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AFATL-TR-77-21

DEVELOPMENT OF A 30MM FRANGIBLE PROJECTILE CRIMPER

AMRON CORPORATION
525 PROGRESS AVENUE
WAUKESHA, WI 53186

FEBRUARY 1977

FINAL REPORT FOR PERIOD
JUNE 1976-JANUARY 1977

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Roll Crimp
Stab Crimp
Bullet Push Force
Non-Ricochet Ammunition

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The hydraulic crimping method used to assemble GAU-8/A (30mm) ammunition has been found unsuited for use with two projectile designs under development by AFATL. One of these, a plastic jacketed washer stack frangible target practice projectile, was chosen as the design-limiting case for the development of an alternative crimping method. A crimper designed to roll crimp plastic

OVER

CONT.

frangible projectiles into standard aluminum GAU-8 cartridge cases in such a manner that adequate projectile retention force is developed without structural damage to either the projectile or the cartridge case has been developed. The crimper consists of a cartridge holder mounted on a table under a rotary crimp head containing three pneumatically actuated crimp roller arms. Compressed air is metered into the air cylinder for gradual buildup of crimping force. On reaching a predetermined pressure, air in the cylinder is exhausted and the revolving crimp arms return to their original position. Two identical prototype crimping machines were fabricated to this design and ammunition assembled with them subjected to both static debulleting tests and Mann barrel firing tests. All design goals were met. Both prototypes include an air compressor to actuate pneumatic components, interlocked safety shields, and explosion-proof electrical components adequate for use in a laboratory ammunition loading environment.

PREFACE

This program was conducted by Amron Corporation, 525 Progress Avenue, Waukesha, Wisconsin 53186, under contract No. F08635-76-C-0262 with the Air Force Armament Laboratory, Armament Development & Test Center, Eglin Air Force Base, Florida. Lieutenant Paul Weber (DLDG) managed the program for the Armament Laboratory. The program was conducted during the period from June 1976 through January 1977.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Gerald P. D'Arcy, Colonel, USAF
Chief, Guns, Rockets and Explosives Division

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SECTION I

INTRODUCTION

The Air Force Armament Laboratory (AFATL) has recently conducted development programs involving two GAU-8/A (30mm) configuration cannon projectiles which, during the course of testing and analysis, have been found unsuited for crimping into cartridge cases with the hydraulically driven rubber collar used with conventional projectiles. The first, a Rocket Assisted API Projectile (RAP) was initially developed under Air Force Rocket Propulsion Laboratory contract F04611-75-C-0053; the second, developed under AFATL contract F08635-76-C-0195, was designed to serve as an inexpensive target practice projectile with reduced ricochet characteristics. The RAP's aft body skirt was relatively thin in order to provide clearance for the rocket nozzles. When subjected to the compressive loads characteristic of the hydraulic crimping operation, the skirt was expected to deform in an unacceptable manner. The target practice projectile consisted of a stack of steel washers surrounded by an injection molded plastic jacket. On impact with the earth, the jacket was to shatter, allowing the relatively light, high-drag washers to scatter. Hydraulic crimping was found to rupture the plastic skin beneath the crimped area leading to inadequate projectile retention force ("bullet pull") and in-flight structural failures.

Since the plastic frangible projectile displayed the lowest aft body strength and was also available in sufficient quantity, it was chosen as the crimper performance-limiting design.

At the request of the plastic frangible projectile program contractor, DeBell and Richardson, Inc., Amron Corporation fabricated a hand-operated roll-type crimper for such projectiles in 1975. It consisted of a pipe cutter modified by replacing the cutting roller with a similar roller having a rounded profile matching the projectile's crimp groove geometry. Static debulleting and Mann barrel firing tests showed that the crimp produced was satisfactory with respect to bullet retention forces and lack of damage to the projectile, but the variation in bullet pull from one trial to the next was unacceptably large. During such crimping, the screw holding the crimp roller was tightened by the operator after each revolution, until the case wall was judged to have reached the bottom of the groove. While this crude tool allowed development of the frangible projectile to proceed with Mann barrel firings and high rate dry cycling in the automatic gun, it was considered desirable to eliminate the human operator variables in the crimping operation. These variables were believed to be the primary cause for the excessive variation in bullet retention forces developed by the crimp.

Development of a 30mm frangible projectile crimper was conducted under contract F08635-76-C-0262. The scope of work called for a concept study phase, during which one or more concepts were to be generated, analyzed, and presented in layout form to permit selection of the best approach at a design review. Detailed design, fabrication, and testing of two functional prototypes would follow. Testing by the contractor was to include both static projectile push tests to determine the force needed for projectile extraction, and Mann barrel firings to demonstrate that the crimping action did not introduce stresses in the projectile which could cause break-up in the bore or at the muzzle. For the extraction tests, the cartridge case primer hole was enlarged by drilling to 9/16 inch to permit introduction of a 1/2 inch rod for pushing the projectile from the case. It had been found earlier that the conventional method of gripping the projectile's bourrelet and pulling often crushed the projectile jacket and produced erroneous extraction force readings.

SECTION II

CONCEPT STUDIES

1. GENERAL

During the concept study phase, two basic concepts were evaluated -- stab crimp and roll crimp. The stab crimp concept covered two crimp techniques -- one with gradually cammed fingers, and one with staggered stepped fingers to be cammed.

The original roll concept is shown in Figures 1 and 2, with Figure 1 showing the use of a modified drill press to provide a table, a frame, and rotary motion for the crimp head. Shop air was to be used to actuate an air cylinder to cam the crimping rollers during crimping. Figure 2 is a section of the crimp head to show details of the crimp mechanism by which downward movement of a cam causes the pivot arms to move out at the top and in at the bottom, where the crimp rollers are located. This original concept was refined during the concept study phase, and the resulting layout drawing became the basis for the actual crimper which was built, and which is described in the next section in more detail.

Figure 3 shows the overall general view of the stab crimp concept, in which the crimper is located in an available conventional press, depicted here as the type in which the press frame mounts an upper hand-operated hydraulic press, to provide controlled pressure against the crimper located on an adjustable base. Figure 4 is a section through the stab crimp mechanism

