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# DESCRIPTION OF THE DEMONSTRATION OF EUROPEAN TESTING EQUIPMENT FOR HOT MIX ASPHALT PAVEMENT


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## ACKNOWLEDGMENTS

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16. Abstract
The Colorado Department of Transportation (CDOT) and the Turner-Fairbank Highway Research Center (TFHRC) will be demonstrating some European testing equipment for hot mix asphalt. The equipment includes the French mixer, French gyratory compactor, French plate compactor, French mixer, Hamburg wheel tracking device and the Georgia loaded wheel tester. The advantages, disadvantages, costs and manufacturers are discussed. The joint research project between CDOT and TFHRC to evaluate the equipment and asphalt mixes is included.

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## APPENDICES

## I. INTRODUCTION

In September 1990, a group of individuals representing AASHTO, FHWA, NAPA, SHRP, AI, and TRB participated in a 2-week tour of six European countries. Information on this tour has been published in a "Report on the 1990 European Asphalt Study Tour" (1). Several areas for potential improvement of asphalt pavements were identified, including the use of performance-related testing equipment used in several European countries. Since the French equipment was commercially distributed and marketed, it was primarily selected for demonstration in the United States. The Colorado Department of Transportation (CDOT) and the FHWA Turner-Fairbank Highway Research Center (TFHRC) were selected to demonstrate this equipment.

The AASHTO Standing Committee on Highways (SCOH) approved an effort to assist, as required, with appropriate investigation and implementation, where warranted, of concepts from the European Asphalt Study Tour. SCOH allocated funding under NCHRP Project 20-7, for Task 49, "Follow-up on U.S.A. Asphalt Study Tour of Europe." A portion of those funds were used for expenses of a trip to Europe by Tim Aschenbrener, CDOT, to learn more about the equipment so a laboratory could be developed and designed. Additionally, some of the specifications used to design hot mix asphalt (HMA) pavement were learned. During the trip the Laboratoire Central des Ponts et Chaussees (LCPC) western headquarters in Nantes, France was visited. A regional laboratory in Angers, France (possibly comparable to a state's district laboratory), and a contractor's laboratory in Lyons, France was visited. Finally, a laboratory in Hamburg, Germany, which utilizes the Hamburg wheel tracking device, was visited.

The purpose of this report is to provide a brief description of the equipment, its use, some of its advantages and disadvantages, and how the equipment can be acquired.

## II. EQUIPMENT

Six major pieces of equipment have been purchased for demonstration in this study. The French mixer, plate compactor, rutting tester, and gyratory compactor are all manufactured and used by the LCPC and marketed by MAP. Details of the French design methodology are described by Bonnot (2). The Hamburg rut tester is manufactured by Helmut Wind and is used by several public and private entities, primarily the City of Hamburg. The Georgia loaded wheel tester will also be evaluated.

**Mixer.** Proper mixing of the materials is critical for obtaining a representative specimen for the design process. Testing in the European "torture" equipment uses large samples, up to 15 kg (33 lb). An 80 kg (176 lb) capacity mixer (Photo 1 Appendix A) will be acquired. The mixer is heated and requires less than 3 minutes to thoroughly mix the specimen. The specimen is mixed in an epi-cycloidal manner. There is an auger which turns and rotates eccentrically and a scraper rod which rotates around the side.

**French Gyratory Compactor.** The presse a cisaillement giratoire (PCG) or French gyratory compactor (Photo 2 Appendix A) is used to mold cylindrical specimens. This test is used to evaluate the compactability of the mix and to estimate the void content after construction. This procedure is used to determine the optimum asphalt content. The PCG has an angle of gyration of $1^{o}$, a vertical compressive pressure of 0.6 MPa (87 psi), a rotational speed of 6 rpm, and the test is performed for 200 gyrations. Although compaction of one specimen requires about 30 minutes, the French believe the slower revolutions provide better repeatability. The specimens have a diameter of 16 cm (6.3 in) and a height of 15 cm (5.9 in). Each sample has a mass of 7 kg (15.4 lbs). The air voids in the specimen are automatically recorded with time. The chamber where the mold is gyrated is heated.

