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TECHNICAL DEVELOPMENT REPORT NO. 395

AN EVALUATION OF RADAR ADVISORY SERVICE TO VFR FLIGHTS

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by

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AN EVALUATION OF RADAR ADVISORY SERVICE TO VFR FLIGHTS

SUMMARY

This report describes an evaluation of a traffic advisory service by use of radar to aircraft operating under visual flight rules. This service was provided by controllers located in the airport control tower at Indianapolis, Ind., using ASR-2 radar data. Pilots requesting the service were advised of the azimuth and range of other aircraft target returns which might be a potential hazard. Since height information was not available to the radar controller, the conflicting traffic frequently was at widely separated altitudes, and in many cases, the conflicting traffic was not seen by the pilot who was advised.

The degree of participation by pilots in the test program varied widely, however, the majority of the pilots commenting on the service favored continuation and extension of the service to other areas. The determination of the success of this visual flight rule radar advisory service in providing additional safety can only be determined by a long-term statistical study of accidents occurring in areas with and without such service.

The report describes equipment and procedures used in this test. Charts to extrapolate the data to higher traffic densities also are provided.

INTRODUCTION

In a CAB analysis[1] of 159 midair collisions occurring in the 10 year period ending in 1957, clear weather prevailed in 94 per cent of the accidents, visibility was in excess of 3 miles in 98 per cent of the accidents, and 94 per cent of the accidents occurred during daylight hours. The altitudes at which these midair collisions occurred ranged from 10 to 4,000 feet, only four having occurred above 9,000 feet.

The operational phases in which these midair collisions occurred are listed in Table I.

[1]"Midair Collisions in U. S. Civil Flying - Calendar Years 1948 - 1957," Civil Aeronautics Board, Bureau of Safety, Analysis Division, May 19, 1958.

TABLE I

OPERATIONAL PHASES OF MIDAIR COLLISIONS
(In Order of Frequency of Occurrences)

Maneuver	Per Cent
Landing Approach	31
Traffic Pattern	29
Normal Flight	25
Takeoff Climb	7
Formation	4
Acrobatics	2
Buzzing	2
Racing	1

Although many midair collisions may have occurred wherein two aircraft converged while each remained in the other's "blind area," the basic cause is that the pilots did not see the other aircraft until too late. Computation of distance, speed, and closure angle of intruding traffic needs to be accomplished by the pilot after sighting, and the time delay required to determine a course of evasive action can be lengthy enough to cause collision. An effective advisory service which would provide the pilot with information on distance and closure angle of intruding traffic could greatly reduce the probability of midair collision. With range and azimuth information on traffic, only a determination of the altitude would remain with the pilot. Therefore, the earlier other aircraft can be detected by the pilot the safer will be his flight.

A test of VFR arrival and departure radar traffic advisory service was made at Weir Cook Municipal Airport, Indianapolis, Ind., from June 23 to August 23, 1958. Pilots were urged to participate, although it was not mandatory that they do so.

The Technical Development Center (TDC) and the Washington and Region Three Offices of Air Traffic Control jointly prepared a NOTAM which was issued about 30 days prior to implementation of the test. See Appendix I. In addition, the information contained in the NOTAM was publicized as a special notice in the Airman's Guide. A bulletin describing the service was distributed to aviation interests within a 200-mile radius of Indianapolis, and the Aeronautics Commissions of five surrounding states were requested to include the bulletin in their newsletters and other publications for pilots.

The VFR radar advisory service was made available to all aircraft using Indianapolis Municipal Airport and all other airports lying within the advisory service area. These airports were called "satellite" airports.

Arrival and departure routes, or corridors, were established for aircraft using the advisory service to afford maximum utility compatible with safety. In accomplishing this, it was contemplated that, wherever feasible, these routes would give reasonable separation from IFR routes. Therefore, boundaries of the corridors were on generally heavily traveled IFR routes, and VFR flights using the service were expected to fly well within the boundaries.

Perimeter visual and radio reporting points for each arrival route were designated to facilitate radar identification. One UHF and one VHF frequency were provided for the arrival advisory service, and similar provisions were made for departure advisory service. In addition, a 122.5-Mc duplex frequency was provided for each service. The service was available on a 24-hour basis.

PROCEDURES

Radar advisory service was given to any pilot requesting it, whether arrival, departure or over-flight, but it was available only on the prescribed frequencies. The advisory service was to be confined to traffic information only, but occasional requests by pilots for other information such as weather, navigation aids, and suggested headings to fly away from congested traffic areas were handled. In general, however, the advice covered information on traffic which appeared to constitute a possible potential hazard to the pilot. Surveillance of the aircraft and issuance of traffic advisories continued until such time as the controller advised the pilot to change to tower frequency or cleared the aircraft to leave the advisory frequency.

If at any time the controller found that he could not continue the radar advisory service because of malfunction of equipment, volume of traffic, or for some other reason, he advised the pilot of the discontinuance of the service and gave such added advice as he deemed necessary.

Prior to takeoff from Indianapolis Municipal Airport and after takeoff from satellite airports, on first radio contact with the Indianapolis tower, pilots of departing aircraft who had not requested the service previously were queried as to whether or not they desired it. After takeoff, pilots who desired the service were advised to contact the VFR departure advisory on the appropriate frequency.

Pilots of arriving aircraft (Indianapolis Municipal and satellite airports) usually contacted the VFR advisory service over the perimeter fixes. However, many initial callups were made both inside and outside the advertised boundary of the service. In some cases, callups were made beyond the range of the tower's radar coverage, in which case pilots were requested by the controller to call again when within range. Those aircraft landing at Indianapolis Municipal Airport were changed to the tower frequency prior to coming within range of the traffic pattern at the airport, and those landing at the satellite airports were cleared to leave the advisory frequency when entering the satellite airport traffic pattern.

Many VFR flights over-flying the Indianapolis terminal area called for traffic advisory service, sometimes on a frequency which was not compatible with the direction of flight for the specific corridor in which they were flying. Depending on the volume of traffic that the controller was working, these flights usually were requested to change to the proper frequency, where they were given the advisory service and advised to leave the frequency at the edge of radar coverage.

EVALUATION OBJECTIVES

The objectives of this evaluation were to determine procedures, regulations, and equipment required to furnish a radar advisory servce to VFR traffic in the Indianapolis terminal area. The tests were designed to:

1. Determine the extent to which VFR advisory service users comply with requested regimentation, especially that of routes or corridors.

2. Determine the optimum configuration of operating positions for dispensing a VFR advisory service.

3. Determine equipment requirements in terms of displays and communications channels.

4. Determine optimum procedures for identification and retention of identity of VFR advisory targets.

5. Determine the over-all effectiveness of the service from an air traffic control and aviation industry standpoint.

6. Determine requirements of other areas for implementation of a VFR advisory service with respect to procedures, equipment, and personnel.

TESTS AND RESULTS

During the test period, data were gathered with clocks, counters, Esterline-Angus recording equipment, and observers who recorded data manually at each VFR advisory service position of operation. It is believed that these data provide a good cross section of the VFR radar advisory service as conducted at Indianapolis.

Staffing.

In the principal mode of operation, there was a VFR departure controller in the tower cab and a VFR arrival controller in the IFR room. Both positions were staffed on a 24-hour basis by journeyman-level controllers, with occasional use of trainees assigned to these positions under supervision of controllers. At times, especially between midnight and 8 a. m., both the VFR arrival and departure positions were combined for operation in the tower cab. Other configurations were tried near the end of the test period, including both inbound and outbound controllers working from a common display in the IFR room, and one controller providing advisory service to both inbound and outbound aircraft from one operating position in the tower cab and from one operating position in the IFR room.

Displays.

The primary radar displays used for the VFR advisory service were 21-inch CONRAC TV monitors. The TI-440 scan-conversion unit was used to convert the ASR-2 radar data to a TV picture showing a 30-mile range. The output of a GPA-30 video mapping unit was mixed with the ASR-2 radar video on the input side of the TI-440 unit.

The 21-inch CONRAC monitor for the VFR departure advisory position in the tower cab was mounted on a small console with the face of the indicator vertical. See Fig. 1. The console had castered wheels to permit it to be positioned for various light conditions. A sliding hood arrangement was tried, to reduce the amount of ambient light falling on the face of the tube and to reduce light reflections from the implosion shield and tube face. This was not satisfactory during some light conditions in the tower. A light trap, using a curved sheet of circularly polarized filter, then was installed. This, together with repositioning of the console to avoid direct sunlight falling on the face of the TV tube, provided a usable display. See Fig. 2.

In the IFR room, the 21-inch TV monitor for the VFR arrival advisory position was mounted on a small desk-like table, Fig. 3, adjacent to the IFR control positions so that A/G radio terminal equipment at that position could be used.

Most of the controllers believed that the 21-inch CONRAC monitor used as a vertical display was too large for normal viewing. It was observed that controllers tended to view the picture on the monitor from distances as close as 8 inches. Preference for a 17-inch indicator, shown in Fig. 4, was indicated.

During the evaluation there were periods when the single TI-440 scan-conversion unit was off for maintenance. At these times the ASR indicators were used, the IFR departure and arrival controllers providing the VFR radar advisory service in addition to IFR control. The departure controller, using a modified ASR-1 radar indicator, was located in the tower cab, and the arrival controller, using an ASR-2 indicator, was located in the tower IFR room. Controllers stated that combining the services is, at times, confusing because some aircraft are being positively controlled by vectoring and others merely are being given traffic information. It was difficult for controllers to remember which aircraft were IFR and which were VFR.

During the last week of the evaluation, a 22-inch horizontal plotting display, Fig. 5, was installed in the tower IFR room. Controllers were asked to use this display with plastic chips carrying aircraft identity as much as possible, so that a comparison with the 21-inch vertical indicators could be made. Many of the controllers had stated previously that for tower radar control at relatively short ranges, they would not require such a display, since they could remember the location of each radar target in contact and its identification. However, after the horizontal plotting display had been in service for one week, several controllers thought it had distinct advantages and found that it was as easy to write the aircraft identification on a plastic chip as on a pad of paper.

In order to display inbound and outbound corridors, and to show the location of radio navigation aids and geographical features used in identifying radar targets, it was necessary to have a map of the area covered by the ASR-2 radar integrated with the radar picture. The original video map which was used at the beginning of the trial period soon was modified to include more geographic points both at the periphery and within the advisory area. The modified map is shown in Fig. 6. This change was brought about by difficulty encountered in identifying and reidentifying targets. The modified map greatly improved this situation.

Since the TV raster of a bright display usually moves when adjustments to the TV picture are made with the vertical and horizontal centering controls, an overlay type of map, although adequate for a raw radar display, would not have been suitable for the scan-conversion radar display. A GPA-30 video mapper, equipped with the video map mentioned above, was used. The GPA-30 output was displayed on all scan-conversion displays in the tower.

Pilot Participation.

The number of aircraft which used the VFR radar advisory service varied considerably with the weather, the hour of the day, and the day of the week. It was observed that on weekends, flying activity increased and consequently, the number of VFR flights using the advisory service increased. Sunday and holiday afternoons were busiest, while Monday through Thursday were the least active days. Daylight hours saw the most VFR activity, with two peaks, usually late morning, 10 to 11 a. m., and midafternoon, 3 to 5 p. m.

