAIL SAFE RELAY IN THE MISSILE IS BEING KEPT OPEN BY THE JAMMER AND SWITCHING GROUND RADAR TO PRF DROPOUT WOULD NOT PREVENT GROUND RADAR COMMANDS FROM BEING RECEIVED BY THE MISSILE.

2. MISSILE FIRING !! U-14.

A. PURPOSE. THE PURPOSE OF THIS TEST WAS TO:

(1) DETERMINE WHETHER OR NOT THE CORPORAL MISSILE COULD BE "CAPTURED" AND COMMANDED IN FLIGHT BY CERTAIN EDL JAMMING EQUIPMENT OPERATING UNDER NEAR SIMULATED COMBAT CONDITIONS.

(2) DETERMINE THE EFFECTS OF THIS JAMMING ON THE GROUND GUIDANCE STATION (GGS).

(3) DETERMINE THE EFFECTS OF THIS JAMMING ON THE MISSILE.

(4) DETERMINE THE EASE WITH WHICH THIS JAMMING MAY BE ACCOMPLISHED.

(5) PROVIDE A MEANS OF FIELD TESTING CERTAIN EDL EQUIPMENT AND JAMMING TECHNIQUES.

B. CONDUCT OF TEST.

(1) THIS TEST WAS CONDUCTED UNDER NORMAL CONDITIONS IN AS MUCH AS THE INFORMATION KNOWN BY EDL WAS LIMITED. EDL WAS AWARE THAT A CORPORAL MISSILE WOULD BE FIRED FROM APPROXIMATELY THE SAME AREA AS !! U-13 SOMETIME AFTER 1800 HOURS. EDL WAS NOT GIVEN THE FOLLOWING INFORMATION:

(A) PULSE RECURRENCE FREQUENCY (PRF) WHICH WAS CHANGED TO 853 PULSE GROUPS PER SECOND FOR THIS FLIGHT.

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(B) THE FREQUENCIES OF ALL RADIATING ELEMENTS. THESE WERE NOT CHANGED FROM THE FIRING OF 11 U-13.

(C) THE LAUNCHING TIME.

(D) THE CODE USED IN THE TRANSPONDER SET.

(2) VOICE COMMUNICATION WAS MAINTAINED BETWEEN THE EDL SUPERVISOR AT HADC AND THE GRO.GRANDE CORPORAL FIRING AREA IN THE EVENT AN EQUIPMENT BREAKDOWN OR CANCELLATION OF FIRING OCCURRED. RANGE SILENCE WAS MAINTAINED ON THE RADAR AND RADAR IMAGE FREQUENCIES.

C. RESULTS OF TEST. THE FOLLOWING IS A CHRONOLOGICAL SEQUENCE OF EVENTS INCLUDING THE ACTION TAKEN BY EDL AND SUBSEQUENT EFFECTS ON THE GROUND GUIDANCE STATION AND THE MISSILE.

(1) X-4 MINUTES. THE GROUND RADAR BEGINS TO RADIATE TO THE MISSILE AND CONTINUES RADIATION UNTIL IMPACT. THE TRANSPONDER SET IN THE MISSILE RECEIVES THE CODED PULSE GROUPS AND TRANSMITS A TRACKING PULSE TO THE RADAR. EDL INTERCEPTS THE RADIATION EMITTED BY THE RADAR, BUT DOES NOT TAKE ACTIVE COUNTERMEASURES.

(2) T + 0 SECONDS. TAILBREAK.

(3) T + 5 SECONDS.

(A) EDL. RECEIVES FIRST INDICATION OF MISSILE SIGNAL INTERCEPT USING AUTOMATIC FREQUENCY DETECTION.

(B) GGS. NO EFFECTS ARE NOTED.

(C) MISSILE. BEGINS TO PROGRAM NORMALLY.

(4) T + 5.8 SECONDS.

(A) EDL. PT OUTPUT POSITIONING DATA IS BAD. TRANSPONDER RESPONSE INDICATES PT RECEIVER IS RECEIVING APPROXIMATELY 900 PULSES PER SECOND MODULATED AT 26 CPS. AGC IS ERRATIC (SEE INCLOSURE 4, CHART 6, GRAPH B11-4; CHART 10, GRAPH A11-2).

(B) GGS. NO EFFECTS ARE NOTED.

(C) MISSILE. CONTINUES TO PROGRAM NORMALLY.

(5) T + 21.0 SECONDS.

SECRET

(A) EDL. NO CHANGE IN RECORDED INDICATIONS.

(B) GGS. RADAR BEGINS TO TRANMIT COMMANDS TO THE MISSILE (SEE INCLOSURE 4, CHART 8, GRAPH C11-6; CHART 9, GRAPH C11-7).

(C) MISSILE. "COMMANDS IN" ACTUATOR B-1, IN THE CONTROLLER FAILS TO OPERATE PREVENTING RADAR (AND JAMMING) COMMANDS FROM PASSING THROUGH THE CONTROLLER TO THE FINS (SEE INCLOSURE 4, CHART 7, GRAPH B 11-1).

(6) T + 34.5 SECONDS.

(A) EDL. PT OUTPUT POSITIONING DATA IS GOOD AND IS SENT TO THE PULSE JAMMER. PT RECEIVED SIGNAL LEVEL (AGC) VERY WEAK BUT STEADY AND USEABLE (SEE INCLOSURE 4, CHART 10, GRAPH A11-2).

(B) GGS. NO EFFECTS ARE INDICATED.

(C) MISSILE. CONTINUES TO FOLLOW AN UNGUIDED TRAJECTORY.

(7) T + 38.3 SECONDS.

(A) EDL. THE PULSE JAMMER IS ENERGIZED AND PROBING IN BOTH FREQUENCY AND CODE BEGINS. CODE PROBE CONSISTS OF A GROUP OF THREE PULSES AT A PRF OF 2192 PULSE GROUPS PER SECOND.

(B) GGS. NO EFFECTS ARE INDICATED.

(C) MISSILE. NO CHANGE.

(8) T + 40 SECONDS.

(A) EDL. FIRST INDICATION OF CODE LOCK IS PRESENT. RECORDINGS INDICATE INTERMITTENT CODE PROBE AND LOCK (SEE INCLOSURE 4, CHART 6, GRAPH A11-1).

(B) GGS. NO EFFECTS ARE INDICATED.

(C) MISSILE. NO CHANGE.

(9) T + 41.5 SECONDS.

(A) EDL. NO CHANGE IN RECORDED INDICATIONS.

(B) GGS. FIRST INDICATION OF JAMMING IS NOTED. AZIMUTH ANGULAR ERROR BECOMES MORE ERRATIC CAUSING AZIMUTH COMMANDS TO BE ERRATIC (SEE INCLOSURE 4, CHART 8, GRAPH C11-6; INCLOSURE 5, PHOTOS D11-1).

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(c) MISSILE. DOES NOT RESPOND TO GUIDANCE COMMANDS BUT CONTINUES ALONG AN UNGUIDED TRAJECTORY.

(10) T + 44.3 SECONDS.

(A) EDL. INCREASE IN PT RECEIVER AGC IS NOTED (SEE INCLOSURE 4, CHART 10, GRAPH A11-2).

(B) GGG. NO CHANGE IN RECORDED INDICATIONS.

(c) MISSILE. NO CHANGE.

(11) T + 49.8 SECONDS.

(A) EDL. SUDDEN INCREASE IN TRANSPONDER RESPONSE IS PRESENT (SEE INCLOSURE 4, CHART 6, GRAPH B11-4), ALSO CODE LOCK IS MAINTAINED DURING THIS PERIOD OF TIME.

(B) GGG. AZIMUTH ANGULAR ERROR AND AZIMUTH COMMANDS BECOME MORE ERRATIC.

(c) MISSILE. NO CHANGE.

(12) T + 59.92 SECONDS.

(A) EDL. SUDDEN SHORT INCREASE IN TRANSPONDER RESPONSE IS PRESENT (SEE INCLOSURE 4, CHART 6, GRAPH B11-4).

(B) GGG. NO APPRECIABLE CHANGE IN AZIMUTH ANGULAR ERROR VOLTAGE IS PRESENT. AZIMUTH COMMANDS ARE SATURATED "GO LEFT".

(c) MISSILE. NO CHANGE.

(13) T + 60.21 SECONDS.

