NHTSA-72-7

NONDESTRUCTIVE TIRE TESTING STUDIES

Adelbert L. Lavery

OCTOBER 1972
PRELIMINARY MEMORANDUM

Prepared for
DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
Research Institute
Washington D.C. 20591

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-TSC-NHTSA-72-7		

4. Title and Subtitle	5. Report Date
NONDESTRUCTIVE TIRE TESTING STUDIES	October 1972
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Adelbert L. Lavery	
9. Performing Organization Name and Address	10. Work Unit No.
Department of Transportation Transportation Systems Center Kendall Square, Cambridge, MA 02142	R-3402
	11. Contract or Grant No.
	HS303
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Preliminary Memorandum
Department of Transportation National Highway Traffic Safety Administration Research Institute Washington, D.C. 20591	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A number of nondestructive testing procedures are being investigated in depth to determine the feasibility of each individually, and in combination, to detect and identify defects in tires that can lead to failure. The facility, equipment, and data handling methods are described. Typical data obtained by X-ray, holographic, infrared, and ultrasonic inspection methods are presented. Subsequent reports will present additional information on the nondestructive method, their ability to detect defects, and the relationship between defects and tire failure.

February 1973

17. Key Words	18. Distribution Statement
Tires Nondestructive Testing	APPROVED FOR NATIONAL HIGHWAY SAFETY ADMINISTRATION ONLY. TRANSMITTAL OF THIS DOCUMENT OUTSIDE THE NHTSA DEPARTMENT OF TRANSPORTATION MUST HAVE PRIOR APPROVAL OF THE TSC ELECTROMECHANICAL BRANCH.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	38	

Form DOT F 1700.7 (8-69)

PREFACE

The work described in this report was performed as a part of the Nondestructive Tire Test program sponsored by the National Highway Traffic Safety Administration, Research Institute. The program's principal objective is to provide a technical basis for safety and quality standards determination. Its secondary objective is to establish a reliable correlation between NDT "signals" and tire faults which lead to typical failure.

TABLE OF CONTENTS

Section	Page
INTRODUCTION	1
INSTRUMENTATION	1
X-Ray	3
Holography	3
Infrared	3
Ultrasonic	7
Materials And Failure Analysis	7
TIRE INSPECTION PROCEDURE	11
DATA CODING SYSTEM	20
MEMORY BANK STORAGE AND RECALL	26
SUMMARY	26

LIST OF ILLUSTRATIONS

Figure | Page

1. Tire Inspection Laboratory........................... 2
2. Closed Circuit Television Fluoroscopy System.......... 4
3. Tire Holographic System............................... 4
4. Hologram of Separation................................ 5
5. Infrared Inspection System............................ 5
6. Data Recorder for Infrared Detection System........... 6
7. Infrared Tire Inspection Data......................... 6
8. Air-Coupled Ultrasonic Detector and Tire Mount........ 8
9. Ultrasonic Transmitting Transducer and Mounting Assembly... 8
10. Fluid-Coupled Ultrasonic Detection of One-Inch Separation.. 9
11. Fluid-Coupled Ultrasonic Detection of Interface Bonding.. 9
12. Materials Laboratory................................. 10
13. Heated Press and Convection Oven..................... 12
14. Small X-Ray Unit..................................... 12
15. Thermogravimetric Analyzer........................... 13
16. Differential Scanning Calorimeter.................... 13
17. Infrared Spectrophotometer........................... 14
18. Stereo Microscope.................................... 14
19. Photomicrograph of Cracks in Tire Section (40x)...... 15
20. Metallograph... 15
21. Microtome.. 16

LIST OF ILLUSTRATIONS (CONT'D)

Figure		Page
22.	Photomicrograph of Crack in Liner (40x)	16
23.	Tire Inspection Flow Diagram	17
24.	Graphic Data Recording Sheet for Holographic Detection System	18
25.	Graphic Data Recording Sheet for X-Ray Inspection	19
26.	Tire Manufacturer History Coding Sheet	27
27.	Tire Test History Coding Sheet	28
28.	Tire Defect Coding Sheet	29
29.	Data Coding and Storage System	30

NONDESTRUCTIVE TIRE INSPECTION STUDIES

INTRODUCTION

In July, 1970, the Department of Transportation's Transportation Systems Center (TSC) was given a task by the National Highway Traffic Safety Administration (NHTSA) to investigate passenger tires with the following objectives:

1. To determine the types of defects that can be reliably and economically detected by nondestructive methods;
2. To determine the relationship between tire defects and failure.

The four major investigative tools which have been used for non-destructive testing of tires are: X-ray, holography, infrared and ultrasonics. Our laboratory has the equipment required to perform each of these procedures and is investigating them in depth to determine the feasibility of using each method. Each procedure has also been investigated to determine whether a modification can be devised to make it more efficient. The procedure or procedures which are ultimately chosen will have to be simple and inexpensive so that they can have wide applicability.

The second objective is equally important. Do all defects necessarily shorten the life expectancy of a tire? Tests by several of the tire manufacturers show that this is clearly not so. We must then try to establish criteria which will tell us, with a high degree of accuracy, that a defect of a certain type will cause failure in one tire, but not in another.

INSTRUMENTATION

The Tire Inspection Laboratory layout is illustrated in Figure 1. Lab 1-15 is the prime work area for maintaining equipment and developing new methods. Lab 1-13 is devoted to X-ray and holographic tire inspection. Lab 1-16 is the tire and rim storage

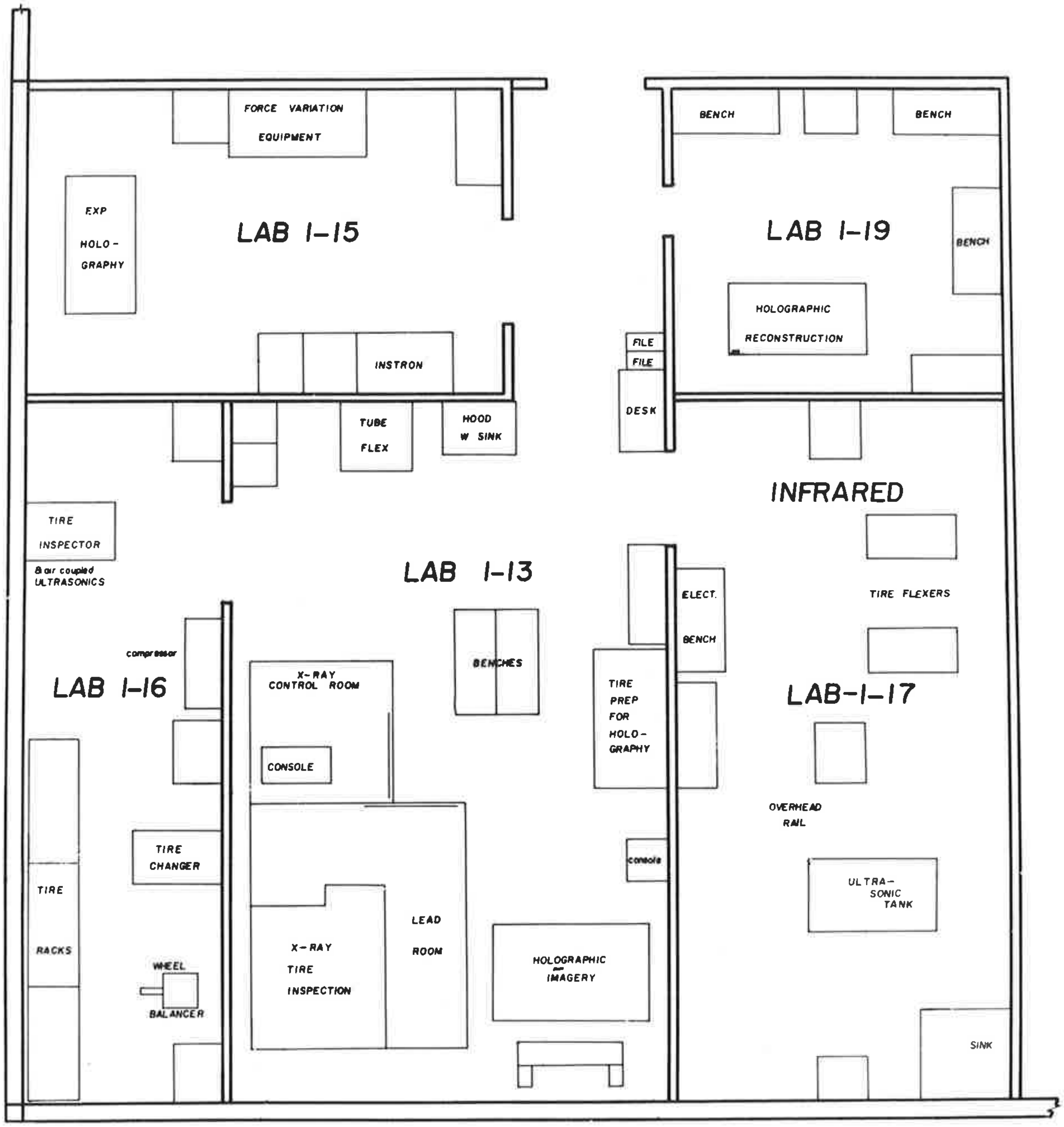


Figure 1. Tire Inspection Laboratory

area and is also used for mounting and balancing. Lab 1-17 contains the infrared inspection system and the air-coupled and high frequency ultrasonic testing equipment. In Lab 1-19 are the holographic reconstruction equipment as well as the real-time holographic equipment. The materials and failure analysis work is conducted in another area which will be discussed later.

