NEW MOTION PICTURE APPARATUS

During the Conventions of the Society, symposiums on new motion picture apparatus are held, in which various manufacturers of equipment describe and demonstrate their new products and developments. Some of this equipment is described in the following pages; the remainder will be published in subsequent issues of the Journal.

SAFEGUARDING THEATER SOUND EQUIPMENT WITH MODERN TEST INSTRUMENTS*

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Since the early days of sound motion pictures, the service branch of the industry has kept pace with the various developments and improvements in the art. In 1928 the field engineer was equipped with a minimum of tools and test equipment. In contrast, today he carries a complete set of modern service instruments and tools which comprise the following:

(*1*) Complete technical data on Photophone and equipment of other manufacturers

(*2*) Special Weston analyzer

(*3*) Special Weston power level meter

(*4*) Socket selector kit

(*5*) Tool kit

(*6*) Special wrenches

(*7*) Speed counter

(*8*) Loud speaker adjustment tool

(*9*) Standard frequency test-film

(*10*) 7000 and 9000-cycle focusing films

(*11*) Lateral adjustment film (buzz track)

(*12*) Push-pull test-film

(*13*) Academy dialog and music film

(*14*) Universal a-c bridge for measurement of resistance, capacity, and inductance

(*15*) Cathode-ray oscillograph

(*16*) Beat-frequency oscillator

(*17*) Emergency amplifier and speaker system

Technical Data.—Each field engineer maintains a complete file of Photophone equipment bulletins and, in addition, is furnished with up-to-date technical

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information on all new improvements in the art. Complete data on equipment other than Photophone are furnished to him and these data are kept up-to-date, so that RCA field engineers can service any type of theater sound reproducing systems.

Analyzer.—The Weston analyzer, together with the power level meter and socket selector kit, were made to RCA specifications for application to theater sound work. The analyzer incorporates a 20,000-ohm-per-volt meter with scales up to 1000 volts. In addition, provision is made for checking any range of current or resistance normally encountered in routine service work. The socket selector kit is designed for checking tubes in the amplifying equipment making it possible to test under dynamic conditions.

Power Level Meter.—Since a 15-ohm output impedance has been standard on Photophone equipment for a number of years, the power level meter is calibrated for this impedance and a 12.5-milliwatt reference level. Charts are provided from which correction factors can be obtained when the meter is used on circuits of different impedance or when other reference levels are necessary. This meter is used in conjunction with the standard frequency film or beat-frequency oscillator in obtaining overall system frequency response or complete transmission runs.

Tool Kit.—The tool kit contains all the necessary tools for proper installation and service operation on the complete equipment. In addition there are special sound-head wrenches and motor alignment tools. A Starrett speed counter is included for accurately measuring film speed.

Frequency Test-Film.—The present frequency test-film has been designed with the view toward making it more useful in field work. Accordingly, identical tracks are recorded on each edge of the film, thereby eliminating the need for rewinding after each test. This greatly speeds up the work of taking response curves.

Thirty-three frequencies are included, from 30 to 10,000 cycles, with the 1000-cycle reference at the beginning and end of each track. Additional frequency recordings are included between 2000 cycles and 3000 cycles to provide a more comprehensive overall response test. The response is held within ±0.5 db throughout the frequency range.

Buzz-Track and 9000-Cycle Film.—For adjustment of film position with respect to the sound-head light-beam, each engineer carries a small section of so-called buzz-track. The recording consists of two narrow chopper tracks so spaced that neither will affect the light-beam if the guide rollers are in proper lateral adjustment. This test-film has been in use since its development, in 1930, by W. W. Jones, now Manager of New York District Service Operations, to whom the patent was originally issued.

On the other edge of the film there is a 9000-cycle recording employed for focusing the light-beam on the film. The film is used in conjunction with an output meter to determine when the beam is correctly focused on the sound-track.

Push-Pull Test-Film.—With the advent of push-pull sound-heads, it was necessary to provide a test-film for adjustment of the optical systems. This film consists of a 6-mil "septum" track on one edge for adjusting the division of the light-beam and a 300-cycle track on the other edge, for correctly balancing the output of the dual photocell. The 300-cycle portion is also used to balance the output from each sound-head.

