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A New 100 KC Counter for Use in Electronics and Industry

ONE of the most useful and interesting of the new *-hp-* electronic measuring instruments is the electronic counter. This instrument counts electrical impulses with a high degree of accuracy—then displays the counted sum on a direct-reading digital system (Figs. 1 and 2). In accuracy the *-hp-* electronic counters are equal to high-quality secondary frequency standards. Operation of the counters is simple; unskilled personnel use them with ease.

For general-purpose electronic work, an electronic counter is most valuable when it is capable of counting up to high frequencies. Such a high-speed counter is the *-hp-* Model 524A which was described in an earlier issue.[1] That instrument directly measures frequencies as high as 10 megacycles.

Many applications, however, do not require the high speed of a 10-megacycle counter. Some of these applications lie in the electronic field; others lie in the industrial field. In either case, the new *-hp-* Model 522B will solve many of the measurement problems that arise.

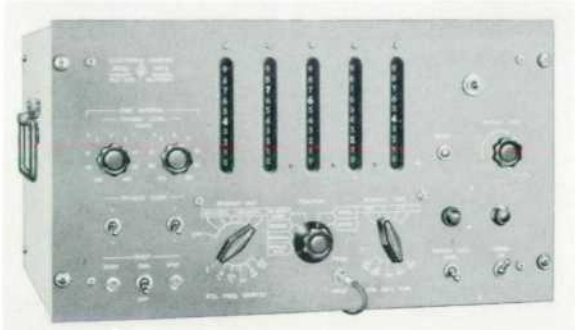

Fig. 1. *New -hp- Model 522B Electronic Counter operates up to 100 kc and includes provision for time interval and period measurements.*

The new 522B has a maximum counting rate of 100 kc and is arranged to make five types of measurements:

1. Frequency. The frequency can be periodic as with electrical frequencies—or random as with nuclear particles.
2. Period (1/f)—the time necessary to complete 1 cycle of an unknown frequency. A panel switch also permits measuring the average of 10 periods to obtain greater accuracy. Period measurements are especially useful for measuring low frequencies. Period measurements can be made of frequencies as low as 0.00001 cps.
3. Time interval—the time between two events. Intervals from 10 microseconds to 100,000 seconds can be measured. An adjustable "threshold" feature is included so that only signals of desired amplitude and polarity will start and stop the measurement.
4. Total events—up to a maximum of 100,000 events. An output connection is provided to operate an external electro-mechanical register to increase the counting capacity if desired.
5. Time ratios for distance measurements. By counting a frequency whose period is equal to propagation time per unit distance, the displayed value will be given directly in distance. Time ratios up to 100,000:1 can be measured.

[1] A. S. Bagley, "The High-Speed Frequency Counter—a New Solution to Old Problems," Hewlett-Packard Journal, Vol. 2, No. 5, January, 1951.

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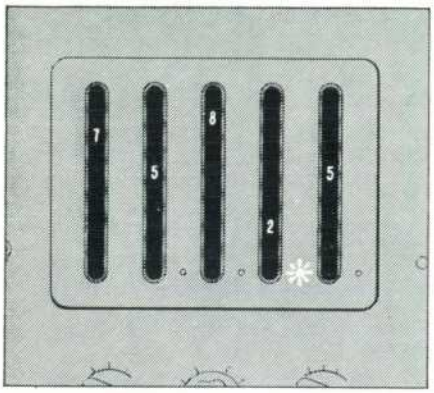

Fig. 2. *Display system of -hp- Model 522B. Illuminated decimal point is automatically located by selector switch.*

The value counted by the instrument is displayed on the system shown in Fig. 2. The display system consists of five columns of numbers with small neon lamps that illuminate the counted value.

The display system is direct-reading in frequency (or total events) and in time. For example, the answer indicated in Fig. 2 would be 7582.5 cycles if frequency were being counted or 7582.5 milliseconds if period or time interval were being measured.

A feature of the display system in the 522B is that the decimal point in the answer is automatically located for each position of the selector switches. The decimal point is illuminated for easy identification. Also, the units in which the answer is displayed (kilocycles, seconds, etc.) are directly indicated by the selector switch.

ELECTRONIC APPLICATIONS

The 522B has many applications in electronic and electrical work. The instrument greatly simplifies frequency calibrating and measuring in the region below 100 kc. All that is necessary for such measurements is to connect the unknown frequency to the input and adjust the selector switch to a position giving a suitable gate time. The measured value is then directly displayed.

Other electronic type measurements that can be made include pulse rate, pulse length, time interval, relay and solenoid operating times, nuclear counting, frequency stability, and the frequency characteristics of networks including sharply tuned networks.

