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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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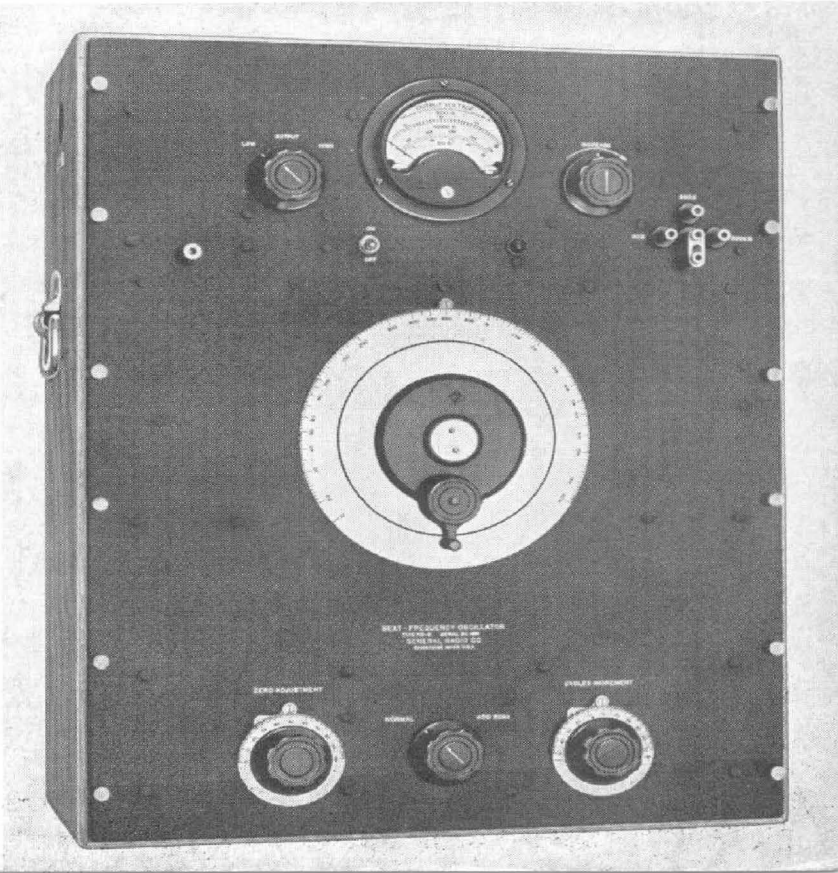
MODERN IMPROVEMENTS FOR THE BEAT-FREQUENCY OSCILLATOR

● **THIS MONTH ANOTHER** best seller comes out in a new edition. Basically the same as its predecessor, but brought up to date in all details, the new TYPE 713-B Beat-Frequency Oscillator possesses several features which are particularly desirable when making measurements on high-fidelity audio-frequency and supersonic equipment.

Among the more important features of the new oscillator are: (1) an increase of the frequency range to 40 kilocycles, (2) a logarithmic frequency scale over the range up to 20 kilocycles, (3) lower harmonic content and the practical elimination of a-c hum, (4) the provision of three different output impedances which remain practically constant regardless of the setting of the volume control, and (5) an output circuit which may be operated either grounded or ungrounded and which is suitable for operation into the average low-

FIGURE 1. Panel view of the TYPE 713-B Beat-Frequency Oscillator



impedance audio-frequency transmission line.

The frequency range between 20 and 40 kilocycles has hitherto been available on special order only. The importance of this range for general laboratory measurement as well as in the rapidly growing supersonic field is now sufficient to justify its inclusion as a standard feature.

The change from the low to the high range is made by shifting the frequency of the fixed oscillator (and consequently the output frequency) by 20 kilocycles. This process is controlled by a panel switch which simultaneously changes the circuits associated with the CYCLES INCREMENT dial so that its calibration is correct for either setting of the FREQUENCY RANGE switch.

A new variable condenser with carefully designed compensating adjustments gives a logarithmic variation of frequency with dial reading for the range up to 20 kilocycles. This is covered in a dial rotation of 250°.

