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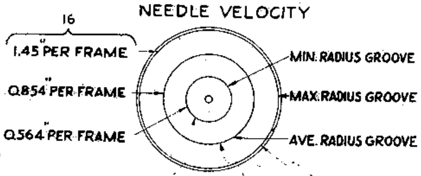
A STUDY OF SOUND RECORDINGS*

By C. F. Goudy† and W. P. Powers‡

THE subject to be presented may seem to be somewhat out of line with the usual radio topics.

Recently, however, a new and rather important industry has come into existence which is demanding the attention of many of our members. I refer to the talking motion pictures. Here we have an industry of already tremendous proportions, although it is but a few months old. It is interesting to note that this new field of activity is here as the natural result of progress in scientific research.

NEEDLE VELOCITY



	MIN. VEL.	AVE. VEL.	MAX. VEL.
12" RECORD 78 R.P.M.	16.3	31 4	46.5
16" RECORD 33⅓ R.P.M.	13 5	20 5	27.5

FIG. I — VEL. IN INCHES PER SEC. NOTE FILM SPEED IS USUALLY 18"/SEC.

Recording of sound on film and disc has been highly developed. These processes are the result of recent advances in photography and the application of electrical recording. Pickup devices have been developed to meet both types of recording. The photoelectric cell is one of the outstanding developments of the day. Electrical pickups for disc records have been improved with great strides. Amplifiers and speakers have arrived quite naturally, having come along with the progress of radio. These developments have been running concurrently and as a result we have the talking pictures. This new industry is already demanding the attention of many from our field of radio. Those of us who are so engaged find it necessary to study these new problems carefully.

There is naturally quite a gap between the motion picture and the field of the radio engineer. If these two industries are to come in contact we must devote some time to the subjects which fall specifically in this gap. This paper relates to recording, which is obviously one of the contact points between the picture industry and the electrical (or radio) industry.

The Recording Process

The recording process may briefly be described as follows: A suitable microphone is connected to the recording device through an amplifier. When possible, the set-up is such that no distortion is contributed by the recording equipment. The air waves hit the microphone and the pressure variations are faithfully reproduced at the recorder. The amplitude of motion of the recorder element is supposed to be a perfect copy of the air pressure wave at the microphone. In the case of film recording, regardless of type, the sound positive film has a distribution of density which will control the light entering the photoelectric cell, so that the instantaneous intensity is proportional to the sound pressure on the microphone diaphragm.

We have, therefore, for both disc and film recordings, a record corresponding to the air pressure at the microphone. Because of this fact, it is interesting to compare corresponding recordings on disc and film. In many cases we find a very striking similarity. The disc recording, of course, is modulated within narrow limits, whereas the film (variable area) is modulated through wide limits.

FREQUENCY-WAVELENGTH RELATION OF 16" RECORD

FREQUENCY	Average Radius 5.875 ★λ in Inches	Radius 5.15 "/min. λ in Inches
35	0.5860	0.5150
50	0.4100	0.3600
100	0.2050	0.1800
500	0.0410	0.0360
1000	0.0200	0.0180
5000	0.0041	0.0036
8000	0.0025	0.0022
10000	0.0020	0.0018

★ LENGTH OF WAVE IN GROOVE OF AVERAGE RADIUS (5.875)
PACENT REPRODUCER CORP — FIG. IA — NEW YORK, N.Y.

Disc Recordings

Commercial records for home use are ten and twelve inches in diameter. Obviously, the larger record accommodates more recording than the smaller record. The minimum groove diameter for both records is approximately 4 inches; the outer diameters are approximately 9⅜ inches and 11⅜ inches for the ten and twelve inch records respectively. The normal speed of these records is 78 r. p. m. As a result of these figures, the following needle velocities are given for the twelve inch record:

Approximate tangential velocities
(Inches per second)

Inside groove	16.3
Middle groove	31.4
Outer groove	46.5

The records as furnished for picture work are sixteen inches in diameter and operate at 33 1/3 r. p. m. The needle speeds are given below:

Approximate tangential velocities
(Inches per second)

Inside groove	13.51
Middle groove	20.49
Outer groove	27.47

(See Fig. 1)

It is noticed that the needle speed is much lower on the sixteen inch record. Because of this fact, the recording and reproducing problems are somewhat increased. Naturally, the lower the needle speed, the shorter will be the total available distance for a given recording. This fact is illustrated by the following fundamental equation:

Tangential needle velocity = wavelength × frequency.

The cutter used in disc recording is triangular in shape and is capable of recording relatively high frequencies. This shape could not be applied to needles for obvious reasons, the most important being the consequent destruction of records. We are com-

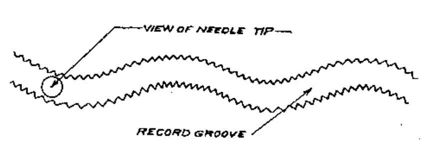
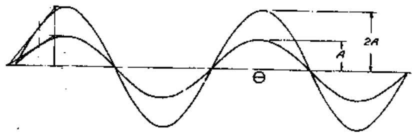


Fig. 2. Path of needle tip.

* Delivered before the Club Feb. 19, 1930.
† Chief Engineer, Pacent Electric Co.
‡ Technical Director, Pacent Reproducer Corporation.

pelled to replace needles frequently in order that the needle point diameter may be small enough to follow the high-frequency modulations. Let us not be upset about this apparent defect or shortage of high-frequency response. Very little amplitude is



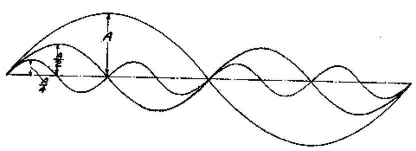
E ∝ AMPLITUDE X FREQUENCY

Fig. 3.

necessary at these frequencies to cause them to register. Obviously, considerable energy is represented in high-frequency impression, even though the amplitude is low.

Needle Diameter vs. Frequency

Recording is more difficult on the inner groove because of the decreased velocity. A detail study of the groove and needle dimensions will show that difficulty is to be expected in reproducing high frequencies because of the physical limitations of the parts concerned. (See Fig. 1A). By consulting this table, it becomes apparent that the higher the frequency the more



GENERATED VOLTAGES ∝ AMPLITUDE X FREQUENCY

Fig. 4.

difficult it becomes for the needle to faithfully follow the groove modulations. In fact, it is quite possible to record frequencies which can not be reproduced by the ordinary needle. (See Fig. 2). This figure roughly illustrates the inability of the needle, owing to its large diameter, (approximately .003 inch) to faithfully follow the minute high-frequency variations as recorded. (Fig. 2 is purposely exaggerated to convey the point under consideration). However, when the needle is new it is capable of doing its best work. It is possibly for this reason that the large records are always cut from inside to outside.

