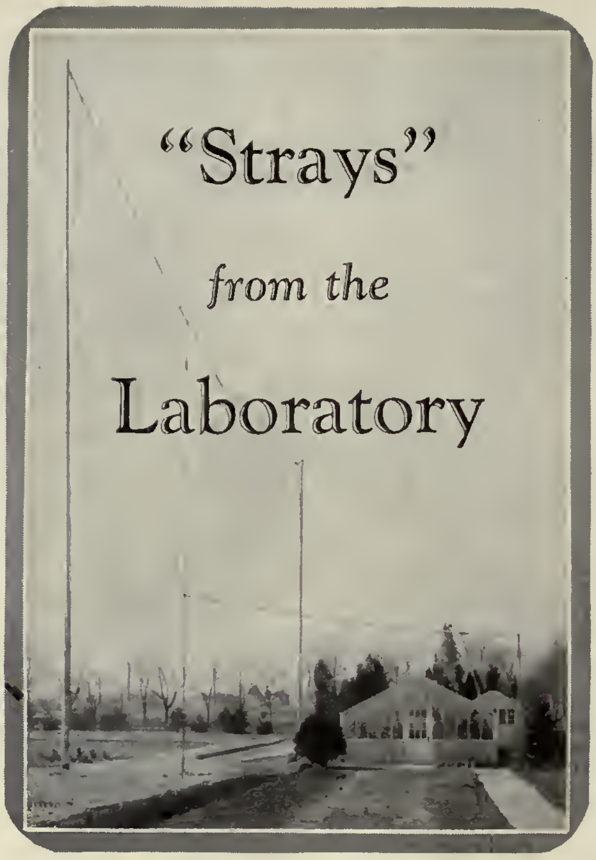
"Strays" from the Laboratory



The "Myracycle"

AMONG the many suggestions made to the newly created Federal Radio Commission is that of a gentleman from the Middle West whose wishes, if they came true, would do away with the term "kilocycle" in favor of a new and perhaps more useful expression, the "myracycle." The myracycle would represent a unit of ten kilocycles, and since stations on the familiar broadcasting band are to be separated by ten-kilocycle—or one-"myracycle"—intervals, the suggestion should not be dismissed without a hearing.

Using the term myracycle would mean that a station operating on 660 kilocycles would be rated at 66 myracycles, and at the top of the broadcasting band a station now on 1500 kilocycles would be known as a 150-myracycle station. This term would do away with the final cipher in our present listing of stations.

It should be remembered, however, that it has taken a number of years to bring the term kilocycle into even the outer consciousness of the average radio listener who still prefers to think in terms of wavelengths, and to introduce another term might put the whole business of frequency designations back into the middle age method of designation by meters. There is already another frequency term, the "megacycle," which represents a thousand kilocycles (one million cycles). We first heard it used in Doctor Pickard's study after his summer spent in measuring the polarization of high-frequency signals, and although it sounded strange at first, it proved to be very useful in speaking of amateur frequencies. The relation between these several units is shown in the table below:

1 cycle = 10^0 cycles = 1 cycle
1 kilocycle = 10^3 cycles = 1000 cycles
1 myracycle = 10^4 cycles = 10,000 cycles = 10 kilocycles
1 megacycle = 10^6 cycles = 1,000,000 cycles = 1000 kilocycles

The Use of Exponents

WHICH brings up another interesting point—the use of exponents in the arithmetical calculations in which all radio engineers must indulge from time to time. Exponents are among the mathematician's most useful shorthand symbols, as the table below will indicate:

$1 = 10^0$ = Units
$10 = 10^1$ = Tens
$100 = 10^2$ = Hundreds
$1000 = 10^3$ = Thousands (Kilo.)
$1{,}000{,}000 = 10^6$ = Millions (Mega.)

$1 = 10^0$ = Units
$.1 = 10^{-1}$ = Tenths
$.01 = 10^{-2}$ = Hundredths
$.001 = 10^{-3}$ = Thousands (Milli.)
$.000001 = 10^{-6}$ = Millionths (Micro.)

Now the rules dealing with these complicated looking figures are simple, and when mastered, provide an exceptionally easy method of handling large numbers, or numbers in which the decimal point of the answer is in doubt. The rules are as follows:

When multiplying numbers, add exponents.
When dividing numbers, subtract exponents.
When squaring numbers, double exponents.
When getting square roots, halve exponents.
When transfering an exponent across the dividing line, change its sign.

