NASA TECHNICAL MEMORANDUM

NASA TM X- 72782

(NASA-TM-X-72782) SOLID-STATE TURN COORDINATOR DISPLAY (NASA) 16 p HC $3.50 CSCL 01D

N76-32186

Unclas
G3/06 04078

NASA TM X-72782

SOLID-STATE TURN COORDINATOR DISPLAY

By Barry D. Meredith, Roger K. Crouch,
and W. Lane Kelly, IV

This informal documentation medium is used to provide accelerated or special release of technical information to selected users. The contents may not meet NASA formal editing and publication standards, may be revised, or may be incorporated in another publication.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA 23665

1. Report No. NASA TM X-72782	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Solid-State Turn Coordinator Display		5. Report Date August 1975
		6. Performing Organization Code
7. Author(s) Barry D. Meredith, Roger K. Crouch, and W. L. Kelly, IV		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address NASA-Langley Research Center Langley Station Hampton, VA 23665		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics & Space Administration Washington, DC 20546		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A solid state turn coordinator display which employs light-emitting diodes (LED's) as the display medium has been developed to demonstrate the feasibility of such displays for aircraft applications.

The input to the display is supplied by a fluidic inertial rate sensor used in an aircraft wing leveler system.

The display is composed of the LED radial display face and the electronics necessary to address and drive the individual lines of LED's.

Three levels of brightness are provided to compensate for the different amounts of ambient light present in the cockpit. Although the techniques described in this report were used to construct a turn coordinator display, they could also be used in the construction of more complex instruments.

17. Key Words (Suggested by Author(s)) Displays, LED's	18. Distribution Statement Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	14	$3.25

*For sale by the National Technical Information Service, Springfield, Virginia 22161

SOLID-STATE TURN COORDINATOR DISPLAY

By Barry D. Meredith, Roger K. Crouch,

and W. Lane Kelly, IV

SUMMARY

A solid-state turn coordinator display which employs light-emitting-diodes (LED's) as the display medium has been developed at Langley Research Center to demonstrate the feasibility of such displays for aircraft applications. The input signal to the turn coordinator display is supplied by a fluidic inertial rate sensor. The display is composed of the LED radial display face and the electronics necessary to address and drive the individual lines of LED's. Three levels of brightness are provided to compensate for the different amounts of ambient light present in the aircraft cockpit. Although the techniques described in this report were used to construct a turn coordinator display, they could also be used in the construction of more complex aircraft displays.

INTRODUCTION

The objective of the effort described in this report was to demonstrate the feasibility of the design and construction of solid-state aircraft displays employing light-emitting diodes (LED) as their display medium. The solid-state turn coordinator display was developed for this purpose. It complements a fluidic inertial rate sensor that was adapted for use in an aircraft wing leveler system (ref. 1) at Langley Research Center. The turn coordinator display provides the pilot with a visual indication of the roll and yaw rate of his aircraft. Mechanical turn coordinator displays presently in use are simple and reliable devices. However, the technique employed in the development of the solid-state LED display can be expanded to applications beyond the capability of mechanical instruments. The solid-state turn coordinator display also offers three levels of brightness to compensate for the different amounts of ambient light present in the aircraft cockpit.

SIGNAL PROCESSING

Display Input Signal

The analog input signal to the solid state-turn coordinator display is generated by a fluidic inertial rate sensor. This sensor consists basically of two self-heated thermistors in a bridge circuit with a laminar jet of air directed between each (ref. 1). When the device is subject to an angular rotation, the inertial properties of the jet causes it to be deflected as shown in figure 1. This results in unequal thermistor temperatures, and an analog difference voltage appears at the output of the bridge circuit. This output voltage varies from +0.1 to -0.1 volts, and since the sensor is tilted with respect to the longitudinal axis of the airplane, is proportional to both yaw and roll rate. The fluidic sensor output signal is used to drive the turn coordinator display as well as the wing leveler system.

Address Electronics

The initial stage of electronics (figure 2) in the solid-state turn coordinator display is an operational amplifier which amplifies the analog output of the fluidic sensor from ±0.1V to ±3.0 V. This amplified voltage is the input to a analog-to-digital (A/D) converter, whose digital signal goes to a decoder where it is decoded into one of 20 mutually exclusive outputs. The decoded output is then inverted for compatability with the LED current drivers.