The specifications for air voids are determined at 2 times. The first is after 10 gyrations which is preconsolidation and approximately represents the compaction behind the screed of the paver. The air voids should be between 15 and 20%. The second requirement considers the layer thickness. Depending on the type of HMA mix, the specified voids of 4% to 9% must be obtained at the gyrations equal to 10 times the lift thickness (centimeters).

This test is performed first since it is quick and simple. If the mix does not meet specifications, adjustments can be made to the mix before proceeding. When the mix is acceptable, the more time consuming performance related tests are performed.

**Plate Compactor.** A LCPC plate compactor (Photo 3 Appendix A) is used to compact two sizes of rectangular slabs. Slabs which are 50 by 18 cm (19.7 by 7.1 in) and 5 to 10 cm (2.0 to 3.9 in) thick are directly usable in the French rutting tester. Slabs 60 by 40 cm (23.6 by 15.7 in) with a thickness of 4 to 15 cm (1.6 to 5.9 in) can be compacted for other tests. These slabs can be cored or sawed for testing fatigue and moisture susceptibility characteristics. A slab can be compacted in 20 minutes.

Two compacting levels, strong and weak, are used to prepare a slab to the desired air void content. The pneumatic tire used for compaction can have different pressures, make a various number of passes, and can be applied with different forces over the loose mix. After compacting these slabs, the density measurement by absorption of gamma rays is performed on the slab to ensure that the air voids are uniform.

**French Rutting Tester.** In order to evaluate the resistance to permanent deformation, the French rutting tester (Photo 4 Appendix A) is used on a slab. The slab is 50 by 18 cm (19.7 by 7.1 in) and can be 20 to 100 mm (0.8 to 3.9 in) thick. It weighs approximately 15 kg (33 lbs).

Two slabs can be tested simultaneously. The slabs are loaded with 5000 N (1124 lbs) by a pneumatic tire inflated to 0.6 MPa (87 psi). The tire loads the sample at 1 cycle per second; one cycle is two passes. The loading time across the center of the slab is approximately 0.1 second. The chamber is typically heated to 60°C (140°F) but can be set to any temperature between 35° and 60°C (95° and 140°F).

When a test is performed on a laboratory compacted slab, it is aged at room temperature for as long as 7 days. It is then placed in the French rutting tester and loaded with 1000 cycles at room temperature. The deformations recorded at the end are the "zero" readings. It is then heated to the test temperature for 12 hours before the test begins. Rut depths are measured after 100, 300, 1,000, 3,000, 10,000, 30,000 and possibly 100,000 cycles. The rut depth after the given number of cycles is calculated as the average of 15 measurements: 5 locations along the length and 3 along the width.

A successful test will have a rut depth that is less than 10% of the slab thickness after 30,000 cycles. The shape of the percent rut depth versus cycles curve and the sensitivity of the curve to void content should also be considered. A pair of slabs can be tested in about 9 hours.

**Hamburg Wheel Tracking Device.** The use of the Hamburg wheel tracking device (Photo 5 Appendix A) is used to measure the resistance to moisture damage. Two slabs are tested simultaneously. The slab size is 25 by 28 cm (9.8 by 11 in) and a thickness of 6 to 9 cm (2.4 to 3.5 in). Each slab is approximately 14 kg (31 lbs).

This device is similar to the French rutting tester except that the slab is immersed in a 50°C (122°F) water bath and loaded by a steel wheel. The temperature can be varied from 30° to 65°C (86° to 149°F). The wheel is loaded with 705 N (158 lbs). The slabs are loaded at one cycle per second; one cycle is two passes. The loading time of any point on the slab is 0.1 sec. The machine is automated and records the deformation after each cycle.

A successful test will have less than 4 mm (0.16 in) rut depth after 20,000 cycles. A pair of slabs can be tested in about 6 hours.

**<u>Georgia Loaded Wheel Tester.</u>** Test results from the Georgia loaded wheel testers (Photo 6 Appendix A) have been shown to correlate with field performance (3). Slabs tested are 7.5 by 7.5 by 38.1 cm (3 by 3 by 15 in) and are 5 kg (11 lbs). The slabs are prepared by using a 267 kN (60,000 lb) press. The testing chamber is maintained at 40.6$^{O}$C (105$^{O}$F). The slab is loaded through a wheel with a 445 N (100 lb) weight that rolls across a hose inflated to 0.7 MPa (100 psi). The rut depth is measured at 3 locations across the length of the slab and recorded to the nearest 0.25 mm (0.01 in).