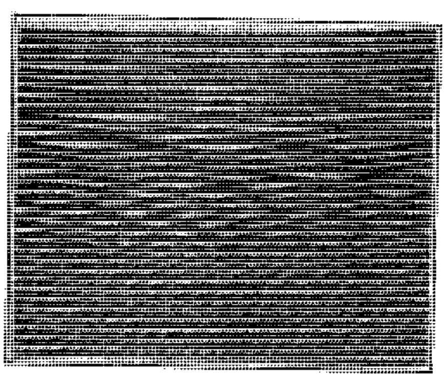
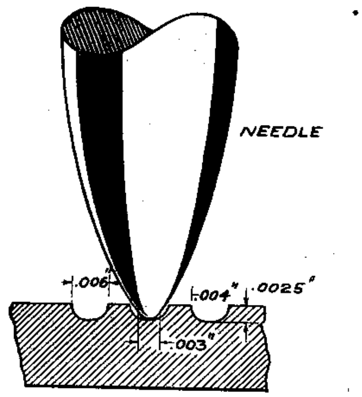


Fig. 4A. Frequency record.

Generated Voltage

The instantaneous generated voltage of a pickup device (for disc) is directly proportional to the instantaneous radial velocity of the needle (armature). This statement is readily appreciated when we cousider that no generated voltage exists when we have no modulation of the groove. (Strictly, however, the groove is never absolutely free from modulation owing



-FIG. 5.-

CROSS SECTION OF RECORD GROOVES.

to the imperfections in material structure).

It is interesting to note that the amplitude of the generated voltage wave is dependent only upon the rate of change of the needle position, radially, with respect to time. The amplitude of the recording groove, however, determines this rate; that is, the higher the amplitude for a given frequency, the greater will be the slope of the curve at a given point. This is readily understood when we consider the expression for a sine wave having an amplitude equal to A, and a similar wave having an amplitude equal to 2A. The slope of this curve is determined by the derivative of the expression for the curve, and in the above case, the solution shows a 2:1 ratio for the slopes at all points along the curves. (See Fig. 3).

If $y = A \sin \theta$; $\frac{dy}{d\theta} = A \cos \theta$

If $y = 2A \sin \theta$, $\frac{dy}{d\theta} = 2A \cos \theta$

For uniform generated voltage at all frequencies the amplitude of the groove modulation must vary inversely as the frequency.

Fig. 4 shows several sine wave grooves fulfilling the requirements for

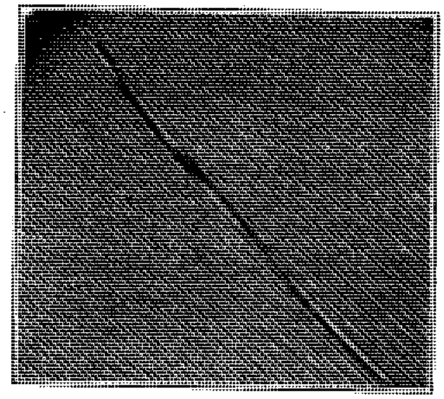
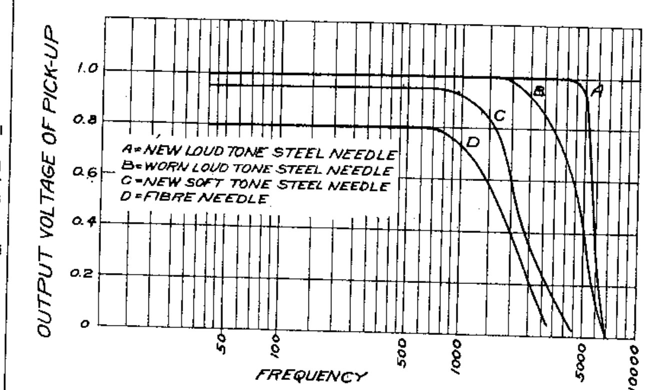


Fig. 6. "Cross-over."

constant generated voltage. It will be noticed that for the lowest frequency the needle travels radially (vertically in the figure) a distance of 4A for the period of one cycle. For the double frequency wave the needle travels radially, a distance of $8 \times \frac{A}{2}$ in the same period of time. For the wave having four times the fundamental frequency, the needle travels radially a distance of $16 \times \frac{A}{4}$ in the same period of time. The average generated voltage, therefore, in each case is the same, inasmuch as the radial distance covered over the period of time in question for each wave is 4A. (See Fig. 4A).

Curves showing pickup behavior with various types of needles.



-FIG. 7.-

THESE CURVES REVEAL THE BEHAVIOUR OF A PHONOGRAPH PICK UP WHEN VARIOUS TYPES OF NEEDLES ARE USED.
PACENT REPRODUCER CORP.

COURTESY, WIRELESS WORLD.

The maximum permissible amplitude of modulation in disc recording is approximately .002 inch. (See Fig. 5). This amplitude is seldom exceeded in order to prevent the possibility of cutting into the adjacent groove. Because of this physical limitation, the voltages corresponding to the frequencies below 250 cycles (approximately) will be relatively reduced. Occasionally, however, recordings have been released which show modulation amplitudes in excess of the above figure. No great difficulty results in producing these records, providing extreme amplitude

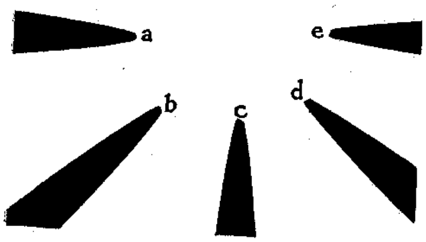
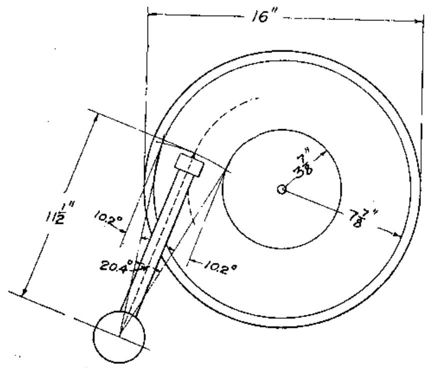


Fig. 8. Needle wear.
a. unused d. 15 min.
b. 5 min e. 20 min.
c. 10 min.

points do not come adjacent on successive grooves. In reproducing, however, difficulty is frequently experienced as a result of the consequent weakened condition of the side wall. Fig. 6 illustrates a "cross-over," which is the obvious result of over-modulation in recording.

