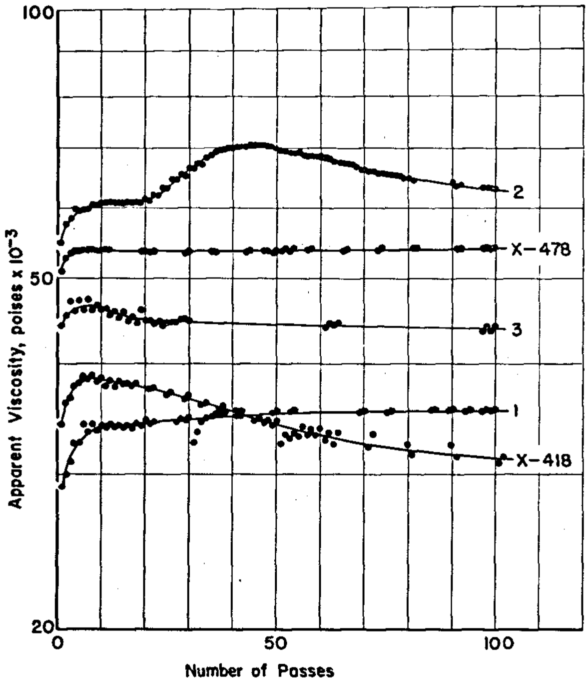


The improved McKee worker-consistometer has proved useful for studying the effect of working on the apparent viscosity of five synthetic (GR–S) rubbers. Specimens *1, 2,* and *3* are experimental samples; *X–418* and *X–468,* commercial products. Temperature—212° F.; rate of shear—99 reciprocal seconds.

The McKee worker-consisometer has also provided important data on the effect of working on the viscosity of five GR–S rubbers: two in commercial production and three special experimental samples. In these tests, 100 passes were made with each sample at a rate of shear of 99 reciprocal seconds and at a temperature of 212° F. There was an increase in viscosity in each case during the first few passes, after which the behavior was different for different samples.

One of the chief advantages of the worker-consistometer is that various materials may be worked and their flow characteristics measured in the same series of operations. The multi-hole disks give flexibility in covering wide ranges of rates of shear and consistency. Moreover, the constant-speed drives permit operation at constant rates of shear and extend the range to high viscosities. The investigations at the National Bureau of Standards indicate the potentialities of the apparatus in the study of the effect of temperature, rate of shear, and mechanical working upon the apparent viscosity of any non-Newtonian materials having thixotropic properties. In fact, the McKee worker-consistometer has already been used to determine consistencies of materials ranging from a light lubricating grease up to and including 100-percent raw rubber.

