The GENERAL RADIO EXPERIMENTER

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ELECTRICAL COMMUNICATIONS TECHNIQUE AND ITS APPLICATIONS IN ALLIED FIELDS

CHRONOGRAPH MEASUREMENTS IN CHEMISTRY

HIGH precision time measurements have recently enabled chemists to measure accurately for the first time the minute change in viscosity which occurs when a pinch of salt is added to a quart of water. By so doing, they were able to prove experimentally certain new modifications of the theory of electrolytic dissociation and to show that in weak solutions of some salts the viscosity actually increases with concentration instead of decreasing as conventional theory predicts.*

This was done by comparing the time required for a given volume of the solution to drain through a certain capillary tube with the time required for the same volume of pure water under identical conditions of temperature, hydrostatic head, etc. It was necessary to determine a time interval of approximately 10 minutes to within 0.01 second, a precision of one part in 60 thousand or 0.002 per cent.

The viscometer used, see Figure 1, was constructed of fused quartz and mounted in a water bath, thermostat-regulated to within 0.001° C. The liquid to be measured was sucked up through the capillary tube until it more than filled the enlargement therein, so that the meniscus was above the upper constriction. Two beams of light were passed through the glass walls of the thermostat tank and accurately focused upon the two constrictions.

As the liquid drained under gravity

OTHER ARTICLES IN THIS ISSUE

*Professor Grinnell Jones and Dr. Samuel Talley, Malinckrodt Chemical Laboratory, Harvard University, through whose courtesy we publish this article. See Jones and Talley: *Jour.* Amer. Chemical Society, Vol. 35, p. 624; *Physics*, Vol. 4, June, 1933.

PLEASE NOTIFY US PROMPTLY WHEN YOU CHANGE YOUR ADDRESS

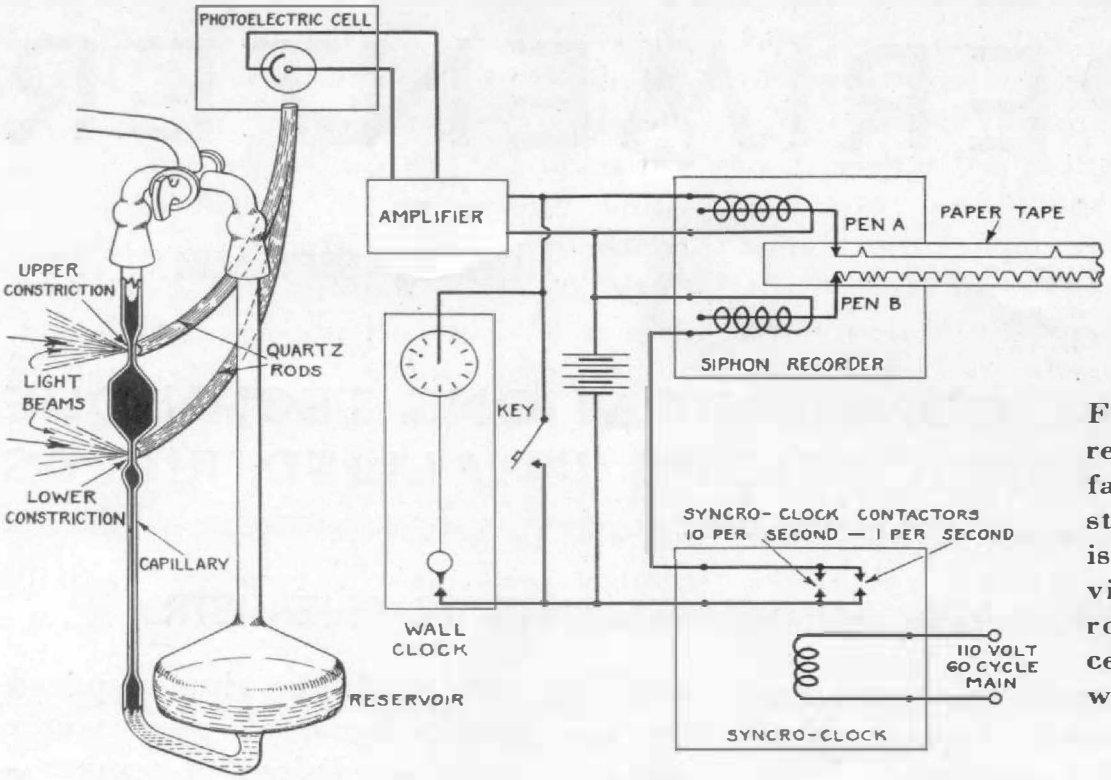


FIGURE 1. The time required for liquid to fall from one constriction to the other is a measure of its viscosity. The quartz rods, photo-electric cell, and chronograph were essential elements in this work

back into the reservoir, the falling meniscus would first pass the upper constriction; and, about 10 minutes later, the lower constriction.

A branched, solid quartz rod was placed in the bath at approximately right angles to the incident light beams, the branched ends terminating close to and on a level with the constriction points. The common end of this quartz Y assembly was brought up from the surface of the thermostat bath and presented to a photo-electric cell.

