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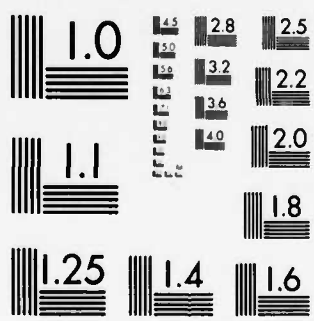

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History and Status of U.S. Marine Radiobeacon System

Arthur E. O'Brien

Transportation Systems Center
Cambridge MA 02142

February 1983
Final Report

U.S. Department of Transportation
United States Coast Guard

Office of Navigation
Washington DC 20593

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16. Abstract

The U.S. Marine Radiobeacon System first became operational with three transmitter sites and a handful of users in 1921 under the jurisdiction of the Lighthouse Service of the Department of Commerce. The system grew rapidly from the time of its inception. By 1939, when the Coast Guard assumed system responsibility, the number of transmitter sites had grown to 141 with an estimated 4,000 users. By January of 1982, the system consisted of 198 transmitter sites with an estimated 423,000 users, most of whom were pleasure boat owners. This report has been prepared to chronicle the development of this system and to report its current status and near term future prospects.

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<u>PREFACE</u>

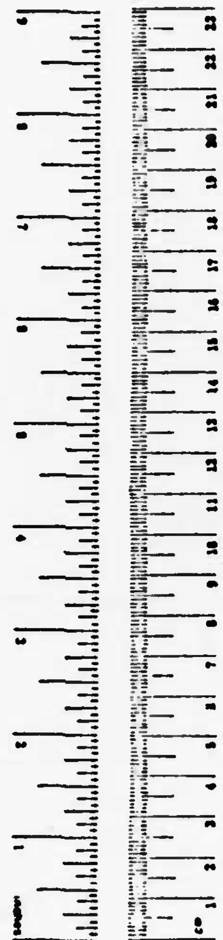
The U.S. Marine Radiobeacon System is maintained and operated by the U.S. Coast Guard under the authority of 14 U.S.C.81(1). Marine radiobeacons are low and medium frequency radio transmitters specifically designed and installed as aids to navigation. Radiobeacons are located at definite points shown on navigation charts and listed in nautical publications. They transmit signals by radio in all directions much the same as lighthouses do by means of light beams. Radiobeacons are located such that bearings from two or more can be obtained for position fixes in most areas about the coasts and Great Lakes.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

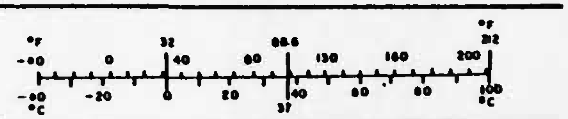
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

This report has been prepared to chronicle the development of the U.S. Marine Radiobeacon System and to report its current status and near term future prospects.

1.1 RADIOBEACON NAVIGATION

Marine Radiobeacons are low and medium frequency radio transmitters specifically designed and installed as aids to navigation. They are located at entrances to heavily travelled harbors, at coastal prominences, and at other key locations and landmarks to transmit radio signals for use by marine navigators. Radio direction finders are specialized radio receivers used by mariners to determine a direction to the radiobeacon transmitting source.

The general problems and practices of navigation when using radio bearings are analagous to those associated with visual bearings on lighthouses or other known objects. The practical differences between radio and visual navigation are not differences in principle, but in the availability of radio signals beyond visual range and under all weather conditions. Radiobeacons are located at definite points shown on navigation charts and are listed in nautical publications. They transmit signals by radio in all directions much the same as lighthouses do by means of light beams. Each radiobeacon is identified by the unique characteristics of the transmitted code much like the visual signal sequences of lighthouses. Radiobeacons are located such that bearings from two or more can be obtained for position fixes in most areas about the coasts and Great Lakes, and can be used to follow a desired or prescribed course.

1.2 RADIOBEACON LOCATIONS

Geographic locations of Marine Radiobeacons and their assigned characteristics, operating frequencies, and service ranges may be obtained from the following sources:

1) Coast Guard Light Lists (CG 158-162); available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

2) Defense Mapping Agency Hydrographic/Topographic Center Publication 117 (Radionavigation Aids); available from the Defense Mapping Agency, Topographic Center, 6500 Brooks Lane, Washington, DC 20315.

3) Nautical Charts, available from the National Oceanic and Atmospheric Administration, National Ocean Survey (C-44), Riverdale, MD 20840.

Changes in operation, outages, and scheduled alterations are announced in Local Notices to Mariners which are available from local Coast Guard District Commanders. It is imperative that users of this system maintain current information at all times to avoid undue problems.

Radiobeacon locations as of 1 January 1982 are listed in Section 3 of this report. Earlier configurations are discussed in Section 2 and the near term future locations are noted in Section 4.

2.0 SYSTEM EVOLUTION

The present Radiobeacon System is the result of evolutionary development over a period of more than sixty years. This development is traced through its various stages in this section.

2.1 EARLY HISTORY

For centuries, mariners relied solely upon visual references to navigate throughout their uncertain world. With time, it became clear that the visible segment utilized a very limited portion of the electromagnetic spectrum. Furthermore, it was discovered that radiowaves, which are not visible, occupied another portion of that spectrum. In addition to peculiar properties of their own, these radiowaves possessed many of the properties of the more familiar visual signals. Thus, the directive properties of radio signals were established early in the development of radio science. This feature, coupled with the long-range all-weather usage properties of radio signals, led to their consideration as an aid to navigation. Considerable time elapsed, however, before theory was reduced to practice and radiowaves were applied as useful aids to navigation. The major problem that had to be solved was finding a radiowave analog to the optical bearing indicator in order to permit the determination of the angle (bearing) from which the transmitted signal arrived at the receiver.

Early work by Farraday, Hertz, and Maxwell in the nineteenth century formed the basis for investigations and experiments by the U.S. Bureau of Standards in 1912 and 1913. These efforts at first produced a simple device which demonstrated the feasibility of direction finding using radio signals, and by 1916 a more practical receiver was constructed by the Bureau. The method of radio direction finding which evolved was based on the directive properties of the so-called coil or loop antenna. It operated on the principle that the amount of electromagnetic force induced in a vertical loop antenna by an incident electromagnetic wave was determined by the angle between the plane of the loop and that of the wave front. When the plane of the loop was aligned with the direction of the incident wave, the induced signal would be at a maximum. As the loop was rotated, the intensity of the received signal would be reduced until a minimum was reached when the plane of the loop became orthogonal to the line of direction of the incident signal. Thus, the direction of origin of an incident wave could be determined by positioning the loop to minimize the received signal since the minimum, which is well defined, could be determined with sufficient accuracy for navigation purposes. The directive characteristics of a loop antenna are shown in Figure 1 and a photograph of an early loop shipboard installation is shown in Figure 2.

Direction finding equipments were installed on the lighthouse tender TULIP and were tested jointly by the Bureau of Standards and the Lighthouse Service of the U.S. Department of Commerce in January of 1917 using signals from a spark gap transmitter located at Navesink Lighthouse in New Jersey.

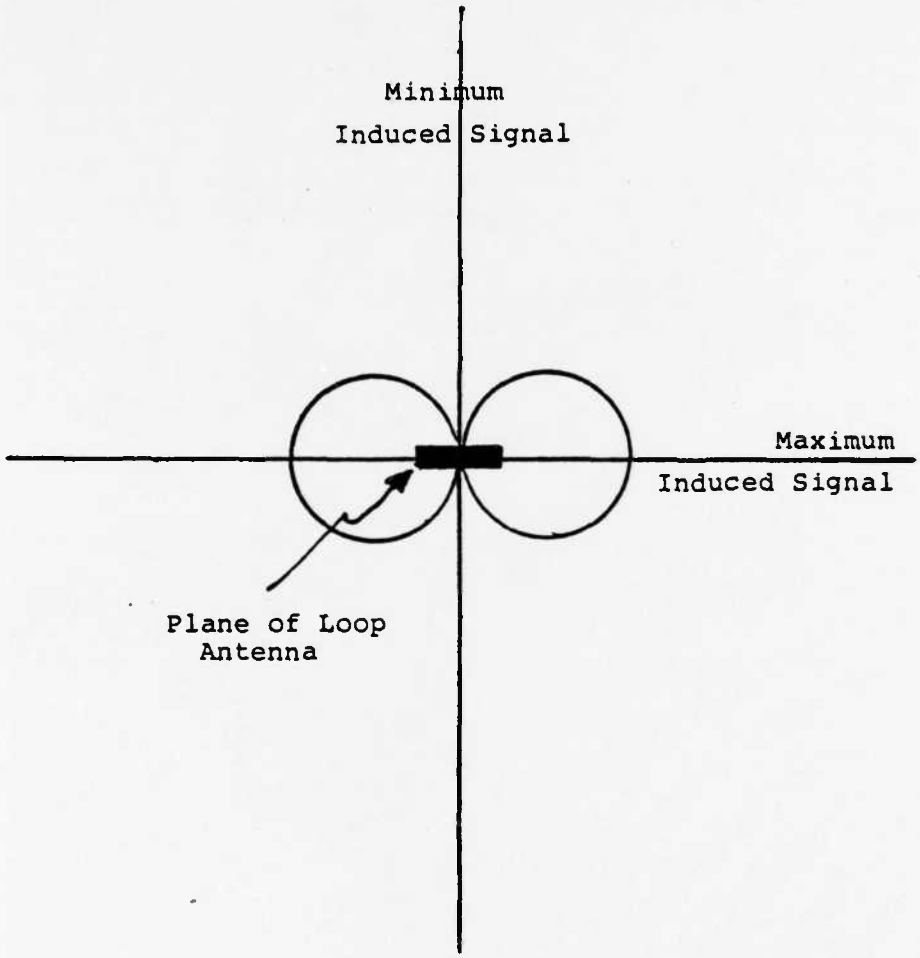

FIGURE 1. DIRECTIVE PROPERTIES OF A LOOP ANTENNA

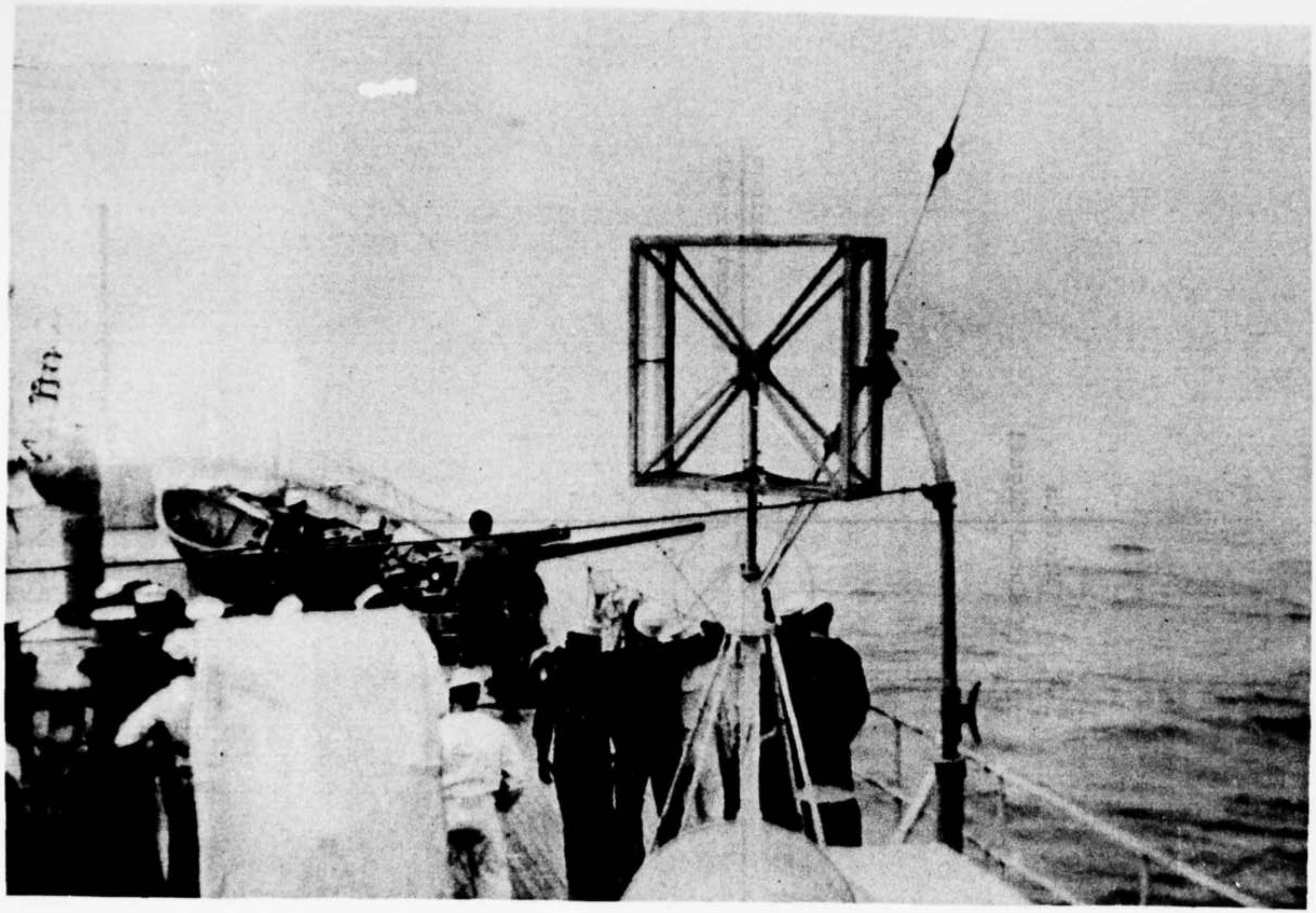

FIGURE 2. EXAMPLE OF EARLY LOOP SHIPBOARD ANTENNA (USCG CUTTER TAMPA)

Although results were promising, the onset of World War I forced a temporary curtailment of further efforts. Tests were resumed in October of 1919 using three experimental transmitters located at lighthouses in Chesapeake Bay and an improved radio direction finder on the tender ARBUTUS.

Equipment improvements followed throughout the next year and prototype spark gap transmitters, similar to that shown in the photograph of Figure 3, were installed at Sea Girt Lighthouse in New Jersey and on AMBROSE and FIRE ISLAND Lightships in the approaches to New York Harbor. Following an extensive test and demonstration period, these three stations became operational as the first elements of the U.S. Marine Radiobeacon Service on 1 May 1921 under the jurisdiction of the aforementioned Lighthouse Service (Ref. 1). Two additional transmitters were commissioned in 1922 - DIAMOND SHOALS Lightship, North Carolina and the first Pacific coast station, SAN FRANCISCO Lightship, California.

When first introduced, radiobeacon transmissions were referred to as "radio fog signals" or "wireless fog signals" since they were originally planned as a supplementary aid under fog conditions. For the first few years, radiobeacon signals were transmitted continuously during fog conditions. Transmissions also were made during the periods of 0900-0930 and 1500-1530 each day to permit vessels equipped with radio direction finders to exercise the method and apparatus in clear weather. This limited operation led to the recognition of radiobeacons as valuable aids in clear weather as well as fog because of the availability of radio signals beyond visual range. As a consequence, hourly operation was introduced on the NANTUCKET Lightship in 1924 and the use of the restrictive term "radio fog signals" was phased out (Ref. 2).

By April of 1924, when the first vacuum tube transmitter was installed on AMBROSE Lightship, the Service had a dozen spark gap transmitters operating on the Atlantic and Pacific coasts on a common frequency of 300 kHz (1000 meters). Over the next few years, conversion to vacuum tube transmitters, an example of which is shown in Figure 4, was accomplished and the number of new radiobeacons increased by at least 10 per year, including the first units about the Great Lakes (LAKE HURON Lightship) and the Gulf Coast (South Pass, Louisiana) in 1925, Alaska (Cape Spencer) in 1926, and Hawaii (Makapuu Point) in 1927 (Ref. 3). This expansion soon led to interstation interference. This factor, along with foreign radiobeacon developments, necessitated the establishment of international regulatory bodies to coordinate and control the use of the available radio frequencyspectrum. One of the first meetings convened to discuss spectrum usage was the International Radiotelegraph Conference which was held in Washington, DC in November of 1927. The regulations established by that conference provided that Marine Radiobeacons, "shall use the waves of 285 to 315 kilocycles per second (1050 to 950 meters)" and that continuous or modulated continuous waves be used. In the United States, this band was divided into 2 kiloHertz channels using the even frequencies as the carriers (e.g., 286 kHz, 288 kHz, 290 kHz) with a few exceptions for operational utility. Transmitter stations were configured in groups of three per frequency and synchronized to a non-interfering operating schedule of one minute on and two minutes silent. Accurate timing of radiobeacon signals was accomplished by use of a signal timer controlled by

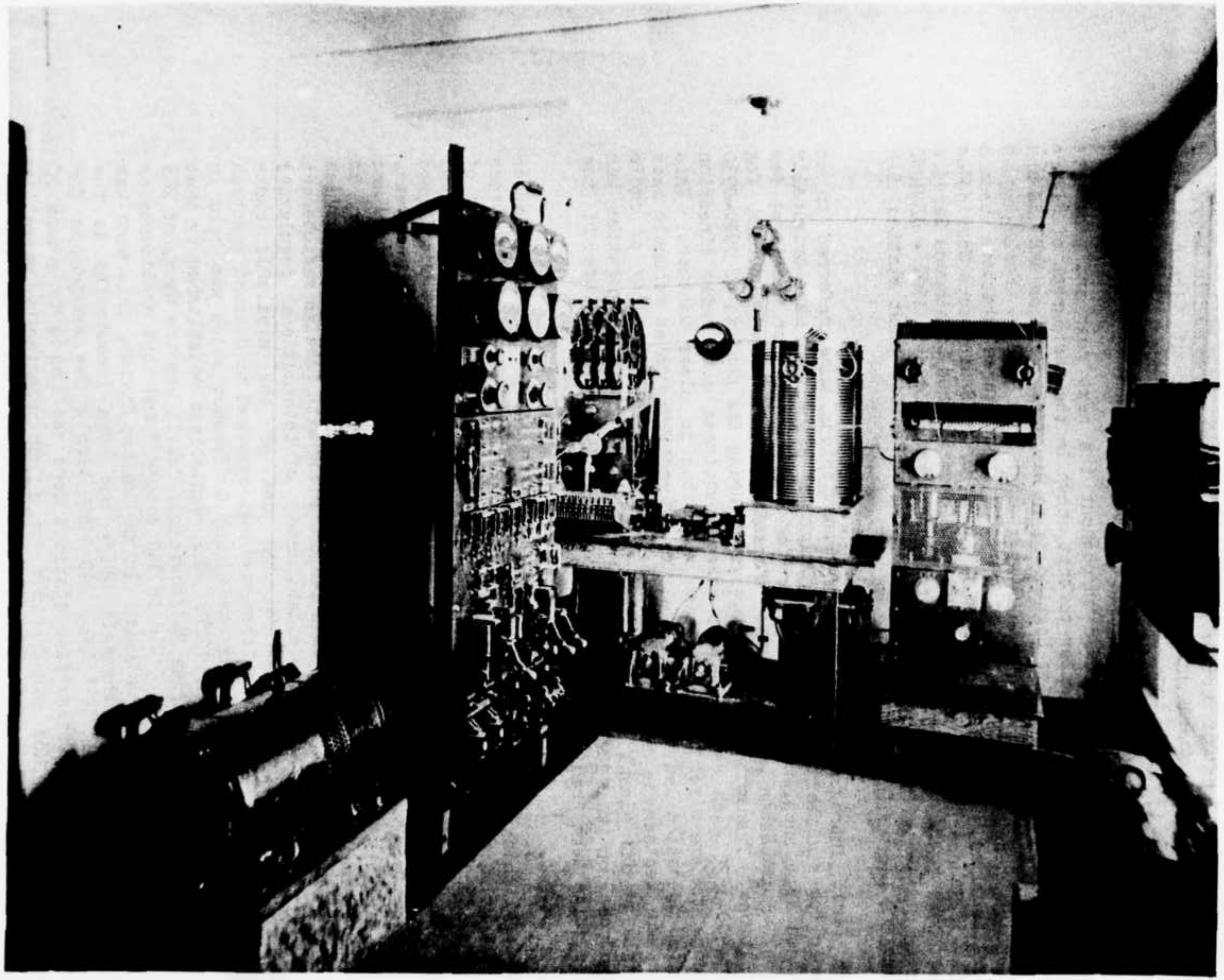

FIGURE 3. TYPICAL RADIOBEACON SPARK GAP TRANSMITTER

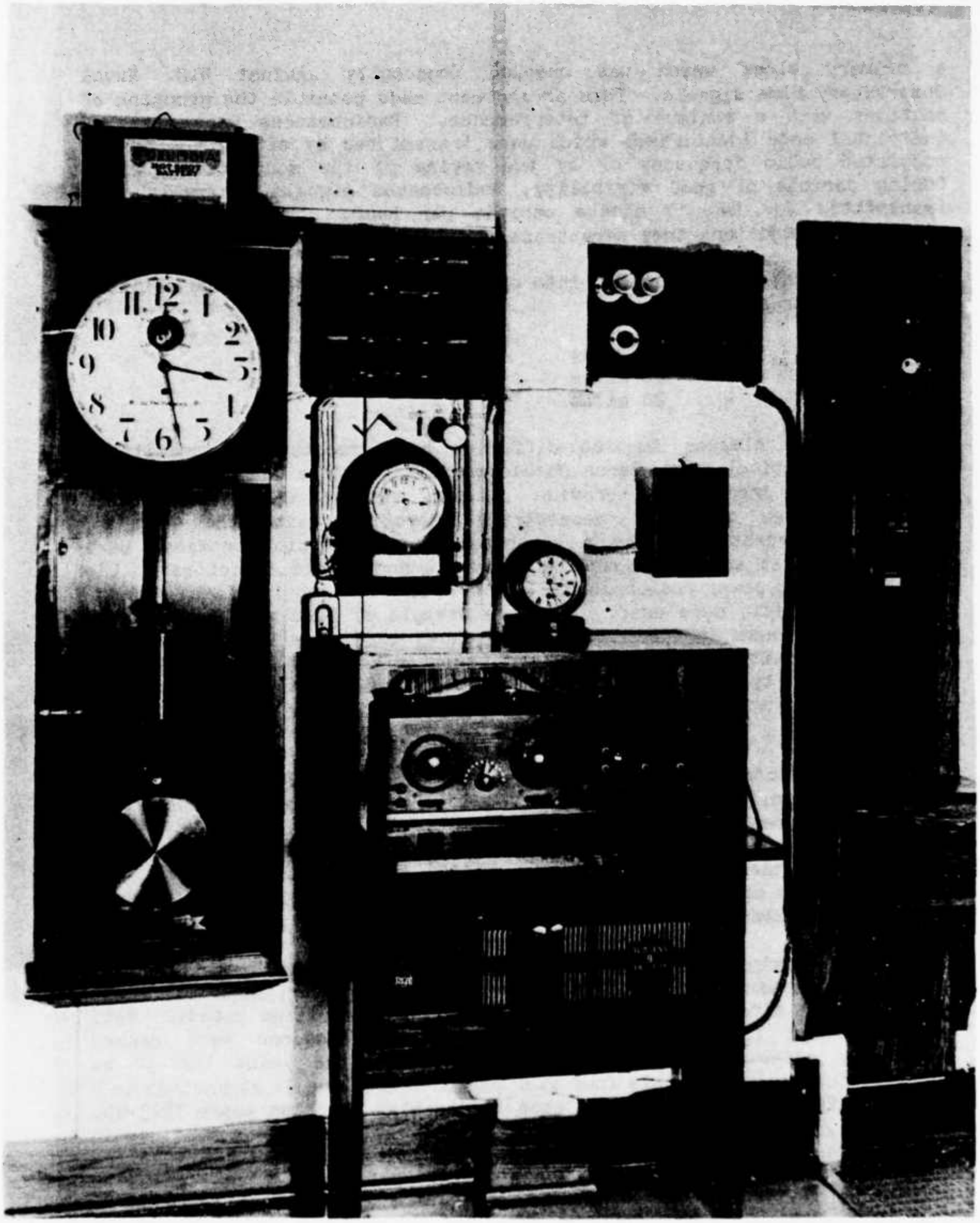

FIGURE 4. PHOTOGRAPH OF VACUUM TUBE TRANSMITTER

a primary clock which was checked frequently against U.S. Naval Observatory time signals. This arrangement made possible the grouping of stations with a minimum of interference. Radiobeacons were assigned individual code identifiers which were transmitted by either keying the modulated audio frequency or by the keying of the modulated carrier. During periods of good visibility, radiobeacon signals generally were transmitted for two 10 minute periods per hour. During fog or low visibility conditions they were transmitted continuously.

