M549 FUZE DESIGN, FABRICATION AND INSTALLATION OF PROTOTYPE ASSEMBLY LINE (TASK B)

AVCO SYSTEMS DIVISION

PREPARED FOR
PICATINNY ARSENAL

JANUARY 1976

M549 FUZE DESIGN, FABRICATION AND INSTALLATION OF PROTOTYPE ASSEMBLY LINE (TASK B)

Final Report

By

R. S. McLaughlin

January 1976

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Contract DAAA 21-75-C-0035

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

This is the final report on progress achieved on the M549 Fuze Product Improvement Program, Contract No. DAAA21-72-C-0566, during the period from June 1975 through February 1976.

The objective of the program was to design, develop, fabricate and debug three major prototype M549 Fuze assembly machine that will be

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20. ABSTRACT (Cont'd)

capable, when included in a balanced production line, of producing 250,000 fuzes per month on a 1-8-5 shift basis. This contract did not require that the line be balanced for a true 1-8-5 shift basis at this time.

The prototype equipment was acquired and installed, with limited acceptance and demonstration quantities processed to verify machine acceptability.

Appendices are included covering a verbal description of each machine's function; a sample purchase description; listing of operation and maintenance manuals, and a list of drawings for the assembly and test machines.

M549 FUZE

DESIGN, FABRICATION AND INSTALLATION

of

PROTOTYPE ASSEMBLY LINE

(TASK B)

FINAL REPORT

By

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January 1976

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AVSD-0075-76-RR

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Contract DAAA 21-75-C-0035

ABSTRACT

This is the final report on the progress of Task B of Contract DAAA21-75-C-0035 dealing with the design, fabrication, and installation of specific M549 fuze assembly line equipment capable when balanced, of producing 250,000 fuzes per month on a 1-8-5 basis.

One each, escapement subassembly, escapement assembly, and final fuze (less spitback) assembly machines were authorized for procurement under this contract.

Subsequent sections of this report cover in detail the specific design and performance requirements, acceptance demonstration data, operating instructions and station by station functions of each machine.

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SECTION I

CONTRACT REQUIREMENTS

The Scope of Work for continuation of the Advanced Production Engineering of Fuze PIBD, M549 - Phase II follows:

I. OBJECTIVES:

a. This Scope of Work covers the Final Evaluation Testing of the M549 Fuze and the Design, Fabrication and Installation of the M549 Fuze Prototype Assembly Line. The object of the Final Evaluation Test Program (Task A) will be to demonstrate that the performance of The Production Engineering Design of the M549 Fuze is comparable to the operational and functional characteristics of the R&D fuze design. The fuze prototype assembly line (Task B) shall consist of one each of the following machines:

(1) Escapement Sub-assembly

(2) Escapement Assembly

(3) Final Fuze Assembly (Less Spitback)

b. The prototype assembly line shall comply with the following:

(1) Capable (when balanced) of producing 250,000 fuzes per month on a 1-8-5 basis.

(2) The final prototype assembly line design concept shall be subjected to a brief performance test after being installed and located according to the installation layout established during the Phase I & II effort of the APE program.

(3) The fuzes assembled on the prototype assembly line equipment shall meet the dimensional and functional requirements when tested in accordance with the finalized M549 Fuze drawings and specifications.

2. PROCEDURES

The contractor shall within a twelve month period, perform the tasks outlined in Para. 2.a. and 2.b. below:

a. Task A:

(1) Conduct a Design and Engineering Study to update the M549, PIBD Fuze.

(2) Develop new and/or update current inspection and test procedures (see MIL-STD-109) for inclusion into Military Specification, MIL-F-50864 to assure the Government of obtaining satisfactory end items at a minimum of cost for inspection, labor and material destroyed in testing.

(3) The contractor shall update the inspection equipment list associated with the M549 Fuze.

(4) The Contractor shall update the reliability plan if applicable to insure the Government that the APE items will meet all design and reliability requirements stated in this document.

(5) Submit recommendations, including calculations, layouts, sketches and drawings, together with a program including a detailed schedule for continuation and completion of the work, for the review and approval of the Contract Project Officer.

(6) Upon written approval by the Contract Project Officer, commence with the acquisition of fuze components and hand-line fabrication of fuzes for the Final Evaluation Test Program and Prototype Assembly Line.

(7) Perform Final Evaluation Tests in accordance with test matrix shown in Attachment I of the contract and evaluate results to assure accomplishment of an acceptable design meeting the objective of Section I.

b. Task B:

(1) Following the completion of the tasks specified in Task A and upon written approval by the Contract Project Officer of what is considered an acceptable design of the fuze, the contractor shall perform the tasks outlined below:

(a) Design of Prototype Assembly Line:

1. Utilizing the drawings and specifications listed in Section 1 para 4 and/or the updated drawings and specifications as a result of changes during the Task A effort and consistent with the objectives of Para 1 and the requirements of Section 1, design a prototype assembly line for the M549, PIBD Fuze.

2. Submit recommendations including layouts, sketches and drawings of the proposed prototype assembly line design, together with a planned program, including a detailed schedule for continuation and completion of work on the prototype assembly line, for the review and approval of the Contract Project Officer.

(b) Fabrication and Installation of Prototype Assembly Line:

1. Upon written approval by the Contract Project Officer of what is considered an acceptable design of the fuze prototype assembly line and approved program schedule, the contractor shall:

a. Commence with the acquisition of the necessary material, tools and equipment for the proposed prototype assembly line.

b. The prototype assembly line shall be located according to the installation layout established during the Phase I & II effort of the APE Program. The machines shall be readjusted to correct possible shipping and handling misalignments. This effort should be accomplished jointly with the machine company representatives on hand at the contractors

facilities. Following the adjustment activities the machines will be subjected to a brief performance test again with the machine vendors representatives on hand for the benefit of the CPO. The machines will be accepted following a successful demonstration run.

2. Prior to or during the fabrication of the prototype assembly line, the contractor may make any necessary changes to the approved prototype assembly line design deemed necessary. The design changes shall be incorporated into the assembly line design after approval by the Contract Project Officer as they become evident.

3. Take any corrective action disclosed during the fabrication of the fuzes on the assembly equipment as directed by the Contract Project Officer.

4. Upon completion of the work outlined in Paragraphs 1 thru 3 above submit the following to the Contract Project Officer for review and approval:

a. Category E, Form 3, Government Design Activity Drawings of the final approved design of the M549 Fuze Prototype Assembly Line. Drawings submitted by the contractor under this contract shall conform to the requirements of the Contract Data Requirements List, (DD Form 1423, Drawings, Engineering and Associated List). Any interpretation or determination of the applicability of the technical requirements for drawings will be made by the Contract Project Officer.

b. A final Technical Report will be prepared which will include a Description of Operation Procedures and Maintenance Manuals of the entire M549 Fuze Prototype Assembly Line. The report will also contain the findings, conclusions and recommendations made in accordance with this work. Two (2) advance copies of the rough draft of the final report will be submitted to the Contracting Officer for approval of the Contract Project

Officer. Upon approval of the rough draft, the contractor will submit one (1) copy of the Final Technical Report, prior to distribution, for approval of the Contract Project Officer. Upon receipt of approval, the Contractor shall make distribution in accordance with the Contract Data Requirements List, DD Form 1423. Prints of the final set of component drawings, inspection equipment drawings and lists and all specifications shall be part of the report.

3. BACKGROUND

This Scope of Work covers the continuation of the Advance Production Engineering of the Fuze, PIBD, M549. The M549 Fuze is a Point Initiating, Base Detonating Mechanical Fuze used on Cartridge, 40MM, HEDP, M430.

4. REQUIREMENTS

The basic design of the M549 Fuze shall not be changed, altered or modified during the continuation of the Advance Production Engineering effort in any way that would downgrade the acceptable operational or functional characteristics obtained during the performance of the Engineering and Service Tests.

c. Scheduled Target Dates

The contractor shall apply a rate of effort necessary to meet the target dates. While due to the nature of the work, some deviations may be necessary, compliance with the date for completion of all work is required.

a. Task A:	Months after Award	
	Initiate	Complete
(1) Update APE Fuze Design	1st month	1st month
(2) Submission of Preliminary updated TDP	1st month	2nd month
(3) Acquisition of Fuze Components for Task A&B	1st month	4th month
(4) Handline Assembly of 500 Fuzes	4th month	5th month
(5) Final Evaluation Test	5th month	6th month
(6) Submission of Final TDP and Final Report (preliminary TDP and report)	5th month	6th month

b. Task B:

	Months after Award	
	Initiate	Complete
(1) Submission of Preliminary Prototype assembly line design	1st month	2nd month
(2) Prototype assembly design	2nd month	6th month
(3) Fabrication of prototype assembly line	6th month	10th month
(4) Installation of prototype assembly line	10th month	12th month
(5) Submission of Final Technical Report (includes description of operation procedures and manuals of the M549 Fuze Prototype Assembly line)	12th month	12th month

e. Applicable Drawings and Specifications

A. The following item drawings and specifications shall form the basis for the continuation of the Advance Production Engineering of Fuze, PIBD, M549:

Drawing No. & Date	Drawing No. & Date	Drawing No. & Date
9287860 - 3-20-74	9287871 - 3-20-74	9287882 - 3-29-74
9287861 - 3-29-74	9287872 - 3-29-74	9287883 - 3-29-74
9287862 - 3-29-74	9287873 - 3-29-74	9287884 - 3-29-74
9287863 - 3-29-74	9287874 - 3-29-74	9287885 - 3-29-74
9287864 - 3-29-74	9287875 - 3-29-74	9287886 - 3-29-74
9287865 - 3-29-74	9287876 - 3-29-74	9287887 - 3-29-74
9287866 - 3-29-74	9287877 - 3-29-74	9287888 - 3-29-74
9287867 - 3-29-74	9287878 - 3-29-74	9287889 - 3-29-74
9287868 - 3-29-74	9287879 - 3-29-74	9287890 - 3-29-74
9287869 - 3-29-74	9287880 - 3-29-74	9187891 - 3-29-74
9287870 - 3-29-74	9287881 - 3-29-74	MS 21318-1 -

B. The recommended design shall comply with the following General Specifications:

Specification	Date
MIL-F-50864	12-8-72
MIL-F-50865	3-16-71
MIL-STD-1316A	12-2-70
MIL-C-50861	3-16-71

SECTION II

TECHNICAL DISCUSSION

One of the basic objectives of Task B of Contract DAAA 21-75-C-0035 was to provide the capability (when balanced) of producing 250,000 M549 fuzes (less spitback) per month on a 1-8-5 basis.

To implement this objective Avco Systems Division prepared purchase descriptions, which defined in specific terms, design and performance requirements for each of the assembly machines.

These purchase descriptions were submitted to nine machine vendors. Of these, four companies responded with proposals. A comprehensive review of each proposal was conducted by Avco personnel with representatives of the machine vendors present to assist in making a sound assessment of their design approach, past performance, schedule, and cost.

During the course of the evaluation effort, API (Automated Process Incorporated, Milwaukee, Wisconsin) and Hill-Rockford, Rockford, Illinois, facilities were surveyed. Previously, a survey was conducted of the Swanson-Erie facility in Anaheim, California. The visit provided significant data on which to base a decision for selection for vendors. It was concluded after reviewing facilities and interviewing key management and technical personnel that the best interest of the program would be served if a maximum of two machines were placed with any one vendor. As a result of this observation, the first ranked vendor, API, and second ranked vendor, Swanson-Erie, were considered relative to the optimum placement of a split machine order. This trade-off resulted in the following final recommendation for procurement of machines:

MACHINE DESIGNATION	VENDOR
Escapement Sub-Assembly	Automated Process Inc.
Escapement Assembly	Automated Process Inc.
Fuze Assembly (Less Spitback)	Swanson-Erie

ASSEMBLY MACHINE RATES

With the objective of providing an assembly line capable of producing 250,000 fuzes per month on a 1-8-5 shift basis, the Purchase Description for Equipment (PDE) was originally prepared with the assumption that at the end of the production line an average yield of 1666 good fuzes per hour is required. This assumes 20 working days per month at eight hours per day. Also, the PDE was based upon an overall machine utilization factor of 80 percent. Therefore, this represents the rates specified for gross machine cycle rate and net yield per hour. These values are shown in the first two columns of Table I for each of the three new machines acquired under this contract. Figure 1 shows a block diagram for the automated line indicating desired input, output, and reject rates for each assembly machine.

A more accurate approach to individual machine requirements is obtained by considering the actual flow of parts and subassemblies, together with the expected fallout at each machine, caused primarily by either bad parts or a machine malfunction. These net output rates, together with optimistic reject percentages, are shown in the third and fourth columns of Table I.