X-Ray.
Figure 2 shows the real-time closed circuit television fluoroscopy system. The principal components are the tire manipulator, the X-ray tube and power supply, the fluoroscopy unit, the shielded room and the control console. With this unit, a trained operator can inspect three or four tires per hour. The tire to be inspected is mounted on the manipulator which spreads the beads so that the head of the X-ray tube can be inserted into the tire well. By remote control, the tire can be rotated at controlled speeds. The control also allows the fluoroscopy tube to be rotated about the tire so that the rim-to-rim aspects can be observed.

Holography.
The original real-time holographic equipment used for laboratory investigations has been replaced by the G.C.O. unit shown in Figure 3. This unit is capable of handling 20 passenger tires per hour; all operations once the tire has been put in place, are automatic. The tires are manually stretched open using four clamps; markers are inserted to permit any defects to be precisely located. After allowing twenty minutes for relaxation of the tire materials, the tires are mounted on a holder and the cover is lowered. Using the monochromatic laser beam, a photograph is taken of one quadrant of the inside surface of the tire. The pressure is then reduced by one p.s.i., and another holograph taken. This is repeated for the other three quadrants of the tire, and the film is then developed. By observing the interference fringes by means of another laser, the precise location and size of a separation can be determined. Figure 4 is a hologram showing two distinct separation areas.

Infrared.
The infrared inspection system being developed at TSC is illustrated in Figure 5. The tire is rotated by a 10-inch diameter roller which is forced against it at pressures up to 500 pounds. The flexing of the tire at speeds up to 20 m.p.h. creates heat in the tire materials. The infrared sensor traverses the tire and detects differences in temperature from point to point. The spatial resolution of the instrument is 1/4 inch, and the temperature difference resolution is 0.1°at 25° C.

The data is recorded on current-sensitive paper in an Alden facsimile recorder as shown in Figure 6, and produces the thermograms shown in Figure 7. With each revolution of the tire, a 1/4 inch wide swath is printed, so that what is shown is the complete 360° rotation of the tire from left to right, and the bead-to-bead coverage from top to bottom. Hot spots on the tire appear as white areas on the thermogram, while cold spots appear dark.