Pressure at Needle Point

It might be of interest, at this time, to consider the unit pressure existing at the needle point. Assuming the diameter of the needle to be .003 inch and the needle pressure 5 oz., the resulting vertical unit pressure is roughly 44,000 lbs. per square inch. If one were to determine the normal drag on the needle point along the direction of motion, startling values would result for the unit pressure perpendicular to the direction of motion when a change in direction is encountered.

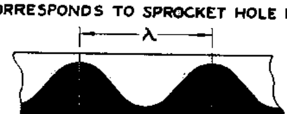


LOCATION OF TONE ARM WITH RESPECT TO RECORD
-FIG. 10.-

A certain amount of vertical needle pressure is necessary to provide proper tracking. As a consequence, records must be made of hard material and they must be abrasive enough to grind the needle in order to reduce the unit pressure at the needle point. This of course results in better coupling between the record and needle. Ordinarily, the unit pressures are sufficiently reduced after one minute of operation. Curves A and B of Fig. 7 show the relative voltages generated

f	λ (inches)	f	λ (inches)
8000	0.0022	800	0.0225
5000	0.0036	500	0.0360
4000	0.0045	400	0.0450
2000	0.0090	200	0.0900
1000	0.0180	*96	0.1875

*CORRESPONDS TO SPROCKET HOLE HUM.

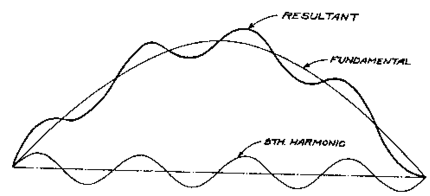


FILM SPEED 90 ft/min
PACENT REPRODUCER CORP. NEW YORK, N.Y.

Fig. 11. Frequency—wavelength table.

by the pickup using new and worn loud tone steel needles. It is evident that as the needle wears, its response favors the low frequencies thus reducing the quality of reproduction. Curve C shows the response using a soft tone steel needle. The somewhat reduced response of this needle is because of its filtering effect. Curve D shows the response obtained when using fibre needles. However, owing to their poor frequency response characteristic, they are not used in commercial sound reproduction. Fig. 8 is an actual photomicrograph of needles showing the amount of wear after service of 5, 10, 15 and 20 minutes. It will be noticed that the most pronounced deformation occurs during the initial period of service.

The tracking of the needle through the groove causes the peaks of the recorded waves to become worn, thus



-FIG. 12.-

Fig. 12. Resultant of fundamental and 8th harmonic

changing the wave shape which produces distortion. This wearing of the groove wall affects the reproduction quality in an ever increasing amount as the record is used. Prior to the arrival of sound pictures, the question of record wear, and the consequent decrease in record life, was of no great importance. In fact, it was probably considered a desirable feature from the point of view of the producer. Today, however, in the motion-picture industry the producer is interested in prolonging the life of records, because he obtains a return in the form of rental from the

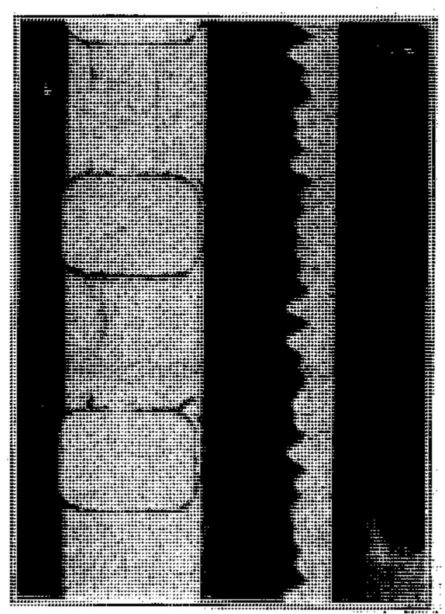
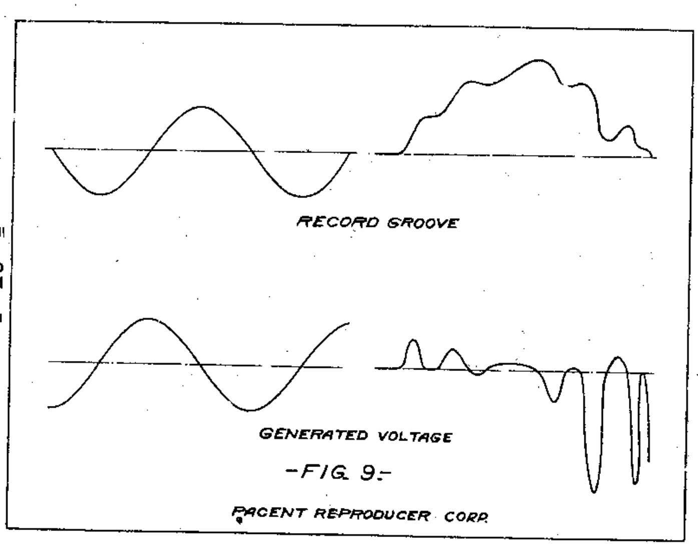


Fig. 12A. Fundamental approx. 154 cycles per sec. with pronounced 5th harmonic

Groove relation to voltage generated



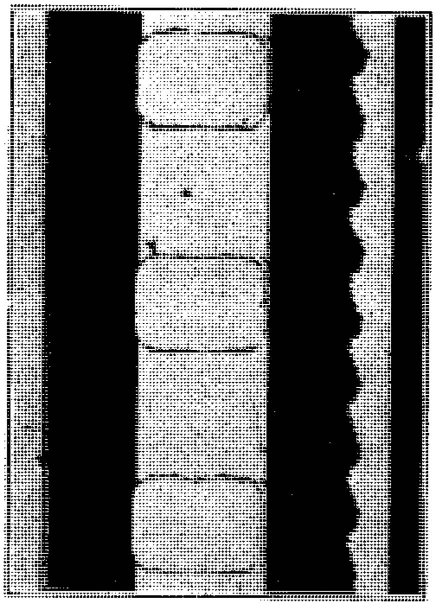


Fig. 12B. Fundamental approx. 330 cycles per sec. with 8th harmonic.

exhibitor. It is hoped that record wear will soon be overcome, not purely from the financial phase of the problem, but because of the improved quality of reproduction which will result.