The performance of the individual machines during the acceptance runs, both at the vendors' plants and at Avco's Wilmington plant, gave some indication of the potential capabilities compared to the desired yield. These figures are shown in the last two columns of Table I.

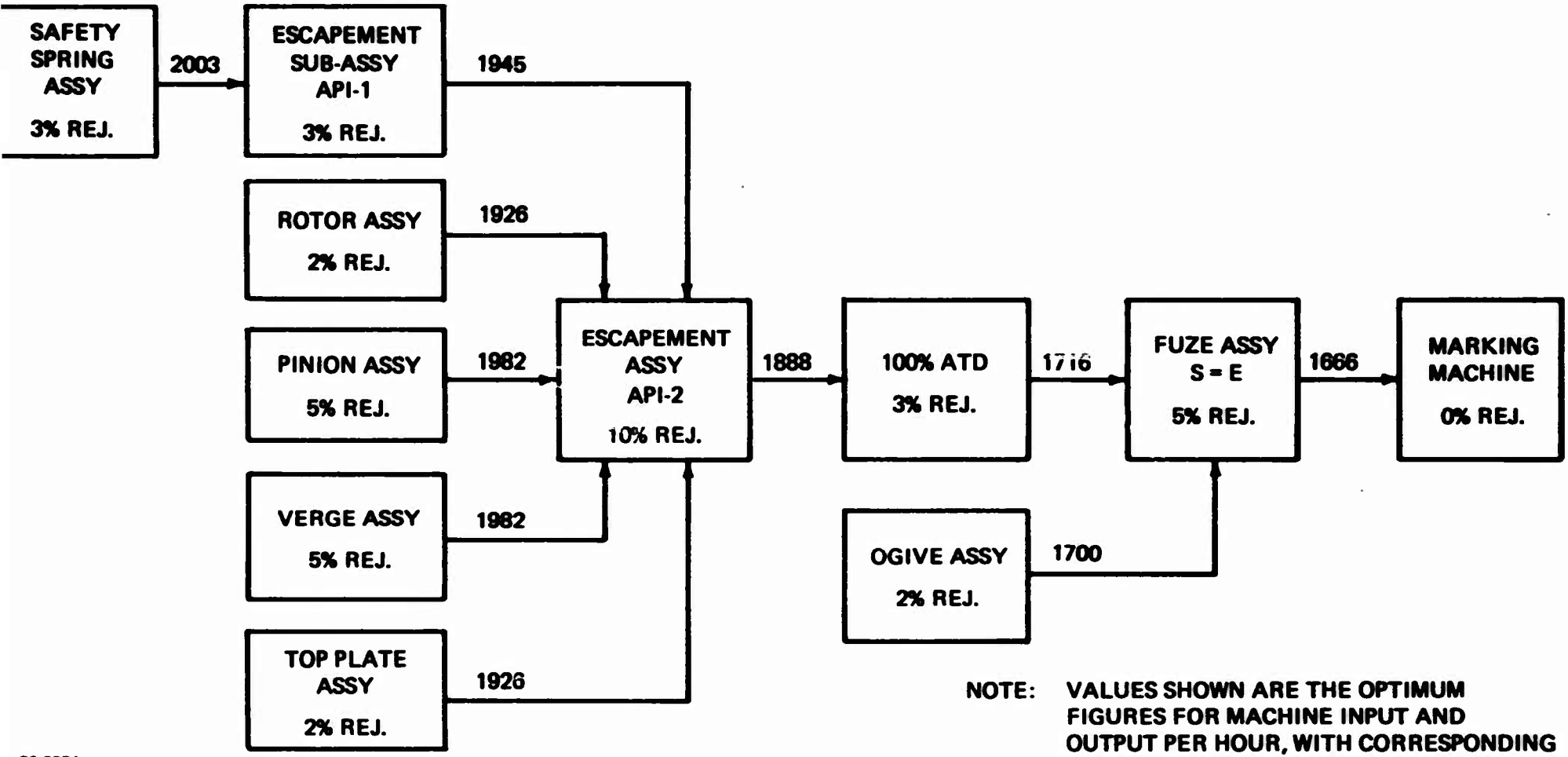

FIGURE 1 BLOCK DIAGRAM M549 FUZE AUTOMATED ASSEMBLY LINE

TABLE I. AUTOMATIC ASSEMBLY MACHINE RATES

ASSEMBLY MACHINE	PURCHASE DESCRIPTION		REQUIRED YIELD FOR NET 1666/HR		ACCEPTANCE RUNS	
	GROSS RATE/HR.	RATE/HR.	NET/HR	REJECT %	NET/HR	REJECT %
Escapement Sub-Assembly	2400	2100	1945	3	1804	5.4
Escapement Assembly	2400	2100	1888	10	1710	11.2
Fuze Assembly	2400	2100	1666	5	1710	10.3

As shown in Table I the Assembly Machines did not meet the anticipated rates of the PDE. Reasons for low acceptance run rates obtained are discussed later in this Section by Machine. Final acceptance of these machines was based upon mutual agreement between Avco and Government personnel. It should be noted that tryout and acceptance hardware was limited because of Government funding.

Every attempt was made to use existing hardware over as many times as possible before it became completely unserviceable. This used hardware was a a major contributor to the high reject and low production rates observed.

In general, the acceptance run yield was reasonably close to that desired. However, these runs were of relatively short duration, and in almost all cases the parts were carefully screened in an effort to minimize down time caused by parts, and thus accentuated any machine deficiencies. During the demonstration, runs using reused parts, excessive down time was experienced which greatly reduced actual yield. Much of this was expected as a natural consequence of continued machine debugging, training of operator, setup and maintenance personnel, and subtle but important changes in parts that had adverse effects on automated assembly.

ASSEMBLY ACCEPTANCE RUNS

Acceptance run data is reported in the following Sections, for each of the three Automatic Assembly Machines, including a Summary of faults observed during these runs.

ESCAPEMENT SUB-ASSEMBLY MACHINE

The escapement sub-assembly machine was produced by Automated Process Incorporated, Milwaukee, Wisconsin in accordance with Avco Specification No. M300-549-0001 Rev. A which describes in detail, specific performance and design requirements for this machine. (See Appendix I.)

The instruction manual, (See Appendix II for sample manual) describes the detail functions of the machine, station-by-station and trouble shooting instructions.

Prior to conducting the Acceptance Run a meeting was convened at API to review the requirements, understandings, and procedures for accepting the escapement sub-assembly machine. Upon reaching an agreement, API dry cycled this machine to observe functioning of all stations, prior to the start of the acceptance runs.

Results of the acceptance runs are shown in Table II.

TABLE II - ESCAPEMENT SUB-ASSEMBLY MACHINE - ACCEPTANCE RUN RESULTS

Run Number	1	2	3	4	5	Totals
Quantity	1000	1000	1793	1818	1216	6827
Total Elapsed Time (min.)	27.3	28.08	60.0	60.0	40.0	215.38
Down Time (min.)	.71	2.05	13.5	15.06	8.2	39.53
Net Running Time (min.)	26.59	26.02	46.5	44.94	31.8	175.85
Good Parts	963	963	1655	1736	1156	6479
Rejects	37	36	138	82	60	353
Production Rate per Hour	2120	2050	1655	1736	1156	1804
Reject Percent	3.7	3.6	7.7	4.5	4.8	5.4

The following is a summary of faults observed during the demonstration run.

Station 1: Escapement housing misloading. Feeding mechanism was adjusted, which eliminated this malfunction on later runs.

Station 5: Safety spring feed problem. Product drawing dimensional tolerances are such that the geometry of the spring assembly can vary significantly and cause feeding problems. It is recommended that the drawing tolerances be reviewed and tightened to insure springs which are consistent in shape.

Station 14: Numerous faults were noted at this station. It was observed that many of the screws were not in accordance with the "MS" drawing. Examples of the problems experienced are lack of knurl on screw body, several dimensions not per print, and probably the most severe problem was the amount of debris, chips, and bits and pieces generated during the manufacturing process. Recommend that vendors screen parts prior to delivery to insure compliance with "MS" drawing.

Station 23: Probe empty nest. Numerous faults were recorded at this station. Almost all of them were attributed to loose screws in nest. API has added an air blast to purge deep recesses of nest, thereby precluding recurrence of this problem.

At the conclusion of the demonstration runs, it was mutually agreed to ship the machine to Avco.

ESCAPEMENT ASSEMBLY MACHINE

The escapement assembly machine was purchased from Automated Process Incorporated, Milwaukee, Wisconsin in accordance with Avco Specification No. M300-549-002 Rev. A. See Appendix I for typical specification.

The instruction manual which describes the detail functions of the machine, station-by-station and trouble shooting instructions is contained in Appendix II.

On 20 October 1975 a meeting was held at API to review the requirement of the purchase description and acceptance requirements. General agreement in the overall requirements was reached; plans were made to begin the acceptance run on 21 October 1975. Results of these runs are shown in Table III.

The following discussion summarizes the machine faults observed during the acceptance runs on this machine.

Station 1: Several faults occurred at this station. Most were attributed to the operator improperly feeding the part. However, several jams caused by the cross feed were corrected by an adjustment in the pick and place linkage.

Station 6: The rotor gear as fabricated by Dixon did not have the counter-sink around the rotor shaft hole as specified on the drawing. A square edge around the lead end of the hole tends to hang up on the shoulder of the rotor shaft. API counter-sunk 500 rotors to the proper dimensions. These fed well with no problem during assembly. Avco reworked an additional 2000 rotor gears, for use in sub-sequent runs.

Station 7: A number of rotors were not properly oriented; i.e., a portion of the rotor would move back and partially cover the setback pin hole. API modified and readjusted the orienting finger, which reduced the number of faults signifi-cantly. The safety spring design should be reviewed to assure the proper configu-ration to assure proper positicning of the rotor gear assembly.

TABLE III - ESCAPEMENT ASSEMBLY MACHINE - ACCEPTANCE RUN RESULTS

Run Number	1	2	3	4	5	6	7	Totals
Quantity	1000	500	500	500	1000	500	500	4500
Total Elaspsed Time (min.)	50.9	27.03	23.6	20.0	42.02	18.12	15.95	197.62
Down Time (min.)	11.02	6.99	1.6	1.4	7.52	2.02	1.96	32.51
Net Running Time (min.)	39.88	20.44	22.0	18.6	35.5	16.1	14.0	166.52
Good Parts	847	432	449	448	924	441	449	3984
Rejects	153	68	51	52	66	59	51	500
Production Rate per hour	1274	1296	1230	1450	1582	1643	1926	1843
Reject Percent	15.3	13.6	10.2	10.4	6.7	11.8	10.2	11.2

Station 17: This station was responsible for numerous faults and was the principal reason for terminating the initial acceptance runs.

The feeder bowl could not deliver to the spring escapement wheel an adequate number of springs properly oriented to meet the assembly machine demand. API contacted Vibromatics, designer and fabricator of the anti-creep spring feeding mechanism, reworked the output end of the feeder bowl to properly orient the anti-creep springs and increase the rate of depositing springs in the pockets of the escapement wheel.

Additional debugging operations were required to correct the problem. 20,000 new safety springs were ordered to replace the old springs in the final acceptance run on this machine.

Following several runs with the reworked feeder bowl and mechanism by API, it was agreed to conduct another acceptance run on the machine.

Station 20: This station worked very well. The big problem experienced during the acceptance run was operator inability to hand feed at a rate high enough to keep up with the machine.

On 17 November 1975 an acceptance run was conducted at API. It was finally agreed that the anti-creep loading station was performing adequately. However, it was felt that some work may have to be accomplished to minimize the reject rates encountered during this run.

The machine was shipped and installed at Avco Systems Division with API conducting a demonstration run on 2 December 1975 consisting of 2500 escapements (1000 of them containing live detonators).

FUZE (LESS SPITBACK) ASSEMBLY MACHINE

The fuze (less spitback) assembly machine was purchased from Swanson-Erie Corporation, Anaheim, California in accordance with Avco Specification No. M300-549-003 Rev. B which describes specific performance and design requirements for this machine. (See Appendix I for sample Specification).

The instruction manual, which describes the detail functions of the machine, station-by-station and trouble shooting instructions, is contained in Appendix II.

A meeting was held on 30 June 1975 at Swanson-Erie, Anaheim, California, to review the design and performance requirements, understandings, intent, and procedures to be used in accepting the fuze (less spitback) assembly machine.

The machine was dry cycled for approximately 10 minutes, which afforded everyone an opportunity to observe the machine in operation. This was followed by a run of 500 fuze assemblies, which included crimping of the ogive. Inspection of the parts disclosed two problem areas which required action. The first was a very noticeable burr or sliver around the periphery of the crimped ogive flange. Crimp tooling was modified to eliminate this unacceptable condition. The second problem area involved the gasket. Being of soft silicone rubber it lacked stiffness and did not feed well. In addition as the ogive was crimped, the gasket "squirted" out from under the crimped flange. This latter problem area persisted throughout the entire acceptance demonstration and was responsible for most of the faults or rejects encountered.

