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DEVELOPMENT OF AN AIR TRAFFIC CONTROL SYSTEM FOR THE MIAMI TERMINAL AREA BY SIMULATION

TECHNICAL DEVELOPMENT REPORT NO. 422

TASK ASSIGNMENT NO. 59-733

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FEDERAL AVIATION AGENCY
Bureau of Research and Development
National Aviation Facilities Experimental Center
Atlantic City, New Jersey

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Director
Bureau of Research and Development
Federal Aviation Agency
Washington 25, D. C.

Subject: Final Report on Technical Development Center (TDC) Project No. 59-733, Titled "Development of an Air Traffic Control System for the Miami Terminal Area by Simulation"

Dear Sir:

A study was conducted to evaluate and make recommendations for the improvement of the Miami, Florida, terminal arrival and departure routes and related preferential route structures. This work was conducted at the Technical Development Center by the Navigation Aids Evaluation Division, utilizing personnel and facilities of TDC, as well as personnel from the Miami Air Route Traffic Control Center and the Miami Tower.

The final report, titled "Development of an Air Traffic Control System for the Miami Terminal Area by Simulation," is herewith enclosed.

Sincerely,

Wm S Cowart Jr

William S. Cowart, Jr.
Director

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DEVELOPMENT OF AN AIR TRAFFIC CONTROL SYSTEM FOR THE MIAMI TERMINAL AREA BY SIMULATION

ABSTRACT

The purpose of this study was to evaluate and make recommendations for the improvement of the Miami terminal arrival and departure routes and related preferential route structures.

The simulation study was divided into three parts. In Part I, the terminal area configuration (System A), as proposed by the Air Traffic Control Division, was tested. Certain modifications to System A were indicated and were incorporated in System B, which was evaluated in Part II. Part III dealt with various northbound departure procedures from the Miami Airport.

Test results indicate that, with the use of Center and Tower radar, the proposed terminal fix configuration serving the Miami Airport is adequate with only minor modifications required. The preferential route structure serving the Miami terminal area must be supplemented by an additional East Coast airway to accommodate any appreciable increase in traffic volume.

INTRODUCTION

In May 1958, the CAA Office of Air Traffic Control requested the Technical Development Center (TDC) to conduct simulation tests of the entire Florida peninsula. The test period was to commence September 16, 1958.

On August 21, 1958, representatives of the Washington Office of CAA, Region Two, and TDC met at the Miami Air Route Traffic Control (ARTC) Center to formulate plans for the simulation program. It was decided at this meeting to divide the program into three separate studies to consist of the Miami, Tampa, and Jacksonville terminals. This report deals with the Miami area study.

Representatives of Region Two and the Miami Center requested that the simulation study evaluate the present terminal area arrival and departure routes and related preferential route structures. Recommendations also were requested for improving the terminal area arrival and departure routes, terminal area holding and feeder fixes, terminal area approach aids, preferential route structures, and preferential en route navigational aids for use of both conventional and jet-type aircraft. Any recommended procedures were to be based upon facilities either existing or available by June 1959.

It also was noted that the Perrine low-frequency range, located approximately 15 miles south of Miami, was programmed for decommissioning in June 1959. This is a primary navigational aid for overseas traffic, and it was requested that the simulation study determine the possible results if the aid were removed.

The time allotment available for the Miami area project consisted of a three-week period for preliminary study and programming and a three-week period for dynamic simulation. Two air traffic control specialists from the Miami Center and Miami Tower assisted in the latter stage of the preliminary planning. During the dynamic simulation period, three additional controllers from the Miami Tower operated the simulated tower facilities and TDC personnel manned the ARTC Center positions.

GENERAL INFORMATION

Air traffic volume in the Miami terminal area is unique insofar as density fluctuations are concerned. The normal volume operating throughout the year is greatly increased by the influx of tourist traffic during the winter months, and an analysis of peak-day flow data indicated that this volume also is concentrated into relatively few hours each day. The major percentage of traffic is in the terminating or departing category, and over or en route aircraft present only a minor problem. The arrival and departure volume peaks generally do not occur during the same periods, that is, at the time the greatest number of aircraft are arriving, comparatively few are departing, and vice versa.

Volume-flow study also indicated that approximately 65 per cent of total operations are to or from terminals north of Miami and the remainder to the south, principally to overseas areas such as Cuba, South America, West Indies, and the Bahama Islands. A considerable portion of the overseas traffic is in the air freighter category, and this heavily loaded type, with its comparatively low rates of climb and forward speed, was at times a major consideration in developing procedures for the simulation study. This overseas traffic also was a determining factor in the consideration to retain or decommission the Perrine low-frequency range, as the majority of the foreign air carriers operate with only low-frequency navigation equipments.

The available airspace in or adjacent to the southern portion of the Florida peninsula is limited by the warning and restricted areas set aside for military and missile-firing activities, and these areas are a major consideration in the development of procedures and airway routings.

The Miami area recently has undergone a major modification of en route aids and associated airway structure with a relocation of the Miami VOR and the addition of the Biscayne VOR, both developments being the culmination of considerable planning on the part of the Miami Center and Regional Office personnel. Center and Tower radar is programmed for the near future, and a primary purpose of the simulation study was to test contemplated radar procedures in conjunction with the new airway structure.

Planning

The Miami simulation study was divided into three parts. Part I consisted basically of a testing of the Miami terminal area vector fix configuration as proposed by the Office of Air Traffic Control and the Miami Center/Tower. This configuration is referred to as System A and is depicted in Figs. 1 and 2. Past studies at TDC have indicated that certain arrangements of radar vector fixes and application of aircraft spacing table provide the optimum as to minimum spacing of aircraft with the least controller workload. See Fig. 3. The proposed configuration met these criteria quite well, and aside from the suggested changes resulting from the tests in Part I, no major changes were made to the proposed system.

Part II of the study evaluated the suggested modifications to System A and also considered the merits of a proposed airway, V501, between V267 and V3. The modified configuration is referred to as System B.

Part III tested various northbound departure procedures from the Miami Airport, using System B as a common basis for comparative purposes.

SIMULATION TEST PROCEDURES

The simulation study encompassed an area of approximately 70 miles' radius from Miami, and included the Miami, Opa Locka, and Fort Lauderdate terminal facilities.

The en route and terminal tests were run simultaneously with the Center using two superimposed panoramic radar displays (SPANRAD). SPANRAD is a device which uses closed-circuit television techniques to superimpose the picture of a target marker with that of a radar target and project both on a bright tube display, as shown in Fig. 4.

The Center en route area was divided into two zones of jurisdiction, north and south, with the Miami localizer courses as the dividing line. The north arrival and departure controllers used one SPANRAD and the south arrival and departure controllers the other. During periods of extensive traffic, an additional controller assisted the north radar operation in maintaining identification of targets.

Miami approach control used three simulated airport surveillance radar (ASR) scopes, as depicted in Fig. 5. One was for south arrival radar, one for north arrival, and the third for departure radar control. Approach control assumed jurisdiction for Miami International, Opa Locka, and Fort Lauderdale Airports.

Test Assumptions

In order to conduct the simulation tests properly, it was necessary to make certain assumptions to govern the operations. These assumptions were.

1. The holding airspace area as defined in TSO-N20A would be increased 50 per cent on the forward end and both sides, as shown in Fig. 6.

2. There were adequate air/ground communications between control facilities and all aircraft.

3. There was adequate radar or secondary radar coverage in the area simulated.

4 Civil jets were controlled in a conventional manner unless approach delays were excessive. Holding at 20,000 feet or above was utilized if excessive delays were anticipated.

5. The airway structure was based solely upon VHF navigation aids; however, feeder fixes and routings from the south to those fixes were compatible with existing low-frequency fixes and routes in order to accommodate foreign air-carrier types.

6. Homestead Air Force Base (AFB) was considered an independent area, with its approach and departure lanes presenting no encroachment upon adjacent airways and holding airspace areas.

7 Both east-west runways at the Miami International Airport were served by instrument landing systems (ILS), one landing west and the other east.

8. Departing flights were controlled to the degree that altitude or time separation existed prior to aircraft departing the test area confines.

9. In order to test certain procedures, aircraft proceeding southbound over Pahokee via Victor Airway 267 and over Bel intersection via Victor Airway 501 were assigned only odd-thousand-foot altitude levels. These altitude assignments were completely random, and sequencing according to landing priority was accomplished only after the aircraft had proceeded south of Pahokee and Bel. The random altitude assignments were incorporated into the traffic sample in order to simulate the end results of nonradar control procedures north of Pahokee It was considered that, without

the use of en route radar in that area and with the volume of traffic present, very little could be accomplished in the way of altitude sequencing prior to aircraft reaching Pahokee. Altitude levels varied from 5,000 to 25,000 feet.

Traffic Samples

From flight data information furnished by the Miami Center, a two-hour traffic sample was constructed in which the peak volume was increased approximately 25 per cent. Civil jet aircraft comprised 20 per cent of this total. In order to duplicate the departure-arrival peaks, the volume was adjusted at 75 aircraft movements per hour, consisting of 50 arrivals and 25 departures the first hour and 50 departures and 25 arrivals the second hour.

Analysis of traffic flow data indicated that 65 per cent of all terminal area traffic was to or from areas north of Miami and of this volume, approximately 83 per cent utilized the east coast routings. The balance, or 17 per cent, used routings to or from the west coast. With the traffic sample volume as a basis, these percentages transposed numerically into 54 aircraft per hour departing and arriving via east coast routings, and 12 per hour via the west coast. Utilizing the present preferential routings from Miami, a further breakdown of flow is approximately 27 aircraft per hour departing via Victor Airway 3 or Victor Airway 3 east, and 27 per hour arriving via Victor Airway 267. In Part I, this volume indicated the need for additional routings, and in Part II, a new airway, designated Victor 501, was located between Victor Airway 3 and Victor Airway 267.