The frequency characteristics of audio-frequency equipment are usually plotted using a logarithmic frequency scale, and consequently the logarithmic oscillator scale is a considerable advantage. Angular dial increments are then proportional to linear increments on the frequency scale. Points on the plot can be spaced evenly, avoiding the crowding which occurs when using a linear oscillator dial. When operating a recorder from the output of the equipment under test, the oscillator dial can be geared directly to a recorder using logarithmic or semi-logarithmic paper.

Waveform and hum level have been improved over that of the TYPE 713-A by providing better balance in the detector circuit and using a degenerative audio amplifier.

The output circuit includes a doubly-shielded transformer which couples the output tubes to a constant-impedance attenuator and a tapped autotransformer. The autotransformer provides three different output impedances, namely, 50, 500, and 5000 ohms, and is

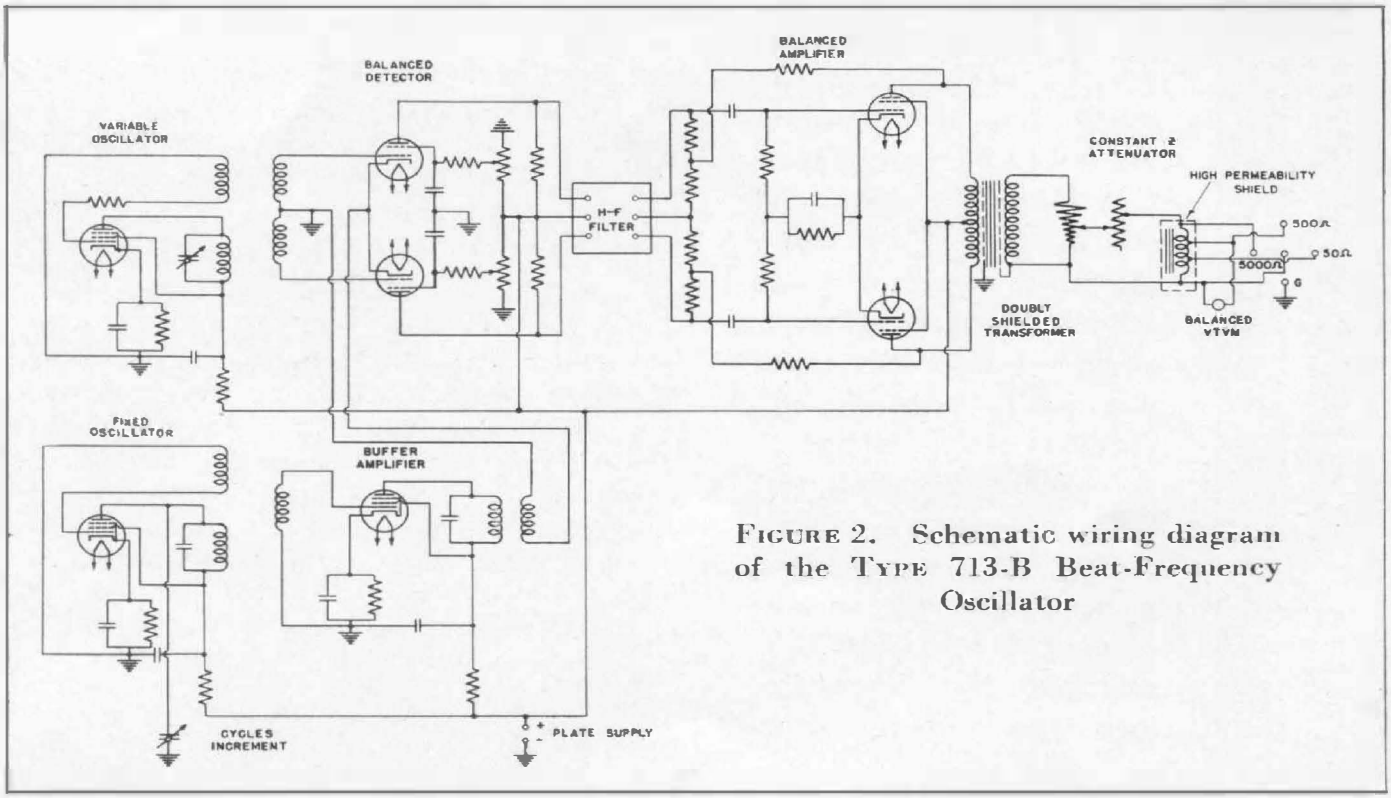


FIGURE 2. Schematic wiring diagram of the TYPE 713-B Beat-Frequency Oscillator

enclosed in a high-permeability shield so that no hum is introduced into the output. The arrangement of the output terminals makes possible rapid and easy connection to any one of the three output impedance windings. The common output terminal may be grounded, or, when working into balanced lines, may be left floating.

Since it is expected that many owners of the TYPE 713-A Oscillators will want some of the additional advantages of the TYPE 713-B, arrangements have been made so that the same changes may be made in earlier models. Either the additional frequency range or the new amplifier and output system, or both, may be added to a TYPE 713-A Oscillator. It is also possible to change the circuit and condenser so as to provide the logarithmic frequency calibration. With these changes the instrument will have exactly the same performance characteristics as a TYPE 713-B. Prices will be gladly quoted by our Service Department.

— H. H. SCOTT

SPECIFICATIONS

Frequency Range: 10 to 40,000 cycles per second.

Frequency Control: The main control is engraved with a logarithmic frequency scale extending up to 20 kilocycles, the total scale length being approximately 17 inches. The FREQUENCY RANGE switch extends the range to 40 kilocycles. There is an INCREMENTAL FREQUENCY control covering a band extending 50 cycles on either side of the frequency determined by the setting of the main dial and the FREQUENCY RANGE switch.

