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Technical Report: NAVTRADEVCEN 1188-1

# FINAL REPORT

# FOR

# STUDY OF PROJECTION IATRON APPLICATION

# TO

# HIGH SPEED MULTICHANNEL PLOTTER

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## ABSTRACT

This was a study to explore the feasibility of using the projection Iatron (FW-201) as the display readout device in a high speed multi-channel electronic plotting display system. The primary task is the evaluation of its suitability as determined by its storage, resolution, brightness, and writing rate. An existing equipment was therefore temporarily modified to provide the proper operating signals and voltages in accordance with the proposed application and the Iatron specifications. The equipment was checked out using an experimental tube loaned to Curtiss-Wright by ITT Federal Labs for this purpose. The two regular projection Iatrons (FW-201) were then tested. The tubes provided high brightness line traces (though somwhat lower than normal) but the resolution obtained at 6,000 and 9,500 foot-lamberts was 0.0625 inches at the screen. This is equivalent to 72 television resolution elements in a 4.5 inch display diameter. This resolution would be degraded still further at the rated saturation brightness value to about 60 television lines. These disappointing results in the resolution area were sufficient to terminate all further testing for the application and the feasibility study program was closed.

## FOREWORD

In this study another step was taken in the constant search for improved tactical display systems to advance training in Anti-Submarine Warfare, Radar and other areas.

The FW-201 Iatron, developed under joint BUSHIPS-FAA sponsorship, provided the opportunity to evaluate another promising system, since it was reported to be a projection storage tube with memory and brightness characteristics worth investigating. Consequently, this study undertook to ascertain the actual projection capabilities of the samples furnished and to determine the feasibility of a new, electronic, high-speed multichannel system designed around this tube.

Laboratory tests, however, demonstrated that the FW-201 Iatron fell short of the characteristics anticipated from data presented by the manufacturer. Pending future improvement or redesign, this tube may now be eliminated from further consideration for the application envisioned in this study.

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# SECTION I
# INTRODUCTION

Curtiss-Wright Electronics has had numerous applications calling for a large screen, high speed, random scan, high brightness display device with reasonable storage. The ITTL Projection Iatron tube had many of the sought for characteristics. This particular type tube had been employed successfully in direct view applications to great advantage in high ambient brightness radar display applications such as commercial and military aircraft cockpits. Curtiss-Wright Electronics therefore prepared a document "Design Considerations for High Speed Multichannel Plotter", 18 October 1961 in which it proposed a display system employing the projection Iatron but at much lower writing speeds which had previously not been employed.

At the lower writing speeds, it was hoped that the resolution would not be degraded as much at the tubes saturation brightness. This was based on the premise that the writing beam current must increase at the higher writing speeds in order that the storage charge per resolution element be sufficient to reach the brightness level of the information. The above referenced CWED document presents and discusses the various design considerations in much more detail with respect to application.

During the planning phase of this project, it became apparent that a one dollar contract with NTDC would not only be of mutual benefit to both parties, but would facilitate acquisition by Curtiss-Wright of the Government equipment needed. A contract was therefore made as well as requests for equipment.

In order to save the expense of new construction for the Iatron, an old radar projector, which had been made for the projection Iatron, was made available to Curtiss-Wright along with two Iatrons. Modifications were made to this equipment to simulate the final operating conditions. Tests were to be performed on the Iatron to establish the resolution - brightness relationship at the required writing speed and storage interval. With reasonable results in this area, areas of tests would then continue in the storage and tube operating parameters.

## SECTION II

## WORK PERFORMED

The laboratory set-up of equipment centered around the I.T.T. PPI radar Projector, Model 305C for which a loan arrangement was made with NAFEC by Curtiss-Wright. The projector head which consisted of Bower Optics deflection yoke, and Iatron tube holder was mounted on a specially prepared mounting plate. This permitted easy access for measurements and adjustments and additionally provided a low cost Iatron tube support.

