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LANGLEY WORKING PAPER

PRELIMINARY TEST RESULTS OF THE JOINT FAA-USAF-NASA RUNWAY RESEARCH PROGRAM

PART I - TRACTION MEASUREMENTS OF SEVERAL RUNWAYS UNDER WET AND DRY CONDITIONS WITH A BOEING 727, A DIAGONAL-BRAKED VEHICLE, AND A MU-METER

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This paper is given limited distribution and is subject to possible incorporation in a formal NASA report.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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1.0 INTRODUCTION

1.1 Since the beginning of modern all weather aircraft operations, there have been landing incidents and/or accidents each year where aircraft have either run off the end or veered off the side of wet or slippery runways. These incidents/accidents have provided the motivation for various government agencies to conduct research into the causative factors involved in slippery runway incidents.

1.2 Research conducted by the U. S. National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), United States Air Force (USAF), United Kingdom, and others has established that braking friction does diminish on wet runway surfaces and the degree of friction reduction is related to many factors including the depth of water on the surface, surface texture, tire pressure, brake application speed and so forth. Much of the research effort has been utilized to establish an understanding of the slipperiness problem. In 1968, a number of friction measuring vehicles were tested at NASA Wallops Station, Virginia, to ascertain the suitability of the various vehicles for measuring friction in a repeatable manner and for providing an index that might be correlated with aircraft stopping performance and/or used to produce information which could be used as an operational guide to pilots during inclement weather conditions (ref. 1). As a result of these and subsequent tests, two ground vehicle measuring methods emerged, each showing promise of correlating with aircraft stopping performance and each showing capability of becoming the basis for an operational technique. The two methods utilized are the NASA diagonal-braked vehicle and the British Mu-Meter. Although testing to date has produced some data which indicate reasonable correlation may exist between these vehicles and aircraft, complete proof has not been obtained to show that such correlation would hold over the range of operational aircraft types and slipperiness conditions likely to be encountered in scheduled air carrier operations.

1.3 In order to establish the degree of stopping distance correlation that might be obtained between modern jet transports and ground friction measurement vehicles over a wide range of slipperiness conditions, the FAA, USAF, and NASA are conducting a "Joint FAA-USAF-NASA Runway Research Program."

> <u>Phase I</u> - Two modern jet transports are to be tested along with the diagonal-braked vehicle and Mu-Meter on several runways which when wetted cover the range of slipperiness likely to be encountered in the United States. These tests are designed to determine if correlation between the aircraft and friction measuring vehicles exists.
>
> <u>Phase II</u> - A computer study of several modern civil/military jet aircraft anti-skid braking systems will be conducted to ascertain which parameters have the major influence in aircraft/ground vehicle correlation.

The results of the program will establish the adequacy of the existing techniques or the need to proceed in the further development of ground friction measuring vehicles.

1.4 The tests of the first airplane in Phase I, a Boeing 727, were conducted during the period of October 4-16, 1971. The test team consisted of members of the three government agencies and representatives from the following industry organizations and foreign governments: The Boeing Company; Aerospace Industries Association; Air Transport Association; United Airlines; Air Line Pilots Association; Ministry of Transport, Canada; Ministry of Defense and Air Registration Board, United Kingdom; Centre D'Essais EnVol, Bretigny, France; and ML Aviation Ltd., United Kingdom. In addition, at several of the test sites, observers from other organizations, such as Airport Operators Council Inc., etc., were present.

1.5 Logistics support for the B-727 tests was provided by a USAF C-141 aircraft. This aircraft transported the two ground vehicles, spare wheels and tires for the aircraft and DBV, runway markers and miscellaneous measuring equipment, the USAF portable phototheodolite, and essential maintenance equipment for changing tires on the B-727 aircraft. The test crew and test aircraft instrumentation spares were transported between stations on the B-727 test aircraft. A test crew of approximately 40 people was necessary for the efficient conduct of this test program.

1.6 This paper presents the preliminary results of an analysis of the aircraft, diagonal-braked vehicle, and Mu-Meter data obtained from the October 1971 tests. These data will be further analyzed and combined with those from a test of a DC-9 airplane, scheduled for February 1972, and will be published at some future date.

2.0 TEST EQUIPMENT

2.1 The initial Phase I test airplane was a Boeing 727-100 jet transport with three rear mounted jet engines depicted in figure 1(a). The maximum authorized landing weight for the airplane tested is 142,500 pounds using 30° landing flaps. At weights of 137,500 pounds or less, a landing flap setting of 40° may be used. Maximum brake application speeds varied, according to weight, from 132 knots down to 78 knots. The test landing brake energy range varied from a WV^2 of 0.882×10^9 lb-kt^2 to 2.42×10^9 lb-kt^2.

2.1.1 During the time period the aircraft was being instrumented at the NASA Langley Research Center, the anti-skid control valves, skid detectors, and electronic control box were removed from the aircraft and sent to the vendor for inspection. The vendor checked the components for proper operation and returned the refurbished components or, in some instances, replacement components, to Langley for installation on the aircraft. This check was made to insure that the aircraft braking system was in tolerance and at peak performance for the flight test program to follow.

2.1.2 Stopping distance, brake application velocity, and time of brake application were the principal measurements required to evaluate the aircraft stopping performance. The instrumentation aboard the aircraft used to measure these principal parameters is listed in table I. Included in the table are the other items which were instrumented in order to obtain data related to the anti-skid braking system and other aircraft characteristics necessary for a thorough evaluation of the stopping performance. Redundant instruments, a nose wheel counter and the Boeing side-mounted phototheodolite, were used to record the principal parameters to insure complete and accurate acquisition of these items. A signal block diagram of the instrumentation listed in table I is shown in figure 2. The accuracy of each of the instrument sensors is listed in table II for the oscillograph system and in table III for the magnetic tape system. Figures 3 and 4 show the main instrumentation rack, and the side mounted phototheodolite, including its instrumentation rack.

2.1.3 The nose wheel counter consisted of a magnetic pickup mounted on the nose strut of the aircraft and two small steel masses mounted 180° apart on the right hand nose wheel, figure 5. The signal produced as each steel mass passes the pickup is fed to a digital counter in the aircraft cockpit, figure 6, and to a magnetic tape channel for permanent recording.

2.1.4 The side-mounted phototheodolite camera system provided by Boeing and shown in figure 4, was located at station 430 on board the test aircraft. The data acquisition system consists of a Giannini multidata 35 mm motion picture camera with a vertical reticle mounted as shown in figure 4(a). The camera is positioned perpendicular to the airplane longitudinal axis and at an appropriate angle with the lateral axis such that markers, placed at 50-foot intervals along the side of the runway, appear in the middle of the film frame when the airplane is on the runway centerline in a nonrotated position. Time is displayed on each film frame to the nearest one-hundredth second using digital display tubes which are pulsed by an Astrodata Model 6190 time code generator. The camera is also triggered by the time code generator at 10 frames per second.

2.2 The diagonal-braked vehicle (DBV) is a 1969 Ford XL sedan with a high performance engine for rapid acceleration to the test speed of 60 mph. This vehicle is equipped with a diagonal braking system to maintain vehicle stability and directional control when the diagonal wheels are locked at high speed. The vehicle is shown in figure 1(b). A schematic diagram of the diagonal braking system is shown in figure 7.

2.2.1 The stopping distance, speed, and acceleration instrumentation on board the DBV is listed in table IV. The key elements of instrumentation are depicted in figure 8. Figure 9 shows typical DBV recorder traces for test runs conducted on dry and wet runway surfaces. The key parameter changes between the dry and wet conditions are the longitudinal acceleration and the time required for the DBV to stop. For the wet condition, the reduced longitudinal acceleration causes the increase in time and stopping distance over that of the dry case. The primary brake application speed and stopping distance measurements used in the analysis of this report are variables 4 and 5, respectively of table IV which are obtained from NASA standard instruments. The stopping distance instrumentation was calibrated by driving the DBV over a 1000-foot measured distance on a straight airport taxiway or on the runway test section. The diagonal-braked wheels are fitted with ASTM smooth tread test tires (specification E-249) inflated to 24 psi. The unbraked wheels are equipped with standard road tires of good tread design inflated to 32 psi. The tracking wheel tire is maintained at 28 psi inflation pressure.

2.3 The Mu-Meter is a side force measuring trailer shown pictorially and graphically in figures 10 and 11. The total weight of the trailer is approximately 530 pounds. It may be towed by any automobile or light truck when the towing vehicle is equipped with a suitable towing hitch.

2.3.1 The Mu-Meter instrumentation consists of a chart recorder, figure 12, driven by the rear center wheel. The chart speed is arranged such that 1 inch on the chart is equal to approximately 450 feet of runway length. The chart recorder has two channels: one for recording the friction reading, scale 0-1.0, and the other for use as an event marker, bulb operated. Figure 13 shows the Mu-Meter chart traces made on the dry runway, and before and after aircraft run 43 on the wet runway at Houston. The Mu-Meter friction reading is calibrated by means of a friction board provided with the Mu-Meter and according to the instruction manual. The tires that measure the side force must be inflated to 10 psi. The tire driving the recorder must be inflated to 30 psi. The Mu-Meter used in these tests was also fitted with a remote reading unit which provides an integrated average friction reading over the entire surface tested.

2.4 The equipment used for artificially wetting the runways varied from airport to airport, but generally consisted of from one to three tank trucks varying in capacity from 3000 gallons to 8000 gallons. Most of these vehicles used a pump to discharge the water at rates varying from 500 to 1600 gallons per minute in order to get the maximum amount of water on the test section in a given time interval. A typical tanker truck wetting operation is shown in figure 14.

2.5 Miscellaneous test equipment consisted of runway markers, figure 15, to identify the test section, water depth gages, figure 16, for measuring water depth, a surface texture depth kit, figure 17, and miscellaneous data gathering equipment including a portable anemometer, Rolatape, thermo-electric temperature gage and a portable psychrometer. A USAF portable phototheodolite, figure 18, which was set up approximately 1000 feet perpendicular to the runway centerline at the approximate midpoint of the runway test section was used to record aircraft and DBV stopping distances. Data from this instrument, although not available for this report, will be available for the final report.

3.0 TEST AND DATA REDUCTION PROCEDURES

3.1 <u>Test Sequence</u> - Two basic test sequences were used—one for dry surface tests and one for wet surface tests.

3.1.1 For the dry surface conditions, the DBV and the Mu-Meter generally made their initial tests prior to the first aircraft stopping distance test. On occasion, a second series of dry tests with the ground vehicles was made while the aircraft was down for refueling.

3.1.2 For the wet surface conditions, the test sequence used is summarized as follows:

1. Water tankers wetted the runway test section in two continuous passes.

2. Water depth measurements were made at each measuring station immediately after the second pass of the water tanker and before the initial ground vehicle runs.

3. Initial ground vehicle measurements were made.

4. Aircraft landed and stopped.

5. Water depth measurements were made at each measuring station.

6. Second ground vehicle measurements were made

7. Water depth measurements were made at each measuring station.

3.2 Wetting Procedure - Artificial wetting of the runway test section was accomplished using from two to three water tankers. The rate at which water was discharged from the tankers was used to establish the speed of the vehicles so that all water was expended at the end of the second pass down the test section. The tankers made the initial wetting pass in a direction the same as that of the landing aircraft. The center 40 to 50 feet of the runway test section was wetted. The time to wet the test section for each wet test and the amount of water used is listed in table V.

3.3 Water Depth and Atmospheric Data Measurements

3.3.1 Water depth measurements were made at six stations (runway markers A-G) spaced down the length of the test section as shown in figure 19. Measurements of water depth were made at each station using the NASA portable water depth gage. These measurements were made on and at 10 feet either side of the runway centerline. The first measurements were made immediately after the water tankers passed each station on the second wetting pass. The second set of measurements were made after the aircraft landing and stop and the third set of measurements were made after the final ground vehicle runs. The average water depths at the time of aircraft stopping test is shown for each test in table V. Table VI presents the average water depth as a function of time relative to the aircraft test. The average water depths in table V were obtained by plotting the data of table VI.

3.3.2 Atmospheric data, consisting of wet and dry bulb temperatures, relative humidity, wind speed and direction, barometric pressure and runway surface temperature were taken at the time of each aircraft test. These data are listed in table V.

3.4 Aircraft Test Procedure - For maximum braking stops, the aircraft was landed short of the test section at a speed sufficiently in excess of the desired brake application speed so that the nose wheel could be placed on the ground, the wing lift spoilers could be raised and the engines could be spooled down to idle rpm (approximately 5 seconds spool down time) by the time the threshold of the test section was reached. Upon entering the test section, maximum brakes were abruptly applied and held in the maximum "ON" position until the airplane came to a complete stop. An exception to this procedure was required when the aircraft exited the wetted test section with wheels locked as is illustrated in figure 33(c). The pilot was preinstructed to release the brakes upon exiting the wetted test section and reapply brakes to stop on the dry surface. On four occasions where locked wheels occurred, the aircraft exited the wetted test section prior to stopping, necessitating the release and reapplication of brakes as the transition from wet to dry surface was made. This procedure was used to minimize tire flat spotting which may result from a locked-wheel skid that occurs on dry pavement. A correction to the stopping distance was necessary as a result of using this procedure. The correction is described later in the paper.

3.5 DBV Test Procedure - The diagonal-braked vehicle was operated in accordance with the following procedures: The car is accelerated to approximately 65 mph prior to reaching the test section, the transmission is then placed in neutral at a point which will result in a speed of 60 mph being attained at the point of entry into the test section. Upon entering the test section, maximum brakes are applied, locking the two diagonal-braked wheels which are equipped with the ASTM smooth tread tires. Maximum brakes are held "ON" until the car has come to a complete stop. Two, and sometimes three, stops were made within the length of the test section. Where only two stops were possible, other segments of the test section were measured on subsequent aircraft tests, if needed. Basic DBV data for the dry surface tests are included in table VII, and data for wet surface tests are included in table VIII. Table VIII shows the test results in relation to the time of the aircraft test.

3.6 Mu-Meter Test Procedure - The Mu-Meter was operated in accordance with procedures developed in the United Kingdom (ref. 2). For each run the towing vehicle was accelerated to the selected towing velocity, usually 40 mph, prior to entering the test section. This velocity was held constant for the run through the test section. Some data were also obtained at speeds of 20 mph and 60 mph. The basic Mu-Meter data for the dry surface conditions are included in table VII and the basic wet surface data are included in table VIII. The latter is shown in a time relationship to the aircraft test.

3.7 DATA REDUCTION

3.7.1 B-727 Aircraft

3.7.1.1 Nose Wheel - The NASA nose wheel revolution counter (2 pulses/revolution) and ground speed meter were installed in the cockpit of the test aircraft (see figures 6 and 20) to provide quick-look capability in the field for measuring aircraft stopping distance and ground speed from the pilot's brake application point. Both of these instruments required an accurate measurement of nose wheel tire rolling radius under test conditions to determine the appropriate instrument calibration factors. The necessary data for this purpose were obtained from the Wallops aircraft calibration runs (runs 1-9). The flight recorder oscillograph records of these runs were analyzed at Wallops and the following calibration factors were determined:

QUANTITY	CALIBRATION FACTOR
Stopping distance, ft	3.95 × number of counter pulses
Ground speed, kt	1.31/dial division (ground speed meter)

These calibration factors were used to obtain the brake application ground speed and stopping distance (from brake application) values listed for the aircraft test runs in table V.

3.7.1.1.1 It should be noted that the values of stopping distance and brake application speed listed in table V were subject to possible reading or recording errors by the flight crew. The possibility also existed that the nose wheel revolution counter on the aircraft on a given run could contain some spurious counts if the pilot lightly engaged the aircraft brakes before maximum brake application at entrance to the runway test section. The magnetic analog tape flight recorder records of all aircraft calibration and test runs were analyzed to validate the nose wheel quick-look data given in table V. This was done to insure that spurious counts had not occurred and to establish a more accurate value of the nose wheel tire rolling radius for the test conditions encountered. Figure 21 shows the variation of nose wheel tire rolling radius with aircraft ground speed as determined from nose wheel angular displacement measurements. The angular displacement method was determined to be the most accurate method of obtaining tire rolling radius. An average nose wheel tire rolling radius of 1.265 feet over the test ground speed range evaluated was determined.

3.7.1.1.2 The aircraft ground speed at brake application was determined by counting the number of nose wheel pulses (magnetic analog tape record) over a 1 second time interval just before and after brake application as shown in figure 22. A more accurate determination of this speed will be made in the final report.

The brake application speed was determined by the equation

$$V_B = \frac{2\ \pi r_e\ N}{2 \times 1.69} = 2.351\ N$$

where

r_e = nose wheel tire rolling radius = 1.265 ft

N = number of nose wheel pulses (2/revolution) per second of time

V_B = brake application speed, knots

The aircraft stopping distance from the nose wheel counter was determined in similar fashion by hand counting the number of nose wheel pulses from brake application speed to a complete stop from the magnetic analog tape test records and by use of the equation

$$S_B = \frac{2\ \pi r_e\ N}{2} = 3.974\ N$$

where

S_B = stopping distance, ft

r_e = 1.265 ft

N = number of nose wheel pulses (2/revolution)

The values of brake application ground speed and aircraft stopping distance obtained by these data reduction techniques from the NASA nose wheel instrumentation measurements are listed in table IX.

3.7.1.2 On Board Phototheodolite - The Boeing Company processed and reduced the test film acquired by its on board side-looking phototheodolite camera during the test program using standard Boeing film data processing and computer program procedures. Values of brake application ground speed and aircraft stopping distance obtained by this theodolite are also listed in table IX.

3.7.1.3 USAF Ground Phototheodolites - At Edwards AFB, the USAF obtained measurements of aircraft brake application speed and stopping distance during test runs from data obtained by operating its fixed (tower) ground phototheodolite equipment. This was in addition to data acquired at each test runway by operating its portable ground phototheodolite during test runs. The measurements of aircraft brake application speed and braking distance obtained by the Edwards ground phototheodolite are presented along with the NASA nose wheel counter and Boeing side-looking phototheodolite instrumentation in table X. It can be seen from this table that the USAF data for speed and distance are in good agreement with the NASA and Boeing data obtained at Edwards AFB. As discussed earlier in the paper, data obtained by the USAF portable phototheodolite during the test program are still being reduced by USAF and therefore not available for incorporation in this paper.

3.7.1.4 Ground Visual Distance - Observers stationed along the runway noted the points on the runway during each test run where the aircraft "over the wing" light (electrically coupled to the pilot's brake pedals) was turned "ON" and "OFF" by pilot brake application. The distance between these points along the runway were measured and noted in tables V and IX. This was a backup quick-look method for measuring aircraft braking distance in case of aircraft instrumentation failure and is not considered as accurate as the other stopping distance measurement methods discussed in this paper.

3.7.1.5 Wet/Dry Stopping Distance Ratio (SDR) - To obtain the aircraft wet/dry stopping distance ratio, it is first necessary to determine the dry stopping distance required for the aircraft under the same brake application speed and landing gross weight conditions of the wet run under consideration. For this purpose, plots of aircraft dry stopping distance, feet, against aircraft braking energy, WV^2, lb-kt^2, were prepared in figure 23 from NASA nose wheel counter and Boeing phototheodolite data obtained from table IX. The equations for the faired lines through these data are

Boeing theodolite $S_{Dry} = 8.809 \times 10^{-7} WV_B{}^2$

NASA nose wheel counter $S_{Dry} = 9.167 \times 10^{-7} WV_B{}^2$

where

S_{Dry} = aircraft dry stopping distance, ft

W = test gross weight, lb

V_B = brake application speed, kt

The data scatter in figure 23 about these faired lines are approximately ±5 percent for the majority of the test runs. This scatter is attributed mainly to differences in airport altitude, runway surface texture, atmospheric conditions, aircraft configuration, and anti-skid braking system performance between the different test runs. It is noted that the NASA data give the aircraft a 3.9 percent longer stopping distance for a given aircraft WV^2 than the Boeing data. The reason for this discrepancy is illustrated in figure 24 where Boeing and NASA values of aircraft stopping distances, brake application speed, and SDR (wet/dry) are directly compared. It can be seen from the data in this figure that the Boeing and NASA stopping distance are in excellent agreement. However, the NASA brake application speeds tend to be lower than the Boeing brake application speeds. A more rigorous analysis of the nose wheel counter data will undoubtedly reduce this discrepancy. As discussed in sections 3.7.1.1.1 and 3.7.1.1.2, an average nose wheel tire rolling radius of 1.265 was used to calculate both brake application speed and stopping distance from the NASA counter data. Actually, the nose wheel rolling radius must increase with increasing aircraft ground speed due to tire centrifugal growth effects, especially at high speeds. For stopping distance calculations, use of the average rolling radius is sufficiently accurate because the ground speed varies from a high speed to zero speed, the same conditions under which the average rolling radius was determined from the Wallops calibration runs. For brake application speed calculations, however, the actual tire rolling radius for a given ground speed must be used with the NASA counter data to obtain correspondence with the Boeing brake application speed data. It is interesting to note that while differences in Boeing and NASA brake application speed are obvious and result in differences in calculations of aircraft WV^2 and dry stopping distances, the aircraft stopping distance ratio (SDR), wet/dry are in excellent agreement. This result is explained by the fact that the NASA speed discrepancy occurs in both numerator and denominator of the ratio resulting in the wet/dry ratio being only slightly affected by small brake application speed variations. In the data comparisons to follow, the aircraft SDR determined by the NASA counter are presented.

3.7.1.6 Data which were recorded on the magnetic analog tape were digitized, converted to engineering units, and displayed in the form of time-history plots. In addition to these time histories, a coefficient of friction has been computed as a function of time using the taped records of acceleration and nose wheel velocity. The following equation was used

$$\mu = (x_M - x_N) \left[(\mu_r C_L - C_D) qS_w + T - \left(\frac{\ddot{x}}{g} + \gamma + \mu_r\right) W\right]$$

$$\times \left\{\left[C_M\bar{c} - (x_{ac} - x_N) C_L + z_{ac} C_D\right] qS_w + \left[z_{cg}\left(\frac{\ddot{x}}{g} + \gamma\right) + x_{cg} - x_N\right] W\right.$$

$$\left. - z_T T\right\}^{-1}$$

where

$$q = \frac{1}{2}\rho (V_w + r_o\omega_N)^2$$

and

C_D = drag coefficient

C_L = lift coefficient

C_M = moment coefficient

$\bar{c}$ = wing reference chord length

g = acceleration of gravity

q = dynamic pressure

r_o = nose wheel rolling radius

S_w = wing reference area

V_w = wind velocity

W = aircraft weight

$\ddot{x}$ = measured aircraft acceleration

x_{ac} = longitudinal position of aerodynamic center

x_{cg} = longitudinal position of aircraft center of gravity

x_M = longitudinal position of main landing wheels

x_N = longitudinal position of nose wheel

z_{ac} = height of aerodynamic center above the ground

z_{cg} = height of aircraft center of gravity above the ground

z_T = height of effective thrust vector above the ground

γ = runway slope

μ = braking coefficient of friction

μ_r = rolling wheel coefficient of friction

ρ = atmospheric density

T = engine thrust

ω_N = nose wheel rotational speed

3.7.2 Diagonal-Braked Vehicle (DBV)

3.7.2.1 The DBV test technique is to apply brakes at 60 miles per hour and measure the stopping distance required to brake the vehicle to zero speed as shown in figure 9. Two independent measuring systems operating from the same trailing fifth wheel on the test vehicle were used in a redundant manner to obtain values of brake application speed and stopping distance. The values of speed and distance obtained by the two measuring systems, one labeled NASA and one labeled prototype, during DBV dry runway tests are listed in table VII and the values obtained from wet runway tests are listed in table VIII. The measurements of brake application speed and stopping distance obtained by the standard (variables 4 and 5 of table IV) and prototype (variables 2 and 3 of table IV) instruments of the DBV are compared in figure 25. For brake application speed, 95 percent of the data points obtained from tables VII and VIII agreed within ±2 percent or within approximately 1 mph. This agreement is considered to be excellent. The measurements obtained for stopping distance by the two instrument systems were not in such good agreement. Only 77.4 percent of the stopping distance measurements agreed within ±2 percent; however, 90.9 percent of the measurements agreed within ±4 percent, while 9.1 percent of the measurements exceeded the 4 percent boundaries. It was noticed at Wallops during pretest trials that the prototype distance counter instrument was affected by DBV cabin temperature and, in some cases, counted spuriously during DBV radio transmissions.

As a result of these data trends, the NASA standard instrument measurements for DBV brake application speed and stopping distance were deemed the most accurate, and are used exclusively in the data comparison to follow. Modifications are being made to the "prototype" system to eliminate sensitivity to temperature and radio interference effects. A modified unit will be compared to the NASA equipment during the forthcoming DC-9 test program.

3.7.2.2 The NASA developed correlation technique between aircraft and DBV requires that the DBV stopping distance ratio, wet/dry, be made on a 60-mph brake application speed base. This requirement necessitated normalizing the DBV stopping distances shown in tables VII and VIII to an equivalent 60-mph brake application speed. Since the stopping distance is known to be dependent upon the kinetic energy, which is a function of V^2, the correction equation to be used when the brake application speed differs from exactly 60 mph is

$$S_{60} = \frac{V_{60}^2}{V_{Test}^2} S_{Test}$$

where

S_{60} = DBV stopping distance from 60 mph, ft

S_{Test} = DBV test stopping distance, ft

V_{Test} = DBV test brake application speed, mph

V_{60} = correlation brake application speed = 60 mph

3.7.2.3 The friction coefficient developed by rubber sliding on runway or other pavement surfaces is affected by the initial rubber temperature at the start of sliding and the incremental rubber temperature increase in the rubber surface due to the skidding energy level developed in the slide. As a consequence of this effect of temperature on tire friction, the DBV stopping distances (diagonal wheels locked) on dry and wet pavements tend to increase with increasing rubber temperature and decrease with decreasing rubber temperature. It is most difficult to measure tire rubber temperature directly on a rolling or even sliding tire mounted on a moving vehicle. The ambient air temperature measured at time of test appears to correlate reasonably well with DBV dry stopping distance, and thus the ambient air temperature seems to be indicative of the tire rubber temperature at the start of vehicle braking (60 mph). In the Joint USAF-NASA Combat Traction Program (ref. 2), the DBV dry stopping distance tests were made on 40 different runway surfaces over a large range of ambient air temperatures. On the basis of these data, the following equation was developed in reference 2 to estimate DBV stopping distance at 60 mph brake application speed as a function of ambient air temperature

$$S_{Dry, 60} = 208 + 1.45\ T$$

where

$S_{Dry, 60}$ = DBV stopping distance, ft (60 mph brake application speed)

T = ambient air temperature, °F

Figure 26 shows the variation of the DBV dry stopping distance predicted by this equation and the DBV dry stopping distances obtained on the six runway surfaces of the present investigation with ambient air temperature. Since there was insufficient data from the B-727 tests to establish a trend over a wide range of temperatures, the procedure used to correct the DBV dry stopping distance for temperature was to draw lines through the available data points parallel to the line established in reference 2. This is shown in figure 26. The equivalent DBV dry stopping distance given in table IX for each wet test run was obtained from figure 26 for the ambient temperature at the time of the test run. Until more data are available showing trends to the contrary, it is felt that this procedure yields the most accurate DBV dry stopping distance for use in determining the DBV SDR (wet/dry stopping distance ratio).

3.7.2.4 As can be seen in table VIII, the DBV stopping distances as well as the Mu-Meter average friction readings vary considerably with the time of test following the wetting of the runway. These variations with time are due to vehicle activity or water drainage from the surface which reduces the effective water depth at the time of the test. Thus, for correlation between aircraft and the ground vehicle runway slipperiness measurements, the data must be time correlated with the aircraft data for any given aircraft test on a wet runway. The procedure employed in this paper for time-correlating the aircraft, ground vehicle, and runway water depth data is illustrated in figure 27.

3.7.2.5 In figure 27, the DBV stopping distance data obtained from table VIII for run 43 has been normalized to a 60-mph base using the equation shown in paragraph 3.7.2.2. These corrected stopping distance data were then plotted against the time from aircraft run data also obtained from table VIII. In this way, it becomes possible to obtain an interpolated value of DBV wet stopping distance at the time of aircraft run that reflects the same runway slipperiness condition as encountered by the aircraft. The sample DBV stopping distance measurements shown in figure 27 were those obtained for run 43 at Houston. The test surface at this airport did not have a uniform surface as shown in figure 19(b). For the first 650 feet of the test section length, the concrete surface was rubber coated from wheel spin-up during landings on runway 8L. This rubber coating when wet produced a more slippery surface than the remaining uncontaminated concrete surface of the test section. (Compare section A, rubber coated, and section B, uncontaminated, data in figure 27.) For comparison purposes, the DBV data obtained on that portion of the test section utilized by the aircraft during its stop were corrected in a proportioning equation to obtain the average DBV wet stopping distance for the time of aircraft run. For run 43 the following computation was used

$$S_{wet} = \frac{842 \times 650 + 731 \times 2810}{3460} = 752 \text{ feet}$$

where

S_{wet} = average DBV wet stopping distance time correlated to aircraft run, ft

842 = DBV stopping distance in section A at time 0 (time of aircraft test) from figure 27, ft

650 = length of rubber-coated surface in test section, ft

731 = DBV stopping distance in section D at time 0 (time of aircraft test) from figure 27, ft

2810 = length of uncontaminated surface in test section, ft

3460 = aircraft stopping distance from start of test section, ft (see table IX)

The average DBV wet stopping distance obtained by this technique for run 43 was 752 feet and this is the value noted in table IX. A similar data reduction technique was used for all DBV runs where the test section surface was not uniform in texture. For uniform test section surfaces, the DBV runs in different areas of the test section were given equal weight and arithmetically averaged to obtain an average wet stopping distance for the time of aircraft run and noted in table IX.

3.7.2.6 The DBV SDR (wet/dry stopping distance ratio) time correlated to each aircraft run was obtained by dividing the wet DBV stopping distance by the dry stopping distance listed in table IX for each wet aircraft test run.

3.7.3 Mu-Meter

3.7.3.1 The Mu-Meter was towed at constant speed (usually 40 mph) over the section of the runway to be measured. In addition to the test speed of 40 mph, some runs in this investigation were made with the Mu-Meter at speeds of 20 and 60 mph to obtain data on the effect of speed on Mu-Meter readings. Typical test records obtained with the Mu-Meter before and after aircraft run 43 at Houston are shown in figure 13. The Mu-Meter instrumentation included a remote mechanical integrator which automatically read out an average friction reading for the length of test section measured by the Mu-Meter on the runway. The integrator average friction reading obtained for each test run of the Mu-Meter is listed in table VIII. For most aircraft runs, the aircraft did not require the full runway test section length to come to a complete stop. Consequently, the Mu-Meter test records were analyzed only over the portion of the test section (see figure 13) in which the aircraft test occurred. In this manner, the average, maximum, and minimum friction readings of the Mu-Meter were obtained for the length of the runway test section associated with the aircraft test. These Mu-Meter average record friction readings for each test run are also listed in table VIII.

3.7.3.2 The Mu-Meter average record friction reading at 40 mph was time-correlated with aircraft test run 43 as shown in figure 27. In this figure, the Mu-Meter average record friction reading at 40 mph taken before and after the aircraft test run was plotted against time from aircraft run data obtained from table VIII. An interpolated Mu-Meter friction reading of 0.423 was obtained by this method as the Mu-Meter runway slipperiness indication at the time aircraft run 43 was made. All of the Mu-Meter test runs made at 40 mph test speed were analyzed in this manner and the time-correlated Mu-Meter average friction readings are listed in table IX.

3.7.3.3 For those Mu-Meter test runs made at speeds other than 40 mph, the time-correlated record average friction readings were plotted against test speed for each airport as shown in figure 28. With the aid of this figure, it was possible to obtain an interpolated record average friction reading value for an aircraft test run at an airport even though the Mu-Meter test speed for the particular aircraft run was not made at 40 mph. For example, the Mu-Meter test speeds before and after aircraft run 46 at Houston were made at 60 mph. From the Houston curve of figure 28, an interpolated friction reading of 0.430 was obtained at 40 mph test speed. This friction reading value is listed in table IX. This technique was followed for all other Mu-Meter runs in which the test speed was not 40 mph and the interpolated friction values listed in table IX.

3.7.4 Average Runway Test Section Water Depth

3.7.4.1 Water depth measurements were made beside each runway marker by the water depth measuring test crew in the aircraft left, nose, and main wheel tracks of the runway test section at three separate intervals during an aircraft test run sequence. These many individual water depth measurements were used to determine the average test section water depth values listed in table VI. These water depth values were plotted against the time from aircraft run data in table VI (see figure 27) so that an interpolated value of average test section water depth at time of aircraft run could be obtained. In figure 27, this technique yielded an average test section water depth of 0.019 at the time aircraft run 43 was made. This procedure was followed for each aircraft wet test run and the results obtained are listed in tables V and IX.

4.0 RESULTS AND DISCUSSION

4.1 All test results have been time-correlated to the time of the aircraft test as explained in paragraph 3.0 above. These results are presented in table IX for each test site by run number. The data contained in table IX and table VI were used, for the most part, in preparing the figures presented in this section.

4.2 NASA Wallops Station

4.2.1 Nine maximum braking stops were made at NASA Wallops Station on runway 10/28 in addition to nine calibration runs and 10 flooded test section tests. The flooded tests are not addressed in this paper, but will be analyzed at a later date. The water depth variation with time for runway 10/28 at Wallops is shown in figure 29(a). It can be seen that for all wet runs except run 12, the average water depth at the time of aircraft landing was 0.01 inch.

4.2.2 For run 12, the water depth at time of aircraft test was 0.019 inch. With this water depth condition, the airplane at a light weight of 99,500 pounds and a relatively high brake application speed of 117 knots, the two outboard wheels locked up six seconds after the brakes were applied. A total of 18 brake pressure application/release cycles were accomplished by the anti-skid system before full lockup occurred. The anti-skid system did not permit the outboard wheels to regain synchronous speed once they had spun down to a speed which caused brake pressure release. This is summarized in table XI. As a result of the wheel lockup, a large reverted rubber patch was generated on each of the outboard tires. Figure 30 shows the nature and size of the reverted rubber patch.

4.2.3 All of the data points obtained at Wallops for the aircraft, DBV, and Mu-Meter are shown in figure 29(a). It is readily apparent that the aircraft point for run 12 falls outside any correlation boundary. This seems obvious since a tire operating in the reverted rubber skidding mode can produce a much reduced friction coefficient compared to that produced by an efficiently operating anti-skid system. The effect of new tires on aircraft stopping distance ratio can also be seen in the figure. Figure 31 shows the actual time histories of the pertinent aircraft parameters for dry, wet (no wheel lockups) and wet (two wheels locked) conditions. The computed coefficient of friction values are also given in these figures. Examination of the coefficient of friction plots indicates, as stated above, that the friction developed in the case where wheel lockups occurred and reverted rubber skids were present is much lower than for the cases where no wheel lockups occurred. This phenomenon will be discussed further in 4.8.1 below.

4.3 Houston Intercontinental Airport

4.3.1 Four dry and six wet maximum braking stops were made at Houston Intercontinental Airport on runway 08L. The water depth variation with time for the six wet runs is shown in figure 29(b). Each run was faired separately to obtain the data shown in table IX. The average water depth varied from 0.016 inch to 0.028 inch at the time of aircraft test. Three of the wet stops experienced lockup of the two outboard wheels. These lockups occurred from 2.14 seconds to 3.82 seconds after brake application. Four to eight anti-skid system pressure application/release cycles occurred prior to lockup (see table XI). These lockups occurred over a wide weight and speed range and in water depths of 0.027 to 0.028 inch.

4.3.2 All of the data points obtained at Houston for the aircraft, DBV, and Mu-Meter are shown in figure 29(b). It is interesting to note that although the aircraft SDR obtained from run 41, which was conducted with worn tires, falls outside the correlation boundaries, the SDR's obtained from runs 46 and 47, which were conducted with new tires, falls within the correlation boundaries. Thus, even in the condition where two outboard wheels are locked and skidding, the inboard wheels, which are really generating the braking force, are much more effective with new tires than with worn tires. Figure 32 shows the actual time histories of the pertinent aircraft parameters for dry, wet (no wheel lockups) and wet (two wheels locked) conditions. The computed coefficient of friction values are also given in these figures. Figure 30 shows the nature and size of the reverted rubber skid patch developed during prolonged locked wheel skids at Houston.

4.4 Edwards AFB

4.4.1 Four dry and eight wet maximum braking runs were made at Edwards AFB on runway 04. In addition, two runs were made using normal reverse thrust on all three engines and maximum braking after touchding down in the wetted test section. The water depth variation with time for the wet runs is shown in figure 29(c). Each run was faired separately to obtain the data shown in table IX. The average water depth varied from 0.024 inch to 0.049 inch. For runs 50 and 53, one percent of organic foam was mixed with the water to obtain a water depth greater than that for water alone. Commencing with run 53A, a third water tanker was used to increase the amount of water discharged onto the runway. All wet stops except run 97 experienced either two- or four-wheel lockups. Table XI shows the time of wheel lockup after brake application and the number of anti-skid pressure/release cycles which occurred prior to lockup. In four instances, prolonged locked wheel skids generated reverted rubber in the tire footprint producing low aircraft decelerations which resulted in the aircraft exiting the wetted test section. For these four cases, a plot of the deceleration versus velocity was made down to the point where the airplane exited the test section. The trend of the curve at that point was extrapolated to zero velocity and the average deceleration was used to compute an incremental distance to stop which would have been realized if the wetted test section had been sufficiently long. The incremental distances used were as follows:

Run	(+)ΔS, ft
50	1111
53	1119
52	1067
56	173

The stopping distances for these runs shown in table IX include these incremental values.

4.4.2 All of the data points obtained at Edwards for the aircraft, DBV, and Mu-Meter are shown in figure 29(c). In all cases, the aircraft data fall outside of the correlation boundaries. This, again, is caused by the low friction realized as a result of wheel lockups and reverted rubber skidding. It is also evident in these data that the new tires effect a reduction in the aircraft SDR. Figure 33 shows the actual time histories of the pertinent aircraft parameters for dry, wet (two wheels locked), wet (four wheels locked), and wet (no wheels locked, reverse thrust applied and brake application speed = 94 knots). The computed coefficient of friction values are also given in these figures. For figure 33(d), the magnitude of the computed friction coefficient is higher than actual since the effect of reverse thrust was not included in the calculation. This effect will be considered in the final report.

4.5 Seattle-Tacoma International Airport

4.5.1 Three dry and five wet maximum braking runs were made at Sea-Tac on runway 16R. In addition, two runs were made using normal reverse thrust on all engines and maximum braking after touching down in the wetted test section. It is characteristic of the Sea-Tac grooved runway that in a matter of seconds after the water tankers passed a water depth measuring station there was no measurable depth of water on the runway. Thus, only a damp condition was available for test. This is reflected in all the data shown in figure 29(d) where the stopping distance ratios in the cases of the aircraft and DBV are very nearly 1.0 and the friction measurement taken by the Mu-Meter is but slightly less than for the dry condition. Figure 34 presents typical time histories of the pertinent aircraft parameters for the dry and wet (damp) surface conditions. The computed coefficient of friction values are also given in these figures. It is typical of some grooved runways that tire tread cutting (chevron cutting) is produced at the initial contact and spin-up of the aircraft tire. The runway at Sea-Tac produced such cutting as is shown in figure 30.

4.6 Lubbock Regional Airport

4.6.1 Four dry and seven wet maximum braking runs were made at Lubbock Regional Airport on runway 08L. In addition, two dry and two wet runs were made using normal reverse thrust on all three engines and maximum braking. On run 98 the brakes were applied gradually over a period of approximately five seconds rather than in an abrupt manner as in all the other maximum braking tests. This was done to assess the stopping distance associated with a normal airline stopping procedure. The water depth variation with time for the wet runs is included in figure 29(e). Each run was faired separately to obtain the data shown in table IX. The average water depth varied from 0.024 inch to 0.034 inch. Five of the wet runs experienced lockups of the two main outboard wheels. Table XI shows the time of wheel lockup after brake application and the number of anti-skid system pressure/release cycles which occurred prior to lockup. The smooth asphalt surface at Lubbock did not produce the type of reverted rubber skid patches on the main gear tires as produced at the other airports. While it is not fully understood at this point, one explanation is that this runway has no raised surface irregularities or macro structure, thus the mechanism for generating high temperature rubber reversion in the tire footprint from tire hysteresis effects was absent. Consequently, the wheels are thought to be experiencing a purely viscous hydroplaning phenomenon rather than a reverted rubber type of skid. Reference 3 describes the various types of hydroplaning phenomena.