EVALUATION METHODS

Measurements

Traffic delay, airport acceptance rates, and communications data were taken during the simulation tests and used whenever possible as a means of determining the merits of the various systems being tested. However, because of the many variables in the total simulation study, it was not always possible to accomplish sufficient test runs on each variable to furnish results that were statistically significant.

Analysis of the simulation tests was influenced to a considerable degree by controller comments as to workload, coordination problems, and so forth. In addition to a day-by-day oral evaluation of test runs, a critique was held at the conclusion of the simulation study. Each controller was given an opportunity to express his opinion and recommendations at this discussion, and to a large extent, portions of this report refer to opinions expressed at this critique.

PART I

The description and evaluation of procedures in Part I are divided into two sections, one dealing with an east arrival and departure operation and the other pertaining to a west operation.

System A

East Operation

Departure Procedures

Departures proceeding northbound via the east coast preferential routes (Victor 3 and/or Victor 3 east) were given short-range clearance limits to Deer or Golden Beach intersections, with a radar handoff from Tower to Center in the vicinity of Dania or Golden Beach. No tunnel restrictions were required on this route. Flights proceeding northwest via Victor 97 or Victor 7 were tunneled at 2,000 feet via Dania until past the holding airspace at the Miami VOR. A 3,000-foot tunnel was required if an approach was in progress at the Opa Locka Airport. Radar handoff to the Center was accomplished when the aircraft cleared the Miami VOR holding pattern.

Departures proceeding southbound via Victor Airway 35 were routed via Biscayne VOR direct to Elliot at an initial altitude of 2500 feet. Radar handoff from Tower to Center was accomplished at Elliot. Southbound departures via Victor 51 were controlled by two methods, either by tunnel at 2,000 feet until reaching Harvey or by climb eastbound on the Miami localizer course to appropriate altitude, then reversing course and continuing climb to final altitude. The tunnel procedure was reserved primarily for slow-climbing air freighter type aircraft.

Arrival Procedures

The primary radar vector fixes used with east approaches were the Miami VOR, Ford, Rancho, Krome, and Kendall. In addition, a secondary clearance limit, New River, was available on Victor 267 to reduce holding congestion at the Miami VOR. The Miami Center normally cleared arriving aircraft to the primary fixes at 4,000 feet and above.

Evaluation of East Departure/Arrival Procedures

En Route

The greatest volume of departures, that is, northbound departures, presented no Center problem. Flights proceeding via Victor 3 or Victor 3 east required little radar service prior to reaching Palm Beach where the two airways converged. A similar situation existed with northwestbound departures via Victor 97 or Victor 7. After radar handoff was accomplished in the vicinity of the Miami VOR, the first airway convergence occurred 70 miles distant at the LaBelle VOR. With the exception of V35, each departure route was independent of arrival routes once departing aircraft were clear of the primary vector fixes. In the case of V35, the small amount of traffic arriving and departing via this routing was easily separated with the use of radar. The fact that there were four available airways for northbound departures, Victor 97 and Victor 7 to the west coast and Victor 3 and Victor 3 East on the east coast, made the Center control comparatively easy.

The opposite was true insofar as arriving aircraft from the north were concerned. As noted in the traffic analysis section of this report, 83 per cent of arrivals from the north proceed via V267. Controller comment after test runs indicated that this large volume of aircraft could not be sequenced efficiently at the Miami VOR due to the controller's inability to maintain individual identification of aircraft in the congestion of targets, even with the assistance of another radar controller. Delay information proved unfavorable, and considerable workload was encountered in reclearing practically all aircraft to and from secondary fixes short of the Miami VOR.

Terminal

Vectoring for east approaches was accomplished from Ford and the Miami VOR by the north arrival controller, and from Krome, Rancho, and Kendall by the south arrival controller. The workload was not distributed equally between the two radar controllers, due to the preponderance of arrivals from the north. The north arrival controller was extended to the limit of his capabilities while the south arrival controller frequently "ran dry" of aircraft at his vector fixes. Ford intersection did not appear practical as a vector fix due to the extended straight-in flight path to the outer locator. This direct flight path precluded any efficient meshing with aircraft from Miami VOR or Rancho unless extreme path-stretching maneuvers were used. This, of course, added to the controller workload and reduced the arrival rate.

As indicated in Fig. 7, the use of tunnel restrictions for departures proceeding through vector fixes required that aircraft on a vector to the outer locator be held at 3,000 feet or above until reaching a descent area. This procedure, while not ideal, did not appear to be too detrimental to controller workload or minimum spacing of aircraft, with the exception of Kendall. Departures proceeding via Victor 35 were tunnelled at 2500 feet due to the assignment of 1500 feet for Homestead AFB departures and missed-approach procedures. This tunnel of 2500 feet entailed a minimum stacking altitude of 3500 feet at Kendall. Due to the proximity of Kendall to the outer locator, aircraft frequently could not dissipate sufficient altitude to execute an approach properly.

System A

West Operation

Departure Procedures

Departures proceeding northbound via Victor 3 or Victor 3E required a tunnel restriction of 2,000 or 3,000 feet until clear of the Dania holding pattern and/or the arrival vector path at Golden Beach (Fig. 2). Radar handoffs from Tower to Center were made at the Martin or Fort Lauderdale intersections. The 3,000-foot restriction was required if an approach was in progress at the Opa Locka Airport. Flights proceeding via Victor 97 or Victor 7 were restricted to 2,000 or 3,000 feet until past the Miami VOR, in order to provide separation from arrivals proceeding via V35 from Ford and via V267 from the north.

Departures proceeding south or southeastbound were restricted to 2,500 feet until past Kendall or Southgate holding pattern airspace. High-performance-type aircraft were climbed westbound on the localizer course to an altitude above holding traffic before proceeding on course Departures proceeding via Victor 51 were routed via the Miami localizer course and Victor 157 and given an unrestricted climb.

Arrival Procedures

The primary vector fixes used with west approaches were Dania, Kendall, and Southgate, with the Miami VOR serving as a secondary clearance limit for Dania. The Miami Center normally cleared arriving aircraft to the primary fixes at 4,000 feet and above.

Evaluation of West Departure/Arrival Procedures

En Route

The Center departure/arrival procedures involved little change from those used with an east operation, and the same major problem, which was the congestion of arriving aircraft on Victor 267, was apparent Aside from the use of the 103° radial of the Biscayne VOR for Bermuda arrivals and departures, the route structure offered the same advantages as were apparent with the east operation The use of the 103° radial of Biscayne as a common route presented no complicating factors as the small volume of traffic using this departure procedure was separated easily by the use of radar

Terminal

The majority of departures were required to pass through the primary fix at Dania or through the vector path at Golden Beach. These aircraft, in conjunction with the arrivals, created a considerable congestion of targets between Dania or Golden Beach, making it difficult for the north arrival controller to identify an aircraft on vector positively until it was well within the descent area (Fig. 8). While a similar problem existed at Kendall, the volume of departures and arrivals was considerably less, thereby making the procedure more workable.

As with east approaches, the division of workload between the north and south arrival controllers was very unequal due to the major number of aircraft arriving from the north.

CONCLUSIONS

Controller comment indicated that the primary disadvantages to System A from the Center viewpoint was the lack of sufficient arrival routes from the north.

The comments on the terminal area configuration dealt primarily with the need for a more equal distribution of workload between the north and south arrival controllers and a modification of departure routings to the north when using west takeoffs. In addition, the location of Kendall was not considered advantageous with either an east or west approach operation.

PART II

In Part II, the following changes were made to System A in order to reduce some of the problem areas. The resulting configuration is referred to as System B (Figs. 9 and 10).

1. An additional airway, Victor 501, was designated between Victor 267 and Victor 3; V159 was redesignated as the direct radials of the Miami and Palm Beach VOR's, and used as a transition from Victor 501 to the Miami VOR.

2. Several possible relocations for Kendall were considered, however, each interfered with the holding pattern airspace required for Rancho during an east operation. Therefore, it was decided to combine the function of Rancho and Kendall into one vector fix designated as Ed (Fig. 11). This fix permitted an east takeoff routing via the Biscayne VOR direct to Elliot without tunnel restrictions insofar as holding aircraft were concerned. The location of Ed also approximated the location of the Perrine L/F radio range, making the primary vector fix compatible for either L/F or VOR-equipped aircraft.

3. To relieve the congestion of targets at Dania during a west operation, the primary vector fix was moved from Dania to Golden Beach. In addition, two radials, 039° and 054°, of the Miami VOR were designated as transition routings for north-bound departures proceeding from the Miami VOR to Victor 3 and Victor 3 East.

4. In System A, the south arrival controller used two vector fixes, Kendall and Southgate, during a west operation; however, the location of Kendall restricted departures proceeding via Victor 35 to a considerable degree. To reduce this restriction, Southgate was designated the primary vector fix and moved as far westward as possible without its holding pattern infringing upon Victor 35, thus eliminating the need for Kendall.

5. As the preponderance of arrivals into the Miami area are from the north, no practical method of dividing the work-load evenly between the approach control north and south arrival controllers was found. However, a partial solution to the problem was to eliminate Ford as a vector fix and reroute West Coast traffic via Victor 35W and Victor 51 to Ed or Southgate. This added approximately 10 miles to the original routing via Ford but permitted a more equitable flow of arrivals, resulting in an increased arrival rate.

