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FMC CORP SANTA CLARA CALIF ENGINEERED SYSTEMS DIV  
LAW PACKOUT SYSTEM.(U)

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## LAW PACKOUT SYSTEM

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18 September 1978

Final Report on Contract DAAA21-75-C-0333

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Prepared for  
U.S. ARMY  
Armament Research and Development Command  
Dover, NJ 07801

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78 10 02 037

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
9 Final rept. 25 Jun 75-30 Jun 78		
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED	
6 LAW Packout System Final Report	Final Report, June 25, 1975 to June 30, 1978	
7. AUTHOR(s)	8. PERFORMING ORG. REPORT NUMBER	
10 William Gerverdinck James Cullinane Dallas Scales	14 FMC-R-3739	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
FMC Corporation Engineered Systems Division 328 Brokaw Road Santa Clara, CA 95052	15 DAAA21-75-C-0333	
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE	
U.S. Army, Armament Research and Development Command, DRDAW-PRW-A, Bldg. 10 Dover, NJ 07801	June 29, 1978	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. NUMBER OF PAGES	
Same		
15. SECURITY CLASS. (of this report)	16. DISTRIBUTION STATEMENT (of this Report)	
Unclassified	SARPA-MT-M (8) AMSAR-MT-I (1) DDC (12) SARPA-MT-F (1) AMCPM-PBM-L (1) SARPA-TS-S (5) DCASR (2) SARLS-0 (1)	
18a. DECLASSIFICATION/DOWNGRADING SCHEDULE	17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)	
	Same as Block 16	
18. SUPPLEMENTARY NOTES	19. KEY WORDS (Continue on reverse side if necessary and identify by block number)	
	Packaging of Rocket M72A2 (LAW), form clusters, place in carton, place carton in bag, evacuate, seal, place in wirebound box, palletize, strap.	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
This report covers the development of a mechanized line to package the M72A2 (LAW) light antitank weapon, providing the degree of mechanization giving the greatest economic return, and no mechanization where operator performance is more economical. The system provides for cluster forming, enclosure in a corrugated carton and moisture barrier bag, placement of three bagged cartons in a wirebound box, placement of three boxes on a pallet, and strapping. System versatility allows ready adaptability for packaging other munitions or products.		

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## I. INTRODUCTION AND SUMMARY

Contract DAAA21-75-C-0333, under the direction of the U.S. Army Armament Research and Development Command (ARRADCOM), called for automating the packout of Rocket, HEAT, 66mm, Antitank, M72A2, w/Coupler (LAW). Under this contract, the FMC Corporation Engineered Systems Division (ESD) has developed the LAW Packout System which is the subject of this report. Final performance and acceptance tests were performed at the FMC facility in Santa Clara, California, the week of June 26, 1978, preparatory to the delivery of the system to Lone Star Army Ammunition Plant (LSAAP).

The method of packaging currently used in loading facilities is the handline, which comprises a number of labor-intensive functions. In its place, the LAW Packout System was to provide the degree of mechanization which would provide the greatest economic return; i.e., provide no mechanization in an area where an operator could more economically perform the task. The system philosophy was to use, where possible, commercially available components and to design only those elements which could not be readily purchased. As will be shown, however, much more design and fabrication of elements was necessary than had been anticipated.

The initial concepts and much of the hardware were developed during the period June 1975 through October 1976. Elements of the system were designed, built, and functionally demonstrated. Other elements, those available as standard commercial items, were specified, purchased, and evaluated. However, the total equipment package was not integrated and operated as a system at this time, as work was suspended from November 1976 to July 1977, when authorization was given to complete the functional LAW packout system.

The equipment system is designed as a group of discrete, functional modules, each totally capable of performing one or more related functions now being performed by hand:

- Forming the cluster and placing the saddles
- Placing the cluster in a carton, sealing the carton with tape, and blunting the corners
- Placing the carton in a bag, evacuating and heat-sealing the bag, and folding and gluing the corners
- Placing three bagged cartons in a wirebound box and closing the box
- Palletizing the boxes in groups of three
- Strapping the boxes to the pallet.

The system operates in the demand mode, in which presence of product sends a signal to the control system to initiate the appropriate machine function. When product is calling for work, the machine module operates at its designated rate. When product is not available or when operations downstream prevent the delivery of the product from that module, the module remains in the standby mode until conditions are present which will permit it to operate.

During the course of design, the philosophy evolved that rather than generating equipment exclusively for packout of a particular ammunition item, the system modules should provide maximum flexibility without, of course, compromising their integrity for their immediate task. Thus, the several individual automatic machine modules are suitable for broad application through the arsenal system, the supply service, and other military and civilian agencies. For example, such elements as the cartoning module (caser/taper/blunter), the bagging module (bagger/sealer/gluer), and the wirebound box machine are directly usable for packaging other equipment or supplies; and the cluster machine, with some modifications, can be used for the packaging of any object of a generally cylindrical configuration.

The FMC-designed LAW Packout System, then, will provide such advantages as the following:

- Decreased labor costs
- Higher reliability



- Consistency and uniformity of the pack
- Adaptability for a variety of uses, including immediate adaptability to the next-generation light antitank weapon -- the VIPER
- Elimination of such safety hazards as inverted rounds
- Provision for greatly increased personnel safety through the removal of all but a minimal number of workers from the environment of an explosive weapons packaging area.

The system layout is illustrated schematically in Figure 1, with the six modules identified according to their principal functions.

