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DESIGN CONSIDERATIONS FOR A LORAN-C TIMING RECEIVER IN A HOSTILE SIGNAL TO NOISE ENVIRONMENT

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ABSTRACT

The environment in which a Loran-C Timing Receiver may function effectively depends to a large extent on the techniques utilized to insure that interfering signals within the pass band of the unit are neutralized. This paper discusses the baseline performance of the present generation manually operated timing receivers and establishes the basic design considerations and necessary parameters for an automatic unit utilizing today's technology. Actual performance data is presented comparing the results obtained from a present generation timing receiver against a new generation, microprocessor controlled, automatic acquisition receiver. The achievements possible in a wide range of signal to noise situations are demonstrated.

INTRODUCTION

The effectiveness of a Loran-C Timing Receiver to operator in a hostile signal to noise environment, at present, uses many devices to apply as tools to aid the operator. These are tunable notch filter rejection, long time averaging coherent detection, envelope recognition schemes, time of coincidence procedures, time of arrival establishment, and special antenna orientation.

The success of making the time measurement, to the accuracy that is present in the Loran-C transmission, depends a great deal on the skill of the operator to employ the tools available as well as his understanding of the particular signal to noise environment in which the measurement must be made.

BASELINE PERFORMANCE

As an initial step to evaluate the performance of a new generation automatic acquisition timing receiver, it is necessary to formalize a baseline of performance. A current generation manual receiver was employed to establish a baseline for Loran-C signal reception in the Austin, Texas area. Key performance indicators of Loran-C reception that pertain to a receiving system are signal to noise ratio, time constantof averaging, equipment gain, and directivity of the antenna. The signal to noise environment depends directly on the transmitter power radiated, conditions prevalent over the path of propagation, and the local noise features. Fortunately, Austin, Texas and in particular the plant site at Austron, Inc., offers an ideal low local noise situation. Therefore the signal to noise is mainly influenced by propagation path and transmitter power. See following chart for transmitters monitored. (Chart #1.)

The antenna system used for Loran-C reception employed alternately a 3 foot loop antenna and a 9 foot whip antenna. The loop antenna was considered as basic to eliminate the effects of local interference but since the site of observation did not experience much local iterference, it was not a major contributor. The 9 foot whip antenna, because of its larger effective height, was very helpful in insuring that adequate signal level was delivered to the input of the receiver. The data collected indicated that measurements taken with the loop antenna were degraded some 19 dB from the signal level received using the whip antenna. These results reinforce our application concept that when local noise is not of paramount consideration, a whip antenna is more advantageous because of the greater effective height. A further consequence of antenna selection is the radiation pattern discrimination of the loop antenna. The loop's figure eight type of radiation pattern would discriminate against long range noise sources that occur at the null points but would also discriminate against a desirable signal arriving from that direction.

Two major operating parameters of the Loran-C receiver are its gain (front end attenuation) and effective time constant (bandwidth). The settings for receiver performance for a manual acquisition receiver normally would range from 5 dB attenuation in a low signal level

MONITORED LORAN-C STATIONS

MANUAL VS AUTOMATIC LORAN-C RECEIVER TECHNOLOGY

STATION	TRANSMITTED POWER	DISTANCE (Km)	RECEIVER LOCATIONS
MALONE	800kW	1215	AUSTIN
GRANGEVILLE	800kW	680	AUSTIN
RAYMONDVILLE	400kW	438	AUSTIN
CAROLINE BEACH	550kW	1915	AUSTIN
SENECA FALLS	800kW	2335	AUSTIN
NANTUCKET	275kW	2775	AUSTIN
DANA	400kW	1410	AUSTIN
BAUDETTE	520kW	2060	AUSTIN
FALLON	400kW	2168	AUSTIN
GEORGE	1.6mW	2665	AUSTIN
MIDDLETON	400kW	2460	AUSTIN
SEARCHLIGHT	500kW	1710	AUSTIN
CAPE RACE	1.8m	2129	WASH., DC (USNO)
CAPE RACE	1.8m	3135	PATRICK AFB, FL

Chart #1

performance for a manual acquisition receiver normally would range from 5dB attenuation in a low signal level situation to as much as 99dB in a strong Loran-C source environment such as in the near field of a radiating transmitter. The approximate setting for the averaging time constant in a manual receiver directly determines the effective bandwidth of performance. A longer period of averaging will allow the receiver to capture more energy coherent with the Loran-C source and reject sources that do not contribute to making the time measurement.

The equipment used to collect the baseline data is shown in Figure 1. The set up consists of both an automatic and manual Loran-C timing receiver; as well as all the ancillary equipment required to provide a comparison. Please also refer to Figure 2 for the geographical features of paths to Austin.

The propagation paths into Austin, Texas that were used to collect data ranged from a 2665 kilometers path with a radiated power of 1.6 megawatt over a stressful total land path to a 438 kilometer path from a nearby transmitter radiating 400kW. In addition, observations were made at receiving sites in Washington, D.C., and at Patrick AFB to get additional path-type observations over various conditions. The two extremes for long path measurements dealt with a path length of 2700 kilometers over mountain and rocky terrain. Total attenuation expected over this path is well over 100 dB. Please refer to Chart 2 for received signal levels and identification of propagation path properties.