During August, a count was made to determine the percentage of aircraft using the service on four days during which good VFR weather conditions existed. Fifty-nine per cent of the VFR departures and 63 per cent of the VFR arrivals at Weir Cook Airport used the service, of which 36 per cent were air carrier, 62 per cent were civil non-air carrier, and two per cent were military. Ninety-four per cent of all VFR air carrier arrivals and departures used the service, while the corresponding figure for VFR non-air carriers was 52 per cent and for VFR military, 31 per cent. Although the largest number of participants were civil itinerant, there was a greater degree of participation by the VFR air carriers.

From June 26 to July 19, data were recorded for periods ranging from 8 to 16 hours a day for a total of 165 hours. During these periods, 709 aircraft used the VFR radar advisory service. These 709 flights were issued 1,082 advisories on conflicting aircraft targets. During a peak 8-hour period when data were being recorded, 87 aircraft used the service and 117 advisories were issued. The maximum number of VFR aircraft simultaneously using the service was six, with the maximum under arrival advisory at any one time being five, and the maximum under departure advisory at any one time being four.

During the time data were being recorded, the observers also counted the number of aircraft radar returns on the scopes at 5-minute intervals. The maximum number of aircraft within the 30-mile range was 22, with a minimum of two. There was, of course, considerable variation from one 5-minute reading to the next.

It was found that the number of participating aircraft was, to some degree, dependent upon the number of aircraft on the scope. By averaging the data from several high-, medium-, and low-activity days, it was possible to show this relationship by the curve in Fig. 7.

From 165 hours of recorded data, the six busiest 8-hour periods were analyzed. These occurred during typically good VFR weather conditions; that is, visibility 6 miles or more and ceiling above 3,000 feet with broken clouds or better. Table II summarizes the data for these 6 busiest periods.

The number of targets about which a pilot was advised was subject to laws of probability, since it depended on random factors such as the number of targets on the scope and the distribution of targets in the area. Figure 8 shows the probability of being advised of one or more traffic targets for several scope densities. As an example: when from 6 to 10 aircraft targets were on the scope, the chance of being advised of at least one target was 53 per cent, when from 16 to 20 aircraft were on the scope, this probability was 80 per cent.

There is a marked relationship between the number of targets per advised aircraft and the number of aircraft on the scope. A study of these data has been made and an extrapolation of these data to higher traffic densities, to indicate the workloads which might be encountered, is discussed later in this report.

Effectiveness of Advisories.

During the data-taking period, pilots were asked by radio whether they saw traffic when they did not volunteer such information. Fourteen per cent of the traffic targets were reported in sight after the first advisory, but it is not known whether they were in sight prior to this advisory. Eight per cent of the targets were sighted on an advisory subsequent to the first, and it is reasonable to assume that these were seen as a result of the advisory. The remaining 78 per cent of the targets never were sighted. The low percentage of targets sighted (22 per cent) can be explained by the fact that the advised aircraft and the conflicting traffic often were at widely separated altitudes. Also, the analysis shows that sometimes advisories were issued for targets which never came within visual range of the pilot due to restricted visibility conditions.

TABLE II

SUMMARY OF SIX 8-HOUR PERIODS OF VFR RADAR ADVISORY SERVICE

Number of Aircraft Using VFR Radar Advisory Service	Arrivals:	4.6 per hour average 11.0 per hour maximum
	Departures:	3.4 per hour average 10.0 per hour maximum
*Total Number of Aircraft Using VFR Radar Advisory Service		8.0 per hour average 17.0 per hour maximum
Maximum Number of Aircraft Using the Service Simultaneously		6.0
Number of Advisories Issued	Arrivals:	6.4 per hour average 23.0 per hour maximum
	Departures:	6.2 per hour average 22.0 per hour maximum
*Total all Aircraft Participating		12.6 per hour average 38.0 per hour maximum
Number of Conflicting Targets Issued Per Aircraft Given an Advisory		1.2 average 6.0 maximum
Number of Aircraft on Scope (30-mile radius) As Recorded at 5-Minute Intervals		11.0 average 22.0 maximum 2.0 minimum

*The hour when the peak number of arriving aircraft used the service was not the same hour that the peak number of departing aircraft used the service.

For the 8 per cent of targets which were sighted after issuance of more than one advisory, the average distance between the targets was 2.5 miles as observed on the radar indicator. A distribution of sighting mileages is shown in Fig. 9. In many cases, these aircraft may have been separated considerably in altitude.

Pilot Comments.

Two questionnaires regarding the service were used to obtain comments from pilot. During the first and major part of the advisory service test period, a simple questionnaire card was used. This card was distributed widely to ATCS within 200 miles, air carrier operations offices, fixed base operators, and others. A percentage distribution of responses to the 412 questionnaires returned follows.

1. Did the VFR radar advisory service contribute to the safety of your flight? Yes 89.3 No 6.4 No Answer 4.3

2. Did you have conflicting traffic in the VFR radar advisory service area on which you were not advised?
   Yes 6.1 No 93.9 No Answer 0

3. Did you experience difficulty with traffic after you changed to tower frequency? Yes 5.7 No 87.1 No Answer 7.2

4. Do you feel that the VFR radar advisory service would be desirable at all airports equipped with radar?
   Yes 95.0 No 3.2 No Answer 1.8

5. Do you feel, from a safety standpoint, that it would be desirable to have specific routes for VFR traffic to and from major airports?
   Yes 60.7 No 32.1 No Answer 7.2

In this questionnaire, pilots were not asked to identify themselves or to indicate the type of operation, whether air carrier, military, or civil. Handwriting on the cards, however, indicated that more than one card was filled out by a number of pilots.

About August 15, a second more comprehensive questionnaire, Appendix II, was available. These were mailed to about 250 pilots and aircraft owners in Marion County, Indiana, who were registered with the Indiana State Aeronautics Commission. They also were furnished to local flight plan offices and air carrier offices on the airport and to fixed base operators in the state of Indiana. About 50 of these questionnaires were returned. A definite trend in the answers is evident. The replies are listed in Appendix II.

To encourage use of the route system published in the NOTAM, controllers advised most pilots via radio of the proper route for inbound and outbound flights, and most pilots so advised followed the proper route. There was a tendency, however, for some pilots to resist deviation from their desired route of flight in order to conform to the route structure. This was true primarily of over-flights which utilized the service. Answers to question 9 on the questionnaire indicated that most pilots preferred to choose their own route. However, it was noted in the remarks on the questionnaires that pilots were willing to accept certain restrictions, such as use of corridors or radar vectoring, when conditions of marginal weather or heavy traffic warranted such procedures. There was a seeming awareness among pilots of their limitations under these conditions, and they placed considerable trust in the controller and radar. However, in general, there was a strong "let me alone" sentiment expressed by pilots in their comments. They appeared to desire information on traffic, but also wished to make their own decisions to avoid other traffic. This sentiment may account, in part, for the relatively large percentage (39 per cent) of VFR flights which did not use the service.

The majority of pilots answering the questionnaire preferred that the VFR radar advisory service be provided on an area basis rather than restricting it to a corridor. Some pilots commented that the necessity of spotting geographical fixes in order to remain inside specific corridors and to report accurately for radar identification reduced their time for scanning for other traffic considerably. Several pilots making this comment also indicated that they were unfamiliar with the Indianapolis area, which contributed to the difficulty in identifying towns and other geographical features.

A large majority of pilots indicated that there was a definite need for receiving altitude information on traffic issued by the VFR radar advisory service, and stated that a great amount of time is consumed in searching for targets when wide altitude separation may exist already.

Controller Interviews.

At the end of the test period, a number of controllers were interviewed and encouraged to comment on the service provided, and the equipment and procedures used. All controllers were in favor of the VFR radar advisory service, because it provided an additional service which contributed to flight safety.

Controllers generally agree that specific routes for inbound and outbound traffic reduce the number of conflicting targets for the aircraft in the proper corridor, as well as the number of fast-closure situations. It provides more time for controller action, since a slower rate of closure exists with primarily overtake situations. However, controllers recognized unanimously the problem presented to the pilot in this situation, and agreed that a desirable boundary for the VFR radar traffic advisory service area would be a circle with a radius of 25 or 30 miles from the airport with random entry and exit points.

During most of the period of evaluation, the VFR departure controller was located in the tower cab and the VFR arrival controller in the IFR room. Other configurations were tried near the end of the test period, including both inbound and outbound controllers working from a common display in the IFR room, with one controller providing service to both inbound and outbound aircraft from one operating position in the tower cab and from one operating position in the IFR room. Controller comments were noncommittal in this respect, although it was indicated that the VFR radar advisory service controllers did not necessarily have to be associated with other control positions connected with other airport traffic control functions.

Most of the controllers estimated that they could provide VFR radar advisory service to 5 to 12 aircraft simultaneously, depending to some degree on the grouping of targets on the radar display. However, during the evaluation period, the maximum number of aircraft provided VFR radar advisory service by one controller at any one time was five. A saturation point of the number of aircraft per controller was neither reached nor sought at this time, in the interest of providing an effective service.

Communications.

The A/G communications provided for the VFR radar advisory service included one discrete VHF and one discrete UHF channel for each operating position (arrival and departure). In addition, the common civil frequency of 122.5 Mc (receiving only) was installed at both positions. This latter frequency had to be shared with other controllers in the tower, including the local controller, ground controller, and occasionally the IFR approach and departure controllers. Due to congestion on this frequency, the alternate common civil channel of 122.7 Mc (receiving only) was added during the evaluation period at the VFR radar advisory departure position. Addition of this frequency helped considerably in relieving the congestion on 122.5 Mc.

One probable reason why participation in the VFR radar advisory service program was not greater is that some of the smaller civil aircraft were not equipped to use the discrete VHF channels. Some pilots of this type aircraft may have believed that it was necessary to use the discrete channels to obtain the service and, not having the frequency in the aircraft, did not request the service. It was common practice for the local controller to advise aircraft departing VFR to "change to 121.1 Mc for VFR radar advisory."

A record was maintained of the communications activity for each VFR radar advisory position. The recording devices automatically recorded, for each frequency, the number of times a transmission was made by a VFR radar advisory controller, elapsed time on the air, length of time per transmission, and number of times on the air during a given period. Both controller and pilot transmissions were recorded on a tape voice recorder.

Evaluation of communications data indicates that during peak hours, channel loading (time in use) reached as high as 46 per cent for one VFR advisory controller. However, voice recordings indicated that a large amount of superfluous conversation of an explanatory nature occurred between controllers and pilots. This affected seriously the value of the communications loading data. The required amount of communications, with proper phraseologies and streamlined operating procedures, would be much less than is indicated.

Altitude Information.

During the evaluation period, many pilots requested altitude information on the traffic issued to them. Other than being able to issue altitude information on aircraft that were under control of an IFR function in the tower, and this only after coordination with the respective controller, none could be given.

A discussion with Gilfillan Company representatives indicated that they might be willing to lend a Quadradar to the FAA for a short period, to evaluate its effectiveness for obtaining relative altitude relationships between aircraft. The height-finder portion of this equipment could be used to obtain altitude data on targets in a small sector by slewing the antenna to the azimuth desired. It would be necessary to set up the displays and controls in the IFR room for the test, since bright display equipment would not be available. Use of this equipment, or other radar height finders, or use of the radar beacon system for obtaining height information, requires evaluation to determine feasibility and controller workload.

