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A REFINED TECHNIQUE FOR MEASURING MOTORCYCLE BRAKING PERFORMANCE BY THE TOW METHOD

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USER'S MANUAL
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16. Abstract

A method for measuring the braking performance of motorcycles was refined and a complete package of test hardware was constructed and demonstrated. The project followed upon a previous NHTSA-sponsored study in which a concept was developed for towing motorcycles as a means of safely and objectively measuring braking system performance. The refined tow-test apparatus is much lighter than the original system and requires no special adaptation for testing any conventional motorcycle. In demonstration testing, performance measurements were made on three motorcycles representing the range of vehicle weights. Tests showed that the new procedures and hardware were quite satisfactory.

The final report includes a Volume II "User's Manual" to instruct those who may operate the NHTSA-owned test system in the future or who may choose to reproduce the system.

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A REFINED TECHNIQUE FOR MEASURING MOTORCYCLE BRAKING PERFORMANCE BY THE TOW METHOD

Volume II

User's Manual

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Highway Safety Research Institute
The University of Michigan

Prepared for:

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1.0 INTRODUCTION

This document, together with separate Hewlett-Packard equipment manuals and other equipment manufacturers' data sheets, constitutes a complete description of the Motorcycle Braking Tow-Test System developed by the Highway Safety Research Institute (HSRI) of The University of Michigan on Contract Number DOT-HS-9-02314 entitled "Motorcycle Brake Test Procedure Changes--Equipment Upgrade," sponsored by the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation. Volume I of the report describes the refined procedures and apparatus and reviews the results of a demonstration test program. Volume II documents the entire tow-test hardware and instrumentation package constructed during this project.

Section 2.0 of this manual describes the components of the system—that is, the components of the motorcycle towing apparatus and of the instrumentation system. A parts list for the instrumentation system is included in Section 2.3. A parts list and bill of materials for the mechanical parts is in Appendix 1. Mechanical drawings are contained in a separate packet. Section 3.0 is a detailed description of the instrumentation system, including a system block diagram, circuit and wiring schematics, system calibration procedures and data, and system operating program, or software, documentation. Section 4.0 details the procedure for attaching a motorcycle to the tow vehicle by using the universal hardware developed for this purpose. Section 5.0 gives step-by-step procedures for operating the tow-test system in performing the test procedures documented in Volume I of this report.

An HP 98035A real-time clock, an accessory to the HP 9825 computer, is included with the instrumentation equipment. The real-time clock was purchased for the purpose of implementing a "speed trap," utilizing tape switches connected to the computer, to measure the initial motorcycle velocity in performing motorcycle stopping distance tests. However, this test function was not implemented.

The following abbreviations are used often throughout this document.

AF	Brake actuator force
FAF	Front brake actuator force
RAF	Rear brake actuator force
TBF	Tow-bar force
TBFE	Tow-bar force error
V	Velocity
FT	Front brake temperature
RT	Rear brake temperature

The following are the manufacturers' manuals and specification sheets which are separate from, but considered part of, this user's manual.

1 - HP 9825T User's Documentation Manual, including:

- -HP 9825 Desktop Computer Operating and Programming Reference. No. 09825-90200
- -HP 9825 Desktop Computer I/O Control Reference. No. 09825-90210
- -Interface Concepts and the 9825. No. 09825-90060
- -Hewlett-Packard 98032A 16-Bit Interface Installation and Service Manual. No. 98032-90000
- -HP 9825, 98035A Real Time Clock. No. 09825-90054
- -HP 98305A Real Time Clock Installation and Operation Manual. No. 98035-9000

1 - HP 6940B Multiprogrammer User's Manual, including:

- -HP 6940B Multiprogrammer User's Guide. No. 59500-90005
- -HP 6940B Multiprogrammer System Throughput Analysis. No. 5952-4017
- -Multiprogrammer, Model 6940B. No. 5952-4025D
- -Multiprogrammer, Model 6940B. Operating and Service Manual. No. HP 6940B
- -High Speed A/D Converter Card, Model 69422A. No. 69422-90001
- -Low Level A/D Converter and Scanner Card, Model 69423A. No. 69423-90001

-Quad D/A Voltage Converter Card, Model 69322A.
No. 69322-90001

-Digital Output Card, Model 69331A. No. 69331-90001

-Frequency Reference Card, Model 69601B. No. 5950-1776

-Voltage Regulator Card, Model 69351B. No. 69351-90002

1 - HP General Utilities Documentation Manual, including:

-9825A General Utility Routines Tape Cartridge.
No. 09825-90004

-9825A/B System Test Cartridge. 9825A/B and Peripherals.
No. 09825-90036

-Hewlett-Packard 9825A Software General Utilities
Routines Manual.

-HP 9825 Desktop Computer Quick Reference. No. 09825-90012

-Hewlett-Packard 9825A Desktop Computer System Test
Booklet. No. 09825-90037

1 - Lebow Model 3663-200 S/N 272 Load Cell Manual

1 - Lebow Model 3663-200 S/N 277 Load Cell Manual

1 - Lebow Model 3169-1000 S/N 966 Load Cell Manual

1 - Laboratory Equipment Corp. Fifth Wheel Manual

1 - Bell Crash Helmet Manual

1 - Honda E1500 K4 Motor-Generator Manual

1 - Analog Devices 2B31J Specification Sheet

2.0 COMPONENTS OF THE SYSTEM

In this section the tow-test apparatus and the instrumentation system are described and their component parts are listed.

2.1 Tow-Test Apparatus

Figure 1 shows the tow-test hardware comprising a pickup truck, with extended cab, to which is affixed a linkage system fastening the test motorcycle. In the foreground of Figure 1 a heavy tubular structure extending back from the truck can be seen. This structure is, in turn, fastened to another heavy frame assembly which bolts directly to the truck load bed, as shown in the overhead view presented in Figure 2. Together, the main truck-mounted frame and the extended side frame structures provide the rigid foundation to which are affixed a towing connection and three lateral links which locate the motorcycle.

Figure 3 is a plan view showing four motorcycle constraints. The tow connection is made by means of an adjustable length chain which connects a yoke-type element on the motorcycle to a load cell affixed to the truck. The yaw, roll and lateral degrees of freedom are rigidly constrained by the three links connecting the motorcycle to the extended side frame. From front to back, respectively, the lateral links fasten to the motorcycle by means of special brackets at the steering head, the foot peg, and the rear shock absorber bolt. As shown in the rear view of Figure 4, the three lateral links are separated from one another vertically so as to provide a roll constraint. The out-board ends of each of the lateral links are fixed to adjustable brackets which can accommodate the longitudinal and vertical variations in the location of the three cited motorcycle mounting points. Width variations, from one motorcycle to the next, are accommodated through screw adjustments in the length of each lateral link. Each lateral link terminates in a spherical rod end, thereby allowing freedom in the vertical, longitudinal, and pitch motions of the motorcycle.

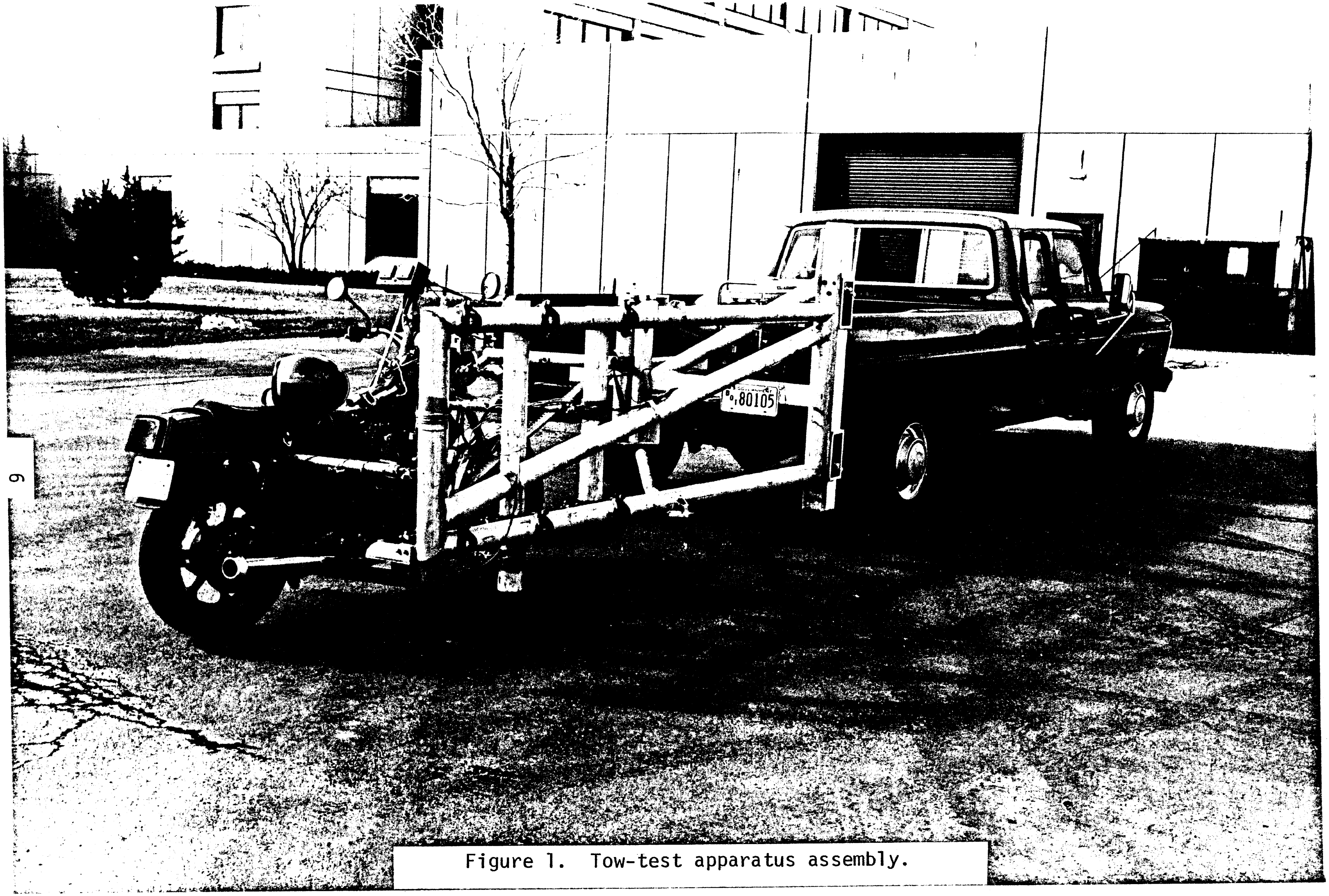


Figure 1. Tow-test apparatus assembly.

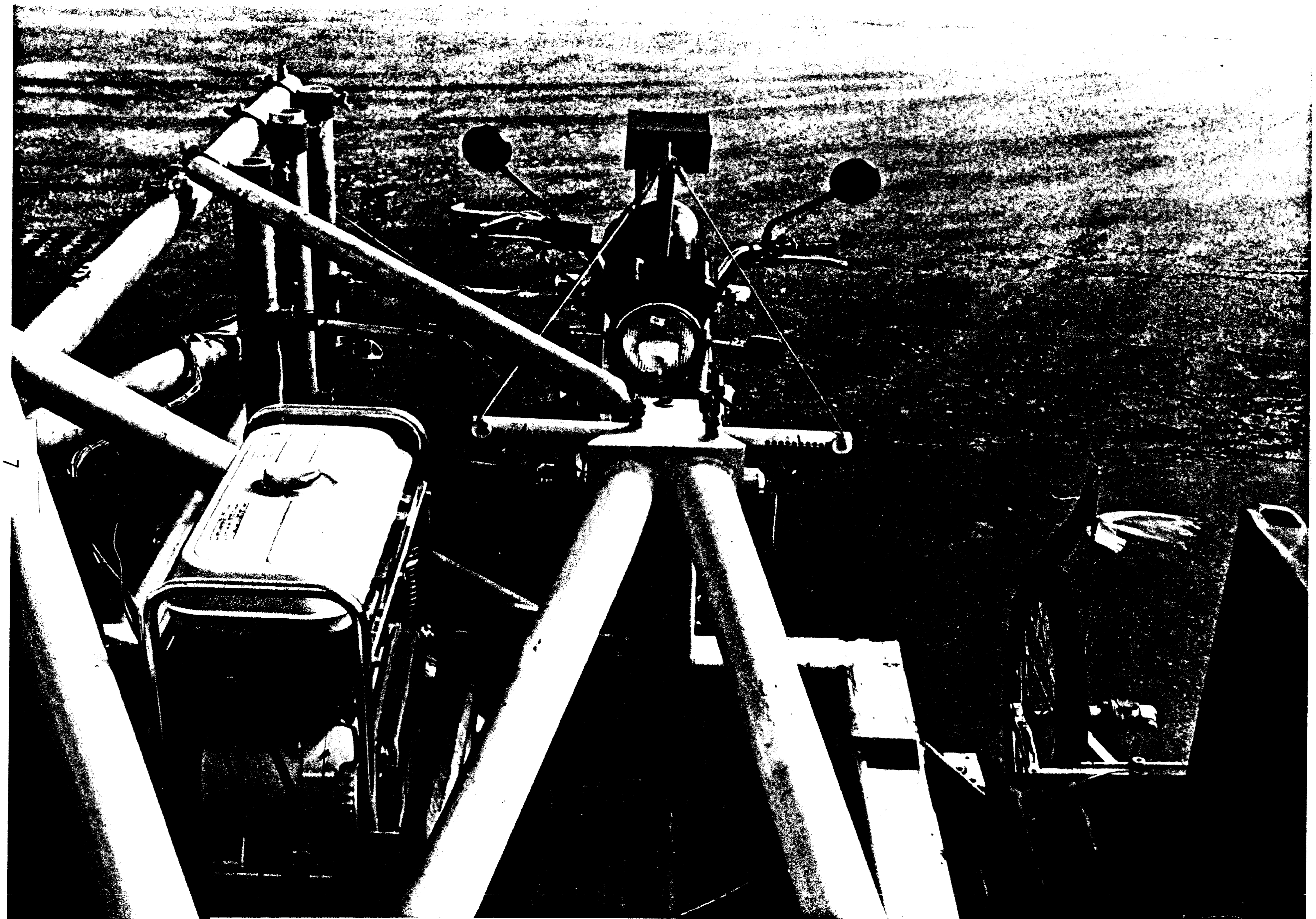


Figure 2. Overhead view of main frame fastened to the bed of the towing vehicle.

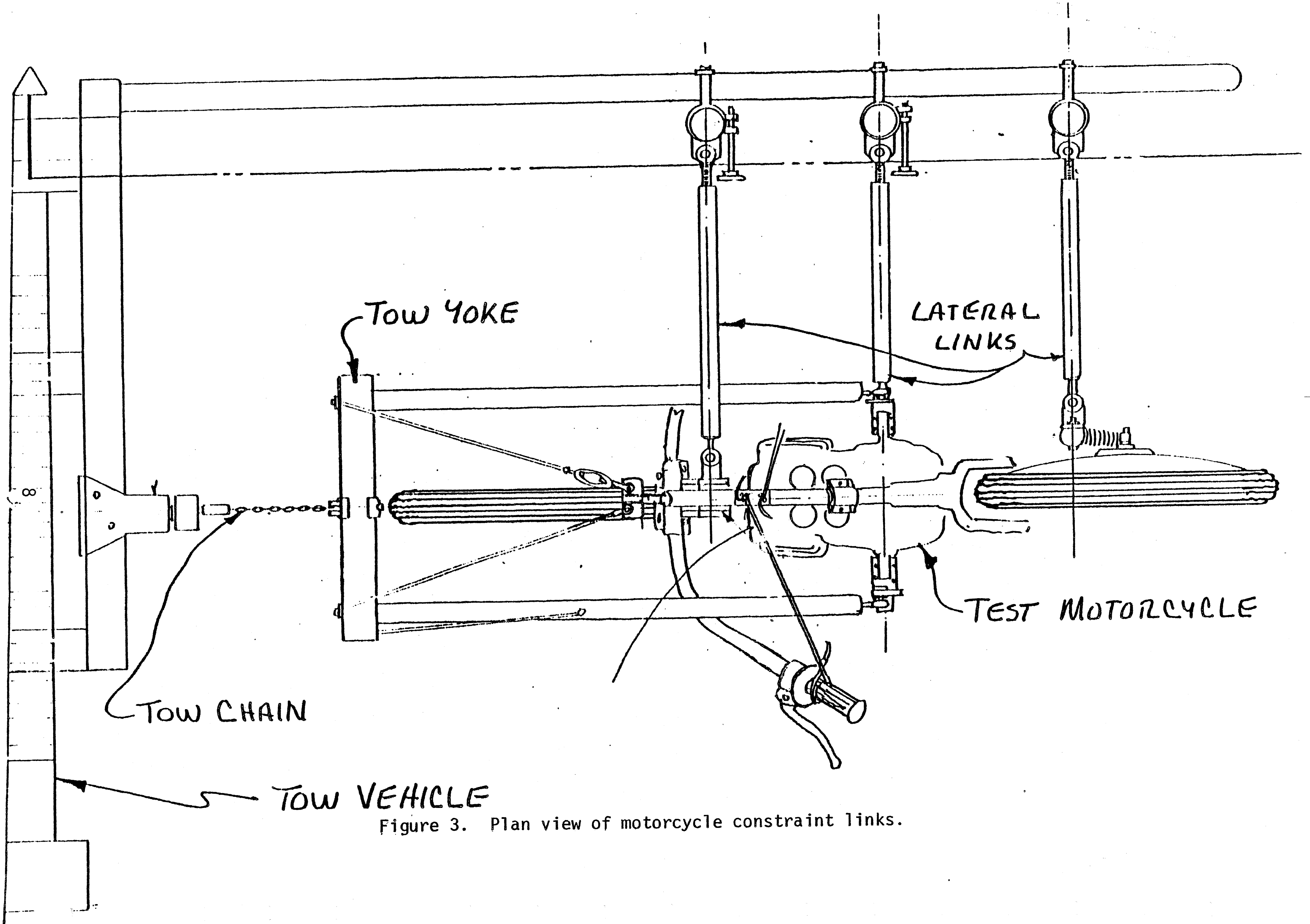


Figure 3. Plan view of motorcycle constraint links.

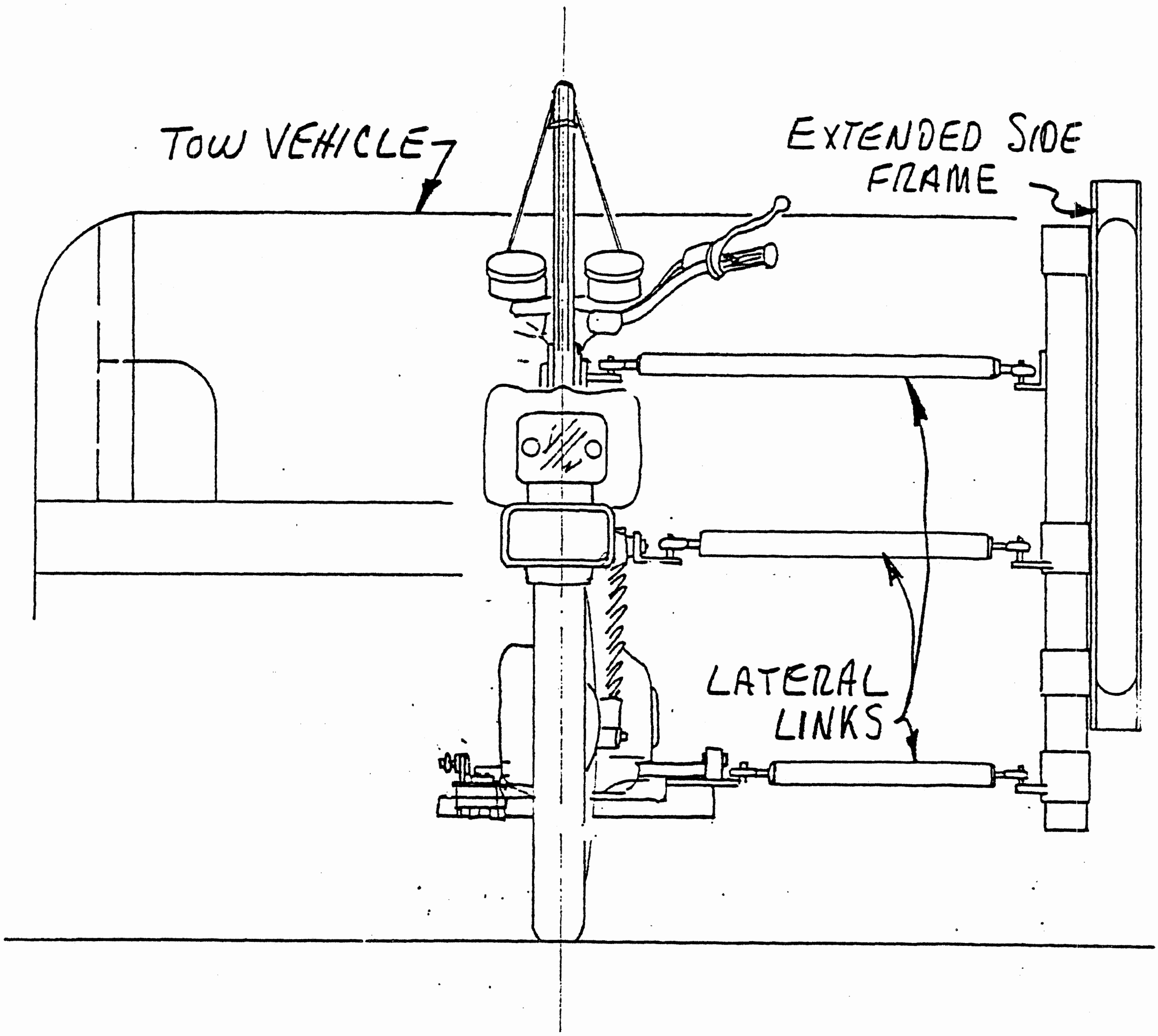


Figure 4. Rear view of motorcycle constraint links.

Figure 5 is a rear view of a motorcycle set up for demonstration testing. The lateral links are seen to serve as convenient members for routing instrumentation cabling and connectors.

Figure 6 is a close-up of the foot peg-attaching bracket. Note that the rubber foot peg sleeve has been removed and the foot peg welded to an intermediate plate which is bolted to the primary bracket. The towing yoke element (see as the tube at upper right in Figure 6) fastens to an extended tab on the foot peg bracket while the lateral link fastens by means of a tapped hole, as seen in the foreground. The foot peg bracket is welded to both pegs, and employs a rigid tublar piece spanning the underside of the motorcycle to connect both sides of the bracket.

Figure 7 shows the motorcycle test setup in the side view. The towing yoke is seen to be attached at the foot peg bracket and, by means of adjustable length cables, to the "strongback" element which fastens to the motorcycle frame at the normal position of the fuel tank. The strongback is connected, at its forward end, to the motorcycle frame by means of a pair of clamping plates with which the front frame section becomes "sandwiched." One hole is drilled through the front frame for fastening the strongback clamping plates, with shims of appropriate thickness, to the motorcycle. At the rear of the strongback, a separate bracket incorporates a short length of roller chain in a loop around the motorcycle frame as a versatile fastening element.

Figure 8 is a frontal view of the test motorcycle illustrating the adjustable cables extending from the top of the strongback to the two out-board sides of the towing yoke. Note that the lateral member of the towing yoke incorporates several holes permitting an adjustable spacing of the side strut elements to account for variations in width across the foot pegs of differing motorcycles. Along the length of both side struts, a pattern of holes is provided to permit adjustment of the height of the towing yoke. The height adjustment is effected by varying the free span of each cable between the towing yoke and the strongback. Locking pins at the end of each cable are inserted into the selected holes in the side struts to establish this adjustment.

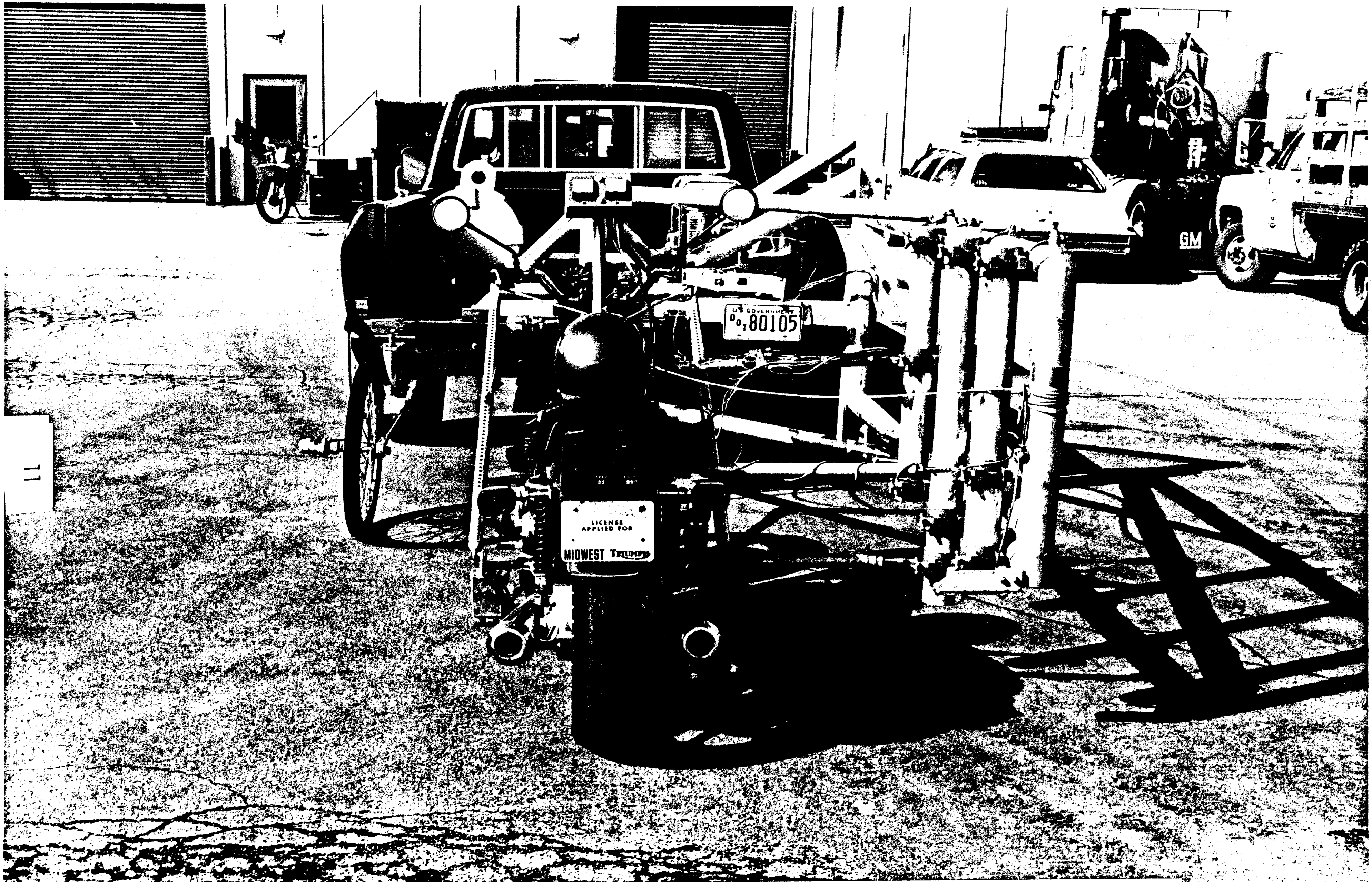


Figure 5. Rear view of Kawasaki KZ-1000 set-up for demonstration test.

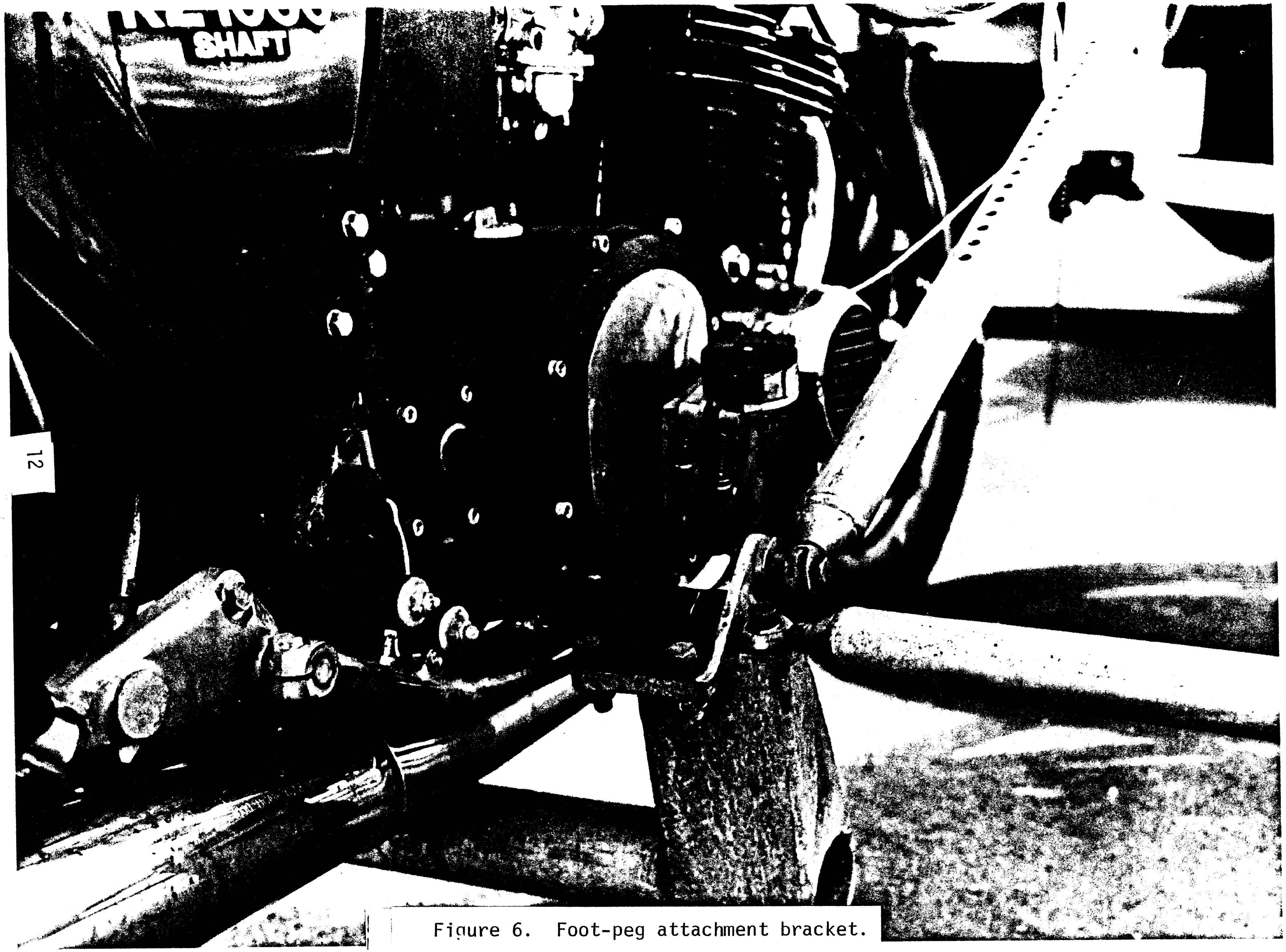


Figure 6. Foot-peg attachment bracket.

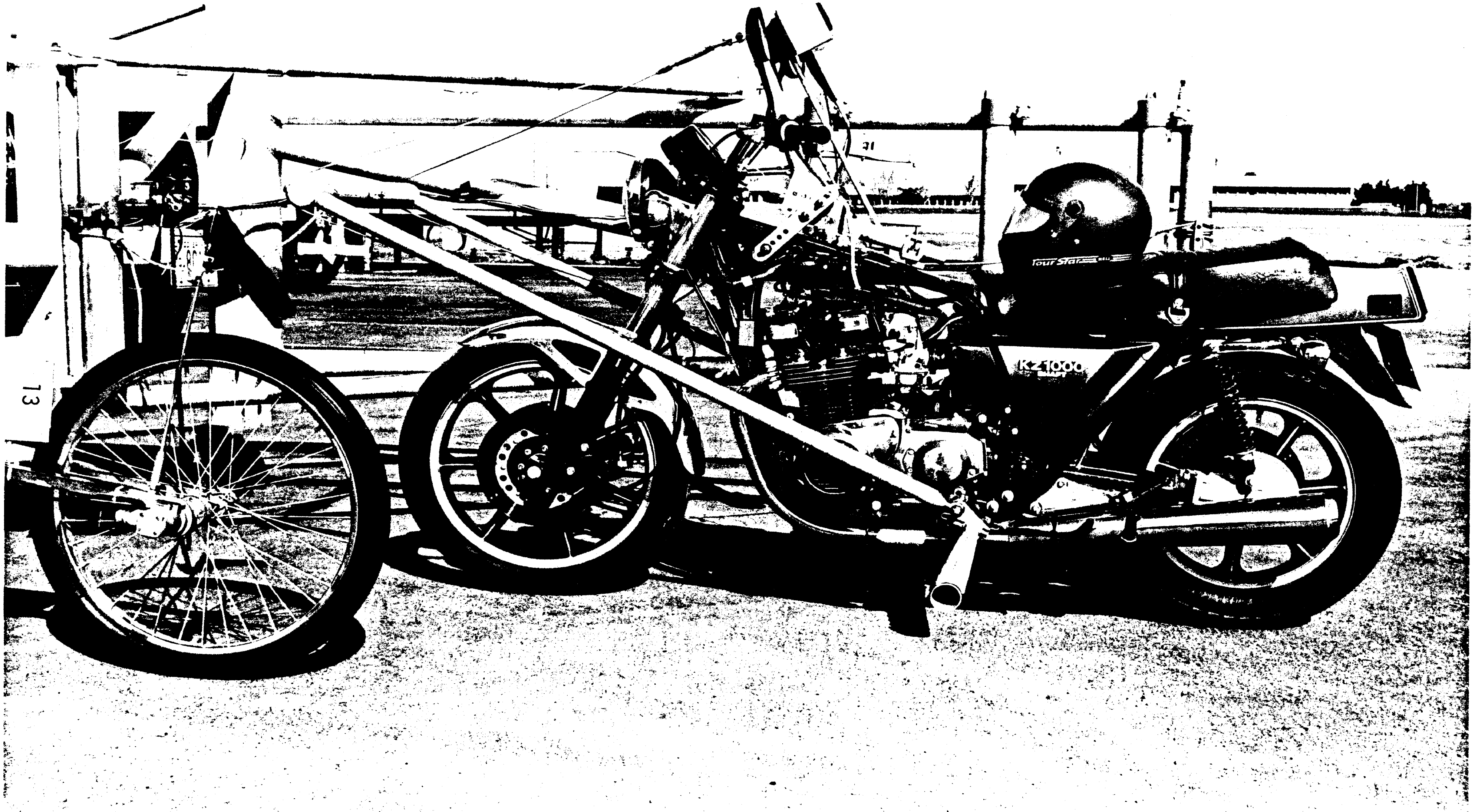


Figure 7. Side view of Kawasaki KZ-1000 set up for demonstration test.

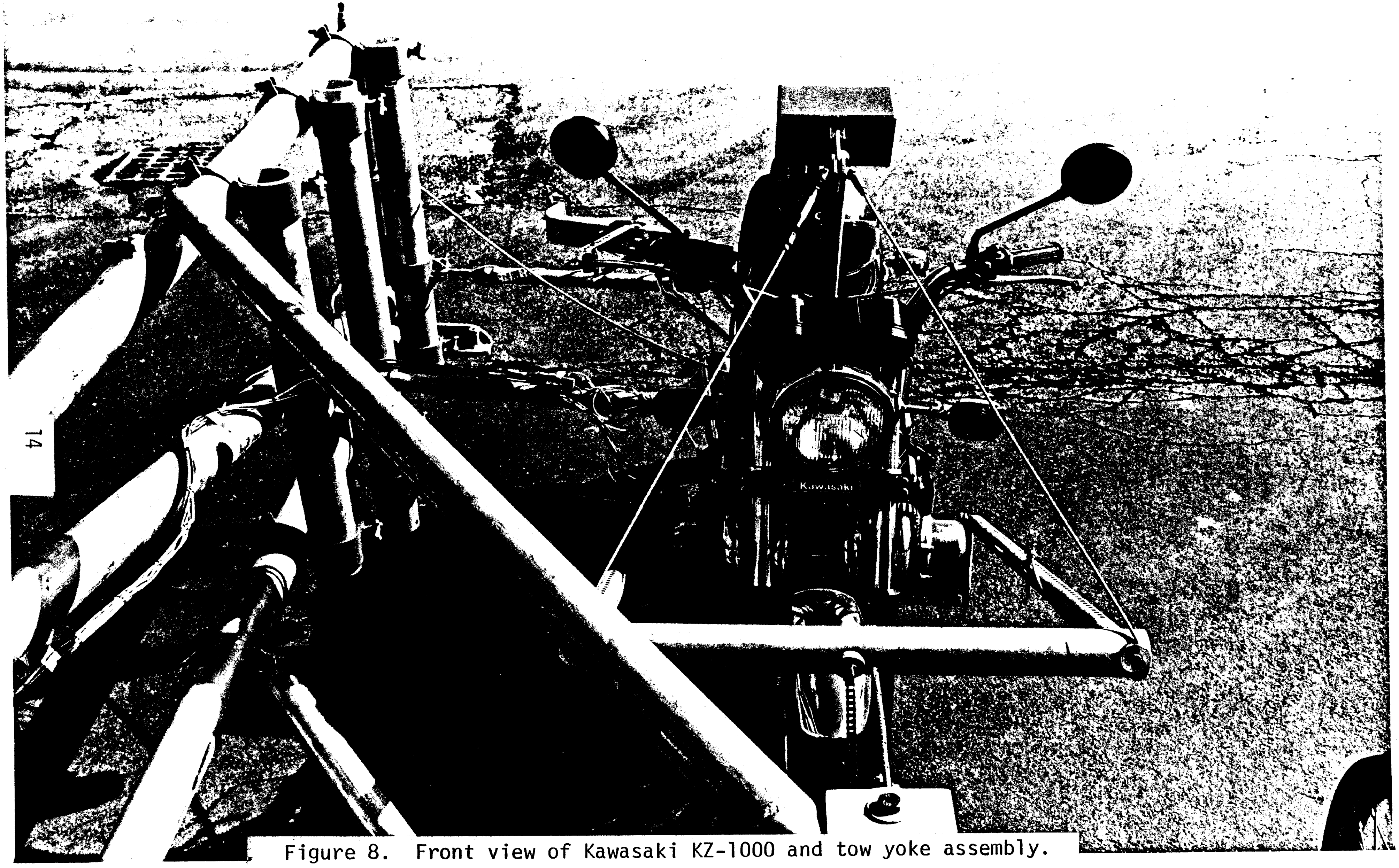


Figure 8. Front view of Kawasaki KZ-1000 and tow yoke assembly.

Shown in Figure 9 is the chain element which connects the towing yoke to the truck. The chain passes through a quick-release locking mechanism whose purpose is to permit an easy adjustment in effective chain length such as is needed each time the tow height is adjusted. (Note that tow chain length is dependent upon tow height because the towing yoke device is rotated about the foot peg bracket to effect a change in the height of the yoke. This rotation causes the distance from the yoke to the truck to vary, thus necessitating an adjustment in chain length.)

The chain-locking mechanism is fastened to the tow force load cell which, in turn, is fastened to a collar which clamps on a vertical column at the selected tow height. Above the chain-locking mechanism are mounted two electrical limit switches whose purpose is to detect the angular inclination of the tow chain. The inclination variable requires monitoring since the height of the towing yoke (and thus the aft-end of the chain) drops by a certain distance due to pitching of the motorcycle on its suspensions during braking. The switches are set such that an "OK" staus lamp is lighted in the tow vehicle cab when the inclination angle criterion is satisfied.

Two additional constraints can be seen the in rear-view photo presented previously as Figure 5. These items comprise a forward-stop cable connecting the motorcycle to the rigid side frame and a pair of short tether ropes between the handlebars and the strongback. The forward-stop cable provides restraint to the motorcycle when the tow vehicle is decelerating. (In normal test operations, the tow vehicle runs at constant velocity such that the forward-stop cable is slack, with the towing link reacting motorcycle braking force. When the tow-vehicle driver applies his brakes, however, the towed motorcycle would overrun the truck except for the constraint afforded by the forward-stop cable.)

The handlebar tether ropes serve to prevent oscillations in the motorcycle steering fork assembly. In early testing of the tow hardware system, it was observed that, even at very low speeds, a strong wobble oscillation occurred unless the motorcycle rider firmly restrained the motion of the

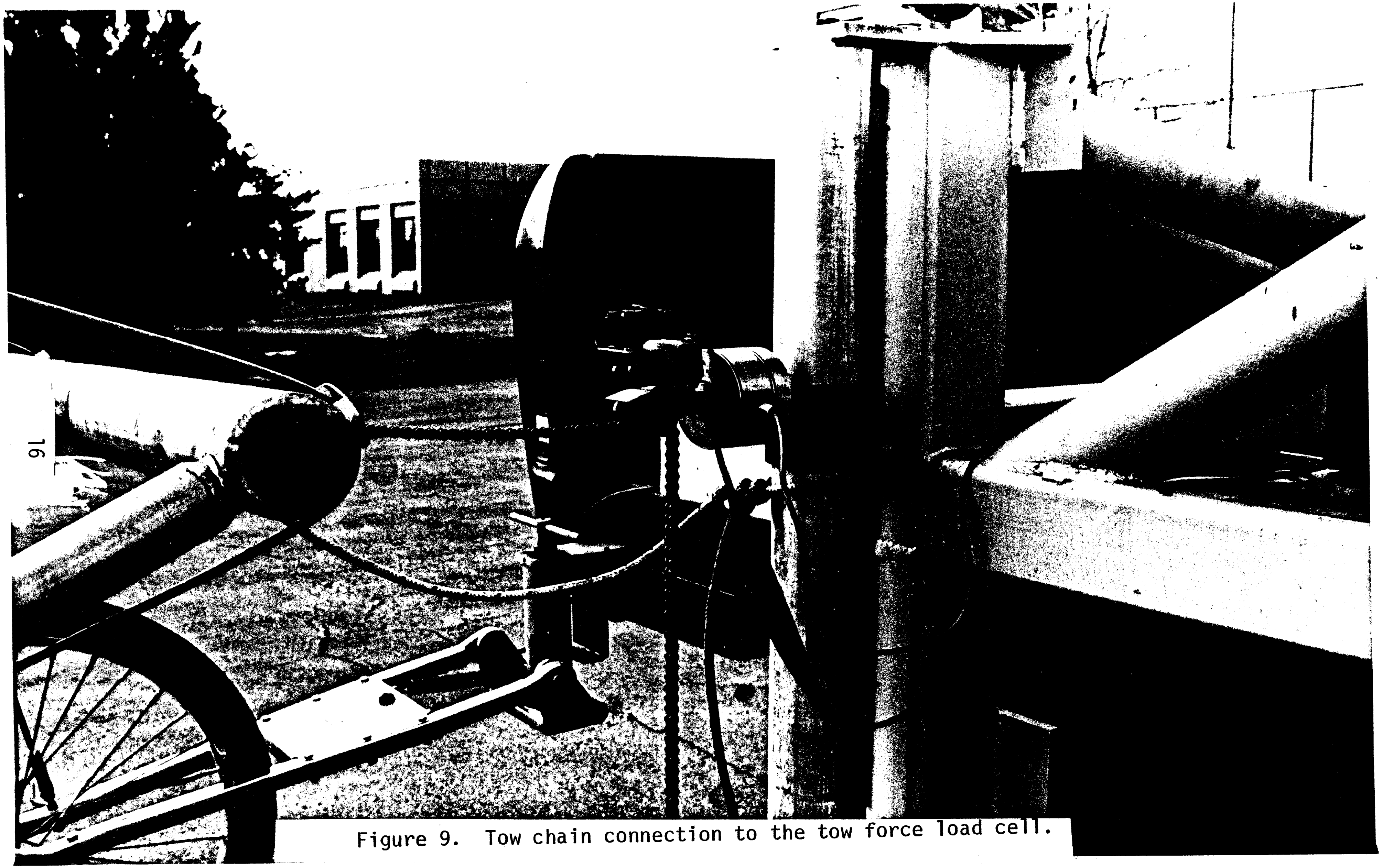


Figure 9. Tow chain connection to the tow force load cell.

handlebars. Using the handlebar tether ropes, the rider can "lash down" the steering freedom of the handlebars during all normal straight-ahead testing and then release the tethers to reduce strain on the motorcycle during short-radius maneuvering of the test vehicle. The tether ropes are clamped tight using a pair of sailboat-type jam cleats mounted on the strongback, as shown in Figure 10.

