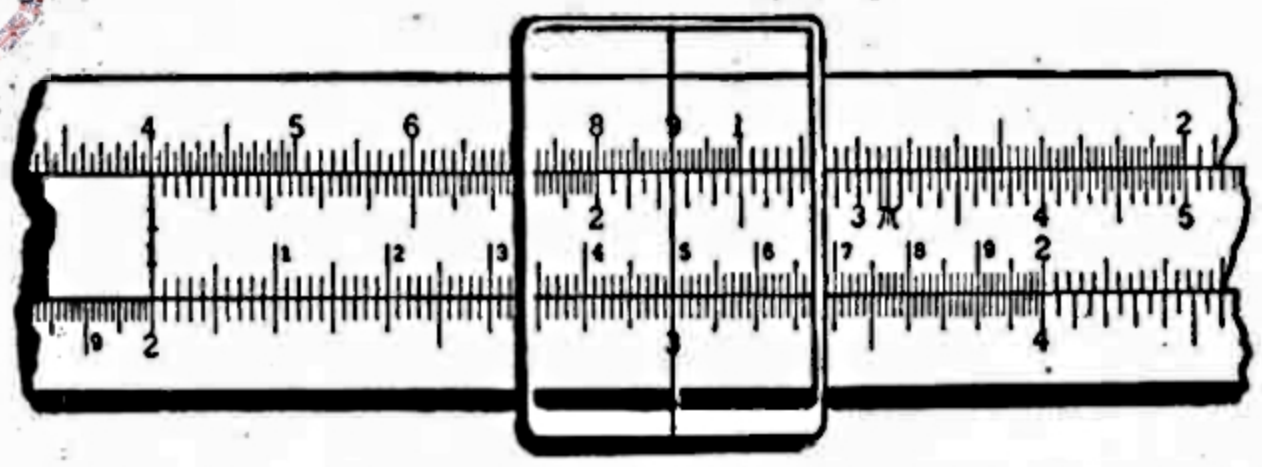
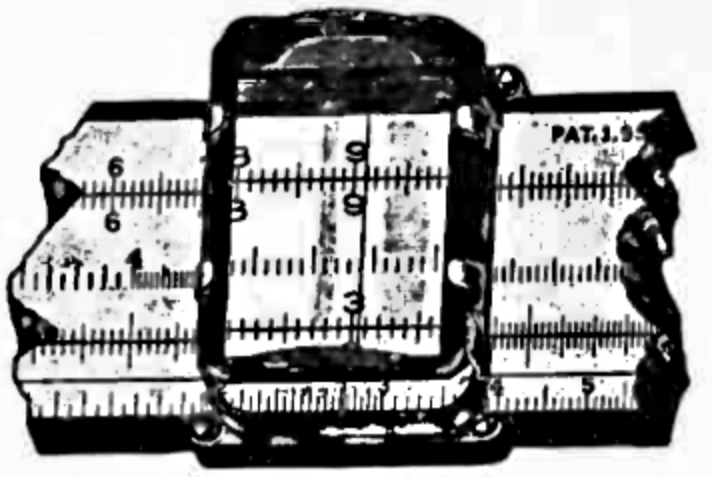


The rule is now set up to multiply 2 by 1.5, to divide 3 by 1.5, or to obtain the square root of 9.



A magnifier makes it easier to read accurately.

Radio and the Slide Rule

By WILLIAM B. MILLER

MANY of the mathematical problems arising in Radio Service work can be solved quickly, easily and accurately with the Slide Rule. Some service men have the mistaken idea that the slide rule is only for engineers, and that one must be thoroughly expert in mathematics to use it. It is really the other way around; problems involving square root can be solved on the rule faster than the problem may be written on paper, and no knowledge of the arithmetical method is needed at all!

Parallel resistors, series condensers, square and cube roots, transformer turns ratios, reciprocals, etc., can all be solved by the slide rule with more than enough accuracy for service work. Instead of a long, detailed exposition on slide rules in general an effort will be made here to present the fundamentals as applied to specific problems encountered by the service man. The theory of the slide rule has been set aside in favor of practical application. In most problems the values will be so familiar to Radio men that the placement of decimal points may be done by inspection, but the simple rules covering these things will be given.

THE RULE AND ITS SCALES

The ordinary slide rule having only four scales on the face is the least expensive and will serve our purpose just as well as the more expensive Polyphase instruments. The stock of the rule has two scales; the A scale across the top and the D scale across the extreme lower edge. Between these is the Slide which also has two scales; the B scale right under the A scale and the C scale just above the D scale. The A and B scales are duplicates of each other, as are the C and D scales.