PROJECTION OF FINDINGS TO HIGHER DENSITY AREAS

Although it is not possible to forecast VFR advisory activity in other areas completely on the basis of the Indianapolis data, some trends were observed at Indianapolis. With these, an attempt has been made to predict what might happen in other areas and with higher traffic densities.

At Indianapolis, it was found that:

1. The average number of conflicting aircraft targets per advised aircraft was approximately equal to one-tenth the number of aircraft targets on the scope. The actual number of conflicting aircraft about which a pilot was advised was subject to the laws of probability, since it depended on random factors such as the distribution of the targets on the scope. Figure 8 shows the probability of being advised of at least one conflicting aircraft target for several scope densities.

2. The average number of aircraft using the advisory service simultaneously, also was equal to about one-tenth of the number of aircraft on the scope. Random factors were present in this case, too. The probability of one or more aircraft using the service at the same time versus scope density is shown in Fig. 10.

In projecting these data, the items of primary interest as far as controller workload is concerned, are the number of conflicting aircraft and advisories issued per unit of time and the number of flights using the advisory service simultaneously. As far as the pilot is concerned, the number of conflicting aircraft pointed out to him during his flight through the advisory areas is important.

Conflicting Aircraft Reported and Advisories Issued.

In order to predict the average number of conflicting aircraft in a given area, per unit of time, data should be obtained on scope densities, and an estimate should be made of the number of aircraft which would participate in the advisory service. Figure 11 then can be used to estimate the number of conflicting aircraft targets which will be reported per hour based upon the assumption that the average number of targets reported will be 0.10 times the number of targets on the scope. The graph is entered by choosing the estimated number of aircraft participating in the advisory service per hour, going up to the average scope density and then over to find the number of conflicting aircraft targets reported per hour. For instance, with 20 aircraft using the advisory service per hour and an average scope density of 30 aircraft, the VFR controllers will report an average of 60 conflicting aircraft targets per hour. Because of randomness of the traffic, during peak periods of a few minutes' duration, the rate at which targets are reported easily may exceed double the average.

In addition, at Indianapolis an average of 1.7 advisories were issued per conflicting aircraft target, in other words, on the average, almost two advisories were issued for each aircraft that appeared to be in conflict. This figure can be used to convert targets reported per hour to advisories issued per hour. In the above example, about 102 advisories would have been given to the 20 aircraft regarding the 60 conflicting aircraft targets during the hourly period.

Simultaneous Use of the Service.

In the prediction of the number of aircraft using the VFR service simultaneously in other areas, the 1:10 ratio of aircraft using the VFR advisory service to total aircraft observed on the radar scope was used. A random distribution about the average number of advisory aircraft was assumed. Figure 12 shows the estimated average number of aircraft using VFR service for scope densities up to 70 aircraft. In addition, two other curves show the number of aircraft which will be using the service during peak periods. In one, during 5 per cent of the time, the number of advisory aircraft will be equal to or greater than the number shown. In the second, corresponding values for 1 per cent of the time are given.

The predictions for targets reported and for VFR aircraft using the advisory service are for total activity. If the service is shared by an arrival and departure controller, the average activity per controller will be one-half that shown by the curves.

Targets Per Aircraft.

The average and peak number of targets which a pilot would expect to be advised of for scope densities up to 70 aircraft will follow the same curves shown in Fig. 12 since, as previously pointed out, a 1:10 ratio exists in both cases.

Caution in Use of Predictions.

An intelligent projection of the Indianapolis data will require a thorough study of local problems. For instance, at one airport a large percentage of the traffic may go in only one of two directions. This would result in a higher VFR advisory workload than indicated by the scope density. It also is reasonable to assume that when an aircraft flies through a cluster of targets it will be impossible to issue individual advisories. In addition, the problem of identifying VFR advisory aircraft in high-density areas has not been discussed. In some cases it will impossible to identify an aircraft without vectoring and, at the same time, it may be advisable to vector the aircraft because of the proximity of other targets.

CONCLUSIONS

The following conclusions were reached on the basis of the tests of the VFR radar advisory service provided by the Indianapolis tower.

Staffing.

1. One arrival and one departure controller were able to provide the VFR radar traffic advisory service adequately to meet the traffic load re-requirements of the Indianapolis, Ind., terminal area. It is believed that one controller could have provided this service most of the time.

2. During peak VFR traffic volume, in good VFR weather when the IFR traffic load is light, it is believed the IFR approach controller and IFR departure controller can be used to supplement the VFR advisory controller.

Displays.

1. Scan-conversion equipment is suitable for producing daylight viewing radar scopes in the control tower cab provided that a light trap, or other device to reduce or eliminate reflections from the implosion shield and face of the CRT, is used. The bright display in the IFR room needs no reflection reducing devices, since the comparatively low ambient light in this environment is not sufficient to cause troublesome reflections from the implosion shield or CRT.

2. A video map, including some geographical fixes and a minimum of radio fixes, is desirable. Use of the AN/UPA-30 video mapper on the input side of the scan-conversion equipment is satisfactory.

Pilot Participation.

1. In the Indianapolis tests, the maximum number of VFR aircraft using the VFR radar advisory service simultaneously was six, with the maximum under arrival advisory at any one time being five, and the maximum under departure advisory at any one time being four.

2. Sampling techniques indicated approximately 94 per cent of all VFR air carrier flights used the service, with 52 per cent of the VFR non-air carrier and 31 per cent of the VFR military flights participating.

Effectiveness of Advisories.

1. Fourteen per cent of the conflicting traffic targets were reported in sight after the first advisory, and 8 per cent were reported in sight after more than one advisory was issued.

2. Seventy-eight per cent of the traffic targets never were sighted. These nonsightings probably were due to aircraft being at widely separated altitudes and in some cases, to reduced visibility conditions so that traffic targets never came within visual range of the advised pilot.

3. The average distance at which traffic targets were sighted was 2.5 miles.

Pilot Comments.

1. The majority of pilots who used the VFR advisory service and advised their opinions of it considered it to be a contribution to safety of flight and a desirable service to have available at all airports.

2. Most pilots prefer that the VFR advisory service be provided on an area basis rather than restricting it to corridors. However, as evidenced in their remarks, they are willing to accept certain restrictions, such as use of corridors or radar-vectoring, if conditions of marginal weather or heavy traffic warrant.

3. Almost all pilots stated that there is a definite need for receiving altitude information with traffic advisories.

Controller Opinions.

1. Controllers agree that specific routes for inbound and outbound traffic reduce the number of fast closures and thereby provide more time for controller action. They believe that the VFR radar advisory service should be provided on an area basis within 25 or 30 miles of the airport.

2. Most controllers believe that they could furnish VFR radar advisory service simultaneously to 5 to 12 aircraft, depending on target grouping on the display.

Communications.

1. The discrete VHF and UHF channels for arrivals and departures using the VFR radar advisory service were supplemented by the common civil frequencies of 122.5 Mc and 122.7 Mc, ground-to-air. These channels provided adequate service, although 122.5 Mc was shared with the tower controller.

RECOMMENDATIONS

1. Other configurations of controllers and displays should be evaluated in other areas to determine optimum arrangements of personnel and equipment. In particular, evaluation of horizontal plotting displays in high-density areas should be made.

2. An evaluation of the use of height-finder radars or beacons, to determine altitude relationship between aircraft, should be accomplished.

3. An evaluation of VFR radar traffic advisory service in en route areas covered by radar should be considered.

APPENDIX I

U. S. DEPARTMENT OF COMMERCE
Civil Aeronautics Administration

NOTAM

Test Evaluation of
VFR Arrival and Departure Radar Traffic Advisory Service
In Indianapolis, Indiana, Terminal Area

Beginning on or about June 23, 1958, at 0601 GMT, and until further advised, the CAA will conduct an evaluation of VFR arrival and departure radar traffic advisory service in the Indianapolis, Indiana, Terminal Area. Pilot participation is urged, but is not mandatory.

VFR RADAR TRAFFIC ADVISORY AREA

The Radar Traffic Advisory Area shall be that encompassed by a line connecting the following points: Lebanon, Ind., Noblesville, Ind., Greenfield, Ind., Shelbyville, Ind., Franklin, Ind., Martinsville, Ind., Putnamville, Ind., and back to Lebanon, Ind. (starting point). (SEE CHART)

Pilots of aircraft without radio, as well as those unable to contact VFR Arrival or Departure Advisory on assigned frequency, are nevertheless urged to conform to routing via designated VFR arrival and departure sectors.

VFR ARRIVAL AND DEPARTURE SECTORS

Arrival Sectors

Pilots destined for any airport within the VFR Advisory Area are urged to enter the area via one of the following designated sectors

Northeast Sector

The area within a line connecting Noblesville and Greenfield, thence west to the White River, thence to Noblesville. Pilots should remain north of US Highway 40/Pennsylvania Railroad and east of the White River.

Southeast Sector

The area within a line connecting Shelbyville and Franklin, thence north to the White River, thence to Shelbyville. Pilots should remain west of the New York Central Railroad and east of the Pennsylvania Railroad.

Southwest Sector

The area within a line connecting Martinsville and Putnamville, thence northeast to the Weir-Cook airport traffic control zone, thence east to the White River, thence to Martinsville. Pilots should remain west of the White River and south of US Highway 40.

Northwest Sector

The area within a line connecting Groveland, Lebanon, Clermont, Avon, thence to Groveland. Pilots should remain north of US Highway 36 and south of the New York Central Railroad.

Departure Sectors

Pilots departing any airport within the VFR Advisory Area are urged to utilize the following designated departure sectors most nearly aligned with their destination.

North Sector

The area within a line connecting Clermont east to the White River, thence to Noblesville, thence west to Lebanon, thence to Clermont. Pilots should remain east of the New York Central Railroad and west of the White River.

East Sector

The area within a line connecting Greenville and Shelbyville, thence northwest to the White River, thence to Greenfield. Pilots should remain south of US Highway 40/Pennsylvania Railroad and north of the New York Central Railroad.

South Sector

The area within a line connecting Franklin and Martinsville, thence north along the White River to the Pennsylvania Railroad, thence south to Franklin. Pilots should remain west of the Pennsylvania Railroad and east of the White River.

West Sector

The area within a line connecting Putnamville, Groveland, Avon, and Plainfield, thence to Putnamville. Pilots should remain south of US Highway 36 and north of US Highway 40.

PROCEDURES

The following procedures should be adhered to by pilots of all aircraft having proper radio equipment en route to and departing from Indianapolis Municipal and all other airports within the advisory area. (See attached chart)

1. Arrivals

a. General

Inbound VFR flights should contact Indianapolis VFR Arrival Advisory on either 118.5 or 290.3 mcs. when entering the advisory area. When practicable, pilots should follow the appropriate VFR arrival sector as indicated on attached chart and maintain listening watch on VFR Arrival Advisory frequency until further advised. If destination is other than Indianapolis Airport, so advise VFR Arrival Advisory.

b. Aircraft Landing Indianapolis (Weir-Cook)

(Weir-Cook) Indianapolis VFR Arrival Advisory will issue landing information (runway, wind, etc.) and radar traffic advisory information. At the appropriate time pilots will be advised to contact Indianapolis Tower on 119.9 or 257.8 mcs. and thereafter radar traffic information will be discontinued. Should runway in use, as specified by VFR Arrival Advisory not be acceptable, pilots should request specific runway desired on initial report to Indianapolis Tower.

c. Aircraft Landing Other Airports

Pilots should advise VFR Arrival Advisory of destination airport on initial contact and maintain a listening watch on the arrival frequency until further advised or until the pilot requests that the service be discontinued. When practicable, pilots should proceed to the traffic pattern of the other airports via the designated VFR arrival sectors.