Whenever the meniscus passed either constriction, the change in the diffraction properties of the filled and the empty tube caused a beam of light to rotate rapidly about the constriction point, in a horizontal plane through the water bath. This beam was momentarily picked up by the corresponding branch of the Y rod so that a short, sudden pulse of light, carried by internal reflection in the bent quartz rod, was passed into the photo-electric cell.

The General Radio TYPE 456 Duplex Siphon Recorder served as the chronograph. This device contained two independently operated pens making adjacent lateral records on a strip of "ticker tape" advanced by a series motor, the speed of which could be adjusted at will.

One of these pens *A* was energized by three independent means: (1) by either the upper or the lower transit of the meniscus, (2) by 1-second impulses from an invar 2-second pendulum in a high grade wall clock, known to be accurate to better than the desired precision, and (3) by a hand key operated to identify any desired second read on the face of the wall clock. The second pen *B* of the chronograph was energized ten times per second by a pair of cam-operated contacts driven by a 600-rpm shaft in the General Radio TYPE 511-S Syncro-Clock, which was energized by the 60-cycle city supply main. This syncro-clock would keep perfect time if supplied with a current of exactly 60 cycles. By means of a

second cam contact (60 rpm), 1-second intervals were likewise indicated on this *B* pen record midway between two of the adjacent high-speed pulses.

Shortly before the falling meniscus reached the upper constriction point (see Figure 1) the operator started the paper tape at full speed and depressed the key momentarily to identify a given second on the face of the wall clock. A few seconds after the upper meniscus transit had been recorded by the *A* pen, the tape was run slowly and, after a 10-minute interval, as the meniscus was seen to approach the lower constriction point, the paper was speeded up and the same procedure repeated.

The accuracy of timing did not depend upon the frequency of the 60-cycle main, but upon the precision of the wall clock. The 0.1-second intervals supplied by the syncro-clock served merely to decimate the 1-second interval recorded by the wall clock within which the meniscus record occurred. In this manner, a frequency stability of the 60-cycle main of only 1 per cent over a 1-second interval was required. Likewise, a paper speed variation of 10 per cent within 0.1 second would not introduce an appreciable error. Since the tape traveled at approximately 12 inches per second, it was readily possible to interpolate to 0.01 second between the 0.1-second markings supplied by the syncro-clock.

Accurate chronographic measurements can thus be made placing no reliance upon the uniform movement of the chronograph tape itself. This is a desirable feature.

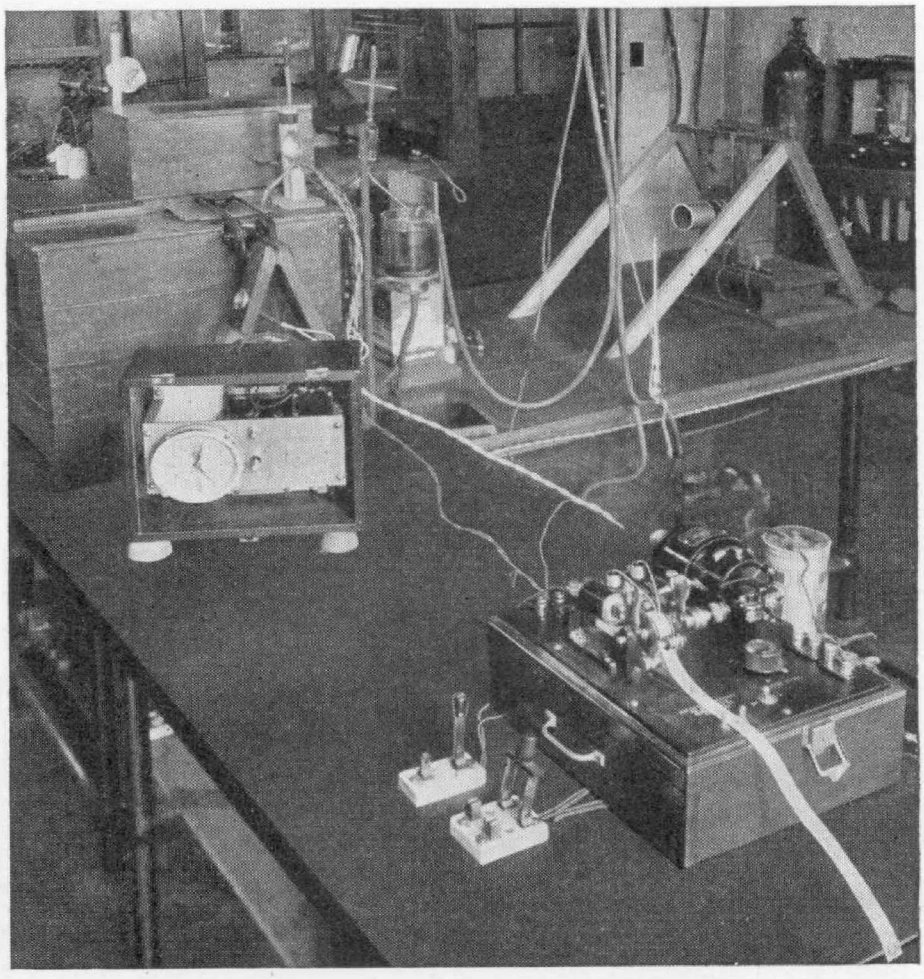


FIGURE 2. The viscosity measuring apparatus. In the foreground is the siphon recorder, behind it the syncro-clock, and, at the rear, the water bath containing the viscosimeter. The light source is at the extreme right