LORAN-C CONDUCTIVITY CHART

STATION	TRANSMITTED POWER	DISTANCE (km)	CONDUCTIVITY/TYPE OF PATH	RECEIVED POWER µWATT/METER
RAYMONDVILLE	400kW	438	GOOD/Sandy Loam Soil	1368.5
GRANGEVILLE	800kW	680	GOOD/Sandy Loam Soil	1697.0
MALONE	800kW	1215	GOOD/Sandy Loam Soil	354.6
JUPITER	275kW	1785	EXCELLENT/ 44% Seawater, 56% Sandy Loam	55.7
CAROLINE BEACH	550kW	1915	POOR/Mountains, Rocky Terrain	98.0
SENECA FALLS	800kW	2335	POOR/Mountains, Rocky Terrain	96.0
DANA	400kW	1410	FAIR/Hilly Terrain	134.6
BAUDETTE	520kW	2060	POOR/Rockey and Hilly Terrain	80.1
FALLON	400kW	2168	POOR/Mountains And Rocky Terrain, Salt Flat	56.9
GEORGE	1.6MW	2665	POOR/Mountains, Rocky Terrain	150.7
MIDDLETON	400kW	2460	POOR/Mountains, Rocky Terrain	44.1
SEARCHLIGHT	500kW	1710	POOR/Hills and Rocky Terrain	114.4
NANTUCKET	275kW	2775	POOR/Mountains, Rocky Terrain	24.0

Chart #2

A long total sea water path of 3153kM was used to provide a test for receiver performance. A shorter path having a mixture of attenuation characteristics is the one from Cape Race, Newfoundland to Washington, D.C., 2129 km, and about half is over sea water. Attenuation over this type of path would be expected to be under 90 dB. Please refer to Figure 3 for geographical features. The resultant performance of these paths is shown in Chart 3.

The accuracy of the Loran-C timing measurement is traceable to the synchronization of the Loran-C transmitter to the U.S. Naval Observatory null second pulse and thus UTC can be derived from the received pulse. The determination of accuracy is best when a solid groundwave signal is present. Under these conditions, a local 1PPS can be developed to better than 1 microsecond with respect to UTC. As the distance from the transmitter to the observation point is increased, the potential for skywave contamination exists. As the distance becomes too large to sustain any groundwave measurement, the Loran-C skywave can be used to determine time but with degraded accuracy. The task of an operator of a Loran-C receiver is to maximize his potential to receive unambiguous groundwave and derive a 1PPS synchronization from it. By virtue of the pulse-type of transmission from Loran-C and the accurate synchronization of transmissions, it is practical to distinquish the groundwave propagated signal clearly from the skywave. The distance from the

PERFORMANCE OVER SEAWATER

Automatic Loran-C Receiver

STATION	RECEIVER LOCATION	DISTANCE (Km)	TRANSMITTED POWER	ESTIMATED RECEIVED POWER	GROUNDWAVE AQUISTION TIME
CAPE RACE, NEWFOUNDLAND	PATRICK A.F.B., FLORIDA	3153.4	1.8MW	180μW	30 minutes
CAPE RACE, NEWFOUNDLAND	U.S.N.O. WASHINGTON, D.C.	2129.1	1.8MW	400μW	30 minutes

Chart #3

transmitter for unambiguous groundwave reception is 1000kM. Skywave presence can become a significant influence at distances greater than 1500kM. The technique for distinquishing groundwave reception has to do with the precise timing synchronization of the pulse transmission. Please review Figure 4 to obtain a better appreciation of the actual observations recorded using a path length over which significant skywave signals are present.

The operator of the manual Loran-C timing receiver must have a basic knowledge of electronic test equipment and an understanding of radio propagation. The test equipment required consists of a time interval counter, an oscilloscope and a strip chart recorder. The ancillary instruments required are a time-of-day clock, frequency source and possibly at long distances in noisy areas, a synchronous filter and/or notch filter. The operator must first obtain a coarse clock synchronization to within 10 milliseconds of UTC by a reference timing signal such as WWV or WWVB. The operator then sets the time-of-day clock to the reference, selects a Loran-C station and accomplishes acquisition. The most difficult step of Loran-C time recovery is to recognize and lock onto the correct tracking point. This is complicated by low signal to noise conditions.

The degree of operator skill required to operate the manual Loran-C timing receiver is inversely proportional to the received Loran-C signal strength, the amount of radio-frequency-interference (RFI), and the noise level. These factors also determine the amount and type of ancillary instruments to achieve proper identification and tracking of the received pulse. The manual operator with minimum skill, within 1000kM of the transmitter of interest and in a relative low noise area will achieve desired results in a short period of time with minimum ancillary instruments. A hostile radio-frequency environment, where the pulse strength is below that of the noise and/or RFI levels, requires the operator to be a very experienced user of Loran-C timing reception techniques and proficient in the use of various ancillary instruments. An automatic receiver that will provide the desired results in both environments reduces the operator skill level required, the operator time involved, and makes a significant decrease in the quantity and type of ancillary instruments required to achieve the acquisition and final tracking of the desired Loran-C pulse.

DESIGN GOALS

The first goal to address in the design of an automatic acquisition receiver is sensitivity. The receiver must adequately amplify a minimum usable signal level of .01 microvolts RMS to the level required by the acquisition and tracking hardware. An additional consideration is band pass filtering. The requirement is to exclude RF energy outside the required information bandwidth of the Loran-C signal. Since any band pass filter limits the faithful reproduction of the input signal while improving the noise performance, the design task is to select the proper bandwidth to optimize performance and obtain the best noise rejection. A narrow BW for acquisition and a wider BW for precise phase tracking are needed and identified as objectives for the design activity.

Gain must be automatically adjustable over the entire dynamic range of operation. This allows automatic selection of the optimum level. In view of the wide variation of propagation conditions, normally observed in long path monitoring of Loran-C transmissions, a decision was made to use an automatic adjustment by a microprocessor system. This concept allows for optimum tracking of the incoming signal in dynamic signal to noise situations. An additional design feature is the use of numerical averaging of the Loran-C signal received to reduce the effects of non-coherent noise and CW interference. The goal for numerical processing of the signal is to improve performance over a manual receiver by 15 dB or more.

The operation of an automatic acquisition Loran-C timing receiver should not require special skills or training of the operator. Ancillary equipment should not be required other than to provide a IPPS coarse time source to within 10 ms of UTC for initial synchronization programmable operations from a remote location are desirable. A standard reference frequency to at least an accuracy of 1 x 10^{-8} is required.

