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PROCESS FOR FRAGMENT LAYUP, FILLER APPLICATION, AND
OUTER COATING FOR PATRIOT GM WARHEAD M248

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND

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DOVER, NEW JERSEY

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20. ABSTRACT (cont)

includes the following features: (1) a tape adhesive for chaining the fragments and adhering them to the warhead, and (2) a Grumman redesigned, fragment chain-wrap mechanism with hopper feed that aligns the fragments on the tape adhesive. The chain-wrap mechanism follows a spiral path to layup the fragments on the warhead ogive. This mechanized layup capability eliminated the need for the glass fabric-reinforced epoxy overwrap, the manual skill for spreading epoxy adhesive over the bonding surfaces, and three separate 12-hr, room-temperature cures (one for each of the fragment layers). The Autowrap System made it convenient to accomplish 100% inspection of the positioned fragments prior to adhesive curing and improved the dimensional and weight controls for the PATRIOT Warhead Inert Parts Assemblies.

FOREWORD

This report presents the results of the technical effort performed in fulfillment of U.S. Army Armament Research and Development Command (ARRADCOM) Solicitation DAAK10-79-C-0376 in which an improved state-of-the-art manufacturing methodology for fragment assembly, filler application and outer coating of the XM248E1 PATRIOT Warhead Inert Parts Assembly was successfully developed. This improved manufacturing procedure utilized the Grumman-designed and Grumman-built PATRIOT Warhead Autowrap System.

The Project Engineer for ARRADCOM was Mr. Julian Z. Starostecki. He was under the direction of Mr. Samuel D. Stein, PATRIOT Development Officer. Mr. Adolph E. Slobodzinski of ARRADCOM/PLASTEC served as Consultant for this program. Mr. Arnold London was the Project Engineer for Grumman Aerospace Corporation. Mr. Charles F. Johnson was responsible for the design of the Autowrap System.

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Section 1

SUMMARY

A mechanized "dry" production capability has been developed to layup steel fragments onto PATRIOT warheads to replace the current "wet layup" process that is labor-intensive and time-consuming. The mechanized process decreases dependence on scarce skills, increases productivity and makes quality controls more manageable. Three layers of steel fragments [1/4-in. (6-mm) cubes] are laid-up with epoxy adhesive. Each layer is spirally wrapped and contains over 7,000 continuous fragments. The Grumman-developed Integrated Autowrap System includes the following features: (1) a tape adhesive for chaining the fragments and adhering them to the warhead, and (2) a Grumman-redesigned, fragment chain-wrap mechanism with hopper feed that aligns the fragments on the tape adhesive. The chain-wrap mechanism follows a spiral path to layup the fragments on the warhead ogive. This mechanized layup capability has eliminated the need for the glass fabric-reinforced epoxy overwrap, the manual skill for spreading epoxy adhesive over the bonding surfaces, and three separate 12-hr, room-temperature cures (one for each of the fragment layers). The Autowrap System has made it convenient to accomplish 100% inspection of the positioned fragments prior to adhesive curing and improved the dimensional and weight controls for the PATRIOT Warhead Inert Parts Assemblies.

Section 2

RECOMMENDATIONS

- A simple lathe or potter's wheel should be used to apply the interfragment and base adhesive fillers. These devices can also be used to speed-up the final coating operations
- After application of the interfragment adhesive filler, it is not necessary to remove excess adhesive from the surface
- An anti-corrosion primer per MIL-P-23377 should be used to coat the fragments before application of the final polyurethane protective coating per MIL-C-81773 and MIL-C-83286
- 6-mil-thick, PVA shrinkable tape (lower cost material) should be substituted for the Teflon and mylar or nylon tapes presently used during the pressure wrap-and-cure operation

Section 3

MAJOR ACCOMPLISHMENTS

The following activities were accomplished for improved production of PATRIOT Warhead Inert Parts Assemblies:

- Successful ARRADCOM vibration testing of the first PATRIOT Warhead Inert Parts Assembly fabricated by the new Autowrap Process
- Fabrication of four PATRIOT Warhead Inert Parts Assemblies for ARRADCOM ballistics verification using the Autowrap Process
- Grumman development of hardware and documentation for implementation of the new process. The following documentation is appended to this report:
 - Appendix A: Preliminary Specification - Fragment Tape Adhesive Material - PATRIOT Warhead Autowrap Fragment Layup Process
 - Appendix B: Specification - Fragment Interstitial Space Paste Adhesive - PATRIOT Warhead Fragment Layup Autowrap Process
 - Appendix C: Specification - Base Filler - PATRIOT Warhead Autowrap Fragment Layup Process
 - Appendix D: Specification - Expendable Shrink Tape (Teflon) - PATRIOT Warhead Autowrap Fragment Layup Process (for use during tape adhesive cure cycle)
 - Appendix E: Specification - Expendable Shrink Tape (Polyester) - PATRIOT Warhead Autowrap Fragment Layup Process (for use during tape adhesive cure cycle)
 - Appendix F: Specification - Alternate Expendable Shrink Tape (Nylon) - PATRIOT Warhead Autowrap Fragment Layup Process (for use during tape adhesive cure cycle)

- Appendix G: Operating Manual - PATRIOT Warhead Autowrap Fragment Layup Machine
- Appendix H: Manufacturing Method - PATRIOT Warhead Autowrap Fragment Layup Process
- Appendix I: Quality Control Plan - PATRIOT Warhead Autowrap Fragment Layup Process

Section 4

BACKGROUND

The epoxy adhesive formulated for the "wet" layup process has a short life as a fluid. At room temperature, the initially thick, syrup-like resin thickens further to the consistency of cold tar in six to seven hours. Although heating the resin can make it run freely, the resin irreversibly hardens in a considerably shorter time.

A trained operator is required to uniformly distribute the adhesive over the bonding surfaces. The operator must complete the fragment layup before the adhesive thickens. The buildup of adhesive can become so excessive that dimensional tolerances are exceeded. On the other hand, the adhesive can be made so fluid that fragments laid up in insufficient resin are released from the warhead.

The adhesive formulation becomes cured in 12 hours at room temperature. A removable, contact adhesive tape is wrapped over the adhesive fragments to hold the fragments in place during this period. The contact tape must be removed before subsequent layers of fragments can be laid-up. As a result, each adhesively bonded layer is cured overnight. Four days are required to complete each warhead. When it is necessary to reach production rates, serious problems will arise with respect to the storage, inspection and quality control of numerous warheads in various stages of completion.

Many large-area structures are adhesive bonded by the aerospace industry using film adhesives that are B-staged for easy handling. These materials, which are quickly cured at elevated temperatures, were considered for use in this program. The B-stage is a state of partial resin cure (advancement) regulated to attain desirable handling and processing characteristics without compromising cured state properties. Both reinforced and unreinforced adhesive films are used. Both contain a specified quantity of uniformly distributed resin necessary to develop reproducible bonds.

Continuous collimated fibers, chopped fiber mats and woven fabrics are used in reinforced adhesive films. These films are made to the widths of reinforcements that are used; tape adhesives are usually slit to width from these films.

To prevent successive layers of film adhesives from adhering to each other, the films are usually rolled with intervening layers of separators (polyethylene release films or treated papers). The tape adhesives also contain release papers or films that are slit together with the adhesive film. It is normally required that the adhesives be sufficiently B-staged so that they will not adhere to the release films but will adhere to the surfaces to which they are applied. The release requirement assures that a predetermined amount of adhesive will be applied to the bonding surface. The B-stage is also advanced just enough to acquire the desired handling characteristics such as drape, tack and flow.

Drape is the ability of the film to comply with the bonding surface curvature without roping or wrinkling. Tack is the ability of the B-staged prepreg resin component to adhere to designated layup surfaces. This property can range from "dry," when judicious use of controlled heat is required to cause the film to adhere to the substrate, through "heavy," when adhesion is aggressive towards the substrate but not so aggressive as to leave residual resin on the release films or backings. Films with excessively heavy tack are unmanageable. The states of tack and flow are dependent upon the resin content in the film and on the advancement of the B-stage for the resin.

Flow, which denotes the mobility of the resin, is required to fill irregularities and promote adhesion. Sometimes the flow of the uncured resin must be controlled, without affecting the capability to fill irregularities or promoting the wetting of surfaces to bring about adhesion during cure. One technique is to blend solid resin into the liquid adhesive formulation by heating and stirring. This type of formulation will flow readily when heated until it cures, even though it approaches the consistency of a solid at room temperature. Flow during thermal cure is sometimes controlled by making the material thixotropic. Such flow control prevents the adhesive from leaving the bonding surface between adherends. Instead, the adhesive forms fillets between the adherends and increases the total bonded area.

The successful tape adhesive for automated processing must incorporate these optimum handling properties.

Section 5

DISCUSSION

5.1 PROGRAM REQUIREMENTS

A target production rate of four PATRIOT Warhead Inert Parts Assemblies per seven hours of operation was assigned. Specified weight and dimensional tolerances were to be consistently attained. The production assemblies were also required to withstand scheduled vibration tests. The test spectrum included sinusoidal vibration from 5-in. double-amplitude (frequencies from 2.0 to 5.7 Hz) up to 1.5 g at 100 to 500 Hz, and shocks to 50 g. In addition, the warheads are required to withstand long-term storage at temperatures from -50°F (-45.6°C) to 150°F (65.6°C). It was also specified that commercial materials be used and that the hardware and software for a single-station capability, including drawings for the hardware, be supplied.

5.2 GRUMMAN APPROACH

The Grumman approach to process development was to automate the existing manually assisted and controlled equipment and develop an adhesive system to accomplish the following:

- To minimize the problems resulting from laying up and curing each layer of fragments separately, all layers of fragments were to be laid-up at one time
- To avoid risks of deteriorated bonds, due to the three separate, overnight, room-temperature cures, the cure requirement would be shortened to just a few hours so that the layup would be quickly stabilized.

5.3 ADHESIVE DEVELOPMENT

The adhesive system that was developed can be cured at 250°-275°F (121°-135°C) within 75 minutes. Since the fragment layup would then be positioned and stabilized, the warhead fabrication could be allowed the option of filling the interstices between the fragments and fairing-out the profile at the base of the fragment layup with epoxy-base fillers that cure at room temperature. Use of an anti-corrosion primer applied to the outer surface is recommended. Application of a suitably pigmented epoxy or polyurethane protective primer would be specified. Because an autoclave cure for fragment bonding would be costly, the assembly would be wrapped with shrinkable tape and cured at 250° to 275°F in a circulating-air oven.

For purposes of automating the existing manually assisted and controlled tape-wrapping machine, it was specified that the tape adhesive should withstand a 20-pound tension load in the tape length direction. Therefore, 3M's SP-341 continuous-collimated, unidirectional glass fiber-reinforced tape adhesive was pre-selected. The cured properties and handling characteristics of this adhesive are summarized in Fig. 1.

PROPERTY	DETERMINED VALUE	SPECIFICATION REQUIREMENT
0° FLEXURAL STR @ 73° F, KSI	223	150 (MIN)
0° FLEXURAL MODULUS @ 73° F, MSI	6.5	5.0 (MIN)
SHORT-BEAM SHEAR STR, KSI		
@ 73° F	13.1	8.0 (MIN)
@ 350° F	6.7	—
PREPREG RESIN CONTENT, %	42	40 ± 3 (MIN)
VOLATILES @ 250° F, %	0.1	1.5 (MAX)
TACK	PASS	PASS/FAIL
1058-001(T)		

R81-1887-001

Fig. 1 Properties of 3M's SP-341 Tape Adhesive

When tried in the initial redesigned machine assembly, the SP-341 tape was found to be deficient. This B-staged adhesive was not tough enough to hold the chained fragments. In addition, the resin content was too low to give the specified aggressive tack. As a result, the initial flow of the uncured adhesive was too great.

The tape could not be stabilized during its placement on the spiral path. It had to be excessively tensioned to lay flat on the ogive. Since the path of the wrap was not geodesic, the tape "roped" as it slid towards a shortened path to relieve the applied tension. Besides "roping" and releasing the fragments, the tape festooned as well and caused fragments to fall off.

The loads at the application points of the tapes to the hopper were measured with a force gauge. When freely dispensed, the tensile load was less than four pounds. The maximum load that could free a tape jammed in the hopper feed mechanism was nine pounds. Greater loads were required when the guide chute and rollers became fouled by build-up of residual adhesive with the mechanism becoming inoperative. The guidance systems were modified to provide more clearance and different tape reinforcements were evaluated.

Tapes reinforced with nylon tricot produced similar results. Modification of the resin content and further B-staging did not help appreciably. All problems associated with "roping" of the tape persisted.

Better results were obtained when tapes reinforced with spun-bonded chopped mat began to be used. Fig. 2 lists the reinforcements and adhesive systems that were evaluated during the initial tape development phase; the adhesives were based on an existing filled 350°F adhesive (MA 429).

ADHESIVE DESIGNATION	SCRIM IDENTIFICATION	SCRIM MATERIAL
MA 429 ⁽¹⁾	TYPE 1922	POLYESTER
	REMA 2441-TYPE 1922	ORGANIC FIBER MAT
	TYPE 1922	WOVEN SYNTHETIC
	TYPE 1922	WOVEN NYLON
	CEREX 1.5, TYPE 1922	SPUN-BONDED NYLON MAT
(1) MC CANN ADHESIVES PRODUCT DESIGNATION MA 429		
1058-002(T)		

R81-1887-002 Fig. 2 Adhesives and Reinforcements Evaluated During Initial Tape Development Phase

A non-filled 250°F epoxy adhesive with controlled flow in the uncured state was then substituted for the filled MA 429 adhesive. Mc Cann Adhesives supplied Grumman with 18 rolls of XMA 4332 and 20 rolls of XMA 4333 experimental tape adhesives, both of which were 1/4-in.-wide and weighed about 0.1 pound per square foot (psf). The XMA 4332 adhesive contained spun-bonded polyester mat carrier which weighed 0.19 gram per linear foot. This tape adhesive was found to be heavier and more "stretchy" than the XMA 4333 adhesive which had spun-bonded nylon mat carrier at 0.10 gram per linear foot. The initial tack of both adhesives was excessively great; the fragments adhered well to the tape, but the fragment-chained tape slid on the assembly, albeit at a very slow rate. The fragments did not remain adhered for a sufficient time.

Because of this slippage, the adhesive systems were chemically advanced (i.e., driven further into the B-stage but not into gelation) by heating them in a forced-air oven preset and maintained at 135°F for intervals of 1/2, 1, 2, 3 and 4 hours. After their respective advancement intervals, the rolls of adhesive were removed from the oven and rapidly cooled by placing them on an aluminum plate in a 0°F freezer where they were stored until used.

A "catenary hang" test was developed to quantify the tack. The procedure involved feeding the 1/4-in.-cube steel fragments (each weighing about 2.0 grams) through the autowrap machine to make 5-ft-long, no-gap chains on the XMA 4332 and XMA 4333 tape adhesives. These adhesive/fragment chains were suspended (with the adhesive up) from both ends to form a catenary. To pass the test, no fragments were allowed to fall off in a 5-minute period. The fragment counts ranged from 42 to 47 fragments per foot. At 45 fragments per foot, the weight of a 5-ft-long chain is 450 grams (about one pound). Both candidate adhesives, when advanced two hours at 135°F, passed this test.

Both the XMA 4332 and XMA 4333 adhesives were found to be capable of placing 22 rows of fragments (5-1/2 in.) fairly uniformly on the nose of the Metal Parts Assembly. The thinner XMA 4333 adhesive was handled better by the autowrap mechanism. In addition, the XMA 4333 adhesive was somewhat stiffer and had less "give" than the XMA 4332 adhesive. In view of these considerations, the XMA 4333 adhesive was selected as the next batch of adhesive for study. The XMA 4333 adhesive was re-ordered with the provision that the adhesive formulation be kept the same but that it be advanced in the resin kettle until its tack and flow are equivalent to that for the 2-hour/135°F oven-staged material. The advancement was to be performed before the adhesive was made into a roll and slit.

Grumman received two versions of the improved XMA 4333 adhesive, designated as MA 4333-1 (adhesive advanced) and MA 4333-2 (adhesive advanced plus thixotropic agent). These adhesives were supplied in 1/4-in.-wide rolls for fragment application and in 1/2-in.-wide rolls for overwrapping. Additional procurement requirements to which this material complied are presented in Fig. 3. The overlap shear strengths and gel times of the McCann adhesives evaluated are shown in Fig. 4. Two versions of MA 4333-1 adhesive were ordered with a tape weight of 0.08 psf because the original XMA 4333 adhesive, which had a tape weight of 0.10 psf, appeared to have too much adhesive on its carrier. Although the tack was good and successful Autowrap machine runs were conducted, there was once again too much slippage of the fragment tape chain down the ogive-shaped aluminum shell with resultant fragment drop-off. Excess adhesive, which was present on the side of the rolls, tended to impede the moving parts of the Autowrap machine necessitating frequent stops for clean-up.

Autowrap machine evaluation of the MA 4333-1 and MA 4333-2 tape adhesives showed that the former had superior properties. The PATRIOT Inert Parts Assembly, which successfully passed ARRADCOM shock and vibration tests, was made with the MA 4333-1 adhesive. However, this adhesive still had a tendency to slide down the aluminum shell

ITEM	REQUIREMENT
1.	180 FEET PER ROLL
2.	9-IN. MAXIMUM ROLL OUTSIDE DIAMETER
3.	SLIT WIDTH TO BE 0.240 (+ 0.000 - 0.020) IN.
4.	CORE TO BE CARDBOARD PLUS FOAM
5.	TAPE WEIGHT TO BE 0.08 psf
6.	TACK AND FLOW TO BE QUALITATIVELY EQUIVALENT TO THAT FOR HEXCEL F-161 PREPREG, RATED "GOOD"
7.	EITHER WHITE OR BROWN RELEASE PAPER COULD BE USED (WHITE BEING THINNER AND SOMEWHAT STRONGER, IS PREFERRED)
8.	STAGE RESIN IN KETTLE RATHER THAN ON THE ROLL
9.	USE EXTREME CARE DURING SLITTING SO AS NOT TO PRODUCE NICKS OR SLIVERS ALONG EDGE OF TAPE OR BACKING
10.	PACK FLAT WITH SLIP SHEETS AND STIFFENERS BETWEEN ROLLS
11.	SHIP COLD AS POSSIBLE; 0° F BEING PREFERRED.
1058-003(T)	

R81-1887-003

Fig. 3 Tape Adhesive Preliminary Quality Control Requirements

TAPE ADHESIVE DESIGNATION	TREATMENT	GEL TIME, AT 250° ±5° F (AVG. OF 3 SPECIMENS)	LAP SHEAR STRENGTH, PSI, CURED @ 250° F/1 HR. (AVG. OF 5 SPECIMENS)
XMA 4333	2 HR. AT 135° F ⁽¹⁾	2 MIN, 30 SEC	2275
XMA 4333	3 HR. AT 135° F ⁽¹⁾	2 MIN, 13 SEC	2213
XMA 4333	4 HR. AT 135° F ⁽¹⁾	2 MIN, 27 SEC	2150
MA 4333-1-0.08	ADVANCED ⁽²⁾ (3)	1 MIN, 48 SEC	2150
MA 4333-1-0.10	ADVANCED ⁽²⁾ (3)	1 MIN, 9 SEC	2213
(1) ADVANCED BY GRUMMAN ONE ROLL AT A TIME. (2) ADVANCED BY THE MANUFACTURER TO THE EQUIVALENT OF 2 HOURS AT 135° F. (3) DIFFERENT WEIGHTS.			
1058-004(T)			

R81-1887-004

Fig. 4 Gel Time and Overlap Shear Strength Measurements of Mc Cann Adhesives for PATRIOT Inert Parts Assembly Bonding

during winding and foul the ways and rollers of the Autowrap machine. A final version was ordered that contained 10 percent more solid base resin and 10 percent less liquid base-epoxy resin with the other ingredients held at the same concentration. This version of the adhesive also had a lower tape weight (0.065 psf). After a successful Autowrap machine evaluation, this final version of the adhesive tape was used to produce PATRIOT Inert Parts Assemblies PEP-1, -2, -3 and -4. All winding operations, which were witnessed by ARRADCOM personnel, were accomplished within the required time, weight and quality control limits. The gel time and overlap shear strength of the final MA 4333-1 adhesive are given in Fig. 5.

TESTING AGENCY	TACK TEST, 5 FT OF FRAGMENTS, 5-MIN. SUSPENSION	GEL TIME, AT 250° ± 5° F. (AVG. OF 3 SPECIMENS)	LAP SHEAR STRENGTH, PSI, CURED @ 250° F FOR 1 HR (AVG OF 5 SPECIMENS)
MC CANN	PASSES-NO DROPS	10 MIN, 37 SEC	1650
GRUMMAN	PASSES-NO DROPS	7 MIN, 42 SEC ⁽²⁾	2290 ⁽³⁾
(1) BATCH NO. MC CANN MFG. 0210333-1, CEREX NYLON MAT CARRIER (2) TEMPERATURE READOUT 259-260° F; HIGHER TEMPERATURE SHORTENED THE GEL TIME (3) THE MODE OF FAILURE WAS 100% ADHESIVE IN ALL TESTS 1058-005(T)			

Fig. 5 Quality Control Measurements for MA 4333-1 Adhesive for PATRIOT Inert Parts Assembly Autowrap Process⁽¹⁾

5.4 FINISHING MATERIALS

Complete descriptions of the fragment interstice filler (Dexter-Hysol EA-934), base filler (Furane Epocast 1310-I/II) and the coating system (Defth Chemical's Defthane-Camouflage Brown or Desoto Chemicals Desothane-Clear) are given in Appendices B, C and H, respectively.

5.5 PROCESS OPTIMIZATION

The PATRIOT Warhead Autowrap System for fragment application was optimized with respect to both the machine and the materials. Fabrication of the PEP-1 through PEP-4 warheads, which was witnessed by ARRADCOM personnel, showed that four warheads could be fragment-wrapped and shrink tape-overwrapped for adhesive curing within the contractually required seven hours. The fragment wrap times for warheads PEP-1 through PEP-4 are given in Fig. 6 together with their respective final weights.

WARHEAD DESIGNATION	WRAP TIME, MINUTES	INERT PARTS ASSEMBLY	
		WEIGHT, LB ⁽²⁾	MID-POINT PER-SIDE CLEARANCE, IN. ⁽¹⁾
PEP-1	67	110.0	0.050
PEP-2	62	111.1	0.050
PEP-3	69	110.5	0.050
PEP-4	85	110.6	0.050
(1) MAXIMUM CIRCUMFERENCE ALLOWED AT MIDPOINT IS 44.75 IN., EQUIVALENT TO 14.244-IN. DIAMETER. MEASURED CLEARANCES ARE SATISFACTORY.			
(2) TARGET WEIGHT RANGE = 110.0 TO 114.0 LB. 1058-006(T)			

Fig. 6 Optimized Process Fragment Wrap Times and Inert Parts Assembly Weights

The fragment wrapping process was optimized in an iterative fashion. After fabrication and assembly of the Autowrap machine, 3M's SP-341 tape was initially used for machine evaluation. It was quickly determined that the combination of the originally designed machine and the glass-reinforced adhesive were not compatible with the PATRIOT Welded Parts Assembly configuration. When the original McCann mat adhesive was substituted for the SP-341 material, good chaining of the fragments to the tape occurred, as well as fair application of the chained tape to the Welded Parts Assembly. This finding revealed areas for improvement of the Autowrap machine.

As subsequent refinement of the McCann adhesive to the final version (MA 4333-1) took place, the Autowrap machine was also revised to its final configuration. Improvement of the tape adhesive made possible refinement of the machine and, consequently, further improvement of the tape adhesive. As these iterative events occurred, other processes were studied including mechanical/solvent cleaning of the fragments, installation of dust covers on the Syntron dispenser and chute, and changing the finish of the Welded Parts Assembly from alodine to anodize/adhesive primer. With the improvements in the tape adhesive and the Autowrap machine, it became possible to use the Welded Parts Assemblies as supplied (alodine finish) and to limit cleaning of the fragments to a solvent rinse/dry or vapor degrease. At present, the Autowrap machine can apply 47-48 fragments per foot of tape adhesive; the rate of application of the chained tape is limited only by the capacity of the Syntron dispenser.

5.6 PILOT SINGLE-STATION FACILITY

The pilot single-station facility utilizes the following equipment

- Degreasing Tank - large enough to clean eight gallons of fragments each day per MIL-F-18264C (sufficient for 4 Inert Parts Assemblies per 7-hr day)
- Autowrap Machine - to apply steel fragments and tape adhesive to the aluminum warhead; for development purposes only, to apply fillers and finishing materials for production, a potter's wheel is recommended
- Ovens - to cure the applied adhesive and finishing materials; should have temperature controllers and recorders, and be large enough to cure four Inert Parts Assemblies per day
- Adjustable-Height Movable Table - to transport Inert Parts Assemblies from one work area to another
- Work Bench - adjacent to the Autowrap machine for general supplementary operations such as mixing and dimensional checking of finished Inert Parts Assemblies with the Quality Control fixture
- Scales - one of small capacity to weigh base and interstitial fillers (two-part epoxy systems) prior to mixing, and one of large capacity to weigh finished warheads (114.0, +0.0/-4.0 lb)

5.7 PROCESS DEMONSTRATION (PEP-1 to PEP-4)

Fabrication of PATRIOT Inert Parts Assembly PEP-1 took place on 23 February 1981 and was witnessed by Mr. A. Slobodzinski of ARRADCOM/PLASTEC. Fragment application time was 67 minutes (not including shrink tape overwrap) with one slow-down occurring during application of the first layer of fragments due to a cam-follower misalignment. Fabrication of Assembly PEP-2 followed immediately; fragment application time was 62 minutes with no processing down-time. Both of these warheads were oven-cured on 24 February 1981. The finishing operations shown in Fig. 7 were also completed.

Assemblies PEP-3 and PEP-4 were processed on 26 February 1981 in the presence of Messrs. S. Stein, J. Starostecki, S. Urban and W. Kozar of ARRADCOM. During this demonstration, a detailed log was maintained. Processing of Assembly PEP-3 was precise and accurate; 69 minutes were required to install three layers of fragments. Another 26 minutes were used for startup preparation, installation of new rolls of MA 4333-1 tape, cleaning of moving parts of the Autowrap machine, change-over of cam followers, and return of the partially wrapped assembly to its start position between wrappings; also, 7 minutes were required to install four layers of shrink tape.

INERT PARTS ASSEMBLY NO.	ARMY IDENTI- FICATION NO. ON ALUMINUM SHELL	FRAGMENT APPLICATION TIME, MINUTES	DATE OF APPLICA- TION	DATE OF CURE	WEIGHT AFTER CURE, LB	DATE OF APPLICA- TION OF FILLERS	DATE FIN- ISHING OPERATIONS COMPLETE	FINAL WEIGHT OF ASSEMBLY, LB	MEASURED MAXIMUM DIAMETER IN.	ARRADCOM WITNESSES
PEP-1	SNO 879 1104 HTO 7879 XP 1137	67	2-23-81	2-24-81	108.5	2-27-81	3-4-81	110.0	14.24	A. SLOBODZINSKI
PEP-2	SNO 8791 098 HTO 6879 XP 1105	62	2-23-81	2-24-81	109.6	3-3-81	3-4-81	111.1	14.24	A. SLOBODZINSKI
PEP-3	SNO 8791 088 HTO 7879 XP 1131	69	2-26-81	2-27-81	109.5	3-3-81	3-4-81	111.0	14.24	S. STEIN, J. STARO- STECKI, S. URBAN, W. KOZAR
PEP-4	SNO 2791 096 HTO 0479 XP 1070	85	2-26-81	2-27-81	109.1	3-9-81	3-9-81	110.6	14.24	S. STEIN, J. STARO- STECKI, S. URBAN, W. KOZAR
1058-007(T)										

Fig. 7 Process Demonstration — Inert Parts Assemblies PEP-1 Through PEP-4

Fragment application time for assembly PEP-4 was 85 minutes; the two problems that did occur during processing were corrected and noted in the log. The overall fragment application time for assemblies PEP-3 and PEP-4 was 2 hours and 34 minutes; ancillary operations during the fragment application process required 46 minutes. The cumulative fragment application time for assemblies PEP-1 to PEP-4 was 4 hours and 43 minutes (not counting curing and finishing operations). It was concluded that the demonstrated processing times for fragment application of the four assemblies satisfied the requirements of the contract. In addition, all four warhead assemblies satisfied the weight and dimensional tolerance requirements of the contract.