LED Drive Circuitry

The LED current drivers consist of 20 transistors with a single line of 10 LED's in the emitter circuit of each transistor (figure 3). When the decoded pulse biases the selected transistor ON, drive current is allowed to flow through the transistor and LED's to ground. This drive current has a control circuit which determines the current pulse timing and duty cycle. The control circuit is a one-shot oscillator whose output is fed to the base of a transistor Q_x (figure 4). This transistor allows current to flow to the selected drive transistor; the length of time that current flows depends on the one-shot oscillator output pulse width. To control pulse timing, the status pulse from the A/D converter is utilized. The status pulse triggers the oscillator only when the output of the converter is locked into its true data levels (fig. 5). Therefore, during the A/D conversion interval, erroneous signals do not appear at the current driver outputs.

By switching between three capacitors of different values in the one-shot oscillator's RC network, the duty cycle of the one-shot output pulse is varied (fig. 6). This change in pulse width varies in length of time the control transitor is activated, thus affecting the average drive current to the LED's. Since the average intensity of the LED's is proportional to the drive current, three different display intensities are obtained.

LED RADIAL DISPLAY

To complement the solid-state electronics section of the turn coordinator display, an appropriate display face was desired. Therefore, the display medium utilizes one of the more promising technologies currently available -- light-emitting diodes (LED's). The diodes are diffused GaAsP bars, 0.25 mm wide x 1.9 mm long x 0.3 mm thick, from Bowmar Canada, Ltd. Company specifications show the peak emission to be approximately 6600 Å with a brightness of about 150 ft-L for 10 ma of current.

The LED's were mounted on a copper disc 6.5 cm in diameter. Initially, the disc was exposed to sulfur fumes producing copper sulfide which blackened the surface. Then 22 grooves were cut along diameters, with an angular separation of 5°. Each groove was approximately 0.5 mm wide and 0.3 mm deep. A hole 2.4 cm in diameter was cut in the center of the disc to provide a feedthrough for the LED power leads. The LED's were metallized by the manufacturer which enabled them to be mounted in the grooves of the disc using a conductive epoxy. Contacts to the top of the diodes were made by a ball-border using 50 μm gold wire. Since no optical coupling optimization was performed, that is, using elliptical reflectors or diffuse epoxies, five diodes were mounted in each radial portion of the grooves (fig. 7). Twenty grooves were used, making a total of 200 LED's in the display. Finally, the display was covered with a Wratten filter #29 to decrease ambient light reflections and mounted with the electronics in an aircraft instrument case (fig. 8).

POSSIBLE DIPSLAY IMPROVEMENTS

The original display developed at Langley Research Center is a prototype which could be improved with a minimal manufacturing effort. For instance, through efficient circuit board layout and packaging, the size of the unit could be reduced by a factor of two.

Also, it would require very little effort in the manufacturing process to cut the grooves of the copper disc in elliptical shapes; plate the grooves with a highly reflective coating; and after mounting the diodes, fill the grooves with an epoxy which has an index of refraction matching that of GaAsP. These procedures would increase the optical coupling to such an extent that each radial segment would require only two LED's, thus reducing the power requirement of the diodes by 60 percent.

CONCLUDING REMARKS

A solid-state turn coordinator display employing light-emitting diodes has been developed to demonstrate the feasibility of such displays for aircraft applications. It interfaces with the fluidic inertial rate sensor which was adapted at Langley Research Center for use in a wing leveler system. The solid-state display was not developed to compete with the present mechanical turn coordinator display but rather to investigate techniques that could be utilized in the develpment of more complex aircraft instrumentation.

REFERENCES

1. Garner, H. Douglas; and Poole, Harold E.: Development and Flight Tests of a Gyro-Less Wing Leveler and Directional Autopilot. NASA TN D-7460, 1974.