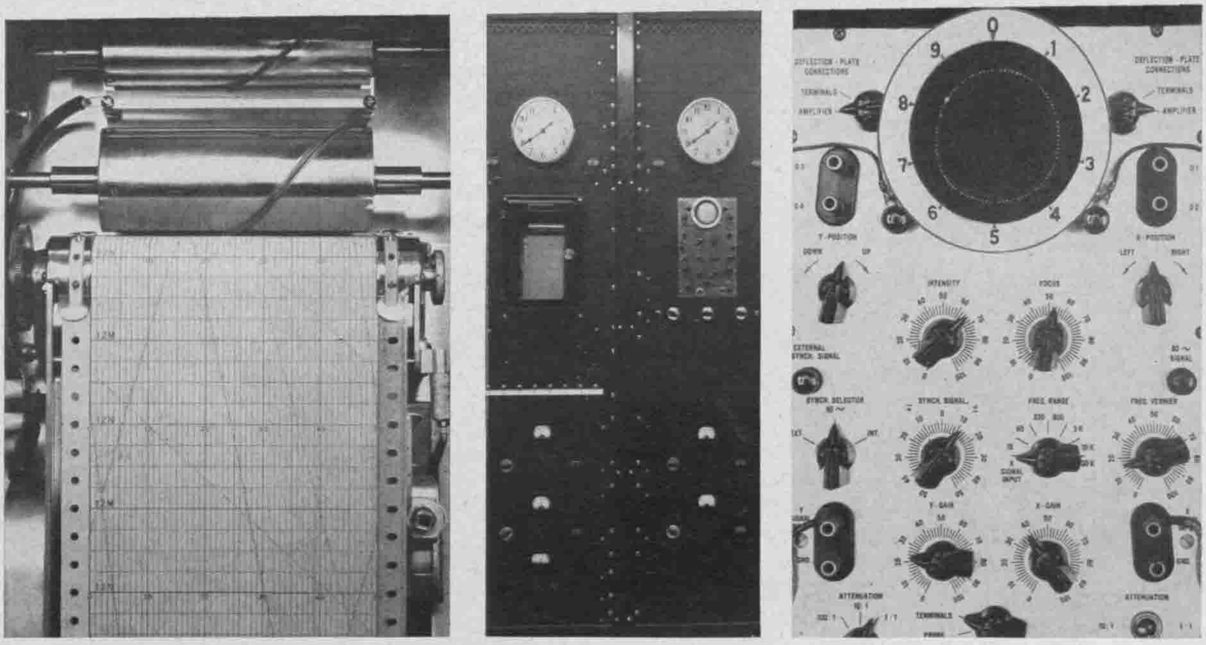
For further technical details, see The McKee worker-consistometer with constant-speed drives, by *S. A. McKee and Hobart S. White, J. Research NBS,* ***46,*** *18 (1951) RP2710. The earlier model of the worker-consistometer is described in NBS Technical News Bulletin* ***33,*** *10 (1949); and ASTM Bulletin No. 153, p. 90 (August 1948).*

New Spark Chronograph and Chronoscope

The National Bureau of Standards' system for monitoring the precision time-keeping of a group of standard crystal clocks has been further refined by J. M. Shaull and C. M. Kortman of the Bureau staff. This refinement consists of an improved spark chronograph and chronoscope, which together record time differences as small as 20 millionths of a second. The new development may be easily applied to checking stability of oscillators and frequency dividers and rating clocks and chronometers over long periods of time. The method is now being applied, in principle, by watchmakers for the rapid adjustment of watches and clocks.

The spark chronograph records time differences of two clocks to 1 millisecond by linearily sweeping a spark discharge point across the waxed paper strip of a specially designed recorder. The chronoscope uses the visual characteristics of the cathode-ray tube to increase the resolution of the chronograph to 0.02 millisecond. Together these instruments constitute a reference clock with which all other crystal clocks comprising the primary standard, including those of the NBS radio station WWV, may be intercompared.

The improved spark chronograph includes a single-turn helix wound on a rotating drum driven by a synchronous motor. Beneath the drum is an insulated knife edge over which a strip of waxed paper slowly passes. A high-voltage pulse causes a spark to jump from the knife edge to the nearest point of the helix, perforating the paper, melting the wax and thus leaving a permanent record. Should the motor driving the drum be supplied by subfrequencies from a standard oscillator while the high-voltage pulse is controlled by another crystal clock, a recorded picture of the relative rates is readily obtained. If the drum-control frequency is equal to the spark-control frequency, each time a spark occurs the rotating drum turns through an angle which is an exact multiple of 360°. Thus, the same point on the helix will be opposite the knife edge, and the record on the waxed paper will be straight line running vertically up the chart. However, should there be a difference in frequencies, the drum will rotate through a greater or smaller angle, causing a different point on the helix to be nearest the knife edge at the time of the spark. As a result, the record will slope to the right if the clock controlling the spark is running faster, or to the left if the clock is running slower. The difference in rates may be evaluated by measuring the amount of displacement over a given period. If the spark-generating equipment is switched, in turn, to each of several clocks, the chronograph provides a convenient method of intercomparing and recording their operation. In practice, a motor-driven switching unit



The improved spark chronograph and chronoscope are shown in the rack (center). The spark chronograph (left) consists essentially of a one-second and 1/10-second drum (top of case). A spark from a knife edge behind the drum strikes the helix and pierces the waxed paper recording strip. The chronoscope (right) visually indicates the differences between two clocks to within 0.02 millisecond.

connects each clock to the spark generator every 15 minutes. In addition, push buttons permit manual checking of a particular clock at any time.