One of the special features useful in time measurements is the adjustable threshold feature. The threshold feature is primarily intended to permit the instrument to discriminate against noise in time interval measurements, but is also useful for other measurements. In Fig. 3, for example, the problem is to measure the duration of various levels of the waveform shown. For this type of measurement the 522B is arranged so that it will "start" and "stop" on either positive- or negative-going voltages. Also, the voltage level for the start and stop are separately adjustable between −100 and +100 volts. This arrangement makes it possible to measure separately the duration of each step of the voltage.

INDUSTRIAL APPLICATIONS

The basic function of the 522B is counting electrical signals or impulses. In electronic and electrical work such impulses ordinarily are readily available for measurement.

In industrial work many mechanical characteristics can be measured by converting the mechanical event being measured into electrical impulses. This is readily done by use of various transducers and photoelectric devices. For example, one of the important uses of the new 522B is in measuring velocity of motion. In general, the motion can be either

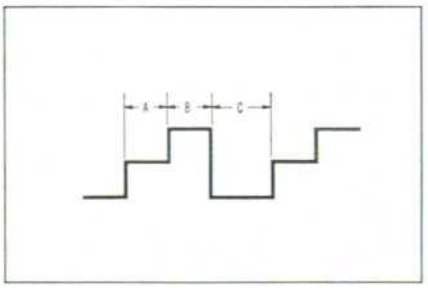

Fig. 3. *Threshold feature for time interval measurements permits measurement of duration of each step of voltage.*

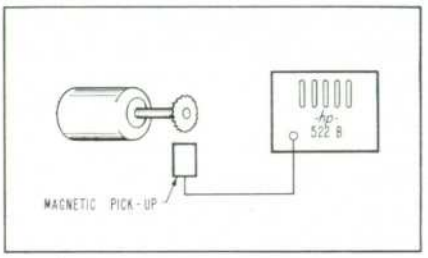

Fig. 4. *Set-up for measuring rotation of high-speed shaft.*

linear, as in measuring projectile velocity, or rotational, as in measuring rpm of centrifuges, jet engines, etc.

Methods for measuring linear and rotational velocity with the 522B are shown in Figs. 4 to 7. In Fig. 4 the rpm of a high-speed shaft is to be measured. To convert mechanical rotation into electrical impulses, a gear is attached to the shaft and is arranged so that its teeth pass a magnetic pick-up type transducer.[2] As each gear tooth passes the pick-up, an electrical impulse is generated. This impulse is applied to the 522B where its frequency is measured. The measured frequency will be proportional to the number of teeth in the gear and should therefore be divided by the number of teeth. The 522B measures at rates up to 6,000,000 impulses per minute, so that even highest speed rotating devices can be measured with this arrangement. By using a gear with 6 or 60 teeth, the reading can be obtained directly in rpm.

When the shaft to be measured has a keyway or other irregularity, the measurement can often be made without attaching a gear. The magnetic pick-up can simply be placed near the shaft; movement of the keyway past the pick-up will then result in the voltage necessary for the measurement.

Another type of measurement that can easily be made with the 522B is the measurement of mechanical "slip" encountered in fluid couplings. This measurement is illustrated in Fig. 5. At the driving and

[2] Transducers of this type complete with gear are commercially available.

load ends of the coupling are inserted identical gears which pass magnetic pick-ups as before. The pick-ups are connected to the 522B through a selector switch so that the rpm of each gear can be measured. The difference in the two readings divided by the number of teeth in one gear is the slip. Where this type of measurement is to be made often, the necessity for switching can be avoided by connecting the pick-ups to an *-hp-* Model 510 mixer. This instrument produces an electrical signal whose frequency is the difference of the two frequencies applied to it. This difference frequency can then be measured with the 522B.

In some industrial applications, it is desirable to measure rotational velocity without mechanically loading the rotating device in any way. This problem can be nicely solved by use of techniques involving light sources and phototubes combined with the 522B.

