The GENERAL RADIO EXPERIMENTER

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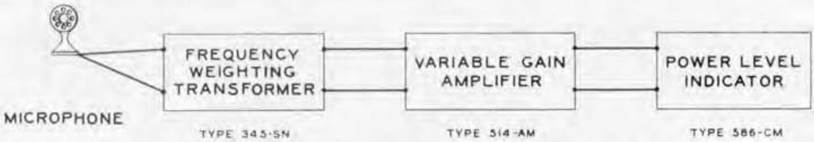
ELECTRICAL COMMUNICATIONS TECHNIQUE AND ITS APPLICATIONS IN ALLIED FIELDS

INEXPENSIVE NOISE-MEASURING EQUIPMENT

MORE and more industry is realizing the fatiguing effects upon human beings of the various noises to which they are subjected, and with the realization comes the endeavor to reduce, so far as practical, all unnecessary sounds. In New York City for example, a noise commission has been making an exhaustive survey of the sources of city noise and means of its prevention. The most disturbing noises are frequently those generated by some common piece of mechanical equipment during its normal operation. Many machines, such as ventilators,

A simple assembly for noise measurement, consisting entirely of standard instruments



Noise is picked up in the microphone, weighted, and amplified. The power level indicator gives the result in decibels, referred to the background noise level, or any level chosen as reference

refrigerating systems, pumps, fans, etc., cause a constant whirring, hissing, or humming sound, which gradually works on the nervous system, causing mental fatigue.

Manufacturers of mechanical equipment are beginning to recognize the importance of quietness in their products.

An intelligent approach to the problem of noise elimination requires a means of quantitative noise measurement. Listening tests are of course of no substantial value in this work. Accordingly, various forms of noise-measuring devices have been developed in order to provide quantitative comparisons of different sounds. An extensive discussion of the problems involved in noise measurement will be found in recent issues of the *Journal of the Acoustical Society*.

The simplest form of noise-measuring set-up consists of a microphone, an amplifier, and a suitable indicator such as a vacuum-tube voltmeter or an oxide-rectifier meter. Sounds picked up by the microphone are amplified and indicated on the meter, giving a definite method of comparison. The meter should preferably be calibrated in decibels, which are the units generally used to express ratios of sound intensities. Where wide ranges of volume are to be measured, the amplifier gain should be adjustable to avoid overloading on loud noises.

In order to present a true picture of the effect of the noise on the human nervous system, the measuring system must have a frequency characteristic similar to that of the normal auditory system, *i.e.*, the low and high frequencies must be discriminated against. Some such discrimination is unavoidable in a microphone and amplifier system, but the normal loss of high and low frequencies should be accentuated.

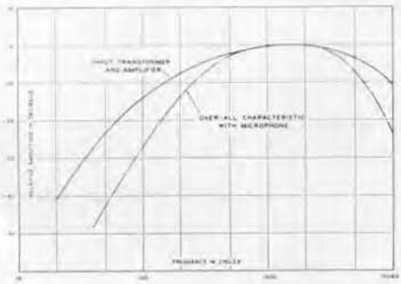
Since a flat frequency characteristic is not desired, an expensive microphone is not generally needed unless very low noise levels are to be encountered. The microphone should, however, show negligible variations with use and age and should have a residual noise level substantially below the lowest noise to be measured. The input transformer or frequency-weighting network should be so designed that its characteristic added to that of the microphone results in a close approximation to the normal ear characteristic.

A noise-measuring set of this type may be composed of several standard General Radio units. The illustration shows a system supplied to a large manufacturer of refrigerating machinery. It consists of a General Radio Type 514-AM Amplifier, a special Type 345-SN Input Transformer, a Type 586-CM Power-Level Indicator, and a microphone. The input transformer matches the microphone impedance to the amplifier and also adjusts the over-all frequency response to approximate that of the human ear. In this particular system, the input transformer is mounted in the amplifier cabinet, and the microphone receives its current from the amplifier filament battery.

The microphone is an inexpensive carbon type, since the noise levels at which it is to be used are comparatively high. The accompanying curves show the over-all frequency response of the noise-measuring system with and without the microphone. It will be noted that the over-all response of the complete system, including microphone, represents a very close approximation to the response of the normal human ear.