A very important design goal of the automatic system is to identify all acquirable Loran-C signals at the selected transmission rate and to establish the most acquirable one. Design decisions were made to use correlation techniques with a narrow band pass filter

(4 kHz bandwidth) and hard limit the RF sampled at a period of 100 microseconds over one transmission frame. The process allows for all usable signals to be identified and graded as to their signal to noise property and represented by quantitative correlation numbers. Subsequent sampling at a wider bandwidth operates on the most desirable stations to identify the proper cycle upon which to make the measurement of coincidence with respect to the Loran-C transmissions.

Much care has been taken in the selection of the time constants that control the digital servo loops and which establish the effective bandwidth of the receiving system. The design approach here is to provide an adaptive time constant which is automatically controlled by the signal to noise ratio. Once the loop error is sufficiently small the receiver goes into a track mode. At this time, the servo system is ready for synchronization with a null second from the Loran-C transmitter.

Additional factors to be considered in the design of an automatic acquisition Loran-C receiver are size, weight, power, cost, reliability, and maintainability. The size selected was the smallest rack-mountable size consistant with proper attention to human factors; such as push button size, observable display and legend readability. The weight and power were minimized by use of large scale integrated circuits and a switching power supply. Reliability was enhanced through use of LSI parts and long lifetime components. The maintainability of the unit is insured by the use of plug in cards with universal bus structure where possible, built in test routines with signature analysis, and flip open front panel for easy access to components. Replaceable software allows for future improvements and additions to the capabilities. Optional remote control capability through the IEEE-488 interface is available for installations requiring remote or fully automated operation.

MEASURED PARAMETERS

Chart #4 summarizes differences between automatic and manual receivers. The key features which permit successful operation in a hostile signal to noise environmnet are automatic gain control and adaptive signal to noise control.

The comparison test of the automatic Loran-C receiver with the manual one was conducted through the use of a relatively inexperienced University of Texas electrical engineering student who was hired specifically to operate the equipment. He had no previous operational experience with low frequency radio propagation or with precise time determination equipment using Loran-C transmission. The key items for making this comparison are acquisition time, operator attention, need to employ a synchronous filter, variation of measured delay, and a relative signal to noise indication. See Chart #5 for data summary.

The significance of operator attention and acquisition time for the different receivers may be too subtle to be clearly obvious. The major point in recording the time data here is to emphasize the lack of constant operator attention needed by the automatic receiver. In the case of

MANUAL vs AUTOMATIC PARAMETERS

RECEIVER SPECIFICATIONS		MANUAL	AUTOMATIC
SENSITIVITY		.01μVRMS	.01μVRMS
GAIN RANGE		0-99 dB	0-128 dB
AUTOMATIC GAIN CONTROL		No	Yes
BANDWIDTH	Acquisition:	5 kHz	4 kHz
	Tracking:	20/50 kHz	40 kHz
AVERAGING TIME CONSTANT		Selectable	Adaptive
TRACKING POINT		Slewable-.1μs Res.	Automatic-8nsec
TIME OF COINCIDENCE SYNCHRONIZATION		Manual	Automatic
OPERATOR SKILL AND ATTENTION REQUIRED		High	Low
ANCILLARY EQUIPMENT REQUIRED		Oscilloscope	N/A
		Time Interval Counter	N/A
		Coarse Time Source (UTC)	Coarse Time Source (UTC)
		1 MHz Freq. Ref.	1, 5, or 10 MHz Ref.
		Strip Chart Recorder	N/A
		Synchronous Filter	Included
		Time of Day Clock	Included
REMOTE CONTROL OPTION		None	IEEE-488

Chart #4

MANUAL vs AUTOMATIC LORAN-C DATA COLLECTION (WHIP ANTENNA)

STATION	SYSTEM	RECEIVED SIGNAL			MEASURED DELAYS µSEC	AUXILIARY EQUIPMENT	ACQUISITION TIME	OPERATOR ATTENTION
		RAW RF mVp-p	NOISE mVp-p	SIGNAL/NOISE				
RAYMONDVILLE	Manual	820	70	21dB	28908.3	no	10 min.	10 min.
	Automatic	820	70	21dB	28907.8	no	5 min.	3 min.
GRANGEVILLE	Manual	700	70	20dB	15066.6	no	15 min.	5 min.
	Automatic	700	70	20dB	15065.8	no	8 min.	5 min.
MALONE	Manual	500	80	16dB	4064.7	no	17 min.	17 min.
	Automatic	500	80	16dB	4064.0	no	6 min.	4 min.
JUPITER	Manual	76.1	60	2dB	51112.7	no	20 min.	20 min.
	Automatic	76.1	60	2dB	51112.2	no	10 min.	5 min.
CARLOLINE BEACH	Manual	48.5	75	-3.8dB	42801.7	yes	50 min.	50 min.
	Automatic	48.5	75	-3.8dB	42801.4	no	20 min.	5 min.
DANA	Manual	210.4	80	8.4dB	4728.4	no	45 min.	45 min.
	Automatic	210.4	80	8.4dB	4727.5	no	15 min.	5 min.
SENECA FALLS	Manual	.271	80	-50dB	38942.7	yes	45 min.	45 min.
	Automatic	.271	80	-50dB	38942.9	no	20 min.	8 min.
BAUDETTE	Manual	.394	80	-46dB	54625.0	yes	1 hr. 30 min.	1 hr. 30 min.
	Automatic	.394	80	-46dB	54624.8	no	30 min.	15 min.
NANTUCKET	Manual	.211	75	-50dB	35383.9	yes	1 hr. 30 min.	1 hr. 30 min.
	Automatic	.211	75	-50dB	35383.2	no	45 min.	15 min.
GEORGE	Manual	.674	80	-42dB	22655.6	yes	1 hr. 45 min.	1 hr. 45 min.
	Automatic	.674	80	-42dB	22654.7	no	45 min.	15 min.
FALLON	Manual	.43	80	-45dB	7282.1	yes	2 hrs.	2 hrs.
	Automatic	.43	80	-45dB	7281.3	no	45 min.	15 min.
SEARCHLIGHT	Manual	52	80	-3.7dB	47640.7	yes	45 min.	45 min.
	Automatic	52	80	-3.7dB	47640.1	no	25 min.	10 min.
MIDDLETON	Manual	.199	80	-50dB	36280.1	yes	1 hr. 45 min.	1 hr. 45 min.
	Automatic	.199	80	-50dB	36279.2	no	40 min.	15 min.