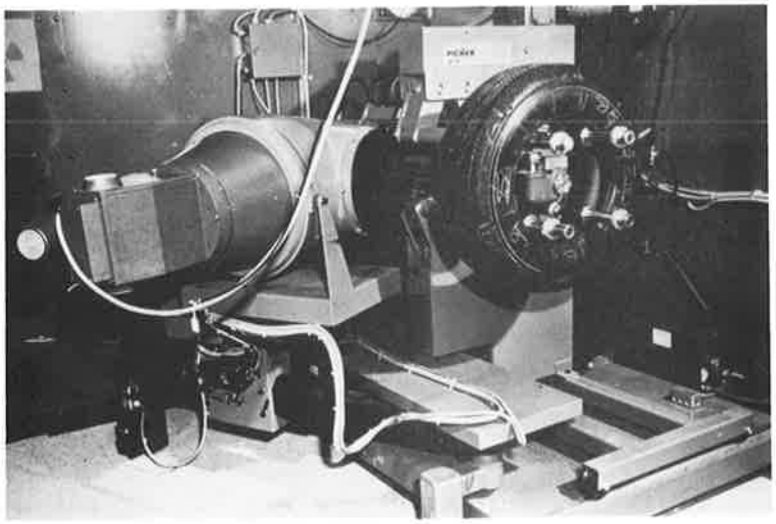


Figure 2. Closed Circuit Television Fluoroscopy System

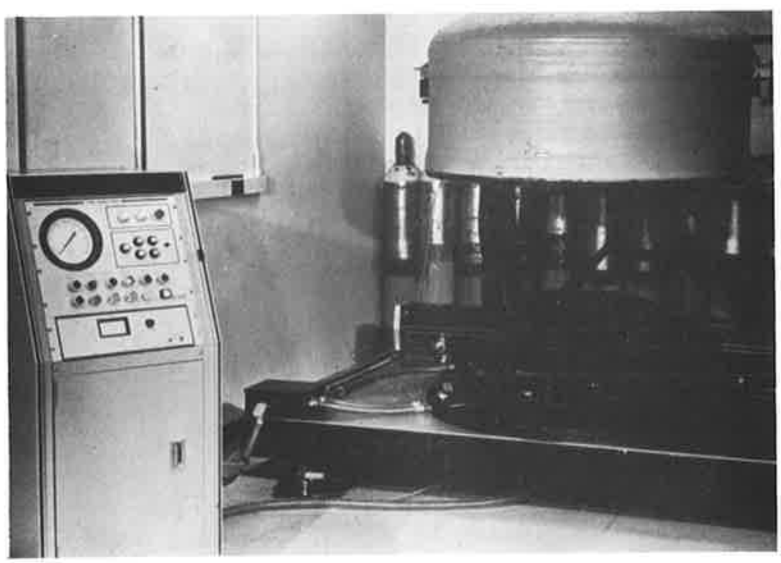


Figure 3. Tire Holographic System

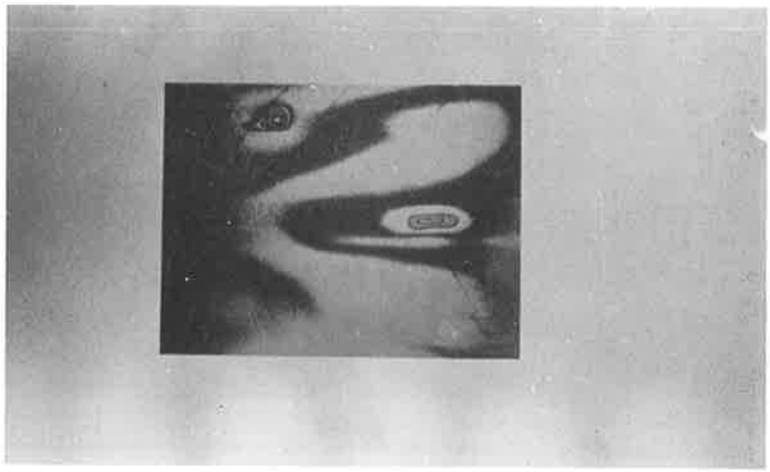


Figure 4. Hologram of Separation

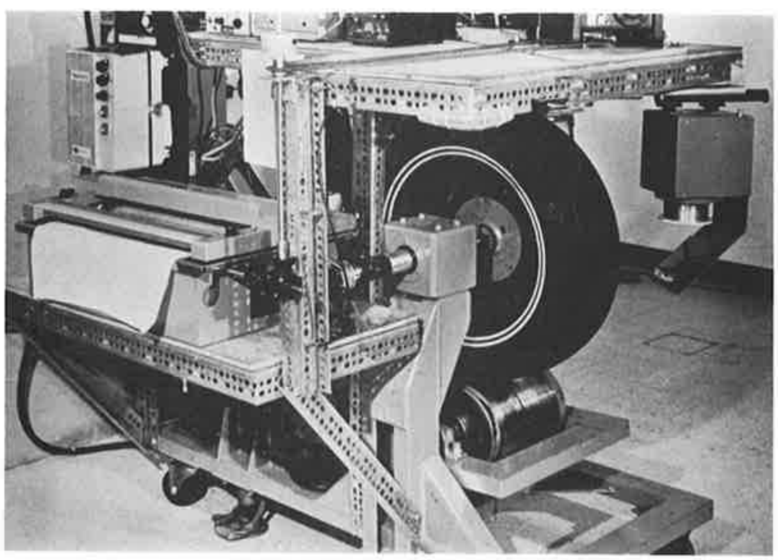


Figure 5. Infrared Inspection System

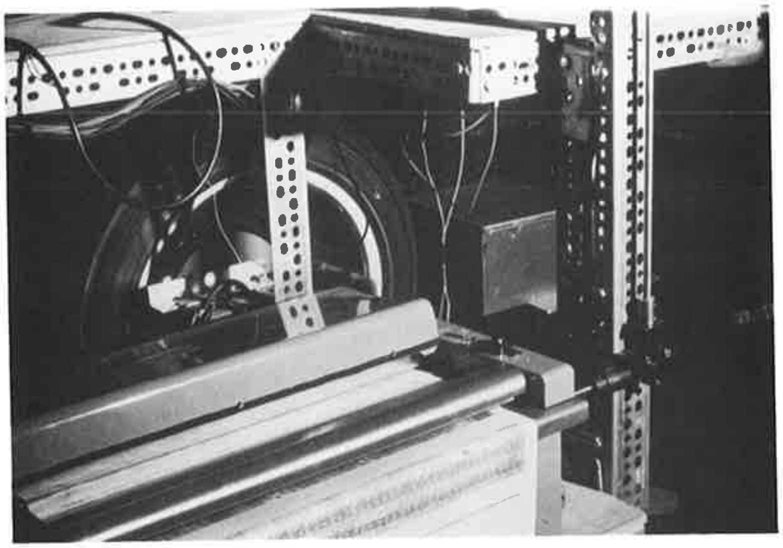


Figure 6. Data Recorder for Infrared Detection System

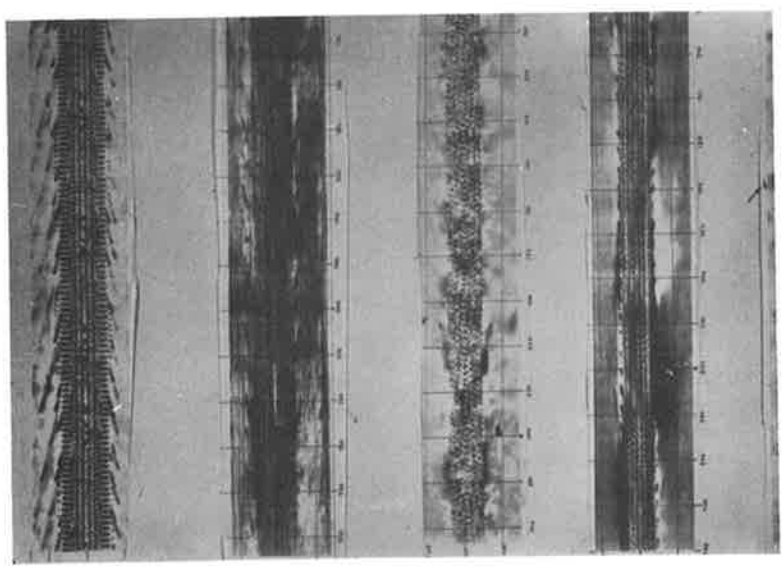


Figure 7. Infrared Tire Inspection Data

Ultrasonic.

The ultrasonic sensor now in use is an air-coupled device called a "Sondicator", manfactured by Automation Industries, which we are currently adapting to tire inspection. This instrument operates on an ultrasonic transmission basis, and consists of a pulser, a receiver, and two piezoelectric transducers operating at 25 KHz. The pulse repetition rate is 20 per second, and since the tire revolves at 1/10th revolution per second, it scans 1/2 inch per pulse. The scan spot itself is one inch in diameter. Figure 8 shows the tire mounted in a Branick tire inspector. One of the transducers is seen aimed at the sidewall. The Sondicator is the small box with the handle in the center of the picture.

Scanning of the tire is accomplished by manually positioning the transducer for each desired ϕ-coordinate value (bead-to-bead direction), after which a single recorder sweep traces the sound transmission as a function of θ for each complete revolution of the tire. Figure 9 shows the transmitting transducer and its mounting assembly. The foam pad around the transducer reduces reverberation noises. The center of rotation is specified at 2.75 inches in from the beads to insure uniformity of the coordinate system. In one revolution of the tire, approximately 10° in the ϕ direction is scanned; so with this arrangement, the transducers have to be realigned for each successive sweep. For each sweep, a trace is made at the appropriate ϕ angle and for the complete 360° rotation, on an X-Y recorder. Separations as small as 3/8 inch can be reliably detected.

At present, one tire can be scanned in approximately ten minutes. This is because the transducers must be repositioned and the electronics trimmed after each scan. With refinements and the use of multiple transducers, an inspection system can be made to completely inspect a tire in 10 to 30 seconds.

Liquid coupled reflection ultrasonics has a greater potential for characterizing the structure of a tire, and should be valuable as a research and development tool. Figure 10 shows the detection of a one-inch separation in a four-ply nylon slab, completed in our laboratory early in this program. Each cord ply can be clearly distinguished.

In Figure 11, reflections are seen from the interfaces of six layers of skim stock cured together. The two innermost layers had been precured so that they would form at best, a weak bond. The three center ripples are reflections from the third, fourth and fifth interfaces.

Materials and Failure Analysis

The function of the Materials and Failure Analysis Laboratory is to verify the findings of the various nondestructive testing instruments and also to determine the mode and mechanism of the failures in tires. Figure 12 is a schematic diagram of this laboratory with some of the equipment which is used for this purpose. It may also be required to investigate the materials of manufacture

