ISSUE 4

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A PUBLICATION DEVOTED TO ELECTRONIC INSTRUMENTATION AND RELATED FIELDS, PROVIDING THE LATEST INFORMATION ON DEVELOPMENTS IN EQUIPMENT, APPLICATIONS AND TECHNIQUES. PERMISSION FOR REPRINTING ANY MATERIAL CONTAINED HEREIN MAY BE OBTAINED BY WRITING TO THE EDITOR AT THE ADDRESS BELOW.

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On The Cover

One of the many ways that flying spot techniques are used commercially is in the Du Mont Iconumerator. The front cover picture shows an operator counting minute bacterial colonies found in some foods. See Part II of the article "Flying Spot Techniques and Application" in this issue.

Important Notice

A policy recently introduced in a few larger concerns, particularly in the aircraft industry, prevents delivery of third class mail to individuals in their employ. For this reason we can no longer send the *Du Mont Instrument Journal* to these people *unless* we can get their home addresses. Any persons working under such company policies can still get this publication by sending us their home address. We'll appreciate your help in obtaining this information.

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MORE DIMENSIONS IN VOLTAGE MEASUREMENT

Careful study of weaknesses exhibited in other vacuum-tube voltmeters prompted development of the Type 405. Such things as crystal diodes replacing vacuum tubes in the pickup circuit, providing dual inputs, unique grounding of chassis and circuits, have helped to obtain new dimensions in voltage measurement. A technical discussion of these and other features is presented.

There is always room for improvement, even in well established equipment. New dimensions in voltage measurement have just been made possible by a recently introduced vacuum-tube voltmeter — the Du Mont Type 405.

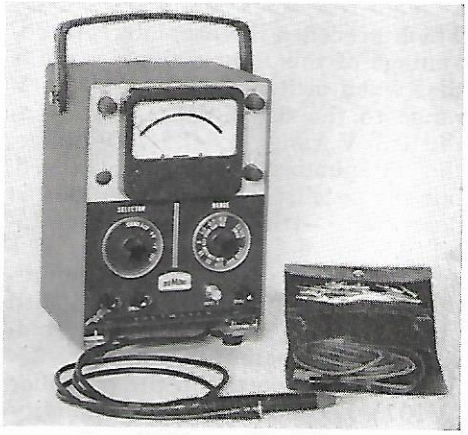
The more important features of the 405 are, in brief: ability to make ac or dc measurements from the millivolt region up to the kilovolt region; measurements can be made from 50 cps to 700 megacycles; it provides various full-scale sensitivities from 0.1 volt up to 1000 volts; enables readings of dual inputs (either ac or dc or both) without disconnecting leads; enables off-ground measurements up to 1000 volts; provides output facilities for running external measuring devices, and has provisions for resistance measurements. All of these are accomplished, necessarily, with the accuracy and stability needed for most laboratory and field work.

Basic Circuit Explanation

The concepts by which these features are accomplished are not complicated. By combining known techniques into different configurations the circuitry has been kept simple and easily explained.

The instrument, as a voltage measuring device, is essentially an impedance transformer which transforms voltage at a high impedance level to a current at a low impedance level. As an ohmmeter, the unknown resistance is effectively placed in parallel with a calibrated load (an attenuator) across which a low-level voltage is applied. The maximum open circuit voltage at the ohmmeter input is 0.09 volts. Voltage changes across this system are then measured and indicated.

The 405 consists of an attenuator, a d-c amplifier, a cathode follower



Type 405 Vacuum-Tube Voltmeter

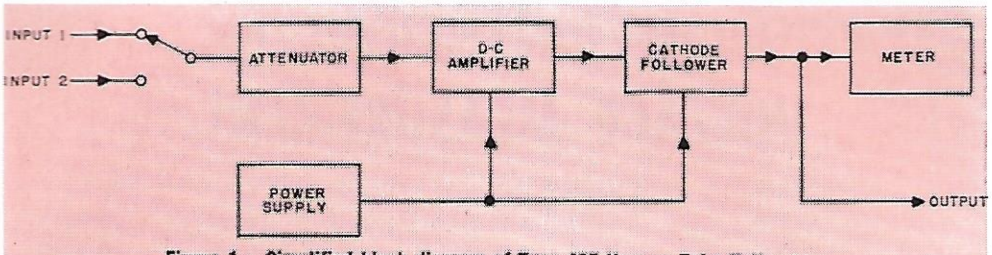


Figure 1. Simplified block diagram of Type 405 Vacuum-Tube Voltmeter.

and a power supply (see **Figure 1**). Amplified input voltages drive the cathode follower which in turn drive the meter movement. Plate voltage for the d-c amplifier and cathode-follower is developed in a full-wave rectifier connected to one secondary of the power transformer. A capacitive input filter and two regulator tubes maintain a constant output. Filament voltages of those two stages are also regulated.

Front-panel switching enables the user to select polarity and sensitivity. An input attenuator provides the selection of full-scale sensitivity and is also used to convert the instrument into an ohmmeter. Sundry crystal diode probes available permit measurements up to 700 megacycles.

Selectable Sensitivity

Nine selections of instrument sensitivity are available — from 0.1 volt full scale up to 1000 volts full scale — on either ac or dc. This selection range is made possible through use of a high resistance input attenuator which precedes the amplifier. An advantage of this attenuation system is that when switching from the 0.1 V range to the 0.3 V range, and from the 0.3 V range to the 1 V range, the attenuator itself is unchanged, but the sensitivity of the amplifier is decreased — thereby increasing stability.

