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DATE 24 July 1939

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Tests of Two RAG-1 Receiving Equipments,

Serial No. 1 and Serial No. 18.

NRL report No. R-1546
Tests of Two RAG-1 Receiving Equipments,
Serial No. 1 and Serial No. 18.



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NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report
on

Tests of Two RAG-1 Receiving Equipments,
Serial No. 1 and Serial No. 18.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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- (f) WML Report No. 2-117.
- (g) WML Report No. 2-118.
- (h) WML conf. ltr. C-287/48 of 8 July 1949.

SCOPE OF TEST

2. The objects of this test were first, to determine the suitability of the Type RM-1 equipment for secondary use, to determine the characteristics in operating characteristics due to service use; third, to detect and estimate the specifications, design, or operation of the equipment as might be improved with advantage.

ABSTRACT OF TEST

3. The two Type RM-1 receiving equipments, serial numbers 1 and 18, were received from the Fleet and subjected to tests in accordance with references (a) and (b). Tests were first conducted using the receivers and tubes as they arrived from the Fleet, with no internal adjustments. Next, the receivers were realigned using the original tubes and tested for sensitivity. Then the receivers were supplied with a new complement of tubes, the same set of tubes being used with both receivers, and the complete test repeated. Tests were conducted to determine:

- (a) Calibration.
- (b) CR sensitivity.
- (c) Noise level.
- (d) Selectivity - optimum gain.
- (e) Sensitivity control range.
- (f) Audio filter characteristics.
- (g) Overall fidelity at 600 micropoles.
- (h) Resonant overload.
- (i) Limiter action.
- (j) Frequency overlap.

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AUTHORIZATION

1. The tests herein reported were authorized by reference (a). Other pertinent data are listed as references (b) to (h), inclusive.

- Reference:
- (a) BuEng.ltr. C-S67/46 (5-22-R6) of 25 May 1939.
 - (b) BuEng. Specifications RE 13A 466C.
 - (c) Instruction Book for Models RAG and RAH Receivers.
 - (d) BuEng. Specifications RE 13A 466B.
 - (e) BuEng. Specifications RE 13A 571A.
 - (f) NRL Report No. R-1178.
 - (g) NRL Report No. R-1093.
 - (h) NRL conf.ltr. C-S67/46 of 6 July 1939.

OBJECT OF TEST

2. The objects of this test were first, to determine the suitability of the Type RAG equipment for reorder; second, to determine the deterioration in operating characteristics due to service use; third, to detect such conditions in the specifications, design, or operation of the equipment as might be improved with advantage.

ABSTRACT OF TEST

3. The two Type RAG-1 receiving equipments, serial numbers 1 and 18, were received from the Fleet and subjected to tests in accordance with references (a) and (b). Tests were first conducted using the receivers and tubes as they arrived from the Fleet, with no internal adjustments. Next, the receivers were realigned using the original tubes and tested for sensitivity. Then the receivers were supplied with a new complement of tubes, the same set of tubes being used with both receivers, and the complete test repeated. Tests were conducted to determine:

- (a) Calibration.
- (b) CW sensitivity.
- (c) Noise level.
- (d) Selectivity - optimum gain.
- (e) Sensitivity control range.
- (f) Audio filter characteristics.
- (g) Overall fidelity at 600 kilocycles.
- (h) Resonant overload.
- (i) Limiter action.
- (j) Frequency overlap.

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CONCLUSIONS

(a) The results of the tests indicate that these RAG-1 receivers, after such actual service as they may have had to date, did not meet the requirements of reference (b), neither as received from the Fleet nor after careful alignment and adjustment according to reference (c).

(b) The receivers were found to have drifted only slightly out of alignment since last adjusted, which may have been at the point of manufacture.

(c) The sensitivity of both receivers was unsatisfactory in Bands 1 and 2, both before and after realignment with new tubes.

(d) The selectivity of both receivers was unsatisfactory in Band 1, both before and after realignment with new tubes. It should be noted that the selectivity curves shown in reference (c) were taken on cw with the beat oscillator in operation, and thus are a measure of only the audio filter selectivity, while the curves included in this report indicate very nearly the true r-f selectivity.

(e) The sensitivity and selectivity of both receivers appeared to have deteriorated in all bands, and could not be improved sufficiently by normal adjustments so as to equal the values previously reported on the original test model. It is felt that this deterioration is largely due to a reduction in circuit Q as the result of aging of the inductances.

(f) The antenna trimmer was found unsatisfactory in that it required adjustment for each frequency in all bands.

(g) The lock nuts on some of the coil unit trimmer condensers were inoperative.

(h) The band-pass audio filter may be considered as meeting the specifications if a frequency of 1000 cycles is used as the reference point. No difficulty should be encountered in meeting much more rigid requirements, as is indicated by the Models RAA and RAB receivers.

(i) The peak audio filters were found to be unsatisfactory at the low and high ends of their range, and at some of the intermediate points.

(j) Harmonics, generated in the detector, were found to produce undesirable fidelity characteristics.

(k) The maximum noise level of one receiver exceeds 300 microwatts in one band. Both receivers fall far below 300 microwatts in some bands, a natural result of the limitation of noise to such a low level. A further result of this limitation is a lack of reserve gain, it being necessary to operate the receivers at maximum gain over most of the frequency range in order to make sensitivity measurements.

(l) Resonant overload occurs in some cases at less than 250 milliwatts, but is considered to be satisfactory in general.

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(m) The manual gain control has a range of more than 100 decibels in both receivers and is satisfactory.

(n) The output limiter action is satisfactory.

(o) The useful sensitivity at some points in the range of the receiver could be improved by the simple expedient of reducing the effective bias on the r.f. tubes, as the present full gain position of this bias control does not give full standard noise level throughout the range. Such a change would not, however, bring the sensitivity within specification limits at the points where standard noise level is obtainable with existing gain and the specification limit is not met. It is believed that specification limits will be met only after improved selectivity is realized.

That the prospective contractor be not only permitted, but urged, to consider a different coupling system in the r.f. amplifier stage than used in the model. It is not apparent that a maximum sensitivity gain noise sensitivity can be realized in an amplifier covering the range of 50 to 100 Kilocycles, employing the auto-coupled tube type used, for all frequencies in this band.

That the variable noise level be not limited to 20 millivolts as specified but that a variation of 100 millivolts be permitted to provide reserve gain to compensate for general degradation of tubes, capacitors, and alignment, resulting from aging.

That the band-pass filter specified under paragraph 2-1(21) of reference (b) be required to be effective at all times, or to operate thereby, and available by means of switching, there be provided a sharp band-pass filter similar to that provided in the Model 241 receiver, the object being to separate the very low frequency channels which are less than 20 cycles apart. The variable frequency characteristics in paragraph 2-1(25) to (28) inclusive of reference (b) are considered very useful under very circumstances, and due to their relatively small space requirement are worthy of retention. The present design could not be copied, however, as it has been found to be mechanically very difficult to reproduce electrically, as indicated by the tests. The band-pass filter in the present model has air core coils of appreciable rather poor efficiency and the entire unit is unnecessarily large. It is possible that the two band-pass filters suggested above, if properly designed, will occupy no more space than the present one.

That provision be made in the detector stage circuit for the use of a d-c meter to be employed for r-f selectivity measurements, and that such jack or terminals as provided be properly aligned to permit the usual receiver performance will provide what is required.

That provision of a dc (oscillator) for all r-f stages be considered.

That the receiving input circuit be designed so that specifications for sensitivity will prevail throughout the range of the receiver. Proper attention has been made for the design of the receiver.

RECOMMENDATIONS

(a) After a careful study of the above test results and in the light of modern practice, it is believed that better performance than demonstrated can be expected in new receivers for the low frequency part of the spectrum. Improvement in sensitivity, overall selectivity, audio selectivity and greater reserve gain can be reasonably expected. With this in mind, the following recommendations are submitted for consideration.

(b) That the performance specifications as given in RE 13A 466C apply to the purchase of new equipment with certain exceptions as listed below and that the inferior performance of the units tested not be considered as acceptable.

(c) That the prospective contractor be not only permitted, but urged, to consider a different coupling system in the r-f amplifier stages than used in the model. It is not apparent that a maximum selectivity, and hence sensitivity, can be realized in an amplifier covering the range of 15 to 600 kilocycles, employing the same choke coil, as a plate load, for all frequencies in this band.

(d) That the maximum noise level be not limited to 300 microwatts as specified but that a maximum of 100 milliwatts be permitted to provide reserve gain to compensate for general depreciation of tubes, components, and alignment, resulting from aging.

(e) That the band-pass filter specified under paragraph 2-1(21) of reference (b) be required to be effective at all times, but in addition thereto, and available by means of switching, there be provided a sharp band-pass filter similar to that provided in the Model RAA receiver, its object being to separate the very low frequency channels which are but 200 cycles apart. The variable frequency attenuators described in paragraph 2-1(25) to (32) inclusive of reference (b) are considered very useful under many circumstances, and due to their relatively small space requirement are worthy of retention. The present design should not be copied, however, as it has been found to be mechanically weak and appears to depreciate electrically, as indicated by the tests. The band-pass filter in the present models has air core coils of apparently rather poor efficiency and the entire unit is unnecessarily large. It is probable that the two band-pass filters suggested above, if properly designed, will occupy no more space than the present one.

(f) That provision be made in the detector plate circuit for insertion of a d-c meter to be employed for r-f selectivity measurements, and that such jack or terminals as provided be properly by-passed to assure that normal receiver performance will prevail when such a meter is used.

(g) That provision of a cw (oscillator) "on and off" switch be considered.

(h) That the receiver input circuit be so designed that specification sensitivity will prevail throughout any one band after the antenna trimmer adjustment has once been made for any point within the band.

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(i) That the coil unit trimmer condensers be equipped with reliable locking devices which will continue to function throughout the life of the receiver.

(j) That the power cable between the receiver and the power unit be completely covered with a conducting braid so tightly woven as to leave no apparent spacing between the individual wires of the braid and that these braid coverings be connected through such coupling means as to assure no appreciable electrical discontinuity between the braid and the box walls at the point of entry of either box. The cables should also have a sturdy outer rubber covering to provide physical protection for the braid shield.

(k) That the antenna and power supply leads be brought into the receiver in such a manner as to reduce the electrical coupling to a minimum. Bringing them into the receiver parallel and adjacent to each other, as in the model, is unsatisfactory.

(l) That provision be made to assure that the contact areas of all component parts such as box aperture edges, panel backs, covers and chassis components, which depend upon pressure contact for electrical continuity or shielding integrity, maintain good conductivity throughout the life of the equipment unless intentionally open circuited by disassembly for repairs or adjustments; and also be assured of regaining good electrical conductivity and shielding after reassembly by the reverse procedure to that of disassembly. The bolting or screw-locking of pressure contacts as between the panel back and the receiver case, where such contacts are anodized and/or lacquered as in the model, is unacceptable.

(m) That all receiver cases be made the equivalent of one piece construction so far as electrical continuity is concerned. The use of riveted lap seams with anodized or lacquered material where such seams admit light for over 90 per cent of their length, as in the model, is not acceptable.

(n) That the receiver be required to operate in a field strength of 10 volts per meter at any frequency within its range with the antenna input binding post shielded so as not to contribute to the receiver input, giving an output under standard gain conditions not exceeding 6 milliwatts. Items 47 - 50 are believed to be necessary as means of accomplishing the requirements of (51).

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MATERIAL UNDER TEST

4. The material under test consisted of two radio receiving equipments, Type RAG-1, Serial No. 1 and Serial No. 18. These equipments were manufactured by the Hygrade Sylvania Corporation, Clifton, New Jersey, and had been in service for some time.

5. The Type RAG-1 equipment covers a rated frequency range of 15 to 600 kilocycles in four bands, by means of tuning condensers and a coil switching mechanism. It consists of the following units:

- (a) Bellini-type VT voltmeter, Type 45, Serial No. 11.
- (b) General Radio heat frequency oscillator, Type 71, Serial No. 11.
- (c) Weston tube analyzer, Model 80-4, Serial No. 11.
- (d) General Radio wave analyzer, Type 470, Serial No. 11.

METHOD OF TEST

7. Tests were conducted in accordance with references (a) and (b).

8. For radio frequency tests the signal generator was coupled to the receiver input terminals through the dummy antenna, and a-4 output being measured across a 600 ohm resistive load by means of the output meter or the Bellini-type voltmeter as desired.

9. Sensitivity measurements were made using a 1000 cycle sine wave in the output, with a signal plus noise output of 5 milliwatts, 10 milliwatts above the noise level.

10. Selectivity measurements were made with the test oscillator representative, and the input signal modulated 50 per cent at 100 cycles for bands 1, 2 and 3 to avoid side-band cutting, and modulated 25 per cent at 100 cycles for Band 4. Due to attenuation in the audio filter, it was necessary to operate at a low output level to avoid excessive overloading. The system is not recommended unless provision is made for passing the audio filter, but was employed as an alternative method of the receiver plate current-change method for which there was no provision.

11. Noise level measurements were made at various points with output voltage trimmer settings for each point.

12. The audio filter characteristics were measured by removing the detector tube and feeding the audio signal into the receiver output directly through a series resistor and capacity of 25,000 ohms and 2 microfarads. The input voltage was maintained constant, while the frequency was varied and the receiver output measured.

13. The overall fidelity at 600 kilocycles was measured by externally modulating the signal generator of the normal band of a heat frequency oscillator of 100 kilocycles carrier, introducing a constant input voltage to the receiver, and measuring its output.

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- (a) One Navy Type CHS-46042 receiver.
- (b) One Navy Type CHS-20032 power unit.
- (c) One set of interconnecting cables.

TEST INSTRUMENTS

6. The following instruments were employed in these tests:
- (a) General Radio signal generator, Model LC-1, Serial No. 18.
 - (b) Naval Research Laboratory 600 ohm output volt-power meter.
 - (c) General Radio dummy antenna, Type 418G.
 - (d) Ballantine VT voltmeter, Type 300, Serial No. 14.
 - (e) General Radio beat frequency oscillator, Type 713A, Serial No. 141.
 - (f) Weston tube analyzer, Model OD-A, Serial No. 395 (corrected for error).
 - (g) General Radio wave analyzer, Type 636A, Serial No. 102.

METHOD OF TEST

7. Tests were conducted in accordance with references (a) and (b).
8. For radio frequency tests the signal generator was coupled to the receiver input terminals through the dummy antenna, the a-f output being measured across a 600 ohm resistive load by means of the output meter or the Ballantine voltmeter as desired.
9. Sensitivity measurements were made using a 1000 cycle cw beat note in the output, with a signal plus noise output of 6 milliwatts, 20 decibels above the noise level.
10. Selectivity measurements were made with the cw beat oscillator inoperative, and the input signal modulated 40 per cent at 100 cycles for Bands 1, 2 and 3 to avoid side-band cutting, and modulated 40 per cent at 400 cycles for Band 4. Due to attenuation in the audio filter, it was necessary to operate at a low output level to avoid detector overloading. The system is not recommended unless provision is made for cutting out the audio filter, but was employed as an alternative instead of the detector plate current-change method for which there also was no provision.
11. Noise level measurements were made at maximum gain with optimum antenna trimmer settings for each point.
12. The audio filter characteristics were measured by removing the detector tube and feeding the audio signal into the detector output circuit through a series resistance and capacity of 25,000 ohms and 2 microfarads. The input voltage was maintained constant, while the frequency was varied and the receiver output measured.
13. The overall fidelity at 600 kilocycles was measured by externally modulating the signal generator in the normal manner with a beat frequency oscillator of low harmonic content, maintaining a constant input voltage to the receiver, and measuring its output.

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14. Resonant overload was measured by recording the receiver output voltage for inputs ranging from 1 microvolt to 1/2 volt, with the receiver adjusted for standard sensitivity.

DATA RECORDED DURING TEST

15. The data recorded during these tests are contained in Table 1 and Plates 1 to 43, inclusive.

PROBABLE ERRORS IN RESULTS

16. The equipment under test and all measuring instruments incorporating vacuum tubes were allowed a warm-up period of at least fifteen minutes before each test.

17. The signal generator output calibration was corrected by measurement with the Ballantine voltmeter, this voltmeter then being used to measure receiver output.

18. The audio beat frequency oscillator and the wave analyzer were calibrated periodically to assure reliable results.

19. The estimated overall error for the various tests is given below:

| <u>Test</u> | <u>Maximum Error</u> |
|---------------------|-----------------------|
| Sensitivity | ± 10% |
| Selectivity | ± 10% (input voltage) |
| Maximum noise level | ± 5% |
| Resonant overload | ± 5% |
| A-F characteristics | ± .3 decibels |
| Limiter action | ± .3 decibels |

RESULTS OF TEST

20. No defective vacuum tubes were found, although the values for S_m were decreased from the rated values. The measured values are recorded in Table 1.

21. In accordance with reference (a), paragraph 8(a), both receivers were tested as they arrived from the Fleet, making no internal adjustments. The results were as follows:

21-1. Calibration. The calibration for RAG-1, Serial No. 18, is shown on Plate 1, and covers the specified range. The calibration for Serial No. 1 is shown on Plate 22, and covers the specified range.

21-2. Antenna Trimmer. Antenna trimmer settings for Serial No. 18 were plotted on Plate 2, failing to reach optimum values in Bands 2 and 3. Antenna trimmer settings for Serial No. 1 were plotted on Plate 23, and resonated satisfactorily.

- 21-3. Sensitivity. Reference (b), paragraph 2-1(1). Sensitivity curves for Serial No. 18 are shown on Plate 3, and for Serial No. 1 on Plate 24. With the antenna trimmer adjusted only once in each band, both receivers failed seriously to meet the sensitivity requirements in all four bands. With the antenna trimmer adjusted for each point of measurement in each band, both receivers still failed to meet the sensitivity requirements except at a few points in Bands 3 and 4.
- 21-4. Selectivity. Reference (b), paragraph 2-1(2). Receiver No. 18 failed to meet the selectivity requirements throughout Band 1, and at one end of Band 2, but met the requirements at all points in Bands 3 and 4. Receiver No. 1 failed to meet the selectivity requirements at some points in Bands 1, 3 and 4. The deviation from the requirements was not large for either receiver however. Selectivity curves for Serial No. 18 are shown on Plates 4 to 7, and for Serial No. 1 on Plates 25 to 28, inclusive.
- 21-5. Band-pass Filter. Reference (b), paragraph 2-1(21). The band-pass filter characteristics are shown on Plate 8 for receiver No. 18 and Plate 29 for receiver No. 1. The filters of both receivers are centered within ± 10 per cent of 800 cycles. If the 1000 cycle output is taken as the reference level, both receivers meet the band-pass requirements, contrary to the statement of reference (h), paragraph 4e. If the 800 cycle output is taken as the reference level, both receivers fail to meet the requirements at the -6 decibel level, concurring in the statement of reference (h), paragraph 4e. Receiver No. 18 showed a pronounced peak at 280 cycles as indicated on the curve.
- 21-6. Peak Filter. Reference (b), paragraph 2-1(26). Since there was no provision in these receivers for disconnecting the band-pass filter during operation, the peak-filter curves on Plates 8 and 29 were taken with the band-pass in operation. The curves for the lowest and highest peak frequencies are very broad and highly attenuated, failing to meet the requirements.
- 21-7. Reference (b), paragraph 2-1(29). Both receivers failed to meet the peak filter band-width requirements.
- 21-8. Reference (b), paragraph 2-1(30). Both receivers failed to meet the peak filter attenuation requirements at the lowest and highest peak audio frequencies, showing a high insertion loss. The intermediate frequencies were satisfactory, however.
- 21-9. Fidelity. Fidelity curves are shown on Plates 9 and 10 for receiver No. 18, and Plates 30 and 31 for receiver No. 1. These curves, taken at 600 kilocycles, show the true response of the receiver to an incoming signal, regardless of whether the audio frequency is obtained from a modulated signal or from beating a cw signal with the local heterodyne oscillator. A study of the receiver by means of the harmonic analyzer indicated that the detector was responsible for the generation of harmonics which appear on the curves as spurious responses.

22. In accordance with reference (a), paragraph 8(b), both receivers were realigned and the sensitivity curves repeated. The lock nuts on the trimmer condensers were found to be unreliable. On several coil units the lock nuts were stuck tightly to the trimmer shafts and rotated with them.
- 22-1. Sensitivity. Reference (b), paragraph 2-1(1). Sensitivity curves are shown on Plates 11 and 32 for the receivers after realignment with the original tubes. Although somewhat improved over the curves of Plates 3 and 24, both receivers failed to meet the sensitivity requirements in some portions of all bands.
23. A set of new RCA tubes with values of S_m slightly better than average was next installed, the same tubes being used in both receivers. Table 1 gives the values of S_m for these tubes. Receiver No. 1 was found to have one mounting screw missing, and the other one very loose at the forward end of the tuning condenser, providing a poor ground and resulting in oscillations with the new tubes. The defect was remedied and the spurious oscillations ceased. Both receivers were then realigned and measurements made of sensitivity, selectivity, maximum noise level, manual gain control, resonant overload, and output limiter.
- 23-1. Calibration. The calibration curves are shown on Plate 13 for receiver No. 18 and on Plate 33 for receiver No. 1.
- 23-2. Antenna Trimmer. Antenna trimmer settings are plotted on Plates 13 and 34. The curves for Serial No. 18 indicate a failure to reach resonance in Bands 2 and 3. This could be corrected by aligning the receiver at about 920 on the tuning dial instead of 900 as instructed in reference (c). That procedure was followed in aligning receiver No. 1, with more favorable antenna trimmer curves, as shown on Plate 34.
- 23-3. Sensitivity. Reference (b), paragraph 2-1(1). The sensitivity control settings used with optimum antenna trimmer settings are shown on Plates 13 and 34. The sensitivity curves are shown on Plates 14 and 35. With the antenna trimmer adjusted at one point in each band, both receivers failed to meet the sensitivity requirements except at a few points in Bands 3 and 4. With the antenna trimmer adjusted at each point in each band, receiver No. 18 met the sensitivity requirements in Bands 3 and 4, but failed in Bands 1 and 2. Receiver No. 1 met the requirements in Band 3 and a portion of Band 4, but failed in Bands 1, 2, and a portion of 4. This paragraph supersedes that of reference (h), paragraph 6b, with which it is not in entire agreement.
- 23-4. Maximum Noise Level. Reference (b), paragraph 2-1(3). Curves of maximum noise level for both receivers are shown on Plates 15 and 36. Receiver No. 18 exceeded 300 microwatts, the specification maximum, in Band 3, reaching a maximum of 1010 microwatts at 195 kilocycles. Receiver No. 1 did not reach a noise level of 300 microwatts at any frequency. The noise level of both receivers was extremely low in Bands 1, 2 and 4, which may be explained by insufficient gain.