A convenient light source and phototube arrangement is available as the *-hp-* Model 506 Tachometer Head. The head is arranged so that light from the self-contained source is reflected from the rotating shaft back to the phototube (Fig. 6). The motor shaft is prepared in advance so that half of its surface is light-reflecting, while the other half is light-absorbing. As the motor shaft rotates, the light reflected to the phototube will be modulated at the

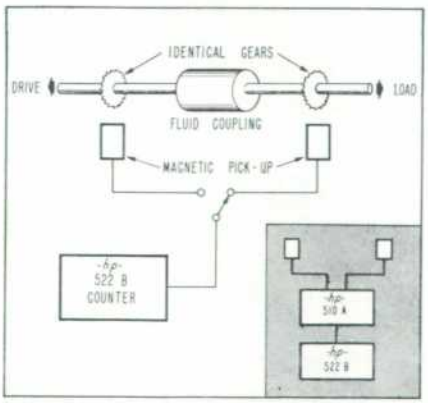

Fig. 5. *Set-up for measuring "slip" in fluid coupling. -hp- 510A mixer can be used to make slip measurements direct-reading.*

velocity of rotation of the shaft. The output of the phototube is a voltage having the same frequency as the rotation of the motor shaft. This frequency is directly indicated by the 522B.

The 522B is arranged with a d-c source which, with an accessory adapter, will supply the phototube in the 506B.

For some measurements the 522B can be combined with other instruments to obtain two types of information in a single measurement. Such a set-up is illustrated in Fig. 7. The problem is to study blade growth in a high-speed turbine. A magnetic pick-up is located so that as blade growth occurs, the output of the pick-up will increase. This increase is measured with an *-hp-* Model 400C VTVM. The frequency

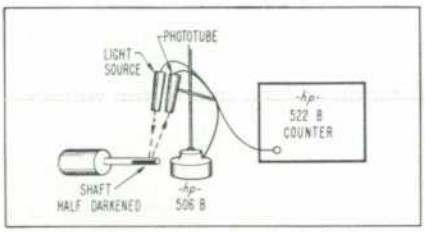

Fig. 6. *Set-up for measuring shaft rotation using -hp- 506B Tachometer Head.*

characteristics of the blade growth are measured by the 522B.

Linear velocity can be measured most conveniently by the time interval method. For this measurement the 522B displays time interval directly in seconds or milliseconds. Interrupted light beams operating into phototubes can be used to provide the 522B with the necessary impulses for velocity or time interval measurements.

Linear velocity can also be measured in some cases by coupling a rotating device to the linearly-moving object. The rpm of the rotating device is then measured and related to the linear velocity.

Other quantities that can be measured in combination with suitable transducers include distance, thickness, weight, pressure, shutter speed, liquid level, etc.

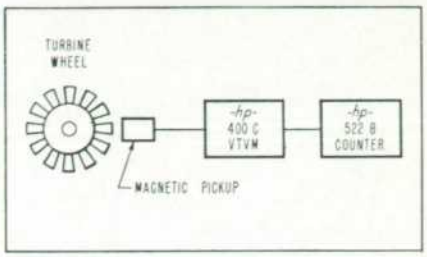

Fig. 7. *Set-up for investigating blade growth in turbine wheels.*

BASIC CIRCUITRY

Fig. 8 indicates the basic circuit arrangement of the 522B. The frequency or impulses to be measured are applied to an electronic gate. When the gate is open, the impulses are passed to the counter circuits. When the gate is closed, the counters display the counted value. The operation of the gate is such that it is open for accurately-determined time intervals from 0.001 to 10 seconds. The counted value is thus displayed directly in frequency.

The gate is designed to have a short opening and closing time of a few microseconds. This time represents but a fraction of a cycle at the 100 kc maximum counting rate specified for the instrument. The gate is therefore positive in its operation, although any gate has an inherent possible error of 1 count on an arbitrary frequency.

The time of opening and closing of the fast gate is controlled by the time base generator through the gate flip-flop. The flip-flop performs the actual operation of opening and closing the fast gate and also actuates the resetting circuit shortly before opening the gate. The resetting circuit clears the counting circuit

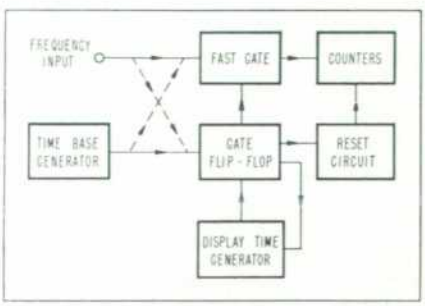

Fig. 8. *Basic circuit arrangement of -hp- Model 522B.*

preparatory to making the next count.

For period and interval measurements, a panel switch interchanges the time base generator and frequency input connections as indicated by the dashed lines in Fig. 8. When the circuits are so connected, the counters count the output of the time base generator for the interval between two of the events whose interval or period is to be measured.

When period and interval are being measured, the time base generator supplies the counting circuits with any one of six, accurate frequencies: 100, 10, and 1 kc, and 100, 10, and 1 cps. When frequency is being measured, the time base generator opens the fast gate for time intervals of 0.001, 0.01, 0.1, 1, or 10 seconds as desired. All of these standard frequencies and time intervals are accurate within 0.001% so that the instrument has a high degree of precision.