It will be noticed that the C and D scales are numbered from 1 to 10, while the A and B are numbered to have just twice the range, having two decades. We need not go into why this is so but this arrangement makes it possible to read square roots directly. When you learn to read the rule correctly the square roots of the numbers on A may be found directly under them on D.

The first operation to learn is that of multiplication. This may be performed on either the A and B, or on the C and D scales. As the latter are the ones usually used we will illustrate with them. The numbers 1 to 10 may be given any values, such as .01 to .1; 1 to 10; 10 to 100; 100 to 1000; etc., just so they are multiples or submultiples of 10. There are ten main divisions between each number which represents one tenth of whatever value is assumed for the main numbers on the scale.

To illustrate we will multiply 2 by 1.5.

Set the left index (the first 1), of scale C to the number 2 on scale D, next move the indicator until the hair line passes through the half way mark between 1 and 2 on scale C (this will be the 1.5 mark). Directly under the hair line will be found the answer on D (3). The hair line is used to line up numbers on one scale with numbers on another scale. It is also useful to mark a mid position in an operation requiring the slide to be moved twice in the same problem.

Suppose we had taken 20 x 15 instead, the setting would be the same with different values assigned to the scale, and the answer would be 300. Thus if we take the whole scale to represent 1 to 10 the separate figures are units of one; if we take the scale as 10 to 100 the figures are tens and the subdivisions are ones, and so on. So we may multiply any number by any other number. The scale may even represent .01 to .1 in which case the subdivisions will be equal to .001.

SETTING THE DECIMAL POINT

There are two simple rules, governing the placement of the decimal point in multiplication, that it will be helpful to remember.

RULE ONE:

WHEN THE SLIDE PROJECTS TO THE RIGHT, IN MULTIPLICATION, THE NUMBER OF PLACES TO THE LEFT OF THE DECIMAL POINT IN THE PRODUCT IS ONE LESS THAN THE SUM OF THE NUMBER OF PLACES TO THE LEFT OF THE DECIMAL POINT IN THE FACTORS.

The number of places to the left of the decimal point is referred to—for convenience—as the characteristic. This sounds involved but the following examples will serve to explain it. Consider:

1.5 x 4. equals 6. Here there is one digit (characteristic) to the left of the decimal point in each factor, so by the rule; 1 plus 1 equals 2 (the sum of the characteristics), and 2 minus 1 equals 1, which gives us 6 for the answer and not .6 or 60. The slide projected to the right in this example, as well as the ones following that deal with Rule One.

25 x 30 equals 750. Here there are two digits (characteristics) to the left of each factor, which gives us 2 plus 2 or 4 and 4 minus 1 equals 3, so our answer is 750 and not 7500 or 75.

We have also to consider such problems where the factors are all to the right of the decimal, as: .03 x .02; and, .3 x .3. To apply the Rule here we consider the numbers to the right of and next to the decimal point such as .1, .4, .7, etc., as having a characteristic of zero; those numbers with one cipher after the decimal, such as .02, .08, as having a minus 1 characteristic, two ciphers as a minus 3 characteristic, and so on. If we tabulate these we can see how the Rule is applied.

1.3 x .05

1.3 has a plus characteristic of 1

.05 has a minus characteristic of 1

1 minus 1 is zero and the Rule says minus 1 from that, so our answer is .065.

.2 x .3. Here we have two zero characteristics so the answer has a characteristic of 0 minus 1 and is .06.

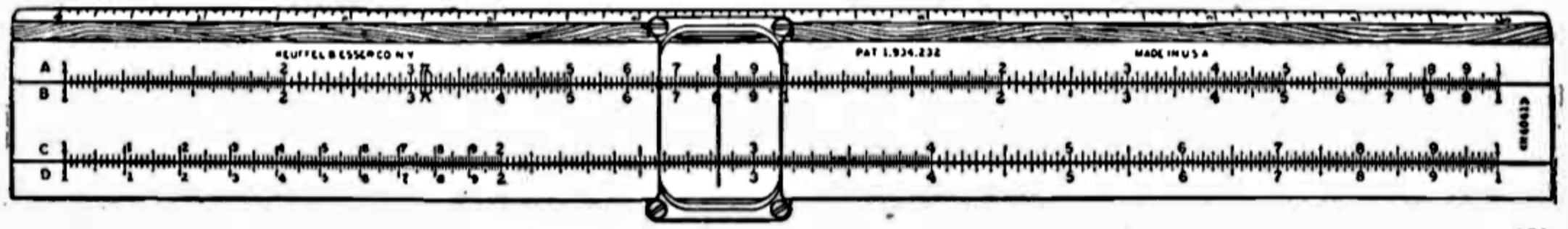
.002 x .004. Each factor has a minus 2 characteristic. 2 and 2 make 4 and 4 minus 1 equals a minus 5 so the answer will have 5 ciphers before the first significant figure. .000008.