For example the following problem may be simplified and solved:

$$\frac{1234 \times 0.02 \times 1000 \times 64}{2468 \times 800 \times 0.001 \times 100}$$

$$= \frac{1.234 \times 10^3 \times 2 \times 10^{-2} \times 10^3 \times 64}{2.468 \times 10^3 \times 8 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64 \times 10^3 \times 10^{-2} \times 10^3}{2.468 \times 8 \times 10^3 \times 10^2 \times 10^{-3} \times 10^2}$$

$$= \frac{1.234 \times 2 \times 64}{2.468 \times 8} = 8.0$$

As a somewhat more practical problem, let us consider the formula which states that the resonant frequency of a tuned circuit in cycles is as given below, when the inductance is in henries and the capacity in microfarads. If the coils and condensers in question are rated in millihenries and micro-microfarads, what will the constant above the line become?

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \text{ h } C \text{ mfd.}}}$$

and since mh. = 10^{-3} hand mmfd. = 10^{-6} mfd., this formula becomes:

$$f \text{ cycles} = \frac{159.2}{\sqrt{L \times 10^{-3} \times C \times 10^{-6}}}$$

$$= \frac{159.2}{\sqrt{(L\,C \times 10^{-3}) \times 10^{-3}}}$$

$$= \frac{159.2 \times 10^3}{\sqrt{L\,C} \times \sqrt{10^{-3}}}$$

$$= \frac{159.2 \times 10^3 \times 31.6}{\sqrt{LC}}$$

$$= \frac{5.033 \times 10^3}{\sqrt{LC}}$$

$$f \text{ kc.} = \frac{5.033}{\sqrt{L\,C}}$$

The Telephone Transmission Unit

THE use of exponents is the basis of our logarithms, as well as the foundation of the transmission unit, TU, which has been explained by Carl Dreher on several occasions in his department "As the Broadcaster Sees It." For example the exponent of 10^2 is 2, that of 10^3 is 3, and all numbers between 100 and 1000 have logarithms to the base 10 somewhere between 2 and 3. This amounts to saying that all numbers between 10^2 and 10^3 have exponents between 2 and 3.

The need for the transmission unit may be explained as follows. Let us suppose we have an electrical circuit—a telephone wire—connecting two points, and at the end of the first mile, the power has dropped to 0.9 of its original value. At the end of the second mile it has lost another 0.1 or is 0.9 of what it was at the end of the first mile, or 0.9 x 0.9, or 0.81, of its original value, and so on, to the end of the line. What is it at the end of eight miles? It is not only unwieldy to manage numbers of this sort but we must multiply them, which is less easy than addition.

Let us assign a unit to the ratio between the power at the end of the first mile to the original power, say A. This then represents the loss in that mile. Likewise, the ratio between the power at the end of the second mile to what appears at the end of the first is also A. In other words, at the end of the second mile we have lost twice A, or two units. If the line is eight miles long we shall have lost 8 units, and as Table No. 1 shows, the power will be 0.43 of its original value.

Reversing the direction of procedure along the line, as we approach the starting point we gain one unit for each mile of progress.

Again let us suppose that at the end of each mile as we go toward the end of the line we interpose an amplifier—a repeater as the telephone people call them—and that it boosts the power back to its original value. It is certainly much simpler to state that the amplifier has a power gain of A units than that it amplifies the power 1.111 times, for it must do such to raise 0.9 of the power back to its original value. The total gain of eight such repeaters will be 8 units.

The telephone engineer's foot rule, the transmission unit, is defined as ten times the logarithm to the base ten of the ratio between any two powers, or twenty times the logarithm of the ratios of voltages or currents into equal impedances. In mathematical language:

$$TU = 10 \log_{10} P_1/P_2 = 20 \log_{10} E_1/E_2 = 20 \log_{10} I_1/I_2$$

Thus an amplifier with a power gain of 100 has a gain of 20 TU since the exponent, or logarithm, of 100 is 2.0. Two of these amplifiers in series will have a gain of 40 TU or a power gain of 100 x 100, or 10,000. When a full orchestra plays fortissimo it is roughly 60 TU's more powerful than when playing pianissimo, a power ratio of 1,000,000. It is fortunate that the ear hears according to a logarithmic scale!