Pickup Distortion to Be Divided

For faithful reproduction it is obvious that distortion must not be introduced by the pickup. It is clear, therefore, that a stiff needle is required for faithful reproduction, otherwise, movements at the armature end of the needle will not represent movements at the groove end. In fact, a

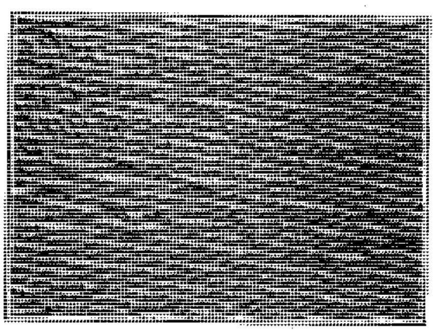


Fig. 13. Difficult recording.

soft tone needle may be considered as a mechanical filter. A magnetic pickup requires damping in order to smooth out resonant points, and at the same time maintain the proper neutral position of the armature. With this design, considerable inherent stiffness is present in the mechanism of the pickup. If too much stiffness exists, relative motion of the armature and field will be reduced, thus defeating the idea of the pickup. The entire pickup will be somewhat compelled to follow bodily the modulation of the groove. Under this con-

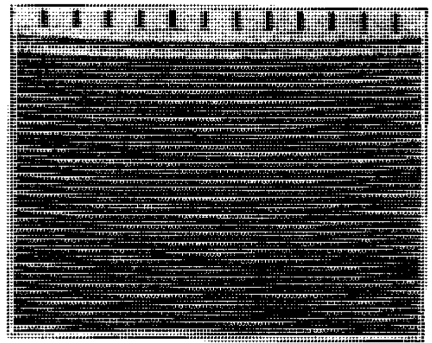


Fig. 14. Low-frequency recording.

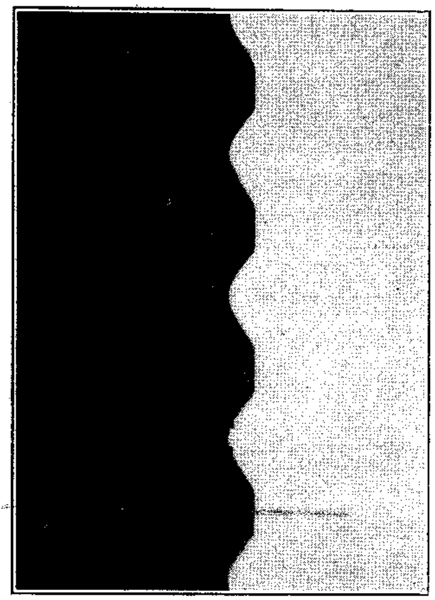


Fig. 15. Section 16 in. record.

dition, the side pressure at the needle will be excessive (on account of the reduced cushioning action) and breakdown of the groove wall may occur.

We desire to have the natural frequency of the system somewhat above the highest frequency to be reproduced. In a mechanical system the mass corresponds to inductance, the compliance to capacitance, and the stiffness to the reciprocal of the capacitance. In the electrical circuit, LC must be kept low; therefore, in the mechanical system we must keep

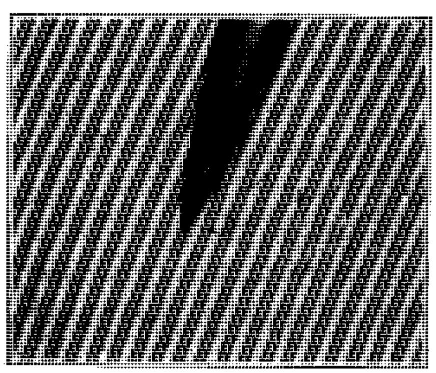


Fig. 16. 10-in. record showing needle.

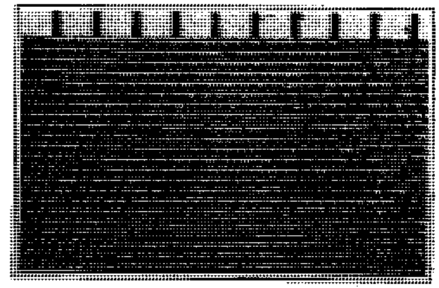


Fig. 17. 2000 cycles per second.

the mass low and the stiffness high. It is desirable to confine this stiffness as far as possible to the needle itself.

The use of half-tone needles has become common among projectionists when reproducing over-modulated records. In fact, many records as released are marked, "Use half-tone needle." (See Fig. 13).

Analysis

When analyzing a disc recording by inspection, we must keep in mind the fact that the actual generated voltage wave is not as a rule similar to the recording. As stated, the generated voltage at any instant is determined by the rate of radial motion of the needle. In other words, we obtain the slope of the recording curve $\left(\text{strictly } \frac{dy}{d\theta}\right)$ at the instant in question in order to determine the magnitude of the corresponding voltage ordinate. For sine waves, this derivative curve will, of course, have the same shape as the recording curve,

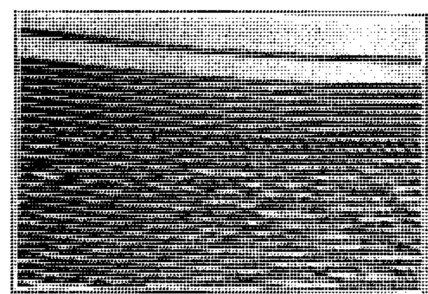


Fig. 18. Steam whistle approx. 1000 cycles per sec.

being a cosine curve. For other waveforms, however, we must not expect any great degree of similarity. (See Fig. 9). The derivative curve is, as a rule, a much more rugged curve.

Fourier's theorem states that any periodic function may be considered as composed of a constant, a fundamental, and a series of harmonics.[1] We therefore think of our complex waveforms as being the result of several simultaneous waves. We may, in fact, consider each component wave as existing separately. Circuits can as a matter of fact be arranged to favor certain terms in this series. A

[1] *See Appendix.*

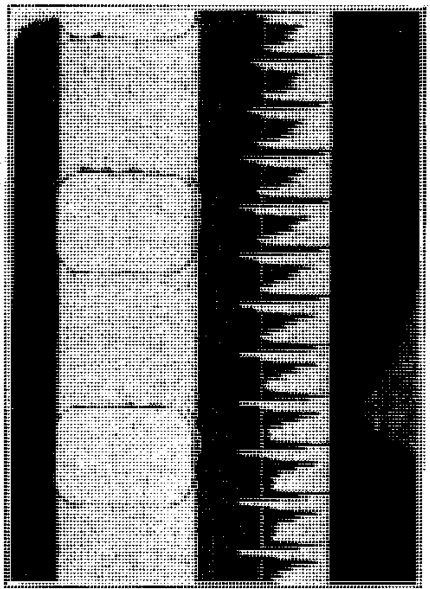


Fig. 19. Voice and piano fundamental approx. 450 cycles per sec.

complex voltage wave is composed, therefore, of several voltage waves of different frequencies. An ordinate of the resulting curve is found by adding the instantaneous ordinates of the components at the particular point in question. The slope of the resulting curve is merely the sum of the slopes of the component curves at the point in question. Hence, in the case of disc recording, the voltage generated at any instant is equal to the sum of the instantaneous voltages of the components of the recording for the instant under consideration.

