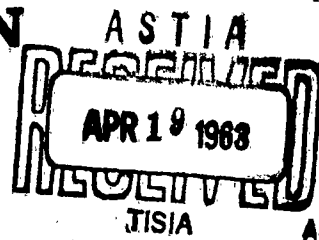


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**RADIO
CORPORATION
OF
AMERICA**



**ELECTRON TUBE DIVISION
HARRISON NEW JERSEY**

THIRD QUARTERLY PROGRESS REPORT
ON
PRODUCTION ENGINEERING MEASURE
FOR
TUBE TYPE 7587

DURING PERIOD OF:
1 DECEMBER 1962 TO 28 FEBRUARY 1963
CONTRACT NO. DA36-039-SC-86732
ORDER NO. 19054-PP-62-81-81

PEM & FACILITIES PROCUREMENT BRANCH
U.S. ARMY SIGNAL SUPPLY AGENCY
PHILADELPHIA 3, PENNSYLVANIA

PRODUCTION ENGINEERING MEASURE

for

TUBE TYPE 7587

THIRD QUARTERLY REPORT

for period of

1 DECEMBER 1962 TO 28 FEBRUARY 1963

OBJECT

To provide critical facilities for high volume, low cost, production of Nuvistor tube types, with special emphasis on tube type 7587, by the development and construction of an automatic grid lathe, exhaust machine, and lead loader.

CONTRACT NO. DA36-039-SC-86732
ORDER NO. 19054-PP-62-81-81

Report Prepared By: W. Ackermann Approved By: E. Rudolph

W. Ackermann

E. Rudolph

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I. ABSTRACT

This third quarterly report contains a detailed account of the effort expended in implementing the design and construction phases of each task. The report indicates the practical design philosophies employed in each equipment and the results of initial machine tests, where applicable. Also included are photographs of completed machine assemblies, both to indicate the specific design features and the degree of construction.

This account shows that the design phase of all tasks is complete and construction is advancing rapidly. The entire fourth quarter period will involve machine construction, with completion of this phase anticipated during the first quarter of the second annual period.

II. PURPOSE

The purpose of this contract is to obtain high volume, low cost manufacturing capability for the Nuvistor tube type 7587 by the creation of several critical equipment facilities. It is an intent of this contract that the subject facilities inherently contain sufficient flexibility to not only service the tetrode line of Nuvistors, but also a broad spectrum of existing triode types and contemplated future types, such as long leaded Nuvistors.

The contract is divided into six phases; namely the development, design, construction, debugging, testing and evaluation of three main tasks:

- (1) An automatic banded truss grid winding and brazing machine.
- (2) An automatic exhaust machine.
- (3) A semi-automatic lead loader.

This effort not only involves the creation and construction of the subject facilities, but a complete in-production evaluation of equipment performance and product quality.

The contract has joint sponsorship, with the development, design and evaluation costs funded by the Army Signal Corps, and the construction costs funded by Radio Corporation of America.

III. NARRATIVE AND DATA

The third three month period of the subject contract involved the completion of the design phases for all tasks, and full scale construction of equipment. The following account is a detailed record of the effort expended during this third quarter, and the results obtained.

A. BANDED TRUSS GRID WINDING MACHINE

The design phase of this task included the layout and piece-parts detailing of the following sub-assemblies:

1. Primary lateral wire winding head.
2. Truss lateral wire winding head.
3. Mandrel roll feed mechanism.
4. Banding cam and platform.
5. Drive and controls.
6. Brazing furnace.
7. Machine frame

Figure 1 shows a schematic illustration of the machine and identifies each of the aforementioned sub-assemblies. In order to illustrate the operational interrelationships of each unit, figure 2 shows a simplified diagram of the system. Items G_1 , G_2 , G_3 and G_4 represent the gear ratios existing between the drive shaft and each mechanism. All gear ratios are variable by means of change gears, except for G_1 , which is fixed. Item "d" represents the diameter of the mandrel drive rolls. Item "R" represents the rise on the banding cam, and angle θ denotes the rise duration in degrees. Each grid parameter will now be defined in terms of the above nomenclature.

The normal primary winding pitch is determined by the value of mandrel advance per revolution of the primary winding head. The mandrel advance is caused by both the roll feed and the cam. Thus,

A. (CONT'D)

the following relationships apply:

$$\text{Pitch due to roll feed} = \pi d \frac{G_1}{G_2} \text{ inches.}$$

$$\text{Pitch due to cam feed} = \frac{360 R G_1}{\theta G_3} \text{ inches.}$$

$$\text{Total pitch} = G_1 \left(\frac{\pi d}{G_2} + \frac{360 R}{\theta G_3} \right) \text{ inches.}$$

$$\text{Number of normal turns per grid} = \frac{\theta G_3}{360 G_1}$$

$$\text{Normal turn length} = \text{Total pitch} \times \text{number of turns.}$$

During banding, the mandrel advance is sponsored by the roll feed and retarded by the cam fall, as shown in the following equations:

$$\text{Pitch due to roll feed} = \pi d \frac{G_1}{G_2} \text{ inches.}$$

$$\text{Pitch due to roll feed} = \frac{360 R G_1}{(360 - \theta) G_3} \text{ inches.}$$

$$\text{Total pitch} = G_1 \left(\frac{\pi d}{G_2} - \frac{360 R}{(360 - \theta) G_3} \right) \text{ inches.}$$

$$\text{Number of band turns per grid} = \frac{G_3}{G_1} \left(1 - \frac{\theta}{360} \right)$$

$$\text{Band length} = \text{Total pitch} \times \text{number of turns.}$$

The truss lateral wire parameter are purely a function of the relationship between the truss head and the roll feed, since the cam weaves both units in unison.

$$\text{Truss wire pitch} = \pi d \frac{G_4}{G_2}$$

$$\text{Number of turns per grid} = \frac{\text{Total Grid Length}}{\text{Truss pitch}}$$

A. (CONT'D)

The above formulae indicate the degree of flexibility inherent in the design of this machine. All the possible parameters of a Nuvistor grid can be varied over a wide range by appropriate changes in gear ratios between each sub-assembly and the drive shaft and various cam geometry. This variability is expedited by the use of standard, commercial change gear transmission, which offer rapid change-over and yet maintain absolute registry. This latter point is extremely important in obtaining perfect repeatability of grid dimensions, and is emphasized by the fact that no slippage is possible in any of the gear trains. In addition, the cam normally will contain a uniform rise geometry to produce a constant pitch winding, however, a variable rise cam can be used to generate a variable pitch grid, should the need ever arise.

In terms of the construction phase of this task, figures 3-7 contain photographs of completed assemblies. Figure 3 illustrates the mandrel feed hopper, which stores and delivers mandrels automatically as required. Figure 4 shows the primary and truss winding heads. Figures 5, 6, and 7 are three views of the roll feed system, showing four drive rolls and the gear system for driving them. At the end of this third quarter period, it is estimated that 25% of the construction phase is complete, and it is anticipated that the machine will be fully erected by mid May.