System B

East Operation

Departure/Arrival Procedures

The control procedures used in conjunction with the above modifications were System B, east operation, and departure procedures. With the exception of the tunnel restrictions required for departures proceeding via Victor 35, control procedures in System B basically were the same as used in System A. The elimination of Kendall as a holding fix permitted the use of altitudes above 2500 feet for Victor 35 departures, and radar handoffs from Tower to Center now were made at the Biscayne VOR, with the Center's only concern being the separation of these departures and aircraft en route to Ed The primary vector fixes for east approaches were Ed and the Miami VOR with two secondary fixes, New River on Victor 267 and Pogo on Victor 501, serving the Miami VOR These secondary fixes were used by the Center as a reservoir to regulate the volume of traffic in the Miami VOR holding stack. Normally, the top altitude utilized at the VOR was 7,000 feet in order to keep the congestion of targets to a minimum. As in System A, the Center cleared arriving aircraft to the primary fixes at 4,000 feet and above.

Evaluation of East Departure/Arrival Procedures

En Route

The addition of Victor 501 simplified the control of arrivals from the north to a large degree. Approximately one-third of the aircraft formerly routed via Victor 267 were rerouted via Victor 501, reducing the congestion of targets on Victor 267 considerably. In addition, the two airways provided more flexibility in sequencing arrivals at the Miami VOR. If an approach sequence of an arrival was in doubt, the controller simply cleared the aircraft to New River on Pogo at the lowest altitude available at these fixes At such time that the exact priority of landing was determined, the aircraft was recleared to the Miami VOR. The use of two secondary fixes permitted much lower initial altitude assignments and correspondingly less delay to aircraft in reaching the lower altitudes. In turn, this reduced the arrival controller workload because of fewer clearances required to descend the aircraft to a minimum stacking altitude.

Terminal

The rerouting of West Coast aircraft to Ed instead of Ford eased the unequal workload of the two arrival controllers somewhat. Where the division of arrivals formerly was 65 per cent to the north vector fix and 35 per cent to the south fix, the division now was 55 per cent to the north and 45 per cent to the south. The use of only two primary fixes also simplified vector procedures. Normally, it was necessary for each arrival controller to have only two or, at the maximum, three aircraft on vector at a time, with the flight paths to the outer locator being short and easily varied for optimum spacing. As illustrated in Fig. 11, the vector areas were compact, which meant that the controller's attention was devoted to a relatively small area.

System B

West Operation

Departure Procedures

Aircraft proceeding via Victor 3 or Victor 3 East were given short-range clearances to Raton and Blake intersections at altitudes of 3,000 and 4,000 feet. The transition from the vicinity of the Miami VOR to these intersections was via either the 039° or the 054° radials of the Miami VOR (Fig. 10). The radar handoff from Tower to Center normally was accomplished after the aircraft had passed the VOR. Aircraft routed via Victor 97 or Victor 7 were controlled in one of two ways, either via the Miami VOR with a tunnel restriction of 3,000 or 4,000 feet, or vectored west of the VOR until intersecting the appropriate airway. The latter procedure eliminated the need for any tunnel restrictions and permitted handoffs from Tower to Center in the vicinity of the Miami localizer course.

Departures proceeding southbound via Victor 35 were given an initial altitude of 2500 feet and handed off from Tower to Center crossing Victor 51. The Center then provided separation between the departure aircraft and aircraft en route to Southgate.

Arrival Procedures

Arrivals from the north on Victor 267 and Victor 501 were routed to Golden Beach via the Miami VOR and the 088° radial of Miami. The normal secondary clearance limit was the Miami VOR; however, during periods of extensive activity, New River and Pogo served as additional holding fixes. Arrivals were held to 5,000 feet or above until passing Sam, at which point the aircraft were descended to lowest available altitude, commencing at 2,000 feet, and released to approach control. The 5,000-foot restriction provided separation from departures at 3,000 and 4,000 feet proceeding to Raton and Blake. Arrivals proceeding to Southgate normally were restricted to 3500 feet until east of Biscayne VOR, then descended to lowest available altitude, commencing at 2,000 feet, and released to approach control.

Evaluation of West Departure/Arrival Procedures

En Route

The modifications to the west departure procedures had no measurable effect on Center operations. The use of the 039° and 054° radials still permitted two separate routings for north departures, with practically the same distance to Palm Beach available for unrestricted climb prior to the convergence of Victor 3 and Victor 3E Departure procedures to the northwest and south involved little change from those used with an east operation. The value of Victor 501 as an arrival routing again was demonstrated in the west operation test runs. The secondary clearance limits of New River and Pogo permitted easy altitude sequencing of arrivals prior to convergence at the Miami VOR, and very little additional holding was required en route to Golden Beach.

Terminal

The fact that Golden Beach and Southgate lay east of the outer locator (Fig. 12) provided the arrival controllers with excellent identification possibilities, and in periods of less than saturated conditions, many aircraft were vectored to the localizer course prior to reaching these holding fixes The ease of identification was due to terminal departure routings now being completely clear of the inbound routes, thereby reducing congestion of targets. As in the case of arrivals from the north, the arrival controller was able to track aircraft from west of Sam to Golden Beach and therefore could preplan his control to a considerable degree.

PART III

Both System A and System B east operation departure procedures required that aircraft routed via Victor 97 or Victor 7 be restricted to 2,000 or 3,000 feet until clear of the Miami holding pattern airspace, the extent of the restriction being dependent upon whether an approach was in progress to the Opa Locka Airport. The altitude restriction was the minimum possible without further penalizing the base holding-stack altitude at the Miami VOR. The tunnel procedure had two detrimental features, one of which was the long departure flight path (30 miles) at minimum altitudes, and the other the necessity of holding arriving aircraft at minimum stacking altitude until within a descent area. The latter requirement precluded any shortened radar vector to the localizer course, as the altitude of the aircraft could not be dissipated prior to reaching the outer locator. In the case of arrivals from the south, the tunnel procedure was tenable because of the relatively low volume of traffic, both inbound and outbound. However, as noted previously, the preponderance of arrivals were from the north, and subsequently, the lengthened vector path of each of the arrivals added to the over-all workload of the north terminal arrival controller. The Opa Locka operation was not particularly emphasized in the Miami study due to the low activity level presently associated with the terminal. However, prior to the initial planning for the study, information was available which indicated that Opa Locka was being considered as an air freight terminal. It is obvious that any substantial increase in the operations at Opa Locka would complicate the control of traffic in the Miami terminal area further, especially with respect to the tunnel procedures through the Miami VOR holding fix. In view of this potential complication, part of the simulation program was reserved for evaluating departure procedures which would accommodate increased activity at Opa Locka, and possibly eliminate the need for a northwest departure routing via the Miami VOR.

The problem of routing departure aircraft beyond a primary vector fix is a common one in the majority of terminals. Basically, there are three ways of meeting the problem. One is to tunnel aircraft through the holding stack at the fix, the second is to take aircraft over the top of the holding stack, and the third is to bypass the holding stack at the fix completely.

The second procedure had no practical application in the case of the Miami VOR holding pattern airspace which occupied altitudes up to 7,000 feet; therefore, a bypass routing was defined via Dania, Raton direct to Pahokee VOR, thence Victor 293 to LaBelle (Fig. 9). This routing added approximately 9 miles to the original route via Victor 97. Various control procedures were used with this bypass routing with respect to crossing Victor 501 and Victor 267. One method was the use of radar as the primary means of separation. Another procedure stipulated that aircraft cross the airways at even-thousand-foot levels, and the third procedure reserved specified altitude blocks. Each procedure proved workable and within the capabilities of the Center departure controller; however, the increased Center workload was apparent as compared to the relatively uncomplicated departure route via the Miami VOR and Victor 97. The radar separation procedure offered the most flexibility and normally consisted of a monitoring of aircraft with no vector service required. Based upon simulated aircraft performance, departures usually reached 11,000 to 13,000 feet before crossing Victor 501, which cleared descending arrival aircraft en route to Pogo. With this type of procedure, departure aircraft enjoyed an unrestricted climb from takeoff until reaching cruising altitude. Nonpressurized aircraft occupied altitudes of 6,000 feet or below, which was below altitudes reserved for arrival traffic.

Another departure procedure tested incorporated a routing via Victor 501 to Pogo, thence direct to LaBelle, with aircraft maintaining 4,000 feet altitude until west of the New River holding pattern airspace. This procedure had several disadvantages, one of which was the long (45-mile) tunnel restriction, and another being the complication of the area west of Victor 267 which provided excellent off-course vectoring airspace for descent of jet aircraft en route to the Miami VOR.

MAP STUDY

Victor Airway 501

Although the value of Victor 501 was demonstrated in Part II of the Miami study, the actual definition of the entire airway using only existing facilities presents some problems. The primary users of Victor 501, in all probability, would be the aircraft routed via Control Area Extension 1150 (C1150). In order for this traffic to be in minimum conflict with Miami departure traffic climbing to cruise altitude, the transition from C1150 should be as far north of Palm Beach as possible; in fact, the activities at Cape Canaveral preclude any practical transition south of Maytown intersection (Fig. 13). With all factors considered, it appears that the Vero Beach and Biscayne VOR facilities offer the most practical solution to the problem. By using the 177° radial of Vero Beach and the 346° radial of Biscayne to define the proposed airway, relatively few waivers for the intermediate altitude airway structure may be required. Although the use of Vero Beach will require a common route on Victor 3 between Maytown and Vero Beach for both arrival and departure aircraft, no other solution appears practical without the installation of additional facilities. Assuming that lateral separation exists between Victor 501 and Victor 3 at a point 15 miles south of Vero Beach, aircraft departing the Miami terminal area would have approximately 120 miles of climb path available prior to convergence of major traffic flows.