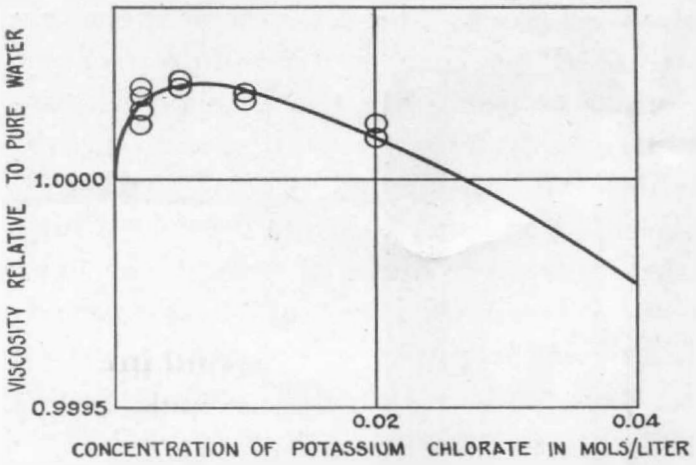


FIGURE 3. Conventional theory predicts a *decrease* in viscosity with an increase of concentration. The data showing *increase* supply evidence for a new modified theory

Had the syncro-clock been driven by an alternating-current source of 60 cycles, or any other frequency with suitable design of the clock, which was constant at all times to the order of one part in one hundred thousand, it would not have been necessary to use the wall clock as a basis of time measurement.

It was possible to secure measurements on duplicate consecutive runs which were identical to within 0.01 second for the 10-minute interval. While taking data, frequent runs were made with distilled water for reference values. This procedure eliminated the possible error due to slow variations in the rate of the wall clock over long periods of time.

An example of the data obtained is indicated in Figure 3, where the abscissa scale represents the fractional part of normal concentration of potassium chlorate, and the ordinate scale represents the measured viscosity in terms of distilled water. The increase in viscosity at low concentration above that of pure water is clearly apparent.

—HORATIO W. LAMSON

A LARGER EDGERTON STROBOSCOPE

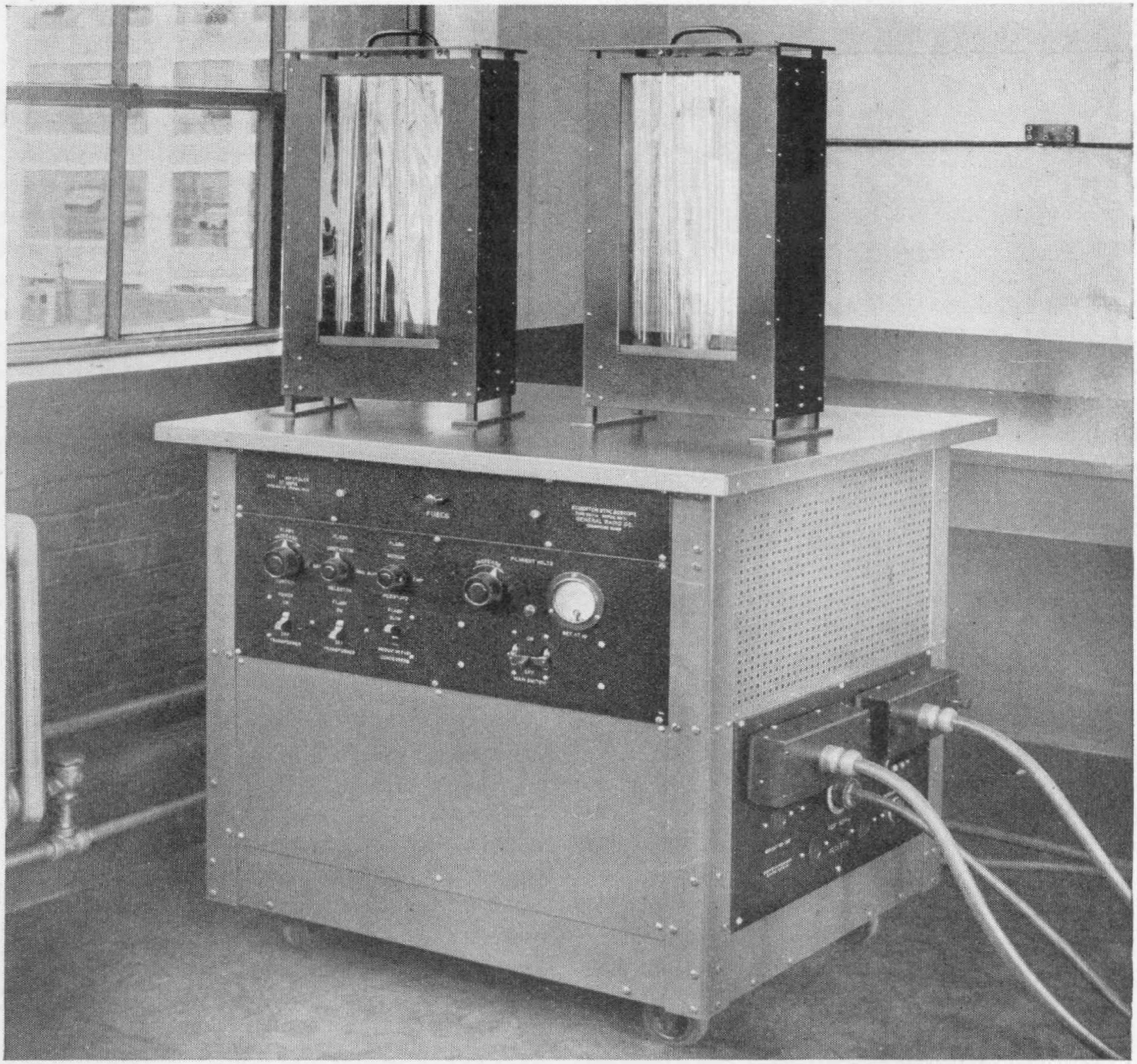
WITH both lamp banks of this new Edgerton Stroboscope in operation, a fair-sized room can be literally flooded with stroboscopic light. Due to the greater brilliance of the illumination provided, this equipment is essentially useful for large scale inspection operations, for the observation of large machines, and for photography.

