SSC-189

THE VIDEO TAPE RECORDING OF ULTRASONIC TEST INFORMATION

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October 1968

Dear Sir:

The increasing use of ultrasonic inspection for quality control of ship welding has prompted the Ship Structure Committee to seek methods of recording the results of this testing for subsequent review and analysis. No such method has been available heretofore. The enclosed report *The Video Tape Recording of Ultrasonic Test Information* by R. A. Youshaw, C. H. Dyer and E. L. Criscuolo describes the development of a first generation method for recording the ultrasonic test information on magnetic tape. Suggestions are made for further development to make the system more useful in shipyards.

This report is being distributed to individuals and groups associated with or interested in the work of the Ship Structure Committee. Comments concerning this report are solicited.

Sincerely yours,

D. B. Henderson

D. B. Henderson
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

SSC-189

Final Report

on

Project 176

"Quality Assurance"

to the

Ship Structure Committee

THE VIDEO TAPE RECORDING OF ULTRASONIC TEST INFORMATION

by

Robert A. Youshaw, Charles H. Dyer
and Edward L. Criscuolo

United States Naval Ordnance Laboratory

under

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Washington, D. C.

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ABSTRACT

A video tape recorder has been converted into a wide band instrumentation recorder. The "A" scan from the ultrasonic tester is directly recorded together with the operator's voice giving the location, transducer position and interpretation of test data. An oscilloscope is used for the playback. The circuitry necessary to couple the output of the ultrasonic tester to the tape recorder is described.

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INTRODUCTION

The lack of a primary record of inspection has decidedly retarded the acceptance of ultrasonics as an independent inspection tool, and much effort has been directed toward devising a means of recording the ultrasonic test information. Limited applications have been found for C scan, (1), strip chart (2), photography (3), and amplitude mapping (4), but, in general, the record obtained using these methods is not complete and a need does exist for a practical recording system which will provide a complete record of the ultrasonic test.

In ultrasonic testing of materials, information is obtained from the presence (or absence) of a signal, the amplitude shape and screen position of the signal, the location and orientation of the transducer, and also from the change in the ultrasonic indications brought about by motion of the transducer. In addition, the extent of meaning which can be attached to these factors is directly related to and dependent upon the calibration of the instrument.

Recording the ultrasonic signal on magnetic tape and supplementing this information by also recording the operator's voice description of the test conditions would provide a complete record. There are, however, certain technical considerations which place restrictions upon the types of tape recorders which can be used for this purpose. If, for example, the ultrasonic test is required to differentiate between distances as small as 1/10-inch and the material is steel with an approximate velocity of sound (transverse waves) of 125,000 inches per second, (5) then the recorder must have a frequency response of 1.25 MHz. Also, from a simple oscilloscope measurement, the width of an average ultrasonic pulse has been determined to be 2 microseconds. A pulse of this width requires a frequency response of at least 1/2-MHz. The frequency response of video recorders meet these technical requirements and the recent marketing of comparatively inexpensive portable models makes this approach practical.

The purpose of this work is to develop a system and study the application of commercially available video magnetic tape recording equipment to the problem of recording ultrasonic test information. Although the inspection examples considered in this work are confined to manually inspected steel welds, the method is applicable to all materials and types of ultrasonic inspection.

THE VIDEO MAGNETIC TAPE RECORDER

A survey was made of the available low cost video recorders, and the Ampex VR7000 was selected for use in this study. This instrument has a frequency response of 3.5 MHz and is commercially available for approximately $3,500. It weighs about 100 pounds and has dimensions of 29"x18"x15".

In the Ampex VR7000 the frequency response of 3.5 MHz is obtained by helically wrapping the magnetic tape around a drum, Fig. 1-A, which is rotated at 3600 rpm (6). The video recording head, which is imbedded in the drum, moves past the tape at about 1000 inches per second while the tape moves at a linear speed of 9 inches per second. Figure 1-B illustrates the way the three recording heads simultaneously record the audio, video and control track signals on one tape.