4.6.2 All of the data points obtained at Lubbock are shown in figure 29(e). In all cases where wheel lockup occurred, the data points fall outside of the correlation boundaries. Once again, the effects of new tires can be seen. It is interesting to note that on this smooth asphalt surface the Mu-Meter predicts a more slippery surface than either the DBV or the aircraft. This phenomenon will be discussed in 4.8.3. Figure 35 presents actual time histories of the pertinent aircraft parameters for dry, wet (no wheels locked) and wet (two wheels locked). The computed coefficient of friction values are also given in these figures.

4.7 John F. Kennedy International Airport

4.7.1 Two dry and two wet maximum braking runs were made at JFK airport on runway 22L. Low visibility, instrument weather precluded making more runs at JFK since the test runway was the primary instrument landing runway. As in the case at Sea-Tac, the grooved runway at JFK, in general, showed no measurable water depth after wetting. However, the runway surface is not as smooth as that at Sea-Tac and isolated water puddles were in evidence after wetting had taken place. All the data points obtained at JFK are shown in figure 29(f). Only one Mu-Meter reading was taken on the wetted surface since the urgency of opening the runway to scheduled traffic after the last aircraft stop eliminated time for a Mu-Meter run. This same condition also precluded rewetting the runway for the second wet aircraft test. The two aircraft points obtained at JFK fall within the correlation boundaries. Figure 36 presents actual time histories of the pertinent aircraft parameters for dry and wet (damp) conditions. The computed coefficient of friction values are also shown in these figures.

4.8 Analysis of Results

4.8.1 The anti-skid braking system design used in these tests allowed wheel lockups to occur over a wide range of weights, brake application speeds, water depth and surface texture conditions. Because these wheel lockups produced reverted rubber skids, the deceleration realized by the airplane under these conditions was much less than if all wheels had been turning at some slip ratio less than one. To briefly study this problem, four runs were selected to determine the magnitude of coefficient of friction variation between dry, wet (all wheels rolling), and wet (four wheels locked) conditions. Runs 39, 40, 48, and 50 were investigated. Runs 39 and 48 are dry stops at Houston and Edwards, respectively. Figure 37 shows that the coefficient of friction produced by the airplane/anti-skid system/runway surface combination to be of comparable magnitude and shape over the speed range considered. Run 40 at Houston represents a wet, all wheels turning, case and shows a continuous increase in friction as the speed decreases which is an expected normal condition. Run 50 at Edwards exhibits the characteristic of very small changes in friction over the speed range experienced and confirms the low friction results obtained at NASA's Landing Loads Track during reverted rubber tests made in 1965 as shown in the upper portion of the figure (ref. 3). In both the laboratory and on the aircraft, it is seen that creation of reverted rubber appreciably reduces the friction available for stopping. Since neither the DBV or Mu-Meter generated reverted rubber under any of the conditions tested, it is concluded that there can be no correlation between either of these vehicles and the aircraft when the aircraft has either two or four wheels locked. For this reason correlation comparisons were made using only that aircraft data in which no wheel lockups occurred.

4.8.2 Figure 38 shows the comparison of the aircraft and DBV stopping distance ratios for the data points obtained without wheel lockup. The worn tire data generally fall inside the ±10 percent correlation boundaries. In three cases, one at Wallops, one at Lubbock, and one at Sea-Tac, the effect of new tires is to reduce the airplane SDR which means, in these cases, the DBV is predicting conditions conservatively, i.e., more slippery than the aircraft will experience. The data obtained at Sea-Tac show that the airplane always realizes a lower SDR than the DBV and, although the exact mechanism is not fully understood, it is believed that the higher pressure aircraft tires tend to "bite" into the grooves during braking thus realizing more friction than either the DBV or Mu-Meter. In the more slippery conditions, represented by SDR's greater than 1.8, the DBV is correlating within the ±10 percent boundary conditions for the worn aircraft tire condition. The number of data points is admittedly small and it is anticipated that the forthcoming DC-9 tests in February 1972 will add sufficient points to this figure to enhance confidence in the correlation now shown.

4.8.3 Figure 39 shows the aircraft SDR and the DBV SDR plotted against Mu-Meter friction reading at 40 mph. The scatter in the aircraft data led to the plot of the DBV/Mu-Meter data in an attempt to understand the trend indicated in the aircraft SDR/Mu-Meter plot. When all data except Lubbock are considered in the DBV/Mu-Meter plot, there appears to be reasonable correlation as shown by the line extending from a Mu-Meter reading of 0.85 and DBV SDR = 1.0 to a Mu-Meter/DBV SDR value of 0.38/2.4. It would appear that for more slippery surfaces, the line should be extended as indicated by the dashed portion. However, when only the Lubbock data are considered, a completely different slope to the correlation line appears logical and when the data are combined a Mu-Meter value of 0.49 is determined, below which the Mu-Meter may or may not predict the airplane/DBV performance depending on the type of surface texture and/or water depth that may be encountered. Note that the lines faired through the aircraft data differ slightly from those of the DBV/Mu-Meter plot. The differences are justified by the slight difference in the actual data. Although it is not exactly clear why the Mu-Meter shows the Lubbock surface to be more slippery than either the aircraft or DBV, it is hypothesized that the low, 10 psi, pressure tires on the Mu-Meter may actually be experiencing hydroplaning on the smooth surface even though the water depth was only 0.030 inch. This phenomenon deserves further evaluation which will be done during the forthcoming DC-9 test program in February 1972.

4.8.4 One other approach was used to compare the aircraft and the ground vehicles. Data from table IX were used to obtain a runway slipperiness ranking based on the average SDR values of the airplane with worn tires (no wheel lockups), the average of the DBV SDR's and the average of the wet Mu-Meter friction readings. This comparison is shown in table XII on page 21. It can be seen that, with the exception of Edwards AFB where no valid aircraft data were available, the aircraft and DBV rate the runways in the same order whereas the Mu-Meter rates Lubbock as being more slippery than either Edwards or Houston.

Table XII.- Slipperiness ranking of runways.

Runway	Airplane Ranking	Airplane SDR**	DBV Ranking	DBV SDR**	Mu-Meter Ranking	Mu-Meter μ**
Sea-Tac	1	1.102	1	1.280	1	0.748
Wallops	2	1.353	2	1.428	2	0.710
JFK	3	1.583	3	1.630	3	0.552
Lubbock	4	2.007	4	2.164	6	0.339
Edwards	*	*	5	2.234	5	0.424
Houston	-	2.230	6	2.374	4	0.442

*No value available. All aircraft wet runs had locked wheels.
**Average of all valid points.

4.8.5 To gain some insight into the meaning of the water depths realized from the artificial wetting used in these tests, figure 40 is presented. This figure shows some meager data obtained at two airports under varying intensities of natural rain. The five data points, by no means conclusive, do indicate a trend of water depth as a function of rain rate under actual conditions. From these data it is seen that it only takes a rain rate of approximately 0.1 to 0.2 inch per hour on these runways to produce a water depth of 0.03 inch. The important conclusion that may be drawn at this point is that for the type of anti-skid system used on the B-727 aircraft only a small rain rate is required to create conditions under which wheel lockup is liable to occur when maximum brakes are applied at normal landing speeds on typical ungrooved asphalt and concrete runways.

5.0 REFERENCES

5.1 Anon.: Pavement Grooving and Traction Studies, NASA SP-5073, 1969.

5.2 Yager, Thomas J.; Phillips, W. Pelham; Horne, Walter B.; and Sparks, Howard C. (With Appendix D by R. W. Sugg): A Comparison of Aircraft and Ground Vehicle Stopping Performance on Dry, wet, Flooded, Slush-, Snow-, and Ice-Covered Runways. NASA TN D-6098, 1970.

5.3 Horne, Walter B.; Yager, Thomas J.; and Taylor, Glenn R.: Review of Causes and Alleviation of Low Tire Traction on Wet Runways. NASA TN D-4406, 1968.

Table I.- B-727 aircraft stopping distance instrumentation.

Variable	Instrument	Recorder: Oscillograph 1/2 in./sec	Recorder: Tape 7 -1/2 in./sec
Ground Speed (also displayed to pilot)	Nose Wheel Antiskid Detector	X	X
Stopping Distance (also displayed by rev. counter in cockpit)	Nose Wheel Revolution Pulses (2/rev)		X
Main Gear Wheel Speed (each wheel)	Main Gear Wheel Antiskid Detectors	X	X
Engine rpm (No. 1 and No. 2 engines)	Tachometer	X	X
Brake Pedal Position (left and right)	Linear Potentiometers	X	X
Brake Pressure (each main gear wheel)	Pressure Transducers	X	X
Antiskid Valve Position (each main gear wheel)	Voltage Applied to Valve Solenoid	X	
Longitudinal, Lateral, and Vertical Accelerations at c.g.	Accelerometers	X	X
Aircraft Heading	Yaw Attitude Gyro	X (± 360°)	X (± 15°)
Aircraft Pitch Attitude	Pitch (free gyro)	X	X
	Pitch (vertical gyro)	X	X
Spoiler Position	Linear Potentiometer	X	X
Event Marker		X	X
Time Correlation		X	X
Distance on Runway	Boeing Phototheodolite	35 mm film camera, 10 frames/sec (Time correlated with NASA recorders)	

Table II.- Oscillograph system accuracy list.

Measurement	Nominal Range	Frequency Response	Accuracy	Remarks
3-Axis Acceleration G.G. (3)	± 1 G	6 cps	± .01 G	
2-Axis Acceleration Cabin (2)	± 1 G	12 cps	±.01 G	
Pitch Angle Relative (1)	± 20°	5 cps	±0.4°	Accuracy is for 30-second data period with gyro drifts
Yaw Angle Relative (1)	± 178°	5 cps	±2.3°	Accuracy is for 30-second data period with gyro drifts
Pitch Angle Vertical (1)	± 15°	5 cps	±2.0°	Accuracy is for 30-second data period with gyro drifts
Engine RPM #1 & #2 (2)	40 - 110%	5 cps	±1.4%	
Brake Pedal Position (2)	Full Scale	5 cps	±1.4%	Percent full scale
Spoiler Handle Position (1)	Full Scale	5 cps	±1.4%	Percent full scale
Brake Pressure (4)	0 - 3000 psi	60 cps	±40 psi	Frequency response excludes pressure tubing
Ground Speed (1)	20 - 150 Kts	5 cps	±1.5 Kts	
Anti-Skid Valve Voltage (4)	0 - 10 Volts	60 cps	±0.1 Volt	Accuracy excluding anti-skid box and sensor
Main Wheel Velocities (4)	20 - 0 Volts	60 cps	±0.2 Volts	Accuracy excluding anti-skid box and sensor
Events (1)	Full Scale	600 cps	———	Excluding operator
Time	999 second	———	±1 part in 3000	Has 0.1 sec. pulses

Table III.- Magnetic tape recording system accuracy list.

Measurement	Nominal Range	Frequency Response	Accuracy	Remarks
3-Axis Accelerometer C.G. (3)	± 1 G	40 cps	±.014 G	
2-Axis Accelerometer Cabin (2)	± 1 G	40 cps	±.014 G	
Pitch Angle Relative (1)	± 15°	5 cps	±0.4°	Accuracy is for 30-second data period with gyro drifts
Yaw Angle Relative (1)	± 15°	5 cps	±0.4°	Accuracy is for 30-second data period with gyro drifts
Pitch Angle Vertical	± 15°	5 cps	±2.0°	Accuracy is for 30-second data period with gyro drifts
Engine RPM #1 & #2 (2)	0 - 110%	5 cps	±1.6%	
Brake Pedal Position (2)	Full Scale	5 cps	±1.5%	Percent full scale
Spoiler Handle Position (1)	Full Scale	5 cps	±1.5%	Percent full scale
Brake Pressure Outboard (2)	0 - 3000 psi	100 cps	±48 psi	Frequency response excludes pressure tubing
Wheel Velocity Outboard	0 - 20 Volts	100 cps	±0.3 Volts	Accuracy excludes 727 Anti-Skid Control box and sensor
Nose Wheel Revolution Pulses (stopping distance)	2 pulses/rev	———	±1 pulse	
Ground Speed (1)	20 - 150 kts	5 cps	±2.2 kts	
Events (1)	Full Scale	100 cps		Excluding operator
Timer	999 second	———	±1 part in 10^6	Has 0.001 sec. pulses

Table IV.- NASA diagonal-braked vehicle (DBV) instrumentation.

NO	VARIABLE	INSTRUMENT	VISUAL DISPLAY	RECORDER (6-CHANNEL)
1	Ground speed	DC generator (5th wheel)		X
2	Brake application speed	Magnetic actuated reed switch coupled with crystal controlled timer (5th wheel) and hold circuit (items 2 and 3)	Digital (1 mph units)	
3	Stopping distance (from brake application)		Digital (1 foot units)	
4	Brake application speed	DC generator (5th wheel) and hold circuit	Digital (0.1 mph units)	
5	Stopping distance (from brake application)	Magnetic pick-up (5th wheel) & hold circuit	Digital (1 foot units)	
6	Stopping distance (from brake application)	Revolution counter (5th wheel) & hold circuit	Digital (1 count/rev.)	
7	Main wheel speed (each wheel)	DC generators		X
8	Longitudinal acceleration (approx. c.g.)	Accelerometer		X
9	Brake application	Brake pedal micro-switch	X	X (Event channel)
10	Timer	Crystal oscillator		X

Table V.- Basic aircraft, atmospheric, and ground data for full stop aircraft runs.

(a) NASA Wallops Station. Date: 10/4-6/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL)		STOPPING DISTANCE, FT		FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F		RELATIVE HUMIDITY, %	WIND		BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING		TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
		BRAKE ON	BRAKE OFF	GROUND VISUAL	NOSE WHEEL CTR.							DRY BULB	WET BULB		VEL., KNOTS	HEAD., DEG.			TIME TO WET, MIN	GALLONS OF WATER USED		
10	1549	96	0	1039	1112	19 000	32.4	113 500	Worn	40	10	72	66	70	6	090	30.01	Dry	—	—	3000	90
11	1607	108	0	1284	1383	15 000	33.2	109 500	Worn	30	10	72	66	70	1	080	30.02	Dry	—	—	3000	90
13	0804	110	0	1678	1772	9000	34.5	103 500	Worn	30	10	65	64	96	Calm	—	30.02	0.010	11	5500	3000	73
12	0850	114	0	2269	2496	5000	34.9	99 500	Worn	40	10	68	67	96	1	200	30.03	0.019	11	5500	3000	79
21A	1227	110	0	2080	2196	42 000	28.8	136 500	Worn	30	10	72.5	68	85	6	180	30.02	0.010	9	5500	3000	85
18	1252	120	0	2268	2374	38 000	30.6	132 500	Worn	40	10	73	69	85	9.5	190	30.00	0.010	8	5500	3000	85
14	1600	118	0	1672	1734	42 000	28.8	136 500	Worn	30	10	76	70	76	5	190	29.94	Dry	—	—	3000	91
17	1629	122	0	1618	1726	37 000	31.2	131 500	Worn	40	10	75	70	78	3	195	29.94	Dry	—	—	3000	90
30*	0816	78	0	811	873	46 000	26.5	142 000	New	40	28	69.5	68	98	7	260	29.80	Damp	Natural Rain		3000	78

*Run 30 was accelerate-stop test

Table V.- Continued.

(b) Houston Intercontinental Airport. Date: 10/7/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL) BRAKE ON	BRAKE OFF	STOPPING DISTANCE, FT GROUND VISUAL	NOSE WHEEL CTR.	FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F DRY BULB	WET BULB	RELATIVE HUMIDITY, %	WIND VEL., KNOTS	WIND HEAD., DEG.	BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING TIME TO WET, MIN	GALLONS OF WATER USED	TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
38	0905	103	0	1132	1205	27 000	31.2	121 500	Worn	40	08L	73	64.5	61	4	010	29.99	Dry	——	——	4000	84
39	0930	103	0	1050	1142	23 200	31.6	117 700	Worn	40	08L	75	66	60	4	030	30.00	Dry	——	——	4000	86
40	0950	100	0	2720	2781	19 000	32.4	113 500	Worn	40	08L	74.5	76.5	61	2	030	30.00	0.022	12	6000	3000	88
41	1023	99	0	3090	3168	14 000	33.4	108 500	Worn	40	08L	79	68.5	56	4	020	30.01	0.027	13	7000	4000	94
42	1242	107.5	0	2844	2963	46 200	27.3	140 500	Worn	40	08L	86	71	35	6	080	30.00	0.016	9	7000	4000	102
43	1316	111	0	3369	3448	39 000	29.3	133 500	Worn	40	08L	88	71	33	3	080	29.99	0.019	14	8000	5000	106
44	1530	116.5	0	1653	1770	46 000	27.3	140 500	New	40	08L	89	68	32	4	110	29.95	Dry	——	——	4000	112
45	1549	125	0	1625	1825	42 500	28.6	137 000	New	40	08L	90.5	69.5	32	4	110	29.94	Dry	——	——	4000	116
46	1707	120.5	0	4148	4210	44 000	28.0	138 500	New	40	08L	91	67	30	6	100	29.93	0.027	8	8000	4000	105
47	1740	115	0	3779	3820	36 500	31.3	131 000	New	40	08L	88	68	35	3	130	29.93	0.028	11	8000	4000	101

Table V.- Continued.

(c) Edwards AFB. Date: 10/9/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL)		STOPPING DISTANCE, FT		FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F		RELATIVE HUMIDITY, %	WIND		BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING		TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
		BRAKE ON	BRAKE OFF	GROUND VISUAL	NOSE WHEEL CTR.							DRY BULB	WET BULB		VEL., KNOTS	HEAD., DEG.			TIME TO WET, MIN	GALLONS OF WATER USED		
48	0751	108	0	1255	1360	25 100	31.5	119 000	Worn	40	04	57.5	46.5	35	Calm	—	27.67	Dry	—	—	5000	75
49	0809	120.5	0	1322	1544	21 100	32	115 000	Worn	30	04	60	47.5	35	Calm	—	27.69	Dry	—	—	5000	78
50	0829	110	43	3936	4005	18 100	32.6	112 000	Worn	40	04	62.5	47	30	3.5	030	27.70	0.049	9	1% Foam 7000	4000	74
50A	0902	91	0	3342	3330	13 100	33.7	107 000	Worn	40	04	62.5	47	30	Calm	—	27.71	0.046	6	8000	5000	79
51	0924	96	0	3780	3930	9 000	34.7	102 900	Worn	30	04	66.5	50	28	1	020	27.71	0.040	6	8000	5000	83
53	1058	131	54	5445	—	46 000	28.0	139 000	Worn	30	04	82.5	59.5	25	Calm	—	27.71	0.024	6	1% Foam 8000	5000	97
52	1132	119	46	5439	5534	39 600	30.2	133 500	Worn	40	04	86	60	19	Calm	—	27.71	0.032	11	9000	5500	104
53A	1203	123	0	5514	5556	33 300	31.2	127 200	Worn	30	04	86	62	21	Calm	—	27.71	0.048	11	13 000	6000	104
96	1236	—	—	3424	2706	27 100	31.3	121 000	Worn	40	04	91	63	17	3	035	27.72	0.034	12	13 000	6000	105
54	1519	136.5	0	2005	2133	44 100	28.3	138 000	New	30	04	106	70	15	5	080	27.63	Dry	—	—	5000	112
55	1546	128.5	0	1678	1789	40 000	30.0	133 900	New	40	04	106	68	12	3	065	27.63	Dry	—	—	5000	119
56	1652	134.0	28	—	5980	45 100	28.0	139 000	New	30	04	108	66	9	2	005	27.62	0.030	12	13 000	6000	100
57	1722	127	0	5149	5190	39 100	30.4	133 000	New	40	04	97	66	18	2	240	27.60	0.032	11	13 000	6000	100
97	1751	—	—	1505	—	34 600	31.2	128 500	New	40	04	92	64	19	3	280	27.60	0.028	10	13 000	6000	92

Table V.– Continued.

(d) Seattle–Tacoma International Airport. Date: 10/11–12/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL) BRAKE ON	GROUND SPEED, KNOTS (NOSE WHEEL) BRAKE OFF	STOPPING DISTANCE, FT GROUND VISUAL	STOPPING DISTANCE, FT NOSE WHEEL CTR.	FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F DRY BULB	AMBIENT AIR TEMPERATURE, °F WET BULB	RELATIVE HUMIDITY, %	WIND VEL., KNOTS	WIND HEAD., DEG.	BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING TIME TO WET, MIN	ARTIFICIAL WETTING GALLONS OF WATER USED	TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
58	0905	102	0	748	861	23 800	28.0	119 500	Worn	40	16R	56	55	80	1.5	165	29.79	Dry	——	——	3000	65
1*	0930			848	——				Worn	40	16R	58	55.5	80	2	200	——	Dry	——	——	3000	67
59A	0939	100	0	869	1015	16 800	28.8	112 500	Worn	40	16R	58	56	80	3	170	29.79	Dry	——	——	3000	67
2*	1059			963	——				Worn	40	16R	59.5	56.5	90	5.5	095	——	Damp	6	5000	3000	69
3*	1232			1330	——				Worn	40	16R	58	55	80	3	175	——	Damp	6	6000	3000	69
64	1422	107	0	1400	1537	42 200	26.1	138 000	Worn	40	16R	64	59	78	3	220	29.85	Damp	7	8000	3000	85
65	1447	115	0	1528	1679	38 000	27.8	133 800	Worn	40	16R	60.5	57	80	1.5	230	29.85	Damp	6	8000	3000	74
66	1509	114	0	——	1414	33 800	28.3	129 500	Worn	40	16R	62	58	90	2	080	29.85	Damp	5	8000	3000	73
61	1529	98.5	0	1128	1232	30 300	27.8	126 000	Worn	40	16R	72	66	75	Calm		29.85	Damp	6	8000	3000	80
62	1559	106	0	1236	1390	24 100	28.0	119 800	Worn	40	16R	75	64	59	3	050	29.82	Damp	6	8000	3000	80
63	1620	112	0	——	1548	20 100	28.4	115 800	Worn	40	16R	65	59	75	2	035	29.82	Damp	6	8000	3000	80
67	0825	101	0	1166	1280	41 200	26.3	137 500	New	40	16R	50	——	——	3	315	29.79	Dry	——	——	3000	58
71	0845	118	0	1598	1730	37 100	27.8	133 600	New	40	16R	50	——	——	2	310	29.79	Damp	6	8000	3000	58

*B-737 aircraft

Table V.- Continued.

(e) Lubbock Regional Airport. Date: 10/12/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL) BRAKE ON	GROUND SPEED, KNOTS (NOSE WHEEL) BRAKE OFF	STOPPING DISTANCE, FT GROUND VISUAL	STOPPING DISTANCE, FT NOSE WHEEL CTR.	FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F DRY BULB	AMBIENT AIR TEMPERATURE, °F WET BULB	RELATIVE HUMIDITY, %	WIND VEL., KNOTS	WIND HEAD., DEG.	BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING TIME TO WET, MIN	ARTIFICIAL WETTING GALLONS OF WATER USED	TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
72	0824	123.5	0	1524	1687	25 000	27.6	122 000	Worn	40	08L	51.5	45	62	8	020	26.77	Dry	—	—	4000	62
73	0846	123.5	0	1452	1639	20 800	28.0	117 200	Worn	40	08L	51.0	45	62	9	000	26.77	Dry	—	—	4000	60
74	0905	109.5	0	644	1027	15 800	28.7	112 200	Worn	40	08L	51.5	45	62	8	015	26.79	Dry	—	—	4000	60
78	1100	120.0	0	3765	3855	39 700	26.6	136 100	Worn	40	08L	62.5	51	51	8	075	26.83	0.032	7	8000	5000	76
79	1131	123.0	0	4291	4361	34 000	27.8	130 000	Worn	40	08L	65	—	—	6	075	26.83	0.031	7	8000	5000	78
80	1200	112	0	1740	1924	28 200	27.5	124 200	Worn	40	08L	66	—	—	6	075	26.82	0.034	7	8000	5000	80
75	1231	112	0	3161	3239	23 400	27.7	119 400	Worn	40	08L	68	53	35	5	080	26.82	0.033	7	8000	5000	82
76	1301	113	0	3304	3369	18 000	28.5	114 000	Worn	40	08L	68	54	37	5	070	26.81	0.026	7	8000	5000	88
77	1332	103	0	1556	1659	13 500	29.2	109 500	Worn	40	08L	70	55	38	4	045	26.79	0.024	8	8000	5000	85
81	1534	131	0	—	2169	37 600	27.6	133 600	New	40	08L	73.5	57.5	35	4	030	26.73	Dry	—	—	4000	102
82	1554	123.5	0	1487	1687	34 000	27.8	130 000	New	40	08L	74.5	57	37	6	070	26.71	Dry	—	—	4000	102
83	1610	116.5	0	1703	1833	30 500	27.5	126 500	New	40	08L	75	58	38	7	110	26.71	Dry	—	—	4000	102
84	1652	133	0	4045	4092	41 000	26.4	137 000	New	40	08L	73	56.5	30	4.5	160	26.70	0.031	9	8000	5000	94
85	1718	126	0	3245	3464	35 800	28.0	131 800	New	40	08L	72	58	40	5	140	26.69	0.033	7	8000	5000	92
98	1750	118	0	3290	3192	30 000	27.5	126 000	New	40	08L	72	57	38	1	110	26.68	0.030	7	8000	5000	87

Table V.— Concluded.

(f) J.F.K. International Airport. Date: 10/15/71

AIRCRAFT RUN NO.	TIME OF TEST HR-MIN	AIRCRAFT CONDITIONS: GROUND SPEED, KNOTS (NOSE WHEEL)		STOPPING DISTANCE, FT		FUEL LOAD, LB	C.G. % MAC	GROSS WEIGHT, LB	MAIN GEAR TIRES	FLAP ANGLE, DEG.	TEST R/W	ATMOSPHERIC CONDITIONS: AMBIENT AIR TEMPERATURE, °F		RELATIVE HUMIDITY, %	WIND		BAROMETRIC PRESSURE, IN./Hg	RUNWAY CONDITION: WETNESS OR WATER DEPTH, IN.	ARTIFICIAL WETTING		TEST SURFACE LENGTH, FT	SURFACE TEMP., °F
		BRAKE ON	BRAKE OFF	GROUND VISUAL	NOSE WHEEL CTR.							DRY BULB	WET BULB		VEL., KNOTS	HEAD., DEG.			TIME TO WET, MIN	GALLONS OF WATER USED		
86	1424	101	0	1080	1185	24 000	27.6	120 000	Worn	40	22L	72	66	78	7	210	30.13	Dry	——	——	3000	90
87	1443	112	0	1298	1418	20 600	28.1	116 600	Worn	30	22L	73	67	74	6	200	30.13	Dry	——	——	3000	89
88	1504	105.5	0	1814	1908	16 300	28.7	112 300	Worn	40	22L	73	67	74	7	180	30.16	Damp	7	5000	3000	84
89	1515	105.5	0	1582	1679	14 800	29.0	110 800	Worn	30	22L	73	67	74	6	190	30.16	Damp	——	——	3000	84

Table VI.- Runway test section average water depth for full stop aircraft tests (based on average water depth measurements taken beside the left main, nose, and right main aircraft wheel tracks in runway test section).

AIRPORT	AIRCRAFT RUN NO.	AIRCRAFT TIME OF TEST (LOCAL)	WATER DEPTH MEASUREMENT TIME LOCAL	WATER DEPTH MEASUREMENT TIME RELATIVE TO A/C TEST, MIN	AVERAGE WATER DEPTH, IN.
WALLOPS	13	0804	0755	-9	0.033
			0806	+2	0.005
	12	0851	0846	-5	0.026
			0852	+1	0.018
			0854	+3	0.008
	21A	1227	1218	-9	0.034
			1229	+2	0.005
			1232	+5	0.005
	18	1252	1244	-8	0.030
			1254	+2	0.005
			1257	+5	0.005
HOUSTON	40	0950	0946	-4	0.035
			0952	+2	0.016
			0956	+6	0.010
	41	1023	1018	-5	0.044
			1025	+2	0.021
			1028	+5	0.009
	42	1242	1237	-5	0.028
			1244	+2	0.012
			1248	+6	0.007
	43	1316	1312	-4	0.036
			1318	+2	0.010
			1322	+6	0.009
	46	1707	1705	-2	0.033
			1709	+2	0.021
			1712	+5	0.013
	47	1740	1738	-2	0.035
			1743	+3	0.018
			1745	+5	0.009
EDWARDS	50	0829	0826	-3	0.057
			0831	+2	0.045
			0835	+6	0.042
	50A	0902	0858	-4	0.055
			0904	+2	0.042
			0906	+4	0.031
EDWARDS	51	0924	0921	-3	0.051
			0927	+3	0.029
			0930	+6	0.017
	53	1058	1055	-3	0.035
			1100	+2	0.017
			1103	+5	0.010
	52	1132	1129	-3	0.047
			1134	+2	0.024
			1136	+4	0.025
	53A	1203	1201	-2	0.054
			1206	+3	0.037
			1207	+6	0.012
	96	1236	1234	-2	0.041
			1239	+3	0.025
			1243	+7	0.016
	56	1652	1650	-2	0.039
			1654	+2	0.023
			1657	+5	0.015
	57	1722	1720	-2	0.041
			1725	+3	0.021
			1727	+5	0.015
	97	1751	1749	-2	0.036
			1753	+2	0.022
			1756	+5	0.016
SEA-TAC	2*	1059	-GROOVED RUNWAY- NO MEASURABLE WATER DEPTH -SURFACE DAMP-		
	3*	1232			
	64	1422			
	65	1447			
	66	1509			
	61	1529			
	62	1559			
	63	1620			
	71	0845			
LUBBOCK	78	1100	1057	-3	0.055
			1101	+1	0.025
			1107	+7	0.017
	79	1131	1127	-4	0.055
			1132	+1	0.025
			1134	+3	0.015
	80	1200	1157	-3	0.055
			1201	+1	0.026
			1204	+3	0.013
	75	1231	1228	-3	0.061
			1232	+1	0.028
			1235	+4	0.020
	76	1301	1258	-3	0.047
			1302	+1	0.020
			1304	+3	0.011
	77	1332	1329	-3	0.046
			1333	+1	0.018
			1335	+3	0.009
	84	1652	1649	-3	0.047
			1653	+1	0.026
			1655	+3	0.017
	85	1718	1716	-2	0.050
			1719	+1	0.021
			1721	+3	0.018
	98	1750	1747	-3	0.045
			1751	+1	0.026
			1754	+4	0.011
JFK	88	1504	GROOVED RUNWAY NO MEASURABLE WATER DEPTH SURFACE DAMP WITH SOME ISOLATED PUDDLES		
	89	1515			

*B-737 AIRCRAFT TEST

Table VII.- Basic DBV and Mu-Meter dry surface data for full stop aircraft tests.

AIRPORT	DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TEST SECTION AREA COVERED	TEMPERATURE, °F		NASA DBV				MU-METER				
								STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
													INTEGRATED AVERAGE	RECORD		
						AMBIENT AIR	RUNWAY SURFACE	BRAKING SPEED, MPH	STOPPING DIST., FT	BRAKING SPEED, MPH	STOPPING DIST., FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
Wallops	9/29/71	DBV	3	1032	A	68	86	60.2	294	60	323					
"	9/29/71	DBV	4	1100	C	68	86	60.5	304	—	317					
"	10/1/71	MU-M	13	Morning	A-G	—	—					60	0.80	0.79	0.79	0.78
"	"	"	14	"	G-A	—	—					60	0.81	0.80	0.81	0.78
"	"	"	15	"	A-G	—	—					40	0.80	0.81	0.82	0.81
"	"	"	16	"	G-A	—	—					40	0.81	0.81	0.82	0.79
"	"	"	17	"	A-G	—	—					20	0.82	0.82	0.83	0.82
"	"	"	18	"	G-A	—	—					20	0.82	0.82	0.83	0.81
"	10/4/71	"	1	1555	A-G	72	90					40	0.80	0.78	0.79	0.77
"	"	DBV	1	1555	A	72	90	60.4	297	61	333					
"	"	MU-M	2	1556	G-A	72	90					40	0.81	0.80	0.81	0.79
"	"	DBV	2	1558	B	72	90	60.2	290	59	296					
"	"	MU-M	3	1559	A-G	72	90					20	0.85	0.83	0.85	0.82
"	"	MU-M	4	1600	G-A	72	90					20	0.84	0.84	0.85	0.84
"	"	DBV	3	1601	C	72	90	60.1	301	60	303					
"	"	MU-M	5	1602	A-G	72	90					60	0.82	0.81	0.83	0.80
"	"	MU-M	6	1604	G-A	72	90					60	0.85	0.84	0.86	0.83
"	10/5/71	DBV	23	1607	A	76	91	60.1	304	59	314					
"	"	DBV	23A	1608	D	76	91	60.6	309	60	318					
"	"	MU-M	38	1609	A-G	76	91					40	0.84	0.84	0.85	0.83
Houston	10/7/71	DBV	1	0833	A	67	80	60.3	303	60	312					
"	"	DBV	1A	0834	C	67	80	60.6	302	60	316					
"	"	MU-M	1	0845	A-G	67	80					40	0.84	0.82	0.83	0.80
"	"	MU-M	2	0855	G-A	67	80					40	0.83	0.82	0.83	0.81
Edwards	10/9/71	MU-M	1	0755	A-G	57.5	75					40	0.78	0.79	0.81	0.77
"	"	DBV	1	0755	A	57.5	75	59.3	338	60	343					
"	"	DBV	1A	0756	C	57.5	75	59.7	326	60	331					
"	"	MU-M	2	0816	A-G	60	78					40	0.83	0.82	0.83	0.79
"	"	MU-M	17	1640	A-G	106	119					40	0.86	0.85	0.86	0.80

Table VII.- Concluded.

AIRPORT	DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TEST SECTION AREA COVERED	TEMPERATURE, °F: AMBIENT AIR	TEMPERATURE, °F: RUNWAY SURFACE	NASA DBV: STANDARD INSTRUMENTS: BRAKING SPEED, MPH	NASA DBV: STANDARD INSTRUMENTS: STOPPING DIST., FT	NASA DBV: PROTOTYPE INSTRUMENTS: BRAKING SPEED, MPH	NASA DBV: PROTOTYPE INSTRUMENTS: STOPPING DIST., FT	MU-METER: TEST SPEED, MPH	MU-METER: FRICTION READING: INTEGRATED AVERAGE	MU-METER: FRICTION READING: RECORD: AVERAGE VALUE	MU-METER: FRICTION READING: RECORD: MAXIMUM VALUE	MU-METER: FRICTION READING: RECORD: MINIMUM VALUE
SEA-TAC	10/11/71	DBV	1	0907	A	56	65	60.3	327	60	328					
"	"	DBV	1A	0908	D	56	65	59.8	321		333					
"	"	MU-M	1	0910	A-G	56	65					40	0.77	0.77	0.80	0.75
"	"	MU-M	2	0912	A-G	56	65					40	0.77	0.77	0.78	0.75
"	"	MU-M	3	0914	G-A	56	65					40	0.77	0.76	0.78	0.74
"	"	DBV	18	1630	G	65	80	60.2	331	60	332					
"	"	DBV	19	1636	G	65	80	59.7	326	59	370					
Lubbock	10/13/71	DBV	1	0818	A	51.5	62	60.0	299	59	337					
"	"	DBV	1A	0819	D	51.5	62	60.2	304	—	321					
"	"	MU-M	1	0818	A-G	51.5	62					40	0.81	0.80	0.83	0.77
"	"	MU-M	2	0828	A-G	51.5	62					40	0.81	0.80	0.81	0.77
"	"	MU-M	16	1541	A-G	73.5	102					40	0.81	0.81	0.83	0.79
"	"	DBV	15	1542	A	73.5	102	60.3	313	60	328					
"	"	DBV	15A	1543	D	73.5	102	59.4	315	58	317					
"	"	MU-M	17	1548	A-G	73.5	102					40	0.82	0.82	0.83	0.80
JFK	10/15/71	DBV	1	1400	A	72	90	58	298	59	385					
"	"	DBV	1A	1401	E	72	90	58	290	59	300					
"	"	MU-M	1	1407	A-G	72	90					40	0.85	0.83	0.85	0.78
"	"	MU-M	2	1430	A-G	72	90					40	0.83	0.83	0.85	0.72

Table VIII.- Basic DBV and Mu-Meter wet surface data for full stop aircraft tests.

(a) Airport: NASA Wallops Station.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/5/71	MU-M	5	0759	-5	A-G					40	0.67	0.67	0.77	0.50
	DBV	6	0759	-5	A	60.0	410	59	412					
	DBV	6A	0800	-4	C	60.1	398	60	400					
	B-727	13	0804	0	A-D+									
	MU-M	6	0806	+2	A-G					40	0.79	0.77	0.80	0.58
	DBV	7	0806	+2	A	59.9	397	59	397					
	DBV	7A	0807	+3	C	60.2	387	60	390					
	MU-M	7	0810	+6	A-G					40	0.79	0.79	0.82	0.58
	DBV	8	0810	+6	B	59.9	418	59	418					
	DBV	8A	0811	+7	D	60.4	381	60	387					
	MU-M	8	0813	+9	A-G					40	0.82	0.80	0.83	0.58
	DBV	9	0815	+11	C	59.8	367	59	370					
	DBV	9A	0816	+12	E	60.7	394	60	404					
	MU-M	9	0820	+16	A-G					40	0.79	0.79	0.83	0.62
	DBV	10	0821	+17	F	59.4	380	59	387					
	MU-M	10	0848	-3	A-G					40	0.62	0.62	0.71	0.28
	DBV	11	0848	-3	A	59.7	485	60	490					
	DBV	11A	0849	-2	C	60.7	479	60	482					
	B-727	12	0851	0	A-E+									
	MU-M	11	0853	+2	A-G					40	0.68	0.67	0.76	0.53
	DBV	12	0853	+2	B	60.2	416	60	425					
	DBV	12A	0854	+3	D	60.4	438	60	440					
	MU-M	12	0855	+4	A-G					40	0.78	0.77	0.82	0.59
	DBV	13	0855	+4	C	60.4	430	61	434					
	DBV	13A	0856	+5	F	60.0	401	60	409					

Table VIII.- Continued.

(a) Airport: NASA Wallops Station.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV STANDARD INSTRUMENTS BRAKING SPEED, MPH	NASA DBV STANDARD INSTRUMENTS STOPPING DIST, FT	NASA DBV PROTOTYPE INSTRUMENTS BRAKING SPEED, MPH	NASA DBV PROTOTYPE INSTRUMENTS STOPPING DIST, FT	MU-METER TEST SPEED, MPH	MU-METER FRICTION READING INTEGRATED AVERAGE	MU-METER FRICTION READING RECORD AVERAGE VALUE	MU-METER FRICTION READING RECORD MAXIMUM VALUE	MU-METER FRICTION READING RECORD MINIMUM VALUE
10/5/71	MU-M	13	1220	-7	A-G					40	0.60	0.58	0.72	0.39
	DBV	14	1221	-6	A	59.5	429	59	459					
	DBV	14A	1222	-5	C	60.6	447	60	448					
	B-727	21A	1227	0	A-F+									
	MU-M	14	1229	+2	A-G					40	0.74	0.73	0.78	0.59
	DBV	15	1229	+2	B	59.8	414	60	427					
	DBV	15A	1230	+3	D	60.5	424	60	427					
	MU-M	15	1233	+6	A-G					40	0.78	0.78	0.80	0.54
	MU-M	16	1246	-6	A-G					40	0.58	0.56	0.73	0.44
	DBV	16	1246	-6	A	60.2	462	60	479					
	DBV	16A	1247	-5	C	60.2	476	60	479					
	B-727	18	1252	0	A-E+									
	MU-M	17	1254	+2	A-G					40	0.71	0.71	0.77	0.51
	DBV	17	1254	+2	B	59.2	465	60	470					
	DBV	17A	1255	+3	D	60.7	441	61	443					
10/6/71	DBV	24	0805	-11	F	59.3	360	59	355					
	B-727	30	0816	0	F-D									

Table VIII.- Continued.

