Instructions for Quality Control of Variable-Area Sound Tracks

RADIO CORPORATION OF AMERICA
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Instructions for Quality Control of Variable-Area Sound Tracks

Section I
INTRODUCTION

1. It is the purpose of this instruction book to describe means of establishing values for the best photographic reproduction of sound, and for maintaining a consistent control. Instruction Book 24416 is available for the use of those who do not have the special equipment necessary to make the rather precise tests described in this book.

2. All photographic sound records of any type must satisfy at least two requirements in order to give faithful reproduction. First, the wave form must be the same as that of the exposing light, and second, the amplitude must be well above the noise level. With the proper values of exposing light and developers, these two conditions can be met. In the variable-area system of recording, the requirement of wave shape similar to the exposing light takes the form of the problems of image spread and sharpness, while the requirement of amplitude well above noise level is the problem of contrast. These photographic problems can be solved by the choice of certain conditions. It is the object of these instructions to describe the test procedure to be followed in order to determine these conditions. A brief explanation of the theory involved is given first.

Section II
THEORY

3. This instruction book includes a copy of a paper "*Modulated High-Frequency Recording as a Means of Determining Conditions for Optimal Processing*," by Baker & Robinson, reprinted from the January, 1938, SMPE Journal. This paper gives an excellent discussion of the fundamental theory of variable-area sound tracks. The following paragraphs summarize this theory.

4. A variable-area track is, fundamentally, nothing more than an oscillographic trace of the original sound wave having all the area on one side of the trace transparent and all the area on the other side of the trace opaque. In order to secure certain operation advantages, the tracks have been engineered in various forms, such as unilateral, bilateral, push-pull, etc. They are all designed, however, to accomplish the same final result; that is, to vary the light intensity reaching the photocell in the reproducer in accordance with the original sound waves.

5. Due to the characteristic of photographic materials, complete opacity and complete transparency are impossible, but it is not difficult to obtain a density contrast that will satisfy all practical requirements. The reason for a high density contrast is to produce a high ratio of signal to noise. In practice a print density of 1.4 with a fog density of 0.02 can be obtained. The density of 1.4 transmits only 4 per cent of the light, and the fog of 0.02 (plus the base of 0.03) transmits 89 per cent

of the light. This leaves only a small amount in volume level to be gained by going to higher density contrasts. However, certain practical considerations frequently indicate a greater freedom from noise at higher print densities.

6. Another requisite of a good print is that the silver image must be exactly the same size and shape as the optical image that formed it. It is characteristic of all photographic materials to diffuse the light that penetrates their surfaces. The degree of diffusion varies with different types of emulsions, the wavelength of the exposing light,* and the angle at which the light strikes the emulsion. In addition to this, the silver image is also affected in sharpness and size by the type of development. The effect of this diffusion on the exposure for any small unit area is that the total exposure in this area is dependent on the exposure of adjacent areas. It follows, therefore, that the boundary of the silver image lacks sharpness and may be larger or smaller than the optical image. On sound-track prints where the unit areas are comparatively large, as is true of the lower frequencies, this image spread is of negligible importance. However, at the higher frequencies (those having a wavelength of less than 4 or 5 mils) the image spread becomes an important factor. After taking advantage of all the factors which reduce the image spread, the silver image on a print at a density of 1.4 is larger than the optical image that formed it. Consequently, in order to produce the correct silver image on the print, it is necessary to introduce a compensating effect (image spread) into the negative; that is, the silver image on the negative must be larger and therefore the clear portion smaller by the amount of image spread in the print, so that when the negative is printed the silver image on the print will be exactly the same size and shape as the optical image that exposed the negative.

7. The problem of determining the amount of image spread for a given set of equipment is solved by the recording and measuring of special frequency tests. The effect of image spread at 1,000 cycles is negligible; therefore this frequency can be recorded for reference. The top of the frequency range for commercial recordings is 9,000 cycles, so this frequency can be used to determine the maximum high-frequency attenuation. It might appear that determination of conditions producing the least high-frequency attenuation would be the answer to the problem. This is true; but such a test is not sufficiently critical to be accurate. The image spread becomes more apparent in a form other than the attenuation of high frequencies. Consider again the fundamentals of a simple variable-area track without noise reduction. The average transmission is 50 per cent and must remain constant regardless of frequency. At the low frequencies image spread merely increases the size of the image slightly. As a fully modulated track moves past the slit, the light reaching the photocell is modulated from 0 to 100 per cent. The average transmission is thus 50 per cent. However, at the higher frequencies, each wave is so close to the adjacent waves that when image spread occurs the waves come together to form a secondary image. This, of course, occurs in the valleys. Consequently, as a fully modulated track moves past the slit, the light reaching the photocell is light modulated from 0 to something less than 100 per cent. If, for example, the modulation at 9,000 cycles of the light passing through the film goes from 0 to only 60 per cent, due to the fill-in from image spread, the average transmission will be only 30 per cent. Therefore, a rapid change from a low to a high frequency, or a rapid change in amplitude of a high frequency will produce a new frequency which is the envelope frequency of the change in average transmissions; or in other words, partial rectification takes place. This effect is sometimes called "filling in the valleys" or "zero shift." An example of this effect is a recording of 9,000 cycles varying in amplitude at the rate of 400 cycles. There will be present in the output three frequencies: the 9,000-cycle carrier and two sidebands of 8,600 cycles and 9,400 cycles. There should be no 400-cycle tone present in the output. However, if there is image spread on the film, an entirely new frequency of 400 cycles will be generated by the partial rectification mentioned above. When the 400-cycle component of such a recording is measured through a band-pass filter, it serves as a very accurate and critical measure of image spread, and the complete absence of 400 cycles will indicate exactly the best photographic conditions for cancellation of image spread.

8. In the reproduction of variable-area sound tracks, image spread is audible as distortion of sibilant sounds. It should be noted, however, that a similar distortion can be produced by "clipping" or "overshooting" these same sibilants.

9. Since this control system measures cancellation, care must be taken to insure that both record-

*Any patent rights which RCA has to the use of restricted bands of light for recording or printing of sound track are restricted to use with RCA recorded film.

ing and reproducing test equipments do not introduce appreciable 400-cycle components. If this precaution is not observed, the point of maximum cancellation will be influenced by the 400-cycle component introduced by the test equipment, and therefore will not indicate the correct photographic conditions. Such a situation may lead to the belief that the control system is not satisfactory, whereas the actual trouble lies in the application of the system.

10. Since all release prints must be standard tracks, conditions must be set up for best processing of standard tracks. The same conditions should be followed for pushpull tracks.

Section III

OUTLINE OF TEST PROCEDURE

11. This brief outline is given so that the general procedure and sequence can be understood before going into the details. Since the picture requirements usually determine print stock and development, these factors are already established.* This leaves the four variables of negative exposure, negative development, mechanical operation of the printer, and print exposure to be determined. Each of these variables must be controlled and its proper value determined before consistently satisfactory processing can be secured.

a. Make a test recording consisting of 1,000 cycles, 9,000 cycles, 9,000/400 cycles (9,000 cycles varying in amplitude at the rate of 400 cycles) at constant amplitude (80 per cent modulation) using a modulated carrier oscillator with good wave form. Repeat this test at several different lamp currents. Expose sensitometric strips in the track area. (See paragraph 12.)

b. Develop this negative in the variable-area negative developer. (See paragraph 13.)

c. Measure and record the densities, amplitude, and track placement of the tests. Measure the sensitometric strips to verify developing conditions. (See paragraph 14.)

d. Print the entire negative including sensitometric strips for print densities of 1.2, 1.3, 1.4, 1.5, and 1.6. Expose sensitometric strips on each roll. (See paragraph 15.)

e. Measure and record track densities and track placement. (See paragraph 16.)

f. In the test reproducing equipment, measure the output of the 1,000 cycles, 9,000 cycles, and 400-cycle component from the modulated 9,000-cycle recording. (See paragraph 16.)

g. After correcting the data recorded as indicated above in accordance with the instructions in paragraph 14, a family of curves should be plotted similar to those shown on figure 6, and then a curve like figure 7 should be plotted from these curves. From these curves it may be determined whether or not the processing is satisfactory. If the processing is satisfactory, then the optimum negative density for a given print density, and the permissible tolerances may be determined. (See paragraph 17.)

* The special case of master sound-track prints for re-recording is discussed in paragraph 22.