B. EXHAUST MACHINE

During this quarter, the construction of the basic pumping system and power supply was completed. This included the mating of the vacuum system with the electrical control cabinets and the assembly of the manifolds, bus bars, and water cooling system. As shown in figures 8 and 9, the machine supports 16 heads in two rows of 8 each, with the bus bars and manifolds running between the rows. The control cabinet is mounted at one end of the frame and situated at eye level. It contains all the voltage sensing and correcting chassis, as shown in figure 10. The cabinet facade contains three indicating instruments; a bus voltmeter, a percent power meter, and a servo control indicator. The voltmeter reads actual bus voltage and is used to set the system temperature. Minor differences in head resistance are independently adjustable by means of a sliding clamp on a resistance rod contained on each head. Once the heads have been individually adjusted, the system temperature can be varied as a whole. The percent power meter indicates the ratio of drawn power to available power and shows the rate of temperature rise. Thus, as the machine attempts to attain the required temperature, this meter will show a high reading, and will taper off towards zero as this limit is reached. The servo control indicator displays the action of the voltage servo and the stability, or regulation, of the system. This latter item is useful in determining the quality of the power regulation and will point out impending problem areas in the control system.

The control cabinet also contains four adjustable timers to program the exhaust cycle. After the machine has pumped down, the first timer automatically starts the pre-heat phase, during which the product is brought to 800°C over a period of one minute. This temperature is specifically selected to be below the processing limits so that any overshoot associated with a rapid rise time does not reach the degas temperature. The second timer brings the

B. (CONT'D)

product temperature to 900°C for four minutes to drive trapped gasses from the tubes. The third timer raises the temperature to 1020°C for 45 seconds to effect sealing. Finally, the fourth timer shuts down the system for cooling and releases the vacuum at the end of the cycle. An inside view of the control cabinet is shown in figure 10.

Essentially, the entire basic machine was assembled during this period and initial performance tests were started. The vacuum system, including manifolds, was lead tested and pumped to 1×10^{-8} mm Hg on twenty successive tests. The prototype head, along with 15 interim heads, were mounted on the manifolds, and the entire package was installed in the manufacturing location. Each head was trimmed for uniformity, and pilot runs were conducted, using triode tube types. At first, only five tubes could be successfully sealed per head. Further adjustments were made, and capacity increased to seven tubes. However, these tests clearly indicated that the hot zone length was insufficient to achieve greater load, and the hot zone was very definitely shifted towards the lower end of the muffle. This condition is illustrated in a temperature profile curve shown as line "A" in figure 11. This curve shows that the top end of the muffle is running cooler than the bottom end, thus effectively causing an apparent downward shift of the hot zone. Since the muffle is rigidly fastened to the upper water cooled end cap, and only slides in a copper-wool gland at the lower end cap, it is reasonable to expect greater thermal losses at the top. However, the extent of the shift is appreciable, making a large portion of the muffle length unusable. Overriding the entire problem is the established fact that the new heads are 20-30% more efficient in terms of power consumption. With this latter benefit, it appears

B. (CONT'D)

that thermal losses can be selectively increased so as to degrade the temperature of the hot zone, as shown in curve "B" of figure 11. Thus, when power input is increased to bring the hot zone temperature up to the limit, the zone will spread, as shown in figure 11 curve "C".

In order to determine the exact procedure for extending the zone length, it was decided to run concurrent tests both on the machine and on a single head mounted on a laboratory exhaust unit. A temperature recorder and the necessary thermocouple sensing equipment is being fitted to one head on the machine. A dummy load of tubes will be fitted with thermocouples, and a profile of the head, in actual use, will be obtained. At the same time, the single head will be altered, in terms of reflective shielding, to achieve the predicted results of curve "C". The shielding will be reduced in the lower portion of the head until the zone extends upward the desired amount. In addition, if required, the head will be lengthened to further increase capacity. When proper conditions are achieved, the final heads will be constructed and mounted for engineering tests.

C. LEAD LOADER

During this period, the design phase of this task was actively pursued and a major portion of both the lead loader and copper washer application units were released for shop construction. As pointed out in the previous report, the copper washer machine represents the bulk of the effort, and its operational performance will far exceed the contract requirements. The indexing turret unit was chosen as a Swanson-Erie unit on the basis of indexing accuracy, and the provision for a center camshaft through the turret. The camshaft will actuate the copper washer die heads and strip feeds from the center of the machine, thus eliminating any cumbersome mechanism around the unit which might obstruct accessibility for maintenance. Also, a spare set of die heads will be provided and are so designed to allow quick replacement for die sharpening.

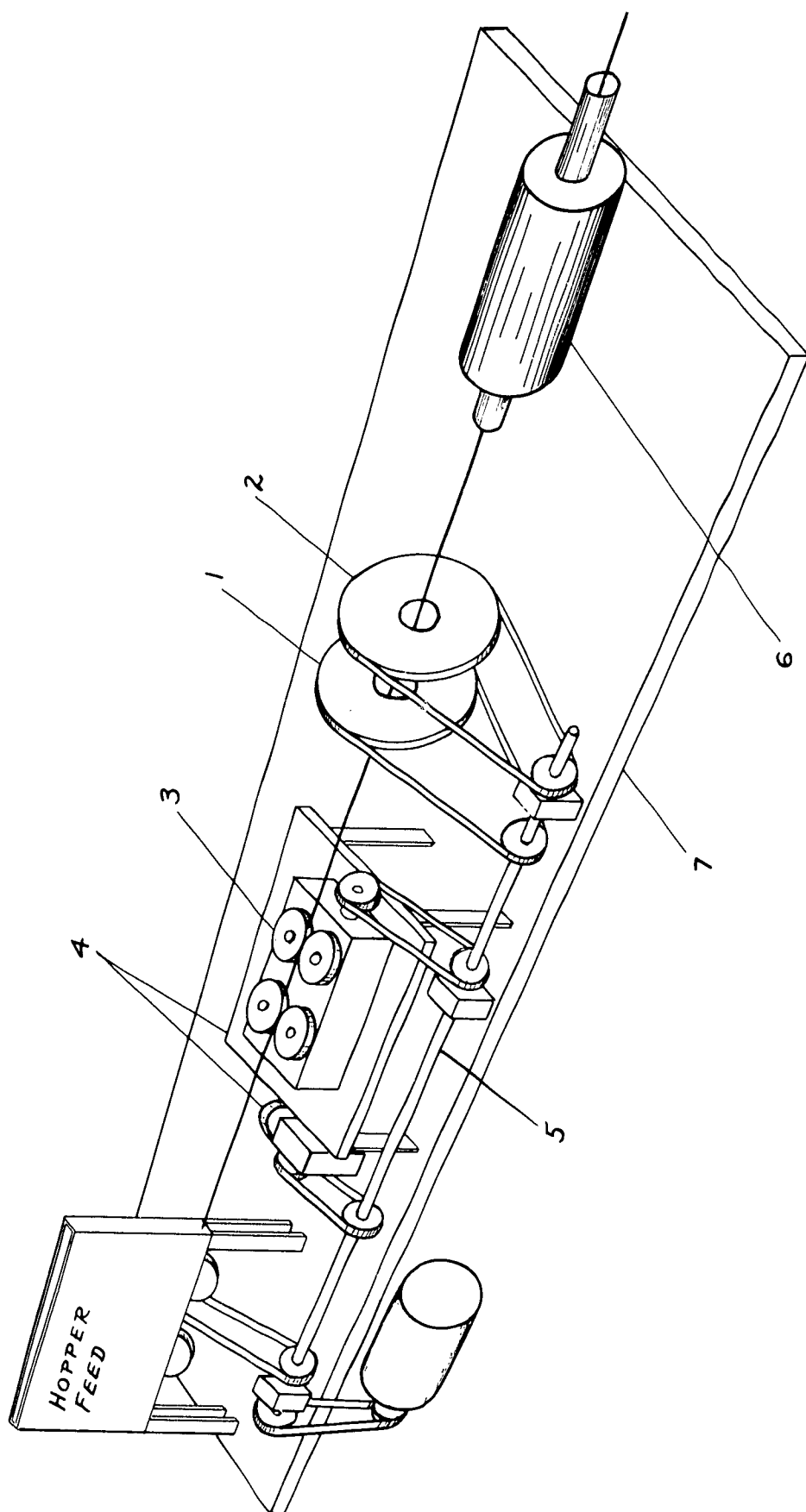
Another feature that was incorporated in the design was provision for handling long leaded Nuvisitors. The die heads and mechanism provide for lead lengths that extend beyond the base wafer by as much as $1\frac{1}{4}$ inches. In general, the copper washer unit will be capable of processing all tube types employing the conventional base wafer and will require only minor retooling for socket lead position changes.