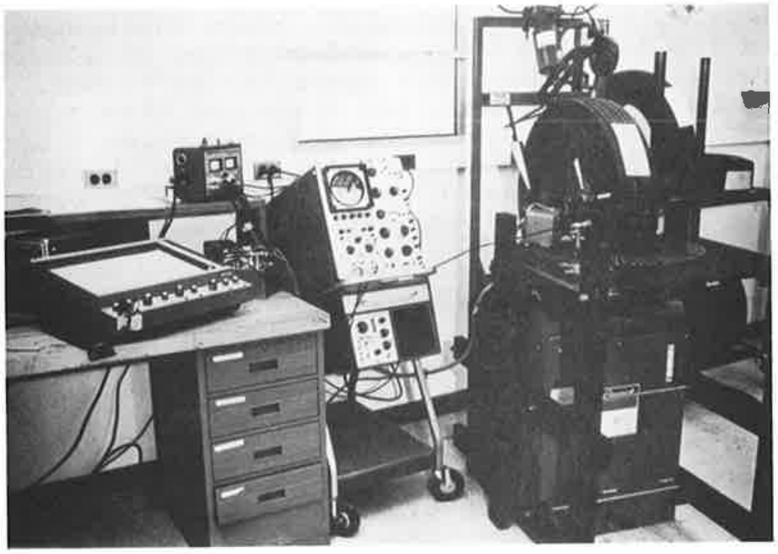


Figure 8. Air-Coupled Ultrasonic Detector and Tire Mount

Figure 9. Ultrasonic Transmitting Transducer and Mounting Assembly

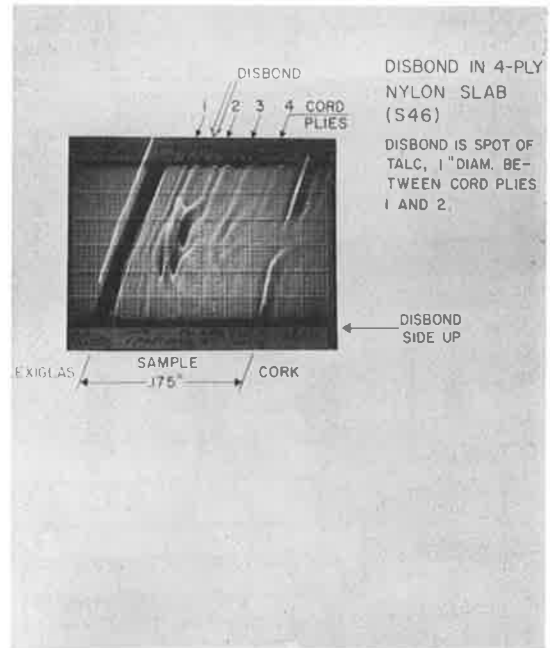


Figure 10. Fluid-Coupled Ultrasonic Detection of One-Inch Separation

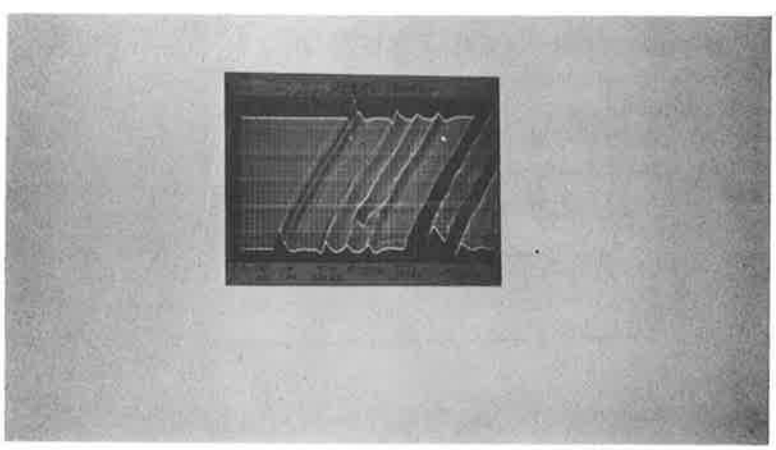


Figure 11. Fluid-Coupled Ultrasonic Detection of Interface Bonding

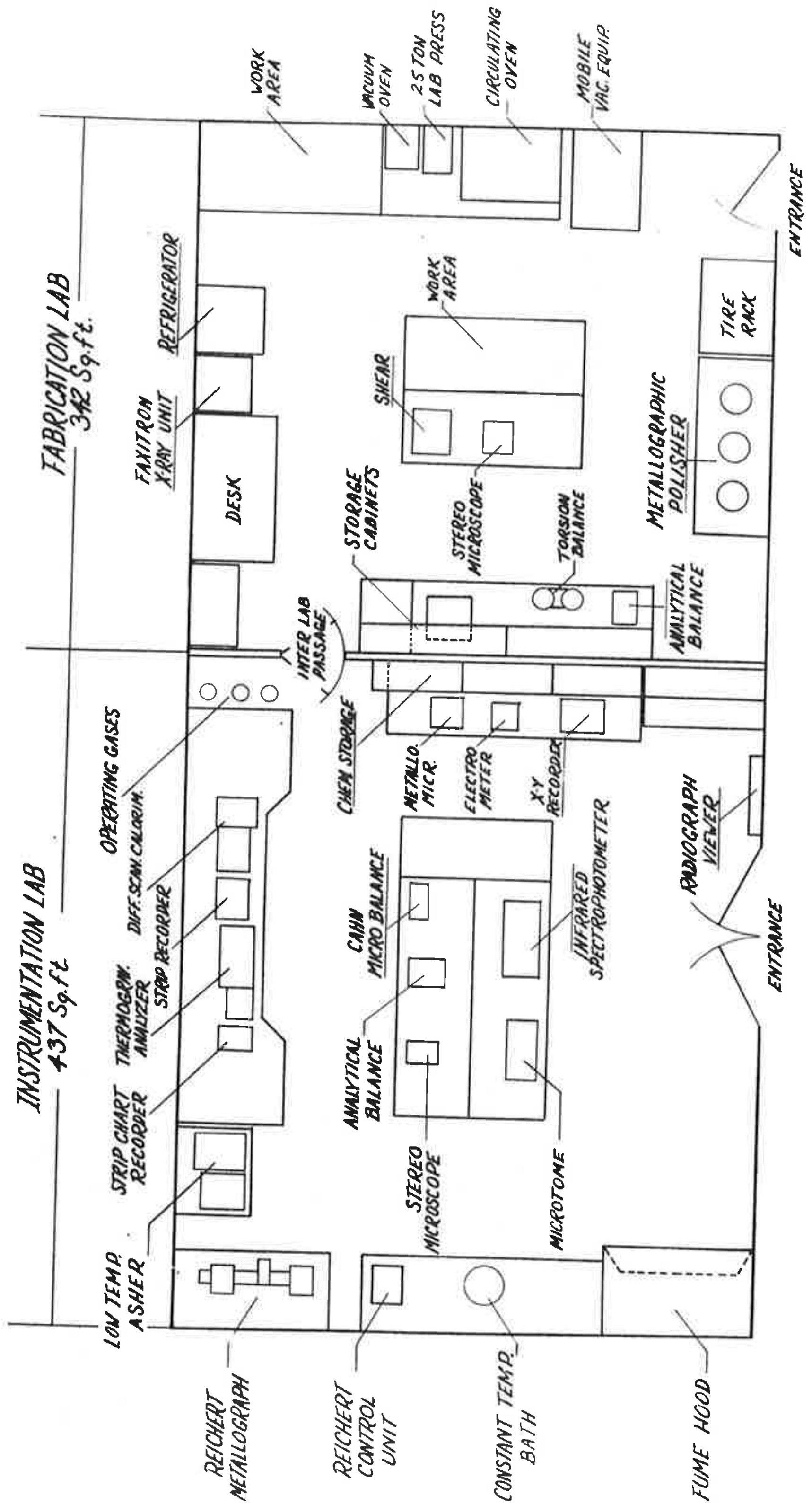


Figure 12. Materials Laboratory

to determine whether the quality of the materials may have contributed to the defect or failure.

Going very briefly through the lab instrumentation, Figure 13 shows a press with heated platens and a convection oven. Both are used to prepare flat and tubular specimens of rubber/cord composites with built-in defects, which are then used to calibrate various sensor instruments. Figure 14 shows a small X-ray unit that makes radiographs of sections of tires to detect cord breaks, fabric defects and to measure cord angles. The thermogravimetric analyzer shown in Figure 15 automatically records weight loss with programmed temperature rise of 20 milligram samples of rubber and cord materials. The differential scanning calorimeter seen in Figure 16 automatically records exothermic and endothermic events in milligram samples as a function of temperature and time. It can, for example, determine the cure characteristics of a rubber sample.

The infrared spectrophotometer shown in Figure 17 is used to analyze rubber samples by the spectrum of the products of pyrolysis. The stereo microscope shown in Figure 18 is used to examine and photograph tire sections. An example of what one can see is shown in Figure 19. A metallograph, shown in Figure 20, is available to examine the fine structure of wire. Figure 21 is a microtome used to obtain thin slices of tire sections to examine the fine structure within a failed area. Figure 22 shows a crack in a tire section extending from the liner inner wall into the second ply layer.

TIRE INSPECTION PROCEDURE

The general procedure for tire inspection is shown in Figure 23. Tires are received prior to compliance testing and are inspected by the X-ray, holographic, infrared and ultrasonic procedures. Each of these test procedures has its own notation sheet. In the case of X-ray and holography, separate sheets that are marked as observations are made (Figures 24 and 25). In the infrared and ultrasonic methods, the notation sheets are the recorder graphs. A file folder is kept on each tire to hold all the raw data from each test and the subsequent failure analysis. Data on the tire manufacturer, size and construction is coded and entered into the computerized data base. In addition, data describing each detected defect is coded and entered into the computer.

The tires are then sent to a compliance testing center where they are subjected to the desired wheel testing. Some of these tires will be monitored during these tests by an infrared radiometer which is expected to provide information on defect location and growth during wheel testing. Data on the compliance test results are coded and entered into the computer.

Upon completion of compliance testing, the tires are re-inspected to locate any new defects and to measure any changes in the original defects such as the propagation of a separation. The

Figure 13. Heated Press and Convection Oven

Figure 14. Small X-Ray Unit

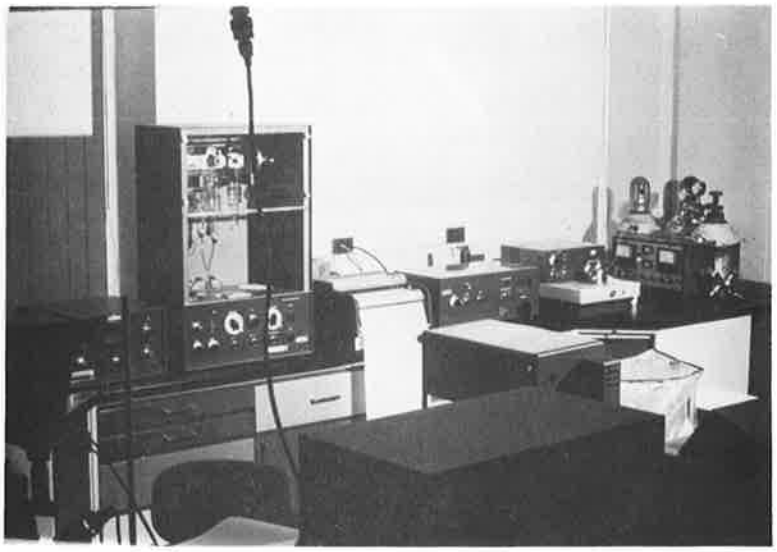


Figure 15. Thermogravimetric Analyzer

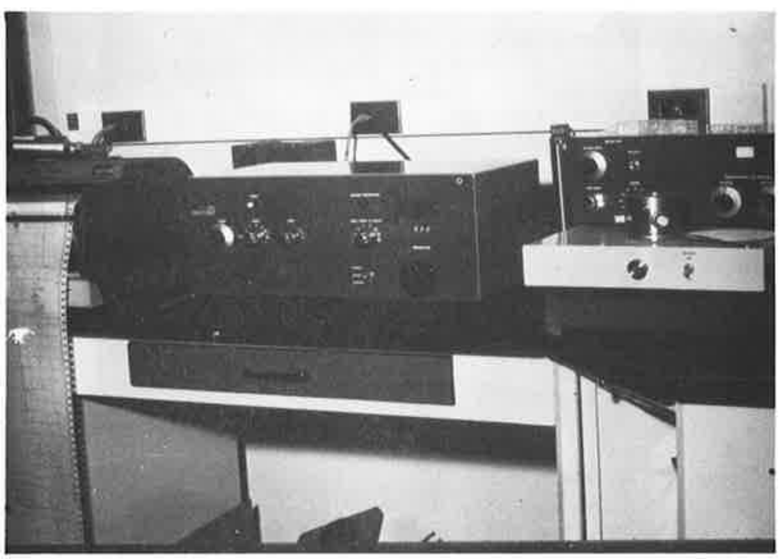


Figure 16. Differential Scanning Calorimeter

Figure 17. Infrared Spectrophotometer

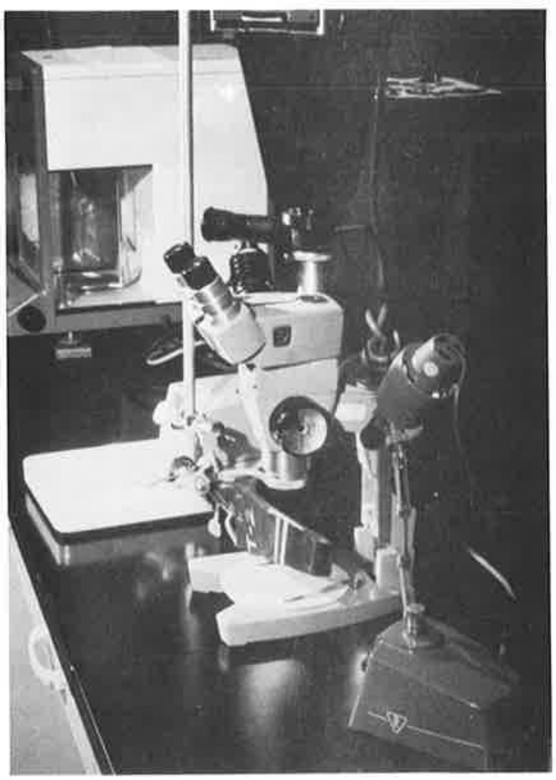


Figure 18. Stereo Microscope

Figure 19. Photomicrograph of Cracks in Tire Section (40x)