To become more familiar with the TU business the following facts may be useful. The average two-stage amplifier as used in broadcast receivers has a voltage gain of about 300, or 50 TU. The difference in power between a 500-watt station and one of 5000 watts is ten TU, and the latter enables a listener equidistant from the two to use 10 TU less amplification to get the same volume, which means that the receiver will be less susceptible to extraneous noises such as static. A variation of 10 TU at the two extremes of the audio-frequency spectrum, say at 100 or 5000 cycles, can be noted by the ear but will not make such an extraordinary difference in quality as some amplifier parts manufacturers would have us believe. That is, the volume at 100 cycles can be reduced by 10 TU, *i.e.*, the power can be reduced to $\frac{1}{10}$ or voltage to 0.316 of its former value before the ear notes it. A further reduction of 10 TU is appreciable.

Another example of the use of the TU, and one which merits very careful study, is shown in Fig. 1; it was taken from the *Bell System Technical Journal* for January, 1927, from an article by Lloyd Espenschied. The data for these curves which show the relative selectivity of several popular types of receivers were taken in the following manner. A laboratory oscillator was modulated at a fixed voice frequency, the receiver was tuned to the carrier, and the detected audio current measured as the oscillator was tuned in 10 kilocycles steps away from the original frequency.

The first significant point to note is that all receivers have a distinct cut-off within 10 kilocycles of resonance. Even at 5000 cycles the better grade receivers are 10 TU "down," which means that audio frequencies of this value will be down, and that a rising characteristic amplifier is probably a good idea. The curves show that the super-heterodyne or double-detector is considerably more selective than the others, and, as was to be expected, the simple single-circuit affairs have very little discrimination between wanted and unwanted signals.

Mr. Espenschied points out that undesired signals may not be bothersome when only 40 TU below the desired signals when the latter are strong, but when the program happens to call for a pianissimo passage the unwanted signals are disturbing. Reducing the level of the unwanted station to 60 TU eliminates this trouble.

The chart shows what may be expected in an area where stations are separated by 50 kilocycles and put an equal field strength about a given listening station. The sets with radio- or intermediate-frequency amplification give a 60-TU discrimination against unwanted signals with some to spare to take care of signals from more powerful stations. If the listener wants to "get out" he imposes a much greater task on his receiver. Suppose he receives 50,000 microvolts from a local station and 500 from a distant station (the example is Mr. Espenschied's). This represents a difference of 100 to 1, or 80 TU in favor of the local station. To reduce the local signals to the same level as the distant station, then, requires a selectivity of 80 TU and to take care of the added 60 TU necessary to reduce the local to the point where its signals will not bother during weak musical passes makes a total discrimination of 140 TU which the receiver must possess. This means a current reduction of the order of 10,000,000 to 1 —a high order of selectivity.

Colored Sockets and Bases

ONE of the most interesting items of news from the "Nema" convention at Hot Springs, Virginia, is that regarding the new color arrangement for sockets and tube bases. According to this code, which was proposed by the Benjamin Electric Company, the bases of radio-frequency and first-stage audio tubes, and the receiver sockets into which these tubes are used, will be colored maroon; the detector will be green, while the final tube, the power amplifier, and its socket, will be colored orange. The arrangement is, therefore, as follows:

MILES	0	1	2	3	4	5	6	7	8
POWER	1	0.9	0.81	0.729	0.657	0.59	0.531	0.478	0.43
"UNITS LOSS"	0	1	2	3	4	5	6	7	8
POWER TO BASE 0.9	0.9^0	0.9^1	0.9^2	0.9^3	0.9^4	0.9^5	0.9^6	0.9^7	0.9^8

TABLE NO. I

Maroon: R. F. and 1st amplifier	201-A, 199, 226
Green: Detector only	200-A, 199, 227
Orange: Power tube only	112, 171, 210, 120

If we wanted to be facetious, we would suggest a crimson tube for Harvard and one for Lindbergh in whatever his favorite color may be.

We wonder what will be done with the other special-purpose tubes, such as the r. f. amplifier tubes with higher amplification factors and consequently higher impedances, rectifier tubes, high-mu tubes for resistance or impedance amplifiers, etc.?

The suggestion, admittedly, provides precaution against the danger of wrecking tubes or receiver through unfamiliarity with the inner workings of a complicated electrical machine. The average user of tubes has very little idea of the functions of the individual parts of his set. In receivers with an unusual arrangement of sockets, he can not know that the third tube from the end is not the detector unless he is warned before, either by reading a more or less dull and technical booklet, or by noting the color of the socket. While this color scheme has much to commend it, it seems somewhat inadequate in its present form.