It is not the purpose of this paper to treat the subject mathematically, but we should not overlook the great possibilities of mathematical analysis. Reproducing arrangements are indeed analyzers of the highest order. It seems hardly possible that in the contour of the resulting recording we have the possibility of reproducing every component in its original form.

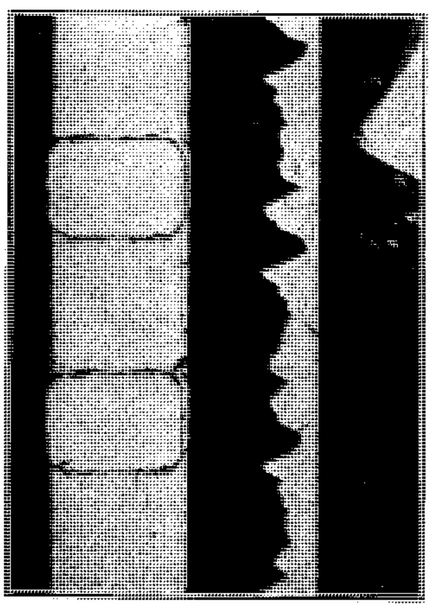


Fig. 20. Repeating waveform fundamental approx. 115 cycles per sec.

In order to reduce groove wear to a minimum it is imperative that the pickup unit be located properly with respect to the record. (See Fig. 10). The pickup arm is shown coinciding with a line drawn tangent to the groove of average radius. Mounted in this position, the pickup imposes the least wear on the sides of the grooves.

Slit Width vs. Frequency

Slit width and needle diameter are analogous in so far as they both impose frequency response limitations in the respective reproducing systems of which they are an integral part.

Perfect scanning of the sound track is obtained only by an ideal slit, that is, a slit having zero width. Since such a slit is purely theoretical, we must be content with an approximation to the ideal slit, or one having finite width.

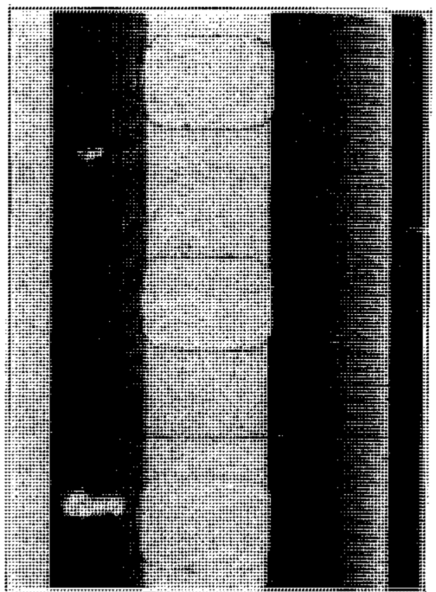


Fig. 21. 5000 Cycles per sec.

The upper limit of frequency response decreases as the slit width increases. If the slit width is equal in length to one cycle there will be no modulation of light and no response for the particular frequency.

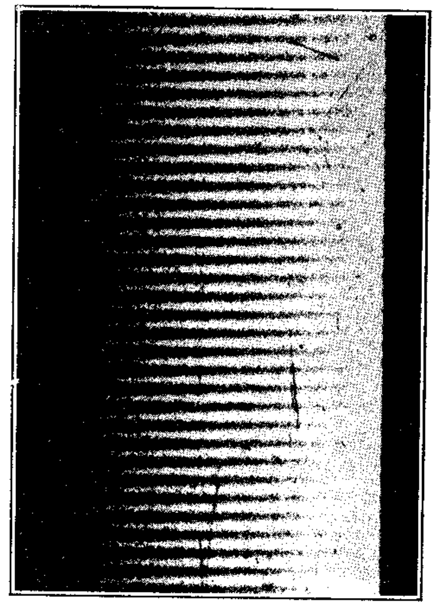


Fig. 22. 5000 cycles per sec. Magnified 30 diameters to show drain.

Since the upper frequency limit decreases with slit width increase, it is obvious that the fidelity of reproduction also decreases accordingly.

Fig. 11 shows a table of frequencies and their corresponding wavelengths as found in sound recording on film.

Comparison of Disc and Film Recordings

Fig. 12 illustrates the contour of the resultant wave formed by the combination of a fundamental and its eighth harmonic. In recording, nearly all waveforms are complex, i.e., they are composed of several sinusoidal waves. By a close inspection of a wave, it is generally possible to determine the pronounced frequencies that are present.

Figs. 12A and 12B are examples of sonnd-on-film recording in which we have a clearly defined fundamental and a superimposed harmonic.

The fundamental frequency and pronounced harmonic which constitute the wave shown in Fig. 12A are (if

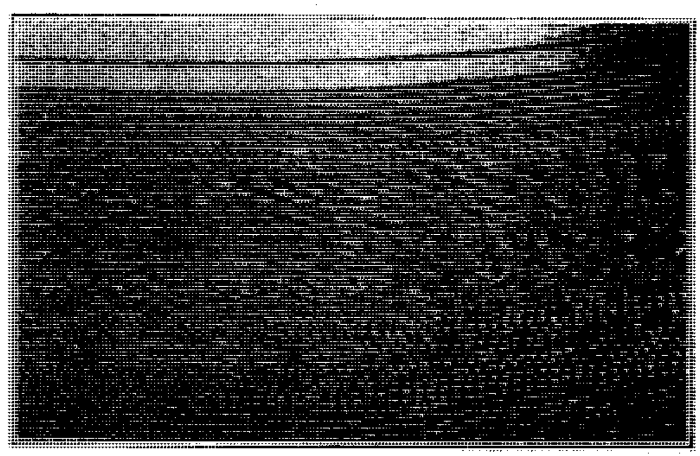


Fig. 23. Complex recording.

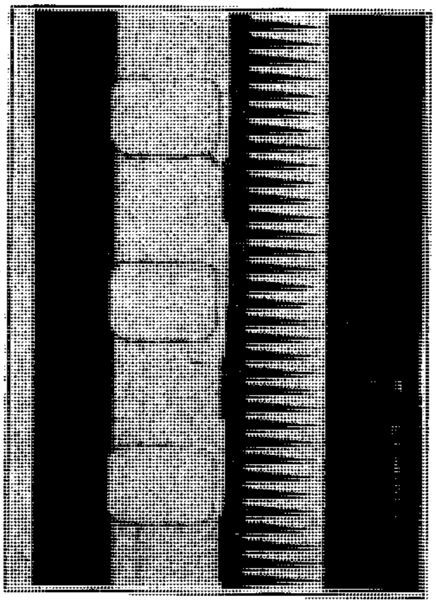


Fig. 24. Whistle approx. 1000 cycles per sec.

accurately scaled) 154 and 770 cycles per second respectively.[2]

Fig. 12B shows a fundamental of approximately 330 cycles, with the corresponding eighth harmonic. (Note the peculiar contour due possibly to the presence of an even harmonic.) This is a piano recording, and it is interesting to note that in general the shape of piano recording is not so complex as voice recording.