2. Departures

a. General

Departing VFR flights should contact Indianapolis VFR Departure Advisory on 121.1 or 284. 6 mcs. When practicable, pilots should depart the radar advisory area via the designated VFR departure sector most nearly aligned with their destination. Pilots should maintain listening watch on VFR Departure Advisory frequency until cleared to leave the frequency or until beyond the limits of the radar advisory area.

b. Aircraft Departing Indianapolis (Weir-Cook)

Pilots who desire VFR Radar Advisory service should so advise the tower prior to take-off. Following take-off, such pilots will be advised when to contact VFR Departure Advisory.

c. Aircraft Departing Other Airports

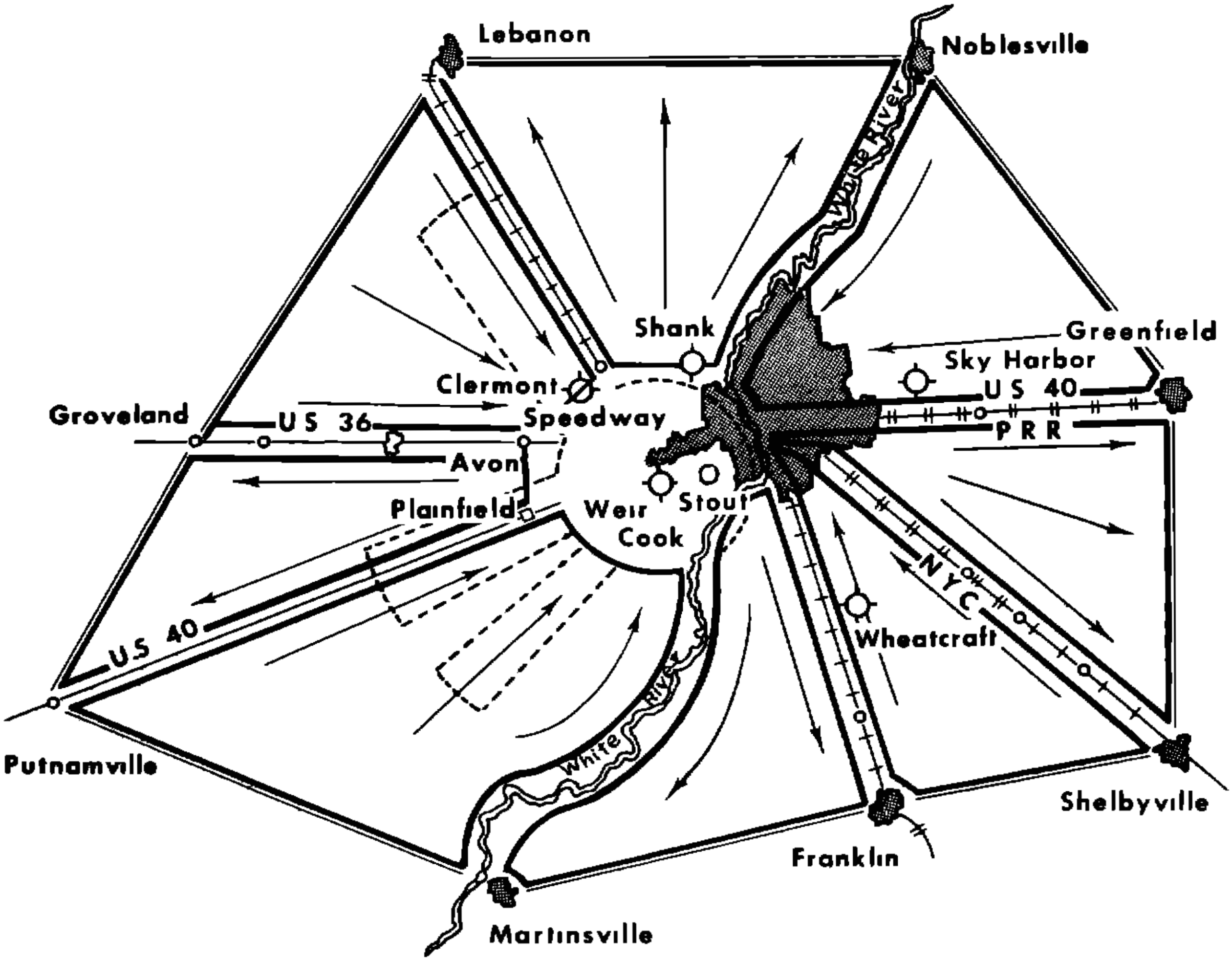
Pilots who desire VFR Radar Advisory service should contact VFR Departure Advisory after take-off and advise point of departure and destination. When practicable, pilots should proceed to the limits of the VFR radar advisory area via the designated VFR departure sector most nearly aligned with the point of destination.

THE SERVICE DESCRIBED HEREIN IS NOT INTENDED TO RELIEVE THE PILOT OF HIS RESPONSIBILITY FOR CONTINUAL VIGILANCE TO SEE AND AVOID OTHER AIRCRAFT. IT IS PROVIDED TO AID HIM IN HIS VISUAL SURVEILLANCE BY CALLING TO HIS ATTENTION A SPECIFIC DIRECTION IN WHICH RADAR INDICATES POSSIBLE CONFLICTING TRAFFIC TO EXIST. PILOTS ARE REMINDED THAT THE SURVEILLANCE RADAR UTILIZED BY THE CONTROLLER DOES NOT PROVIDE ALTITUDE INFORMATION.

PILOTS' COMMENTS AND RECOMMENDATIONS ARE SOLICITED AND SHOULD BE FORWARDED TO:

CAA Technical Development Center, TD-367
P. O. Box 5767
Indianapolis 44, Indiana

FRANKED, SELF-ADDRESSED POST CARDS FOR THIS PURPOSE ARE AVAILABLE AT FLIGHT OFFICES AND CAA FACILITIES WITHIN A 200 MILE RADIUS OF INDIANAPOLIS.



INDIANAPOLIS VFR ARRIVAL AND DEPARTURE RADAR ADVISORY AREA

When practicable, pilots are urged to conform to routing via designated VFR sectors and perimeter visual reporting points

"Indianapolis VFR Arrival Advisory" transmits and guards 118 5 and 290 3 Mc , guards 122 5 Mc

"Indianapolis VFR Departure Advisory" transmits and guards 121 1 and 284 6 Mc guards 122 5 Mc

APPENDIX II

U. S. DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

CAA VFR RADAR ADVISORY SERVICE

	ARRIVAL	DEPARTURE
Transmits and Guards	118.5 & 290.3 mc	121.1 & 284.6 mc
Guards	122.5 mc	122.5 mc

The CAA VFR Arrival and Departure Radar Traffic Advisory Service provides a warning service to pilots in the Indianapolis Terminal area. Pilot participation is urged, but is not mandatory.

THIS SERVICE IS NOT INTENDED TO RELIEVE THE PILOT OF HIS RESPONSIBILITY FOR CONTINUAL VIGILANCE TO SEE AND AVOID OTHER AIRCRAFT. IT IS PROVIDED TO AID YOU IN YOUR VISUAL SURVEILLANCE BY CALLING TO YOUR ATTENTION A SPECIFIC DIRECTION IN WHICH RADAR INDICATES POSSIBLE CONFLICTING TRAFFIC TO EXIST. PILOTS ARE REMINDED THAT THE SURVEILLANCE RADAR UTILIZED BY THE CONTROLLER DOES NOT PROVIDE ALTITUDE INFORMATION.

YOU CAN

USE the VFR Radar Advisory Service and help to evaluate the Service. Then complete this form, fold, fasten and mail it. (No postage is required.)

CAA Technical Development Center, TD-367
P. O. Box 5767
Indianapolis 44, Indiana

Budget Bureau No. 41-5843.1
Approval Expires Jan. 31, 1959

Percentages shown are for 50 questionnaires returned.

1. The total flight time I have logged is about ________ hours.

   Maximum: 18,000 hours Minimum: 88 hours 50% of pilots had more than 2050 hours.

2. I used the VFR Radar Advisory Service for: (CIRCLE appropriate words)

(Arrival)	(Departure)	(Overflight)	(Local Area)
41%	39%	6%	14%

3. The flight on which I used the VFR Radar Advisory Service was: (CIRCLE ONE)

(Personal or Pleasure)	(Business)	(Military)	(Air Carrier)
25%	53%	0%	22%

4. How many aircraft did the Advisory Service Operator bring to your attention?

(CIRCLE one)	(None)	(One)	(Two)	(Three)	(Four)	(Five or more)
	2%	2%	15%	23%	17%	41%

5. How many of the aircraft had you already seen before he mentioned them?

(CIRCLE one)	(None)	(One)	(Two)	(Three)	(Four)	(Five or more)
	42%	29%	25%	4%	---	---

6. How many of the aircraft that the operator advised you of did you fail to find even after you looked for them?

(CIRCLE one)	(None)	(One)	(Two)	(Three)	(Four)	(Five or more)
	22%	44%	22%	5%	2%	5%

7. The primary uses I made (or would make) of the VFR Radar Advisory Service are: (LIST in order of importance)

   For traffic information while flying the area, 49%; during arrival and departure, 19%. For traffic information during marginal weather conditions while flying in the area, 15%; during arrival and departure, 5%. As a navigational aid during marginal weather, 10%; for vectoring when lost, 2%.

8. If you are advised of traffic, which would you rather have the Advisory Service Operator do? (CIRCLE appropriate letter)

   (a) Tell you specific headings to fly so that you would be kept clear of others. 34%
   Air Carrier: 56% Business: 29% Personal or Pleasure: 29%

(b) Tell you where the other aircraft are and let you figure out what to do. 66%
Air Carrier: 44% Business: 71% Personal or Pleasure: 71%

9. If I am on a VFR flight within the Advisory Area, I should be: (CIRCLE all that apply)

(a) permitted to go by any route I want. 47%
(b) required to follow a specific route. 17%
(c) kept separate from the IFR routes. 19%
(d) Other (describe) 17% (see text)

10. I would prefer to have Radar Advisory Service provided on an: (CIRCLE one)

(a) AREA basis (called for anywhere within a 30 mile radius.) 92%
(b) CORRIDOR basis (called for only within specific corridors.) 6%
(c) Other (describe) 2%

DO NOT SKIP ANY OF THE FOLLOWING ITEMS

These items and statements should be completed on the basis of your own experiences, opinions and beliefs.

A. There is (CHECK one) ( ) very great 67% ( ) moderate 33% ( ) little -- ( ) no -- need for VFR Radar Advisory Service at busy airports.

