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Subject Category: METALLURGY AND CERAMICS

SUPERSONIC FLAW DETECTOR, MODEL 1 T

(Final Report on Part of P.A. No. 154-ML-54-3, F.S. 31)

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Robert F. Plott

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Summary

The object of the work reported here is to investigate and to apply supersonic waves to the non-destructive detection of flaws in the bond of the Hanford slug. The Auto-Radiograph Test and the Isothermal Frost Test are the only other non-destructive tests for this purpose, the Fracture Analysis being a destructive test.

The Supersonic and Auto-Radiograph Tests are most often in agreement (96.2%). The Supersonic and Frost Tests show equal agreement (40.5%) with the Auto-Radiograph and Fracture Analysis. The Fracture Analysis and the Frost Test agree in 64.2% of the cases, but the Frost Test usually did not indicate the exact location of the defect defined by the Fracture Analysis which does not necessarily reveal all of the defects because the fracture plane does not pass through them all. These measurements were made upon twelve single dip Al-Si slugs. The Supersonic and Auto-Radiograph Tests indicate non-wetted and partially wetted areas on the can and on the core more frequently than did the Frost Test.

This investigation has not been completed because of a program change at this laboratory. Preliminary conclusions indicate the Supersonic Flaw Detector is a valuable tool in the determination of bond perfection and, therefore, it merits more consideration as the necessity for high quality slugs is defined.

Prepared by *Plot*

Submitted by _____

Frank Frost
Section Chief

Approved by:

Charles M. C...
Division Director

A. B. Heninger
Associate Division Director

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Introduction

The work upon the problem of bond defect detection by the use of supersonic waves was begun in January 1944 at Chicago and by Prof. F. A. Firestone through the Department of Engineering Research at the University of Michigan. Prof. Firestone was in charge of the construction of the supersonic equipment and this laboratory built the scanning mechanism. The chuck was designed by F. A. Firestone and William Langton of Michigan. The electrostatic shield and crystal mounts were built at Chicago. The Supersonic Flaw Detector, Model 1 T (ML 21108) was put into operation at Chicago late in July 1944. The experimental investigation presented in this report was stopped early in September due to a program change to write a record report with the data already recorded.

This report is not intended to be a thorough evaluation of the Supersonic Flaw Detector, but rather a preliminary investigation into detection of bond defects in the Hanford slug by supersonic waves. The apparatus in its present state can be used for the production testing of cores and slug assemblies, however, the value of the instrument is diminished by the lack of 'fool-proofing' which is necessary before it is put in the hands of an operator. About four man-months of technical grade work are necessary to complete the evaluation and to make necessary improvements. The instrument would fit best into a precision coatings program.

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SCHEMATIC DIAGRAM OF SUPERSONIC FLAW DETECTOR OPERATION

FLAW DETECTION DONE IN CASTOR OIL
TO ATTENUATE, MARKEDLY, REFLECTED WAVES, R.

MET. LAB. U. OF C.

SUPERSONIC FLAW DETECTOR - MODEL 1 T

Figure 1 shows the Supersonic Flaw Detector in operation. The Flaw Detector is an instrument consisting of five parts:

1. Scanning Mechanism
2. Transmitter
3. Receiver
4. Recorder
5. Accessory Equipment:
 - (a) Vacuum tube voltmeter for monitoring the transmitter output.
 - (b) Voltage stabilizer.
 - (c) Variac for adjustment of voltage.
 - (d) Voltmeter.

The scanning mechanism rotates and translates the slug past a fixed supersonic generator and a fixed supersonic receiver immersed in a tank of castor oil and surrounded by suitable electrostatic shielding. Castor oil is used because it greatly attenuates the reflected supersonic waves from the convex surface of the slug and prevents these reflected waves from impinging upon the supersonic receiver, after several successive reflections, with appreciable energy so as to produce a troublesome "background". The scanning mechanism is actuated by a belt-gear reduction unit driven by an electric motor. The electrical control of the motion is made possible with the control switches mounted upon the inclined arm, the relay circuits in the control box and the limit switches within the chassis.