It should be noted that this package of tow-test apparatus, as described above, has been designed to accept any modern full-size motorcycle.

In addition to the apparatus which locates the motorcycle during testing, a self-contained hand-lever force transducer was also constructed. This device was developed to permit a ready measurement of the hand-lever force without requiring one to apply either strain gauges directly to the hand lever, itself, or to install a pressure transducer in the hydraulic brake line. Figure 11 shows the integral hand-lever force transducer developed in this project. This device is attached to the hand grip by means of a hose clamp and to the brake lever by means of a small clamping bracket. An end view of the hand grip in Figure 12 further illustrates the lever-attachment clamp. The device incorporates a pre-packaged force transducer which is placed in tension when the rider pulls on the curved outer end of the "wand." The device is clamped onto the hand grip such that the hand-lever force is nearly normal to the hand grip throughout the hand-lever stroke.

The remaining elements of test hardware are unchanged from conventional practice, as employed in the conduct of FMVSS 122—namely, the foot-pedal force transducer and the thermocouples installed in the front and rear linings are implemented according to normal practice. On most motorcycles, however, the foot-pedal force transducer must be shimmed up by approximately two inches to permit the rider to easily access the transducer with his foot.

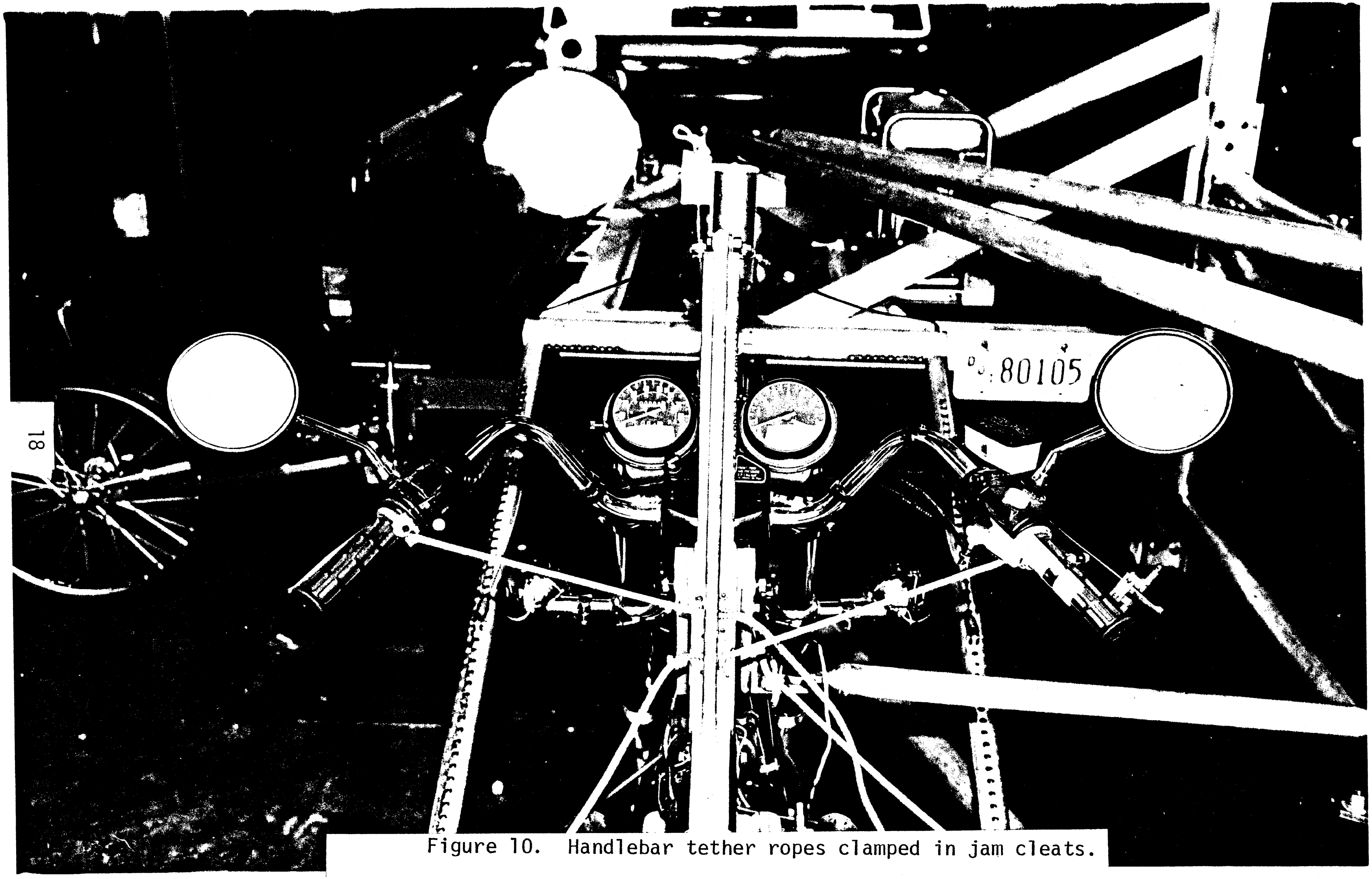


Figure 10. Handlebar tether ropes clamped in jam cleats.

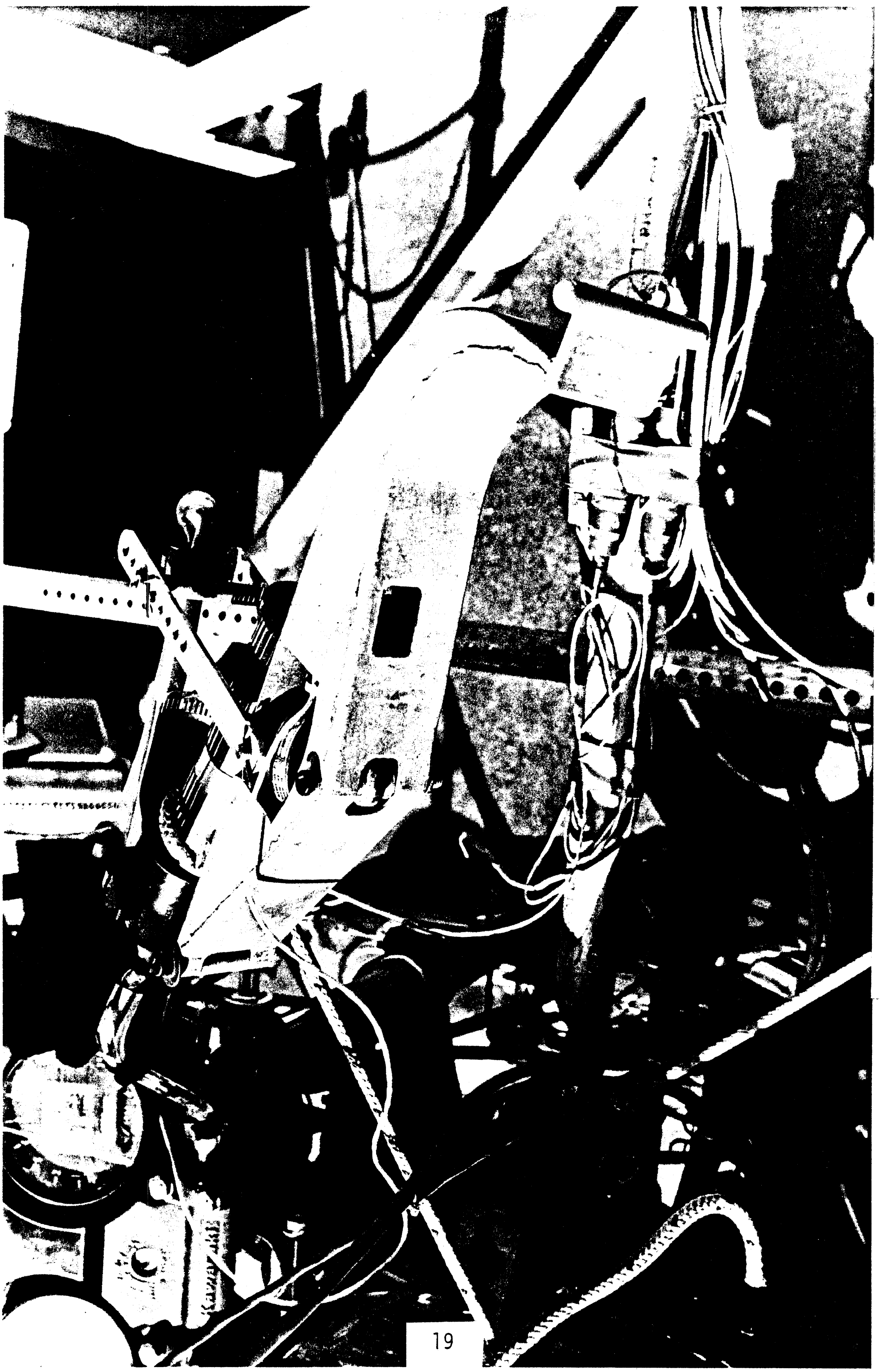


Figure 11. Hand-Lever Force Transducer.

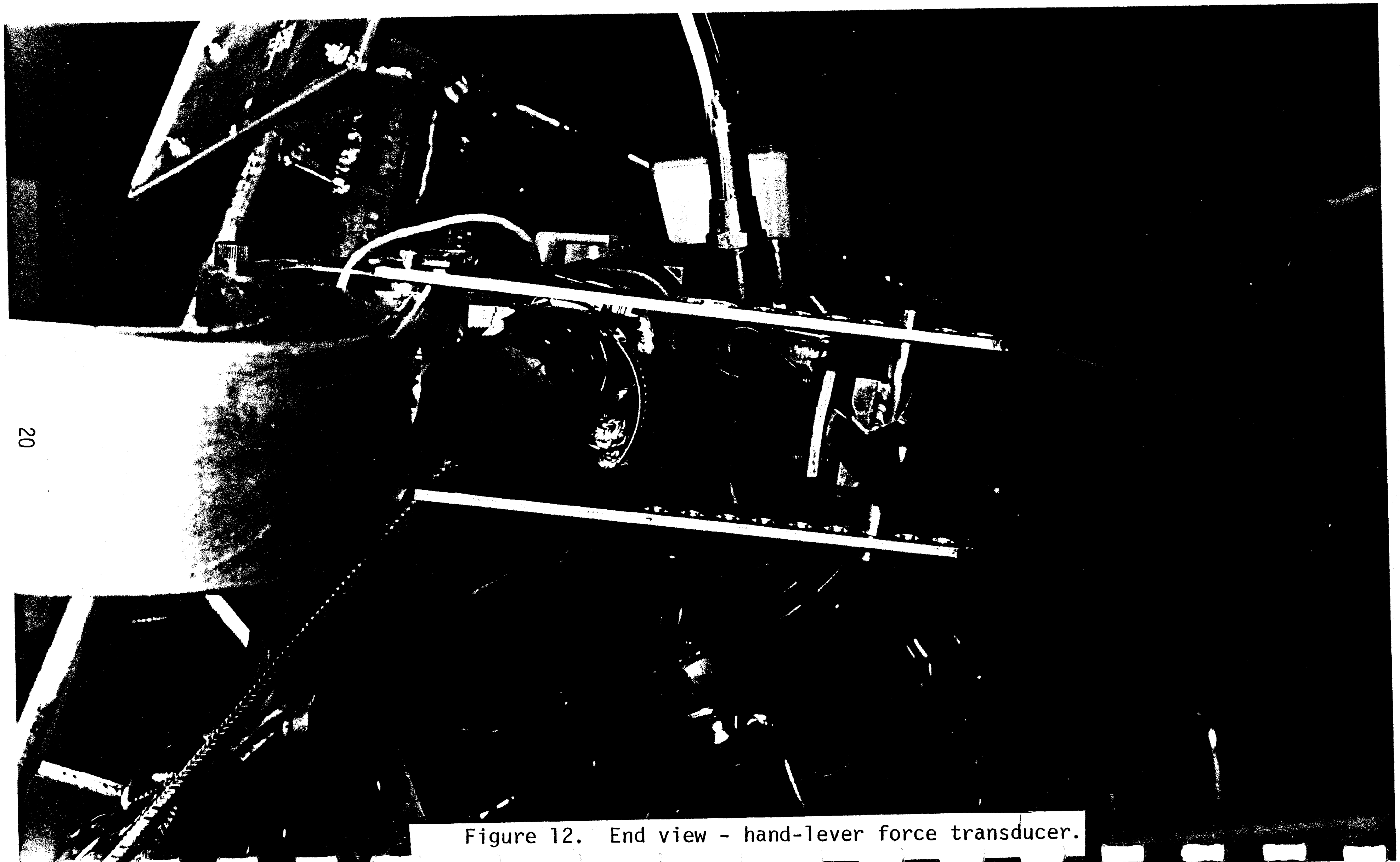


Figure 12. End view - hand-lever force transducer.

2.2 Instrumentation System

Figure 13 presents a pictorial schematic of the instrumentation system. The system incorporates a Hewlett-Packard HP 9825T computer and a HP 6940B multiprogrammer chassis. The multiprogrammer chassis, with its plug-in circuit cards, interfaces the sensors and the rider display with the computer. Figures 14, 15, and 16 present views of the instrumentation system installed in the cab of the tow vehicle.

The computer is programmed such that it will accept typed-in values of the test motorcycle's parameters and then guide the test operator through the entire procedure for effectiveness, burnish and thermal fade tests. The test operator advises the driver of the tow vehicle and, by means of a headset intercom, the motorcycle rider, on the actions required for each test.

Test data are outputted directly in the form of a printed paper tape record, while each test is underway, and by means of an automatically summarized paper tape printout after the computer reads information from a permanent record stored on a magnetic tape cassette at the conclusion of the test sequence.

A detailed description of the instrumentation system, together with the software program which was written to accommodate the step-by-step tow-test procedure, is given in Section 3.

2.3 Components List

The following is a list of components used in the construction of the tow-test instrumentation system. Some electronic components (resistors, capacitors, integrated circuits, etc.) not included in this list are specified in the various schematics shown in Section 3. Appendix 1 contains a list of the mechanical parts of the system and a bill of materials.

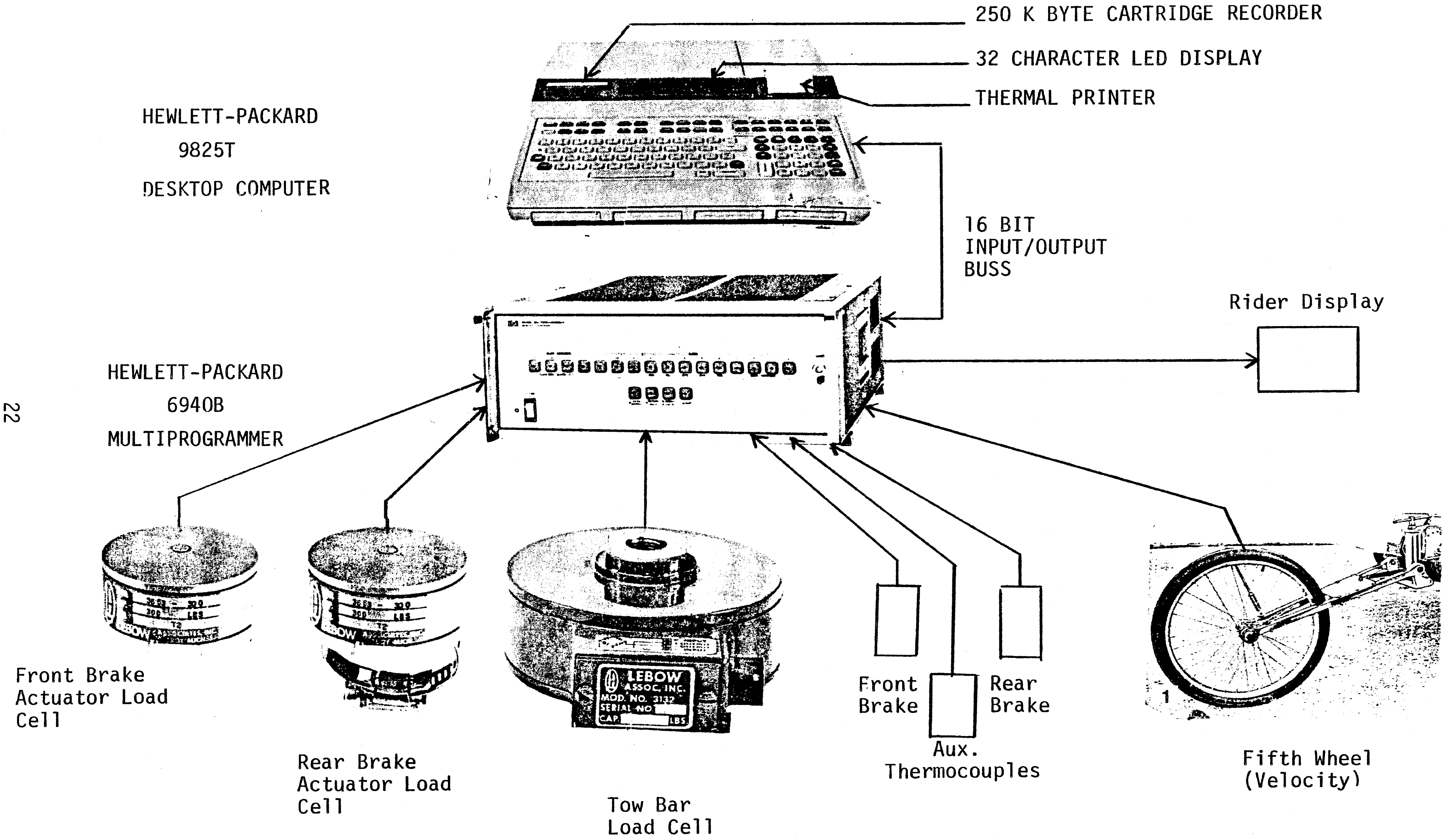


Figure 13. Pictorial schematic of the instrumentation system.

Figure 14. Cab interior showing computer in background and interface module, or multiprogrammer, in foreground (under the table).

Figure 15. Cab interior showing computer in foreground and intercom amplifier, 12-volt regulator, and tow-angle indicator in background.

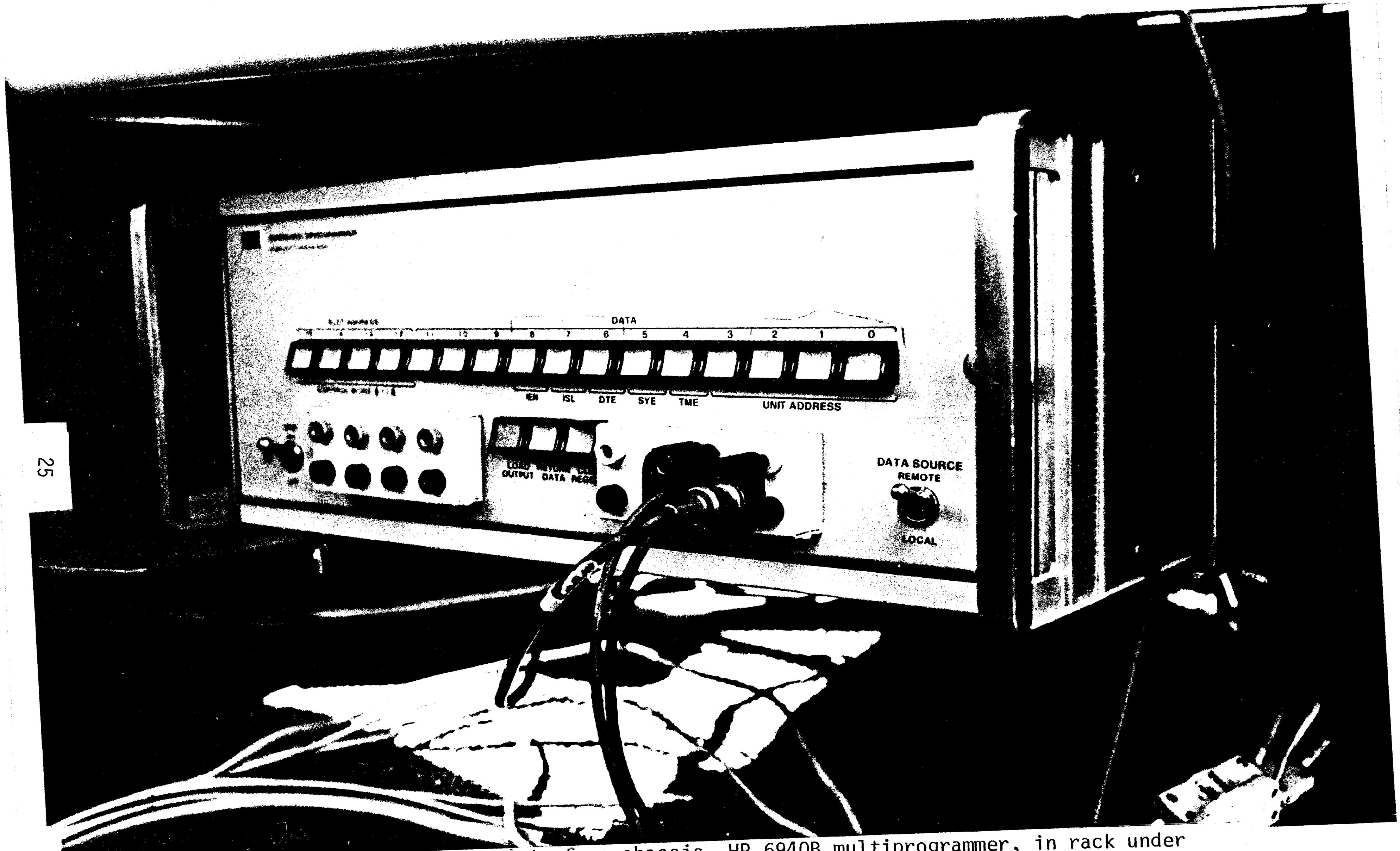


Figure 16. Computer interface chassis, HP 6940B multiprogrammer, in rack under the table in truck cab.

1 - Hewlett-Packard, HP 9825T Desktop Computer

1 - Hewlett-Packard, HP 6940B Multiprogrammer

4 - HP 69422A High-Speed A/D Converter Cards

1 - HP 69423A Low-Level A/D Converter and Scanner Card

1 - HP 69331A Digital Output Card

1 - HP 69322A Quad D/A Voltage Converter Card

1 - HP 69601A Frequency Reference Card

1 - HP 69351B Voltage Regulator Card

1 - HP 69280A Breadboard Card

1 - HP 98035A Real Time Clock

1 - HP 98032A 16-Bit I/O Card with Cable

2 - HP 5060-7901 Extender Cards

1 - HP 14556A Software Library of Utility Subroutines

Expendables:

HP 9270-0479 6-roll pack of printer paper

HP 98200A 5-pack of tape cartridges

1 - HSRI Quad Signal Conditioning Card (constructed with the HP 69280A breadboard card)

1 - Laboratory Equipment Corp. LABLO Fifth Wheel with Tachometer

2 - Lebow Model 3663-200 Pedal Force Load Cells

1 - Lebow Model 3169-1000 Load Cell

1 - Honda E1500 K4 Motor Generator

1 - Bell Motorcycle Helmet with HSRI-Installed Microphone and Speaker

1 - Telex Head-Set with Boom Mike

1 - HSRI Intercom Amplifier Box

1 - HSRI Rider Display Box

1 - HSRI 12-VDC Regulator Box

1 - HSRI Tow-Chain Angle Indicator Box

1 - Set of HSRI System Interconnection Cables

3.0 DETAILED DESCRIPTION OF THE INSTRUMENTATION SYSTEM

In this section, the instrumentation system is described in detail. The description, together with the manufacturers' manuals on the commercial components used in the system, provides sufficient information for system calibration and maintenance by technical personnel. Included are descriptions and schematics of all circuits not covered in the manufacturers' manuals, cable and wiring diagrams, calibration procedures, and a thorough discussion of the system software program.

3.1 Honda Motor Generator and 12-VDC Voltage Regulator

Prime power, 115 VAC, 60 Hz, and unregulated 12 VDC, are supplied by a 1500-watt Honda motor generator mounted in the bed of the tow truck, as seen in Figure 2. AC power is distributed to instruments in the truck via a switchable AC distribution plug strip located behind the computer (Figure 15).

The 12-VDC generator output is intended for battery charging. It is unregulated and has a peak voltage of about 25 volts at zero load. A voltage regulator, located in the box on top of the intercom amplifier box in the upper left rear corner of the truck cab (Figure 15) regulates the generator DC output to 12 volts. The regulated output is then distributed to the intercom, the rider's display box, and the tow angle indicator circuits. A schematic of the regulator circuit is shown in Figure 17.

3.2 Intercom Amplifier

An intercom provides continuous two-way communications between the system operator and the motorcycle rider. An inexpensive lapel mike and a pillow speaker are mounted inside the rider's crash helmet. A head-set with one earphone and a boom mike is provided for the operator. The intercom amplifier, mounted in the upper left rear corner of the truck cab (Figures 14 and 15), has separate volume controls for the rider and operator. A schematic of the amplifier circuit is shown in Figure 18.

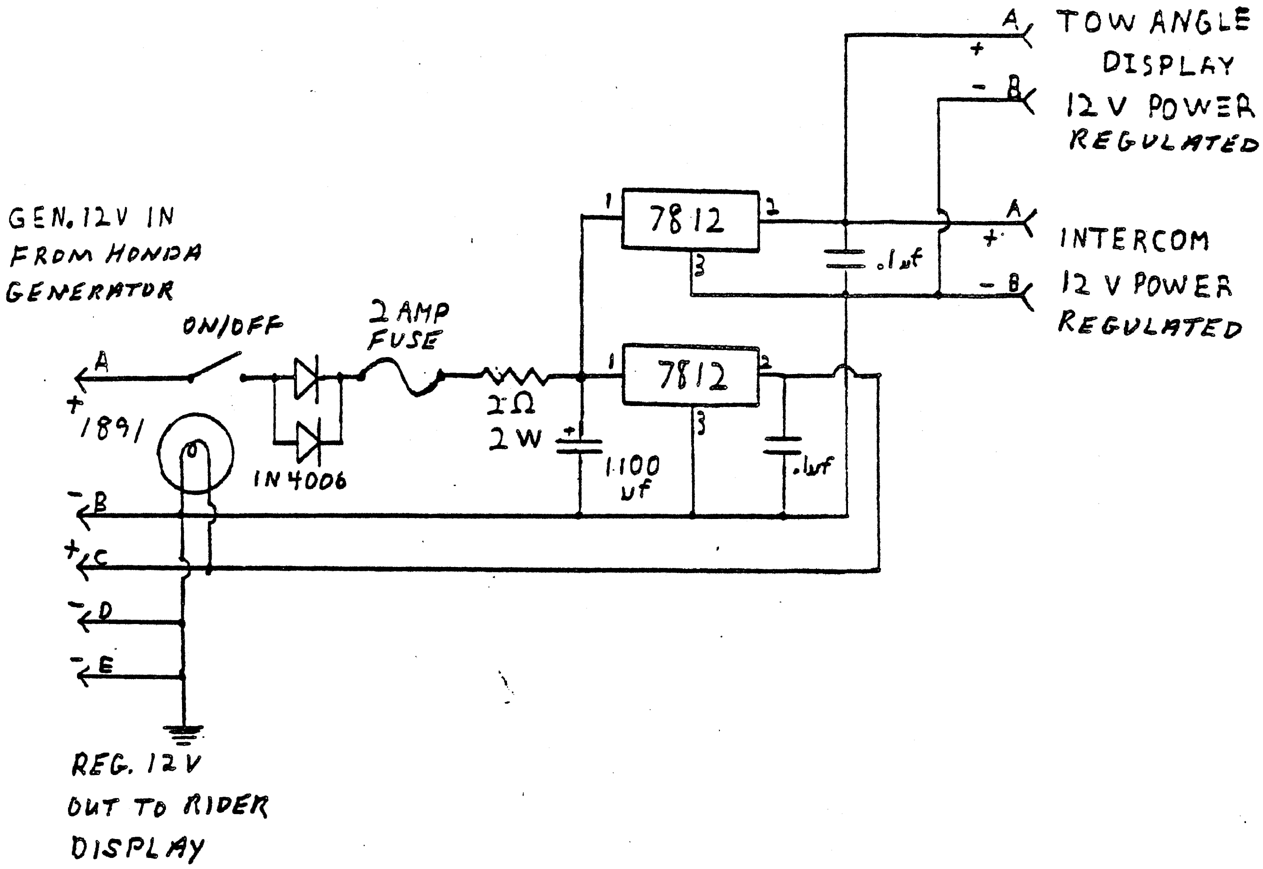


Figure 17. Schematic of the 12-VDC regulator circuit.

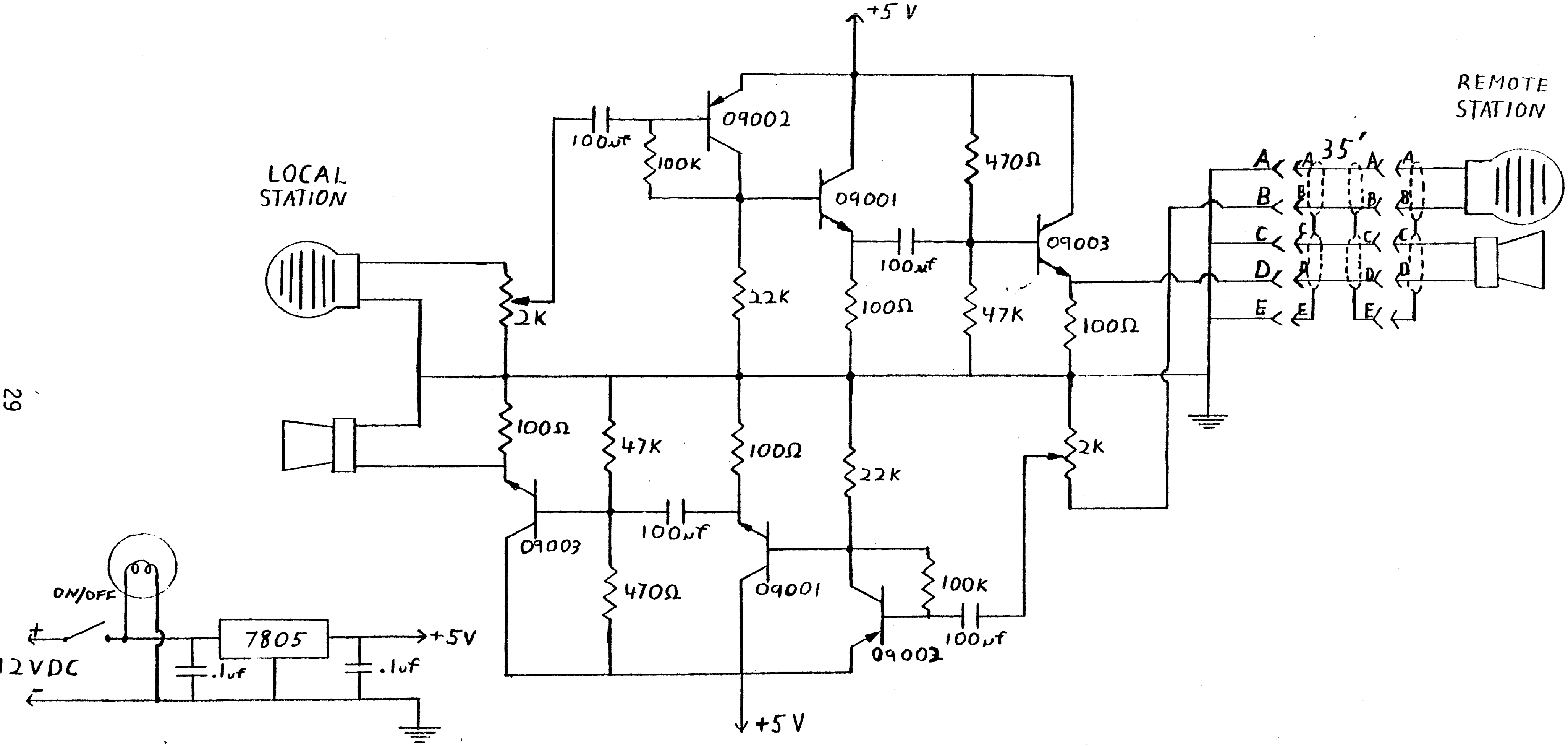


Figure 18. Schematic of the intercom amplifier circuit.

3.3 Tow-Chain Angle Indicator

The tow angle indicator consists of three lamps in a box mounted in the upper left rear corner of the truck cab (Figures 14 and 15). The lamps are switched on by two microswitches which are actuated by a lever in the tow-chain adjustment mechanism located by the tow-force load cell (Figure 9). Red (HI), green (GO), and yellow (LO) indicate that the tow-chain angle with respect to horizontal is high, within required limits, or low, respectively. The microswitches are adjusted so the green (GO) lamp is on for tow angles between $\pm$ 3 degrees. This tolerance is established by setting the two respective microswitches to close at switch deflections which are plus and minus .080 inches from the condition of a horizontal tow chain inclination. A schematic of the tow angle indicator circuit is shown in Figure 19.

3.4 Rider Display

The rider display box mounted on top of the strongback bar, as seen in Figures 5 and 7, contains two meters and two lamps. Either the front or rear actuator force, selected by the computer, is displayed on the meter on the right. Full-scale deflection is 100 lbs. In those tests which require a brake application to achieve a constant tow-bar force, the tow-bar force error, that is, the difference between the required and the actual tow-bar force, is displayed on the null meter on the left. Full-scale deflection on the null meter is scaled by the computer to be equal to the required tow-bar force for each test.

The two lamps, controlled by the computer, are turned on to tell the rider when to apply the front brake (top lamp) or the rear brake (bottom lamp) and turned off when the rider is to release the brake. Figure 20 shows a schematic of the rider display box circuits.

3.5 Thermocouples

Chromel-Alumel (Type K) thermocouples are used to sense the front and rear brake pad temperatures, and the ambient temperature. The computer

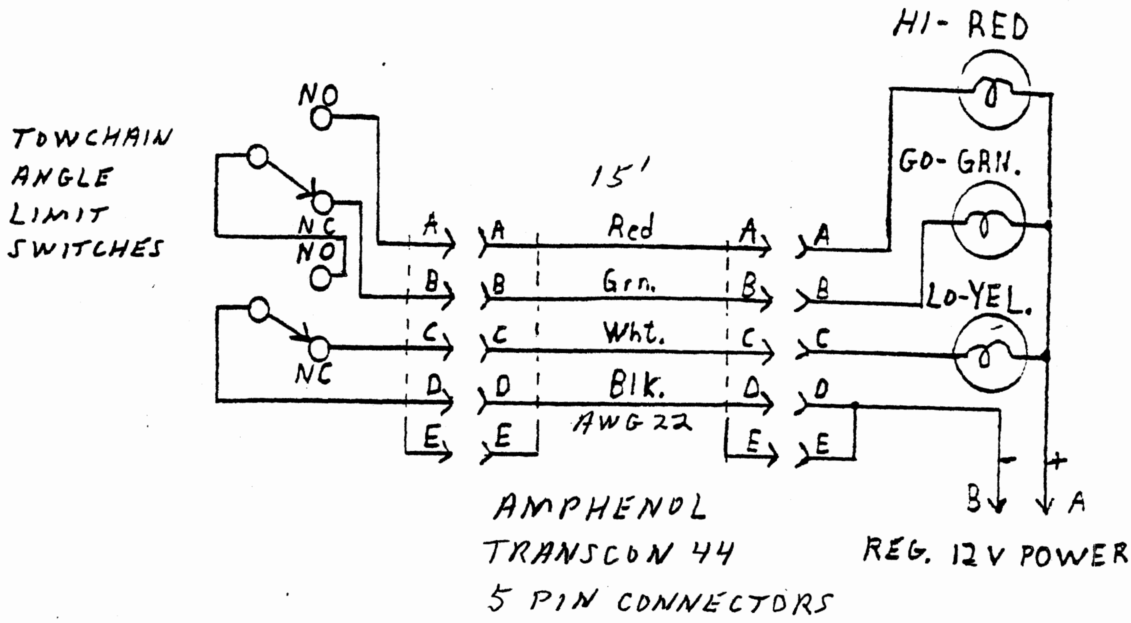


Figure 19. Schematic of the tow angle indicator circuit.

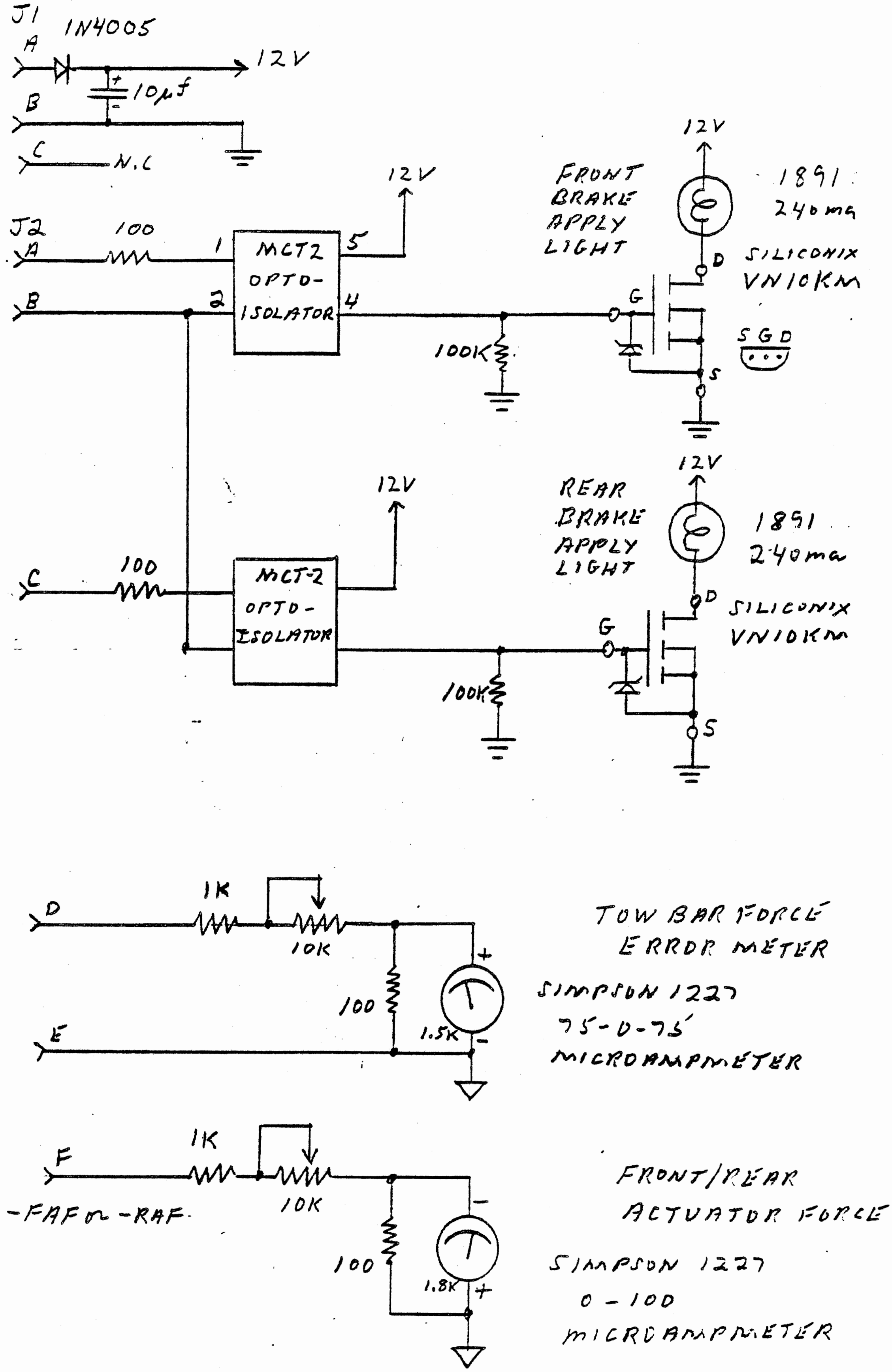


Figure 20. Schematic of the rider display box circuits.

is programmed to convert type K thermocouple outputs to temperature readings in degrees fahrenheit. Use of other thermocouple types will result in erroneous readings. The thermocouples are mounted in the brake pad according to SAE standard practice.

3.6 Data Acquisition and Control System

A Hewlett-Packard automatic measurement and control system is used to control the motorcycle brake test system and to acquire, process, display, and store data. The Hewlett-Packard system consists of an HP 9825T desktop computer and an HP 6940B multiprogrammer. These units are shown in the pictorial diagram in Figure 13. Their location in the motorcycle tow vehicle is shown in Figures 14, 15, and 16.

The multiprogrammer interfaces the computer with the external sensors and display elements. Digital control signals and data are transferred between the multiprogrammer and the computer on a 16-bit bi-directional buss.

Each time the computer is powered up, the Motorcycle Brake Test Program must be loaded from the program tape cartridge. After the program is loaded, specific operations or data collection procedures are initiated when the operator presses specific keys on the computer keyboard. Data is stored on a data tape cartridge. Hard copy of data is obtained on the thermal printer. System messages, current data such as velocity and brake temperature, and other information required by the operator are displayed on the 32-character LED display or output on the thermal printer.

The multiprogrammer accepts a variety of standard HP plug-in circuit cards. Cards installed for implementation of the Motorcycle Brake Test System are called out in the parts list in Section 2.3. Detailed operation and maintenance information on the Hewlett-Packard equipment is contained in separate Hewlett-Packard manuals. The following is a detailed description of (1) the interconnections between the circuit cards, and between the circuit cards and the external sensors, test jacks, and displays; (2) the circuits on the breadboard card; and (3) the system operating program.

3.6.1 System Interconnections and Signal Paths. All external connections to the circuit cards and interconnections between the circuit cards, except power supply distribution, are made via "front-plane" wiring at connectors on the front of each card located behind the hinged front panel of the multiprogrammer. Cables from these connectors pass below the card cage and exit from the rear of the multiprogrammer box. The card cage back-plane wiring connects the circuit cards with the multiprogrammer power, control, and computer interface circuits and is described in the Hewlett-Packard Multiprogrammer Manual.

Figure 21 is a block diagram of the front-plane connections and signal paths. Specific circuit cards must be plugged into the numbered card slots as shown on the block diagram.

Signals from the three load cells and the fifth wheel go to the breadboard card in slot 406, where they are amplified, filtered and then output to the four A/D (analog-to-digital) converter cards, in slots 401 to 404, and to the analog signal test jacks on the left side of the multiprogrammer front panel (Figure 16). Full-scale signal amplitude at the test jacks is 10 volts. Signal conversion factors are:

Front Actuator Force, FAF	20 lbs/volt
Rear Actuator Force, RAF	20 lbs/volt
Tow-Bar Force, TBF	100 lbs/volt
Velocity, V	10 mph/volt

Analog-to-digital conversions by the four A/D converter cards are initiated by a common trigger signal from the breadboard card. When the A/D conversions are completed, about 30 microseconds after a trigger, the A/D card in slot 403 generates an interrupt to the computer which then reads the digital data outputs from one or more of the four A/D cards as required for the particular test in progress.

An A/D conversion rate (trigger frequency) of 0, 1, 10, or 100 Hz is selected under computer control through the Digital Output Card in slot 409 and an electronic switch on the breadboard card. Inputs to the electronic switch are 1, 10, and 100 Hz square waves from the Frequency Reference Card in slot 408, and conversion-frequency select logic, bits B00 and B01, from the Digital Output Card in slot 409.

