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NAVY DEPARTMENT

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Report on

Development of Type RA-46125

Experimental Models of Superfrequency Radio Receivers

For Single and Double Modulation

(A Part of Model XAP Equipment)

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Prepared by: G. E. Pray, Associate Radio Engineer

Reviewed by: T. McL. Davis, Radio Engineer, Chief of Section

A. Hoyt Taylor, Head Physicist, Superintendent, Radio Division

Approved by: H. G. Bowen, Rear Admiral, USN., Director.

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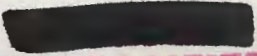
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ABSTRACT

Two receivers were developed and tested with the object of demonstrating the principles of double modulation, and comparing the characteristics with those of single modulation. Each receiver is capable of both types of modulation, with comparable sensitivities. It was further desired to demonstrate the practicability of gang tuning of high Q preselector circuits for high frequencies. The frequency range covered in the preselectors showing the best characteristics is 130 to 210 MC, with 4 to 5 per cent extension. It was found practicable to obtain reliable operation, and more stable frequency-temperature characteristics than ever produced for service in previous equipments at any frequency without the use of crystals or ovens. The tests of these receivers is covered in a separate test report, R-1736.

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AUTHORIZATION

1. This research was authorized by reference (a). Other pertinent material is included in references (b) and (c).

Reference: (a) Bu.Eng. letter C-S67/46 (7-28-R8) of 30 July 1938.
(b) Bu.Eng. Specification RA 13A 240.
(c) NRL Report R-1736.

STATEMENT OF PROBLEM

2. The several problems involved in the development were as follows: It was decided to construct two receivers, each capable of either single or double modulation reception, to cover a frequency range of 130 to 210 MC for at least one preselector, and a range of at least 132 to 156 MC for another preselector.

3. On single modulation each receiver must be capable of receiving a carrier signal, modulated at audio frequency. On double modulation, the receiver must receive a carrier, modulated at an intermediate or primary modulation frequency between 175 and 225 KC, which in turn may or may not be modulated at audio frequency. If no audio modulation is present on double modulation, the receiver must be capable of producing an audio heterodyne beat note for CW communication.

4. On double modulation, provision must be made for five modulation channels falling in the range 175 to 225 KC, the desired channel to be selected by means of a 5 position switch.

5. The double modulation channel selectivity must be such that if a transmitter is modulated by all five channels simultaneously and in equal amounts, the receiver may distinguish the desired channel without serious interference from the other four.

6. The carrier frequency tolerance allowable was set at $\pm .04$ per cent; that is, if the transmitter and receiver were off frequency in opposite directions by $.04$ per cent, the signal must not be attenuated by more than 6 db. This required a band width of $.08$ per cent in the receiver, which amounts to 168 KC at 210 MC. To allow for error in tuning, a band width of 250 KC was chosen. This required that on single modulation the preselector and all i-f stages must have a band width of 250 KC with a total attenuation of not more than 6 db. In order to provide reasonably close spacing of carrier channels, the 60 db width was required to be not more than 1250 KC wide. The I-F selectivity curves in the test report R-1736 show that the actual width at 60 db attenuation is only 911 KC.

7. A tentative channel separation of 0.6% had been chosen,

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which would vary from 780 to 1260 KC over the tuning range, with adjacent channel operation possible without prohibitive interference at a distance of 700 yards. In actual tests, it was found possible to work duplex operation with a frequency separation of 1000 KC with no interference when transmitting and receiving antennas were separated only 50 feet.

8. On double modulation, since the maximum primary modulation frequency was 225 KC, the preselector and i-f band width must be at least twice this value plus a tolerance. A band width of 600 KC was chosen to allow for first oscillator drift and tuning errors. This required that the carrier channels must be more widely separated than for single modulation, but the primary modulation channels on any one carrier may be as close as 12.5 KC apart.

9. A sensitivity of 5 to 10 microvolts for 1 to 3 watts output with a signal to noise ratio of 7.4 db was chosen as satisfactory for both types of modulation.

10. A fidelity of ± 2 db over the audio range of 350 to 3500 cycles was considered desirable, and was met satisfactorily on single modulation. On double modulation, in order to obtain 40 db attenuation of a channel only 12.5 KC off the resonant channel, it was found desirable to modify the fidelity requirement to avoid more complex and expensive design.

11. The receiver was required to make use of resonant transmission line circuits in the preselector and first oscillator, without any temperature control oven. The frequency tolerance given in Par. 6 was to be met under all conditions of operation if practicable.