Although equipment of this sort is generally used to determine the decibels difference between normal noise level and noise with some machine operating, the equipment can, of course, be calibrated against any arbitrary standard desired. The threshold of hearing at 1000 cycles for an average person is frequently used as a reference level.

A convenient manner of calibrating the noise-measuring set is as follows: a 1000-cycle tone may be obtained from



The frequency characteristic of the system is made to approximate that of normal hearing

a suitable oscillator in conjunction with a loud-speaker. The observer should be so placed that he is approximately the same distance from the loud-speaker as the microphone and reasonably close to the microphone so that it may be assumed that the sound intensity reaching the observer is practically the same as that reaching the microphone. If the volume of sound from the loud-speaker is then reduced until the threshold of hearing is reached, the reading of the noise-measuring set at that point may be taken as the reference level.

With some types of microphones, the residual noise may be enough to cause an appreciable error in reading of the set at the threshold of audibility. Where very weak sounds are to be measured it is recommended that a microphone of the condenser or moving coil type be employed, but if loud noises are to be measured, the following method of calibration will be found quite satisfactory.

The oscillator used for obtaining the test tone should have a reasonably large power output and should be equipped with a calibrated volume control. If this is not the case, a suitable amplifier and attenuator may be used in conjunction with the oscillator. The loud-speaker should be reasonably linear in so far as power output is concerned, that is, doubling the power input to the speaker should double the power output. This of course means that the loud-speaker must not be overloaded. Placing the observer and microphone as mentioned before, the threshold of hearing should be obtained in the same manner and the reading of the calibrated attenuator or volume control on the oscillator or associated amplifier noted. The output of the loud-speaker should then be increased by adjusting the calibrated attenuator until a reasonably loud sound intensity is obtained. An increase of the order of 40 or 50 db is generally sufficient. It is not important that the intensity be increased by any exact amount, but only that the amount of increase be known. The reading of the noise-measuring set at that point, referred to the threshold of hearing, will equal the amount by which the output of the loud-speaker was increased.

For best results, these calibrations should be performed in an acoustically dead room or in the open air at some place where absolute quietness may be obtained. It is also advisable to perform the calibration with several individuals and use the average as a final value. —H. H. Scott

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For the convenience of those desiring to construct noise-measuring sets similar to the one described above, the following table gives the list of General Radio equipment which may be used, and the prices.

Type 514-AM Amplifier (without tubes and batteries) . . . $76.00

Type 586-CM Power-Level Indicator $75.00

Type 345-SN Transformer (for use in conjunction with single-button carbon microphone to obtain approximate characteristic of human ear) $15.00

If it is desired to have the special input transformer mounted within the amplifier unit and the amplifier input circuit arranged so that microphone current is obtained from the amplifier "A" battery, an additional charge of $15.00 will be made. The complete noise-measuring set as described in the foregoing article, including microphone, microphone case, suitable shielded cable connectors, and all tubes and batteries, will cost $230.00.

A BOOSTER AMPLIFIER FOR 500-OHM LINES

In modern communications systems, lines and equipment having impedances of 400 to 600 ohms are generally widely used. The high-quality transmission lines associated with radio broadcasting and sound pictures equipment generally have characteristic impedances within this range, and, accordingly, a large percentage of faders, mixers, and speech-input amplifiers have input and output impedances of approximately 500 ohms.

A compact line amplifier

Transmission lines should, of course, be operated at a volume level sufficiently high to minimize the effects of noise and crosstalk which may be picked up from nearby electrical equipment or other transmission lines. A level of +2 db is generally recommended. Increase in volume level also tends to reduce noises which may be encountered in fading and mixing equipment.

Two of the General Radio Company's new transformers, Type 541-G and Type 541-P, are finding widespread favor among engineers for use in connection with 500-ohm equipment. Type 541-G is a line-to-grid transformer designed for operation into either a single tube or a balanced (push pull) stage. Type 541-P is a plate-to-line output transformer for operation from a single amplifier tube or a balanced stage into a 500-ohm line. Using these two transformers, a line-booster amplifier may be constructed which will provide high insertion gain with an excellent frequency characteristic.