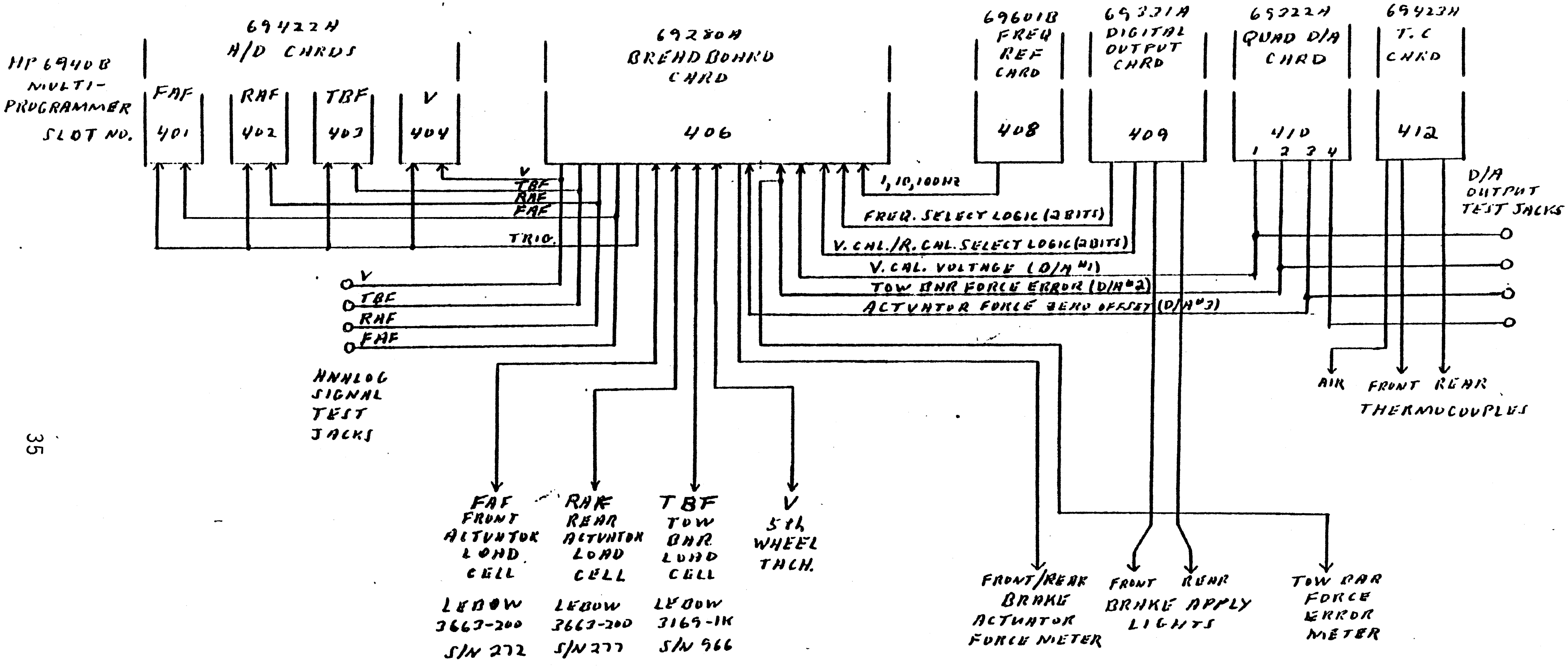


Figure 21. Diagram of the multiprogrammer card front-plane connections and signal paths.

The four analog data channels, FAF, RAF, TBF, and V, are checked and calibrated under computer control through relays on the breadboard card. The relays disconnect the sensors and switch a calibration voltage into the amplifier inputs in the V CAL mode or switch a shunt calibration resistor across one arm of the load cell strain gauge bridge circuits in the R CAL mode. The relays are controlled by the V CAL/R CAL select logic, bits B03 and B02, respectively, from the Digital Output Card in slot 409. A precision calibration voltage, set by the computer, is obtained from D/A #1 (digital-to-analog converter) on the quad D/A card in slot 410.

Voltage to the Tow-Bar Force Error Meter is generated in the computer and output to the meter through D/A #2. Although this signal is also wired to the breadboard card connector, it is not used on the breadboard card.

The Front/Rear Actuator Force Meter receives voltage from an analog summing amplifier located on the breadboard card. This amplifier subtracts the actuator force Zero Data Offset Voltage, supplied from the computer via D/A #3, from the actuator force analog voltage and outputs the result to the meter. A relay on the breadboard card controlled by the F/R actuator force logic, bit B06, from the Digital Output Card, selects the front or rear actuator force analog signal for the summing amplifier input.

The D/A converter outputs, from the quad D/A card, are connected to the four D/A output test jacks on the right side of the multiprogrammer front panel (Figure 16).

Thermocouple readings are made by the computer through the low-level A/D converter and scanner card, or thermocouple card, in slot 412.

Figure 22 shows the wiring diagram of the multiprogrammer card front-edge connectors. Note that outputs from the frequency reference card and the digital output card enter the breadboard card on a 14-pin dip plug. Figures 23 and 24 are diagrams of the system interconnection cables.

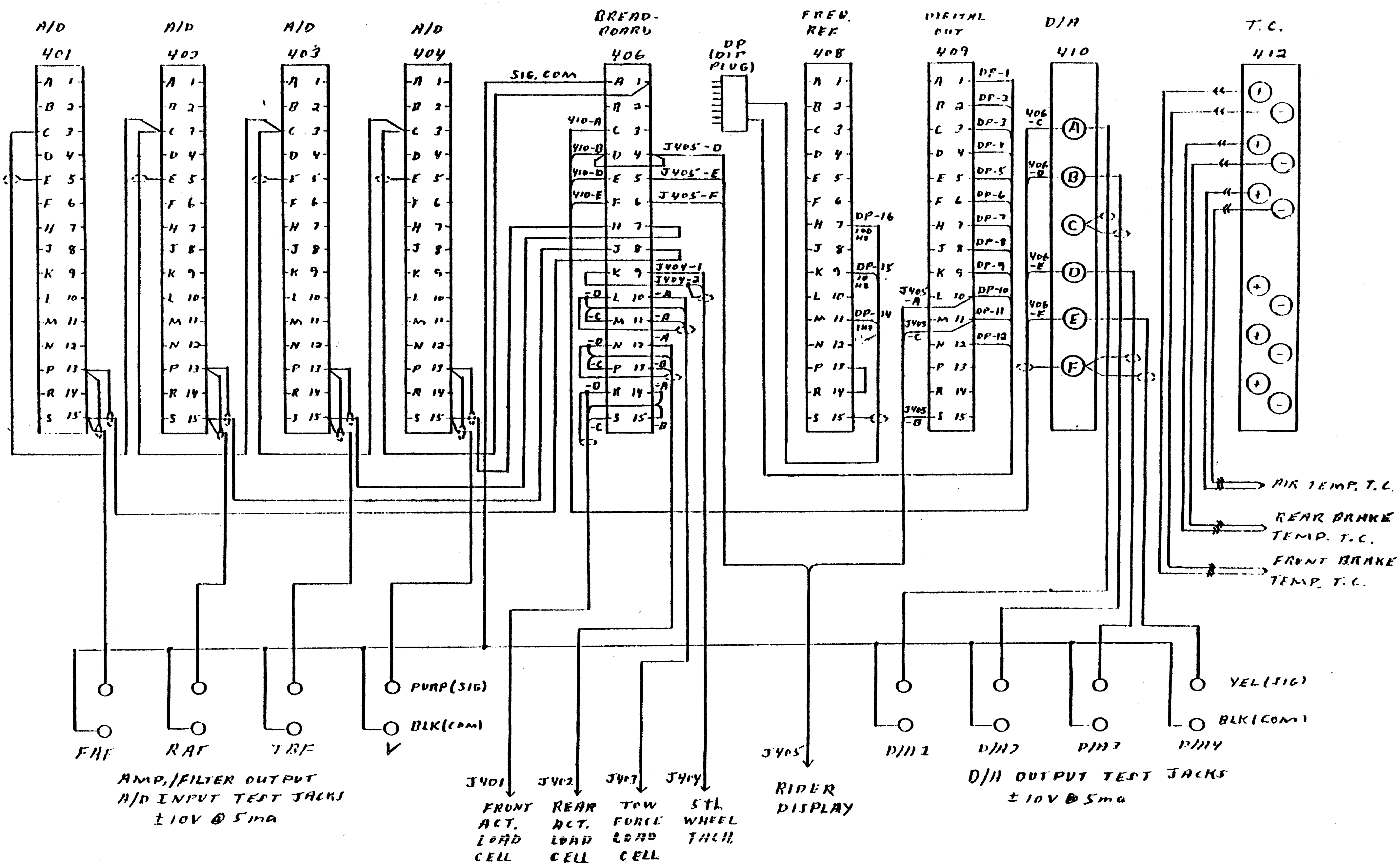


Figure 22. Wiring diagram of the multiprogrammer card front edge connections.

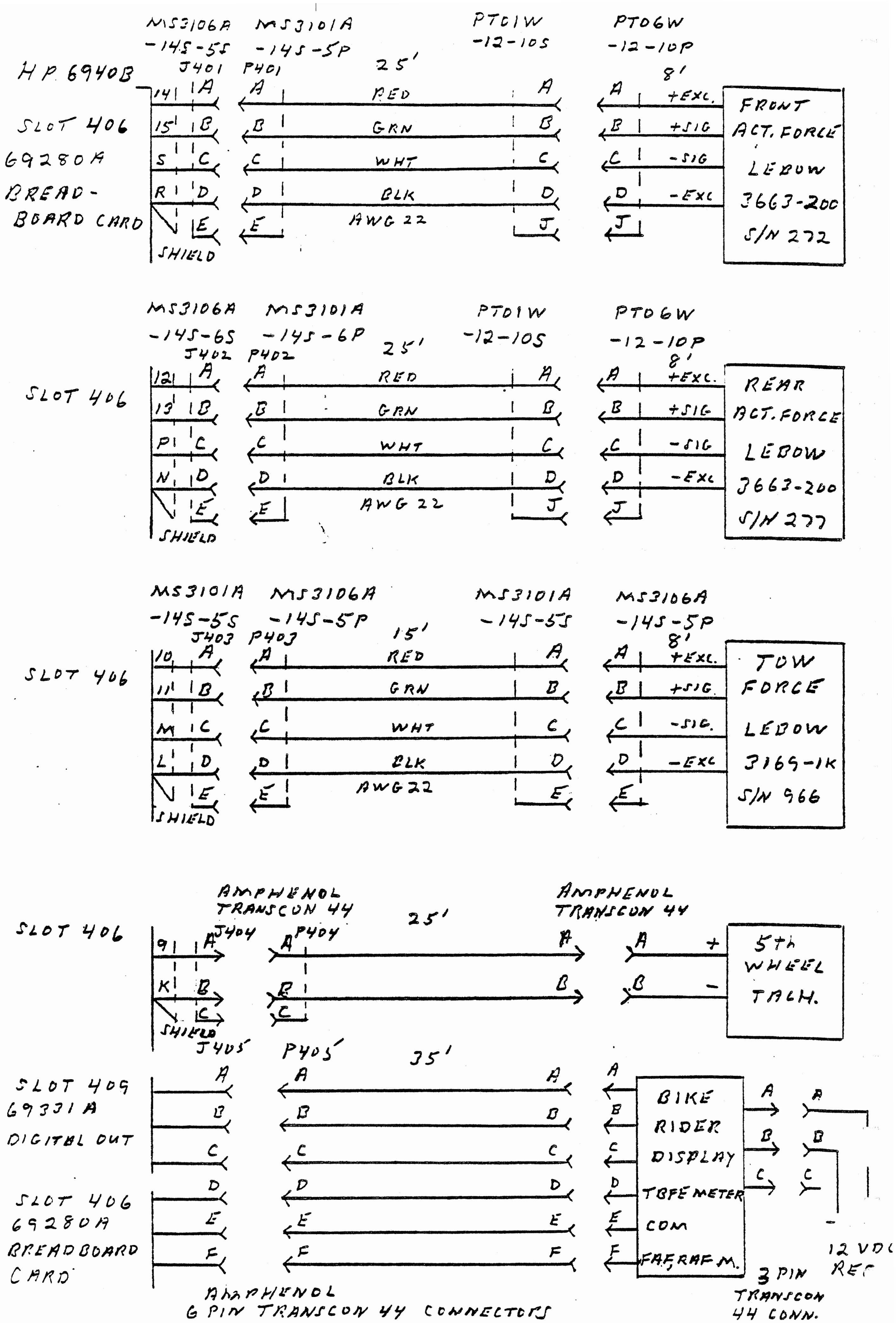


Figure 23. System interconnection cables—multiprogrammer to sensors and rider display.

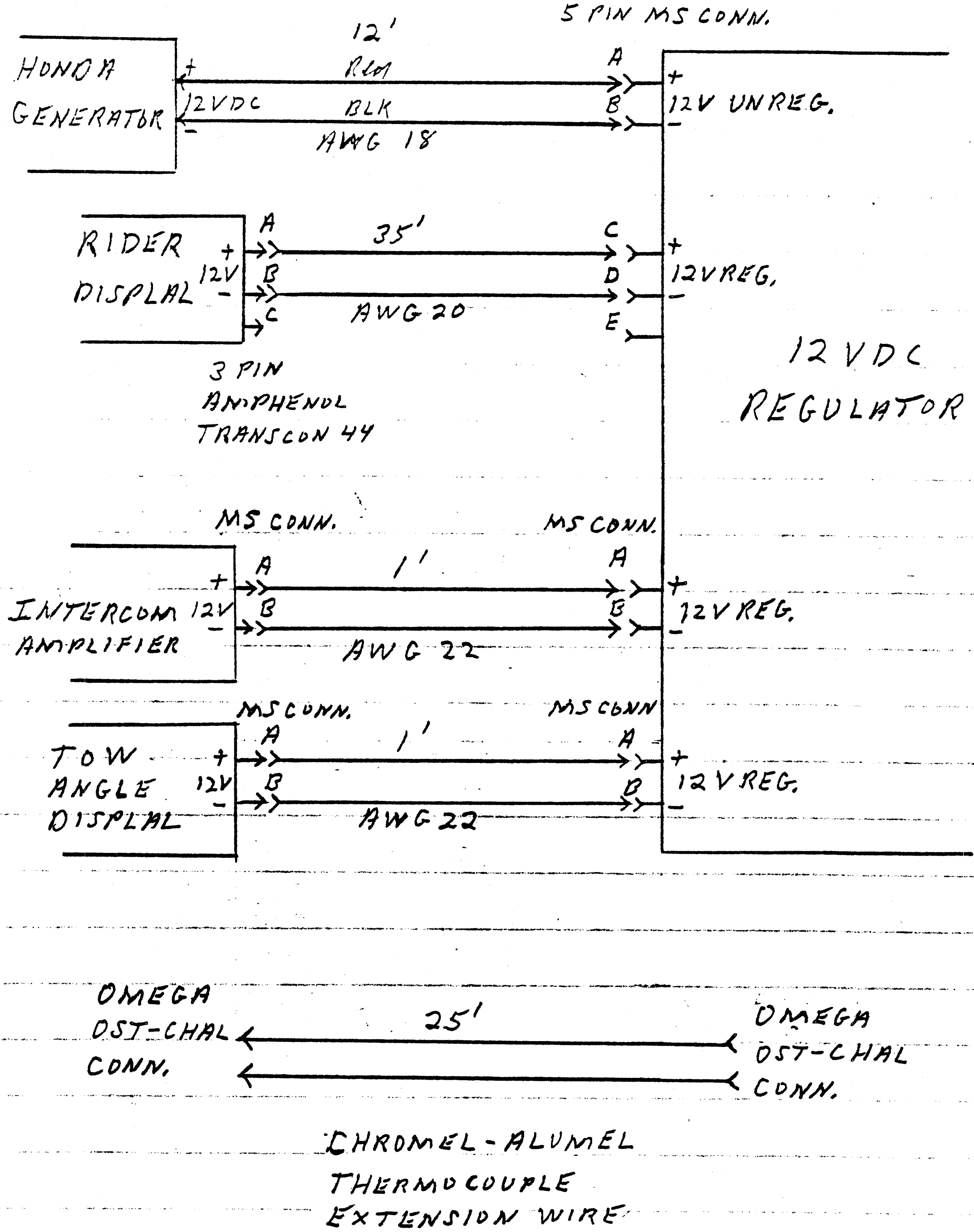


Figure 24. System interconnection cables.

3.6.2 Breadboard Card Circuits. Circuits constructed on the breadboard card are shown in detail in the schematics in Figures 25 through 29. An Analog Devices 2B31J amplifier-filter signal conditioning module is used in each of the four analog data channels shown in Figures 25 and 26. The 2B31J contains an instrumentation amplifier, a resistor-capacitor programmable 3-pole low-pass filter, and a regulated voltage source for bridge excitation.

The three load cell channels are almost identical. The bridge excitation voltages at TP5, TP6, and TP7 are set to 10.00 volts by the excitation adjustment potentiometers connected between pins 22 and 25 of each module. Three other calibration potentiometers in each load cell channel are for Fine Gain, Output Offset, and Bridge Balance adjustments. Output from each load cell bridge is connected to its respective amplifier input terminals through the normally closed contacts of the V CAL relays K2, K4, K6, and K7. Signals are connected to the amplifier inputs in the polarity required to produce a positive voltage output at pin 7 of the signal conditioning module for tension on the tow force and front actuator force load cells and for compression on the rear actuator load cell.

The calibration voltage, V CAL, from D/A #1, enters the breadboard card on pin C. V CAL is attenuated by a factor of 1000 by a precision resistor divider to obtain V CAL/1000 which is connected to one normally open contact, pin 1, of the V CAL relays. The other normally open contact, pin 8, of the V CAL relays is connected to signal ground. A high logic level on bit B03 from the Digital Output Card, entering the breadboard card on pin 4 of the dip socket, actuates the V CAL relays through VN 10 KM FET (field effect transistor) relay drivers. Each FET controls two relays. Actuation of the V CAL relays ties one input of the load cell amplifier to ground and applies V CAL/1000 to the other input.

The R CAL relays, K1, K3, and K5, switch a precision 100K ohm shunt calibration resistor across one arm of each load cell bridge producing calibrated load cell outputs. A high logic level on bit B02 from the Digital Output Card entering the breadboard card on pin 3 of the dip socket actuates the R CAL relays. The shunt calibration resistors are placed across an arm of the bridge resulting in a positive output from the amplifier module.

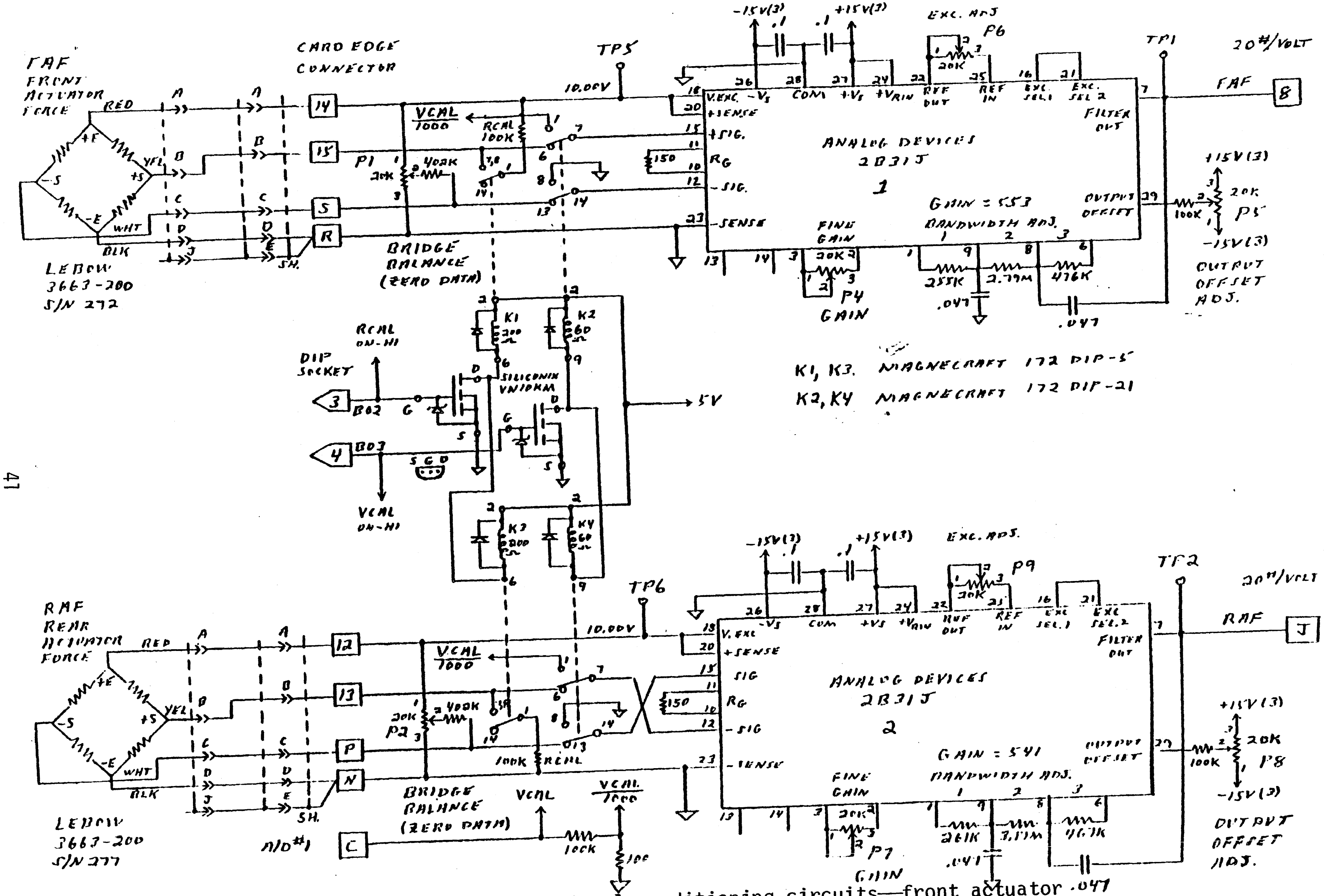


Figure 25. Breadboard card. Analog signal conditioning circuits—front actuator force and rear actuator force channels.

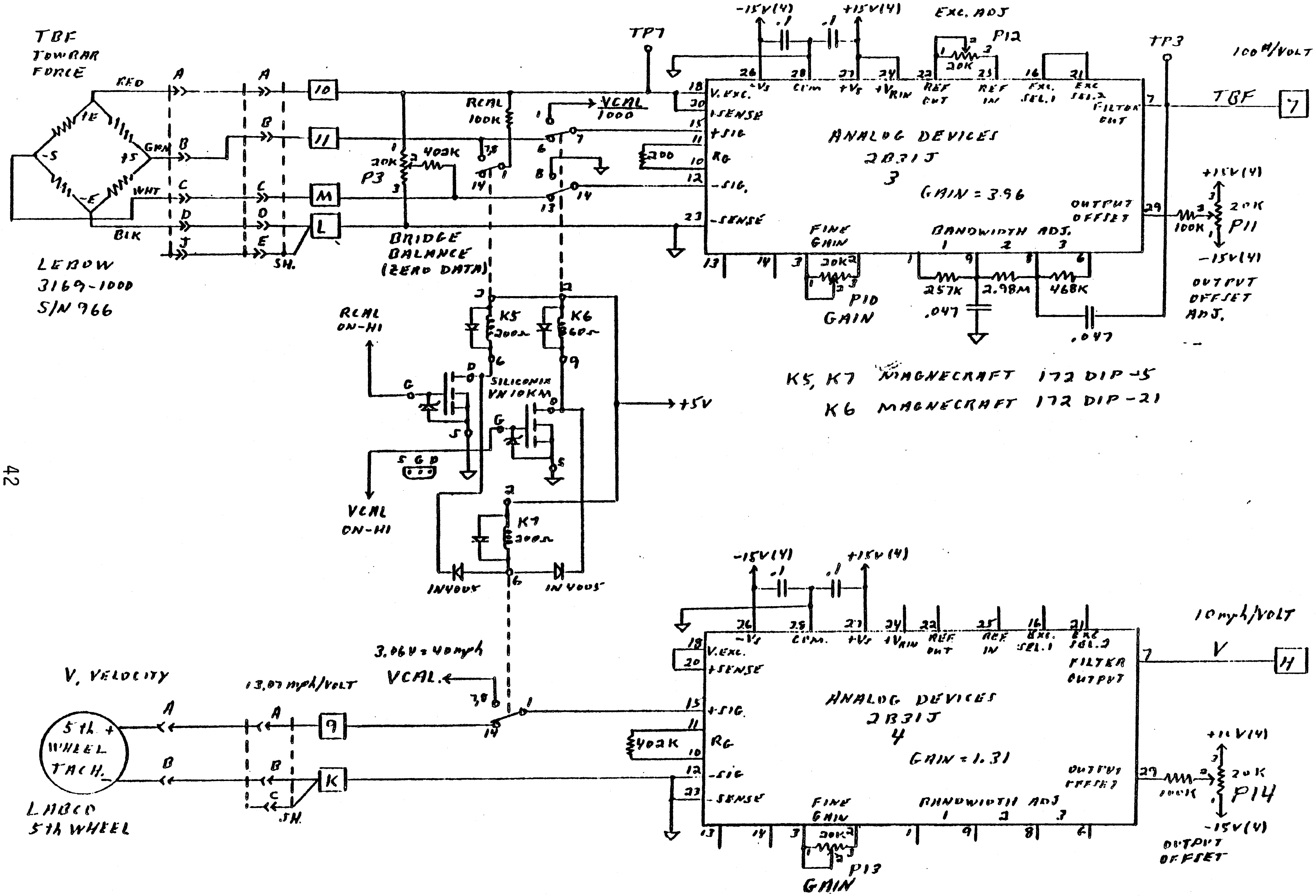


Figure 26. Breadboard card. Analog signal conditioning circuits—tow-bar force and velocity channels.

The filter programming resistors and capacitors connected to pins 1, 6, 7, 8, and 9 of the amplifier/filter modules in the load cell channels are selected to give matched 3-pole low-pass Butterworth filter characteristics with a cutoff frequency of 10.0 Hz.

Only two calibration adjustment potentiometers are in the velocity channel circuit shown in Figure 26, Fine Gain and Output Offset. The calibration voltage, V CAL, is switched onto the amplifier input by relay K7 in both the V CAL and R CAL modes. No filter programming components are connected to the module resulting in a 3-pole low-pass Bessel filter characteristic with a cutoff frequency of about 2 Hz. (See the 2B31J data sheet.) The procedure for calibrating the four analog data channels is given in Section 3.7.

The summing amplifier circuit, which drives the actuator force meter in the rider display, is shown in Figure 27. An LM 308 operational amplifier is connected as a gain of -1 summing amplifier. Inputs to the summing amplifier are: (1) the negated front or rear actuator channel Zero Data Offset Voltage entering the card on pin E from the computer via D/A #3 and (2) the front or rear actuator force analog signal from pin 7 of the 2B31J modules. A high logic level on bit B06 from the Digital Output Card entering the breadboard card on pin 7 of the dip socket actuates relay K8 to select the rear actuator force signal. A low logic level selects the front actuator force signal.

Figure 28 shows the electronic switch circuit which selects the A/D conversion trigger rate under computer control. The SN 74151 is an 8-line to 1-line data selector. Only four inputs, D0 through D3, are used in this application. Three square wave signals at frequencies of 1, 10, and 100 Hz from the Frequency Reference Card are connected to inputs D1, D2, and D3, respectively. D0 is tied to signal common. Bits B00 and B01 from the Digital Output Card select one of the four inputs to be output at Y to the A/D converter cards, according to the truth table shown in Figure 28. Although bits B00 through B12 from the Digital Output Card are connected to the breadboard card through the dip plug, only bits B00, B01, B02, B03, and B06 are used on the card.

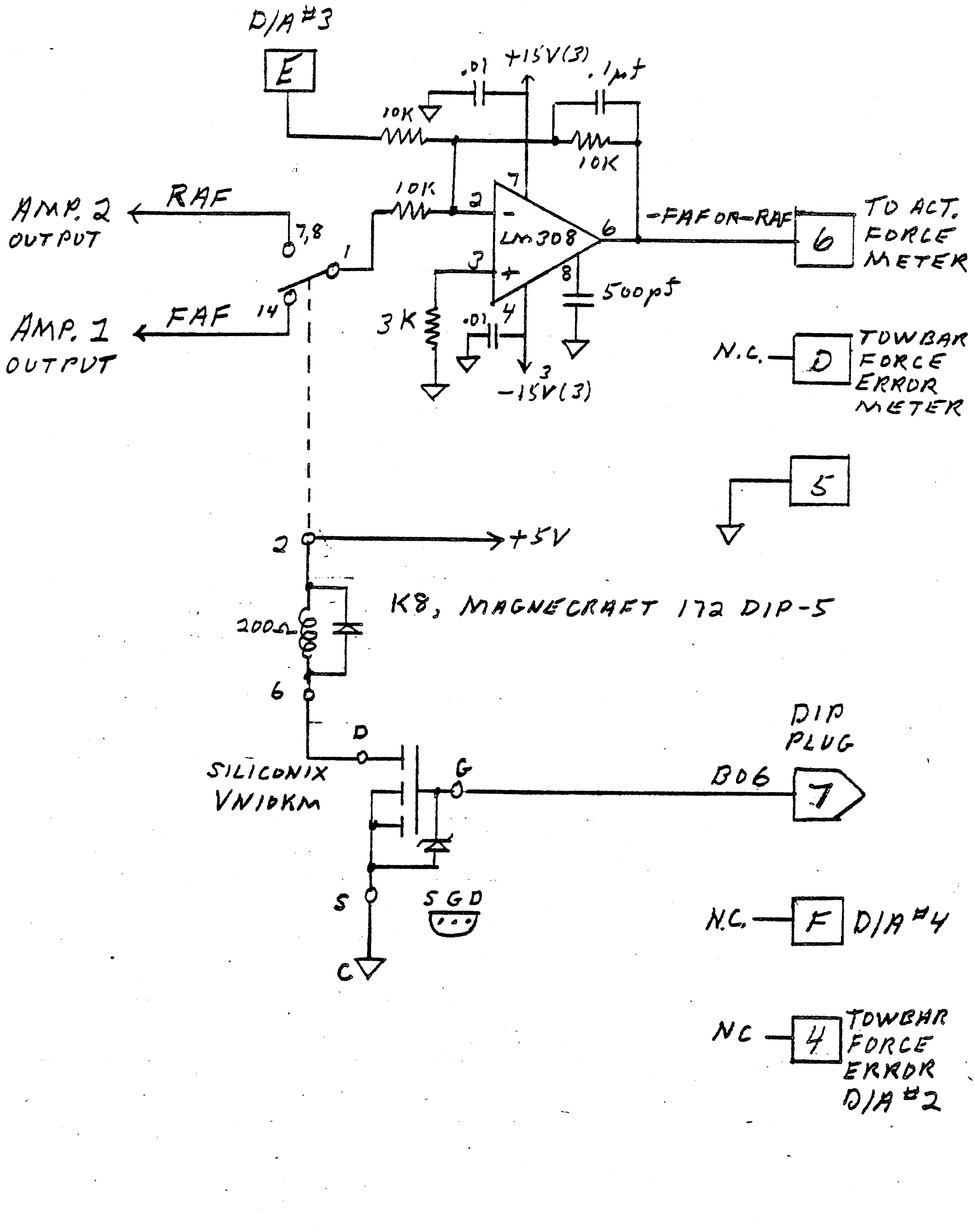


Figure 27. Breadboard card. Summing amplifier-actuator force meter driver.

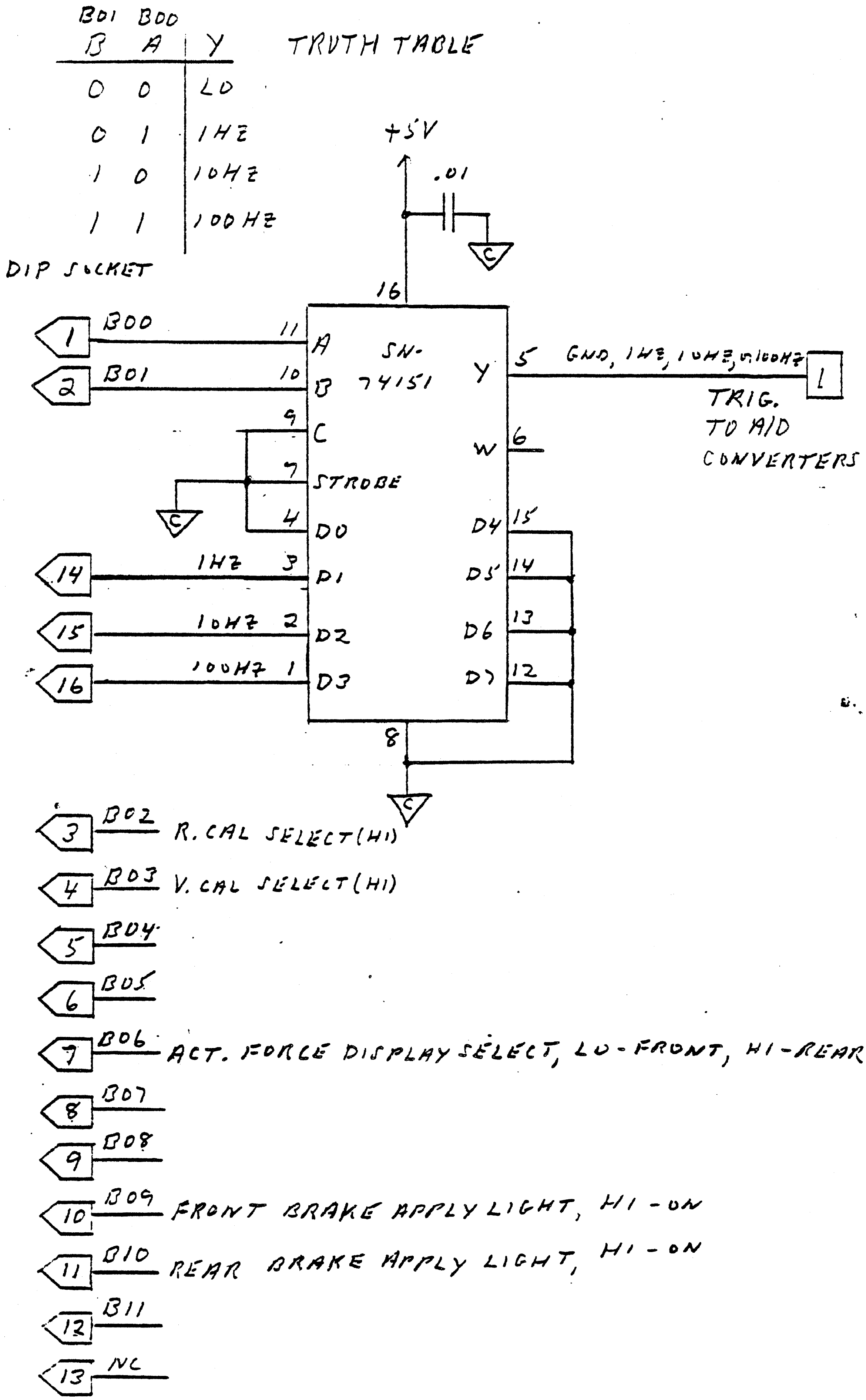


Figure 28. Breadboard card. Digital inputs and electronic switch circuit.

3.6.3 System Power Distribution and Grounds. Power from five isolated power supplies are distributed to all cards plugged into the 400 series card slots. These are +5 volts, ±15V (1), ±15V (2), ±15V (3), and ±15V (4). Regulators for the four isolated ±15V power supplies are on the HP 69351B Voltage Regulator Card in slot 600. (The reader is referred to the Hewlett-Packard manuals on the HP 6940B multiprogrammer and the HP 69351B Voltage Regulator Card for further details about the power supplies. All cards in the 400 series card slots using ±15-volt power, except the breadboard card, receive power from the ±15V (1) power supply. Figure 29 shows the power supply jumpers, filter capacitors, and power distribution on the breadboard card. Amplifier modules 1, 2 and the LM 308 summing amplifier are powered from the ±15V (3) supply, and amplifier modules 3 and 4 are powered from the ±15V (4) supply.

Common, or ground, for all four ±15-volt power supplies are tied together on the breadboard card. This is the only place these commons are connected together. The +5-volt power supply common, referred to as Data Common in the Hewlett-Packard literature, is connected to the case of the multiprogrammer which also is connected to the safety ground pin of the three-prong AC power plug. The ±15-volt common, or Analog Common, is isolated from Data Common throughout the system. If isolation is not maintained, a significant degradation in system noise rejection and accuracy may result, particularly if the Analog Common is connected to the Data Common at more than one point thereby generating a ground loop.

Since Data Common is connected to the multiprogrammer case and to the AC plug safety ground pin, the Analog Common could be inadvertently connected to Data Common in several ways. For example:

1. Many recorders and oscilloscopes have non-isolated input terminals. That is, the low input terminal is tied to the instrument case and to the AC power safety ground. When such an instrument is connected to one of the analog test jacks on the front of the multiprogrammer, the Analog Common (black banana jack) is connected to Data Common through the safety ground unless, of course, the instrument is powered from an AC source whose safety ground is

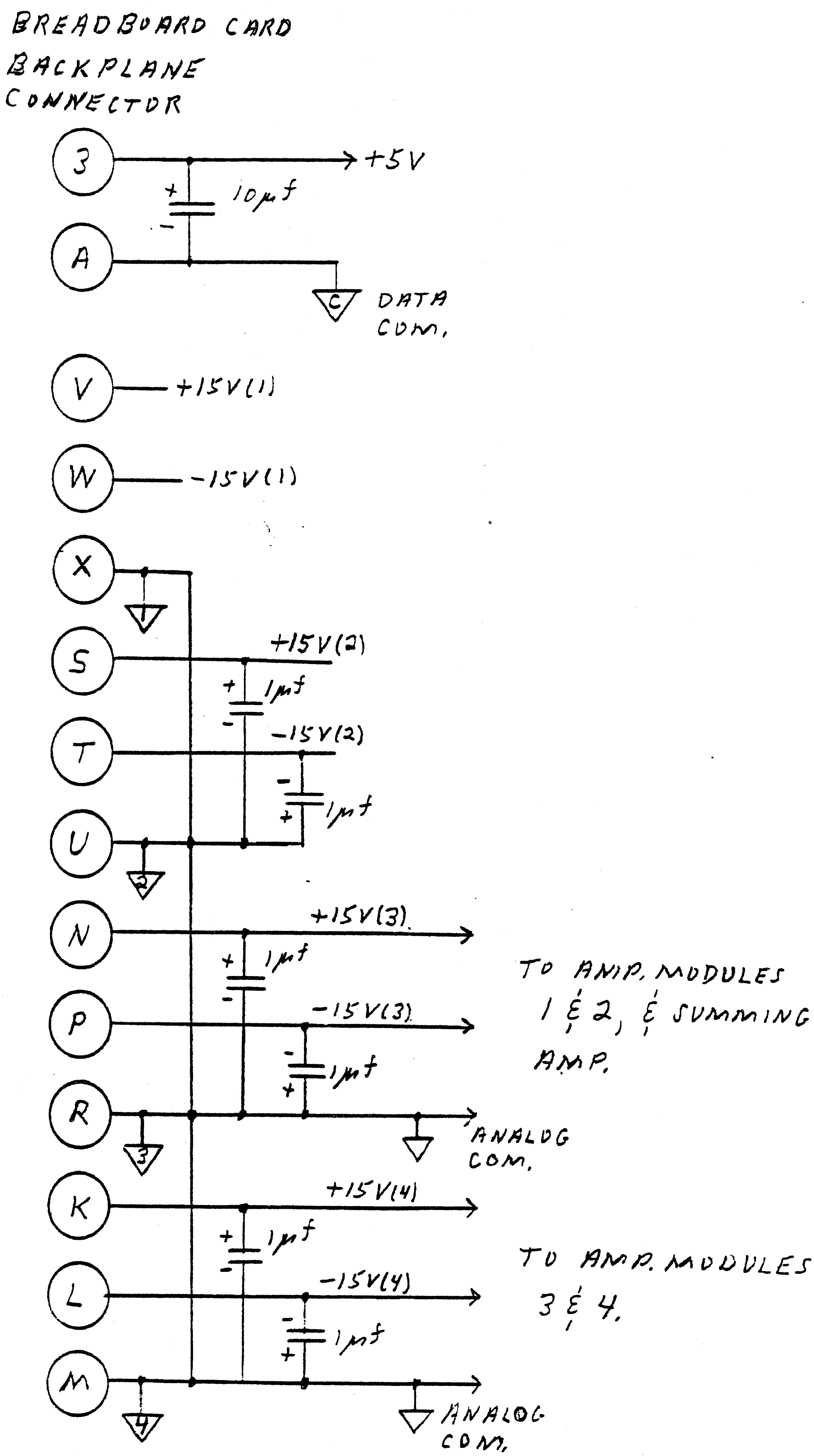


Figure 29. Breadboard card. Power supply jumpers, common or ground jumpers, and power distribution.

isolated from the multiprogrammer and computer safety grounds.

2. The multiprogrammer case is mounted in a metal frame which is connected to the vehicle chassis and then to the motorcycle chassis through the motorcycle tow assembly. Shielded cables to the load cells, fifth wheel, etc., have their shields tied to Analog Common at the multiprogrammer. Thus, if a metal part pierces the cable insulation and touches the cable shield a connection may be made from Analog Common to Data Common through the vehicle frame.

3. One wire of the thermocouple extension cable is connected to Analog Common on the low level A/D card. If the brake pads are made of a conductive material (metallic brake linings, for example), a conductive path may be established through the thermocouple, the brake lining, the brake assembly, the motorcycle-truck structure to the multiprogrammer case and thus to Data Common. Isolated thermocouples should be used in metallic or conductive brake linings.

3.7 System Calibration

The calibration procedure given here covers in detail only those adjustments made to potentiometers located on the breadboard card. Detailed calibration procedures for the Hewlett-Packard hardware, for example, the A/D converters and the D/A converters, are given in the Hewlett-Packard manuals.

Each time the system is powered up, the computer performs an automatic system calibration under control of the Motorcycle Brake Test Operating Program. If this calibration is not completed, the program will not proceed to the Motorcycle Brake Test (see Section 5.5).

In performing the automatic system calibration, the computer measures and stores two quantities for each data channel: (1) the Zero Data Offset Voltage and (2) the Signal Conversion Gain. Zero Data Offset Voltage is the voltage measured by the computer with no load applied to the load cells and the fifth wheel stopped. Signal Conversion Gain is the channel sensitivity in pounds per volt for the load cell channels and mph per volt for the velocity channel. To obtain the Signal Conversion Gain for the load cell channels, a shunt calibration resistor is switched across one arm of the load cell bridge producing an output equal to that of a known force. The computer measures the resulting output voltage and computes the Signal Conversion Gain which is the known force divided by the output voltage minus the Zero Data Offset Voltage. For the velocity channel, the procedure is the same except a precision voltage from D/A #1 equal to the fifth wheel tachometer output at a given velocity (40.0 mph) is switched into the amplifier input in place of the tachometer. By utilizing these calibration factors in processing subsequent data, the computer compensates for long-term drift of offset voltage and gain. If the offset voltage is greater than $\pm$0.5 volts or if the gain differs from the normal value by more than 5%, the computer will output a message indicating the out-of-range quantity. When this occurs, the system should be calibrated by the procedure given here.

The only test equipment required is a 3-1/2 digit, 0.1% accurate, digital voltmeter and two calibrated weights, one about 50 lbs and another about 500 lbs. Other equipment may be required for calibrating the Hewlett-Packard hardware (see the Hewlett-Packard manuals).

A short calibration program stored in file #3 on the Motorcycle Brake Test Program tape is used. This program is listed in Table 1, however, this listing is not required to run the program.

Table 1. System Calibration Program Listing.

```
0: moct;2→D;6→S;
 12→V
1: 0→E→B→C;dim
 M[4];dim K[4]
2: 20→K[1];20→K[
 2];100→K[3];
 10→K[4]
3: ent "MODE:D=D
 ATA, S=SHUNT
 CAL, V=VCAL",A
4: wti 0,11;wtb
 9,170140,110000
 +A
5: oni 9,"S";
 wtb 9,170260,
 30000;eir 9
6: gto 18
7: "S":wti 0,11;
 wti 4,10000;
 rdi 4→M[1];wti
 4,20000;rdi
 4→M[2]
8: wti 4,30000;
 rdi 4→M[3];wti
 4,40000;rdi
 4→M[4]
9: for I=1 to 4
10: if M[I]>=100
 000;M[I]-100000
 →M[I]
11: otdM[I]→M[I]
12: if M[I]>2047
 ;M[I]-4096→M[I]
13: .005M[I]→M[I
 ]
14: if A<12;K[I]
 *M[I]→M[I]
15: next I
16: dsp M[1],
 M[2],M[3],M[4]
17: wtb 9,170260
 ,30000;eir 9;
 iret
18: C/.02→C;if
 C<0;C+1024→C
19: dtoC→C
20: wtb 9,170140
 ,120000+C,12200
 0+C,124000+C,
 126000+C
21: if E#B;E→B→C
 ;gto 18
22: jmp -1
```

3.7.1 <u>Calibration Set-Up</u>. Connect the three load cells to the multiprogrammer <u>with the same cables</u> used in the motorcycle set-up. Either connect the fifth wheel tachometer to the multiprogrammer through the cable normally used, or short pin A to pin B in the connector on the fifth wheel cable exiting from the back of the multiprogrammer. Connect the 16-bit parallel interface cable to the computer and multiprogrammer. Turn on AC power. Place the LOCAL/REMOTE switch on the multiprogrammer in REMOTE.

Insert the Motorcycle Brake Test Program tape cartridge in the tape slot in the computer.

Type into the keyboard; ldf3. Press, EXECUTE.

The tape will run briefly. When the tape stops, press RUN. Observe the display

MODE: D=DATA, S=SHUNT CAL, V=V CAL

From this point in the program, the operator can select any one of three modes, DATA, SHUNT CAL, or V CAL by entering upper case D, S, or V, respectively, followed by CONTINUE. The program can be returned to this selection point at any time by pressing STOP and then RUN. The mode selected determines the status of the V CAL and R CAL relays on the breadboard card (see Figures 25 and 26) and the quantities displayed by the computer, as follows:

DATA MODE. No relays are actuated. The amplifier inputs are connected to the sensors. The computer reads the outputs from the A/D converters and displays the values read in pounds for the load cell channels and in mph for the velocity channel. With no load applied to the load cells and the velocity input equal to zero, the values displayed are the Zero Data Offsets.