Section IV

METHOD OF SETTING UP LIMITS FOR QUALITY CONTROL

Recording

12. Make test recordings as indicated below, carefully observing all equipment considerations:

a. *Oscillator.* For these tests an oscillator is required which provides a source of 1,000 cycles, 9,000 cycles, and 9,000 cycles modulated by 400 cycles. The wave form should be good. In accordance with the well-known theory of modulation, when the oscillator* is delivering modulated 9,000 cycles, there is present in the output 8,600, 9,000, and 9,400 cycles, and these are the frequencies with which we are concerned. The residual 400-cycle output should be at least 90 db below the high-frequency output. Four-hundred cycles has been selected as the modulating frequency because of the availability of band-pass filters required in the reproducing circuit, and this frequency must be held within ±10 cycles.

b. *Recorder and Recording Amplifier.* Before making any film tests, the recorder should be carefully checked for track location, azimuth, and focus according to instructions furnished with the recorder. Also, the amplifying equipment should be checked for cross-modulation at the level at which it will be operated. As the film measurements often go below 40 db, the equipment cross-modulation should be down at least 60 db. The importance of having the proper recording equipment is stressed here because any defects of this equipment will give false values for processing conditions. For instance, incorrect focus or azimuth will show an attenuation of high frequencies which is not due to processing. The most important factor is the linearity of the recording system. Any nonlinearity would cause cross-modulation and therefore introduce a 400-cycle component into the modulated 9,000 cycles. This could then be cancelled in processing, but the combination of negative and print densities for cancellation would be incorrect for the best photographic conditions. In the event cross-modulation exists in the amplifiers, the 400-cycle component produced can be eliminated by the use of a suitable high-pass filter between the amplifier and the galvanometer.

c. *Recording.* Record a test negative (modulated 80 per cent) of 1,000 cycles at different values of lamp current. Then record 9,000 cycles at the same lamp settings and same amplitude. Next record modulated 9,000 cycles at the same level and lamp settings. At least 5 modulated 9,000-cycle sections should be recorded, but it may be possible to record only one 1,000-cycle section and three 9,000-cycle sections if the general processing conditions are sufficiently well-known to be able to get the 1,000-cycle section and the second 9,000-cycle section near the normal density. The frequency recordings should be at least 8 feet in length to facilitate readings. An unmodulated full-track exposure should be made at the end of each frequency to provide a sufficiently large area for making density readings. Because the negative density is between 2.0 and 2.8, it is suggested that an exposure test be made first, and developed normally, to determine the range of lamp currents required for these values of density.

NOTE: It is common practice to record negatives which will be used to make dubbing prints at the same density as negatives for release prints. This is merely for the sake of convenience in recording, and to avoid possible confusion due to having negatives at different densities, but is not necessary photographically.

d. *Sensitometer.* A standard Eastman IIB sensitometer is preferred as a standard exposure device for the establishing and maintaining of developer control.

e. *Sensitometric Strips.* Expose sensitometric strips in the track area of the negative roll. This exposure should be in the track area so that a "print through" gamma strip will be made when the negative is printed.

Negative Development

13. Develop the negative made as described in paragraph 12 in a variable-area negative developer. If the negative is a test on general overall quality, it should be developed under normal conditions previously established.

a. *White-Light Specification.* If conditions are being established in a new laboratory, the developer should have the following characteristics when used with recent fine-grain stock. The density values below include a base density of 0.24.

TABLE I—DEVELOPER SPECIFICATIONS FOR WHITE-LIGHT EXPOSURE

Factor	*Value*
(a) Gamma	above 3.4
(b) Density of 8th Step (from light end)	2.5-2.6
(c) Density of 1st Step (light end)	less than 0.35
(d) Fog	less than 0.30 (0.06 without base density)
(e) Toe break	less than 1.0
(f) Shoulder break	above 3.0

b. *Ultra-Violet Specifications.* In establishing developer control there are some advantages in using sensitometric strips exposed through the same type of filter as the sound track. This is done by replacing the standard filter in the sensitometer with a four-inch square of the same filter material as

* Instruction Book 2R12-4.2 gives a description of the MI-10803 oscillator which is designed for this purpose.

is used in the recorder. A Corning 597 filter, 3mm thick, is currently recommended. This gives a different characteristic than obtained from the standard positive IIB sensitometer exposure, but more nearly duplicates the conditions of exposure on the sound track. If this procedure is followed, a different set of specifications must be established. The U. V. specifications corresponding to the white-light specifications given above are as follows. The density values include a base density of 0.24.

TABLE II—DEVELOPER SPECIFICATIONS FOR ULTRA-VIOLET EXPOSURE

Factor	*Value*
(a) Gamma	above 2.6
(b) Density of 12th Step (from light end)	above 2.4
(c) Denstiy of 1st Step (light end)	less than 0.35
(d) Fog	less than 0.30
(e) Toe break	less than 1.00
(f) Shoulder break	above 2.4

c. *Developer Formula.* The type of developer required to produce the above results compared to average positive developers will be found to create more contrast, give a higher density speed, lower toe, and less fog. It is difficult to recommend a developing formula that will produce these results as the character of the development is affected by the mechanics of the developing machine. A formula that has been found to be very satisfactory in a particular machine is the following:

Elon	0.9 grams
Sodium Sulphite	62.8 grams
Hydroquinone	15.7 grams
Sodium Carbonate	23.5 grams
Potassium Bromide	2.1 grams
Water to make	1.0 liter

Preferably the time of development should be seven minutes or over, since long time development is known to give better results than short time development.

Negative Measurements

14. Measure and record the densities, amplitude, and track placement of the tests as indicated below. It is desirable to have a convenient data sheet to record all measurements. Figure 4 shows a typical data sheet with space for a negative and only one print.

a. *Microscope.* A magnification of twenty-five diameters is quite suitable for all observations. The microscope must be equipped with some means of measuring amplitudes and track location. A calibrated eyepiece reading directly in mils is most convenient for this purpose.

b. *Visual Inspection.* At this time visual inspection of the negative is desirable. Any trouble condition found at this time can then be corrected and the tests repeated before further time and film are used in making prints. The focus should be observed and the sharpness should be the best possible and similar to the sample shown in the envelope attached to the inside cover. Any streaks in the track can often be traced to dirt in the recorder slit or some other part of the optical system where the image is in focus. The symmetry and wave shape of the image should also be checked.

c. *Amplitude Measurements.* Measure and record the amplitude of each section. Since most routine film tests are made on equipment having at least 1 db volume control steps, it is necessary to correct for the actual amplitude recorded on the track. This can best be measured on the negative because the 9,000 cycles on the prints are not usually well enough defined to make accurate measurements. Note on the data sheet (fig. 4) that a space is provided for each half of the track. This is worthwhile for reference to the alignment of the recorder optical system. Reference to figure 2 shows the amplitude of the 1,000 cycles to be .061 inches (80 per cent) and the amplitude of the 9,000 cycles to be .057 inches (75 per cent). On figure 3 read 61 mils as the reference frequency on the abcissa and 57 mils as the test frequency on the ordinate. This gives a value of +0.58 db to be added to the 9,000-cycle readings as in this example:

TABLE III—SAMPLE CORRECTION FOR 9,000-CYCLE READINGS

Freq.	*Amplitude*			*Correction*			*VI Readings*	*9000 Cy. Referred to 1000 Cy.*	*Corrected Output*
	Sproc. Side	*Picture Side*	*Total*	*For Amplit.*	*For Amplif.*	*Total*			
1000	.0306	.0304	.061	0	0	0	+6	0	0
9000	.0287	.0283	.0570	+0.58	0	+0.58	+2	—4	—3.42

TABLE IV—SAMPLE CORRECTIONS FOR MODULATED 9,000-CYCLE READINGS

Freq.	Amplitude			Correction			VI Readings	9000 Cy. Referred to 1000 Cy.	Corrected Output
	Sproc. Side	Picture Side	Total	For Amplit.	For Amplif.	Total			
1000	.0306	.0304	.061	0	0	0	+6	0	0
9000/400	(.0307) + (.0305) —(.005 + .005)		.0512	+1.5	—25	—23.5	—1	—7	—30.5

In measuring the amplitude of modulation of the modulated 9,000 cycles, it is necessary to obtain the difference between the maximum and minimum modulation of the 9,000 cycles. Referring to figure 2, the maximum value of the 9,000 cycles is shown to be 80 per cent. For practical reasons it is impossible to obtain 100 per cent modulation of the carrier wave. However, the maximum modulation is A + B and the minimum is G + H. The value to be determined is (A + B)-(G + H). In figure 2, the values are as follows: A — .0307, B — .0305, G — .005, H — .005. Therefore, the amplitude is (.0307 + .0305)-(.005 + .005) or .0512 inches (67 per cent). Again taking the 1,000-cycle amplitude of 61.0 mils as the reference, and the 9,000/400 cycle amplitude of 51.2 mils as the test, the correction is read off as +1.5 db and should be added to the amplifier correction. For example, if the amplifier correction is —25 db, the total correction to be applied to the 9,000/400 cycle readings is —23.5 db.

Also, check the track placement of the negative at this time. Figure 1 shows the most recently published standards for film and track dimensions.

d. *Densitometer.* A "Capstaff Purdy" densitometer is quite satisfactory, and has the advantage that a smaller spot is required for density measurements than for some other types of instruments. However, it is desirable to reduce the size of the aperture still further by masking in order to be able to measure quarter-width track. Since quarter-width track is 19 mils, satisfactory results can be obtained with an aperture having a diameter of 12 mils.

The "ERPI" densitometer is finding wide use in the industry but the slit now supplied can be used only with half-width or full track.

e. *Density Measurements.* Measure and record the track densities, and check the uniformity of density across the track. Measure the sensitometric strips. These will serve as a check of developing conditions.

Printing and Developing

15. Print the negatives according to the following specifications:

a. *Release Prints.* Paragraph 18 (*"Possible Sources of Unsatisfactory Results"*) discusses printer troubles and adjustment of printers. Print the entire negatives made as described in paragraph 12 including sensitometric strips at print densities of 1.20, 1.30, 1.40, 1.50 and 1.60. This print should be developed in the normal release-print developer.

