THE General Radio EXPERIMENTER

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A DYNAMIC MICROPHONE FOR THE SOUND-LEVEL METER

Also IN THIS ISSUE

● **IN THE DESIGN** of a general-purpose sound-level meter, one of the important problems is the choice of a microphone. Among the many desirable microphone characteristics, there are several that are essential if the instrument is to do a creditable job of measurement. In addition to having a non-directional, wide, flat, frequency response and high sensitivity, the microphone should give a linear response over a wide range of sound pressure levels, and its output should be stable over long periods of time — not adversely affected by variations of temperature or humidity.

The National Production Authority Regulation 4 provides a uniform procedure by which any business enterprise, government agency, or public or private institution may use a priority rating to obtain "minor capital additions" as well as specified quantities of maintenance, repair and operating supplies (MRO).

Within the restrictions of the Regulation, a rating of DO-97 may be used on orders for these materials and services. Specific authorization for each order is not required. Test equipment and laboratory apparatus of the kind manufactured by General Radio are usually accounted as capital additions. The Regulation permits your use of the priority rating when the cost of one complete capital addition does not exceed $750.

In general, the amount that may be obtained under the rating is limited, with minor adjustments, to a total dollar value per quarter equal to one-fourth of the amount that was spent in 1950 for MRO.

Because so many priority-rated orders are being received, deliveries against unrated orders are becoming increasingly uncertain. We recommend that, if no other rating is available, DO-97 be used whenever it is applicable.

NPA Regulation 4 should be consulted for details. Copies are available from your nearest Department of Commerce field office.

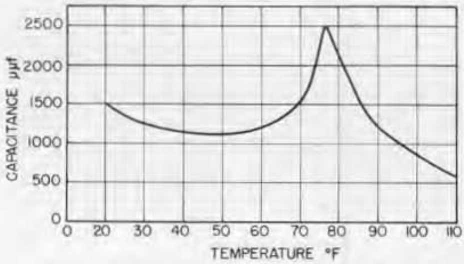


Figure 1. Capacitance variation as a function of temperature for a typical Rochelle salt crystal microphone.

THE ROCHELLE SALT CRYSTAL MICROPHONE

The Rochelle salt crystal, diaphragm-type microphone chosen for use on the General Radio Type 759-B Sound-Level Meter is a low-cost device, which fulfills all of these requirements satisfactorily so long as the microphone is connected directly to the input terminals of the sound-level meter, and so long as moderate variations of temperature and humidity are encountered.

However, when it becomes necessary to make measurements with the microphone separated from the sound-level meter by a long cable or when high temperatures and humidity are encountered, the Rochelle salt crystal microphone becomes a less satisfactory pickup. While the output voltage of the microphone changes by about .02 db per degree F., its capacitance varies considerably as the temperature changes so that loss added by a long cable is very markedly a function of temperature.

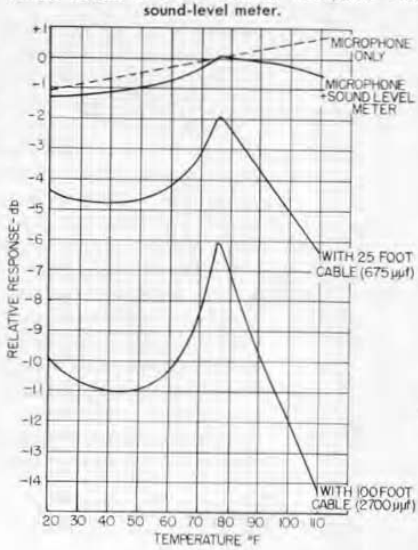
Figure 1 shows the variation in capacitance with temperature for a typical Rochelle salt crystal microphone. At the top of Figure 2 the dashed curve shows the change in output of the microphone with temperature, and the solid curve shows the change in meter reading of the Type 759-B Sound-Level Meter due to temperature changes at the microphone with the microphone mounted on the sound-level meter. The two lower curves show the large changes in meter readings that occur when 25-foot and 100-foot cables respectively are used between the microphone and the sound-level meter. The maximum safe temperature at which the Rochelle salt unit can be used is about 115° F., since it is permanently damaged at temperatures above 135° F. Although the unit is sealed, extensive use at a relative humidity below 30% or above 85% should be avoided.

THE DYNAMIC MICROPHONE

The errors arising from these effects can be avoided by the use of a dynamic, or moving coil, microphone for those applications where a long cable must be used between microphone and sound-level meter, or where extremes of temperature and humidity are encountered.