(b) Airport: Houston Intercontinental.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTE-GRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/7/71	MU-M	3	0945	-5	A-G					40	0.37	0.37	0.45	0.23
	DBV	2	0945	-5	A	65.6	1089	—	1003					
	DBV	2A	0946	-4	D	62.7	811	61	831					
	B-727	40	0950	0	A-E+									
	MU-M	4	0952	+2	A-G					40	0.56	0.56	0.64	0.35
	DBV	3	0953	+3	A	61.4	873	60	877					
	DBV	3A	0954	+4	D	61.5	684	62	688					
	MU-M	5	1020	-3	A-G					60	0.29	0.29	0.36	0.10
	DBV	4	1020	-3	A	59.9	912	60	917					
	DBV	4A	1021	-2	D	61.3	829	61	835					
	B-727	41	1023	0	A-E+									
	MU-M	6	1025	+2	A-G					60	0.43	0.42	0.52	0.23
	DBV	5	1025	+2	A	60.4	891	60	894					
	DBV	5A	1026	+3	D	60.4	715	60	718					
	MU-M	7	1235	-7	A-G					20	0.54	0.54	0.56	0.51
	DBV	6	1235	-7	A	59.4	889	60	892					
	DBV	6A	1236	-6	D	60.3	734	61	745					
	DBV	6B	1237	-5	G	61.3	856	59	860					
	B-727	42	1242	0	A-E+									
	MU-M	8	1244	+2	A-G					20	0.58	0.58	0.64	0.52
	DBV	7	1244	+2	A	60.8	697	60	705					
	DBV	7A	1245	+3	D	60.2	636	60	637					
↓	DBV	7B	1246	+4	G	60.8	636	61	646					

Table VIII.- Continued.

(b) Airport: Houston Intercontinental.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/7/71	MU-M	9	1314	-2	A-G					40	0.37	0.37	0.41	0.32
	DBV	8	1313	-3	A	60.1	922	60	938					
	DBV	8A	1314	-2	D	60.3	775	60	792					
	DBV	8B	1315	-1	G	60.9	857	60	860					
	B-727	43	1316	0	A-F+									
	MU-M	10	1319	+3	A-G					40	0.50	0.50	0.58	0.39
	DBV	9	1319	+3	A	60.3	772	60	775					
	DBV	9A	1320	+4	D	59.5	644	59	648					
	DBV	9B	1321	+5	G	60.3	652	60	665					
	MU-M	11	1705	-2	A-G					60	0.26	0.26	0.31	0.18
	DBV	10	1705	-2	A	60.1	1006	60	1010					
	DBV	10A	1706	-1	D	60.3	840	60	840					
	B-727	46	1707	0	A-G+									
	MU-M	12	1709	+2	A-G					60	0.33	0.33	0.47	0.18
	DBV	11	1709	+2	A	56.9	790	56	793					
	DBV	11A	1710	+3	D	60.9	728	61	779					
	DBV	11B	1711	+4	G	60.4	755	60	757					
	MU-M	13	1738	-2	A-G					20	0.54	0.54	0.56	0.50
	DBV	12	1738	-2	A	60.5	1004	60	1007					
	DBV	12A	1739	-1	D	61.3	847	61	855					
	B-727	47	1740	0	A-F									
	MU-M	14	1743	+3	A-G					20	0.57	0.57	0.60	0.46
	DBV	13	1743	+3	A	59.9	892	60	899					
	DBV	13A	1744	+4	D	60.1	751	61	757					
↓	DBV	13B	1745	+5	G	60.7	765	61	783					

Table VIII.- Continued.

(c) Airport: Edwards AFB.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTE-GRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/9/71	MU-M	3	0826	-3	A-F+					40	0.34	0.33	0.38	0.25
	DBV	2	0826	-3	A	60.5	843	60	851					
	DBV	2A	0827	-2	D	60.6	949	60	952					
	B-727	50	0829	0	A-G+									
	MU-M	4	0832	+3	A-F+					40	0.36	0.35	0.38	0.32
	DBV	3	0832	+3	A	59.9	828	59	831					
	DBV	3A	0833	+4	D	60.2	764	60	765					
	MU-M	5	0858	-4	A-G					40	0.33	0.34	0.36	0.29
	DBV	R-2	0858	-4	A	60.0	879	60	911					
	DBV	R-2A	0859	-3	D	59.4	769	59	770					
	B-727	50A	0902	0	A-E+									
	MU-M	6	0904	+2	A-G					40	0.42	0.42	0.66	0.33
	DBV	R-3	0904	+2	A	60.3	830	60	833					
	DBV	R-3A	0905	+3	D	60.5	746	61	765					
	DBV	R-3B	0906	+4	F	60.2	727	60	728					
	MU-M	7	0923	-1	A-G					60	0.28	0.28	0.31	0.21
	DBV	4	0922	-2	A	60.4	884	61	886					
	DBV	4A	0923	-1	D	59.5	781	59	783					
	DBV	4B	0923	-1	F	60.1	829	60	838					
	B-727	51	0924	0	A-E+									
	MU-M	8	0927	+3	A-G					60	0.33	0.33	0.38	0.24
	DBV	5	0927	+3	A	60.4	792	59	799					
	DBV	5A	0928	+4	D	60.3	740	60	744					
	DBV	5B	0929	+5	F	59.9	787	60	790					

Table VIII.- Continued.

(c) Airport: Edwards AFB.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTE-GRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/9/71	MU-M	9	1054	-4	A-G					20	0.62	0.62	0.76	0.53
	DBV	6	1054	-4	A	59.6	923	59	928					
	DBV	6A	1055	-3	D	60.4	831	60	833					
	DBV	6B	1056	-2	F	60.6	923	60	927					
	B-727	53	1058	0	A-G+									
	MU-M	10	1100	+2	A-G					20	0.66	0.65	0.78	0.47
	DBV	7	1100	+2	A	59.9	800	59	804					
	DBV	7A	1101	+3	D	60.0	754	60	757					
	DBV	7B	1102	+4	F	60.3	809	59	813					
	MU-M	11	1128	-4	A-F+					40	0.33	0.33	0.37	0.30
	DBV	8	1128	-4	A	60.2	930	60	930					
	DBV	8A	1129	-3	D	59.9	811	60	813					
	DBV	8B	1130	-2	F	60.0	904	60	906					
	B-727	52	1132	0	A-G+									
	MU-M	12	1134	+2	A-G					40	0.39	0.39	0.53	0.31
	DBV	9	1134	+2	A	60.2	823	60	825					
	DBV	9A	1135	+3	D	60.3	760	60	763					
	DBV	9B	1136	+4	F	60.1	810	61	812					
	MU-M	13	1200	-3	A-G					40	0.37	0.37	0.45	0.26
	DBV	R-6	1200	-3	A	59.2	865	60	866					
	DBV	R-6A	1201	-2	D	59.7	842	59	842					
	DBV	R-6B	1202	-1	F	60.1	906	60	917					
	B-727	53A	1203	0	A-G+									
	MU-M	14	1205	+2	A-G					40	0.40	0.39	0.48	0.27
	DBV	R-7	1205	+2	A	60.0	847	60	849					
↓	DBV	R-7A	1206	+3	D	60.4	784	60	785					

Table VIII.– Continued.

(c) Airport: Edwards AFB.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (–)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV: STANDARD INSTRUMENTS: BRAKING SPEED, MPH	NASA DBV: STANDARD INSTRUMENTS: STOPPING DIST, FT	NASA DBV: PROTOTYPE INSTRUMENTS: BRAKING SPEED, MPH	NASA DBV: PROTOTYPE INSTRUMENTS: STOPPING DIST, FT	MU-METER: TEST SPEED, MPH	MU-METER: FRICTION READING: INTEGRATED AVERAGE	MU-METER: FRICTION READING: RECORD: AVERAGE VALUE	MU-METER: FRICTION READING: RECORD: MAXIMUM VALUE	MU-METER: FRICTION READING: RECORD: MINIMUM VALUE
10/9/71	DBV	R-7B	1207	+4	F	60.0	816	59	820					
	MU-M	15	1234	–2	A–E+					40	0.39	0.38	0.48	0.32
	DBV	10	1234	–2	A	58.9	814	59	815					
	DBV	10A	1235	–1	D	60.0	837	61	840					
	B-727	96	1236	0	A–E+									
	MU-M	16	1238	+2	A–G					40	0.54	0.54	0.58	0.44
	DBV	11	1238	+2	A	59.8	847	60	849					
	DBV	11A	1239	+3	D	60.3	719	61	734					
	DBV	11B	1240	+4	F	60.1	845	61	849					
	MU-M	18	1650	–2	A–F+					40	0.39	0.39	0.48	0.28
	DBV	12	1649	–3	A	60.7	908	61	913					
	DBV	12A	1650	–2	D	60.1	884	61	916					
	DBV	12B	1651	–1	F	61.2	951	60	957					
	B-727	56	1652	0	A–G+									
	MU-M	19	1654	+2	A–G					40	0.46	0.46	0.59	0.33
	DBV	13	1654	+2	A	60.7	818	60	819					
	DBV	13A	1655	+3	D	59.9	762	60	765					
	DBV	13B	1656	+4	F	59.8	807	60	821					
	MU-M	20	1720	–2	A–G					40	0.43	0.43	0.47	0.30
	DBV	14	1719	–3	A	60.3	889	61	891					
	DBV	14A	1720	–2	D	59.3	810	59	811					
	DBV	14B	1721	–1	F	60.4	913	61	931					
	B-727	57	1722	0	A–G+									
	MU-M	21	1724	+2	A–G					40	0.52	0.52	0.58	0.37
	DBV	15	1724	+2	A	60.4	——	60	——					

Table VIII.- Continued

(c) Airport: Edwards AFB.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV STANDARD INSTRUMENTS BRAKING SPEED, MPH	NASA DBV STANDARD INSTRUMENTS STOPPING DIST, FT	NASA DBV PROTOTYPE INSTRUMENTS BRAKING SPEED, MPH	NASA DBV PROTOTYPE INSTRUMENTS STOPPING DIST, FT	MU-METER TEST SPEED, MPH	MU-METER FRICTION READING INTEGRATED AVERAGE	MU-METER FRICTION READING RECORD AVERAGE VALUE	MU-METER FRICTION READING RECORD MAXIMUM VALUE	MU-METER FRICTION READING RECORD MINIMUM VALUE
10/9/71	DBV	15A	1725	+3	D	59.9	756	61	759					
	DBV	15B	1726	+4	F	60.6	811	61	815					
	MU-M	22	1749	-2	A-F+					40	0.42	0.42	0.52	0.23
	DBV	16	1748	-3	A	60.8	904	61	907					
	DBV	16A	1749	-2	B	59.9	849	61	851					
	DBV	16B	1750	-1	F	60.7	914	62	920					
	B-727	97	1751	0	A-E+									
	MU-M	23	1753	+2	A-F+					40	0.56	0.55	0.66	0.41
	DBV	17	1753	+2	A	60.2	807	61	810					
	DBV	17A	1754	+3	D	60.7	770	60	770					
	DBV	17B	1755	+4	F	60.5	807	61	808					

Table VIII.- Continued.

(d) Airport: Seattle-Tacoma International.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/11/71	DBV	6	1419	-3	A	59.9	432	60	434					
	DBV	6A	1420	-2	D	60.3	437	60	458					
	MU-M	8	1420	-2	A-E+					40	0.76	0.75	0.78	0.74
	B-727	64	1422	0	A-D									
	DBV	7	1424	+2	A	59.7	413	58	417					
	DBV	7A	1425	+3	D	60.1	427	61	455					
	MU-M	9	1425	+3	A-E+					40	0.75	0.75	0.77	0.72
	DBV	8	1444	-3	A	60.3	426	60	430					
	DBV	8A	1445	-2	D	59.9	416		439					
	MU-M	10	1445	-2	A-G					60	0.75	0.72	0.76	0.68
	B-727	65	1447	0	A-E									
	DBV	9	1450	+3	A	60.0	420	60	420					
	DBV	9A	1451	+4	D	60.1	411	60	423					
	MU-M	11	1451	+4	A-G					60	0.74	0.72	0.74	0.70
	MU-M	12	1506	-3	A-G					20	0.77	0.77	0.80	0.75
	DBV	10	1507	-2	B	59.8	428	59	433					
	B-727	66	1509	0	A-E									
	MU-M	13	1512	+3	A-G					20	0.76	0.75	0.78	0.72
	DBV	11	1512	+3	B	59.3	393	60	396					
	MU-M	14	1527	-2	A-G					40	0.75	0.75	0.77	0.69
	DBV	12	1527	-2	B	60.5	433	—	470					
	B-727	61	1529	0	A-D									
	MU-M	15	1531	+2	A-G					40	0.77	0.75	0.78	0.73
	DBV	13	1531	+2	B	59.7	422	60	480					

Table VIII.— Continued.

(d) Airport: Seattle-Tacoma International.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/11/71	MU-M	16	1558	-1	A-G					40	0.75	0.75	0.78	0.70
↓	DBV	14	1558	-1	B	60.0	441	60	444					
	B-727	62	1559	0	A-D									
	MU-M	17	1601	+2	A-G					40	0.75	0.74	0.78	0.71
	DBV	15	1601	+2	B	59.5	428	59	431					
	MU-M	18	1617	-3	A-G					40	0.76	0.75	0.78	0.73
	DBV	16	1617	-3	B	59.9	440	60	443					
	B-727	63	1620	0	A-D									
	MU-M	19	1622	+2	A-G					40	0.77	0.75	0.77	0.74
↓	DBV	17	1622	+2	B	59.7	431	59	439					
10/12/71	MU-M	20	0842	-4	A-G					40	—	0.76	0.80	0.68
↓	DBV	20	0842	-4	B	59.6	423	59	424					
	B-727	71	0846	0	A-F									
	MU-M	21	0848	+2	A-G					40	—	0.76	0.77	0.75
↓	DBV	21	0848	+2	B	59.9	412	60	416					

Table VIII.- Continued.

(e) Airport: Lubbock Regional.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/13/71	MU-M	4	1058	-2	A-F+					40	0.30	0.32	0.40	0.23
	DBV	3	1058	-2	A	59.6	636	58	655					
	DBV	3A	1059	-1	D	61.6	691	59	706					
	B-727	78	1100	0	A-F+									
	MU-M	5	1110	+10	A-F+					40	0.41	0.41	0.53	0.33
	DBV	4	1101	+1	A	60.2	661	61	673					
	DBV	4A	1102	+2	D	60.6	607	61	624					
	MU-M	6	1128	-3	A-F+					60	0.14	0.13	0.20	0.04
	DBV	5	1128	-3	A	60.1	682	59	685					
	DBV	5A	1129	-2	D	59.4	661	60	663					
	B-727	79	1131	0	A-G+									
	MU-M	7	1133	+2	A-F+					60	0.26	0.25	0.43	0.15
	DBV	6	1132	+1	B	60.1	640	60	643					
	DBV	6A	1133	+2	E	60.2	607	60	610					
	MU-M	8	1158	-2	A-F+					20	0.68	0.66	0.73	0.60
	DBV	7	1158	-2	B	60.0	693	60	694					
	DBV	7A	1159	-1	E	60.1	692	60	706					
	B-727	80	1200	0	A-E+									
	MU-M	9	1203	+3	A-G					20	0.67	0.66	0.75	0.55
	DBV	8	1202	+2	B	59.6	628	59	631					
	DBV	8A	1203	+3	E	59.8	605	59	607					

Table VIII.- Continued.

(e) Airport: Lubbock Regional.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTE-GRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/13/71	MU-M	10	1229	-2	A-F+					40	0.29	0.29	0.38	0.20
	DBV	9	1228	-3	C	59.8	708	60	711					
	DBV	9A	1229	-2	F	60.5	676	60	679					
	B-727	75	1231	0	A-F+					40	0.36	0.37	0.52	0.27
	MU-M	11	1234	+3	A-G									
	DBV	10	1232	+1	C	59.8	611	60	613					
	DBV	10A	1233	+2	F	59.9	665	60	673					
	MU-M	12	1258	-3	A-G					40	0.28	0.28	0.38	0.11
	DBV	11	1258	-3	C	60.0	726	59	725					
	DBV	11A	1259	-2	F	60.3	748	60	754					
	B-727	76	1301	0	A-F+									
	MU-M	13	1303	+2	A-G					40	0.36	0.38	0.45	0.27
	DBV	12	1303	+2	C	59.9	689	59	692					
	DBV	12A	1304	+3	F	60.1	674	60	676					
	MU-M	14	1329	-3	A-G					40	0.33	0.32	0.47	0.19
	DBV	13	1329	-3	C	60.1	726	59	730					
	DBV	13A	1330	-2	F	60.0	751	61	753					
	B-727	77	1332	0	A-E+									
	MU-M	15	1334	+2	A-G					40	0.41	0.42	0.57	0.29
	DBV	14	1333	+1	B	60.2	676	61	675					
	DBV	14A	1334	+2	E	59.6	644	60	646					

Table VIII.- Continued.

(e) Airport: Lubbock Regional.

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTE-GRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/13/71	MU-M	18	1650	-2	A-F					40	0.27	0.28	0.40	0.20
	DBV	16	1649	-3	C	59.8	762	60	762					
	DBV	16A	1650	-2	F	—	—	—	—					
	B-727	84	1652	0	A-G+									
	MU-M	19	1658	+6	A-F+					40	0.41	0.41	0.58	0.30
	DBV	17	1653	+1	C	59.7	723	60	726					
	DBV	17A	1654	+2	F	60.4	679	60	682					
	MU-M	20	1717	-1	A-F					40	0.25	0.24	0.34	0.14
	DBV	18	1716	-2	B	59.9	780	60	779					
	DBV	18A	1717	-1	F	60.0	742	60	745					
	B-727	85	1718	0	A-F+									
	MU-M	21	1721	+3	A-F					40	0.33	0.33	0.44	0.21
	DBV	19	1720	+2	B	60.8	745	60	748					
	DBV	19A	1721	+3	F	59.7	675	60	675					
	MU-M	22	1749	-1	A-F					40	0.31	0.29	0.38	0.17
	DBV	20	1748	-2	B	60.2	729	60	730					
	DBV	20A	1749	-1	E	59.8	752	60	759					
	B-727	98	1750	0	A-F+									
	MU-M	23	1755	+5	A-F+					40	0.39	0.38	0.52	0.27
	DBV	21	1754	+4	B	60.2	674	60	688					
	DBV	21A	1755	+5	E	60.0	665	59	688					

Table VIII.- Concluded.

(f) Airport: J.F.K. International

DATE	TEST VEHICLE	RUN NO.	TIME OF TEST, HR-MIN	TIME FROM AIRCRAFT TEST, MIN (-)BEF (+)AFTER	TEST SECTION AREA COVERED	NASA DBV				MU-METER				
						STANDARD INSTRUMENTS		PROTOTYPE INSTRUMENTS		TEST SPEED, MPH	FRICTION READING			
											INTEGRATED AVERAGE	RECORD		
						BRAKING SPEED, MPH	STOPPING DIST, FT	BRAKING SPEED, MPH	STOPPING DIST, FT			AVERAGE VALUE	MAXIMUM VALUE	MINIMUM VALUE
10/15/71	MU-M	3	1503	-1	A-G					40	0.49	0.49	0.64	0.24
	DBV	2	1459	-5	A	60.8	666	61	667					
	DBV	2A	1500	-4	D	60.7	597	61	597					
	B-727	88	1504	0	A-D+									
	MU-M	4	1506	+2	A-G					40	0.66	0.66	0.73	0.33
	DBV	3	1506	+2	A	60.8	593	60	590					
	DBV	3A	1507	+3	D	60.1	499	60	510					
	DBV	4	1510	+6	B	63.2	570	61	612					
	DBV	4A	1511	+7	D	62.1	528	63	547					
	B-727	89	1515	+11	A-D									

Table IX.– Time correlated aircraft to ground vehicle data summary.

AIRPORT	RUN NO.	TYPE OF TEST	SURFACE CONDITION	AVERAGE WATER DEPTH, IN.	AMBIENT AIR TEMPERATURE, °F	AIRCRAFT: GROSS WEIGHT, LB	AIRCRAFT – NASA DATA: GROUND VISUAL STOPPING DISTANCE, FT	NASA DATA – NOSE WHEEL COUNTER: STOPPING DISTANCE, FT	NOSE WHEEL COUNTER: BRAKE ON GROUND SPEED, KNOTS	NOSE WHEEL COUNTER: WV^2 LB-KTS^2 $\times 10^{-9}$	NOSE WHEEL COUNTER: S.D.R.	BOEING DATA – ON BOARD THEODOLITE: STOPPING DISTANCE, FT	ON BOARD THEODOLITE: BRAKE ON GROUND SPEED, KNOTS	ON BOARD THEODOLITE: WV^2 LB-KTS^2 $\times 10^{-9}$	ON BOARD THEODOLITE: S.D.R.	GROUND VEHICLES – NASA DBV: STOPPING DIST., FT DRY[1]	NASA DBV: STOPPING DIST., FT WET[2]	NASA DBV: S.D.R.	MU-METER: AVERAGE FRICTION READING[3] AT 40 MPH
Wallops	10	MB	Dry	——	72	113 500	1039	1106	98.30	1.097	——	1097	99.43	1.122	——	—	—	—	0.810
	11		Dry	——	72	109 500	1284	1370	112.41	1.384	——	1353	114.61	1.438	——	—	—	—	0.810
	13		Wet	0.010	65	103 500	1678	1744	112.64	1.313	1.448	1766	114.31	1.352	1.483	287	395	1.374	0.766
	12*		Wet	0.019	68	99 500	2269	2380	117.11	1.365	1.902	2398	119.17	1.413	1.926	291	448	1.539	0.683
	21A		Wet	0.010	73	136 500	2080	2202	117.11	1.872	1.283	2192	119.05	1.935	1.286	298	422	1.416	0.718
	18		Wet	0.010	73	132 500	2268	2392	121.70	1.963	1.330	2385	123.08	2.007	1.349	298	456	1.550	0.674
	14		Dry	——	76	136 500	1672	1739	119.35	1.945	——	1729	120.71	1.989	——	—	—	—	0.760
	17		Dry	——	75	131 500	1618	1730	122.29	1.967	——	1714	124.39	2.035	——	—	—	—	0.760
	30		Wet	Damp	69	142 000	811	886	78.78	0.882	1.096	856	77.48	.852	1.140	292	368	1.260	——
Houston	38		Dry	——	73	121 500	1132	1203	103.47	1.301	——	1190	105.30	1.346	——	—	—	—	0.820
	39		Dry	——	75	117 700	1057	1136	103.47	1.260	——	1132	104.38	1.283	——	—	—	—	0.820
	40		Wet	0.022	75	113 500	2720	2781	103.00	1.204	2.519	2814	104.26	1.234	2.589	310	736	2.372	0.510
	41*		Wet	0.027	79	108 500	3090	3176	101.12	1.110	3.123	3195	102.25	1.135	3.195	316	786	2.486	0.430
	42		Wet	0.016	86	140 500	2844	2965	109.94	1.698	1.905	2973	111.30	1.741	1.938	326	678	2.081	0.430
	43		Wet	0.019	88	133 500	3369	3460	111.70	1.666	2.266	3460	113.31	1.714	2.291	329	752	2.285	0.423
	44		Dry	——	89	140 500	1653	1764	116.99	1.923	——	——	119.29	1.999	——	—	—	—	0.820
	45		Dry	——	90	137 000	1625	1820	122.28	2.049	——	1812	124.32	2.118	——	—	—	—	0.820
	46*		Wet	0.027	91	138 500	4148	4225	120.64	2.016	2.286	4255	123.84	2.124	2.274	333	833	2.501	0.430
	47*		Wet	0.028	88	131 000	3779	3836	114.64	1.722	2.431	3916	119.05	1.857	2.394	328	827	2.520	0.430
Edwards	48		Dry	——	57	119 000	1255	1362	107.78	1.382	——	1348	109.33	1.422	——	—	—	—	0.790
	49		Dry	——	60	115 000	1322	1552	120.41	1.667	——	1543	122.17	1.716	——	—	—	—	0.820

NOTES:
1. DBV dry stopping distance values, corrected to 60 mph brake application speed, were temperature (ambient air) adjusted according to figure 26.
2. DBV wet stopping distance values, corrected to 60 mph brake application speed, were time correlated with aircraft run according to figure 27.
3. Mu-meter average friction readings for the test section length covered by the aircraft test were time correlated with the aircraft run according to figure 27. For mu-meter test speeds other than 40 mph, the friction readings were corrected to 40 mph base by means of friction reading-velocity curves.

MB = Maximum brake application

NB = Normal brake application

RT = Reverse thrust

*Two wheels locked during stop
**Four wheels locked during stop
***Aircraft did not stop in wetted test section

Table IX.- Continued.

AIRPORT	RUN NO.	TYPE OF TEST	SURFACE CONDITION	AVERAGE WATER DEPTH, IN.	AMBIENT AIR TEMPERATURE, °F	AIRCRAFT										GROUND VEHICLES			
						GROSS WEIGHT, LB	NASA DATA					BOEING DATA				NASA DBV			MU-METER
							GROUND VISUAL STOPPING DISTANCE, FT	NOSE WHEEL COUNTER				ON BOARD THEODOLITE				STOPPING DIST., FT		S.D.R.	AVERAGE FRICTION READING[3] AT 40 MPH
								STOPPING DISTANCE, FT	BRAKE ON GROUND SPEED, KNOTS	WV^2 LB-KTS^2 $\times 10^{-9}$	S.D.R.	STOPPING DISTANCE, FT	BRAKE ON GROUND SPEED, KNOTS	WV^2 LB-KTS^2 $\times 10^{-9}$	S.D.R.	DRY[1]	WET[2]		
Edwards	50**	MB	Wet	0.049	62	112 000	5047	5141	109.35	1.339	4.190***	5144	110.87	1.377	4.241	344	851	2.473	0.394
	50A*	↓	Wet	0.046	62	107 000	3342	3335	100.65	1.084	3.355	3361	102.69	1.128	3.381	344	800	2.325	0.370
	51*	↓	Wet	0.040	66	102 900	3780	3940	108.41	1.209	3.556	3970	110.87	1.265	3.564	351	811	2.310	0.430
	53*	↓	Wet	0.024	82	139 000	6564	6669	129.58	2.334	3.117***	6675	133.58	2.480	3.055	374	835	2.232	0.430
	52**	↓	Wet	0.032	86	133 500	6506	6607	119.47	1.905	3.784***	6655	122.20	1.994	3.788	380	835	2.197	0.374
	53A*	↓	Wet	0.048	86	127 200	5514	5590	122.29	1.902	3.207	5639	125.16	1.993	3.211	380	856	2.250	0.388
	96*	RT&MB	Wet	0.034	91	121 000	3424	2735	118.53	1.699	1.756	2820	121.90	1.798	1.568	387	851	2.198	0.468
	54	MB	Dry	—	106	138 000	2005	2130	131.70	2.393	—	2120	132.81	2.434	—	—	—	—	0.800
	55	↓	Dry	—	106	133 900	1678	1795	127.93	2.191	—	1785	130.08	2.266	—	—	—	—	0.800
	56*	↓	Wet	0.030	108	139 000	—	6163	131.93	2.419	2.780***	6161	136.25	2.580	2.711	411	855	2.080	0.423
	57*	↓	Wet	0.032	97	133 000	5149	5200	124.64	2.066	2.745	5262	128.72	2.204	2.710	395	835	2.114	0.470
	97	RT&MB	Wet	0.028	92	128 500	1505	1585	94.07	1.137	1.521	—	95.52	1.172	—	388	839	2.162	0.495
Sea-Tac	58	MB	Dry	—	56	119 500	748	866	89.01	0.947	—	852	90.60	0.981	—	—	—	—	0.770
	59A	↓	Dry	—	58	116 000	869	1021	99.36	1.111	—	1009	100.62	1.174	—	—	—	—	0.770
	64	↓	Wet	Damp	64	138 000	1400	1546	106.06	1.552	1.086	1527	108.32	1.619	1.071	333	427	1.282	0.745
	65	↓	Wet	Damp	60	133 800	1528	1689	114.76	1.762	1.046	1674	117.45	1.846	1.030	328	418	1.273	0.746
	66	RT&MB	Wet	Damp	62	129 500	—	1423	117.00	1.773	0.876	1416	119.23	1.841	0.873	330	420	1.273	0.746
	61	MB	Wet	Damp	72	126 000	1128	1240	98.18	1.214	1.114	1223	97.71	1.203	1.154	344	426	1.238	0.750
	62	MB	Wet	Damp	75	119 800	1236	1399	104.65	1.312	1.163	—	—	—	—	348	438	1.258	0.750
	63	RT&MB	Wet	Damp	65	115 800	—	—	111.24	1.433	—	1646	114.90	1.529	1.222	334	437	1.308	0.750
	67	MB	Dry	—	50	137 500	1166	1288	102.53	1.445	—	1254	102.16	1.435	—	—	—	—	0.770

NOTES:
1. DBV dry stopping distance values, corrected to 60 mph brake application speed, were temperature (ambient air) adjusted according to figure 26.
2. DBV wet stopping distance values, corrected to 60 mph brake application speed, were time correlated with aircraft run according to figure 27.
3. Mu-meter average friction readings for the test section length covered by the aircraft test were time correlated with the aircraft run according to figure 27. For mu-meter test speeds other than 40 mph, the friction readings were corrected to 40 mph base by means of friction reading-velocity curves.

MB = Maximum brake application

NB = Normal brake application

RT = Reverse thrust

*Two wheels locked during stop
**Four wheels locked during stop
***Aircraft did not stop in wetted test section

Table IX.- Concluded.

AIRPORT	RUN NO.	TYPE OF TEST	SURFACE CONDITION	AVERAGE WATER DEPTH, IN.	AMBIENT AIR TEMPERATURE, °F	AIRCRAFT: GROSS WEIGHT, LB	NASA DATA: GROUND VISUAL STOPPING DISTANCE, FT	NASA DATA, NOSE WHEEL COUNTER: STOPPING DISTANCE, FT	NASA DATA, NOSE WHEEL COUNTER: BRAKE ON GROUND SPEED, KNOTS	NASA DATA, NOSE WHEEL COUNTER: WV^2 LB-KTS^2 $\times 10^{-9}$	NASA DATA, NOSE WHEEL COUNTER: S.D.R.	BOEING DATA, ON BOARD THEODOLITE: STOPPING DISTANCE, FT	BOEING DATA, ON BOARD THEODOLITE: BRAKE ON GROUND SPEED, KNOTS	BOEING DATA, ON BOARD THEODOLITE: WV^2 LB-KTS^2 $\times 10^{-9}$	BOEING DATA, ON BOARD THEODOLITE: S.D.R.	GROUND VEHICLES, NASA DBV: STOPPING DIST., FT DRY[1]	GROUND VEHICLES, NASA DBV: STOPPING DIST., FT WET[2]	GROUND VEHICLES, NASA DBV: S.D.R.	GROUND VEHICLES, MU-METER: AVERAGE FRICTION READING[3] AT 40 MPH
Sea-Tac	71	MB	Wet	Damp	50	133 600	1598	1741	118.76	1.884	1.008	1719	121.07	1.958	0.997	313	417	1.332	0.753
Lubbock	72	MB	Dry	—	51	122 000	1524	1749	121.35	1.796	—	1658	122.66	1.835	—	—	—	—	0.800
	73	MB	Dry	—	51	117 200	1452	1649	122.87	1.769	—	1624	123.67	1.792	—	—	—	—	0.800
	74	RT&MB	Dry	—	51	112 200	644	1029	108.18	1.313	—	1013	107.33	1.292	—	—	—	—	0.800
	78	MB	Wet	0.032	62	136 100	3765	3879	119.93	1.957	2.162	3894	123.72	2.083	2.122	308	644	2.090	0.336
	79*	MB	Wet	0.031	65	130 000	4291	4399	124.05	2.004	2.395	4409	127.39	2.110	2.372	313	641	2.048	0.375
	80	RT&MB	Wet	0.034	66	124 200	1740	1935	111.00	1.530	1.380	1942	112.60	1.574	1.400	314	665	2.117	0.375
	75*	MB	Wet	0.033	68	119 400	3161	3263	109.94	1.443	2.466	3273	111.71	1.490	2.493	317	653	2.059	0.325
	76*	MB	Wet	0.026	68	114 000	3304	3430	112.88	1.452	2.577	3411	114.49	1.494	2.592	317	709	2.235	0.348
	77	RT&MB	Wet	0.024	70	109 500	1556	1661	103.47	1.172	1.546	1671	106.21	1.237	1.533	319	692	2.169	0.404
	81	MB	Dry	—	73	133 600	—	2182	131.93	2.325	—	2168	135.50	2.453	—	—	—	—	0.810
	82	MB	Dry	—	74	130 000	1487	1693	121.70	1.925	—	1682	122.42	1.948	—	—	—	—	0.820
	83	RT&MB	Dry	—	75	126 500	1703	1892	123.46	1.928	—	1875	128.75	2.097	—	—	—	—	0.820
	84*	MB	Wet	0.031	73	137 000	4045	4129	132.63	2.410	1.869	4146	136.62	2.557	1.841	324	723	2.230	0.314
	85*	MB	Wet	0.033	72	131 800	3245	3485	124.64	2.047	1.858	3502	128.34	2.171	1.832	323	740	2.291	0.282
	98	NB	Wet	0.030	72	126 000	3290	3430	126.58	2.019	1.853	3456	129.52	2.114	1.856	323	723	2.238	0.300
JFK	86	MB	Dry	—	72	120 000	1080	1192	108.17	1.404	—	1170	101.42	1.234	—	—	—	—	0.830
	87	↓	Dry	—	73	116 600	1298	1427	111.23	1.442	—	1403	111.48	1.449	—	—	—	—	0.830
	88	↓	Wet	Damp	73	112 300	1814	1919	105.82	1.257	1.666	1934	107.40	1.295	1.695	315	566	1.795	0.552
	89	↓	Wet	Damp	73	110 800	1582	1689	105.35	1.229	1.500	1688	106.45	1.256	1.526	315	462	1.465	—

NOTES:

1. DBV dry stopping distance values, corrected to 60 mph brake application speed, were temperature (ambient air) adjusted according to figure 26.
2. DBV wet stopping distance values, corrected to 60 mph brake application speed, were time correlated with aircraft run according to figure 27.
3. Mu-meter average friction readings for the test section length covered by the aircraft test were time correlated with the aircraft run according to figure 27. For mu-meter test speeds other than 40 mph, the friction readings were corrected to 40 mph base by means of friction reading-velocity curves.

MB = Maximum brake application

NB = Normal brake application

RT = Reverse thrust

*Two wheels locked during stop

**Four wheels locked during stop

***Aircraft did not stop in wetted test section

Table X.– Comparison of NASA nose wheel counter, Boeing side-looking phototheodolite, and USAF Askania ground phototheodolite measurements of aircraft stopping distance and brake application speed at Edwards AFB.

RUN NO.	NASA		BOEING		USAF	
	BRAKE DISTANCE, FT	BRAKE SPEED, KNOTS	BRAKE DISTANCE, FT	BRAKE SPEED, KNOTS	BRAKE DISTANCE, FT	BRAKE SPEED, KNOTS
48	1362	107.78	1348	109.33	1322	108.35
49	1552	120.41	1543	122.17	1493	120.63
50	5141	109.35	5144	110.87	5084	109.82
50A	3335	100.65	3361	102.69	3342	102.14
51	3940	108.41	3970	110.87	3940	110.43
53	6669	129.58	6675	133.58	6639	131.69
52	6607	119.47	6655	122.20	6687	121.94
53A	5590	122.29	5639	125.16	5605	124.69
96	2735	118.53	2820	121.90	2713	120.95
54	2130	131.70	2120	132.81	2082	131.71
55	1795	127.93	1785	130.08	1733	129.06
56	6163	131.93	6161	136.25	6217	136.00
57	5200	124.64	5262	128.72	5222	127.89
97	1585	94.07		95.52	1586	95.41

TABLE XI.- Summary of wheel spin-up times, brake application, and anti-skid operation during B-727 aircraft test runs.

RUN NO.	TYPE OF TEST	MAIN GEAR TIRES	WHEEL SPIN-UP TIME-SEC			TIME TO BRAKES ON, SEC	TIME TO WHEEL LOCKUP, SEC		DEGREE OF WHEEL SKID		NOTES
			LOB	RIB	NOSE		OUT'BD	IN'BD	SHALLOW	DEEP	
24-2	TD-MW	Worn	0.64	0.57	—	—	—	—	—	—	Flooded ungrooved concrete surface
24-A	TD-NW	—	—	—	3.80	—	—	—	—	—	Flooded ungrooved concrete surface; apparent bounce; 7 to 9 revolutions before full spin-up attained
16	TD-MW	Worn	0.60	0.65	—	—	—	—	—	—	Flooded grooved concrete surface
16A	TD-NW	—	—	—	2.03	—	—	—	—	—	Flooded grooved concrete surface; apparent bounce; 8 revolutions before full spin-up attained
10	MB-Dry	Worn	0.65	0.72	0.17	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
11	MB-Dry	Worn	0.95	0.95	0.18	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
13	MB-Wet	Worn	0.75	0.80	0.20	LOB-0.25 RIB-0.30	—	—	—	—	Slight brake pressure applied prior to full application - LOB = -1.2 sec; RIB = -0.87 sec pressure dumps - both wheels
12	MB-Wet	Worn	0.80	0.93	0.15	0.10	6.0	—	RIB	LOB	18 pressure applications on LOB prior to lockup; slight pressure on left brake 1.45 sec prior to full application; occasional pressure dumps on RIB
21-A	MB-Wet	Worn	0.89	1.05	0.15	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
18	MB-Wet	Worn	0.95	1.19	0.15	0.10	—	—	—	—	Full pressure dumps - both wheels
23	MB-Fld	Worn	—	—	—	0.10	1.48	—	RIB	LOB	Ungrooved concrete; 4 pressure applications on LOB prior to lockup; nose wheel tended to spin-down then recovered
25	MB-Fld	Worn	—	—	—	0.32	—	—	RIB	LOB	Ungrooved concrete - full pressure dumps - both wheels
15	MB-Fld	Worn	—	—	—	0.10	1.2	—	—	LOB RIB	Grooved and ungrooved concrete; deep skids and full pressure dumps on both wheels on grooved surface; LOB lockup on ungrooved surface
19	MB-Fld	Worn	—	—	—	0.10	—	—	—	LOB RIB	Grooved and ungrooved concrete; full pressure dumps on both wheels; nose wheel partial spin-down on all surfaces
20	MB-Fld	Worn	—	—	—	0.10	—	—	LOB RIB	—	Grooved and ungrooved concrete; pressure dumps on both wheels; no tendency for nose wheel to spin-down
14	MB-Dry	Worn	0.96	1.15	0.15	0.10	—	—	—	—	Occasional moderate pressure dumps - LOB
17	MB-Dry	Worn	1.05	1.20	0.15	0.15	—	—	—	—	Occasional moderate pressure dumps - both wheels
24-B	TD-NW	—	—	—	—	—	—	—	—	—	Flooded ungrooved concrete surface; only slight tendency for nose wheel spin-up
30	MB-Wet	New	—	—	—	0.10	—	—	LOB RIB	—	Full pressure dump - RIB; several full pressure dumps - LOB
38	MB-Dry	Worn	0.72	0.76	0.20	0.10	—	—	—	—	Occasional shallow skids and moderate pressure dumps - LOB
39	MB-Dry	Worn	0.72	0.80	0.21	0.10	—	—	—	—	Occasional moderate pressure dumps - LOB
40	MB-Wet	Worn	0.72	0.91	0.27	0.10	—	—	RIB	LOB	Full pressure dumps - both wheels
41	MB-Wet	Worn	0.71	0.81	0.20	0.10	2.14	—	RIB	LOB	4 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
42	MB-Wet	Worn	0.81	0.95	0.29	0.10	—	—	RIB	LOB	Full pressure dumps - both wheels
43	MB-Wet	Worn	0.82	1.02	0.27	0.10	—	—	RIB	LOB	Full pressure dumps - both wheels
44	MB-Dry	New	0.87	1.03	0.23	0.10	—	—	—	—	Occasional moderate pressure dumps - LOB
45	MB-Dry	New	0.96	1.20	0.48	0.10	—	—	—	—	Occasional moderate pressure dumps - LOB

LOB - Left outboard wheel
RIB - Right inboard wheel
TD - Touchdown

MW - Main wheels
NW - Nose wheels
MB - Maximum brake application

TABLE XI.- Continued.