(A) EDL. TRANSPONDER RESPONSE RETURNS TO APPROXIMATELY 900 PULSES PER SECOND (SEE INCLOSURE 4, CHART 6, GRAPH B11-4).

(B) GGG. AZIMUTH COMMANDS ARE SLIGHTLY MORE ERRATIC, HOWEVER ARE ESSENTIALLY SATURATED "GO LEFT" (SEE INCLOSURE 4, CHART 8, GRAPH C11-6).

(c) MISSILE. VERY SMALL YAW FIN MOVEMENT IS DETECTED. THE MOVEMENT IS TO THE LEFT AND IS COINCIDENT WITH COMMANDS FROM THE GGS.

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(14) T + 85.0 SECONDS.

(A) EDL. INTERMITTENT PROBE AND LOCK CONTINUES. MANUAL FREQUENCY TUNING IS BEING EMPLOYED. PT RECEIVED SIGNAL LEVEL IS STEADY. TRANSPONDER RESPONSE REMAINS STEADY (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4; CHART 10, GRAPH A11-2).

(B) GGs. VERY SMALL CHANGES ARE INDICATED IN THE AZIMUTH ANGULAR ERROR VOLTAGE, BUT AZIMUTH COMMANDS REMAIN SATURATED "GO LEFT" (SEE INCLOSURE 4, CHART 8, GRAPH C11-6).

(C) MISSILE. YAW FIN RECORDINGS INDICATE A SLIGHT YAW LEFT POSITION. MISSILE T6 AGC BEGINS TO COME OUT OF SATURATION (SEE INCLOSURE 4, CHART 8, GRAPHS B11-6 AND B11-7; CHART 10, GRAPH B11-5).

(15) T + 105.0 SECONDS.

(A) EDL. INTERMITTENT PROBING AND JAMMING CONTINUES (SEE INCLOSURE 4, CHART 6, GRAPH A11-1).

(B) GGs. ERRATIC INDICATIONS ARE PRESENT IN THE ELEVATION ERROR CHANNEL. RANGE TRACKING APPEARS TO BE UNSTEADY (ROUGH). AZIMUTH ANGULAR ERROR IS ONLY SLIGHTLY ERRATIC; HOWEVER, AZIMUTH COMMANDS ARE STILL SATURATED "GO LEFT."

(C) MISSILE. NO CHANGE IN RECORDED INDICATIONS.

(16) T + 114.0 SECONDS.

(A) EDL. SHARP DROP IN PT RECEIVER AGC IS PRESENT (SEE INCLOSURE 4, CHART 10, GRAPH A11-2).

(B) GGs. NO CHANGE IN RECORDED INDICATIONS.

(C) MISSILE. NO CHANGE IN RECORDED INDICATIONS.

(17) T + 122.74 SECONDS.

(A) EDL. PT RECEIVER AGC IS STEADY.

(B) GGs. RANGE CORRECTION COMMANDS ARE BEING TRANSMITTED TO THE MISSILE.

(C) MISSILE. RANGE CORRECTION COMMANDS ARE RECEIVED BY THE MISSILE (SEE INCLOSURE 4, CHART 7, GRAPH B11-1).

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(18) T + 124.4 SECONDS.

(A) EDL. PULSE JAMMER LOCKS IN SOLID. TRANSPONDER RESPONSE INCREASES TO APPROXIMATELY 2,000 PULSES PER SECOND (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4).

(B) GGS. AZIMUTH ANGULAR ERROR BECOMES VERY ERRATIC. AZIMUTH COMMANDS CHANGE FROM SATURATED GO LEFT TO SATURATED GO RIGHT. RADAR AGC DECREASES SLIGHTLY (SEE INCLOSURE 4, CHART 8, GRAPH C11-6; CHART 10, GRAPH C11-5).

(C) MISSILE. YAW FINS CHANGE FROM APPROXIMATELY 2 DEGREES YAW LEFT TO 0 DEGREES YAW (SEE INCLOSURE 4, CHART 8, GRAPHS B11-6 AND B11-7).

(19) T + 130.8 SECONDS.

(A) EDL. FOUR PULSE JAMMING BEGINS (THE FOURTH PULSE IS POSITION MODULATED AT 72 CPS IN ORDER TO PRODUCE A GO LEFT COMMAND IN THE MISSILE). JAMMER PRF IS REDUCED FROM 2192 PULSE GROUPS PER SECOND TO 1475 PULSE GROUPS PER SECOND. JAMMING BECOMES INTERMITTENT. TRANSPONDER RESPONSE DECREASES TO APPROXIMATELY 731 PULSES PER SECOND WITH OCCASIONAL RISES TO APPROXIMATELY 1200 PULSES PER SECOND (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4).

(B) GGS. AZIMUTH ANGULAR ERROR CHANGES DIRECTION. AZIMUTH COMMANDS CHANGE FROM SATURATED GO RIGHT TO SATURATED GO LEFT. RADAR AGC BEGINS TO INCREASE SLIGHTLY (SEE INCLOSURE 4, CHART 6, GRAPH C11-4; CHART 8, GRAPH C11-6; CHART 10, GRAPH C11-5).

(C) MISSILE. BEACON AGC BEGINS TO DECREASE SLIGHTLY. YAW FINS MOVE TO APPROXIMATELY 2 DEGREES YAW LEFT.

(20) T + 159.2 SECONDS.

(A) EDL. JAMMER LOCKS IN SOLID FOR APPROXIMATELY 1.5 SECONDS. TRANSPONDER RESPONSE INCREASES TO APPROXIMATELY 1400 PULSES PER SECOND DURING THIS PERIOD.

(B) GGS. AZIMUTH ANGULAR ERROR CHANGES DIRECTION. AZIMUTH COMMANDS CHANGE FROM SATURATED GO LEFT TO SATURATED GO RIGHT. INDICATIONS OF ERRATIC RANGE TRACKING (SEE INCLOSURE 4, CHART 8, GRAPH C11-6, AND INCLOSURE 5, PHOTOS D11-2).

(C) MISSILE. YAW FINS RESPOND TO SATURATED COMMANDS TO A LIMITED DEGREE (SEE INCLOSURE 4, CHART 8, GRAPHS B11-6 AND B11-7). MISSILE BEACON AGC BECOMES STEADY (SEE INCLOSURE 4, CHART 10, GRAPH B11-5).

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(21) T + 178.5 to 202.1 SECONDS.

(A) JAMMER ESTABLISHES SOLID LOCK. TRANSPONDER RESPONSE INCREASES TO APPROXIMATELY 1400 PULSES PER SECOND (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4).

(B) GGS. AZIMUTH COMMANDS SATURATE INTERMITTENTLY IN BOTH DIRECTIONS. AZIMUTH ANGULAR ERROR BECOMES VERY ERRATIC. RADAR AGC IS VERY ERRATIC. PRF IS DROPPED OUT AT T + 188.7 SECONDS. RADAR IS SWITCHED FROM AUTOMATIC TO MANUAL AT T + 199.8 SECONDS (SEE INCLOSURE 4, CHART 8, GRAPH C11-6; CHART 10, GRAPH C11-5; CHART 7, GRAPH C11-3).

(C) MISSILE. YAW FINS INDICATE A SLIGHT MOVEMENT IN RESPONSE TO HARD GO RIGHT COMMAND. PITCH FINS MOVE TO EXECUTE RANGE CORRECTION MANEUVER AT T + 197.0 SECONDS. MISSILE BEACON AGC IS EXTREMELY ERRATIC (SEE INCLOSURE 4, CHART 8, GRAPHS B11-6 AND B11-7; CHART 10, GRAPH B11-5).

(22) T + 202.1 SECONDS.

(A) EDL. JAMMING BECOMES INTERMITTENT. PT RECEIVER AGC DECREASES (INDICATING A WEAK RECEIVED SIGNAL). TRANSPONDER RESPONSE DECREASES TO APPROXIMATELY 400 PULSES PER SECOND (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4; CHART 10, GRAPH A11-2).

(B) GGS. AZIMUTH ANGULAR ERROR CHANGES DIRECTION. AZIMUTH COMMANDS ARE SATURATED TO GO LEFT.

(C) MISSILE. NO CHANGE IN RECORDED INDICATIONS.

(23) T + 204.9 SECONDS.

(A) EDL. JAMMER ESTABLISHED SOLID LOCK UNTIL NEAR IMPACT. PT RECEIVER AGC INCREASES AND REMAINS NEARLY CONSTANT UNTIL IMPACT. TRANSPONDER RESPONSE INCREASES TO APPROXIMATELY 1500 PULSES PER SECOND, BUT IS VERY ERRATIC UNTIL IMPACT (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4; CHART 10, GRAPH A11-2).