A paraphase amplifier configuration is used in the Type 405, with potentiometer adjustments for balance of both sections (see **Figure 2**). A 6SU7GTY is used in the amplifier (V101) because it is a high quality instrument tube with inherently low grid current and a high degree of balance and stability, all of which provides an overall accuracy of ±2% full scale. This is true down to the lowest — 0.1 volt sensitivity range.

The use of a crystal diode in the pick-up probe of the Type 405 also enhances the ability to detect and measure on the low — 0.1 volt full scale — sensitivity range. This is discussed in detail later in paragraphs.

The amplifier circuit has gas-tube regulated heater and dc voltage supplies. Tubes used in the instrument are operated with approximately five volts on the heaters. Operating at this lower voltage, grid current is reduced and tube life is extended.

Ac Measurement With Crystal Diode Probes

Ac performance is obtained by using a crystal diode probe ahead of

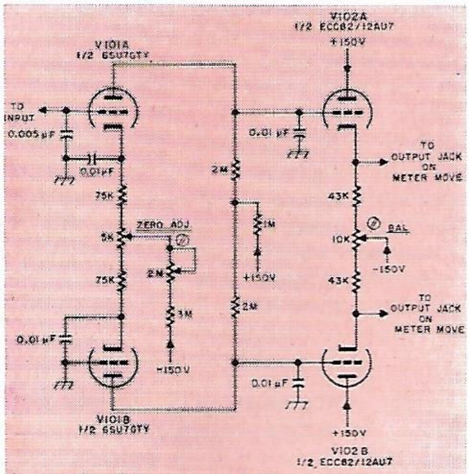


Figure 2. Schematic of Type 405 amplifier (V101) and cathode-follower (V102) for driving meter movement.

the attenuator. Three probe types are available, two of which are supplied with the unit as selected by the purchaser (see probe theory). These probes are shunt, peak reading type rectifiers which rectify the ac and supply dc to the instrument. Scale markings on the 405 are calibrated in rms.

Crystal diodes are utilized in these probes, in contrast to vacuum tube diodes in other makes of probes, for several reasons. Crystal diodes are small compared to vacuum tube diodes, they require no heater power, they generate no heat, have no contact potential, they rectify efficiently at high frequencies if current requirements are not severe, they are light in weight and easily mounted.

Crystal diodes, as used in the 405, enable the user to obtain 100 millivolt full-scale sensitivity — which is lower than that practically obtainable by vacuum-tube diodes. This is because a contact potential, of one volt for example, on a vacuum tube diode would have to be balanced out by an equal voltage. Any drift of either voltage would result in a difference voltage, resulting in an undesirable signal to the instrument. On the 100 millivolt sensitivity range then, a drift of 1% could result in an error reading of 10 millivolts—which of course would be commercially unacceptable. Because of this, utilizing the conventional vacuum-tube diode in a pick-up probe becomes impractical for sensitivities much in excess of one volt full scale.

Crystal Diode Probe Theory

The probe consists simply of an input capacitor, a shunt rectifier and a series resistor (see Figure 3). The rectifier conducts when the signal is in a positive going direction, thereby charging the input capacitor. The capacitor can only discharge through the load resistance or the back resistance of the diode. It is this voltage that appears across the input resistor and is measured by the d-c voltmeter. After the first few cycles only the peak of the input signal will cause the diode to continue conduction. The remainder of the time it will simply be biased off by the negative voltage across it.

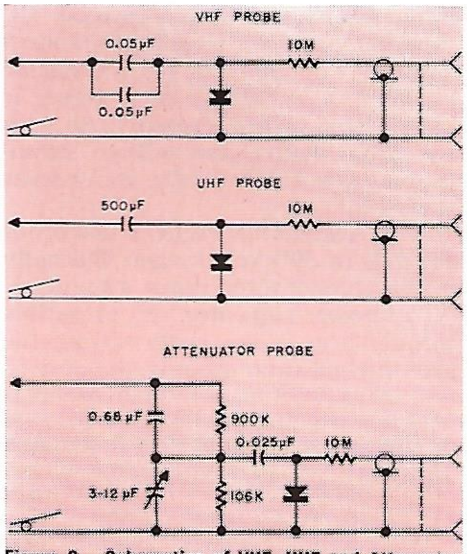


Figure 3. Schematics of VHF, UHF and Attenuator Probes available with the Type 405.

To cover the full range of frequencies and votages measureable by this instrument, three a-c probes were designed for particular use with the 405, but also to be useful with other instruments. The three probes are the VHF Probe, the UHF Probe and the Attenuator Probe.

The VHF probe covers the frequency spectrum from about 50 cps up to several hundred megacycles. It must be appreciated however, that since the back resistance of a germanium diode is a function of voltage level, accuracy at 50 cycles is limited to ranges above 0.3 volts full scale. Ranges from 0.1 volts full scale to 30 volts full scale may be utilized, however, at higher frequencies.

The UHF Probe is constructed in a similar manner to the VHF Probe except that the input capacitor has been made physically as small as possible to obtain the best possible high frequency characteristics. The low frequency limit of this probe is about 10 kc. The high frequency limit, when used with a special "T" connector, is approximately 700 megacycles. The special "T" connector establishes a fixed ground plane; it is available as an accessory. As with the VHF Probe, the voltage limitation of the UHF Probe is 30 volts rms.

The Attenuator Probe is useful for the 100 to 300 volt ranges. Basically it is a compensated input attenuator. A trimmer capacitor is accessible through the probe cover to set the attenuation ratio exactly as desired at higher frequencies. This probe is useful from line frequencies to over 20 megacycles.