12. A space limitation of 1.75 cubic feet was set up for the complete receiver.

PERTINENT FACTS FROM PREVIOUS WORK

13. The principle of double modulation had been investigated and demonstrated at this Laboratory during 1936, with a typical experimental laboratory set-up. The results indicated the practicability of the system, and warranted the establishment of the present project.

14. The use of tuned transmission lines for resonant circuits had been investigated spasmodically since the work of J. W. Conklin and G. E. Pray of RCA in 1929, reported in the Proceedings of I.R.E. for November, 1931. In 1936, two types of receivers were constructed at this laboratory using tuned lines. One type, similar to the Dunmore receiver, was reproduced in two models, covering a frequency range of 150 to 300 MC, using concentric lines whose length was varied for tuning. This was a cumbersome device, not adapted to proper gang tuning. Another type

of receiver used short concentric lines, tuned by capacity. The capacity consisted of two circular plates whose spacing was varied by a screw thread. This device was also cumbersome and not adapted to gang tuning, but indicated some merit in the use of tuned lines for receiver circuits.

15. In 1937, a receiver was developed at this Laboratory for Radar work, covering the range of 170 to 230 MC with ganged tuning of the four preselector circuits. Each preselector circuit consisted of a short concentric line, tuned by a conventional type of 5 plate variable condenser. The preselector was compact, efficient, and simple to tune with its single dial control.

16. In 1938 an experimental receiver was developed which used parallel bar lines or frames, tuned by the conventional type of 5 plate variable condenser. The condensers for the four stages were ganged to a single tuning dial, and covered a frequency range of 130 to 210 MC. The final tuned stage was a super-regenerative detector, and all circuits were made to track satisfactorily. A sensitivity of about 5 microvolts was obtained for 6 milliwatts output and a signal to noise ratio of 10 db. The tuned frame type of circuit was considered to be more practical mechanically and equal electrically to the concentric line type for this frequency range.

17. The values of Q obtainable from any of the transmission line type of circuits is dependent upon the loading of the line by the tubes. The circuit by itself may have a very high Q , but the tube impedance is low and loads the line heavily. However, if the tubes are tapped down to the proper point on the line, the loading of the line is reduced, and the effective Q increased toward the unloaded value. As the tube tapping point is moved upward the low impedance end of the line, the voltage at the tap decreases and the inductive reactance of the tube leads becomes appreciable as compared to the tapping point impedance. This results in a reduction in voltage gain in the circuit; and if the tapping point is moved too far toward the low impedance end of the line an overall voltage loss will occur. It is necessary that some gain be realized in the first circuits in order to obtain a favorable signal to noise ratio. It is not considered practical at the present state of the art to gang circuits whose Q exceeds 200 when the preselector covers a two to one frequency range, and manufacturers in general do not gang circuits with Q 's much above 50.

SOLUTION OF PROBLEMS

18. In order to meet the requirements which had been set up, it was necessary that the receiver be of the superheterodyne type. It was decided to construct the receiver in three sections, combined into a single unit. The first section contains the superfrequency preselector and oscillator; the second section contains all i-f and a-f components; and the third section contains the power pack. This type of construction was adopted to facilitate

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the convenient interchange of experimental preselectors in order to determine their relative merits and practicability. The power pack may be replaced by a dynamotor or other unit for tests in aircraft. The dynamotor could be mounted in the space normally occupied by the power pack, or it could be mounted as a separate unit if the receiver was encased in a smaller cabinet. Connections between the various sections are made by Jones plug fittings and short cables.

19. The first experimental model was not considered successful, but will be described briefly in order to make this report complete. On single modulation the signal came through the r-f amplifier and mixer to a 13 MC i-f amplifier which had a band width of 250 KC. Three stages of i.f. were used, with type 6AC7 tubes, then a 6H6 detector and the audio system. A sensitivity of better than one microvolt was obtained for one watt output, and was considered to be very nearly the ultimate for single modulation. On double modulation, the detection of the primary modulation took place in the type 954 tube which was normally used as a mixer for single modulation. The first oscillator tube was inoperative on double modulation, leaving the first detector to act as a rectifying detector, its output being the 175 to 225 KC primary modulation frequency. The primary of the first 13 MC i-f transformer was connected to the plate of the first detector. The low side of this primary was connected to the high side of the primary modulation selector circuit. The 13 MC stages were not used for double modulation. The low side of the primary modulation selector circuit was by-passed to ground. Thus, it is seen that the single and double modulation primary circuits were connected in series with the plate of the first detector. For double modulation then, the signal came through the preselector, was rectified for primary modulation in the first detector, then fed to a mixer where it was heterodyned up to a fixed i.f. of 480 KC, went through two stages of 480 KC, i-f amplification, to the 6H6 final detector, then the audio system. The 480 KC i-f gain was so high that the primary modulation selector circuit noise was very strong. The preselector gain was small, and the first detector was acting as a square law device on double modulation, resulting in inefficient first detection because of the low level of the signal at this stage. Consequently an input of about 300 microvolts was necessary on double modulation to produce enough primary modulation voltage to override the noise in the primary modulation mixer circuit. After unsuccessful attempts to obtain more efficient first detection the circuit was abandoned.