In parallel with the above work efforts, the necessary modifications to the writing rate and erase pulse generator were initiated. For this purpose, the following schematics on the 305C (made available by R. W. Hunter of ITTFL, Fort Wayne, Indiana in a letter to C. Singleton on 17 May 1962) were employed.

| | |
|---|---|
| Video Amplifier, Schematic | D. ( ) |
| Power Supply Unit, Schematic | H-5K83103-100 |
| Sweep Generator, Schematic, Fig. 1 | D. ( ) |
| Sweep Output, Schematic, Fig. 2 | D. SK-23903-111-1 |
| Servo Unit, Schematic | D. SK-83103-101D |
| Video Switching Unit - Schematic | D. SK-310-C |
| Rack Cabling Diagram | H. ( ) |

The model 305C equipment consisted of sweep generator, sweep output, servo unit, video switching, erase pulse generator and supporting low and high voltage power supplies. The projection head contained the deflection and focus coils for the Iatron and the optical system. In addition, the final video amplifier was located on the projection head.

In order to fulfill the program objective, minor circuit modifications (of a temporary nature) were made to the following areas. The sweep generator when on the 200 mile range provided a sweep of 2.44 milli-seconds. This was stretched by increasing the timing capacity until a 16.7 millisecond sweeptime was realized. The trigger for this modified sweep generator was obtained from the "erase" pulse free running oscillator. The erase oscillator frequency was changed from 1/2 cps. to 1/3 cps. The width of the "erase" pulse was kept constant at three milliseconds. The trailing edge of the erase pulse triggered the 16.7 millisecond sweep and the whole erase-write sequence repeated after three seconds.

The servo unit was deactivated and the sweep waveform was applied to the E-W channel after the key-clamping diodes, which circuit was also deactivated. In this manner, a single horizontal trace of proper timing could be written whole maintaining horizontal and vertical positioning adjustments.

Unblanking of the FW-201 was achieved by using a 16.7 millisecond rectangular pulse available from the sweep generator. This pulse was applied to the video amplifier wherein some circuit modification was necessary to preserve the proper wave shape.

When the signals described above were simultaneously available, a 5ZP16 substitute tube was used for sweep and unblanking verification. This proved satisfactory and the tube supplied by ITTL for experimental set-up was inserted into the projection head as a support.

When the first Iatron (#126003) was fired up, the flood anode power supply became overloaded. Investigation showed that the flood anode and high side of the flood gun filament were internally connected. Unfortunately, there was no indication in any of the tube specifications that this was the case. The recommended electrode voltages indicated that the first anode should be +14VDC with respect to cathode. To accomplish this the cathode was connected to a negative supply of -8 volts and the filament voltage which was supplied was 6.0VDC. The voltages on the other electrodes were all close to the recommended values with the exception of the collector voltage which could not be increased beyond +170VDC, without internal breakdown in the tube. By adjustment of the various collimating electrodes of the flood gun, it was impossible to obtain an evenly flooded screen. After 45 minutes of operation of the Iatron (#126003) a sudden breakdown with the tube damaged the phosphor layer on the screen in several places near its periphery. At the time of the breakdown, the high voltage on the screen was only 7.0KV and all other operating potentials were proper.

It appears that the breakdown has been caused by a slight loss in the high vacuum under which this tube must operate to get useful operation for a spacing of only 0.2 inches between the target mesh and the screen.

The above tube was one loaned to Curtiss-Wright for set-up purposes. The remainder of the work took place during July 1962.

During this latter interval, the two remaining tubes were tested. The first of these was SN126002. Direction was sent from Bureau of Ships to Material Laboratory Code 921 N.Y. Naval Shipyard via speed letter (Ref. 30A-541 Ser. 681A1B2-755) to furnish this tube to Curtiss-Wright for use as the GFM stipulated under this contract. The second tube SN036202 is the property of BuShips, under contract Nobsr 72783 and was shipped to Curtiss-Wright under ITTFL order number 04117880.