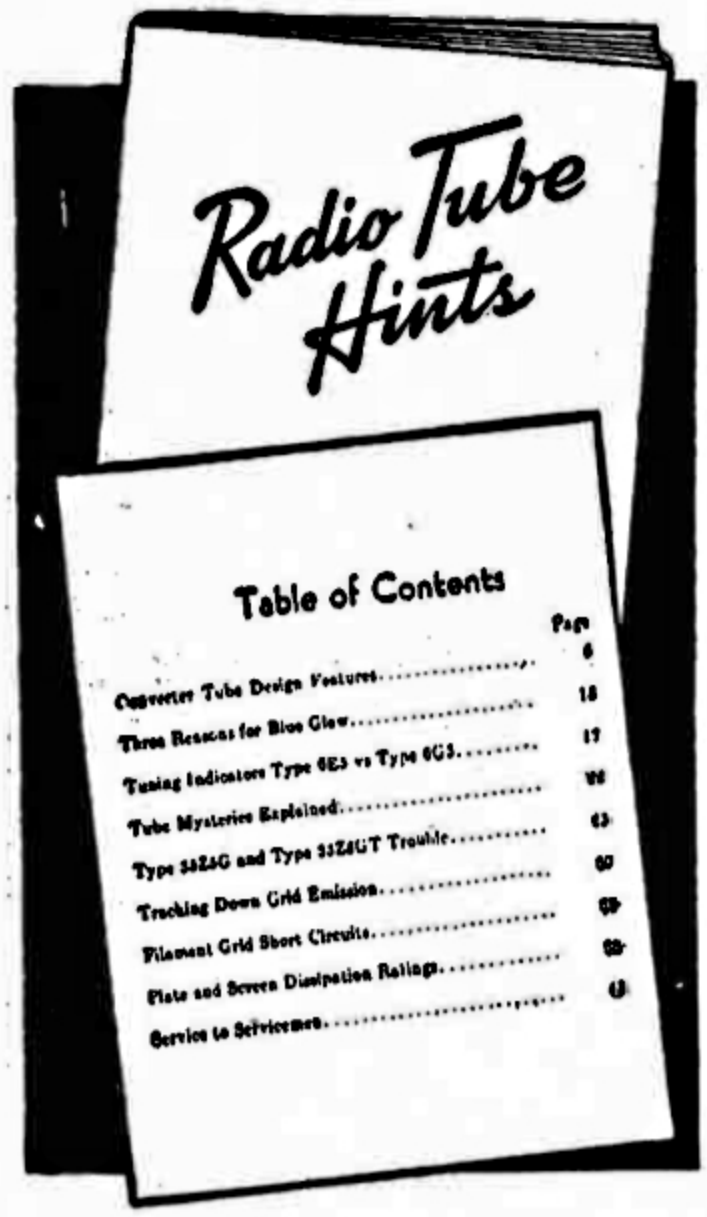
Some problems require that the slide project to the left instead of the right and the rule for this is—

RULE TWO:

WHEN THE SLIDE PROJECTS TO THE LEFT IN MULTIPLICATION THE CHARACTERISTIC OF THE PRODUCT IS EQUAL TO THE SUM OF THE CHARACTERISTICS

(Continued on page 184)





PUBLIC ADDRESS RELAY SYSTEM

(Continued from page 141)

List of Parts Used in Oscillator and Modulator

L—Cathode line, ⅜ inch O.D. copper tubing seven inches long
L—Plate line, ⅜ inch O.D. copper tubing four inches long
Both cathode and plate lines are spaced ¾ inch between centers
L—Copper antenna loop 1 inch wide and 2 inches long
C—See text
C—See text
C—See text
R—I.R.C. 25,000 ohm, 1 watt resistor
M—Triplett 0-50 ma. meter
T—Thordarson small modulation transformer. Hammarlund acorn sockets were used in this oscillator.
Note: In addition to above parts, Johnson insulators were used throughout all three units and Eveready batteries were used to power the transmitter.