NOTE: OPERATOR SKILL - Four hours of training on each receiver system just prior to start of test.

<u>Chart #5</u>

Seneca Falls, the time to acquire for an automatic receiver was 20 minutes as compared to 45 minutes for the manual receiver. On the other hand, the operator attention time was reduced from 45 minutes to 8 minutes.

The data collected from Raymondville, Texas indicated a very stong signal of 820 millivolts. Either technique required a minimum amount of acquisition time and similar operator attention spans. The worst case condition for time to acquire was noted in the signal from Fallon, Nevada which, at the peak cycle, measured only 430 microvolts, showing a signal difference of 66 dB. In this situation, the manual receiver required the use of the synchronous filter and took 2 hours of acquisition time and constant operator attention. The automatic receiver made the measurement in 45 minutes and took 15 minutes of operator attention. The best performance using the manual receiver unaided by the synchronous filter was monitoring Jupiter, Florida. The acquisition and operator attention required using the manual, receiver was 20 minutes. The automatic receiver performed the task in 10 minutes and required only 5 minutes of operator attention.

The variation of measured delay between the automatic receiver and the manual one was never any greater than 0.9 microsecond in the range of data collected. The difference between the two measurements had a standard deviation of 0.22 microseconds and a mean value of 0.66 microseconds. In addition, it should be noted that the synchronous filter was necessary to complete the time measurement using the manual receiver in eight out of the 13 transmitters monitored and that operator attention in these situations using the automatic receiver was never longer than 15 minutes.

SUMMARY AND CONCLUSIONS

The present manual system of precise time determination uses a number of ancillary items and operator assist devices to accomplish a time measurement to an accuracy of one microsecond. Please refer to Figure 5 for a view of the total manual system. The large variety of propagation conditions, noise environment and long range potential possible with Loran-C make an automatic microprocessor controlled receiver a very desirable instrument.

We have attempted to show clear evidence of reception success over a wide range of conditions using an automatic Loran-C timing receiver. Please see Figure 6 for a comparison of the relative complexity of automatic instrumentation versus manual.

A key factor demonstrated in the measurements is the reduction in operator attention. Demonstrated differences show a reduction of operator attention from 2 hours to 15 minutes for the worst case situation.

A good ground wave time measurement was made to better than one microsecond of UTC over a sea water path of length of 3153 kilometers from a 1.8 megawatt transmitter and over a land path of length of 2665 kilometers from a 1.6 megawatt transmitter using the automatic receiver.

One of the most serious operational complications that arises in establishing an accurate time using Loran-C is the ability to deal with the skywave presence at long ranges from the transmitter. The automatic receiver has successfully detected and made an accurate time measurement in the presence of skywave signals more than 20 dB greater than ground wave.