Theater Sound Test-Reel.—RCA field engineers are now equipped with the latest theater sound test-reel produced by the Research Council of the Academy of Motion Picture Arts and Sciences. The following description of the film is taken from the Academy *Technical Bulletin:*

"The reel contains sound and picture, the sound consisting of dialog and music recordings so chosen that the assembled reel contains a representative example of sound as currently recorded by each sound department. One of these recordings is a 'Hi-Range' print which serves as a check on the amplifier capacity in relation to the volume of the auditorium under consideration.

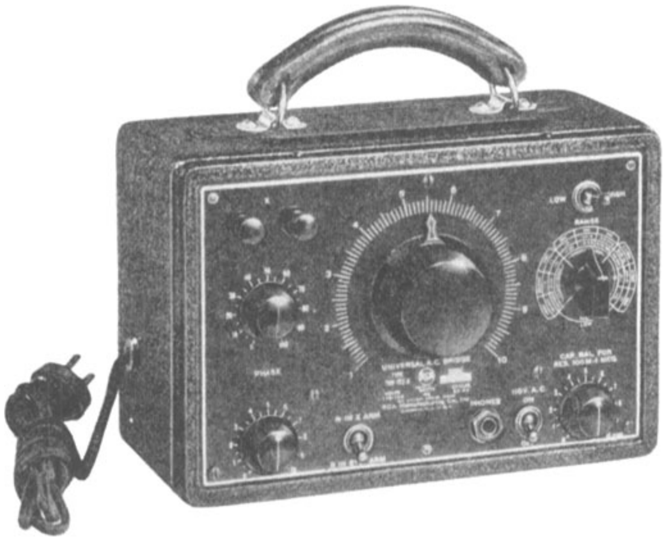

FIG. 1. Universal Inductance, Capacity, and Resistance Bridge.

"The reel also contains approximately 100 feet of piano and 12 feet of 3000-cycle recordings included for the purpose of furnishing a more critical flutter test.

"After setting the theater sound reproducing equipment to the Standard Electrical Characteristic, the Theater Sound Test-Reel furnishes a tool by which an optimum setting for presence and intelligibility, combined with a natural balance between high and low frequencies, may be obtained for all current product and for the individual theater.

"The use of this reel demonstrates the inadvisability of having too much low-frequency electrical response which brings out noise-reduction bumps, footsteps and parasitic low-frequency noises present on the set.

"It might be pointed out that judgment is required in the use of the Theater Sound Test-Reel, as the product must be evaluated in terms of the material at hand, that is, crowd noises and people talking in loud voices or excited manners should not be expected to have the same quality and chest tones which are present in conversational dialog in a quiet, intimate scene.

"The Research Council and the Committee have always felt that electrical and acoustical curves furnish valuable means of setting equipment, but that the final criteria should be critical listening tests of the equipment. For this reason all Theater Sound Reproducing Equipment Standards to date have been set up on the basis of listening tests correlated with engineering data.

"One of the purposes of the Standard Electrical Characteristic is to provide a basis for an eventual standard recording characteristic. We believe that the new Theater Sound Test-Reel demonstrates the fact that the recording characteristics of the various studios are very much closer together than they were a year or two ago.

FIG. 2. Cathode-Ray Oscillograph.

"The material contained in the reel is not necessarily a sample of the best recording available but is typical of the average.

"In an average theater, set to the Standard Electrical Characteristic, the reel will play through entirely upon one fader setting (with, of course, the exception of the Hi-Range print sequence, for which the fader must be raised 6 db)."

Universal A-C Bridge.—To enable the field engineer to measure inductance and capacity as well as resistance, the RCA universal bridge (Fig. 1) is employed. This instrument is invaluable for checking reactors and transformers for shorted turns or other trouble, and for accurately determining values of capacitors. The measuring ranges are 100 μh to 10h, 10$\mu\mu$f to 10μf, and 1 ohm to 1 megohm. For higher values of resistance, the test analyzer is employed, since this has ranges up to 10 megohms.

The instrument consists of a variable-ratio-arm Wheatstone bridge having three standards each of inductance, capacity, and resistance. A vacuum-tube 1000-cycle oscillator and a two-stage amplifier, together with their power supply, make up the major part of the equipment. The only additional equipment required is a "null" indicator, for which the power level meter is employed. Power is obtained from any 110 to 120-volt, 25 to 60-cycle source. The complete instrument weighs only 6 pounds.

