THE OSCILLOGRAPHER

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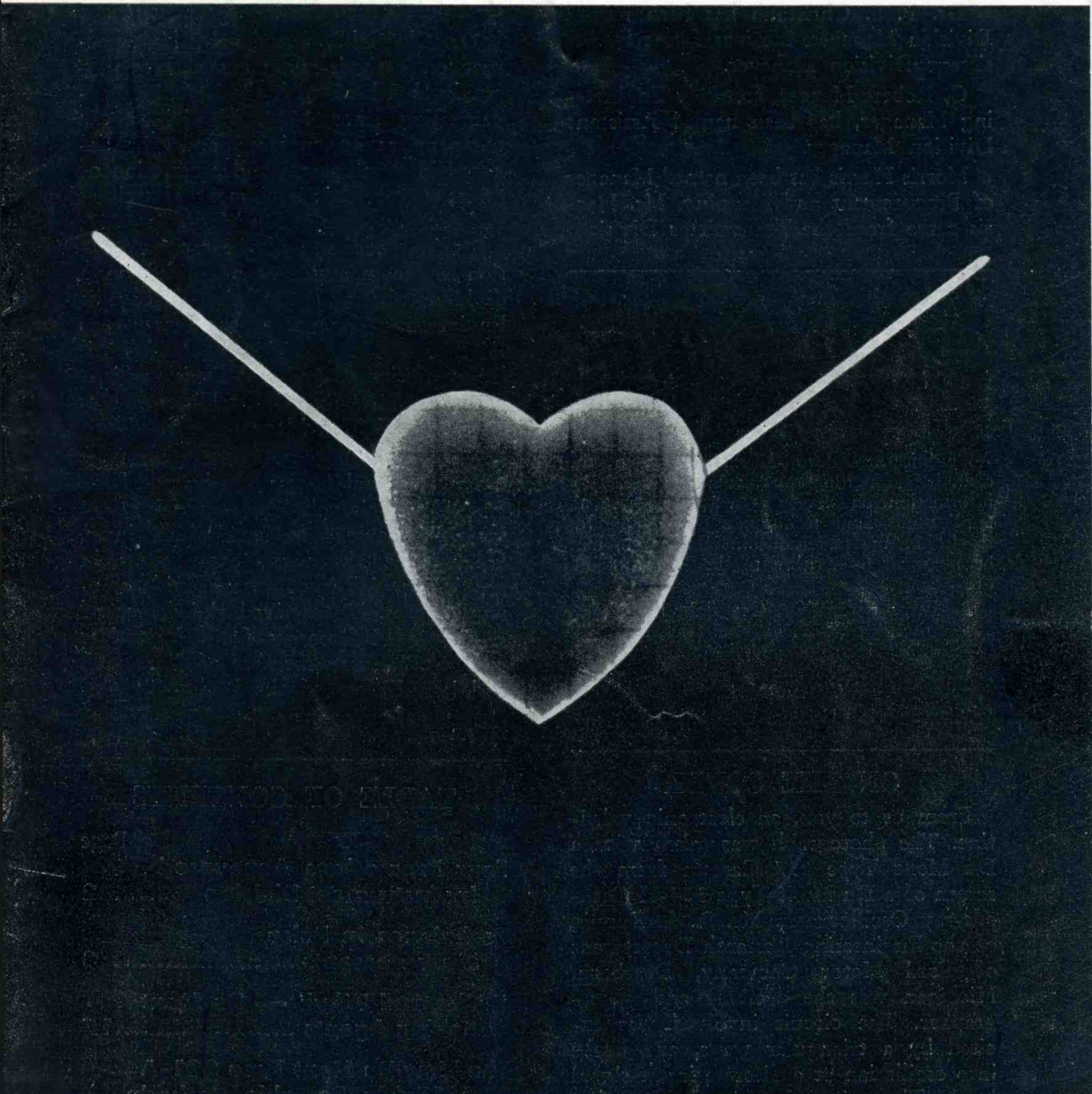

ELECTRONIC VALENTINE SEE PAGE 2

Four Promotions Announced By Instrument Division

Promotion of two top members of the Instrument Division to new key posts within the division, and filling of two other key positions in the Instrument Division by other Du Mont men was announced in mid-November, 1953, by Allen B. Du Mont Laboratories, Inc.

The appointees and their new posts are as follows:

Dr. P. S. Christaldi has been named Division Manager. He was formerly Assistant Division Manager.

G. Robert Mezger, formerly Engineering Manager, has been named Assistant Division Manager.

Morris Harris has been named Manager of Procurement and Planning. Mr. Harris came from the Transmitter Division.

Arthur J. Talamini, also a former member of the Transmitter Division, has been appointed Engineering Manager.

"These additions to the management group," said Dr. Christaldi, new Division Manager, "will enable the Instrument Division to further strengthen its activity in the engineering, manufacture, and sale of cathode-ray instruments and associated electronic equipment."

Dr. Christaldi, a nationally know expert on cathode-ray tubes and oscillographs, has been with the Du Mont organization since 1938. He joined the company as an engineer, and was engaged in development and production of military electronic equipment as well as cathode-ray tubes at Du Mont. In 1947, when in the course of the rapid expansion the company was organized on a divisional basis, Dr. Christaldi became Engineering Manager of the Instrument Division, which position he held until his promotion to Assistant Division Manager in 1951. Dr. Christaldi served as Assistant Division Manager until his recent promotion.

Dr. Christaldi was graduated from Rensselaer Polytechnic Institute in 1935 with the degree of Electrical Engineer. He returned as a graduate fellow in physics, specializing in wave guide communications. He received the degree of Doctor of Philosophy from Rensselaer in 1938. He is a member of Sigma Xi, and is a Fellow of the Radio Club of

(*Continued on Page* 17)

THE OSCILLOGRAPHER

A publication devoted exclusively to the cathode-ray oscillograph, 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 address below.

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Neil Uptegrove, — Editor

ON THE COVER

From us to you, an electronic valentine. The photograph was taken with a Du Mont Type 297 Camera from the screen of a Du Mont Type 304-H Cathode-ray Oscillograph. Mr. R. L. Dennis, of the Engineering Research Department of Ford Motor Company, Dearborn, Michigan was the operator and photographer. The circuit involved was excited by a triangular wave, and broke into oscillation at a discrete input signal level. The triangular signal thereafter modulated the envelope of the display.

TABLE OF CONTENTS

Techniques in Pulse Measurements

by

Melvin B. Kline

Assistant Engineering Manager, Instrument Division

PART 2

Examples Of Correct And Incorrect Techniques

The following set of examples and illustrations will demonstrate correct pulse techniques and common errors that are made. The first one to be discussed is the problem of impedance measurement or matching. Figure 9 shows a block diagram of a typical setup for making such measurements with pulses. The setup is extremely simple, and impedance may be measured precisely. The technique is nothing more than sending a pulse down the line and noting the presence or absence of reflections. With R varied until no reflections are received from the end of the line, a proper termination or impedance match is made and R may then be accurately measured on a bridge if a precise measurement of impedance is desired. Figure 10 illustrates this technique. The middle photograph shows a line which is correctly terminated. Note that there are no reflections. The top photograph shows the case where the terminating resistance is greater than the characteristic impedance. The pulses are all reflected in the same polarity. Note that the first reflection is greater in amplitude than the original pulse. If the end of the line were left open-circuited, the first reflection (assuming there were no losses along the line) would have twice the amplitude of the initial pulse. The bottom photograph illustrates the case where R is less than Z_0. In this case the pulses alternate in polarity. It should also be noted that the attenuation may be measured by measuring the amplitudes of the reflections and that the velocity of propagation may be computed by timing the spacing between reflections. Suppose, for example, that the line is 150 feet long

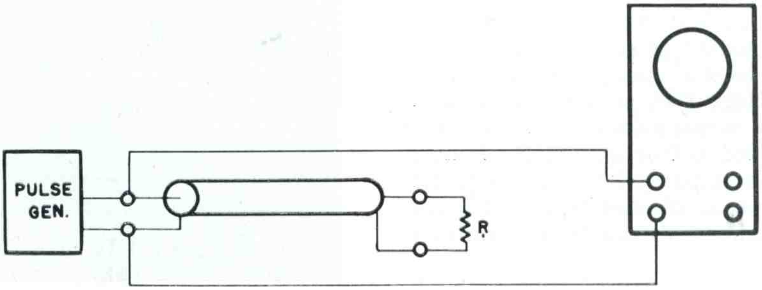


Figure 9. Typical setup for making line impedance measurements with pulses

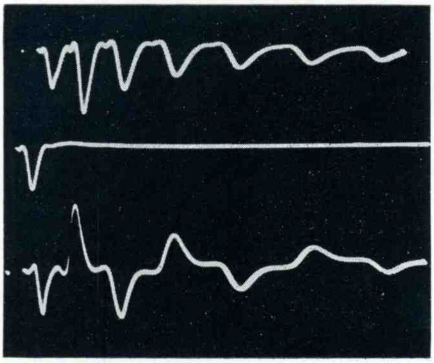


Figure 10. Oscillogram of line impedance measurements made with pulses

for a 0.5 μs separation between pulses. The velocity of propagation can be computed to be 114,000 miles per second or 61% of the speed of light. (Note — It must be remembered that the pulse travels twice the length of the line.) A typical delay cable, RG-65/U, for example, has a delay of 24 feet per microsecond (traveling once down the line). The velocity of propagation of this delay cable can therefore be calculated and measured as 44,000 miles per second or 24% of the speed of light. Figure 11 illustrates another case of impedance matching. In this case a long pulse is used, such that the pulse duration is longer than the length of the line. Timing waves shown here are 1 μs. In the lower picture R is greater than Z_O and we see that a positive reflection is received at a time equal to twice the delay time of the line. In the upper picture R is less than Z_O and a negative reflection is obtained. In the center picture R is equal to Z_O and there is no reflection.

