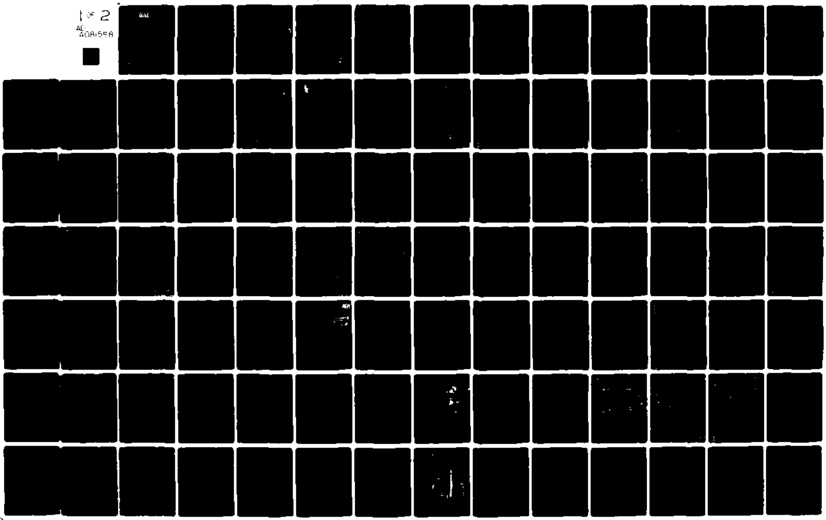
AD-A081 558 NOVATRONICS INC POMPANO BEACH FLA F/G 13/8
FEASIBILITY STUDY OF ALTERNATIVE FABRICATION METHODS.(U)
AUG 79 DAAK10-78-C-0286
UNCLASSIFIED NL

1 of 2
AD
A081558



ADA081558

LEVEL

# FINAL REPORT

* * *

Feasibility Study of Alternative

Fabrication Methods

Prepared for

DTIC
MAR 6 1980
C

U.S. Army Armament Research and
Development Center
Dover, New Jersey





NOVATRONICS, INC. P.O. BOX 878, POMPANO BEACH, FLORIDA, 33061
500 S.W. 12 AVE. (305) 942-5200



80 1 31 059

# DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

2

9

FINAL REPORT

6

# Feasibility Study of Alternative Fabrication Methods

11

August 1979

12

178



John L. Sullivan
Project Engineer

15 DAAK10-78-C-0286

Danielle Kessler
Program Manager

Russell T. Gruszynski
Director of Engineering

Edwin L. Agnew
Director of Contracts



261580

## TABLE OF CONTENTS

## 1.0 INTRODUCTION

This report is a summary of studies performed by Novatronics, Inc. on alternate ways to manufacture four different sized but similarly constructed center core propellent bags, as follows:

- 155mm, M119A1
- 155mm, M203
- 8 inch, M188
- 8 inch, M188, E2 increment 9

These studies were conducted in accordance with the directives outlined per ARRADCOM contract number DAAK10-78-C-0286.

Novatronics' goal was to study ways to achieve reductions in manpower requirements and production costs while at the same time increasing production output and quality. These problems were approached in three different ways: fixturization, mechanization, and automation. These three approaches were covered in the first report submitted to ARRADCOM entitled "Feasibility Study of Alternative Fabrication Methods", January, 1979.

This final report covers the mechanization approach. The report is divided into three major sections. The first major section (2.0) covers the jury rig efforts accomplished by Novatronics during this study project. The second major section (3.0) covers two mechanization systems: the Body and Liner Assembly System which is a viable production system, and the Body Assembly System which cannot be economically justified. The third major section (4.0) is entitled "Engineering and Management Considerations."

This section covers human engineering, quality control, safety and hazards, reliability and concludes with the savings and return-on-investment of the Body Liner Assembly System. Additional information about the Body Assembly System is contained in the appendix at the end of this report.

## 2.0 JURY RIG INVESTIGATIONS

### 2.1 Body and Liner Assembly System

Two separate pieces of jury rig hardware were developed to evaluate the area of technical risk associated with the Body and Liner Assembly System. This area of technical risk was highlighted by ARRADCOM during the July 2, 1979 Feasibility Study Presentation at Dover, NJ. This area of technical risk is defined as the handling techniques of the non-homogeneous web (cloth web with liners sewn to it) that are proposed for the Body and Liner Assembly System.

The first jury rig simulated the pulling of the web through the Liner Place, Sew and Creaser Station with force-loaded nip rollers and the supply loop going into the Tube Sew Station (see Figure 2-1). The top nip roller was weighted with 70 pounds to simulate a spring load (see Figure 2-2). Both nip rollers are covered with a ¼-inch-thick rubber material. The bottom nip roller is the driven roller (see Figures 2-3 and 2-4).

The web with the lead liners affixed to the web was tensioned to greater than 5-3/4 pounds per linear inch of web width. This is much greater (approximately 100% greater) than the maximum requirement for the Body and Liner Assembly System. At this high web tension the web was driven through the nip rollers without any sign of slippage or damage to the material. However, as the lead liner entered the supply loop and was still held by the nip rollers, it would bend and crack at the nip rollers from the weight of the supply loop. This situation was corrected by the addition of a curved sheet of metal which supported the liner as it exited from the nip rollers (see Figure 2-5).

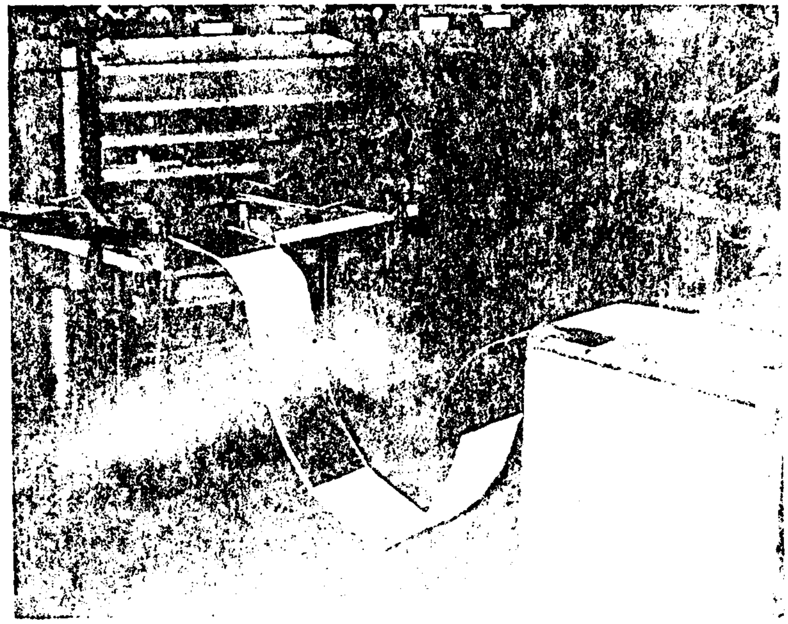



Figure 2-1

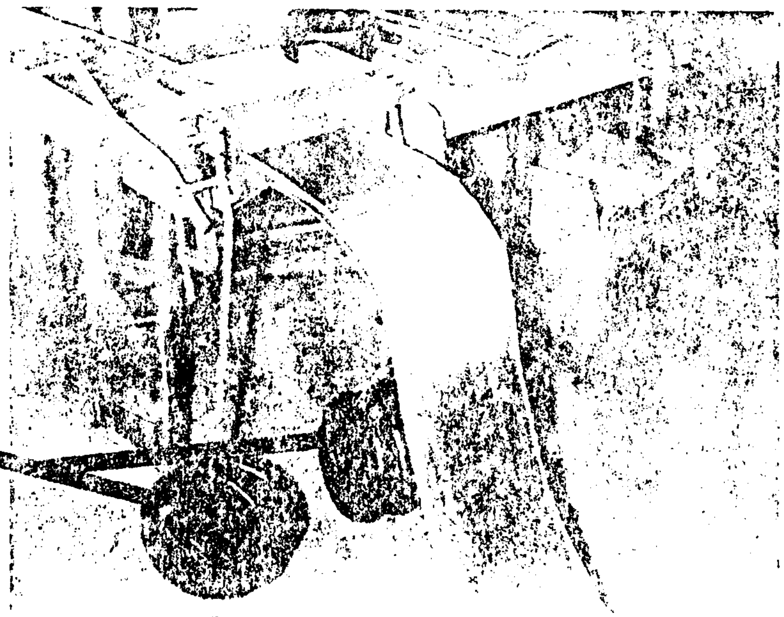



Figure 2-2

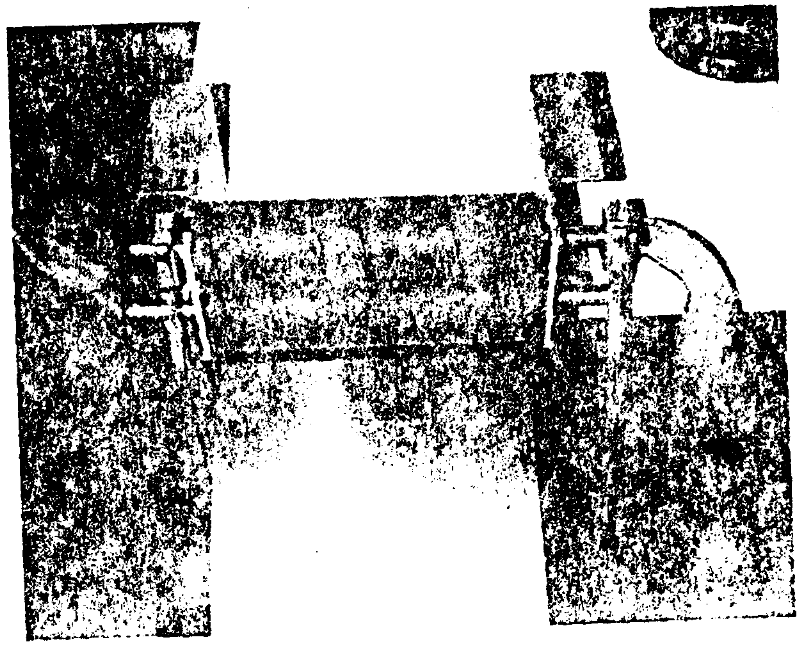


Figure 2-3

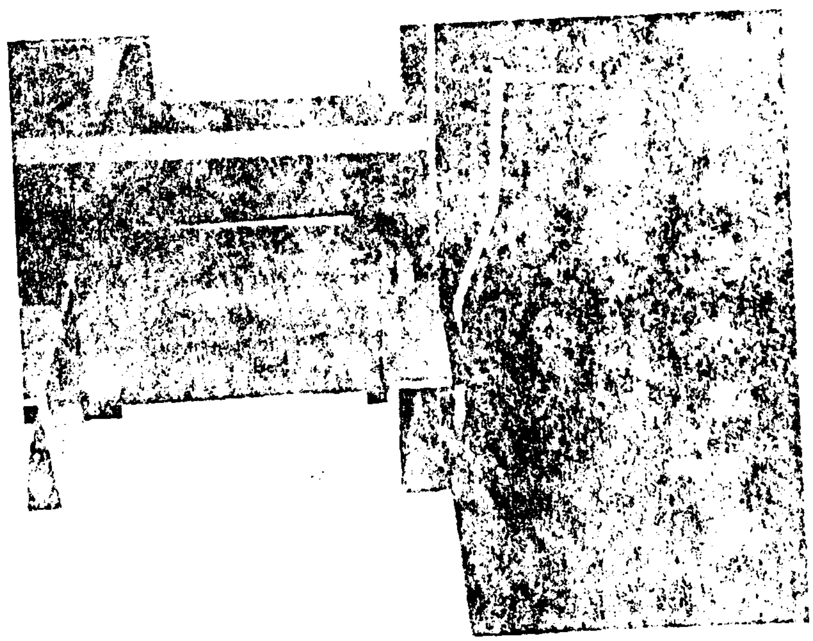


Figure 2-4


Figure 2-5

The web was manually pulled out of the supply loop over another curved tray which represents the input to the Tube Sew Station (see Figure 2-6). It was also shown that with the liners attached to the web, the web can be mechanically edge guided.

The second web processing jury rig simulated the web folding station (see Figure 2-7). The lead liners were creased down their centerline using a method similar to that proposed for the Body and Liner Assembly System. These creased liners were then attached to the flat web with the proper spacings between liners. The web with liners (full size 155mm) was pulled out of the supply loop over the same curved tray discussed above (see Figure 2-8). The crease of the liner is deflected downward by a 3/8-inch diameter folding rod (see Figure 2-9). The web is pulled through a pair of simulated vertical nip rollers (two curved vertical pieces of sheet metal) that complete the fold (see Figures 2-10 and 2-11). This jury rig showed no signs of possible problem areas.

## 2.2 Body Assembly System

Two separate pieces of jury rig hardware were developed to evaluate three areas of technical risk associated with the Body Assembly System as defined in the Feasibility Study Report of January 1979. The areas of the technical risk were defined as:

1) Axial alignment of the body and liner assembly to the end assembly on the flat finger
2) Concentric loading of the body and liner assemblies over the end assemblies on the flat finger
3) 3-D end sewing of the tube and liner assembly to the end assembly.

In order to evaluate the areas of technical risks identified in 1) and 2) above, a Transfer Station jury rig was developed (see

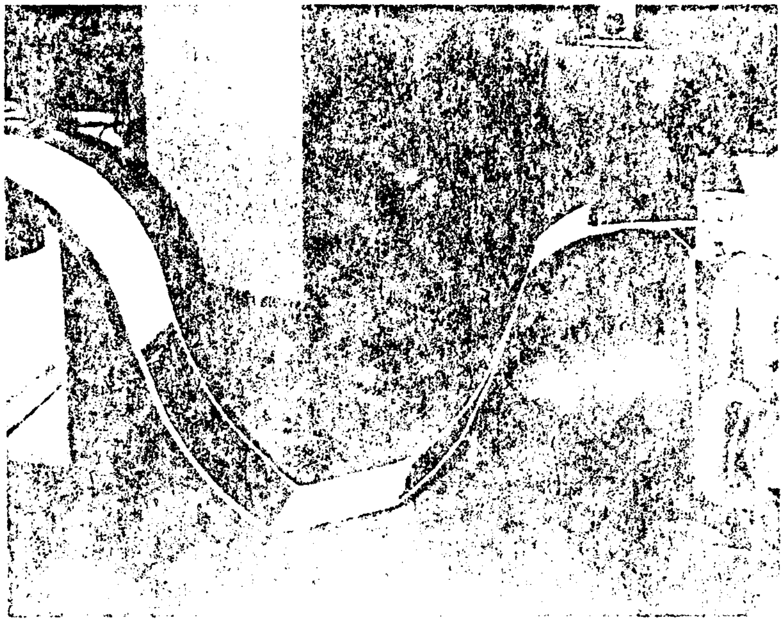


Figure 2-6

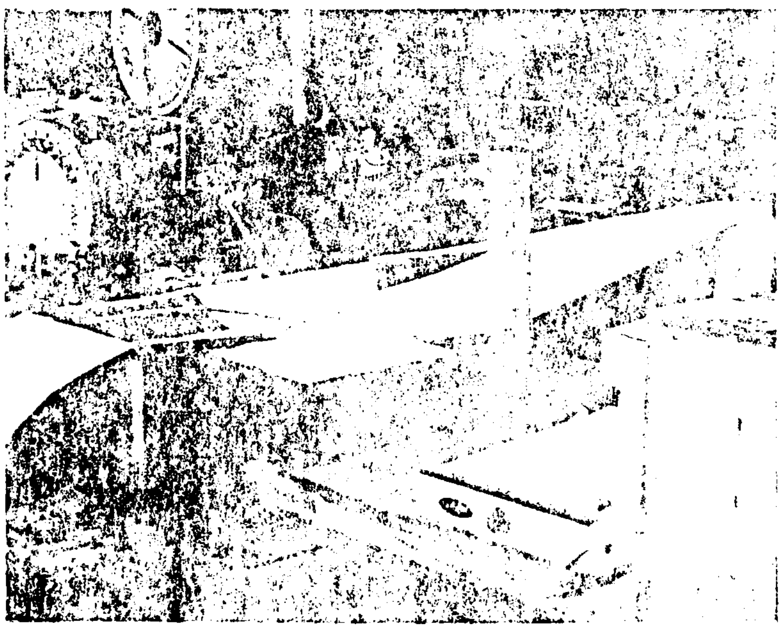


Figure 2-7

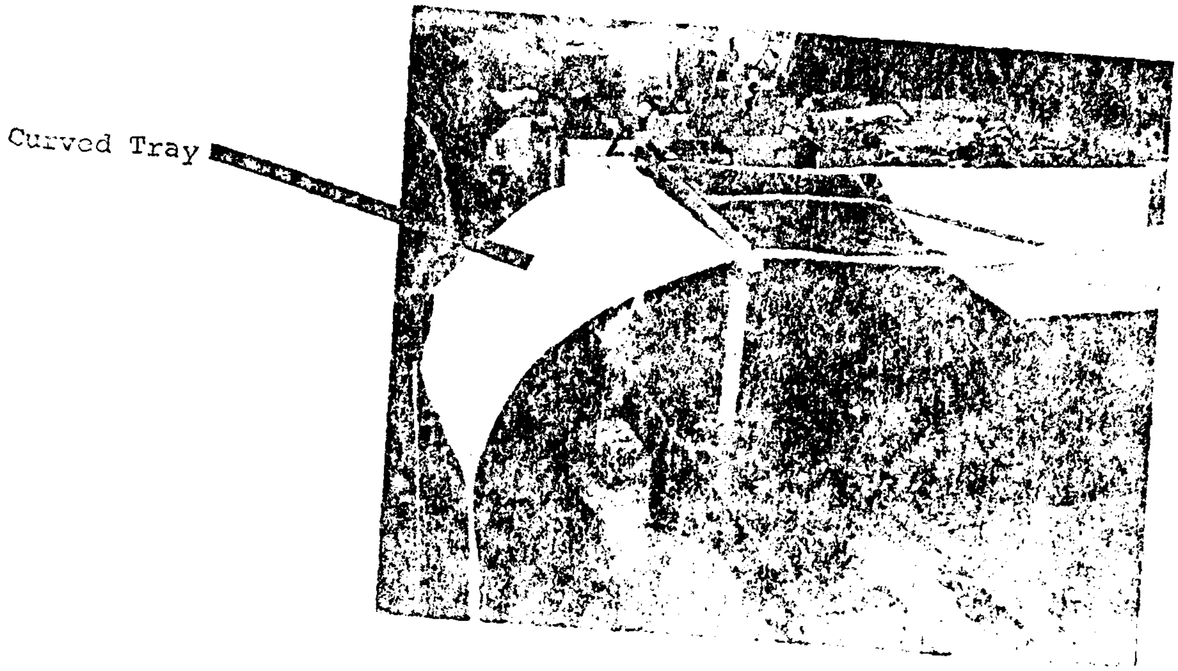



Figure 2-8

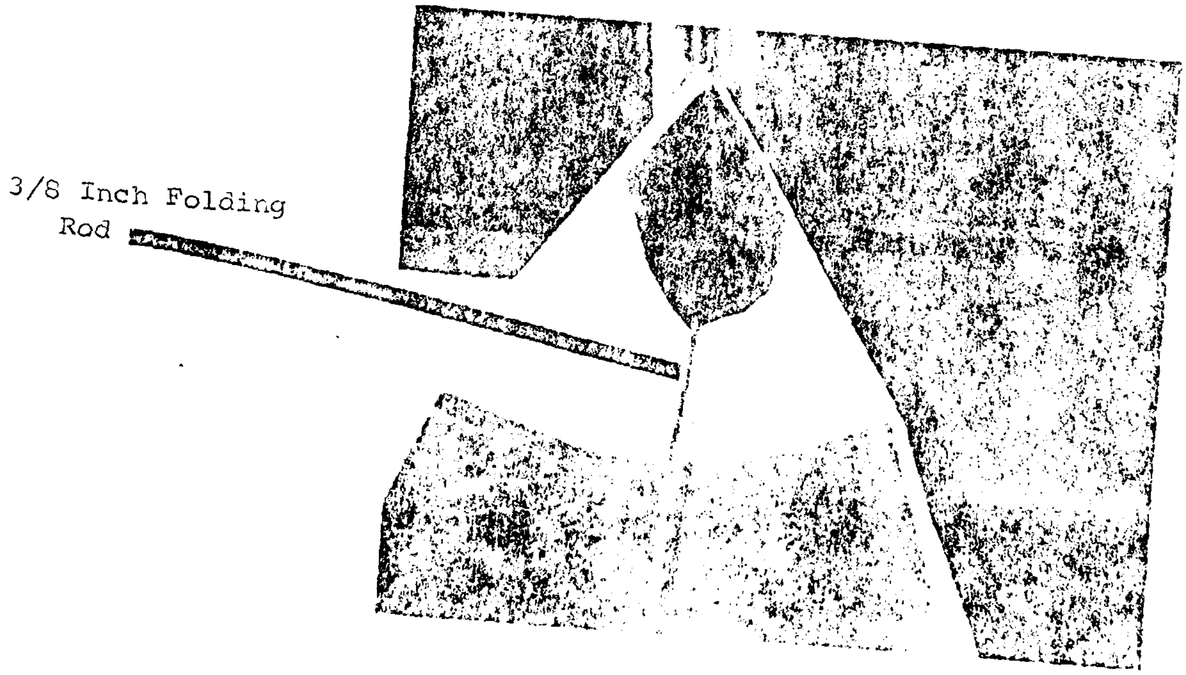
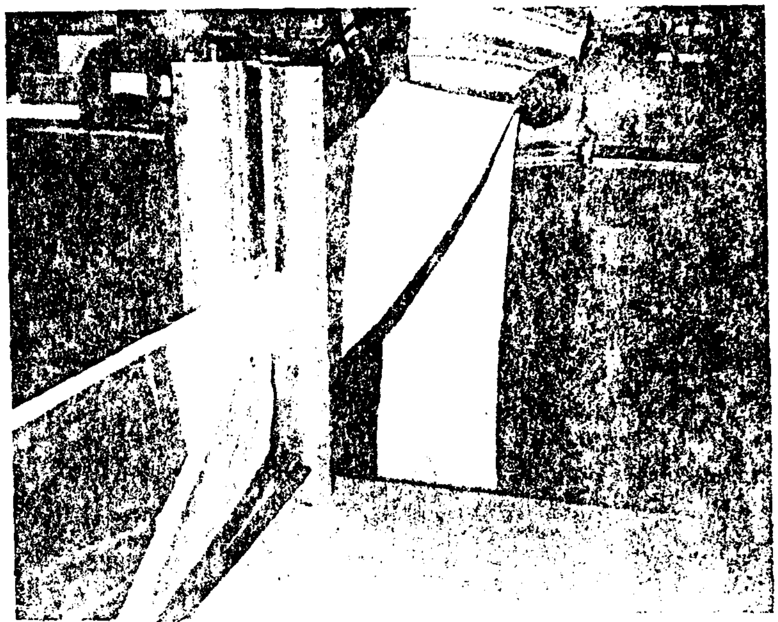



Figure 2-9



Simulated
Vertical
Nip Rollers

Figure 2-10

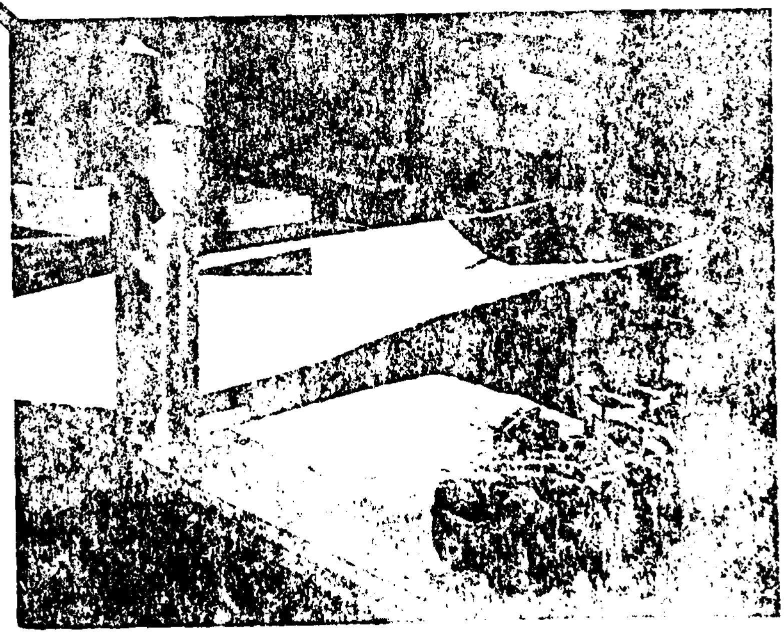


Figure 2-11

Figures 2-12 and 2-13). The jury rig consists of a flat finger, an up/down movable pick-up head, a chain drive system with a speed controlled motor and pneumatic valves, a regulator, and air cylinders for control.

The Transfer Station jury rig actually simulated two stations: the End Assembly Pick-up and Load Station, and the Body and Liner Assembly Pick-up and Load Station.

Typical operation of the jury rig would be as follows. Place a stack of end assemblies at the pick-up point at the proper height for the pick-up head (see Figure 2-14). Turn on the speed control motor forward to move the pick-up head to the proper point over the end assemblies for pick-up. This is about 1-½ inches from the end of the end assembly. Activate the pneumatic valve to cause the pick-up head to move down to the end assembly stack (see Figure 2-14). Activate the valve to pinch the top ply of the end assembly. Put a screw into the pick-up head to serve as a stop on the up stroke of the pick-up head (this is to align the center of the end assembly opening with the flat finger). Activate the pick-up head lift valve to raise the front end of the end assembly (see Figure 2-15). Reverse the motor's direction and drive the end assembly onto the flat finger (see Figure 2-16). Deactivate the valve to release the end assembly.

Place a stack of body and liner assemblies at the pick-up area. Run the motor forward until the pick-up point is over the liner-to-tube seam (see Figure 2-17). Activate the valve to lower the pick-up head onto the stack of body and liner assemblies. Turn on the pincher and manually clamp the material with the back clamp. Remove the screw from the pick-up head so that the body and liner assembly will lift higher than the end assembly.

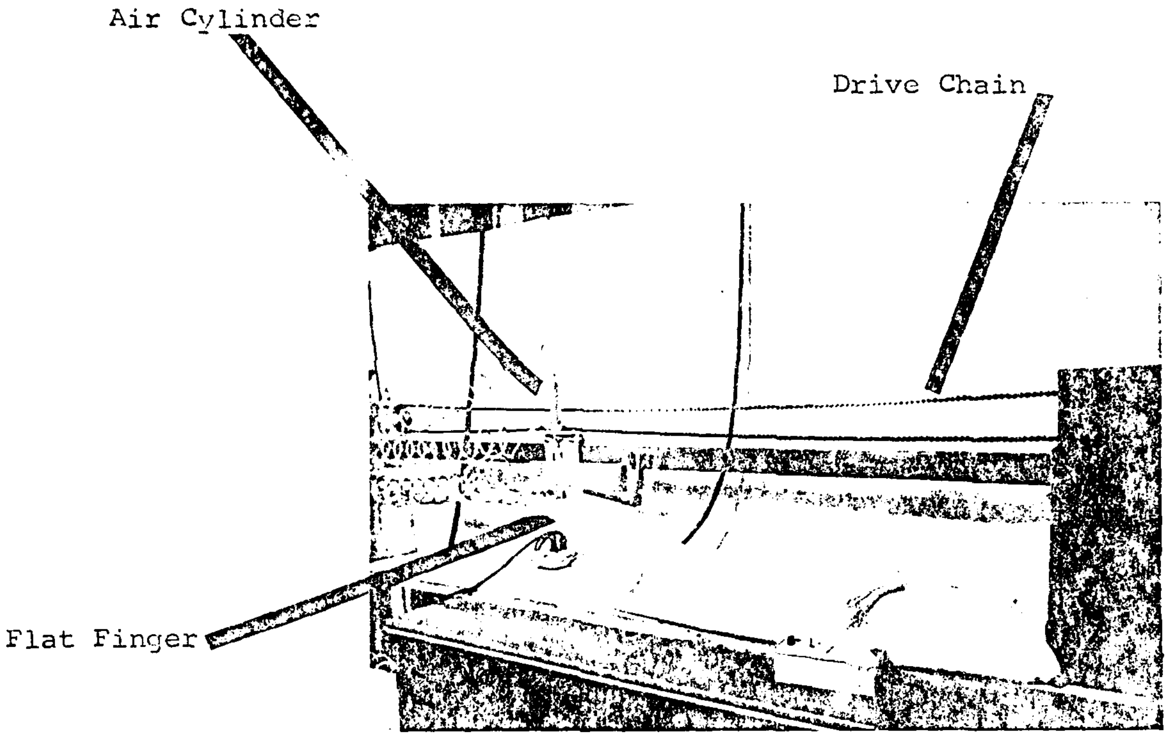



Figure 2-12

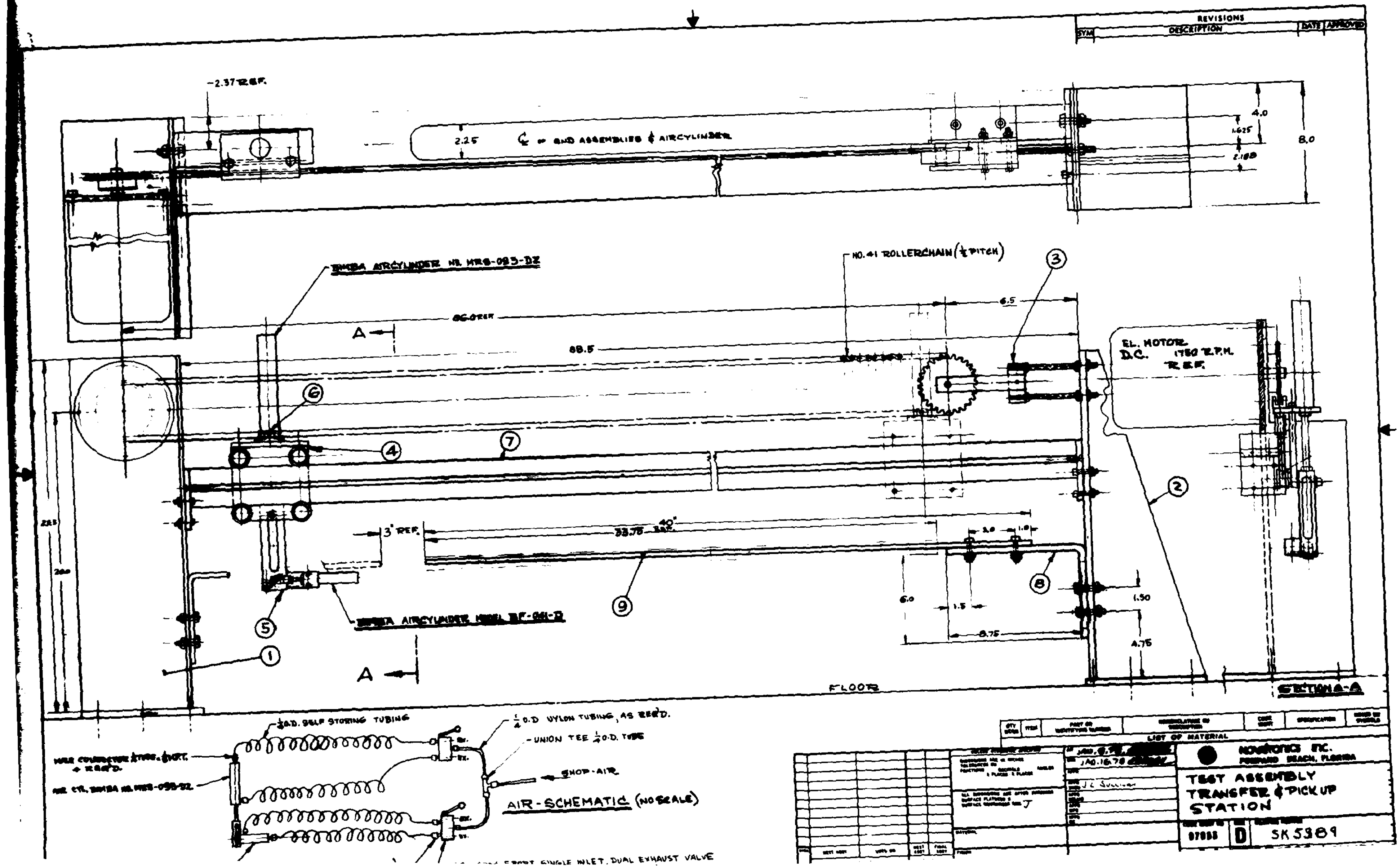

REVISIONS
SYM
DESCRIPTION
DATE
APPROVED
-2.37 REF.
2.25
℄ OF END ASSEMBLIES & AIRCYLINDER
4.0
1.625
2.188
8.0
NO. 41 ROLLERCHAIN (½ PITCH)
6.5
EL. MOTOR
D.C.
1750 R.P.M.
REF.
88.5
A
3" REF.
40"
6.0
1.5
8.75
1.50
4.75
FLOOR
SECTION A-A
AIR-SCHEMATIC (NO SCALE)
¼ O.D. NYLON TUBING, AS REQ'D.
UNION TEE ¼ O.D. TUBE
SHOP-AIR
LIST OF MATERIAL
NOVATRONICS INC.
POMPANO BEACH, FLORIDA
TEST ASSEMBLY
TRANSFER & PICK UP
STATION
D
SK5389
JAN. 16, 78


Figure 2-14

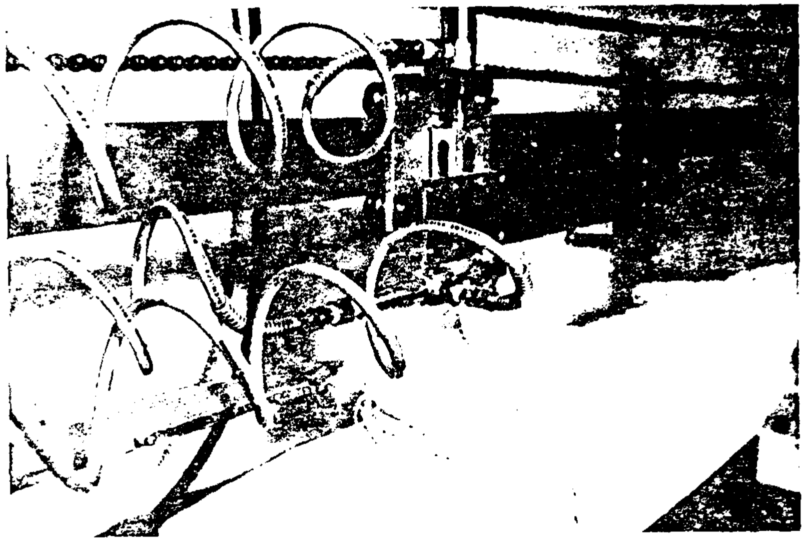


Figure 2-15

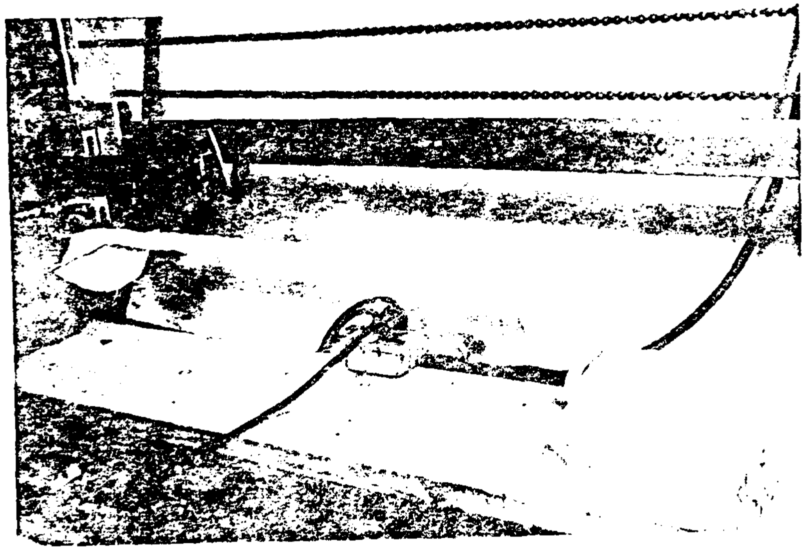


Figure 2-16

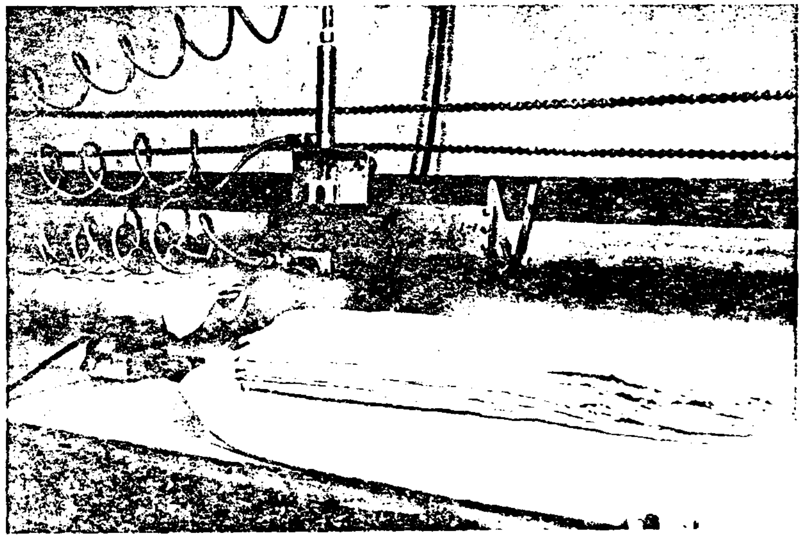


Figure 2-17

Raise the pick-up head (see Figure 2-18). (If the body and liner assembly was manually produced and was not handled up to this point, it would have to have its sides gently squeezed to open the assembly. Manual assemblies that have been handled as well as simulated assemblies from the Body and Liner Assembly System open from their own weight.) Reverse the drive motor to carry the body and liner assembly over the end assembly (see Figure 2-19). Stop and release the body and liner assembly (see Figure 2-20). This completes one operating cycle of the Transfer Station jury rig.

In order to maintain axial alignment it was determined that the end assembly, since it is out of the operator's sight, must be mechanically maintained straight. To accomplish this a flat finger was developed (see Figure 2-21) that would track the seams of the end assembly as it is being loaded onto the finger. This tracking was accomplished by the special contour of the cross sectional area of the flat finger. The point of the flat finger allows for some misalignment in locating the opening of the end assembly.

In order to accomplish concentric loading of the body and liner assembly over the end assembly on the flat finger, several actions must take place. First, the end assembly must be retained on the flat finger while the body and liner assembly is being passed over it. This action creates frictional drag forces which tend to pull the end assembly along with the body and liner assembly. It was found that the end assemblies can be retained by the use of a pair of springs as shown in Figure 2-22. Second, the placement of the end assembly on the flat finger is important. The end of the end assembly must not hang over the flat finger because the body and liner assembly will catch and double it over backwards. Third,

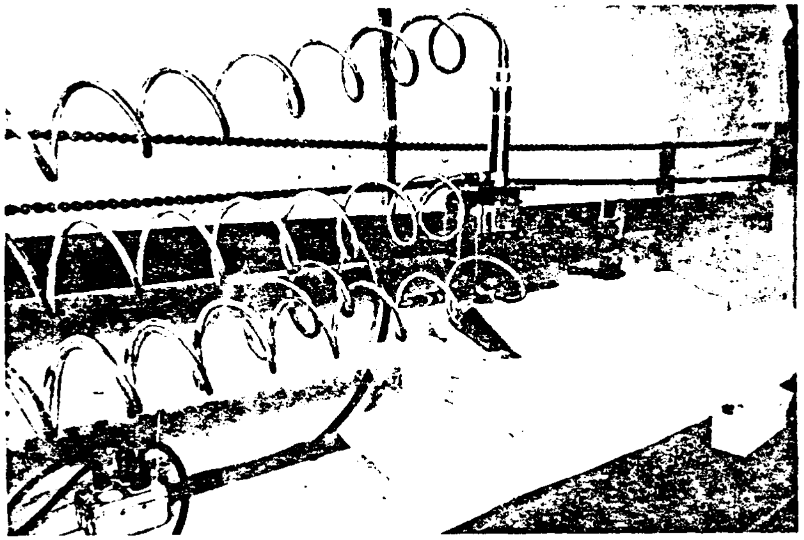


Figure 2-18

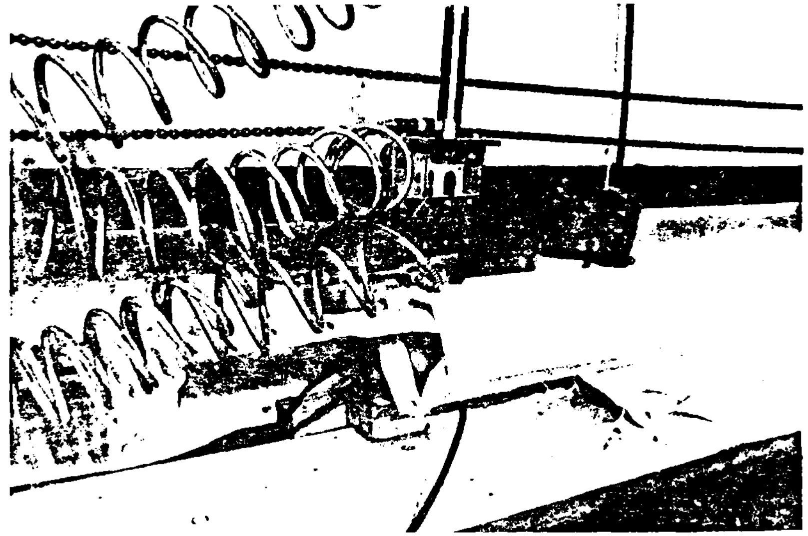


Figure 2-19

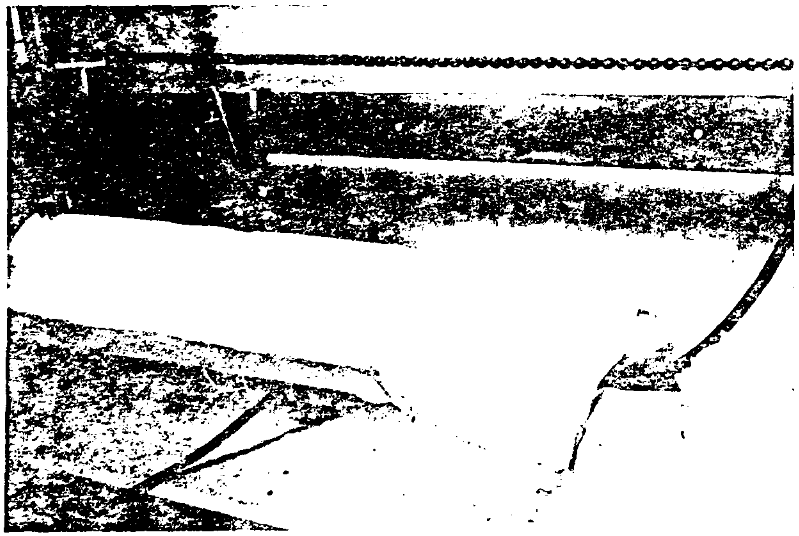


Figure 2-20

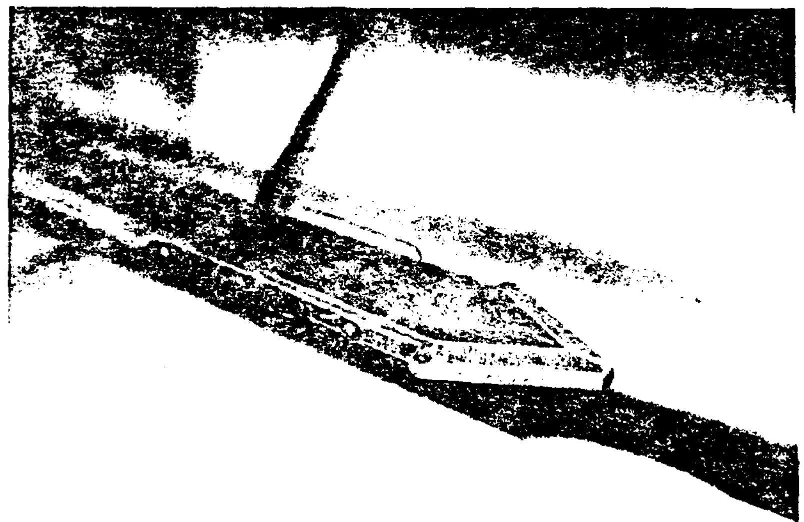


Figure 2-21

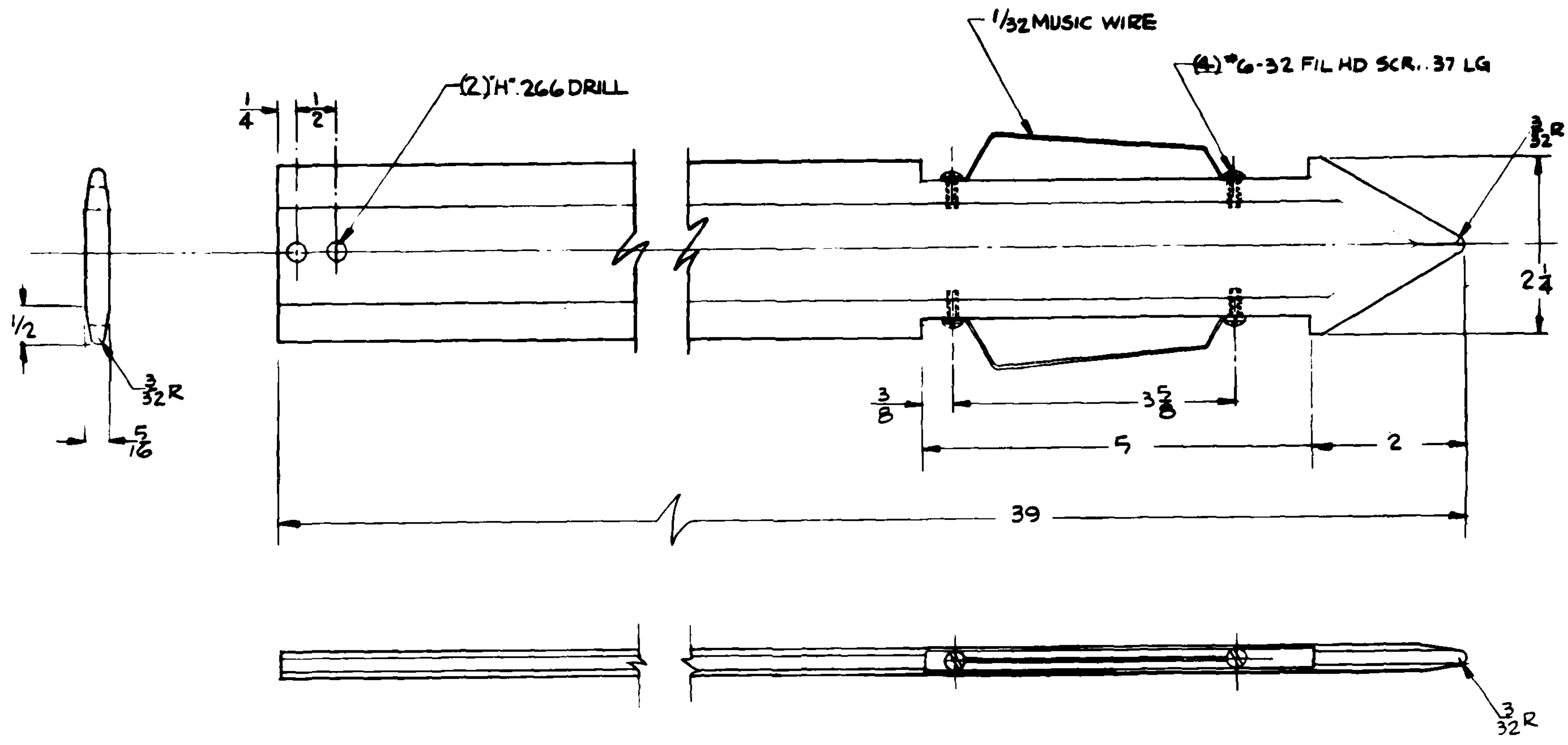



Fig. 2-22

PART NO.

| | | | |
|---|---|---|---|
| MECHANICAL PROPERTIES | DO NOT SCALE DRAWING UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ± | ORIGINAL DATE OF DRAWING 6-6-79 | U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND DOVER, NEW JERSEY 07801 |
| YP, TS, EL2, RA, BH, RH | | DRAFTSMAN T.L. JONES / CHECKER | FLAT FINGER |
| NEXT ASSY / USED ON | | ENGR J.L. SULLIVAN / ENGR | SIZE C / CODE IDENT NO 19200 / 9331530 |
| APPLICATION | | ENGR / ENGR | SCALE / UNIT WT |

the body and liner assembly must be picked up at two points along its length because of its weight (over 1-1/2 pounds). If the body and liner assembly was picked up only at the front, the back of the assembly would drag over the end assembly during loading.