One of the features of the circuit is that it includes a variable display time controlled by a panel knob. The knob adjusts the display time over a range from 0.1 to 10 seconds. A switch position at the end of the control range provides for continuous display.

The instrument is also arranged to count events over long periods of time or until it reaches its maximum capacity of 100,000 counts. When so operated, the counting period is started and stopped by a manually-operated switch on the front panel. The count capacity can be increased by using an external electro-mechanical register.

ACCURACY

The time base generator in the instrument is accurate within 0.001%. The generator consists of a crystal-controlled oscillator operating at 100 kc with a series of positive-acting frequency dividers. The crystal for the oscillator is oven-controlled.

On frequency measurements the accuracy of the instrument is the sum of the tolerances of the time base generator and the fast gate. As described before, the fast gate has a possible error of ±1 count. Thus, on 1-second gate times, the instrument has an accuracy of 0.001% ±1 cps or, on a 10-second gate, 0.001% ±0.1 cps.

On period measurements, the unknown frequency becomes the time base and the frequency of the time base generator is counted by the counting circuits. Since the rate-of-change of low frequency voltages is small, the tolerance in the operation of the time base amplitude discriminator must be considered. The performance of the discriminator is such that the accuracy of period measurements is within 0.03% plus or minus the 1 count possible error of the counter circuits.

For time interval measurements, the accuracy will be within 0.001% plus or minus one period of the standard frequency counted (100, 10, or 1 kc, and 100, 10, or 1 cps).

NEW 522A 1-SECOND COUNTER

Another new *-hp-* counter is the *-hp-* Model 522A. This instrument is designed for applications requiring a basic frequency counter without provision for time interval or period measurement. The 522A has a maximum counting rate of 100 kc and a maximum capacity of 100,000 counts.

The counting period of the 522A is fixed at 1 second. The accuracy of the instrument is the same as the accuracy of the 522B (.001% ±1 count).

—E. A. Hilton

THIRD CONFERENCE ON HIGH-FREQUENCY MEASUREMENTS

Under the joint sponsorship of AIEE, IRE and the National Bureau of Standards, the Third Conference on High-Frequency Measurements will be held in Washington on January 14-16, 1953. This Conference will follow the pattern of similar meetings held in 1949 and 1951 and will be devoted exclusively to the techniques and problems of high-frequency measurements, with particular emphasis on new developments.

SPECIFICATIONS
-hp-
MODEL 522B
ELECTRONIC COUNTER

FREQUENCY COUNTING

Range: 100 kc maximum.

Accuracy: ± 1 count ± .001% (± .1 cps ± .001% on 10 sec. gate).

Input Requirements: 2 volts peak minimum.

Input Impedance: Approximately 1 megohm, 50 mmf shunt.

Gate Time: .001, .01, .1, 1, 10 seconds. By use of manual switch on panel, measurements can be made for any integral multiple of 10 seconds (i.e., 20, 30 . . . 200, 210 seconds, etc.).

Display Time: Continuously variable from 0.1 to 10 seconds. In manual operation will display until reset.

Direct reading in cps or kc with decimal point indicated.

PERIOD MEASUREMENT

Range: 0.00001 cps. to 10 kc.

Accuracy: 0.03% ± 10 μs.

Input Requirements: 2 volts peak minimum.

Input Impedance: Approximately 1 megohm, 50 mmf shunt.

Gate Time: Counts for 1 cycle or 10 cycles of input signal.

Display Time: Same as for frequency counting.

Direct reading in seconds or milliseconds with decimal point indicated.

TIME INTERVAL MEASUREMENT

Range: 10μs to 100,000 seconds.

Accuracy: ± .001% ± 1 count of reference frequency.

Minimum Input Requirements: 2 volts peak with 10 volts-per-second minimum rate-of-rise.

Input Impedance: Approximately 250,000 ohms, 50 mmf shunt.

Independent Start and Stop Channels: May be set to trigger for either positive-going or negative-going input voltages at levels from — 100 to + 100 volts.

Display Time: Same as for frequency counting.

Direct reading seconds or milliseconds with decimal point indicated.

CONNECTORS

Standard BNC type.

PRICE: $900.00 f.o.b. Palo Alto, California.

MODEL 522A

Similar to *-hp-* 522B, except gate time is 1 second only and decimal point register is omitted. Provisions for period or time interval measurement not included.

PRICE: $775.00 f.o.b. Palo Alto, Calif.

Data subject to change without notice.