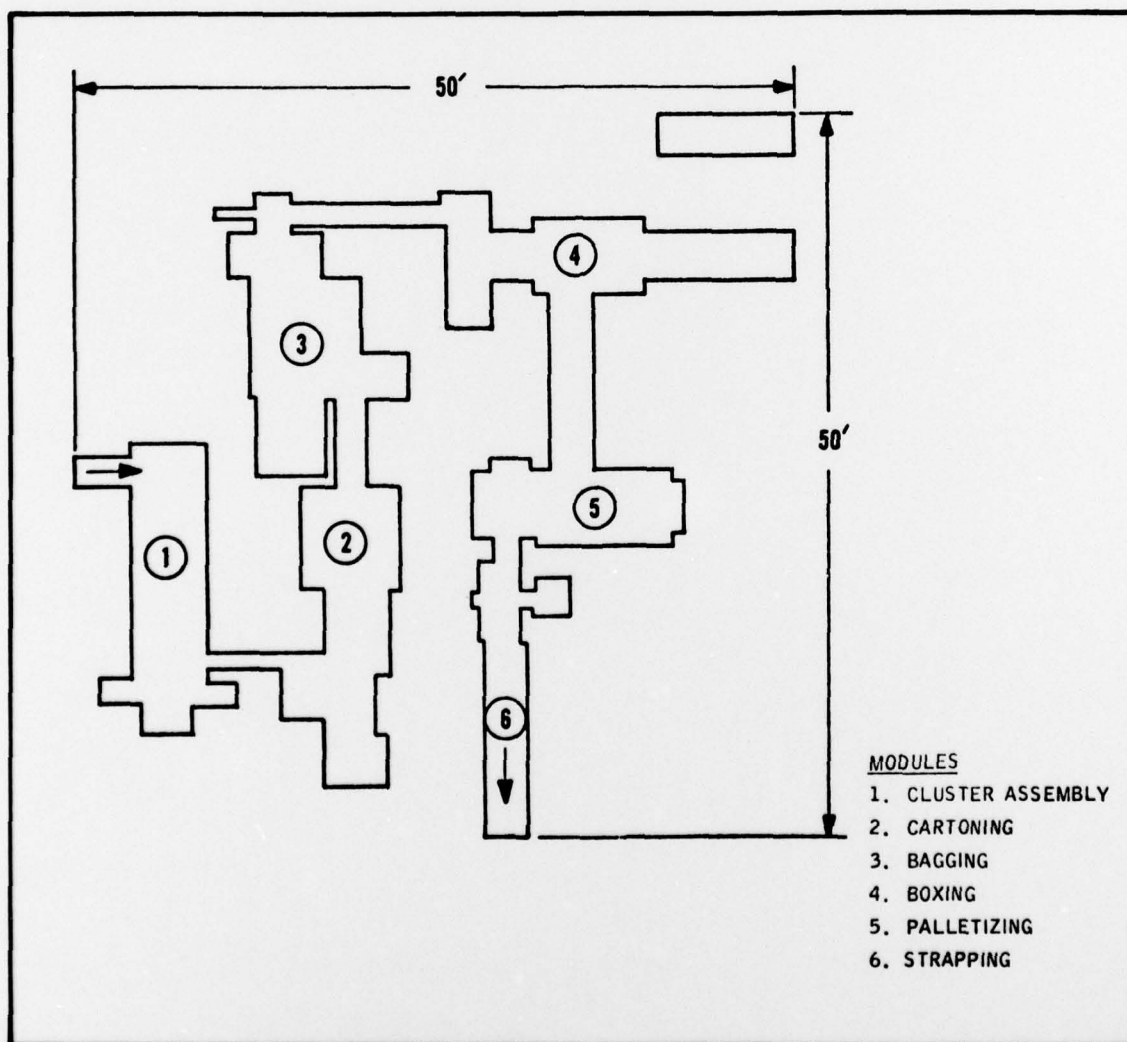


Figure 1 LAW PACKOUT SYSTEM LAYOUT

## II. TECHNICAL DISCUSSION

It was originally anticipated that the majority of the equipment items to be used in the LAW Packout System would be obtained through commercial sources, but the fact that vendors could not furnish equipment to meet applicable military specifications dictated the design and fabrication of all elements other than the automatic carton loader, the palletizer, and the strapping equipment.

Thus, the designing of the system proved to be a very challenging undertaking. Particularly difficult was the cluster assembly machine, with its requirement of placing five launchers in the proper configuration to match the preformed saddles. This unique machine has no counterpart in the packaging industry.

Each section of the system has been designed to operate not only as part of the LAW Packout System but also independently where such a function is desired, or as part of a different system. This arrangement also permits maximum flexibility in the layout of the packaging line. An overall view of the system is shown in Figure 2.

Each module operates on demand, initiated by the arrival of a package at any station. The package is not released if the next station is not empty to receive it. This action automatically inhibits all upstream stations from operating until flow downstream resumes. Instrumentation is provided in all modules to detect any condition requiring operator attention.

Pneumatic controls are used extensively in the packout line. They offer the advantage of low cost, reliability, and intrinsic safety, as they cannot generate sparks in a hazardous area.