- 23-5. Manual Gain Control. Reference (b), paragraph 2-1 (33, 34, 36, 37, 38, 39). The manual gain (sensitivity) controls on both receivers complied with the specifications. Curves are shown on Plates 16 and 37.
- 23-6. Selectivity. Reference (b), paragraph 2-1(2). Selectivity curves are shown for receiver No. 18 on Plates 17 to 20, and for receiver No. 1 on Plates 38 to 41. Both receivers failed to meet the selectivity requirements at some points in Bands 1, 2 and 3, the deviation being small in Bands 2 and 3. In general, the selectivity of both receivers was unsatisfactory in Band 1, and satisfactory in Bands 2, 3, and 4.
- 23-7. Resonant Overload. Reference (b), paragraph 2-1(4). Resonant overload curves are shown on Plates 21 and 42. The curves for receiver No. 18 show that at a frequency of 15 kilocycles, overload occurred at 11.8 volts or 232 milliwatts output. At the other frequencies tested, overload occurred above 250 milliwatts output. Receiver No. 1 overloaded below 250 milliwatts at all five test frequencies as follows:

| <u>Frequency</u> <u>Kilocycles</u> | <u>Input</u> <u>Microvolts</u> | <u>Overload Point</u> | |
|---------------------------------------|-----------------------------------|-------------------------------|------------------------------------|
| | | <u>Output</u> <u>Volts</u> | <u>Output</u> <u>Milliwatts</u> |
| 15 | 73 | 10.1 | 170 |
| 38 | 160 | 11.4 | 217 |
| 95 | 46 | 11.1 | 205 |
| 240 | 32 | 12 | 240 |
| 600 | 23 | 11 | 202 |

The maximum output obtained was approximately 375 milliwatts for each receiver, and decreased to 60 milliwatts in Band 2 for a signal input of 1/2 volt.

- 23-8. Output Limiter. Reference (b), paragraph 2-1 (41-46). The output limiter action for receiver No. 1 is shown on Plate 43. The variation in output is within the specified limit of 2 to 1 in voltage (6 decibels) for changes in input of 10 to 1 for all inputs above 10 microvolts with the limiter control set at 10 or 5, and for all inputs above 20 microvolts with the limiter control set at 0. The limiter introduces an insertion loss of 1.8 decibels at the 6 milliwatt standard sensitivity level. No tolerance is given in the specification. The limiter action of receiver No. 18 was not measured.

CONCLUSIONS

24. The results of the tests indicate that these RAG-1 receivers, after such actual service as they may have had to date, did not meet the requirements of reference (b), neither as received from the Fleet nor after careful alignment and adjustment according to reference (c).

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25. The receivers were found to have drifted only slightly out of alignment since last adjusted, which may have been at the point of manufacture.

26. The sensitivity of both receivers was unsatisfactory in Bands 1 and 2, both before and after realignment with new tubes.

27. The selectivity of both receivers was unsatisfactory in Band 1, both before and after realignment with new tubes. It should be noted that the selectivity curves shown in reference (c) were taken on cw with the beat oscillator in operation, and thus are a measure of only the audio filter selectivity, while the curves included in this report indicate very nearly the true r-f selectivity.

28. The sensitivity and selectivity of both receivers appeared to have deteriorated in all bands, and could not be improved sufficiently by normal adjustments so as to equal the values previously reported on the original test model. It is felt that this deterioration is largely due to a reduction in circuit Q as the result of aging of the inductances.

29. The antenna trimmer was found unsatisfactory in that it required adjustment for each frequency in all bands.

30. The lock nuts on some of the coil unit trimmer condensers were inoperative.

31. The band-pass audio filter may be considered as meeting the specifications if a frequency of 1000 cycles is used as the reference point. No difficulty should be encountered in meeting much more rigid requirements, as is indicated by the Models RAA and RAB receivers.

32. The peak audio filters were found to be unsatisfactory at the low and high ends of their range, and at some of the intermediate points.

33. Harmonics, generated in the detector, were found to produce undesirable fidelity characteristics.

34. The maximum noise level of one receiver exceeds 300 microwatts in one band. Both receivers fall far below 300 microwatts in some bands, a natural result of the limitation of noise to such a low level. A further result of this limitation is a lack of reserve gain, it being necessary to operate the receivers at maximum gain over most of the frequency range in order to make sensitivity measurements.

35. Resonant overload occurs in some cases at less than 250 milliwatts, but is considered to be satisfactory in general.

36. The manual gain control has a range of more than 100 decibels in both receivers and is satisfactory.

37. The output limiter action is satisfactory.

DECLASSIFIED

38. The useful sensitivity at some points in the range of the receiver could be improved by the simple expedient of reducing the effective bias on the r.f. tubes, as the present full gain position of this bias control does not give full standard noise level throughout the range. Such a change would not, however, bring the sensitivity within specification limits at the points where standard noise level is obtainable with existing gain and the specification limit is not met. It is believed that specification limits will be met only after improved selectivity is realized.

| Location of | Tube Type | Original | Proposed | Remarks |
|-------------|-----------|----------|----------|---------|
| 1st AF | 6X4-3000A | 2500 | 1500 | |
| 2nd AF | 6X4-3000A | 1500 | 1000 | |
| 3rd AF | 6X4-3000A | 1000 | 750 | |
| Detector | 6X4-3000A | 1000 | 750 | |
| 1st IF | 6X4-3000A | 1000 | 750 | |
| 2nd IF | 6X4-3000A | 1000 | 750 | |

Measurements made with E_p of 250 volts, and frequency of 1000 kc/sec.

TABLE 1

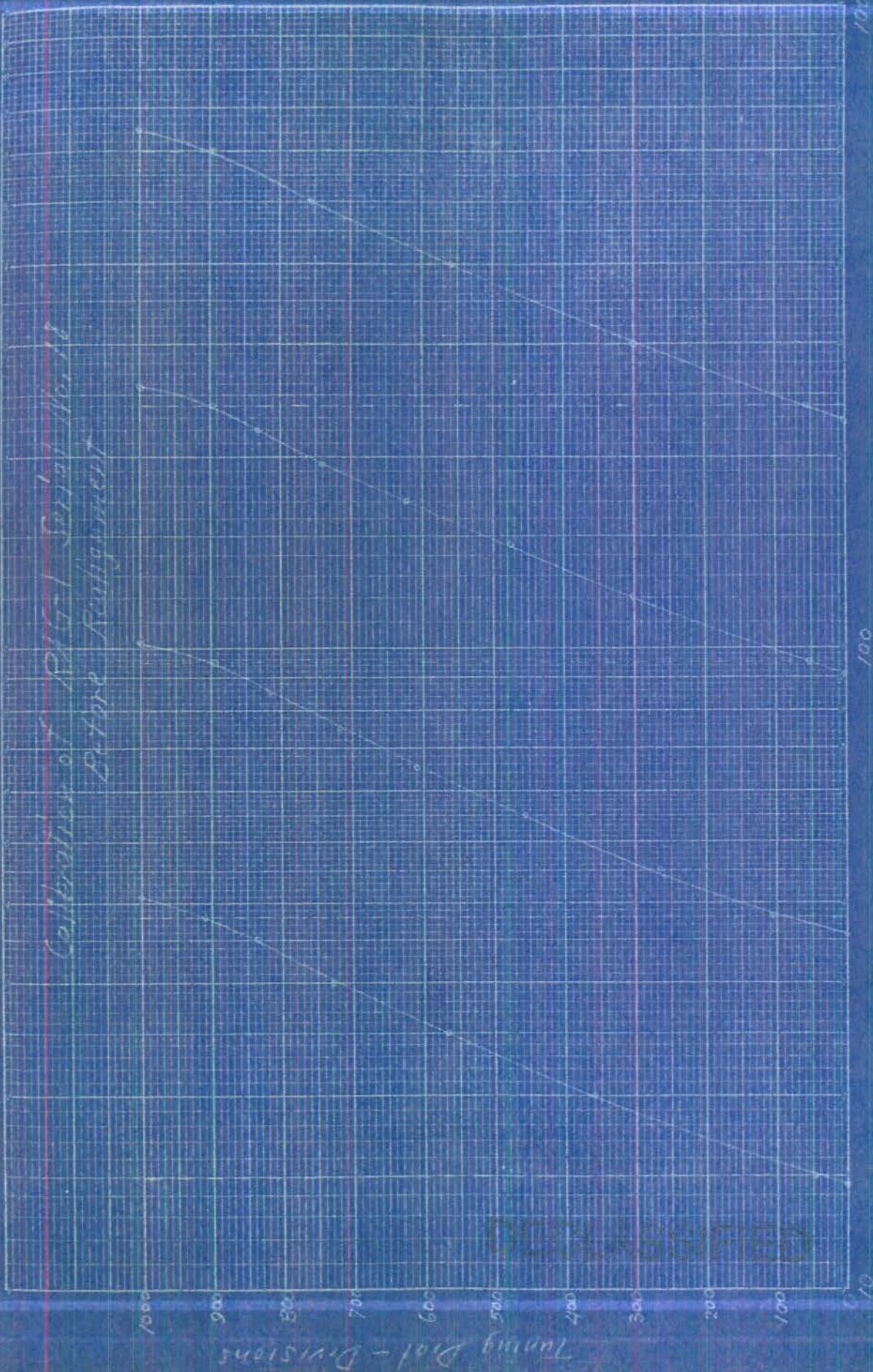
Mutual Conductance of Tubes Used in
Tests of RAG-1 Receiving Equipment,
Serial No. 18 and Serial No. 1.

| Position of Tube | Navy Type No. | Mutual Conductance | | |
|---------------------|------------------|-------------------------|-----------|--------------------|
| | | Original Sylvania Tubes | | New RCA Tubes |
| | | Ser.No. 18 | Ser.No. 1 | For both Receivers |
| 1st R.F. | CHS-38646 | 1760 | 1670 | 1760 |
| 2nd R.F. | CHS-38646 | 1640 | 1640 | 1780 |
| 3rd R.F. | CHS-38646 | 1560 | 1670 | 1760 |
| Oscillator | CHS-38646 | 1690 | 1630 | 1790 |
| Detector | CHS-38076 | 1200 | 1320 | 1530 |
| 1st A.F. | CHS-38076 | 1260 | 1120 | 1520 |
| Output | CHS-38041 | 1920 | 2200 | 2470 |

Measurements made with E_p of 250 volts, and corresponding screen and bias potentials.

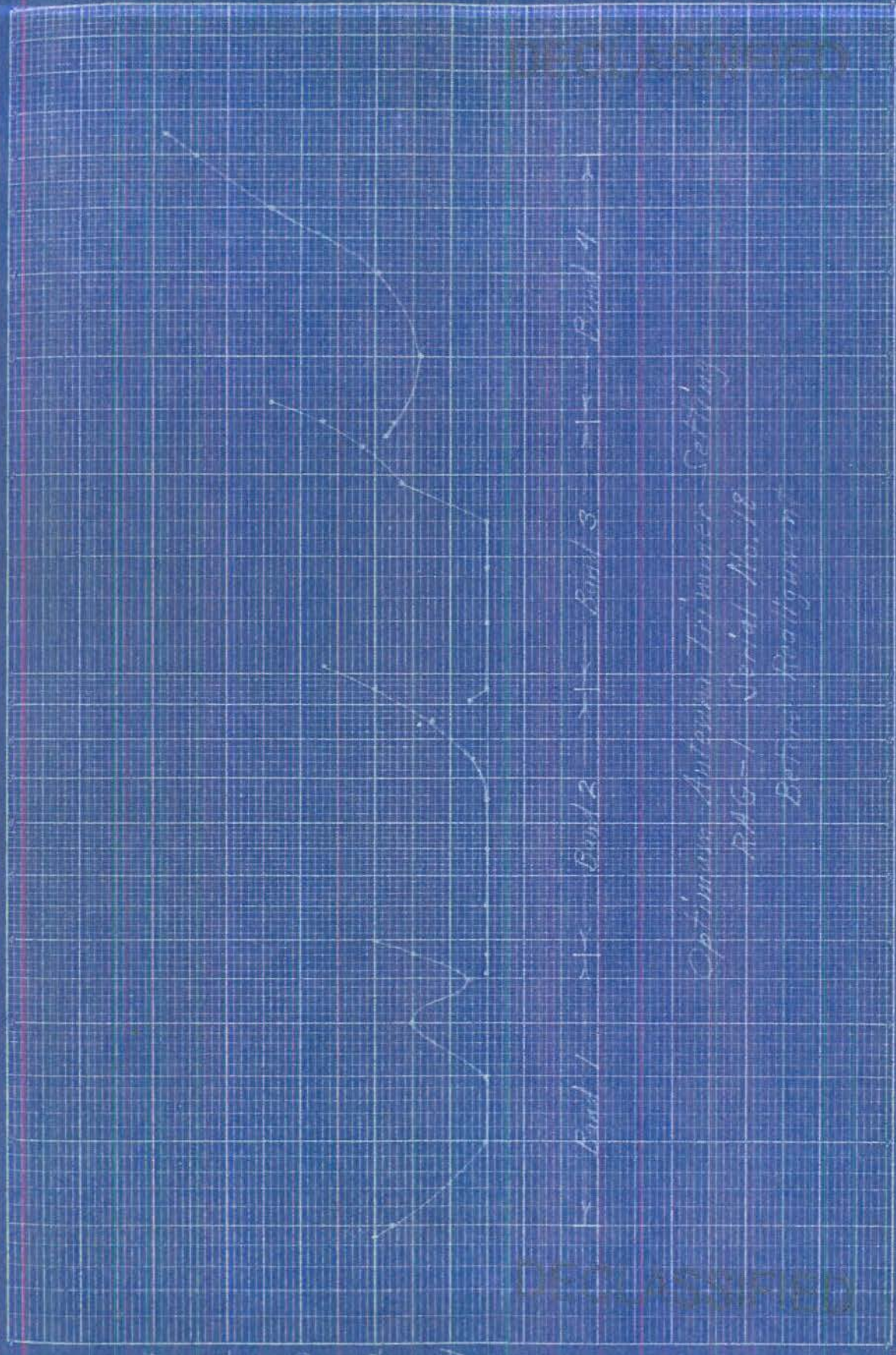
DECLASSIFIED

Calibration of P117-1 Signal Wave
Picture Requisition



Frequency - K.C.

Tuning Dial - Divisions



1000

100

10

Frequency - KC.

Optimum Average Settings

RAG - Serial Mode

Both Radgating

Antenna Trim - Divisions

PLT 2

Sensitivity - Microphone

Plate 3



ear sensitivity for
6 mm output
RAS-1 Serial No. 18
after re-alignment

Loudspeaker
Sensitivity - Telephone on 2500
cycles
- duplicate frequency curves
for Ear and Plate