Radiobeacons also were divided into classes based on the average reliable range of their signals:

Class A	-	200 miles
Class B	-	100 miles
Class C	-	20 miles

The different classes imposed different requirements on transmitting equipment, particularly antenna characteristics. Since radiobeacons were strategically located to provide optimum service to mariners, the available sites were not necessarily compatible with the best of installation practices. As a consequence, transmitting antennas were selected to best suit the power requirements and physical factors of the site. For high power radiobeacons, electrically matched insulated towers, typically 125 ft., were used. A unique example of such matching was the top-loaded antenna at Cape Cod Station shown in Figure 5. Low power or limited range sites generally used an insulated vertical mast or vertical whip antenna, typically 35 ft. in height, with a ground system or a counterpoise system of radials where soil conditions precluded a ground system.

Automatic radiobeacon operation was introduced in 1928 and distance finding beacons, wherein radio and fog signals were synchronized, were first commissioned at Cape Henry, VA, in 1929. The replacement of the obsolete spark gap transmitters was completed in 1930 and the system configuration that resulted in July of 1931 is shown in Figure 6. The characteristics of the various transmitter sites were as noted in Table I (90 active transmitters, 12 under construction) (Ref. 2).

Radiobeacon navigation was readily accepted by the maritime community. Because of the many factors affecting navigation, however, it is difficult to assess the effect of radiobeacon navigation on maritime safety. Yet, the following figures are of interest. Radiobeacons were deemed remarkably effective on the Great Lakes during the years 1927-30 by shipping interests. In this four year period there were 31 strandings in a group of 470 vessels, or one for each 15 vessels. For the years 1923-26, immediately before the advent of radiobeacons, there were 76 strandings in a comparable group of 572 vessels, or 1 stranding for each 7.5 vessels. Shipping interests considered the availability of radiobeacon signals to be the most important factor in this reduction (Ref. 4).

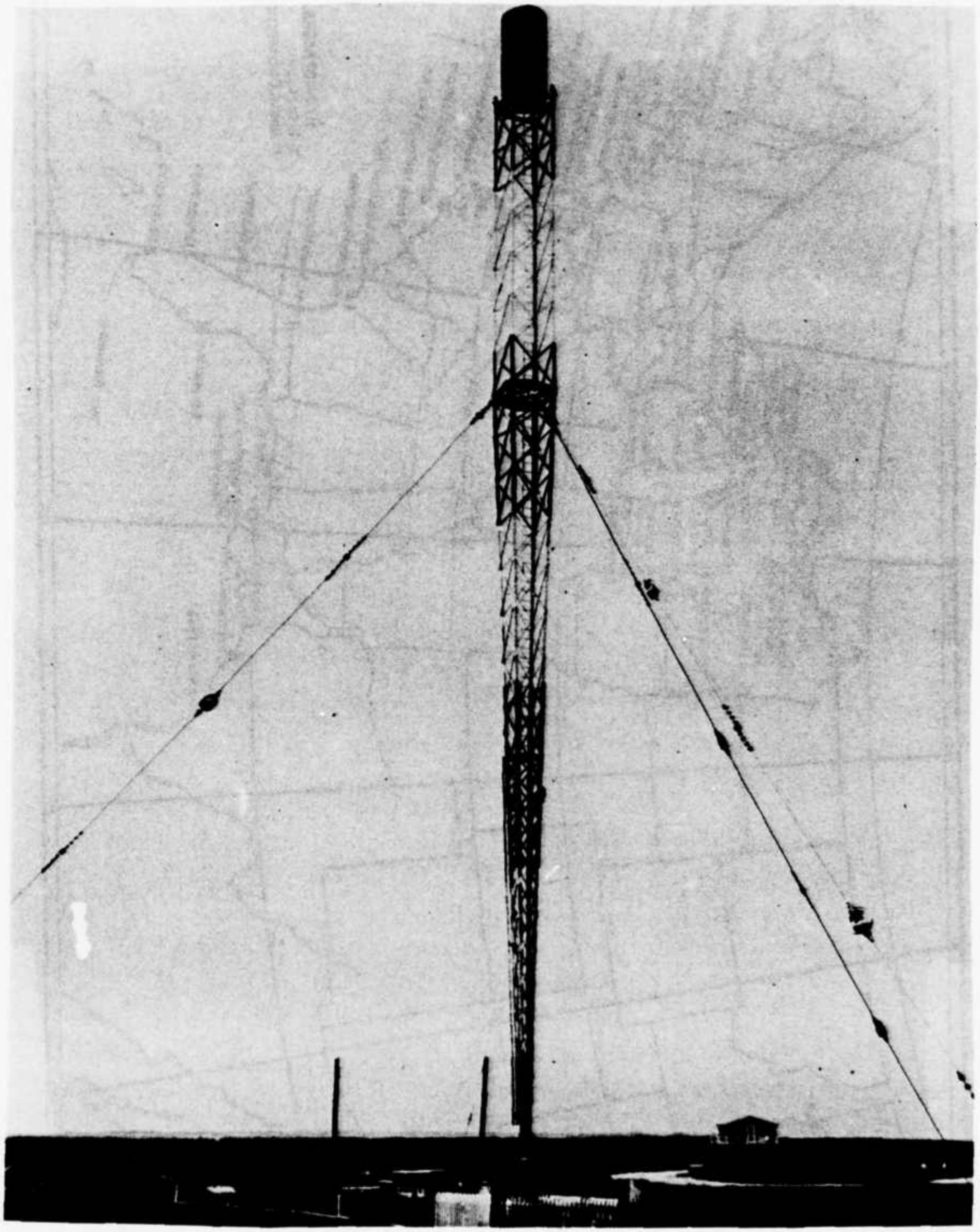

FIGURE 5. TOP-LOADED RADIOBEACON AT CAPE COD STATION CIRCA 1930

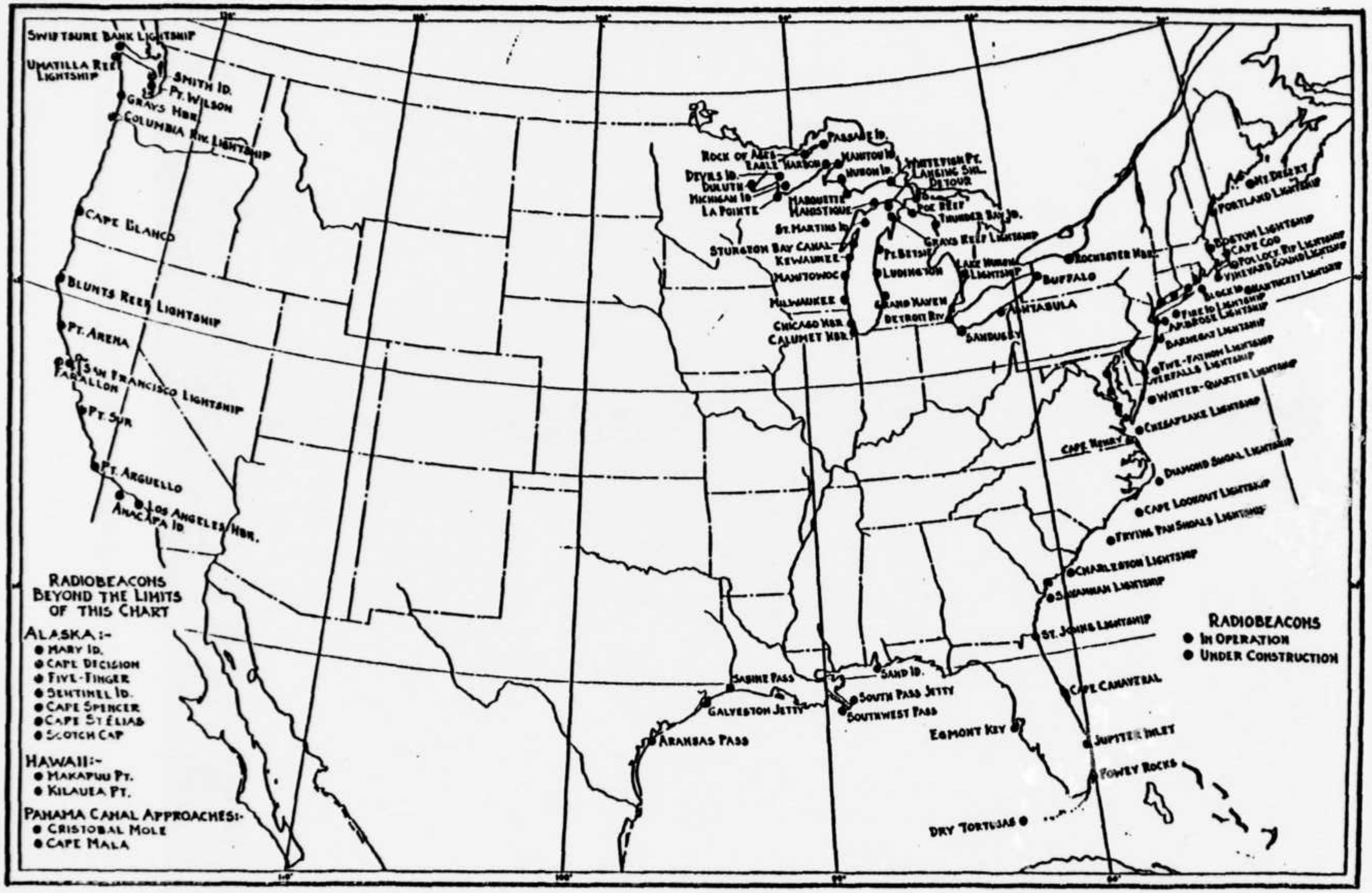

FIGURE 6. RADIOBEACON CONFIGURATION, 1 JULY 1931.

Location	Class	Frequency	Characteristic	Clear weather daily periods	Year established
Atlantic and Gulf coast:					
Mount Desert, Me.[1]	C	284	—••	24	1931
Portland Lightship, Me.	B	284	—•—	21	1928
Boston Lightship, Mass.	B	284	——••	24	1923
Cape Cod, Mass.	B	284	——•—	21	1930
Cape Cod Canal, Mass.	C	310	••—	(3)	1929
Pollock Rip Slue Lightship, Mass.	C	314	—•—	24	1928
Vineyard Sound Lightship, Mass.	C	314	•——	24	1928
Nantucket Shoals Lightship, Mass.	A	314	————	24	1923
Point Judith, R. I.[1]	C	285	—••		1931
Block Island S. E., R. I.[1]	C	307	••—•	24	1931
Little Gull Island, N. Y.	C	290	•———	2	1928
Stratford Shoal, N. Y.	C	290	•——•	2	1927
Execution Rocks, N. Y.	C	290	—•—	2	1928
Fire Island Lightship, N. Y.	C	300	——	21	1921
Ambrose Channel Lightship, N. J.	B	300	•	24	1921
Scotland Lightship, N. J.[1]	C	307	—•—•	2	1931
Barnegat Lightship, N. J.	C	300	———	21	1928
Five Fathom Bank Lightship, N. J.	B	290	••——	24	1921
Overfalls Lightship, Del.	C	290	•—•	21	1930
Winter Quarter Shoals Lightship, Va.	B	290	———•	24	1927
Chesapeake Lightship, Va.	B	285	•——•	24	1928
Cape Henry, Va.	C	285	—•—	4	1923
Diamond Shoals Lightship, N. C.	A-B	300	——•	21	1922
Cape Lookout Shoals Lightship, N. C.	B	290	•—•—	24	1927
Wolf Trap, Va.	C	305	——••	4	1930
Smith Point, Va.	C	305	—••—	4	1928
Cove Point, Md.	C	305	•——	4	1928
Sandy Point, Md.	C	305	•—•	4	1930
Frying Pan Shoals Lightship, N. C.	B	310	——	24	1928
Charleston Lightship, S. C.[1]	C	310	—••	21	1931
Savannah Lightship, Ga.	B	310	••——	24	1930
St. Johns River Lightship, Fla.	B	285	—•—	21	1928
Cape Canaveral, Fla.	B	290	——••	21	1931
Jupiter Inlet, Fla.	A-B	290	•———	21	1928
Fowey Rocks, Fla.[2]	D	290	—•••	21	1931
Dry Tortugas, Fla.	A	300	———	21	1927
Egmont Key, Fla.	B	305	•——•	21	1930
Sand Island, Ala.	B	300	•—•	8	1929
South Pass, La.	A	286	——	24	1925
Southwest Pass, La.	B	286	————	21	1929
Sabine Pass, La.	B	305	——•	8	1929
Galveston Jetty, Tex.	A	314	—•—	24	1925
Aransas Pass, Tex.	B	300	—•—	8	1929

Location	Class	Frequency	Characteristic	Clear weather daily periods	Year established
Pacific coast:					
Los Angeles Harbor, Calif.	B	304	•——	48	1928
Anacapa Island, Calif.[1]	C				
Point Arguello, Calif.	A-B	304	———	48	1925
Point Sur, Calif.	B	304	•——•	46	1925
Farallon Islands, Calif.[1]	C				
San Francisco Lightship, Calif.	A	290	——	21	1922
Point Arena, Calif.	B	295	——•	15	1928
Blunts Reef Lightship, Calif.	B	305	•—•—	7	1923
Cape Blanco, Oreg.	B	290	———•	7	1925
Columbia River Lightship, Oreg.	B	310	———	8	1923
Grays Harbor, Wash.	B	295	————	7	1926
Umatilla Reef Lightship, Wash.	B	305	•—•	4	1926
Swiftsure Bank Lightship, Wash.	A-B	290	——	24	1921
Smith Island, Wash.	C	311	——•	21	1930
Point Wilson, Wash.	C	314	——•—	21	1930
Alaska:					
Mary Island	B	295	—•	4	1931
Five Finger Island[1]	B	295	—••	21	1931
Cape Decision[1]	B	300	••——	21	1931
Sentinel Island	B	295	—•—	4	1928
Cape Spencer	A	310	—	7	1926
Cape St. Elias	A	290	————	21	1929
Scotch Cap	A	300	——	48	1930
Hawaiian Islands:					
Makapuu Point	A	290	———	14	1927
Kilauea Point	B	300	——	24	1930
Panama Canal:					
Cristobal Mole	A	305	—	48	1929
Cape Mala	A	295	——	48	1929
Great Lakes:					
Rochester, N. Y.[1]	C	302	——	24	1931
Buffalo, N. Y.	B	294	————	24	1925
Ashtabula, Ohio	B	311	——•	21	1929
Sandusky, Ohio[1]	C	306	—••—	21	1931
Detroit River, Mich.	C	306	——	21	1925
Lake Huron Lightship, Mich.	B	308	———	21	1925
Thunder Bay Island, Mich.	B	298	—•—	24	1930
Poe Reef, Mich.	C	294	•——	21	1929
Detour, Mich.	B	296	————	24	1925
Whitefish Point, Mich.	B	298	———•	21	1925
Marquette, Mich.	B	302	•——	21	1928
Huron Island, Mich.	C	311	—•—	21	1929
Manitou, Mich.	B	302	——	21	1925
Eagle Harbor, Mich.	C	311	•———	21	1929
Rock of Ages, Mich.	C	296	——••	21	1929
Michigan Island, Wis.	C	296	•——	21	1929
La Pointe, Wis.	B	311	————	21	1927
Devils Island, Wis.	B	294	———	24	1925
Duluth Range, Minn.	C	314	———•	21	1925
Passage Island, Mich.	B	302	—•—	24	1927
Grays Reef Lightship, Mich.	C	311	—••—	21	1929
Point Betsie, Mich.	B	314	•——•	21	1927
Ludington, Mich.	C	302	————	21	1927
Grand Haven, Mich.	C	302	•———	21	1927
Calument Harbor, Ill.	B	298	—•—	21	1927
Chicago Harbor, Ill.	B	298	•—•—	24	1928
Milwaukee, Wis.	B	298	——	21	1927
Manitowoc, Wis.	C	302	———	21	1927
Kewaunee, Wis.	C	294	——•	21	1930
Sturgeon Bay, Wis.	C	314	———•	21	1930
St. Martin Island, Mich.	C	294	—•—•	21	1931
Manistique, Mich.	C	294	•—•—	21	1930
Lansing Shoal, Mich.	B	314	——••	24	1927

[1] Full details as to these signals are given in the Light Lists, and on the radiobeacon charts. Wave frequencies are expressed in kilocycles per second. To obtain approximately the corresponding wave length in meters, divide 300,000 by the number of kilocycles.
[2] Under construction.
[3] Fog only.

TABLE I.
LIST OF U.S. RADIOBEACONS
FOR MARINE USE (1 JULY 1931).

Establishment of new radiobeacon transmitter installations virtually stopped during the years 1932-1934; however system refinement was pursued and in 1934 the Lighthouse Service established an unattended aid by equipping a lightship for radio remote control of all facilities, including light, fog signal, and radiobeacon (Ref. 3). Construction of new transmitter installations resumed in 1935 and in that same year officers of the U.S. and Canadian Lighthouse administrations adopted identical principles of radiobeacon operation. A simplified signal timer was introduced in 1936 and a radiobeacon buoy transmitter was successfully tested in 1938. During 1939, the first radiobeacon buoy was placed in service as North Channel Radiobeacon Buoy No. 10 in Boston Harbor, MA.

By March 1939, the Radiobeacon System had grown to 141 transmitters with an estimated 4000 users (Ref. 5). The system configuration at that time is shown in Figures 7, 8, and 9 (Ref 6).

2.2 COAST GUARD INVOLVEMENT

Under Presidential Reorganization Plan No. 11, made effective 1 July 1939, by Public Resolution No. 20, it was provided "that the Bureau of Lighthouses in the Department of Commerce and its functions be transferred to and consolidated with and administered as a part of the Coast Guard. This consolidation, made in the interest of efficiency and economy, will result in the transfer to and consolidation with the Coast Guard of the system of approximately 30,000 aids to navigation (including light vessels and lighthouses) maintained by the Lighthouse Service on the sea and lake coasts of the United States, on the rivers of the United States, and on the coasts of all other territory under the jurisdiction of the United States with the exception of the Philippine Islands and Panama Canal proper." (Ref. 7)

Thus did the Coast Guard, then a part of the Treasury Department, become responsible for the operation and maintenance of the Radiobeacon System, a function which continues to this day under the authority of 14 U.S.C. 81(1). (Ref. 8)

Few changes were made in the early years of Coast Guard administration with one notable exception, that of refinement of buoy instrumentation. In May of 1941, the initial buoy installation in Boston Harbor was replaced by a newly designated Graves Lighted Whistle Radiobeacon Buoy 5. This was followed in June 1941 by the establishment of Cape Ann Lighted Whistle Radiobeacon Buoy 2 and York Split Channel Lighted Whistle Radiobeacon Buoy 1A. A fourth radiobeacon buoy was approved for the entrance to Cape Fear River, NC, and many others were to follow. These buoy installations were designated Class D radiobeacons having an average effective range of 10 miles. (Ref. 9)