Cathode-Ray Oscillograph.—Another device which has been in general use for over three years and has proved extremely useful in theater service, is the cathode-ray oscillograph (Fig. 2). This instrument is probably the most versatile device yet developed for the study of radio and audio-frequency phenomena.

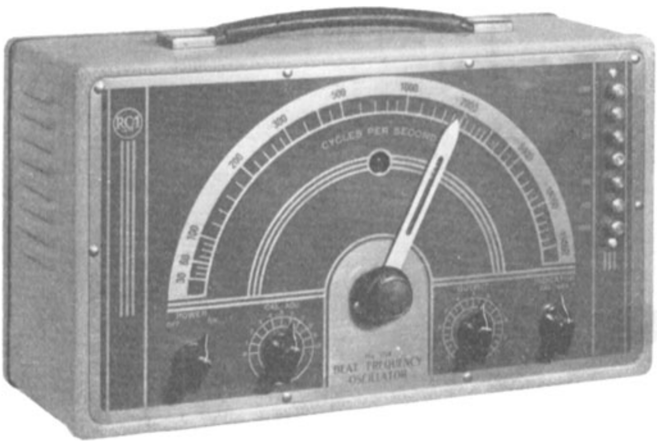

FIG. 3. Portable Beat-Frequency Oscillator.

By means of the oscillograph the field engineer can quickly localize sources of hum in the sound systems and check hum patterns, determine where distortion is introduced, check phasing of networks, and perform many other routine checks which up to a few years ago were impossible to do. This instrument weighs 21 pounds complete and is entirely self-contained, requiring only a source of a-c power supply.

Beat-Frequency Oscillator.—For quickly checking the audio-frequency response and power output of a theater sound system, the RCA portable beat-frequency oscillator (Fig. 3) is provided. This instrument is extremely rugged, weighs only 15 pounds, and is remarkably stable for its size. The hum level is 60 db below maximum output.

Besides its use in checking audio amplifiers, it is also extremely valuable for determining source of buzzes, rattles, *etc.*, in stage surroundings and auditorium fixtures. It is also used as a routine check on the loud speaker systems to be sure that the units are free from distortion.

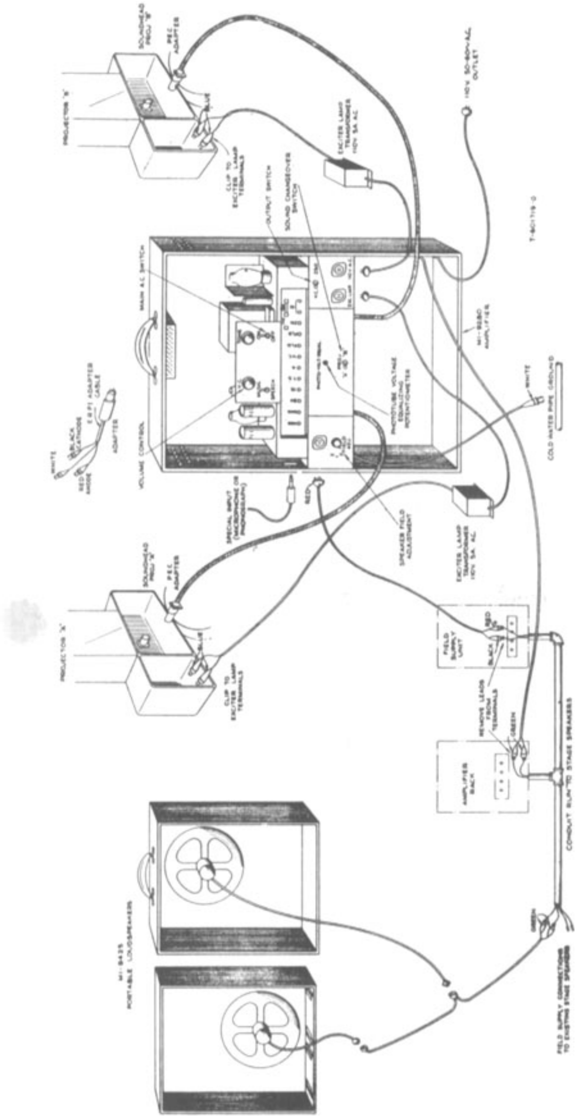

FIG. 4. *PG-109-B* equipment set-up.