(B) GGS. AZIMUTH COMMANDS ARE SATURATED GO RIGHT UNTIL IMPACT. RADAR AGC INDICATES A FAIR RETURN SIGNAL LEVEL. PRF IS SWITCHED "IN" AND REMAINS IN UNTIL IMPACT (SEE INCLOSURE 4, CHART 8, GRAPH C11-6; CHART 10, GRAPH C11-5; CHART 7, GRAPH C11-3).

(C) MISSILE. YAW FINS INDICATE VERY SMALL RESPONSE TO COMMANDS. PITCH FINS MOVE TO COMPLETE THE RANGE CORRECTION MANEUVER. MISSILE BEACON AGC DECREASES INDICATING A DECREASE IN RECEIVED SIGNAL LEVEL (SEE INCLOSURE 4, CHART 8, GRAPHS B11-6 AND B11-7; CHART 10, GRAPHS B11-5).

(24) T + 213.99 SECONDS.

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(A) EDL. JAMMER BEGINS TO PROBE. PT RECEIVER AGC FALLS TO ZERO. TRANSPONDER RESPONSE DECREASES TO APPROXIMATELY 400 PULSES PER SECOND, THE LOWEST CALIBRATED LEVEL (SEE INCLOSURE 4, CHART 6, GRAPHS A11-1 AND B11-4; CHART 10, GRAPH A11-2).

(B) GGS. AZIMUTH COMMANDS ARE SATURATED GO RIGHT. RADAR AGC DISAPPEARS.

(C) MISSILE. THE MISSILE IMPACTS 2714 METERS RIGHT AND 749 METERS SHORT OF THE INTENDED TARGET.

D. ANALYSIS OF RESULTS. REFERENCE IS MADE TO PARAGRAPH 2c, THIS INCLOSURE. THE FOLLOWING ANALYSIS IS PRESENTED WHERE NECESSARY. TO FACILITATE RAPID CORRELATION OF EVENTS, REFERENCE WILL BE MADE TO T + TIMES.

(1) T + 21.0 SECONDS. THE "COMMANDS IN" ACTUATOR B-1 (LOCATED IN THE CONTROLLER OF THE MISSILE) IS A MOTOR DRIVEN DEVICE CONNECTED TO TWO WIRE WOUND POTENTIOMETERS AND NECESSARY TELEMETERING AND POLARITY REVERSING SWITCHES. WITHIN TWO SECONDS AFTER BEING ENERGIZED, ACTUATOR B-1 WILL DRIVE THE CONTACT ARMS OF THE TWO YAW AND PITCH COMMAND POTENTIOMETERS ADMITTING YAW AND PITCH DC SIGNALS FROM THE TRANSPONDER SET INTO THE YAW AND PITCH MODULATORS IN THE CONTROLLER. DEFINITE FAILURE OF THIS UNIT IS INDICATED AS NO TELEMETERING BLIP IS RECEIVED, AND NO COMMANDS ARE SEEN ON ALL FIN RECORDINGS PRIOR TO SHUTOFF. THE MOST OBVIOUS POSSIBILITY OF FAILURE IS THAT THE ACTUATOR MOTOR JAMMED.

(2) T + 40 SECONDS. INTERMITTENT CODE PROBE AT THIS TIME AND LATER INFIGHT, INDICATE THAT EDL WAS HAVING DIFFICULTY INTERROGATING THE TRANSPONDER. THIS IS BELIEVED TO HAVE BEEN CAUSED BY THE MALFUNCTION MENTIONED IN PARAGRAPH 5c, BASIC LETTER.

(3) T + 59.92 SECONDS. GROUND RADAR YAW COMMANDS ARE PRE- DOMINANTLY "GO LEFT" FROM ABOUT T + 40 SECONDS TO ABOUT T + 124 SECONDS. THE MISSILE COULD NOT RESPOND TO THESE COMMANDS (SEE DISCUSSION UNDER T + 21 SECONDS).

(4) T + 60.21 SECONDS. YAW FIN MOVEMENTS AT THIS TIME ARE PROBABLY A RESULT OF ACTUATOR B-1 TURNING A SMALL AMOUNT ALLOWING A SMALL PORTION OF THE DC SIGNAL TO BE PICKED OFF. THE TURNING OF ACTUATOR B-1 COULD HAVE BEEN CAUSED BY VIBRATION DURING SHUTOFF OF THE MISSILE MOTOR (SEE DISCUSSION UNDER T + 21 SECONDS).

(5) T + 105.0 SECONDS. DURING THIS TIME (APPROXIMATE TIME FOR RANGE CORRECTION) THE ELEVATION ERROR AND SLANT RANGE MEASUREMENT ARE ERRATIC. RANGE CORRECTION COMMAND, 8X1, IS COMPUTED NEAR MIDTRAJECTORY

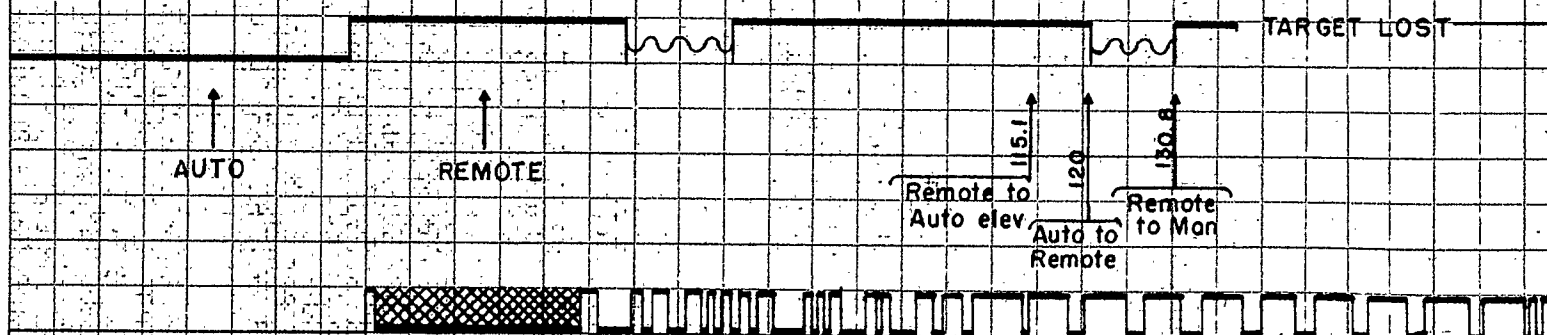
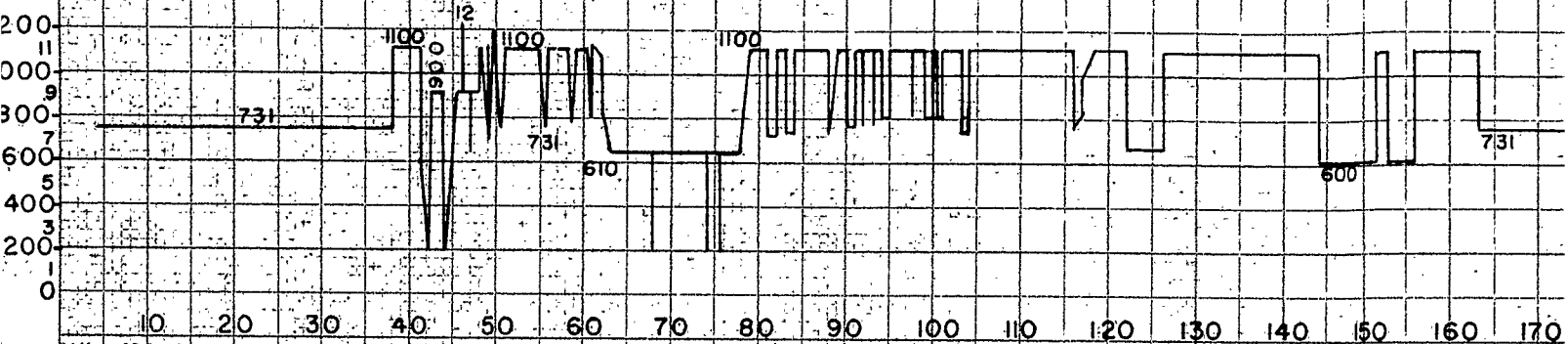
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FROM ERRORS IN MISSILE VELOCITY, SLANT RANGE, ELEVATION ANGLE, AND RATE OF CHANGE OF ELEVATION ANGLE. RANGE CORRECTION COMMAND NORMALLY INDICATES THE EXPECTED RANGE ERROR AT IMPACT PROVIDED THE REMAINDER OF MISSILE FLIGHT IS UNDISTURBED BY GUIDANCE COMMAND, OR RECEIVED SIGNALS EXTERNAL TO THE MISSILE ($\delta x_f = A \Delta R' + B \sin \beta + C \sin \beta + D$). A, B, C, AND D ARE CONSTANTS SET TO PRECALCULATED VALUES TAKEN FROM THE CORPORAL FIRING TABLES. THE RECORDED VALUE OF $\Delta R_f = 150 \sin \beta$, AND TIME AT WHICH RC VELOCITY WAS REACHED ALL INDICATE NEGATIVE RANGE ERRORS AT IMPACT WERE ANTICIPATED. THE MISSILE POSITION AT THIS TIME, AS SEEN BY THE GROUND RADAR, WAS IN ERROR BY AN APPRECIABLE AMOUNT. HOWEVER, BASED ON THE MISSILE POSITION AND VELOCITY ERRORS SEEN BY THE GROUND GUIDANCE SYSTEM, THE SYSTEM SHOULD HAVE COMPUTED AND TRANSMITTED TO THE MISSILE A "GO LONG" COMMAND OF APPROXIMATELY 914 METERS. ACTUAL COMMAND COMPUTED, AND ACTED UPON BY THE MISSILE, WAS A "GO SHORT" COMMAND OF APPROXIMATELY 812 METERS. RANGE CORRECTION VELOCITY WAS REACHED ABOUT 3 SECONDS EARLIER THAN EXPECTED AND THE RECORDED SLANT RANGE ERROR (ΔR_f) WAS SATURATED IN A POSITIVE DIRECTION. NORMALLY A VOLTAGE LIMITING NETWORK IN THE RADAR R_0 RANGE UNIT LIMITS THE VALUE OF ΔR_f TO 10 VOLTS UNDER THE ABOVE CONDITION. A POSSIBLE MALFUNCTION OF THE VOLTAGE LIMITING NETWORK IN THE RADAR R_0 RANGE UNIT CAUSED THE VALUE OF ΔR_f TO BE APPROXIMATELY + 17 VOLTS WHEN RANGE CORRECTION VELOCITY WAS REACHED BY THE MISSILE. THE ERROR IN ΔR_f AT THIS TIME CAUSED THE RANGE CORRECTION COMMAND (δx_1) TO BE IN ERROR IN BOTH POLARITY AND AMPLITUDE.