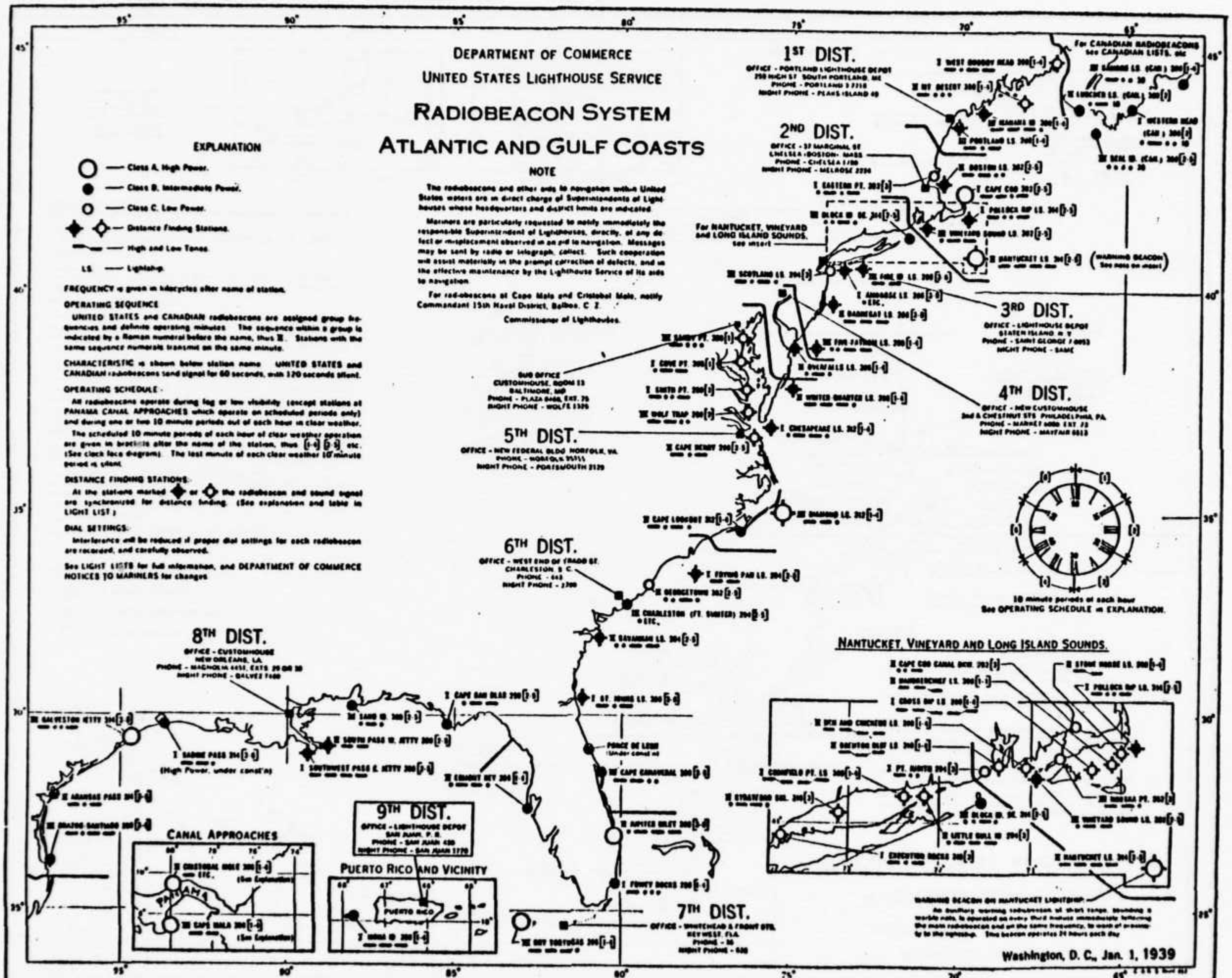

FIGURE 7. ATLANTIC AND GULF COASTS RADIOBEACON CONFIGURATION, 1939

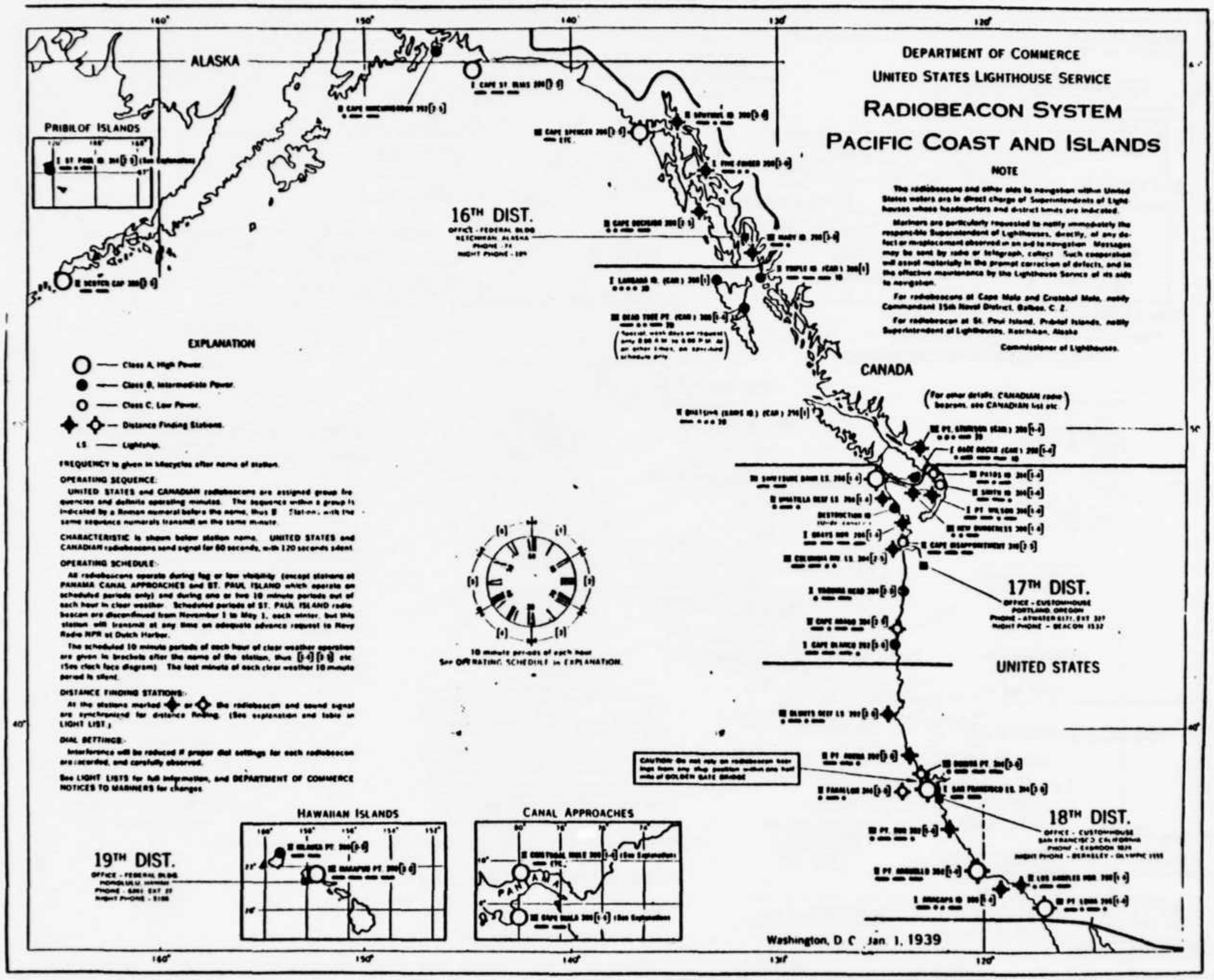

FIGURE 8. PACIFIC COAST AND ISLANDS RADIOBEACON CONFIGURATION 1939

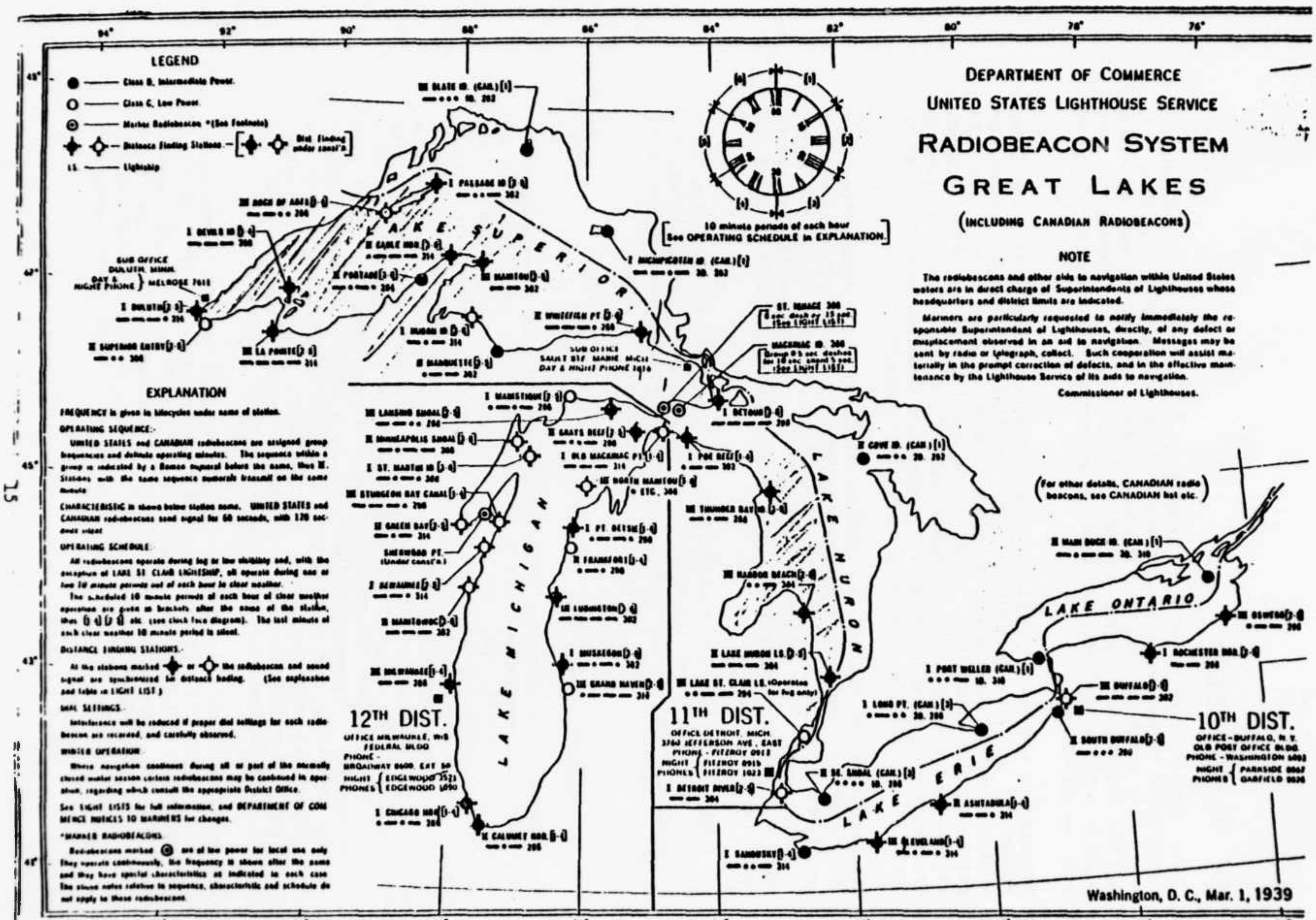

FIGURE 9. GREAT LAKES RADIOBEACON CONFIGURATION 1939

2.3 THE WARTIME PERIOD

Under the provisions of its establishing act, the Coast Guard was transferred to the Department of the Navy on 1 November 1941. With U.S. entry into World War II in the following month, numerous changes were made to the Radiobeacon System, including the immediate silencing of most Alaskan stations and modifications to the operational characteristics of many coastal sites.

Dimouts and blackouts of individual radiobeacons, as well as power level reductions and site relocations, were instituted to various degrees at various times during the wartime years in such a manner as to insure safe passage of U.S. and allied vessels while denying the use of radiobeacon signals to the enemy. Despite these restrictive actions, the Radiobeacon System actually experienced growth during this troublesome period with at least 10 new installations being established annually.

The year 1944 saw the end of radiobeacon silence at Alaskan sites, the lifting of most operational restrictions at coastal installations and the establishment of 18 new radiobeacon stations, mostly along the North Atlantic coast. The reconstituted Radiobeacon System provided essential support to maritime efforts which contributed to an allied victory and the cessation of hostilities in 1945.

The Coast Guard was returned to Treasury Department juristiction on 1 January 1946, to resume its normal peacetime mission. At that time, the Radiobeacon System consisted of 191 transmitter sites with an estimated 10,000 users.

2.4 THE POST-WAR PERIOD

Construction of radiobeacons leveled off after World War II because of the comprehensive coverage provided by the stations then operating. It was during this period that the first major revision was made to the Radiobeacon System. Individual transmitters were assessed on the basis of their coverage both singularly and with respect to other transmitters and on the basis of accessibility to the transmitter site. As a result of this effort many transmitters were moved back from jettys and other difficult to reach sites. The transmitted power levels of some transmitters were changed, while other transmitters were deemed unnecessary and were disestablished. Transmitters were installed at new sites to increase coverage capability, and technological innovations from the wartime period were introduced to the system as particular situations warranted. Following this adjustment, the count of radiobeacon transmitters was 186 in April of 1949, and users numbered an estimated 20,000. (Ref. 4).

This period also saw changes in the rules, regulations, and international agreements governing the use of Marine Radiobeacons. The International Telecommunication Union (ITU) meeting at Atlantic City in 1947 recommended a change in the radiobeacon frequency allocation from the prior established band of 285-315 kHz to an expanded band of 285-325 kHz for marine operation in ITU Region II. (The entire U.S. Marine Radiobeacon

System is within the area defined by the Atlantic City Conference as Region II.) The Extraordinary Administrative Radio Conference held in Geneva in 1951 for the preparation and adoption of new international frequency lists for the various radio services agreed to the adoption of this expanded band with an effective date of 1 November 1952. Thus, following the channel spacing used in the band 285-315 kHz, five new fundamental radiobeacon frequencies became available (316 kHz, 318 kHz, 320 kHz, 322 kHz, and 324 kHz). However, since aeronautical radiobeacons were then operating on these frequencies, it was some time before the entire expanded band became fully dedicated to maritime usage.

The importance of the Radiobeacon System as an aid to navigation was evidenced when the Communications Act of 1934, as amended and revised to 1 September 1948, required that any passenger vessel of 5000 tons or more, navigating in the open seas, be provided with an efficient radio direction finding device.

International recognition of the value of this system was achieved when the International Conference on Safety of Life at Sea, held in London in 1948, established the requirement that every ship of 1600 tons or more must be provided with an approved radio direction finding apparatus when engaged in international voyages. Through this action, the Radiobeacon System became the only internationally mandated radionavigation system - a distinction which continues to this day. In addition, the Safety of Life at Sea Conference recognized that the field strengths necessary to obtain usable bearings at the edges of the advertised service ranges depended upon the sensitivity and selectivity of direction finders and the noise levels due to atmospherics and other causes. Hence, it was recommended that direction finding equipments (receivers) should have a sensitivity of no less than 50 microvolts per meter ($\mu v/m$). Upon acceptance of this recommendation by the ITU, the Coast Guard adjusted the transmitted power of each U.S. Marine Radiobeacon to provide a field strength of 50 $\mu v/m$ at its advertised service range.

2.5 THE FIFTIES AND EARLY SIXTIES

By June of 1953, the number of radiobeacons had once again risen to the level of 191 installations, an increase of but 5 from the 1949 level (Ref. 10). The user community had, however, grown much more significantly to an estimated level of 40,000, spurred in large part by the regulatory actions of the late forties. The Radiobeacon System remained essentially the same over the next decade or so, adding or deleting a beacon here or there to satisfy the immediate needs of the user community with minimal effect on the overall system. However, one major modification was introduced - that of field strength criteria at advertised service ranges. Pursuant to the Radio Regulations adopted by the 1959 ITU Conference in Geneva, the field intensities at the extremity of the advertised range in Region II were changed to the following levels to permit satisfactory bearing determination in the presence of atmospheric noise:

50 $\mu v/m$ for Radiobeacons north of 40°N
75 $\mu v/m$ for Radiobeacons between 40°N and 31°N
100 $\mu v/m$ for Radiobeacons between 31°N and 30°S

The Coast Guard adopted these field strength criteria in January of 1961 at which time the system consisted of 194 radiobeacons (Ref 11). All Marine Radiobeacons had their field intensities adjusted as determined by their latitude. A few exceptions, accepted by the ITU, were made to improve the service rendered in troublesome areas. The nominal field intensities required to meet these criteria are listed in Table II (Ref. 12). The listed intensity levels have been fixed since 1961 and consequently are those in current practice.

The 1959 Radio Regulations also stipulated that all radiobeacon emissions must occupy the minimum practical frequency spectrum (bandwidth) and must possess a frequency stability of a least 0.01%, characteristics that were commonly observed in U.S. radiobeacon practice prior to that mandate.

Over the years, different types of radiobeacons evolved to satisfy particular needs. For instance, local or marker beacons for local use at a nominal distance of 10 miles, transmitted a series of 0.5 second dashes for a period of 15.5 seconds then remained silent for 14.5 seconds. Sequenced beacons, in groups of three on a common frequency, transmitted an identifying code for one minute and remained silent for two minutes during two 10 minute periods each hour. These beacons operated throughout the hour in limited visibility situations. Continuous beacons transmitted an identifying code at all times in all weather conditions. Distance finding beacons sent out synchronized radio and fog signals to permit measurements of distance over limited ranges. Calibration stations operated upon request to allow a mariner to determine the precision of his direction finding equipment.

The locations and characteristics of the various elements of the U.S. Marine Radiobeacon System as it existed in early 1963 are shown in Figures 10, 11, and 12 (Ref 13).

Radio direction finders (ship board receivers) also developed in sophistication over time and automatic direction finding (ADF) equipments found their way into the user inventory. The operational utility of ADF equipments on large vessels coupled with increased acceptance of radiobeacon navigation by the pleasure boat community presaged the need for a reassessment of transmitted signal characteristics and an ulti ate realignment of the Radiobeacon System.

2.6 SYSTEM REALIGMENT OF 1963

Ease of operation and low cost to the user made the Marine Radiobeacon System a major aid to navigation for the pleasure craft owners as well as for the commercial users. Due to the phenomenal rise in small boating in the late 1950's and early 1960's, additional radiobeacon transmitter sites were sought to accommodate the more than 100,000 members of this user class. However, the available radio spectrum had become saturated to the point that it was virtually impossible to add another station without undue interference. In an effort to alleviate this problem, the entire Radiobeacon System was reassessed during the early 1960's and several major changes were effected during the months of June and July 1963.

TABLE II.

FIELD INTENSITY REQUIREMENTS

ADVERTISED RANGE (Mi)*	REQUIRED INTENSITY AT ONE MILE* IN MICROVOLTS PER METER			
	SEA WATER			GREAT LAKES
	50 µV/m	75 µV/m	100 µV/m	
10	500	750	1000	550
15	750	1125	1500	800
20	1000	1500	2000	1100
25	1300	1950	2600	1450
30	1500	2250	3000	1800
35	1800	2700	3600	2150
40	2100	3150	4200	2550
45	2400	3600	4800	2950
50	2700	4050	5400	3400
55	3000	4500	6000	
60	3300	4950	6600	4350
65	3600	5400	7200	
70	3900	5850	7800	5400
75	4200	6300	8400	
80	4500	6750	9000	6600
85	4900	7350	9800	
90	5300	7950	10600	7850
95	5600	8400	11200	
100	6000	9000	12000	9300
110	6800	10200	13600	
120	7600	11400	15200	
130	8400	12600	16800	
140	9300	13950	18600	
150	10400	15600	20800	
160	11500	17250	23000	
170	12600	18900	25200	
180	13800	20700	27600	
190	15100	22650	30200	
200	16600	24900	33200	
250	25100	37650	50200	
300	37500	56250	75000	
350	54900	82350	109800	