A test is successful if the average rut depth is less than 7.6 mm (0.30 in) after 8000 cycles. A test takes about 4 hours.

## III. ADVANTAGES AND DISADVANTAGES

The European equipment offers many new ways to forecast the performance of an HMA mixture. These tests are very different from the standard methods of testing currently used by most state highway agencies (SHAs).

The first difference is the sample size. It is traditional to test 1200 gm (2.6 lb) samples. These devices require sample sizes which range from 7 to 15 kg (15.4 to 33 lbs). These sizes are much larger and more cumbersome to test. However, the larger sample sizes are believed to be more representative of the HMA mixture actually placed in the field.

Another difference is the testing time required. Many of these tests require 20 to 30 minutes to compact one sample and approximately 6 to 9 hours to test. This is quite a drastic change from the production normally used in many SHA laboratories where it may take only 5 minutes to compact a sample and another 5 minutes to test it. Although it may not ever be possible to test every project using the European "torture" tests because of time limitations, the more accurate tests using more representative samples could be used on the larger projects on high volume roads. It would be possible to use the European "torture" tests on the high profile projects within a state to ensure the HMA pavement will perform.

Many of the tests performed by the Europeans are empirical. The tests have been shown to accurately forecast the performance of HMA pavements in Europe (4). However, the traffic and environmental conditions in the United States are different than those in Europe. It would be reasonable to expect that there may be adjustments to the specifications to accurately forecast pavement performance in the United States. It is unknown at this time what those adjustments should be.

Finally, the cost of this equipment is not within the normal range of traditional equipment costs. However, it is believed that the ability of this equipment to accurately forecast the performance of a pavement greatly exceeds that of the traditional testing equipment used by many SHAs such as Colorado. The approximate costs are summarized on Table 1.

**Table 1. Approximate Costs of Testing Equipment**

| | |
|---|---|
| LCPC 80 kg Mixer | $ 90,000 (USD) |
| LCPC Gyratory Compactor | 110,000 |
| LCPC Plate Compactor | 105,000 |
| LCPC Rutting Tester | 80,000 |
| Hamburg Wheel Tracking Device | 45,000 |
| Georgia Loaded Wheel Tester | 11,000 |
| USA Linear Kneading Compactor | 30,000 |

## IV. STUDIES

A research proposal has been developed for the demonstration of the European equipment by the CDOT. In order to demonstrate the equipment the CDOT will work with the TFHRC. It was clearly understood that assistance would be provided to SHRP within the available resources during the demonstration of this equipment. The study is divided into five primary tasks.

**Testing Mixes of Known Field Performance.** The first task is to verify the predictive capabilities of this equipment by performing tests on mixtures of known field performance. Sites of known field performance were identified in terms of rutting and stripping. This information will be used to determine the applicability of the European equipment to the conditions that pavements in Colorado typically encounter.

Samples which had a history of rutting and of good performance will be tested in the French rutting tester, and selected samples will be tested in the simple shear device being developed at the University of California at Berkeley. The simple shear device is being considered by SHRP to predict permanent deformation characteristics.

Samples which had a history of stripping and of good performance will be tested in the Hamburg wheel tracking device and selected samples will be tested in the Environmental Conditioning System (ECS) being developed at the Oregon State University. The ECS is being considered by SHRP to predict moisture sensitivity characteristics.

**Testing Baseline Data.** In order to determine a comparative quality level of mixes placed in Colorado to mixes placed in Europe, 10 to 20 mixes will be tested in all of the devices. The standard CDOT stability and Lottman tests will also be performed. Most of the samples will be the standard CDOT gradings with the standard asphalt cements. Some of the mixes will be gradations with high VMA and polymerized asphalt cements. This information will serve as a baseline by which future improvements in HMA quality can be measured.