The lead loader is designed to accept brazing jigs containing the electrodes and base wafer. As shown in previous reports, the eleven leads will be cut and loaded simultaneously. The tooling can be easily removed for sharpening, and changes in lead lengths are readily possible by inserting new stops in the feed mechanism.

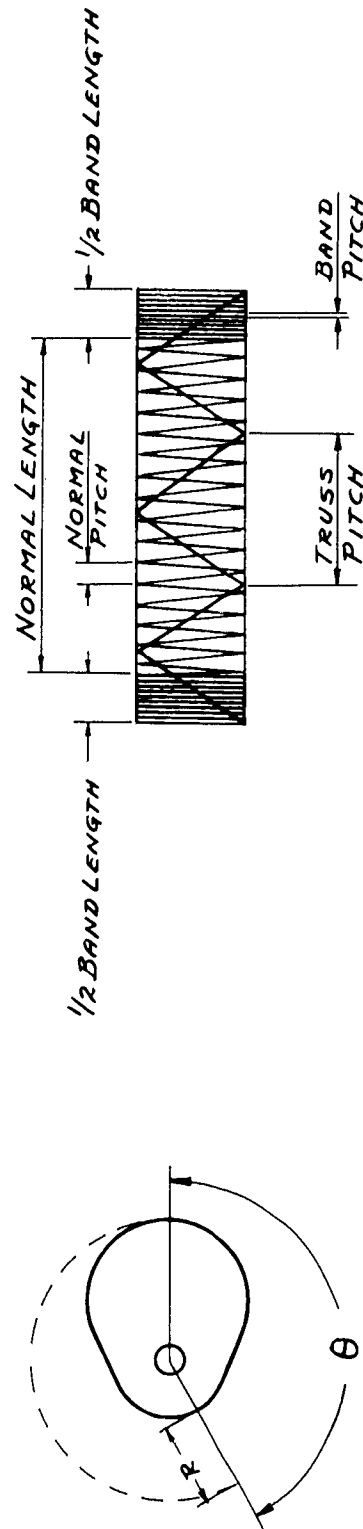
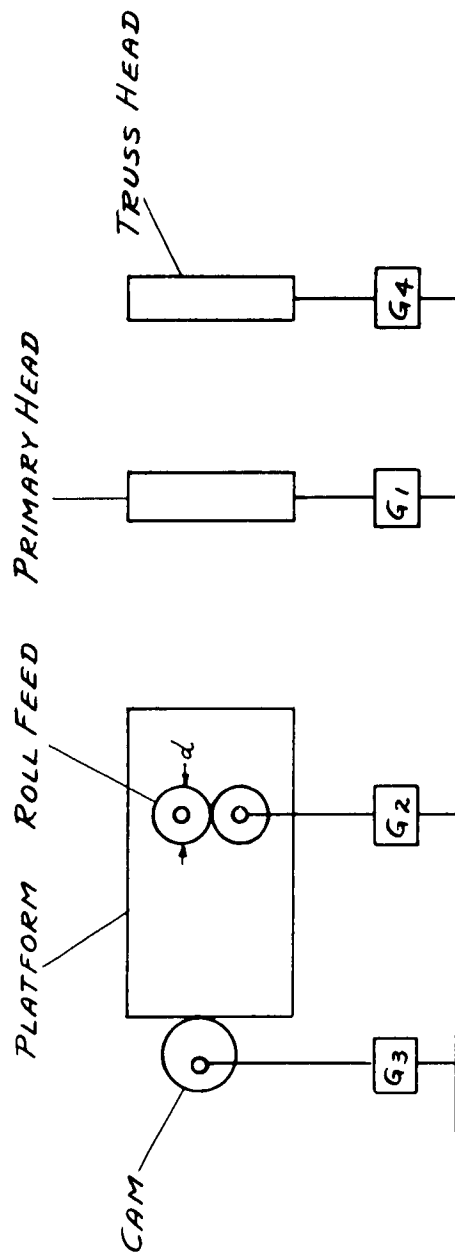
It is anticipated that final detail drawings of this phase will be completed and released for construction by March 15. A detailed description and accompanying photographs will be available for the annual report due in June, 1963.

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SCHEMATIC OF TRUSS GRID MACHINE
FIG. 1



