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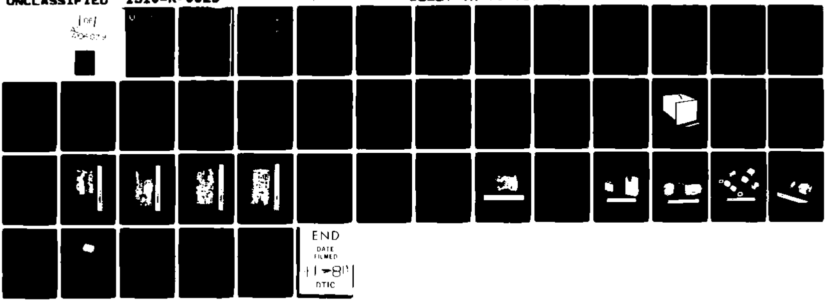

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HIGH CONTRAST CRT MODULE

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August 1981

Interim Report for Period 1 April 1980 - 30 September 1980

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Prepared For: ELECTRONICS TECHNOLOGY AND DEVICES LABORATORY

ERADCOM

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The objective of this program is the development of a miniature high contrast color CRT module compatible with the AN/APR-39 system, except for an increase in overall length compared to the monochrome AN/APR-39 display indicator.

The second interim period of this program has resulted in completion of the electrical and mechanical design of the Advanced Development Module (ADM) and initial ADM fabrication.

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HCCM Second Interim Report
1 April 1980 to 30 September 1980

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List of Illustrations

1.0 CONFERENCES

1.1 4 September 1980 at Thomas Electronics

Report of conference held at Thomas Electronics, Wayne, New Jersey on 4 September 1980 with Norden Systems and Thomas Electronics concerning Contract DAAK 20-79-C-0290. High Contrast CRT Module.

PERSONNEL PRESENT

Norden Systems

M. Kalmanash
G. Budd

Thomas Electronics

B. Waxenbaum

ERADCOM

P. Krzyzkowski

The purpose of the conference was to discuss dimensional limitations associated with the manufacture of the HCCM CRTs, particularly the anode lead connection, and the potting around the faceplate/bulb seal. The maximum permissible CRT diameter (including faceplate and faceplate-bulb potting), was defined as 3.083 inches. It was agreed that the position of the anode button could be moved an additional 1/8 inch back to increase the potting margin. This is a desireable change, and Thomas agreed to make future tubes in this manner.

The 3.083 inch maximum CRT diameter does not present a problem with the sapphire faceplate tube, which has a maximum diameter of 3.005 inches, but faceplate potting margins may be marginal for the 1710 faceplates which have a diameter of 3.065 inches.

1.2 16 October 1980 at ERADCOM

Report of conference held at ERADCOM, Ft. Monmouth, New Jersey on 16 October 1980 with Norden Systems.

PERSONNEL PRESENT

Norden Systems

M. Kalmanash
R. Laskos

ERADCOM

P. Krzyzkowski

The purpose of the conference was to demonstrate the breadboard HCCM system and perform initial integration with the AN/APR-39(V)1 system test bed and ERADCOM's IDIGRAPH random scan exerciser, to simulate the AN/APR-39(V)2 system. The demonstration verified the satisfactory performance of the breadboard units, with additional alignments required as a result of the initial integration effort being subsequently performed at Norden.

2.0 INTRODUCTION

2.1 Background

Increased mission requirements for military aircraft warrant the use of color displays to improve identification of warning information and enhance speed and accuracy of response. Two restraints on the widespread use of cockpit color display systems have been limited display contrast available from color CRTs and concerns about the additional size, weight and power dissipation associated with the color display electronics.

Recent advances in penetration color phosphor technology have improved efficiency to the point where attainment of adequate contrast to permit operation in direct sunlight is feasible. ERADCOM has supported a more aggressive approach by sponsoring the development of high contrast beam penetration CRT screens using transparent thin film phosphors deposited over a black layer which serves to absorb incident ambient light and thus improve display contrast. The CRTs under development using the thin film high contrast screens have 3 inch faceplates and use magnetic deflection, electrostatic focus guns.

In the present program, Norden Systems is developing an extremely compact multicolor display indicator which will utilize the high contrast CRT described above. The indicator, dubbed the High Contrast CRT Module (HCCM) is used with the AN/APR-39 radar warning system. It is housed in a form factor identical to the monochrome AN/APR-39 display indicator, but with an increase in overall length to accommodate the additional color circuitry.

The HCCM is a fully self-contained unit, and meets or exceeds monochrome AN/APR-39 display operating characteristics.

The development of circuitry capable of high speed color switching and of meeting exacting standards of color registration accuracy and inter-color brightness uniformity within the power and volume restraints imposed, marks a breakthrough in display indicator technology. When completed, the HCCM development will demonstrate conclusively that cockpit color display presentations are available with minimum impact on system size, power or cost.

In the initial period of this program, as covered in the first Interim Report, the basic feasibility of the HCCM was verified and an initial breadboard unit was designed and constructed. Partitioning and preliminary mechanical packaging studies for the Advanced Development Models were completed and initial printed circuit board layout was begun. During the second interim period as reported on herein, Norden has produced a refined breadboard system, more suitable for demonstration and evaluation, and has conducted further development and fabrication and test of the Advanced Development Models.

2.2 Statement of the Problem

The basic problem addressed by this program is the development of a high contrast display indicator capable of being demonstrated in flight in conjuntion with an AN/APR-39 radar warning system. The indicator is to be compatible with both the (V)1 and (V)2 versions of this system and additionally is to operate in a general purpose X-Y mode.

Key to the success of the program is the development of a compact color switch capable of rapidly driving the CRT anode voltage through an 8 kV range. Switch size, complexity and dissipation must be minimized to permit packaging within the overall module outline dimensions. Additionally, switching speed and settling time must be optimized to permit writing shortly after the color switch commands.

Since the color HCCM is required to operate at anode voltages far in excess of the monochrome AN/APR-39 indicator (18 kV vs. 7.5 kV), deflection currents are intrinsically greater in the former. Care must be taken that deflection power be minimized to avoid undue thermal stresses within the box.

To attain optimum performance within the exacting guideline specified, it is an unwritten requirement that the HCCM be designed synergistically, so that operational requirements are satisfied by the functional elements in a manner that reduces parts count and power, and maximizes performance.

2.3 Technical Guidelines

2.3.1 Scope: High Contrast CRT Module

These technical guidelines outline a program describing the performance, design, development and testing of a CRT display module for airborne use, incorporating a newly developed high contrast CRT. The module, when interfaced to the AN/APR-39 or other similar equipment, shall provide a multi-color display comfortably legible in direct sunlight. The program objective is for the module to meet all performance guidelines enumerated herein. The module shall be designed to be electrically and physically compatible with the AN/APR-39 for test and evaluation purposes.

2.3.2 Applicable Documents

2.3.2.1 The following document of the issue in effect on the date of the request for proposal form a part of this technical guidelines except as specified herein. In the event of conflict between the documents referenced herein and the content of this technical guideline, the contents of this technical guideline shall be considered a superseding requirement.

2.3.2.2 Military Specifications:

MIL-E-1	Electron Tubes, General Specification for
MIL-S-19500	Semiconductor Device, General Specification for
MIL-E-5400	Electronic Equipment, Airborne Aircraft, General Specification, for
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-C-14806	Coating Reflection Reducing, for Instrument Cover Glasses
MIL-STD-810	Environmental Test Methods

MIL-R-49121(EL)	Radar Signal Detecting Set, AN/APR-39(V)1 (Confidential)
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of

2.3.2.3 Other Documents

TM-11-5841-283-20	Detecting Set, Radar Signal AN/APR-39(V)1, June 1977
TM-11-5841-283-34	Detecting Set, Radar Signal AN/APR-39(V)1(U), October 1977 (Confidential)
TM-11-5841-288-34	Processor, Digital CM-480/APR-39 (V), Control, Detecting Set C-10412/APR-39(V)(U) July 1978 (Confidential)

Specification (Preliminary) - High Contrast CRT

2.3.2.4 Army Drawings

DL-SM-B-877076	Indicator, Radar Signal IP-1150/APR-39(V)
SM-D-876940	Cover, Indicator
SM-D-876950	Chassis, LH Assembly
SM-D-876953	Panel, Front
SM-D-876983	Chassis, RH Assembly
PL-SM-B-877004	Parts List, CCA Deflection Amplifier
SM-C-877014	Light, Indicator

SM-C-877040	Indicator, Radar Signal IP-1150/APR-39(V)
SM-D-877063	Printed Wiring Board HV Power Supply
PL-SM-B-877064	CCA, HV Power Supply
SM-C-877065	Transformer, HV Power Supply
SM-C-877076	Indicator, Radar Signal
PL-SM-B-877076	Parts List, Indicator Radar Signal
SM-D-877090	Power Supply Assembly, H.V.
SM-A-877100	Coil, Tube Deflection
SM-E-877284	Connection Diagram

2.4 REQUIREMENTS

2.4.1 General

This program shall be directed towards the design, fabrication and test of an advanced development model of an airborne display module that will use a newly developed high contrast multi-color CRT. The module shall consist of the 3-inch CRT, yoke, digitally controlled high voltage power supply and the necessary deflection, focus and blanking interface circuitry required to operate the module as the display indicator for present and planned versions of the AN/APR-39. It is intended as a form, fit and function retrofit for the existing module; however a slight extra length to accommodate the switching power supply will be allowed. No external optical filters except a high efficiency antireflective (HEA) coating on the CRT faceplate are intended. Performance objectives will include, but not necessarily be limited to the features outlined in the following paragraphs.

2.4.2 Detailed Program Objectives;

2.4.2.1 Performance

2.4.2.1.1 Displayed Information

The module shall be capable of displaying graphical data and alphanumeric symbology. Strobe-type displays shall be the primary graphic display consideration.

2.4.2.1.2 Cathode Ray Tube

The display device shall be a newly-developed penetration screen CRT type with superior contrast capabilities. It incorporates a transparent phosphor and black background with a nominal 3" diameter faceplate. Preliminary specifications for the CRT are referenced in paragraph 2.3.

2.4.2.1.3 Display Luminance

The CRT luminance as a result of signal modulation shall be sufficient to produce a comfortably legible display under dynamic writing conditions, consistent with 3.2.1.5. To this effect, each color should be capable of luminance levels of a minimum of 20 fl. The intensity of each available color is to be internally adjustable within the module to allow a single front panel mounted intensity control on the module to provide satisfactory legibility of displayed information under all ambient conditions.