A suitable dynamic microphone for use with the Type 759-B Sound-Level Meter is now available, in combination with a transformer, a cable, and tripod.

Figure 2. Variation in response as a function of temperature for the crystal microphone alone and with various lengths of cable between microphone and sound-level meter.



This combination, the Type 759-P25 Dynamic Microphone and Accessories, is shown in Figure 3.

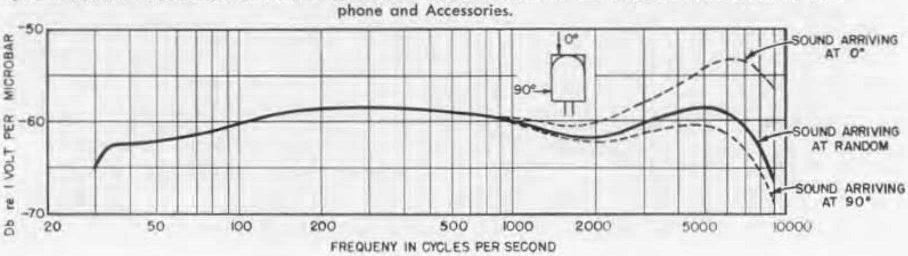
The dynamic microphone, the Western Electric type 633-A, now manufactured by Altec Lansing Corporation, is well established as a dependable and rugged instrument. Its output level is about −90 db re 1 volt per microbar compared to a level of −60 db for the crystal microphone, so that a transformer with a turns ratio of 30:1 is required to raise the output to the desired level. The Type 759-322 Transformer does this with no effect on the frequency response over the working range of the microphone. In addition the transformer is well shielded, so that pickup from stray magnetic fields is well below any such pickup by the microphone itself. The cable furnished is 25 feet of shielded, double conductor with vinylite sheath. A 100-foot cable is also available.

Figure 3. View of the Type 759-P25 Dynamic Microphone and Accessories connected to a Type 759-B Sound-Level Meter.

Figure 4 shows a typical field response for the Type 759-P25 assembly used with a Type 759-B Sound-Level Meter on the *C* (flat) weighting network. For sounds arriving at random, the response falls within the tolerances allowed in the ASA Standards on sound-level meters (Z24.3 1944). It should be noted, however, that the response below 1000 cycles is not so flat as that of the crystal diaphragm-type microphone, as can be seen by comparing Figure 4 with Figure 5. The response at 400 cycles, for the dynamic microphone, is near the center of a broad maximum, so that if the gain of the sound-level meter is set to give correct readings based on the 400-cycle sensitivity of the microphone, sound-level readings of average or broad-band noises will be low. At frequencies below 30 cycles the output of the dynamic microphone falls off sharply while the output of the crystal unit is good to 20 cycles and lower.

At frequencies above about 6000 cycles the operation of the dynamic microphone is superior to the operation of the crystal microphone. For sounds arriving at random, the difference in operation is not great. As shown in Figures 4 and 5,

Figure 4. Typical response curves for the Type 759-B Sound-Level Meter with Type 759-P25 Dynamic Microphone and Accessories.



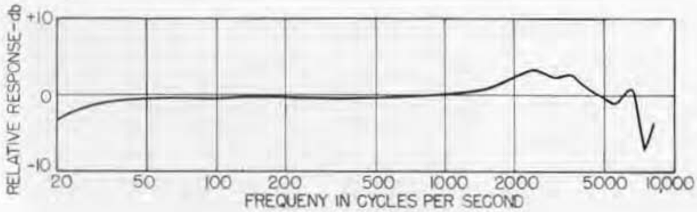


Figure 5. Typical response curve (random incidence) for sound-level meter and crystal microphone.

the response of the dynamic microphone holds up very well to 9000 cycles and the response of the crystal microphone extends out to 8000 cycles.

For sounds arriving parallel to the diaphragm, the crystal microphone does very well up to about 6000 cycles. Beyond this frequency, the dimensions and mechanical construction of the crystal microphone diaphragm cause rather large changes in the microphone output as it is rotated about an axis perpendicular to its diaphragm. These variations for a representative microphone are illustrated in Figure 6. Variations in output of the Type 633-A Dynamic Microphone under the same conditions remain within 2 db up to 9000 cycles.