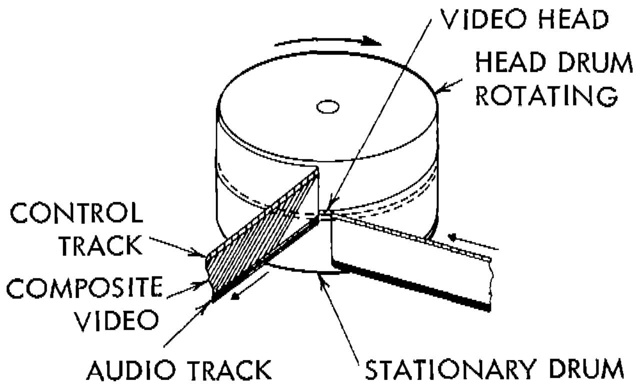

Fig. 1-A Video Head Drum.

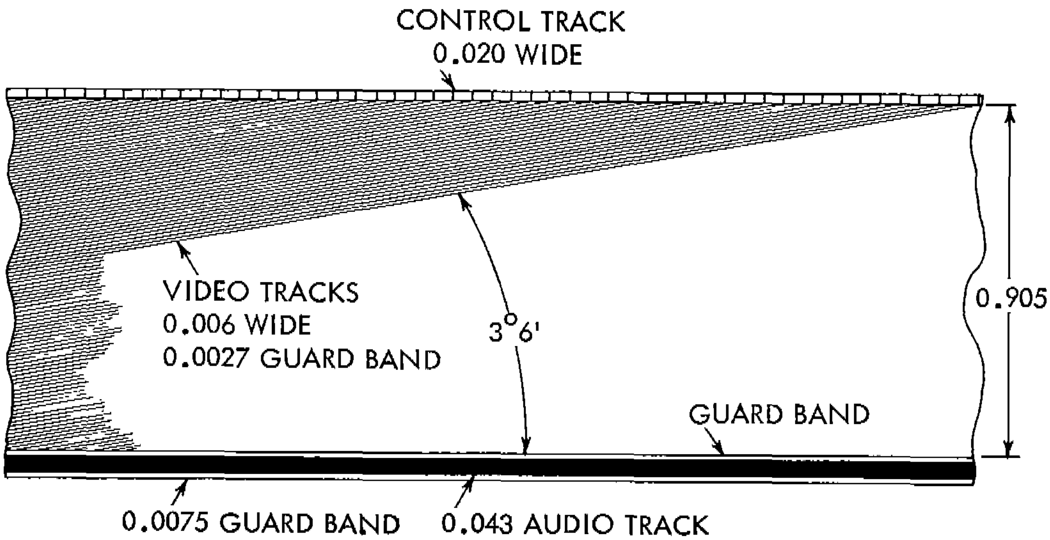

Fig. 1-B Videotape Recording.

The instrument has adjustable audio and video signal strength controls for record and playback. The presence of a proper strength signal is assurance that the instrument is recording. The control track signal is supplied automatically and is used to synchronize and to control the speed of the rotating drum.

The instrument can be stopped for study or to make measurements on a particular recorded frame. Slight manual movement of the tape is usually required to obtain the sharpest image.

Rewind time for a one-hour tape is four minutes. Fast forward time is 14 minutes. The instrument has a tape footage indicator which is helpful in locating a particular segment of tape recording.

The maximum strength video signal which the recorder can accept is a one volt peak-to-peak (6). The recorder output is identical to the input within the one volt maximum limitation. The video input and output impedance is 75 ohms unbalanced (6).

COMBINING THE ULTRASONIC TESTER AND THE VIDEO RECORDER

A Model 50-C Branson Ultrasonic Tester was used in this study. This instrument is so designed that the horizontal sweep begins on the cathode ray tube simultaneously with the application of a short pulse of voltage to a piezoelectric crystal. The crystal (transducer) converts the electrical energy into sonic energy which is introduced into the work material through a coupling liquid. After the initial ringing, the transducer is damped and is then used as a receiver for the reflected sound waves. The transducer converts the received sonic vibrations into electrical voltages which are suitably amplified and applied to the vertical deflection plates of the cathode ray tube. This sequence is repeated at rates between 60 and 600 Hz.

The marker system is a saw tooth wave which is superimposed on the base line of the cathode ray tube. It may be turned on or off at the will of the operator. The marker signal is applied to only one of the vertical deflection plates while the ultrasonic signal is divided between both plates. Also, from measurements it was learned that the vertical deflection plate voltage saturates at 75 volts on either plate.

Considering the 75 ohms input impedance of the video recorder and the limitations of one volt maximum on the input signalto the recorder and also the desirability of including the marker wave in the recording without changing the vertical proportions of the ultrasonic signal, the construction of an intermediate electronic system was necessary.