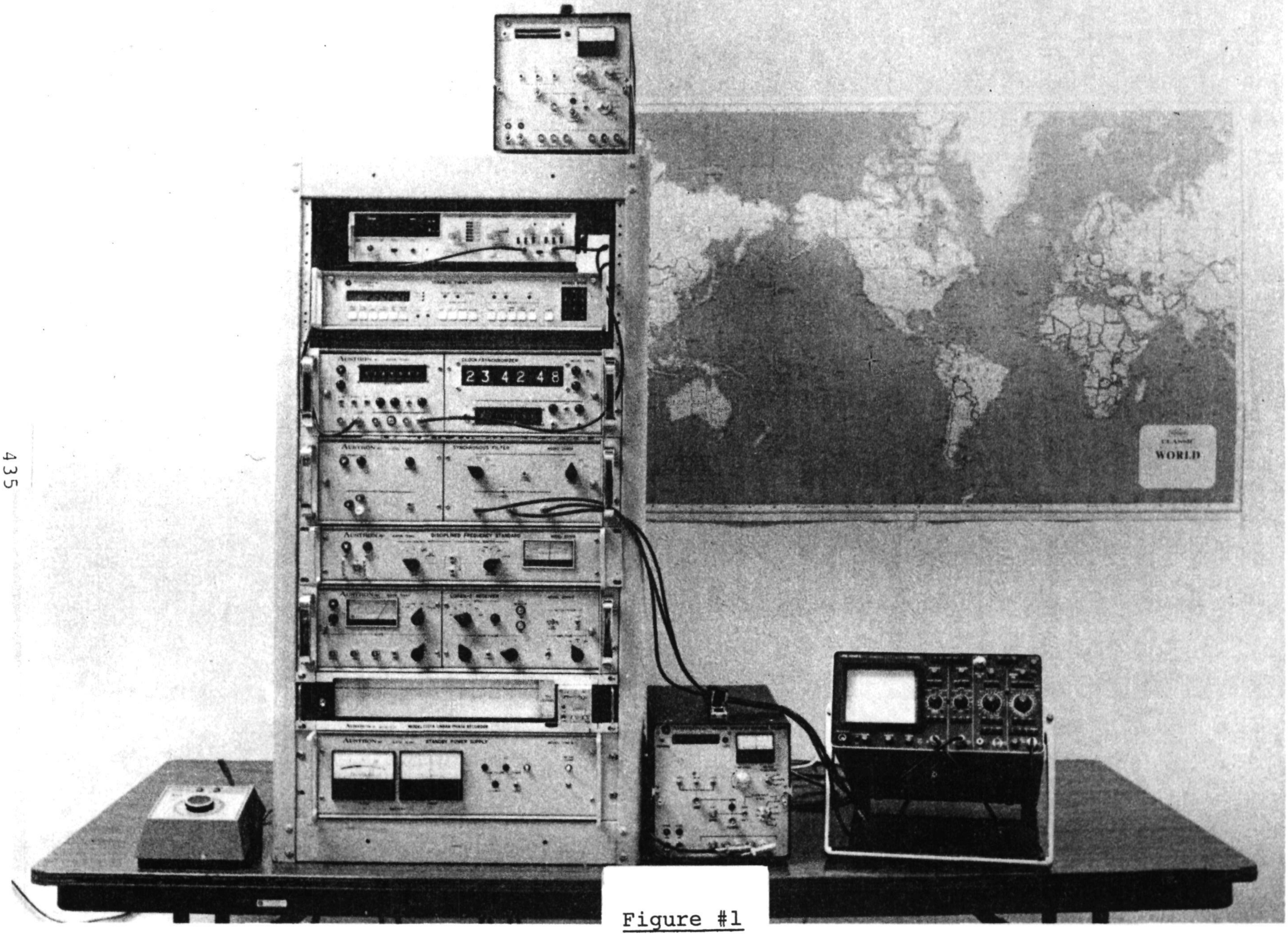

CLOCK/SYNCHRONIZER
2 3 4 2 4 8
AUSTRON
SYNCHRONOUS FILTER
DISCIPLINED FREQUENCY STANDARD
LORAN-C RECEIVER
LINEAR PHASE RECORDER
STANDBY POWER SUPPLY
WORLD

Figure #1

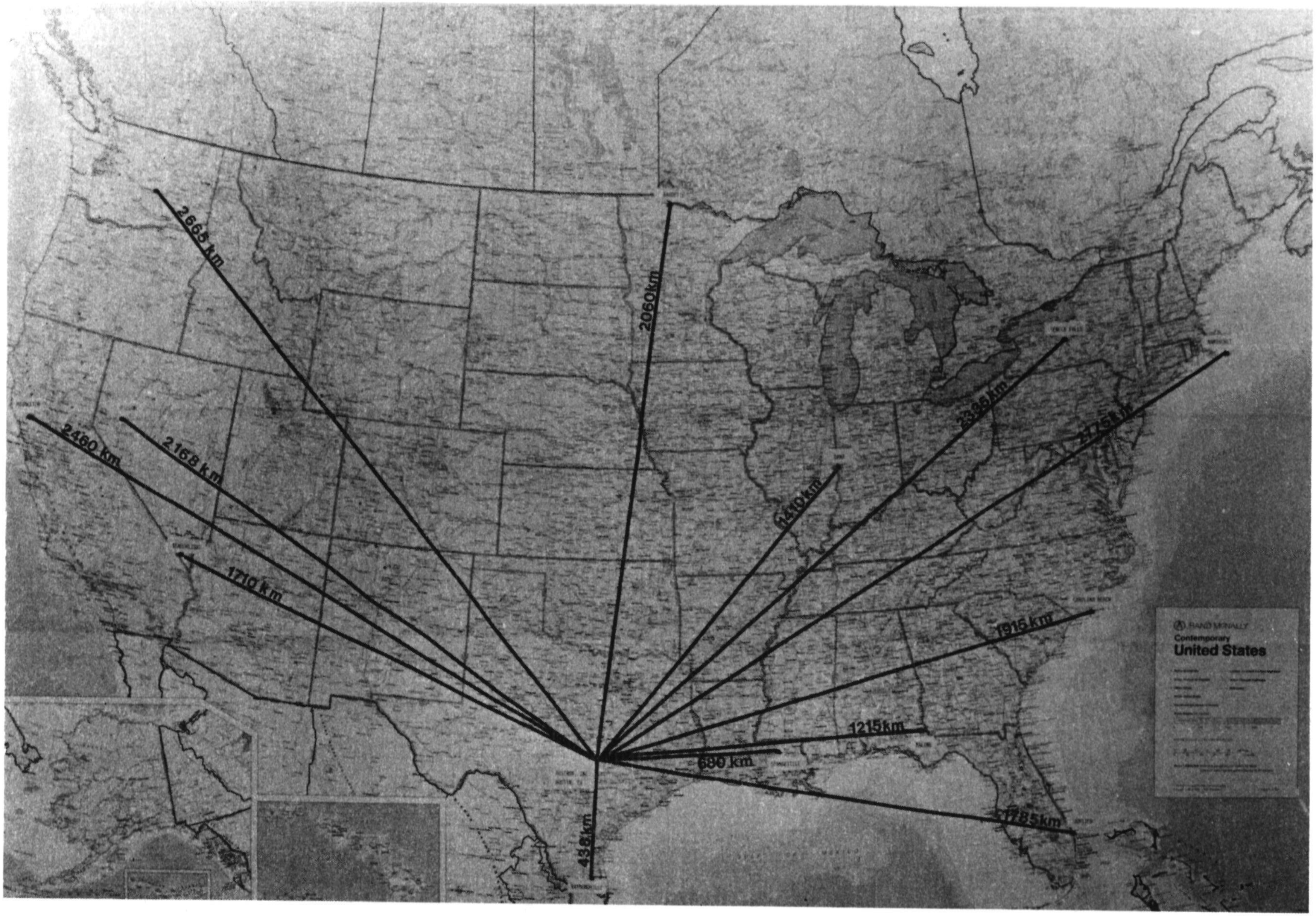

2665 km
2060km
2460 km
2168 km
1710 km
1410km
2395km
2775 km
1915 km
1215km
680 km
1785km
438km
RAND McNALLY
Contemporary
United States