20. It was decided that the signal level should be amplified to a value of at least one millivolt in order to obtain efficient detection. This required that the first oscillator be operative, and the first mixer be used as a mixer for both single and double modulation. Also it necessitated the common use of some of the 13 MC i-f stages for both types of modulation. The single modulation system required a band width of 250 KC, while the double modulation system required a width of 600 KC. The first

two stages, including two i-f transformers and two 6AC7 tubes were made common to the two systems, with a band width of 600 KC, which meant that the system was no longer ideal for single modulation. Reference to the receiver layout on Plate 1, and to the circuit diagram 46 F 456, will help to clarify this discussion. The third i-f stage, consisting of two more i-f transformers, one 6AC7 tube, and the 6H6 final detector, were used only on single modulation, with a band width of 250 KC. For double modulation, the circuit splits up after the second i-f stage, being coupled through a third broad i-f transformer to the primary modulation detector. This detector is a 6SJ7, biased for plate rectification. From this detector, the signal goes to the primary modulation channel selector circuit in the input of the second mixer. A 6SJ7 second oscillator of the electron coupled type with its own selector circuit, beats with the primary modulation frequency to produce a constant i-f of 480 KC. The second oscillator therefore operates at a frequency that is always 480 KC higher than the primary modulation frequency. The selector circuits are tuned by combinations of fixed and adjustable condensers, controlled by a five position ganged switch to provide five primary modulation channels. The oscillator potential is coupled capacitively to the first grid of the 6SA7 second mixer. The 480 KC output of the second mixer goes through one stage of i-f amplification consisting of one type 6SK7 tube and two transformers of 8.8 KC band width, then to the second anode of the 6H6 final detector.

21. For CW operation on double modulation a CW beat oscillator, using a 6SJ7 tube, injects a beat frequency voltage of about 0.5 volt into the final detector input circuit. The beat oscillator is of the electron coupled type, and its frequency may be varied from 480 KC over a small range by adjustment of a trimmer condenser controlled from the front panel, to provide the desired audio beat note. An "on-off" switch controls the operation of this oscillator.

22. It is not necessary to beat the primary modulation frequency up to a fixed i.f. of 480 KC as has been done in these receivers. In previous work, the primary modulation frequency has at times been amplified through several stages at its fundamental frequency. However, in order to reduce the problem of switching channels to its simplest form, and to obtain a reasonably good fidelity, it was decided that the present system offered the better solution to the problem. Wherever this system is used, care must be observed in the placing and shielding of the second oscillator, as its harmonics in the neighborhood of the twentieth may produce objectionable beats with the 13 MC i-f signal.

23. An audio volume control potentiometer, connected between the 6H6 detector and the 6SJ7 first audio tube, provides control of the receiver output. The resistance of the potentiometer is .5 megohm to match the output of the detector.

24. An i-f gain control potentiometer operates in the cathodes

of all i-f stages to control the gain for CW reception or when the AVC switch is in the "off" position. This control is operative for both single and double modulation, and should be at a position for nearly maximum gain when the AVC switch is in the "on" position. The potentiometer has a resistance of 1000 ohms, and is supplied with definite biasing voltage from a bleeder circuit across the plate supply. This bleeder circuit consists of the potentiometer and two fixed resistors, of 25,000 and 15,000 ohms respectively, and provides screen potential for the i-f tubes. The gain control was placed in the cathodes to provide a definite and uniform control over the tubes while their screen and plate potentials remain normal. It has been frequently practiced in receiver design to control the gain by varying the screen voltage, since the current through a potentiometer in such a circuit, and consequently the power dissipated, is very small. Where self bias is used, the screen control system is not advisable, since the bias varies with the screen voltage and often provides a very non-uniform control of the gain. This cannot occur with the system used in this receiver.

25. The rectified and filtered output of the 6H6 final detector provides AVC bias for all i-f stages and for the second mixer. The detector load resistor has a value of one megohm and provides both a-f signal and AVC voltage. The AVC voltage is filtered through another one megohm resistor and a .1 microfarad condenser, then through individual filters in each i-f grid circuit. The a-f signal is coupled through a .01 microfarad condenser to the a-f volume control potentiometer. The AVC action of the detector is biased at one volt to delay the building up of AVC voltage. No delay is introduced in the detector action. The result is that normal receiver noise and very weak signals will not actuate the AVC circuit. The bias is obtained from two fixed resistors of 500 and 50,000 ohms respectively, connected across the regulated 105 volt circuit.