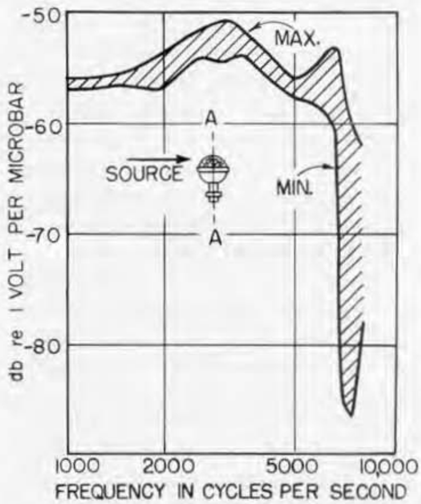


Figure 6. Variation in output of typical Rochelle salt crystal, diaphragm-type crystal microphone as a function of frequency as the microphone is rotated about axis A — A perpendicular to its diaphragm. Sound incidence is parallel to plane of diaphragm.

CALIBRATION

A calibration tag gives the 400-cycle level, the average level of the microphone plus transformer, and the proper setting for the sound-level meter, based on the average level of the microphone when the over-all system is calibrated using the Type 1552-A Acoustic Calibrator.

For the measurement of sound levels, with components above 70 db, the dynamic microphone can be used directly at the input of the Type 760-B Sound Analyzer or the Type 1550-A Octave Band Analyzer. The absolute level can be determined by using the Type 1552-A Sound-Level Calibrator.

No corrections are necessary for cables up to 100 feet long.

SPECIFICATIONS

Sensitivity: Open-circuit output of typical microphone is 90 db below one volt per microbar, and of microphone plus transformer is 60 db below one volt per microbar.

Maximum Safe Sound Pressure Level: 140 db.

Net Weight: 4⅝ pounds.

Type		*Code Word*	*Price*
759-P25	**Dynamic Microphone and Accessories (with 25-foot cable)**	NABOR	**$150.00**
759-P22	**Extra 100-foot Cable**	NASAL	**30.00**

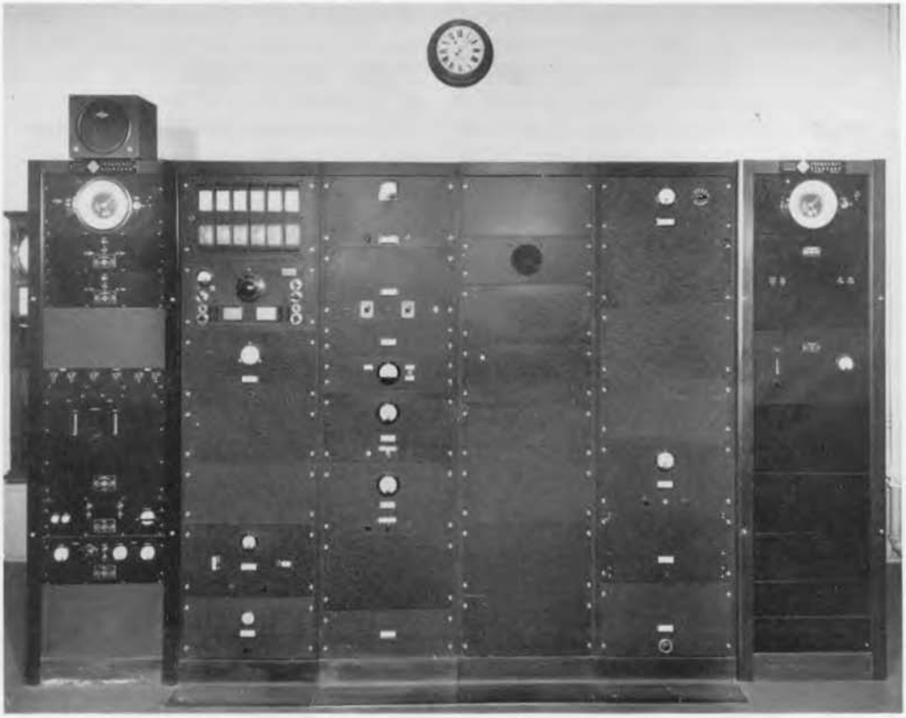
EMERGENCY POWER EQUIPMENT FOR FREQUENCY STANDARDS

Official time for all Canada is provided by the Dominion Observatory at Ottawa, whose time signals, sent by direct wire and radio, are available to the Canadian public from Halifax to Victoria, and northward to the limits of radio reception.

The crystal clock has superseded the pendulum type as the primary timekeeper at the Dominion Observatory, although here, as in most observatories, the pendulum, because of its simplicity and reliability, is still an important element in the time-determining system.