Frequency Calibration: The calibration may be standardized at any time by setting the instrument to zero beat. This adjustment can easily be made with an error of less than one cycle. The calibration of the frequency-control dial can be relied upon to within ±2% ± one cycle after the oscillator has been correctly set to zero beat, and for one year from date of purchase. The incremental frequency dial is marked with one division for every one-cycle interval over a range of −50 to +50 cycles. Its calibration is correct to ±2 cycles per second or better.

Frequency Stability: Care has been taken in the design of the oscillator to provide adequate thermal insulation and ventilation, thereby greatly minimizing frequency drifts due to temperature changes. The oscillator may be accurately reset to zero beat at any time, thereby eliminating even the small remaining frequency drifts.

Output Impedance: The output circuit includes a tapped autotransformer providing output impedances of 50, 500, and 5000 ohms. The output circuit is electrostatically shielded and isolated from ground, thus making it practical to operate into an ungrounded load such as a transmission line. The output circuit is sufficiently well balanced for operating into the average audio-frequency transmission lines throughout the entire frequency range of the oscillator when using the 50-ohm output terminals. When using the 500-ohm output terminals, the balance is satisfactory up to 15 kilocycles. When using the 5000-ohm output terminals, the balance is satisfactory up to 3 kilocycles. Obviously, the output circuit may be operated ungrounded at higher frequencies than those specified, provided a close balance to ground is not necessary. When it is desired to ground definitely one side of the load, this may be accomplished by means of the grounding strap provided on the oscillator panel.

Output Power and Voltage: The open-circuit output voltage of the oscillator is approximately 150 volts. The maximum power delivered to a matched load is slightly over one watt when the output control is in the HIGH position. When the output control is in the LOW position, the maximum power is approximately 0.02 watt.

For a matched resistive load the output voltage varies by less than ±0.5 db between 30 and 12,000 cycles, and by less than 1 db between 15 and 16,000 cycles.