NOTE: For every negative density, there is an optimum print density. However, it is necessary for the print density to be above 1.3 to obtain most of the possible output level and noise reduction.

b. *Dubbing Prints.* If dubbing processing conditions are being determined, the print should be

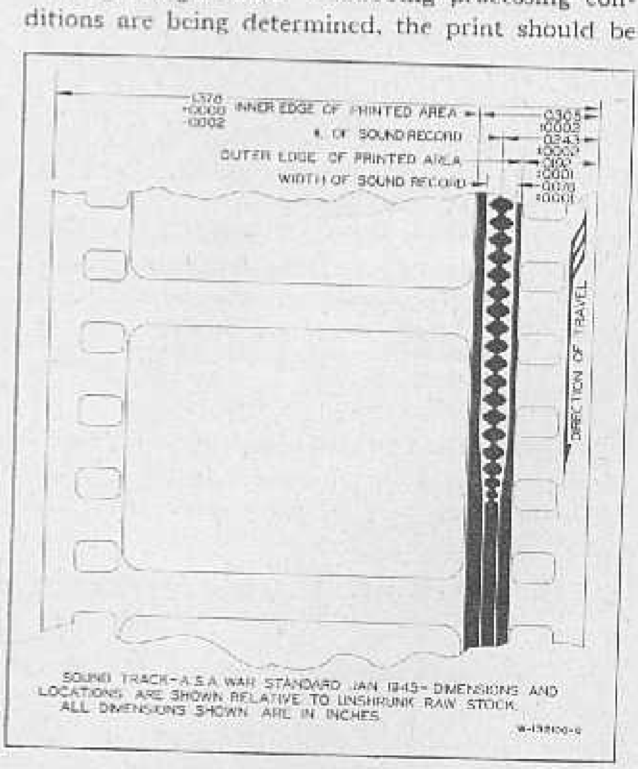

Figure 1—35 mm Sound Track Dimension Standards.

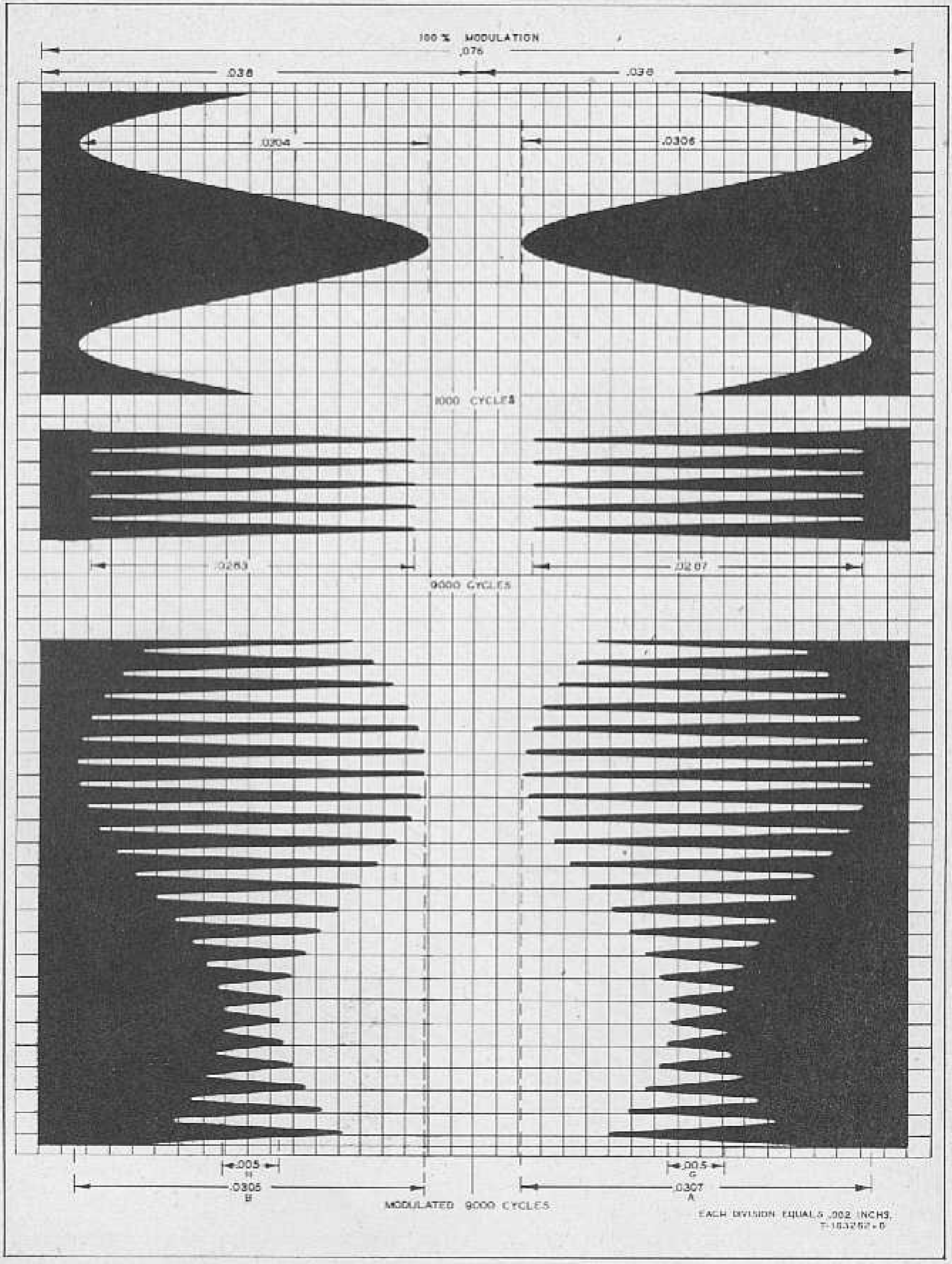

Figure 2—Image Spread Test Film.

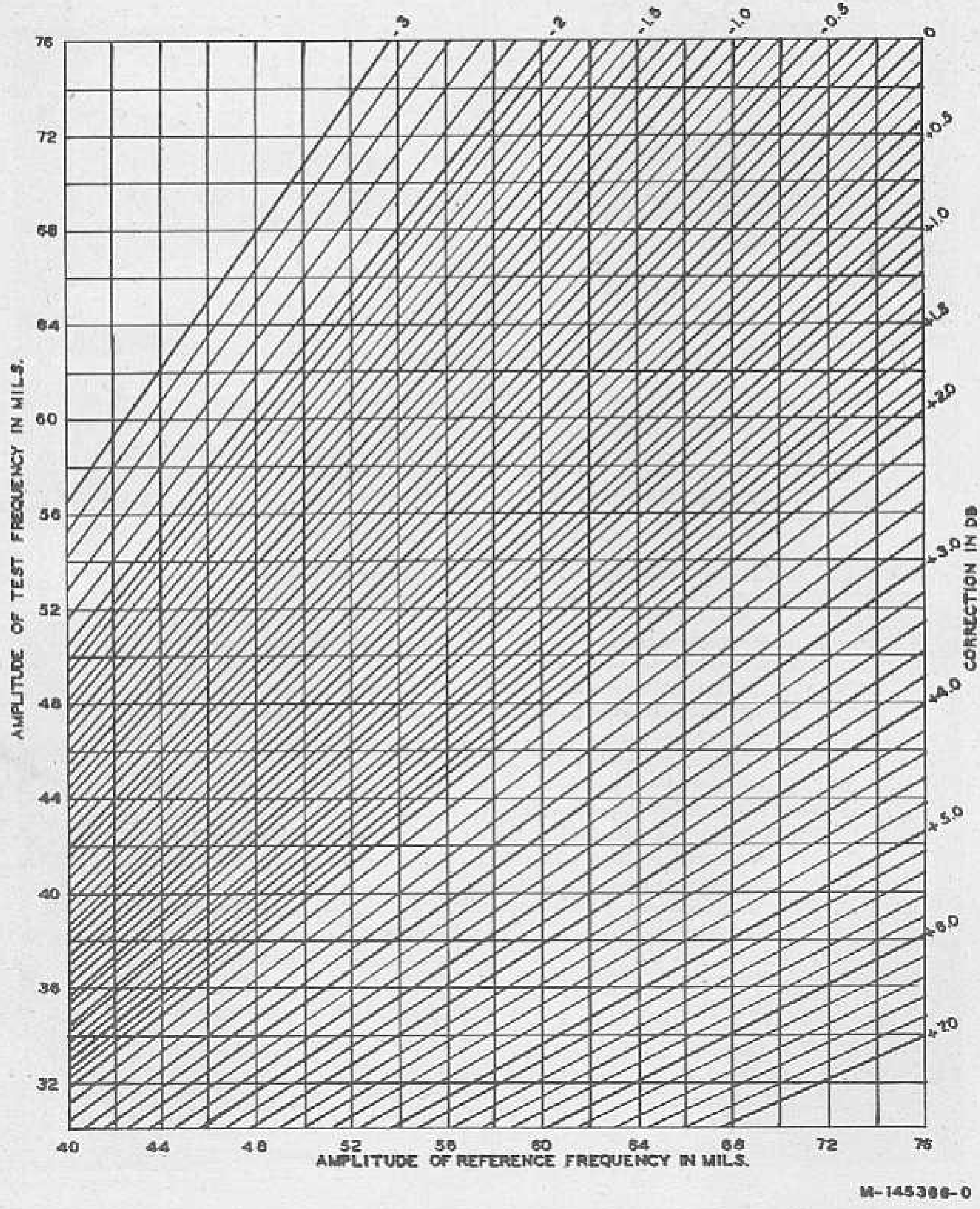

Figure 3—Correction Factor in DB for Difference in Amplitude Between Test Frequency and Reference Frequency.