Perrine Low-Frequency Range

One objective of the Miami simulation study was to determine the results if the Perrine L/F range were removed and its function assumed by a nondirectional low-frequency homing facility located adjacent to the Miami VOR. As noted previously, a considerable part of the arrival traffic from the south is of foreign registry and equipped only for low-frequency navigation. Because of this traffic, an attempt was made in all phases of planning to keep the locations of the VOR primary clearance limits, which lay south of the Miami localizer course, compatible with L/F fix locations. In System B, with east approaches, both Ed and the Perrine range served as vector fixes and Southgate and Fowey served west approaches.

At the conclusion of the tests, controller comment indicated the following objections to the removal of Perrine·

1. The loss of Perrine would preclude the location of any L/F vector fixes south of the Miami Airport. This would

require all low-frequency-equipped arrival aircraft to cross the Miami localizer course, thereby complicating an ideal vector pattern.

2. The sequencing of L/F arrivals into the north vector stacks again would unequalize the distribution of traffic between terminal arrival controllers.

3. The transfer of traffic from the south Center arrival controller to the north Center arrival controller would create additional, unnecessary workload.

4. The lack of an L/F range leg south of Miami Airport would complicate the control of L/F departing aircraft during east takeoffs, if such aircraft were proceeding via the equivalent of Victor 51. The transition to the appropriate airway would require continuous vector service.

5. The east course of Perrine defines the north boundary of the Homestead AFB and offers sufficient navigational guidance for L/F-equipped aircraft to preclude an infringement on the Homestead area. As in Item 4, the lack of such guidance would require continuous radar monitoring to prevent the violation of airspace reserved for Homestead operations.

CONCLUSIONS AND RECOMMENDATIONS

1. Although the present en route preferential airway structure is excellent, the addition of Victor 501, or a similar airway, would simplify the control of traffic north of the Miami terminal area to a considerable degree; therefore, such an airway should be designated as soon as possible. While the definition of Victor 501 as described in this report would be adequate temporarily, permanent installations of additional VOR facilities should be made to permit simultaneous operations on Victor 267, Victor 501, and Victor 3 between the Orlando and Miami areas.

2. A primary vector fix system capable of supporting both an east and west operation as described in System B, and capable of accommodating at least a 25 per cent increase in present-day traffic with the use of Center and terminal radar, should be commissioned as soon as practicable.

3. The Perrine low-frequency range should be retained, if at all possible, as the loss of the facility would complicate the control of traffic in the Miami terminal area to a considerable degree.

4. In the event that Opa Locka operations increase appreciably, present east departure terminal procedures may not be satisfactory. An alternate departure procedure is available although it entails an increased Center workload.

5. The use of the 039° and 054° radials of the Miami VOR simplifies the terminal control of north departures during a west operation without increasing Center workload, therefore, such radials should be designated as standard departure routes at such time as System B is commissioned.

6. The comparative isolation of the Miami terminal area is such that an operation incorporating both terminal and Center radar control in a common facility appears to offer distinct advantages insofar as coordination problems are concerned. Such an operation has been tested by simulation techniques for other terminal areas and proven practical. The testing of such a facility for the Miami area may be a basis for future simulation studies.

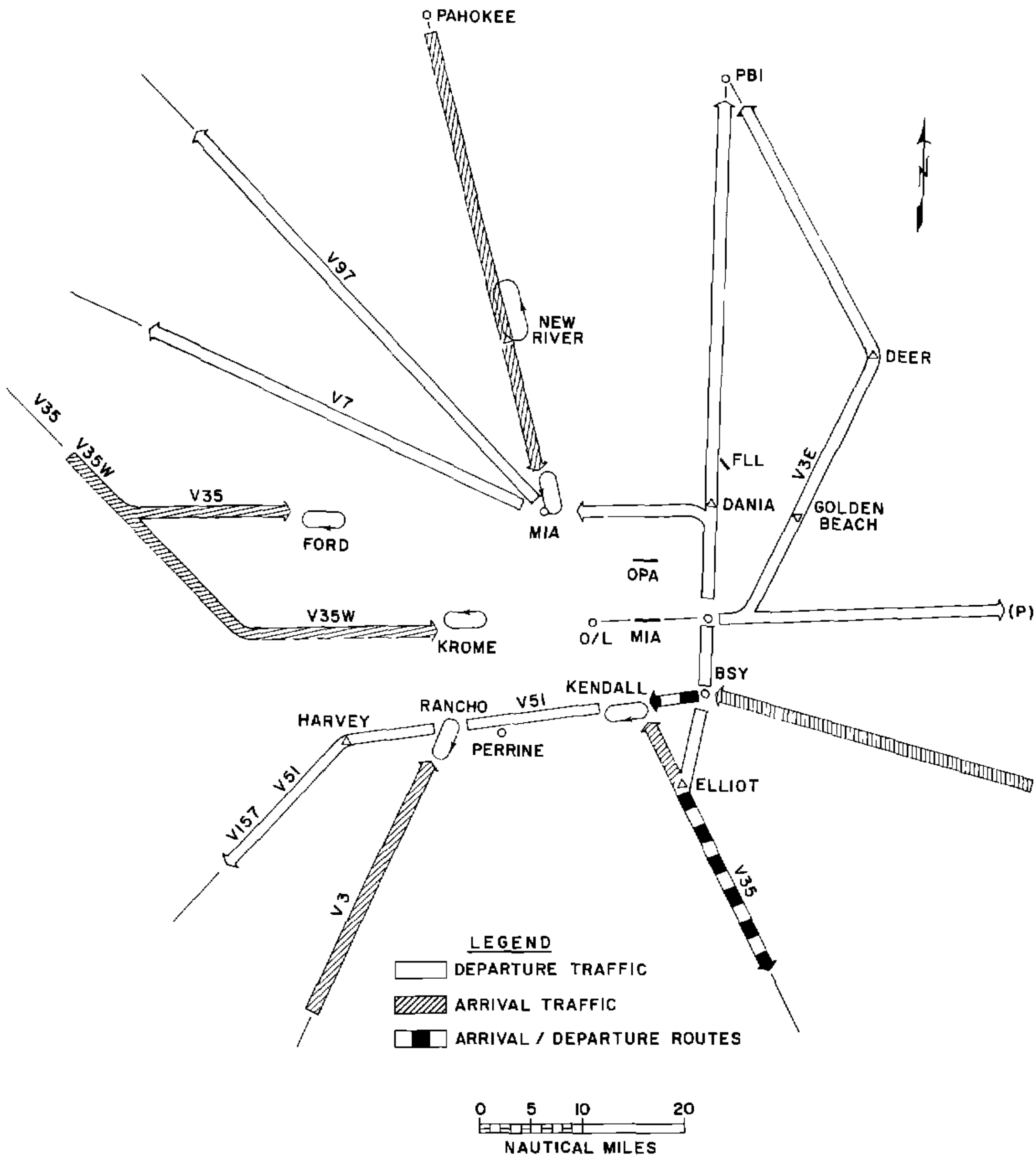


FIG. 1 SYSTEM A - EAST OPERATION

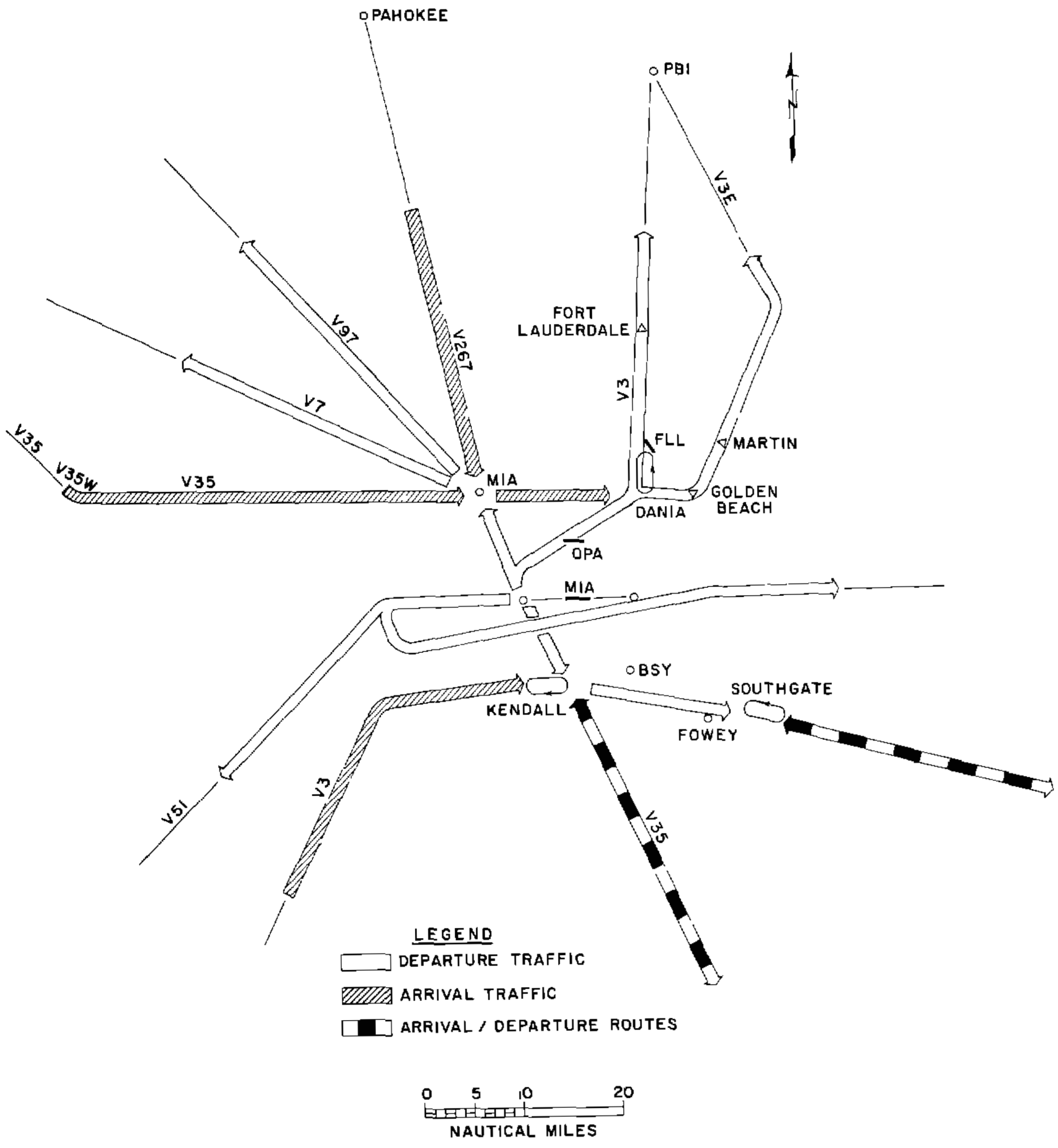
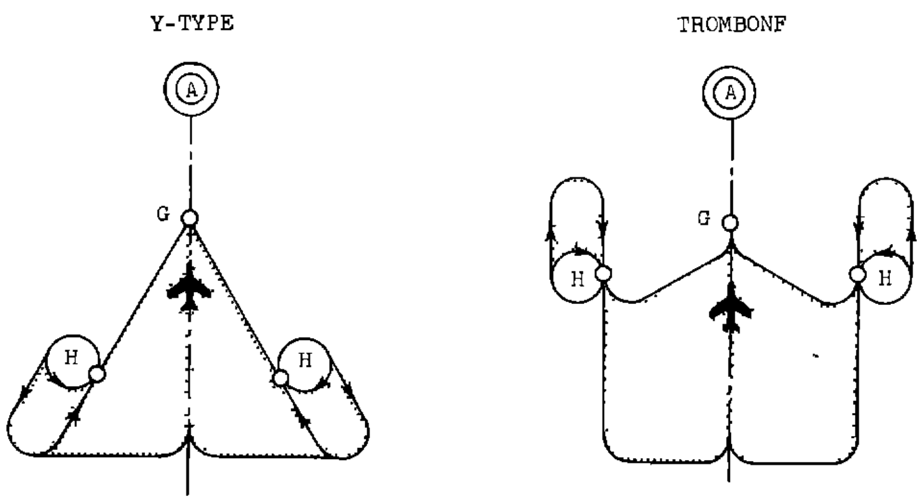