It was also determined that for the body and liner assembly to be able to open, the front pick-up point must be immediately adjacent to the liner-to-tube seam, otherwise the liner would bend or buckel in the opposite direction and would not allow the tube to open.

Fresh, unhandled body and liner assemblies that are currently being hand produced would not repeatedly open when picked up as described above. This is because they frequently have two folds in the lead liner and also because these folds are not straight and therefore they resist opening. To open these, a device would have to be constructed that would slightly depress both sides of the body and liner assembly as it is hanging from the pick-up heads to assist in opening the assembly. This will not be necessary for body and liner assemblies that are produced on the Body and Liner Assembly System because they will have only one fold which will be straight. Also, they will have six additional creases longitudinally along the liner that eliminate any resistance to opening.

This jury rig proved the feasibility of being able to axially and concentrically load body and liner assemblies over end assemblies.

A second jury rig was designed and built to test the feasibility of producing a mechanized 3-D sewing system for the production of the body assemblies (see Figure 2-23). This jury rig was built around a Clinton #1229 sewing machine. A layout of the initial approach is shown in Figure 2-24. The operation of the

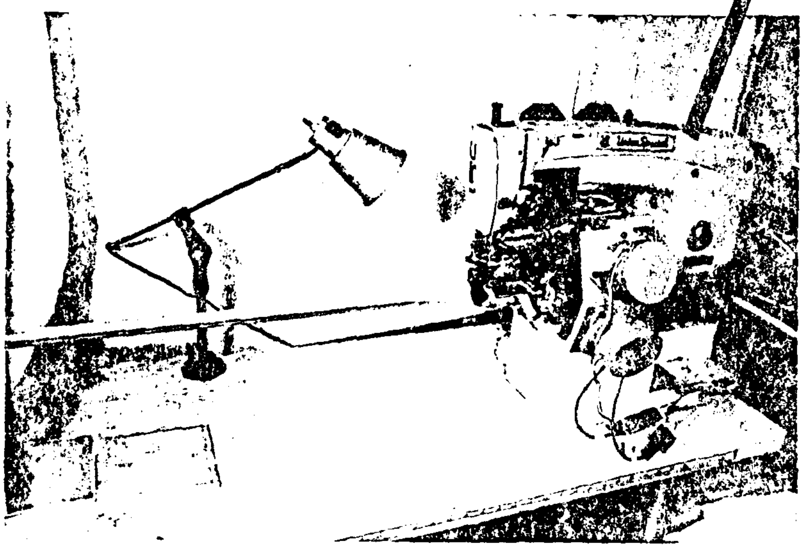



Figure 2-23

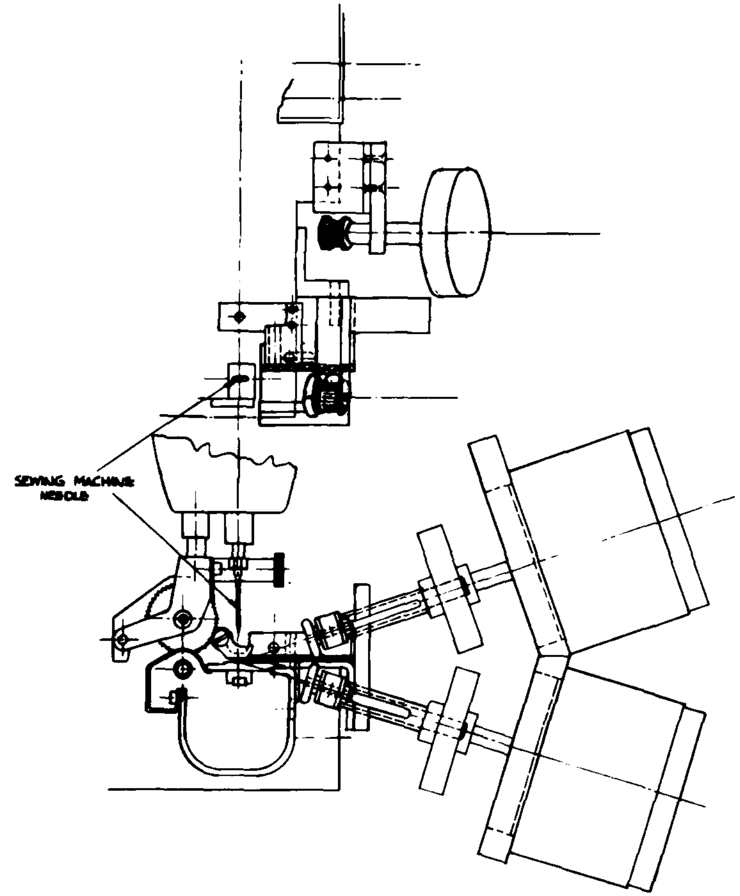



Fig. 2-24

PART NO.

| | |
|---|---|
| | 3D SEW STATION<br>JURY RIG |
| D | 19200 |
| 9331524 | |
| SCALE FULL | SHEET 1 OF 1 |

2-2-79

system was a pair of simple bang-bang servo systems. The inputs to the servo systems were a pair of optical sensors, one for each ply of cloth, just before the sewing machine needle. The plies of material were separated by the cloth guide which enabled each sensor and servo system to control one ply. The ply position as it was being sewn was controlled by a 3/8-inch diameter spring loaded wheel that maintained light pressure on the cloth against the cloth guide. This wheel is driven by timing belts from a stepper motor that is driven by the servo system (see Figure 2-25). The pieces being sewn were supported on a long round bar which simulated the flat finger.

Using this approach it was determined that a production system to automatically sew the end assembly inside of the body and liner assembly was not feasible. Several modifications would have to be made before this could become a workable system. First, three of the four end assemblies have corners that protrude beyond the edge to which the seam is spaced. This causes the edge guide system to track the corner instead of the desired edge. On these end assemblies (155mm/M119, 155mm/M203, and the 8-inch/M188), the corners would have to be removed on the cutting table when the pieces are initially cut.

Second, the diameters of the two assemblies should be readjusted so that the two assemblies to be joined together have the same nominal circumference along the seam to be sewn. The current production units do not have the same diameters and therefore have pleats that must be manually inserted to make up for the difference in diameters. If there is a ¼-inch difference between the two diameters, the pleat size will be greater than 3/4 of an inch (probably two 3/8-inch pleats). This is because a change in diameter creates a change in circumference of 3.14 times the change in the diameter.

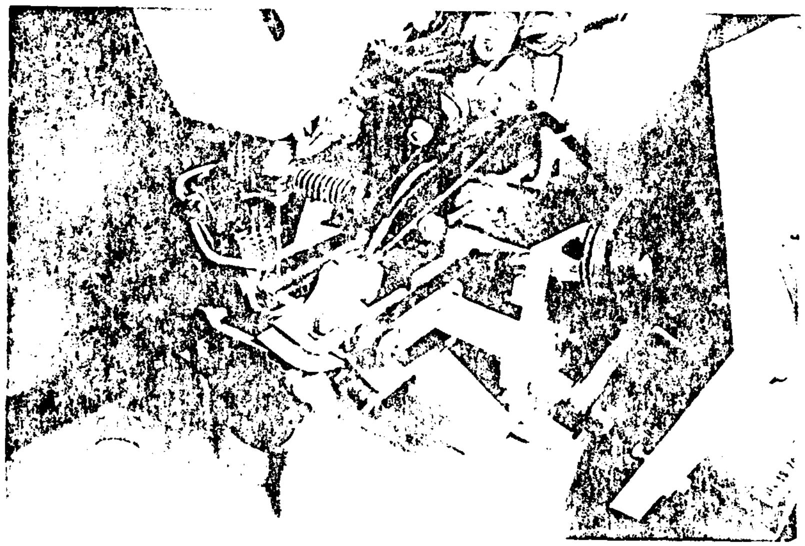
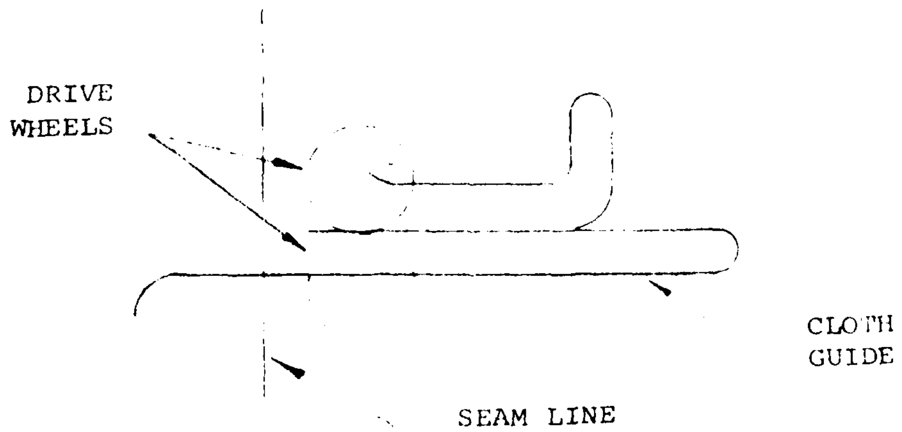


Figure 2-25

Third, it was found that the body and liner assembly and the end assembly, after being loaded straight into the guide and sew head, had to be rotated synchronously with the sewing. The cloth tube is not capable of transmitting the force from the sewing drive to the lead liner to cause it to rotate with the sewing; instead, it tends to twist the cloth tube which has a tendency to pull the material out of the guiding system. Therefore, for 3-D sewing to be successful, the assemblies would have to be driven synchronously with the sewing operation.

The cloth guide had several constraints that determined its shape. A cross sectional view is shown below:




The cloth guide had to keep the two plies separated so that each ply could be monitored and then controlled by the drive wheel which was spring loaded against the center plate. The center plate had to be short since it separated the two plates and as the two plies were sewn together, the leading edge of the sewn part had to pass back through the guide for closure; therefore the center plate could not extend between the two plies more than the seam-to-edge distance.

The guide must also have adequate space for a folded seam (three plies plus stitching) to freely pass, yet at the same time not be too large for one ply. This was accomplished in the jury rig. The problem area occurs when the system tries to sew a cone shaped end assembly into the shape of a cylinder. This causes the material to buckel as it enters the guide and subsequently fold in the guide and thus creates edge guide problems. This problem was not resolved.

The last problem area was caused by the stiffness of the lead liner. This problem only occurs on the end of the body tube next to the lead liner. It was discovered that if the sewing contour of the sewing path through the machine was different from the path of the lead liner, the stiffness of the liner offered too much resistance to the edge guide system and would consequently pull the cloth out of the guide. In order to overcome this problem, two possible solutions could be investigated. Both solutions are methods to make the lead liner and sewing path line up with each other. One solution would be to continually deform the lead liner as it goes through the sewing path to make it conform to the sewing path. The second method would change the sewing path so that it forms an arc, and mechanically maintain the lead liner in a round configuration so that the two line up.

From this 3-D jury rig, it was concluded that the cost of this one operation and the potentially great reliability problems prohibit mechanization and that, at this time, manual sewing is the best method of accomplishing this complex operation.

# 3.0 MECHANIZATION SYSTEMS

This section deals with a description of the feasible system for mechanization of the current handline production. Mechanization involves automating the handline operations for high volume production where bag components will be machine processed with minimum operator assistance and product components must remain compatible with existing designs.

Our intent is to offer a mechanization concept that requires minimal operator assistance but, at the same time, is the most economical means of mass producing propellant bags. Novatronics, Inc. judged each individual operation with the intent that the design offered in this study shall be the optimum balance of cost effectiveness and degree of mechanization. This section is divided into two major parts. The first is the Body and Liner Assembly System which has an excellent return on investment. The second is a modified Body Assembly System which is similar to Concept III presented in the January report with the exception that the automated sewing be done by the operator. This system's savings is too small for Novatronics to recommend implementation.

When computing the labor cost for an operation throughout this report, the current union rates, as obtained from the Bag Room Manager, are used. Also added to the rates is a 25% additional expense for out-of-pocket fringe benefit costs. The pay rate is \$5.79 per hour for a Sew/Piece and Inspect Operator and \$6.01 for an Auto-Sew Operator. When the out-of-pocket fringe benefit costs are considered, these rates become \$7.24 per hour and \$7.51 per hour, respectively.

Table 3-1 shows the performance rates of the four basic operations performed by the present bag assembly handline that is being studied in this report.

Table 3-1
Performance Rate, Handline

| Operation | Body Assembly Type | | | |
|---|---|---|---|---|
| | 155mm M119 | 155mm M203 | 8 Inch M188 | 8 Inch Increment 9 |
| Sew Body Tube Side Seam | 36.2 sec/pc<br>99.5 pcs/hr<br>715.7 pcs/shift | 44.3 sec/pc<br>81.2 pcs/hr<br>585 pcs/shift | 33.6 sec/pc<br>107.2 pcs/hr<br>772 pcs/shift | 11.4 sec/pc<br>315.2 pcs/hr<br>2268 pcs/shift |
| Roll and Insert Liner | - | 31.8 sec/pc<br>113.1 pcs/hr<br>814.4 pcs/shift | 13.7 sec/pc<br>262.4 pcs/hr<br>1893.6 pcs/shift | 12.5 sec/pc<br>288.8 pcs/hr<br>2079 pcs/shift |
| Sew in Liner | 35 sec/pc<br>102.7 pcs/hr<br>739 pcs/shift | 115.4 sec/pc<br>31.2 pcs/hr<br>224.9 pcs/shift | 130.4 sec/pc<br>27.6 pcs/hr<br>198.4 pcs/shift | 65.2 sec/pc<br>55.2 pcs/hr<br>397.6 pcs/shift |
| Sew Body Assembly | 82.7 sec/pc<br>43.5 pcs/hr<br>310.7 pcs/shift | 97.2 sec/pc<br>37 pcs/hr<br>266.5 pcs/shift | 132.3 sec/pc<br>27.2 pcs/hr<br>196 pcs/shift | 65.2 sec/pc<br>55.2 pcs/hr<br>397.6 pcs/shift |

Since the labor content is so varied between bag assemblies (i.e., the 155mm, M203 has a labor content of 340 seconds per assembly while the 8 inch, Increment 9 has a labor content of only 181 seconds per assembly), the necessity of knowing the quantity distribution becomes imperative. This was clarified at ARRADCOM on September 11 during Novatronics' visit. Sixty percent of production is for 155mm size bag assemblies while the remaining 40% is for the 8-inch bag assemblies. There are an equal number of 155mm M119's and M203's produced while there are an equal number of 8-inch M188's and Increment 9 assemblies produced.

After knowing the performance rate and distribution of quantities produced it is necessary to know the total quantity of bags desired per year. The specification states that fabrication of the four bags should be at the rate of 10 bags per minute for three shifts. ARRADCOM defined this to Novatronics, Inc. by telephone during November, 1978 to be 10 bags per minute total for all bag sizes. ARRADCOM also defined that a shift is 7.2 hours long. This is a total of 3,110,400 bag assemblies per year, based on a 48-week year. Using the bag production percentage and the total quantity of 3,110,400 bag assemblies per year, this breaks down to 1,866,240 155mm bag assemblies and 1,244,160 8-inch bag assemblies per year.

## 3.1 Body and Liner Assembly System Description

The Novatronics concept of a body and liner assembly machine is one which produces body and liner assemblies in an automated mode with semi-skilled operator functions generally limited to resupplying expended material and removing finished products. A pictorial description of this system can be found in Figure 3-1.

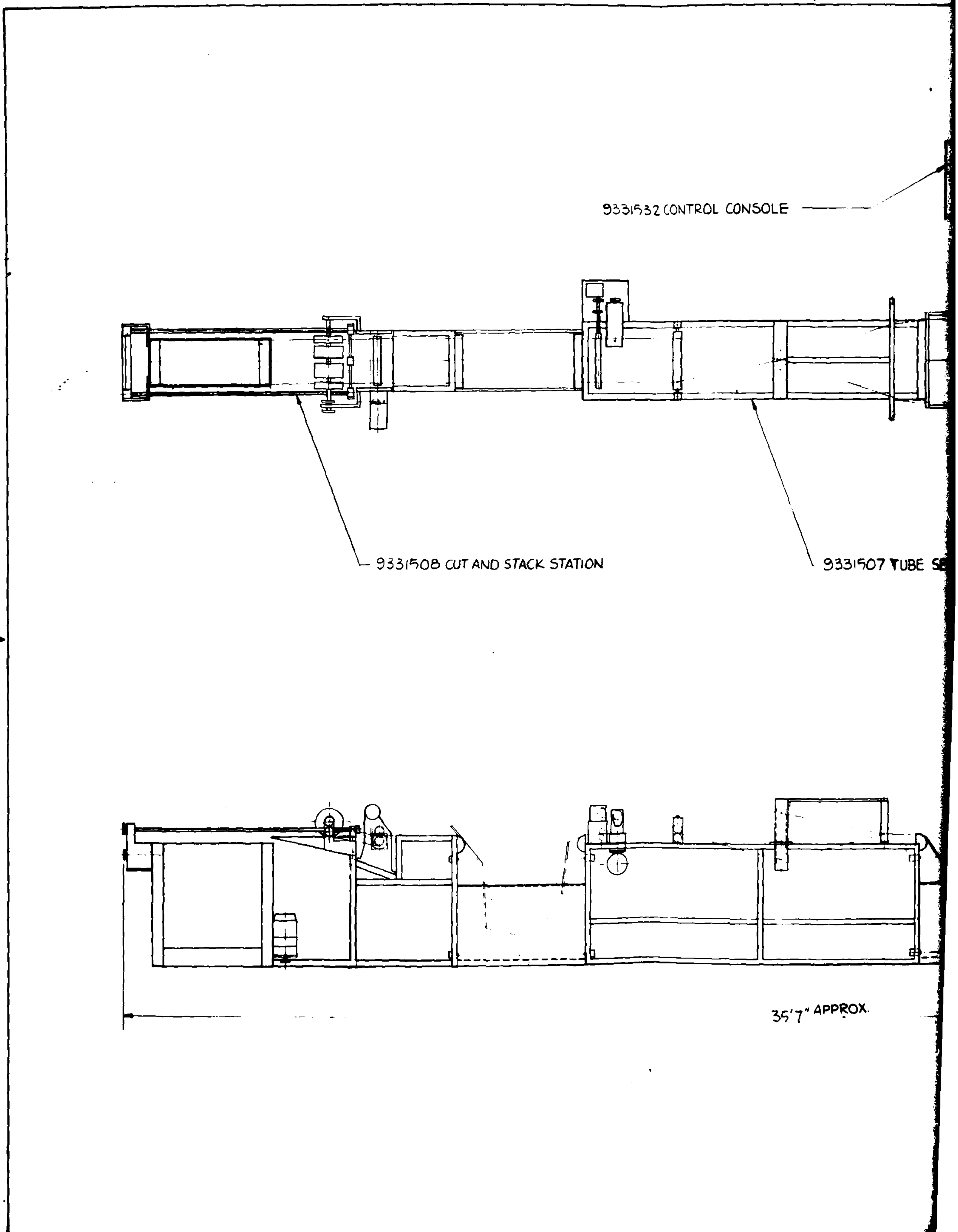
The output product of this system will be body and liner assemblies. This is a body tube seamed and sewn with its lead liner properly placed and sewn inside the tube. The following part numbers will be the end products of the system:

9278973 - Body and Liner Assembly for 155mm, M203

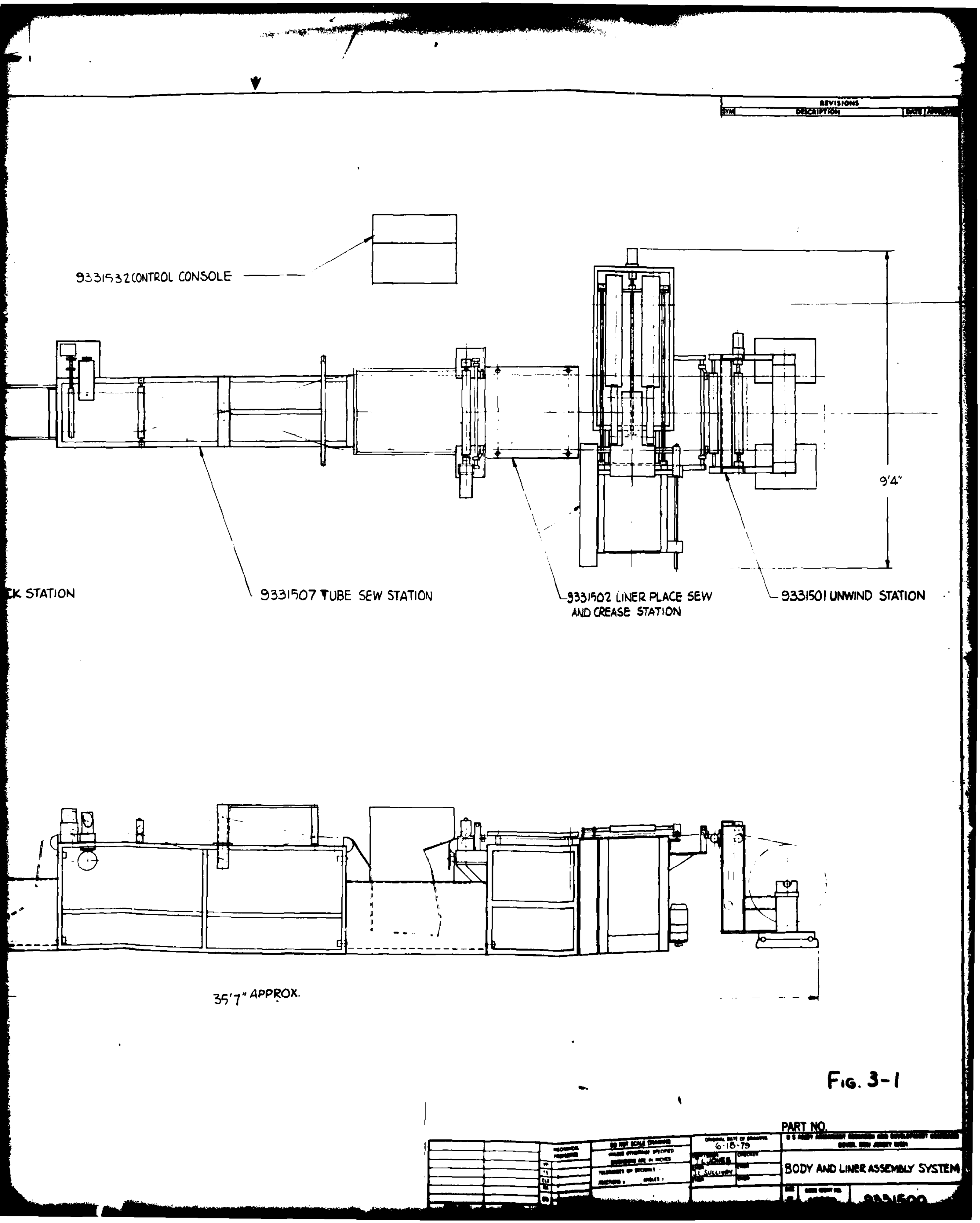
9326078 - Body for 155mm, M119A1

9277176 - Body and Liner Assembly for 8-inch M188

No Part Number - Increment 9 Assembly, 9277181 less the End Assembly 9277184 for 8-inch, M188E2 (no part number for Body and Liner Assembly).



9331532 CONTROL CONSOLE
9331508 CUT AND STACK STATION
9331507 TUBE SE
35'7" APPROX.



REVISIONS
SYM
DESCRIPTION
DATE
9331532 CONTROL CONSOLE
K STATION
9331507 TUBE SEW STATION
9331502 LINER PLACE SEW
AND CREASE STATION
9331501 UNWIND STATION
9'4"
35'7" APPROX.
PART NO.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
6-18-79
BODY AND LINER ASSEMBLY SYSTEM


FIG. 3-1

The system material input is a roll of cloth whose width depends on the diameter of the assemblies being produced, a stack of liners, and sew machine bobbins.

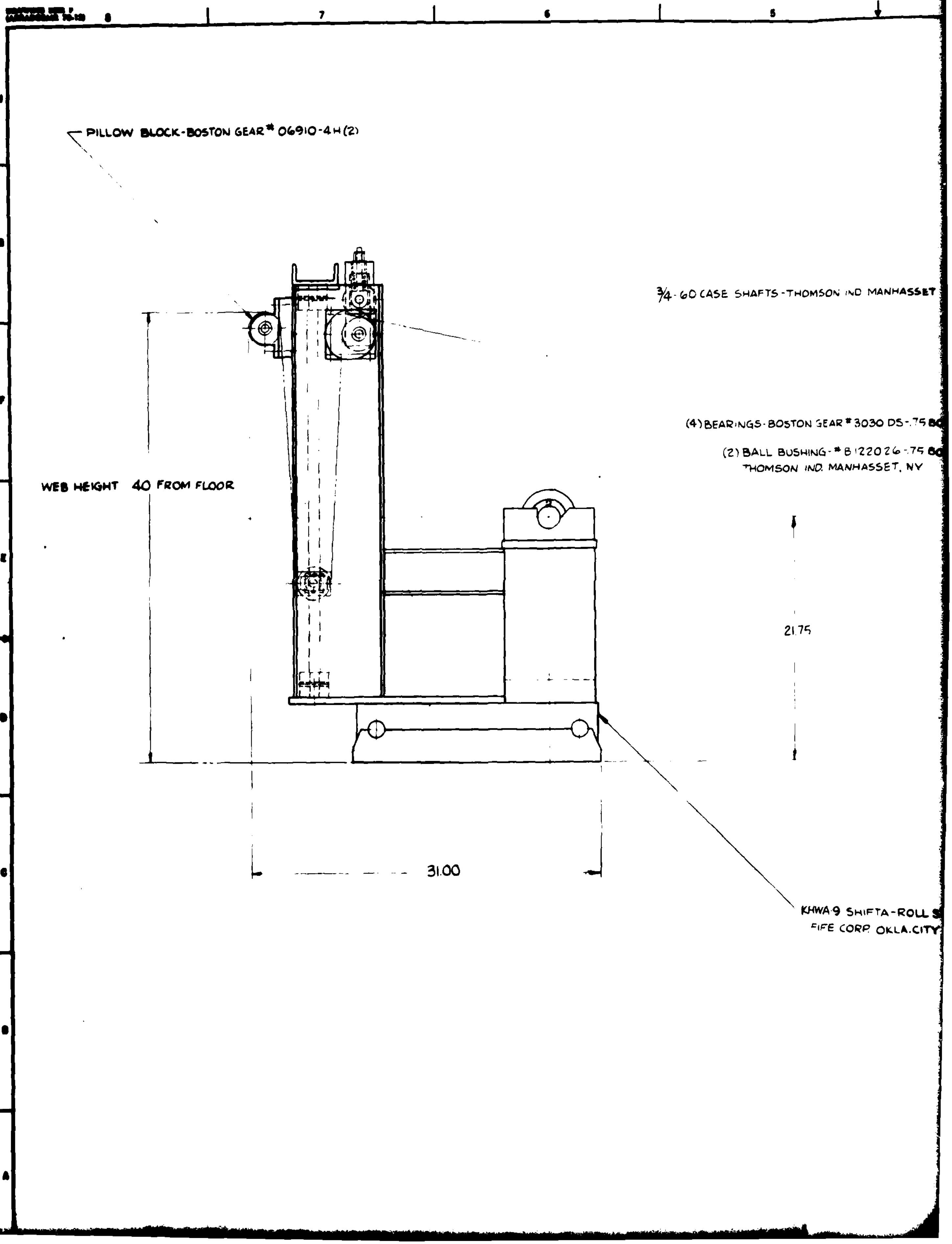
This system can be divided into four semi-independent stations: Unwind Station; Liner Place, Sew and Crease Station; Tube Sew Station; and Cut and Stack Station (refer to Figure 3-1).

These stations are considered to be semi-independent since they do not have to be synchronized with each other. Their only interdependence is that they have adequate material supply and adequate room for their processed material.

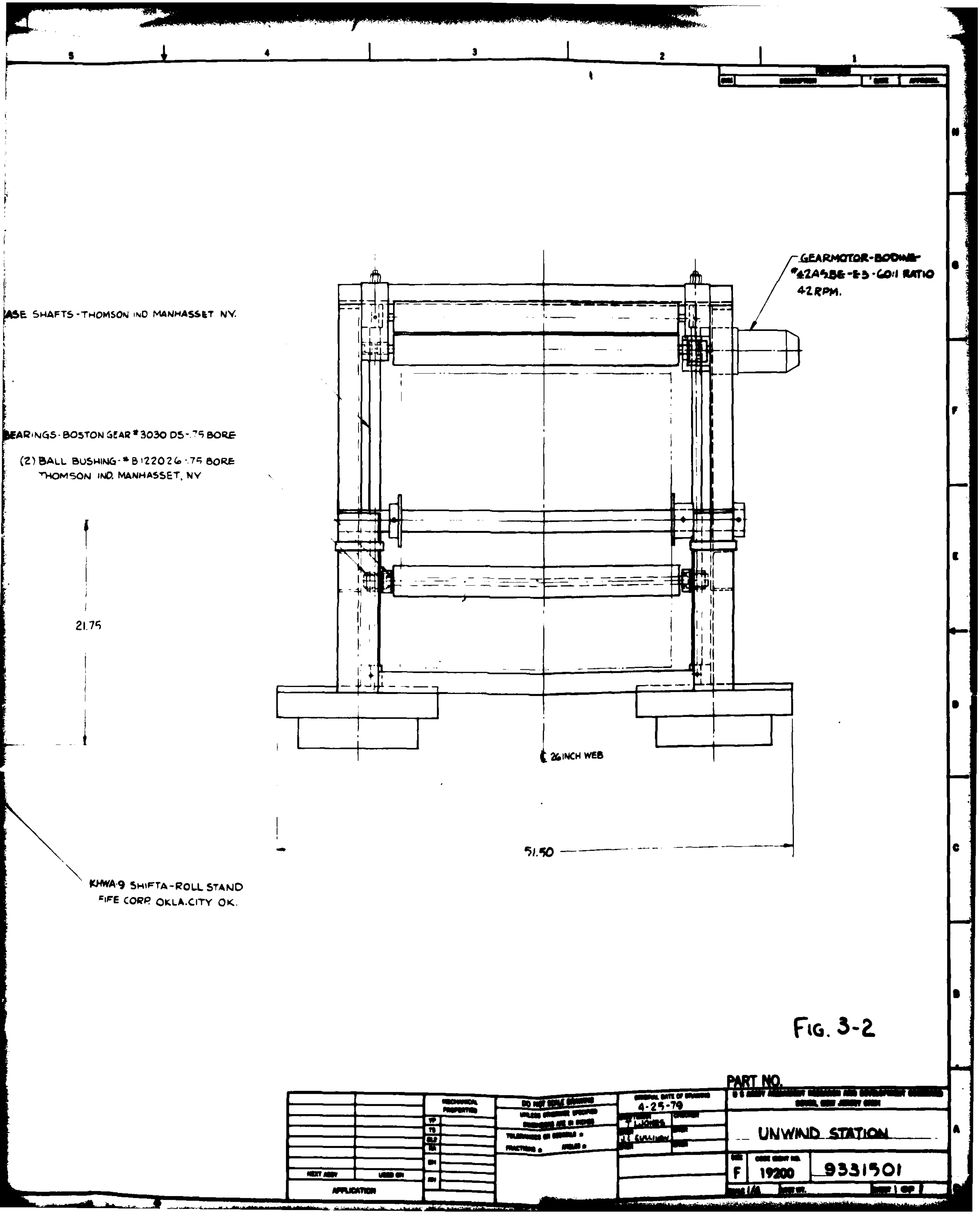
3.1.1 The Unwind Station (see Figure 3-2) dispenses a cloth web from rolls which have been pre-slit to the desired width. It handles 20-inch wide rolls for the 155mm diameter tubes and 26-inch wide rolls for the 8-inch diameter tubes. The web width (cloth roll width) is the body-tube circumference. This station is capable of handling all four bag sizes.

The Unwind Station consists of a typical motor-driven unwind stand and a cloth take-up dancer arm. It dispenses a cloth web in response to downstream needs. The unwinding is controlled by the position sensing of the dancer roller in the slack take-up loop (see Figure 3-3). The material is fed from the supply roll to the slack take-up loop at a rate faster than the liner assembly requires. This characteristic creates a buffer of cloth web rendering this station asynchronous from the downstream operations.

A roll of cloth is placed on the unwind stand on a platform that has notches to accept the shaft holding the roll. The web of cloth is pulled off the roll by two nip rollers. The bottom roller is motor driven. These rollers feed the cloth upon demand to the



PILLOW BLOCK-BOSTON GEAR # 06910-4H(2)
3/4-60 CASE SHAFTS-THOMSON IND MANHASSET
(4) BEARINGS-BOSTON GEAR # 3030 DS-.75
(2) BALL BUSHING-# B122026-.75
THOMSON IND. MANHASSET, NY
WEB HEIGHT 40 FROM FLOOR
21.75
31.00
KHWA-9 SHIFTA-ROLL
FIFE CORP. OKLA.CITY



ASE SHAFTS-THOMSON IND MANHASSET NY.
EARINGS-BOSTON GEAR # 3030 DS-.75 BORE
(2) BALL BUSHING-# B122026-.75 BORE
THOMSON IND. MANHASSET, NY
21.75
KHWA-9 SHIFTA-ROLL STAND
FIFE CORP. OKLA.CITY OK.
GEARMOTOR-BODINE-
#42A5BE-E3-60:1 RATIO
42 RPM.
℄ 26 INCH WEB
51.50
PART NO.
4-25-79
UNWIND STATION
F
19200
9331501


FIG. 3-2

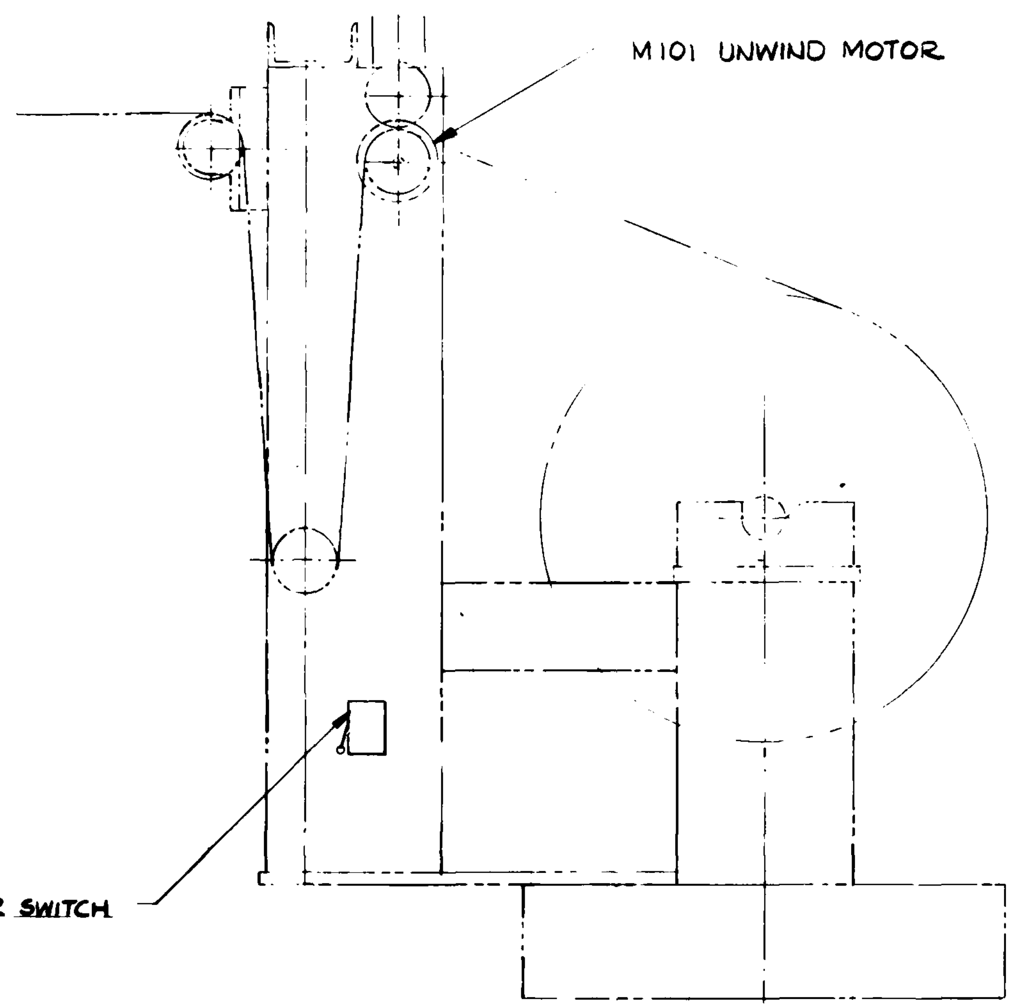



Fig. 3-3

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

CONTROL
UNWIND STATION

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

ORIGINAL DATE OF DRAWING 5-15-79

SIZE C | CODE IDENT NO. 19200 | 9331514

SCALE NONE | UNIT WT. | SHEET 1 OF 1

REVISIONS: SYM | DESCRIPTION | DATE | APPROVAL

NEXT ASSY | USED ON | APPLICATION

MECHANICAL PROPERTIES

DRAWING SIZE C

dancer assembly. In the dancer assembly a weighted roller is mounted on two ball bushings. The roller moves up and down on two ball bushing shafts; one on each side of the dancer assembly. This allows the web to feed around the dancer roller as needed. The web then goes around another roller which levels the web at the working height of 40 inches. The web is kept taut through the next station by means of weights attached to the dancer roller.

A Shifta-Roll stand forms the base of the Unwind Station. The Shifta-Roll stand is part of a commercially available system made by Fife which is used for center guiding webs. There will be two center guide systems used in the Body and Liner Assembly system; one will be used in the Unwind Station.

The unwind stand is capable of handling a 28-inch diameter roll of cloth. This roll will weigh approximately 230 pounds and will be 800 yards long. The weight of the roll plus the weight of the dancer assembly and the web tension weights will be approximately 550 pounds which is well within the 800 pound limit of the Fife center guide system.

A 42 rpm, 270 inch-pound gear motor will drive the web through the nip roller and into the dancer assembly. The drive roller is three inches in diameter and will drive the web into the dancer assembly at the rate of 6.7 inches per second. The Liner Place, Sew and Crease Station indexes one bag length of webbing out of the unwind stand every 6.4 to 8.4 seconds depending upon bag size. The time it takes to resupply this material into the dancer assembly is shown in Table 3-2.

The number of yards of cloth per shift to be processed and the number of roll changes per shift are also shown in this table.

Table 3-2. Unwind Station

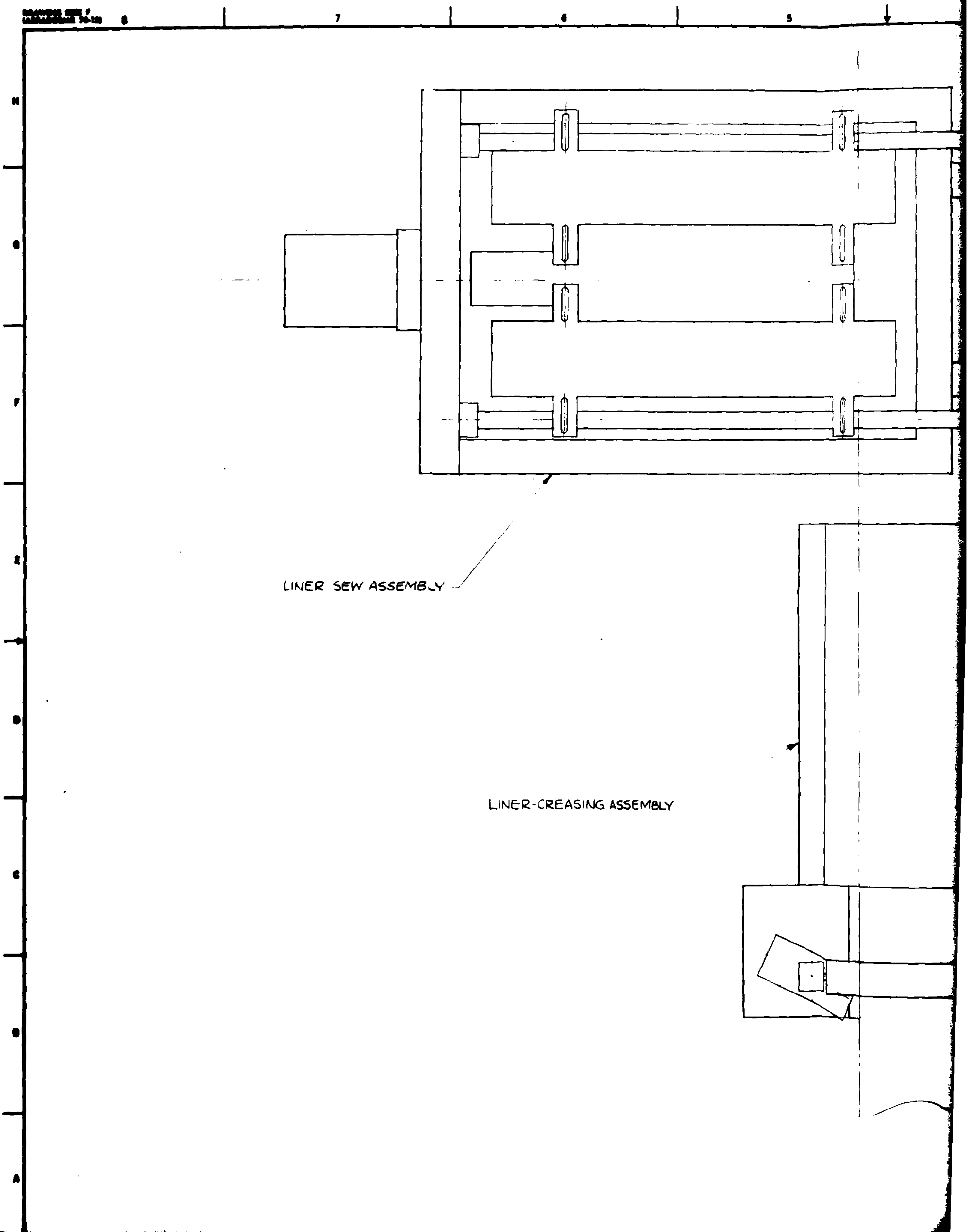
| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
|---|---|---|---|---|
| Roll Unwind Time | 3.95 | 4.52 | 4.10 | 1.26 |
| Yards/Shift | 1790 | 1880 | 1450 | 486 |
| No. of Roll Changes/Shift | 2.2 | 2.4 | 1.8 | 0.6 |

### 3.1.2 Lead Liner Place, Sew and Crease Station

The Lead Liner Place, Sew and Crease Station is comprised of four semi-independent assemblies: the Liner Elevator, the Liner Transfer Assembly, the Liner Sew Assembly, and the Liner Crease Assembly (see Figure 3-4).

A stepper motor advances the proper length of cloth body material into this station. The web is guided through the station by two Fife center guiding systems to insure the web is positioned with sufficient accuracy (approximately 0.030 inch) to allow proper liner placement. The Liner Transfer Assembly picks up a sheet of lead liner, aligns it, and places it on the web at the proper location by means of edge sensors. The Liner Transfer Assembly retracts while the two sewing machines sew the liner to the cloth web. Simultaneously, the Liner Creaser Assembly creases the previously sewn assembly along the center line of the assembly.