Waveform: When the OUTPUT switch is on the LOW position, the total harmonic content is less than 0.2% throughout the frequency

range from 250 to 2000 cycles and less than 1% between 70 and 10,000 cycles. At 20 cycles the harmonic content is approximately 3%. When operating on the LOW output position, the harmonic content is practically unaffected by any load impedance between one-half of the rated value and an open circuit.

With the output switch on the HIGH position and when operating the oscillator into a matched load, the maximum amplitude of the harmonics is less than 2% of the output voltage in the audio-frequency range above 70 cycles, regardless of the setting of the volume control. Below 70 cycles the harmonics increase to about 8% at 20 cycles. Operation of the oscillator into an open circuit at full output voltage causes a small increase in the harmonic content, which is, however, negligible for frequencies above 40 cycles or when the OUTPUT control is turned down. Operation of the 5000-ohm terminals into an extremely low impedance, so that they are practically short-circuited, causes the harmonic content to be doubled approximately.

The power-supply ripple is less than 0.1% of the output voltage for either position of the OUTPUT switch and for any value of output voltage which can be read on the panel voltmeter, when the oscillator is operated from a 60-cycle line.

Voltmeter: A voltmeter is provided on the panel for indicating the output voltage of the oscillator. The voltmeter is of the vacuum-tube type employing a balanced circuit, so that no appreciable harmonics are introduced into the output voltage. The voltmeter is provided with three scales, one for each set of output terminals.

Mounting: This instrumeut is available in either cabinet or relay-rack mounting. The cabinet is a heavy oak case fitted with carrying handles. For relay-rack mounting, the cabinet is replaced with a metal dust cover and shield.

Power Supply: 110-120 volts, 40-60 cycles alternating current. A simple change in the connections to the power transformer allows the instrument to be used on 220-240 volts. The total consumption is about 115 watts.

Tubes: The following tubes are required:

2 — Type 41	2 — Type 6L6
1 — Type 6D6	2 — Type 6H6
2 — Type 6C6	1 — Type 5Y3G

A complete set of tubes is supplied with each instrument.

Accessories: A seven-foot connecting cord is supplied.

Dimensions: Panel, (width) 19 x (height) 24¼ inches, over-all. Cabinet size, including handles, (width) 20½ x (height) 25 x (depth) 11 inches.

Screw holes in the panel are the standard spacing for mounting the instrument in a TYPE 480 (standard) 19-inch relay rack.

Net Weight: 93 pounds.

Type		*Code Word*	*Price*
713-BM	Cabinet Model	DEBAR	$485.00
713-BR	Relay-Rack Model	DETER	510.00

This instrument is licensed under patents of the American Telephone and Telegraph Company, solely for utilization in research, investigation, measurement, testing, instruction, and development work in pure and applied science.

OUR OFFICE IS CLOSED ON SATURDAY

● **ALTHOUGH OUR PLANT** has been closed on Saturday since 1919 and our office since 1931, we find that many of our customers call or telegraph on Saturdays, expecting rush shipments or replacement parts. While we endeavor to make prompt shipments in order to give our customers the best possible service, it is impractical to arrange for Saturday shipments.

VARIACS USED AS CONTROLS IN FLEXIBLE STAGE-LIGHTING UNIT

● **THE DECEMBER, 1933, AND FEBRUARY, 1936,** issues of the *Experimenter* described other installations in which Variacs were used as dimming controls for the lights in little theatre projects. The switchboard described in this article makes use of some features which were not described in the other two articles, ingenious improvements suggested by Mr. Dawes who was responsible for the unit described in the first article.

The switchboard shown in the illustration, Figure 1, was developed to control the lights on a small church stage. It is not intended to be portable, but installed permanently, hence is mounted on a large 24-inch square steel switch box on a wall. The panel is hinged so that it may be dropped 90° to be worked upon during original installation. The power available is three-wire balanced, 230-volt, 60-cycle, and the panel is so wired that the loads are balanced about its vertical center line.

Reference to the illustration will help clarify the detailed description of the switchboard.