Figure 12 illustrates the testing of a delay line or delay cable. The timing wave is 10 mc or 0.1 μs per inch. The lowest trace shows the input pulse, rise time is approximately 0.01 μs. The highest trace shows the output pulse and the delay may be measured as 0.22 μs. The center trace shows the output pulse repositioned for a more precise measurement of the rise time which in this case is approximately 0.02 μs.

To study the effect of resistance dividers across the output of a pulse generator and the effect of unbalanced capacitance across such dividers, we arrange the circuit setup as shown in Figure 13. In this figure the value of both resistances were made the same and will have no effect upon the pulse generator providing $2R > Z_O$. Otherwise the series R and the terminating Z_O shown on the diagram may be calculated as an L-pad according to equations (9) and (10). As the value of R is increased, the stray capacitance unbalances the divider action and the circuit of the corresponding attenuator is as shown in Figure 14.

$$R_1C_1 = R_2C_2 \tag{11}$$

For faithful reproduction of the pulse at the junction, the values of R's and C's should satisfy equation (11). Therefore, as resistance goes up to the point where the capacitive impedance becomes effective, one must properly compensate the attenuator.

Figures 15 and 16 show the effect of varying the values of the resistors. The timing marker shown at the bottom of the figures is 0.1 microsecond per inch. Looking at the pulses going from bottom to top, the bottom pulse shows the output of the pulse generator with no resistance

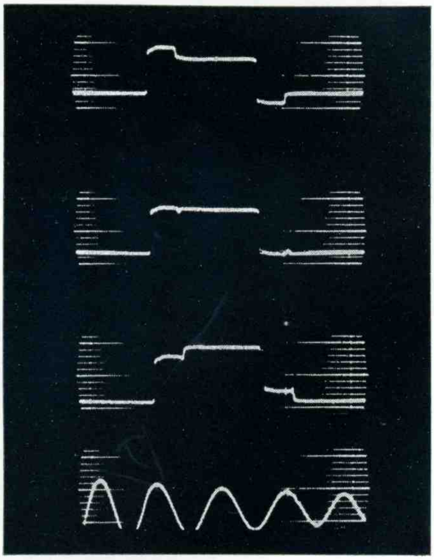


Figure 11. Oscillogram of line impedance measurements with long pulses

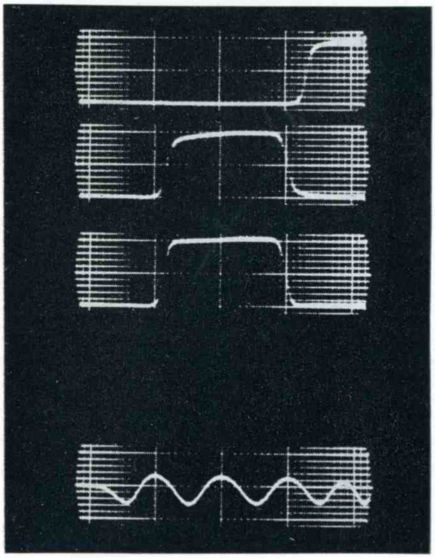


Figure 12. Oscillogram illustrating testing of delay line or delay cable

divider and the three pulses above it are for dividers having values of 200 ohms, 1000 ohms and 2000 ohms for each of the resistors. Note how the rise time deteriorates as the resistance increases. With proper capacitive compensation, this may be overcome.

The difference between Figures 15 and 16 regarding the waveshape of the pulses and the amount of ringing illustrates another point previously made and that is the effect of fixed and variable amplitude controls in the pulse generator. Figure 15 was taken with the variable amplitude control set at its optimum waveshape position in the particular pulse generator used and the pulse brought to the desired amplitude level by adjustment of the decade attenuator built into the pulse generator which had previously been found to be free of frequency discrimination. The ringing on top of the pulse is due to the connection to the deflection plate terminals of the cathode-ray tube. Note how the resistance divider has effectively damped this ringing.

Figure 16 shows what happens when the amplitude control is adjusted for the proper pulse amplitude and very distinctly shows waveshape distortion introduced by the amplitude control when compared with Figure 15. Notice the character of the ringing. Notice that this ringing appears in the rise of the pulse and that any attempt to make rise time measurements is ineffective. Notice also that the effect of the series damping resistors is not as great as in the previous figure until an appreciable amount of resistance is used. This illustrates the point that the characteristics and limitations of the test equipment should be well-known in order not to give the user misleading results. It would be easy in such a case to blame the circuit under test for introducing such unwanted distortions and here we have a clear-cut example of —

1. Frequency distortion introduced by the variable amplitude control of the pulse generator.

2. Ringing introduced by leads into the deflection plate terminals of the oscillograph.

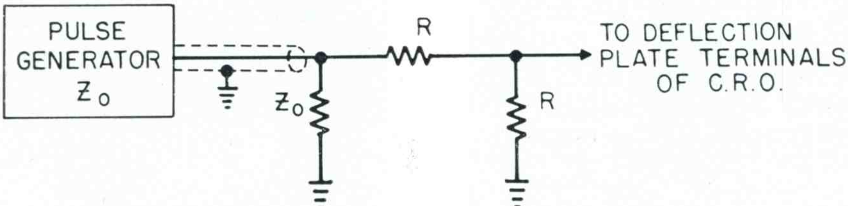


Figure 13. Circuit for studying effect of resistance dividers

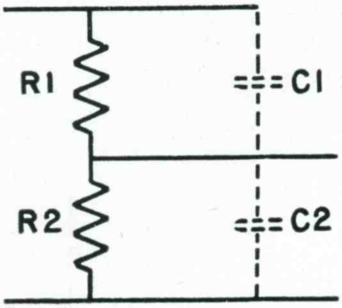


Figure 14. Attenuator circuit resulting from unbalancing stray capacitance

Figures 17 and 18 show a test of a fixed attenuator, such as illustrated in Figure 14, built into a high frequency cathode-ray oscillograph. Proceeding from the bottom pulse where no attenuation was introduced, successive attenuations of 10 db per step were introduced in the oscillograph and at the same time 10db was taken out of the attenuation from the pulse generator so that the amplitude level would remain the same. Knowing in advance that the pulse generator fixed attenuator did not introduce distortion, these figures indicate that the oscillograph attenuator also did not introduce distortion. Figure 18 is the same as Figure 17, except that the time base is much faster so that the effect on rise time may be seen. It may be noted that no deterioration in rise time is evident.

Ringing on top of the pulse due to leads from the deflection plate terminals to the cathode-ray tube was previously mentioned. Figure 19 illustrates this effect. Once again, the timing wave is 0.1 μs/inch. The lower pulse is applied from the pulse generator to the deflection plate terminals on the side of the cathode-ray tube. From these terminals are connected capacitors and leads to the deflection plates on the neck of the cathode-ray tube. Although the length of these leads are small, just a matter of no more than about 2-3 inches, it is evident that this is enough to cause oscillation or ringing at a frequency of about 100mc. The upper pulse shows the pulse generator connected right at the terminals on the cathode-ray tube neck, and the absence of ringing may be noted. The slight amount of overshoot evident exists in the pulse generator