2.4.2.1.4 Display Uniformity

The CRT luminance over the active viewable area, for any selected color and all colors, when operated at a set anode voltage for optimum color discrimination, shall not vary more than plus or minus 20% of the average brightness determined over the screen as determined under dynamic writing conditions.

2.4.2.1.5 Legibility

The display symbology or strobes shall be comfortably viewable at angles with plus or minus 30 degrees to the display normal under all ambient conditions from direct sunlight (10,000 fc), to moonless night conditions (.001 fc). Reflection reducing coatings such as HEA coating, per MIL-C-14806, shall be used to reduce specular reflectance at the CRT front surface.

2.4.2.1.6 Night Vision Goggles

The display should be comfortably legible with use of night vision goggles, independent of display color, and the module shall not therefore be a source of stray light under any circumstances.

2.4.2.1.7 Symbol Line Width

Symbol line width for all colors shall not exceed 0.012 plus or minus 0.004 inch when luminance is sufficient to meet the high ambient conditions at the scanning speed stated in paragraph 3.2.1.8.

2.4.2.1.8 Writing Conditions

The luminance and line width requirements shall be measured under typical AN/APR-39 display conditions. A 20,000 in/sec scanning speed at 2.5 kHz refresh, 12% duty cycle, for all colors for strobe displays and a scanning speed of 50,000 in/sec at a 50 Hz refresh rate, 1% duty cycle for all colors for symbology could be typical.

2.4.2.1.9 Spot Position

The center of the nondeflected, focused spot for all color fields shall fall within a circle of 1/16 inch radius concentric with the center of the tube face, with the tube shielded. X and Y deflection centering controls shall be screw driver adjustable to the optical center of the display, internal to the module if required.

2.4.3 High Voltage Power Supply

2.4.3.1 Physical Size

The anode power supply shall be designed to fit within the overall dimensions of this module. Some allowance is permitted for lengthening of the overall module, maximum increase not to exceed 3-inches. This power supply shall be encapsulated for electriclal isolation and environmental conditions. It is desireable that the anode supply be contained within a single housing.

2.4.3.2 <u>Anode Voltage Levels</u>

Two anode ranges shall be provided. A voltage range of approximately 10 kV to 18 kV is of primary concern and a reduced voltage range of approximately 7 kV to 12 kV is of secondary concern. The two ranges may be incorporated into a single supply or interchangeable single range units may be utilized. Each voltage range shall be capable of four voltage levels, each level coincident with a different defined color from the CRT. Intermediate voltage levels shall be internally adjustable.

2.4.3.3 <u>Anode Current Characteristics</u>

The anode current supply should be sufficient to operate the CRT consistent with the preliminary CRT specifications (2.3.2.3) and paragraph 2.4.2.1.

2.4.3.4 <u>Color Control</u>

Means shall be provided and contained within the module to digitally control the anode voltage level with a two bit TTL command. This control signal shall be interfaced to the rear of the module in the form of a standard connector or incorporated into the main module interface connector. A test point is desirable to monitor the anode voltage without direct connection to the high voltage output.

2.4.3.5 <u>Anode Voltage Switching Time and Repetition Rate</u>

The switched anode voltage level shall reach 0.5% of its final value in 75 usec. Switching or repetition rate of the supply shall be considered in relation to the AN/APR-39 system. A maximum repetition rate is desirable in addition to the above characteristics.

2.4.3.6 <u>Anode Voltage Switch Busy Signal</u>

Means shall be provided in the form of a TTL level signal, to sense when the anode voltage power supply is in the switching mode in order to disable data flow until a quiescent voltage level as per 2.4.3.5, is reached.

2.4.3.7 Input Power

The anode power supply shall operate from typical +28VDC aircraft power supplies as per MIL-STD-704. Total current drain should be less than 1 amp.

2.4.3.8 Output Voltage Characteristics

Regulation to line or load shall be 0.5% or less. Output ripple at all voltage levels shall be 0.1% to peak or less.

2.4.3.9 High Voltage Output Connector

A standard high voltage output connector, such as AMP 832692, shall be used to connect to the anode lead of the CRT.

2.4.4 CRT Sensitivity Correction

2.4.4.1 Deflection Sensitivity Correction

Means shall be provided within the module to electrically correct for the change in deflection sensitivity with anode voltage change. Such correction should be controlled from the color bit input signals and result in a maximum convergence error not to exceed 0.006 inch anywhere over the usable area of the screen.

2.4.4.2 Focus Sensitivity Correction

If necessary to meet the requirements of 2.4.2.1.7, means shall be provided within the module to electrically correct for the focus sensitivity change with anode voltage. It is desirable that focus sensitivity correction be controlled from the color bit input signals.

2.4.5 Controls

The module front panel shall include only a single luminance control. The luminance of the display shall be continuously variable to meet paragraphs 2.4.2.1.5 and 2.4.2.1.6 in less than one revolution of the control knob.

2.4.6 Module Signal Input Interface

The module shall be capable of functioning as the display module for the AN/APR-39 system at given anode voltage, and interface through the approved connector 2JI, as per Drawing SM-C-877040.

2.4.6.1 APR-39 Deflection Interface

The deflection interface of the subject module shall be compatible with the current deflection interace of the AN/APR-39 as noted in Para. 3.5.1.6.1 of MIL-R-49121(EL), 10 Mar 1977 Confidential.

2.4.6.2 General Purpose Deflection Interface

In addition to the special APR-39 deflection system, a general purpose deflection system, shall also be provided. To this effect, a random scan mode of operation using X & Y bipolar voltage deflection signals compatible with conventional random scan display generators (see deliverable item #3) shall be incorporated. It is desireable that such incorporation be included in the module, with the two deflection schemes conveniently switchable, however this added capability may be included in a minimal sized add-on, or as two separate modules. These alternatives should be analyzed in the proposal.

2.4.6.3 Unblank Interface

The unblank interface of the module shall be compatible with unblank characteristics of the AN/APR-39 as noted in TM-11-5841-283-20.

2.4.6.4 Missile Alert Light

The missile alert light shall meet the requirements set forth in paragraphs 2.4.2.1.5 and 2.4.2.1.6.

2.4.7 Service Conditions

It shall be considered a goal of this program that the module be designed for quality and environmental standards comparable to that of the existing AN/APR-39 indicator module.

2.4.7.1 Environmental

Although qualification testing is not part of this program, the module should be designed and fabricated to meet certain environmental conditions as noted in MIL-STD-810, specifically:

Vibration: Method 514.2, Procedure I, Part I, Curve B (2g)

Shock: Method 516.2, Procedure I, in accordance with Figure 516.2-2 for flight vehicle equipment.

Temperature-Altitude: Method 504.1, Procedure I for Class 5 equipment is in accordance with Table 504.1 for equipment in the non-operating simulated 40,000 feet above sea level mode shall be used.

Humidity: Method 507.1, Procedure II, with test measurement Step 4 and during the last five hour period of the fifth 48-hour in step 6. Moisture accumulation on the face of the module shall not constitue failure of test.

2.4.7.2 Primary Power

The module shall remain safe and operate normally under changes in prime power as per MIL-STD-704 and MIL-R-49121(EL). It is desirable that the module power supply current be minimized when operated at the nominal +28VDC normal aircraft operating voltage.

2.4.7.3 Form Factor and Weight

The module shall be identical to the existing AN/APR-39 module as per TM-11-5841-283-20, with some allowance for greater length (see 3.2.2.1) and weight, if necessary.

2.4.7.4 Electrical Connections

The electrical connections on the module shall be compatible with AN/APR-39 system as per paragraphs 3.2.5.

2.5 Testing, Documentation and Drawings

2.5.1 General

It shall be a requirement of this program that sufficient engineering drawings and complete documentation covering all components, assemblies and circuitry be included to enable follow-on programs by qualified system contractors.

2.5.2 Performance Testing

An appropriate number of modules shall undergo engineering testing to assure that they meet the requirements of these guidelines, and all data shall be appropriately recorded. Tests shall include transfer characteristics and tolerance limits on all interfacing parameters to insure that tolerance limits are adequate to insure module interchangeability. Paragraphs 2.4.1.2, 2.4.2.1.3, 2.4.2.1.4, 2.4.2.1.5, 2.4.2.1.6, 2.4.2.1.7, 2.4.3.5, 2.4.3.7, 2.4.3.8, 2.4.4.1, and 2.4.7.1, shall be emphasized.

2.5.3 Module Display Scenarios

Static displays of typical AN/APR-39 scenarios shall be provided and utilized for evaluation and demonstration of the capabilities of the display module when operated in the AN/APR-39 modes.

3.0 TECHNICAL APPROACH

3.1 Functional Description

The HCCM may be described by the functional block diagram of Figure 1.

Anode voltage for the CRT is derived from a color switch transformer whose output is offset by a baseline HVPS. The color switch output dynamic range is plus or minus 4KV around the baseline HV output, while the latter is itself adjustable from 10KV to 18KV. For monochrome operation, such as in the APR-39(V)1 mode, the color switch transformer differential output is held at zero, and the baseline HVPS output is varied between 10KV and 18KV to produce the different colors. For multicolor operation such as in the APR-39 (V)2 mode, the baseline HVPS output is set to 14KV and the different colors are addressed dynamically by the color switch transformer. The anode voltage range 10KV-18KV is accessed by dynamically operating the switch transformer in the range plus or minus 4KV. This transformer is under control of the color switch driver which sets up the required waveforms in response to incoming color bits.

The anode voltage is sensed and used to provide dynamic control of the deflection sensitivity as a function of color. Regulation of the baseline HVPS is provided by sensing the baseline focus output voltage.