The upper half of the panel contains four Variac circuits. Each Variac, a TYPE 200-CU, is provided with a 15-ampere, double-pole toggle switch, a

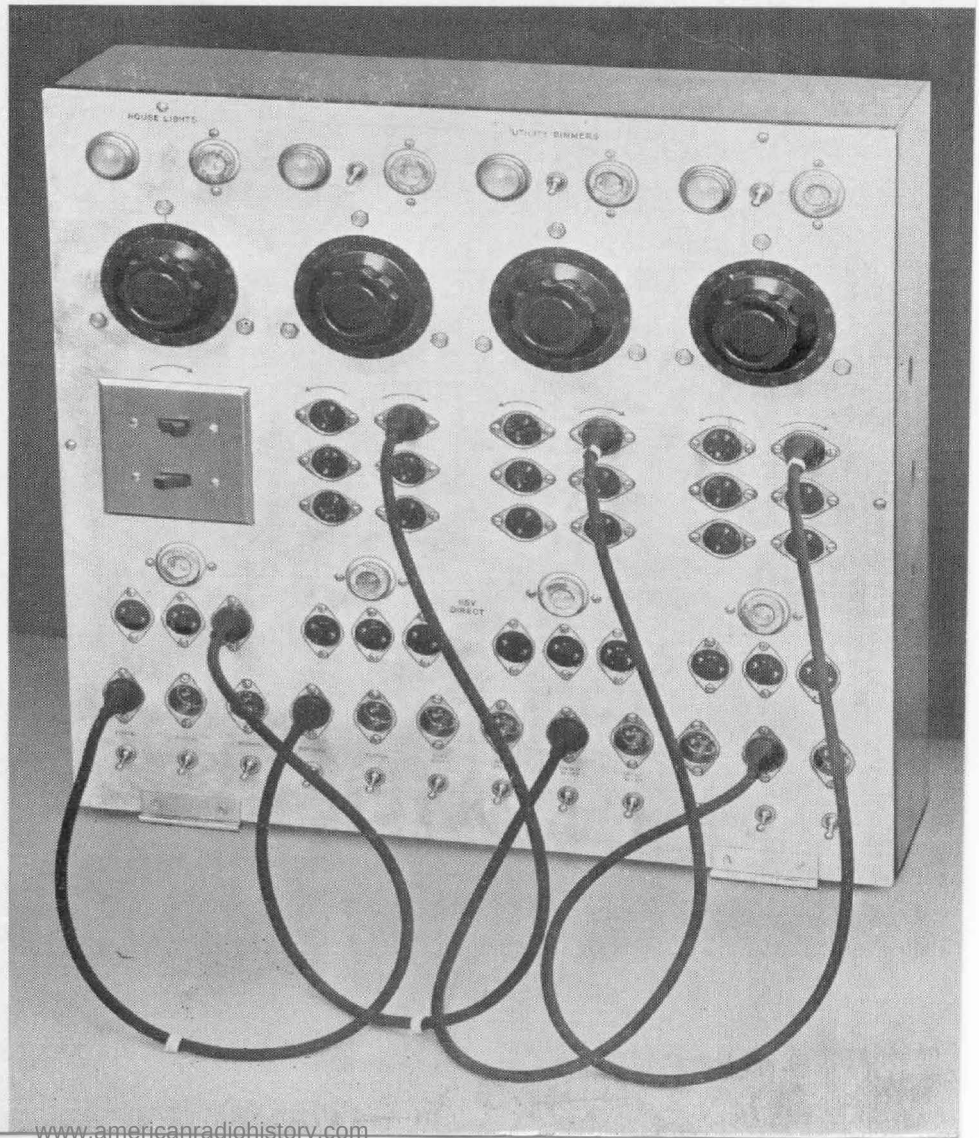


FIGURE 1. Panel view of the stage-lighting control board described in this article. Interesting features of this board are the use of patch cords for flexibility in setting up the circuits and the connection of the Variacs as faders to dim one circuit while bringing up another

fuse, and a pilot light. The primary fusing is adequate for the secondary loading. The pilot light is to prevent the operator's closing the switchboard with the primary of any Variac connected across the line and drawing magnetizing current. The Variac at the left, with the two wall-type toggle switches behind a switch plate directly beneath it, is for control of house lights. The other three are utility dimmers, to be used as needed. Each one has beneath it a number of female cup receptacles for access to its output.