RUN NO.	TYPE OF TEST	MAIN GEAR TIRES	WHEEL SPIN-UP TIME-SEC			TIME TO BRAKES ON, SEC	TIME TO WHEEL LOCKUP, SEC		DEGREE OF WHEEL SKID		NOTES
			LOB	RIB	NOSE		OUT'BD	IN'BD	SHALLOW	DEEP	
46	MB-Wet	New	0.90	1.10	0.30	0.10	3.45	—	RIB	LOB	7 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
47	MB-Wet	New	0.89	1.09	0.22	0.10	3.82	—	RIB	LOB	8 pressure applications on LOB prior to lockup
48	MB-Dry	Worn	0.73	0.80	0.23	0.10	—	—	LOB	—	Occasional moderate pressure dumps - both wheels
49	MB-Dry	Worn	0.94	1.12	0.23	0.10	—	—	LOB	—	Occasional moderate pressure dumps - both wheels
50	MB-Wet	Worn	0.78	0.96	0.23	0.10	1.63	8.33	—	LOB RIB	3 pressure applications on LOB and 17 pressure applications on RIB prior to lockup; full pressure dumps - both wheels
50A	MB-Wet	Worn	0.82	0.90	0.23	0.10	1.37	—	RIB	LOB	3 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
51	MB-Wet	Worn	1.03	1.03	0.23	0.10	1.47	—	RIB	LOB	3 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
53	MB-Wet	Worn	1.08	1.47	0.23	0.10	1.47	—	RIB	LOB	3 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
52	MB-Wet	Worn	1.00	1.17	0.23	0.10	1.17	6.47	—	LOB RIB	2 pressure applications on LOB and 16 pressure applications on RIB prior to lockup; full pressure dumps - both wheels
53A	MB-Wet	Worn	1.02	1.32	0.23	0.10	1.51	—	RIB	LOB	4 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
96	MB-Wet	Worn	1.47	1.43	1.26	LOB-2.60 RIB-2.55	4.80	—	RIB	LOB	TD in water; normal reverse; brakes on at 118 knots; 7 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
54	MB-Dry	New	1.05	1.31	0.23	0.10	—	—	—	—	No skids; no pressure dumps
55	MB-Dry	New	1.05	1.39	0.26	0.10	—	—	LOB	—	Occasional moderate pressure dumps - LOB
56	MB-Wet	New	1.08	1.48	0.13	0.10	2.48	—	RIB	LOB	5 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
57	MB-Wet	New	1.00	1.33	0.14	0.21	2.59	—	RIB	LOB	5 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
97	MB-Wet	New	1.46	1.48	0.72	0.12	—	—	RIB	LOB	TD in water; normal reverse; brakes on at 94 knots; full pressure dumps on LOB; partial pressure dumps on RIB
58	MB-Dry	Worn	0.64	0.70	0.13	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
59	MB-Dry	Worn	0.88	1.10	0.23	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
64	MB-Wet	Worn	0.79	0.86	0.15	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
65	MB-Wet	Worn	0.95	0.95	0.20	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
66	MB-Wet	Worn	0.70	0.80	0.19	0.14	—	—	—	—	Normal reverse thrust; occasional moderate pressure dumps - both wheels
61	MB-Wet	Worn	0.77	0.85	0.26	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
62	MB-Wet	Worn	0.79	1.02	0.28	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
63	MB-Wet	Worn	0.70	0.76	0.20	LOB-2.01 RIB-1.86	—	—	—	—	Normal reverse thrust; occasional pressure dumps - both wheels
67	MB-Dry	New	0.79	0.87	0.18	0.10	—	—	—	—	No pressure dumps
71	MB-Wet	New	0.90	1.00	0.20	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
72	MB-Dry	Worn	0.80	0.99	0.20	0.23	—	—	—	—	Occasional moderate pressure dumps - LOB

LOB - Left outboard wheel
RIB - Right inboard wheel
TD - Touchdown

MW - Main wheels
NW - Nose wheels
MB - Maximum brake application

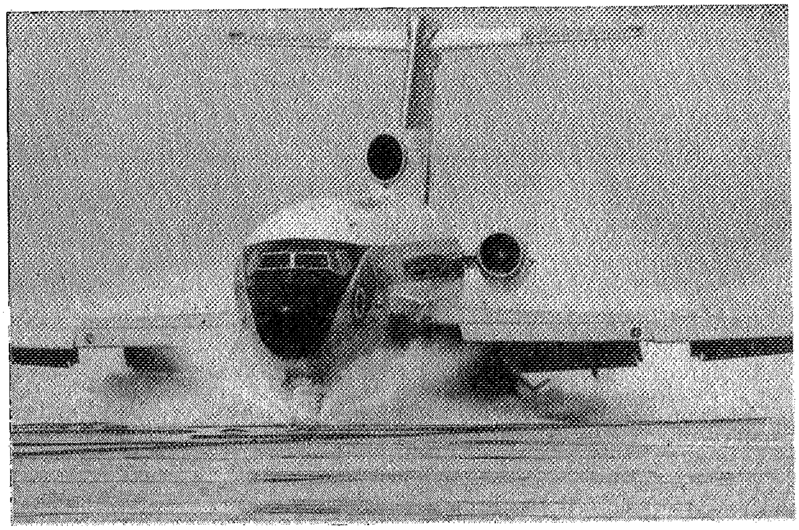
TABLE XI.- Concluded.

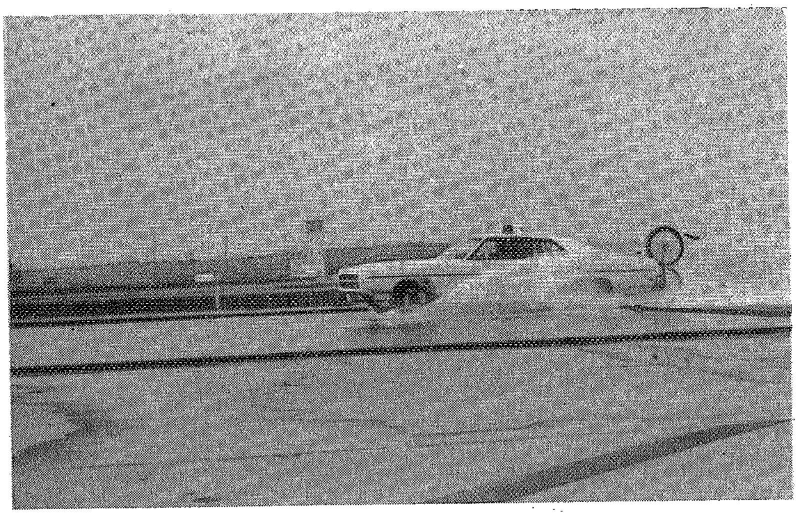
RUN NO.	TYPE OF TEST	MAIN GEAR TIRES	WHEEL SPIN-UP TIME-SEC			TIME TO BRAKES ON, SEC	TIME TO WHEEL LOCKUP, SEC		DEGREE OF WHEEL SKID		NOTES
			LOB	RIB	NOSE		OUT'BD	IN'BD	SHALLOW	DEEP	
73	MB-Dry	Worn	0.83	0.98	0.25	0.10	—	—	—	—	Occasional moderate pressure dumps - LOB
74	MB-Dry	Worn	0.70	0.76	0.20	0.18	—	—	—	—	Normal reverse thrust; occasional pressure dumps - both wheels
78	MB-Wet	Worn	0.89	1.02	0.26	0.10	—	—	RIB	LOB	Full pressure dumps - both wheels; anti-skid control box "F"
79	MB-Wet	Worn	0.90	0.84	0.29	0.10	2.30	—	RIB	LOB	4 pressure applications on LOB prior to lockup; full pressure dumps - both wheels; anti-skid control box "B"
80	MB-Wet	Worn	1.10	1.05	0.33	0.10	—	—	RIB	LOB	Normal reverse thrust - full pressure dumps - both wheels
75	MB-Wet	Worn	0.90	0.95	0.19	0.10	2.55	—	RIB	LOB	5 pressure applications on LOB prior to lockup; full pressure dumps - both wheels; anti-skid control box "F" for this and subsequent runs
76	MB-Wet	Worn	0.75	0.81	0.18	0.28	2.26	—	RIB	LOB	6 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
77	MB-Wet	Worn	1.45	1.10	0.23	LOB-0.23 RIB-0.20	—	—	RIB	LOB	Normal reverse thrust; full pressure dumps - both wheels
81	MB-Dry	New	0.87	1.11	0.23	0.27	—	—	—	—	No pressure dumps
82	MB-Dry	New	0.90	0.87	0.21	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
83	MB-Dry	New	0.80	0.91	0.20	1.97	—	—	—	—	Normal reverse thrust; occasional pressure dumps - both wheels
84	MB-Wet	New	0.96	1.22	0.20	0.20	4.28	—	RIB	LOB	8 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
85	MB-Wet	New	0.92	1.12	0.20	LOB-0.58 RIB-0.35	7.20	—	RIB	LOB	11 pressure applications on LOB prior to lockup; full pressure dumps - both wheels
98	NB-Wet	New	1.30	1.42	0.99	LOB-4.40 RIB-6.10	—	—	RIB	LOB	TD in water; normal brake application; full pressure dump - both wheels
86	MB-Dry	Worn	0.72	0.80	0.33	0.10	—	—	—	—	Occasional moderate pressure dumps - both wheels
87	MB-Dry	Worn	0.83	1.04	0.23	0.20	—	—	—	—	Occasional moderate pressure dumps - both wheels
88	MB-Wet	Worn	0.86	0.95	0.20	0.32	—	—	—	—	Full pressure dumps - both wheels
89	MB-Damp	Worn	0.81	0.97	0.18	0.24	—	—	—	—	Full pressure dumps - both wheels

LOB - Left outboard wheel
RIB - Right inboard wheel
TD - Touchdown

MW - Main wheels
NW - Nose wheels
MB - Maximum brake application

(a) B-727 test aircraft.





(b) NASA DBV

(c) Towing vehicle and Mu-Meter

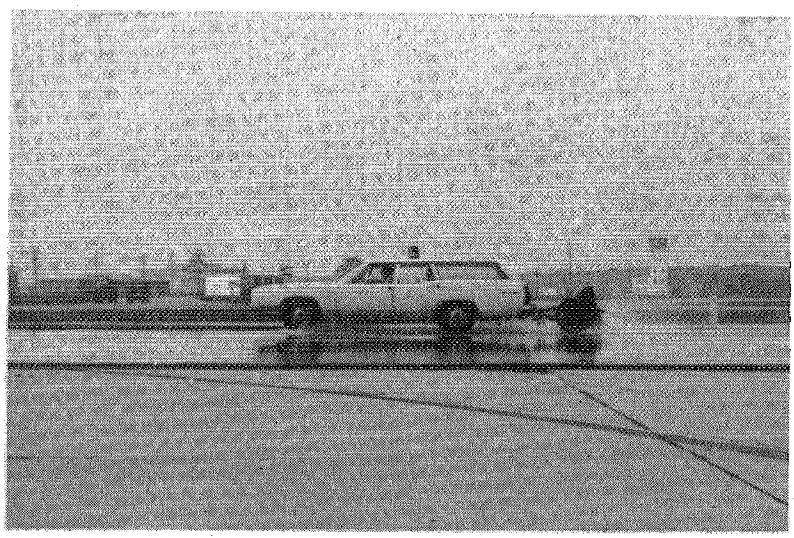


Figure 1 .- Test aircraft and ground vehicles.

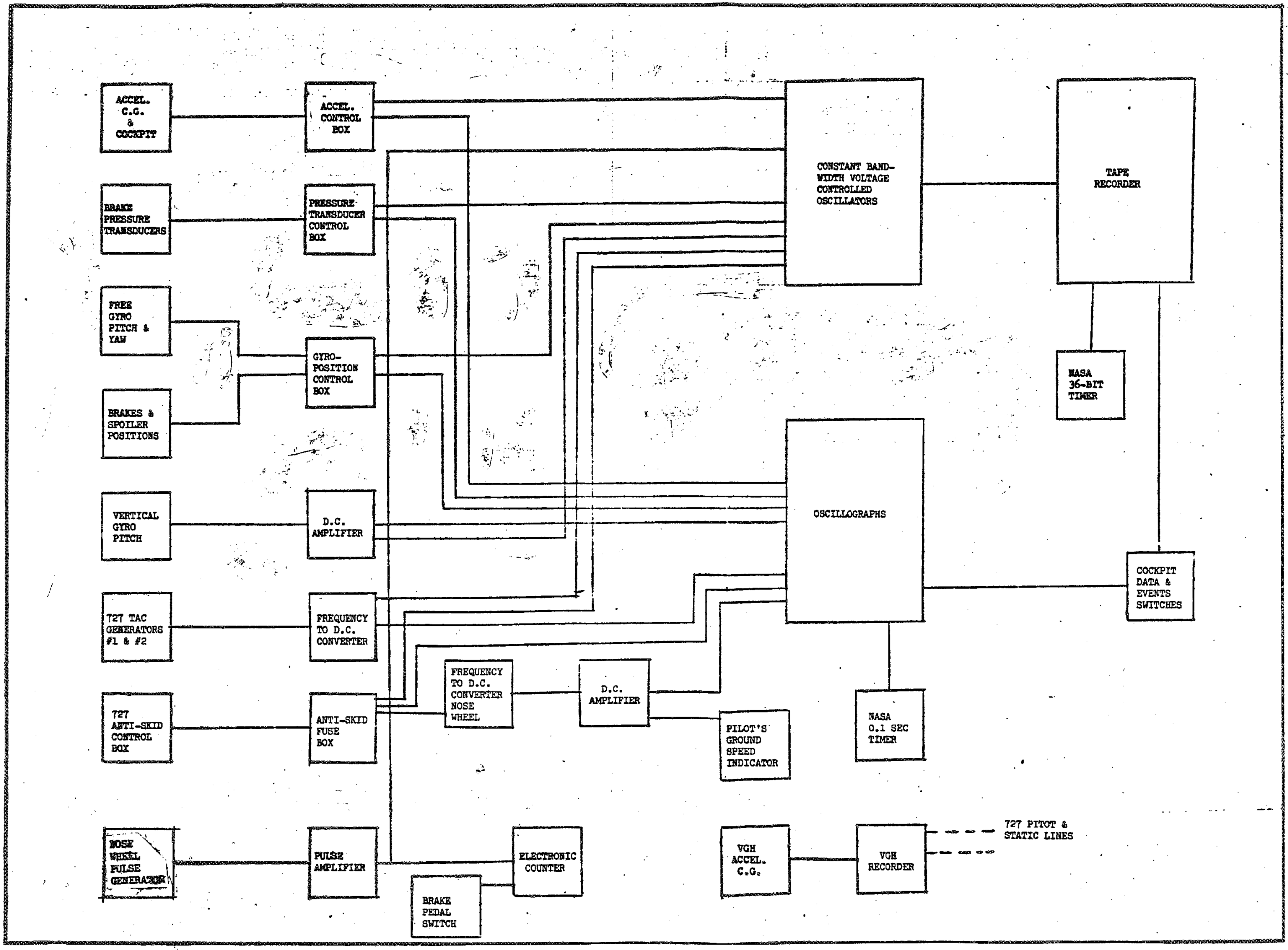


Figure 2.- Signal block diagram for NASA instrumentation on B-727 test aircraft.

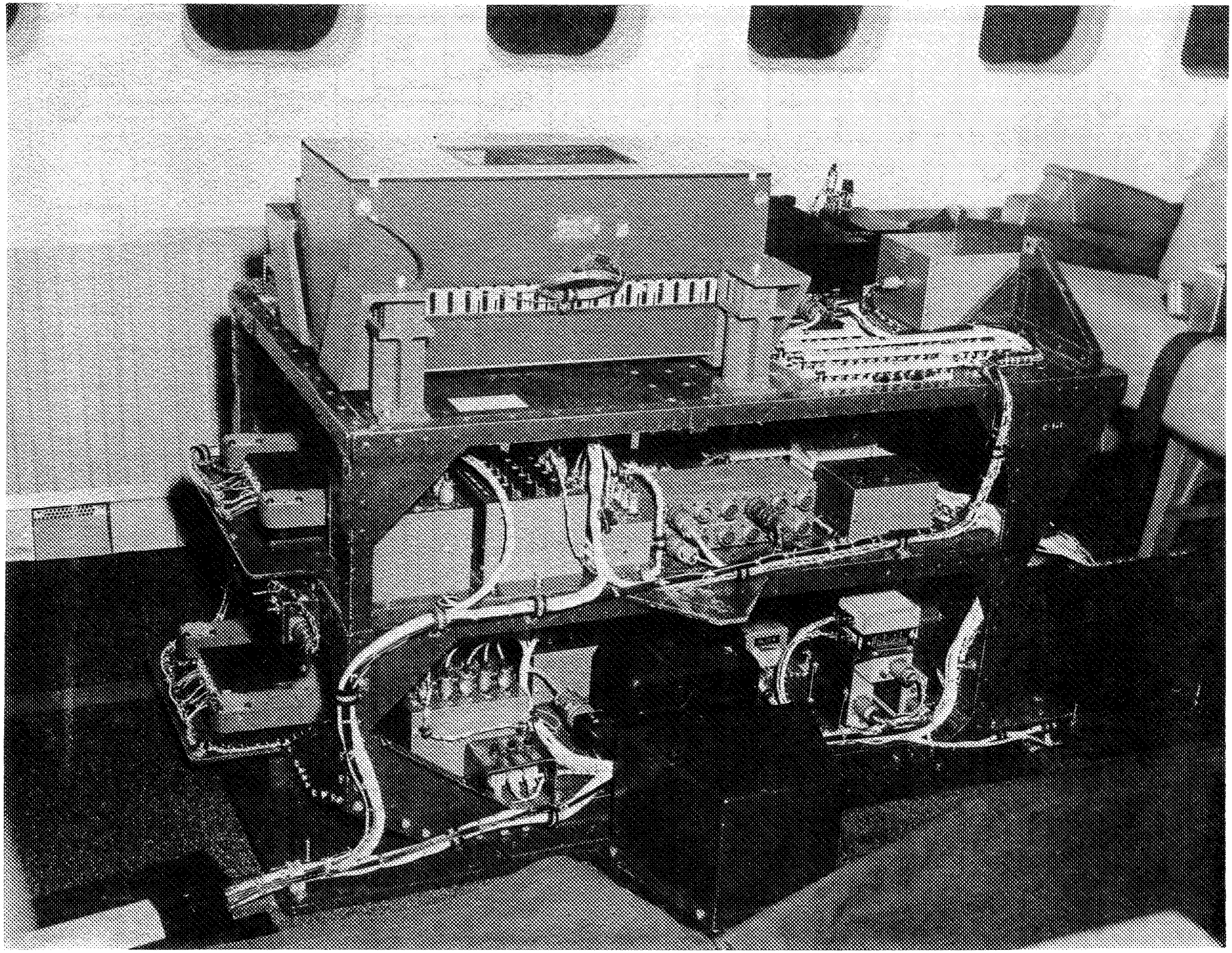
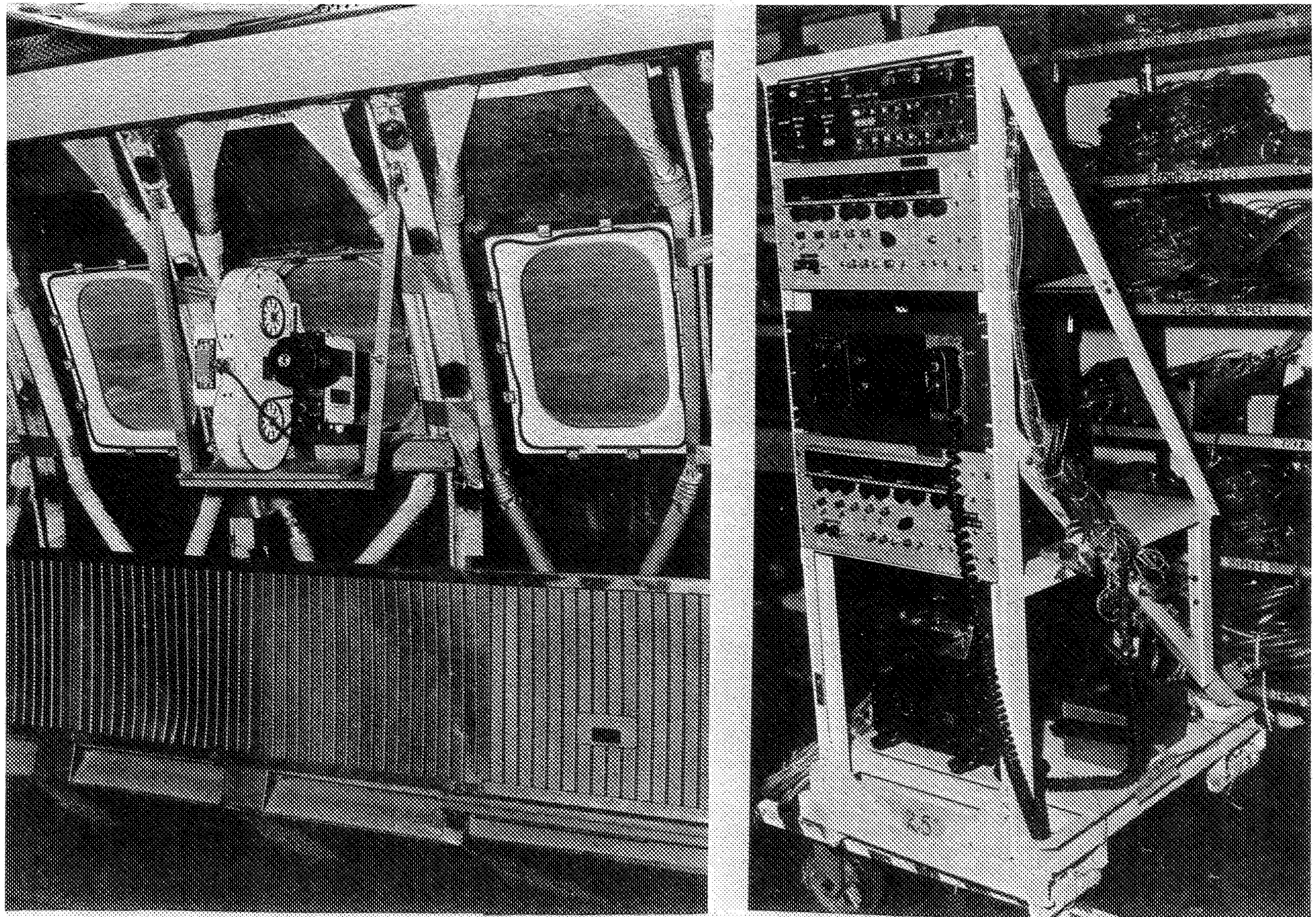


Figure 3.- NASA instrumentation rack on B - 727 aircraft.



a) Camera installation

b) Instrumentation

Figure 4.- Boeing phototheodolite tracking camera system on B - 727 aircraft.

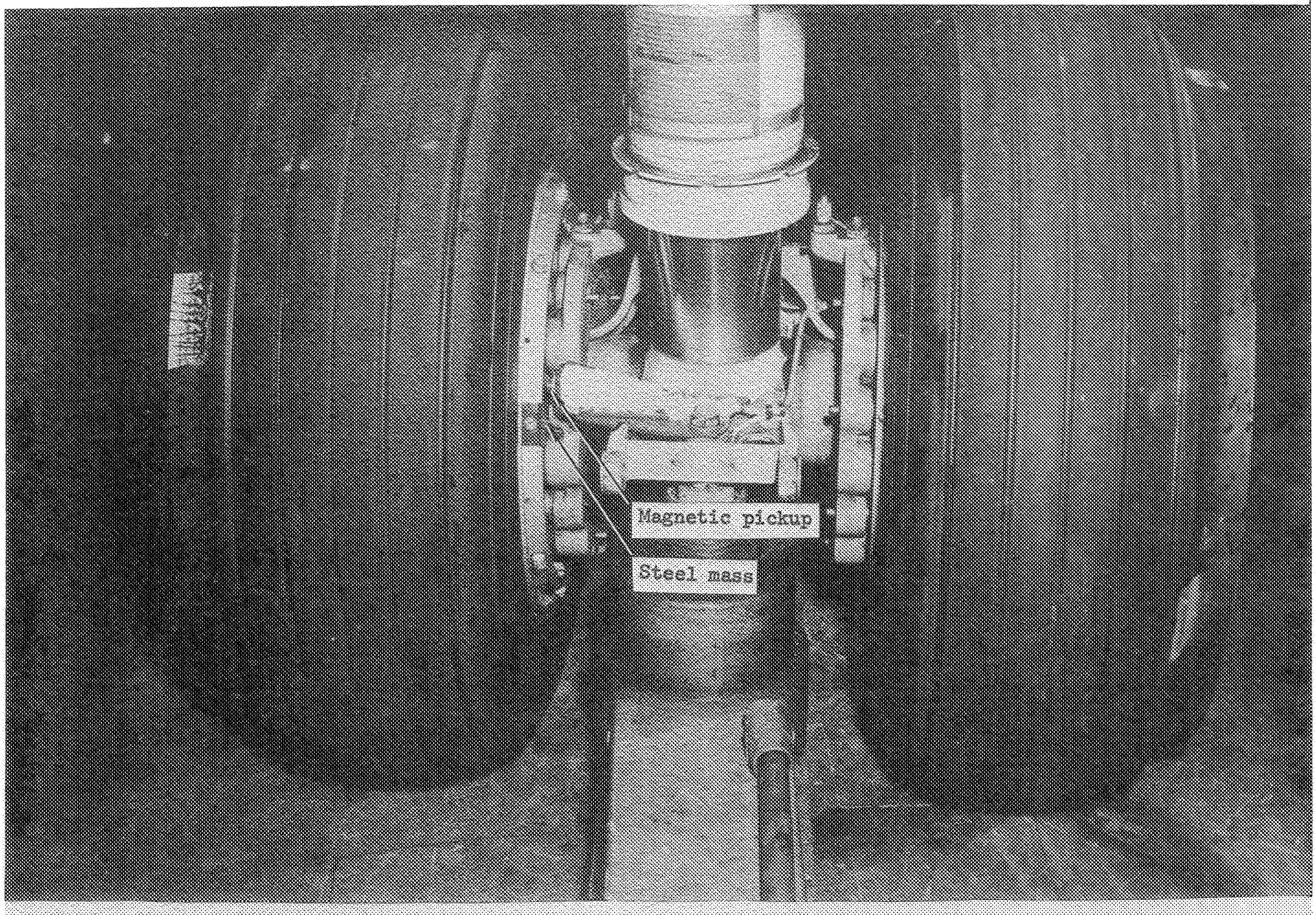


Figure 5.- NASA magnetic pick-up installation to measure nose wheel angular displacement (2 pulses/revolution)

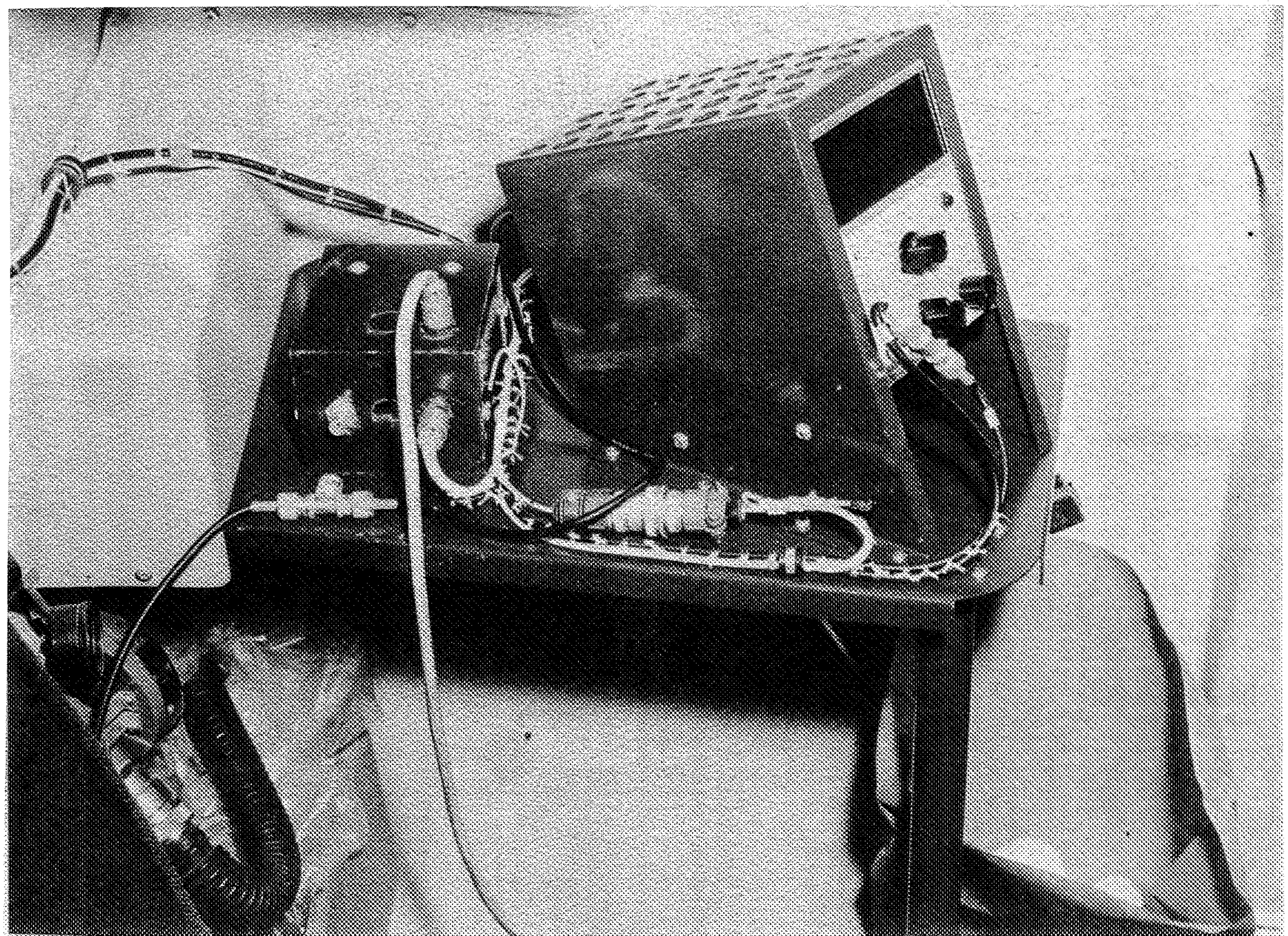


Figure 6.- Nose wheel revolution counter indicator mounted in B - 727 flight deck.

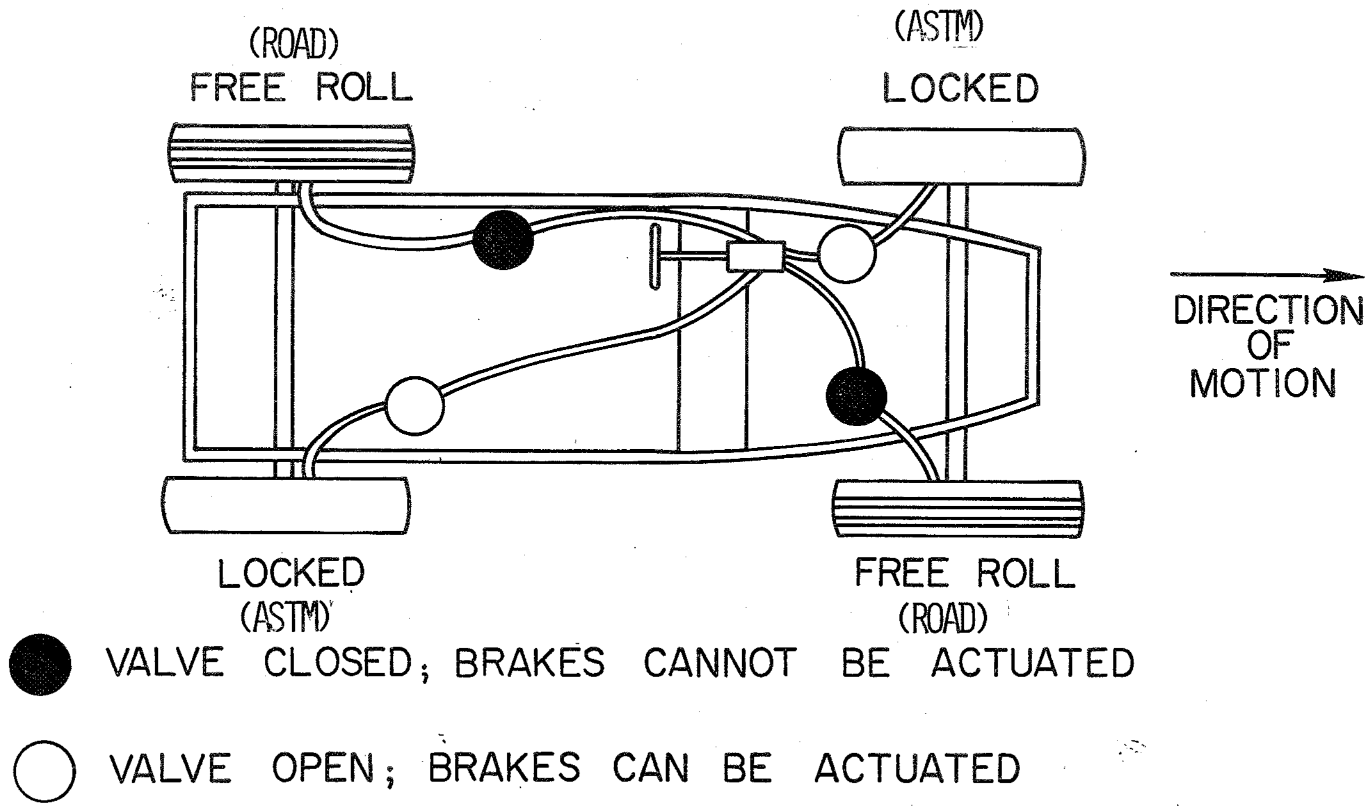


Figure 7.- Diagonal-braking system.

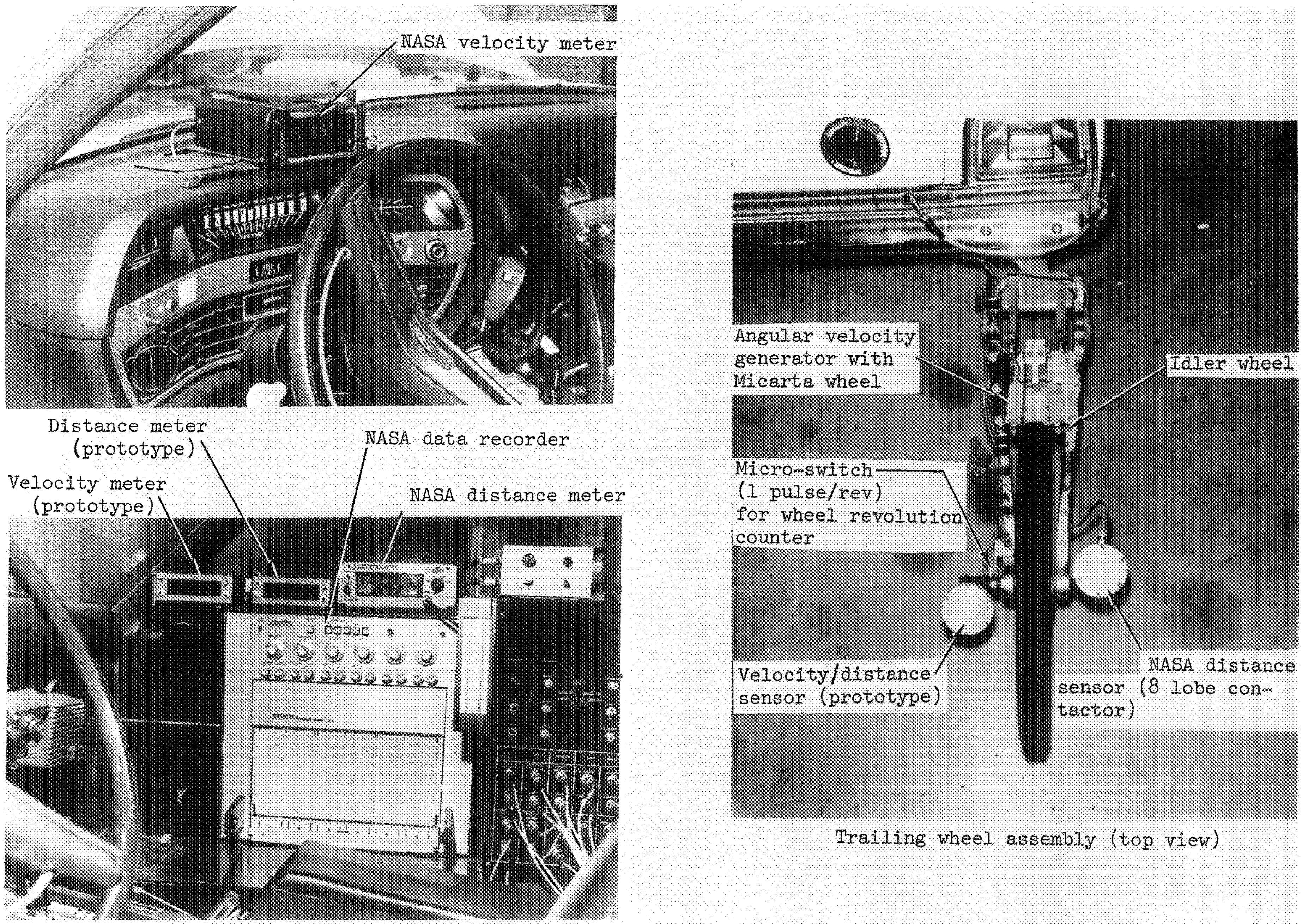
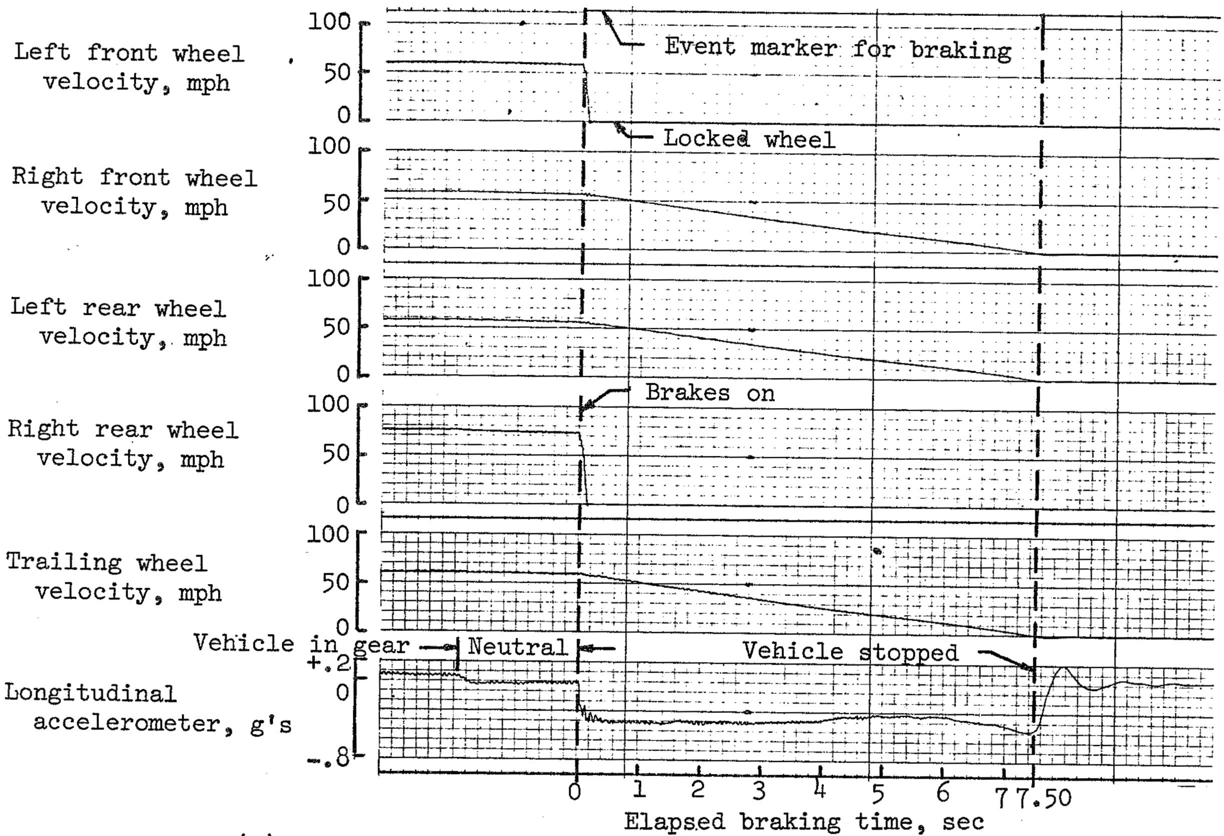
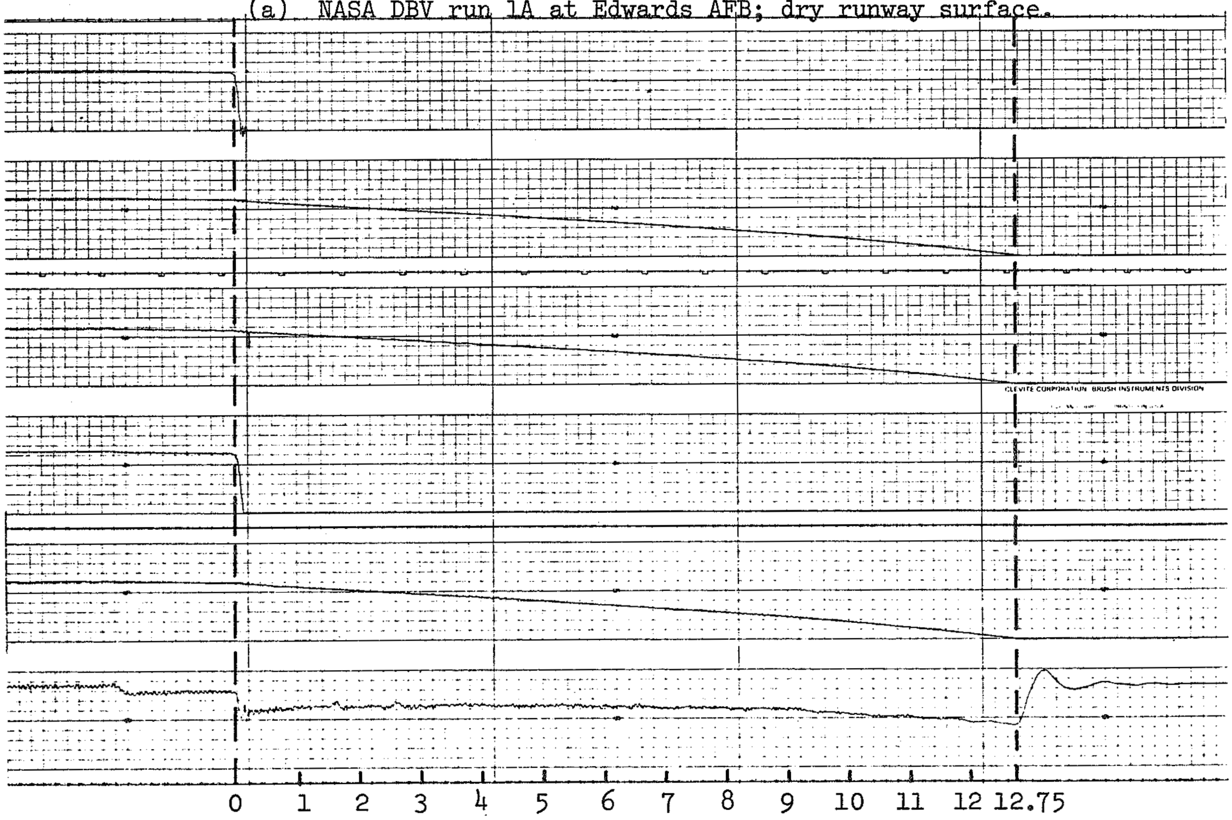


Figure 8.- NASA DBV instrumentation.