**Repeatability Study.** The two primary laboratories conducting this study will be the CDOT and the TFHRC. Other laboratories desiring to participate will be invited. Ten replicates of two mixes will be tested in each of the rut testers: Hamburg wheel tracking device, French rut tester, and Georgia loaded wheel tester.

**Improve Quality of HMA Pavements.** The primary objective of the research project will be to develop HMA mixes which have superior performance. Approximately 5 HMA paving contractors with commercial sources that are frequently used on CDOT projects will be selected. The CDOT will work 1-on-1 with each contractor to improve the quality of the HMA mixture to pass the European "torture" tests. By working with the contractor, costs, constructability, and material selection can be considered.

When a HMA mixture is developed which meets the tough testing standards, the CDOT will send samples of the HMA to TFHRC for testing. The CDOT will then place this mix on a project for field evaluation. A control section of a standard CDOT mix will be included.

**Field Evaluation of Improved Quality HMA Mixtures.** When a HMA mixture is developed which meets the tough testing standards, it will be placed and evaluated on a project in Colorado. The project will be evaluated prior to paving and during paving. Follow up evaluations will be performed right after paving and annually for 5 years. The evaluations will include crack mapping, rutting measurements, and deflection testing. To evaluate stripping, cores will be obtained and visually inspected twice during the 5-year evaluation. The cores will also be tested in the Hamburg wheel tracking device.

## V. EQUIPMENT ACQUISITION

The equipment discussed in this report is commercially available. Part of the purpose of this report was to inform other public and private entities of the contacts who distribute this equipment.

The North American distributor for the equipment marketed by MAP and developed by the LCPC is:

Emaco (Canada) ltd./ltee
Pierre Kuhn — Tel (514) 331-0551
2685 Paulus — FAX (514) 331 5023
Montreal, Quebec, Canada H4S 1E9

The Hamburg wheel tracking device is available from:

Helmut Wind Machines and Apparatus
Helmut Wind — Tel 040/655 11 99
Steger Waldring 2/Legienstr. — FAX 040/655 18 04
2000 Hamburg 74

The Georgia loaded wheel tester can be purchased from:

Benedict Slurry Seal, Inc.
C. Robert Benedict — Tel (513) 298-6647
P.O. Box 127 — FAX (513) 426-3368
Alpha, Ohio 45301

A linear kneading compactor manufactured in the USA which can make slabs for both the French rutting tester and the Hamburg wheel tracking device can be obtained from:

RH Specialty Machine
Robert Hasbrouck — Tel (812) 232-0781
P.O. Box 763 — FAX (812) 232-0781
Terre Haute, Indiana 47808

## VI. CONCLUSIONS

The use of the European torture tests will be demonstrated by the CDOT and the TFHRC. The purpose of the demonstration will be to improve the quality of HMA pavements and to assist SHRP within the resources available.

## REFERENCES


1. Report on the 1990 European Asphalt Study Tour (June 1991), American Association of State Highway and Transportation Officials, Washington, D.C., 115+ pages.

2. Bonnot, J. (1986), "Asphalt Aggregate Mixtures", Transportation Research Record 1096, TRB, National Research Council, Washington, D.C., pp. 42-51.

3. Lai, J.S., and T.M. Lee (1990), "Use of a Loaded Wheel Testing Machine to Evaluate Rutting of Asphalt Mixes", Transportation Research Record 1269, TRB, National Research Council, Washington, D.C., pp. 116-124.

4. Kast, O., and W. von der Weppen (1978), "Beurteilung der Standfestigkeit un Asphaltbeton-Deckschichten mit Hilfe des Spundbildungstestes", Bitumen 6, pp. 180-183.