The transmitter is an electron coupled oscillator of low power output which can be tuned to resonance at the resonance frequency of the X-cut quartz crystal of the supersonic generator. The output signal of the transmitter is transmitted to the supersonic generator via a co-axial cable. This signal is monitored by the vacuum tube voltmeter.

The receiver is a standard communications receiver with changes in parts of the circuit to perform the desired function. The electrical signal from the X-cut quartz crystal in the supersonic receiver is conveyed by a co-axial cable to the input circuit of the modified communications receiver. The signal is here transformed to an electrical signal of audio frequency, the intensity of which is measured by the Decibel meter in the upper portion of the panel.

The recorder is a standard GE Photoelectric Recording Microammeter (8CELJ34). The signal from the output of the modified communications receiver is sent through a suitable resistance to the input side of the recorder. The impressed signal is recorded upon the moving chart which is calibrated against the DB (Decibel) meter and is synchronized in speed to the translational speed of the slug past the fixed supersonic generator and receiver. This 1:1 correspondence between the chart speed and slug speed merely permits rapid location of observed defects when the slug is torn apart.

The voltage regulating equipment is necessary to attain reproducible results.

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VTVM. = Vacuum Tube Voltmeter

XMTR. = Transmitter

Figure 2 shows a front view of the Supersonic Flaw Detector with the interior of the chassis exposed to view. Power is transmitted from the shaft of the gear reduction portion of the 'Vari-drive' to the square shaft by a pair of mitre gears. The square shaft drives a hollow shaft with a square thread of $1/8$ " pitch running along its length and which is free to rotate and translate through a threaded oil-tight female member into the tank above it. The limit of travel of the threaded shaft is limited by the setting of the limit switches which contact the annular ring affixed to the threaded shaft.

Figure 3 presents a close-up view of castor oil-filled tank with the upper portion of the electrostatic shield visible. The co-axial cables leading to the supersonic generator (marked XTR) from the electron coupled oscillator and to the receiver (marked REC.) from the supersonic receiver are shown. The two handles connect to a yoke mechanism which permits the slug to be lifted upward after it has reached the lower limit of travel, and turned end to end and the other half scanned.

The control switches are mounted upon the control panel. Reading from top to bottom are: UP, DOWN, STOP, AUTO-HAND, Automatic Reversing Button, Pilot light, START-STOP. When the switch is on HAND, the UP and DOWN buttons must be pushed to reverse the direction of translation and rotation of the slug. When the switch is on AUTO the motion will continue to the limit in that direction and the motion will be reversed automatically until the STOP button is pushed. If the motion is AUTO and the Automatic Reversing Button is depressed, the motion will be reversed no matter what the direction may be as long as the button remains depressed. If the button is released the motion will continue in a direction opposite to that which existed just before the button was released. This button provides a means for rescanning any desired part of the slug with a minimum of effort.

The tank is mounted to the boiler plate top by means of socket head cap screws. The joint is made oil tight by means of a neoprene gasket 1/16" thick between the flange and the boiler plate.

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Figure 4 shows the operation of lifting a slug after the topmost half has been scanned. The slug is then turned end-to-end and the bottom half is scanned. There is sufficient scanning overlap to assure on that none of the central portion of the slug will be missed.

In actual operation it is desirable to use a glove on the hand when performing the inverting operation. A suitable pair of tongs might also be used for the same purpose.

Figure 5 shows the electrostatic shield removed from the tank and resting in the operating position upon the sliders which fit in the guides mounted in the tank. In the foreground are two crystal mounts showing the supersonic lenses.

The electrostatic shield is essentially two brass boxes open on one side and held in four holders seen at the edges of the pair of boxes. The two boxes are separated from each other by a sheet of bakelite for supersonic insulation. Both boxes and other attachments are electrically grounded.

The crystal mount holder marked HOLDER is for the crystal mount with the supersonic lens. These crystal mounts are relatively insensitive to 'wobbling' of the slug. The distance of the lens from the slug is about $\frac{1}{4}$ ". The contact crystal mount holder is used for the contact crystal mount which rides upon the cylindrical portion of the slug. This type of crystal mount is more sensitive to the 'wobbling' of the slug and must be used with care. Not visible in this holder is a phosphor bronze strip with adjusting screws which keeps the contact crystal mount against the slug.