FIG. 2 SYSTEM A - WEST OPERATION

5 MILES FROM OMK	AIRCRAFT SEQUENCE		GATE SEPARATION (MILES)
	No 1	No 2	
6.6	S	M	5.1
7.5	S	F	5.5
10.0	S	J	6.6
3.6	M	S	3.1
5.7	M	F	4.5
7.8	M	J	5.8
3.0	F	S	3.0
3.4	F	M	3.5
7.0	F	J	5.2
	J	SMF	4.0
	SAME	TYPE	4.0

AIRCRAFT CATEGORY		APPROXIMATE APPROACH SPEED	
		MPH	KT
S	SLOW	120	104
M	MEDIUM	140	122
F	FAST	150	130
J	JET	180	156

OPTIMUM AIRCRAFT SPACING TABLE
MIAMI ILS ZERO WIND CONDITION



LEGEND A-AIRPORT
G-APPROACH GATE
H-HOLDING FIX
SHADING INDICATES AREA
USED FOR SPACING
ADJUSTMENTS

FIG. 3 DUAL STACK SYSTEMS

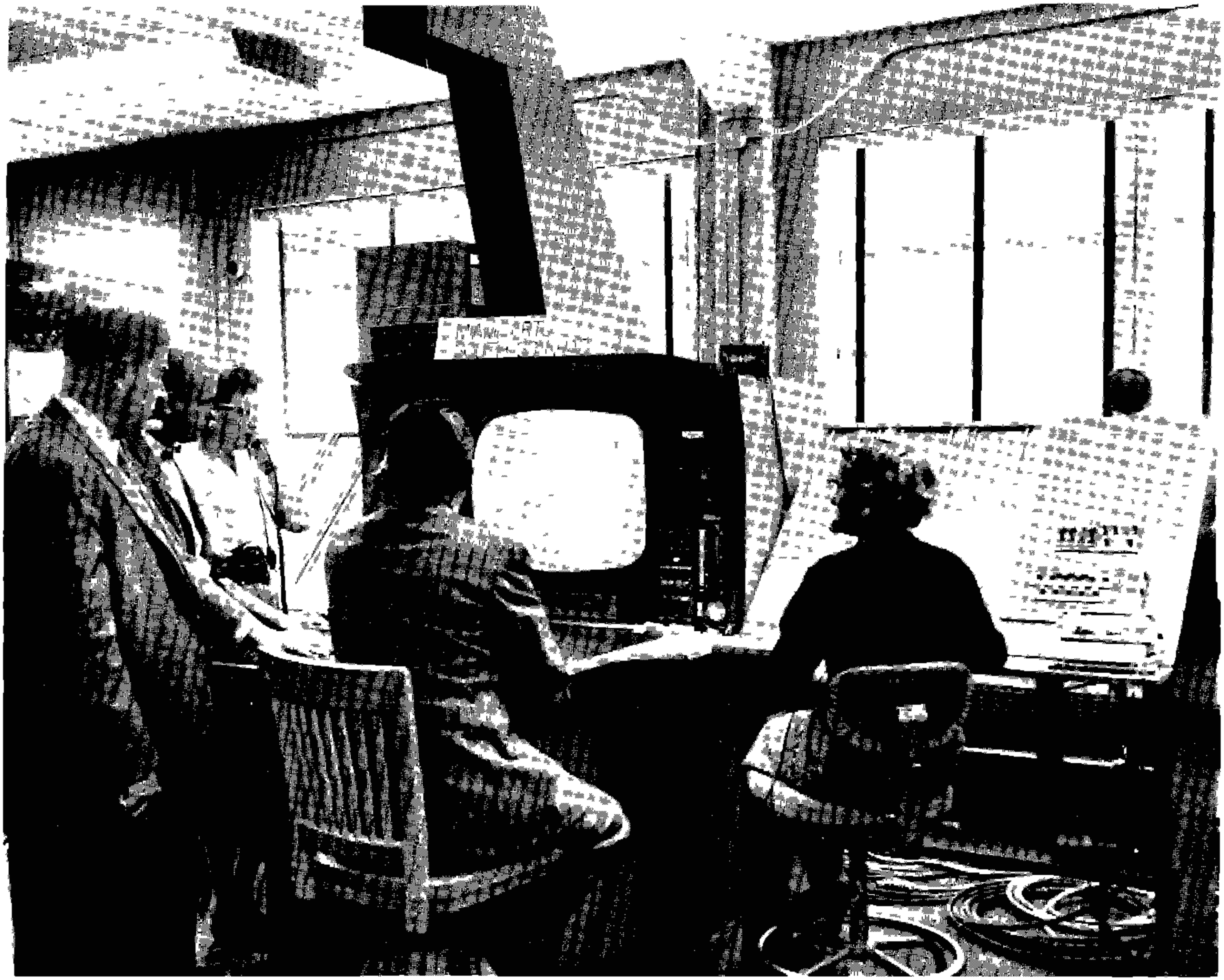
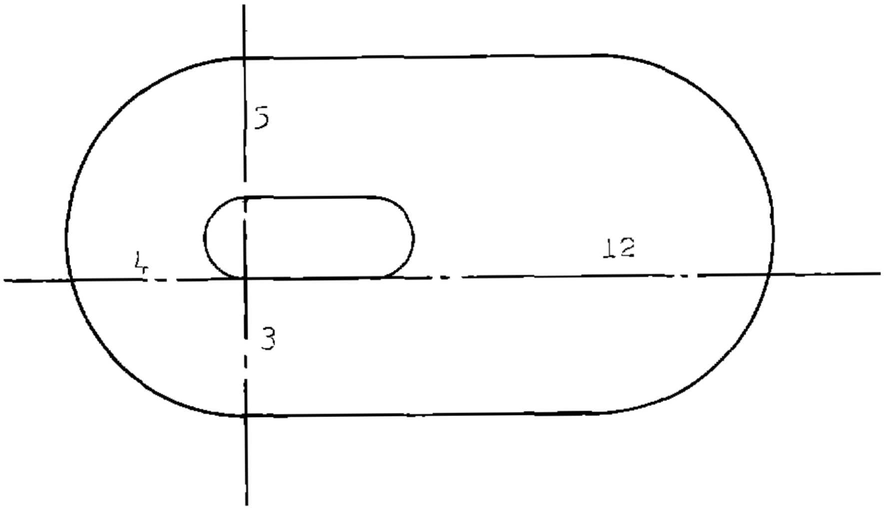
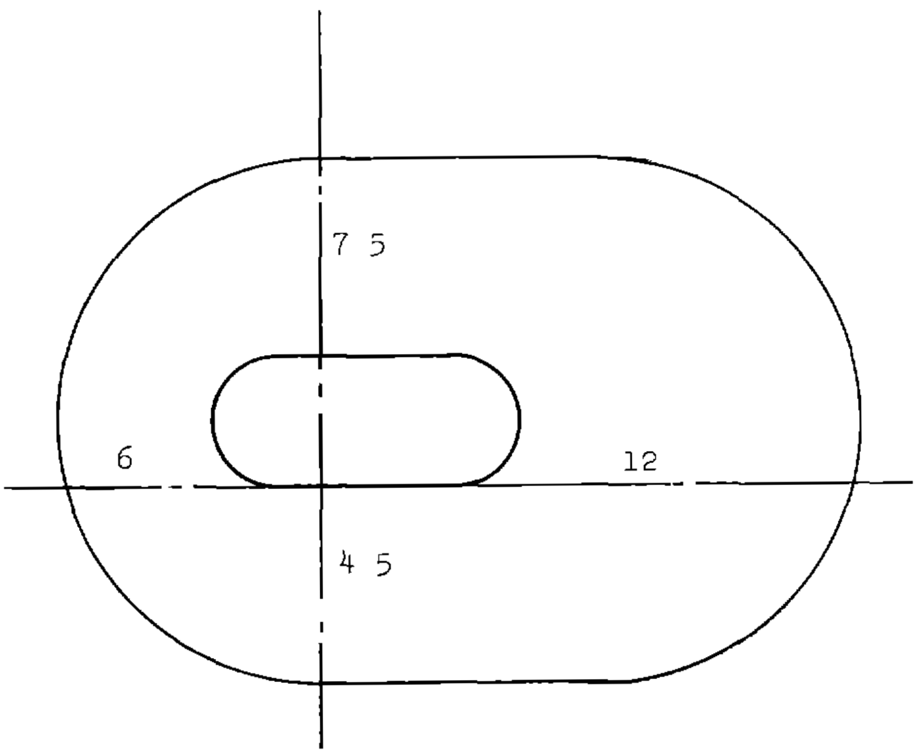