*Nautical Miles for Sea Water
Statute Miles for Great Lakes

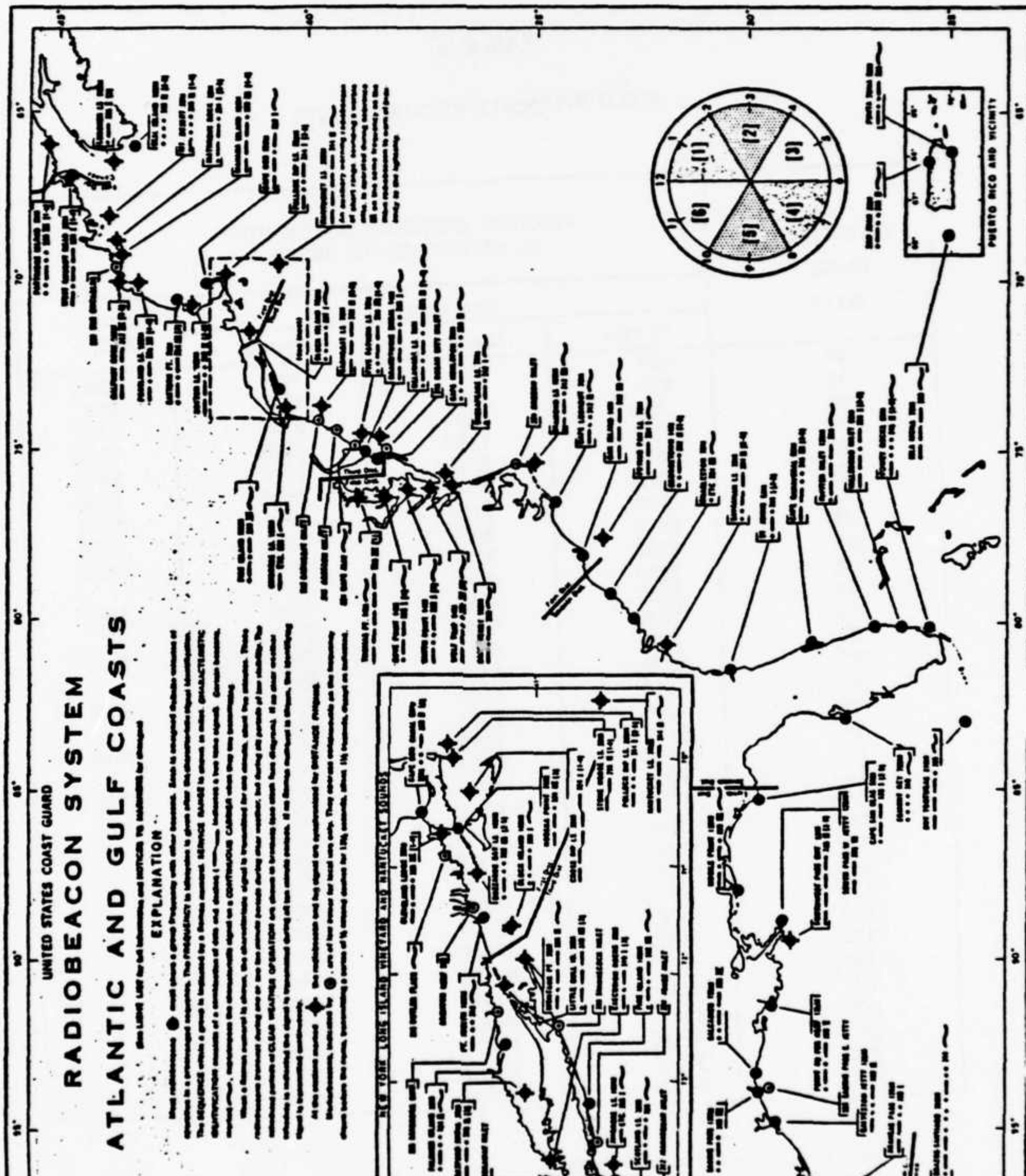

FIGURE 10. ATLANTIC AND GULF COASTS RADIOBEACON CONFIGURATION, EARLY 1963

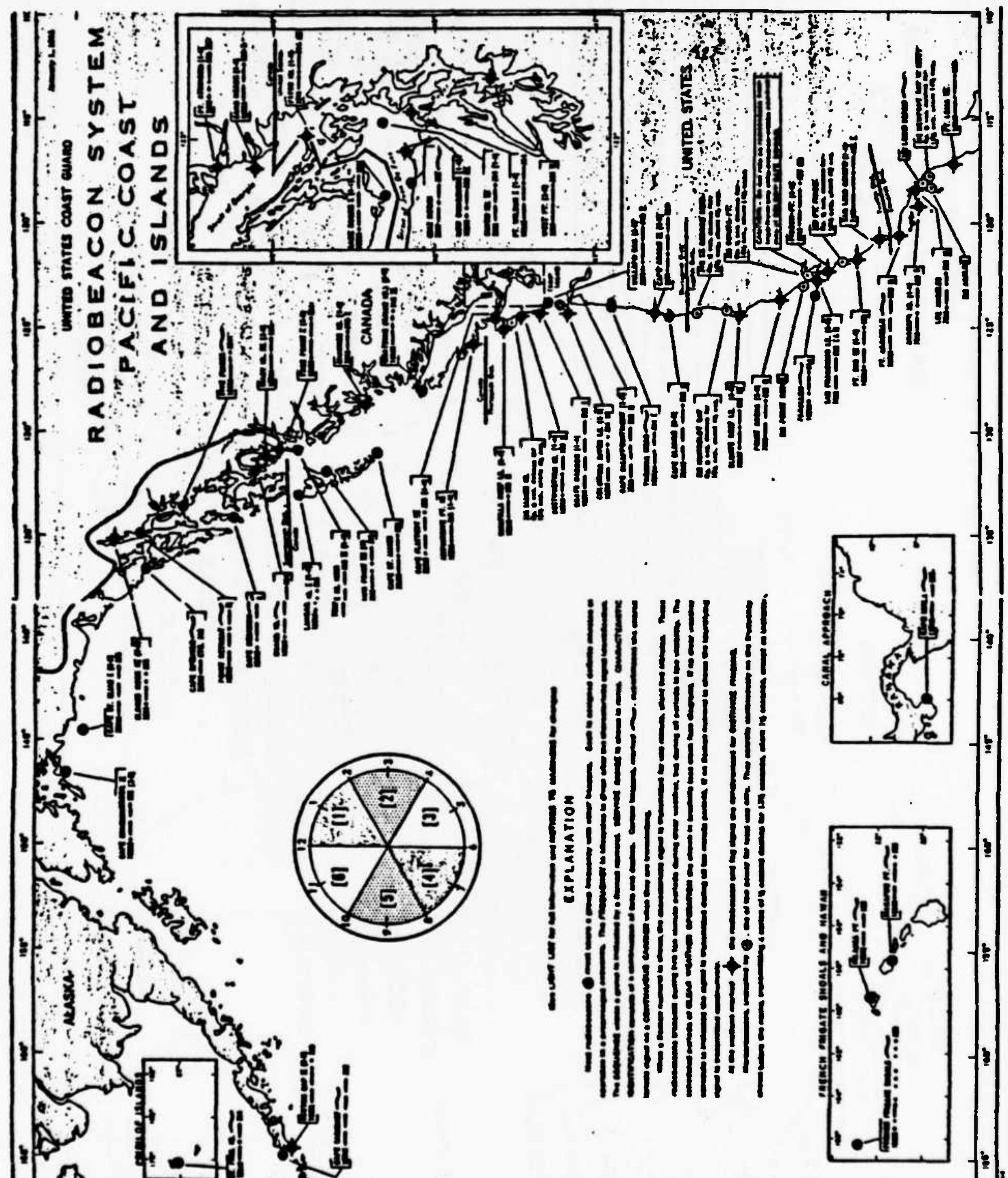

FIGURE 11. PACIFIC COAST AND ISLANDS RADIOBEACON CONFIGURATION, EARLY 1963

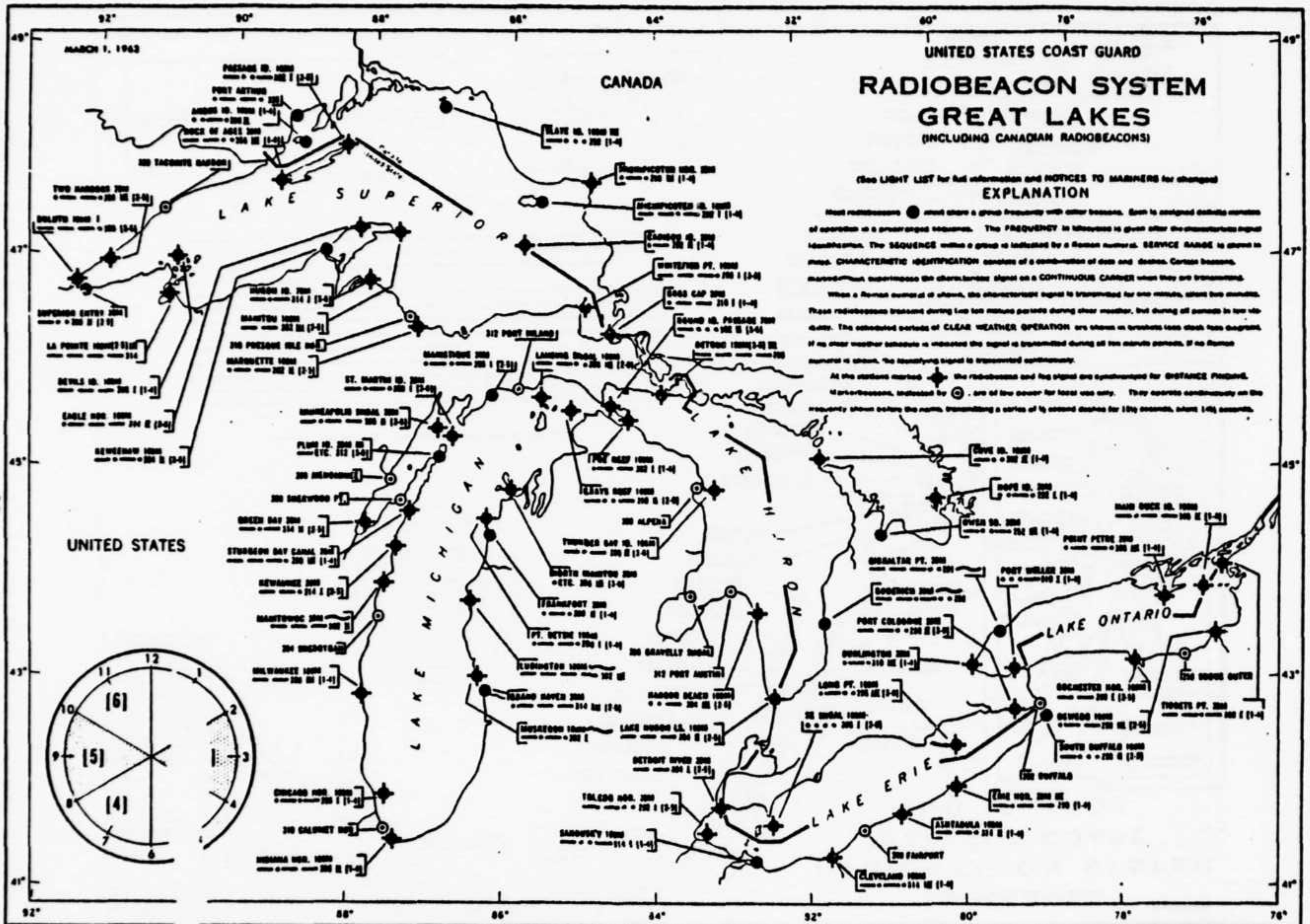

FIGURE 12. GREAT LAKES RADIOBEACON CONFIGURATION, EARLY 1963

As noted earlier, a sequenced beacon is one whose transmission are time shared with other beacons operating on the same frequency. Historically, three stations time-shared two ten minute periods each hour in fair weather and operated throughout the hour in foul weather. A major revision to system operation was introduced in June of 1963 whereby sequenced beacons would operate one minute on/five minutes off in groups of six radiobeacons to a frequency. The purpose of the change was to relieve band congestion and to make room for possible additional radiobeacons. In addition to the re-grouping modification, the distinction between fair and foul weather operation was eliminated, thus providing ten minutes of operation per hour from each station under all weather conditions. All radiobeacons in the United States and Canada were changed to the new mode of operation by the end of July 1963. This was a tremendous engineering feat requiring the utmost of planning, coordination, and cooperation amoung the U.S. Coast Guard, the Canadian Department of Transport, and the user community (Ref. 14). Comparison of the resultant configuration, Figures 13, 14, and 15, (Ref. 15) with the immediately preceeding configuration, Figures 10, 11, and 12, clearly shows the enormous scope of this near-immediate system realignment.

Concurrent with the above change, the type of radiobeacon emission was changed from keyed-carrier keyed-tone transmission to continuous carrier keyed tone transmission. This latter type of emission is more suitable than the former to ADF usage in that a continous carrier minimizes jitter and hunting effects. As an added aid to those users with manual direction finders, a 10 second dash was added at the end of each operating minute at all sequenced stations to enhance their ability to obtain accurate bearings in a timely fashion.

A further related modification was a change from amplitude modulation to dual carrier emission (Ref. 16). In radiobeacon usage, dual carrier emission is the simultaneous transmission of two RF carriers whose frequencies are separated by 1020 Hz (the desired modulation frequency). One carrier operates continuously at the designated station frequency. The second carrier operates 1020 Hz above the first and is keyed in accordance with the station code. The keyed carrier is transmitted at half the power of the continuous carrier thereby yielding a modulation of 70% after detection. This type of emission, which remains in current usage, has the advantage of transmitting the same amount of information while using half the bandwidth required by amplitude modulation. In theory, this change allowed the addition of more radiobeacon stations. In practice, however, full advantage of the narrow bandwidth characteristic of dual carrier emission could not be realized until direction finders were redesigned with compatible narrow IF bandpasses. This was a very gradual process over the next several years.

Following the realignment of 1963, the system configuration remained essentially unchanged over the next few years with only minor adjustments where necessitated by operational considerations. System instrumentation did, however, exhibit change with the gradual introduction of various solid state components and sub-systems which partially replaced some of the older tube-type equipments. This was followed by the eventual deployment of fully solid state transmitters in the mid-sixties.

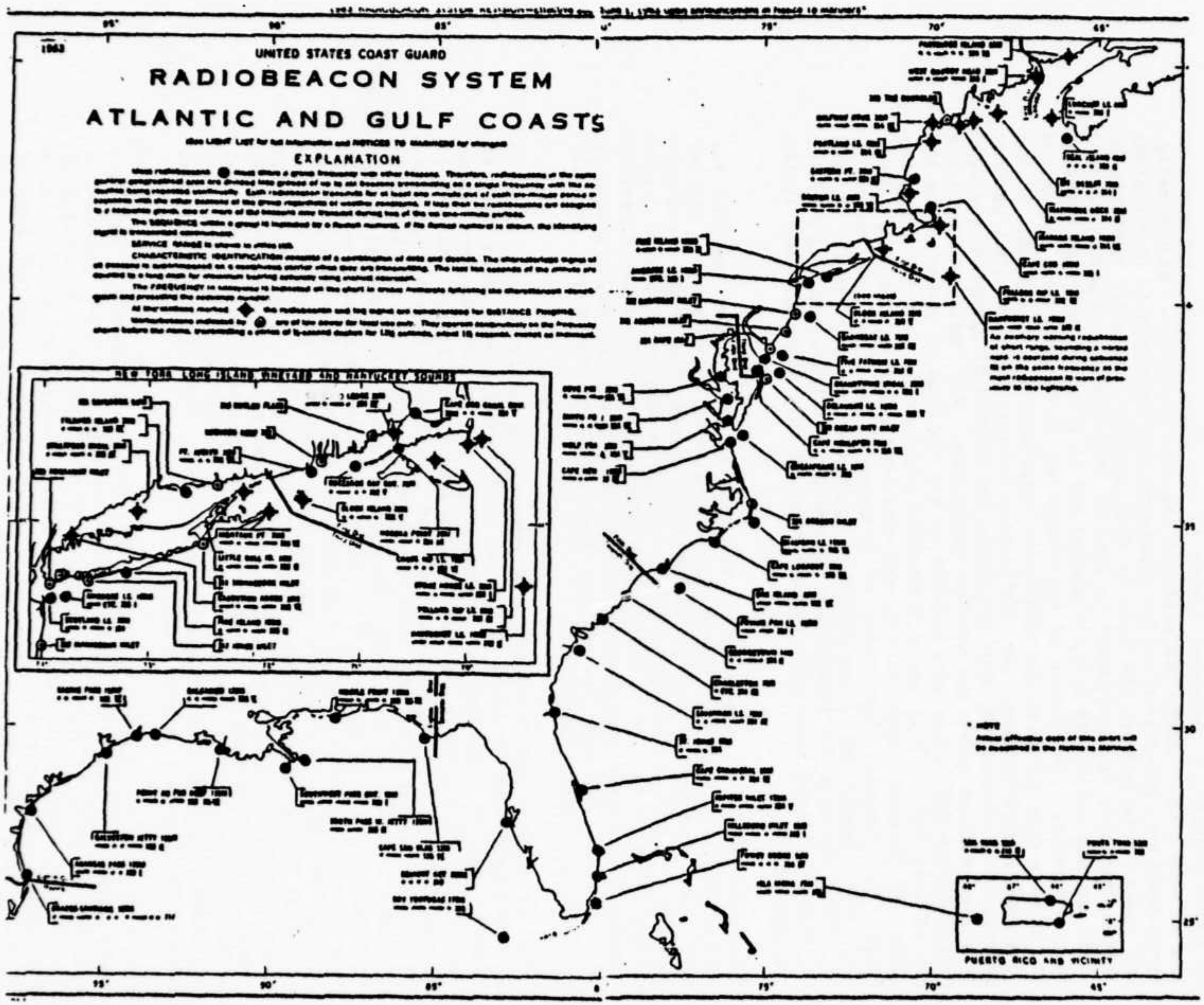

FIGURE 13. ATLANTIC AND GULF COAST RADIOBEACON CONFIGURATION, LATE 1963.

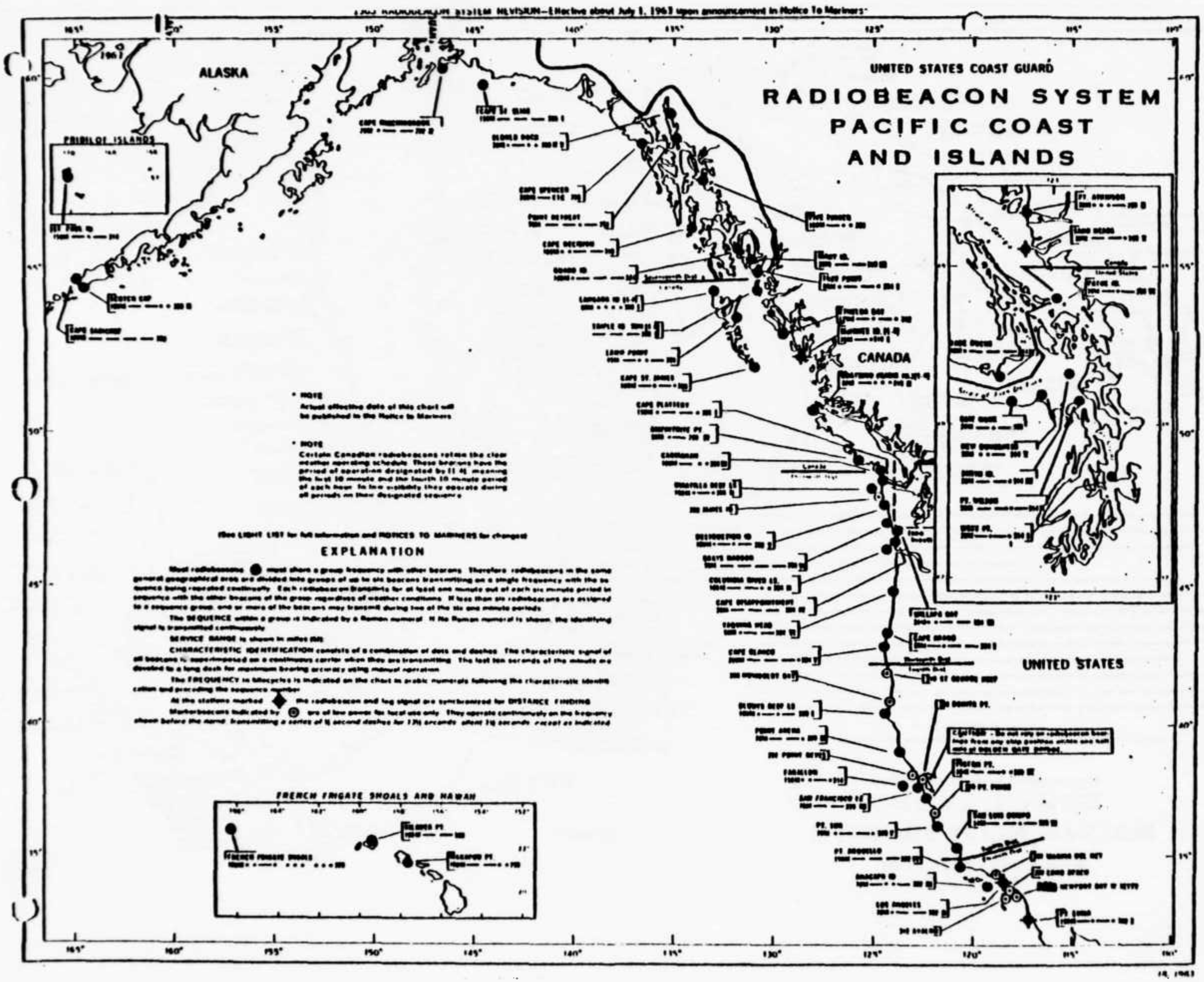

FIGURE 14. PACIFIC COAST AND ISLANDS RADIOBEACON CONFIGURATIONS, LATE 1963.

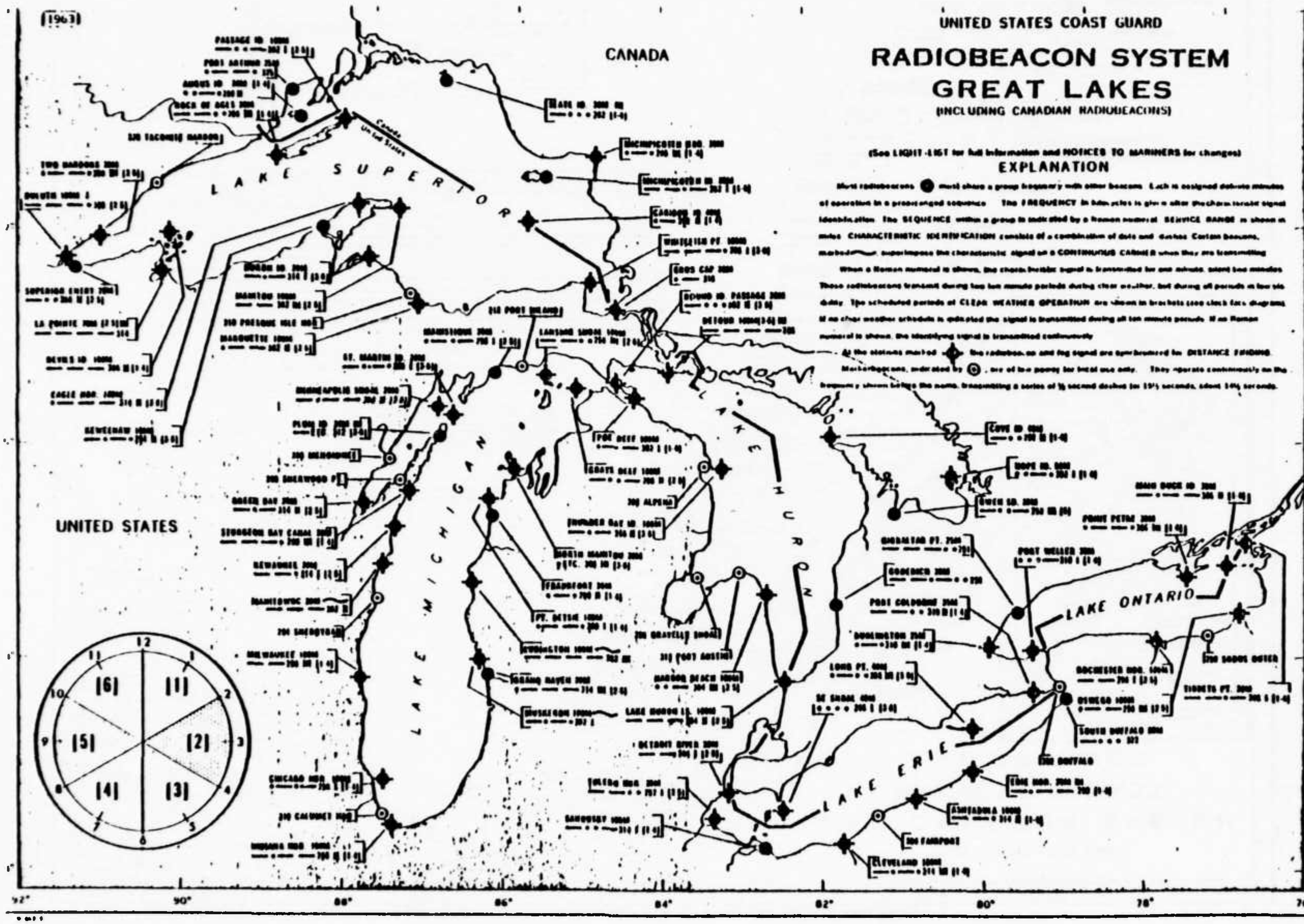

FIGURE 15. GREAT LAKES RADIOBEACON CONFIGURATION, LATE 1963.

2.7 THE DEPARTMENT OF TRANSPORTATION YEARS

In April of 1967, the U.S. Coast Guard was assimilated into the newly formed Department of Transportation (DOT). This administrative change had no immediate effect on the Radiobeacon System and the Coast Guard continued with the routine maintenance, operation and refinement of the system. In its charter, the DOT was designated as the principal provider of civil air, maritime, and terrestrial navigation systems. This function received statutory recognition in Public Law 89-670, the legislation creating the New Department. In April 1972, the DOT published a National Plan for Navigation (NPN) to address the major civil air and marine navigation systems. Prominent among the latter was the Radiobeacon System about which it was stated in part that:

> "Continued operation of the marine radiobeacon system will be required for backup to more accurate systems and to provide a navigation system which is suitable for the multitude of recreational boats... Current plans are that the transmitting system will be augmented and reconfigured to provide better service to the large number of users of the system in selected areas of the United States."

At the time the NPN was published, the recreational boat user community exceeded 200,000 members. The Coast Guard, anticipating the increased needs of these users, had already initiated a planning activity to satisfy such needs while concurrently maintaining and improving the service provided to the commercial user. This activity, eventually formalized as the Radiobeacon Improvement Program of 1974, identified the following goals:

1. Optimization of radiobeacon service to meet current requirements
2. Reduction of support costs

The separate Coast Guard Districts responded with plans to address these goals which incorporated inputs from perceived needs as voiced in Coast Guard conducted surveys of the user communities and requirements analyses conducted within the involved Districts.

During the years 1975 and 1976, coordinated plans were prepared for the Atlantic and Gulf Coasts, the West Coast, and the Great Lakes areas by consolidating the individual plans submitted earlier by the various Coast Guard Districts. Although the resultant plans did not accomodate all of the specific recommendations of all commands, they were the result of an exhaustive analysis of what had been recommended and what could be accomplished under the constraints of frequency availability and interference protection. The plans did, however, provide for the orderly transition from the then existing system to a new configuration which satisfied the cited goals in the following manner:

Optimization

1. Provide the mariner with improved radiobeacon service where he wants it and the type of service he desires.

2. Effect efficient utilization of the existing marine radiobeacon frequency band.

3. Convert as many radiobeacons as possible from sequenced to continuous operation in order to provide the mariner with maximum fix information per time unit, convert marker beacons to continuous coded operation, and convert all beacons from single characteristic code to multiple characteristic codes.