5.8 ENVIRONMENTAL IMPACT STATEMENT

All materials called out by Grumman for use in the PATRIOT Warhead Autowrap Process have been cleared with OSHA. It is our considered opinion that the high-production-rate process described in this report will not have adverse environmental consequences. If it is demonstrated that any material or processing technique called out herein is unsatisfactory in this regard (i.e., EPA, OSHA and local environmental regulations), suggestions will be made for making the technology acceptable.

APPENDIX A

PRELIMINARY SPECIFICATION

FRAGMENT TAPE ADHESIVE MATERIAL

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. A

Preliminary Material Specification: Fragment Tape Adhesive Material -
PATRIOT Warhead Autowrap Fragment Layup Process

TAPE, ADHESIVE, PRESSURE-SENSITIVE, DOUBLE-FACED, STEEL FRAGMENT
(PN 9226307) - TO - ALUMINUM METAL PARTS WELDED ASSEMBLY
(PN 9312580), PERMANENT BONDING

1 SCOPE

1.1 Form. - This specification covers a thermosetting tape adhesive in the form of a carrier with epoxy adhesive on both sides.

1.2 Application. - Primarily for use with ARRADCOM/Grumman PATRIOT Warhead Autowrap Process. Because of its uncured pressure-sensitivity (tack), this tape picks up 1/4-in. cubical steel fragments, transports and adheres them to a rotating aluminum shell, and then forms a permanent bond, after a 250°F/1 hr heat-cure.

2 APPLICABLE DOCUMENTS

The following publications form a part of this specification to the extent specified herein.

2.1 Government Documents.

2.1.1 MIL-A-9067C, Adhesive Bonding, Process and Inspection Requirements for

2.1.2 MMM-A-132, Adhesive, Heat-Resistant, Airframe Structural, Metal-to-Metal.

2.1.3 MIL-HDBK-106, Multi-level Continuous Sampling Procedure and Table for Inspection by Attributes.

2.1.4 Federal Specification. - PPP-T-680, Tape, Pressure Sensitive Adhesive, Packaging and Packing of

2.2 ASTM Documents. -

2.2.1 D1000, Pressure-Sensitive Adhesive Coated Tapes Used for Electrical Insulation, Testing.

3 TECHNICAL REQUIREMENTS

3.1 Material. - Shall be 1/4-in. wide (0.240 to 0.250-in.) tape adhesive consisting of nylon mat carrier impregnated with a predetermined amount of epoxy adhesive.

SPECIFICATION

No. A

3.1.1 Carrier Tape. - Shall be Cerex spun-bonded nylon mat which weighs 0.1 gram per linear foot and is 0.0056-in. $\pm$ 0.0005-in. thick.

3.1.2 Adhesive. - Shall consist of an epoxy/cyanoguanidine mixture conforming to the AMMRC characterization applied in equal thickness to both sides of the mat carrier so as to provide uniform impregnation.

3.1.3 Tape Adhesive. - Shall be supplied in lengths of 180 to 200 ft per roll, so that the outside diameter is $7\pm 1/4$ in.

3.2 Properties. - Tape shall conform to the following requirements:

3.2.1 Color. - Natural, unless otherwise specified.

3.2.2 Thickness. - Shall be 0.0094 in. $\pm$ 0.0002 determined in accordance with ASTM D1000.

3.2.3 Weight. - Shall be 0.080 $\pm$ 0.005 lb per square ft.

3.2.4 Initial Adhesion. - The tack and flow of the uncured tape adhesive shall be adequate to attain the following requirements at working (room) temperature [75.2°F (24°C) maximum or 68°F (20°C) minimum]:

- (a) A sufficient length of tape and adhesive shall be chained with 60 in. (153 cm) of 1/4-in. (6 mm) steel cubes by a method that simulates the hopper feed mechanism of the Autowrap machine, as agreed to by vendor and user.
- (b) The tape shall be made to span two points in a horizontal plane, to form a 6-in. catenary, with the fragments suspended from the lower face of the tape.
- (c) The tape shall retain all steel cubes for five minutes.
- (d) The results may be verified by the user.
- (e) When the tape is removed from the backing, no measurable amount of resin shall be retained by the release paper or film, as determined by the user.

3.2.5 Final Adhesion (Cured Bond Strength). - Shall be such that the overlap shear strength of the cured adhesive (as tested per MMM-A-132) is 1500 psi average or greater for five specimens, at room temperature.

SPECIFICATION

No. A

3.2.6 Gel Time. - Shall be 9.0 ± 2.0 minutes when the adhesive is tested at $250^\circ \pm 5^\circ\text{F}$ on an isothermal hot plate. Approximately one (1) gram of the tape adhesive is placed on the hot plate and stirred with a toothpick. Zero time is recorded with the aid of a timing device. The time at which the adhesive reaches the point of non-spreadability is to be recorded as the gel time.

3.2.7 Odor. - Tape adhesive shall not emit any objectionable odor during normal use in the Autowrap process.

3.2.8 Shelf Life. - Tape adhesive shall meet the requirements of 3.2.1 through 3.2.7 up to six (6) months from date of receipt by purchaser after storage at -10°F to 0°F within a freezer. The "out-time" before use on the Autowrap machine shall not exceed three (3) days; discard adhesive that has been at room temperature for more than three (3) days (72 hours) without being used.

3.2.9 Pot Life. - After the tape has been used to apply fragments to the Welded Metal Assembly, it may be allowed to stand at room temperature for seven (7) days, provided that the Assembly and fragments are covered with shrink tape or a similar tight-fitting protective covering.

3.3 Quality. - Tape adhesive, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from external and internal imperfections detrimental to its usage.

3.3.1 Separation. - There shall be no visual evidence of separation of the adhesive from its backing upon unwinding from the roll. However, the B-stage advancement shall meet the requirements of 3.2.4.

3.3.2 Backing Paper. - Shall be capable of continuous normal operation without breakage on the Autowrap machine during the fragment application process and winding on the take-up spool.

4 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. - The tape vendor shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by paragraph 4.5. Purchaser reserves the right to sample and to perform such confirmatory testing as he deems necessary to ensure that the tape conforms to the requirements of this specification.

4.2 Classification of Tests.

SPECIFICATION

No. A

4.2.1 Acceptance Tests. - Tests to determine conformance to requirements for color (3.2.1), thickness (3.2.2), weight (3.2.3), initial adhesion (3.2.4), final adhesion (cured bond strength) (3.2.5), gel time (3.2.6) and odor (3.2.7) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests. - Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed on the initial shipment of tape to the purchaser, when a change in material or processing requires re-approval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling. - Shall be in accordance with all applicable requirements of Federal Test Method Standard No. 147 with an Acceptance Quality Level (AQL) of 4.0; a "lot" shall be all tape produced in a single production run from the same batches of raw materials under the same fixed conditions and submitted for vendor's inspection at one time.

4.4 Approval.

4.4.1 Unless waived, sample tape shall be approved by purchaser before tape for production use is supplied. Results of tests on production tape shall be essentially equivalent to those on the approved sample.

4.4.2 Vendor shall use ingredients, manufacturing procedures and processes, and methods of inspection on production tape which are essentially the same as those used on the approved, qualified sample tape. If any change is necessary in ingredients, in type of equipment for processing, or in manufacturing procedures, vendor shall submit the proposed changes in materials and/or processing and revised sample tape for requalification. Production tape made by the revised procedure shall not be shipped prior to requalification.

4.5 Reports. - Unless waived by purchaser, the vendor of tape shall furnish with each shipment three copies of a report showing the results of tests to determine conformance to the acceptance test requirements and stating that the tape conforms to the other technical requirements of this specification. This report shall include the purchase order number, preliminary specification number, lot number, vendor's material designation, lot size, and quantity.

SPECIFICATION

No. A

4.6 Resampling and Retesting. - If any specimen used in the above tests fails to meet the specified requirements, disposition of the tape may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the tape represented and no additional testing shall be permitted.

Results of all tests shall be reported.

5 PREPARATION FOR DELIVERY

5.1 Packaging and Identification.

5.1.1 Length. - Unless otherwise specified, tape shall be supplied in rolls of 180 to 200 ft wound on suitable cores with an ID of three (3) in. Wound tape shall be protected by an easily removed overlap release liner, which can be the backing paper of paragraph 3.3.2. The outer diameter of the roll shall be $7\pm 1/4$ in.

5.1.2 Identification. - Tape shall be packaged and identified in accordance with PPP-T-680 (2.1.4). The core of each roll of tape shall be marked on the ID with not less than the date of manufacture, the manufacturers name and designation of the tape.

5.1.3 Packages of tape shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the tape to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.1.4 For direct U.S. Military procurement, packaging shall be in accordance with PPP-T-680 (2.1.4), Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1.2 and 5.1.3 will be acceptable if it meets the requirements of Level C. In all cases, however, the tape rolls should be packed flat, with slip sheets between each roll, and shall be shipped flat. A maximum of 15 rolls shall be sealed in individual polyethylene bags. The shipping container shall contain sufficient dry ice (solid carbon dioxide) to keep the adhesive at zero degrees Fahrenheit (0°F) until its destination is reached. To achieve this, the net weight (of adhesive) and gross weight (container plus dry ice) shall be stated on the packing slip and on the outside of the container.

6 ACKNOWLEDGEMENT

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

SPECIFICATION

No. A

7 REJECTIONS

Tape not conforming to this specification or to modifications authorized by purchaser will be subject to rejection.

8 NOTES

8.1 Tape should be stored in a freezer maintained at -10° to 0°F . A temperature not higher than 25°C (75°F) and relative humidity not higher than 60% is recommended when the adhesive is being used outside the freezer ("out-time"); the out-time (3.2.8) is 72 hours.

8.2 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification

Width of tape desired

Quantity of tape desired

Applicable level of packaging (See D5.1.4).

8.3 As of this date (June 1981), McCann Adhesives, Box 429, Route 14A, Oneco, Connecticut 06373, (203) 564-4046, is the only Approved Manufacturer listed.

APPENDIX B

SPECIFICATION - FRAGMENT

INTERSTITIAL SPACE PASTE ADHESIVE

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. B

Material Specification: Fragment Interstitial Space Paste Adhesive -
PATRIOT Warhead Autowrap Fragment Layup Process

Fragment Interstitial Adhesive, Trowelable Paste, Epoxy Resin

1 SCOPE

1.1 Form. - This specification covers a thermosetting trowelable adhesive paste consisting of a filled epoxy resin that will cure at ambient temperature or elevated temperature upon the addition of a hardener.

1.2 Application. - Primarily for use with ARRADCOM/Grumman PATRIOT Warhead Autowrap Process as trowelable fragment interstitial adhesive.

1.3 Characteristics. - The fragment interstitial adhesive material procured in accordance with this specification shall have a service capability over the range of -67°F to 160°F, be trowelable, and cured either at room temperature or elevated temperature as described in Table I.

2 APPLICABLE DOCUMENTS

2.1 Government Documents. - The following document of the issue shown (referred to under the basic number in subsequent paragraphs) forms a part of this specification to the extent specified herein:

STANDARD

Federal

Federal Test Method
Standard No. 406

Plastics: Method of Testing

SPECIFICATIONS

Federal

MMM-A-132

Adhesive, Heat Resistant,
Airframe Structural, Metal-
to-Metal

2.2 Availability of Documents. -

2.2.1 Government Documents. - Copies of Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

SPECIFICATION

No. B

2.3 Precedence. - This specification shall have precedence over all applicable subsidiary specifications.

2.4 Deviations. - Deviations from the requirements of this specification shall not be permitted without prior written approval from ARRADCOM. Materials and processes which do not comply with the requirements specified herein shall be subject to rejection.

3 REQUIREMENTS

3.1 Material. - The two-component paste adhesive covered by this specification shall consist of an epoxy base compound which will cure at ambient or elevated temperature upon the addition of a hardener. Curing of the two-part material shall take place by chemical reaction and shall not depend on solvent evaporation.

3.2 Properties. - The paste adhesive material specified herein shall meet the requirements of Table II.

3.2.1 The paste adhesive shall be sufficiently cured after a minimum of 8 hours at a temperature not exceeding 65°F to allow subsequent operations such as sanding and coating. Full cure shall be as noted in Table I.

3.3 Storage Life (Shelf Life). - Materials shall be capable of meeting the requirements specified herein, when stored in their original unopened containers, as specified in Table III.

4 QUALITY ASSURANCE PROVISIONS

4.1 Inspection. - Unless otherwise specified in the purchase order or this specification, the seller is responsible for the performance of all the inspection requirements specified herein. The seller may utilize his own test facilities or any commercial laboratory acceptable to ARRADCOM Quality Control.

4.2 Certificate of Conformance. - Unless otherwise specified in the purchase order, the seller shall furnish with each shipment, a certified report (in triplicate) signed by a duly authorized representative of the seller, stating conformance to the requirements specified herein and listing the specific results of all the acceptance tests. This report shall also include this specification number, the purchase order number, and the batch number.

SPECIFICATION

No. B

4.2.1 Subcontractor Certification. - When material is purchased directly by a subcontractor, the subcontractor shall be responsible for determining that each batch of material meets all the requirements of this specification. With each part shipment to ARRADCOM, the subcontractor shall submit one copy of the certification report specified in 4.2.

4.3 Inspection Records. - The sellers inspection records of examination and tests for conformance to the requirements of this specification shall be kept complete and available to ARRADCOM upon request.

4.4 Reinspection. - ARRADCOM Quality Control reserves the right to perform or witness any of the inspections specified herein, when these inspections are deemed necessary to substantiate material conformance. Tested materials which do not meet these requirements shall be subject to rejection.

4.5 Inspection Lot. - A lot may consist of material from more than one batch forming part of one purchase order and submitted for acceptance at one time. Under these circumstances, each batch shall be subjected to the herein specified acceptance tests. A batch shall be that quantity of material compounded and mixed at one time.

4.6 Test Conditions. -

4.6.1 Test Temperatures shall be as specified in Table II and the relative humidity 65 percent maximum.

4.7 Test Specimen Preparation. -

4.7.1 Mixing. - The base compound and hardener shall be mixed in the applicable ratio per manufacturers instructions.

4.7.2 Curing. - The mixed adhesive material shall be fully cured in accordance with Table I.

4.8 Classification of Tests. - The inspection and testing of the herein specified material shall be classified as follows:

(a) Qualification Test (see 4.9)

(b) Acceptance Tests (see 4.10)

SPECIFICATION

No. B

4.9 Qualification Tests. - The initial qualification tests shall demonstrate compliance with all the requirements of Section 3 and Table II. The seller shall submit a test report listing the specific results of all the qualification tests and samples of the material to ARRADCOM for evaluation. Approval for listing of this material on the AML shall be the responsibility of ARRADCOM and seller requalification, when required, shall be as specified in 4.9.1.

4.9.1 Requalification. - Once a product is approved and listed on the Approved Materials List (AML), any change in formulation or processing which would affect the properties of the material shall be submitted in writing, by the manufacturer, to ARRADCOM. The material shall then be subject to requalification, and failure shall be cause for removal of the material from the AML.

4.10 Acceptance Tests. - The acceptance tests shall consist of the tests of Table II.

4.10.1 Compression Tests. - Compression tests shall be run at $75^{\circ} \pm 5^{\circ}\text{F.}$

5 PREPARATION FOR DELIVERY

5.1 Packaging. - The material shall be packaged in tubes or containers as specified in the purchase order, in accordance with the best commercial practice. The base compound and hardener shall be supplied in separate containers within individual packages. The ratio of the packaged base compound to the hardener shall be the same as the recommended mixing ratio.

5.2 Identification Marking. - Each container of base compound and hardener shall be permanently marked with the following data:

FRAGMENT INTERSTITIAL ADHESIVE, TROWELABLE PASTE, EPOXY RESIN

SPECIFICATION NO.

MANUFACTURER'S NAME, TRADEMARK OR SYMBOL

MANUFACTURER'S PART NUMBER

MANUFACTURER'S BATCH NUMBER

DATE OF MANUFACTURE

BASE COMPOUND FOR: CURING AGENT TYPE

SPECIFICATION

No. B

5.2 (Continued)

CURING AGENT FOR: BASE COMPOUND TYPE

MIXING AND CURING INSTRUCTIONS

CONTAINER CAPACITY

STORAGE LIFE (see Table III)

5.3 Packing. - Units packaged as specified in 5.1 shall be packed in exterior-type shipping containers in a manner that will assure safe delivery and acceptance at their destination. Shipping containers shall comply with carrier regulations applicable to the mode of transportation. Type II materials require refrigerated packing and/or shipping unless otherwise specified on the purchase order.

5.4 Marking of Shipment. - Each shipping container shall be marked with the following data:

FRAGMENT INTERSTITIAL ADHESIVE, TROWELABLE PASTE, EPOXY RESIN

SPECIFICATION NO.

CONTRACT OR PURCHASE ORDER NUMBER

MANUFACTURER'S NAME, TRADEMARK OR SYMBOL

MANUFACTURER'S PART NUMBER

MANUFACTURER'S BATCH NUMBER

DATE OF MANUFACTURE

CONTAINER SIZE AND QUANTITY

STORAGE LIFE

SPECIFICATION

No. B

6 NOTES

6.1 Ordering Data. - The purchase order shall specify the following:

- (a) Title, number and date of this specification
- (b) Container size and quantity required
- (c) Refrigerated transportation, if required

6.2 Product Availability. As of this date (June 1981) EA 934 A/B manufactured by Dexter-Hysol Corporation, 2580 Willow Pass Road, P.O. Box 812, Pittsburgh, California 94565 is the only approved material.

TABLE I

Full Cure	
Qualification Tests	Acceptance Tests
70 ± 5°F for 7 ± 2 days	70 ± 5°F for 7 ± 2 days or 150 ± 5°F for 2 hours ± 10 minutes

TABLE II

Test No.	Property	Test Temp. °F ± 5°F	Units	Requirements	Test Methods
1	Application Life	75	Minutes Minimum	20	The application life shall be considered expired when a 100 ± 0.5 gram mass of catalyzed material is no longer spreadable.
2	Specific Gravity	75	(Maximum Value)	1.60	FTMS 406, Method 5011 or Method 5012

SPECIFICATION

No. B

TABLE II (Contd)

Test No.	Property	Test Temp. °F ± 5°F	Units	Requirements	Test Methods
3	Compressive Strength at 2% Deflection	75	PSI Minimum	3000	FTMS 406 Method 1021 1 Number of Specimens: Qualification: 3 specimens from each of 3 batches per Test Temperature. Acceptance: 5 specimens for each required test temperature (4.10.1)
4	Hardness	75	Barcol	45-60	Barcol Impressor 935
5	Bond Strength	75	PSI, Avg.	1500	MMM-A-132 2

NOTE: 1 Specimen size shall be 0.50 x 1.00 x 2.00 inches. Allowable tolerance is ± 0.015 inch. Load shall be applied perpendicular to the 0.50 x 1.00 inch faces.

2 Five specimens required.

TABLE III

Storage Temperature	Retest Period 1
Below 80°F	One Year
NOTE: 1 Material shall meet the requirements of Table II.	

APPENDIX C

BASE FILLER SPECIFICATION -

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. C

Material Specification: Base Filler - PATRIOT Warhead
Autowrap Fragment Layup Process

BASE FILLER, TWO-PART THIXOTROPIC TROWELABLE EPOXY,

1 SCOPE

1.1 Scope. - This specification establishes the requirements for a two-component, epoxy-resin-based compound used for filling and fairing the gap between the Steel Fragments (Part No. 9226307) and the base of the aluminum Metal Parts Welded Assembly (Part No. 9312580) of the PATRIOT Warhead. This material shall not be used to fill the interstices between the fragments in the outer layer.

1.2 Type. - This material is recommended for service at temperatures ranging from -67°F to 350°F.

1.3 Form. - This material is classified as a thixotropic trowelable paste which cures to form a fill material of intermediate density.

2 APPLICABLE DOCUMENTS

2.1 Government Documents. - The following documents of the issue shown (referred to under the basic number in subsequent paragraphs) form a part of this specification to the extent specified herein:

STANDARDS

Federal

Federal Test Method
Standard No. 406

Plastics: Methods of Testing

2.2 Other Documents. - The following documents of the issue shown form a part of this specification to the extent specified herein:

SPECIFICATIONS

American Society for Testing and Materials

D 1824-66 Apparent Viscosity of Plastisols and Organosols at Low
Shear Rates by Brookfield Viscometer, Test for

SPECIFICATION

No. C

2.3 Availability of Documents. -

2.3.1 Government Documents. - Copies of Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

2.3.2 Other Documents. - Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, 19103.

2.4 Precedence. - This specification shall have precedence over all applicable subsidiary specifications.

2.5 Deviations. - Deviations from the requirements of this specification shall not be permitted without prior written approval from ARRADCOM.

3 REQUIREMENTS

3.1 Material. - The compounds covered by this specification shall consist of an epoxy-resin base with non-corrosive, low-density, flow-controlling fillers such as flocculated silica or glass microballoons, and a liquid curing agent. Curing of the compounds shall take place by chemical reaction and shall not depend on solvent evaporation for setting. Compounds specified herein shall not cause corrosion or otherwise deteriorate aluminum, titanium, cadmium plate or stainless steel materials contacted. The material shall be mixed in compliance with the manufacturers directions.

3.2 Properties. - The compounds cured in accordance with this specification shall meet the following physical requirements:

Cured Density: 45-55 lb/cu ft

Compressive Strength: 73°F - 4000 psi
270°F - 1200 psi

3.3 Storage Life (Shelf Life). - The compound shall be capable of meeting all the requirements specified herein when stored in their original unopened containers for 12 months at 40°F or below.

4 QUALITY ASSURANCE PROVISIONS

4.1 Inspection. - Unless otherwise specified in the purchase order or this specification, the seller is responsible for the performance of all inspection requirements specified herein. The seller may utilize his own test facilities or any commercial laboratory acceptable to ARRADCOM Quality Control.

SPECIFICATION

No. C

4.2 Certificate of Conformance. - Unless otherwise specified in the purchase order, the seller shall furnish with each shipment, a report (in triplicate) signed by a duly authorized representative of the seller stating conformance to the requirements specified herein and listing the specific results of all the acceptance tests. This report shall also include this specification number, the purchase order number, and the batch number.

4.2.1 Subcontractor Certification. - When material is purchased directly by a subcontractor, the subcontractor shall be responsible for determining that each batch of material meets all the requirements of this specification. With each part shipment to ARRADCOM, the subcontractor shall submit one copy of the certification report specified in 4.2.

4.3 Inspection Records. - The seller's inspection records of examinations and tests for conformance to the requirements of this specification shall be kept complete and available to ARRADCOM upon request.

4.4 Reinspection. - ARRADCOM Quality Control reserves the right to perform or witness any of the inspections specified herein, when these inspections are deemed necessary to substantiate material conformance. Tested materials which do not meet these requirements shall be subject to rejection.

4.5 Inspection Lot. - A lot may consist of material from more than one batch, forming part of one purchase order and submitted for acceptance at one time. Under these circumstances, each batch shall be subjected to the herein specified acceptance tests. A batch shall be that quantity of material compounded and mixed at one time.

4.6 Test Conditions.

4.6.1 Standard Conditions. - Unless otherwise specified herein, all tests shall be conducted at a temperature of $75 \pm 5^{\circ}\text{F}$, and a relative humidity of 65 percent maximum.

4.6.2 Elevated Temperature. - Elevated-temperature tests shall be performed at the designated temperature $\pm 5^{\circ}\text{F}$ after a 10-minute stabilization of the specimen at the temperature.

4.7 Test Specimen Preparation.

4.7.1 Mixing And Curing. - To 100 parts by weight of epoxy base add 11 parts by weight of curing agent. The pot life of the mixed material is 30-40 minutes at 75°F . Cure 24-48 hours at $70-80^{\circ}\text{F}$.

SPECIFICATION

No. C

4.7.2 Acceptance Tests. - The acceptance tests shall be as follows:

4.7.2.1 Specific Gravity. - per Method 5011 or 5012 of Federal Test Method Standard No. 406.

4.7.2.2 Compression Strength. -

a) Test Specimen - The test specimen shall be a right prism having rectangular cross-sectional dimensions of 1 ± 0.005 by 0.50 ± 0.005 by 2 ± 0.010 in.

b) Test - The compression strength shall be determined in accordance with Method 1021 of Fed. Test Method Std. No. 406. The load shall be applied at a constant cross-head rate of 0.05 in. per minute (ipm).

5 PREPARATION FOR DELIVERY

5.1 Packaging. - The two-component compound shall be supplied in one-quart, one-gallon or five-gallon kits as specified in the purchase order. Containers for base compounds or curing agents shall provide adequate protection from normal hazards during shipment and storage.

5.2 Identification Marking. - Each container of compound shall be permanently marked with the following data:

MANUFACTURER'S NAME, TRADEMARK OR SYMBOL

MANUFACTURER'S PART NUMBER

MANUFACTURER'S BATCH NUMBER

DATE OF MANUFACTURE

BASE COMPOUND FOR: CURING AGENT TYPE (WHERE APPLICABLE)

CURING AGENT FOR: BASE COMPOUND (WHERE APPLICABLE)

CONTAINER CAPACITY

SHELF LIFE

STORAGE TEMPERATURE

SPECIFICATION

No. C

5.3 Packing. - Units packaged as specified in 5.1 shall be packed in exterior-type containers in a manner that will assure safe delivery and acceptance at their destination. Shipping containers shall comply with carrier regulations applicable to the mode of transportation. Refrigerated packing (5.1.2) and/or shipping shall be as required unless otherwise specified on the purchase order.

5.4 Marking of Shipment. - Each shipping container shall be marked with the following data:

BASE FILLER, TWO-PART THIXOTROPIC TROWELABLE EPOXY

SPECIFICATION NO. (CLASSIFICATION NO.)

CONTRACT OR PURCHASE ORDER NUMBER

MANUFACTURER'S NAME, TRADEMARK OR SYMBOL

MANUFACTURER'S PART NUMBER

MANUFACTURER'S BATCH NUMBER

DATE OF MANUFACTURE

CONTAINER QUANTITY AND SIZES

SHELF LIFE

6 NOTES

6.1 Ordering Data. - The purchase order shall specify the following:

- (a) Title, number and date of this specification
- (b) Form of compound desired (see 1.3).
- (c) Container size and quantity required (see 5.1).
- (d) Packing/shipping information, where required (see 5.3).

6.2 As of this date (June 1981) EPOCAST 1310-I/9223 (manufactured by Furane Plastics, Div. of M&T Chemicals, Inc., 5121 San Fernando Road West, Los Angeles, CA 90039, Phone (213) 247-6210) is the only approved material.

APPENDIX D

SPECIFICATION - EXPENDABLE SHRINK TAPE (TEFLON)

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. D

Material Specification: Expendable Shrink Tape (Teflon) - PATRIOT
Warhead Autowrap Fragment Layup Process

EXPENDABLE SHRINK TAPE FOR USE DURING TAPE ADHESIVE CURE CYCLE

1 SCOPE

1.1 Items shall meet the requirements specified herein.

1.2 For design feature purposes, this specification takes precedence over the documents referenced herein which shall be of the issue in effect on date of invitation for bids.

1.3 The seller(s) listed are the approved sources of supply for the items shown herein. Any change made to items by seller(s), without prior approval, may result in rejection of items and in seller disqualification.

1.4 Unless otherwise specified, dimensions are in inches.

2 MATERIAL

2.1 Backing: 1.0 mil (nominal) Teflon film

2.2 Adhesive: Silicone, pressure-sensitive

2.3 Tape: Type C, Clear per

3M ITEM NO.(1)	CHR ITEM NO.(1)	WIDTH, IN.
5430	TEMP-R-TAPE	1
-	TEMP-R-TAPE	2
5430	TEMP-R-TAPE	4

3 ENVIRONMENTAL SERVICE

(1) See Section 9

3.1 Temperature Range: -51°C to 196°C

4 PHYSICAL PROPERTIES

4.1 Thickness (Backing plus Adhesive): 0.0020 to 0.0035 in.

4.2 Per Federal Test Method Standard 147:

4.2.1 Tensile Strength: 20 lb/in. width (minimum)

SPECIFICATION

No.
D

4.2.2 Elongation: 70% (minimum) at break

4.2.3 Adhesion to Metal: - 15 oz/in. width (minimum)

5 STORAGE OR SHELF LIFE

Items shall be capable of meeting all the requirements specified herein, when stored in their original unopened containers at 27°C or below, for a period of one year from date of receipt.

6 PACKAGING

Unless otherwise specified on the purchase order, packaging and packing shall be in accordance with Level C of PPP-T-680.