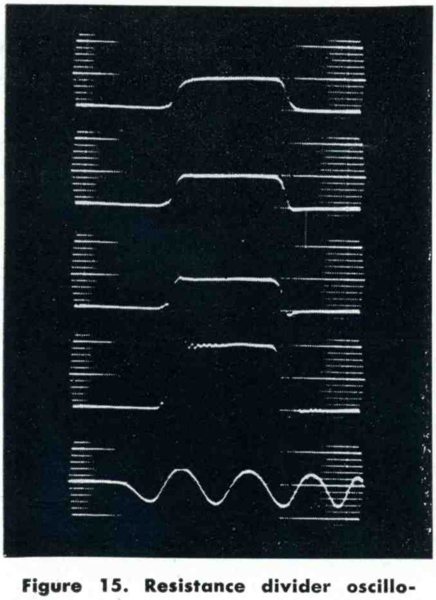


Figure 15. Resistance divider oscillogram

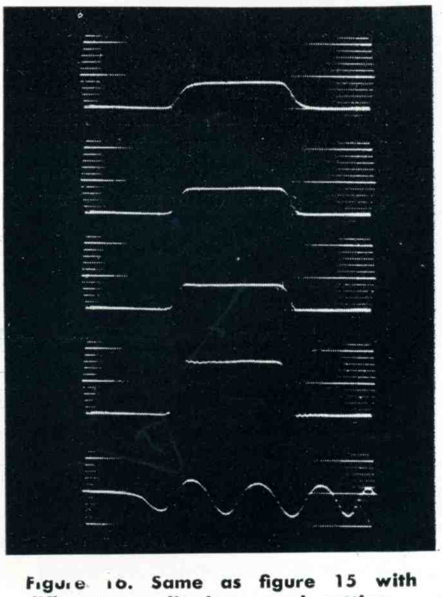


Figure 16. Same as figure 15 with different amplitude control setting

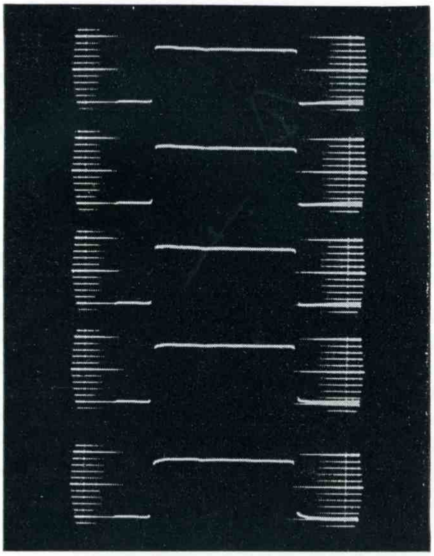


Figure 17. Oscillogram of a fixed attenuator test

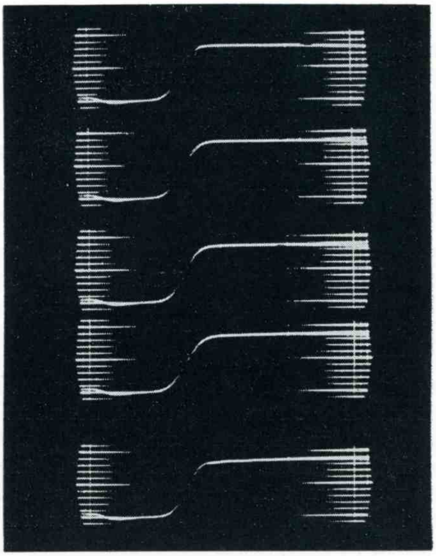


Figure 18. Oscillogram of a fixed attenuator test; using fast time base

so that this may be treated as an accurate photograph of the output of the pulse generator. The rise time shown is approximately 0.01 μs.

Figure 20 effectively shows what happens when signal and ground leads are too long and illustrates the care that one should take in order to keep such leads as short as possible. The timing wave is 0.1 μs/inch. The lower pulse is the same pulse previously seen applied to the deflection plate terminals of the cathode-ray oscillograph where the ringing frequency is approximately 100 mc due to the leads inside the oscillograph. The top pulse illustrates what happens when long open leads are connected from the pulse generator to the deflection plate terminals, in this case about six inches of lead. The effect on the oscillations is quite pronounced and the ringing frequency has been reduced to approximately 50 mc. The center pulse shows what happens when there is a long ground lead. In this case there is only several inches of ground lead. Here again, the character of ringing is changed and the ringing frequency is now about 25 mc. Note how it appears in the rise time and how it is impossible to get a reasonable measure of rise time when such an indication is received. It can thus be seen that interconnection of equipment and length of leads may have pronounced effects on measurements to be made, even to rendering them meaningless.

Figure 21 is another illustration of ground problem difficulties. Timing markers are 0.1 μs/inch. In this case the photo illustrates a ground loop difficulty in connection with the use of a delay line. The lower trace, with incomplete grounding, shows oscillation occuring just ahead of the rise and ahead of the beginning of the fall of the delayed output pulse. Frequency in this case is approximately 300 mc. The upper trace shows what happened when a proper ground was made. Notice that the ringing is absent, but there is a slight notch shown which indicates high frequency coupling across the delay line, for example, capacitance existing directly from input to output terminals of the delay line so that some high frequency component goes right through and is not delayed. This is also an undesirable effect and can be troublesome in the design or use of delay lines. Some losses in the delay line are also shown by the expotential rounding of the top corner of the rise and the bottom corner of the fall.

Proper grounding of signal leads as just shown is extremely important and even more so when dealing with high-powered, high-current phenomena where high peak currents may flow in ground circuits, such as in the case of testing of high-powered pulsed magnetrons operating in the microwave region. In one recent case it was desired to measure the plate current pulse of such a magnetron, and this pulse was derived from a low resistance shunt connected directly to the deflection plates of an oscillograph as shown in Figure 22. The figure also indicates the effective lead lengths from terminal board connections through coupling capacitors to the deflection plates and the rather long ground return. Figure 23 shows the resulting oscillogram that was obtained and it may be seen that there is so much spurious signal, including some frequencies in the microwave regions, that it is not possible to note the character of the pulse or say anything much about it.

Study of the circuit showed that there was a rather long path between deflection plate D4 and the ground return. This was found to be about six inches long, including a coupling capacitor. When the leads were made short and direct with all grounds connected to a common point and returned to a single chassis ground, satisfactory results were obtained. This shortened path is illustrated schematically in Figure 24 and the resultant oscillogram in Figure 25. Now, it may be seen that the pulse shape can be distinguished and the pulse characteristics measured.

Not long ago, Du Mont's aid was solicited by a manufacturer of pulse-forming networks. It was indicated that a customer had rejected networks as not meeting specifications on duration or rise time

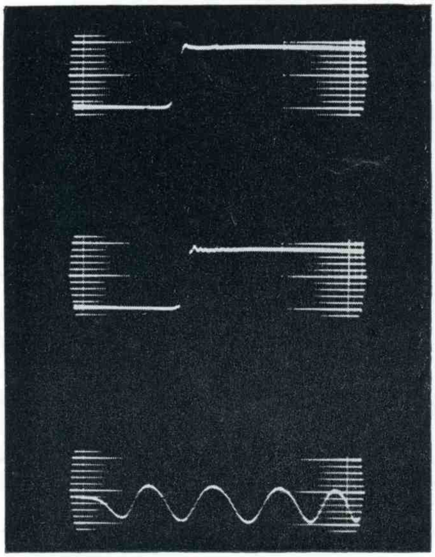


Figure 19. Pulse at deflection plates and neck of cathode-ray tube

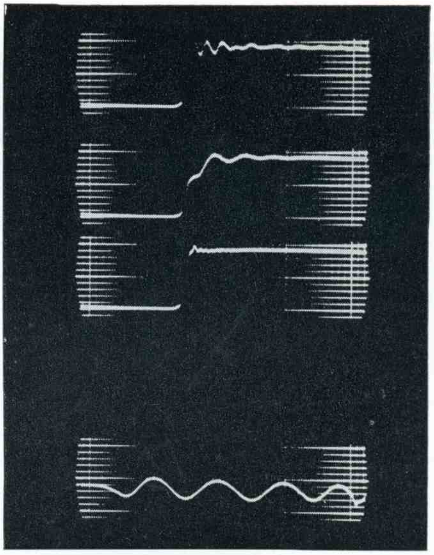


Figure 20. Same as figure 19, showing effect of long signal and ground leads

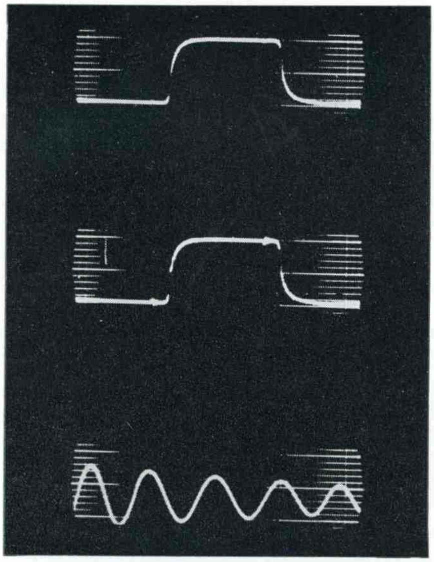


Figure 21. Effect of ground loop difficulty in connection with use of delay line

measured at various points. Du Mont agreed to set up and test one of these networks. It soon became evident that the pulse-forming networks were satisfactory, but that the measuring techniques of the customer were not. The network was designed to deliver pulses having a duration of approximately 0.5 μs at an amplitude of several hundred volts in the test circuit used. The rise time was of the order of 0.03 μs. The customer's oscillogram indicated such severe oscillation and overshoot that it was next to impossible to obtain a sensible measurement of the pulse at the specified points. Figure 26 shows the oscillogram that was made by the customer of the pulse-forming networks, based upon which, these networks were rejected. It is obvious from looking at this oscillogram that the techniques are questionable. In the setup used by Du Mont, the 50 ohm output impedance of the pulse-forming network was matched carefully to a 50 ohm cable terminated directly at the deflection plates of the oscillograph, and with proper setup and care paid in terminating the network and using short direct leads, the pulse waveform shown in Figure 27 was obtained. It can be seen that the pulse looks much different and is much cleaner. The measurements made by the customer were reconstructed by using open-wire leads to the deflection plates, simulating the lead lengths inherent in the equipment employed. The importance of impedance matching and in keeping short and direct any open-wire leads from the end of the properly terminated cable to deflection plates was again demonstrated.