When the sewing machines have sewn across the liner, they cut the threads, lift and retract back to the starting positions. While they are retracting to their initial starting position, two other operations are also occurring. The cloth drive stepper motor


LINER SEW ASSEMBLY
LINER-CREASING ASSEMBLY

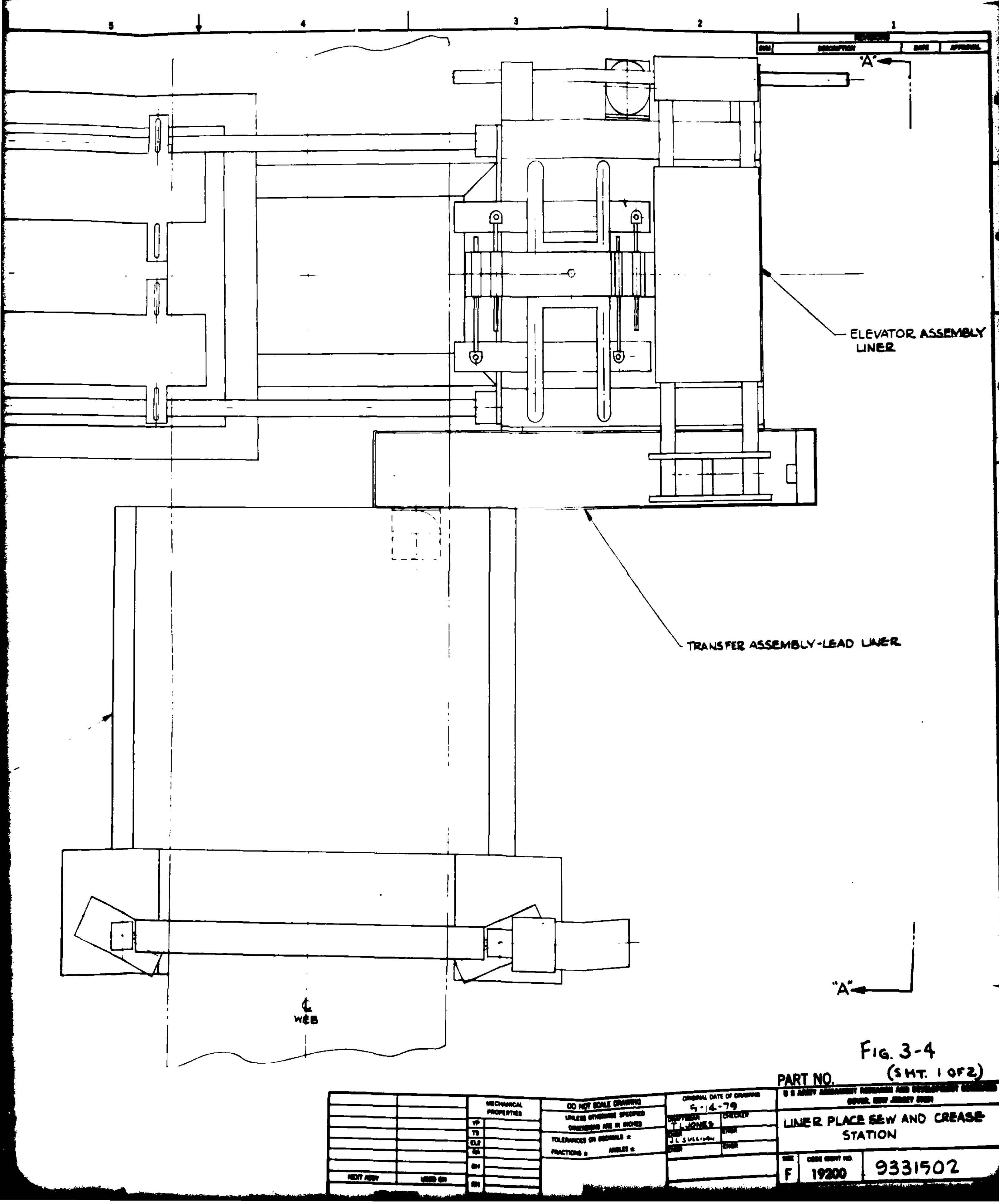
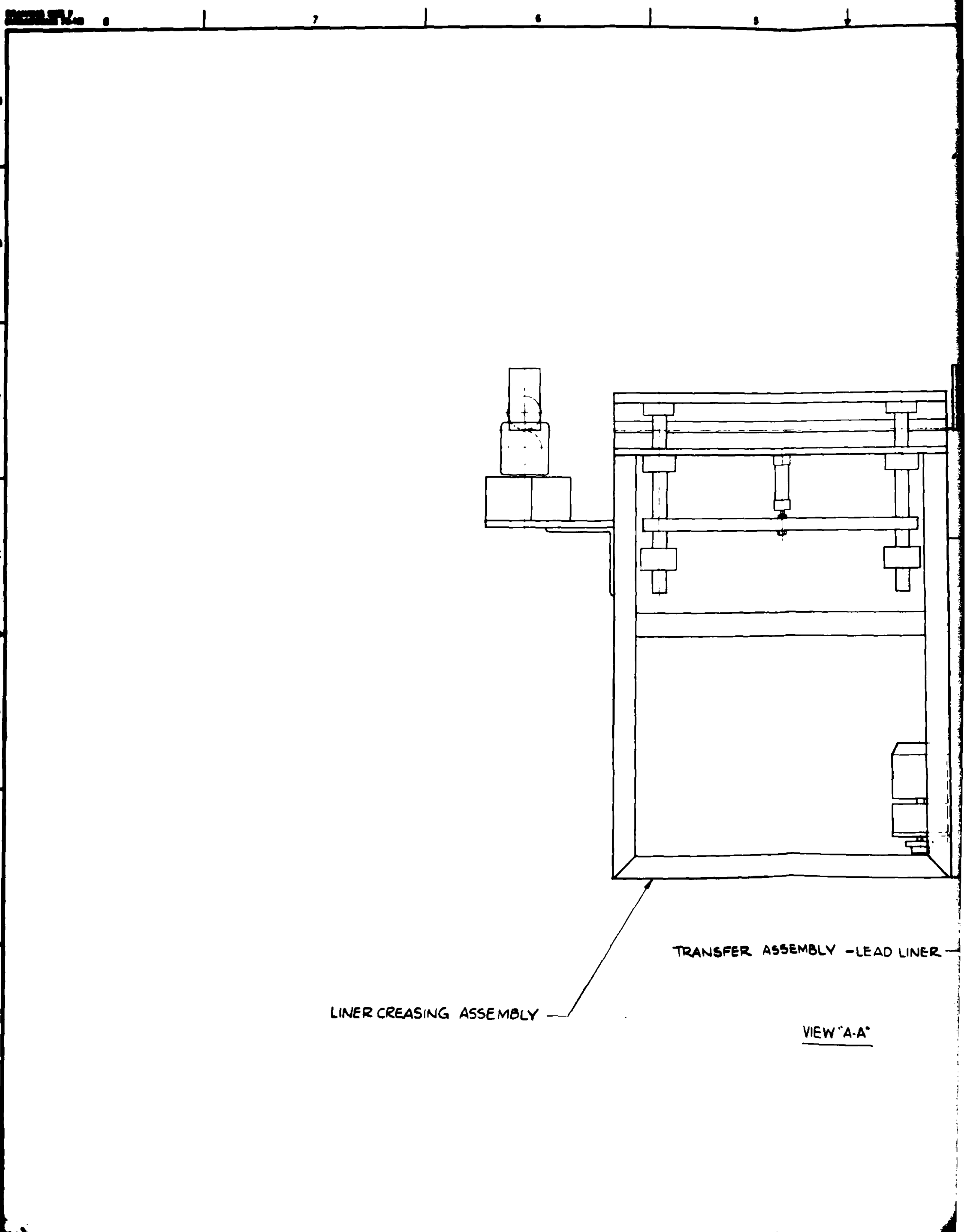



Fig. 3-4
(SHT. 1 OF 2)



TRANSFER ASSEMBLY -LEAD LINER
LINER CREASING ASSEMBLY
VIEW "A-A"

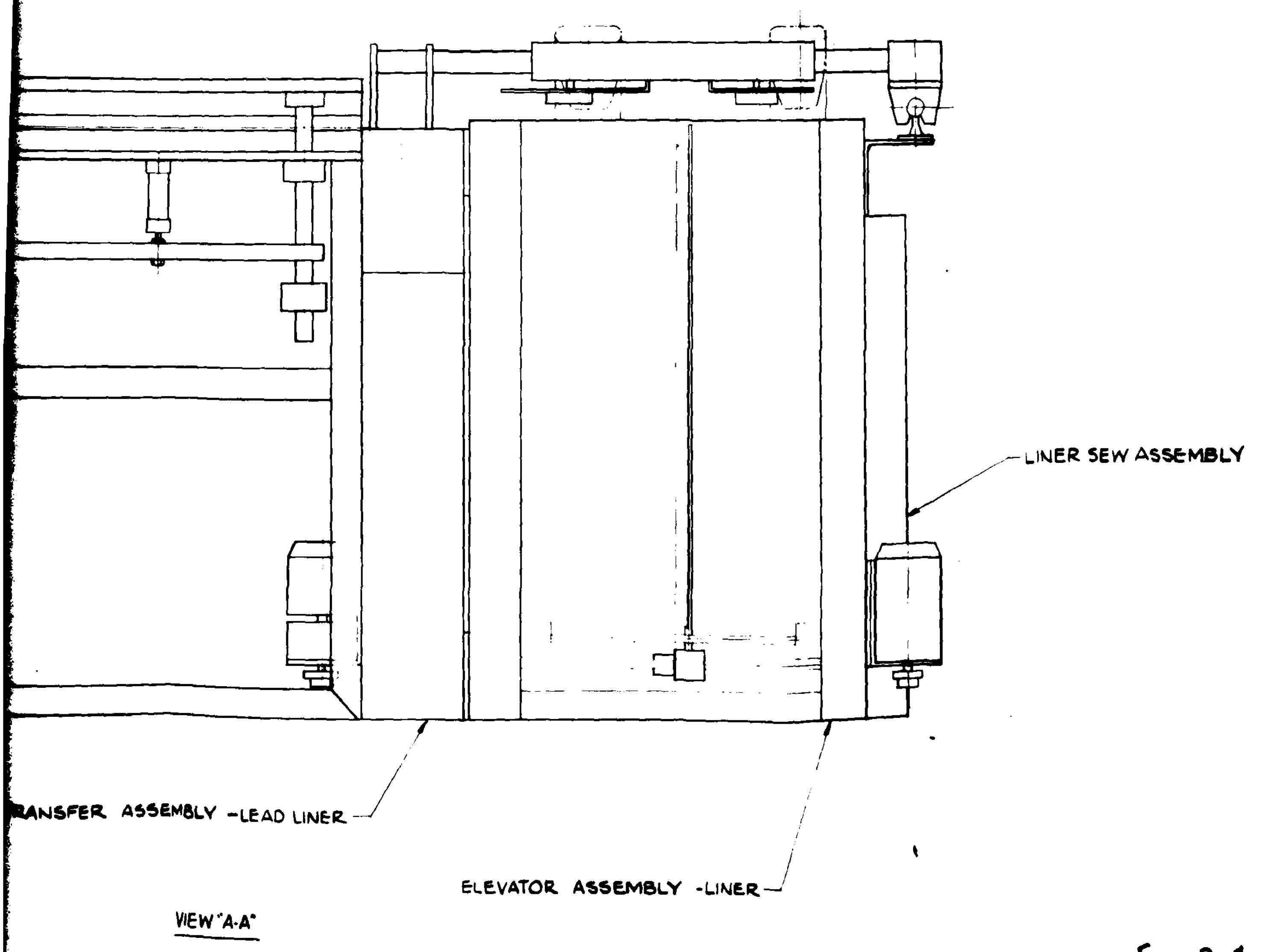



Fig. 3-4
(SHT. 2 OF 2)

PART NO.

LINER PLACE SEW AND C[illegible]
STATION

DO NOT SCALE DRAWING

MECHANICAL PROPERTIES

5-14-79

F | 19200 | 9331502

advances the next assembly into position, and the Liner Transfer Assembly picks up, aligns and starts the next transfer process.

The cloth web with the creased liners sewn in place is fed from the Liner Place, Sew and Crease Station into the supply loop for the Tube Sew Station.

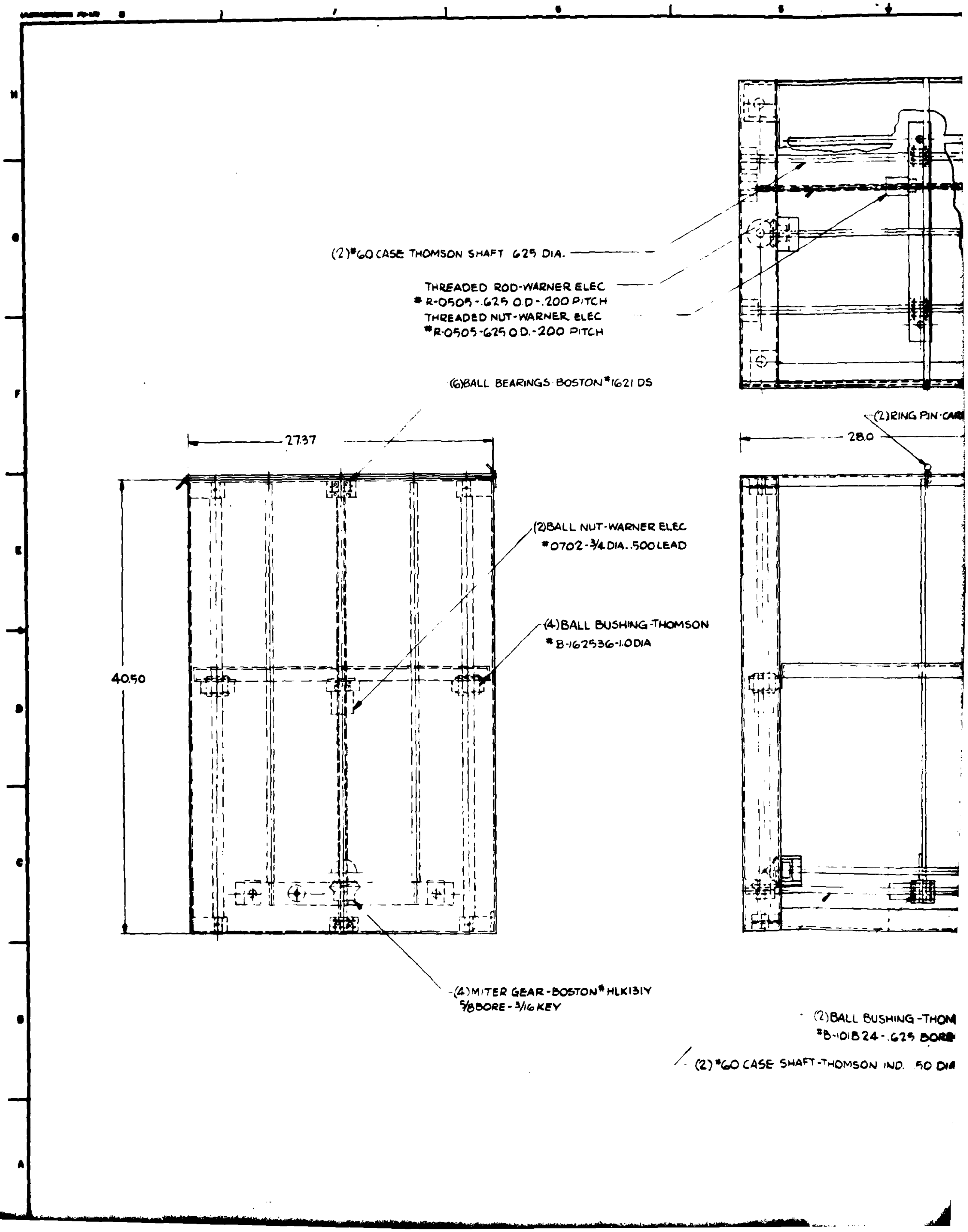
### 3.1.2.1 Liner Elevator Assembly

The Liner Elevator Assembly is a box-like structure with a lift platform. This unit maintains the stack of lead liners at a constant height for the Liner Transfer Assembly by means of a liner proximity sensor, an electric brake motor, and a drive mechanism (see Figure 3-5).

The lift platform (see Figure 3-6) is driven by an electric brake motor to two 0.5 inch ball screws. Four hardened and ground shafts, one in each corner, stabilize the lift platform by means of four ball bushings mounted to the lift platform. A hand crank at the bottom of the assembly lets the operator adjust the size of the lift platform for different liner sizes. An access opening at the rear of the elevator allows easy lead liner replenishment.

There are 31 linear inches of storage capacity which is approximately 600 pounds of lead liners. The liners can be loaded by hand onto the lift platform. The hand loading operation (calculated below) would take approximately 6.1 minutes: Refer to Table 3-3 for additional elevator data.

| | |
|---|---|
| Turn Off Station and Lower Tray | 1.5 min. |
| Load 12 Liners(8 sec/12 liners to load) | 4.1 min. |
| Turn System On | 0.5 min. |
| | 6.1 min. |



(2)*60 CASE THOMSON SHAFT .625 DIA.
THREADED ROD-WARNER ELEC
*R-0505-.625 O.D-.200 PITCH
THREADED NUT-WARNER ELEC
*R-0505-.625 O.D.-.200 PITCH
(6)BALL BEARINGS BOSTON*1621 DS
27.37
28.0
(2)RING PIN
40.50
(2)BALL NUT-WARNER ELEC
*0702-3/4 DIA..500 LEAD
(4)BALL BUSHING-THOMSON
*B-162536-1.0DIA
(4)MITER GEAR-BOSTON* HLK131Y
5/8 BORE-3/16 KEY
(2)BALL BUSHING-THOM
*B-101B24-.625 BORE
(2)*60 CASE SHAFT-THOMSON IND. .50 DIA
H
G
F
E
D
C
B
A

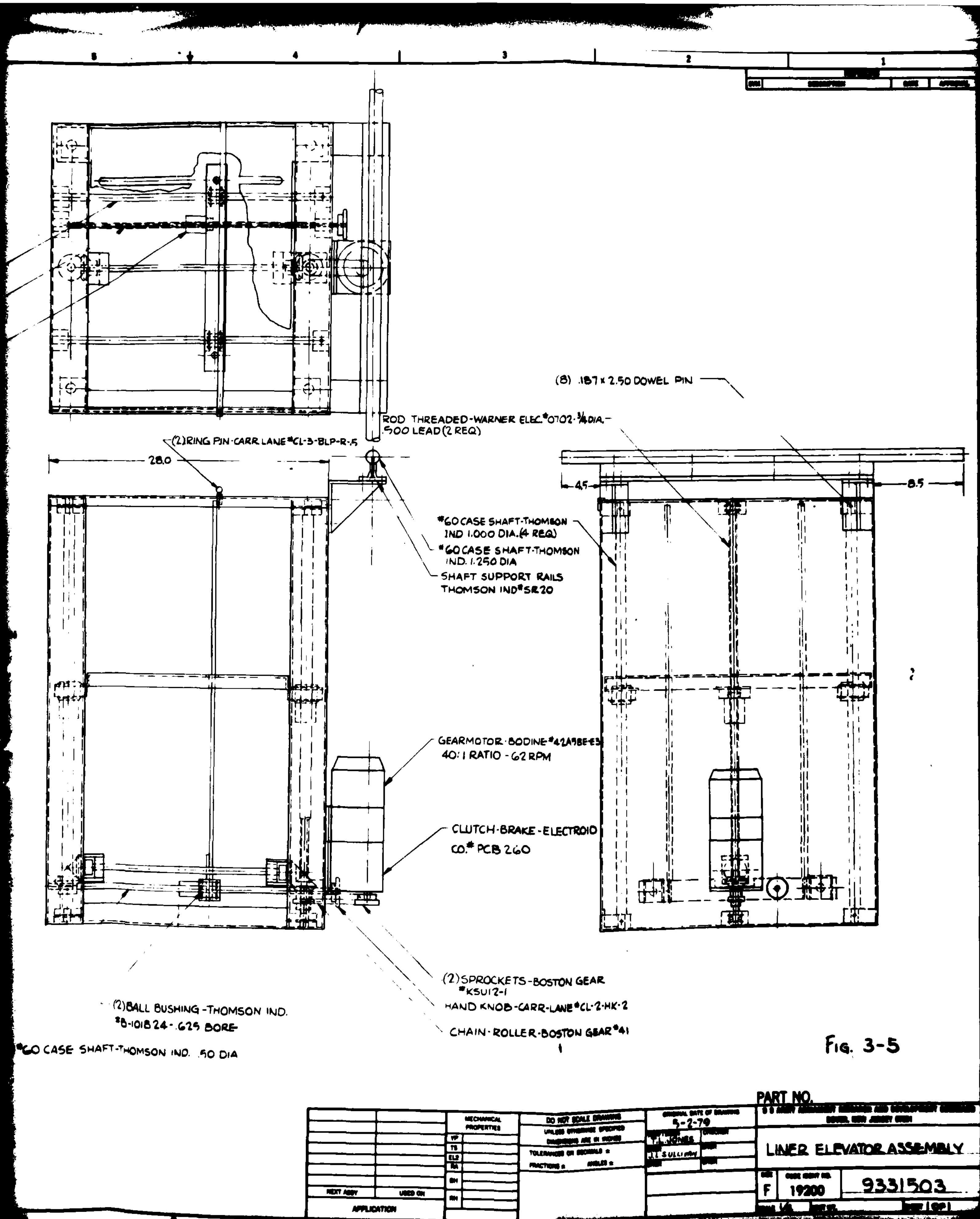

(8) .187 x 2.50 DOWEL PIN
ROD THREADED-WARNER ELEC.#0702-3/4 DIA.-.500 LEAD (2 REQ)
(2) RING PIN-CARR LANE #CL-3-BLP-R-.5
28.0
4.5
8.5
#60 CASE SHAFT-THOMSON IND 1.000 DIA. (4 REQ)
#60 CASE SHAFT-THOMSON IND. 1.250 DIA
SHAFT SUPPORT RAILS THOMSON IND #SR20
GEARMOTOR-BODINE #42A9BE-E3 40:1 RATIO - 62 RPM
CLUTCH-BRAKE-ELECTROID CO.# PCB 260
(2) SPROCKETS-BOSTON GEAR #KSU12-1
HAND KNOB-CARR-LANE #CL-2-HK-2
CHAIN-ROLLER-BOSTON GEAR #41
(2) BALL BUSHING-THOMSON IND. #B-101824-.625 BORE
#60 CASE SHAFT-THOMSON IND. .50 DIA
PART NO.
5-2-79
T.L. JONES
J. SULLIVAN
LINER ELEVATOR ASSEMBLY
F
19200
9331503
NEXT ASSY
USED ON
APPLICATION
MECHANICAL PROPERTIES
DO NOT SCALE DRAWING

FIG. 3-5

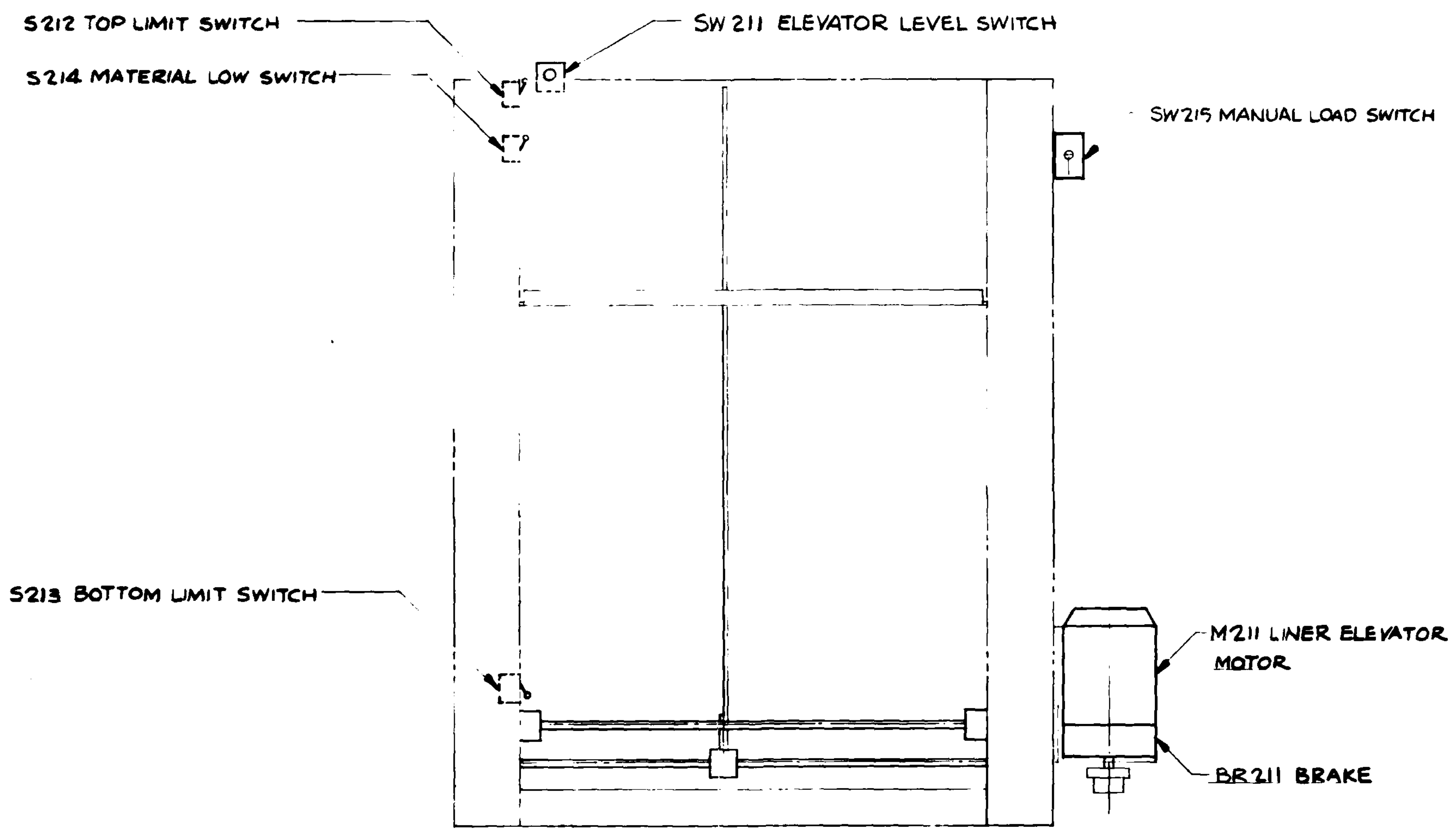



FIG. 3-6

PART NO.

| | |
|---|---|
| DO NOT SCALE DRAWING | ORIGINAL DATE OF DRAWING 5-15-79 |
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES | DRAFTSMAN T. L. JONES |
| TOLERANCES ON DECIMALS ± | CHECKER |
| FRACTIONS ± ANGLES ± | ENGR |
| U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND DOVER, NEW JERSEY 07801 | LINER ELEVATOR ASSEMBLY CONTROL |
| SIZE C | CODE IDENT NO. 19200 |
| DWG NO. | 9331515 |
| SCALE NONE | UNIT WT. |
| SHEET 1 OF 1 | |

NEXT ASSY | USED ON

APPLICATION

The time required to hand load the liners (see Table 3-3) still allows for the use of a 70% efficiency factor.

These liners can be placed in a magazine and the magazine loaded onto the lift platform. This would reduce downtime for liner replenishment.

Table 3-3. Elevator Data

| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
|---|---|---|---|---|
| Elevator Storage Capacity | 930 | 372 | 372 | 744 |
| Liner Assemblies per inch | 30 | 12 | 12 | 12 |
| No. of Liner Refills/Shift | 2.6 | 6.0 | 5.1 | 5.5 |
| Liner Refill Time (mins)/ Shift | 15.9 | 36.6 | 31.1 | 56.1 |

The driver motor for the lift platform is a 62 rpm, 270 in-lb motor. The motor drives the two ball screws which elevate the lift platform. The ball screws have a 0.5 inch pitch. Therefore the lift platform has a travel speed of 31 inches/minute.

The driving torque required to turn the ball screw and move the 600 pound load of liners can be determined by the following equation:

$$T = \frac{P \times l}{2 \times \quad \times e}$$

where:

T = Torque (inch-pounds)
P = Load
l = Screw lead (inches/turn)
e = Ball bearing screw efficiency (90%)

thus:

$$T = \frac{600 \text{ lbs} \times 0.5}{2 \times \quad \times 0.9} = 53 \text{ in-lbs}$$

Due to the high efficiency of the ball screw, a brake on the motor is necessary to prevent the platform weight from turning the motor backwards. The backdriving torque (torque created by an applied load) can be found by the following equation:

$$T = \frac{P \times l \times e}{2}$$

$$T = \frac{600 \times 0.5 \times 0.9}{2}$$

$$T = 43 \text{ in-lbs backdriving torque}$$

The critical column load for the ball screws must be considered. The critical column load is a function of the end bearing fixity, unsupported length, and the screw root diameter. The critical column load can be found by the following equation:

$$P_{CR} = C_C \times 14.05 \times 10^6 \times \frac{D^4}{L^2}$$

where:

$P_{CR}$ = Critical load (lbs.)

$C_C$ = End fixity factor

D = Minimum diameter (inches)

L Unsupported length (inches)

thus:

$$P_{CR} = 1 \times 14.05 \times 10^6 \times \frac{0.628^4}{37.5^2} = 1,554 \text{ lbs.}$$

The critical column load for the ball screws used in the liner elevator assembly is 1,554 pounds while the actual maximum applied load per ball screw is only 320 pounds.

All mechanical devices have several natural vibration frequencies. If a ball screw rotates at an angular velocity equal to one of the ball screw's natural frequencies, a severe vibration will be set up in the screw. The critical speed of ball screws should always be considered. In this application, the operating speed of 62 rpm's is well below the critical speed. The critical speed can be found by the following equation:

$$N = C_S \times 4.76 \times 10^6 = \frac{D}{L^2}$$

where: $N$ = Critical speed

$C_S$ = End fixity factor

$D$ = Mean diameter

$L$ = Length between bearing supports

thus:

$$N = 0.36 \times 4.76 \times 10^6 = \frac{0.694}{37.5^2}$$

$$N = 845 \text{ rpm}$$

The preceeding calculations (driving torque, backdriving torque, critical column loading, and critical speed) are typical of the calculations performed at each station to determine the proper and adequate hardware design approach. These calculations will not be included in this report; however, their results can be seen in the hardware design and selection as exhibited is this report.

### 3.1.2.2 Liner Transfer Assembly

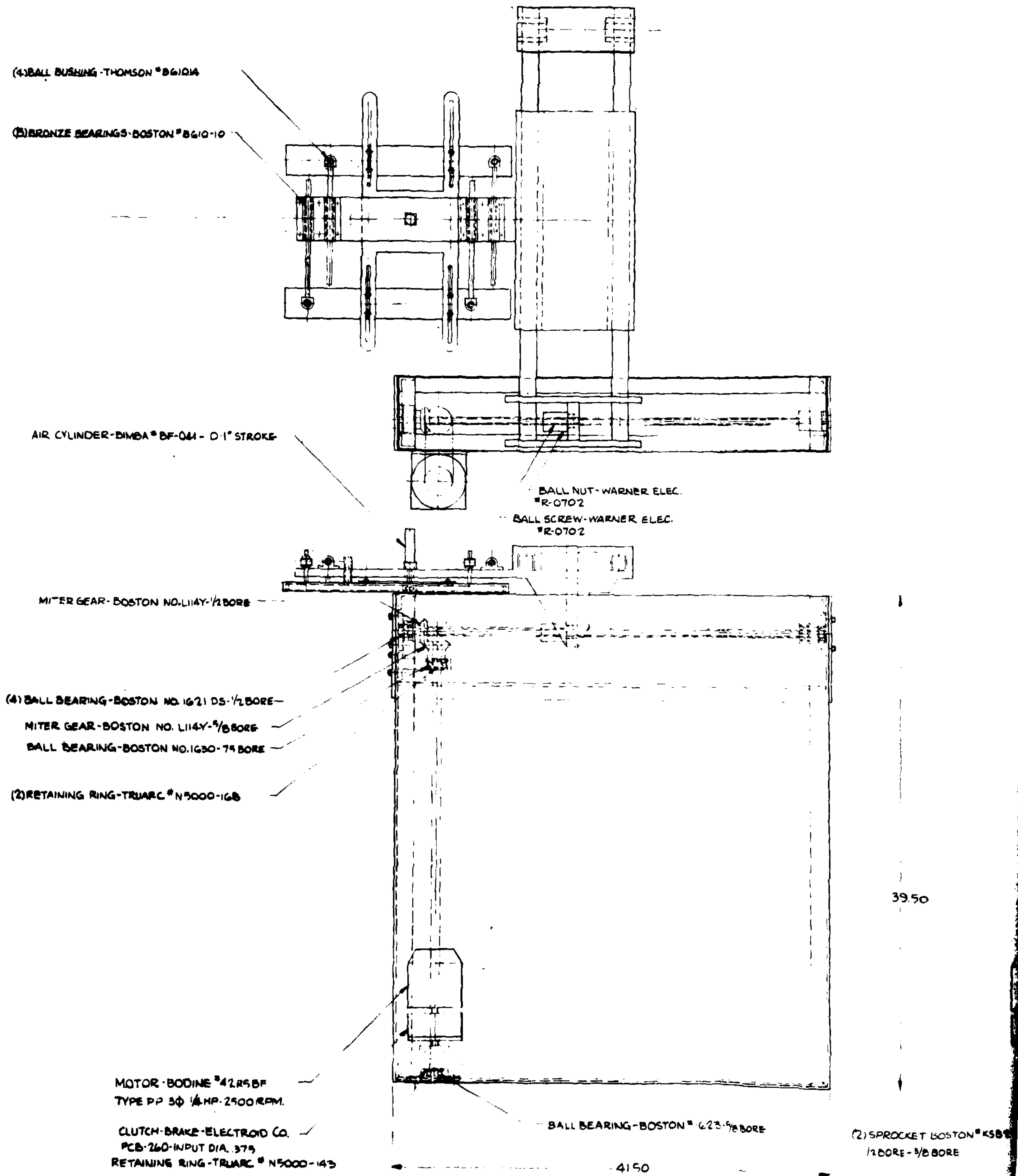
The Liner Transfer Assembly consists of a movable structure on top of the liner elevator assembly and is driven by an electric brake motor (see Figure 3-7). Attached to the top of the structure are two vacuum chambers which are adjustable for different liner sizes. These vacuum chambers are actuated vertically by a one-inch stroke air cylinder. The movable structure is driven forward and backwards by means of a ball screw and nut from the electric brake motor. The opposite end of the assembly is supported by a ball bushing and a hardened and ground shaft attached to the liner elevator.

The Liner Transfer Assembly motor runs at 2500 rpm with a one-to-one ratio to the ball screw propelling the Transfer Assembly at 20.8 in/sec. Considering the linear and rotational inertias of the 32 pound Transfer Assembly, the PCB-260 brake can stop the assembly in less than 1/8 inch. Assuming a repeatability within 20%, the leading edge of all liners will be placed within 0.025 inch of the reference line.

The Liner Transfer Assembly will take approximately 1.54 seconds to transfer the liner to the web. By the use of flow controls (see Figure 3-8), the up/down speed of the vacuum heads can be controlled. It is estimated that they will be set to approximately 0.5 second up and 0.2 second down.

This station's total cycle time will be as follows:

| | Time (sec) |
|---|---|
| Vacuum Heads Down | 0.2 |
| Align Liner | 0.8 |
| Liner Up | 0.5 |
| Transfer to Web | 1.54 |



(4) BALL BUSHING - THOMSON # B61014
(8) BRONZE BEARINGS - BOSTON # B610-10
AIR CYLINDER - BIMBA # BF-041 - D 1" STROKE
BALL NUT - WARNER ELEC. # R-0702
BALL SCREW - WARNER ELEC. # R-0702
MITER GEAR - BOSTON NO. L114Y - 1/2 BORE
(4) BALL BEARING - BOSTON NO. 1621 DS - 1/2 BORE
MITER GEAR - BOSTON NO. L114Y - 5/8 BORE
BALL BEARING - BOSTON NO. 1630 - 75 BORE
(2) RETAINING RING - TRUARC # N5000-168
39.50
MOTOR - BODINE # 42R5BF
TYPE PP 3Φ 1/4 HP - 2500 RPM.
CLUTCH - BRAKE - ELECTROID CO.
PCB-260 - INPUT DIA. .375
RETAINING RING - TRUARC # N5000-143
BALL BEARING - BOSTON # 623 - 5/8 BORE
41.50
(2) SPROCKET BOSTON # KSB
1/2 BORE - 3/8 BORE

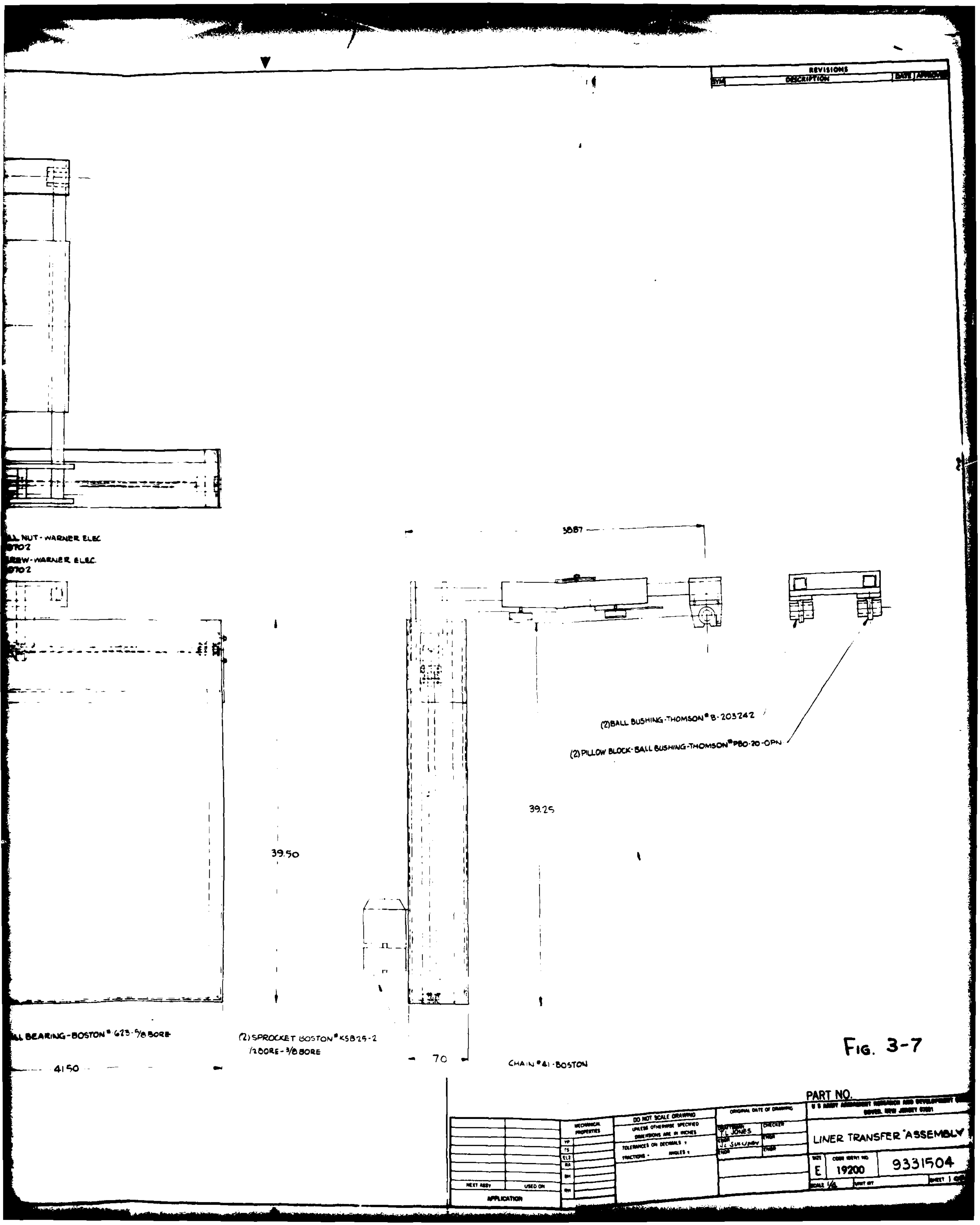

REVISIONS
SYM
DESCRIPTION
DATE
APPROVED
3887
...LL NUT-WARNER ELEC
...8702
...REW-WARNER ELEC.
...8702
(2) BALL BUSHING-THOMSON # B-203242
(2) PILLOW BLOCK-BALL BUSHING-THOMSON # PBO-20-OPN
39.50
39.25
...LL BEARING-BOSTON # 623-5/8 BORE
(2) SPROCKET BOSTON # KS825-2
1/2 BORE-3/8 BORE
70
CHAIN # 41-BOSTON
41.50
PART NO.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
MECHANICAL PROPERTIES
ORIGINAL DATE OF DRAWING
T. L. JONES
CHECKER
NEXT ASSY
USED ON
APPLICATION
LINER TRANSFER ASSEMBLY
SIZE
E
CODE IDENT NO.
19200
9331504
SCALE 1/4
UNIT WT
SHEET 1

FIG. 3-7

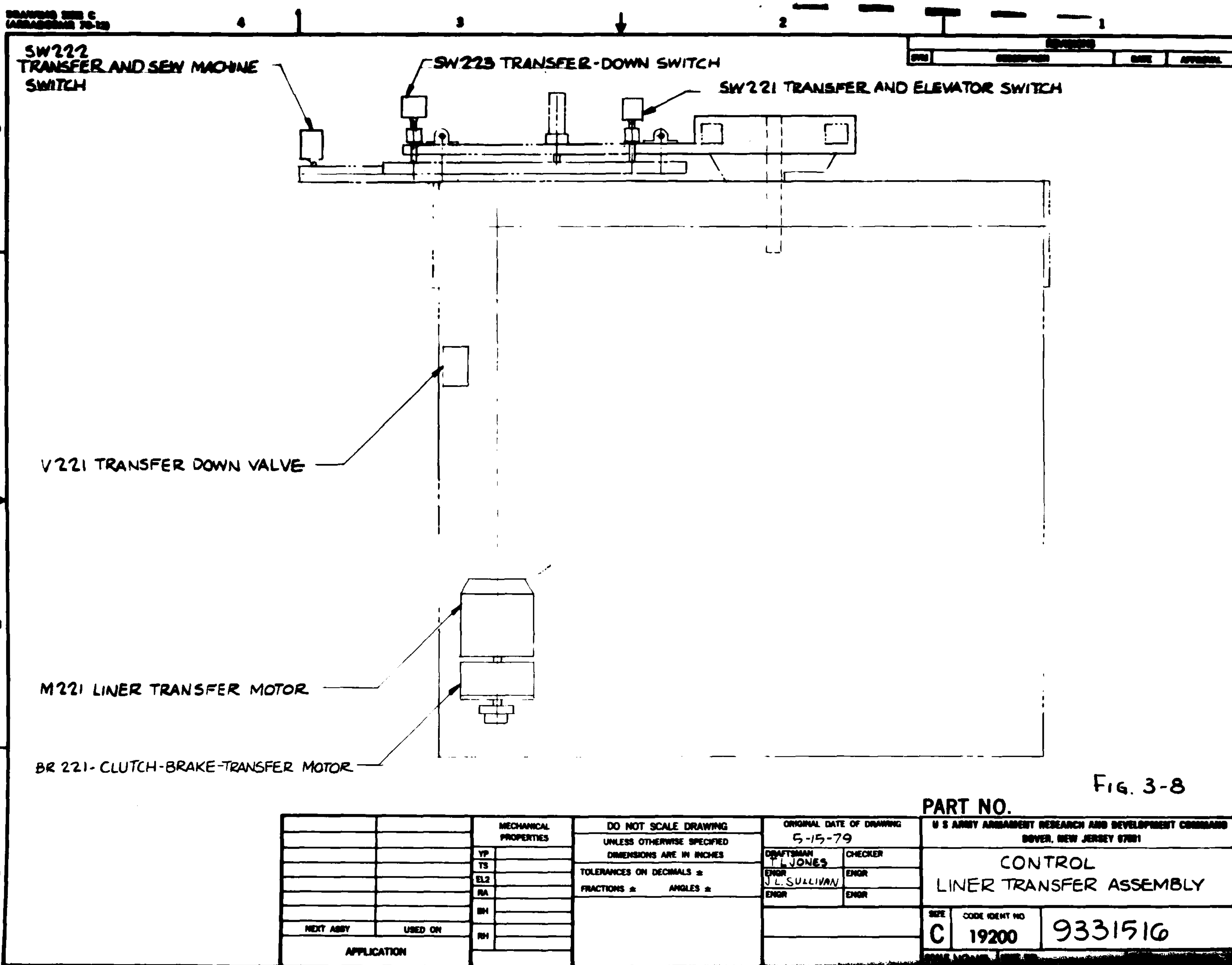

SW222 TRANSFER AND SEW MACHINE SWITCH
SW223 TRANSFER-DOWN SWITCH
SW221 TRANSFER AND ELEVATOR SWITCH
V221 TRANSFER DOWN VALVE
M221 LINER TRANSFER MOTOR
BR 221-CLUTCH-BRAKE-TRANSFER MOTOR
PART NO.
MECHANICAL PROPERTIES
YP
TS
EL2
RA
BH
RH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ±
ANGLES ±
ORIGINAL DATE OF DRAWING 5-15-79
DRAFTSMAN T L JONES
CHECKER
ENGR J L SULLIVAN
ENGR
ENGR
ENGR
U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND DOVER, NEW JERSEY 07801
CONTROL
LINER TRANSFER ASSEMBLY
SIZE C
CODE IDENT NO 19200
9331516

FIG. 3-8

| | Time (sec) |
|---|---|
| Lower Liner | 0.2 |
| Pause During Sew Machine Start-up | 0.5 |
| Vacuum Heads Up | 0.5 |
| Transfer to Elevator | 1.54 |
| | 5.78 seconds |

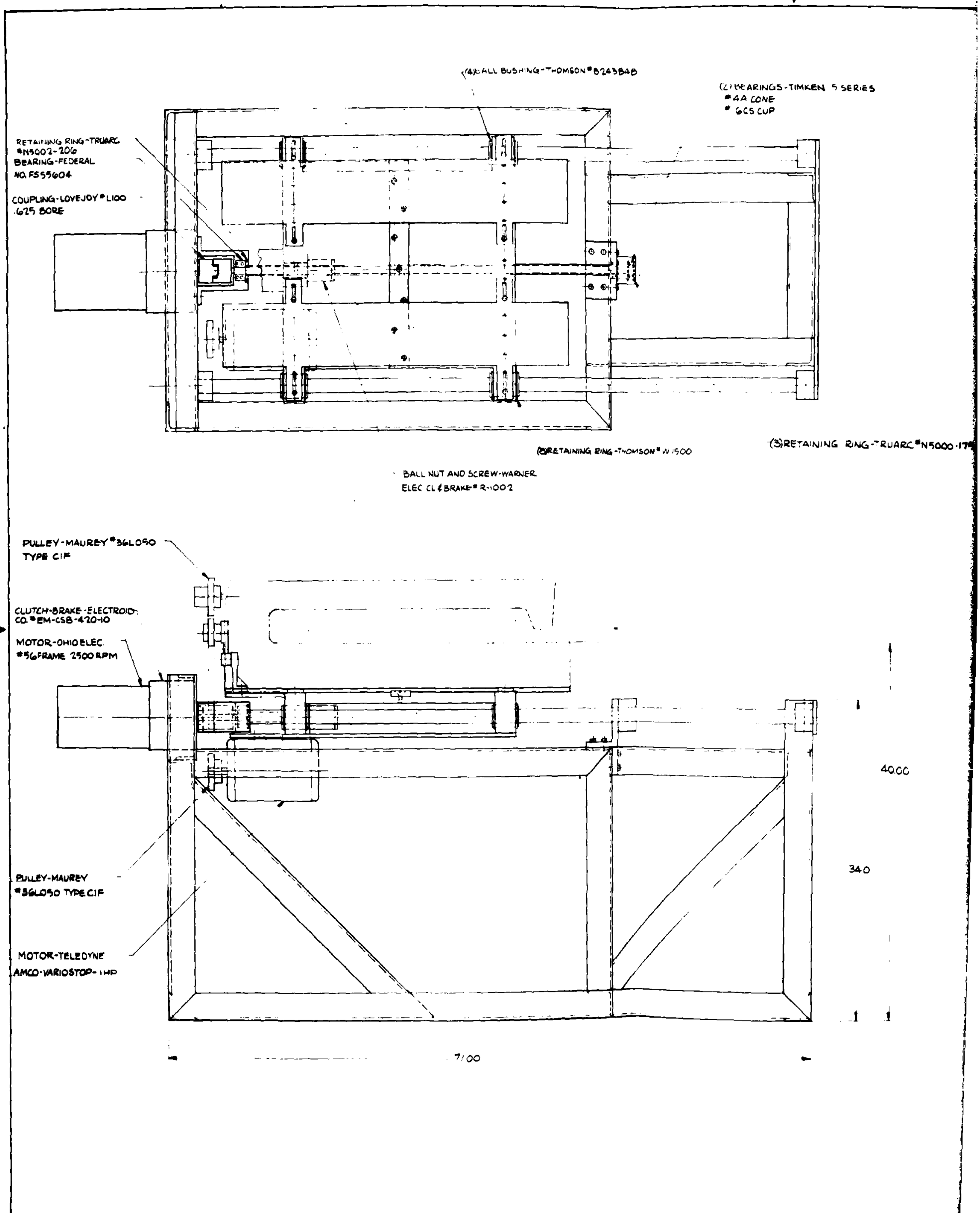
The total cycle time is approximately 5.8 seconds. Most of the cycle time occurs in parallel with the liner sewing operation.

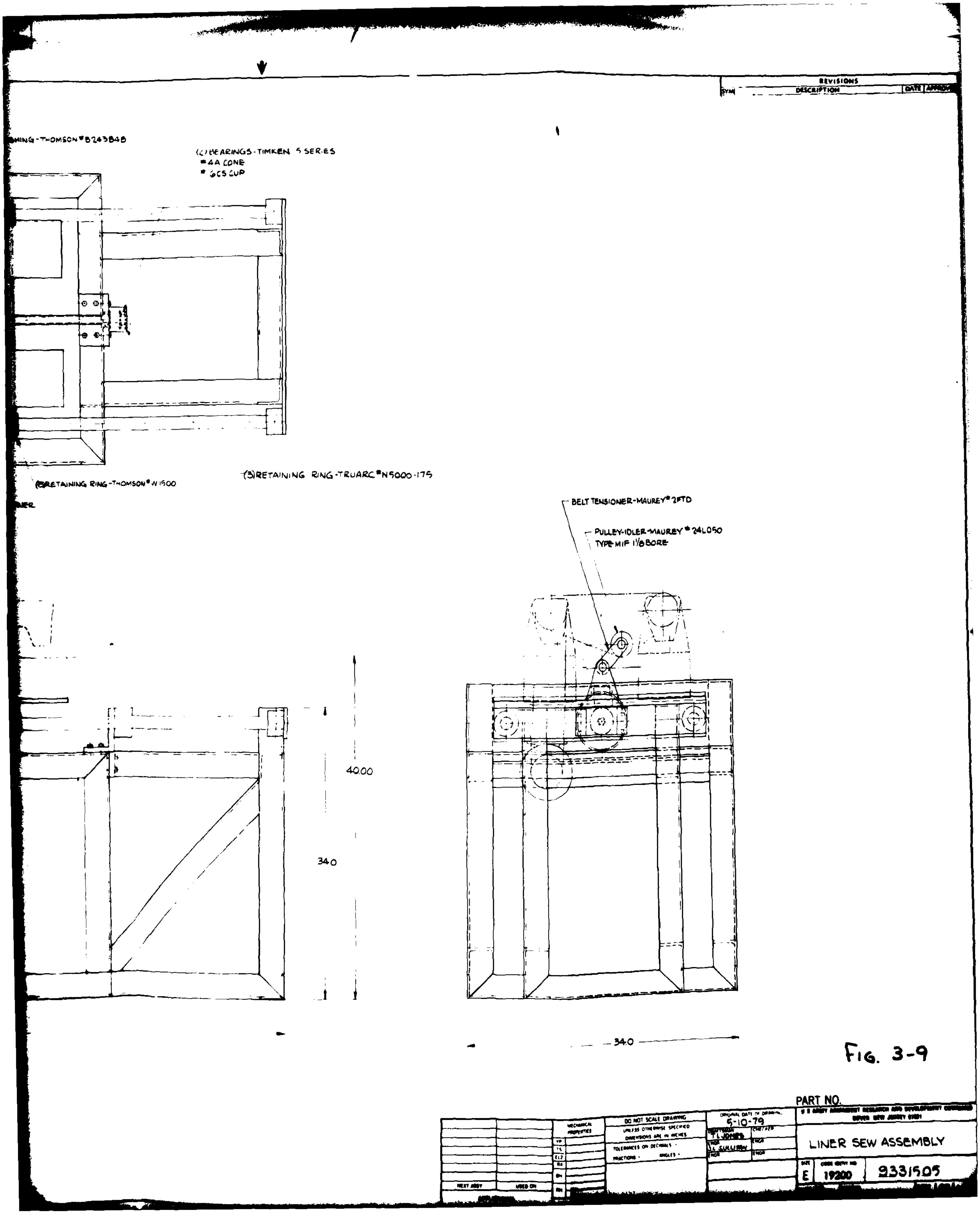
### 3.1.2.3 Liner Sew Assembly

The Liner Sew Assembly is designed to move two sewing machines across the width of the web and sew both edges of the liner to the web (see Figure 3-9).

The bottom structure will have mounted to it a speed controlled motor which directly drives a ball screw through a clutch brake. The ball screw drives a ball nut which is affixed to the sew machine table. Also, there are two hardened and ground shafts on the bottom structure used to support the weight of the sew machine table.

The two sewing machines are adjustably mounted on the sew machine table. The table is supported by four linear bushing that slide on the hardened and ground shafts on top of the bottom structure. Also mounted to this table is the sew machine drive motor and electronic control (see Figure 3-10). Both sew machines run synchronously from the motor by means of a timing belt. The sew machine table travel is controlled by adjustable limit switches for different web widths.


