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A DUAL PURPOSE ELECTRONIC SWITCH

A NEW electronic switch has been developed which incorporates many features not found in previous instruments. The switching rate is approximately 6 to 2,000 times per second, which range permits observation of either extremely low or high frequencies. The switching impulses or tails have been reduced to a point where they are no longer objectionable. In this new device the patterns may be displaced at will to facilitate close observation of each pattern. In addition to its value as an electronic switch this instrument may be used as a square-wave generator between the frequencies of 60 and 400 cycles per second. Its flexibility results in adaptability to many applications.

For the benefit of the reader who is not entirely familiar with this type of instrument and its uses we will begin with a description of the device and its applications. The electronic switch permits the observation of two phenomena at the same time on a single cathode-ray oscillograph. This is accomplished by switching from one source to another at rates of speed that are beyond the capability of the eye. Thus the actual transfer cannot be seen while the retentivity of the eye causes both phenomena to appear as present at the same time. As its name indicates, it is an electronic device and, of course, has no moving or vibrating parts. It is of necessity a comparative device since the single cathode-ray oscillograph has but one synchronizing circuit. Therefore it should be remembered that in order to have both of the patterns stationary they must be the same frequency or some multiple of it.

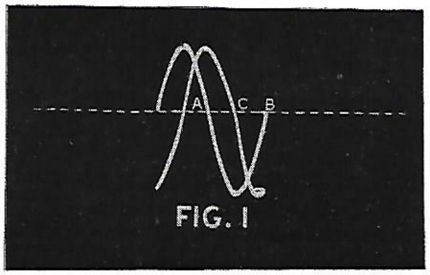

FIG. 1

Its special province lies in the fact that not only can two patterns be compared for amplitude and wave shape but their exact phase relationship can actually be seen. In Fig. 1 we have a typical example of phase difference, and it becomes apparent that we can determine the approximate phase shift by just glancing at the pattern, while if exact measurements are applied to the simple formula of

$$\Delta\theta / AC = 180^\circ / AB$$

we will obtain an accurate result. The question now arises as to how dependable are these results and how much trouble would be involved to check the instrument. Checking can be done so quickly that we recommend that it be done whenever the user feels that he may be outside the range of the instrument or doubts its operation. It should be apparent that if the two inputs are tied together and connected to the frequency under observation that the electronic switch should show these patterns as exactly coinciding, as under these conditions there is, of course, no chance for phase shift. The second part of the test is determining whether the attenuators must be taken into consideration, and within the rating of the instrument there should be no phase shift where one input is attenuated below the level of the other.

How well this is accomplished is best shown in Figs. 2 A B & C. Here we have a frequency of 120 cycles per second applied, with three different stages of attenuation on one of the inputs. Figs. 3 A & B show the results obtained at a frequency of 100,000 cycles which is naturally a far greater test of the performance of the device than the previous illustration. It might be well to point out that the published range at the high frequencies of the instrument was taken at the point where phase shift could be noticed when one channel was attenuated to approximately half the value of the other. You can assume, therefore, that the only place where phase shift is introduced is in the input attenuator and if the problem you have in mind is one in which both levels are practically the same, the rated range can be exceeded considerably.