Millimicrosecond Techniques

Earlier in the paper, the use of millimicrosecond techniques and pulses having rise times in millimicroseconds was discussed. In applying pulses having rise times of the order of 0.01 microseconds little attention has to be paid as to what the equivalent circuit of the cathode-ray tube deflection-plate system looks like. However, when applying pulses having rise times of the order of 1 millimicrosecond, it is not possible to neglect such an equivalent circuit. For example, it has been found that when a fast pulse having a width of 0.02 microseconds and a rise time of about 1 millimicrosecond is applied to the deflection plates of a Type 5XP-cathode-ray tube, the resultant pattern indicates ringing at a frequency of about 500 mc. Assuming the deflection plate capacitance is $2\mu\mu f$, then it is apparent that inside the tube the leads that connect the deflection plates to the caps on the wall of the tube must introduce an inductance of approximately 0.05 μh. Figure 28 shows the circuit that exists inside the cathode-ray tube. If the terminals are close together, the self-resonant frequency of the cathode-ray tube with a short across the two terminals of no more

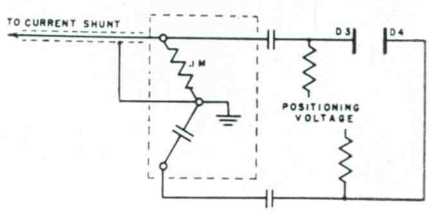


Figure 22. Long deflection plate ground return circuit

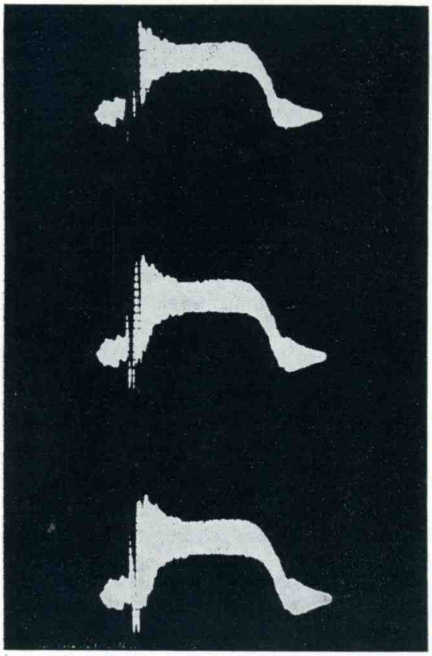


Figure 23. Oscillogram resulting from use of circuit in figure 22

than an inch may be measured, and this has been measured to be 50 to 100 mc less than the 500 mc ringing frequency. To compensate for this ringing, the network shown in Figure 28 has been used and this has resulted in a clean pulse. The R-C time constant of this network is 0.1 millimicrosecond and therefore has negligible effect on the rise time, while effectively damping the oscillation.

Much attention must be paid, when working with such fast pulses, to attenuators and cables that are used. In one case a well-known attenuator having a steady-state response of better than 200 mc was thought to be good enough for millimicrosecond work, but it was found upon use of this attenuator that the cut-off characteristic was so sharp that ringing was introduced. This attenuator had a 50 ohm characteristic impedance and had been frequently used with pulses having rise times of 0.01 microseconds without any bad effects. However, with the use of a pulse with a 1 millimicrosecond rise time, the effect became quite noticeable.

Such an effect is shown in Figure 29. As a matter of fact, this figure shows what was originally obtained when applying a 0.02 μs wide pulse through this attenuator to the deflection plates of the cathode-ray tube. The pulse pattern obtained was found to be a little difficult to understand at first as there was an evident ringing plus some rounding indicating losses as well. Figure 30 shows the same pulse pattern when the attenuator is not used. The loss causing the rounding on the front and back ends of the pulse was not thought to be characteristic of the pulse itself. In the test setup, 100 feet of RG-58A/U cable was used in order to introduce enough delay to allow observa-

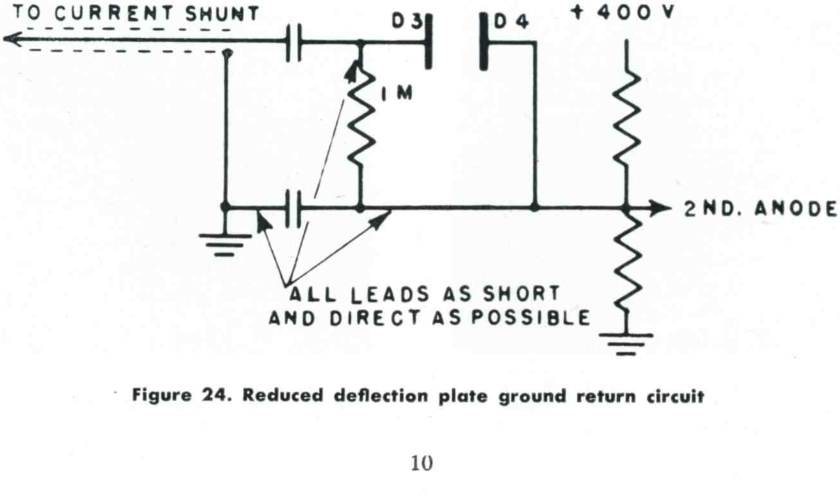


Figure 24. Reduced deflection plate ground return circuit

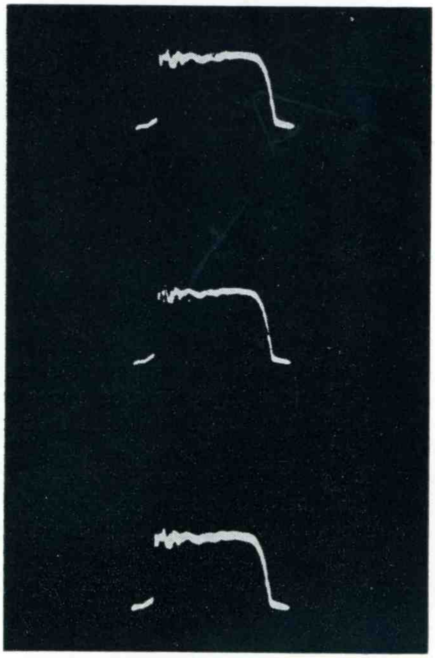


Figure 25. Oscillogram resulting from use of circuit in figure 24

tion of the entire pulse. The direct pulse would trigger the sweep of the oscillograph and the cable would introduce enough delay to see the leading edge. Investigation showed that RG-58A/U had a loss of 22db per 100 feet at 100 mc. Replacing this cable by RG-17/U, which has only a loss of 4.2 db per 100 feet at 100 mc, the results shown in Figure 31 were obtained. The upper picture shows the pulse fed through the attenuator and cable combination and the lower pulse through the cable only. Once again the ringing introduced by the attenuator is shown, but the sharpness of the pulse and the absence of the rounding due to loss in the cable is quite evident. Incidentally, the upper picture is exactly the same type of picture that is obtained when the pulse is applied directly to the deflection plates of the cathode-ray oscillograph without the matching network shown in Figure 28 and the ringing frequency is 500 mc in this picture.

Figure 32 shows the waveform of the pulse from the pulse generator which has a width of 0.02 μs and a rise time of slightly less than 1 millimicrosecond. The upper picture shows the complete pulse and the lower picture shows the pulse on a faster sweep so that its rise time may be observed and measured. Timing markers on the lower picture are 1000 mc or 1 mμs separation. It can be seen that the rise time of the pulse is about 1 mμs and that there is a slight overshoot on the pulse which can be measured to be approximately 3%.