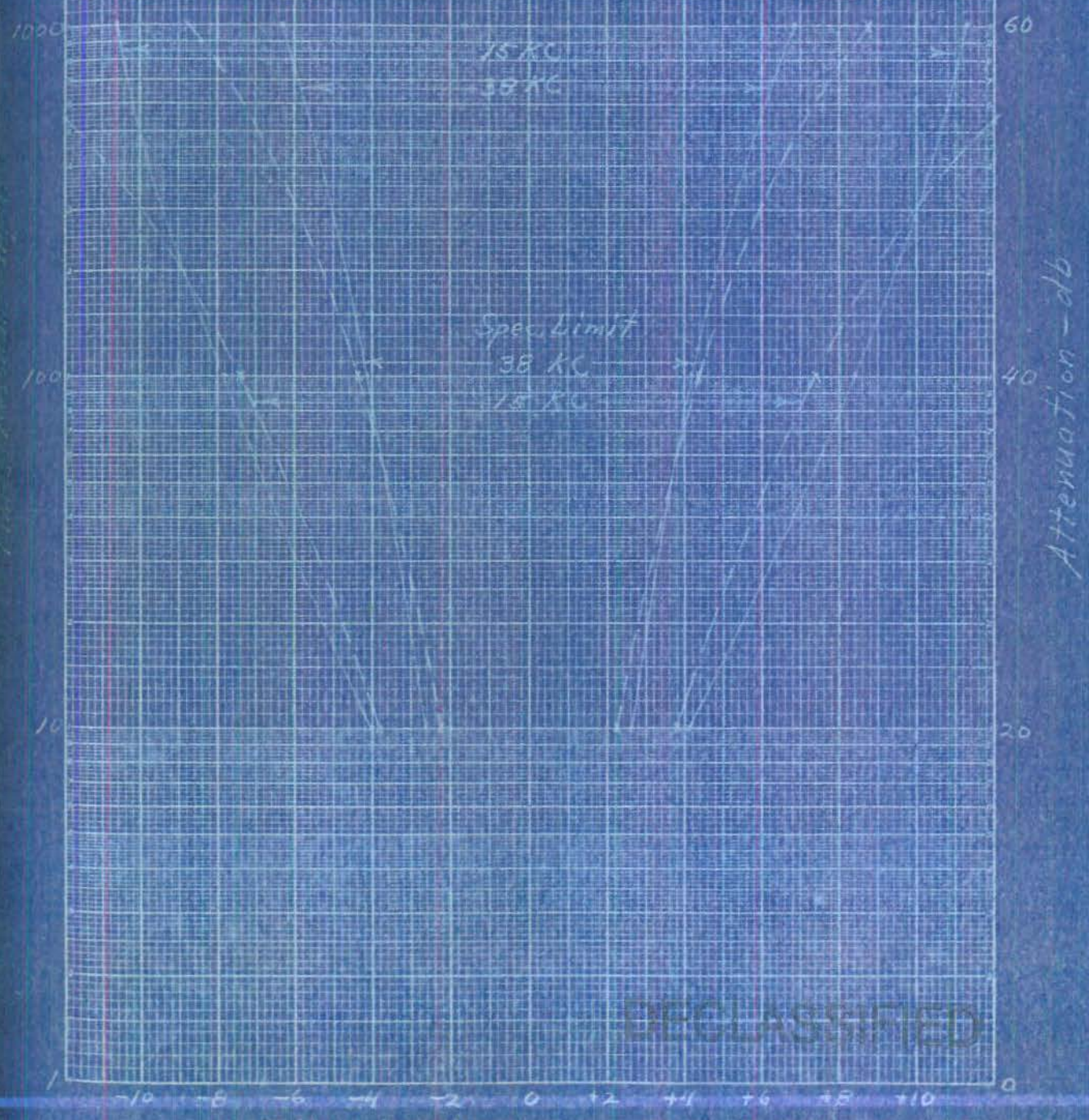
Sensitivity - Ear - plotted

The graph shows bands with similar sensitivity

Frequency - KC

DECLASSIFIED

Selectivity - Optimum Gain
R45-A Serial No. 18
Panel 1
Before Realignment



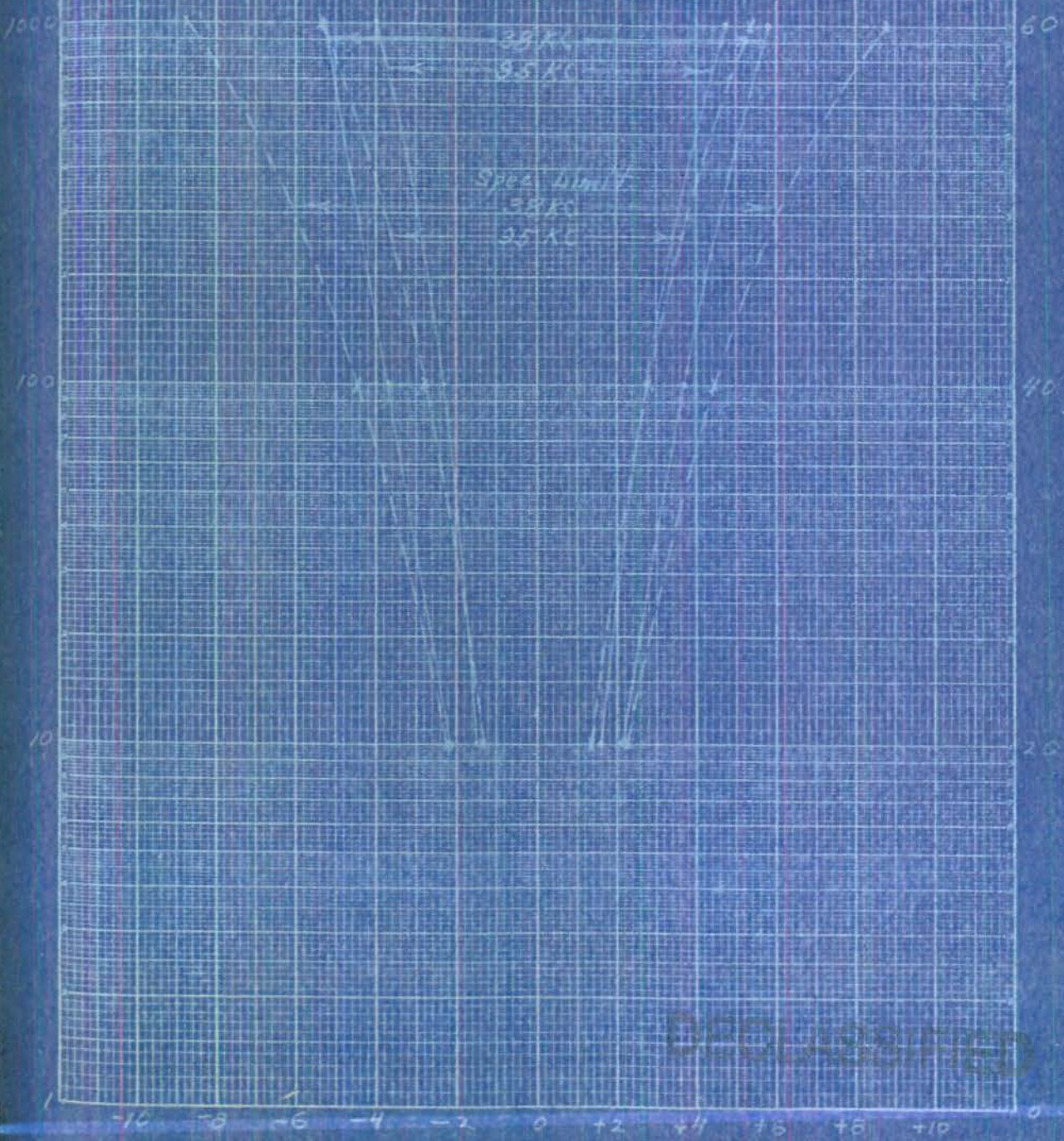
DECLASSIFIED

Percent Off Resonance

Plate 4

QRC 450112

selectivity - Optimum Gain
R1571 Serial No. 12
Band 2
Before Realignment



Attenuation - db

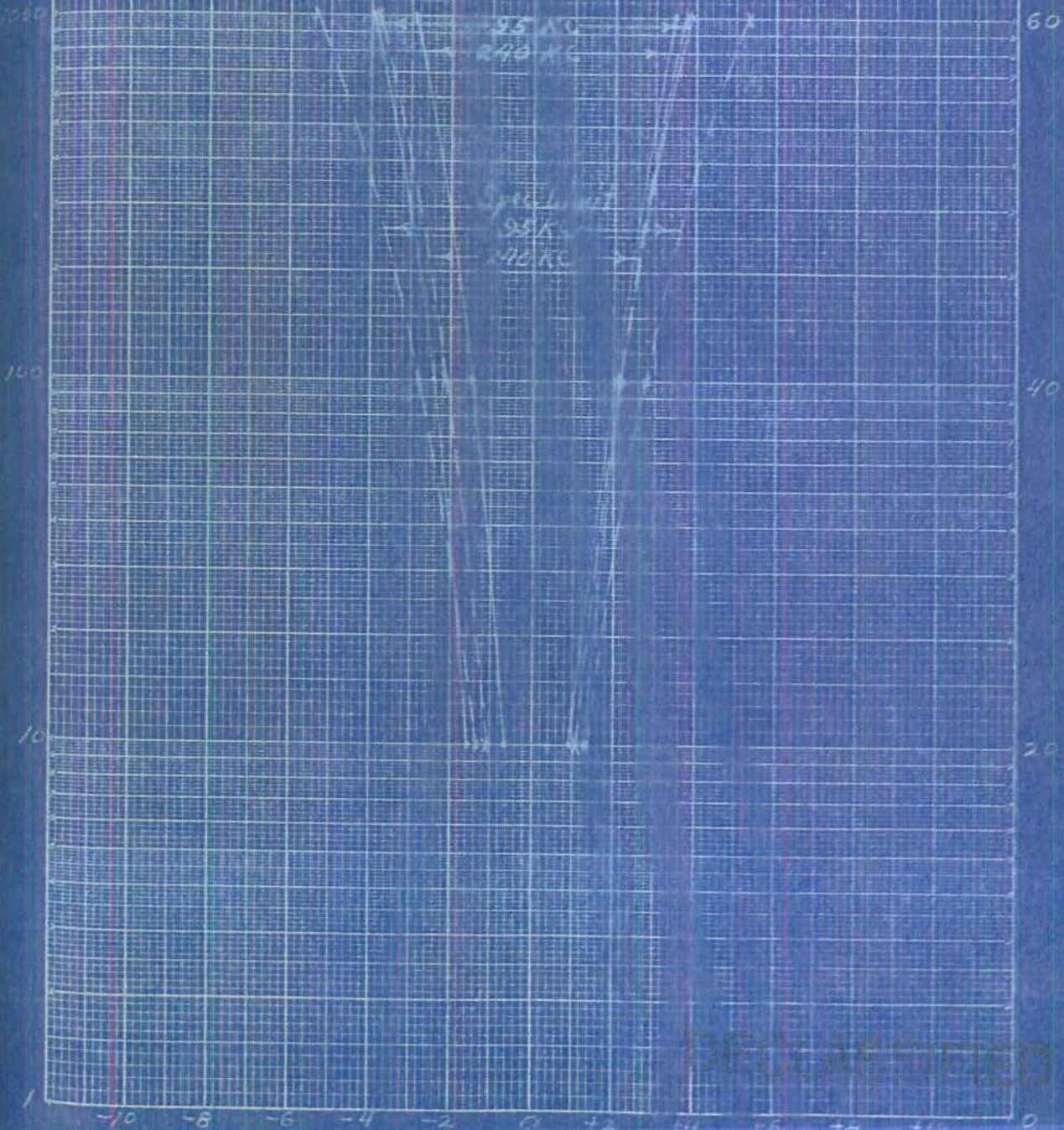
QRC 450112

-10 -8 -6 -4 -2 0 +2 +4 +6 +8 +10

Percent Off Resonance

DECLASSIFIED

Sensitivity - Optimum Gain
TRG-1 Serial No. 19
Band 3
Before Realignment



DECLASSIFIED

Percent Off Resonance

DECLASSIFIED

Selectivity - Optimum Gain
RAG-1 Serial No. 19
Band 4
Before Realignment

1000

← 240 KC →
← 600 KC →

60

Spec Limit

← 240 KC →
← 600 KC →

100

40

Attenuation - db

10

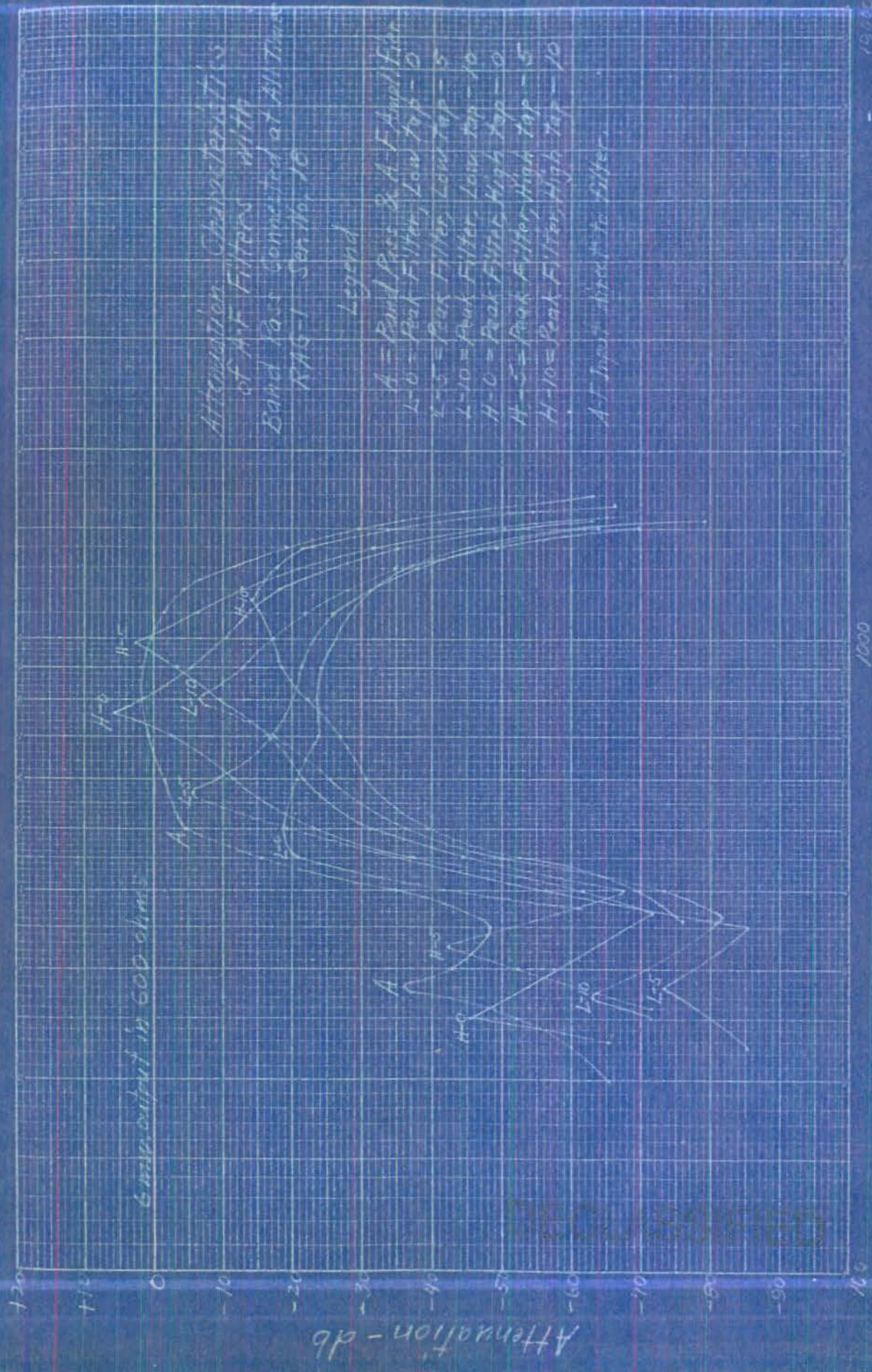
20

DECLASSIFIED

-10 -8 -6 -4 -2 0 +2 +4 +6 +8 +10 0

Percent Off Resonance

D14 4



Attenuation Characteristics
of A-F Filters with
Band Pass Connected at All Taps
R45-1 Ser. No. 18

Legend

- A = Band Pass & A-F Equalizer
- L-0 = Peak Filter, Low Tap - 0
- L-5 = Peak Filter, Low Tap - 5
- L-10 = Peak Filter, Low Tap - 10
- H-0 = Peak Filter, High Tap - 0
- H-5 = Peak Filter, High Tap - 5
- H-10 = Peak Filter, High Tap - 10

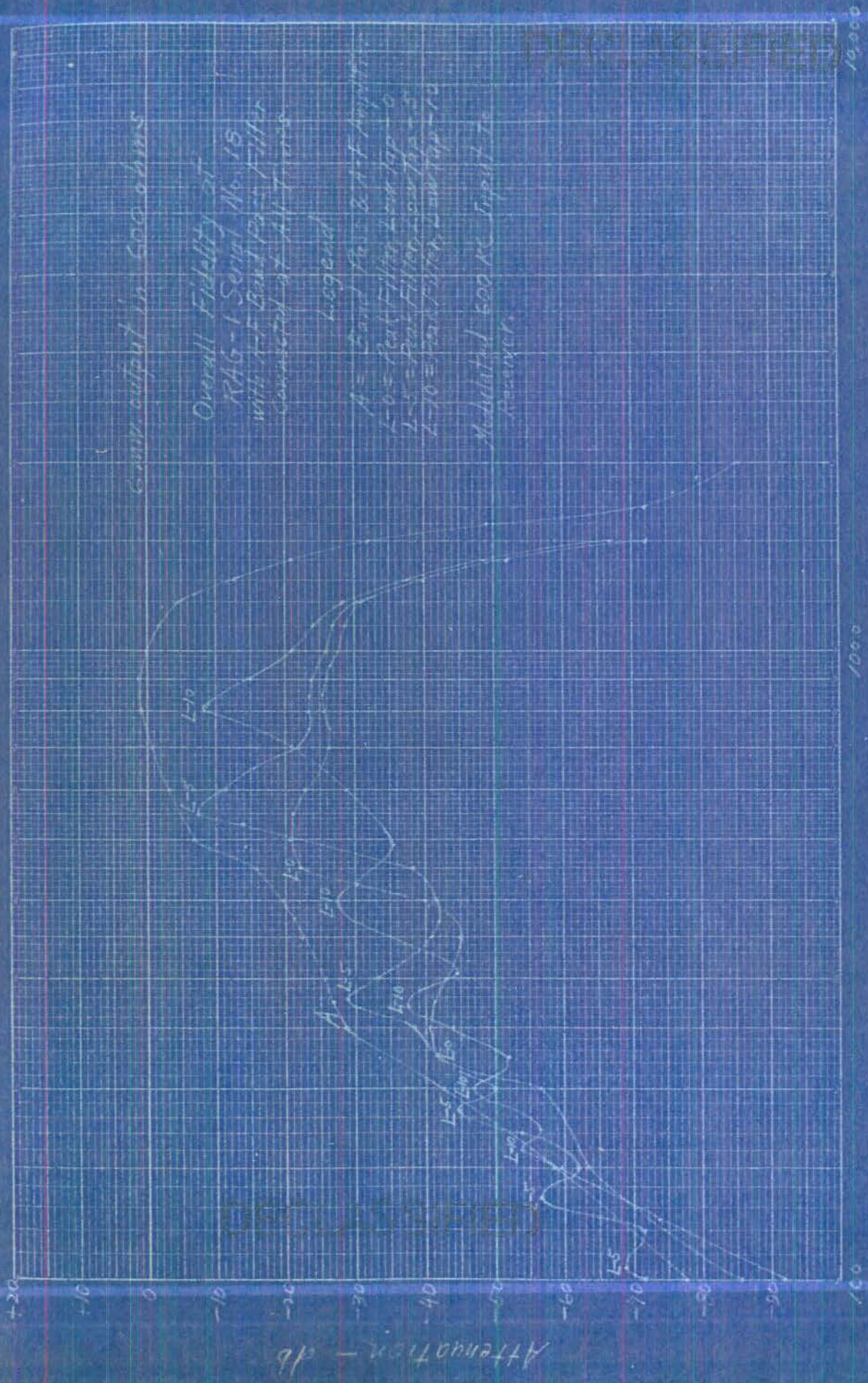
A-T Input Direct to Filter

6000 output is 600 ohms

1940

1000

Frequency - Cycles



Overall Fidelity at
 MAG-1 Servo No. 18
 with H-F Band Pass Filter
 Connected at All Times

Legend
 A = Band Pass & H-F Amplifier
 L-0 = Band Filter, Low Pass
 L-10 = Band Filter, Band Pass
 L-20 = Band Filter, Low Pass

Modulated 600 KC Input to
 Receiver.

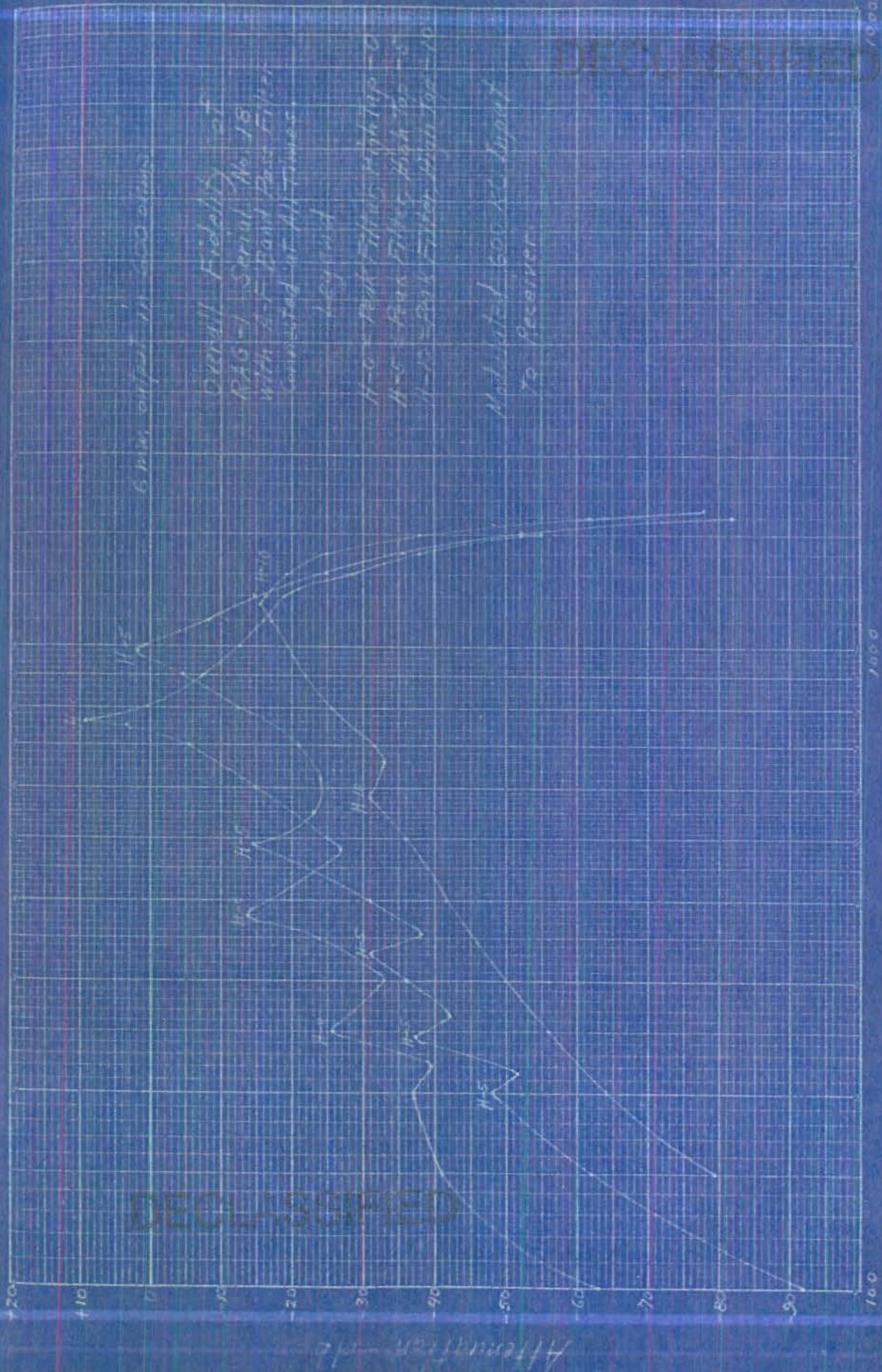
Attenuation - db

Frequency - Cycles

10000

1000

100



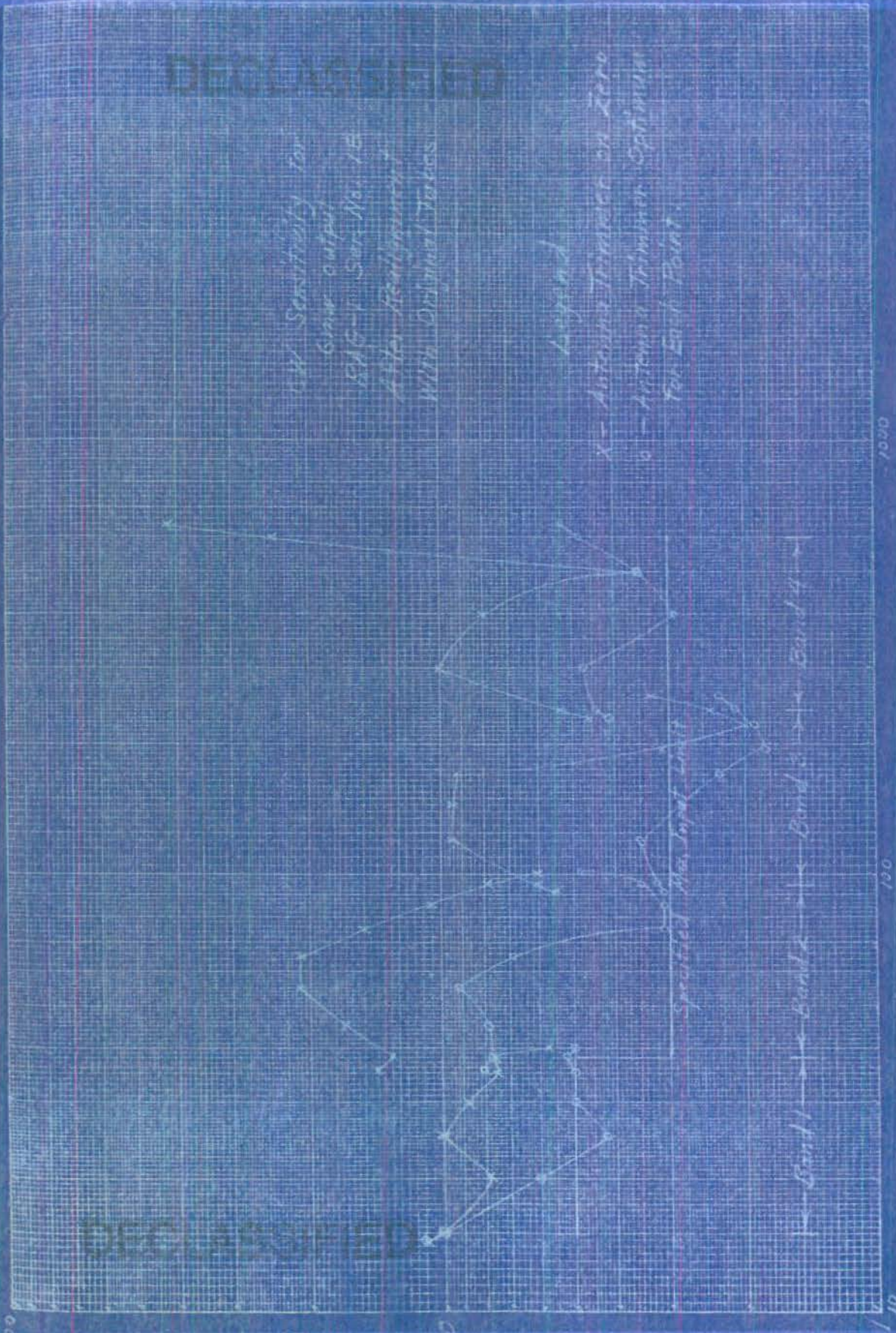
Frequency - Cycles

DECLASSIFIED

Old Sensitivity for
GWR output
SAG-1, Ser. No. 15
After Readjustment
With Original Tubes

Legend

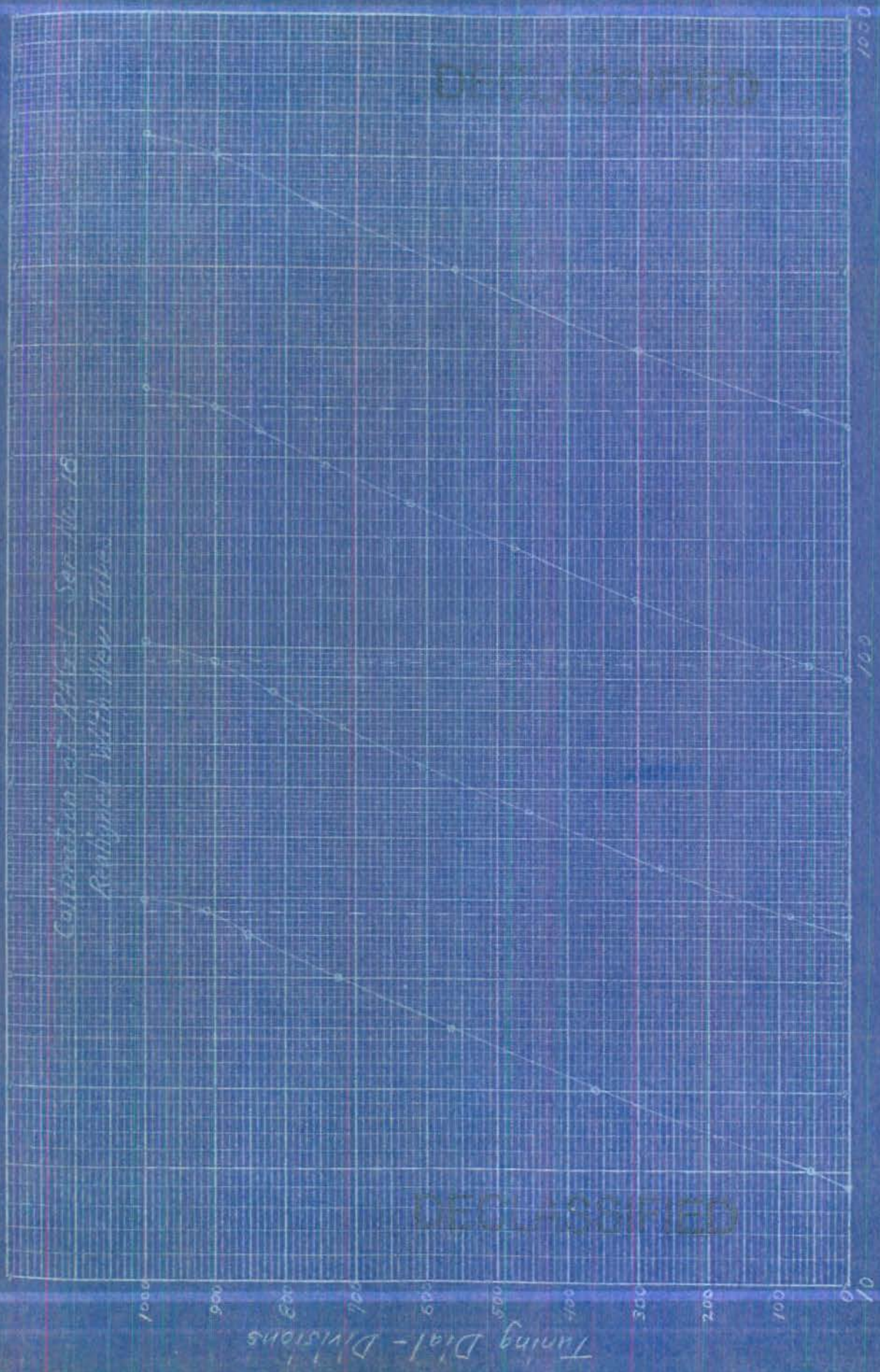
X - Automatic Trimset on Zero
O - Automatic Trimset Optimum
For Each Point.