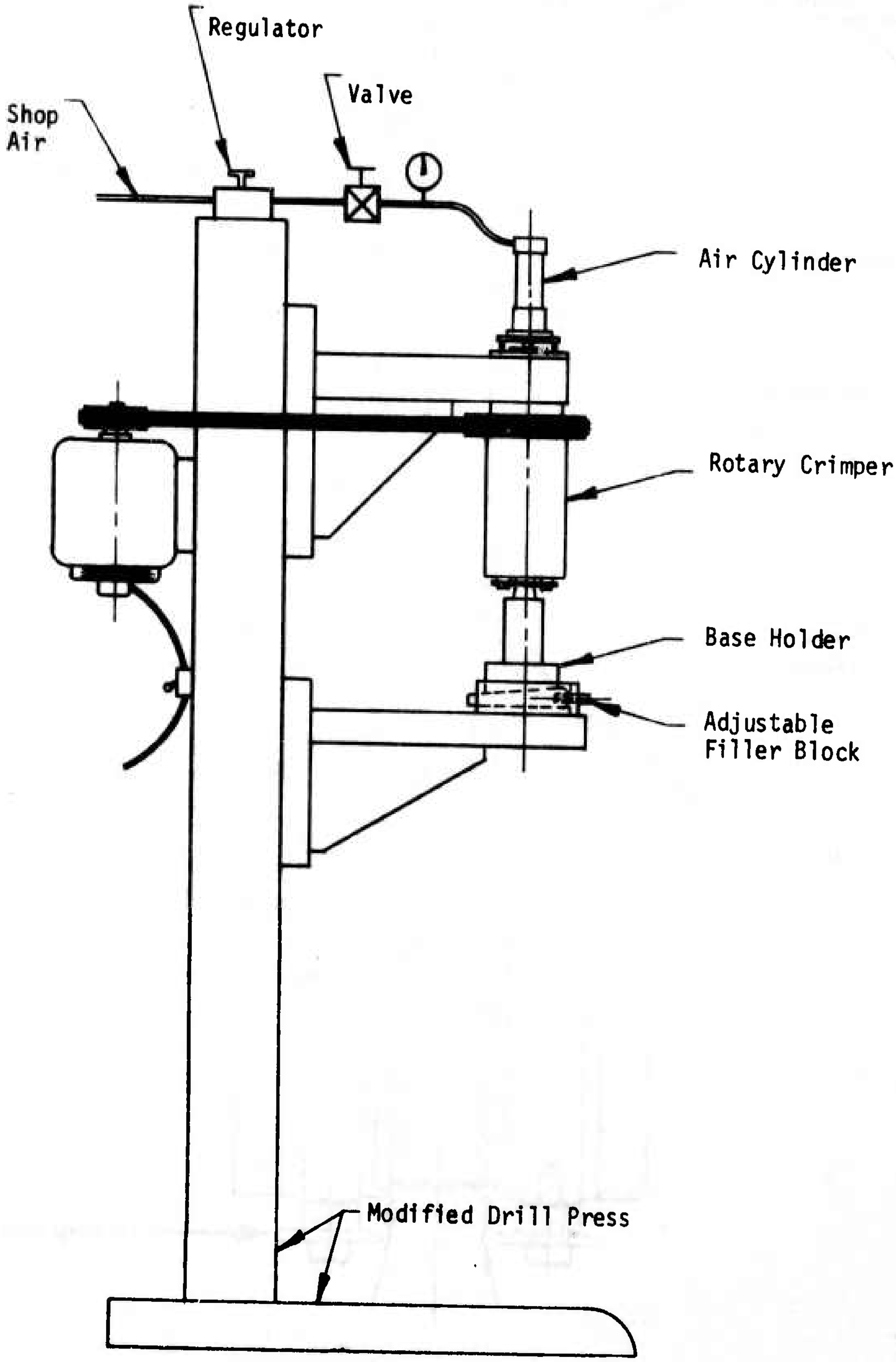


Figure 1 - Roll Crimp Concept - General

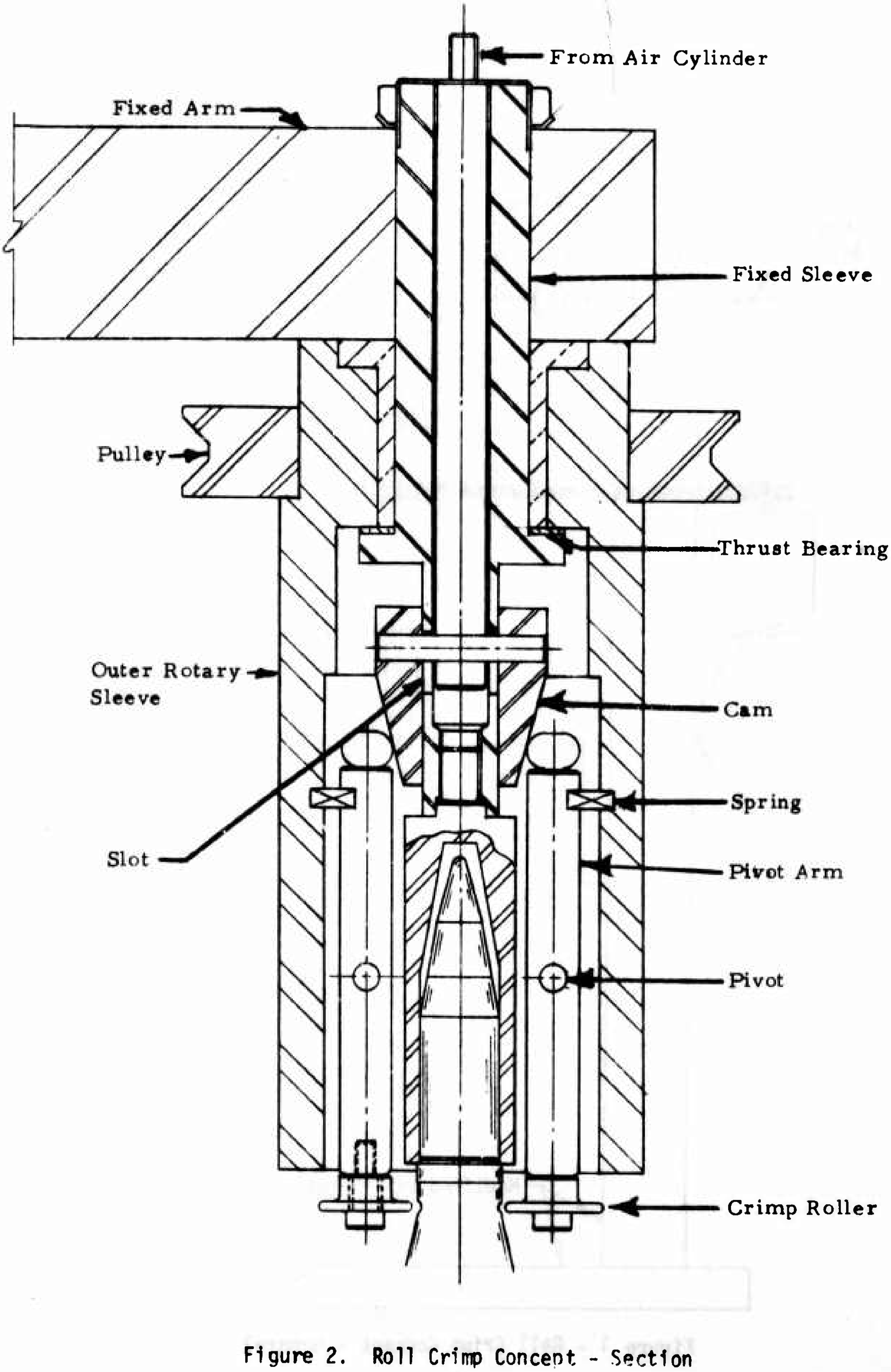


Figure 2. Roll Crimp Concept - Section

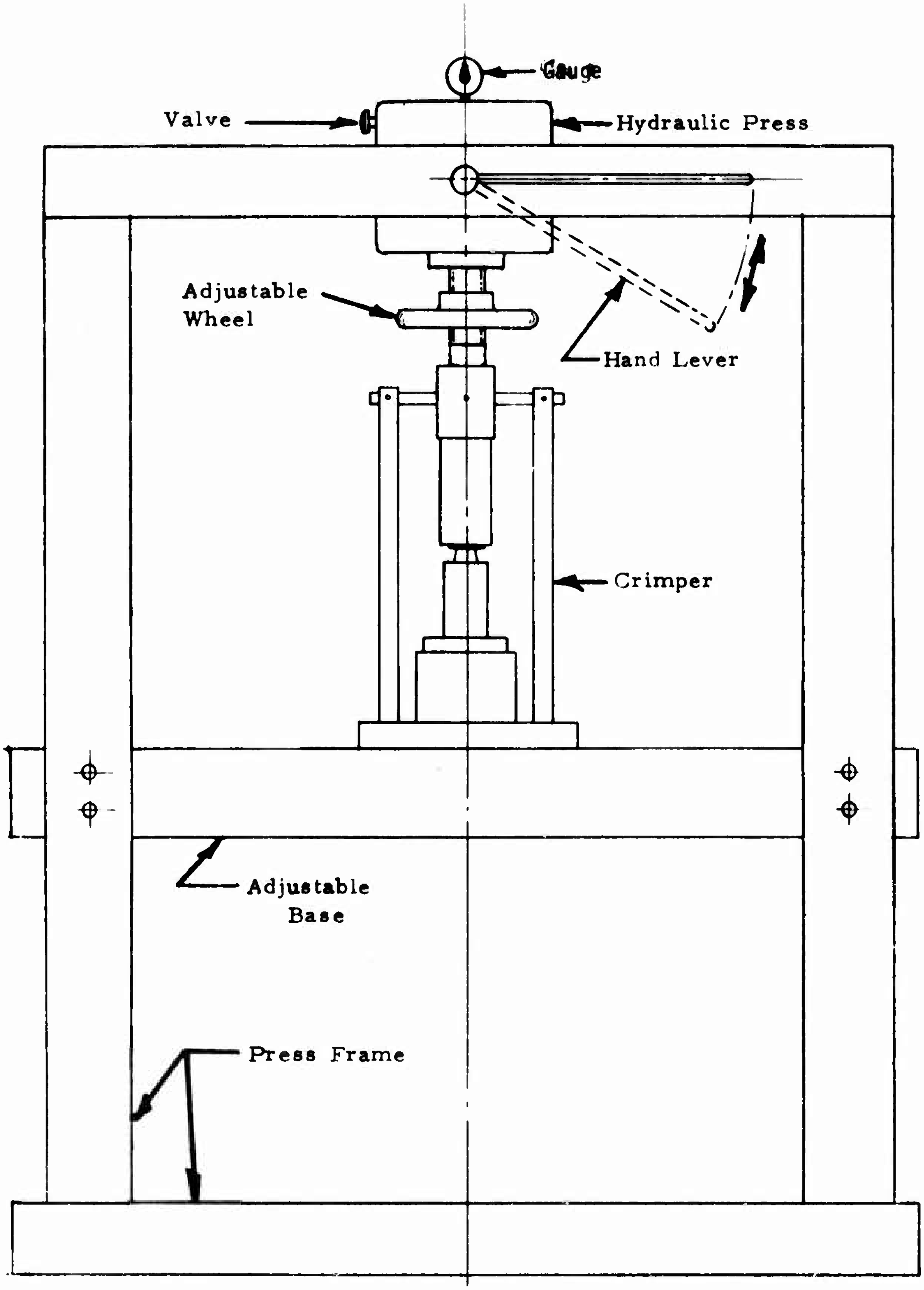


Figure 3. Stab Crimp Concept - General

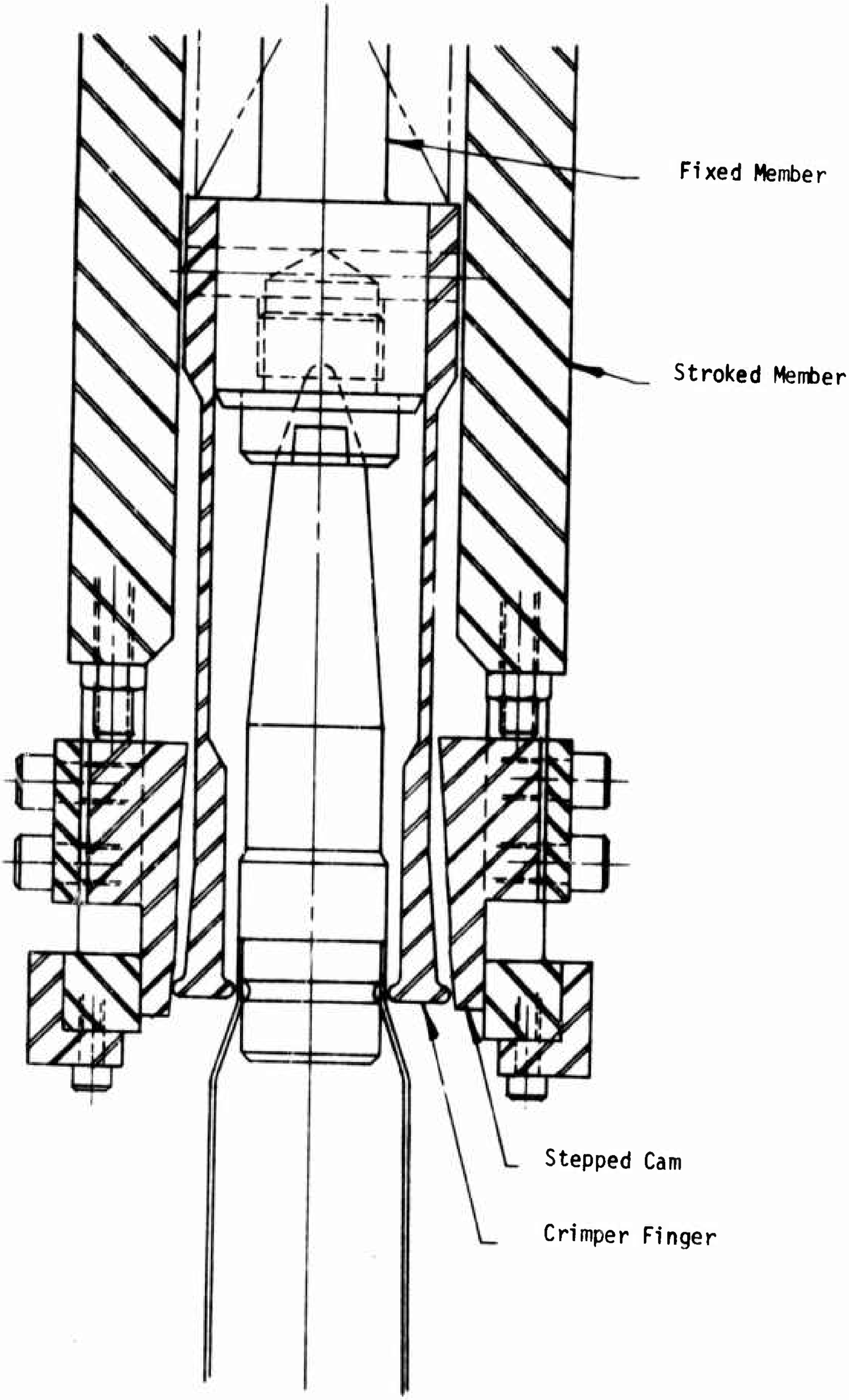


Figure 4. Stab Crimp Concept with Adjustable Fingers

resulting from the concept study phase. This particular concept includes six adjustable stepped cams mounted on flexible fingers, with the steps of each cam staggered with respect to adjacent cams to permit successive crimping around the case neck. A simpler concept included eight nonadjustable crimp fingers, with simultaneous crimp action from all eight fingers as the stroked member is forced downward, camming the crimper fingers inward.

2. DESIGN REVIEW AND DECISION

The minutes of the Design Review No. 1 meeting held at Eglin AFB 2 August 1976 cover a discussion of the three concepts, advantages and disadvantages of each and the decision to proceed with the roll crimp concept, and are presented in Appendix B.

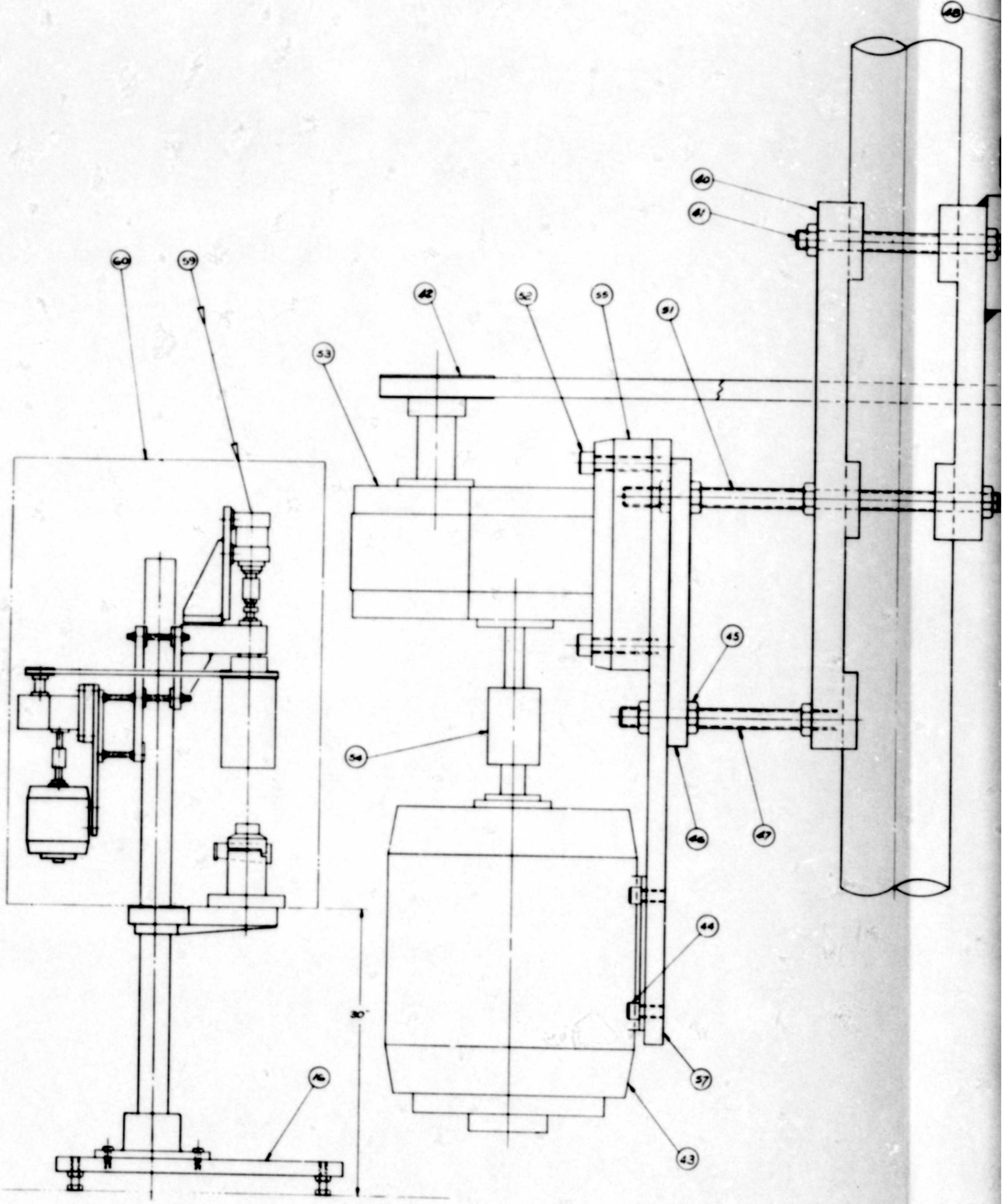
SECTION III

DESCRIPTION

An assembly drawing of the crimper, less air compressor and shields (or guards) is shown in Figure 5. Figure 6 shows the crimper with shield in place, and the air compressor to the rear. An operator is shown in the process of inserting the cartridge with cartridge holder into position under the crimper head. Figure 7 is a close-up side view of the crimper with shield removed, and most of the air compressor is visible. The control and adjustable features of the crimper are visible in this photograph, so this figure will be used extensively in the next section covering operation.

Figure 5 shows an elevation view of the entire crimper in the lower left hand corner. The principal drawing in Figure 5 is a section through the crimper head. As shown in the elevation view, a pipe-like 4-inch column attached to a heavy base with four leveling screws serves as the main support, which in turn carries the table at a height 30 inches above the floor, and the main upper bracket supports the electric drive motor which runs at 1725 rpm. The 24:1 gear reduction attaches directly to the motor and drives the small pulley at 72 rpm. With a 2:1 further reduction between the small pulley and the pulley on the crimper head, the crimper head rotates at 36 rpm, making about 1.7 rps. Above the rotating crimper head is a 3-1/4 inch diameter air cylinder. With a relief valve setting of 35 psi, the air cylinder exerts a maximum downward force of 290 pounds.

Referring to the sectioned view of the crimp head, this downward stroke moves a tapered nonrotating cam through a distance of about 5/8 inch, and this



