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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

APPROXIMATE FREQUENCY ANALYSIS FROM WEIGHTING-NETWORK DATA IN ACOUSTIC NOISE MEASUREMENTS

Also IN THIS ISSUE

● **IN THE EVALUATION** of the character of a noise, there is no adequate substitute for a frequency analysis by either a continuous-spectrum analyzer or an octave-band analyzer, whether the purpose of the measurement be to determine the characteristics of a noise source or to estimate the effects of a noisy environment. In some noise surveys, however, which are commonly made with a single instrument, such as the Type 1555-A Sound-Survey Meter, it is often helpful to be able to estimate the spectral distribution of the noise.

The following article by Mr. Jerome R. Cox, Jr., of the Loss Prevention Department, Liberty Mutual Insurance Company, outlines a method of making this estimate.

—*Editor*

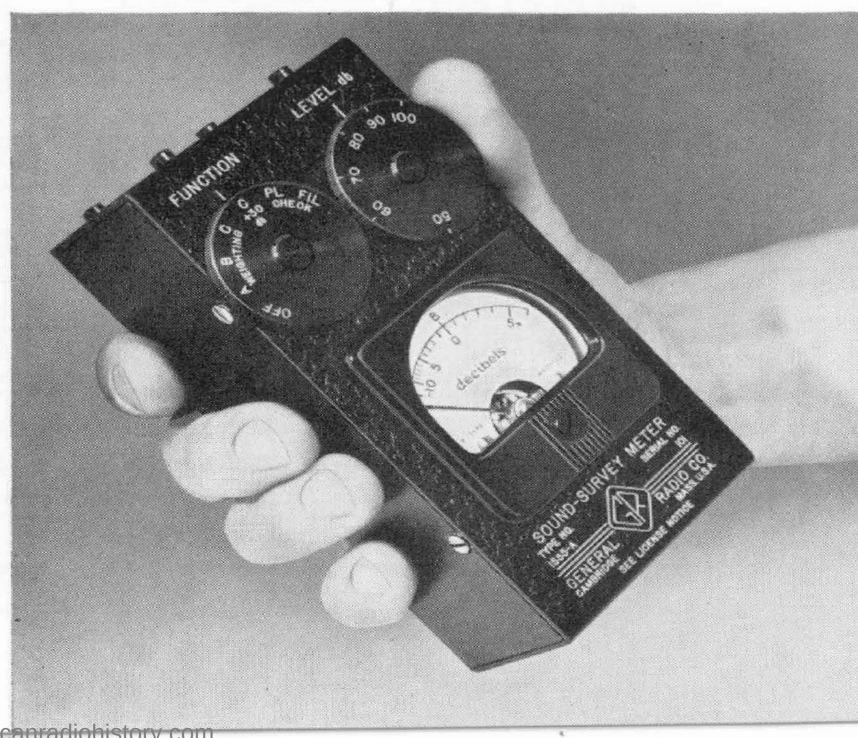


Figure 1. View of the Type 1555-A Sound-Survey Meter. When noise measurements are made with this instrument, the approximate frequency analysis is particularly useful.

The standard sound-level meter[1] has three weighting networks, which have the frequency characteristics shown in Figure 2. One of these is usually selected for a given measurement according to the observed level, so that only one reading is taken. Actually, of course, since these weighting networks differ in frequency response, one can expect to learn more about the noise by taking three readings than by taking only one. Consequently, many engineers regularly use all three weighting networks whenever they measure a noise.

On the basis of the relative readings obtained by using the three weighting networks, some estimate of the distribution of noise energy as a function of frequency is often made. This estimate is usually colored by the experience and intuition of the engineer, particularly when he is guided by a subjective estimate of the sound.

It is possible, however, to set up a systematic procedure to estimate the approximate frequency distribution. As an initial attempt in this direction, the set of charts shown in Figure 3 has been prepared. Obviously, this method of determining the spectrum of a noise is not an accurate one; the weighting networks are not designed to perform the function of frequency analysis, and the tolerances on the response of these networks are comparatively large.

[1]ASA Z24.3—1944, Sound-Level Meters, American Standards Association.