Sensitivity - Microvolts

Frequency - KC

Calibration of Reflected Series 10
Rehydrated with New Tubes



DECLASSIFIED

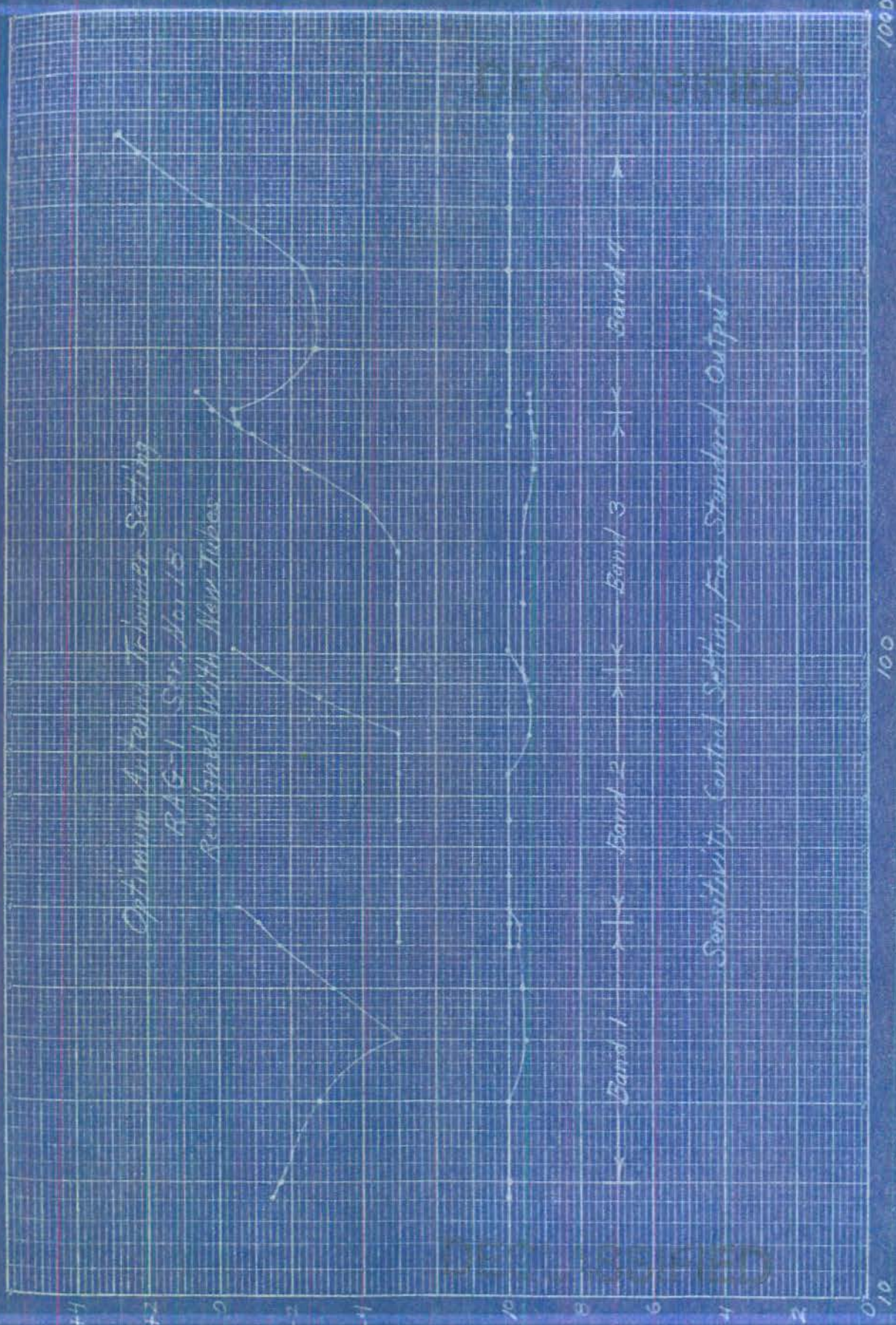
DECLASSIFIED

Frequency - KC

Tuning Dial - Divisions

Antenna Tuner - Divisions

Sensitivity Control - Divisions



Optimum Antenna Tuner Setting
 RAG-1 Ser. No. 18
 Revisited with New Tubes

Sensitivity Control Setting For Standard Output

DECLASSIFIED

Band 1 - 2000 - 3000 - 4000 - 5000 - 6000 - 7000 - 8000 - 9000 - 10000

CW sensitivity for
6000 output
ATC-1, 5000 Hz 10
Resonant with New Tube

Legend

1 - Minimum sensitivity
2 - Added 10 dB
3 - Added 20 dB
4 - End Point



1000

100

10

Frequency - KC

Sensitivity - Microvolts

DECLASSIFIED

Noise Level - Microwatts

Plate 15

Band 1 Band 2 Band 3 Band 4

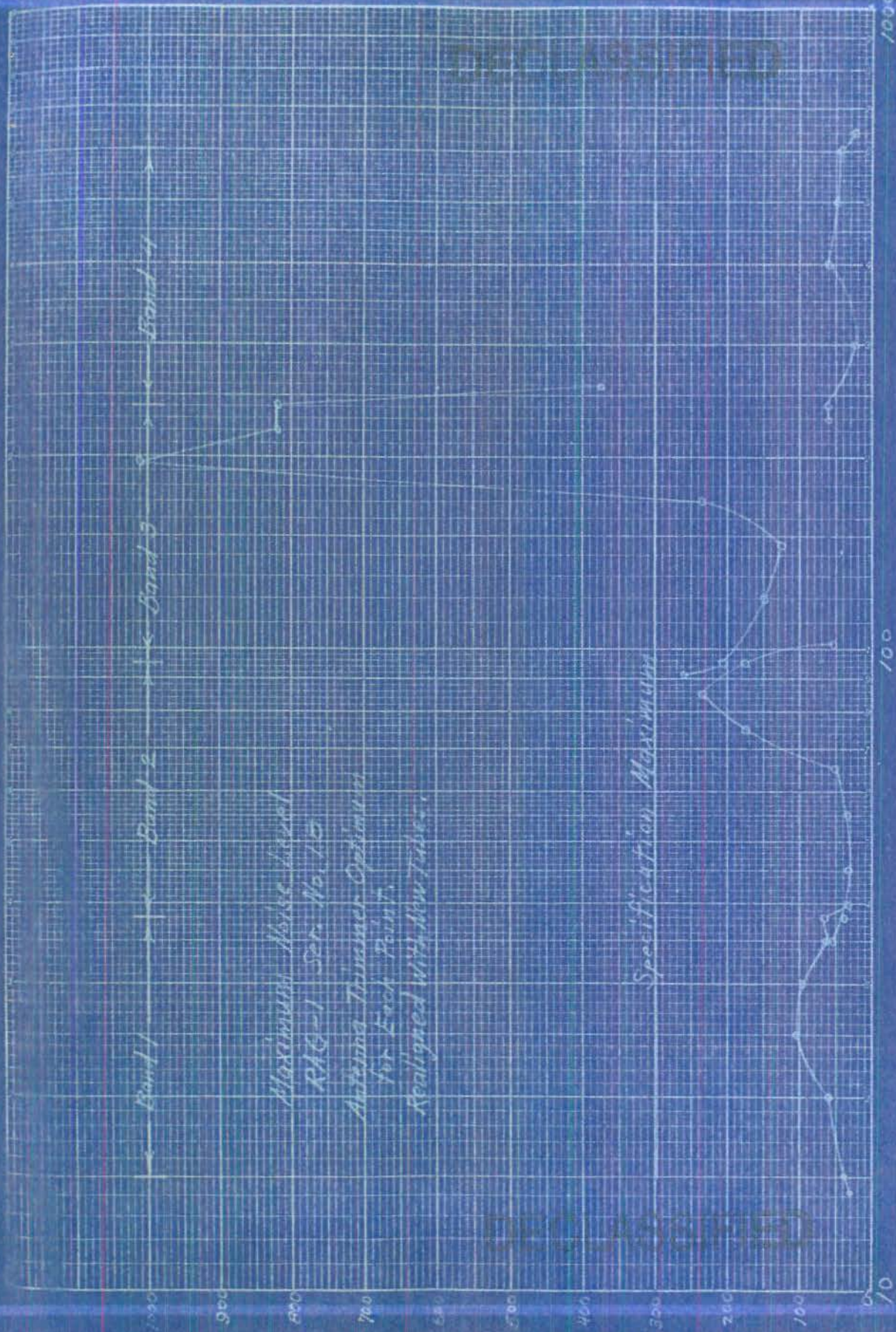
Maximum Noise Level
RAG-1 Ser. No. 10
Antenna Trimmer Optimized
for Each Point.
Realigned with New Tubes.

Specification Maximum

1000

100

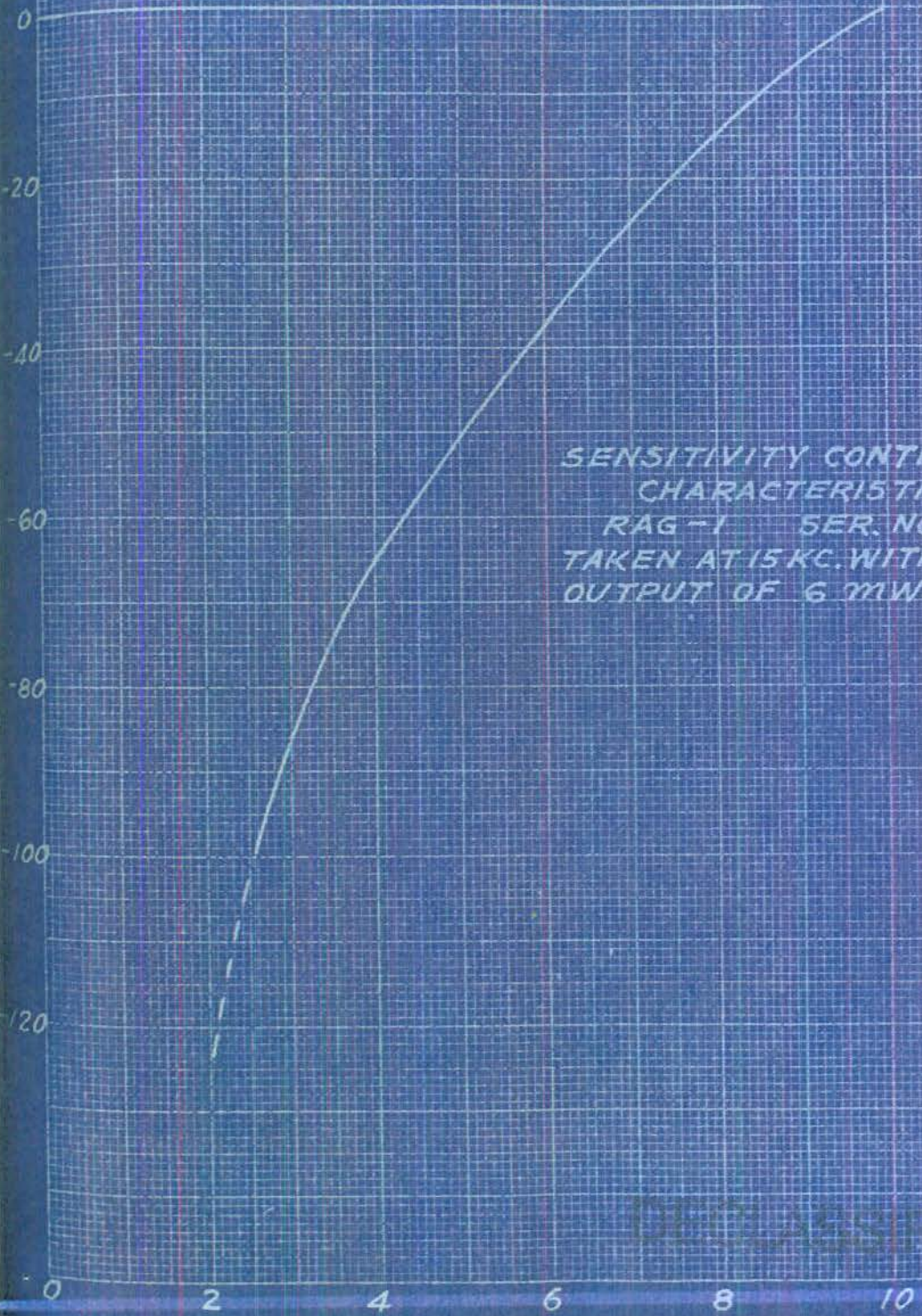
Frequency - KC



CLASSIFIED

INPUT REQUIRED FOR STANDARD OUTPUT

SENSITIVITY CONTROL
CHARACTERISTICS
RAG-1 SER. NO. 18
TAKEN AT 15 KC. WITH CONSTANT
OUTPUT OF 6 MW.

