

NovaScope 5000

OPERATING MANUAL

NOVASCOPE™ 5000

Ultrasonic Thickness Gage

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SAFETY SUMMARY

This summarized safety summary is intended for both operating and service personnel.

WARNING TERMS OF INSTRUMENT

Caution means a personal injury hazard that is not immediately accessible as the markings are read, or a property/instrument hazard. **DANGER** means a personal injury hazard that is immediately accessible as the marking is read.

POWER SOURCE

This NovaScope is intended to operate from an AC power source that supplies either a nominal 115 VAC to 230 VAC (rms) between the supply conductors or between either supply conductor and ground. Before applying AC power, the LINE VOLTAGE must be within the AC power voltage - otherwise, a safety hazard or equipment damage could occur.

GROUNDING THE PRODUCT

The NovaScope is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before making any connections to the NovaScope input or output terminals. **A protective ground connection, by way of the grounding conductor in the power cord, is essential for safe operation.**

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts -- including knobs and controls that may appear to be insulating -- could render a dangerous electric shock.

USE THE PROPER POWER CORD

Use only the power cord and connector specified for the NovaScope.

Use only a power cord that is in good condition.

Read Section 11 for power-cord and connector information.

USE THE PROPER FUSE

To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating specified on the back panel of the NovaScope and in Table V.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

To avoid explosion, do not operate the NovaScope in an explosive atmosphere.

REMOVAL OF COVERS OR PANELS

Because of the dangerous high voltages inside the NovaScope, only skilled, authorized technicians should remove the cover/panels when either setting internal adjustments (see Section 12) or for servicing. Do not operate the NovaScope without the covers and panels properly installed.

LIMITED WARRANTY

1. WARRANTY: NDT Systems, Inc. warrants that reasonable care was used in the choice of materials and the manufacture of this instrument, and that the instrument conforms to the published ratings and characteristics applicable to the instrument at the time the instrument is shipped to the Buyer. This warranty shall extend for a period of one year from the date of shipment of the instrument (FOB Seller's plant) and shall in no event extend beyond such term. The Buyer shall notify NDT Systems, Inc. within the time and in the manner specified herein shall constitute a waiver of any such claim of defect or breach of warranty. The final determination of the existence of a defect or breach of this warranty shall be made by NDT Systems, Inc. This warranty shall extend to the buyer only, and shall not be assignable or transferable to any other person.

2. DISCLAIMER OF WARRANTIES THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OTHER THAN THOSE WARRANTIES SET FORTH IN THE PARAGRAPH ENTITLED "WARRANTY" ABOVE.

The above warranty shall not apply to digital panel meters and items with a limited life, such as batteries, probes or cables, nor to any instruments which have been subjected to misuse, improper installation or repair, alteration, or use beyond the published rating of the instrument.

3. BUYER'S REMEDIES: The Buyer's sole exclusive remedy for breach of the above warranty shall be the repair or replacement of the instrument by NDT Systems, Inc., free of charge. The Buyer shall return the instrument to NDT Systems, Inc., transportation prepaid. NDT Systems, Inc. shall promptly repair or replace the instrument and return same to Buyer, FOB Seller's Plant, collect.

If, for any reason, NDT Systems, Inc. is unable or unwilling to repair or replace the instrument or, because of circumstances, the exclusive remedy provided herein fails of its essential purpose, or operates to deprive either party of the substantial value of its bargain, then the Purchaser's exclusive remedy will be the return of the purchase price for the instrument. The liability of NDT Systems, Inc. shall in no event be greater than the full amount of the purchase price for the instrument.

Any attempt by NDT Systems, Inc. to repair or replace any instrument sold hereunder shall not constitute an admission that the instrument, or any part thereof, is defective within the meaning of the above warranty, nor that NDT Systems, Inc. has any legal responsibility to make such repair or effect such replacement.

Any such attempts, if unsuccessful, shall not create any liability on the part of NDT Systems, Inc. and the purchaser is limited to the remedy set forth herein.

4. LIMITATION ON LIABILITY: NDT Systems, Inc. shall not, under any circumstances, be liable for direct, incidental or consequential damages for any breach of contract, breach of warranty or misrepresentations, including the negligence of NDT Systems, Inc., including, but not limited to, damages resulting directly or indirectly from the use, or loss of use, of the instrument sold hereunder, or the business of the Buyer or third persons wherein the instrument is utilized.

The above warranty, and the obligations of NDT Systems, Inc. hereunder, are expressly in lieu of, and the Buyer expressly waives, any other liability of NDT Systems, Inc. based upon warranty, express or implied, contract, or the negligence of NDT Systems, Inc., including, but not limited to, negligence in the design of the instrument or in the choice of the materials therefor, or negligence in the repair or replacement of the instrument, whether such repair or replacement is required by the terms hereof or is voluntary, upon the part of NDT Systems, Inc.

Except as provided herein, no person is authorized to assume on behalf of NDT Systems, Inc. any other or additional liability or responsibility in connection with the instrument. These terms and warranty are applicable to and part of all quotations, sales and transactions with the Buyer, and by placement of a purchase order, Buyer signifies complete acceptance of such a binding legal agreement.

1. SPECIFICATIONS

DIGITAL DISPLAY	Four Digit "Virtual" (LED), With 0.05 Second Update						
DIMENSIONAL READOUT	English And Metric (Selector Switch)						
GAGING RANGE	English: 0.005-10"; Metric: 0.13mm To 100mm (Depending Upon Material)						
DIGITAL RESOLUTION	<table> <tr> <td><u>English</u></td><td><u>Metric</u></td></tr> <tr> <td>±0.0001" On 1" Range</td><td>±0.001mm On 10mm Range</td></tr> <tr> <td>±0.001" On 10" Range</td><td>±0.01mm On 100mm Range</td></tr> </table>	<u>English</u>	<u>Metric</u>	±0.0001" On 1" Range	±0.001mm On 10mm Range	±0.001" On 10" Range	±0.01mm On 100mm Range
<u>English</u>	<u>Metric</u>						
±0.0001" On 1" Range	±0.001mm On 10mm Range						
±0.001" On 10" Range	±0.01mm On 100mm Range						
GAGING MODE CONTROL	Sets Mode For Contact, Delay Line Or Immersion Transducers						
THICKNESS/VELOCITY SWITCH	Selects Digital Display Of Thickness Or Velocity						
PULSER Risetime Selectable Amplitude Selectable Rep Rate	5 To 10 ns Into 50 Ohms, Depending On Pulser Voltage 90, 150 And 300 Volts Peak Into 50 Ohms 625, 1200, 2500 And 5000 pps						
RECEIVER Manual Gain Mode AGC Mode Reject Bandwidth Attenuator	72 dB 40 dB Dynamic Range, 72 dB Gain Variable Threshold To Full-Scale Display 30 MHz (6 dB Down), 20 MHz (3 dB Down) 0, 10 And 20 dB Selectable						
DAMP CONTROL	To Optimize Echo Waveshape, 15-350 Ohms						
SCOPE DISPLAY Sweep Speed Bandwidth Dual Trace A-Scan Video Sweep Delay T-Gate IP-Gate IF-Gate T-Gate Start/Stop TAC Gate	Switchable To 50 ns/Div. + Continuously Adjustable 50 MHz A-Scan + Selectable Gate Traces (IP, IF, T or TAC) Full RF, Positive and Negative Rectified Delay Sync 1 us To 80 us Thickness Gate, Adjustable Sync 0.25 To 20 us On Contact, 1.0 To 90 us On Delay And Immersion 0.1 To 8.0 us Selects Polarity Of Echo's Leading Half-Cycle Multi-Adjustable Time Compensated Gain: Start Control.....0.2 To 6 us Amplitude Control.....0 To 17 dB Slope Control.....1 To 50 us						
ALARMS	Three-Function, LO, HI, LO & HI						
OUTPUTS/INPUTS	Multi-Pin Port With High-Speed Binary Output, RS-232C I/O, PortaScan Outputs, And HI/LO Alarm; Input Of External PRF Sync; IP Sync Output; Analog Thickness Output (0-5V)						
AC POWER REQUIREMENTS Line Input Voltages Line Frequency Power Consumption (Max)	Nominal 115 V - 220VAC (90-264V) 47 - 63 Hz 70 Watts						
OPTIONS Single/Double Transducer Mode Model 5000L	Two Transducer Connectors And Switch For Single Pulse-Echo, Dual (Pitch-Catch) And Through Transmission Modes. Addition Of On-Board Datalogger And Hand Command Module To Standard 4500 Model.						
SIZE	5.4" (138mm)H x 12.9" (327mm)W x 17.2" (438mm)D. Inclusion Of Tilt Handle Increases W To 15.0" (380mm) And D (Fully Extended) To 20.1" (511mm).						
WEIGHT	16 Lbs. (7.3 Kg)						

2. INTRODUCTION

The NovaScope 5000 is the most significant improvement in the NovaScope series of precision ultrasonic thickness gages and represents the most versatile and precise digital ultrasonic thickness gage available on the market today. By means of its dual-trace CRT based scope display and variety of “virtual” Touch Screen controls, the NovaScope 5000 is specifically designed for complex, difficult and ultra-critical gaging applications (where the more common portable/non-scope ultrasonic thickness gages either won't operate or are too risky in their interpretation to use).

Operating on the ultrasonic pulse-echo principle, the NovaScope 5000 gages sectional thickness with access to only one surface of the material. Furthermore, its versatile design permits the gaging of both stationary or in-motion products-using either a manual or automatic mode of operation.

The NovaScope, which operates from either a standard nominal 115 or 230 VAC power outlet. It also features a highly versatile dual digital port. This port offers both high speed binary or RS-232C digital interfacing with peripheral equipment, computers, printers, other test instruments and NDT Systems, Inc's **PortaScan** portable ultrasonic imaging system.

A wide selection of specifically designed NovaScope thickness-gaging transducers (probes) are available to further optimize application performance. The use of various other types, sizes and frequencies of contact, delay line and non-contact immersion (focused or non-focused) transducer are included. When required to suit specific customer applications, NDT Systems' transducer engineering department can custom design and fabricate transducers to meet virtually any situation.

Many other features of the NovaScope 5000 will become evident upon reading and understanding this Operating Manual.

3. GENERAL APPLICATIONS

3.1 BASIC MATERIAL REQUIREMENTS - The basic criterion for gaging suitability is that the material must be ultrasonically conductive and ultrasonically uniform. Geometrically, the two surfaces of the sectional thickness to be gaged must be virtually parallel.

3.2 SUITABLE MATERIALS - A very large number of common industrial materials and products typically qualify for ultrasonic gaging suitability. Included are metals, plastics, glass, certain ceramics, many rubber/elastomeric materials, advanced aerospace composites and fiberglass. The actual gaging range and accuracy depend upon the properties of the specific material involved.

3.3 TYPICAL PRODUCT CONFIGURATIONS - Some of the common product configurations which can be gaged with the NovaScope include:

tubing	graphite composites	machined parts
pipe	Kevlar™ composites	light bulbs
sheet	fiberglass composites	bottles
plate	liners and casings	cans
extrusions	turbine blades	lenses
billets	chem-milled parts	tanks/drums
rounds	valves	pressure vessels
bars	forgings	corrosion/erosion
ingots	tires	discs
castings	cladding	drawn/spun parts
stampings	heat exchangers	blow-moldings

3.4 GAGING STATIONARY PRODUCTS - Many products with simple or complex shapes/contours can be gaged manually with small handheld transducers (contact or delay line types). For gaging on particularly sharp contours or in very small spots, effective results can be obtained using a bubbler (or immersion transducer with a finely-focused ultrasonic beam).

A non-contact immersion-type transducer (mounted in a miniature water jet squirter assembly) can be automatically scan-indexed across a product's surface to collect thickness data with the NovaScope. The data processed by the NovaScope can be presented as a familiar C-scan or fed (via rear panel digital or analog outputs) to a computer, recorder/logger or NDT Systems portable ultrasonic imaging system, **PortaScan**.

3.5 MONITORING IN-MOTION PRODUCTS - The NovaScope can monitor the sectional thickness of in-motion products by employing a non-contact water jet squirter/immersion type transducer mounted in proximity to the product's surface. The product can be presented in a continuous form (i.e., a web); discrete lengths (i.e., pipe); or as rapidly-indexed small parts (i.e., bottles or forgings).

Various digital and analog outputs of thickness data and alarms are available on the rear panel to interface with recorders, controllers, loggers or computers. Such system setups permit automatic thickness monitoring and, in certain situations, process feedback control.

4. GENERAL OPERATING PRINCIPLES

This section presents an elementary overview of the ultrasonic principles and general instrumentation concepts for the NovaScope. Detailed discussions on the specific controls/features and operational/calibration procedures for the NovaScope are presented in subsequent sections. The small amount of time spent in review of this section will lead to a more thorough understanding of thickness gaging in general.

4.1 ULTRASONIC PRINCIPLES

4.1.1 Nature of Ultrasound - The basic physical principle behind the NovaScope is ultrasound. Ultrasound refers to sound waves whose frequency (pitch) lies beyond the upper limit of hearing for humans, which is about 20 kHz (kilohertz). The NovaScope employs high frequency ultrasound (and electronics) in the range of about 0.1 - 50 MHz (megahertz).

Ultrasound, like any frequency of sound, is basically mechanical vibrations that propagate or travel through a medium (gas, liquid or solid) in a wave-like fashion. The velocity at which ultrasonic waves travel depends upon the physical and chemical properties, as well as the temperature of the medium. If these properties are virtually constant throughout the medium supporting the ultrasound, then velocity is also constant. Table I lists the nominal velocity for a variety of common materials. Note that sound waves travel relatively slowly through gases (like air), with medium velocities through liquids, and fastest through solids (metals).

As a sound wave travels through a material, it loses a portion of its energy due to a process known as attenuation (a combination of wave scattering from inhomogeneities and absorption). Sound waves typically attenuate much more in gases than in many common liquids and solids. Also, attenuation normally increases rapidly with frequency (for example, high frequency [MHz-range] ultrasonic energy travels only exceedingly short distances through air before it is virtually attenuated).

Ultrasonic waves behave quite similarly to light waves and microwaves (radar) in that they also reflect, refract, interfere, and travel as beams (radiation patterns). Higher frequencies permit ultrasound to be shaped into fairly well-collimated and even sharply-focused beams.

Ultrasound is highly reflective at boundaries (surfaces) between most dissimilar materials (technically, those with substantially different acoustic impedances). The greater the impedance mismatch between two materials, the greater the reflection at their interface.

Ultrasound is almost totally reflected at a solid-gas (i.e., solid-air) interface. The ultrasonic reflectivity is so high at a metal-air interface that even the interface between two pieces of flat polished metal tightly pressed together still contains enough air molecules to produce a strong reflection. Typically, the great majority of energy in an ultrasonic beam is reflected from a solid-liquid interface, while considerably less is typically reflected from a molecularly-bonded solid-solid interface (between dissimilar solids).

Because of its beam-shaping and high reflectivity characteristics, plus the ability to travel through optically opaque materials (like metals), ultrasound is very well suited for measuring the dimensions of and inspecting the interior of solid materials, while requiring access to only one surface of the material.

TABLE I
Characteristic Ultrasonic Velocities for Some Selected
Common Materials (At Room Temperature,
Unless Otherwise Noted)

<u>MATERIAL</u>	<u>VELOCITY - in/us</u>	<u>VELOCITY - mm/us</u>
ACRYLIC RESIN	0.105*	2.67*
AIR (20EC)	0.014	0.34
ALUMINUM	0.249	6.32
BRASS, NAVAL	0.174*	4.43*
BRONZE, PHOSPHO	0.139*	3.53*
R	0.181*	4.60*
CAST IRON	0.183*	4.66*
COPPER	0.267*	6.79*
GLASS, WINDOW	0.076	1.92
GLYCERINE	0.050	1.28
HYDROGEN (0EC)	0.225*	5.72*
INCONEL	0.232	5.90
IRON	0.248	6.31
MAGNESIUM	0.237	6.02
MONEL	0.069	1.74
MOTOR OIL	0.222	5.63
NICKEL	0.232	5.90
STEEL, MILD	0.230	5.85
STEEL, 4340	0.223	5.66
STEEL, 303 CRES	0.239	6.07
TITANIUM	0.058	1.48
WATER (20EC)	0.183	4.65
ZIRCONIUM		

* may exhibit wide velocity variations depending upon alloy or type

NOTE: These reported ultrasonic velocities are only approximations because of effects due to chemical and physical variations.

4.1.2 Thickness Gaging Concept - The NovaScope operates on a pulse-echo principle quite similar to that used for ranging with both sonar and radar. With regard to the NovaScope, a very short pulse (burst) of megahertz-frequency ultrasonic energy is introduced into the material to be gaged for thickness. The pulse travels through the material and reflects back an echo from the opposite parallel surface of the material. The period of time for this pulse-echo round trip to occur is related to the material thickness and the characteristic ultrasonic velocity for that material according to the simple ratio relationship:

$$t = \frac{2x}{v}$$

where

- t = pulse-echo round trip across material sectional thickness
- x = material sectional thickness
- v = characteristic ultrasonic velocity for material
- 2 = compensation factor for the fact that the round trip time represents twice the time for the ultrasonic energy to travel across the material thickness.

This relationship shows that, for a given material (of constant ultrasonic velocity), the pulse-echo time period will double if the thickness doubles. Also, this linear relationship indicates that its pulse-echo time period will be only half as long if the material's characteristic ultrasonic velocity is twice that for another material of the same thickness. Thus, measurement of the pulse-echo time period alone cannot sort out the individual effects of material thickness or ultrasonic velocity. The pulse-echo period will determine (yield) a material's thickness only if the material's ultrasonic velocity is known or compensated for (and vice-versa).

Fortunately, the characteristic velocity for a given applicable material is usually constant enough (doesn't exhibit excessive unknown, inherent velocity variations) to permit accurate thickness measurement. In fact, many common industrial materials have velocities so constant that very precise measurements can be made. However, changes in composition, grain structure/direction and even temperature or residual/applied stress can affect the characteristic velocity for a given material - resulting in thickness gaging errors (the magnitude depending upon the degree of change in the material).

All factors considered, the ultrasonic pulse-echo ranging concept is a practical and well-proven method to measure material thickness.

4.2 INSTRUMENTATION CONCEPTS

4.2.1 Basic Pulse-Echo Circuit - Figure 1 shows a highly simplified functional diagram for the NovaScope. The basic components of this functional circuit include a pulser, transducer, receiver, and display (digital readout plus scope).

The pulser is an electronic circuit that generates a very short-duration electrical pulse, having an adjustable amplitude typically in the range of 90 to 350 volts (peak). Since the risetime of the pulse is about 10 nanoseconds (billionths of a second), it has electrical characteristics (spectral) well into the desired megahertz region.

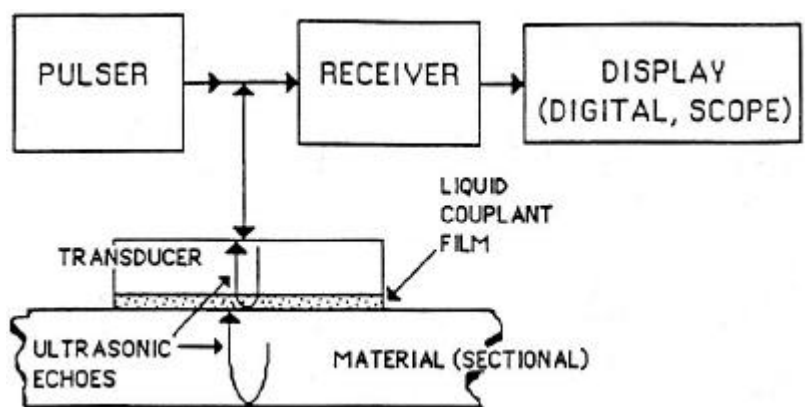


Figure 1

The transducer is generally an ultrasonic transceiving probe that contains a piezoelectric material

which converts electrical energy into mechanical energy and vice-versa. The piezoelectric material in the transducer is shaped into a thin wafer whose thickness is resonant at the ultrasonic frequency range desired. An ultrasonic (mechanical) damping agent is bonded to the back surface of the wafer so that the transducer pulse duration (pulse width) is very short.

The receiver collectively consists of a high-frequency, broadband amplifier and signal processing/timing circuits capable of handling the relatively low amplitude electrical signals.

The display is a digital readout of material thickness with a supplemental scope for presentation of the ultrasonic echo patterns and other information.

A liquid couplant (ultrasonic couplant) must be applied between the transducer and the test material surface. This couplant, usually consisting of a light oil film, gel film or water, is necessary to allow the high frequency ultrasonic vibrations (pulses) to pass back and forth between the transducer and test material.