Figure 6 presents a view of the underside of the electrostatic shield showing the slug guides which aid the chuck in the centering of the slug. The S-shaped spring attached to the movable slug guide at the left was necessary to the centering when the slug was rotated either clockwise or counter-clockwise. Micarta appears to be the most suitable material for the slug guides.

Note the adjustment features of the crystal mount holder for the supersonic lens in both Figures 5 and 6. These adjustments are necessary to assure the focus of the supersonic waves from the generator upon the receiver.

Figure 7 shows the tank emptied of castor oil and the electrostatic shield removed. The guides for the sliders of the electrostatic shield are visible. Note the adjustable stop visible on the one guide. This stop adjustment determines the height of the shield in the tank.

The three bakelite jaws center the slug in the chuck. Only one of these jaws is movable, the other two being fixed.

The button upon which the slug rests is attached to the yoke by the bar which is set in the floor of the chuck. The three springs hold the yoke assembly in the position shown. When the two handles shown are lifted, the ring to which they are attached contacts the yoke assembly and further upward motion on the handles raises the slug, when in place, about one and one-half inches.

Figure 8 shows the standard brass slug in place in the chuck. Good centering of the slug is attained by the three point contact of the jaw in the chuck, one jaw being movable and the three point contact of the slug guides attached to the underside of the electrostatic shield, one of which is movable.

REFLECTOGRAMS

The Reflectograms are photographs of the screen of the cathode ray tube of the Supersonic Reflectoscope. These pictures represent a measure of the soundness (freedom from defects such as voids, pipes, cracks, etc.) and of the transmission of supersonic energy in the alpha-rolled Tuballoy slug before it has been canned. The Supersonic Reflectoscope offered the only non-destructive test for the defects at the time the twelve standard slugs were canned. Since the completion of the Supersonic Flaw Detector it is possible to scan the un-canned Tuballoy slugs for defects with this instrument. (MUC-FF-173)

A brief description of the principles of the Supersonic Reflectoscope and information for the correct interpretation of the Reflectograms are made in MUC-FF-140, issued July 28, 1944 by F. Foote.

There are twelve sets of Reflectograms, one set for each of cores of the standard Tuballoy slugs. Each core is tested at 1, $2\frac{1}{4}$, and 5 Megacycles/sec. respectively. The symbol, P, represents the pulse of supersonic energy sent along the length of the 8" Tuballoy slug from an X-cut quartz crystal. The numbers 8, 16, 24, 32, and 40 represent the first, second, third, fourth and fifth reflections of that energy pulse emitted by the quartz crystal, from the opposite end of the Tuballoy slug, 8" away from the end from which the pulse is sent. The reflection is received by the same quartz crystal during the time interval between which the supersonic energy pulses are being generated. The correct location of the reflections can be determined by counting the "inch marks", the lines of greatest height which are superimposed upon the sweep. Since the metal specimen is 8" in length there will be a reflection indicated every 8" along the sweep until the attenuation (damping) of the supersonic waves reaches an energy level below which the apparatus will not respond. The other reflections indicated in the Reflectograms may be from the cylindrical walls of the specimens or from actual defects in the metal.

The supersonic frequency which gives the maximum number of reflections in all except one specimen (No. B-4) is 2.25 Mc./sec. In the exception indicated, the number of reflections for both 1 and 2.25 Mc./sec. are the same. We have in these twelve Tuballoy slugs good to excellent supersonic transmission (medium to low attenuation) and also freedom from any except the minimum of defects, both as to magnitude and frequency. These properties are desirable in the Tuballoy which is to be coated, when the Supersonic Flaw Detector is used to detect flaws in the bond.

The Supersonic Reflectoscope was developed by F. A. Firestone, Dept. of Engineering Research, University of Michigan. Pictures were made by D. Barton.