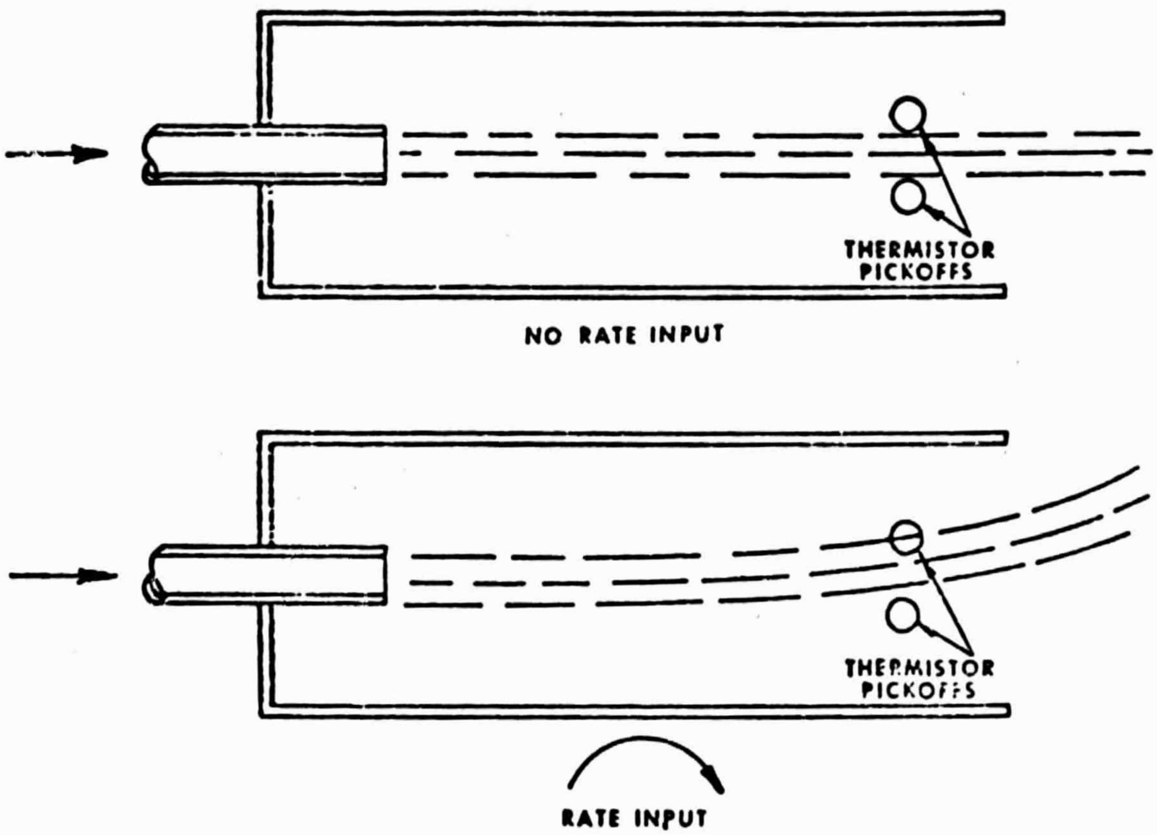

Figure 1. – Laminar Jet Rate Sensor Concept

PRECEDING PAGE BLANK NOT FILMED