Division into Three Bands

Since there will be three readings for each noise, it has been assumed that approximate levels in three bands could be obtained. A study of the network characteristics led to a division of the spectrum as follows: A low-frequency band from 20 to 150 c; a middle frequency band from 150 to 600 c; and a high-frequency band from 600 to 8,000 c. For comparison, the eight bands of the octave-band analyzer are 20 to 75 c, 75 to 150 c, 150 to 300 c, 300 to 600 c, 600 to 1200 c, 1200 to 2400 c, 2400 to 4800 c, and 4800 to 10,000 c.

The band from 600 to 8,000 c seems unusually wide, but it is easy to see that this width is dictated by the network characteristics. Figure 2 shows that the response of the three networks is essentially the same above 600 c. Thus a noise that has no components below 600 c would give nearly the same readings on a sound-level meter for all three weighting networks, and one could not tell directly from the three level read-

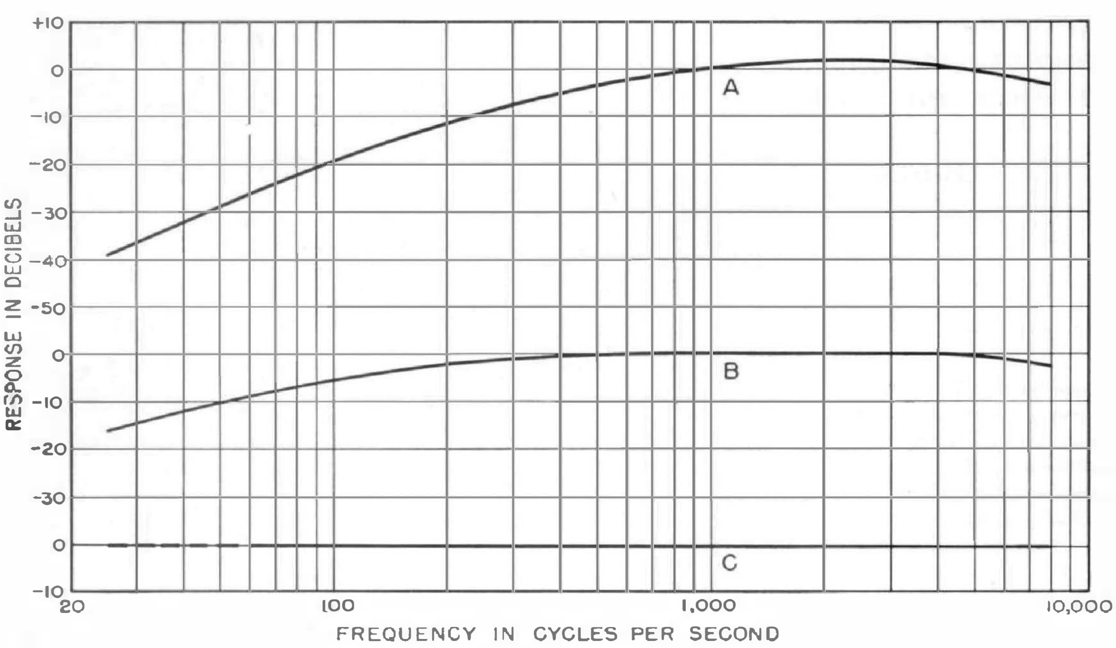
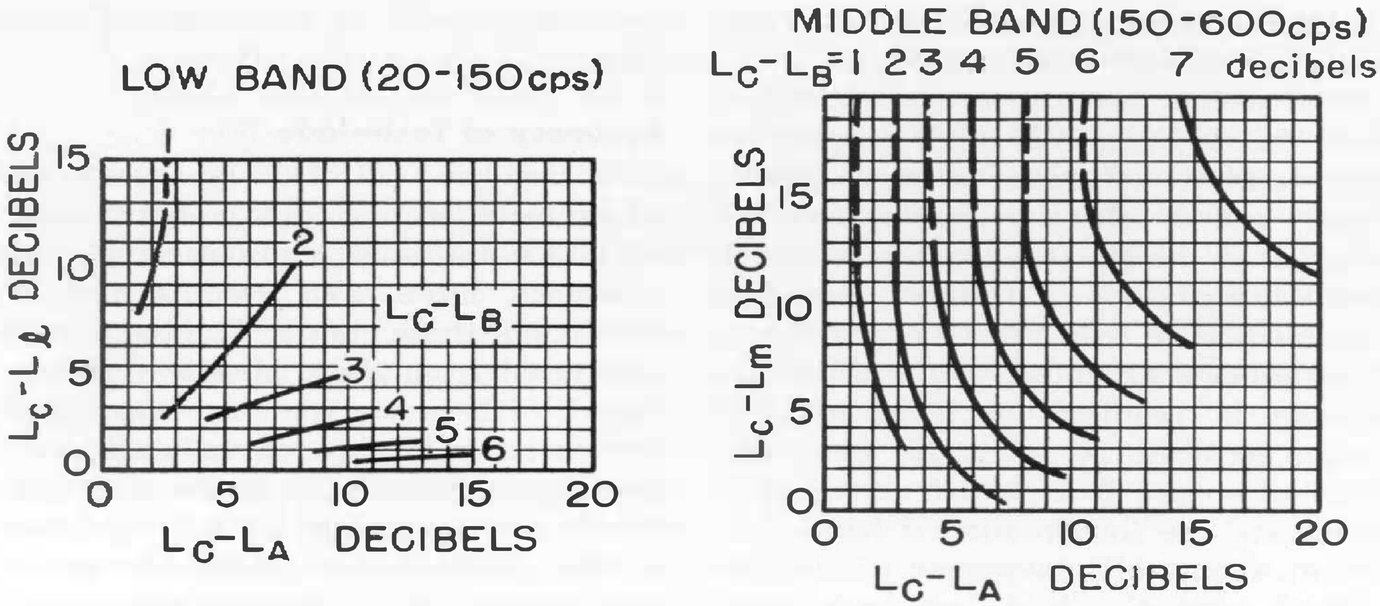