B. The primary contributions of the VFR Radar Advisory Service to air traffic safety are: (LIST in order of importance)
Three primary categories:
1. Avoid collision: 83%
2. Radar navigation during marginal weather: 11%
3. Get weather information: 6%

C. The following improvements in the VFR Radar Advisory Service are needed: (LIST in order of importance)

1. Provide altitude information: 57%
2. Provide better communications: 20%
3. Universal application of the service: 7%
4. As a radar navigation aid: 5%
5. Provide service on area basis: 5%
6. Provide vector from traffic: 3%
7. No improvement: 3%

D. Other pertinent Remarks: The following are typical comments:

"I think this additional service is very good particularly in high density terminal areas where there is also a good deal of light aircraft activity."

"I do not use the advisory system. I believe a great deal can be observed by watching close and also a listening watch is helpful..."

"This service has great possibilities if it can be along the lines of information rather than control."

"I hope it is continued."

"I am very much in favor of this service... how much planes I haven't seen or wouldn't have seen unless advised."

"Wonderful!"

"I don't believe it practical..let's not take all the pleasure out of pleasure flying by being too restrictive."

"...It is my personal feeling that more control is needed in the vicinity of busy airports."

"A very welcome service appreciated by all taxpayers who fly."

MAILING INSTRUCTIONS

(1). Holding the sheet just as you are now, fold the pages under along the two dotted lines. This will leave the address exposed.

(2). Make sure the address is on the outside. Then fasten with staple or sticker.

(3). Drop in any mail box. No postage required.

(4). Thank you for your assistance.

Fold Along This Line

- -

U. S. DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION
INDIANAPOLIS, INDIANA

POSTAGE AND FEES
PAID
U.S. DEPT. COMMERCE

OFFICIAL BUSINESS

CAA TECHNICAL DEVELOPMENT CENTER, TD-367
P. O. Box 5767
Indianapolis 44, Indiana

Fold Along This Line

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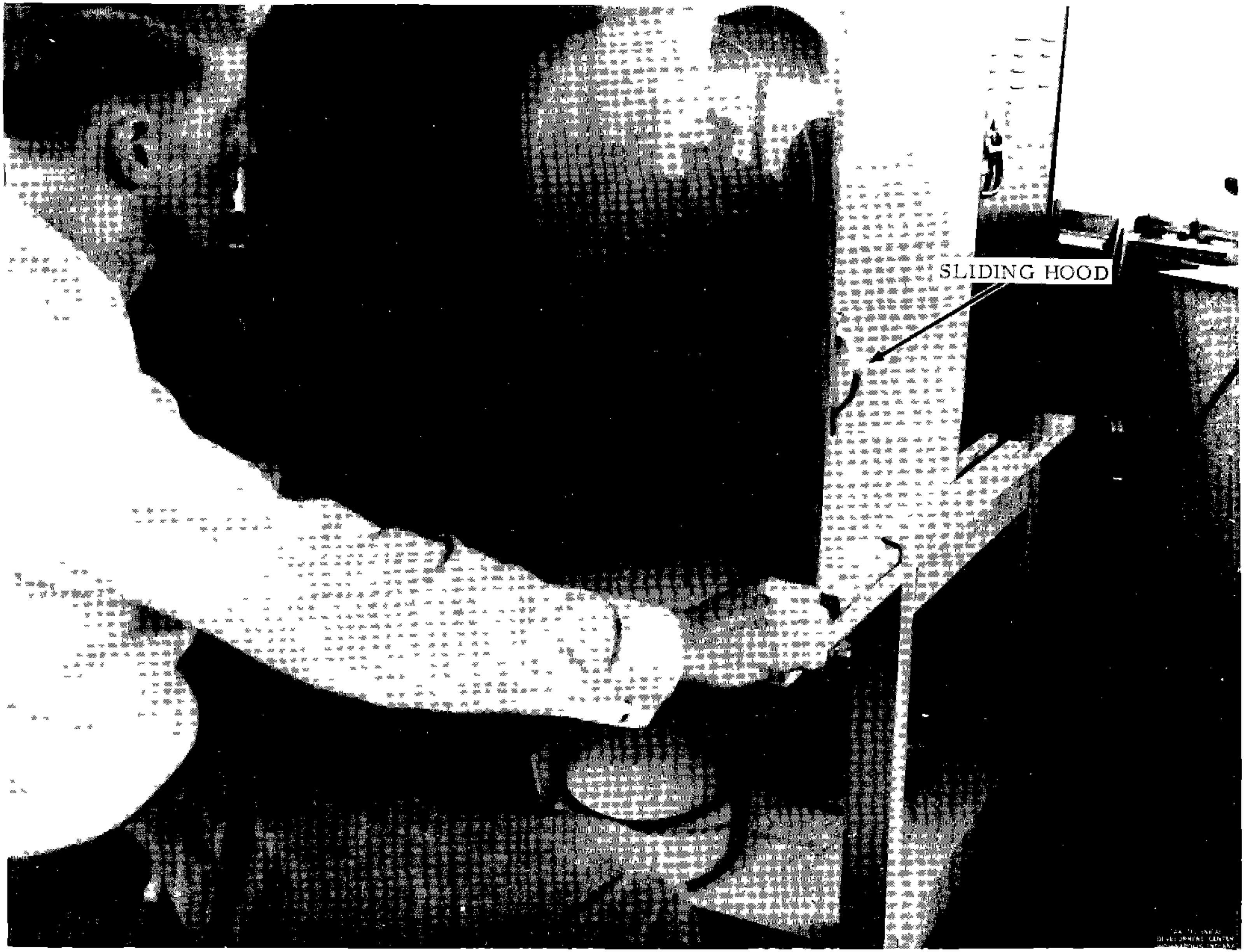

FIG 1 THE 21-INCH TV MONITOR AT THE DEPARTURE CONTROL POSITION IN INDIANAPOLIS TOWER CAB, WITH SLIDING-HOOD LIGHT CONTROL

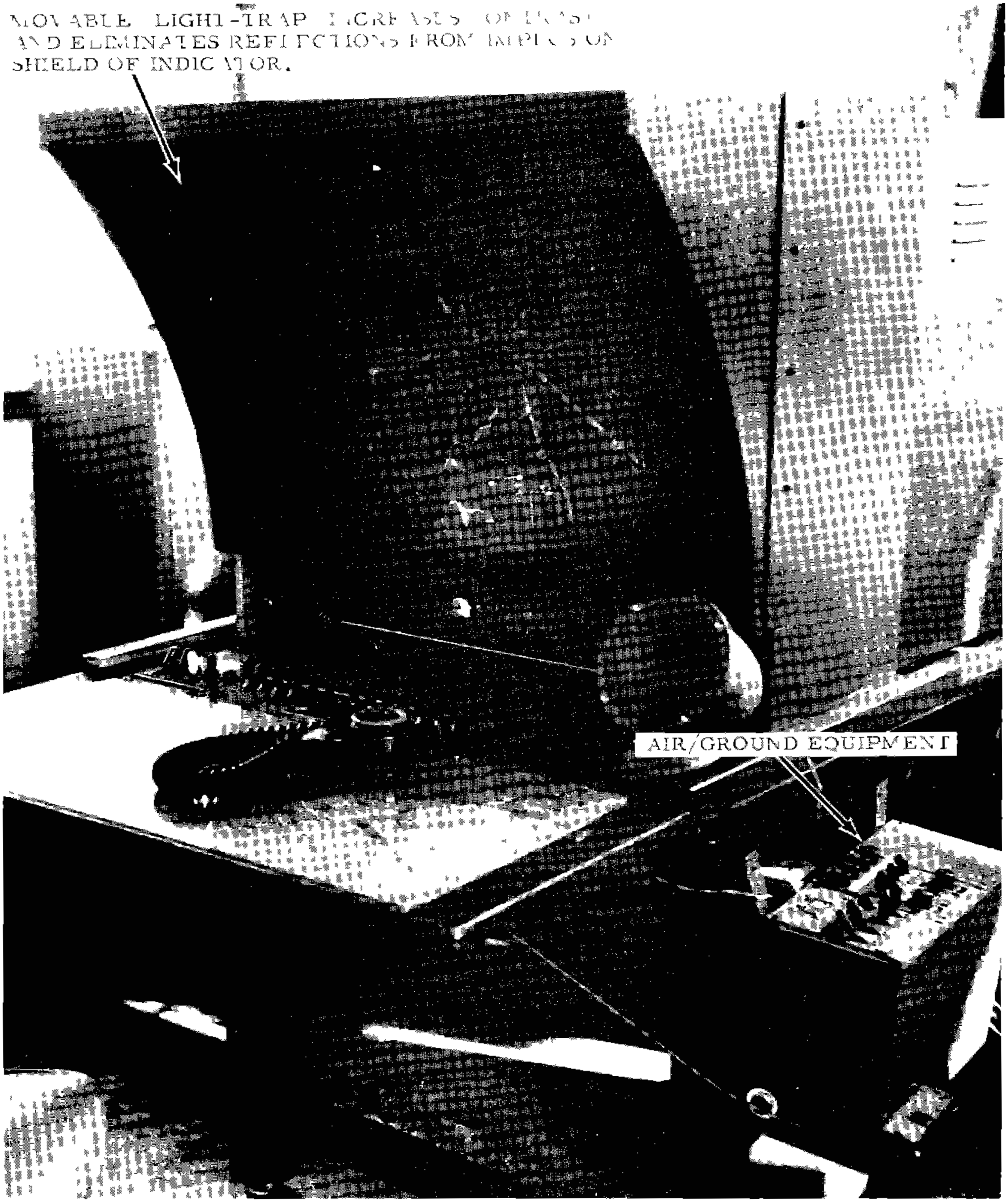

FIG 2 THE 21-INCH TV MONITOR AT THE DEPARTURE CONTROL POSITION IN INDIANAPOLIS TOWER CAB USED DURING VFR ADVISORY SERVICE