To conserve piece parts, several of the acceptance run trials were run with the crimping heads "locked-out". Results are shown in Table IV.

TABLE IV - FINAL FUZE ASSEMBLY MACHINE - ACCEPTANCE RUN RESULTS

Run Number	1	2	3	4	5	6	7	Total
Quantity Run	500	500	1301	2910	1034	804	4451	11500
Good	465	425	1147	2718	847	724	4287	10613
Reject	35	75	154	192	187	80	464	1187
% Rejects	7	15	12	6.6	18	9.9	10.3	10.3
Production Rate	1612	1500	1877	1677	1634	1727	1725	1710
W/ or W/O Crimp	W	W	W	W/O	W/O	W	W/O	

Following the "4-hour run," was the first one-half hour crimping and the next three hours without, after a few minor modifications were incorporated, the machine was deemed ready for shipment.

The machine was installed at Avco Systems Division, and on 8 September 1975 a Swanson-Erie technician was present for the initial start up and running of the fuze assembly machine. Approximately 550 parts were assembled with the machine performing as expected and as well as it did during the acceptance runs at Swanson-Erie.

SECTION III

TESTING OF M549 FUZES FROM THE AUTOMATED LINE

All debugging operations and acceptance runs were conducted using inert components. However, in order to evaluate the safety of each of the machines, 1050 HE Fuzes less spitback were assembled over this equipment from hardware remaining from the acceptance runs. Each Escapement Assembly was checked for Arming Time Delay Values at 12000 RPM prior to final assembly.

Fifty fuzes were selected at random from this lot and subjected to the following ballistic tests.

TABLE V - LOT ACCEPTANCE TEST RESULTS

No. Tested	Target	Temp.	Range	Results	
				High Order	Function
10	3/4" Plywood	AMB	60 ft	0	10
40	2" AP Vertical	AMB	150 ft	40	0

All fuzes were packed for storage Less Spitback Assemblies.

Upon completion of the Ballistic Test, the balance of 1000 M549 Fuzes identified as Lot AVR 1-1 were packed for storage pending receipt of government furnished HE Spitbacks for final fuze assembly.

SECTION IV

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Defense Documentation Center Cameron Station Alexandria, Virginia 22314	 12
Avco Systems Division 201 Lowell Street Wilmington, MA 01887 Attn: B. J. Long Contract Manager	 2

APPENDIX I

OPERATING PROCEDURES

INTRODUCTION

As initially planned and setup, the Automatic Line for assembly of the M549 PIBD Fuze consists of three items of equipment. One each Escapement Sub-assembly,Escapement Assembly, and Final Fuze Assembly Less Spitback. Each machine stands independently of each other with various assemblies being fed from storage by hand on feeder tracks.

Automatic Assembly Equipment for the Top Plate Assembly, Safety Spring Assembly, and Ogive Assembly, or 100% Inspection Equipment was not included in the procurement covered by this contract.

The Assembly Sequence is shown in Figure 2. The rectangles on the left represent those sub-assemblies required by the machines represented by the blocks on the right. The Assembly Sequence begins at the lower left, and proceeds as indicated by the arrows. The 100% ATD and Sample Inspection Machines are not represented in Figure 2. The 100% Inspection operation would be performed between the Escapement and Final Assembly Machines.

FIGURE 2 - M549 FUZE ASSEMBLY SEQUENCE

A description of the detailed functions of each machine by Station, as of the date of this report, is given in the following paragraphs.

ESCAPEMENT SUB-ASSEMBLY MACHINE

The Escapement Sub-Assembly Machine was supplied by Automated Process Inc. of Milwaukee, Wisconsin. (See Figure 3.) It is a rotary type machine with 24 stations to assemble the Escapement Housing, Rotor Shaft, Safety Spring Assembly and Rivet. The function of each Station is as follows:

STATION NUMBER	DESCRIPTION
1	Load Housing
2	Probe Housing
3	Idle
4	Idle
5	Load Rotor Shaft
6	Probe Rotor Shaft
7	Idle
8	Load Safety Spring
9	Probe Safety Spring
10	Idle
11	Idle
12	Idle
13	Idle
14	Load and Seat Drive Screw
15	Probe Drive Screw
16	Idle
17	Idle
18	Idle

STATION NUMBER	DESCRIPTION
19	Unload Good Assemblies
20	Idle
21	Idle
22	Unload Reject Assemblies
23	Probe Empty Nest
24	Idle

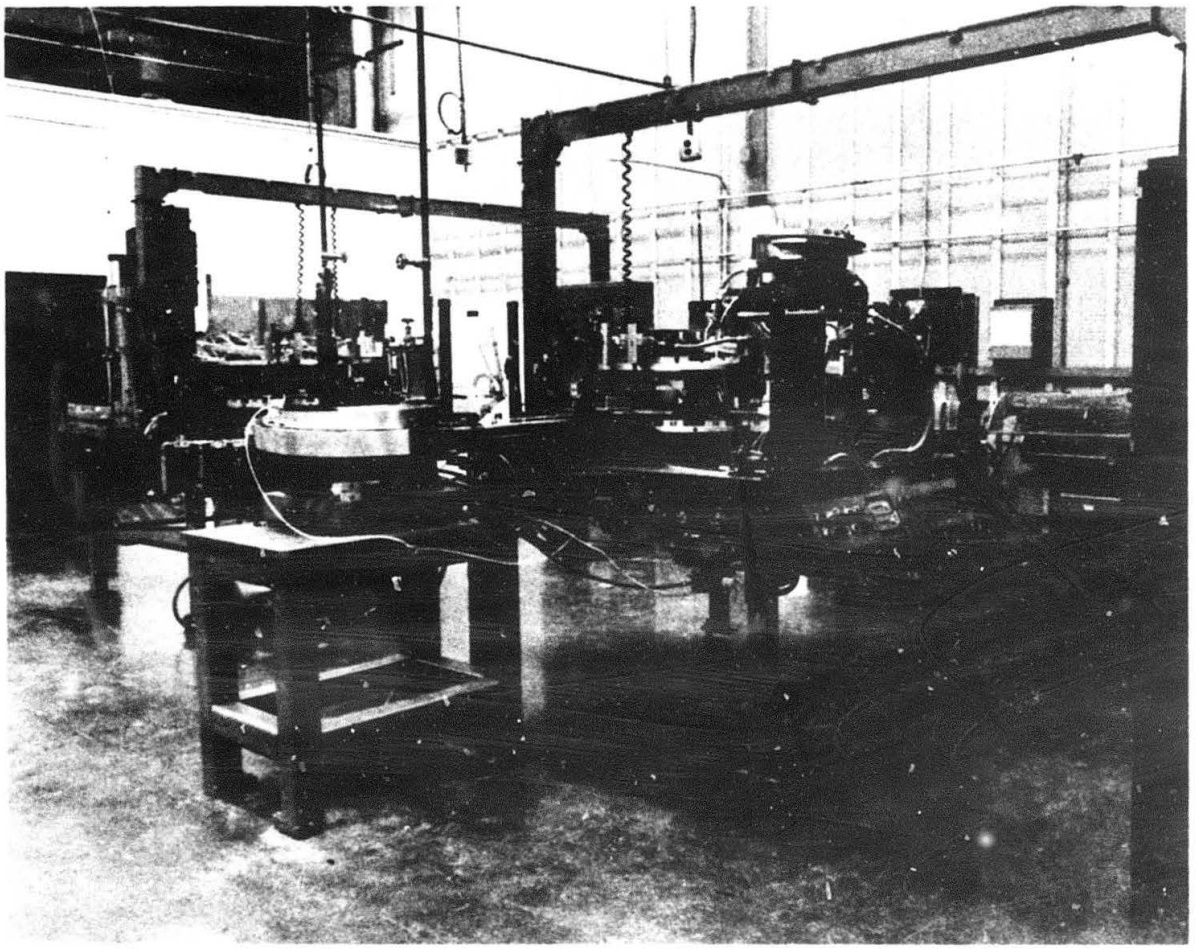


FIGURE 3 - ESCAPEMENT SUB-ASSEMBLY MACHINE

ESCAPEMENT ASSEMBLY MACHINE

The Escapement Assembly Machine was supplied by Automated Process Inc. of Milwaukee, Wisconsin. (See Figure 4.) It is a rotary type machine with thirty-two stations to assemble the Escapement Housing Sub-Assembly Rotor Assembly, Verge Assembly, Pinion Assembly, Anti-Creep Spring, and Top Plate. The function of each Station is as follows:

STATION NUMBER	DESCRIPTION
1	Load Housing
2	Probe Housing
3	Idle
4	Idle
5	Idle
6	Load Rotor Assembly
7	Orient Rotor Assembly
8	Probe Rotor (Position & Presents)
9	Idle
10	Load Verge Assembly
11	Probe Verge Assembly
12	Idle
13	Load Pinion Assembly
14	Probe Pinion Assembly
15	Idle
16	Idle
17	Load Anti-Creep Spring
18	Probe Anti-Creep Spring
19	Probe Presence of Spring (Optical)
20	Load Top Plate
21	Locate Top Plate

STATION NUMBER	DESCRIPTION
22	Probe Top Plate
23	Idle
24	Ultra-Sonic Staking of Top Plate
25	Probe Staking
26	Idle
27	Unload Good Assemblies
28	Idle
29	Idle
30	Unload Reject Assemblies
31	Probe Empty Nest
32	Idle

FIGURE 4 - ESCAPEMENT ASSEMBLY MACHINE

FUZE ASSEMBLY MACHINE LESS MARKING

The Fuze Assembly Machine was supplied by Swanson-Erie Corporation of Erie Pennsylvania. (See Figure 5.) It is a Rotary Type Machine with 20 Stations to assemble the Ogive Assembly, Escapement Assembly, Set Back Pin, Set Back Spring, Bottom Plate and Gasket. The final operation Crimps the Ogive over the Bottom Plate. The function of each Station is as follows:

STATION NUMBER	DESCRIPTION
1	Load and Probe Ogive
2	Idle
3	Load Escapement Assembly
4	Probe Escapement Presence and Unarmed Condition
5	Load Set-Back Pin
6	Idle
7	Load Set-Back Spring
8	Probe Presence and Position of Set-Back Pin Spring
9	Probe Presence and Position of Set-Back Pin
10	Load and Probe Bottom Plate
11	Idle
12	Load Gasket
13	Probe Gasket
14	Pre-Crimp Ogive
15	Final Crimp Ogive
16	Idle

STATION NUMBER	DESCRIPTION
17	Check Maximum Height (1.334 DIM.)
18	Unload Good Assembly
19	Unload Reject Assembly
20	Probe Empty Nest