ELEVATION VIEW
1/6 SCALE

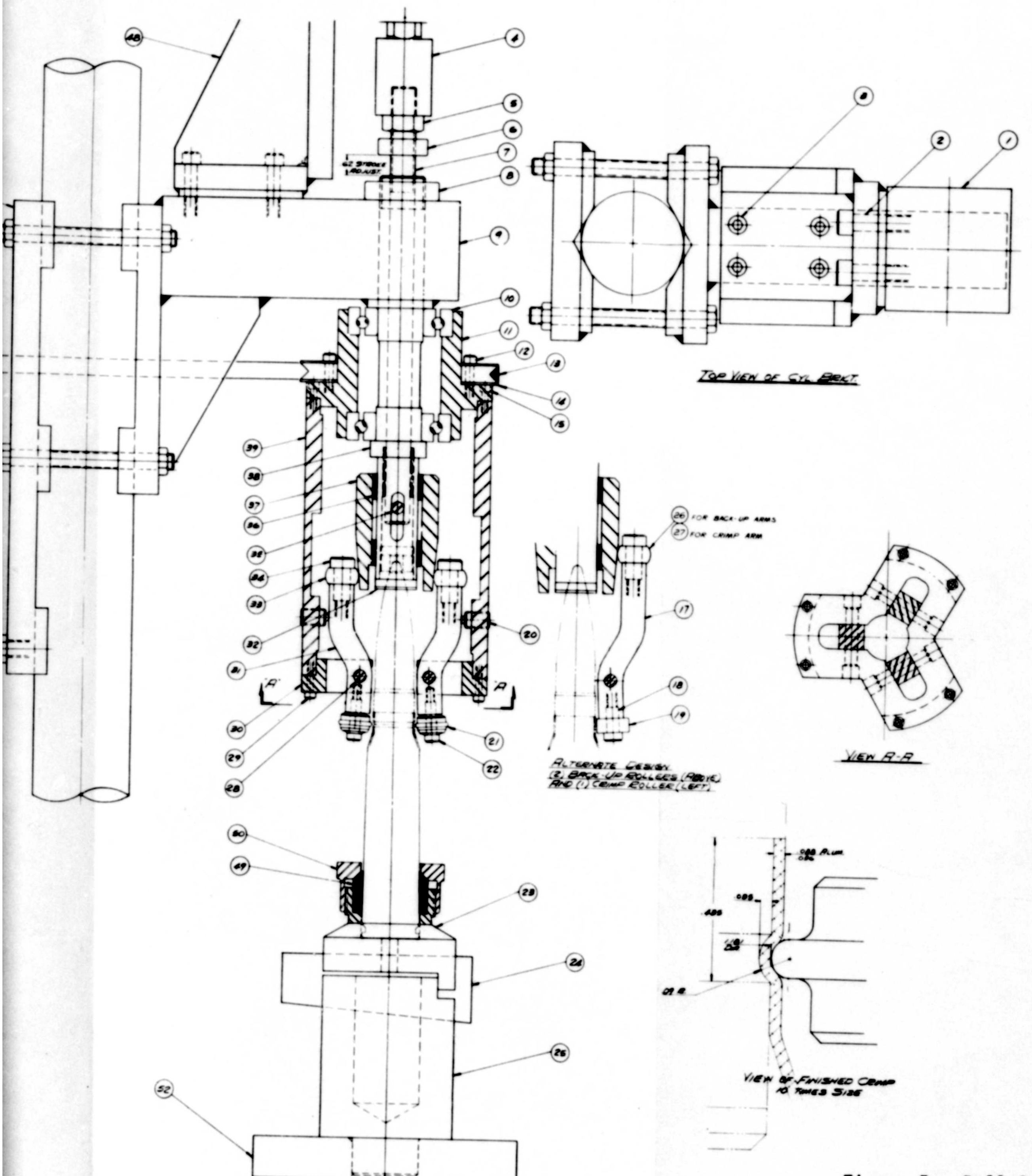


Figure 5. Roll Crimper

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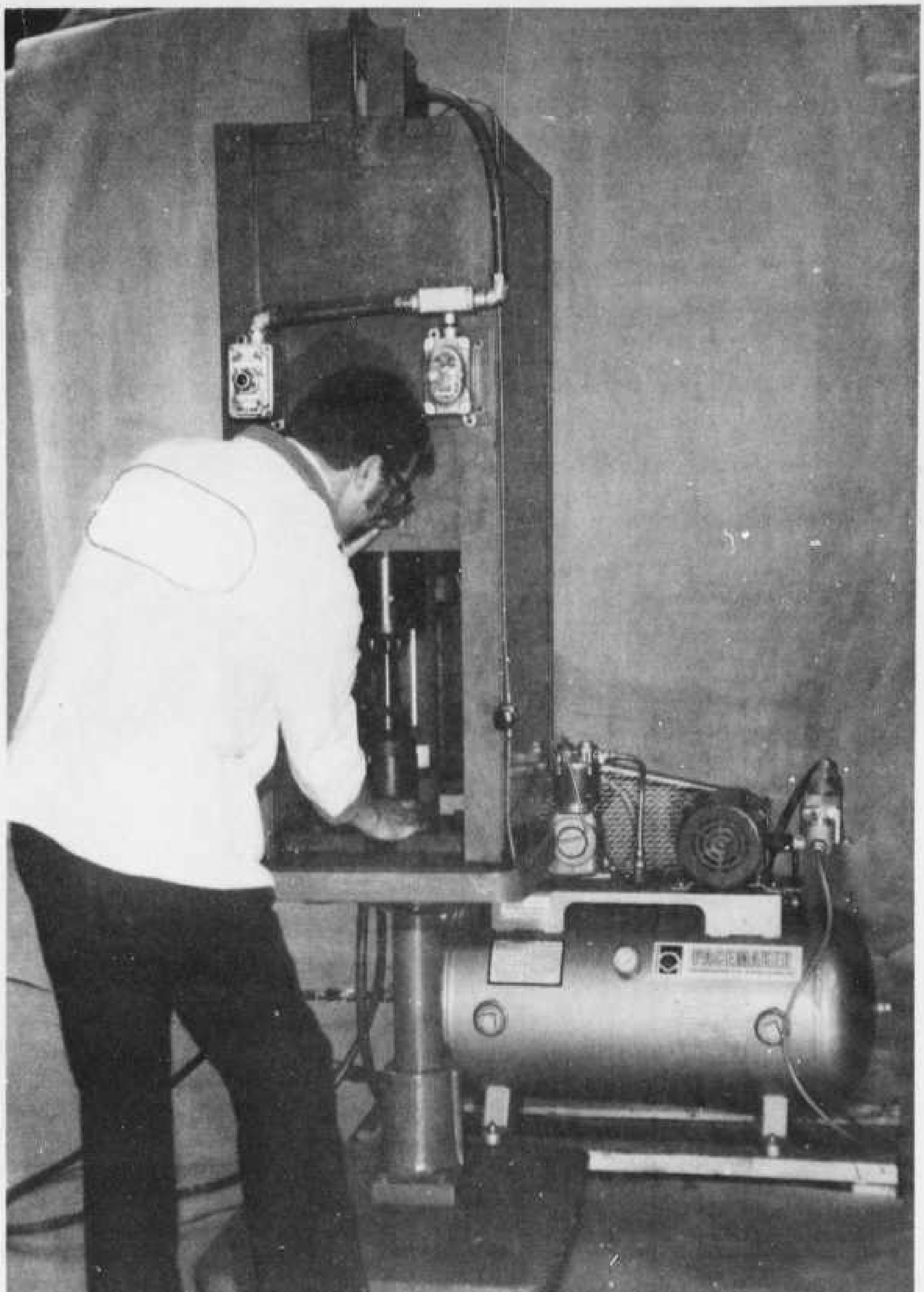


Figure 6. Crimper with Guard

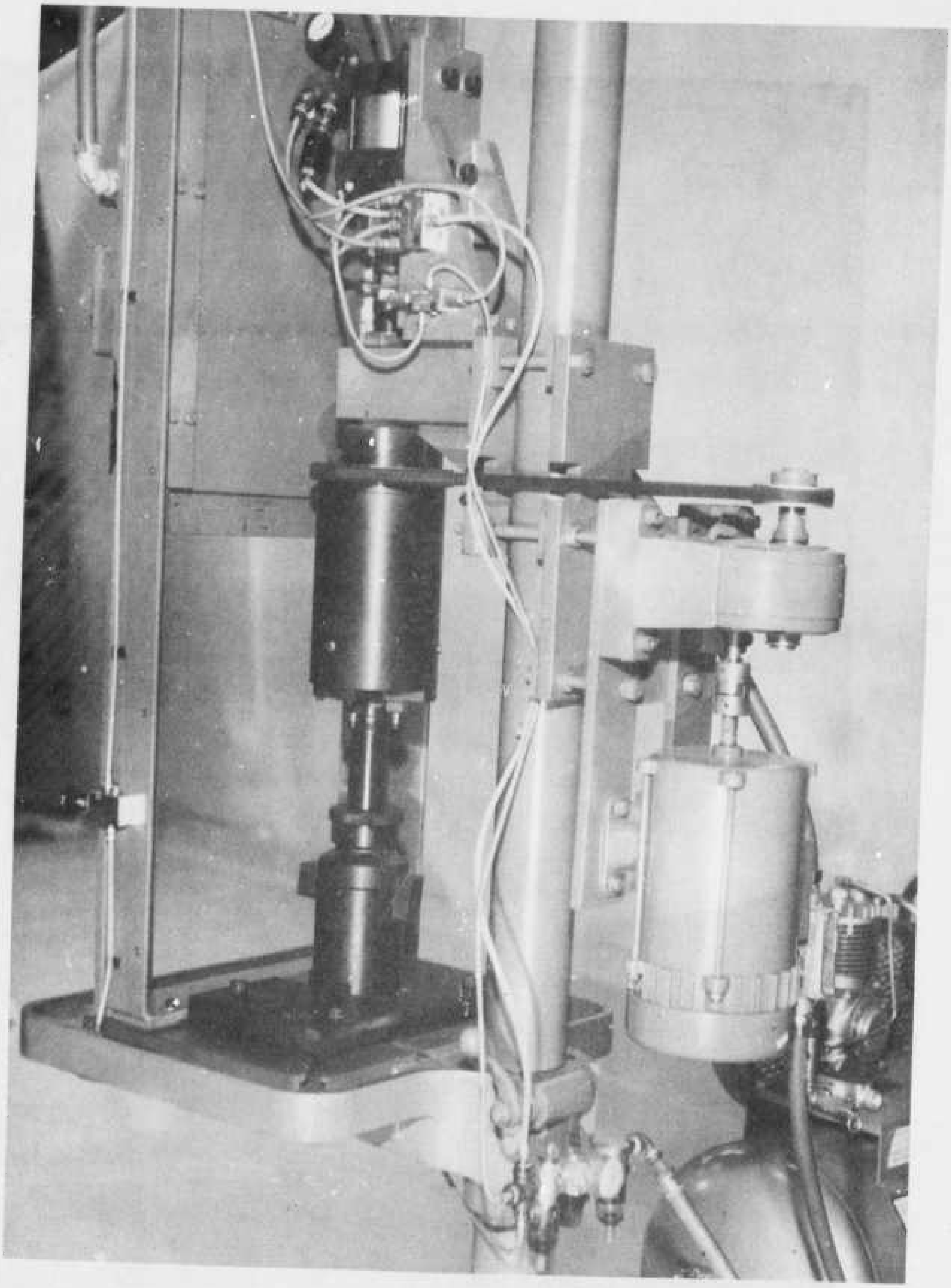


Figure 7. Crimper less Guard

tapered cam forces the upper end of the rotating pivot arms to move outward, which in turn, moves the lower rollers in toward the crimp groove in the projectile under the case neck. Either all three lower rollers can be working rollers, or only one can be working, while the other two rollers are flat, merely riding on the case mouth as shown in the alternate design. With flat rollers, the pivot arms are longer, so that the upper end can ride on the cylindrical part of the cam, while the working pivot arm's upper roller is resting against the tapered part of the cam. On completion of a cycle, sensed by the relief valve reaching the maximum pressure set and dumping the trapped air to atmosphere, the piston returns to the upper position, and the pivot arms move out at the lower crimping end under the action of springs at (20). The crimp rollers (21) have belleville washers above and below the rollers to allow the roller to seek the projectile crimp groove, thus allowing for tolerances in location of groove with respect to the upper conical projectile nose locator part (32).

The lower end of the cartridge is held tightly by a tapered rubber bushing (49) which is forced against the cartridge case by tightening the knurled bushing (50). The entire cartridge is pressed tightly upward against the projectile nose locator by means of the tapered wedge, allowing for variation in cartridge overall length.

The pivot arms are held in a spider-like assembly shown partially in View A-A. By loosening six screws (29), this assembly can be lowered for insertion of shims, if required, due to variation from normal of the groove to upper datum dimension of the projectile. Also, the entire assembly can be removed for shift of pivot arms and rollers from one to three working rollers, as desired.

Electricity is turned on by the main switch to the upper right of the operator's head in Figure 6. This turns a red light on, to the upper left of the operator's head, which stays on except when the crimp motor is operating. To begin a crimp cycle, the shield door is closed, which closes an interrupt switch in a pneumatic control line, and the operator presses the button on the column to his right. Motion downward of the piston in the air cylinder closes a switch which starts the crimp motor. On return to the upper position, the crimp motor is turned off.

Also shown in Figure 6 is the shielding or guards. The side shields are of plywood and sheet steel to contain fragments if a case should rupture due to propellant ignition during crimping. The solid steel sliding door in front of the operator is counterbalanced by a weight in the main crimper column, attached to the door via a cable and two pulleys. Once the main switch is activated, the air compressor runs continuously. The operating pressure is normally set for about 75 to 80 psi, and the controls cam the valves into position to allow the compressor to continue running at idle when the desired pressure level has been reached.

SECTION IV

OPERATION

The main switch on the right front of the crimper is placed in the On position. This starts the air compressor. Operating pressure of about 75 psi should be obtained before attempting crimp operations. If for any reason the operating pressure level needs to be increased or decreased, the pressure control adjustment, above the tank in front of the compressor, can be adjusted by loosening the lock nut and turning the adjustment screw with a screwdriver. The air pressure gauge is observed as pressure is regulated within a range of about 5 psi, and readjusted as required to obtain the desired setting. Pressure levels between 70 and 80 psi are recommended, since the regulator on the crimper will normally be set at about 60 psi. As noted in Figure 7, the air line to the crimper may be shut off by the valve at the tank, next to the quick disconnect. As the air hose reaches the crimper at the lower rear of the crimper, in a short distance the air goes through a filter, a regulator with gauge reading downstream pressure, and an oil filter. The knob on the regulator is turned for an initial setting of 60 psi. This setting may be changed up or down later if desired, for fine tuning of the crimper revolutions per cycle.

The crimper normally is equipped for operation with one working roller, the other two lower flat rollers merely riding on the case mouth as back-up support. If it should be desired to change to three working rollers, proceed as follows:

(a) Remove six screws from the lower face of the crimp head, and lower the level support assembly, tapping with a drift pin as necessary to avoid cocking.

(b) The upper rollers are available in 1-1/8 and 1-1/4 inch diameter sizes, and there are short and long lever arms. The following chart may be used as a guide when changing the number of working rollers:

No. of Working Rollers	Short Levers	Long Levers	Dia. of Upper Rollers
1	1	2	1-1/8 inches on Short Lever 1-1/4 inches on Long Lever
3	3	0	1-1/8 inches

As received, the machine is adjusted to crimp projectiles whose distances from center of groove to the 0.665 nose datum deviates from the normal 4.096 dimension by running undersize an average of 0.023 inch. If either by measuring the projectiles for this dimension, or attempting to crimp and finding the crimped groove misaligned by observed lack of symmetry, the pivot arm assembly can be raised or lowered by placing a shim about 1/4 x 1 inch between each of the three sets of screws in pairs supporting the pivot arm assembly. The thicker the shim, the lower the crimp rollers will be placed, thus increasing the distance from the conical projectile nose locator. When changing crimp rollers at the lower end of the pivot arm, reassemble with a belleville washer on either side, with the large diameter next to the roller. The pivot pins are a light press fit, and may be removed or reassembled in a press, or with a suitable drift pin, for interchanging long or short lever arms.

Before crimping cartridges, test cycling should be carried out to observe the number of crimp head revolutions per cycle. The interrupt switch button under the door is closed and the operating knob pressed and immediately released. Revolutions to the nearest tenth are observed by means of a chalk mark on the head. For three working rollers this should be 1 to 1.5 revolutions and for 1 working roller, this should be 2.5 to 3 revolutions.

Also observe on the gauge just above the air cylinder the maximum pressure reached (see Figure 7). This should be near 35 psi and if not, adjust the relief valve regulator by loosening the lock nut and turning the set-screw slightly. With the cut-off pressure near 35 psi, the revolutions per cycle are adjusted mainly by the orifice bleed adjustment which is the cylindrical collar just under the air pressure gauge (see Figure 7), with graduated notches around the circumference numbered from 1 to 10. If this valve is moved toward the arrow Close, the air will build up pressure in the cylinder more slowly, and the crimp head will have a greater number of revolutions per cycle. Consider the orifice as a course setting, and the regulated air pressure (above or below 60 psi) to be the means of fine tuning. (See Figure 8 for a plot of regulated pressure versus crimp revolutions per cycle.)

With crimp revolutions per cycle in the desired range, a cartridge case with frangible projectile pressed into the case mouth, may be crimped. Remove the base from the machine, insert the cartridge base down and tighten securely by hand, by means of the knurled collar, so that the case does not slip in the holder. Insert the projectile nose up into the crimper, tang of holder to the rear. Slide the lower half of the base into position, flat side against the tang. Introduce the wedge into the wedge slot from the wide opening side. Turn the assembly about 90 degrees, and tap the wedge sufficiently to hold the projectile nose tightly against its support. (If the case should turn, the wedge is not in tight enough.)

Close the door, press the operating button and release immediately. The red light will go out. When the light comes on again, the cycle is completed.