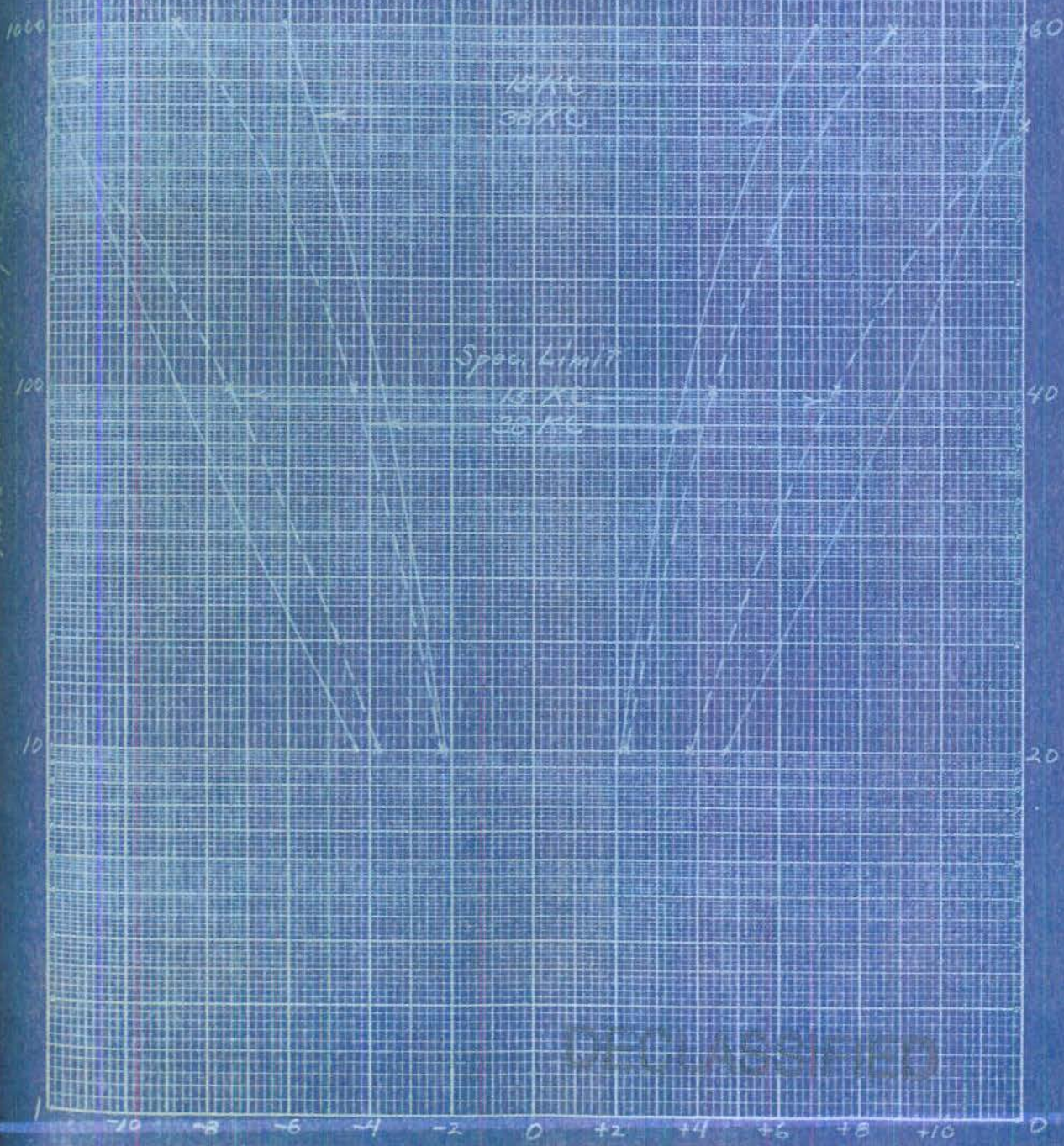


SENSITIVITY CONTROL - DIVISIONS

CLASSIFIED

DECLASSIFIED

Subsidiary - Optimum Gain
Filter - Ser. No. 12
Band 1
Realigned with New Tables



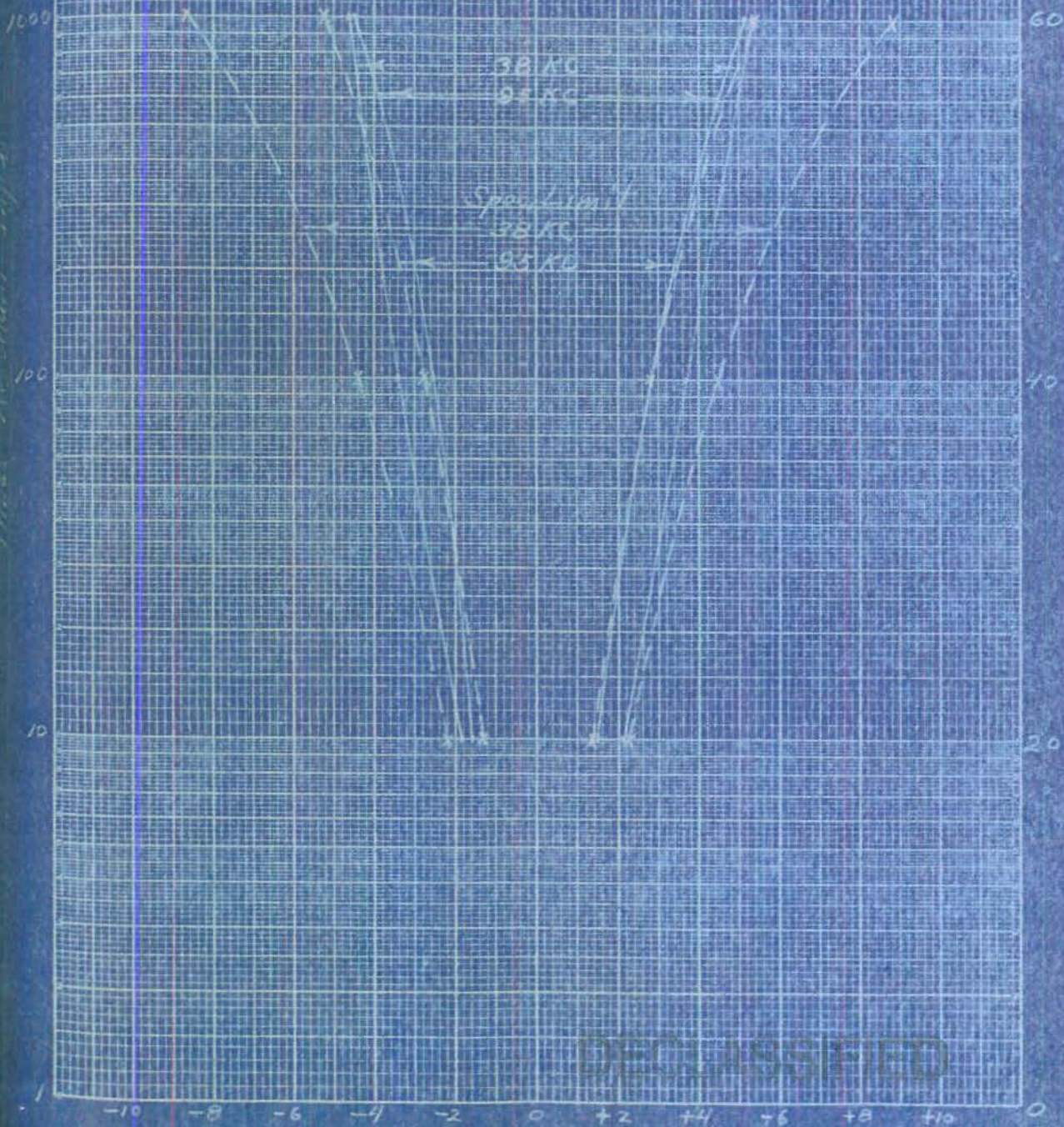
Attenuation - db

Percent Off Resonance

DECLASSIFIED

DECLASSIFIED

Selectivity - Optimum Gain
RMS-1, Ser. No. 10
Band 2
Realigned with New Tubes

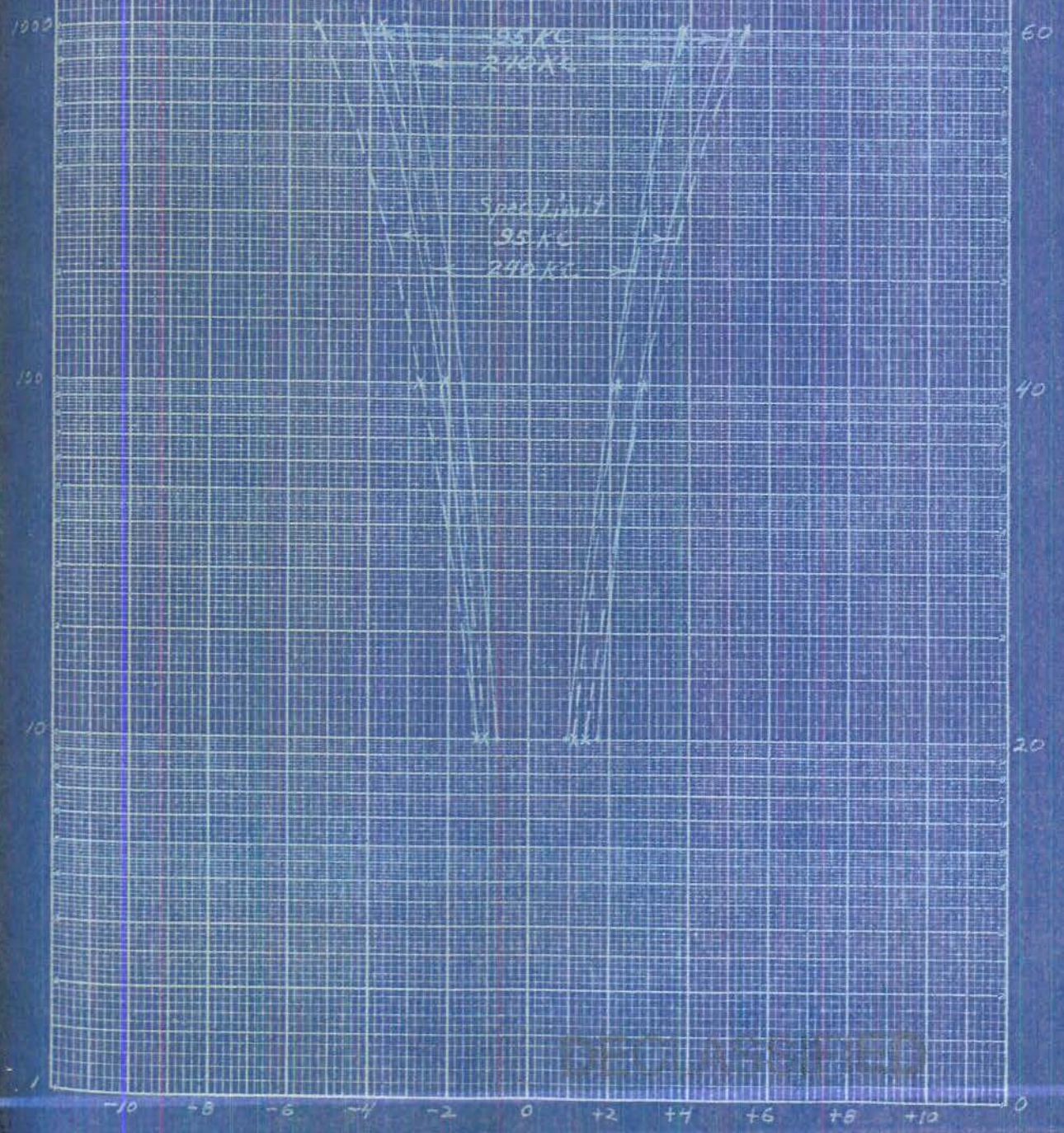


Attenuation - db

DECLASSIFIED

Percent Off Resonance

Selectivity - Optimum Gain
 RAG-1 Ser. No. 15
 Band 3
 Realigned With New Tubes

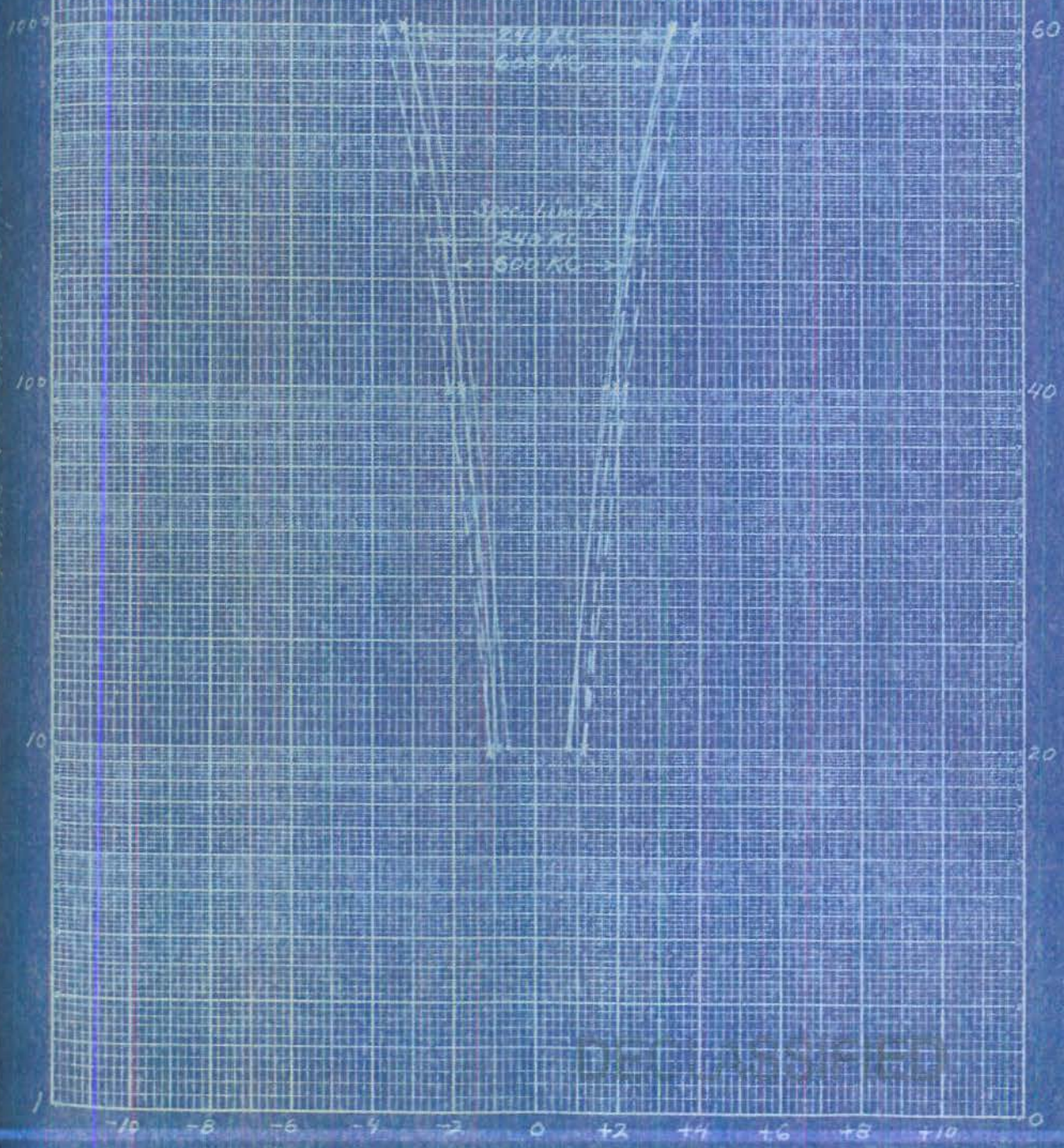


Attenuation - db

Percent Off Resonance

UNCLASSIFIED

Selectivity - Optimum Gain
RAG-1 Section 10
Band 4
Realigned With New Tubes



Attenuation - db

Percent Off Resonance

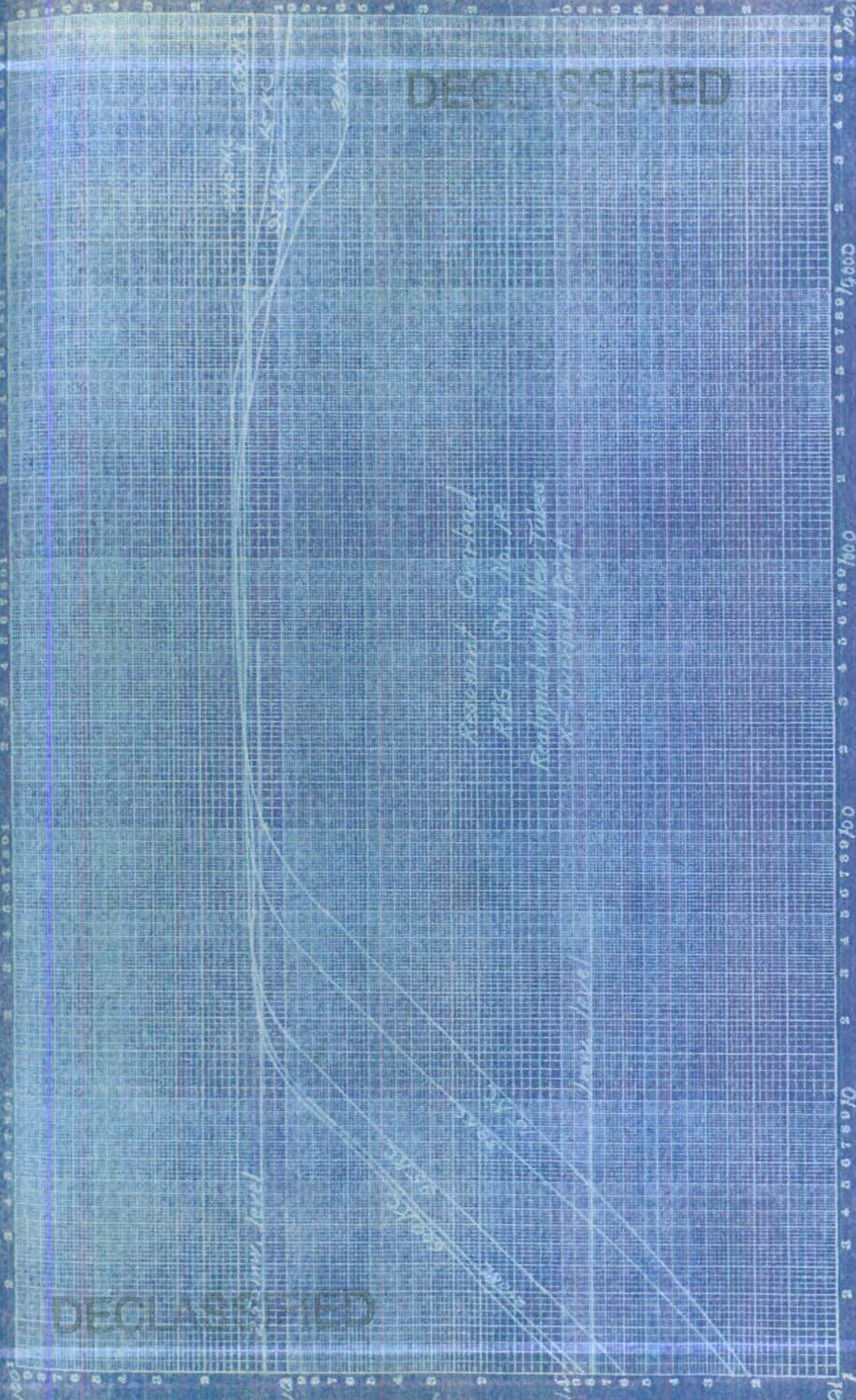
DECLASSIFIED

DECLASSIFIED

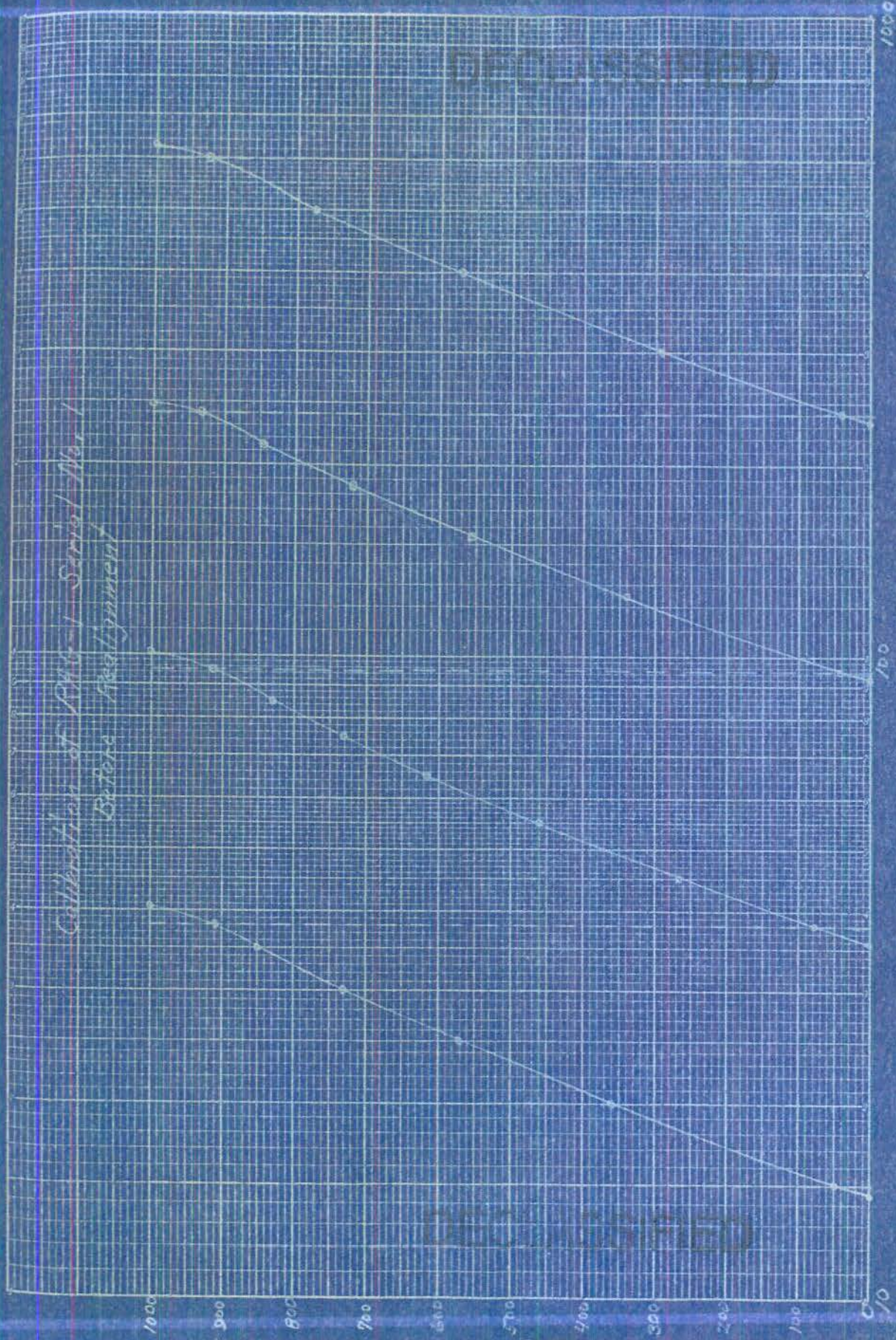
A-F Output - Volts

R-F Input - Microvolts

Assessment Circuit
RAG 1.000 to 10 Hz
Configured with New Tubes
& Improved Part



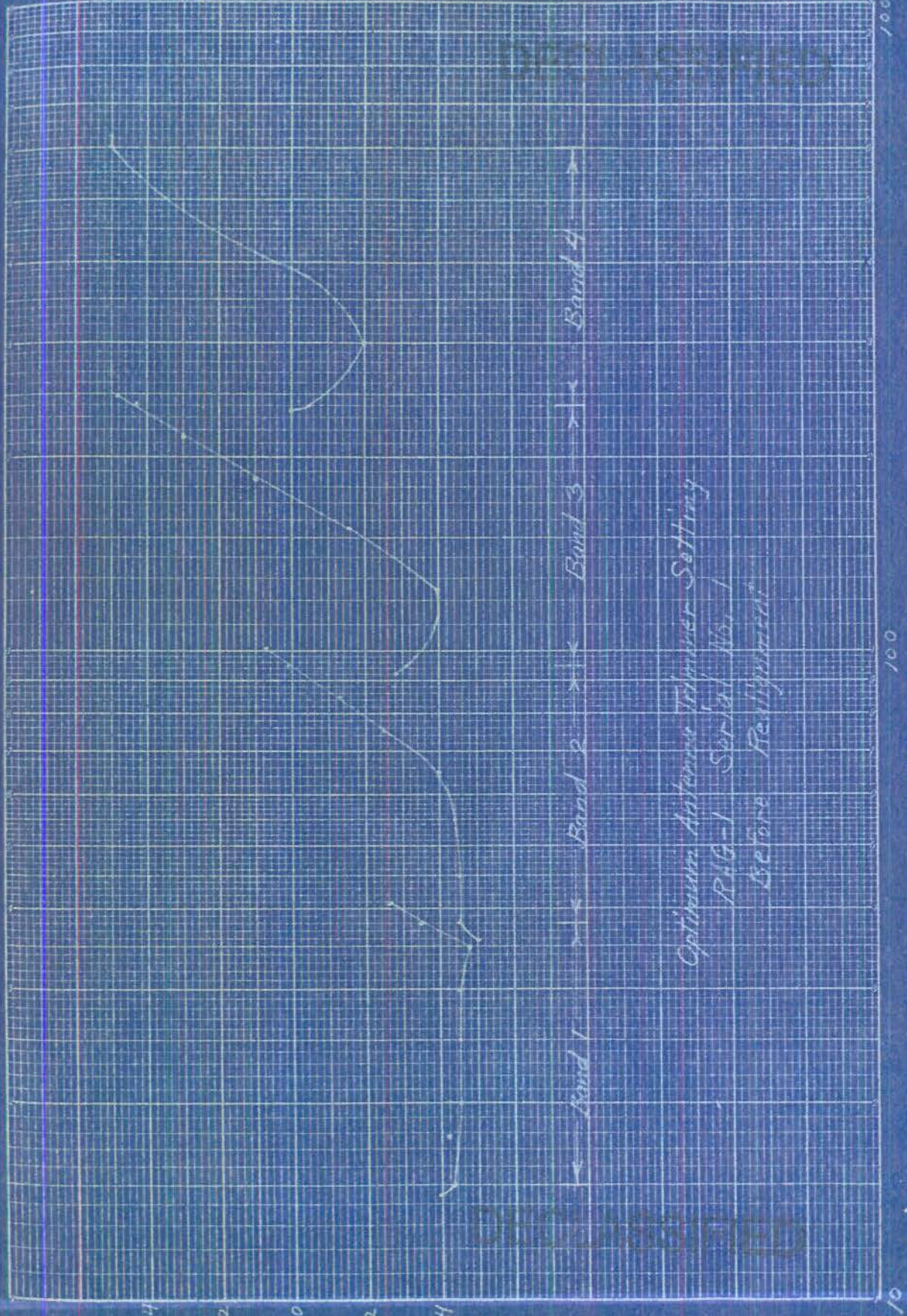
Calibration of DPO-1 Serial No. 1
Before Readjustment