Very often, in the mesurement of such pulses, the only way a precise measurement may be obtained is by means of photography. In such cases a photograph is taken and projected and measurements made on the projection. It should be noted

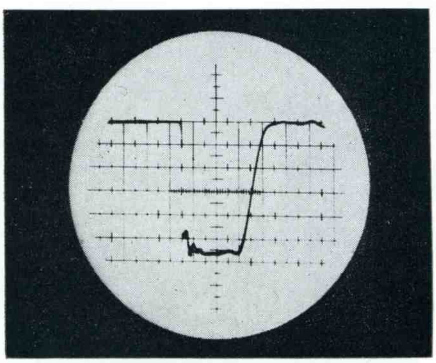


Figure 26. Pulse forming network oscillogram, resulting from incorrect measuring techniques

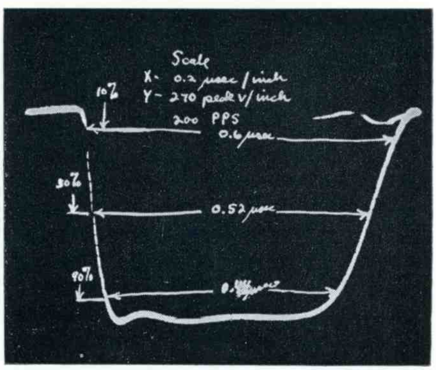


Figure 27. Same as figure 26, but using correct measuring techniques

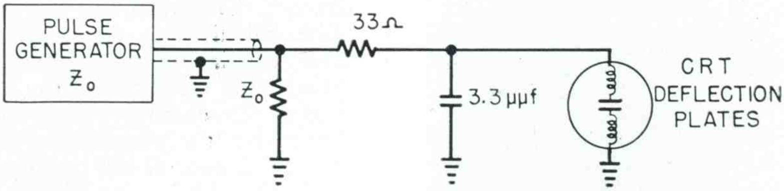


Figure 28. Circuit to compensate for deflection plate inductance

that the right angle alignment of the two sets of deflection plates is important in such cases. Where the pulse is spread out only to a slight extent on the sweep, the right angle alignment may make an appreciable error in the measurement. As a matter of fact, it may even make the pulse appear perfect or seem to have a negative rise time. Recently, tighter tolerance cathode-ray tubes have become available where the right angle alignment is held within one degree rather than three degrees which has previously been the normal tolerance. This helps greatly in improving the accuracy of such measurements

An interesting application in the pulse testing of distributed amplifiers is worthy of mention at this point. It has long been known that the limitation on the use of amplifiers for obtaining wide bandwidths has been due to insufficiently high g_m or insufficiently low shunt capacitance. Attempts made to improve this by, for example, paralleling tubes to increase the g_m show no improvement in the overall bandwidth since the unwanted shunt capacitance is paralleled in a like manner and the overall results are the same. The distributed amplifier configuration overcomes this difficulty since it is possible effectively to parallel tubes and the resultant g_m is equal to the sum of the individual g_m's while the resultant capacitance is effectively that of only one tube. The general theory of the distributed amplifier is too detailed to be discussed here, but it is felt that a brief description of how the distributed amplifier works will be helpful, since with such amplifiers, it is possible to increase the bandwidth of the video amplifier from the order of 20 mc to the order of 200 mc.

Figure 33 shows a typical distributed amplifier. Its operation is as follows: The tubes are connected as shown so that the grids are connected to a delay line and the plates to a similar delay line. It is im-

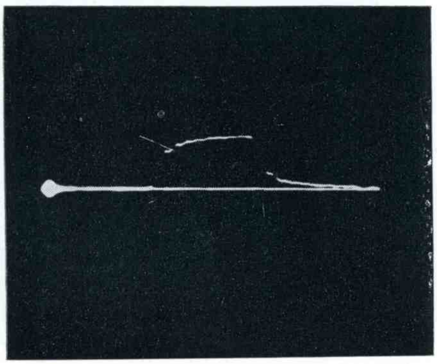


Figure 29. Microsecond response, using attenuator and long cable

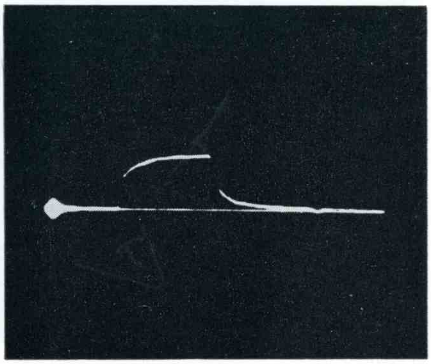


Figure 30. Microsecond response, long cable and no attenuator

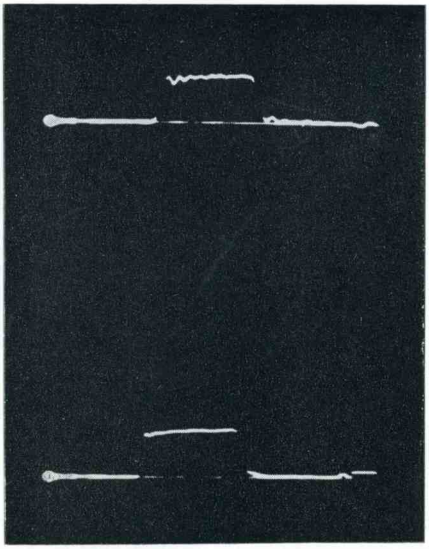


Figure 31. Microsecond response using RG-17/U cable

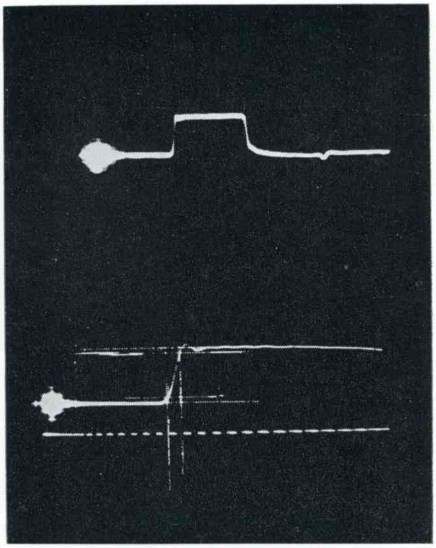
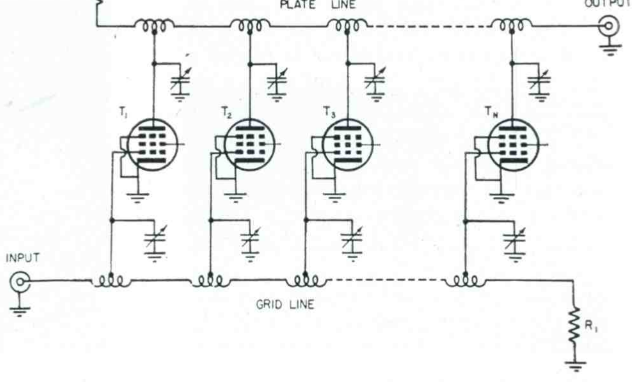


Figure 32. Pulse with a one millimicrosecond rise time

portant that the delay from the grid of tube one to the grid of tube two be exactly equal to the delay from the plate of tube one to the plate of tube two, etc., in order for the amplifier to operate successfully. Transit time in the tubes is usually negligible but, if necessary, could be compensated for in the lines. If a signal, such as pulse, is applied to the input terminal, it will arrive at the grid of T_1 and subsequently appear at the plate of T_1. The grid signal will then continue to travel down the line until at sometime later, depending upon the delay time of the line between the grids of T_1 and T_2, the pulse will appear at the grid of T_2. At the same time the pulse appearing at the plate of T_1 will travel in both direc-

Figure 33. Typical distributed amplifier circuit. Pulse output at plate Tn has n times the amplitude of that at plate of T_1



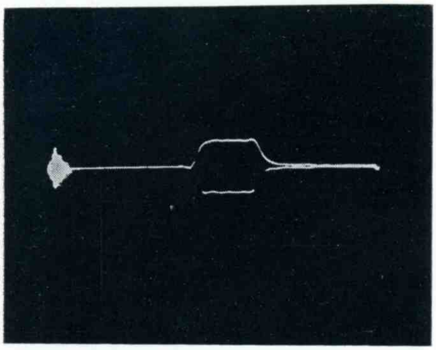


Figure 34. Oscillograms of properly adjusted grid and plate delays superimposed

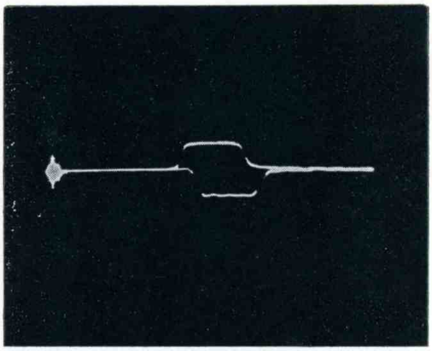


Figure 35. Oscillograms of improperly adjusted grid and plate delays

tions down the plate line. Looking at the forward direction the pulse from the plate of T_1 will appear at the plate of T_2 at a time determined by the delay of the plate line, and if this is exactly equal to the delay of the grid line it will arrive at the plate of T_2 just as the pulse generated at the plate of T_2 by the grid of T_2 appears there, and we thus achieve addition of the two pulses. This happens similarly along the line at the various grids and plates, so that as a result, with everything properly matched, a pulse will appear at the plate of T_n which has n times the amplitude of that appearing at the plate of T_1.

In order to prevent pulses that have reached the end of the grid line from reflecting back along the line in the opposite direction once again and thus introducing additional pulses in the plate line, a terminating resistance is placed at the end of the grid line. Similarly, in the plate line, in order to prevent pulses traveling backward down the line from reflecting from the end of the line, the plate line is terminated as shown. This gives a result such that only the desired response appears at the output terminal.