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AUTO

REMOTE

Remote to
Auto elev

Auto to
Remote

Remote
to Man

TARGET LOST

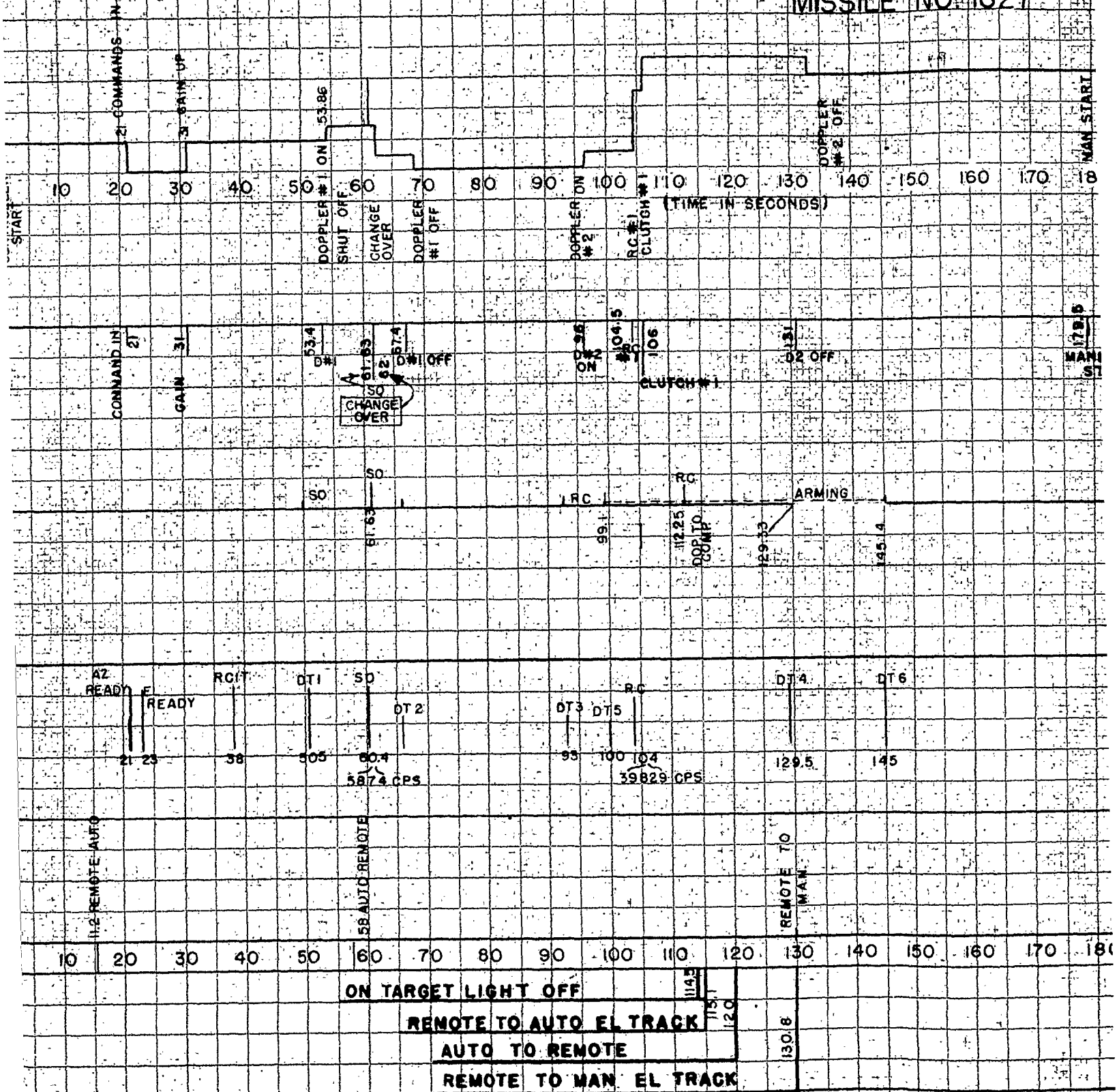
3 Pulses
JAM
PROBE

4 Pulses

INCL 4

SECRET

SECRET
MISSILE NO. 1627



SECRET

SECRET

MISSILE NO. 1627

FIN POS

FIN

NORTH

62

FIN

SOUTH

64

RIGHT

(OFF TAPE)

GROUND

LEFT

SECRET

(OFF TAPE)

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
INCL 4 (TIME IN SECONDS)