Deflection system sensitivity is maintained by a combination of programmed gain adjustment as a function of color bits, and linear correction based on dynamic sensing of the actual CRT

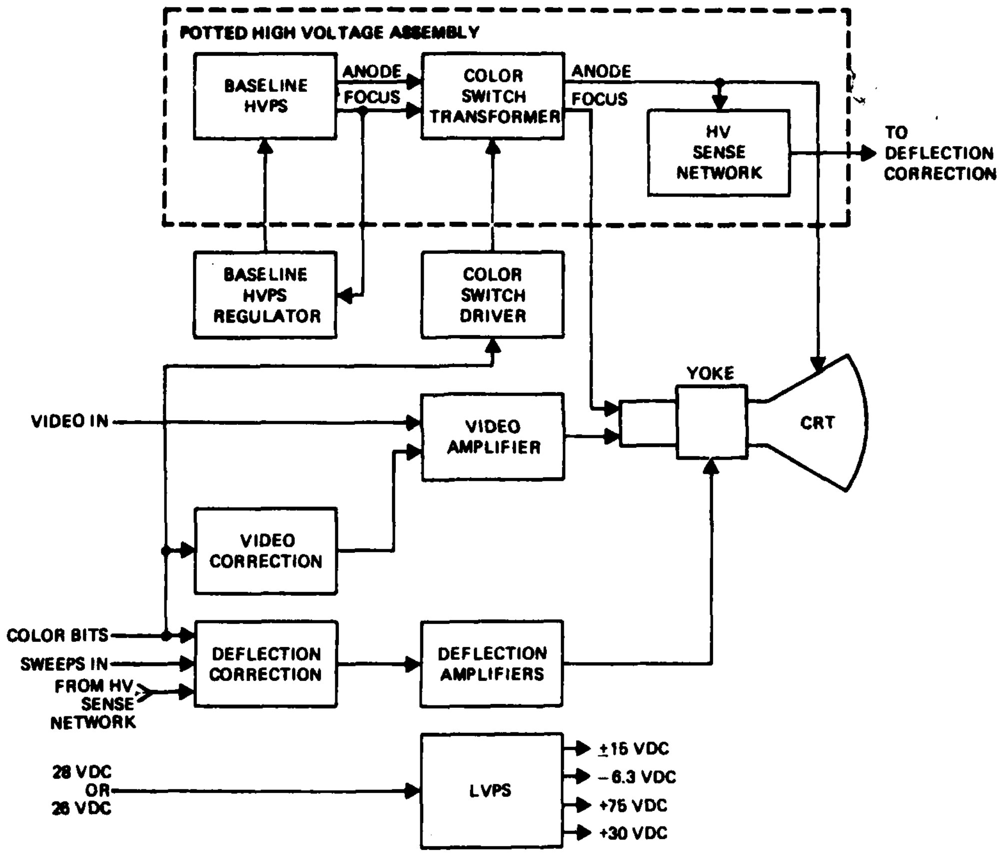


Figure 1. HCCM Functional Block Diagram

anode voltage. The deflection amplifiers are current sinking amplifiers driving a 4 winding push-pull deflection yoke. Power dissipation is minimized by maintaining zero quiescent current in the deflection amplifiers. Deflection system power dissipation is thus a function of display load.

An internal LVPS operates from the line voltage and generates all the regulated voltage required for the HCCM.

3.2 Interface Description

The HCCM interface is shown in Figure 2 and is in two parts; the operator interface and the electronics interface. The operator interface consists of the brightness control and the MODE control. The brightness control varies the gain of the video amplifier. Internal circuitry adjusts the gain as a function of color such that brightness uniformity between colors is maintained over the entire range of the brightness control.

The MODE control selects between V1 and V2 modes of operation, and serves basically to set the color levels on the HCCM. Since the V1 mode is monochrome, selection of this mode disables the color control circuitry from the incoming color bits. Instead, color (RED or GREEN) is determined by the position of the MODE control when selecting V1 mode. In the V2 mode, color is determined by the incoming color bit pattern, which selects between RED, ORANGE, YELLOW, and GREEN. Additionally, a standby (STDBY) mode position is provided, in which the CRT anode voltage is held at zero.

The electronics interface to the HCCM consists of power and signal lines. The power interface is from a single DC source. In the V1 mode, this source is unregulated 28VDC (per MIL-STD-704), while in V2 mode the HCCM interfaces with a 26VDC regulated source. This difference is primarily due to the need to limit power dissipation in the V2 mode by limiting input voltage excursions, much the same as in the monochrome V2 system.

The video input signal is a TTL compatible unblanking signal which gates the video amplifier. CRT drive is internally adjusted as a function of color to maintain intercolor brightness uniformity.

The deflection inputs are differentially received. The four sweep inputs from the AN/APR-39 system are combined into two bidirectional signals, horizontal and vertical. Color correction is applied to these signals and they are then channelled into four unidirectional signals to drive the yoke. In the random scan XY-mode, the horizontal and vertical sweep signals are applied directly to the horizontal and vertical receivers. The

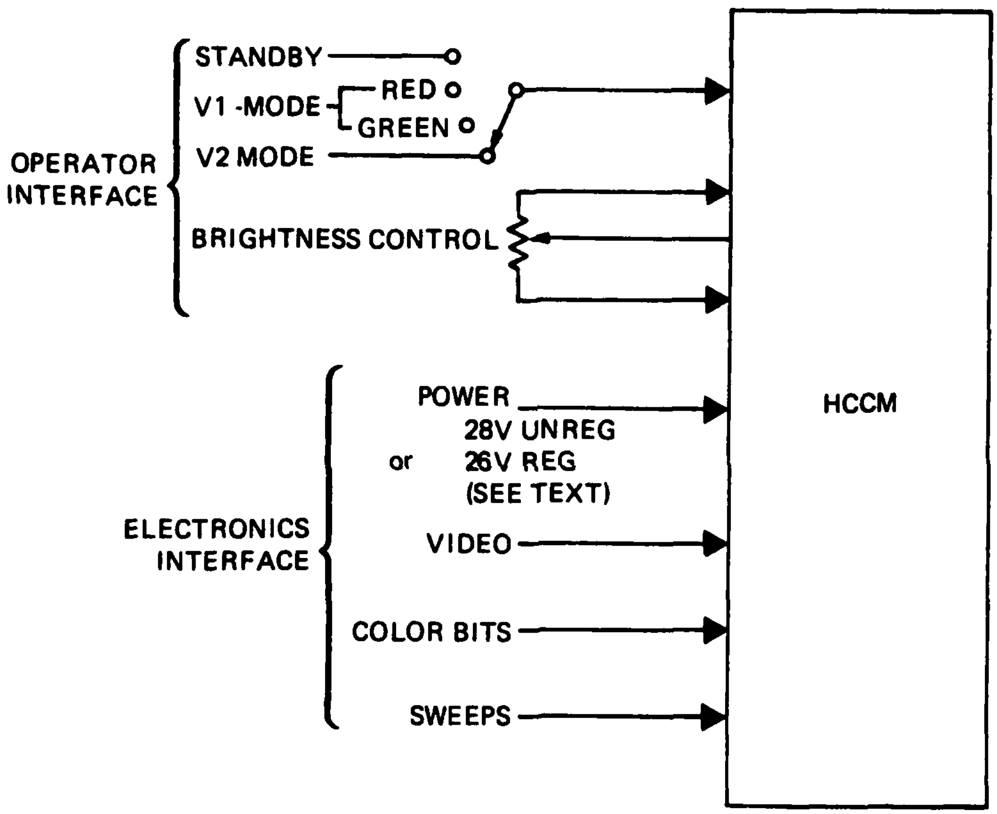


Figure 2. HCCM Interface

coordinate transformation between the random scan and AN/APR-39 display modes may be effected by a 45 degree rotation of the yoke.

Three color bits interface the HCCM. The two color control bits determine the color to be displayed, however the actual high voltage transition does not occur until the enable bit is activated.

4.0 TECHNICAL STATUS

4.1 Breadboard

A refined breadboard version of the HCCM has been developed and is illustrated in Figure 3. The system uses the same circuit modules as the original breadboard described in the first interim report, but contains a number of improvements which enhance its use as a vehicle for demonstration and evaluation of HCCM capabilities. Unlike the original breadboard this system houses a prototype 3-inch thin film high contrast CRT developed by Watkins-Johnson and provided as GFE by ERADCOM. Furthermore, in this unit, the high voltage elements are interconnected within a protective housing, reducing personnel hazards. Finally this breadboard system uses a standard AN/APR-39 display module connector (2J1 per drawing SM-C-877040) for ease of interface with an AN/APR-39 (V)1 or (V)2 system exerciser. Connector pinout is standard as for the monochrome AN/APR-39 display module, with previously spare pins being used for color bits. The pin designations for this deliverable breadboard, which are the same as for the Advanced Development Models, are given in Figure 4.

Design and performance features of the breadboard system are similar to those for the Advanced Development Models (ADMs). With minor modifications, the breadboard circuitry has been repackaged to fit the ADM envelope. The only significant differences between the breadboard unit and the ADM units are in the color switch.

To understand these differences, recall that operation of the color switch is based on the color window principle, where a given color is accessed for a given time period (write window), sufficient to write a block of data. In the early course of this program a number of adjustments to the Technical Guidelines were made, that resulted in wider color windows being required. The color switch elements in the breadboard represent an interim stage in the development of the final system configuration.

The breadboard color switch transformer is capable of 400 microsecond color windows, compared to the 600 microsecond