The accompanying diagram shows the circuit and frequency response of a balanced amplifier using two of the new 56-type tubes. The over-all amplification is approximately 20 db. 227-type, 230-type, or 237-type tubes may also be used, if desired, with a slight decrease (approximately 1.5 db) in gain. If a larger amount of output power is desired, 210-type tubes may be used. —H. H. Scott

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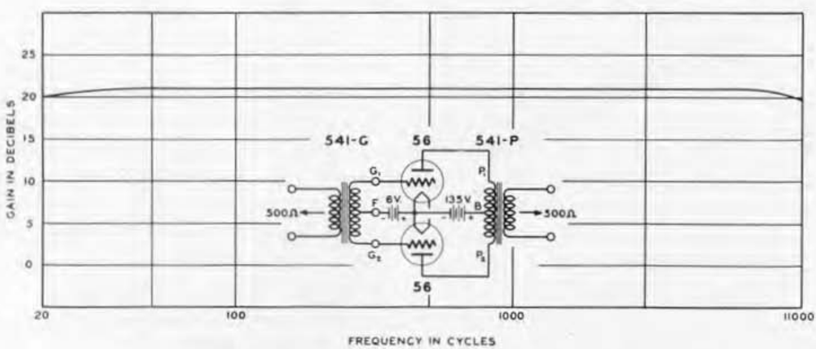
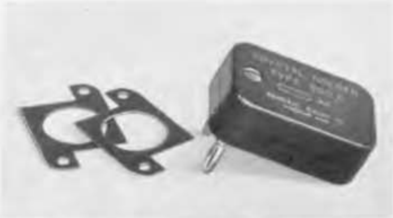
Prices on equipment used in the booster described above are as follows:

Type 541-G Line-to-Grid Transformer $12.00
Type 541-P Plate-to-Line Transformer $12.00
2 Type 438 5-Prong Sockets . .70
Special Base — Nickel-plated Brass with Binding Posts $3.00



An excellent frequency characteristic is obtained

AMATEUR CRYSTAL HOLDER



The Type 560-A Crystal Holder assembled

The crystal is held under light pressure

The crystal is of course not included in the price of the holder

In general, quartz-crystal holders for amateur and experimental-transmission use are constructed with two major considerations in view — frequency stability and maximum power output. In amateur operation it is generally advisable to sacrifice some frequency stability to gain in power.

The two types of holders commonly in use are the air-gap and pressure-plate types. The former are used in circuits in which frequency stability of the highest order is essential, and the latter where stability may be subordinated to power output.

The decreased air gap between the top plate and the crystal in a pressure-type holder reduces the series capacitance in the crystal circuit, affording material increase in output.

In the pressure-type holder any considerable amount of lateral motion of the crystal will cause variation in frequency and output. This "sliding" tendency of the crystal, when operated in a power circuit, should be restricted by means of some form of retention device which should limit the motion of the crystal without definitely preventing its natural oscillation.

The pressure requirements of the top plate vary with different crystals and with frequency. In some cases the weight of the top electrode alone is sufficient, while in others, pressure, supplied by a spring, is required.

The contact surfaces of both holder electrodes must be smooth and as flat as possible to insure uniform operation of the holder with different crystals.

An enclosed case is desirable to protect the crystal from dust or other foreign matter.

General Radio has designed a holder to fill the above requirements. The holder will accommodate crystals up to 1⅛ inches in diameter, and of thicknesses to 4 millimeters. Three blank retention plates of fabricated bakelite sheeting are provided so that the user may readily cut out the blanks to accommodate crystals of various shapes. Pressure on the top plate is provided by a flat spring, the tension of which is adjustable. Both electrodes are chromium plated. The case of the holder is of moulded bakelite, dust proof, and easily opened. Standard General Radio spacing of ¾ inch is used between the plug terminals. This is known as the Type 560-A Crystal Holder. The price is $2.25, including three fabricated bakelite retention blanks.

STANDARD-RELAY RACKS

TELEPHONE practice for a long time has been to mount equipment on racks of standard dimensions. Rack and panel dimensions have been worked out so that provision is made for instruments requiring various amounts of panel space.

The standard relay rack takes a panel width of 19 inches. The maximum allowable width of apparatus behind the panel is 17½ inches.