26. For ideal AVC action, the AVC circuit should be tapped off about one stage ahead of the detector, should use a separate tube, and should contain one stage of amplification. This system should be used in any receiver having only one i-f system, but was not practical for the present receiver with its multiple i-f system. A possible improvement in the present system would be to apply some AVC voltage to the first audio tube. This would reduce the distortion at high signal levels, and would flatten out the overload curve on reduced output levels.

27. The 105-volt regulated supply is obtained from the power pack, and is used to furnish plate voltage to the first oscillator, and screen voltage to the preselector, all mixers, the second and third oscillators, and the first a-f amplifier. This is one of the important features which provides uniformity of operation, and frequency stability.

28. The 13 MC i-f transformers were designed around the RCA high frequency i-f transformers, using polystyrene forms and

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iron core trimming. Each winding is loaded by a 50 micromicrofarad ceramic condenser. The turns of the winding are spaced approximately one wire diameter. The primary and secondary windings are spaced from 3/8 to 9/16 inch, depending upon the band width required. This spacing results in overcoupling, with a dip in the nose of the selectivity curve. The nose was flattened out to correct this condition by shunting a resistor of appropriate value across the primary winding. To compensate for the expansion and contraction of the polystyrene forms due to temperature changes, the iron cores are mounted on brass screws which are supported from the end of the form. Thus the cores tend to position themselves to maintain a constant inductance in the windings. R-f filter circuits consisting of resistance and capacity are included in each transformer primary and secondary circuit at the low potential end to insure proper isolation of r-f voltages.

29. As seen in Plate 1 and Plate 3, the output of the second 13 MC i-f tube is coupled to the primaries of two transformers, one for single and one for double modulation. This is an undesirable combination since some reaction is bound to occur between the two transformers due to their electrical coupling. However, the chassis had been designed for the previously described receiver, and upon changing over to the present design was not easily adapted to a more satisfactory circuit. It was considered necessary to obtain the i-f gain of two tubes for the double modulation, and necessary to obtain the 250 KC band pass characteristics of two transformers for single modulation. The present circuit was chosen since it satisfied these requirements and allowed the use of the chassis which was available. Coupling to the broad band transformer is through a 5 micromicrofarad condenser, and reduces the reaction to a small amount. The amount of reaction still remaining requires very careful aligning of the transformers to prevent distortion of the selectivity curves. Such alignment may be obtained by using a sweep oscillator to modulate the alignment oscillator, and adjusting both transformers to obtain the desired characteristics as seen on an oscilloscope. In any future design, it should be remembered that one transformer can be loaded by two tubes without reaction in the branch circuits, but one tube cannot be loaded by two transformers of the same frequency without some reaction between the circuits.

30. The 480 KC i-f transformers are of standard Aladdin type, with universal coils on iron cores, mounted in bakelite frames, with adjustable coupling, and tuned by air dielectric condensers. These two transformers were slightly overcoupled to give a band-width of 8.8 KC. No appreciable dip was caused in the nose of the selectivity curve, so no resistance loading was required. However, due to the gain being more than necessary, it was found desirable to utilize only part of the voltage from one of these transformers, so the output was tapped off across one of two 1/4 megohm resistors.

31. The second and third oscillator circuits, and the

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second mixer input circuit were made up of Aladdin i-f transformer parts by installing the proper coils, and changing the circuits to suit the purpose. It was found necessary to shunt the grid of the 6SA7 second mixer with a 75,000 ohm resistor to reduce the Q of the channel selector circuit. This reduced the sideband cutting and allowed better overall fidelity on double modulation.

32. The fidelity of the audio system is flat to 2 db over the range of 50 to 20,000 cycles at one watt output. The drop in fidelity above 3500 cycles is obtained by detector filter action on single modulation. On double modulation the fidelity begins to drop off above 2000 cycles since the close spacing of channels required that the sidebands be cut somewhat in order to obtain proper attenuation of adjacent channels. For higher normal power output, the audio system would require a larger output transformer and a different tube arrangement. It is believed, however, that lower output may be satisfactory, since the latest loudspeaker system is provided with its own amplifier which requires an input of only six milliwatts.

33. The power pack is of normal design using a choke input to the filter in order to obtain good regulation. A voltage regulator tube type VR-105 is connected in series with a 5000 ohm voltage dropping resistor across the output of the power pack to provide a constant source of 105 volt supply for oscillators and screens. The total load on the 110 volt 60 cycle supply is only 75 watts, so the power pack could be reduced in size without overloading.