SN126002 Tests

The tube was installed in the modified Radar PPI Projector equipment and the set-up procedure was initiated. At first, the phosphor screen indicated that a rectangular raster had been burned in on the target. This showed up as the unequal brightness distribution on the line trace as the line was positioned on the usable area of the tube. The set-up procedure continued by adjusting electrode voltages and currents for best collimation and maximum brightness. The maximum collector voltage capability was found to be +175V.D.C. Beyond this setting, flashing in four equally spaced areas around the periphery of the screen was introduced. The voltages for optimum performance of the Iatron SN126002 were recorded and are listed below:

Flood Section

| | |
|---|---|
| Viewing Screen | ⁄13.0 KVDC @ 2.3 ma |
| Backing Electrode | ⁄4.0 V.D.C. |
| Collector Electrode, Anode 3&5 | ⁄175 V.D.C. |
| Anode 4 | ⁄3.0 V.D.C. |
| Anode 2 | ⁄110 V.D.C. |
| Anode 1, High Side of Filament | ⁄12 V.D.C. |
| Cathode | 0 V. @ 35 ma. |
| Filament | 6.3 V.A.C. |

Writing Section

| | |
|---|---|
| Grid 2 | 0. |
| Grid 1 (cut-off) | -2528 V.D.C.* |
| Cathode | -2500 V.D.C. |
| Filament | 6.3 V.A.C. |

* This was obtained by floating a voltmeter relative to cathode.

Performance Data

| | |
|---|---|
| Brightness | 6000 Foot Lamberts |
| Erase Pulse Duration | 3 milliseconds |
| Storage Time | 3 seconds |

It was found that the high voltage could not be increased beyond 13.0 K.V. which was limited by the high voltage power supply regulation. The brightness obtained at reduced high voltage (86.7%) and reduced viewing screen input power (29.9 watts instead of the nominal 45 watts) is in the expected range considering the voltage loss due to the effective penetration of the phosphor screen.

It will be observed that the recorded changes were necessary to get the proper cathode current flowing in the flood gun structure. The flood gun filament circuit was modified by inserting a filament transformer and inserting anode 1 voltage on the high side of the filament. (The high side of the filament and anode 1 were connected internal to the tube.)

Tests on resolution showed that at the required high brightness for the Multi-channel plotter application, the resolution was unacceptable. A single line thickness was measured to be 1/16th inch at the Iatron screen surface. This was done by using an optical magnifier and making measurements in the image plane and then referring these back to the Iatron phosphor screen. In light of these very disappointing results, it was decided to insert and calibrate the latest tube hoping that it would result in the required performance capabilities.

SN036202 Tests

This tube was the most recently manufactured tube. It was installed and set up. The high voltage and consequently the maximum brightness were limited by the high voltage power supply regulation as recorded below.

Flood Section

| | |
|---|---|
| Viewing Screen | ⁄10.3 KVDC @ 3.3 ma |
| Backing Electrode | ⁄11.5 VDC |
| Collector Electrode, Anode 3&5 | ⁄200 VDC |
| Anode 4 | ⁄3.0 VDC |
| Anode 2 | ⁄100 VDC |
| Anode 1, High Side of Filament | ⁄12 VDC |
| Cathode | 0 @ 35 ma. |
| Filament | 6.3 VAC |

Writing Section

| | |
|---|---|
| Grid 2 | 0 |
| Grid 1 (cut-off) | -2536 VDC |
| Cathode | -2500 VDC |
| Filament | 6.3 VAC |

Performance

| | |
|---|---|
| Brightness | 9,500 ft. Lamberts |
| Erase Pulse Duration | 3 milliseconds |
| Storage Time | 3 seconds |

The 9,500 foot lamberts brightness was obtained with 34 watts screen excitation. The reason for the reduced brightness could be the fact that the collector voltage could not be brought up to the recommended value of ⁄250 VDC. If this increase were attempted, an internal breakdown would occur in the Iatron tube.

Results on resolution tests were essentially the same as on the previous tube. This series of tests on the last tube indicated to the people on the project that the tube was unsatisfactory for the application. The test set-up was maintained intact until it had been seen in operation by the key technical specialists and the Chief Engineer.