Operationally, the pulser applies a short electrical pulse, known as the IP (Initial Pulse) or main bang to the transducer. The transducer, in turn, transmits a corresponding short ultrasonic pulse. This ultrasonic pulse is coupled from the transducer into the test material. A portion of the ultrasonic pulse reflects as an echo from the material surface adjacent to the transducer, while the remainder of the pulse propagates through the material and reflects back as an echo from the opposite parallel surface.

These two echos from the material surfaces sequentially impinge on the transducer and are thereby converted into similarly-shaped and similarly-time-sequenced electrical pulses. This pair of electrical pulses (echos) is fed to the receiver for amplification and processing.

The period (time duration) between the pair of electrical pulses represents the travel time the ultrasound needed to make a round trip back and forth across the material thickness. Material thickness, a direct function of the echo round-trip time and ultrasonic velocity is then electrically determined via calibration controls (in accordance with the principles discussed in Section 4.1.2).

Once the above-described pulse-echo cycle is completed, it is again repeated at some prescribed pulse repetition frequency (PRF), or rep rate. NovaScope rep rates typically range from 625 to 5000 pulses per second.

4.2.2 Scope Display - A scope can graphically display the shape of a waveform on its CRT (Cathode Ray Tube) by showing waveform amplitude as a function of time. This is accomplished by sweeping the CRT trace at a constant speed, called sweep speed, starting from left to right across the face of the CRT.

Figure 2(a) shows the full (entire) waveform or RF display for a typical highly damped ultrasonic pulse. The amplitude of the pulse is shown vertically, while the elapsed time is shown horizontally.

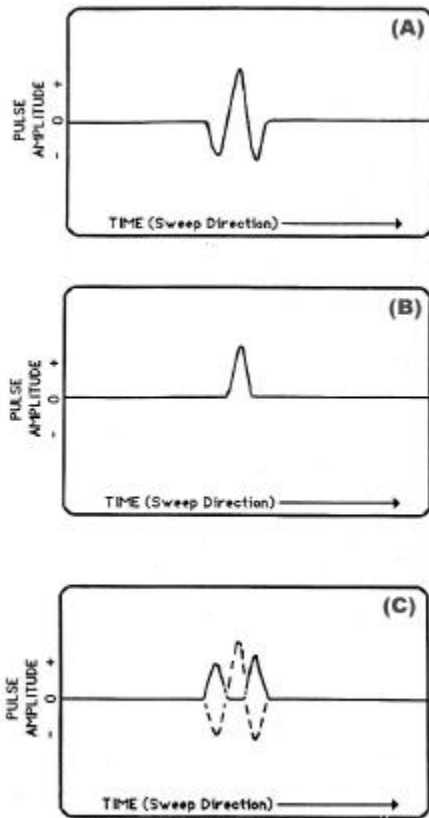


Figure 2

The horizontal axis across which no signal occurs (zero amplitude) is called the baseline. Such a time-amplitude display readily depicts the vibrational nature of the ultrasonic pulse as a burst of damped oscillations (damped sinusoid) at a given frequency (spectral central frequency).

In addition to the full waveform RF display, two other displays from the RF are commonly used, namely the positive-rectified and negative-rectified displays. Figure 2(b) shows that the positive-rectified display shows only the upper (positive) half of the full RF waveform, while Figure 2(c) shows that the negative-rectified (and inverted) display shows only the negative half of the full RF waveform.

Depending upon the application and setup, the polarity of the waveform in Figure 2 can be inverted (or flipped). Thus, the side of the subject waveform with only one peak (half-cycle) could be oriented in either the positive or negative polarity direction.

A single half-cycle rectified display will be used in this Operating Manual except where it is more informative to use the RF display.

4.2.3 A-Scan Presentation - The most common scope display for observing ultrasonic echo patterns taking place in the material being gaged is called an A-scan presentation. Figure 3 shows the A-scan presentation for a thickness gaging situation involving a thin and thick section of a given material. The scope A-scan displays the ultrasonic echo amplitude in the vertical direction and the echo round-trip time for the echo to return to the transducer in the horizontal direction. Stronger (higher amplitude) echoes are represented by higher pulses on the trace, while longer echo round trip times for greater material thicknesses are shown increasing toward the right side of the scope.

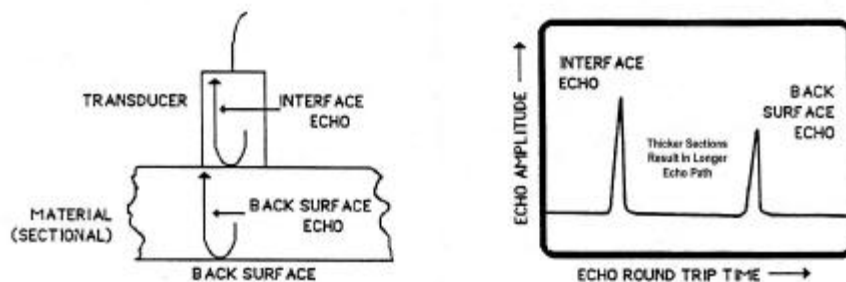
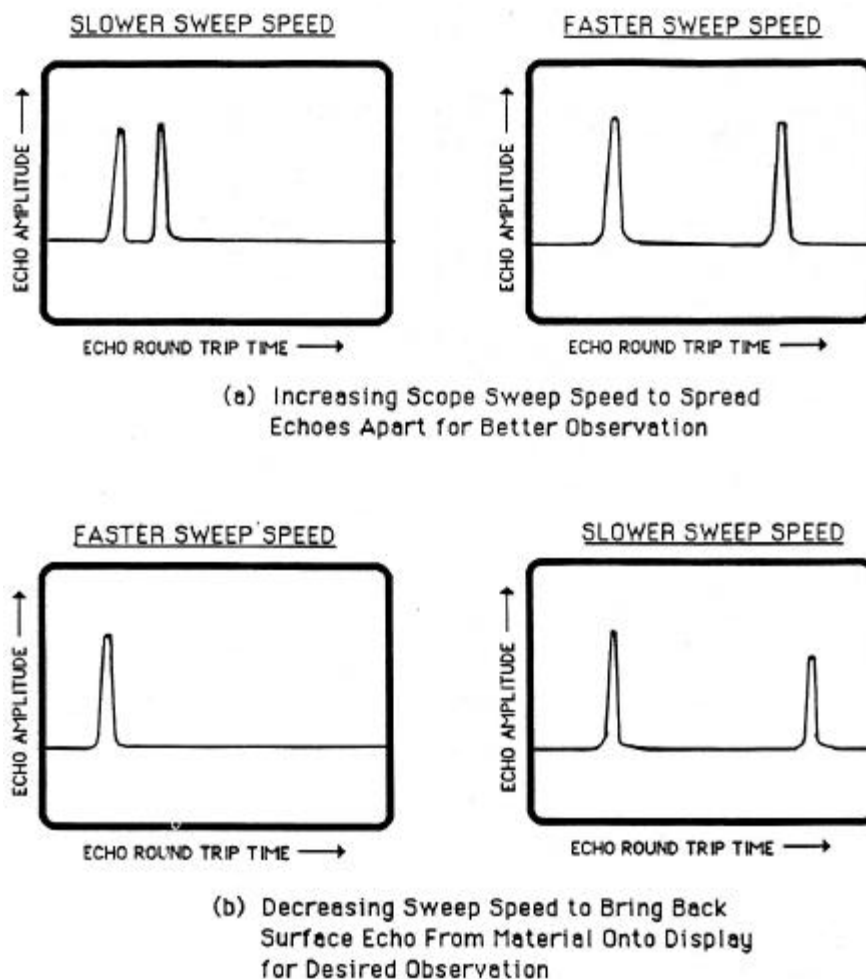


Figure 3b

With respect to the transducer location, the echo on the left side of the A-scan is called the **interface echo**, while the echo on the right side of the A-scan is called the **first back surface echo**. The time duration between the occurrence of the interface echo and the first back surface echo is proportional to the material thickness (see Section 4.1.2).

With all the other conditions being equal, the echo from a thickness twice as great will be displayed twice as far to the right across the scope screen. As shown in Figure 3(b), the echo height from a thicker section is normally reduced in amplitude due to the ultrasonic attenuation phenomenon discussed in Section 4.1.1.

The ultrasonic velocity differences between two materials understandably affects the echo round-trip time. For a given thickness of two different materials, the echo round-trip time is longer in the material with a slower characteristic ultrasonic velocity. If one material is twice as thick and has twice the velocity as that of another material, identical A-scans will result. Thus, it is not possible to differentiate between material thickness and velocity variations by using the pulse-echo ultrasound method - even with the A-scan scope readout. Fortunately, for applicable materials, changes in echo round-trip time essentially can be ascribed to thickness changes rather than ascribed to unknown, inherent velocity variations in a given material.



One fundamentally important scope (instrument) control which affects the A-scan appearance is the sweep speed control. The sweep speed control changes the time base along the horizontal axis of the A-scan trace. This feature, as shown in Figure 4, permits the space (not the time) between the two echoes to be conveniently expanded (spread apart) or compressed (squeezed together). For ease of operation, it is particularly valuable to spread out the display between echoes too closely spaced together. For the same reason, slowing the sweep speed will "bring" an echo onto the display which otherwise falls so far out in round-trip time that it is "off" the right-hand side of the scope.

It is important to understand that sweep speed only affects the horizontal aspect of the display and does not change the time (duration) of the actual ultrasonic echo period (which is related to material thickness and velocity).

Figure 4

Another fundamentally very important electronic control which affects the A-scan appearance is the receiver gain control. The gain control changes the amplitude scale along the vertical axis of the A-scan trace. A gain control permits the height of the echos to be either conveniently increased or decreased.

If a material is somewhat attenuative, it may be necessary to increase the receiver gain until the echos are readily observable. On the other hand, if the gain is too high for a given material, the echos may detrimentally saturate the receiver or cause an excessively noisy baseline on the A-scan.

Normally, when a material is not too attenuative or too thick, the A-scan will actually indicate a series of equally-spaced echos, known as multiples (see Figure 5). These multiples are secondary inter-reflections of the initial ultrasonic pulse reverberating back and forth between the two surfaces of the material. The spacing between any two successive multiples represents the echo round-trip time in the material and, thus, also can be used for gaging thickness (in addition to the initially described interface to first back surface echo period). The dotted curve across the tips of the echos in Figure 5 shows the rate at which the amplitude of the echo multiples decreases or decays and is related to the degree of ultrasonic attenuation for a given material. This entire echo pattern of such multiples is sometimes called a ringing pattern.

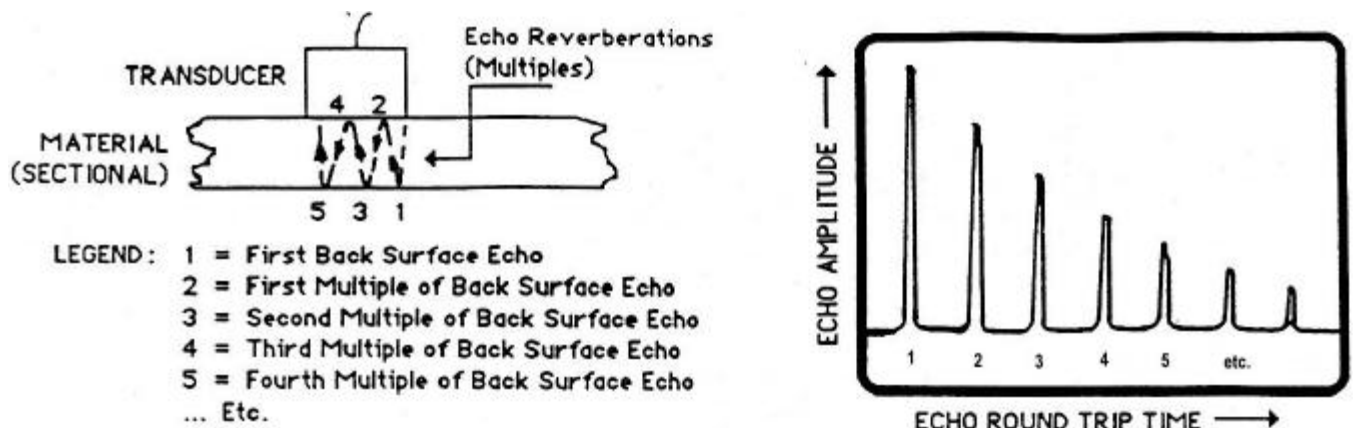


Figure 5

4.2.4 Resolving Power and Sensitivity - One of the performance characteristics always associated with pulse-echo ultrasonics and A-scan presentations is range resolving power (resolution). It refers to the instrument and transducer's ability to clearly separate two sequential echos along the A-scan trace. Figure 6 shows pairs of completely resolved, partially resolved and unresolved echos.

The resolving power of an instrument is defined as the closest echo separation it can make, expressed in terms of time (i.e., nanoseconds), or more commonly, in terms of some minimum specified material thickness. The limiting ultrasonic factor is the pulse width (or pulse length) of the echos, as inferred in Figures 6a, b & c. Thus, highly damped, high frequency transducers produce much better resolving power (shorter ultrasonic pulse lengths) than lowly-damped, low-frequency transducers. It follows that instrumentation with short IPs (main bangs), broadband receiver amplifiers and high-speed processing circuits have higher resolving power.

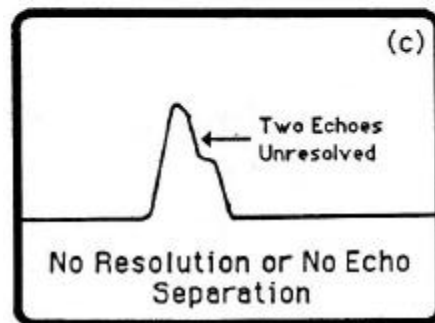
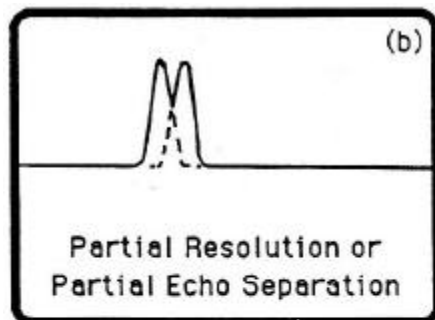
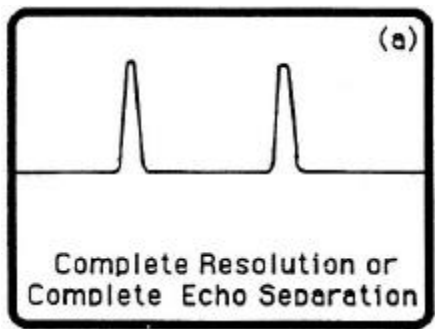


Figure 6

It is more difficult to resolve the interface echo and a very quickly following first back surface echo (because of the high amplitude of the interface echo) than it is to resolve echo multiples. Thus, echo multiples can generally allow the gaging of thinner sections as compared to the interface-to-first back surface echo (if the material permits multiples).

Another performance characteristic associated with pulse-echo ultrasonics and A-scan presentations is sensitivity. For thickness gaging, it refers to the overall equipment ability (both instrument and transducer) to detect an echo from the back surface of a given material. Equipment that detects back surface echos from thick materials or attenuative materials is said to have a higher sensitivity than equipment that is unable to detect such echos. Sensitivity can be increased by using higher-amplitude pulsers, higher-gain receivers and lower frequency or higher sensitivity (lower damped) transducers. Thus, a thickness gaging application (material type and thickness) requires a compromise between resolution and sensitivity.

4.3 THICKNESS GAGING MODES

The NovaScope offers two basic thickness gaging modes which are governed by the method selected to couple the ultrasonic energy between the transducer and the material surface, namely the contact mode and the immersion/delay line mode.

4.3.1 Contact Mode - The contact mode utilizes a contact transducer during the thickness gaging procedure. The contact transducer is distinguished by having a thin wearplate face of some wear-resistant material (like alumina ceramic) which is bonded directly to the internal piezoelectric element. The contact transducer is manually placed in contact with the material surface while employing a thin film of couplant on the contacting region. During operation, the IP (main bang) and interface (IF) echo are virtually superimposed because of the very close proximity of the piezoelectric element to the material surface. During contact transducer gaging, the superimposed IP and interface echo are simply referred to as only the IP. Due to its simplicity, this contact transducer mode of coupling was "ideally" assumed throughout Section 4.2.3.

Figure 7 shows a contact transducer A-scan. For contact gaging, the material thickness is typically determined by measuring the time from the IP (virtually time-coincident with the superimposed IF echo) to the return of the first back surface echo. This is called synchronizing the thickness echo period measurement with the IP (or main bang) or, more commonly, IP sync. With IP sync, the scope sweep initiation is also synchronized with the IP. This is called IP sweep sync.

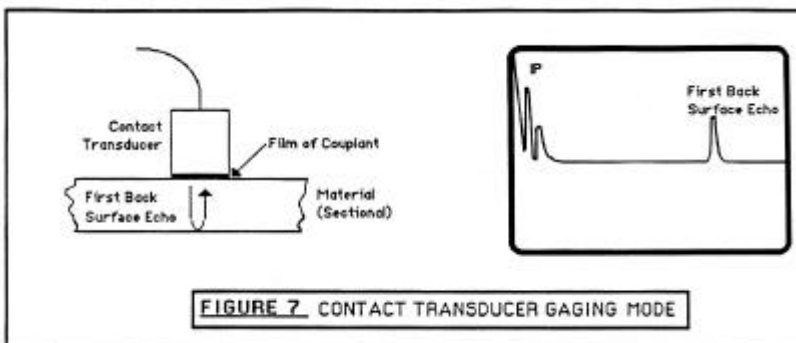


Figure 7

Note the distorted, non-ideal (and quite wide) signal on the left side of the trace in Figure 7 representing the complex superposition of the IP and the IF echo. Because of this wide IP-IF signal and a receiver "dead" listening zone directly following the IP (receiver amplifier saturate, contact transducer gaging doesn't generally permit the best obtainable resolution needed for the gaging of thin materials. However, contact transducers usually permit

additional sensitivity for gaging thicker or attenuative materials by allowing relatively large amounts of ultrasonic energy to be transmitted into the material.

4.3.2 Immersion/Delay Line Mode - The immersion/delay mode of coupling employs either a thick "buffer" layer of liquid (water) or solid (usually plastic) between the transducer and the material surface. An immersion transducer is used in conjunction with the water buffer coupling mode.

Immersion transducers have a thin waterproof plastic face which can be either flat for producing a non-focused ultrasonic beam or curved (typically concave) to form an ultrasonic lens for producing a frequently advantageous focused ultrasonic beam. Commonly, the immersion transducers are categorized as either flat or focused types.

The non-contact feature of the immersion coupling mode permits non-contact gaging of moving materials or for non-contact scanning of the immersion transducer over the surface of a stationary material. Immersion gaging can be accomplished by submerging the material in water and locating the transducer at some selected distance above the surface or by placing the transducer in a water squirter nozzle and accomplishing coupling via a small diameter water jet between the nozzle and material surface. Sometimes a bubbler method is used which consists of the nozzle held in contact with the test surface (or vice-versa) and a very slowly "bubbling" output of water for achieving coupling.

A delay line transducer employs the solid buffer coupling mode. It typically has a plastic buffer rod (ultrasonic delay line) attached to the piezoelectric element. This plastic tip can be permanently bonded into the transducer housing to produce an integral delay line transducer, or the tip can be replaceable with an accompanying screw-on metal collar to produce a removable delay line transducer. The tip of delay line transducers is manually placed in contact with the material surface while employing the thin film of couplant on the contacting region.

As shown in Figure 8, the immersion/delay line transducer coupling mode serves the important purpose of delaying the initiation of the IF-echo until the receiver has fully recovered from being undesirably saturated by the high amplitude IP. Thus, considerably better resolving power and, hence, thinner material gaging results when compared to contact gaging. The thicker the buffer material, the longer it takes the ultrasonic pulse to travel through it and, hence, the longer the time delay between the IP and the IF echo.