(4) BALL BUSHING-THOMSON # B243848
(2) BEARINGS-TIMKEN 5 SERIES
# 4A CONE
# 6CS CUP
RETAINING RING-TRUARC
# N5002-206
BEARING-FEDERAL
NO. FS55604
COUPLING-LOVEJOY # L100
.625 BORE
(3) RETAINING RING-THOMSON # W1500
(3) RETAINING RING-TRUARC # N5000-17
BALL NUT AND SCREW-WARNER
ELEC CL & BRAKE # R-1002
PULLEY-MAUREY # 36L050
TYPE CIF
CLUTCH-BRAKE-ELECTROID
CO. # EM-CSB-420-10
MOTOR-OHIO ELEC.
# 56 FRAME 2500 RPM
PULLEY-MAUREY
# 36L050 TYPE CIF
MOTOR-TELEDYNE
AMCO-VARIOSTOP-1HP
40.00
34.0
71.00



REVISIONS
SYM
DESCRIPTION
DATE
APPROVED
HING-THOMSON#B243848
(2) BEARINGS-TIMKEN 5 SERIES
#4A CONE
#6CS CUP
(2) RETAINING RING-THOMSON# W1500
(3) RETAINING RING-TRUARC#N5000-175
BELT TENSIONER-MAUREY# 2FTD
PULLEY-IDLER-MAUREY# 24L050
TYPE-MIF 1 1/8 BORE
40.00
34.0
34.0
PART NO.
U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER NEW JERSEY 07801
MECHANICAL PROPERTIES
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS
FRACTIONS
ANGLES
ORIGINAL DATE OF DRAWING
5-10-79
T.L.JONES
L.SULLIVAN
LINER SEW ASSEMBLY
E
19200
9331505
NEXT ASSY
USED ON


Fig. 3-9

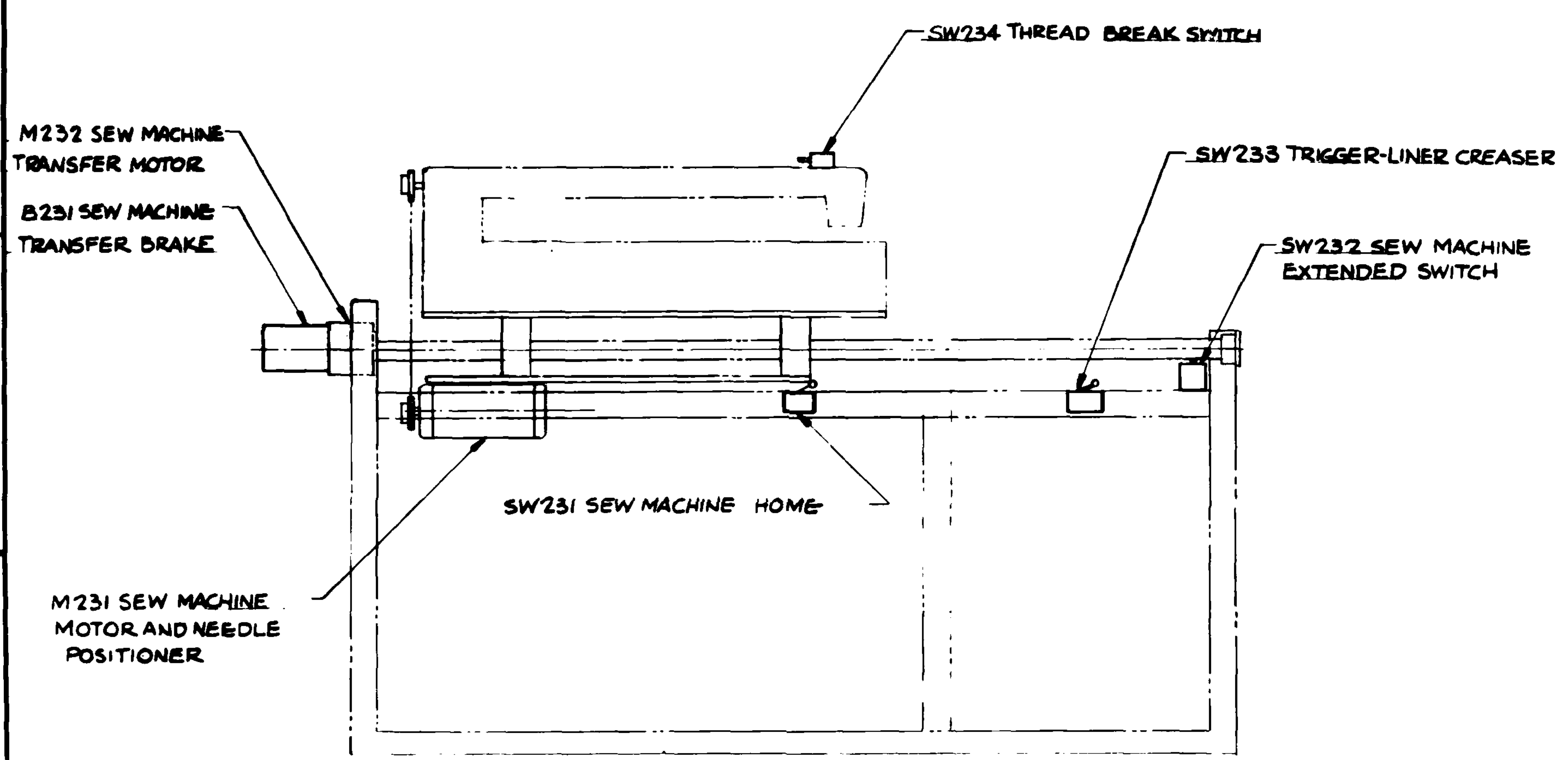



FIG. 3-10

PART NO.

| | |
|---|---|
| U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND, DOVER, NEW JERSEY 07801 | |
| LINER SEW ASSEMBLY CONTROL | |
| DO NOT SCALE DRAWING. UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ± | |
| ORIGINAL DATE OF DRAWING | 5-15-79 |
| DRAFTSMAN | T.L. JONES |
| ENGR | J.L. SULLIVAN |
| SIZE | C |
| CODE IDENT NO | 19200 |
| | 9331517 |
| SCALE | NONE |
| SHEET | 1 OF 1 |
| NEXT ASSY / USED ON | APPLICATION |

Two Singer 491 machines with changes made by MPG Manufacturing Co. can be used for this application. The major modification would be to lengthen the arm and bed of the machine so that there would be 28 inches of space to the right of the needle. The minor modifications include the addition of the plunging pressor foot, the removal of the feed dog, top shaft extension for an extra timing pulley, and the addition of the needle bearing supports on each arm and bed shaft. The bobbin of the Singer 491 will 75 yards of polyester thread, type I, class 1, size E. The number of liners per bobbin can be found in Table 3-4. The specification sheet on the 491 is included on the following page.

Table 3-4. Liner Sew Assembly

| | BAG TYPE | | | |
|---|---|---|---|---|
| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
| Sewing Time at 2700 spm (sec) | 4.4 | 4.4 | 6.0 | 6.0 |
| Cut Thread (sec) | 0.25 | 0.25 | 0.25 | 0.25 |
| Return Sewing Machine* (sec) | 1.33 | 1.33 | 1.80 | 1.80 |
| Index Web* (sec) | 1.41 | 1.61 | 1.46 | 0.23 |
| Transfer Liner* (sec) | 1.54 | 1.54 | 1.54 | 1.54 |
| Lower Liner to Web (sec) | 0.2 | 0.2 | 0.2 | 0.2 |
| Total Cycle Time (sec) | 6.39 | 6.46 | 8.25 | 8.25 |
| No. of Sewn Liners per Bobbin | 90 | 67 | 50 | 100 |
| Time to Change Bobbins (sec) | 75 | 75 | 75 | 75 |
| Bobbin Change Time per Cycle (sec) | 0.83 | 1.12 | 1.5 | 1.5 |

*These operations are in parallel; therefore, only the longest time is used in computing cycle time.

Single Needle Lockstitch Machines

Federal Stitch Type 301

# 491

## Description of Class

[illegible]

[illegible] the trimming mechanism. [illegible]

## Features

[illegible]

## General Specifications

### Mechanical

[illegible] Data Chart

### Length of Stitch

[illegible]

### Speed

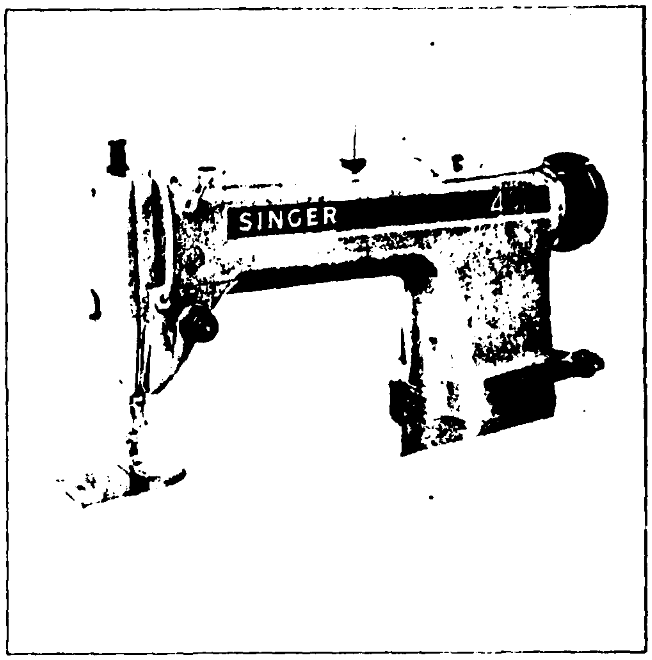
[illegible] Data Chart

### Lubrication

[illegible]

### Machine Bed

[illegible]




## Electrical

[illegible] Watts) High Speed

[illegible]

| | | |
|---|---|---|
| | [illegible] Size | [illegible] Size |
| Speed | [illegible] | [illegible] (Hertz) |
| 4000 | [illegible] | 4 [illegible] |
| 4500 | [illegible] | 4 [illegible] mm) |
| 5000 | 4 [illegible] | 5 [illegible] mm) |
| 5500 | 4 [illegible] | [illegible] 140 mm) |

Effective V Belt [illegible] of Machine Driving Pulley [illegible] mm

Standard [illegible]

Light Cat 996257-501 or equivalent

Stand 60/2063 or equivalent

Table 60/044 or equivalent

Table 3.4. (Cont.)

| | BAG TYPE | | | |
|---|---|---|---|---|
| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
| No. of Bobbin Changes/ Day | 25 | 31.5 | 35.2 | 80 |
| Cycle Time Including Bobbin Change Time(sec./ assy) | 7.22 | 7.58 | 9.75 | 9.75 |
| Time per Assy Including Bobbin Change Time(sec./ assy) | 7.22 | 7.58 | 9.75 | 4.88 |
| Time per Assembly (chain stitch)(sec./ assy) | 6.39 | 6.46 | 8.25 | 4.12 |
| Cloth output Rate (chain stitch (in/sec.) | 4.1 | 4.6 | 3.3 | 1.0 |
| Avg. Cloth Output Rate Including Bobbin Change in/sec.) | 3.7 | 4.0 | 2.8 | 0.87 |
| Station Output Rate Including Bobbin Changes pcs/hr) | 499 | 475 | 369 | 738 |
| Station Output Rate (chain stitch)(pcs/hr) | 563 | 557 | 436 | 873 |

After modification the maximum reliable operating speed of the sew machine will be 3000 rpm. The sew machine will be furnished with an extra long top drive shaft for the mounting of a timing pulley. Only one sewing machine will be driven directly from the motor while the second machine will be driven by a timing belt from the first machine. Only one needle positioner will be used since the timing belts insure that both needles are syncronized.

The sew machines will be powered by a 3/4 HP motor and needle positioner (e.g., Quick Stop or Teledyne/Amco Variostop). It is a variable speed motor which also controls the underbed thread cutter and foot up operations automatically.

The sewing machine travel is a smooth continous motion, not an incremental motion sycronized with the needles. This method of sewing is very similar to machine quilting. The plunging pressor foot will hold the material down to the bed of the sew machine while the needle is in the material to prevent flagging.

The total weight of the sew table including sew machines, motor and electronic control is approximately 275 pounds. The total travel distance of the sew table is 27 inches maximum. The sew table travels on two 1-½ inch diameter hardened and ground shafts which have a length of 64 inches between supports. Also, the 1 inch diameter 0.5 inch lead ball screw that drives the sew table has a 40 inch span between supports.

The critical speed of the ball screw has been calculated to be 6200 rpm which is well above its maximum operating speed of 1800 rpm. While sewing, the sew table travels across the liner at 270 inches per minute which is 540 rpm of the ball screw. The return of the sew table is at 1800 rpm which takes about 1.8 seconds to travel the 27 inches.

At the high return speed, the 240 in-lbs clutch brake will stop the table in 0.012 seconds, which is 0.093 inches of travel or 67° of screw rotation. This will create 864 pounds of thrust on the ball screw shaft bearing. The ball screw under these operating conditions will have a life in excess of 1,000,000,000 inches of travel which is a life of 18,520,000 cycles.

By using two 1.5 inch diameter hardened and ground shafts to support the weight of the sew machine table, the downward deflection will be less than 0.02 inch as the machines traverse the middle of the shafts.

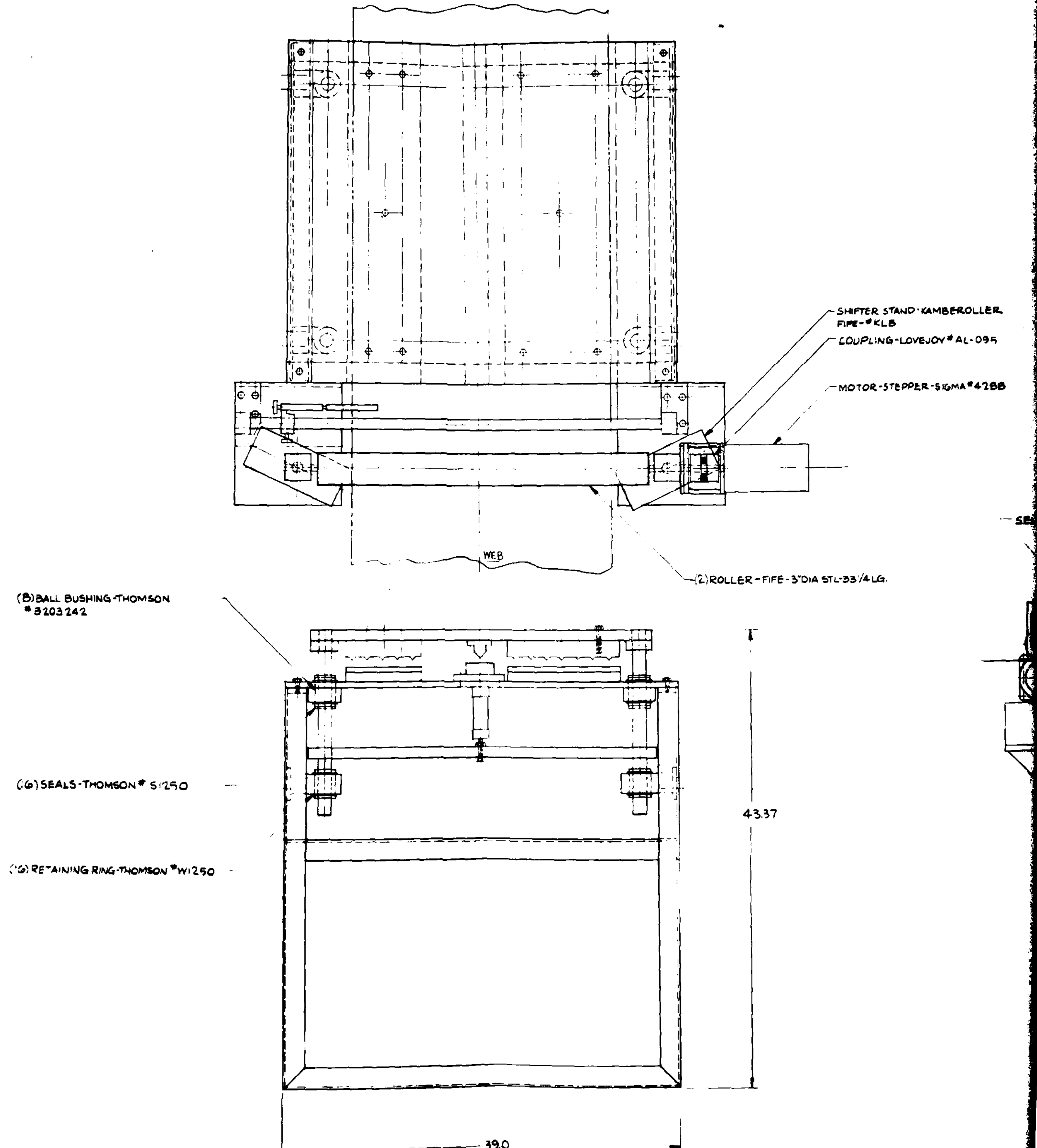
Because of the possibility of being able to sew the liner to the web and the tube seam with chain stitching, the timing and rates for chain stitching are shown in Table 3-4.

### 3.1.2.4 Lead Liner Creaser Assembly

The Liner Creaser Assembly (see Figure 3-11 and 3-12) is a boxlike structure that has an adjustable die to longitudinally crease the liner down the center line after it has been sewn to the web. This is to allow the web to fold easily for later sewing into a tube.

The top section of the assembly moves up and down by means of an air cylinder. The top rides on four ball bushings through four rods giving it greater stability. Between the top section which is movable and the bottom section which is fixed is a die. This die consists of a steel die on top and a rubber die on the bottom. The die indents the liner so that it can be easily handled during later manual operations. The amount of indentation in the lead liner can be controlled by the regulated air pressure to the top die air cylinder. The creasing operation takes approximately one second and occurs while the next liner is being sewn to the web.

The hourly output rate from this station is shown in Table 3-5.



SHIFTER STAND-KAMBEROLLER FIFE-#KLB
COUPLING-LOVEJOY#AL-095
MOTOR-STEPPER-SIGMA#42BB
WEB
(2) ROLLER-FIFE-3"DIA STL-33 1/4 LG.
(8) BALL BUSHING-THOMSON #B203242
(16) SEALS-THOMSON# S1250
(16) RETAINING RING-THOMSON #W1250
43.37
39.0


VIEW "A-A"

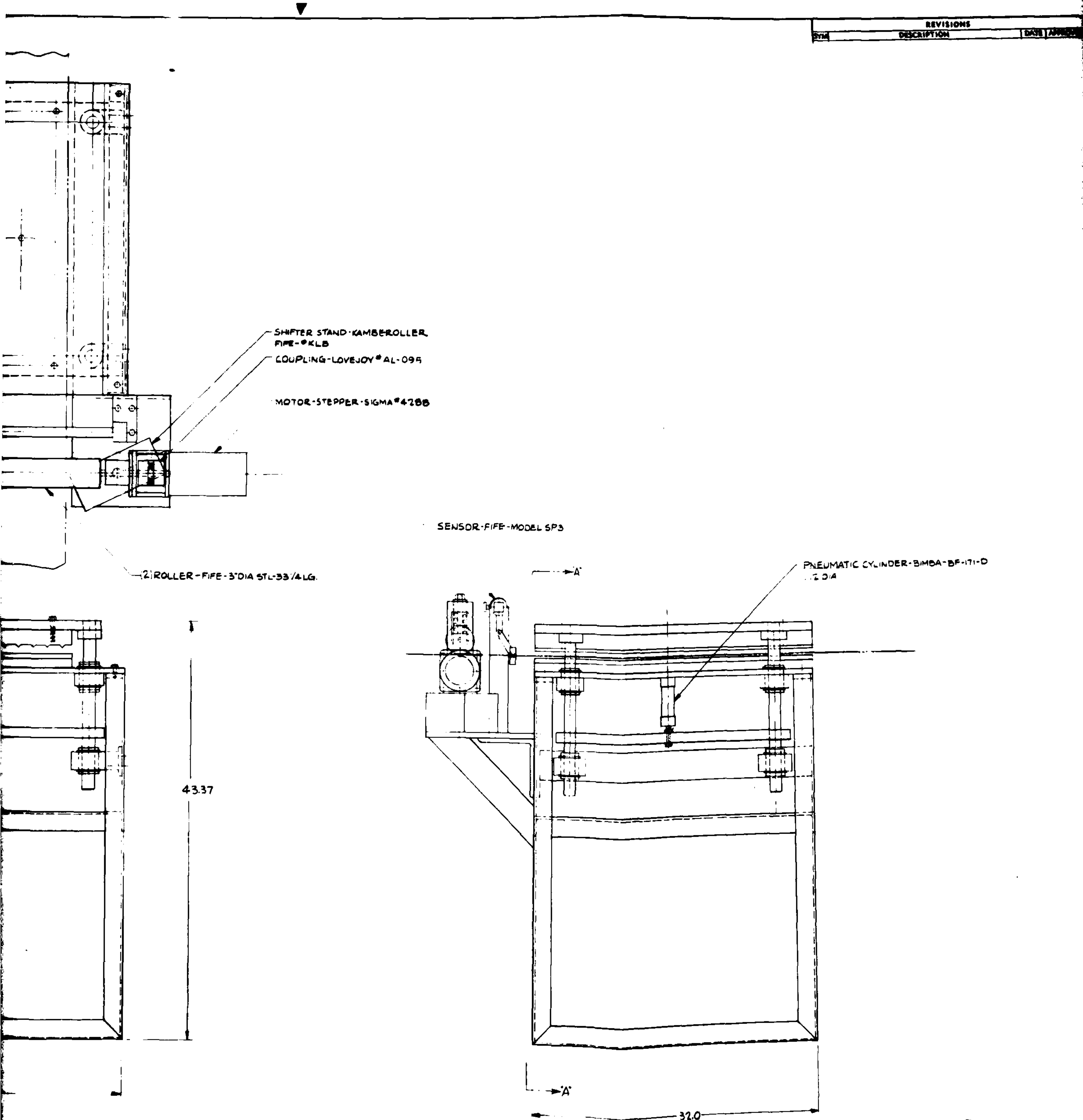



Fig. 3-11

PART NO.

| DO NOT SCALE DRAWING<br>UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON DECIMALS ±<br>FRACTIONS ± ANGLES ± | ORIGINAL DATE OF DRAWING 5-11-79<br>T. JONES | CHECKER | LINER CREASER ASSEMBLY |
|---|---|---|---|
| | | | E 19200 9331506 |

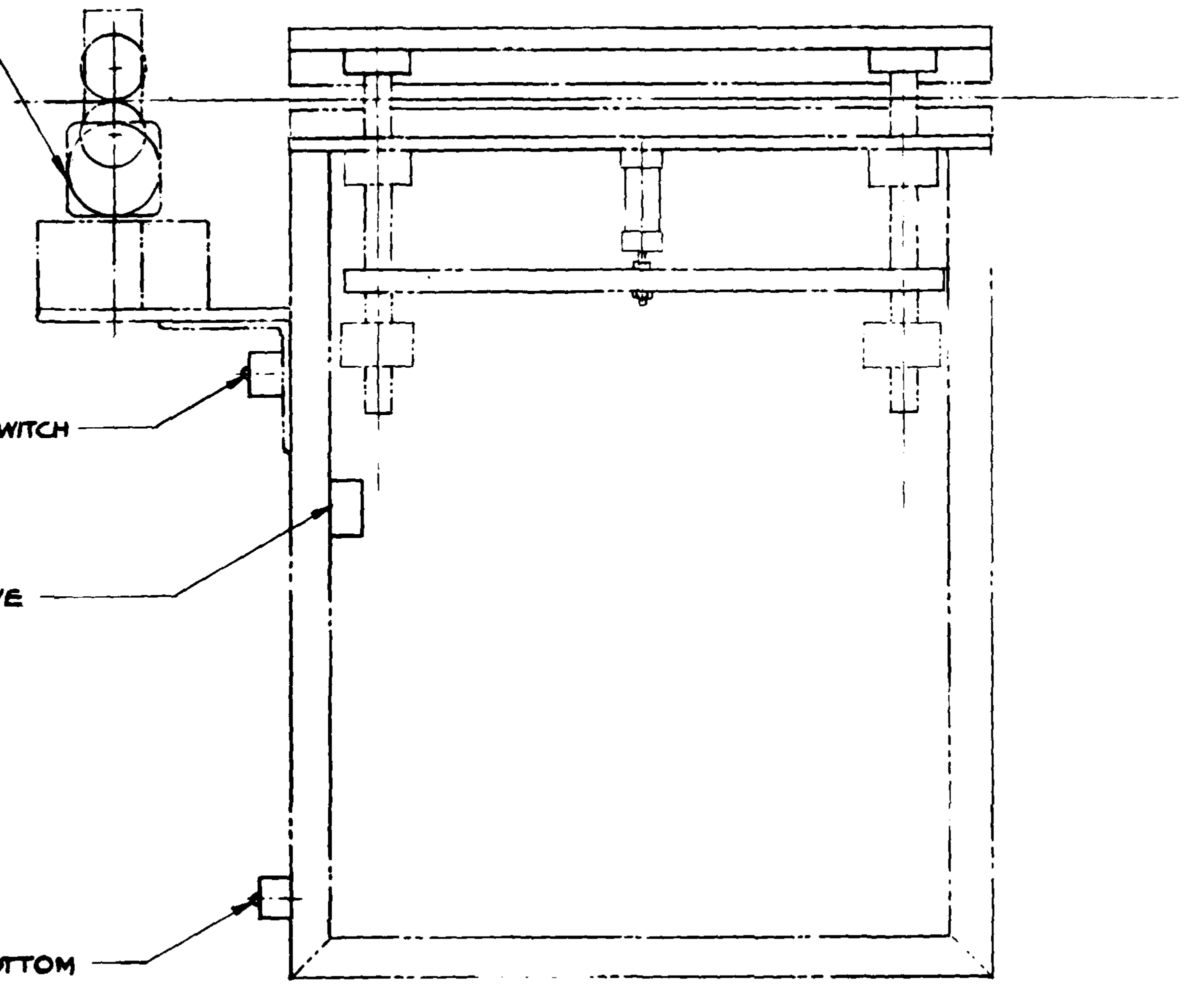



FIG. 3-12

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

LINER CREASER ASSEMBLY CONTROL

ORIGINAL DATE OF DRAWING 5-16-79
DRAFTSMAN T. L. JONES
ENGR J. L. SULLIVAN

DO NOT SCALE DRAWING

SIZE C | CODE IDENT NO. 19200 | 9331518

SCALE NONE | UNIT WT. | SHEET 1 OF 1

Table 3-5.

Lead Liner Place, Sew and Crease Station Output

| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
|---|---|---|---|---|
| Time per Assy (Chain stitch) (sec./assy) | 6.39 | 6.46 | 8.25 | 8.25 |
| Time per Assy (including Bobbin Change) (sec/assy) | 7.22 | 7.58 | 9.75 | 4.88 |
| No. of Bobbin Changes per Shift | 25 | 31.5 | 35.2 | 80 |
| Hourly Station Output Rate (Chain stitch) (pcs./hr.) | 563 | 557 | 436 | 873 |
| Hourly Station Output Rate (including Bobbin Change) (pcs./hr.) | 499 | 475 | 369 | 738 |

At the downstream end of the assembly are the pneumatic sensors for the web center guidance system and the Kamberoller assembly on which mounts the stepper motor for web indexing. The sensors and the Kamberoller assemblies are supplied by Fife. The Kamberoller must be modified to accept the spring loaded nip roller stepper motor drive.

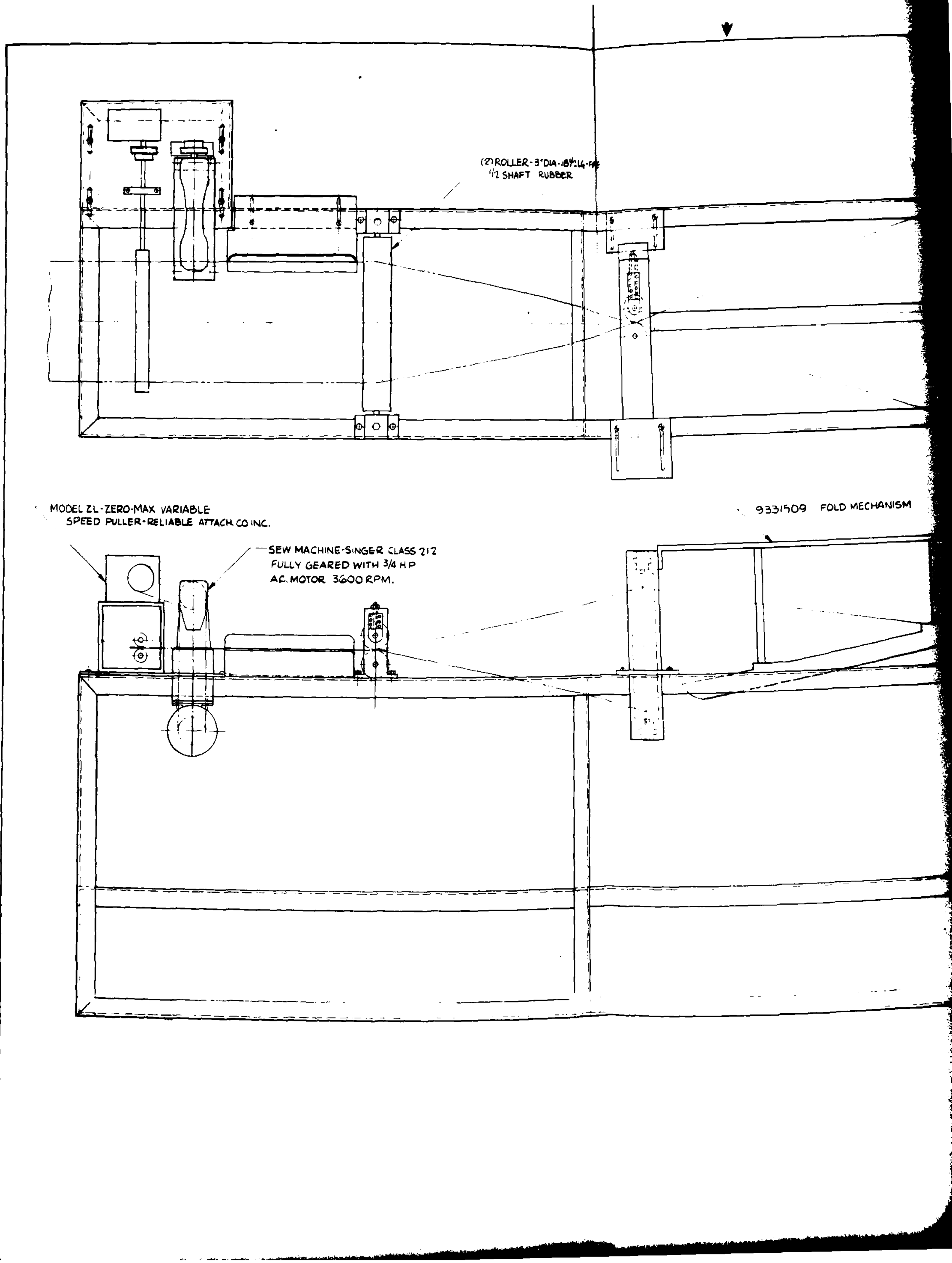
The ideal web center guiding system would have the web totally unsupported for eight feet from the unwind stand to the driven spring loaded nip roller. A one-half inch sag across this span would be acceptable. Based on the span length, allowable sag and weight of the web plus liners per foot of span, the required amount of web tension has been determined to be 75 pounds (2.9 pounds per inch of web width). From the jury rig effort it was determined that the driven rubber covered, spring loaded nip rollers have a coefficient of friction greater than 0.9. Using a 50% factor of safety it was determined that 125 pounds of force are necessary in the spring of the nip rollers. This is 4.8 pounds of force applied normally per linear inch of web width. The web with liner attached was satisfactorily tested at 6.7 pounds per inch in the jury rig set-up with no cracking or deforming of the lead liner.

### 3.1.3 Tube Sew Station

The Tube Sew Station (see Figure 3-13 and 3-14) operates independently of the Liner Place, Sew and Crease Station and the web unwind stand. As long as there is material available in the Tube Sew Station's material supply loop, and the Cut and Stack Station's material supply loop is not full, the Tube Sew Station is able to operate.

The Tube Sew Station folds the web and attached creased lead liner down the centerline of the web (controlled by the crease location), then sews the two loose edges together to form a tube. The web is mechanically guided through the station.

This station is mounted on a large welded frame base. At the upstream end of this station is the fold mechanism (see Figure 3-15). The fold mechanism is shaped like a plough and is used to control the direction of the fold and also to locate the crease in the liner. The fold mechanism is adjustable to be able to handle all four sizes. At the end of the folder are two sets of spring loaded nip rollers (see Figure 3-13). The first set is vertically oriented and is used to complete the fold while the second set is horizontally placed and is used to bring back to the established horizontal plane.


(2) ROLLER - 3" DIA - 18½" LG - F/E
½ SHAFT RUBBER
MODEL ZL - ZERO-MAX VARIABLE
SPEED PULLER - RELIABLE ATTACH. CO INC.
SEW MACHINE - SINGER CLASS 212
FULLY GEARED WITH 3/4 H.P
AC. MOTOR 3600 RPM.
9331509 FOLD MECHANISM

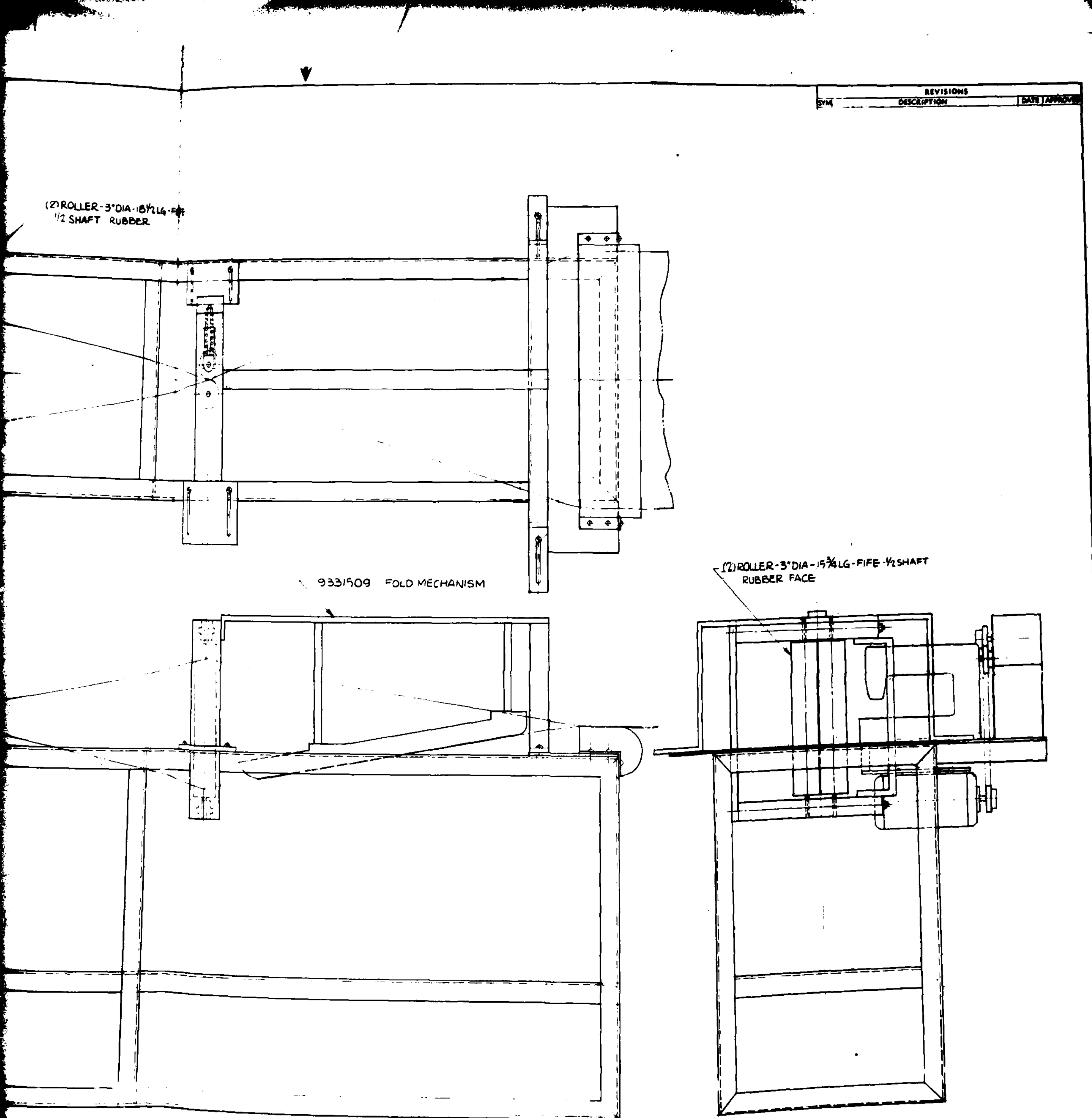



Fig. 3-13

PART NO.

| | | | | | |
|---|---|---|---|---|---|
| MECHANICAL PROPERTIES | DO NOT SCALE DRAWING<br>UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON DECIMALS -<br>FRACTIONS - ANGLES - | ORIGINAL DATE OF DRAWING 5-17-79 | DRAFTSMAN T. L. JONES<br>ENGR J. SULLIVAN<br>ENGR | CHECKER<br>ENGR<br>ENGR | TUBE SEW STATION |
| YP | | | | | SIZE |
| TS | | | | | CODE IDENT NO |
| EL2 | | | | | 9331507 |
| RA | | | | | |

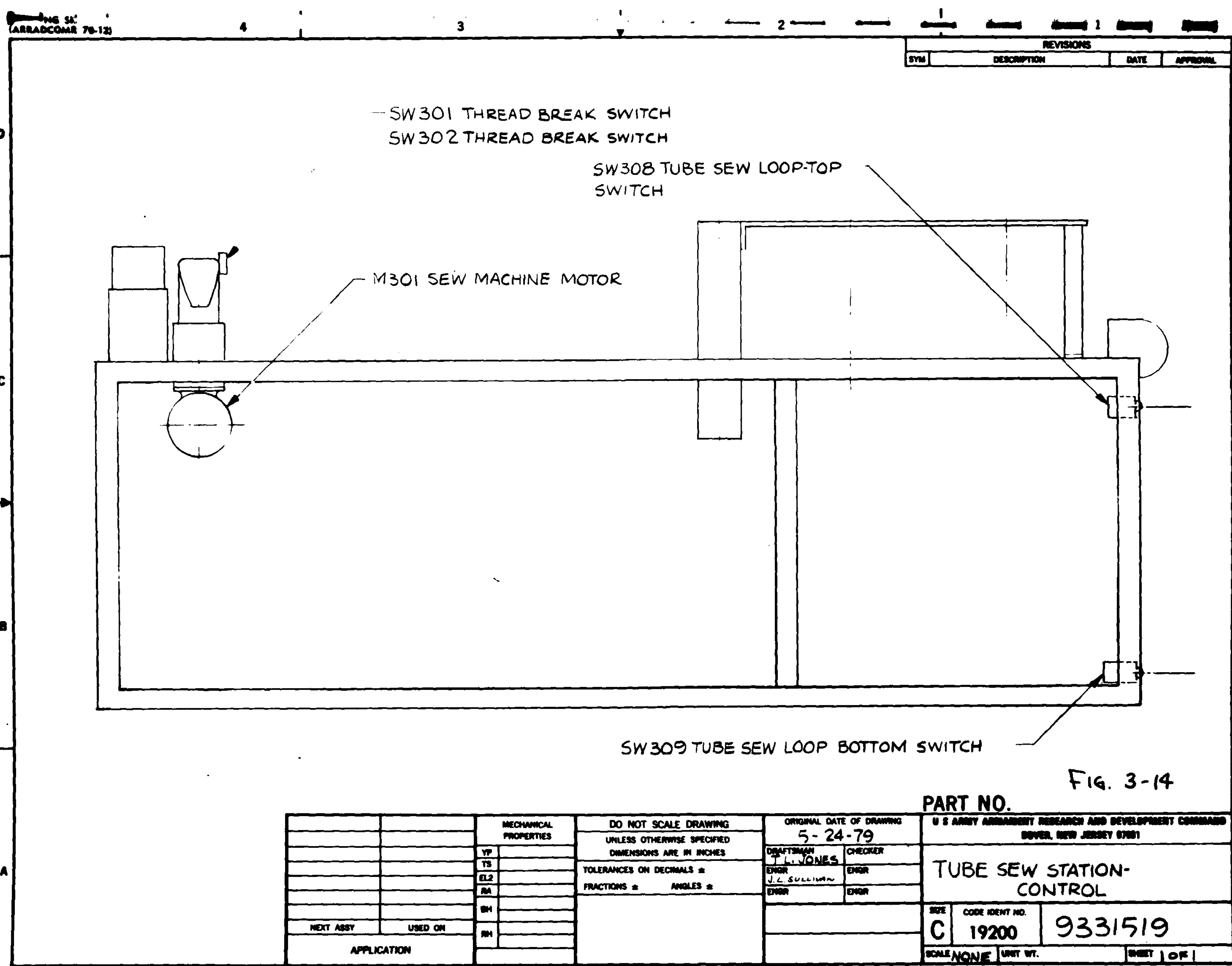
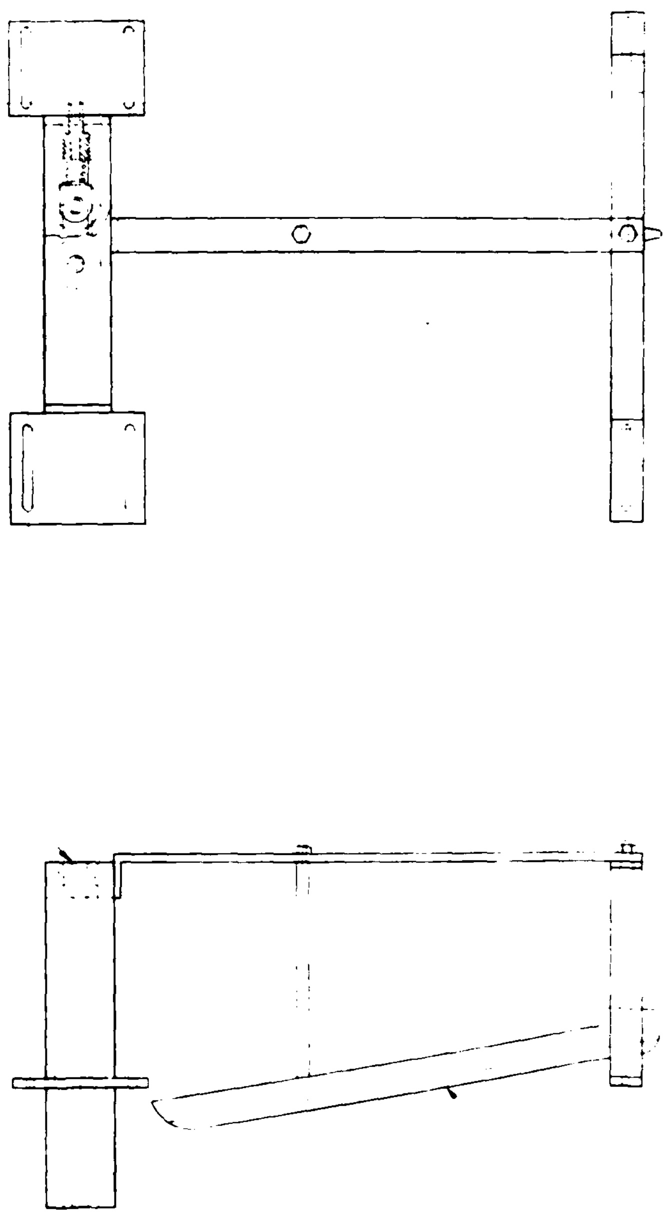

SW301 THREAD BREAK SWITCH
SW302 THREAD BREAK SWITCH
SW308 TUBE SEW LOOP-TOP SWITCH
M301 SEW MACHINE MOTOR
SW309 TUBE SEW LOOP BOTTOM SWITCH
REVISIONS
SYM
DESCRIPTION
DATE
APPROVAL
PART NO.
NEXT ASSY
USED ON
APPLICATION
MECHANICAL PROPERTIES
YP
TS
EL2
RA
BH
RH
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ±
ANGLES ±
ORIGINAL DATE OF DRAWING
5-24-79
DRAFTSMAN
T.L. JONES
CHECKER
ENGR
J.L. SULLIVAN
ENGR
ENGR
ENGR
U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801
TUBE SEW STATION-CONTROL
SIZE
C
CODE IDENT NO.
19200
9331519
SCALE NONE
UNIT WT.
SHEET 1 OF 1

Fig. 3-14



(2) M1215-16 BRONZE BEARINGS
BOSTON GEAR OR EQUIV.

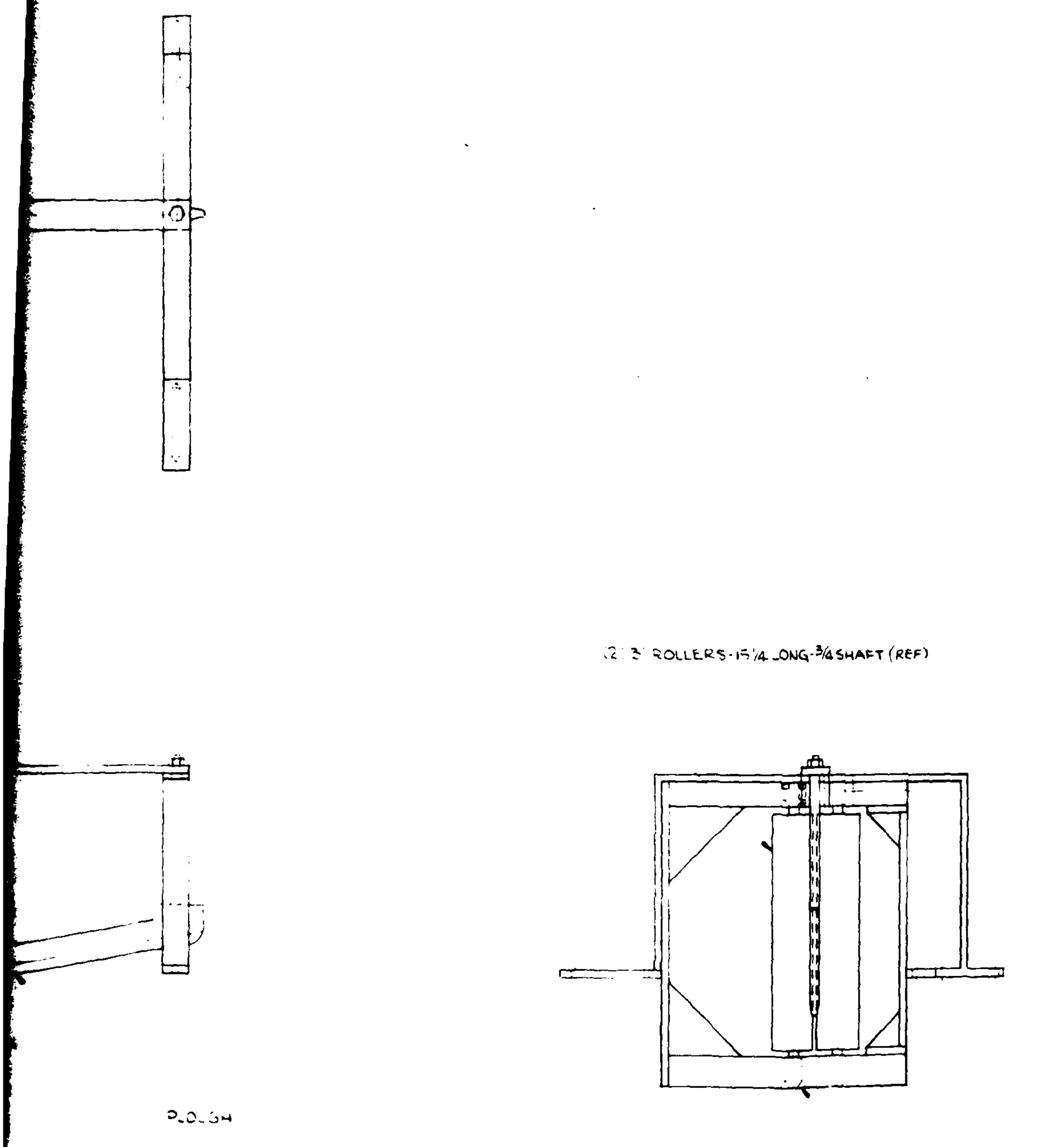



FIG. 3-15

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

FOLD MECHANISM

| | |
|---|---|
| ORIGINAL DATE OF DRAWING | 4-24-79 |
| DRAFTSMAN | JONES |
| ENGR | J. SULLIVAN |
| SIZE | F |
| CODE IDENT NO | 19200 |
| DWG NO | 9331509 |
| SCALE | 1/2 |
| SHEET | 1 OF 1 |

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

MECHANICAL PROPERTIES

NEXT ASSY | USED ON

APPLICATION

A Singer 212 sewing machine will be used to sew the side seams (see page 3-19a for literature on the Singer 212).