With this last presentation, it was decided that the objective of this contract had been fulfilled and that it only remained to write the Final Engineering Report.

## SECTION III

## RESULTS, CONCLUSIONS & RECOMMENDATIONS

This whole effort has been aimed at seeking reasonable resolution at reasonably high brightness in order to meet the requirements of the High Speed Multichannel Plotter. The results of the feasibility program shows that resolution in the order of 60 elements in a 4.5 inch diameter can be expected at 100% saturation brightness. At reduced brightness, the resolution improves but the technique becomes useless to the program objective at these greatly reduced light levels. The above resolution figure at the required high brightness is not "good display" and therefore this effort has been terminated. Alternative techniques will be used to satisfy the individual CWED requirements as they are raised.

Secondary conclusions based on the results of this work effort are now listed providing general data relative to the FW-201.

1. Set-up conditions apparently vary considerably from tube to tube and may constitute an operational and maintenance problem in the field.

2. Corona was noticed around the screen insulator on humid days. This may be a problem in a military environment.

3. Loose phosphor particles on cathode material could cause disastrous breakdown if they were to lodge in critical regions. The tube apparently requires a sustained high vacuum to prevent phosphor sparking.

This project effort has resulted in the elimination of the projection Iatron from consideration in this application. Other forms of high brightness display (thermoplastic storage and projection, Eidophor and scan converter with storage or image tube with long term storage) would have to be evaluated for the individual application.