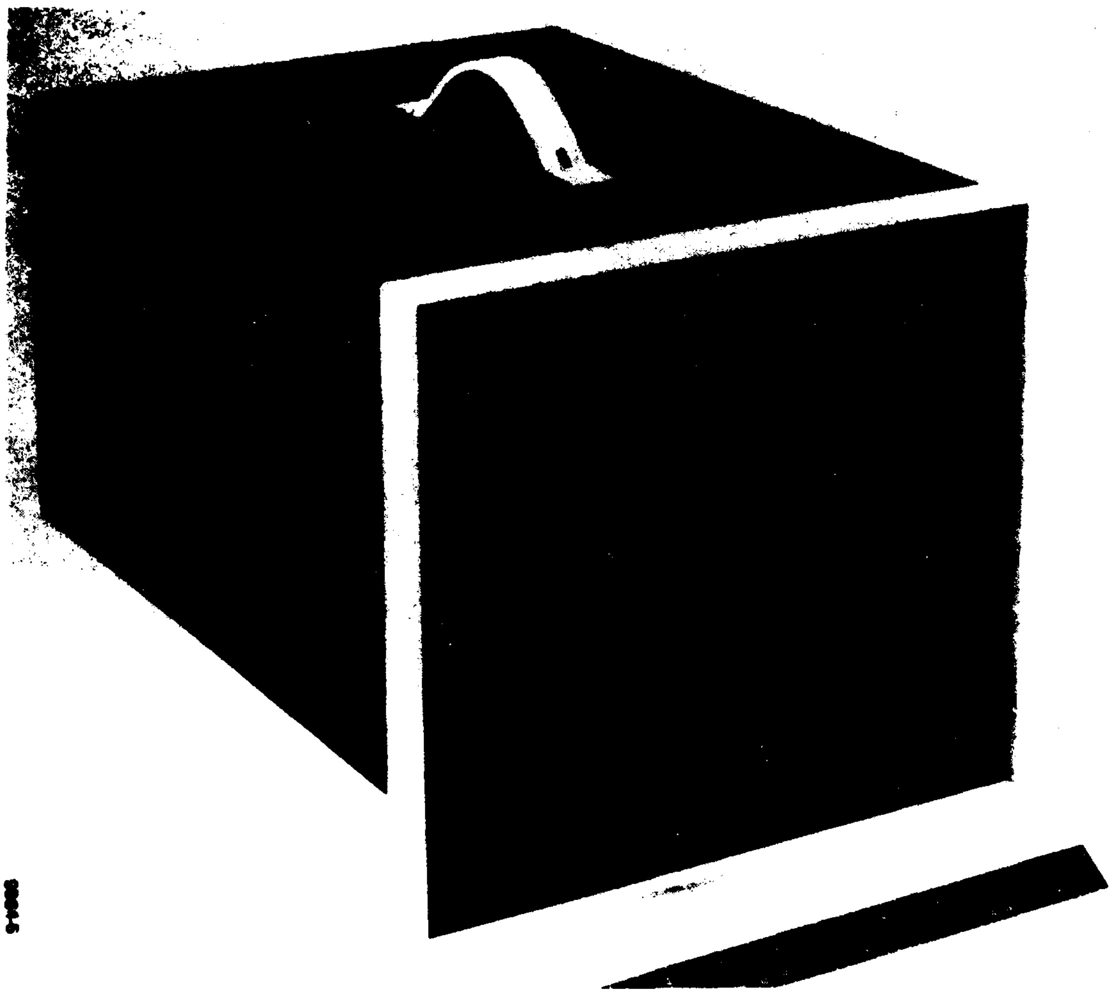


Figure 3. HCCM Breadboard

1	FR
2	AR
3	AL
4	FL
5	UNBLANK
6	SHIELD (CHASSIS)
7	(MA LAMP DRIVE)
8	SPARE
9	+26 VOLTS DC
10	26 VOLT RETURN
11	B1 (COLOR BIT)
12	B2 (COLOR BIT)
13	ENABLE (COLOR BIT)

Figure 4. Connector Pin Designations

windows provided in the ADM units. Physical size reduction in the ADM color switch transformer are due to refinements in packaging, whereas for the baseline portion of the color switch a physically smaller core was used in the ADM units, necessitating a mechanical redesign of the baseline assembly. The electrical design of the entire color switch is consistent between the breadboard and ADM versions, except for the differences noted above.

4.2 Advanced Development Model

Figure 5 shows the module partitioning of the Advanced Development Models. External dimensions of the ADM HCCM are identical to the monochrome AN/APR-39 display unit, except for an additional depth behind the mounting plane to house the additional color circuitry.

The ADM is a self-contained unit and requires only signal inputs and 28VDC power to operate. It has been designed to be compatible with the environmental stresses of the military cockpit, per the Technical Guidelines, and is cooled through free convection, without any internal or external fans.

The ADM circuitry is housed on five printed circuit modules, plus the yoke and CRT, with high voltage elements being contained in a potted high voltage unit, or brick, which forms the rear third of the unit.

A special deflection yoke was developed for this program, of much smaller outside diameter than the original (monochrome) AN/APR-39 display unit yoke: 1.875 inches vs. 2.39 inches. This reduction in yoke diameter permits extension of the printed circuit boards adjacent to the yoke and forward to the front surface of the yoke. The two inner circuit boards are notched to accommodate the yoke. These inner boards, the video amplifier and the low voltage power supply, are illustrated in Figures 6 and 7 respectively.

The two outermost printed circuit boards house the deflection and color switch driver circuitry and are illustrated in Figures 8 and 9 to Norden specifications. The power output transistors for the deflection and color switch drivers are contained in dual Darlington hybrid arrays packaged in a TO-3 configuration which are themselves mounted on heatsinks that form the outer sides of the HCCM. Two hybrid types are used, both dual Darlingtons manufactured by Solitron Devices Inc. to Norden specifications. Each printed circuit board houses one half of the color drive circuitry and one deflection amplifier channel (horizontal or vertical). The deflection hybrid, Solitron Part CBCA 116, is illustrated in Figure 10 while the color switch hybrid, Solitron