SHUNT CAL MODE. The R CAL relays are actuated in the load cell channels and the V CAL relay is actuated in the velocity channel. The computer displays the measured channel outputs in pounds and mph.

V CAL MODE. The V CAL relays are actuated. V CAL/1000 is applied to the load cell amplifier inputs and V CAL is applied to the velocity channel amplifier input.

The V CAL voltage is set by the computer and output to the breadboard card through D/A #1. However, this program sets the outputs of all four D/A converters to the same value. When any one of the three modes is selected, the D/A outputs are initialized to 0 volts. Thereafter, the operator can change the D/A outputs to any value between 0 and ± 10 volts, while the program is running, by entering the desired value into the variable E. For example, to enter 5.25 volts, the key entries would be 5.25 → E EXECUTE. Note this is an upper case E, that is, press the shift key while E is pressed.

3.7.2 Check Calibration of the D/A Converters. Select the V CAL mode. That is, press V, then press CONTINUE.

Check the voltage at the D/A output jacks on the front of the multiprogrammer with a digital voltmeter, DVM. The readings should be 0.00 ± 0.02 volt.

Set the D/A outputs to 5.00 volts. That is, enter 5 → E EXECUTE

Check that the D/A outputs are 5.00 ± 0.02 volts.

Enter 10.00 volts. That is, enter 10 → E EXECUTE

Check that the D/A outputs are 10.00 ± 0.02 volts.

Repeat for -5.00 and -10.00 volts.

If any D/A output is in error by more than ± 0.02 volts, the D/A converters should be calibrated by the procedure given in the Hewlett-Packard manual on the HP 69322A, Quad D/A Converter Card.

3.7.3 Check Calibration of the A/D Converters. Select the V CAL mode; V CONTINUE.

The four numbers that appear on the display are the voltages read by the computer from the analog-to-digital, A/D, converters. Reading from left to right, the outputs are from: the front actuator channel, FAF; the rear actuator channel, RAF; the tow-bar force channel, TBF; and the velocity channel, V. For example, the display may be

FAF	RAF	TBF	V
0.04	0.06	-0.06	0.02

Measure the input voltages to the A/D converters at the corresponding test jacks on the front of the multiprogrammer, marked FAF, RAF, TBF, and V. They should be equal to the voltages displayed by the computer ± 0.02 volts.

Repeat for D/A output voltages of -5, +10, and -10 volts. Note that when the D/A #1 output is greater than approximately ±7.5 volts, the voltage displayed by the computer for the velocity channel will be saturated at ±10.24 volts, the maximum output of the A/D converter, although the voltage at the test jack will be larger. If the readings on a channel are in error by more than ±0.02 volts, the A/D converter should be calibrated by the procedure given in the Hewlett-Packard manual on the HP 69422A high-speed A/D converter card.

NOTE: The breadboard card must be placed on an extender card to make adjustments described in Sections 4.7.4, 4.7.5, and 4.7.7. Turn the multiprogrammer power off when removing and inserting cards. Allow five minutes minimum warm-up time after applying power before making any adjustments.

3.7.4 <u>Set the Bridge Excitation Voltages</u>. Turn off power to the multiprogrammer and place the breadboard card on an extender card. Turn on power and allow at least five minutes warm-up time.

Connect a digital voltmeter between TP5, at the front edge of the breadboard card, and Analog Common, that is, any of the black banana jacks on the multiprogrammer front panel. Adjust P6, located by the FAF channel amplifier module, to obtain 10.00 ±0.02 volts.

Repeat for the RAF and TBF channels measuring the voltage at TP6 while adjusting P9 and TP7 while adjusting P12, respectively.

3.7.5 <u>Set Amplifier Voltage Offsets to Zero</u>. Select the V CAL mode; V CONTINUE.

Using a digital voltmeter check that the D/A #1 output voltage at the output jack on the multiprogrammer front panel is 0.00 ±0.02 volts. The voltage at the inputs to the 2B31J amplifiers on the breadboard card is now zero.

Adjust the output offset potentiometer located by each 2B31J module (P5, P8, P11, and P14) to obtain 0.00 ±.02 volts displayed on the computer for each channel.

3.7.6 Set Zero Data Offsets to Zero. Select the DATA mode; D CONTINUE.

The zero data offsets on the load cell channels are set with the three bridge balance pots, P1, P2, and P3, located at the front edge of the breadboard card. On the velocity channel, Zero Data Offset is the same as the voltage offset and is set according to the procedure given in Section 4.7.5.

Adjust the bridge balance potentiometer to obtain a reading of 0.00 ±0.02 on the computer display for FAF and RAF, and 0.00 ±1.00 on the computer display for TBF. The values displayed are scaled in units of pounds for FAF, RAF, and TBF, and units of mph for velocity.

3.7.7 Set the Gain of the Amplifier. Select the SHUNT CAL mode; enter S CONTINUE.

Set D/A #1 output to 3.06 volts; enter 3.06 → E EXECUTE.

A 100K ohm shunt cal resistor is now switched across one arm of each load cell bridge and 3.06 volts is connected to the velocity channel amplifier input in place of the fifth wheel tachometer, producing the the following equivalent inputs to each channel:

FAF	98.1 pounds
RAF	96.2 pounds
TBF	348 pounds
V	40.0 mph

Adjust the fine gain potentiometer located beside the amplifier module for each channel (P4, P7, P10, and P13) to obtain these values on the computer display. That is

98.10	96.20	348.00	40.00

3.7.8 <u>Check the Voltage Gain of the Amplifiers</u>. The normal amplifier voltage gain values are:

Channel	Gain
FAF	553 volts/volt
RAF	-541
TBF	396
V	1.31

If after performing the calibration procedures in Sections 3.7.2 through 3.7.7 the load cell amplifier gains are found to differ from the above values by more than one percent, it is an indication that a problem exists with the load cell, the cal resistor, or in the interconnecting circuit, that is, the R CAL relay, wiring, or cable; in which case, a dead weight calibration check should be made and the circuit should be checked.

To check the gain of the amplifiers, select the V CAL mode; V CONTINUE.

Check that the calibration voltage from D/A #1 output is 0.00 V $\pm$0.02 V. The amplifier inputs are now at 0 volts and the computer display shows the voltage offsets of the amplifiers. For example

-.02	+.03	.00	-.01

Set A/D #1 output to 10 volts; enter 10 → E EXECUTE. The calibration voltage is now V CAL/1000 = 0.010 volts at the load cell amplifier inputs and V CAL = 10.00 volts at the velocity channel amplifier input. The output voltage is displayed on the computer, for example

5.51	-5.36	3.96	10.24

The amplifier gain is the output voltage minus the offset voltage divided by the input. In this example, for the FAF amplifier, this is [5.51-(-.02)] ÷ .010 = 553. Similarly, the TBF amplifier gain is 396. The velocity channel is saturated at this input level.

Now enter V CAL = -10.00 volts. That is, set the D/A #1 output to -10.00 volts; enter -10 → E EXECUTE. Note that the normal output of the RAF load cell in compression is negative. Thus a negative cal voltage is used to check the amplifier gain. The display is, for example

-5.53	5.44	-3.95	-10.24

and the gain of the RAF amplifier is [5.44-.03] ÷ (-0.010) = -541.

To check the velocity channel amplifier gain, set V CAL = 1.00 volt. That is, enter 1 → E EXECUTE. Observe the display, for example

.55	-.54	.40	1.30

The velocity channel gain is seen to be [1.30-(-.01)] = 1.31.

Note that if the negative voltage outputs in this example are used to check the gains, the values obtained are slightly different. The values are: [-5.53-(-.02)] ÷ (-.010) = 555; [-5.36-.03] ÷ (.010) = -539; [-3.95-.00] ÷ (-.010) = 395. The normal difference is less than 0.5 percent. It is due to a slight asymmetry of channel gain for positive and negative voltages.

3.7.9 <u>Overall Data Channel Check</u>. An overall check of the analog data channels can be made by placing a known weight on the load cells and by inputting an accurate DC voltage at the fifth wheel cable, while the system is in the DATA mode. The weight in pounds and the velocity corresponding to the DC voltage will be displayed by the computer in pounds and mph, respectively. The weight should be in the range of

50 to 100 pounds for checking the brake actuator load cells and 300 to 500 pounds for checking the tow-force load cell. The rear brake actuator load cell should be loaded in compression and the front actuator and tow-force load cells should be loaded in tension.

Calibration of the fifth wheel should be checked periodically on a fifth wheel test stand. When new, its scale factor was 13.07 mph per volt. Thus at 40.0 mph, its output is 3.06 volts, which is the calibration voltage used in the calibration procedure given above and in the automatic calibration procedure run by the computer just prior to running motorcycle brake tests. If the fifth wheel calibration changes significantly because a different fifth wheel is used, the tire becomes excessively worn or the tire is replaced, for example, the new calibration values for the fifth wheel and the velocity channel gain must be entered in the Motorcycle Brake Test Program on the program tape. The location of these values in the program are given in Section 3.8.1.

3.7.10 Load Cell and Shunt Cal Resistor Calibration. If a load cell is replaced, the load cell channel must be re-calibrated using an accurate load to determine the new channel amplifier gain and the equivalent force of the 100K ohm shunt cal resistor. This can be done using the system calibration program as follows.

1. Load the calibration program, see Section 3.7.1.
2. Check the D/A and A/D converter calibrations, Sections 3.7.2 and 3.7.3.
3. Set the amplifier voltage offset to 0. Section 3.7.5.
4. Select the DATA mode. Adjust the Zero Data Offset to 0 with no weight on the load cell. Section 3.7.6.
5. Place the calibrated weight on the load cell. Adjust the amplifier gain on the breadboard card to obtain a reading on the computer display equal to the weight in pounds.
6. Repeat 4 and 5 until stable readings are obtained. There is a small interaction between gain and zero data offset.

7. Select the SHUNT CAL mode. The reading displayed on the computer is the equivalent force calibration of the shunt CAL resistor for the load cell.

8. Measure the amplifier voltage gain. Section 3.7.8.

The values for amplifier voltage gain and the shunt cal resistor equivalent force must be entered in the program on the Motorcycle Brake Test Program tape. The location of these values in the program are given in Section 3.8.1.

3.8 Motorcycle Brake Test Program

The Motorcycle Brake Test Program is stored on a magnetic tape cartridge labelled "MBT Program Tape." Three identical tapes are supplied to provide back-up in the event a program tape is damaged or lost. The "record" lever on the program tapes should always be in its left-most position to prevent accidental over-writing or erasure of the program. A complete listing of the program is given at the end of this section from which a new program tape could be made if required. The program consists of 982 lines of code written in the Hewlett-Packard HPL language, a language similar to BASIC.

This section contains the following:

1. The program line numbers containing system calibration data. If sensors (load cells and fifth wheel) are replaced and/or recalibrated, the new calibration factors must be entered in the program.

2. Characteristics of the digital filters implemented in the program to filter the effectiveness test data.

3. A description of the effectiveness test "Data Point" algorithm by which the computer selects the tow-force and actuator-force data point.

4. A step-by-step outline of the operations performed by the computer.

5. The program listing in HPL code.

6. Lists of subprograms, subroutines, variables, matrices and data files.

3.8.1 System Calibration Factors-Program Storage Location. The program contains two calibration factors for each analog data channel which are determined by the calibration of the three load cells and the fifth wheel tachometer. If these calibration factors change, for example, when a sensor is replaced, the new calibration factors must be entered in place of the old ones in the program. This is done by loading the program into the HP 9825T computer, entering the new values using the editing procedures given in the Hewlett-Packard manual, and then storing the edited program on the program tape.

The sensors and pertinent calibration factors for each channel, as of January 1, 1981, are:

Load Cell	100K Ohm Shunt Cal Eq. Force	Amplifier Voltage Gain
Front Actuator Force, FAF Lebow Model 3663-200 S/N 272	98.1 lbs	553
Rear Actuator Force, RAF Lebow Model 3663-200 S/N 277	96.2 lbs	541
Tow-Bar Force, TBF Lebow Model 3169-1K S/N 966	348 lbs	396

Fifth Wheel/Tachometer	Calibration	Amplifier Voltage Gain
Labeco 1968481 S/N 1963	Tire Press. 32 psi 13.07 mph/volt	
Labeco 1968621 S/N 55 (Tachometer)	40.0 mph = 3.06 volt	1.31

The underlined numbers, above, are the numbers stored in the computer program in lines number 520, 521, and 578, as shown in the following computer printout:

```
520: 553→N[1];
 541→N[2];396→N[
 3];1.31→N[4]
521: 10→V[1];-
 10→V[2];10→V[3]
 ;3.06→V[4]
```

```
578: 98.1→V[1];
 96.2→V[2];348→V
 [3];40→V[4]
```

3.8.2 Digital Filter Characteristics. In order for the computer to accurately select the required data points from the digitized tow-force and actuator-force data in the effectiveness test, it was determined that noise frequencies in the range of 4 to 10 Hz on the tow-bar force signal due to vibrations would have to be strongly attenuated by filtering. For this purpose, a sharp cutoff digital filter giving minimal attenuation of signals in the 0 to 2 Hz frequency range was implemented in the computer program.

Figure 30 shows the amplitude-frequency characteristic of the tow-force-signal filter. Figure 31 shows a typical time history plot of the unfiltered and filtered tow-force signal.

Since noise on the actuator-force signal is small, a less agressive digital filter was implemented for filtering the actuator-force signal. Its amplitude-frequency characteristic is shown in Figure 32. Figure 33 shows a typical plot of the unfiltered and filtered actuator force.

The full-scale pulses appearing at the start and end of the analog data output, as seen in Figures 31 and 33, serve to scale the plot in time and amplitude. They are 5.0 seconds apart in real data time and 10.0 volts in amplitude, which equals 200 pounds and 1000 pounds on the actuator and tow-bar force plots, respectively. An additional full-scale pulse indicates the location of the specific data point selected by the computer—in this case, the peak tow-bar force. Five hundred samples are collected in the five-second period. Each data sample in the filtered TBF data is a weighted average of 40 samples before and after a given sample, therefore, the first and last samples in the filtered data are sample numbers 40 and 460, respectively. Thus, the filtered data plot

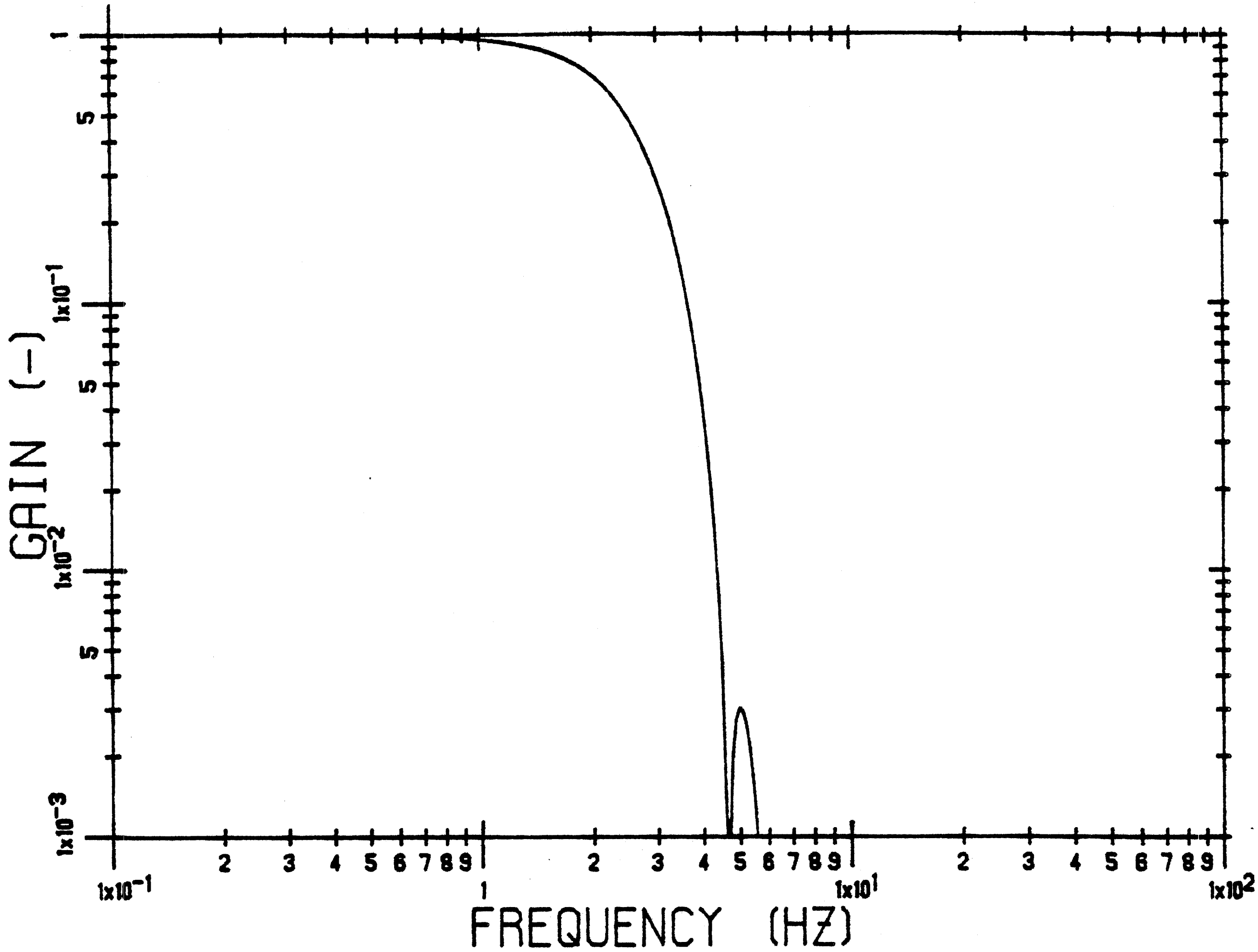


Figure 30. Digital filter amplitude characteristic—tow-force signal filter.

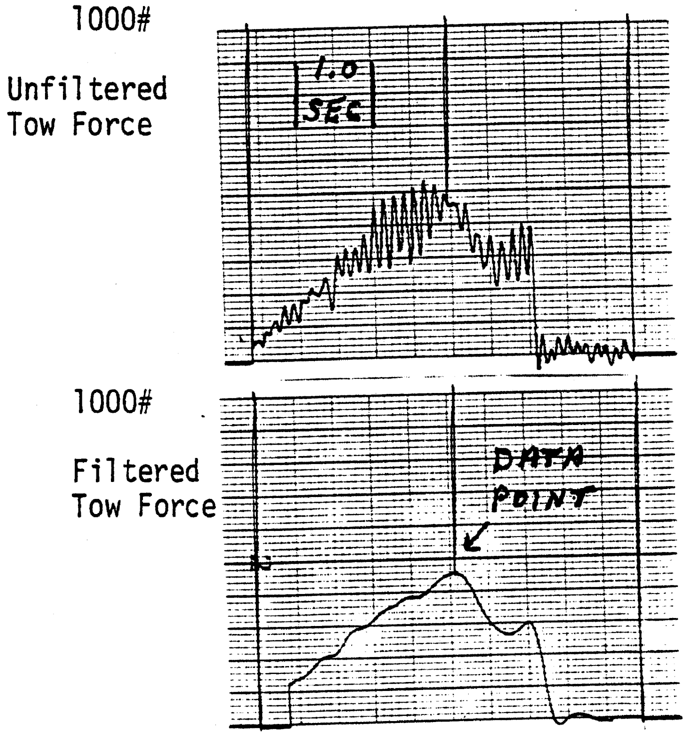


Figure 31. Unfiltered and filtered tow-force signal time history.

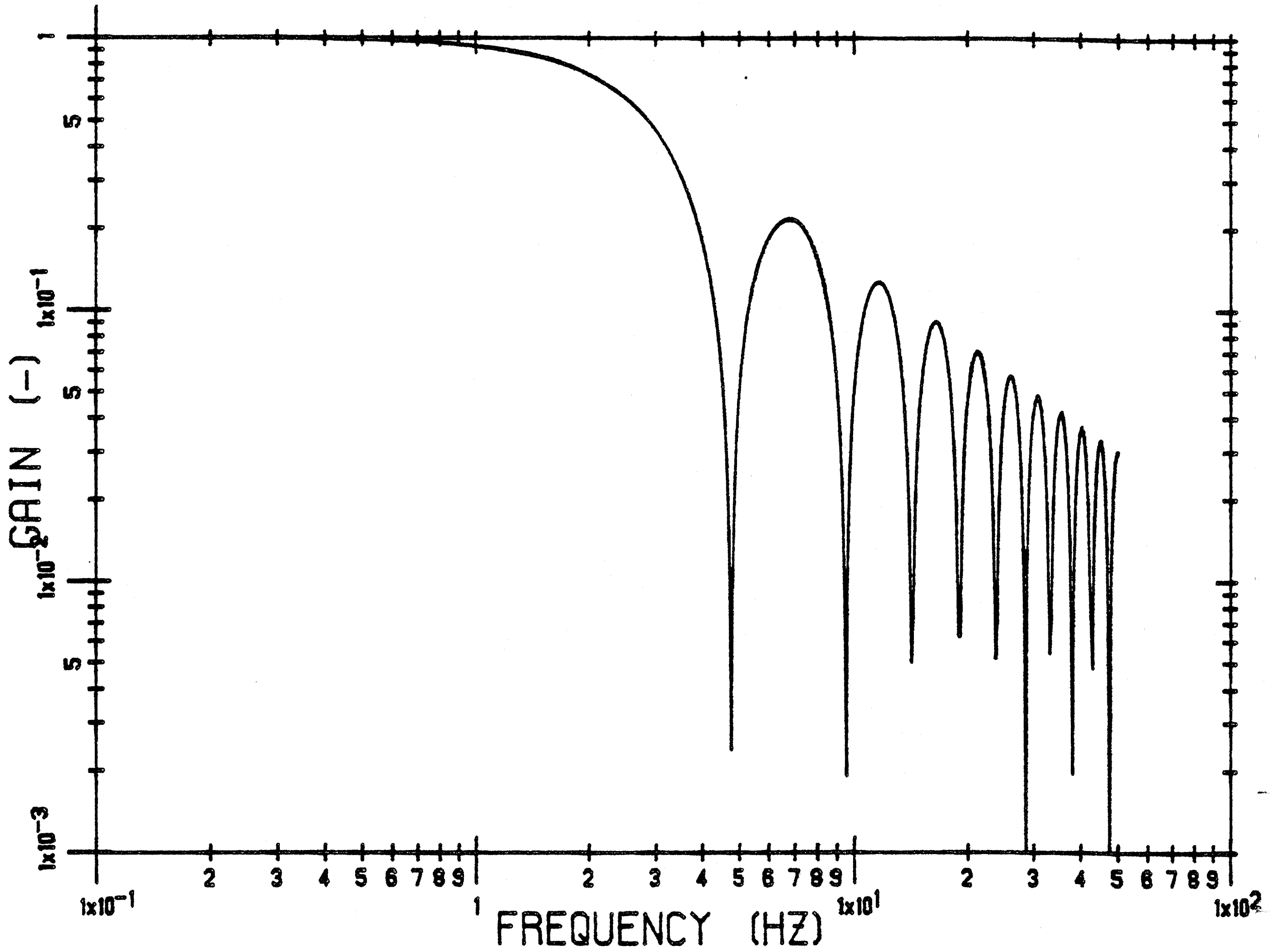


Figure 32. Digital filter amplitude characteristic—actuator-force signal filter.

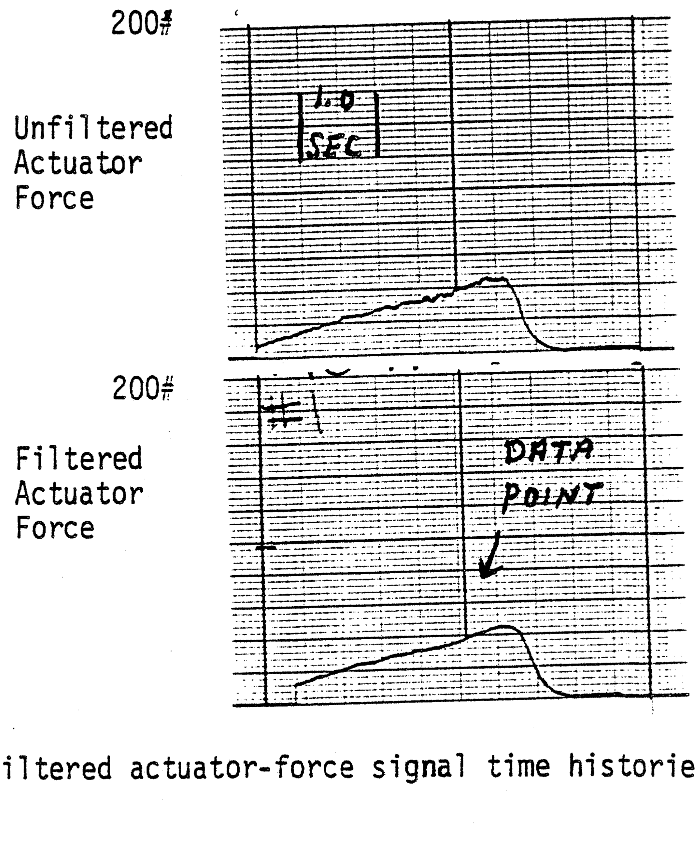


Figure 33. Unfiltered and filtered actuator-force signal time histories.

starts at 0.4 seconds and ends at 4.6 seconds, as seen in the filtered analog data time histories.

The digital filters are implemented in the computer program by replacing each digitized data sample value by a new value equal to the normalized weighted sum of the sample and 40 consecutive samples on both sides of the sample, inthe case of the tow-force signal filter, and 10 samples on both sides of the sample in the case of the actuator-force filter.* The weight or multiplier of each sample is listed in Table 2 for the tow-force signal filter. In this list, the digits 1 through 40 are the sample numbers relative to the central sample, number 0, and the number following the digit is the weight or multiplier of that sample. The weights are normalized so their sum (81 values) is equal to 1. For the actuator-force filter, the weights are all equal to 1/21.

Table 2. Digital Filter Weighting Factors, Tow-Force Channel.

0.	0.04980440	13.	0.01695800	26.	-0.00326720
1.	0.04952950	14.	0.01372030	27.	-0.00313530
2.	0.04871170	15.	0.01070230	28.	-0.00290370
3.	0.04737160	16.	0.00794560	29.	-0.00260520
4.	0.04554250	17.	0.00548160	30.	-0.00226950
5.	0.04326960	18.	0.00333110	31.	-0.00192150
6.	0.04060830	19.	0.00150390	32.	-0.00158170
7.	0.03762240	20.	0.00000000	33.	-0.00126520
8.	0.03438190	21.	-0.00119020	34.	-0.00098180
9.	0.03096070	22.	-0.00208440	35.	-0.00073680
10.	0.02743460	23.	-0.00270750	36.	-0.00053070
11.	0.02387840	24.	-0.00308940	37.	-0.00036070
12.	0.02036400	25.	-0.00326400	38.	-0.00022090
				39.	-0.00010350
				40.	-0.00000000

*"Digital Signal Processing," William D. Stanley, Recton Publishing Co., Inc., 1975.

3.8.3 Final Data Point Selection Algorithm. For effectiveness tests, the computer is programmed to select a data point which is a set of two simultaneous sampled data values, one from the filtered tow-bar force signal and the other from the filtered actuator-force signal. In the case where wheel lockup occurs or the brake is torque limited at an actuator force less than 55 pounds (front) or 90 pounds (rear), the data point taken is the peak tow-bar force and the corresponding actuator force. Otherwise, the data point is the tow-bar force corresponding to 55 pounds of front actuator force or 90 pounds of rear actuator force.

The algorithm used in the computer to select the data point marked by the central full-scale pulse appearing in the actuator force and tow-bar force time histories is described below.

Figure 34 shows a drawing of actuator force and tow-bar force time histories which serve to illustrate the data point selection process performed through the programmed algorithm. The vertical lines represent data sample points on the analog curve. For clarity, less than the full 500 samples are shown.

Algorithm:

Let i = the data sample number

AF_i = the i-th actuator force sample amplitude

TF_i = the i-th tow force sample amplitude

PAF = the maximum actuator force sample amplitude before the i-th sample

PTF = the maximum tow force sample amplitude before the i-th sample

AF = the actuator force data point amplitude

TF = the tow force data point amplitude

t = final data point time in seconds

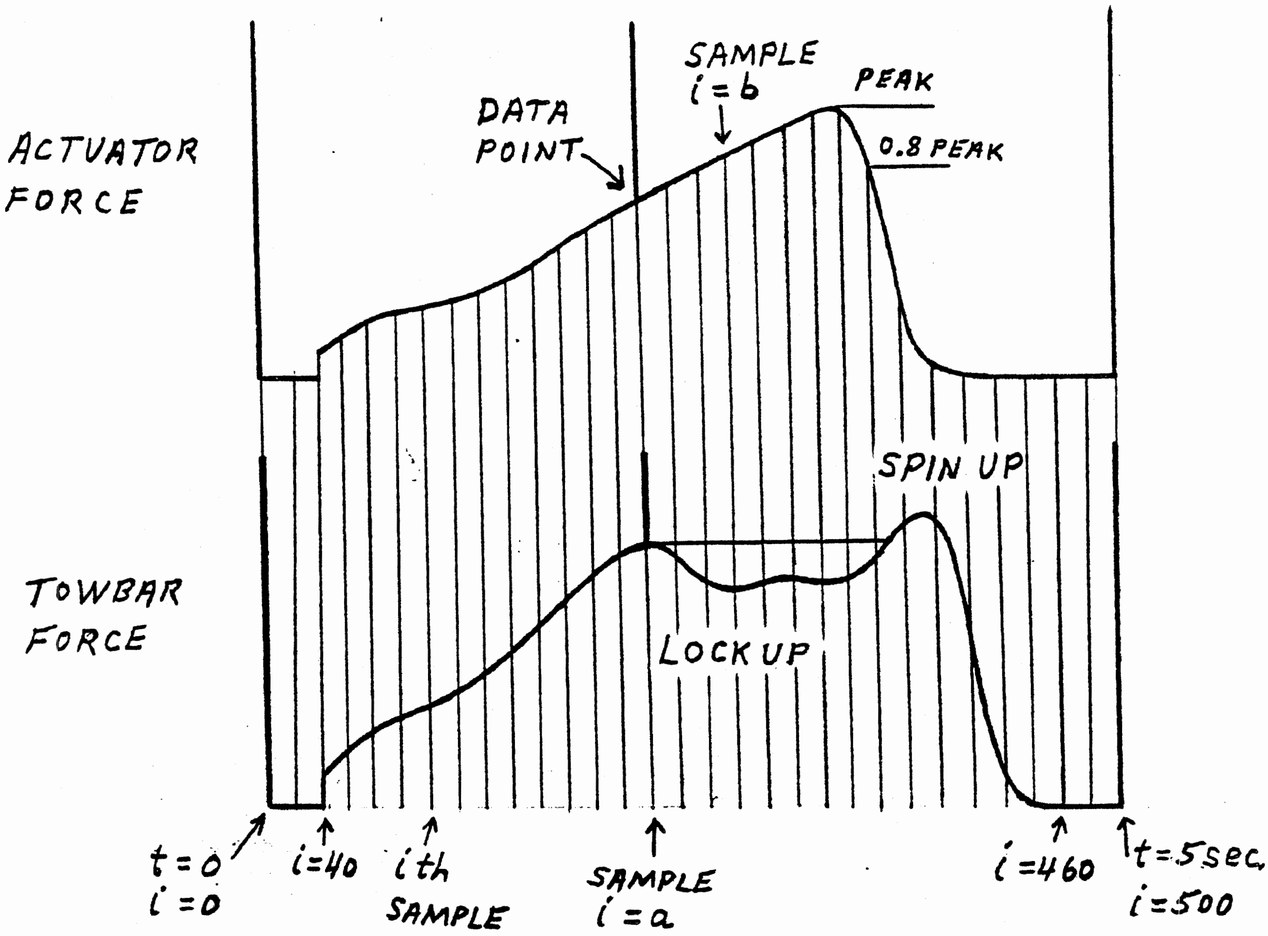


Figure 34. Drawing of actuator force and tow-bar force time histories showing sampled data points and the data point selected by the programmed algorithm.

1. Set PAF = PTF = S = a = b = 0

2. for i = 40 to 460

3. if $AF_i > PAF$; set $PAF = AF_i$

4. if $TF_i > PTF$; set $PTF = TF_i$, a = i

5. if $AF_i \geq$ 55 lbs (front) and b = 0 ; set b = i
   90 lbs (rear)

6. if $AF_i < 0.8$ PAF ; set i = 461

7. next i

8. if $AF_a <$ 55 (90) lbs set $AF = AF_a$, $TF = TF_a$, t = 0.01a

9. if $AF_a \geq$ 55 (90) lbs set $AF = AF_b$, $TF = TF_b$, t = 0.01b.

The following explains steps 1 through 9.

1. The variables listed are set to 0.

2. Sets up a For-Next loop for i = 40 to 460. That is, steps 3 through 6 are repeated with the value of i increased by 1 each time.

3. Sets PAF equal to the maximum or peak actuator force.

4. Sets PTF equal to the maximum or peak tow-bar force and sets, a, equal to the sample number of the peak tow-bar force.

5. Sets, b, equal to the number of the first sample (when b = 0) at which the actuator force became greater than or equal to 55 pounds for front brake test or 90 pounds for rear brake test.

6. By setting i = 460, stops execution of the For-Next loop when the actuator force drops below 80 percent of the peak actuator force reached before the brake was released. When the brake is released after a wheel lockup, tow force increases briefly, sometimes exceeding the first peak, as shown in Figure 34, due to dynamic properties of the tow system during wheel spin-up. This peak value always lags

the peak of actuator force, thus this condition prevents detection of the spin-up peak as the tow-bar force peak value when it is larger than the peak value that occurred prior to wheel lockup.

7. Indexes i by 1. Then, if i is less than 461, steps 3 through 7 are repeated; if i = 461, then steps 8 and 9 are performed.

8. If $AF_a < 55$ (90) lbs, peak tow-bar force occurred before the actuator force reached 55 pounds front or 90 pounds rear (or 55 pounds front, 90 pounds rear was not reached), sample i = a, the peak tow-bar force is taken for the data point, and the data point time, after start of the test, is t = .01a.

9. If $AF_a \geq 55$ (90) lbs, 55 or 90 pounds actuator force was reached before wheel lockup, sample i=b, the tow-bar force corresponding to an actuator force of 55 (90) pounds is taken for the data point, and the data point time is t = .01b.

3.8.4 Motorcycle Brake Test Program Operations. The following is an outline description of the operations performed by the computer and controlled by the system program which is stored on the Motorcycle Brake Test (MBT) Program tape. The reader may find the System Operating Procedures, given in Section 5, helpful in following the computer operation outline here.

Numbers given in parentheses in this outline refer to lines in the program and are given to direct the reader to the program lines where the given operations are performed. A listing of the complete program is given in Section 3.8.5. A good knowledge of the Hewlett-Packard HPL programming language and of the HP 9825T computer and HP 6940B multiprogrammer interface programming is required to follow and understand the program line by line. The program contains subprograms, subroutines, and functions which are called many times by the main program. Therefore, jumps forward and backward in the program are common, as indicated by the list of program line numbers following many of the described operations.

Each outline heading corresponds to the label by one of the special function keys on the computer, which is pressed by the operator to initiate the procedure outlined. A word or symbol underlined, for example 1 or CONTINUE, indicates a computer key pressed by the operator.

This section, together with Section 5, completely defines the operations performed during the motorcycle brake test.

1. READY (424).

    1. Display "READY." This indicates the MBT program is loaded and the system is ready to receive operator keyboard commands.

    2. The computer is holding at line (425).

2. MARKT (655). Mark Tape.

    1. Display "Place Blank Tape In Slot; CONT." (656).

    2. CONTINUE. Operator keyboard entry.

    3. Display "BUSY MARKING TAPE" (659). The computer marks all files in which data will be stored on the tape (660).

    4. Display "Input Motorcycle Name, Notation:" (662, 291-292).

    5. Store the motorcycle name and other notations, e.g., the date, entered by the operator. The maximum is 80 characters including spaces (292).

    6. Request and store motorcycle parameters. The parameters asked for are: total bike weight (293); static front wheel load (294); static rear wheel load (295); center of gravity height (296); and wheelbase (297).

    7. Record motorcycle name, notation, and parameters on the data tape (298, 663).

    8. Print motorcycle name, notation, and parameters on the printer (664, 205-213, 665). See sample printout in Section 5.3, page 135.

9. Return to READY (665, 424).

10. Display "READY" (425).

3. LOAD P (666). Load Parameters.

1. Display "Insert Data Tape; CONT" (667).

2. CONTINUE.

3. Load motorcycle name, notation, and parameters from the data tape into the computer (668).

4. Print motorcycle name, notation, and parameters on the printer (669, 205-213, 670).

5. Return to READY (670, 424).

6. Display "READY" (425).

4. CAL (435). System Check and Calibration.

1. Print "System Check + Calibration Mode" (436-438).

2. Display "Test # ?" (445). Requests a test number input by operator.

3. Run any one or all of five system check/calibration tests selected by the test # entered (446-452). See Section 5.5 for additional discussion of each test.

4. 1, CONTINUE. Run all tests given below in the sequence 3, 4, 5, 2, 6. Return to ready when test #6 is finished (446, 454-461, 452, 424-425).

5. 2, CONTINUE. Run test #2, C 0 cal. Automatic calibration (447, 554).

6. Display "All Cables Slack? CONT" (556).

7. CONTINUE

8. Display "Busy" (557).

9. Set A/D conversion rate to 10 Hz (559).

10. Store the sum of 10 samples from each A/D channel, FAF, RAF, TBF, and V (558-561, 39-41, 163-169, 42-44, 562).

11. Set A/D conversion rate to 0 Hz (562).

12. Print "Zero Data Offset Voltage Calibration" (563-564).

13. Print "Ch Meas Norm" (565, 442, 566).

14. Divide the four sums from step 10 by 10 to obtain average values of the Zero Data Offset Voltages O[1], O[2], O[3] and O[4] (568).

15. Store and print the Zero Data Offset Voltages and their normal values. See sample printout in Section 5.5, page 141.

16. CONTINUE.

17. Print "*-Out of Range" if a value was out of range, otherwise print "**OK**" (574, 201-204, 575).

18. Print "*Sig Conv Gain Calibration*" (576).

19. Display "BUSY" (580).

20. Set D/A #1 output (calibration voltage) to 3.06 volts (40 mph). Set R CAL relays ON. Set A/D conversion rate to 10 Hz. Wait 2 seconds for amplifier to settle (581, 158-162, 582-583).

21. Store the sum of 10 samples from each A/D channel, FAF, RAF, TBF, and V (583, 45-47, 163-169, 48-50, 584).

22. Set D/A #1 output to 0. Turn R CAL relays OFF. Set A/D conversion rate to 0 Hz (584).

23. Print "Ch Meas Norm" (585, 442, 586).

24. Divide the sums from step 21 by 10 to obtain average values and subtract the Zero Data Offsets obtained in step 14 above. Divide the channel calibration values stored in V[1] to V[4] by the results to obtain the Signal Conversion Gains, G[1], G[2], G[3] in pounds per volt and G[4] in mph per volt (587-589).

25. Store and print the Signal Conversion Gains and their normal values. See sample printout in Section 5.5, page 141. If a Signal Conversion Gain value is different from its normal value by more than five percent, print an asterisk by its value in the printout (590-593, 439, 594), and display "XXX* SC Gain Out of Range CONT?" (594). XXX is the quantity name. See sample printout in Section 5.5, page 142.

26. CONTINUE.

27. Print, "1-3 Units lbs/V" (596).

28. Print, "Ch 4 Units mph/V" (597).

29. Print, "-*Out of Range" if a value was out of range, otherwise print "*OK*" (598, 201-204, 599).

30. Return to display "Test #?" (599-600, 445).

31. 3 CONTINUE. Run Test #3, AO chk. Analog output check (448, 462).

32. Print, "*Analog Output Check*" (463).

33. Set A/D #1 through A/D #4 outputs to 0.00 volts (464).

34. Display "D/A Outputs = 0.00V ; CONT?" (465).

35. CONTINUE.

36. Set A/D #1-A/D #4 outputs to 5.00 volts (466).

37. Display "D/A Outputs = 5.00V ; CONT?" (467).

38. CONTINUE.

39. Set A/D #1-A/D #4 outputs to 10.00 volts (468).

40. Display "D/A Outputs = 10.00V ; CONT?" (469).

41. CONTINUE.

42. Print, "**OK**" (470, 441, 471).

43. Return to display "Test #?" (471-472, 445).

44. 4 CONTINUE. Run Test #4, RD chk. Rider Display Check (449, 473).

45. Print, "*Light Check*" (474).

46. Turn ON the front and rear actuator apply signal lights on the Rider Display (475).

47. Display, "Front and Rear Lights ON ; CONT?" (476).

48. <u>CONTINUE</u>.

49. Turn OFF the front and rear actuator apply signal lights on the Rider Display (477).

50. Display, "Front and Rear Lights OFF ; CONT?" (478).

51. <u>CONTINUE</u>.

52. Print, "**OK**" (479, 441, 480).

53. Print, "*Meter Check*" (480).

54. Display "BUSY" (482).

55. Set the A/D conversion rate to 10 Hz. Store the sum of 10 samples from the front actuator force channel, FAF, A/D converter (483-485, 26-27, 163-169, 28-30, 486).

56. Set the A/D conversion rate to 0 Hz (486).

57. Divid the sum of the ten samples from step 55 by 10 to obtain the average FAF Zero Data Offset Voltage, A (487).

58. Output -A volts on D/A #3 and
-10 volts on D/A #2 (488, 158-162, 489).

59. <u>CONTINUE</u>.

60. Output (2.75 -A) volts on D/A #3 and -2 volts on D/A #2 (490, 158-162, 491).

61. Display "AF = 55 TBFE = 10 ; CONT?" (491).

62. <u>CONTINUE</u>.

63. Output (4.5 -A) volts on D/A #3 and 0 volts on D/A #2 (492, 158-162, 493).

64. Display "AF = 90 TBFE = 0 ; CONT?" (493).

65. CONTINUE.

66. Print "**OK**" (494, 441, 495).

67. Return to display "Test #?" (495-496, 445).

68. 5 CONTINUE. Run Test #5, VO chk. Amplifier Voltage Offset and Gain Check (450, 497).

69. Display "BUSY" (499).

70. Print, "*A/D Channels*" (500).

71. Set D/A #1 output to zero volts. Turn the V CAL relays ON. Set the A/D conversion rate to 10 Hz. Wait 1 second for the amplifier to settle (502).

72. Store the sum of 10 samples from each of the four A/D channels (501-504, 31-32, 163-169, 33-34, 504).

73. Set the A/D conversion rate to 0 Hz. Turn the V CAL relays OFF (505).

74. Print, "*Offset Voltage*" (506).

75. Print, "Ch Meas Gain" (508, 442, 509).

76. Divide the four sums from step 72 by 10 to obtain the average values of the Output Offset Voltages of the four amplifier channels (511).

77. Print the Output Offset Voltages and their normal values. If an Output Offset Voltage magnitude is greater than 0.5 volts, print an asterisk by its value in the printout (512-514, 439, 115), and display "XXX*Offset Out of Range CONT?" (515).

78. CONTINUE.

79. Print "* - Out of Range" if a value was out of range, otherwise print "**OK**" (517, 201-204, 518).

80. Set normal channel gain values in variables N[1]-N[4] (520).

81. Set V CAL values ; V[1] = 10 volts, V[2] = -10 volts, V[3] = +10 volts, V[4] = 3.06 volts (521).

82. Display, "BUSY" (523).

83. Store the sum of 10 samples taken at 10 samples per second from each of the four A/D channels, FAF, RAF, TBF, and V with V CAL inputs of 10 volts, -10 volts, +10 volts, and +3.06 volts, respectively. Wait 2 seconds after changing V CAL to allow the amplifiers to settle before reading the A/D converter outputs. Divide each sum by 10 to obtain the average values (518-525, 158-162, 526-527, 35-36, 163-169, 37-38, 528-530).

84. Print, "*A/D Channels, Voltage Gain*" (531-532).

85. Print, "Ch Meas Norm" (533, 442, 534).

86. Compute the Amplifier Voltage Gains. Print the Amplifier Voltage Gain values and their normal gain values. If a measured gain value is different from its normal value by more than five percent, print an asterisk by the value in the printout (535-541, 439, 542), and display "XXX*Chan Out of Range CONT?" (542).

87. <u>CONTINUE</u>.