We have mentioned the importance of the delays being equal on the grid and plate lines. In order to check these lines for proper delays, one technique that has been used is to put the delay lines into their proper circuit configuration so that the capacitances are proper and to keep the tubes deactivated. The lines can be matched through a simple technique. Figure 34 shows a picture, actually two pictures superimposed on the same photograph, of a pulse going down a plate line and a pulse going down a grid line. One can see that the pulses appear exactly opposite each other and therefore that the delays are proper. Figure 35, for example, shows a similar picture where the delays are not equal. In order to adjust the lines while watching the pattern, a cancellation setup has been devised. In this setup pulses are applied at the same time to both the grid and plate lines and each line is connected to one of the deflection

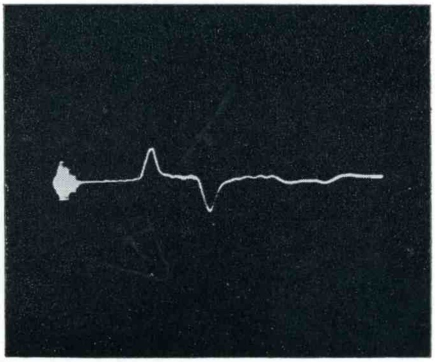


Figure 36. Oscillogram of improperly cancelled delays

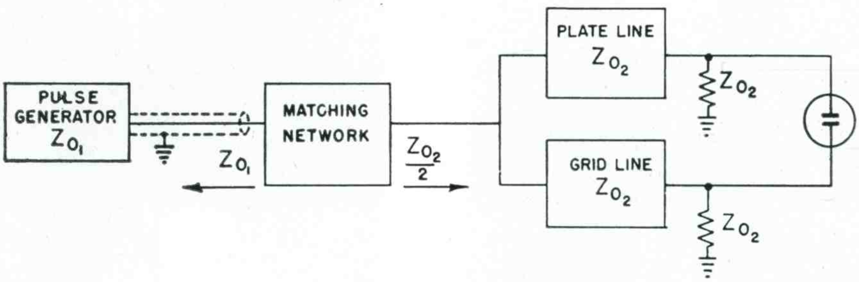


Figure 37. Cancellation setup

plates of a cathode-ray tube. If they are properly adjusted, pulses will cancel each other and no deflection will be noted. Figure 36 shows a photograph of the improperly cancelled delay lines shown in Figure 35 using the cancellation technique. It can be seen that the two pulses shown are the result of the two areas where no cancellation occurs.

The cancellation setup is shown in Figure 37. The matching network is inserted so that the correct terminating impedances are seen by the pulse generator and the plate line and exactly half the voltage will appear at each point. It is not necessary that the plate and grid lines have the same characteristic impedance in distributed amplifier work, but for the purposes of simplification they have been shown the same in this figure. One quickly recognizes that this is nothing more than a bridge setup, where the generator is connected between the input to the two lines and ground, and the cathode-ray tube as the indicator is connected across the junctions of the plate and grid lines and their respective terminating impedances. Figure 38 shows the resultant cancellation pattern superimposed upon the individual plate and grid lines previously shown for properly adjusted lines. It is thus seen that plate and grid lines may be adjusted to a high order of accuracy.

In conclusion, it may be said that by and large good pulse techniques boil down to careful analysis of the problem and methods to be used, understanding of the problem and of the equipment to be employed, systematic analysis of the results sought and the methods to be employed, and the continued application of ordinary common sense. Nothing should ever be taken for granted. The simple techniques and rules that are found to be proper for use in high frequency measurements using sine waves are just as applicable for use in pulse measurements.

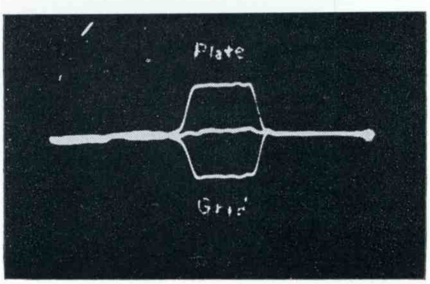


Figure 38. Oscillogram of properly adjusted delays cancelled

Dr. P. S. Christaldi

G. Robert Metzger

PROMOTIONS

(*Continued from Page* 2)

America and the Institute of Radio Engineers.

Mr. G. Robert Mezger will assist Dr. Christaldi in over-all division planning and administration. He has been a member of the Du Mont organization since 1936 when he graduated from Rensselaer Polytechnic Institute as an Electrical Engineer. Mr. Mezger was actively engaged in the development of cathode-ray instruments until 1939, at which time he was appointed Technical Sales Manager. In 1941 he went on active duty with the Navy and was assigned to instrument development work at the David Taylor Model Basin, Washington, D. C. From 1944 to 1945, before leaving the Navy as a Commander to return to Du Mont, he was active in the design of naval radar equipment. Mr. Mezger was Sales Manager for the Instrument Division until 1947, then served as Engineering Manager until his promotion to Assistant Division Manager. He is a member of the IRE and American Institute of Engineers.

Morris Harris

Mr. Morris Harris began his career at Du Mont in 1945. Mr. Harris left the Transmitter Division as Production Control Manager to take over the newly established position of Manager of Procurement and Planning in the Instrument Division. He is a graduate of Fordham University, having received a Bachelor of Laws degree. He practiced law in

Passaic, N. J., for a number of years, and instructed in Production Control at Fairleigh-Dickinson College in Rutherford, N. J. Mr. Harris is a former member of the Passaic City Bar Association.

Mr. Arthur J. Talamini, Jr., newly appointed Engineering Manager of the Instrument Division, was formerly Assistant Engineering Manager and Government Engineering Manager for Du Mont's Transmitter Division. He joined Du Mont Laboratories in 1945. Prior to his coming to Du Mont, Mr. Talamini worked with Federal Telephone and Radio Corporation, was Technical Supervisor of National Radio and Television Institute, and was active in early television development with Kolorama Laboratories. He is a senior member of the Institute of Radio Engineers and a member of the Society of Motion Picture and Television Engineers.

Arthur J. Talamini, Jr.

"Who and Why"

Du Mont Selling Agents

Editor's Note: With the idea in mind of expounding on the "who and why" of our many Du Mont selling agents, we are publishing the first in a series of biographical sketches on the "reps." We plan to publicize some of the highlights in the lives of at least one representative selected at random, in each OSCILLOGRAPHER issue henceforth.

Walter A. Knoop, Jr.
Company: Gawler-Knoop Co.

Walter A. Knoop, Jr., was born in Chicago, Ill., in 1919. After attending New Trier Township High School, he earned a Bachelor of Electrical Engineering Degree from Rensselaer Polytechnical Institute in Schenectady.

In his earlier career days, Walter Knoop worked as an instrument calibration technician with Central Hudson Gas & Electric Corp., as a clerk with Detroit Edison Co., and a radio operator-weather observer at Whiteface Mountain Observatory in Lake Placid, N. Y.

Walter A. Knoop, Jr.

In 1941 Walter Knoop joined Allen B. Du Mont Laboratories. His first two years with Du Mont were spent doing design and application engineering work

(*Continued on Page* 24)

The New Du Mont Type 301 - A

A Highly-Portable Cathode-ray Oscillograph

Introduction

Allen B. Du Mont Laboratories, Inc. has developed a small, highly portable, uniquely designed instrument for the field technician, the Type 301-A Cathode-ray Oscillograph. The Type 301-A, despite its size (the front panel is a little smaller than this *Osocillographer* page), is a rugged, wide-band, quantitative instrument that gives the high-quality performance you would expect from a much larger and heavier laboratory bench instrument.

Small, Rugged and Complete

The Du Mont Type 301-A Cathode-ray Oscillograph has many design features unique to instruments to date. Its compact design and aluminum construction throughout make it especially useful for applications where portability and high accuracy are prime factors. The complete unit weighs only 20 pounds, and has been compactly engineered for housing in a cabinet $16\frac{5}{8}''$ deep, $9\frac{1}{8}''$ and $6\frac{1}{2}''$ wide. The Type 301-A operates from a 115 volt $\pm 10\%$, 50-1000 cps power source which makes it operative from practically any local a-c power source in the world.

For the first time with a commercial cathode-ray oscillograph, a complete set of probes is supplied that extends the use of the unit as a portable laboratory, the probes permitting input signal application over a wide range of impedance requirements. These probes are packed neatly within a front panel protective cover, and are supplied at no extra cost.

The Type 301-A has been engineered for continuous use under adverse conditions. Wherever feasible the standard miniature components utilized in this instrument were chosen for their reliability and wide-range temperature rating. As a result it has been possible to specify an ambient temperature range of $-54°C$ to $+65°C$, and a maximum altitude of 10,000 feet for the unit. A standby heater is incorporated to prevent moisture condensation and fungus growth under adverse climatic conditions. The Type 301-A can be purchased with ruggedized tubes to lengthen service life and increase reliability even with the roughest handling.

Even though the unit was intentionally designed small for portability purposes, no normal functions of a cathode-ray oscillograph were eliminated because of space limitations. To make this possible, miniature components in the unit have been installed very compactly; however, all circuits are accessible for servicing as a result of a hinged-door chassis construction. In some instances, components were designed specially to permit a saving of space without losing the accuracy expected of the instrument.