A-1

A-2

A-3

B-1

B-2

B-3

B-4

B-5

B-6

B-7

B-8

B-9

REFLECTOGRAMS

Notes on Charts A-1 to E-9

The input voltage to both the transmitter and receiver was 111. volts A.C. The output voltage of the transmitter to the supersonic generator was 6.55 volts at $2\frac{1}{2}$ megacycles/second and for all of the records of the Supersonic Flaw Detector the R.F. gain was set upon 80, the receiver being tuned to resonance. The Recorder had 0.4 megohms in series with input to that instrument.

Acenaphthene frost was used to obtain the Frost Test records per conditions indicated upon the charts.

The approximate register of the records of these tests was obtained by aligning the Auto-Radiograph (positive) with the Al cap-Tuballoy interface shown in the Supersonic Records. The Fracture Analysis pattern was aligned in the same manner and the Frost Test aligned to the Fracture Analysis pattern by direct measurement of gage marks upon the stripped Al can. The supersonic beam is $\frac{1}{8}$ " in height as shown to full scale upon the original of each chart. Any point on the original chart can be out of alignment by about $\pm 1/8$ ".

The horizontal lines across the chart were drawn more or less at random with no statistical weighting implied. The 'statistics' taken between these lines across the whole of the chart are just a 'shorthand' method of describing the charts without going into too much detail.

All interpretations were made from the original charts and 'mistakes' are probably due to faulty reproduction of the Auto-Radiograph (positive) which exhibits a very wide range of density in the emulsion.

In the Supersonic Record not only the low transmission values but also the contrast or difference between the high and low transmission values indicate defects. Regions of sharp contrast due to a number of defects entering and leaving the beam during a short period of time cause the formation of heavily inked regions upon the chart. The chart on the recorder was recalibrated against the DB meter of the receiver before each specimen was scanned.

The twelve slugs studied were canned by the single-dip Al-Si process and deliberate attempts were made to produce defective bonds.

A thorough metallographic study of the defects detected by the Supersonic Flaw Detector should be made as well as an investigation of the chart record of artificial defects of various sizes and shapes.

For the metallographic evaluation of the Auto-Radiograph Test and the Frost Test of (Al-Si) W-slugs please refer to MUC-FF-61, 64, 69, 70 and 86.

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CHART NO. A-1

The lead sheet number in the Auto-Radiograph Test was not present during any of the other tests.
P indicates partial wetting of the 2S-Al can and the Black area indicates no wetting and no bond in the Fracture Analysis Test.
M indicates the melted area in the acenaphthene in the Frost Test.

Composite Analysis of Chart No. A-1

Symbols: * indicates flaw in bond detected.
- indicates flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	-
BB to CC	*	*	-	-
CC to DD	*	*	*	*
DD to EE	*	*	-	-
EE to FF	*	*	*	*
FF to GG	*	*	-	-
GG to HH	*	*	-	-
HH to II	*	*	-	-
II to JJ	*	*	*	*
JJ to KK	*	*	*	*

No. of times all four methods in agreement4 or 40%

No. of times three in agreement

Supersonic-Auto-Fracture5
Supersonic-Auto-Frost4
Auto-Fracture-Frost4
Supersonic-Fracture-Frost4

No. of times any three in agreement17 or 42 1/2%

No. of times two in agreement

Supersonic-Auto10
Supersonic-Fracture5
Supersonic-Frost4
Auto-Fracture5
Auto-Frost4
Fracture-Frost9

No. of times any two in agreement37 or 62 1/2%

20

CHART NO. A-2

The lead sheet number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis Test.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. A-2

Symbols: * indicates flaw in bond detected.
-- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	*
BB to CC	*	*	-	-
CC to DD	*	*	*	-
DD to EE	*	*	-	-
EE to FF	*	*	*	-
FF to GG	*	*	-	-
GG to HH	*	*	-	*
HH to II	*	*	*	*

No. of times all four methods in agreement 2 or 25%

No. of times three in agreement

Supersonic-Auto-Fracture 4

Supersonic-Auto-Fracture 3

Auto-Fracture-Frost 2

Supersonic-Fracture-Frost 2

No. of times any three in agreement 11 or 35%

No. of times two in agreement

Supersonic-Auto 8

Supersonic-Fracture 4

Supersonic-Frost 3

Auto-Fracture 4

Auto-Frost 3

Fracture-Frost 2

No. of times any two in agreement 24 or 50%

[illegible]