The schematic of the intermediate system is shown in Fig. 2. Essentially, this is a high input impedance differential amplifier wherein the polarity of the signal from one of the vertical deflection plates is inverted and combined with the signal from the other deflection plate. Also, the combined voltage is proportionally reduced to less than one volt maximum.

The television signal is composed of a video signal and sychronizing pulses. The function of the synchronizing pulse is to control, at the receiver, the rate at which rasters are formed, usually 60 per second. Since the ultrasonic tester does not generate a suitable sychronizing pulse, it was necessary to provide such a pulse. This was done by connecting the control track part of the recorder to an internally generated 60 pps signal. This modification effectively converts the device into an instrument recorder.

The ultrasonic test instrument is entirely unsuited for displaying the recorded ultrasonic signals and a standard laboratory-type oscilloscope was used for this purpose. The oscilloscope controls allow for synchronizing on the strong initial pulse and offer a wide choice of vertical and horizontal

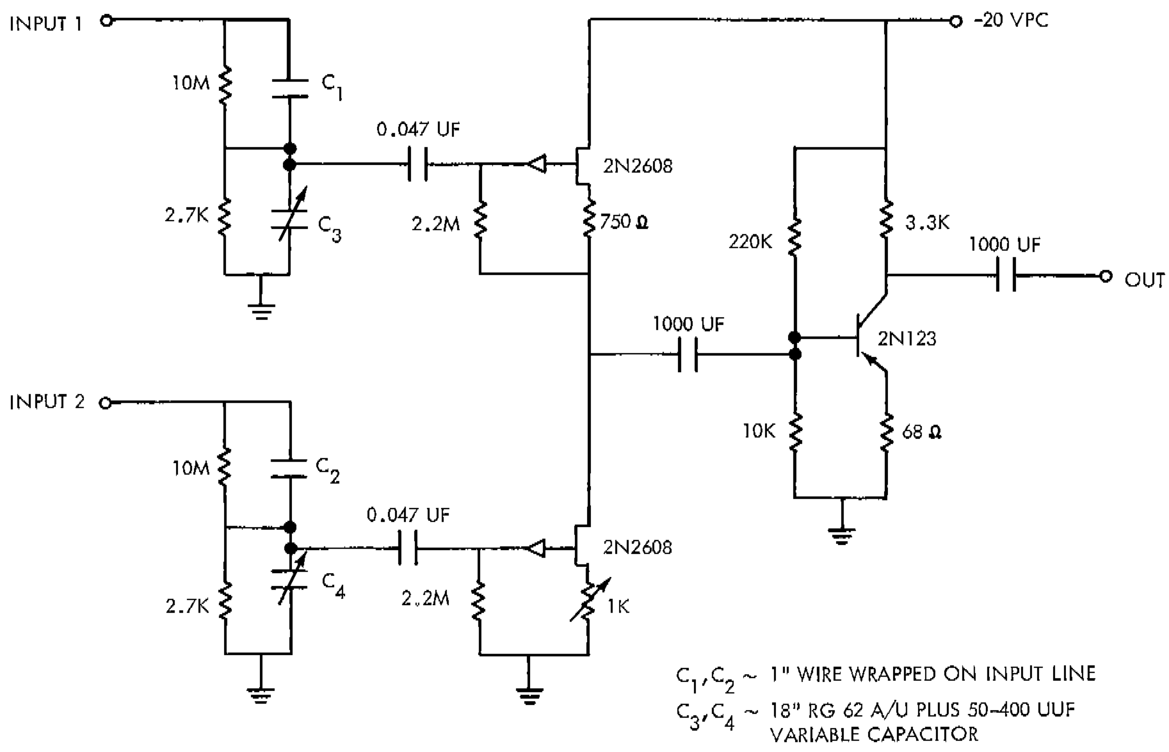

Fig. 2 Wiring Diagram For The Differential Amplifier.

scales. Figure 3 illustrates the arrangement of the ultrasonic equipment, differential amplifier, video recorder and oscilloscope.

Figure 4(a) shows a typical signal as displayed on the ultrasonic test equipment. Figure 4(b) shows the oscilloscope display of this signal after algebraically adding the vertical deflection voltages and reducing the sum to less than one volt with the differential amplifier. Figure 4(c) shows the oscilloscope display of the recorded playback, and Fig. 4(d) shows stop motion (a still frame).