7 MARKING

7.1 Items: - None

7.2 Packages: Packages shall be legibly marked with the manufacturer's name or trademark, item number, date of manufacture, and batch and/or lot number.

8 ENGINEERING INFORMATION

8.1 Chemical Resistance: Excellent

8.2 Uses: Mark edges of overlap seams in metal bonding processes, mark for plating or anodizing, and medium to apply shrink pressure to cure adhesives and laminates.

9 PROCUREMENT INFORMATION

9.1 Suggested Sources of Supply:

9.1.1 Minnesota Mining and Manufacturing (3M) Company,
Industrial Tape Division, St. Paul, Minnesota (FSCM 26066)

9.1.2 CHR Industries Incorporated, An Armco Company, New
Haven, Connecticut (FSCM 71643)

9.2 Other:

9.2.1 One (1) roll is 72 yards

APPENDIX E

SPECIFICATION - EXPENDABLE SHRINK TAPE (POLYESTER)

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. E

Material Specification: Expendable Shrink Tape (Polyester) -
PATRIOT Warhead Autowrap Fragment Layup Process

EXPENDABLE SHRINK TAPE OVERWRAP FOR USE DURING TAPE ADHESIVE CURE CYCLE (POLYESTER PRESSURE-SENSITIVE ADHESIVE TAPE)

1 SCOPE

1.1 Items shall meet the requirements specified herein.

1.2 For design feature purposes, this specification takes precedence over the documents referenced herein which shall be of the issue in effect on date of invitation for bids.

1.3 The seller(s) listed are the approved sources of supply for the items shown herein. Any change made to items by seller(s), without prior approval, may result in rejection of items and in seller disqualification.

1.4 Unless otherwise specified, dimensions are in inches.

2 MATERIAL

2.1 Backing: 1.0 mil (nominal) polyester film.

2.2 Adhesive: Silicone, pressure-sensitive.

3M ITEM NO. ⁽¹⁾	AIRTECH ITEM NO. ⁽¹⁾	CHR ITEM NO. ⁽¹⁾	WIDTH, IN.
8403-1	FLASH BREAKER (ONE), 1-IN. WIDE	M66, 1-IN. WIDE	1
8403-2	FLASH BREAKER (ONE), 2-IN. WIDE	M66, 2-IN. WIDE	2
8403-4	FLASH BREAKER (ONE), 4-IN. WIDE	M66, 4-IN. WIDE	4

(1) See Section 9

3 ENVIRONMENTAL SERVICE

3.1 Temperature Range: -51°C to 196°C

4 PHYSICAL PROPERTIES

4.1 Thickness (Backing plus Adhesive): 0.0020 to
0.0035 in.

4.2 Per Federal Test Method Standard 147:

SPECIFICATION

No. E

- 4.2.1 Tensile Strength: 20 lb/in. width (minimum)
- 4.2.2 Elongation: 70% (minimum) at break
- 4.2.3 Adhesion to Metal: 15 oz/in. width (minimum)

5 STORAGE OR SHELF LIFE

Items shall be capable of meeting all the requirements specified herein, when stored in their original unopened containers at 27°C or below, for a period of one year from date of receipt.

6 PACKAGING

Unless otherwise specified on the purchase order, packaging and packing shall be in accordance with Level C of PPP-T-680.

7 MARKING

7.1 Items: None

7.2 Packages: Packages shall be legibly marked with the manufacturer's name or trademark, item number, date of manufacture, and batch and/or lot number.

8 ENGINEERING INFORMATION

8.1 Chemical Resistance: Excellent

8.2 Uses: Mask edges of overlap seams in metal bonding processes, mask for plating or anodizing, and medium to apply shrink pressure to adhesives and laminates.

9 PROCUREMENT INFORMATION

9.1 Suggested Sources of Supply:

9.1.1 Minnesota Mining and Manufacturing (3M) Company, Industrial Tape Division, St. Paul, Minnesota (FSCM 26066).

9.1.2 Airtech International, Inc., Torrance, California (FSCM 53912).

9.1.3 CHR Industries, Inc., an Armco Company, New Haven, Connecticut (FSCM 71643).

9.2 Other:

9.2.1 One (1) roll is 72 yards

APPENDIX F

SPECIFICATION - ALTERNATE EXPENDABLE SHRINK TAPE (NYLON)

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

SPECIFICATION

No. F

Material Specification: Alternate Expendable Shrink Tape (Nylon) -
PATRIOT Warhead Autowrap Fragment Layup Process

EXPENDABLE SHRINK TAPE OVERWRAP FOR USE DURING TAPE ADHESIVE CURE CYCLE (NYLON, HIGH-TEMPERATURE, PRESSURE-SENSITIVE ADHESIVE TAPE)

1 SCOPE

1.1 Items shall meet the requirements specified herein.

1.2 For design feature purposes, this specification takes precedence over the documents referenced herein which shall be of the issue in effect on date of invitation for bids.

1.3 The seller(s) listed are the approved sources for the articles shown herein. Any change made to items by seller(s), without prior approval, may result in rejection of items and in seller disqualification.

1.4 Unless otherwise specified, dimensions are in inches.

2 MATERIAL

2.1 Backing: 0.002-in. (nominal) nylon tape

2.2 Adhesive: Synthetic rubber, pressure-sensitive

3M ITEM NO.	WIDTH, IN. (± 0.031)	THICKNESS, IN. (± 0.0005)
855-1/4	0.250	0.0035
855-3/8	0.375	0.0035
855-1/2	0.500	0.0035
855-5/8	0.625	0.0035
855-3/4	0.750	0.0035
855-7/8	0.875	0.0035
855-1	1.000	0.0035
855-2	2.000	0.0035
855-3	3.000	0.0035
855-4	4.000	0.0035

3 ENVIRONMENTAL SERVICE

3.1 Temperature Range: -40°F to 350°F (-40°C to 177°C)

SPECIFICATION

No. F

4 PHYSICAL PROPERTIES

- 4.1 Thickness (Backing plus adhesive): 0.0035 in.
- 4.2 Per Federal Test Method Standard 147:
 - 4.2.1 Adhesion Strength to Steel: 30 oz/in. width (minimum)
 - 4.2.2 Tensile Strength: 20 lb/in. width (minimum)
 - 4.2.3 Elongation: 300% (minimum) at break

5 STORAGE OR SHELF LIFE

Items shall be capable of meeting all the requirements specified herein, when stored in their original unopened containers at 27°C or below, for a period of one year from date of receipt.

6 PACKAGING

Unless otherwise specified on the purchase order, packaging and packing shall be in accordance with Level C of PPP-T-680.

7 MARKING

- 7.1 Items: - None
- 7.2 Packages: Packages shall be legibly marked with the manufacturer's name or trademark, item number, date of manufacturer, and batch and/or lot number.

8 ENGINEERING INFORMATION

- 8.1 Chemical Resistance: Excellent
- 8.2 Uses: Mark edges of overlap seams in metal bonding processes, mark for plating or anodizing, and medium to apply shrink pressure to cure adhesives and laminates.

9 PROCUREMENT INFORMATION

- 9.1 Suggested Source of Supply:
 - 9.1.1 Minnesota Mining and Manufacturing (3M) Company, Industrial Tape Division, St. Paul, Minnesota (FSCM 26066)
- 9.2 Other
 - 9.2.1 One (1) roll is 72 yards

APPENDIX G

OPERATING MANUAL

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP MACHINE

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

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Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

1 PURPOSE

The purpose of this document is to describe the standard operating procedures for the PATRIOT Warhead Autowrap System. Facilities requirements for the operation of the system, as well as machine and part preparation procedures, are also included.

2 INTRODUCTION

The PATRIOT Warhead Autowrap System is designed to dispense fragments continuously onto a tape adhesive for the wrapping process for the XM248E1 PATRIOT Warhead Inert Parts Assembly. With the exception of tape loading and fragment compaction on the Inert Parts Assembly, all operations are mechanized. Manual over-rides and controls are provided to allow for operator intervention and control should anomalies occur.

Inert Parts Assembly Drawing No. 9312581 and Fragment Drawing No. 9226307 were provided by ARRADCOM, Dover, N.J., as reference documents about which the criteria of the machine were established.

3 MAJOR COMPONENTS (Fig. G-1)

The major components of the PATRIOT Warhead Autowrap System are:

- Syntron Vibrator
- Tape/Fragment Alignment Chute
- Tape Supply Spool
- Take-Up Spool
- Cross-Slide Mechanism
- Welded Parts Assembly Holding Brackets
- Longitudinal Drive System
- Rotational Drive System
- Control System

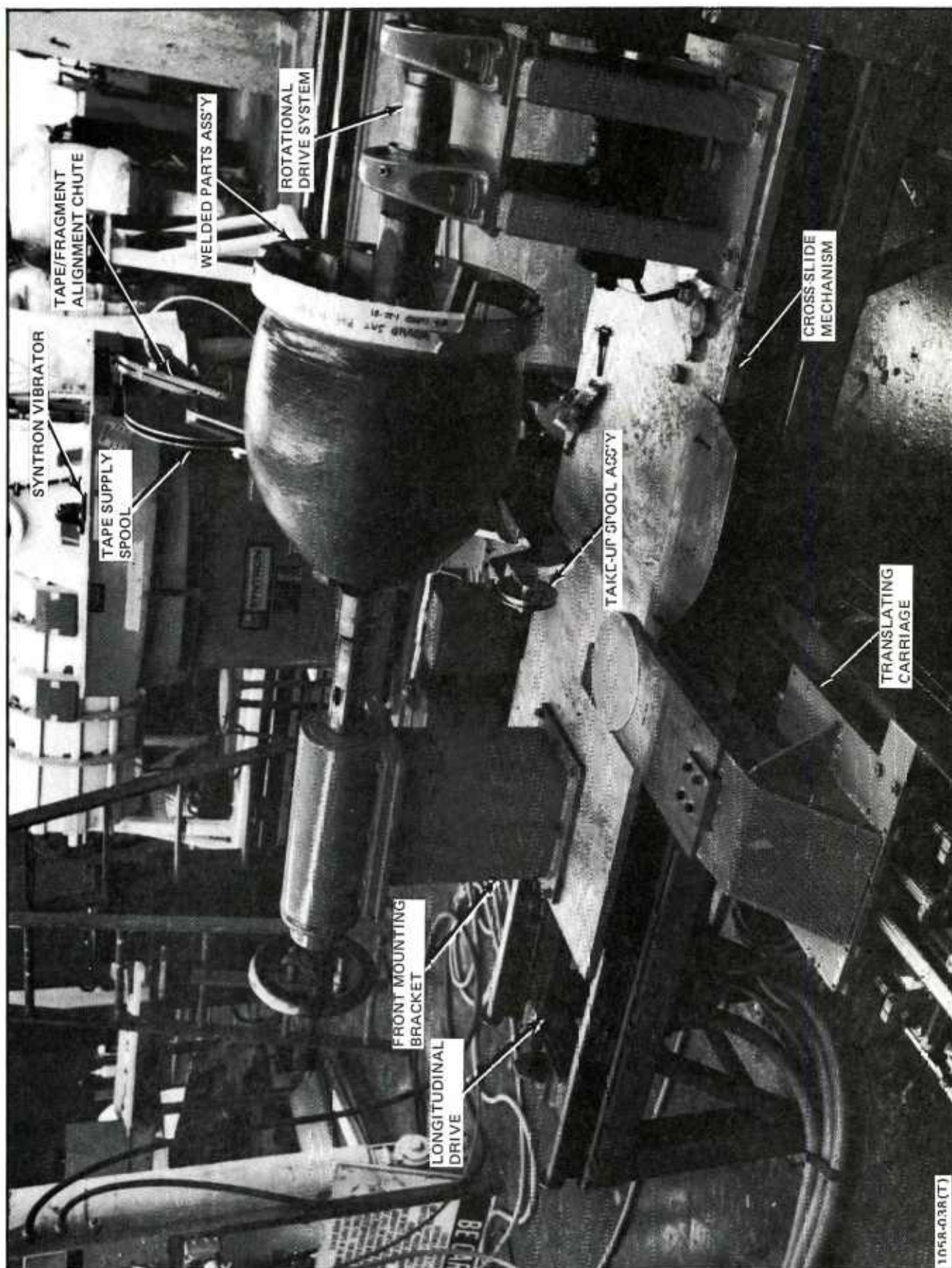


Fig. G-1 Overall Arrangement of Autowrap Fragment Layout Machine for PATRIOT Warhead

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

3.1 Syntron Vibrator (Ref. Fig. G-1). -

The Syntron Vibrator stores the cubic steel fragments for wrapping about the Metal Parts Assembly. Through its operation, the fragments are aligned into a single row in preparation for tape application and the formation of a continuous fragment chain. It is automatically operated through the control console (Fig. G-2) switch labeled VIB-HOPPER and supplies fragments as a function of the rate of fragment usage. The "ON-OFF" operation of the vibrator is controlled by an air-operated diaphragm switch (Fig. G-3) and an air jet whose path crosses the alignment chute. When fragments are being used, the air jet is uninterrupted thereby triggering the Syntron to turn "ON". When the alignment chute is filled up, the air jet is interrupted and the Syntron shuts "OFF". The maximum rate of fragment chain formation is dependent on the Syntron Vibrator output.

3.2 Tape/Fragment Alignment Chute (Fig. G-4 and G-5). -

This mechanism contains all of the detail parts (i.e., guide rollers, alignment brackets, compactor roller, vibrator, etc.) that are necessary for aligning the tape to the fragments, applying the required pressure to tack the fragments onto the tape, forming a continuous fragment chain, and guiding and properly aligning the fragment chain during the wrapping process.

3.3 Tape Supply Spool (Fig. G-4). -

This mechanism holds the roll of adhesive tape on the machine and keeps it properly aligned as it is dispensed into the guide chute for application to the fragments.

3.4 Take-Up Spool (Fig. G-6). -

This mechanism provides automatic take-up of the backing paper as it is removed from the adhesive carrier prior to application of the adhesive to the Warhead Welded Parts Assembly. The operation of the take-up spool is coordinated by the control console (Fig. G-2). It operates only when the switch labeled MODE on the control panel is in the "OPER" position and the START switch has been pushed. Manual operating capability is provided on the take-up spool control box (Fig. G-7) by turning the toggle switch to the "MANUAL" position. By adjusting the tension springs to increase friction from the drive motor and increasing the motor speed by turning the dial on the control box (Fig. G-7) to a higher number, this mechanism also facilitates feeding of the fragment chain through the system.