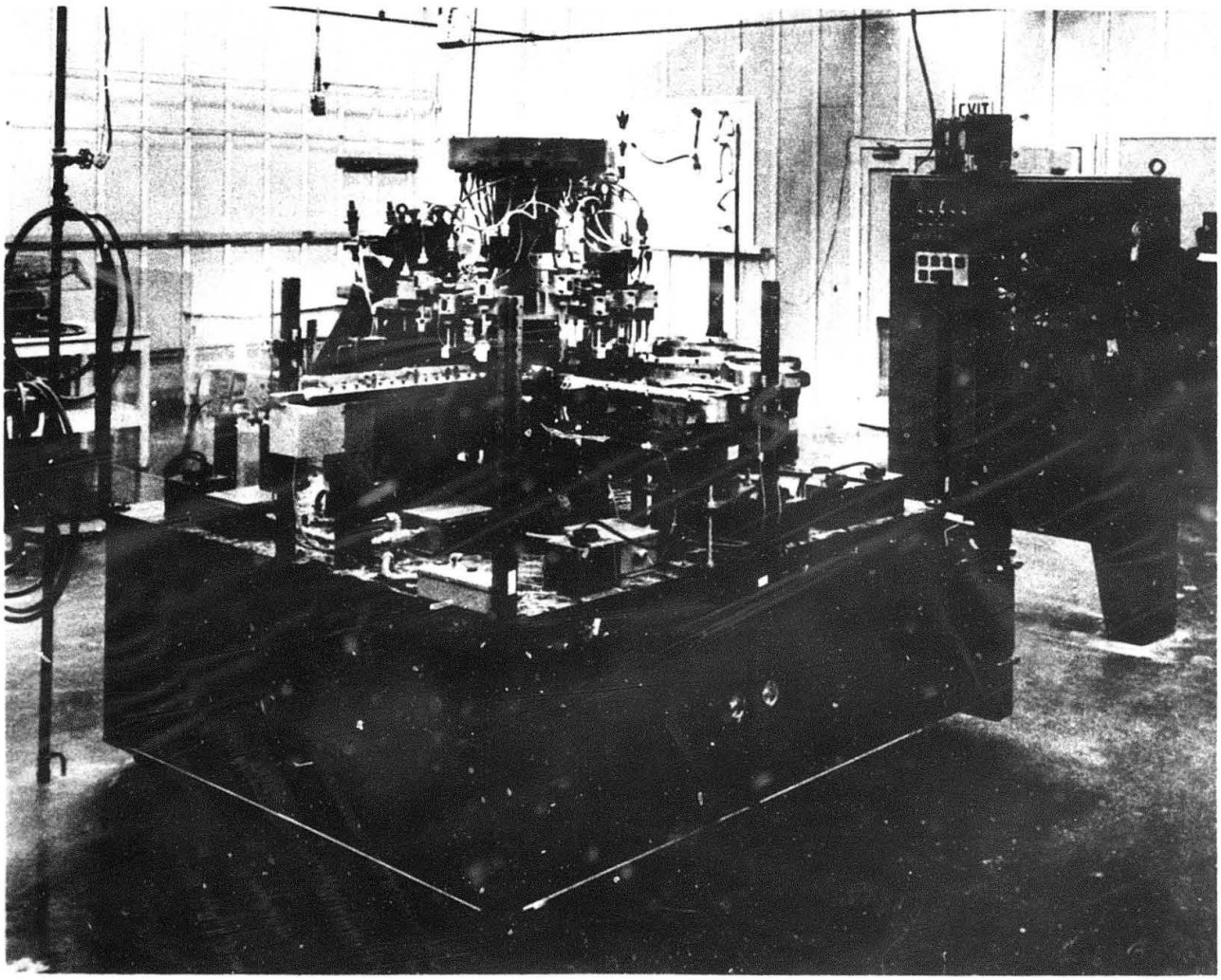


FIGURE 5 - FINAL FUZE ASSEMBLY MACHINE

APPENDIX II

PURCHASE DESCRIPTIONS

This section includes a sample Purchase Description typical for all three machines. The complete list of Purchase Descriptions follows:

M300-549-0001	Rev. A	Escapement Sub-Assembly
M300-549-0001	Rev. A	Escapement Assembly
M300-549-0003	Rev. B	Fuze less Spitback Assembly

AVCO

Avco Spec. No. M300-549-0001 Rev. A

ITEMS DIVISION
OWELL STREET, WILMINGTON, MASSACHUSETTS 01887

AVCO SYSTEMS DIVISION

EQUIPMENT SPECIFICATIONS

AUTOMATIC ESCAPEMENT SUB-ASSEMBLY MACHINE

EQUIPMENT SPECIFICATION FOR

AUTOMATIC ESCAPEMENT SUB-ASSEMBLY MACHINE

1.0 Scope. - This specification defines the requirements for an automatic assembly machine for the M549 Escapement Sub-Assembly. The machine shall have capability to orient, load, assemble and inspect the Escapement sub-assembly components. The machine must also have inspection capability to accept or reject the inspected assemblies. The assembly machine must perform at a normal rate with reasonable maintenance for at least (5) years.

2.0 Applicable Drawing. - The following drawings define all the detail parts to be assembled.

Part Nomenclature		Drawing No.
a.	Escapement sub-assembly	Pictorial view (Figure 2 attached)
b.	Escapement housing	383073
c.	Safety spring assembly	383074
d.	Drive screw	MS21318-1
e.	Rotor shaft	9287868

3.0 Design Requirements

3.1 Rate

a. The Escapement Sub-Assembly Machine shall be capable of a rate of 2400 cycles per hour with an optimum running rate of 2100 cycles per hour.

b. The machine shall produce a minimum of 1900 acceptable escapement sub-assemblies per hour. The machine reject rate, excluding defective parts, must not reduce the minimum net production rate below 1900 assemblies per hour.

c. The specified net hourly rate shall be maintained even though detail parts may vary within tolerances shown on the drawings of Paragraph 2.0. A burr on the part within drawing tolerance limits shall not interfere with the performance of the assembly machine.

3.2 Feed System

a. Equipment supplier shall provide the automatic feed system for each of the parts listed in Paragraph 2.0, b thru e. The parts will be bulk loaded manually. The output (acceptable assemblies) shall be fed into an automatic dispensing track.

b. The feeding of all detail parts in proper oriented position shall be at a rate faster than the maximum machine cycle time.

c. Transfer mechanisms shall be of suitable design to transfer parts from feeders, nests or tracks as required and must have smooth acceleration and deceleration.

d. All feed mechanisms shall be constructed to prevent any damage to components. Materials chosen are to be wear resistant for efficient long life use.

e. Feeder bowls, where used, shall meet the OSHA noise level requirements. The noisy feeder bowls will be covered with a suitable sound absorbent material inside and outside. The bowl shall be equipped with a flow control system which will operate the feed only when parts are needed. The bowls shall also have adjustable sub-bases for leveling and height adjustment.

f. Height of input or output tracks shall be 48 to 50 inches from the floor.

3.3 Inspection System

a. The machine shall have inspection stations to detect the presence and the orientation of the part (or parts) and to inspect the acceptability of assembled parts after each assembly operation.

b. Master set-block will be provided by the supplier for selected work stations to enable setting and checking of tooling with minimum of effort. Avco/SD Quality Control Department will select the stations.

3.4 Drive Mechanism

a. The Escapement Sub-Assembly Machine shall be equipped with a variable drive. The range of variation shall be 900 to 2400 cycles per hour.

b. The drive unit must provide smooth acceleration and deceleration of index. Automatic disengagement and signal device shall indicate when an overload occurs. The drive unit shall allow manual disengagement and provide a jog system to facilitate hand clearing and setup.

4.0 Control System

a. The Escapement Sub-Assembly Machine shall be controlled and operated by one (1) operator using no more than normal effort.

b. The Escapement Sub-Assembly Machine shall have a triple fault memory system that is adjustable from one (1) to three (3) faults. A negative signal at a probe station shall allow continued operation, unless it is set for single fault, and lockout subsequent operations. Faulty assemblies shall be unloaded at the reject station.

c. The memory system shall control the operational assembly sequence. The memory may use mechanical pins or shift register, whichever is more feasible. The sequential memory system is comprised of components which "remember" the status of all previous operations and stores this information, regardless of input power loss, at each inspection station. Each inspection station electro-mechanically senses the Go/No-go status of a previous operation. The information (Go/No-go) is then passed to the appropriate memory unit. At each succeeding index in the assembly sequence, the memory "follows"

any faulted part and locks out any additional assembly operation. At the proper index point, the memory initiates the reject feature removing the faulted part. The memory system also maintains a fault count. Each inspection station has in addition to the memory, a setable counter. If any inspection station registers one or more successive faults according to its setting, the machine is stopped and a fault indicator is illuminated which allows the operator to quickly locate the problem station.

d. A negative probe signal shall be visually displayed on the control panel for an empty nest, and stop the machine with tooling retracted just prior to index.

e. The reject station shall provide safe disposal of incomplete assemblies.

f. Controlled machine stoppage, either operator initiated or automatic fault, shall be with tooling retracted just prior to table index. A machine stoppage due to a malfunction can not again be started until operator manually depresses a reset button after having corrected the cause of the stoppage.

g. All electrical controls to be readily accessible and plainly labeled. Trouble indicators shall be visible 360° around the machine. Stop buttons shall be accessible on two (2) opposite sides of the machine.

The specific information regarding the above mentioned areas can be obtained from MIL-STD-1472A. Avco/SD will review and approve the design.

5.0 Construction

a. The Escapement Sub-Assembly Machine shall be of sturdy construction and braced to withstand maximum operation and shipping loads. The machine shall take only a minimum of space and be free standing on the floor.

b. All mechanisms shall be simple, rugged and adjustable. Standard commercially available parts shall be used where possible. Parts that are subject to wear, must be replaceable and dimensionally controlled for interchangeability. Parts that are subject to wear shall be reviewed for applicability to Paragraph 8.0c.

c. All adjustable mechanism must be simple, fail safe and readily accessible to the operator.

d. It is preferable that the mechanism shall be driven by mechanical means. If pneumatic systems are contemplated they are to be subjected to Avco/SD for review and approval.

e. Mechanical sensing switches on valves to be cam operated.

f. Two (2) flush mounted duplex outlets wired for 110 VAC fuzed for 20 AMP service shall be provided on two (2) opposite sides of the machine.

h. Pressure sensitive switch shall be provided to stop the machine if the air pressure drops below a preset level.

i. The main control station shall have the following minimum controls:

I. Start

II. Stop

III. Run

IV. Jog - Single cycle - Auto cycle

V. Reset

j. The control panel shall be equipped with spare wiring (labeled spare) for 15% future additions.

k. The machine shall have three (3) counters. Two (2) counters will be key re-setable. One (1) shall register "accepted", the other "rejected" assemblies. The third counter will register total machine cycles and shall not be re-setable.

l. The following human engineering criteria shall be taken into account while designing the control panel.

I. Transilluminate Displays.

II. Color Coding: Machine Status and flow indicator

III. Control size and configuration

IV. Functional grouping of displays and controls

V. Lines of sight and visual field requirements of operator.

VI. Legibility of labels

VII. Lock-out mechanisms

g. If the following type of equipment is part of the assembly machine, the manufacturer specified shall be used. Equivalent equipment must be approved by Avco/SD.

I. Solenoid valves to be Numatic or Bellows-Valvair.

II. Air regulators, filters and dryers to be Norgren or Schrader Heavy Duty.

h. All probes, punches, nests and chutes shall be constructed to prevent any damage to component parts or finished assembly.

i. Work stations shall be self contained and removable. Covers or enclosure shall be provided as necessary to prevent foreign material from entry into mechanisms.

j. All pivot points shall be supported on anti-friction bearing for accuracy, rigidity and long life.

k. All stops shall be provided with hardened contact surfaces. Stop adjusting screws must be hardened and have sufficient contact area provided to assure long life and minimum re-adjustment.

l. Shot pins, lock blocks or other positive stop method shall be utilized at all working stations to insure repeatability and accuracy.

m. A central lubricating system shall be provided, with sufficient capacity, to insure adequate lubrication of all functional parts. Lubrication requirements shall not exceed daily applications.

n. Surfaces which are subject to corrosion shall be protected against corrosion; unpainted surfaces may be protected by permanent rust inhibitor. Lubrication of all working surfaces shall be considered adequate corrosion protection.

o. The assembly machine shall be guarded to protect operators, equipment and accessories. The guards and protection methods shall comply with the OSHA Standards of Paragraph 6.0.

p. The machine exterior surfaces shall have one (1) coat of primer and two (2) coats of No. 23-76 Vista Green Lavax Machinery Enamel (Pittsburgh Paint Co.) minimum. Electrical boxes and accessories shall be painted as above except use No. 23-81 Focal Orange (Pittsburgh Paint Co.).

q. The general construction of the equipment must be provided for easy access for maintenance, part replacement, adjustment and lubrication.

6.0 Standards. - Electrical systems shall be Underwriter Laboratory qualified and meet NEMA Standards. The equipment shall comply with Federal Occupational Safety and Health Act of 1970, P.L. No. 91-596.

7.0 Input Power Requirements

a. Electrical power shall be 440 volts, 1 phase, 60 Hz. Electrical motors and associated starters shall be for use with 220/440 VAC connected for 440 volts, 3 phase, 60 Hz. Electrical motors of 1/3 horsepower or less may be 110 volts, 1 phase, 60 Hz. Reduced

voltage transformers shall be integral with the equipment. All control circuits shall be 110 VAC maximum.

b. When compressed air is used, Avco/SD shall conduct a review of the intended use and approve each application employed in the Escapement Sub-Assembly Machine. The final design and assembly drawing must clearly indicate where compressed air is to be used.

c. Pneumatic service shall be 80± 10 Psi compressed air. If equipment has a high demand rate (greater than 12 cubic feet per minute), a surge tank shall be provided.

d. Component parts using compressed air to actuate motion shall have the capacity to provide more than the anticipated power required and meet the OSHA Standards of Paragraph 6.0.