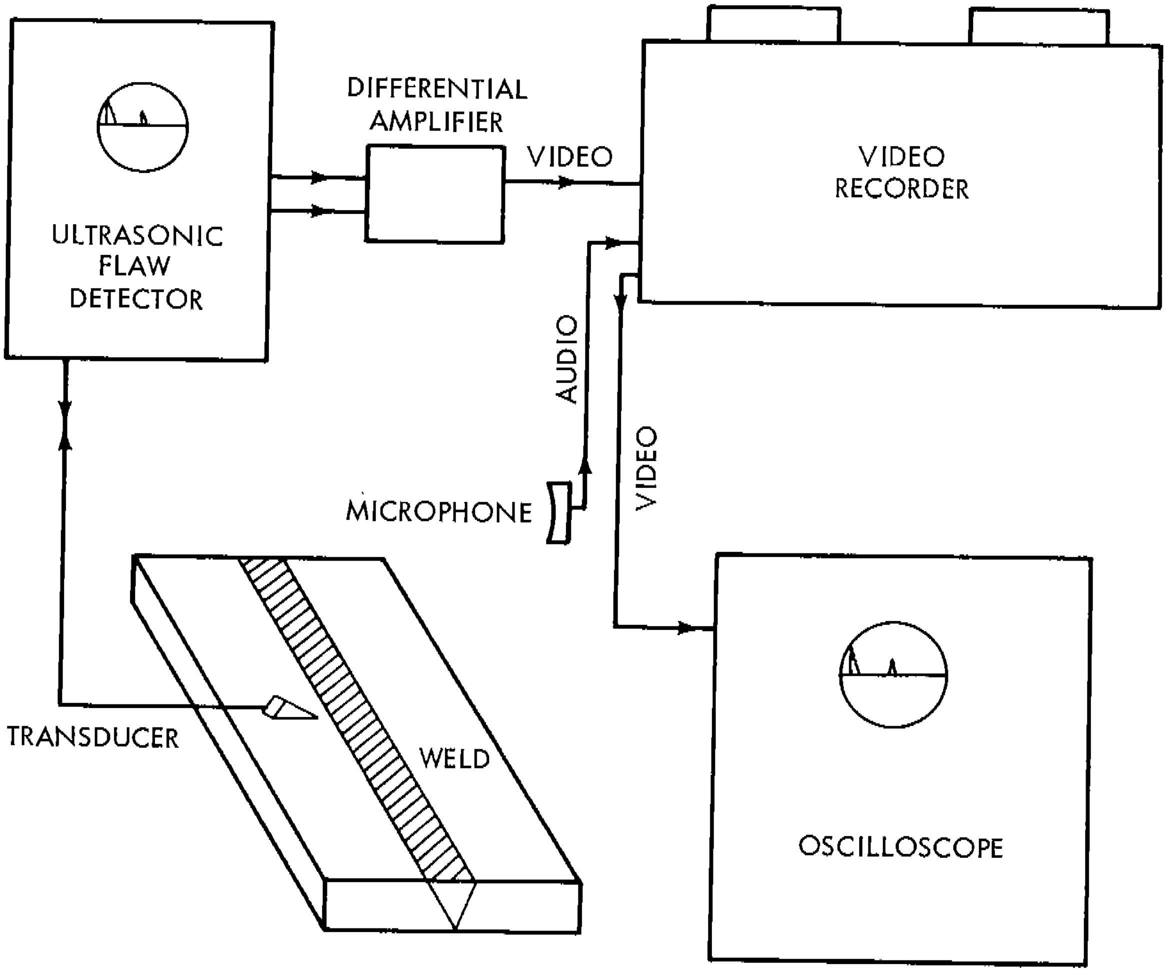

Fig. 3 Schematic Arrangement Of The Ultrasonic Equipment, Differential Amplifier, Video Recorder And Oscilloscope.

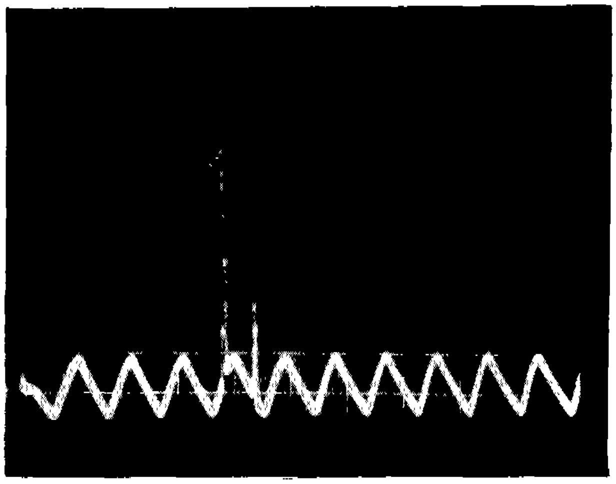

Fig. 4a A Typical Ultrasonic Test Indication.