A commercially available puller such as Zero Max (see literature on page 3-19b) will be mounted on the sewing machine plate and driven by the speed controlled sewing machine motor. This puller is the web motivating force for the station. The sewing machine plate is adjustable for the different web widths. A sheet metal folder (also commercially available) can be mounted on the front of the sewing machine.

The Tube Sew Station must not restrict the operation of the Liner Place, Sew and Crease Station; therefore, the Tube Sew Station must be capable of processing the product at a slightly faster rate.

The maximum output rate of the Liner Station is 4.6 inches per second for the M203 bag. The Tube Sew Station will run 5% faster than the Liner Station so, for the M203 bag, the Tube Sew Station will run at 4.8 inches per second. To accomplish this, the Tube Sew Station sewing machine will operate at 2,880 rpm.

The speed control for the Tube Sew Station sewing machine should be set for each bag size to minimize the number of start and stops of this station. See Table 3-6 for sew machine speeds and web output rates relative to bag size.

Table 3-6.

Tube Sew Station Output Rates

| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Incrmt 9 |
|---|---|---|---|---|
| Station Output Rate of Web (in/sec) | 4.3 | 4.8 | 3.46 | 1.05 |
| Sew Machine Speed (rpm) | 2580 | 2880 | 2076 | 630 |
| System Downtime for Bobbin Change (sec) | 46.3 | 47 | 42.7 | 21.8 |

**Two Needle**
**Flat Bed**
**Lockstitch Machines**

# 212G

## Description of Class

[illegible]

## Length of Stitch

[illegible]

## Speed

[illegible]

## Lubrication

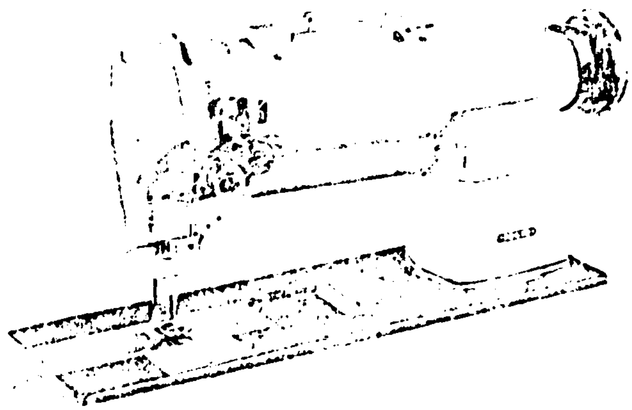
[illegible]

## Machine Bed

[illegible]

## Electrical

[illegible]



## Features

[illegible] vertical [illegible] hooks [illegible] can be removed without disturbing the hook shafts.

[illegible] can be furnished at [illegible] charge.

[illegible] can be timed independently of the hooks.

[illegible] stitch length adjustment controlled by eccentric on bed shaft.

[illegible] in [illegible] Feed [illegible]

[illegible] matched at end of seam.

[illegible]

[illegible] back [illegible] seam reinforcement.

Knee lifter.

## General Specifications

## Mechanical

[illegible]

Clearance under presser foot [illegible] mm)

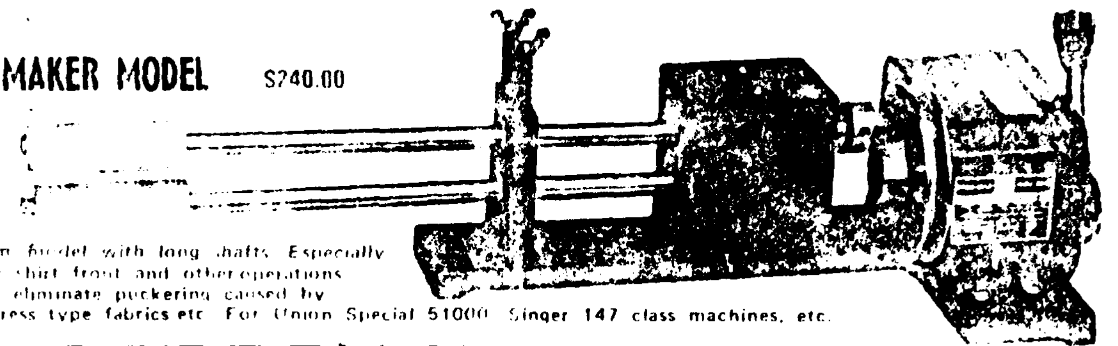
[illegible] Variety Data Chart

# ARTWOOD VARIABLE SPEED CLOTH PULLERS

ARTWOOD PULLERS Feature The Following: Oil-Less Nylon Bearings to Eliminate Oil Spotting. All Parts Plated to Eliminate Rust. Equipped with 1 Knurled and 1 Rubber Roller at No Additional Cost. Belt Guard and Gear Cover Eliminates Thread Wrapping Shafts and Gears. Lightweight Aluminum Castings in Attractive Grey Finish.

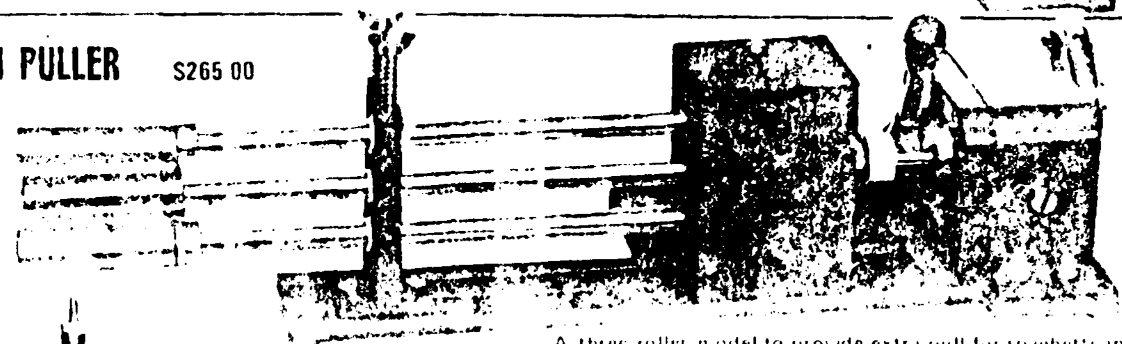
**ZERO-MAX SPEED REDUCERS SYNCHRONIZES PULLER SPEED WITH THE MACHINE**

## SHIRTMAKER MODEL $240.00



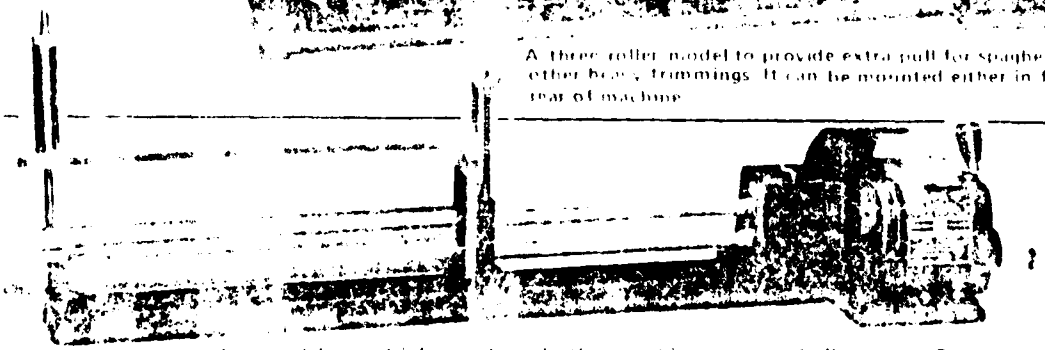
A short arm model with long shafts. Especially designed for shirt front and other operations. Designed to eliminate puckering caused by Permanent Press type fabrics etc. For Union Special 51000, Singer 147 class machines, etc.

## SPAGHETTI PULLER $265.00



A three roller model to provide extra pull for spaghetti and other heavy trimmings. It can be mounted either in front or rear of machine.

## TOP SUPPORT MODEL



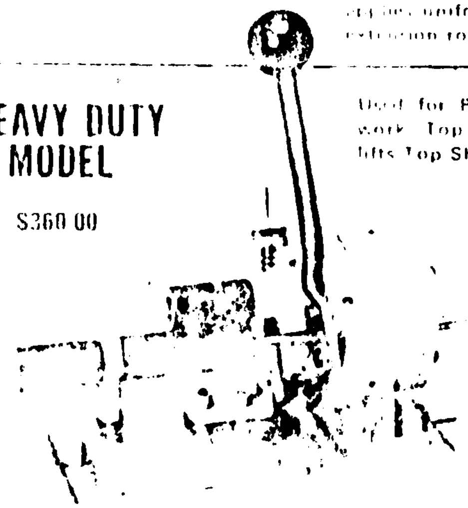
$300.00

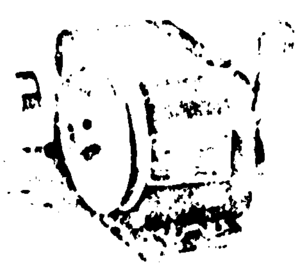
Designed for multiple needle and other machines running bulky pieces. Overarm support assures uniform pressure along entire length of roller. Extra long bottom shaft with an extension roller acts as a conveyor to move out the work.

## HEAVY DUTY MODEL

$360.00

Used for Bedspread Joining, Carpet Serging and Binding, Draperies, and other heavy work. Top Shaft adjusts to thick work and is always parallel to bottom shaft. Handle lifts Top Shaft for easy insertion and removal of work.





Model HDA for Overlock and other machines where horizontal distance between needle and puller drive pulley is 6 in. to 11 in.

Model HDB for longer arm machines where horizontal distance between needle and puller drive pulley is 11 in. to 17 in.

**ELIMINATES PUCKERING, PULLING AND FEEDING PROBLEMS**

SECTION 2

Table 3-6. (Cont.)
Tube Sew Station Output Rates

| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Incrmt 9 |
|---|---|---|---|---|
| Bobbin Change Time/ Assy (sec/assy) | 1.7 | 1.94 | 1.63 | .13 |
| Assy per Bobbin | 27 | 23.8 | 26.2 | 169.4 |
| Bobbin Cycle Time | 3 min. 42 sec. | 3 min. 23 sec. | 4 min. 21 sec. | 12 min. 22 sec. |
| No. Bobbin Changes/ Day | 83 | 88.7 | 67.3 | 23.6 |
| Time/Assy (includes Bobbin Changes) (sec) | 9.0 | 9.54 | 11.43 | 5.03 |
| Time/Assy (chain stitching) | 6.39 | 6.46 | 8.25 | 4.12 |
| Hourly Output Rate (includes Bobbin Changes) (assy/hr) | 400 | 377 | 315 | 715 |
| Hourly Output Rate (chain stitch) (assy/hr) | 563 | 557 | 436 | 873 |

There are five feet of web in the Tube Sew Station input supply loop. When the Tube Sew Station stops for a bobbin change the Liner Station will continue to operate until the Tube Sew Station material supply loop is filled. On the average there will be one-half of the material supply left to be filled. The amount of time that the Liner Station runs to fill the Tube Sew Station supply loop reduces the overall system downtime for the bobbin change. It is estimated that a bobbin change and preparation for an overlap tack will take approximately 60 seconds. The actual time the system is down for the bobbin change is dependent upon the bag size and can be seen in Table 3-6.

The bobbins for the machine are relatively small (approximately 20 yards) since it is a two needle, vertical axis, hook machine.

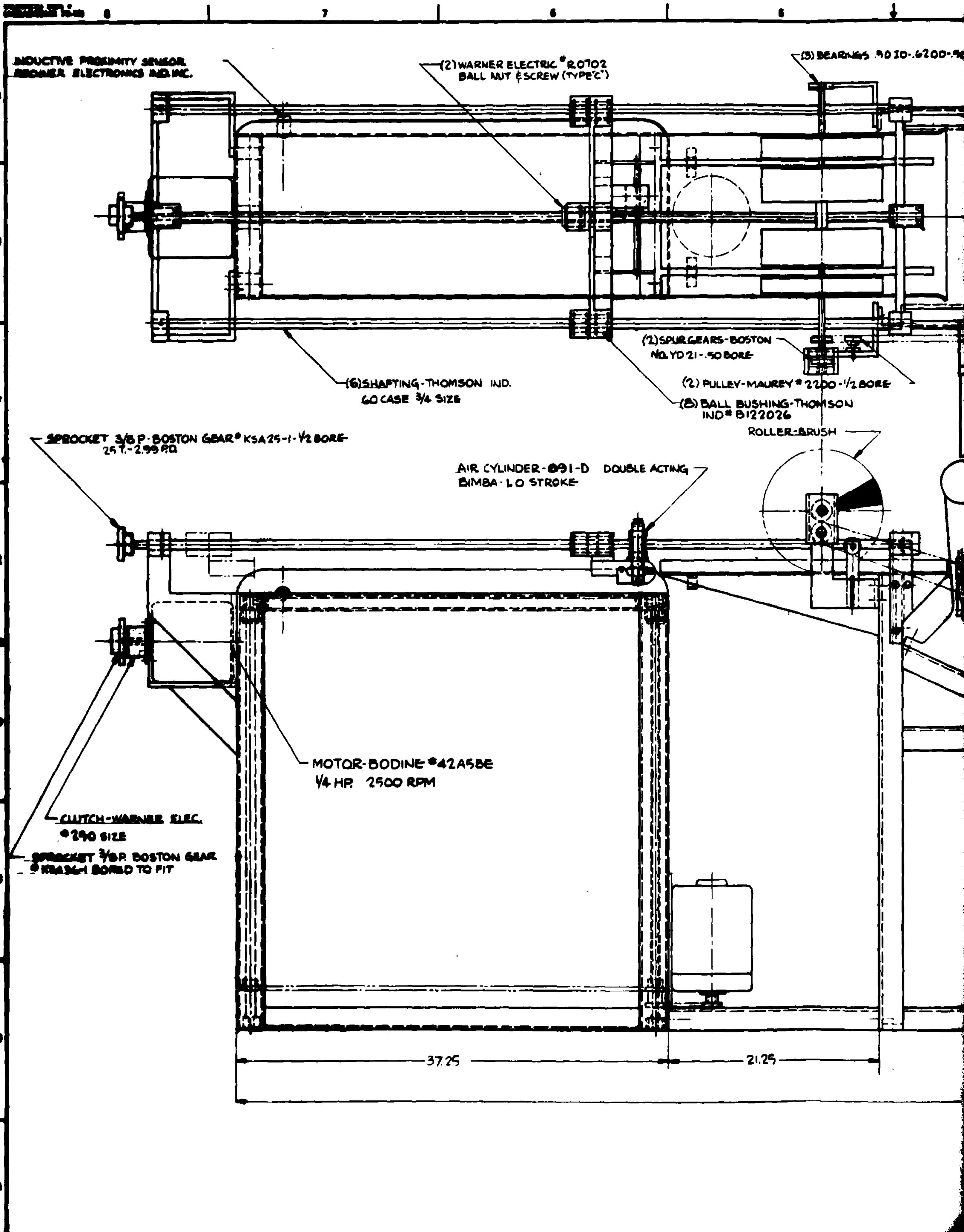
### 3.1.4 Cut and Stack Station

The Cut and Stack Station (see Figure 3-16) cuts the web at the proper location (with respect to the lead liner) to form the specified body tube assembly. This station is also an asyncronous station and operates as long as there is material available in the cutter/stacker material supply loop and as long as there is space available in the stacker assembly to collect the body and liner assemblies.

At the front of the station is the cut position sensor (see Figure 3-17) which is adjustable for all bag sizes. The cut position sensor is an inductive type sensor that looks for the leading edge of the lead liner to trigger the cutting operation.

The cutter will be a modified Artos cutter, MLL-14-1, which is a well proven, industry accepted cutter. The Artos cutter has an integral cut-to-length drive that must be modified by adding a separate motor controlled by the cut position sensor to drive the web to the proper length.

A brush roller is used at the cutter assembly exit to prevent the web from wrinkling and to make sure that it is extended to its full length for pick-up by the stacker. This brush roller (refer to Figure 3-16) is driven by the added motor on the Artos cutter through sprockets, a chain, and two spur gears (for direction reversal).



INDUCTIVE PROXIMITY SENSOR
BRONNER ELECTRONICS IND.INC.
(2) WARNER ELECTRIC #R0702
BALL NUT & SCREW (TYPE 'C')
(3) BEARINGS .50 ID-.6200-
(6) SHAFTING-THOMSON IND.
60 CASE 3/4 SIZE
(2) SPUR GEARS-BOSTON
NO. YD 21-.50 BORE
(2) PULLEY-MAUREY # 2200-1/2 BORE
(8) BALL BUSHING-THOMSON
IND # B122026
ROLLER-BRUSH
SPROCKET 3/8 P. BOSTON GEAR # KSA25-1-1/2 BORE
25 T.-2.99 P.D.
AIR CYLINDER-091-D DOUBLE ACTING
BIMBA-1.0 STROKE
MOTOR-BODINE #42A5BE
1/4 HP. 2500 RPM
CLUTCH-WARNER ELEC.
#290 SIZE
SPROCKET 3/8 P. BOSTON GEAR
# KSA36-1 BORED TO FIT
37.25
21.25
8
7
6
5

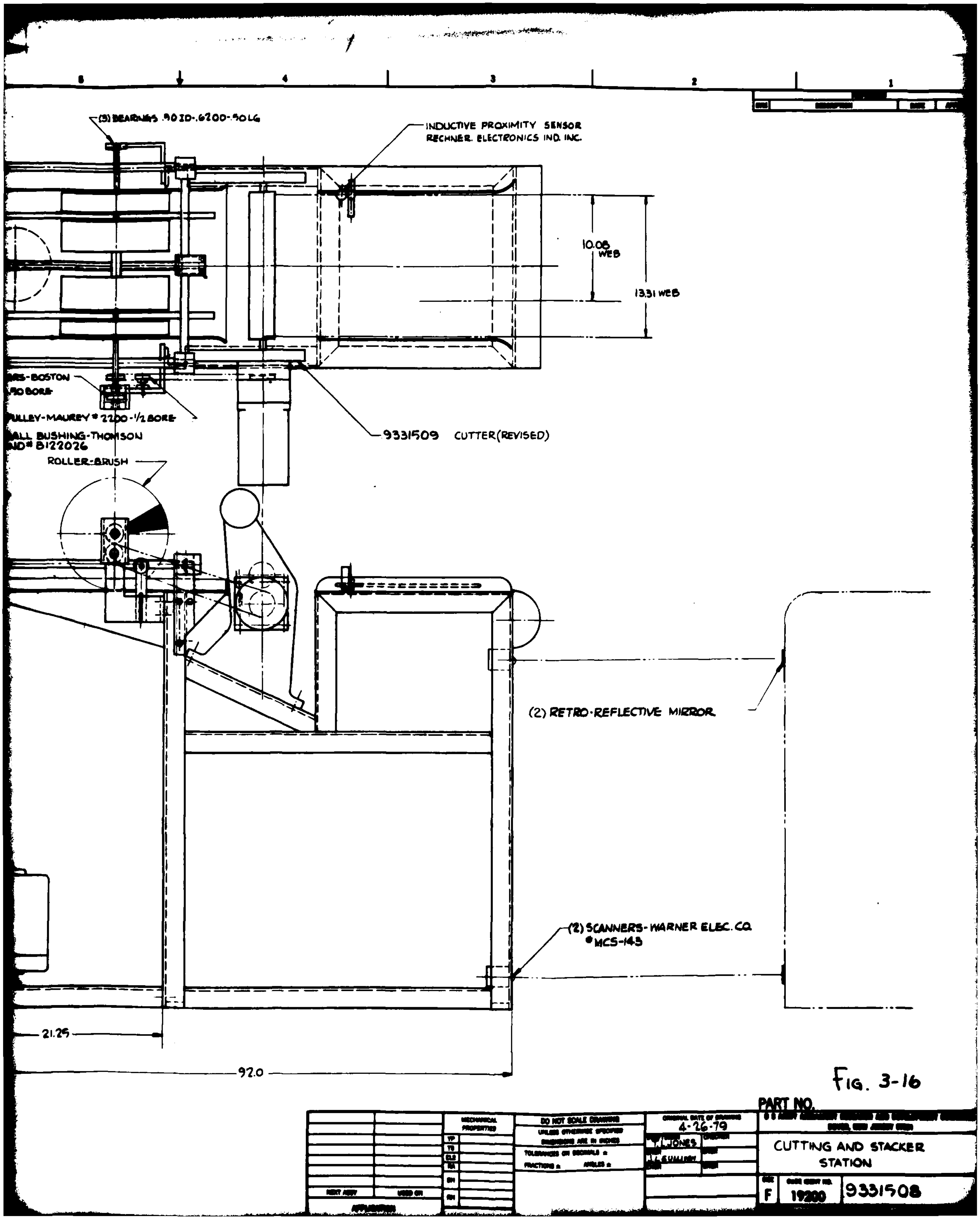

(3) BEARINGS .90 ID-.6200-.50 LG
INDUCTIVE PROXIMITY SENSOR
RECHNER ELECTRONICS IND. INC.
10.08 WEB
13.31 WEB
RS-BOSTON
.50 BORE
ULLEY-MAUREY # 2200-1/2 BORE
ALL BUSHING-THOMSON
ND# B122026
ROLLER-BRUSH
9331509 CUTTER(REVISED)
(2) RETRO-REFLECTIVE MIRROR
(2) SCANNERS-WARNER ELEC. CO.
# MCS-143
21.25
92.0
PART NO.
DO NOT SCALE DRAWING
4-26-79
J. JONES
CUTTING AND STACKER
STATION
F
19200
9331508

Fig. 3-16

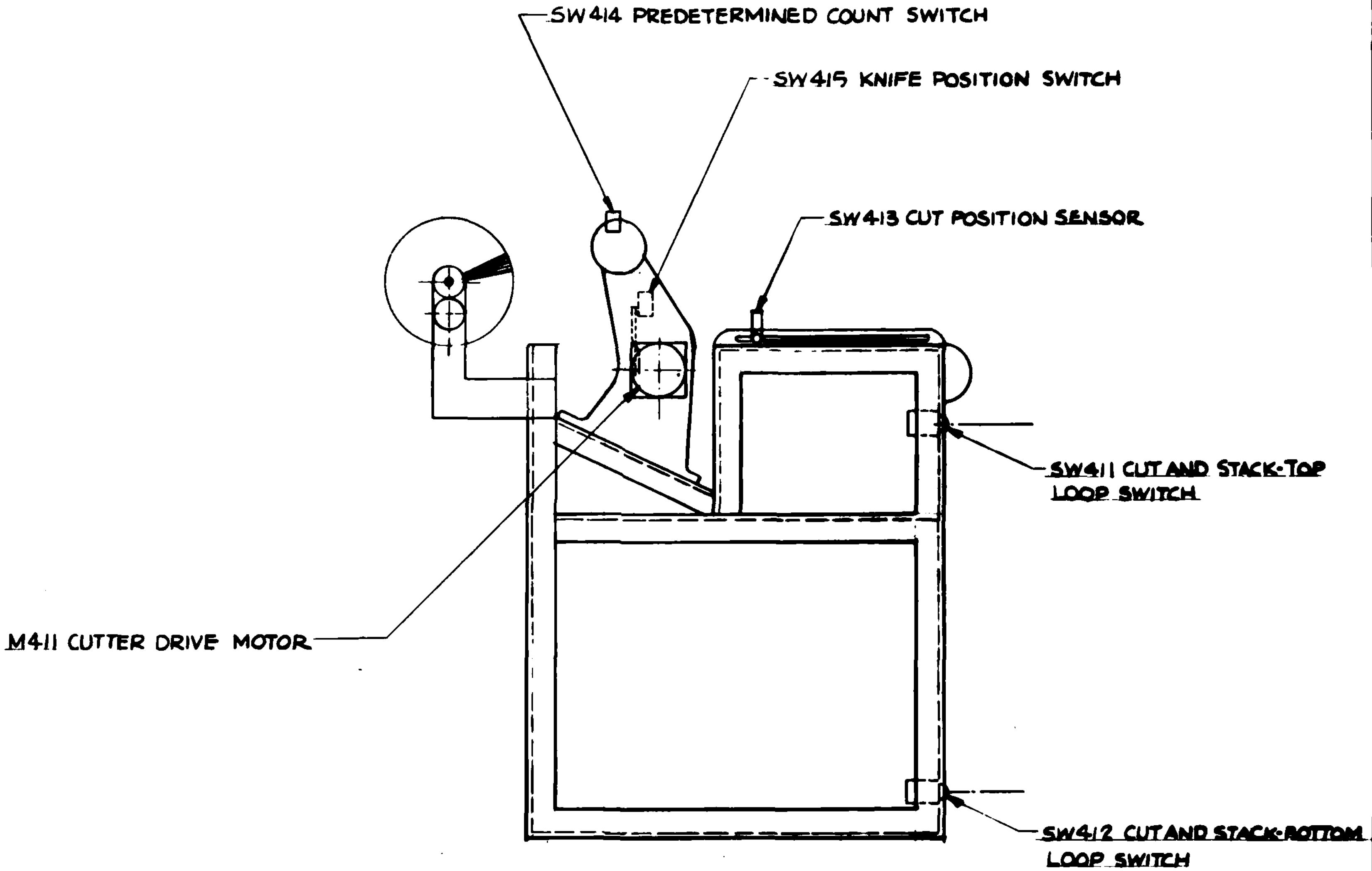



Fig. 3-17

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY

CUTTER ASSEMBLY CONTROL

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

MECHANICAL PROPERTIES

ORIGINAL DATE OF DRAWING 5-24-79
DRAFTSMAN L. JONES
CHECKER
ENGR W. SULLIVAN

NEXT ASSY | USED ON
APPLICATION

SIZE C | CODE IDENT NO. 19200 | 9331520
SCALE NONE | UNIT WT. | SHEET 1 OF 1

The stacker assembly takes the cut tubes extending from the cutter and neatly places them in a stack on the elevator.

The stacker assembly is mounted to the body tube elevator on one end and to the cutter stand at the other end. Mounted to the body tube elevator is an electric brake motor that drives the stacker assembly (see Figure 3-18). The stacker assembly consists of a set of three pincher type pick-up fingers on a movable assembly. The outside of the movable assembly has ball bushings which ride on hardened and ground steel shafts and in the middle is mounted a ball nut. The ball nut and screw are driven by a chain and sprockets from the brake motor that is mounted on the elevator. As the bag assemblies are cut, the fingers pick up the leading edge of each assembly and pull them over the elevator where they are dropped into position on the stack.

The body tube elevator is a boxlike structure (see Figure 3-19) which has a platform that is driven downward as the stack size increases to maintain a constant stack height. Maintaining a constant stack height enhances the quality of the stack and the reliability of the operation. A constant height for the stacking operation is achieved by means of a proximity sensor, electric brake motor and the elevator drive mechanism (refer to Figure 3-20). The elevator platform is driven by an electric brake motor and two 0.5 inch ball screws and nuts. Four hardened and ground shafts, one in each corner, stabilizes the elevator platform by means of four ball bushings mounted to the elevator platform.

The body and liner assemblies stack up in a tray on the elevator platform. There is an opening in the side of the elevator assembly that allows for easy access and removal of the tray of completed body and liner assemblies and placement of an empty tray for the

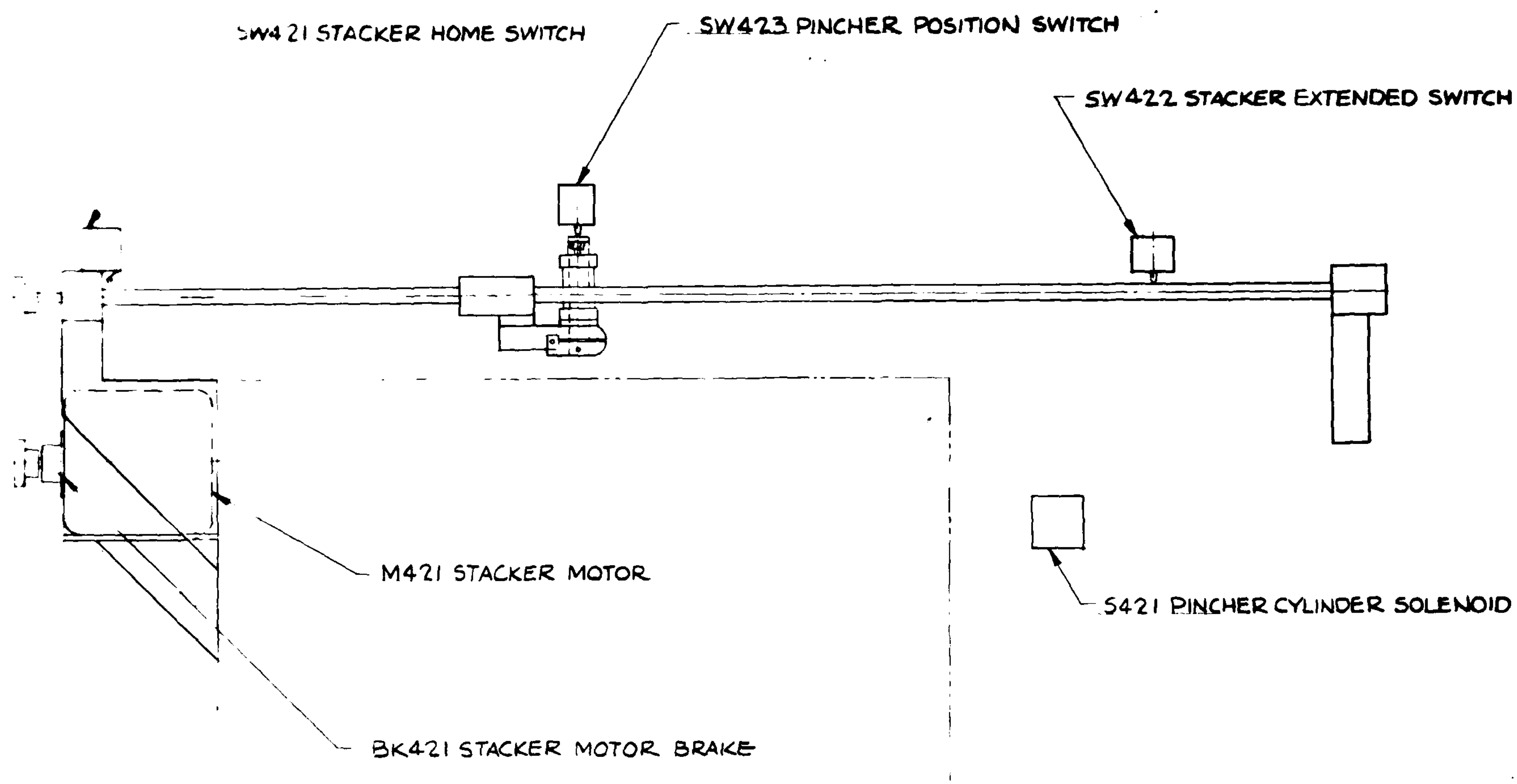



FIG. 3-18

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

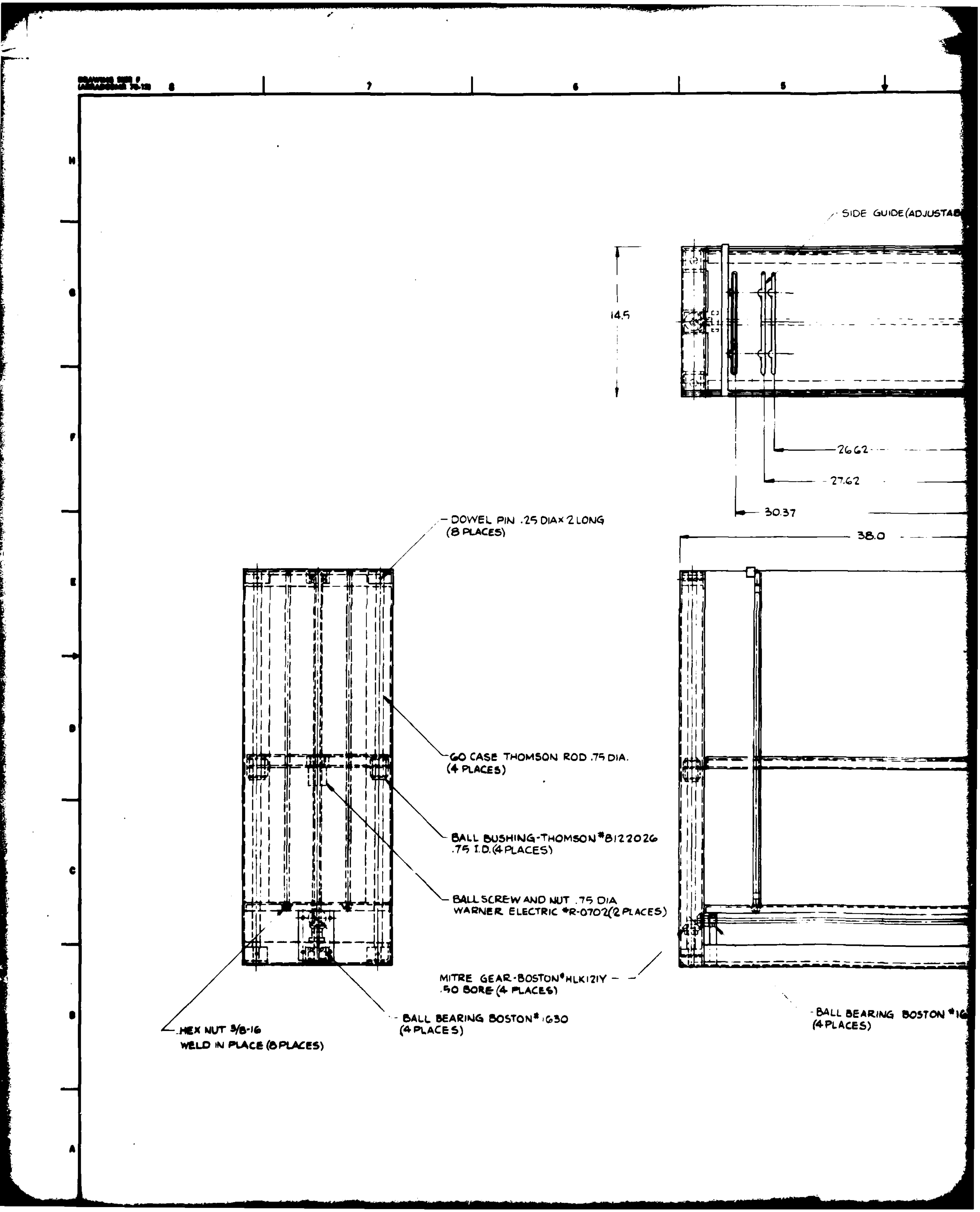
STACKER ASSEMBLY CONTROL

| | |
|---|---|
| ORIGINAL DATE OF DRAWING | 5-24-79 |
| DRAFTSMAN | T.L. JONES |
| ENGR | J.L. Sullivan |
| SIZE | C |
| CODE IDENT NO | 19200 |
| DRAWING NO | 9331521 |
| SCALE | NONE |
| UNIT WT. | |
| SHEET | 1 OF 1 |

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

MECHANICAL PROPERTIES: YP, TS, EL2, RA, BH, RH

NEXT ASSY | USED ON
APPLICATION



SIDE GUIDE(ADJUSTAB
14.5
26.62
27.62
30.37
38.0
DOWEL PIN .25 DIA x 2 LONG
(8 PLACES)
60 CASE THOMSON ROD .75 DIA.
(4 PLACES)
BALL BUSHING-THOMSON #B122026
.75 I.D.(4 PLACES)
BALL SCREW AND NUT .75 DIA
WARNER ELECTRIC #R-0702(2 PLACES)
MITRE GEAR-BOSTON #HLK121Y
.50 BORE (4 PLACES)
BALL BEARING BOSTON #1630
(4 PLACES)
HEX NUT 3/8-16
WELD IN PLACE (8 PLACES)
BALL BEARING BOSTON #16
(4 PLACES)

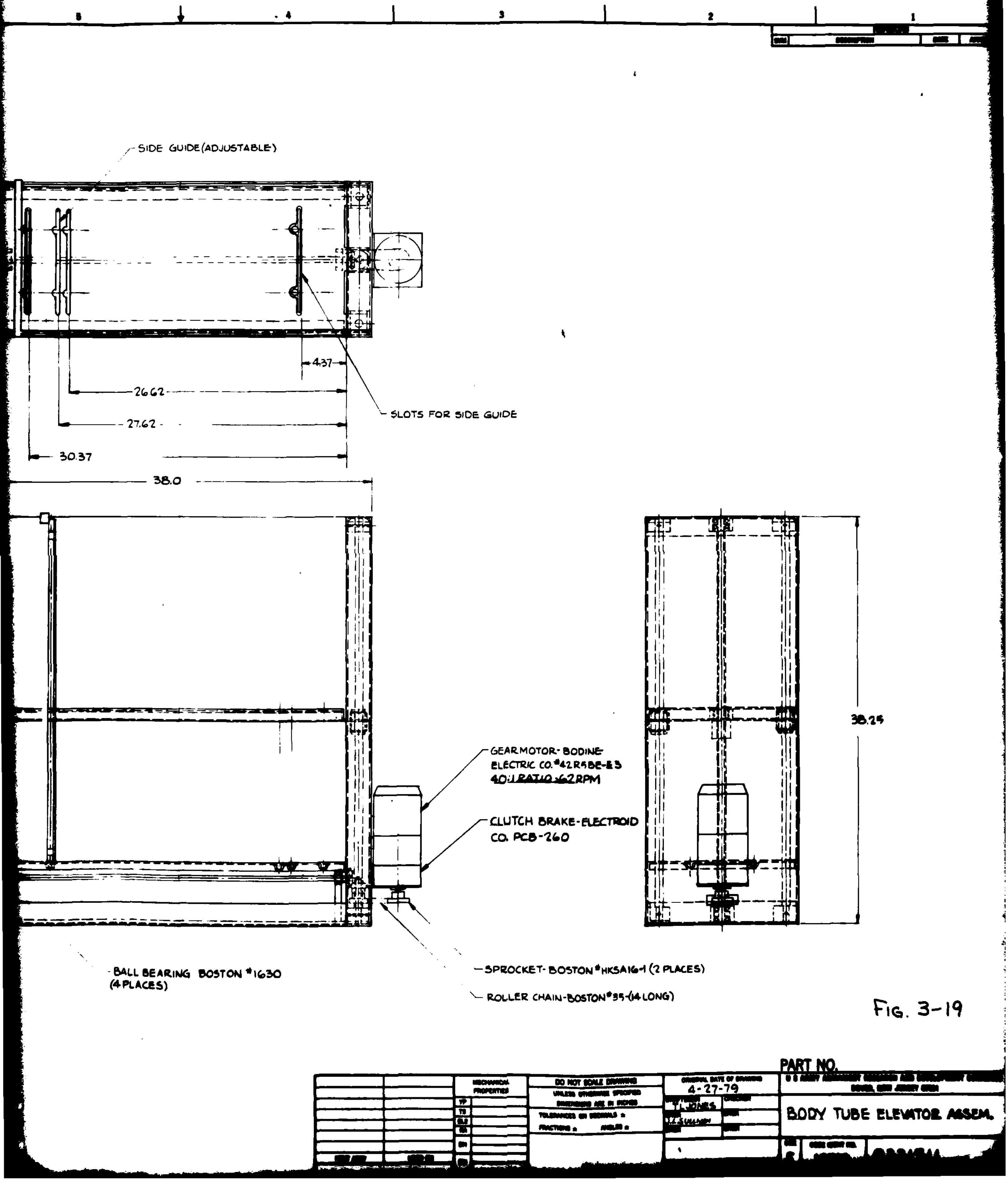

SIDE GUIDE (ADJUSTABLE)
4.37
26.62
27.62
30.37
38.0
SLOTS FOR SIDE GUIDE
38.25
GEARMOTOR-BODINE ELECTRIC CO. #42R5BE-E3 40:1 RATIO-62 RPM
CLUTCH BRAKE-ELECTROID CO. PCB-260
BALL BEARING BOSTON #1630 (4 PLACES)
SPROCKET-BOSTON #HKSA16-1 (2 PLACES)
ROLLER CHAIN-BOSTON #35-(14 LONG)

FIG. 3-19

PART NO.
MECHANICAL PROPERTIES
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
4-27-79
T. JONES
BODY TUBE ELEVATOR ASSEM.

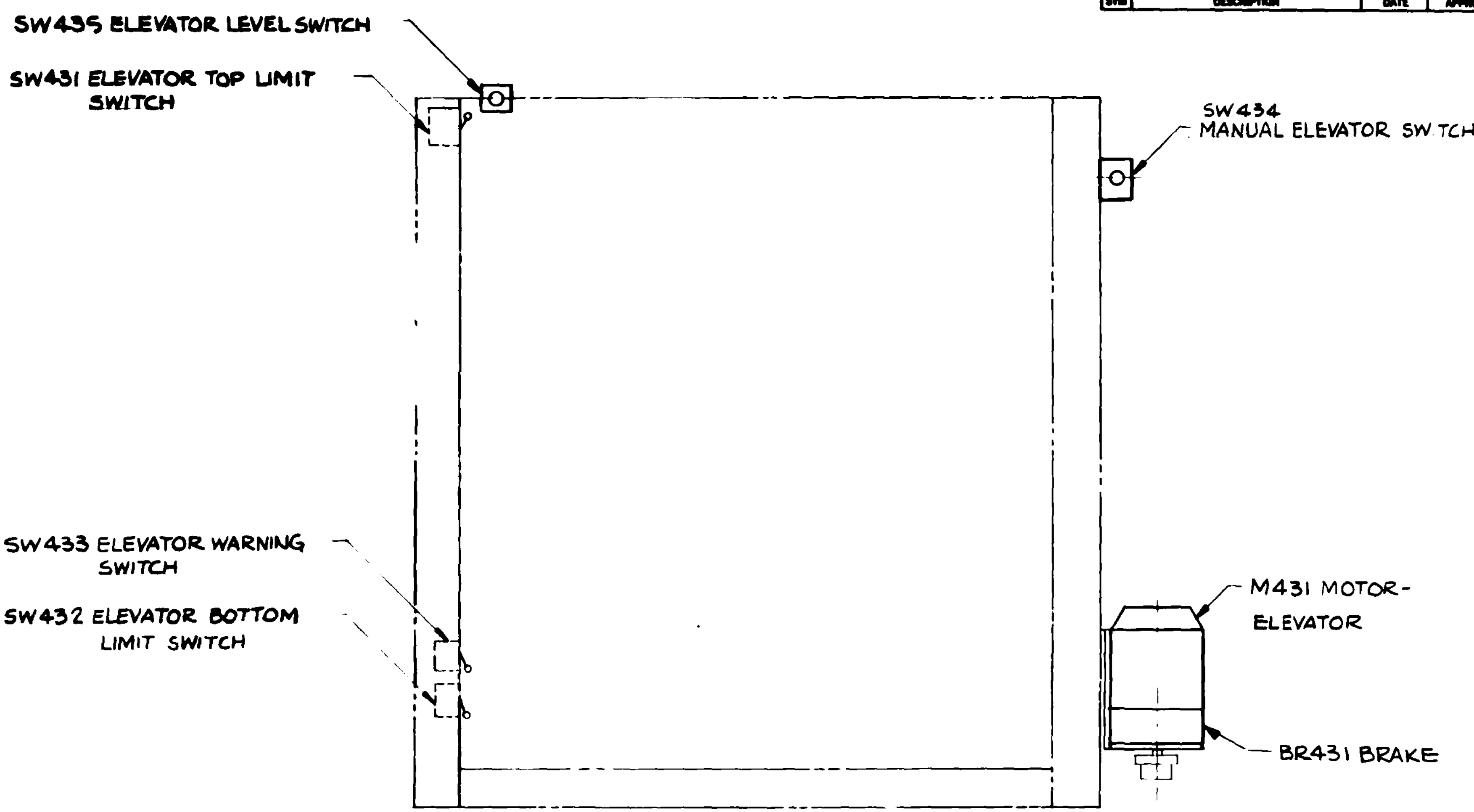



Fig. 3-20

PART NO.

| | |
|---|---|
| U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND DOVER, NEW JERSEY 07801 | |
| BODY TUBE ELEVATOR ASSEMBLY CONTROL | |
| ORIGINAL DATE OF DRAWING | 5-15-79 |
| DRAFTSMAN | T L JONES |
| ENGR | J.L. SULLIVAN |
| SIZE | C |
| CODE IDENT NO | 19200 |
| DRAWING NO. | 9331522 |
| SCALE | NONE |
| UNIT WT. | |
| SHEET | 1 OF 1 |

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

MECHANICAL PROPERTIES: YP, TS, EL2, RA, BH, RH

NEXT ASSY | USED ON
APPLICATION

next production lot of bag assemblies.

Table 3-7 depicts the output rates for various bag sizes from the Cut and Stack Station.

Table 3.7. Cut and Stack Station

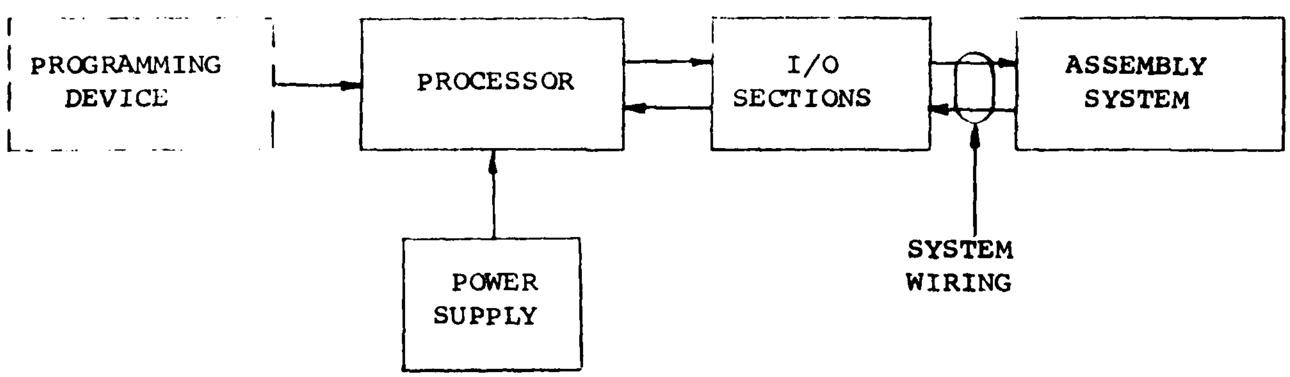
| | 155mm M119 | 155mm M203 | 8 inch M188 | 8 inch Increment 9 |
|---|---|---|---|---|
| No. of Assy per inch of Stack Height | 12 | 5 | 5 | 5 |
| Max Operating Capacity of Stacker | 320 | 130 | 130 | 130 |
| Weight of Full Tray(lbs) | 168 | 224 | 266 | 60 |
| No. of Stack Removals/ Shift (lock stitch) | 7.0 | 16.2 | 13.6 | 30.8 |
| No. of Stack Removals/ Shift (chain stitch) | 12.7 | 30.8 | 24.1 | 48.4 |
| Station Output Rate (lock stitch)(assy/hr) | 400 | 377 | 315 | 715 |
| Station Output Rate (chain stitch)(assy/hr) | 563 | 557 | 436 | 873 |

### 3.1.5 Control System

The heart of the control system will be a programmable controller. Programmable controllers are solid state devices which have been designed to perform logic decisions for industrial control applications. Programmable controllers are used as direct replacements for relays in solid state electronics in an industrial environment. A programmable controller will continuously monitor operating status of machine devices such as limit switches, pushbuttons, selector switches, photo switches, etc. From this monitored status, the controller will make logic decisions and accurately control output devices such as solenoids, valves, motor relays, etc. on the machine while also performing timing and counting functions. Programmable controllers have the following advantages:

- Solid-state device for maximum reliability.
- Designed to operate in hostile industrial environment (i.e., heat, electrical transients, EMI, vibration, etc.) without fans, airconditioning, or electrical filtering.
- Programmed with a simple ladder diagram language.
- Easily reprogrammed with a portable panel.
- Indicator lights provided at major diagnostic points to simplify troubleshooting.
- No custom designed, one-of-a-kind, electronics.
- Maintenance is simple, based upon module replacement, and insures minimum downtime and maximum production.
- Smaller cabinet size and floor space requirement - fits in an 8" deep NEMA enclosure. Will easily fit in control console.
- Retentive memory of logic and timer/counter values.
- Programming devices plug directly into controller.

A typical programmable controller can be divided into three components. These components are the Processor, Power Supply and an Input/Output (I/O) Section.



The processor is a completely solid state device designed to replace relays and timer/counters. It can also be expanded to include computational capabilities as well as simulation of stepper switches. The processor is programmed in a relay ladder diagram symbology utilizing up to ten relay contacts per rung.

The processor operates on dc power which is supplied by the power supply. This internal dc power is also routed through the processor to operate the I/O section. Once the ladder diagram program is entered into the processor, it remains resident until deliberately changed. The program is unaltered through power failure or power off conditions.

A wide variety of I/O modules are available, designed either to be output driving or input handling circuits. The input and output modules are easily removed or plugged into their housings.