34. The tuned frame preselector, two of which were constructed, consists of one stage of r-f amplification, a first mixer, and a first oscillator, as shown on Plate 2. Each stage uses a tuned frame for a resonant circuit, the frame consisting of a parallel conductor transmission line whose physical length is less than one quarter wavelength, and consequently acts as an inductance. The tubes are standard acorn types, 954's for amplifier and mixer, and a 955 for the oscillator. The oscillator operates with the cathode at ground potential, the grid tapped up on one leg of the frame, and the plate tapped up on the other leg. Coupling to the mixer cathode is made through a 500 micromicrofarad condenser, tapped near the ground end of the oscillator plate leg of the frame and resulting in an injection of 3 to 4 volts at the mixer. This condenser also acts as a cathode bypass to ground for the carrier frequency. The design of the frames is covered in the following paragraphs.

35. The frame material is of invar, heavily silver plated according to the NRL formula developed under this project. The parallel bar members have a diameter of 1/4 inch and spacing, center to center of 3/4 inch, or $b = 3/4"$, and $a = \frac{d}{2} = 1/8"$.

$$\frac{b}{a} = \frac{3/4}{1/8} = 6.$$

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$Z_0 = 276 \log \frac{b}{a} = 214.5$ ohms, surge impedance. The tuning condenser has a capacity variation of 19 μmf .

The frequency range, including overlap is

$$\Delta f = 125 \text{ to } 220 \text{ MC}$$

C_1 = minimum capacity

$$C_2 = \text{maximum capacity} = C_1 + \Delta C$$

$$\frac{C_1}{C_2} = \left(\frac{f_2}{f_1} \right)^2 = \frac{C_1}{C_1 + \Delta C}$$

$$\text{or } \frac{C_1}{C_1 + 19} = \left(\frac{125}{220} \right)^2 = .323$$

$$C_1 = .323 (C_1 + 19) = .323 C_1 + 6.14$$

$$C_1 = 9.07 \mu\text{mf}$$

$$C_2 = 9.07 + 19 = 28.07 \mu\text{mf}.$$

The inductance required to tune with this capacity is,

$$L = \frac{1}{(2\pi)^2 \times f^2 \times C_2} = \frac{1}{39.4 \times (125)^2 \times 28.07} = .0578 \mu\text{h}$$

The inductive reactance at say 200 MC is,

$$X_L = 6.28 \times 200 \times .0578 = 72.5 \text{ ohms}$$

The sending end impedance of a line appreciably shorter than $\lambda/4$ is very nearly a pure inductive reactance, or

$$Z_s = Z_0 \tan 2\pi \frac{l}{\lambda} = 72.5 \text{ ohms}$$

$$\text{or } Z_s = 214.5 \tan \left(\frac{l}{\lambda} \times 360^\circ \right) = 72.5 \text{ ohms}$$

$$\tan \left(\frac{l}{\lambda} \times 360^\circ \right) = \frac{72.5}{214.5} = .338 = \tan 18.67^\circ$$

$$\frac{l}{\lambda} = \frac{18.67}{360} = .0519$$

For 200 MC, $\lambda = 150$ cm, or

$$l = 150 \times .0519 = 7.78 \text{ cm.} = 3.06 \text{ inches,}$$

the length of frame required.

The frames were made 3.25 inches long, and C_1 was adjusted by means of fixed ceramic compensating condensers and adjustable trimmers to give a tuning range of

$$\Delta f = 125 \text{ to } 223 \text{ MC}$$

The oscillator circuit was computed in a similar manner, to operate at frequencies 13 MC higher than the carrier to produce the intermediate frequency, and found to require a shorter length, and a higher value for C_1 . The oscillator frame was constructed to the same dimensions as the others, then provided with an adjustable slider for shortening its length to the right value.

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36. The Q of the unloaded frames may be computed as follows. The spacing factor for the leg members is,

$$M = 1.06$$

and for the end bar is,

$$M' = 1.00$$

$$a = .3175 \text{ cm.}$$

The resistance in all members due to skin effect is,

$$\begin{aligned} \sum R &= \ell (M83.2 \frac{\sqrt{f}}{a} \times 10^{-9}) + (b - 2a) (M'83.2 \frac{\sqrt{f}}{a} \times 10^{-9}) \\ &= 6.94 (3.93 \times 10^{-3}) + 1.27 (3.7 \times 10^{-3}) \\ &= (27.25 + 4.7) \times 10^{-3} = 31.95 \times 10^{-3} \text{ ohms.} \end{aligned}$$

The second term in the above equation is the resistance in the end bar, which has been ignored by previous investigators, but which has an appreciable effect on the Q.

$$Q_L = \frac{Z_s}{\sum R} = \frac{72.5}{31.95} \times 10^3 = 2270, \text{ the maximum value for}$$

the frame with no load.

$$Z = Q_L X = 2270 \times 72.5 = 164,800 \text{ ohms, maximum value with no load.}$$

The Q is dropped to a usable value of 200 for gang tuning, by tapping the tube leads up higher on the frames than would be done for accurate matching of impedances.