Dual Input Feature: Off Ground Measurements

An extra input jack and a switch on the front panel facilitates dual input performance on ac or dc when desirable. This enables measurement of more than one circuit without having to remove or reconnect probes; simply switching (see Figure 4). One advantage of this feature is that connections for a-c measurements can be made on one input and d-c on the other with no problem. A third spring loaded position on the switch enables the user to check the zero adjustment without having to short the probe input. Polarity is also selectable by a front panel switch.

The ground return circuitry of the instrument is insulated from the panel and chassis. Chassis ground is connected to circuit ground through a link on the front panel. If the front panel link is removed, off-ground measurements may be made between the probe and circuit with common mode voltages up to 1000 volts dc. With a slight modification in wiring, off-ground a-c voltages can be measured up to approximately 5 kc. This wiring modification is described in the instruction manual, but is not done in the factory unless requested.

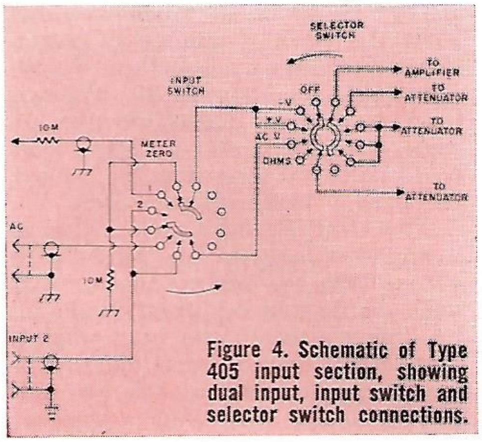


Figure 4. Schematic of Type 405 input section, showing dual input, input switch and selector switch connections.

Output For External Records

An output jack is provided at the rear of the instrument for pluging in a recorder, or other device, to monitor variations of voltage referred to the input. When operating in this manner the instrument acts as an impedance transformer, or power amplifier, with a gain of over two million. This feature is useful when voltage changes in a high impedance circuit are to be recorded.

The input resistance of the 405 is high enough to prevent loading the circuit, and the sensitivity of the amplifier can be switched to the range which best covers the magnitude of the voltage to be measured. By inserting the proper phone plug in the output jack, the meter movement is disconnected and the plugged-in circuit replaces it. Considering that a signal of 0.1 volt across 121 megohms (the 405 input resistance) will cause a current of one milliamp to flow through approximately 100 ohms, the power gain is in excess of 60 db — although the output voltage and input voltage are equal. When used in this manner, the output appears as a differential voltage around a common mode voltage of approximately 60 volts. The output at the jack is limited to one milliampere.

A recorder connected in this way can easily be calibrated. A handy way to measure a drift, for example, would be to set the device which is being monitored to a specific voltage reading on the meter. When the recorder is plugged in, disconnecting the meter movement, whatever point the recorder moves to will correspond to the reading the meter had before it was disconnected. The system is left operating in this manner for a specified time to measure the drift of the device being monitored. At the end of the prescribed time the recorder is pulled out and the meter reading observed. The recorder is now automatically calibrated since the new meter reading will correspond to the point to which the recorder has moved.

Who and Why

John T. Hill

John T. Hill, born July 14, 1915 in Vinton, Iowa, is the eldest of three sons born to Jerry T. Hill — pioneer West Coast sales representative and founder of the J. T. Hill Company. John is now General Manager of the firm, which represents Du Mont in California, Arizona and Nevada.

"Gentleman" John attended Beverly Hills High School, Los Angeles Junior College, and the University of New Mexico before associating with his father's firm in 1937. Other than serving 3½ years as 2nd Lieutenant for the Medical Administrative Corps, he has been working his way up through the firm ever since. His interests, besides professional, are primarily baseball, golf, football, his daughter Cheryl—age 11, and his son Jerry—age 6; John says he is an avid fan of all of them.

The company's new main office, a modern 7500 square-foot building especially designed for their use, is located on a historic site near the "Mission de San Gabriel" in San Gabriel, California. They maintain a branch office in San Carlos to cover the San Francisco Bay Area, and another in San Diego, California.

John is especially proud of their new San Gabriel headquarters at 420 South Pine Street, which was completed in 1955. It houses all of the facilities necessary for efficient 30-man operations as technical representatives. It includes a large instrument demonstration laboratory, service and repair shop, warehouse, complete mailing department for their direct mail program, order service and follow-up, engineering laboratory and complete administrative services.

John is active in Industry Association affairs. He has been president of the Los Angeles Chapter of "The Representatives" and is now serving on the Chapter Board of governors as well as the National Board of Governors of that organization. He looks forward to the growth of the company, which we're sure they'll have, in the mushrooming West Coast electronic industry.

FLYING SPOT TECHNIQUES AND APPLICATION

Part II

by: H. P. Mansberg
Manager, Applications Engineering and Market Research
Du Mont Instrument and Automotive Equipment Divisions

This is a continuation of an article originating in the last issue of the "Du Mont Instrument Journal." In it are discussed basic techniques for the electronic scanning of microscopic and macroscopic fields, applications to industrial inspection or measurement, and relating biological and industrial instrumentation.