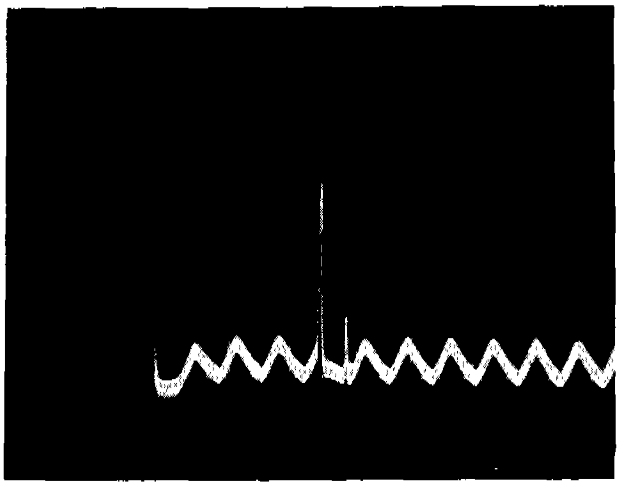

Fig. 4b Oscilloscope Display Of The Signal Applied To The Recording Head.

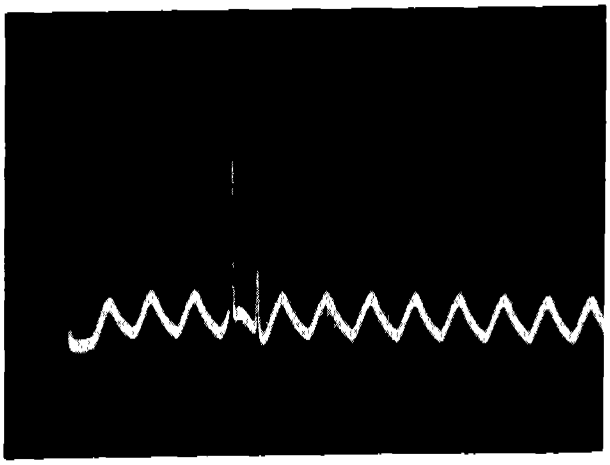

Fig. 4c Oscilloscope Display Of The Recorded Ultrasonic Signal During Playback.

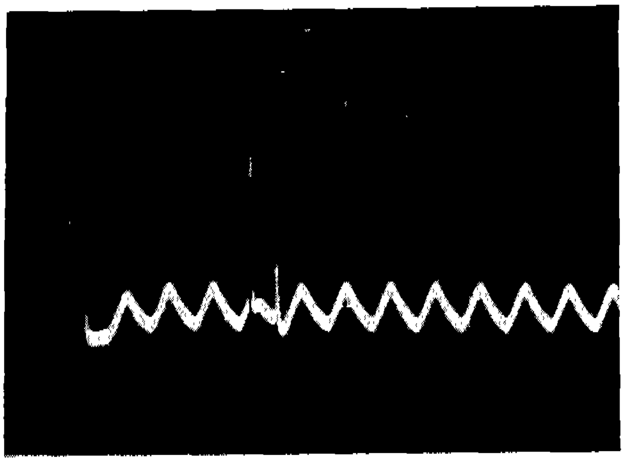

Fig. 4d Oscilloscope Display Of Stopped Motion During Playback.

WELD INSPECTION WITH ULTRASONICS

For recording purposes, the ultrasonic test information can be divided into three categories. First, such information as the date, type of equipment and accessories, description and location of the test weld, type of material, joint configuration, description of the weld bead, surface preparation, the couplant, and a statement indicating the use of distance-corrected gain or the predetermined attenuation rate in terms of decibels per inch. Second, there is the demonstration of proper instrument calibration, and third, the significant indications of the ultrasonic test.

The separate audio track of this instrument affords an easy solution for recording the first category of information. However, there is a need for brevity of speech and a sequential key work code can be used to advantage. For example:

a. Operator's identity
b. Date
c. Type of instrument
d. Transducer type, size, frequency and angle
e. Identification of test object
f. Location of the weld
g. Type of material
h. Thickness of base plate
i. Type of joint and configuration
j. Condition of the weld bead
k. Couplant
l. Attenuation factor.