4. Assign maximum ranges, up to 150NM where possible, to all radiobeacons where such increases prove merited and beneficial to the mariner.

5. Provide an almost continuous two line fix capability at least to 50NM offshore or to the 100 fathom curve, whichever is greater.

Cost Reduction

1. Convert to a standardized totally solid state design transmitter installation.

Implementation of the various features of the plans was initiated by a Coast Guard directive, since overall responsibility for the Radiobeacon System was made a Headquarters function of the Radionavigation Aids Branch of the Aids to Navigation Division, Office of Marine Environment and Systems. In the past, the separate Coast Guard Districts were somewhat autonomous in regard to radiobeacons under their jurisdiction.

In contrast to the almost immediate change of 1963, the improvement of 1974 was a very gradual undertaking eventually leading to the system as it exists today. The revised DOT NPN of 1977 attested to the fact that the Radiobeacon System was undergoing change and the Federal Radionavigation Plan, prepared jointly by DOT and DOD in 1980, contained the following reference to the status of Marine Radiobeacons:

> "There are approximately 200 Coast Guard-operated marine radiobeacons. Operation of these systems will continue through the 1990's. The system is being modernized, expanded slightly and reconfigured to provide better sevice in response to the increasing demand. This effort includes establishing 37 new stations,relocation of some others, changes in type of operation of selected beacons, and changes in frequency. These changes will improve service by providing more beacons, improving signal availability, and providing service in many area where coverage does not exist. The changes in frequency will result in more efficient use of the RF spectrum and will allow for additional beacons in some areas if needed."

The optimization portion of the system improvement of 1974 was substantially completed by the end of 1980. Of the many changes introduced, the most observable were the conversion of many radiobeacons from sequenced to continuous operation. The operational changeover greatly simplified the equipments necessary at the affected transmitter sites. Evidence of this simplification is shown in the before and after photographs of the transmitter configuration at a typical installation (Eastern Point, MA), Figures 16 and 17. In sequenced operation, Figure 16, considerable hardware was required to maintain the necessary time reference control. In continuous operation, Figure 17, these equipments were no longer needed, greatly reducing the complexity of the site.

As to cost reduction, experience with solid state transmitters established the superiority of such equipment over older vacuum tube designs in terms of reliability, maintainability and savings in power consumption. The efficacy of such designs, demonstrated over the preceding decade, led to the development of specifications for the first Coast Guard-wide standardized solid state transmitter in 1977 (Figure 18). The first installation of this design was established at Guard Island, Alaska in August of 1978. In the final version of the Radiobeacon Improvement Program of 1974, adopted in the Spring of 1980, provision was made to introduce Radiobeacons of common total solid state design throughout the near-term future system.

An organizational change also occurred in this time period - the formulation of the Office of Navigation within the Coast Guard in May of 1980. With this change, responsibility for the operation and maintenance of the U.S. Marine Radiobeacon System was assigned to the OMEGA/Radiobeacon Branch of the Radionavigation Division of that Office.

3.0 THE CURRENT SYSTEM

On 1 January 1982, the system consisted of 199 radiobeacons configured as shown in Figures 19, 20, and 21. Individual site characteristics were as noted in Appendix A (Ref. 17). Radiobeacon installations by Coast Guard District at that time were:

CG District	No. Radiobeacons
1	23
3	19
5	13
7	12
8	11
9	62
11	15
12	20
13	17
17	7

The Federal Radionavigation Plan of 1980 projected that the Radiobeacon System would provide service to some 423,000 users by 1982.

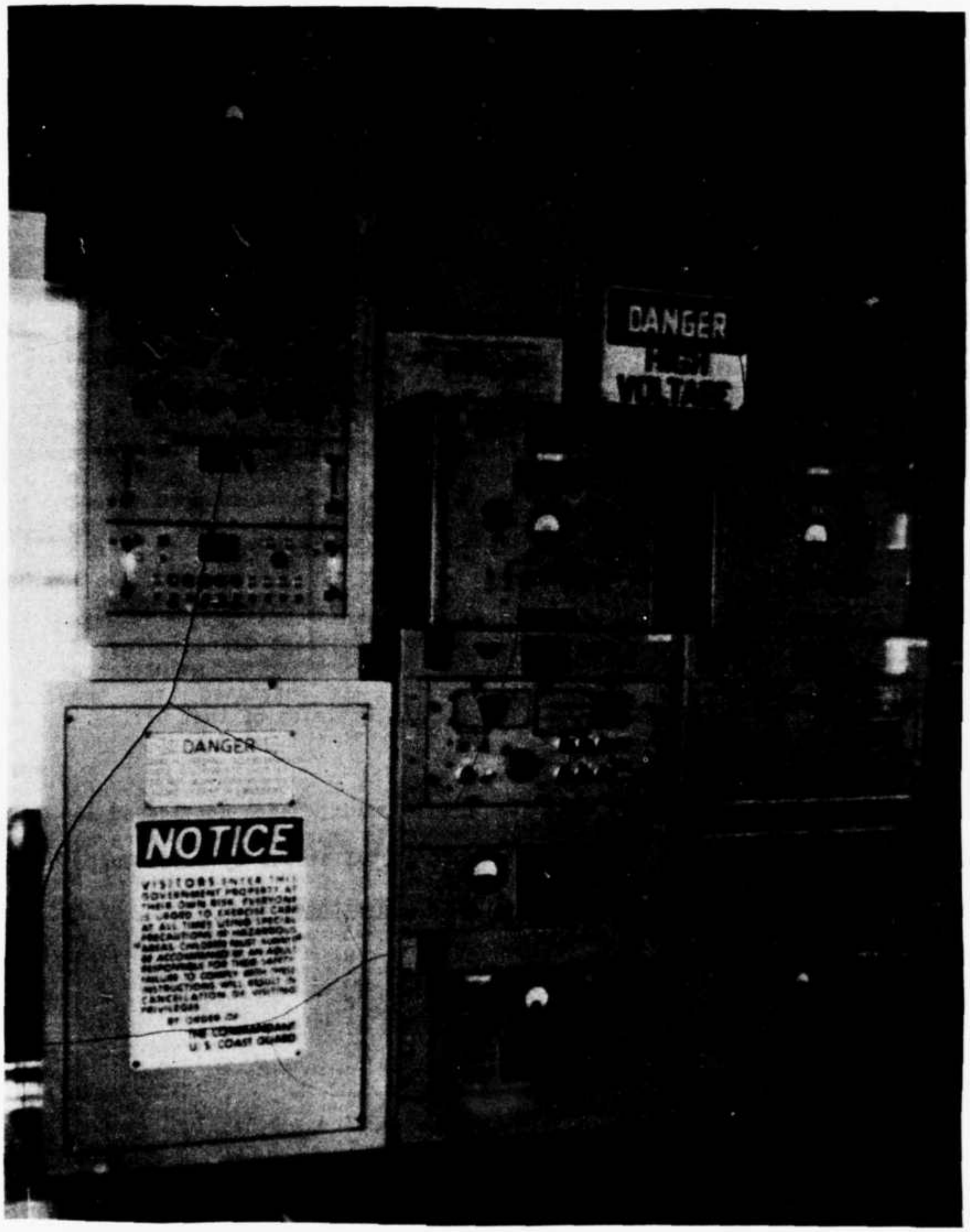

FIGURE 16. SEQUENCED RADIOBEACON AT EASTERN POINT, MA 18 JULY 1977

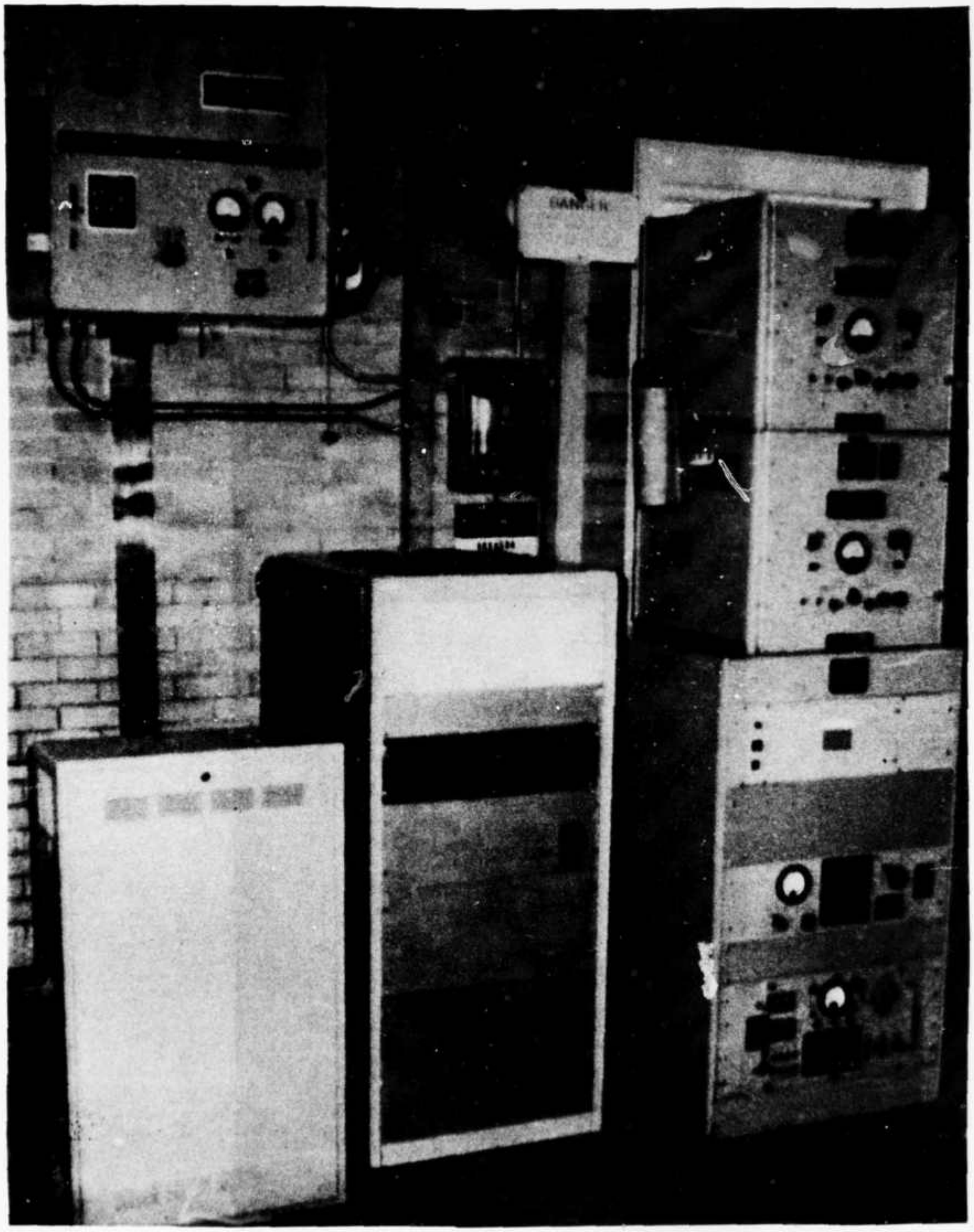

FIGURE 17. CONTINUOUS RADIOBEACON AT EASTERN POINT, MA 14 JANUARY 1980

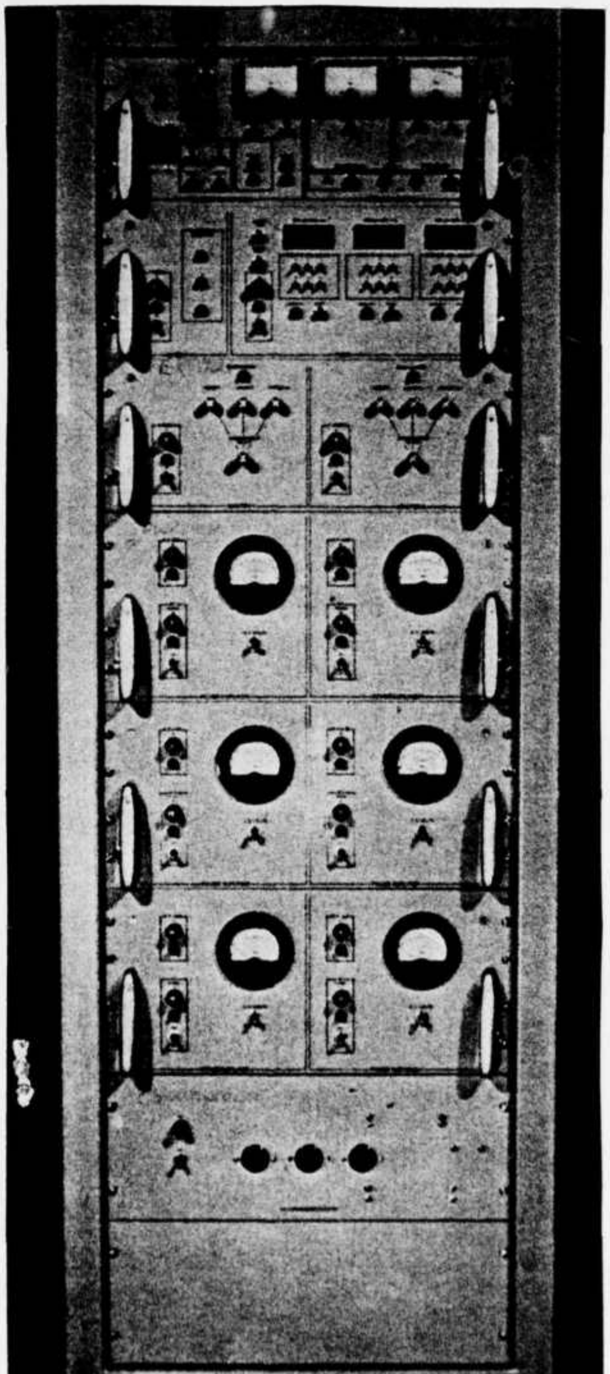

FIGURE 18. SOLID STATE RADIOBEACON TRANSMITTER (AN/FRN-40)

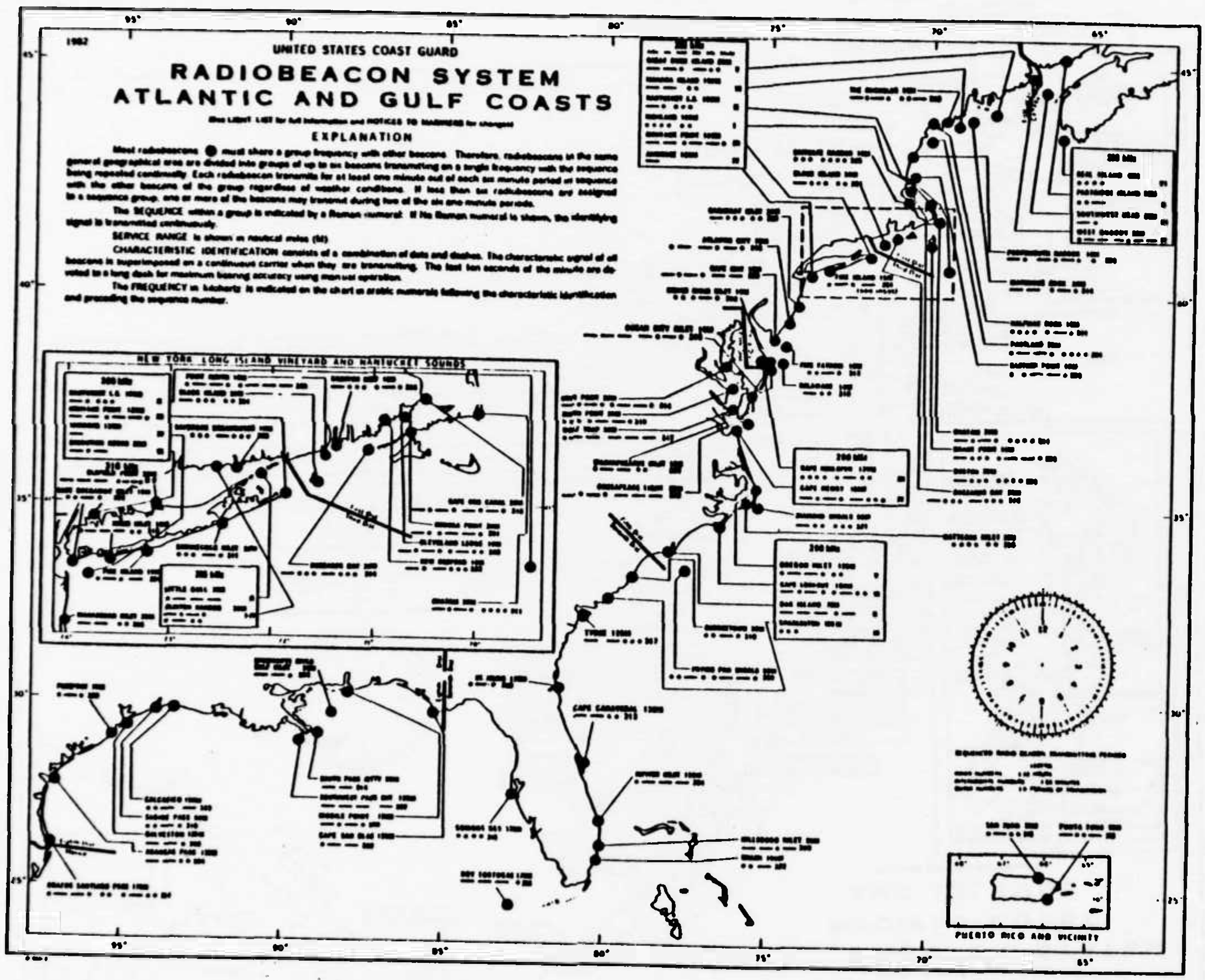

FIGURE 19. RADIOBEACON SYSTEM, ATLANTIC AND GULF COASTS, 1 JANUARY 1982

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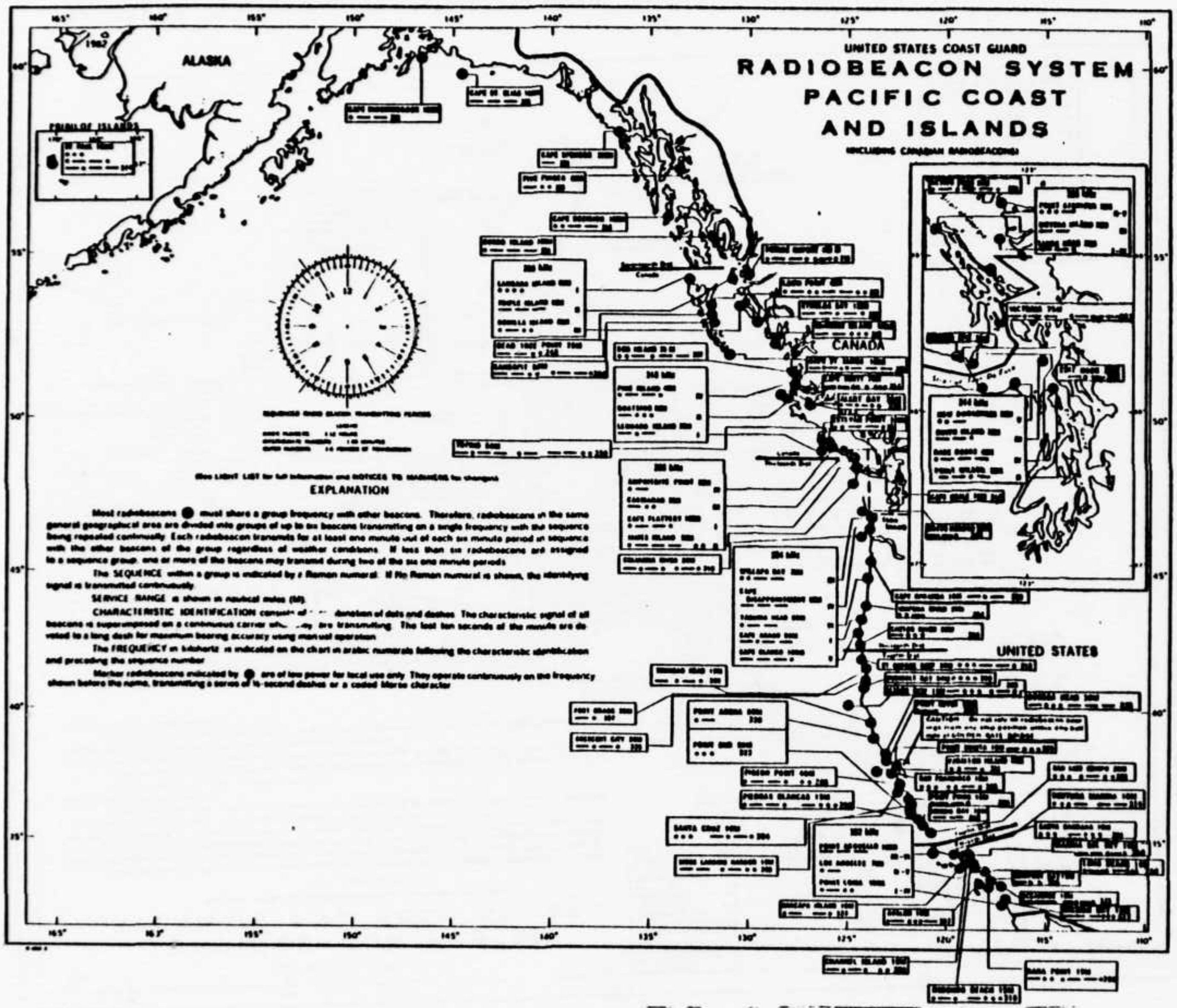

FIGURE 20. RADIOBEACON SYSTEM, PACIFIC COAST AND ISLANDS, 1 JANUARY 1982

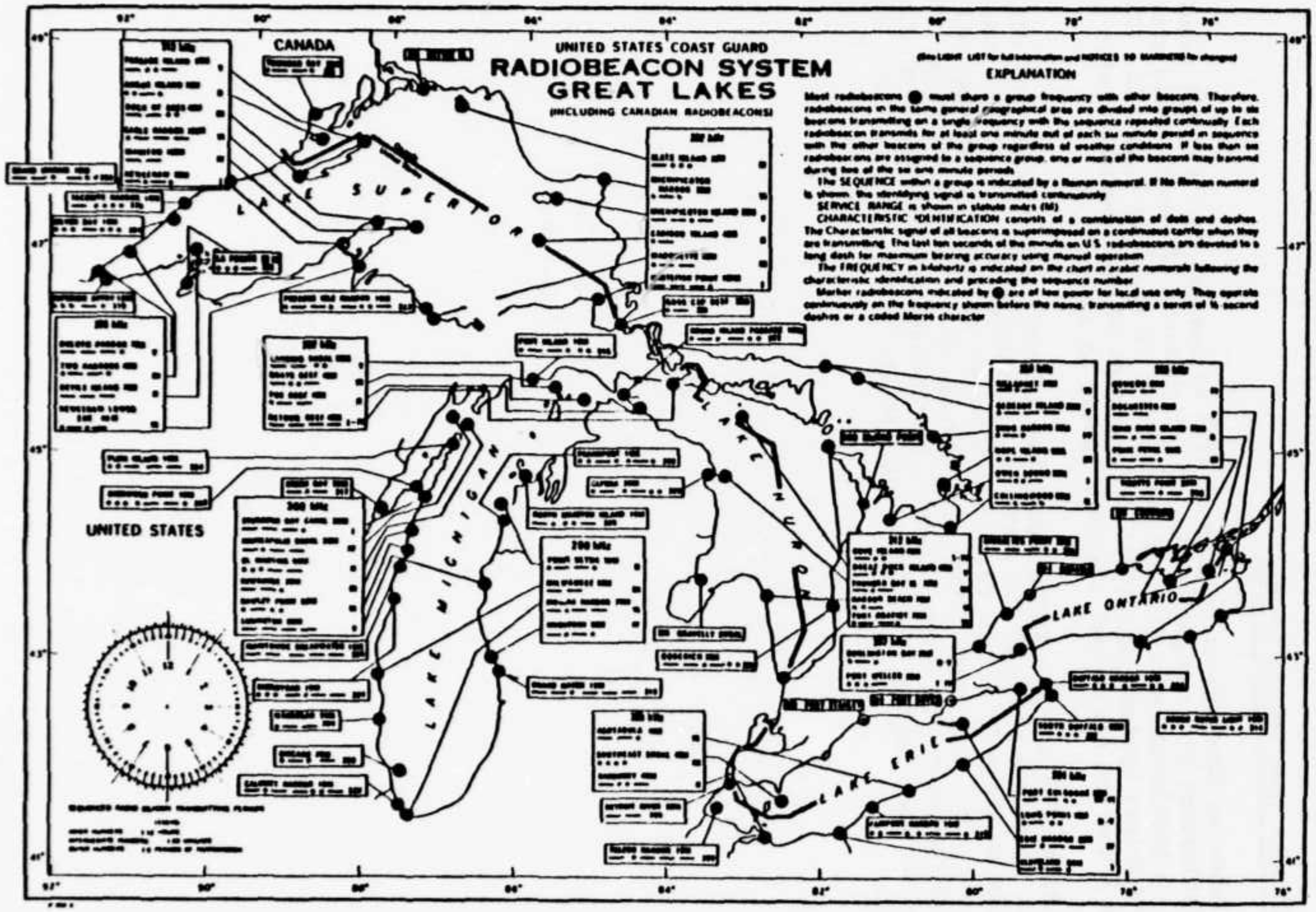

FIGURE 21. RADIOBEACON SYSTEM, GREAT LAKES, 1 JANUARY 1982

The bearing coverage provided by this system is shown graphically in Figures 22, 23, and 24. Fix coverage (two or more beacon coverage) is shown in Figures 25, 26, and 27. Fix coverage is provided everywhere within the Great Lakes.

