Inexpensive Micromanometer

Walter R. Debler
Department of Engineering Mechanics, The University of Michigan, Ann Arbor, Michigan 48104
(Received 24 May 1966)

An inexpensive manometer has been constructed to measure pressure differences of the magnitude that one is able to observe with commercially available micromanometers. The principal advantage of this new instrument is its low cost and, therefore, its more general availability. Figure 1 shows the general construction features as well as the heart of the instrument, a dial indicator that moves up and down on a vertical rod to measure the changes in fluid elevation associated with changes in pressure. This indicator with a range of 10 cm (2 in.) can be purchased from a mail-order house for about $30. It is the most expensive piece in the manometer. There is no need of having a costly and accurately made lead screw. A commercially threaded brass rod was used in the instrument that is illustrated.

Other design details are the use of nylon sleeve bearings to support the dial indicator and manometer tube assembly on the vertical rod; a loose sleeve on the rod to act as a stop and thereby prevent the indicator from being jammed inadvertently against the upper horizontal support; a bull's-eye level on the topmost horizontal surface; and a drive nut that was free to translate but not rotate on the threaded rod. If the nut can move horizontally relative to the indicator tube bracket, painted white in Fig. 1 (left photograph), the nut does not become jammed on the threads due to any misalignment between the drill rod column and the threaded rod. The unit that is illustrated has a drive nut with a tab which moves in a slot. This permits the nut to move parallel to the plane of the front of the instrument. No great amount of precision machining is necessary to produce the instrument. A unit, not shown, was made out of commercially available aluminum sections that were hand riveted together. The first model of the manometer had an aspirator bottle for the reservoir. This has an opening on the side, near the bottom. The fact that it was readily available and required no machining made it appear suitable; however, the large volume of air that was situated above the liquid in the reservoir had an adverse effect on the response of the instrument. Design modifications could have rendered the bottle useful as a reservoir but instead it was decided to fabricate the one that is illustrated.

The 10 cm dial indicator does not give the range of pressure readings that is available with some commercial instruments. Nevertheless, for the uses for which it is intended, measurements in a low speed wind tunnel and student laboratory use, it has proved to have the sensitivity of its more expensive counterparts. The manometer is almost 25 cm high and this, coupled with its light weight, makes it very portable.

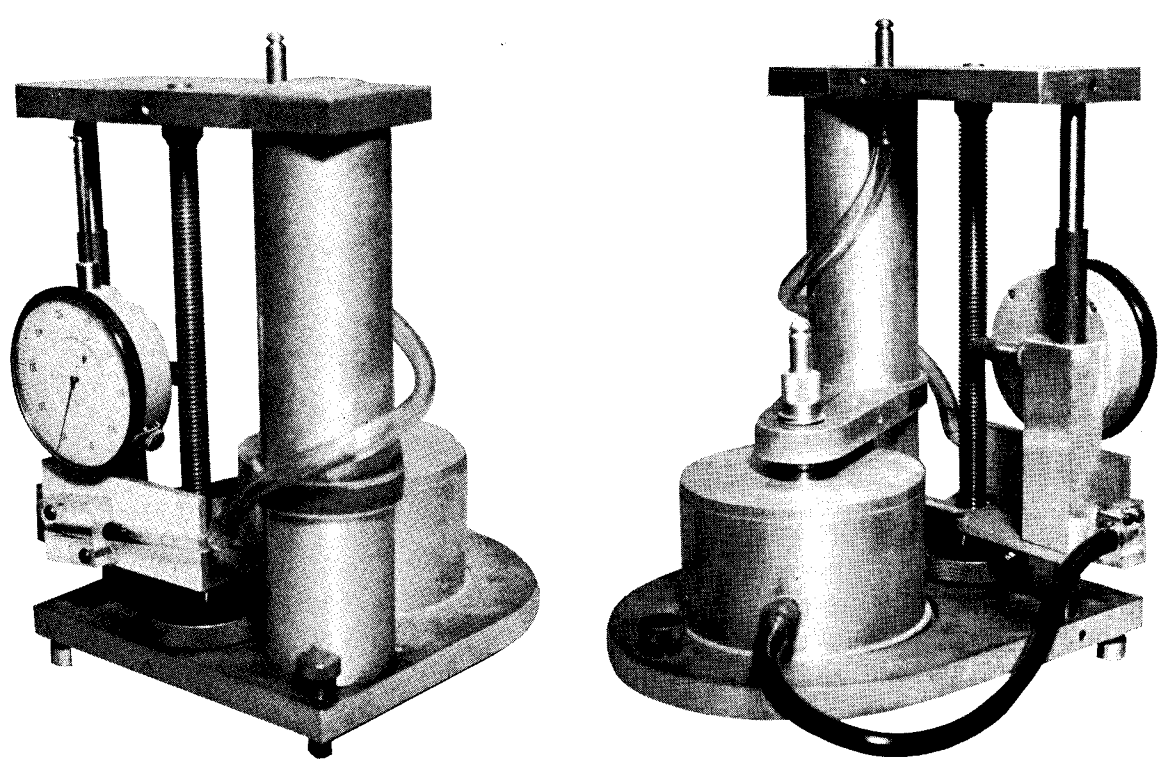

Fig. 1. Microamanometer; left—front view, and right—rear view.