Fig. 13 is a view (magnification 12½ diameters) of a 16 inch record showing difficult recording. The weakened condition of the groove wall at the points of high lateral cuts is plainly visible. Great care is necessary when these records are reproduced to prevent the formation of a cross-over.

The exceedingly high amplitude cuts employed in recording low frequencies are shown in Fig. 14. Here the recorded frequency (inside groove) is approximately 50 cycles. The wavelength at this frequency is readily appreciated when comparison is made with the millimeter scale along the top of the picture. Ten diameters is the magnification at which this picture was taken.

A cross-section view (magnification 57 diameters) of record grooves is shown in Fig. 15. This view accurately shows the dimensional relations between the groove width, the groove depth, and the wall thickness. It might be well at this time to refer to Fig. 5 which shows all the above dimensions.

Fig. 16 shows a needle tracing a groove. From this figure we obtain some idea of the relative dimensions in the vicinity of the needle tip.

A constant frequency recording at 2000 cycles is shown in Fig. 17. A millimeter scale is included for purposes of comparison. The photomicrograph was taken at a radius of approximately 6.5 inches and a magnification of 10 diameters. It can be seen that at this radius there are approximately four wavelengths per millimeter, which corresponds to the designated frequency marked on the record.

A pronounced 1000 cycle note corresponding to a steam whistle as recorded on the trailer of "The Toilers" appears in grooves eight and nine of Fig. 18.

Fig. 19 is a typical example of the resulting waveform obtained by the simultaneous recording of voice and piano. Here the waveform repeats approximately 4.6 times in every 3/16 inch indicating that the fundamental frequency is roughly 450 cycles.

Another interesting uniformly repeating wave is shown in Fig. 20. The fundamental frequency here is approximately 115 cycles.

A very good example of high-frequency recording (5000 cycles) is shown in Fig. 21. The wavelength corresponding to this frequency is .0036 inches.

Fig. 22 shows the same 5000 cycle recording but at a much higher magnification (30 diameters). This view clearly brings out the relative size of the emulsion grain. It is apparent that the granular structure of the emulsion is one of the serious limiting factors in high-frequency recording.

Fig. 23 shows a variety of wave shapes. Attention is called to the recording on the seventh groove where a series of wave groups is found. The frequency can be scaled as 333 cycles per second, (one-third of the whistle frequency shown in groove nine) and checks closely with the corresponding portion of film recording shown in Fig. 26. (3.4 wavelengths per sprocket hole.)

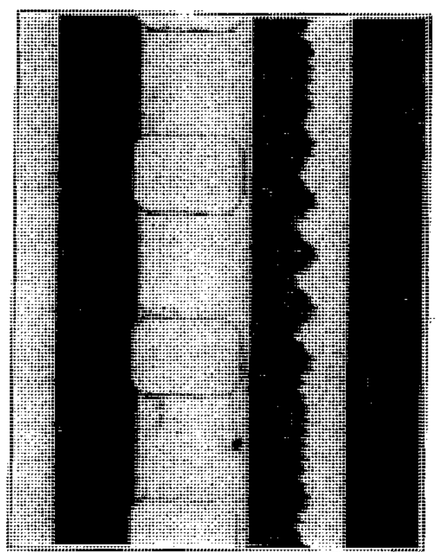


Fig. 26. Periodic low frequency groups.

Referring again to Fig. 23, grooves nine and ten show a 1000 cycle frequency recording previously referred to and shown in Fig. 18. This whistle frequency checks closely with the corresponding film impression shown in Fig. 24. (10.5 wavelengths per sprocket hole—1008 cycles per second.)

It is interesting to note that this whistle frequency occurs again on the twenty-ninth groove and is easily identified by inspection. The thirty-fourth groove shows this whistle frequency superimposed on a lower frequency. The corresponding film recording is shown in Fig. 25.

Intensive experimental work on pickups is being conducted by the Pacent Electric Company at the present time. Highly interestiug facts have been revealed as a result of this research, but unfortunately they were not available in time to include them in this paper. Undoubtedly they will be presented to the Radio Club at some future time.

In closing, we wish to acknowledge the cooperation of the following:

Max C. Batsel, Chief Engineer, RCA Photophone, Inc., who furnished film and disc records for a study.

Dr. Percy Hodge, Professor of Physics, Stevens Institute of Technology, who took many photographs and conducted the study microscopically.

P. H. Evans, Chief Engineer, The Vitaphone Corp. and J. G. Aceves of Amy, Aceves & King, for many valuable suggestions.

Adney Wyeth, Educational Director, Pacent Reproducer Corp., for valuable assistance in preparing the paper.

Appendix

Consider a voltage wave composed of a fundamental, 3rd harmonic, and a 5th harmonic (constant term equal to zero)

then: $e = E_1 \sin \omega t + E_3 \sin (3\omega t + a_3) + E_5 \sin (5\omega t + a_5)$.

When this voltage is applied to a

[2] *The inclusion of the sprocket holes in the illustrations affords a means of determining the magnification, inasmuch as the sprocket hole pitch is 3/16 inch.*

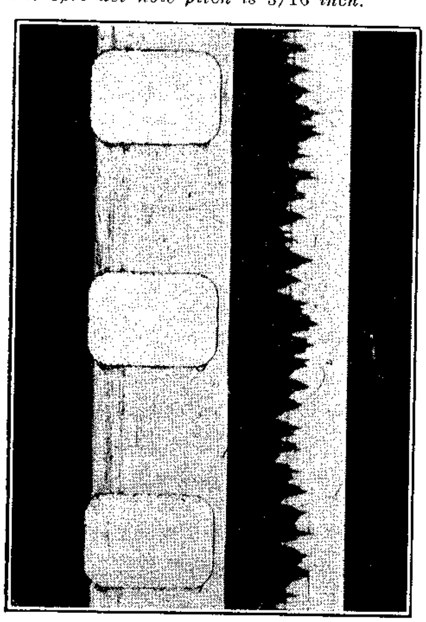


Fig. 25. Whistle frequency with other frequencies.

circuit having resistance and reactance, the current is:

$$i = \frac{E_1}{\sqrt{R^2 + X_1^2}} \sin(\omega t - \theta_1) + \frac{E_3}{\sqrt{R^2 + X_3^2}} \sin(3\omega t + a_3 - \theta_3) + \frac{E_5}{\sqrt{R_1^2 + X_5^2}} \sin(5\omega t + a_5 - \theta_5).$$

Denoting the coefficients by I_1, I_3, I_5, etc., we have, $i = I_1 \sin(\omega t - \Theta_1) + I_3 \sin(3\omega t + a_3 - \Theta_3) + I_5 \sin(5\omega t + a_5 - \Theta_5)$.