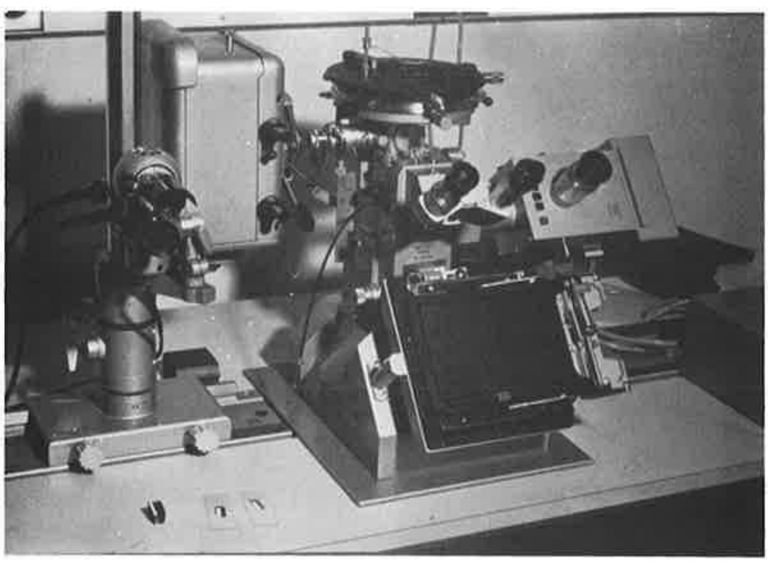


Figure 20. Metallograph

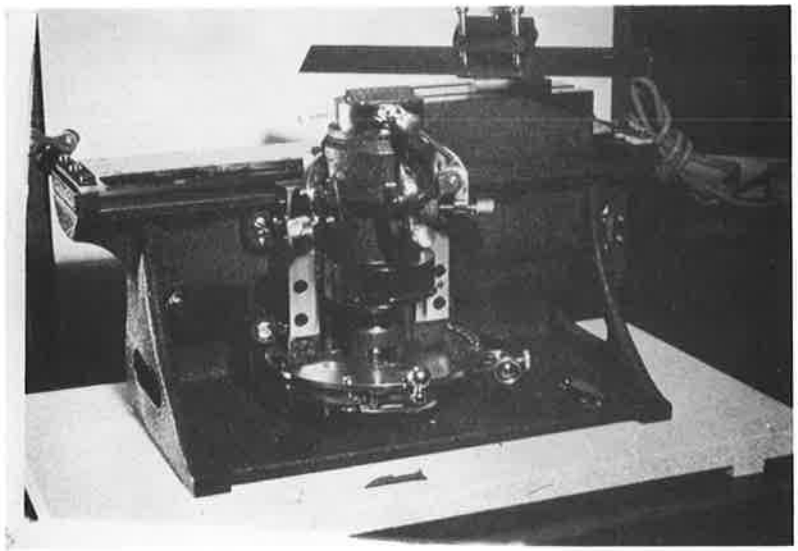


Figure 21. Microtome

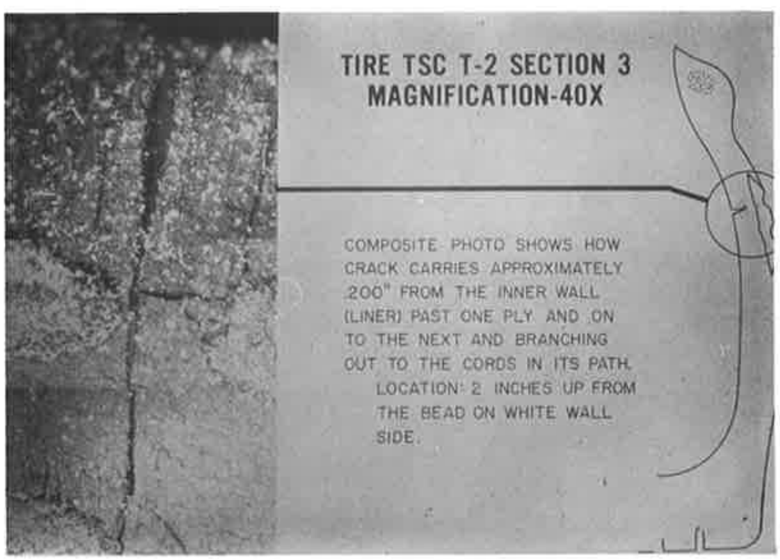


Figure 22. Photomicrograph of Crack in Liner (40x)