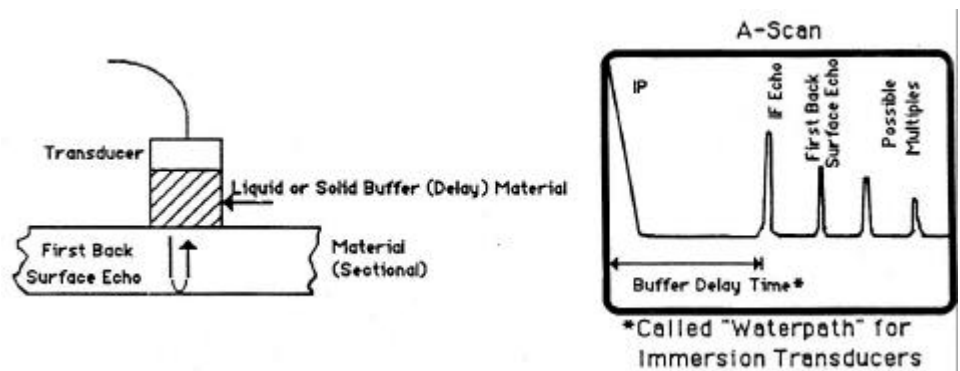
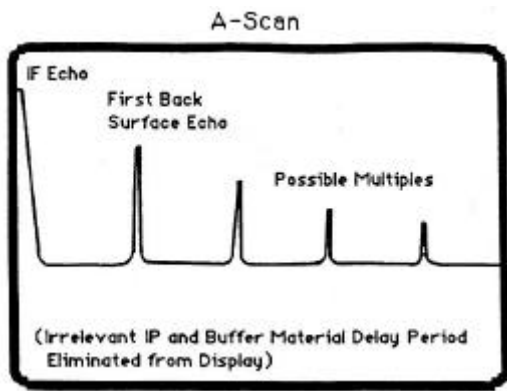


Figure 8

For immersion/delay line transducer gaging, the material thickness is frequently determined two different ways. First, thickness can be determined by measuring the echo period between the IF echo and first back surface echo. Secondly, thickness can also be determined by measuring the period between the first back surface echo and the first multiple echo, or by measuring the period between two successive multiples.

The scope sweep start for immersion/delay line gaging is normally synchronized with the IF echo (unlike contact gaging where IP sweep sync is used). This is called IF sync. Figure 9 shows the standard IF sync A-scan for immersion/delay line gaging. Note that the IF echo appears at the beginning of the scope sweep (extreme left side of display) and that the irrelevant IP and long delay time period in the buffer material is conveniently eliminated from the display (compare Figures 8 and 9). Also, the echos can be conveniently "spread-out" (IF echo remaining on the left edge of the display) for better visibility by increasing the scope sweep speed.

4.4 GATES



Standard Delay Line or Immersion
Coupling Mode With InterFace Sync Mode

Figure 9

Gates are important supplementary circuits in the NovaScope that help gage thickness and enhance the overall performance of a gaging instrument. A gate is a time interval or "window" along the A-scan which either permits or prevents an instrument response to an echo(s) occurring within that window. Gates are designed to be constantly on (operational) or to be turned off whenever desired. Furthermore, they can be manually or automatically adjustable, in terms of when and how long they turn on or off.

Gates can be conveniently shown (time-aligned) on an additional trace located beneath the respective A-scan trace, as shown in Figure 10(a). This standard type of gate shown has a rectangular waveshape along the lower baseline trace which sweeps in synchronization with the associated upper A-scan trace. The gate is on only during the time that the trace is elevated above the normal gate baseline position. It turns off as soon as the trace falls back to the baseline (i.e., the right-hand vertical edge of the pulse).

The length of time (duration) that the gate is on is known as the gate width (or length). When a gate turns on, it is known as the gate start and when a gate turns off, it is known as the gate stop.

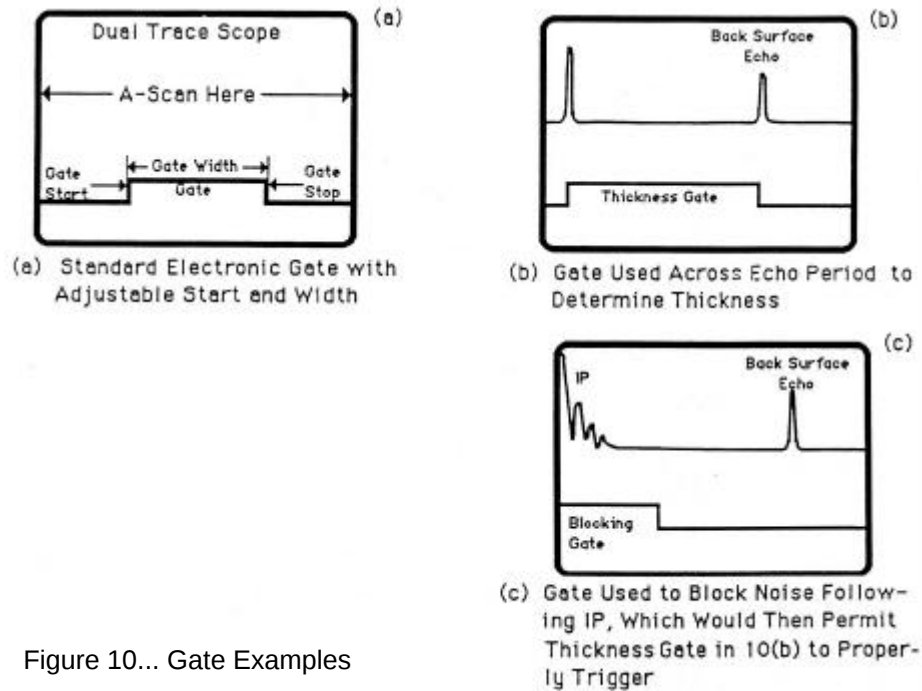


Figure 10... Gate Examples

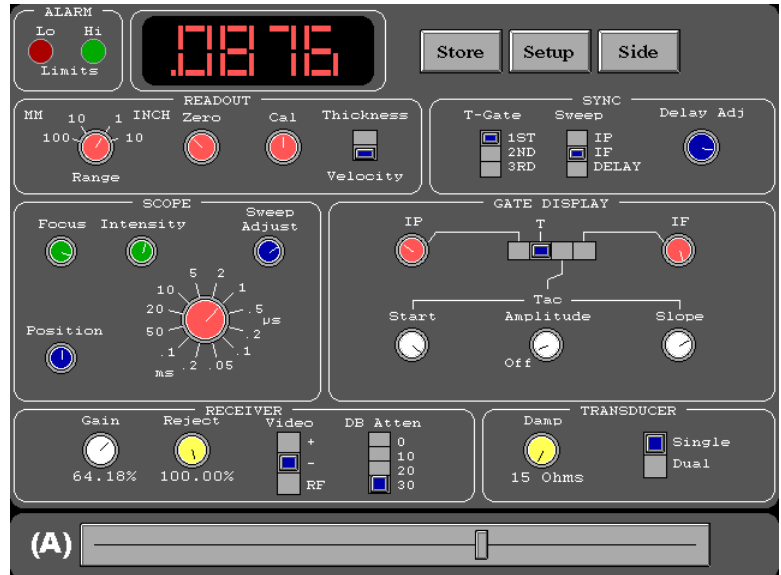
The most important function for a gate in ultrasonic thickness gaging is to select (and indicate) the thickness echo period across which the instrument is to compute the thickness. Figure 10(b) shows such a "thickness gate" set to automatically trigger across the IP-first back surface echo period. Thickness gates can be used to trigger between virtually any two echos.

A relatively common situation occurring during the desired setting of a thickness gate is irrelevant echos (noise) between the start echo and stop echo representing the thickness period. The noise will cause the automatic thickness gate to erroneously stop or "hang-up". Such noise can be "blocked" from interfering with the setting of the thickness gate by simultaneously using another adjustable gate, called a blocking gate. Figure 10(c) shows how a blocking gate can be adjusted so its width is long enough to block the IP noise - which would otherwise prevent the thickness gate from properly triggering between the IP and first back echo shown in Figure 10(c). A similar blocking gate is used to block the noise in front of the IF echo during immersion or delay line transducer gaging.

A dual trace scope conveniently permits the gates to be selectively displayed (one at a time), although they are always operational (when turned on) whether or not being displayed.

5. FUNCTIONAL DESCRIPTION OF NovaScope CONTROLS

Section 5 describes the functions of all NovaScope controls located on its “*virtual*” front and sidepanels. These virtual controls are meant to function in a similar fashion to those located on on previous NovaScope generations. From the early NovaScope 3000s to the latest generation of NovaScope 4500, mechanical knobs and switches have been located in roughly similar positions. The primary advantage to this approach in familiarity is the benefits in training. Generally, if you were familiar with a previous generation NovaScope little training will be required.



5.1 GENERAL TOUCH INTERFACE INSTRUCTIONS



TSO Knob

This latest NovaScope, offers a major improvement in it's function by way of it's Touch Screen Operation (TSO). As you view the color flat panel screen on the right side of the unit you will notice images of various knobs and switches, with a few new items. These items include virtual buttons in the upper right hand corner of the screen. These controls offer the most significant improvement in the NovaScope in several generations by permitting the user to save and recall all setup parameters with up to 60 alphanumeric characters. With this you can save descriptive setup names. For example, A file could be saved including the users name, transducer used and part under inspection, all as part of the file name.

There are a couple of options to interface with these controls. First and foremost, to select any control to adjust simply touch it. If it is a “knob” it will start to “flash” indicating it is selected. There are now a few ways to adjust its function:

- 1) If a knob has a discrete number of positions, such as the sweep speed knob, repeated taps on the knob will rotate it one position clockwise.
- 2) Another option for use is the TSO Knob. This is the *only* knob, located in the upper right of the front panel. Turning this knob to the left or the right will rotate the virtual knob on the color flat panel display.
- 3) **“The Slider”...** (A) This feature pops up at the bottom of the screen for various functions. By using your finger or other pointing device simply press and slide the handle left or right to act on the selected control. This feature can be particularly useful for long range controls for abrupt adjustments to another position within the selected control's position.
- 4) Switch functions simply toggle position one step. For example, if the thickness switch were

touched, it's position would move to the velocity display mode. Another touch would toggle the position back to thickness.

Figures 11 and 16 can be used as a convenient reference for locating each of these controls during their description. Section 4 of this manual should be read and understood before proceeding with this section.

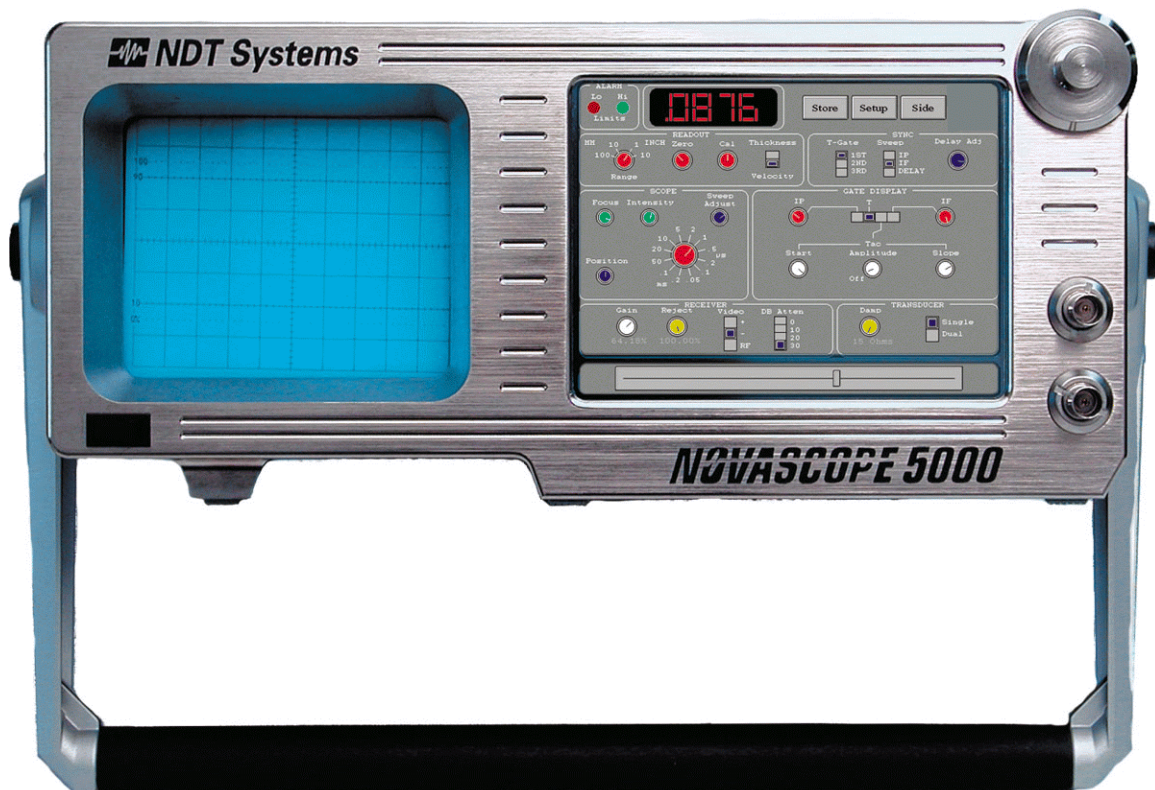


Figure 11 NovaScope Front Panel

"VIRTUAL" FRONT PANEL CONTROLS

(Refer To Figure 11)

5.2 SCOPE SWEEP SPEED - Variable scope sweep speed control. This control changes speed in discrete steps.

5.2.1 VARIABLE SWEEP SPEED CONTROL - Provides a continuous adjustment between the discrete sweep speed steps.

5.3 SCOPE INTENSITY - Adjusts the Scope's CRT brightness. If intensity is set to high the traces may appear to blur.

5.4 SCOPE FOCUS - Adjusts the Scope's CRT focus.

5.5 SCOPE TRACE ROTATION - Screwdriver adjustment to refine horizontal alignment of scope baseline traces.

5.6 POWER - Rocker switch that turns the AC power on and off.

5.7 READOUT RANGE - Selects thickness range over which gaging may be performed. Digital gaging resolution (readout precision) depends upon range selection (± 0.0001 " on Range, ± 0.001 " on 10" Range, ± 0.001 mm on 10mm Range, ± 0.01 mm on 100mm Range. Any range position can be used with contact, delay line or immersion mode gaging.

5.8 READOUT CAL - Calibration control for material thickness or ultrasonic velocity compensation.

5.9 ZERO - A time-delay control for calibrating the readout at the thin end of the thickness range to be gaged. Technically, it automatically compensates for

- 1) inherent time delays in the electronics
- 2) An extra half-cycle that is sometimes required in the T-GATE to produce the most reliable, practical thickness readout.
- 3) Slight mechanical variations in the transducer or probe used in a given inspection.

5.10 READOUT THICKNESS/VELOCITY SWITCH - Sets instrument to gage thickness in THICKNESS position and to measure material ultrasonic velocity of a known material thickness in the VELOCITY position.

5.11 TRANSDUCER DAMPING - Control that varies the electrical impedance across the transducer/pulser/cable to help optimize the ultrasonic pulse waveshape for a given setup. Basically, it is adjusted to provide the shortest echo pulses (minimum number of half cycles) with the least distortion of the echo signal as well as minimum baseline noise.

5.12 TRANSDUCER T/R - BNC connector for the ultrasonic transducer cable.

5.13 RECEIVER GAIN - Control to manually change the receiver amplification level.

5.14 RECEIVER GAIN/AGC - Variable GAIN control. In the most CCW position the Automatic Gain Control is turned on for automatically maintaining echo amplitudes at a constant level.

5.15 RECEIVER REJECT - Removes baseline noise from being displayed on the scope and also from entering the logic circuits by controlling the threshold detection level of the unprocessed pulse waveforms. As you rotate this control clockwise, you will notice the echo amplitude decrease into the baseline.

5.16 RECEIVER VIDEO - Three-position switch for selecting A-scan display of any echos. The RF position shows the full bi-polar realistic waveform of the sinusoidal ultrasonic echos. The "+" or "-" show either the positive or negative half-wave-rectified side only of the RF waveform; however, both rectified displays are always oriented in the positive direction on the trace (more convenient for observation). RF is sometimes used for initial setups and advanced applications, while either "+" or "-" is normally used during operation (simpler displays). See Figure 2 in Section 4.2.2.

5.17 RECEIVER DB ATTEN - Attenuates the incoming unprocessed video signals when necessary to help prevent receiver amplifier saturation.

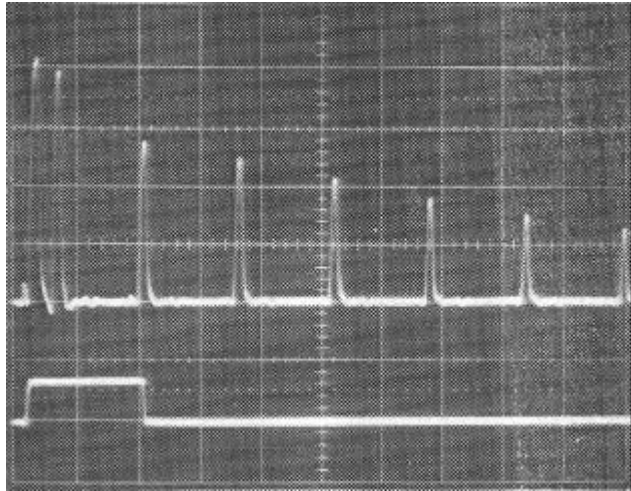
5.18 SYNC SWEEP - Determines when the A-scan sweep starts across the scope. In the IP position, with the virtual side panel CONTACT-DELAY/IMMERSION switch in the CONTACT position, the sweep initiates from the IP for normal contact transducer operation. When the SWEEP SYNC switch is in the IF position, and with the sidepanel CONTACT-DELAY/IMMERSION switch in the DELAY/IMMERSION position, the sweep initiates from the IF for normal delay line transducer or immersion transducer operation.

When the SWEEP SYNC switch is in the DELAY position, the adjustable DELAY control (delay sync) is activated to allow the sweep to be delayed from the IP, allowing adjustable movement of the echo pattern across the display. Also, the sweep speed can be increased in this position to expand the echo waveshapes for better visual analysis of their half-cycles. The DELAY feature operates for both the contact and delay/immersion mode.

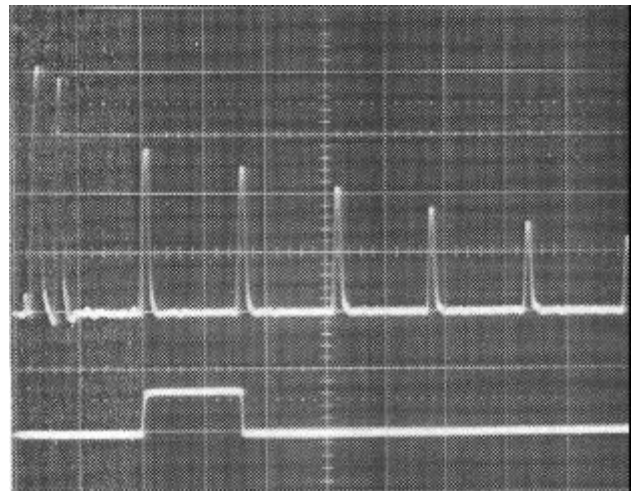
5.19 SYNC T-GATE - Operative only in the IF (immersion/delay line) mode, this thickness gate switch permits the selection of the echo period over which to gage thickness. The "1st, 2nd and 3rd" positions respectively, select either the IF echo-to-first back surface echo period, first back surface echo-to-first multiple period, or the first multiple-to-second multiple echo period over which the T-Gate will synchronize. When in the 3rd position, multiple periods beyond the 3rd can be conveniently selected for T-Gate sync by adjusting the IF-Gate far enough to start to sync on echos subsequent to the IF echo.

Figure 12 depicts these four modes for synchronizing the T-Gate during either delay line transducer or immersion transducer gaging. The width of the T-Gate automatically extends between the start and stop echo of the period over which it is synchronized.

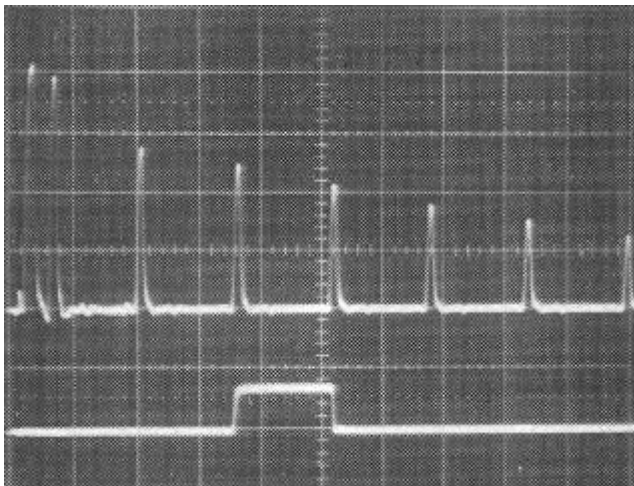
5.20 GATE DISPLAY SWITCH - Selects any one of the four indicated gates for display on the lower scope trace.