All input and output circuits are individually isolated with photo diodes to prevent transients on the wiring from affecting the internal logic. No periodic maintenance is required. Indicators are provided on each module to indicate the field power status and output fuse condition. I/O modules and field wiring can be located in any configuration possible without regard to voltage level (i.e., 115 VAC vs. 5 VTTL).

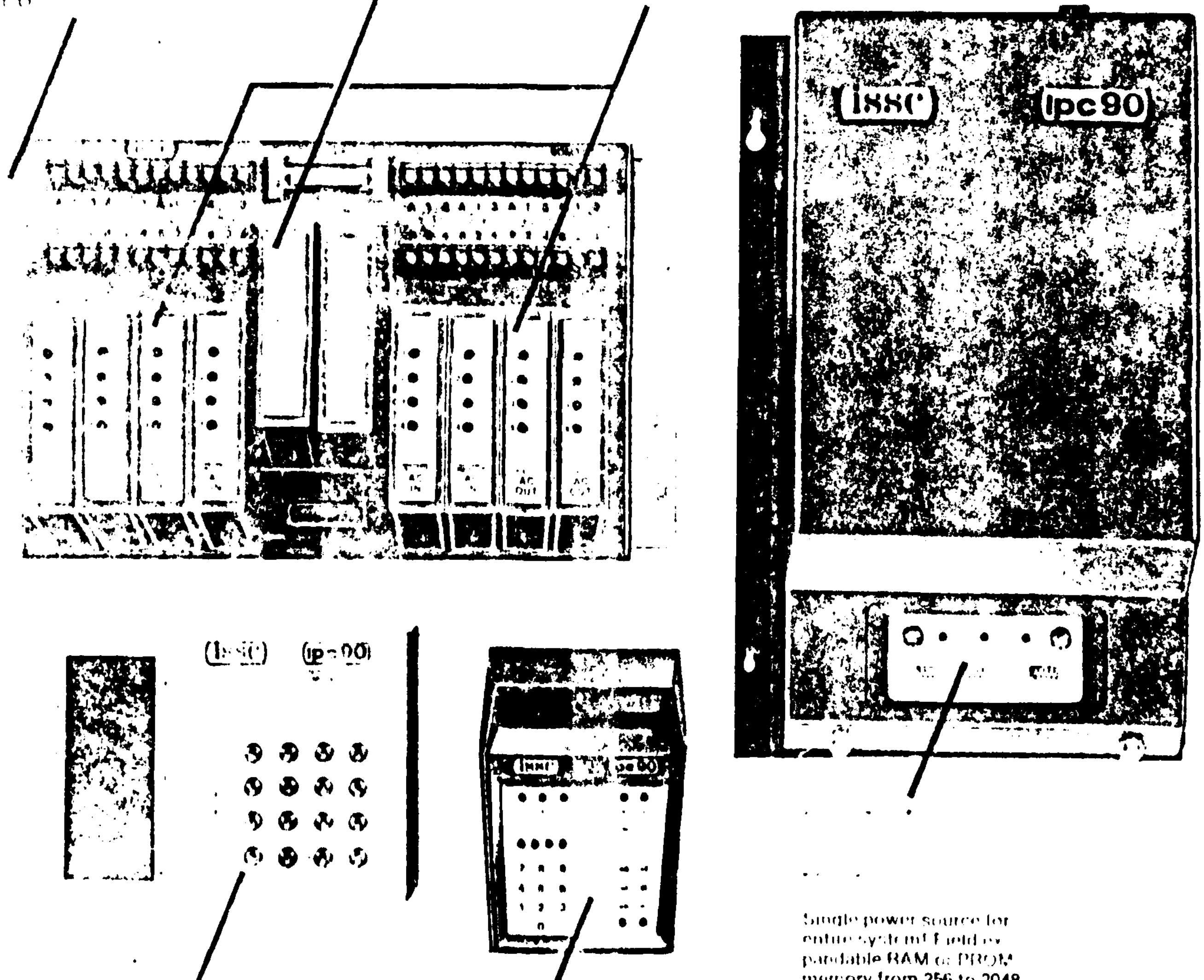
Two programmable controllers that could be used in the Body and Liner Assembly System that have been considered are the Gould Modicon Division model 484 and the Industrial Solid State Controls, Inc., model no. IPC 90 (see following page).

# A new addition to the proven ISSC family of microprocessor-based programmable controllers

Quick, easy installation. Each base provides 32 inputs and outputs. System expandable to six Mounting Bases for total capacity of 192 I/O

Provides system flexibility of I/O groupings on same mounting base

Convenient plug-in interchangeable modules. Available in 4 voltage ranges




Single power source for entire system. Field expandable RAM or PROM memory from 256 to 2048 words.

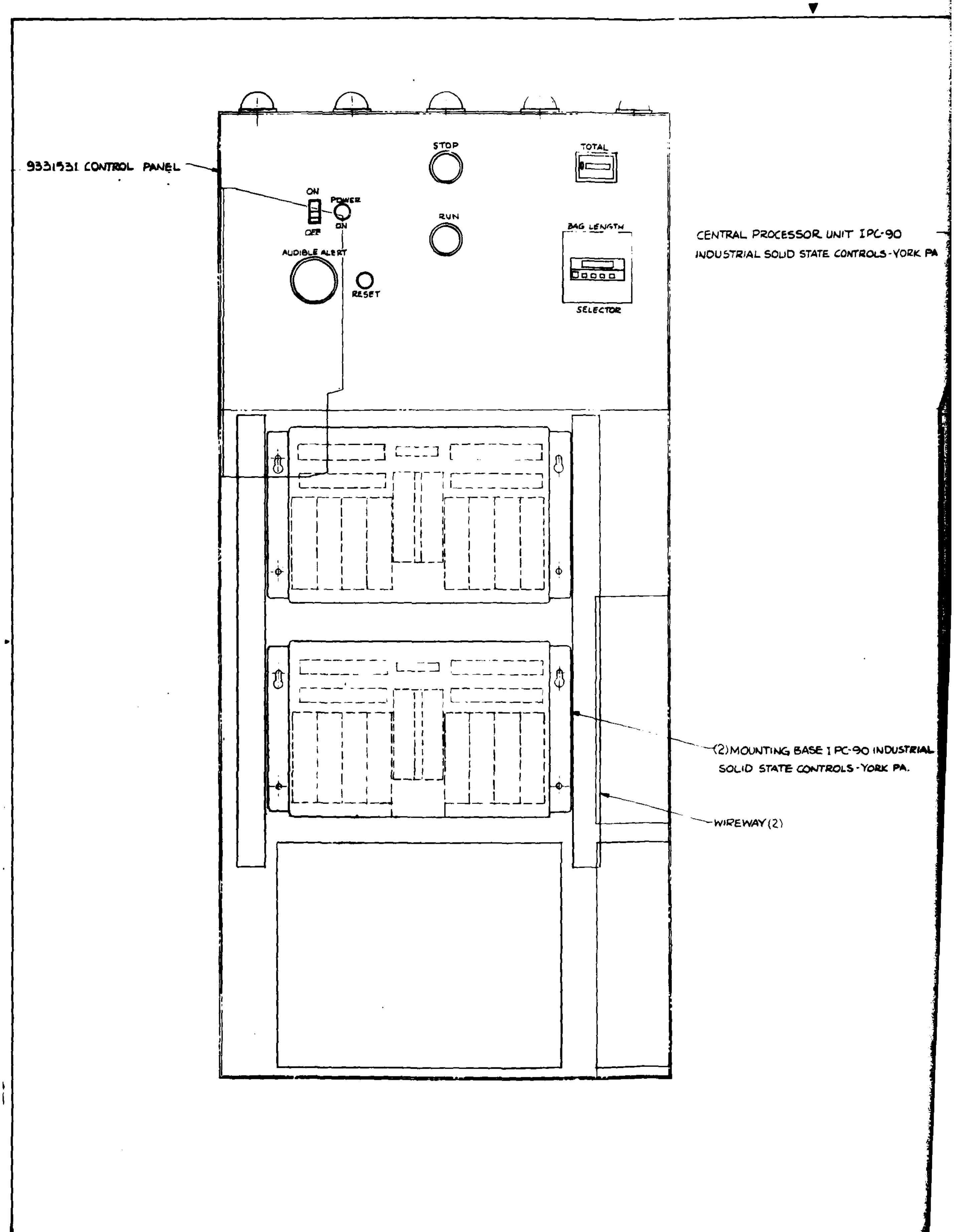
Desk-top design permits creation and debugging of new programs at the convenience of your desk

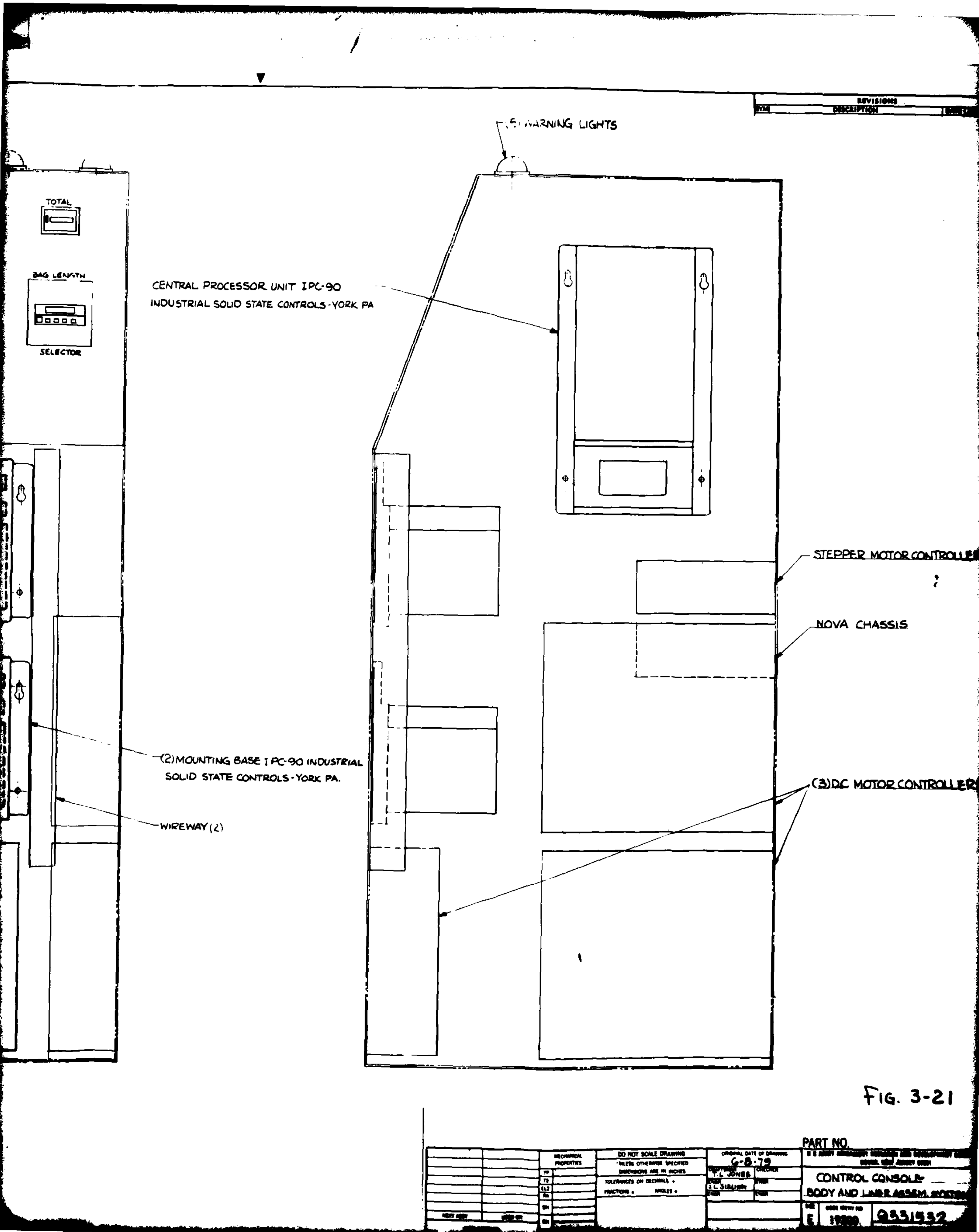
Compact, lightweight hand held loader provides complete programming, editing and real-time monitoring

The system will be controlled from the control console as shown in Figure 3-21 so that the operator may see the system when operating the control panel.

Located on the control panel will be the master circuit braker controlling power applied to the system, a POWER ON indicator light, system STOP button, system RUN button, a total output counter, a bag length selector, an audible alert speaker with a reset button, and on top of the panel console will be running indicators lights for each station. The total output counter is a resettable counter that can be used to total the system's daily output. The bag length selector is an operator selectable predetermining control that counts the number of increments that the stepper motor makes in the Liner Place, Sew and Crease Station. Because of the accuracy of the system, the web bag length indexing will be to within 0.050 inch of the length selected by the operator. The warning indicator lights are omni-types mounted on top of the console so that they can be seen by both operators. They are wired in parallel with the warning lights at each station. These lights indicate the need for operator attention for such things as material replenishments, finished product removal, thread breaks, bobbin change, etc.

Limit switches, proximity sensors, photo switches, and manual (override) switches are the main control system input devices to the programmable controller. The input signals are processed in the controller according to preprogrammed logic. An example of these logic equations can be seen seen by looking at the control equations for the Body Tube Elevator Assembly (see Figure 3-20).


9331531 CONTROL PANEL
ON
OFF
POWER
ON
AUDIBLE ALERT
RESET
STOP
RUN
TOTAL
BAG LENGTH
SELECTOR
CENTRAL PROCESSOR UNIT IPC-90
INDUSTRIAL SOLID STATE CONTROLS-YORK PA
(2) MOUNTING BASE I PC-90 INDUSTRIAL
SOLID STATE CONTROLS-YORK PA.
WIREWAY (2)



REVISIONS
DESCRIPTION
(5) WARNING LIGHTS
TOTAL
BAG LENGTH
SELECTOR
CENTRAL PROCESSOR UNIT IPC-90
INDUSTRIAL SOLID STATE CONTROLS-YORK PA
STEPPER MOTOR CONTROLLER
NOVA CHASSIS
(2) MOUNTING BASE I PC-90 INDUSTRIAL
SOLID STATE CONTROLS-YORK PA.
WIREWAY (2)
(3) DC MOTOR CONTROLLER
PART NO.
MECHANICAL PROPERTIES
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
ORIGINAL DATE OF DRAWING
6-8-79
CHECKER
T.L. JONES
J.L. SULLIVAN
CONTROL CONSOLE
BODY AND LINER ASSEM. SYSTEM
E
9331532


FIG. 3-21

The Body Tube Elevator Assembly is the assembly at the end of the Body and Liner Assembly System that receives the finished tubes from the cutter. It holds the tubes in a stack and automatically lowers the stack tray in order to maintain a constant distance to the top of the stack. The logic equations are as follows:

| Function | | Logic |
| --- | --- | --- |
| Motor M431 DOWN | = | $\overline{SW432\cdot}$ $(SW435.\overline{SW434}\ UP + SW434\ DN)$ |
| Motor M431 Up | = | $\overline{SW431\cdot}$ $SW434\ UP\cdot\ \overline{SW435}$ |

where:

SWXXX means SWITCH MADE

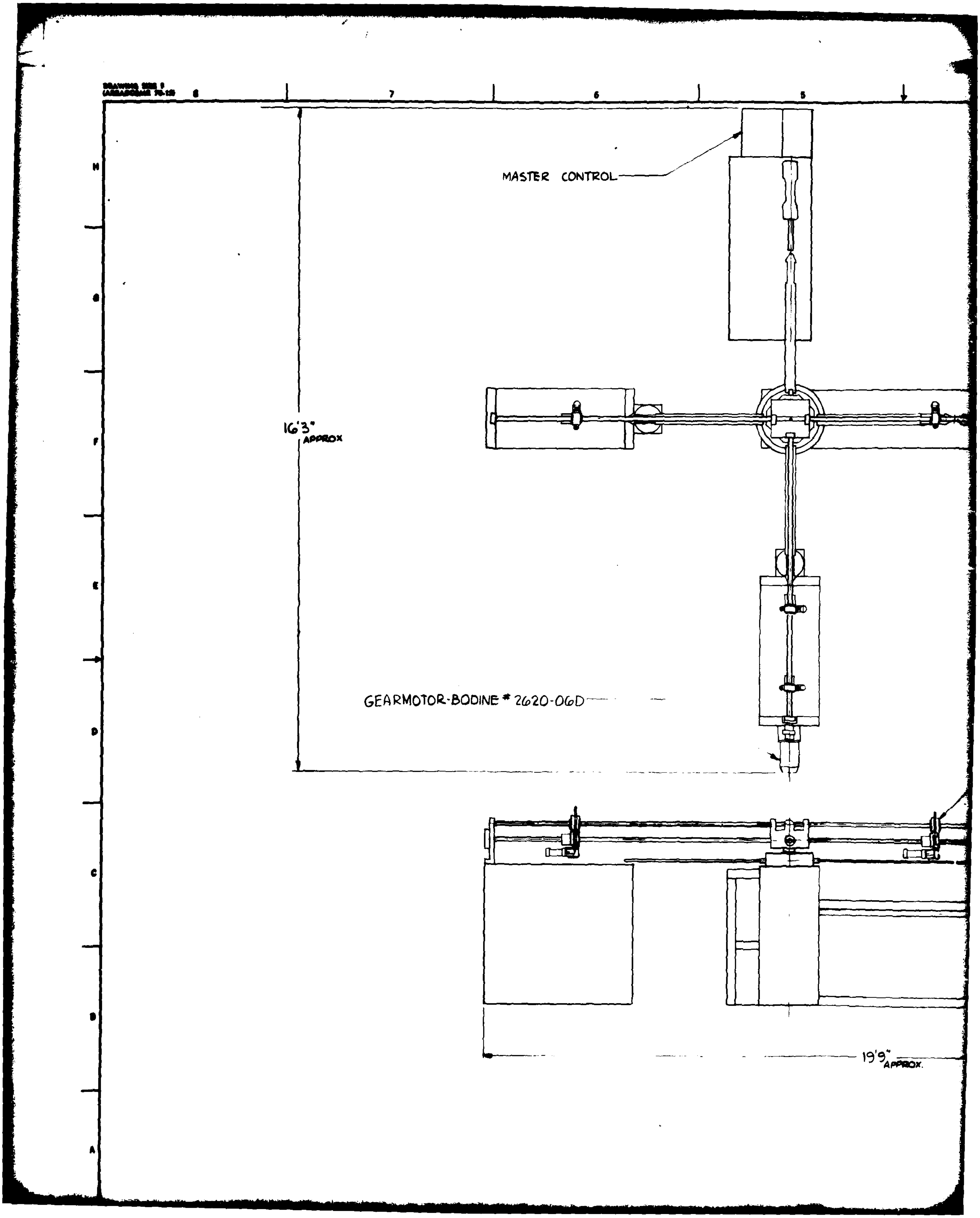
$\overline{\text{SWXXX}}$ means SWITCH NOT MADE

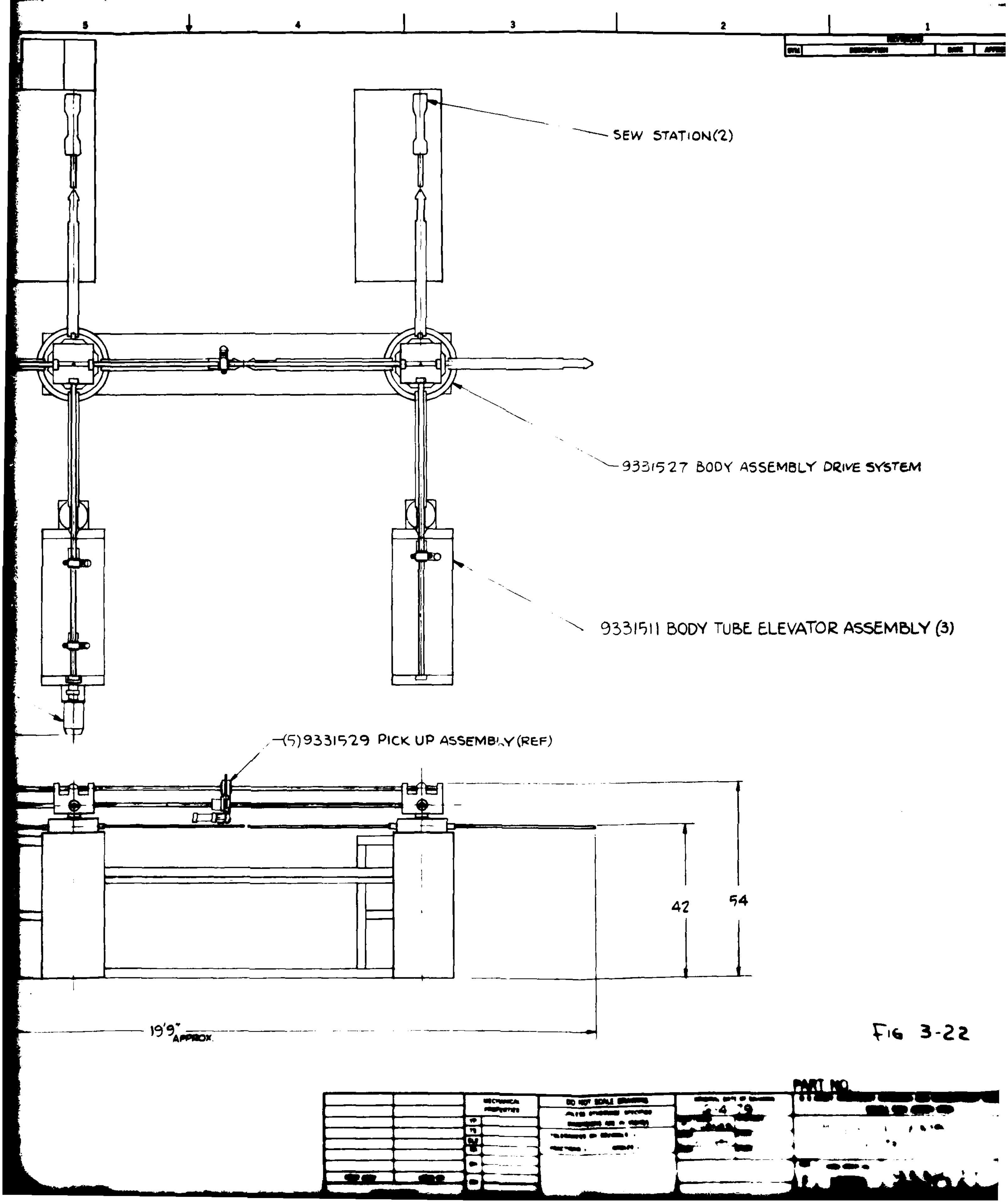
Switches SW431 and SW432 are the elevator top and bottom limit switches which limit the travel distance of the tray. Switch SW434 is a manual switch that overrides the normal operation of the elevator. This switch will be used to empty the assembly of a stack of finished body and liner assemblies and then may be used to drive the tray back to the starting position. Switch SW435 is a proximity sensor that detects the top of the stack.

### 3.2 Body Assembly System

The Body Assembly System is an indexing system that produces body assemblies for three of the four propellent bag types in an automated mode with operator functions limited to sewing the end assembly to the tube and resupplying expended material. An illustration of this system can be found in Figure 3-22.

The output of this system is body assemblies. This is a body and liner assembly with an end assembly sewn around the ends inside the tube.


MASTER CONTROL
16'3" APPROX
GEARMOTOR-BODINE # 2620-06D
19'9" APPROX.



SEW STATION(2)
9331527 BODY ASSEMBLY DRIVE SYSTEM
9331511 BODY TUBE ELEVATOR ASSEMBLY (3)
(5)9331529 PICK UP ASSEMBLY(REF)
42
54
19'9" APPROX
PART NO

Fig 3-22

AD-A081 558 NOVATRONICS INC POMPANO BEACH FLA F/G 13/8
FEASIBILITY STUDY OF ALTERNATIVE FABRICATION METHODS.(U)
AUG 79 DAAK10-78-C-0286
UNCLASSIFIED NL

2 OF 2
AD
A081558

NOVATRONICS

END
DATE
FILMED
4-80
DTIC

The following part numbers will be the end products of this system:

9326077 - Body Assembly for 155mm, M119A1

9278967 - Body and End Assembly for 155mm, M203

9277178 - Body Assembly for 8 inch, M188 (less tying straps)

The Increment 9 Assembly is too short to be processed by this machine. The input to this system is a stack of body and liner assemblies and a stack of end assemblies. The Body Assembly System can be divided into six separate stations: End Assembly Pick-up Station, Body and Liner Assembly Pick-up Station, End Sewing Station, Partial Body Assembly Transfer Station, End Sewing Station (opposite end), and a Stacking Station for finished body assemblies.

The bag assemblies are moved from station to station on flat fingers (see Figure 3-23) which are approximately 39-inch-long and 5/16-inch-thick cantilevered beams. Different widths are used depending upon the size of the end assembly that is being produced. These flat fingers are mounted on bearings so that they are free turning for sewing. At the base of the flat finger is a cam which controls the rotation of the flat finger. At the sewing station the cam leaves the cam guide and is free to rotate as the ends are being sewn manually. From the jury rig effort it was determined that until the Auto 3-D sewing could be proven feasible, the station would have to remain a manual sew station.

The flat fingers are mounted to two rotary indexing heads (see Figures 3-24 and 3-25). The first index head has the End Assembly Pick-up Station, Body and Liner Assembly Pick-up Station, End Sewing Station, and Partial Body Assembly Transfer Station where the partially finished assembly is transferred to the second rotary head.

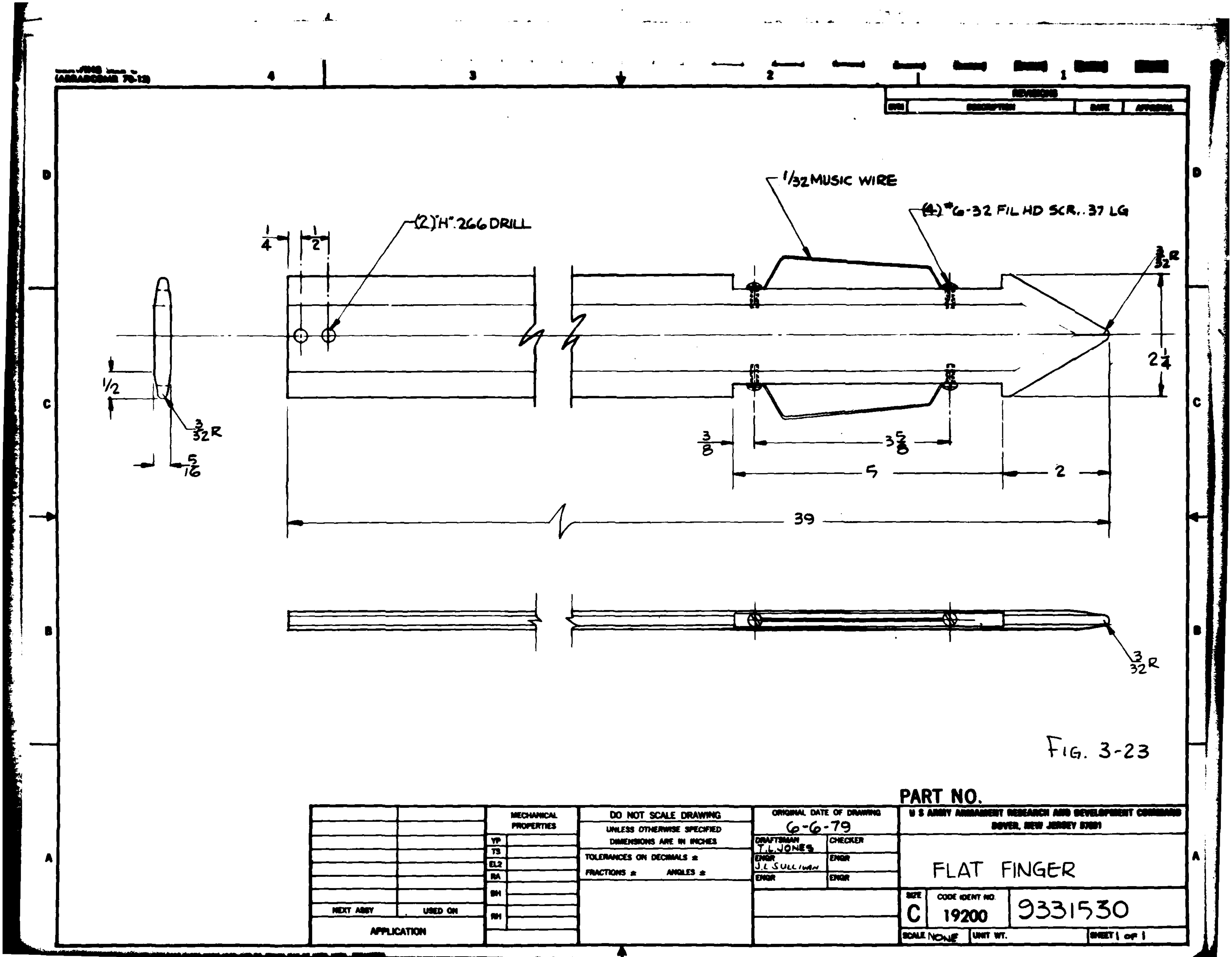
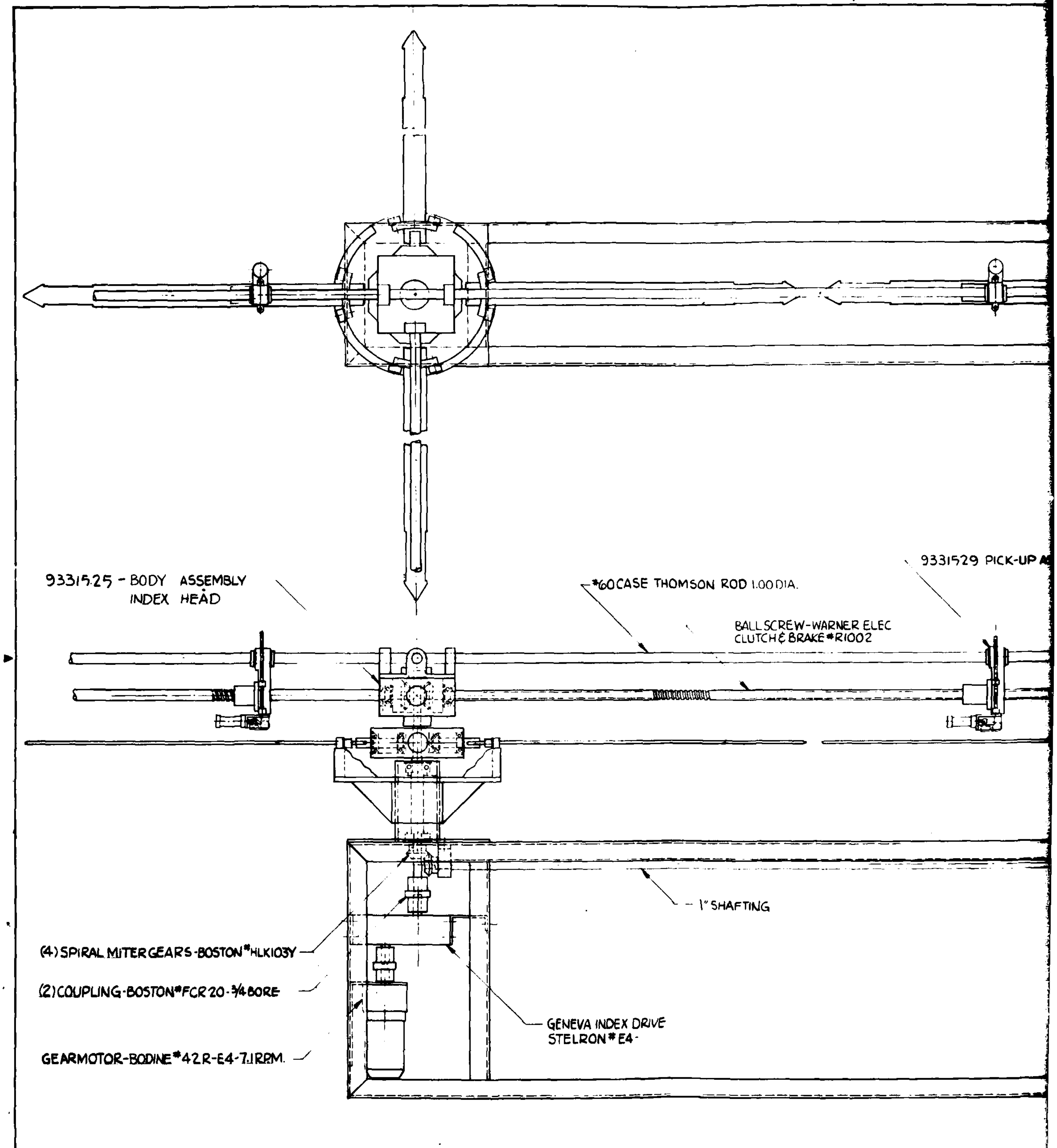

(2) "H" .266 DRILL
1/32 MUSIC WIRE
(4) #6-32 FIL HD SCR. .37 LG
3/32 R
2 1/4
1/4
1/2
5/16
3/8
3 5/8
5
2
39
REVISIONS
SYM
DESCRIPTION
DATE
APPROVAL
PART NO.
U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801
FLAT FINGER
SIZE C
CODE IDENT NO. 19200
9331530
SCALE NONE
UNIT WT.
SHEET 1 OF 1
ORIGINAL DATE OF DRAWING 6-6-79
DRAFTSMAN T.L.JONES
CHECKER
ENGR J.L.SULLIVAN
ENGR
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ±
ANGLES ±
MECHANICAL PROPERTIES
YP
TS
EL2
RA
BH
RH
NEXT ASSY
USED ON
APPLICATION

Fig. 3-23


9331525 - BODY ASSEMBLY
INDEX HEAD
*60 CASE THOMSON ROD 1.00 DIA.
9331529 PICK-UP A
BALL SCREW-WARNER ELEC
CLUTCH & BRAKE *R1002
1" SHAFTING
(4) SPIRAL MITER GEARS-BOSTON *HLK103Y
(2) COUPLING-BOSTON *FCR 20-3/4 BORE
GEARMOTOR-BODINE *42R-E4-7.1 RPM.
GENEVA INDEX DRIVE
STELRON *E4-

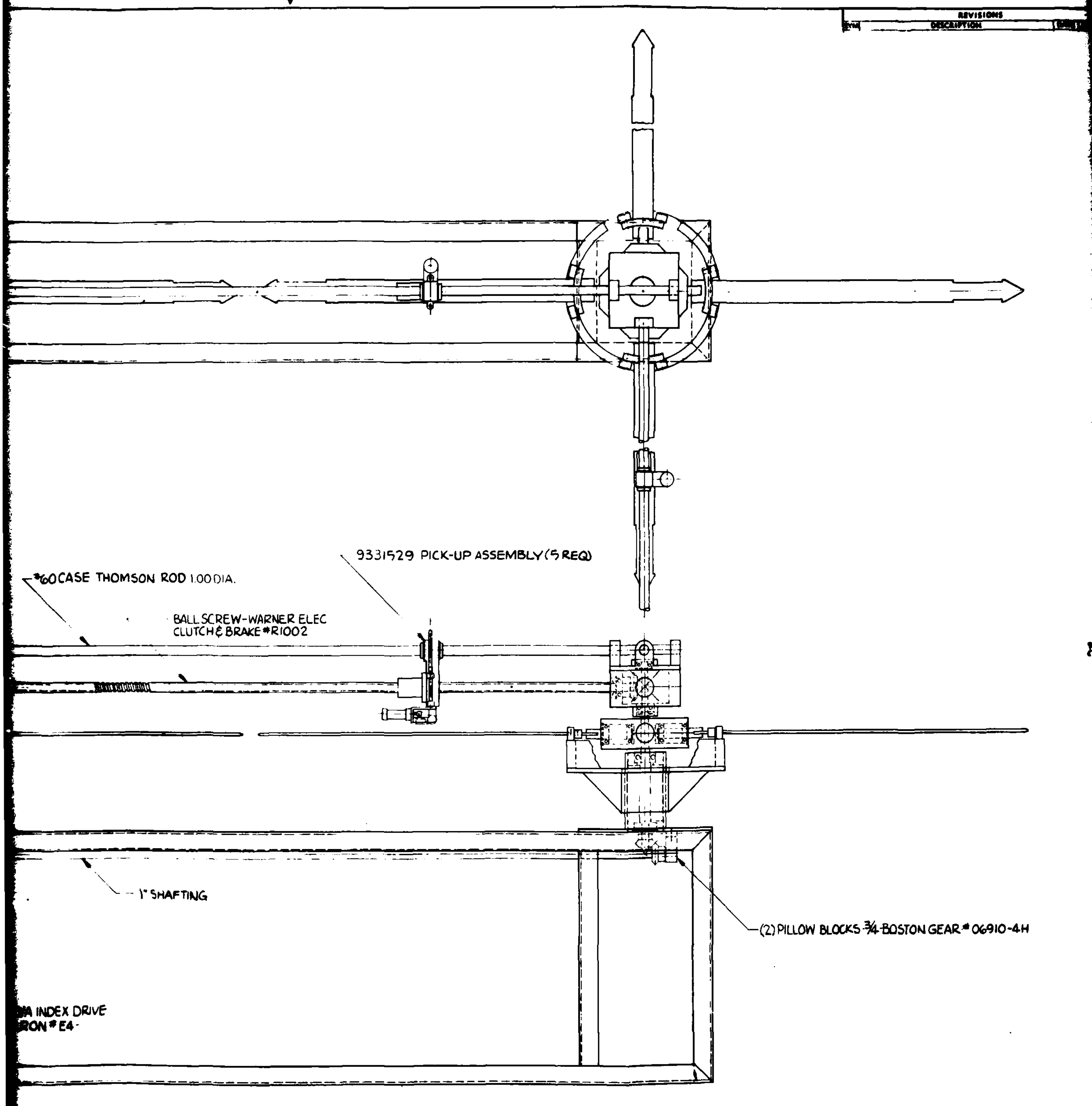



FIG. 3-24

PART NO.

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

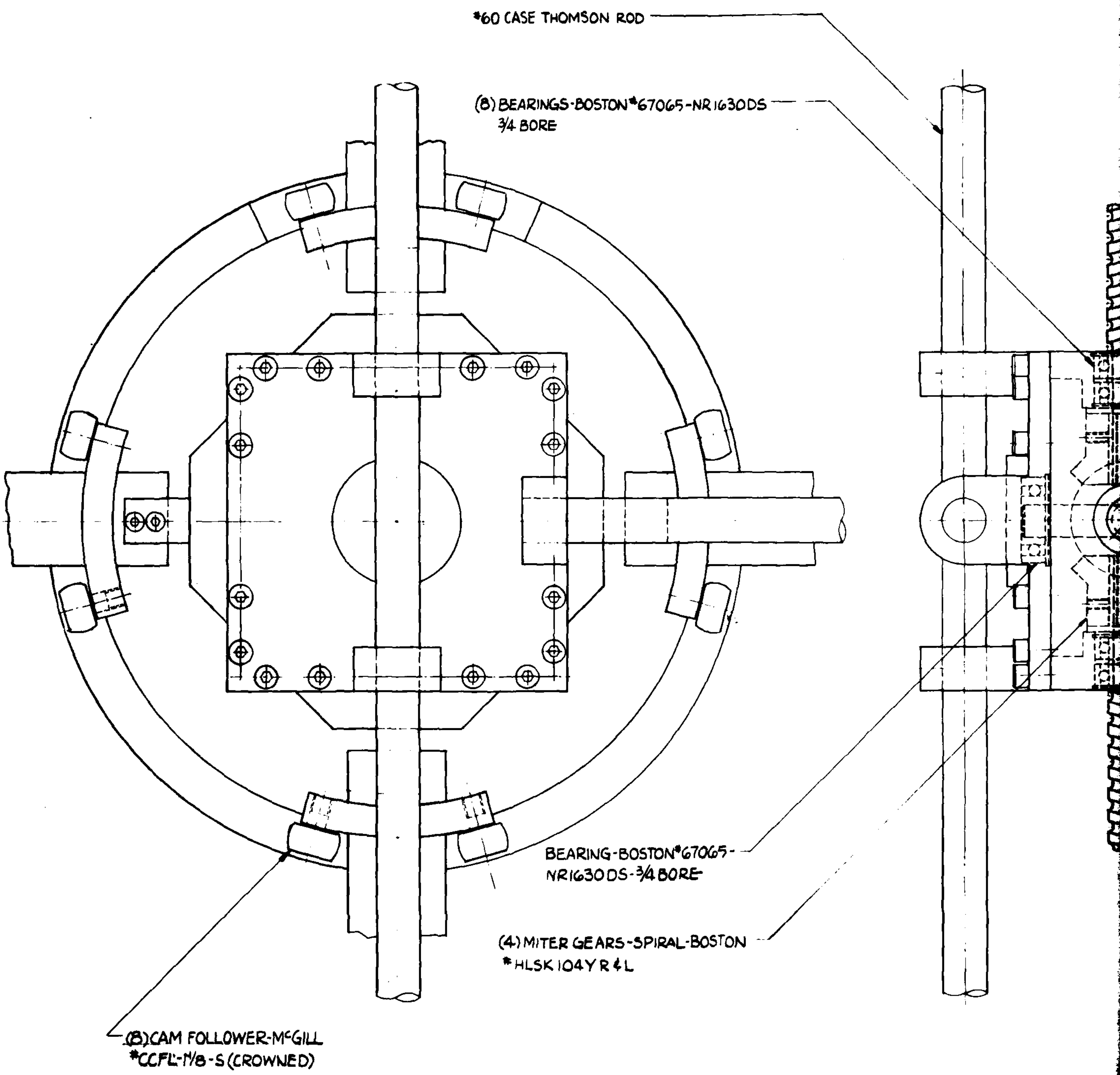
MECHANICAL PROPERTIES

NEXT ASSY — USED ON

ORIGINAL DATE OF DRAWING 5-30-79
DRAFTSMAN T. JONES
ENGR J.J. SULLIVAN

BODY ASSEMBLY
DRIVE SYSTEM

E 9331526



*60 CASE THOMSON ROD
(8) BEARINGS-BOSTON *67065-NR1630DS
3/4 BORE
BEARING-BOSTON *67065-
NR1630DS-3/4 BORE
(4) MITER GEARS-SPIRAL-BOSTON
*HLSK104YR&L
(8) CAM FOLLOWER-McGILL
*CCFL-1 1/8-S (CROWNED)

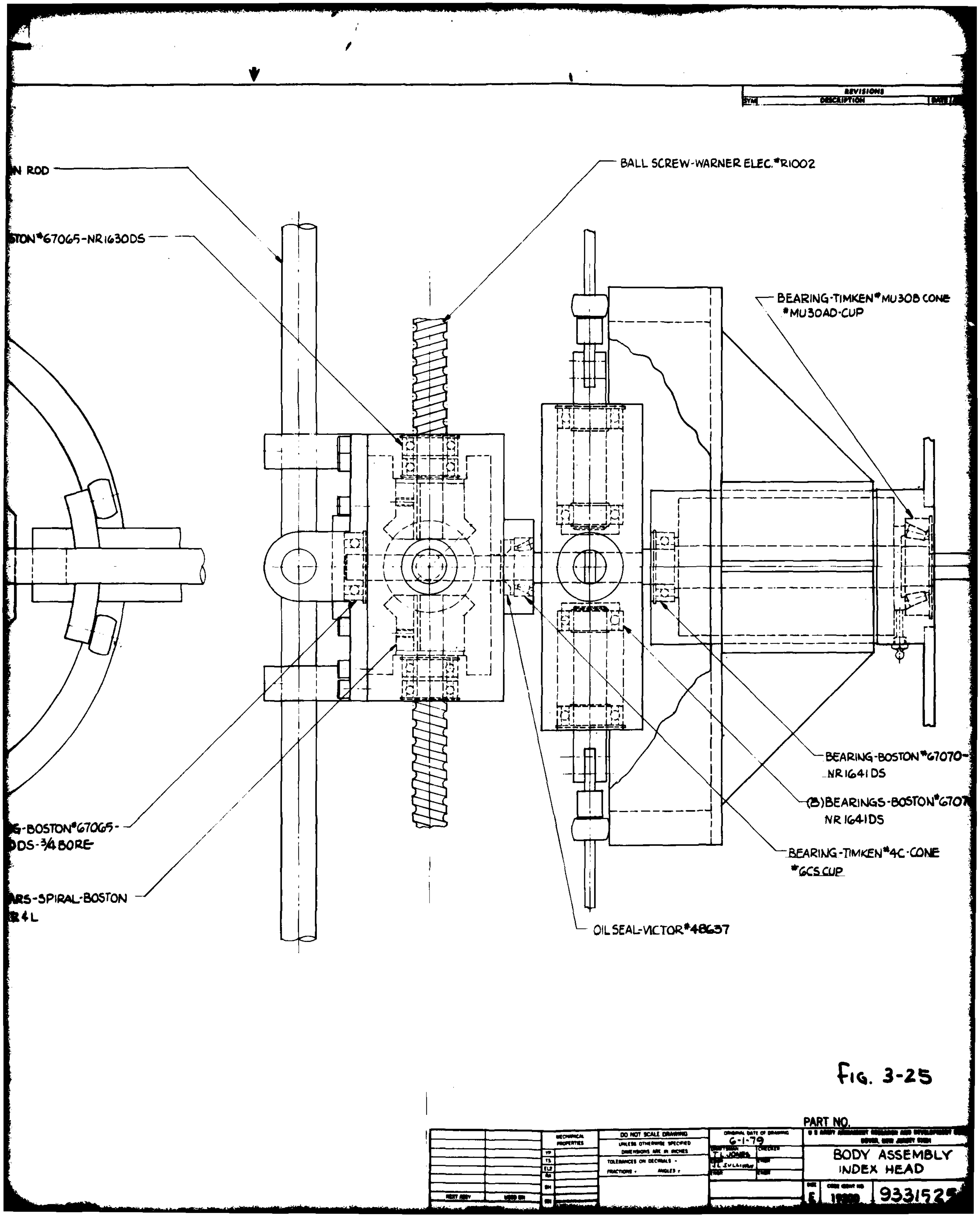

REVISIONS
SYM
DESCRIPTION
N ROD
STON*67065-NR1630DS
BALL SCREW-WARNER ELEC.*R1002
BEARING-TIMKEN*MU30B CONE
*MU30AD-CUP
BEARING-BOSTON*67070-
NR1641DS
(2)BEARINGS-BOSTON*6707
NR1641DS
BEARING-TIMKEN*4C-CONE
*6CS CUP
G-BOSTON*67065-
DDS-3/4 BORE
ARS-SPIRAL-BOSTON
R4L
OIL SEAL-VICTOR*48637
PART NO.
MECHANICAL PROPERTIES
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
ORIGINAL DATE OF DRAWING
6-1-79
T.L. JONES
J.L. SULLIVAN
CHECKER
NEXT ASSY
USED ON
BODY ASSEMBLY
INDEX HEAD
E
19200
9331525

Fig. 3-25

This index head's input is from the Transfer Station and takes the product to the second End Sewing Station for manual sewing. After the assembly is sewn, it is carried to the Stacking Station where it is removed and stored.

This system only shows a 9% ROI based on its estimated cost of $60,000. Because of its low ROI, this system is not recommended for production development.

In the appendix, we present a more detailed description of this system along with the detailed concept drawings.

# 4.0 ENGINEERING AND MANAGEMENT CONSIDERATIONS

## 4.1 Human Engineering

The Human Engineering effort has been a continuing integral part of this feasibility study.

The principles and criteria of Human Engineering have been applied during the development of this assembly system in order to achieve an effective integration of man into the design of this system. Within the requirements of this system, a Human Engineering effort was provided to improve the man/machine interface and to achieve maximum effectiveness of personnel performance during system operation/control and to make economical demands on manpower resources, skills, training and costs.