Compactness and low power consumption in the Type 301-A have been greatly facilitated by circuits engineered for power economy. The one (310V) low-voltage power supply is used for the vertical deflection amplifier circuit, the same current then energizes a 110 volt regulator, the output of which is again used for operating a calibrator and other circuits. Filament voltage for all tubes, other than for the cathode-ray tube and a high voltage rectifier, is taken from only one secondary winding of the miniature power transformer. Bleeder current from the high-voltage supply circuit is used in a brightening gate circuit and is then returned to and used in the operation of a negative voltage supply circuit. By utilizing the power in this manner it has been possible to keep the power transformer size, number of required tubes, components, and thus the weight, to a minimum.

Accurate Measurement Features of the Type 301-A

The Type 301-A features a vertical amplifier with a bandwidth that extends from 10 cps to 4 mcps—down not more than 20% at either end (refer to Figure 2). The unit offers a rise time of 0.08 usec (with less than 3% overshoot), and a broad range of sweeps variable in duration from 10 usec to 0.2 second. The linear sweeps are generated by a very linear vacuum-tube time-base generator which enables the operator to obtain reliable measurements over the entire sweep range.

Intensity timing markers are available, compatible with the sweep speeds, that permit time measurements accurate to within 5%. Even for the fastest sweep of 10 usec duration, with the trace expanded to its maximum of twice the tube diameter, four 1 usec intervals of time could be depicted on the screen which can be subdivided even further by the calibrated lines of the engraved scale. These markers assure very accurate time measurements over small increments of sweep, of practically any phenomena normally encountered.

For amplitude measurements the Type 301-A incorporates an accurate voltage standard. The voltage standard is a precise square wave at power-line frequency which is introduced behind an accurately calibrated attenuator, affording

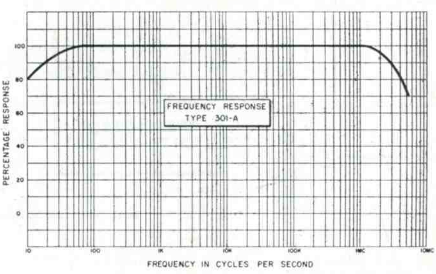


Figure 2. Frequency response characteristic of Type 301-A

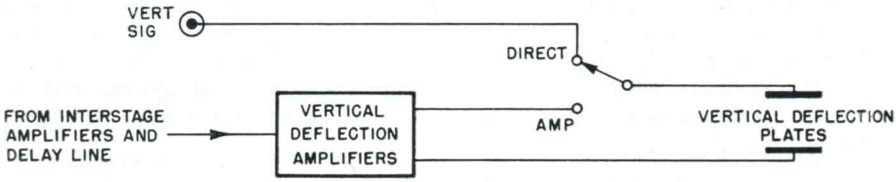


Fig. 3 Vertical deflection output circuit, block diagram

a means of calibrating the screen in volts-per-inch with a precision of 5%.

Unique Operating Features

All operating controls and connection jacks are available on the front panel. This has been made possible by a tight mechanical layout and the use of concentric controls. A few operational features of the Type 301-A, utilizing the front-panel setup, are unique.

Circuitry includes the provision for connection of the selected signal source to the vertical deflection plates of the cathode-ray tube directly at the front panel. As can be seen in Figure 3, the signal on the vertical deflection plates can come from either the vertical deflection amplifier, or one deflection plate can be fed directly from a signal coupled to the VERTical DIRECT jack on the front panel. The signals on the CRT deflection plates, coming from the vertical deflection amplifier, are opposite in polarity but equal in amplitude as a result of the signal-balancing amplifier circuitry. By setting a front-panel switch and feeding an input signal to the VERTical DIRECT jack on the front panel, the incoming signal is connected directly to a CRT vertical deflection plate without making the usual laborious back-of-panel connections.

A dual SWEEP TIME control enables the operator to select a 10, 20, 200, 2K, 20K or 200K microsecond sweep (outer knob), or have continuous control of any sweep duration in between those coarse stages (inner knob).

Timing markers, in the form of blanking markers on the trace, are available at intervals of 1, 10, 100, 1K, or 10K microseconds. These markers are also available as output signals, as selected by the setting of a front panel selector switch (MARKER INTERVAL). This switch determines the time interval between the successive timing markers supplied by a built-in, stable, time-marker generator.

The operator has a choice of three methods for sweep initiation. It is only necessary to set one switch (SYNCHRONIZATION), and connect the input to the appropriate front-panel jack to complete a choice. The sweep can be triggered from a power line frequency source by setting the SYNCHRONIZATION switch to Line (either polarity). By setting the switch to EX and connecting the input signal to the SYNC IN jack, the sweep will be triggered from an external source. The ±V position couples a portion of the undelayed signal from the vertical amplifier to the

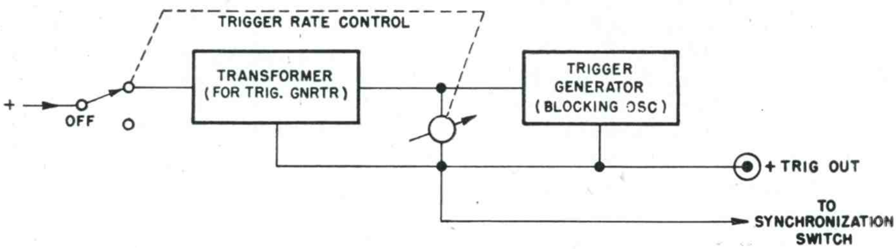


Fig. 4 Trigger generator, block diagram

sync amplifier, thus allowing the sweep to be initiated by either the positive or negative edges of the signal under study 0.3 microsecond before the signal itself reaches the vertical deflection plates.

There is a TRIG position on the SYNCHRONIZATION switch which allows the internal trigger generator to be applied to the sync circuit for sweep initiation (refer to figure 4). The trigger generator consists of a blocking oscillator stage and associated circuitry which comprise a source of positive trigger pulses at variable repetition rates. The rate of the trigger generator is continuously variable between 45 and 5500 pulses per second, and is controlled by the setting of the front-panel TRIGGER RATE control. The output of the trigger generator is fed to a +TRIG OUT jack and to the SYNCHRONIZATION switch on the front panel. This signal from the +TRIG OUT jack is 100 volts ±30% in amplitude. It can be coupled to another unit to initiate action while triggering its own sweep generator, thus making the Type 301-A a virtual synchroscope.

Standard Operating Features

Other front-panel controls enable the operator to perform such normal oscillographic operations as calibrating the amplitude of an input signal connected to the VERTical SIGnal jack. Several cycles of internally generated square-waves are easily obtained for calibration purposes. These square-waves are formed by a built-in voltage calibrator (see figure 5). A 0.6 volts p-to-p square wave, at power-line frequency, is available at the "CALibrator OUT .6V p-p" jack on the front panel for external calibration use, or for internal use by depressing the PRESS TO CALibrate push button. Adjusting the instrument sensitivity (VERTical GAIN control) for a given deflection, amplitude of signals connected to the VERT SIG jack can be read directly from the calibrated scale over the CRT screen. The sensitivity of the vertical amplifier is determined by the VOLTS PER INCH switch; a choice of 0.3, 1, 3, 10, 30 or 100 volts per inch deflection factor is available at near maximum sensitivity, and these factors may be doubled by adjustment of the VERTical GAIN control.

Traces on the screen can be positioned approximately 2½ inches vertically by a VERTical POSition control. By using a dual HORizontal GAIN and HORizontal POSition control, the trace can be expanded horizontally to twice the screen diameter without any appreciable distortion, and can be positioned horizontally so that any portion of the sweep can be seen.

Added Operating Features Utilizing Supplied Probes

Three probes — a Cathode Follower Probe, an Attenuator Probe, and a Detector Probe, two accessory cables, a 75-ohm Termination, two BNC-to-binding post adapters, spare fuses and indicator lamps, and an Allen wrench for knobs are stored within a front-panel protective cover of the Type 301-A. Operating instructions, plastic protected, are also contained in the front cover.