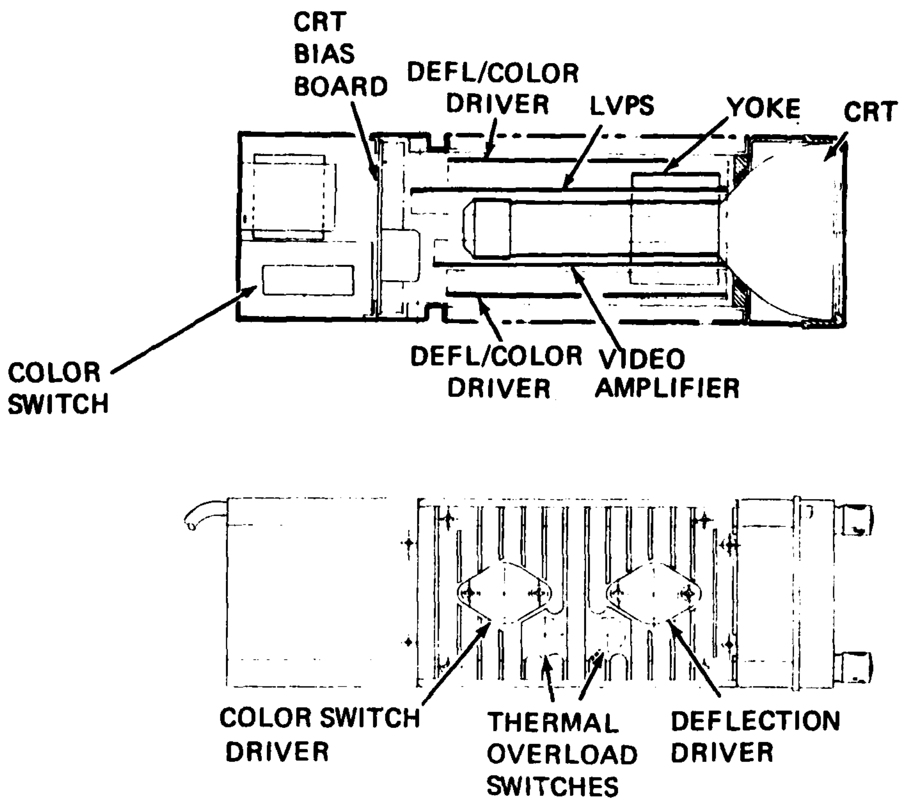


Figure 5. ADM Partitioning

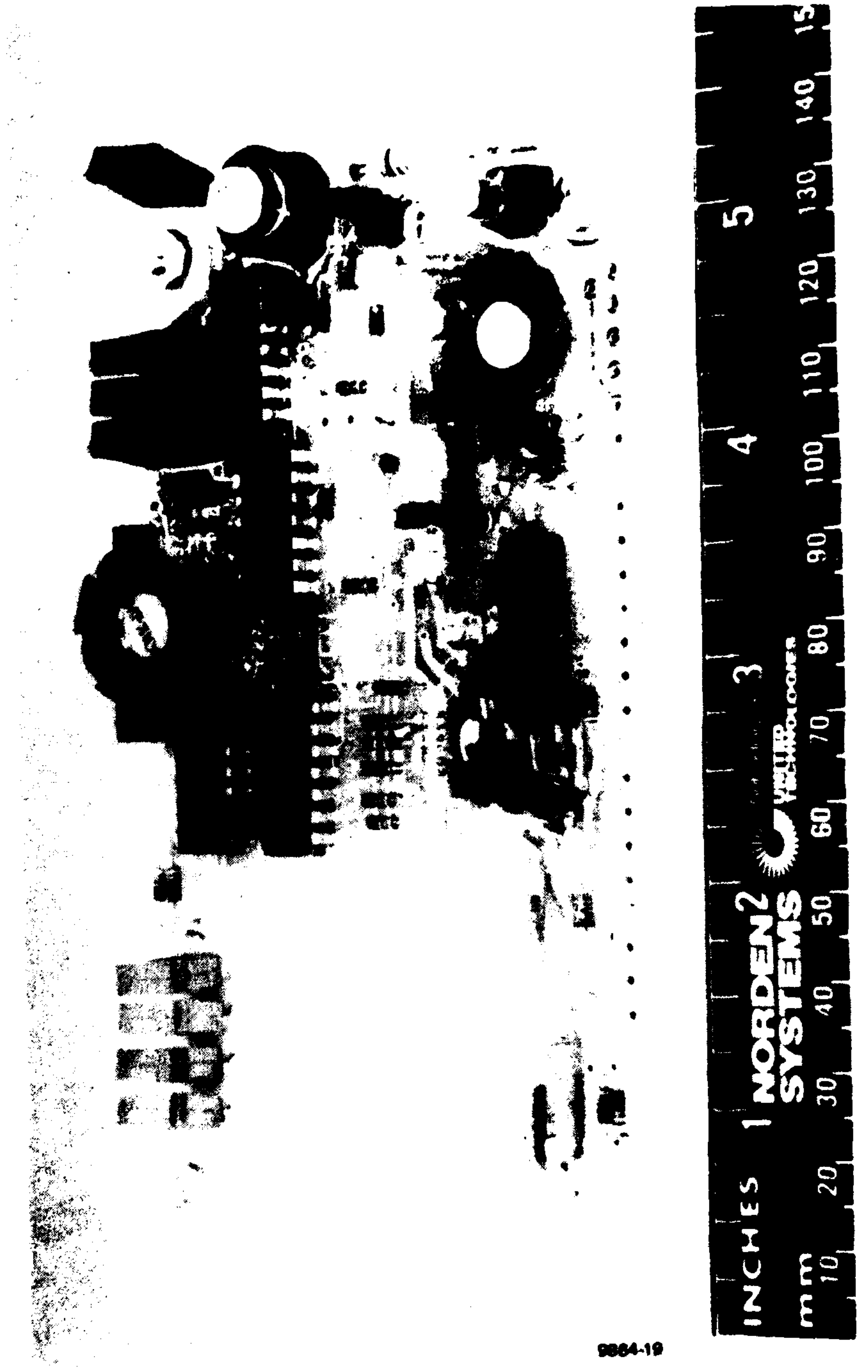


Figure 6. Video Amplifier

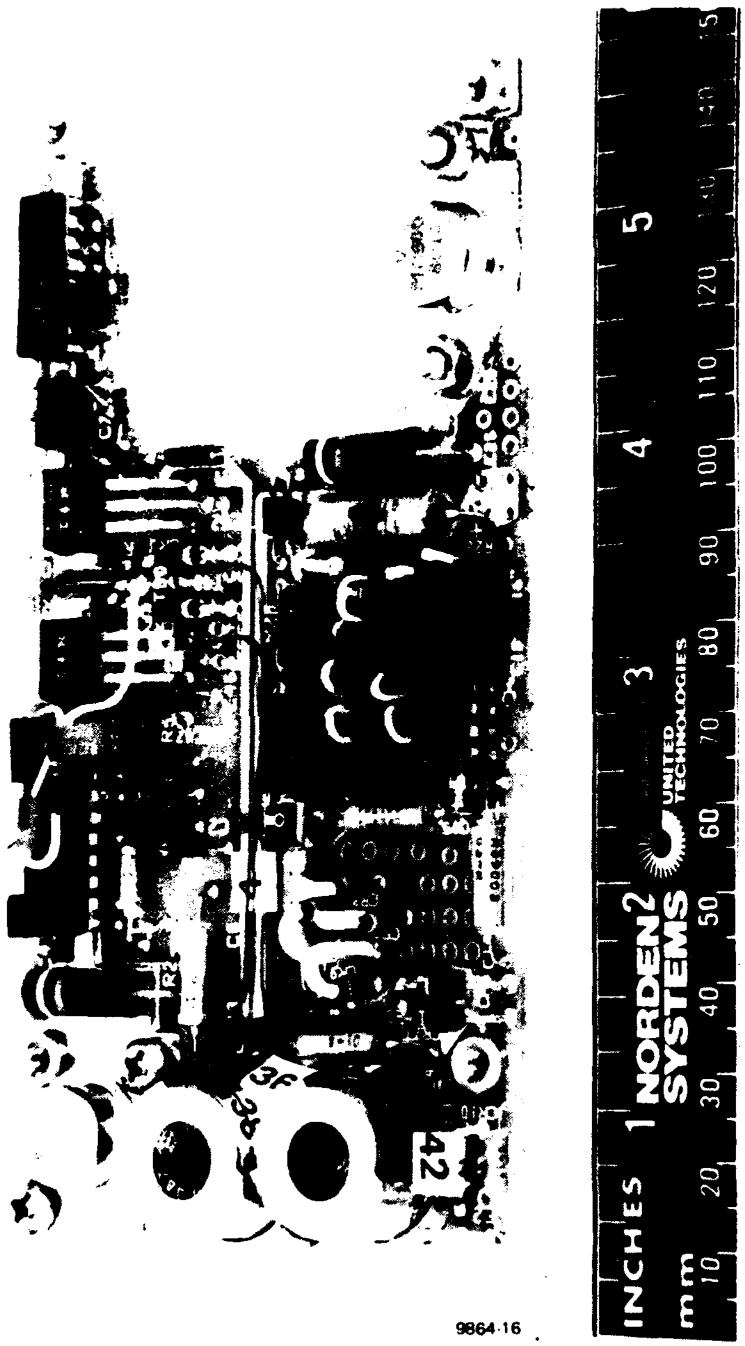


Figure 7. Low Voltage Power Supply

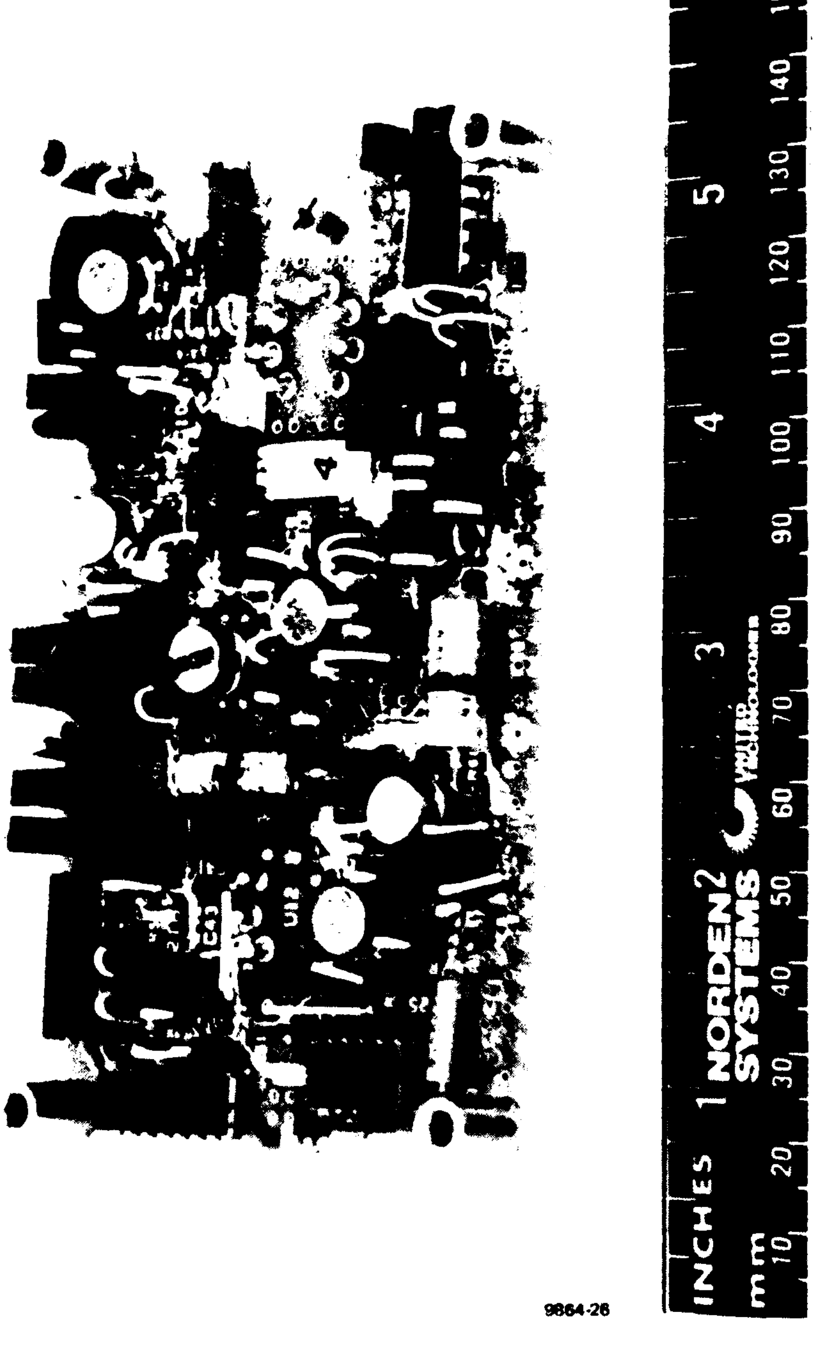


Figure 8. Horizontal Deflection Amplifier

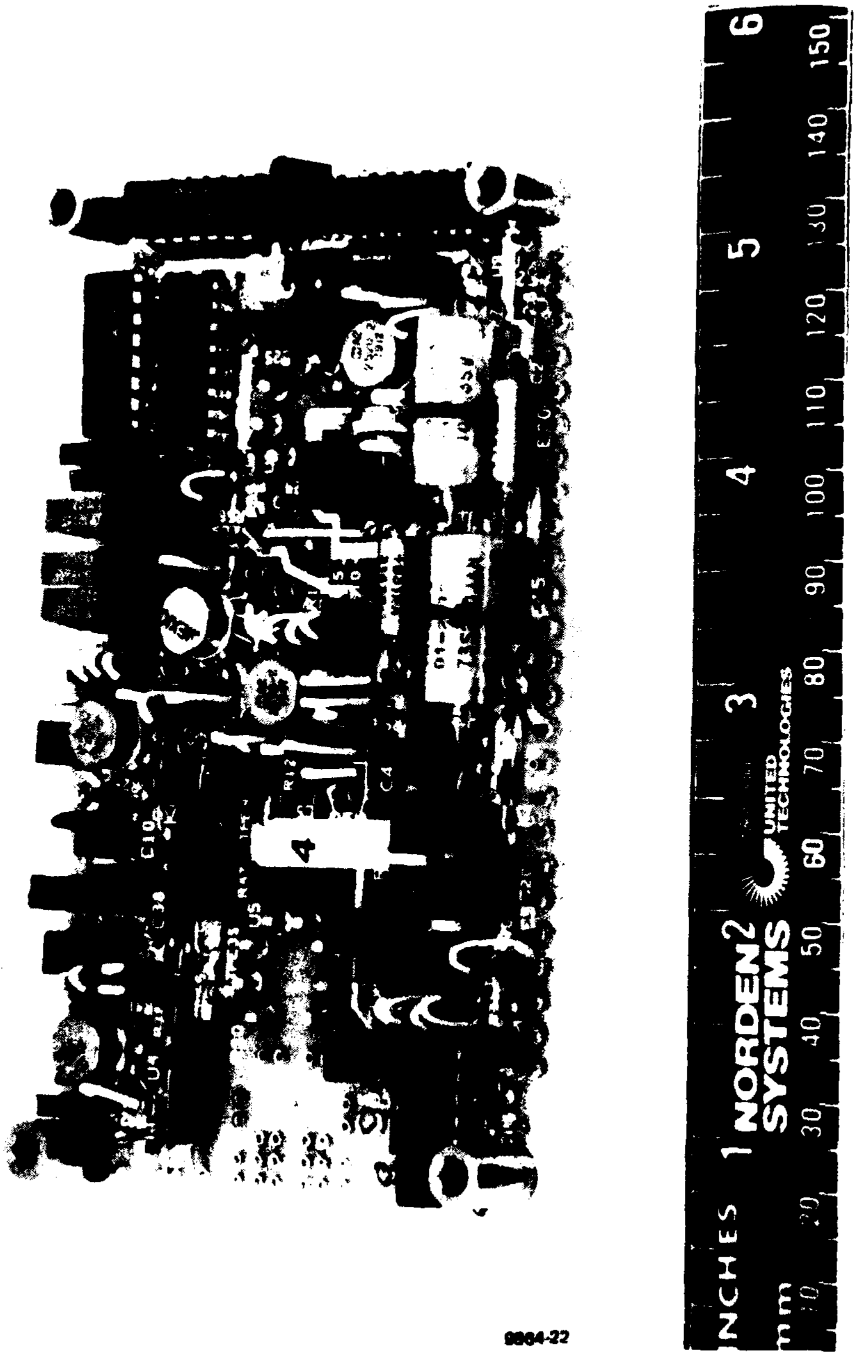


Figure 9. Vertical Deflection Amplifier

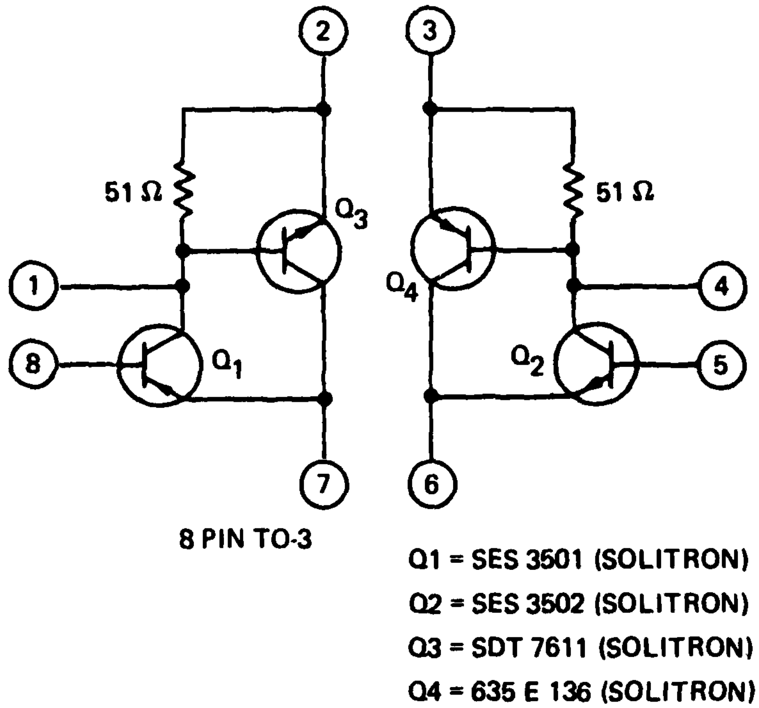


Figure 10. Color Switch Hybrid

part CBCA 117, uses a complementary NPN-PNP configuration as illustrated in Figure 11.