CHART NO. A-3

The lead sheet number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. A-3

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	*
BB to CC	*	*	-	-
CC to DD	*	*	-	-
DD to EE	*	*	-	-
EE to FF	*	*	-	-
FF to GG	*	*	-	*

No. of times all four methods in agreement 1 or 17%

No. of times three in agreement

Supersonic-Auto-Fracture 1

Supersonic-Auto-Frost 2

Auto-Fracture-Frost 1

Supersonic-Fracture-Frost 1

No. of times any three in agreement 5 or 21%

No. of times two in agreement

Supersonic-Auto 6

Supersonic-Fracture 1

Supersonic-Frost 2

Auto-Fracture 1

Auto-Frost 2

Fracture-Frost 1

No. of times any two in agreement 13 or 36%

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CHART NO. B-1

The lead sheet number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart B-1

Symbols * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	-
BB to CC	*	*	-	-
CC to DD	*	*	-	-
DD to EE	*	*	*	-
EE to FF	*	*	-	-
FF to GG	*	*	-	*

No. of times all four methods in agreement 0 or 0%

No of times three in agreement

Supersonic-Auto-Fracture 2

Supersonic-Auto-Frost 1

Auto-Fracture-Frost 0

Supersonic-Fracture-Frost 0

No. of times any three in agreement 3 or 12 1/2%

No. of times any two in agreement

Supersonic-Auto 6

Supersonic-Fracture 2

Supersonic-Frost 1

Auto-Fracture 2

Auto-Frost 1

Fracture-Frost 3

No. of times any two in agreement 15 or 42 1/2%

A 10x10 grid of dots. The dots are arranged to form a stylized drawing of a person sitting at a desk with a lamp. The person is on the left, the desk is in the middle, and the lamp is on the right. The drawing is composed of black dots on a white background.

CHART NO. B-2

The lead sheet number in the Auto-Radiographic Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart B-2

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	-
BB to CC	*	*	-	-
CC to DD	*	*	-	-
DD to EE	*	*	-	-
EE to FF	*	*	-	*
FF to GG	*	*	*	*

No. of times all four methods in agreement 1 or 17%

No. of times three in agreement

Supersonic-Auto-Fracture 2

Supersonic-Auto-Frost 2

Auto-Fracture-Frost 1

Supersonic-Fracture-Frost 1

No. of times any three in agreement 6 or 25%

No. of times two in agreement

Supersonic-Auto 6

Supersonic-Fracture 2

Supersonic-Frost 2

Auto-Fracture 2

Auto-Frost 2

Fracture-Frost 4

No. of times any two in agreement 18 or 50%

28

CHART NO. B-2

CHART NO. E-3

The lead sheet number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart E-3

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	-
BB to CC	*	*	-	-
CC to DD	*	*	-	-
DD to EE	*	*	*	*
EE to FF	*	*	-	*

No. of times all four methods in agreement 1 or 20%

No. of times three in agreement

Supersonic-Auto-Fracture 2

Supersonic-Auto-Frost 2

Auto-Fracture-Frost 1

Supersonic-Fracture-Frost 1

No. of times any three in agreement 6 or 25%

No. of times two in agreement

Supersonic-Auto 5

Supersonic-Fracture 2

Supersonic-Frost 2

Auto-Fracture 2

Auto-Frost 2

Fracture-Frost 3

No. of times any two in agreement 16 or 53%

CHART NO. B-3

CHART NO. B-4

The lead number in the Auto-Radiograph Test was not present during any of the other tests. The white patch at the top left corner is for negative number for filing purposes.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. B-4

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	-	*
BB to CC	*	*		*
CC to DD	*	*	*	*
DD to EE	*	*	-	*
EE to FF	*	*	*	*
FF to GG	*	*	*	*