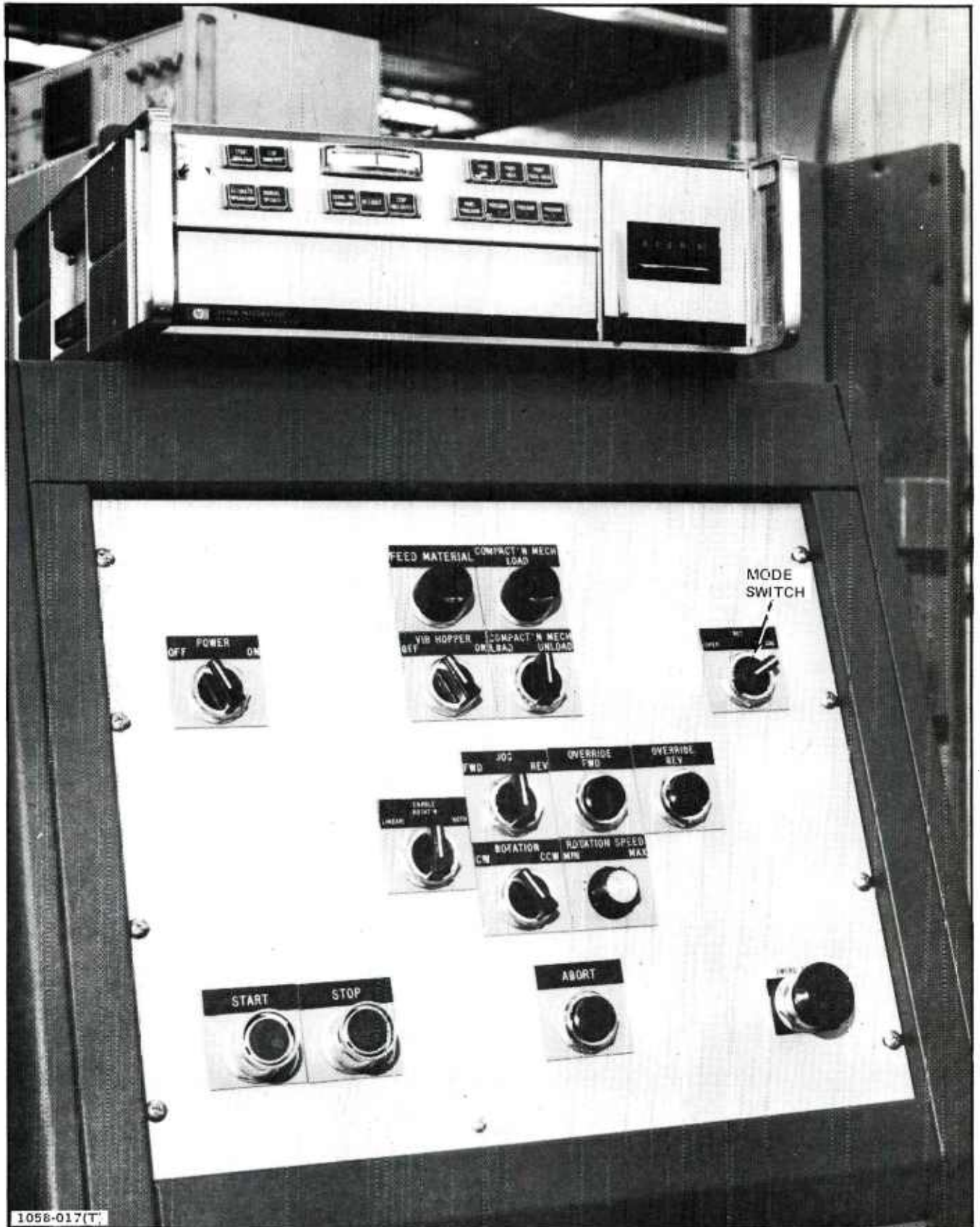


Fig. G-2 Control Console

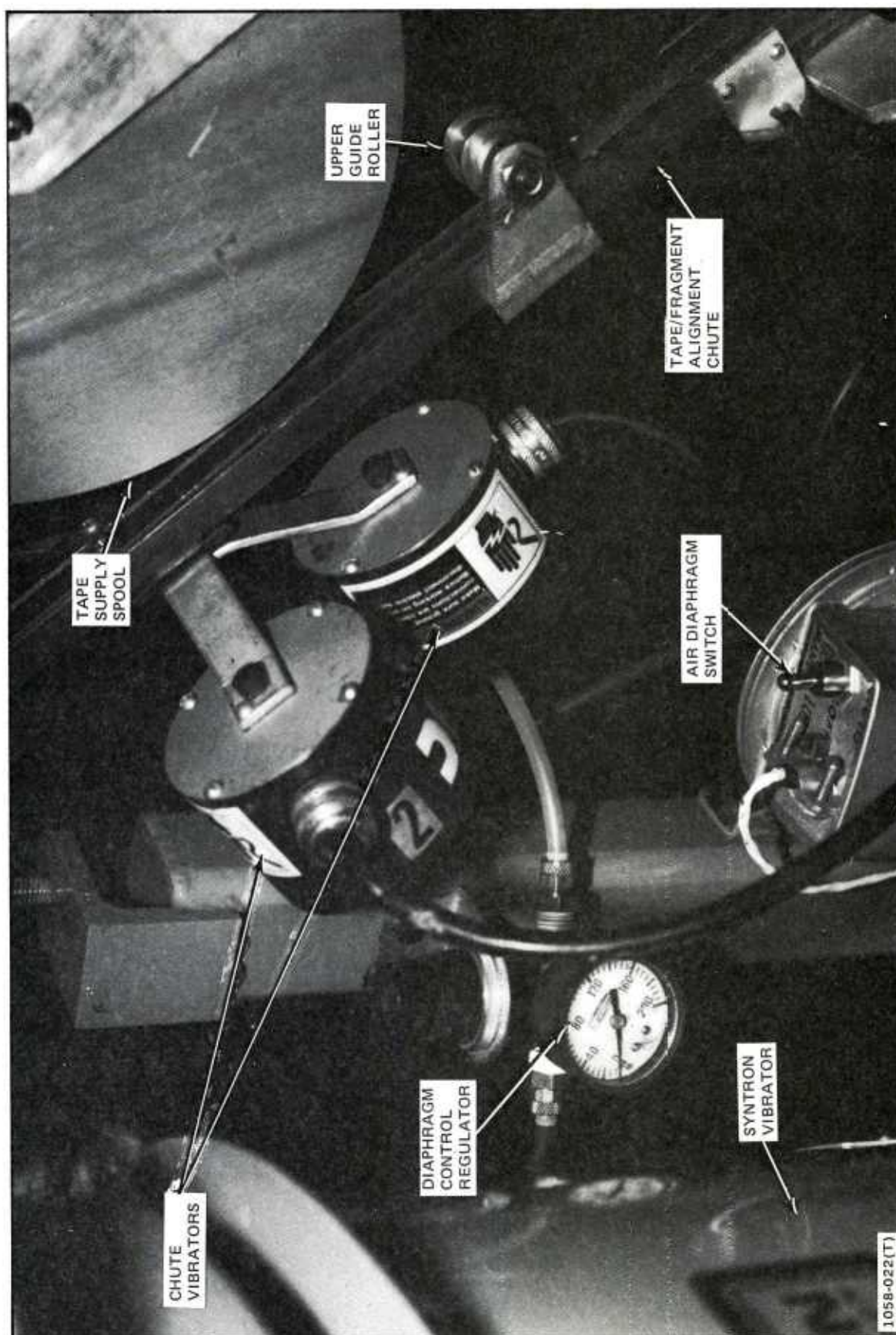


Fig. G-3 Air Diaphragm Regulator and Control Box

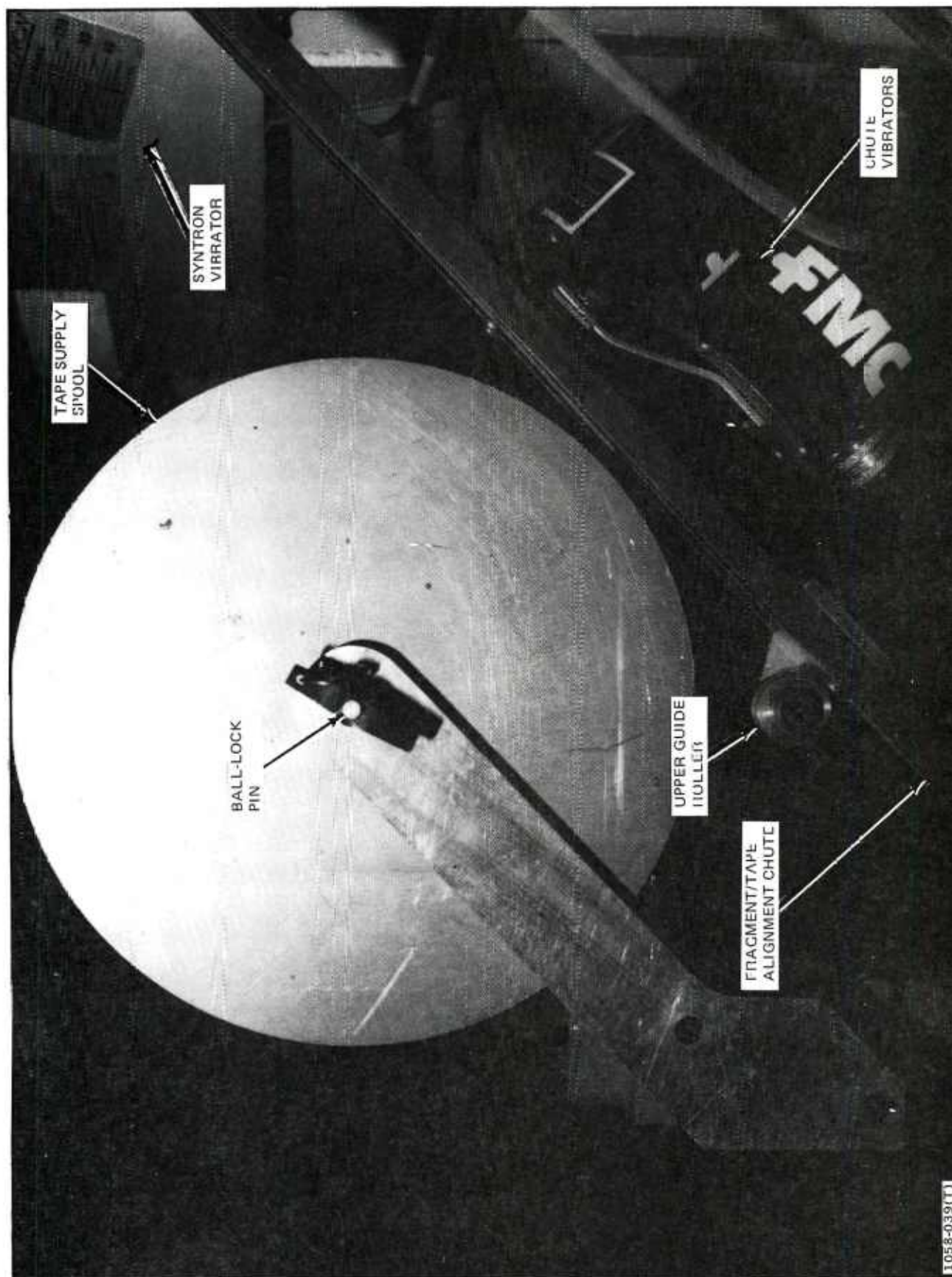


Fig. G-4 Close-Up View of Supply Spool

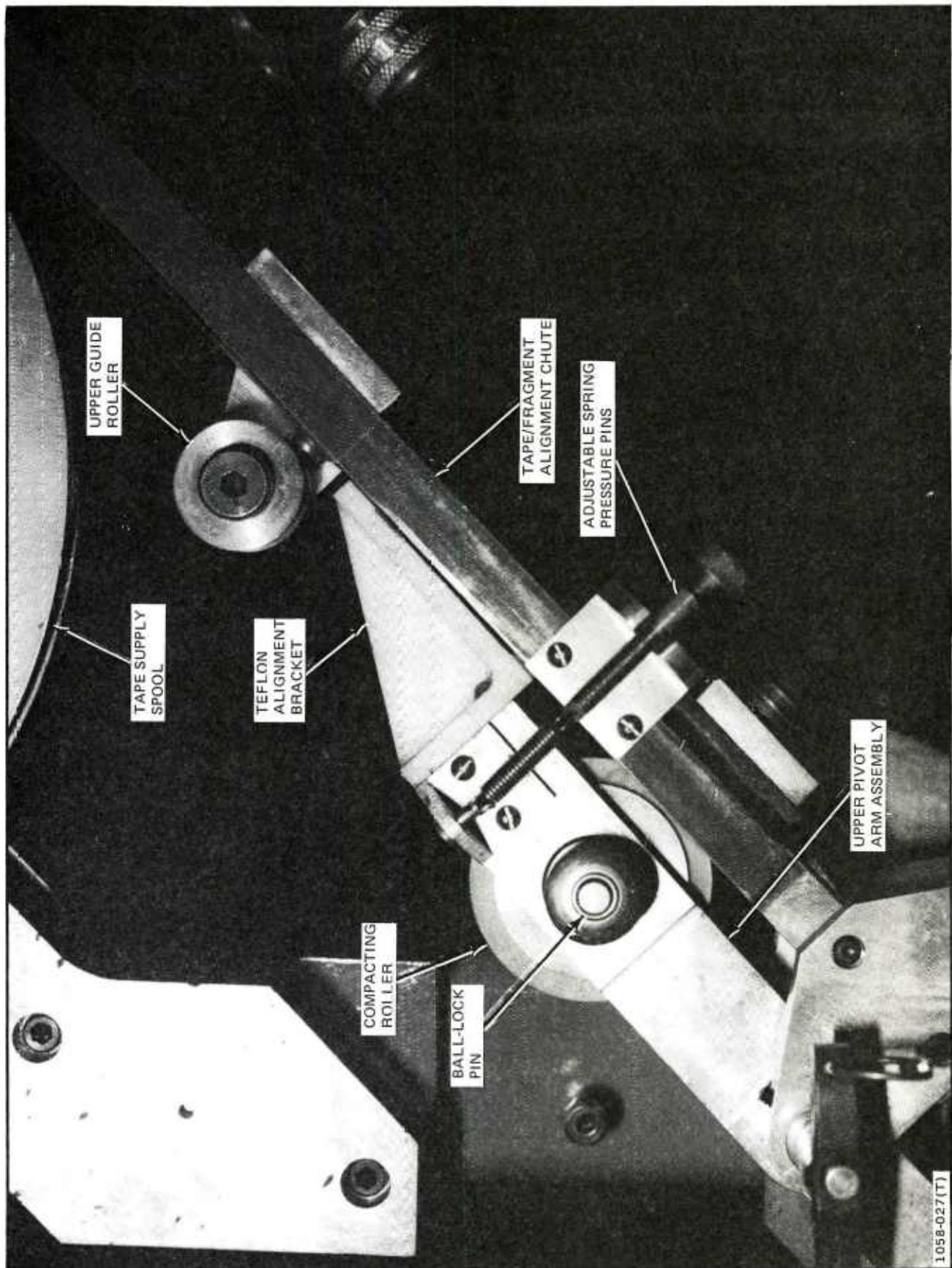


Fig. G-5 Upper Pivot Arm with Tension Springs on Guide Bracket

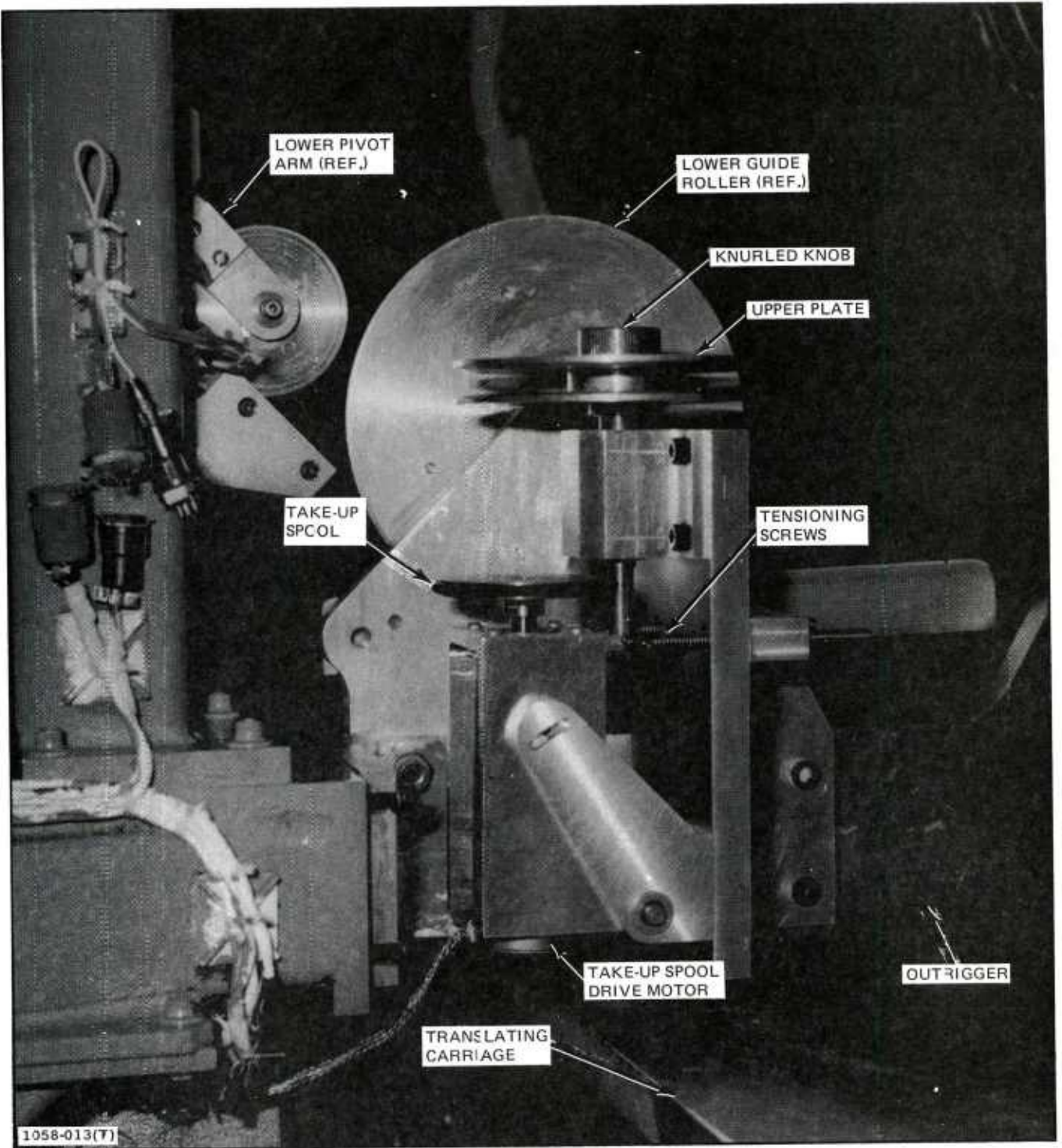


Fig. G-6 Take-Up Spool

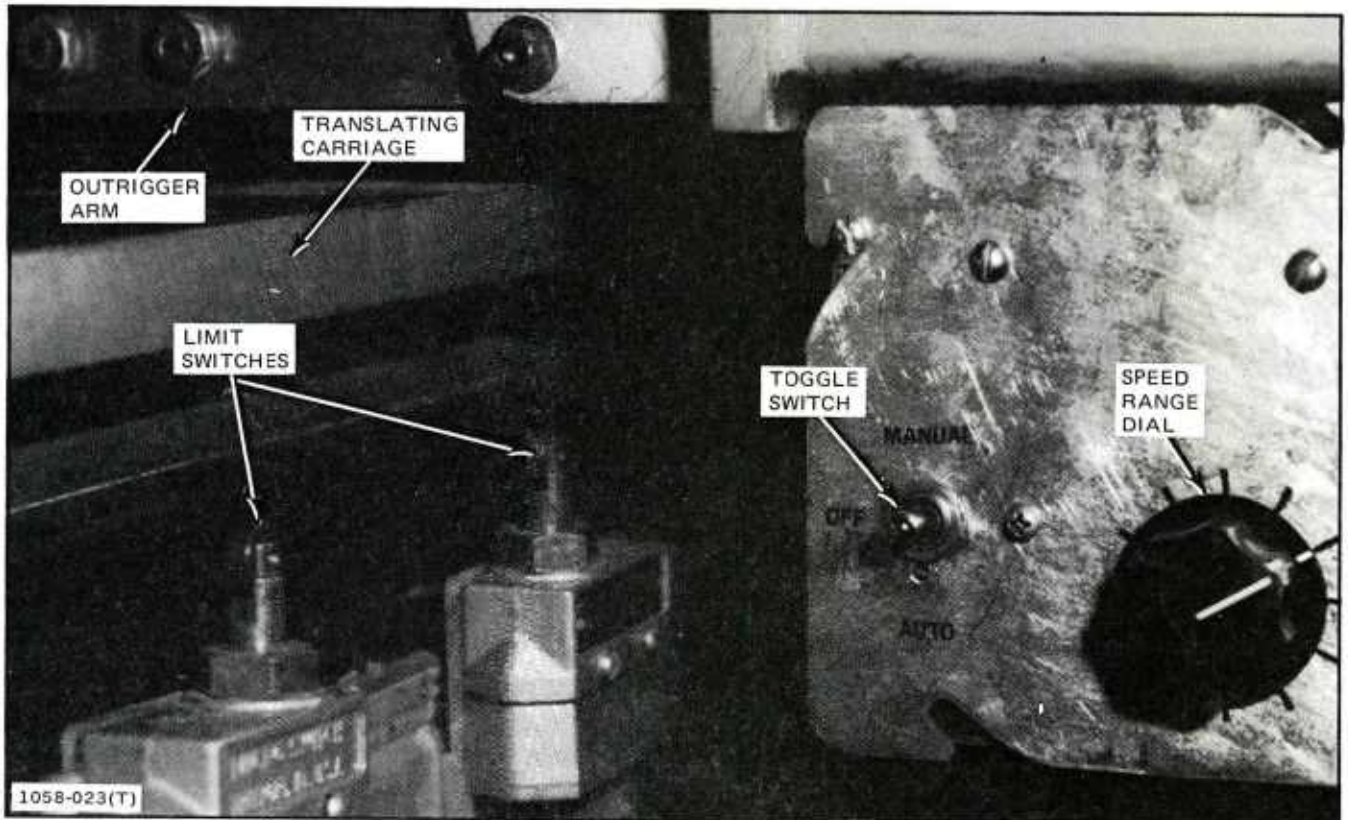


Fig G-7 Take-Up Spool Control Box

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

3.5 Cross-Slide Mechanism (Fig. G-8). -

This mechanism contains the cam follower bracket and a linear potentiometric displacement transducer that is used to provide coordination between the longitudinal speed rate of the carriage and the rotational speed of the Welded Parts Assembly. Its operation is controlled through the control console (Fig. G-2) switch labeled COMPACT'N MECH which activates an air cylinder, through a solenoid valve, to bank the cam-follower on the cam plate. As the carrier moves forward or back, the pressure-activated air cylinder keeps the cam follower on the cam plate. The cross-slide mechanism moves in and out, as regulated by the cam plate; the linear potentiometric displacement transducer also moves with it, as regulated by the cam action. Thus, the radial motion is coordinated with the axial travel. Three cam followers are provided for coordinating the radial and axial motions. They are designated sequentially for each successive layer of fragment wrap (1, 2 and 3). No. 2 is larger than No. 1, and No. 3 is the largest in diameter. The smallest, No. 1, is used for laying up the first layer of fragments.

3.6 Welded Parts Assembly Holding Brackets (Fig. G-9 and G-10). -

These brackets, consisting of the front and rear adapters, hold the Welded Parts Assembly in its proper position on the machine and provide a method for rotating the warhead in either the clockwise or counterclockwise directions. The rear adapter is a sleeved-shaft that fits into the centrally located hole in the rear casting of the Welded Parts Assembly. This adapter also has an off-set hole with Teflon liner that is used to drive the Warhead rotationally. The front adapter is a 3-finger detail that slides into the hole in the front casting of the Welded Parts Assembly. It contains a live center which permits the Welded Parts Assembly to rotate while keeping the supporting shafting still.

3.7 Longitudinal Drive System (Fig. G-1).-

This mechanism is a DC motor-driven ball screw which is attached to the translating carriage through its integral ball nut. The movement of this mechanism actuates the carriage in either the FORWARD direction for wrapping or the REVERSE direction for returning it to its starting position. Its operation is controlled automatically through the LINEAR ENABLE and JOG SWITCHES on the control panel (Fig. G-2). Manual over-rides and controls are provided for the operator's convenience.

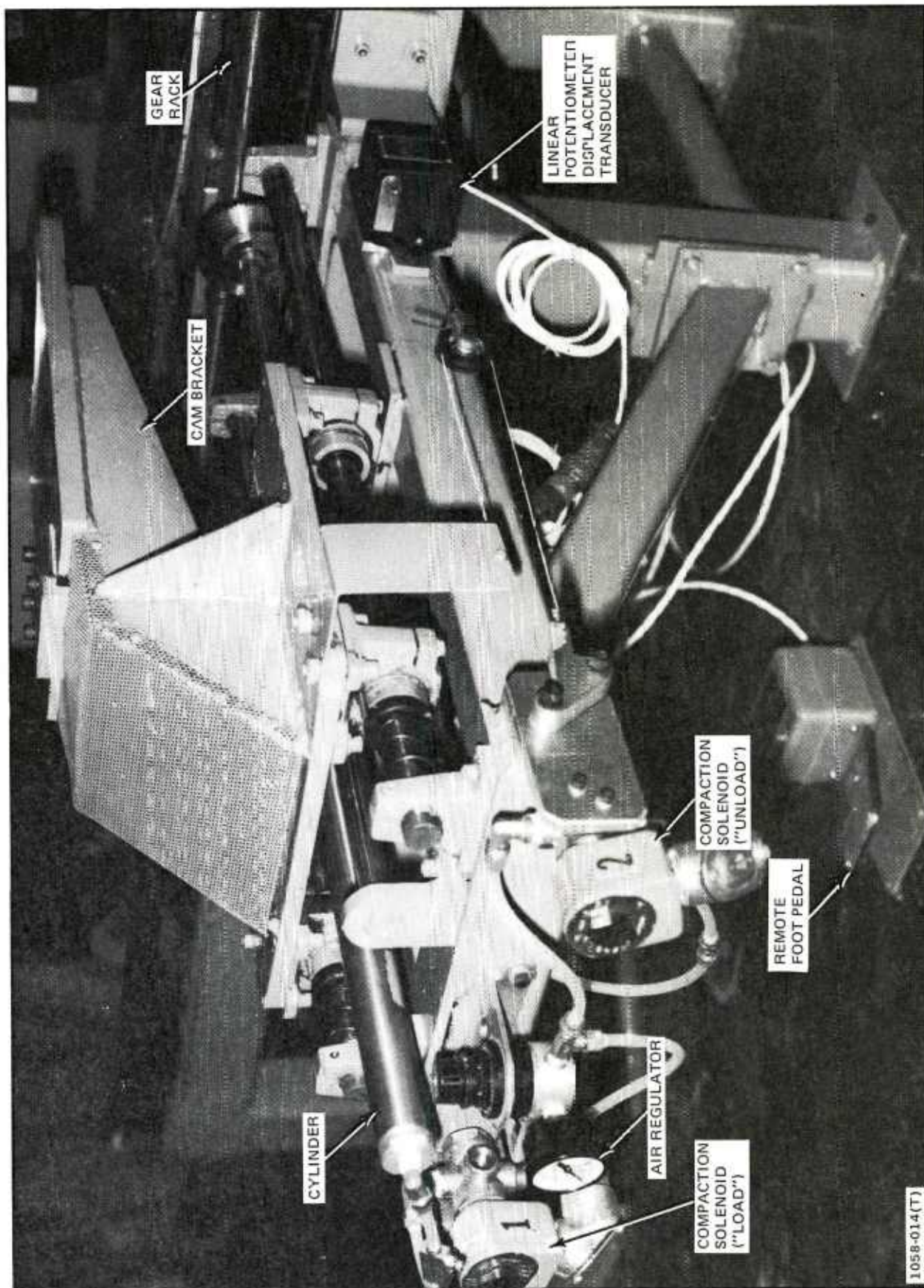


Fig. G-8 Cross-Slide Mechanism

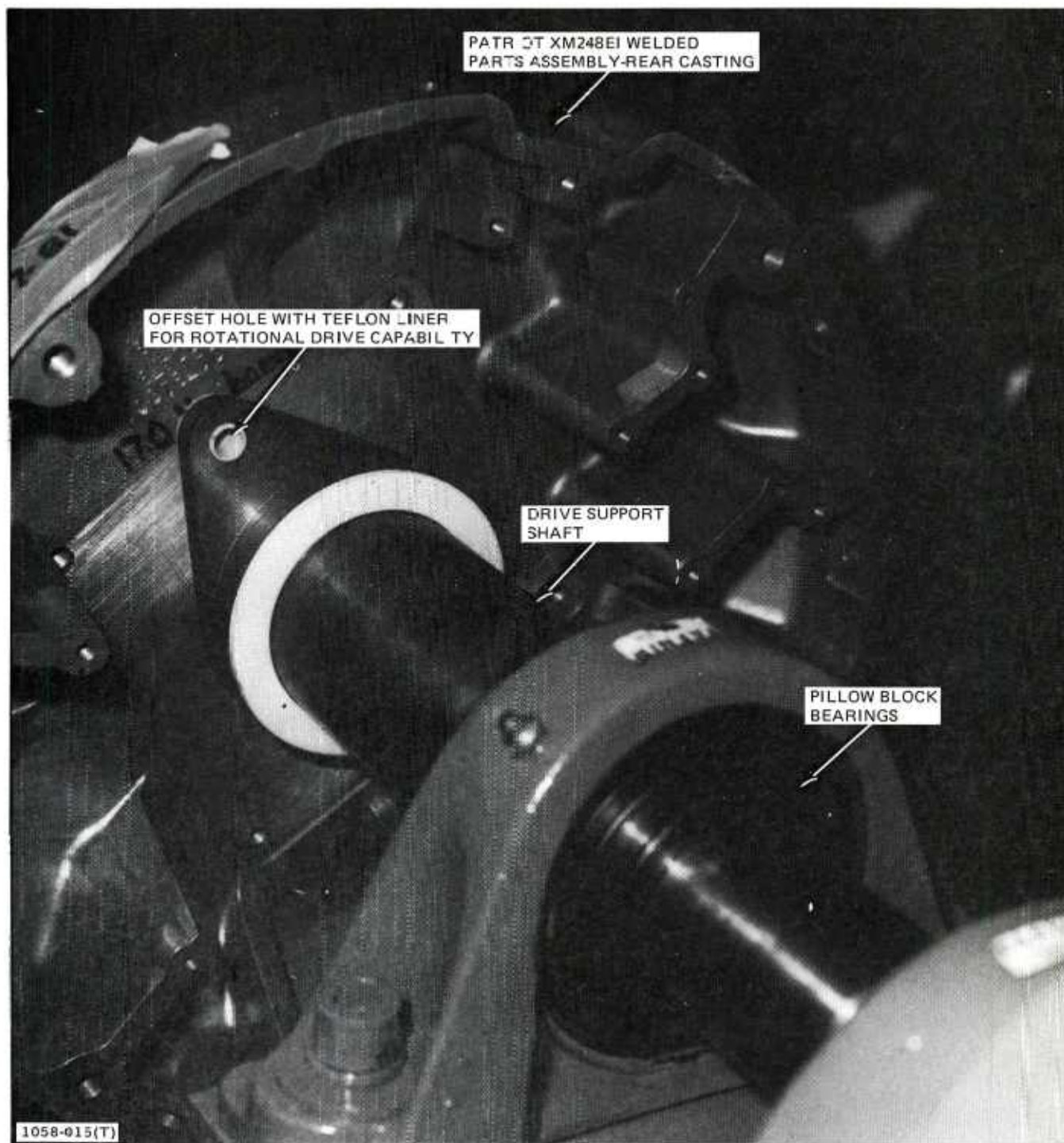


Fig. G-9 Rear Mounting Shaft with Drive Pin Provisions

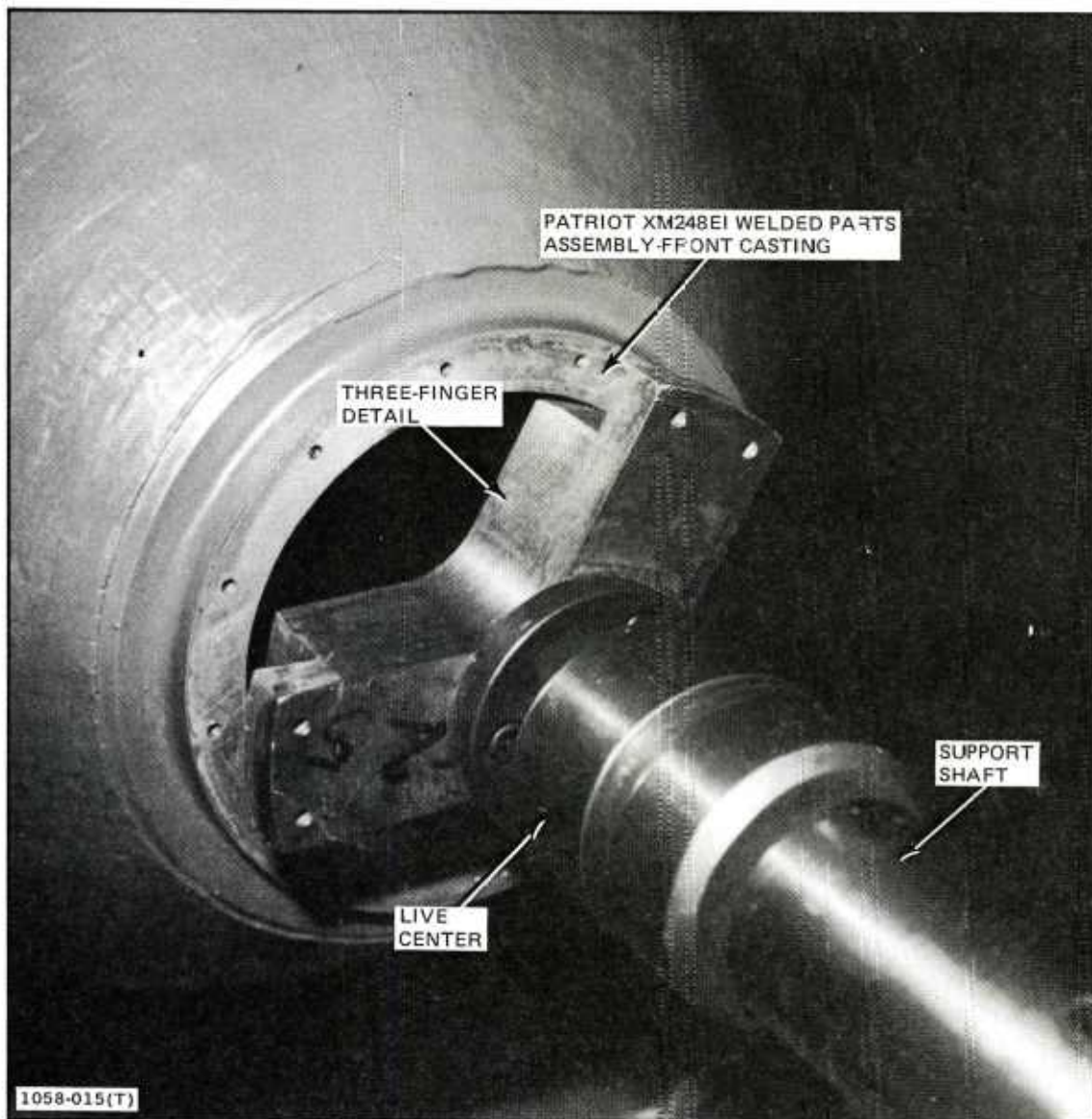


Fig. G-10 Front-Mounting Finger Bracket with Live Center

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

3.8 Rotational Drive System (Fig. G-1). -

This mechanism is a DC motor-driven belt and pulley system that is directly attached to the rear shaft adapter that holds the Welded Parts Assembly on the machine. Its operation is controlled automatically through the ROTATION ENABLE and ROTATION Switches on the control panel (Fig. G-2). Manual over-rides and controls are provided for the operator's convenience.

4 CONTROL SYSTEM

The control system provides the necessary machine controls and has the capability of being operated in either the automatic mode (OPER) or in the manual mode (JOG). It controls and synchronizes the longitudinal motion of the translating carriage to the rotational speed of the Welded Parts Assembly when in the "OPER" mode. The control system also controls the Syntron Vibrator, the chute vibrators, the take-up spool mechanism and the air diaphragm parts detector.

The system control panel is shown in Fig. G-2. The functions of the indicators are summarized below.

- POWER ON-OFF - Two-position switch to control electrical power to the system.
- START SWITCH - Lighted push-button switch to start an automatic or manual operation. The switch light is controlled by the system to provide feedback to the operator when the "START" request is acknowledged.
- STOP SWITCH - Lighted pushbutton switch to stop an automatic or manual operation. The switch light is controlled by the system to provide feedback to the operator when the "STOP" request is acknowledged.
- EMER. STOP - Two-position switch, which when depressed, will de-activate the entire system including the drive motors. This switch must be pulled out in order for power to return to the drive motors. After this is accomplished, the operator must push the START switch again in order to continue the wrapping cycle.

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PATRIOT Warhead Autowrap Fragment Layup Machine

- ABORT BUTTON - Single-position pushbutton switch to permit JOG or RET operations if it is desired to discontinue the automatic wrapping operation. With the STOP switch depressed and lit, pressing the ABORT switch will allow the operator to "JOG" or "RET" (return) as required.
- ROTATION SPEED - A calibrated dial to control the rotational speed of the Welded Parts Assembly.
- ROTATION CW/CCW - Two-position switch to establish the direction of rotation of the warhead during manual jogging.
- JOG FWD/REV - Two-position switch to establish the direction of rotation or linear motion of the warhead during manual jogging.
- OVERRIDE FWD - Pushbutton switch that allows the operator to over-ride the limit switches that control the length of stroke of the translating carriage in the FWD direction.
- OVERRIDE REV - Switch that allows the operator to over-ride the limit switches that control the length of stroke of the translating carriage in the REV direction.
- ENABLE LINEAR/ROTATION/BOTH - Three-position switch that allows the operator to run the linear and rotational axes individually or both at the same time. In order to do this, the switch labeled MODE must be in "JOG" position.
- MODE OPER/RET/JOG - Three-position switch that allows the operator to change from manual (JOG) to automatic (OPER) operation. All manual operations must be performed with this switch in the "JOG" position. The "RET" position allows the operator to automatically return to the original starting position by pushing the START switch.
- FEED MATERIAL - Controls Syntron Vibrator Operations, allowing fragments to be dispensed.

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

VIB HOPPER
ON/OFF - Two-way switch that applies the electrical power to the Syntron Vibrator (but does not control its operation) and also turns on the chute vibrators. The Syntron Vibrator is turned "ON & OFF" as required by the air-operated diaphragm switch (Sect. 3.1).

COMPACT'N
MECH LOAD - Two-way springloaded switch which, when activated, applies cylinder pressure to keep the cam follower in contact with the cam plate. The light is controlled by the control system to provide feedback to the operator when the request is acknowledged.

COMPACT'N
MECH LOAD/
UNLOAD - Not in use at present time.

5 SYSTEMS PREPARATION

For the system to operate properly, a certain amount of system preparation is necessary to ensure the best possible operating conditions. The suggested procedures are outlined below.

5.1 Adhesive

The adhesive should remain in freezer storage (0°F) until needed.

5.2 Fragments

The fragments should be cleaned prior to being used; cleaning contributes to the tape adhesive's ability to adhere to the fragments. The fragments should be cleaned in batches large enough to wrap one complete Inert Parts Assembly. Any delays in the wrapping process to clean a new batch of fragments would be prohibitive to continuing with the "in process" roll of adhesive.

5.3 Syntron Vibrator

Prior to operating the system, the Syntron Vibrator should be completely emptied and thoroughly cleaned with soap and water using clean cheese cloth to remove loose contaminants that may interfere with the adhesive sticking to the fragments. Denatured alcohol (Synasol) and compressed air should be used for the final cleaning operation.

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PATRIOT Warhead Autowrap Fragment Layup Machine

5.4 Supply Spool

The supply spool should be cleaned with MEK and a layer of Teflon tape should be applied to the inner face of each guide plate. This will minimize the sticking of any overflow of adhesive from the tape spool to the supply spool side plates, thereby eliminating restriction of the fragment chain as it is pulled through the system (Fig. G-4).

5.5 Guide Rollers and Brackets

The upper guide roller (Fig. G-4), the Teflon guide bracket (Fig. G-5), the fragment guide chute, the compacting roller (Fig. G-5), the lower guide rollers (Fig. G-11) and the outrigger guide roller (Fig. G-12) should be cleaned with MEK prior to their use and also after each layer of fragment wrapping has been completed. This will eliminate restrictions to the fragment chain due to adhesive buildup and will provide the best possible operating conditions for the system.

5.6 Metal Parts Welded Assembly

The Base Cover, 932806, should be removed and stored in a convenient location. The warhead should be solvent-wiped (acetone or MEK) before starting the fragment wrapping operations.

6 OPERATIONAL SET-UP

6.1 Plug in the control console power cord (15 amps/115 VAC) and turn power switch located on the control panel to the "ON" position. (Fig. G-9)

6.2 Plug in the Syntron Vibrator power cord (440 v/AC/10 amps) and turn two-way lever-type switch located on the small control box (Fig G-13) to the "OFF" position. If the Syntron Vibrator begins to operate after either one of the above two steps, turn the VIB-HOPPER switch to the "OFF" position.

6.3 Open the rear door of the control console and turn the toggle switch on the Rotation Motor Speed Controller, Bodine Electric Model 945, (Fig. G-14) to the "ON" position.

6.4 Connect an adequate supply (80 psi recommended) of filtered shop air to the system regulator located on the rear of the Syntron (Fig. G-15) and adjust pressure to 40 psi.