37. The tuning condensers were all of equal values of capacity, and have been described in the performance report R-1736. They were mounted at the open end of each frame, and ganged together by flexible coupling units. These couplers are not considered the ideal assembly method, but were felt to be the most practical at the present state of the art. Also the condenser shafts are too small in diameter, and allow some torsional lash in tuning. This is probably a more serious defect than the use of the couplers. The tuning assembly is driven by a National 20 to 1 reduction gear drive and 500 division dial which has negligible backlash. The trimmer condensers have a capacity range of about 1/2 micromicrofarad. The ceramic temperature compensating condensers have fixed values of between 2 and 3 micromicrofarads, depending upon the circuit loading, and a negative temperature coefficient of .00035 uuf/uuf/degree. With the proper values of these condensers, the proper adjustment of trimmers, and proper adjustment of oscillator inductance, very little bending of the r-f and mixer tuning condenser plates is required for tracking. If one outer plate of the r-f and mixer tuning condenser were serrated the tracking procedure might be simplified, but this was not found necessary in the present models.

38. The input to the r-f stage is from a 70 ohm transmission line through a standard Navy plug fitting. The present receivers have two fittings to provide for a balanced input, but this should not be required with most antennas. The fitting is coupled to a low impedance point on the r-f frame through a 10 micromicrofarad zero temperature

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efficient condenser. Condensers of this type in their proper values were used in the circuit wherever their effect upon the frequency was considered appreciable.

39. The circuit diagrams and preselector constructional details are covered by drawings:

46 F 440
46 A 455 (Plate 2)
46 F 456 (Plate 3)

40. Two concentric line preselectors of different designs were also constructed. The first one contains two concentric line units with individual tuning, and is covered by drawings 46 F 439. This preselector was designed to cover the range 130 to 160 MC, which it did successfully. The oscillator unit, however, was constructed to the same physical dimensions as the r-f (mixer input) unit, and did not lend itself to adjustment of inductance, nor to tracking with the r-f unit. The tuning was accomplished by capacity variation, by a differential screw thread which varied the spacing between the two plates of the condenser. The design was cumbersome, and production quite expensive, resulting in a preselector that would not be practical to manufacture.

41. The second concentric line preselector contains three concentric line units tuned by rotary condensers similar to those used in the frame preselectors, and ganged to a single tuning dial. This preselector is shown in detail in drawings 46 F 462. The oscillator unit has a concentric line whose ratio of diameters of outer to inner conductor is less than that for the r-f and mixer units, resulting in less inductance. Also this unit has been provided with inductance trimmers for more accurate adjustment. The tuning condensers have the same range as for the frame preselectors. The inductance of a very short concentric line is the same as for a single turn toroid, and may be found from,

$$L = .0117l \log_{10} \frac{r_2}{r_1}$$

where l , r_2 and r_1 are in inches. The resistance due to skin effect, including that for the ends of the line, is

$$R_L = \left[\frac{l}{2\pi} \left(\frac{1}{r_1} + \frac{1}{r_2} \right) + .734 \log_{10} \frac{r_2}{r_1} \right] .26 \sqrt{f \times 10^{-6}} \text{ ohms}$$

This second concentric line preselector has been completed mechanically, but has not been wired as yet. Input to the r-f stage may be by an inductive coupling loop, or by capacitive coupling to the inner conductor.

RESULTS

42. The results of this development have been covered in the test report R-1736.

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CONCLUSIONS

43. Receivers of high sensitivity for single and double modulation have been successfully developed.

44. Single dial control of tuning, with relatively high Q circuits, was found to be practical at these frequencies of 130 to 210 MC.

45. The tuned frame type of preselector was found to be practical mechanically and with good electrical characteristics at these frequencies.

46. Due to the circuit complexity of combining single and double modulation in one receiver, the equipment does not give the best possible results for either type of reception. The Receivers do not comply with reference (b) in some respects.

