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How and Why the Talkies

By HORATIO W. LAMSON, Engineering Department

The keen interest shown during the past few months in the synchronism of sound, both vocal and instrumental, with motion pictures has led us to believe that our readers would welcome a resume of the scientific principles underlying this new art.

The great majority of us recall, no doubt, how, in the early days of broadcasting, we were frequently entertained by "canned" music, that is, phonograph records broadcast over the air. During those years the electric phonograph and the modern public-address systems were reaching an advanced state of perfection. It was only natural, then, that our motion picture producers, always keen for a new appeal to the public, should visualize the combination of an electric phonograph with the public-address system to give a synchronized sound accompaniment to feature pictures in their theatres. All this sounds very simple, but in reality the present day achievements have been attained only by painstaking and costly experimentation. A considerable amount of credit for this is due to the researches of the Bell Laboratories and associated concerns.

There are two fundamental systems of synchronizing sound: first, that which employs a disc record similar to the familiar phonograph disc; and, second, that which utilizes an optical record imprinted either along the edge of the motion picture film or, in some cases, on a separate film run in synchronism with the picture.

Let us examine the technique of the former method. A long series of factors enter into the satisfactory recording and reproduction of sound picture entertainment by the disc process. Taken in sequence these are, in the studio:

(1) A skilful rendition of the program by instrumental or vocal artists.

(2) A correct treatment of the acoustical features of the studio.

(3) The proper location and fidelity of the microphones.

(4) A skilful operation of the mixing controls.

(5) A high degree of fidelity in the recording amplifiers.

(6) The perfection of the electromechanical recording device.

(7) Care and attention in preparing the wax record before and during recording.

(8) Exact synchronization of recording with photography.

(9) The skilful reproduction of playing records from the original "wax."

In the theatre:

(10) The fidelity of the pickup or electrical reproducer, is a critical problem.

(11) Perfect synchronization must be maintained between the reproducer and the picture film projector.

(12) Proper use of the fader is essential. This device serves to shift from one record to the other and likewise functions as a volume control.

(13) A high degree of fidelity is required in the reproducing amplifier system.

(14) The output control panel must be properly adjusted.

(15) The loud-speaking equipment must be suitable for the purpose.

(16) A study must be made to give the proper acoustical treatment of the individual theatre.

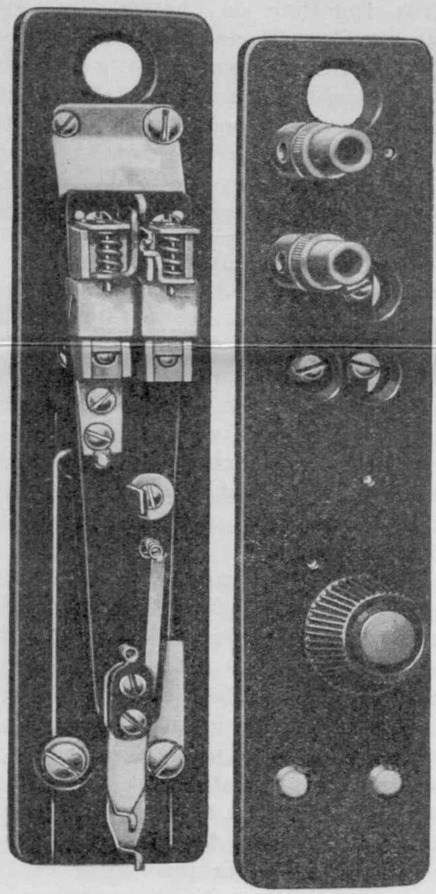
In order to obtain a realistic and pleasing reproduction throughout the whole theatre, it is essential that all these factors function to give a true rendering over a wide scale of frequencies and a large range of intensity level. Good reproduction demands impartiality to frequencies from 50 to 5000 cycles per second. Decreasing the lower limit to 30 or 25 cycles gives a noticeable improvement to certain types of music, while if the upper limit is increased to 8000 cycles an improvement in naturalness and articulation is attained.

Consider, for example, the specific problem in which the producer desires to furnish his audiences with a sound record of a large orchestra to accompany a motion picture of this orchestra in action. The members of the orchestra would be seated in the customary manner in semicircular tiers. Two or more cameras would be brought into play, one to obtain long shots of the full orchestra in action and one or more to obtain closeups of various artists during the rendition of solo parts. These cameras must be installed in soundproof booths in order that the clicking of their mechanism may not be picked up by the impartial microphones and reproduced audibly during pianissimo passages.