A typical statement of general test conditions might be as follows: John Doe, 5 Sep 1967, Branson 50-C, Barium Titanate, 1/2"x1", 2.25 MHz, 45°, Merchant Ship, Virginia Beach, 22'4-1/2" below top centerline, 5'7" forward of Rib #3, HY-80 steel, 3/4", Butt-double "V", ground flush, glycerin, 2 decibels per inch. This information can be recorded in 15 to 20 seconds.

If the instrument is already calibrated, then it is only necessary to show a few check points with the calibrating block. In the case of the International Institute of Welding test block (Fig. 5), with the transducer positioned as shown in Fig. 6, the range spikes are known to occur at 100 mm (3.95") and 225 mm (8.9"). If the markers are correctly preset, the range calibration is easily demonstrated and recorded. After the range calibration is established, the amplitude calibration can be shown using the 1-1/2 mm diameter side drilled hole (Fig. 7). The signal from the side drilled hole will appear at a specific screen location depending upon transducer angle, which is easily verified by the calibrated marker. This aspect of the recording will vary in time but if the recorder is turned off while the operator manipulates the transducer to locate the specific position for each phase of the calibration then the recording time will usually be less than one minute.

In the ultrasonic inspection of welds the operator can usually establish the location of the reflecting flaw by considering the sonic travel distance in relation to the geometry of the weld and base metal and the position of the transducer. In order to record this information the marker system of the ultrasonic tester must be used and all auxiliary information, such as the position and orientation of the transducer, must be verbally added to the record.