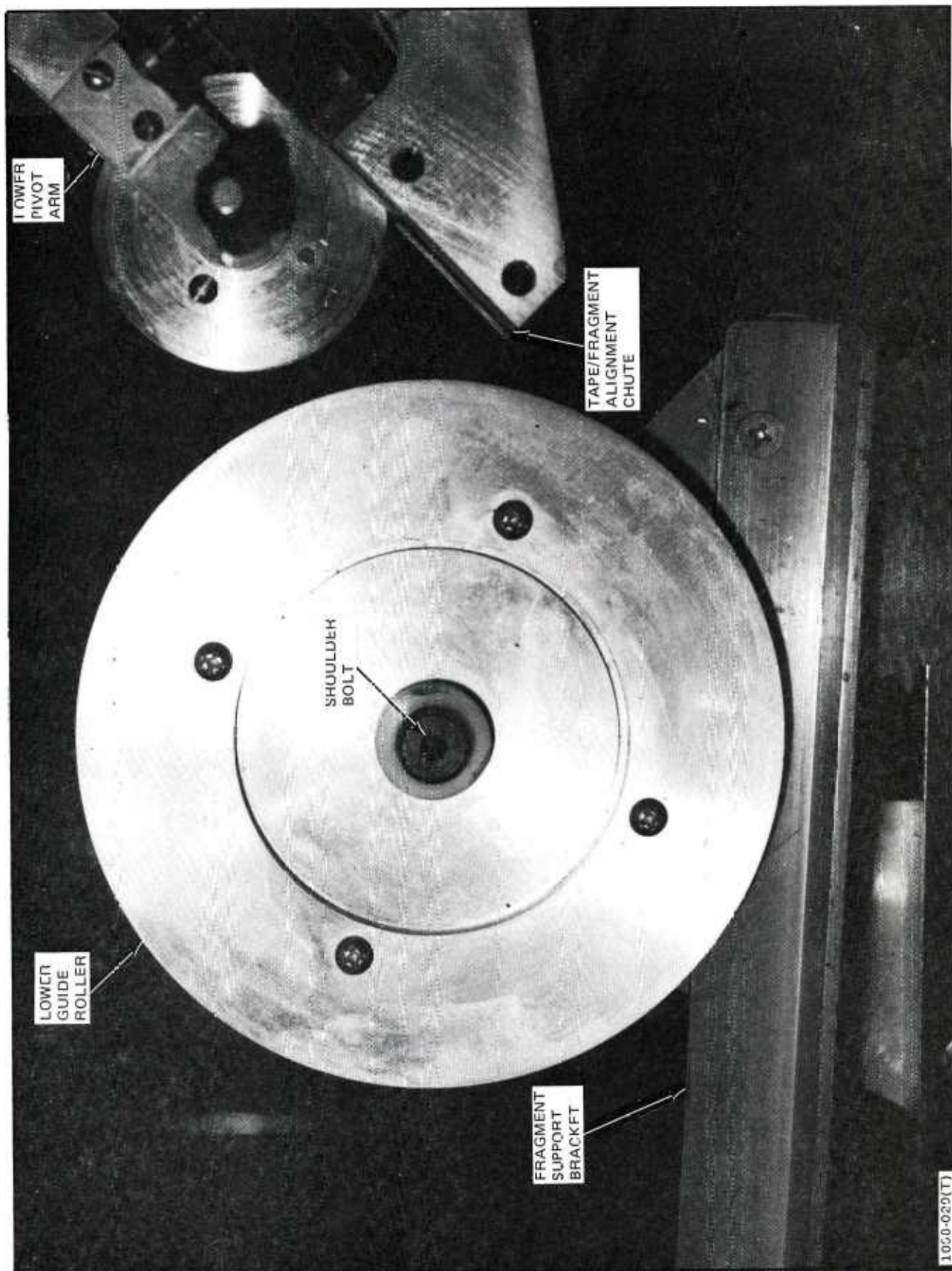


Fig. G-11 Lower Guide Roller

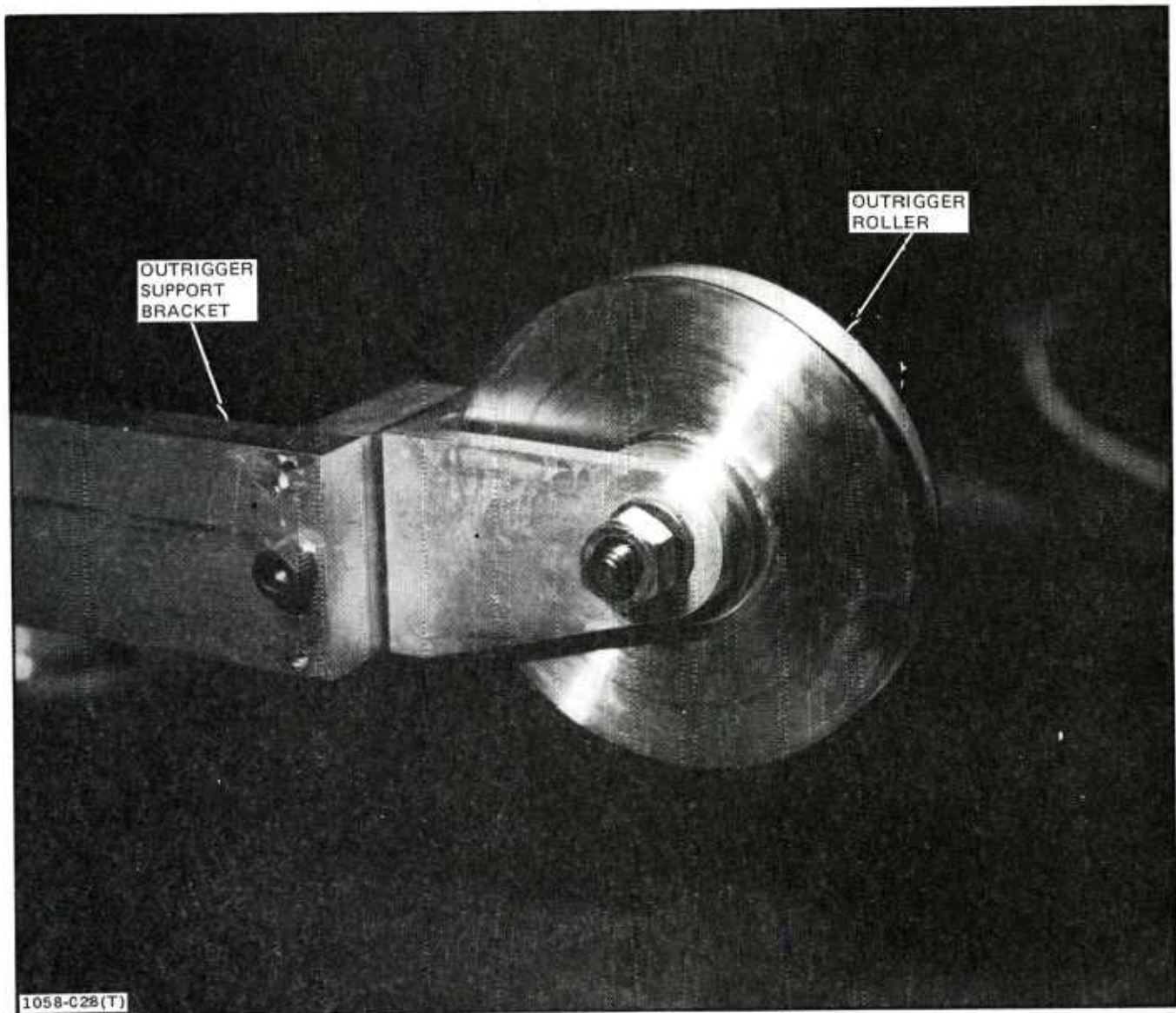
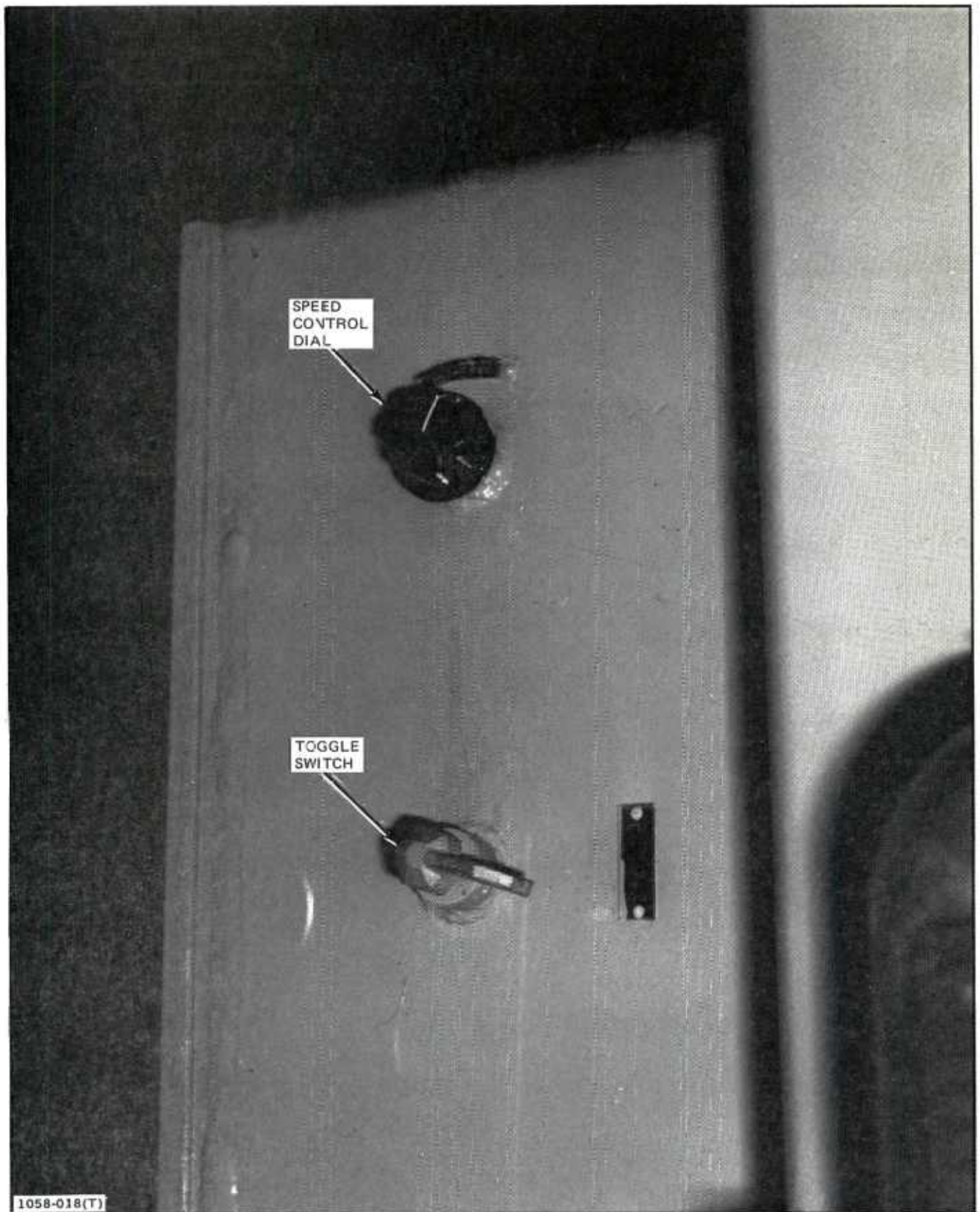


Fig. G-12 Outrigger Roller



SPEED
CONTROL
DIAL

TOGGLE
SWITCH

1058-018(T)

Fig. G-13 Syntron Power Control Unit

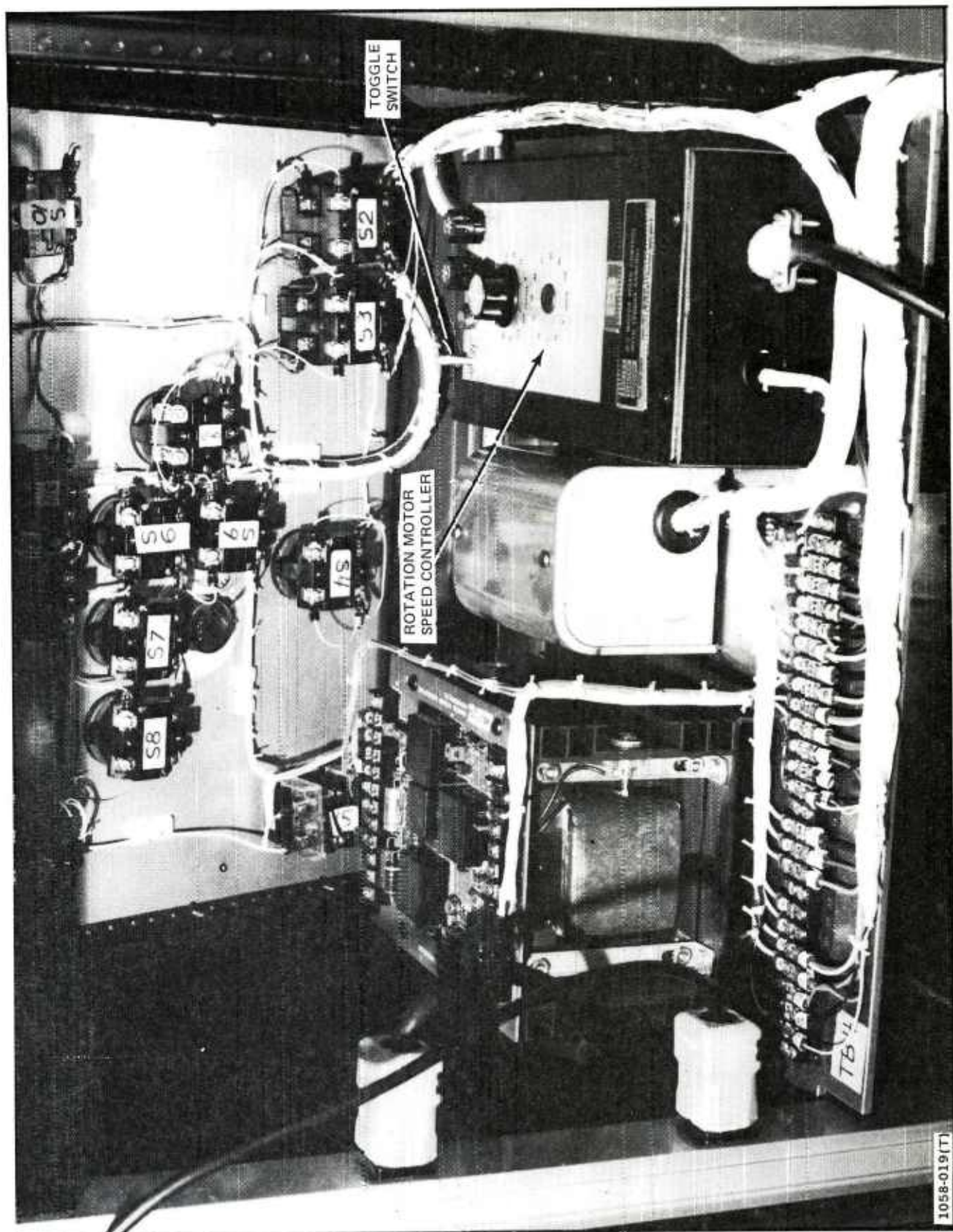


Fig. G-14 Motor Speed Controller

1058-019(T)

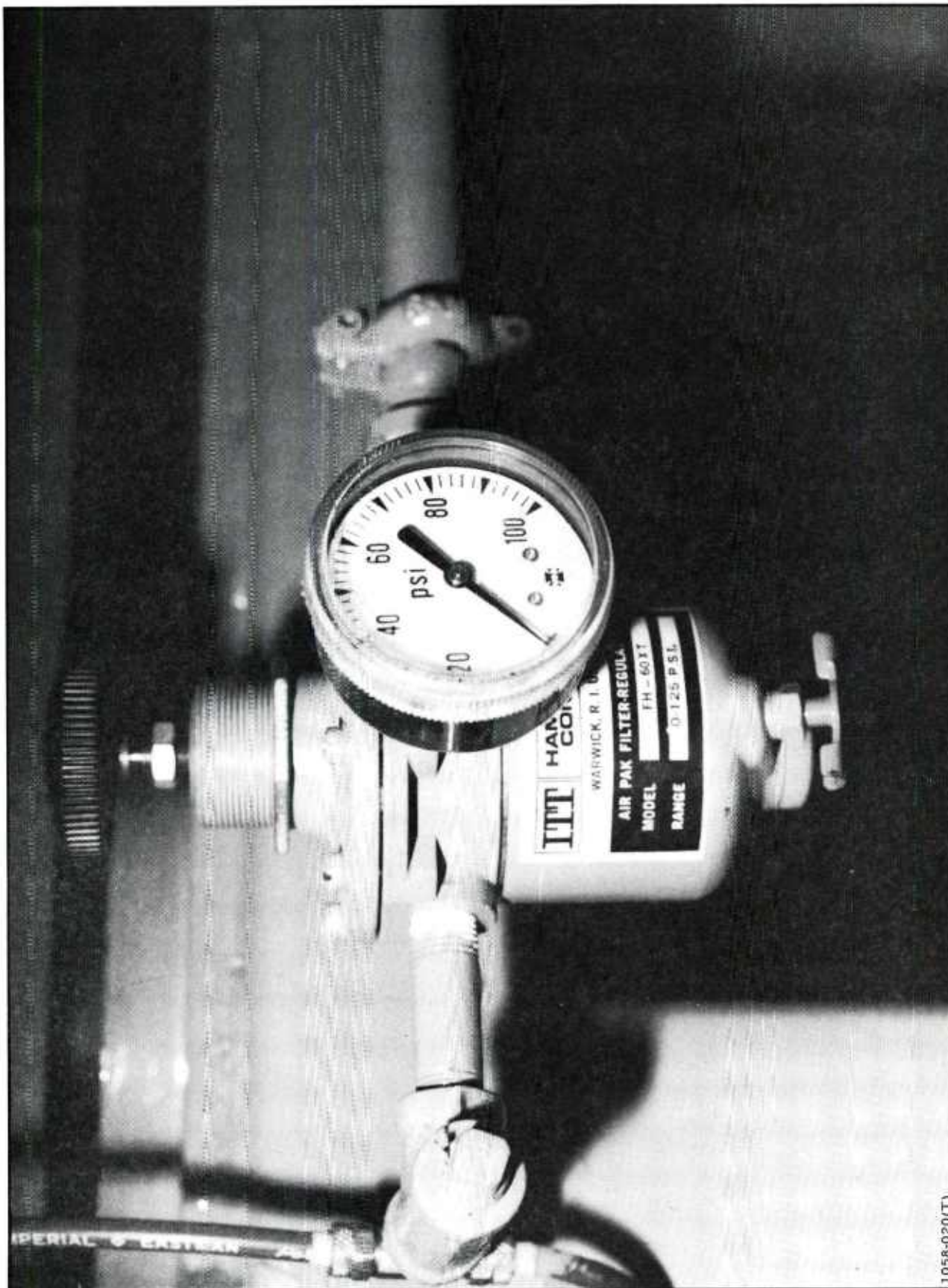


Fig. G-15 Main Air Supply Regulator Valve

1058-020(T)

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

6.5 Set the cross-slide regulator valve, located on the rear side of the cross slide mechanism (Fig. G-16) to 20 psi.

6.6 Set the take-up spool controlling toggle switch located under the outrigger arm (Fig. G-7) to the "MANUAL" position. Adjust the dial so that the indicator arrow points to No. 7. This will make the spool rotate at a fairly rapid speed. Set the toggle switch back to the "AUTO" position and leave it there.

6.7 Remove the clear plastic protective cover from the Syntron Vibrator and store until the wrapping of one complete warhead is finished. Then replace the cover until the next wrapping process begins.

6.8 Set the air diaphragm regulator valve located under the fragment guide chute (Fig. G-3) to 3 psi and its controlling toggle switch, located just below it, to the "OFF" position.

6.9 Turn the VIB-HOPPER switch on the control panel Fig. G-2) to the "ON" position. This switch will also automatically turn on the chute controllers and vibrators. (Should the Syntron Vibrator require adjustment, only qualified personnel should attempt to do it, and then only after consulting with the manufacturer.)

6.10 Turn the controlling toggle switch on the air diaphragm control box to the "AUTO" position. The Syntron Vibrator should begin to operate at this point. If it does not operate, adjust the air regulator upwards until it does. As the fragments line up in the guide chute and block off the air jet, the Syntron should shut off. If it does not shut off, adjust the air regulator downwards until it does. This procedure may have to be repeated several times in order to arrive at the exact setting.

6.11 Set the RANGE dial on the chute vibrator control box located on the side of the Syntron Vibrator (Fig. G-17) to 3.5.

6.12 Turn the spring-loaded COMPACT'N MECH switch on the control panel (Fig. G-2) to the "LOAD" position momentarily and release.

NOTE: Each time the system is turned "OFF" and then "ON" again, this switch must be actuated.

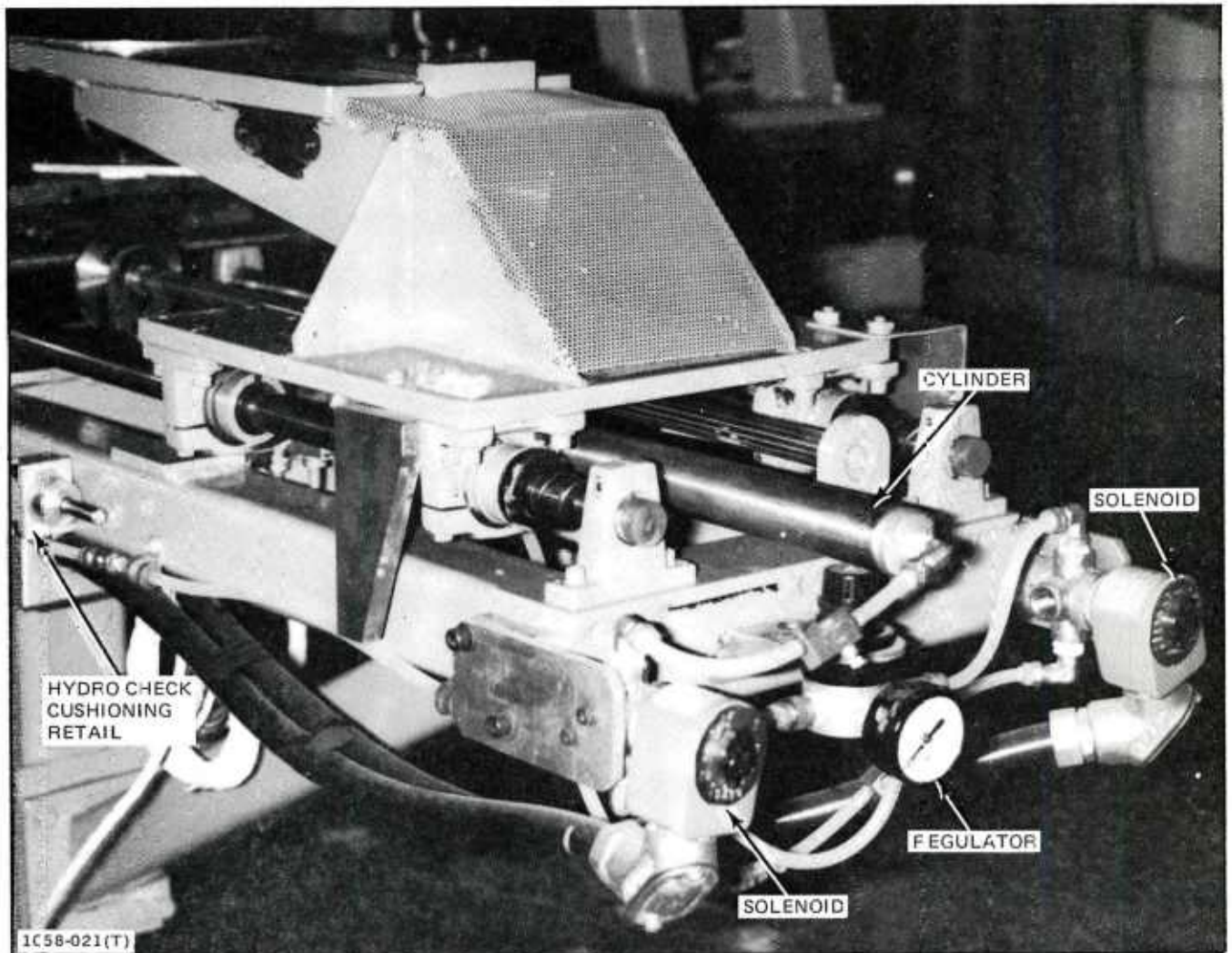


Fig. G-16 Cross-Slide Air Regulator

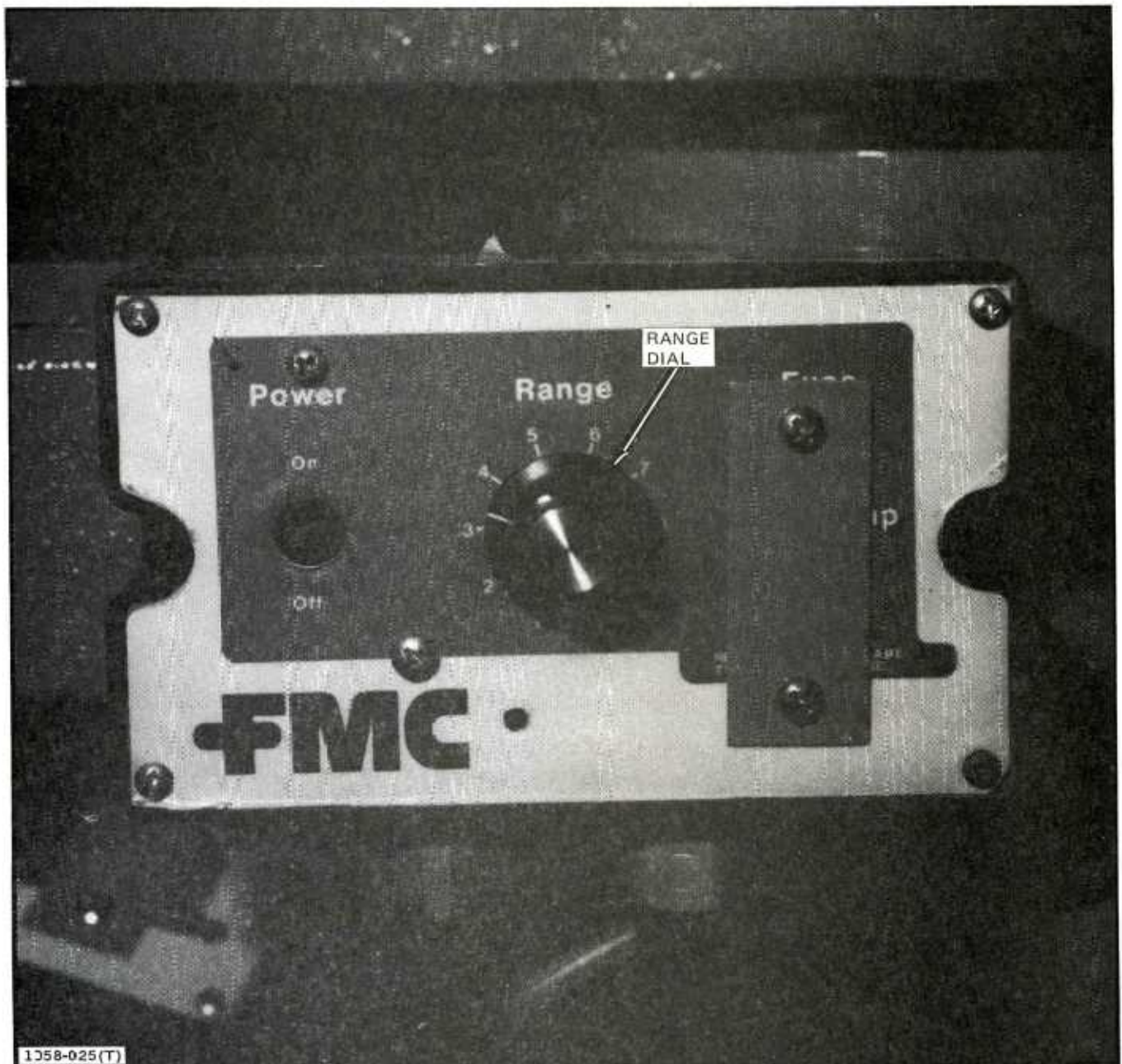


Fig. 3-17 Chute Vibrator Control Box

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

6.13 Turn the switch labeled MODE on the control panel (Fig. G-2) to the "RET" position and push the "START" button. The carriage will automatically return to its original starting position and stop. This is the linear starting position for the fragment wrapping process.