Figure #2

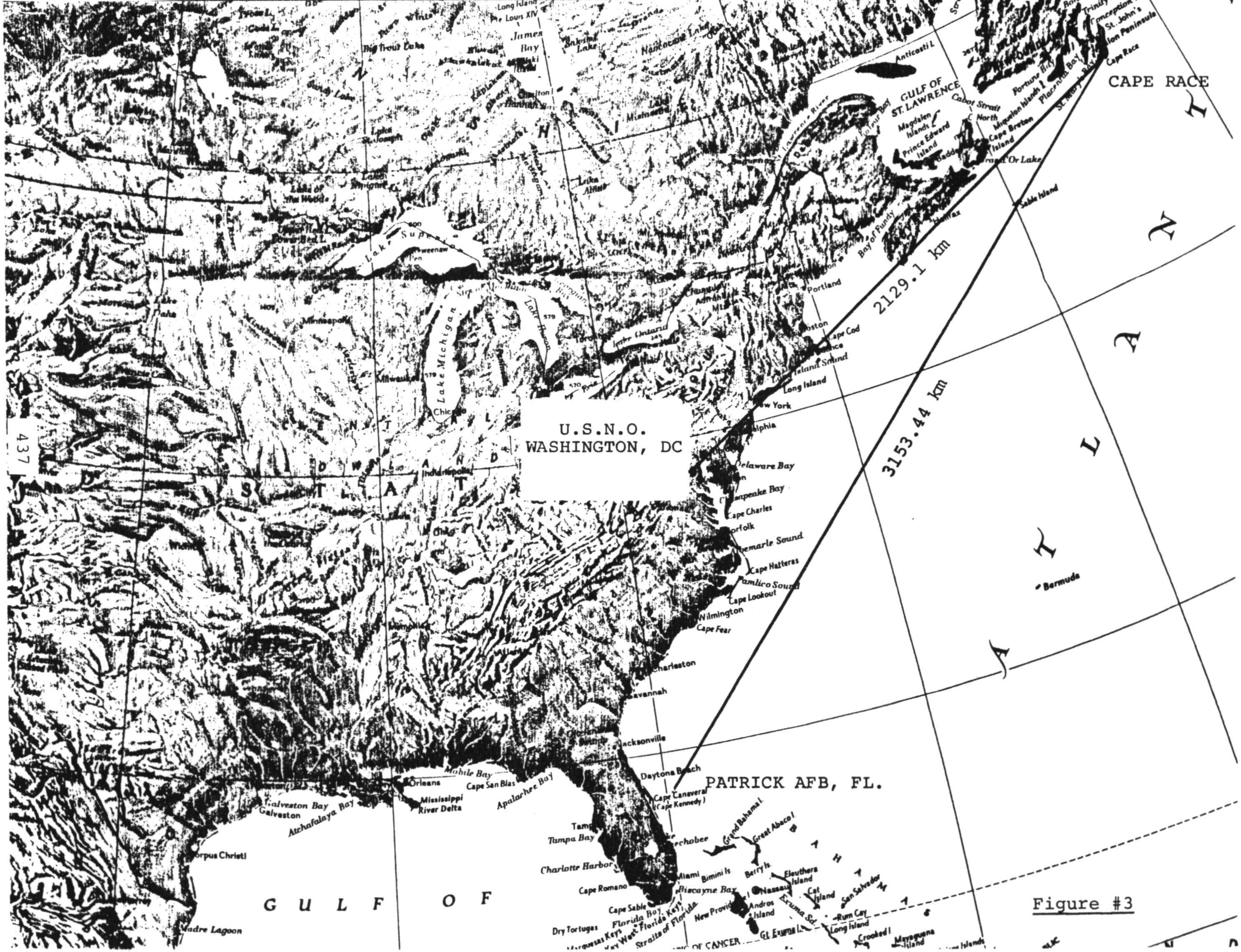
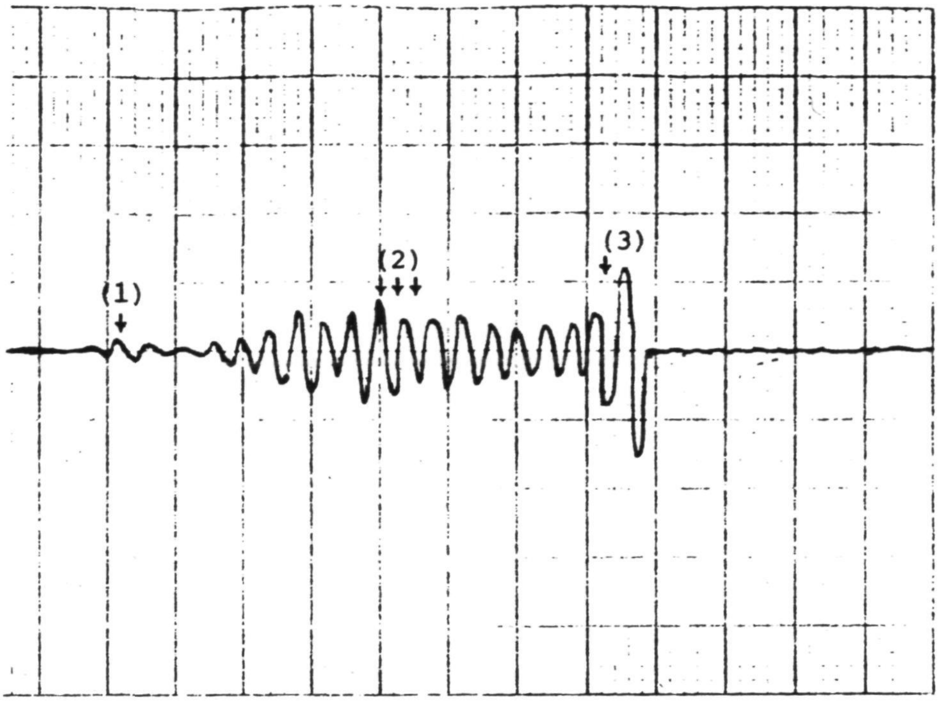

CAPE RACE
2129.1 km
3153.44 km
U.S.N.O.
WASHINGTON, DC
PATRICK AFB, FL.