No. of times all four methods in agreement 4

No. of times three in agreement

Supersonic-Auto-Fracture 4

Supersonic-Auto-Frost 4

Auto-Fracture-Frost 4

Supersonic-Fracture-Frost 4

No. of times any three in agreement 16 or 67%

No. of times two in agreement

Supersonic-Auto 6

Supersonic-Fracture 4

Supersonic-Frost 6

Auto-Fracture 4

Auto-Frost 6

Fracture-Frost 4

No. of times two in agreement 30 or 83%

32

CHART NO. B-4

CHART NO. B-5

The lead number in the Auto-Radiograph Test was not present during any of the other tests. The white patch at the top left corner is for negative number for filing purposes.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart B-5

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	-	*
BB to CC	*	*	-	-
CC to DD	?	*	-	-
DD to EE	?	*	-	-
EE to FF	*	*	-	-
FF to GG	*	*	*	-

? Doubtful. The pattern is nearly that produced by slug "wobble".

No. of times all four methods in agreement 0 or 0%

No. of times three in agreement

Supersonic-Auto-Fracture 1

Supersonic-Auto-Frost 1

Auto-Fracture-Frost 0

Supersonic-Fracture-Frost 0

No. of times any three in agreement 2 or 8 1/3%

No. of times two in agreement

Supersonic-Auto 4

Supersonic-Fracture 1

Supersonic-Frost 1

Auto-Fracture 1

Auto-Frost 1

Fracture-Frost 4

No. of times two in agreement 12 or 33%

34

CHART NO. B-6

The lead number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. B-6

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	-	-
BB to CC	*	*	-	-
CC to DD	*	*	-	-
DD to EE	*	*	-	-
EE to FF	*	*	-	*

No. of times all four methods in agreement 0 or 0%

No. of times three in agreement

Supersonic-Auto-Fracture 0

Supersonic-Auto-Frost 1

Auto-Fracture-Frost 0

Supersonic-Fracture-Frost 0

No. of times any three in agreement 1 or 5%

No. of times two in agreement

Supersonic-Auto 5

Supersonic-Fracture 0

Supersonic-Frost 1

Auto-Fracture 0

Auto-Frost 1

Fracture-Frost 4

No. of times two in agreement 11 or 37%

36

CHART NO. B-6

CT-2635

CHART NO. B-7

The lead number in the Auto-Radiograph Test was not present during any of the other tests. The white patch at the top left corner is for negative number for filing purposes.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-A1 can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. B-7

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	*
BB to CC	*	*	*	*
CC to DD	*	*	-	-
DD to EE	*	*	-	-
EE to FF	*	*	*	-
FF to GG	*	*	-	-
GG to HH	*	*	-	-
HH to II	*	*	-	-
II to JJ	*	*	-	-

No. of times all four methods in agreement 2 or 22%

No. of times all three in agreement

Supersonic-Auto-Fracture 3
Supersonic-Auto-Frost 2
Auto-Fracture-Frost 2
Supersonic-Fracture-Frost 2

No. of times any three in agreement 9 or 25%

No. of times any two in agreement

Supersonic-Auto 9
Supersonic-Fracture 3
Supersonic-Frost 3
Auto-Fracture 3
Auto-Frost 2
Fracture-Frost 8

No. of times any two in agreement 27 or 50%

CT-263

CHART NO. B-8

The lead number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. B-8

Symbols: * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	*
BB to CC	*	*	*	*
CC to DD	*	*	*	-
DD to EE	*	*	*	-
EE to FF	*	*	*	*
FF to GG	*	*	*	*
GG to HH	*	*	-	*
HH to II	*	*	*	*
II to JJ	*	*	*	*

No. of times all four methods in agreement 6 or 67%

No. of times three in agreement

Supersonic-Auto-Fracture 5

Supersonic-Auto-Frost 7

Auto-Fracture-Frost 6

Supersonic-Fracture-Frost 6

No. of times any three in agreement 27 or 75%

No. of times two in agreement

Supersonic-Auto 5

Supersonic-Fracture 2

Supersonic-Frost 7

Auto-Fracture 5

Auto-Frost 7

Fracture-Frost 6

No. of times any two in agreement 45 or 83%

40

CHART NO. B-8

CHART NO. B-9

The lead number in the Auto-Radiograph Test was not present during any of the other tests.

P indicates partial wetting and the Black area indicates no wetting and no bond for the 2S-Al can in the Fracture Analysis.