6.14 Place the proper cam follower in position on its bracket under the cross-slide mechanism.

7 PARTS LOADING

7.1 Obtain an aluminum Welded Parts Assembly and bring it to the machine for loading.

7.2 Position the rear casting housing hole on the rear sleeved shaft adaptor and align the 3/8-in.-dia. drive pin in the offset hole provided (Fig. G-9).

7.3 Rotate the front 3-finger adapter fitting clockwise, using the handwheel, until it slides snugly into the hole in the front casting (Fig. G-10).

7.4 Crank the handwheel further clockwise until the Welded Parts Assembly seats itself on the rear adapter shaft.

7.5 Crank the handwheel counter-clockwise so that the banking face just moves away from the casting machined face.

7.6 Finally, crank the handwheel clockwise until the finger detail banks on the machined face of the casting. A piece of 0.001-in.-thick feeler stock may be used here as a set-up gauge.

7.7 On the control panel (Fig. G-2) turn the switch labeled MODE to the "JOG" position and the ENABLE switch to the "ROTAT'N" position.

7.8 Step on the remote control foot pedal. The Welded Parts Assembly will begin to rotate and will continue to do so as long as the foot pedal is depressed. However, the carriage will not translate.

7.9 Rotate the Welded Parts Assembly so that the indented starting notch at the front end of the warhead is on the top centerline of the assembly. Remove foot from remote control foot pedal at the proper time. This is the rotational starting position for the fragment wrapping process.

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PATRIOT Warhead Autowrap Fragment Layup Machine

8 ADHESIVE LOADING AND SYSTEM START-UP

- 8.1 Remove ball-lock pin and tape supply spool from its holding bracket (Fig. G-4).
- 8.2 Place tape spool on a flat surface and remove the upper flat disc.
- 8.3 Slip adjustable spring pressure pins out of their respective retaining slots on the fragment guide chute (Fig. G-18).
- 8.4 Remove ball-lock pin holding the upper pivot arm in place and remove upper pivot arm (Fig. G-18 and G-19).
- 8.5 Pivot lower arm up out of the way (Fig. G-19).
- 8.6 Remove knurled knob and upper plate of the take-up spool assembly (Fig. G-6).
- 8.7 Remove tape from freezer (one roll only).
- 8.8 Load tape on the tape supply spool as shown in Fig. G-20 and pull about 10-in. out from between the plates (10-in. tail).
- 8.9 Replace the upper flat disc cover plate on the supply spool.
- 8.10 Install tape and supply spool on bracket so that the tape exits from the tape spool AWAY from the Syntron Vibrator and replace ball-lock pin (Fig. G-4 and G-20).
- 8.11 Feed tape (adhesive face down) under upper guide roller (Fig. G-6), down through the fragment guide chute and out under the lower guide roller (Fig. G-11 and G-20), using 10-in. long tail, sticky side down.
- 8.12 Pivot lower arm down into position and replace spring retaining pins in slots provided (Fig. G-18).
- 8.13 Replace upper pivot arm and ball-lock pin. Then guide tape into Teflon guide chute and lock spring pins in place in the slots provided (Fig. G-18).
- 8.14 On the air diaphragm control box (Fig. G-3) turn the toggle switch to the "AUTO" position. The Syntron will operate, fragments will fill up the chute, and the Syntron will stop when the air jet is blocked off.

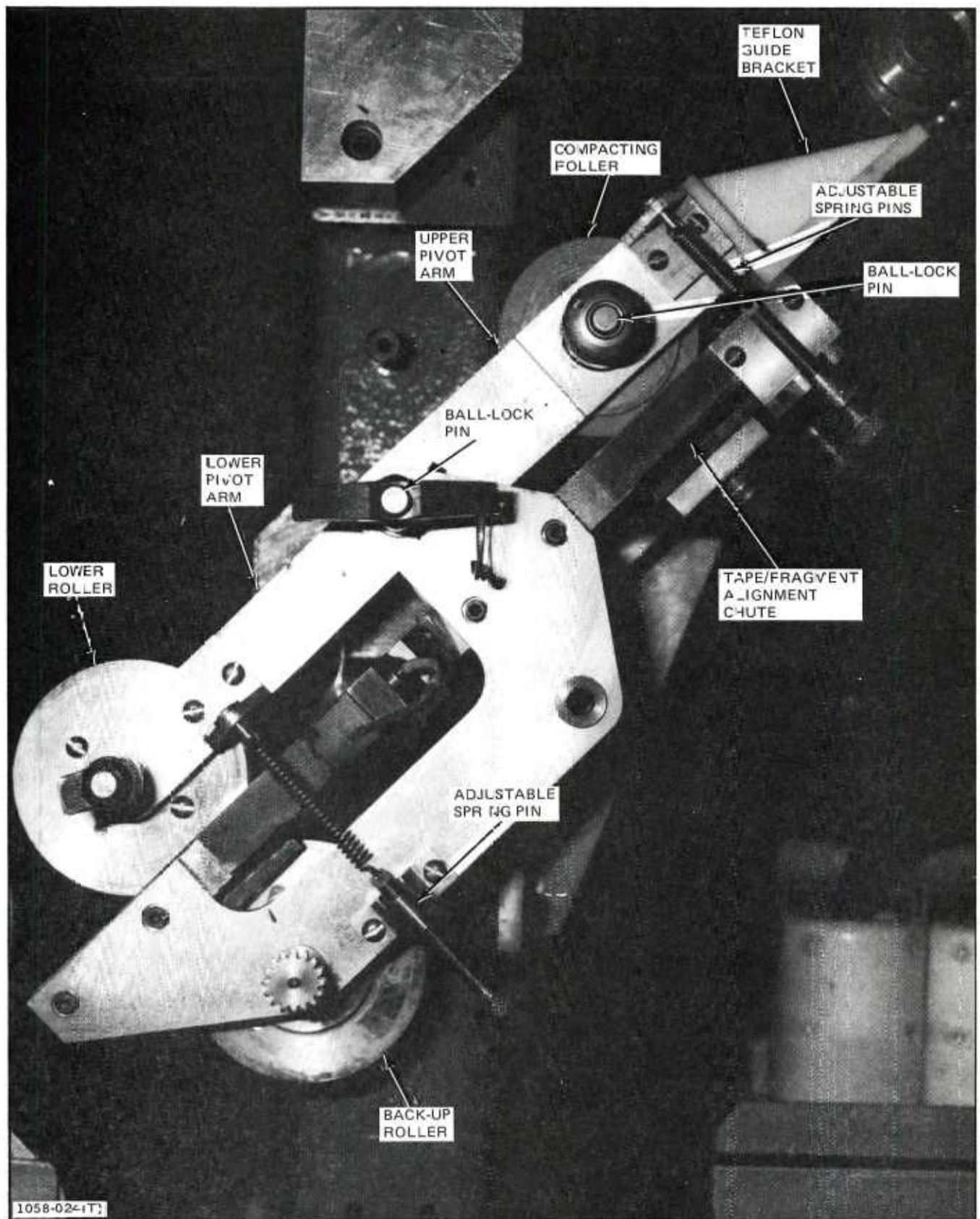


Fig. G-18 Compactor and Guide Bracket in Position

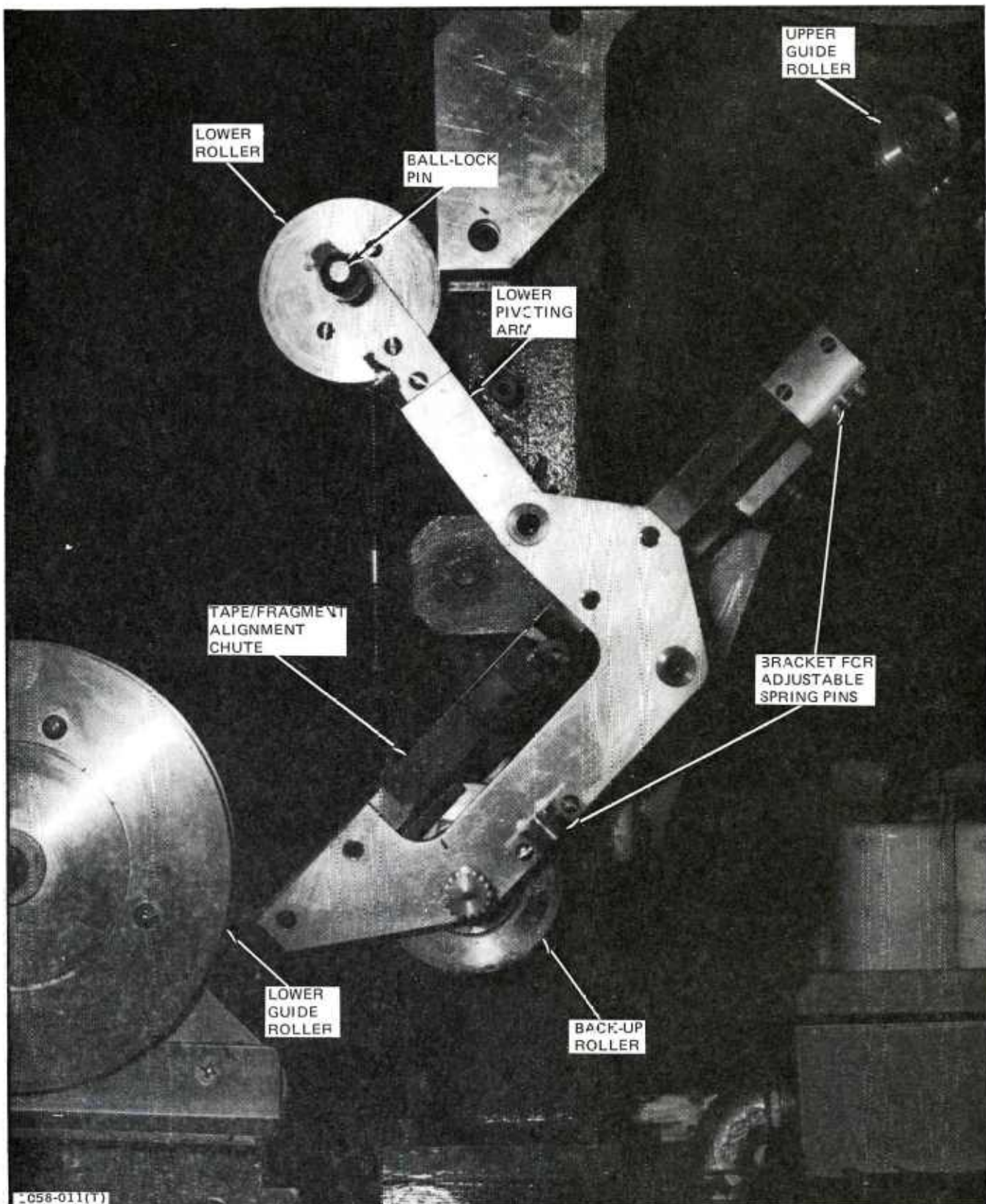


Fig. G-19 Compactor and Guide Bracket Removed

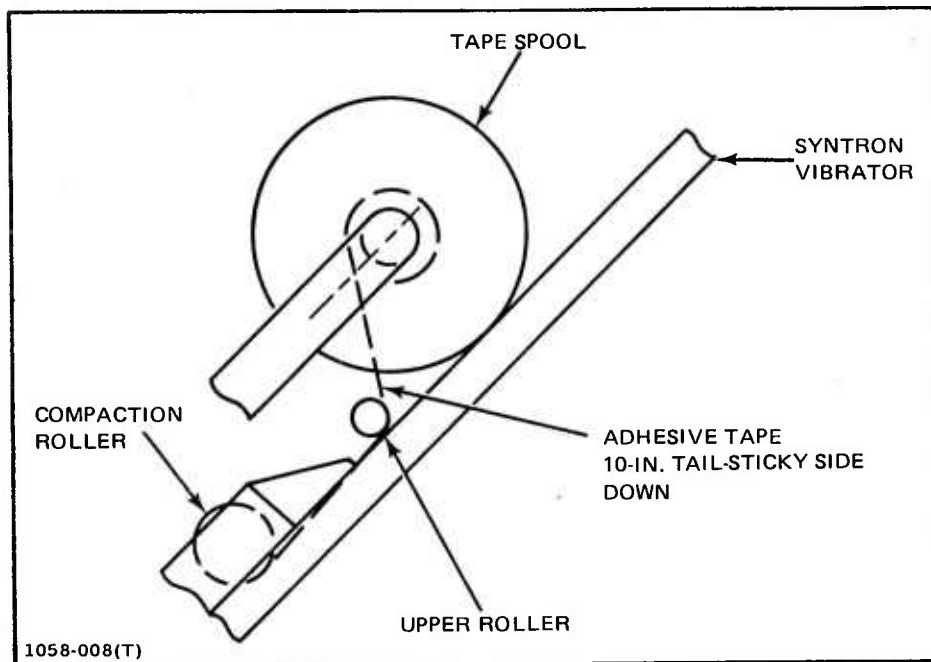


Fig. G-20 Schematic Representation of Tape Spool Loading

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

8.15 Manually pull the adhesive/fragment chain out from under the lower guide rollers (Fig. G-11) and then continue out under the outrigger roller (Fig. G-12).

8.16 Pull the fragment chain out about twelve (12) inches past the outrigger roller.

8.17 Using a knife, carefully cut through the adhesive immediately adjacent to the first fragment on the chain.

8.18 Feed the carrier paper around the outrigger roller (Fig. G-12) and back over to the take-up spool mechanism (Fig. G-6).

8.19 Place the end of the carrier paper into the slot on the take-up spool and rotate it around several times until the slack in the paper is taken up. Then replace the upper cover and the knurled knob. (The slack can also be taken up by putting the take-up spool controlling toggle switch (Fig. G-7) into the "MANUAL" position; however, be sure to switch it back over to the "AUTO" position before continuing.)

8.20 Place the end of the fragment chain on the warhead at the indented starting notch on the front end of the Metal Parts Assembly and carefully guide the fragments into position along the starting edge by hand.

8.21 On the control panel (Fig. G-2) put the switch labeled MODE into the "JOG" position, the ENABLE switch into the "ROTAT'N" position, the ROTATION switch to "CW", and step on the remote foot pedal control. This will allow the Metal Parts Assembly to rotate (but not the carriage to translate) and take up the slack in the fragment chain. When the slack is taken up, remove foot from the remote foot pedal control.

8.22 The system is now ready for automatic operation. Prior to starting, check that the following items are as they should be:

() 115 V POWER PLUGGED IN	() ENABLE: BOTH	() AIR DIAPHRAGM: AUTO
() 440 V POWER PLUGGED IN	() JOG: FWD	() TAKE UP SPOOL CONTROL: AUTO
() POWER: ON	() ROTATION: CW	() CORRECT CAM ON BRKT.
() VIB-HOPPER: ON	() ROTATION SPEED: 3	() AIR: CONNECTED
() COMPACT'N MECH: LOAD	() EMER. STOP: OUT	
() MODE: OPER	() SYNTRON: LOADED	

Operating Manual
PATRIOT Warhead Autowrap Fragment Layup Machine

8.23 If all of the above criteria are met, push the START button and begin wrapping. It will be necessary at times for the operator to guide the fragments onto the Metal Parts Assembly during the wrapping process and to compact them in the forward direction. From experience, a small piece of Teflon tape-covered wood serves this purpose.

8.24 During the wrapping process, the operator must maintain watch over the following events to prevent stoppage of the operation:

- Fragments are filling the chute; fragments are not jamming; spacing of fragments on chain is correct
- Fragments are sticking to warhead during wrapping without sliding
- Take-up spool is operating properly. No breaks occur in the adhesive or carrier paper.

Problems with any of these processes may be significant enough to stop wrapping.

9 FACILITIES REQUIREMENTS

Electric - Control Panel 15 amps, 115 v AC, single-phase
 - Syntron Vibrator 10 amps, 440 v AC, 3-phase

Air - 80-psi shop air

Area - 150 square feet (see Fig. G-21)

10 LIST OF DRAWINGS

 A listing of the applicable drawings is presented in Fig. G-22.

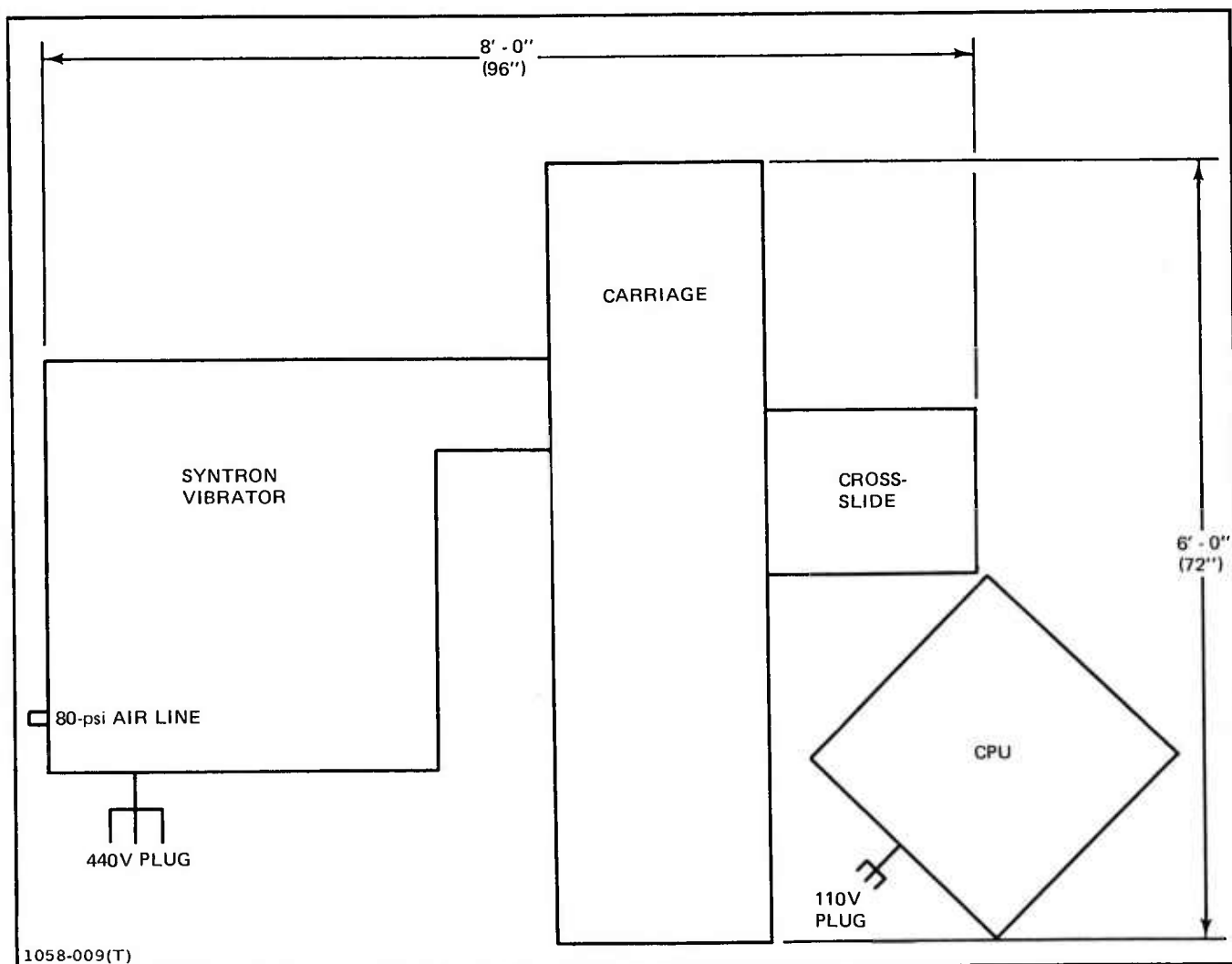


Fig. G-21 Floor Plan Layout

FIG. G-22 LIST OF DRAWINGS (SHEET 1 OF 3)

DRAWING NO.	SHT. NO.	LETTER CHG.	NOMENCLATURE
RDM447-1819	1	NC	SYNTRON VIBRATOR STAND
-1820	1	A	BASE FRAME WELDMENTS
-1821	1	A	BALL SCREW ASSEMBLY
-1822	1	A	ROTATE DRIVE SYSTEM
-1823	1	A	FRONT MOUNT DETAILS
-1824	1	A	CROSS-SLIDE WELDMENT
-1825	2	B	CROSS-SLIDE DETAILS
-1826	1	B	CROSS SLIDE ASSEMBLY
-1827	1	NC	CHUTE SUPPORT BRACKETS
-1828	1	A	CHUTE GUIDE DETAILS
-1829	1	A	CHUTE SUPPORT BRACKETS
-1830	1	B	CHUTE SUPPORT BRACKETS
-1831	1	NC	CHUTE ASSEMBLY
-1832	1	A	CROSS-SLIDE PIVOT DETAILS
-1832	2	NC	ROTATE MOTOR BRACKET
-1833	1	D	CROSS-SLIDE PIVOT DETAILS
-1833	2	B'	SOLENOIDS & SWITCHES
-1834	1	B	MISCELLANEOUS DETAILS
-1835	1	NC	CROSS-SLIDE PIVOT ASSY.
-1836	1	NC	BASE PLATE
-1837	1	NC	CAM & RACK INSTALLATION
-1838	1	NC	FINAL ASSEMBLY

FIG. G-22 LIST OF DRAWINGS (SHEET 2 OF 3)

RDM447-1978	1	NC	PIVOT DETAILS
-1978	2	NC	PIVOT DETAILS
-1979	1	B	OUTRIGGER BRACKET DETAILS
-1980	1	NC	ROLLER DETAILS
-1980	1	NC	ROLLER DETAILS
-1981	1	NC	CROSS-SLIDE PROTECTIVE COVER
-1982	1	NC	CROSS-SLIDE CUSHION ASSY.
-1983	1	NC	CHUTE DETAILS
-1983	2	A	CHUTE DETAILS
-1985	1	A	CHUTE DETAILS
-1986	1	NC	SUPPLY SPOOL DETAILS
-1986	2	NC	SUPPLY SPOOL DETAILS
-1987	1	NC	CHUTE DETAILS
-1988	1	NC	TAPE UP SPOOL DETAILS
-1994	1	NC	CHUTE ROLLER DETAILS
-1950	1	NC	SYSTEM BLOCK DIAGRAM
-1950	2	NC	SYSTEM CONTROL STATE LOGIC DIAGRAM
-1951	1	NC	CONTROL SWITCHES
-1951	2	NC	CONTROL SWITCHES
-1952	1	NC	INTERFACE BUFFERS
-1952	2	NC	INTERFACE BUFFERS
-1952	3	NC	INTERFACE BUFFERS
-1953	1	NC	TERMINAL STRIP WIRING
-1954	1	NC	FEED MATERIAL SENSORS
-1955	1	NC	MOTOR CONTROLLERS
-1956	1	NC	SIGNAL CONDITIONING & MOTOR LOGIC
-1957	1	NC	CONTROL STATE LOGIC

FIG. G-22 LIST OF DRAWINGS (SHEET 3 OF 3)

RDM447-1958	1	NC	DISCRETE COMPONENTS
-1959	1	NC	SYSTEM POWER DISTRIBUTION
-1960	1	NC	SYNTRON VIBRATORY FEEDER
-1961	1	NC	CONTROL PANEL
-1961	2	NC	IC LAYOUT

APPENDIX H

MANUFACTURING METHOD

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

Manufacturing Method for
PATRIOT Warhead Autowrap Fragment Layup Process

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Manufacturing Method for
PATRIOT Warhead Autowrap Fragment Layup Process

ILLUSTRATIONS

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Manufacturing Method For PATRIOT Warhead Autowrap Fragment Layup Process

1 INTRODUCTION

This document describes the manufacturing methodology for a low-cost, bag molding process for the application (layup and cure) of fragments and fairing to the XM248E1 PATRIOT Warhead Inert Parts Assembly. The procedure is as follows: Three layers of fragments (9226307) are individually wrapped around a cleaned Metal Parts Welded Assembly (9312580) using the developed PATRIOT Warhead Autowrap System (Fig. H-1). To facilitate wrapping and attachment (bonding), the fragments are applied in the form of a fragment/tape adhesive chain. After fragment wrapping, multiple layers of tightly wound plastic adhesive tape are applied as the bagging/pressure media. The bagged assembly is then oven-cured to establish the permanent bond between the fragments and the welded assembly. After cure, a thixotropic thermosetting resin filler is applied between the base (9278872) and the exposed three-layer-thick edge of the wrapped fragments. Following this operation, the fragment interstices are filled with a thermosetting adhesive and the assembly is cured. A polyurethane paint is then applied as a protective coating, thereby completing the fabrication of an Inert Parts Assembly (9312581).

2 PATRIOT WARHEAD AUTOWRAP SYSTEM OPERATIONS

The operating procedures for the PATRIOT Warhead Autowrap System are described in detail in the operating manual for the PATRIOT Warhead Autowrap Machine (See Appendix G). They involve the following basic steps: Install a prepared (degreased or solvent-cleaned) Metal Parts Assembly. Load the Syntron Vibrator with clean steel fragments and install a roll of tape adhesive. Start the fragment/tape chain and pass it through the ways and rolls of the machine. Separate the tape adhesive backing and install the backing onto the take-up spool. Manually pull the fragment/tape chain through the machine, affixing it firmly to the Metal Parts Assembly at the starting notch. Recheck all control panel settings; particularly make sure that the proper cam follower is installed.

3 FRAGMENT/TAPE CHAIN WRAPPING

Wrap the first layer of fragments from the starting notch to the base, stopping at first contact with the head-to-base attachment weld; cut the fragment/tape chain with a knife or scissors. (The fragment/tape chain wrap may be continued to attain the target weight.) Secure the cut end of the fragment/tape chain to the Metal Parts Welded Assembly with masking tape. Details for application of the first layer are given in Appendix G, Section 8, and are repeated below for continuity.

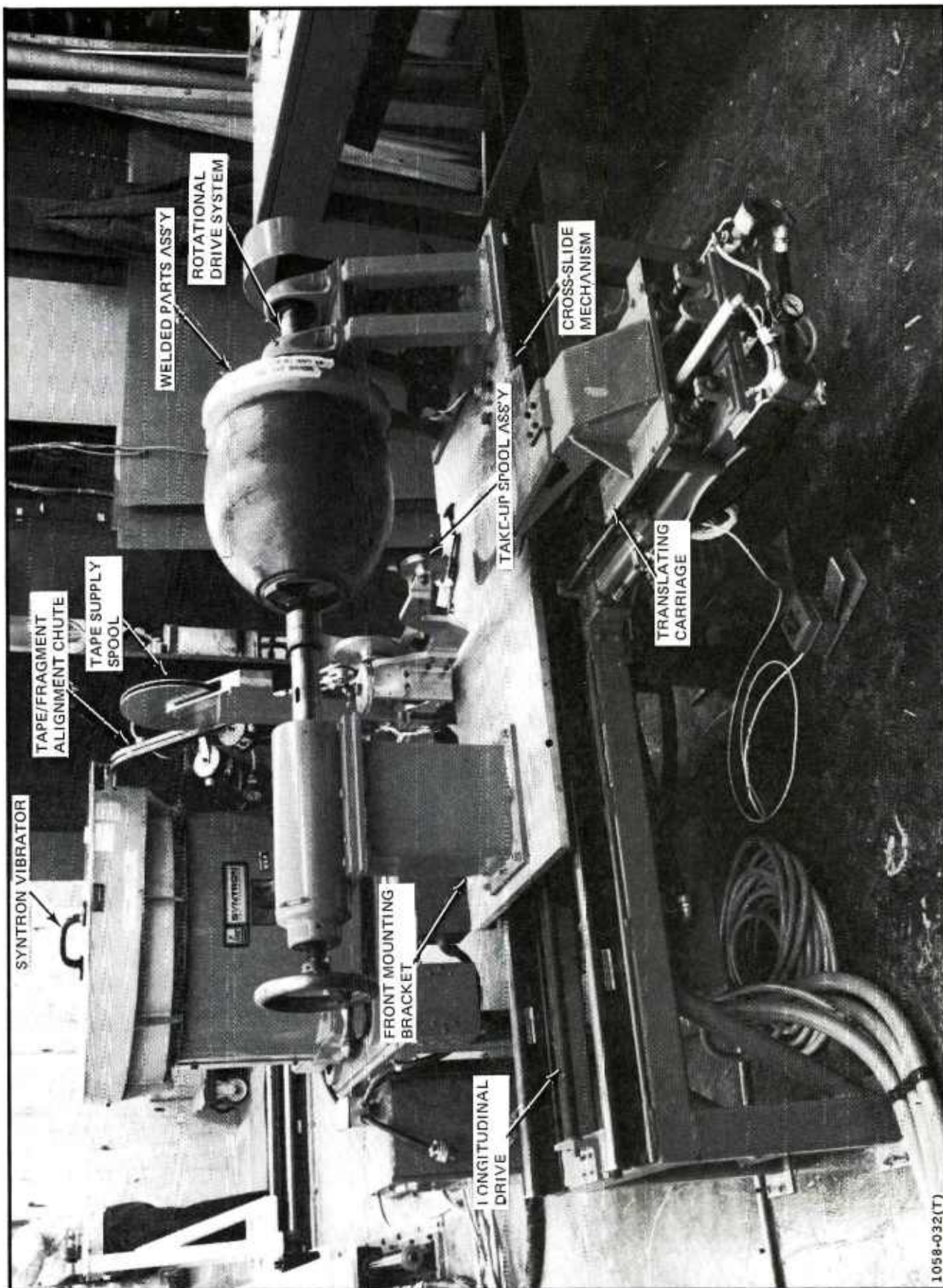


Fig. H-1 Overall Arrangement of Autowrap Fragment Layout Machine for PATRIOT Warhead

Manufacturing Method for
PATRIOT Warhead Autowrap Fragment Layup Process

4 TAPE APPLICATION DETAILS

4.1 Remove ball-lock pin and tape supply spool from its holding bracket (Fig. H-2).

4.2 Place tape spool on a flat surface and remove the upper flat disc.

4.3 Slip adjustable spring pressure pins out of their respective retaining slots on the fragment guide chute (Fig. H-3).

4.4 Remove ball-lock pin holding the upper pivot arm in place and remove upper pivot arm (Fig. H-3 and H-4).

4.5 Pivot lower arm up out of the way (Fig. H-4).

4.6 Remove knurled knob and upper plate of the take-up spool assembly (Fig. H-5).

4.7 Remove tape from freezer (one roll only).

4.8 Load tape on the tape supply spool as shown in Fig. H-6 and pull out about ten (10) inches from between the plates (10-in. tail).