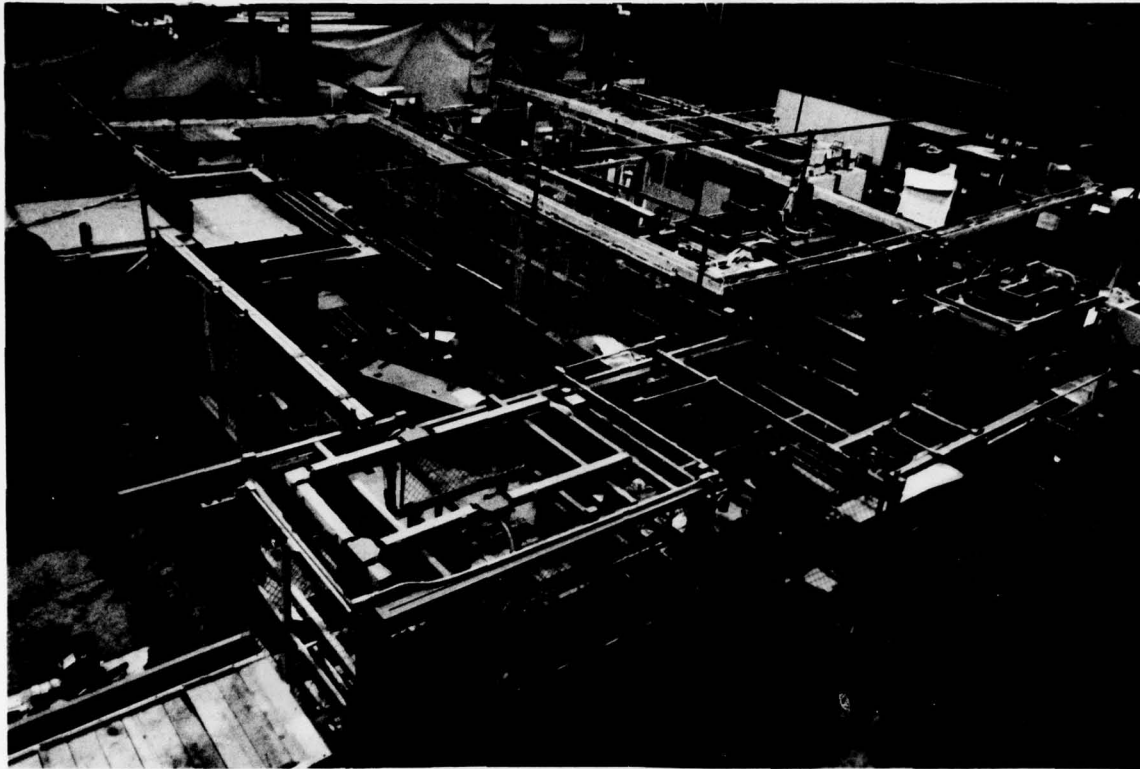


Figure 2 LAW PACKOUT SYSTEM OVERALL VIEW

The following paragraphs present the results of the design of the LAW Pack-out System, in the form of a system-operation description.

#### A. CLUSTER FORMING MODULE

The operation of the cluster forming module involves the interaction of the following elements:

- Feed conveyor
- Singulator
- Accumulator conveyor
- Shuttle conveyor
- Cluster assembly fixture
- Saddle magazines
- Saddle feed mechanism
- Saddle holders
- Takeaway conveyor.

The feed conveyor supplies the launchers in two parallel streams in a pre-oriented manner (i.e., on the side, nose end first, sight on the right as viewed facing downstream). As each pair of rockets is properly received, the combined signal from the limit switches contacted by each rocket activates the singulator. The singulator then advances two pitches, feeding the accumulator conveyor, as the next singulator vanes advance and receive the next two rockets.

As they enter the accumulator conveyor, the rockets are checked automatically for proper orientation. Detection of an improper orientation signals the conveyor to stop, and an annunciator changes color. Thus alerted, the operator will open the safety door, correct the misorientation, close the door, and restart the machine. When five launchers are accumulated in the proper position, the first of the two shuttles which make up the shuttle conveyor picks them up and moves them to a position above the cluster assembly, as the singulator resumes feeding rockets to the accumulator conveyor and the second shuttle moves to the pickup position. Figure 3 shows the shuttle (empty for clarity) positioned above the cluster assembly.

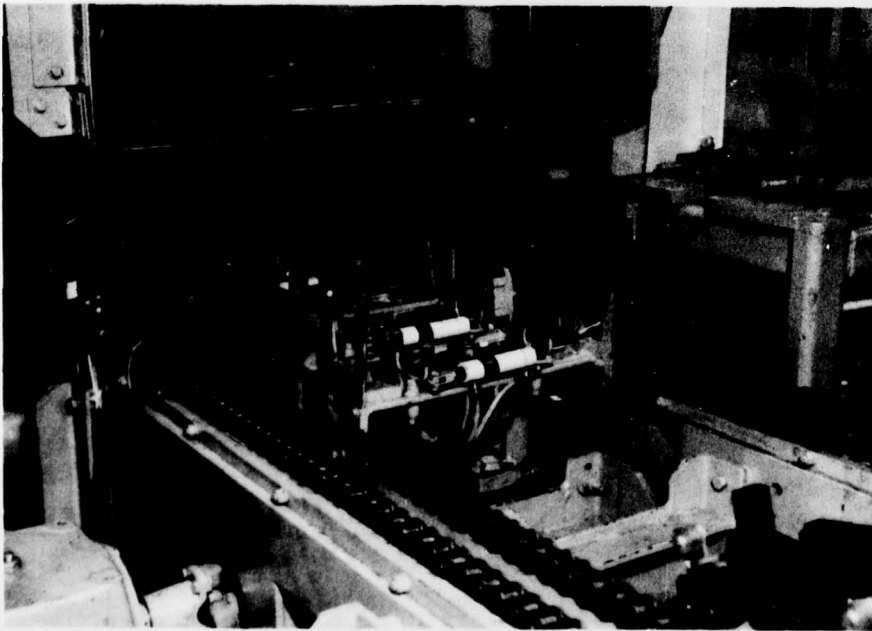


Figure 3 SHUTTLE IN POSITION ABOVE  
CLUSTER ASSEMBLY



The cluster assembly fixture secures the five launchers from the conveyor and positions them to receive the saddles, as shown in Figure 4. The saddle holders move in from either side and place a preformed saddle on each end of the cluster of five launchers, and then move forward to place the assembled package on the takeaway conveyor. The saddle holders receive another pair of saddles from the saddle magazines via the saddle feed mechanism, and return to the ready position for the next cluster.