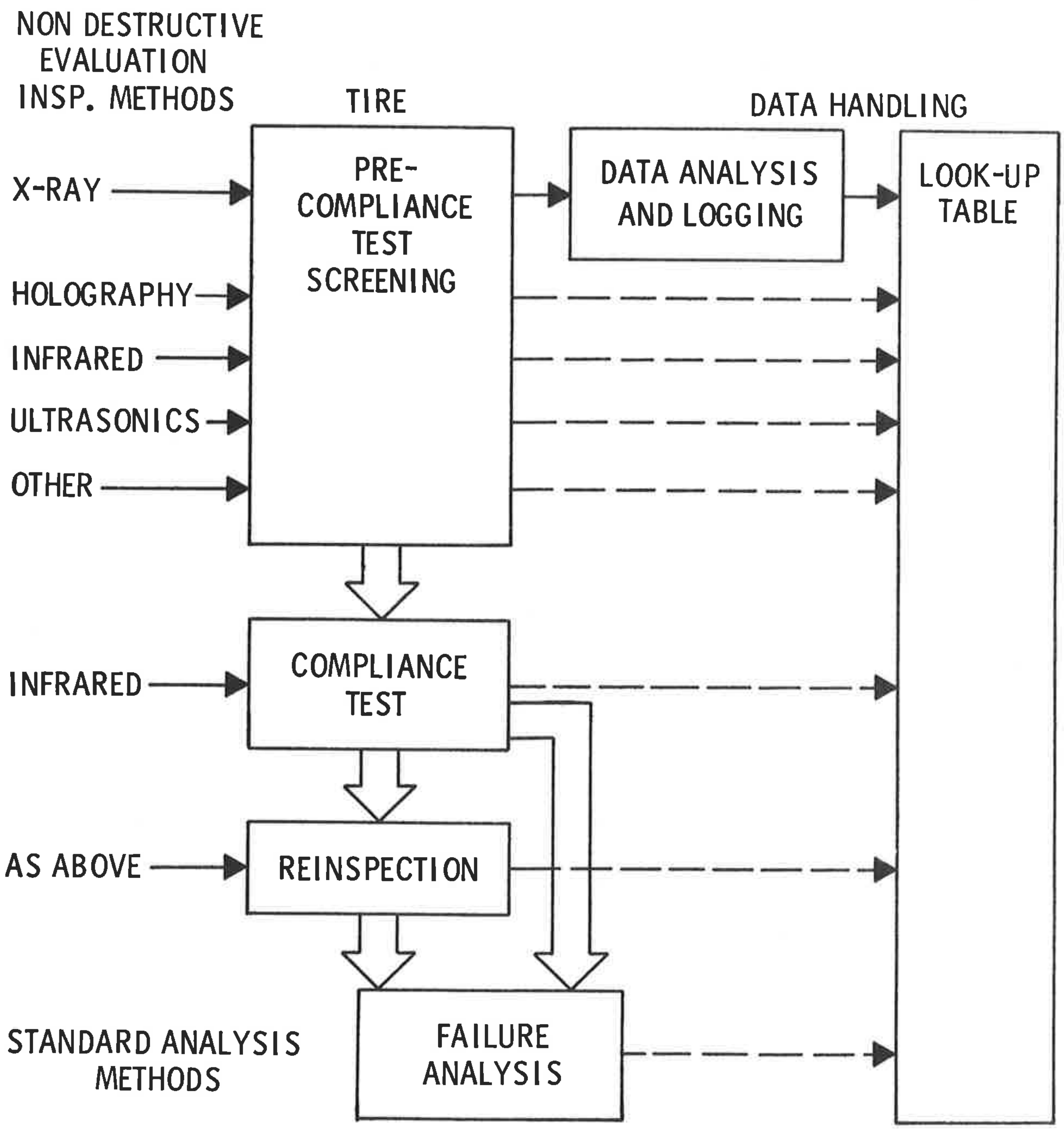


Figure 23. Tire Inspection Flow Diagram

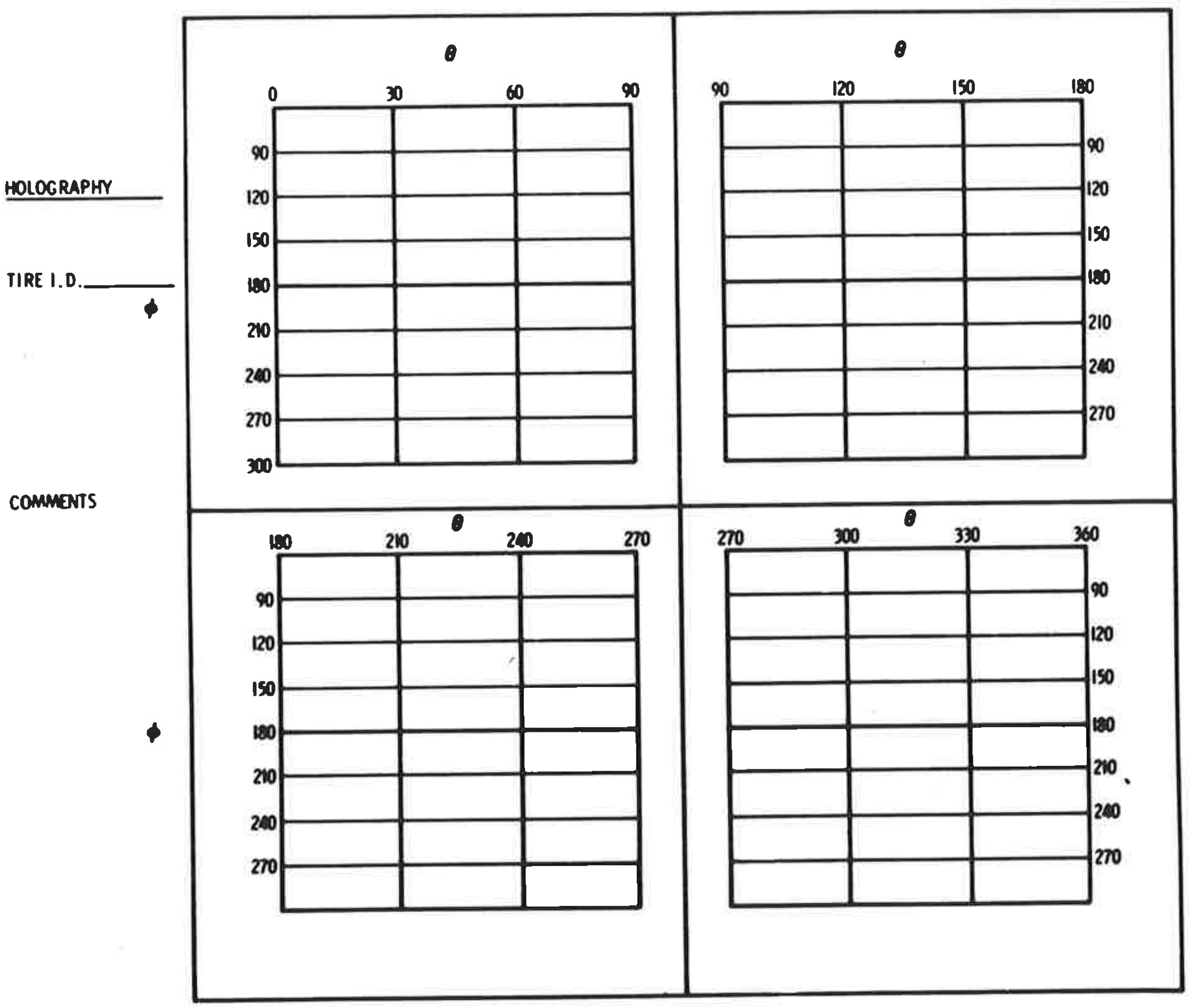


Figure 24. Graphic Data Recording Sheet for Holographic Detection System

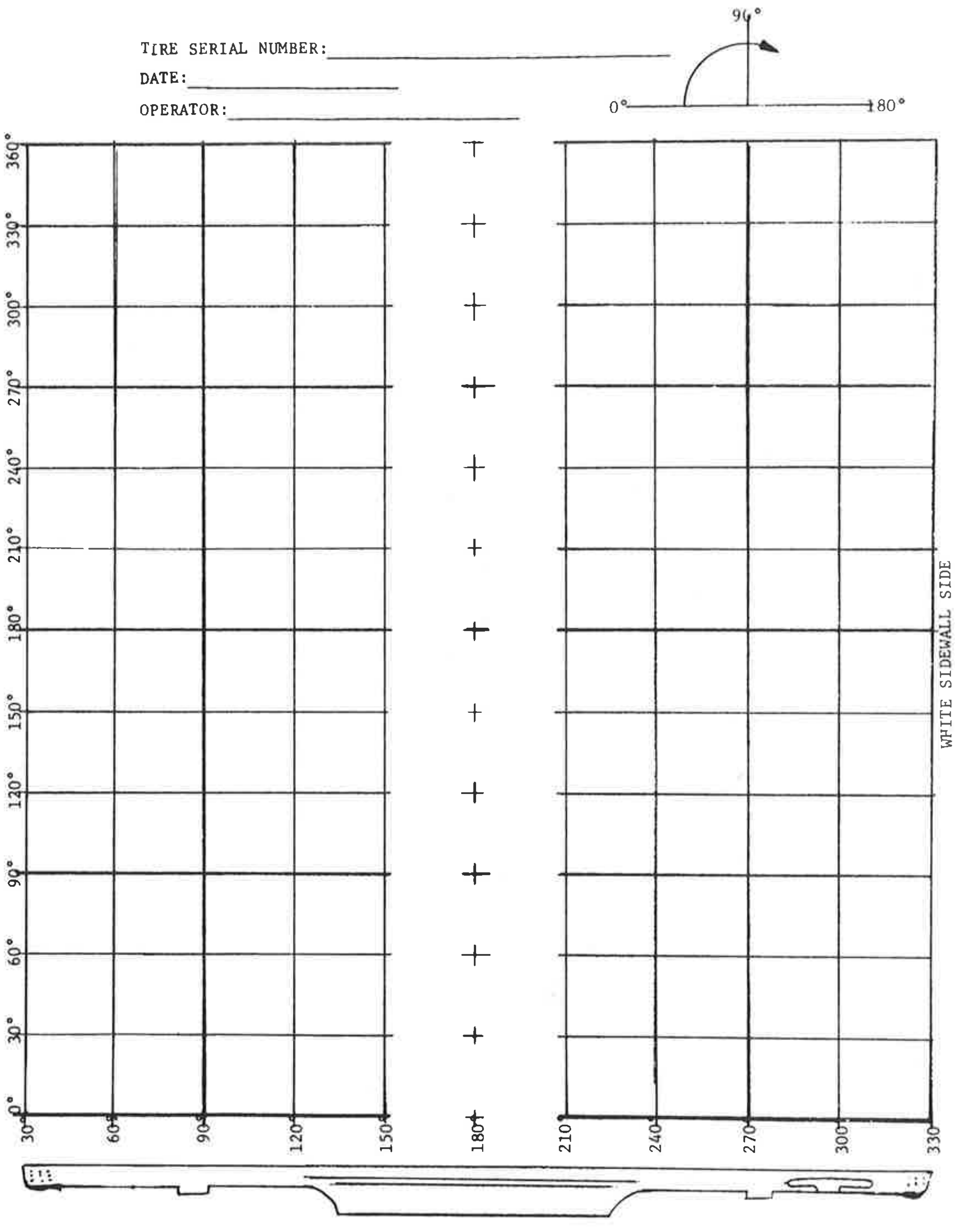


Figure 25. Graphic Data Recording Sheet for X-Ray Inspection

data are then coded and entered into the computer. All tires are finally subjected to destructive failure analysis to permit positive identification of defects that have been observed by NDT. Furthermore, it is necessary to understand the failure mechanism in order to correlate this with the types and location of defects observed. The failure analysis data are also coded and entered into the data bank.

DATA CODING SYSTEM

Now let us back-track a bit and see how the data coding system operates. This system was devised to store the many lists of information concerning individual tires during the many manipulations between the time that they are received and their final destruction in failure analysis. It also allows the recall and correlation of any of these bits of information so that eventually an overall real picture may become apparent.

The operators of the individual nondestructive testing equipment record the observed singularities using the following set of characters:

1. ASSIGNED SERIAL NUMBER CODE AND TEST LOCATION CODE
   (Data type 1, 2, and 3; Col. 2, 3, 4, 5, 6, 7, 8, and 9)
   (Data type 2, Col. 10)

The following code will be used for assigning and interpreting tire serial numbers:

First character of serial number and test location code;
- A - Automotive Research Associates, San Antonio, Texas
- E - Electrical Testing Laboratories Inc., New York, N. Y.
- C - Compliance Test Inc., Ravina, Ohio
- G - General Test, Springfield, Virginia
- I - International Rubber Inc., Louisville, Ky.
- N - Safety Systems Laboratory, NHTSA, Wash., D. C.
- ϕ - Ogden Technology Laboratory Inc., Long Island, N. Y.
- R - Retreading Research Inc., McLein, Va.
- S - Southwest Research Institute Inc., San Antonio, Texas
- T - Transportation Systems Center, DOT, Cambridge, Mass.
- D - Dayton T. Brown Inc., Islip, New York

Second character;
- N = Fiscal year, i.e., 1, 2, etc.