The ease of reading the instrument was enhanced by using a very fine wire around the glass tube as a fiducial instead of a scribed mark on the glass tube, and by lighting the meniscus.

Fast Pulse Signal Averaging*

W. E. WILSON AND W. C. ROESCH
Pacific Northwest Laboratory, Battelle Memorial Institute, Richland, Washington 99352
(Received 9 May 1966)

THIS note describes a simple, useful combination of the techniques of signal averaging and sampling that permits retrieving fast signals under unfavorable noise conditions, averaging fast signals, or both. Only simple modifications to join commercially available digital oscilloscopes and sampling oscilloscopes are necessary.

Signal averaging to enhance signal-to-noise ratio is receiving wide spread application, especially in NMR experiments.[1] The basic operation is the addition of many repetitions of the signal being analyzed. If the signals are added in-phase, then the sum of n repetitions is just n times an individual signal. The sum for noise, which is incoherent with the signal, is $n^{\frac{1}{2}}$ times that for a single repetition. One, therefore, achieves an enhancement of $n^{\frac{1}{2}}$ in signal-to-noise ratio by this method. This particularly simple result actually holds exactly only for a special class of noise spectra; Ernst[2] and Ernst and Anderson[3] have given theoretical discussions of time averaging.

Averaging of signals can be done with commercially available digital devices called digital oscilloscopes. The time required for the memory cycle of these devices limits how fast a signal can be measured. For example, a typical 10 μsec cycle time puts an upper limit on the frequency components of the signals that one can measure at about 100 kHz. Klein and Barton[1] pointed out this limitation and suggested that sampling methods could be applied to extend the application to higher frequency signals.

The sampling technique employed by commercial sampling oscilloscopes can be thought of as a method for slowing signals that are too fast for conventional display methods. In the application described here, a sampling oscilloscope is used to slow high frequency signals so a conventional digital oscilloscope can handle them. Signals with frequency components up to 1 GHz can be slowed down for this purpose. This application is basically the same as that of Steingraber and Berlman[4] who used a modified pulse height analyzer and sampling oscilloscope to add repetitions of small, fast signals. The chief advantage of the system described here is the simplicity of the modifications required to join the two devices.

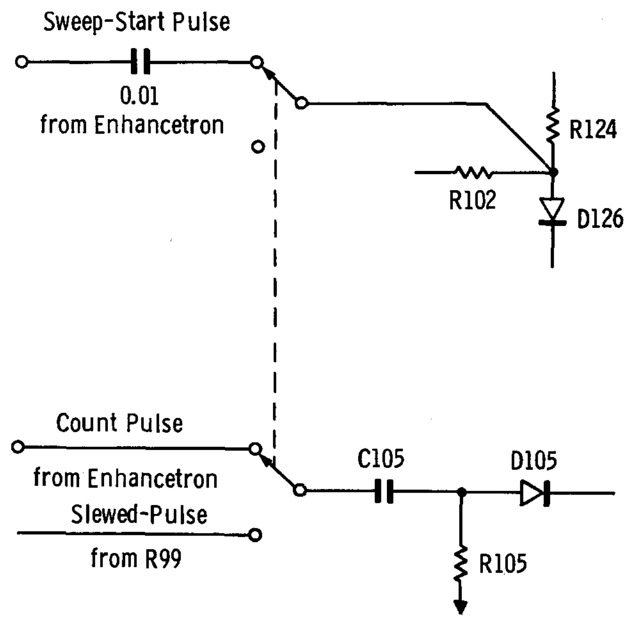

FIG. 1. Modifications to the 3T77 plug-in unit (refer to staircase generator circuit diagram). The pulses from the Enhancetron are brought in through unused pins on the connector plug of the 3T77. Reduce C156 and C157 to provide ~50 dots/div and operate sampling[1] 'scope in single sweep mode.

Our system employs particular commercial equipment[5]; however, the general features of the method should be applicable to other equipment. The voltage analog of the input signal to the sampling oscilloscope, which is the slowed waveform referred to above and which provides the vertical deflection in the sampling oscilloscope display, is available at an output jack on the front panel of our sampling oscilloscope. This waveform is attenuated 10:1 and made the input to the digital oscilloscope. Figure 1 shows the changes that we had to make to synchronize the sweeps of our sampling and digital oscilloscopes. The sampling oscilloscope normally advances the relative time of sampling automatically after each sample is taken so that the next one is taken at a later relative time. This automatic feature is interrupted between R99 and C105[6] and the advance command is furnished by the *count* pulse from the digital oscilloscope, thereby providing a one-to-one correspondence between time in the sampling oscilloscope sweep and channels in the memory of the digital oscilloscope. The sampling oscilloscope is operated in the single sweep mode and the *start sweep* pulse from the digital oscilloscope resets it to begin each sweep. These logic pulses from our digital oscilloscope are of the proper polarity and of sufficient size to synchronize the two components; in other cases buffer circuits may be necessary to prevent distortion of the logic pulses or to change their characteristics.

The only other change was to alter the number of