For the Body and Liner Assembly System, it has been determined that two operators will be necessary. These operators need only be semi-skilled and have their primary functions generally limited to resupplying expended material and removing finished body and liner assemblies. These functions can be broken down into the following categories:

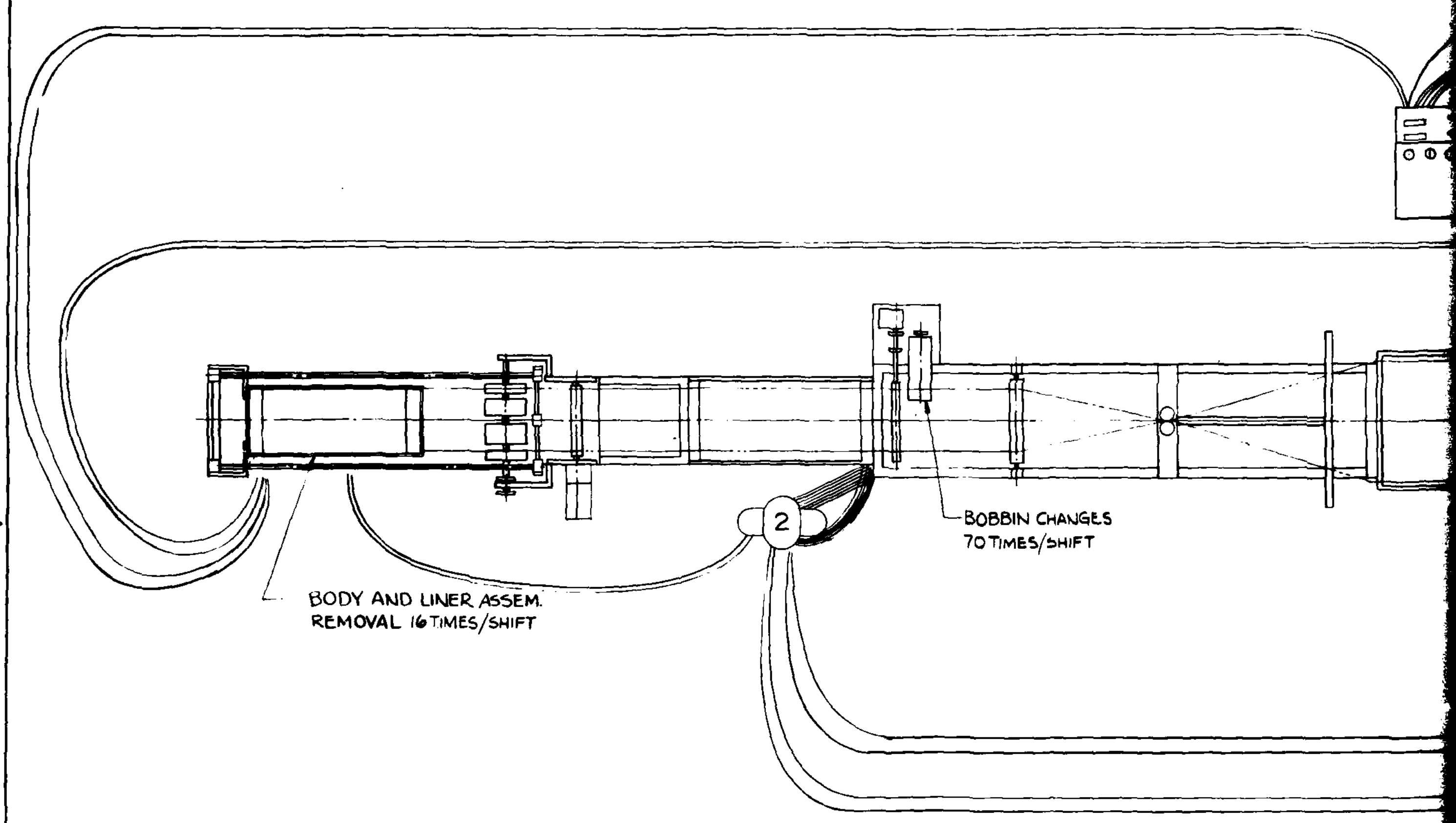
- Cloth roll changes
- Lead liner replenishment
- Liner sew machine bobbin changes
- Tube sew machine bobbin changes
- Body and liner assembly removals

Each of these basic work functions have been analyzed and time estimates to complete these tasks have been generated. These are shown in Table 4-1 by bag size.

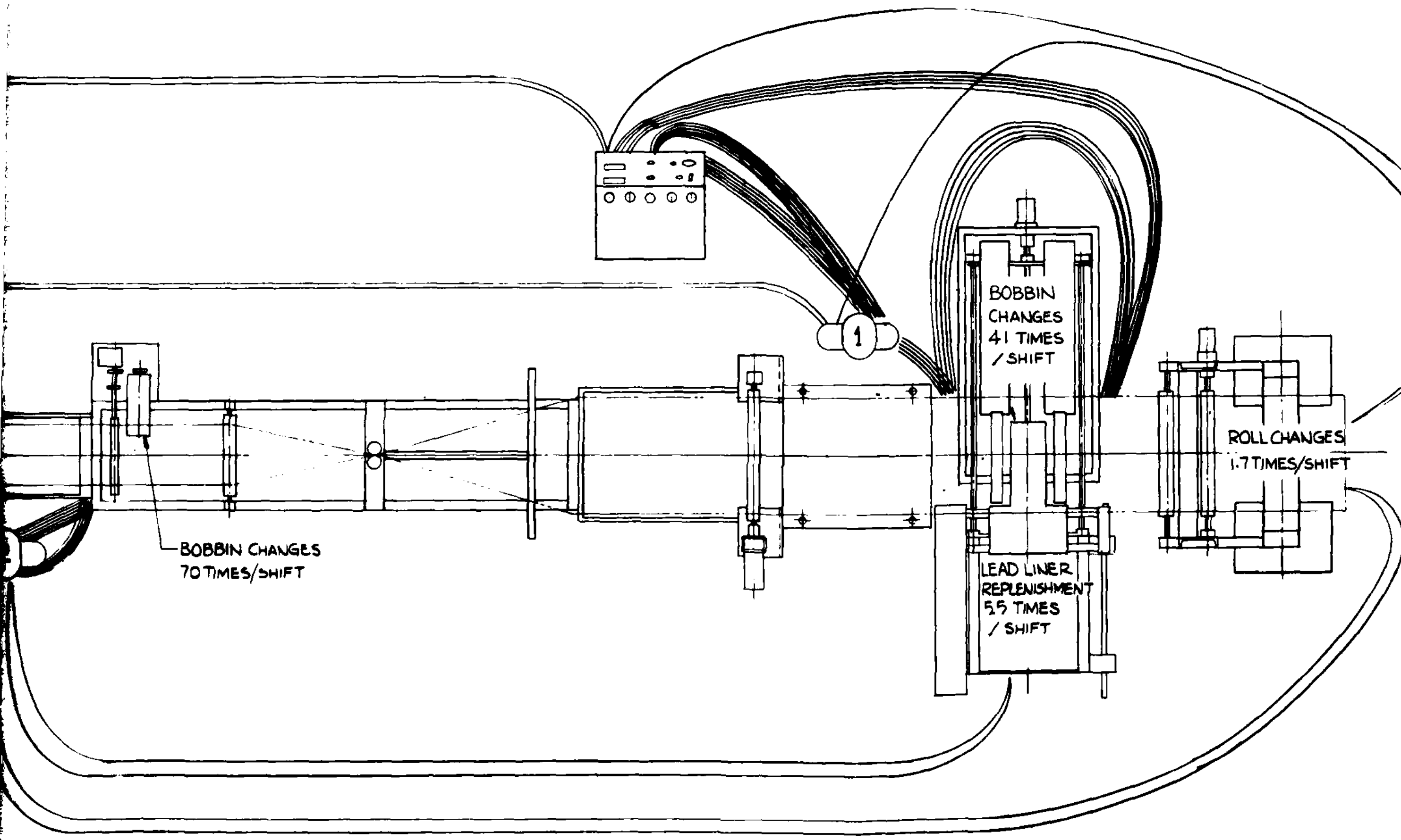
By studying these basic operator functions, the individual and crew workload analysis was performed. It was determined that the control operator is to operate the master control panel, change the liner sew bobbins, assist in cloth roll replenishment, and assist in finished body and liner assembly removal. The other operator is to change tube sew bobbins, replenish the liner elevator, assist in cloth roll replenishment, and assist in finished body and liner assembly removal.

From the loading analysis, several "man travel path" drawings were generated with drawing number 9331538, entitled "Body and Liner Assembly System Man Travel Paths", evolving as the optimum. Each line on the drawing coming from or going to the operator represents 10 trips that would have to be made by that operator. The numbers shown at each location where a basic function is performed is the average number of times that it is performed for all bag sizes.

This system will be operating in the environment of the Bag Room, Building 1001 at I.A.A.P., Charlestown, Indiana.


BOBBIN CHANGES
70 TIMES/SHIFT
BODY AND LINER ASSEM.
REMOVAL 16 TIMES/SHIFT
2

| REVISIONS | | | |
|---|---|---|---|
| SYM | DESCRIPTION | DATE | APP |




NOTES:

1. EACH LINE REPRESENTS 10 MAN TRAVEL PATHS OR A FRACTION THEREOF
2. THE MATERIAL REPLENISHMENTS AND REMOVAL IS AN AVERAGE OF ALL FOUR BAG SIZES

MECHANICAL PROPERTIES

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS ±

FRACTIONS ± ANGLES ±

ORIGINAL DATE OF DRAWING 6-21-79

DRAFTSMAN T.L. JONES

CHECKER

ENGR J.C. SULLIVAN

ENGR

PART NO.

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT

DOVER, NEW JERSEY

BODY AND LINER ASSEMBLY SYS

MAN TRAVEL PATHS

Table 4-1 Work Function Time Estimates

| | BAG SIZE | | | |
|---|---|---|---|---|
| | 155mm | | 8 Inch | |
| | M119 | M203 | M188 | Incrmt 9 |
| Time to Change Cloth Roll (Min/Roll) | 5 | 5 | 5 | 5 |
| No. of Roll Changes per Shift | 2 | 2 | 1.6 | 0.5 |
| Time per Shift for Roll Changes (Min/Shift) | 10 | 10 | 8 | 2.5 |
| Time to Replenish Lead Liners (Mins/Refill) | 6.1 | 6.1 | 6.1 | 8.0 |
| No. of Lead Liner Replenishments per Shift (Refills/Shift) | 2.4 | 5.7 | 4.7 | 10.8 |
| Time per Shift for Liner Replenishments (Mins/Shift) | 15 | 35 | 29 | 86 |
| Time to Change Liner Bobbins (Secs) | 75 | 75 | 75 | 75 |
| No. of Liner Bobbin Changes per Shift | 27.5 | 31.5 | 35.2 | 80 |
| Time to Change Liner Bobbins per Shift (Min/Shift) | 34.4 | 39.4 | 44 | 100 |
| Time to Change Tube Sew Bobbins (Secs) | 60 | 60 | 60 | 60 |

Table 4-1 (Continued)

BAG SIZE

| | 155mm | | 8 Inch | |
|---|---|---|---|---|
| | M119 | M203 | M188 | Incrmt 9 |
| No. of Tube Bobbin Changes per Shift | 83 | 95 | 70.5 | 26.7 |
| Time to Change Tube Sew Bobbins per Shift (Mins/Shift) | 83 | 95 | 70.5 | 26.7 |
| Time to Remove Stack of Finished Body and Liner Assys (Sec.) | 2.3 | 2.3 | 2.3 | 2.3 |
| No. of Finished Body and Liner Assy Stack Removals per Shift | 7.0 | 16.2 | 13.6 | 30.8 |
| Time Spent Removing Finished Body and Liner Assys per Shift (min/Shift) | 16.1 | 37.3 | 31.3 | 70.8 |

The noise levels generated by the Body and Liner Assembly System will be at an acceptable level per industry standards. The requirements for adequate space for the operators and maintenance personnel and their movements were considered in the system layout.

Adequate physical, visual, and auditory links between the operators and the system have been planned. Each station will have omni warning and stop lights. Each station will have shutdown switches. Also, on the top of the control console, omni warning and stop lights for each station will be mounted along with an audible alarm mounted in the front panel of the console.

Additional analysis of operator functions has revealed that greater production can be achieved by changing all bobbins at the same time rather than changing individual bobbins as they become empty. The overall result is to increase thread waste while reducing machine downtime and increasing bag output.

In the production of the M203 bag assembly, the liner sew machine has approximately 75 yards of thread per bobbin while the tube sew machine has approximately 20 yards of thread per bobbin. There are 31.5 bobbin changes per shift at the Liner Sew Station and approximately 89 bobbin changes per shift at the Tube Sew Station. This gives a ratio of 2.8 Tube Sew Station changes to 1 Liner Sew Station change. Therefore, if the bobbins are changed at the Tube Sew Station every time they are changed at the Liner Sew Station, an increase in output for each shift may be realized. (the Tube Sew Station bobbin being removed will be approximately 20% full). This will increase the number of bobbin changes at the Tube Sew Station from 89 to 95 per shift, but it will reduce system downtime associated with Tube Sew Station bobbin changes from 68 minutes per shift to 49 minutes. This changes the average Tube Sew Station cycle time from 9.54 seconds/cycle to 9.0 seconds/cycle. This decrease in cycle time will increase bag production to 400 assemblies per hour (compared to 377 per hour) and total shift output will increase to 2,240 assemblies from 2,111 at the cost of 6-1/3 bobbins of thread. Refer to Table 4-2.

Table 4-2 Bobbin Change Analysis

| | BAG TYPE M119 | M203 | M188 | Incrmt 9 |
|---|---|---|---|---|
| Bobbin Changes/Shift- Liner Sew | 25 | 31.5 | 35.2 | 80 |
| Bobbin Changes/Shift- Tube Sew | 83 | 88.7 | 67.3 | 23.6 |
| Ratio of: Tube Sew Bobbin Changes / Liner Sew Bobbin Changes | 3.3 | 2.8 | 1.91 | 0.30 |
| New Bobbin Changes/Shift - Liner Sew | 27.5 | 31.5 | 35.2 | 80 |
| New Bobbin Changes/Shift - Tube Sew | 83 | 95 | 70.5 | 26.7 |
| Tube Station Bobbin Change Downtime (Mins.) | 63.5 | 68 | 47.9 | 8.5 |
| New Tube Station Bobbin Change Downtime (Mins.) | 63.5 | 49 | 25 | 0 |
| Liner Station Bobbin Change Downtime (Mins.) | 31.2 | - | 44 | 100 |
| | Change Liner bobbin with every third Tube bobbin change. | Change Tube bobbin with every Liner bobbin change. | Change Tube bobbin with every Liner bobbin change. | Change Tube bobbin with every third Liner bobbin change. |

Table 4-2 (Continued)

| | BAG TYPE | | | |
|---|---|---|---|---|
| | M119 | M203 | M188 | Incrmt 9 |
| New Liner Station Bobbin Change Downtime (Mins.) | 6.2 | - | 44 | 100 |
| Tube Station Cycle Time | 9.0 | 9.54 | 11.4 | 5.03 |
| New Tube Station Cycle Time | 8.3 | 9.0 | 10.6 | 4.9 |
| Liner Station Cycle Time (sec.) | 7.2 | - | 9.8 | 4.9 |
| New Liner Station Cycle Time | 6.6 | - | 9.8 | 4.9 |
| System Output | 400 | 377 | 315 | 715 |
| New System Output | 434 | 400 | 339 | 735 |
| No. of Bobbins Wasted | 2.7 | 6.3 | 3.2 | 3.5 |
| Assys Gained/Shift | 190 | 129 | 134.4 | 112 |
| | Change Liner bobbin with every third Tube bobbin change. | Change Tube bobbin with every Liner bobbin change. | Change Tube bobbin with every Liner bobbin change. | Change Tube bobbin with every third Liner bobbin change. |

## 4.2 Quality Control System

The Body and Liner Assembly System has been designed to produce items of equal or better quality than those previously made on the bag handline. Automated inspection equipment has been designed into the system wherever practical to reduce the need for visual/manual checks. Sensors and detectors have been used to control machine operations and to monitor the supply of component items; i.e., material roll low, lead liner supply low, output stacker near maximum capacity, etc. Other quality control functions will be monitored such as:

1) Detect GO/NO GO on the lead liner position prior to sewing to web.
2) Detect web edge in the Liner Place, Sew, and Crease Station.
3) Detect thread breakage on all three sewing machines.
4) Detect edge of web at folder.
5) Detect proper stack height in output stacker (improper stacker activity).

When an out-of-tolerance/reject condition is sensed, the system will stop and the appropriate warning light will come on for operator attention. The bags that have out-of-tolerance or reject conditions can be marked and then removed from the system at the stacker. A black ink marking system can be used. The bad bags will be sprayed with black ink and a photo detector at the stacker will sense and reject them into an open container for possible rework.

The Body and Liner Assembly System will not be able to produce the body and liner assemblies per their existing specifications. This is because the existing specifications were toleranced and dimensioned for hand assembly. The specifications will have to be updated and modified to reflect mechanized assembly techniques.

The two major areas of changes are the seam locations. The liner seam locations presently are dimensioned from each edge of the line which is the proper way for manual sewing since the operator guides the stitching relative to each edge. But the two liner sewing machines in the Body and Liner Assembly System have a fixed dimension from needle to needle (for each bag size). Therefore, the drawings for this operation should be dimensioned with one dimension from seam to edge and one dimension from seam to seam.

The liners will not be able to overlap since they are sewn to the web in a flat condition. If they did overlap, they would interfere with the tube sewing process. The 155mm assemblies are adequate, but the two 8-inch assemblies should be changed to read, "Flush to ½ gap."

Also, if the 8-inch, M188 assembly tube seam could be changed from a $LS_b$-2 to a SSa-2, all tube seams would be alike. This change is not necessary but would standardize this seam.

The present condition and the recommended condition of these drawings are shown in Table 4-3.

Table 4-3. Summary of Proposed Changes to Bag Assembly Drawings

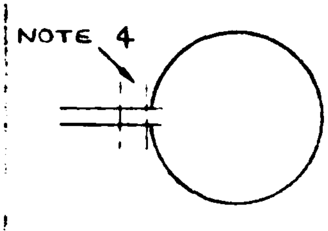
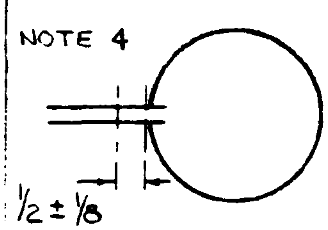
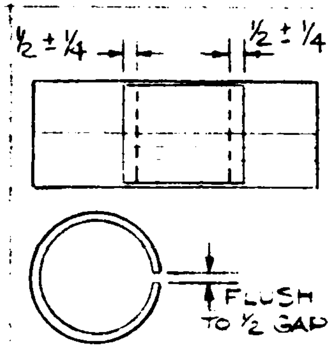
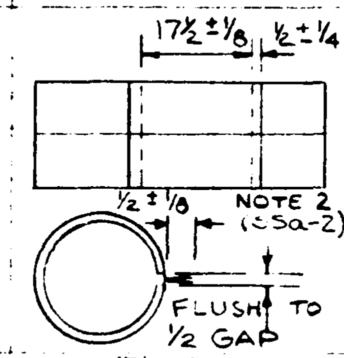
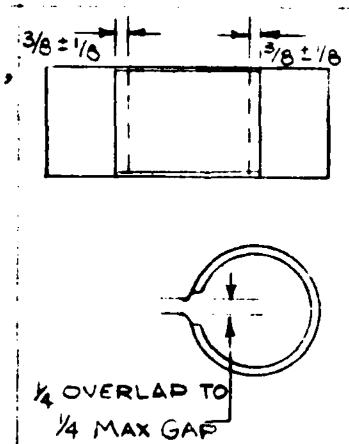
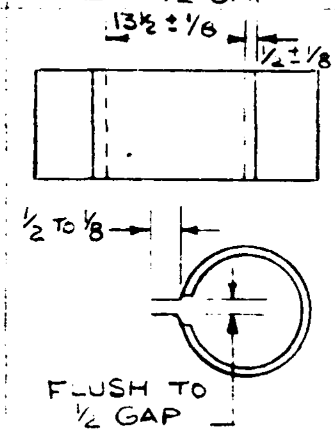
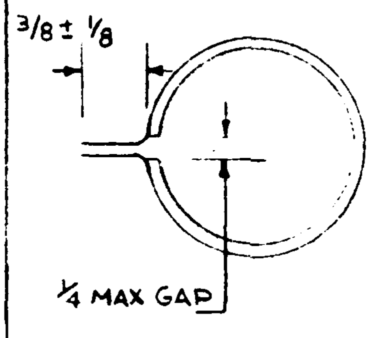
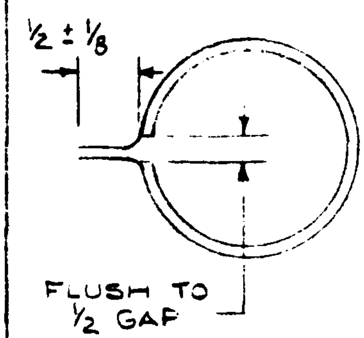
| Drawing No. | Bag Type | Present | Proposed | Reason |
|---|---|---|---|---|
| 9326078 | 155mm, M119A1 |   |   | Need to call out tube seam-to-edge dimension. |
| 9278973 | Body and Liner Assembly 155mm, M203 |   |   | Need to dimension between liner seams. Change tube seam to SSa-2. Need to call out tube seam-to-edge dimension. |
| 9277176 | Body and Liner Assembly 8 inch, M188 |   |   | Need to dimension between liner seams. Change tube seam from $LS_b$-2 to a SSa-2 (not necessary but would standardize seam). Need to eliminate liner overlap. |

Table 4-3. (Continued)

| Drawing No. | Bag Type | Present | Proposed | Reason |
|---|---|---|---|---|
| 9277181 | Increment 9 Assembly 8-inch, M188E2 |  |  | Need to eliminate liner overlap. Change tube seam to edge (to standardize, not necessary). |

## 4.3 Safety and Hazards

A preliminary safety hazard analysis, which is essential for the evaluation of potential hazards of this design approach, has been completed.

Novatronics will establish and maintain an effective safety program for the Body and Liner Assembly System per MIL-STD-882A and Army Regulation No. 385-16 that is planned and integrated into all phases of development and which can be integrated into production and operation of the Assembly System at I.A.A.P.

The hazard severity category which this system will meet is Category III - *Marginal* (per MIL-STD-882A) which is defined and established as:

"Conditions such that personnel error, environmental conditions, design inadequacies, procedural deficiencies, system, subsystem or component failure or malfunction may cause minor injury, minor occupational illness or minor system damage."

The safety program will include the following objectives:

1. Safety consistent with the system requirements is designed into the system in a timely, cost-effective manner.

2. Safety data from other systems produced by Novatronics will be considered and used, where appropriate.

3. Minimum risk is involved in accepting and using of the new Assembly System.

4. Retrofit actions required to improve safety will be minimized through the timely inclusion of safety features during the development of this system.

5. Modifications do not degrade the inherent safety of this system.

The National Electrical Code which was developed mainly by the National Fire Protection Association is widely accepted as giving the minimum requirements for electrical equipment to safeguard people and property from electrical hazards. The Army Material Command has determined that electrical equipment used in AMC establishments must comply with the requirements of the latest edition of the National Electrical Code. The Body and Liner Assembly System will comply with the latest edition of the National Electrical Code per AMCR 385 (Army Material Command Safety Manual). Also, OSHA's Occupational Safety and Health Standards, vol. 39, no. 125, part II, subpart O, section 1910.212 entitled "General requirements for all machines", will have special emphasis placed on it.

4.4 Repair and Maintenance Manual

A preventive as well as an in-process maintenance program will be fully outlined in the Repair and Maintenance Manual for the Body and Liner Assembly System.

The program will recommend types of maintenance as well as frequency; it will recommend which tasks are static in nature (system need not operate) as well as those that must be performed while the system is running.

Procedures for establishing proper maintenance records will be recommended and sample forms will be submitted. Manpower requirements will be recommended, based on job descriptions applicable at that time at I.A.A.P.

Contents of the Repair and Maintenance Manual will be as indicated in the following outline:

REPAIR AND MAINTENANCE MANUAL

**OUTLINE**

BODY and LINER ASSEMBLY SYSTEM
105MM PROPELLENT AUTOMATED CHARGE ASSEMBLY SYSTEM

Section 1

1.0 INTRODUCTION

1.1 Scope of Manual

Manual coverage and any other applicable introductory information.

## Section 2

2.0 INSTALLATION

2.1 Scope of Section 2

2.2 Required Preparations

General requirements for siting, data needed, and pre-installation preparations.

2.3 Installation Procedure

Detailed information on installation.

2.3.1 Power.

2.3.2 Fluid connections.

2.3.3 Safety considerations.

2.3.4 Order of installation with references to other drawing data.

2.3.5 Mounting and leveling of equipment assembly.

2.3.6 Wiring connections and precautions.

2.3.7 Inspection on completion.

2.4 Equipment Adjustments

2.4.1 Detailed adjustments for system and individual elements, stations, etc., as required and illustrated as necessary.

2.4.2 Personnel involved.

2.4.3 Step-by-step procedure in required order.

2.4.4 System checkout.

2.4.5 Pre-operational lubrication, etc.

2.4.6 System test at completion of installation.

Section 3

3.0 PREVENTIVE MAINTENANCE

3.1 Scope of Section 3

3.2 Maintenance Schedule

3.2.1 Tabular and text coverage of required scheduled maintenance defining intervals and type of maintenance.

3.2.2 Warnings and cautions to avoid danger or damage.

3.2.3 Lubrication.

3.2.4 Adjustment and calibrations as applicable.

3.2.5 Inspections.

3.2.6 Checkouts (if any).

3.3 Maintenance Procedures

3.3.1 Detailed method of accomplishing various maintenance activities scheduled in Section 3.2.1 above.

3.3.2 Shutdowns and precautions (with any notifications required for scheduled maintenance).

3.3.3 Materials and supplies required.

3.3.4 Forms (logs), as applicable.

3.3.5 Performance of checkouts, as applicable, after maintenance.

3.3.6 Disassembly and reassembly procedures required.

3.3.7 Lubrication.

## Section 4

## 4.0 TROUBLESHOOTING AND REPAIR

### 4.1 Scope of Section 4

### 4.2 Detailed Troubleshooting

4.2.1 System, including Control Center.

4.2.2 Equipment in tabular and text form with illustrations as required.

### 4.3 Corrective Action and Repairs

4.3.1 Disassembly and reassembly required.

4.3.2 Part or assembly replacement (reference to parts lists for various elements).

4.3.3 Coverage for mechanical and electrical.

4.3.4 Records/forms.

4.3.5 Cautions and warnings.

4.3.6 Requirement for minimum downtime.

4.3.7 Tests upon completion of repairs.

4.4 Illustrated Table of Parts

Lists of mechanical and electrical parts providing the following information for each part:

a) Part name

b) Part function

c) Manufacturer's part number

d) Vendor code or name and address of manufacturer.

## Section 5

## 5.0 OUTLINE OF MAJOR OVERHAUL

5.1 Scope of Section 5

5.1.1 Tabular and text information referencing required information and drawings, etc.

5.1.2 Vendor's brochures or other pertinent information, including interface data.

5.1.3 Inspections and tests to determine condition of equipment and need for replacement.

## 4.5 System Reliability

This section contains the reliability analysis for the Body and Liner Assembly System as required by the statement of work. The data presented is a priori data.

A reliability prediction has been conducted by Novatronics in order to estimate the mean-time-between-failure (MTBF) of the system. This analysis is consistent with the requirements of MIL-STD-756A design prediction procedures. Appropriate K-factors are applied as pertaining to the class of components.

Reviews shall be made at appropriate stages of development and production to evaluate achievement of the reliability program. The planned reviews should include, to the extent applicable but not necessarily limited to, (1) potential design or production (derived from reliability analyses) problem areas, and control measures necessary to preserve the inherent reliability, (2) effects of engineering decisions, changes and trade-offs upon reliability achievements, potential and growth, within the functional model framework, (3) status of subcontractors and supplier's programs, and (4) status of previously approved design review actions. The results of reliability reviews shall be documented.

### 4.5.1 Method of Calculations

For the calculations used in this analysis, reliability is mathematically defined as:

$$R = e^{-\lambda t}$$

where: $R$ = Reliability

$\lambda$ = Failure rate times $10^{-6}$

$t$ = Time of operation.

Failure rates used are all based on number of failures per $10^6$ hours. When available failure rates were specified for another time base, the $\lambda$ was adjusted to the $10^6$ hour base.

The design goal for reliability is arbitrarily set to be 95% for an 80 hour period; therefore, all calculations used t = 80. The system reliability was calculated as follows:

$$R\ system = R_1 \times R_2 \times R_3 \times R_4 \times R_5 \times R_6 \times R_7 \times R_8 \times R_9$$

where:

$R_1$ = Reliability of Unwind Station = 0.998656

$R_2$ = Reliability of Liner Elevator Assembly = 0.998071

$R_3$ = Reliability of Liner Transfer Assembly = 0.997317

$R_4$ = Reliability of Liner Sew Assembly = 0.982850

$R_5$ = Reliability of Liner Creaser Assembly = 0.996186

$R_6$ = Reliability of Tube Sew Station = 0.990934

$R_7$ = Reliability of Cut and Stack Station = 0.994279

$R_8$ = Reliability of Body Tube Elévator Assembly = 0.997959

$R_9$ = Reliability of Master Control Station = 0.994360

$R_{system}$ = Reliability of Body and Liner System = 0.951581

$\lambda_{system}$ = 0.00062

$MTBF_{system}$ = 1612.9 hours

Unless otherwise stated in this report, all failure rates for electronic parts are from RADC Notebook Vol 2. When failure rates were not available in the RADC Notebook, and for failure rate of mechanical parts, other reliability publications or appropriate industrial experience were utilized in determining the failure rates.

Figure 4-1 is a mathematical model for the Body and Liner Assembly System. Each block shown on the figure is a major subsystem.

The reliability number for each substation is derived from $R = e^{-\lambda t}$, where $\lambda$ is the summation of the individual

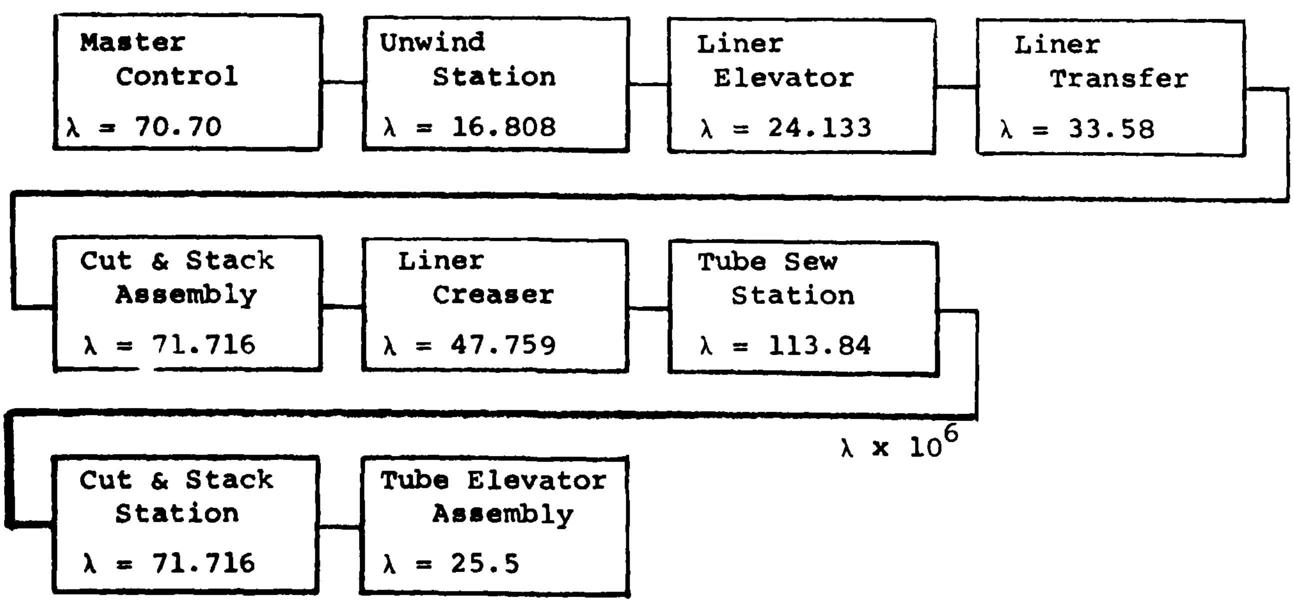



Figure 4-1. Reliability Model for Body and Liner Assembly System

components final failure rate and t is an 80-hour operating time.

### 4.5.2 Reliability Calculations

The quantity and type of components has been estimated as shown in the Reliability Prediction Charts. At all times during final design of the system, reliability enhancement will be considered to be of prime importance.

The MTBF of the system has been calculated as follows:

$$MTBF_{system} = \frac{1}{\lambda_{system}} = \frac{1}{0.00062} = 1612.9 \text{ hours.}$$

## RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Master Control

TEMP: +25 °C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Programmable Controller | 1 | 10.0* | 1 | 10.0 |
| 2 | Power Supply | 1 | 5.0* | 1 | 5.0 |
| 3 | Total Counter | 1 | 4.2 | 1 | 4.2 |
| 4 | Predetermine Counter | 1 | 4.2 | 1 | 4.2 |
| 5 | Switch | 6 | 0.10 | 1 | 0.60 |
| 6 | Lights | 6 | 0.15 | 1 | 0.90 |
| 7 | Relays | 10 | 0.10 | 1 | 1.00 |
| 8 | IC's | 40 | 0.572 | 1 | 22.88 |
| 9 | Resistors | 75 | 0.043 | 1 | 3.22 |
| 10 | Capacitors | 20 | 0.09 | 1 | 1.8 |
| 11 | Transistors | 20 | 0.5 | 1 | 10.0 |
| 12 | Buzzer | 1 | 0.6 | 1 | 0.60 |
| 13 | Circuit Breaker | 1 | 0.3 | 1 | 0.30 |
| 14 | Diodes | 30 | 0.2 | 1 | 6.0 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 70.70 |

*Estimate

# RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System — DATE: 22 June 1979

TITLE: Unwind Station — TEMP: +25°C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Hydraulic Cylinder | 1 | 0.008 | 1 | 0.008 |
| 2 | Ball Bushings | 4 | 1.8 | 1 | 7.20 |
| 3 | Ball Bearings | 2 | 0.875 | 1 | 1.75 |
| 4 | Ball Bearings | 4 | 0.875 | 1 | 3.50 |
| 5 | Ball Bushings | 2 | 1.8 | 1 | 3.60 |
| 6 | Gearhead | 1 | 0.20 | 1 | 0.20 |
| 7 | Electric Motor | 1 | 0.3 | 1 | 0.30 |
| 8 | Dancer Switch | 1 | 0.25 | 1 | 0.25 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 16.808 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Lead Liner Elevator Assembly

TEMP: +25 °C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Ball Nuts | 3 | 1.80 | 1 | 5.40 |
| 2 | Ball Bearings | 6 | 0.875 | 1 | 5.25 |
| 3 | Ball Bushings | 4 | 1.80 | 1 | 7.20 |
| 4 | Miter Gears, Spiral | 4 | 0.05 | 1 | 0.20 |
| 5 | Gearhead | 1 | 0.20 | 1 | 0.20 |
| 6 | Motor | 1 | 0.30 | 1 | 0.30 |
| 7 | Microswitches | 3 | 0.25 | 1 | 0.75 |
| 8 | Manual Load Switch | 1 | 0.063 | 1 | 0.063 |
| 9 | Optical Sensor | 1 | 4.70 | 1 | 4.70 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 24.133 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Liner Transfer Assembly

TEMP: +25°C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Ball Bushings | 6 | 1.80 | 1 | 10.8 |
| 2 | Bearings-BZ | 8 | 0.50 | 1 | 4.0 |
| 3 | Ball Bearings | 6 | 0.875 | 1 | 5.25 |
| 4 | Sprockets | 2 | 0.12 | 1 | 0.24 |
| 5 | Chain | 1 | 0.4 | 1 | 0.40 |
| 6 | Miter Gears | 2 | 0.12 | 1 | 0.24 |
| 7 | Electric Motor | 1 | 0.3 | 1 | 0.30 |
| 8 | Clutch Brake, Magnetic | 1 | 0.6 | 1 | 0.60 |
| 9 | Microswitches | 3 | 0.25 | 1 | 0.75 |
| 10 | Solenoid Valve | 1 | 11.0 | 1 | 11.00 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 33.58 |

## RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Liner Saw Assembly

TEMP: +25 °C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Ball Bearings | 3 | 0.875 | 1 | 2.625 |
| 2 | Coupling | 1 | 0.687 | 1 | 0.687 |
| 3 | Pulleys | 2 | 0.12 | 1 | 0.24 |
| 4 | Clutch Brake, Magnetic | 1 | 0.60 | 1 | 0.60 |
| 5 | Electric Motor | 1 | 0.30 | 1 | 0.30 |
| 6 | Electric Motor | 1 | 0.30 | 1 | 0.30 |
| 7 | Ball Nut | 1 | 1.80 | 1 | 1.80 |
| 8 | Ball Bushings | 4 | 1.80 | 1 | 7.20 |
| 9 | Bearings, Tapered | 2 | 0.50 | 1 | 1.00 |
| 10 | Saw Heads | 2 | 100 | 1 | 200.00 |
| 11 | Pulley Tensioner | 1 | 0.24 | 1 | 0.24 |
| 12 | Microswitches | 5 | 0.25 | 1 | 1.25 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 216.232 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Liner Creaser Assembly

TEMP: +25 °C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Ball Bushings | 8 | 1.80 | 1 | 14.40 |
| 2 | Seals | 16 | 0.30 | 1 | 4.80 |
| 3 | Coupling | 1 | 0.687 | 1 | 0.687 |
| 4 | Stepper Motor | 1 | 0.37 | 1 | 0.37 |
| 5 | Rollers (Fife) | 2 | 1.75 | 1 | 3.50 |
| 6 | Air Cylinder | 1 | 0.004 | 1 | 0.004 |
| 7 | Hydraulic Cylinder | 1 | 0.008 | 1 | 0.008 |
| 8 | Ball Bushing | 2 | 1.80 | 1 | 3.60 |
| 9 | Optical Sensors | 2 | 4.70 | 1 | 9.40 |
| 10 | Solenoid Valve | 1 | 11.00 | 1 | 11.00 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 47.759 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Tube Sew Station

TEMP: +25°C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Gear Box | 1 | 0.20 | | 0.20 |
| 2 | Sew Machine | 1 | 100.0 | | 100.00 |
| 3 | Pulleys | 2 | 0.12 | | 0.24 |
| 4 | Ball Bearings | 4 | 0.875 | | 3.50 |
| 5 | Optical Sensor | 2 | 4.70 | | 9.40 |
| 6 | Microswitches | 2 | 0.25 | | 0.50 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 113.84 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Body Tube Elevator Assembly

TEMP: +25°C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Ball Bushings | 4 | 1.80 | 1 | 7.20 |
| 2 | Ball Nuts | 2 | 1.80 | 1 | 3.60 |
| 3 | Miter Gears, Spiral | 4 | 0.12 | 1 | 0.48 |
| 4 | Ball Bearings | 8 | 0.875 | 1 | 7.00 |
| 5 | Gearhead | 1 | 0.20 | 1 | 0.20 |
| 6 | Electric Motor | 1 | 0.30 | 1 | 0.30 |
| 7 | Clutch Brake, Magnetic | 1 | 0.60 | 1 | 0.60 |
| 8 | Sprockets | 2 | 0.12 | 1 | 0.24 |
| 9 | Chain | 1 | 0.40 | 1 | 0.40 |
| 10 | Microswitches | 3 | 0.25 | 1 | 0.75 |
| 11 | Optical Sensor | 1 | 4.70 | 1 | 4.70 |
| 12 | Manual Switch | 1 | 0.063 | 1 | 0.063 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 25.533 |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Cut and Stack Station

TEMP: +25 °C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 1 | Sensor Indicators, Proximity | 2 | 4.70 | 1 | 9.40 |
| 2 | Ball Nuts | 2 | 1.80 | 1 | 3.60 |
| 3 | Ball Bearings | 3 | 0.875 | 1 | 2.625 |
| 4 | Spur Gears | 2 | 2.175 | 1 | 4.35 |
| 5 | Pulleys | 2 | 0.12 | 1 | 0.24 |
| 6 | Ball Bushings | 8 | 1.80 | 1 | 14.40 |
| 7 | Sprockets | 2 | 0.12 | 1 | 0.24 |
| 8 | Magnetic Clutch | 1 | 0.60 | 1 | 0.60 |
| 9 | Electric Motor | 1 | 0.30 | 1 | 0.30 |
| 10 | Air Cylinder | 1 | 0.004 | 1 | 0.004 |
| 11 | Eye Scanner | 1 | 4.70 | 1 | 4.70 |
| 12 | Chain | 1 | 0.40 | 1 | 0.40 |
| 13 | Microswitch | 1 | 0.25 | 1 | 0.25 |
| 14 | Optical Sensor | 1 | 4.70 | 1 | 4.70 |
| 15 | Predetermined Count Switch | 1 | 4.20 | 1 | 4.20 |
| 16 | Solenoid | 1 | 11.00 | 1 | 11.00 |
| | | | | | |
| | | | | | |

RELIABILITY PREDICTION

PROJECT: Body and Liner Assy System

DATE: 22 June 1979

TITLE: Cut and Stack Station

TEMP: +25°C

K FACTOR CLASS: Lab

| Item No. | Description | Qty | Basic F.R. x $10^6$ | K Factor | Final F.R. x $10^6$ |
|---|---|---|---|---|---|
| 17 | Ball Bearings | 2 | 0.875 | 1 | 1.75 |
| 18 | Bushings | 4 | 0.875 | 1 | 3.50 |
| 19 | Pulley | 1 | 0.12 | 1 | 0.12 |
| 20 | Spur Gears | 2 | 2.175 | 1 | 4.35 |
| 21 | Coupling | 1 | 0.687 | 1 | 0.687 |
| 22 | Electric Motor | 1 | 0.30 | 1 | 0.30 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | 71.716 |

## 4.6 Parts Requirements

The following list of commercially available subassemblies and components is based on the existing design as submitted.

Final selection of actual suppliers of standard components will be subject to delivery and pricing terms existing at the time purchases are made.

Any system or component improvement which, in the opinion of Novatronics Inc., enhances performance, reliability or appearance, may necessitate certain substitutions at the time of fabrication. All changes will be reflected in the final parts list following completion of the system.

A bill of material for the following assemblies is included in this section:

- Unwind Station
- Liner Elevator Assembly
- Liner Transfer Assembly
- Liner Sew Assembly
- Liner Creaser Assembly
- Tube Sew Station
- Cut and Stack Station
- Body Tube Elevator Assembly

BILL OF MATERIAL

TITLE: Unwind Station

DWG. NO. 9331501

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| B6910-4H | Pillow Block, 3/4 bore | Boston Gear Co. | 2 |
| None | 60 Case Rod, 3/4 O.D. | Thomson Industries | 1 |
| 1030D S | Ball Bearings, 3/4 bore | Boston Gear Co. | 4 |
| B122026 | Ball Bushings, 3/4 bore | Thomson Industries | 2 |
| 42A5BH-E3 | Gear Motor, 60:1, 42rpm, 115V, 60Hz | Bodine Electric | 1 |
| KHM4-9 | Shifta-Roll Stand | Fife Corporation | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## BILL OF MATERIAL

TITLE: Linear Elevator Assembly    DWG. NO. 9831503

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| None | No. 60 Case Rod, 0.625 dia. | Thomson Industries | 2 |
| R-0505 | Ball Screw, 0.625 dia | Warner Electric | 1 |
| R-0505 | Ball Nut, 0.625 I.D. | Warner Electric | 1 |
| 1621-DS | Ball Bearing, 1/2 bore | Boston Gear | 6 |
| R-0702 | Ball Screw, 3/4 dia., 0.500 lead | Warner Electric | 2 |
| R-0702 | Ball Nut, 3/4 I.D., 0.500 lead | Warner Electric | 2 |
| HL8K131Y | Spiral Miter Gear, 0.625 bore | Boston Gear | 4 |
| None | No. 60 Case Rod, 1.125 dia. | Thomson Industries | 1 |
| B101824 | Ball Bushing, 0.625 I.D. | Thomson Industries | 2 |
| None | No. 60 Case Rod, 1.00 dia. | Thomson Industries | 4 |
| SR20 | Shaft Support Rail | Thomson Industries | 1 |
| 42A5BE-E3 | Gear Motor, 40:1, 62rpm, 115V, 60Hz | Bodine Electric | 1 |
| PCB-260 | Clutch Brake, 0.75 input, 0.50 output | Electroid Corp. | 1 |
| NSU12-1 | Sprocket, 0.500 bore | Boston Gear | 2 |
| CL-2-HK-2 | Hand Knob | Carr Lane | 1 |
| No. 41 | Roller Chain | Boston Gear | 1 |
| | | | |
| | | | |
| | | | |

**BILL OF MATERIAL**

TITLE: Linear Transfer Assembly

DWG. NO. 9331904

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| B61014 | Ball Bushing, 0.375 bore, 0.625 O.D. | Thomson Industries | 4 |
| B610-10 | Bronze Bearing, 0.375 I.D., 0.625 O.D. | Boston Gear | 8 |
| BF-040-50 | Air Cylinder, 1.0 stroke | Bimba | 2 |
| L114Y | Miter Gear, 0.50 bore | Boston Gear | 1 |
| L114Y | Miter Gear, 0.625 bore | Boston Gear | 1 |
| 1621DS | Ball Bearing, 0.500 bore | Boston Gear | 4 |
| 1630DS | Ball Bearing, 0.750 bore | Boston Gear | 1 |
| 42R5BF | Motor, 2500 rpm, 1/4HP, 115, 60 Hz, 1Ø | Bodine Electric | 1 |
| BCB-360 | Clutch Brake | Electroid Corp. | 1 |
| 1623 | Ball Bearing, 0.625 bore | Boston Gear | 1 |
| KSB25-2 | Sprocket, 0.500 bore | Boston Gear | 1 |
| KSB25-2 | Sprocket, 0.375 bore | Boston Gear | 1 |
| B203242 | Ball Bushing, 1.250 I.D. | Thomson Industries | 2 |
| PBO-20-OPN | Pillow Block, 2.000 O.D., open | Thomson Industries | 2 |
| No. 41 | Roller Chain | Boston Gear | 1 |
| | | | |
| | | | |
| | | | |
| | | | |

# BILL OF MATERIAL

TITLE: [illegible] Assembly

DWG. NO. [illegible]

| Part Number | Description | Manufacturer | Qty |
| --- | --- | --- | --- |
| FB25606 | Ball Bearing, 3/4 bore | Federal | 1 |
| L100 | Coupling, 5/8 bore | Lovejoy | 2 |
| 36L050 | Pulley, 3/4 bore | Maurey | 2 |
| [illegible]-420-10 | Clutch Brake | Electroid Corp. | 1 |
| 56 Frame | Electric Motor, 1 HP, DC-36V, 1750rpm | Ohio Electric | 1 |
| [illegible] | Motor, 1 HP, 2500rpm | Teledyne Variostep | 1 |
| R1002 | Ball Screw Nut, 1.00 I.D., 0.500P | Warner Electric | 1 |
| R1002 | Ball Screw, 1.00 dia., 0.500P | Warner Electric | 1 |
| 243B48 | Ball Bushing, 1.00 bore | Thomson Industries | 4 |
| 4A Cone | Tapered Bearing, 5 Series, 3/4 bore | The Timken Company | 2 |
| 6GE Cup | Tapered Bearing, 5 Series, 3/4 bore | The Timken Company | 2 |
| 2FTD | Belt Tensioner | Maurey | 1 |
| 24L050 | Pulley Idler, 1-1/8 bore, type MIF | Maurey | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# BILL OF MATERIAL

TITLE: [illegible] Assembly DWG. NO. 9331506

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| B203242 | Ball Bushing, 1.250 I.D. | Thomson Industries | 8 |
| S1250 | Oil Seal, 1.250 I.D. | Thomson Industries | 16 |
| NLA | Shifter Stand (Kamberoller) | Fife Corporation | 1 |
| AL-095 | Coupling, 0.750 bore | Lovejoy | 1 |
| 4288 | Stepper Motor | Sigma | 1 |
| None | Roller, 3.00 dia., rubber | Fife Corporation | 1 |
| Model SP3 | Sensor | Fife Corporation | 1 |
| BF-171-D | Air Cylinder, 1.50 dia., 1.00 stroke | Bimba | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

BILL OF MATERIAL

TITLE: Tube Saw Station

DWG. NO. [illegible]

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| None | Rubber Roller, 3.00 dia., 18.5 lg, 1/2 shaft | Fife Corporation | 2 |
| None | Rubber Roller, 3.00 dia., 15.75 lg, 1/2 shaft | Fife Corporation | 2 |
| ZL | Zero Max. Variable Speed Puller | Reliable Attachment | 1 |
| Class 212 | Sew Machine, 3/4 HP motor, full gear | Singer Company | 1 |
| M1215-16 | Bronze Bearings, 1/2 bore | Boston Gear | 2 |
| None | Rubber Roller, 3.00 dia., 3/4 shaft | Fife Corporation | 2 |
| 3030DS | Ball Bearings, 3/4 I.D. | Boston Gear | 4 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## BILL OF MATERIAL

TITLE: Cut and Stack Station  DWG. NO. 9131508

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| None | Induction Proximity Switch | Bechner Electronics | 2 |
| NBA25-1 | Sprocket, 1/2 bore | Boston Gear | 1 |
| No. 250 size | Clutch | Warner Electric | 1 |
| NBA36-1 | Sprocket, 1/2 bore | Boston Gear | 1 |
| 42A5BE | Motor, 1/4 HP, 2500rpm, 115V, 60Hz | Bodine Electric | 1 |
| None | No. 60 Case Rod, 0.750 dia. | Thomson Industries | 6 |
| R-0702 | Ball Screw Nut, 0.75 I.D. | Warner Electric | 1 |
| R-0702 | Ball Screw, 0.75 dia. | Warner Electric | 1 |
| 090.5D | Air Cylinder, 1.0 stroke | Bimba | 1 |
| KBA25-1 | Ball Bearing, 1/2 bore | Boston Gear | 3 |
| 2208 | Pulley, 1/2 bore | Maurey | 2 |
| 122026 | Ball Bushing, 0.750 I.D. | Thomson Industries | 8 |
| MCS143 | Scanner | Warner Electric | 2 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# BILL OF MATERIAL

TITLE: Body Tube Elevator Assembly DWG. NO. 9831511

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| None | No. 60 Case Rod, 0.750 dia. | Thomson Industries | 4 |
| B122026 | Ball Bushing, 0.750 I.D. | Thomson Industries | 4 |
| R-0702 | Ball Screw, 0.750 O.D., 0.500 P | Warner Electric | 2 |
| R-0702 | Ball Screw Nut, 0.750 I.D., 0.500 P | Warner Electric | 2 |
| HSLK1214 | Miter Gear, 1/2 bore, spiral | Boston Gear | 4 |
| 1630 | Ball Bearing, 0.625 bore | Boston Gear | 8 |
| 42R5BE-E3 | Gear Motor, 40:1, 62rpm, 115V, 60Hz | Bodine Electric | 1 |
| BCB-260 | Clutch Brake | Electroid Corp. | 1 |
| NBSA16-1 | Sprocket, 0.625 bore | Boston Gear | 2 |
| No. 35 | Roller Chain | Boston Gear | 1 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## 4.7 Economic Considerations

The Body and Liner Assembly System will operate 120 hours per week with an efficiency of greater than 70%. However, as required for this study, we used 70%. The 30% downtime includes operator breakdown, material replenishment, unexpected machine downtime (e.g., thread breaks, repairs, etc.), bag size change over, etc. The 30% downtime does not include bobbin change time since this is considered to be part of the normal operation during the 70% uptime.