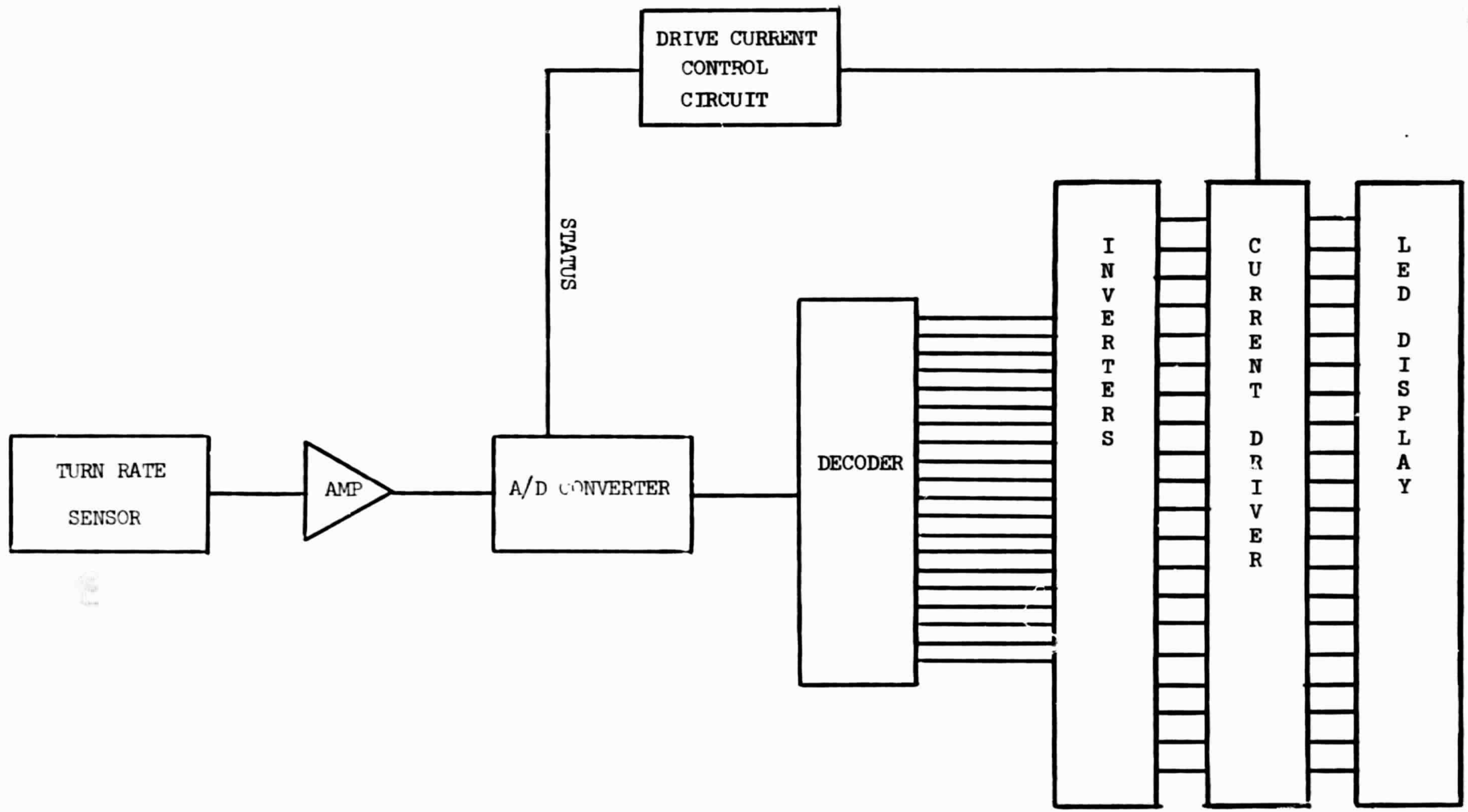

Figure 2. - Block Diagram of the Solid State Turn Coordinator Display.