FIG. 4 MIAMI ARTC SPANRAD DISPLAY - SOUTH SECTOR

FIG. 5 MIAMI APPROACH CONTROL ASR POSITIONS



A. PRESENT 1 MINUTE HOLDING PATTERN



B. MODIFIED 1 MINUTE HOLDING PATTERN AIRSPACE

SCALE - STATUTE MILES

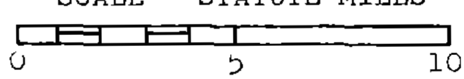


FIG. 6 TSO-N20A HOLDING PATTERN AIRSPACE

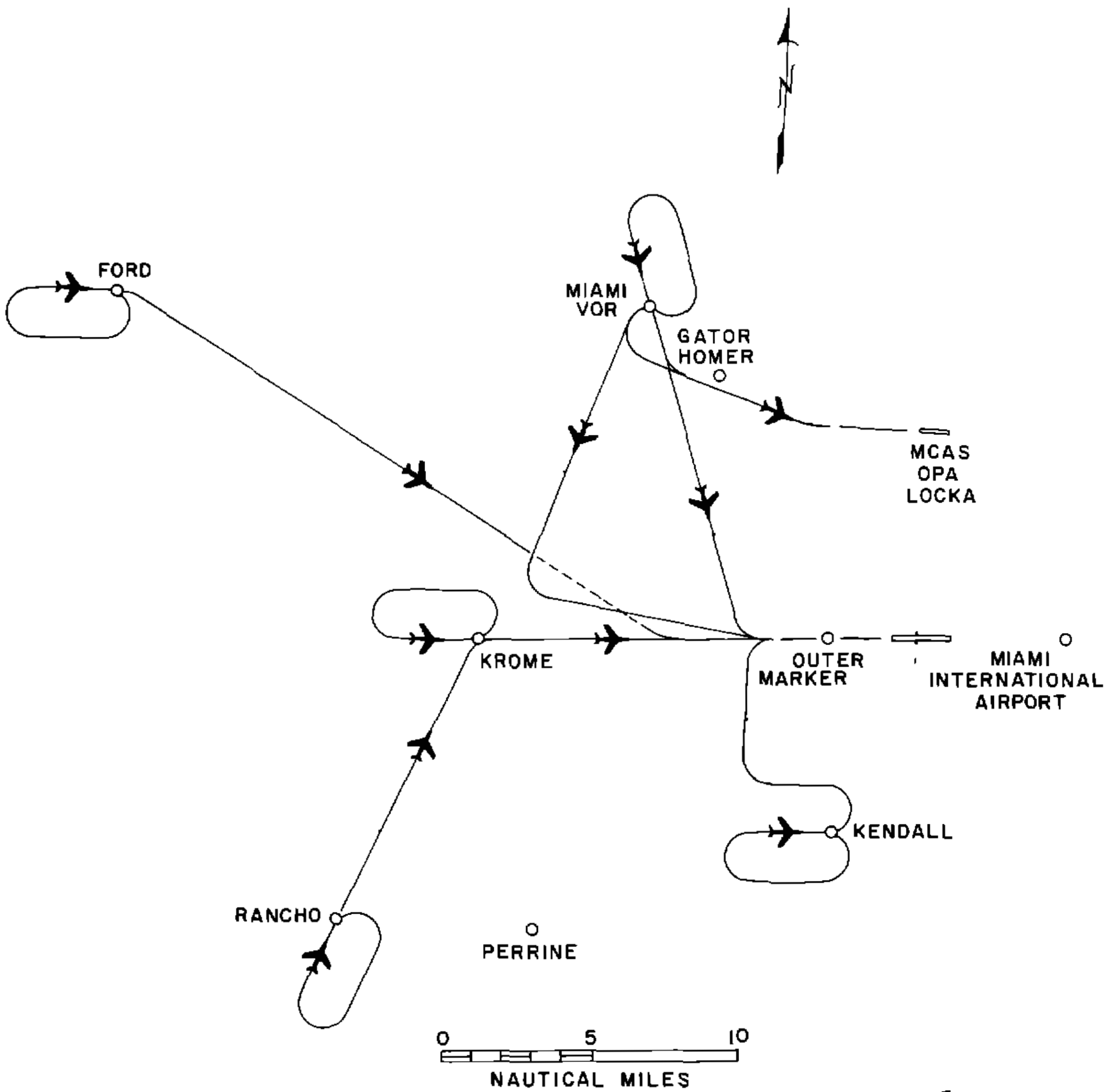


FIG. 7 SYSTEM A - EAST OPERATION DESCENT AREA

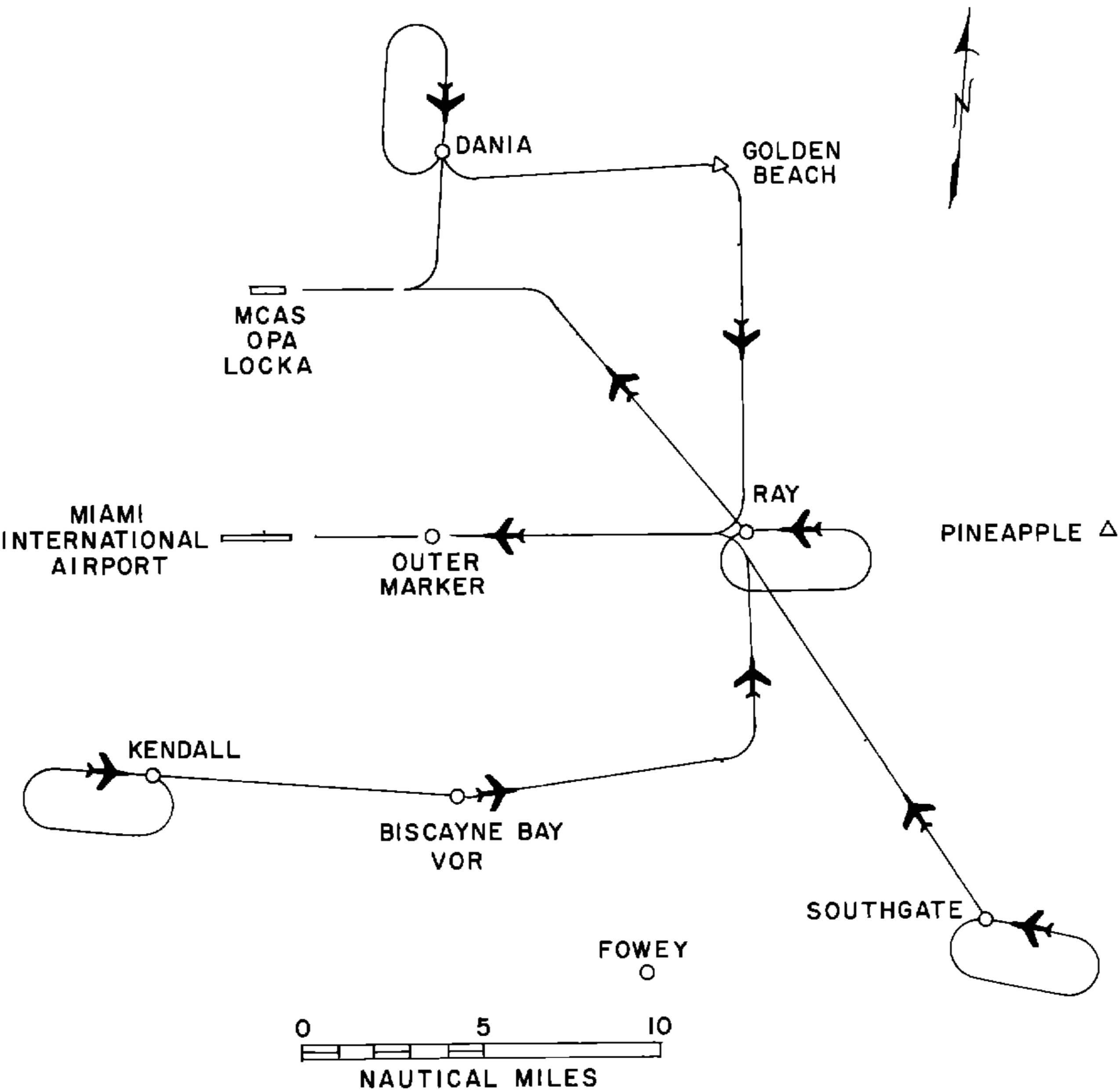


FIG. 8 SYSTEM A - WEST OPERATION DESCENT AREA

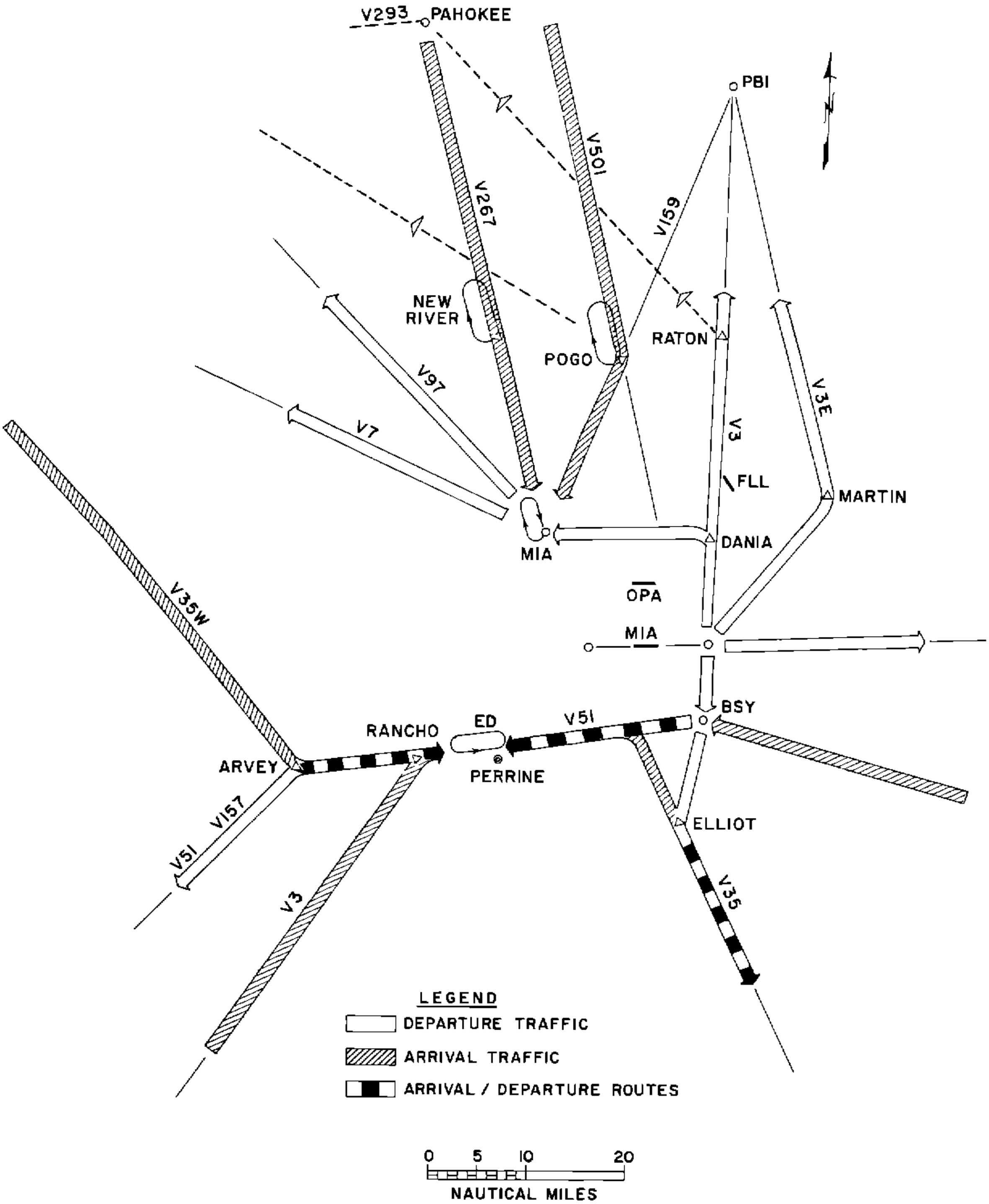


FIG. 9 SYSTEM B - EAST OPERATION

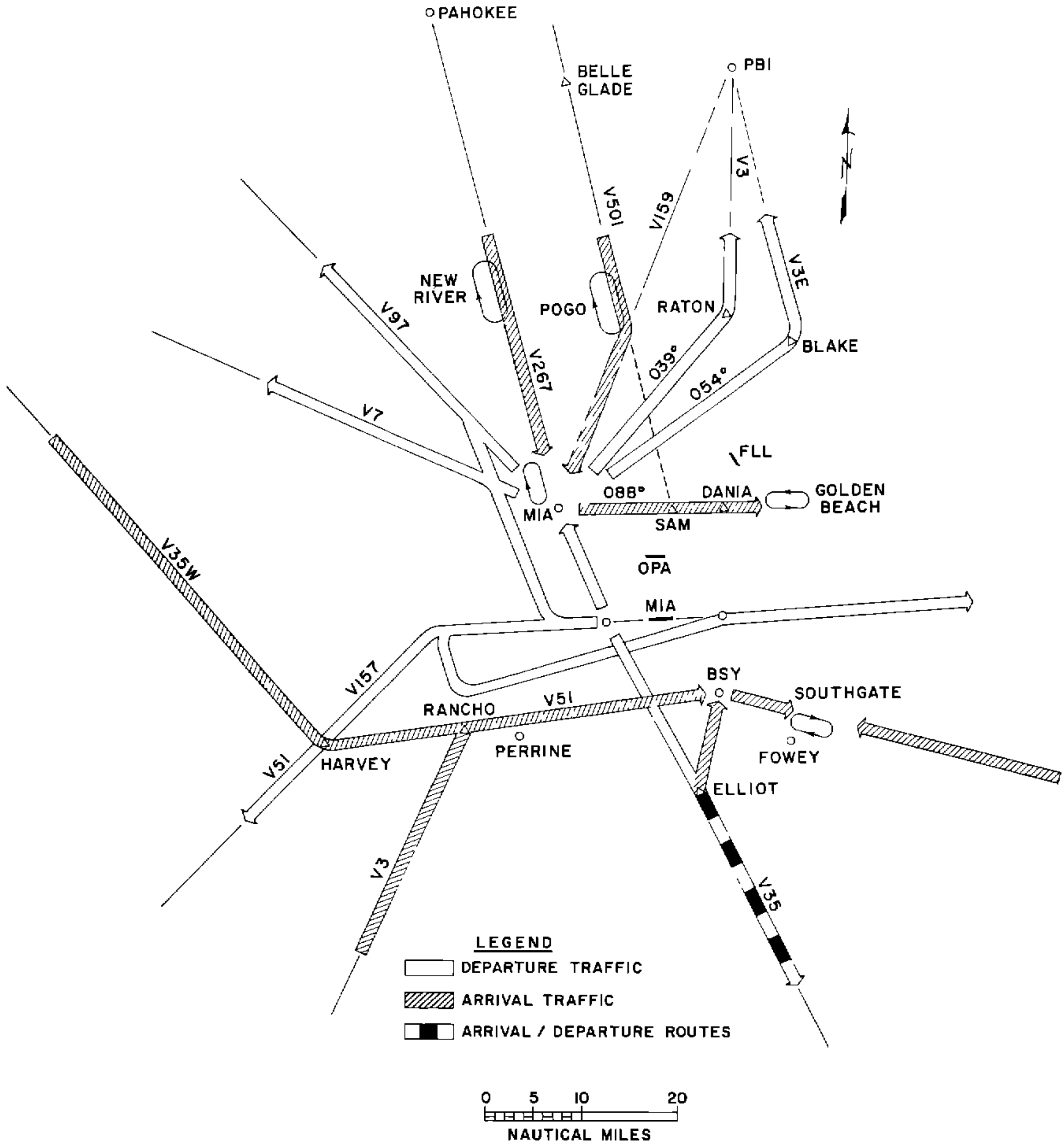