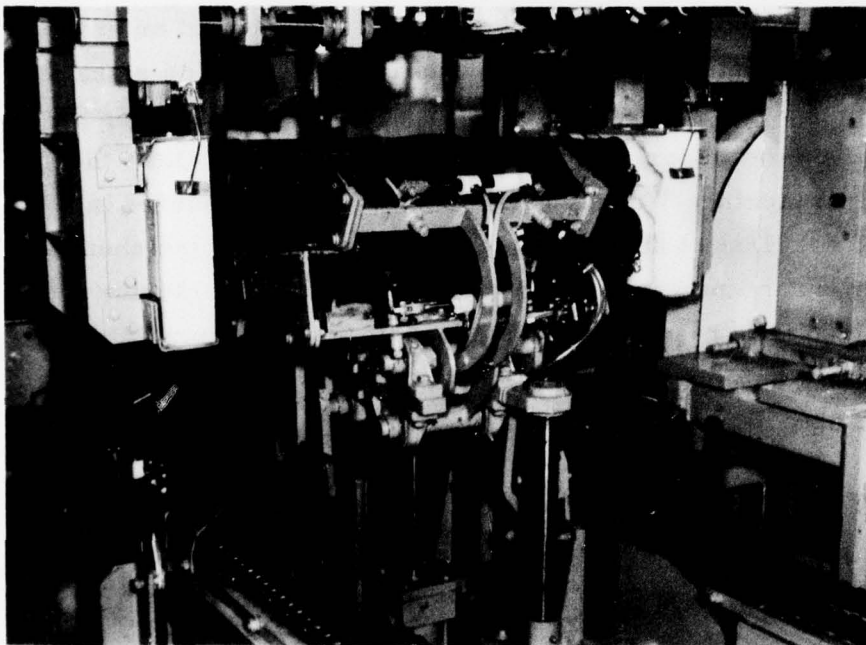


Figure 4 CLUSTER ASSEMBLY WITH FIVE POSITIONED LAUNCHERS AND SADDLES

The cluster forming module was developed especially to form a cluster of five LAW rockets and two end saddles, ready to insert into a corrugated carton. If the LAW packout line is applied to packaging of some other product, it is unlikely that this cluster forming module will be required. It can be removed and replaced with a completely different module which arranges a group of products preparatory to insertion into the carton. If the product does not require this grouping operation, it can be fed directly into the next module of the system, cartoning.

## B. CARTONING

The equipment in the cartoning module performs six operations related to enclosing a cluster in a corrugated carton:

- Open a flat, premanufactured carton.
- Insert a cluster.
- Fold the carton flaps.
- Apply tape to retain the flaps.
- Blunt the carton corners.
- Print identification on the carton.

The first machine element in this module is a commercial carton loader. Premanufactured cartons, received in a flat condition, are manually loaded into a magazine. The machine removes the bottom carton from this magazine, automatically opens it, and places it on an indexing conveyor, with the flaps on both ends open.

The opened carton is moved to a loading position and dwells while a ram pushes a cluster of five rockets and two saddles into the carton. As the carton is indexed to the next station, fixed plows cause the flaps to be folded inward, closing the carton. Side rails retain the flaps in this closed position.

On the next index, the carton moves past a specially designed tape applicator, which applies a strip of pressure-sensitive tape on each end of the carton. When the carton stops moving, four rollers extend, folding this tape around the carton ends and pressing the tapes tightly against the sides of the box, to hold the flaps securely closed. This station is illustrated in Figure 5, just before the tape is actually applied.

Specifications called for short pull tabs on each end of these tapes which do not adhere to the carton, so the tapes can easily be pulled off to open the carton. The initial approach to this requirement was folding the tape ends over, to join the two adhesive surfaces. No commercial equipment was available to accomplish this, and any special mechanism would be, apparently, very complex. Instead, FMC engineers satisfied the requirement by dispensing a short piece of plain tape and placing it against the adhesive of the two inch wide fiberboard carton sealing tape at a predetermined location.

During start up, the tape is manually attached to the first carton on the indexing conveyor when it is in the position before the taping station. As the conveyor advances, tape is dispensed and pressed against the carton, and another piece of plain tape is positioned on the sealing tape. The indexing conveyor has now placed cartons in the position where the tape dispensing equipment is between them. During the dwell period of the conveyor, four rollers press the tape along the sides of the two cartons and a knife blade extends, cutting the sealing tape at the center of the attached plain tape, thus forming the pull tabs on each end of the sealing tape. The operation is now set up in the automatic mode and applies tape to each carton as it passes. This solution is accomplished with rather simple mechanisms.