The TYPE 521-A Edgerton Stroboscope operates from any 115-volt, 60-cycle supply main and requires from 1 kw to 3.5 kw, depending upon the operating conditions. One lamp bank may be used alone or the two may be used simultaneously. Both can be moved around within the range of the long cables.

The stroboscope may be flashed by a motor-driven contactor, by the 60-cycle line, or by an oscillator, provided that sufficient voltage is available. About 100 volts is required at 60 cycles and somewhat higher voltages for the higher frequencies.

Arrangements can be made to take instantaneous flash photographs such as would be required for the analysis of non-repeating motions.

This apparatus is representative of



The power supply and the control equipment for the TYPE 521-A Edgerton Stroboscope are contained inside the truck. The two lamp banks on the table top can be moved anywhere within range of the cables at the right

a new line of high power stroboscopes that General Radio has had under development for some time. Designs have been completed for standard modifications to meet special conditions by the addition of standardized accessories.

The price of the TYPE 521-A Edgerton Stroboscope with one lamp bank is $1200. Specific performance data will gladly be sent on request. A statement of the proposed operating conditions should, if possible, be included.

IMPROVING QUALITY IN BROADCAST TRANSMISSION

A FEW weeks ago, the owner of a fair-sized broadcasting station came to us with a tale of woe. For some reason, people didn't listen to his station and program sponsors were becoming scarcer and scarcer.

The studios of this particular station, although not equipped like those of some of the large metropolitan broadcasters, were modern and entirely adequate. Acoustical treatment had been installed and the station boasted of its dynamic and ribbon microphones. Its transcription equipment was the best.

Nevertheless, a few minutes of listening to this station disclosed why it was not more popular. We were tempted to ask the owner if he had ever listened to his own transmitter. Certainly the program sponsor would not be particularly pleased with the inhuman racket which the transmitter ground out as his program.

A careful checkup of the transmitter with a General Radio modulation meter and distortion-factor meter disclosed that, under some conditions, the total harmonics in the output exceeded 30 per cent (the upper limit that the distortion-factor meter will measure). Furthermore, the frequency-response characteristic was down approximately 30 decibels at 60 cycles and at 5000 cycles.

Replacement of a few tubes and a defective transformer, together with readjustment of biasing voltages in the modulator unit, produced a marked improvement. By careful adjustment, the harmonic distortion was brought down to 5 per cent and the frequency characteristic was made a practically straight line. The total cost of the new tubes and transformer and of the necessary measuring equipment was considerably less than the station had previously spent in a vain effort to improve the quality of the transmission.

The owner of this broadcasting station had spent large sums for elaborate equipment, much of which was not really necessary, and, at the same time, had neglected other parts of his transmitting setup, taking it more or less for granted that they were perfect because they were expensive. While well-designed transmitters do not easily get out of adjustment, normal aging and changes in climatic conditions may produce shifts which will affect the operation very seriously.

This is particularly true of vacuum tubes, which frequently change their characteristics as they grow older to such an extent that appreciable amounts of harmonic distortion and frequency discrimination are introduced into the transmitting system. Resistors used as grid leaks, bias controls and voltage dividers frequently open up or shift with climatic changes, so that the adjustment is no longer correct for best operating conditions. Some audio-frequency transformer cores become saturated or lose their permeability after continued use.

Most of these effects take place slowly and are hardly noticeable at first. As the sum total of distortion begins to increase, however, a marked reduction in the quality of transmission becomes apparent. By the time