FIG. 10 SYSTEM B - WEST OPERATION

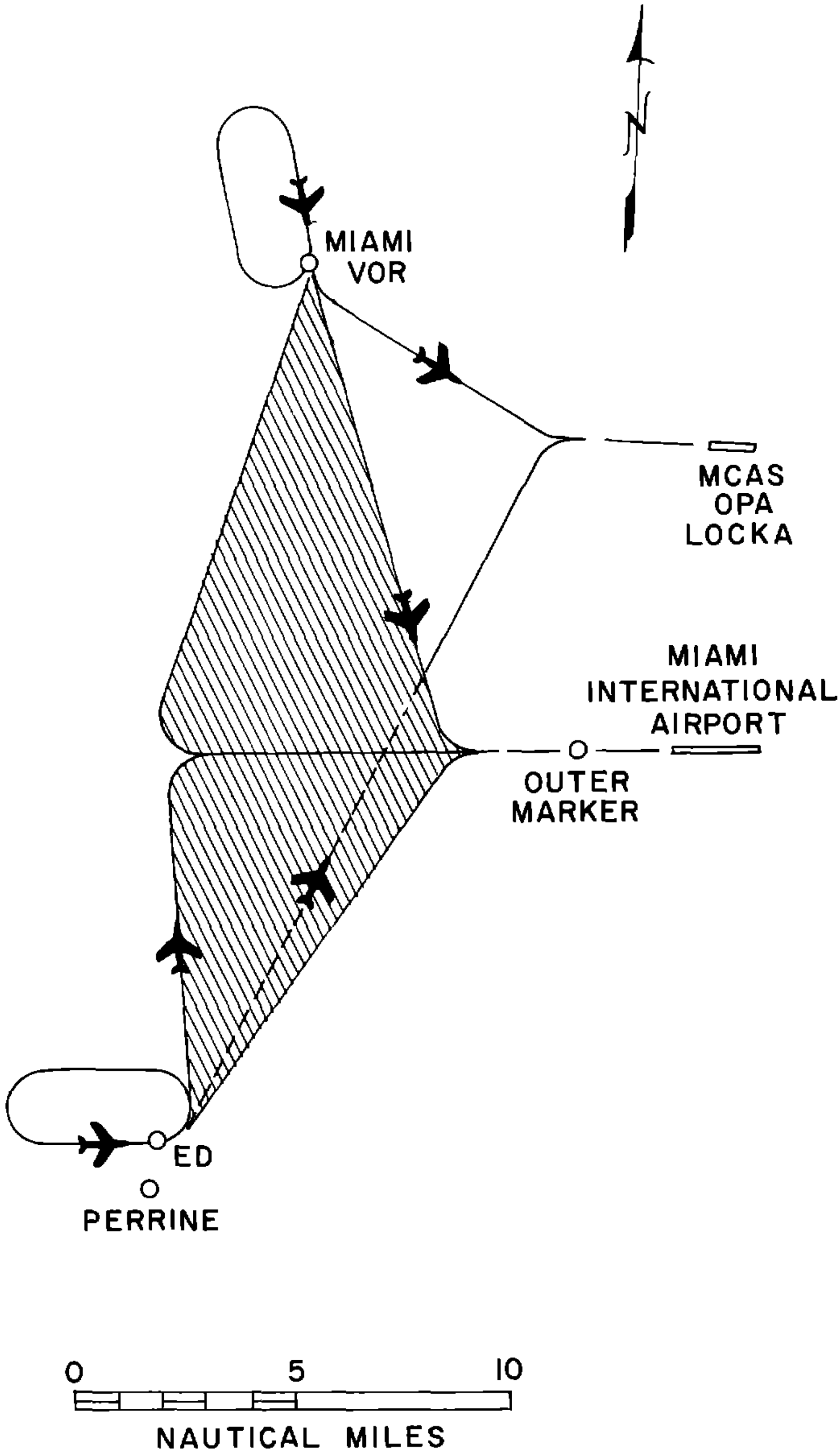


FIG. 11 SYSTEM B - EAST OPERATION

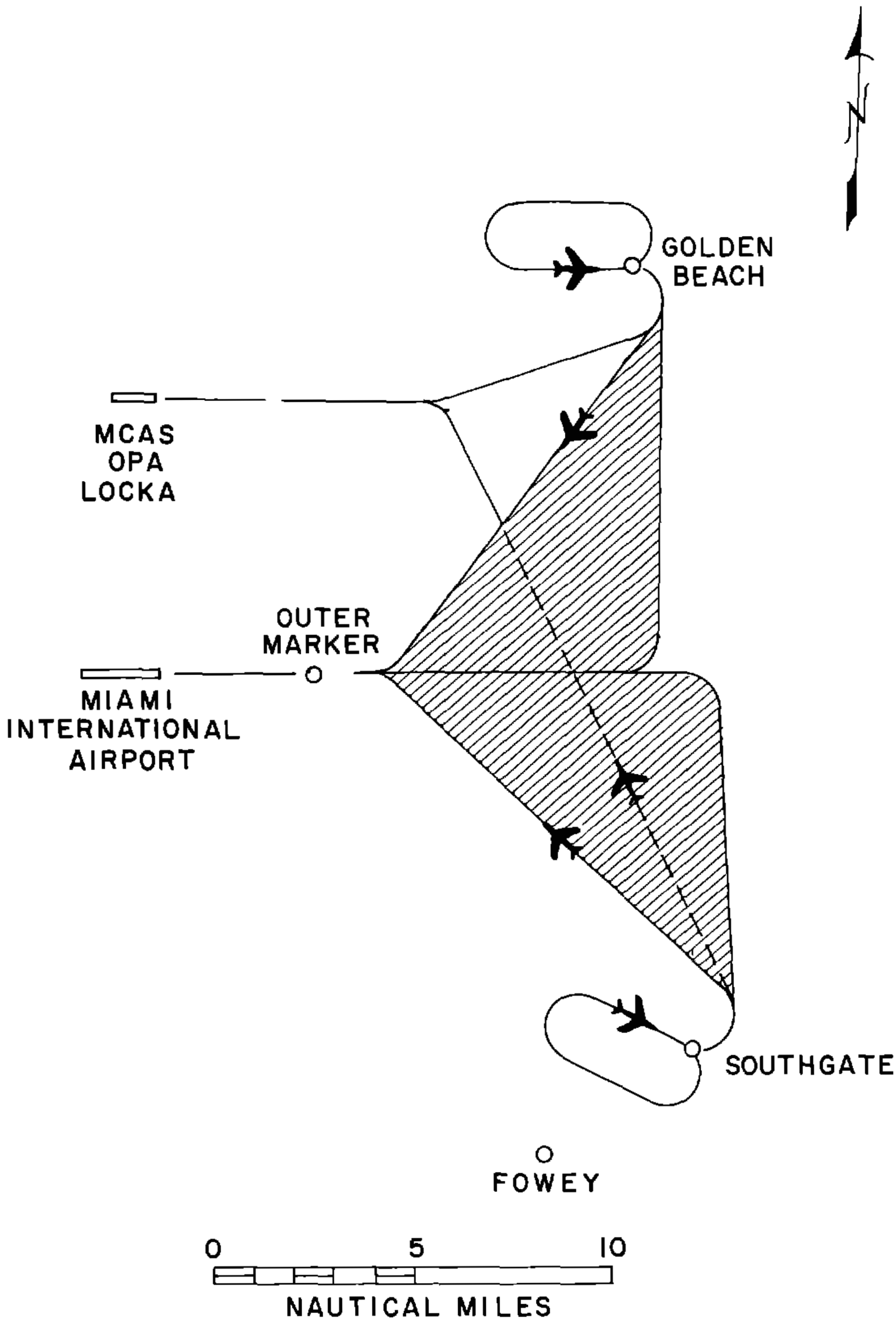


FIG. 12 SYSTEM B - WEST OPERATION

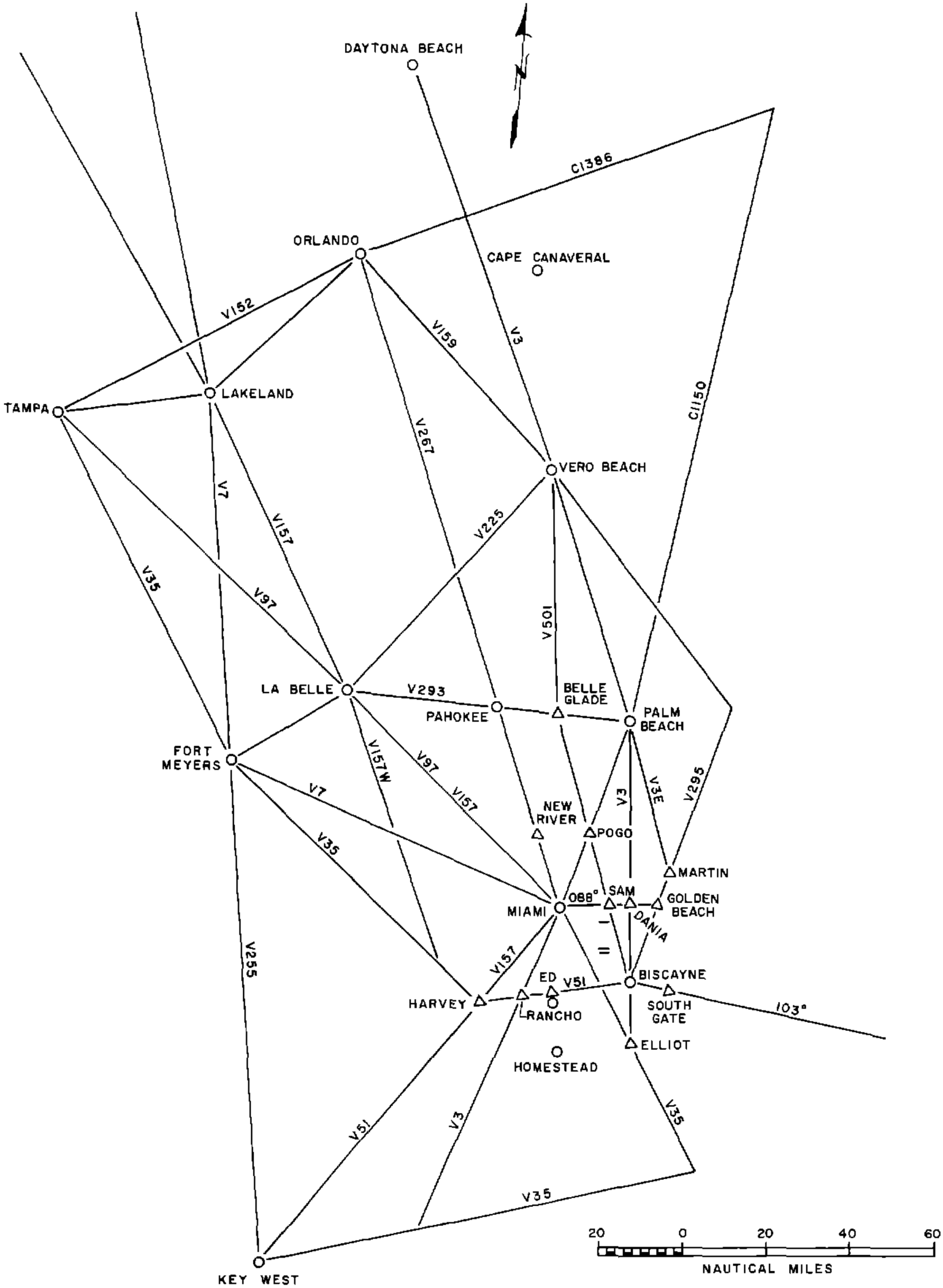


FIG. 13 SYSTEM B - EN ROUTE SYSTEM