The acoustical director has two major problems to consider. First, he must see that the arrangement of the artists and the acoustical nature of the studio is such that no trouble-

A Double String Element

In response to the request from several of our friends we have developed a double string element which may, when desired, be substituted directly into the General Radio Type 338 Oscillograph.



The two strings, which are made of 0.4 mil tungsten wire, as in the case of the single string element, are insulated from each other electrically so that they may be used to observe simultaneously any two different electrical phenomena. An example of this would be to show the phase difference between currents and voltages in different or the same parts of a circuit and so forth. One string may be vibrated at a known frequency to serve as a timing element for the other string.

Electrical connection with the extremities of one of the strings is made through the same pair of spring contacts, mounted on the base panel of the instrument, that are used with a single string assembly, while the extremities of the second string terminate in a pair of binding posts near the top of the assembly. These posts are properly spaced to permit the use of the convenient Type 274 Plug. The second string will, of course, have no voltage divider unless one is provided externally.

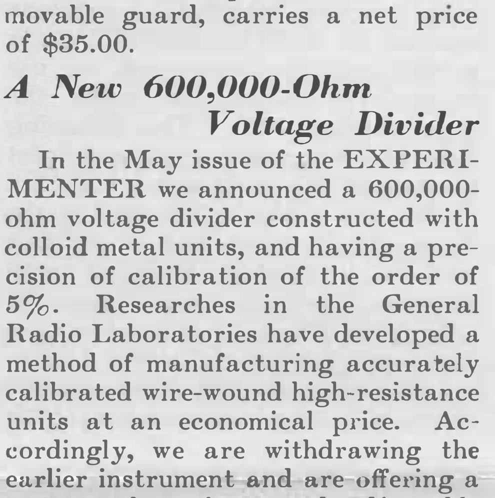
By means of a headless adjusting screw the separation between the two strings can be varied by moving one with respect to the other. Two similar screws serve to vary the tension, independently, on either string. This adjustment is accomplished by a pull directly along the line of the string so that the separation and parallelism of the two strings is not affected thereby. A thumbscrew serves to move both strings together across the light field, thus providing means for properly aligning them upon the viewing screen.

Both strings vibrate near their center point in the damping oil vein, which renders them nearly aperiodic. Since both of the strings must vibrate essentially in the same plane in order that they may be sharply focused it is not feasible to attempt to adjust them until their images overlap. Two simultaneous waveforms projected side by side on the same screen can, however, be nicely shown with this device.

The Type 338-D Double String Holder, which is provided with a removable guard, carries a net price of $35.00.

A New 600,000-Ohm Voltage Divider

In the May issue of the EXPERIMENTER we announced a 600,000-ohm voltage divider constructed with colloid metal units, and having a precision of calibration of the order of 5%. Researches in the General Radio Laboratories have developed a method of manufacturing accurately calibrated wire-wound high-resistance units at an economical price. Accordingly, we are withdrawing the earlier instrument and are offering a 600,000-ohm wire-wound adjustable voltage divider calibrated in fifteen steps of 2 TU each. The instrument is likewise calibrated in voltage ratios. Either of these calibrations is, of course, valid only when no current is drawn from the output terminals.



This device makes an excellent and thoroughly reliable gain control for a speech amplifier when used in the manner suggested in the diagram.

This Type 452-C Voltage Divider is mounted in a walnut cabinet 7″ square by 4″ deep, and carries a net price of $60.00.

Bargains

At the present time, the items listed below are in excess of our regular inventory requirements, and in order that our stock may be kept fresh and up to date, this material is being offered at special prices. All material carries our standard guarantee for new material. It is offered at the special prices only in the minimum quantities indicated, and is subject to prior sale. Here is a good chance for service men and manufacturers of experimental equipment to stock up. Be sure to mention special sale prices when placing orders.

500 Type 369 Impedances. 100 henrys. Carries 10 milliamperes. Suitable for impedance-coupled amplifiers, parallel plate-feed systems, and as audio chokes. Regular price, $2.50. Sale prices: Lots of 10, $1.25; 50, $1.00; 100, $0.75.

500 Type 227-A and B Coils. Tuning coils for short-wave work below the broadcast band down to 25 meters. Type 227-A, 14 microhenrys; Type 227-B, 55 microhenrys. Regular price, $1.00. Sale prices: Lots of 10, $0.60; 50, $0.45; 100, $0.35.