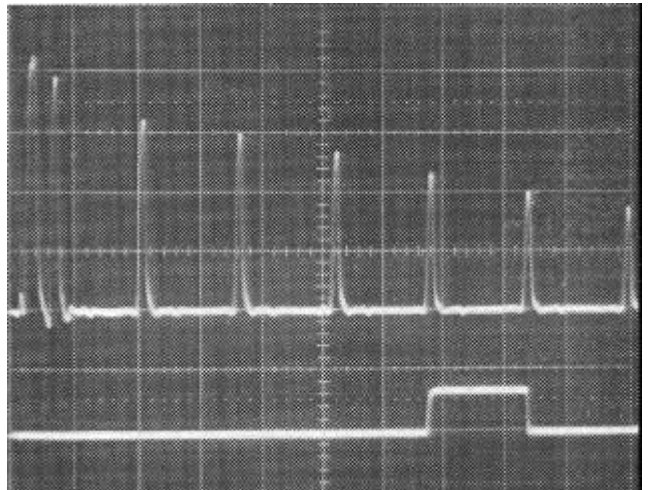
(A) IF-To-First back surface echo in "1st" switch position



(B) First back surface echo-to-first multiple in "2nd" switch position



(C) First multiple-to-second multiple in "3rd" switch position



(D) Arbitrary selection of multiple period with switch in 3rd position

FIGURE 12

Selection of T-Gate thickness period with SYNC T-Gate switch during delay line or immersion transducer gaging

5.21 GATE DISPLAY "T" - The T-Gate or thickness gate (see Figure 12) which indicates the echo period over which thickness is being gaged. The T-Gate, always operational, is displayed when the GATE DISPLAY switch is in the "T" position.

5.22 GATE DISPLAY "IP" (Initial Pulse, or Main Bang) - The IP-Gate is an adjustable blocking gate synchronized (starting) from the IP. It is displayed by setting the GATE DISPLAY switch in the IP position.

During contact gaging, the IP-Gate is adjusted to prevent noise following the IP from false-triggering the T-Gate. See Figure 13(a). During immersion or delay line transducer gaging, the IP-Gate is adjusted to prevent noise in the waterpath or plastic delay line (i.e., between the IP and IF echo) from interfering with synchronizing on the IF echo. As shown in Figures 13(b) and 13(c), this is accomplished by adjusting the IP-Gate so it stops just prior to the IF echo. The IP-Gate is always operational, whether or not it is being displayed.

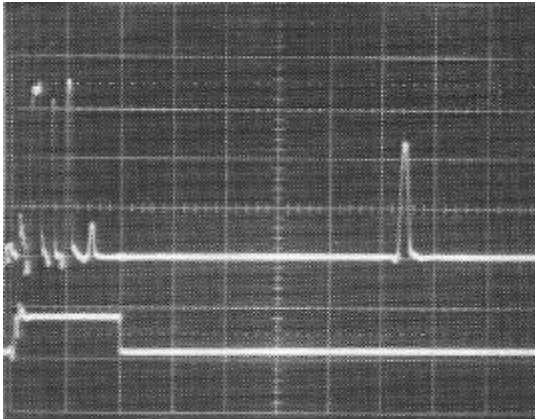
5.23 GATE DISPLAY "IF" - The IF-Gate is an adjustable blocking gate synchronized (starting) from the IF echo. Operation only during delay line or immersion gaging (when the CONTACT-DELAY LINE IMMERSION switch is in the DELAY LINE/ IMMERSION position), the IF-Gate then can be displayed by setting the GATE DISPLAY switch in the IF position.

The IF-Gate is adjusted to prevent noise following the IF echo from false-triggering the T-Gate. See Figure 14. Also, as mentioned in Section 5.18 and shown in Figure 12(d), the IF-Gate can be adjusted to choose on which multiple echo period the T-Gate synchronizes. The IF-Gate is operational whether or not it is being displayed.

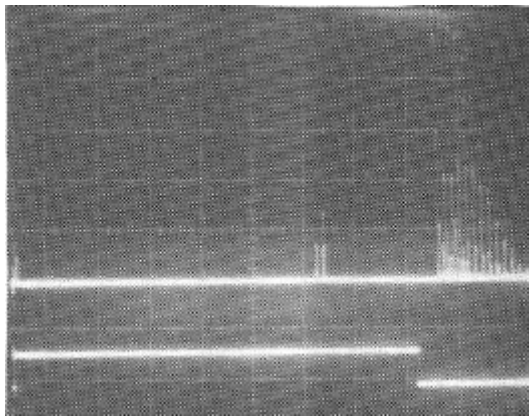
5.24 GATE DISPLAY "TAC" - TAC, or Thickness Amplitude Compensation, is a supplemental adjustable gate that changes the receiver amplifier gain as a function of time along the A-scan baseline. It is valuable for accentuating the back echo amplitude for proper T-Gate sync by adjustably reducing the gain on precursory noise arrays along the A-scan. TAC is synchronized from whichever SYNC SWEEP mode is being used (IP, IF or DELAY).

The TAC-Gate is activated by rotating the TAC AMPLITUDE control CW from its OFF position. TAC, a saw-tooth-shaped gate, is displayed by setting the GATE DISPLAY switch in the TAC position. Its multi-functional controls, namely START, AMPLITUDE and SLOPE control the saw-tooth shape. See Figure 15. START sets the initiation time of TAC along the baseline. AMPLITUDE adjusts the amount of maximum gain reduction (negative near-vertical gate trace deflection) that occurs at TAC start. SLOPE determines the rate at which that maximum amount of negative gain is removed with sweep time - until the receiver gain is no longer affected by TAC. The SLOPE function is the positively-sloped line portion of the gate which, after TAC start, eventually returns to the horizontal baseline. When activated, TAC is operational whether or not being displayed.

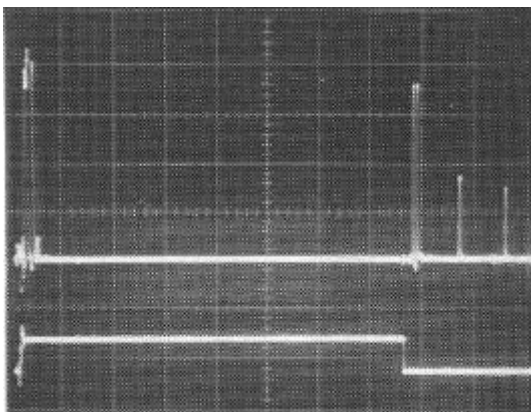
For the special case of using TAC with the SYNC DELAY (Delay Sync) mode, its initiation can be even set prior to the IF echo.



(A) Contact Gaging
Blocking IP noise



(B) Immersion Gaging
Blocking potential waterpath noise
between IP & IF echo
Preliminary setup (Slow Sweep
Speed). Note Blocked Noise
echo occurring prior to IF echo
and back echo pattern



(C) Delay line transducer
Gaging - Blocking plastic delay
line path just prior to IF echo.

FIGURE 13

Functions of Manually-Adjustable IP-Gate

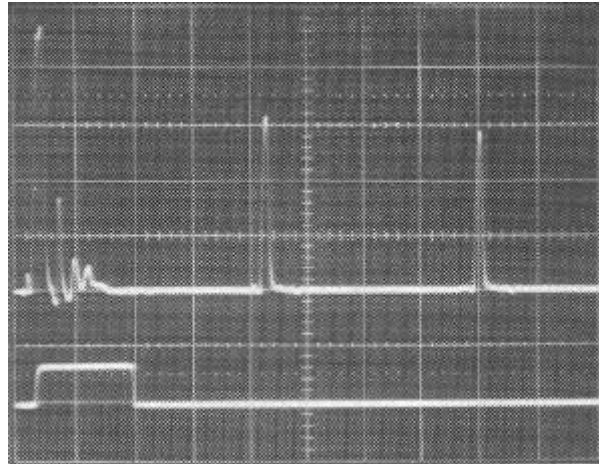


FIGURE 14

Use of IF-Gate to block noise following IF-Sync Sweep mode during immersion or delay line transducer gaging

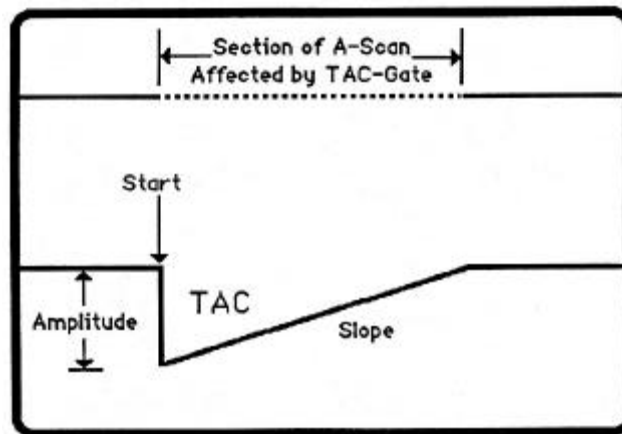
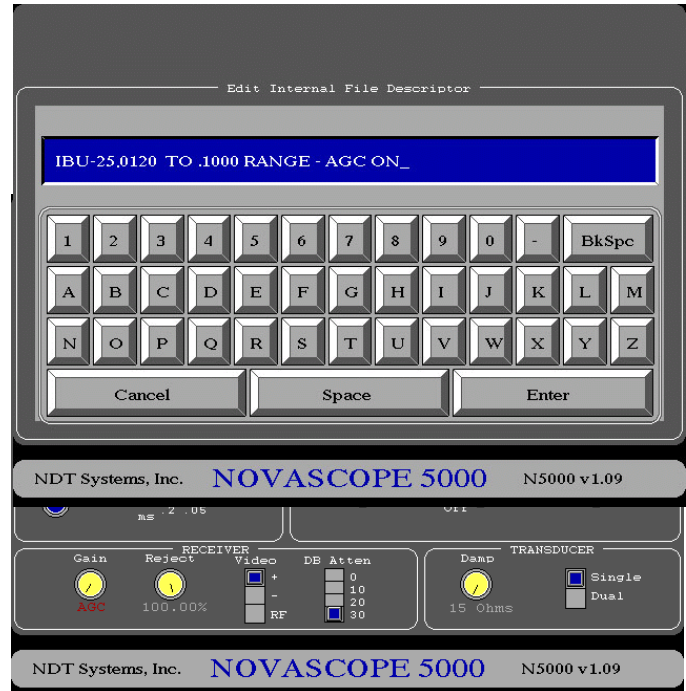


FIGURE 15

TAC-Gate and its three adjustable functions

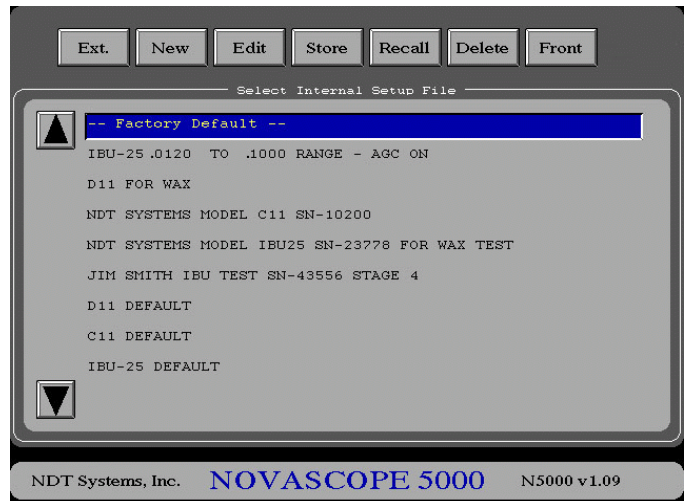
5.25 ALARM - Alarm light “Virtual LEDs” which illuminates whenever either the LO, HI or both LO/HI alarm levels are exceeded by the thickness reading. The ALARM controls are on the sidepanel.

5.26 Setup Button - The setup function button allows the user to save a set of calibration settings under a new record or file name, Recall a setup, Delete a setup or Edit the name of an existing setup. The name may consist of up to 65 characters. All setup parameters will be saved for future recall on either internal or removable media. The optional removable media is located on the rear panel and is discussed later in this manual. Pressing the store button leads to the following screen and associated options...



5.27 Save and Recall Screen - When the STORE button is pressed the user is presented with the following screen and several options.

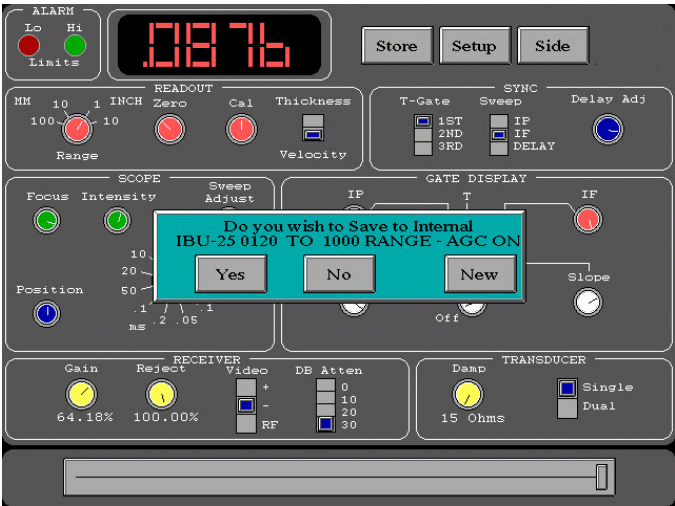
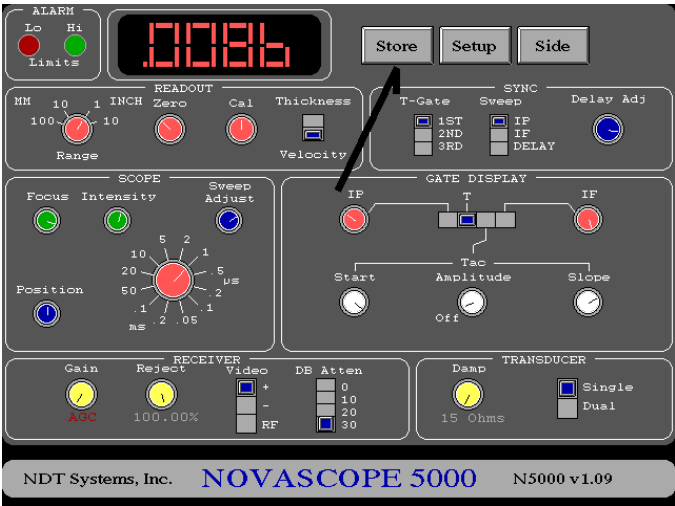
- 1) **FRONT** - Return to the front panel mode. No changes are saved
- 2) **DELETE** - Select (highlight) and then press delete to delete a previously saved setup. You will be prompted for confirmation of the request.
- 3) **RECALL** - highlight a desired setup and then press RECALL. The setup will be recalled and you will be returned to the front panel. At this point you may change the setup in any way.
- 4) **STORE** - This option performs an option similar to “save as”, allowing the user to save a setup with an existing name on the list. Caution is recommended in this case as the selected file name will be overwritten with the new instrument settings. You will be asked for confirmation of the request.
- 5) **EDIT** - Will allow the user to edit an existing file name. A graphical keyboard will be displayed for text modification. (See next page)
- 6) **NEW** - Allows the user to save a given set of instrument settings under a new name. A graphic keyboard will be displayed for text entry. Up to 65 characters are permitted. We would suggest some of the following information be included in the file name: Part number under inspection, transducer model used, serial number of transducer and perhaps the user name.
- 7) **EXT** - Selects the external BUDDy (Back Up Device) card as the device to save and recall settings to and from. This can be useful when you would like to recall a setup used on another



NovaScope. *NOTE: the optional BUDdy card must be installed prior to the NovaScope being turned on. If it is not, save the existing setup internally and exit to the front panel view and turn the unit off. Insert the BUDdy card into the rear panel slot and then restart the 5000.* The following is an example procedure for the saving of a setup from one NovaScope for recall to another NovaScope.

- a) From the front panel select setup
- b) If this is new setup select the NEW button and save the setting “locally” or internally using the pop-up keypad and then select ENTER on the keypad. You will be returned to the Save-Recall screen. Notice the text above the keyboard. At this point it is reminding you that the setting will be save internally.
- c) Press the EXT button. You should notice that the text over the Save-Recall screen reflects External device selected.
- d) You will now notice the EXT button name has changed to INT (internal). You may now select STORE to save the existing setup to the EXTERNAL device under the same name as you did under the INTERNAL setup name. Otherwise, you may select NEW and the Keyboard will be displayed permitting you to save the setup under a new name to the EXTERNAL BUDdy card.
- e) If you are interested on moving this setup to another NovaScope, Select the INT button and then exit to the front panel and turn NovaScope unit one off. Remove the BUDdy card from unit one and insert it to unit two. Turn on unit two.
- f) Select SETUP, EXT
- g) Select the desired EXT file name
- h) Press RECALL
- i) Press the INT button
- j) Press STORE and the file will be saved internally on unit two as the same name.

5.28 Store Button - The STORE button permits the user to save a given set of setup or calibration parameters under the existing file name. You will be prompted for confirmation as all settings associated with this name will be changed. If you desire to save a given setup under a new name it is advised to use the NEW function. Pressing SETUP leads to the following screen. Pressing NEW will provide the Pop-Up keypad



“VIRTUAL” SIDEPANEL CONTROLS

The following controls are accessed by touching the “SIDE” button on the top left of the main screen.

5.29 PULSER - LO, MED, and HI selectively set the IP pulse amplitude (and energy) for exciting the transducer.

5.30 T-GATE/START/STOP - Consists of a pair of POS/NEG (positive/negative) switches that select the polarity of the leading first or second half-cycle of the thickness period start and stop echos over which the T-Gate synchronizes. The settings for these special switches are factory-prescribed for typical applications (see Section 6).



Figure 16

Virtual “Side” Panel

5.31 ANALOG OUTPUT OFFSET - A control to adjust the left sidepanel analog thickness output voltage so attached recorders, etc. can be “zeroed” at some reference thickness value.

5.32 CONTACT - DELAY/IMMERSION - Switch for selecting either contact or delay line/immersion testing. The front panel SYNC and GATE DISPLAY controls/switches are set in accordance with the mode selected with the CONTACT-DELAY/IMMERSION switch.

5.33 ALARMS - Three-function alarms for indicating thickness readings below a selectable lower tolerance (LO), above a selectable upper tolerance (HI) or both (LO/HI). The four-position switch activates the alarm(s) and permits the selection of either the LO, HI, or combination LO/HI function. The LO and HI controls adjust the respective alarm trigger levels. Out-of-tolerance is indicated by the illumination of the front panel ALARM light and also by a signal level change on the left sidepanel multi-pin DATA port (signals for LO, HI or LO/HI).

5.34 PULSE RATE - Selects the rep rate (PRF or pulser repetition rate) for exciting the transducer. Four values of 625, 1200, 2500, and 5000 pulses per second are available for selection. The highest PRF rate should be chosen to maximize scope trace brightness without causing the occurrence of a “rep rate overlap” problem (see Section 6.3).

5.35 MAT'L - Two-position switch set to METAL when gaging metals (or other similar higher-velocity materials, such as glass), or set to PLASTIC when gaging plastics (or other similar lower-velocity materials, like rubber or fiber-resin composites). Basically, it sets the operational range for the front panel CAL calibration control.

6. OPERATIONAL SETUP

Prior to calibrating the NovaScope for accurate thickness reading (Section 7), the following preliminary instrument control adjustments must be made. Also, the information presented in Sections 5 and 11 should be understood before proceeding with this section.

6.1 CONTACT THICKNESS GAGING SETUP

6.1.1 Getting Started - Set the NovaScope controls for contact gaging, in accordance with Table II. Be certain that the side panel CONTACT-DELAY/IMMERSION switch is in the CONTACT position. BE sure to have the appropriate reference standard at hand for the material to be inspected

6.1.2 Turn Power On - Initially, refer to Section 11 regarding the proper setup for using AC line sources and corresponding line fuses. The AC Line Voltage Selector switch and fuse on the rear panel of the NovaScope must be set to match the AC line voltage of the source. **CAUTION: Only activate power in accordance with Section 11.** Turn power on by pressing the POWER switch to its ON position. The red LED light will illuminate when the POWER switch is depressed and the NovaScope is consuming electrical current.

6.1.3 Select Transducer - Attach the contact transducer believed most suitable from the intended application. Refer to Section 9. Some brief preliminary experimentation may be necessary to determine the optimum choice of transducer. Couple the selected transducer, using a suitable liquid couplant, to the material (or sample of the material) to be gaged. See Section 10 regarding choice of ultrasonic liquid couplants.

6.1.4 SYNC SWEEP - Set switch to IP position.

6.1.5 Initial SCOPE SWEEP SPEED Adjustment - Couple the transducer to the thickest step on the reference standard and adjust the Sweep Speed control so that the first back surface echo is displayed along the A-scan on the CRT. See Table II.

6.1.6 Adjusting Echo Amplitude - If necessary, refine the setting of the RECEIVER REJECT control to remove any minor baseline noise along the A-scan between the IP (initial pulse) and first back surface echo.

If an adequate back surface amplitude does not exist,

- 1) Try increasing the PULSER amplitude. Caution should be used if a high frequency transducer (ie 10MHz or greater) is connected. Using the Hi-Power pulser may damage these sensitive transducers.
- 2) Manually adjustable the gain (instead of using AGC) by rotating the RECEIVER GAIN control CW.
- 3) Try a higher-power or lower-frequency transducer.