The crystal clocks at the Dominion Observatory are General Radio Primary Frequency Standards. Both are equipped with Syncronometers indicating mean time. Two additional Syncronometers, controlled by one of the crystal clocks, are used, one to compare the mean-time clocks with radio time signals from other observatories, particularly Washington and Greenwich, and the other to initiate the time signals transmitted from the Observatory. Time signals in a standard identification sequence are transmitted by a pendulum-controlled time-signal machine, upon which a signal from a crystal clock circuit is superimposed as a gate for the beginning of each second's impulse.

Figure 1. Bay of equipment in the Time Room at the Dominion Observatory. The two racks at either end contain the two General Radio Frequency Standards, or crystal clocks. The four racks in between contain a receiver, several relays and amplifiers, and the terminal blocks for the cables of wires which supply a multitude of services within the Observatory and to points outside.



POWER SUPPLY

Pendulum clocks pose no serious power supply problems, because they operate from batteries, which are continuously charged by rectifier equipment operating from the a-c power line. In the event of line failure, emergency charging equipment automatically takes over in a matter of a few seconds.

The crystal clock, however, when operated directly from the a-c line, stops operating when a power interruption of even short duration occurs. Because the crystal clock offers so much greater precision than the pendulum type, considerable effort has been expended by the Dominion Observatory in devising a satisfactory method of bridging the power-supply interruptions.

One of the original methods adopted to provide continuity of power was complete battery supply for both high voltage and low voltage. The battery bank meanwhile is kept up to strength by means of a trickle charge. Immediately the power line fails, the batteries carry over, and, when the power returns, the trickle charge to the batteries is resumed. All the essential equipment for the maintenance of the time-signal machine and its primary pendulum at the Dominion Observatory is maintained by this floating battery method.

There are, however, certain objections to the use of the floating battery. The space required by batteries for full-voltage supply becomes excessive, particularly with the modern tubes which use higher plate voltages. The fumes from such a large bank may not be inconsiderable at times and must be drawn off. When the charge is withdrawn, the voltage changes fairly abruptly by about ten per cent, providing all the cells of the bank are good. If any bad cells exist, which is quite possible, the change in voltage from charge to no charge can be still greater. It is expecting a good deal of present-day equipment to provide a smooth continuity of output with fluctuations in power supply even as great as five per cent. Furthermore, when the equipment is designed for normal 60-cycle operation, special leads must be installed to adapt it for battery operation. Against these disadvantages, of course, is the great advantage that the power available to the equipment never falls below the battery level, and usually long continuity of service may be expected.

Another type of emergency for bridging periods of power failure involves the use of batteries and a 60-cycle, 110-volt dynamotor or motor generator. During normal operation, the battery drives the dynamotor, which in turn supplies the required power to the electronic equipment. The a-c line operates through a rectifier to provide the batteries with charge sufficient to maintain the dynamotor, and also to compensate for the normal battery decay. At the moment of an interruption in the line, the batteries continue independently and maintain the dynamotor. Resumption of the line returns the charge circuit to its normal rate. A dynamotor, which operates from a 32-volt battery bank, will involve a compromise between efficiency and economy of space, and equipment designed for normal 110-volt, 60-cycle operation will require no change. Objectionable features include the fact that rotating machinery requires maintenance and involves some noise and vibration. With an interruption in the line and the charge removed from the battery, the voltage applied to the dynamotor drops quickly by one-tenth or more, and the input voltage to the equipment also drops.