(a) NASA DBV run 1A at Edwards AFB; dry runway surface.



(b) NASA DBV run 7A on Houston wet runway conducted three minutes after aircraft run 42.

Figure 9.- Sample NASA DBV records of test runs performed during B-727 aircraft flight test program.

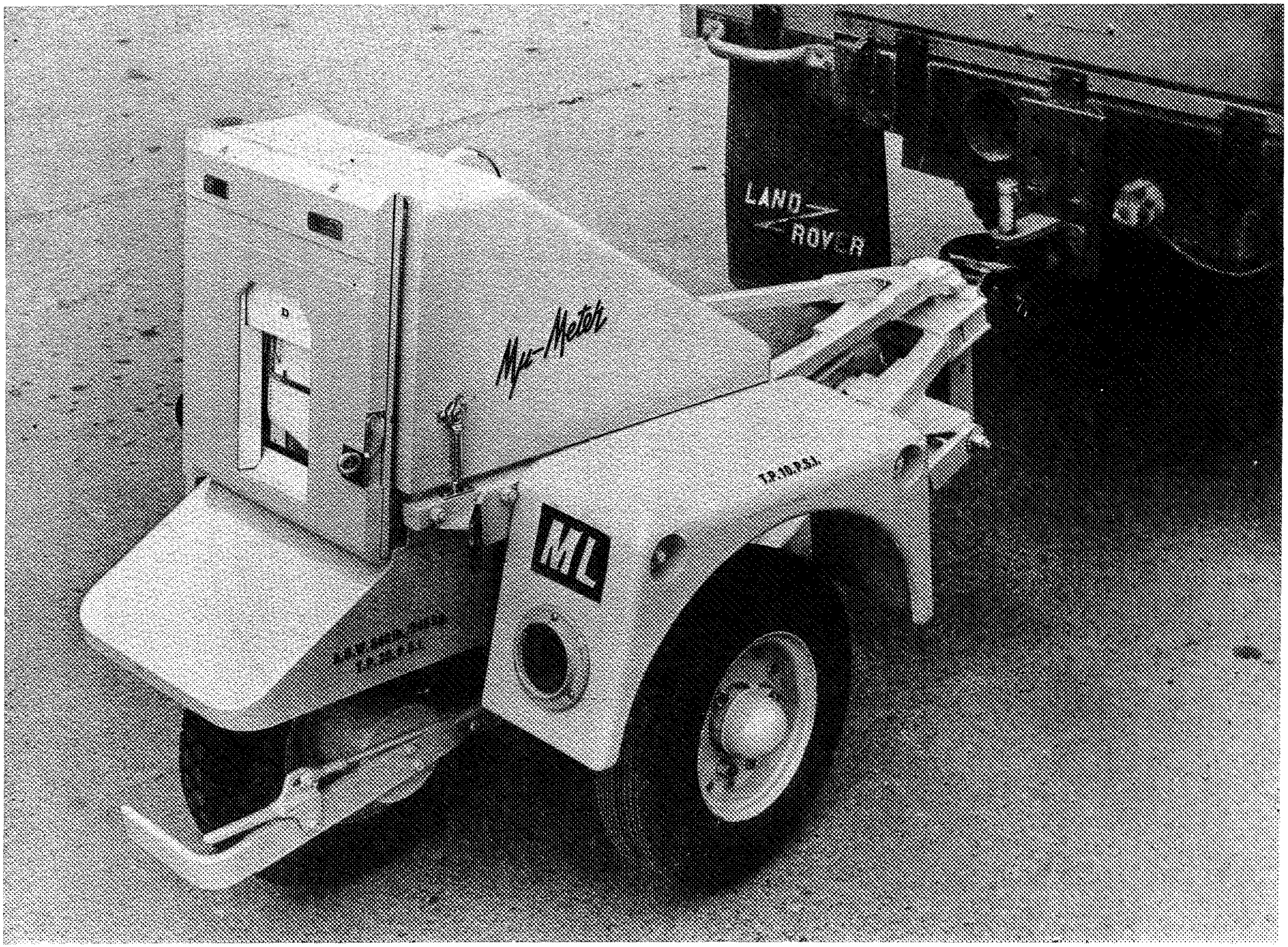


Figure 10.- Runway friction meter (Mu-Meter)

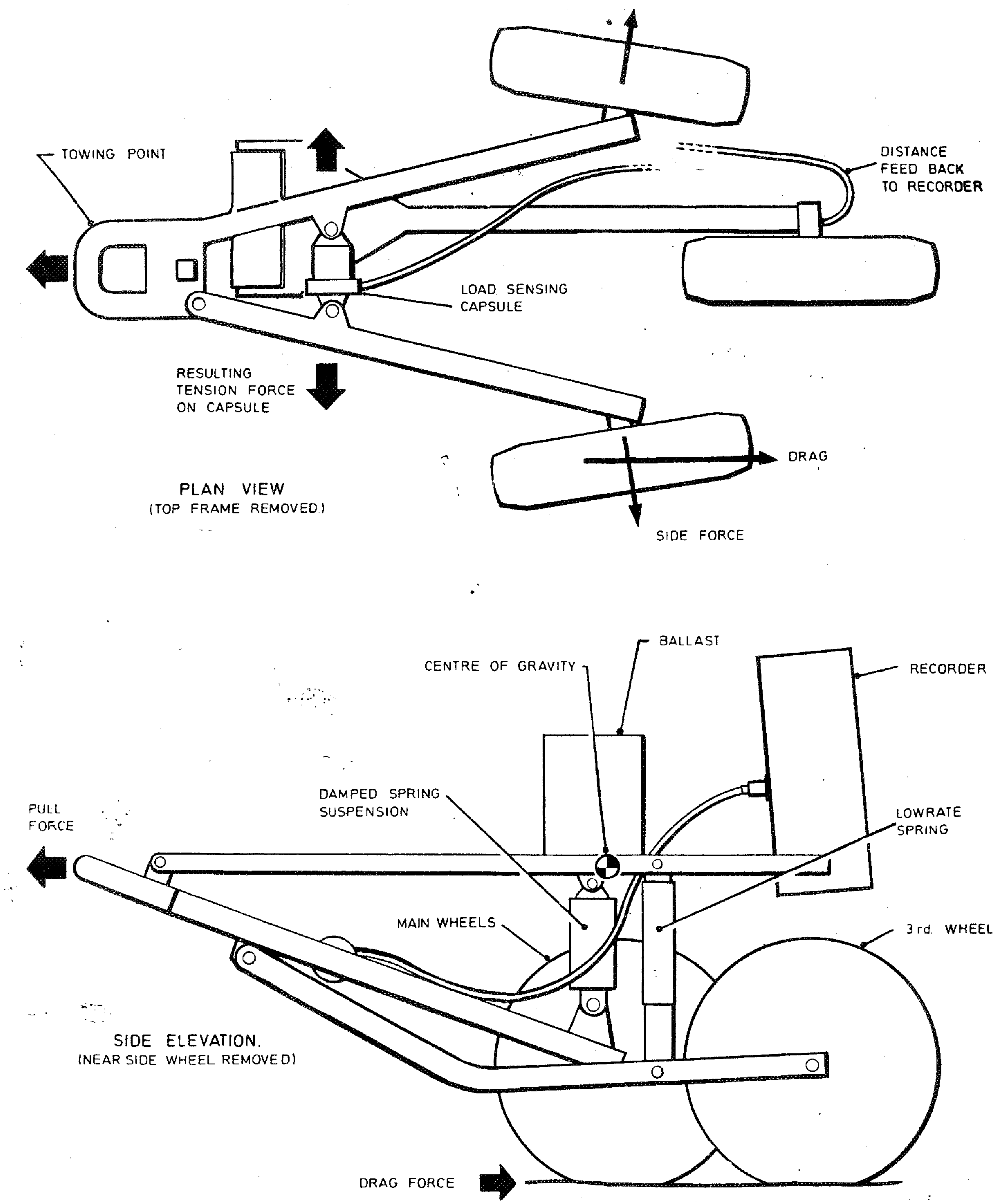


Figure 11.- Diagrammatic layout of Mu-Meter

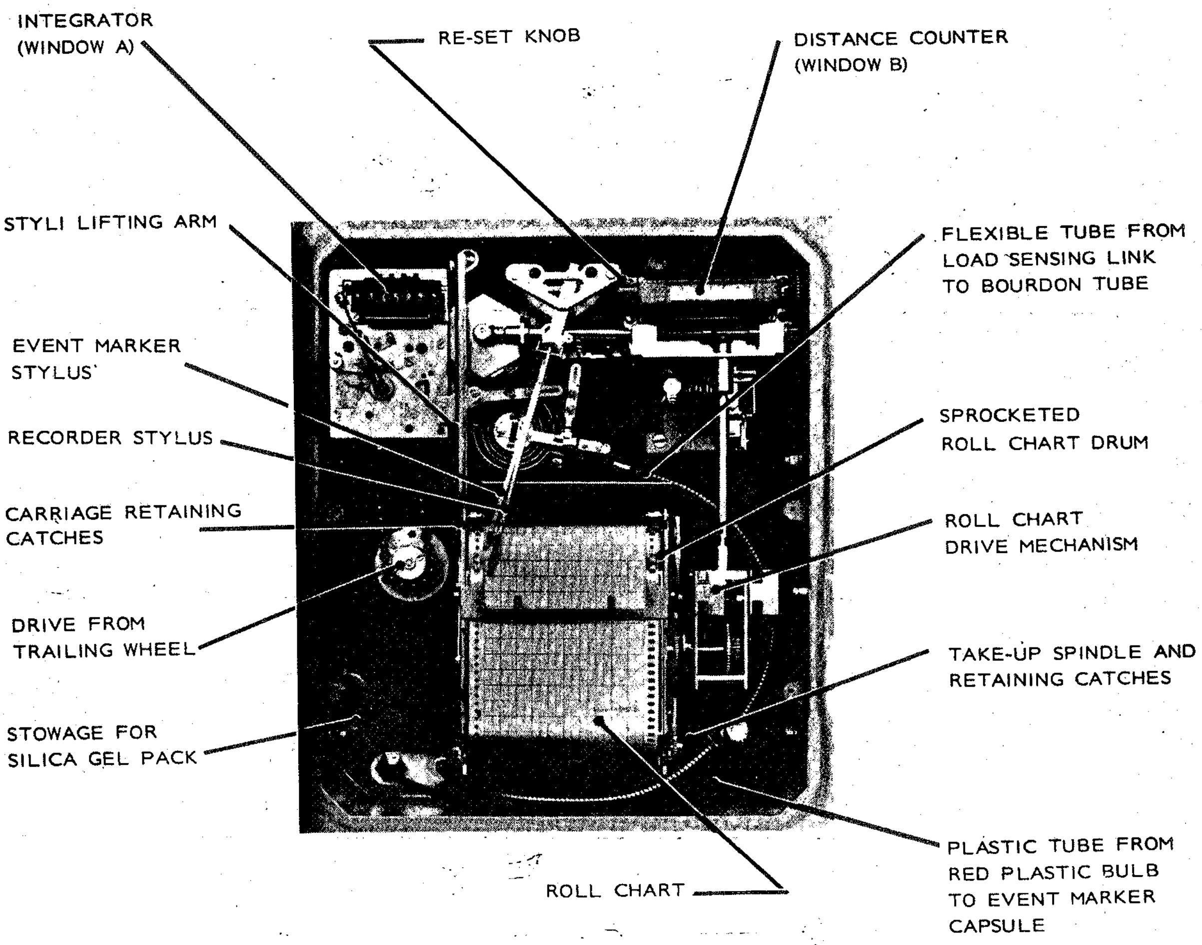
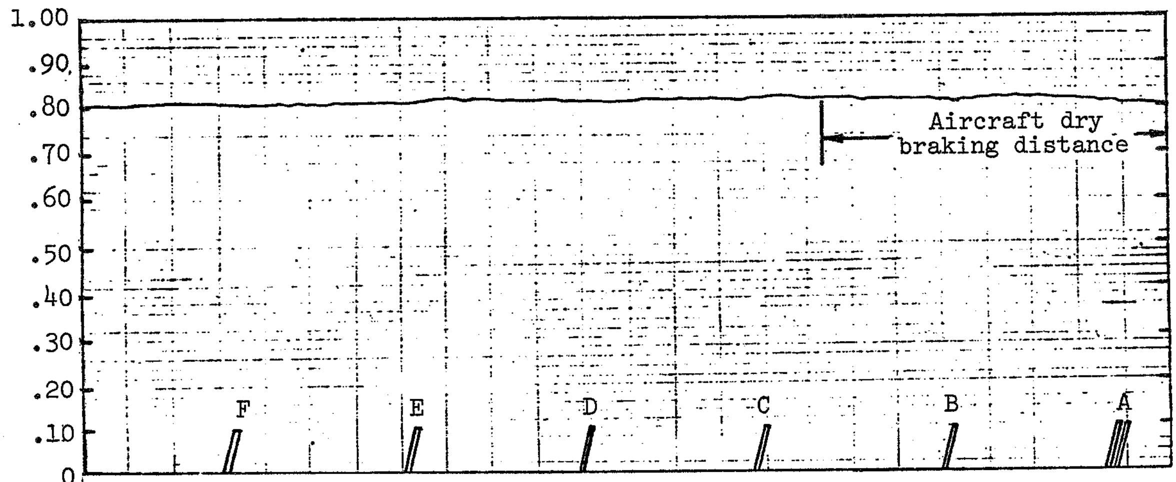
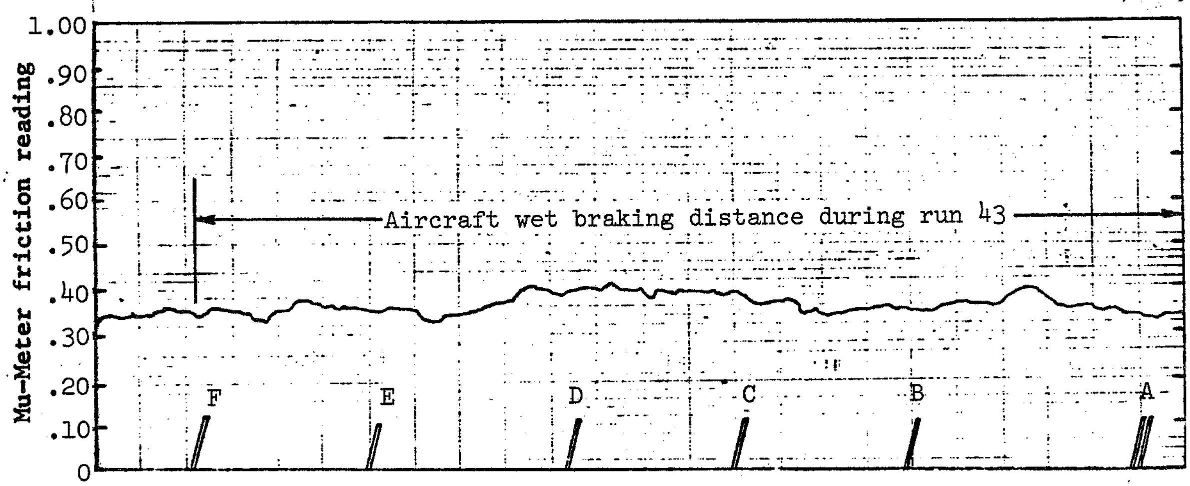


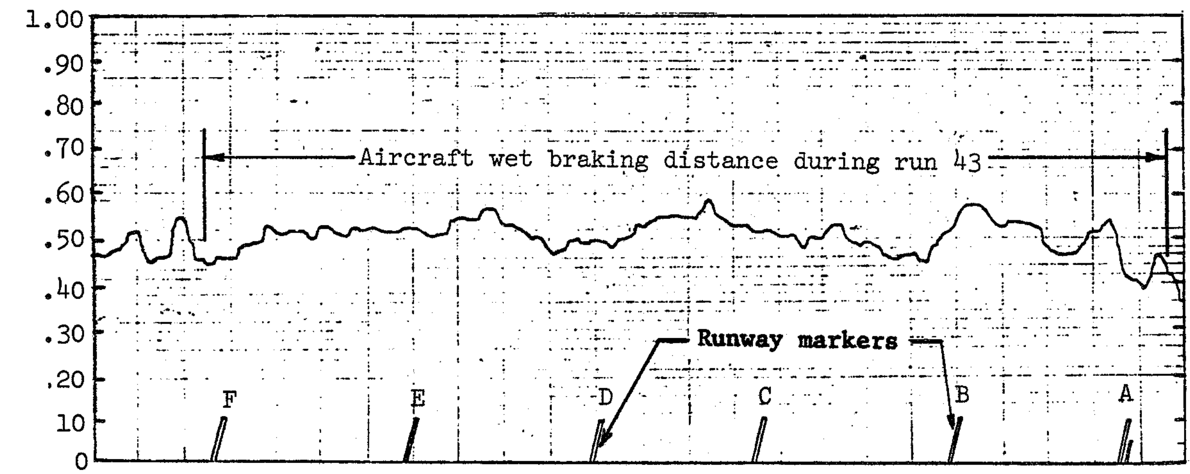
Figure 12.- Mu-Meter instrumentation



(a). Mu-Meter run 1; 40 mph; dry runway surface.



(b) Mu-Meter run 9; 40 mph; conducted two minutes before aircraft run 43.



(c) Mu-Meter run 10; 40 mph; conducted three minutes after aircraft run 43.

Figure 13.- Typical Mu-Meter records of test runs performed during B-727 aircraft flight test program on runway 8L/26R at Houston Intercontinental Airport.

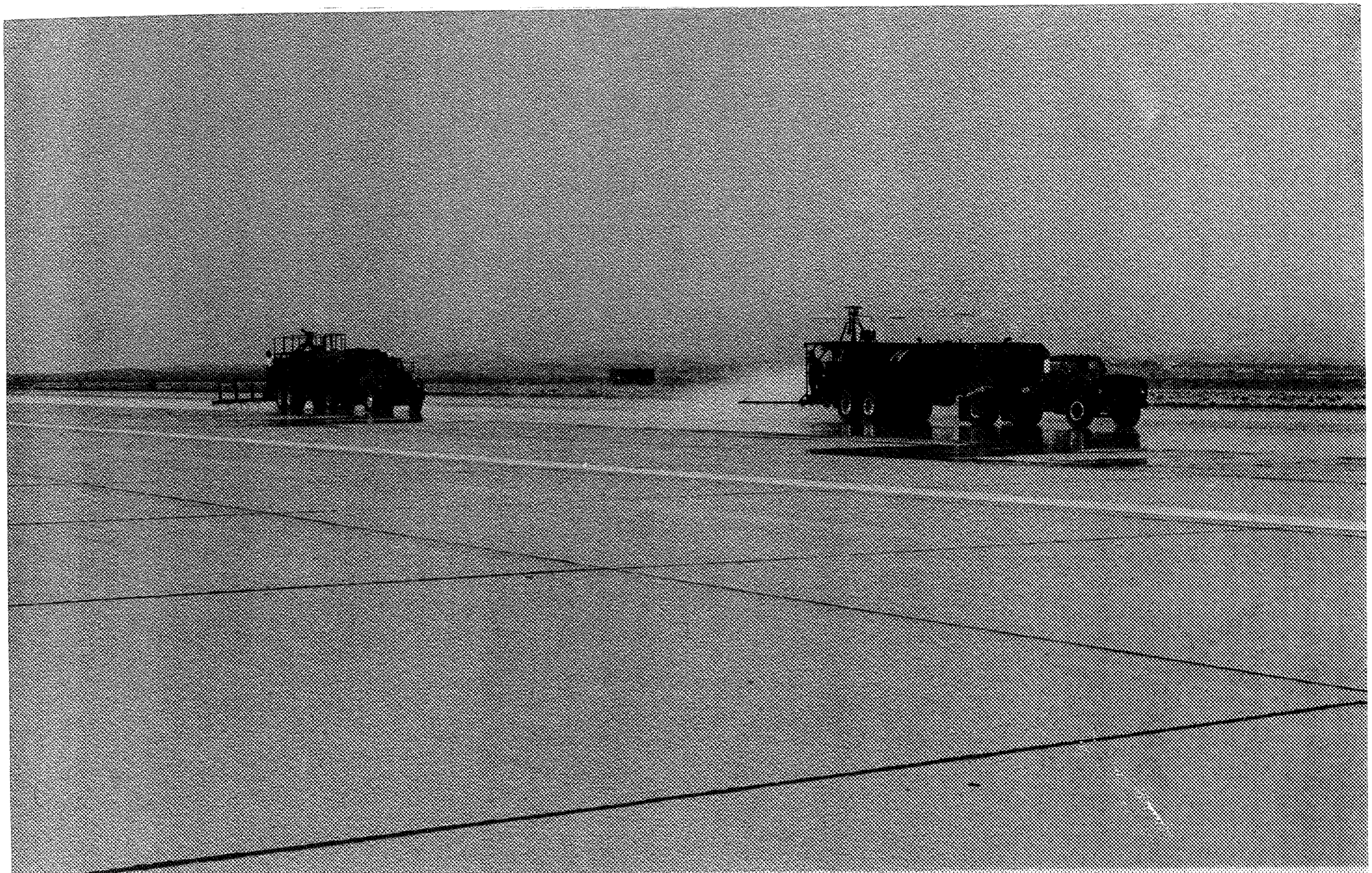


Figure 14.- Typical runway wetting equipment and operation during testing at Edwards AFB.

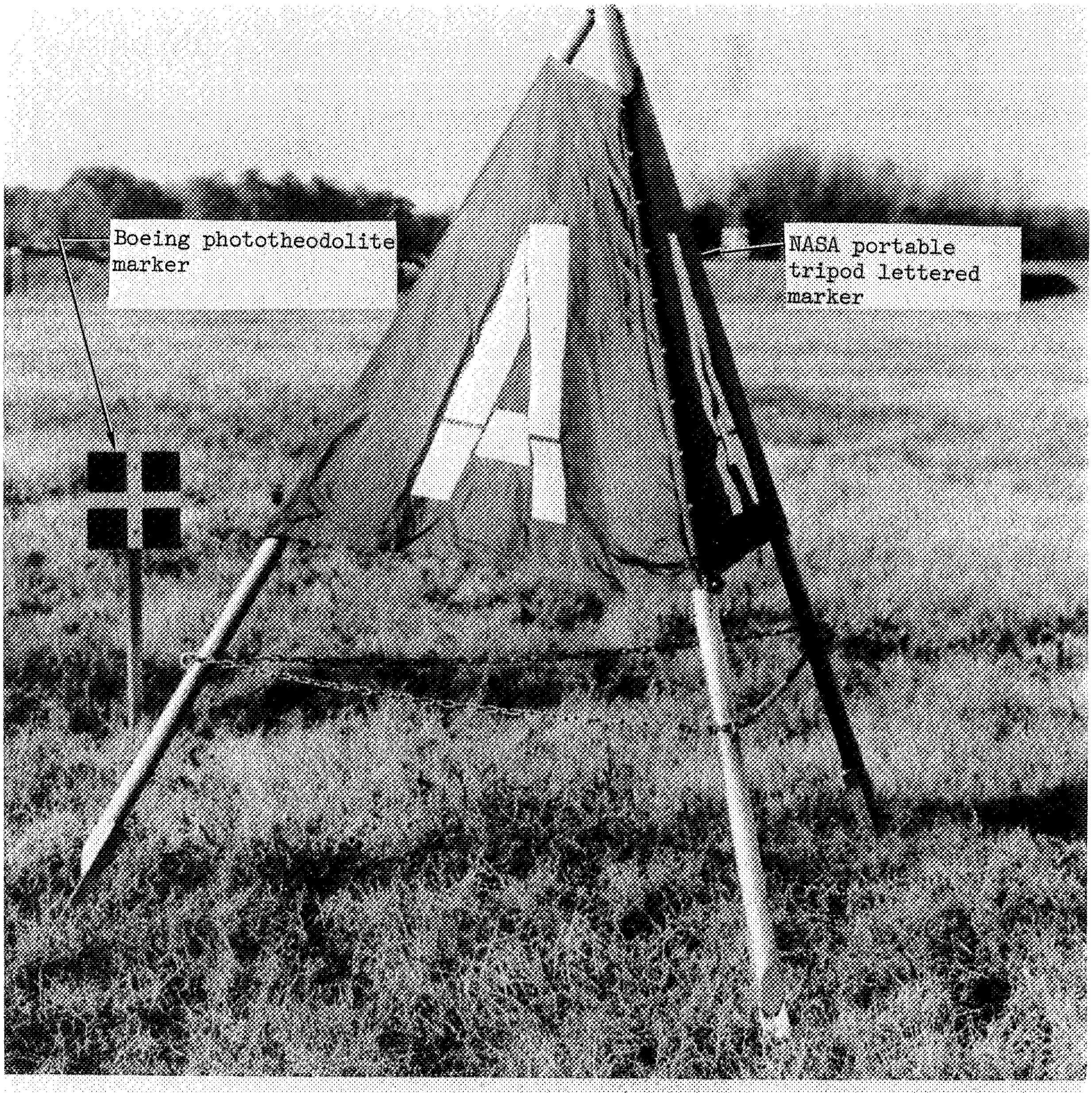
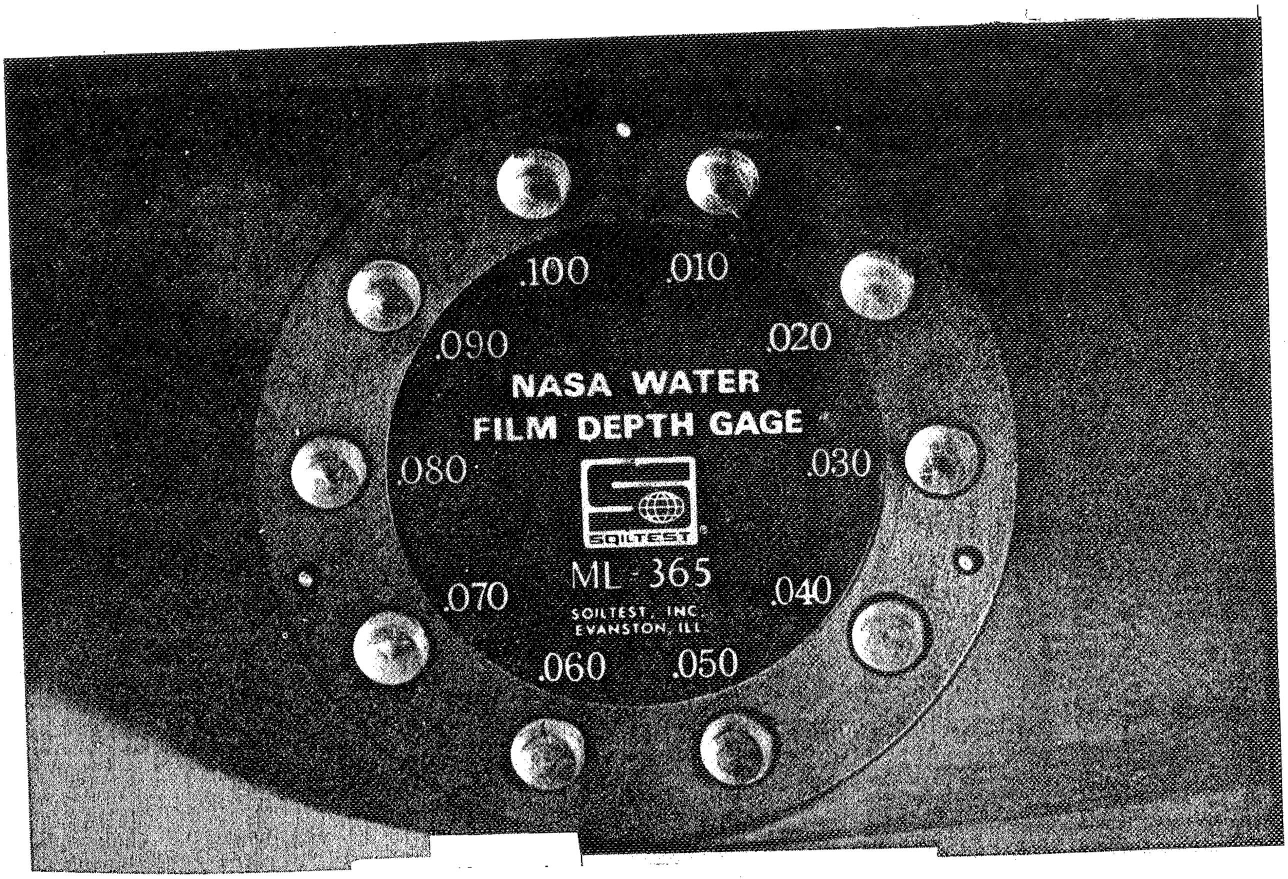
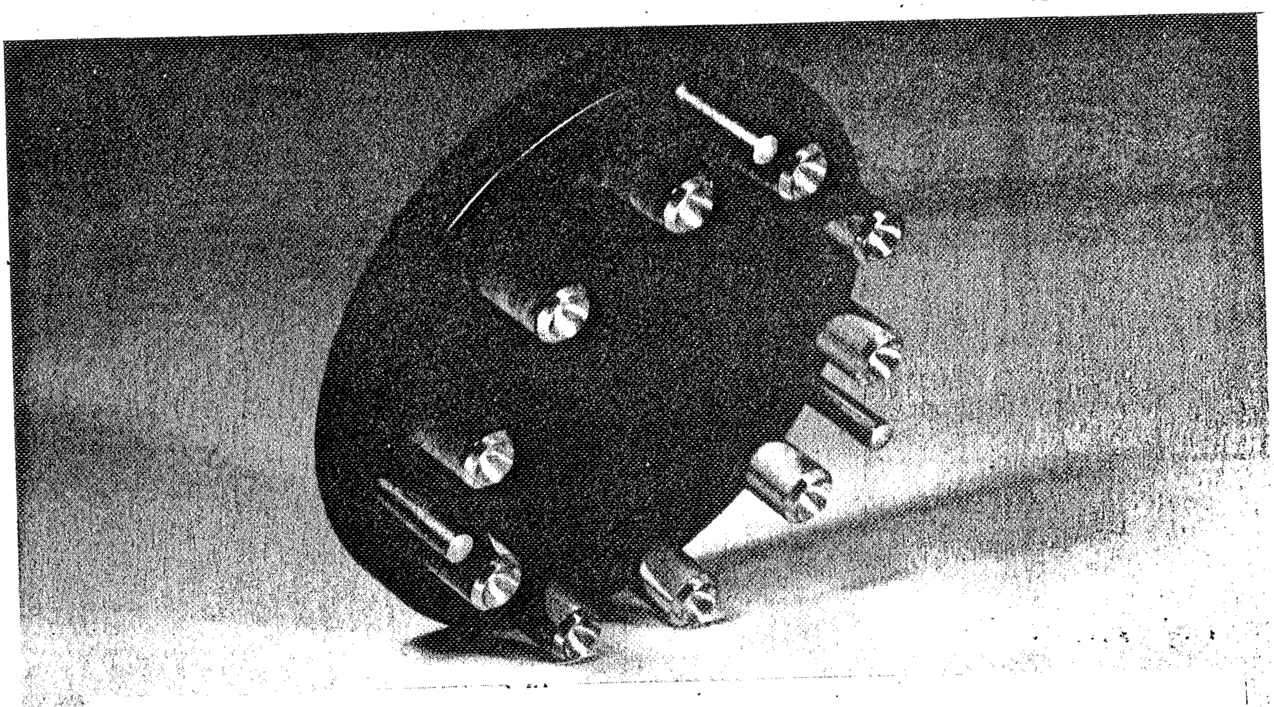


Figure 15.- Markers used to define runway test section and coordinate data acquisition.



(a) Front view



(b) 3/4 Rear view

Figure 16.- NASA water depth gage.

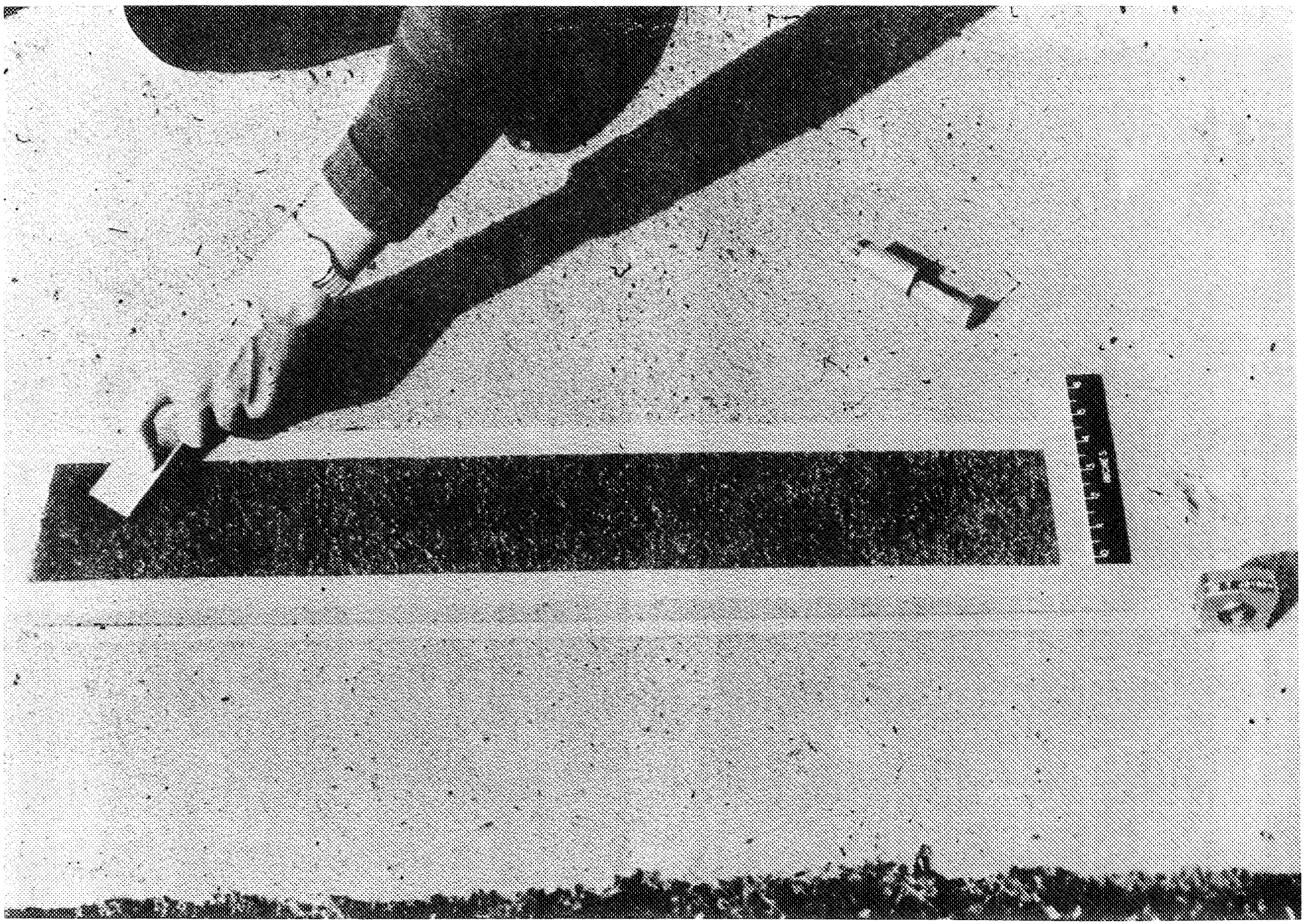


Figure 17.- Runway texture depth measuring kit.