Infrequently, the echo amplitudes may be so high that they saturate the receiver even at low GAIN settings (typically, near the IP). If this occurs, try removing the saturation by setting the DB ATTEN switch to 10 (or, rarely, to 20). The GAIN and REJECT controls would need to be re-adjusted in conjunction with the use of the DB ATTEN switch.

TABLE II

Preliminary Operational Control Settings

FRONT PANEL CONTROLS

<u>POWER</u>	OFF (CAUTION: Refer to Section 11 Before Proceeding.)
<u>SCOPE SECTION</u>	Set as Desired
INTENS, FOCUS, TRACE ROTATION	Select Setting that Displays First Back Surface Echo
SWEEP SPEED	(Usually 0.05 - 1.0 us/DIV for Thinner Materials, and up to 1.0 us/DIV for Thick Materials.
<u>READOUT SECTION</u>	Select Desired English or Metric Range. See Specification
RANGE	(Section 1).
<u>TRANSDUCER SECTION</u>	Attach Transducer Coax Cable To BNC Connector.
T/R	Full CCW
DAMP	
<u>RECEIVER SECTION</u>	Set to AGC Position (Totally CCW Until Control "Clicks").
GAIN	1/4 - Turn CW.
REJECT	"+" For Contact and Delay Line Transducers,
VIDEO	"-" for Immersion Transducers.
	0 Position
DB ATTEN	
<u>GATE DISPLAY SECTION</u>	Full CCW
IP and IF Controls	Turn Off by Setting TAC AMPLITUDE to Off.
TAC Controls	

VIRTUAL "SIDE PANEL" CONTROLS

<u>PULSER SECTION</u>	Set Switch to LO
<u>T-GATE SECTION</u>	<u>CONTACT</u> <u>DELAY LINE</u> <u>IMMERSION</u>
START Switch	Inoperative POS NEG
STOP Switch	POS POS NEG
<u>CONTACT-DELAY/IMMERSION</u>	
<u>Mode Switch</u>	Set to CONTACT Position if Using a Contact Transducer or to the DELAY/IMMERSION Position if Using Either a Delay Line or Immersion Transducer.
<u>ALARMS SECTION</u>	Set Switch to OFF Position.
<u>PULSE RATE SECTION</u>	Set Switch to 5000 On Thinner Materials or as High as Possible Without Causing <u>Rep Rate Overlap Problems</u> . See Section 6.3.
<u>MAT'L SECTION</u>	Set Switch to Metal Position When Gaging Metals and Other Higher Velocity Materials or to Plastic When Gaging Plastics and Other Slower Velocity Materials. See Table I in Section 4.1.1.

6.1.7 SYNC SWEEP DELAY - Occasionally, when the material being gaged is relatively thick (or its ultrasonic velocity is relatively low), the SYNC SWEEP DELAY (Delay Sync) feature now can be used to selectively "move" (position) the A-scan for improved observation of the first back surface echo and the IP.

To operate in Delay Sync, set the SYNC SWEEP switch to the DELAY position. Then, adjust the DELAY ADJ control and SCOPE SWEEP SPEED control in conjunction with one another until an adequately-expanded first back surface echo is displayed at a desirable location along the scope A-scan trace. See Figure 17.

During the initial operational setup, it will be necessary to go back and forth between the IP and SYNC SWEEP DELAY. Once the NovaScope is set up and calibrated, it is optional as to whether or not to use SYNC SWEEP DELAY continuously during the gaging procedure.

6.1.8 Setting DAMP Control - The Damping control is adjustable in one ohm increments. Carefully and slowly adjust the DAMP control to optimize the shape of the IP and first back echo (the temporary use of manual Receiver Gain, instead of AGC is preferred during this important adjustment). Also, the Sweep Sync Delay function should be used whenever needed to enhance the display of the first back surface echo.

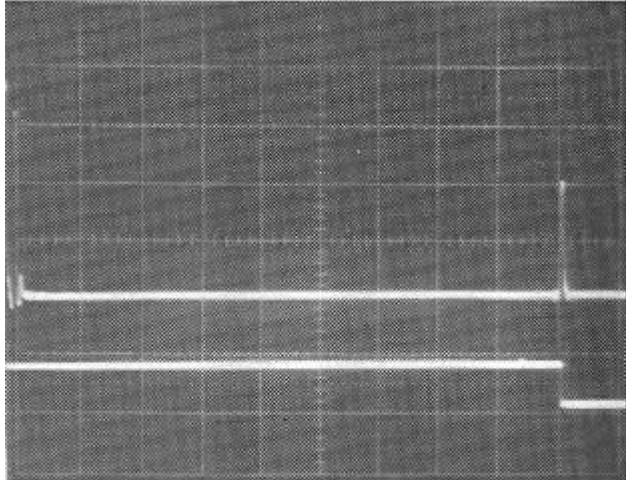
The setup is optimized when it has (1) the shortest first back surface echo pulse length (fewest half-cycles), (2) the sharpest risetime on leading first half-cycle of the back surface echo, (3) the least baseline noise immediately following IP and just prior to the first back surface echo, (4) the least overall echo distortion, and (5) a relatively high echo amplitude. See Figure 18. Note that the temporary use of the optional RF VIDEO display can be helpful when setting the DAMP control.

While very slowly rotating the DAMP control, all of the above-mentioned optimum waveshape characteristics typically tend to occur almost simultaneously - making it relatively easy to detect when the DAMP control is properly adjusted. This usually occurs somewhere within the first 50% rotation of the DAMP control from its full CCW position.

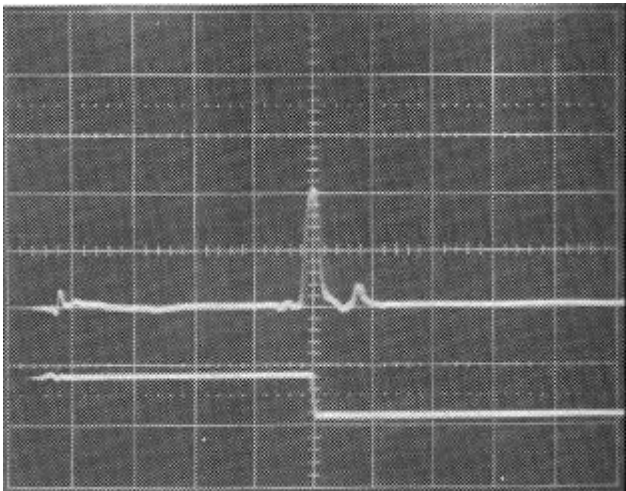
When gaging certain attenuative materials that require particularly high sensitivity, it is sometimes helpful to rotate the DAMP control further CW than normal. This procedure adds extra energy/amplitude to the IP for increased sensitivity. It also tends to reduce resolving power and precision; however, this is normally not a factor for the types of applications requiring this special DAMP adjustment.

6.1.9 Setting IP-GATE - Set GATE DISPLAY switch to the IP position. Adjust the IP control until the IP-Gate is slightly (but safely) beyond any IP noise or surface echo noise. This will block IP noise from affecting the T-Gate, as shown earlier in Figure 13(a).

6.1.10 Setting T-GATE - Set the GATE DISPLAY selection switch to the "T" position to display the T-Gate (the IP-Gate setting in 6.1.9 remains operative even though not displayed). The T-Gate should now extend precisely from the IP to the first back surface echo, as shown in Figure 19. If the T-Gate doesn't synchronize properly, try refining the adjustments.



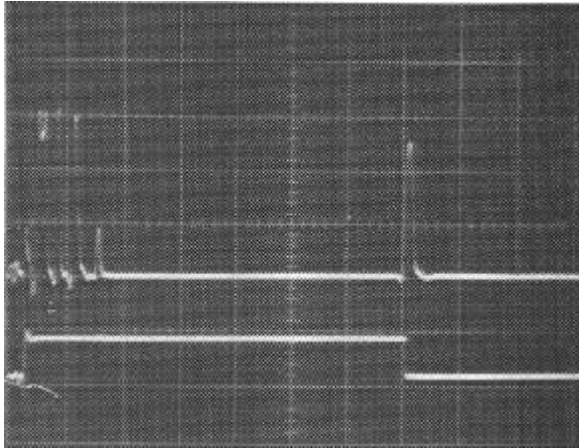
(A) Without Sweep Delay and sweep speed expansion - first back surface echo highly “compressed” causing poor visibility of echo details



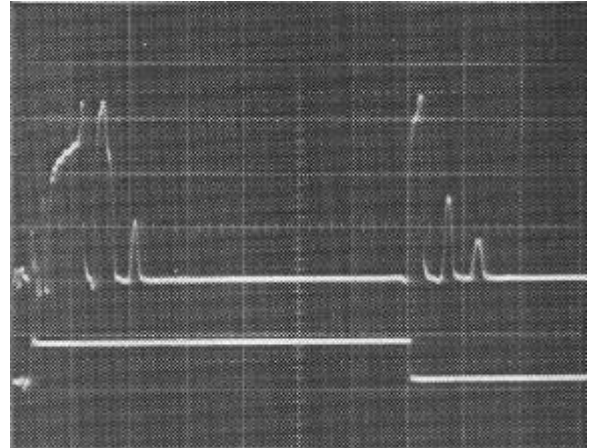
(B) With Sweep delay and sweep speed expansion - first back surface echo details clearly visible

FIGURE 17

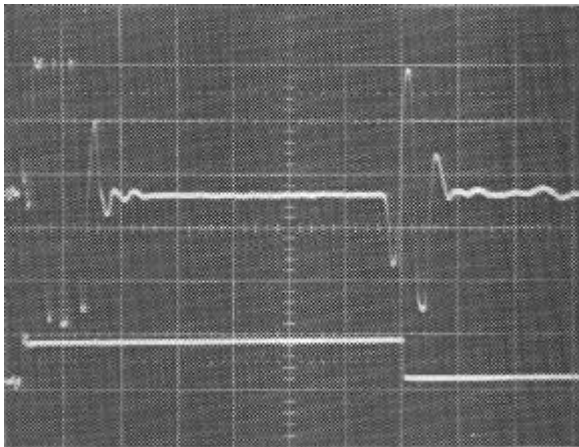
Use of SYNC SWEEP DELAY Control (Delay Sync)
During Contact Transducer Gaging of Thicker Materials



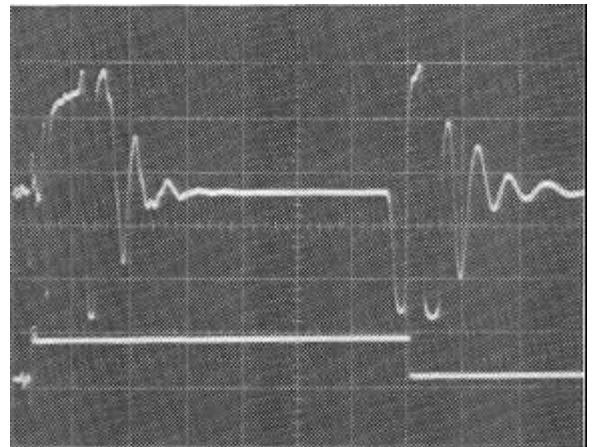
(A) POSITIVE VIDEO - Proper setting of damp control



(B) POSITIVE VIDEO - Improper setting of damp control



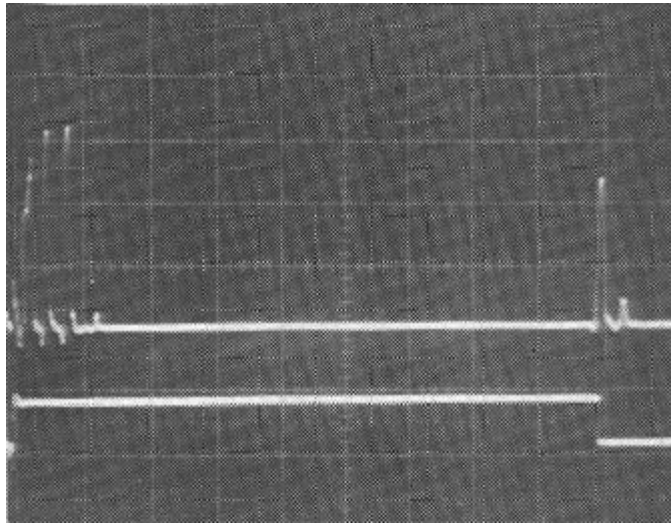
(C) RF VIDEO - Proper setting of damp control (same setting as 17a)



(D) RF VIDEO - improper setting of damp control (same setting as 17b)

FIGURE 18

**Proper and Improper DAMP Control
Adjustment for Contact Gaging**



NOTE: IP Noise on extreme left blocked by preliminary adjustment of IP Gate

FIGURE 19

Proper A-Scan and T-Gate Sync
for Contact Gaging

6.1.11 Choice Between AGC and Manual Gain - The choice to operate on either AGC or manual gain technically depends upon the specific application involved. However, as a general rule, operation in the AGC mode is the preferred choice (this is almost always true for on-line monitoring or scanning applications and the more straightforward contact/delay line applications).

If the AGC mode does not seem to yield satisfactory performance, then the manual gain mode should be tried.

Some brief comparative experimentation with both AGC and manual gain for a specific application is the best procedure to verify the proper choice.

6.1.12 Thickness Calibration - If the T-Gate reliably synchronizes per Section 6.1.10, the NovaScope should be ready for thickness calibration. See Section 7.

6.1.13 Gaging Difficulties - If the standard operational setup does not provide a satisfactory response for a more difficult gaging application, refer to Section 6.4 for possible help from the NovaScope's supplemental functions. Contact NDT Systems, Inc., its dealers or one of their local field sales representatives when further or more advanced assistance is necessary.

6.2 DELAY LINE AND IMMERSION GAGING SETUP

6.2.1 To Start - Set the NovaScope controls for delay line and immersion gaging, in accordance with Table II. Be certain that the side panel **CONTACT DELAY/IMMERSION** switch is in the **DELAY/ IMMERSION** position. If immersion gaging is to be used, see Section 6.2.15 for additional information.

6.2.2 Turn Power On - Refer to Section 11 regarding the proper setup for using AC line sources and corresponding line fuses. The AC Line Voltage Selector switch and line fuse on the rear panel of the NovaScope must be set to match the AC line voltage. Turn power on by pressing the PWR switch to its inner (depressed) position (outer, extended position is the power off setting). The adjacent red LED will illuminate when power switch is depressed and the NovaScope is consuming electrical current. **CAUTION: Only activate power in accordance with Section 11.**

6.2.3 Select Transducer - Attach the transducer believed most suitable for the intended application. Refer to Section 9. Some brief preliminary experimentation may be necessary to determine the optimum choice of transducer. Couple the transducer to the material (or sample of the material) to be gaged.

6.2.4 SYNC SWEEP - Set switch to IF position.

6.2.5 Initial SCOPE SWEEP SPEED Adjustment - Adjust the Sweep Speed so that the first back surface echo is displayed along the A-scan. See Table II. Also, see section 6.2.10 if the A-Scan does not show a proper IF sync and first back surface echo.

6.2.6 Immersion Transducer Only - In conjunction with Section 6.2.7, properly normalize and focus the ultrasonic beam to obtain maximum echo amplitudes. The receiver GAIN control must be switched off the AGC position and rotated CW for adequate echo amplification during transducer normalization/focusing. After this procedure, the GAIN control can again be returned to the AGC position.

6.2.7 Adjusting Echo Amplitudes - If necessary, refine the setting of the RECEIVER REJECT control to remove any minor baseline noise along the A-scan between the IF echo and the first back surface echo (or between multiples, etc., if not selecting the IF echo-to-first back surface echo for the thickness period).

If an inadequate back echo amplitude exists, (1) try increasing the PULSER amplitude, or (2) try manually-adjustable gain (instead of AGC) by rotating the RECEIVER GAIN control CW, or (3) try a higher-power or lower-frequency transducer.

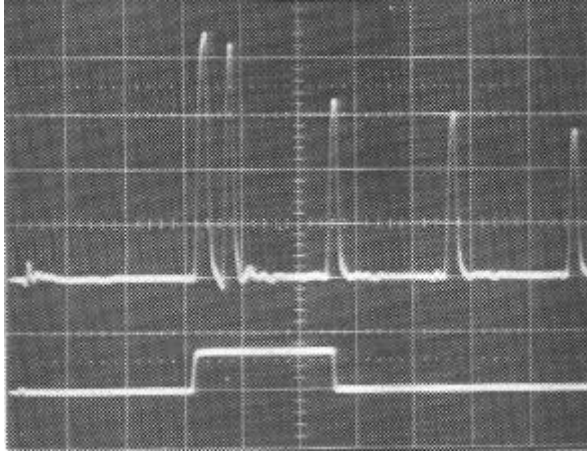
Infrequently, the echo amplitudes may be so high that they saturate the receiver even at low GAIN setting (typically, near the IF). If this occurs, try removing the saturation by setting the DB ATTEN switch to 10 (or, rarely, to 20). The GAIN/REJECT controls would need to be readjusted in conjunction with the use of the DB ATTEN switch.

6.2.8 SYNC SWEEP DELAY - Occasionally, when the material being gaged is relatively thick (or its ultrasonic velocity is relatively low), SYNC SWEEP DELAY (Delay Sync) can now be used to selectively move (position) both the IF echo and first back surface echo along with A-scan for improved observation.

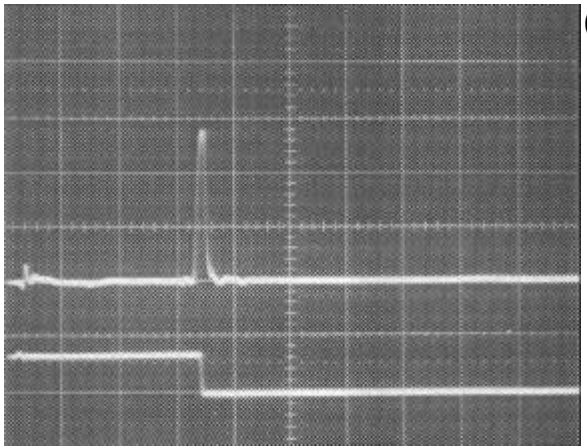
To operate in Delay Sync, set the SYNC SWEEP switch to the DELAY position. Then, adjust the DELAY ADJ control and the SCOPE SWEEP SPEED control in conjunction with one another until the adequately-expanded echo being observed is displayed at a desirable location along the A-scan trace. See Figure 20.

During the initial operational setup, it will be necessary to go back and forth between IF and SYNC SWEEP DELAY. Once the NovaScope is set up and calibrated, it is optional as to whether or not to use Sync Sweep Delay continuously during the gaging procedure. Since Sync Sweep Delay is always triggered (synchronized) from the IP, any waterpath changes during immersion gaging will cause the A-scan and displayed gate trace to move back and forth with the changing waterpath length. If this is bothersome, operate in IF. Operating in SYNC SWEEP DELAY with either delay line transducers or bubbler transducers should not produce this effect because the length of the solid delay line and the waterpath of the bubbler setup are both fixed (unchangeable).

6.2.9 Setting DAMP Control - Carefully and slowly adjust the TRANSDUCER DAMP control to optimize the shapes of the IF echo and first back surface echos (the temporary use of manual Receiver Gain, instead of AGC, is preferred during this important adjustment). Also, the Sweep Delay function should be used whenever needed to assist with the DAMP control waveshape optimization. The waveshapes for these echos are optimized when they have (1) the shortest pulse length (fewest half-cycles), (2) the sharpest risetime on leading first half-cycle, (3) the least baseline noise immediately following the IF echo and between the two echos of the thickness period, (4) the least overall echo distortion, and (5) a relatively high echo amplitude. See Figure 21. Note that the temporary use of the optional RF VIDEO display can be helpful when setting the DAMP control.