# Appendix A

PHOTOGRAPHS

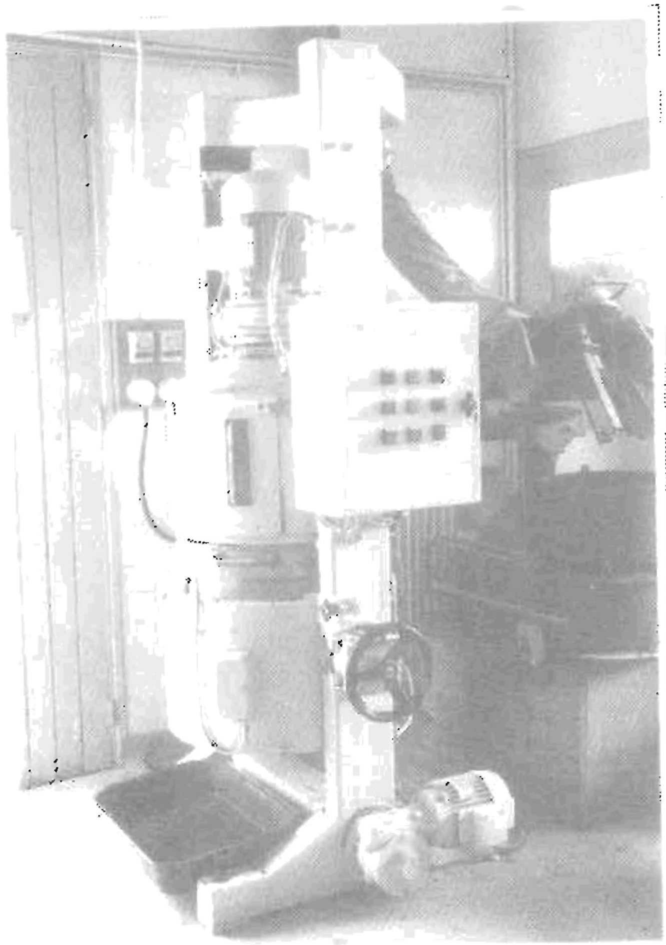

Photo 1. 80 kg Thermo-regulated, Epi-cycloidal Mixer

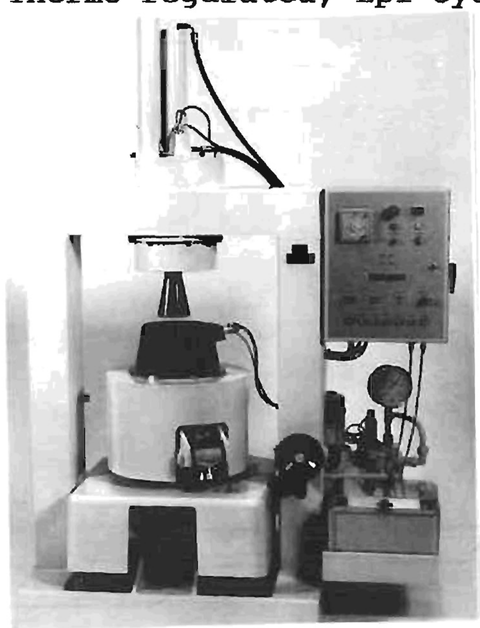

Photo 2. French Gyratory Compactor (PCG)