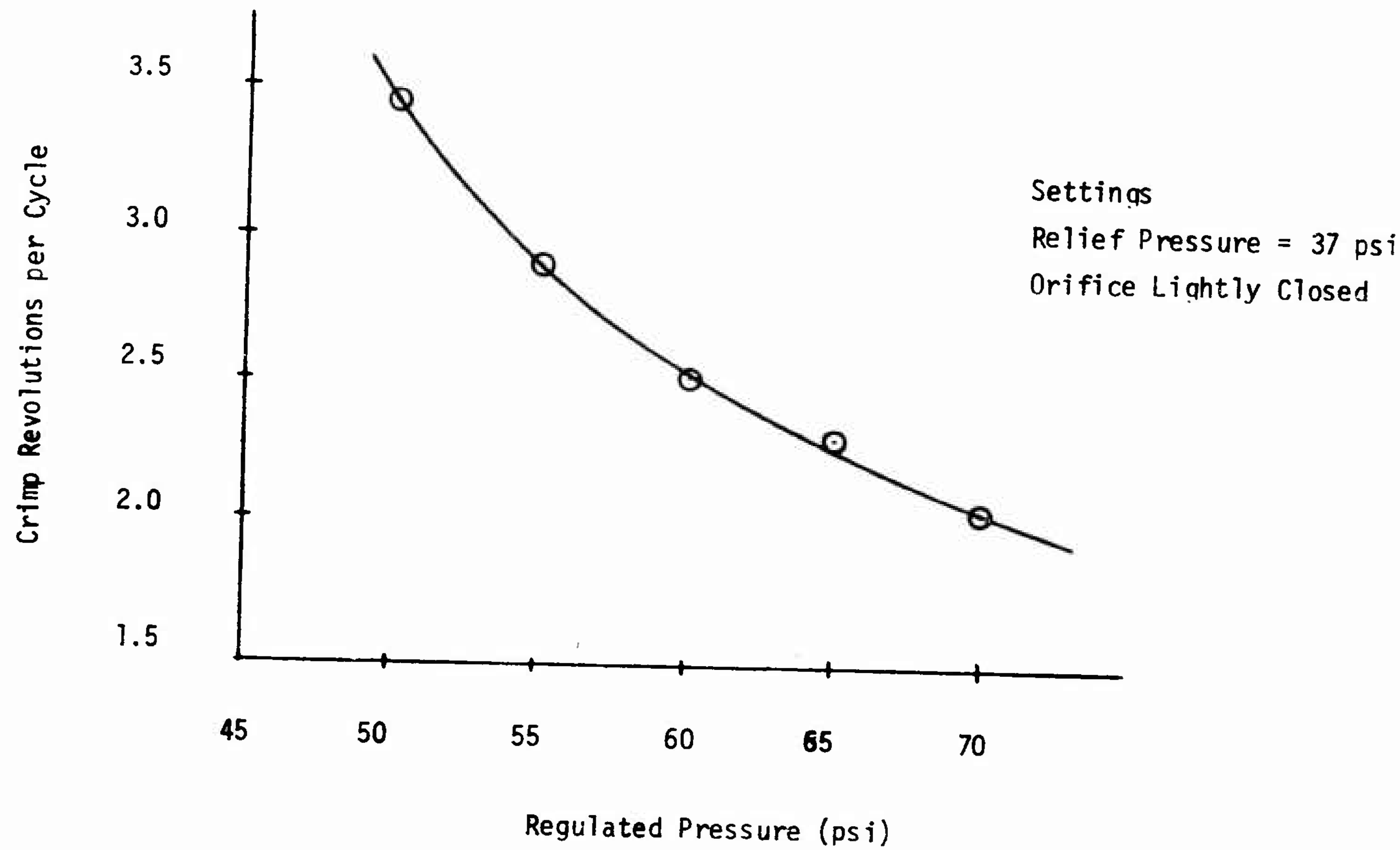


Figure 8. Control by Regulated Pressure

Open the door, tap out the wedge, and remove the cartridge with base. Loosen the knurled collar, and remove the cartridge.

At this point, check for symmetry of the crimped groove. A symmetrical groove enlarged 20:1 is shown in Figure 9. Note that the two sharp corners are at the same distance down from the case wall, and the deflected zones on either side are symmetrical. Ideally, the groove should be symmetrical to slightly low. If roller is slightly low, the lower sharp corner will be higher. With the crimp roller slightly low, bullet push will be higher, due to the case metal being worked into a steeper angle with the lower edge of the projectile crimp groove. If too low, the case may split in this area when the projectile is pushed out. If the roller is slightly high, projectile push force will begin to drop off.

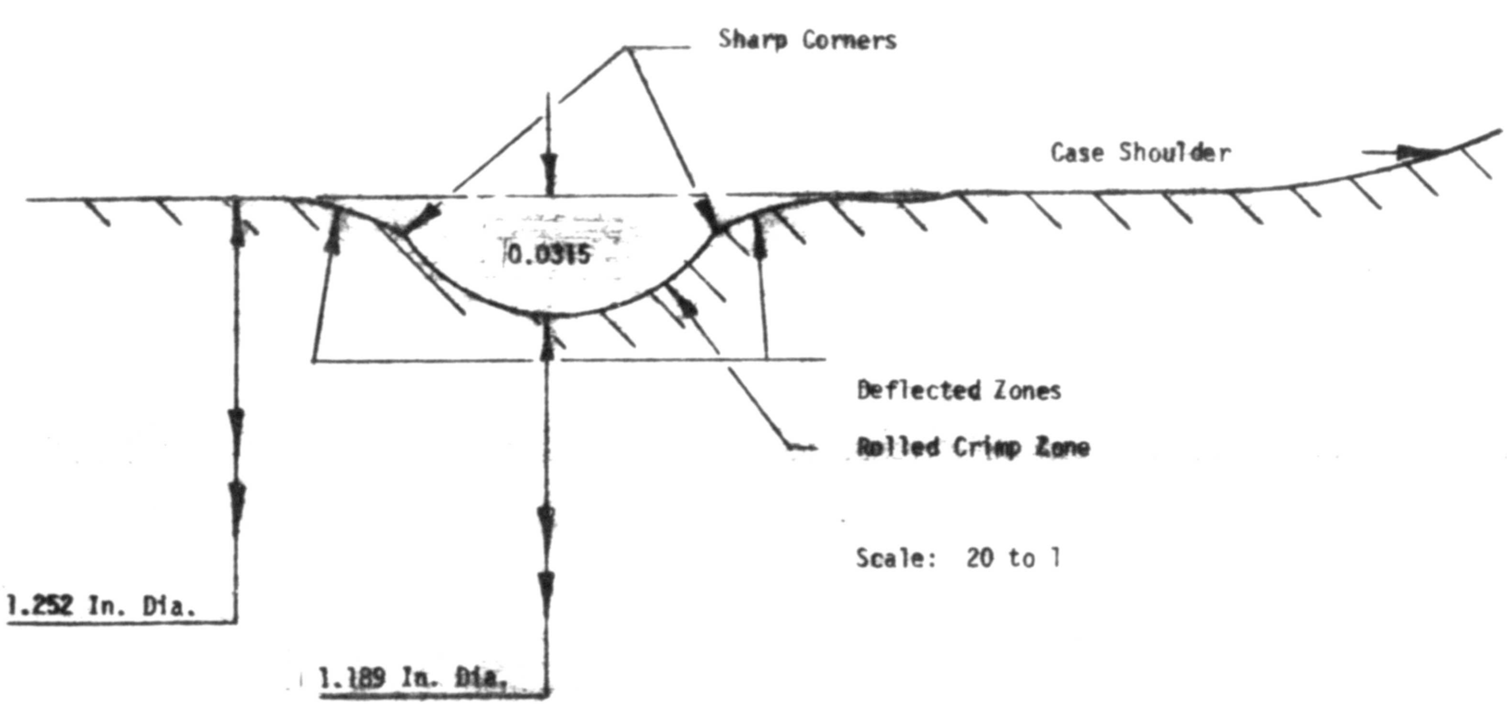


Figure 9. Typical Symmetrical Crimp Profile

SECTION V

TEST RESULTS

1. GENERAL

Test results are presented in two categories, developmental tests and acceptance tests. The developmental tests had as objectives the understanding of crimper operation as various parameters affected bullet push force, standard deviation of such force, and case integrity as observed in bullet push tests. The acceptance tests constituted the demonstration of crimped cases subjected to two types of tests -- bullet push tests and Mann barrel firing tests. The acceptance tests applied to the two crimpers fabricated under the contract.

2. DEVELOPMENTAL TESTS

Preliminary crimp testing conducted 19 November 1976 without pressure cut-off controls, but simply with shop air regulated to 60 psi, led to significant conclusions. One was that the high speed of the crimper head (about 875 rpm) needed to be drastically reduced, and it was decided to introduce the 24:1 mechanical gear speed reducer, to be attached directly to the electric motor. The slower speed was considered necessary to exercise reasonable control over quality and integrity of the roll crimp. The other conclusion was that a combination of hydraulics and pneumatics offered unnecessary complication, and that pneumatics alone would do a better job.

With relatively long dwell, it was noted that case metal surface finish flaked excessively, and the case neck wall thinned out on the order of 20 percent of its thickness before crimping. Bullet push techniques were worked out with these cases, using a 1/2 inch push rod about 9 inches long, and an oversize mouth tapering die. Bullet push forces ranged from 1270 to 1860 pounds. It was decided to fabricate a thrust collar for such tests whose dimensions approximated the gun chamber in the vicinity of the neck and shoulder area of the case. The tighter fit over the crimped area was expected to substantially increase bullet push force.

With speed reduced to 36 rpm, and a relief valve set to release air in the cylinder on reaching about 37 psi, Table 1 shows results of crimper tests conducted 2 December 1976 at the vendor's plant. Bullet push ranged from 1920 to 2810 pounds, while variables included four shim thicknesses, two orifice settings (for control of rate of pressure buildup in the cylinder), and two roller set-ups -- either one working roller or three working rollers. Table 2 covered first tests at the contractor test facility, on 7 December 1976. All tests were with three working rollers, and shim thickness varied from 0 to 0.015 inch. This was the first test using the separate air compressor instead of shop air. Table 3 covers tests 8 December with one working roller and all with 0.015 inch shims. Table 4 on 9 December test is included here as that test served both as development and acceptance testing. Tables 5 and 6 on 13 December and 21 December tests respectively complete development testing conducted on Crimper No. 1 which was shipped to Eglin AFB 6 January 1977.

Shown in Table 7 is a summary of crimper tests conducted on Crimper No. 1. Conclusions of developmental testing are as follows:

TABLE 1. CRIMPER TEST 2 DECEMBER 1976

Test No.	Proj No.	4.096 Datum Tolerance (in)	Shim Thickness (in)	Orifice Setting *	Crimp Turns	Working Rollers **	Crimped Groove Min. Dia. (in)	Tolerance Groove Dia. (in)	Crimp Symmetry ***	Bullet Push (lbs)
1	5	0.019	0.021	5	2.5	1	1.184	0.005	Poor, RL	2810
2	22	0.019	0.014	5	2.5	1	1.183	0.003	Fair, RL	2485
3	30	0.019	0.008	5	3	1	1.181	0.002	Good, RSL	2580
4	7	0.019	0	5	4	1	1.181	0.004	Good, RSH	2285
5	19	0.026	0	5	2.5	1	1.180	0.004	Good, RSH	2540
6	16	0.031	0	5	2.5	1	1.181	0.002	Good	2310
7	3	0.025	0	5	4	1	1.179	0.003	Good, RSH	2005
8	28	0.023	0	5	2.5	1	1.182	0.003	Good	2195
9	29	0.021	0	9	1.5	1	1.187	0.005	Good	1920
10	15	0.022	0	9	2	3	1.182	0.002	Good	2400
11	18	0.027	0	9	2	3	1.184	0.002	Good, RSH	2425
12	21	0.026	0	9	2	3	1.182	0.002	Good	2350
13	24	0.024	0	9	2	3	1.182	0.002	Good	2190

* Orifice setting - 5 slow, 9 fast.
** Initial tests (1-9) with one working roller, two flat rollers; last four (10-13) with three working rollers.
*** RL - Roller Low; RSL - Roller Slightly Low; RSH - Roller Slightly High; with roller low conditions, belleville washer movement noted on actuation without rotation after crimping.

TABLE 2. CRIMPER TEST 7 DECEMBER 1976

(All with 3 working rollers)

Test No.	Proj. No.	4.096 Datum Tolerance (in)	Shim Thickness (in)	Orifice Setting	Crimp Turns	Crimp Symmetry	Bullet Push (lbs)	Comments
1	46	0.023	0.015	5	2.5	RL	2885	
2	45	0.024	0.015	5	2.5	RL	2370	Double Crimp (Operator Error), Split, Case Turned
3	43	0.028	0.015	5	2.7	RL	2525	Split (180^{o}, Rear of Groove)
4	44	0.021	0.015	5	2.7	RL	2475	Split
5	49	0.014	0	5	2.7	RC	1925	
6	47	0.024	0	5	2.5	RC	2215	
7	50	0.024	0	5	2.5	RC	2170	
8	50 (Reused)	0.024	0	5	2.5	RC	2045	Reuse of Projectile-Drops Pull 125 lbs.
9	48	0.020	0	9	0.3	NA	-	1/8 inch Incomplete Crimp
				7	0.3	NA	-	1/8 inch Incomplete Crimp
				5	2.5	RC	2220	See Note Below

NOTE: Incomplete crimp on Test No. 9, compared to 2 December results with complete crimps; 9 (fast) orifice.

1. Separate compressor now used instead of shop air, pulsations and varying air pressure.
2. Pressure regulator used in circuit before smoothing and reducing air pressure.
3. Only set up with 3 rollers working; before had both 1 and 3 working. Pressure came so rapidly that crimpers released before 1/3 of turn made.

Variables for future investigation:

1. Try .007 shim with regulated pressure; lower pressure, one roller working.
2. Depending on results, try .015 shim again, seeking 2800 pound bullet push, without split. Consider one roller working with set up Test No. 1 - 4 above, no other change.

TABLE 3. CRIMPER TEST 8 DECEMBER 1976

(All with one working roller)

Test No.	Proj. No.	4.096 Datum Tolerance (in)	Shim Thickness (in)	Orifice Setting	Crimp Turns	Crimp Symmetry	Bullet Push (lbs)	Comment
1	42	0.023	0.015	5 (slow)	2.8	RSL	2820	
2	40	0.022	0.015	5 (slow)	2.7	RSL	2770	
3	39	0.025	0.015	5 (slow)	2.6	RSL	2770	
4	38	0.029	0.015	5 (slow)	2.4	RSL	3040	
5	8	0.024	0.015	5 (slow)	2.8	RSL	2580	
5A	8	0.024	0.015	5 (slow)	2.4	RSL	2860	Projectile Crimped to a Second Case
6	31	0.023	0.015	5 (slow)	2.3	RSL	2500	

RSL - Roller Slightly Low on All Crimps

TABLE 4. CRIMPER TEST 9 DECEMBER 1976

Orifice Setting - 5 (Slow); Working Rollers - 1

Test No.	Proj. No.	4.096 Datum Tolerance (in)	Shim Thickness (in)	Crimp Turns	Air Pressure (psi)	Crimp Symmetry *	Bullet Push (lbs)	Comments
1	35	0.020	0.015	2.7	60	RSL	2455	Plastigage w/lube in groove; under 0.002.
2	41	0.023	0.015	2.3	60	RSL	2450	Mouth split at rear of crimp groove.
3	32	0.027	0.007	3.3	55**	RSH	2560	Mouth split at rear of crimp groove.
4	36	0.023	0.007	2.9	60	RC	2210	For test Nos. 4-13: $\bar{p}$ = 2060 lbs; σ = 127 lbs
5	34	0.026	0.007	2.8	60	RC	2220	
6	37	0.025	0.007	2.7	60	RSL	2020	
7	33	0.025	0.007	2.6	60	RSL	2030	
8	12B	0.023	0.007	2.5	60	RC	2070	
9	10B	0.030	0.007	2.8	60	RC	2190	
10	11B	0.022	0.007	2.5	60	RC	2015	
11	8B	0.015	0.007	2.4	60	RSH	1830	
12	9B	0.020	0.007	2.5	60	RC	1920	
13	7B	0.023	0.007	2.5	60	RSH	2090	
14	6B	0.019	0.007	2.9	60	RC	2565	Piper case, thicker mouth.
15	5B	0.027	0.007	2.8	60	RSH	2620	Piper case, thicker mouth.
16	3B	0.018	0.007	3.3	60	RC	1950	Plastigage w/lube in groove; under 0.002.
17	4B	0.027	0.007	2.9	60	RC	1825	Plastigage w/lube in groove; under 0.002.