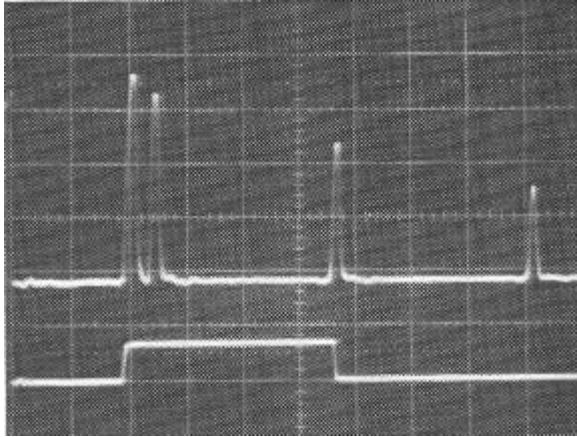
(A) Positioning and sweep expansion of IF Echo (normally observed only against left side of display in IF sync mode). T-Gate shown



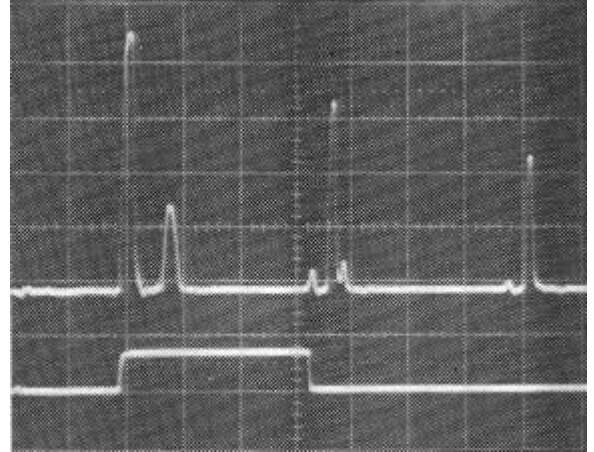
(B) Positioning and Sweep expansion of first back surface echo or multiple echos (normally, possibly "Compressed" on IF Sync or for thicker or lower ultrasonic materials). T-Gate mode shown

FIGURE 20

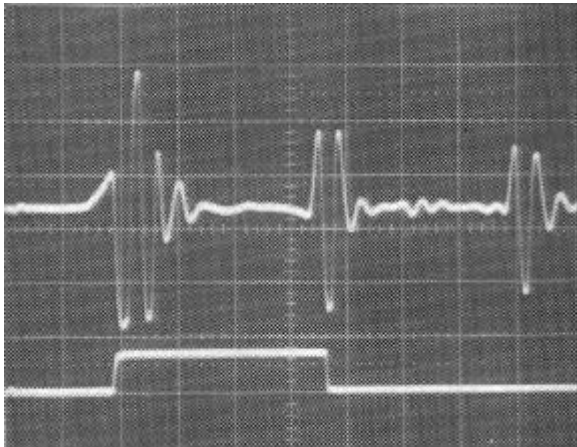
Use of SYNC SWEEP DELAY Control (Delay Sync)
During Immersion or Delay Line Transducer Gaging



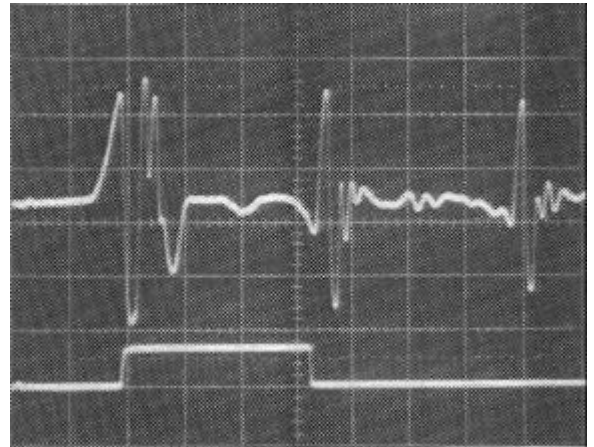
(A) Negative VIDEO - Proper setting of Damp Control



(B) Negative VIDEO - Improper setting of Damp Control



(C) RF VIDEO - Proper setting of DAMP control (same setting as 20a)



(D) RF VIDEO - Improper setting of damp control (same settings as 20b)

FIGURE 21

Proper and Improper DAMP Control Adjustment
for Either Immersion or Delay Line Transducer Gaging
with SYNC SWEEP DELAY Control Operational

When gaging certain attenuative materials that require particularly high sensitivity, it is sometimes helpful to rotate the DAMP control further CW than normal. This procedure adds extra energy/amplitude to the IP for increased sensitivity. It also tends to reduce resolving power and precision; however, this is normally not a factor for the types of applications requiring this special DAMP adjustment.

While very slowly rotating the DAMP control, all of the above-mentioned optimum echo waveshape characteristics typically tend to occur almost simultaneously - making it relatively easy to visually detect when the DAMP control is properly adjusted. This usually occurs somewhere within the first 50% rotation of the DAMP control from its full CCW position.

6.2.10 Setting IP-Gate - Temporarily set the SWEEP SYNC switch to IP and reduce (slow) the Sweep Speed until the IF echo appears across the display from the IP. Temporarily set the GATE DISPLAY switch to IP and adjust the IP-Gate from false synchronizing on any noise that may occur between the IP and the IF echo (especially useful for protecting against waterpath noise during immersion of bubbler/squitter gaging). See Figures 13(b) and 13(c). Now, set the SYNC SWEEP switch back to IF and increase the Sweep Speed to its earlier value.

6.2.11 Setting IF-Gate - With the IF-echo-synchronized A-scan now on the display, set the GATE DISPLAY switch to the IF-Gate position and adjust the IF-Gate control so that any apparent IF-area noise is blocked from false-triggering the T-Gate, as shown earlier in Figure 14.

6.2.12 Setting T-Gate - Set the GATE DISPLAY switch to the "T" position to display the T-Gate (the IP-Gate and IF-Gate remain operative even though the GATE DISPLAY switch now prevents their display). Optionally, set the SYNC Section T-GATE to "1st" for IF echo-to-first back surface echo gaging. The T-Gate should now synchronize between these two T-Gate Start/Stop echos, as shown in Figure 12(a). If the T-Gate doesn't

synchronize properly, try refining the adjustments.

As an alternative, the T-Gate can be set to synchronize between the first back surface echo-to-first multiple or between the first multiple-to-second multiple by setting the SYNC Section T-Gate switch to either the "2nd" or "3rd" position, respectively, as shown in Figures 12B and 12(c). Furthermore, it can be set to sync on virtually any desired subsequent multiples by rotating the IP-Gate control CW until the T-Gate advances (jumps) to synchronize between the desired multiple echo period, as shown in Figure 12(d). If the T-Gate doesn't synchronize properly, try refining the adjustments.

6.2.13 Choice Between AGC and Manual Gain - The choice to operate on either AGC or manual gain technically depends upon the specific application involved. However, as a general rule, operation in the AGC mode is the preferred choice (this is almost always true of on-line monitoring or scanning applications and the more straightforward contact/delay line applications).

Some brief comparative experimentation with both AGC and manual gain for a specific application is the best procedure to verify the proper source. If the AGC mode does not seem to yield satisfactory performance, then the manual gain mode should be tried.

6.2.14 Thickness Calibration - If the T-Gate reliably synchronizes per Section 6.2.12, the NovaScope should be ready for thickness calibration. See Section 7.

6.2.15 Immersion/Delay Line Gaging Limits - Due to necessary design considerations, Table III and Table IV list the NovaScope's actual limits for gaging thickness and waterpath/delay line length, respectively. These design limits were chosen as the best overall compromise for all the various typical situations which occur. When necessary, these limits can be altered by NDT Systems, Inc. to accommodate non-typical situations.

Especially during immersion transducer gaging, a spurious echo phenomenon, known as water multiples, can detrimentally affect the set up and thickness readout. Water multiples result from the multiple reverberation of ultrasonic pulses between the transducer and the near surface of the material. This can sometimes cause a spurious echo pattern overlap condition which visually appears similar to the Rep Rate overlap phenomenon described in Section 6.3.

Water multiples (and Rep Rate overlap) are identified by their relatively rapid movement across the A-Scan while the waterpath is being changed. Furthermore, water multiples can be differentiated from Rep Rate overlap because water multiples do not move or disappear when the Rep Rate is altered.

6.2.16 Gaging Difficulties - If the standard operational setup does not provide a satisfactory response for a more difficult gaging application, refer to Section 6.4 for possible help from the NovaScope's supplemental functions. Contact NDT Systems, Inc., its dealers or one of their local field sales representative when further or more advanced assistance is necessary.

TABLE III

Thickness Gaging Limits During Immersion
Or Delay Line Transducer Gaging

RANGE SWITCH POSITION	SYNC T-GATE SWITCH POSITION	NOMINAL ECHO PERIOD (us)	EQUIV. STEEL THICK
1"	1st	6.40	0.75"
1"	2nd	3.10	0.36"
1"	3rd	2.20	0.25"
10"	1st	6.41	4"
10"	2nd	3.19	2"
10"	3rd	2.26	1.3"
10mm	1st	6.4	19.1mm
10mm	2nd	3.1	9.1mm
10mm	3rd	2.2	6.4mm
100mm	1st	34.3	101.6mm
100mm	2nd	17.2	50.8mm
100mm	3rd	11.2	33.0mm

TABLE IV

Waterpath Limits During
Immersion Transducer Gaging

RANGE SWITCH POSITION	NOMINAL	WATERPATH MINIMUM	LIMITS* MAXIMUM
1"	0.2"		Rep Rate Dependent
10"	1.0"		Rep Rate Dependent
10mm	5.1mm		Rep Rate Dependent
100mm	25.4mm		Rep Rate Dependent

*Rep Rate Overlap (see Section 6.3) and Water Multiples Must Be Considered with Above Information.

6.3 PULSE RATE (PRF) SELECTION

It is always necessary that the Pulse Rate (PRF or Rep Rate) be chosen to be slow enough that the IP and echo pattern for the next pulse (IP) doesn't initiate before the completion of the thickness period for the prior pulse (IP). This Rep Rate "overlap" or "wrap-around" condition can obviously interfere with the T-Gate sync and the thickness measurement, as shown in Figure 22.

The basic rule is to use a Rep Rate whose time period (one divided by the Rep Rate) is longer than the total time period between the IP and the selected echo on which the T-Gate should stop. During contact transducer gaging, this time period is that between the IP and first back surface echo. During immersion/delay line gaging, it is the total time period representing the IP-to-IF echo waterpath/delay line length plus the time between the IF echo and either the first back surface echo or a multiple echo (whichever is selected to stop the T-Gate).

Rep Rate overlap conditions can be quickly identified and eliminated by selecting a lower setting on the PULSE RATE switch, while noticing if the spurious echos disappear.

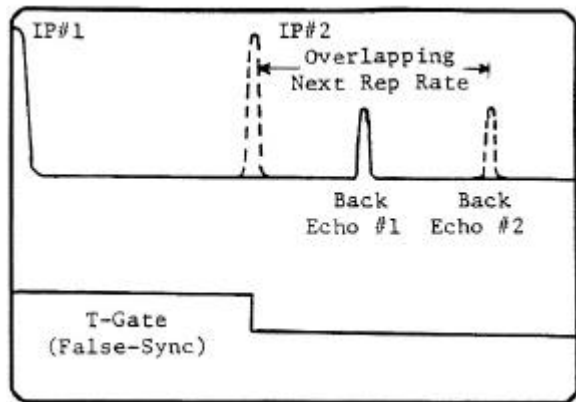
During immersion transducer gaging, Rep Rate overlap patterns also can be identified by their movement across the display while the waterpath is being changed. Decreasing the waterpath can eliminate the condition, if a slower Rep Rate isn't desired. Another similar spurious echo phenomenon which can occur during immersion (or delay line) transducer gaging is known as water multiples (see Section 6.2.14).

Use as high a Rep Rate as possible to maintain the brightest possible display and/or the fastest thickness data collection for automated applications.

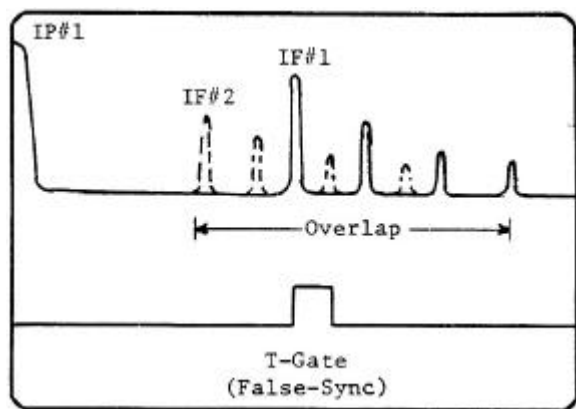
6.4 SUPPLEMENTAL FUNCTION

6.4.1 Special TAC-GATE - Occasionally, a material may be so attenuative (noisy due to wave scatter) or so thick that when the GAIN control is increased to display the first back echo, an array of noise echos appears within the candidate thickness echo period. If the echo noise array can't be satisfactorily removed by the preceding procedures, TAC should be tried.

To operate TAC, first rotate both the TAC START and TAC SLOPE controls a few turns CW from their full CCW positions. Then activate TAC by rotating its AMPLITUDE control from the full CCW OFF position to about 1/2 turn CW. To display TAC, set the GATE DISPLAY switch to TAC position. TAC, like the other adjustable Gates is operational on the A-scan whether or not it's being displayed on the lower gate trace. At this point, the saw-tooth-shaped TAC-Gate should be appearing on the lower trace, as shown in Figure 23(a). All adjustable TAC parameters are shown in Figure 23(a).



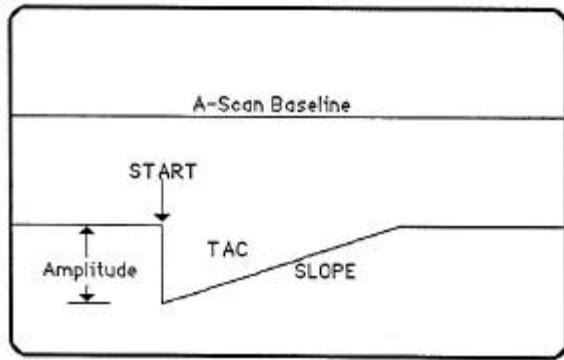
(A) Contact Transducer Gaging - Material too thick or material velocity too slow for selected Rep Rate. Select a slower Rep Rate



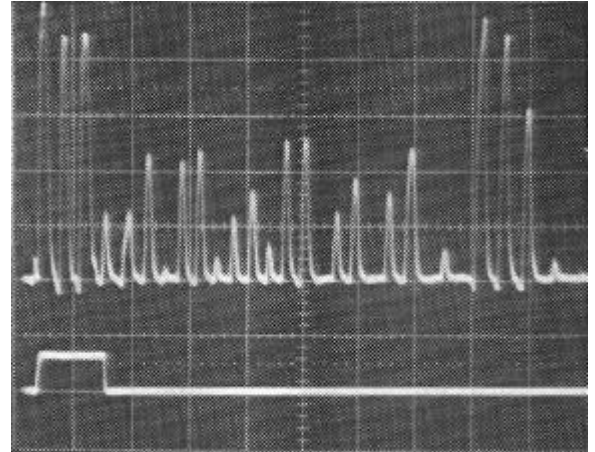
(B) Immersion/Delay Line Transducer Gaging - Combination of water path/delay line length plus material thickness too great for selected Rep Rate. Select a slower Rep Rate

FIGURE 22

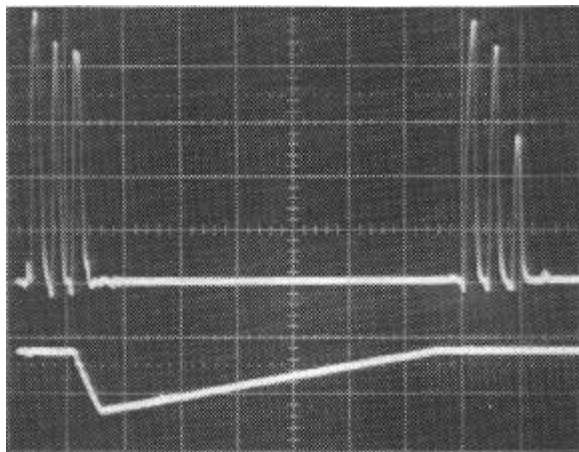
Rep Rate Overlap Conditions



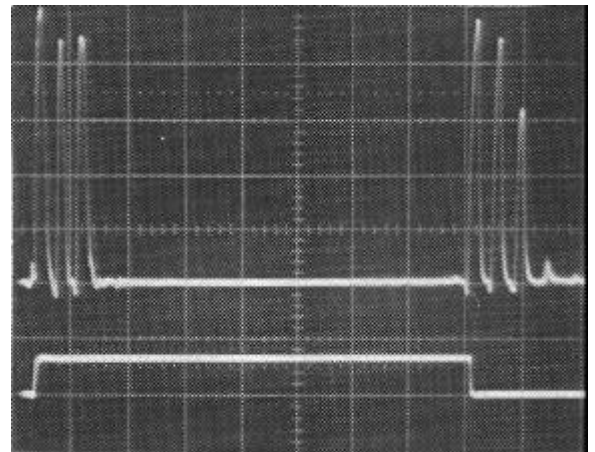
(A) TAC-GATE Initially turned-on
(A-Scan not shown for clarity)



(B) Unsuccessfully gaging “noisy”
material without TAC



(C) Adding proper TAC to (b), with
GATE DISPLAY switch in TAC position



(D) Results of proper T-GATE Sync with
TAC in (c). GATE DISPLAY switch is
now int the “T” position

FIGURE 23

Setting Up TAC-Gate Function

Since the highest-amplitude noise echos normally occur closest to the beginning of the thickness echo period, adjust the TAC START control so that the TAC-Gate also initiates there. Now, adjust the TAC AMPLITUDE control until the noise echos closest to the beginning of the echo period barely disappear (due to TAC acting on the receiver gain in this time interval). Then, adjust the TAC SLOPE control so the SLOPE line suppresses the noise echos extending along the baseline toward the back surface echo. Repeat/refine the adjustments of TAC START, AMPLITUDE, and SLOPE (along with the refined adjustment of the receiver GAIN and REJECT controls) until a noise-free baseline is achieved across the thickness echo period. Now, the IP-Gate can be used to block any noise near the beginning of the thickness echo period that was not suppressed by TAC. The T-Gate should now synchronize dependably. Figures 23(b), 23(d), and 23(e) show an example of selectively suppressing a noise array with TAC.

TAC also can be used to suppress localized noise well beyond the beginning of the thickness echo period by adjusting the START control to start TAC just prior to the localized noise and, then, adjusting the TAC AMPLITUDE and SLOPE controls as needed.

Furthermore, when operating in the DELAY/IMMERSION switch mode, setting the SYNC SWEEP switch to DELAY will permit TAC to be adjusted (with TAC START control) to occur even prior to the IF echo. Sometimes this special procedure allows improvements in resolving power where the IF echo is too high in relationship to a small first back surface echo.

6.4.2 T-GATE START/STOP Switches for Contact Transducer Gaging

6.4.2.1 General - The two START/STOP switch positions prescribed in Table II for the contact transducer mode should be adequate for typical gaging applications.

If, for some reason (such as non-typical gaging application) the T-Gate and, thus, the digital readout exhibit a slight erratic, unstable behavior in spite of no visible A-scan baseline noise, improper half-cycle synchronization of the T-Gate on the first back surface echo (T-Gate Stop) should be suspected. The T-Gate Start cannot be suspect because it automatically triggers on the IP during contact transducer gaging (the START switch is inoperative in the contact gaging mode).

To select the proper setting for the T-GATE/STOP switch, temporarily set the RECEIVER VIDEO switch in the RF position. Also, use the GAIN control in the manual position to establish unsaturated echos. Then, perform the following procedure:

6.4.2.2 Setting T-GATE/STOP Switch - Temporarily set the RECEIVER VIDEO switch in the RF position. Next, if the material being gaged is quite thick (or its ultrasonic velocity is quite slow), use the SYNC SWEEP DELAY mode (see Section 6.1.7) to suitably expand and position the first back surface echo on the display. Then, using the RF VIDEO display mode, observe the first back surface echo waveform and set the T-GATE/STOP to the polarity position that allows the T-Gate to stop on the higher-amplitude half-cycle of the two leading (first two) half-cycles (typically, this is the second half-cycle that follows the smaller leading

half-cycle). See Figure 24.

After the T-GATE/STOP switch has been properly set, return the VIDEO to the proper polarity, the GAIN control, if desired, to AGC and the SYNC SWEEP control to IP.

6.4.3 T-GATE START/STOP Switches for Immersion or Delay Line Transducer Gaging

6.4.3.1 General - These switches determine on which of the two leading half-cycles (positive or negative polarity) of the thickness period's start and stop echos the T-Gate synchronizes. The two START/STOP switch positions prescribed in Table II for the delay line/immersion transducer mode should be adequate for typical gaging applications.

If, for some reason (such as a non-typical gaging application) the T-Gate and, thus, the digital readout exhibit a slight erratic unstable behavior in spite of no visible baseline noise, improper half-cycle synchronization of the T-Gate on the start and stop echos of the selected thickness period should be suspected. To properly set the START/STOP switches, refer to the remaining discussions and procedures of this Section.

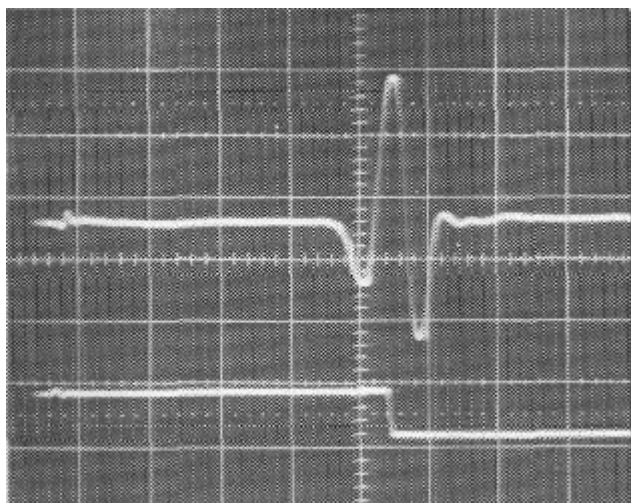
6.4.3.2 Typical Echo Polarities - The typical echo polarities during delay line transducer gaging are inverted (or reversed) from those normally associated with immersion transducer gaging. See Figure 25. These polarity inversions are caused by the differences in the acoustic impedances experienced by the ultrasonic pulses as they travel through the different transducer types and coupling media.