The rotating drum is made of stainless steel; a helical groove is cut into its surface, and a steel spline is soldered into this groove. The synchronous motor drives the drum at a rate of 10 revolutions per second, causing the helix to cover a time interval of 0.1 second per sweep. The length of the drum is 5 inches, and the paper is of the same width; thus 0.001 second is represented by 0.05 inch across the paper chart. The chart is ruled with 10 lines per inch, and values are easily interpolated to the nearest millisecond.

Because the drum rotates at 10 revolutions per second, some method is needed to indicate in which tenth of a second the helix is turning. For this purpose, a smaller drum is mounted above the major one and is geared down to rotate at a speed one-tenth as great, and passes over another knife edge that is divided into 10 parts. A switch is provided so that the high-voltage pulses can be applied to the smaller drum and the tenths position noted visually.

A pulse-shaping circuit provides the desired pulse for spark generation with different types of input signals. Tests with sine-wave input have shown that the circuit will operate between 10 and 400 cycles when less than 10 volts rms is applied, and over a much wider range with greater amplitude.

As the chronograph records only to 0.5 millisecond, the chronoscope was developed primarily as a vernier device to permit the determination of long intervals with greater accuracy. In this instrument, the output of one crystal clock and frequency divider is used to produce a circular sweep with small, fixed marker dots on the face of a 3-inch cathode-ray tube. A pulse from another crystal clock produces a large bright spot on the sweep. By observing the position of this spot in relation to the marker dots, it is possible to measure relative time changes within a very small fraction of the interval required for one circular sweep. The time base and marker frequencies are obtained from the same frequency dividers that supply the chronograph drive, so that the chronograph and chronoscope are locked in time phase just as are the minute and sweep-second hands of a conventional clock mechanism.

The circular sweep is obtained by applying 100-cycle voltages in phase quadrature to the deflection plates of the cathode-ray tube. Thus a 360° sweep is accomplished in 0.01 second. The grid of the cathode-ray tube is biased below cut-off, so that no trace appears on the face of the tube except when a positive pulse is applied with sufficient amplitude to let the tube conduct. A 10-kilocycle signal applied to the grid therefore produces a circle composed of 100 dots, each 0.1 millisecond apart. Reference points are produced by a 1-kilocycle sine wave shaped to give negative pulses just wide enough to blank out every tenth one of the 10-kilocycle dots. Thus the cathode-ray tube shows ten groups of nine dots, each separated by a blank space. The signal to be measured is fed to the chronoscope as a strong positive pulse, which places an enlarged dot on the face of the tube. The entire circular sweep represents 0.01 second, while the distance between dots corresponds to an interval of 0.1 millisecond. By estimating fifths between the small dots, the position of the larger dot may be determined with sufficient accuracy to measure the change in relative time, as kept by two clocks, within 0.02 millisecond.

For greater resolution a larger cathode-ray tube may be used to increase the span between adjacent markers. For greater accuracy, 100-kilocycle markers could also be added. Another possibility is the use of a second chronoscope starting with either a 1-kilocycle or 10-kilocycle time based and using 100-kilocycle or 1-megacycle markers to permit higher resolution.

Precise measurements of time and frequency are becoming increasingly important in many technical fields—for example, in long-range radio navigation systems, in the upper range of the microwave region where atomic systems can serve as electronic components, and in basic research in microwave spectroscopy and molecular structure.

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*Reprints from Journal of Research, volume **45**, number 5, November 1950.*

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RP2146. An improved apparatus for determining moisture in rubber by distillation with toluene. Max Tryon. 10 cents.

RP2147. Porcelains within the beryllia field of the system beryllia-alumina-zirconia. Stewart M. Lang, Laurel H. Maxwell, and Milton D. Burdick. 10 cents.

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