Tuning Dial - Divisions

Frequency - KC

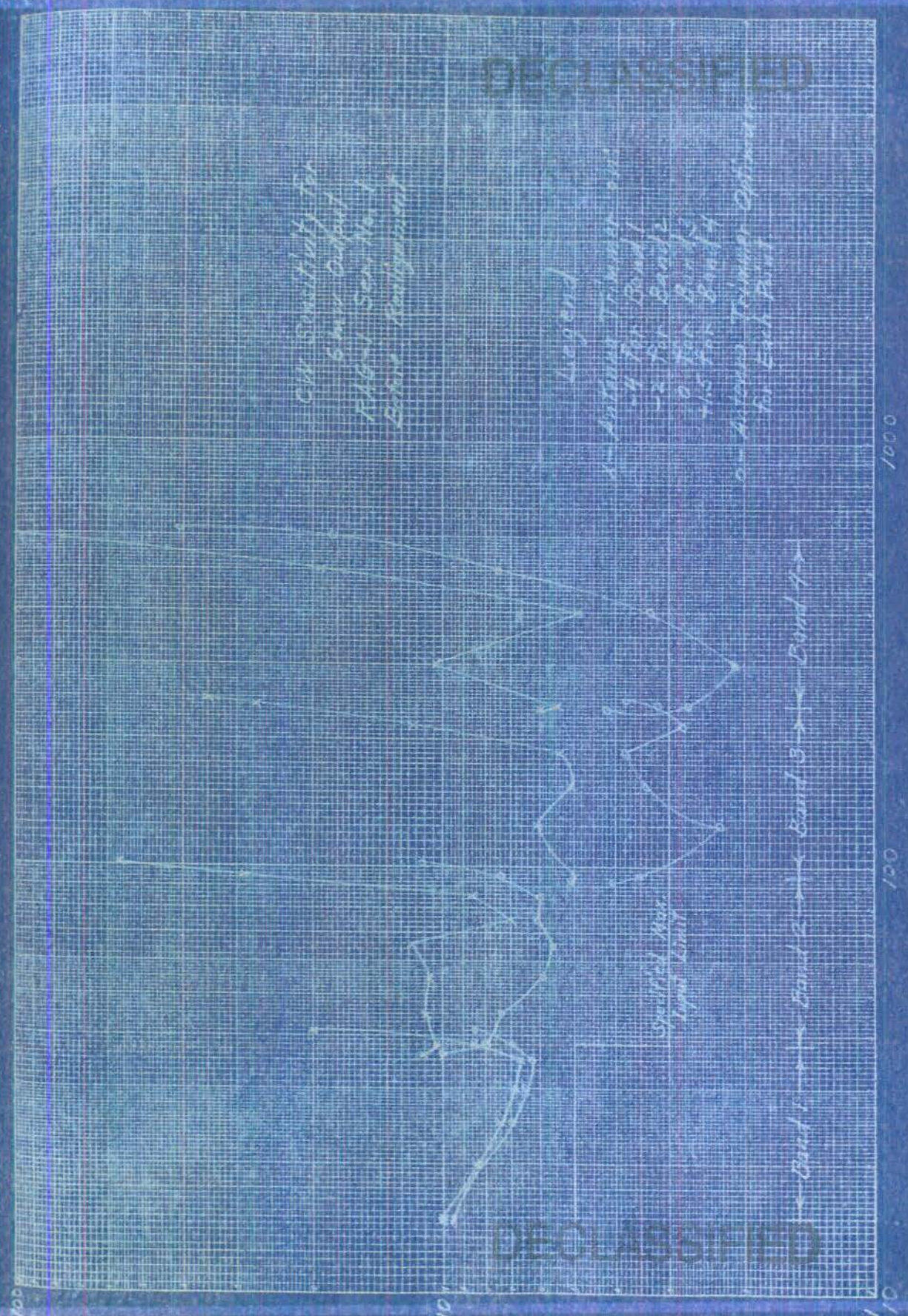
Antenna Trimmer - Divisions



Optimum Antenna Trimmer Setting
RFG-1 Serial No. 1
Sector Reassignment

Frequency - KC

DECLASSIFIED



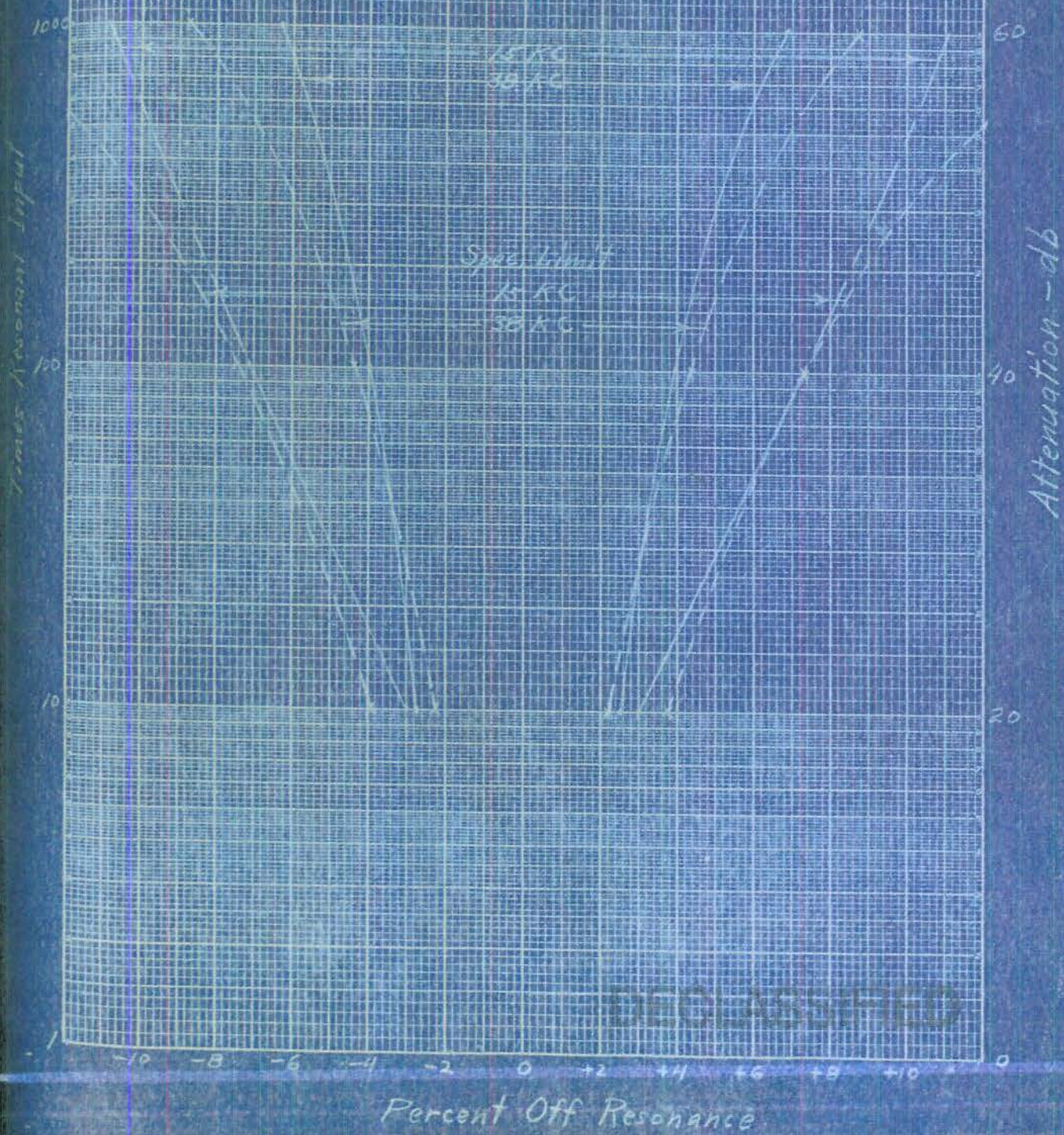
Sensitivity - Microvolts

Frequency - KC

DECLASSIFIED

DECLASSIFIED

Sensitivity - Optimum Gain
R19-1 Serial No. 1
Band 1
Before Realignment



Times Resonant Input

Attenuation - db

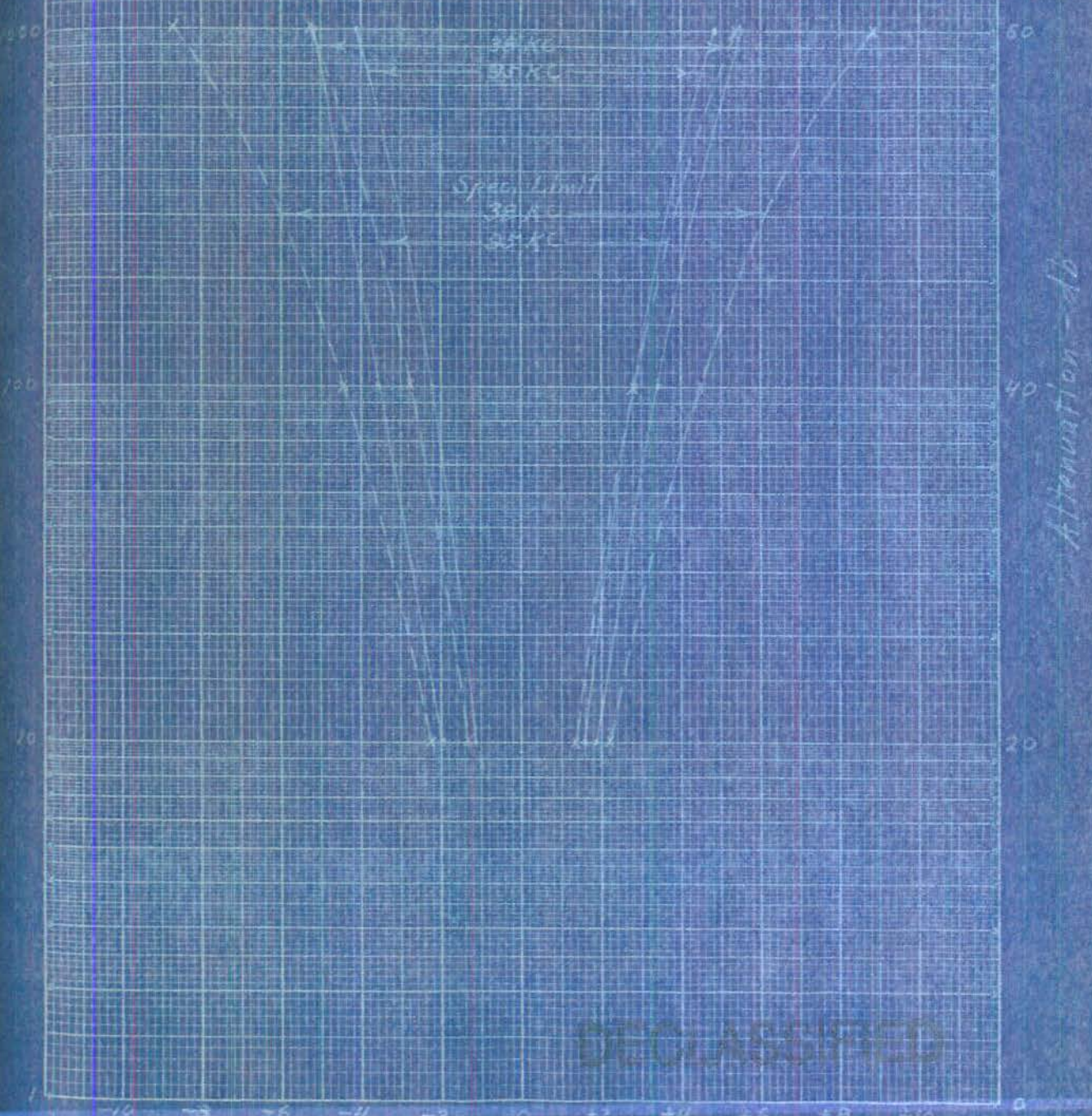
DECLASSIFIED

Percent Off Resonance

D116

DECLASSIFIED

Sensitivity - Optimum Gain
RFS-1, Serial No. 1
Band #
Before Realignment

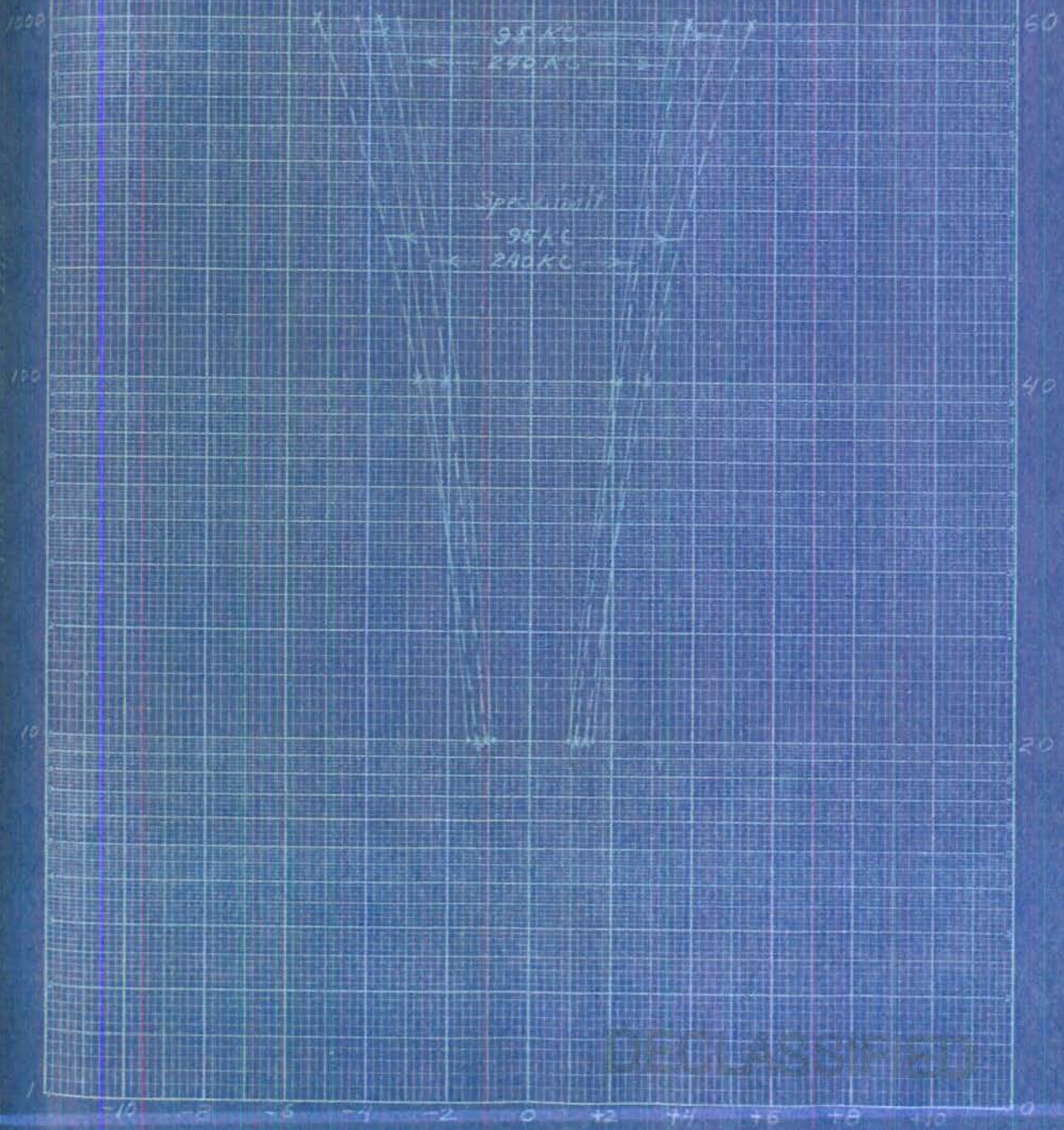


DECLASSIFIED

Percent Off Resonance

DECLASSIFIED

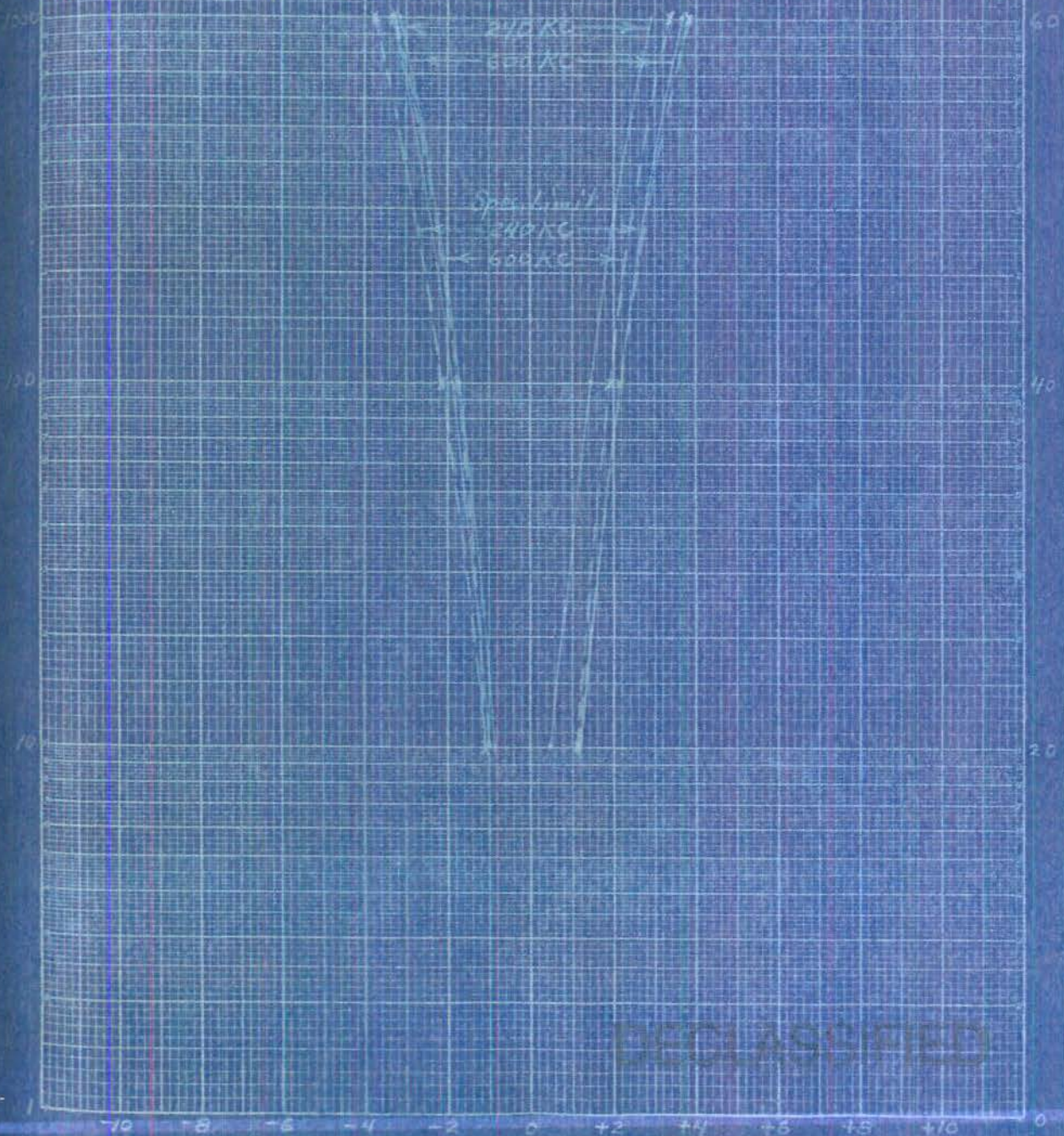
Selectivity - Optimum Gain
RAG-1, Serial No. 1
Band 13
Before Realignment



DECLASSIFIED

DECLASSIFIED

Series Fevity - optimum Gain
Rheo-1, Serial No. 1
Band 4
Before Reassignment

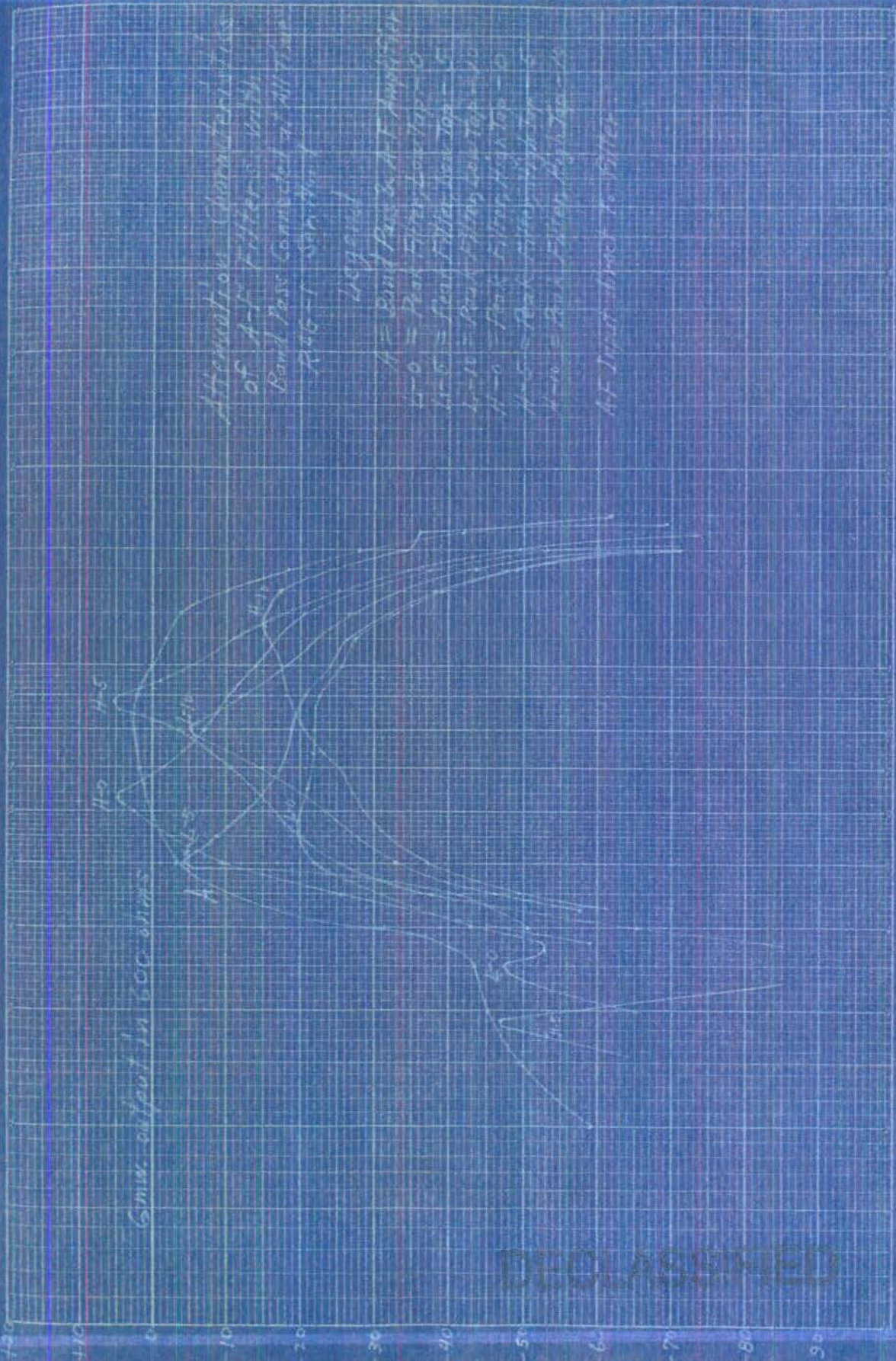


Attenuation - db

DECLASSIFIED

Percent Off Resonance

DECLASSIFIED



Smir. output in 500 ohms

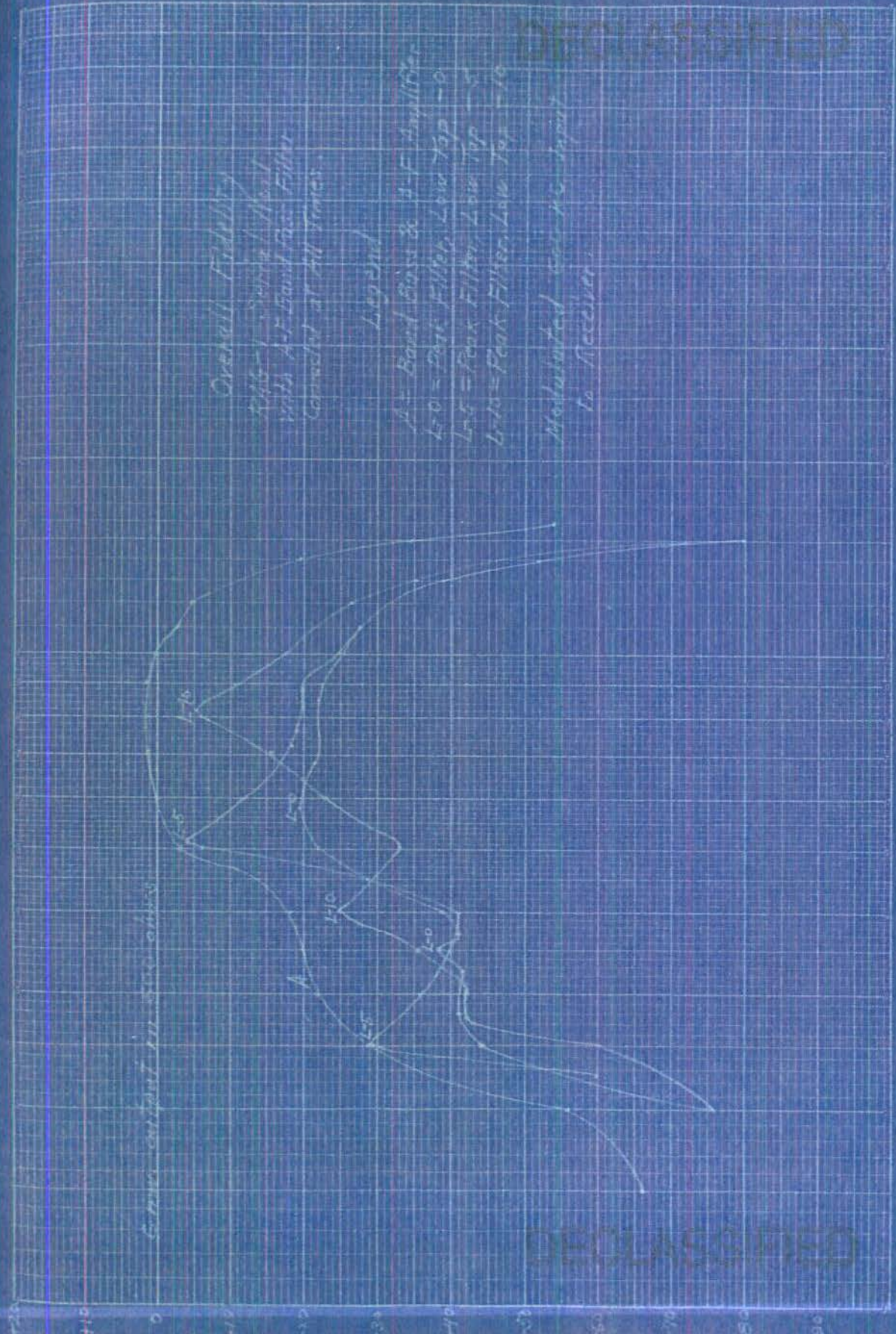
Attenuation Characteristics
 of A-type Filters
 Band Pass Connected to Milliman
 A-6-T Series
 Legend
 A = Band Pass & T-Attenuation
 F-0 = Peak Filter Output
 F-5 = Peak Filter Output
 F-10 = Peak Filter Output
 F-15 = Peak Filter Output
 F-20 = Peak Filter Output
 F-25 = Peak Filter Output
 F-30 = Peak Filter Output
 F-40 = Peak Filter Output
 F-50 = Peak Filter Output
 F-60 = Peak Filter Output
 F-70 = Peak Filter Output
 F-80 = Peak Filter Output
 F-90 = Peak Filter Output
 F-100 = Peak Filter Output
 F-110 = Peak Filter Output
 F-120 = Peak Filter Output
 F-130 = Peak Filter Output
 F-140 = Peak Filter Output
 F-150 = Peak Filter Output
 F-160 = Peak Filter Output
 F-170 = Peak Filter Output
 F-180 = Peak Filter Output
 F-190 = Peak Filter Output
 F-200 = Peak Filter Output
 F-250 = Peak Filter Output
 F-300 = Peak Filter Output
 F-400 = Peak Filter Output
 F-500 = Peak Filter Output
 F-600 = Peak Filter Output
 F-700 = Peak Filter Output
 F-800 = Peak Filter Output
 F-900 = Peak Filter Output
 F-1000 = Peak Filter Output
 F-1500 = Peak Filter Output
 F-2000 = Peak Filter Output
 F-3000 = Peak Filter Output
 F-4000 = Peak Filter Output
 F-5000 = Peak Filter Output
 F-6000 = Peak Filter Output
 F-7000 = Peak Filter Output
 F-8000 = Peak Filter Output
 F-9000 = Peak Filter Output
 F-10000 = Peak Filter Output

AF Input level is 100 mV

Frequency - Cycles

DECLASSIFIED

Attenuation - dB



Curve output in sine wave

Overall Fidelity

High - Low Pass Filter
with 4-F Band Pass Filter
connected at all times.