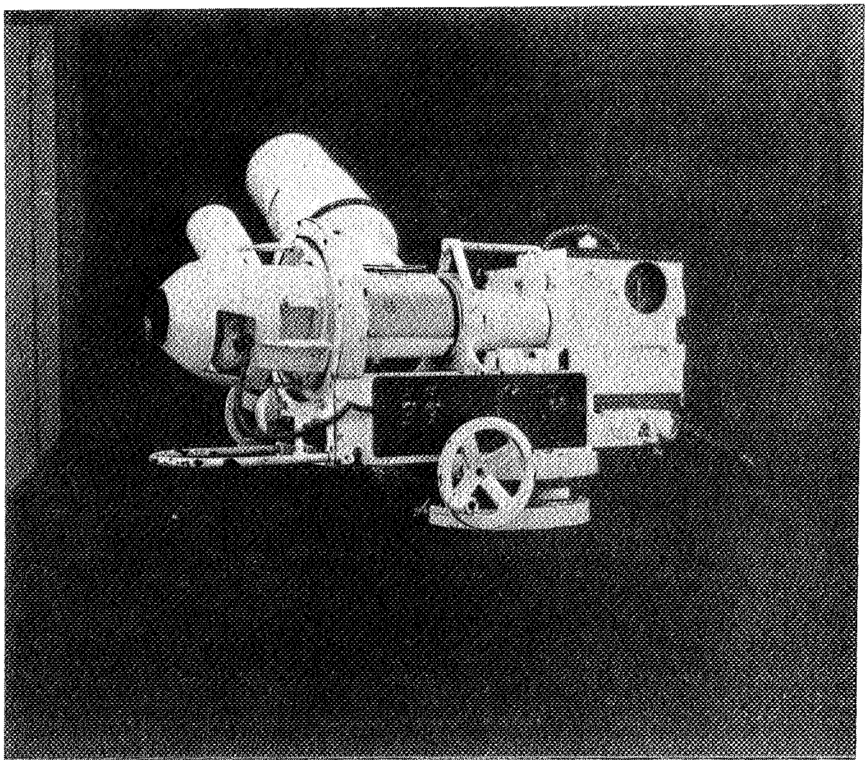
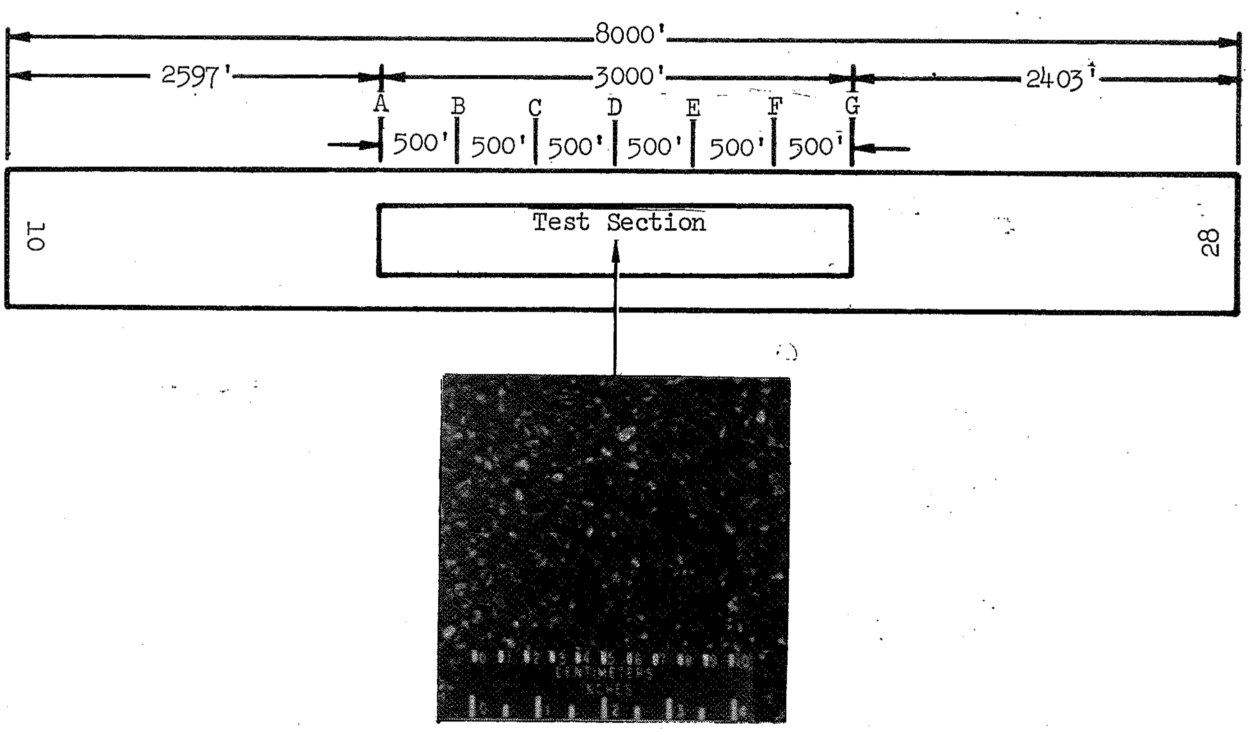


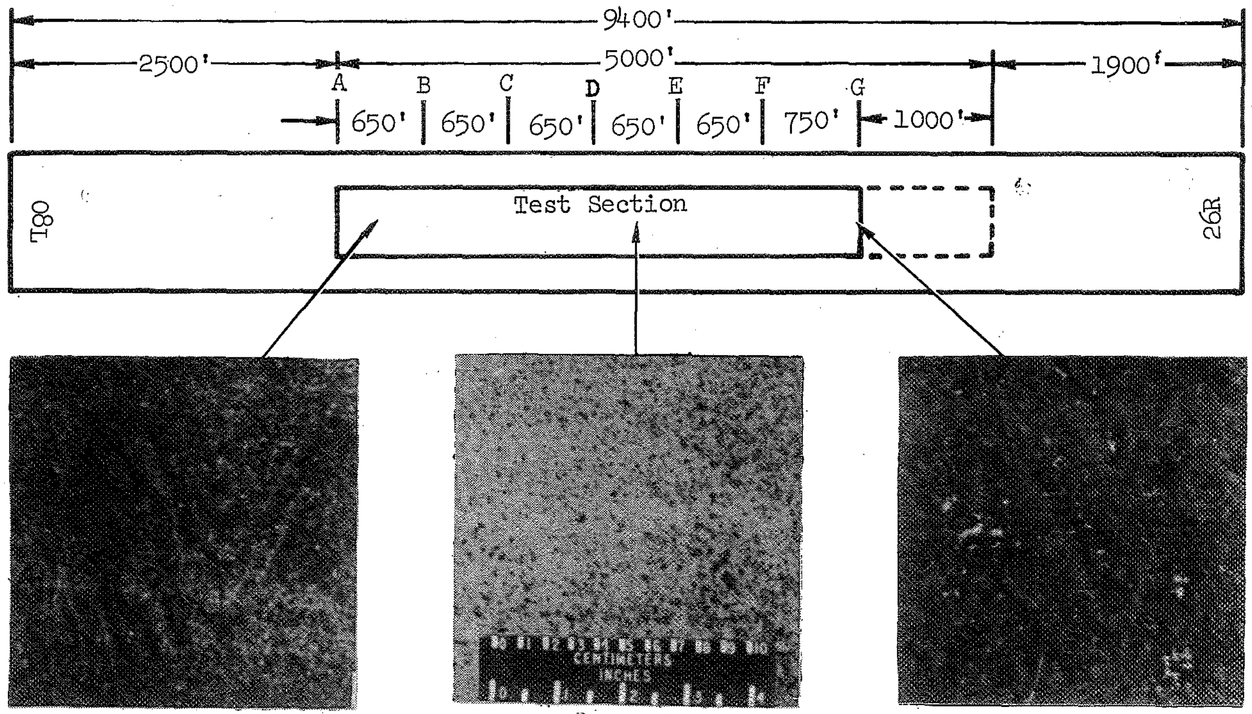
Figure 18.- USAF portable phototheodolite.



Runway	Test Section
Elevation: 38 ft Width: 200 ft Crown: 1 percent Surface Type: Slurry seal asphalt Effective gradient: Variable	Rubber contamination: Negligible Average texture depth: 0.28 mm Effective gradient: 0

(a) NASA Wallops Station.

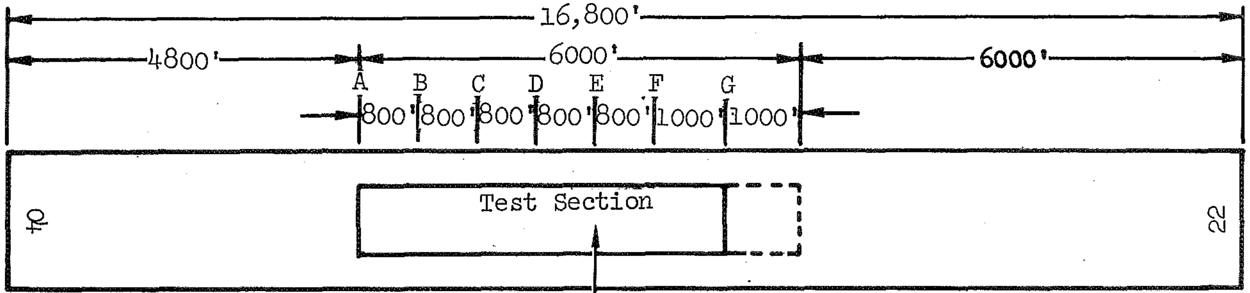
Figure 19.- Test runway schematics and surface characteristics.

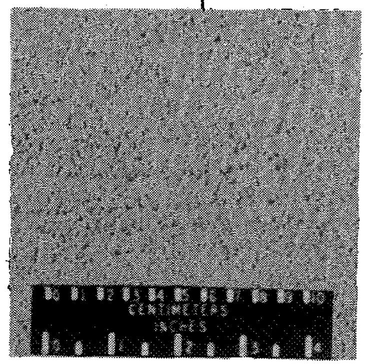


Runway	Test Section
Elevation: 98 ft Width: 150 ft Crown: 1 percent **Surface type: Canvas-belted finished PCC** **Effective gradient: 0.035 percent**	Rubber contamination: Markers A-B (650 ft) Marker G + (1000 ft) Average texture depth: 0.20 mm Effective gradient: -0.035 percent

(b) Houston Intercontinental Airport.

Figure 19.- Continued.

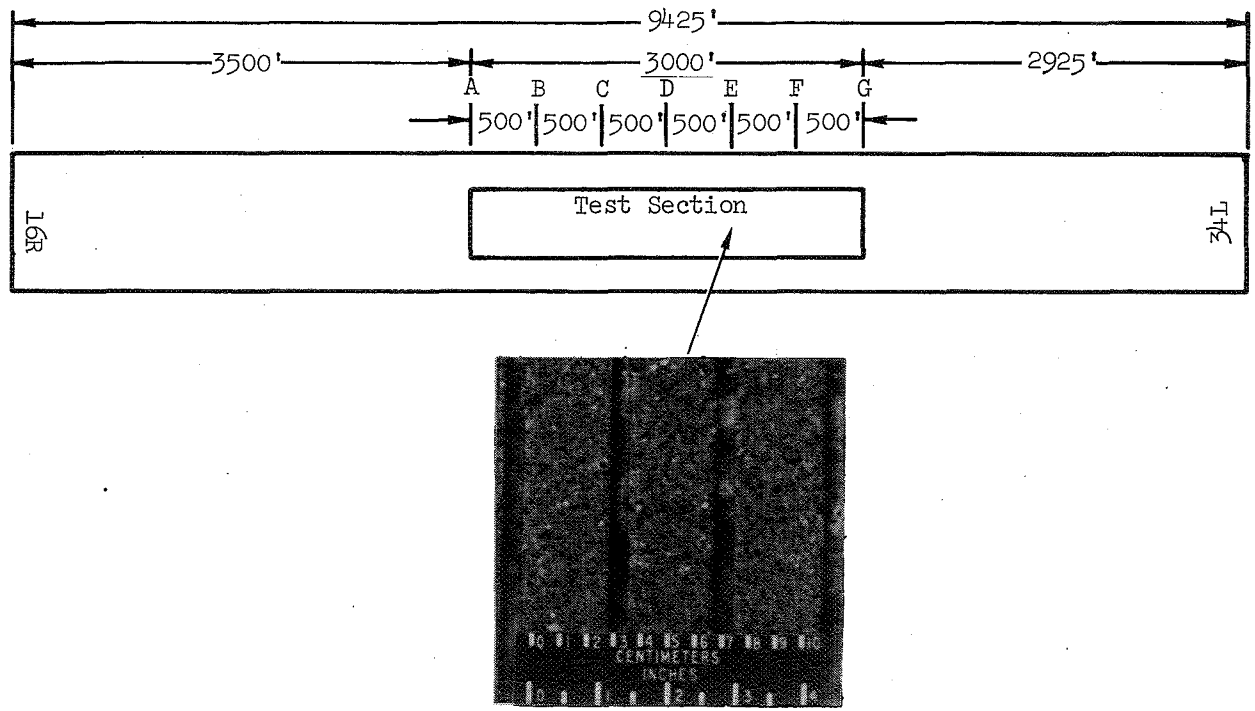




Runway	Test Section
Elevation: 2307 ft Width: 300 ft Crown: 0.5 percent Surface type: Longitudinal **belt-finished** PCC Effective gradient: 0.140 percent	Rubber contamination: Negligible Average texture depth: 0.12 mm Effective gradient: -0.140 percent

(c) Edwards Air Force Base

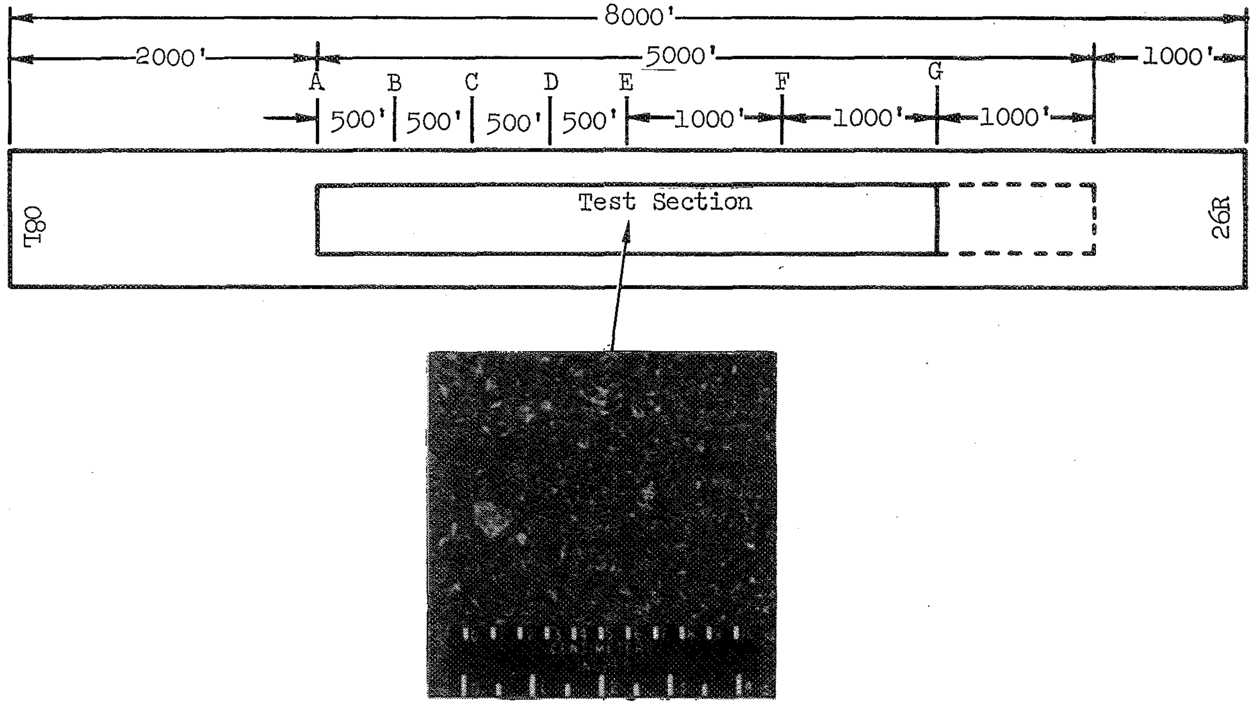
Figure 19.- Continued.



Runway	Test Section
Elevation: 428 ft Width: 150 ft Crown: 1 percent Surface type: Transversely grooved concrete Groove pattern: 1-1/2" × 1/4" wide × 1/4" deep Effective gradient: 0.67 percent	Rubber contamination: Negligible Average texture depth: ——— Effective gradient: -0.67 percent

(d) Seattle-Tacoma International Airport.

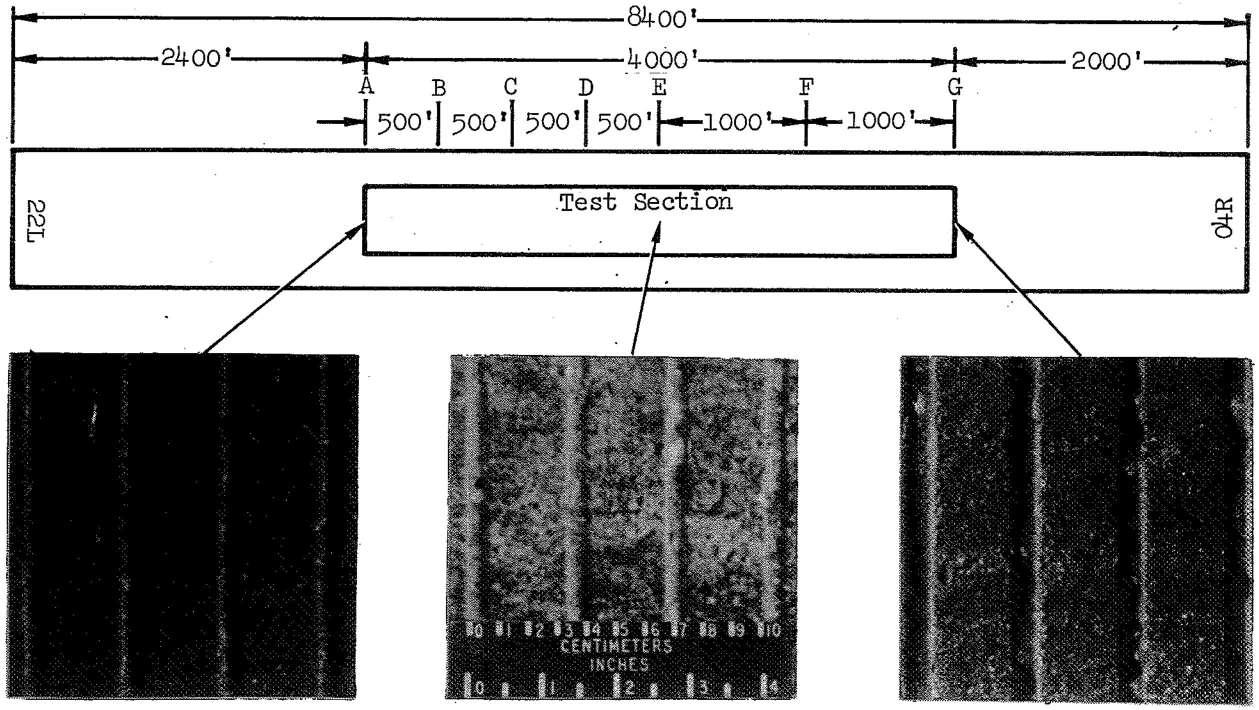
Figure 19.- Continued.



Runway	Test Section
Elevation: 3269 ft Width: 150 ft Crown: 1 percent Surface type: Plant mix asphalt Effective gradient: 0	Rubber contamination: Marker G + (1000 ft) Average texture depth: 0.16 **mm** Effective Gradient: 0

(e) Lubbock Regional Airport.

Figure 19.- Continued.



Runway	Test Section
Elevation: 12 ft Width: 150 ft Crown: 1 percent Surface type: Transversely grooved burlap-drag finished PCC Groove pattern: 1-3/8" × 3/8" top, 3/16" bottom width × 1/8" deep NOTE: Groove depth irregular due to surface unevenness Effective gradient: 0	Rubber contamination: Markers A-B (500 ft) Markers F-G (1000 ft) Average texture depth: ——— Effective gradient: 0

(f) J.F.K. International Airport.

Figure 19.- Concluded.

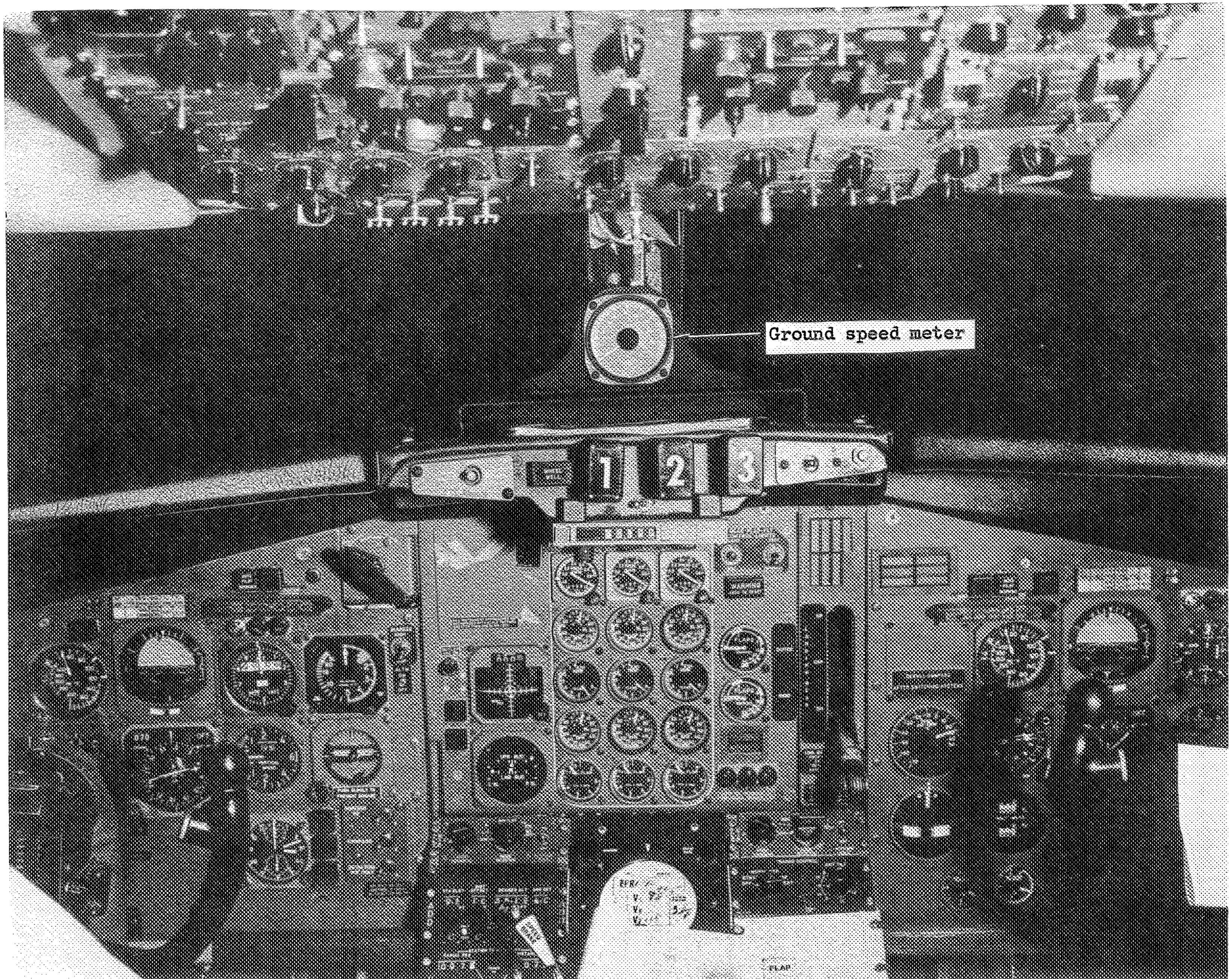


Figure 20.- NASA ground speed meter for B - 727 test aircraft.

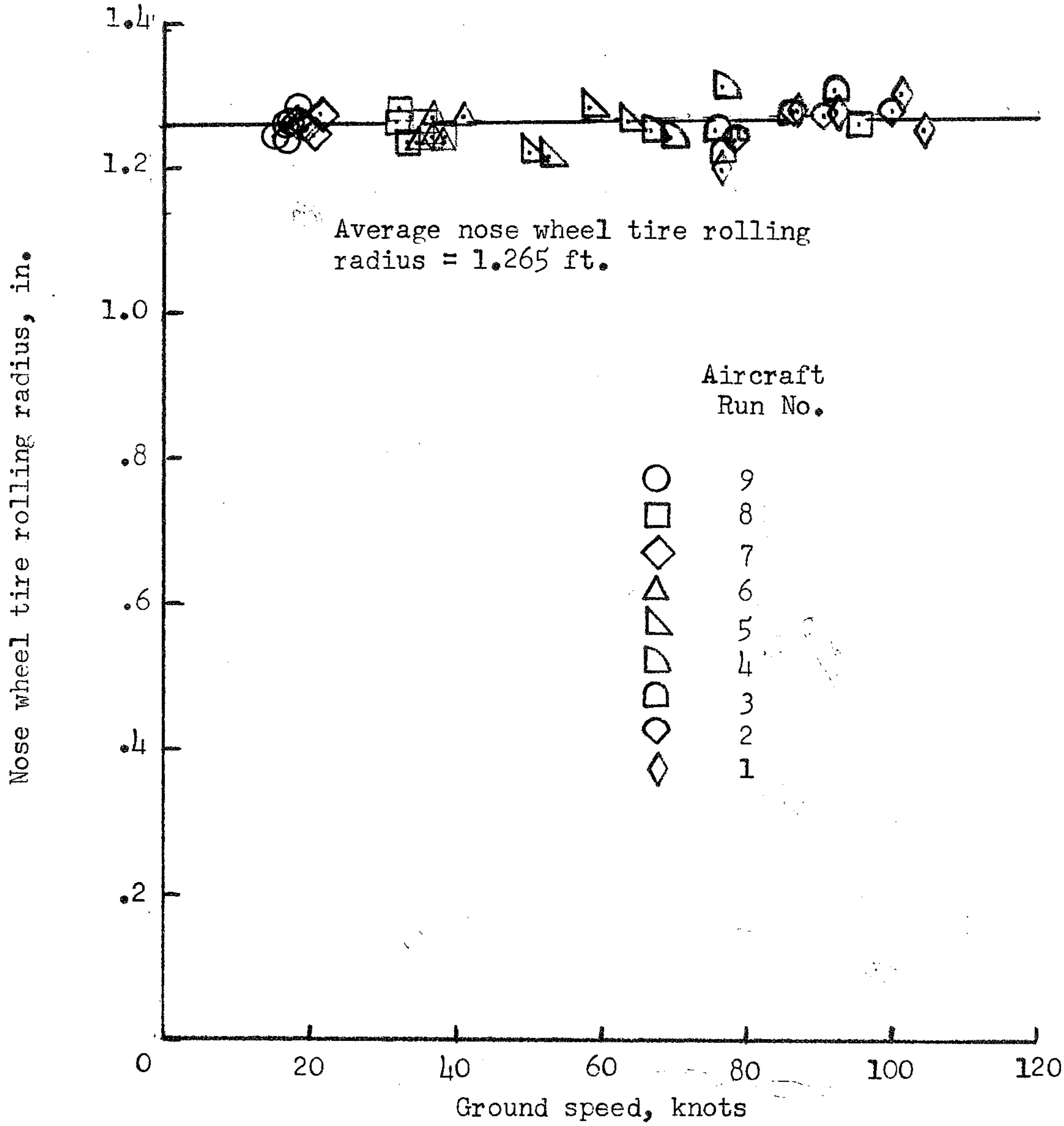


Figure 21.- Variation of nose wheel tire rolling radius with ground speed.

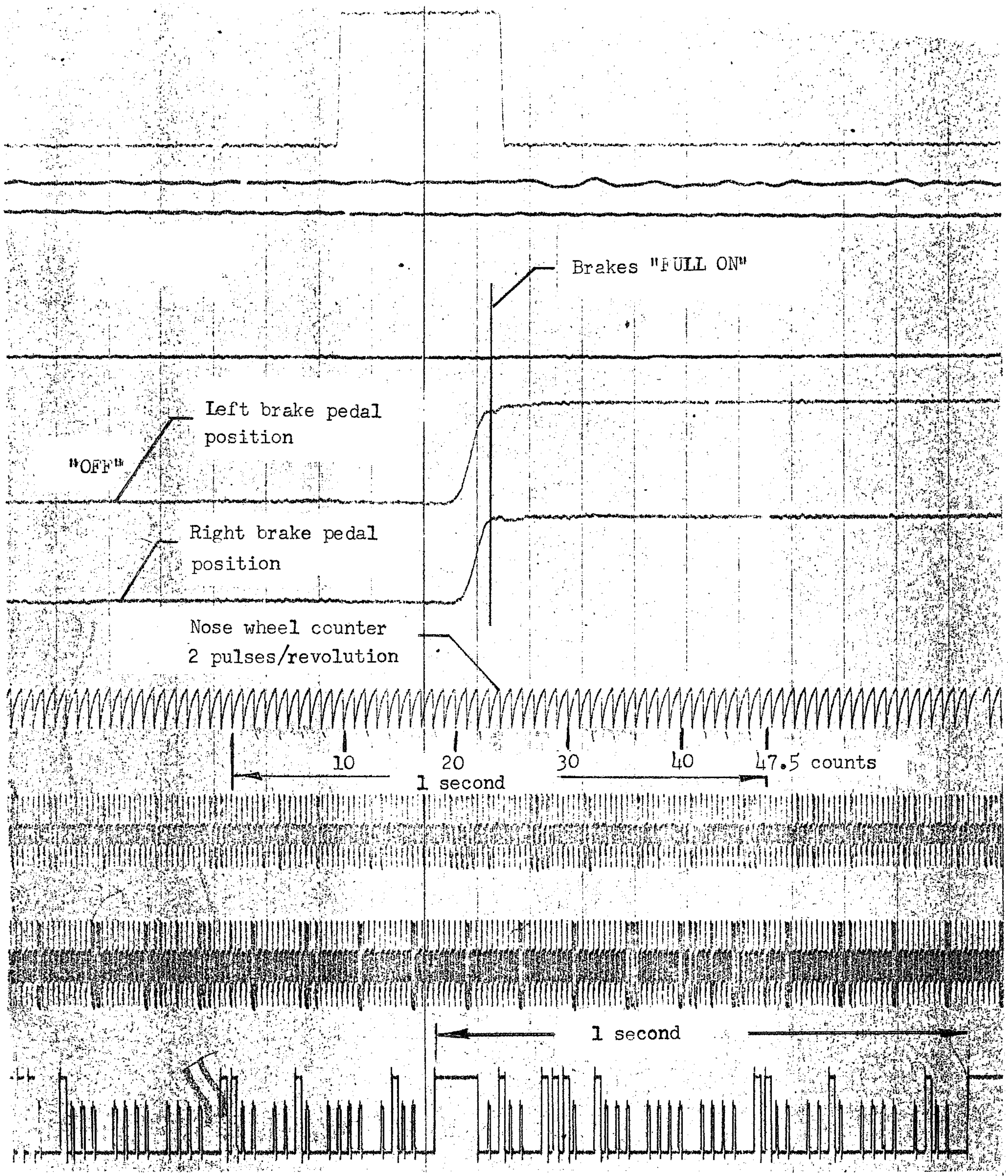


Figure 22.- Sample determination of aircraft brake application speed from magnetic tape recorder nose wheel counter and time traces for aircraft run 43.

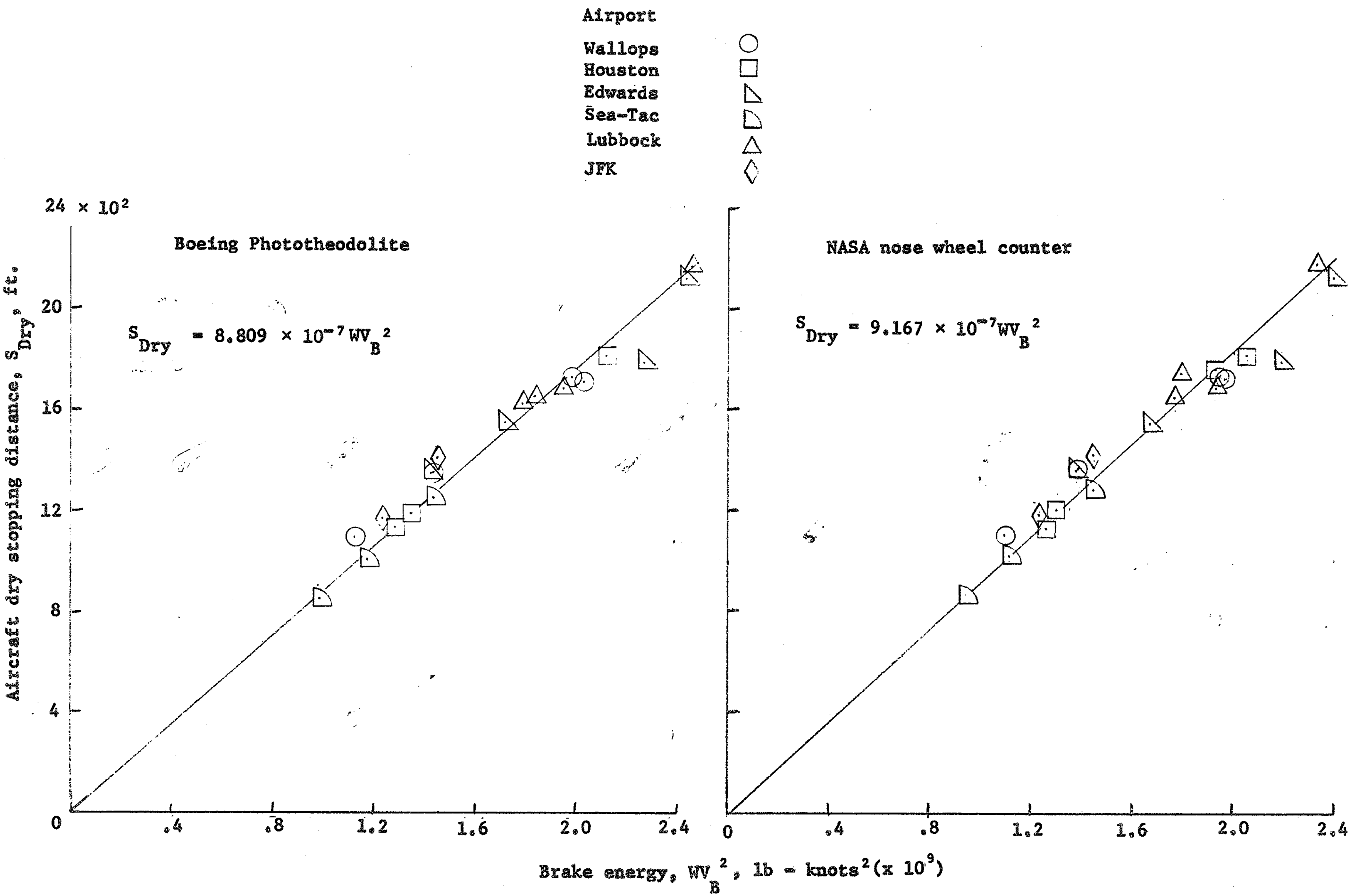


Figure 23.- Variation of aircraft dry stopping distance with aircraft energy at brake application speed.

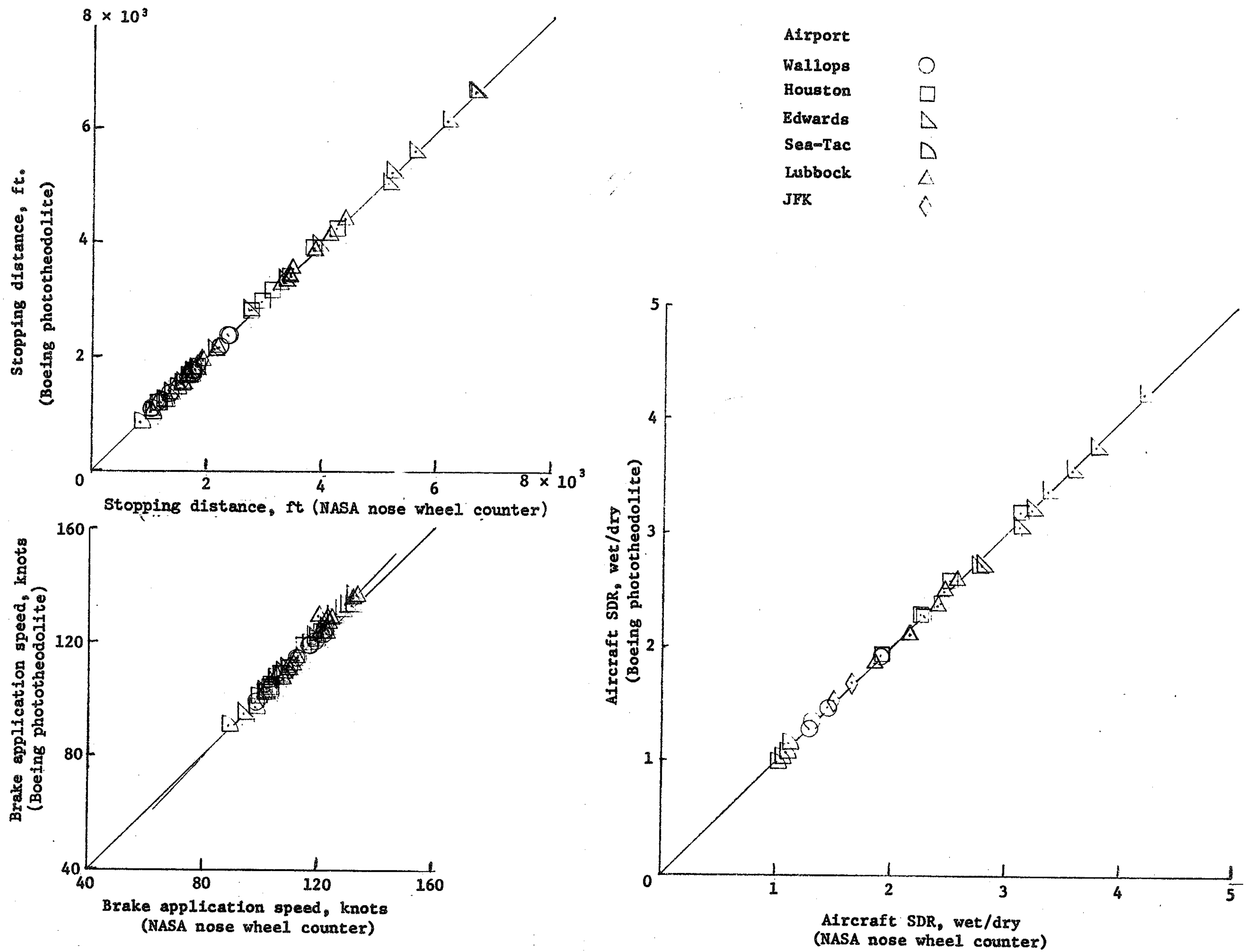


Figure 24.- Correlation between NASA nose wheel counter and Boeing phototheodolite stopping distance, brake application speed, and SDR (wet/dry) data for the B - 727 test aircraft.