FUNCTION DIAGRAM OF TRUSS GRID MACHINE
FIG. 2

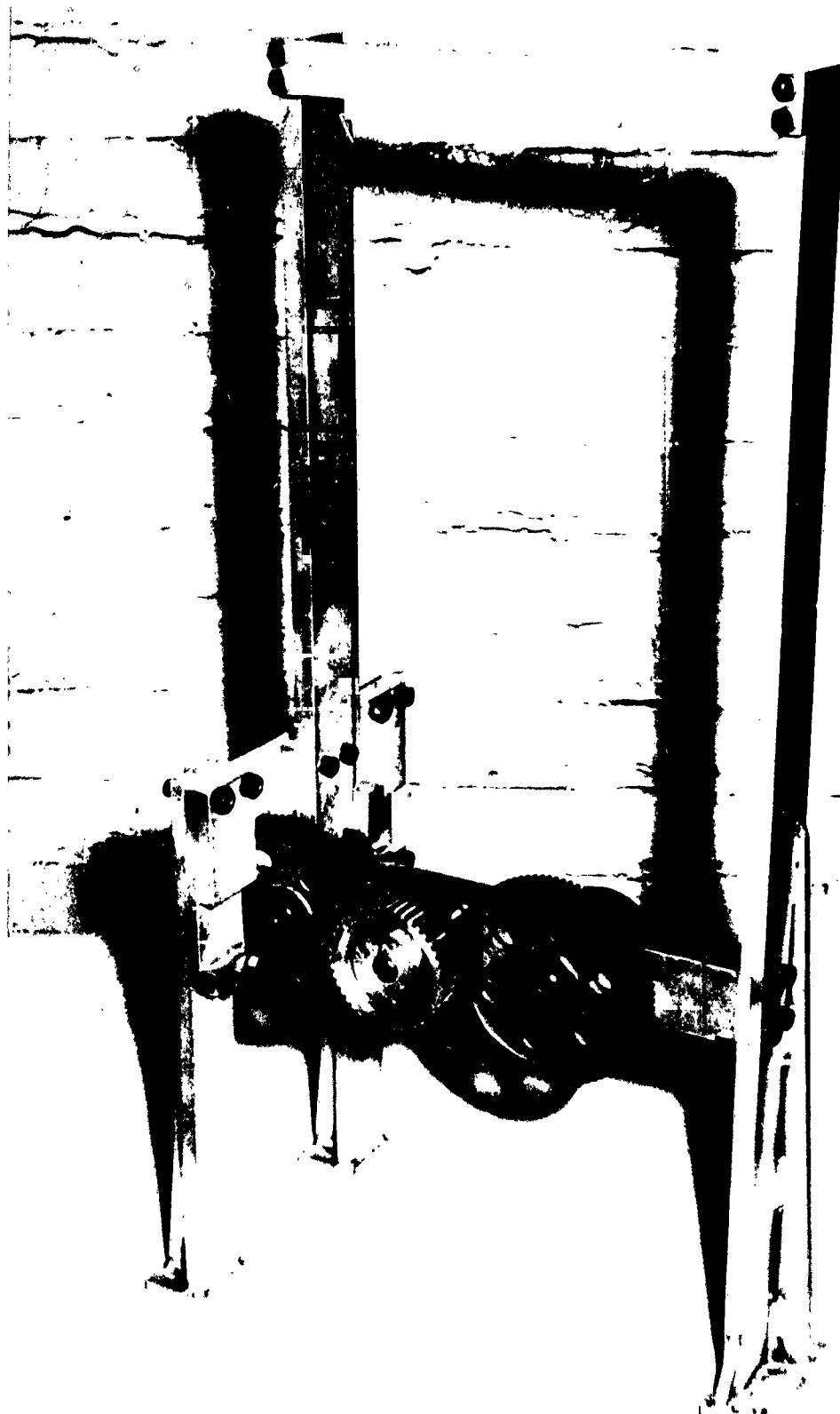


FIG. 3 MANDREL FEED HOPPER