88. Print, "*-Out of Range" if a value was out of range, otherwise print, "**OK**" (544, 201-204, 545).

89. Return display to "Test #?" (545-546, 445).

90. <u>6 CONTINUE</u>. Run Test #6, TC chk. Thermocouple Check (451, 547).

91. Print, "*Thermocouple*" (548).

92. Read isothermal block reference temperature (549, 170-176, 550). See Hewlett-Packard Low Level A/D Converter and Scanner Card manual for details of thermocouple read programs.

93. Read and print "Front," "Rear," and "Aux" thermocouple temperatures in deg. F (550, 177-183, 551). Note conversion from deg. C to deg. F in line (183). See sample printout in Section 5.5 page 141.

94. Print, "**OK**" (551, 441, 552).

95. Return display to "Test #?" (552-553, 445).

96. <u>0</u> <u>CONTINUE</u>. Return to "READY" (452, 424-425).

5. <u>WARM</u> (343). Brake Warming.

 1. Compute desired tow-bar force (343-346).

 2. Compute 95 percent of desired tow-bar force (347).

 3. Display, "Input Sec of Warming Application" (348).

 4. <u>XX</u> <u>CONTINUE</u>. XX = any two-digit number of seconds.

 5. Measure "Drag Force," the average of 10 samples of TBF taken at 10 samples per second. Store in A (349, 304-308, 90-91, 163-169, 92-94, 308-311, 350).

 6. Display, "Ready for Brake Warming Run" (350).

 7. Print, "Front" or "Rear" (354-355).

 8. Print, "Warming Run," "Sec.-XX" and "Temp: XX.XX" (356). The temperature printed is the last temperature measured, R, before starting the warming procedure. See sample printout in Section 5.6, page 146.

 9. Turn ON the front (358) or rear (359) brake apply light on the Rider Display. Output the tow-bar force error, the difference between the actual tow-bar force (minus the "Drag Force") and the desired tow-bar force to the tow-bar force error, TBFE, meter at a rate of 10 computed values of TBFE per second. When XX seconds (warming time entered in 4 above) have elapsed after the tow-bar force first exceeds 95 percent of the desired tow-bar force, turn the brake apply light OFF (357-361, 104-105, 163-169, 106-109, 152-157, 158-162, 110, 361-363).

6. PRE-B (671) or POST-B (671). Effectiveness Test

   1. If system has not been calibrated, print, "System Must Be Calibrated" and return to READY (672, 424-425).

   2. If parameters have not been loaded, print, "Parameters Must Be Loaded" and return to READY (673, 424-425).

   3. Print, "*Effectiveness Test Mode*" (674).

   4. Print, "Insert Data Tape Do Not Remove Until Tests Complete." Display, "Insert Data Tape; CONT" (675, 299-303, 676).

   5. CONTINUE.

   6. Display, "Ent 0-Start or 1-Cont Front Test" (676). If the Rear Effectiveness Tests were completed previously, enter 1 CONTINUE. Display, "BUSY LOADING REAR EFFECT DATA" (720). Load rear effectiveness data from tape (677, 719-721), then start the Front Effectiveness Test at line (722). Otherwise, enter 0 CONTINUE and start Rear Effectiveness Test at line (678).

   7. Print, "Start 4 Rear Tests" (679).

   8. Display, "Tow-Bar Height: 48 in. CONT" (680).

   9. CONTINUE.

   10. Sample rear temperature and velocity once per second. Display, "Rear T XX.XX V XX.XX *GO*" (681-684, 333-337, 95-96, 163-169, 97, 170-176, 98, 177-183, 99-103, 337).

   11. WARM, if the rear brake temperature is low (see WARM subprogram outline, page 75).

   12. GO, if the rear brake temperature and velocity are OK (338-342, 685).

   13. Display, "*Rear Effectiveness Run*" (686).

   14. Output FAF Zero Data Offset on D/A #3 (687, 158-162, 688).

   15. Measure "Drag Force," the average of 10 samples of TBF taken at 10 samples per second. Store in A (688, 304-308, 90-91, 163-169, 92-94, 309-311, 689).

16. Set a RAF threshold, B, equal to 9.0 lbs plus the RAF Zero Data Offset in pounds (690).

17. Set the A/D conversion rate to 100 Hz, select the RAF on Rider Display actuator force meter, turn ON the rear brake apply light on the Rider Display (692).

18. Sample the RAF (at 100 Hz). When the RAF first exceeds the threshold of 9 pounds, display, "5 Second Sample Period," and store the next 500 samples of the RAF and the TBF (691-693, 2-5, 693, 6-7, 693-694, 8, 695).

19. Display, "BUSY Comp Data Point, X" (315). Convert data points X = 1-500 to voltage values and store in matrices A[L] and D[L] for subsequent processing. Convert the data values to integers and store in strings F$[L] and G$[L] for subsequent storage on tape (696, 312-323, 697).

20. Display, "BUSY Avg Data Point X" (373). Filter (average) the RAF and TBF data stored in A[L] and D[L], and select the final data point by the algorithm described in Section 3.8.3 (697, 364-388, 698-699).

21. Print, "Preburnish" or "Postburnish" (700, 214-217, 701).

22. Print, "*Rear Effect*" (701).

23. Print data. See sample printout in Section 5.6, page 148. The temperature and velocity printed are the last values measured before <u>GO</u> (line 12, above) (702, 218-229, 703).

24. Display, "Select Option or CONT" (704).

25. <u>1 CONTINUE</u>, to repeat last run (705, 682).

    <u>2 CONTINUE</u>, to output analog data of the RAF and the TBF from the last run (706).

    <u>CONTINUE</u>, to record the following data from the last run on tape and then proceed to the next run: The 500 raw data samples of RAF and TBF, the drag force, A, and the Zero Data Offset Voltage and Gain of the RAF and TBF channels (707-708).

26. 2 CONTINUE, output analog data (706, 389).

27. Display, "Select A/D #3 Output Type:" (390).

28. Enter 1 CONTINUE, for unfiltered TBF.

    2 CONTINUE, for unfiltered AF.

    3 CONTINUE, for filtered TBF.

    4 CONTINUE, for filtered AF.

29. Display, "Select A/D #4 Output Type:" (391).

30. Enter any one of selections given in line 28 above.

31. Set data point time marker in analog output (392-393).

32. Set D/A #3 and D/A #4 outputs to 0 (394).

33. Display, "Press CONT To Start Graph" (395).

34. CONTINUE.

35. Display, "BUSY OUTPUTTING ANALOG DATA" (396).

36. Output selected analog data through D/A #3 and D/A #4 at 10 samples per second, i.e., one-tenth of real data time. Place a 10-volt (full-scale) pulse coincident with sample number 1 (397), sample number 500 (401), and the data point (17, 22) in the analog output (397-400, 15-22, 158-162, 23-25, 401).

37. Set D/A #3 and D/A #4 outputs to 0 (402-403, 704).

38. Display, "Select Option or CONT" (704).

39. CONTINUE.

40. Record data on tape (see line 25 above), go to next run (707-708, 782).

41. When CONTINUE is pressed after the fourth rear run, print, "4 Rear Tests Complete" (709).

42. Print, "Final Avg Data" (710).

43. Compute the average value of RAF and TBF from the four final effectiveness runs (711, 324-332, 712), and compute the effective rear friction coefficient (712). Print the computed data (714, 230-234, 715). See sample printout in Section 5.6, page 152.

44. Display, "BUSY STORING REAR EFFECT DATA" (715). Store rear effectiveness data on tape (716).

45. Print, "Rear Effect Test Complete" (717).

46. Print, "Start 4 Front Tests" (722).

47. Print, "Starting Tow-Bar Height in: XX.XX" (723).

48. Display, "Tow-Bar Height: XX.XX in, CONT" (724).

49. CONTINUE.

50. Sample front temperature and velocity once per second. Display, "Front T XX.XX V XX.XX *GO*" (725-730, 333-337, 95-96, 163-169, 97, 170-176, 98, 177-183, 99-103, 337).

51. WARM, if the front brake temperature is low (see WARM subprogram outline, page 75).

52. GO, if the front brake temperature and velocity are OK (338-342, 731).

53. Output the RAF Zero Data Offset Voltage on D/A #3 (732, 158-162, 733).

54. Display, "*Front Effectiveness Run*" (733).

55. Measure "Drag Force," the average of 10 samples of TBF taken at 10 samples per second. Store in A (734, 304-308, 90-91, 163-169, 92-94, 309-311, 735).

56. Set a FAF threshold, B, equal to 5.0 lbs plus the FAF Zero Data Offset (736).

57. Set the A/D conversion rate to 100 Hz, select the FAF on the Rider Display actuator force meter. Turn ON the front brake apply light on the Rider Display (738).

58. Sample the FAF at 100 Hz. When the FAF first exceeds the threshold of 5 pounds, display, "5 Second Sample Period," and store the next 500 samples of the FAF and the TBF (737-739, 9-12, 739, 13-14, 739-740, 8, 741).

59. Display, "BUSY Comp Data Point, X" (315). Convert data points X = 1-500 to voltage values and store in matrices A[L] and D[L] for subsequent processing. Convert the data values to integers and store in strings F$[L] and G#[L] for subsequent storage on tape (742, 312-323, 743).

60. Display, "BUSY Avg Data Point X" (373). Filter (average) the FAF and TBF data, store in A[L] and D[L], and select the final data point by the algorithm described in Section 3.8.3 (743, 364-388, 744-745).

61. Print, "Preburnish" or "Postburnish" (746, 214-217, 746). Print, "Front Effect " (746).

62. Print data. See sample printout in Section 5.6, page 148. The temperature and velocity printed are the last values measured before <u>GO</u> (line 52 above) (747, 218-229, 748).

63. Display, "Select Option or CONT" (749). The options are the same as after rear effectiveness runs. See lines 25-38 above.

64. <u>CONTINUE</u>.

65. Display, "BUSY STORING FRONT EFFECT DATA." Record data on tape. Go to next run (752, 762-764, 728).

66. When CONTINUE is pressed after the third run, compute a new tow-bar height using the average value of TBF from the previous three runs (753-756).

67. Print, "New TB Height XX.XX" (757).

68. Print, "Diff From Last XX.XX" (758).

69. Display, "Input 1 to Repeat Series or CONT" (759).

70. 1 CONTINUE. Repeat series of three runs, with new tow-bar height, starting at line (726), or CONTINUE. Display, "BUSY Storing Effect Data" (762). Store data from last run on tape (763) and proceed to a fourth run at the same tow-bar height (764, 728).

71. After the fourth run is completed, print, "4 Front Tests Completed Final Avg Data" (765).

72. Compute the average value of the FAF and TBF from the four final front effectiveness runs (766, 324-332, 767). Compute the effective deceleration (768), and the effective stopping distance from 60 mph (769).

73. Print the front effectiveness test data (770, 235-241, 771). See sample printout in Section 5.6, page 154.

74. Store front effectiveness test data on tape (771).

75. Print, "Effectiveness Testing Complete" (772).

76. Return to READY (773, 424-425).

7. BURNISH (601). Brake Burnishing.

1. If the motorcycle parameters have not been loaded, print, "Parameters Must Be Loaded," and return to READY (602, 424-425).

2. If system has not been calibrated, print, "System Must Be Calibrated," and return to READY (603, 424-425).

3. Print, "*Burnish Mode*" (604).

4. Print, "Insert Data Tape. Do Not Remove Until Tests Complete." Display, "Insert Data Tape; CONT" (605, 299-303, 606). CONTINUE.

5. Load last burnish run data from tape (606).

6. Display, "Set Tow-Bar to XX.XX Inches CONT" (607).

7. CONTINUE.

8. Set distance counters to 0 (609).

9. Once per second measure and display: front and rear brake temperatures, distance, and front and rear burnish count (612-614, 51-56, 184-185, 163-169, 186-188, 57, 170-176, 58, 177-183, 59-61, 614). See sample display in Section 5.7, page 155.

10. F or R, select Front or Rear burnish run.

11. Output the front or rear actuator channel Zero Data Offset on D/A #3 (617, 158-162, 618).

12. Set the A/D conversion rate to 10 Hz (621), update distance (622), compute the front or rear desired tow-bar force (624 or 627), display, "Front Burnish Run" or "Rear Burnish Run" (626 or 629). Set a TBF threshold equal to 95% of the desired TBF (631). Store the last reading of Front or Rear Brake Temperature and Velocity (632).

13. Measure "Drag Force," the average of 10 samples of TBF taken at 10 samples per second. Store in A (634, 62-63, 163-169, 64, 69-70, 634, 65).

14. Update distance (66, 184-185, 163-169, 186-188, 67). Distance is updated once each second during the burnish run.

15. Turn ON the front or rear brake apply light on the Rider Display and apply the FAF or RAF signal to the Rider Display actuator force meter (67-68, 69-70, 634).

16. Update the distance count once per second (73). Store the FAF or RAF and the TBF (74-75). Output the TBF Error, the difference between the actual TBF (minus the "Drag Force") and the desired TBF to the TBF Error meter on the Rider Display (76). When the TBF (minus the "Drag Force) first exceeds 95% of the desired TBF (77) store the sum of the next 40 samples of the FAF or RAF and the TBF (78-80). At the time of the 38th sample, turn OFF the brake apply light on the Rider Display (81). (634, 71-73, 184-185, 163-169, 186-188, 74, 163-169, 75, 163-169, 76, 152-157, 158-162, 77-84, 634).

17. Set the A/D conversation rate to 1 Hz (638). Continue updating the distance count once per second (637-638).

18. Divide the sums of 40 samples of the FAF or RAF and TBF from step 16 above by 40 to obtain the average AF and TBF for the run (639).

19. Set the front or rear distance count to 0 (640).

20. Store the burnish data (run number, initial velocity and brake temperature, and average FAF or RAF and TBF) for every tenth run on tape. Display, "BUSY WRITING DATA TO TAPE" while data is being stored (641-644).

21. Print the burnish run data. See sample printout in Section 5.7, page 156 (645-648, 281-290, 649).

22. Return to step 9 above, ready for the next burnish run (649-651, 610).

24. HALT. If entered during a burnish run, display, "Burnish Run Aborted" for 2 seconds, then return to step 9 above (635, 610).

    HALT. If entered after a burnish run is completed, display, "BUSY WRITING DATA TO TAPE," store the last burnish run on tape, including the front and rear run count, and return to READY (652-654, 424-425).

8. THERMAL (774). Thermal Capacity Test.

   1. If motorcycle parameters have not been loaded, print, "Parameters Must Be Loaded," and return to READY (775, 424-425).

   2. If the system has not been calibrated, print, "System Must Be Calibrated," and return to READY (776, 424-425).

   3. Print, "Thermal Fade Gain Test Mode" (777).

   4. Print, "Insert Data Tape. Do Not Remove Until Tests Complete." Display, "Insert Data Tape; CONT" (778, 299-303, 779). CONTINUE.

5. Print, "Set Tow-Bar Height To XX.XX" (779).

6. Display, "Tow-Bar Height: XX.XX In, CONT" (780).
CONTINUE.

7. Print, "Now Do 3 Front and 3 Rear FG Baseline Runs" (781).

8. Set run number counters, C[1] and C[2], to 0 (782).

9. At one second intervals, read and display the following: Front and rear brake temperatures, velocity, front and rear run count. See sample display in Section 5.8 page 159 (783, 189-194, 126-127, 163-169, 128, 170-176, 129, 177-183, 130, 177-183, 131-136, 194).

10. WARM, if the brake temperature is too low. Display, "Front or Rear Warming." When F or R is pressed, go to Warm subprogram (see WARM subprogram outline, page 75 (194-198, 404-410, 199, 190-194).

11. F or R. Enter front or rear brake to be tested.

12. Index front or rear run counter by 1 (196-197, 200, 784).

13. Store last front or rear temperature and velocity reading (786-787).

14. Output the FAF or RAF Zero Data Offset Voltage on D/A #3 (788, 158-162, 789).

15. Measure "Drag Force," the average of 10 samples of TBF taken at 10 samples per second. Store in A (789, 304-308, 90-91, 163-169, 92-94, 309-311, 790).

16. Compute front or rear desired TBF. Store in D (792-793). Store 95% of D in B (795).

17. Turn ON the front or rear brake apply light on the Rider Display. Switch the FAF or RAF on to the Rider Display actuator force meter. Set A/D conversion rate to 10 Hz (798-799).

18. Output the TBF Error, the difference between the desired TBF (minus the "Drag Force," A) and the actual TBF to the TBF Error meter on the Rider Display (796-801, 111-114, 163-169, 115-121, 152-157, 158-162, 122-125, 801).

19. When the TBF (minus the "Drag Force") first exceeds 95% of the desired TBF, D, out of the next 40 samples, store the sum of samples 21 through 40 (117-120) of the FAF or RAF and the TBF (801, 111-125, 801).

20. Turn OFF the brake apply light and set the A/D conversion rate to 0 Hz (802).

21. Compute the 2-second average of the FAF or RAF and the TBF. That is, divide the sums from step 19 by 20 (804-805).

22. Print, "Front Baseline" or "Rear Baseline" (806-807).

23. Print, "Pass #X" where X = 1, 2, or 3 (808).

24. Print the baseline pass data, that is, the initial velocity and temperature (stored in step 13 above) and the average FAF or RAF and TBF. See sample printout in Section 5.8, page 161 (809, 252-261, 810).

25. If the front or rear run count, C[1] or C[2], is less than three, return to line (783), step 9 above.

26. If the front and rear run counts are equal to three, compute the baseline average data from the three front and three rear runs (811-821).

27. Print, "Baseline Chk Complete Final Avg Data" (822-823).

28. Print the front and rear baseline average data. See sample printout in Section 5.8, page 162 (824, 242-251, 825).

29. Print, "Now Do 1 Front and 1 Rear Thermal Fade Series" (826).

30. Set front and rear run counters, C[1] and C[2], to 0 (827).

31. At one-second intervals read and display the following: Front and rear brake temperatures, velocity, front and rear run count. See sample display in Section 5.8, page 162 (830, 189-194, 126-127, 163-169, 128, 170-176, 129, 177-183, 130, 177-183, 131-136, 194).

32. WARM, if the brake temperature is too low, display "Front or Rear Warming." When F or R is pressed, go to WARM subprogram. (See WARM subprogram outline, page 75 (194-198, 404-410, 199, 190-194).

33. F or R. Enter front or rear brake to be tested.

34. Index front or rear run counter by 1 (196-197, 200, 831).

35. Set distance counters, D[1] and D[2], to 0 (832).

36. Compute front or rear desired TBF. Store in D (833-839). Store 95% of D in B (840).

37. Output the FAF or RAF Zero Data Offset Voltage on D/A #3 (841, 158-162, 842).

38. Set the A/D conversion rate to 1 Hz (845).

39. Once per second store distance (distance since end of last run), velocity, and front or rear brake temperature. Display front or rear distance. See sample display in Section 5.8, page 163 (842-846, 138-140, 184-185, 163-169, 186-188, 141, 170-176, 142, 177-183, 143-147, 846).

40. If the distance is greater than 0.39 miles or the run counter equals 1, store the last sampled values of velocity and front or rear brake temperatures in matrices (849-850).

41. Set the A/D conversion rate to 10 Hz (855).

42. Measure "Drag Force," the average of 10 samples of the TBF and store the average value in A. Output the TBF Error, the difference between the actual tow-bar force (minus the "Drag Force," A) and the desired TBF, to the TBF Error meter on the Rider Display. Turn ON the front or rear brake apply light on the Rider Display, and apply the FAF or RAF to the Rider Display actuator force meter. Continue to update the distance counter, each second. When the TBF (minus the "Drag Force," A) first exceeds B (95% of the desired TBF, D), store the last distance count in matrix H[5,J] and out of the next 60 data samples of the FAF or RAF and the TBF store the sum of samples 31 through 50 (854-856, 148-149, 163-169, 150-151, 856, 111-113, 184-188, 114, 163-169, 115-125, 856).

43. Set the A/D conversion rate to 1 Hz (860). Set the distance count to 0 (861). Update the distance count once each second (859-8XX, 85-86, 184-185, 163-169, 186-188, 87-89, 8XX+1).

44. Compute the two-second average of the FAF or RAF and the TBF. That is, divide the sums from step 42 by 20 (862-863). Compute the front or rear faded gain, FFG or RFG, which is the averaged TBF divided by the averaged FAF or RAF (864).

45. Print, "Pass #X" (865).

46. Print the front or rear faded gain run data. See sample printout in Section 5.8, page 163 (866, 262-274, 867).

47. Immediately following a distance counter update, if 10 front or rear runs are not completed, return to line (842), step 39 above (869). The front or rear brake apply light is turned On automatically at 0.39-mile intervals until 10 runs are completed.

48. If 10 front (or rear) runs are completed, print the average of the last three front faded gains (870, 275-277, 872) or the average of the last three rear faded gains (871, 278-280, 872).

49. Print, "10 Passes Completed" (872).

50. If 10 passes have yet to be completed on either the front or rear, print "Continue" and return to step 31 above (873).

51. If 10 runs are complete on both front and rear brakes, display, "BUSY Recording Tape Data." Record the thermal capacity data on tape (874-875).

52. Print, "Thermal Fade Tests Complete" (876).

53. Return to READY (877, 424-425).

54. HALT - If entered between baseline runs, return to READY.

- If entered during a baseline run, return to start of that run.

- If entered between runs during 10 faded gain run series, return to start of series.

- If entered at start of series, return to READY.

9. PRTOUT (878). Printout Data from Data Tapes.

1. Print, "Tape Data Output Mode" (879).

2. Print, "Insert Data Tape. Do Not Remove Until Tests Complete" (880, 299-301).

3. Display, "Insert Data Tape; CONT." CONTINUE (302-303, 881).

4. Display, "Select Printout Option" (883).

5. L PARA (889). Print motorcycle parameters.

   PRE-B (887). Print preburnish effectiveness test data.

   POST-B (887). Print postburnish effectiveness test data.

   THERMAL (890). Print thermal capacity test data.

   BURNISH (888). Print burnish data (every tenth run).

   GO (886). Print all the above in the order listed.

   HALT (885). Return to READY.

6. GO (886). Print all tape data.

7. Print motorcycle parameters (883-886, 892-894, 205-213, 895).

8. Print preburnish effectiveness test data (897-901, 214-217, 902-904, 218-222, 226-229, 905-906, 218-225, 229, 907-908, 230-234, 909-910, 235-241, 911).

9. Print postburnish effectiveness test data (912, 899-901, 214-217, 902-904, 218-222, 226-229, 905-906, 218-225, 229, 907-908, 230-234, 909-910, 235-241, 913).

10. Print thermal capacity test data (913, 915-919, 252-257, 261, 919, 920-921, 252-254, 258-261, 921, 922-923, 242-251, 924-925, 262-269, 274, 925, 926, 275-277, 927-928, 262-265, 270-274, 928, 929, 278-280, 930-931).

11. Print burnish run data (931, 933-944, 281-286, 290, 945, 946-952, 281-283, 287-290, 953-954).

12. Return to READY (955, 424-425).

10. GRAPH (957). Analog Output of the FAF, RAF, and TBF from Effectiveness Test.

1. Print, "Graph Output Mode" (958).

2. Display, "Insert Data Tape, CONT (959). CONTINUE.

3. Display, "Enter Raw Data File #, CONT" (960).

4. X CONTINUE. Enter file number X. Table 5, page 166 lists the file numbers (5-20) and their contents. File 5, for example, is Run #1, Rear Brake, Preburnish Effectiveness Test.

5. Print, "Preburnish or Postburnish" (962, 214-217, 963).

6. Print, "Rear" (963) or "Front" (964).

7. Print, "Effectiveness Data Graph" (965).

8. Print, "File #X" (966).

9. Print, "Run #Y" (967-970).

10. Load data from specified file on tape into the computer (971).

11. Display "BUSY Comp Data Point X," X = 1-500. Convert data from integer to floating point and store in matrices A[L] and D[L] (972, 411-417, 973).

12. Display, "BUSY Avg Data Point X," X = 40-460. Filter the data and select the numeric data point (973, 364-388, 974).

13. Print the numeric of the data point. That is, the TBF, the FAF (or RAF) and the Data Point Time (974-976).

14. Output analog data selected by the operator on A/D #3 and A/D #4. For details, see the effectiveness test description, lines 25 to 38, pages 78-79 (977, 389-403, 978).

15. Display, "Select Option or CONT" (278).

1 CONTINUE. Return to display "Enter Raw Data File #." Select new data file to output (980, 960).

2 CONTINUE. Select outputs from current data file (981, 977, 389-403, 978).

CONTINUE. Return to READY (979, 424-425).

11. TK1, TK2. Tape Track Selection.

Pressing TK1 or TK2 selectes tape track 1 or track 2, respectively. All data from the test of one motorcycle fits on one track of a data tape. Thus, data for one motorcycle can be recorded on track 1 and data for a second motorcycle can be recorded on track 2 of one data tape.

Each time the computer is turned on, it automatically selects track 1. Track 2 must be selected by the operator. Extreme care must be exercised when recording data on track 2. If track 2 is not selected each time after turning the computer on, data intended for track 2 will be recorded on track 1, over-writing data previously recorded on track 1. Because of this possibility, it is recommended that data from only one motorcycle is stored on each data tape. Otherwise, data should be recorded on track 2 first.