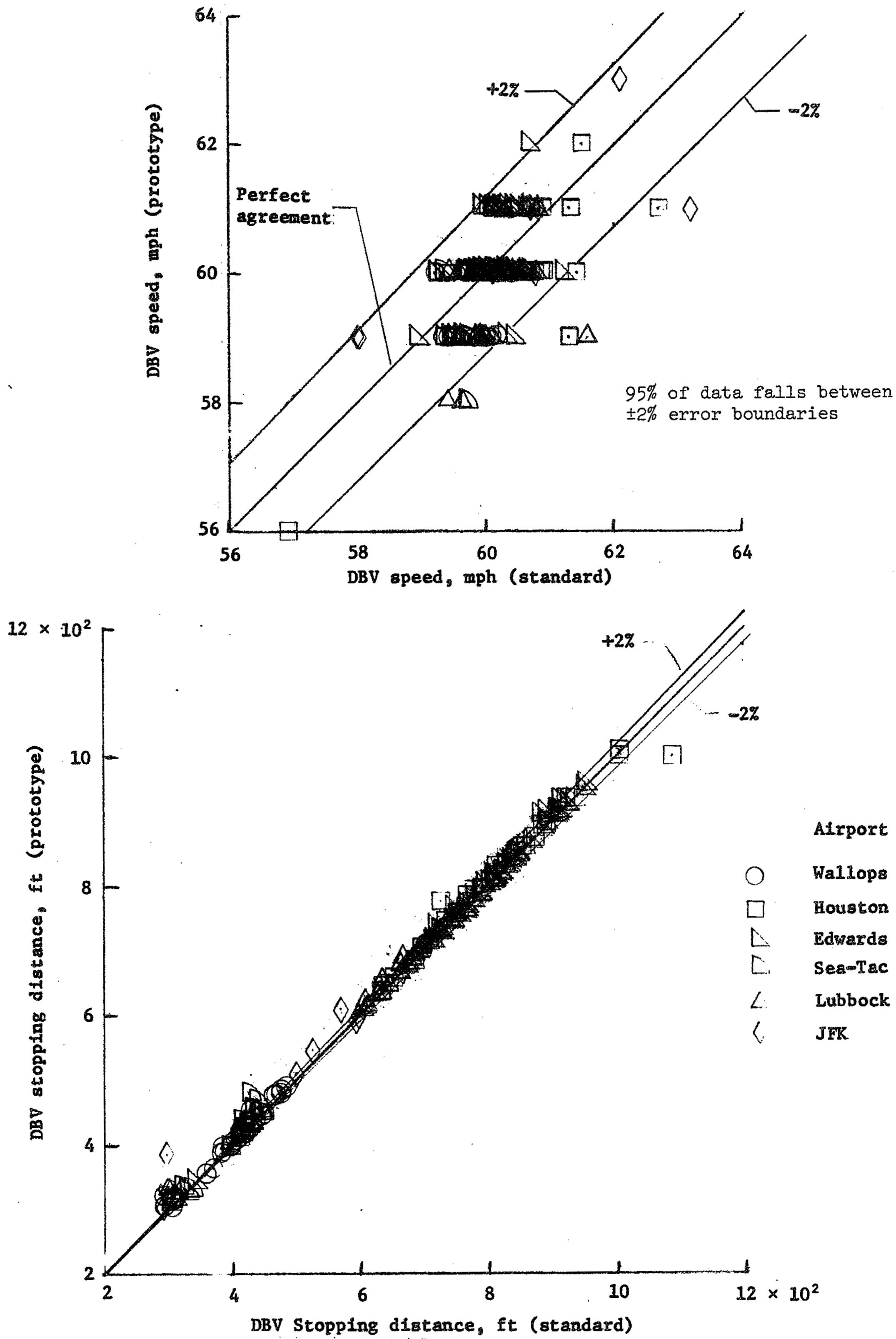


Figure 25.- Comparison of standard and prototype instrument measurements of DBV brake application speed and stopping distance.

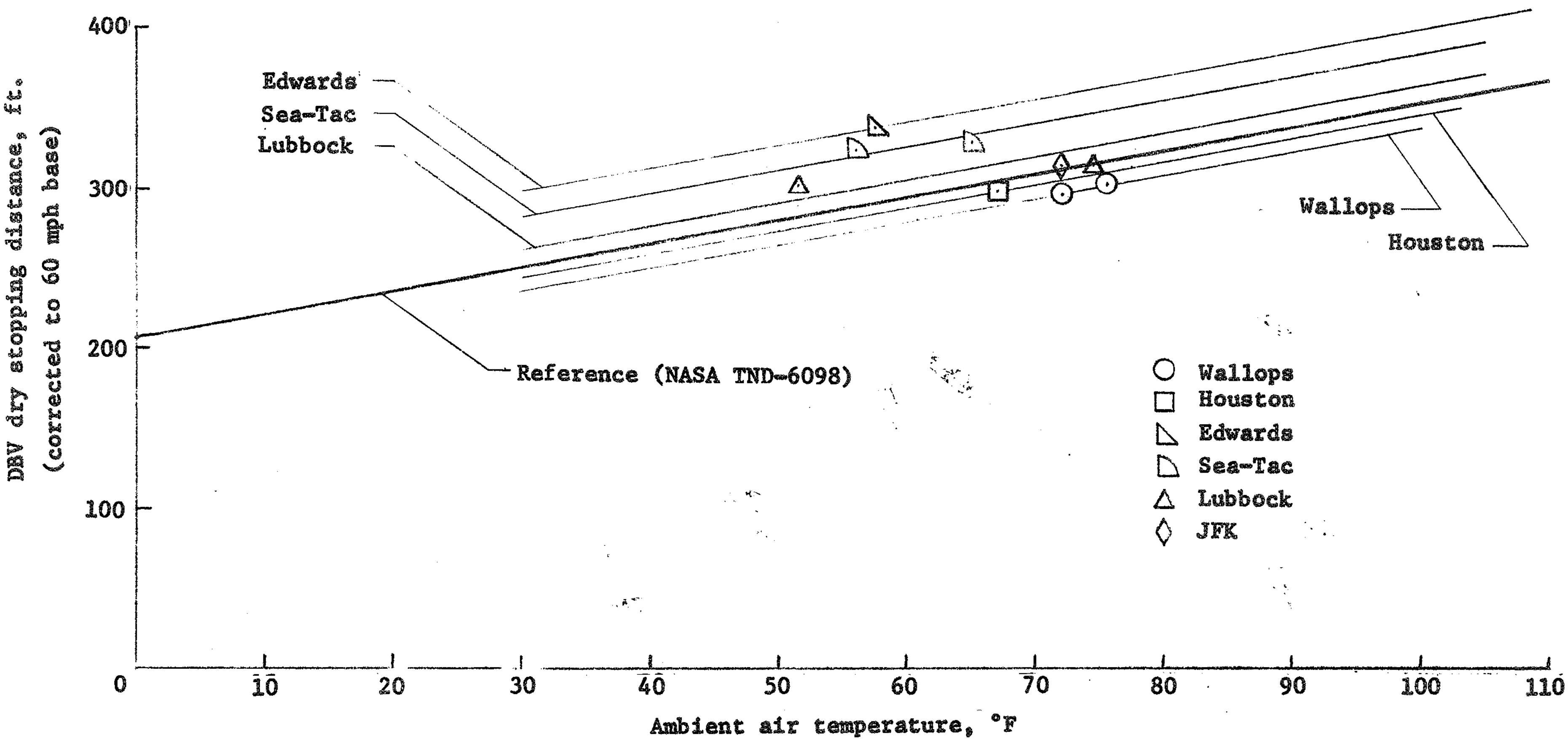


Figure 26.- Variation in NASA DBV dry stopping distances with air temperature.

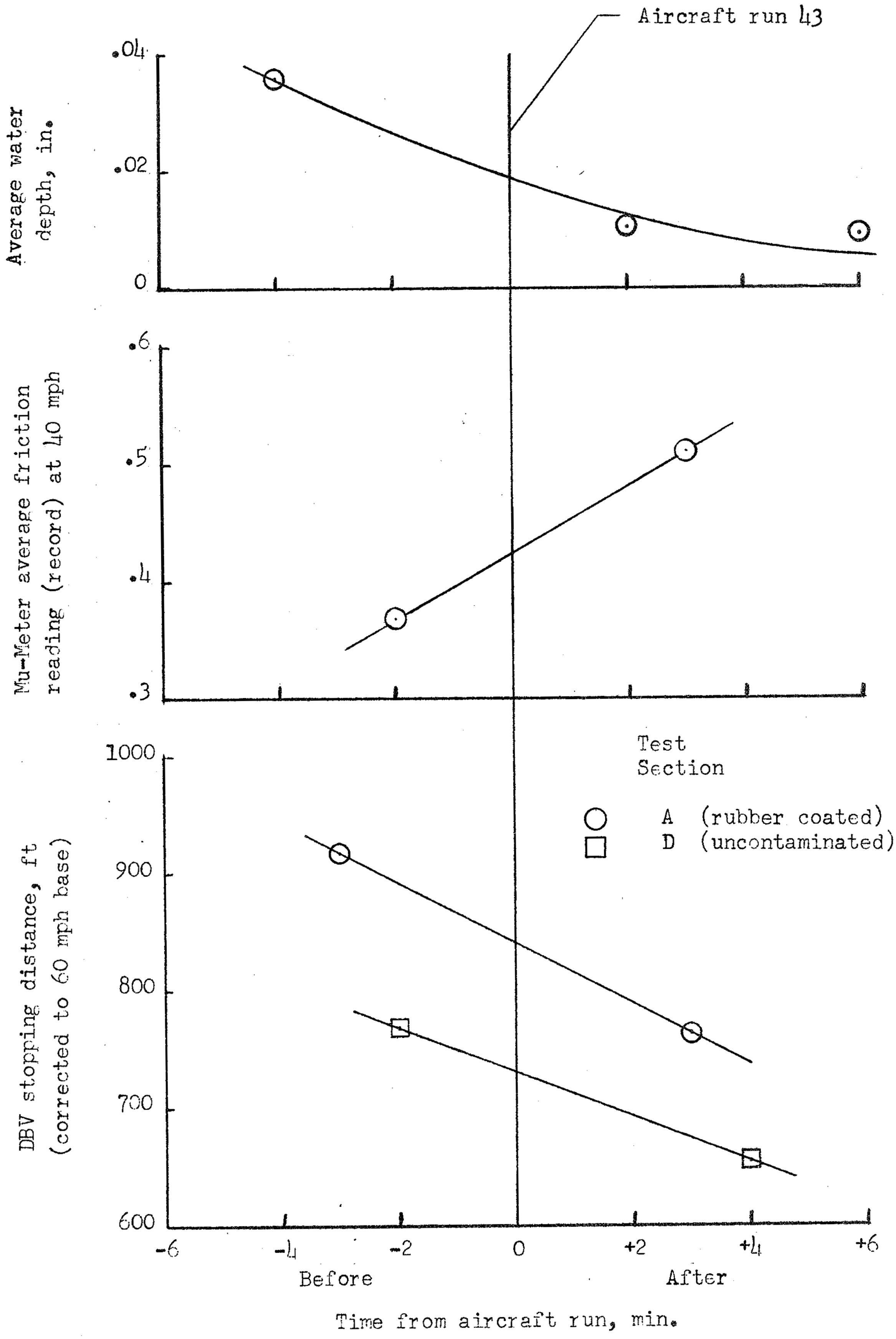


Figure 27.- Example of method used to time-correlate water depth, Mu-Meter friction reading, and DBV stopping distance measurements with time of aircraft test run on a wet runway.

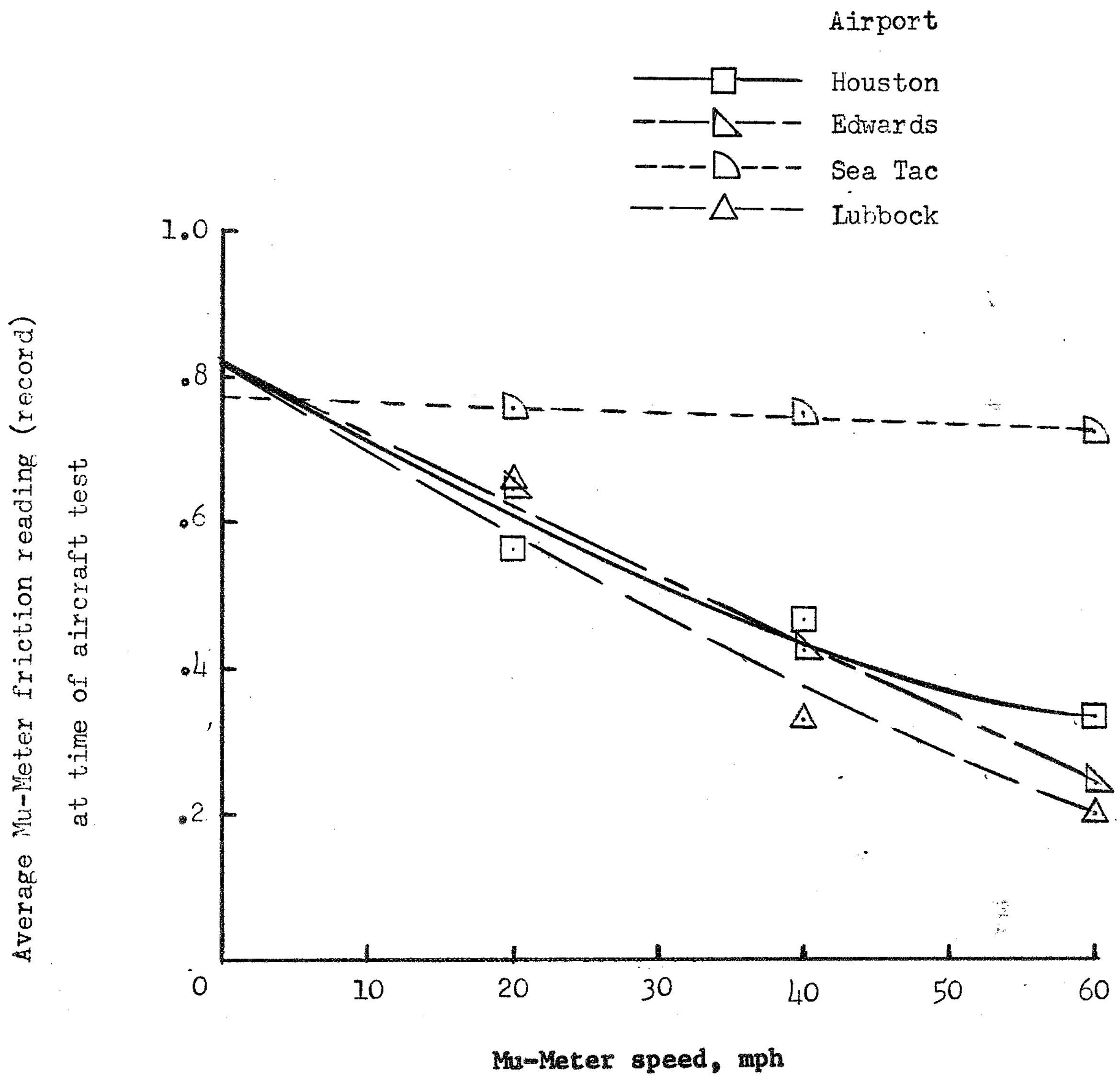
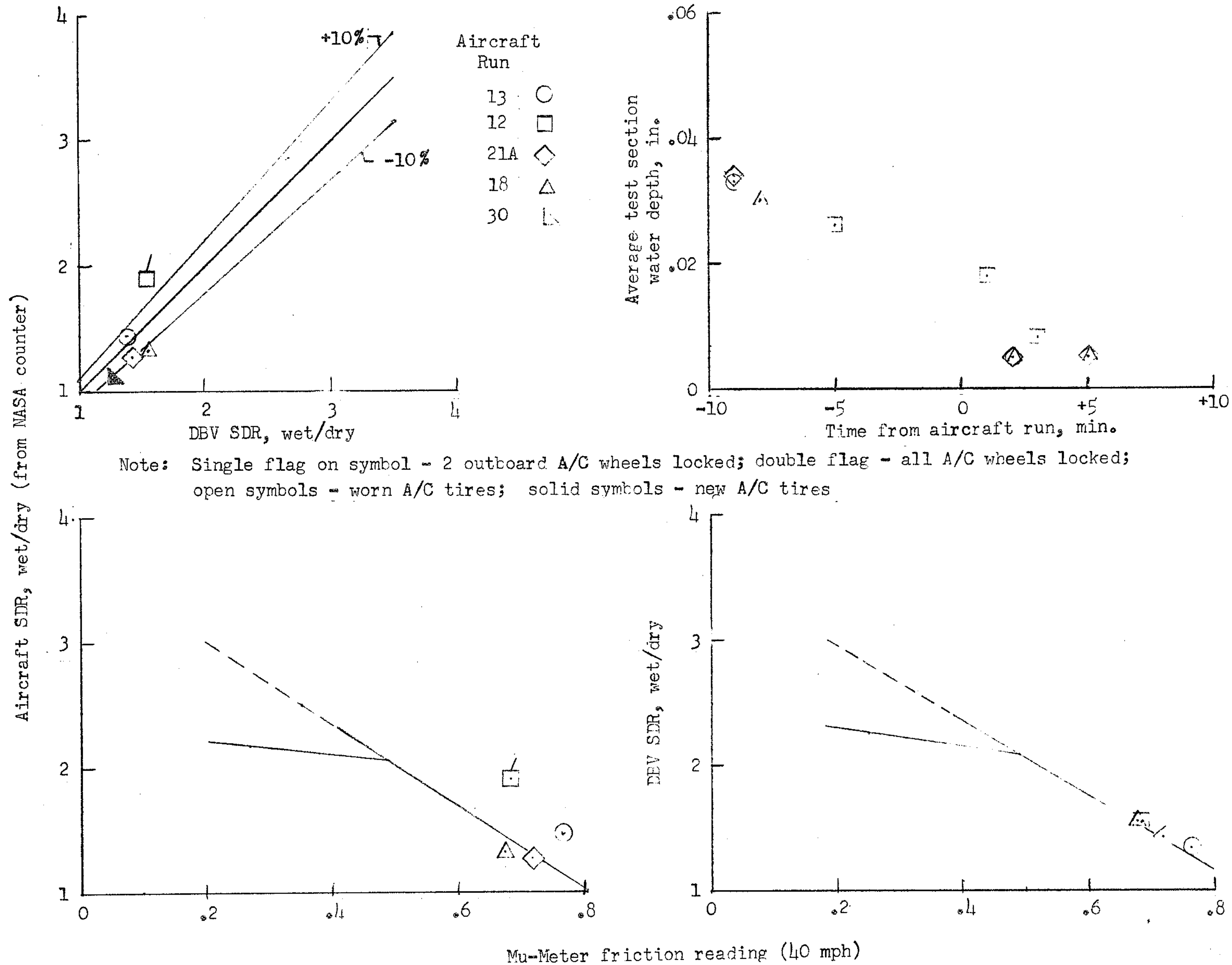
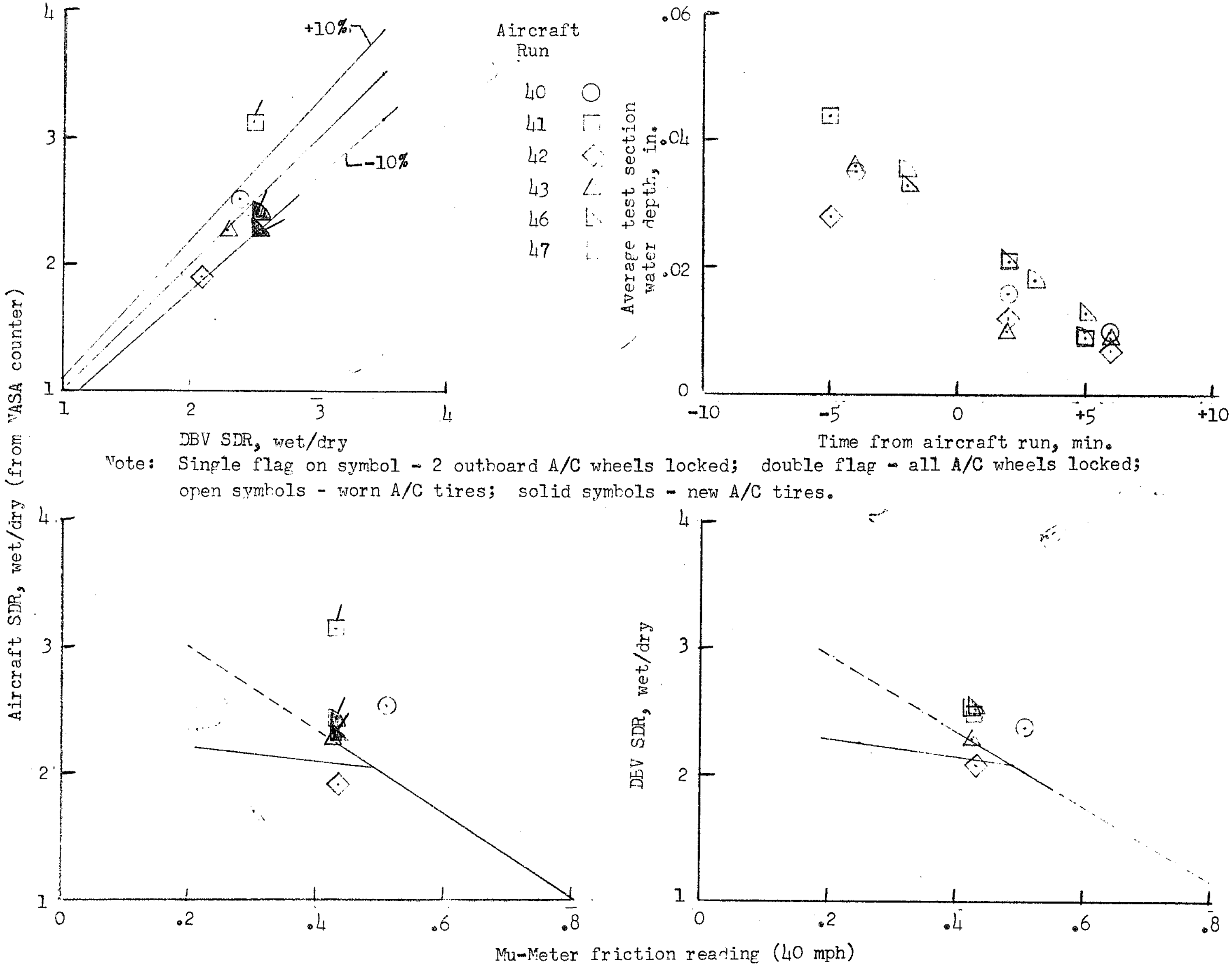


Figure 28.- Variation of Mu-Meter friction reading with speed for several runways.



(a) Wallops

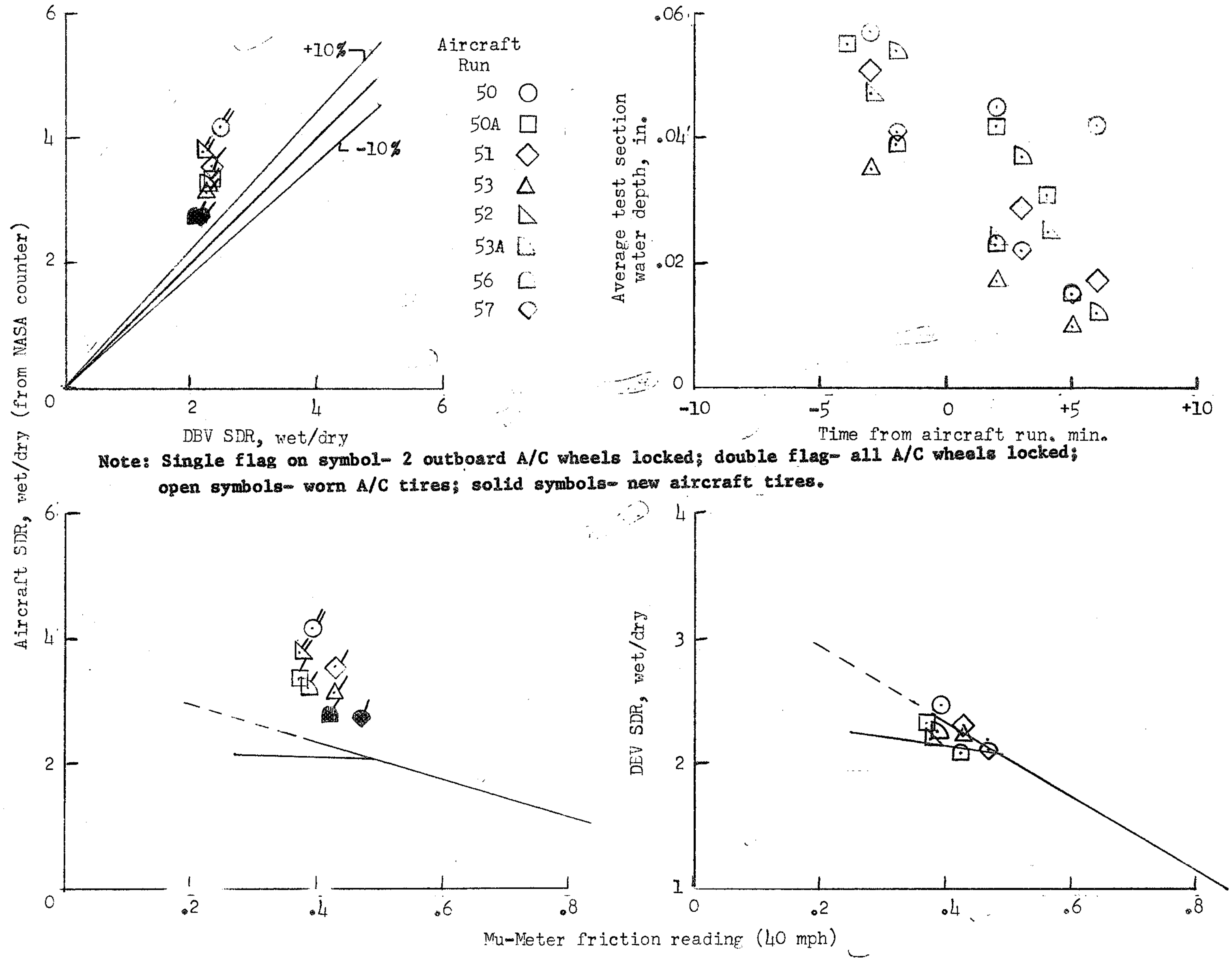
Figure 29.- Drainage characteristics and correlation between B-727 aircraft, NASA DBV, and Mu-Meter stopping or friction performance on wet test runway surface.



Note: Single flag on symbol - 2 outboard A/C wheels locked; double flag - all A/C wheels locked; open symbols - worn A/C tires; solid symbols - new A/C tires.

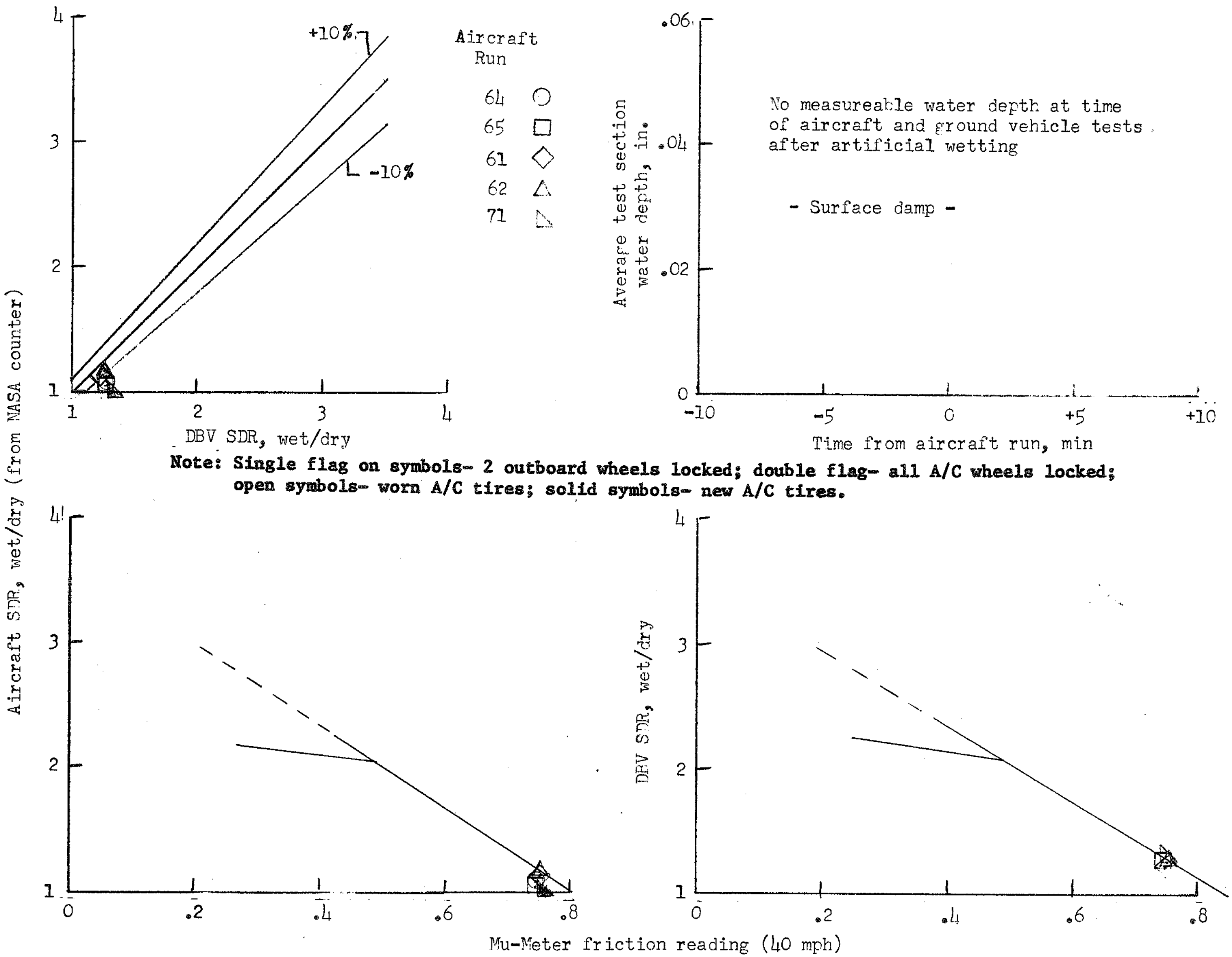
(b) Houston

Figure 29.- Continued.



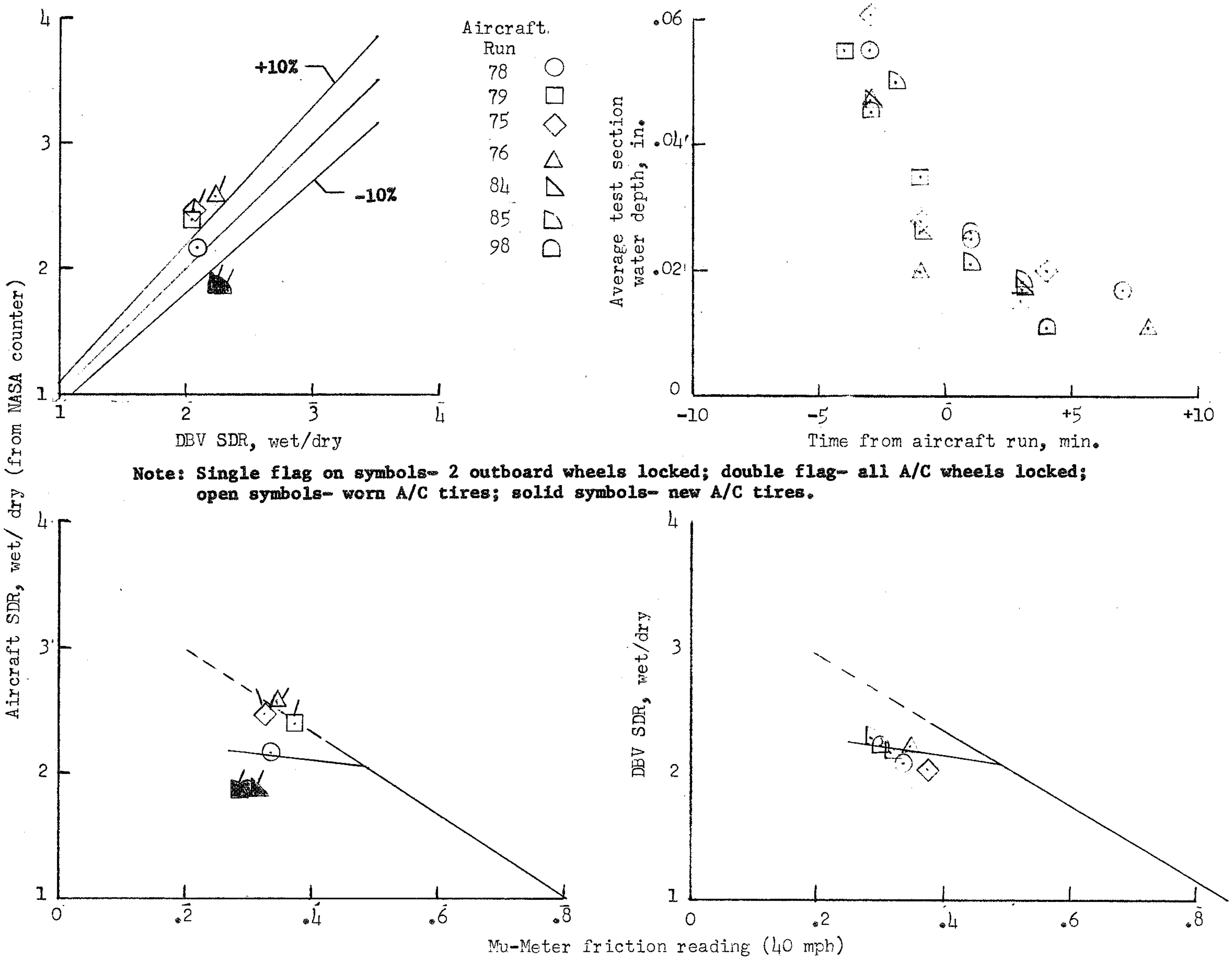
(c) Edwards

Figure 29.- Continued.



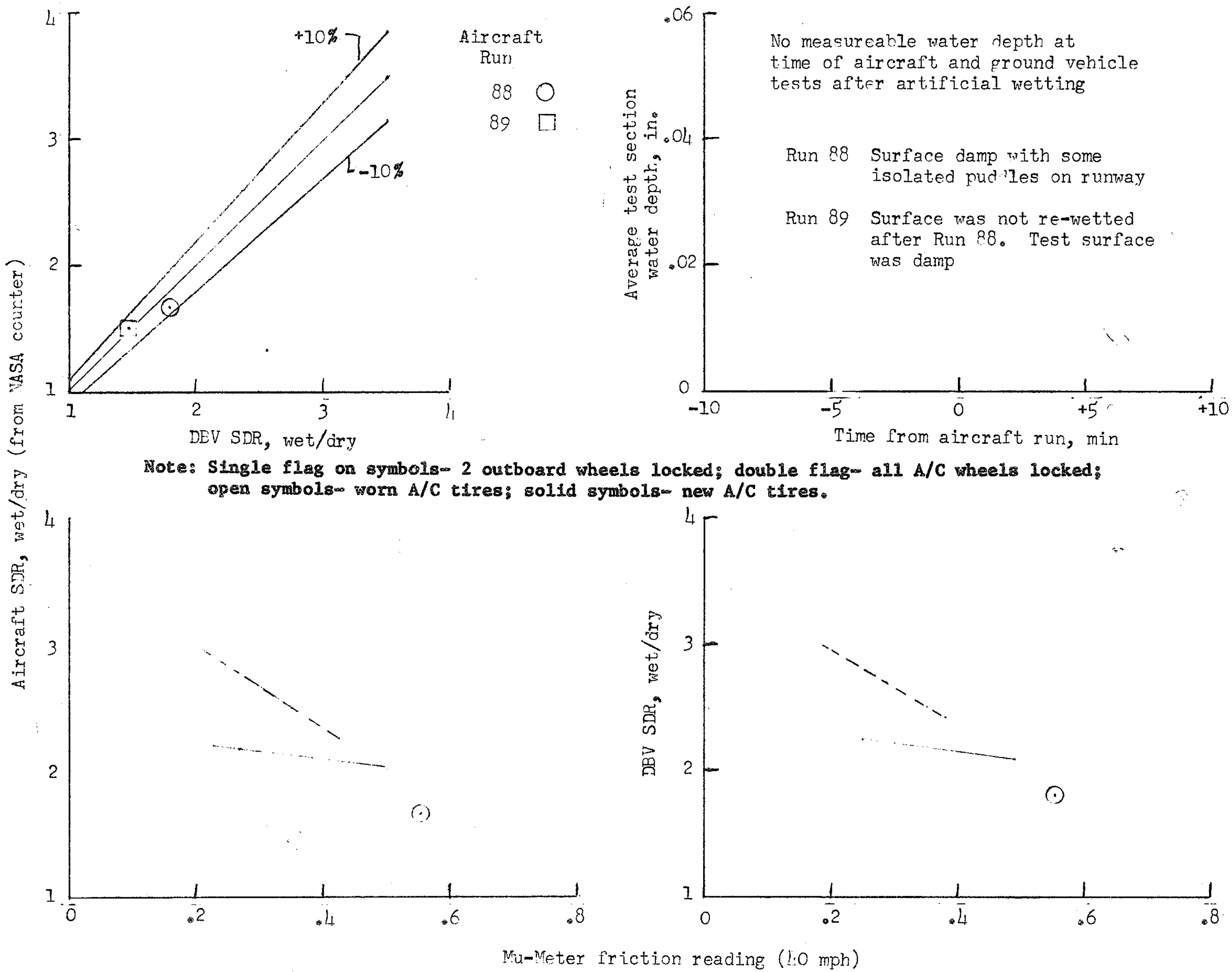
(d) Sea-Tac

Figure 29.- Continued.



(e) Lubbock

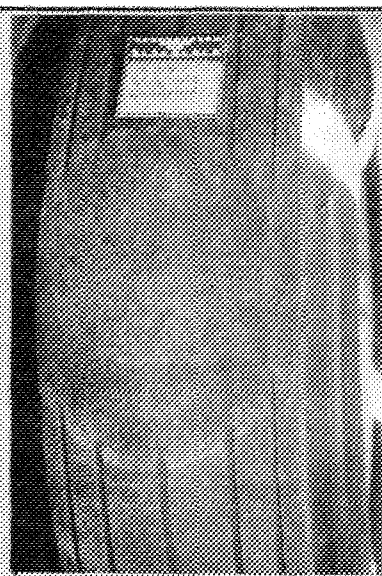
Figure 29.- Continued.

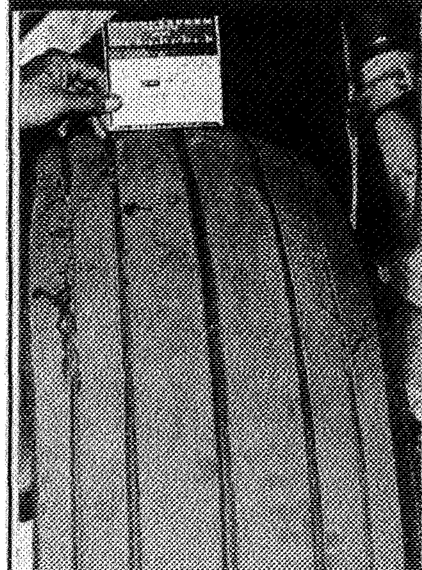


(f) JFK

Figure 29.- Concluded.

TEST SITE: Wallops Station
TEST SURFACE: Slurry seal asphalt
SURFACE CONDITION: Wet (0.019")
AFTER AIRCRAFT RUN NO.: 12
TREAD CONDITION: Reverted rubber skid patch
REMARKS: Outboard wheels experienced full lockup at aircraft ground speed of 83.0 knots and remained locked for 1331 ft resulting in reverted rubber skid patch shown in photograph. Inboard wheels, which did not experience prolonged lockups, showed no evidence of tread reversion. Worn tire condition.





TEST SITE: Houston Intercontinental Airport
TEST SURFACE: Canvas-belt finished PCC
SURFACE CONDITION: Wet (0.028")
AFTER AIRCRAFT RUN NO.: 47
TREAD CONDITION: Reverted rubber skid patch
REMARKS: Outboard wheels experienced lockup at aircraft ground speed of 99.1 knots and remained locked for 3004 ft resulting in reverted rubber skid patch shown in photograph. Inboard wheels, which did not experience prolonged lockups, showed no evidence of tread reversion. New tire condition.