Emergency Amplifier System.—In the latter part of 1936, RCA introduced to exhibitors a complete portable emergency sound system, so designed that it would be possible to keep the show running if every piece of equipment were down except one sound-head and projector (Fig. 4). This system proved so valuable that more than 150 are now located in theaters throughout the country, and besides this nearly every RCA field engineer carries one as standard equipment.

The most recent design incorporates many improvements for greater ease and simplicity in operation. The amplifier and all controls are housed in a small metal cabinet, with all necessary cables for making connections to sound-heads and stage lines. Sufficient audio power is available to carry even the largest theater, and connections can be made to any type of sound equipment regardless of manufacture.

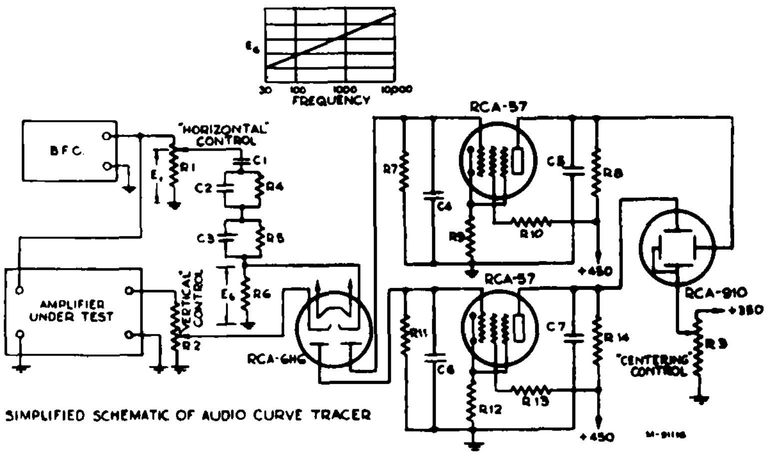

FIG. 5. Audio Curve Tracer, simplified circuit.

SPECIAL EQUIPMENT

While the various pieces of standard equipment already described are usually adequate for routine service work, quite often problems arise which require specialized test equipment. RCA is continually at work developing new test equipment to handle these problems, as well as new equipment and methods to simplify and speed up routine tests.

Audio Curve Tracer.—One of the recently developed instruments in this classification is the audio curve tracer. This is a portable device which traces an amplifier response curve automatically on the screen of a cathode-ray tube. By using a tube with a long-persistence screen, such as the *RCA-910*, the image is retained long enough for it to be studied, photographed, or a second curve superimposed on it for comparison. With this instrument it is possible to run an accurate frequency response curve in approximately thirty seconds.

Fig. 5 is a schematic drawing showing the operation of the instrument. The output of a beat-frequency oscillator is fed both into the "horizontal control" potentiometer *R-1* and into the input of the amplifier under test. The voltage developed across *R-1* is fed through a resistor-capacitor network to ground. The characteristics of this network are such that with a constant voltage *E-1* impressed across the network, the voltage developed across *R-6* varies directly as the logarithm of the frequency impressed. This is shown in the small curve above. The voltage *E-6* is impressed across a diode section of the *RCA-6H6* tube and is rectified. The rectified voltage causes current to flow through resistor *R-7* producing a negative bias voltage at the grid of the *RCA-57* d-c amplifier tube. The greater the voltage *E6* becomes the more negative the bias on the *RCA-57* becomes. The plate supply voltage to the d-c amplifier is 450 volts. The actual voltage at

