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INITIAL EVALUATION OF TWO BRIGHT RADAR DISPLAYS IN THE INDIANAPOLIS TOWER

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SUMMARY

This report describes tests of an Iatron display and a television display for presenting ASR radar data in a control tower cab. The evaluation was conducted in the control tower at Weir Cook Municipal Airport, Indianapolis, Indiana, using ASR-2 radar data. The tests were conducted to evaluate these bright radar displays in the high ambient light conditions encountered in control towers.

A bright radar display would be an aid to the local controller for sequencing arriving aircraft operating in visual flight rule conditions, and also could be used by departure or arrival controllers for controlling traffic operating in instrument flight rule conditions. Bright displays could improve coordination between controllers handling both instrument flight rule and visual flight rule air traffic.

The Model 305A Iatron display was not acceptable for use in high ambient light conditions during daylight hours. Lack of adequate trail information made it necessary for controllers to study the Iatron indicator for too long a time to determine identity and heading of aircraft targets. Resolution of targets also was inadequate. Precipitation clutter returns integrated on the display to such an extent that aircraft targets could not be seen in these areas even during light precipitation.

The television radar display produced by use of the Model TI-440 scan-conversion equipment was found generally acceptable from an operational standpoint. With a minimum number of light shields or baffles, a usable picture could be obtained in high ambient light. Resolution, contrast, and trail characteristics were considered very good.

Although the televised display was not used for control of instrument flight rule air traffic during this evaluation, it is believed that both arrival and departure control can be effectively accomplished with the display.

INTRODUCTION

Many airports have been equipped with surveillance radars to expedite the control of air traffic in the vicinity of the airport. Approach

and departure control service for aircraft operating under instrument flight rules (IFR) normally is provided by these facilities. Due to the lack of suitable bright radar indicators, it has been general practice to install radar indicators for approach control service in an IFR room below the control tower cab where they may be operated in a darkened area. Radar indicators for departure control service frequently are installed under a tent-like arrangement in the tower cab itself. This permits more direct verbal coordination between the local controller in the cab who is controlling use of the active runway and the radar departure controller. The tent-like structure is undesirable because of the limited space available and the possible obstruction to the local controller's vision. Coordination between the radar approach control positions in IFR rooms and the local control position in the tower cab is accomplished by light indicators and interphone circuits. During heavy traffic conditions, the volume of radio communications limits the controller's time for verbal coordination with other control positions. In some cases air traffic is delayed because of the time required for coordination between control positions. It was felt that a bright radar display at the local control position could reduce the amount of verbal coordination required and provide more information than is carried by lights or other mechanical coordination devices.

The local controller also has a need for a bright radar display to give position information on movement of aircraft operating under visual flight rules (VFR) in the terminal area. The accurate position information available with radar makes more efficient control of VFR traffic possible. Radar position information is especially valuable during periods of reduced visibility due to smoke, haze, or fog, and at night, when it is more difficult to judge aircraft distance from the airport visually. Increased safety for VFR flights is possible since the local controller can determine more accurately the positions of aircraft and provide more accurate traffic information. This is of special value to pilots having limited visibility from cockpits and for pilots of high-speed aircraft with the attendant rapid closing rates with other aircraft on converging courses. Some exchange of traffic information is made today when aircraft are within sight of the control tower, however, radar position information can increase the range at which this service can be offered and it can be done with greater accuracy.

As a part of the work being done to meet the need for a bright radar display for use in the high ambient light conditions of a control tower cab, a rear-projection Iatron radar indicator and a television display of radar information (scan-converted by the CSF Model TI-440 equipment) were evaluated in the control tower at Weir Cook Municipal Airport, Indianapolis, Indiana. The Iatron equipment was installed in March 1957, and the evaluation continued for a period of approximately 90 days. Following these tests the

television display evaluation was made over a period of several months. Since the Model TI-440 equipment was needed for other tests at the Technical Development Center (TDC), the television radar display normally was available to the tower from 5 p.m. until 8:30 a.m. the next morning during the week. On Saturdays and Sundays it was available on a continuous 24-hour basis.