3.8.5 The MBT Program.

1. Program Listing:

```
0: gto 418
1: " Motorcycle
 Brake Test Prog
 ram. Jan 27,
 1981":
2: "PRS":wti 4,
 20000;rdi 4→M;
 if M>3777;M+
 170000→M
3: if bit(15,
 add(B,M))=1;
 jmp 2
4: dsp "5 Second
 Sample Period"
 ;oni 9,"RS"
5: wtb 9,170260,
 30000;eir 9;
 iret
6: "RS":C+1→C;
 wti 4,20000;
 rdi 4→Y[C];wti
 4,30000;rdi
 4→M[C]
7: wtb 9,170260,
 30000;eir 9;
 iret
8: "Stop":wtb 9,
 170140,110000;
 cfg 9;iret
9: "PFS":wti 4,
 10000;rdi 4→M;
 if M>3777;M+
 170000→M
10: if bit(15,
 add(B,M))=1;
 jmp 2
11: dsp "5 Secon
 d Sample Period
 ";oni 9,"FS"
12: wtb 9,170260
 ,30000;eir 9;
 iret
13: "FS":C+1→C;
 wti 4,10000;
 rdi 4→Y[C];wti
 4,30000;rdi
 4→M[C]
14: wtb 9,170260
 ,30000;eir 9;
 iret
15: "OG":C+1→C
16: for N=1 to 2
17: if C=X[4];
 10→X[3];jmp 5
18: if X[N]=1;
 (A[C]-A)*G[3]/
 100→X[3]
19: if X[N]=2;
 (D[C]-O[U])*
 G[U]/20→X[3]
20: if X[N]=3;
 M[C]/100→X[3]
21: if X[N]=4;
 Y[C]/20→X[3]
22: moct;wtb 9,
 170140,'VO'(X[3
 ],2+N)
23: next N
24: if C#500;
 wtb 9,170260,
 30000;eir 9
25: iret
26: "MCavg":C+
 1→C
27: 'IVI'(1)+A→A
28: if C=10;sfg
 9;iret
29: wtb 9,170260
 ,30000;eir 9
30: iret
31: "CO":C+1→C
32: for L=1 to
 4;F[L]+'IVI'(L)
 →F[L];next L
33: if C=10;sfg
 9;iret
34: wtb 9,170260
 ,30000;eir 9;
 iret
35: "CG":C+1→C
36: E[L]+'IVI'(L
 )→E[L]
37: if C=10;sfg
 9;iret
38: wtb 9,170260
 ,30000;eir 9;
 iret
39: "CC":C+1→C
40: for L=1 to 4
41: O[L]+'IVI'(L
 )→O[L]
42: next L
43: if C=10;sfg
 9;iret
44: wtb 9,170260
 ,30000;eir 9;
 iret
45: "GC":C+1→C
46: for L=1 to 4
47: G[L]+'IVI'(L
 )→G[L]
48: next L
49: if C=10;sfg
 9;iret
50: wtb 9,170260
 ,30000;eir 9;
 iret
51: "Bupdt":
52: if flg8;sfg
 9;iret
53: if K[2]=1;
 sfg 8;1→U
54: if K[2]=2;
 sfg 8;2→U
55: if K[3]=1;
 sfg 5;sfg 9;
 iret
56: cll 'Dist'
57: cll 'TCref'
58: 'Temp'(1)→T[
 1];'Temp'(2)→T[
 2]
59: wrt .1,T[1],
 T[2],D[1],D[2],
 C[1],C[2]
60: moct;wtb 9,
 170260,30000;
 eir 9
61: iret
62: "Bavg":C+1→C
63: A+'IVI'(3)→A
64: if C#10;jmp
 5
65: oni 9,"Bpass
 ";A/10→A
66: cll 'Dist'
```

```
67: if U=1;wtb
 9,170140,111002
 ;jmp 2
68: wtb 9,170140
 ,112102
69: wtb 9,170260
 ,30000;eir 9
70: iret
71: "Bpass":C+
 1→C
72: if K[3]=1;
 sfg 5;sfg 9;
 iret
73: if Cmod10=0;
 cll 'Dist'
74: ('IVI'(3)-
 A)*G[3]→F[3]
75: ('IVI'(U)-
 O[U])*G[U]→F[4]
76: wtb 9,170140
 ,'VO'('Error'(F
 [3],D),2)
77: if G=0 and
 F[3]<B;jmp 6
78: G+1→G
79: F[3]+E[3]→E[
 3]
80: F[4]+E[4]→E[
 4]
81: if G=38;wtb
 9,170140,120002
82: if G=40;sfg
 9;jmp 2
83: wtb 9,170260
 ,30000;eir 9
84: iret
85: "Fdist":
86: cll 'Dist'
87: if flg8;sfg
 9;iret
88: wtb 9,170260
 ,30000;eir 9
89: iret
90: "Asamp":C+
 1→C
91: A+'IVI'(3)→A
92: if C=10;sfg
 9;iret
93: wtb 9,170260
 ,30000;eir 9
94: iret
95: "Eupdt":
96: ('IVI'(4)-
 O[4])*G[4]→V[J]
97: cll 'TCref'
98: 'Temp'(U)→T[
 J]
99: if 1=U;dsp
 "Front T:",T[J]
 ,"V:",V[J],"*
 GO*";jmp 2
100: dsp "Rear
 T:",T[J],"V:",
 V[J],"*GO*"
101: if K[3]#0;
 sfg 9;jmp 2
102: moct;wtb 9,
 170260,30000;
 eir 9
103: iret
104: "WS":
105: ('IVI'(3)-
 A)*G[3]→T
106: if C=0 and
 T<G;jmp 2
107: C+1→C
108: if C=N;sfg
 9;jmp 2
109: wtb 9,17014
 0,'VO'('Error'(
 T,D),2),170260,
 30000;eir 9
110: iret
111: "Tsamp":C+
 1→C
112: if K[3]=1;
 sfg 5;sfg 9;
 iret
113: if C/10=int
 (C/10);cll 'Dis
 t'
114: ('IVI'(3)-
 A)*G[3]→T
115: if flg1
 and G=0;D[1]→H[
 5,J]
116: if G=0 and
 T<B;jmp 5
117: G+1→G
118: if G<E[1]
 or G>E[2];jmp 3
119: F[1]+T→F[1]
120: F[2]+('IVI'
 (U)-O[U])*G[U]→
 F[2]
121: wtb 9,17014
 0,'VO'('Error'(
 T,D),2)
122: if flg1
 and G=60;sfg 9;
 jmp 3
123: if not flg1
  and G=E[2];
 sfg 9;jmp 2
124: wtb 9,17026
 0,30000;eir 9
125: iret
126: "Tupdt":
127: ('IVI'(4)-
 O[4])*G[4]→S
128: cll 'TCref'
129: 'Temp'(1)→T
 [1]
130: 'Temp'(2)→T
 [2]
131: fmt 1,"FT:"
 ,f3.0," RT:",
 f3.0," V:",f5.2
 ," C: ",f2.0,"
 ",f2.0
132: wrt .1,T[1]
 ,T[2],S,C[1],
 C[2]
133: if K[3]=1;
 sfg 5;sfg 9;
 jmp 3
134: if K[2]#0
 or K[3]=3;sfg
 9;jmp 2
135: moct;wtb 9,
 170260,30000;
 eir 9
136: iret
137: "TTwait":
138: if K[3]=1;
 sfg 5;sfg 9;
 iret
139: if flg8;
 sfg 9;iret
140: cll 'Dist'
141: cll 'TCref'
142: 'Temp'(U)→T
 [1]
143: if D[1]>=.3
 9 or C[U]=1;
 sfg 8
144: if U=1;dsp
 "Front D:",D[1]
 ;jmp 2
145: dsp "Rear
 D:",D[1]
```

```
146: moct;wtb 9,
 170260,30000;
 eir 9
147: iret
148: "Tavg":C+
 1→C
149: 'IVI'(3)+
 A→A
150: if C=10;
 oni 9,"Tsamp";
 A/10→A;wtb 9,
 170140,X
151: wtb 9,17026
 0,30000;eir 9;
 iret
152: "Error":
153: p2-p1→p3;
 if p3=0;0→p4;
 jmp 5
154: -(p3/p2*
 10)→p4
155: if p4<-10;-
 10→p4
156: if p4>10;
 10→p4
157: ret p4
158: "VO":
159: (p2-1)*1024
 →p3
160: p1/.02→p4
161: if p4<0;p4+
 1024→p4
162: ret dto(p3+
 p4)+120000
163: "IVI":wti
 0,11
164: dtop1*10000
 →p3
165: wti 4,p3
166: rdi 4→p2
167: if p2>=1000
 00;p2-100000→p2
168: otdp2→p2;
 if p2>2047;p2-
 4096→p2
169: ret p2*.005
170: "TCref":
171: moct;wtb 9,
 170160,140007,
 170260
172: wti 4,14000
 0;rdi 4→p2
173: (otdp2-4096
 )*(10/4352)→p2
174: 3923.7225/
 (13.158+ln(-
 p2))-273.2→p2
175: p2(39.44887
 2+p2(2.458362e-
 2+p2*9.0918433e
 -6))1e-6→K;mdec
176: ret
177: "Temp":moct
178: wtb 9,17016
 0,140000+dtop1,
 170260
179: wti 4,14000
 0;rdi 4→p2
180: ((otdp2→p2)
 -(p2>2047)4096)
 1e-5→p2
181: (K+p2)1e6→p
 2
182: p2(2.438324
 8e-2+p2(9.78302
 51e-9+p2(3.6276
 965e-12+p2*-
 2.5756438e-16))
 )→p2
183: mdec;ret
 1.8*p2+32
184: "Dist":
185: ('IVI'(4)-
 O[4])*G[4]*2.77
 77e-4→V
186: D[1]+V→D[1]
187: D[2]+V→D[2]
188: ret
189: "Twait":
190: cfg 9;cfg 5
191: 0→K[3]→K[2]
 →F[1]→F[2]
192: oni 9,"Tupd
 t"
193: moct;wtb 9,
 170140,110001,
 170260,30000;
 eir 9
194: if not flg9
 ;jmp 0
195: if flg5;
 jmp 5
196: if K[2]=1
 and C[1]<Q;C[1]
 +1→C[1];1→U;
 jmp 4
197: if K[2]=2
 and C[2]<Q;C[2]
 +1→C[2];2→U;
 jmp 3
198: if K[3]=3;
 cll 'Fwarm'
199: jmp -9
200: ret
201: "Pend":
202: if flg1;
 prt "*-Out Of
 Range";jmp 2
203: prt "    **
  OK **"
204: ret
205: "PPara":fxd
  2
206: prt "Basic
 Motorcycle","
  Parameters"
207: prt "Bike
 Name:",A$
208: prt "Total
 Weight:",P[3]
209: prt "Front
 Wheel Load",
 P[1]
210: prt "Rear
 Wheel Load:",
 P[2]
211: prt "CG
 Height:",P[4]
212: prt "Wheelb
 ase:",P[5]
213: ret
214: "POPB":
215: if flg5;
 prt "* Postburn
 ish  *";jmp 2
216: prt "*
 Preburnish  *"
217: ret
218: "Peff":
219: 0→P;if J>4;
 4→P
220: fxd 0;prt
 "Run#",J-P
221: fxd 2;prt
 "V:",V[J]
222: if P=0;jmp
 4
```

```
223: prt "FT:",
 T[J]
224: prt "FTBF:"
 ,F[J]
225: prt "FAF:",
 Z[J];jmp 4
226: prt "RT:",
 T[J]
227: prt "RTBF:"
 ,F[J]
228: prt "RAF:",
 Z[J]
229: ret
230: "PRavg":
231: fxd 2;prt
 "Avg RTBF",E[2]
232: prt "Avg
 RAF",E[1]
233: prt "Rear
 Friction","Coef
 ficient:",S[1]
234: ret
235: "PFavg":
236: fxd 2;prt
 "Avg FTBF",E[4]
237: prt "Avg
 FAF",E[3]
238: prt "Final
 Towbar","Height
 ",S[4]
239: fxd 4;prt
 "Eq Free Stoppi
 ng","Decel.",
 S[2]
240: fxd 2;prt
 "Eq Free Stoppi
 ng","Dist. From
 ","60 mph",
 S[3]
241: ret
242: "PBLavg":
243: prt " Rear
 Baseline","
 Avg Data"
244: fxd 2;prt
 "Avg RTBF:",
 I[1,8]
245: prt "Avg
 RAF:",I[2,8]
246: prt "Baseli
 ne RBG:",I[3,
 8];spc
247: prt " Front
  Baseline","
  Avg Data"
248: prt "Avg
 FTBF:",I[1,4]
249: prt "Avg
 FAF:",I[2,4]
250: prt "Baseli
 ne FBG",I[3,4]
251: ret
252: "PBLpass":f
 xd 2
253: prt "V:",
 I[4,J]
254: if J>4;jmp
 4
255: prt "FT:",
 I[3,J]
256: prt "FTBF:"
 ,I[1,J]
257: prt "FAF:",
 I[2,J];jmp 4
258: prt "RT:",
 I[3,J]
259: prt "RTBF:"
 ,I[1,J]
260: prt "RAF:",
 I[2,J]
261: ret
262: "PFGpass":
263: fxd 2;prt
 "D:",H[5,J]
264: prt "V:",
 H[4,J]
265: if J>10;
 jmp 5
266: prt "FT:",
 H[3,J]
267: prt "FTBF:"
 ;H[1,J]
268: prt "FAF:",
 H[2,J]
269: prt "FFG:",
 H[6,J];jmp 5
270: prt "RT:",
 H[3,J]
271: prt "RTBF:"
 ,H[1,J]
272: prt "RAF:",
 H[2,J]
273: prt "RFG:",
 H[6,J]
274: ret
275: "PFFGavg":
276: prt "Final
 3 FFG avg:",
 (H[6,8]+H[6,9]+
 H[6,10])/3
277: ret
278: "PRFGavg":
279: prt "Final
 3 RFG avg:",
 (H[6,18]+H[6,
 19]+H[6,20])/3
280: ret
281: "Pburn":fxd
  2
282: prt "V:",
 E[2]
283: if U=2;jmp
 4
284: prt "FT:",
 E[1]
285: prt "FTBF:"
 ,E[3]
286: prt "FAF:",
 E[4];jmp 4
287: prt "RT:",
 E[1]
288: prt "RTBF:"
 ,E[3]
289: prt "RAF:",
 E[4]
290: ret
291: "Parameters
 ":
292: ent "Input
 Motorcycle Name
 , Notation:",A$
293: ent "Input
 Total Bike Weig
 ht, lbs.",P[3]
294: ent "Input
 Static Front
 Wheel Load,lbs"
 ,P[1]
295: ent "Input
 Static Rear
 Wheel Load lbs.
 ",P[2]
296: ent "Input
 Center Of Gravi
 ty Hgt. in.",
 P[4]
297: ent "Input
 Wheelbase, in."
 ,P[5]
298: ret
299: "Tchk":
300: prt "Insert
  Data Tape","
 Do Not Remove",
 "  Until Tests"
```

```
301: prt "
 Complete";spc 3
302: dsp "Insert
  Data Tape;
 CONT";stp
303: ret
304: "PreAvg":
305: cfg 9;0→C→A
306: oni 9,"Asam
 p"
307: moct;wtb 9,
 170140,110002;
 170260,30000;
 eir 9
308: if not flg9
 ;jmp 0
309: wtb 9,17014
 0,110000
310: A/10→A
311: ret
312: "BtoRD":
313: moct;7777→p
 3;170000→p4
314: for L=1 to
 500
315: fxd 0;dsp
 "BUSY  Comp
 Data Point",L
316: M[L]→p5;
 Y[L]→p6
317: band(p5,
 p3)→p5
318: if bit(11,
 p5)=1;ior(p4,
 p5)→p5
319: if bit(11,
 p6)=1;ior(p4,
 p6)→p6
320: otdp5*.005→
 A[L];otdp6*.005
 →D[L]
321: fti (otdp5)
 →F$[L];fti (otd
 p6)→G$[L]
322: next L
323: ret
324: "4avg":
325: 0→F→Z
326: cfg 4;if
 U=1;sfg 4
327: for L=1+
 flg(4)4 to 4+
 flg(4)4
328: F+F[L]→F
329: Z+Z[L]→Z
330: next L
331: F/4→F;Z/4→Z
332: ret
333: "Ewait":
334: cfg 2;cfg
 9;0→K[3]
335: oni 9,"Eupd
 t"
336: moct;wtb 9,
 170140,110001,
 170260,30000;
 eir 9
337: if not flg9
 ;jmp 0
338: if K[3]#3;
 jmp 3
339: T[J]→R;cll
 'Warm'
340: jmp -6
341: cfg 2;if
 K[3]=1;sfg 2
342: ret
343: "Warm":
344: 0→A→C
345: if U=1;.31(
 P[1]+P[4]/P[5]*
 P[3]*.31)→D;
 jmp 2
346: .31(P[2]-
 P[4]/P[5]*P[3]*
 .31)→D
347: .95D→G
348: ent "Input
 Sec Of Warming
 Aplication",N
349: cll 'PreAvg
 '
350: dsp "Ready
 For Brake Warmi
 ng Run"
351: N*10→N
352: cfg 9
353: 0→C→K[3]
354: if U=1;prt
 "     FRONT";
 jmp 2
355: prt "
 REAR"
356: prt "  Warm
 ing Run","Sec:"
 ,N/10,"Temp:",
 R;spc 3
357: oni 9,"WS"
358: if U=1;wtb
 9,170140,111002
 ;jmp 2
359: wtb 9,17014
 0,112102
360: wtb 9,17026
 0,30000;eir 9
361: if not flg9
 ;jmp 0
362: wtb 9,17014
 0,110001
363: ret
364: "Mavg":
365: 0→W[3]→W[4]
 →P→p5;cfg 10
366: 55→R;if
 U=2;90→R
367: O[U]*G[U]→p
 1
368: G[U]/21→p2
369: A*G[3]→p3
370: for L=0 to
 39;J[L]*G[3]→Q[
 L];next L
371: for L=1 to
 40;0→M[L]→Y[L]→
 M[501-L]→Y[501-
 L];next L
372: for L=40
 to 460
373: fxd 0;dsp
 "BUSY   Avg
 Data Point",L
374: A[L]*Q[0]→p
 4
375: for D=1 to
 39;p4+(A[L+D]+
 A[L-D])*Q[D]→p4
 ;next D
376: p4-p3→M[L]
377: D[L]→p4
378: for D=1 to
 10;p4+(D[L-D]+
 D[L+D])→p4;next
  D
379: p4*p2-p1→Y[
 L]
380: if Y[L]>=R
 and W[4]=0;L→W[
 4]
381: if M[L]>P
 and not flg10;
 M[L]→P;L→W[3]
382: if Y[L]>p5;
 Y[L]→p5
383: if Y[L]<.8p
 5;sfg 10
384: next L
```

```
385: if Y[W[3]]<
 R;M[W[3]]→W[1];
 Y[W[3]]→W[2];
 1→N[J];jmp 2
386: M[W[4]]→W[1
 ];Y[W[4]]→W[2];
 0→N[J];W[4]→W[3
 ]
387: if W[3]<200
  or W[3]>450;
 prt "DATA POINT
  TIME"," OUT
 OF BOUNDS"
388: ret
389: "Goutput":0
 →C
390: ent "Select
  A/D #3 Output
 Type:",X[1]
391: ent "Select
  A/D #4 Output
 Type:",X[2]
392: if N[J]=1;
 W[3]→X[4];jmp 2
393: W[4]→X[4]
394: moct;wtb 9,
 170140,124000,
 126000
395: dsp "Press
 CONT To Start
 Graph";stp
396: dsp "BUSY
 OUTPUTTING ANAL
 OG DATA"
397: moct;wtb 9,
 170140,'VO'(10,
 3),'VO'(10,4);
 wait 100
398: oni 9,"OG"
399: wtb 9,17014
 0,110002,170260
 ,30000;eir 9
400: if C#500;
 jmp 0
401: wtb 9,17014
 0,'VO'(10,3),
 'VO'(10,4);wait
  100
402: wtb 9,17014
 0,124000,126000
403: ret
404: "Fwarm":
405: 0→K[2]
406: dsp "Front
 or Rear Warming
  ?";if K[2]=0;
 jmp 0
407: K[2]→U
408: T[U]→R
409: cll 'Warm'
410: ret
411: "Unpack":
412: for L=1 to
 500
413: dsp "BUSY
 Comp Data Point
 ",L
414: itf(F$[L])*
 .005→A[L]
415: itf(G$[L])*
 .005→D[L]
416: next L
417: ret
418: dim C[2],
 B[20,8],A[500],
 E[4],F[8],N[8],
 S[4],T[8],V[8],
 Z[8]
419: dim A$[80],
 P[5],D[500],
 K[4],M[500],
 Y[500],B$[32]
420: dim W[4],
 R[2],Q[0:39],
 H[6,20],I[4,8]
421: dim A,O[4],
 G[4],F$[500,2],
 G$[500,2],J[0:3
 9],X[4]
422: wti 0,11
423: ldk 1;ldf
 2,J[*]
424: "Ready":cfg
  14;0→K[1]→K[2]
 →K[3]→K[4]
425: dsp "READY"
 ;if not flg14;
 jmp 0
426: if K[1]=1;
 gto "Effective"
427: if K[1]=2;
 gto "System
 Check"
428: if K[1]=3;
 gto "Burnish
 Setup"
429: if K[1]=4;
 gto "LPara"
430: if K[1]=5;
 gto "MarkT"
431: if K[1]=7;
 gto "Thermal"
432: if K[1]=8;
 gto "PrtOut"
433: if K[1]=9;
 gto "Graph"
434: gto "Ready"
435: "System
 Check":
436: prt "# Syst
 em Check #"
437: prt "# +
 Calibration #"
438: prt "#
 Mode     #";
 spc 3
439: "FAF RAF
 TBF V   FAF*
 RAF*TBF*V*
 "→B$
440: fmt 4,"*-
 Out Of Range"
441: fmt 3,"    *
 * OK **"
442: fmt 9,"Ch
  Meas   Norm"
443: fmt 1,c4,
 f4.0,"   ",f4.0
444: fmt 2,c4,
 f5.2,"   ",f5.2
445: ent "Test
 #?",T
446: if T=1;cll
 'ALL'
447: if T=2;cll
 'COcal'
448: if T=3;cll
 'AOchk'
449: if T=4;cll
 'RDchk'
450: if T=5;cll
 'VOchk'
451: if T=6;cll
 'TCchk'
452: if T=0;gto
 "Ready"
453: jmp -8
```

```
454: "ALL":
455: cll 'AOchk'
456: cll 'RDchk'
457: cll 'VOchk'
458: cll 'COcal'
459: cll 'TCchk'
460: 0→T
461: ret
462: "AOchk":
463: prt "*Analo
 g Output *","*
      Check    *"
464: moct;wtb 9,
 170140,120000,
 122000,124000,
 126000
465: dsp "D/A
 Outputs=0.00V;
      CONT?";stp
466: wtb 9,17014
 0,120372,122372
 ,124372,126372
467: dsp "D/A
 Outputs=5.00V;
      CONT?";stp
468: wtb 9,17014
 0,120764,122764
 ,124764,126764
469: dsp "D/A
 Outputs=10.00V;
      CONT?";stp
470: wrt 16.3;
 spc 3
471: mdec;10→T
472: ret
473: "RDchk":
474: prt "* Ligh
 t Check  *"
475: moct;wtb 9,
 170140,113000
476: dsp "Front
 and Rear Lights
  On;  CONT?";
 stp
477: wtb 9,17014
 0,110000
478: dsp "Front
 and Rear Lights
  Off; CONT?";
 stp
479: wrt 16.3;
 spc 3
480: prt "* Mete
 r Check  *"
481: 0→C→A
482: dsp "BUSY";
 cfg 9
483: oni 9,"MCav
 g"
484: wtb 9,17014
 0,110002,170260
 ,30000;eir 9
485: if not flg9
 ;jmp 0
486: wtb 9,17014
 0,110000
487: A/10→A
488: wtb 9,17014
 0,'VO'(-A,3),
 'VO'(-10,2)
489: dsp "AF=0
 TBFE=50; CONT?"
 ;stp
490: wtb 9,'VO'(
 2.75-A,3),'VO'(
 -2,2)
491: dsp "AF=55
  TBFE=10; CONT?
 ";stp
492: wtb 9,'VO'(
 4.5-A,3),'VO'(0
 ,2)
493: dsp "AF=90
  TBFE=0; CONT?"
 ;stp
494: wrt 16.3;
 spc 3
495: mdec;10→T
496: ret
497: "VOchk":
498: 0→F[1];0→F[
 2];0→F[3];0→F[4
 ]
499: dsp "BUSY";
 0→C;cfg 9
500: prt "* A/D
 Channels *"
501: oni 9,"CO"
502: moct;wtb 9,
 170140,120000,
 110012;wait
 1000
503: wtb 9,17026
 0,30000;eir 9
504: if not flg9
 ;jmp 0
505: wtb 9,17014
 0,110000
506: prt "*Offse
 t Voltage*"
507: cfg 1
508: wrt 16.9
509: for L=1 to
 4
510: 0→U
511: F[L]/10→F[L
 ]
512: if abs(F[L]
 )>.5;16→U;sfg 1
513: U+(L-1)*4+
 1→S
514: wrt 16.2,
 B$[S,S+3],F[L],
 0
515: if U=16;
 dsp B$[S,S+3],
 "Offset Out Of
 Range    CONT?"
 ;beep;stp
516: next L
517: cll 'Pend';
 spc 3
518: "CGchk":
519: 0→C→E[1]→E[
 2]→E[3]→E[4]
520: 553→N[1];
 541→N[2];396→N[
 3];1.31→N[4]
521: 10→V[1];-
 -10→V[2];10→V[3]
 ;3.06→V[4]
522: for L=1 to
 4
523: dsp "BUSY";
 0→C;cfg 9
524: oni 9,"CG"
525: moct;wtb 9,
 170140,'VO'(V[L
 ],1),110012;
 wait 2000
526: wtb 9,17026
 0,30000;eir 9
527: if not flg9
 ;jmp 0
528: wtb 9,17014
 0,110000
529: E[L]/10→E[L
 ]
530: next L
```

```
531: prt "* A/D
 Channels *"
532: prt "* Volt
 age Gain *"
533: wrt 16.9
534: cfg 1
535: for L=1 to
 4
536: 0→U
537: abs((E[L]-
 F[L])/(V[L]/
 1000↑(not L=4))
 )→D[L]
538: if abs(D[L]
 -N[L])>.05*N[L]
 ;16→U;sfg 1
539: 1+U+(L-1)*
 4→S
540: if L=4;wrt
 16.2,B$[S,S+3],
 D[L],N[L];jmp 2
541: wrt 16.1,
 B$[S,S+3],D[L],
 N[L]
542: if U=16;
 beep;dsp B$[S,
 S+3],"Chan Out
 Of Range   CONT
 ?";stp
543: next L
544: cll 'Pend';
 spc 3
545: mdec;10→T
546: ret
547: "TCchk":
548: prt "* Ther
 mocouple *"
549: cll 'TCref'
550: prt "Front:
 ",'Temp'(1),
 "Rear :",'Temp'
 (2),"Aux  :",
 'Temp'(3)
551: wrt 16.3;
 spc 3
552: 10→T
553: ret
554: "COcal":
555: 0→C→O[1]→O[
 2]→O[3]→O[4]
556: dsp "All
 Cables Slack?
    CONT";stp
557: dsp "BUSY";
 cfg 9
558: oni 9,"CC"
559: moct;wtb 9,
 170140,110002
560: wtb 9,17026
 0,30000;eir 9
561: if not flg9
 ;jmp 0
562: wtb 9,17014
 0,110000
563: prt "*
 Zero Data   *",
 "*Offset Voltag
 e*"
564: prt "* Cali
 bration  *"
565: wrt 16.9
566: cfg 1
567: for L=1 to
 4
568: O[L]/10→O[L
 ]
569: 0→U;if abs(
 O[L])>.5;sfg 1;
 16→U
570: U+1+(L-1)*
 4→S
571: wrt 16.2,
 B$[S,S+3],O[L],
 0
572: if U=16;
 beep;dsp B$[S,
 S+3],"Offset
 out of Range
 CONT?";stp
573: next L
574: cll 'Pend';
 spc 3
575: "NGcal":
576: prt "* Sig
 Conv Gain*","*
 Calibration  *"
577: 0→C→G[1]→G[
 2]→G[3]→G[4]
578: 98.1→V[1];
 96.2→V[2];348→V
 [3];40→V[4]
579: 20→N[1];
 20→N[2];100→N[3
 ];10→N[4]
580: dsp "BUSY";
 cfg 9;oni 9,
 "GC"
581: wtb 9,17014
 0,'VO'(3.06,1),
 110006;wait
 2000
582: wtb 9,17026
 0,30000;eir 9
583: if not flg9
 ;jmp 0
584: wtb 9,17014
 0,110000,120000
585: wrt 16.9
586: cfg 1
587: for L=1 to
 4
588: 0→U
589: V[L]/(G[L]/
 10-O[L])→G[L]
590: if abs(G[L]
 -N[L])>.05*N[L]
 ;16→U;sfg 1
591: U+1+(L-1)*
 4→S
592: fmt c4,f7.2
 ," ",f3.0
593: wrt 16,B$[S
 ,S+3],G[L],N[L]
594: if U=16;
 beep;dsp B$[S,
 S+3],"SC Gain
 Out Of Range
 CONT?";stp
595: next L
596: prt "1-3
 Units lbs/V"
597: prt "Ch 4
 Units Mph/V"
598: cll 'Pend';
 spc 3
599: mdec;10→T
600: ret
601: "Burnish
 Setup":
602: if P[4]=0;
 prt "Parameters
 ","Must Be Load
 ed";spc 3;gto
 "Ready"
603: if G[1]=0;
 prt "System
 Must Be","
 Calibrated";
 spc 3;gto "Read
 y"
```

```
604: prt "* Burnish Mode *";
 spc 3
605: cll 'Tchk'
606: ldf 1,C[*],
 B[*]
607: dsp "Set
 TowBar To",P[4]
 ,"Inches CONT";
 stp
608: fmt 1,"T ",
 f3.0," ",f3.0,
 " D ",f4.2," ",
 f4.2," C ",f3.0
 ," ",f3.0
609: 0→D[1]→D[2]
610: "Wait":
611: 0→K[2]→K[3]
 →Y→Z→C;cfg 5;
 cfg 8;cfg 9
612: oni 9,"Bupd
 t"
613: moct;wtb 9,
 170140,110001,
 170260,30000;
 eir 9
614: if not flg9
 ;jmp 0
615: if flg5;
 gto "Bend"
616: "Burnish":
617: moct;wtb 9,
 170140,'VO'(-
 O[U],3)
618: 0→C→A→G
619: cfg 8;cfg 9
620: oni 9,"Bavg
 "
621: wtb 9,17014
 0,110002,170260
 ,30000;eir 9
622: D[1]+V→D[1]
 ;D[2]+V→D[2]
623: if U=2;jmp
 4
624: .373*(P[1]+
 P[4]/P[5]*P[3]*
 .373)→D
625: 0→W
626: dsp "Front
 Burnish Run";
 jmp 4
627: .373*(P[2]-
 P[4]/P[5]*P[3]*
 .373)→D
628: 4→W
629: dsp "Rear
 Burnish Run"
630: C[U]+1→C[U]
631: .95D→B
632: T[U]→E[1];
 V/2.7777e-4→E[2
 ]
633: "Controll
 Loop":
634: if not flg9
 ;jmp 0
635: if flg5;
 C[U]-1→C[U];
 dsp "BURNISH
 RUN ABORTED";
 wait 2000;gto
 "Wait"
636: cfg 8;cfg 9
637: oni 9,"Fdis
 t"
638: wtb 9,17014
 0,110001,170260
 ,30000;eir 9
639: E[3]/40→E[3
 ];E[4]/40→E[4]
640: 0→D[U]
641: if C[U]/
 10#int(C[U]/
 10);jmp 4
642: E[1]→B[C[U]
 /10,1+W];E[2]→B
 [C[U]/10,2+W]
643: E[3]→B[C[U]
 /10,3+W];E[4]→B
 [C[U]/10,4+W]
644: dsp "BUSY
 WRITING DATA
 TO TAPE";rcf 1,
 C[*],B[*]
645: if U=1;prt
 "*Front Burnish
 *";jmp 2
646: prt "* Rear
 Burnish *"
647: fxd 0;prt
 "Run #",C[U]
648: cll 'Pburn'
 ;spc 3
649: sfg 8
650: if not flg9
 ;jmp 0
651: gto "Wait"
652: "Bend":
653: dsp "BUSY
 WRITING DATA
 TO TAPE";rcf 1,
 C[*],B[*]
654: gto "Ready"
655: "MarkT":
656: dsp "Place
 Blank Tape In
 Slot; CONT.";
 stp
657: 0→C[1]→C[2]
658: for L=1 to
 20;for J=1 to
 8;0→B[L,J];next
 J;next L
659: dsp "BUSY
 MARKING TAPE";
 rew
660: mrk 1,200;
 mrk 1,1500;mrk
 2,500;mrk 1,
 2000;mrk 16,
 4200
661: rcf 1,C[*],
 B[*]
662: cll 'Parame
 ters'
663: rcf 0,A$,
 P[*]
664: cll 'PPara'
 ;spc 3
665: gto "Ready"
666: "LPara":
667: dsp "Insert
 Data Tape;
 CONT.";stp
668: ldf 0,A$,
 P[*]
669: cll 'PPara'
 ;spc 3
670: gto "Ready"
671: "Effective"
 :
672: if G[1]=0;
 prt " System
 Must Be ","
 Calibrated";
 spc 3;gto "Read
 y"
673: if P[1]=0;
 prt "Parameters
 Must"," Be
 Loaded";spc 3;
 gto "Ready"
```

```
674: prt "*Effec
 tiveness *","*
  Test Mode   *
 ";spc 3
675: cll 'Tchk'
676: 0→N;ent
 "Ent 0-Start
 or 1-Cont Front
  Test",N
677: if N=1;gto
 "Cont at Feff"
678: "Start R
 Effect":
679: prt "  Star
 t 4 Rear  ","
   Tests";spc 3
680: dsp "Towbar
  Height:",48,
 "in CONT";stp
681: for J=1 to
 4
682: "Reff":
683: 2→U
684: cll 'Ewait'
685: if flg2;
 gto "Ready"
686: dsp "*Rear
 Effectiveness
 Run*"
687: moct;wtb 9,
 170140,'VO'(-
 O[2],3)
688: cll 'PreAvg
 ';fxd 2
689: 0→C
690: dto(-(O[2]+
 .45)/.005)→B
691: oni 9,"PRS"
692: wtb 9,17014
 0,112103,170260
 ,30000;eir 9
693: if C#500;
 jmp 0
694: sfg 9;oni
 9,"Stop"
695: if flg9;
 jmp 0
696: cll 'BtoRD'
697: cll 'Mavg'
698: W[1]→F[J]
699: W[2]→Z[J]
700: cll 'POPB'
701: prt "* Rear
  Effect  *"
702: cll 'Peff'
703: fxd 2;prt
 "Data Point
 Time","Sec:",
 W[3]/100;spc 3
704: 0→N;ent
 "Select Option
 or CONT",N
705: if N=1;gto
 "Reff"
706: if N=2;cll
 'Goutput';jmp -
 2
707: rcf 4+J+
 flg(5)8,A,O[*],
 G[*],F$,G$
708: next J
709: prt "  4
 Rear Tests  ",
 "    Complete";
 spc 3
710: prt " Final
  Avg Data ";
 spc 1
711: cll '4avg'
712: F/(P[2]-48/
 P[5]*F)→S[1]
713: F→E[2];Z→E[
 1]
714: cll 'PRavg'
 ;spc 3
715: dsp "BUSY
 STORING REAR
 EFFECT. DATA"
716: rcf 2+flg5,
 E[*],F[*],N[*],
 S[*],T[*],V[*],
 Z[*]
717: prt "*
 Rear Effect *",
 "*Tests Complet
 e*";spc 4
718: jmp 4
719: "Cont at
 Feff":
720: dsp "BUSY
 LOADING REAR
 EFFECT. DATA"
721: ldf 2+flg5,
 E[*],F[*],N[*],
 S[*],T[*],V[*],
 Z[*]
722: prt " Start
  4 Front","
 Tests ";spc 3
723: prt "Starti
 ng Towbar","Hei
 ght in:",P[4]+
 6;spc 3
724: dsp "Towbar
  Height:",P[4]-
 6,"in ,CONT";
 stp
725: P[4]+6→H
726: "SFeff":
727: for J=5 to
 8
728: "Feff":
729: 1→U
730: cll 'Ewait'
731: if flg2;
 gto "Ready"
732: moct;wtb 9,
 170140,'VO'(-
 O[1],3)
733: dsp "*Front
  Effectiveness
 Run*"
734: cll 'PreAvg
 ';fxd 2
735: 0→C
736: dto(-(O[1]+
 .25)/.005)→B
737: oni 9,"PFS"
738: moct;wtb 9,
 170140,111003,
 170260,30000;
 eir 9
739: if C#500;
 jmp 0
740: sfg 9;oni
 9,"Stop"
741: if flg9;
 jmp 0
742: cll 'BtoRD'
743: cll 'Mavg'
744: W[1]→F[J]
745: W[2]→Z[J]
746: cll 'POPB';
 prt "* Front
 Effect *"
747: cll 'Peff'
748: prt "Data
 Point Time",
 "Sec:",W[3]/
 100;spc 3
```

```
749: 0→N;ent
 "Select Option
 or CONT",N
750: if N=1;gto
 "Feff"
751: if N=2;cll
 'Goutput';jmp -
 2
752: if J#7;jmp
 10
753: 0→F
754: for N=5 to
 7;F+F[N]→F;next
 N
755: F/3→F
756: P[5]*(P[2]*
 S[1]+F)*(P[4]/
 (P[5]+P[4]*S[1]
 ))/F→S[4]
757: prt "New
 TB Height",S[4]
758: prt "Diff
 From Last",S[4]
 -H;spc 3
759: 0→N;ent
 "Input 1 To
 Repeat Series
 or CONT",N
760: if N=1;S[4]
 →H;gto "SFeff"
761: H→S[4]
762: dsp "BUSY
 STORING FRONT
 EFFECT. DATA"
763: rcf 4+J+
 flg(5)8,A,O[*],
 G[*],F$,G$
764: next J
765: prt "4 Fron
 t Tests","Compl
 eted";spc 3;
 prt "Final Avg
 Data";spc 1
766: cll '4avg'
767: F→E[4];Z→E[
 3]
768: (F+S[1]*
 (P[3]-(P[1]+
 S[4]/P[5]*F)))/
 P[3]→S[2]
769: 88↑2/(64.4*
 S[2])→S[3]
770: cll 'PFavg'
 ;spc 3
771: rcf 2+flg5,
 E[*],F[*],N[*],
 S[*],T[*],V[*],
 Z[*]
772: prt " Effec
 tiveness","
 Testing","
 Complete";spc 3
773: gto "Ready"
774: "Thermal":
775: if P[1]=0;
 prt "Parameters
   Must","   Be
 Loaded";spc 3;
 gto "Ready"
776: if G[1]=0;
 prt " System
 Must Be","
 Calibrated";
 spc 3;gto "Read
 y"
777: prt "* Ther
 mal Fade *","*
    Gain      *
 ","*  Test Mode
    *";spc 3
778: cll 'Tchk'
779: prt "Set
 Towbar","Height
  To:",P[4];spc
 3
780: dsp "Towbar
  Height:",P[4],
 "in ,CONT";stp
781: prt "Now
 Do:","3 Front
 and","3 Rear",
 "FG Baseline
 Runs";spc 3
782: 0→C[1]→C[2]
783: "FGBLgo":3→
 Q;cll 'Twait'
784: if flg5;
 gto "Ready"
785: 0→W;if U=2;
 4→W
786: S→I[4,C[U]+
 W]
787: T[U]→I[3,
 C[U]+W]
788: moct;wtb 9,
 170140,'VO'(-
 O[U],3)
789: cll 'PreAvg
 '
790: cfg 1
791: 0→G→C
792: if U=1;.466
 *(P[1]+P[4]/
 P[5]*P[3]*.466)
 →D;jmp 2
793: .466*(P[2]-
 P[4]/P[5]*P[3]*
 .466)→D
794: 21→E[1];
 40→E[2]
795: .95D→B
796: oni 9,"Tsam
 p"
797: cfg 9;cfg 5
798: if U=2;wtb
 9,170140,112102
 ;jmp 2
799: wtb 9,17014
 0,111002
800: wtb 9,17026
 0,30000;eir 9
801: if not flg9
 ;jmp 0
802: wtb 9,17014
 0,110000
803: if flg5;
 C[U]-1→C[U];
 gto "FGBLgo"
804: F[1]/20→I[1
 ,C[U]+W]
805: F[2]/20→I[2
 ,C[U]+W]
806: if U=1;prt
 " Front Baselin
 e";jmp 2
807: prt " Rear
 Baseline"
808: fxd 0;prt
 "Pass #",C[U]
809: C[U]+W→J;
 cll 'PBLpass';
 spc 3
810: if C[1]#3
 or C[2]#3;gto
 "FGBLgo"
811: "Compute
 Baseline Avg
 Data":
812: for L=1 to
 4;0→I[L,4]→I[L,
 8];next L
```

```
313: for L=1 to
 3
314: I[1,L]+I[1,
 4]→I[1,4]
315: I[2,L]+I[2,
 4]→I[2,4]
316: I[1,L+4]+
 I[1,8]→I[1,8]
317: I[2,L+4]+
 I[2,8]→I[2,8]
318: next L
319: for L=1 to
 2;I[L,4]/3→I[L,
 4];I[L,8]/3→I[L
 ,8];next L
320: I[1,4]/I[2,
 4]→I[3,4]
321: I[1,8]/I[2,
 8]→I[3,8]
322: prt "  Base
 line chk","
 Complete";spc 1
323: prt " Final
  Avg Data";spc
 1
324: cll 'PBLavg
 ';spc 3
325: "Wait for
 F or R Select":
326: prt "Now
 Do","1 Front
 and","1 Rear",
 "Thermal Fade",
 "Series";spc 3
327: 0→C[1]→C[2]
328: 31→E[1];
 50→E[2]
329: 0→X;dtoX→X
330: "FGwait":10
 →Q;cll 'Twait'
331: if flg5;
 gto "Ready"
332: 0→D[1]→D[2]
333: if U=2;jmp
 4
334: .466*(P[1]+
 P[4]/P[5]*P[3]*
 .466)→D
335: 111002→X
336: 0→W;jmp 4
337: .466(P[2]-
 P[4]/P[5]*P[3]*
 .466)→D
338: 112102→X
339: 10→W
340: .95D→B
341: moct;wtb 9,
 170140,'VO'(-
 O[U],3)
342: "FGgo":
343: cfg 5;cfg
 8;cfg 9;0→K[3]
344: oni 9,"TTwa
 it"
345: moct;wtb 9,
 170140,110001,
 170260,30000;
 eir 9
346: if not flg9
 ;jmp 0
347: if flg5;
 0→C[U];gto "FGw
 ait"
348: C[U]+W→J
349: V/2.7778e-
 4→H[4,J]
350: T[1]→H[3,J]
351:
352: 0→C→G→F[1]→
 F[2]→A→K[3]
353: sfg 1;cfg
 5;cfg 9
354: oni 9,"Tavg
 "
355: wtb 9,17014
 0,110002,170260
 ,30000;eir 9
356: if not flg9
 ;jmp 0
357: if flg5;
 gto "FGwait"
358: cfg 8;cfg 9
359: oni 9,"Fdis
 t"
360: wtb 9,17014
 0,110001,170260
 ,30000;eir 9
361: 0→D[1]
362: F[1]/20→H[1
 ,J]
363: F[2]/20→H[2
 ,J]
364: F[1]/20/
 (F[2]/20)→H[6,
 J]
365: fxd 0;prt
 "Pass #",C[U]
366: cll 'PFGpas
 s';spc 3
367: sfg 8
368: if not flg9
 ;jmp 0
369: if C[U]#10;
 C[U]+1→C[U];
 gto "FGgo"
370: if U=1;cll
 'PFFGavg';spc
 3;jmp 2
371: cll 'PRFGav
 g';spc 3
372: prt "   10
 Passes","
 Completed";spc
 3
373: if C[1]#10
 or C[2]#10;prt
 "     Continue";
 spc 3;gto "FGwa
 it"
374: dsp "BUSY:
 Recording Tape
 Data"
375: rcf 4,H[*],
 I[*]
376: prt "  Ther
 mal Fade","
 Tests Complete"
 ;spc 3
377: gto "Ready"
378: "PrtOut":
379: prt "#
 Tape Data    #",
 "# Output Mode
  #";spc 3
380: cll 'Tchk'
381: 0→K[1]→K[2]
 →K[3]
382: cfg 14
383: dsp "Select
  Printout Optio
 ns";if not flg1
 4;jmp 0
384: cfg 1
385: if K[3]=1;
 gto "Ready"
386: if K[3]=2;
 sfg 1;cll 'Pear
 aF'
```

```
887: if K[1]=1;
 cll 'PeffF'
888: if K[1]=3;
 cll 'PburnF'
889: if K[1]=4;
 cll 'PparaF'
890: if K[1]=7;
 cll 'PthermF'
891: jmp -10
892: "PparaF":
893: ldf 0,A$,
 P[*]
894: cll 'PPara'
 ;spc 3
895: if flg1;
 gto "PeffF"
896: ret
897: "PeffF":
898: if flg1;
 cfg 5
899: "PeffFgo":
900: ldf 2+flg5,
 E[*],F[*],N[*],
 S[*],T[*],V[*],
 Z[*]
901: cll 'POPB'
902: prt " Effec
 tiveness","
 Test Data";spc
903: prt "
 Rear Brake","
     Data";spc
904: for J=1 to
 4;cll 'Peff';
 spc ;next J;
 spc 2
905: prt "  Fron
 t Brake","
  Data";spc
906: for J=5 to
 8;cll 'Peff';
 spc ;next J;
 spc 2
907: prt "
 Rear Brake","
   Avg Data";
 spc
908: cll 'PRavg'
 ;spc
909: prt "  Fron
 t Brake","
 Avg Data";spc
910: cll 'PFavg'
911: spc 4
912: if flg1
 and not flg5;
 sfg 5;gto "Peff
 Fgo"
913: if flg1
 and flg5;gto
 "PthermF"
914: ret
915: "PthermF":
916: prt "
 Thermal","
 Capacity","
 Fade Gain","
 Test Data";spc
917: ldf 4,H[*],
 I[*]
918: prt "  Fron
 t Brake"," Base
 line Data";spc
919: for J=1 to
 3;fxd 0;prt
 "Run #",J;cll
 'PBLpass';spc ;
 next J;spc 2
920: prt "
 Rear Brake","
 Baseline Data";
 spc
921: for J=5 to
 7;fxd 0;prt
 "Run #",J-4;
 cll 'PBLpass';
 spc ;next J;
 spc 2
922: prt "
 Avg Data","
   And","  Basel
 ine BG";spc
923: cll 'PBLavg
 ';spc 2
924: prt "  Fron
 t Brake","
 Thermal Fade",
 " Gain Test
 Data";spc
925: for J=1 to
 10;fxd 0;prt
 "Pass #",J;cll
 'PFGpass';spc ;
 next J;spc
926: cll 'PFFGav
 g';spc 2
927: prt "
 Rear Brake","
 Thermal Fade",
 " Gain Test
 Data";spc
928: for J=11
 to 20;fxd 0;
 prt "Pass #",J-
 10;cll 'PFGpass
 ';spc ;next J;
 spc
929: cll 'PRFGav
 g';spc 2
930: spc 3
931: if flg1;
 gto "PburnF"
932: ret
933: "PburnF":
934: prt "  Burn
 ish Run","
  Data";spc
935: ldf 1,C[*],
 B[*]
936: prt "  #
 Completed","
 Burnish Runs"
937: prt "Front:
 ",C[1]
938: prt "Rear:"
 ,C[2];spc 2
939: 1→U
940: prt " Front
  Burnish","
   Data";spc
941: for J=1 to
 int(C[1]/10)
942: for L=1 to
 4;B[J,L]→E[L];
 next L
943: fxd 0;prt
 "Run #",J*10
944: cll 'Pburn'
 ;spc
945: next J
946: spc 3
947: 2→U
948: prt "  Rear
  Burnish","
   Data";spc
```

```
949: for J=1 to
 int(C[2]/10)
950: for L=1 to
 4;B[J,L+4]→E[L]
 ;next L
951: prt "Run
 #",J*10
952: cll 'Pburn'
 ;spc
953: next J
954: spc 3
955: if flg1;
 gto "Ready"
956: ret
957: "Graph":
958: prt "* Grap
 h Output *","*
     Mode      *
 ";spc 3
959: dsp "Insert
  Data Tape,
 CONT";stp
960: ent "Enter
 Raw Data File
 #, CONT",N
961: cfg ;if
 N>12;sfg 5
962: cll 'POPB'
963: if N>4 and
 N<9 or N>12
 and N<17;2→U;
 prt "        REAR
 ";jmp 2
964: 1→U;prt "
     FRONT"
965: prt " Effec
 tiveness"," 
 Data Graph"
966: fxd 0;prt
 "File#",N
967: if N=5 or
 N=9 or N=13 or
 N=17;prt "Run#"
 ,1;jmp 4
968: if N=6 or
 N=10 or N=14
 or N=18;prt
 "Run#",2;jmp 3
969: if N=7 or
 N=11 or N=15
 or N=19;prt
 "Run#",3;jmp 2
970: prt "Run#",
 4
971: ldf N,A,O[*
 ],G[*],F$,G$
972: cll 'Unpack
 '
973: 1→J;cll
 'Mavg'
974: fxd 2;prt
 "TBF:",W[1]
975: prt "AF:",
 W[2]
976: prt "Data
 Point Time",
 "Sec:",W[3]/
 100;spc 3
977: cll 'Goutpu
 t'
978: 0→X;ent
 "Select Option
 Or Cont",X
979: if X=0;gto
 "Ready"
980: if X=1;jmp
 -20
981: if X=2;jmp
 -4
982: jmp -4
*17467
```

2. Program Tape Format

File #	Contents	Size (Bytes)
0	Main Program	30000
1	Function Key Assignments	500
2	Effectiveness Test Filter Weighting Factor Array, J[39]	500
3	Calibration Program	700

3. Data Tape Format

File #	Contents	Size (Bytes)
0	Basic Motorcycle Parameters	200
1	Burnish Data File	1500
2	Preburnish Effectiveness Data	500
3	Postburnish Effectiveness Data	500
4	Thermal Capacity Data	2000
5	Test #1, Rear Preburnish Effect Raw Data	4200
6	Test #2, Rear Preburnish Effect Raw Data	4200
7	Test #3, Rear Preburnish Effect Raw Data	4200
8	Test #4, Rear Preburnish Effect Raw Data	4200
9	Test #1, Front Preburnish Effect Raw Data	4200
10	Test #2, Front Preburnish Effect Raw Data	4200
11	Test #3, Front Preburnish Effect Raw Data	4200
12	Test #4, Front Preburnish Effect Raw Data	4200
13	Test #1, Rear Postburnish Effect Raw Data	4200
14	Test #2, Rear Postburnish Effect Raw Data	4200
15	Test #3, Rear Postburnish Effect Raw Data	4200
16	Test #4, Rear Postburnish Effect Raw Data	4200

3. Data Tape Format (Cont.)

File #	Contents	Size (Bytes)
17	Test #1, Front Postburnish Effect Raw Data	4200
18	Test #2, Front Postburnish Effect Raw Data	4200
19	Test #3, Front Postburnish Effect Raw Data	4200
20	Test #4, Front Postburnish Effect Raw Data	4200

4. Function Key Assignments

Key	Label	Function
f0	Go	2 → K[3]
f1	Halt	1 → K[3]
f2	F	1 → K[2]
f3	R	2 → K[2]
f4	Print Out	sfg 14; 8 → K[1]
f5	L Para	sfg 14; 4 → K[1]
f6	Preburnish Effect	sfg 14; cfg 5; 1 → K[1]
f7	Postburnish Effect	sfg 14; sfg 5; 1 → K[1]
f8	Burnish	sfg 14; 3 → K[1]
f9	Thermal	sfg 14; 7 → K[1]
f10	Cal	sfg 14; 2 → K[1]
f11	Warm	3 → K[3]
f12	Ready	go to "Ready"
f14	Trk 1	Trk 0
f15	Trk 2	Trk 1
f16	Graph	sfg 14; 9 → K[1]
f17	Mark T	sfg 14; 5 → K[1]

Note: f12-f23 are upper case f0-f11.

5. Program Variables

General Program Variables

Parameters

P[1] - Static Front Wheel Load

P[2] - Static Rear Wheel Load

P[3] - Total Bike Weight

P[4] - C.G. Height

P[5] - Wheelbase

Calibrated Channel Offset Voltages

O[1] - FAF

O[2] - RAF

O[3] - TBF

O[4] - V

Calibrated Channel Conversion Gains

G[1] - FAF

G[2] - RAF

G[3] - TBF

G[4] - V

K - Thermocouple Reference Voltage

<u>Burnish Program Variables</u>

T[1] - Current Front Temp

T[2] - Current Rear Temp

T[3] - Current Front Count

T[4] - Current Rear Count

T[5] - Current Front Distance

T[6] - Current Rear Distance

A - Initial Tow-Bar Voltage (Drag Force - Volts)

B - .95 D

C - Sample Counter

D - Desired Tow-Bar Force

G - Sample Counter

U - (1) - Front (2) - Rear

V - Velocity, Miles/Sec, Assigned in "Dist"

W - Data Array Buffer

flg 5 - Halt

flg 8 - Timing

flg 9 - Timing

E[1] - Run Temp (T)

E[2] - Run Velocity (V)

E[3] - Run Avg. TBF

E[4] - Run Avg. AF

F[3] - Avg. TBF Buffer

F[4] - Avg. AF Buffer

Burnish Data Array: Dim C[2], B[20, 8], contains data for every 10th run.

ℓdfl, C[*], B[*]

Burnish (Cont.)

B[C[1]/10, 1] - Front Run T
B[C[1]/10, 2] - Front Run V
B[C[1]/10, 3] - Front Run Avg TBF
B[C[1]/10, 4] - Front Run Avg AF

B[C[2]/10, 5] - Rear Run T
B[C[2]/10, 6] - Rear Run V
B[C[2]/10, 7] - Rear Run Avg TBF
B[C[2]/10, 8] - Rear Run Avg AF

Mark T Program Variables

C[*] B[*] - Burnish Data Arrays
A$, P[*] - Motorcycle Parameters

Motorcycle Parameters Data File
ldf 0, A$, P[*]

A$ - Name, Notation
P[1] - Static Front Wheel Load
P[2] - Static Rear Wheel Load
P[3] - Total Bike Weight
P[4] - C.G. Height
P[5] - Wheelbase

Effectiveness Program Variables

TBF and AF Raw Data Arrays
Dim M[500], Y[500], A[500], D[500],
F$[500,2], G$[500,2]

M[C] - Binary TBF, or TBF in pounds
Y[C] - Binary AF, or AF in pounds
A[C] - Integer TBF
D[C] - Integer AF
F$[C] - Packed Integer TBF for Tape Storage
G$[C] - Packed Integer AF for Tape Storage

Effectiveness (Cont.)

A - Initial TBF, volts

B - Actuator Trig. Force, Binary

C - Sample Counter

F - Avg 4 Runs TBF

H - Last TB Height

N - Operator Options Buffer

Z - Avg 4 Runs, AF

R - Temp for Warming Printout

U - (1) - Front, (2) - Rear

J - For-Next Loop Counter

W[1] - Peak TBF W[2] - Peak AF W[3] - Sample # of Peak TBF W[4] - Sample # of AF	Returned from "Mavg"

flg 2 - Return to ready flag

flg 5 - Clear-preburnish, set-postburnish

flg 9 - Stop flag

Effectiveness Test Final

Data Arrays:

Dim E[4], F[8], N[8], S[4], T[8], V[8], Z[8]

rcf 2+flg 5, E[*], F[*], N[*], S[*], T[*], V[*], Z[*]

J - For-Next Loop Counter, 1-4 Rear, 5-8 Front

F[J] - Peak TBF Z[J] - Peak AF T[J] - Temp V[J] - Velocity N[J] - Spare	Data for each run

Effectiveness (Cont.)

S[1] - Rear Friction Coefficient

S[2] - Free Stopping Deceleration

S[3] - Free Stopping Distance

S[4] - Final TB Height

E[1] - Avg of 4 RAF

E[2] - Avg of 4 RTBF

E[3] - Avg of 4 FAF

E[4] - Avg of 4 FTBF

Thermal Capacity Program Variables

C[1] - Count Front

C[2] - Count Rear

T[1] - Temp Front

T[2] - Temp Rear

D[1] - Distance

F[1] - Avg TBF Buffer

F[2] - Avg AF Buffer

E[1] - Low Sample

E[2] - High Sample

A - Initial Avg TBF (Drag Force - volts)

B - .95 D

C - Sample Counter

D - Desired TBF

E - TBF Error

G - Sample Counter

J - For-Next Loop Counter

S - Velocity, miles/hour

T - Tow-Bar Force Buffer

U - (1) - Front, (2) Rear

V - Velocity, miles/sec

W - Data Array Buffer

X - Light & Clock, Binary Output

Thermal Capacity (Cont.)

flg 1 - Clear-Baseline, Set-Thermal Fade, 10 Timed Passes

flg 5 - Halt, Return to Ready

flg 8 - Timing

flg 9 - Timing

Thermal Capacity Data Arrays:

Dim H[6,20], I[4,8]

rcf 4, H[*], I[*]

I[4,8] - Baseline Fade Gain Data:

I[1,*] - TBF

I[2,*] - AF

I[3,*] - T

I[4,*] - V

* = 1-3 Front Run Data 1-3

5-7 Rear Run Data 1-3

I[1,4] - Avg of 3 Runs: FTBF

I[2,4] - Avg of 3 Runs: FAF

I[3,4] - Front Baseline Fade Gain

I[4,4] - Spare

I[1,8] - Avg of 3 Runs: RTBF

I[2,8] - Avg of 3 Runs: RAF

I[3,8] - Rear Baseline Fade Gain

I[4,8] - Spare

H[6,20] - Thermal Capacity Data Array

H[1,*] - TBF

H[2,*] - AF

H[3,*] - Temp

H[4,*] - Velocity

H[5,*] - Distance

H[6,*] - Fade Gain

* = 1-10: Front FG runs, 1-10

11-20: Rear FG runs, 1-10

System Check and Calibration Program Variables

T - Test Select

T = 0 - Return to READY
1 - Complete check and cal
2 - Calibrate offset and gains
3 - Analog output check
4 - Rider Display check
5 - V offset and amp gain check
6 - Thermocouple check

"AOchk" - Analog (D/A) output check

"RDchk" - Rider Display check

A - Front brake V offset
C - Sample counter
flg 9 - Sample end flg

"VOchk" - Voltage offset check

F[1]-F[4] - Measured channel offset voltages
B$ - Label string
U - Label string printout buffer
C - Sample counter
S - Label printout buffer
flg 1 - Out of range flg
flg 9 - Sample end flg

"CGchk" - Channel gain check

E[1]-E[4] - Measured channel gains
N[1]-N[4] - Normal gains
V[1]-V[4] - V CAL voltages
D[1]-D[4] - Computed gains
F[1]-F[4] - Voltage offsets, from "VOchk"

B$ - Channel labels
U - Label printout buffer
S - Label printout buffer

System Check (Cont.)

flg 1 - Out of range

flg 9 - Timing

"COcal" - Channel Zero Data Offset calibration

O[1]-O[4] - Measured Zero Data Offsets

B$ - Label string

U - Label printout buffer

S - Label printout buffer

C - Sample counter

flg 1 - Out of range

flg 9 - Timing

"NGcal" - Conversion gain calibration

G[1]-G[4] - Measured conversion gain

N[1]-N[4] - Normal conversion gain

V[1]-V[4] - V CAL voltages

U - Label printout buffer

S - Label printout buffer

C - Sample counter

flg 1 - Out of range

flg 9 - Timing

Alphabetical List of Subroutines and Their Program Locations

Alphabetical List (Cont.)

4.0 PROCEDURE FOR ATTACHING A MOTORCYCLE TO THE TOW VEHICLE

The following is a recommended procedure for attaching a conventional motorcycle to the towing vehicle.

1) Install thermocouples in front and rear brake linings per methods illustrated in test procedure, Appendix 2, Volume I.

2) Conduct parameter measurements to determine the cycle's c.g. height, cycle weight, deflected seat height, and the wheelbase.

3) Remove motorcycle fuel tank.

4) Install strongback as follows:

   -Locate strongback along cycle centerline and establish a suitable angular position for the front head clamping plates so that a bolt can be installed through the front head structure, securing the forward end of the strongback. Note, for example, in Figure 35 that the clamping plates have been inclined considerably to provide for placement of the through-bolt. Note also in Figure 35 that the clamping plates are installed with the slotted end upward.

   -Having located the clamping plates, spot and drill for the 3/8" diameter through-bolt.

   -Identify the thickness of the front head shims needed to space the clamping plates laterally away from the strongback.

   -Install and tighten the three bolts fastening the clamping plates to the strongback and to the motorcycle. As shown in Figure 36, note that the through-bolt is also used to fasten the connecting bracket for the forward lateral link.

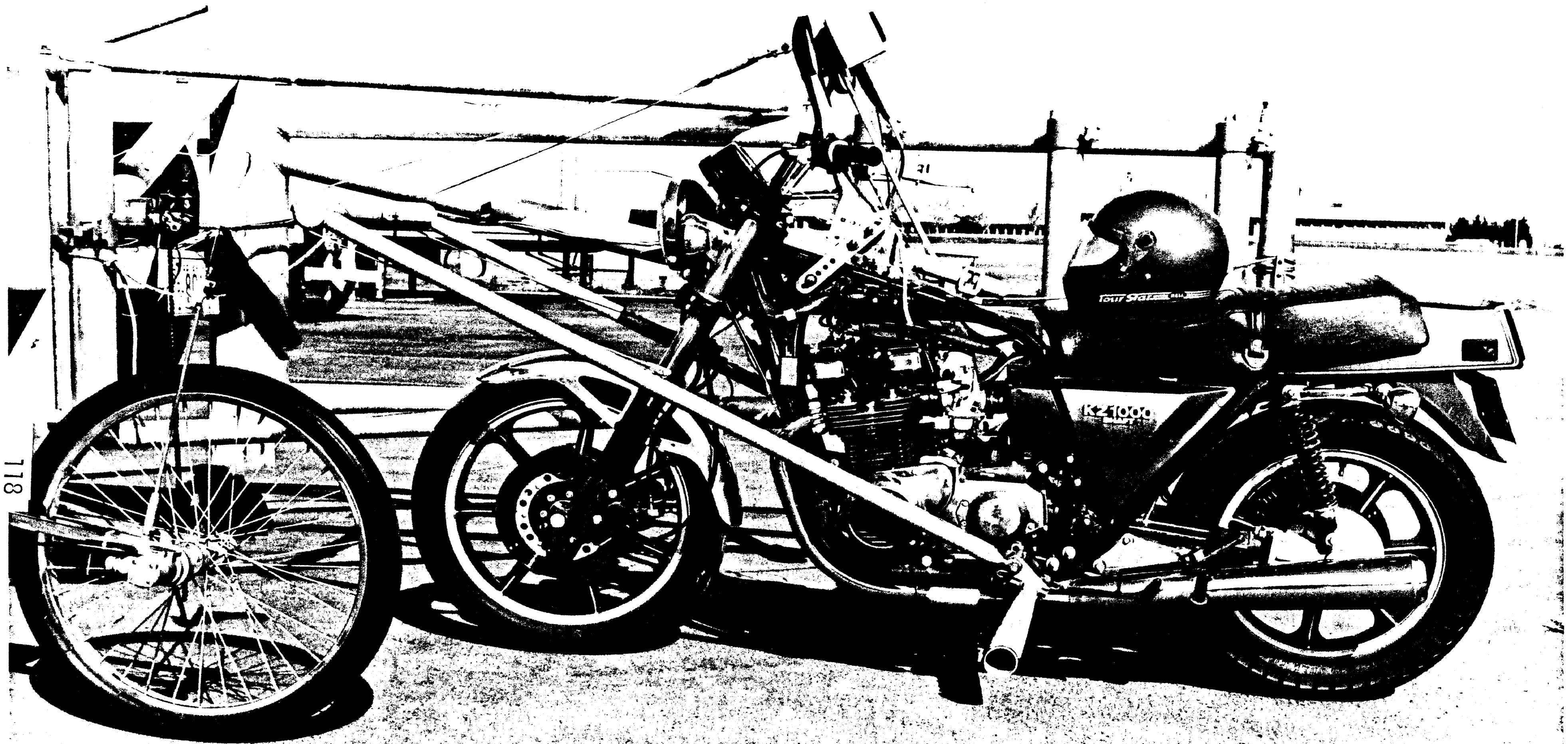


Figure 35. Side view of motorcycle showing strongback mounting.