Using the 70% efficiency factor, the available hours of actual machine operation (machine uptime) per year is:

$$\text{Machine uptime} = 0.70 \times 8 \frac{\text{hours}}{\text{shift}} \times 3 \frac{\text{shifts}}{\text{day}} \times 5 \frac{\text{days}}{\text{week}} \times 48 \frac{\text{wk}}{\text{yr}}$$

$$\text{Machine uptime} = 4032 \text{ hours/year}$$

Since 60 percent of production is dedicated to producing the 155mm bag assemblies and the remaining 40 percent is dedicated to 8-inch bag assembly production, the following equations were used to find the system output for each bag size:

(No. of 155mm bags)= (1.5) (no. of 8-inch bags)

(Avg. rate of 155mm bags) (4032 -X)= (1.5) (avg. rate of 8-inch bags) (X) where:

X = total hours spent producing 8-inch bags.

Therefore:

Avg. rate of 155mm bags =

$$\frac{(\text{rate of M119}) \left[(4032-X) - Y\right] + (\text{rate of M203}) \quad (Y)}{(4032 - X)}, \text{ and}$$

Avg. rate of 8-inch bags =

$$\frac{(\text{rate of M188}) \ (Z) + (\text{rate of Incrmt. 9}) \ (X - Z)}{X}$$

where:

Y = total hours spent producing 155mm, M203 bags

Z = total hours spent producing 8-inch, M188 bags

No. of 155mm, M119 bags = No. of 155mm, M203 bags

Rate of M119 ((4032 -X) -Y) = Rate of M203 (Y)

also:

No. of 8-inch, M188 bags = No. of 8-inch, Incrmt. 9 bags

Rate of M188 (Z) = Rate of Incrmt. 9 (X - Z).

Using the system output as shown in Table 4-4, it can be seen that this system can produce 738,536 of the 8-inch body and liner assemblies and 1,107,844 of the 155mm body and liner assemblies per year. To meet the total yearly requirements as described in Section 3.0 of this report, it will take 1.7 of these systems (refer to Table 4-5). These systems will produce 3,692,760 body and liner assemblies per year when operated at 70% efficiency, three shifts per day.

Drastic improvements in the output of this system could be made if downtime associated with bobbin changes could be eliminated. This could possibly be accomplished by the use of chain stitch machines. Using the system output for chain stitching as shown in Table 4-4, it can be seen that this system can produce 958,515 of the 8-inch body and liner assemblies and 1,437,800 of the 155mm body and liner assemblies per year. Using chain stitching, it will take 1.3 systems to meet the total yearly requirements as described in Section 3.0 of this report on a three shift basis.

A summary of savings and costs relative to the use of one Body and Liner Assembly System can be found in Table 4-4. As can be seen, both the lock stitch and the chain stitch systems show very good returns on investment; however, the chain stitch system, based on one system, shows the higher ROI because of its higher output capabilities.

It is estimated that the total development cost for the Body and Liner Assembly System, either lock stitch or chain stitch, will be $160,000.

A summary of savings and costs relative to the use of the Body and Liner Assembly Systems to meet the total production requirements of 3,110,800 body and liner assemblies per year can be found in Table 4-5. It can be seen from the table that there is virtually no savings in terms of ROI between chain stitch and lock stitch when considering the total production requirements.

Table 4-4. Summary of Savings and Costs for One Body an

| Type | Yearly Output/Sys. | | Direct Cost to Operate per Year | Direct Cost/Yr. for Handling to Produce Same Quantity | Savings Over Hand- line (Yr.) |
|---|---|---|---|---|---|
| | 155mm | 8 inch | | | |
| Body and Liner Assy. System (Lock stitch) | 1,107,844 | 738,536 | $77,890 | $544,911 | $467,021 |
| Body and Liner Assy. System (Chain stitch) | 1,437,800 | 958,515 | $77,890 | $706,160 | $628,270 |

Table 4-5. Summary of Savings and Costs for Body and Liner Assembly Sy

| Type | Yearly Output Requirements | | Number Systems Required | Direct Cost to Operate per Year | Direct Cost for Handling | Yearly Savings Over Handline | Number Operat |
|---|---|---|---|---|---|---|---|
| | 155mm | 8 inch | | | | | |
| Body and Liner Assy. System (Lock stitch) | 1,866,240 | 1,244,160 | 1.7 | $132,413 | $917,452 | $785,039 | 10.[illegible] |
| Body and Liner Assy. System (Chain Stitch) | 1,866,240 | 1,244,160 | 1.3 | $101,257 | $917,452 | $816,195 | 7.[illegible] |

ary of Savings and Costs for One Body and Liner Assembly System

| ct Cost perate Year | Direct Cost/Yr. for Handling to Produce Same Quantity | Savings Over Hand- line (Yr.) | No. of Operators | No. of Handline Operators for Same Quantity | Estimated Equipment Cost Installed | % ROI Based on Installed Cost |
|---|---|---|---|---|---|---|
| 7,890 | $544,911 | $467,021 | 6 | 39.2 | $160,000 | 170% |
| 7,890 | $706,160 | $628,270 | 6 | 50.8 | $165,000 | 220% |

nd Costs for Body and Liner Assembly Systems to Handle Total Production Requirements

| d | Direct Cost to Operate per Year | Direct Cost for Handling | Yearly Savings Over Handline | Number of Operators | Number of Handline Operators | Estimated Equipment Cost Installed | %ROI Based on Installed Cost | % ROI Based on Installed Cost and Developme Cost |
|---|---|---|---|---|---|---|---|---|
| | $132,413 | $917,452 | $785,039 | 10.2 | 66 | 320,000 | 144% | 98% |
| | $101,257 | $917,452 | $816,195 | 7.8 | 66 | 330,000 | 145% | 99% |

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

A detailed and theoretical design analysis of the Body and Liner Assembly System has been presented in this report. The Novatronics concept of a machine to automate a presently manual production line has been successfully tested by jury rig methods and the feasibility of this concept is assured.

The jury rig systems proved that the Novatronics approach to axially align and concentrically load body and liner assemblies over end assemblies can be achieved. However, since the concept of the 3-D jury rig did not prove to be attainable and therefore should remain a manual operation, the Body Assembly System only gives a 9% return-on-investment and is not recommended for implementation.

The web handling techniques for the Body and Liner Assembly System were also proven feasible by jury rig methods and conversion to an automated operation employing this equipment will provide an impressive 98% return-on-investment.

The results of the Novatronics analysis of alternative methods for automating production show that based on an efficiency factor of 70% and operating the equipment on a three-shift-per-day basis, one system can produce 1,846,380 body and liner assemblies per year. (553,922 155mm body and liner assemblies and 369,268 8-inch body and liner assemblies). At these output rates, only two systems are required to meet total I.A.A.P. production requirements.

The total cost for two systems, including the nonrecurring engineering and installation, is estimated to be $480,000.

Based on current labor and material rates, these two systems will save I.A.A.P. more than $785,000 annually over the present manual production methods.

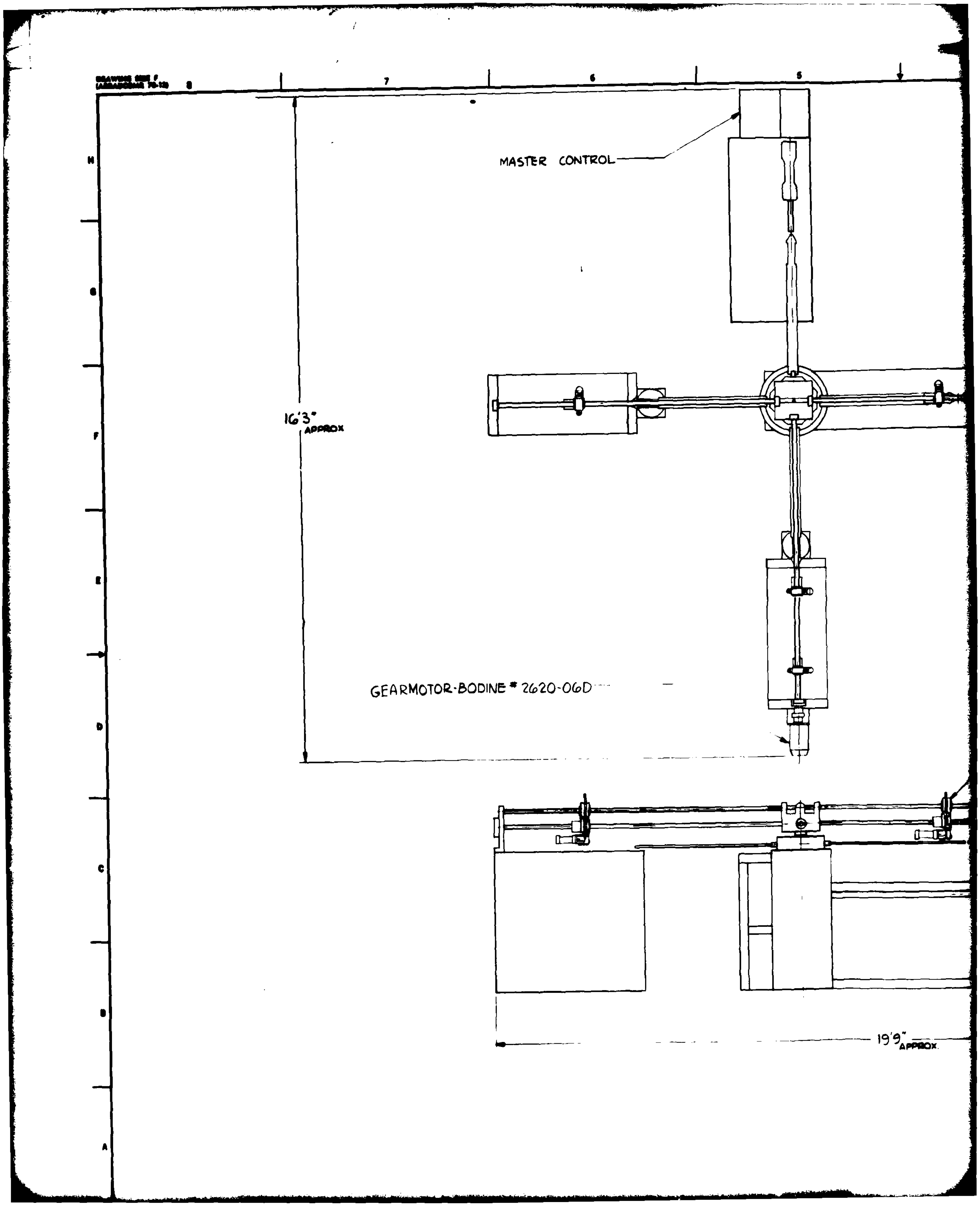
# APPENDIX

BODY ASSEMBLY SYSTEM DESCRIPTION

## A.1 Body Assembly System Operation

The Body Assembly System (see Figure A-1) consists of two rotary indexing heads with four arms on each, placed at 90 degree increments and driven by the same drive. The kidney and the tubes are located in separate elevators which move up one increment as the top piece is picked up. The arm at the kidney elevator picks up the kidney by means of a pick-up head moving on a ball screw nut and a ball screw rod. A solid bar with a ball bushing is used to keep the pick-up head stable. The pick-up device is a clincher type. It forces a bit of cloth between a serrated wheel and a spring loaded angle clamp. The kidney is picked up, opened and is easily placed over the arm by means of the pickup. While this is being accomplished at this station, the next elevator has advanced upward and the body tube is ready for placement on the arm which is now 90 degrees from the first arm. The kidney is already on the arm, being placed on the arm as described above.

At this station, the tube is picked up by two pick-up heads, one at the front and one at the back of the tube. See Figure A-2. The pickup then lifts causing the tube to open and, as the pickups move forward simultaneously, the tube is placed over the kidney on the arm. The arms at this point are riding on a cam which keeps them stable and flat. When the arm rotates 90 degrees to the sewing machine station,


DRAWING SIZE F
MASTER CONTROL
16'3" APPROX
GEARMOTOR-BODINE # 2620-06D
19'9" APPROX

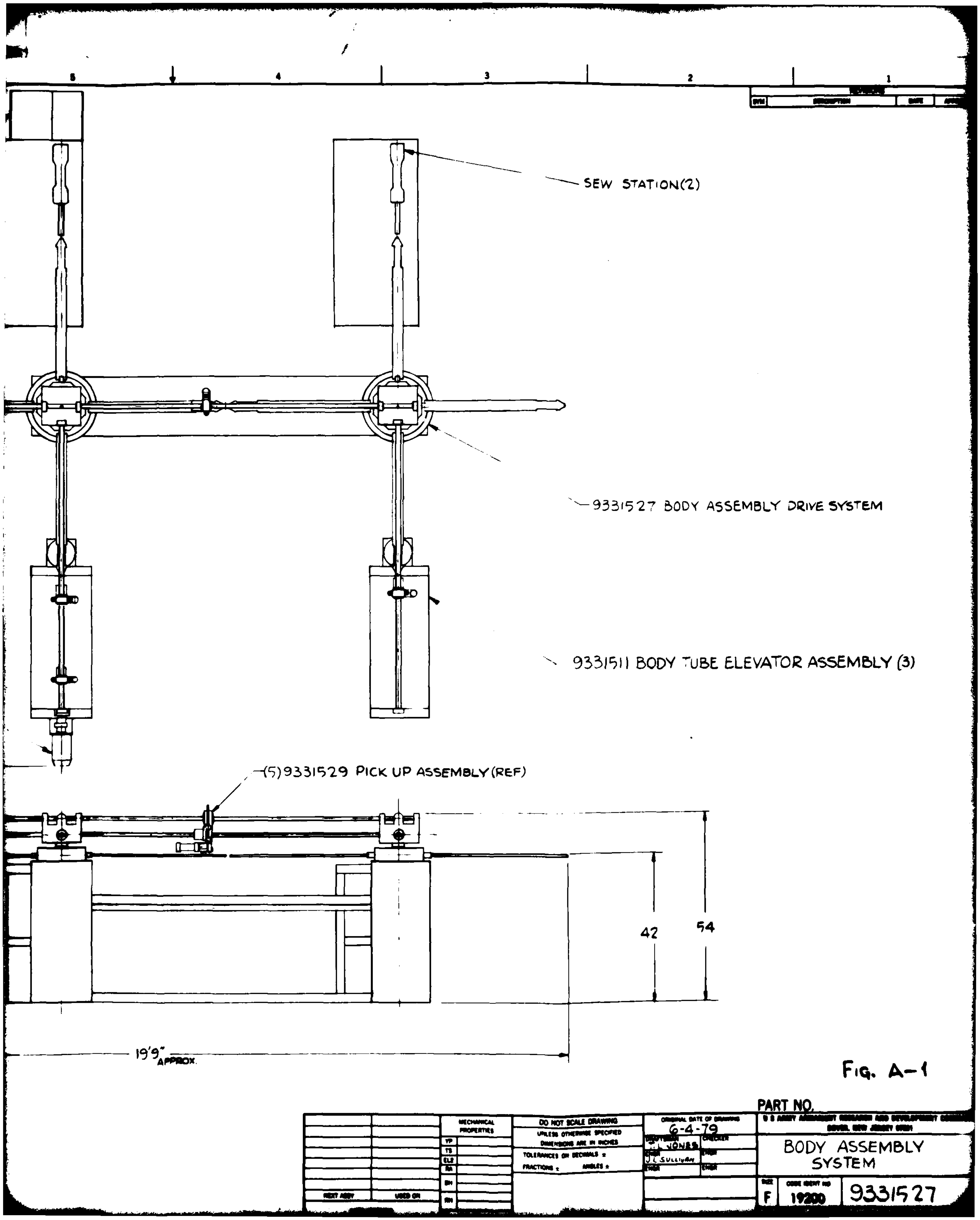
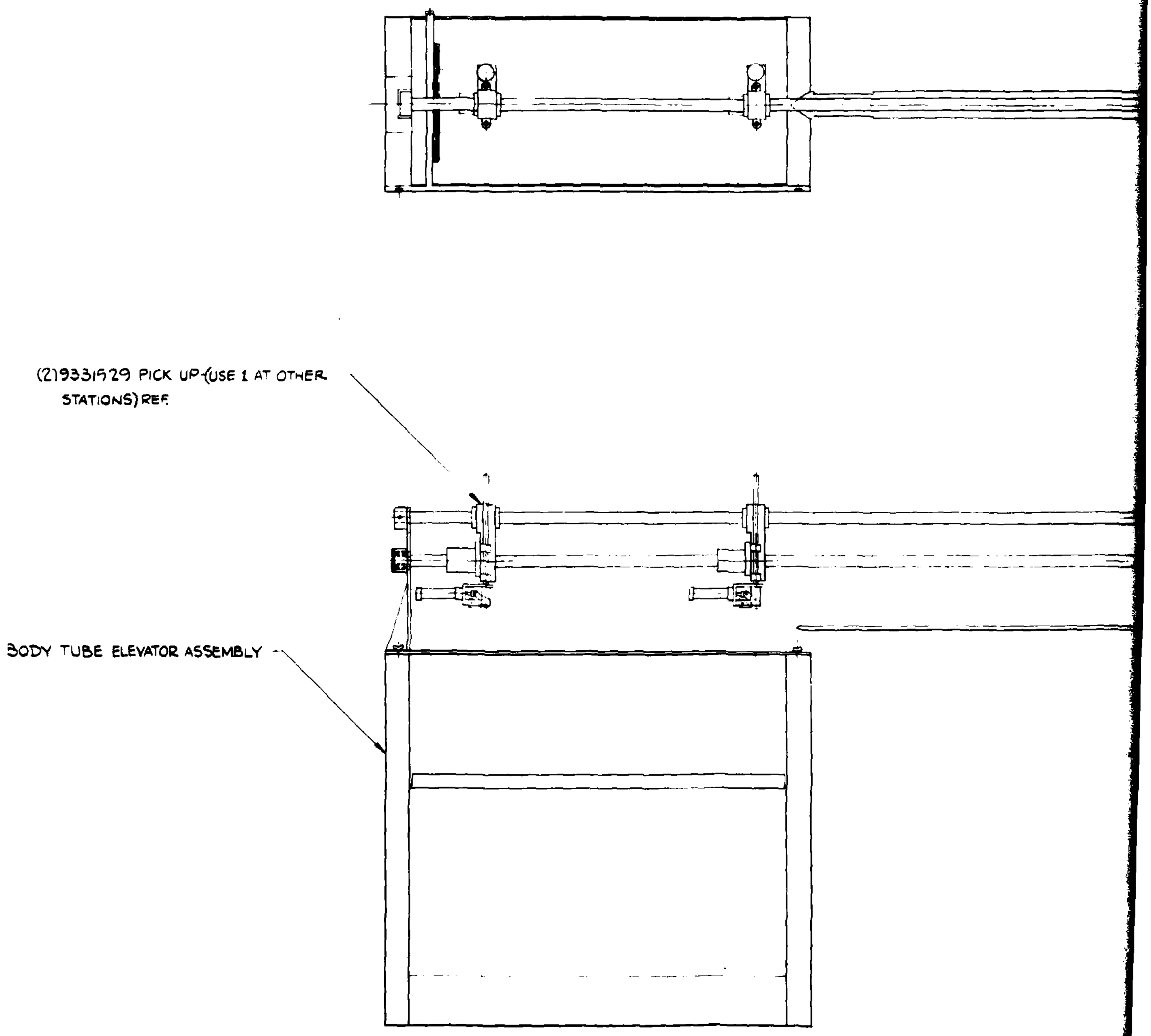

5
4
3
2
1
SEW STATION(2)
9331527 BODY ASSEMBLY DRIVE SYSTEM
9331511 BODY TUBE ELEVATOR ASSEMBLY (3)
(5)9331529 PICK UP ASSEMBLY (REF)
42
54
19'9" APPROX
PART NO.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
MECHANICAL PROPERTIES
NEXT ASSY
USED ON
6-4-79
J L JONES
J L SULLIVAN
BODY ASSEMBLY
SYSTEM
F
19200
9331527

FIG. A-1


(2)9331529 PICK UP-(USE 1 AT OTHER STATIONS) REF.
BODY TUBE ELEVATOR ASSEMBLY

REVISIONS

| SYM | DESCRIPTION | DATE |
|---|---|---|

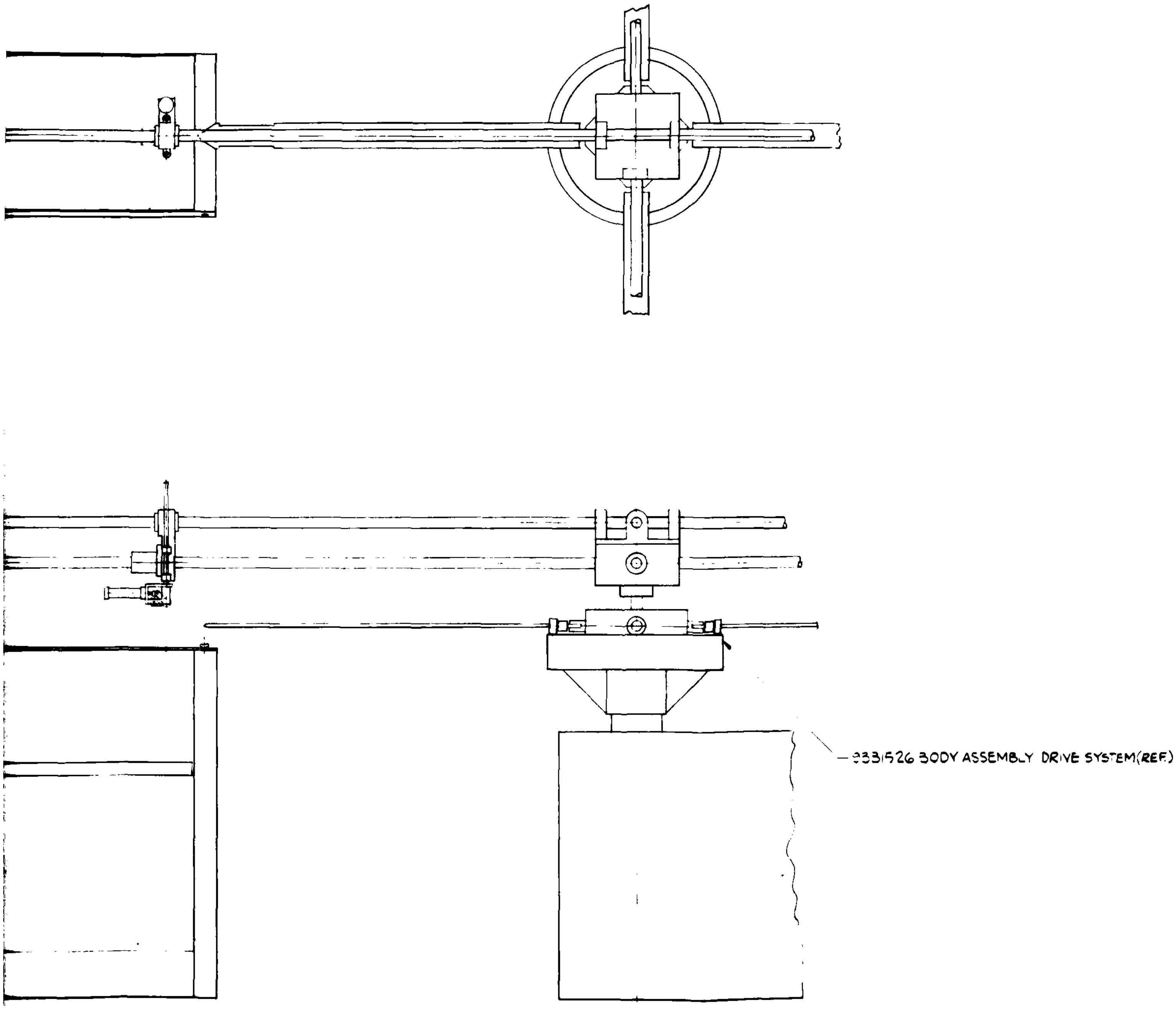



FIG. A-2

PART NO.

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS
FRACTIONS ± ANGLES ±

MECHANICAL PROPERTIES

ORIGINAL DATE OF DRAWING 6-6-79

DRAFTSMAN T. JONES

ENGR J. C. SULLIVAN

CHECKER

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

TUBE PICK-UP- BODY ASSEMBLY SYSTEM

CODE IDENT NO

9331524

the arm is released to turn about its own axis because there is no cam track at this point. At this station, the end of the tube is sewn in place by hand. The tube can be pulled partially off the arm with the kidney inside and rotated by the operator to conform to the speed of the sewing machine. After the end of the tube is sewn, the operator causes the rotary head to actuate and move 90 degrees to the Transfer Station. A pickup then grasps the tube and slides it onto the arm of the second rotary indexing head which moves simultaneously with the first rotary index head. Sliding from one arm to the other at the Transfer Station, the open or unsewn end of the tube is now facing outward. At the next 90 degree increment, there is another sewing station and operator to hand sew the other end of the tube closed. The arm is also free to turn at this station, thus simplifying the sewing operation. After the tube is sewn shut at both ends, the rotary index head moves through a 90 degree index. At the next station or 90 degree increment, an elevator stacks the completed bag by means of a pickup. The pickup grasps the bag at the front end and slides it off the arm to a position over the stack in the elevator where the bag is placed on top of the stack. After the elevator stack is filled, the stack of bags is easily removed to allow a new stack to be filled.

## A.2 Index Drive Mechanism

The Body Assembly System drive mechanism is basically two rotary index heads with four arms on each head at 90 degree increments. Both heads are driven by one motor which drives an indexer (Geneva) with four stops per revolution. The first index head is driven directly by the indexer while the second head indexes in the same direction by a miter gear drive from one index head to the other. Above the drive mechanism is the actual index head with four arms at 90 degree increments. Each of these four arms has a crosspiece with two cam followers riding on a flat cam. This keeps the four arms stable, flat and parallel to the floor so that the units to be transferred to the arms can be easily placed. At the sewing station, a segment of the cam falls away allowing the arm to rotate about its own axis by hand for ease of sewing. When the machine rotates, the arm automatically rolls by means of the cam followers until it is parallel to the floor before it reaches the next 90 degree increment. The arm stays level because it is fixed in the rotary index head with two radial bearings spaced well apart.

Above the index head and placed on two bearings so that it will not rotate is the drive for the pickup (see Figure A-3). The pickup consists of a ball screw and a ball nut driven by a motor on the kidney elevator through miter gears. Above this head are solid rods and a ball bushing. The pickup

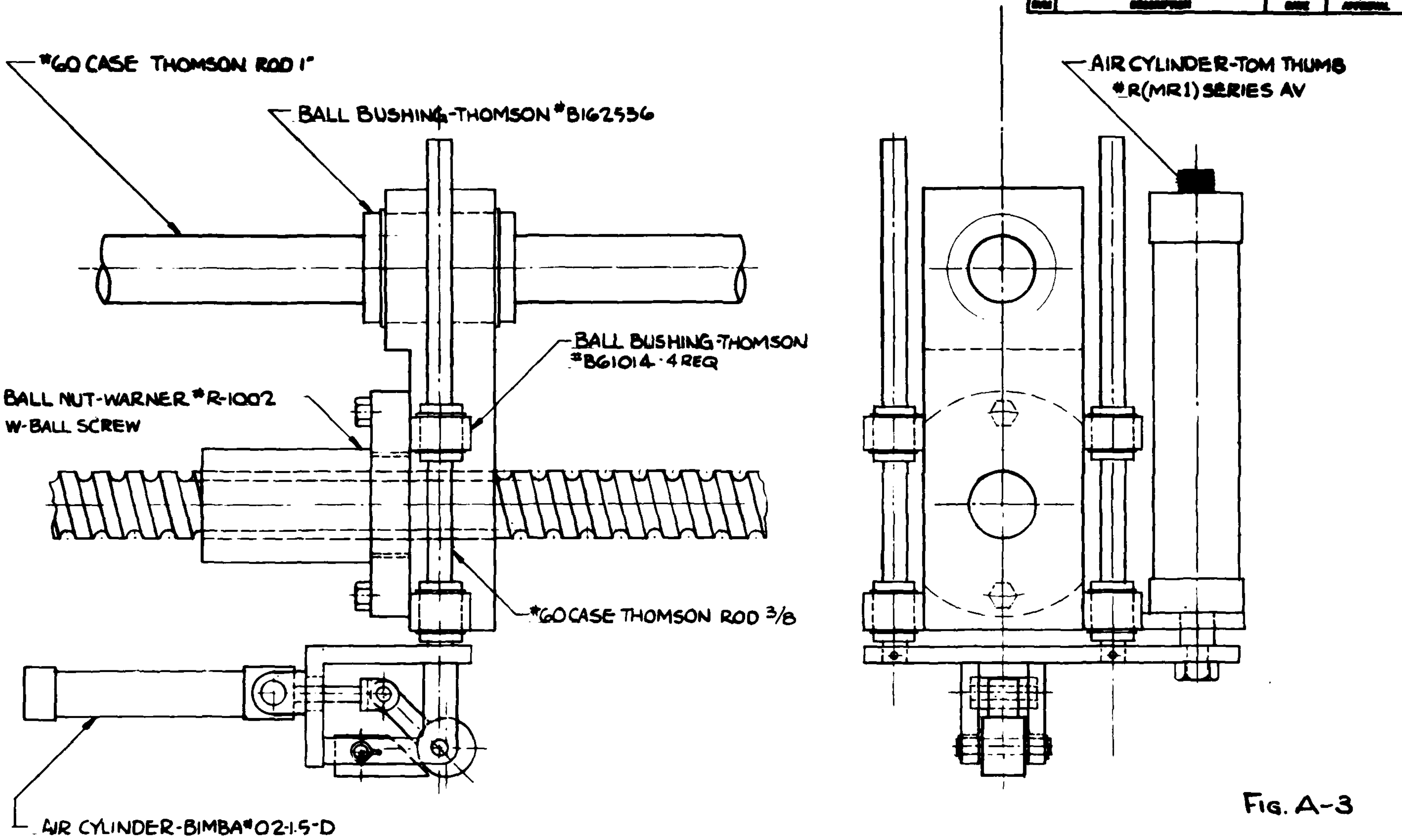



Fig. A-3

PART NO. 5 REQ

U S ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY 07801

PICK-UP- ASSEMBLY

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±

ORIGINAL DATE OF DRAWING 6-5-79
DRAFTSMAN T. L. JONES
ENGR J. L. SULLIVAN

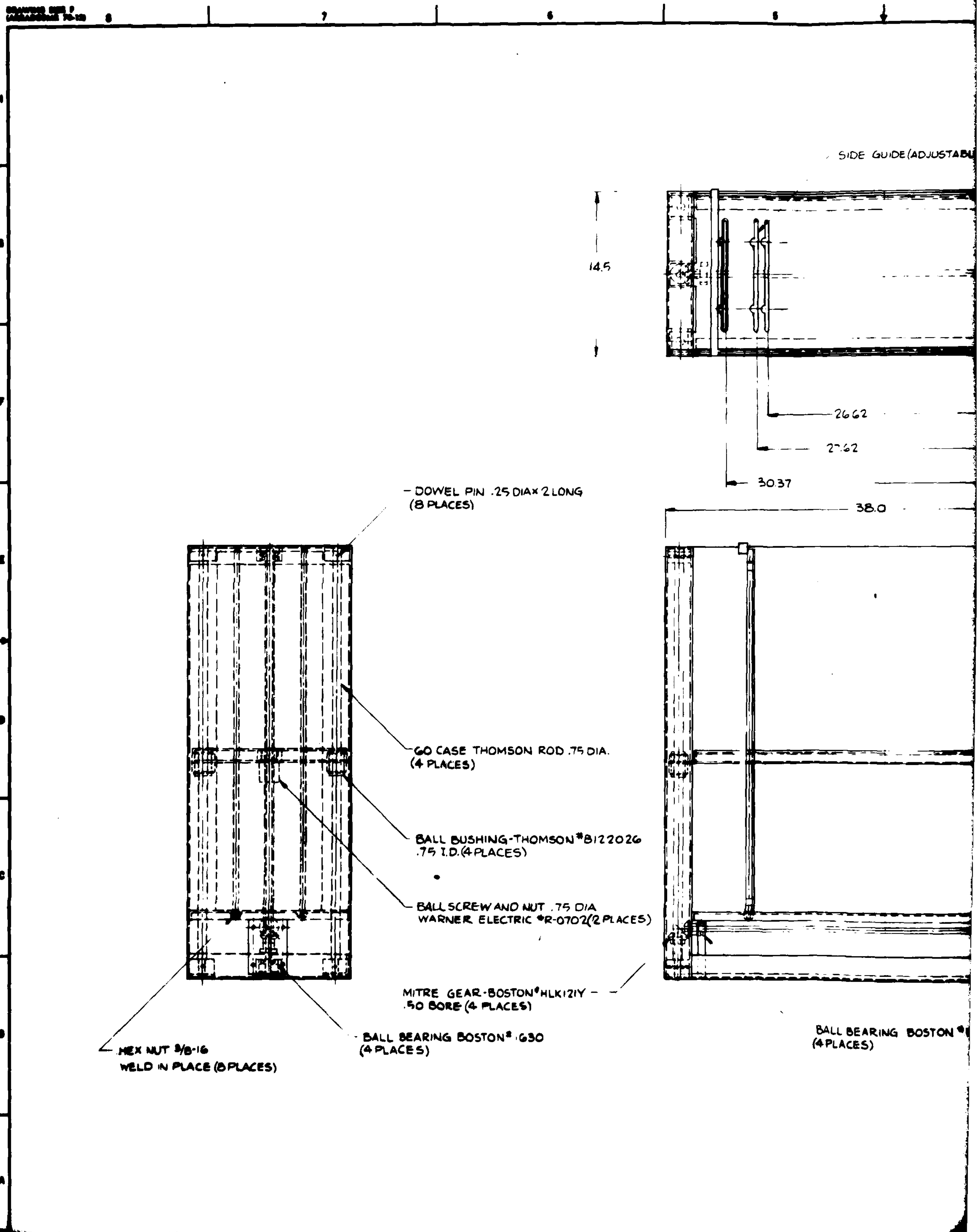
SIZE C | CODE IDENT NO. 19200 | 9331529
SCALE FULL | UNIT WT. | SHEET 1 OF 1

NEXT ASSY | USED ON
APPLICATION

point is below the screw and solid rod. It consists of a serrated roller and a spring loaded wedge. The cloth is forced into the space between them when the wheel rotates. As the ball screw turns, the pickup moves along the screw until it gets to the desired position for picking up the cloth units or releasing them. The pickups on the second rotary index head are driven from the first rotary index head through miter gears and a screw shaft. The second rotary index head is driven from the first by means of a set of miter gears and a shaft between them. The top section of the rotary index head on the second drive is identical to the first head. Thus the entire system can be driven with only two motors; one to drive the index heads and one to drive the pickups.

## A.3 Elevators for Body Assembly System

There are three elevators in the Body Assembly System all very similar in operation and function (see Figure A-4). An electric motor drives two ball screws on each elevator. Two ball nuts located on the moveable elevator platforms drive the platforms up and down. Four round rods are placed at each corner and the platforms have four ball bushings on the posts, one at each corner. This gives the platform stability and causes the platform to raise and lower parallel to the top of the elevator. On the top and at the rear of



SIDE GUIDE (ADJUSTAB
14.5
26.62
27.62
30.37
38.0
DOWEL PIN .25 DIA × 2 LONG (8 PLACES)
GO CASE THOMSON ROD .75 DIA. (4 PLACES)
BALL BUSHING-THOMSON #B122026 .75 I.D. (4 PLACES)
BALL SCREW AND NUT .75 DIA WARNER ELECTRIC #R-0702 (2 PLACES)
MITRE GEAR-BOSTON #HLK121Y .50 BORE (4 PLACES)
BALL BEARING BOSTON # 630 (4 PLACES)
HEX NUT 3/8-16 WELD IN PLACE (8 PLACES)
BALL BEARING BOSTON #
(4 PLACES)

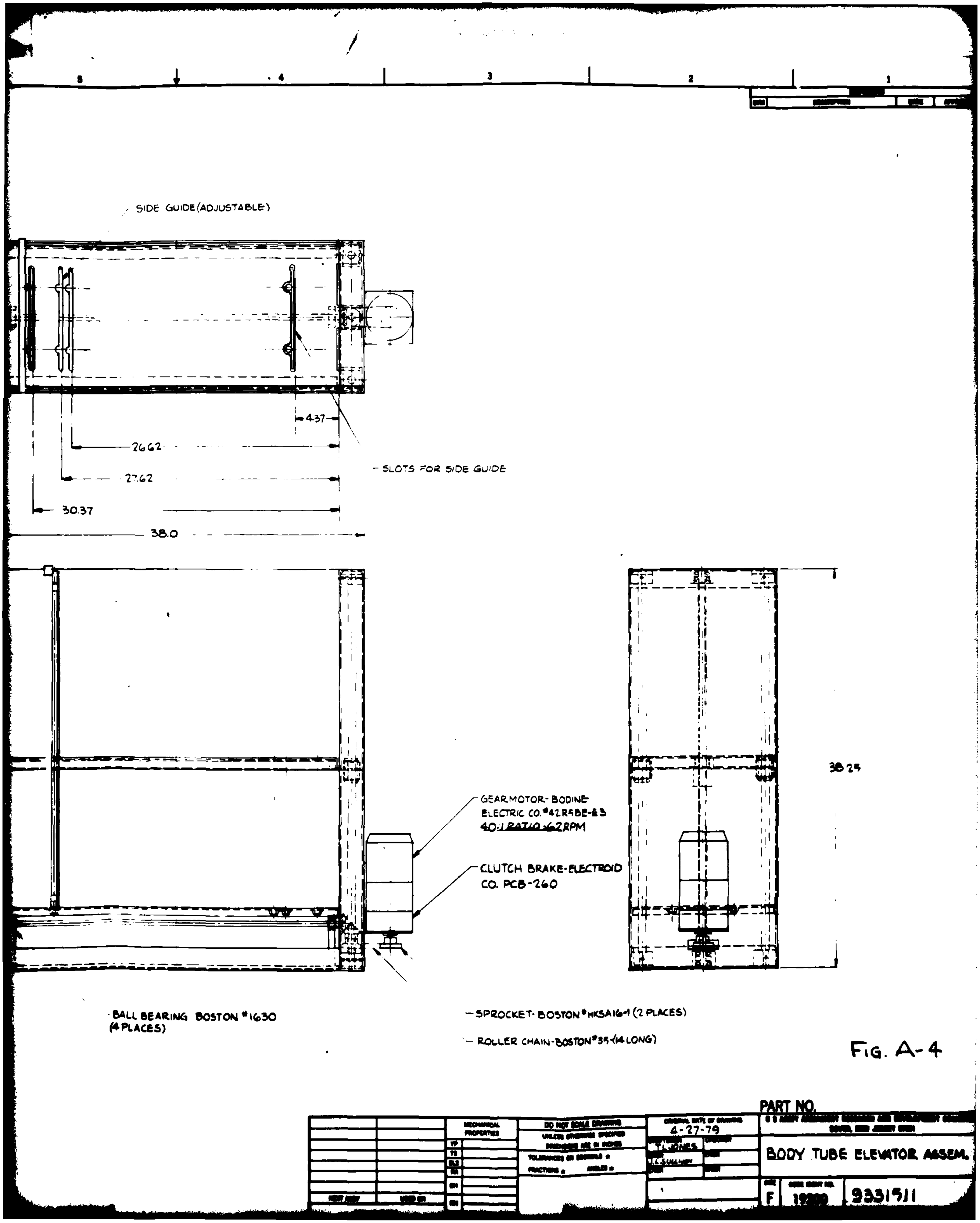

SIDE GUIDE (ADJUSTABLE)
4.37
26.62
27.62
30.37
38.0
SLOTS FOR SIDE GUIDE
GEARMOTOR-BODINE ELECTRIC CO. #42R5BE-E3 40:1 RATIO 62RPM
CLUTCH BRAKE-ELECTROID CO. PCB-260
38.25
BALL BEARING BOSTON #1630 (4 PLACES)
SPROCKET-BOSTON #HKSA16-1 (2 PLACES)
ROLLER CHAIN-BOSTON #35-(14 LONG)
PART NO.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
4-27-79
T.L. JONES
BODY TUBE ELEVATOR ASSEM.
F
19200
9331511

FIG. A-4

the end assembly elevator is a electric motor for driving the ball screws. This motor drives all of the pickup ball screws through the miter gears. The other two elevators have bearings for the ball screws and a fixed joint mounted over the ball screw bearings lending rigidity to the whole structure as well as stabilizing the pickup.

## A.4 Production Rate

The bag output rate of this system is heavily dependent on the End Sewing Station which has the longest cycle time. The End Sew Station timing is shown in Table A-1. The difference in cycle times is caused by the difference in diameters and handling characteristics of the three different bag sizes.

Table A-1. Production Output - Body Assembly System

| Activity | 155mm M119 | 155mm M203 | 8 in M188 |
|---|---|---|---|
| Index Head Rotate | 3.0 | 3.0 | 3.0 |
| Load and Sew | 21.0 | 25.0 | 33.0 |
| Remove | 3.0 | 3.0 | 3.0 |
| Bobbin Change | 1.1 | 1.1 | 1.7 |
| Time Cycle (sec) | 28.1 | 32.1 | 40.7 |
| Pieces/hour | 128.1 | 112.1 | 88.4 |

Table A-1. Production Output - Body Assembly System (continued)

| Activity | 155mm M119 | 155mm M203 | 8 in M188 |
|---|---|---|---|
| Pieces/Shift | 717.4 | 628 | 495.3 |
| Pieces/year | 516,528 | 452,160 | 356,616 |
| Yearly Reqmts. | 933,120 | 933,120 | 622,080 |
| No. of Systems Required | 1.81 | 2.06 | 1.74 |

Table A-2 shows the direct cost per assembly produced by this system compared to the handline.

Table A-2. Cost Comparison

| Activity | 155mm M119 | 155mm M203 | 8 in M188 |
|---|---|---|---|
| Handline Labor Content (sec/piece) | 82.7 | 97.2 | 116* |
| Body System Labor Content (sec/piece) | 56.2 | 64.2 | 81.4 |
| Handline Cost/Assy ($) | .184 | .217 | .259 |
| Body System Cost/Assy ($) | .161 | .184 | .233 |
| Handline Operators per Shift | 4.135 | 4.86 | 3.86 |
| Body System Operators per Shift | 3.62 | 4.12 | 3.48 |

*** The performance rate for the 8 inch M188 is 132.3 seconds per piece. This includes tying straps placement times. The 116 seconds per piece has been adjusted to exclude the tying strap placement time.**

There is a requirement for 6 (5.61) Body Assembly Systems. This would take 33.66 operators per year (11.22 operators/shift) at a cost of $467,900 per year. The handline has 38.5 operators per year (12.85 operator/shift). The Body Assembly System gives a yearly savings of $67,300. This is $11,216 per system per year savings based on the specified production requirements.

It is estimated that the Body Assembly System will cost $60,000 each installed with the total engineering development cost at $110,000. Based on the $60,000 installed cost, this system has a 9% Return on Investment.

Development of the system cannot be justified at this low ROI. Based on the $11,216 savings per year per system, the installed system cost cannot exceed $34,000 in order to show an ROI of 20%. It is therefore recommended that this station not be mechanized at this time but remain a manual assembly station.

## BILL OF MATERIAL

TITLE: Body Assembly System DWG. NO. 9331527

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| 67065-NR1630DS | Ball Bearing, 0.75 Bore | Boston Gear | 18 |
| 67070-NR1641DS | Ball Bearing, 1.00 Bore | Boston Gear | 18 |
| MU30B Cone | Tapered Bearing, 1.180 Bore | Timken Co. | 2 |
| MU30AB Cup | Tapered Bearing, 1.180 Bore | Timken Co. | 2 |
| 4A Cone | Tapered Bearing, 0.750 Bore | Timken Co. | 2 |
| 6 CS Cup | Tapered Bearing, 0.750 Bore | Timken Co. | 2 |
| 48637 | Oil Seal, Bore 1.752, O.D. 1.756W, 7/16 | Victor Oil Seals | 2 |
| R1002 | Ball Screw, 1.0 dia | Warner Electric | 8 |
| NONE | No. 60 Case Rod, 1.0 dia | Thomson Industries | 8 |
| HLSK104YR & L | Spiral Miter Gears, 3/4 Bore and Key | Boston Gear | 8 |
| CCFL - 1 1/8 | Cam Follower, 1 1/8 O.D. Crowned | McGill | 16 |
| 06910-4H | Pillow Block 3/4 I.D. | Boston Gear | 2 |
| HLSK103Y | Miter Gear, Spiral, 3/4 Bore | Boston Gear | 4 |
| FCR-20 | Coupling, 3/4 Bore | Boston Gear | 1 |
| 42R-E4 | Gearmotor 7.1 to 1-115V, 60Hz, 1ϕ | Bodine Electric Co. | 1 |
| E4 | Index Drive, 4 indices | Stelron | 1 |
| R1002 | Ball Screw, 1.00 dia pitch | Warner Electric | 4 |
| 2620-06D | Gearmotor, 300 rpm- 1/50 HP, 115V, 1ϕ, 60HZ | Bodine Electric Co. | 1 |
| | | | |

BILL OF MATERIAL

TITLE: Elevator - 3 ea.

DWG. NO. 9331511

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| NONE | No. 60 Case Rod, 1.00 dia | Thomson Industries | 12 |
| B122026 | Ball Bushing, 1.00 I.D. | Thomson Industries | 12 |
| R7002 | Ball Screw, 0.750 O.D | Warner Electric | 6 |
| R7002 | Ball Nut, 0.750 Bore | Warner Electric | 6 |
| 1630 | Ball Bearing 3/4 Bore | Boston Gear | 24 |
| 42R5BE-E3 | Gearmotor, 40.1 ratio 60 rpm 115V 1ϕ 60 HZ | Bodine Electric Co. | 3 |
| HKSA16-1 | Sprocket, 3/4 Bore, 1 5/8 O.D. ½ W. | Boston Gear | 6 |
| # 35 | Roller Chain | Boston Gear | 3 |
| HSLK1214 | Miter Gear, Spiral, ½ Bore | Boston Gear | 4 |
| PCB 260 | Clutch Brake | Electroide Corp. | 1 |

BILL OF MATERIAL

TITLE: Pick-Up Assembly

DWG. NO. 9331529

| Part Number | Description | Manufacturer | Qty |
|---|---|---|---|
| NONE | No. 60 Case Rod, 1.00 dia | Thomson Industries | 5 |
| B162536 | Ball Bushing, 1.00 I.D. | Thomson Industries | 5 |
| B61014 | Ball Bushing .375 I.D. | Thomson Industries | 20 |
| NONE | No. 60 Case Rod, 0.375 dia | Thomson Industries | 20 |
| R1002 | Ball Screw Nut | Warner Electric | 5 |
| R1002 | Ball Screw | Warner Electric | 5 |
| R-(MRI) | Air Cylinder, Series AV | Tom Thumb | 5 |
| 02-1.5-D | Air Cylinder | Bimba | 5 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

NOVAtronics