900 Type 236 Fixed Condensers. Tested at 300 volts. Suitable for by-pass work in receivers. Two hundred are 0.4 microfarad; seven hundred are 0.3 microfarad. Regular price, $1.00. Sale prices: Lots of 10, $0.30; 50, $0.25; 100, $0.20.

4000 Type 309 Socket Cushions. Sponge rubber. Will fit our Types 156, 349 and 438 Sockets. Regular price, $0.25. Sale prices: Lots of 10, $0.15; 50, $0.12: 100, $0.10.

3000 Type 301 Rheostats, 6 and 12 ohms. Regular price, $1.00. Sale prices: Lots of 10, $0.60; 50, $0.50; 100, $0.40.

3000 Type 301 Rheostats, without knobs, 10 ohms. Regular price, $0.75. Sale prices: Lots of 10, $0.40; 50, $0.30; 100, $0.25.

4000 Type 214-A Rheostats, 20 ohms. Regular price, $1.50. Sale prices: Lots of 10, $0.75; 50, $0.60; 100, $0.50.

Special prices on 247-H, 247-M, 247-P, 334-K, 334-M, 334-N, 334-P, 374-F, 374-N Condensers in quantities of 10, 25, and 100.

some echoes or reverberations exist, while, on the other hand, the studio should not be so "dead" as to produce a muffled record lacking in the desired brilliancy. A greater amount of reverberation is desired to give a pleasing brilliancy to an orchestral number than can be tolerated for the best articulation of solo singing or speech. Where both solo and orchestral music occur in the same program a compromise is usually attained.

The director's second concern is the proper distribution of a battery of microphones, similar in form to the broadcast studio microphones, at proper points around the orchestra. These microphones, sometimes as many as six in number, are connected to an instrument in the recording booth appropriately known as a "mixer." By means of this device the amount of electrical energy taken from each individual microphone may be varied at will in aggregating the total response which is fed to the recording mechanism. The placing of the microphones and the proper manipulation of the mixer controls to give the most realistic record constitute an art in which proficiency is attained only by experience. Once mixed, the energy level of the ensemble can be raised or lowered, but the relative importance of the several instruments cannot readily be varied.

The composite electrical impulses are then amplified to a sufficient degree and fed into the recording mechanism. This is essentially a cutting stylus which is made to vibrate in strict accordance with the energizing current. In the "lateral" type of recording, this vibration is along a radius of the disc record so that the stylus cuts a spiral groove on the disc of constant depth (about 0.0025") but of varying width. In the "hill and dale" type of recording, the vibration of the stylus is perpendicular to the surface of the disc giving a spiral groove of constant width but of varying depth. The lateral method is used almost exclusively in sound picture records. The original "wax" is a disc of metallic soap from 13" to 17" in diameter and about 1" thick. This is initially given a high polish and is then mounted horizontally on a turntable driven at a very uniform rate and synchronized with the film passing through the cameras. This synchronization is accomplished by electrical means of a highly technical nature.

Contrary to practice with ordinary phonograph records, the stylus is made to travel outward from the center of the disc at such a rate that it cuts a spiral having the pitch of about one hundred turns per inch. The table rotates approximately 30 revolutions per minute, which is less than one-half the speed of the ordinary phonograph. The larger records have a playing time of from eleven to twelve minutes and the stylus cuts its way over the wax at speeds varying from 70 to 140 feet per minute.

After the wax has been cut it is, of course, very desirable to be able to "play" it at once in order to detect any flaws. For this purpose a special reproducer known as the "play-back" is employed. This is made extremely light so as to produce no appreciable wear on the relatively soft wax record. If the wax is declared satisfactory, it is then dusted with a fine conducting powder and electroplated, giving thus a negative copy of the wax, which is called the "master." By successive electroplating steps duplicates of the "master," known as "stampers," are obtained, from which large quantities of playing records may be pressed. By taking proper precautions the acoustical fidelity of the record is in no way injured during these processes.

Let us now experience a quick transportation from the producer's studio to our favorite motion picture theatre.

In the projecting booth a horizontal turntable is mounted beside each projection machine. This table is rotated by the same motor which drives the film through the projector so that, if the operator sets the needle of the reproducer at a marked point on the record coincident with threading a marked portion of the film over the driving sprocket, then perfect synchronism between sound and picture will be maintained.