Because of these polarity inversions, it is necessary to choose different T-Gate start and stop half-cycle polarities.

6.4.3.3 START/STOP Switch Operational Concept - The T-GATE START switch selects which polarity (between the two leading half-cycles) of the IF echo actually starts the "listening period". The IF echo is always considered the first echo occurring after the end of the adjustable IP-Gate.

When the SYNC T-GATE switch is in the "1st" position, the START switch also determines the polarity of the T-Gate start because it extends (in time) from the selected half-cycle of the IF echo to the first back surface echo. In the "1st" mode, the T-GATE STOP switch selects which polarity (between the two leading half-cycles) of the first back surface echo stops the listening period.

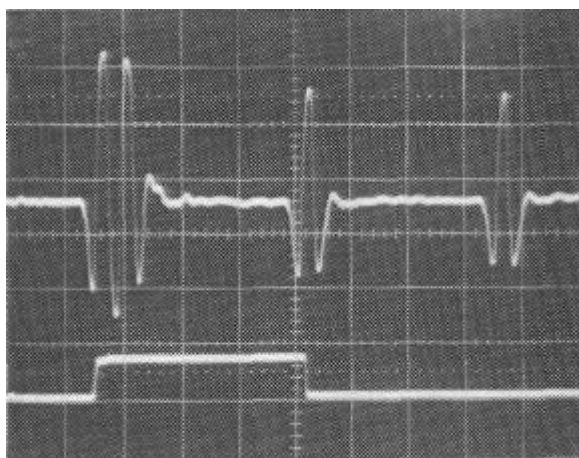
When the SYNC T-GATE switch is set in the "2nd" or "3rd" positions, the T-GATE START switch still selects the IF echo polarity; however (unlike in the "1st" mode), it does not enter



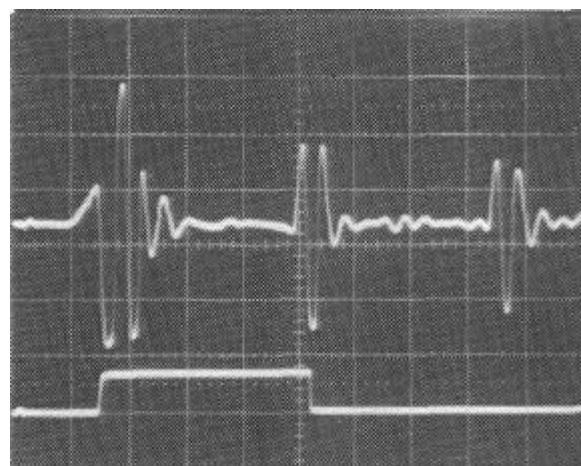
Proper Setting - T-GATE STOP switch set to "POS" to Sync on higher amplitude, positive polarity, second half cycle of back surface echo. The first, smaller, negative half cycle would not be the most suitable or stable half cycle to use, due to the fact that it is close to the same amplitude as the second negative half cycle thereby creating a condition where potential exists to "false trigger" between the two. If the above echo happened to be INVERTED then the appropriate half cycle to use would have been negative.

FIGURE 24

Setting the T-GATE STOP Switch on the Proper Higher-Amplitude Half-Cycle of the First Back Surface Echo During Contact Gaging



(A) RF Display for Delay Line transducer gaging (IF echo is on left)



(B) RF Display for immersion transducer gaging (IF echo is on left)

FIGURE 25

Echo Polarity Inversion Between Delay Line and Immersion Transducer Gaging

into selecting the half-cycle polarity of the thickness period start echo. Instead, the T-GATE STOP switch selects the same polarity for both the thickness period start and stop echos (multiples). As shown in Figure 25, the first back surface echo and the multiples typically have the same polarity (which are inverted when compared to the associated IF echo). Moreover, this typically leads to measuring across a "true" echo period (no extra half-cycle involved).

6.4.3.4 Gaging IF Echo - First Back Echo - Temporarily set the VIDEO switch in the RF position and use SYNC SWEEP DELAY to position the IF echo near the middle of the A-Scan display, as shown in Figure 26. Also, use the GAIN control in the manual position to establish unsaturated echos. Then, set the SYNC T-GATE switch in the "1st" position.

Now, set the T-GATE START switch to the polarity of the higher amplitude of the two leading half-cycles of the IF echo. Then, do the same for the T-GATE STOP switch with the first back surface echo. See Figure 26. When this small-amplitude leading half-cycle is present, select the next half-cycle (opposite in polarity) for starting the T-Gate. This usually leads to incorporating an extra half-cycle into the thickness period; however, the extra time involved is compensated for during calibration with the ZERO control.

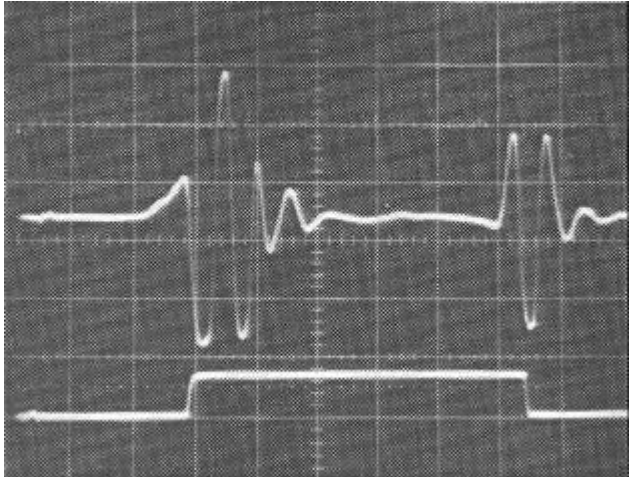
If the third half-cycle is improperly selected for T-Gate start, then the thickness readout will probably not be as stable because the T-Gate may sometimes false-trigger on the small-amplitude leading half-cycle.

If the small leading half-cycle of the IF echo can be successfully suppressed at all times with the RECEIVER REJECT or GAIN controls, the largest "third" half-cycle can be considered a candidate for the T-Gate Stop. Typically, this small first half-cycle doesn't enter into the situation for the first back surface echo or for multiples because it's damped to an inconsequential level by then.

6.4.3.5 Gaging On Multiples - Temporarily set the VIDEO switch in the RF position and use SYNC SWEEP DELAY to position the IF echo near the middle of the A-Scan display. Then, set the SYNC T-GATE switch in the "2nd" or "3rd" position.

Now, set the T-GATE START switch to the polarity of the highest amplitude of the two leading half-cycles of the IF echo. (Refer to Section 6.4.3.4 regarding consideration of the possible occurrence of a small amplitude leading half-cycle in the IF echo.) Then, do the same for the T-GATE STOP switch and the pair of selected multiple echos representing the thickness period. See Figure 27. The polarity setup on multiples typically leads to the T-Gate synchronizing over a true echo period because the pair of echos have the same polarity.

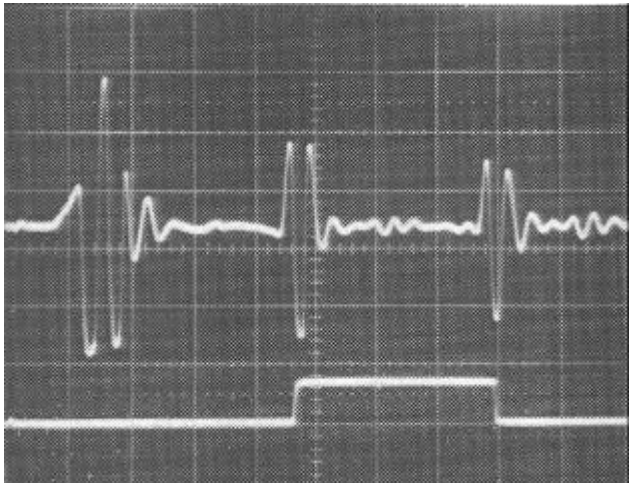
As previously mentioned, thickness echo periods beyond the "3rd" can be selected by rotating the IF-Gate control CW until the T-Gate "jumps" to the desired multiple period.



NOTE: The second half-cycle is selected (regardless of polarity) because it has a higher amplitude than the “actual” first half-cycle. The amplitude of the small first (positive) half-cycle depends on the impedance (reflectivity) of the material being measured.

FIGURE 26

Proper Identification and Selection of First Half-Cycle During Immersion Gaging



T-GATE STOP switch set to NEG in this example to Sync on the two higher amplitude negative half-cycles for multiple echo gaging. (Typical for immersion or bubbler flat stock transducer gaging)

FIGURE 27

Setting the T-GATE STOP Switch on Multiples for Delay or Immersion Transducer Gaging

Also, refer to Section 6.4.3.4 and Figure 26 regarding the proper selection of the first half-cycled T-Gate sync on the IF echo.

After setting the START/STOP switches, return the VIDEO to the proper polarity, the GAIN control, if desired, to AGC and the SYNC SWEEP control to IF.

6.4.4 Blocking Actual IF Echo - Sometimes, during delay line or immersion transducer gaging, it may be desirable to select either the first back surface echo or a multiple and treat it as an "artificial IF echo". This is accomplished by setting the IP-Gate beyond the true IF echo and any subsequent echos until the sweep syncs on the desired echo. To utilize this special technique requires that the artificial IF echo possesses an adequate amplitude to create a reliable sync.

6.4.5 HI RES/NORM Switch - The NovaScope allows the selection of either normal or exceptionally high resolving power, via the left sidepanel HI RES/NORM switch for only those interface gating applications (using a delay line or immersion transducer) where **plastic** thickness is being gaged between the interface echo and the first back surface echo. **This switch should be set in the NORM (normal) position for all "standard" type transducers.** It can optionally be set to the HI RES (high resolution) position only for immersion and delay line transducers that are exceptionally high in frequency and exceptionally well damped - for thickness gaging very thin **plastic** materials by means of the interface-to-first back surface echo approach. A modification is available to adapt this ultra-high resolution switching ability to metals. Contact NDT Systems, Inc. regarding such applications and transducers.

7. CALIBRATION PROCEDURES

Calibration should be conducted only after properly setting-up the NovaScope initially, in accordance with Section 6.

7.1 THICKNESS CALIBRATION WITH SAMPLES

- a. Read Sections 8,9, and 10.
- b. Set the THICKNESS/VELOCITY switch in the THICKNESS position.
- c. Select the thickness range to be covered and the units of measurement (English or Metric) with the RANGE switch.
- d. With the transducer coupled to the calibration sample of the material representing the upper end of the anticipated thickness range, adjust the front panel CAL control until the digital display precisely reads that thickness.
- e. Then, couple the transducer to the sample of the material representing the thin end of the anticipated thickness range and adjust the front panel ZERO control until the digital display precisely reads that thickness.
- f. Repeat and refine the CAL and ZERO adjustments until the digital display reads both thicknesses precisely without further adjustment.
- g. Always re-calibrate whenever changing the echo period over which the T-Gate operates (except where no errors result when gaging on multiples with either delay line or immersion transducers).

7.2 THICKNESS CALIBRATION WITH VELOCITY

If the ultrasonic velocity for the material to be gaged is accurately known, set the THICKNESS/VELOCITY switch in the VELOCITY position and adjust it until the known velocity value appears on the digital display. Be certain that the units of readout selected (English or Metric) on the RANGE switch agree with the units for velocity. Once the velocity is entered on the readout, set the same switch to its THICKNESS position for the thickness gaging.

To accurately utilize this velocity-input feature, it is necessary that the ZERO control has been properly set previously (to compensate for the inherent time delays in the electronics and specific transducer/coax cable being used).

Refer to Section 7.3 regarding the NovaScope procedure for determining the velocity of a given material. Once determined, the velocity value can be used (as described above) to conveniently thickness-calibrate the NovaScope without the subsequent need for a material

calibration sample. In general, thickness calibration by using samples (Section 7.1) is preferred for optimal precision.

7.3 MATERIAL VELOCITY MEASUREMENT

The NovaScope velocity readout feature can be used to characterize the properties of a material whose thickness is known precisely.

The basic setup/calibration procedure consists of initially adjusting the NovaScope's CALIBRATE and ZERO control to obtain an accurate thickness readout on a thin and thick sample of any given suitable material (using a given transducer and T-Gate selection). Then, typically, a material's unknown velocity can be determined by (1) setting the READOUT switch to the THICKNESS position and adjusting the digital display to read that thickness value (as measured with a micrometer), and (2) changing the same switch to its VELOCITY position and noting the value of ultrasonic velocity displayed by the digital readout (the transducer does not need to be coupled to the material to retain this value).

7.4 CALIBRATION OF ALARMS

- a. Calibrate the thickness readout of the NovaScope per Section 7.1 or 7.2.
- b. Obtain a sample of the material to be gaged whose thickness falls within the anticipated thickness range.
- c. Be certain that the THICKNESS/VELOCITY switch is set in the THICKNESS position.
- d. Set the Alarms function switch to the function desired - either LO, HI, or LO/HI.
- e. Couple the transducer to the material described in Section 7.4.2.

7.4.1 To Calibrate Only the LO Control - With the transducer coupled to the material, initially adjust the CAL control until the digital readout precisely displays the thickness reading representing the low thickness tolerance limit. Next, with the transducer still coupled to the material, adjust the ALARMS LO control until the front panel ALARM warning light just barely illuminates (the trigger level). Finally, re-calibrate the NovaScope for proper thickness readout (per Section 7.1 or 7.2).

7.4.2 To Calibrate Only the HI Control - With the transducer coupled to the material, initially adjust the CAL control until the digital readout precisely displays the thickness reading representing the high thickness tolerance limit. Next, with the transducer still coupled to the material, adjust the ALARMS HI control until the front panel ALARM warning light just barely illuminates (the trigger level). Finally, re-calibrate the NovaScope for proper thickness readout (per Section 7.1 or 7.2).

7.4.3 To Calibrate for LO/HI Combination - Perform Section 7.4.6 and 7.4.7. Then set the

ALARMS function switch to LO/HI. It is necessary to re-calibrate for proper thickness readout after both LO and HI are set.

8. CALIBRATION SAMPLES

The NovaScope must be calibrated on test samples which are identical in composition to the material to be gaged because each material has a characteristic ultrasonic velocity. Only two samples are generally needed for a given material which represent the thick and thin ends of the range to be gaged; however, it is good practice (especially for critical applications) to have several reference thicknesses over the range of interest. Whenever practical, use a step-wedge machined from a single piece of the material involved. The sample thicknesses must be known, at least, as precisely as that readout accuracy desired by the NovaScope. The NovaScope gaging accuracy cannot be any better than the precision of the calibration samples.

Flat calibration samples are satisfactory for gaging flat or gently contoured surfaces. Whenever relatively small diameters or small radii of curvature are involved, it usually becomes necessary to use calibration samples with similar contours so that good gaging accuracy is assured.

Experience will show that some liberty can be taken in the need to use a calibration standard for each alloy of similar composition. This is true for many groups of steels, aluminum alloys and magnesium alloys, especially if optimum gaging precision is not needed. (There are noticeable ultrasonic velocity differences even between similar alloys or heat treat conditions which can lead to small calibration errors.) Experimentation is necessary to establish what liberties can be taken in this regard.

9. TRANSDUCER SELECTION

NDT Systems, Inc. has designed and manufactured a wide variety of contact, delay line and immersion transducers (including bubbler types) for thickness gaging with the NovaScope. These transducers possess the proper type of resolution (damping, etc.) and sensitivity to offer optimum thickness gaging performance.

A complete description of NovaScope transducers can be found in the **OPTIMA™** Transducer Catalogue, which can be obtained from NDT Systems, Inc., its dealers or their local field sales representatives.

10. COUPLANT SELECTION FOR CONTACT AND DELAY LINE TRANSDUCERS

It is necessary to use a liquid couplant film between contact or delay line transducers and the test surface.

The type of ultrasonic couplant to be used is determined by the specific application. Commercially sold liquid and gel couplants, light machine oil, glycerine, or a water-glycerine mixture are suitable for most smooth surfaces. For rough surfaces, a more viscous couplant such as commercial heavy-duty couplants, thick oil and gels, or pure (undiluted) glycerine is normally better.

11. AC POWER START-UP REQUIREMENTS

11.1 SAFETY - CAUTION: Prior to connecting the NovaScope to an AC power source, please read this section carefully, otherwise an operator safety hazard or damage to the NovaScope could occur. Also, read the SAFETY SUMMARY at the front (preface) of this manual, regarding AC power source, grounding and other safety considerations. Refer to Figure 28 while reading this section.

11.2 AC LINE VOLTAGE SELECTION - The NovaScope is designed to operate from a nominal 115 volt - 240VAC (95-264 volt) AC power line with any frequency from 47 Hz to 63 Hz, autoselecting. Prior to connecting the power cord to the NovaScope, be certain that the supply voltage matches the nominal voltage of the specific AC line power source to be used (see Figure 28, Table V and information on the NovaScope rear panel). The NovaScope may be damaged if operated with the wrong AC line voltage applied.

TABLE V

Rear Panel Electrical Information For Voltage Selector Switch, Fuse And Power Cord Receptacle			
Line Voltage	Acceptable Line Voltage Range	Fuse (250 V) UL 198.6 (3AG) <u>1/4" x 1/4"</u>	Fuse (250 V) IEC 127 <u>5 x 20mm</u>
115 VAC	95 - 128 VAC	2.0 A slow	1.6 A slow (T)
230 VAC	190 - 250 VAC	1.0 A slow	0.8 A slow (T)

The detachable power cord may need to be replaced to match the AC line source to be used (see Section 11.4).

11.3 AC LINE FUSE - After properly identifying the LINE VOLTAGE (and prior to attaching the required power cord), verify that the AC LINE FUSE, located in the rear panel LINE FUSE holder, is the type specified for the AC line voltage to be used. See Figure 28 for the rear panel location of the AC LINE FUSE holder and AC LINE FUSE type information table. Also, refer to this same information in Table V. NovaScopes are normally shipped with the proper line fuse.

NovaScope 5000 Rear Panel View

- 1) Analog Output - 0-5 VDC
 - 2) Ext. Trigger In
 - 3) Ext Trigger Out
- Mouse input for future application expansion
 - VGA is for external VGA use... remember, this is for the graphics screen view only. Touch Screen is active on front panel only. This is also provided for future application expansion.



**AC Line Input
FUSE**

FIGURE 28
NovaScope Rear Panel Photo
&
Line Fuse And Power Cord Receptacle

Use the following procedure to verify that the proper AC LINE FUSE is installed or to install a replacement fuse:

- a. Unplug the power cord from the power source (if applicable).
- b. Press in and slightly rotate the fuse-holder cap counterclock-wise to release it.
- c. Pull the cap (with the attached fuse inside) out of the fuse holder.
- d. Verify that the fuse is the same type listed on the back of the instrument. Again, the two types of fuses listed are not directly interchangeable; they require different types of fuse caps.
- e. Reinstall the fuse (or replacement fuse) in the proper fuse-holder cap.
- f. Replace the fuse holder and cap.

11.4 POWER CORD - NovaScopes are normally shipped with power cords/plugs specific to the country of the customer. A wide variety of NovaScope power cords are available and should be specified by the customer at time of order placement. Information regarding NovaScope power cords can be obtained by contacting NDT Systems, Inc. in Huntington Beach, CA, USA, or by contacting one of its local offices, representatives or dealerships.

Once the proper AC LINE FUSE (Section 11.3) inspections have been performed, the detachable AC line power cord can now be attached as follows:

11.4.1 Attachment To NovaScope - Insert the female connector on the power cord into the appropriate receptacle on the rear panel of the NovaScope (see Figure 28). The NovaScope has a three-wire power cord with a three-contact plug for connection to both the power source and protective ground. The ground contact on the plug connects through the power cord to the external metal parts of the NovaScope.

11.4.2 Attachment To AC Power Source - Now, insert the male plug of the power cord into the proper AC power source receptacle. For electrical shock protection, insert this plug only into a power source outlet that has a properly grounded protective ground contact (which then grounds the external metal parts of the NovaScope via the third wire ground wire in the cord).

11.5 INSTRUMENT COOLING - Maintain adequate airflow to prevent instrument damage from internally generated heat. Before turning on the power, verify that the spaces around the air-intake holes on the bottom, sides, top and rear of the cabinet are free of any obstruction to airflow.