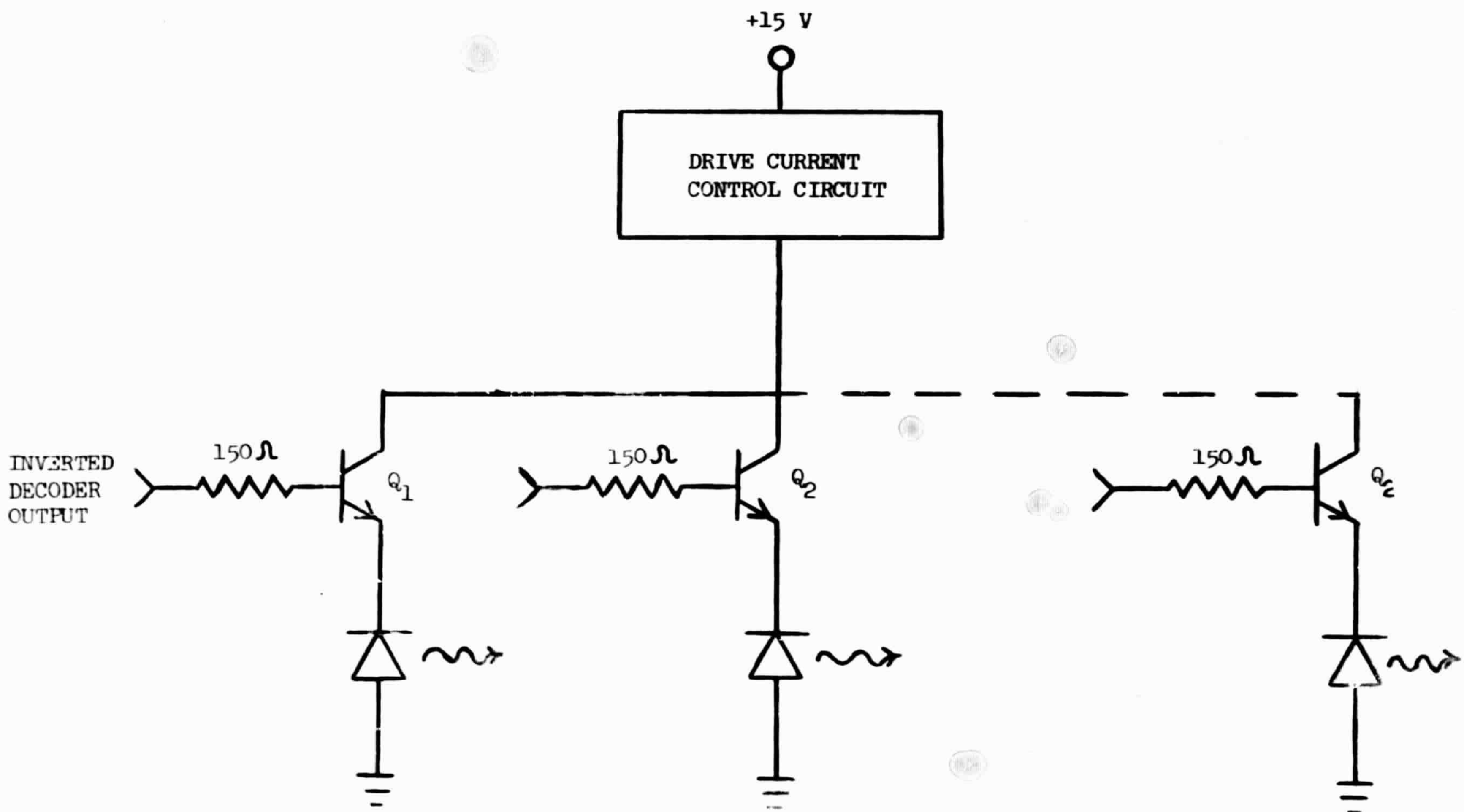

Figure 3. - Current Drivers

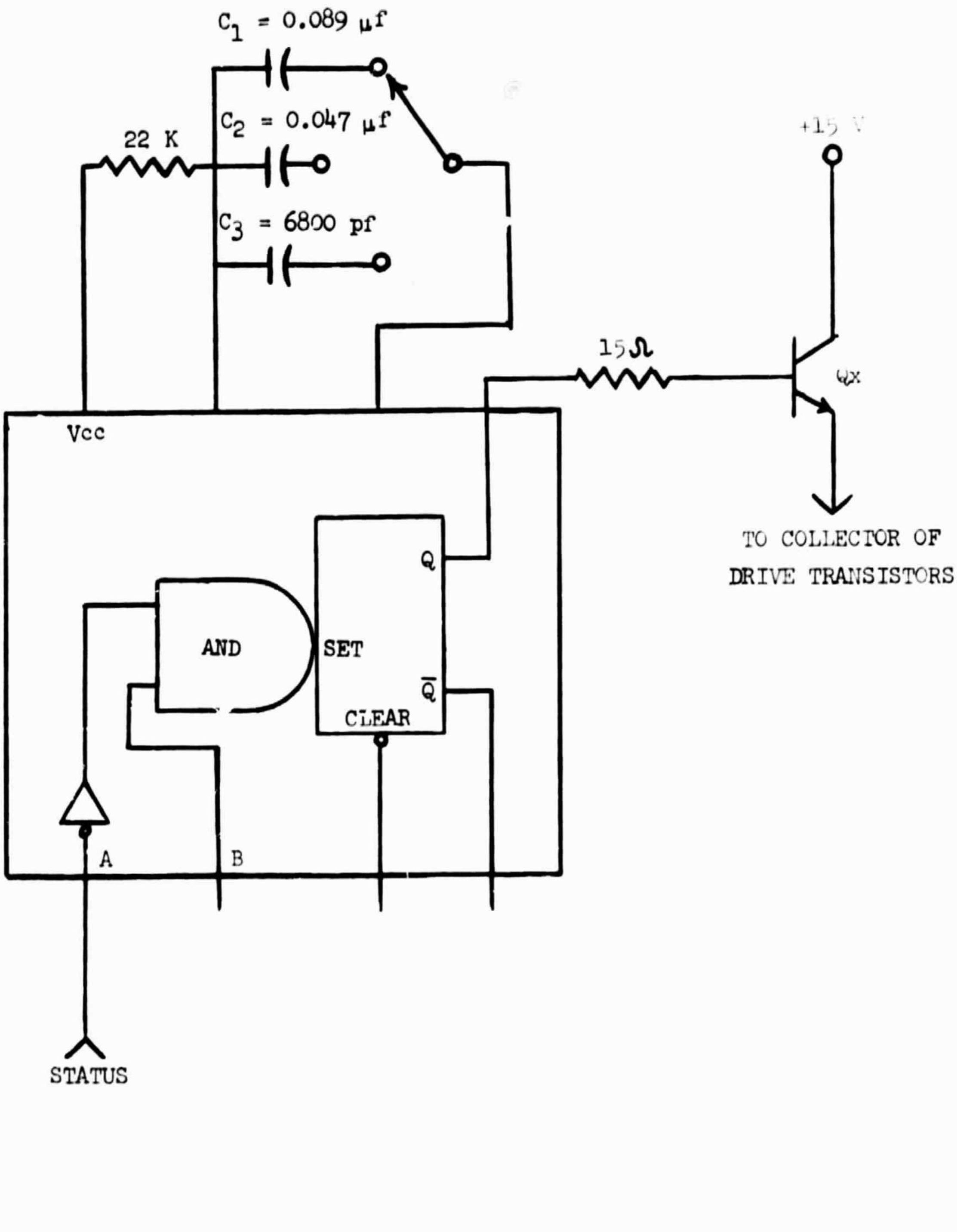

Figure 4. - Drive Current Control Circuit

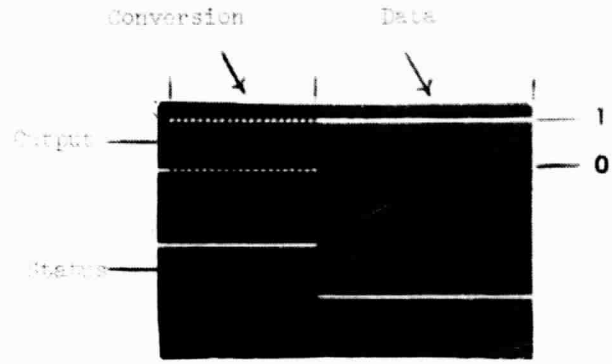

Figure 5. – Converter Output and Status Pulse.