## APPENDIX

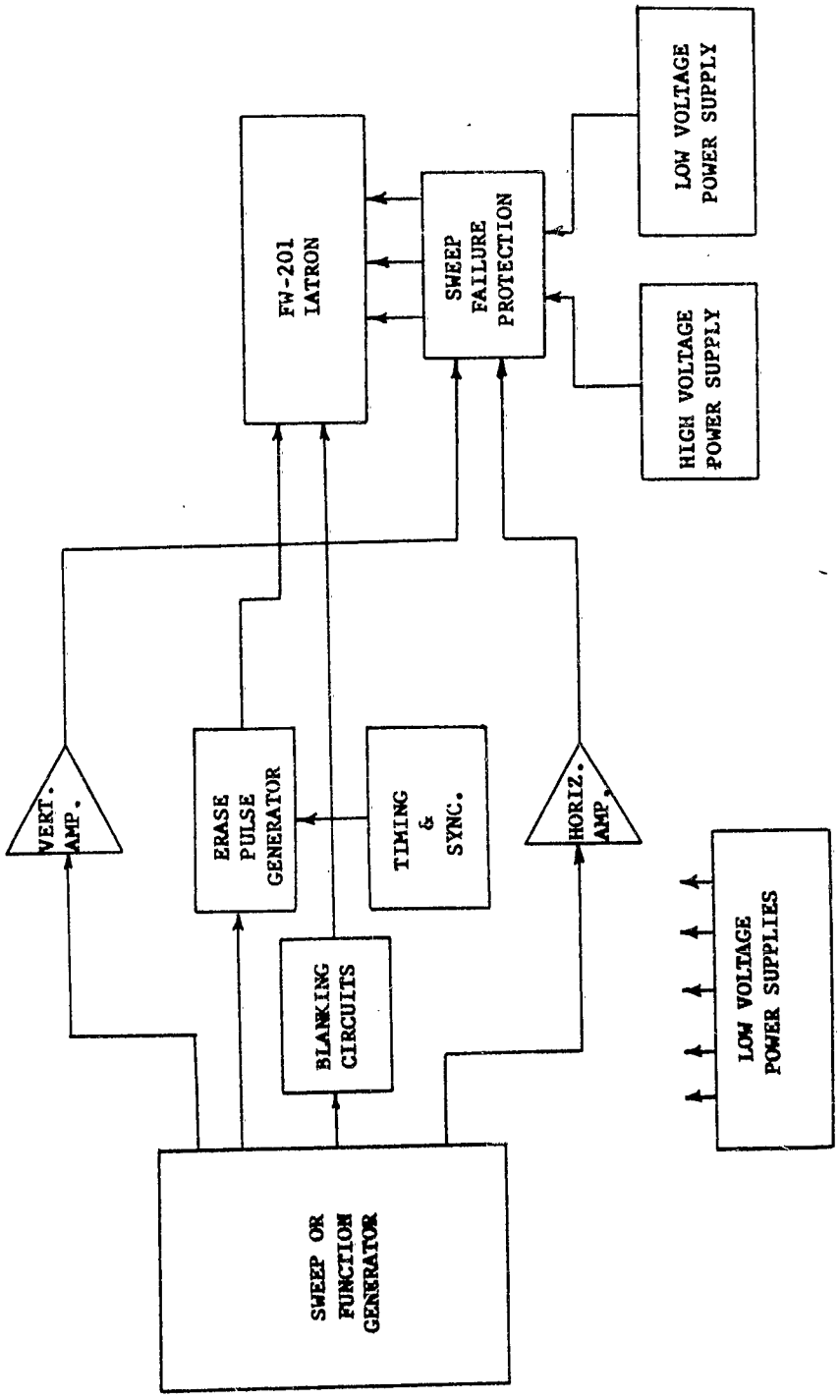


Figure 1. Block Diagram - Laboratory Setup of FW-201 Iatron

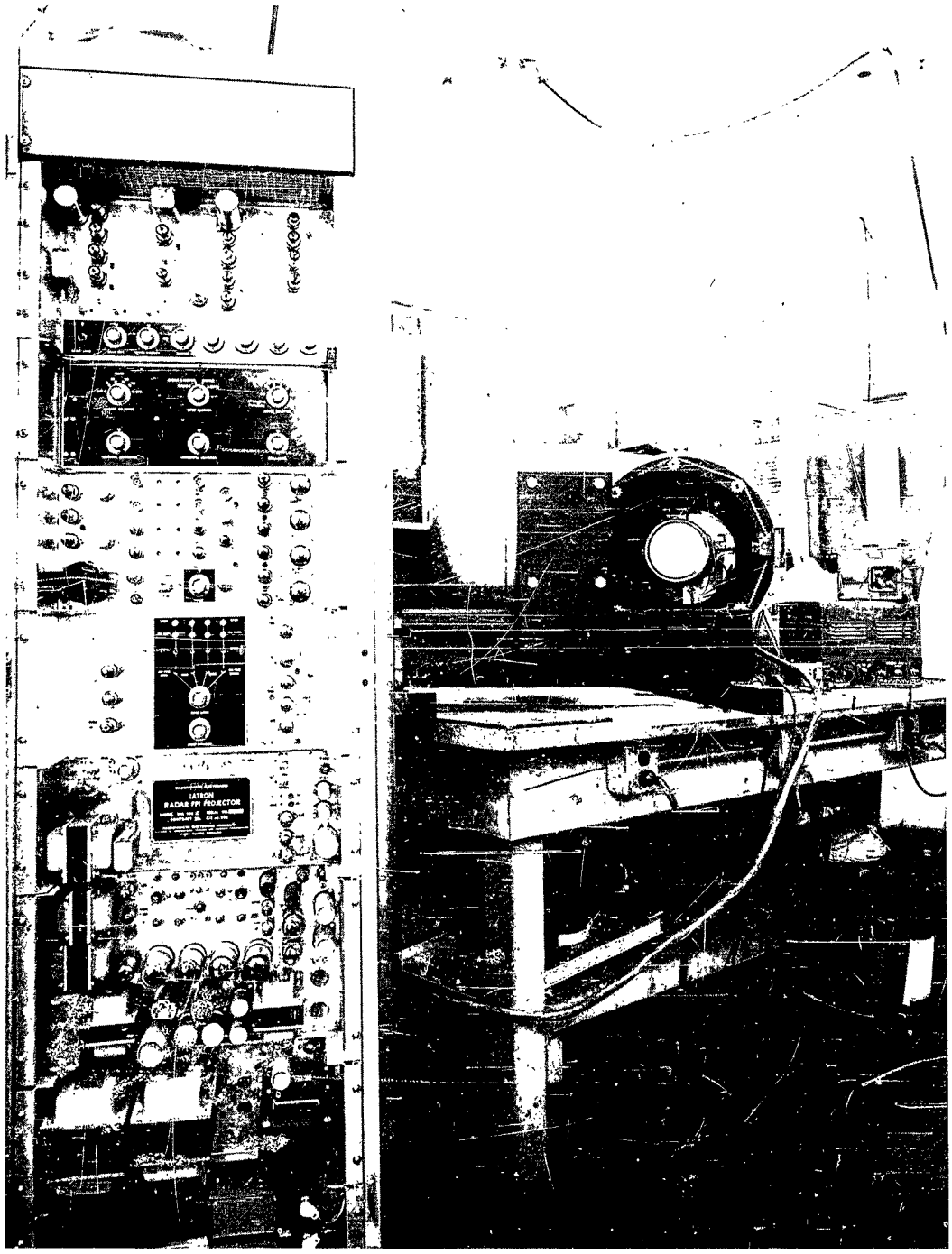


Figure 2. Left Quarter-View, Laboratory Setup of FW-201 Iatron

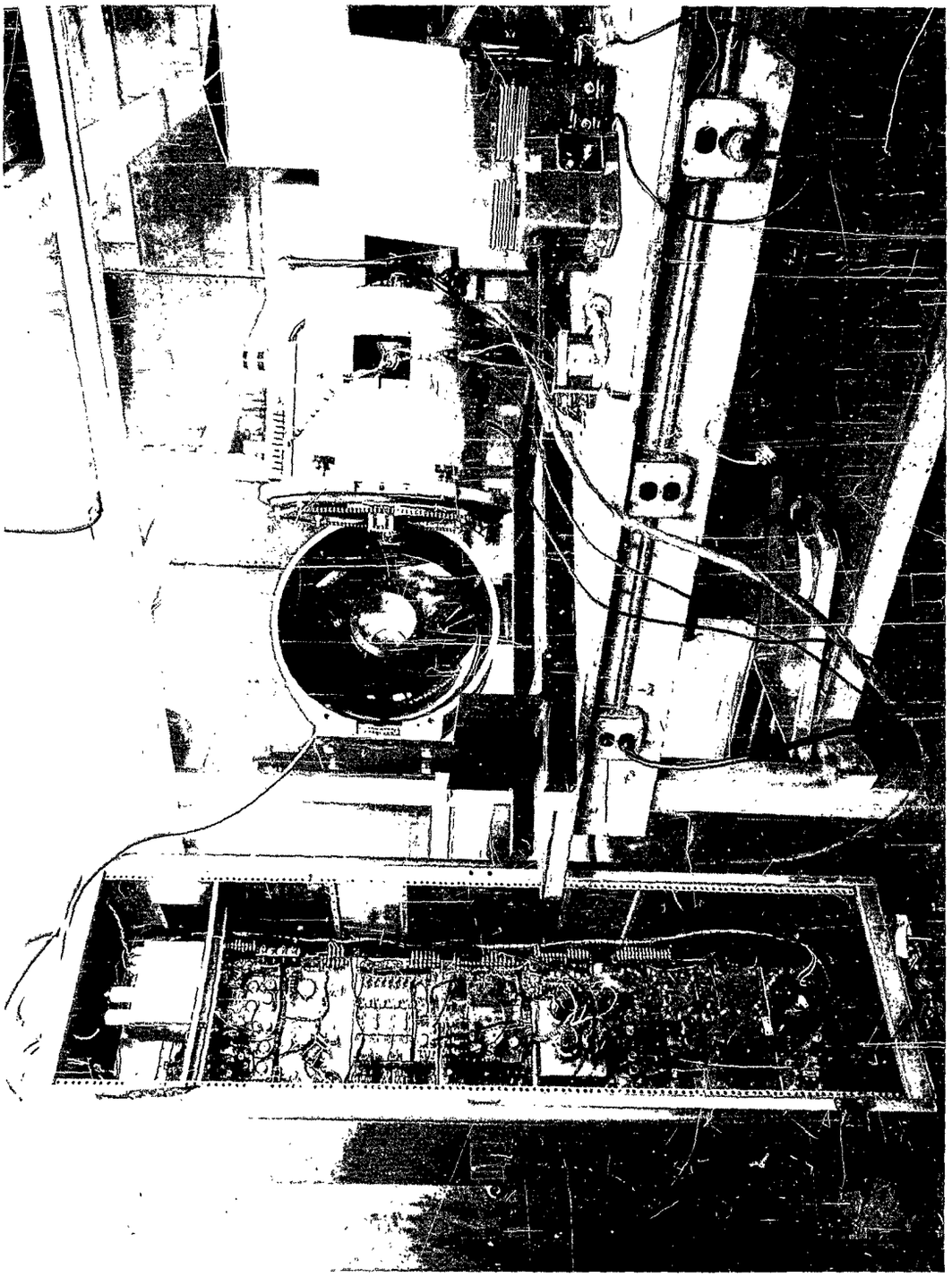

Figure 3. Right Quarter View, Laboratory Setup of FW-201 Iatron

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# FW-201

(Tentative Specifications)

6-INCH PROJECTION IATRON

STORAGE CATHODE-RAY TUBE WITH AN

ELECTROMAGNETICALLY FOCUSED AND DEFLECTED

WRITING GUN CONCENTRIC WITH THE FLOODING GUN

The FW-201 is a high intensity storage tube designed for use with reflective projection optical systems. At a final anode voltage of only 15 kv, the brightness of the tube display is about 20,000 foot-lamberts. Like other storage tubes, operator controlled persistence and signal integration is possible.