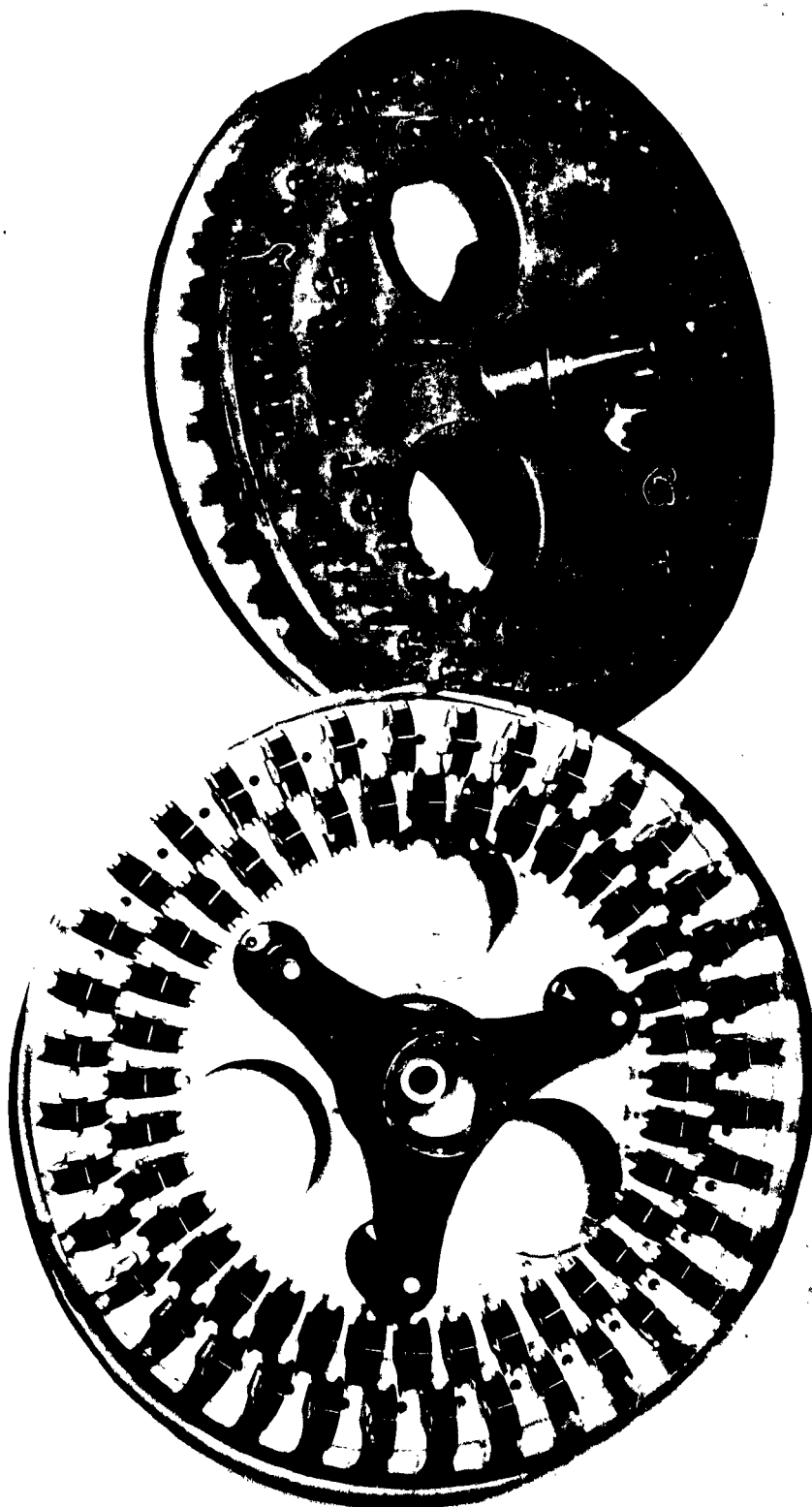
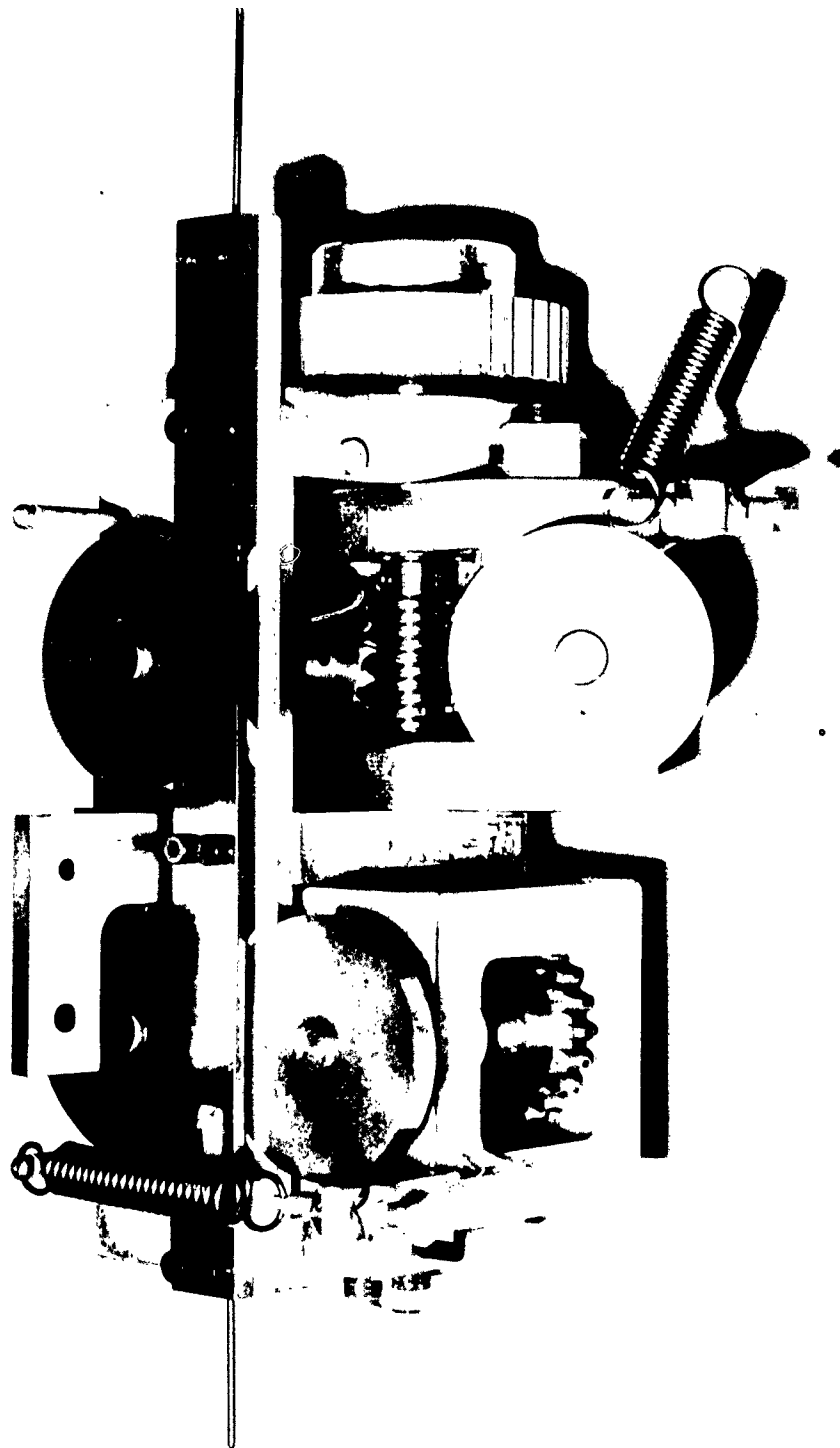
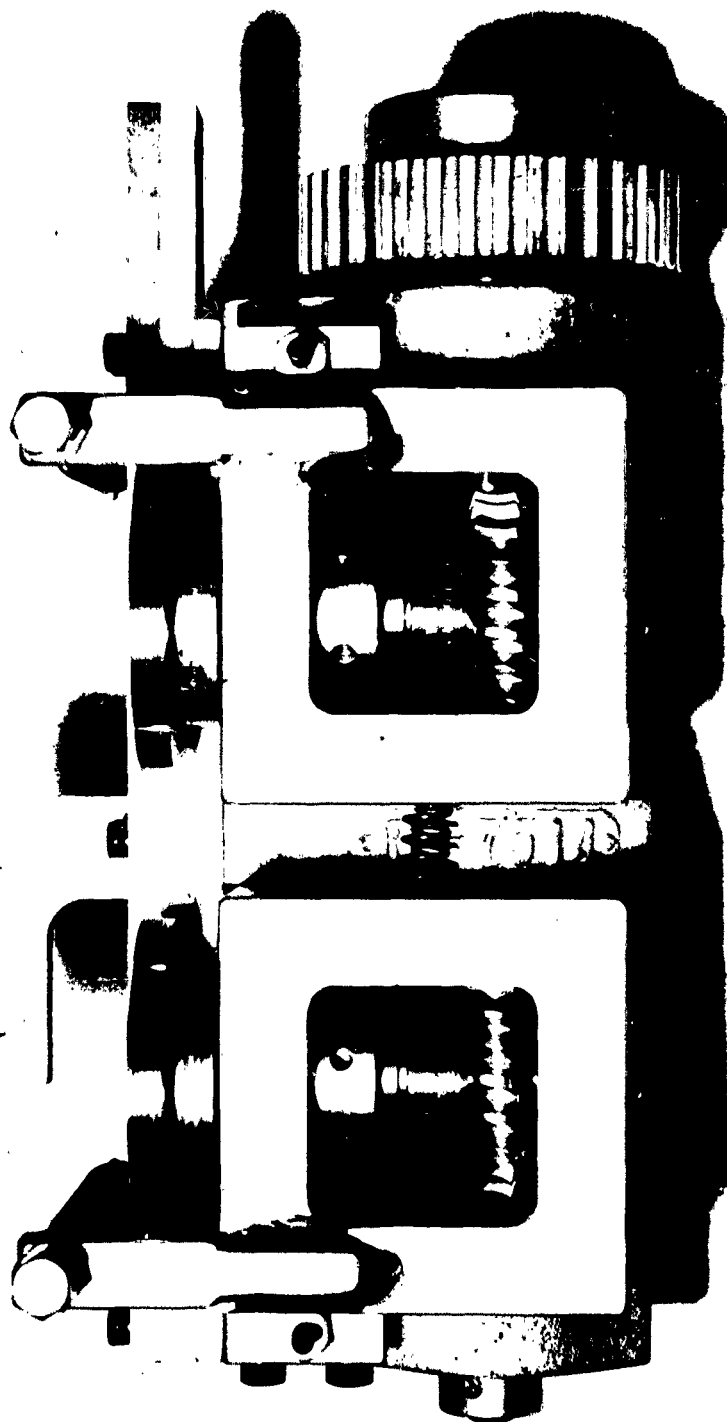