SECRET

MISSILE NO. 1627

FIN POS

FIN

EAST

63

FIN

WEST

518

UP

GROUND

DOWN

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

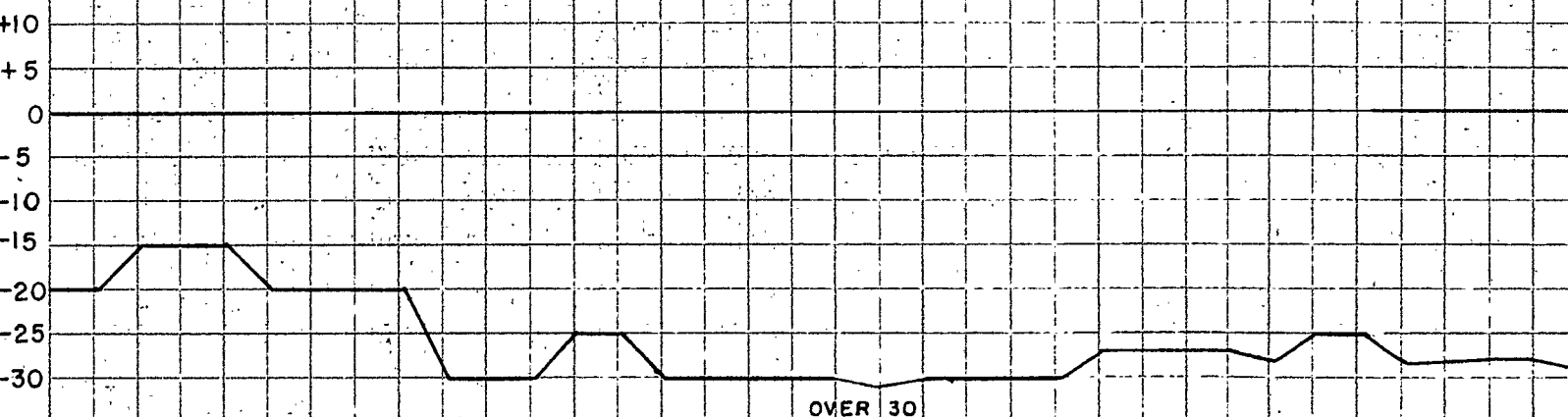
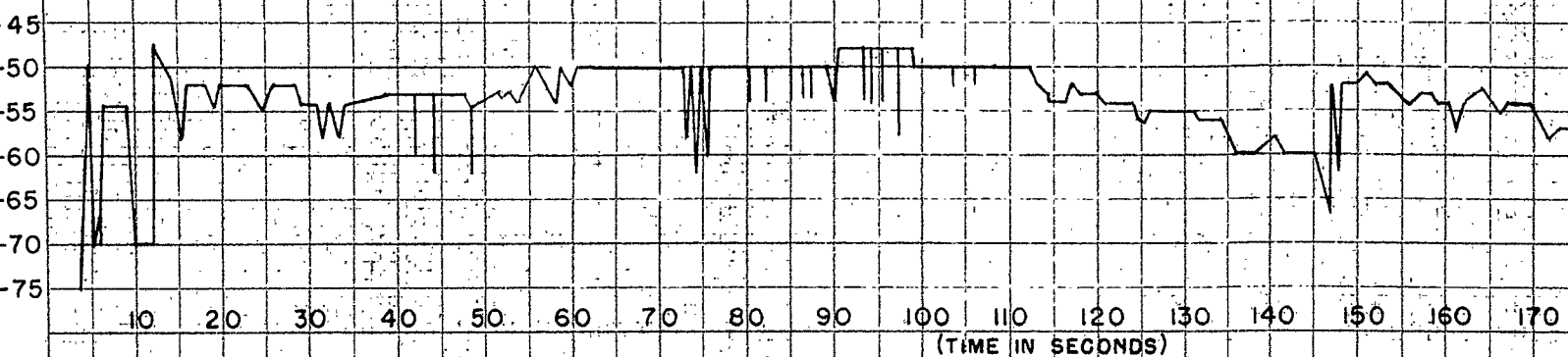
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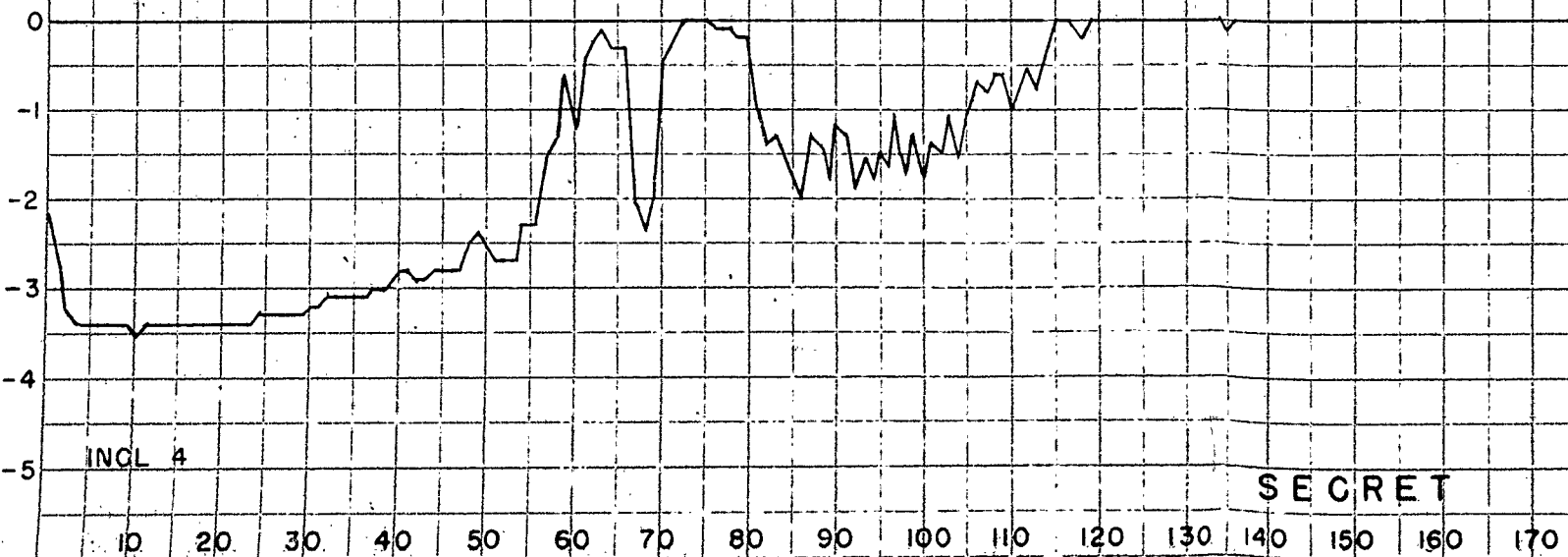
INCL 4

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MISSILE NO. 1627



OVER 30

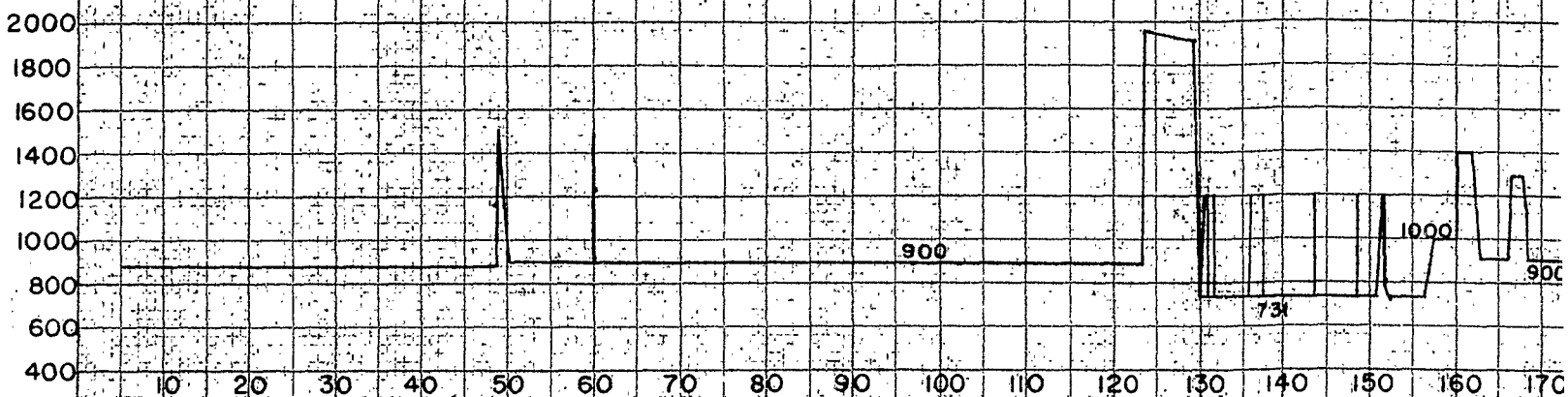


INCL 4

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MISSILE IIU-14 166



MALFUNCTION IN MISSILE — NO "COMMANDS IN"