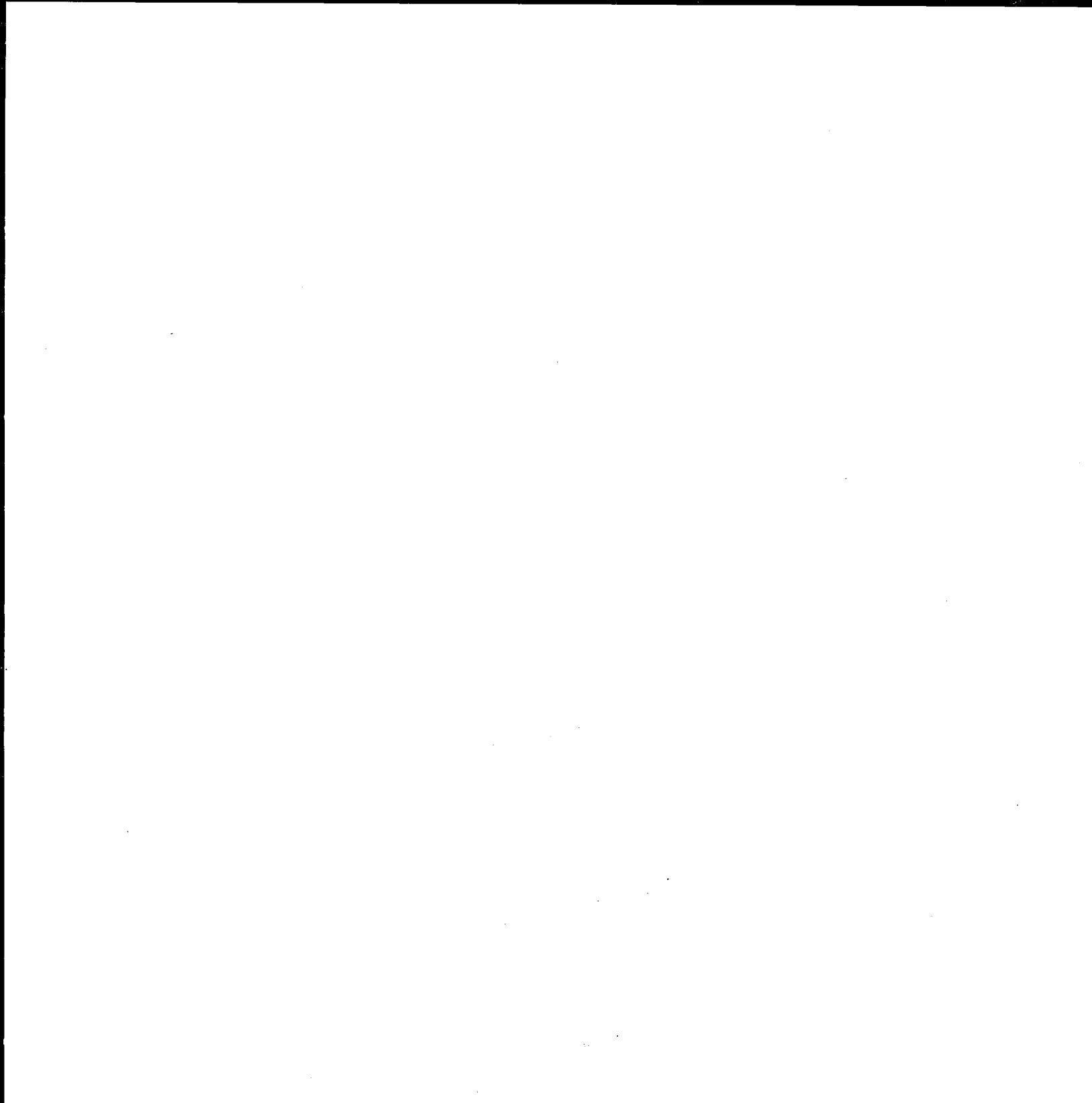
47. The i-f band width, and consequently the carrier channel spacing, are dependent upon the stability of the first oscillator and the Q of the preselector circuits. This receiver has higher Q preselector circuits and far greater frequency stability from a percentage standpoint than any previous equipment produced for service without the use of crystals or temperature control units.

48. Any closer channel spacing than obtained with this receiver would require complications in design which would be expensive and might reduce the general utility of the equipment.