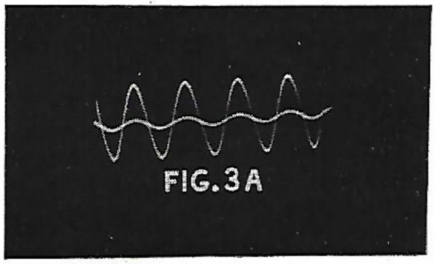
FIG. 3A

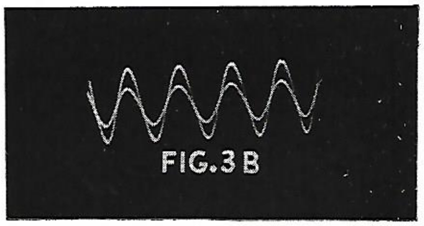
FIG. 3B

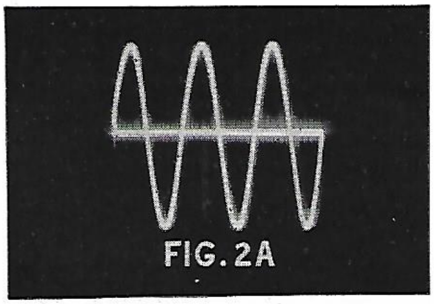
FIG. 2A

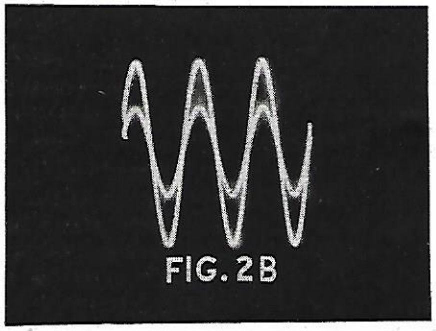
FIG. 2B

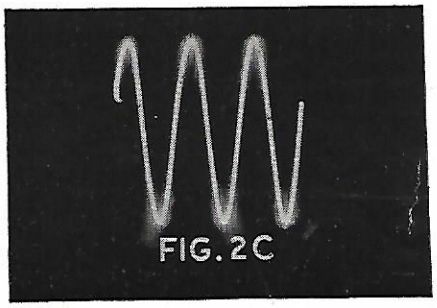
FIG. 2C

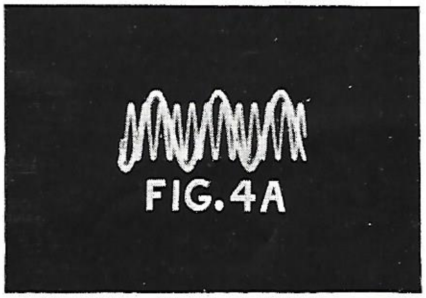
FIG. 4A

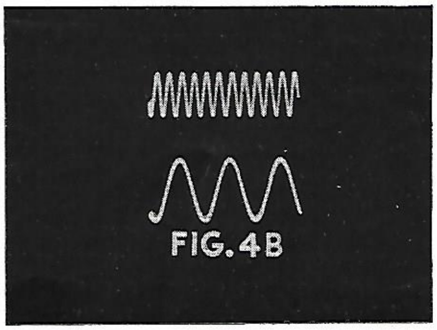
FIG. 4B

Close examination of the illustrations discloses several of the points of interest in the new instrument. First, the switching impulses or tails are reduced to a point where they are not troublesome, and, second, a higher switching rate can be employed which will remove the flickering of the patterns when higher frequencies are studied or photographed.

Another feature makes possible the use of displaced patterns, in other words, the two base lines do not have to coincide and it is permissible to separate the patterns where detailed study is necessary. In Fig. 4A we have the comparison of two frequencies, one of which is considerably higher than the other. Fig. 4B shows how the turning of the balance control allows the patterns to be displaced at will, to facilitate individual observation. It is possible, of course, to encounter a condition where an irregular shaped wave is practically in perfect phase with respect to the timing wave and in cases of this type it is essential to displace the patterns for intelligent results. The switching range has been extended to cover from 6 to 2,000 cycles per second. We have previously covered the fact that this higher adjustable switching rate does keep the jumping and flickering out of higher frequency observations but this is by no means the only advantage of the extended range. For example, a low-frequency transient could not be detected by a slow switching speed but by using a high switching rate it would be found that the dotted line produced will follow the major wave shape, and observation or photography is entirely practical. Fig. 5 was taken at a switching speed of 2,000 times per second and since the transient photographed was of the non-recurrent variety use was made of the single sweep arrangement and the transient itself started the action. The timing wave depicts clearly the point where the transient started and its duration.

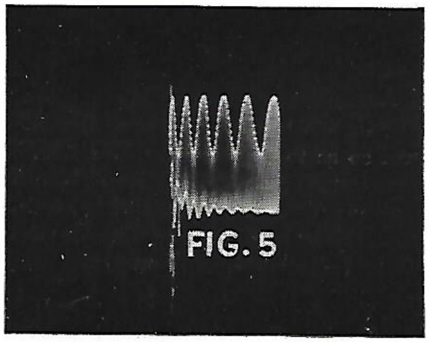
FIG. 5

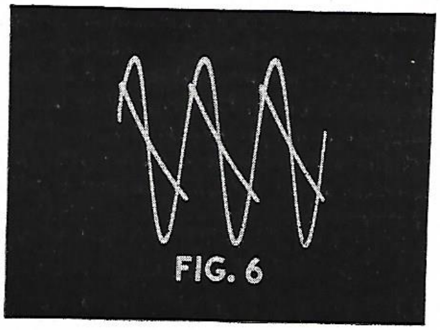
FIG. 6

Another application is shown in Fig. 6, which is a study of the action of the synchronizing control on the sweep circuit of an oscillograph. In it the resulting saw-tooth wave of the sweep circuit is shown in its relationship to the incoming signal applied. The saw-wave can be moved within certain limits by the synchronizing control and the phase easily observed.