List of Parts Used in Receiver Pick-up

ANT—¼ inch brass roll with sliding sleeve. The length can be varied from 15 to 25 inches
C1—National type M-30 mica condenser
R1—I.R.C. 5 megohm ½ watt resistor
C2—Cornell-Dubilier .00025 mica condenser
C3—National type UM, cut down to three plates
L—No. 6 copper wire bent as shown. ½ inch wide and 1¼ inches long
RFC—15 turns No. 20 DCC copper wire, close wound in one layer and bound with collodion
T—Thordarson T-13A34 transformer
C4—Sprague ½ mfd. paper condenser
C5—Sprague .1 mfd. paper condenser
R2—I.R.C. 2500 ohm 1 watt resistor
R3—I.R.C. 100,000 ohm ½ watt resistor
R4—I.R.C. 1 megohm ½ watt resistor
R5—Electrad 50,000 ohm volume control

List of Parts Used in Speech Amplifier

C1, C2, C3, C4, C5, C6—Sprague .05 paper condensers
R1—I.R.C. 3 megohm ½ watt resistor
R2—Electrad 200,000 ohm volume control
R3, R8—I.R.C. 1 megohm ½ watt resistor
R4, R7—I.R.C. 100,000 ohm ½ watt resistor
R5, R6—I.R.C. 25,000 ohm ½ watt resistor

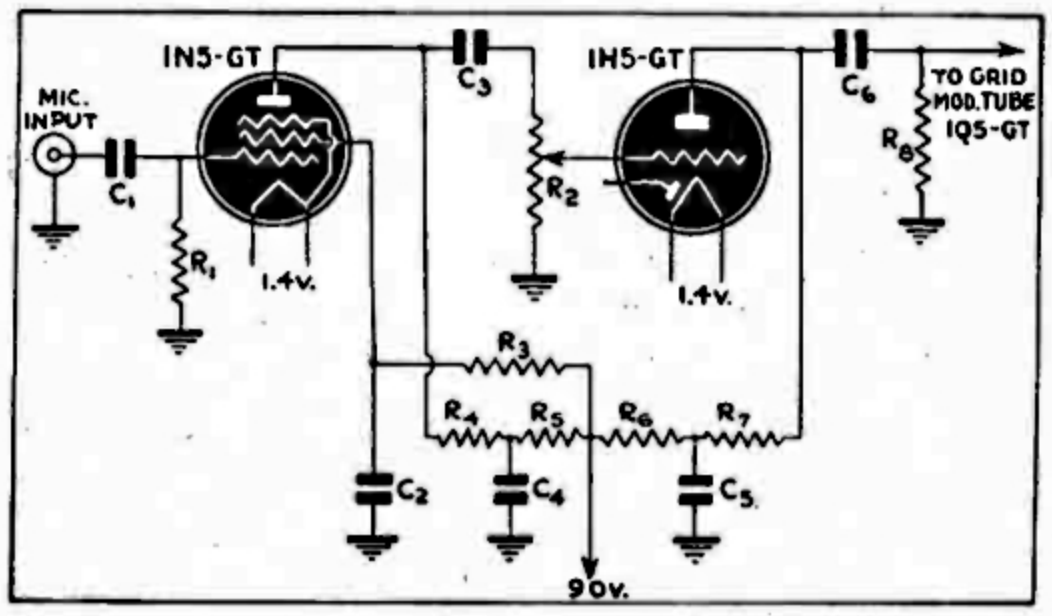


Fig. 3.—The speech amplifier uses a pair of high-amplification tubes to supply sufficient excitation to the grid of the modulator. Diode of the 1H5-GT may be attached to the negative end of the filament or left floating.

SLIDE RULE

(Continued from page 153)

OF THE TWO FACTORS.
Examples:

.07 x .55 equals .0385

.07 has a minus 1 characteristic, .55 has a zero characteristic. Zero added to a minus 1 equals a minus 1 so the answer has one cipher after the decimal.

6.2 x 41. equals 254.2

6.2 equals 1, 41 equals 2, 1 plus 2 equals 3 so the answer is 254.2 and not 2542. or 25.42 or some other number using the same figures.

SOME RESISTOR PROBLEMS

After a little practice in setting the slide to different numbers and learning the close reading of the numbers we are ready to do any problem in multiplication. Although multiplication will not solve all our service problems without the aid of square root and division it is best to learn its rules first and acquire a familiarity with the slide rule before going into the rest of the operations.

Suppose we want to know if a one watt resistor will be heavy enough to carry 3 Ma. with an applied voltage of 325. P equals ExI so we set the left index of scale C to 3 on D, then under 325 on C we will find 975. The characteristic of 325 is plus 3, .003 (3 Ma.) has a minus 2 characteristic. As the rule projects to the right we use Rule One so 3 added to a minus 2 equals 1, and 1 minus 1 equals zero, thus our answer has a zero characteristic and is .975 watts. A one watt resistor would allow no margin for safety, so we use a 2-watt resistor.