The reproducer is an electromagnetic pickup device driven by the needle as it vibrates across the irregularities in the spiral groove on the record. This device is quite similar in action to any of the variety of electrical phonograph reproducers on the market. It contains, however, a number of refinements which improve its fidelity over a wider range of frequency and volume.

The picture film and sound record are, of course, started together and both have the same playing time. If the subject is a multi-reel feature, as the end of the record is approached a duplicate projection machine and sound table are loaded with the succeeding film and sound record and, at a given cue in the picture, are set in motion. Immediately thereafter the transition or "change-over" is made. This is done on the screen by closing the shutter of the expiring projector and instantly opening the shutter of the new machine. The change-over between the sound records is accomplished by a device known as a fader, by which the intensity of the response coming from the expiring record is reduced to zero and, subsequently, the response from the new record is brought up to any desired level. This transition may be accomplished gradually or rapidly, as is desired, and, like the change-over on the screen, is rarely perceptible to the layman in the audience.

The electrical impulses coming from the fader are then passed through a series of special amplifiers where they are enormously intensified. As an illustration let us consider the case of the Bell Laboratories' system. This consists of three units. The first is a three-stage resistance-coupled amplifier employing low-power tubes energized by direct current. The second unit consists of a push-pull stage of medium-power tubes heated by alternating current, while the third unit consists of a push-pull stage using high-power tubes energized by alternating current. Plate potentials for all tubes are obtained from rectified alternating current. Small theatres require only the first two units, while large theatres take one or possibly two of the third type units to obtain sufficient volume of sound for the auditorium without overloading. The three units have a maximum gain of 80 TU, that is, they are capable of multiplying the energy of the reproducer one hundred million fold.

The output of the last amplifier is brought to the output control panel where the energy is subdivided among several loud-speakers or horns, usually four in number. Two of these are placed in the orchestra pit and directed more or less toward the balconies, while the other two are located behind the upper edge of the screen and directed downwards towards the rear floor seats. A small monitoring horn is placed in the projection booth for the convenience of

(Continued on page 4)

An Apology

The EXPERIMENTER wishes to express its regret at the fact that an article discussing methods of audio coupling appearing in the October issue seems to have caused serious offense to a competitor and a contemporary publication. The article in question was intended as a good-natured, helpful criticism of what seemed to us to be excessive enthusiasm of an advertising man. It was in no sense intended to cast reflections on the apparatus discussed, which, as we stated and believe, has undoubted merit. Our regret at having precipitated the incident is intensified by the unfriendly tone of the reply appearing in this contemporary manufacturer's bulletin.

Particular offense was caused, it seems, by our emphasis on the circuit, which it is said, is not claimed as new, and by our failure to mention the novel features of low-frequency resonance, and the elimination of "hysteretic distortion." We extend our apology to the matter of resonance, and confess that it did not even occur to us that this well-known means of improving coupling at low frequency

Incidentally, the conditions set forth in the curve illustrating this article never exist in a properly designed amplifier, and the magnetization curve has a decided bend near the origin at the point where the core works when direct current is excluded. Since theoretical analysis makes it difficult to determine whether harmonic distortion due to the presence of iron is actually decreased by elimination of direct current from the core, the author of this article would confer a great benefit on the art by publishing the experimental data on which he undoubtedly bases his claims.

In conclusion, may we add one more apology, not only to our offended contemporary, but to all our readers, for the latitude taken by our printer in his spelling of principles in the heading of the article in question.

Coil Data for Amateur Bands

The tuning condenser used in the Type 558 Amateur-Band Wavemeter has been described in a previous issue of the EXPERIMENTER. It is also available unmounted, for use

free from the shaft with diagonal cutting pliers.

This new range of adjustment will be such that the 20 and 40-meter bands cover practically the whole dial. The proper inductance can be obtained by slightly crowding the turns together on the 20 and 40-meter coils. It must be understood that in tuning over such a narrow band, slight adjustments of inductance may be necessary in order to compensate for various antennas and stray capacitances, in order to obtain a proper coverage.

(Continued from page 2)

the operators. A special type of screen, reflecting light well but transparent to sound, is desirable. The long exponential horns used, having an effective length of about fourteen feet, are capable of receiving up to five watts of electrical energy and, being very efficient, they will convert from 30 to 50% of this energy into sound.

Provision is made on the output control panel for varying the amounts of power delivered to the individual horns. When the equipment is first install