4.0 THE NEAR TERM FUTURE SYSTEM

The Radiobeacon Improvement Program of 1974 as amended to 1980 will result in the deployment of a new generation of radiobeacons of common solid state design. A photograph of a typical transmitter is shown in Figure 28. The near-term future system (late 1984) will consist of the stations listed in Appendix A and the additional stations listed in Appendix B.

The addition of 8 installations about the Atlantic and Gulf Coasts will result in increased areas of fix coverage, particularly off the west coast of Florida as shown in Figure 29. The envelope of bearing coverage will remain the same as that shown in Figure 22. The additional 14 installations about the Great Lakes will increase the redundancy of fix coverage in that region. Pacific and Alaskan coast coverage will be unchanged.

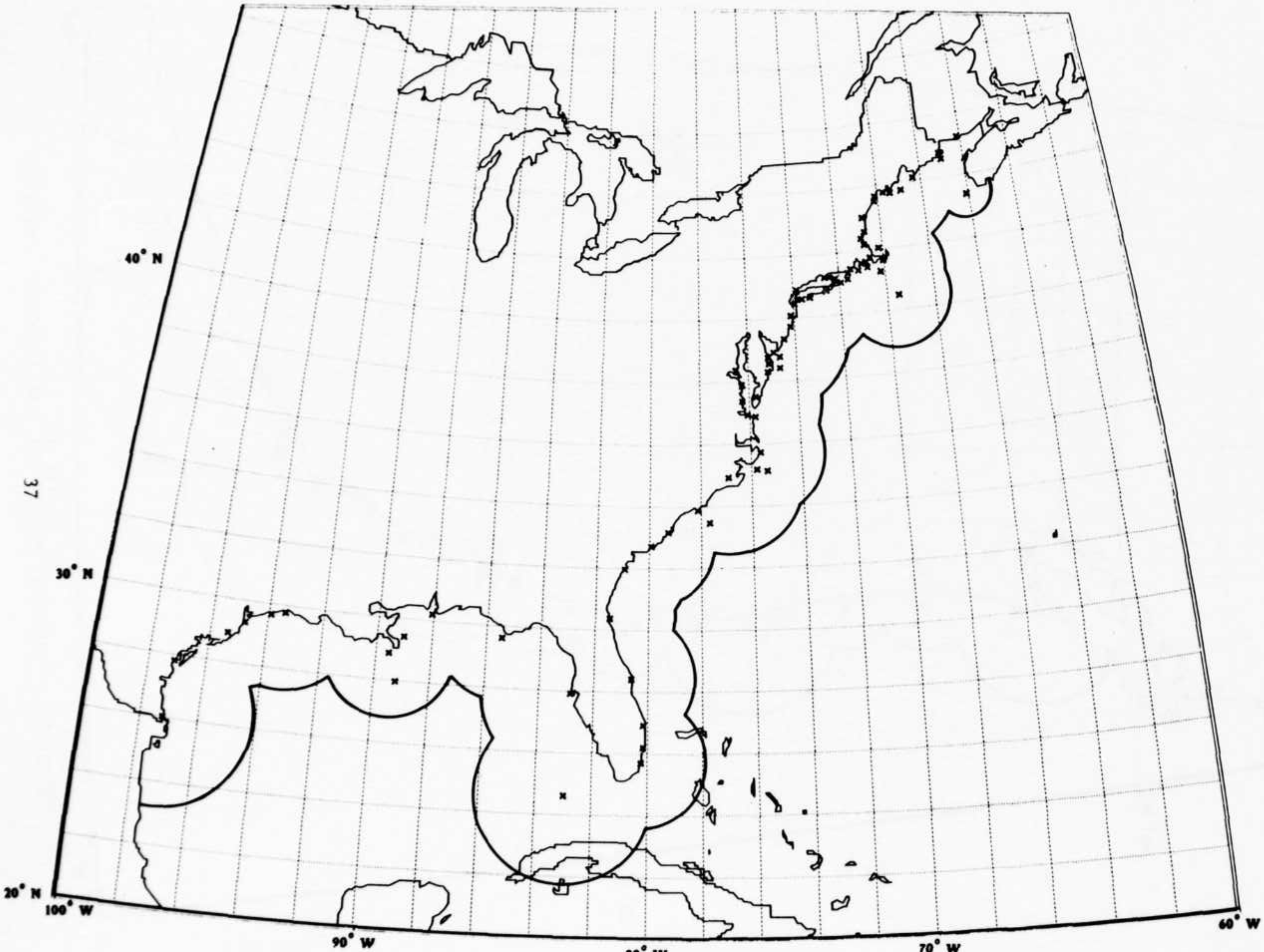

FIGURE 22. RADIOBEACON COVERAGE, ATLANTIC AND GULF COASTS - BEARING (1982)

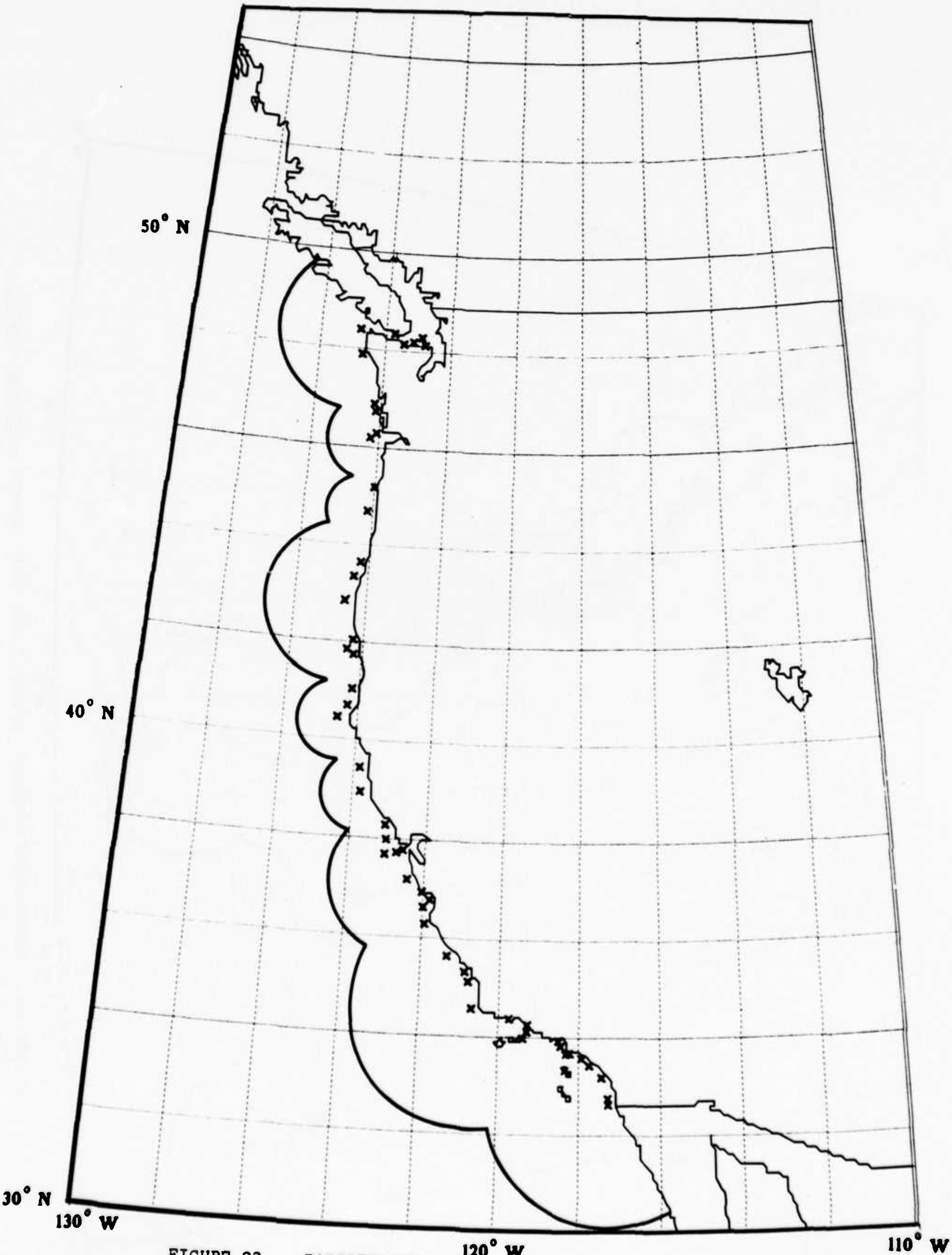

FIGURE 23. RADIOBEACON COVERAGE, PACIFIC COAST - BEARING

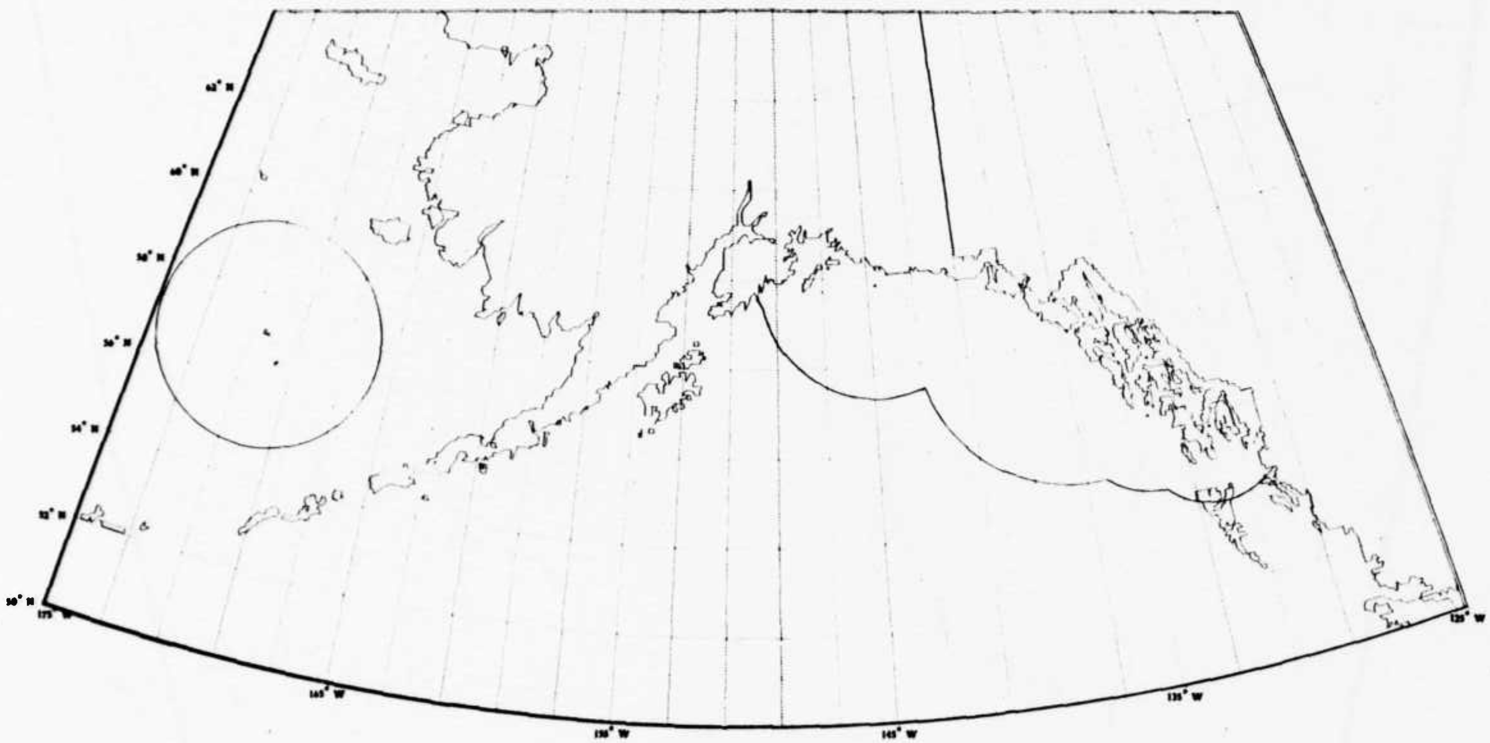

FIGURE 24. RADIOBEACON COVERAGE, ALASKAN COAST - BEARING

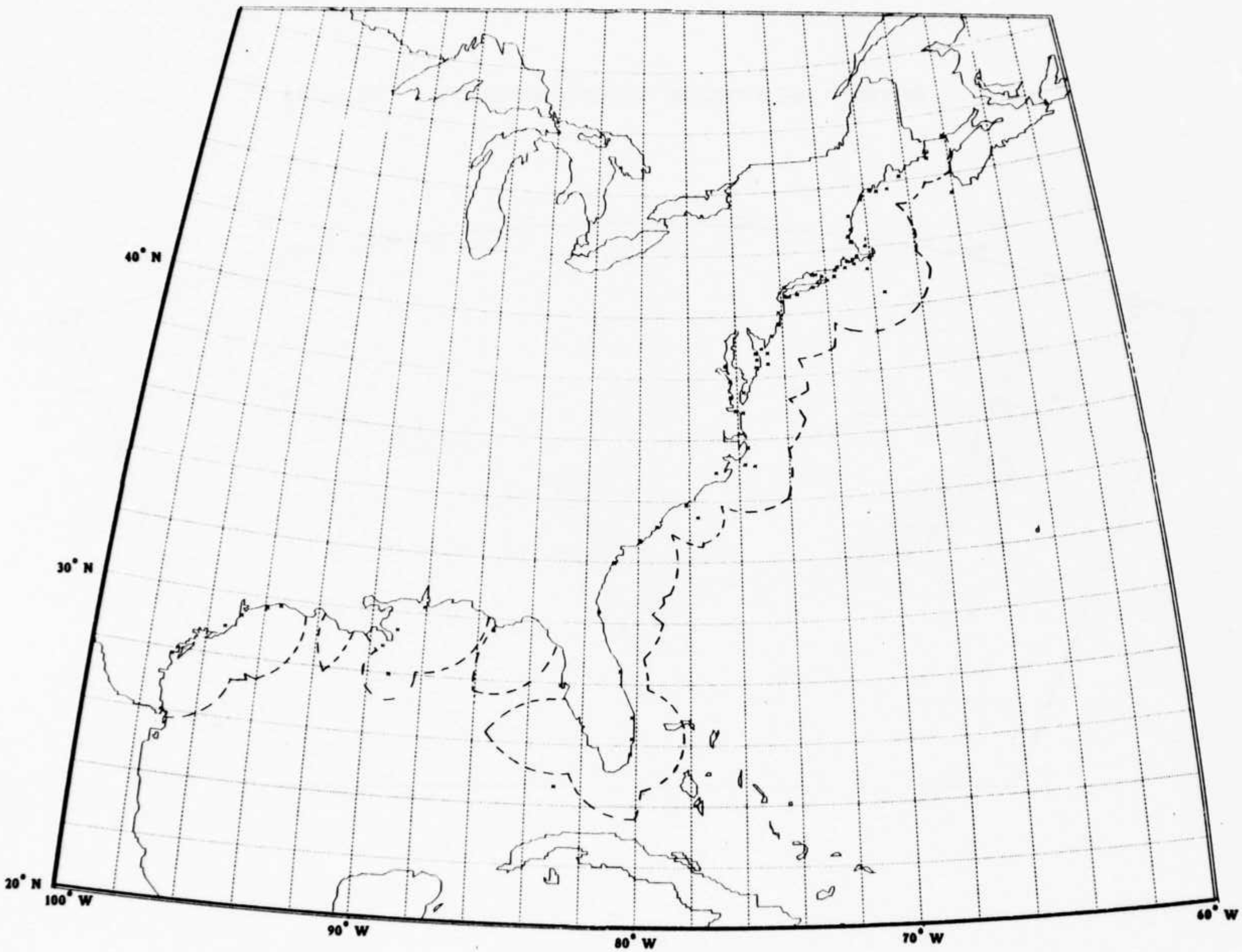

FIGURE 25. RADIOBEACON COVERAGE, ATLANTIC AND GULF COASTS - FIX (1982)