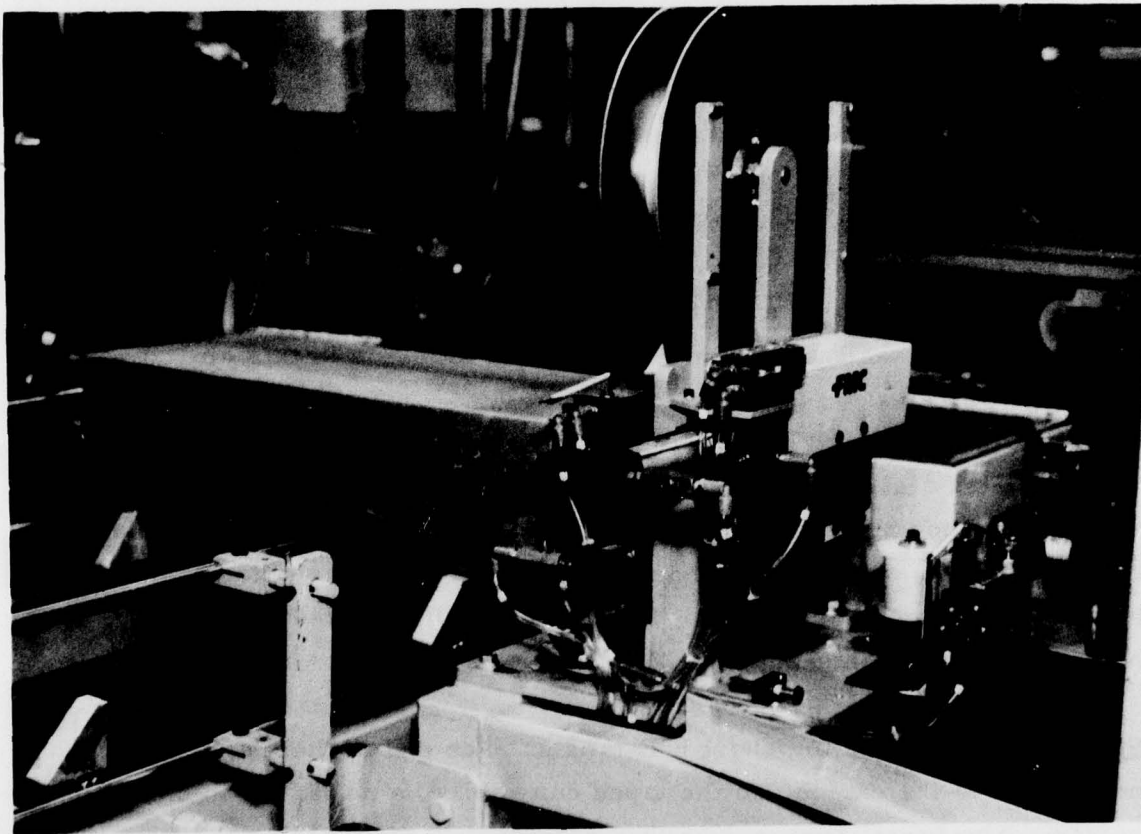


Figure 5 CARTON TAPING STATION

The taping operation requires, at each end of the carton, two rolls of tape, one roll for the pressure-sensitive sealing tape and one roll for the plain tapes which creates the nonadhering tabs.



The next conveyor index brings the carton to a station where air cylinders drive steel pressure pads against the eight corners of the box, to blunt or flatten them slightly so that there are no sharp corners present which might tear the barrier bag when the carton is pushed into it. A marking roller is rolled onto the carton to print the lot number and date.

The commercial carton loader is adjustable, to handle cartons of other sizes, if the module is used on some other application.

### C. BAGGING MODULE

The indexing conveyor of the carton loading machine has positioned the carton at the infeed station of the bagging module.

An operator manually loads multiwall, laminated bags, in a flat condition, into a bag magazine. Vacuum cups lift the top bag of the stack slightly and feed the edge into a set of rollers which propel it to the loading position. Here, the bottom layer of the bag is held down by vacuum, and two vacuum cups move down to pick up the top layer. When a gap is created, a pair of guides enter and open vertically, holding the open bag mouth securely and acting as shoehorns to guide the carton into the bag.

The carton is inserted by a ram, and the bagged carton is indexed to the evacuation and heat sealing station. At this station evacuating nozzles enter the bag on either side of the center and move outward horizontally, stretching the bag mouth slightly. A set of rubber-padded jaws close to clamp the bag mouth and a vacuum pump pulls the air out of the bag, through the nozzles. The nozzles are then withdrawn and heat-sealing jaws are closed to weld the bag surfaces together by heat and seal the bag.

When heat-sealing is completed, the bagged carton indexes past a marking wheel which prints the lot number and date on the bag and then arrives at the adhesive station where a small amount of cyanoacrylate adhesive is applied to the bag in four places. Following application of the adhesive, rollers fold the ends of the bag down on the adhesive which sets quickly and holds them



securely to form a neat package, easily handled during the remaining operations. (This adhesive is not usable on certain very glossy bag materials, as it will not adhere to such surfaces.)

Figure 6 shows the bagged cartons, the bag on the right having just been sealed and the bag on the left awaiting transfer to the next module.