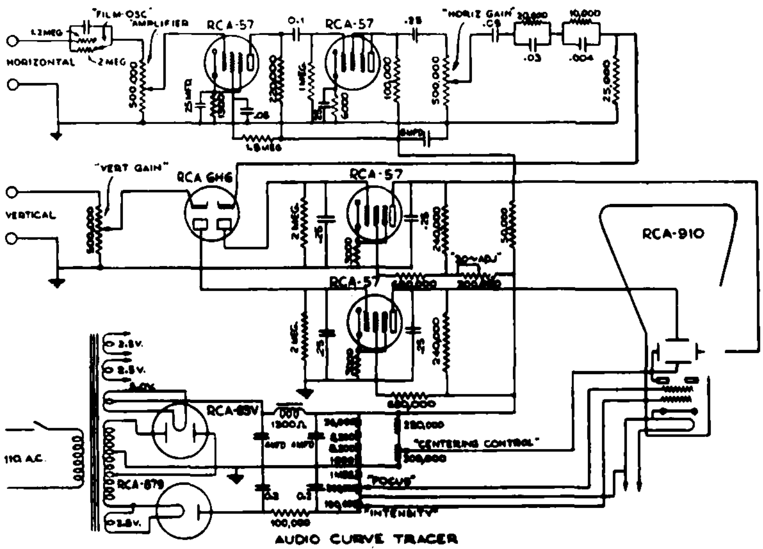

FIG. 6. Overall schematic diagram of complete Audio Curve Tracer.

the plate of this tube is equal to this voltage minus the voltage drop in the plate resistor *R-8* caused by the flow of plate current. Hence, as the plate current is reduced the drop across the plate resistor is reduced and the voltage at the plate of the tube becomes higher. The plate voltage is applied directly to one of the horizontal deflection plates of the cathode-ray tube. The opposite deflection plate is at some potential above ground which is determined by the setting of the centering control potentiometer *R-3*.

When the beat-frequency oscillator is set at a low frequency the voltage *E6* is low. Hence the current through *R-7* is small and therefore the value of negative bias is small. This causes a large plate current to flow in the *RCA-57* and reduces the voltage at the plate of the tube because of the large drop in the plate resistor. This reduces the voltage applied to the right deflection plate below that at which the left is set causing the beam to be deflected to the left (that is, toward the more positive plate).

When the frequency of the oscillator is raised the voltage *E6* goes up, more current passes through *R-7* producing a higher bias voltage, the plate current of the *RCA-57* is reduced, and the drop across *R-8* is very small, leaving the voltage at the plate of the tube and consequently at the right deflection plate higher than the voltage of the left deflection plate. Under this condition the negative beam of electrons is deflected toward the right plate which is now the more positive.

Thus by merely tuning the beat-frequency oscillator through its frequency

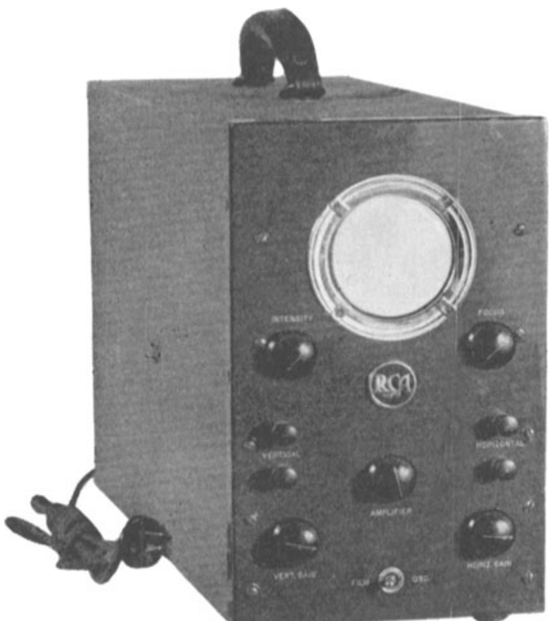

FIG. 7. Audio Curve Tracer.

range the electron beam is moved across the screen horizontally with a displacement which is always proportional to the logarithm of the frequency impressed.

The output of the amplifier is fed through the "vertical control" potentiometer *R-2* to ground. A portion of the output voltage is rectified by the second diode in the *RCA-6H6*, amplified by a d-c amplifier identical to the one already described and applied to the vertical deflection plates. By analysis similar to that for the horizontal deflection circuits, it is evident that an increase in amplifier output will cause an upward deflection of the beam.

Thus, for any given frequency at which the oscillator may be set, the frequency determines the horizontal position of the spot, and the output level of the amplifier determines the vertical position of the spot. Therefore, if the oscillator is swept through its frequency range the spot will trace a response curve of the amplifier under test. Fig. 6 shows the overall schematic diagram of the complete audio curve tracer.