This tube has the writing gun located on the tube axis and a special ring shaped flooding gun disposed co-axially around the tube axis. This structure maintains the same bulb form as conventional cathode-ray tubes and is easily packaged in equipment.

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## Typical Operating Data

| Flooding Section | Voltage | Current |
|---|---|---|
| Viewing Screen | 15 kv max | 3 ma |
| Backing Electrode | + 15 volts | |
| Collector Screen | Common lead | |
| Anode No. 3 | 250 volts | 14.5 ma |
| Anode No. 5 | | |
| Anode No. 4 | 15 volts | 200 μa |
| Anode No. 2 | 100 volts | 350 μa |
| Anode No. 1 | 18 volts | 25 μa |
| Heater | 6.3 volts | 2.1 a |
| Cathode | 0 volts | 45 ma |
| **Writing Section** | | |
| Heater | 6.3 volts | 0.6 a |
| Cathode | -2500 volts | 2 ma |
| Control Grid No. 1 (cutoff) | -2530 volts | |
| Grid No. 2 | 0 volts | 1.9 ma |

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## Typical Performance Data

| | |
|---|---|
| Minimum erase pulse amplitude required for flooding current cutoff | 9 volts |
| Minimum time required to erase tube from saturation brightness to cutoff | 3 milliseconds |
| Maximum resolution at 10 percent of saturation brightness | 130 raster lines/in |
| Average brightness at saturation | 20,000 foot-lamberts |
| Writing speed at 90 percent of saturation brightness at zero bias | $4 \times 10^4$ in/second |
| Viewing time | 30 seconds |
| Display diameter | 4.5 inches |