RCA SOUND RECORD TEST

Producer: RCA — Prod. No.: A321 — Date: 11-14-45

RCA Test No.: 123 — Recorder No.: 2 — Laboratory: —

Negative Stock: 1372 — Negative Roll No.: 1 — Negative Fog: 0.30 INC. BASE DENSITY

Print Stock: 1302 — Printer No.: 2 — Print Fog: 0.04

NEGATIVE MEASUREMENTS

Lamp I	Neg. Den.	Freq.	VI	Amplitude: Sproc. Side	Amplitude: Pic. Side	Amplitude: Total	Corrections: Amplitude	Corrections: Amplifier	Corrections: Total	VI ± 1000~	Film Output
6.1	2.42	1000	+2.8	27	27	54	0	0	0	0	0
5.5	1.18	9000	+2.2	27	28	55	-0.12	0	-0.12	-0.6	-0.7
5.8	1.79	9000	+2.5							-0.3	-0.4
6.1	2.42	9000	+1.3							-1.5	-1.6
6.4	2.79	9000	-0.2	19	19	38	+3	-25	-22	-3.0	-3.1
6.0	2.15	9000/400	+5.4							+12.6	-19.4
6.1	2.25	9000/400	+6.5							+3.7	-18.3
6.2	2.48	9000/400	+8.4							+5.6	-16.4
6.3	2.65	9000/400	+9.3							+6.5	-15.5
6.4	2.77	9000/400	+10.5							+7.7	-15.3
6.5	2.90	9000/400	+11.3							+8.5	-13.5

PRINT MEASUREMENTS

Neg. Den.	Print Den.	Freq.	VI	Total Corr.	VI ± 1000~	Film Output
2.42	1.22	1000	+5.9	0	0	0
1.18		9000	-3.0	-0.12	-8.9	-9.0
1.79		9000	+3.2		-2.7	-2.8
2.42		9000	+4.0		-1.9	-2.0
2.79		9000	+3.3		-2.6	-2.7
2.15		9000/400	+5.5	-22	-0.4	-22.4
2.25		9000/400	+1.0		-4.9	-26.9
2.48		9000/400	-10		-15.9	-37.9
2.65		9000/400	-9		-14.9	-36.9
2.77		9000/400	-2		-7.9	-29.9
2.90		9000/400	+4.5		-1.4	-23.4

CONCLUSIONS

Tolerances for 30 db Cancellation

Max. Neg. Dens.: 2.85

Max. Print Dens.: 1.40

Min. Neg. Dens.: 2.59

Min. Print Dens.: 1.30

9000 Cycle Output: -3 DB

Remarks: 9000~ READINGS WERE CONSTANT WITHIN 0.5 DB

Figure 4—Sound Record Test Data Sheet.

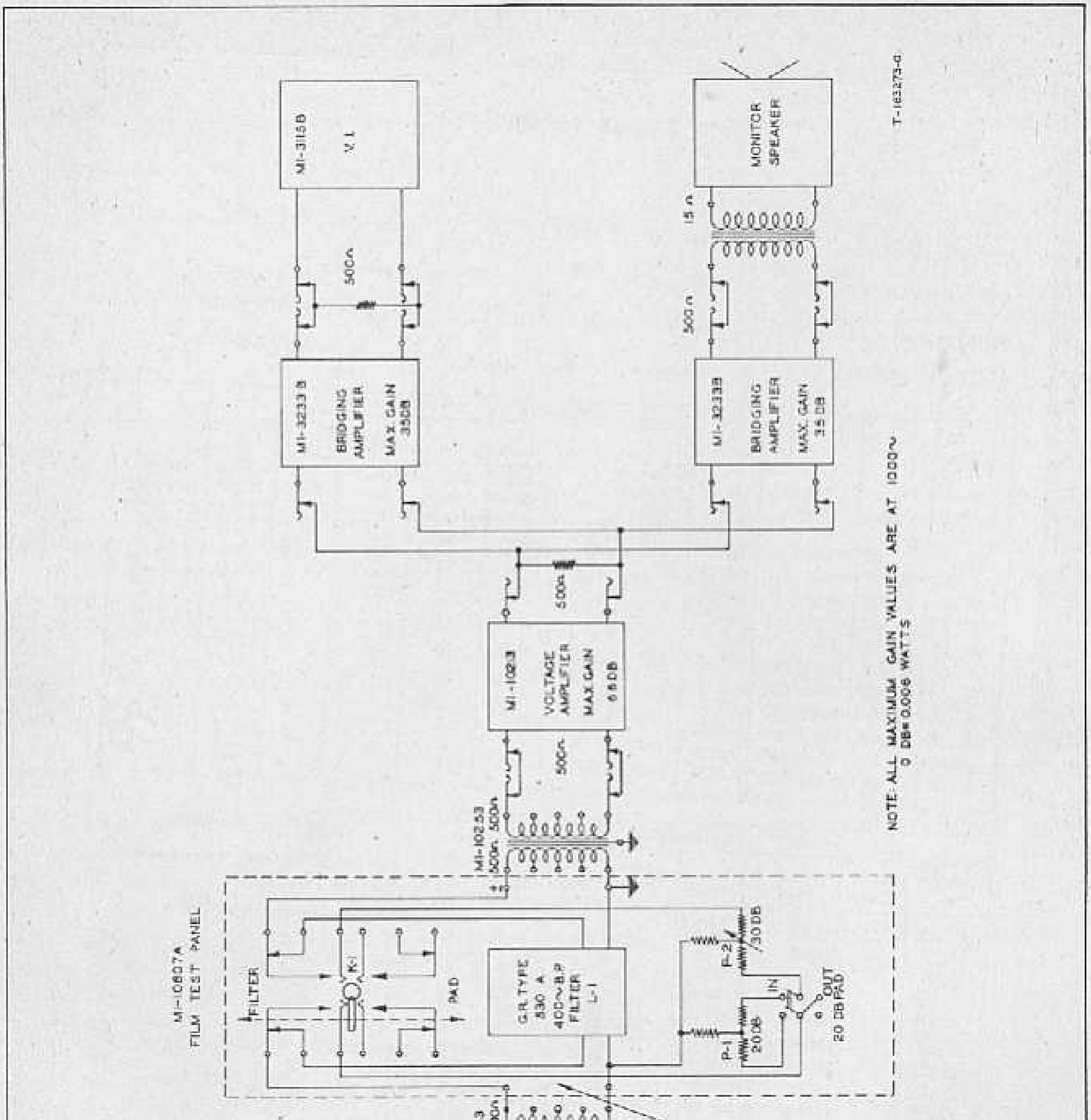

Figure 5—Test Setup Diagram.

developed in the special negative developer for best results. The print density will be considerably higher than release print density if the negatives were made at the same density as negatives for release prints.

Print Measurements

16. Measure and record the densities of the prints and check the track placement. It may happen that the track placement will be off on the print although it was correct on the negative. If it is outside the tolerances shown on figure 1, the trouble should be corrected before more prints are made.

a. *Reproducing Equipment.* The reproducing equipment should consist of a good film phonograph, calibrated amplifiers, MI-10807-A Film Test Panel,* and a volume indicator. The amplifying system should have at least 110 db gain, and should be accurately calibrated for frequency characteristic and freedom from distortion. The recommended setup is shown in figure 5. The normal jack conections shown in this figure have proven very satisfactory. The use of patch cords makes it possible to test different amplifiers without the trouble of disconnecting the amplifier leads. The object of the switching arrangement with the filter and attenuator is to facilitate taking all readings without changing the amplifier gain as the modulated 9,000-cycle output is considerably lower than the 1,000- and 9,000-cycle outputs. It is convenient to use 28 db attenuation when reading the 1,000 and 9,000 cycles and, since the filter has 3 db loss, 25 db is therefore subtracted from the modulated 9,000-cycle readings. The MI-10210-A Amplifier is supplied with 7 db rise at 9,000 cycles, with the alternative of obtaining a flat response by removing the jumper. Using either of these setups will require a correction to equal the reproducing slit loss. For example, if the 7 db rise is used, and the slit loss is 4 db, the correction is then 3 db which should be subtracted from the 9,000-cycle readings. If the jumper is removed, and the overall channel is known to have a flat frequency characteristic, a correction factor equal to the slit loss should be added to the 9,000-cycle readings. A more convenient arrangement would be to modify the amplifier to give a rise at 9,000 cycles equal to the slit loss, so that no corrections would be necessary. This is assuming that the amplifier is to be used for tests only and not for production recording. This setup will also reduce the possibility of error as there would be no variation in output if the high-frequency section was not recorded at exactly 9,000 cycles. If a sloping characteristic is used, a change in frequency will cause a considerable change in output.