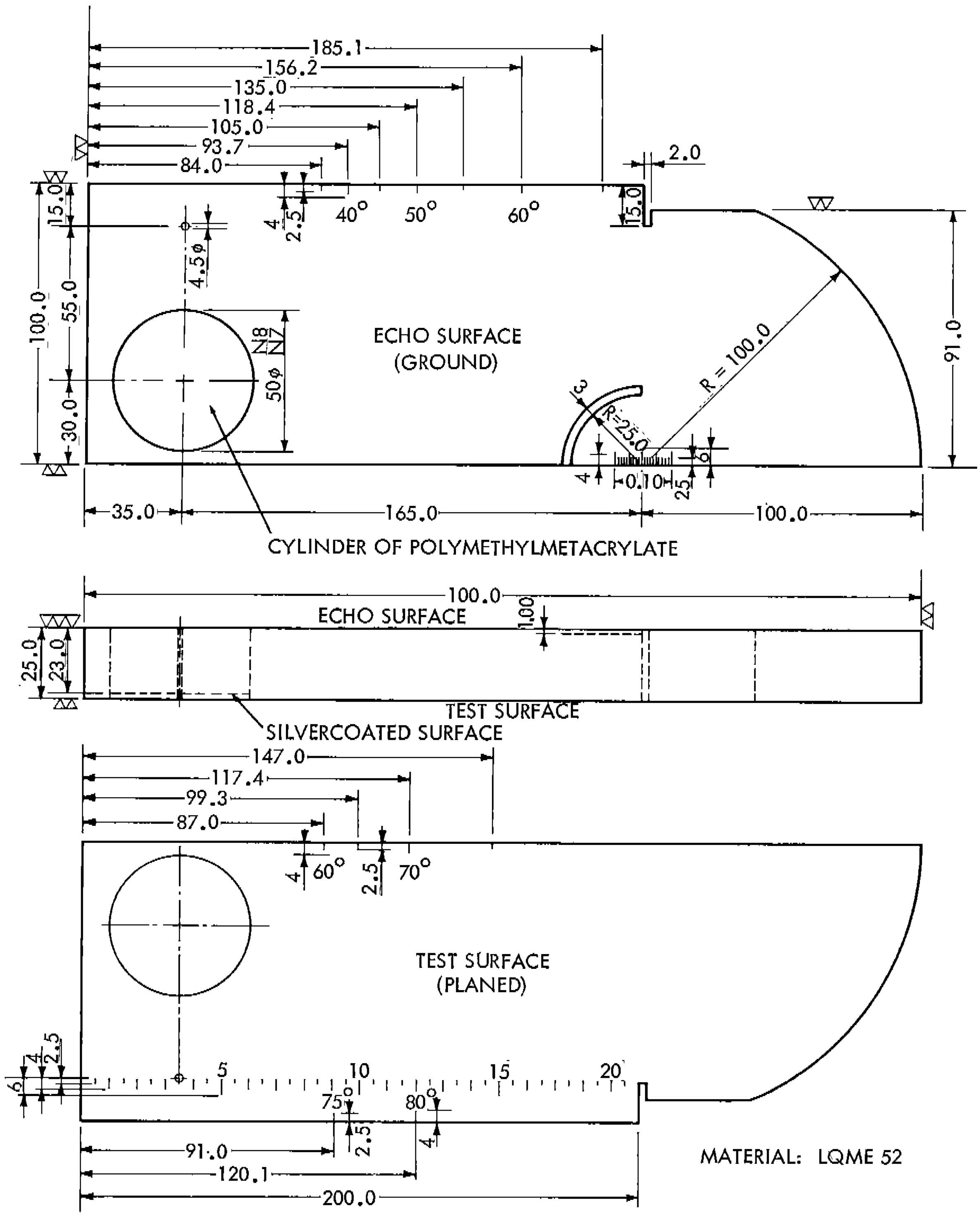

Fig. 5 International Institute Of Welding, Calibration Block For Ultrasonic Test Equipment.

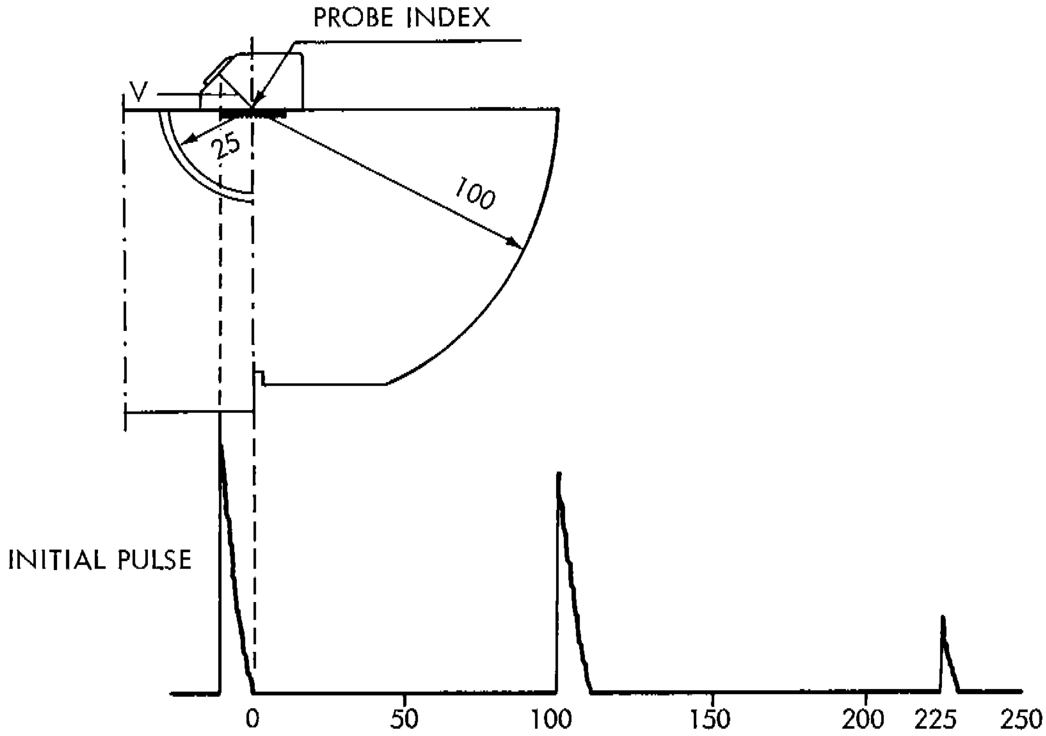

Fig. 6 Procedure For Calibrating The Range Using The IIW Ultrasonic Test Block.