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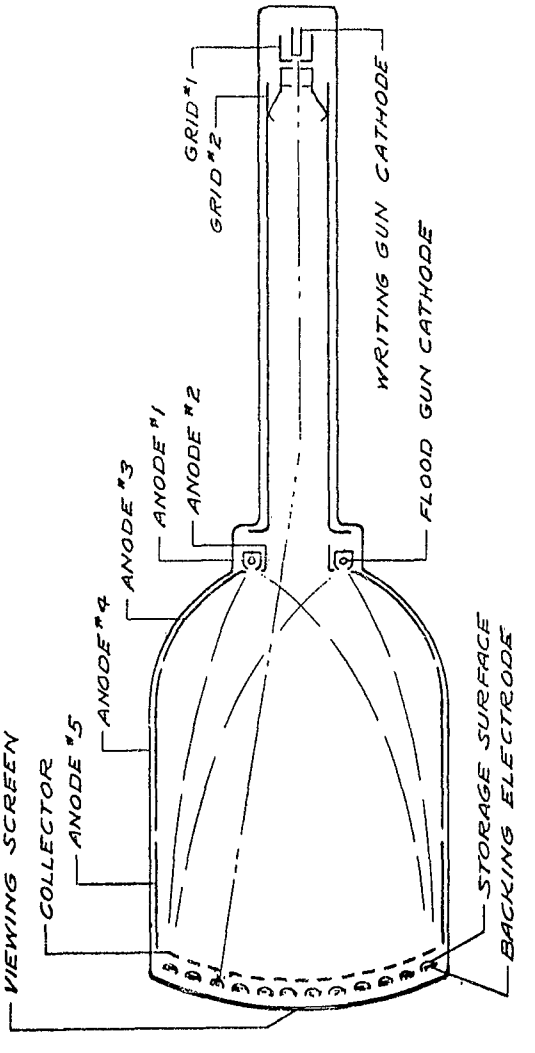


FW-201 Operational Schematic

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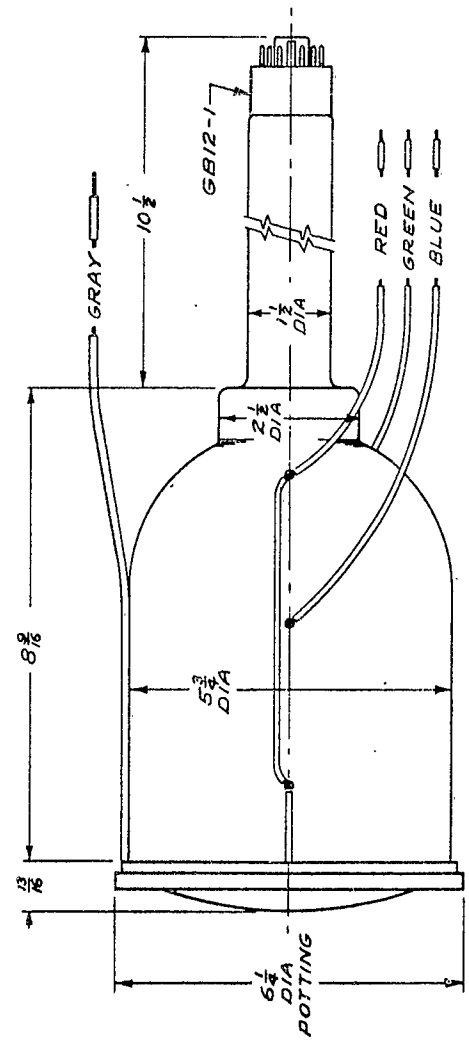


**BULB CONNECTIONS**

| | |
|---|---|
| RED WIRE | COLLECTOR |
| | ANODE #3 |
| | ANODE #5 |
| GREEN WIRE | BACKING ELECTRODE |
| BLUE WIRE | ANODE #4 |
| GRAY WIRE | VIEWING SCREEN |

**12 PIN BASE (GB12-1)**

| PIN | |
|---|---|
| 1 | WRITING GUN HEATER |
| 2 | WRITING GUN HEATER |
| 3 | WRITING GUN CATHODE |
| 4 | CONTROL GRID #1 |
| 5 | NO CONNECTION |
| 6 | GRID #2 |
| 7 | FLOOD GUN HEATER |
| 8 | FLOOD GUN HEATER |
| 9 | FLOOD GUN CATHODE |
| 10 | ANODE #1 |
| 11 | ANODE #2 |
| 12 | NO CONNECTION |

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