In addition to the beat-frequency oscillator as a source of signal, a continuously variable frequency test-film is available which can be run through the sound-head to produce an overall response curve of the complete sound system.

The "film-oscillator" switch at the input of the horizontal amplifier connects either of two high-frequency boosters in the circuit. In the "oscillator" position a slight rise is added to make up for the reduction in output of the oscillator at the high frequencies. A more pronounced rise is provided in the "film" position to compensate for the optical losses in the sound-head at the high-frequency end.

An additional control, the "30-cycle adjustment," has been added so that the

FIG. 8. Flutter Indicator.

voltage drop at the plate of the horizontal d-c amplifier can be lowered independently of the voltage at the vertical d-c amplifier, making it possible to move the spot horizontally without affecting its vertical position.

Fig. 7 is a picture of the audio curve tracer. This is housed in a carrying case similar to that of the three-inch oscillograph. The front panel contains the "focus" and "intensity" controls, the "horizontal" and "vertical" inputs, the "horizontal gain" and the "vertical gain" controls, the "horizontal amplifier gain" control and the "film-oscillator" compensation switch. The "centering control" and the "30-cycle adjustment" control are screw-driver adjustment controls on the side of the case.

Flutter Indicator.—Early in 1933 RCA introduced the rotary stabilizer sound-head, which revolutionized sound reproduction by minimizing to a large extent the flutter which was characteristic of the earlier types of sound-heads. However, since there are still thousands of older equipments in use which are subject to flutter trouble, RCA has available a Flutter Indicator which will aid the service engineer in making adjustments to reduce flutter to a minimum (Fig. 8).

Flutter is actually frequency modulation of the reproduced tone caused by irregular motion of the film past the scanning beam; hence any one of several frequency-discriminating circuits may be used to detect these irregularities.

In the past few years, several different types of flutter-measuring devices have been built. Most of these employ circuits which are quite similar to those used in automatic frequency-control circuits used in broadcast receivers, or frequency-deviation meters used in transmitting stations. While these instruments are extremely accurate, they require the use of one or more vacuum-tubes together with associated power supply circuits. This reduces the portability and hence makes the units unsuitable for field work.

The discriminating network used in this instrument is merely the familiar Wheatstone bridge used as an impedance bridge with reactive impedances in two of the legs. The constants have been chosen so that when a 3000-cycle signal is fed into the network it can be balanced, and a meter placed across the network will read zero. If the frequency of the input signal varies above and below 3000 cycles, the network will become unbalanced by an amount that is proportional to the variation and the meter will show a corresponding deflection.

A specially recorded 3000-cycle film with low flutter content is run through the sound-head under test and the flutter indicator is connected to the output of the system amplifier. Any variations in output can be measured directly on the meter.

The input transformer has several impedance taps, so this instrument can properly terminate the system amplifier without the use of additional load resistors. An input control provides vernier adjustment of the input level to the measuring network. The "read-calibrate" switch allows the meter to be used for calibrating the input to the measuring network or for reading the flutter voltage developed across the output of the network. Two ranges of sensitivity are made available through the use of the range selector switch. These ranges are 0.5 per cent full scale or 2 per cent full scale. Resistance and capacity balance controls allow the resonance frequency of the measuring network to be shifted slightly to compensate for slight variations in speed between various sound-heads. The meter is a 5000-ohm rectox type volume indicator with a scale that is hand-calibrated directly in per cent flutter.

By using this instrument as a guide in adjusting the tension in the sound-gates of older types of sound-heads, it has been possible to reduce the flutter from as much as 2 per cent to as little as 0.3 per cent.

Scanning Illumination Test-Track.—Another new tool, which is available through the Academy of Motion Picture Arts and Sciences, to give the field engineer a better check on the operation of the theater sound system is the scanning illumination test-track.