High

- A = Band Pass & 4-F Amplifier
- B = Pass Filter, Low Pass - 0
- C = Pass Filter, Low Pass - 5
- D = Pass Filter, Low Pass - 10

Modulated wave is input
to Receiver.

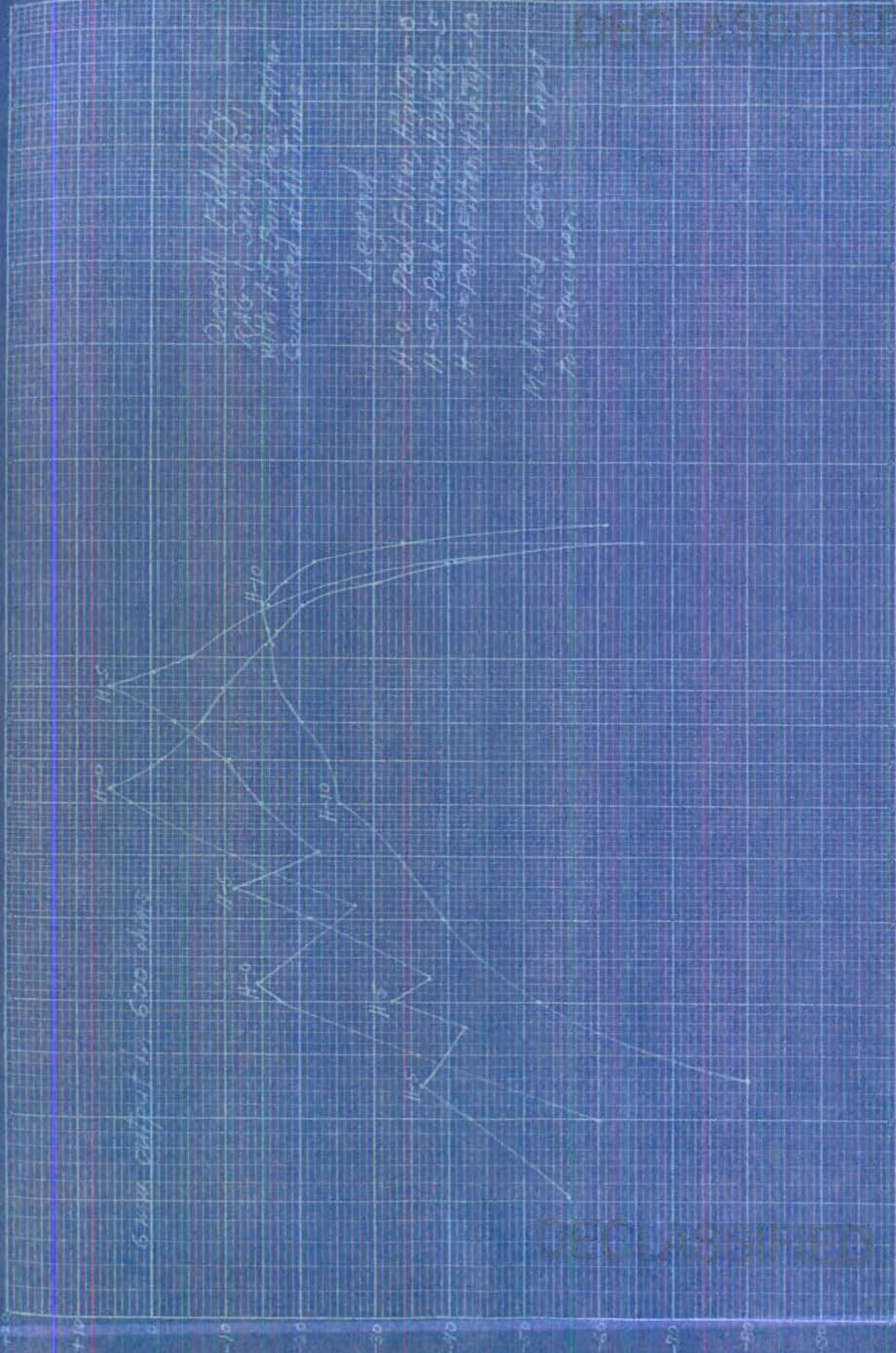
DECLASSIFIED

Frequency - Cycles

10,000

1,000

100



Gain output to 500 idms

Double stability
 with peak filter
 compensated at 1000

Legend

- H-0 - Peak Filter, High Top - 0
- H-5 - Peak Filter, High Top - 5
- H-10 - Peak Filter, High Top - 10

Modulated 600 at Input
 to Receiver

DECLASSIFIED

DECLASSIFIED

Frequency - Cycles

Attenuation - dB



- All curves plotted on
 1000 cycle grid paper
 with frequency
 with 1000 cycles

- All curves plotted on
 1000 cycle grid paper
 with frequency
 with 1000 cycles

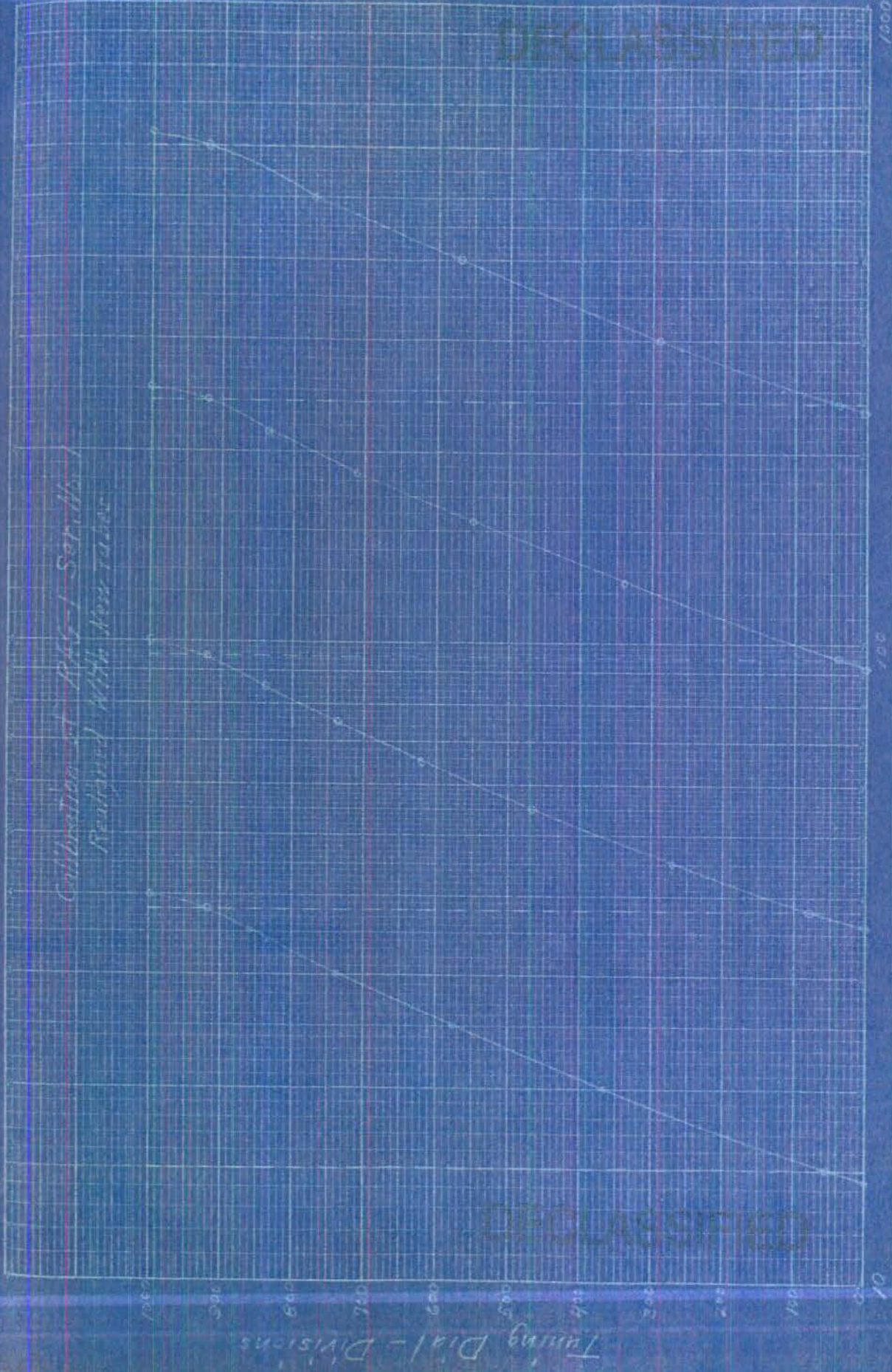
- All curves plotted on
 1000 cycle grid paper
 with frequency
 with 1000 cycles

- Band 1 - Band 2 - Band 3 - Band 4

Frequency - Kc

DECLASSIFIED

Calibration of RAG-1 Series,
Rechecked with New Tables

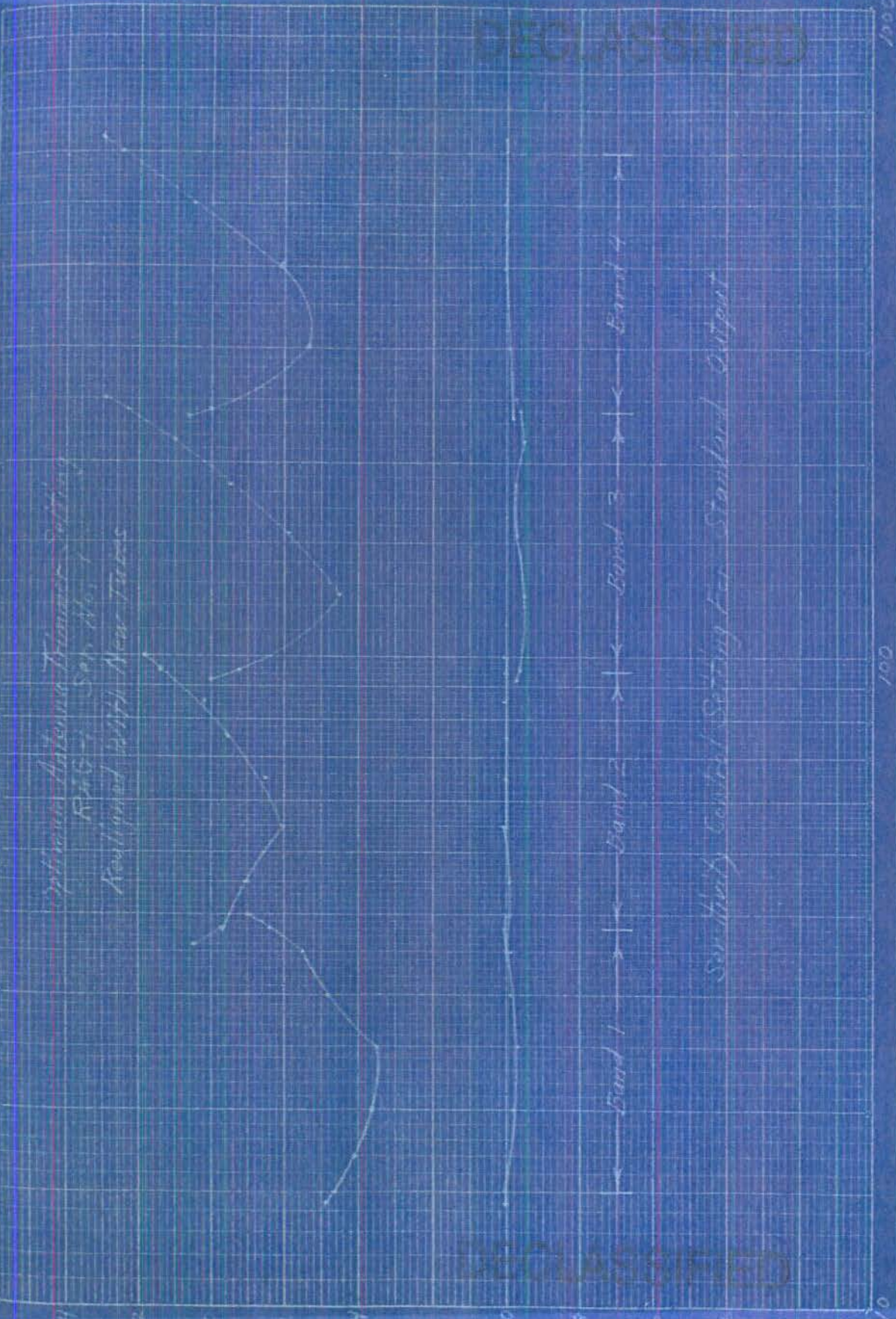


Frequency - KC

Tuning Dial - Divisions

DECLASSIFIED

DECLASSIFIED



Optimum Antenna Trimmer Setting
 Band 1 - 100 - 150 KC
 Band 2 - 150 - 200 KC

Band 1 → ← Band 2 → ← Band 3 → ← Band 4 → ←

Sensitivity Control Setting for Standard Output

100

100

Frequency - KC

DECLASSIFIED

Antenna Trimmer - Divisions

Sensitivity Control - Divisions

100

DECLASSIFIED

Band 3 and Band 9 of the ...

Ch Sensitivity At
5 mV output
8001, 8001, 8001
Realized with New Tubes

Legend

- x - 6001, 6001, 6001, 6001
- o - 6001, 6001, 6001, 6001
- Δ - 6001, 6001, 6001, 6001