Iconumerator System

The *exact number* can be obtained directly from a spot scan by the following method:

An example of the type of logic circuits which have been successfully applied to this problem is shown in Figure 6, which is a block diagram for an automatic particle counting system known as the Du Mont Type

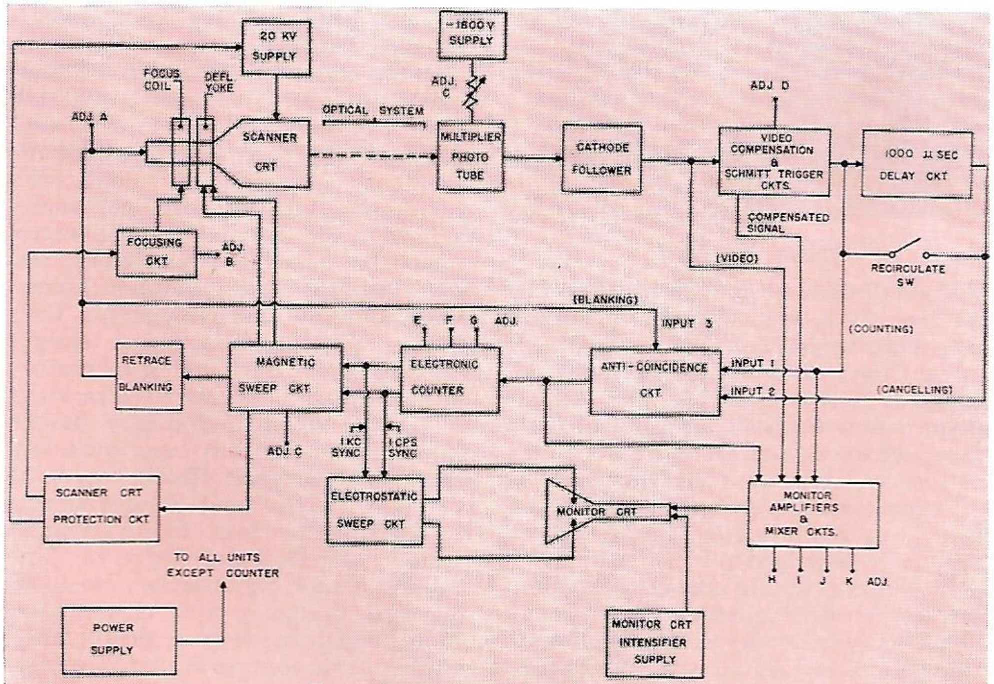


Figure 6. Iconumerator Block Diagram

3003 Iconumerator. The flying spot scanning tube in this system produces a 1000 line raster at a one-second frame repetition rate to scan a transparent field approximately four-inches in diameter. The purpose of this machine is to count opaque particles on a transparent surface, or transparent spots — such as holes — on an opaque surface. The rather complex circuits in this block diagram were necessary to permit only one count for each particle, regardless of its size and the number of scanning lines it intercepted.

To prevent multiple counting of particles larger than a single scanning line width, the intercept pulses are fed to a memory unit which stores these pulses for exactly one scanning line interval. The output of the memory unit, which consists of an ultrasonic delay line, are fed to an anticoincidence circuit together with the undelayed signal pulses. The anti-coincidence circuit uses a time-overlap criterion to determine whether a pulse is associated with a previous intercept belonging to the same particle. In effect, this provides a means of detecting the top or bottom tangency of each particle.

The principle is illustrated in Figure 7, which shows a series of scanning lines covering the area containing the particles. For clarity the lines are shown spaced far apart and the waveforms at the bottom of the illustration show idealized pulses. In actual practice the scanning lines are very closely spaced and, for all but the very smallest particles, a large number of scanning lines intercept each particle. It is seen that line A does not intercept a particle, and a pulse is not produced. Line B, however, intercepts the particle for the first time and produces a pulse as shown. This pulse is fed to the one-line delay so that it will again appear at the input to the anti-coincidence circuit in time to cause at least some overlap with a pulse produced by Line C. The anti-coincidence circuit is designed so that a count pulse is produced when the pulse on Line B appears *without* a coincident pulse from Line A. As shown, the pulses on Lines B and C *do* overlap and therefore no additional count is produced. Line D produces a pulse which is overlapped by the pulse on Line C and again no additional count is produced.

ABOUT THE AUTHOR

Mr. H. P. Mansberg is presently manager of Applications Engineering and Market Research for Du Mont's Instrument and Automotive Equipment Divisions. Prior to this assignment, Hy was section head of the Scanning Instrumentation group of the Engineering Department, which was responsible for the type of flying spot scanning instrumentation described in this article. He was also project engineer on the development of the Du Mont Iconumerator mentioned. Hy is a member of the IRE, Optical Society of America, Society of Photographic Engineers and Scientists, Biophysics Society and the A.A.S.S.

Very large numbers of particles may be counted in any given field by this means within the resolution de-

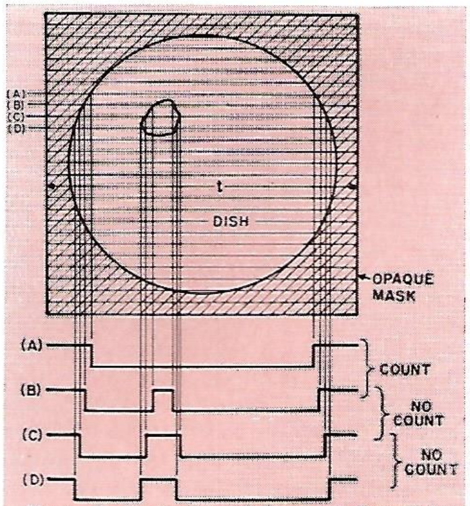


Figure 7. Illustration of Tangency Detection

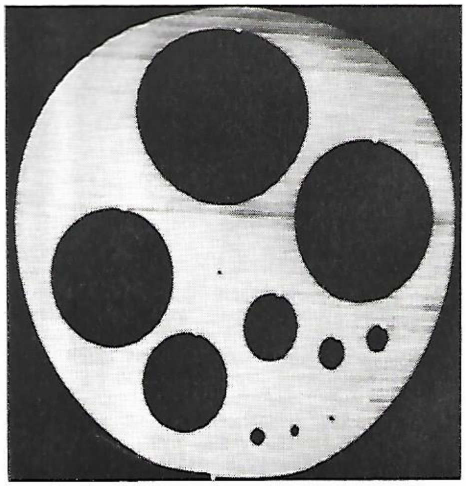


Figure 8. Count Pulses Superimposed on Image of Particles

termined by the diameter of the scanning spot. The size and shape of the particle does not effect the counting accuracy except for particles which have a re-entrant profile causing multiple horizontal tangencies to occur. Under this condition the particle may be counted more than once depending upon its orientation with respect to the scanning lines and the number of re-entrant portions on its contour.