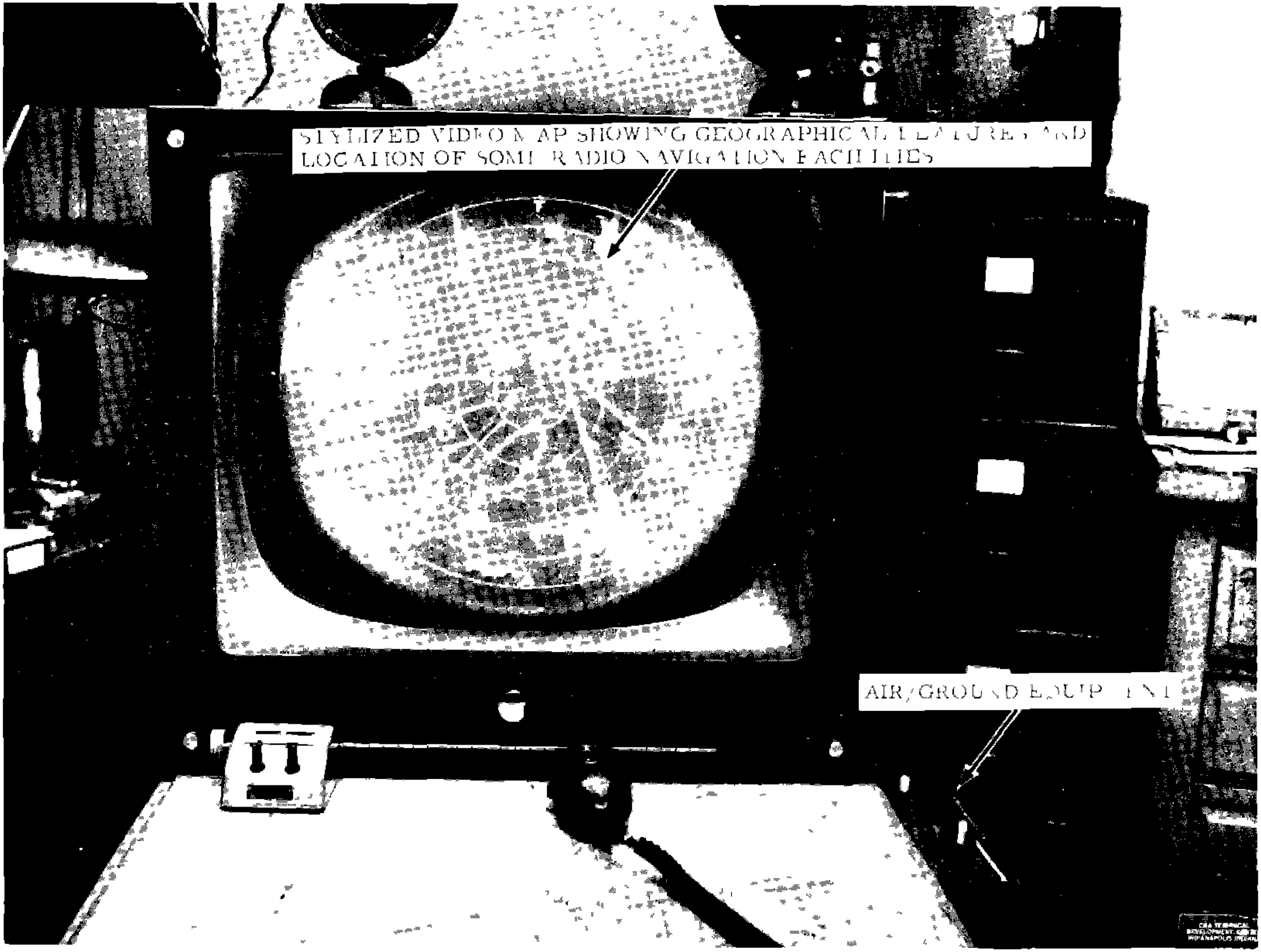

FIG 3 THE 21-INCH TV MONITOR AT THE ARRIVAL CONTROL POSITION IN INDIANAPOLIS TOWER IFR ROOM USED DURING VFR ADVISORY SERVICE

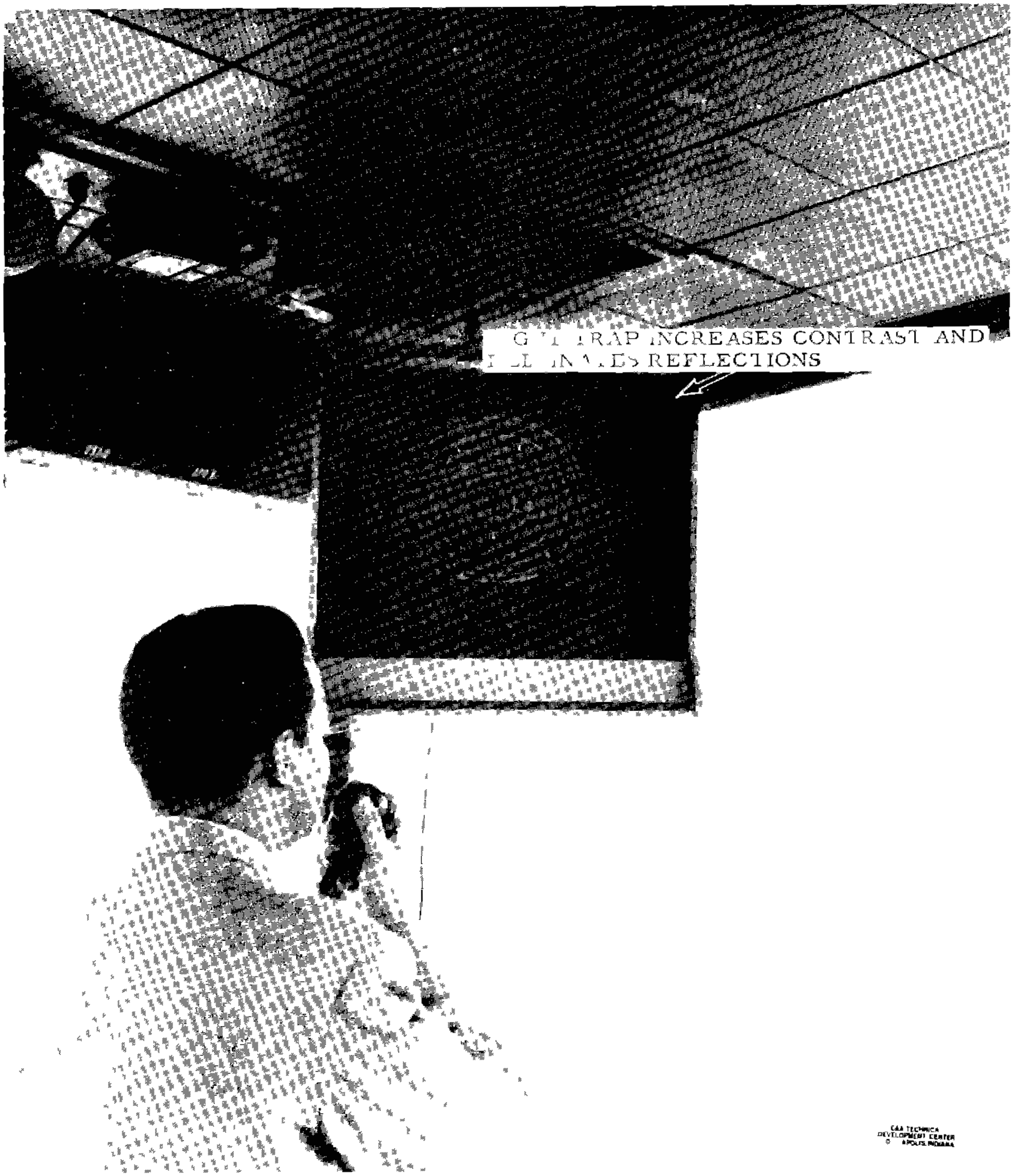

FIG 4 THE 17-INCH TV MONITOR AT THE LOCAL CONTROL POSITION IN INDIANAPOLIS TOWER USED OCCASIONALLY DURING THE VFR ADVISORY SERVICE TEST