OPERATIONAL ENVIRONMENT AND EQUIPMENT

Control Tower.

A Type ASR-2 radar system is used to provide approach control service at Indianapolis. The one radar indicator available is located in an ITR room two floors below the tower cab. No standard radar indicators are installed in the cab at the present. The tower cab is approximately 14 feet square. The local control operating position is located at the north end of the control desk which extends across the airport (west) side of the tower cab. Because of the temporary status of the installations and the need for evaluation in several positions to test for operational convenience and various light conditions, the experimental bright display indicators were mounted in movable consoles. The consoles normally were located in the area immediately behind the local control position next to the tunable receiver rack.

Iatron Display.

The Iatron radar projection indicator, Model 305A, manufactured by the Farnsworth Electronics Co., is an experimental PPI equipment for use with various types of search radar. It was designed originally to provide a four-foot projected display for en route air traffic control. The Iatron tube is a four-inch-diameter, high-brightness, direct-view storage tube. The Iatron display used in this test was equipped with two types of erase or storage-control features. One was a cyclic erase which could be adjusted to erase the image instantaneously after any time interval from 2 to 100 seconds. The second feature made it possible to erase the image gradually by providing continuous partial erasure. The latter feature was designed to eliminate complete loss of the image during the erasing process and provide some target trail.

The Iatron projection unit was mounted in a wooden console for rear projection on a translucent screen. See Fig. 1. A 75 mm f-1.9 Wollensak lens was used with a throw distance of 17 1/4 inches to produce a 15-inch-diameter display. See Fig. 2. Two materials were used as rear projection screens. One of these was a plastic Fresnel lens and the other was a special plastic screen called Polacoat Lenscreen. Due to its directivity, the plastic Fresnel lens provided a target brightness approximately twice

that observed on the Polacoat screen when viewed from a position directly in front of the screen. However, there was considerable reduction of brightness of the Fresnel lens when viewed from an angle to the screen. Since data on the Polacoat Lenscreen could be seen from more oblique angles, it was considered the more desirable. However, during bright daylight it was necessary to use the Fresnel lens to obtain more light output.

Since the Type ASR-2 radar was not equipped with video mapping, map information was drawn on the front surface of the plastic screens. A shading hood was provided to minimize the amount of light falling directly on the plastic screen.

Television Display.

The following equipment was used to present a televised radar picture in the tower cab:

1. Model TI-440 scan-conversion equipment. This equipment is manufactured by the Compagnie Generale de Telegraphie Sans Fil (CSF) of France and is distributed in the United States by Intercontinental Electronics Corp. It is a scan-conversion unit which converts the normal rotating PPI radar sweep to a television picture. The important element of the TI-440 equipment is the scan-conversion memory tube, Type TMA-403X, which is a double-ended, two-gun, cathode-ray tube (CRT). One electron gun writes the polar scan radar information on an internal target grid and the other gun reads out the information stored on this target in a television raster scan. The Type TMA-403X memory tube permits storage of radar information with a gradual decay, and the persistence control can be adjusted for storage times of approximately 20 to 120 seconds.

2. Video map generator. The video map generator was part of the original Model SRD-1 bright tube display equipment built by Allen B. DuMont Laboratories.[1] It uses a flying spot-scanner. The desired map is interposed between a photocell and a CRT having a quick decay phosphor. A bright TV raster synchronized with the output of the TI-440 unit is written on the CRT. The phototube is energized as the raster is scanned and light passes through lines or symbols on the film. The resulting video map output is combined with the video from the TI-440 by a simple mixing circuit.

[1]William E. Miller, Marvin H. Yost, and David S. Crippen "Evaluation of the DuMont SRD-1 Bright Radar Display and Initial Study of Other Display Techniques," CAA Technical Development Report No. 288, July 1956.

3. Video line driver. Since the TI-440 equipment was located in a laboratory at TDC, an existing coaxial cable approximately one-half mile long was used to carry the video signal from the scan-conversion equipment to the control tower. A Type CA-2404 radar video line driver modified to provide wider bandpass and improved low-frequency response was used. Some difficulties were encountered due to the difference in "ground" potential between the two locations. Although not available for this test, a stabilization amplifier at the tower end would have been desirable for reducing noise and hum pickup to provide a more stable picture.