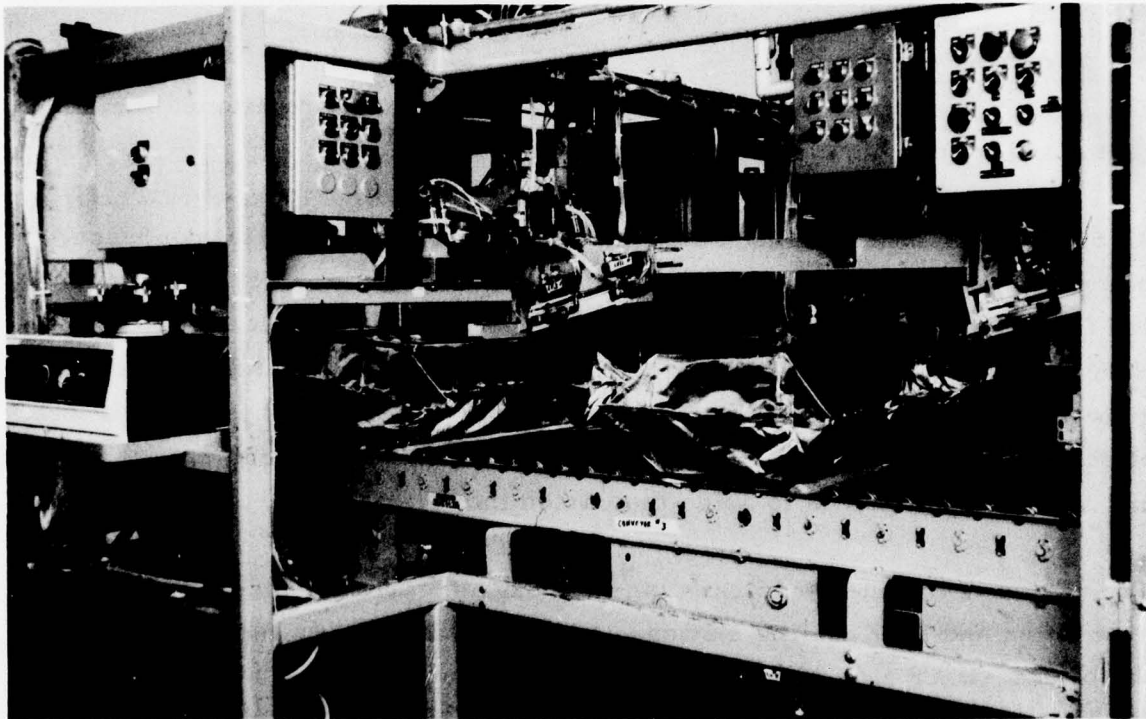


Figure 6 BAGGED CARTONS

#### D. BOX LOADING MODULE

The box loading module is provided for loading a group of three bagged cartons plus shock-absorbing filler material into a wirebound wooden box. The first operation in this module is a 90 degree rotation of the assembly while maintaining the nose end position and installation of a cotton webbing carrying strap on the package, secured by buckles. It was not considered feasible nor economical to automate this operation, so an operator performs this task. This same operator performs a visual inspection function and removes defective packages from the line.

After the carrying strap has been installed, the product moves to the collator, where three bagged cartons are placed side by side by an automatic mechanism and an operator adds the box end pieces, the fillers, and the foam pad. The collator then transfers this assembled load onto the box blank, which was previously placed in the box machine by an operator, and automatically advanced to the loading position, so it is in position to receive the load of three bagged cartons.

The box machine (Figure 7) folds the box around the load and an operator enters the enclosure, checks for presence of the pad, and clinches one loop. The operator closes the door and the box is moved automatically from the closing station to a rotary table where the box is rotated 180 degrees. Another operator enters the enclosure and clinches the remaining loops on the wire-bound box. If the box and contents pass his inspection, he places a lead seal on one of the clinched loops, leaves the enclosure, and closes the door to restore the interlock. When the interlock has been restored, the table automatically rotates 180 degrees to its original position and the box is moved to the palletizer elevator. (The rotation of the box is necessary to position the side of the box containing the wire loops next to the operator.)

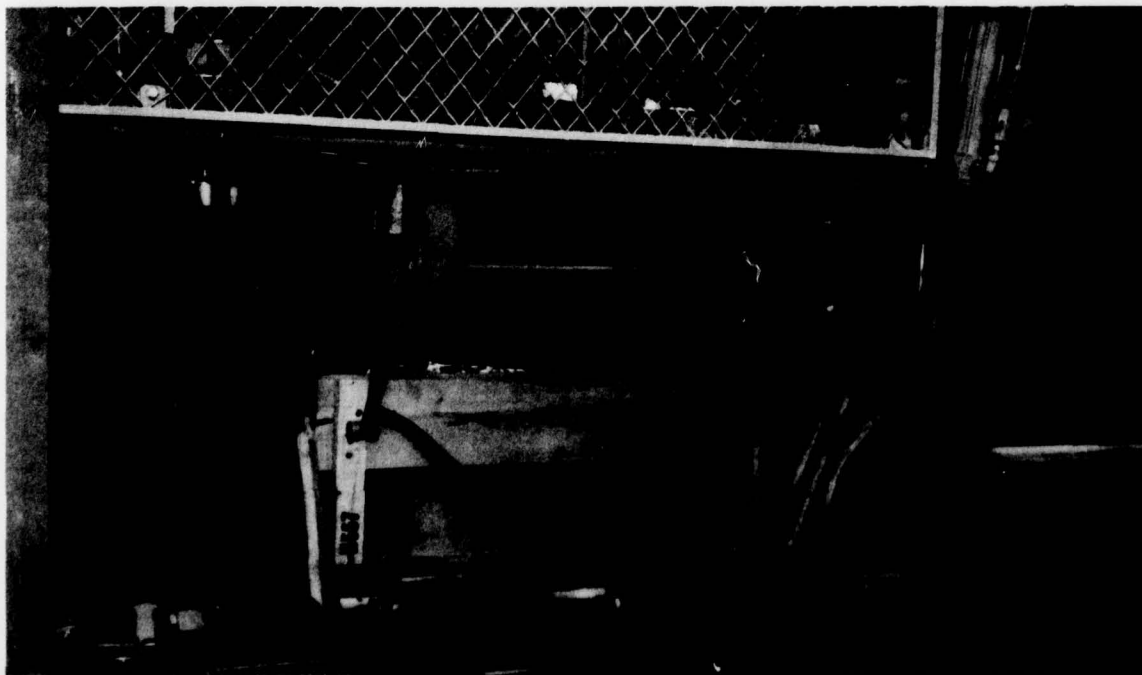


Figure 7 BOX FORMING/LOADING MODULE

Conventional manual assembly of wirebound boxes is a disagreeable job as the box blanks are large and awkward to handle. Generally, the box is formed prior to loading, with the end pieces stapled to the wraparound section. This makes it difficult to load product into the box without damaging it.

Opening the box requires prying it open, which usually splits the boards and makes reuse impossible. By contrast, the FMC box loading machine wraps the box around the load with no danger of product damage, and the box is easily opened, without damage, and can be reused if logistics permit.

#### E. PALLETIZING MODULE

The box moves onto the elevator platform of a purchased commercial palletizer, which is automatically activated by the arrival of the box. Figure 8 shows the palletizer from the pallet magazine side. As the elevator raises the box, printing rollers press against the sides of the box, marking the date and lot number. The box is moved off the elevator platform onto a loading plate and then onto a wooden pallet. The pallet is lowered, as boxes are added, until a full load of three boxes is in place on the pallet.