Figure 2. Frequency response characteristics for sound-level meters. ***American Standard for Sound-Level Meters, Z24.3-1944.***



L_C = Level reading obtained when using the C-weighting network = *Over-all Level.*
$L_C - L_A$ = Difference in readings of level with C-weighting and A-weighting networks.
$L_C - L_B$ = Difference in readings of level with C-weighting and B-weighting networks.
$L_C - L_l$ = Level to be subtracted from the C-weighting level to obtain "Low-Band" (20–150 c.p.s.) level.
$L_C - L_m$ = Level to be subtracted from the C-weighting level to obtain "Middle-Band" (150–600 c.p.s.) level.
$L_C - L_h$ = Level to be subtracted from the C-weighting level to obtain "High-Band" (600–8,000 c.p.s.) level.

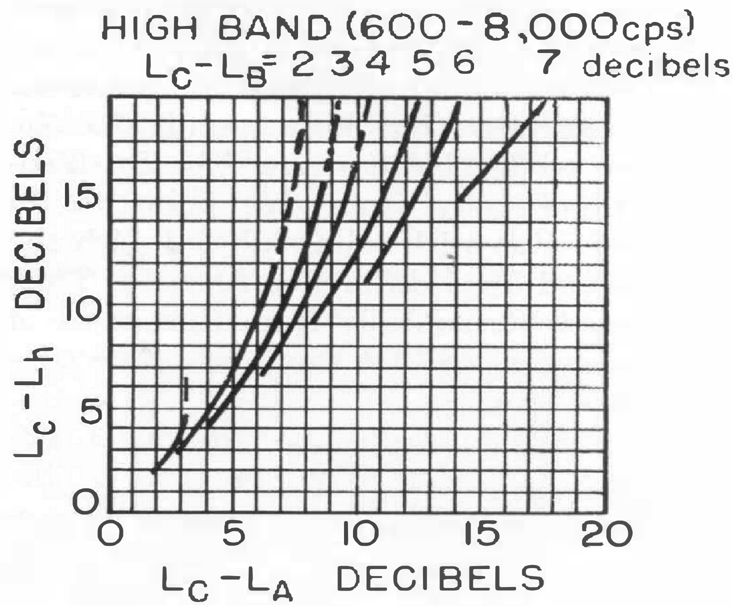


Figure 3. Curves for calculating an approximate frequency analysis in three bands from level readings taken when using the three sound-level meter weighting networks. The measured value of $L_C - L_A$ is entered at the abscissa of each graph, proceeding vertically to the curve labeled with the measured value of $L_C - L_B$, then horizontally to the ordinate value for each of the three bands corresponding to the difference between the individual band levels and the over-all level.

ings anything about the distribution within this broad band. Here is where an experienced engineer can use his subjective estimate of the noise to distinguish between a broad-band hiss and a narrow-band, pitched noise. Frequently, he can in this way make a good estimate of how the noise energy is distributed in this high-frequency band.