To determine which way to set the slide is no problem at all. You will find that if you set the left index of scale C to a number on D (in multiplication) and the other number is off the scale simply reverse the procedure and use the right hand index of scale C.

DIVISION AND SQUARE ROOTS

Division is the reverse of multiplication. To illustrate we will divide 8 by 4. Set the 4 on scale C to the 8 on scale D, then under the left index of C will be found the answer, 2. The divisor is found on scale C and placed in line with the dividend on D, then the quotient is found below the index of C that is not projecting beyond the rule.

To divide 8 by 9 the 9 is found on C and placed over the 8 on D and under the right index of C will be found the answer, .889. To reverse this and divide 9 by 8, the 8 is found on C and put in line with the 9 on D, then under the left index of C will be the answer, 1.125. The rules for placement of the decimal point are just as simple as are those of multiplication.

RULE THREE:

WHEN THE SLIDE PROJECTS TO THE LEFT IN DIVISION, THE CHARACTERISTIC OF THE QUOTIENT EQUALS THE CHARACTERISTIC OF THE DIVIDEND MINUS THAT OF THE DIVISOR.

RULE FOUR:

WHEN THE SLIDE PROJECTS TO THE RIGHT, THE CHARACTERISTIC OF THE QUOTIENT EQUALS THE CHARACTERISTIC OF THE DIVIDEND MINUS THAT OF THE DIVISOR PLUS 1.

In the above examples 9 divided by 8 illustrates Rule Four and 8 divided by 9 illustrates Rule Three.

Now that we can both multiply and divide the slide rule becomes really useful,

even without square root. To illustrate with a few examples:

We want to know what resistance is needed to bias a tube. The required voltage is —16.5 and the rated cathode current is 12 Ma. The formula for this is:

$$R \text{ equals } \frac{\text{Bias volts} \times 1{,}000}{\text{Rated cathode Ma.}}$$

16.5 x 1,000 equals 16,500, we find this on scale D as it is the dividend. The small figures between the 1 and 2 are used. Over this place the 12 on C, then under the left index will be found 1375. As the slide projected to the right we use rule four which, in this case, gives a characteristic of 4, so the required resistor is one of 1375 ohms.

Suppose we have a 25000 ohm resistor and wish to put another one in parallel so that the effective resistance will be 8500. The formula for this is:

$$R2 \text{ equals } \frac{R1 \times Rt}{R1 - Rt}$$

Rt is the multiplier so we set the right index of C to 85 on D, then move the indicator until it is on the 25 mark on C, the hair line will pass through 2125 on D. Do not move the hair line. This is now the dividend, the divisor (R1) is 25000 less (RT) 8500, or 16500 which we find on C and place it under the hair line to correspond with the 2125 mark on D. Then under the left index of C we will find 1289 (1300 would be close enough, or 1250, for practical use).

The slide projected to the left in the multiplication which gave a characteristic of 9 (Rule Two); in the division the slide was to the right so by Rule Four the characteristic of the quotient is equal to that of the dividend, minus that of the divisor, plus 1. The dividend had 9, the divisor (16500) had 5; 9 minus 5 leaves 4, and adding 1 makes 5, so the answer 1289 needs a cipher to make it 12,890 ohms (or 12,500).

EASIER THAN IT SOUNDS

It takes a good deal more time to explain this than it does to do it. With a little practice, a problem like this may be solved in twenty seconds.

When a problem involves both multiplication and division, as did the last one, the intermediate answer need not be read, just mark it with the hair line and note its characteristic, then continue with the division.

The same method is used in figuring series condensers. While in the above example we could have placed the decimal point from experience, it will be found considerably harder to do with series condensers if they are far apart in values. Let us take two condensers and see how it works out.

$$Ct \text{ equals } \frac{C1 \times C2}{C1 + C2}$$

Let C1 be 2.mfd. and C2 be .004 mfd.

C1 x C2 equals .008.

The left index of C is set to the 2 on D and under 4 on C will be found 8 on D. The slide projected to the right so the characteristic will be minus 2 (.008). Set the hair line to this and run the slide back until 2.004 (C1 plus C2) lines up with the indicator, then under the left index of C will be found 3994. By Rule Four the characteristic will be minus 2 making the answer .003994. Notice should be taken that the 2.004 mark is not quite half way between the 2 and the very first division line following it. Setting and reading these close approximations should be practiced and the results checked with paper and pencil until you are sure of your skill.