* RSL - Roller slightly low; RSH - roller slightly high; RC- roller centered.

** After Test No. 3, pressure regulated.

TABLE 5. CRIMPER TEST 13 DECEMBER 1976

One Working Roller - 0.007 in. Shim Thickness									
Test No.	Proj. No.	4.096 Datum Tolerance (in)	Crimp Turns	Air Pressure (psi)	Crimp Symmetry	Case Color	Bullet Push (lbs)	Orifice Setting	Comments
1	26B	0.023	2.8	65	RSL	Yellow	3030	5+	5+, Throttle lightly closed.
2	27B	0.021	2.8	65	RSL	Yellow	2960	5+	
3	28B	0.025	2.7	65	RSL	Yellow	3015	5+	Case Mouth Split
4	29B	0.023	3.5	59	RSL	Yellow	3015	5+	
5	30B	0.029	2.1	59	RSL	Yellow	2670	5.1	Case Mouth Split; Throttle slightly open.
6	31B	0.025	2.8	59	RSL	Green	2495	5-	5-, Throttle tightly closed.
7	32B	0.027	2.5	65	RSL	Green	2390	5-	
8	33B	0.021	2.9	59	RSL	Green	2440	5-	
9	34B	0.024	2.8	59	RSL	Green	2400	5-	
10	35B	0.021	2.8	59	RSL	Green	2745	5-	

RSL: Roller Slightly Low

NOTES:
1. Yellow cases; mouth slightly thicker and harder than green cases.
2. For Series 1-4, one split, Mean Push: 3019 lb Std Dev: 46 lb
3. For Series 6-10, no splits, Mean Push: 2496 lb Std Dev: 146 lb
4. Adverse factors in No. 5 case mouth split: Case mouth slightly harder and thicker, -0.029 datum tolerance high, 5.1 orifice setting speeded crimp rate up for 2.1 turns to crimp.

TABLE 6. CRIMPER TEST 21 DECEMBER 1976

Three Working Rollers - 0.007 Inch Shim Thickness						
Test No.	Proj. No.	4.096 Datum Tolerance Inch	Crimp Turns	Crimp * Symmetry	Bullet Push (lbs)	Comment
1	36	0.023	1.4	RSL	2405	With 4 new projectiles:
2	37	0.025	1.4	RSL	2355	Mean Push: 2266 lbs.
3	38	0.029	1.4	RSL	2165	Std. Dev.: 133 lbs.
4	39	0.025	1.4	RSL	2140	
PROJECTILES REUSED - SECOND CRIMP TEST						
1	47	0.024	1.4	RC	1920	With 10 reused projectiles:
2	1	0.027	1.4	RC	2085	Mean Push: 2090 lbs.
3	26	0.023	1.4	RC	2235	Std. Dev.: 133 lbs.
4	24	0.024	1.4	RSL	1840	
5	49	0.014	1.4	RSL	2015	
6	33B	0.021	1.4	RSL	1945	
7	11	0.023	1.4	RSL	2290	
8	2	0.018	1.3	RC	2180	
9	29	0.021	1.4	RC	2200	
10	45	0.024	1.4	RSL	2185	

NOTE: On 23 December, just prior to crating, rollers changed back to One Working Roller, 60 psi regulated pressure, 2.8 revolutions per crimp (by adjusting orifice); Bullet Pulls: 2235, 2460, 2205 with reused projectiles, for mean bullet pull of 2300 lbs. (196 lb. lower than similar test 13 Dec. w/new proj)

Pressure Levels: Regulated, 56 psi
Cut-off, 36 psi

* Crimp Symmetry: RC: Roller Centered
RSL: Roller Slightly Low

TABLE 7. SUMMARY CRIMPER TESTS. CRIMPER NO. 1

Test Date	Working Rollers	Orifice Setting	Shim Thickness (Inch)	Bullet Push (lbs) Mean	Bullet Push (lbs) Std. Dev.	Sample Size	Comment
2 Dec.	1	5 (slow)	0	2307	139	5	Roller slightly high
2 Dec.	3	9 (fast)	0	2341	106	4	Roller slightly high
8 Dec.	1	5 (slow)	0.015	2747	174	6	Roller slightly low
9 Dec.	1	5 (slow)	0.007	2060	127	10	Roller Centered
13 Dec.	1	5+	0.007	3019	46	4	Yellow cases; 1 split Roller slightly low
13 Dec.	1	5-	0.007	2496	146	5	Roller slightly low
21 Dec.	3	5+	0.007	2266	133	4	Roller slightly low
21 Dec.	3	5+	0.007	2090	152	10	Reused projectiles; Rollers centered or slightly low

(a) Either 3 or 1 working roller will produce satisfactory crimps. Considering only tests of 10 as sample size, bullet push force and standard deviations were as follows:

No. of Working Rollers	Bullet Push (lbs) Mean	Std. Dev.
1	2060	127
3	2090	152

(b) Whether the roller is centered, low, or high is a function of basic projectile groove to datum length and thickness of shims used. If the roller is centered, as pictured in Figure 9, bullet pushes of the order of 2100 pounds may be expected, with standard deviations of the range of 125 to 150 pounds.

If shimmed to give rollers slightly low, with the groove nonsymmetrical, and the flange steeper and more cold worked on the critical lower side of the crimp groove, bullet push will go up to the 2500 to 2800-pound region, with some increase in standard deviation. If groove is allowed to go toward roller low, rather than slightly low, some cases will be split on projectile separation at the rear edge of the crimp groove.

Groove to 0.665 inch datum was expected to be 4.096 $\pm$ 0.005 inch. Actual dimensions were closer to 4.073 $\pm$ 0.010 inch for the 100 frangible projectiles provided. Fortunately, the use of shims permits control of groove symmetry, and the belleville washers on either side of the rollers allow roller to shift at least 0.010 inch in either direction without adverse effects.

(c) A relief pressure of 32 to 37 psi is considered near optimum as to providing sufficient final crimp force to bottom out in the projectile groove, but without excessive force as to damage case or projectile. Excess relief pressure can cause split cases, as observed in initial tests of No. 2 crimper.

(d) Control of crimp head rotations per cycle should allow a rotation of 1 to 1.4 turns with 3 working rollers, or 2.5 to 3 with 1 working roller. This insures that each element crimped will have been pressed into the groove at least twice and not more than four times. Excess pressings can cause splits by excessive cold working. Inadequate pressings can cause nonuniformity of crimp.

Control of crimp head turns per cycle can be obtained by two methods: orifice adjustment for course control, and regulated air pressure level for fine control. The revolutions per cycle will decrease slightly when crimping a case as compared to cycling without a case being present, since the final volume in the cylinder is greater in the latter case if the fixed stop is not used.

(e) The compressor tank pressure should be about 10 to 25 psi above the regulated pressure. For example, with initial regulated pressure of 60 psi, compressor operating range might be 70 to 85 psi. The regulated pressure might drop to 50 psi or go to 65 psi without bothering to adjust the compressor pressure.

(f) Piper cases were the only cases other than contractor cases tested. With mouth wall slightly thicker, slightly higher bullet push forces were obtained (see Table 4).

(g) Reuse of plastic projectiles a second time in new cases can be expected to drop bullet push forces about 175 pounds (see Table 6).

(h) When crimping with 3 rollers working, it is necessary to use greater force in clamping the case to the holder, and in wedging the cartridge up into the crimp head to prevent the case turning during crimping. With excess turning, the crimp can be irregular or incomplete.

(i) Table height for the crimper is set to be least fatiguing to the operator if seated, rather than standing.

(j) The various motions of inserting, clamping and removing of cartridges may vary from operator to operator, depending on such factors as left or right handedness. After making a dozen or so crimps, the operator will settle into a pattern which is least fatiguing to him, and will accomplish the job with least lost motion.

Shown in Table 8 is a summary of crimper tests conducted on Crimper No. 2. The last series, on 12 January 1977, also serve as acceptance tests. Conclusions of developmental testing with this crimper, supplementing the conclusions with the first crimper, are as follows:

(a) Final tests employed the positive stop to control case cracks at the groove area in bullet push, and to reduce bullet push to desired levels. Using one working roller, results were as follows:

Position Stop Nut Down (Turns)	Crimped Dia. (In)	Bullet Push (Lbs) Mean	Std. Dev.	Cases Cracked
2	1.181	2978	238	6
3	1.186	2278	167	0

TABLE 8. SUMMARY CRIMPER TESTS. CRIMPER NO. 2

Date	Pos. Stop Nut Down (Turns)	Working Rollers	Proj. Type	Number Crimped	Relief Pressure (psi)	Crimp Turns	Crimped Dia. (inches)	Bullet Push (lbs)	Std. Dev. Push (lbs)	Cases Cracked
29 Dec. 76	0	3	New	4	36	1.5	1.175	2494	133	3
29 Dec. 76	0	1	New	5	36	2.5	1.174	2951	445	4
5 Jan. 77	0	1	New	3	32	3.2	1.176	2445	-	0
5 Jan. 77	0	1	Old	2	32	3.2	1.176	2612	-	0
11 Jan. 77	2	1	Old	2	37	3.2	1.181	2190	-	0
11 Jan. 77	2	1	New	8	40	2.6	1.181	2978	238	6
12 Jan. 77	3	1	New	8	36	2.6	1.186	2278	167	0

Note 1: On 4 Jan. crimper piston and cylinder lubricated to eliminate chatter; resulted in greater crimp load transmitted due to reduced friction.

Note 2: Mouth wall thickness varied from 0.030 to 0.034 inch.

Conclusion: Proper use of positive stop to control crimped diameter eliminated cracks, lowered bullet push force, and improved bullet push standard deviation.

(b) Addition of lubrication to the air cylinder above the gland packing area and on the shaft below it smoothed out jerking motions, but increased the transmitted crimp load, as judged by cases cracked in the crimped area after pushing.

(c) Finer control by the adjustable orifice bleed control sleeve for crimper revolutions per cycle was observed with Crimper No. 2 than had been experienced with Crimper No. 1.

(d) Variation in case mouth wall thickness can increase the spread in bullet push force and the incidence of cracked cases. However, by use of the positive stop, final crimped diameter can be closely controlled and cracks eliminated. With the positive stop operating, the working roller compresses plastic material under the crimped zone and on passage of the roller, the cold worked metal and compressed plastic spring back to the finally measured crimped diameter. The compressibility of the plastic has the effect of ironing out peaks and valleys in crimping force due to variations in case wall thickness.

Shown in Table 9 are the results of limited tests with crimping thin wall steel cases under development in Air Force Contract F08635-77-C-0092. Case mouths are about 0.014 inch thinner than with aluminum cases. To minimize upper roller changes, tests were run only with three rollers working. For the first test on 14 January 1977, upper rollers of 1.198 inches diameter were made up. These proved to be too small, resulting in shallow crimp depths, and low bullet pull. Crimped diameter was 1.157 inches and mean bullet push was 1217 pounds. With the fabrication of two additional 1-1/4 inch rollers, used in conjunction with the one

TABLE 9. SUMMARY - CRIMPER TESTS WITH THIN WALL STEEL CASES

(Cases as developed under AF Contract F08624-77-C-0092)

Date	Pos. Stop Nut Down (Turns)	Working Rollers	Upper Roller Dia. (Inches)	Proj. Type	No. Crimped	Relief Pressure (psi)	Crimp Turns	Crimped Dia. (inches)	Bullet Push (lbs)	Std. Dev. Push (lbs)	Case Cracks
14 Jan. 77	0	3	1.198	Old	4	40	1.8	1.157	1216	17	0
17 Jan. 77		3	1.248	Old	5	43	2.3	1.146	1167	63	0

Note: Maximum crimped diameter for no clearance under groove = 1.144 inches existing 1-1/4 inch roller, full crimp depth was obtained with the positive stop nut turned down two turns. This yielded a crimped diameter of 1.146 inches, but a mean push force of only 1167 pounds. The crimped steel cases showed unusually low standard deviations in push force. For the first test this was 17 pounds, and for the second test it was 63 pounds.

Due to the thin wall dimensions of the thin wall steel case, bullet push force is lower than usual with conventional projectiles. As expected, the push force is similarly lower with plastic frangible projectiles, as compared to results with aluminum cases.

3. ACCEPTANCE TESTS

Shown in Figure 10 are the results of Mann barrel firing tests of 13 cartridges crimped in Crimper Number 1 on 9 December 1976. Ten were fired at a chamber pressure of about 46,000 psi, and three at about 55,000 psi. Muzzle velocities were about 3340 ft/sec at the lower pressure, and 3420 ft/sec at the higher. Microflash pictures at the muzzle and witness screens indicated that there was no projectile damage attributable to the crimping operation, and the amount of yaw, though large, was characteristic of the projectile when fired uncrimped. One of the shots showed equivocal evidence of nose discard in the photograph, but this phenomena was judged a projectile fabrication fault unrelated to crimper performance by the project engineer.

The acceptance crimping tests for bullet push were as shown in Table 4, which combines acceptance and development testing. Mean bullet push for 10 cartridges was 2060 pounds with standard deviation of 125 pounds.