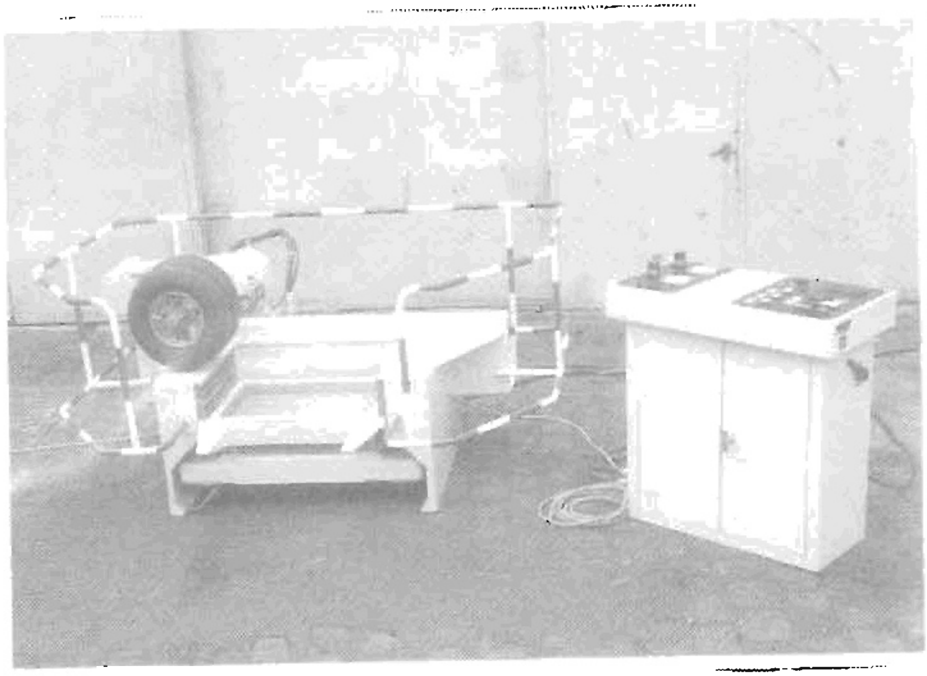

Photo 3. LCPC Plate Compactor

Photo 4. LCPC Pavement Rutting Tester

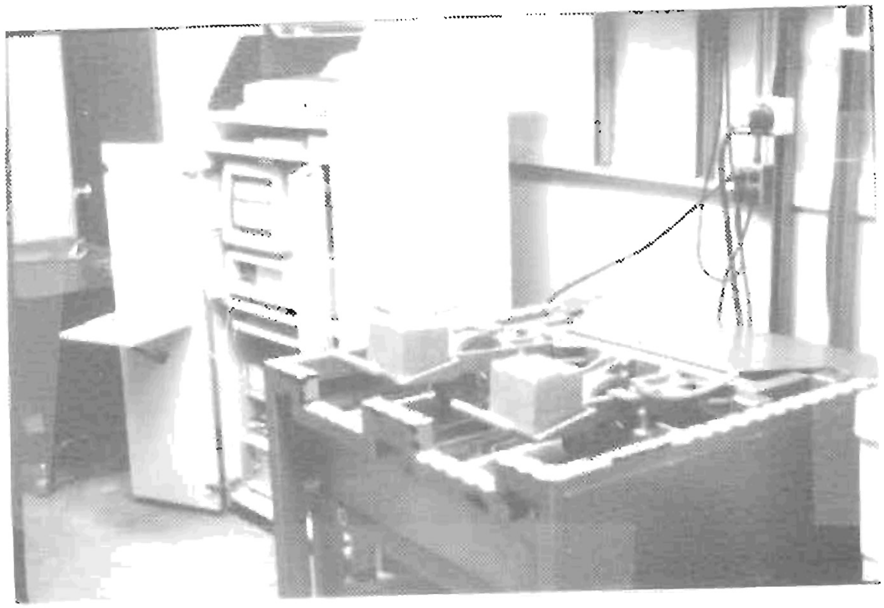

Photo 5. Hamburg Wheel Tracking Device

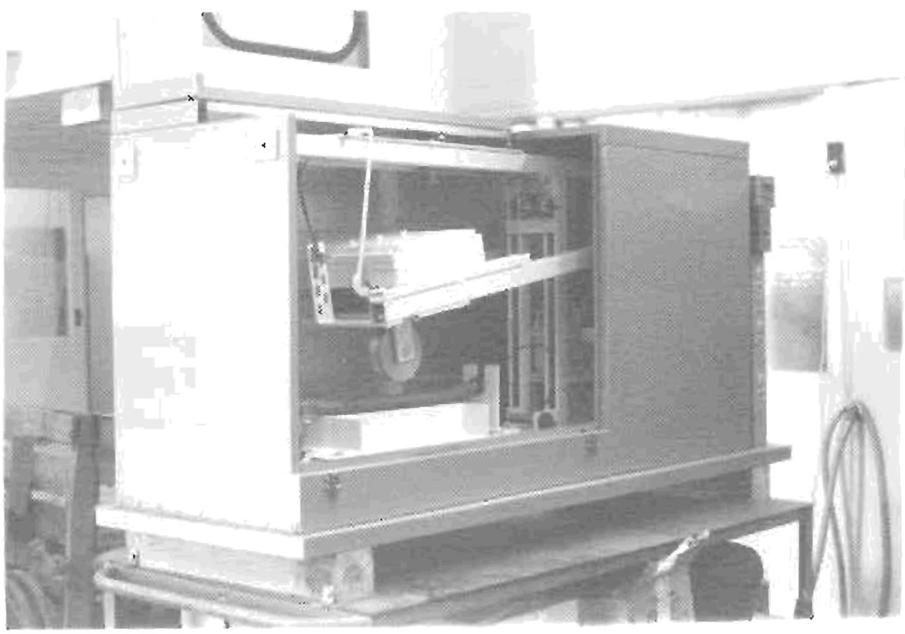