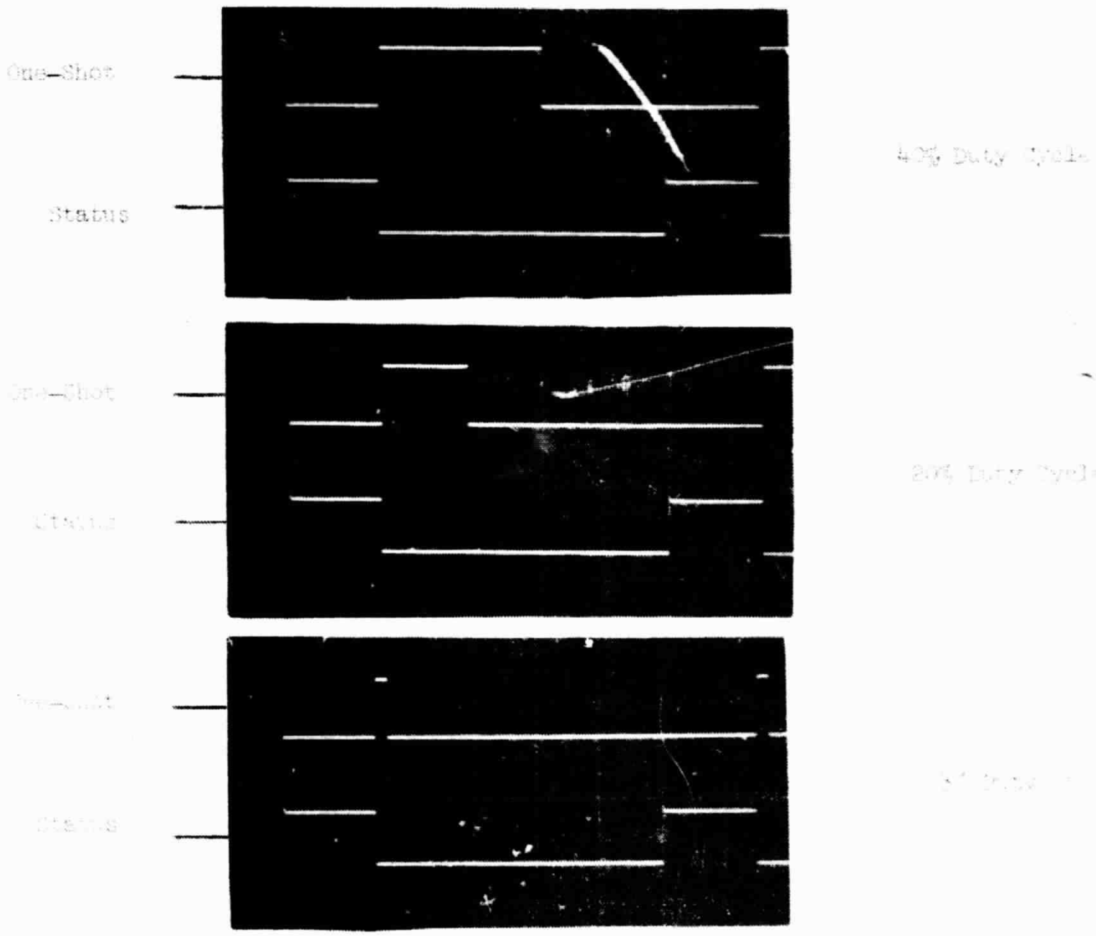

Figure 6. – [illegible]

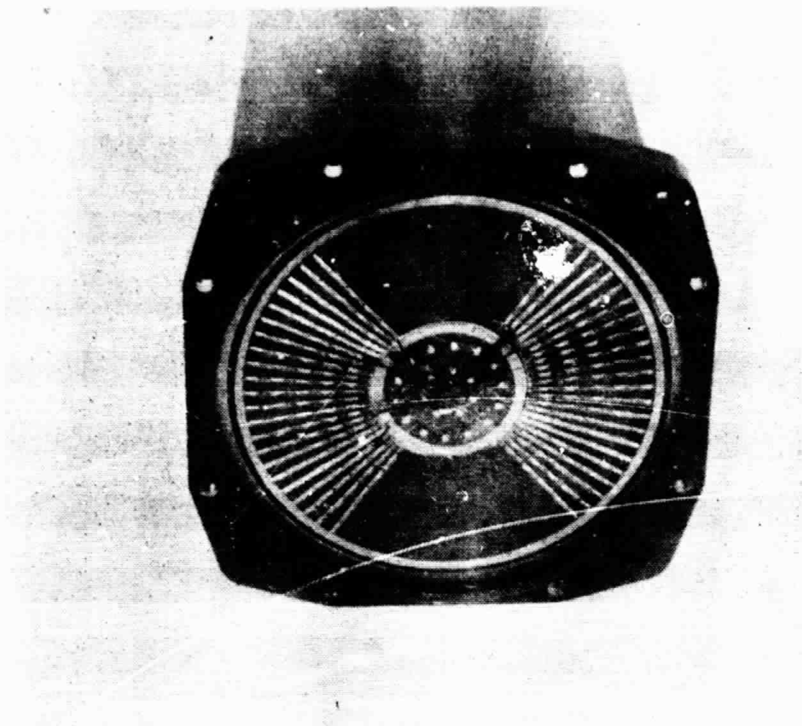

Figure 7. – LED Display without Filter.