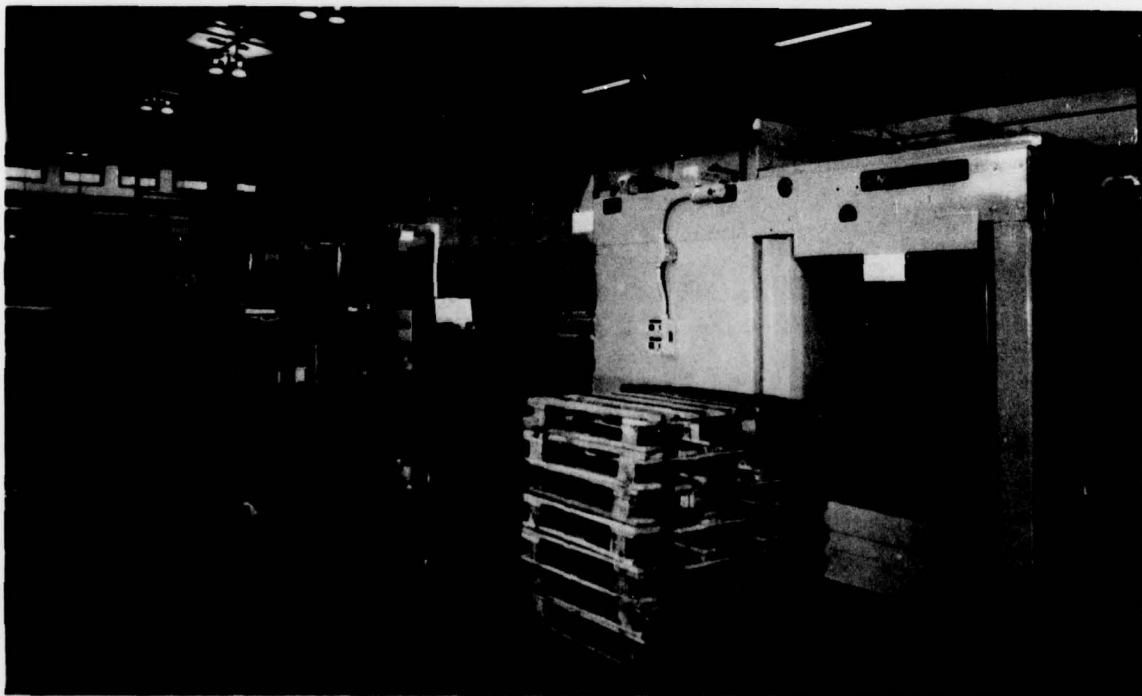


Figure 8 PALLETIZER

The pallet is then automatically lowered and rolled out of the palletizer. Figure 9 shows a loaded pallet just exited from the palletizer onto the powered conveyor to the strapping module.

The palletizer can be adjusted to handle other sizes of pallets and boxes.

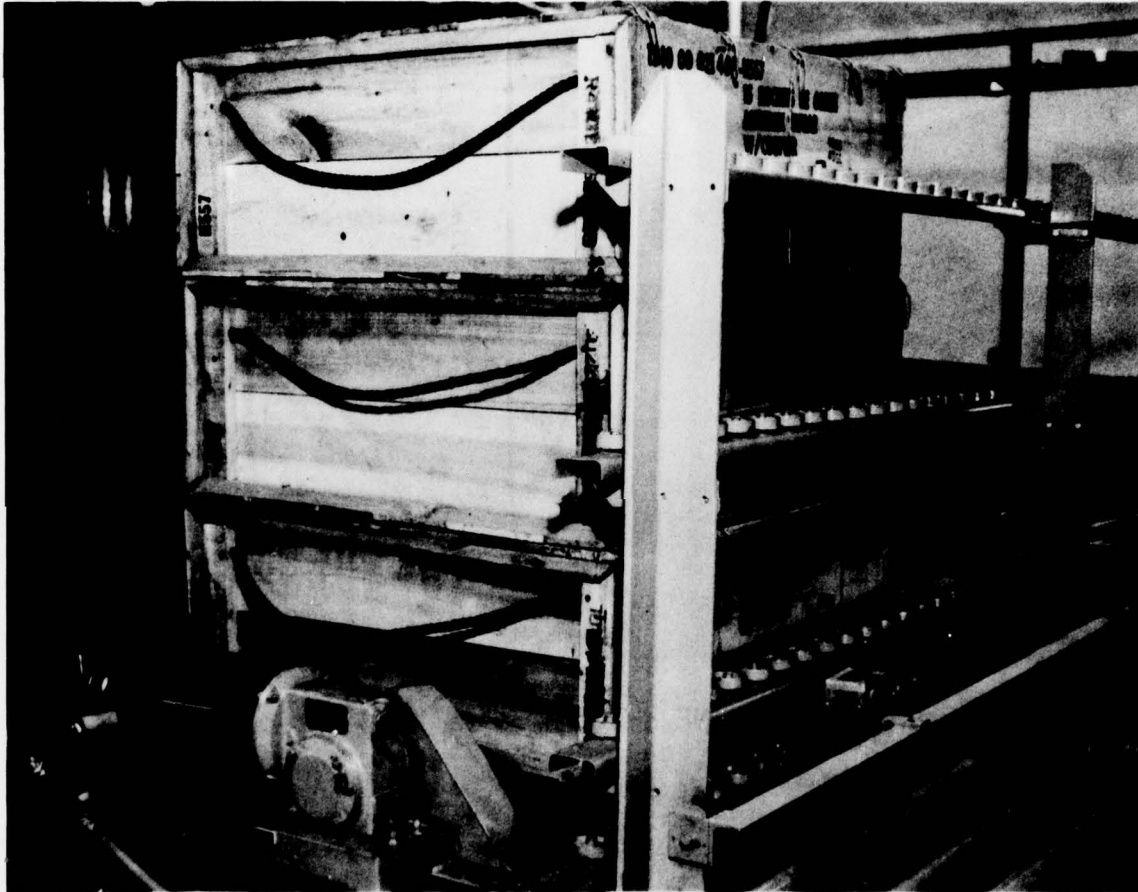


Figure 9 LOADED PALLET EXITED FROM PALLETIZER

#### F. STRAPPING MODULE

A powered conveyor transports the pallet and three boxes to a strapping machine, which is a commercial item. This machine is illustrated in Figure 10. Two steel straps are placed around the pallet load, tightened, and secured. The conveyor then moves the pallet away from the strapper and rolls it onto a gravity-type conveyor where it awaits removal by forklift truck.