This film is made up of seventeen consecutive sound-tracks, each of which is displaced a different distance from the guided edge of the film. The individual tracks are unilateral tracks approximately 7 mils in width and modulated approximately 100 per cent at 1000 cycles. The distance between the centerlines of the consecutive tracks is 6 mils, allowing a slight overlap from one track to the other. The centerline of the first track occurs at approximately 197 mils from the edge of the film and the centerline of the last track 292 mils from the edge of the film, and the total track width is approximately 110 mils. Each track announces itself by number at the start, and the length of steady-state condition is 10 feet with 2 feet allowed for moving from one track to the next and 1 foot allowed for the announcement. This makes a total of 13 feet for each of seventeen sections.

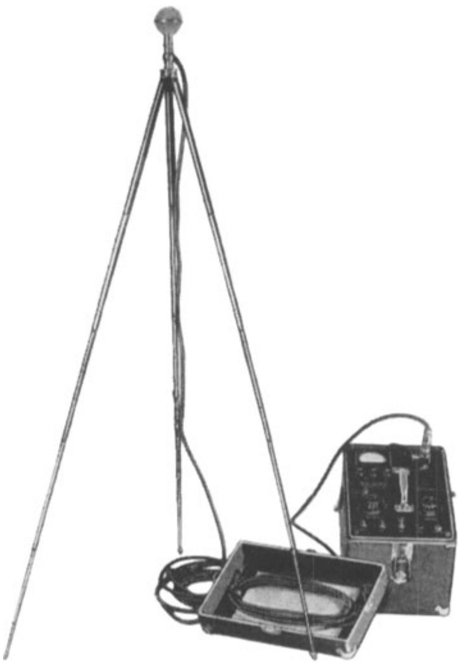

FIG. 9. Sound-Level Meter.

A single running of this film provides the following information:

(*1*) The length of the slit
(*2*) The uniformity of illumination across the slit
(*3*) The approximate amount of weave in the machine

As an example of the information obtained from running this film, it was run through an older type equipment and the following facts were established: The effective length of the slit was approximately 73 mils; the illumination across the slit was uniform within ±1 db; and the weave in the machine was approximately 6 mils.

Sound-Level Meter.—While listening tests in theaters are final criteria for good sound reproduction, very often acoustic response readings taken in the auditorium will indicate where changes are necessary to improve quality. RCA has employed the General Radio *759-A* sound level meter (Fig. 9) for this purpose since the early part of 1937. In addition, it is extremely useful for checking noise levels in projection rooms and the theater proper, for checking extraneous noise produced by fans in air-conditioning systems, and the effectiveness of vibration insulation of power equipment.

For checking acoustic response of speaker systems, a warble-tone frequency reel is employed as a source of signal, to reduce as much as possible the effects of standing waves in the theater. The microphone is set up at various points throughout the theater, and then readings are taken from 30 cycles to 9400 cycles at each station. The plotted curves so obtained indicate approximately the acoustic response in various sections of the theater, and this can usually be confirmed by listening tests.

On the basis of the acoustic response so obtained, adjustments can be made for proper sound quality from the speaker system. This procedure has been used in numerous theaters and the results as compared to listening tests were very gratifying.

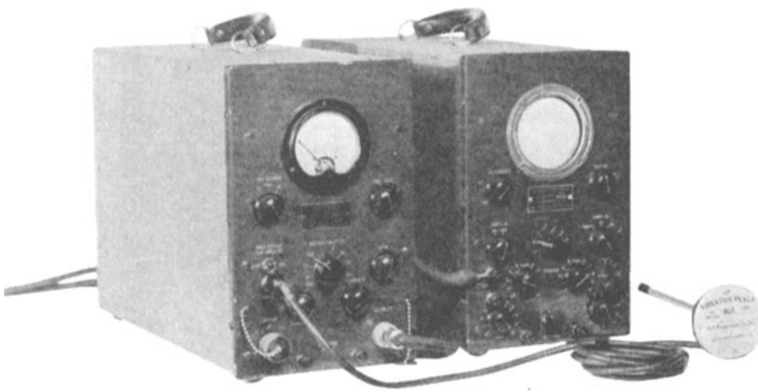

FIG. 10. Vibration Pick-Up.

This device is also very valuable in checking the sound distribution throughout the auditorium. Response curves run at several points quickly show up any deficiencies. The speakers can be accurately angled on the basis of such readings to give the optimum sound distribution.