These assemblies also contain sweep fail and other protective circuitry. The sweep fail circuit protects the CRT phosphor by sensing loss of sweeps and blanking the tube. It senses the voltage across each of the yoke windings and generates a logic level signal if writing speed falls below a preset threshold level. This sweep fail logic signal is then transferred to the video amplifier assembly where it is used to gate the unblanking input signal in the absence of adequate writing speeds, blanking the CRT.

In addition to the sweep fail circuit, thermal switches embedded in the heatsinks near each of the power hybrids provide an additional measure of protection to the HCCM. In the event of overheating of the deflection output transistors, closure of the thermal switches engages circuitry that reduces deflection sensitivity by approximately 80%, limiting deflection currents and reducing power dissipation. When the cause of overheating is removed, the system automatically returns to normal operation.

Similarly, thermal switches sensing temperature of the color switch hybrids will respond to an overheating condition by gating the color switch enable signal, disabling the color switching and curtailing dissipation in these driver devices. Here too, the HCCM reverts to normal operation upon removal of the fault condition.

Thus, overheating in the HCCM is protected against in a manner which minimizes catastrophic failure, yet preserves the information carrying characteristics of the HCCM as far as possible.

The fifth printed circuit board is placed transversely in the HCCM, in front of the high voltage brick. This board, denoted the CRT bias board and shown in Figure 12, contains the main interface to the high voltage brick. Critical high voltage sensing for the color correction circuitry is on this board as are the focus and G2 outputs for the CRT. This assembly also contains the output drive components baseline HVPS regulator. The focus adjust controls are located on this board also.

The high voltage brick contains all of the high voltage elements of the HCCM. A block diagram is shown in Figure 13. The key elements in the brick are the baseline and color switch transformer assemblies, shown in Figures 14 and 15 respectively, with the breadboard unit assemblies shown for a size comparison. Exploded views of the ADM baseline and color switch transformer assemblies are shown in Figures 16 and 17, respectively.