Where X_1, X_3, and X_5 are the reactances of the circuit for the fundamental, 3rd harmonic, and 5th harmonic respectively,

$$\theta_1 = \tan^{-1}\frac{X_1}{R};\ \theta_3 = \tan^{-1}\frac{X_3}{R};\ \theta_5 = \tan^{-1}\frac{X_5}{R}$$

DISCUSSION

J. G. Aceves

FROM the interesting presentation of Professor Powers, there seems to be a number of similarities and contrasts between the recordings by means of discs and those by means of films.

It will be noted that in the case of film recording, if the phases have not been altered during the process that follows from the air pressure variations at the microphone to the light intensity variations applied to the film, the contour of the film record curve would be exactly of the same shape as that of the air pressure variations. The reproduction of such records by means of a perfect amplifier would result in an electrical pressure variation (e.m.f.) of exactly the same shape as that of the original sound wave.

In the case of recording by means of disc, aud assuming the same perfection in the process, the amplitudes of the wave in the disc at any time would be proportional to the air pressures which originated them. (This is not mathematically true unless the diameter of the disc is infinite). However, the generated instantaneous voltages due to the motion of the needle and armature of the pickup are proportional to the rate of change of the ordinates in the recorded wave; or as Professor Powers pointed out, to the derivative of such curve. Hence, for higher frequencies of the same amplitude, the generated e.m.fs are correspondingly higher. It is therefore expected there will be a very "tinny" reproduction of music with very little depth of tone, according to this theory. Yet, the very same amplifier may be thrown either on the pickup from the discs or from the photoelectric cell in many commercial moving picture machines, and the music or speech comes about the same in quality whether a film or a disc is used for the same selection.

The answer, it seems to me, may be found in the fact that the track in the disc recordings does not actually represent the instantaneous air pressure variations at the microphone, even ignoring the well-known reduction in relative amplitude of the very low tones. By inspection of the microphotographs shown by Professor Powers, it will be noted that the frequencies above one kilocycle are scarcely visible; in fact, the picture of the one thousand cycle "whistle" is about the only instance where a frequency as high as this is clearly discernible, and let us not forget that a steam whistle does not speak in whispers.

Another interesting point to mention is, that in compound sound waves, the ear receives identical impressions from waves of entirely different shape, so long as the component simple harmonic frequencies have the same amplitudes, regardless of original phase displacements with respect to each other. This is very fortunate, since there are innumerable phase retardations, and displacements in the amplifiers, as well as in the "motors" that cut the disc and reproduce it. Only in case of transients of extremely short duration the phases may make some appreciable difference, but even here we are saved by the fact that the human ear does not recognize sounds having less than 10 to 20 complete cycles.

Percy Hodge

PROFESSOR POWERS' lecture and the discussion which followed it certainly brought out some most interesting facts as to the present status and difficulties of the sound-picture industry.

Both the film and disc methods of recording and reproducing have defects which are not easy to overcome, and there is still much research to be done before we can sit in a movie theatre with our eyes shut and imagine we are listening to the real play or opera.

As regards the disc records it would seem that one of the first things which should be considered is how to get rid of the enormous pressure at the needle point (amounting to as much as 40,000 pounds per square inch) which causes the needle to begin to wear and change its shape immediately and to produce rapid deterioration of the record. The necessity for such a high pressure is not easily apparent unless it is required in order to make the needle follow the groove accurately and not slide up on one side or the other. Is it impracticable to use any shape of groove except the nearly semi-circular one which has been adopted? Could not a groove be designed which would offer a more positive lateral thrust for a given downward pressure?

In sound-picture records it is customary to start the groove at the inside of the record instead of at the outside as in ordiuary phonograph records. This is done because the needle wears less at low speeds and the speed increases as the needle moves outward. There must be on the other hand more likelihood of imperfect recording of very short waves belonging to high harmonics when the speed is slow, as at the inner rings, than when it is faster, as at the outer ones. It is obviously impossible to so alter the angular speed of the record as to produce a constant linear speed of the needle such as might be found desirable.

It occurs to one that the old form of cylinder record would have important advantages over the disc if it could be used.

The matter of constant speed with such a record is easily taken care of. Also a cylinder with a diameter equal to that of the average groove of a disc record would only have to be as long as the width of the groove surface of the disc in order to hold as large a record. A cylinder a foot long would hold four times as much recording as a disc with three inches of recording. One of the difficulties in making disc records is to prevent the adjacent grooves from approaching too near together where large amplitudes occur, thus weakening the wall between and causing "cross-overs." This could easily be prevented on a cylinder.

The practical difficulty which presents itself at once is that of reproducing a master record in a lot of duplicates, and there are doubtless others.

Professor Powers stated that, since the high harmonics possess great energy for very little amplitude, they can afford to lose a part of that by wear of the record groove and will still have plenty of energy left. Is this necessarily a correct inference? In phonograph records the absence of consonant sounds in speech is particularly noticeable, and these sounds involve very high frequencies. Can we afford to have them partly suppressed by wear?

As regards the relative merits of film and disc recording and reproduction there are many plausible arguments on both sides.

The use of a sound track involves an optical system which, from the point of view of a lecturer on optics, appears rather formidable. Can such a system be made fool-proof enough for the average operator?

In view of the probable development in the near future of larger screen pictures economy of film space is an important consideration, and the present sound track occupies about one eighth that of the standard film. It would be desirable to leave it off if possible.

It appears to be the ambition of the manufacturers to make sound pictures available for home use. The film generally adopted for this class of pictures is the 16 mm. On such a film the sound track must necessarily be reduced in size, and there enters the possibility that the grain of the photographic emulsion may cause trouble by its irregularities. It would seem that, for home use, the disc recording offers both a simpler and more rugged form of apparatus than the film. Phonograph records as now made, when played with a good electric pick-up, are certainly not far from perfect, and such sound production coupled with suitable pictures should be acceptable to anybody.

Of course it will not do to make the home sound pictures too good or people won't go to the movies. One theatre at least has found it necessary to broadcast Amos and Andy every evening in order not to have the house empty for the early performance. Many people have stopped going to concerts because they can hear almost as good music over the radio. However no form of entertainment has ever offered so much for one's money as the movies, and it is hardly likely that the theatres will feel the effect of any home product for a long time to come.

One of the engineers pointed out that sound records made only a year ago are now of the nature of antiques, so it is probable that we shall not have to wait long for the perfect sound picture at the rate things are going.