Incidentally, the directivity characteristics of the microphone at high-frequencies can also be helpful in making this estimate, but a discussion of that procedure will not be attempted here.

Description of Charts

The charts of Figure 3 were prepared by a method of successive approximations from the characteristics of the three weighting networks. This method used experimental data taken on industrial noise spectra to make the final adjustment of the curves. The distribution of energy in these spectra did not vary rapidly with frequency.

The charts use the symbol L for a level in decibels (all with respect to the standard reference level of 0.0002 μbar), and a subscript on this symbol is used to designate a particular level. For example, L_C is the level reading obtained when using the weighting network labeled C, and $L_C - L_A$ is the difference in readings of level with C-weighting and A-weighting networks. The subscripts l, m, and h are used to designate the low-frequency band (20–150 c), the middle-frequency band (150–600 c), and the high-frequency band (600–8000 c), respectively.

The charts are used as follows:

1. Obtain the difference in readings of level with the C-weighting and A-weighting networks ($L_C - L_A$) and with the C-weighting and B-weighting networks ($L_C - L_B$).

2. On each graph find the point on the abscissa that corresponds to the observed level difference $L_C - L_A$. Proceed vertically from this point to an intersection with a line labeled with the observed level difference $L_C - L_B$. Then proceed horizontally from this point of intersection to find the level to be subtracted from L_C.

3. Subtract from L_C the level obtained in this fashion on each of the three graphs. The result is then the approximate level in each of the three bands.

Accuracy of Technique

A number of field measurements, which included both octave-band analyses and sound-level readings on all three networks, have been used to test the validity of these charts. The band levels computed from these charts were compared with levels for the same bands computed from the octave-band analyses. The comparison indicates that band levels corresponding to solid portions of the curves on the graphs are usually accurate to ±3 db. There is a significant percentage of irregular cases, however. For example, if the noise energy is concentrated in a narrow band, which is true for a pure tone, or if the noise fluctuates markedly in level with time, larger errors than ±3 db can be expected. If the A, B, and C readings cannot be repeated within 0.5 db, good accuracy cannot be expected.

Certain noises in which the energy is localized at one end or the other of the lower and middle bands cannot be analyzed by this method. Usually this type of spectrum will result in $L_C - L_A$ values that do not fall on the $L_C - L_B$ curves. Here, again, an experienced observer can sometimes use a subjective estimate of the noise to guide him in estimating the spectrum when the charts fail, but little confidence should be attached to extrapolation of these curves. Similarly, the dotted portions of the curves are regions of poor accuracy.

Examples of Use

An analysis of the frequency distribution of the noise energy is usually essential for the satisfactory solution

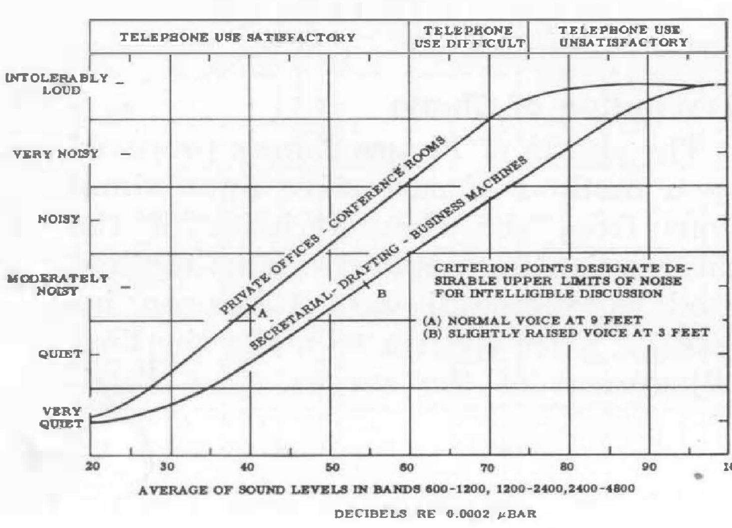


Figure 4. Rating chart for office noises. (Courtesy Beranek and Newman)

of a noise problem. The analysis obtained from the charts of Figure 3 is only a partial step in providing the information required for a solution, but it usually gives a better idea of the magnitude of the problem than one can obtain from a single sound-level reading. In addition, subsequent measurements and analyses can be more adequately planned after the preliminary survey has been made.