Photo 6. Georgia Loaded Wheel Tester

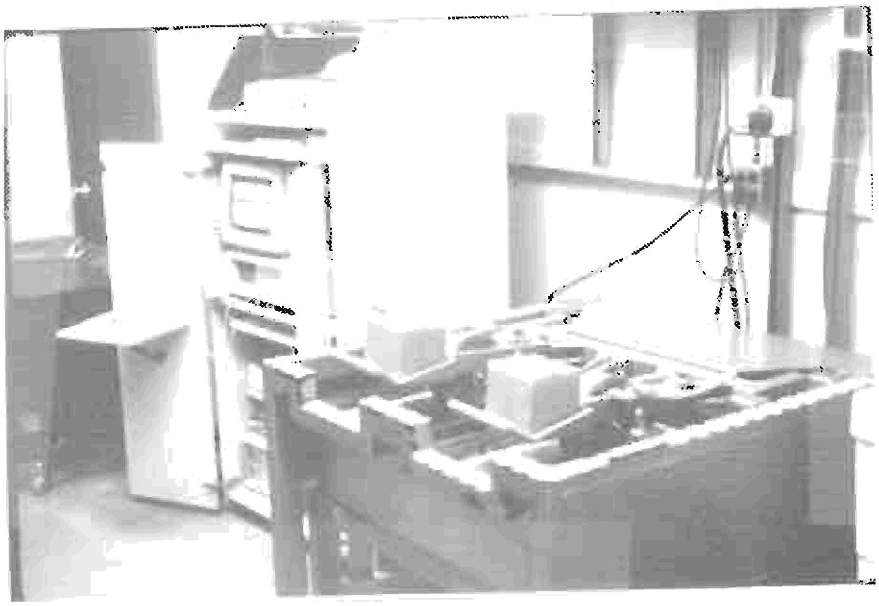

Photo 5. Hamburg Wheel Tracking Device

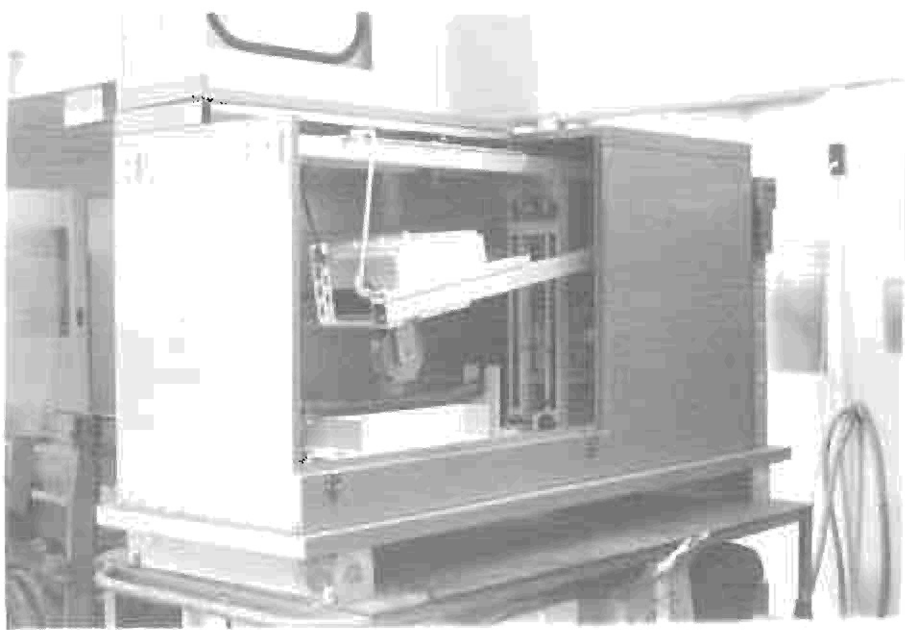

Photo 6. Georgia Loaded Wheel Tester