M indicates the melted area in the acenaphthene film in the Frost Test.

Composite Analysis of Chart No. B-9

Symbols * indicates flaw in bond detected.
- indicates no flaw or flaw in bond not detected.

LEVEL	SUPERSONIC FLAW DETECTOR	AUTO-RADIOGRAPH TEST	FRACTURE ANALYSIS	FROST TEST
AA to BB	*	*	*	*
BB to CC	*	*	*	*
CC to DD	*	*	*	*
DD to EE	*	*	*	*
EE to FF	*	*	*	*
FF to GG	*	*	*	*
GG to HH	*	*	*	*
HH to II	*	*	*	*

No. of times all four methods in agreement 2 or 100%

No. of times three in agreement

Supersonic-Auto-Fracture 3
Supersonic-Auto-Frost 3
Auto-Fracture-Frost 2
Supersonic-Fracture-Frost 2

No. of times any three in agreement 10 Or 12 1/2%

No. of times two in agreement

Supersonic-Auto 9
Supersonic-Fracture 3
Supersonic-Frost 3
Auto-Fracture 3
Auto-Frost 3
Fracture-Frost 6

No. of times any two in agreement 27 or 56%

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TABULATION OF AGREEMENT

Supersonic-Auto-Fracture-Frost

No. of times all four in agreement = 23 out of 84 total or 27.4%.

Supersonic-Auto-Fracture

No. of times in agreement = 35 out of 84 total or 41.7%.

Supersonic-Auto-Frost

No. of times in agreement = 32 out of 84 total or 38.1%.

Auto-Fracture-Frost

No. of times in agreement = 23 out of 84 total or 27.4%.

Supersonic-Fracture-Frost

No. of times in agreement = 23 out of 84 total or 27.4%.

No. of times any three in agreement = 113 out of 336 total, 33.6%.

Supersonic-Auto

No. of times in agreement = 81 out of 84 total or 96.2%.

Supersonic-Fracture

No. of times in agreement = 36 out of 84 total or 42.9%.

Supersonic-Frost

No. of times in agreement = 34 out of 84 total or 40.5%.

Auto-Fracture

No. of times in agreement = 34 out of 84 total or 40.5%.

Auto-Frost

No. of times in agreement = 34 out of 84 total or 40.5%.

Fracture-Frost

No. of times in agreement = 54 out of 84 total or 64.2%.

No. of times any two in agreement = 273 out of 504 total, 50.4%.

SUPERSONIC FLAW DETECTOR, MODEL 1 T

OPERATING INSTRUCTIONS

The chassis of all instruments should be grounded through the power lines for best operation. This can be determined by touching the chassis with a neon test lamp. If the lamp lights, the plug to the power source should be reversed to ground the chassis in the absence of a short to ground. An additional ground made up of No. 10 gage copper wire connecting each of the chassis to a grounded water pipe often removes disturbing instability in the Flaw Detector.

The better the voltage regulation the more stable the apparatus will be after warming up for about an hour. A good "warmed-up" criterion is the constancy of the frequency as indicated when tuning the receiver with "SHARP XTAL" setting and the "XTAL PHASE" adjusted to a max reading on the DB meter. The final tuning is done with the Band Spread dial. If insufficient voltage regulation exists, then the field of vacuum tube voltage regulators should be surveyed for a unit which will give the best operating conditions to the Flaw Detector.

Another routine check upon the stability of operation can be made by testing the tubes in the transmitter and receiver as well as the photo-electric recorder and discarding any which are below standard. When a tube is discarded one should always recalibrate the apparatus.

The supersonic lenses are made to focus properly when the front surface of the polystyrene spacer ring is 0.3" from the specimen. Focusing can be obtained by placing the spacers as described and moving the crystal mounts until a maximum signal is registered upon the DB meter, with the apparatus tuned to resonance. The identification markings upon the crystal mounts are:

"S" indicating sharp focus and "P" indicating parallel beam
2.25 means the resonant frequency of the X-cut quartz crystal
in the mount; i.e. 2.25 megacycles per second

In the preliminary work no definite advantage was found between either the "S" or the "P" types of focus. The work presented in this report was made with the "S" type focus and at 2.25 megacycles per second which is near the middle of the low attenuation region for tuballoy.