11.6 INITIAL START-UP - Up to now, the following preparations should have been made:

- a. Safety information read.
- b. Verification that the LINE VOLTAGE SELECTOR switch is set for the source voltage to be used.
- c. Fuse type verified.
- d. Power cord attached into the NovaScope's receptacle.
- e. Adequate ventilation ensured around the instrument.
- f. Power cord plugged into the appropriate power-source outlet that has a properly grounded protective ground contact.

Now turn on the NovaScope by pressing in the POWER switch. Observe that the graphic display illuminates and the system boots.

12. OUTPUT/INPUT PORTS

Figure 28 shows the location of the various outputs and inputs, all located on the rear panel. Each of these is discussed below.

12.1 ANALOG OUT - SMB connector providing an analog output of the thickness reading (or velocity reading) appearing on the front panel digital display. The output specifications for the ANALOG Output are given in Table VI.

The virtual "sidepanel", is accessed by pressing the "SIDE" button on front panel menu. The ANALOG OUTPUT OFFSET control (see Figure 16) provides an adjustable DC-bias voltage to set a "zero" (or reference) for a given thickness output. It is particularly useful for zeroing the pen stylus on a strip chart recorder during its thickness calibration across a given stylus deflection range. The dynamic range of the OFFSET control is equal to the maximum thickness limit on the READOUT RANGE switch position selected.

12.2 IP SYNC (Output) - SMB connector for internal IP (initial pulse/main bang) trigger output. It can be used to sync peripheral instrumentation to the NovaScope IP (including other NovaScopes - see Section 12.3). The output electrical specifications for the IP SYNC OUTPUT are given in Table VII.

TABLE VI
Electrical Specifications for Rear panel
Analog Output of Thickness Reading

RANGE SWITCH POSITION	MAXIMUM LINEAR VARIATION FROM SELECTED NOMINAL THICKNESS	OUTPUT SENSITIVITY MILLIVOLTS/UNIT THICKNESS
S))))))))))))))))))Q	S))))))))))))))))))Q	S))))))))))))))))))Q
1"	±0.050"	10 mV/0.0001"
10"	±0.500"	10 mV/0.001"
10mm	±1.27mm	10 mV/0.001mm
100mm	±12.7mm	10 mV/0.01mm

Analog Output Voltage:	5 Volts Full Scale on Range Selected
Analog Output Impedance:	1,000 Ohms
Analog Output Offset ("Side" Panel Control):	0 to Full Range
Modification Options:	Specified Values can be Altered to Meet Special Gaging Situations

TABLE VII
Electrical Specifications For Rear Panel IP Sync Output

Waveshape:	Square Wave, 0-5 Volts
Frequency:	Rep Rate Selected By PULSE RATE Switch
Current:	±1 mA

12.3 EXT PRF (Input) - This input permits the NovaScope's PRF (pulse repetition frequency) to be controlled/synchronized from some suitable external source - such as from another NovaScope (via its IP/SYNC output), an ultrasonic flaw detector or a "main" sync/trigger module. The input signal specifications for the external PRF sync device are given in Table VIII. Thus, the NovaScope becomes a "slave" to some other "master" peripheral device.

TABLE VIII
Electrical Specifications for
Rear Panel EXT PRF Input

Waveshape:	Square Wave, 0-5 Volts
Frequency:	625 - 5000 Hz (Rep Rate)
EXT PRF Input Impedance:	10 K-Ohm

In order to use the external PRF sync input, the NovaScope's internal PRF "clock" must be disengaged (switched out of operation). This disengagement is accomplished by rotating the PULSE RATE Switch (on the "sidepanel") to its full counterclockwise position.

Important Notice: The VELOCITY function on the front panel THICKNESS/VELOCITY Switch is not useable (inoperative) when the NovaScope is being slaved via its EXT PRF mode. Therefore, if calibration is to be performed by entering a known velocity value, temporarily switch the NovaScope to one of its own Pulse Rate values (so it's operating on its own built-in PRF sync) and, then, enter the velocity value. Once this is accomplished, the NovaScope (now calibrated) can be switched to the EXT PRF mode (as described above). It should be pointed out that the NovaScope can always be calibrated while in the EXT PRF mode by using the THICKNESS function on the front panel THICKNESS/VELOCITY Switch and a reference sample of accurately-known thickness of the material to be gaged (see Section 7.1).

12.4 DATA PORT - DATA is a microprocessor-based port (type DB-25S, 25-pin connector on the rear panel) which features an unidirectional high-speed binary output and a bi-directional RS-232C port. Additional outputs available on this 25-pin connector are the three function ALARMS and special (PortaScan) Range/Units data. The pin callout/identity for this digital port is shown in Figure 30.

12.4.1 High-Speed Binary Thickness Output - The high-speed binary thickness output

is 14-bits parallel at whatever PRF (pulse repetition frequency) is selected (625 to 5,000 pps). Refer to Figure 30 for the pin identity of the high-speed binary output on the 25-pin DATA connector. Each of the 14 bit lines in the output read 0 volts (ground) for binary 0 or +5 volts for binary 1.

The high-speed binary thickness output is ideal for digital interfacing applications which require a high speed response - such as for scan-imaging or on-line monitoring of moving products. For example, the high-speed binary output is used for the NDT Systems, Inc. portable ultrasonic scan-imaging system called PortaScan. An appropriate parallel interfacing (data acquisition) plug-in circuit card and associated software are necessary in the computer to handle the high-speed binary input.

Referring again to Figure 29, note that a data line for electrical ground (0 volts) is provided on Pin 1 and a data line for thickness "over range" is provided on pin 15 (where) volts represents a "valid" in range reading and +5 volts represents an overrange condition)

The high-speed binary output does not include the units of thickness (English or metric) nor an ultrasonic velocity readout.

In addition to providing an external output, the high-speed binary data is used to derive the virtual LED thickness readout on the front panel of the NovaScope. The virtual LED display which updates approximately 10 times per second (which is a suitable speed for visual observation), obtains its input as averaged high-speed binary (accomplished in conjunction with the micro-processor).

12.4.2 RS-232C Interface

12.4.2.1 General - The DATA connector provides an RS-232C bidirectional port (see pin callout in Figure 29) for digitally interfacing with serial input printers, loggers, computers and other similar peripherals. Refer to Figure 30, as necessary, in conjunction with the RS-232C sections below.

Either thickness or velocity information can be sent to the NovaScope's RS-232C port by simply choosing the respective position on the front panel THICKNESS/VELOCITY switch. Furthermore, the chosen position of the front panel RANGE switch will correctly set the decimal point, range (for computers) and the readout units (English/metric) of the RS-232C output.

12.4.2.2 BAUD Rates - The RS-232C interface features eight selectable BAUD rates ranging from 150 to 19,200, with a factory preset value of 9600. These rates are selectable via a control on the Virtual "side" panel, by pressing the side button.

For the RS-232C port to communicate with a peripheral device, both must be set to the same BAUD rate. If the factory preset rate of 9600 BAUD in the NovaScope is not desirable for some reason, then select a matching/desirable BAUD rate using this internal adjustment.

REAR PANEL VIEW OF MULTI-PIN RECEPTACLE
TYPE DB-25S (USE MATING PLUG TYPE DB-25P ON CABLE)

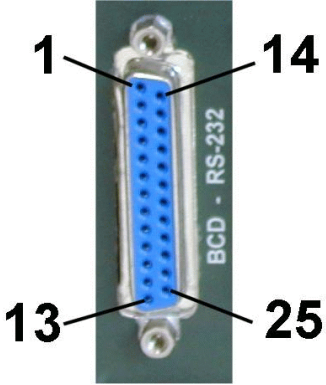
PIN NO.	DESCRIPTION	
3 S))))))Q	Bit 13 (MSB)	HIGH SPEED BINARY Low = 0 = Grd (0V) High = 1 = +5V 
5 S))))))Q	Bit 12	
16 S))))))Q	Bit 11	
4 S))))))Q	Bit 10	
17 S))))))Q	Bit 9	
18 S))))))Q	Bit 8	
6 S))))))Q	Bit 7	
19 S))))))Q	Bit 6	
7 S))))))Q	Bit 5	
20 S))))))Q	Bit 4	
8 S))))))Q	Bit 3	
21 S))))))Q	Bit 2	
9 S))))))Q	Bit 1	
22 S))))))Q	Bit 0 (LSB)	
15 S))))))Q	Spare Pin	
23 S))))))Q	RS-232C Out	RS-232C
11 S))))))Q	RS-232 In	
12 S))))))Q	CTS (Clear To Send)	
14 S))))))Q	Print Command	
13 S))))))Q	HI Alarm	ALARMS Off = 0V, On = +5V (Open Collectors With 5.7 K-Ohm Pull-up Resistors)
25 S))))))Q	LO Alarm	
24 S))))))Q	HI/LO Alarm Combination	
10 S))))))Q	Range: Short Or Long	PortaScan Applications
2 S))))))Q	Units: English Or Metric	
1 S))))))Q	Ground	

FIGURE 29
DATA Port Pin Descriptions

TABLE IX
NOVASCOPE RS-232C PORT BAUD RATE vs INTEGRATIONS

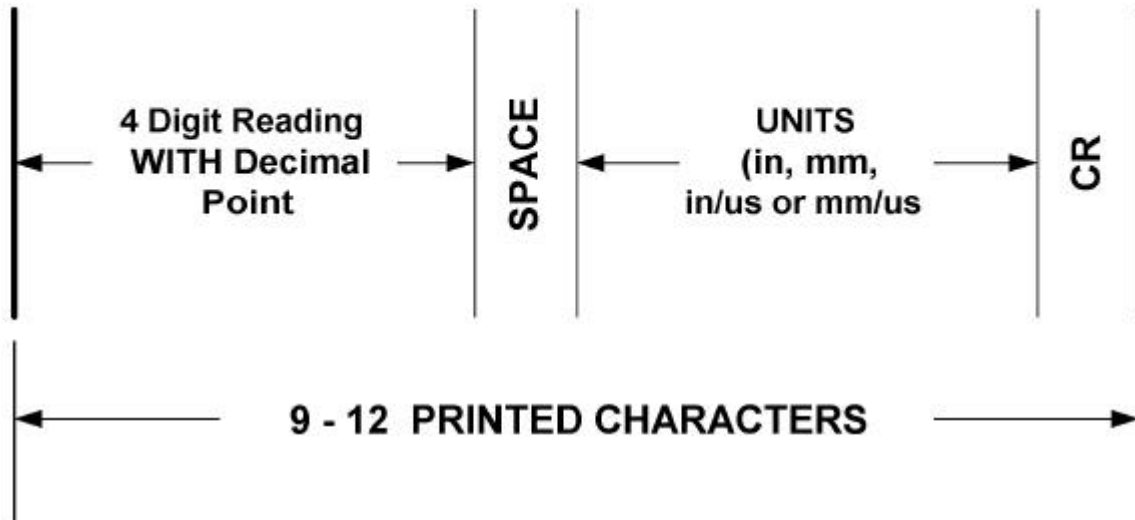
BAUD RATE	No. Of Binary Integrations
150	128
300	128
600	64
1,200	32
2,400	6
4,800	8
9,600	4
19,200	2

All NovaScope 5000's are factory set at 9600 BAUD. This is easily changed using the SIDE button and selecting the appropriate BAUD rate

12.4.2.3 Serial Printer Interfacing - Figures 30 and 31 present the digital *format and interface* connection respectively between a typical serial printer and the NovaScope. In both cases, note that the NovaScope's output is produced by momentary closure of a PRINT Command pushbutton switch (normally open/momentary closure type). For operator convenience, this pushbutton switch is usually of a handheld, benchtop (mounted in small box) or foot pedal configuration. Also, note that the information format for digital printers contains the actual measurement units (in., in/us, mm, mm/us). The word "overrange" is printed whenever the thickness value (T-Gate) exceeds that specified on the front panel range switch.

12.4.2.4 Computer Interfacing - Figures 32 and 33 show the digital *format and interface* connection respectively between a typical computer and the NovaScope, while Figure 34 shows the specific cable interconnect with an IBM (or IBM-Compatible) computer. Note that the RS-232C information is sent from the NovaScope DATA port upon receipt of an ASCII "?" (HEX 3F) prompt from the computer. As shown in Figures 30, 32, the transmission format for computers contains a string of single letter codes (abbreviations) to represent the measurement units, range and test mode: E or M (English or millimeters) followed by S or L (short or long range) followed by T or V (thickness or velocity). Note that this is in contrast with the actual measurement units sent to a serial printer (Section 12.4.2.3).

RS-232 Format For Serial Printers



Information Format

- 8 Data Bits
- 2 Stop Bits
- No Parity
- Selectable BAUD Rate

FIGURE 30
RS-232C Format For
Serial Printers

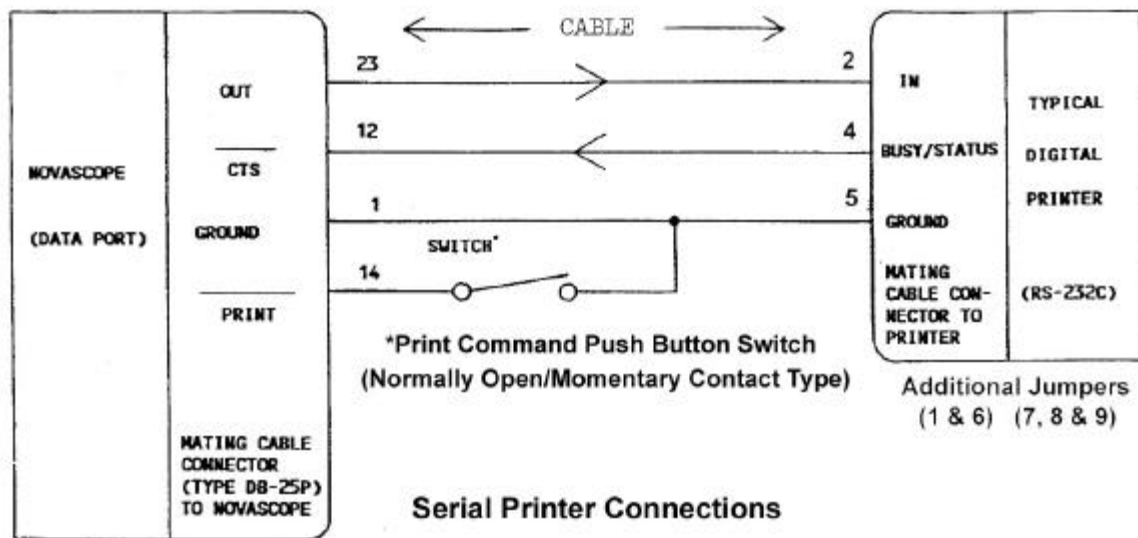
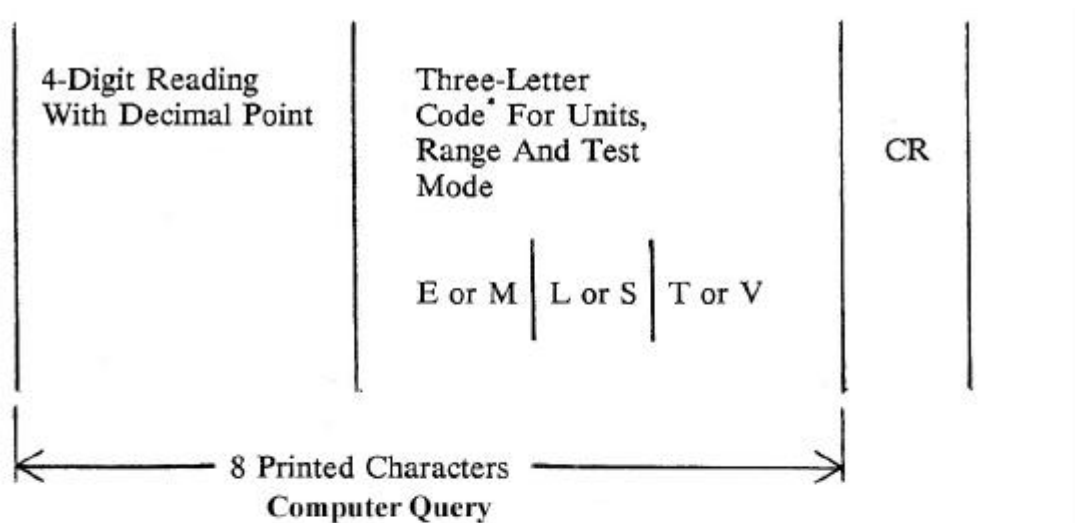


FIGURE 31

Typical RS-232C Interconnect Between
NovaScope 5000 And Serial Printer



*** Letter Codes:**

- E - English
- M - Millimeter
- L - Long Range
- S - Short Range
- T - Thickness
- V - Velocity

(a) Information Format

- ✱ 8 Data Bits
- ✱ 2 Stop Bits
- ✱ No Parity
- ✱ Selectable BAUD Rate
- ✱ For NovaScope Serial Output (Pin 23, Computer Prompts With "?" In ASCII (3F HEX).

(b) Transmission Format

FIGURE 32
RS-232C Format For
Computers

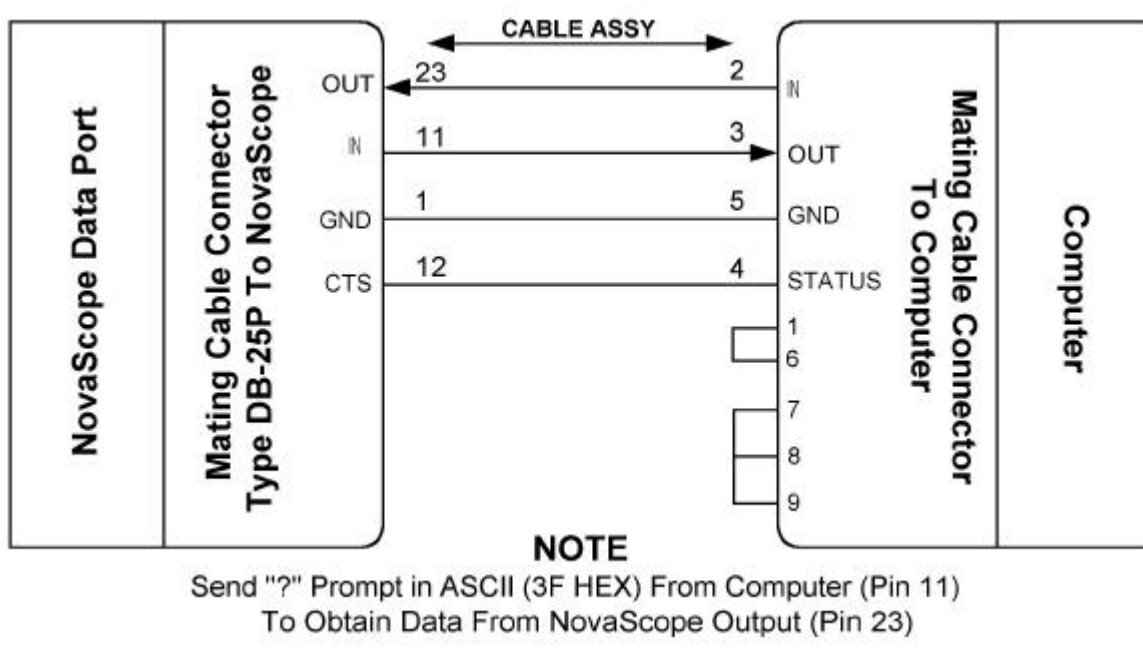


FIGURE 33

RS-232C Interconnect Between
The NovaScope 5000 And A PC
(Or IBM-Compatible) Computer

12.4.3 ALARMS Output - The three-function NovaScope alarms (HI, LO, HI/LO) appear as a TTL-compatible output on pins 13, 24 and 25 of the DATA multi-pin connector. Refer to Figure 30. The ALARMS response speed is equal to 1-3 IP's (initial pulses) at whichever pulse rate (PRF) is selected. The precise speed depends upon the amount of change in material thickness. Smaller or slower rates of thickness change will produce the fastest ALARMS response speed (approaching the PRF).

These internal alarm outputs can be used to drive relay circuits, etc. for on-line monitoring applications; however, if a high-speed computer interface is involved in the system, it is better to permit the computer's software to set alarm levels, etc., based on the digital thickness information from the NovaScope's DATA port.

12.4.4 PortaScan RANGE/UNITS Output - Referring to Figure 29, RANGE (Pin 10) and UNITS (Pin 2) are special outputs (0/5 volt) used in conjunction with the high-speed binary NovaScope-Computer interface for the PortaScan imaging system. Both outputs are determined by the selected position of the front panel RANGE switch, namely "Range" of short or long in "Units" of English or metric. Of course, the RANGE/UNITS outputs are available for other special applications, if required by the customer.

13. STANDARD NOVASCOPE MODEL OPTIONS

Other variations of the NovaScope may be available from time to time in the future. Be sure to check our website at www.ndtsystems.com for upgrade or optional hardware/software configurations