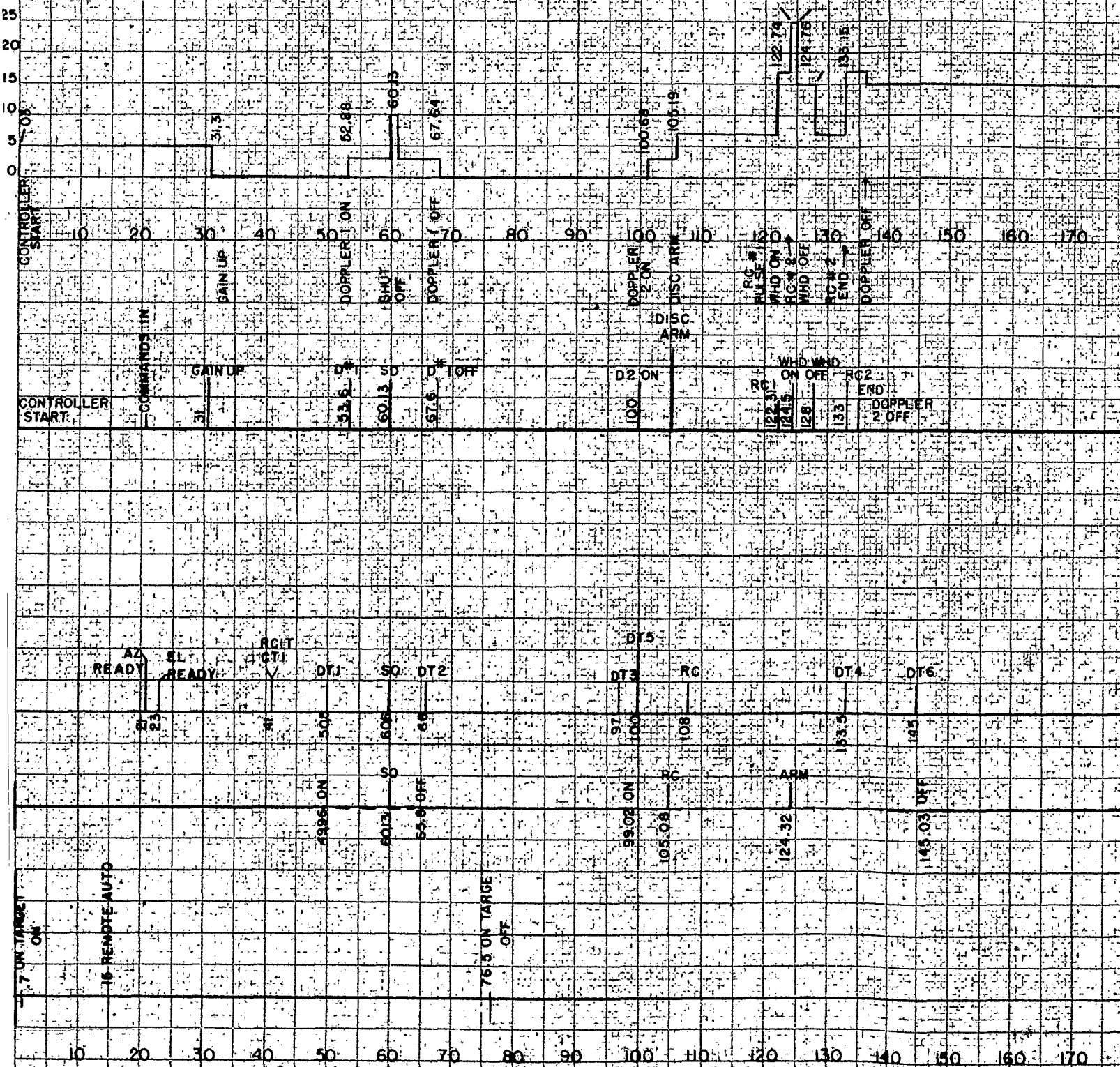


(TIME IN SECONDS)