FIG. 4 PRIMARY & TRUSS WINDING HEADS

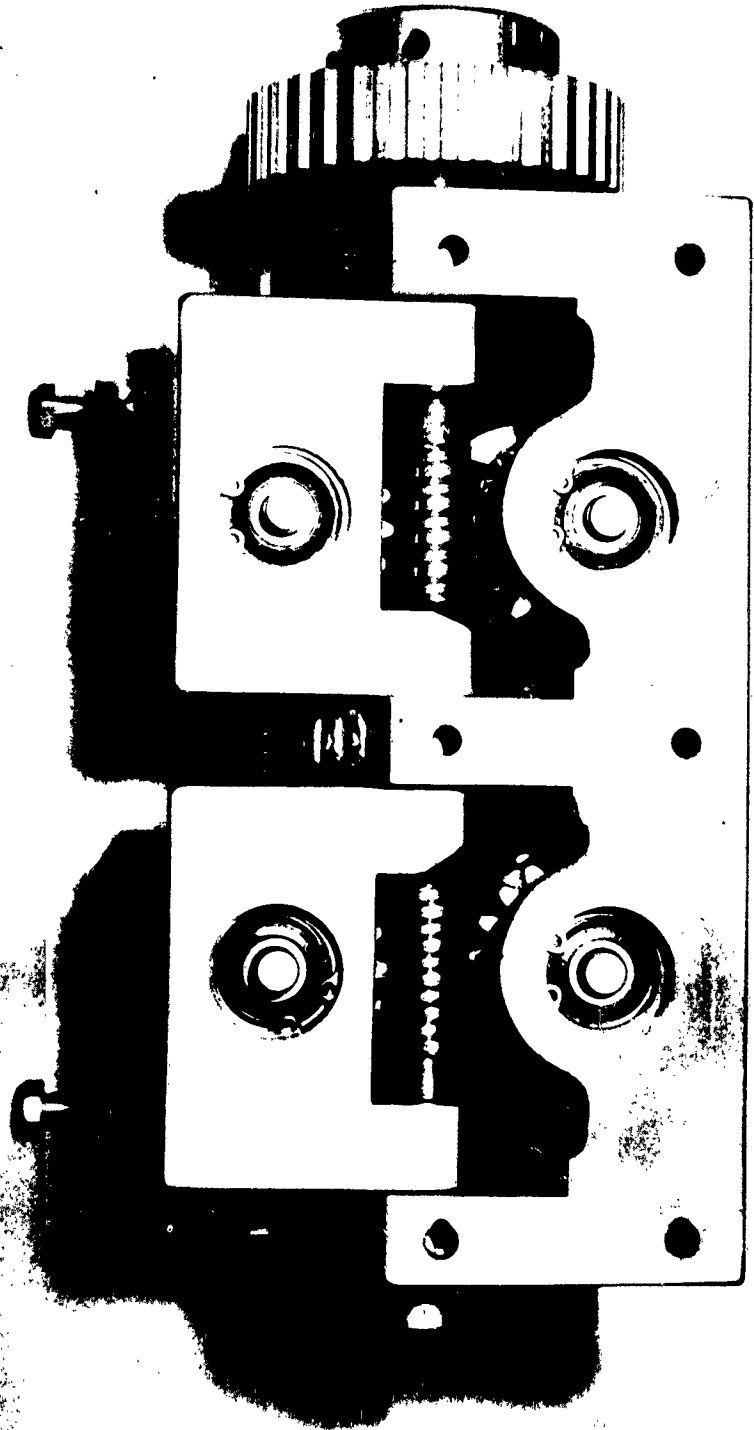


*FIG. 5 ROLL FEED DRIVE
SHOWING INSERTED MANDREL*
15



*FIG.6 ROLL FEED DRIVE
TOP VIEW*

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I
I
I
I



*FIG. 7 ROLL FEED DRIVE