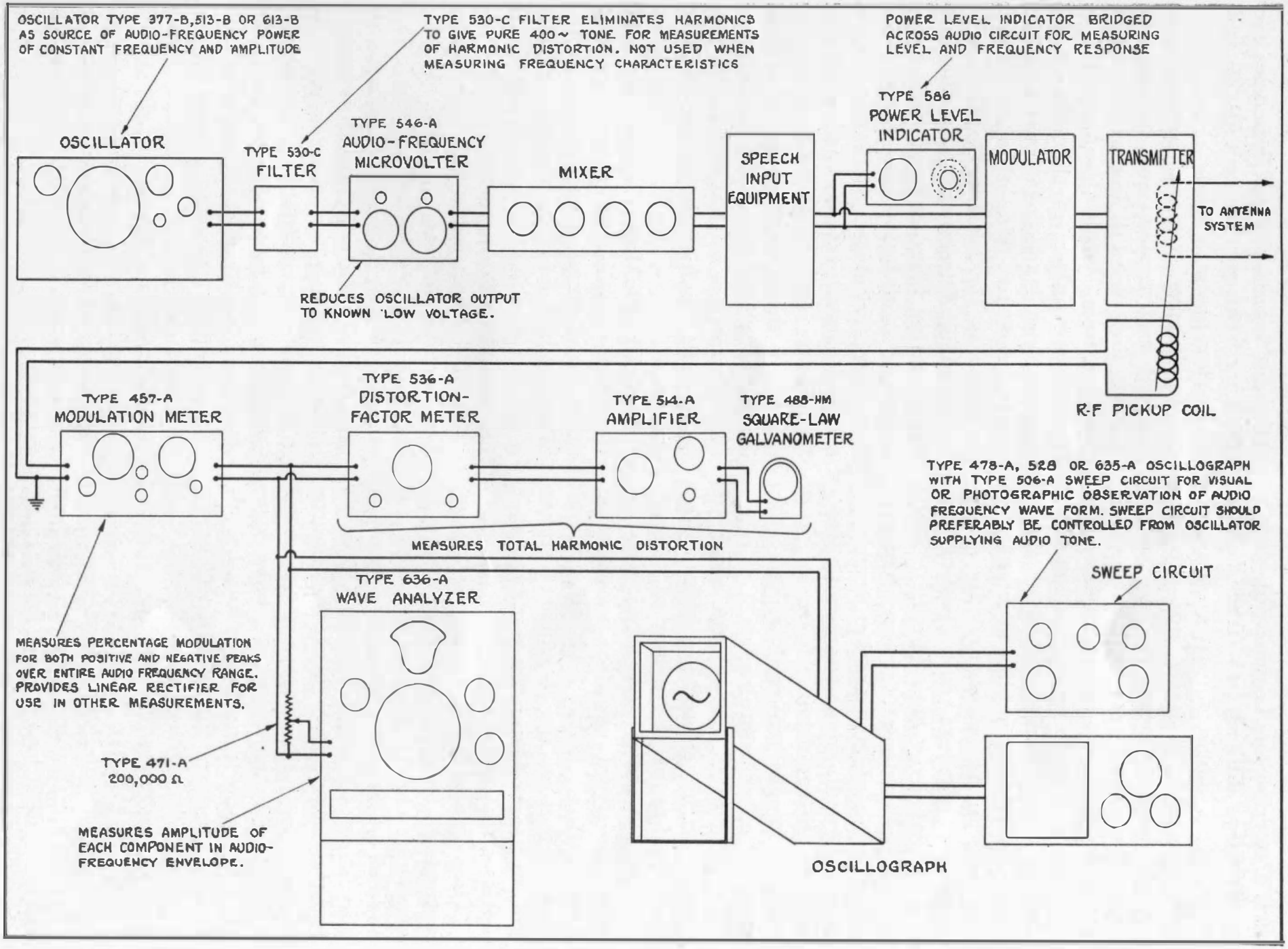


FIGURE 1. Schematic diagram showing apparatus required for broadcast transmission measurements. (See opposite page)

such distortion has become noticeable, it is very difficult to trace, since replacing a single faulty component will generally, in itself, not produce enough improvement to be readily detected except by sensitive measuring instruments. Furthermore, any attempt to remedy a fault by the cut-and-try method is necessarily uneconomical.

The question of quality is constantly receiving more attention by both broadcast listeners and sponsors of commercial programs. The Bell Telephone Laboratories' recent binaural transmission demonstration seems to have received as much favorable comment on the remarkable frequency and volume ranges covered as on the binaural effects obtained.

There is no reason why the owner of a small station should not insist on as good quality as the owner of a large multi-kilowatt transmitter. Broad-range receivers require broad-range broadcasting. With 2A3 tubes and diode detectors, the broadcast listener will no longer blame the squawks and rattles on his set.

The General Radio Company manufactures all the equipment necessary to determine closely the quality of transmission of any broadcasting station. The TYPE 457-A Modulation Meter* and the TYPE 536-A Distortion-Factor Meter,* as well as several styles of audio-frequency oscillators, have been used for some time by leading broadcasting stations. Several of the newer instruments, such as the TYPE 546-A Audio-Frequency Microvolter† and the TYPE 636-A Wave Analyzer,† are also extremely valuable for this work. There is hardly any need to mention the TYPE 586 Power-Level Indicators,* which are quite generally used by the radio and sound-picture industries for checking frequency characteristics and measuring power levels.

Two Boston stations having consistently high transmission quality are WNAC and WAAB, operated by the Shepard Broadcasting Company. These stations are unique in that they both transmit simultaneously from a single vertical radiator. The other afternoon, we called up Mr. Paul A. DeMars, who is Technical Director of the Shepard Broadcasting Company and who purchased a modulation meter and distortion-factor meter when they were first announced, several years ago. Mr. DeMars is quite enthusiastic in his praise of these instruments. He has instituted a regular testing routine for the transmitters so that any faults can be remedied before they have become serious.