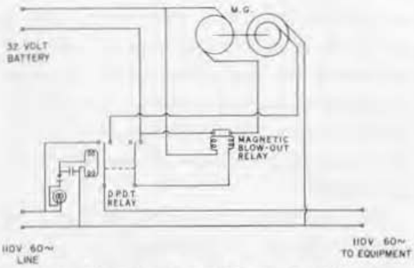


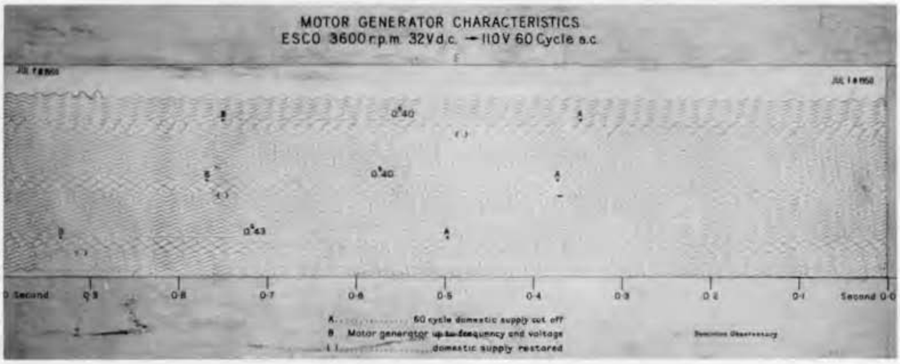
Figure 2. Schematic of the 32-volt d-c, 110-volt a-c motor generator set used in connection with each of the crystal clocks to provide emergency power with little delay. While a unit of this nature is capable of operating for a considerable time, limited only by the condition of the batteries, its main purpose is to provide a very quick source of 110 volts ac to tide over the short interval required for the gas-driven motor generator to build up.

A variation of the above method, and one which has been placed in service at the Dominion Observatory, includes the use of a 32-volt dynamotor and a bank of lead cells to provide the required 32 volts. In this system the 60-cycle, a-c line is used to provide power for the electronic equipment, and also a trickle charge to the battery. A line switch is so arranged that when the power fails the line is cut off, the battery is cut in to the dynamotor, and the a-c output of the dynamotor is cut in to the equipment.

The measured delay from the time that the a-c line is interrupted till the time that the dynamotor builds up to full frequency and voltage proves to be about 0.6 second. The normal power supply has to be provided with additional high voltage storage to bridge a time gap of this size. In the case of the frequency standards at the Dominion Observatory, seven electrolytic condensers of eighty microfarads provide adequate storage.

The initial charging of such a large condenser is beyond the normal ability of the ordinary rectifier tube without some protection. With a resistance of say three thousand ohms in series when the condenser is initially charged, the job can be handled quite well by the familiar type 80 tube. Once the charge has been made, the resistor may be shorted out because, in short intervals of a second, the condenser will suffer only a partial discharge. Tests in service indicate that it does serve effectively to maintain the high voltage during the period of switch over. No such precaution is necessary for the cathode power, since the ordinary type of heater tube suffers little change with a power cutoff of one second. On restoration of the domestic a-c supply, the line switch again closes, the dynamotor cuts off to await the next interruption, and the batteries return to their trickle charge.

Figure 3. A recording on a drum which rotates at one revolution per second shows that the build-up time of the motor generator emergency power supply is less than half a second. The instant when the domestic power supply was cut off by pulling the switch is marked by A. The interval from A to B was required for the motor generator supply to build up to full frequency and voltage.



The build-up time of 0.6 second referred to above was measured on a drum chronograph which is made to rotate synchronously at one revolution per second. The syphon pen can be made to record the 60-cycle wave from the line at the point where it is fed into the frequency standard. When a line interruption is simulated by opening the line switch, there is an immediate interruption in the a-c pattern being recorded. As the dynamotor comes up to speed, the emergency a-c supply operates the pen, showing clearly the moment when full frequency and voltage are attained, and the elapsed time proves to be about 0.6 second.

There are certain inherent faults in the use of a dynamotor and stand-by battery as an emergency source of power. The ordinary switch will maintain itself over a wide range of voltage, which means that the domestic a-c supply might drop to a low voltage due to a partial short without the switch operating. A drop to say 80 volts, which might be quite adequate to maintain a switch in the up position, would be quite inadequate to maintain a frequency standard at normal operation. However, such a condition is rather infrequent, and the experience at the Observatory to date has not indicated the need to adopt one of the sensitive type of switches which would operate within very narrow voltage limits.

The emergency power supply described above is designed for rapid pickup. It will, as a matter of fact, give continuous service for several minutes, or even hours, depending on the state of the batteries. Normally the heavy duty stand-by power plant, which is gas driven, takes over within a quarter of a minute, so that the use of the emergency supply is for short intervals only.

In the several years that this emergency system has been in operation, there has been no failure caused by power interruptions in the frequency standard which is now being used as the primary timekeeper at the Dominion Observatory.

The information on which this article is based was supplied by J. P. Henderson and M. M. Thomson of the Dominion Observatory, Ottawa, Ontario. Additional information on the time service supplied by the Observatory will be found in an article by Mr. Thomson entitled "Canada's Time Service," published in the *Journal of the Royal Astronomical Society of Canada*, XLII, 3, pp. 105-120, 1948.

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