REAR VIEW*

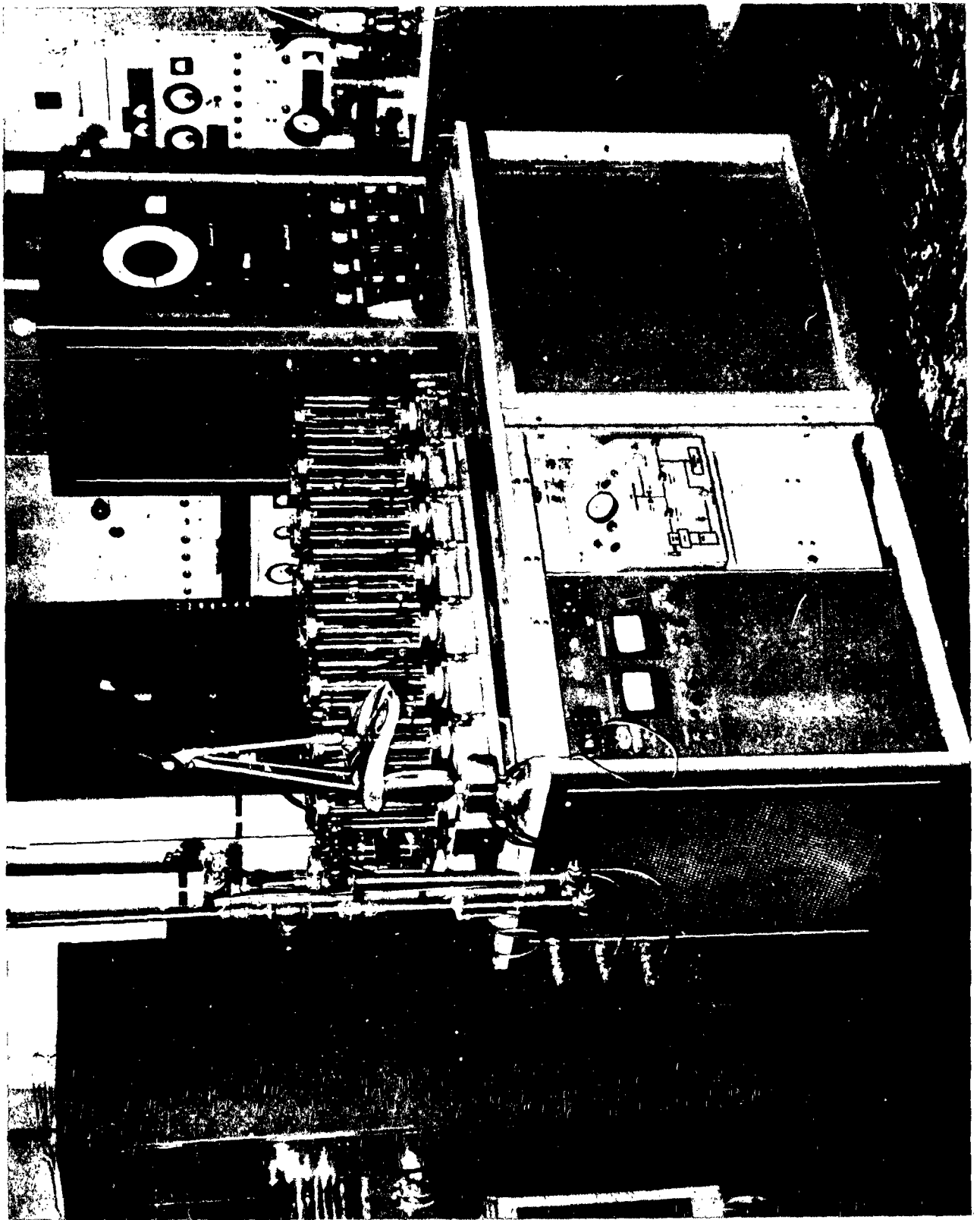


FIG. 8 EXHAUST MACHINE
FRONT VIEW
18

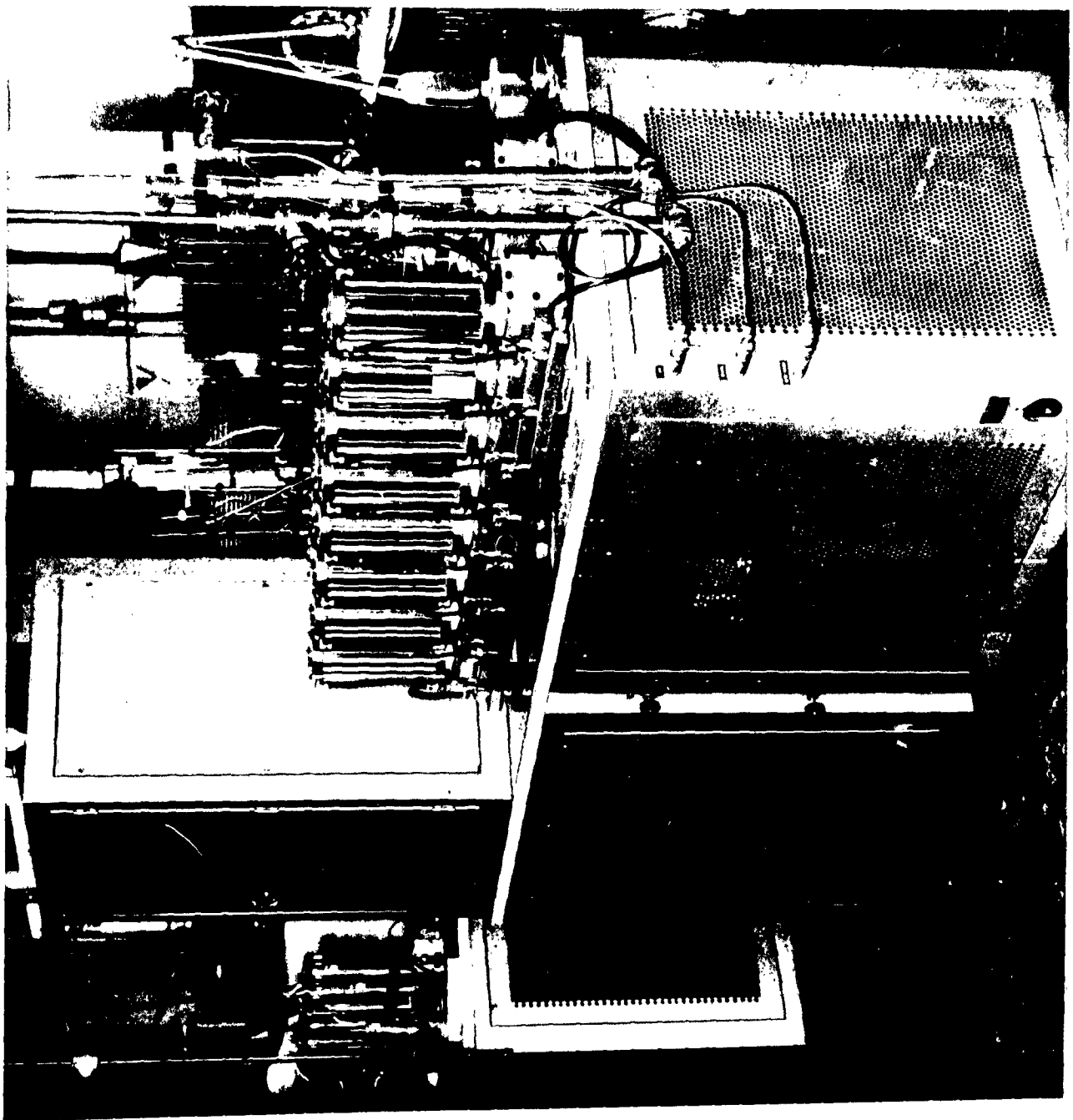
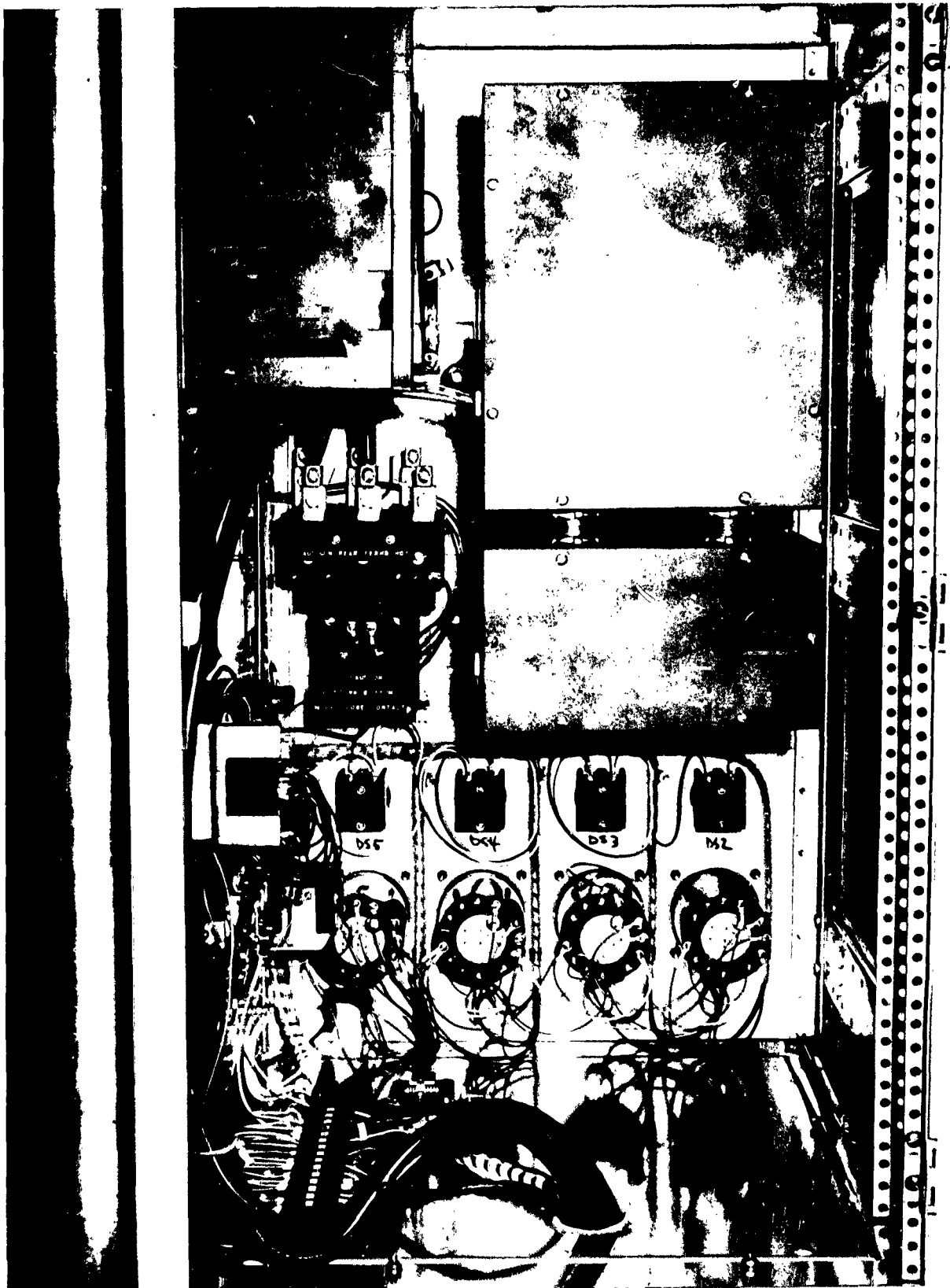
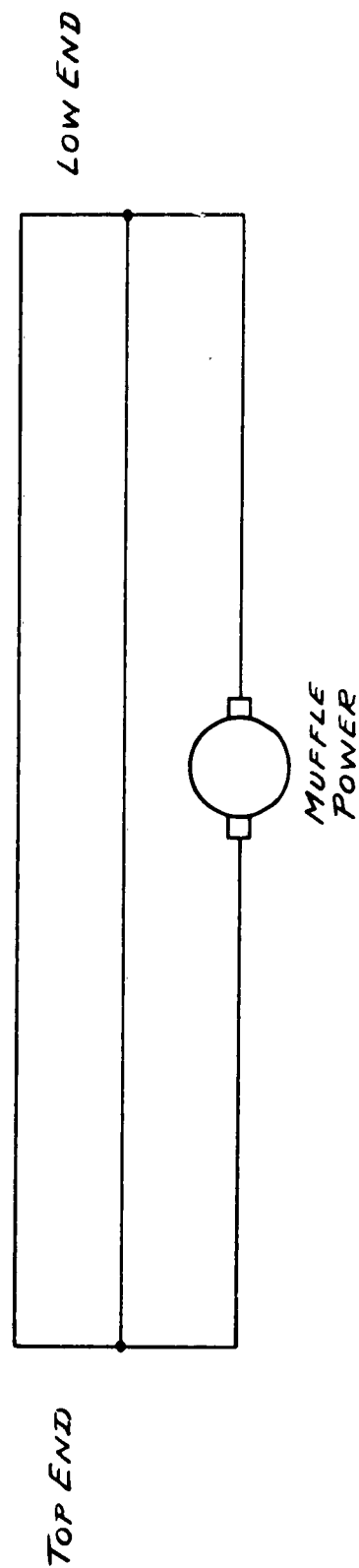
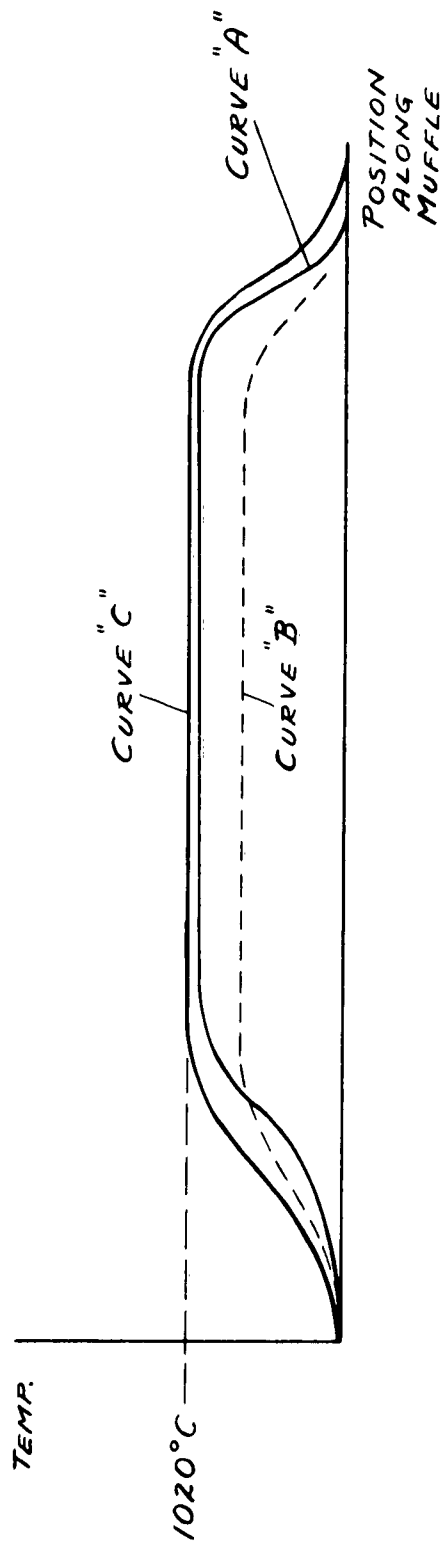