3.0 Documentation & Services

a. A complete set of reproducible drawings, schematics, wiring diagrams and parts lists. All drawings are to be prepared on Avco format in accordance with MIL-D-1000 Cat. E Form 3. (Note paragraps 3.11, 3.12, 3.13, & 3.14 of MIL-D-1000 shall apply). The above drawings and lists are to be provided one (1) week prior to shipment of the equipment to Avco/SD.

b. Three (3) Instruction Manuals containing operating, setup, maintenance and trouble shooting instructions for each station or position including ancillary equipment. The manuals shall be provided one (1) week prior to shipment.

c. A list indicating the repair parts for perishable tooling, pneumatic components and electrical components shall be identified by the equipment supplier based on expected attrition due to use or breakage. This list shall be available for Avco/SD review and approval one week prior to shipment of the machine.

d. Prior to starting formal design drawings, the expected foot print dimensions, input and output track locations shall be supplied to Avco/SD. During the design phase, this information shall be updated as necessary.

e. Avco/SD personnel shall have the right to periodically examine the production of the machine at any time during its manufacture.

f. The service of a field engineer to supervise setup, installation. The field engineering service shall be provided for at least one (1) week.

g. Monthly progress reports. Written monthly progress reports shall be provided to Avco/SD no later than the 5th day of the month. These reports shall include as minimum the following information:

1. Status of machine design, fabrication, assembly, test and debug efforts as appropriate.
   (1) Progress of feeder bowl vendors.
   (2) Status of piece part and or subcontract activities.
2. Identification of existing and/or potential problem areas.
3. Worked planned for the upcoming month.

9.0 Avco/SD Responsibility

a. A drawing of each component part showing tolerance, to be assembled.

b. A drawing of the completely assembled Escapement Sub-Assembly.

c. A complete set of detail parts for 10,000 assemblies to functionally test and debug the machine at the equipment supplier's facility.

d. Timely approval or review of the following:

I. Spare parts list (Ref. Paragraph 8.0c)

II. Pneumatic systems (Ref. Paragraph 5.0d)

III. Parts

IV. Assembly sequence

V. Design concept (Ref. Paragraph 10.0).

e. Moving machine at Avco/SD to a location within Avco/SD.

f. Setup and connect assembly machine to the necessary power under the direction of the field engineering (Ref. Paragraph 8.0f)

10.0 Design Approval

The design concept shall be approved by Avco/SD prior to manufacture. This approval does not relieve the equipment supplier's responsibility to meet the requirements set forth in this specification. The approval only indicates that the general design is satisfactory and meets at least minimum overall system requirements.

11.0 Machine Acceptance

The final acceptance of the Escapement Sub-Assembly Machine shall be accomplished in two (2) phases.

Phase 1: Vendor's Facility

A complete demonstration run of the Escapement Sub-Assembly Machine shall be conducted in presence of Avco/SD representative at supplier's facility. During this demonstration, the Escapement Sub-Assembly Machine shall meet the production requirements of paragraph 3.1 (a, b and c) for four (4) continuous hours. During this demonstration run the machine shall also meet the one operator requirement of paragraph 4.0a in total.

Phase 2: Avco's Facility

The final machine acceptance run will be conducted, following installation, alignment and adjustment of the Escapement Sub-Assembly Machine at Avco/SD facility. The machine shall again meet the production output requirement of paragraph 3.1 (a, b, and c) for four (4) continuous hours and satisfy the requirement of paragraph 4.0a. in total. The machine operator shall be Avco/SD personnel, under the surveillance of a vendor field engineer, during this final acceptance run.

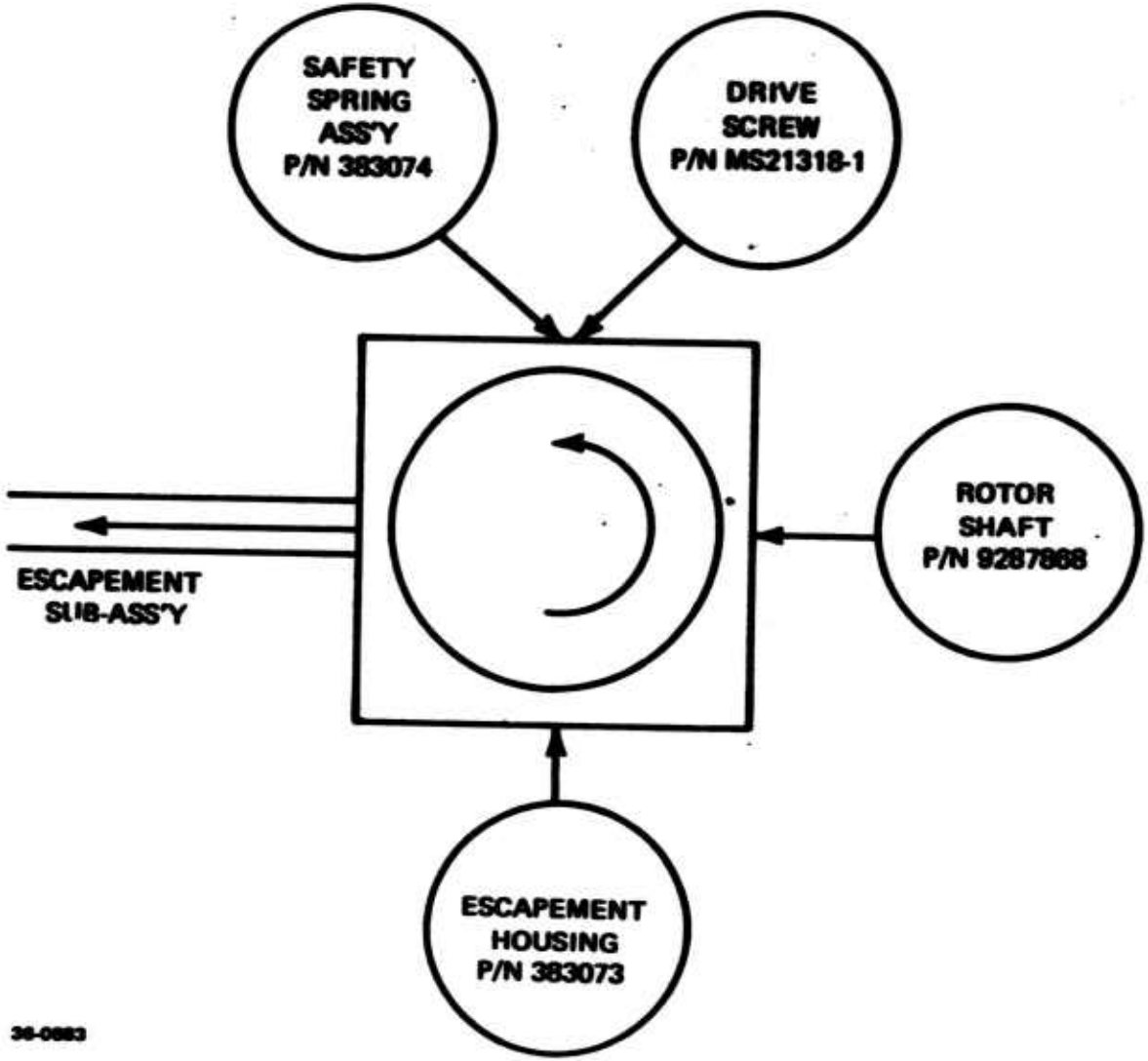
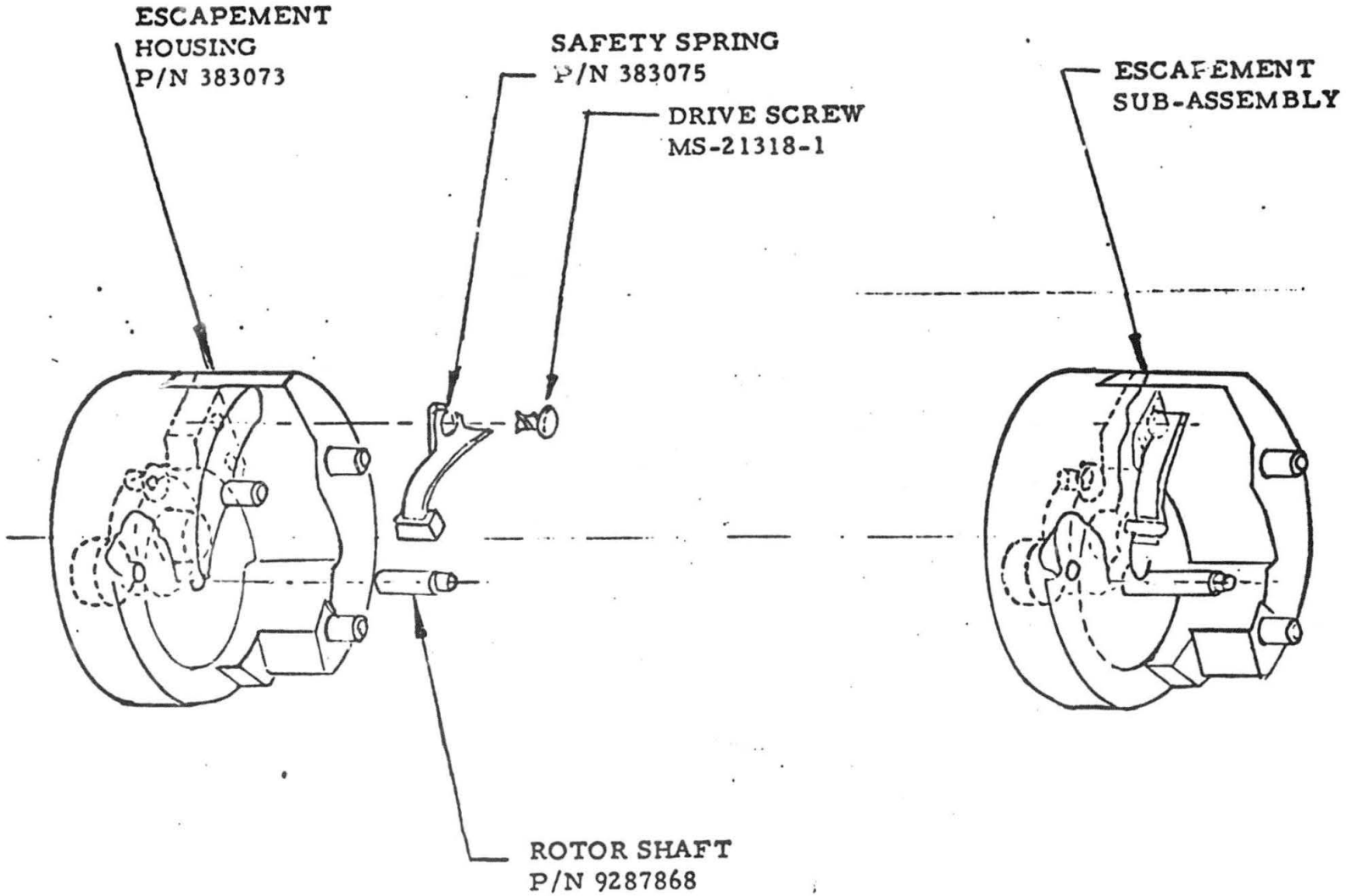


FIGURE 6 ESCAPEMENT SUB-ASSEMBLY MACHINE PART INPUT – OUTPUT SEQUENCE



ESCAPEMENT SUB-ASSEMBLY

FIGURE 7

APPENDIX III

INSTRUCTION MANUALS LISTING

Job No. A12-23-74	ESCAPEMENT SUB-ASSEMBLY MACHINE, AUTOMATED PROCESS INC.
Job No. A12-24-74	ESCAPEMENT ASSEMBLY MACHINE, AUTOMATED PROCESS INC.
Job No. 3945	FINAL FUZE ASSEMBLY MACHINE-SWANSON-ERIE CORPORATION

Instruction manual for the Escapement Sub-Assembly Machine is enclosed as an example.

APPENDIX III

INSTRUCTION MANUAL

AVCO/SD

ESCAPEMENT SUB-ASSEMBLY MACHINE

DESIGNED AND BUILT BY

AUTOMATED PROCESS, INC.