In order to interpret the band levels given by this partial analysis, it is usually helpful to convert the levels into values similar to those used for the octave-band analyzer. For example, the speech-interference level[2, 3] is a useful reference value that can be obtained from an octave-band analysis. With slightly less accuracy than the band charts have, this speech-interference level is approximately equal to the level in the high-frequency band less 6 db (speech-interference level $= L_h - 6$). If this speech-interference level is high, the ability to converse will be seriously interfered with. For example, if you are trying to give involved instructions to a workman two feet away, your voice will have to be very loud to be heard satisfactorily when the noise produces a speech-interference level of 70 db.

Another use of speech-interference level is in rating office noises[2] as shown in Figure 4. These curves can be used to determine the desirability of noise control.

An analysis of the noise is also important for planning the steps necessary for reducing noise levels, since the most suitable control measures depend on the frequency spectrum of the noise. For example, the ordinary acoustic treatment has little effect at low frequencies. Because this simple three-band analysis does indicate how the noise energy is distributed, one can use the results of the analysis as a guide in selecting the noise reduction technique to be tried in a given situation.

—J. R. Cox, Jr.

[2] Leo L. Beranek, "Noise Control in Office and Factory Spaces," *Transactions* of Chemical-Engineering Conferences, Bulletin No. 18, 1950, Industrial Hygiene Foundation, Mellon Institute, pp. 26—33.
[3] H. O. Parrack, "Physiological and Psychological Effects of Noise," *Proceedings* of the Second Annual Noise Abatement Symposium, October 5, 1951, pp. 21—38.

Figure 5. Determining noise level and speech-interference level in a business office with the Type 1551-A Sound-Level Meter.

TWO-TERMINAL DIELECTRIC MEASUREMENTS OVER A WIDE TEMPERATURE RANGE

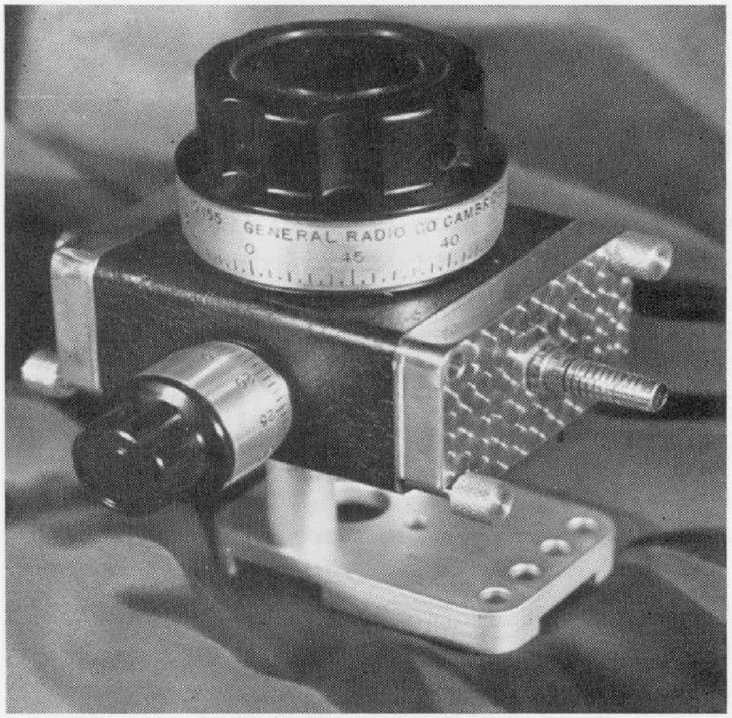


Figure 1. View of the modified dielectric sample holder with the special cover plates installed.

To simplify the measurement of solid dielectric samples over a considerable range of temperature, the Research Laboratories of the Tennessee Eastman Company, Division of Eastman Kodak Company, have developed an interesting modification of the Type 1690-A Dielectric Sample Holder. This modification avoids the long leads usually associated with a conditioning oven, which ordinarily requires a three-terminal system to eliminate the effects of lead capacitance.