* Refer to instruction book IB-24303-1 for instructions on the film test panel.

b. *Reproducing Measurements.* By means of this test reproducing equipment, measure the output of 1,000 cycles, 9,000 cycles, and the 400-cycle component from the modulated 9,000-cycle recording, observing at the same time the degree of variation in the output of each reading.

(1) Variation in output is probably an indication of poor printer contact or film motion. If the variation is so great that accurate readings cannot be made, it is useless to proceed further until improvements have been made in the printer, and a new print made.

(2) Another factor which may cause unsteadiness, loss of high frequencies, and high distortion is improperly dried film, frequently called "fresh" or "green" film. Such a print, when first reproduced, will exhibit a large amount of unsteadiness which will disappear as the print ages or dries. This occurs because the film is not flat and runs in and out of focus in the reproducer. However, a print made from an improperly dried negative will exhibit the same variations due to changes in printer contact, and therefore such a print will not improve with aging or drying.

(3) After correcting the output measurements in accordance with the instructions in paragraph 14c (*"Amplitude Measurements"*), a family of curves should be plotted similar to those shown on figure 6. A curve similar to figure 7 should then be made by plotting the two negative densities at which the curve for each print density crosses the 30 db cancellation line. When these points are connected by two lines, as shown, and the print density requirements set, the tolerance in negative density is readily apparent.

Conclusion from Measurements

17. The curves plotted as described above (similar to figures 6 and 7) are used to determine whether or not the processing is satisfactory and if so, to determine the optimum print density for a given negative density, the optimum negative density for a given print density, and permissible tolerances. For example, from figure 6 the optimum print density for a negative density of 2.4 is 1.05, and the optimum negative density for a print density of 1.37 is 2.75. It has been found by experience that cancellation of zero shift of 30 db or

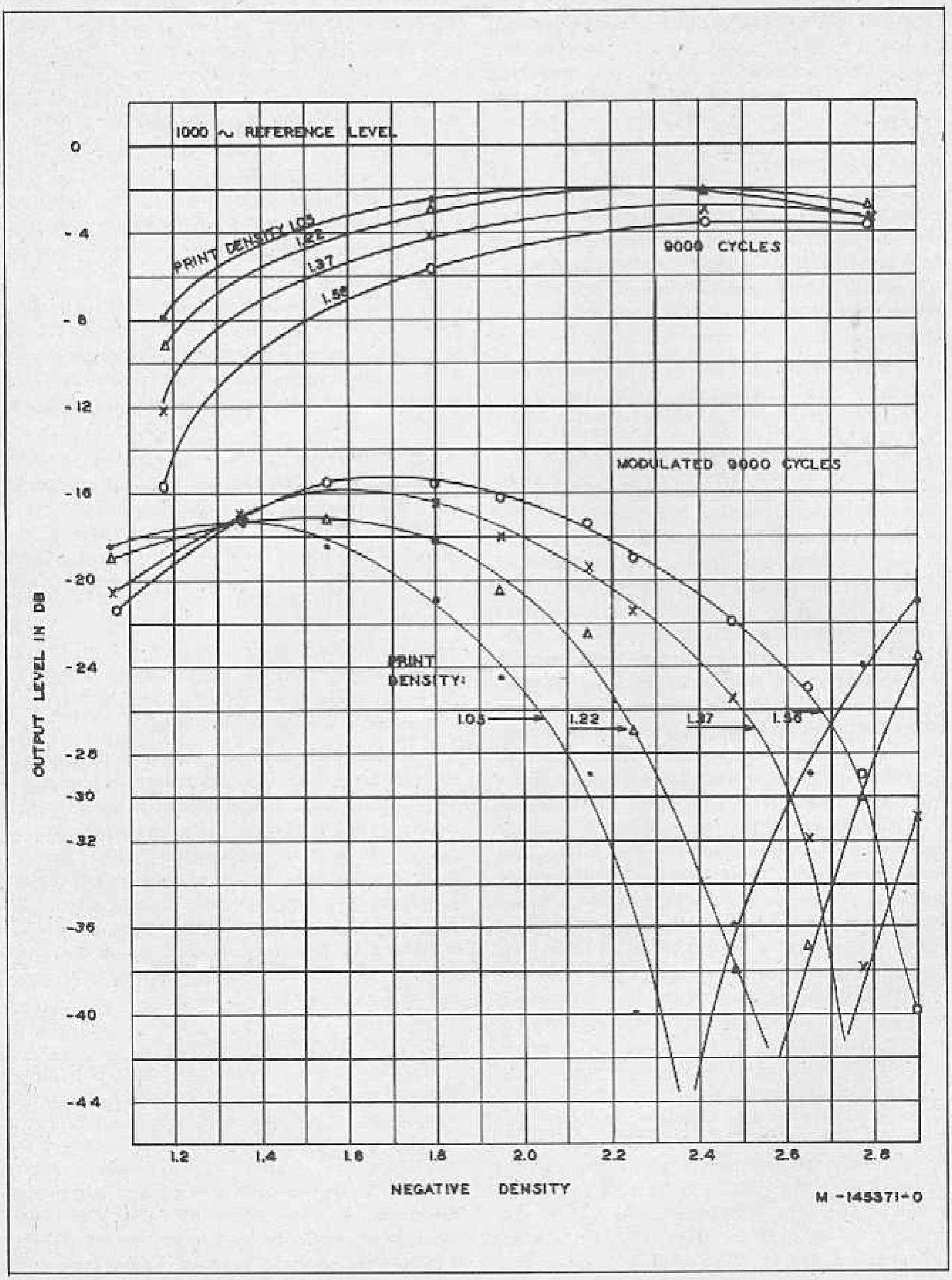

Figure 6—Family of Prints (processing characteristics).

greater is satisfactory. As shown on figure 7, for print densities lying between 1.3 and 1.40, the negative density may vary from 2.59 to 2.85 with cancellation of 30 db or greater. These figures are average commercial values and will give satisfactory results, but should not be considered the best that it is possible to obtain. There are many possible combinations of negative and print density which will give 30 db cancellation, but the high-frequency attenuation must also be considered. Within the tolerance limits the 9,000-cycle attenuation should not be more than 4 db. Reference to figure 6 shows that this requirement is also met with the negative and print tolerances permitted by satisfactory cancellation of zero shift.

Possible Sources of Unsatisfactory Results

18. If the tests described above do not show normal values, the following suggestions are presented as the result of experience in various laboratories:

NOTE: It is assumed that the recording machine has been properly aligned, and therefore its focus, azimuth, and track placement are correct. These tests are of no value unless the recorder is correctly aligned as recommended in the recorder instruction book.

a. If the tests show that proper tolerances may be secured at *higher* print densities, this is indicative of unusually *good* processing and printing, or unusually *poor* negative conditions. The recorder focus and negative developer are possible sources of trouble. If no improvement can be made in the negative, it should be reprinted to cover a higher print-density range.

b. If the test shows that *lower* print densities are required, this may be a trouble condition and should be investigated along the following lines:

(1) The negative should be checked for underexposure or underdevelopment. When the print requires lower density and therefore less image spread, it is possible that the negative has less image spread than normal. Therefore, if the density is normal, the development was probably not sufficient to bring out all of the latent image on the negative.

(2) The printer and print developer should be investigated. If more image spread than normal is introduced by this process, it is reasonable to assume that the image spread introduced by density alone must be reduced by using a lower print density.

c. *Printing is the most critical operation performed on sound tracks.* Experience has shown

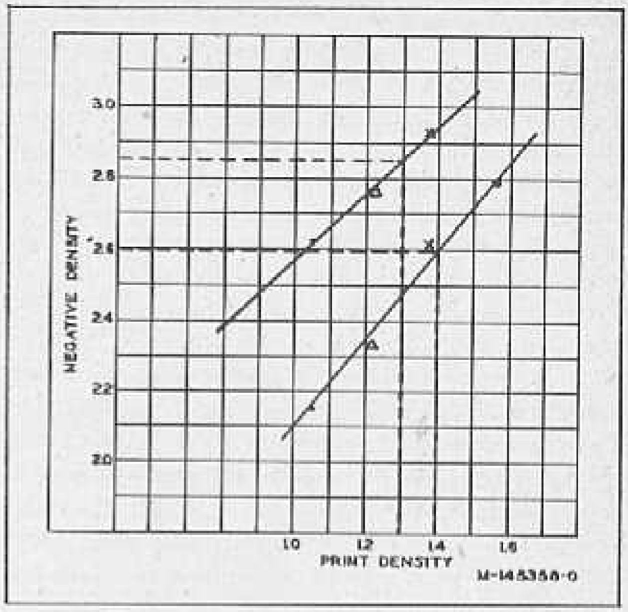

Figure 7—Family of Prints Tolerance Limits for 30 db Cancellation.

that the mechanical operation of the printer, including contact, slippage and motion is the most frequent source of trouble. This transfer probably introduces more quality loss due to image spread than any other operation. Even under the most ideal printing conditions the image spread caused by the diffusion of the negative silver grains is large compared with that produced by the recording optical system. Printers may also cause the attenuation of high frequencies, zero shift, variations in output level, incorrect track placement and low-frequency noises. The attenuation of high frequencies by a printer may not be important in itself, but indicates the likelihood of serious distortion throughout the frequency range if the high-frequency loss is due to poor printer contact, slippage, or other mechanical deficiencies. Each of these factors may be observed in the frequency tests. In practice it is very difficult to maintain the negative and print in contact and prevent slippage between the two films. On most commercial printers the irregularity of contact and slippage cause the most image spread. There are a number of points that should be checked on whatever printer is used.