Said Mr. DeMars, "Before we had the distortion-factor meter, correct lining up of a transmitter was a matter of anybody's opinion. Now, we set up a definite standard of operation which the equipment must meet."

At 30 per cent modulation, the limit for harmonic distortion which Mr. DeMars has set is 3 per cent. This means that at lower percentages of modulation, the distortion is somewhat less, being less than 1 per cent at 10 per cent modulation. By careful adjustment, it is possible to keep the distortion low even at high percentages of modulation. For instance, at 90 per cent modulation, the harmonic distortion is less than 10 per cent.

Figure 1 shows how General Radio measuring equipment is connected to a transmitter. A perfect transmitter

*See Catalog G, General Radio Company.
†General Radio *Experimenter*, June–July, 1933.

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NEW KNOBS AND DIALS

WHERE controls have to be manipulated for long periods or where fine adjustment of controls has to be made, all present types of knobs fail to be entirely satisfactory. To meet the need for an easier-to-handle knob, General Radio has designed a series of new knobs of polished black bakelite.

TYPE 637 FLUTED KNOBS

1⅛-INCH DIAMETER

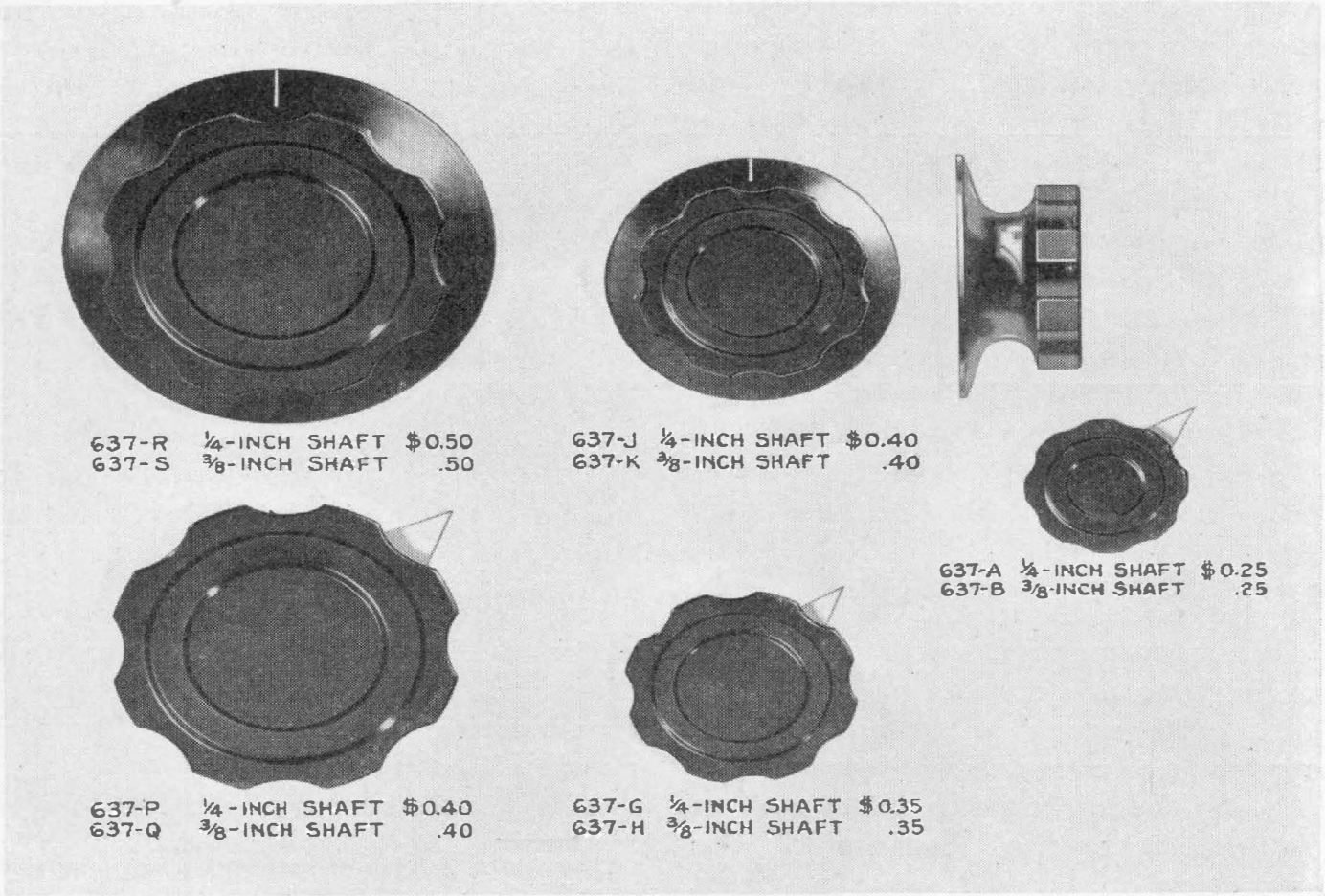
Type	*Shaft Diam.*	*Description*	*Code Word*	*Price*
637-A	¼ in.	With Pointer	NURLNOBANT	$0.25
637-B	⅜ in.	With Pointer	NURLNOBOY	.25