As a result of the acceptance tests, Crimper No. 1 was accepted, and Design Review No. 2 held at the contractor's 10 December 1976, recorded this, with the

Powder HC25 and HC26	Bullet As shown	
Charge As shown	Time Fired:	Test 30mm Frangible Crimper
Primer Lot M36A2	Date 9 Dec 76	Microflash of projectile
4-19	Start 1155 Finish 1600	20 ft beyond muzzle

Shot No	Proj No	Crimping Data Time (Sec)	Crimping Data Revol.	Type Proj	Weights (grains)	Muz Vel (fps)	Weights (grains)	Prop	Pressures (psi)
1	-	-	-	AOMC TP	2300	3306	5775	HC25	50,300
2	18	6	2.8	Plastic	2300	3330	5498	HC25	46,100
3	17	6	2.8	Plastic	2300	3328	5498	HC25	46,400
4	16	6	2.8	Plastic	2300	3334	5498	HC25	46,500
5	15	5.5	2.6	Plastic	2300	3330	5498	HC25	46,000
6	14	6	2.8	Plastic	2300	3355	5498	HC25	47,600
7	19	-	-	Plastic	2300	3298	5498	HC25	44,500
8	20	6	2.8	Plastic	2300	3340	5498	HC25	47,100
9	21	6	2.8	Plastic	2300	3360	5498	HC25	48,000
10	22	6	2.8	Plastic	2300	3333	5498	HC25	48,200
11	23	6	2.8	Plastic	2300	3358	5498	HC25	48,400
12	-	-	-	-	-	-	-	-	-
13	13	6	2.8	Plastic	2200	3422	5498	HC26	55,500
14	25	6	2.8	Plastic	2200	3422	5498	HC26	55,600
15	24	6	2.8	Plastic	2200	3405	5498	HC26	52,800

Remarks:	Chronographer Roy Rayle
Transducer No. 955	Gunner Jerry Dobbs
Witnessed by Lt. P. Weber and O. Donaldson,	
Eglin AFB and Bob Wutke, Milwaukee DACASD	
No case casualties; all projectiles intact	

Figure 10. Ballistic Test Data - Crimper No. 1

request that certain changes be made to the crimpers before shipping. These changes were accomplished on both crimpers.

Changes to be accomplished by the contractor on the two crimpers were identified as follows:

(a) Drill 1/2 inch clearance hole in case holder at point adjacent to primer.

(b) Provide quick disconnect explosive-proof electrical connection for easy separation of air compressor and crimper when the units are moved.

(c) Move the air pressure regulator and gage from the air compressor to a convenient location under the crimper table.

(d) Etch markings on 1-1/8 and 1-1/4 inch diameter rollers for easy identification.

(e) Remove sharp edges from the cartridge case holder for ease of handling

Shown in Figure 11 are the results of firing tests in Mann barrel of 10 cartridges crimped in Crimper No. 2 on 18 January 1977. Maximum pressures ranged from 49,900 to 58,700 psi. Muzzle velocities ranged from 3318 to 3681 ft/sec. By microflash pictures and witness screens, as set up for Crimper No. 1, it was determined that there were no case casualties. Figure 12 is a microflash picture of one of these frangible projectiles in flight.

Powder As shown	Bullet As shown	
Charge	Time Fired:	Test 30mm Frangible Crimper
Primer Lot M36A2	Date 19 Jan. 77	Microflash of projectile
4-19	Start 1415 Finish -	20 ft beyond muzzle

Shot No	Proj No	Crimping Data Time (Sec)	Crimping Data Revol.	Type Proj	Weights (grains)	Muz Vel (fps)	Weights (grains)	Prop	Pressures (psi)
1	Warmer	-	-	AOMC TP	2300	3334	5775	HC25	51,600
2	Warmer	-	-	-	2300	3323	5775	HC25	51,200
3	56B	5.3	2.5	Plastic	2200	3442	5498	HC26	56,500
4	Warmer	-	-	AOMC TP	2300	3318	5775	HC25	49,900
5	59B	5.0	3.0	Plastic	2200	3407	5498	HC26	53,400
6	57B	5.0	3.0	Plastic	2200	3361	5498	HC26	57,400
7	53B	4.5	2.7	Plastic	2200	3681	5498	HC26	56,600
8	54B	4.5	2.7	Plastic	2200	3595	5498	HC26	58,500
9	55B	4.5	2.7	Plastic	2200	-	5498	HC26	58,700
10	51B	4.5	2.7	Plastic	2200	3400	5498	HC26	53,500
11	52B	4.5	2.7	Plastic	2200	3388	5498	HC26	53,900
12	58B	4.5	2.7	Plastic	2200	3394	5498	HC26	56,600
13	60B	4.5	2.7	Plastic	2200	3401	5498	HC26	52,700

Remarks:	Chronographer Roy Rayle
Crimp diameters were measured as follows:	Gunner Jerry Dobbs
Shot No. 3 - 1.182/4; 5 - 1.182; 6 - 1.183/4	
7 - 1.184/6; 8 - 1.184/5; 9 -	
1.184/6; 10 - 1.184/5; 11 - 1.185/6; 12 -	
1.184/5; 13 - 1.186. Shot No. 9 - no	
velocity, projectile hit screen. Transducer	
serviced after shot No. 7. No case casual-	
ties; all projectiles intact in flight.	
Witnessed by: Rayle, Dobbs, Regner	

Figure 11. Ballistic Test Data - Crimper No. 2

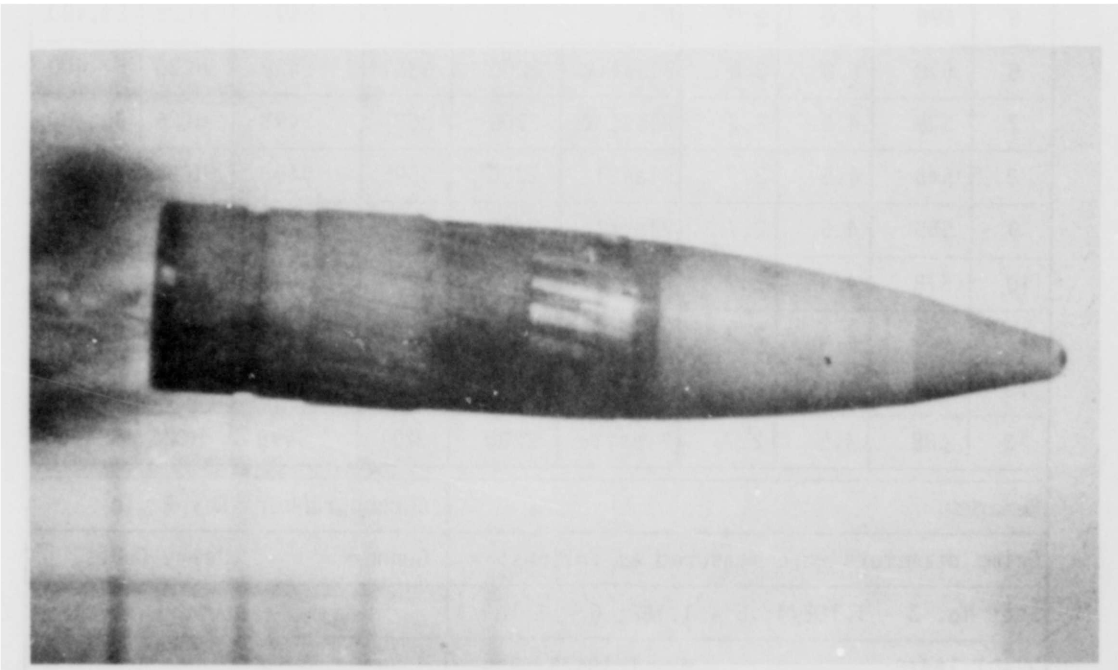


Figure 12. Microflash Picture of Projectile in Flight

SECTION VI

CONCLUSIONS

The ammunition crimping method embodied in the modified hand operated pipe cutter has been successfully mechanized. The two prototype crimping machines fabricated for this program were not intended for production line uses, and are not suited for such work primarily because they lack automated projectile and cartridge case handling facilities. However, they do accurately demonstrate the critical parameters involved in roll crimping GAU-8 configuration 30mm ammunition, and are well suited for low rate assembly of prototype ammunition for testing in a laboratory environment.

The 30mm plastic frangible projectiles used as the crimper design and performance goal have a single semicircular crimp groove; therefore, the crimp forming rollers provided with both prototypes are designed for a single semicircular projectile crimp groove. New crimp forming rollers will have to be fabricated in order to use the machines on projectiles with other groove geometries.

The exact location of the crimp formed by the prototype machines is determined by the distance from a datum diameter at the nose of the projectile to the projectile's crimp groove(s). Use of the machines with projectiles other than the washer stack frangible may require fabrication of different projectile nose locating collars (item number 32, Figure 5).

The prototype crimping machines fabricated under this contract, and the principle of operation they utilize, provided a highly useful ammunition development tool.

SECTION VII

MAINTENANCE

1. GENERAL

Crimper maintenance is presented in two parts -- one covering the main crimper unit and the other covering the air compressor. In both areas, it is recognized that maintenance literature on components assumes generally continuous type operation whereas the intended use of the two crimpers built is for sporadic occasional use, in connection with development of frangible projectiles, rather than continuous operation. Hence, emphasis is on maintenance after a given number of hours of operation, rather than by time periods.

2. MAIN CRIMPER MAINTENANCE

Crimp Rollers (Each 200 Hours of Operation)

The principle wear points are in the rollers at either end of the three pivot arms in the crimper head. To maintain a suitable electrical ground, as required in explosive-proof devices, the rollers are now lubricated with a commercial powdered graphite, carried in a liquid solvent which evaporates, leaving the graphite in the bearing area and on the belleville washer bearing surfaces, adjacent to the lower working rollers. Removal of the crimp lever assembly, followed by removal of the upper and lower roller screws by means of an Allen wrench to apply graphite lubrication each 200 hours of operation is recommended to minimize wear on these rollers.

Oiler and Filter (Each 200 Hours of Operation)

The air filter, located behind the main column, under the shield, should be kept dry and clean. The filter can be observed through the glass bowl. If any liquid accumulates in the bowl, remove the bowl and clean it out. Unless dusty air passes the compressor filter, there should be no reason for the filter to become dirty. If it does show dirt, cleaning in a solvent, and drying off with an air hose is recommended.

The oiler is in the same area and is kept half full to full by removing the front filler screw, adding light disc oil, and observing the level through the glass bowl. The oil feed to the air cylinder is adjusted by a screw at the rear to give one drop of oil about every 10 to 20 crimp cycles. The drop of oil can be seen flowing, then dropping, from the tube visible through the upper glass cover of the oiler. The main purpose of the oiler is to lubricate the air cylinder above the crimper head.

Reduction Gear (For period, see note)

The 24:1 reduction gear set is located just above the electrical drive motor. Recommended oil is as follows:

Ambient (Room) Temperature	Recommended High Quality Mineral Oil	Viscosity (SUS at 100°F)
20° to 60°F	Mobil DTE Oil, Heavy Medium	290 to 300
50° to 125°F	Mobil DTE Oil, Extra Heavy	590 to 610

In the vertical mounting position, as on the crimper, a square head magnetic drain plug is under the gear housing, while a vented filler plug is on top. The oil level should be 1-1/4 inches measured down from the outer surface of the housing of the oil filler hole (or 1-1/2 inches depth of oil as measured by a dipstick touching the bottom). Oil capacity is 1/2 quart.

NOTE: RELUBRICATION PERIODS

After 80 hours of operation, the oil should be drained while warm, and replaced. Next interval for oil change is 250 hours, and after that 1,000 hours.

These hours are based on hours of operation of the reduction gear, not the crimper unit. For example, a typical cycle is about 3 seconds, and if 50 cases are crimped in an hour, this would come to about 2-1/2 minutes operation of the reduction gear. For a normal development program, it is unlikely that even the first 80 hours of operation will be reached.

Electric Motor

The electric motor is of the enclosed, explosive-proof type, and periodic lubrication is not required. If the motor becomes dirty, an air jet may be used to clean it.

Belt

Keep the belt tightened just enough to prevent slipping. Adjust by means of four nuts, two on each side of the bracket.

Air Compressor

The air compressor data is furnished in Appendix A. However, the explosive-proof electric motor was obtained from Dayton Electric Manufacturing Co., Chicago, IL, 60648, and the same maintenance comments apply as for the motor and belt on the crimper. Maintenance comments are provided in Appendix A, extracting pertinent portions of the manufacturer's data.

APPENDIX A

AIR COMPRESSOR MAINTENANCE

This Appendix comprises extracts from two manuals furnished by the manufacturer of the air compressor:

Owners Guide - Air Compressor

Air Compressor - Installation, Maintenance
and Instructions

Manufacturer and data:

Pacemaker
Henke Manufacturing Co., Inc.
431 West Florida St.
Milwaukee, WI 53204

Model No. NT1B-A

INSTALLATION AND OPERATING INSTRUCTIONS

Your new Air Compressor is constructed to exacting standards of materials and workmanship. Following the instructions below will provide trouble-free operation and long service life.

LOCATION AND MOUNTING

1. Portable air compressors of course can be located anywhere, however, if possible use **only in clean, cool, dry place.** Permanently installed **compressors must be located in a clean, well ventilated dry room so compressor receives adequate supply of fresh, clean, cool, and dry air.**
2. Compressors should never be located so close to a wall or other obstruction that flow of air through the fan bladed flywheel, which cools the compressor, is impeded. **Permanently mounted units should have flywheel at least 12" from wall.**
3. Place portable or stationary compressors on firm level ground or flooring. **Permanent installations seldom require bolting to floor,** however, bolt holes in tank or base feet are provided. Before bolting or lagging down, **shim compressor level. Avoid putting a stress on a tank foot by pulling it down to floor.** This will only result in abnormal vibration, and possible cracking of Air Receiver. **Suggest leave on shipping skid.**

WIRING

1. **CAUTION:** Be sure electric service matches compressor specifications.
2. Compressor is pre-wired at factory. It is necessary only to bring lines from external power source to motor control device mounted on compressor, and attach to terminals as indicated on schematic diagram located inside cover of control. **Be sure that power circuit and voltage correspond with specifications.**
3. Connections should always be made by qualified electrician.

LUBRICATION

1. **Tank or base mounted compressors are shipped with special break-in oil in crankcase.** Compressors not mounted (pump only) are shipped without oil in crankcase and should be filled with best available non additive (straight grade) SAE 20 W motor oil for break-in. **After** a break-in period of approximately **40 hours running time—to insure piston ring seating—the compressor crankcase should be drained completely and refilled** with the best available quality SAE 10-W-30 multi-grade, for service MS-DG-DM-SD.
   CAUTION: DURING BREAK-IN, CAREFUL AND REGULAR CHECK OF OIL LEVEL SHOULD BE EXERCISED. MAINTAIN OIL LEVEL AT FULL LINE.
2. Fill engine crankcase, if gasoline engine operated, in accordance with engine manufacturers recommendations found in engine manual.
3. Electric motors are equipped with sealed for life bearings and require no additional lubrication.

CARE AND MAINTENANCE

DAILY CARE

1. **Check oil level.** add quality grade motor oil as required. **See paragraph 2** under lubrication above.
2. **Drain moisture** from tank by opening tank drain cock located in bottom of tank.
3. Turn off compressor at the end of each day's operation. **Shut off** air supply by closing globe valve. Turn off power supply at wall switch.

WEEKLY CARE

1. Turn power off. **Clean dust and foreign matter** from cylinder head, motor, fan blade, air lines and tank.
2. **Remove and clean intake air filters.**
3. **Check V-Belts for tightness.** Drive belts must be kept tight enough to prevent slipping. Belt tension should be adjusted to allow approximately 3/8 inch play.

EVERY 90 DAYS OR 500 HOURS

1. **Change crankcase oil.** Use type and grade oil as specified in paragraph 2 under Lubrication above.
2. **Check entire system** for air leakage around fittings, connections, and gaskets, using soap solution and brush.
3. **Tighten nuts and capscrews as required.**
4. **Check and clean compressor valves.**
   CAUTION Valves must be replaced in original positions. Valve plate gaskets should be replaced each time valves are serviced.