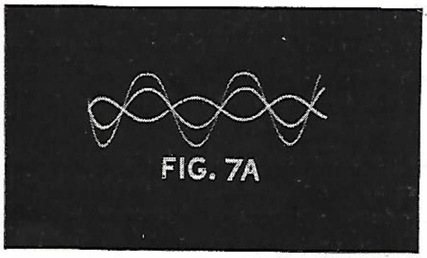
FIG. 7A

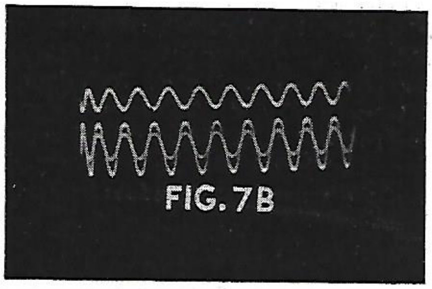
FIG. 7B

Figs. 7 A & B demonstrate the ability of the switch to handle a square wave as well as to generate one. The setup consists of two electronic switches, the output of one being coupled to one of the inputs of the other. This subtracts one channel and we have left the facilities for three patterns. For easy observation the standard or timing wave was switched at a moderate rate to secure a solid trace line while the two variables were switched at a high rate and appear as dotted lines, thereby preventing confusion with the timing trace. By the use of the two balancing controls we can cause all the base lines to coincide or we can displace any or all of the patterns and compare them individually. This is an unusual application but it shows flexibility and convenience of instrument.

So far we have described the applications and performance of the instrument and neglected its simplicity of use and the small number of controls needed. There are but five controls, which are as follows: two input attenuators, the balance or displacement control, the range control which provides four ranges of switching frequency and the fine frequency control which makes these ranges continuously variable. The switching rate does not have to be calibrated or even considered in average use. It can be set at any point that allows the best observation and no consideration of the rate of switching is necessary as there is little or no tendency on the part of the switching oscillator to synchronize with the signal applied. If a switching rate faster than the frequency under observation is used a broken or dotted line will result which, if not desired, can be corrected by simply reducing the switching rate.

The second use of this instrument is as a square-wave generator. It is not claimed that it produces a precision square wave or that the entire switching range from 6 to 2000 cycles is perfectly square. A 10% tailing will not interfere seriously with the results obtained by the electronic switch and this would, of course, be quite noticeable on a square wave form. We do feel, however, that between 60 and 400 cycles the square wave produced is sufficiently perfect to be of considerable value in the laboratory. Fig. 8 is of the square wave produced where the amplifier in the oscillograph is capable of handling the range. While Fig. 9 is the same wave where the range of the amplifier is inadequate. To use as a square-wave source it is only necessary to set the two input controls to zero and turn the balance control so as to displace the base line. With the present popularity of the square wave as a means of checking amplifiers, it is not believed necessary to explain its use in detail in this article.

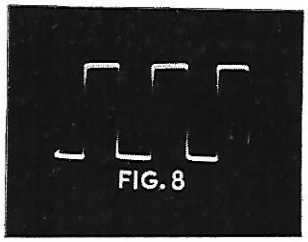

FIG. 8

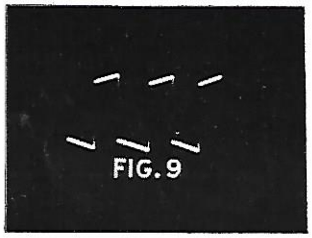

FIG. 9

The uses for an electronic switch are too varied to discuss in detail and the number of applications possible depend upon the ingenuity of the circuit engineer. Anything that can be converted into electrical energy such as sound, light, vibration, motion, etc., can be compared with some other phenomena or standard. Its value to such applications as the study of synchronizing circuits in television, power-line transmission, design of shaded-pole electric motors, motor studies such as compression, etc., is unquestioned. It is equally of value in the educational field where the visual demonstration of the calculated change is desired.

By NORMAN C. HALL

ALLEN B. DU MONT LABORATORIES, Inc.
2 Main Avenue, Passaic, New Jersey

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