4.9 Replace the upper flat disc cover plate on the supply spool.

4.10 Install tape and supply spool on bracket so that the tape exits from the tape spool AWAY from the Syntron Vibrator and replace ball-lock pin (Fig. H-2 and H-6).

4.11 Feed tape (adhesive face down) under upper guide roller (Ref. Fig. H-5) down through the fragment guide chute and out under the lower guide roller (Fig. H-6 and H-7), using the 10-in. long tail, sticky side down.

4.12 Pivot lower arm down into position and replace spring retaining pins in slots provided (Fig. H-3).

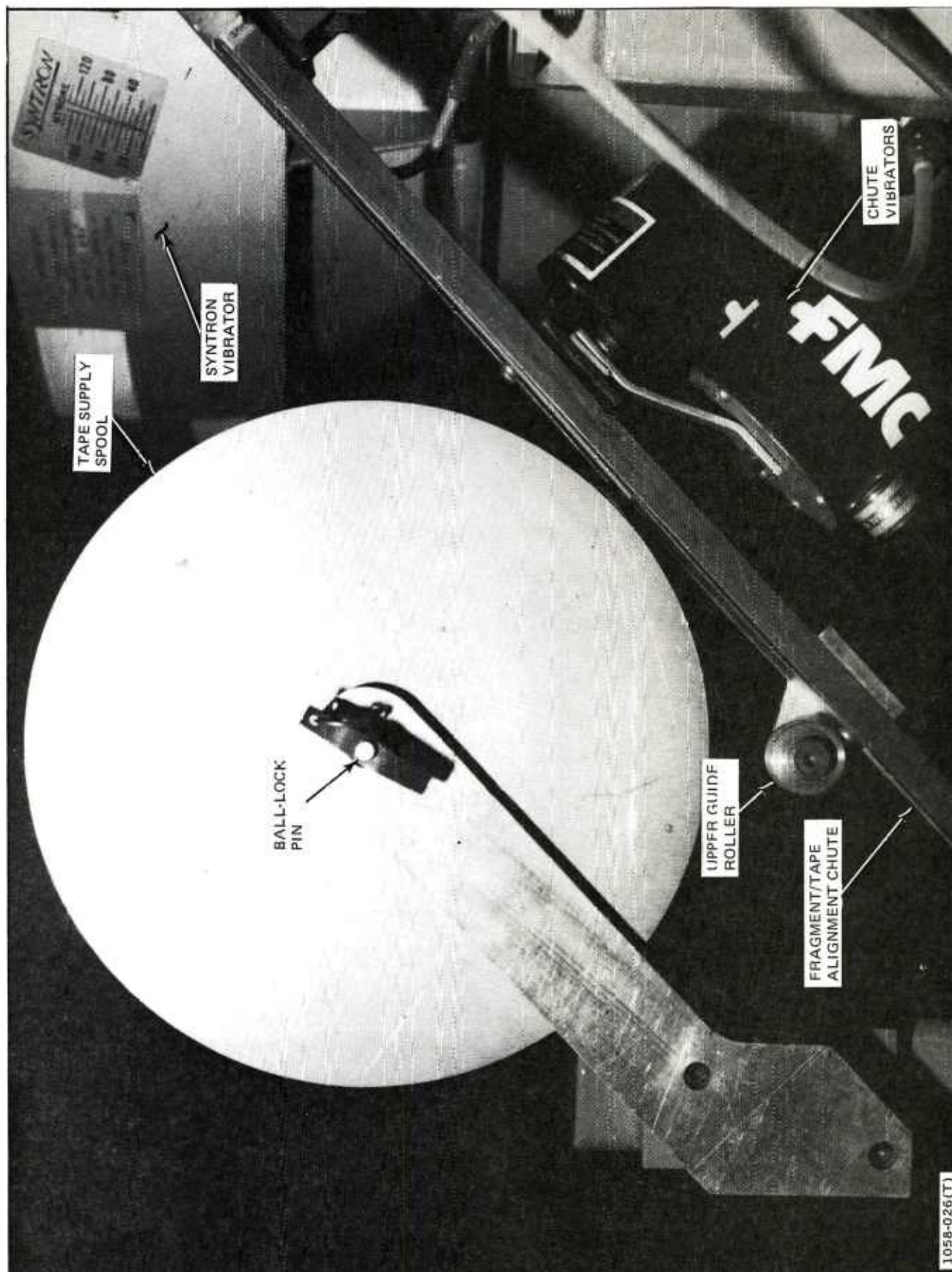


Fig. H-2 Close-Up View of Supply Spool

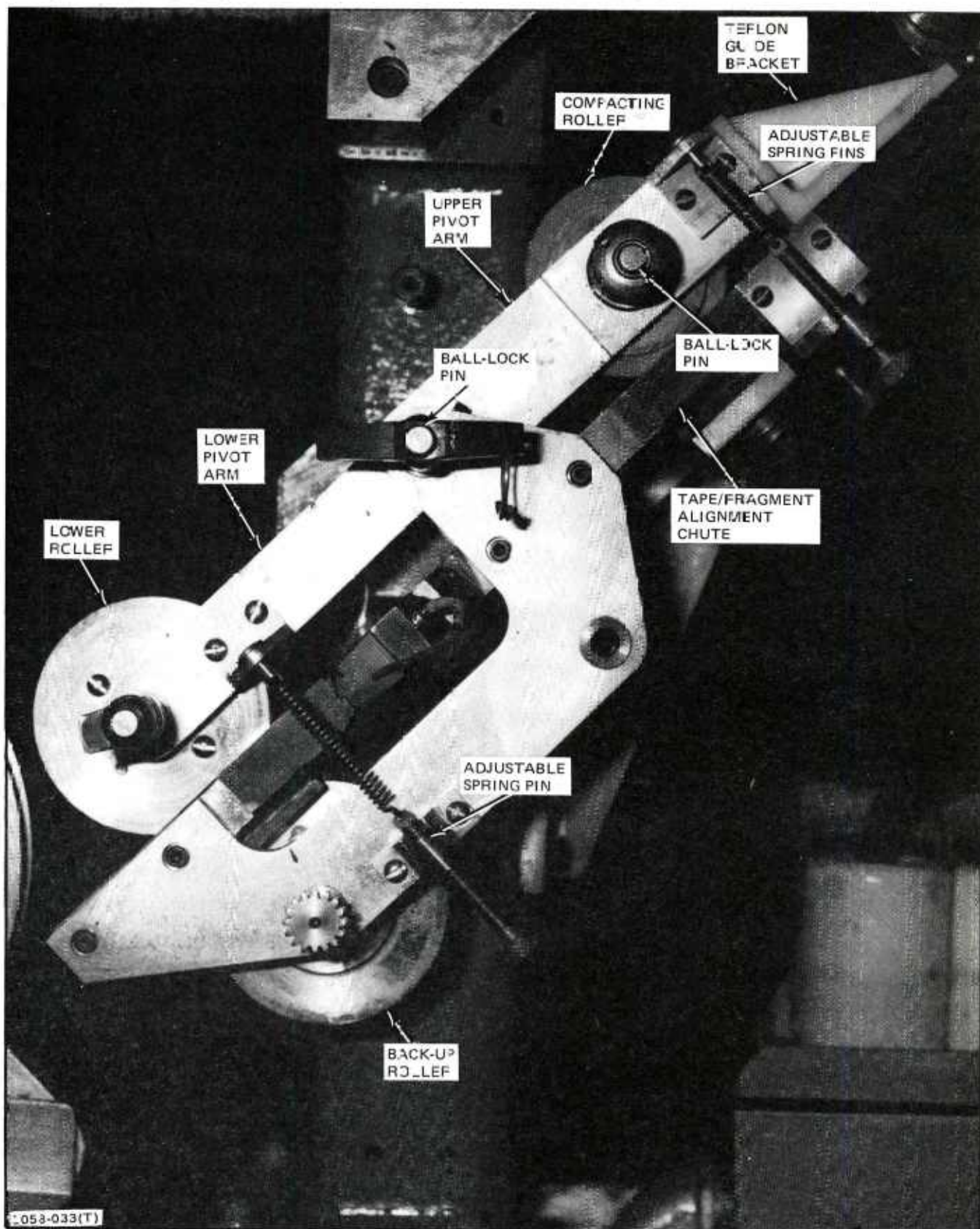


Fig. H-3 Compactor and Guide Bracket in Position

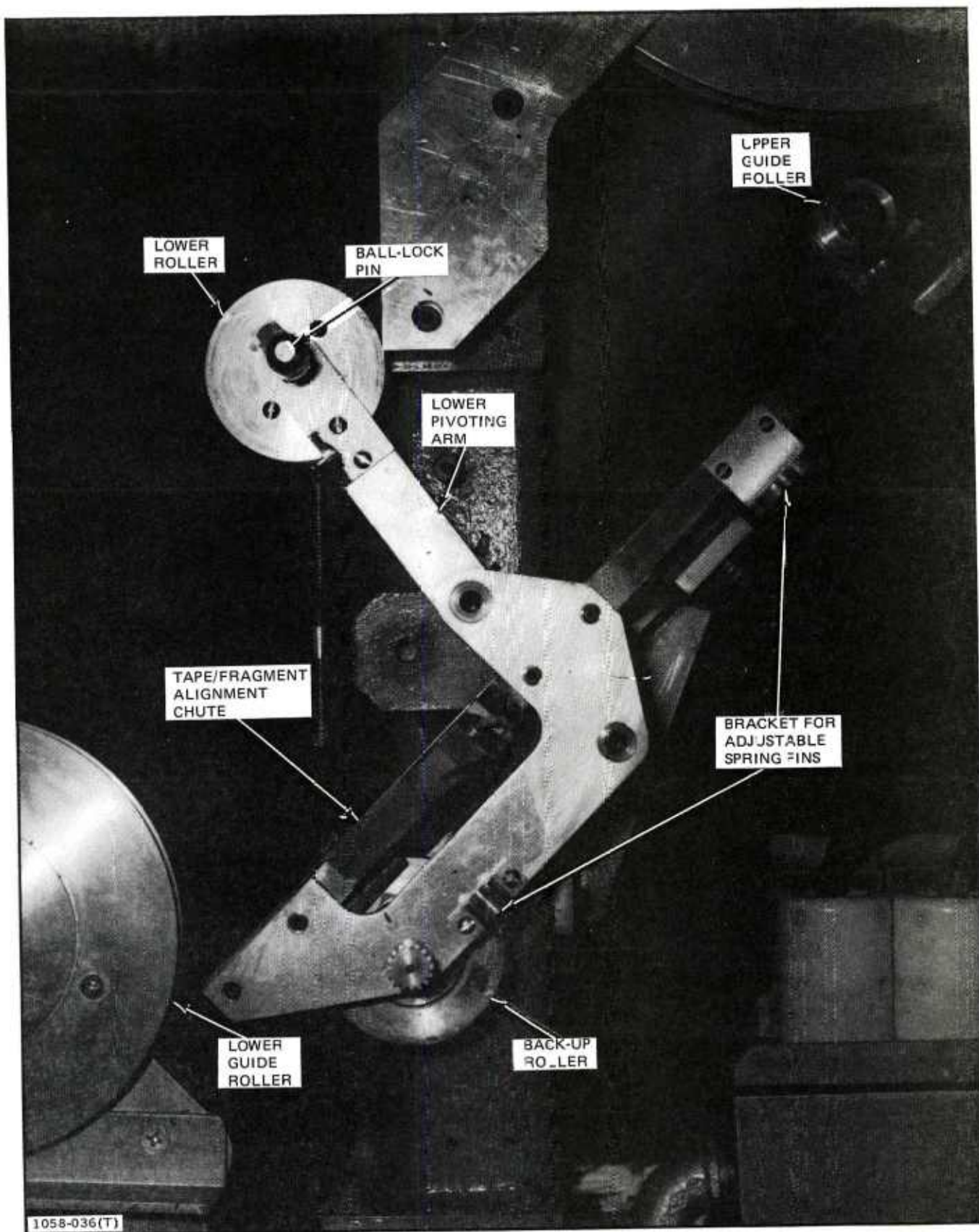


Fig. H-4 Compactor and Guide Bracket Removed

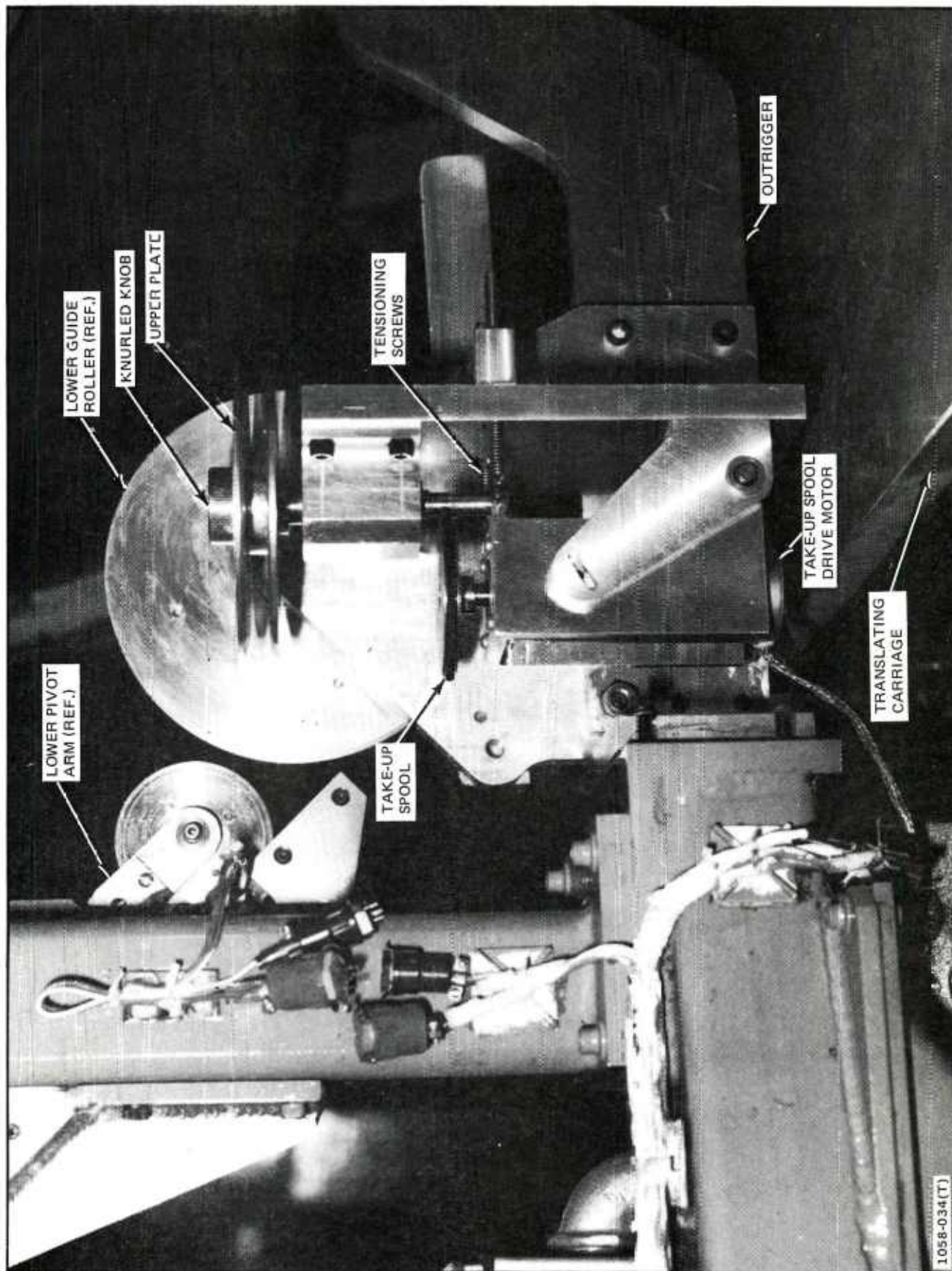


Fig. H-5 Take-Up Spool

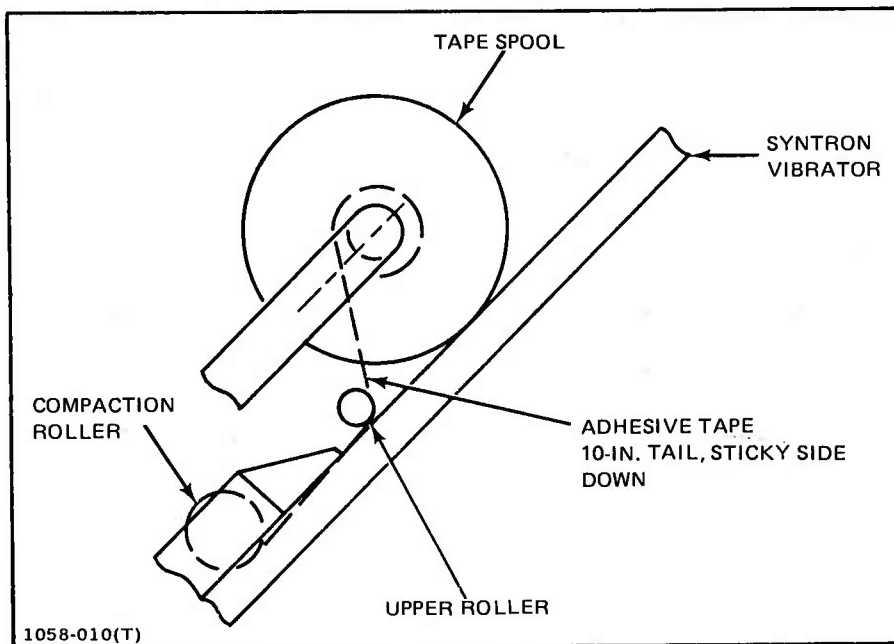


Fig. H-6 Schematic Representation of Tape Spool Loading

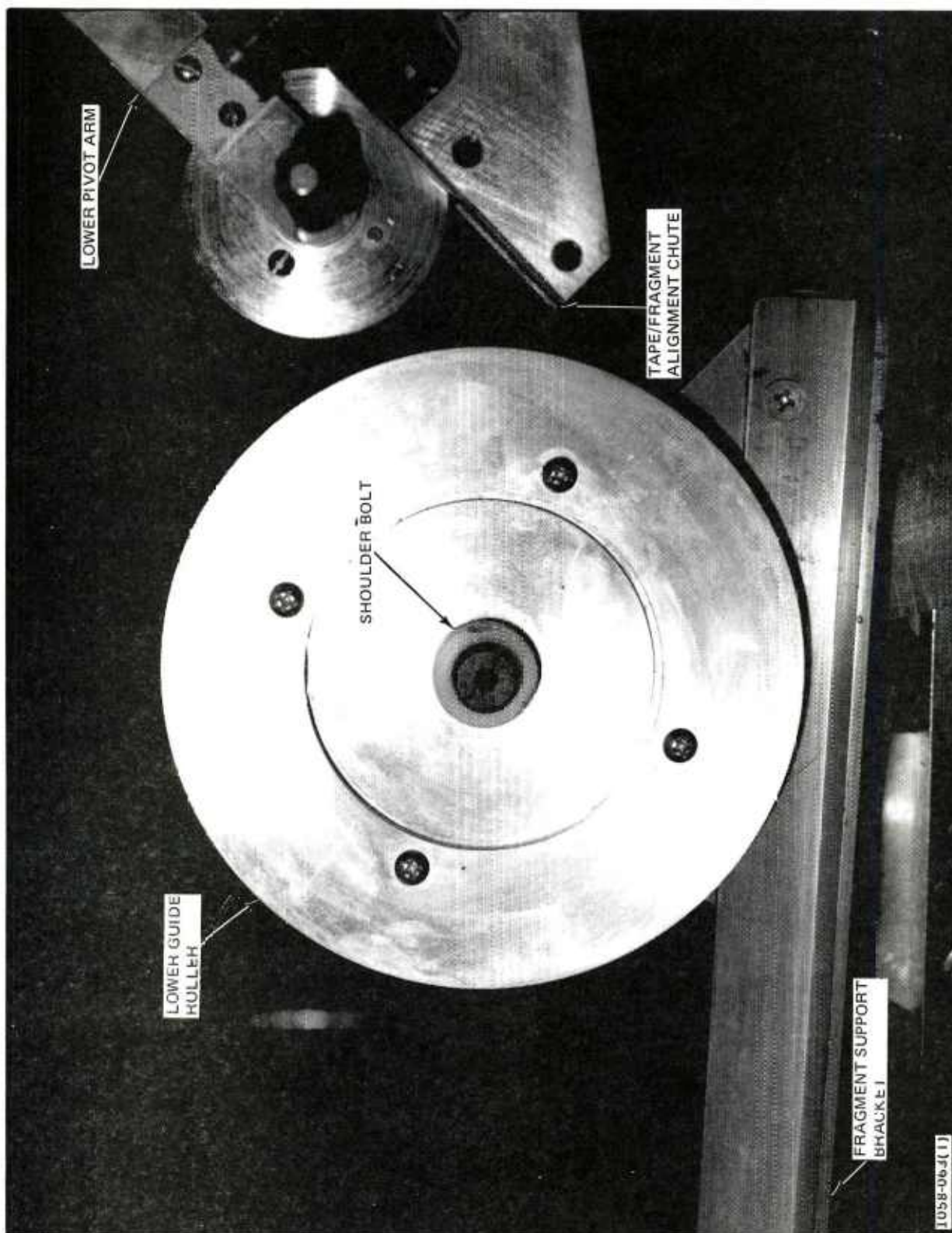


Fig. H-7 Lower Guide Roller

Manufacturing Method For
PATRIOT Warhead Autowrap Fragment Layup Process

4.13 Replace upper pivot arm and ball-lock pin. Then guide tape into Teflon guide chute and lock spring pins in place in the slots provided (Fig. H-3).

4.14 On the air diaphragm control box (Fig. H-8) turn the toggle switch to the "AUTO" position. The Syntron Vibrator will operate, fragments will fill up the chute, and the Syntron will stop when the air jet is blocked off.

4.15 Manually pull the adhesive/fragment chain out under the lower guide rollers (Ref. Fig. H-7) and then continue out under the outrigger roller (Fig. H-9).

4.16 Pull the fragment chain out about twelve (12) inches past the outrigger roller.

4.17 Using a knife, carefully cut through the adhesive immediately adjacent to the first fragment on the chain.

4.18 Feed the carrier paper around the outrigger roller (Ref. Fig. H-9) and back over to the take-up spool mechanism (Ref. Fig. H-5).

4.19 Place the end of the carrier paper into the slot on the take-up spool, rotate it around several times until the slack in the paper is taken up. Then replace the upper cover and the knurled knob. (The slack can also be taken up by putting the take-up spool controlling toggle switch (Fig. H-10) into the "MANUAL" position; however, be sure to switch it back over to the "AUTO" position before continuing.)

4.20 Place the end of the fragment chain on the warhead at the indented starting notch on the front end of the Metal Parts Assembly, and carefully guide the fragments into position along the starting edge by hand.

4.21 On the control panel (Fig. H-11) put the switch labeled "OPER RET JOG" into the "JOG" position, the ENABLE switch into the "ROTAT'N" position, the rotation switch to CW, and step on the remote foot pedal control. This will allow the Metal Parts Assembly to rotate (but not the carriage to translate) and take up the slack in the fragment chain. When the slack is taken up, remove foot from the remote foot pedal control.