ASSOCIATED EQUIPMENT

Other test instruments have been developed by various branches of RCA for specific applications. These are often used for theater work in routine service or solving special problems. One of these is the RCA vibration pick-up (Fig. 10).

Vibration Pick-Up.—This unit, with its associated equipment, is very useful in locating defective gears, bearings, or other moving parts. Such defects usually show up as "knocks" occurring at regular intervals, or as vibrations at an audio frequency. If the approximate location and the frequency of the "vibration" can be determined, the exact location of the defect is rather easy to find.

The output of this vibration pick-up is fed into an amplifier and in turn to the vertical plates of a cathode-ray oscillograph. A prod is provided on the vibration pick-up for prodding around the sound-head until the approximate source of the vibration is located, as indicated by a maximum deflection on the oscillograph screen.

If the frequency of this vibration or knock is known the problem is still further simplified. The frequency can be determined by using the cathode-ray oscillograph externally synchronized by an audio beat-frequency oscillator or an RCA synchronizing generator.

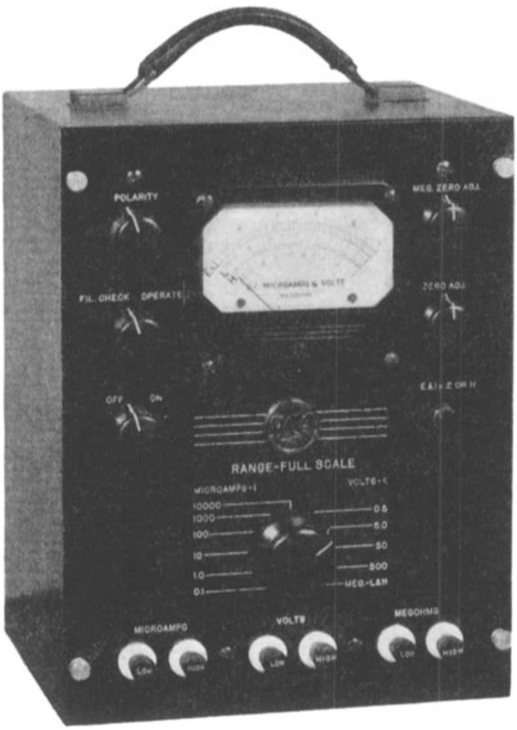

FIG. 11. Ultrasensitive D-C Meter.

If the synchronizing generator is used, it is coupled to the projector crank shaft or to a sound-head sprocket shaft. It generates a synchronizing voltage at intervals which are directly related to the rpm of the shaft. The synchronizer also provides a movable marker voltage which can be impressed on the signal under observation and gives a means of marking the oscillograph trace with respect to the angular position of the shaft.

Knowing the rpm of the motor and sound-head sprockets, the problem is still further reduced and can be solved by associating the frequency of knock or vibration with the rpm of the moving parts in the vicinity of the source of vibration.

Ultrasensitive D-C Meter.—Another instrument developed by RCA for use in laboratories and handling special field measurements is the ultrasensitive d-c meter (Fig. 11). This is a ruggedly built, portable precision device, for measuring small values of current and voltage, and a wide range of resistance.

Current measurements as low as 0.02 microampere and up to 10,000 microamperes can be made over twelve different scale ranges. D-c voltage measurements from 0.1 volt to 500 volts over eight scale ranges can be made. Resistance values from 0.1 megohm up to 200,000 megohms can be checked with this instrument.

The instrument consists of a multiplicity of input circuits, a three-stage d-c feedback amplifier, and a meter circuit. The amplifier is so designed that the meter can not burn out or even deviate in calibration through overload unless the sensitivity push-button is held down.

The sensitivity of the instrument approaches that of the average reflecting galvanometer. The overall accuracy for all ranges of current or voltage measurements is ± 2 per cent of full scale at ambient temperatures of 50° to 100°F and normal humidity. For resistance measurements the maximum deflection error is ± 0.1 inch at mid-scale and approaches zero at ends of the scale.

The instrument is particularly useful in theater sound work for measuring photocell currents, leakage currents between tube electrodes, and between circuit elements. The unusually high input resistance, five megohms or better, on all ranges of the voltmeter circuit enables accurate measurement of d-c voltages across high-impedance circuits such as those existing between tube electrodes or across circuit elements such as bias-resistors.