4. Indicators. A 17-inch monitor built by CONRAC was mounted in a wooden console and used to present the television radar picture in the tower cab. This is shown in Fig. 3. To reduce the effects of direct light on the tube face and reflections from the TV monitor implosion shield, adjustable blinders or light baffles were added to the console around the face of the tube.

During part of the tests, a 17-inch CONRAC monitor was set up in the IFR room. A 17-inch portable TV set which had been modified also was installed in the corner of the tower cab near the ceiling, as shown in Fig. 4, to determine if this location was advantageous.

TEST RESULTS

Iatron Display.

The Iatron display was not bright enough during daylight hours to be acceptable. The headings of aircraft were difficult to determine unless the display was observed for several rotations of the antenna, a period of several seconds at the 26-rpm radar antenna scan rate. It was difficult to distinguish moving aircraft targets from fixed ground clutter returns, even though the latter were at a low level in the MTI area. Target resolution was inadequate. Radar returns from aircraft in close proximity frequently merged into one target. Precipitation clutter, even though very light, integrated on the display rather quickly to maximum brightness so that tracking of aircraft returns through such areas was not possible. In many cases aircraft could be followed through areas of light precipitation on a standard PPI display having a P7 phosphor, whereas these same returns could not be followed on the Iatron display.

As a result of these defects, when the local controller used the display his attention was diverted from visual observation of aircraft on the landing area and in the traffic pattern for too long a time. A survey of the personnel in the Indianapolis tower at the conclusion of the 90-day test period indicated that a majority of the controllers were not able to

use the Iatron display for sequencing VFR arrival traffic. It was not considered satisfactory for use as a bright display in the tower.

Television Display.

The television scan radar display proved quite effective for presenting radar data in the tower cab. Even in the very high ambient light conditions during daylight hours, the display was usable provided that it was positioned so that direct sunlight or bright reflections did not fall on the tube face. With suitable light shields, or blinders, around the face of the tube, and by positioning the display console properly, the TV display was usable at all times. The TV display could be viewed through a fairly wide angle. The display had adequate target resolution. The long trails on moving targets, as seen in Fig. 5, permitted controllers to quickly identify aircraft targets and determine headings of the aircraft. This was an essential feature since the local controller should be able to pick up information from the radar display with a minimum of study. He must maintain visual observation of the active runway and air traffic around the airport.

A survey of the personnel in the tower after approximately four months of use indicated that controllers were unanimous in approving the television radar display and desired a permanent installation in the tower. All controllers stated that they were able to use the display in local control operations for sequencing VFR arrival traffic.

Since this was a temporary installation of an experimental nature for evaluation tests, it was not considered desirable to cut into the permanent operating desk in front of the local controller to test this location for the display. Many of the controllers felt this would be the best location. It is believed that this location should be tested, and that, simultaneously, a test should be made of orientation of the radar display to correspond to the geographic orientation of the airport as viewed by the local controller. In the Indianapolis tower, this would place West at the top of the local controller's display. In the tests with the display mounted vertically in a console, North was always at the top of the display, corresponding to normal orientation of the standard radar indicators.

Until it was installed, it was thought that the overhead display mounted in the corner of the tower cab near the ceiling would be a good location since the indicator could be seen from more than one control position. However, this proved to be an undesirable location during daylight hours due to the strong light reflections from the face of the indicator. At night, this location was considered good since the local controller, departure controller, and ground controller could see the display.

Although the television scan radar display was not used for IFR control, it is believed that it would be adequate for this purpose. No quantitative measurements were made of the accuracy of video maps or of other possible nonlinearities in the system. It is believed that these factors can be held to acceptable tolerances with properly designed equipment.

CONCLUSIONS

1. Iatron. The Iatron Model 305A was not satisfactory as a bright radar display for use in the high ambient light conditions found in a control tower cab. Target trail information and target resolution were inadequate. The length of time needed to study the display is too great to permit use by a local controller in sequencing VFR arrival traffic at an airport.