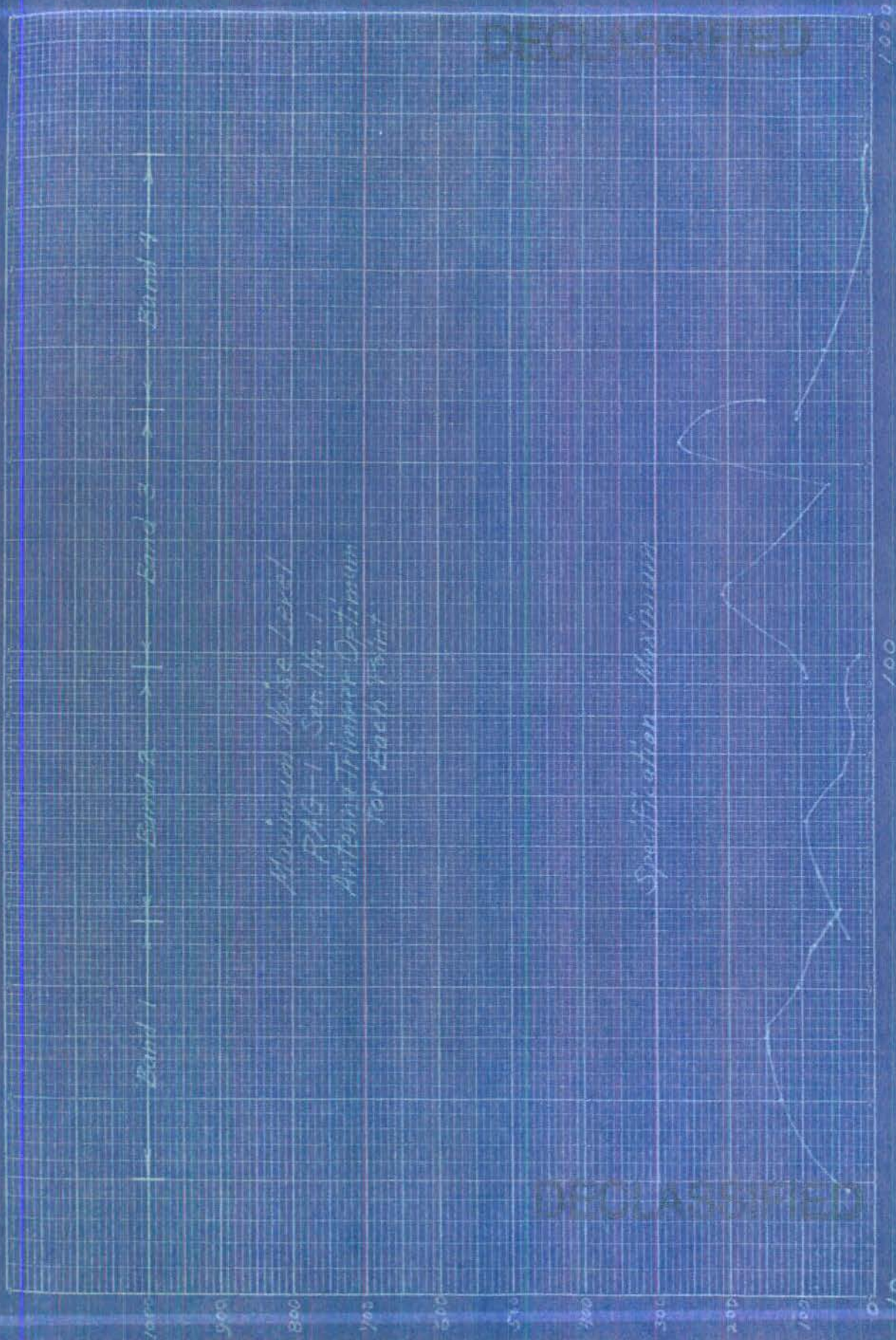
DECLASSIFIED

Sensitivity - Microvolts

Plot

Frequency - Hz

DECLASSIFIED



Band 1 Band 2 Band 3 Band 4

Minimum Noise Level
FIG-1 See Mr. J.
Anthony's Report
for each point

Specification Maximum

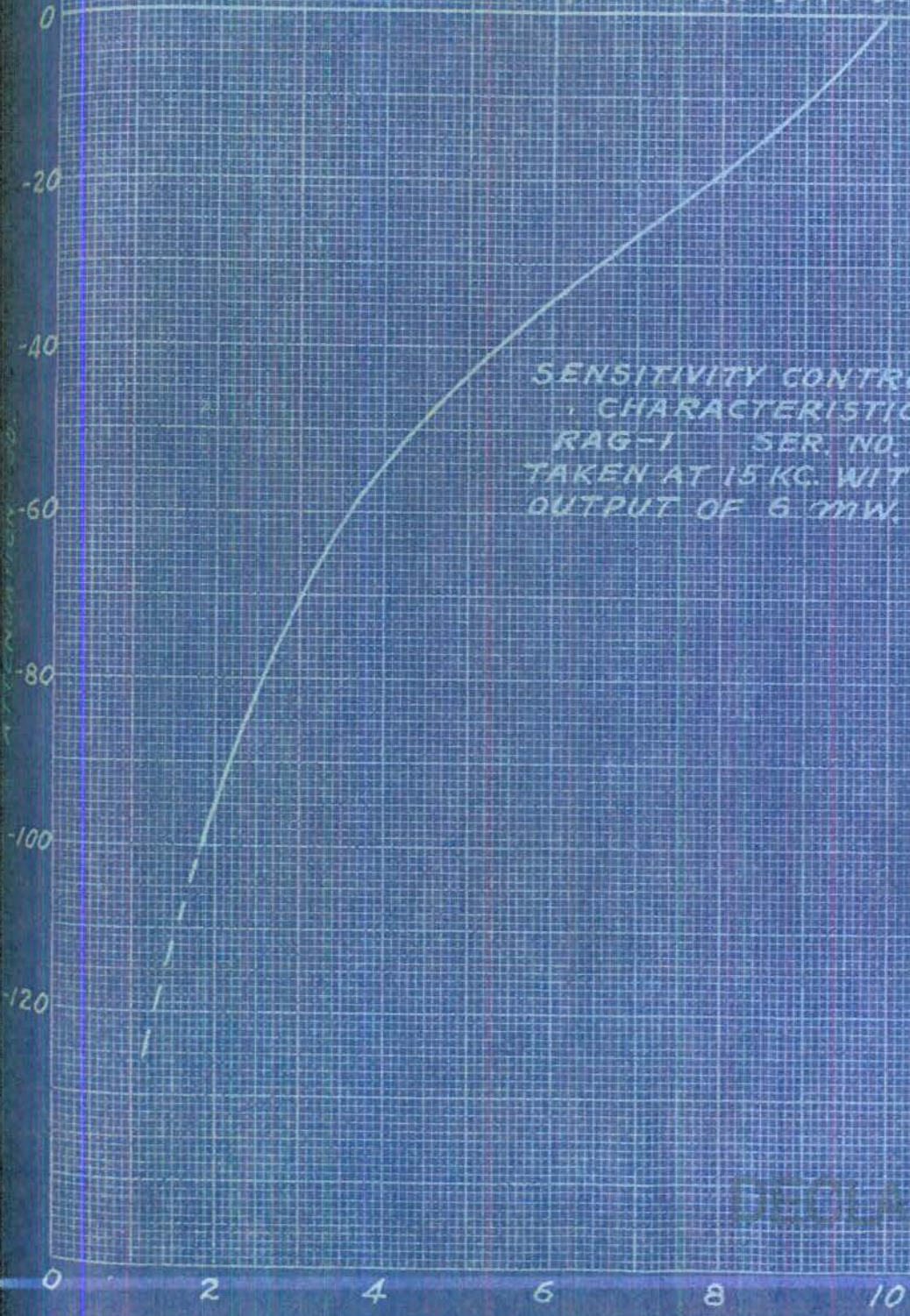
DECLASSIFIED

Noise Level - Microwatts

Frequency - KC

CONFIDENTIAL

INPUT REQUIRED FOR STANDARD OUTPUT

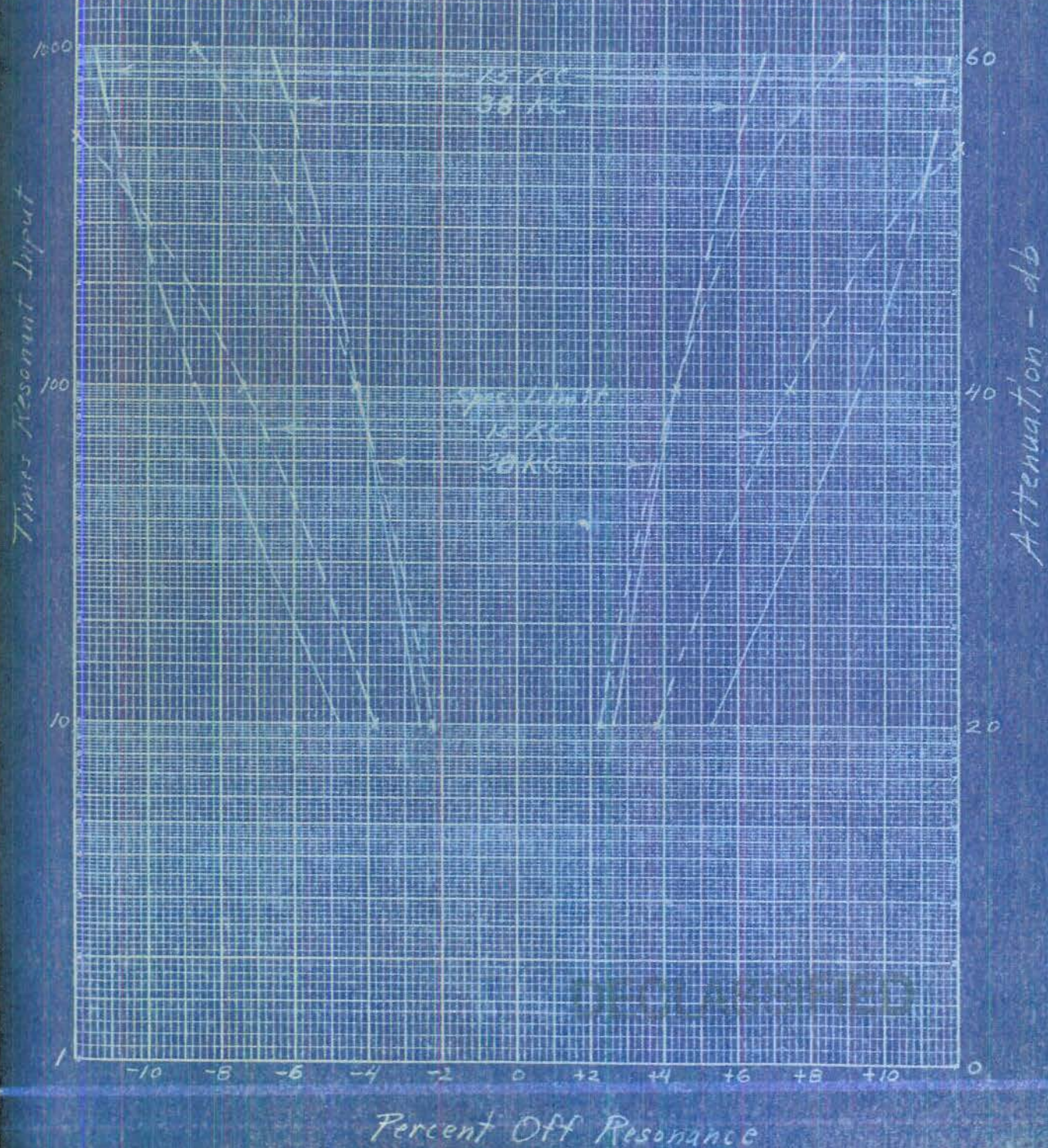


SENSITIVITY CONTROL
CHARACTERISTICS
RAG-1 SER. NO. 1
TAKEN AT 15 KC. WITH CONSTANT
OUTPUT OF 5 MW.

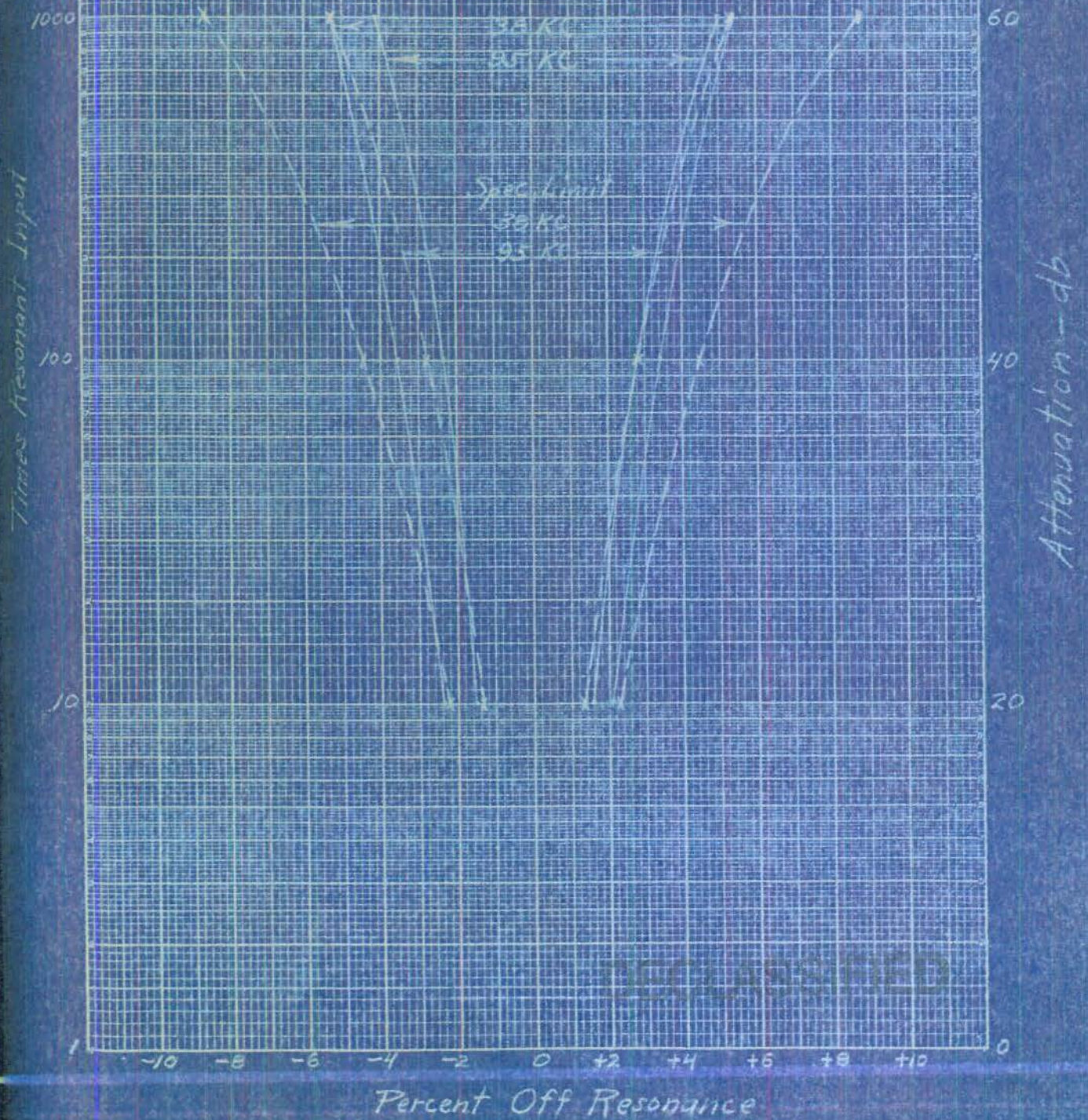
CONFIDENTIAL

DECLASSIFIED

Selectivity - Optimum Gain
RAG-1 Set No. 1
Band 1
Realized with New Tubes

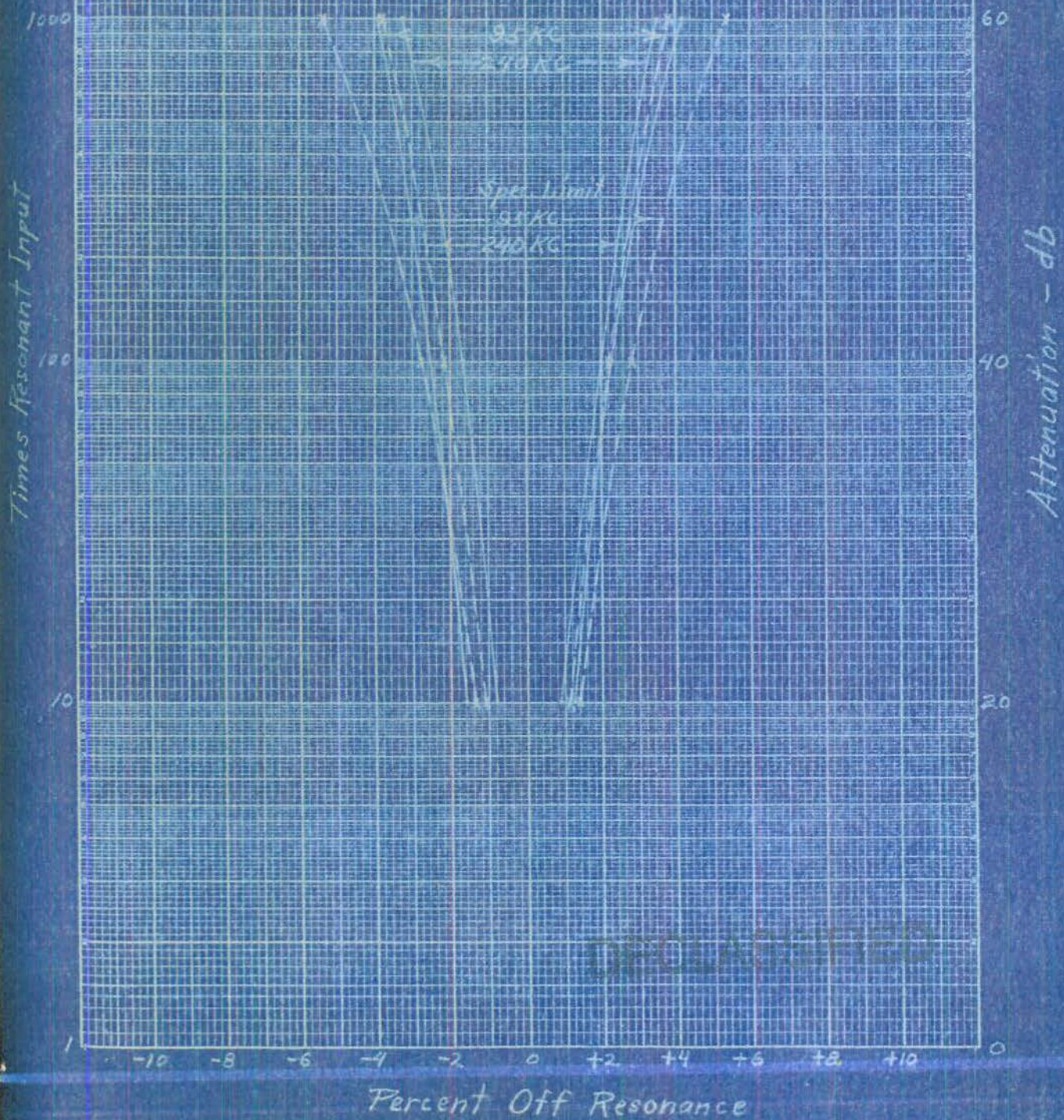


Sensitivity - Optimum Gain
KAG-1, Ser. No. 1
Band 2
Realigned with New Tubes



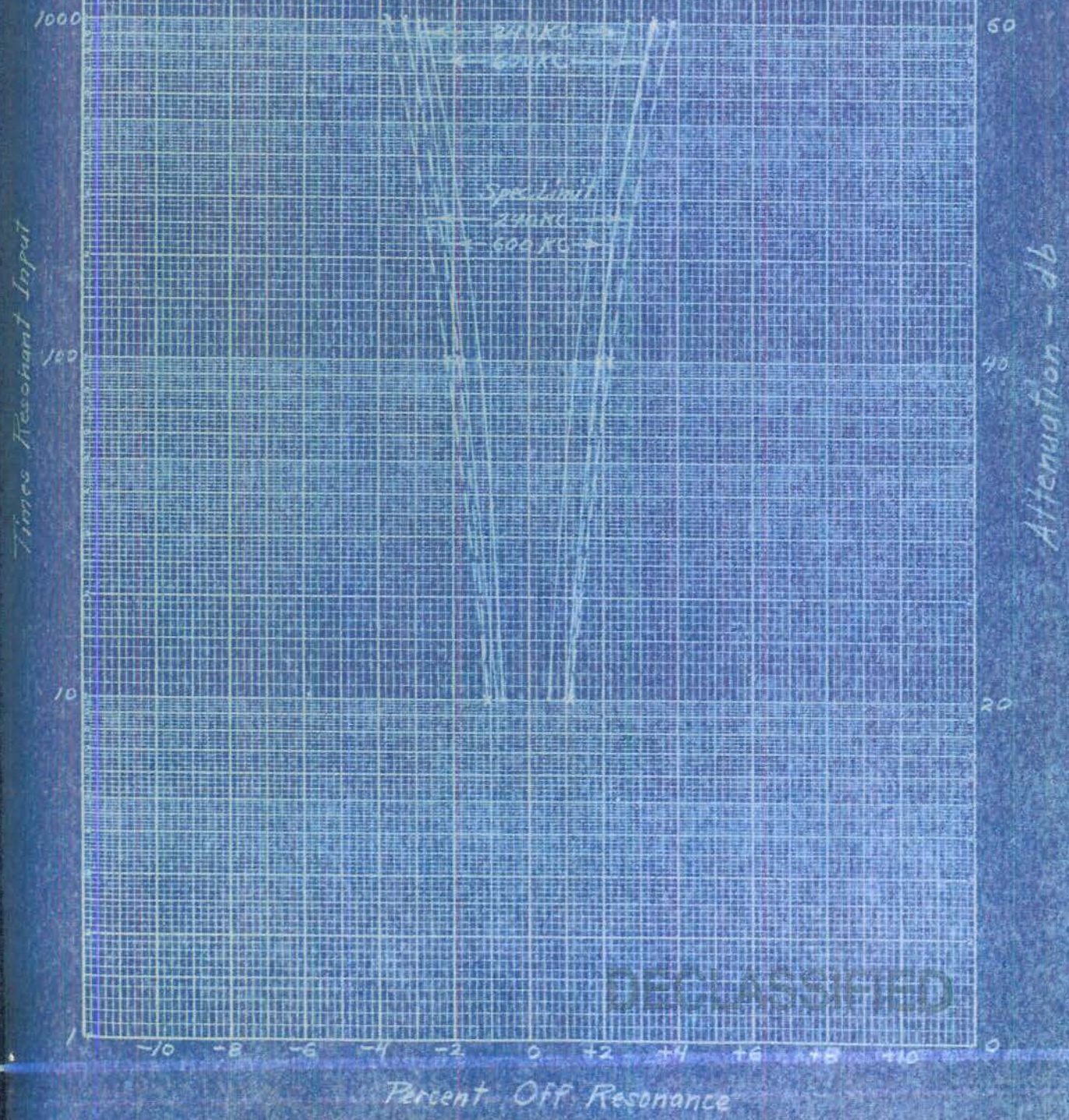
DECLASSIFIED

Selectivity - Optimized Gain
WAG-1, Ser. No. 1
Band 3
Redesigned with NEW TYPES

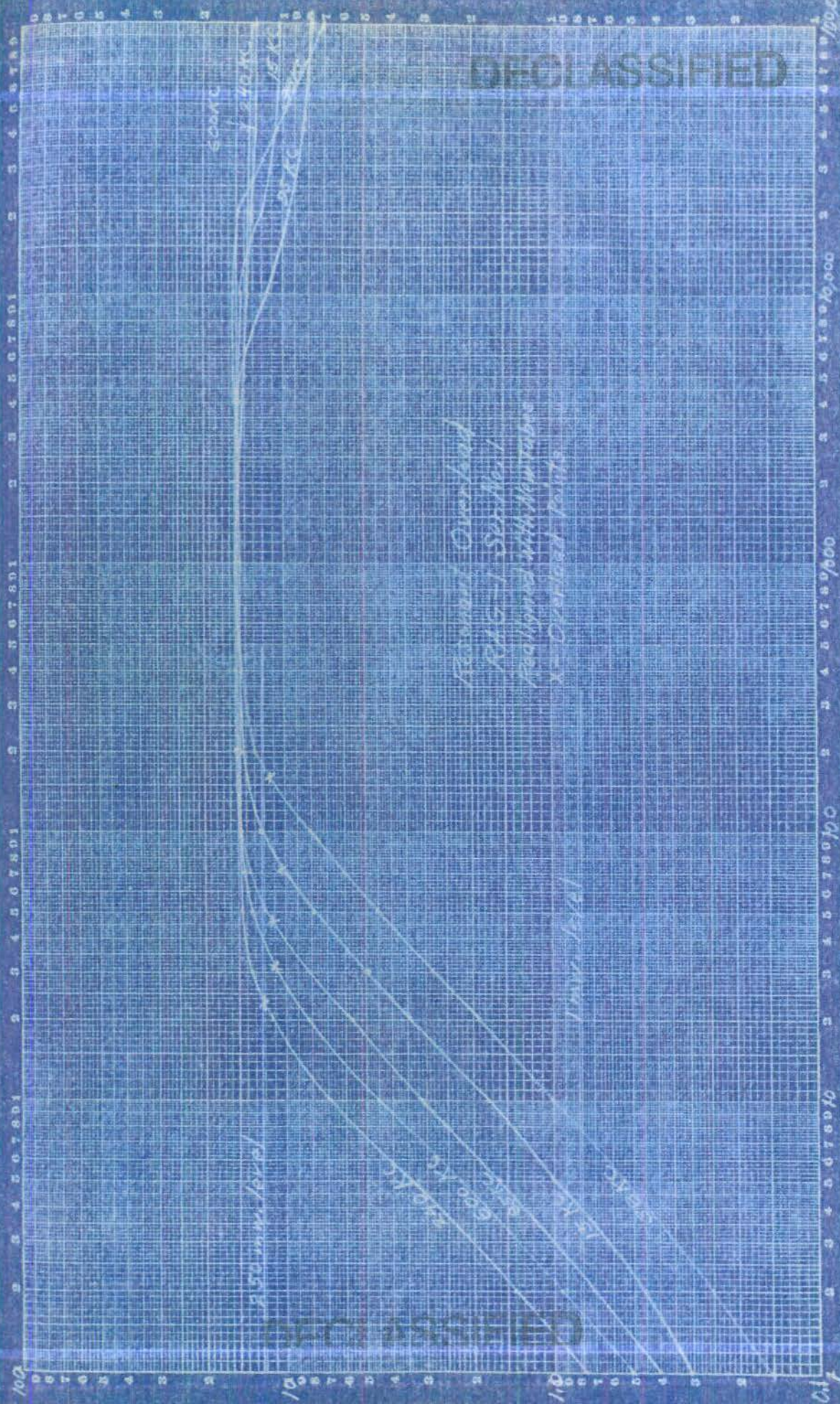


DECLASSIFIED

Sensitivity - Continuous Gain
RMS-1 Ser. No. 1
Band 4
Realigned with New Tubes



DECLASSIFIED



A-F Output - Volts

Plate 42

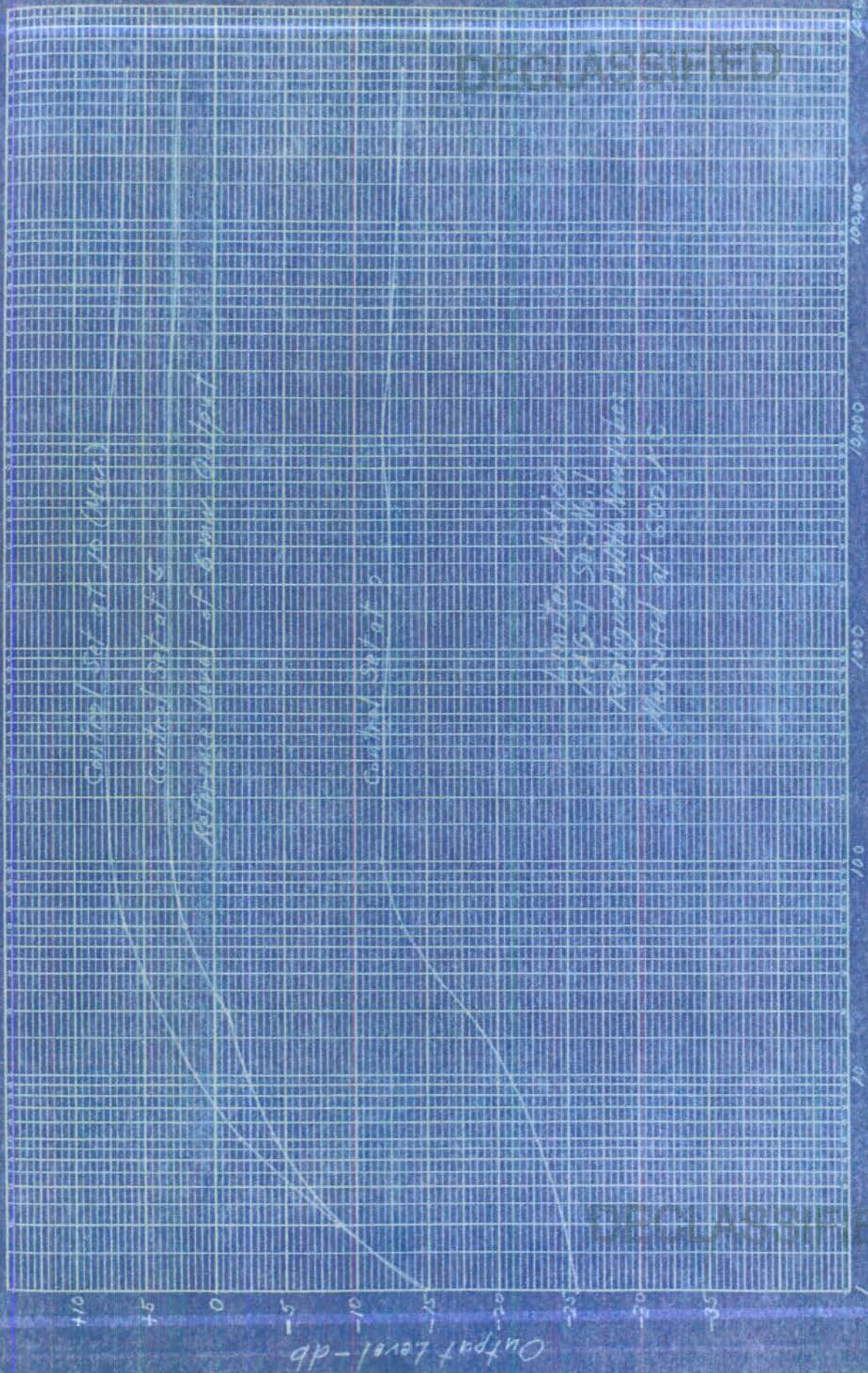
RF Input - Microvolts

100V/100

100V/1000

Frequency Overload
 PAG-1 Section
 Resonant with 400mhz
 X - Overload points

100V/100



R-F Input - Microvolts