A photograph of the screen of a picture monitor displaying the images of a group of different sized round particles being scanned and counted is shown in Figure 8. Superimposed upon the video signal information which produced these images is a pulse derived from the counting circuit, so that it appears as a small bright check mark at the top of each particle. Note that each particle has a single check mark indicating that it has been counted once regardless of its size.

The complete Type 3003 Iconumerator which operates on the principles described may be seen in Figure 9. Although this instrument was originally designed specifically to count visible bacteria colonies on standard 100 mm Petri dishes, it has been used to scan and count images to count flaws such as pinholes in metal foils.

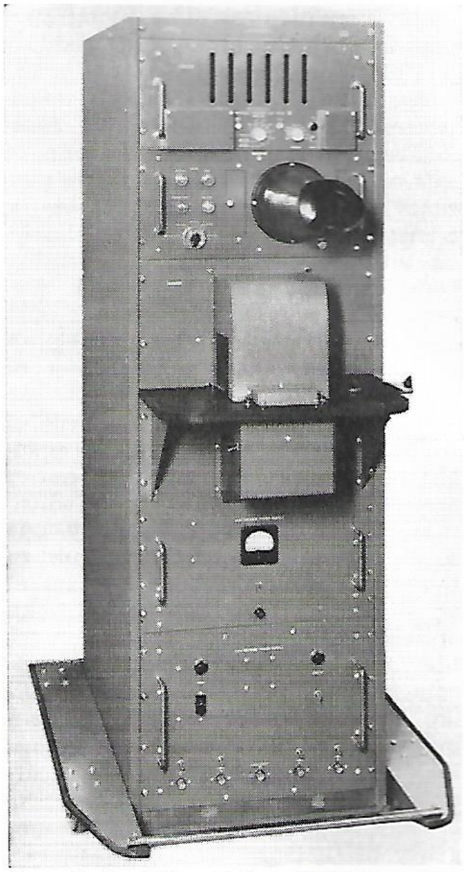


Figure 9. Front View of Type 3003 Iconumerator

Particle Size Measurement

As additional logic circuitry is added to the basic flying spot optical-electronic transducer, more complex measurements of a visual field may be made. One method that has been used to provide a measure of particle or flaw size is shown in the block diagram of Figure 10. The principle used in this system is to subtract a fixed width from each pulse generated by the phototube, leaving a residue only when the signal pulse width exceeds the selected width.

As shown in the block diagram, a shaping circuit which preserves the pulse width information is used to start a linear saw generator, which in turn is fed to an adjustable amplitude selector. At a selected ampli-

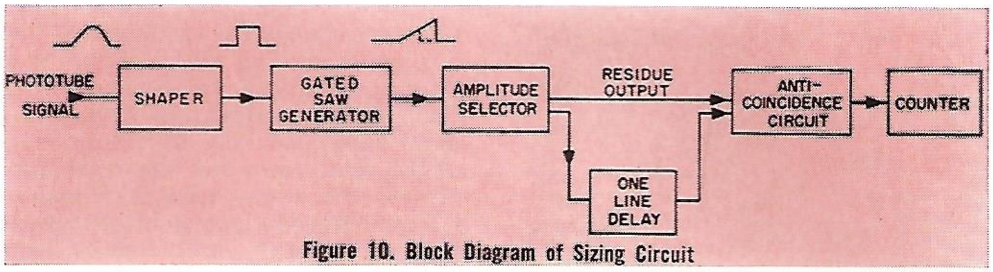


Figure 10. Block Diagram of Sizing Circuit

tude, corresponding to a desired pulse width, an output pulse appears which may be considered a residue because a fixed width has effectively been subtracted. This residue pulse is fed into the anti-coincidence circuit and a one-line-delay unit, as previously described, to produce a counting pulse at the first residue that appears.

Repeated counting of the same parcle is inhibited in the manner previously described. The effect is demonstrated by the picture monitor photograph in Figure 11 which shows the same round particles of varying size as in Figure 8. The amplitude selector has been set so that only the three largest particles in the field produce a residue signal. Since each signal pulse leading edge intercept is delayed by the same amount, the residue pulses produce an elliptical shaped image with the count pulses appearing at the top of each.

To obtain the effect of the "ghost" image of each entire particle, the monitor was first permitted to display the signal without intercept delay, as in Figure 8, and then switched to show a fixed intercept delay. The persistence of the phosphor on the picture monitor was sufficient to record a faint image of the complete particle contour.

To obtain a particle size analysis of a field containing a large number of particles by this method, the amplitude selector is first set to zero delay so that all the particles are counted. The selector is then set to a particular desired maximum size group and all particles exceeding this size are counted. By setting the selector to succeedingly smaller sizes the number of particles falling in each successive size group may be found by subtracting each count from the previous one.

It should be realized that this method permits a size measurement of the particle in one direction only, that is, in the direction of the horizontal motion of the scanning spot. The sample can be rotated after each field scan to obtain size distributions in other orientations. The same limitations with respect to reentrant profile shapes pertain as in the case of the counting system. The accuracy of size measurement by this technique is limited by the deflection vs. time linearity of the scanning spot. Of course, this method may be applied to the measurement of hole diameters as well as to the diameter of particles.