New A. C. Tubes

THE new R. C. A. tubes marked 226 and 227 operate from raw a. c.; their existence was vigorously denied by representatives of both the R. C. A. and Cunningham staffs only a short time ago. One day, seemingly, the very thought of new tubes is abhorrent to these companies, while the next day complete operating data, photographs, etc., drop into the Laboratory, by special delivery, like a bolt from the blue. In the meantime—that is, between our statement last month and the time of going to press this month—a. c. tubes have been received and tested from the Armstrong Electric and Manufacturing Company, the Van Horne Company, the Sovereign Company, and. the makers of the familiar Marathon tubes. Others proposed or available are the Arcturus, the Schickerling, the Quadrotron, the Zons, and probably others.

These tubes in general use are of two types, those using a low-voltage high-current filament, and those employing an extra heater which is not electrically connected to the receiving circuit. These latter tubes require several seconds to heat up and "get under way." The others are ready for reception as soon as the current is turned on. The R. C. A. has tubes—ready perhaps early in July—of both types; the R. C. A. high-current tube is for all positions except detector, and the heater type is for the detector socket. All of these tubes require different values of filament voltage and current, making the problem for the transformer manufacturer, or the home constructor, difficult, to say the least.

The new a. c. tubes can be used in place of d. c. tubes now in use, but we must admit that with a high-quality amplifier and a high-quality loud speaker, we have not heard a receiver using the a. c. tubes which was as "absolutely without hum" as the advertising would indicate. This, however, may be the fault of the receiver or plate-supply unit design. Time will tell.

Complete data on the various a. c. tubes will be prepared in time to appear in the September RADIO BROADCAST, we hope.

New Apparatus Received

DURING the month of May, the following apparatus has been received in the Laboratory: Frost's new line of rheostats, jacks and sockets; resistances from American Resistor Company, Arthur H. Lynch Incorporated, De Jur, Electro-Motive Engineering Corporation, Aerovox, International Resistance Company, and Amsco; condensers from Aerovox, John E. Fast Company, Dubilier, and Globe Art Manufacturing Company; sockets and cables from Howard B. Jones; A. C. tubes from Marathon, Van Horne, Armstrong, Sovereign Electric and Manufacturing Company; d. c. tubes from the Allan Manufacturing Company, Supertron, Magnavox, and Cable Supply Company; a pair of push-pull, high-quality transformers from Samson; a midget cone speaker from the Alden Manufacturing Company; a fine supply of Benjamin apparatus, including sockets, switches, condensers, etc.; a "Baritone" loud speaker unit; output filters from Federal, Erla, Muter, and Centralab; a new dry rectifier unit from Kodel; X-L binding posts; the Varion, a Raytheon A, B, C unit made by the Morrison Electric Supply Company, and recently described in *Popular Radio*; Marathon's new rectifier tubes; and as this is written, two very beautiful Westinghouse high-resistance volt meters.

The General Radio transformer type 285-N is for use as a coupling device between the element of the string oscillograph and a high-impedance bridge or tube circuit, and not as mentioned recently in these columns.

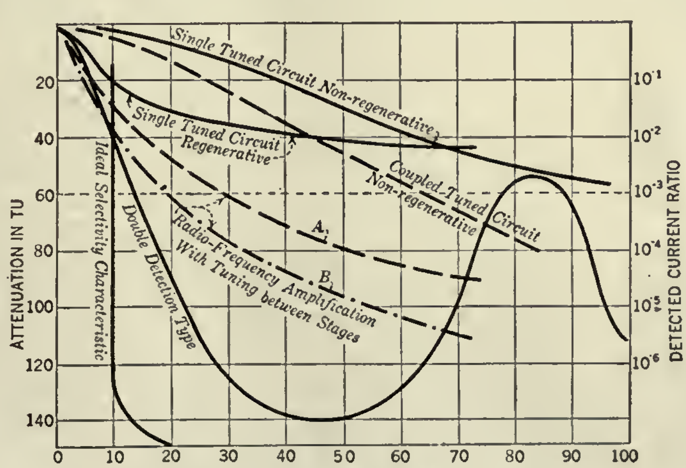


FIG. 1