The Cathode-Follower Probe is em-

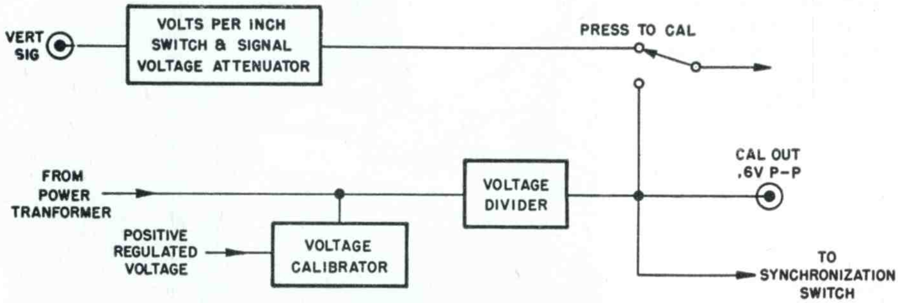


Fig. 5 Voltage calibrator, block diagram

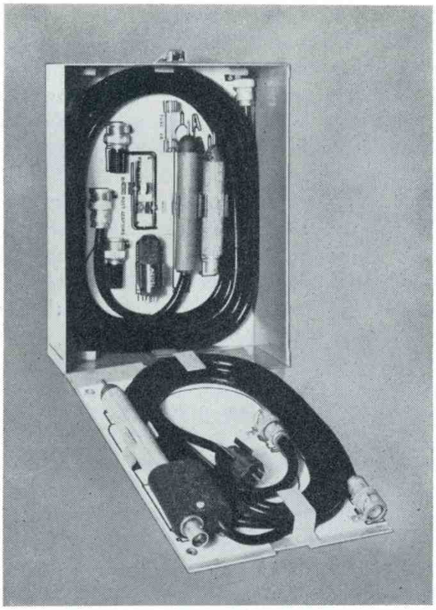


Figure 6. Front panel cover contains complete set of test probes, cables and operating instructions.

ployed where a very high impedance (6 megohms, 10 $\mu\mu$f) must be presented to the circuit under test to avoid loading. It attenuates the signal to 70% of input value.

The Attenuator Probe has a fixed attenuating ratio of 20:1. It offers a very high input resistance (8 megohms) with low input shunting capacity (8 $\mu\mu$f) to the circuit under test. With the same impedance requirements, the Attenuator Probe would be employed in those applications where the Cathode-Follower Probe would be unsuitable because of high signal voltage. The maximum permissible a-c signal input for the Attenuator Probe is 600 volts peak, as compared to two volts rms maximum for the Cathode-Follower Probe. The signal cable for the Attenuator Probe is permanently attached, since the cable capacity forms part of the circuit for frequency compensation of the probe.

The Detector Probe will demodulate signals in the 10 cps - 15K cps range over a carrier-frequency range of 0.5 to 400 mcps. The audio frequency response is within 6 db at any carrier frequency in the operating range.

The 75-ohm Termination is a plug-in adapter and connects to the front-panel C. F. PROBE socket. When connected, it provides a 75-ohm matching impedance for the VERTical SIGnal at all positions of the VOLTS PER INCH switch.

The binding-post adapters supplied enable the operator to connect wire-type

Figure 7. The highly-portable Type 301-A is invaluable in locations where equipment is not readily accessible

test leads to the coaxial jacks on the front panel.

MANY USES FOR THE TYPE 301-A

Even Du Mont can't foretell the number and variety of uses to which the Type 301-A may be put, but it was designed with some specific applications in mind. Of these applications, because of its small size, wide power-frequency range, extensive ambient temperature range, and high maximum operational altitude, the unit is paramount for maintaining airborne equipment. It is invaluable in any localities where portable generating equipment with unstable frequency outputs may be used.

In addition, the Du Mont Type 301-A is rugged, is moisture proof, and has a built-in space heater to prevent the internal formation of moisture or fungus growth. These assets make it ideal for maintenance work on mobile units on land or sea. Remote areas, such as microwave relay line localities, become more readily accessible with this unit.

With the Type 301-A Oscillograph, the traveling technician is virtually able to carry all basic test equipment with him in one instrument.

Additional information on the Du Mont Type 301-A Cathode-ray Oscillograph may be obtained by writing the Instrument Division, Technical Sales Dept., 760 Bloomfield Avenue, Clifton, New Jersey.

SPECIFICATIONS

CATHODE-RAY TUBE—Tight-tolerance Type 3 WP-1 cathode-ray tube operated at overall acceleration of 1400 volts.

VERTICAL DEFLECTION—Deflection Factor: through amplifier, 0.28 p-p (0.1 rms) volts/inch; direct, 47 p-p (17 rms) volts/inch.

Sinusoidal Frequency Response (any setting of gain or attenuator controls): down not more than 20% at 10 cps and 4 mc. **Rise Time:** 0.08 usec max.

Undistorted Deflection: 2 inches minimum

Signal Delay: built-in delay of 0.35 usec allows time for sweep initiation before signal is applied to vertical deflection plates.

Input Impedance: through amplifier, 1 megohm, 28 uuf ±2 uuf for all positions of "Volts per Inch" switch; direct 4.7 megohms, 30 uuf.

Maximum Allowable Input Potential: 600 volts d.c. plus peak a.c.

LINEAR TIME BASE—Sweep Range: driven sweep only, continuously variable in duration from 200,000 usec to 10 usec.

Maximum Sweep Speed: 0.55 inches/usec

Sweep Gating: brightening gate turns beam on for sweep duration

Synchronization: Internal sync, ½" pattern produces adequate sync. External sync, 0.2 volts p-p for repetition rates between 50 cps and 200 kc, 0.8 p-p v for repetition rates below 50 cps, provided that rise time of trigger is equal to, or less than, that of a 5 cps sine wave; 0.8 p-p v for repetition rates between 200 kc and 2 mc.

TRIGGER GENERATOR—(Trigger available at front panel) range: 45-5500 cps; amplitude: 100 peak volts ±30% with load in range from infinity to 5000 ohms paralleled by 1500 uuf; 25 peak volts (approx.) with 75 ohm load; rise time; less than 0.5 usec; duration: 1-2 usec approx.

VOLTAGE CALIBRATION—Source: square-wave 0.6 p-p volts in amplitude introduced behind attenuator (imposed by a momentary push-button switch); attenuator is calibrated to 0.3, 1, 3, 10, 30, and 100 volts/inch; precision ±2%, calibration waveform available at front panel.

TIME CALIBRATION—Source: blanking markers at 10,000 usec, 1000 usec, 100 usec, 10 usec, 1 usec intervals; accuracy ±5%; available at front panel with an internal impedance of 120,000 ohms.

INTENSITY MODULATION—Front panel connection, positive 10 volts peak signal provides adequate blanking at normal intensity settings; input impedance, 1.2 megohms, 30 uuf.

TUBE COMPLIMENT—6-12AT7, 3-6AN5, 3-6AK5, 3-12AU7, 3-6AU6, 2-6X4, 1-5651, 1-5702, 1-1Z2.
PRIMARY POWER—115 volts, 50-1000 cps, 110 watts. Standby heater consumes 15 watts.

PHYSICAL CHARACTERISTICS—Housed in small, well-ventilated, light-gray, combination metal cabinet with light gray, smooth panel; direct-etched, white filled numerals; two protective handles on front panel, carrying handle on top of cabinet; supporting foot for instrument folds under cabinet.

Size: Height, 9-1/8"; width, 6-1/2"; depth, 16-5/8"; weight, 20 lbs. complete, 17-1/2 lbs. without cover and accessories.

Accessories Supplied: Calibrated scale, filter; **Cables,** 4' and 6', RG-62/U terminated in BNC connectors; input termination, 75 ohm, 2 watt $\pm 10\%$ plug-in adapter; **Probes,** Cathode Follower, input impedance 6 megohms, 10 uuf, gain 0.70 approx., bandwidth 10 cps-7 mc, power cable (power supplied by instrument); passive, attenuation 20:1 $\pm 3\%$ (on vertical input terminal), input impedance 8 megohms, 8 uuf, overall length 72"; Detector, carrier frequency range 0.5-400 mc, demodulation frequency range 10 cps to 15,000 cps ± 6db, input impedance 20,000 ohms, 7 uuf, input voltage less than 125 volts inverse peak on detector, for use with separate coaxial cable; adapters (2), BNC to binding post; spare fuses and indicator lamps; Allen wrench for knobs.

(Probes, cables and termination, spare fuses, bulbs, etc. fit in protective cover.)

CAT. NO.	TYPE NO.	DESCRIPTION
1640-E	301-A	Cathode-ray oscillograph for 115 volts 50-1000 cps, with Type 3WP-1 Cathode-ray Tube.
1641-E	301-A	Same as above, with ruggedized Tubes.

"Who and Why"

(*Continued from Page* 17)

on cathode-ray tubes and oscillographs. He then became manager of the Contract Division, which was responsible for all liaison, technical and administrative work with the government procurement agencies and laboratories, and World War II prime contractors. He was appointed Technical Sales Manager at Du Mont in 1945, and he was responsible for the sale of the company's industrial products.

Along with H. C. Gawler and C. L. Gawler, Walter Knoop founded the present Gawler-Knoop Company. The Gawler-Knoop Company is the Du Mont representative in District 14; this includes parts of New Jersey and Pennsylvania, and all of Maryland, Delaware and Virginia, as well as the metropolitan area of New York.

Mr. Knoop is a member of Sigma Xi and Tau Beta Pi honorary societies, Theta Chi social fraternity, and is an active member of the I.R.E. and A.I.E.E. societies. He is also a member of the Instrument Society of America, Radio Club of America, Montclair Society of Engineers, Essex County Engineering Society, and Society of American Military Engineers.

He is a registered Professional Engineer in New York, New Jersey and North Carolina.