(1) First, the sprockets must fit the film. In general it has been found that most sprocket-type printers are designed for more negative shrinkage than now occurs in the stock. This is especially true on new negatives. The feed sprocket is important as well as the printing sprocket, as any

irregular film motion caused by the feed sprocket is transferred to the printing aperture through slippage (caused by the film). In some cases it has been found that the negative was not sufficiently dried to fit the printer. That is, negative dried so it is equal to the length of raw stock is too long to fit most sprocket-type printers. Any misfit of the sprockets causes poor contact and slippage. Short-pitch film has been used effectively to compensate for the difference between the printer sprockets and the lack of shrinkage in modern film. The preferred solution, however, is to obtain sprockets which fit the film being processed. On many commercial printers used for printing unshrunk film such as dailies, an improvement in print quality is obtained by replacing the feed sprocket with an RCA sprocket, Stock No. 26826. This sprocket has a larger root diameter which fits unshrunk film stock.

(2) The height of the printing aperture, or the distance over which the film is printed, has much to do with the quality of the printed track. This is effective in the following way. Some slippage is nearly always occurring on a sprocket printer. If this slippage is taking place over a distance of three eighths of an inch (the size of the aperture on many printers) its effect is quite large. However, if the aperture is reduced to one-eighth of an inch the effect of slippage is reduced to one-third of its former value. It therefore becomes desirable to reduce this aperture as much as possible. If it is reduced too much, trouble will be encountered with non-uniformity of track density caused by irregularity of speed of the printing sprocket. Also, it may be difficult to secure sufficient light intensity. For these reasons a one-eighth inch aperture has proven most satisfactory.

(3) Adjustment of the gate shoe holding the films in contact is very critical. To secure the best results the final adjustment can only be made by trial. Air pressure applied between the gate shoe and the film has been found helpful in many cases.

(4) If the printer slippage, contact, and track placement are correct, check fog on the print—this should be less than 0.04. If the fog is higher than 0.04, the problem of improving print development should be discussed with the laboratory, since high values of fog are objectionable for picture purposes as well as for sound track.

19. If none of the above suggestions reveals the source of trouble, repeat the measurements, and if no measurement errors are discovered, the entire test should be repeated.

Section V

MAINTAINING QUALITY CONTROL

20. After the proper conditions of exposure and processing have been determined, control can be maintained by constant and systematic testing. Careful records of these tests will prove of great value when trouble occurs, and in controlling the process to get the best results.

Routine Tests

21. The negative exposure must be controlled so that with normal developing conditions, the negative density will be within the tolerance limits. The temperature and the age of the stock are two of the factors which should be considered. At high temperatures, less exposure is required. By careful observations, a chart can be worked out which will serve as a guide. This precaution need only be observed when the change in temperature during recording is large, such as 20 degrees or more from the test conditions.

a. *Daily*. Record a test negative on each machine at the exposure used for the day's work. This test is then developed and printed with the work simply as another scene. This test will be representative of each day's work for each company. Of course this test need not be as long as the tests to determine conditions. It should be sufficient to record only one 1,000-cycle test, one 9,000-cycle test, and one 9,000/400-cycle test, all at the same density as the work. Measurement of the daily test negatives will indicate whether or not all of the companies fall within the operating tolerances. If for any reason a company does not fall within the specifications, the test can be used to trace the trouble and determine how to make the best print. For the purpose of checking the daily operation of the printers, make a daily print on each printer of the 1,000, 9,000, and 9,000/400 cycle section at the optimum negative density found by the previous week's complete check of tolerance and overall conditions (see sub-paragraph b "*Weekly*"). This daily test of each printer is necessary because it has been found by experience that the mechanical operation of printers is the greatest source of processing troubles. It might appear that, because of the rugged construction of these machines, once they are adjusted to produce a good print, no further maintenance would be required. This has not proven to be the case, but rather that only by careful daily maintenance and tests can consistently good prints be obtained. For this reason it is apparent that simply determining that a print has the proper density is not sufficient information to prove that it is a good print. The contact and slippage produced by the printer are large controlling factors in print quality, and can only be measured by frequency tests or examined under the microscope. Printers are discussed in more detail in paragraph 18, "*Possible Sources of Unsatisfactory Results.*" Still another factor affecting print quality is development. It is generally assumed that the print development is fixed by the picture requirements. However, it has been found in some cases that changes were made in the positive developer control which seriously affected the track. Therefore this factor cannot be neglected when looking for processing troubles.

A daily graph of the following will be found quite helpful for reference:

(1) Negative gamma
(2) Density of sensitometer control step
(3) Negative fog density
(4) Track density for each recorder
(5) Print gamma
(6) Print through gamma
(7) Print fog density
(8) 9,000-cycle attenuation for each recorder
(9) Cancellation for each recorder

Records must be maintained of the production number and scene number that each cancellation test represents, as this information is used later for making the master tracks for re-recording.

b. *Weekly.* A complete test as described in "*Outline of Test Procedure*" should be made each week for the purpose of checking the density tolerances and overall recording conditions, which information the daily tests do not supply.

Master Tracks for Re-recording

22. Since the sound quality in the final production is dependent on the master tracks that are used, every precaution should be taken in their preparation. First, the data on the weekly tolerance tests must be examined to determine if there has been any change in these tolerances during the production. Next, the daily records must be examined to determine if any particular scene falls outside the tolerance for the production.

The Re-recorded (Release) Negative

23. Where it is expected that the release print will be made in another laboratory, a test negative should be recorded on each roll of re-recording. This test should be an integral part of the negative reel of the production when footage permits and should not be removed by the laboratory. These tests will then be printed as a part of the answer or preview print. Measurement of these prints will indicate whether or not the processing was satisfactory and will serve as a guide to the release laboratory. Where several negative tests have been made and they are all found to be alike, only one test negative need be sent to the release laboratory.

Domestic (Release prints from original negative)

24. By controlling the processing by means of the test negative shipped with the picture, the release laboratory may insure quality equal to that obtained at the studio. It is, therefore, necessary that the release laboratory familiarize itself with these tests, and provide the necessary measuring equipment. Where a large number of release prints are required, the number of prints of the test negative which should be made must be determined by the release laboratory since it is a function of the consistency of their operation.

Foreign (Release prints usually made outside the United States from photographic duplicates)

25. The specifications for the duplicating process may be determined by the obvious application of the test procedure previously outlined in this report, and once this process has been determined, it may be readily controlled by permitting the test negative employed in checking of re-recording and release print processing to follow through the duplicating process.

26. As a guide to setting up the proper duplicating processes, the following data indicate values

which have been satisfactory, in particular developers, for the particular stocks noted. While specific stocks are indicated, it is not the intention of this report to recommend the use of these stocks, but merely to show examples of values which have been satisfactorily employed in certain instances.

TABLE V—SAMPLE VALUES FOR DUPLICATING PROCESS

(Picture and Track)	*Stock*	*Exposure*	*Gamma*	*Density*
Original Negative	1372	UV 597	2.9—3.3	2.7
Master Positive	1365	W.L.	1.45	2.33
Dupe Negative	1203	5mm. 556	0.55	1.62
Release Prints	1302	UV 584	2.50	1.70

By the application of the test procedure given in these instructions, the proper values may be established for these or other duplicating stocks.

27. Although part of the duplicating process is carried out in the foreign laboratory, frequent tests should be made in the studio laboratory to check the quality that can be obtained by the recommended duplicating procedure. The test should include both the measurement of modulated-frequency records and practical listening tests of speech and music. In some cases a master positive is sent to the foreign laboratory, and in others a duplicate negative is sent. A print from the dupe negative will check both the duplicate negative and master positive, and prove conclusively that satisfactory foreign-release prints can be obtained.

Section VI

MODULATED HIGH-FREQUENCY RECORDING AS A MEANS OF DETERMINING CONDITIONS FOR OPTIMAL PROCESSING*

J. O. Baker and D. H. Robinson

SUMMARY.—The quality of variable-width sound records depends to a great extent upon image definition. The requirements for a perfect sound-track are complete transparency in the clear portion, complete opacity in the dark portions, an extremely sharp boundary between the clear and dark portions, and exact duplication of the wave traced upon the track by the galvanometer.

Distortion is introduced by any change in average transmission in recording high-frequency waves. At high densities the average transmission is reduced, and at very low densities is increased by the presence of the high-frequency waves. The average transmission is compared to the transmission through the film for a 50 per cent exposed track without signal.

It is possible to find a density at which there is little, if any, change in average transmission, and this density corresponds to most nearly perfect image definition and least distortion. On an original or negative recording with present commercial recording stocks, this density is extremely low, of the order of 0.6 to 0.8. For least ground-noise, the negative must be recorded at much higher density. A change in average transmission of the negative can be tolerated, since by proper choice of print density, minimum distortion in the positive track can be attained.

A modulated high-frequency recording affords an extremely accurate means of determining correct negative and print densities for given conditions of laboratory processing. An oscillator, designed for several carrier frequencies, is provided with a 400-cycle modulator for recording. The modulated carrier is recorded for several values of lamp current and processed to several negative densities. Prints are then processed to various values of density, and the 400-cycle output measured on suitable reproducing equipment. The combination of negative and print densities that gives least 400-cycle output indicates the condition for best image definition and least distortion.