A much more accurate technique of measuring particle size or gauging holes is illustrated by the block diagram of Figure 12. Here the scan-

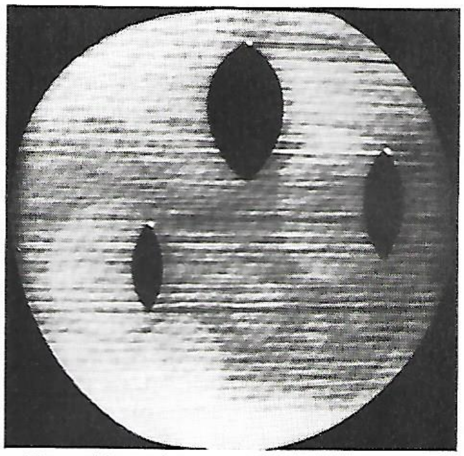


Figure 11. Residue Effect in Sizing Particles

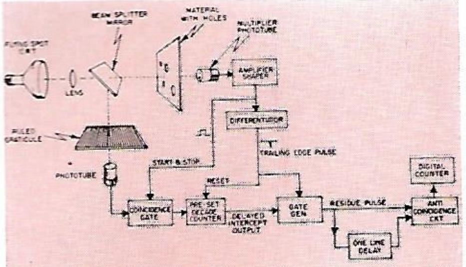


Figure 12. Automatic Hole Gauge and Counter

ning beam is split into two parts so that one part scans the material containing the holes, while the other scans a finely ruled graticule. The output of the phototube observing the material is used to open a coincidence gate circuit, permitting a preset decade counter to start counting the graticule pulses. At a pre-determined count, the preset counter puts out a pulse—unless the trailing edge of the signal automatically resets the preset counter to zero and closes the coincidence gate. The output of the preset counter is therefore a delayed leading edge intercept pulse similar to the one obtained by Figure 10. This is fed to a gate generator, and in combination with the differentiated trailing edge of the hole intercept signal, forms a residue pulse which is counted and displayed in the same manner as in Figure 6. By making a series of successive scans using increasing leading edge intercept delays, by means of the preset decade counter, a point will be reached at which no output pulse is obtained for a given hole. This setting then corresponds to the maximum diameter of the hole in the direction of the horizontal scan. By means of a stepping switch the preset decade counter may be automatically programmed to increase the delay interval for each successive field scanned.

Logical extensions of this technique would also permit the location of each hole with respect to the reference edge. For example, another counter can be used to total the graticule lines intercepted between one reference edge of the material and the leading or trailing edges of the hole intercepts. The accuracy and precision of measurement of this technique is limited only by the spacing of the ruled lines and the resolution of the cathode-ray tube spot, and it is completely independent of deflection non-linearity or objective lens distortions.

Glass Flaw Detection

As mentioned previously, the problem of automatically detecting flaws in glass is particularly suited to flying spot inspection techniques. One of the glass flaw detection problems that has been investigated is the automatic inspection of television tube face plates. These face plates are manufactured by automatic machinery which requires relatively few personnel in the actual manufacturing process. One of the costly bottlenecks in the manufacturing process has been the need for visual inspection of each face plate as it leaves the annealing ovens. Tests with flying spot scanning equipment have shown that it is entirely feasible to automatically detect at least 90% of the flaws commonly existing in face plates, such as blisters, stones, opaque spots, seeds and cracks.

The inspection of television tube face plates requires the examination of two zones, a central A zone and a surrounding B zone in accordance with standards that have been set up in the industry. This involves a determination of the size and quantity of the flaws in each of the zones. One approach to this flaw detection problem is illustrated by the block diagram of Figure 13.

To achieve the resolution necessary for the inspection of 21″ rectangular face plates, three high resolution 5 inch flying spot scanning tubes are necessary as shown in the illustration. Associated with the three scanning tubes are three multiplier phototubes and three condenser lens systems. The central cathode-ray tube scans only a strip correspond-

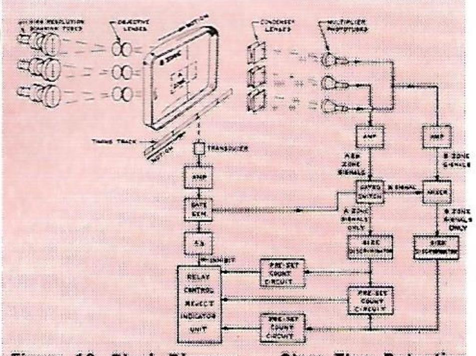


Figure 13. Block Diagram — Glass Flaw Detection and Measurement

ing to the A zone of the face plate. The cathode-ray tube scan is applied in one direction only, while the face plate is caused to move in a perpendicular direction to achieve the required number of scanning lines for each face plate. A timing track moving in synchronism with the face plate produces timing pulses which actuate a gated switch so that the output of the central phototube produces A zone signals only. The signals from the two outer phototubes added to the gated signal from the central phototube provide signal information from the B zone. Both of these signals are fed to size discrimination circuits similar to those previously described, and then to predetermined counters set up in accordance with the size — quantity specifications. The outputs of these predetermined counters operate a relay control unit which indicates rejection or acceptance and actuates the control mechanisms on an automatic production line to accept or destroy the particular face plate.

The problems in making reliable flaw measurements on, or beneath the surface of television tube face plates is complicated by factors such as curvature of the face plate and frosting of the inside surface of the plate. Therefore, the extent to which automatic measurements of television tube face plate flaws are carried depends upon the economic factors involved in developing such an equipment.