Just below the center and extending horizontally across the panel are four groups of female cup receptacles supplying uncontrolled power direct from the line. Each group of three receptacles is beneath its associated fuse.

Extending horizontally across the bottom of the panel are the controls and terminations for the load circuits. The termination is a male cup receptacle, and its control, directly below it, a 15-ampere double-pole toggle switch. These load positions are labeled to indicate the circuits they control, such as BORDER 2, FLOODS, BABY SPOT, etc.

The special features previously referred to are:

(1) the use of patch cords for flexibility in setting up the circuits, and

(2) provision of means to use the Variacs as fading controls to bring up the lights in one circuit while dimming those in another.

The use of patch cords is advantageous in several ways. Firstly, it is simpler and more flexible than switching, and allows the controlling normally desired to be accomplished with fewer Variacs. Each Variac in the February, 1936, article could supply only two circuits. With the present arrangement any Variac may be connected to any load circuit. Secondly, by selectively inserting the plug ends of the cords into the proper receptacles, the loads may be distributed between Variacs, between sides of the three-wire power line, and between other circuits so as to prevent overloading Variacs or fuses and to produce a balanced load on the system. Thirdly,

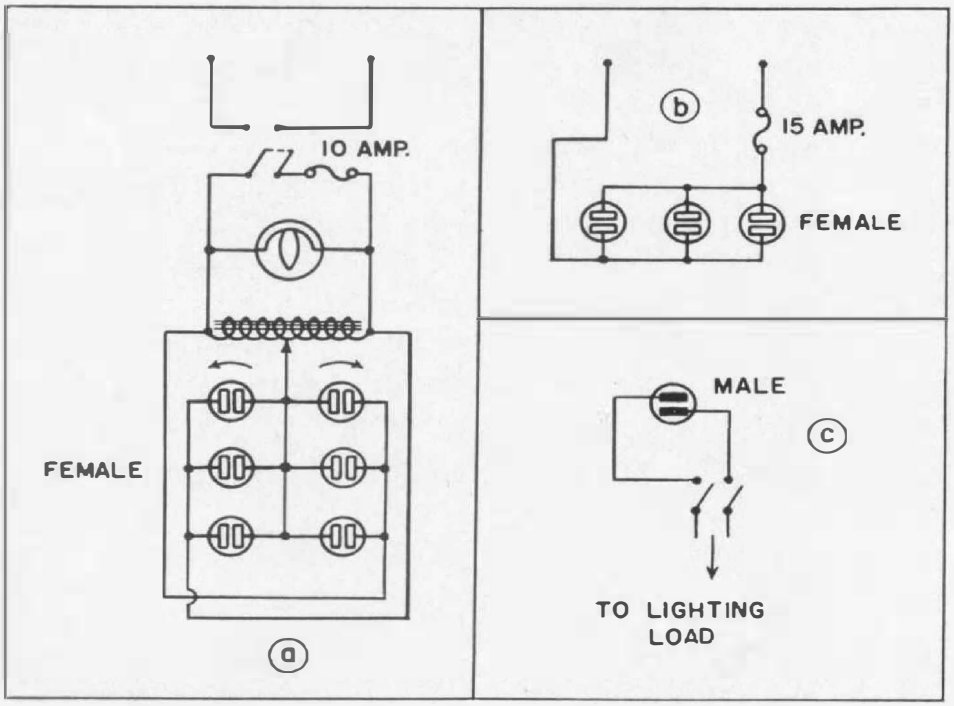


FIGURE 2. Wiring diagrams of each of the basic circuits of the control board

and this is quite important in a semi-public place where many uninformed persons would have access to the switchboard, tampering can be effectively prevented by removing and locking up the patch cords when they are not actually in use during a performance.