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MISSILE NO. 1668 BLIP STRIP

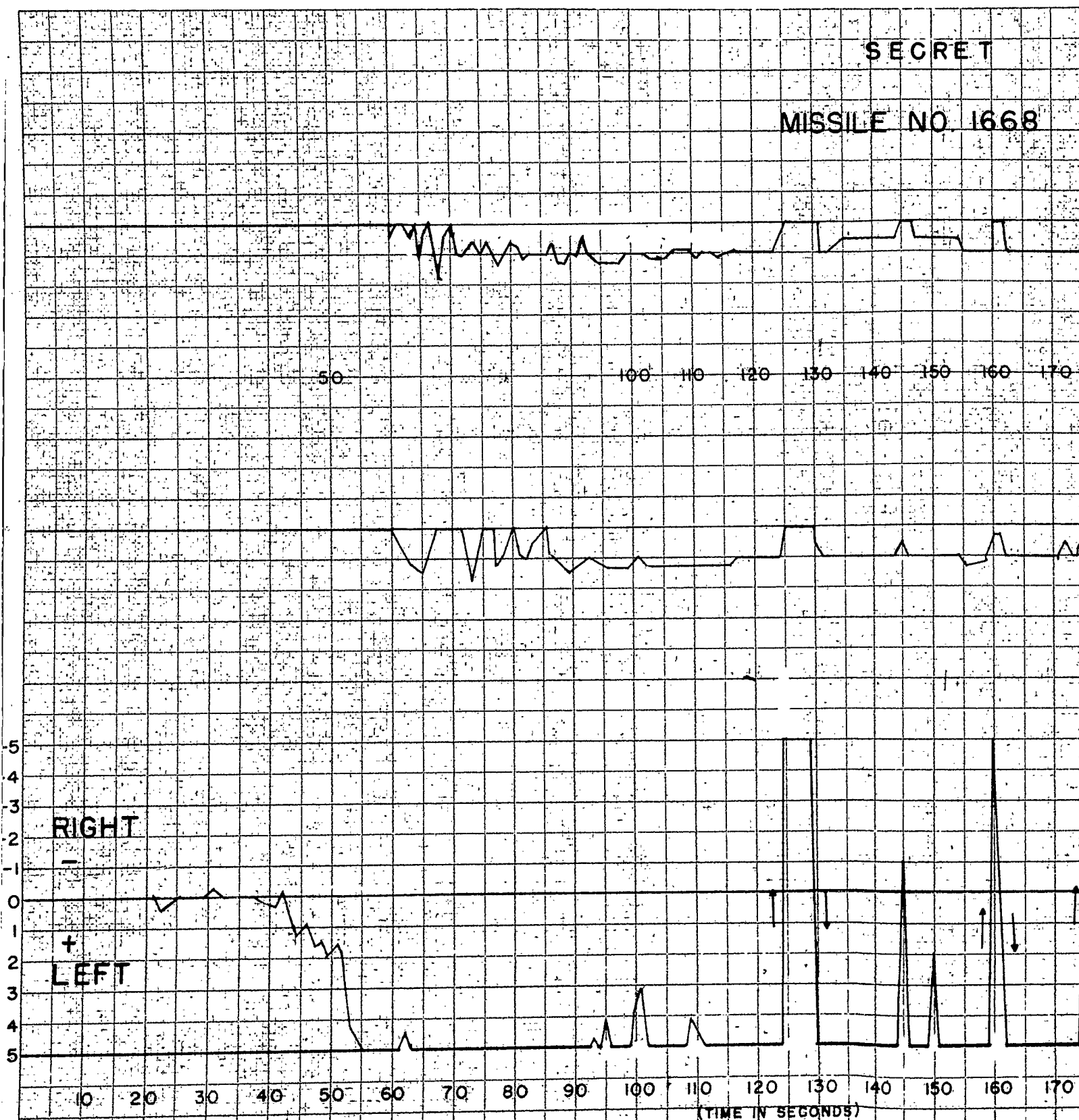


INCL 4

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MISSILE NO. 1668



SECRET

SECRET

MISSILE NO. 1668 Fin

G3

G18

UP

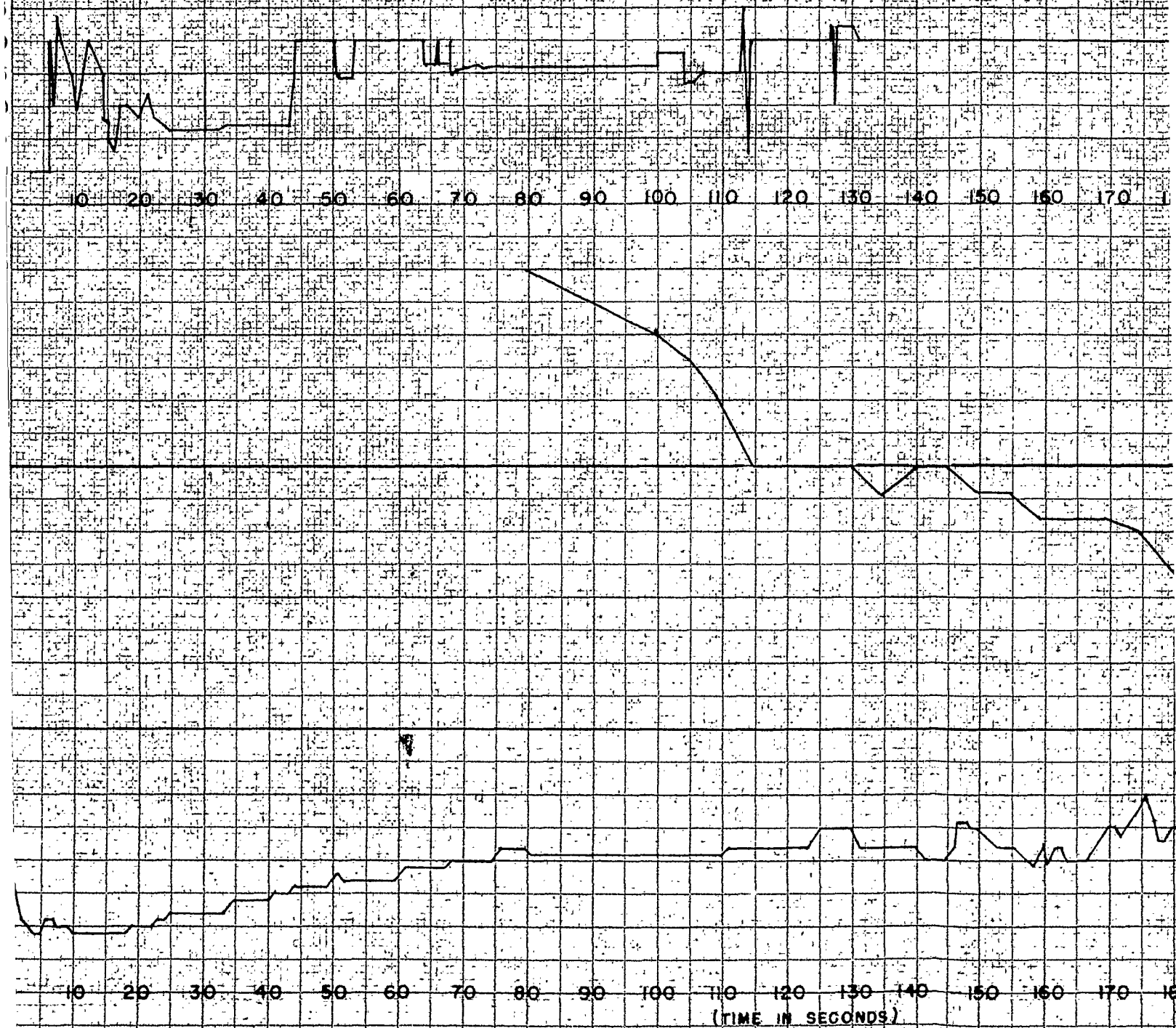
+
DOWN

(TIME IN SECONDS)

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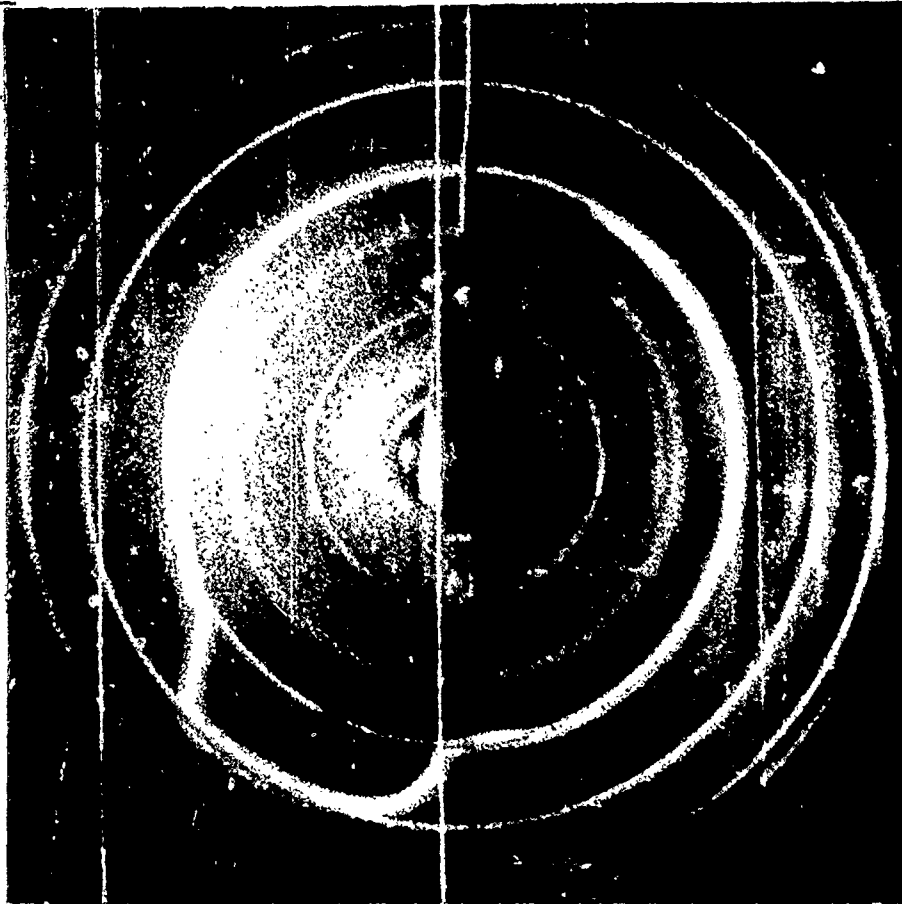
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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

FORT BLISS, TEXAS
NEGATIVE NR GM 170-7

PHOTO NR DI-1--NORMAL PULSE RECEIVED FROM MISSILE.

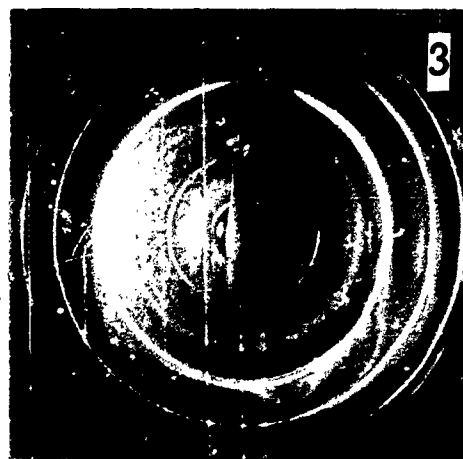
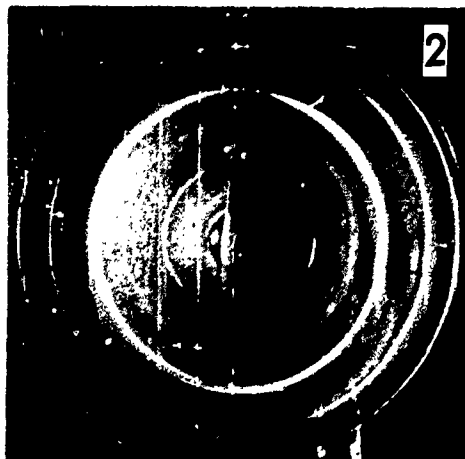
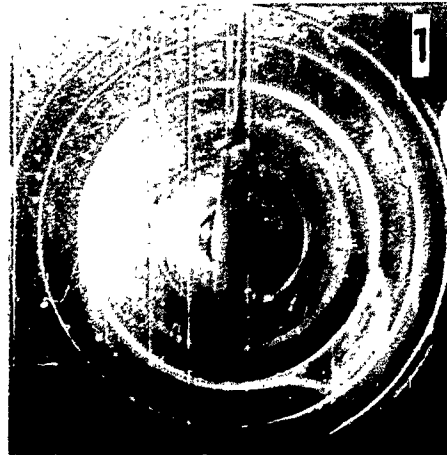
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INCLOSURE 5