Care must be exercised in the design and construction of the oscillator to maintain the 400-cycle output at a minimum.

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Pages 3 to 17 inc.

The quality of variable-width sound records will depend upon how closely the requirements for perfect wave-form, low ground-noise, and freedom from volume distortion are met. Papers have been published in the JOURNAL from time to time dealing with one or the other of these requirements. Kellogg[1] in 1935 discussed all three in a rather comprehensive manner. It is the purpose of this paper to consider the problem of wave-form in detail, and to describe a method for determining the conditions for optimal processing.

In 1927, Hardy,[2] treating the general subject theoretically, stated ". . . the quality of sound reproduced by the variable-width type of record does not depend upon the conditions of exposure or development of either the negative or positive." This is essentially true of the variable-width system, in contrast to the variable-density system,, and is quite true for the low frequencies up to those of the order of 4,000 cps., provided the exposure or development are not too radically different from the correct values. The higher the frequencies recorded, the greater the necessity for correct exposure and development.

Jones and Sandvik[3] in 1930 mentioned certain factors affecting the structure of the photographic image, with which this discussion is primarily interested: namely, image contraction, image growth, and the mutual action of adjacent images. For high-quality reproduction at 4,000 cps. and above, these factors become of considerable importance.

Maurer,[4] in setting values for the sound negative and positive densities, based his consideration upon resolving power and contrast. While these factors are necessary in variable-width records for frequency and volume range, the structure of the photographic image must also be considered when high frequencies are recorded. Dimmick[5] in 1931 admirably treated the subject of negative and print densities for maximum output at the higher frequencies. Imperfection of the wave-form introduces not only harmonics and volume distortion at high frequencies, but also extraneous sounds, commonly known as "raspiness" or "hash." This distortion bears no frequency relation to the recorded frequency, but is dependent upon the change of amplitude and the recurrence of the recorded high frequency. Fig. 1 illustrates this statement. A shows how the distortion increases with increase of volume. B illustrates the introduction of a new frequency due to the repetition of the normal build-up and decay of a high-frequency wave-train. Since speech and music are made up of wave-

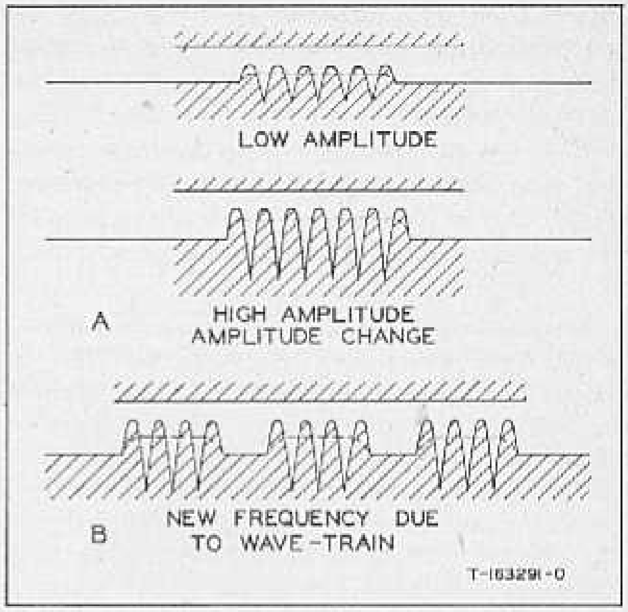

Figure 1(A)—Increase of distortion with volume. (B)—Introduction of new frequency due to wave train.

trains of such type, it can be seen that the distortion continuously changes in frequency and amplitude. A mathematical treatment of wave-form distortion was given by Cook[6] in 1930 and by Foster[7] in 1931, and need not be repeated here. This paper will be limited to an illustrative discussion and explanation of experimental data for showing how the distortion occurs in processing, and how it can be minimized.

Mees[8] in 1935 stated quite concisely the condition for minimum distortion: namely, "The point of minimum distortion occurs when the lack of sharpness, due to light scattered by the optical system and by the photographic emulsion in the recording process, is compensated for by a corresponding spreading of the image in the printing process."

Dimmick suggested the use of a modulated high-frequency recording for the practical determination of the distortion introduced by spreading of the photographic image. E. P. Schultz designed and built the first modulated high-frequency oscillator and Dimmick was the first to use it to practical advantage, in the early part of 1936. Since then, improvements have been made in the design and construction of the oscillator and much information has been obtained on the behavior of image-spread for various emulsions, different types of developer, and printers.

Without a doubt, this oscillator is the most powerful tool found to date, and is useful not only for studying the processing conditions of photographic sound records, but also for checking other sources of distortion such as found in amplifiers, loudspeakers, printers, etc.

The purpose of this paper is to show only its use for photographic sound records. A description and explanation of its operation will be given later for the benefit of those who wish to take advantage of this method.

Image Definition.—In order to understand fully the problem involved, it will be desirable to consider the image definition and the factors affecting it, together with the requirements for a perfect sound-track of the variable-width type. A perfect sound-track would be one having complete transparency in the clear portions, complete opacity in the exposed or dense portions, an extremely sharp boundary between the clear and dense portions, and an exact duplication of the wave traced upon the track by the galvanometer.

The transparency of the clear portion depends upon the inherent properties of the photographic material and fog: the opacity of the dense portion depends upon the exposure and development; and the sharpness of the boundary upon the characteristics of the photographic emulsion and development, assuming the edge in recording to be of perfect sharpness.

The exact duplication of the wave traced by the galvanometer depends upon the image definition in both the negative and print. As stated previously, the structure of the image is affected by three factors, image contraction, image growth or spread, and mutual action of adjacent images. All emulsions exhibit these three factors depending

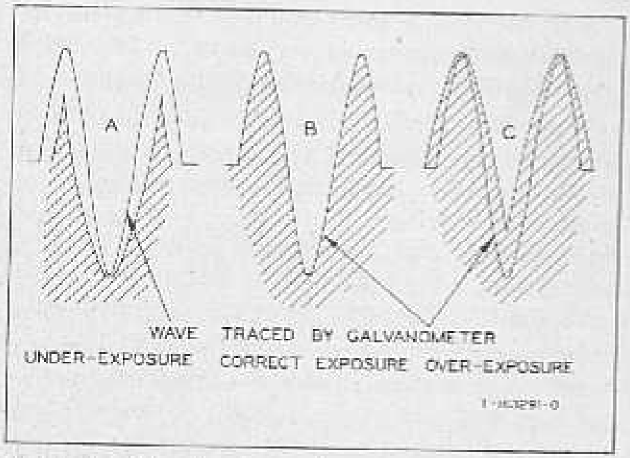

Figure 2—Showing how the structure of the image is affected by image contraction, image growth, and mutual action of adjacent images.

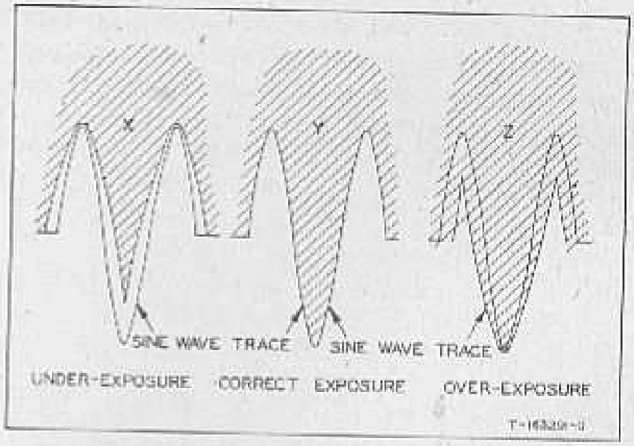

Figure 3—Effect of exposure upon positive.

upon the exposure and development. Fig. 2 helps to visualize this a little more clearly. B is the sine wave as traced by the galvanometer. A is the condition for underexposure, which shows image contraction, and C is the condition for overexposure, which shows image growth. An exposure can be found where neither contraction nor growth of the image occurs. For convenience, we shall hereafter refer to the density at which this occurs as the "balance-density." At first thought, this would seem to be the proper exposure to use. However, with present available emulsions for variable-width sound recording, this balance occurs at too low a density, and, therefore, does not meet the requirement for a perfect sound record. Another factor is the present method of making prints from a recorded negative. Due to the image characteristics of the positive emulsion and printer slippage, the balance-density of the print track made from a recorded track of balance-density would be extremely low, probably of the order of 0.4 to 0.5, introducing considerable noise and having very low output.

Therefore, of necessity, image-spread must be introduced in the recorded track and then balanced out by the image-spread in the printed track.

Under- and overexposure have the same effect upon the printed positive as upon the negative. Fig. 3 illustrates these conditions. X and Y would be obtained from Fig. 2(B). Y, from Fig. 2(B), would give perfect image definition, but would be too low in density for best noise-reduction and maximum output. Z would be obtained from Fig. 2(A). Y satisfies the requirements and is obtained from Fig. 2(C).