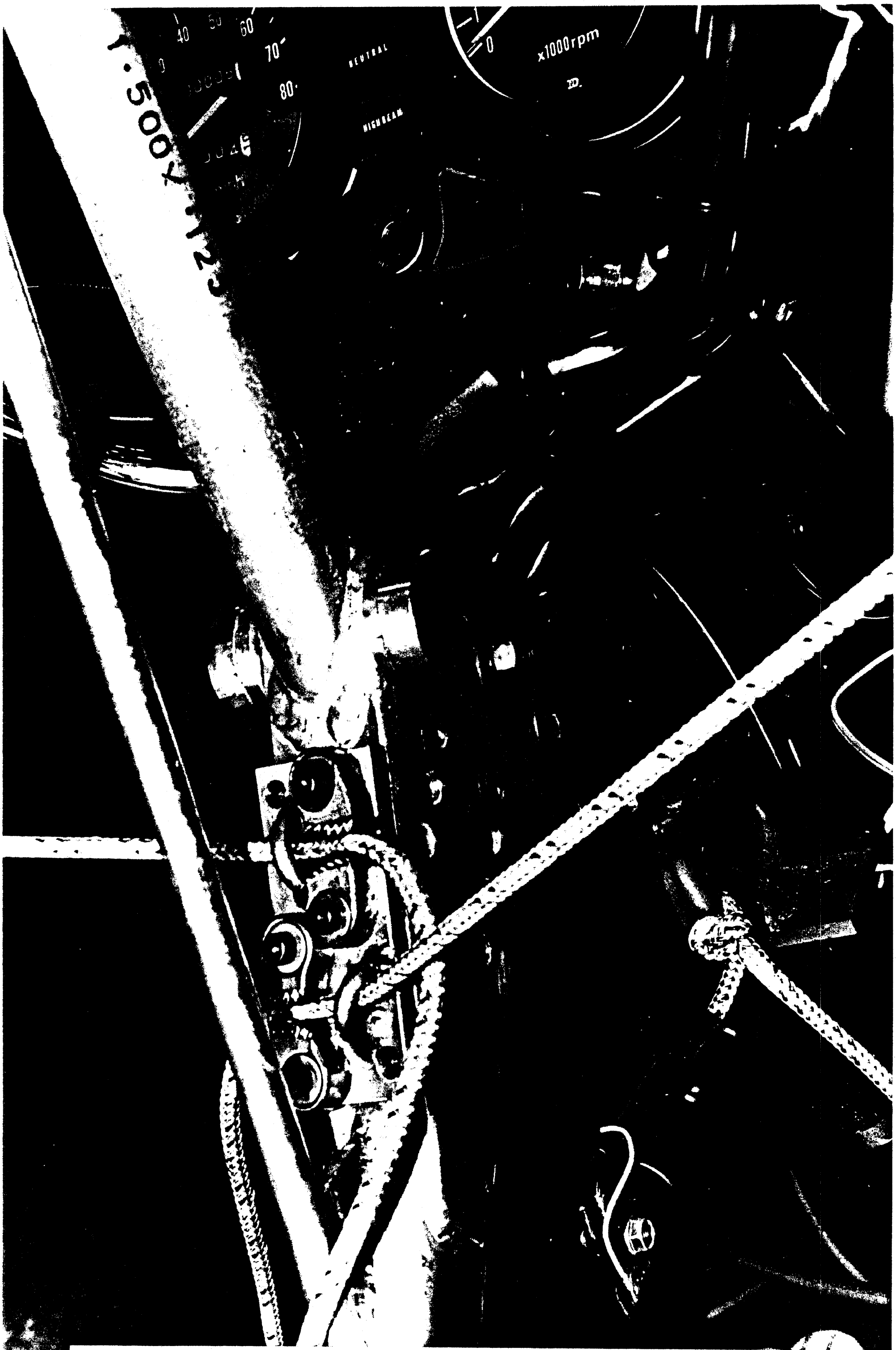


Figure 36. Strongback clamping plate and connecting bracket for forward lateral link.

-Attach the aft strongback fastening bracket, tightening the attachment chain around the available frame member of the motorcycle, as shown in Figure 37.

5) Install foot-peg bracket as follows:

-Remove rubber foot-peg covers.

-Bolt the blank steel foot-peg weld plates to the right- and left-hand foot-peg bracket assemblies.

-Adjust the right-left position of the left-side foot-peg bracket on the tubular cross member so that the steel weld plates lie just under the foot pegs, as shown in Figure 38. Tighten the hose clamps fastening the left-side bracket to the tubular cross member.

-Weld the foot pegs to the steel weld plates.

Attach tow yoke assembly as follows:

-The tow yoke permits adjustment of the lateral spread between the side struts by means of multiple holes drilled in the cross tube. Note in Figure 39, for example, that the side struts have been located at the outermost hole positions on the cross tube since the motorcycle in the photo has an especially wide dimension across the foot pegs. Having noted the width across the test cycle's foot-peg bracket, then, adjust and tighten the side strut connection.

-Upon tightening the side struts, note, as shown in Figure 40, that the tow yoke cable passes down through the slotted cap piece. Be certain that the cap is oriented as shown, with the slot positioned to the outside of the tow yoke.

-Insert both tow strut pins in identically numbered holes in both side struts.

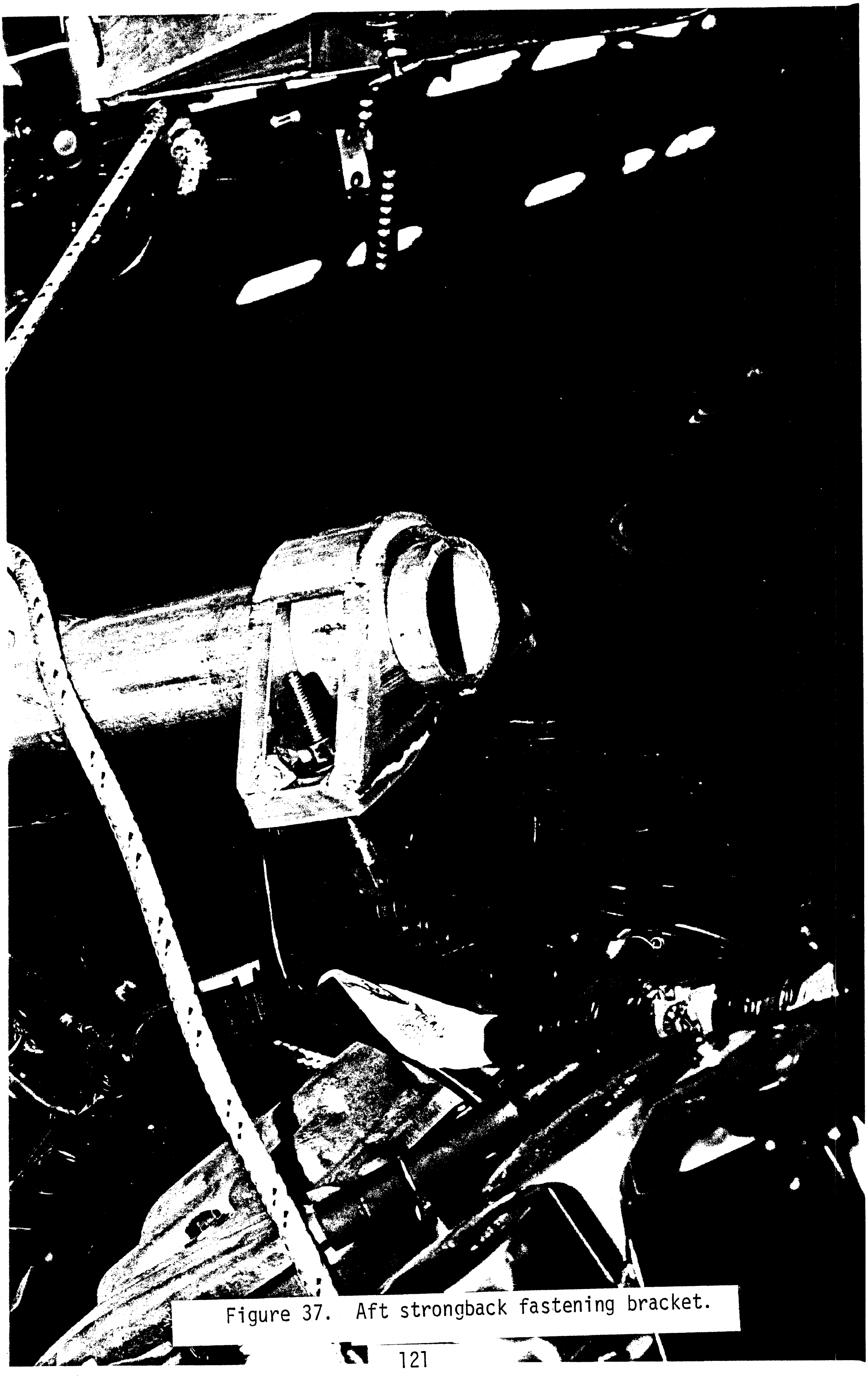


Figure 37. Aft strongback fastening bracket.

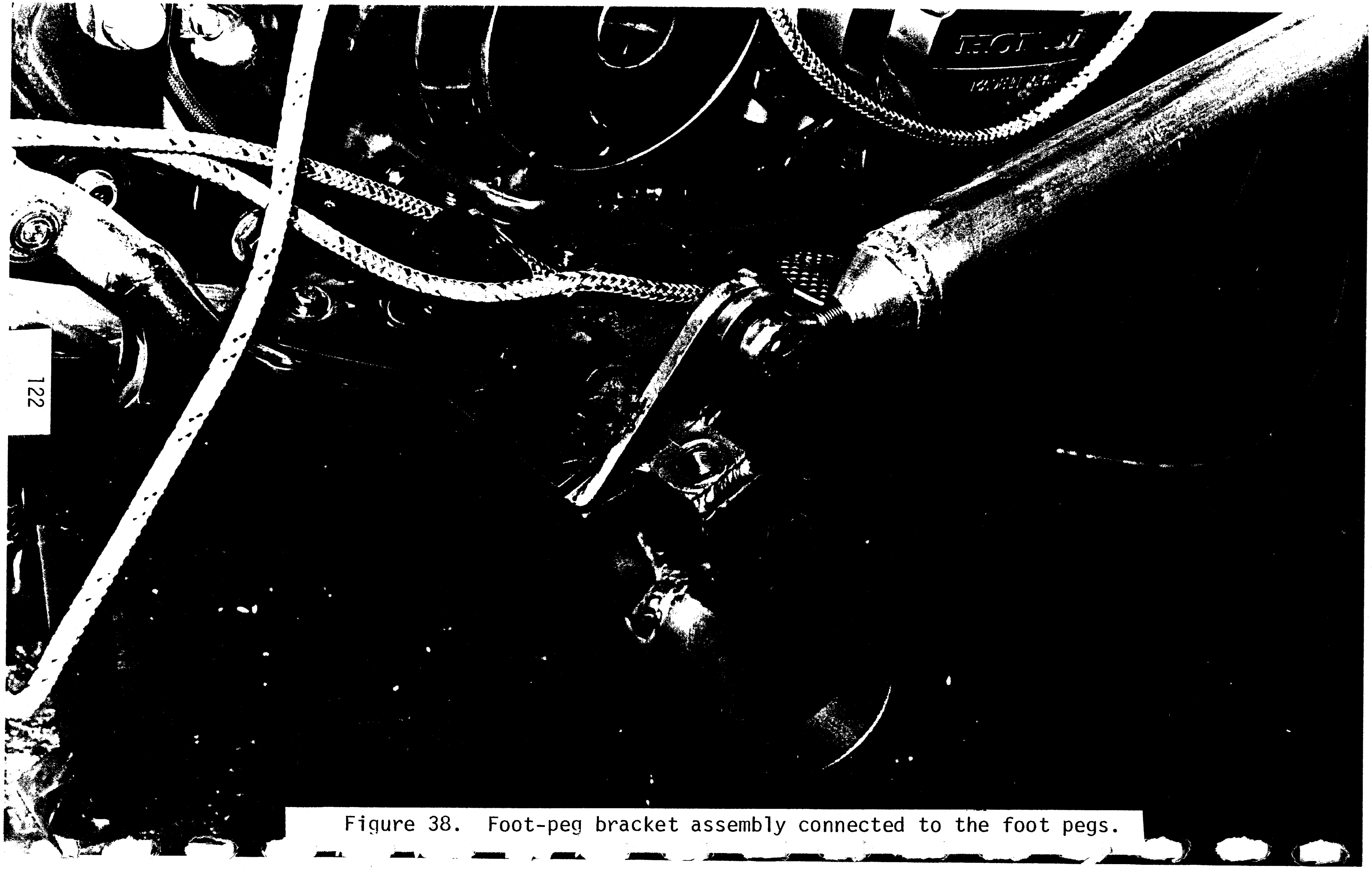


Figure 38. Foot-peg bracket assembly connected to the foot pegs.

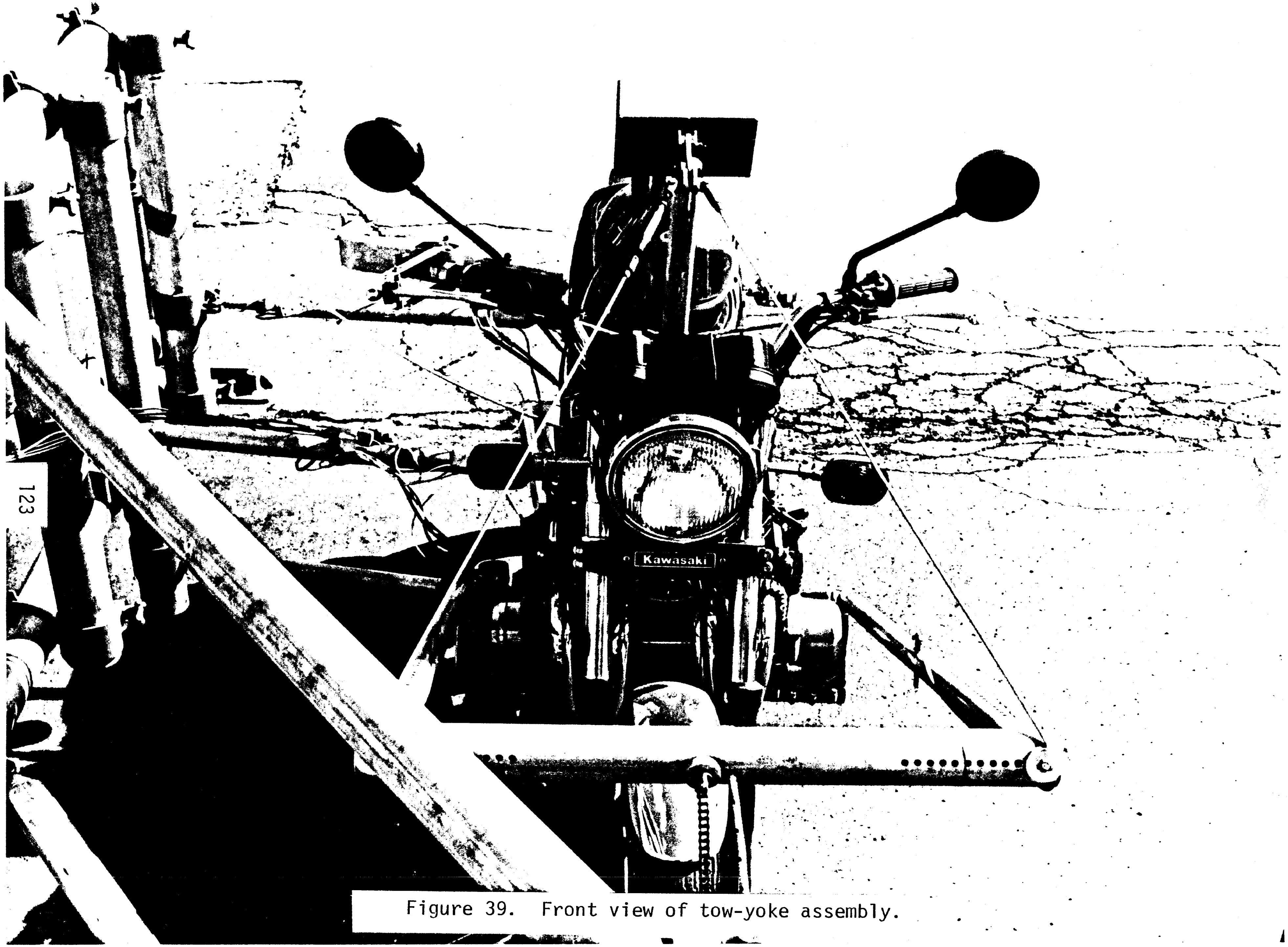


Figure 39. Front view of tow-yoke assembly.

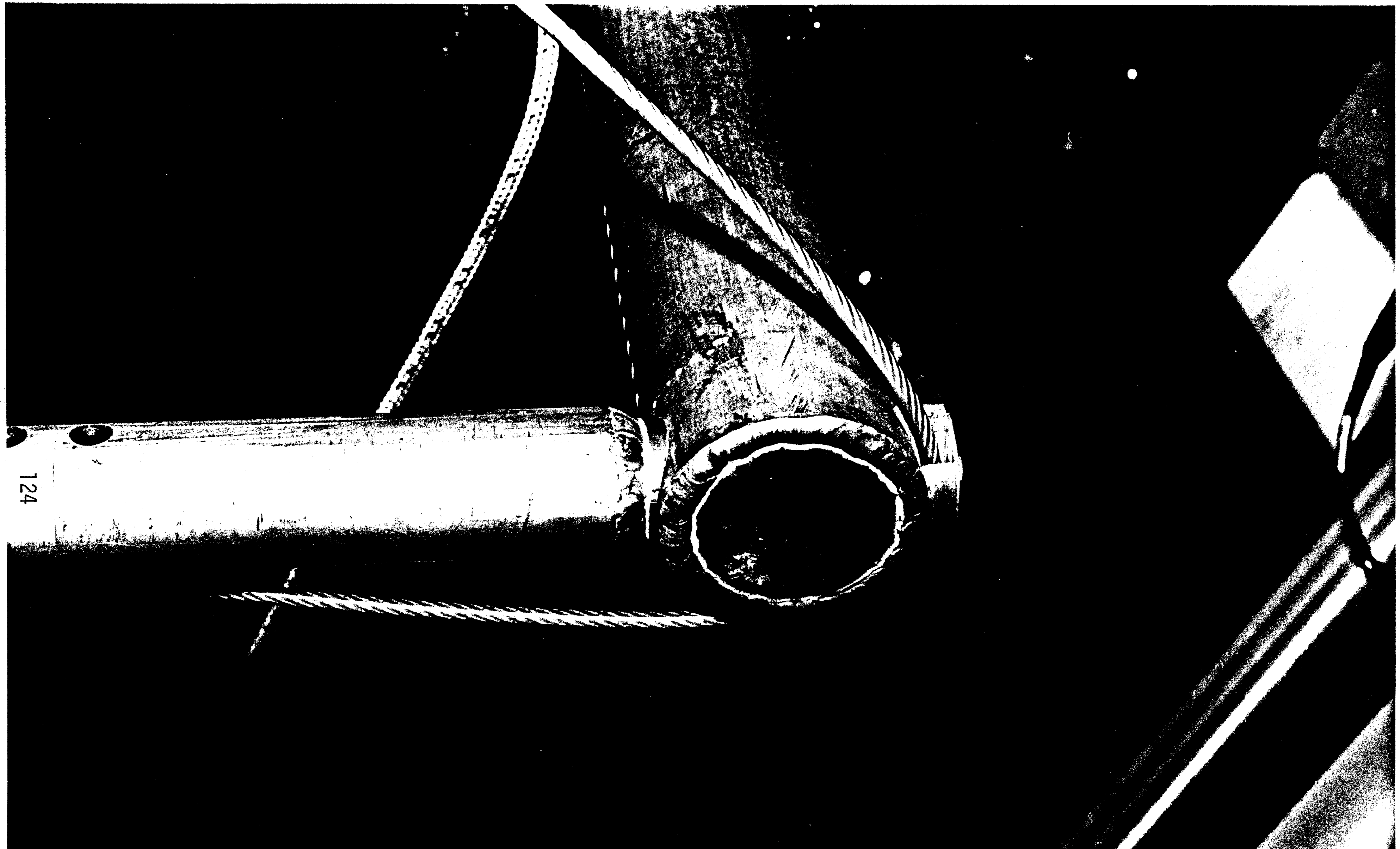


Figure 40. Tow-yoke cap piece and cable.

-Connect cable clevis to top of strongback.

-As shown in a previous photo, Figure 38, attach both side struts to the foot-peg bracket, employing the fabricated washer and nut parts. Do not tighten the attaching screws firmly.

-Looking at the assembled tow yoke, as in the view of Figure 39, establish the appropriate adjustment at the point of attachment of the side struts to the foot-peg brackets. When the cross tube is approximately centered, right/left, on the motorcycle, tighten the foot-peg attachment screws to secure the tow yoke. Fine right/left adjustment of the towing bolt position on the cross tube is done by sliding the tow bolt in its slot, and then re-tightening.

-Again looking at the tow yoke as in Figure 39, adjust the cable turnbuckle to level the cross tube.

7) Install the link fastening bracket on the top right-hand shock absorber bolt for attachment of rear lateral link.

8) Adjust the longitudinal positions of the three vertical aluminum pipes on the extended side frame. The rear-most pipe should always be left in its most rearward location. The motorcycle is then positioned so that its top right-hand shock absorber bolt is just opposite the rear-most vertical pipe. The two other pipes are then adjusted to line up with the foot-peg and front-head brackets intended for attaching lateral links to the motorcycle.

9) Adjust the elevation of the rod-end connection straps on each of the three vertical pipes so as to line up with the corresponding points on the motorcycle.

10) Install the three lateral links. Each link is to be oriented such that the screw adjustment is placed on the opposite end from the motorcycle, as shown in Figure 41.

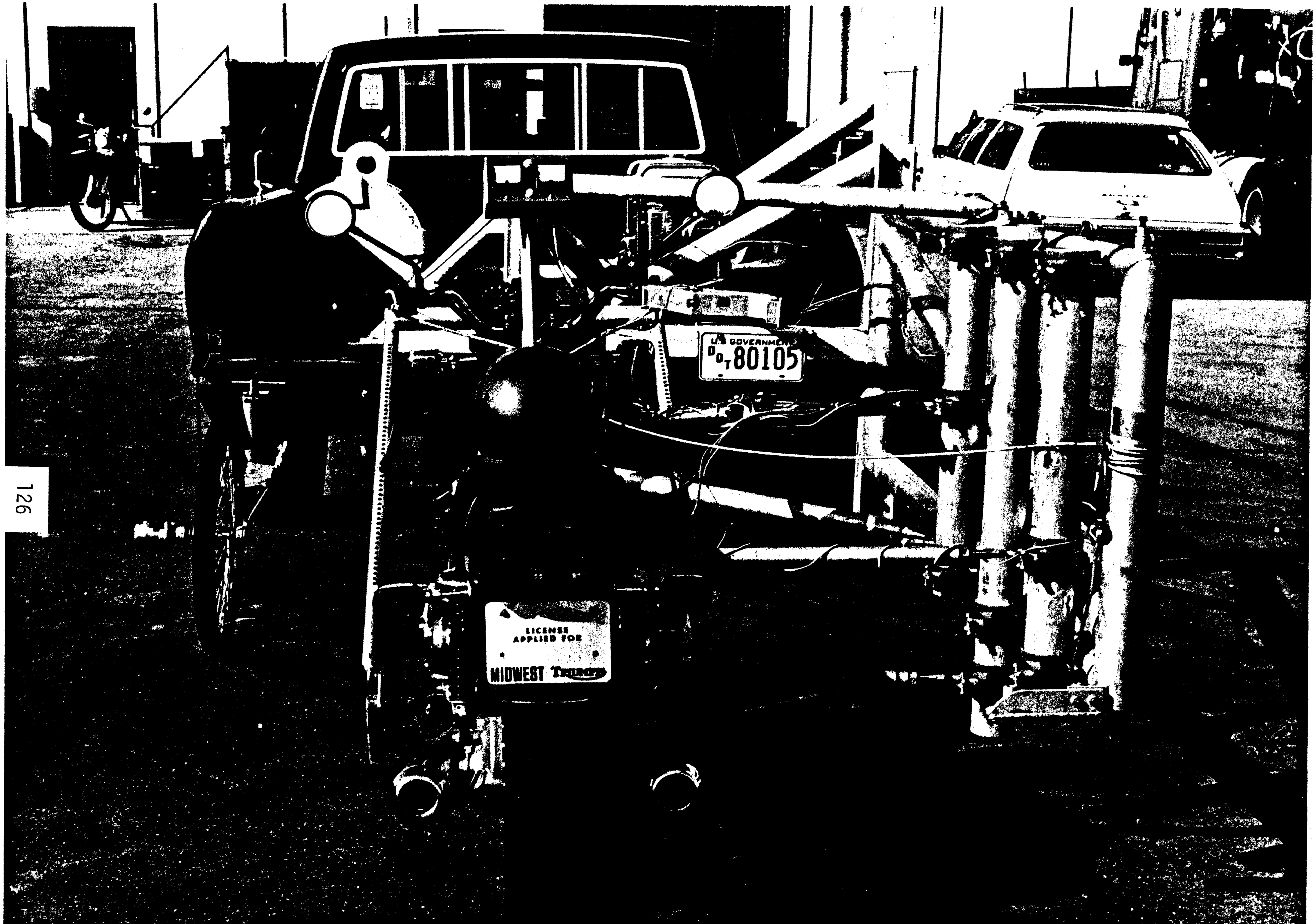


Figure 41. Rear view of motorcycle showing the three lateral links.

11) Adjust the length of each link so as to establish the alignment of the longitudinal and vertical axes of the motorcycle with those of the tow vehicle. Adjustments of the length of each lateral link should be done using the heavy threaded section and not by means of the threaded shank on the spherical rod ends.

12) Install forward-stop cable between the rear of the extended side frame and the loop on the link-fastening bracket at the front head of the motorcycle. The cable should be adjusted to arrest the forward motion of the motorcycle with the lateral links normal to the motorcycle's longitudinal axis.

13) Install safety aft-stop rope between the tow column and the tow yoke cross tube. This rope is to be adjusted to provide a few inches of slack, thus not interfering with the tow force measurement during the normal test process, although serving as back-up restraint to the motorcycle's rearward motion in the event that the tow chain locking mechanism was improperly set.

14) Install handlebar tether ropes. When actual test runs are being made, the tether ropes are to be held taut in the jam cleats mounted on the strongback assembly (see Figure 36).

15) Install brake hand-lever force transducer as follows:

-Attach force measurement "wand" to the hand grip by means of hose clamp as shown in Figure 42.

-Attach hand-lever bracket such that the point of application of force to the hand lever is 1.2 inches in from the outboard end of the lever.

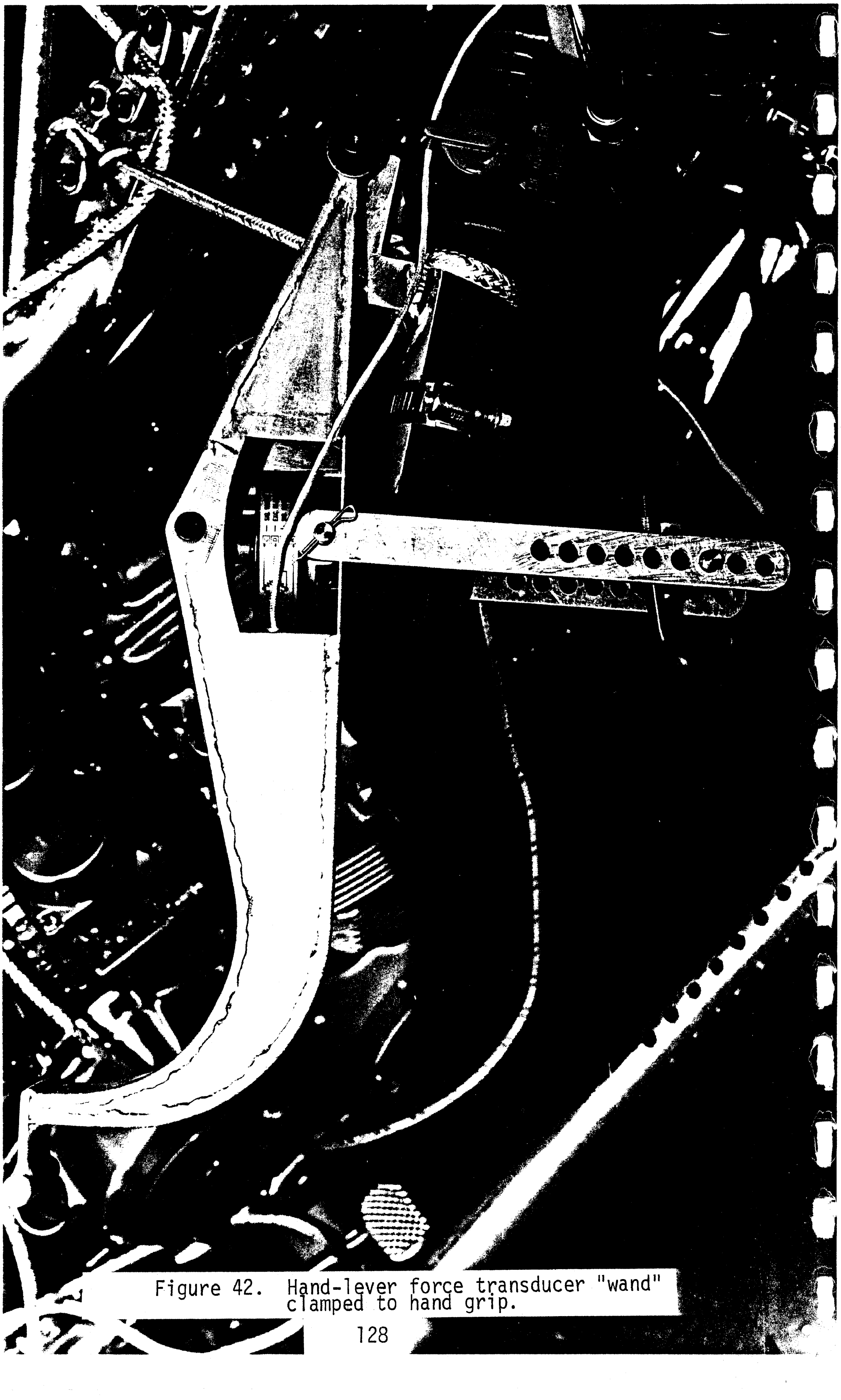


Figure 42. Hand-lever force transducer "wand" clamped to hand grip.

-Attach the two brake lever links, selecting a mounting hole which leaves the transducer unloaded when the hand lever is in its "rest" position.

16) Install foot-pedal force transducer by means of hose clamp directly to the pedal. It may be necessary in certain installations to shim the foot-pedal force transducer so as to elevate it to permit access for the rider's foot without suffering interference from the side strut of the tow yoke assembly.

4.1 Procedure for Adjusting Tow Height

1) Set the height of the towing clamp such that the centerline of the tow force load cell, shown in Figure 43, is at the desired tow height value above the ground.

2) Pull the two tow strut pins and rotate the tow yoke assembly until the point of tow chain attachment to the tow bolt is established at a height equal to the desired tow height plus 1-1/2 inches.

3) Stretch the two cables tight with the tow yoke at this elevation and place the tow strut pins in the nearest holes in the two side struts. Assure that both pins are inserted into the same-numbered holes.

4) With the tow chain threaded into the tow cell fixture, pull the cycle forward until the forward-stop cable becomes taut.

5) Holding the tow chain taut, engage the chain in the jam sprocket and pull the chain upward through the fixture, setting the sprocket in the locking position.

6) If, in testing at the established height setting, the tow angle lights show an improper angle at the time of brake actuation, the hole selection for placement of the tow strut pins must be changed up or down as necessary.

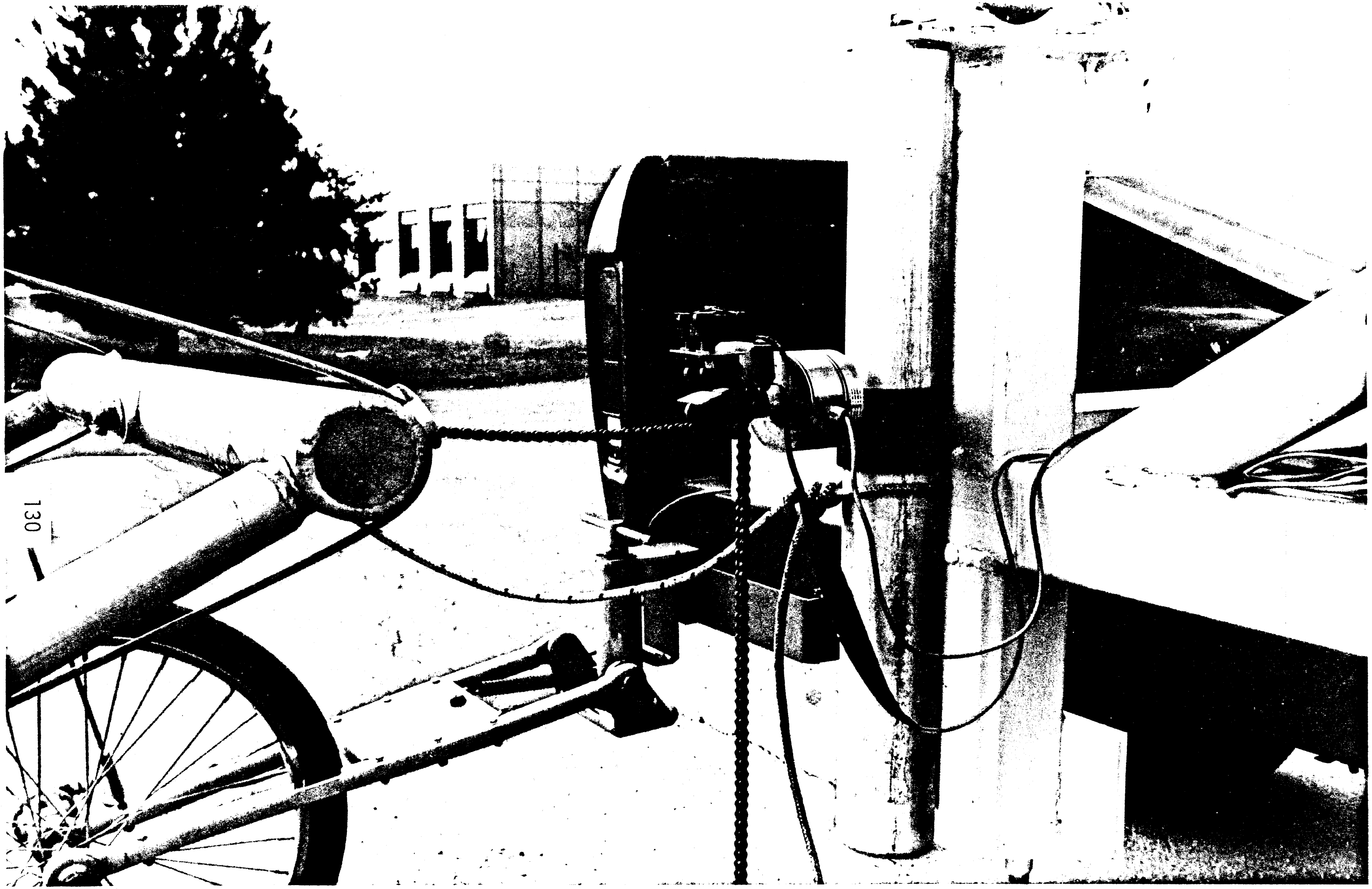


Figure 43. Tow-force load cell mounting.

5.0 SYSTEM OPERATING PROCEDURE

This section gives a step-by-step procedure for operation of the computerized motorcycle brake test instrumentation system in performing the complete series of motorcycle brake tests which include: preburnish and postburnish effectiveness test, burnish and thermal capacity test. All final test data are stored on a magnetic tape cartridge. Procedures are also given to reproduce data from the data tape.

Three people are required to run the motorcycle tests: a driver, a rider, and an operator. The driver controls the tow vehicle to arrive at the required position on the test track, moving at the required test velocity when each test is initiated. Riding on the motorcycle, the rider applies the brakes as required for each test while receiving instructions and feedback from the operator via an intercom and from the computer via the Rider Display lights and meters. In the rear seat of the truck, the operator monitors information from the computer on a 32-character line display and a paper tape printer, cues the driver and rider on subsequent tests, initiates each test by making appropriate computer keyboard entries, and reviews the resulting test data.

The computer provides a highly automated test procedure which the operator must follow precisely, particularly with respect to keyboard inputs. In writing the system program, an effort was made to protect the system against operator errors. Thus, some wrong or out of order keyboard operations are either ignored or result in a message output on the computer display. However, all possible errors are not covered. In some instances, a wrong keyboard entry can make the computer stop program execution or shift to a different part of the program. If this happens during a test sequence, data not yet stored on tape will be lost, and the test sequence must be started again.

The computer keyboard seen in the photograph in Figure 15 is described in detail in the Hewlett-Packard literature. The 12 "special function" keys in the upper right corner of the keyboard are programmable and are programmed to initiate the several test modes and other special computer operations such as data printout and analog output. The special function assigned to each key, that is, PRE-B (preburnish effectiveness test), BURNISH, THERMAL (thermal capacity test), CAL (system calibration), etc., are marked on a template placed around the keys.

5.1 Apply System Power

The following sequence of steps is recommended for powering up the system:

1. Set the AC power strip switch (in the truck) and the AC power switch on the Honda generator to OFF.

2. Start the Honda generator. Turn the generator AC power switch ON. Adjust the AC output to 120 volts, as seen on the generator output meter.

3. Inside the truck, turn the following switches to ON:

   AC power strip switch
   DC power switch
   Intercom DC power switch
   HP 6940B multiprogrammer AC power switch

4. Place the multiprogrammer Data Source switch on Remote.

5.2 Load the System Program

The Motorcycle Test System Program is stored on a program tape. Each time the computer is turned on, the program must be reloaded from the tape.

1. Turn the HP 9825T computer AC power switch to OFF.

2. Insert the program tape cartridge into the tape slot in the computer.

3. Turn the computer AC power switch ON. The program is loaded automatically when AC power is applied. After the tape stops and the computer displays READY, remove the program tape.

Each of the programmed computer functions labeled above and below the 12 special function keys, f0-f11, can be accessed from the READY mode by pressing that key. Labels above a key are "upper case" and the function is accessed by pressing the shift key and the special function key. As long as the system program is stored in the computer, it can be returned to READY by pressing STOP and then pressing SHIFT and READY, i.e., upper case f0.

The use of each function key is described in the following procedures.

5.3 Mark a Data Tape, MARK T

Before a tape can be used to store motorcycle test data, it must be "MARKED" with preassigned files. This is done automatically by the MARK T function (upper case f5). This function also provides for storing motorcycle identification and parameter data on the data tape.

1. Place the system in the READY mode (see 5.2).
2. Insert a blank tape cartridge in the tape slot.
3. Press SHIFT and MARK T (upper case f5). Observe the display:

Place Blank Tape In Slot; CONT.

4. With a blank tape in the slot, press CONTINUE.

BUSY MARKING TAPE

About 60 seconds is taken to mark the files, then the tape rewinds, stops and the computer displays

Input Motorcycle Name, Notation:

5. Enter requested information through the keyboard.

An entry is displayed as it is typed. Up to 80 characters may be entered including spaces. (If an error is made, press the character editing keys BACK or FWD until a light rectangle is positioned over the character to be changed and then type the correct character.) Later, the entry will be printed on the paper tape with 16 characters per line. The entry can include spaces so the printout does not end a line in the middle of a word. For example:

9 spaces

Enter:

HONDA CB650 1/26/81

When printed this will appear:

```
HONDA CB650
    1/26/81
```

With 1 space instead of 9,
the printer output will be:

```
HONDA CB650 1/26
/81
```

A beep is sounded upon entry of the 73rd character, indicating space for 7 more characters. If an attempt is made to enter more than 80 characters, a beep sounds and the character is not entered in the display.

After the entry is made correctly, press CONTINUE. Observe the display:

Input Total Bike Weight, lbs.

Enter (for example): 673, press CONTINUE

Display: | Input Static Front Wheel Load, lb |

Enter (Ex.): | 292 | , press CONTINUE

Display: | Input Static Rear Wheel Load, lb |

Enter (Ex.): | 381 | , press CONTINUE

Display: | Input Center of Gravity Hgt. in. |

Enter (Ex.): | 24.2 | , press CONTINUE

Display: | Input Wheelbase, in. |

Enter (Ex.): | 59 | , press CONTINUE

Printer:

```
Basic Motorcycle
   Parameters
Bike Name:
HONDA CB 650
    1/26/81
Total Weight:
          673.00
Front Wheel Load
          292.00
Rear Wheel Load:
          381.00
CG Height: 24.20
Wheelbase: 59.00
```

Display: | READY |

Check the printout for errors. If an error was made, repeat the Tape Marking procedure. The motorcycle parameter values shown on the printout are stored in the computer and used in subsequent test procedures in computing test parameters, such as tow height, desired tow-bar force, effective rear friction coefficient, etc. Thus the values must be correct. Do not MARK a data tape after test data has been recorded. The data will be erased.

5.4 Load Parameters, LOAD P

Each time the computer is powered up, the motorcycle parameters must be reloaded into the computer before motorcycle brake tests are started. If the data tape is already MARKED (Sec. 5.3), this is done using the LOAD P function (special function key f5). When a motorcycle test is initiated before the parameters are loaded, the message "Parameters Must Be Loaded" is printed and the system returns to READY. LOAD P also may be used to place a header on the paper tape.

1. Place the system in the READY mode.
2. Insert the previously MARKED data tape in the tape slot.
3. Press, LOAD P. Observe the display:

| Insert Data Tape; CONT. |

This is a reminder to the operator that a data tape must be in place. If it is not, when CONTINUE is pressed, program execution will halt and "error 41" will be displayed. If the program tape, rather than the data tape, is in the slot, "error 55" is displayed and for a blank tape "error 47" is displayed. (See the error message booklet under the computer cover.) In case of such errors, return the system to READY and try again.

4. Press CONTINUE. The tape runs a few seconds, stops, the basic motorcycle parameters are printed, as shown near the end of Section 5.3, and the system returns to READY.

5.5 System Check and Calibration, CAL

The CAL function provides an operational check of all system hardware and calibrates the four data channels; i.e., velocity (V), front actuator force (FAF), rear actuator force (RAF), and tow-bar force (TBF). All of the CAL function tests should be performed prior to starting motorcycle brake tests each time the system is powered up.

Test #2 of the CAL function procedure derives and stores the Zero Data Offset and Conversion Gain of each channel which is used during subsequent motorcycle tests to properly scale the data. It is "good practice" to calibrate the system just before and after each motorcycle test series to determine that no significant changes in calibration (offset and gain) occurred during the test. If test #2 calibration has not been executed since the computer was powered up, the message "System Must Be Calibrated" is printed when a motorcycle test sequence is initiated and the system returns to READY.

During a test #2 calibration the front and rear actuators must not be applied, the tow chain must be slack, and the fifth wheel must not be turning.

1. Place the system in the READY mode.

2. Press the CAL function key f10. Observe the printout and display:

```
# System Check #
# +Calibration #
#     Mode     #
```

Test #?

The operator must now select one of the seven options listed in Table 3 by entering the option number and then pressing CONTINUE. Test #1 guides the operator through all the others in the sequence 3, 4, 5, 2, 6, 0, returning to READY at the end. If any of tests #2 through 6 is selected, only that test is executed and the computer again asks for a test number. Test #0 provides a convenient return to READY from this condition. The following is an example of the sequence which proceeds after the selection of test #1, demonstrating the execution of each of the CAL function tests.

Table 3. System Check and Calibration Test Options.

Test No.	Description
0	Return to READY
1	Complete System Check and Calibration
2	Zero Data Offset and Conversion Gain Calibration
3	D/A Converter Analog Output Check
4	Rider Display Check
5	Voltage Offset and Voltage Gain Check
6	Thermocouple Check

3. Operator: Enter 1, press CONTINUE

Display: D/A Outputs = 0.00V; CONT?