Figure #3



RECORDING OF RECEIVED LORAN-C SIGNAL

TRANSMITTER: George, Washington

TRANSMITTER POWER: 1.6 MW

PATH DISTANCE: 2665 KM

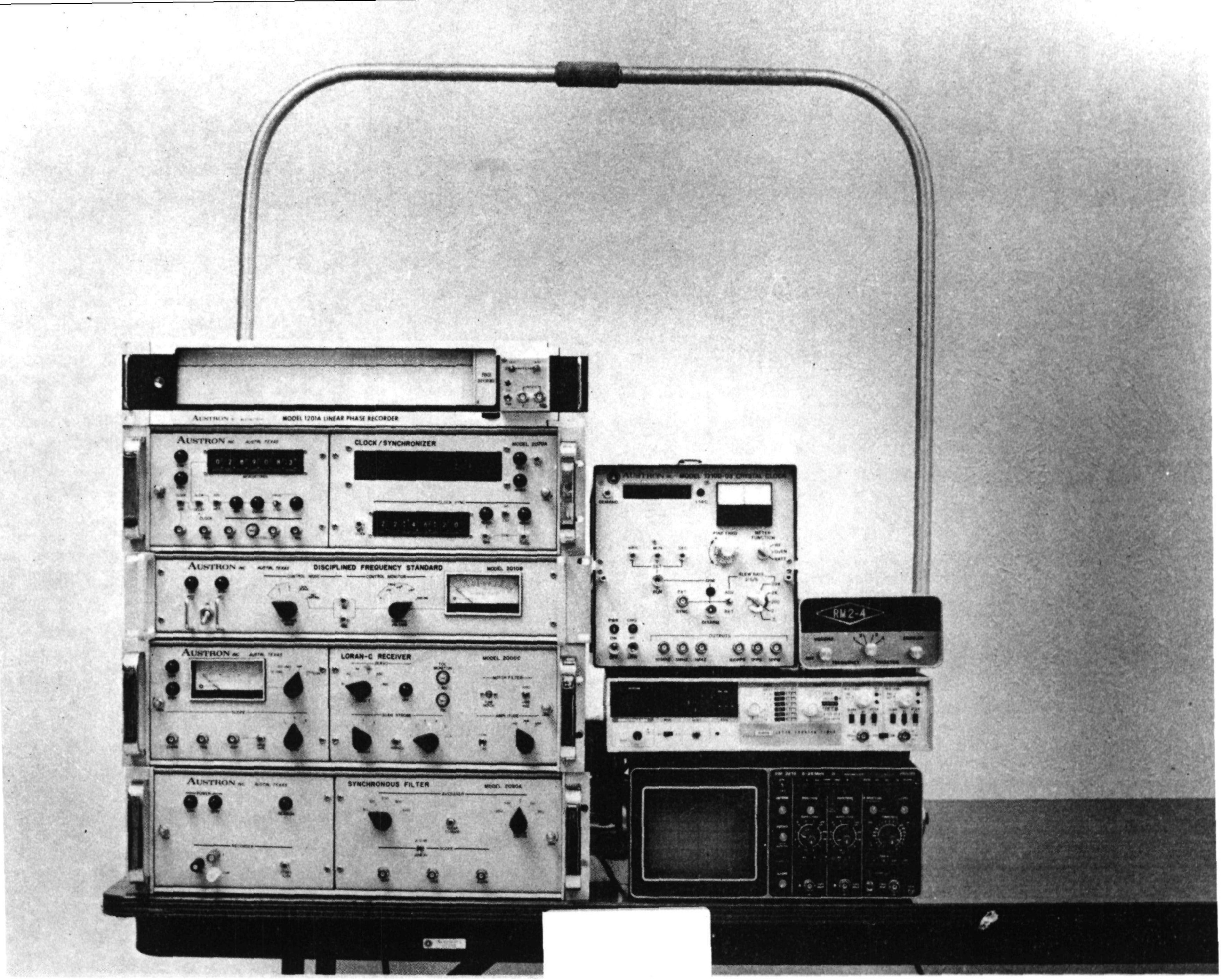
TIME OF RECORDING: 0300 Hours UTC
9:00 PM Local

RECEIVER SITE: AUSTIN, TEXAS

TYPE RECEIVER SYSTEM: Manual Receiver with Ancillary instruments.

NOTES:
(1) Groundwave
(2) First Hop
(3) Second Hop

Figure #4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AUSTRON INC. AUSTIN, TEXAS
CLOCK / SYNCHRONIZER
MODEL 2070A
DISCIPLINED FREQUENCY STANDARD
MODEL 2010B
LORAN-C RECEIVER
MODEL 2000C
SYNCHRONOUS FILTER
MODEL 2090A
AUSTRON INC. MODEL 1210D-03 CRYSTAL CLOCK
RM2-4