In order to protect the thyatron, the plate current switch is in off position for at least 30 seconds after the receiver is turned on.

The scanning mechanism is driven by a U.S. Varidrive Synchro-gear Motor, type VEU-GD, Frame No. 12-59-10, the speed being continuously variable between 76 r.p.m. to 10.8 r.p.m.

The Recorder is the General Electric Photoelectric Recording Microammeter No. 8CEICJ34, with a high torque chart carriage and a set of rate gear units which give chart speeds from $\frac{1}{2}$ " per hour to 72" per minute.

The VTVM used as monitor on the transmitter is a Hewlett-Packard, Model 400A.

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AWR.FP

52A REV

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CT-2633

BASIC CIRCUIT - MODEL SX-25 HALLIGRAFTERS COMMUNICATIONS RECEIVER

SWITCHES

- SW1 AC ON-OFF on Gain Control
- SW2 Standby SPST
- SW3 BFO ON-OFF SPST
- SW4 A.M.L. ON-OFF SPST
- SW5 High-Low Tone SPST
- SW6 "S" Meter on RF Gain Control

CONDENSERS

NO.	CAPACITY	VOLTS
G1	Main Tuning Gang	
2	2 Pl. RD. Spr. Sec.	
3	5 Pl. RD. Spr. Sec.	
4	.01 mfd	200
5	.05 mfd	200
6	.05 mfd	200
7	.02 mfd	400
8	.05 mfd	200
9	.35 mfd	
10	.05 mfd	200
11	.02 mfd	400
12	.05 mfd	200
13	5 mfd.	
14	.35 mfd.	
15	.05 mfd	200
16	.05 mfd	400
17	.02 mfd	400
18	4.5 mfd	
19	10 mfd	350
20	.05 mfd	200
21	.25 mfd	
22	1.5 to 18 mmfd	
23	1.5 to 18 mmfd	
24	.05 mfd	400
25	.02 mfd	400
26	.05 mfd	200
27	.02 mfd	400
28	50 mfd	
29	100 mfd	
30	.3 mfd	
31	.02 mfd	400
32	.02 mfd	400
33	.05 mfd	200
34	.002 mfd	1,600
35	.250 mfd	
36	.05 mfd	400
37	10 mfd	25
38	.05 mfd	400
39	10 mfd	25
40	.002 mfd	1,600
41	.1 mfd	400
42	10 mfd	350
43	30 mfd	350
44	.01 mfd	600
45	100 mmfd

BOTTOM VIEW

SHORTING PLUG WHICH MUST BE IN SOCKET FOR D.C. OPERATION CONNECT 270 V+ TO PIN 3, - TO PIN 5 P FOR A.C. OPERATION 6 V+ TO PIN 3, - TO PIN 5

RESISTORS				RESISTORS			
NO.	OHMS	WATTAGE		NO.	OHMS	WATTAGE	
R1	100,000	1/3		16	15,000	1	
2	400	1/3		17	4,000	1	
3	100,000	1/3		18	100,000	1/3	
4	10,000	1/3	R.F. Gain	19	500,000	1/3	
5	500	1/3	S Meter	20	800	1/3	
6	100	1/3		21	3,000	1/3	
7	3,000	1/3		22	1,000	1/3	
8	100,000	1/3		23	3,000	1/3	
9	400	1/3		24	50,000	1/3	
10	500	1/3		25	250,000	1/3	
11	3,000	1/3		26	100,000	1/3	
12	100,000	1/3		27	250,000	1/3	
13	400	1/3		28	2,000,000	1/3	
15	30,000	1		29	1,000,000	1/3	
14	50,000	1/3		30	500,000	1/3	A.F. Gain

MODEL IT SUPersonic FLAW DETECTOR -RECEIVER-

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3/23/45

---- UNUSED

NO. 53

A 10x10 grid of dots. The dots are arranged to form the number 1. The first column is fully filled. The second column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The third column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The fourth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The fifth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The sixth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The seventh column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The eighth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The ninth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The tenth column has dots at rows 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10.