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

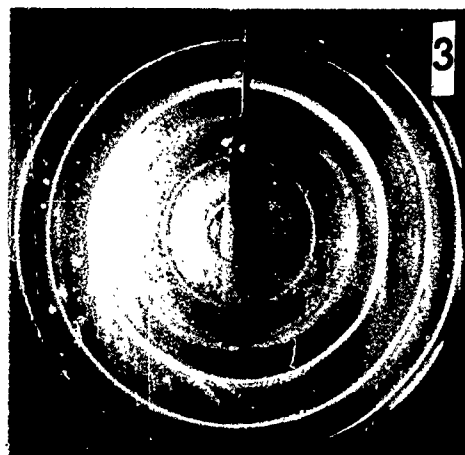
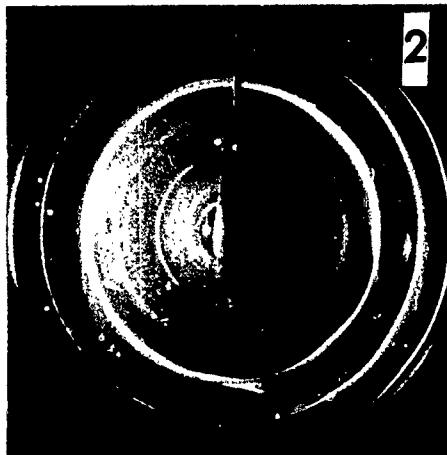
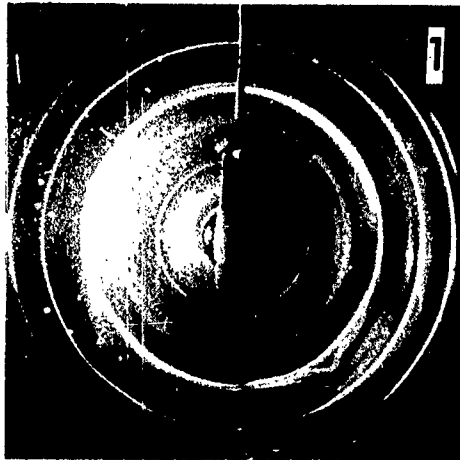
FORT BLISS, TEXAS
NEGATIVE NR GM 170-8

PHOTO NR D1-2--THREE CONSECUTIVE PHOTOS SHOWING RETURN PULSE DURING THREE
PULSE JAMMING.

INCLOSURE 5

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

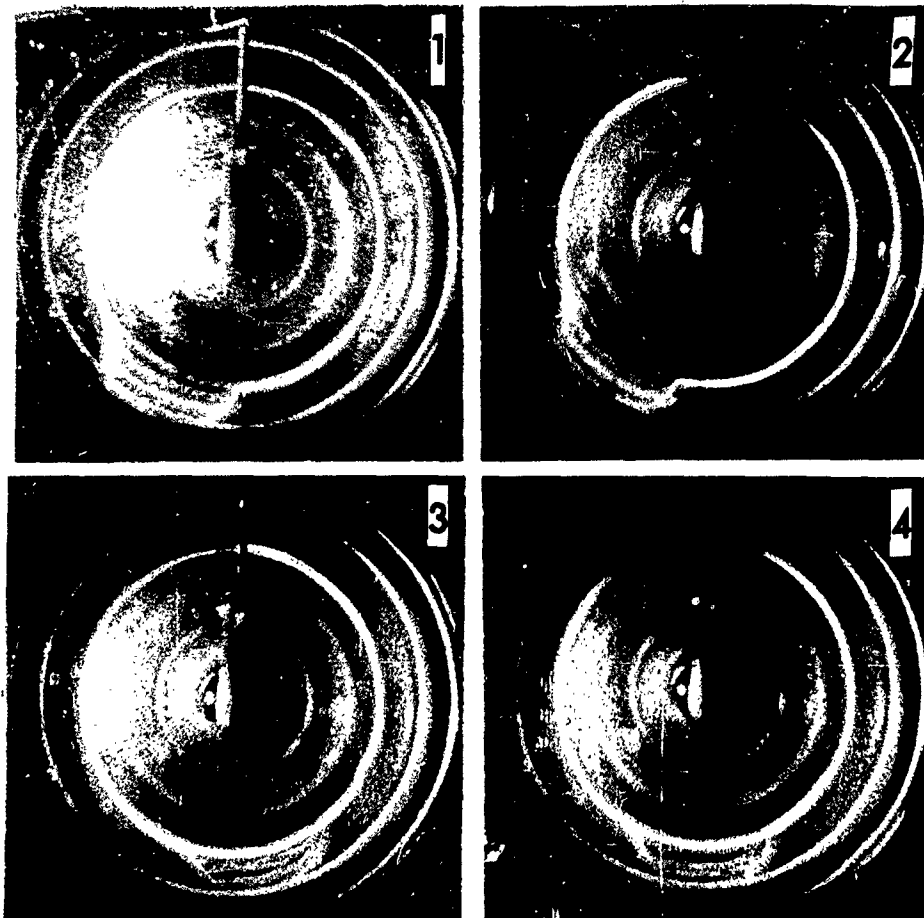
FORT BLISS, TEXAS
NEGATIVE NR GM 170-9

PHOTO NR DI-3--THREE CONSECUTIVE PHOTOS SHOWING RETURN PULSE DURING FOUR
PULSE JAMMING.

INCLOSURE 5

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REPORT OF PROJECT NR GM 551

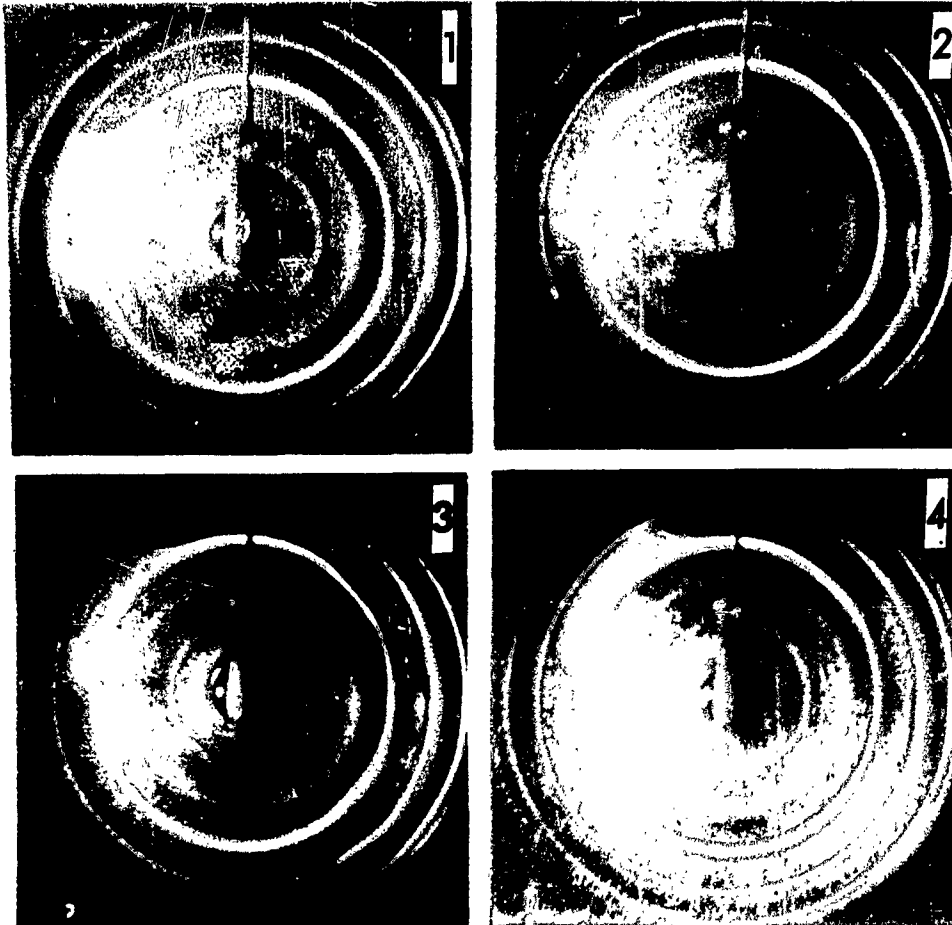
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NEGATIVE NR GM 170-10

PHOTO NR D11-1--FOUR CONSECUTIVE PHOTOS DURING THREE PULSE JAMMING. NOTE
BASELINING AND SHIFT IN RANGE IN NUMBERS 3 AND 4.

INCLOSURE 5

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BOARD NR 4 CONARC
REPORT OF PROJECT NR GM 551

FORT BLISS, TEXAS
NEGATIVE NR GM 170-11

PHOTO NR D11-2--FOUR CONSECUTIVE PHOTOS DURING FOUR PULSE JAMMING.

INCLOSURE 5

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