As indicated in Figure 1, the removable covers at the ends of the main body of the sample holder have been replaced by specially designed covers fitted with tubular connections to permit the circulation of heated or cooled air through the holder.

The covers, which are shown in detail in Figure 2, are hollow chambers. Air is fed into the tubular intake and exhausted at lower velocity into the sample compartment through a slot of five times the intake area. Air leaves the sample compartment through the slot in the other cover. The entire cell is thus a plenum chamber in which the pressure is maintained well above atmospheric level. The location of the slots (intake at the bottom of the cover, outlet at the top) produces sufficient turbulence to avoid hot spots.

The compressed air supplied to the cell is heated by passage through a spiral copper tube in intimate contact with an electrically heated aluminum block. This modified sample holder has been used successfully at temperatures up to 110°C.

The complete measurement setup, consisting of a Type 716 Capacitance Bridge, a Type 1231 Amplifier and Null Detector, and a Type 722 Precision Condenser, is shown in Figure 3.

Although used by Tennessee Eastman at audio frequencies, the arrangement described has particularly interesting possibilities at higher frequencies. The measuring circuits may be used in a normal manner, obviating the problems of placing the specimen holder or the

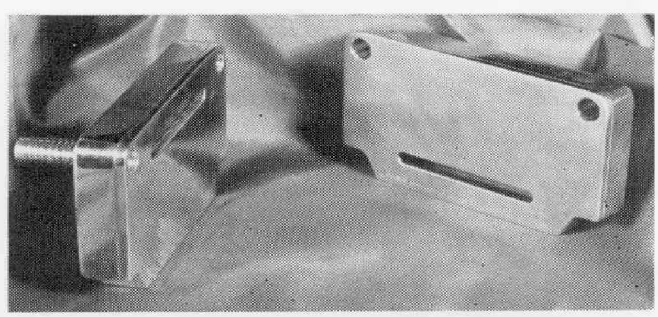


Figure 2. Close-up view of the covers, showing the slots through which air is pumped into, and exhausted from, the sample compartment.

measuring circuits themselves in a conditioning chamber.

Editor's Note:

The information on which the foregoing article is based was furnished by Mr. R. G. Devany of the Research Laboratories, Tennessee Eastman Company. The covers for the sample holder were made by Mr. Blake Chapman of the Instrument Development Shop, Tennessee Eastman Company, Kingsport, Tenn.

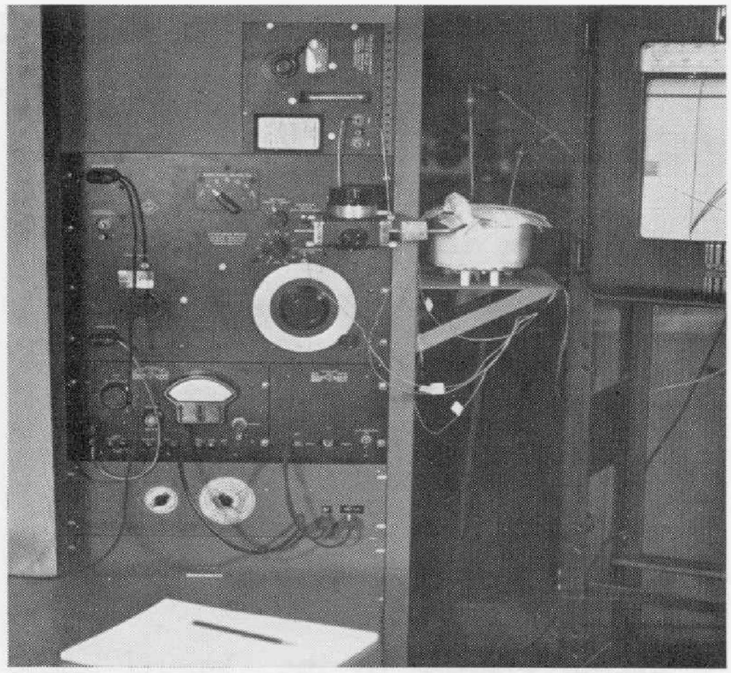


Figure 3. View of the measuring assembly at the Tennessee Eastman Company laboratories, showing the modified sample holder connected to a Type 716 Capacitance Bridge.