FIG. 9 EXHAUST MACHINE
REAR VIEW



*FIG. 10 CONTROL CABINET
INSIDE VIEW*



TEMPERATURE PROFILE ANALYSIS
FIG. 11

IV. CONCLUSIONS

A. TRUSS GRID WINDING MACHINE

The design phase is complete, and construction has proceeded to the 25% point. No technical problems seem apparent, and the machine is scheduled for shop completion by May 15, 1963.

B. EXHAUST MACHINE

The basic unit has been assembled and installed in the production location. The performance of the pumping system and power supply has been tested and found satisfactory. Sixteen interim heads were fitted to the unit, and production tests indicate that the hot zone is of insufficient length to accomodate the required tube capacity. Work is in process to lengthen the zones by selected alterations to the head design. Final head design and construction will take place during the fourth quarter.

C. LEAD LOADER

Design is progressing on schedule, and this phase will be completed by March 15, 1963. The copper washer unit will be capable of processing all Nuvistor tube types using conventional base wafers, and also $1\frac{1}{4}$ inch, long leaded types. The construction phase is in process, and completion is scheduled for June 15, 1963.

D. GENERAL OPERATIONS

All tasks are on schedule with completion dates as indicated above.

V. PROGRAM FOR NEXT INTERVAL

A. TRUSS GRID MACHINE

The construction phase of this task will be completed to the 90% point.

B. EXHAUST MACHINE

Head tests will be completed and a final design will be released for construction.

C. LEAD LOADER

The design phase will end on March 15, 1963 and construction will be completed to the 75% point.

D. GENERAL OPERATIONS

A report of proposed tube testing facilities will be submitted in March, 1963 for approval.

VI. PUBLICATIONS AND REPORTS

Monthly Letter Report:

No. 6 for period of November 1962

No. 7 for period of December 1962

No. 8 for period of January 1963

VII. IDENTIFICATION OF TECHNICIANS

A. MANPOWER EFFORT DURING THIRD QUARTER

1. Technical

G. Lalak	366 hours
C. Lindsley	46 hours
T. Matteson	116 hours
G. Shaffer	32 hours
M. Tuttle	210 hours

2. Semi-Technical

P. Agh	33 hours
L. Cottino	296 hours
F. Hoth	27 hours
R. Satriano	160 hours
B. Sherman	176 hours
G. Simmons	361 hours

B. PERSONNEL BIBLIOGRAPHIES
(Personnel added during third quarter.)

P. Agh

Mr. Agh joined R.C.A. in October, 1962 as a designer draftsman. He had held this position in other firms for the past six years, engaged in the design and detailing of various manufacturing equipment for the Can Making and Sewing Machine Industries.

L. Cottino

Mr. Cottino was engaged by R.C.A. in November, 1962 as a designer draftsman. Prior to this employment he had 10 years experience with various other service machine tool companies in the design and detailing of dies, jigs, fixtures and machine shop equipment.

B. (CONT'D)

T. Matteson

Mr. Matteson's primary service in this contract is the checking of drawings released to the shop for accuracy and completeness. He has been employed with R.C.A. since 1930 and has designed a broad spectrum of tube making equipment. His wealth of experience has been very aptly used in maintaining the quality of the design and detailing.

R. Satriano

Mr. Satriano has been employed with R.C.A. since August, 1955 as a designer draftsman. He has been associated with the construction of Nuvistor equipment for the past four years and is very familiar with the problems of the manufacturing activity. Prior to his employment with R.C.A. he had six years of experience with various design and engineering service companies.