1⅝-INCH DIAMETER

Type	*Shaft Diam.*	*Description*	*Code Word*	*Price*
637-G	¼ in.	With Pointer	NURLNOBGUN	$0.35
637-J	¼ in.	With Skirt (2 1/16″ diameter) and Engraved Line	NURLNOBJIM	.40
637-H	⅜ in.	With Pointer	NURLNOBHAT	.35
637-K	⅜ in.	With Skirt (2 1/16″ diameter) and Engraved Line	NURLNOBKOP	.40

2⅜-INCH DIAMETER

Type	*Shaft Diam.*	*Description*	*Code Word*	*Price*
637-P	¼ in.	With Pointer	NURLNOBPIG	$0.40
637-R	¼ in.	With Skirt (3″ diameter) and Engraved Line	NURLNOBRAM	.50
637-Q	⅜ in.	With Pointer	NURLNOBQUO	.40
637-S	⅜ in.	With Skirt (3″ diameter) and Engraved Line	NURLNOBSUM	.50



The new knobs are fluted with all contact edges rounded to minimize wear and tear on the fingers of the operator; they are supplied with two setscrews to insure permanent setting, and they are available with either a celluloid pointer (which may be pried off) or with a wide flanged skirt which assists in ease of handling, prevents the fingers from touching any "live" parts and materially improves the appearance of the associated equipment. The skirted knobs are provided with a white engraved index line.

The present general-purpose types of General Radio dials are also available with the new knobs. For the present we will stock both styles of knobs and dials for the convenience of persons using equipment with the old-style knob.

TYPE 702 FRICTION-DRIVE DIALS
TYPE 710 PLAIN DIALS
2¾-INCH DIAMETER

Type	Shaft Diam.	Dial Arc	Dial Divisions	Friction-Drive Ratio	Knob Style	Code Word	Price
702-A	¼ in.	180°	100	1:3.3	637-J	DIACK	$1.75
710-A	¼ in.	180°	100	....	637-J	DIALY	1.00
702-B	¼ in.	270°	100	1:3.3	637-J	DIBOG	1.75
710-B	¼ in.	270°	100	....	637-J	DIBIN	1.00
702-F	⅜ in.	180°	100	1:3.3	637-K	DIFAG	1.75
702-G	⅜ in.	270°	100	1:3.3	637-K	DIGOD	1.75
710-G	⅜ in.	270°	100	....	637-K	DIGUT	1.00

TYPE 703 FRICTION-DRIVE DIALS
TYPE 717 PLAIN DIALS
4-INCH DIAMETER

Type	Shaft Diam.	Dial Arc	Dial Divisions	Friction-Drive Ratio	Knob Style	Code Word	Price
703-A	¼ in.	180°	100	1:5	637-R	DIANT	$2.00
717-A	¼ in.	180°	100	....	637-R	DIARM	1.50
703-B	¼ in.	270°	200	1:5	637-R	DIBUT	2.00
717-B	¼ in.	270°	200	....	637-R	DIBAR	1.50
703-F	⅜ in.	180°	100	1:5	637-S	DIFUN	2.00
717-F	⅜ in.	180°	100	....	637-S	DIFIT	1.50
703-G	⅜ in.	270°	200	1:5	637-S	DIGUM	2.00
717-G	⅜ in.	270°	200	....	637-S	DIGAR	1.50

(Continued from page 8)

would, of course, have equal percentage modulation on both positive and negative peaks for any audio-frequency and any percentage modulation up to 100 per cent. Careful adjustment of most transmitters will result in a close approach to this condition.

If the frequency of the audio oscillator is varied over the audio-frequency band and the input to the mixer system held constant, the readings of the modulation meter will give a direct indication of the frequency response of the transmitting system as a whole.*

The distortion-factor meter reads directly in total harmonic distortion. This, together with the modulation meter and suitable accessories (see Figure 1), is indispensable in any broadcasting station desiring the best possible quality.

The wave analyzer will be found

*This instrument has no appreciable frequency error up to 20,000 cycles per second.