MILWAUKEE, WISCONSIN

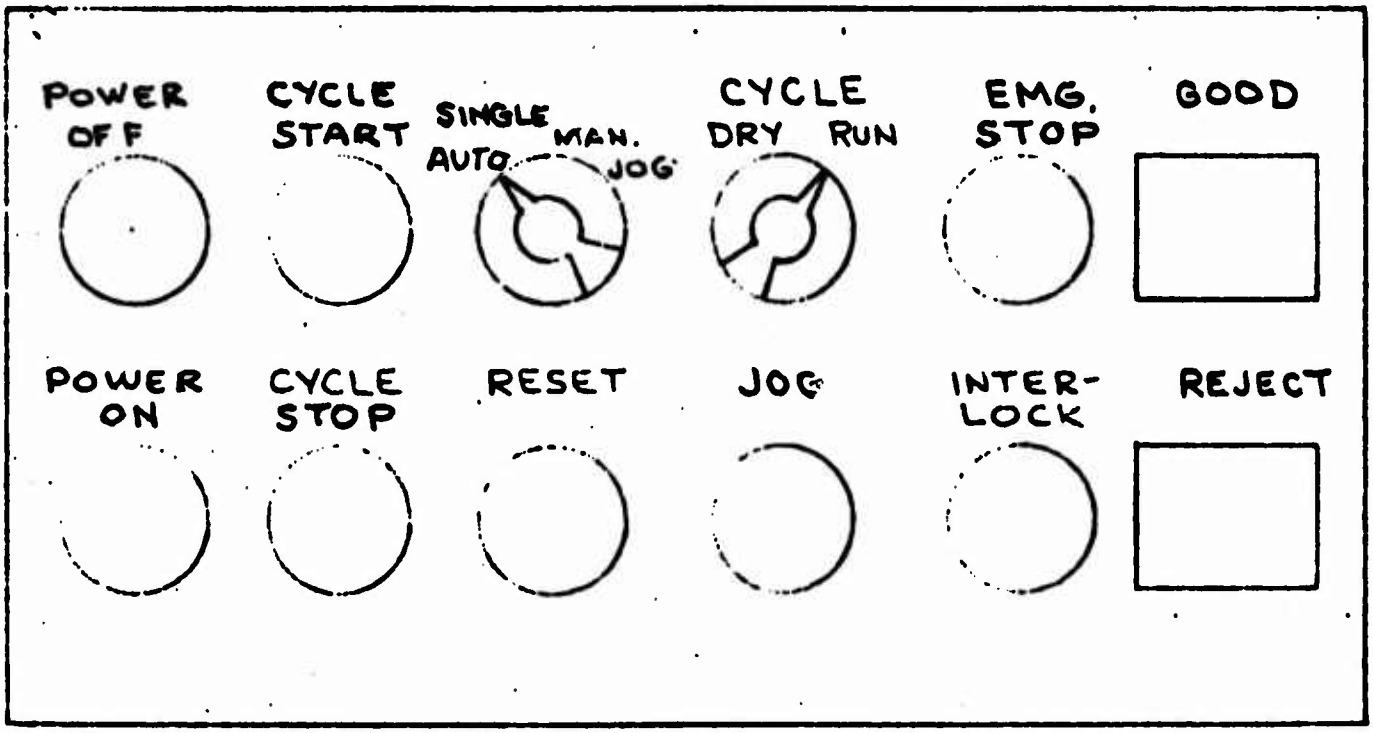
PHONE: (414) 354-4370

JOB NO. A12-23-74

TABLE OF CONTENTS

I. CONTROLS

A. OPERATOR'S STATION



EMERGENCY STOP

Pressing this button causes the machine to stop <u>immediately</u>. Before starting the machine, the syncrocam must be returned to the "Zero" position. (See machine functions, basic machine).

POWER ON

Pressing this button brings power to the machine. This is an illuminated (green) push button.

POWER OFF

Pressing this button shuts off power to the machine. This would normally be used at the end of a day's run.

CYCLE START

Pressing this button will start the machine and it will continue to cycle automatically until stopped by a "Cycle Stop", a malfunction, or an "Emergency Stop". NOTE: The "Power On" light must be on for this button to operate.

CYCLE STOP

Pressing this will stop the machine at the end of its cycle. This button is normally used for short stops during a day's run.

RESET

This button is pressed after clearing any malfunction as indicated by a trouble light. Pressing this button will turn off the trouble lights and enable the "Cycle Start" button to operate.

AUTO/SINGLE/MANUAL/JOG

This selector switch must be turned to "Auto" for automatic cycling. Whenever the machine is hand-cranked through a cycle, the selector switch must be turned to "Manual". Also, whenever the jog button is used, the selector switch must be turned to "Jog".

The "Single" selection position will allow only a single cycle to occur.

JOG

Pressing this button when the above mentioned selector switch is in "Jog", will allow an operator to jog the machine through a cycle. The speed of the indexer in jog is slower than automatic cycling. (An adjustable speed control is located in the main electrical cabinet.)

Caution must be exercised in jogging because the Gilman indexer has an overload feature on the dial which can actuate because an inertia loads when jogging. The machine should always be jogged back to "Zero".

CYCLE - RUN/DRY

This selector switch allows the machine to be run without parts if in the "Dry" position.

For normal cycling, this switch must be in the "Run" position.

INTERLOCKS (LIGHT)

This light indicates that one or more of the guards around the machine is not in place. The light will go off when all guards are proper.

If a guard is opened when the machine is running, the machine stops immediately.

COUNTERS GOOD-REJECT

These counters record the acceptable and unacceptable assemblies. they are key resetable.

Another set of push button controls is located 180° from this main control.

The buttons incorporated are:

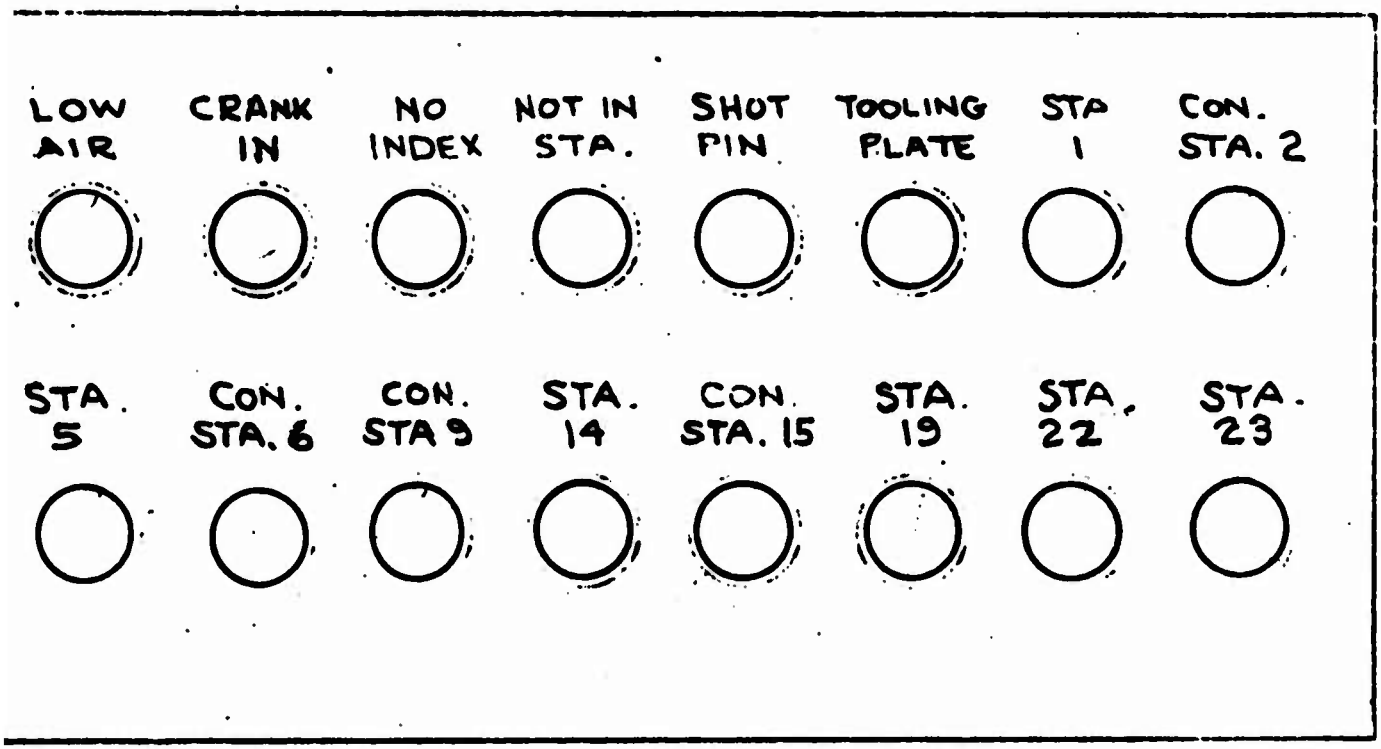
1. Cycle Start
2. Cycle Stop
3. Reset
4. Emergency Stop

Their function is the same as listed above.

B. TROUBLE LIGHTS

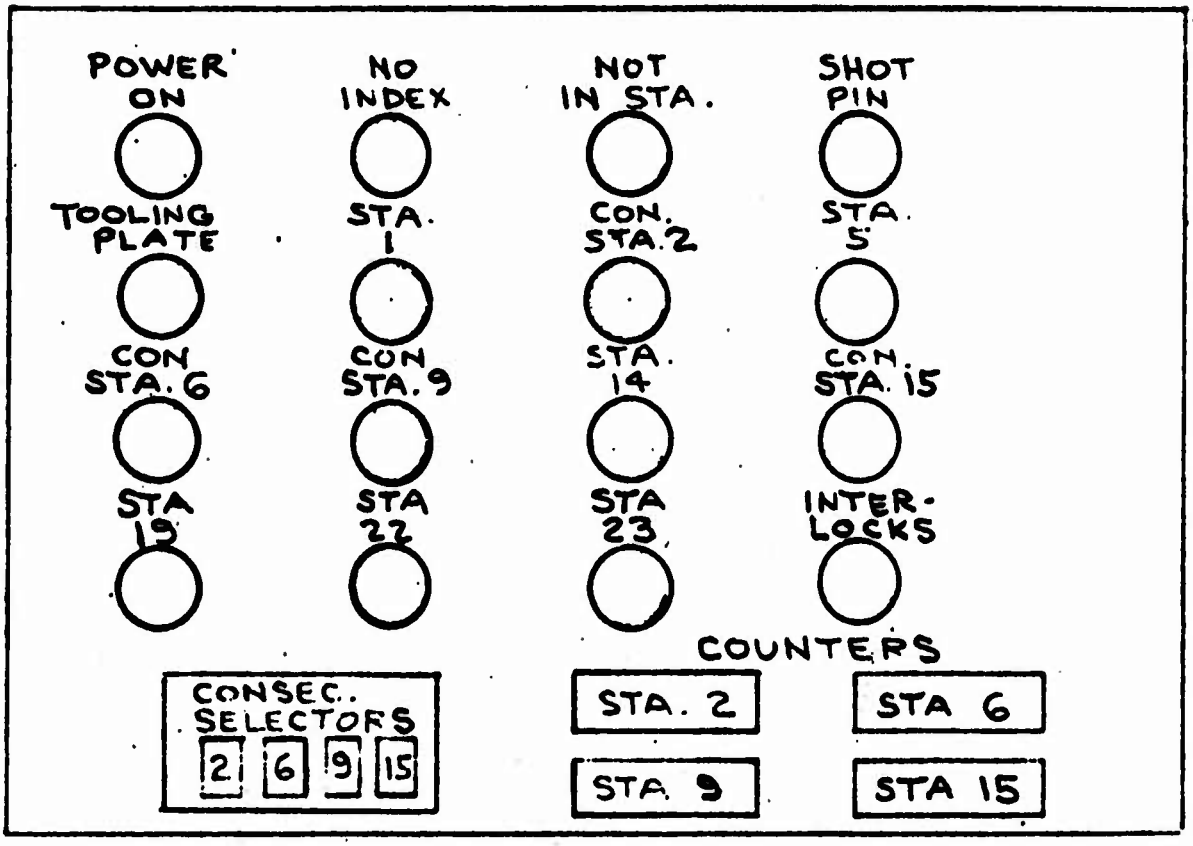
Two sets of trouble lights are provided.

ON MACHINE



B. (continued)

ON MAIN ELECTRICAL CABINET



LOW AIR

This light will come on whenever the air pressure drops below the setting on the pressure switch. (The pressure switch is set at 50 PSI). Before power to the system can be turned on, this light must be off.

CRANK IN

This light will come on whenever the hand crank is engaged with the indexer input shaft. The machine cannot be cycled automatically if this light is on. When cycling manually, this light should be on.

NO INDEX

This light will come on at the 20° point on the syncrocam, if the dial plate has not begun indexing. This will stop the machine immediately and it must be hand cranked forward to the "Zero" mark on the syncrocam.

NOT IN STATION

This light will come on at the 90° point on the syncrocam, if the dial plate is not in station. This is determined by a limit switch not being tripped. This will stop the machine immediately and it must be hand cranked forward to the "Zero" mark on the syncrocam.

TOOLING PLATE

This light will come on at the 220° point on the syncrocam, if the tooling plate has not come down 2". This will stop the machine immediately and it must be hand cranked forward to the "Zero" mark on the syncrocam.

SHOT PIN

This light will come on at the 135° point on the syncrocam, if the shot pin has not entered the dial plate. This will stop the machine immediately and it must be hand cranked forward to the "Zero" mark on the syncrocam.

TROUBLE LIGHTS

These lights will come on whenever a malfunction occurs at its respective station. In the case of station #2, #6, #9, and #15, consecutive rejects will cause that particular light to come on. The number of consecutive rejects is adjustable from 1 to 3 for each station.