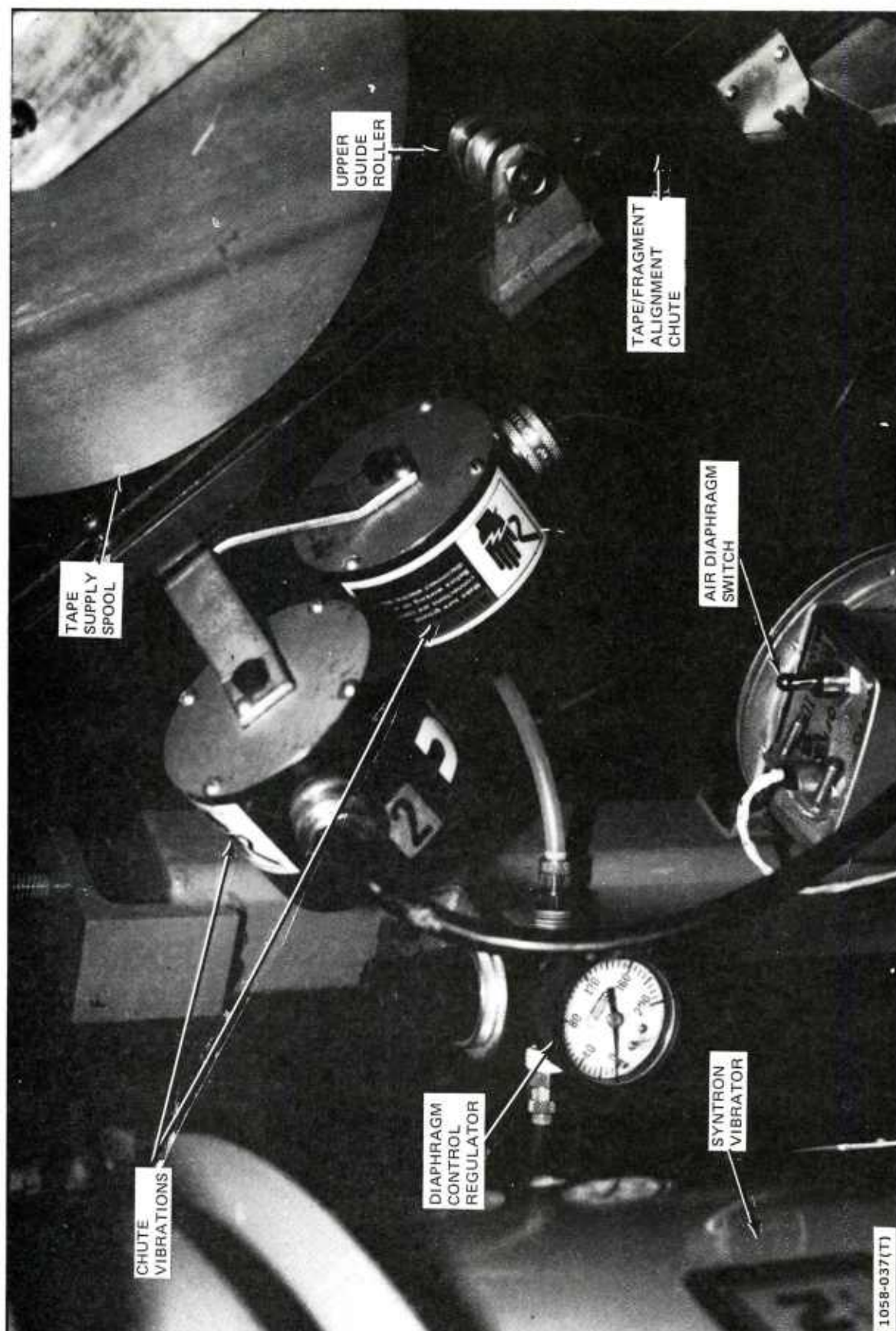


Fig. H-8 Air Diaphragm Regulator and Control Box

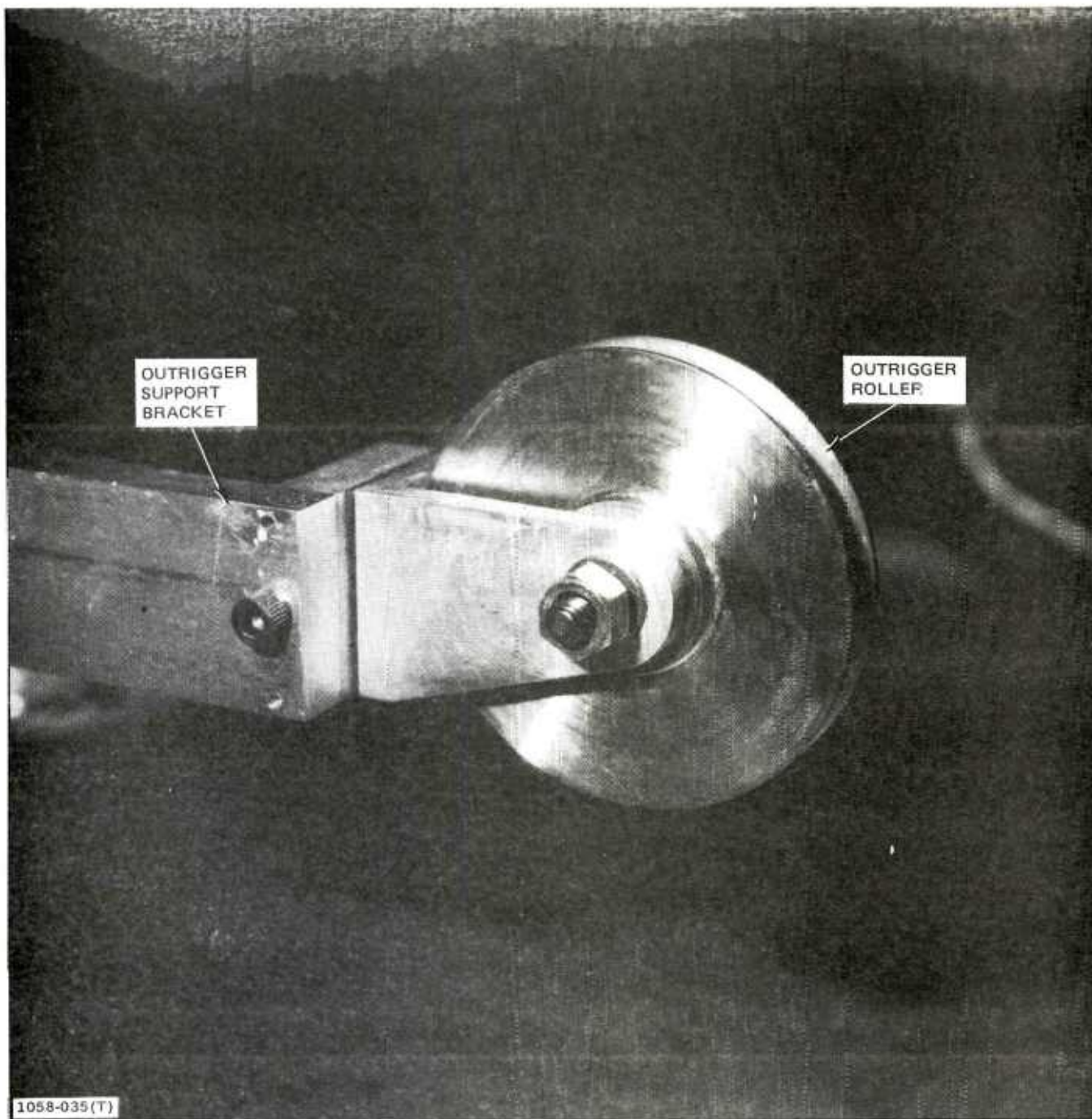


Fig. H-9 Outrigger Roller

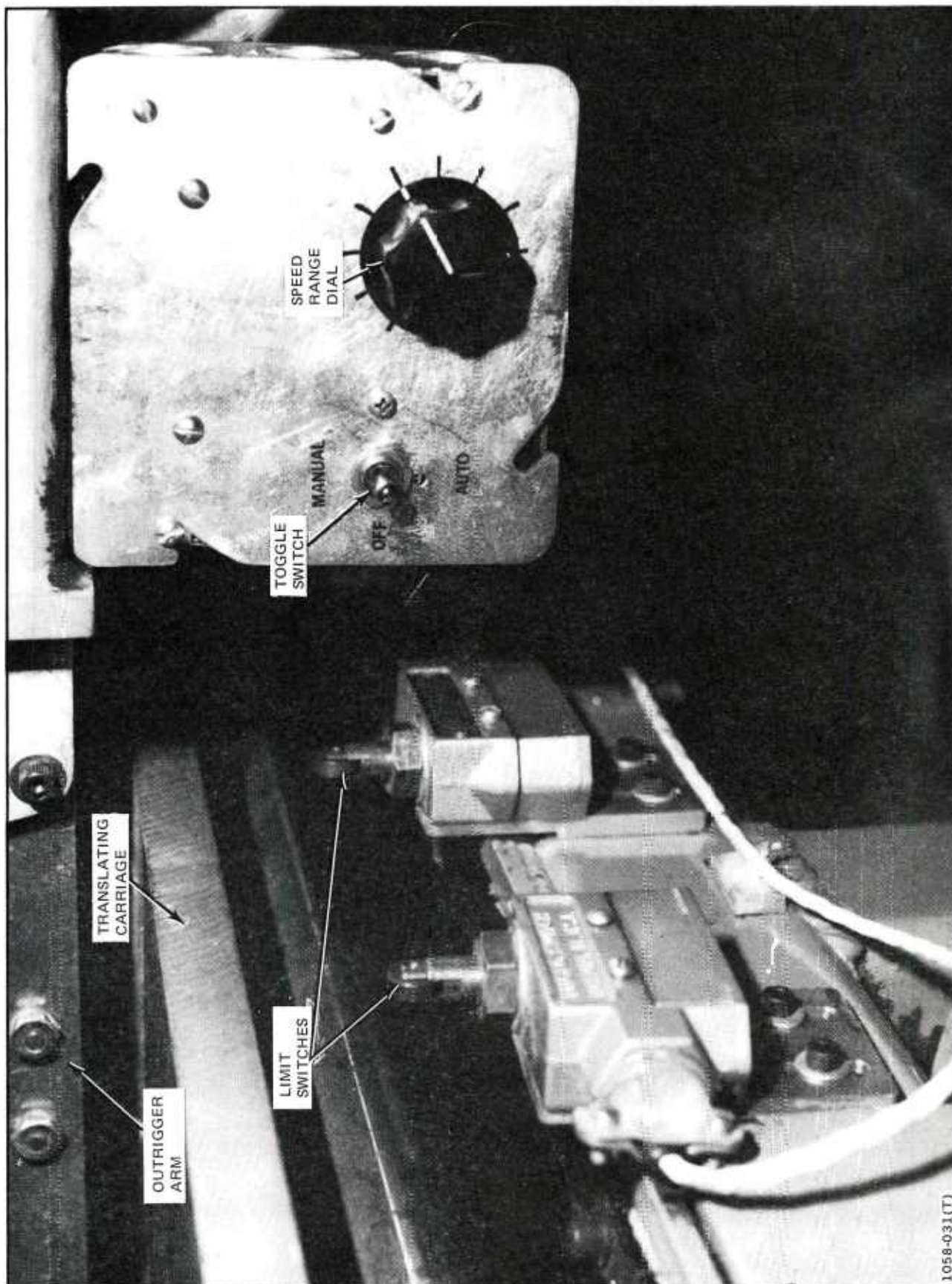


Fig. H-10 Take-Up Spool Control Box

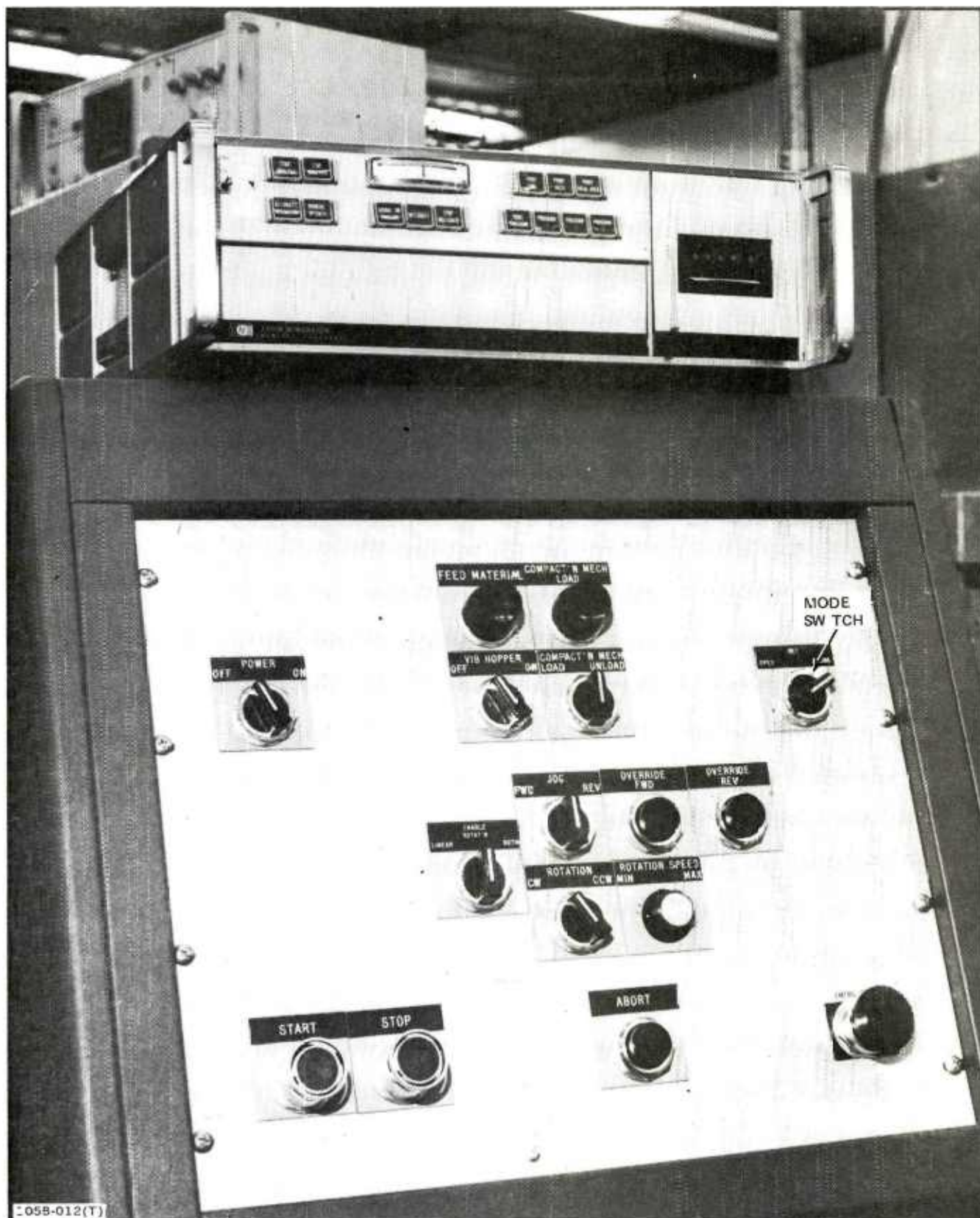


Fig. H-11 Control Console

Manufacturing Method For
PATRIOT Warhead Autowrap Fragment Layup Process

4.22 The system is now ready for automatic operation.
Prior to starting, check that the following items are as they should be:

☐ 115 V POWER PLUGGED IN	☐ ENABLE: BOTH	☐ AIR DIAPHRAGM: AUTO
☐ 440V POWER PLUGGED IN	☐ JOG: FWD	☐ TAKE-UP SPOOL CONTROL: AUTO
☐ POWER: ON	☐ ROTATION: CW	☐ CORRECT CAM ON BRKT
☐ VIB-HOPPER: ON	☐ ROTATION SPEED: 3	☐ AIR: CONNECTED
☐ COMPACT'N MECH: LOAD	☐ EMER. STOP: OUT	
☐ MODE: OPER	☐ SYNTRON: LOADED	

4.23 If all of the above criteria are met, push the START button and begin wrapping. It will be necessary at times for the operator to guide the fragments onto the Metal Parts Assembly during the wrapping process and to compact them in the forward direction. From experience, a small piece of Teflon tape-covered wood serves this purpose quite well.

4.24 During the wrapping process, the operator must maintain watch over the following:

- Fragments filling chute and not jamming
- Spacing of fragments on chain
- Fragments sticking to warhead during wrapping
- Take-up spool operating properly
- No breaks in adhesive or carrier paper.

Problems with any of these processes may be significant enough to stop wrapping.

Continue wrapping the fragment-chained tape around the Welded Parts assembly from the starting notch to the base, stopping when contact is made with the base weld. Cut the chain and fasten the end to the base with masking tape.

4.25 Set the MODE switch to "RET" and push the START button to return the Metal Parts Assembly (on its carriage) back to the start position. Keep the Metal Parts Assembly rotating by setting the MODE control to "JOG", the ROTATION switch to "CW", the ENABLE switch to "CW" and by pushing the START button. This motion will help retain the steel fragments onto the Metal Parts Assembly. If application of subsequent layers is delayed, the applied fragments should be over-wrapped with clear Teflon tape (2 or 4-in. wide) to secure them in place, and the Welded Parts Assembly rotated until fragment application is resumed.

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4.26 Turn the COMPACT'N MECH switch to "UNLOAD" and allow the cam follower mechanism to move away from the table. Change the cam follower, as follows: No. 2 for the second layer, No. 3 for the third. After the cam follower has been changed, turn the COMPACT'N MECH switch to "LOAD," which will bring the cam following mechanism back into its correct operating position. If clear Teflon tape has been applied, remove it when ready to start application of the next layer of fragments. Turn ROTATION switch to "CCW:", MODE switch to "JOG", and ENABLE switch to "ROTAT'N." Step on foot switch to start Metal Parts Assembly turning and peel off the tape, making sure all of it is removed.

4.27 Repeat steps 4.1 through 4.26 for fragment layers 2 and 3.

5 BAGGING AND CURING

5.1 Bagging. -

Turn switch controls to "JOG" and "ROTATION" and set rotation speed to "5" or "6". Starting at the wide diameter of the wrapped Metal Parts Assembly (base) apply a layer of clear 2- or 4-in.-wide shrinkable tape. Initially, apply the shrinkable tape to those fragments adjacent to where the last 1/4-in.-wide chain stops; then rotate the Metal Parts Assembly one full turn. Wrap the tape over the exposed edge of the last chain of fragments towards the base and wind tightly for two full turns using strong hand tension. Place about half the tape width over the exposed edge of the fragments onto the head-to-base attachment weld and half over the top. The idea is to compact the three layers as tightly as possible down and towards the nose of the Metal Parts Assembly. Proceed to wind the shrinkable tape down to the fragment application start point, advancing the tape helically about one-in. per turn. Hand tension should be just sufficient to cause the tape to "neck down"; the tape must be applied under tension since this will be the source of pressure during the cure cycle. Wrap the tape around the small diameter end twice, half onto the aluminum and half onto the fragments, then stop, cut off the tape and attach the cut end to the already-covered fragments.

Repeat the above operation to apply a second layer of shrinkable tape. Then apply two layers of green mylar or white nylon tape, the former being preferred due to lower cost. The outer two layers impart strength to the wrapped bag.

Manufacturing Method For
PATRIOT Warhead Autowrap Fragment Layup Process

5.2 Curing. -

A single oven-curing cycle is required, and is performed as follows. Remove the bagged Metal Parts Assembly from the Autowrap machine and place it nose down in a circulating-air oven. Attach a thermocouple to the Metal Parts Assembly in a representative position and secure insulating material over it, so that the temperature of the Metal Parts Assembly, and not the circulating air, is measured. Attach the thermocouple to a potentiometric recording chart so that the time and temperature of the cure cycle can be permanently recorded. If more than one Metal Parts Assembly is being cured in the same oven during the same cycle, place the thermocouple on the most representative part.

Set the oven temperature for $260^{\circ}\pm 10^{\circ}\text{F}$ and turn on the heat and blowers. When the temperature reaches $260^{\circ}\pm 10^{\circ}\text{F}$, set the oven controls to hold this temperature for 75 ± 15 minutes. When the chart indicates that the Metal Parts Assembly has been cured for the required time at temperature, turn off the heaters but keep the air circulators and temperature recorder operating. Do not open the oven doors, but open the oven vent. Allow the Metal Parts Assembly to cool to 100°F or less - slowly - before removing it from the oven. When the Metal Parts Assembly has cooled to room temperature outside the oven, remove the wrapped tape plastic bag by slitting with a knife and peeling off. As an option to oven cool-down, the Assembly may be removed from the oven and allowed to cool slowly to room temperature. This can be accomplished by use of an insulating blanket placed over the Assembly. Slow cool-down is required to prevent cracking due to the different thermal coefficients of the steel fragments adjacent to the aluminum shell. Make sure that all traces of the bag have been removed. Weigh the Metal Parts Assembly; 110.5 ± 2.0 lb is the specified target weight at this point.

6 FINISHING OPERATIONS: FILLING AND PAINTING

6.1 Cleaning. -

Place the cured fragment-loaded Metal Parts Assembly onto a lathe or potters wheel so that it can be revolved slowly in either the horizontal or vertical plane. Rotate the Metal Parts Assembly and wipe the exterior surface with a lint-free cloth saturated with acetone or methylethylketone (MEK); immediately dry the wetted surface with a second, dry, lint-free cloth or wiper. Repeat as necessary until the surface is clean, as indicated by the absence of discoloration of the dry cloth. Using clean, dry, oil-free compressed air, blow off the surface to remove any trapped dirt or solvent. Again, wipe the surface.

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6.2 Masking. -

Place 1-in.-wide masking tape circumferentially over the bottom rows of fragments right up to the edge. Similarly, wrap a layer of tape on the aluminum base at the parting line of the low-density filler, which will be used to fill the gap between the last rows of fragments and the base.

6.3 Application of Base Filler. -

The low-density thixotropic filler to be used is called out in Appendix C and is qualified under the specification called out there-in. The two components are thoroughly mixed with a spatula for five minutes or until the color becomes uniform throughout; no unmixed spots of resin or hardener are allowed. A clean spatula should be used to apply the mix to the base, which is slowly revolved. No filler is allowed past the masking tape delineated surface. The filler is applied so that no air is entrapped and is made as free of voids as possible. A second, smaller batch of filler may also be required. When the gap has been filled, the plastic material is carefully faired to the level of the three layers of fragments on one side and to the masking tape on the base. When the base filling operation is complete, remove the masking tape immediately and discard.

6.4 Application of Fragment Filler. -

The high-strength paste adhesive to be used for interstitial filling of the Metal Parts Assembly is called out in Appendix B and is qualified under the specification called out therein. After five minutes of mixing the two components, the paste adhesive is ready for application. Do not use the mixing spatula (wood or metal) for application of the adhesive paste filler. After troweling the filler well into the rotating Metal Parts Assembly, use a plastic (Teflon, polyethylene or polypropylene) squeegee to force the adhesive between the fragments, squeezing out air and filling the voids thoroughly. Work the adhesive in all directions. Spread a slight excess uniformly over the fragments' surface so that the steel can be seen through the screeded and smoothed adhesive when the application is completed. Two things are important; (1) the spaces between the fragments should be filled as deeply and thoroughly as possible, and (2) the adhesive should not overlay either the light-weight plastic filler at the base of the warhead or the aluminum casting at the top of the fragment layers, which would possibly establish an excess in weight or in dimensions.

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PATRIOT Warhead Autowrap Fragment Layup Process

6.5 Curing of the Fillers. -

After the epoxy base and fragment fillers have been applied to the Metal Parts Assembly, they should be cured until hard; an overnight (16-hour) cure at room temperature is desirable as well as time-efficient. A short bake, 150°F for one hour in a still or circulating-air oven, may be used to speed up the Filler cure cycle.

6.6 Application of Coating System. -

A clear, two-component, polyurethane coating should be applied over the filled Metal Parts Assembly as a protective coating, from the narrow end covering the fragments down to and covering the base filler, and fairing into the aluminum castings at top and bottom. Prepare the coating by mixing Component I, [(03-X-30 Base) coating, polyurethane, aliphatic, weather resistant clear, MIL-C-81773 (AS), clear Defthane enamel] with Component II [(03-X-30 catalyst), clear hardener for gloss clear, MIL-C-81773 (AS)]. Purchase of this coating from Deft Chemical, Irvine, CA. 92714 is recommended. After mixing the two components thoroughly, allow the mixture to stand for 30 minutes so that the polymerization reaction may start. Apply the coating by brush or spray to the warhead. If applied by brush; masking is not required; if applied by spray gun; all areas not to receive paint must be masked off. A minimum of two coats should be applied, each coat being about 1.5 to 2.5 mils thick, allowing overnight (16 hours) drying after each coat. A final bake at 150°F for one hour is recommended, if required to speed up the drying time.

An alternative clear polyurethane coating is also recommended -- Desothane 820-731/732. These clear coatings, being unloaded with pigment, deposit more resin per layer and, therefore, act as a better sealant. The Desothane coating is supplied by Desoto Chemical Co., 1700 Mt. Prospect Road, Chicago, ILL. 60018.

7 FINAL ACCEPTANCE OPERATIONS

The completed Inert Parts Assembly is weighed and inspected dimensionally. To be acceptable weight-wise, the Inert Parts Assembly must weight 112 ± 2 lb. Dimensional inspection is done with the G.F.E (ARRADCOM) checking fixture, which must clear all fragments, fillers and coatings on the completed Inert Parts Assembly, when mounted and rotated on the Inert Parts Assembly. This procedure is specified by ARRADCOM in Document DAAK-10-79-C-0376.

APPENDIX I

QUALITY CONTROL PLAN

PATRIOT WARHEAD AUTOWRAP FRAGMENT LAYUP PROCESS

Quality Control Plan For PATRIOT Warhead Autowrap
Fragment Layup Process

1 INTRODUCTION

The quality control system shall be in conformance with specification MIL-Q-45208 and shall include procedures for measurement standards, review of engineering drawings and specifications, receiving inspection, process control, manufacturing inspection, shipping, functional tests, control of non-conforming material, and maintaining records.

2 INCOMING MATERIAL INSPECTION

2.1 Metal Parts Welded Assemblies. - per requirements of ARRADCOM Drawing F9312580, Sheets 1 and 2, dated 23 August 1978.

2.2 Metal Fragments. - per requirements of ARRADCOM Drawing B9226307, dated 25 April 1977.

2.3 Tape Adhesive McCann Manufacturing MA-4333-1, - per requirements of Appendix A.

2.4 Base Filler, Furane Epocast 1310 Type II, - per requirements of Appendix C.

2.5 Coating - Deft Chemical Defthane. - per MIL-C-81773(AS), color clear, or DeSoto Chemical Company Desothane, same specification (see Appendix H).

2.6 Fragment Interstitial Space Filler. - Dexter Hysol Corporation EA 934 A/B per the requirements of Appendix B.

2.7 Shrink Tape, Expendable. - Connecticut Hard Rubber (CHR) Co. Temp-R-Tape, or 3M Company 5430 per the requirements of Appendix D.

2.8 Shrink Tape Overwrap, Expendable. - 3M Company 8403, Airtech International Inc. FLASH BREAKER or CHR Industries, Inc. M66 per the requirements of Appendix E.

3 IN-PROCESS QUALITY CONTROL PLAN

3.1 Pre-process Inspection. -
Recertify materials to requirements of
Section 2.

Quality Control Plan For PATRIOT Warhead Autowrap
Fragment Layup Process

3.2 Process/Inspection Criteria

3.2.1 Fragment Cleaning.

Vapor degrease fragments - no inspection.

3.2.2 Welded Parts Assembly Cleaning.

Solvent-clean Welded Parts Assembly that has been mounted in Autowrap machine by wiping with acetone or MEK. Dry immediately with lint-free cloth and visually inspect for discoloration. Repeat until wiper does not pick up color (white-glove inspection).

3.2.3 Fragment/Tape Chain Inspection.

Cut off section of Autowrap-processed chain and count fragments. Count must be 47-48 fragments per linear foot; adjust machine if count is lower.

3.2.4 Winding Operation.

3.2.4.1 Fragment Compaction. - Fragments are to be tightly compacted on Welded Parts Assembly towards nose as assembly is rotated. Inspect for closeness of packing of succeeding rows. Criterion is metal-to-metal contact of fragments; compact manually if required.

3.2.4.2 Surface Coverage. - Fragments which fall off must be replaced by hand. Inspection criterion is 100% coverage (i.e., no voids).

3.2.4.3 Cam-follower Installation. - Cam Follower No. 1 for first layer, No. 2 for second layer, No. 3 for third layer. Inspection involves a check of installation.

3.2.4.4 Cam/Cam-follower Operation. - Cam/cam-follower operation must provide continuous correct positioning of fragment/tape chain as it contacts the Inert Parts Assembly. Inspection procedure is visual examination of chain position and/or physical detection of mechanical interference.

3.2.4.5 Layer End Detection. - Inspect visually for weld line that will prevent fragment/tape chain from making uniform positive contact with Welded Parts Assembly. Inspect to see that masking tape has been temporarily installed to keep chain end in place, after layer has been applied. Tape must be removed before covering layer is completed.

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3.2.4.6 Tape Adhesive Interference. - Inspect rolls for excess adhesive on sides; do not use those with this condition prevailing. After winding each layer, inspect reels, rollers, guides and ways of Autowrap machine for adhesive that may have been incidentally transferred thereupon. Clean off with MEK or acetone and wipe surfaces dry with lint-free cloth or paper toweling.

3.2.4.7 Third Layer Completion. - Inspect starting point; tape/fragment layer should be level with cut-out on Welded Parts Assembly.

3.2.5 Bagging Operation.

3.2.5.1 Shrink Tape Application. - Visually inspect for complete coverage of each of two layers.

3.2.5.2 Fragment Inspection. - Visually inspect fragments through transparent tape for separation or drop-offs; correct as required.

3.2.5.3 Protective Tape Application. - Visually inspect surface for complete coverage of nylon or mylar tape.

3.2.6 Curing Operation (Adhesive Oven Cure).

Maintain and save oven cure cycle chart of thermocouple that has been attached to Inert Parts Assembly and insulated from circulating hot air. Inspection of chart should show heatup to 250°F, one (1) hour hold at 250°F and cool-down to room temperature (73°F).

3.2.7 Finishing Operations.

3.2.7.1 Base Filler Installation. - Save 10-gram portion of mixed base filler (Furane Epocast 1310 I/II). Inspect for completeness of cure by testing compression strength in accordance with Method 1021 of Fed. Test Method Std. No. 106. Compression strength shall be 7000 psi at 75°F (24°C), at 2% strain, minimum.

3.2.7.2 Fragment Interstitial Adhesive. - Save 10 grams of mixed adhesive (EA934A/B). Inspect for completeness of cure by testing for hardness, with a Barcol Hardness Tester, (Type 935). Inspection criterion is Barcol Hardness 65-90.

3.2.7.3 Paint Installation. - Inspect coating thickness and completeness of cure per MIL-C-81773 (AS).

Quality Control Plan For PATRIOT Warhead Autowrap
Fragment Layup Process

4 INERT PARTS ASSEMBLY FINAL INSPECTION

4.1 Weight Test. -

Weigh Inert Parts Assembly on scale accurate to ± 0.1 lb; criterion for acceptance is weight of 112.0 ± 2.0 lb.

4.2 Dimension Test

Use GFE dimensional check gauge. Mount Inert Parts Assembly on flat plate. Install gauge over assembly concentric with base and resting on flat plate. Criterion for acceptance is visual observation of clearance of gauge while being rotated around Inert Parts Assembly; no part of gauge shall make contact with the completed Inert Parts Assembly.

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