2. Television Display. The television radar display produced by use of the Model TI-440 scan conversion equipment was suitable as a bright radar display for use in the high ambient light conditions of a tower cab. The radar information displayed on the television indicator was easily interpreted in a minimum amount of time. The heading of the aircraft could be determined readily with the amount of trail available. It is believed that displays of this type can provide increased safety and more expeditious air traffic control service.

RECOMMENDATIONS

1. Television displays of radar data, through suitable scan-conversion equipment, are recommended for use in control tower cabs. They are recommended for use at local control positions for assistance to the controller in sequencing VFR arrival traffic and to improve coordination with radar departure and arrival controllers.

2. Additional in-service tests of these displays should be made for IFR radar departure control and radar approach control. As part of these tests, the optimum location of the display for each position of operation should be determined.

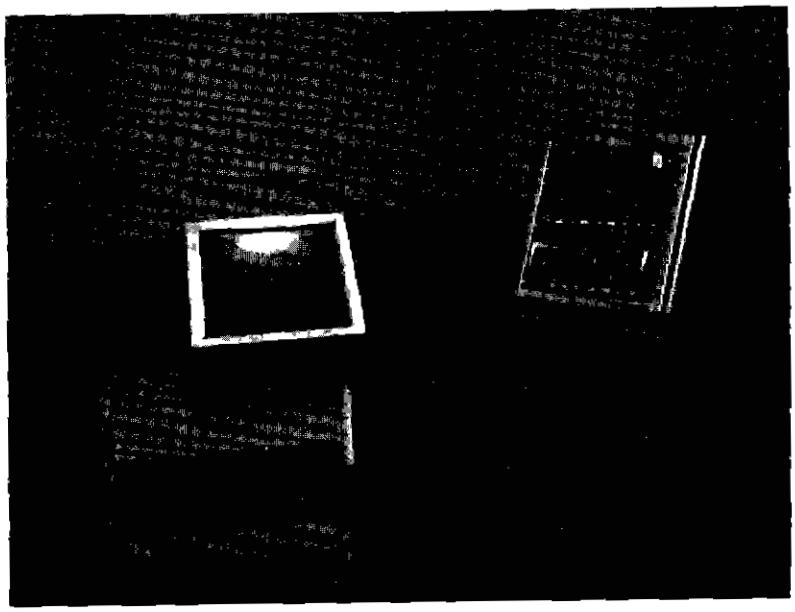

FIG. 1 IATRON REAR PROJECTION DISPLAY CONSOLE

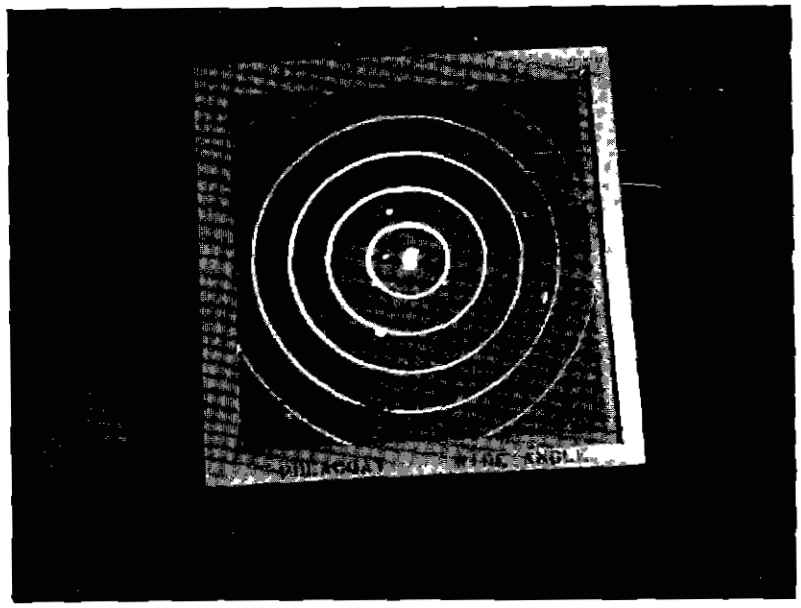

FIG. 2 IATRON DISPLAY

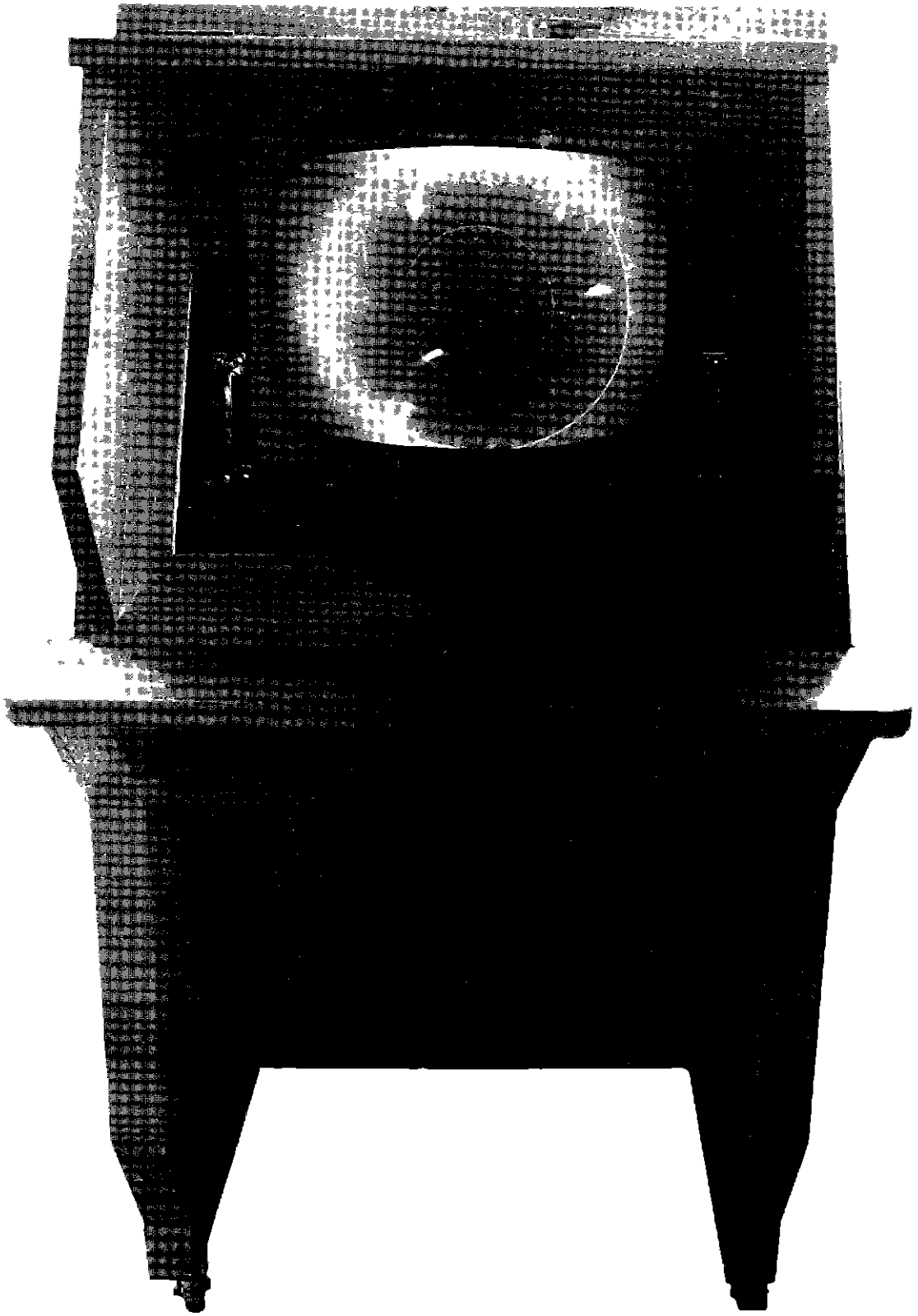

FIG. 3 TV MONITOR INSTALLED IN INDIANAPOLIS TOWER WITH OUTPUT FROM SCAN-CONVERSION EQUIPMENT AND ASR-2 RADAR

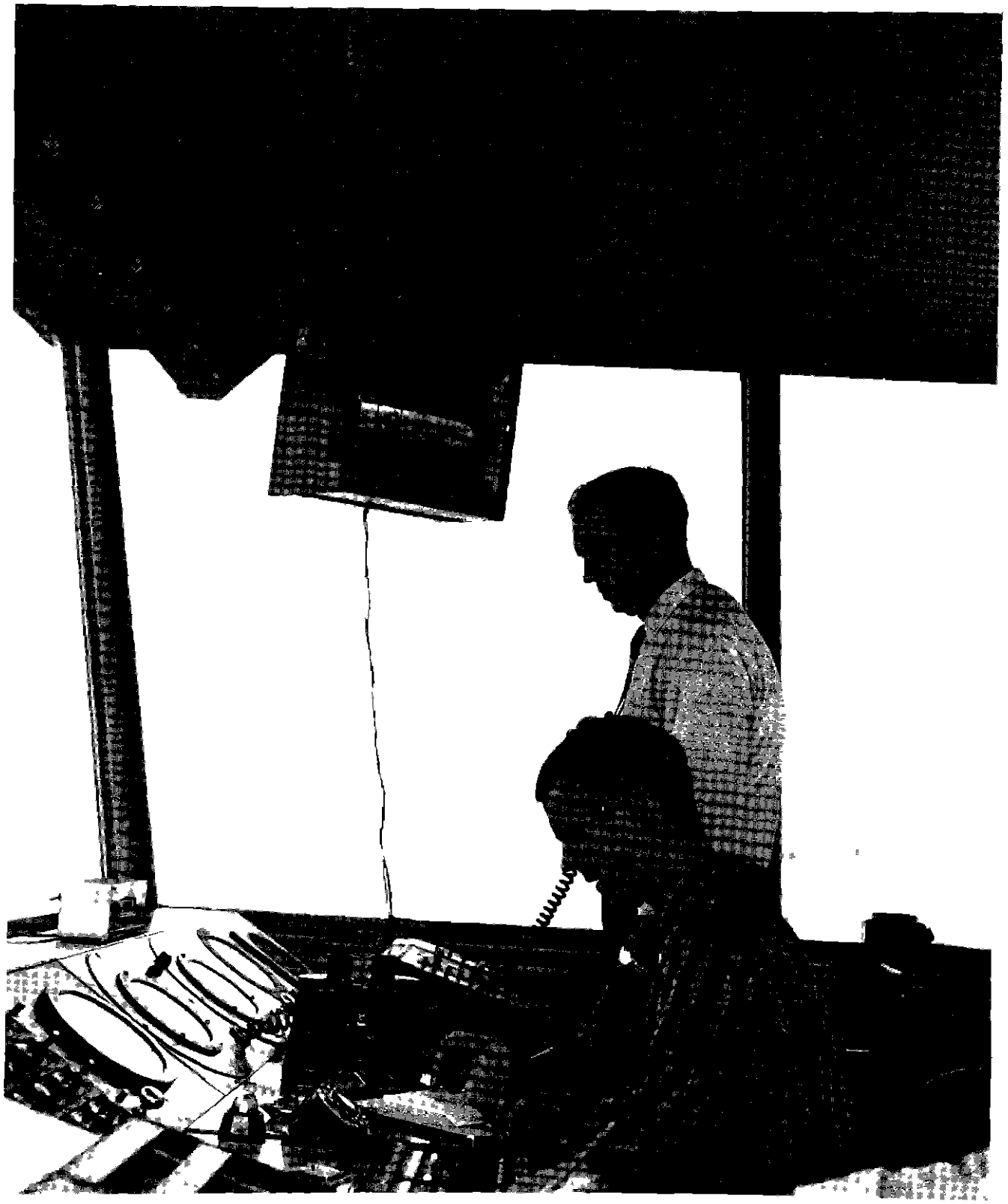

FIG. 4 CEILING INSTALLATION OF TV MONITOR AT LOCAL CONTROL POSITION IN INDIANAPOLIS TOWER WITH OUTPUT FROM SCAN-CONVERSION EQUIPMENT AND ASR- RADAR