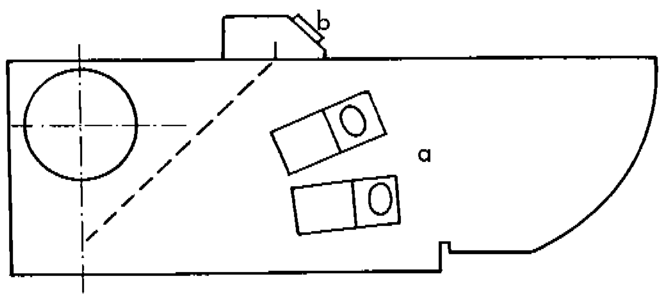

Fig. 7 Procedure For Setting The Sensitivity Using The IIW Ultrasonic Test Block.

If the amplitude of an indication is important, then the decibel attenuator can be used to compare the indication in question with a known standard, such as the IIW test block. This comparison can be recorded along with the operator's

statement of the number of decibels added to or subtracted from the system.

The end points of a linear defect, such as incomplete penetration, are located by finding the positions where the steady value of the amplitude drops to one-half (4). At these points half of the sonic beam is intercepted and reflected by the flaw and the end of the linear defect is located along the centerline of the transducer. A meaningful record of a linear defect should include the demonstration of both the steady amplitude and the half value with verbal descriptions of transducer positions and any decibel attenuation changes made by the operator.

The half-amplitude technique is also applicable to the determination of "extent of depth" of a defect which is oriented perpendicular to the surface of the base metal. The recording technique for "extent of depth" would require the operator's statement of transducer position at one-half amplitude point and the amount of linear motion as the transducer is moved to cause the signal to increase through the peak and then to reach the other half-amplitude point.

Large single gas holes are recognized by being detectable from any direction. This is also true for clusters of porosity; however, the signal obtained from the cluster is more bulbous. Both of these conditions can be recorded by stating the multi-directional detection of the flaw, showing a typical ultrasonic indication and noting the position and orientation of the transducer.

Certain defects such as lack of fusion are more readily detected from a particular side of the weld with marked difference in signal strength between the two directions of inspection. This difference is usually attributed to the orientation of the defect at some angle from the vertical. The recording for this type of defect should include inspection from both sides of the weld.

Entrapped slag is not a good reflector of sonic energy and the noticeable difference between the size (profile) of the flaw and the signal amplitude is an aid in identifying this defect. The length and extent of depth can be established as previously described. These two dimensions provide a crude profile and the amplitude can be evaluated with the decibel attenuator. When compared with the profile the numerical values of the signal strength are seen to differ markedly from air gap type defects. The recording should include the determinations of flaw size and peak amplitude.

Cracks are considered to be serious defects and usually necessitate repair. Both the length of the crack and the depth are important and should be a part of the record of inspection.

Undercut can be detected with ultrasonics as well as by visual inspection. Usually finger damping of the undercut will establish this flaw as the source of an ultrasonic signal. The effect of the finger damping on the ultrasonic signal can be shown with a verbal explanation if this condition is of importance.

Since the test information is recorded on long playing tape, a note should be made of the footage indicator reading for each separate recording. This will make it easier to retrieve specific recordings.

SUMMARY

The acceptance of ultrasonics as an independent inspection tool has been retarded by the lack of a primary record of inspection. Although many different systems have been tried, a comprehensive recording method has not existed. It appeared feasible to couple a magnetic voice recording with portable video recording equipment and thus record all pertinent information. Such an attempt was made by slightly modifying commercially available equipment. Although some improvements are still desired, a more satisfactory recording of ultrasonic test information has essentially been realized.

CONCLUSIONS

The ultrasonic test information is at present recorded with reasonably good fidelity. Some change is necessary, however, before this equipment can be considered suitable for use at a shipyard.

The video tape recording of ultrasonic test information is satisfactory for immediate use in training equipment operators, inspection and specification writing personnel.

RECOMMENDATIONS

In its present physical state, this equipment is too bulky and cumbersome to apply to shipyard problems as it hinders the operator's freedom of movement. It is recommended that a system be devised for transmitting both audio and video signals to a stationary recorder.

The magnetic tape is not utilized efficiently in recording ultrasonic signals because the lapsed time between pulses exceeds the actual recording period. To achieve greater economy it is recommended that information be recorded on both edges of the tape and the ultrasonic tester and the recorder be synchronized.

In the course of this work, it was observed that the recorder generates a 55 Hz pulse which is sufficient to pretrigger the oscilloscope on playback. These pulses have been traced to certain silicon control rectifiers which are a part of the motor drive circuit but time did not permit determining whether this is inherent to the instrument or the result of faulty components. It is therefore recommended that such pre-triggering be eliminated, if possible.

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13. ABSTRACT

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