FIG 5 THE 22-INCH HORIZONTAL PLOTTING DISPLAY IN INDIANAPOLIS TOWER IFR ROOM USED DURING THE VFR ADVISORY SERVICE TEST

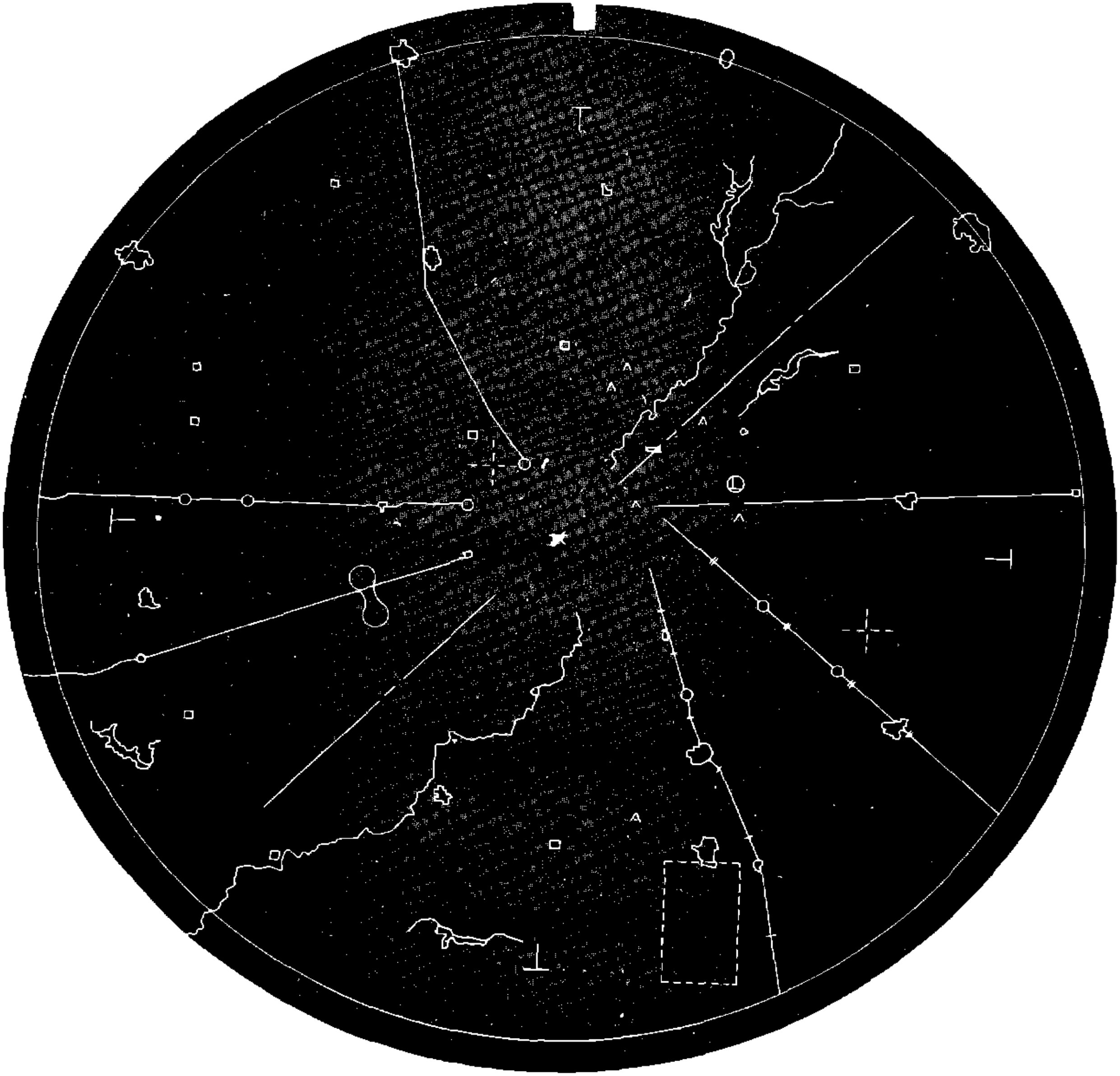

FIG 6 MODIFIED VIDEO MAP USED FOR VFR RADAR ADVISORY SERVICE

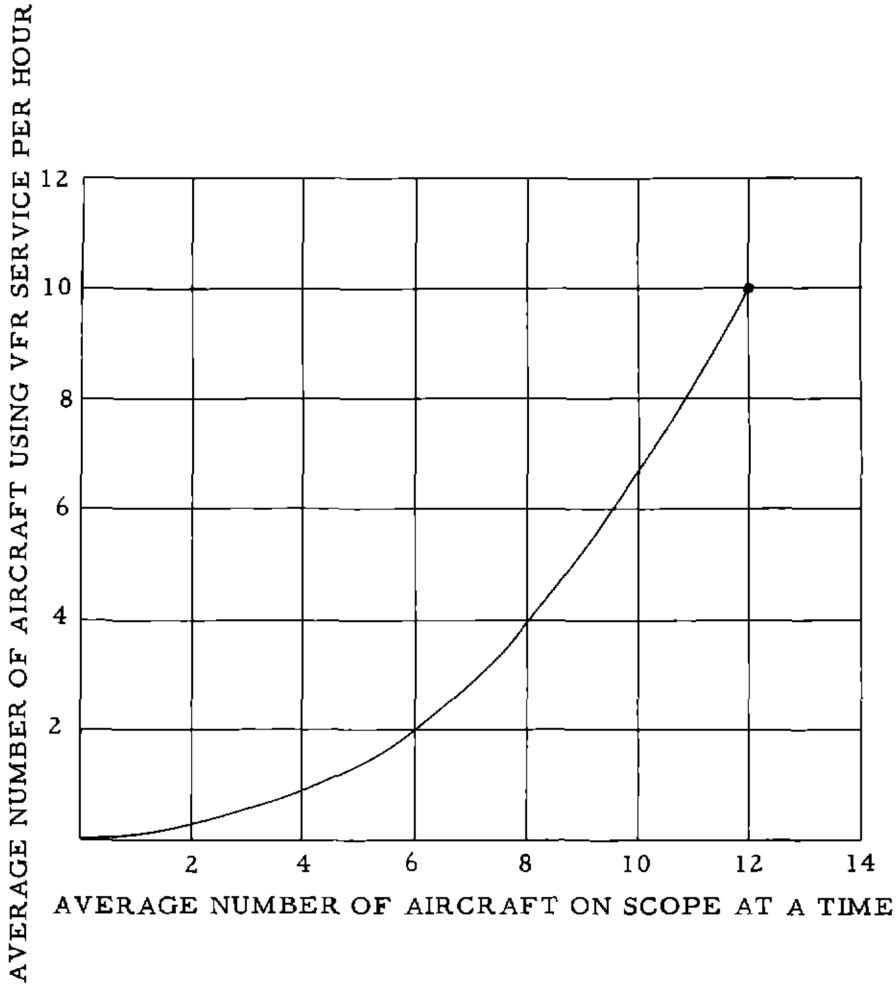

FIG. 7 NUMBER OF AIRCRAFT PARTICIPATING IN ADVISORY SERVICE VERSUS NUMBER OF AIRCRAFT ON SCOPE

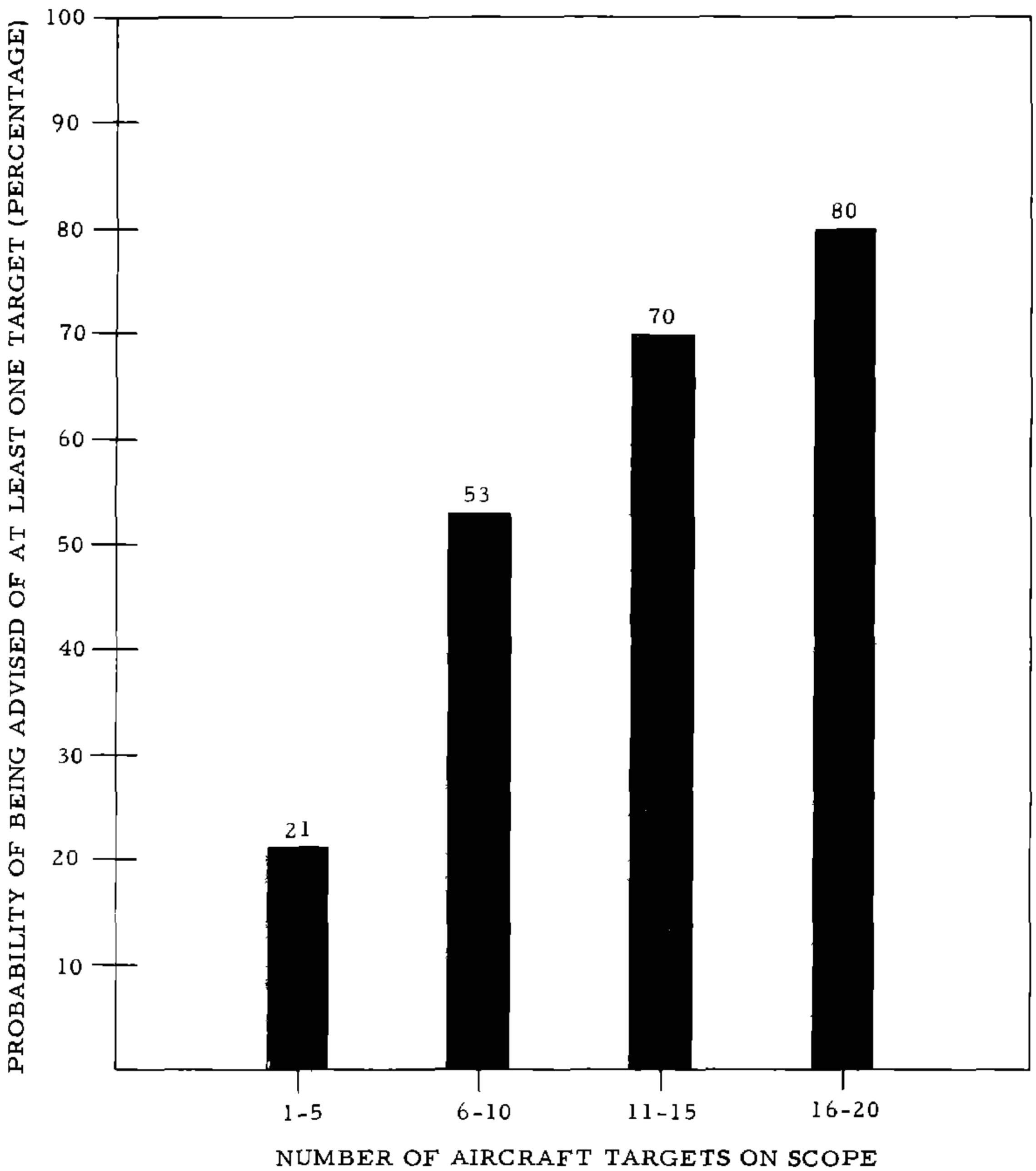

FIG 8 PROBABILITY OF AT LEAST ONE TRAFFIC TARGET VERSUS NUMBER OF AIRCRAFT TARGETS ON SCOPE