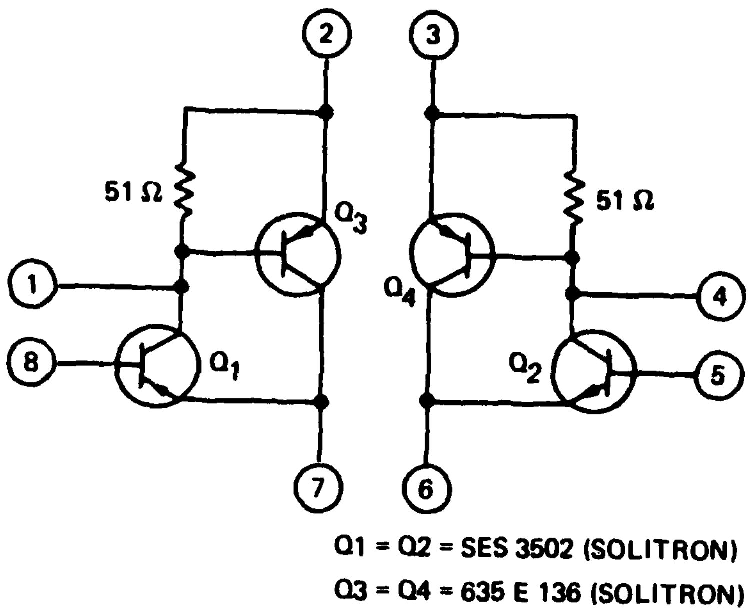


Figure 11. Deflection Hybrid

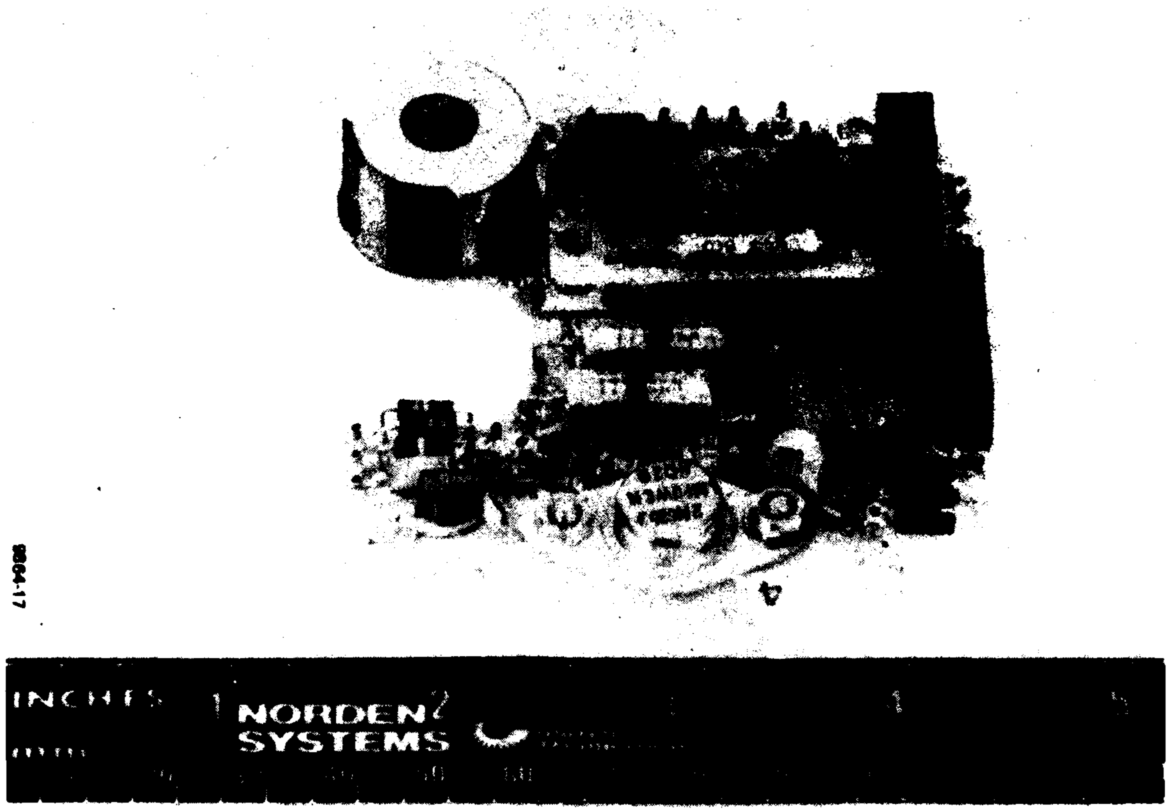


Figure 12. CRT Bias Board

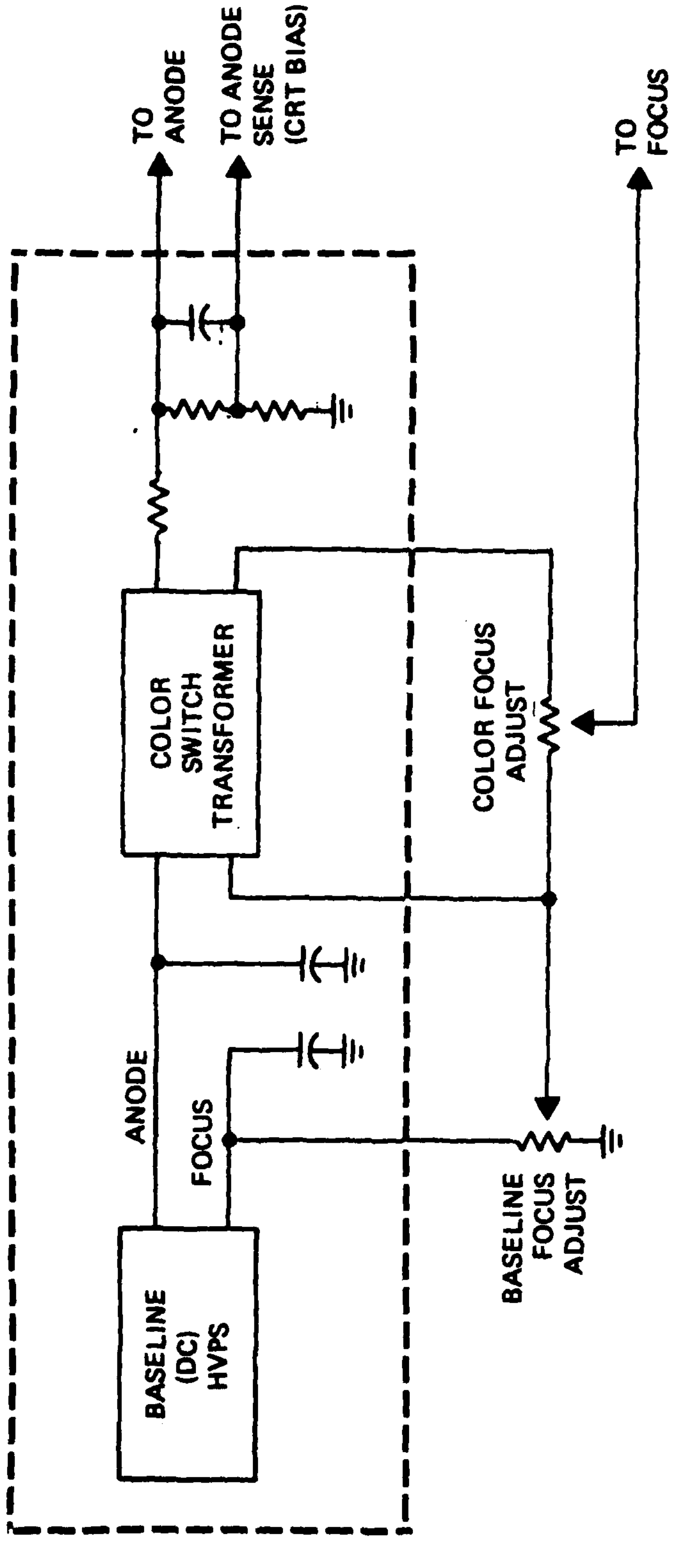


Figure 13. HV Brick Block Diagram

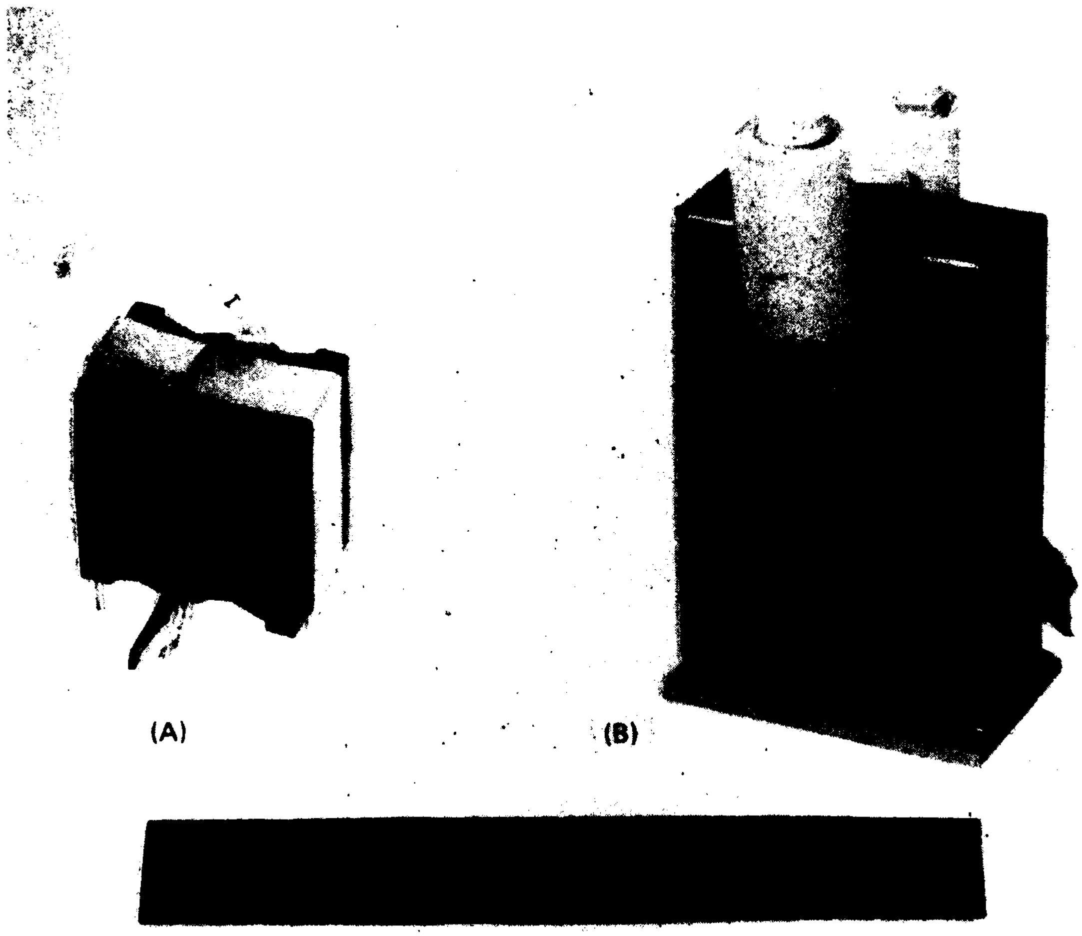


Figure 14. Baseline HVPS (A) ADM (B) Breadboard

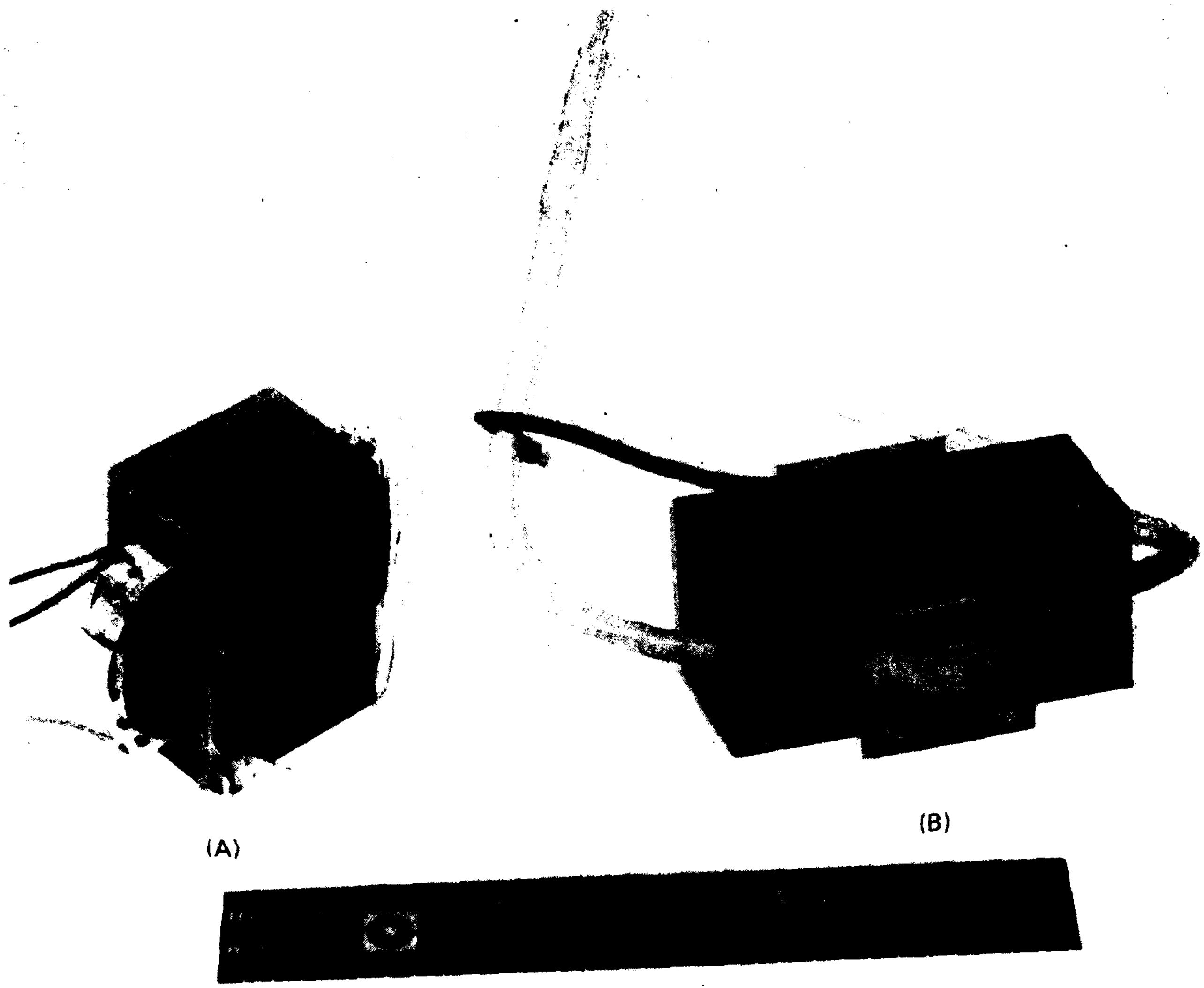


Figure 15. Color Switch Transformer (A) ADM (B) Breadboard

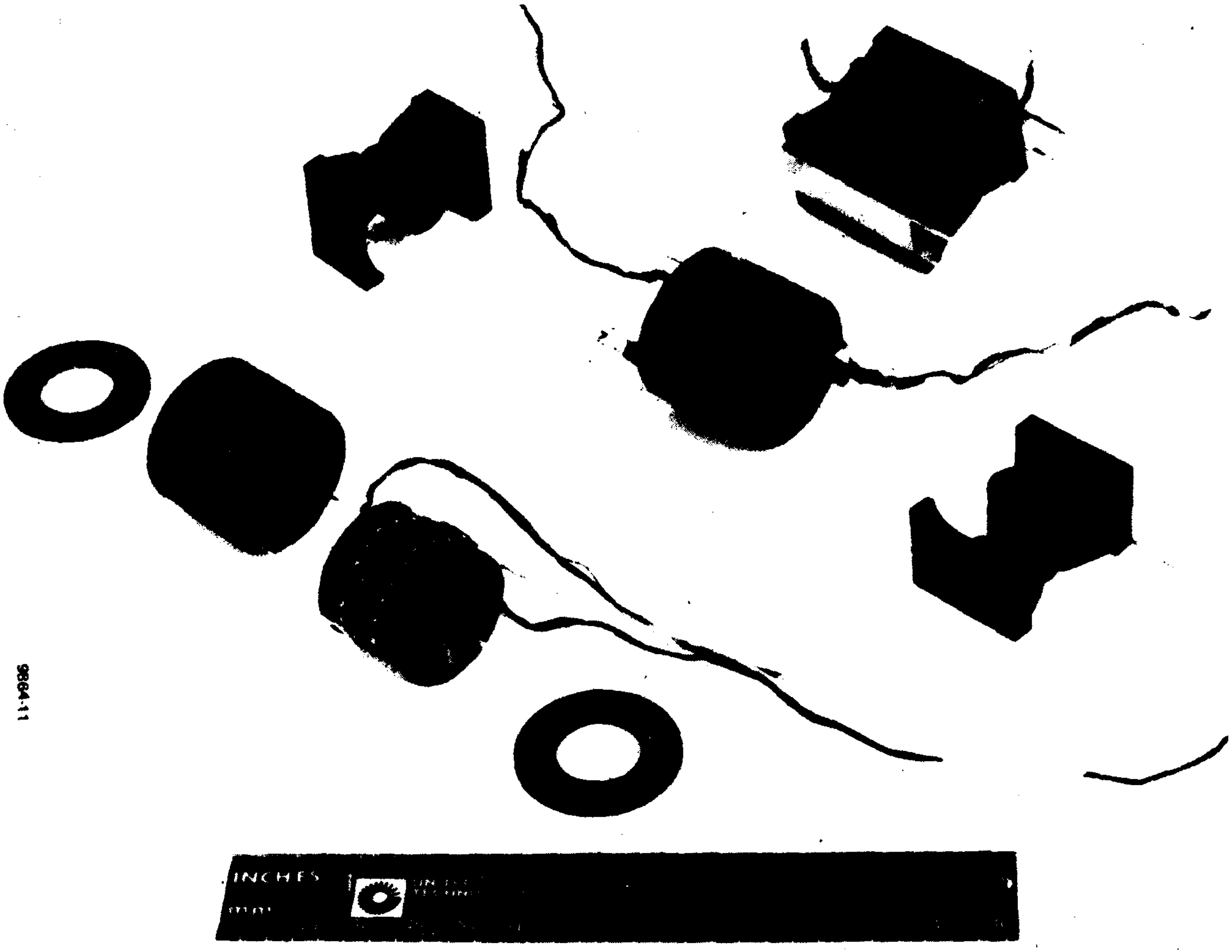


Figure 16. ADM Baseline HVPS Assembly

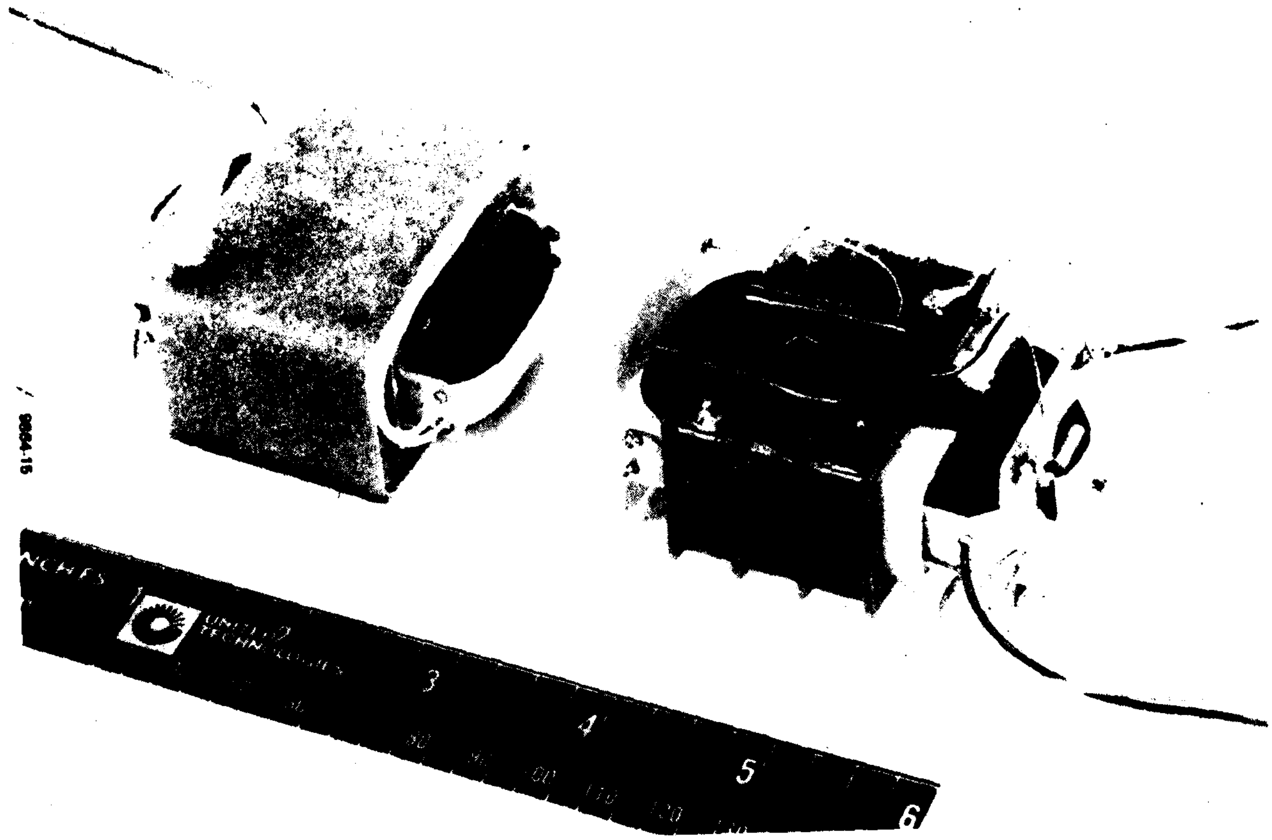


Figure 17. ADM Color Switch Transformer Assembly

As has been described earlier, the HCCM requires a regulated 26VDC interface for (V)2 mode operation. Under laboratory conditions, a standard regulated power supply may be used for this purpose. For airborne testing and demonstration of the HCCM operating with an AN/APR-30(V)2 system, a power supply capable of interfacing with the MIL-STD 704 input line and providing regulated power to the HCCM is required. Such a supply has been ordered and delivery to Norden is expected early in 1981. The unit is the Tecnetics model 3100-28-128 DC to DC converter. Specifications and physical characteristics of this unit are shown in Figure 18. It is anticipated that this unit will be demonstrated and delivered to ERADCOM with one of the ADM units, to enable airborne testing of the HCCM.

5.0 CONCLUSIONS

The first interim period of this program had demonstrated the feasibility of the basic concepts to be used in the HCCM. In the second interim period, these basic concepts have been refined and the design of the Advanced Development Models has been completed. Printed circuit boards are being assembled and unit fabrication is underway. Additionally a breadboard unit has been completed and is expected to be delivered shortly to ERADCOM. This unit will demonstrate the performance capabilities of the HCCM.

The concepts being reduced to practice in this program should form the basis for a new class of miniature color display indicators. The versatility of the color window concept has been demonstrated, and completion and demonstration of the ADM units operating in conjunction with the high contrast CRTs being developed by ERADCOM should extend the arena of applicability of color displays in the military cockpit.

6.0 PROGRAM FOR NEXT INTERIM PERIOD

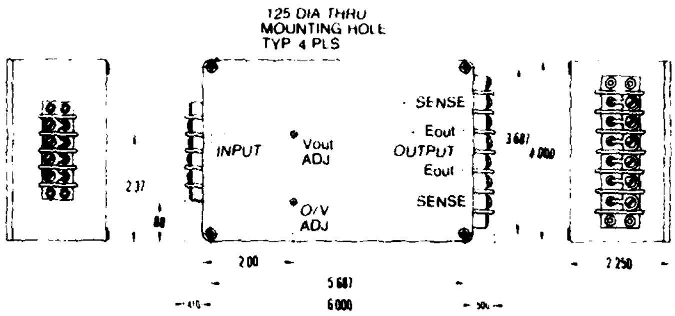
This program will be completed during the next interim reporting period. Early in this period, the breadboard HCCM unit will be delivered to ERADCOM and will be used there to verify performance and demonstrate the capabilities of the high contrast CRTs.