CLUB NOTES

New Members

W. R. G. Baker*

John R. Bizzelle

Arthur D. Chesley

Frederic R. Colie

Charles Oliver Cressy

Samuel Dominus

James A. Dowie

Louis Funke

Grover C. Kirchhof

Herbert G. Klawunn

Frank Licata

Oliver B. Parker

Harold A. Persett

George H. Rodgers

Michael A. Romano

Frank D. Thorne

Louis C. Tienken

Emerick Toth

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* Elected a Fellow.

Membership News

At the meeting of the Board of Directors, January 10, 1930, Cecil E. Brigham was raised to the grade of Fellow.

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New Business Connections

Robert M. Arnold.
Formerly with Sanderson & Porter, New York City, is now with the United Air Cleaner Corporation, 9705 Cottage Grove Avenue, Chicago.

Gilbert Brown.
Is permanently located with the RKO Studios in Hollywood. His home address is 6928 Clinton Street, Hollywood, Cal.

Christopher G. Clarke.
Can be reached at the Splitdorf Radio Corporation, Silver Lake, N. J.

F. Clifford Estey.
Formerly with United Producers Corporation, is now connected with the Aluminum Co. of America, 2400 Oliver Bldg., Chicago.

Dr. Alfred N. Goldsmith.
Formerly Chief Broadcast Engineer of the Radio Corporation of America at 70 Van Cortlandt Park South, New York City, is now Vice-President and General Engineer of the company at 233 Broadway.

Keith Henney.
Connected with *Radio Broadcast* for five years as Director of the Laboratory, is now Associate Editor of *Electronics*, a publication of the McGraw-Hill Publishing Company, New York City.

A. V. Loughren.
Now connected with Radio Frequency Laboratories, Inc., Boonton, N. J.

Harry Sadenwater.
Formerly with General Electric Company, is now in the Engineering Department, Field Engineering Division of the RCA-Victor Company, Inc., Camden, N. J.

Alexander Strelzoff.
Is now connected with the Steinite Manufacturing Company, Fort Wayne, Indiana.

Roger M. Wise.
Has left E. T. Cunningham, Inc., and is Chief Engineer of the Sylvania Products Company, Emporium, Pa.

▲

Missing Members

If the present address of any of the following is known, please advise the Club office:

John S. Conway, 99 Oraton Street, Newark, N. J.

Eugene D. Forbes, 415 West 118th Street, New York, N. Y.

Verner A. Hendrickson, 126 Wentworth Avenue, Providence, R. I.

Harold W. Kephart, 110 Bridge Street, Brooklyn, N. Y.

Jack L. Rifkin, F. A. D. Andrea, Long Island City, N. Y.

Robert J. Sanford, 446 East 89th Street, New York, N. Y.

Fred Simpson, Jr., Box 2318, Boston, Mass.

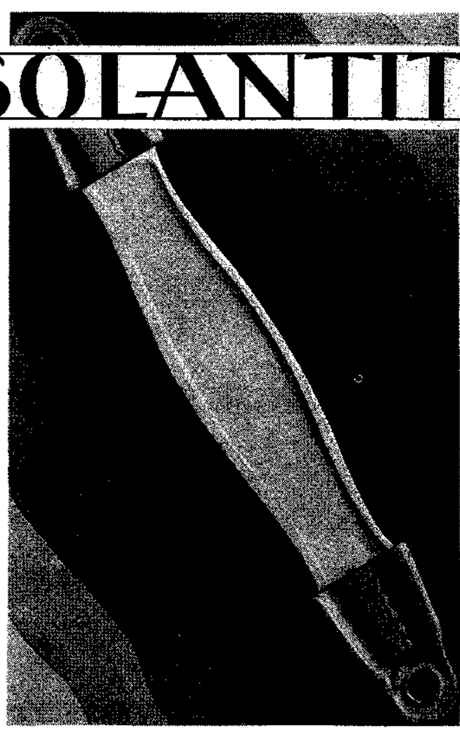
Leslie G. Thomas, 417 Valley View Road, Englewood, N. J.

CARL E. TRUBE

It is with deep regret that we announce to the membership the death of Carl E. Trube, a Fellow member of the club, on Tuesday, March 11, 1930, at his home, 216 Spring Street, Ossining, N. Y. His death was the result of burns received from an explosion which occurred while he was experimenting on a new type of reciprocal engine for the use of various types of fuel.

Mr. Trube was a graduate of Stevens Institute of Technology, with the degree of Mechanical Engineer, also a member of the Delta Tau Delta Fraternity, as well as of one of the main engineering honor societies. He was the inventor of the Thermiodyne Circuit and held several other radio patents. His name is well known in the amateur field, having formerly operated Station 2BK in Yonkers, and having been successful in the Trans-Atlantic Amateur Contest held in 1923. Mr. Trube was devoting his time to experimental work in his own laboratory and had no connection with any business concern.

At the time of his death, he was twenty-nine years of age, and is survived by his wife, his young son, and his parents.



Message From The Membership Committee

THE Membership Committee asks your cooperation in the expansion of our membership. It has always been the policy of the Club, in the past, to encourage a natural increase in membership rather than to expand too quickly and thereby incur the danger of reducing our present standards. However, we feel that you must number among your acquaintances many men who ought to be in the Club and who simply have not been approached. We would like you to keep this constantly in mind and see to it that the advantages of membership are presented to such of your friends without delay. This is the ideal method of increasing our membership, since by so doing a personal recommendation will accompany each application. It need hardly be pointed out to you that The Radio Club of America is not only a technical organization but also a Club, and therefore we should endeavor to have the membership consist of men possessing good personality in addition to their technical ability or interests.

The advantages of the Club are manifold. The fact that it is the oldest radio club in the world, combined with the fact that its membership comprises outstanding pioneers in the radio art, ought to offer an inducement to any prospective member to become one of us. Papers containing information on all new developments in the art are presented monthly at Columbia University, and these papers are later printed in our Proceedings which are mailed to each member. At least once a year the members get together at a banquet or some other congenial gathering. Our ultimate aim is to establish a Club House which will offer all the ordinary advantages of a New York club in addition to our common interest in radio.

We cannot urge you too strongly to keep constantly on the lookout for prospective members of the type we desire, since the membership after all is the Club itself, and by making it your concern the welfare of our organization will be assured.

FRANK KING, *Chairman.*

Membership Committee

Frank King, *Chairman*

F. X. Rettenmeyer	C. F. Goudy
Daniel E. Harnett	Fred A. Klingenschmitt
L. M. Clement	W. C. White
E. H. Armstrong	H. Sadenwater
C. W. Horn	L. C. F. Horle