The small wiring diagram, Figure 2(a), shows the way in which the Variac is used for fading. Three of the receptacles below each Variac are connected in parallel between the arm and one end of the Variac, the other three in parallel between the arm and the other end. The curved arrows engraved above each group of receptacles indicate the direction in which the Variac knob must be rotated to bring up the voltage on that group. This arrangement not only provides means for achieving special effects, but promotes flexibility by requiring fewer Variacs under certain conditions.

Figure 2(b) shows the wiring of one group of direct 115-volt receptacles, and Figure 2(c) of one set of load-control devices.

In use, the female end of a patch cord would be attached to one male receptacle (in Figure 2(c)), then plugged into a controlled female receptacle (in Figure 2(a)) or into an uncontrolled one (in Figure 2(b)). — P. K. McElroy

MEASURING 100,000 RPM

● **MEASURING AND CONTROLLING THE SPEED** of an ultra-centrifuge rotating at 100,000 rpm presents an interesting problem. Physicists at the laboratories of the U. S. Department of Public Health have developed an ingenious and thoroughly workable solution.

The centrifuge used in this laboratory is driven by a compressed air stream and rotates on a similar stream for its bearing. The obvious method of measurement, using a Strobotac operated at a submultiple of the rotational speed, is open to three objections: (1) that the method does not permit accurate measurement rapidly, because submultiples are too close together on the Strobotac scale; (2) that safety considerations prevent the operator from being too near the centrifuge when it operates at these speeds, and (3) that it provides no means for controlling the speed.

The method now proposed uses a Type 834-A Electronic Frequency Meter to indicate the speed. A beam of light is reflected from the surface of the rotating element and falls on a photo-electric cell. A black spot painted on the rotating surface interrupts the light once each revolution. The amplified output of the photocell is applied to the electronic frequency meter, which reads the speed directly in revolutions per second.

Carrying the project one step farther, a marginal relay in the d-c meter circuit is then used to control the pressure of the air stream driving the centrifuge, providing an automatic speed control.

MISCELLANY

● **AN ENGINEERING COLLOQUIUM** is held each Tuesday afternoon at General Radio for the purpose of discussing problems of interest to members of our engineering and production departments. The speakers are usually members of the engineering staff, but at times we are fortunate in securing speakers from other companies.

One of the most interesting of these meetings was recently addressed by Mr. A. G. Clavier of the L. M. T. laboratories, Paris, who discussed experiments in 20-centimeter radio transmission.

Accompanying Mr. Clavier on his visit to our plant was Mr. George H. Gray, Transmission Engineer of International Telephone and Telegraph Corporation, New York.

● **ANOTHER RECENT VISITOR** was Mr. Paul Fabricant of the Paris firm Radiophon, agents for General Radio equipment in France. Mr. Fabricant also addressed one of these colloquia.

● **MR. H. H. SCOTT** of the engineering staff will speak at three professional society meetings early in April on sound measurement and analysis, stroboscopes, and high speed motion pictures. His schedule is: April 4, Buffalo Section, Society of Automotive Engineers; April 6, Erie, Pennsylvania Section, American Society of Mechanical Engineers; April 8, Madison, Wisconsin Section, American Institute of Electrical Engineers.

● **THE SCIENCE CLUB** of the Western Electric Company at Hawthorne, Ill., was addressed on the subject of "Stroboscopes" by Mr. A. E. Thiessen on February 18.

● **MR. THIESSEN** also spoke at the March 11 meeting of the Boston Section, I. R. E., on "Distortion and Modulation Measurements on Broadcast Transmitters."

● **THREE ENGINEERS** collaborated in the design of the TYPE 713-B Beat-Frequency Oscillator described in this issue: Messrs. H. H. Scott, L. B. Arguimbau and A. G. Bousquet.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company name, company address, type of business company is engaged in, and title or position of individual.

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