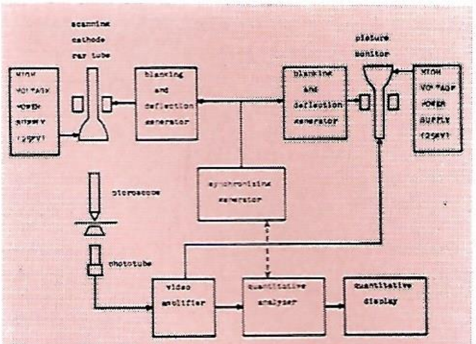


Figure 14. Block Diagram — Flying Spot Microscope

The Flying Spot Microscope

Flying spot scanner instrumentation and measurement is by no means limited to large visual fields. By the proper use of microscope systems, the measurements previously described for large visual fields can be applied to microscopic fields. Automatic particle counting and sizing is of greater importance for microscopic fields than for macrosopic fields. A flying spot microscope particle counter and sizing device can be applied to the study and analysis of pigment powders, photographic emulsion grain structure, dust precipitation measurements, autoradiography of biological material, fine particle filter evaluation, and to a host of many other industrial and biological studies.

A general block diagram showing the basic units of a flying spot microscope is shown in Figure 14. The major problem in using a flying spot microscope to make complex automatic determinations is that of achieving a high enough signal to noise ratio. No average figures for S/N can be given because this usually depends on the type of specimen. However, as equation (4) shows, the illumination decreases with the square of the magnification so that the S/N decreases with increasing magnification. (Equations (5) and (6)).

An example of the type of signal that can be obtained in scaning a microscope field is shown in Figure 15. An experimental flying spot mi-

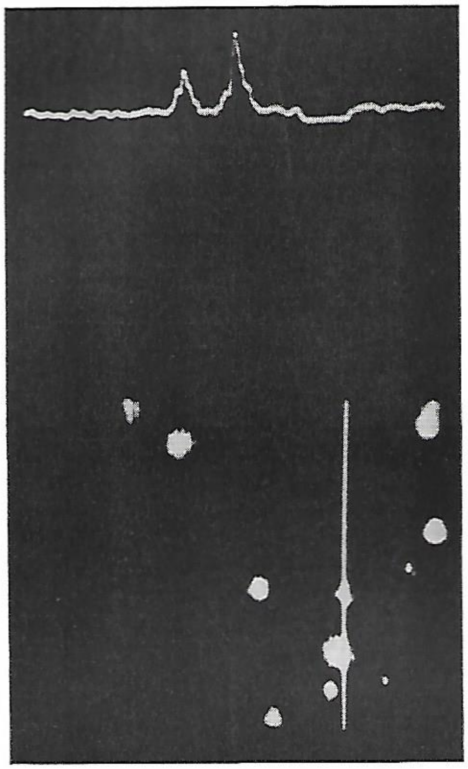


Figure 15. Flying Spot Microscope Scanning Signal for Small Oil Droplets

croscope was used to scan a slide containing oil droplets varying in size from one to approximately 20 microns. The upper half of Figure 15 is a photograph of a picture monitor field produced in scanning these particles. One particular scanning line was selected for display on a cathode-ray oscillograph and this line is shown as a bright line in the upper illustration intercepting two of the particles. The waveform below, preceeding from left to right, shows the pulse output obtained with the scanning spot moving from the bottom to top of the upper illustration. The signal-to-noise ratio apparent in the oscillogram shows that it is feasible to count these oil droplets by the techniques previously described. The scope of this article cannot even begin to describe the many applications of flying spot techniques to microscopy, and the reader is referred to other discussions of this subject.

Photographic Film Data Reduction

Another field of flying spot scanning instrumentation beyond the scope of this paper is that of automatic data reduction and processing of images recorded on photographic film. Photographic film is, of course, well known to have an extremely high information storage capacity, but there has always been a problem in achieving rapid access to this information. The flying spot optical-electronic transducer, because of its inherent linearity, provides a means of three dimensional analysis of film; that is, length, width, and density, making it possible to analyze information stored as black and white bits or within the gray scale of the image.

Conclusion

In this article the author has described just a few of the flying spot scanning techniques that may be applied to measurement and inspection problems. The scope of application of these techniques is so broad that it covers an almost unlimited variety of industrial and resarch applications. One particular form of flying spot instrumentation, the Flying Spot Microscope, can provide such a powerful tool to industrial and biological research laboratories that it appears destined to follow a path of development somewhat similar to that of the electron microscope. Flying Spot Microscopes are already being applied in England to problems of coal dust studies, and in the United States as a research tool in cancer studies. It has been demonstrated, for example, that an ultra-violet light emitting cathode-ray tube may be used to scan living tissue specimens for many hours without lethal effects. It has not been possible to accomplish this previously because of the lethal doses of radiation required when other ultra-violet light sources and techniques are used to examine the specimens.

The flying spot optical-electronic transducer is a remarkably versatile measuring tool and, in this capacity, it may even transcend its contribution to other fields such as television, radar, and oscillography.

Summary

Flying spot scanning systems provide versatile means for extracting information in electrical form from visual fields. This information can be processed by electronic computer techniques to provide many of the decisions normally made by human observers. A flying spot scanning tube with suitable combination of optics and phototubes may be used to scan any plane area at very high speeds. In many cases optical information concerning this area can be obtained at far greater rates than by visual observation.