DECLASSIFIED

DECLASSIFIED


UNCLASSIFIED



RECOMMENDATIONS

49. It is recommended that fleet tests be conducted to determine the relative merits of single and double modulation.

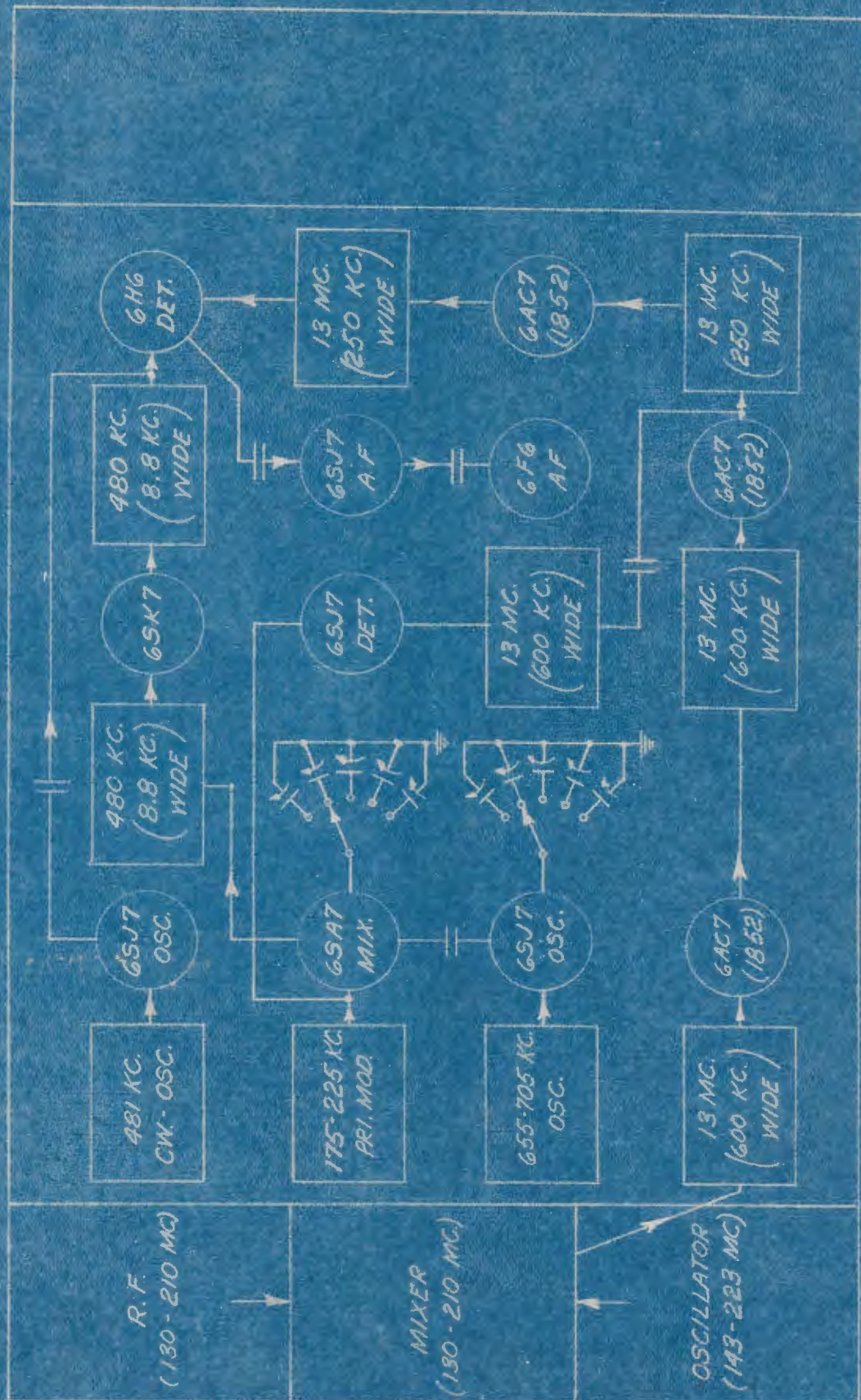
50. The unfinished gang-tuned concentric line preselector should be tested to determine its electrical characteristics and practicability.

51. If both types of modulation are retained for service, the receivers for each type should be separate units.

52. Further preselectors should be developed for higher frequencies than are covered by these receivers.

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POWER PACK

I-F & A-F UNIT

TOP VIEW OF RECEIVER LAYOUT

PRESELECTOR

FOI ASSIFIED

NOT ASSIFIED

NOTE: ALL DIMENSIONS PLUS OR MINUS

UNLESS OTHERWISE SPECIFIED

J. S. NAVAL RESEARCH LABORATORY BELLEVUE, D. C.

ALTERATIONS	
DRAWN	A. G. K. - 9-12-43
CHECKED	
APPROVED	

NAME TUNED FRAME PRESELECTOR FOR
MULTIPLE MODULATION RECEIVER, 130-210 MC
WIRING DIAGRAM

MATERIAL

FINISH

REFERENCE NUMBER

46A455