Average Transmission.—Referring to Fig. 4, and translating image definition into light transmission, image contraction results in an increase of average

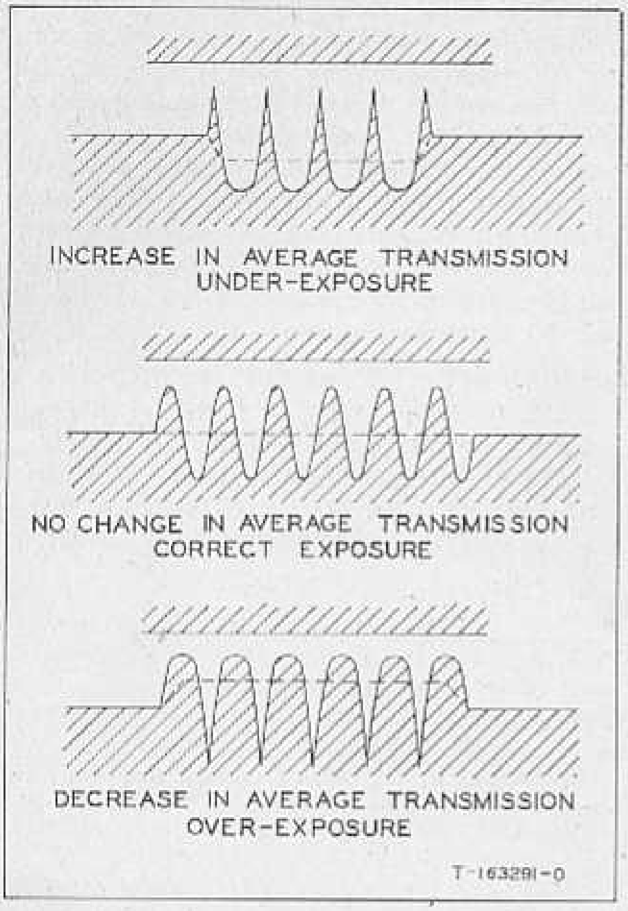

Figure 4—Effect of exposure upon average transmission.

transmission, where the average transmission is taken for unmodulated half-track, and image-growth results in a decrease in average transmission. Perfect image definition for the condition of balance-density does not change the average transmission. Image definition can be determined in a number of ways utilizing this fact of its effect upon the average transmission. One method would be to record a half-track and a high frequency, and measure the change of average transmission on a microdensitometer. This is not a practicable method. The method of measuring the d-c change of photocell current when the recording is played on a reproducer requires either a d-c amplifier or a sensitive galvanometer.

The modulated high-frequency recording provides means for measuring the change of average transmission in terms of alternating current which can be amplified conveniently and measured on suitable reproducing equipment.

Modulated High Frequency.—When the image definition is not perfect, the change in average transmission of a high-frequency recording depends upon the amplitude and recurrence of the high frequency. If, therefore, a high-frequency note is modulated with a comparatively low-frequency note the average transmission of the high frequency will vary in accordance with the low frequency.

In Fig. 5(A), the modulated high-frequency recording is shown for the three conditions of under-, correct, and overexposure. For underexposure, the average transmission is increased proportionally to the amplitude of the high-frequency note and varies between maximum and minimum in accordance with the low frequency. A similar phenomenon takes place with overexposure, except in this case the average transmission is decreased. With correct exposure and balance-density, the average transmission is unchanged. Fig. 5(B) is a microphotograph of a modulated 9,000-cycle track.

Any change of average transmission is indicated by playing the modulated track on a distortion-free reproducer and measuring the low-frequency output through a band-pass filter that attenuates all frequencies except the modulating frequency. The output will give positive readings for all conditions of under- and overexposure, and will read a minimum for the condition of correct exposure. Hence, the differentiation between over- and under-exposure can be determined only by curves plotted from a number of readings.

Graphic Interpretation.—For better understanding and uniform interpretation, the following method of plotting the results has been adopted. Recordings are made of 1,000 and 9,000-cycle notes, and a 9,000-cycle note modulated 75 per cent by a 400-cycle note, of equal amplitudes for

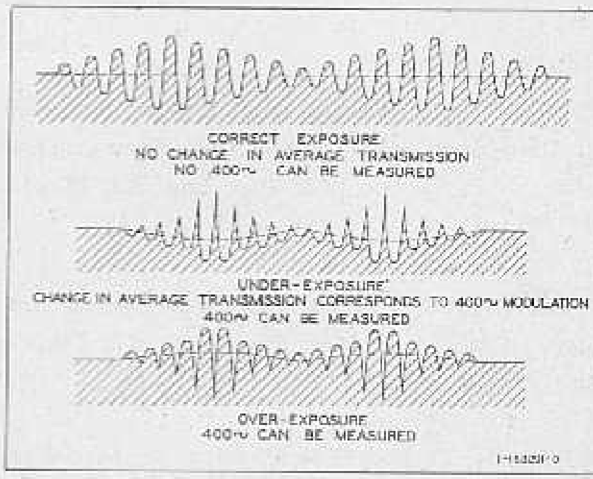

Figure 5(A)—Effect of exposure upon transmission of modulated high-frequency recording.

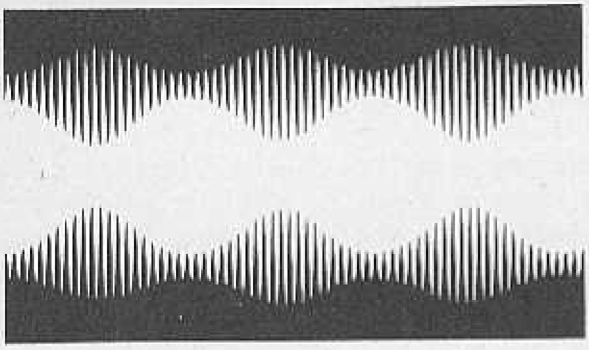

Figure 5(B)—Modulated high-frequency, 9000 cycles with 400 cycles.

several values of exposure or recording lamp current, with a few inches of unmodulated track at the end of each recording for density measurements, and processed in accordance with standard practice for variable-width sound negatives. A series of prints is then made from each negative and given the standard release print processing. The prints when measured on a reproducer, using a 400-cycle band-pass filter for the modulating frequency only, will give readings for a number of combinations of negative and print densities.

THIS PAPER FORMERLY INCLUDED A DESCRIPTION AND A CIRCUIT DIAGRAM OF AN EXPERIMENTAL OSCILLATOR WHICH HAS BEEN SUPERSEDED BY THE MI-10803 OSCILLATOR DESCRIBED IN INSTRUCTION BOOK 2R12-4.2.

REFERENCES:

[1] KELLOGG, E. W.: "A Comparison of Variable-Density and Variable-Width Systems," *J. Soc. Mot. Pict. Eng., XXV* (Sept., 1935), No. 3, p. 203.

[2] HARDY, A. C.: "The Rendering of Tone Values in the Photographic Recording of Sound," *Trans. Soc. Mot. Pict. Eng., XI* (Sept., 1927), No. 31, p. 475.

[3] JONES, L. A. AND SANDVIK, O.: "Photographic Characteristics of Sound Recording Film," *J. Soc. Mot. Pict. Eng., XIV* (Feb., 1930), No. 2, p. 180.

[4] MAURER, J. A.: "The Photographic Treatment of Variable-Area Sound Film," *J. Soc. Mot. Pict. Eng., XIV* (June, 1930), No. 6, p. 636.

[5] DIMMICK, G. L.: "High-Frequency Response from Variable-Width Records as Affected by Exposure and Development," *J. Soc. Mot. Pict. Eng., XVII* (Nov., 1931), No. 5, p. 766.

[6] COOK, E. D.: "The Aperture Effect," *J. Soc. Mot. Pict. Eng., XIV* (June, 1930), No. 6, p. 650.

[7] FOSTER, D.: "The Effect of Exposure and Development on the Quality of Variable-Width Photographic Sound Recording," *J. Soc. Mot. Pict. Eng., XVII* (Nov., 1931), No. 5, p. 749.

[8] MEES, C. E. K.: "Some Photographic Aspects of Sound Recording," *J. Soc. Mot. Pict. Eng., XXIV* (April, 1935), No. 4, p. 285.

GLOSSARY:

SANDVIK, O.: "A Study of Ground-Noise in the Reproduction of Sound by Photographic Methods," *Trans. Soc. Mot. Pict. Eng., XII* (Sept., 1928), No. 35, p. 790.

STEINBERG, J.: "The Quality of Speech and Music," *Trans. Soc. Mot. Pict. Eng., XII* (Sept., 1928), No. 35, p. 633.

MILLER, D. C.: "The Physical Properties of Music and Speech," *Trans. Soc. Mot. Pict. Eng., XII* (Sept., 1928), No. 35, p. 647.

BIELICKE, W. P.: "The Processing of Variable-Width Sound Records in the Film Laboratory," *J. Soc. Mot. Pict. Eng., XVII* (Nov., 1931), No. 5, p. 778.

SANDVIK, O., HALL, V. C., AND GRIMWOOD, W. K.: "Further Investigations of Ground-Noise in Photographic Sound Records," *J. Soc. Mot. Pict. Eng., XXII* (Feb., 1937), No. 2, p. 83.

DIMMICK, G. L., AND BELAR, H.: "Extension of the Frequency Range of Film Recording and Reproduction," *J. Soc. Mot. Pict. Eng., XIX* (Nov., 1932), No. 5, p. 401.