C. CONSECUTIVE REJECT SELECTOR STATIONS

To program the number of consecutive rejects at stations #2, #6, #9, and #15, before the machine will stop, individual selector knobs are provided. The consecutive rejects can be programed from one to three.

D. STATION REJECT COUNTERS

Individual key resetable counters have been provided for the probing stations #2, #6, #9, and #15.

The total count of these may not agree with the total reject counter because it is possible for rejects to be counted at a probe station but not yet ejected from the machine.

E. CONTROLS INSIDE THE MAIN ELECTRICAL BOX

Located inside the main control box is:

1. Automatic machine cycle control. VR-1.
2. Jog machine cycle control. VR-2.
3. Total cycle counter. (Non resetable).
4. Time delay, on and off, for storage controls. (Refer to electrical diagram before making any of these adjustments).

II. MACHINE FUNCTIONS

A. SEQUENCE OF OPERATIONS

STA.

1. Load Housing
2. Probe Housing
3. Idle
4. Idle
5. Load Rotor Shaft
6. Probe Rotor Shaft
7. Idle
8. Load Spring
9. Probe Spring
10. Idle
11. Idle
12. Idle
13. Idle
14. Load And Seat Drive Screw
15. Probe Drive Screw
16. Idle
17. Idle
18. Idle
19. Unload Acceptables
20. Idle
21. Idle
22. Unload Reject Parts
23. Probe Empty Nest
24. Idle

B. BASIC MACHINE

This machine is designed around a Gilman Model 250 Indexer. (Other indexer information is):

1/4 index - 3/4 dwell, 24 stations, counter-clockwise rotation, adjustable cycle time, a reciprocating plate with 2 " stroke.

The indexer is powered by a 3/4 H.P., D.C. motor.

The reciprocating plate has limit switches at the top and bottom of its stroke.

The hand crank has a safety limit switch interlock. The machine cannot be run with the hand crank engaged.

The dial has an "In-Station" switch, which insures that the dial has indexed and also that the dial is properly oriented.

A shot pin is used to more accurately position the dial. Interlock limit switches check both engaged and retracted positions.

Other types of controls incorporated are:

Auto-manual selector

Power-on button and light

Power-off button

Emergency stop

Cycle start button

Cycle stop button

Reset button

Low air switch and light

Good part counter

Reject counter

Total cycle counter

C. STATIONS:

STA. 1: LOAD THE HOUSING

The housing is orientated and fed to the machine with a vibratory feed system consisting of a 21" diameter bowl and an 18" in-line drive unit with 28" of stainless steel track. The bowl and in-line are mounted to a common base plate which is self-supported to the floor. Storage controls on the in-line control the bowl.

The in-line feeds the parts into an isolation device which moves one (1) unit into the load mechanism. The isolation device is air operated.

The load mechanism is mechanically connected to the reciprocating plate. This mechanism is over-load protected. As the reciprocating plate moves down, the housing is loaded into the nest. As the reciprocating plate moves up, the pusher retracts out of the dial. An interlock switch checks to see that the pusher has traveled through its full forward stroke.

Incorporated in the nest design are two spring loaded pins. These pins are used to locate the housing in the nest. Before the housing can be loaded, these pins must be retracted. This is accompleished with an air operated "Pull-Down" located under the dial. The pins are returned to the up position during the time that the reciprocating plate is in the "Dwell-Down" position.

The "Pull-Down" device has an interlock switch to check that the unit is in the up position before index.

STA. 2: PROBE THE HOUSING

A standard two limit switch A.P.I. probe is used to check the presence and position of the housing. This probe is mounted to the reciprocating plate.

The probe is designed to locate over the three posts of the housing. The function of this probe is basically a height check.

STA. 3: IDLE

STA. 4: IDLE

STA. 5: LOAD THE ROTOR SHAFT

A 12" diameter vibratory bowl orients the shaft feeding them end to end with the small diameter end trailing into a discharge chute.

An air operated escapement allows one (1) shaft at a time to be released into a looped tube connected to the reciprocating plate.

At the proper time, the shaft is blown from the tube into a positioning block mounted to the reciprocating plate. The shaft stops against an air operated arm.

As the reciprocating plate moves down, the positioning block stops on the nest and the arm is actuated out of the way. The shaft is pressed into the housing by means of an air cylinder. An interlock switch checks to see that the cylinder has made a complete forward stroke.

STA. 6: PROBE THE ROTOR SHAFT

This probe checks two dimensions.

1. By design it checks the position of the small end of the rotor shaft with relationship to the three posts in the housing.

2. By use of a "Federal" electricator, it checks the height of the step in the rotor shaft with respect to the top of the housing.

The probe is mounted to the reciprocating plate.

STA. 7: IDLE

STA. 8: LOAD THE SPRING

The spring is oriented and fed to the machine with a vibratory feed system consisting of a 15" diameter bowl and an 11" in-line with 18" of tooled steel track. Storage controls on the in-line will control the bowl.

The part orientation as presented to an isolation mechanism is:

Hanging by weight, the long dimension of the weight parallel to the direction of travel, with the hole down and leading.

STA. 8: LOAD THE SPRING Continued

The isolation mechanism is mechanically actuated. The part is rotated 90° to the pick-up point.

The transfering of the part into the nest is done with a stelron pick and place unit, to which has been attached a vacuum head.

The vacuum head has a spring loaded pilot pin which locates in the hole of the spring.

When the piece part has been placed on the nest, an air blast through the vacuum holes insures that it has been stripped from the pick up head.

STA. 9: PROBE SPRING

A standard two limit switch A.P.I. probe is used to check the presence and position of the spring.

This probe is mounted to the reciprocating plate.

STA. 10: IDLE

STA. 11: IDLE

STA. 12: IDLE

STA. 13: IDLE

STA. 14: LOAD AND SEAT DRIVE SCREW

A "Dixon" automatic parts positioner model AP 107 is used to feed and drive the screw into the housing. This is a completely self-contained unit with a parts hopper, feed track and driver head. It is an air operated device.

STA. 15: PROBE THE DRIVE SCREW

A standard two limit switch A.P.I. probe is used to check the presence and position of the screw.

The probe is mounted to the reciprocating plate.

The function of the probe is basically a height check.

STA. 16: IDLE

STA. 17: IDLE

STA. 18: IDLE

STA. 19: UNLOAD ACCEPTABLES

The acceptable parts are unloaded from the nest onto an 11" in-line with 18" of track.

Upon demand, the pins in the nest are retracted by an air mechanism. The part is then ejected from the nest by a pusher connected to an air cylinder.

The cylinder used to retract the pins has an interlock switch to check that the unit is in the up position before index.

The pusher cylinder has interlock switches on both ends of its stroke.

STA. 20: IDLE

STA. 21: IDLE

STA. 22: UNLOAD REJECT PARTS

The reject parts are unloaded from the nest onto an inclined chute.

The pins in the nest are retracted by an air mechanism and the parts are then pushed out of the nest with a mechanism connected to the reciprocating plate.

The cylinder used to retract the pins has an interlock switch to check that the unit is in the up position before index. An air blast is used to insure that loose parts have been ejected from the nest.

STA. 23: PROBE EMPTY NEST

A standard one limit switch A.P.I. probe is used to check that the nest is empty.

The probe is mounted to the reciprocating plate.

STA. 24: IDLE

III. CAM SWITCH FUNCTIONS

CAM SWITCH	FUNCTION	STATUS	DEGREES
1	"Zero" Stop	Actuated	5° to 345°
2	"No Index" Check	Released	25° to 35°
3	"Not In Station" Check	Released	90° to 100°
4	Shot Pin	Actuated	90° to 310°
5	"Tooling Plate Down" Check	Released	210° to 220°
6	Escapement Station 1	Released	20° to 140°
7	Pull-Down Station 1	Released	100° to 220°
8	Check Probing Stations	Released	260° to 270°
9	Air Blast Station 5	Released	50° to 90°
10	Jaw Station 5	Released	175° to 340°
11	Escapement Station 5	Released	180° to 310°
12	Vacuum Station 8	Actuated	40° to 260°
13	Blow-Off Station 8	Released	240° to 280°
14	Dixon Cycle Station 14	Released	120° to 285°
15	Pull-Down Sta. 19 & 22	Actuated	100° to 300°
16	Eject Station 19	Released	180° to 270°
17	Clock (Memory)	Released	5° to 90°
18	Air Press Station 5	Released	220° to 285°
19	Spare		
20	Spare		

IV. INITIAL SETUP

A. Remove skid and braces from machine and bowl stands.

B. Remove all tape used to secure loose members.

C. Level machine and anchor to floor, if desired.

D. Align housing bowl and in-line.

E. Connect main air supply. Set main regulator to 60 PSI.

F. Connect main electrical wiring.

Service Required: 460V., A.C., 1 Phase, 15 AMP., 60Hz.

V. OPERATOR FUNCTIONS

A. Check that the indexer is on the "Zero" point on syncrocam.

B. Turn disconnect on door of electrical box, to "On".

C. Turn selector switch to "Auto".

D. Press "Power On" button.

E. Check that all trouble lights are off.

F. Check that all feeder bowls are filled and that the in-lines are not jammed.

G. Press "Cycle Start" button.

H. To stop machine at end of cycle, press "Cycle Stop" button.

I. To stop machine immediately, press "Emergency Stop" button.

J. To turn off trouble lights (after problem has been corrected), press "Reset" button.

K. To turn off power for a long period of time, turn disconnect to "Off".

If the operator presses the "Emergency Stop" during a cycle, all air operated devices will return to their "Zero" or "Power Off" positions. The machine should not be cycled until the syncrocam is back to "Zero".

To do this:

1. Turn selector switch to "Manual".
2. Push in hand crank and turn clockwise until syncrocam is at the "Zero" position.
3. Pull out hand crank and replace swinging "C" washer.
4. Turn selector switch to "Auto".
5. Turn power on.
6. Machine can now be cycled automatically by pressing "Cycle Start" button.

VI. MAINTENANCE RECOMMENDATIONS

A. MACHINE MAINTENANCE

1. As required: Drain the air filters.

   Fill the oilers with #10 SAE oil.

   Clean the machine with special attention to feeder bowls and in-lines.

   NOTE: The coating on the rotor shafts causes a build up in the tube leading from the bowl to the escapement. This tube has to be cleaned frequently to prevent shafts form hanging up.

2. Weekly: Check the automatic greasing reservoir.

SPARE PARTS (ELECTRICAL)

SOFTWARE

Quantity	Description	Supplier
1	700-6-1004	Tenor
1	700-6-1005	"
1	700-6-1010	"
1	700-6-1011	"
2	700-6-1012A	"
1	700-6-1013	"
1	700-6-1015	"
1	700-6-1021	"
1	700-6-1023B	"
1	700-6-1030	"
2	700-6-1117	"
2	720-6-1212	"
1	720-6-1213	"
1	720-6-1221	"
1	720-6-1247A	"
1	720-6-1254	"

HARDWARE

Quantity	Description	Supplier
1	20246-83 Relay	Deltrol
1	TLS-1 Storage Light	Micro
2	800S-N60-Sera Bulb	A-B
1	TPC-OL Photo-Cell	Micro
1	6-Y-1-2-RMF-PM-115VA CNT.	Durant
1	BZE6-2RN Limit Switch	Micro
1	R-HC-04-10 Reed Switch	Tom Thumb

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Parts Feeders • Auxiliary Hoppers • Tracks • Escapements • Small Placing Heads

215 South Munsie (Cumberland)
Indianapolis, Indiana 46229

OPERATING INSTRUCTIONS
Automated Process, Inc.
Job No. 6971, P. O.No. 2374-07-M
To feed P/N 383073 Esc. Hsg.
Attn: Mr. Peter Ahl.

1. This feeder was constructed to operate with approximately 2" of parts (measured at the inside edge of track) in the bottom of the bowl.

2. We operated this feeder at power control setting of 58, running rates of 55 to 60. Since power settings do vary with the local line voltage and individual controls, some trial and error may be needed to determine the proper setting best suited to meet your requirements and insure the specified rate. We used an inline setting of 80.

3. The air supply to the air manifold block should come from a filtered air regulator adjusted to 60 PSI. The air jets which are controlled by individual valves in the manifold block should perform the following functions:

   Air jet No. 1 should aid the part in rolling and orienting itself at the scalloped selector area.

4. The track section of this system has been removed to prevent damage during shipment. When installing, allow .015 to .020 between the track and the bowl discharge. These should not strike under vibration. Also, .015 to .020 should be allowed between a vibrating track (inline) and any non-vibrating parts nest or placing mechanism.