Third character;
- X - experimental (all TSC tires will be coded X)
- E - Original equipment
- S - Standard 109 test
- R - Retest tire

Fourth to seventh character;
- XXXX - Sequential numerical characters

Eighth character;
A - Strength test
B - Endurance wheel test
C - High speed wheel test
R - Research tire (all TSC tires will be coded R)
Example;
T2X0043R

2. DATE CODE
(Data type 1, Col. 10, 11, 12; 20, 21, 22; and 31, 32, 33)
(Data type 2, Col. 13, 14, 15)
(Data type 3, Col. 10, 11, 12)

The following date code will be used:

First and second character;
XX - Week of the calendar year
Third character
X - Calendar year
Example;
401 - 40 week of 1971

3. TEST TYPE CODE
(Data type 2, Col. 11 and 12)

The following code will be used to describe the type of test a tire has been subjected to:

EN - endurance to MVSS 109
HS - high speed to MVSS 109
PL - plunger or strength to MVSS 109
ST - storage at ambient conditions

4. TIRE TYPE CODE
(Data type 1, Col. 34, 35, and 36)

The following code will be used to describe the primary tire characteristics:
A. First Character (construction);
B - Bias, 2 ply
C - Bias, 4 ply
D - Bias, 6 ply
E - Bias, 8 ply
F - Bias, 10 ply

G - Belted, 2 ply/2 belt
H - Belted, 2 ply/3 belt
I - Belted, 2 ply/4 belt
J - Belted, 4 ply/2 belt
K - Belted, 4 ply/3 belt
L - Belted, 4 ply/4 belt

M - Radial, 2 ply/2 belt
N - Radial, 2 ply/ 3 belt
ϕ - Radial, 2 ply/4 belt
P - Radial, 4 ply/2 belt
Q - Radial, 4 ply/3 belt
R - Radial, 4 ply/4 belt

B. Second character (material)

A - Rayon
B - Nylon
C - Polyester
D - steel
E - rayon/rayon
F - rayon/nylon
G - rayon/polyester
H - rayon/glass
I - rayon/steel
J - nylon/rayon
K - nylon/nylon
L - nylon/polyester
M - nylon/glass
N - nylon/steel
ϕ - polyester/rayon
P - polyester/nylon
Q - polyester/polyester
R - polyester/glass
S - polyester/steel
T - steel/steel

C. Third character (other features);

A - highway, tube, blackwall
B - highway, tube, whitewall
C - highway, tube, red stripe
D - highway, tube, raised letters
E - highway, tubeless, blackwall
F - highway, tubeless, whitewall
G - highway, tubeless, red stripe
H - highway, tubeless, raised letters
I - snow, tube, blackwall
J - snow, tube, whitewall
K - snow, tube, red stripe
L - snow, tube, raised letters
M - snow, tubeless, blackwall
N - snow, tubeless, whitewall
ϕ - snow, tubeless, red stripe
P - snow, tubeless, raised letters

5. TIRE DEFECT CODES
(Data type 3, Col. 31, 32, and 33)

A. <u>CORD AND PLY DEFECTS</u>:

CBn - Cord, broken (n = 1 - 9)
CWI - Cord, wild
CNL - Cord, non-uniform or distorted
CNS - Cord, non-uniform spacing or dispersion

CPR - Cord, paired
CSP - Cord, spread
BCR or PCR - Belt or Ply, crack or tear
BDL or PDL - Belt or Ply, dog ear
BφE or PφE - Belt or Ply, overlap excessive
BφN or PφN - Belt or Ply, Overlap none
BST or PST - Belt or Ply, telescopic splice
BNS - Belt, no step
BCN - Beadchafer, non-uniform
BnC or PnC - Belt or Ply number "n" off center
PFW - Ply fold wrinkle or buckle
PDT - Ply, distorted turnup

B. BEAD DEFECTS:

BBR - Bead broken
BKI - Bead kinked
BLE - Bead, loose end
BSE - Bead separation

C. RUBBER DEFECTS:

REX - Rubber, excess
RIM - Rubber, inclusion multiple
RIS - Rubber, inclusion single
RIN - Rubber, insufficient
RPφ - Rubber, porous
RVφ - Rubber, void
RIC - Rubber, innerliner crack
RMW - Rubber, metal weighted
RHS - Rubber, heavy splice
RTS - Rubber, thin splice
SCL - Surface cracks, large
SCS - Surface cracks, small
SCM - Surface cracks, micro (checking)
TCH - Tread chunking
TDU - Tread depth uneven
TGC - Tread groove cracks

D. INTERFACE DEFECTS:

BRP - Bead to rubber, poor bond
BRS - Bead to rubber, separation
BTP - Belt to tread, poor bond
BTS - Belt to tread, separation
BnP - "n" blet to (n+1) belt, poor bond
BnS - "n" belt to (n+1) belt, separation
CRP - Cord to rubber, poor bond
CRS - Cord to rubber, separation
LPP - Liner to ply, poor bond
LPS - Liner to ply, separation
PBP - Ply to belt, poor bond
PBS - Ply to belt, separation
PSP - Ply to sidewall, poor bond
PSS - Ply to sidewall, separation
PnP - "n" ply to (n+1) ply, poor bond
PnS - "n" ply to (n+1) ply, separation
SEP - Separation

E. GENERAL:

BAL - Balance
RφR - Runout, radial
RφL - Runout, lateral
PHP - Puncture, hot patch
SRE - Section repair
AφK - No defects observed

6. NONDESTRUCTIVE TIRE INSPECTION METHOD CODES
(Data type 3, Col. 13)

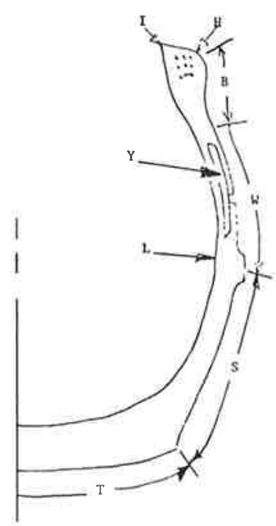
The following code will be used to describe inspection methods:

A - air coupled ultrasonics
C - Barnes infrared camera
F - failure analyses
H - GCO holograph
I - Infrared imager (TSC)
R - Infrared radiometer (TSC)
S - Infrared radiometer, Sensors Inc.
T - Holograph, TSC
U - Ultrasonics, high frequency or liquid coupled
V - Visual inspection
W - X-ray, Watertown
X - X-ray, Picker
Y - Force variation

7. TIRE PART CODE
(Data type 3, Col. 21)

The following code will be used to describe tire parts:

B - bead region
H - bead heel
I - bead toe
L - liner
S - shoulder region
T - tread region
W - sidewall region
Y - white sidewall



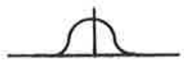
8. DEFECT SHAPE CODE
(Data type 3, Col. 22 and 23)

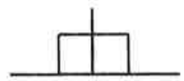
The following code will be used to describe defect shape:

CI - circle
CL - curved line
DI - discontinuity
EL - ellipse or oval
LI - line
RD - rod
RE - rectangle
SQ - square
TR - triangle

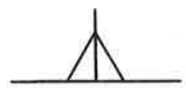
9. "Z" PROFILE CODE
(Data type 3, Col. 34 and 35)

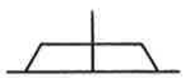
The following code will be used to describe "Z" profiles:

GA - Gaussion 

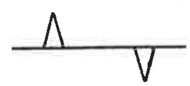
RE - Rectangular 

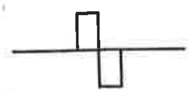
SI - Sine 

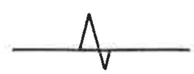
TR - Triangular 

TZ - Trapezoidal 

nP - "n" = 1-9 peaks 

DT - Differentiated triangle 

DR - Differentiated rectangle 

DI - Differentiated impulse 

10. COMMENT CODE
(Data type 3, Col. 40 and 41)

The following will be used to code comments:

GT - Good tire (low probability of failure)
BT - Bad tire (high probability of failure)
MI - Minor defect
MA - Major defect
SA - Suspicious area

Data Type 1, Figure 26, is the logging-in sheet which records all data required to identify incoming tires, including an assigned serial number, date received, manufacturer's name code, size, type and date of manufacture, for both new and retreaded tires.

Data Type 2, Figure 27, records the tire test history, providing information on the testing location, the type of test to which the tire was subjected, date and duration, and mileage run to failure or to successful completion of the test.

Data Type 3, Figure 28, is the defect coding sheet. On this sheet is recorded the method of testing, the defect locations using the θ (circumferential) and ϕ (bead-to-bead) coordinates, the tire part in which the defect is located, and the defect shape and size.

MEMORY BANK STORAGE AND RECALL

When the code sheets have been filled out for each day's operation, they are duplicated and then continue to follow the procedure as shown in Figure 29. Two sets of cards are key-punched from the code sheets: Deck A (manilla), and Deck B (blue). Once each week a paper tape is made from Deck A; the tape is entered into the Honeywell 516 computer and verified. The data are now stored in the 516 disc files.

When reference needs to be made to the data, recall may be made for any one of the input codes, or for any combination of these codes. For example, one might want to know what percentage of the tires had separations in the shoulder region of the blackwall side, and then categorize these by manufacturer.

SUMMARY

A number of nondestructive testing procedures are being investigated in depth to determine the feasibility of each individually, and in combination, to detect and identify defects in tires that can lead to failure. New and retreaded tires are examined by these procedures, and defects are recorded. The tires are exercised by SS109 endurance and high speed tests, and then reexamined. Failures and propagated defects are again investigated by NDT and finally, by destructive failure analysis. A memory and recall computer is used to record and correlate all data.

It is hoped that this program can lead to the further development of nondestructive devices for tire analysis, and that the statistical treatment of the data will eventually provide a method for accurately predicting tire failure.