ELECTRIC MOTOR OR GAS ENGINE: For service refer to separate manual or chart attached to equipment.

SAFETY VALVE: The safety valve is an automatic pop valve. Each valve is properly adjusted for the maximum pressure permitted by tank specifications and working pressure of the unit on which it is installed. If it should pop, it will be necessary to drain all the air out of the tank in order to reseat properly.

TANK DRAIN VALVE: Drain valve is located at end of tank. Open drain valve to drain condensation. The automatic tank drain equipped compressor makes this unnecessary.

PRESSURE SWITCH: The pressure switch is automatic and will start compressor at the low pressure and stop when the maximum pressure is reached. It is adjusted to start and stop compressor at the proper pressure for the unit on which it is installed.

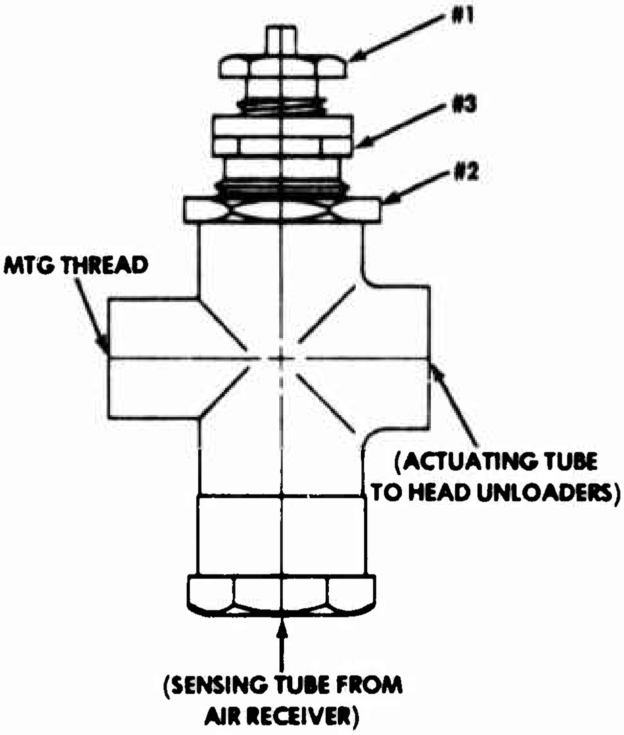
BELTS: Drive belts must be kept tight enough to prevent slipping. If belts slip or squeak, loosen the four nuts which hold the motor and slide back on base, then tighten the four nuts. **CAUTION: if belts are too tight, overload will be put on motor and motor bearings.**

COMPRESSOR VALVES: If compressor fails to pump air or seems slow in filling up tank, remove valves and clean thoroughly. After cleaning exceptional care must be taken that all parts are replaced in exactly the same position and all joints must be tight or the compressor will not function properly. When all valves are replaced and connections tight, close shut off valve to air line at tank for final test.

CHECK VALVE: The check valve closes when the compressor stops operating, preventing air from flowing out of the tank through the pressure release. After the compressor stops operating, if air continues to escape through the release it is an indication that the check valve is leaking. If check valve is worn badly, replace same. **CAUTION: before opening check valve be sure all air is drained out of tank.**

LUBRICATION OF COMPRESSOR: Fill crankcase level with oil fill plug. Keep crankcase filled as required by usage.

OPERATION AND ADJUSTMENT OF PILOT VALVES



The Pilot Valve is designed to act as an automatic "on" and "off" air switch. When in the "on" position it allows air to flow from the tank thru the valve to some device such as a compressor head unloader mechanism, thus actuating it. In the "off" position this valve stops the flow of air thru the valve and releases the pressure in the line to the device.

The pilot Valve works as follows: Tank air pressure acts on the bottom of the valve. When pressure is great enough to overcome spring force holding valve down on lower seat, it lifts off seat and allows air to flow around valve and out through side opening in Pilot Valve. When valve lifts off lower seat it moves up and seats on upper seat where it is held by tank air pressure. When pressure in tank and on valve drops, spring forces valve back down on lower seat. Air in line to device being actuated can then escape through upper seat and out vent hole. The pressure at which the Pilot Valve is "on" or "off" is controlled by the spring which has been installed at the factory. A small adjustment can be made in the field by changing the spring force by compressing the spring more or less with the adjusting screw provided on the Pilot Valve.

PILOT VALVES

ASSEMBLY PART NO.	PRESSURE RANGE
Z-180C	35 - 40
Z-180B	80 - 100
Z-180A	120 - 140
Z-180	140 - 170

ADJUSTING PRESSURE

The unload pressure is adjusted by turning the pressure adjusting nut #1 clockwise to increase, and counter-clockwise to decrease, pressure.

Changing the differential (difference there is between load and unload pressure) is accomplished by holding the lock nut closest to the body of the valve #2 so it does not move, then turning the large nut #3 next to it very slightly clockwise to increase the differential, and counter-clockwise to decrease it.

STARTING AND OPERATING INSTRUCTIONS

BELTS

Check belt tension and pulley alignment using a straight edge. The motor may have shifted in transit or have been loosened by vibration or rough handling. Abnormal belt wear indicates poor alignment. Belts should be kept tight enough to prevent slipping on the motor pulley – (heating of motor pulley indicates slippage).

Slots in the platform or motor rails make it easy to slide the motor back and forth to adjust belt tension.

OILING COMPRESSOR

All compressors are shipped without oil. Before starting, fill compressor base with a good grade of compressor oil meeting the following specifications:

Ambient Or Room Temp °F	Viscosity at 100°F S S U	Flash Point F (Min.)	Four Point °F (Min.)	Carbon Residue % (Max.)	Preferred Base
55 to 120	490 to 600	430	+20	.15	Napthenic
32 to 55	290 to 350	390	+ 5	.10	Napthenic
0 to 32	160 to 230	350	−10	.05	Napthenic
Above 120 or Below 0	Consult factory giving details of installation and operation.				
NOTE: For operation in damp or humid locations, addition of a rust inhibitor is recommended					

A good grade of compressor oil will not form gummy or carbon deposits at cylinder and head temperatures – assuring efficient compressor valve operation. Consult factory or your oil company for recommended type of lubricant. Some automobile oils are suitable for intermittent use but not for heavy duty operation. The compressor oil capacity is shown on the oil tag attached to the pump. Keep oil level to the line on the visual oil gauge at all times. Some compressors are not equipped with visual oil gauges. For these models keep oil level between marks on the bayonet gauge or as indicated on the base filler opening:

Drain oil from crankcase at least once every three months and refill with fresh oil. If in daily use, change oil once every month.

CARE, SERVICE AND MAINTENANCE

INTAKE FILTER – COMPRESSOR

Failure to compress air is frequently due to a clogged filter which prevents free intake of air. Inspect the filter element daily and clean if necessary.

If the filter element is a wire mesh type, remove when dirty, wash in kerosene or other solvent, and dry. Then dip in new oil, drain, and replace. Felt pad type elements may be cleaned in the same manner but should not be oiled.

Never operate the compressor without the intake filter since dirt can be drawn into the compressor preventing proper valve action and possibly scoring cylinder and piston walls.

DRAIN VALVE

Atmospheric moisture is condensed and deposited in the tank. Open tank drain valve at least once a week and blow out moisture.

If drain valve leaks, replace complete assembly – parts not furnished separately.

In Massachusetts, Gate valves are used in place of drain cocks for tank drains:

13231 Gate Valve ¼" Pipe Thread
34525 Gate Valve ½" Pipe Thread

PRESSURE GAUGE

Pressure gauge indicates pressure of air stored in tank. While compressor is new, note length of time required to run from cut-in to cut-out pressures and make a record of it for future reference concerning pump condition. Pressure gauge is non-repairable and if defective, replace with a new unit.

12571 Gauge 200# – Back connected
17088 Gauge 300# – Bottom connected
13219 Gauge Test cock (Mass. and Calif. only)

CHECK VALVES – VERTICAL TYPE

Operation and Care

A check valve is used on automatic switch controlled or centrifugal unloader compressor to seal off the storage tank from the pumping unit and make it possi-

CARE, SERVICE & MAINTENANCE (Cont'd.)

ble to relieve pressure from the aftercooler so the motor can start against no pressure load. When the compressor stops running, trapped air rushes out through the automatic switch relief valve piping or the centrifugal unloader outlet for a few seconds until the aftercooler has been drained.

If air continues to escape from that opening while compressor is idle, a leaky check valve is indicated. This condition can prevent the electric motor from starting or cause it to accelerate slowly when current is turned on, thereby damaging the starting mechanism and windings. It is therefore of utmost importance that the check valve be kept in good condition.

1. Drain all air from the storage tank.

2. Disconnect tubing and remove check valve from tank.

3. Hold hexagon section of body in a vise and unscrew retainer with a wrench.

Type "A"

4. (a) Clean parts thoroughly being sure the small hole in the bottom of retainer is open and that piston moves freely in retainer.

   (b) Re-seat the piston and composition seat by rubbing on very fine (No. 400) emery or sandpaper held on a smooth, flat surface. If badly worn or pitted – replace.

5. Insert spring, piston and seat in retainer and hand tighten retainer to body – then tighten securely with pipe wrench. Using a pencil or similar instrument, make certain piston moves up and down freely.

Type "B" and Pokorny

6. Clean parts thoroughly. Replace teflon disc or plunger.

7. Replace spring if broken.

8. Before installing check valve, operate compressor for a few moments, tapping the aftercooler lightly with a wooden stick, to discharge any loose dirt or carbon particles.

9. Replace check valve in tank and connect aftercooler and relief valve piping using a small amount of thread sealing compound (e.g. white lead) on the pipe threads.

ORDER PARTS BY NAME AND INDICATE PIPE SIZE OF BODY OR MODEL OF UNIT

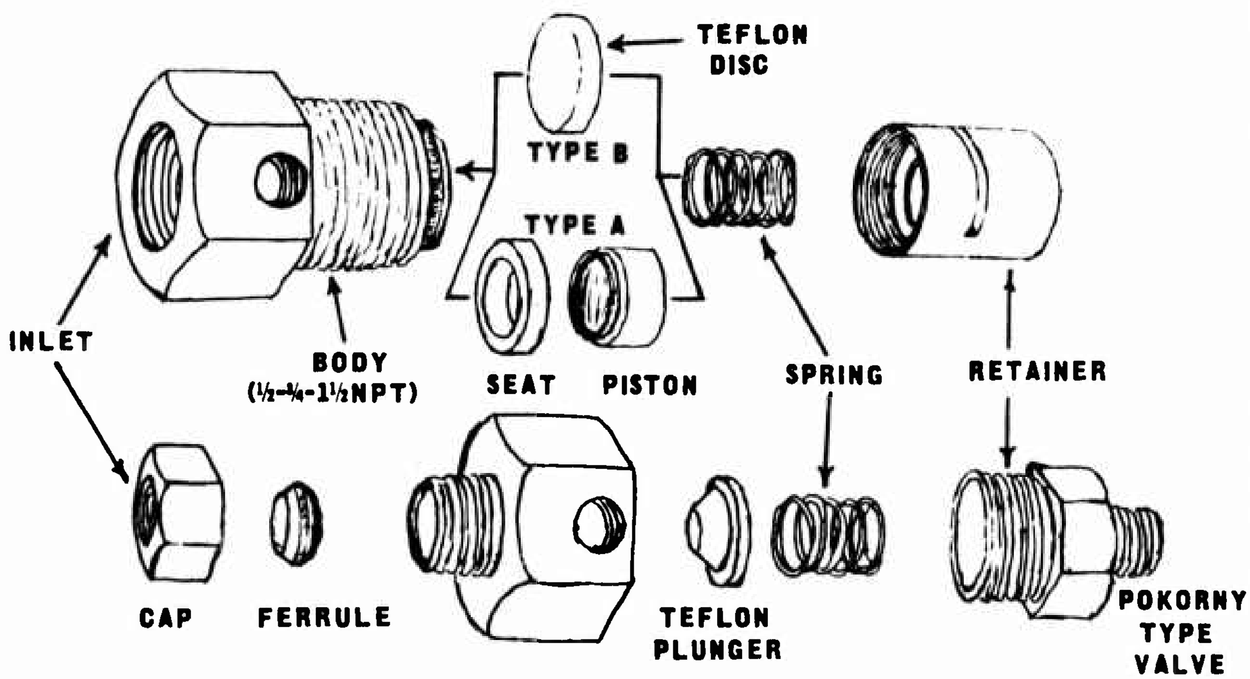


FIG. 1

RELIEF VALVE, AND CENTRIFUGAL UNLOADER

Proper action of the check valve, located between the compressor and the tank, together with the relief valve on pressure switch relief valve units, and the centrifugal unloader on centrifugal unloader units is essential to the performance of the compressor unit. Trouble with the check valve and relief valve and/or centrifugal unloader will be indicated at points "A" of Figure #3 or "B" of Figure #4.

IMPORTANT

1. Air escaping from "A" or "B" while the compressor is running indicates a leaky relief valve or centrifugal unloader.

2. Continuous escape of air from "A" or "B" when motor is *not* running (when motor stops, air should escape for a few seconds), indicates a leaky check valve. Instructions for repairs are given in detail in the check valve section.

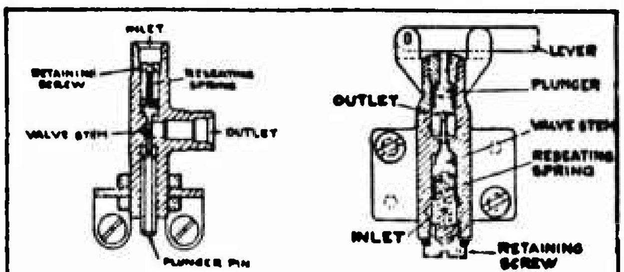
3. No escape of air from "A" or "B" when the motor stops indicates that the relief valve or centrifugal unloader is not opening properly or the unloader tube to the relief valve or centrifugal unloader is plugged. When the automatic switch stops the compressor, the air trapped between the check valve and the head is bled out through the relief valve at "A" or the centrifugal unloader at "B". This allows the compressor to start without load.

The following types of relief media are used on automatic switch controlled compressors.

1. Pressure Switch – with relief valve.

2. Pressure Switch – in conjunction with centrifugal unloader.

Two pressure switch relief valves of the mechanical type are shown below.



Type A Relief Valve **FIG. 2** Type B Relief Valve

When ordering parts or replacement, specify make and type or class of switch.

Type "A" – with plunger pin directly operated by a horizontal pin or lever extending through the switch casing and actuated by the switch "on" and "off" mechanism.

Type "B" – similar to type "A" except with a lever attached to operate the plunger.

Usually type "A" valves are attached to the switch housing by means of two lock nuts and type "B" by two screws. In either event they must be mounted so that the plunger is *free* when the compressor is running and *depressed* when the switch contacts open to stop the compressor.

If the compressor is stopped by a manual control switch before it completes its cycle, the relief valve plunger should be actuated by hand before starting again to eliminate pressure in the pump head and aftercooler.

The centrifugal unloader is designed to relieve the load on the motor when starting. Used in conjunction with a pressure switch without a relief valve, it functions as a relief valve when the compressor unit is stopped. Refer to the centrifugal unloader part sheet for details of operation.