Operator: Check the voltage at the four A/D output jacks on the right side of the multiprogrammer front panel with a digital voltmeter. (The voltage should be equal to the value shown on the display ± 0.02 volts. If a larger deviation is observed, the A/D converters should be recalibrated by the procedure in the Hewlett-Packard manual.) Press CONTINUE.

Display: | D/A Outputs = 5.00V; CONT? |

Operator: Check voltages. Press CONTINUE.

Display: | D/A Outputs = 10.00V; CONT? |

Operator: Check voltages. Press CONTINUE.

Printer:

*Analog Output *
*   Check   *
** OK **

Display: | Front and Rear Lights On; CONT? |

Operator: Check with rider over the intercom. Both the front and rear actuator apply lights should be on. Press CONTINUE.

Display: | Front and Rear Lights Off; CONT? |

Operator: Check with rider. Press CONTINUE.

Printer:

* Light Check *
** OK **

Display: | AF = 0   TBF = 50; CONT? |

Operator: Check the actuator force, AF, and tow-bar force error, TBFE, meter readings with the rider. Meter readings should be within 3 percent of values indicated. Note: The front brake actuator must not be applied during this check. Press CONTINUE.

Display:

AF = 55 TBFE = 10; CONT?

Operator: Check meter readings with rider. Press CONTINUE.

Display:

AF = 90 TBFE = 0; CONT?

Operator: Check meter readings with rider. Press CONTINUE.

Printer:

```
* Meter Check *
   ** OK **
```

Display:

BUSY

Printer: After 2 seconds

```
* A/D Channels *
*Offset Voltage*
ch   Meas   Norm
FAF -0.03   0.00
RAF  0.01   0.00
TBF -0.03   0.00
V    0.01   0.00
    ** OK **
```

Printer: After 10 seconds

```
* A/D Channels *
* Voltage Gain *
Ch   Meas   Norm
FAF  552    553
RAF  540    541
TBF  396    396
V    1.30   1.31
    ** OK **
```

Display: | All Cables Slack? CONT. |

Operator: Tell the rider to leave the brake actuators free and place slack in the tow chain by pushing the bike forward. Press CONTINUE.

Display: | BUSY |

Printer: After 1 second

```
*  Zero Data   *
*Offset Voltage*
* Calibration  *
Ch   Meas   Norm
FAF -0.12   0.00
RAF  0.50   0.00
TBF -0.01   0.00
V    0.02   0.00
    ** OK **
```

Printer: After 3 seconds

```
* Sig Conv Gain*
* Calibration  *
Ch   Meas   Norm
FAF   20.04  20
RAF   20.05  20
TBF  100.45 100
V     10.06  10
1-3 Units lbs/V
Ch 4 Units Mph/V
    ** OK **
```

Printer: After 1 second

```
* Thermocouple *
Front:     72.62
Rear :     72.62
Aux  :     72.18
   ** OK **
```

Display: | READY |

The thermocouple readings, in degrees fahrenheit, are the front and rear brake lining temperatures and the ambient temperature at the auxiliary thermocouple location at the rear of the truck. By observing the thermocouple test readings, the operator must judge if the readings are reasonable and that the thermocouples are functioning properly. Malfunction in the thermocouple channels usually results in obviously wrong values.

During the voltage offset/gain test #5 and the calibration test #2, the measured values are compared with the normal values shown on the printout. If the difference is outside of preset limits, an asterisk is printed by the out of range value, the printer stops, and the name of the out of range quantity is displayed. For example:

Printer:

```
*  Zero Data   *
*Offset Voltage*
* Calibration  *
Ch   Meas   Norm
FAF -0.13   0.00
RAF* 0.55   0.00
```

Display: RAF * Offset Out Of Range CONT?

The printer is stopped to call the operator's attention to the out of range condition. When CONTINUE is pressed, the printout is completed, that is

Printer:

```
*  Zero Data   *
*Offset Voltage*
* Calibration  *
Ch   Meas   Norm
FAF -0.13   0.00
RAF* 0.55   0.00
TBF -0.03   0.00
V    0.02   0.00
*-Out Of Range
```

Normal operation of the system may be continued with out of range calibration values, but this condition indicates that a basic system recalibration is in order. Grossly out of range calibration values indicate a system malfunction. The preset limits are: ±0.5 volts on A/D channels offset voltage and on Zero Data Offset Voltage; and ±5% of the normal value on A/D channels voltage gain and on signal conversion gain.

When READY is displayed after parameters are loaded and calibration test #2 is executed, the system is ready to proceed with the motorcycle brake test. The normal test sequence is: Preburnish Effectiveness, Burnish, Postburnish Effectiveness, and Thermal Capacity. However, each of these can be initiated at any time from the READY mode by pressing the corresponding special function key.

5.6 Effectiveness Tests, PRE-B and POST-B

Preburnish and postburnish effectiveness tests are identical except for being initiated by different function keys, PRE-B and POST-B. The test conditions and general procedures are:

1. Velocity: 40 ±1 mph.
2. Initial Brake Temperature: 130°F $\leq$ T $\leq$ 180°F.
3. Number of "Final data" test runs: 4 each front and rear.
4. Rear brake test tow height: 48 ± 1/2 inch.
5. Front brake test tow height: Initial tow height is equal to the rider/bike center of gravity height plus 6.0 inches. A new tow height is computed using the average results of three "good" front-application runs. Additional sets of three repeat front tests are conducted with each new tow height until:
    a. wheel lockup occurs and the new tow height is equal to the last tow height ± 1 inch
    b. wheel lockup did not occur but the new tow height is greater than or equal to (within -1 inch) the last tow height.

If either of the above criteria (a or b) are satisfied, a fourth run is made at the last tow height.

6. Brake actuator force: A ramp input of actuator force is applied, with the force increasing smoothly until a definite wheel lockup occurs or the force exceeds 90 pounds on the rear actuator or 55 pounds on the front actuator. Total application time must be less than 4.5 seconds.

7. Tow-chain angle: Tow angle changes with motorcycle pitch angle as the tow force increases. The tow-yoke height must be set higher than the tow height such that the tow chain becomes nearly horizontal (as confirmed by the lighting of the green tow-angle indicator light) at the time the tow force data point occurs. In the cases of wheel lockup or a torque-limited brake, this data point equals the peak tow-bar force. Otherwise, it equals the tow-bar force corresponding to 90 pounds (rear) or 55 pounds (front) of actuator force. The first test run must be repeated until the correct tow-yoke height is found.

The step-by-step effectiveness procedure is demonstrated below.

1. Check the paper tape supply. If the paper tape runs out during the test, the program stops and an error message is displayed. Test must then return to the start of the effectiveness test series.

2. Place the system in the READY mode.

3. Press the PRE-B function key, f6.

Printer:

```
* Effectiveness*
*  Test Mode   *

Insert Data Tape
 Do Not Remove
  Until Tests
    Complete
```

Display: | Insert Data Tape; CONT |

Operator: Insert data tape, press CONTINUE.

Display: | Ent 0-Start or 1-Cont Front Test |

If the rear tests were run previously, enter 1, CONTINUE. The message "BUSY LOADING REAR EFFECT DATA" is displayed while the rear effectiveness test data is loaded from tape into the computer. The program then advances to the start of the front test (page 152).

If the rear tests have not been run:

Operator: Press 0, CONTINUE.

Printer:

Start 4 Rear
Tests

Display: | Tow-Bar Height: 48.00 in CONT |

Operator: Set tow-bar height to 48 inches. Set the tow yolk about one inch higher to compensate for pitch. Press CONTINUE.

Display (Ex. Values): | Rear T: 73.40 V: 35.40 *GO* |

This sample display shows a rear brake temperature of 73.40 ° F and a velocity of 35.40 mph. *GO* indicates the operator is to press the GO function key, f0, to initiate the test when the temperature and velocity are within the required ranges: 130° F < T < 180° F and 39 mph $\leq$ V $\leq$ 41 mph. If the brake requires warming, the WARM function is used.

Operator: Tell the driver to hold 30 mph. When the speed is 30 $\pm$1 mph, press the WARM function key, f11.

Display: Input Sec of Warming Application

Operator: Enter an estimate of the warming time required (maximum of 22 seconds). For example, enter 10. Tell the rider a warming run is coming up. Press CONTINUE.

Printer:

REAR
Warming Run

Sec:	10.00
Temp:	71.97

Display: Ready For Rear Warming Run

Rider: When the "rear" brake apply light goes on, apply a constant rear brake force that zeros the Tow-Force Error meter. When the light goes off, release the brake.

Display (Ex) :

Rear T: 154.00 V: 30.40 *GO*

Operator: -During the warming run, observe the tow angle HI, GO, LO lights. If the LO (yellow) or GO (green) light goes on, the tow yoke probably should be raised one increment.

-If the temperature is still below 130° F after it reaches a peak value, do another warming run. The printout of the time and initial temperature from the previous run is helpful in estimating the next application time.

-If the temperature is OK, tell the driver to hold a steady velocity of 40 ±1 mph.

-Check temperature and velocity. Tell the rider a rear effectiveness test is coming up. Be prepared to watch the tow angle height during the effectiveness run.

-Press GO.

Display:

Rear Effectiveness Run

Rider: -When the "rear" light goes on, apply a ramp input of rear actuator force as seen on the Actuator Force meter.

-Smoothly increase the actuator force up to 95 pounds or at least one second, but no more than 2 seconds, after wheel lockup is perceived. Release brake.

-(The desired time for a brake application from start to release is 2.5 to 4.5 seconds.)

At the moment the rear actuator force exceeds 5 pounds, a five-second data sampling period is started (100 samples per second) and the display is:

5 Second Sample Period

When the sample period ends, the "rear" light on the Rider Display goes off and, for 11 seconds, the display is:

Busy Comp Data Point 1-500

During this time, the computer is doing a computation on each data point. Then the display changes to:

BUSY Avg Data Point 40-460

which is displayed for about one minute and 35 seconds. The computer digitally filters the data and finds the peak tow-bar force and the corresponding actuator force; or the tow force at the ergonomic limit of 90 pounds rear actuator force. These values, in pounds, labeled RTBF and RAF are then printed along with the data point time (seconds after the sampling period started), the test number (1 to 4), the initial velocity, V mph, and the initial temperature, RT, deg F.

Printer:

```
*  Preburnish   *
*  Rear Effect  *
Test #          1
V:          40.10
RT:        168.07
RTBF:      251.30
RAF:        43.79
Data Point Time
Sec:         2.41
```

Display: | Select Option or CONT |

The operator must now select one of the three options from Table 4. Usually option 2 is selected first with output types

Table 4. Operator-Selected Options—Continue, Repeat, or Graph Output.

Option	Enter	Description
0	CONTINUE	Proceed to next test
1	1 CONTINUE	Repeat last test
2	2 CONTINUE	Output analog data to recorder.

Output Type	Data Output Selections
1	Unfiltered TBF
2	Unfiltered AF
3	Filtered TBF
4	Filtered AF

3 and 4 to obtain an analog plot of the filtered tow-bar and actuator forces. By inspecting these plots and the printed data, the operator determines if the data is good and decides to repeat the test or continue to the next test. Any two desired output types, 1 through 4, can be selected to be reproduced at the A/D #3 and A/D #4 output jacks. For example:

Operator: Press 2, press CONTINUE.

Display: | Select A/D #3 Output Type |

Operator: Press 3 (filtered TBF), press CONTINUE.

Display: Select A/D #4 Output Type

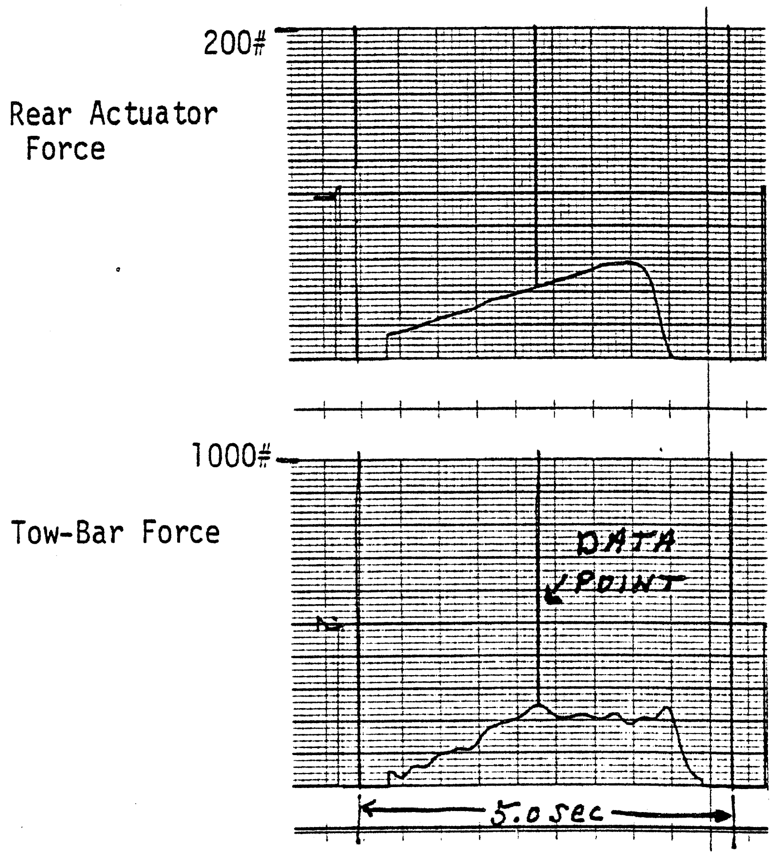
Operator: Press 4 (filtered AF), press CONTINUE.

Display: Press CONT To Start Graph

Operator: Start strip chart paper drive, press CONTINUE.

Display: BUSY OUTPUTTING ANALOG DATA

Strip Chart:



Analog data is reproduced at one-tenth real time. Thus 50 seconds are required to plot the five-second test. The analog output includes strip chart calibration information. The 0.1-second-wide pulses appearing at the start and end of an analog output sample are 50 seconds apart (five seconds in real data time) and the pulse amplitude is 10 volts, which equals 200 pounds for the actuator force plot and 1000 pounds for the tow-bar force plot. The location of the specific data point selected by the computer is marked by an additional full-scale pulse.

When the analog output is completed, the display returns to

Selection Option; CONT.

Operator: Enter 1, CONTINUE to repeat the test (that is, if the outputted data showed an invalid run) or enter CONTINUE to go on to the next test.

Display:

Rear T: XXX.XX V: XX.XX *GO*

When a test is repeated, the new data are written over the old data in the computer memory and the repeat run is labeled with the same test number. Data from the <u>final</u> four runs are stored on tape.

The above procedure is repeated for all effectiveness test runs. When the operator enters CONTINUE at the end of the fourth rear effectiveness test, the printer outputs the average data for the four tests and the computed effective rear friction coefficient.

Printer:

4 Rear Tests
Complete

Final Avg Data

Avg RTBF 235.67
Avg RAF 41.48
Rear Friction
Coefficient:
0.85

Printer:

* Rear Effect *
Tests Complete

Display:

BUSY STORING REAR EFFECT DATA

After the tape stops:

Printer:

Start 4 Front
Tests

Starting Towbar
Height: 31.40

At this point, the system may be shut down and the front effectiveness test started at a later time. When the system is powered up, option 1 is selected (see page 145) to continue at the start of the front effectiveness test.

Display:

Towbar Height: 31.40 in CONT

Operator: Set up new tow height. Press CONTINUE.

Display: | Front T: XXX.XX V: XX.XX *GO* |

After three effectiveness tests are completed, a new tow height is computed. The new tow height and the change in height is printed:

Printer:

New Towbar Height
30.80

Diff. From Last
-0.60

Display: | Input 1 To Repeat Series or CONT |

The series of three runs is repeated until:

1. Wheel lockup occurs and the new tow height is equal to the last tow height ±1 inch. That is, the difference is within ±1 inch.

2. Wheel lockup did not occur but the new tow height is greater than or equal to (within -1 inch) the last tow height. That is, the difference is greater than -1 inch.

Operator: Press 1, CONTINUE to repeat the series, or press CONTINUE to proceed to front-application test #4.

When the series is repeated, new data are written over the data from the previous series in computer memory, and the only record saved is the paper tape printout and the strip chart plots.

When the operator selects the CONTINUE option after test #4, data from the four final runs is averaged, an equivalent free deceleration and equivalent free stopping distance from 60 mph are computed and data is output on the printer.

Printer:

```
Final Avg Data

Avg FTBF  569.03
Avg FAF    42.32
Final Towbar
Height     31.84
Eq. Free Stopping
Decel.    0.8840
Eq. Free Stopping
Dist. From
60 mph    136.03

 Effectiveness
    Testing
    Complete
```

The system then returns to READY.

5.7 Burnish Procedure, BURNISH

Two hundred applications of the front and rear brake are required for the burnish sequence. Each brake application lasts four seconds at a constant speed of 40 mph. The braking interval for each brake is that distance needed to reduce the temperature to 150°F or one mile, whichever occurs first.

1. Check the paper tape supply
2. Place the system in the READY mode.
3. Press the BURNISH function key, f8.

Printer:

```
* Burnish Mode *

Insert Data Tape
 Do Not Remove
  Until Tests
    Complete
```

Display: | Insert Data Tape; CONT. |

Operator: Insert MARKED data tape, press CONTINUE.

Display (Ex.) : | Set Towbar to 24.20 Inches CONT |

Display (Ex.) : | T 70.04 71.49 D 0.00 0.00 C 0 0 |

Reading from left to right the display shows: Temperature; Front Brake, 70°F; Rear Brake, 72°F; Distance (since last brake application); Front 0.00 miles; Rear 0.00 miles; Count of brake applications; Front 0, Rear 0.

Operator: -Tell the driver to hold a constant speed of 40 mph. Monitor the display.

-Warn the rider when a front or rear brake application is coming up.

-When the temperature is less than 150°F or the distance is 1.00 mile for the front or rear brake, press the corresponding F or R function key. For example: press F.

Display: | Front Burnish Run |

Rider: -Watch the Rider Display panel.

-When the "Front" light goes on apply a constant front actuator force to zero the Tow-Bar Force Error meter.

-When the "Front" light goes off (four seconds), release the brake.

Display (Ex.) :

T	140	72	D	0.04	0.41	C	1	0

Printer:

*Front Burnish *	
Run #	1
V:	40.03
FT:	70.04
FTBF:	158.38
FAF:	10.11

Repeating the above for the rear brake, that is, when the operator presses the R function key, the printer output is:

Printer:

* Rear Burnish *	
Run #	1
V:	40.25
RT:	71.49
RTBF:	114.96
RAF:	20.01

Display:

T	130.00	150.00	D	0.32	0.04	C	1	1

The items printed are: Run number or application count; the velocity in mph and brake temperature in degrees F, taken at the start of the run; and the average values of tow-bar force and actuator force in pounds, averaged over the four-second application time. Data is printed after each run so the operator can monitor the operation of the system to immediately detect malfunctions and monitor the performance of the driver and rider in achieving the desired velocity and tow-bar force. Data shown on the printer, for every tenth front and rear burnish, is also stored on tape.

The desired tow-bar force is different for the front and rear burnish. At the start of each run the correct value is computed and stored in variable D. Thus, the current value in D is always the desired tow force for the last burnish run, front or rear. Between burnish runs, the operator can acquire this value of D without interrupting the program by pressing D (shift for upper case) and then EXECUTE. The current value in D in units of pounds will be displayed for about one second. Also, the value in D can be printed by entering prt D and pressing EXECUTE.

Always use the HALT function key to exit from the burnish routine. When HALT is pressed, the current front and rear burnish counts are stored on tape and the system returns to READY, and the system may be shut down. Provided this data tape is in the cartridge slot when the burnish function is later recalled, the last burnish counts are automatically entered and displayed.

If a system failure occurs during burnish (power failure, paper tape runs out, etc.), the burnish program must be reentered from the READY mode by pressing the burnish function key. The numbers of the last burnish runs stored on tape, a multiple of 10, will appear on the display. For example, if the burnish counts at the time of failure were front 47 and rear 59, the display would come up:

```
T  XX.XX  XX.XX  D  00.00  00.00  C  40  50
```

The count can be changed to the right values by making the following keyboard entries: 47 → C[1], EXECUTE; 59 → C[2], EXECUTE. Then the display will be:

```
T  XX.XX  XX.XX  D  00.00  00.00  C 47  59
```

When 200 front and rear burnish runs are done, exit the burnish mode by pressing the HALT function key. After burnishing, the brakes must be readjusted to manufacturer's specifications before proceeding to the postburnish effectiveness test.

5.8 <u>Thermal Capacity Test. THERMAL</u>

A thermal capacity test on each brake consists of three baseline runs, followed by ten fade runs, all made at a constant speed of 30 mph. Each baseline run is made at an initial temperature between 130°F and 180°F with the brake applied for a duration of four seconds at a constant tow force level. The series of ten fade runs is started at an initial temperature between 130°F and 150°F. The interval between brake applications is 0.4 miles. A constant tow-force level is held for six seconds at each application. The tow height for all thermal capacity tests is equal to the cycle/rider center of gravity height.

1. Check the paper tape supply.
2. Place the system in the READY mode.
3. Press the THERMAL key, f9.

Printer:

```
* Thermal Fade *
*    Gain      *
*  Test Mode   *

Insert Data Tape
 Do Not Remove
  Until Tests
    Complete
```

Display: | Insert Data Tape; CONT |

Operator: Insert data tape in slot. Press CONTINUE.

Printer: Set Towbar Height To: 25.00

Display (Ex.) :

Towbar Height: 25.00 in, CONT

Operator: Set the tow-bar height to 25.00 inches. Set the tow yoke about one inch higher. Press CONTINUE.

Printer: Now Do:
3 Front and
3 Rear
FG Baseline Runs

Display (Ex.) :

FT: 74.00 RT: 75.00 V: 30.40 C: 0 0

The display shows the front and rear brake temperatures in deg. F, the velocity in mph, and the run count, front and rear.

Baseline runs can be made in any sequence of front and rear brake applications selected by pressing the F (front) and R (rear) function keys. However, the front and rear runs cannot be intermixed on the fade test.

If the brake temperatures are low, warming runs must be made using the WARM function.

The following example demonstrates the thermal fade procedure.

Operator: Tell driver to hold 30 mph. When the speed is steady at 30 $\pm$ 1 mph, press the WARM function key.

Display: | Front Or Rear Warming? |

Operator: Press the F function key, f2.

Display: | Input Sec Of Warming Application |

Operator: Enter an estimate of the warming time required (maximum of 22 seconds total). For example, enter 10. Tell the rider a warming run is coming up, press CONTINUE.

Printer:

FRONT
Warming Run
Sec: 10.00
Temp: 73.92

Display: | Ready For Brake Warming Run |

Rider: When the "front" brake apply light comes ON, apply a constant front brake force to zero the Tow-Bar Force Error meter. Release the brake when the light goes OFF.

Display (Ex.) : | FT: 185.00 RT: 75.00 V: 30.20 C: 0 0 |

At this point, the operator may choose to: (1) warm the rear brake and then do the three front and three rear baseline runs in a sequence determined by the brake temperature, i.e., the runs may alternate, F, R, F, etc.; or (2) run the three front baseline runs, then warm the rear brake and run the three rear baseline runs. Following the latter, the procedure continues:

Operator: When the front temperature is between 130°F and 180°F, tell the rider a front baseline run is coming up and press the F function key, f2.

Rider: When the "front" brake apply light comes ON, apply a constant brake force to zero the Tow-Bar Force Error meter. When the light goes OFF, release the brake.

At the end of the run, the data is printed and the run count is updated in the display:

Printer:

Front Baseline	
Pass #	1
V:	30.58
FT:	154.02
FTBF:	165.69
FAF:	12.77

Display (Ex.) :

```
FT: 210.00  RT: 75.00  V: 30.50  C: 1  0
```

Operator: Repeat for baseline runs 2 and 3, then warm the rear brake and do the three rear baseline runs following the above procedure, but initiating the runs by pressing the R function key, f3.

Upon completion of three front and three rear baseline runs, a data summary is printed giving the average tow-bar force, the average actuator force and the baseline gain, for the front and rear brake. Baseline gain is the average tow force divided by the average actuator force.

Printer:

```
 Baseline chk
   Complete

 Final Avg Data

 Rear Baseline
    Avg Data
Avg RTBF: 135.24
Avg RAF:   31.86
Baseline RBG:
            4.24

 Front Baseline
    Avg Data
Avg FTBF: 153.24
Avg FAF:   12.01
Baseline FBG:
           12.76

Now Do
1 Front and
1 Rear
Thermal Fade
Series
```

Display (Ex.) :

FT: 125.00 RT: 145.00 V: 30.20 C: 0 0

The brake fade series of 10 runs per brake continues immediately following the baseline runs. The operator may select either the front or rear first. In the above sample display, the rear temperature is within the required range for the start of the fade series, that is, between 130°F and 150°F, so the rear is made first. Once the series is initiated, the rider's brake apply light is turned on automatically at 0.40 miles between runs until 10 runs are completed.

Operator: Tell the rider the first rear fade pass is coming up. Press the R function key, f3.

Display (Ex.) :

Rear D : 0.01

Rider: When the "rear" brake apply light comes ON, apply a constant rear actuator force to zero the Tow-Bar Force Error meter. Release the brake when the light goes OFF.

Printer:

Pass #	1
D:	0.03
V:	29.89
RT:	144.74
RTBF:	119.79
RAF:	20.09
RFG:	5.96

Display (Ex.) :

Rear D : 0.04 to 0.39

After pass #1, this display shows the operator the distance traveled since the end of the last pass. The distance displayed before pass #1 and printed with pass #1 data are not significant information.

Operator: Watch the distance display. When the distance is about 0.35 miles, tell the rider the next pass is coming up.

Rider: When the "rear" light goes ON, apply the brake, etc.

The distance displayed always stops at 0.39 miles, however, the distance count actually continues until the rider applies the brake. This is reflected in the printed distance data if the rider is slow in applying the brake after the light goes on.

After printing pass #10 data, the average value of the faded gain from the last three runs is computed and printed.

Printer:

Final 3 RFG Avg:
6.25

10 Passes
Completed

Continue

Display:

FT: 90.00 RT: 254.00 V: 30.05 C: 0 10

After a warming run to warm the front brake to between 130°F and 150°F, the 10 front faded brake runs are initiated when the operator presses the F function key, f2. The display shows

Front D : 0.01

and the front test proceeds as before. After the tenth fade pass, the average values from the last three runs are printed and then the display reads

Busy Recording Data On Tape

while all of the thermal capacity data is stored on the data tape. When the data transfer is completed, "Thermal Fade Test Complete" is printed and the system returns to READY.

5.9 Print Out Stored Data

All numeric data stored on tape during the motorcycle test series can be printed at a later time by use of the PRTOUT function, special function key upper case, f4. The operator may select to have all numeric data printed or only data from a specific test. The computer does not have to be connected to the multiprogrammer chassis when printing out numeric data. To obtain data printouts, perform the following:

1. Load the system program and place the system in the READY mode.

2. Press the PRTOUT function key. Observe the printer output and display:

```
#  Tape Data  #
# Output Mode #

Insert Data Tape
 Do Not Remove
  Until Tests
    Complete
```

   Display: | Insert Data Tape; CONT |

3. Insert the data tape. Press CONTINUE.

   Display: | Select Printout Options |

4. Printout options are selected by pressing appropriate special function keys. The key press options and the resulting printouts are:

   LOAD P: Basic Motorcycle Parameters

   PRE-B: Preburnish Effectiveness Test Data

   POST-B: Postburnish Effectiveness Test Data

   THERMAL: Thermal Capacity Test Data

   BURNISH: Burnish Data

GO: All of the above, printed in the order listed

HALT: Stop the printout, and return to READY.

In order to have an identification header on the paper tape, the LOAD P option should be made before selecting one of the four separate test data options.

5.10 Reproduce Effectiveness Test Analog Data, GRAPH

Five hundred raw data samples of tow-bar force and actuator force are stored on the magnetic tape data cartridge for each of the "final data" effectiveness test runs. These data are stored in specific tape files listed in Table 5.

Table 5. Effectiveness Test, Raw Data Tape Storage File Numbers.

File No.	Effectiveness Test
5	Preburnish Effect. Rear Test #1
6	Preburnish Effect. Rear Test #2
7	Preburnish Effect. Rear Test #3
8	Preburnish Effect. Rear Test #4
9	Preburnish Effect. Front Test #1
10	Preburnish Effect. Front Test #2
11	Preburnish Effect. Front Test #3
12	Preburnish Effect. Front Test #4
13	Postburnish Effect. Rear Test #1
14	Postburnish Effect. Rear Test #2
15	Postburnish Effect. Rear Test #3
16	Postburnish Effect. Rear Test #4
17	Postburnish Effect. Front Test #1
18	Postburnish Effect. Front Test #2
19	Postburnish Effect. Front Test #3
20	Postburnish Effect. Front Test #4

The GRAPH function key, f4, initiates a subprogram which allows the operator to select any of the test data listed in Table 5 to be output through the digital-to-analog converters, D/A #3 and D/A #4. After the raw data is loaded from tape into the computer, it is processed exactly the same as it was immediately following the actual test. (See Section 5.6, pages 149 through 151.) The values of the tow-bar force and actuator force at the computer-selected data point are printed and then the operator must enter an "output type" for each A/D converter. The output types (also listed in Section 5.6, Table 4) are:

1) unfiltered tow-bar force
2) unfiltered actuator force
3) filtered tow-bar force
4) filtered actuator force

The following demonstrates the procedure to obtain an analog plot from effectiveness test data stored on tapes.

1. Load the system program (program tape) and place the system in the READY mode.

2. Press the GRAPH function key, f4. Observe the printer output and display:

Printer:

```
* Graph Output *
*     Mode     *
```

Display: | Insert Data Tape, CONT |

3. Insert the data tape. Press CONTINUE.

Display: | Enter Raw Data File # , CONT |

Operator: For example, press 5, press CONTINUE. This selects file number 5, the preburnish effectiveness, rear test #1 (Table 5).

Display: BUSY Computing Data Point 1-500

After about 10 seconds the display changes to:

Display: BUSY Avg Data Point 40-460

After about one minute and 35 seconds, the computer prints its selected data point information.

Printer:

```
*  Preburnish  *
      Rear
 Effectiveness
   Data Graph
File#          5
Run#           1
TBF:      251.30
AF:        43.73
Data Point Time
Sec:        2.41
```

and the display becomes

Display: Select A/D #3 Output Type:

If, for example, a plot of the unfiltered and filtered tow-bar force is desired:

Operator: Press 1, press CONTINUE.

Display: Select A/D #4 Output Type:

Operator: Press 3, press CONTINUE.

Display: | Press CONT To Start Graph |

Operator: Start the recorder paper drive, then press CONTINUE.

Display: | BUSY OUTPUTTING ANALOG DATA |

Fifty seconds is required to output the five seconds of analog data. The analog output format is the same as that demonstrated and described in Section 5.6, page 150.

When analog output is finished, the display becomes

Display: | Select Option Or CONT. |

Operator: -Press CONTINUE to return system to READY mode.

-Press 1, CONTINUE to call a new raw data file. The display will change to

| Enter Raw Data File #, CONT |

-Press 2, CONTINUE to make another plot from the same data set. The display will change to

| Select A/D #3 Output Type |

5.11 HALT Key Functions

When the HALT key is pressed, the current procedure is stopped and the program jumps to a predetermined point, depending on the current procedure as defined in the following.

Effectiveness Tests:

When HALT is pressed between effectiveness tests, the program returns to READY. Effectiveness test must then be restarted from the beginning of the rear or front series.

Burnish:

When HALT is pressed during a burnish run, "Burnish Run Aborted" is displayed for two seconds and the program returns to the start of the aborted burnish run, waiting for front or rear to be selected.

When HALT is pressed after a burnish run is completed, "BUSY WRITING DATA TO TAPE" is displayed, data for the last burnish run is stored on tape and the program returns to READY. When BURNISH is called again, the last burnish run count (front and rear) is displayed.

Warm:

When HALT is pressed during a warming run, the program returns to the point from which WARM was called.

Thermal Capacity:

When HALT is pressed between baseline runs, the program returns to READY.

When HALT is pressed during a baseline run, the program returns to the start of that run, waiting for front or rear to be selected.

When HALT is pressed between runs of the 10-run fade series, the program returns to the start of the series, waiting for front or rear to be selected.

When HALT is pressed at the start of the 10-run fade series, the program returns to READY.

5.12 TK1 and TK2 Function Keys

Pressing TK1 or TK2 selects tape track 1 or track 2, respectively. All data from the test of one motorcycle fits on one track of a data tape. Thus, data for one motorcycle can be recorded on track 1 and data from a second motorcycle can be recorded on track 2 of the same data tape.

However, each time the computer is turned on, it automatically selects track 1. Track 2 must be selected by the operator. Thus extreme care must be exercised when recording data on track 2. If track 2 is not selected each time after turning the computer on, data intended for track 2 will be recorded on track 1, overwriting data previously recorded on track 1. Because of this possibility, the use of one data tape per motorcycle is recommended; otherwise, record data on track 2 first.

5.13 Changing Tape Notation After Recording Data

The tape notation entered during the MARK T function can be changed or added to after motorcycle test data has been recorded on the data tape, but not by use of the MARK T function which would erase the data.

The tape notation can include up to 80 characters, including the motorcycle name and spaces. (See Section 5.3.) To change or add to the notation, proceed as follows:

1. Place the data tape in the tape slot.
2. Press REWIND, wait until the tape stops.
3. Enter: ldf 0, A$, P[*] EXECUTE.
4. Enter: "New Notation - 80 Characters Max. Including spaces" → A$ EXECUTE. Note the new notation must be enclosed in quotation marks as shown.
5. Enter: rcf 0, A$, P[*] EXECUTE. The new notation, A$, and the unchanged motorcycle parameters, P[*], are recorded back on tape.

5.14 System Operating Procedure—Condensed Summary

The following condensed summary of the system operating procedures is provided as a quick reference for the system operator.

System Check and Automatic Calibration

1. From "READY" select CAL.
2. Select test options:

   0 - Return to READY

   1 - Complete system check and automatic calibration

   2 - Automatic calibration only

   3 - D/A output check

   4 - Rider Display check

   5 - Amplifier offset and gain check

   6 - Thermocouple check

Effectiveness Tests

1. Load parameters.
2. Calibrate the system (Auto CAL - CAL Option #2).
3. From "READY" select PRE-B or POST-B.
4. Set tow-bar height to 48 inches for rear brake tests.
5. If the brake temperature is low - WARM.
6. When the display temperature and velocity are within specified range (T: 130°F to 180°F, V: 40 ±1 mph), press GO to start a rear test.
7. When the run is completed and the data is processed by the computer, select option:

   CONTINUE - to proceed to next test.

   1 CONTINUE - to repeat last test.

   2 CONTINUE - to output analog data on D/A #3 and D/A #4.

Analog output type options:

1. Unfiltered TBF
2. Unfiltered AF
3. Filtered TBF
4. Filtered AF

8. Repeat steps 5-7 until four final rear tests are completed and the average data and rear friction coefficient are printed.

9. Start four front tests. Front tests proceed the same as the rear tests except the tow-bar height must be set to the height requested by the computer which is different for each motorcycle. After each series of three tests, a new tow-bar height is computed and displayed. When the tow height has converged, make a fourth test at the last tow height.

<u>Burnish</u>

1. Load parameters.

2. Calibrate the system (Auto CAL - CAL Option #2).

3. From "READY" press BURNISH.

4. Set tow-bar height.

5. Select: F to do a front brake burnish
   R to do a rear brake burnish.

6. Repeat burnish runs (at 40 mph) at one-mile intervals or when the brake temperature drops below 150°F, until 200 front and rear burnish runs are completed.

7. Press: HALT to record current burnish data and take a break.

Thermal Capacity

1. Load parameters.
2. Calibrate the system (Auto CAL - CAL Option #2).
3. From "READY" press THERMAL.
4. Set tow-bar height.
5. When the brake temperature and velocity are within specified range (T: 130°F to 150°F, V: 30 $\pm$1 mph, WARM brake if required), do three front and three rear baseline runs. Enter:

   F - front

   R - Rear

   HALT - to return to READY.
6. When the brake temperature and velocity are within range (same as 5 above), do a series of 10 fade runs front and rear at 0.4-mile intervals. Enter:

   F - front

   R - rear

   HALT - return to wait for selection of front or rear fade series.

PRINTOUT

1. From "READY" select PRTOUT.
2. Insert data tape.
3. Select printout option:

   GO - Print out all data

   PRE-B - Print preburnish effectiveness data

   POST-B - Print postburnish effectiveness data

   THERMAL - Print thermal capacity data

   BURNISH - Print burnish data (every tenth run).

GRAPH

1. From "READY" select GRAPH.

2. Insert data tape.

3. Select data file number (see Table 5).

4. After data is processed, select analog output type:

   1 - Unfiltered TBF
   2 - Unfiltered AF
   3 - Filtered TBF
   4 - Filtered AF

5. Select option:

   CONTINUE - Return to READY
   1 - Load new data file and plot
   2 - Replot present data.

APPENDIX 1

TOW-TEST APPARATUS
BILL OF MATERIAL, MECHANICAL

No. Req'd.	Part No.	Part Name	Material Needed to Construct the Total Number of Each Indicated Part
(1)	101	Main truck frame	22 ft. 3" Sch 40 steel pipe, 24 ft. 4'x4'x1/4" steel tubing, 4'x'4'x1/2" steel plate
(1)	102	Extended side frame	4 ft. 4x5/16 channel, alum., 33 ft. 3" Sch 40 pipe, alum.
(1)	103	Upper inboard diagonal brace	6 ft. 2-1/2" O.D. x 14 G a (.083) wall alum. tubing, (2) Spherco TRE-6 rod ends
(1)	104	Upper outboard diagonal brace	6 ft. 2-1/2" O.D. x 14 G a (.083) wall alum. tubing, (2) Spherco TRE-6 rod ends
(1)	105	Lower inboard diagonal brace	6 ft. 2-1/2" O.D. x 14 G a (.083) wall alum. tubing, (2) Spherco TRE-6 rod ends
(1)	106	Lower outboard diagonal brace	6 ft. 2-1/2" O.D. x 14 G a (.083) wall alum. tubing, (2) Spherco TRE-6 rod ends
(8)	107	End plug, diagonal brace	2 ft. 2-1/2" O.D. round stock - 6061 - T6 alum.
(4)	108	Rod end connection button	6" 1" dia. alum. round stock
(4)	109	Rod end connection button	6" 1" dia. steel round stock
(2)	110	Upright adjustment tubes, Nos. 1, 3	6 ft. 3" Sch. 40 alum. pipe
(1)	111	Upright adjustment tube, No. 2	4 ft. 3" Sch. 40 alum. pipe
(10)	112	Adjustment clamps	3 ft. 3-1/2" Sch. 40 steel pipe, 4 ft. 3/4x1-1/4 steel bar stock
(10)	113	Locking handle	5 ft. 1/2" drill rod, (10) McMaster-Carr #6047k17 (10) Waldes Truarc 5100-50
(3)	114	Rod end connection strap	6 in. 3/8"x1-1/2" steel flat
(6)	115	Tube connection strap	(6) McMaster-Carr #4571N33
(2)	116	Towing mast plate	8"x16"x1/2
(1)	117	Towing column	3 ft. 3" Sch. 40 pipe, alum., 3"x6"x1/4 alum. plate

No. Req'd.	Part No.	Part Name	Material Needed to Construct the Total Number of Each Indicated Part
(1)	118	Towing strap	(1) 1/2-20x1" grade 8 bolt
(1)	201	Lateral link, forward	3 ft. 1-1/2 O.D. x .065 wall alum. tubing, 6" 1-1/2 O.D. alum. round, (2) Spherco TRE-6 rod ends
(1)	202	Lateral link, center	3 ft. 1-1/2 O.D. x .065 wall alum. tubing, 6" 1-1/2 O.D. alum round, (2) Spherco TRE-6 rod ends
(1)	203	Lateral link, aft	3 ft. 1-1/2 O.D. x .065 wall alum. tubing, 6" 1-1/2 O.D. alum round, (2) Spherco TRE-6 rod ends
(3)	204	Lateral link adjustment screw	3 ft. 3/4" O.D. round stock - 416 stainless
(1)	205	Right foot-peg bracket	4"x3"x1/2" alum. plate, 5"x2x1/4 alum. plate 12"x6"x1/8" alum. plate, 2-1/2 O.D. x 1/8 x 3 ft. alum. tubing
(1)	206	Left foot-peg bracket	Same as Part 205, but no tubing material and also add: (4) Ideal hose clamps, 2-1/2" diam.
(2)	207	Foot-peg weld plate	3x6x1/4 hot rolled steel plate
(1)	208	Fore-link fastening bracket	5"x1-1/2"x1/4 hot rolled steel
(1)	209	Aft-link fastening bracket	5"x1-1/2"x1/4 hot rolled steel
(2)	210	Outboard clamp washer	2"x1-1/2 dia. round - hot rolled steel
(2)	211	Inboard clamp washer	2"x1-1/2 dia. round - hot rolled steel
(2)	212	Side strut	10 ft. 1-1/2 O.D. x .125 wall alum. tube 8" 1-1/4 O.D. alum. round
(2)	213	Side strut cap	2", 1-1/2" dia. alum. round
(2)	214	Tow bolt cap	2", 1-1/2" dia. alum. round
(1)	215	Cross tube	2-1/2 ft., 2-1/2 O.D. x .125 wall alum. tube, 6061-T6, 6"x3"x1/8 alum. plate
(1)	216	Tow bolt	6"x3/4 dia. stainless round

No. Req'd.	Part No.	Part Name	Material Needed to Construct the Total Number of Each Indicated Part
(2)	217	Tow strut pin	8"x1/2" dia. stainless round
(1)	218	Strongback	3 ft. 1-1/2" dia. x .125 wall alum. tubing - 6061-T6; 2 ft. 1/2" dia. alum. round, 12"x12"x1/8" alum., 4"x4"x1/4" alum.
(1)	219	Top cable clevis	3"x6"x1/4" hot rolled steel
(2)	220	Front head clamping plate	2 ft.x1-1/2x1/2 alum.
(8)	221	Front head shims	1 ft.x1-1/2x3/8, 1 ft.x1-1/2x1/4, 1 ft.x1-1/2x1/8, 1 ft.x1-1/2x1/16
(1)	222	Strongback aft fastener	2 ft. 2x3/8 alum., 2"x2"x1/8" alum., 1 ft. No. 35 roller chain
(2)	223	Tightening pin	3", 1/2" dia. steel round, 4140 or equiv.
(1)	224	Tow strut cable assembly	10 ft. McMaster-Carr #3451T17 aircraft cable, 1/8" dia., (3) clevises, McMaster-Carr #3473436, (1) turnbuckle, McMaster-Carr #3476T13
(1)	225	Tow chain	5 ft. #35 roller chain with two master links
(1)	226	Jam-cleat assembly	2-1/2x5x3/16 alum., (2) sailboat jam-cleat assemblies for 1/4" dia. line
(1)	301	Tow clevis	3" 1-1/4" dia. hot rolled steel round
(1)	302	Jam link	4" 1-1/2x5/8 flat stainless
(1)	303	Modif. master link	(1) #80 roller chain master link
(1)	304	Jam sprocket	(1) Boston KSA8-1 sprocket for #35 pitch chain
(1)	305	Spacer	1" 5/8" dia. alum. round
(1)	306	Limit switch bracket	2"x8"x1/16 stainless
(2)	307	Limit switch	(2) Honeywell Micro Switch #BZ-2RQ18
(2)	308	Side link	(2) side links from (2) #80 roller chain master links

No. Req'd.	Part No.	Part Name	Material Needed to Construct the Total Number of Each Indicated Part
(1)	309	Spring	(1) extension spring, .040 wire, 7 turns, 1/4" dia., 1" free length
(1)	310	Tow load cell	(1) Lebow Model 3169-1K load cell,
(1)	401	Wand	12"x18"x16 GA Alum., 6"x1/2" dia. alum. round 4"x3/8" dia. alum. round, 2"x1"x1/8" alum.
(1)	402	Modified rod end	(1) Spherco TR-4 rod end
(1)	403	Load cell base plate	2"x2"x1/2" alum.
(2)	404	Load cell spacer	1"x3/8" dia. alum. round
(1)	405	Load cell pin	4"x1/4" dia. stainless round
(2)	406	Brake lever link	16"x5/8"x1/8" alum.
(1)	407	Brake lever bracket	3"x3/8" dia. stainless round, 1"x2"x5/16" stainless
(1)	408	Brake lever back strap	1-1/4x1/2x1/8 stainless
(1)	409	Handle grip attachment	3"x1-1/2 O.D. x 1/8 wall alum. tubing, 2"x1-1/4x1-1/4 alum., 2"x1/2" dia. alum. round
(1)	410	Hand lever load cell	(1) Lebow Model 3663-200 load cell,
(2)	411	Load cell rod end spacer	1"x3/8" dia. alum. round
(1)	412	Foot pedal load cell	(1) Lebow Model 3663-200 load cell,