A CLIP-TYPE LOCK FOR TYPE 874 CONNECTORS

General Radio TYPE 874 Connectors have been designed for best electrical performance and greatest convenience in use in the laboratory. The screw lock found on most coaxial connectors has, therefore, been omitted, because the sliding friction between mated connectors is sufficient under ordinary conditions to prevent accidental opening.

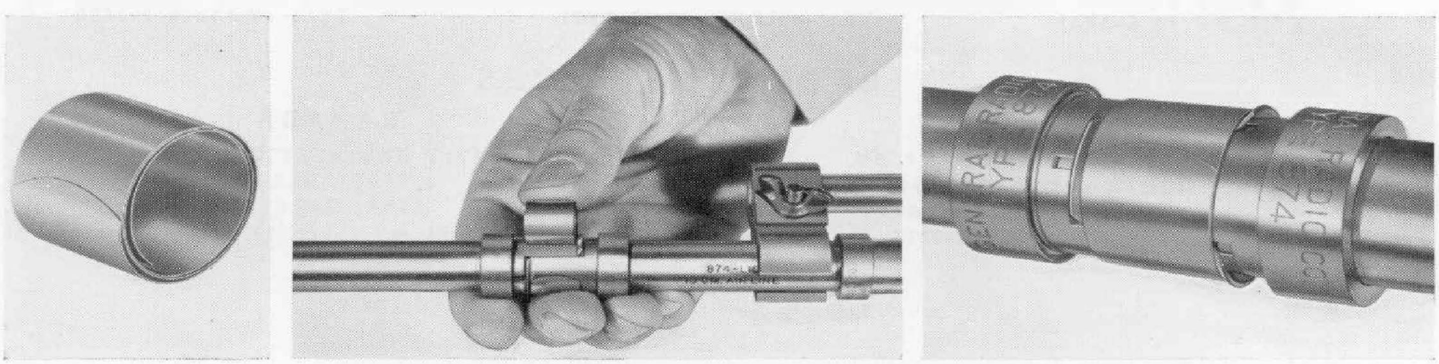
In setups where line length must be adjusted frequently, some kind of lock between connectors may be desirable. The flared ends on the outer conductors of the TYPE 874 Connectors make it possible to use an extremely simple locking device.

The TYPE 874-Y Cliplock, designed for this purpose, consists of a flat, stainless-steel spring, which is easily rolled over the joint of two connectors to produce a compact, neat, locked joint. The edges of the spring fit between the overlapping flanges of a mated connector pair and prevent it from pulling apart. To increase the holding power of the lock, the spring has been pre-stressed to make it a Negator.[1]

[1]W. J. Cook and P. C. Clark, *Product Engineering*, July, 1949; H. Mankonen, *Instruments*, 1952; F. A. Votta, Jr., Paper No. 51-F-11, The American Society of Mechanical Engineers, June, 1951.

Type		*Code Word*	*Price*
874-Y	**Cliplock**	COAXLOCKER	10 for **$1.75**

The Cliplock before installation. To install, simply roll the spring around the mated connectors. Spring clings tightly to connectors, holding them firmly together.



MISCELLANY

SUMMER CLOSING

Vacation — During the weeks of July 27 and August 3 most of our employees will be vacationing. Manufacturing departments will be closed, and other departments will be manned by a skeleton staff. Every effort will be made to take care of urgent business, but repairs cannot be made, except in hardship cases. Our Service Department requests that shipments of material to be repaired be scheduled either to reach us well before this vacation period or delayed until afterward.

Recent Visitors to the General Radio Plant and Laboratories — Mr. Harold Page, Head of Radio Section, Research Department, British Broadcasting Corporation; Dr. Otto Brune, Principal Research Officer, National Physical Laboratory, Pretoria, South Africa; and Dr. Tatsuo Hayashi, Director, Radio Precision Corporation, Osaka-Fu, Japan.

ERRATA

Our attention has been called to an error in the diagram on page 7 of the March issue of the *Experimenter*, in the article entitled, "Portable Test Autotransformers."

In the leads to the selector switch, the lead to the switch arm shown as 230V should have no markings; the lead shown as 270V should be 230V; the lead to the other point on the switch should be marked 270V.

On page 1 of the March issue, the date of publication of Mr. Giacoletto's article (footnote 2, page 1) should have been given as March, 1953.

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