Overall, six Advanced Development Models will be fabricated and delivered to ERADCOM. These will demonstrate HCCM compatibility with the AN/APR-39 physical requirements and will permit ground and flight evaluation of the units operating with the (V)1 and (V)2 systems.

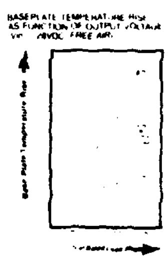
DC-DC High Efficiency Regulated Converters, 28Vin and 48Vin

100 Watt 3100 Series

Features at a glance — Efficiencies up to 79% — Power densities up to 1.85 Watts per cubic inch — Short circuit protection — Remote error sensing insures proper voltage at point of load



NOTE
Dimensional tolerances
1 Length width height ±0.05
2 adj location ±0.10
3 all other dimensions ±0.02



Dash Number	Output Voltage Volts Nom.	Output Current Amps Nom.	28Vin Model 3100-28 Typical Efficiency FL
128	28	3.57	75

Specifications

Input:
Voltage 3100 28 xxx
28VDC nominal
Range 21.5 to 32VDC continuous
36VDC for 5 sec max
Reverse protection to 100VDC
Current 0.2A max at no load

Output:
Voltage and Current (see chart)
Voltage adjustment ±5% by screwdriver control accessible through hole in cover

Regulation:
Line (Low and High)	0.3%
Load (1/2L to FL)	0.1%
Load (NL to FL)	0.4%
Temperature	0.005%/°C typical
	0.01%/°C max

Ripple:
V (peak to peak) less than 2% of rated output voltage
Frequency 50KHz ±10%

Load Transient Recovery Time
No load to full load recovery time 150μsec max
under shoot less than 5%
Full load to 25% load recovery time 150μsec max
over shoot less than 3%
Full load to 3% load recovery time 1.0 msec max

Impedance
0.003 ohms/volt output 0-10KHz

Remote Error Sensing:
Separate remote sensing terminals are provided. This feature will correct for load lead voltage drops of up to 10% Vout

Polarity
Output is isolated, either output terminal may be grounded

Protection:
Overload and short circuit of any duration by current limit (115-130% of nominal Iout)
Overvoltage (option) at 110-130% of nominal Vout

Isolation:
Input to output	1000VDC
Input to case	500VDC
Output to case	500VDC

MTBF:
25,000 hours per MIL HDBK 217 at 70°C baseplate temperature, airborne environmental factor

Environmental:
Operating temp −55°C ambient to +90°C case
Storage temp −55°C to +105°C
Base Plate Temperature Rise: See graph
Vibration, shock, humidity and altitude: designed to meet the requirements of MIL E 5400P

EMI:
Input filter reduces reflected power line ripple

Mechanical:
Dimensions 6 × 4 × 2.25 inches
(15.2 × 10.2 × 5.7 cm)
Terminals: barrier strip
Case: Aluminum with black anodize finish
Encapsulation: Elastomeric silicone
Weight: 60 oz fully encapsulated

Modifications:
Contact field representative or phone Tecnetics for modifications in electrical, mechanical and environmental specifications

Figure 18. 26VDC Power Supply Data Sheet

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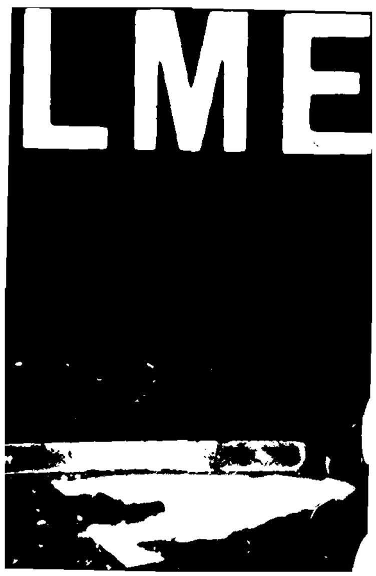
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