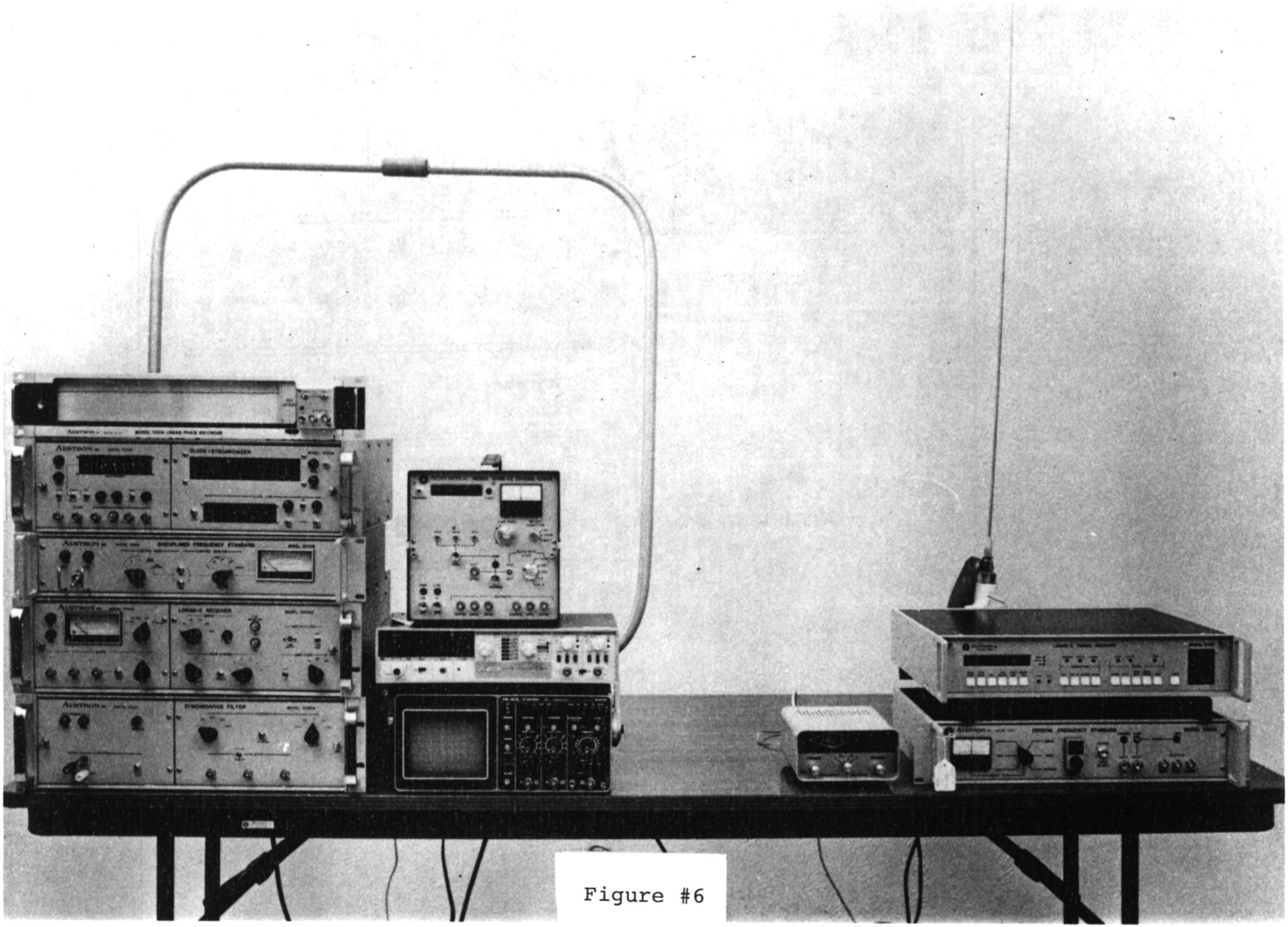
AUSTRON
MODEL 1201A LINEAR PHASE RECORDER
AUSTRON
CLOCK/SYNCHRONIZER
AUSTRON
DISCIPLINED FREQUENCY STANDARD
AUSTRON
LORAN-C RECEIVER
AUSTRON
SYNCHRONOUS FILTER
LORAN-C TIMING RECEIVER
AUSTRON
CRYSTAL FREQUENCY STANDARD

Figure #6

QUESTIONS AND ANSWERS

DR. WINKLER:

You mentioned that your receiver has the IEEE 488 bus capability. I just wonder whether you can increase that time that you have listed of eight minutes, or so by simply connecting it to a controller.

MR. PRICE:

That is right. If it is remotely programmable and can be controlled from a mobile location, you can replace the person sitting there watching it.

Yes?

MR. BANERGEE:

How is this table system going to improve the performance?

MR. PRICE:

I think your question is will this receiver improve the performance of capturing the ground wave in the face of the sky wave?

Is that the question?

MR. BANERGEE:

The question is that we can't receive the ground wave because we are out of the range.

MR. PRICE:

Well, how far out is your distance? Are you like 1,500 kilometers, are you like 2,000 kilometers?

MR. BANERGEE:

More than 1,500 kilometers.

MR. PRICE:

More than 1,500 kilometers?

MR. BANERGEE:

Much more than 1,500 kilometers.

MR. PRICE:

I think probably in that case you might just have too much attenuation to get a significant ground wave and you may need to make a sky wave measurement. What is your accuracy requirements for time?

MR. BANERGEE:

I would like to know how we could receive these with this type of receiver?

MR. PRICE:

Okay, if we were using a sky wave signal which we didn't talk about using a measurement because I would rather use a ground wave, we can probably get about 50 microseconds accuracy. UTC, within 50 microseconds, if you are using the ground wave you might expect to get within a microsecond.

MR. BANERJEE:

Thank you.

MR. JERRY PUNT, Interstate Electronics

What is the difference between the 15 minutes of operator time and the 8 minutes of operator time in this function?

MR. PRICE:

Jerry, either the signal-to-noise environment is tougher where you take a little longer period of time, or it might just be it has some trouble sorting out the sky wave from the ground wave because of the particular distance that you are from the transmitter.

We haven't really analyzed exactly why those figure differences are there, but I think that all of those factors bear on the amount of time a receiver takes to make a measurement.

MR. PUNT:

I understand the receiver time, but what about the operator time, what does the operator have to do that this requires 15 minutes in certain cases and only 8 minutes in another case?

MR. PRICE:

Sometimes he has to just wait for another TOC, because there is 15 minutes separation between TOC on some of the chains. Time of Coincidence is what the Naval Observatory calls it.

PROFESSOR LESCHIUTTA:

Just for my information I would like to know if using the IEEE bus, could we possibly give instruction to the receiver in order to study at one time the ground wave and at some other time the sky way; or perhaps the instruction to the receiver that always tries to get the first signal, the ground signal?

MR. PRICE:

My answer is that that is not normally the way we would expect it to be programmed. With the flexibility that we have we could work with you and hopefully we could make some arrangements to do some of those things.