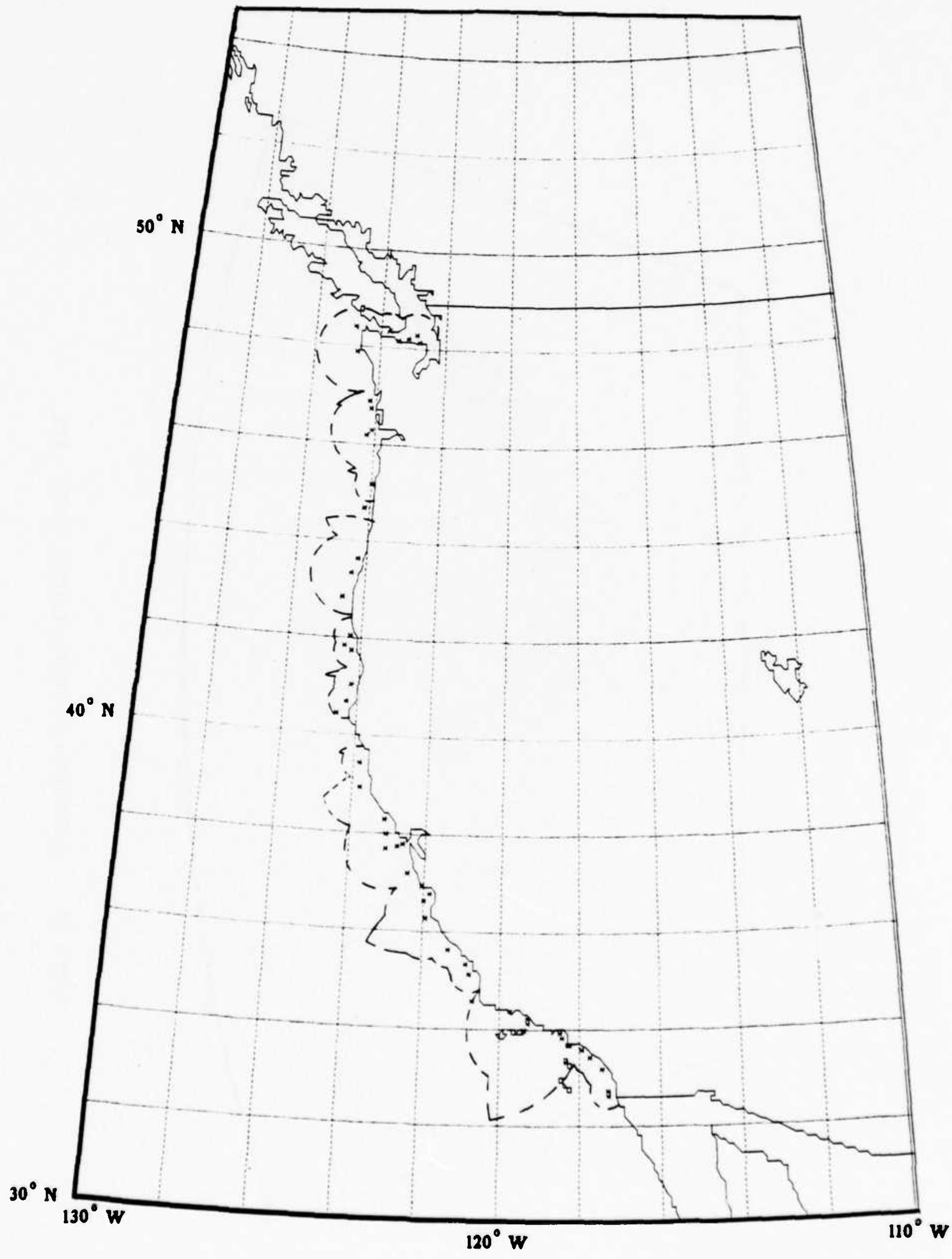

FIGURE 26. RADIOBEACON COVERAGE, PACIFIC COAST - FIX

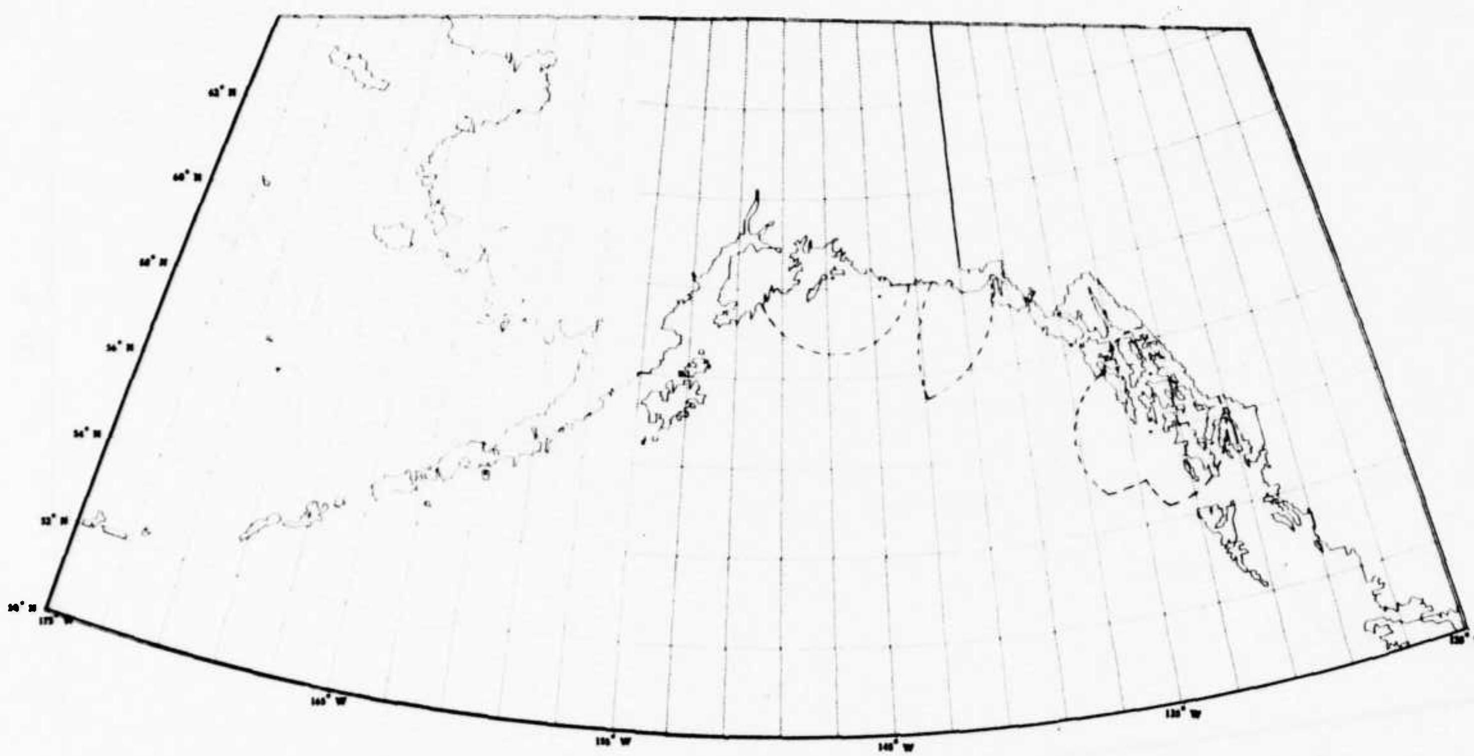

FIGURE 27. RADIOBEACON COVERAGE, ALASKAN COAST - FIX

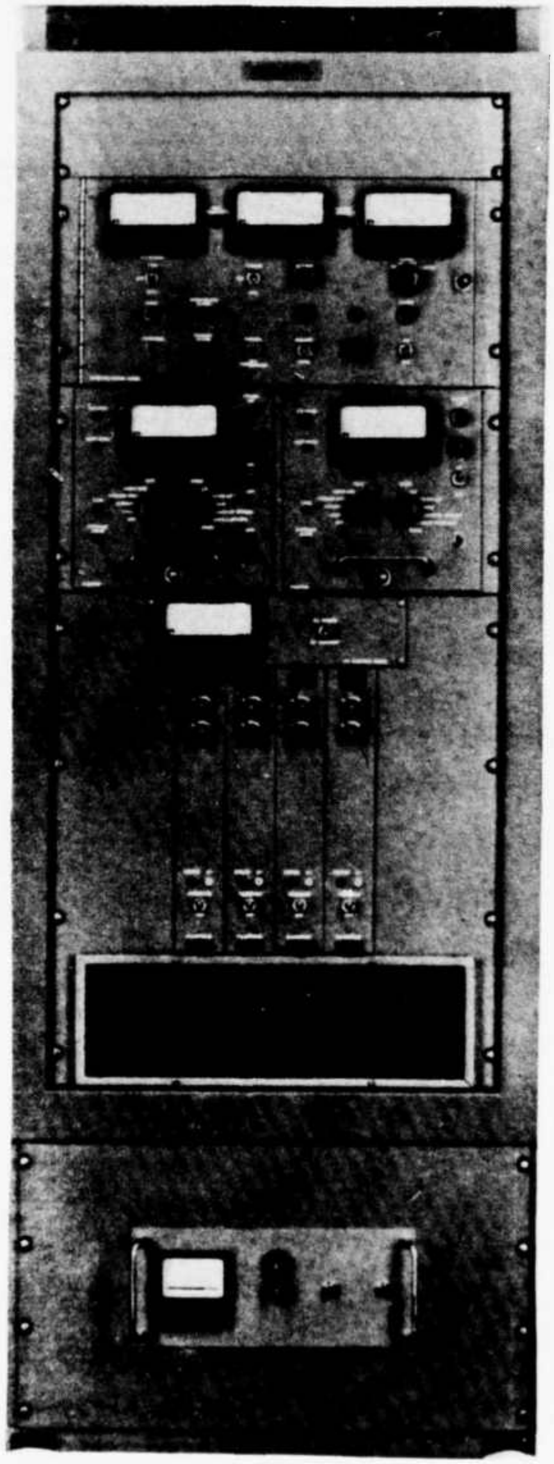

FIGURE 28. TRANSMITTER, RADIOBEACON, CDWQ-NX1000BD (250W)

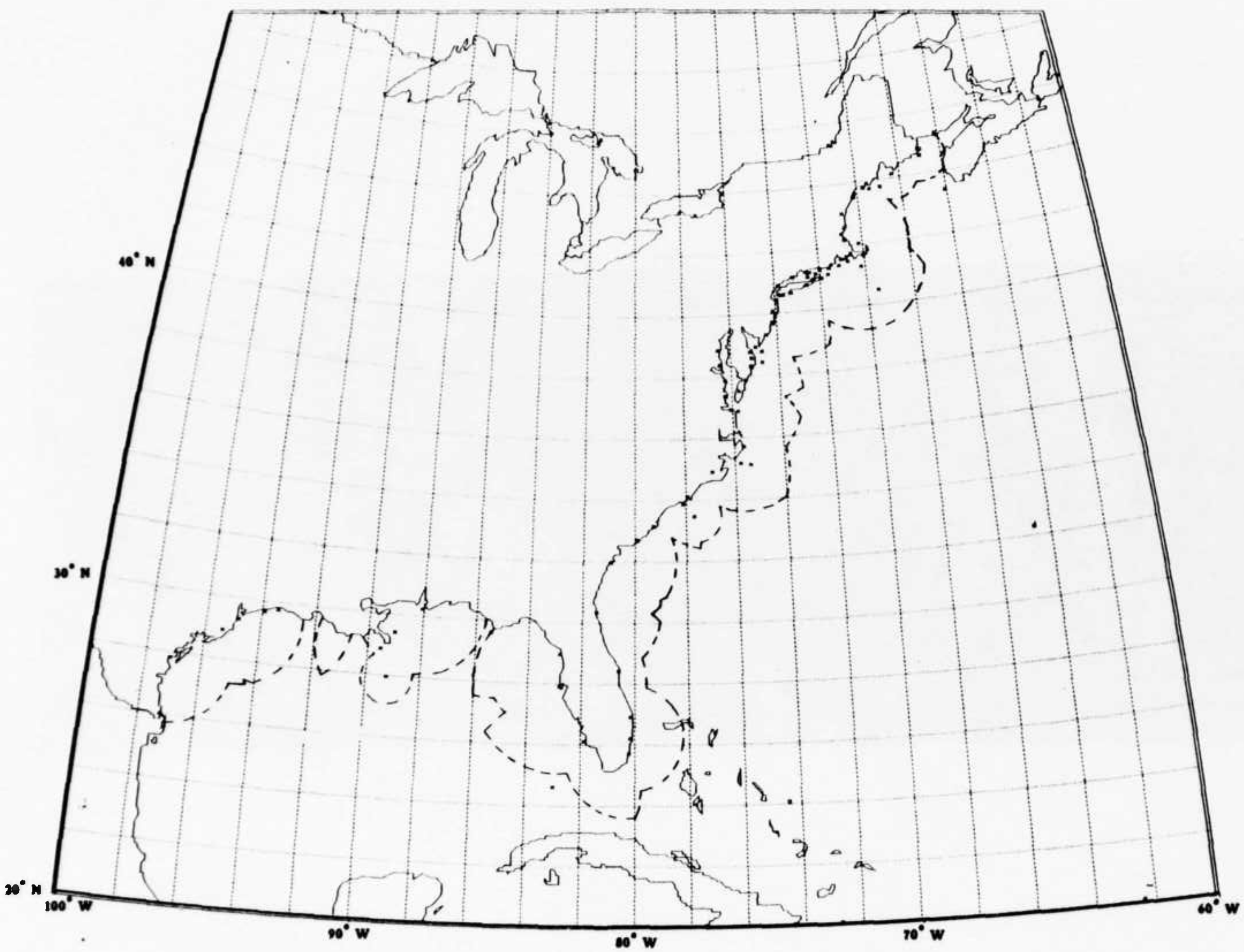

FIGURE 29. RADIOBEACON COVERAGE, ATLANTIC AND GULF COASTS - FIX (1984)

REFERENCES

1. The Lighthouse Service, John S. Conway, Department of Commerce, Lighthouse Service, 1923.

2. Radiobeacons and Radiobeacons Navigation, George R. Putnam, Department of Commerce, Lighthouse Service, July 1931.

3. Chronology of Aids to Navigation and the Old Lighthouse Service, 1716-1939, Department of Transportation, U.S. Coast Guard, CG-458, 1974.

4. Electronic Navigational Aids, Treasury Annual Report, 1931-42.

5. U.S. Coast Guard Abstract, Treasury Annual Report, 1931-42.

6. Light List, Department of Commerce, Lighthouse Service, 1939.

7. Annual Report of the Secretary of the Treasury on the State of Finances for the Fiscal Year Ended June 30, 1939.

8. U.S. Code, Title 14, Section 81, Paragraph 1.

9. Coast Guard Bulletin, Vol. 1, No. 25, July 1941.

10. Study of the Direction Finder Marine Radiobeacon System, RTCM, March 1954.

11. Study of Roles and Missions of the U.S. Coast Guard, Vol. 1, Section D, Aids to Navigation, U.S Treasury Report to the Secretary, June 1962.

12. Coast Guard Manual M 10550.4, Vol. II, Chapter 2.

13. Light List, Department of Transportation, U.S. Coast Guard, 1963.

14. Development of Electronic Aids to Navigation for the Small Craft Navigator, Lt. L.J. DeGraw, USCG, Navigation, Journal of the Institute of Navigation, Vol. 13, No. 2, Summer 1966.

15. Light List, Department of Transportation, U.S. Coast Guard, 1964.

16. A Close Look at the Dual-Carrier Radiobeacon System, P.J. Culicetto, U.S. Coast Guard Engineers Digest (CG-133), January-March 1968.

17. Light List, Department of Transportation, U.S. Coast Guard (CG-158-162), 1982.

APPENDIX A

U.S. MARINE RADIOBEACON SYSTEM 1 JANUARY 1982

RADIOBEACON SYSTEM—ATLANTIC AND GULF COASTS

SPECIAL RADIO DIRECTION FINDER CALIBRATION STATIONS

All stations transmit continuously during the time required for calibration with keyed tone modulated carrier (A—2 emission), except where noted, and have a reliable range of 5 miles. Their assigned characteristic is transmitted twice followed by a 20—second dash, the complete sequence being repeated twice per minute. The antenna is located on the light structure unless otherwise indicated under "Remarks." In the event special calibration service interferes with the operation of regular radiobeacon transmission, the special calibration service will not be given.

Special calibration operation will be made only upon request in advance to the district commander in whose district the calibration station is located, the address and district limits of which are listed on p. III. The day, time and frequency on which special calibration service is desired must be stated. If service is desired on both frequencies listed, the time that transmission on each frequency is desired must be specified. Upon arrival at the station on the date and hour specified, station personnel may be contacted by means of the usual whistle signal or flag hoist.

Station	Position: Latitude, N ° ' "	Position: Longitude, W ° ' "	Frequency (kHz)		Characteristic	Remarks
Eastern Point Station, MA [1]	42 34 48	70 39 54	298	325	EP (• ••••)	Antenna is located on an orange and white checkered building
Coney Island Light Station, NY	40 34 35	74 00 35		480	C3 (•••• •••••)	Calibration available 0800 to 1800 (local time) only on request to Rockaway Station on 156.8 mHz FM
Cape May Point, NJ [2]	38 56 00	74 57 42	305	480	C5 (•••• •••••)	Antenna located on light
Cape Henry Light Station, VA [4]	36 55 37	76 00 26	306	480	F2 (•••• •••••)	Special fixed white light of 100 cp displayed at north center of light tower during calibration, visible from 909° to 270°
Thomas Point Light Station, Md [3]	38 53 56	76 26 11	293	480	F3 (•••• •••••)	For calibration 293 kHz follow procedure on p XVI, XVII, to change to 480 kHz, dip flaghoist

[1] Request for special calibration service may be made via Coast Guard Radio Marshfield (NMF) or via Gloucester Station on 2182 kHz. During calibration direct communication with Eastern Point Light Station can be made on VHF 157.1 mHz

[2] Request for calibration service must be received 24 hours in advance via VHF-FM channel 16 (156.8 mHz) or in writing to Commander, Coast Guard Group Cape May, Cape May, N J 08204

[3] Request for calibration service may also be made in advance directly to Commander, Baltimore Group, U S Coast Guard, Bldg 70 USCG yard Baltimore, Md 21226

[4] Request for calibration service may also be made Via Coast Guard Group Hampton Roads On VHF-FM Channel 16 (156.8 mHz)

RADIOBEACON SYSTEM—ATLANTIC AND GULF COAST—By Frequencies

SEQUENCED

Freq. kHz		Station		Characteristic	Range (nautical miles)	Lat. (N) ° ' "	Long. (W) ° ' "
286	I	HIGHLAND	HI	(• • • • • • •)	100	42 02 24	70 03 40
	II	NANTUCKET LS.	NS	(• • • • • •)	100	40 30 00	69 28 00
	III	MONTAUK POINT	MP	(• • • • • • •)	125	41 04 02	71 51 47
	IV	AMBROSE	T	(•)	125	40 27 32	73 49 52
	V	GREAT DUCK ISLAND	GD	(• • • • • • •)	50	44 08 32	68 14 47
	VI	EXECUTION ROCKS	K	(• • •)	20	40 52 41	73 44 18
	VI	MANANA ISLAND	MI	(• • • •)	100	43 45 48	69 19 38
298	III	CAPE HENLOPEN	HL	(• • • • • • • • •)	125	38 47 39	75 05 26
	IV	CAPE HENRY	CB	(• • • • • • • • •)	150	36 55 35	76 00 27
	V	OREGON INLET	PI	(• • • • • • •)	125	35 46 06	75 31 24
	VI	CAPE LOOKOUT	CL	(• • • • • • • • •)	150	34 36 00	76 32 16
	II	OAK ISLAND	OA	(• • • • • •)	70	33 53 33	78 02 06
	III	CHARLESTON	S	(• • •)	125	32 45 28	79 50 36
306	II	LITTLE GULL	J	(• • • •)	20	41 12 22	72 06 29
	I, IV	CLINTON HARBOR	CL	(• • • • • • • • •)	20	41 16 00	72 31 10
308	II	PARTRIDGE ISLAND (C)	U	(• • •)	50	45 14 13	66 03 17
	III	SOUTHWEST HEAD (C)	N	(• •)	50	44 36 03	66 54 20
	IV	WEST QUODDY	WQ	(• • • • • • • •)	20	44 48 54	66 57 04
	VI	SEAL ISLAND (C)	H	(• • • •)	40	43 23 28	66 00 53

RADIOBEACON SYSTEM—ATLANTIC AND GULF COASTS—By Frequencies (Cont'd)

CONTINUOUS

Freq. kHz	Station		Characteristic	Range (nautical miles)	Lat. (N) ° ′ ″	Long. (W) ° ′ ″
286	DRY TORTUGAS	OE	(••• •)	170	24 37 56	82 55 18
288	PUNTA TUNA	X	(••••)	55	17 59 25	65 53 08
290	CHESAPEAKE LIGHT	CO	(•••• •••)	50	36 54 15	75 42 47
290	FRYING PAN SHOALS	FP	(•••• ••••)	50	33 29 07	77 35 24
290	FREEPORT	R	(•••)	20	28 56 27	95 18 04
291	NOBSKA POINT	NP	(•• ••••)	20	41 30 58	70 39 20
291	HALFWAY ROCK	HR	(•••• •••)	10	43 39 21	70 02 15
291	FIRE ISLAND	RT	(••• •)	15	40 37 48	73 13 09
293	OCEAN CITY INLET	OC	(••• ••••)	10	38 19 30	75 05 18
294	MISSIPPI RIVER GULF OUTLET APPROACH LIGHTED HORN BUOY NO	G	(•••)	20	29 26 24	88 56 54
294	JUPITER INLET	J	(••••)	125	26 56 54	80 04 54
295	SCITUATE HARBOR	SH	(••• ••••)	10	42 11 56	70 43 12
295	BRENTON REEF	BR	(•••• •••)	10	41 25 35	71 23 22
296	GALVESTON	G	(•••)	125	29 19 40	94 44 20
299	HILLSBORO INLET	Q	(••••)	25	26 15 33	80 04 52
300	MOBILE POINT	C	(••••)	125	30 13 38	88 01 24
301	PORTLAND LIGHTED HORN BUOY P	PH	(•••• ••••)	30	43 31 37	70 05 31
301	BLOCK ISLAND	BI	(•••• ••)	20	41 09 09	71 33 07
302	EAST ROCKAWAY INLET	ER	(• •••)	10	40 35 11	73 45 11
304	BOSTON LIGHTED HORN BUOY B	BH	(•••• ••••)	30	42 22 42	70 47 00
304	ARANSAS PASS	Z	(••••)	125	27 50 18	97 03 32
306	ST. JOHNS	R	(•••)	125	30 23 09	81 23 51
307	SOUTHWEST PASS ENT.	OT	(••• •)	125	28 54 19	89 25 43
308	CLEVELAND LEDGE	CL	(•••• ••••)	10	41 37 51	70 41 42
308	MANASQUAN INLET	MI	(•• ••)	20	40 06 03	74 02 03
308	INDIAN RIVER INLET	IR	(•• •••)	10	38 36 35	75 04 06
309	HATTERAS INLET STATION	HI	(•••• ••)	30	35 12 27	75 42 21
310	SMITH POINT	SP	(••• ••••)	20	37 52 47	76 11 03
310	GEORGETOWN	P	(••••)	30	33 13 21	79 11 06
310	EGMONT KEY	H	(••••)	170	27 36 02	82 45 39
310	SABINE PASS	P	(••••)	30	29 42 19	93 51 13

RADIOBEACON SYSTEM—ATLANTIC AND GULF COASTS—By Frequencies (Cont'd)

CONTINUOUS

Freq. kHz	Station		Characteristic	Range (nautical miles)	Lat. (N) ° ′ ″	Long. (W) ° ′ ″
311	CHATHAM	CH	(•••• ••••)	20	41 40 17	69 57 02
311	SHINNECOCK INLET	SN	(••• ••)	20	40 50 32	72 28 44
312	FIVE FATHOM BANK LIGHTED HORN BUOY F	F	(••••)	10	38 47 18	74 34 36
313	CAPE CANAVERAL	Z	(••••)	125	28 27 36	80 32 36
314	MATINICUS ROCK	MR	(•• •••)	20	43 47 00	68 51 19
314	BUZZARDS BAY	BB	(•••• ••••)	20	41 23 47	71 02 02
314	COVE POINT	CP	(•••• ••••)	20	38 23 10	76 22 55
314	SOUTH PASS WEST JETTY	M	(••)	50	28 59 25	89 08 29
314	BRAZOS SANTIAGO PASS	PIL	(•••• •• ••••)	175	26 04 23	97 09 31
316	ATLANTIC CITY	AC	(•• ••••)	15	39 21 57	74 24 37
317	WOLF TRAP	WO	(••• •••)	20	37 23 24	76 11 24
317	TYBEE	TB	(• ••••)	125	32 01 18	80 50 45
318	CAP COD CANAL BREAKWATER	CC	(•••• ••••)	20	41 46 19	70 30 04
318	SAN JUAN	L	(••••)	18 28 14	66 07 03	
319	JONES INLET	JI	(•••• ••)	10	40 34 50	73 34 24
319	DELAWARE LIGHTED HORN BUOY D	D	(•••)	10	38 27 18	74 35 06
320	THE CUCKOLDS	CU	(•••• •••)	10	43 46 46	69 39 02
320	SAYBROOK BREAKWATER	SB	(••• ••••)	10	41 15 47	72 20 36
320	CAPE SAN BLAS	W	(•••)	125	29 40 10	85 21 26
321	DIAMOND SHOALS	DS	(••• •••)	50	35 09 13	75 17 50
322	PORTSMOUTH HARBOR (NEW CASTLE) LIGHT	NCE	(•• ••••)	10	43 04 16	70 42 38
322	NEW BEDFORD	NB	(•• ••••)	10	41 37 28	70 54 22
322	BARNEGAT INLET	BI	(•••• ••)	20	39 45 28	74 06 21
322	MIAMI	U	(•••)	100	25 45 42	80 08 02
323	CALCASIEU	UT	(••• •)	150	29 46 42	93 20 34
324	WACHAPREAGUE INLET	WI	(••• ••)	10	37 34 24	75 37 30
325	EASTERN POINT	EP	(• ••••)	10	42 34 50	70 39 54
325	POINT JUDITH	PJ	(•••• ••••)	10	41 21 39	71 28 33
325	BRANT POINT	H	(•••• ••••)	10	41 17 23	70 05 27
325	CAPE MAY	CM	(•••• ••)	10	38 56 38	74 52 20

RADIOBEACON SYSTEM—PACIFIC COAST AND PACIFIC ISLANDS

SPECIAL RADIO DIRECTION FINDER CALIBRATION STATIONS

All stations transmitted continuously during the time required for calibration with keyed tone modulated carrier (A—2 emission), except where noted, and have a reliable range of 5 miles. Their assigned charcteristic is transmitted twice followed by a 20—second dash, the complete sequence being repeated twice per minute. The antenna is located on the light structure unless otherwise indicated under "Remarks." In the event special calibration service interferes with the operation of regular radiobeacon transmission, the special calibration service will not be given.