If relief valve gives trouble it is usually possible to clean the valve seat by pressing the plunger pin or lever several times while the compressor is running. If leak persists, disconnect the relief valve tubing and remove the valve from the switch. Some valves can be disassembled for more thorough cleaning but if the leak cannot be stopped, replace the complete relief valve (when ordering always give the *name* and *type* switch). Always be sure the relief valve is properly mounted with respect to the operating pin or lever.

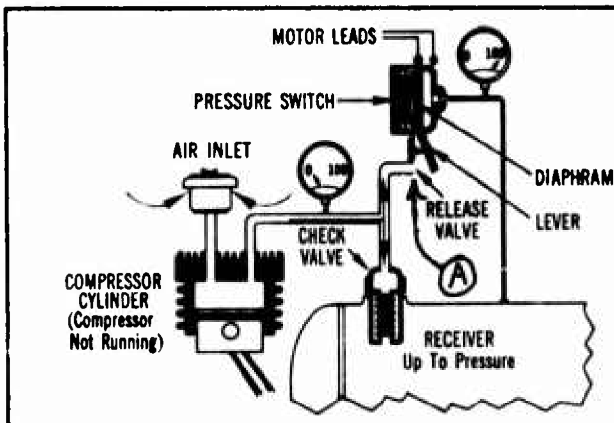


FIG. 3 — PRESSURE SWITCH CONTROL

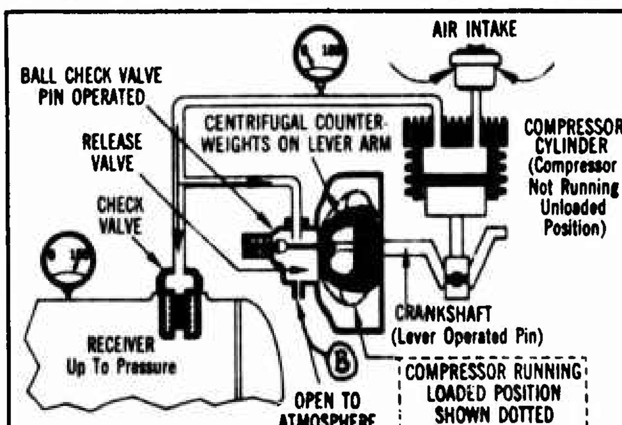


FIG. 4 — CENTRIFUGAL UNLOADER

F ESSURE SWITCHES

Some compressors have pressure switches with integral unloaders so that when the switch shuts off the electric motor, pressure between the compressor head and the check valve is bled off to the atmosphere through a relief valve. The compressor is then free to start again when needed. Other units feature a centrifugal unloader as part of the compressor pump and use no relief valve.

Motor Protection – A pressure switch does not afford motor protection. However, it is quite frequently used as a pilot to operate a starter providing these desirable features.

Differential – Pounds pressure between "cut-in" and "cut-out" is known as differential. This is set at the factory to stop the motor when the maximum operating pressure is reached. When the tank pressure drops to the "cut-in" point, the switch automatically starts the motor. Differential adjustment affects "cut-out" point only. To increase the differential, turn down the nut, on top of the case, which increases tension on differential spring. By backing off this nut, differential will be narrowed. If "cut-in" point is apparently incorrect, do not attempt to change the setting above the original factory setting without first checking with supplier to find out if it can be safely done. Higher pressures usually necessitate speed reduction and sometimes replacement of parts.

To Replace Diaphragm – Remove switch from tank and then remove screws holding diaphragm in place. To remove switch, use an open end wrench on hex nut at bottom of switch. NEVER use the switch body for leverage when tightening or loosening.

To Replace Contacts – It is not necessary to remove switch from tank. Remove screws holding contact unit in place and replace unit.

NEVER OIL OR GREASE ANY PART OF SWITCH.

CAUTION: *Never remove pressure switch unless the tank pressure is "O".*

DESCRIPTION OF AUTOMATIC SWITCH CONTROLLED COMPRESSOR OPERATION

ESSENTIAL ELEMENTS OF THIS UNIT ARE:

1. Electric Motor – drives the air pump.

2. Pump – takes air from atmosphere and compresses it into tank.

3. Tank – stores compressed air.

4. Automatic Switch – starts and stops the motor at predetermined pressures.

5. Relief Valve or Centrifugal Unloader – releases "back" pressure on pump when stopping or starting the motor.

6. Check Valve – holds air in the tank when compressor stops and allows the relief valve or centrifugal unloader to function.

The part designated as a Relief Valve may be any of the following general types:

1. Mechanical (type "A" or "B") – mechanically connected to the pressure switch. Opens and closes with the switch contacts.

2. An integral part of the pump. Closes as the pump comes up to operating speed, opens if the pump stops.

Regardless of the type used, the purpose of the relief valve is to prevent as completely as possible overloading the motor while starting by eliminating pressure in the aftercooler.

SAFETY VALVE – The safety valve is tested and set at the tank working pressure by the manufacturer.

ASME and Mass. Standard safety valves are set and sealed to operate at the pressure stamped on the body or name plate. If such valves leak or do not open at the desired pressure, they should be replaced. Order new valves by indicating *pipe size* and *desired maximum pressure setting*. Sometimes leaks caused by loose dirt on the valve seat can be stopped by operating the valve manually several times in rapid succession.

Some compressors, mounted on standard tanks, are equipped with "standard" safety valve 8603.

CONSTANT SPEED CONTROLS

Several systems are available that will automatically regulate the delivery of compressed air while the motor and compressor operate continuously. All gas engine driven units are equipped with constant speed control.

INLET VALVE REGULATION

An automatic pilot valve senses receiver pressure and when the required pressure has been established, the valve admits compressed air to the inlet valve regulators. These consist of a set of fingers, arranged to

CONSTANT SPEED CONTROLS (Cont'd.)

reach into and press on the inlet valve plates, to hold them open. Air rushing in, on the piston downstroke, is pushed out again, on the piston upstroke, whenever the inlet valve is held open. Since no compression occurs, idling h.p. is very low.

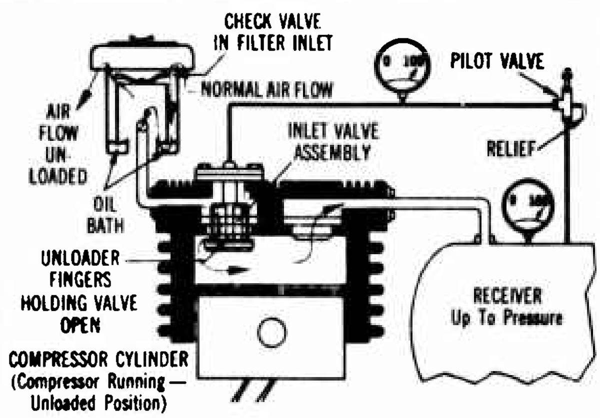
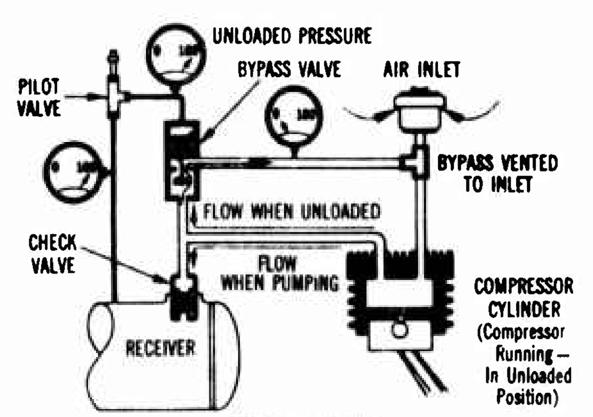


DIAGRAM — INLET VALVE REGULATION

BYPASS REGULATION

Discharge air is returned to the compressor inlet through a bypass valve, located on the air compressor discharge while a check valve retains tank pressure. Since no discharge pressure is established, motor load is low while the compressor idles.



BYPASS REGULATION

TOTAL CLOSURE REGULATION

When the receiver pressure is satisfied, a pilot valve admits tank pressure to actuate a valve installed on the compressor inlet. Since, with the inlet air valve closed no air can enter the compressor, it follows that none can leave to increase the tank pressure. In this instance, the compressor interstage is drawn down to a vacuum and motor load is very low while the compressor is "unloaded."

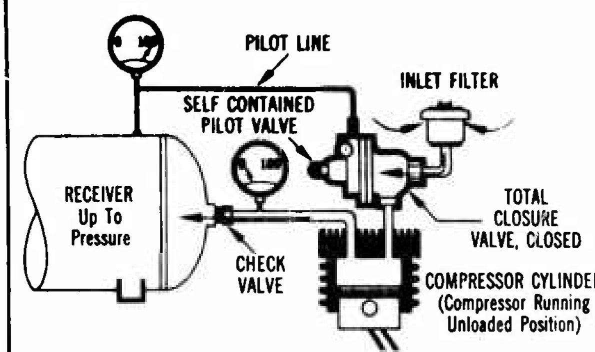


DIAGRAM — TOTAL CLOSURE REGULATION

DUAL CONTROL

A compressor having both start-stop control and constant speed control is said to have "dual control." This is the best selection for widely varying loads or for installations where full load operation is required over 80% of the time.

UNLOADER PILOT VALVE

Application – Unloader pilot valves are part of a constant speed control system.

Operation – When the receiver reaches the required pressure previously set, the valve instantly unloads the mechanism in the compressor. The compressor will then run unloaded until the action of the valve is reversed by reaching the minimum (or load pressure) previously set. This will permit the compressor to load and pump air until top pressure is again reached.

Servicing – This valve has only one moving part and the unit should operate for long periods without servicing – provided the lines are kept clean and the compressor is in good operating order.

Setting – The unload pressure is adjusted by turning the pressure adjusting nut clockwise to increase, and counterclockwise to decrease, pressure.

Changing the differential (difference between load and unload pressures) is accomplished by holding the lock nut closest to the body of the valve so it does not move, then turning the large nut next to it very slightly clockwise to increase the differential, or counterclockwise to decrease it.

For units with lever type adjustment, see instruction accompaning valve.

APPENDIX B

MINUTES OF MEETING

DESIGN REVIEW NO. 1 - CRIMPING DEVICE

Design Review No. 1 for the crimping device/30mm frangible projectiles was held at Eglin AFB 2 August 1976. This review was attended by:

Name	Organization	Phone
Paul A. Weber, 1st Lt. USAF	AFATL/DLDG	904-882-4035
Arthur J. Williams, Mgr., Q.C.	Amron	414-547-1661
Kenneth R. Roach, Pres.	Kenematics	608-752-6460
Roy E. Rayle, Sr. Staff Dev. Engr.	Amron	414-547-1661
Henry C. Rushing	ADTC/ACCE	904-882-5756
A. H. Gautier	ADTC/ACCE	904-882-5756

a. Cases to be Used for Crimper Development Testing

Eglin had planned to GFE 100 IVI cases, as these have been used to date on the frangible projectiles program. A WPAFB metallurgical evaluation of these cases dated 23 July 1976 was distributed by Lt. Weber at the meeting and reviewed. After some discussions, it was tentatively agreed that the main testing would be done with Amron cases, rejected for case base defects, and that Eglin would furnish only a check test quantity of ten each of cases by IVI, Piper and Norris. Amron is to send a letter to this effect to the Eglin PCO.

The contract also calls for 50 thin wall steel (Amron) cases to be GFE and tested. For the present, emphasis is to be placed on use of aluminum cases, as arrangements for supplying the thin wall cases have not yet been worked out.

b. Review of Design Concepts

The introductory comments by Amron on the design concepts indicated that there were three concepts to be reviewed, and if at the end of the meeting a choice could not be made, Amron would require an additional three to four weeks if two concepts were to be detailed and a prototype of each built, and that approximate cost estimate of such added scope could be provided.

Mr. Kenneth Roach, Kenematics, then presented the three concepts, explaining the design approach for each concept, using layout drawings distributed at the meeting.

c. Roll Crimp Concept

Variables to be tested in this design concept include adjustment of the pressure level reduced from shop air level to working levels for the hydraulic actuator, adjustment of the base to properly position each cartridge to be crimped, and the use of two types of rollers in various combinations, such as all three to be designed to roll in the metal to be crimped, or only one to roll crimp while two are provided with flat roller surfaces for guidance and support only.

It was decided that belleville type washers would be used on either side of the crimp rollers to permit sufficient axial movement to adjust to projectile tolerance variables and allow the roller to seek out the crimp groove while rolling in the metal of the case mouth.

It was decided that rather than leave it up to the operator to decide when to retract the actuator crimp shaft, provision would be made to sense when the bottom-out stop is reached in order to automatically retract the shaft. In this area, Amron was to investigate the idea of elimination of the need for shop air supply, and provide for electric power as the only required utility.

Safety requirements for crimping TP projectiles to be primed and loaded cases were discussed by Mr. Williams, such as sealed electric motors and switches, proper grounding of all components, and use of 3/8-inch steel protective shielding, including a sliding door with electrical interlock, as well as proper guards for V-belts. After some discussion, it was ageeed that Amron would investigate this area further.

d. Stab Crimp Concept, Six Adjustable Fingers

This concept was explained, in which adjustments to the crimp fingers permit variation of both rate of crimping, and sequencing of individual crimp fingers. Type material for the crimp fingers would minimize wear.

e. Stab Crimp Concept, Eight Fixed Fingers

This concept was similar to the previous concept, except the adjustable feature was omitted, which permitted room for eight instead of six crimp fingers.

f. Discussion of Advantages and Disadvantages of Each Concept

The roll crimp concept more nearly simulated the only successful crimp technique used to date on frangible projectiles, namely the hand-operated pipe crimper with crimp rollers. This concept would be slower than the stab crimp concept on a production line, but since propellant loading of such a line controls the line rate, use of the roll crimp would not necessarily slow the line down. The roll crimp concept provides full 360 degree crimp, and with plastic projectiles, no sealant may be required.

The roll crimp concept is more expensive to fabricate than either of the stab crimp concepts.

g. Decision

After comments were heard from all present, it was the unanimous recommendation, and the decision announced by Lt. Weber, that the roll crimp concept alone should be selected for the next phases of detail design, fabrication and testing. The Air Force was to advise Amron officially in this regard through contracts.

INITIAL DISTRIBUTION

Hq USAF/RDQRM	1
Hq USAF/SAMI	1
ASD/ENFEA	1
TAC/DRA	1
AUL/LSE 71-249	1
AMXSY-DD	1
DRXBR-TE	1
SARPA-TS/Picatinny Ars	1
Navl Surface Wpns Ctr/Tech Lib	2
AF Wpns Lab/Tech Lib	1
DDC/TC	2
OO-ALC/MMWMP	2
AFATL/DL	1
AFATL/DLOU	1
Hq USAFE/DOQ	1
Hq PACAF/DOOFQ	3
AFATL/DLODR	1
COMIPAC/I-232	1
ASD/XRP	1
US Army TRADOC Sys Analysis Activity/ATAA-SL	1
TAC/INA	1
AFATL/DLODL	9
AFATL/DLYV	1
AFATL/DLDL	1
AFATL/DLDA	1
AFATL/DLDG	20
AFIS/INTA	1
Frankfort Ars/Library	1
DeBell & Richardson, Inc	1
Amron Corp	3
AFML/MXE	1

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