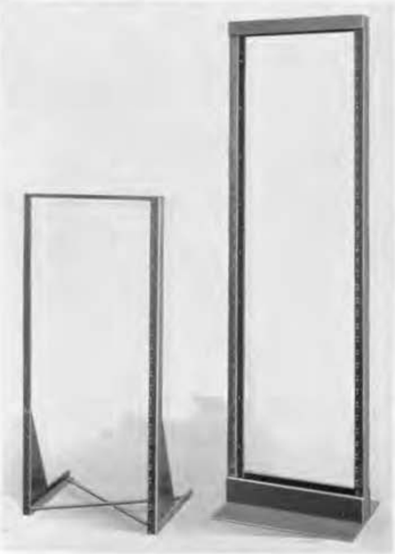
A drilling arrangement for the uprights of the rack has been worked out which permits the mounting of any size panel in any position on the rack provided certain standard panel widths and slotting arrangements are used.

The basic unit of panel width is 1¾ inches. An allowance of $\frac{1}{32}$ inch is made between panels for fitting so that the standard panel sizes are $n(1\frac{3}{4})-\frac{1}{32}$ where n is any integer.

The drilling and slotting arrangements for the panels are illustrated in the figure. Holes are tapped for 10/32 screws.

Panel slots should be laid out on the assumption that the top of the panel comes between two holes placed at ½ inch intervals.

It is of course not necessary to slot the panel for each hole in the rack upright. The holes are at such intervals that a symmetrical arrangement of slots can be made in practically all cases. The figure illustrates the location of slots in three typical cases showing in heavy lines the positions actually slotted. General practice is to use two slots for panels up to and including five rack units ($8\frac{23}{32}$) wide, three slots or the six-unit width, and four slots for panel sizes up to eleven units.

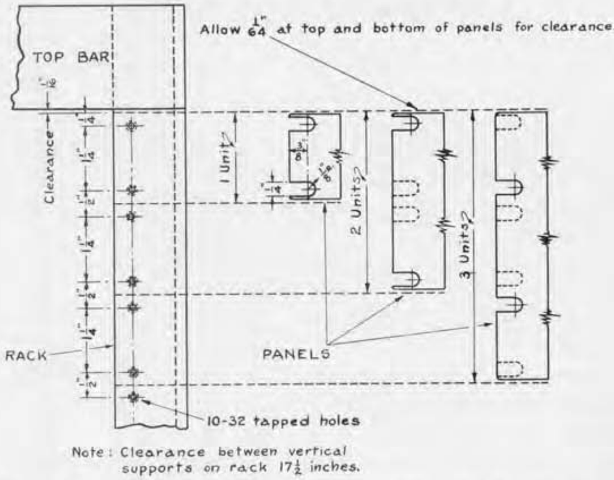


TYPE 480 Relay Racks: TYPE 480-B (*left*), TYPE 480-A (*right*)

These numbers would be modified for unusually light or unusually heavy installations.

The General Radio Company is listing two types of relay rack. One of these is a full size standard rack designed for mounting large assemblies of laboratory equipment. It contains mounting space for the equivalent of thirty-six panel units.

A smaller unit is provided for bench mounting. This is ideal for installation of laboratory assemblies consisting of several portions such as oscillators and their rectifiers. This type of rack lends itself to mounting at the back of laboratory tables to hold permanently installed equipment, thus freeing the table surface for other apparatus. The rack is also ideal for assembling of



Standard dimensions for panel cutting and drilling. Panel units are in multiples of 1¾ inches high by 19 inches wide. Maximum width of apparatus behind the panel 17½ inches

amateur-radio transmitters. This rack will mount twenty-five panel units.

Both racks are of steel frame and can be bolted to the floor or table, although this is usually not necessary. Both racks are drilled as shown in the illustration above. Holes are tapped for 10/32 panel mounting screws. Mounting screws, washers, and bridle rings for cabled wiring are supplied.

The large rack stands 63 inches from the floor and has a panel mounting space of 43¾ inches by 19 inches. The price of the large rack (Type 480-A) is $40.00; that of the smaller (Type 480-B) is $15.00.

Panels for mounting apparatus on these racks should be of ¼ or ⅛-inch aluminum depending upon the weight of the apparatus to be supported. Panels can be obtained cut to size with finished edges from the Aluminum Company of America or its local jobber.

The General Radio Company mails the Experimenter, without charge, each month to engineers, scientists, and others interested in communication-frequency measurement and control problems. Please send requests for subscriptions and address-change notices to the

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