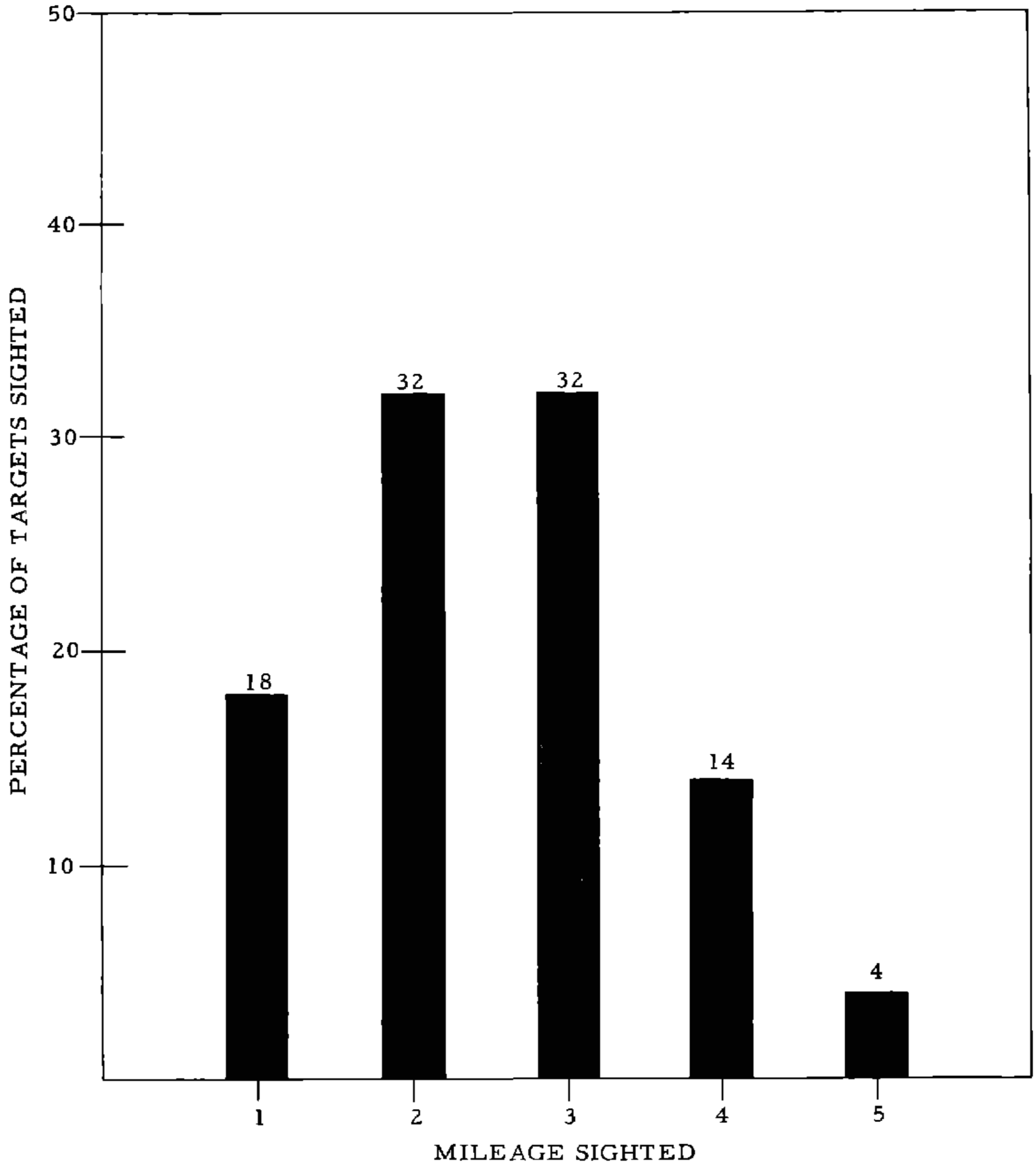

FIG 9 DISTANCE BETWEEN TARGETS AS OBSERVED ON RADAR WHEN PILOTS REPORTED SIGHTING AIRCRAFT AFTER MORE THAN ONE ADVISORY

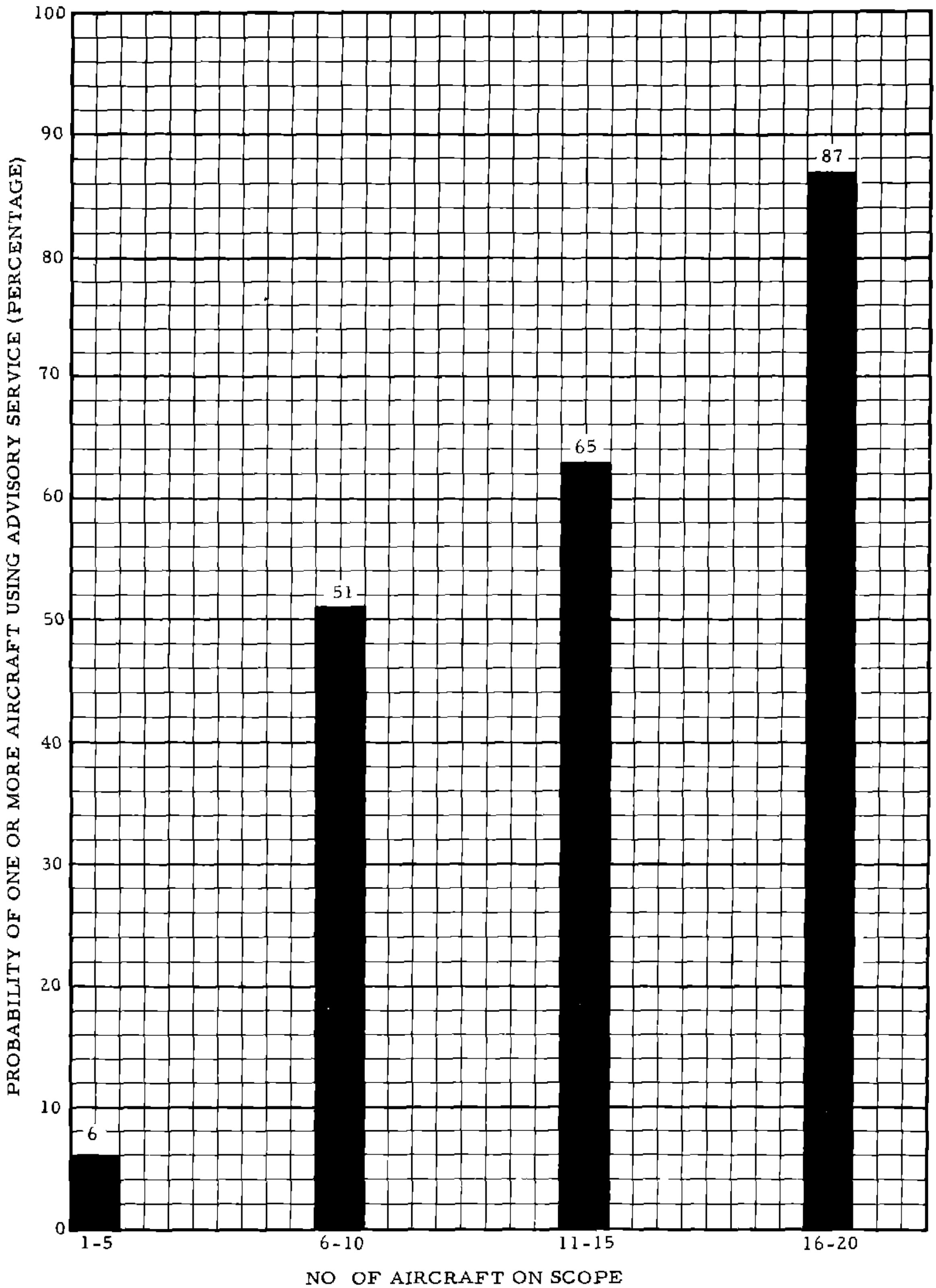

FIG. 10 SIMULTANEOUS USE OF SERVICE BY ONE OR MORE AIRCRAFT VERSUS SCOPE DENSITY

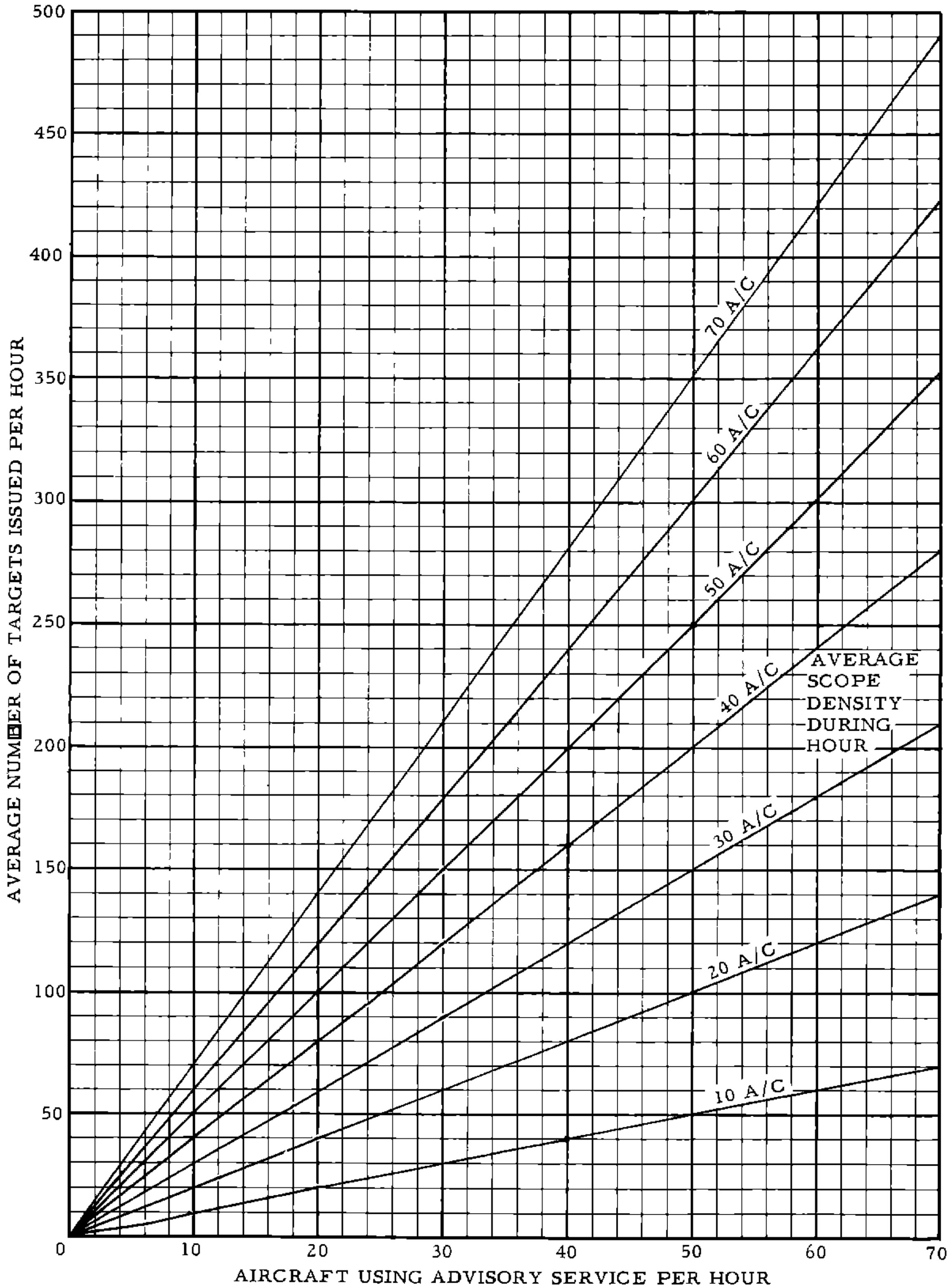

FIG 11 TARGETS ISSUED PER HOUR FOR VARIOUS ADVISORY SERVICE ACTIVITY AND SCOPE DENSITIES

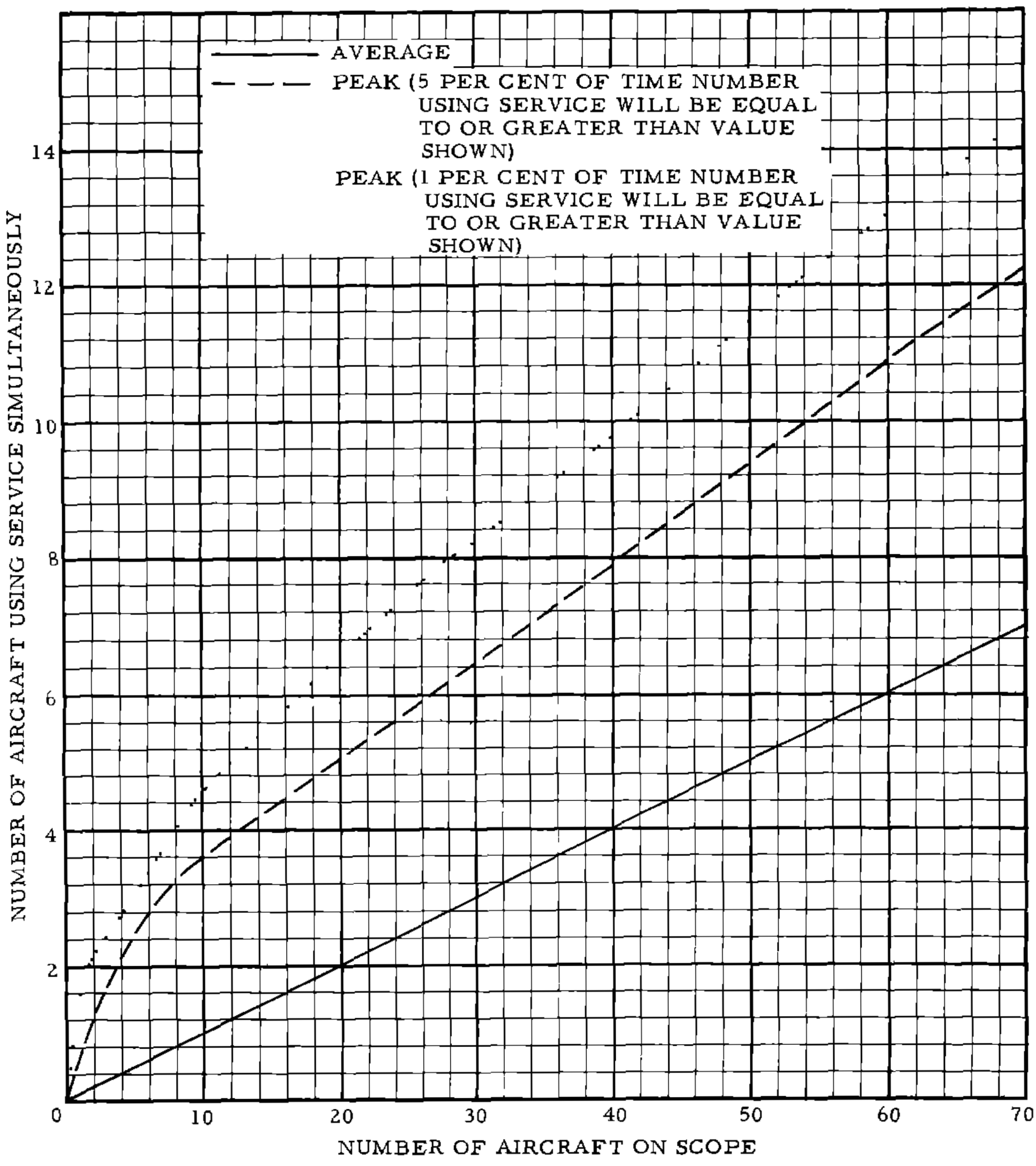

FIG. 12 PREDICTION OF SIMULTANEOUS USE OF SERVICE VERSUS TRAFFIC DENSITY