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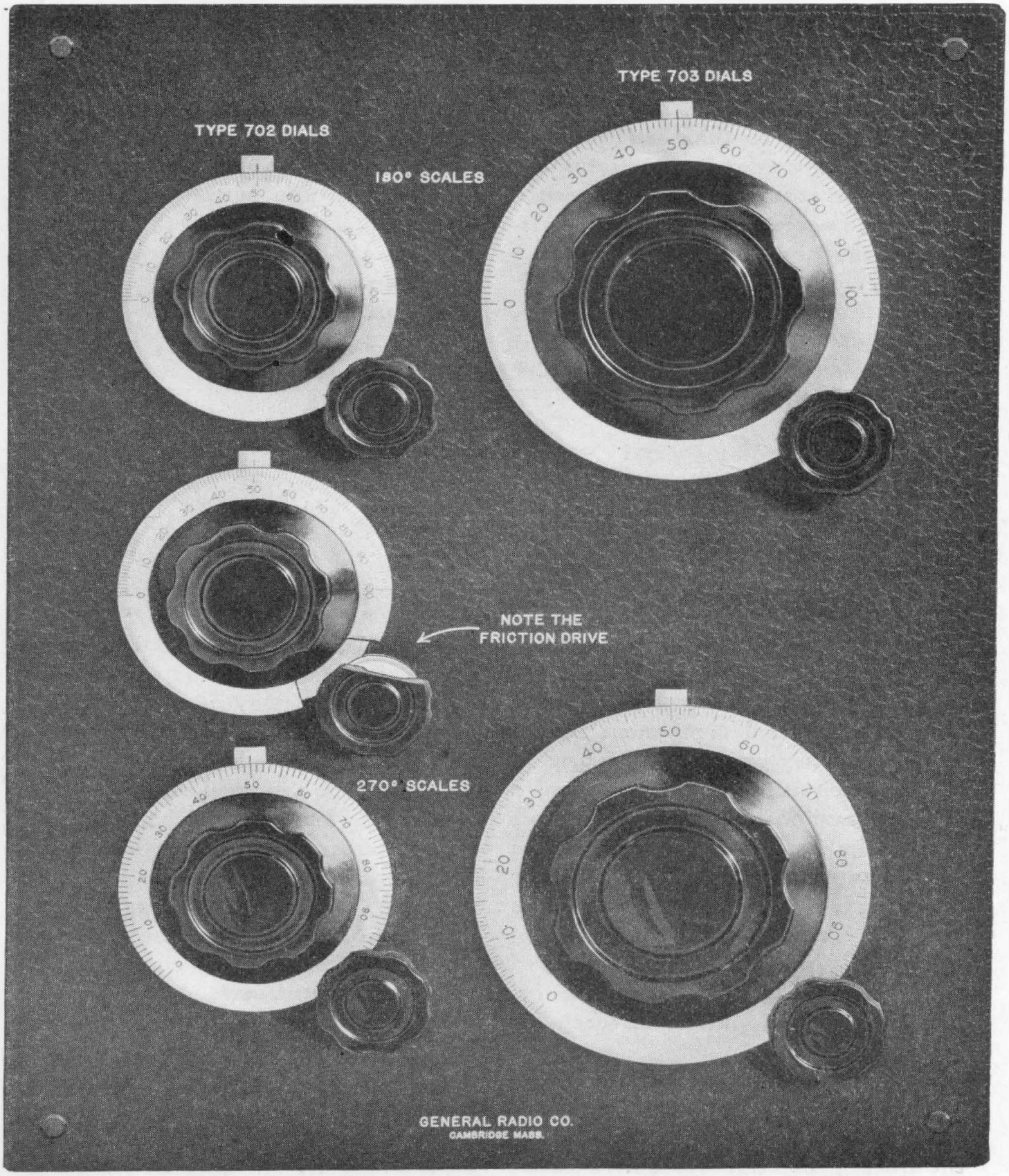

Both the TYPE 702 (2¾ inch) Dials and the TYPE 703 (4 inch) Dials shown above are available without the friction drive. (See the table on the opposite page)

NEW SPECIFICATIONS FOR TYPE 505 CONDENSERS

THE TYPE 505 Condensers are a new line of semi-precision mica condensers described in the January, 1933, issue of the *Experimenter*. Since the publication of that article, additional laboratory data and information gained from manufacturing experience have made necessary the several specification changes noted in the following table.

The statement of a maximum peak voltage in connection with a frequency means that the condenser will stand the alternating-current voltage whose peak equals the given rating, up to the given frequency. Above that frequency the allowable voltage decreases inversely with the square root of the frequency. This is due to the fact that the power loss and, therefore, the allowable voltage increase with the square of the frequency.

Type	*Capacitance*	*Adjusted to Within*	*Power Factor*	*Maximum Voltage*		*Price*
				Voltage	*Frequency*	
505-A	100 μμf	10%	0.1%	1200 volts	1100 kc	$3.50
505-B	200 μμf	5%	0.1%	1200 volts	550 kc	3.50
505-E	500 μμf	2%	0.05%	1200 volts	220 kc	3.50
505-F	0.001 μf	1%	0.05%	700 volts	320 kc	3.50
505-G	0.002 μf	1%	0.05%	700 volts	160 kc	3.50
505-K	0.005 μf	1%	0.05%	700 volts	64 kc	4.00
505-L	0.01 μf	1%	0.05%	350 volts	160 kc	4.50
505-M	0.02 μf	1%	0.05%	350 volts	80 kc	5.50
505-Q	0.05 μf	1%	0.05%	350 volts	32 kc	7.50

(Continued from page 10)

valuable for measuring harmonic distortion at frequencies other than 400 cycles and for measuring the amplitude of each individual component in the audio-frequency envelope. The oscillograph is helpful, since the shape of a distorted audio wave frequently gives a clue to the source of distortion. These instruments and the distortion-factor meter may, of course, be bridged across practically any audio circuit to measure the distortion in different parts of the system. Complete operating instructions are supplied with each instrument.

A careful checkup on the operating characteristics of any transmitter will prove of great assistance in improving the quality of transmission. Without exact data as to the nature and cause of any distortion which may take place, attempts to remedy it are generally unsatisfactory. Any broadcasting station doing a reasonable amount of business should be equipped with the proper apparatus for maintaining a high quality of output. Stations which cannot afford complete equipment of this sort would do well to engage the services of reliable consulting engineers who have the necessary equipment.

An investment in good transmission pays large dividends in the form of more and bigger commercial accounts. Other things being equal, the station having the best quality transmission is certain to be the most highly favored by the listener. —H. H. SCOTT

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