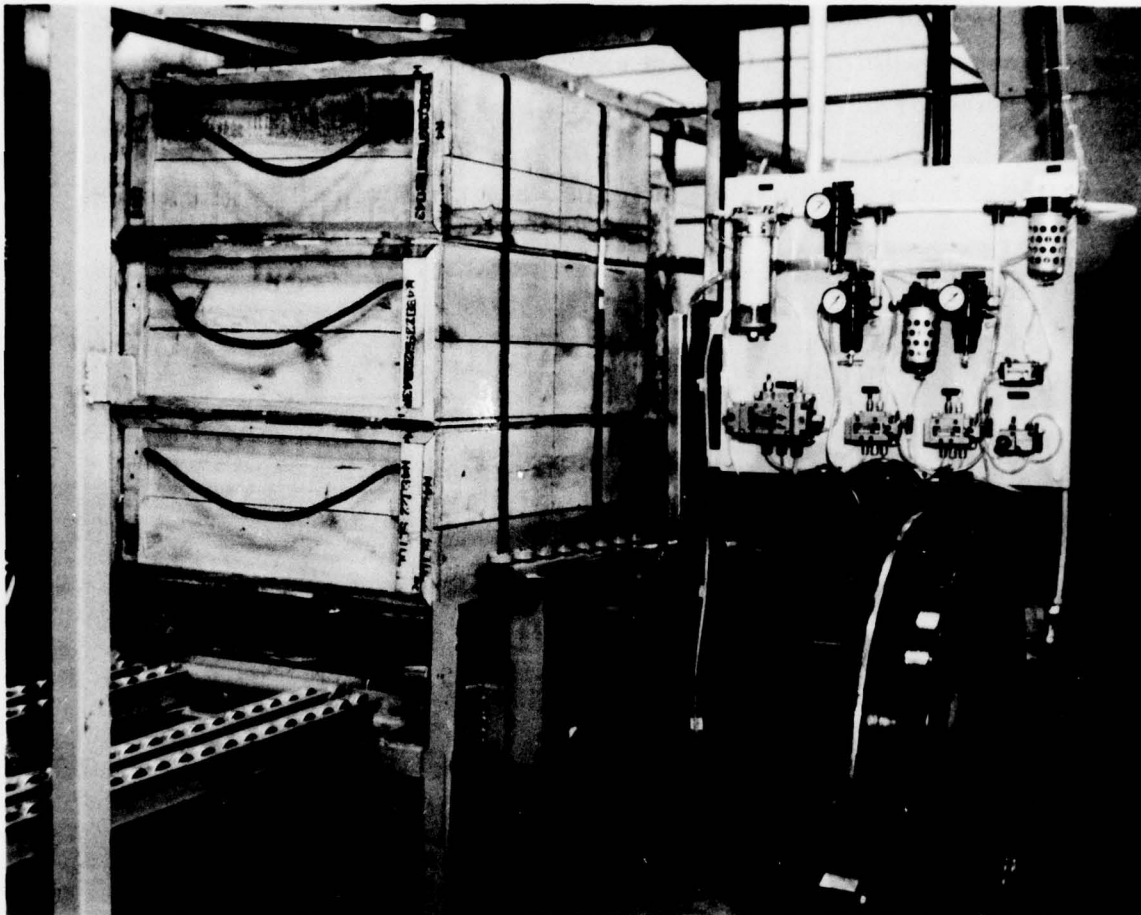


Figure 10 STRAPPING MACHINE

### III. CONCLUSIONS

The FMC-designed LAW Packout System provides adaptability, labor savings, safety, and packaging quality.

In terms of adaptability, the modularity of this system will permit its use not only as an entity in the packaging of LAW and VIPER rockets but also the use of the individual modules as an adjunct to hand packaging lines for other products. The modules may also be used as parts of other systems in which additional packaging modules have been purchased or designed. The system is also adaptable to limited-space facilities, for as presently composed, the entire system occupies a space of less than 2,500 square feet.

In terms of labor savings, the specification that no mechanization would be provided in an area where an operator could more economically perform the task has been met in such a way as to require a minimal number of operators. Thus, the LAW Packout System greatly reduces the number of personnel required by the labor-intensive handline.

In terms of safety, the LAW Packout System is well engineered, including explosion-proof wiring, which avoids hazards to operating personnel. As a function of the labor reduction, far fewer personnel are exposed to the inherently hazardous environment of a loaded weapons packaging facility.

As for packaging quality, the LAW Packout System mechanizes the required packaging characteristics of clustering the rockets so they are not in contact with each other or the carton walls; of cartoning the clusters; of bagging the cartons in heavy-duty, vacuum-evacuated, heat-sealed barrier bags; of collecting the bagged rockets in wirebound boxes; and of strapping the boxes to pallets for easy storage and/or transport. Thus, the rockets are protected against shock, cold, heat, and moisture. Finally, the wirebound boxes themselves are so designed that they can be reused, if logistics permit.