JC:emw

cc: John Mazza

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215 South Munsie (Cumberland)
Indianapolis, Indiana 46229

OPERATING INSTRUCTIONS
Automated Process, Inc.
Job No. 6973, P. O. No. 2374-09-M
To feed P/N 383074, Safety Spring
Attn: Mr. Peter Ahl

1. This feeder bowl was constructed to operate with approximately 3/4" of parts (measured at the inside edge of track) in the bottom of the bowl.

2. We operated this feeder at power control setting of 56, averaging in excess of 150 parts per minute. Since power settings do vary with local line voltage and individual controls, some trial and error may be needed to determine the proper setting best suited to meet your requirements and insure the specified rate.

3. The track section of this system has been removed to prevent damage during shipment. When installing, allow .015 to .020 between the track and the bowl discharge. These should not strike under vibration. Also, .015 to .020 should be allowed between a vibrating track (inline) and any non-vibrating parts nest or placing mechanism.

JC:emw

cc: John Mazza, Jr.

ervice
ngineering
nc.

215 South Munsie (Cumberland)
Indianapolis, Indiana 46229

OPERATING INSTRUCTIONS
A.P.I., Job No. 6987
P. O. No. 2374-21-M
To feed P/N 9287868 .1025 dia. x .556 long
Attn: Mr. P. Ahl.

1. This feeder was constructed to operate with approximately 3/4" of parts (measured at the inside edge of track) in the bottom of the bowl.

2. We operated this feeder at power control setting of 40, and 45, averaging 80 parts per minute. Since power settings do vary with the local line voltage and individual controls, some trial and error may be needed to determine the proper setting best suited to meet your requirements and insure the specified rate.

3. The air supply to the air manifold block should come from a filtered air regulator adjusted to 60 PSI. The air jets which are controlled by individual valves in the manifold block should perform the following functions:

   Air jet No. 1 should push parts traveling small diameter first down and out of the selector.

4. Alignment of the tube adaptor to the bowl discharge is critical. Allow .015 to .020 between the tube adaptor and bowl discharge. They should not strike under vibration.

JC:cmw

cc: Mr. John Mazza

REV._____

AUTOMATED PROCESS INC., MILWAUKEE, WISCONSIN

CUSTOMER: Avco DATE: 9-16-75

TITLE: Sub-Assembly Machine

JOB NO.: A12-23-74 SHEET 1 OF 5

STATION NO.	DESCRIPTION OF SUB-ASSEMBLY	CHARGE NO.	RELEASED TO MFG.	REMARKS
-00	Basic Machine	-00		(7 Sheets)
	Table			
	Dial			
	Tooling Plate			
	Legs			API 1010-6
	Stationary Aux. Tooling Plate			
	In-Station L/S			API 1024
-01	Machine Drive	-01		(5 Sheets)
	Motor			
	Handcrank Assembly			
-02	Auxilary Drives	-02		(5 Sheets)
	(Stelrons & Syncrocams Etc.)			
-03	Nest Fixture			(4 Sheets)
-04	Shot Pin			API 1025
-05	---------			
-06	---------			

REV._____

AUTOMATED PROCESS INC., MILWAUKEE, WISCONSIN

CUSTOMER: Avco DATE: 9-16-75

TITLE: Sub-Assembly Machine

JOB NO.: A12-23-74 SHEET 2 OF 5

STATION NO.	DESCRIPTION OF SUB-ASSEMBLY	CHARGE NO.	RELEASED TO MFG.	REMARKS
-07	Timing Diagram			(1 Sheet)
-08	Pneumatics			(1 Sheet)
-09	Electrical Circuit			(5 Sheets)
1	Load "Housing"	-10		(9 Sheets)
	L/O Assembly Drawing			
	Details			
2	Probe "Housing"	-20		(2 Sheets)
	L/O Assembly Drawing			
	Details			
3	Idle			
4	Idle			
5	Load "Rotor Shaft"	-50		(7 Sheets)
	L/O Assembly Drawing			
	Details			

REV.____

AUTOMATED PROCESS INC., MILWAUKEE, WISCONSIN

CUSTOMER: Avco DATE: 9-16-75

TITLE: Sub-Assembly Machine

JOB NO.: A12-23-74 SHEET 3 OF 5

STATION NO.	DESCRIPTION OF SUB-ASSEMBLY	CHARGE NO.	RELEASED TO MFG.	REMARKS
6	Probe "Rotor Shaft"	-60		(3 Sheets)
	L/O Assembly Drawing			
	Details			
7	Idle			
8	Load "Safety Spring	-80		(10 Sheets)
9	Probe	-90		(2 Sheets)
	L/O Assembly Drawing			
	Details			
10	Idle			
11	Idle			
12	Idle			
13	Idle			

REV._____

AUTOMATED PROCESS INC., MILWAUKEE, WISCONSIN

CUSTOMER: Avco DATE: 9-16-75

TITLE: Sub-Assembly Machine

JOB NO.: A12-23-74 SHEET 4 OF 5

STATION NO.	DESCRIPTION OF SUB-ASSEMBLY	CHARGE NO.	RELEASED TO MFG.	REMARKS
14	Load & Seat	-140		(1 Sheet)
	"Drive Screw"			
	L/OAssembly Drawing			
	Details			
15	Probe	-150		(2 Sheet)
	L/OAssembly Drawing			
	Details			
16	Idle			
17	Idle			
18	Idle			
19	Unload "Good"	-190		(8 Sheets)
	L/OAssembly Drawing			
	Details			
20	Idle			
21	Idle			

REV._____

AUTOMATED PROCESS INC., MILWAUKEE, WISCONSIN

CUSTOMER: Avco DATE: 9-16-75

TITLE: Sub-Assembly Machine

JOB NO.: A12-23-74 SHEET 5 OF 5

STATION NO.	DESCRIPTION OF SUB-ASSEMBLY	CHARGE NO.	RELEASED TO MFG.	REMARKS
22	Unload "Reject"	-220		(6 Sheets)
	L/O Assembly Drawing			
	Details			
23	Probe "Empty Nest"			(2 Sheets)
	L/O Assembly Drawing			
	Details			
24	Idle			

APPENDIX IV

M549 FUZE ASSEMBLY

MATERIAL REQUIREMENTS FOR MACHINE SUPPLIERS

APPENDIX IV

M549 FUZE ASSEMBLY

MATERIAL REQUIREMENTS FOR MACHINE SUPPLIERS

1) A. P. I.

Fuze Escapement Sub-Assembly Machine
Machine No. 1

Part	Total Required	Shipped
Housing	15,000	6/13
Rotor Shaft	15,000	6/13
Safety Spring Assy	15,000	6/20
Drive Screw	15,000	6/13

The following additional parts are required and will be run through No. 1 Machine for use in checking out No. 2 Machine:

Housing	9,000
Rotor Shaft	9,000
Safety Spring Assy	9,000
Drive Screw	9,000

2) A. P. I.

Fuze Escapement Assembly Machine
Machine No. 2

Part	Total Required
Rotor	15,000*
Verge Assy	15,000
Pinion Assy	15,000
Top Plate Assy	15,000
Anti-Creep Spring	16,000**

* 5,000 rotors already shipped with inert detonators. Balance of 5000 shipped without detonators, making a total of 10,000 without detonators.

** 3,000 top plates were shipped without firing pins installed. Balance of 4,000 parts shipped with firing pins installed, making a total of 12,000 top plate assemblies with firing pins.

3) Swanson-Erie
Fuze Assembly Machine
Machine No. 3

Part	Total Required
Ogive	15,000***
Escapement Assy	15,000
Setback Pin	15,000
Setback Spring	15,000
Bottom Plate	15,000
Gasket	15,000

*** 3,200 ogives shipped with actuators installed. Remaining 6,800 shipped without actuators. 1,000 of balance with lead chamfer on crimp flange for machine evaluation.

APPENDIX V

LIST OF EQUIPMENT DRAWINGS

INTRODUCTION

The Drawing Lists that follow are presented in two groups according to vendor. Each machine is identified by the Manufacturers drawing number, which is given along with the machine description in the sequence listed.

VENDOR: Automated Process Inc., Milwaukee, Wisconsin

A12-23-74-00 Escapement Sub-Assembly Machine

A12-24-74-00 Escapement Assembly Machine

VENDOR: Swanson Erie Corporation, Erie, Pennsylvania

75000-100 Final Fuze Assembly Machine

ESCAPEMENT SUB-ASSEMBLY MACHINE

AUTOMATED PROCESS INC.

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
	Escapement Subassy Machine	A12-23-74-00
	Machine Drive	A12-23-74-01
	Auxiliary Drive	A12-23-74-02
	Nest Assembly	A12-23-74-03
	Standard Shot Pin Assembly	A12-23-74-04
	Timing Diagram	A12-23-74-07
	Pneumatic Schematic	A12-23-74-08
	Electrical Diagram	A12-23-74-09
1	Load Housing	A12-23-74-10
2	Probe Presence & Position	A12-23-74-20
3	Idle	
4	Idle	
5	Load Rotor Shaft	A12-23-74-50
6	Probe Rotor Shaft	A12-23-74-60
7	Idle	
8	Load Spring	A12-23-74-80
9	Probe Presence & Position	A12-23-74-90
10	Idle	
11	Idle	
12	Idle	
13	Idle	
14	Load & Seat Drive Screw	A12-23-74-140
15	Probe Presence & Position	A12-23-74-150
16	Idle	

ESCAPEMENT SUB-ASSEMBLY MACHINE (Cont'd.)

AUTOMATED PROCESS INC.

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
17	Idle	
18	Idle	
19	Unload Acceptable	A12-23-74-190
20	Idle	
21	Idle	
22	Unload Rejects	A12-23-74-220
23	Probe Empty Nest	A12-23-74-230
24	Idle	

ESCAPEMENT ASSEMBLY MACHINE

AUTOMATED PROCESS INC.

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
	Escapement Assy Machine	A12-24-74-00
	Machine Drive	A12-24-74-02
	Auxiliary Drives	A12-24-74-03
	Timing Diagram	A12-24-74-07
	Pneumatic Schematic	A12-24-74-08
	Electrical	A12-24-74-09
1	Load Housing Subassy	A12-24-74-10
2	Probe Housing	A12-24-74-20
3	Idle	
4	Idle	
5	Idle	
6	Load Rotor Assy	A12-24-74-60
7	Orient Rotor Assy	A12-24-74-70
8	Probe Rotor	A12-24-74-80
9	Idle	
10	Load Verge Assy	A12-24-74-100
11	Probe Verge	A12-24-74-110
12	Idle	
13	Load Pinion Assy	A12-24-74-130
14	Probe Pinion	A12-24-74-140
15	Idle	
16	Idle	
17	Load Anti-Creep Spring	A12-24-74-170
18	Probe Spring	A12-24-74-180

ESCAPEMENT ASSEMBLY MACHINE (Cont'd)

AUTOMATED PROCESS INC.

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
19	Probe Anti-Creep Spring	A12-24-74-190
20	Load Top Plate	A12-24-74-200
21	Top Plate Rap Station	A12-24-74-210
22	Probe Top Plate	A12-24-74-220
23	Idle	
24	Staking Housing Posts	A12-24-74-240
25	Probe Staking	A12-24-74-250
26	Idle	
27	Unload Good Assy	A12-24-74-270
28	Idle	
29	Idle	
30	Unload Reject Assy	A12-24-74-300
31	Probe Empty Nest	A12-24-74-310
32	Idle	

FINAL FUZE ASSEMBLY MACHINE

SWANSON ERIE CORPORATION

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
	General Assembly	75000-100
	Pneumatic Panel	75000-1 & -2
	Nest Assembly	75000-200
1	Load & Probe Ogive	75000-300
2	Idle	
3	Load Escapement Assy	75000-400
4	Probe Presence & Position Unarmed Escapement Assy	75000-500
5	Load Setback Pin	75000-600
6	Idle	
7	Load Setback Spring	75000-800
8	Probe Presence & Position of Setback Spring	75000-900
9	Probe Presence & Position of Setback Pin	75000-700
10	Load & Probe Bottom Plate	75000-1000
11	Idle	
11	Load Gasket	75000-1100
13	Probe Presence of Gasket	75000-1200
14	Crimp Ogive	75000-1300
15	Crimp Ogive	75000-1300
16	Idle	
17	Check Crimp Height	75000-1400
18	Unload Good Parts	75000-1500
19	Unload Bad Parts	75000-1600

FINAL FUZE ASSEMBLY MACHINE (Cont'd)

SWANSON ERIE CORPORATION

STATION NUMBER	DESCRIPTION	DRAWING NUMBER
20	Probe for Empty Nest	75000-1700
	Auxiliary Cam Motions for Sta.'s 14, 15, & 18	75000-1800
	Timing Chart	75000-1900
	Pneumatic Schematic	75000-2000
	Electrical Schematic	75000-2100
	Set Block Assy	75000-2200