Speical calibration operation will be made only upon request in advance to the district commander in whose district the calibration station is located,the address and district limits of which are listed on p. III. The day, time and frequency on which special calibration service is desired must be stated. If service is desired on both frequencies listed, the time that transmission on each frequency is desired must be specified. Upon arrival at the station on the date and hour specified, station personnel may be contacted by means of the usual whistle signal or flag hoist.

Station	Position: Latitude, N. ° ′ ″	Position: Longitude, W. ° ′ ″	Frequency (kHz)		Characteristic	Remarks
Los Angeles Light Station, Calif[1]	33 42 30	118 15 02	311	400	M2 (•• •••••)	
Point Blunt Light, Calif.	37 51 10	122 25 04		310	N2 (•• •••••)	
Alki Point Light Station, Wash.[3]	47 34 35	122 25 10	300	400	O2 (••• •••••)	
Guard Island Light Station, Alaska	55 26 47	131 52 45	294	400	Q2 (•••• •••••)	
Barbers Point Light, Hawaii[5]	21 18 00	158 06 30	310	400	BP (•••• ••••)	
Point Loma Light, Calif.	32 39 54	117 14 30	311	400	Y2 (•••• •••••)	
Albert Head Light, B.C. (Can.)[2]	48 23 13	123 28 56		300	T (•)	
Point Atkinson Light, B.C. (Can.)[2]	49 19 50	123 15 48		320	T (•)	
Fort Stevens Wharf Light[4]	46 12 24	123 57 00	293	400	K5 (••• •••••)	

[1] Request for special calibration service may also be made to C. G. Base Terminal Island or Commander, Eleventh Coast Guard District (oan).
[2] On request through Victoria Marine Radio, VAK.
[3] On request through Commander Thirteenth Coast Guard District, Seattle, Wash.
[4] On request through Coast Guard Station Astoria, or submit letter to Commander Thirteenth Coast Guard District (oan) Seattle, Wash. 98174
[5] On request through Coast Guard Communications Station Honolulu, Air Station Barbers Point or submit letter to Commander, Fourteenth Coast Guard District (oan) Honolulu, Hawaii.

RADIOBEACON SYSTEM—PACIFIC COAST AND PACIFIC ISLANDS—By Frequencies

SEQUENCED

Freq. kHz		Station	Characteristic		Range (nautical miles)	Lat. (N) ° ' "	Long. (W) ° ' "
288	I	CAPE FLATTERY	P	(••••)	100	48 23 50	124 44 08
	II	JAMES ISLAND	JI	(•••• ••)	50	47 54 16	124 38 46
	III	CARMANAH, (Can.)	D	(•••)	35	48 36 43	124 45 01
	IV	AMPHITRITE POINT, (Can.)	A	(••)	50	48 55 31	125 32 24
296	I-IV	SANDS HEAD, (Can.)	G	(•••)	20	49 06 22	123 18 06
	II-V	POINT ATKINSON, (Can.)	V	(••••)	30	49 19 51	123 15 49
	III	SISTERS ISLAND, (Can.)	M	(••)	30	49 29 13	124 26 00
302	I-IV	POINT LOMA	L	(••••)	150	32 39 59	117 14 34
	II-V	LOS ANGELES	A	(••)	70	33 42 31	118 15 03
	III-VI	POINT ARGUELLO	O	(•••)	150	34 34 42	120 38 34
304	I	CAPE ARAGO	Y	(••••)	50	43 20 29	124 22 27
	III	WILLAPA BAY	UT	(••• •)	20	46 44 03	124 04 38
	IV	CAPE DISAPPOINTMENT	O	(•••)	50	46 16 35	124 03 02
	V	CAPE BLANCO	OE	(••• •)	100	42 50 18	124 33 48
	VI	YAQUINA HEAD	W	(•••)	50	44 40 36	124 04 42
308	I	LANGARA ISLAND, (Can.)	H	(••••)	60	54 15 23	133 03 30
	II	TRIPLE ISLAND, (Can.)	O	(•••)	50	54 17 35	130 52 50
	III	BONILLA ISLAND, (Can.)	L	(••••)	60	53 29 34	130 38 08
314	II	POINT WILSON	Q	(••••)	30	48 08 40	122 45 12
	III	SMITH ISLAND	G	(•••)	20	48 19 06	122 50 33
	IV	RACE ROCKS, (Can.)	J	(••••)	40	48 17 53	123 31 48
	V	NEW DUNGENESS	U	(•••)	30	48 10 54	123 06 30
318	I	LENNARD ISLAND, (Can.)	K	(•••)	30	49 06 38	125 55 20
	II	QUATSINO, (Can.)	B	(••••)	50	50 26 29	128 01 51
	IV	PINE ISLAND, (Can.)	P	(••••)	40	50 58 33	127 43 35

MARKER

Freq. kHz	Station	Lat. (N) ° ' "	Long. (W) ° ' "
304	WHIFFIN SPIT	48 21 31	123 42 56
310	CAPE BEALE, (Can.)	48 47 12	125 12 51

RADIOBEACON SYSTEM—PACIFIC COAST AND PACIFIC ISLANDS—By Frequencies

CONTINUOUS

Freq. kHz	Station	Characteristic	Range (nautical miles)	Lat. (N) ° ' "	Long (W) ° ' "
207	EGG ISLAND	UEM (••• • ••)	25	51 14 58	127 49 57
218	PRINCE RUPERT	PR (•••• •••)	100	54 15 49	130 25 20
233	VICTORIA, (Can.)	YJ (•••• ••••)	75	48 37 45	123 19 00
248	DEAD TREE, (Can.)	Z (••••)	25	53 21 01	131 56 23
285	NEWPORT BAY	NE (•• •)	15	33 35 18	117 52 43
286	CAPE SPENCER	T (•)	200	58 11 58	136 38 17
286	BLUNTS REEF LIGHTED HORN BUOY B	BR (•••• •••)	15	40 26 25	124 30 15
286	PIGEON POINT	PI (•••• ••)	40	37 10 51	122 23 36
288	SAN LUIS OBISPO	SL (••• ••••)	20	35 09 45	120 45 35
289	MARINA DEL REY	MR (•• •••)	10	33 57 46	118 27 40
290	POINT PINOS	P (••••)	10	36 38 02	121 55 58
292	CAPE ST. JAMES, (Can.)	CJ (•••• ••••)	100	51 56 10	131 00 54
292	CAPE HINCHINBROOK	W (•••)	100	60 14 18	146 38 48
292	DANA POINT	DP (••• ••••)	15	33 27 15	117 41 26
292	POINT REYES	R (•••)	10	37 59 45	123 01 20
292	TRINIDAD HEAD	TR (• •••)	15	41 03 15	124 08 58
294	SANTA BARBARA	SB (••• ••••)	10	34 24 24	119 41 36
294	SANTA CRUZ HARBOR	SC (••• ••••)	10	36 57 38	122 00 03
295	FIVE FINGER	D (•••)	60	57 16 18	133 37 42
296	CHETCO RIVER	B (••••)	20	42 02 49	124 16 01
296	LONG BEACH	LB (•••• ••••)	10	33 43 23	118 11 10
296	POINT BONITA	B (••••)	10	37 48 55	122 31 42
296	PIEDRAS BLANCAS	PB (•••• ••••)	15	35 39 54	121 17 06
298	CAPE ST. ELIAS	O (•••)	150	59 47 48	144 36 18
298	MOSS LANDING HARBOR	ML (•• ••••)	10	36 48 24	121 47 15
300	HUMBOLDT BAY	H (••••)	50	40 41 04	124 13 15
302	ETHELDA BAY, (Can.)	TC (• ••••)	125	53 03 05	129 41 12
305	SAN FRANCISCO APPROACH LIGHTED HORN BUOY SF	SF (••• ••••)	17	37 45 00	122 41 30
307	AVALON	AV (•• ••••)	10	33 20 56	118 19 29
307	FORT BRAGG	N (••)	20	39 25 51	123 48 29
308	CHANNEL ISLAND	CI (•••• ••)	10	34 09 21	119 13 33
310	MORRO BAY	M (••)	15	35 21 46	120 52 08
310	ST GEORGE REEF	SG (••• •••)	20	41 50 13	124 23 46

RADIOBEACON SYSTEM—PACIFIC COAST AND PACIFIC ISLANDS—By Frequencies (Con'd)

CONTINUOUS

Freq. kHz	Station		Characteristic	Range (nautical miles)	Lat. (N) ° ' "	Long. (W) ° ' "
314	FARALLON ISLAND	F	(..-.)	50	37 41 48	123 00 02
314	ST. PAUL	SPY	(... .--. -.--)	150	57 09 30	170 13 36
314	VENTURA MARINE	VM	(...- --)	15	34 14 46	119 16 09
316	COLUMBIA RIVER APPROACH LIGHTED HORN BUOY CR.	CR	(-.-. .-.)	20	46 11 06	124 10 58
317	MISSION BAY	MB	(-- -...)	15	32 45 30	117 15 33
318	CAPE DECISION	UT	(..- -)	100	56 00 07	134 08 04
319	REDONDO BEACH	RB	(.-. -...)	15	33 50 27	118 23 40
320	POINT ARENA	A	(.-)	50	38 57 20	123 44 28
320	CAPE KIWANDA	K	(-.-)	15	45 12 58	123 58 12
322	POINT SUR	S	(...)	50	36 18 22	121 54 02
322	EDIZ HOOK	K	(-.-)	20	48 08 25	123 24 04
323	ANACAPA ISLAND	AN	(.- -.)	10	34 00 57	119 21 32
323	OCEANSIDE	OC	(--- -.-.)	10	33 12 34	117 23 37
324	GUARD ISLAND	J	(.---)	100	55 26 47	131 52 45
324	UMPQUA RIVER	U	(..-)	20	43 39 49	124 11 50
325	CRESENT CITY	C	(-.-.)	20	41 44 11	124 11 23
325	BODEGA HEAD	BO	(-... ---)	20	38 18 39	123 03 52
325	GRAYS HARBOR	G	(--.)	50	46 54 17	124 07 50
335	ALERT BAY, (Can.)	AL	(.- .-..)	2[illegible]	50 35 12	126 55 28
354	CAPE SCOTT, (Can.)	ZES	(--.. . ...)	75	50 46 57	128 25 31
359	TOFINO, (Can.)	YAZ	(-.-- .- --..)	50	49 02 54	125 42 16
368	SANDSPIT, (Can.)	ZP	(--.. .--.)	50	53 11 48	131 56 33
374	ESTEVAN POINT, (Can.)	EP	(. .--.)	100	49 22 59	126 32 30
378	ACTIVE PASS, (Can.)	AP	(.- .--.)	25	48 52 26	123 17 23
380	MCINNES ISLAND, (Can.)	MS	(-- ...)	100	52 15 42	128 43 18
385	LAWN POINT, (Can.)	LZ	(.-.. --..)	45	53 25 24	131 54 49

GREAT LAKES RADIOBEACON SYSTEM — By frequencies

SEQUENCED

Freq kHz	Group Sequence	Station		Characteristic	Range (miles)	Lat (N) ° ' "	Long (W) ° ' "
292	I	WHITEFISH POINT, MI.		(● ● ●●)	100	46 46 18	84 57 28
	II	CARIBOU ISLAND, ONT.	A	(● ●)	40	47 20 25	85 49 32
	III	MARQUETTE, MI.	W	(● ● ●)	60	46 32 47	87 22 30
	IV	SLATE ISLAND, ONT.	B	(● ● ● ●)	30	48 37 11	86 59 46
	V	MICHIPICOTEN ISLAND, ONT.	Q	(● ● ● ●)	30	47 45 13	85 55 43
	VI	MICHIPICOTEN HARBOR, ONT.	R	(● ● ●)	30	47 56 33	84 54 27
294	I	CLEVELAND, OH.	C	(● ● ● ●)	50	41 30 32	81 43 04
	II	LONG POINT, ONT.	L	(● ● ● ●)	40	42 33 00	80 03 20
	III	PORT COLBORNE, ONT.	Z	(● ● ● ●)	35	42 52 07	79 15 10
	IV	ERIE HARBOR, PA	Y	(● ● ● ●)	20	42 09 21	80 04 17
	V	LONG POINT, ONT.	L	(● ● ● ●)	40	42 33 00	80 03 20
	VI	PORT COLBORNE, ONT.	Z	(● ● ● ●)	35	42 52 07	79 15 10
296	II	DEVILS ISLAND, WI.	O	(● ● ●)	70	47 04 46	90 43 44
	III	TWO HARBORS, MN	P	(● ● ● ●)	40	47 00 31	91 39 48
	V	DULUTH HARBOR, MN		(● ● ● ●)	70	46 46 49	92 05 16
	VI	KEWEENAW LOWER ENT		(● ● ● ●)	40	46 58 12	88 25 54
298	II	POINT BETSIE, MI	P	(● ● ●●)	50	44 41 30	86 15 18
	III	MILWAUKEE, WI	M	(● ●)	50	43 01 37	87 52 35
	IV	MUSKEGON, MI	C	(● ● ● ●)	50	43 13 56	86 20 23
	VI	INDIANA HARBOR, IN	Y	(● ● ● ●)	70	41 40 31	87 26 28
	I	OWEN SOUND, ONT.	X	(● ● ● ●)	50	44 34 43	80 56 19
	II	COLLINGWOOD, ONT.	C	(● ● ● ●)	50	44 30 29	80 12 33
	III	HOPE ISLAND, ONT	F	(● ● ●●)	50	44 54 50	80 10 00
	IV	SNUG HARBOR, ONT	R	(● ● ●)	50	45 22 26	80 18 38
	V	GEREAUX ISLAND, ONT.	J	(● ● ● ●)	30	45 44 39	80 39 35
	VI	KILLARNEY, ONT.	K	(● ● ●)	50	45 58 05	81 29 22
302	I	DETOUR REEF, MI.		(● ● ● ●)	40	45 56 58	83 54 12
	II	P^E REEF, MI	W	(● ● ●)	40	45 41 41	84 21 43
	IV	D TOUR REEF, MI		(● ● ● ●)	40	45 56 58	83 54 12
	V	L/ NSING SHOAL, MI.	Z	(● ● ● ●)	50	45 54 12	85 33 42
	VI	G: AYS REEF, MI	X	(● ● ● ●)	40	45 45 57	85 09 13
	I	PORT WELLER, ONT.	V	(● ● ● ●)	30	43 14 39	79 13 06
	II	BURLINGTON BAY, ONT.	R	(● ● ●)	25	43 18 04	79 47 26
	IV	PORT WELLER, ONT	V	(● ● ● ●)	30	43 14 39	79 13 06
	V	BURLINGTON BAY, ONT	R	(● ● ●)	25	43 18 04	79 47 26
306	II	MAIN DUCK ISLAND, ONT.	Y	(● ● ● ●)	30	43 55 53	76 38 20
	III	POINT PETRE, ONT	P	(●● ● ●)	30	43 50 20	77 09 19
	IV	OSWEGO, N.Y.	W	(● ● ●)	60	43 28 24	76 31 01
	V	ROCHESTER, NY	M	(● ●)	60	43 15 25	77 36 11
	II	SANDUSKY,OH	X	(● ● ● ●)	40	41 29 17	82 41 39
	III	SOUTHEAST SHOAL, ONT	H	(● ● ● ●)	40	41 49 40	82 27 40
	VI	ASHTABULA, OH	G	(● ● ●)	40	41 55 06	80 47 46

GREAT LAKES RADIOBEACON SYSTEM — By frequencies (Cont'd)

SEQUENCED

Freq kHz	Group Sequence	Station		Characteristic	Range (miles)	Lat (N) ° ' "	Long (W) ° ' "
308	I	STURGEN BAY CANAL, WI		(• • • •)	20	44 47 42	87 18 48
	III	KEWAUNEE, WI	G	(• • •)	20	44 27 27	87 29 55
	IV	MINNEAPOLIS SHOAL, MI	Y	(• • • •)	20	45 34 54	86 59 56
	V	LUDINGTON, MI		(• • • •)	50	45 57 11	86 27 36
	VI	RAWLEY POINT, WI	L	(• • • •)	50	44 12 40	87 30 30
	II	ST. MARTINS, MI	SM	(• • • • •)	60	45 30 16	86 45 28 ......
312	I	KEWEENAW, MI	C	(• • • •)	50	47 13 40	88 57 27
	II	ANGUS ISLAND, ONT	F	(• • • •)	30	48 14 09	89 00 25
	III	ROCK OF AGES, MI	Z	(• • • •)	40	47 52 00	89 18 50
	IV	MANITOU, MI	M	(• •)	100	47 25 12	87 35 18
	V	PASSAGE ISLAND, MI	X	(• • • •)	80	48 15 24	88 21 54
	VI	EAGLE HARBOR, MI	J	(• • • •)	100	47 27 40	88 09 32
	I	COVE ISLAND, ONT	D	(• • •)	40	45 19 40	81 44 09
	II	HARBOR BEACH, MI	U	(• • •)	70	43 50 46	82 37 55
	III	THUNDER BAY ISLAND, MI	K	(• • •)	70	45 02 15	83 11 40
	IV	COVE ISLAND, ONT	D	(• • •)	40	45 19 40	81 44 09
	V	GREAT DUCK ISLAND, ONT	B	(• • • •)	40	45 38 30	82 57 48
	VI	FORT GRATIOT, MI	P	(• • • •)	70	45 00 17	82 25 22

CONTINUOUS

285		CHICAGO, IL	RT	(• • • •)	20	41 53 21	87 55 26
286		BUFFALO HARBOR, NY	BL	(• • • • • • • •)	10	42 52 14	78 54 09
286		GODERICH, ONT	GD	(• • • • • •)	30	43 44 48	81 43 55
286		GROS CAP REEF, ONT	A	(• •)	20	46 30 45	84 36 54
286		SHERWOOD POINT, WI	SP	(• • • • • • •)	10	44 55 34	87 26 00
288		FRANKFORT, MI	FR	(• • • • • • •)	10	44 37 50	86 14 42
288		LA POINTE, WI	V	(• • • •)	20	46 45 44	90 47 05
289		MANITOWOC BREAKWATER WI	MO	(• • • • •)	10	44 05 34	87 38 57
290		DETROIT RIVER, MI	M	(• •)	20	42 00 05	85 08 28
290		GIBRALTER POINT, ONT.	TZ	(• • • • •)	25	45 36 50	79 25 10
293		TIBBETS POINT, NY	Q	(• • • •)	20	44 06 03	76 22 14
304		SILVER BAY,MN	SB	(• • • • • • •)	10	47 16 55	91 15 51
304		WAUKEGAN, IL	W	(• • •)	10	42 21 38	87 48 48
314		SODUS OUTER LIGHT, NY	SZ	(• • • • • • •)	10	45 16 39	76 58 27
316		GRAND HAVEN, MI	GO	(• • • • • •)	10	43 05 27	86 15 22
316		PORT INLAND, MI	PI	(• • • • • •)	10	45 58 09	85 52 38
316		SUPERIOR ENTRY SOUTH BREAKWATER, WI	SN	(• • • • •)	10	46 42 57	92 00 22
317		GREEN BAY, WI	K	(• • •)	20	44 59 12	87 54 04
318		FAIRPORT HARBOR, OH	FP	(• • • • • • • •)	10	41 46 04	81 16 52
320		ALPENA, MI	AL	(• • • • • •)	20	45 05 36	85 25 22
320		CALUMET HARBOR, IL	KX	(• • • • • • •)	10	41 45 34	87 29 36
320		NORTH MANITOU ISLAND MI	NU	(• • • • •)	10	45 01 16	85 57 27
320		TACONIT HARBOR, MN	TH	(• • • • •)	10	47 51 18	90 55 24
320		TOLEDO HARBOR, OH	TJ	(• • • • •)	15	41 45 45	85 19 44
322		PRESQUE ISLE HARBOR, MI	PX	(• • • • • • • •)	10	46 34 28	87 22 28
322		ROUND ISLAND PASSAGE, MI	RD	(• • • • • •)	10	45 50 34	84 36 55
322		SOUTH BUFFALO, NY	B	(• • • •)	60	42 50 01	78 52 04
324		PLUM ISLAND, WI	UM	(• • • • •)	10	45 18 42	86 57 28
324		SHEBOYGAN, WI	SY	(• • • • • • •)	10	43 44 58	87 42 15
325		THUNDER BAY, ONT	P	(• • • •)	25	48 25 57	89 11 46

GREAT LAKES RADIOBEACON SYSTEM - By frequencies (Cont'd)

MARKER

Freq. kHz	Station	Lat. (N) ° ' "	Long. (W) ° ' "
286	BATTLE ISLAND, ONT.	48 45 06	87 33 24
288	COGOURG, ONT.	43 57 12	78 09 53
290	GRAVELLY SHOAL, MI.	44 01 12	83 32 18
299	PORT STANLEY, ONT.	42 39 18	81 12 49
306	McNAB POINT, ONT.	44 28 23	81 23 36
314	OSHAWA, ONT.	43 15 52	78 49 19
316	PORT DOVER, ONT.	42 46 51	80 12 06

APPENDIX B

NEAR FUTURE ADDITIONAL RADIOBEACON STATIONS

Freq kHz	Station	Range Mi	Lat (N) ° '	Long (W) ° '
	ATLANTIC AND GULF COASTS			
290	Yankeetown, FL	150	29 00	82 45
303	Chincoteague Inlet, VA	20	37 54	75 22
306	Watch Hill Light, RI (V)	10	41 18	71 55
306	Horton Point, NY (III, VI)	20	41 05	72 26
313	Wrightsville Beach, NC	20	34 09	77 50
316	Stratford Point Lt, CT (III, VI)	20	41 09	73 06
316	Naples, FL	20	26 09	81 48
322	Thomas Point, MD	20	38 53	76 26
	GREAT LAKES			
285	Pentwater, MI	10	43 46	86 28
285	Port Washington, WI	10	43 22	87 50
287	Holland Harbor, MI	10	42 45	86 15
289	Michigan City, IN	10	41 43	86 53
298	Racine, WI (V)	80	42 43	87 45
300	Port Clinton, OH	10	41 30	82 54
302	Oak Orchard, NY (III, VI)	30	43 23	78 30
302	Charlevoix, MI (IV)	30	45 20	85 19
302	Tawas, MI (III)	70	44 16	83 29
314	Manastee, MI	10	44 15	86 24
320	Port Senelac, MI	20	43 25	82 30
322	Algoma, WI	10	44 35	87 28
323	Huron Harbor, OH	20	41 24	82 33
325	St. Joseph, MI	70	43 19	86 53

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