NAME ____________________ LOG IN DATE ____________________

DATA TYPE (1)	TIRE ID: ASSIGNED SERIAL NUMBER (2–9)	DATE REC'D: WEEK (10–11)	DATE REC'D: YEAR (12)	NEW TIRE ID: MFG. ID (13–14)	NEW TIRE ID: SIZE (15–16)	NEW TIRE ID: TYPE (OPT) (17–19)	NEW TIRE ID: DATE: WEEK (20–21)	NEW TIRE ID: DATE: YEAR (22)	RETREAD ID: MFG. ID (23–25)	RETREAD ID: SIZE (26–27)	RETREAD ID: TYPE (OPT) (28–30)	RETREAD ID: DATE: WEEK (31–32)	RETREAD ID: DATE: YEAR (33)	TSC TYPE (34–36)	COMMENTS (37–62)
1	Ø1TG161B	41	1	WU	HX		14	1						MIF	SUPER LOW PROFILE 60
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															
1															

TSC F 5840.1 (11/71)

Figure 26. Tire Manufacturer History Coding Sheet

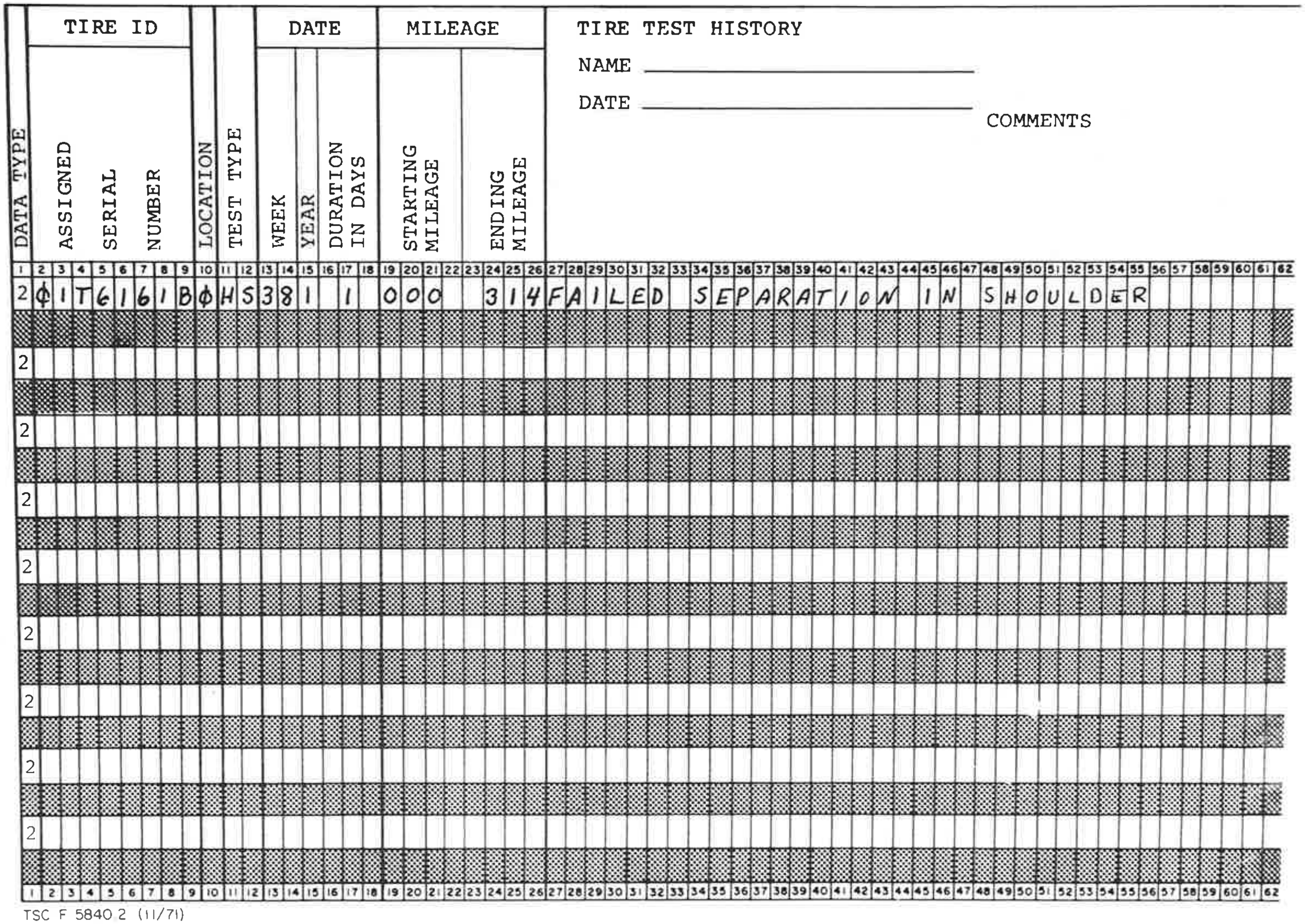


Figure 27. Tire Test History Coding Sheet

TIRE DEFECT CODING SHEET

TECHNIQUE ________________ DATE ____________

DATA TYPE (1)	INSPECTION DATE: WEEK (2–3)	INSPECTION DATE: YEAR (4)	INSPECTION: METHOD (5)	INSPECTION: OPERATOR (6)	TIRE ID: ASSIGNED SERIAL NUMBER (7–14)	DEFECT LOCATION: θ^{o} (15–17)	DEFECT LOCATION: ϕ^{o} (18–20)	TIRE PART CODE (21)	DEFECT SHAPE (x & y): SHAPE CODE (22–23)	DEFECT SHAPE (x & y): MAJOR AXIS IN DEGREES (24–26)	DEFECT SHAPE (x & y): SIZE WITH DECIMAL POINT IN INCHES OR DEGREES (27–30)	DEFECT SHAPE (z): DEFECT TYPE CODE (31–33)	DEFECT SHAPE (z): Z PROFILE (34–35)	DEFECT SHAPE (z): MAX. OR MIN. VALUE WITH SIGN AND DECIMAL POINT (36–39)	COMMENT CODE (40–41)	COMMENTS (do not keypunch) (42–65)
3	42	1	A	R	Φ1T6161B	200	150	T	EL	090	16		GA	- 45	BT	
3																
3	42	1	X	S	Φ1T6161B	180	070	B	RE	000	0.50	PDL			M1	
3																
3																
3																
3																
3																
3																
3																
3																
3																
3																
[illegible]																
3																
[illegible]																
3																
[illegible]																

TSC F 5840.3 (11/71)

Figure 28. Tire Defect Coding Sheet

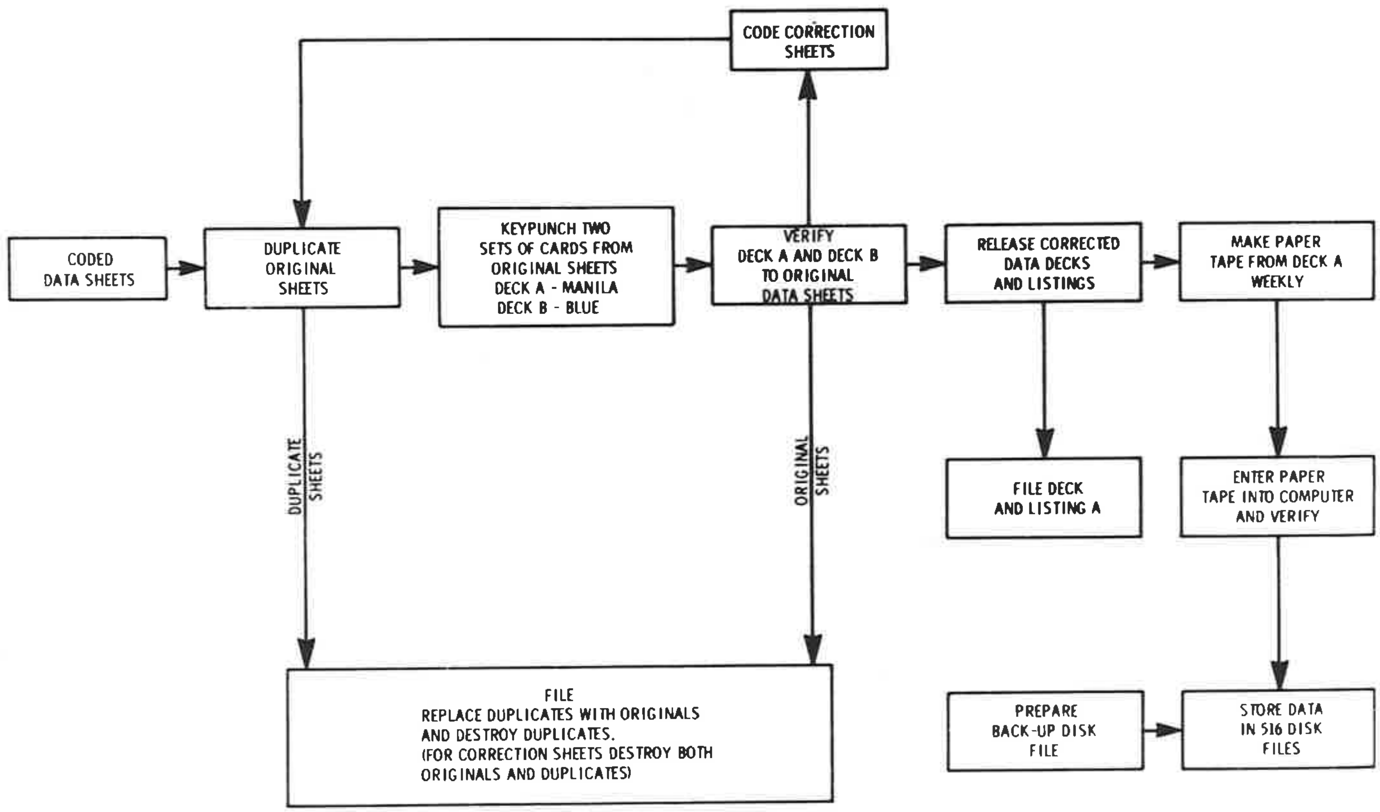


Figure 29. Data Coding and Storage System