Bibliography

1. Berkley, C. and Mansberg, H. P. "Some Applications of Scanning Techniques." **IRE Convention Record,** Part 9 (1955). pp 138-140
2. Berkley, C. Mansberg, H. P. and Yamagami, Y. "Spot Scanner Counts Micron-Sized Particles." **Electronics,** Dec. 1957, pp 142-146
3. Bonner, W., Montgomery, P. O. B. and Roberts, F. "The Flying Spot Monochromatic Ultra-Violet Television." **Nature,** Vol. 177 (June, 1956). pp 1172
4. Hardy, A. C. and Perrin, F. H. **The Principles of Optics.** New York: McGraw-Hill Book Co., Inc. 1932
5. Jenkins, F. A. and White, H. D. **Fundamentals of Physical Optics.** New York: McGraw-Hill Book Co., Inc. 1950
6. Lagercrantz, C. "On the Theory of Counting Individual Microscopic Cells by Photoelectric Scanning. An improved Counting Apparatus." **Acta Physiologica Scandinavica,** Vol. 26, Supplement 93
7. Leverenz, H. W. **An Introduction to Laminescence of Solids.** New York: John Wiley and Sons, Inc., 1950
8. Roberts, F. and Young, J. Z. "The Flying Spot Microscope." **Proceedings of the British Institute of Electrical Engineers,** (April, 1952). pp 747

The Engineer Speaks

With the article below we introduce the new regular feature "The Engineer Speaks", as promised in our last issue. The purpose of this feature is to give you, our readers, an opportunity to express an idea, or perhaps an appropriate gripe pertaining to some phase of the industry. Maybe a suggestion that will help others, such as the contribution for this issue, could come from your pen. Send your thoughts to the editor, at the address given on page 2. Your expressions will reach a potential international reading audience of over 42,000 technical people. We'll print the story over your name and company name unless you indicate to the contrary.

Pulse rise times as short as 0.2 milli-microsecond have been displayed on cathode-ray tubes with traveling wave deflection systems, such as in the Du Mont Type K1421. Some tubes with conventional deflection plates have rise times in the order of one milli-microsecond. For example, we have found the rise time of the Du Mont Type K1409 Cathode-Ray Tube to be not worse than 0.8 milli-microsecond.

This measurement required the development of a special pulse generator, sweep circuit, and timing waveform generator. However, when the system was first assembled and operated, observations were confounded by cross coupling between the horizontal and vertical deflection plates which caused severe distortion of the time base.

This we reasoned, could be eliminated by securing a balanced deflection. But how? A phase inverter for a 0.1 milli-microsecond pulse seemed a large order. The solution turned out to be quite simple. We pass it on in hopes that it may sometime help you.

The system consists of three "T" connectors, four lengths of RG8 coaxial cable, an open circuit termina-

(*continued on page* 16)

tion, and a short circuit termination arranged as in Figure 1.

The signal pulse from the generator enters the first "T", connector splits into two pulses, which travel along cables A and B respectively. The two pulses reach the deflection plates simultaneously but cause no beam deflection since they are identical. They continue past the deflection plates through cables C and D, at the end of which they are reflected back toward the generator. The pulse in cable D, having been reflected from a short circuit, returns reversed in polarity, but otherwise the same.

When the pulses reach the deflection plates this time they are equal in amplitude but opposite in polarity, causing a balanced deflection of the electron beam. After several reflections here and there, the pulses are ultimately absorbed by the source resistance and cable losses. The time base terminates before the pulses again return to the deflection plates.

The following limitations on cable length are imposed: Let V equal the phase velocity of pulses in the cables. Then L_1/V_1 must be longer than half the pulse width, and L_2/V_2 must be longer than half the pulse width plus twice L_1/V_1. These restrictions assure no interfering common mode signals or reflected transients occuring during the pulse being observed on screen.

The system was successfully demonstrated using two 20-feet lengths and two 10-feet lengths of RG8 cable, and three type C connectors. It should be noted that the waveform appearing between the deflection plates is twice the amplitude of the original pulse, giving a voltage gain of two.

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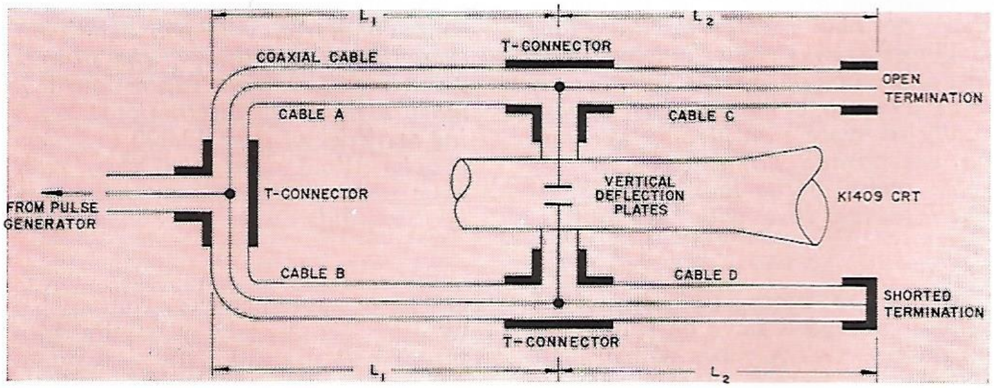

At the time of this printing we have received over one-hundred orders for the vinyl plastic binder for the Du Mont Instrument Journal, as advertised in our last issue. A delay in the bindery has set our shipping date back to the beginning of January. We are still taking orders for this attractive binder, especially designed to hold several years worth of our journal issues. Your check or money order for $1.50, accompanying your order, will assure delivery of this binder early in January, 1958.

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Our next issue will feature a basic article on the synthesis of the "optimum" pulse channel characteristic for an oscilloscope. It's general approach to the problem will make good reading for all scope users and designers.