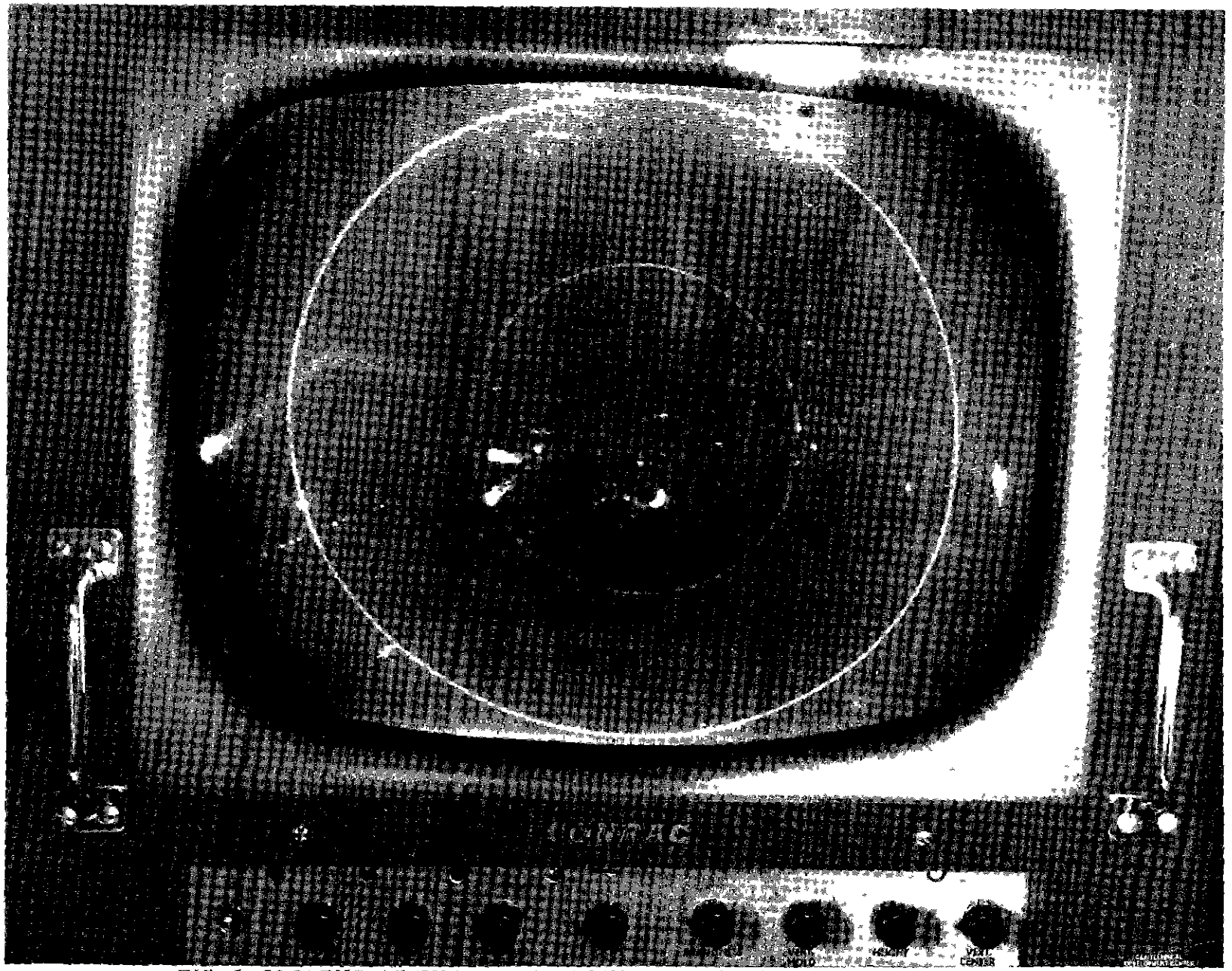

FIG 5 CLOSEUP OF TV MONITOR IN INDIANAPOLIS TOWER WITH OUTPUT FROM SCAN-CONVERSION EQUIPMENT AND ASR-7 RADAR