TEST SITE: Seattle-Tacoma International Airport
TEST SURFACE: Transversely grooved PCC
GROOVE PATTERN: 1-1/2" spacing x 1/4" wide x 1/4" deep
SURFACE CONDITION: Dry
AFTER AIRCRAFT RUN NO.: 60 (aborted)
TREAD CONDITION: Chevron cuts in touchdown area
REMARKS: Photograph shows typical chevron cutting experienced by aircraft main gear tires at touchdown on dry grooved surface prior to wheel spin-up. Once wheel spin-up occurred, chevron cutting ceased. The nose tires did not experience chevron cutting. Worn tire condition.

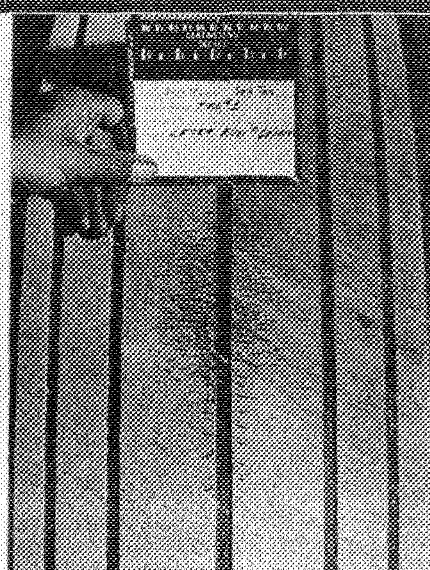
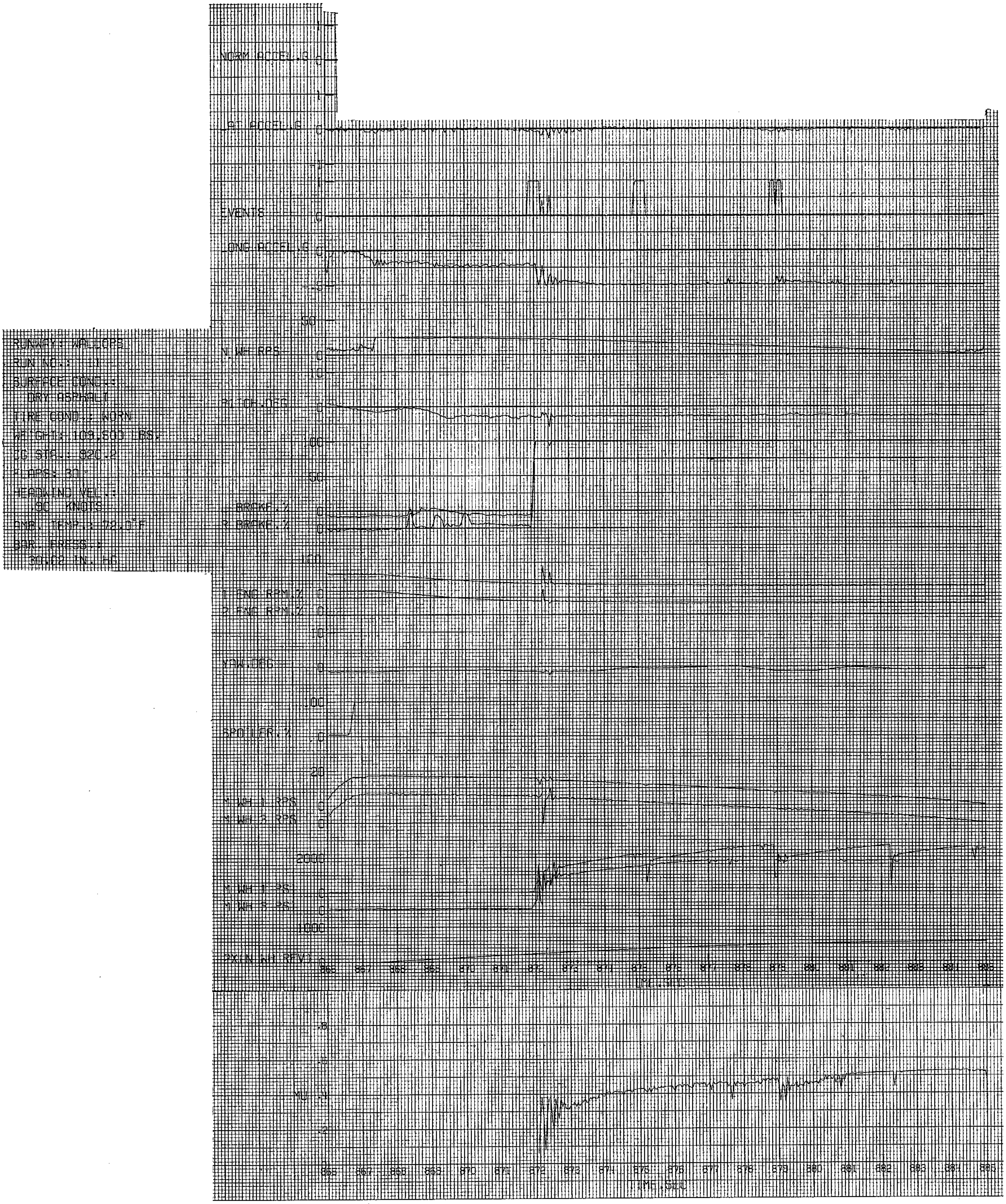
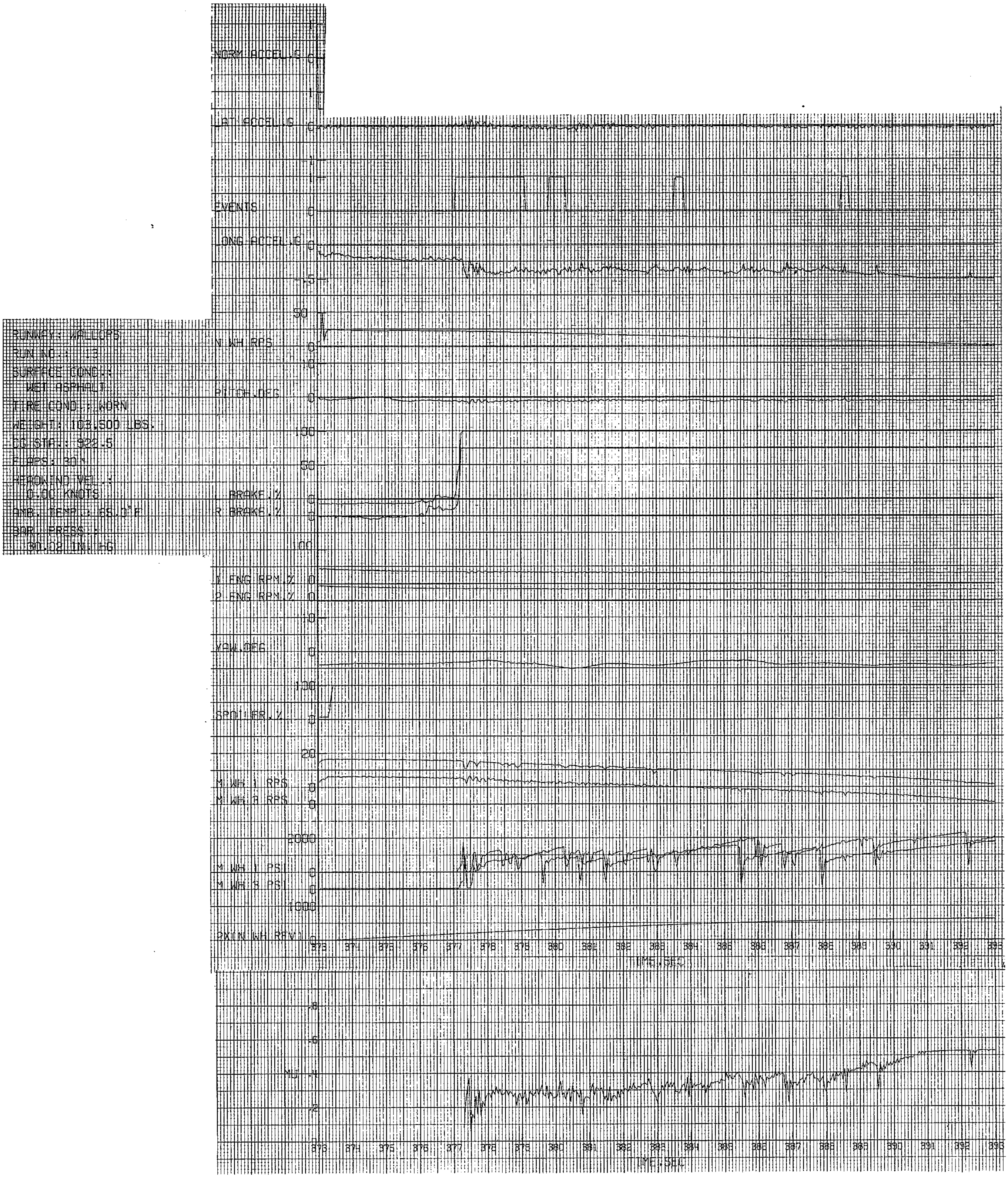


Figure 30.- Various tire tread conditions experienced by aircraft main-gear tires during test program.



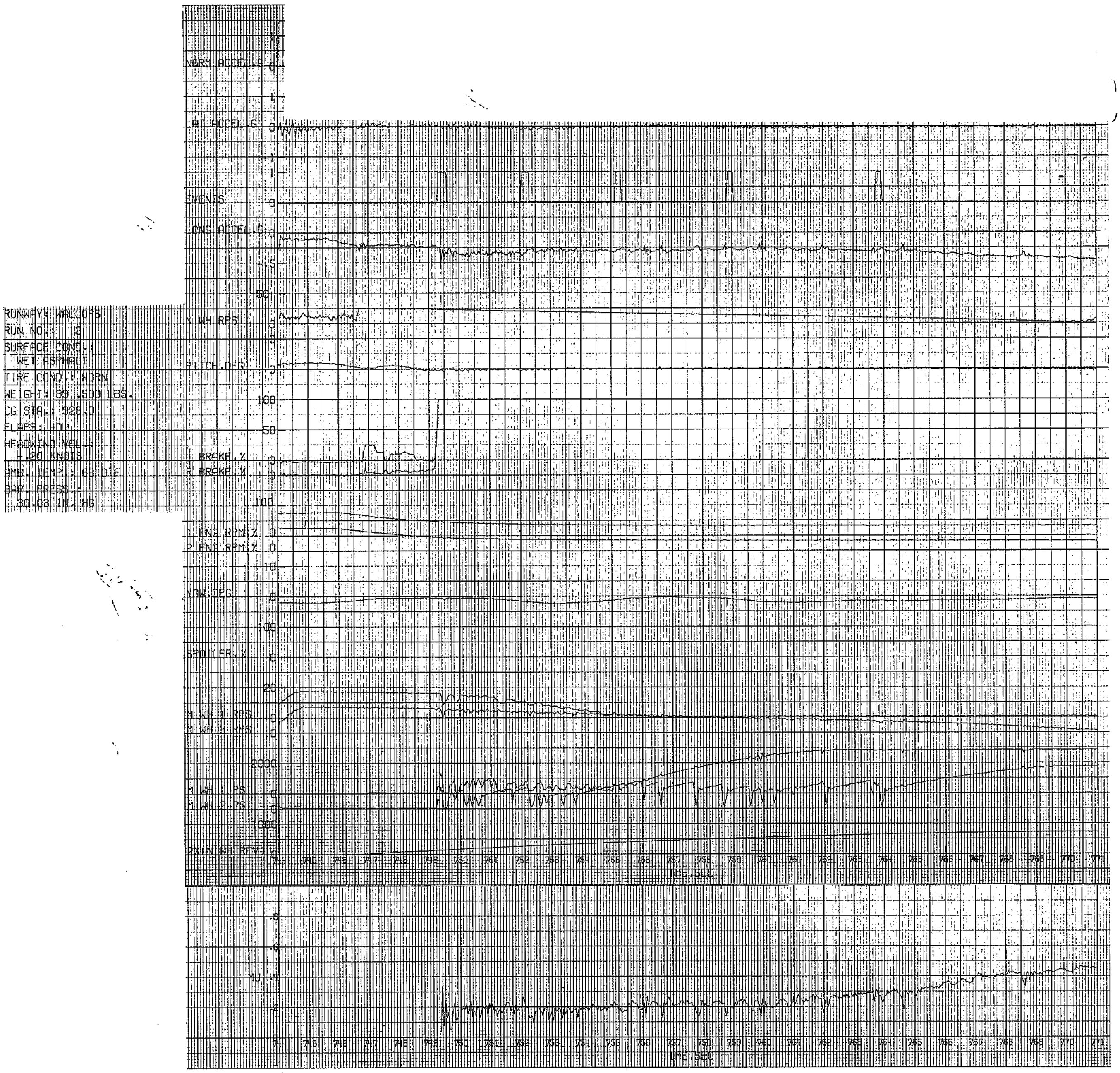
(a) Dry runway

Figure 31.- Typical time histories of aircraft test runs at Wallops.



(b) Wet runway; all wheels turning

Figure 31.- Continued.

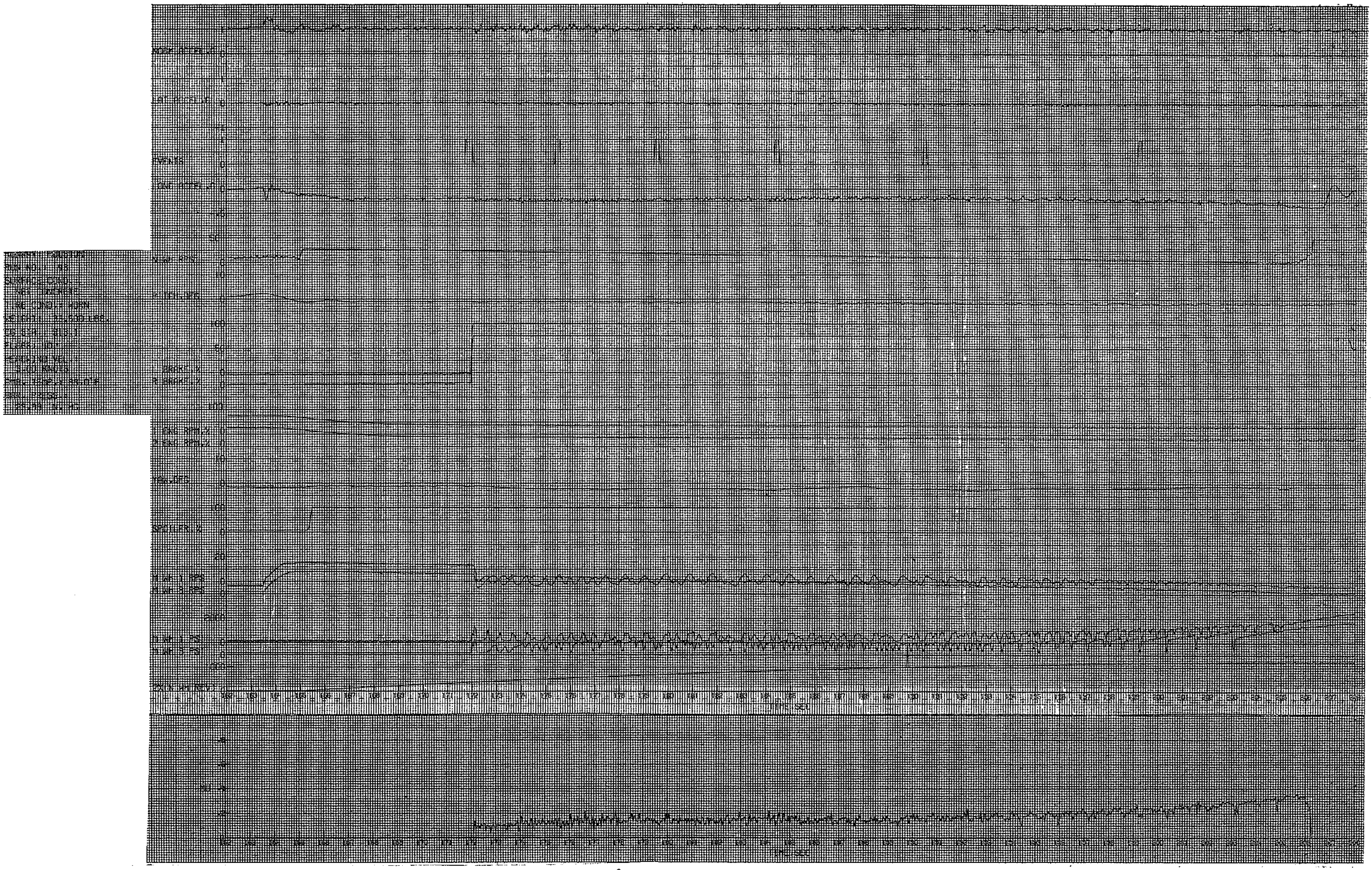


(c) Wet runway; two outboard wheels locked

Figure 31.- Concluded.

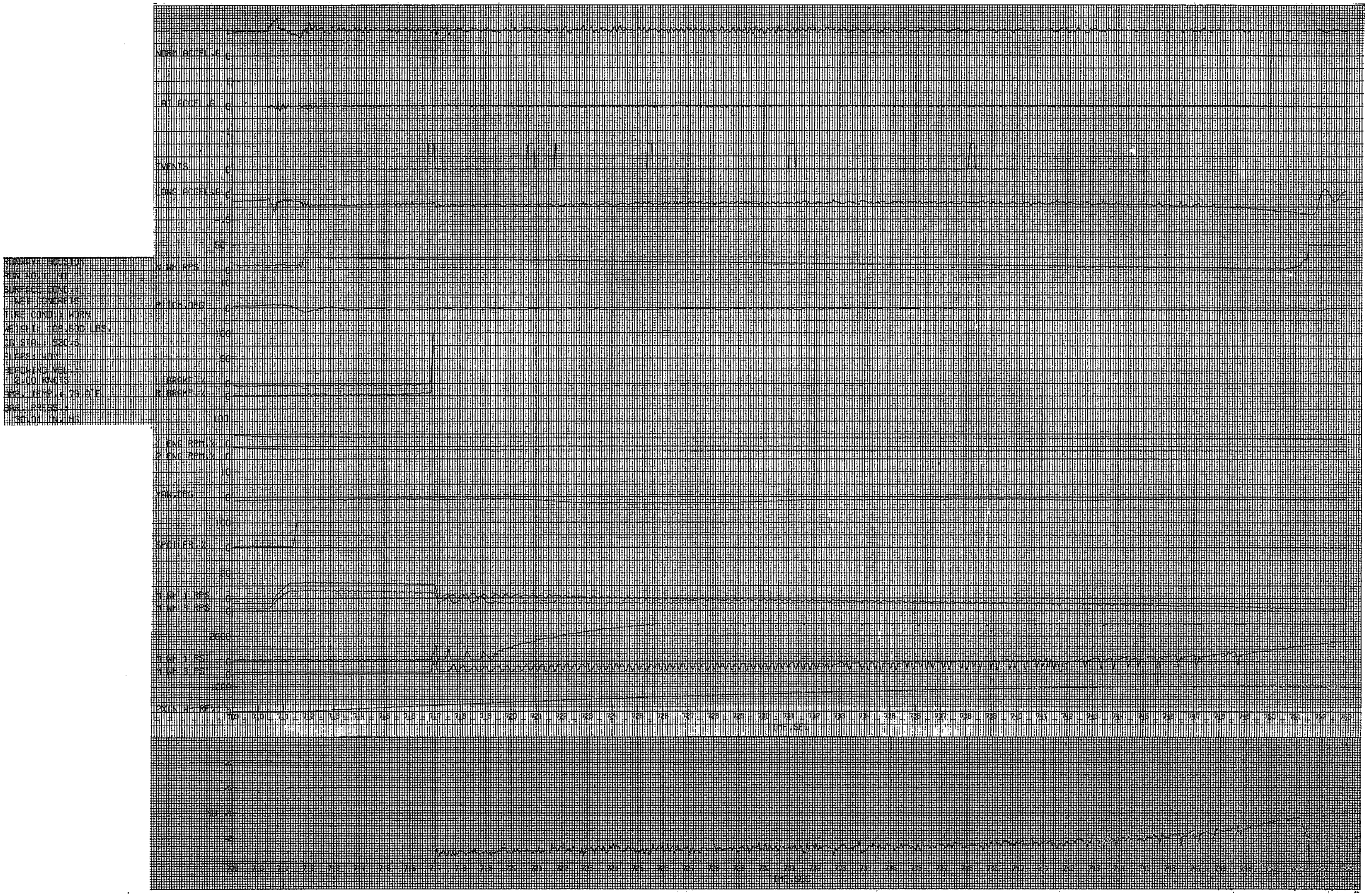
(a) Dry runway

Figure 32.- Typical time histories of aircraft test runs at Houston.



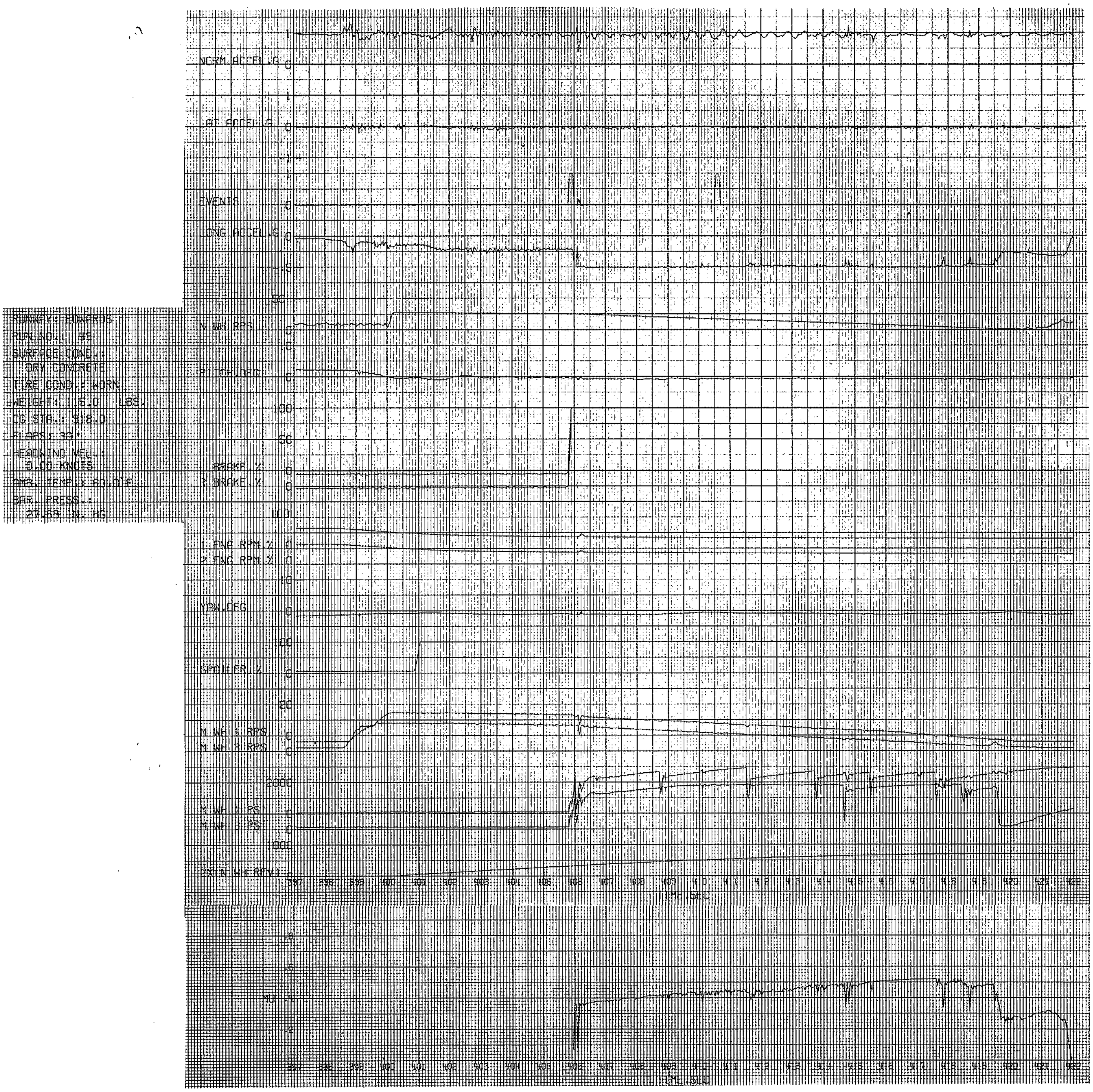
(b) Wet runway; all wheels turning

Figure 32.- Continued.



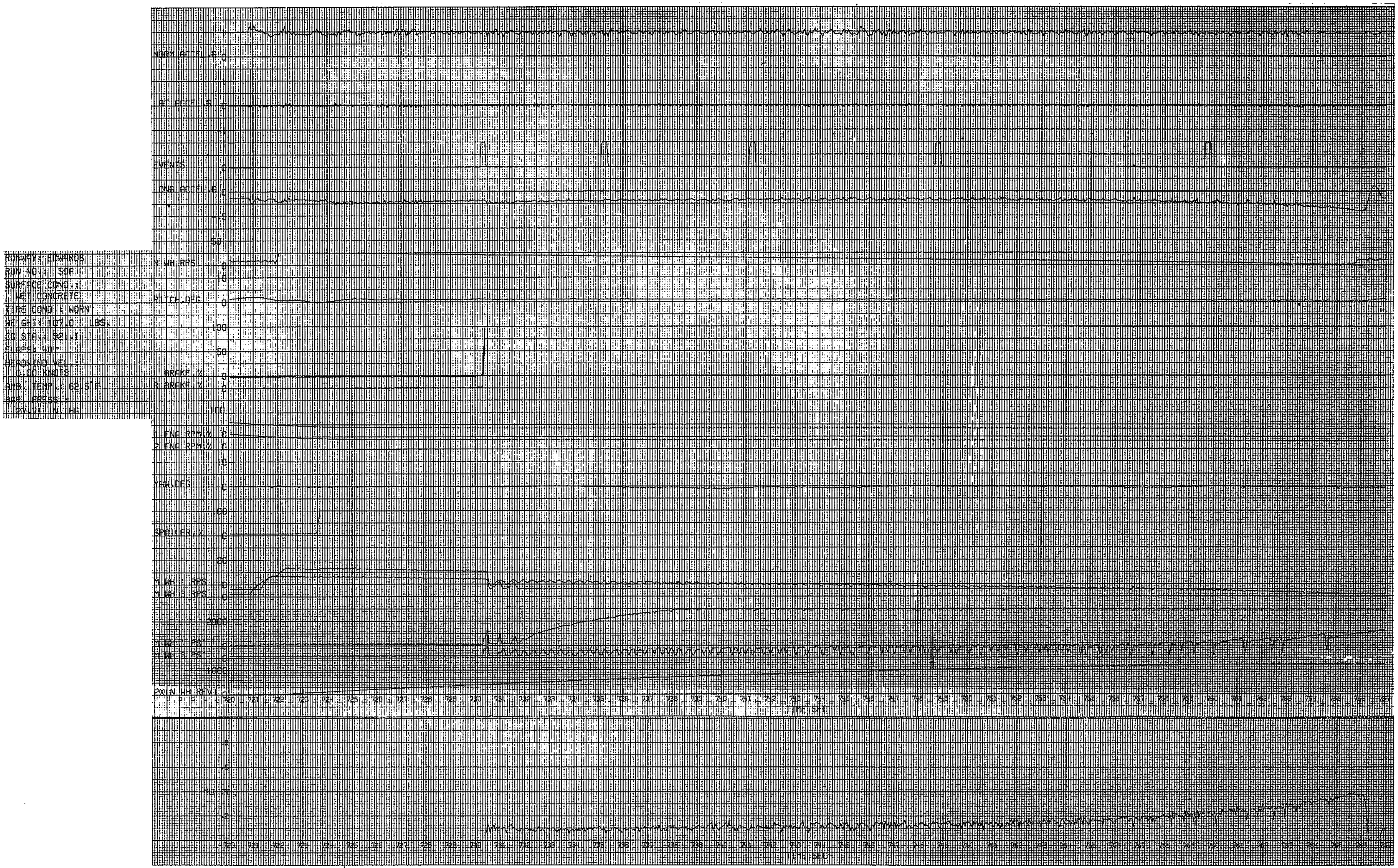
(c) Wet runway; two outboard wheels locked

Figure 32.- Concluded



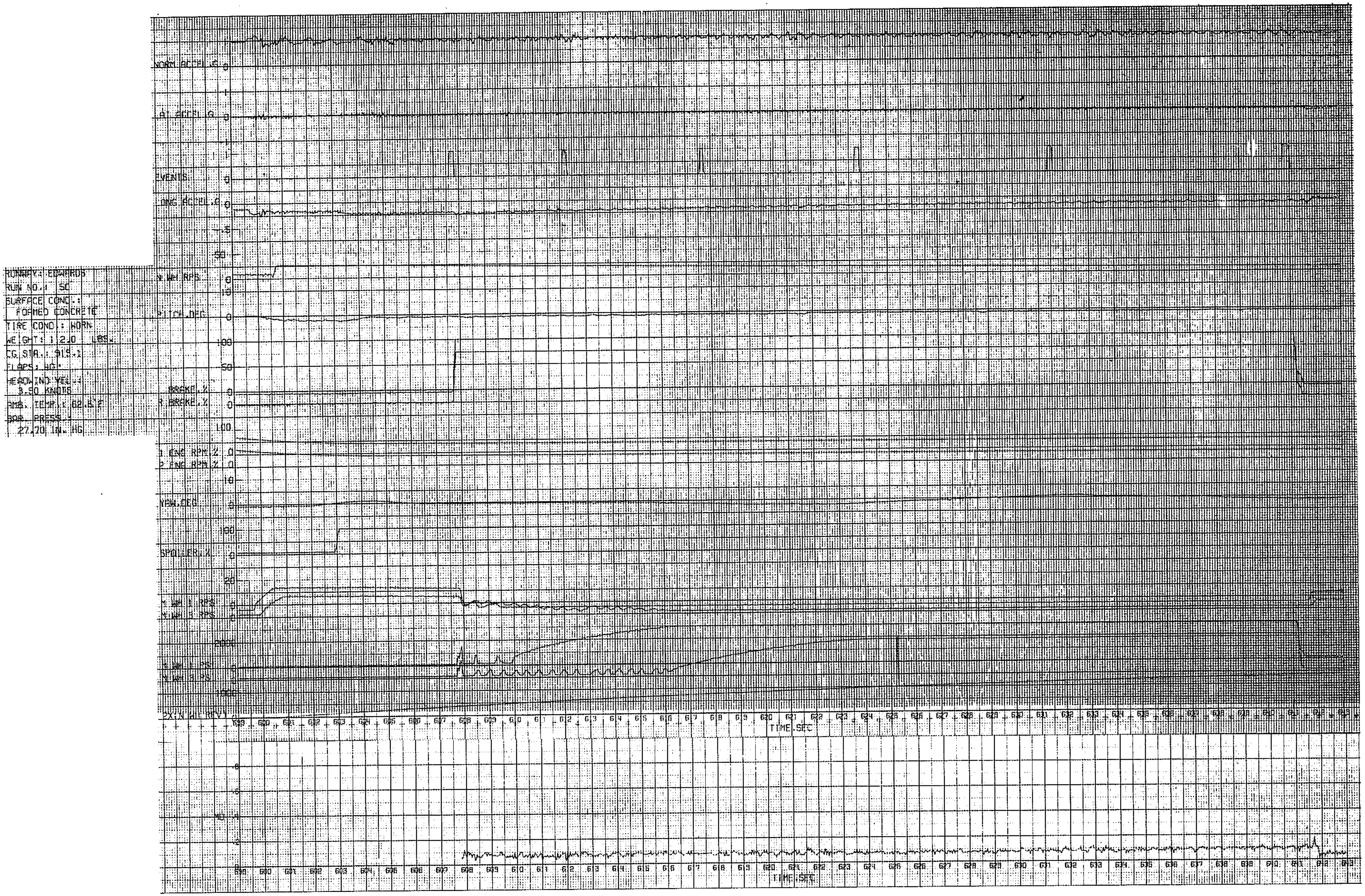
(a) Dry runway

Figure 33.- Typical time histories of aircraft runs at Edwards.



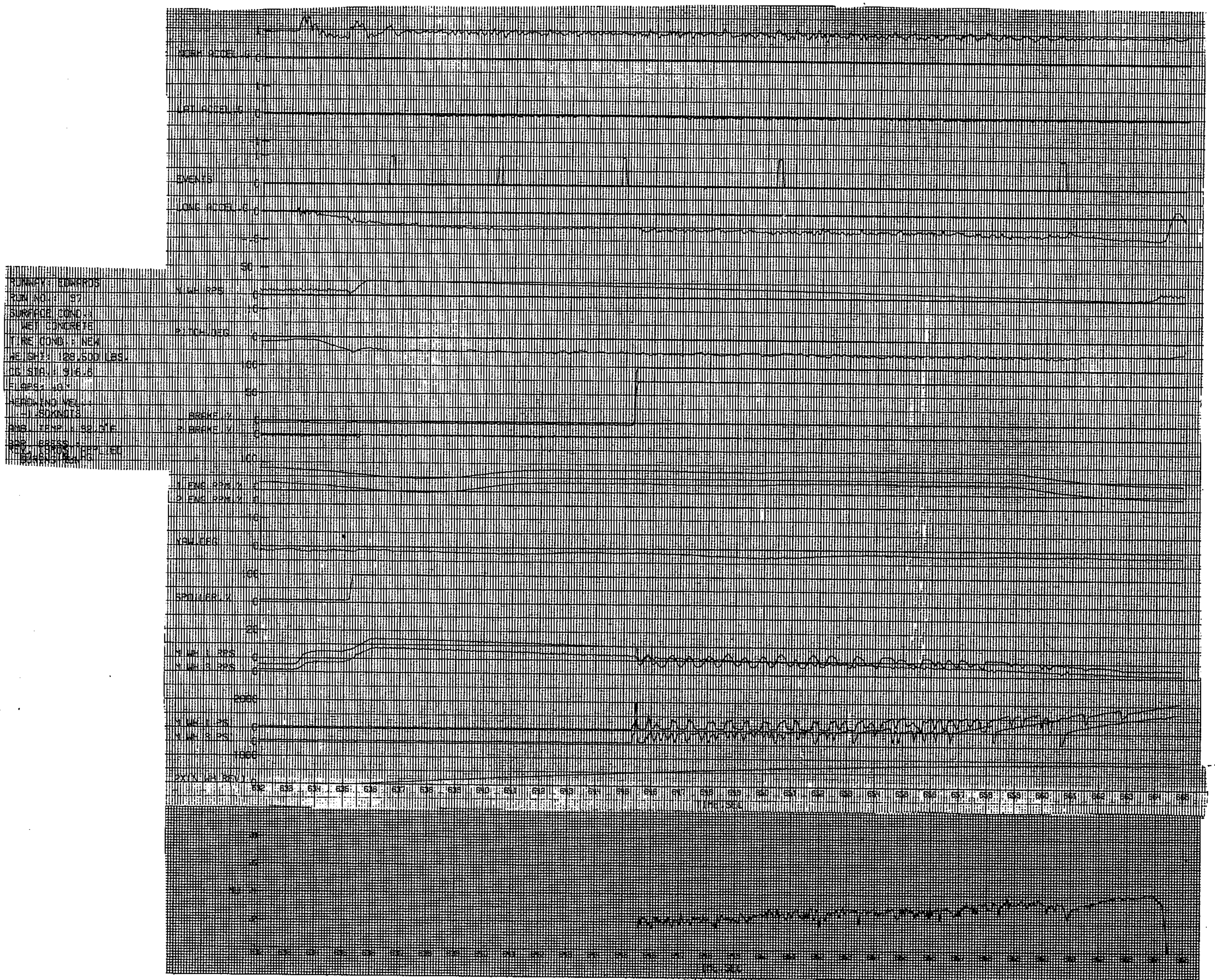
(b) Wet runway; two outboard wheels locked

Figure 33.— Continued.



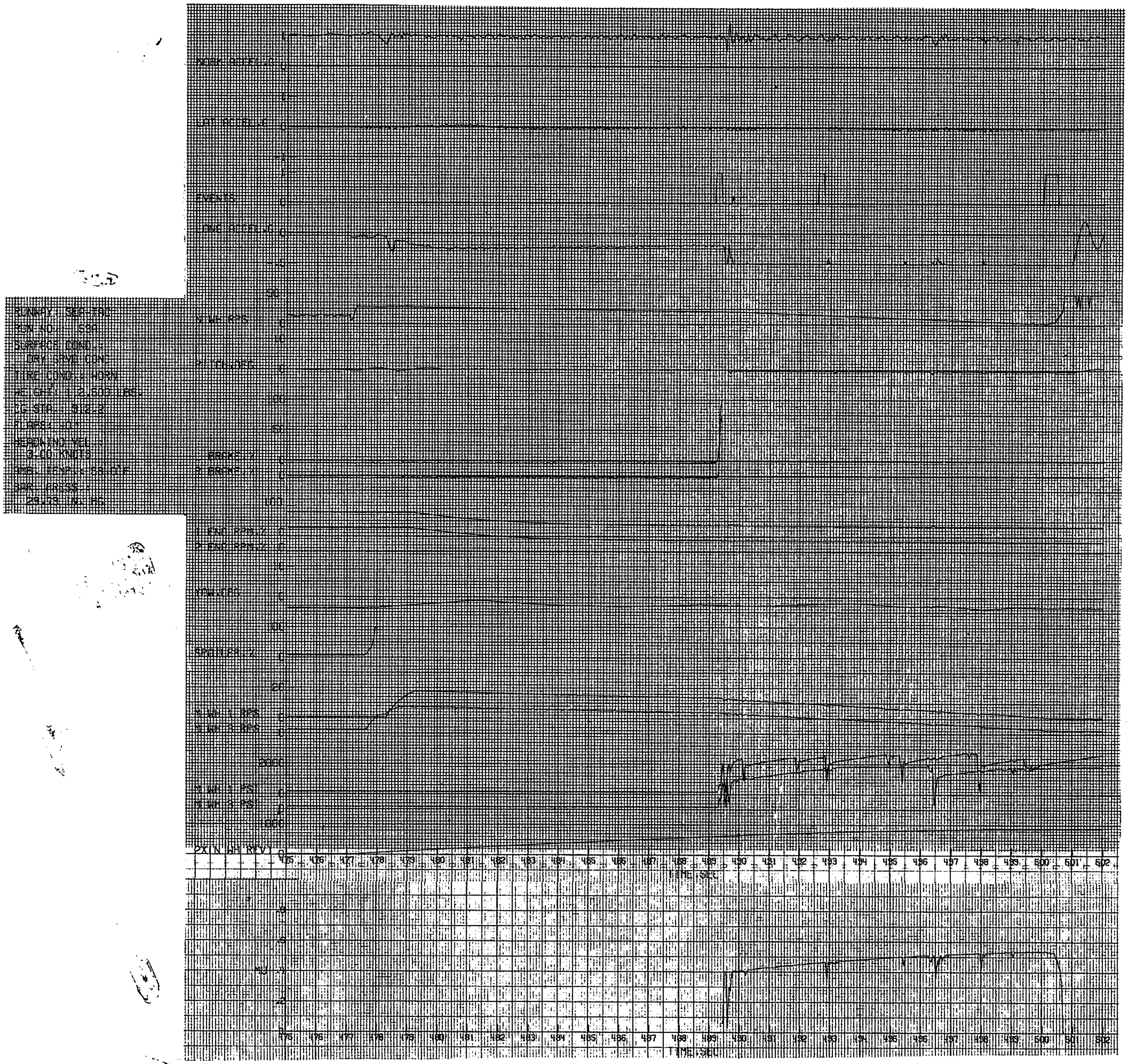
(c) Wet runway; all main wheels locked

Figure 33.- Continued.



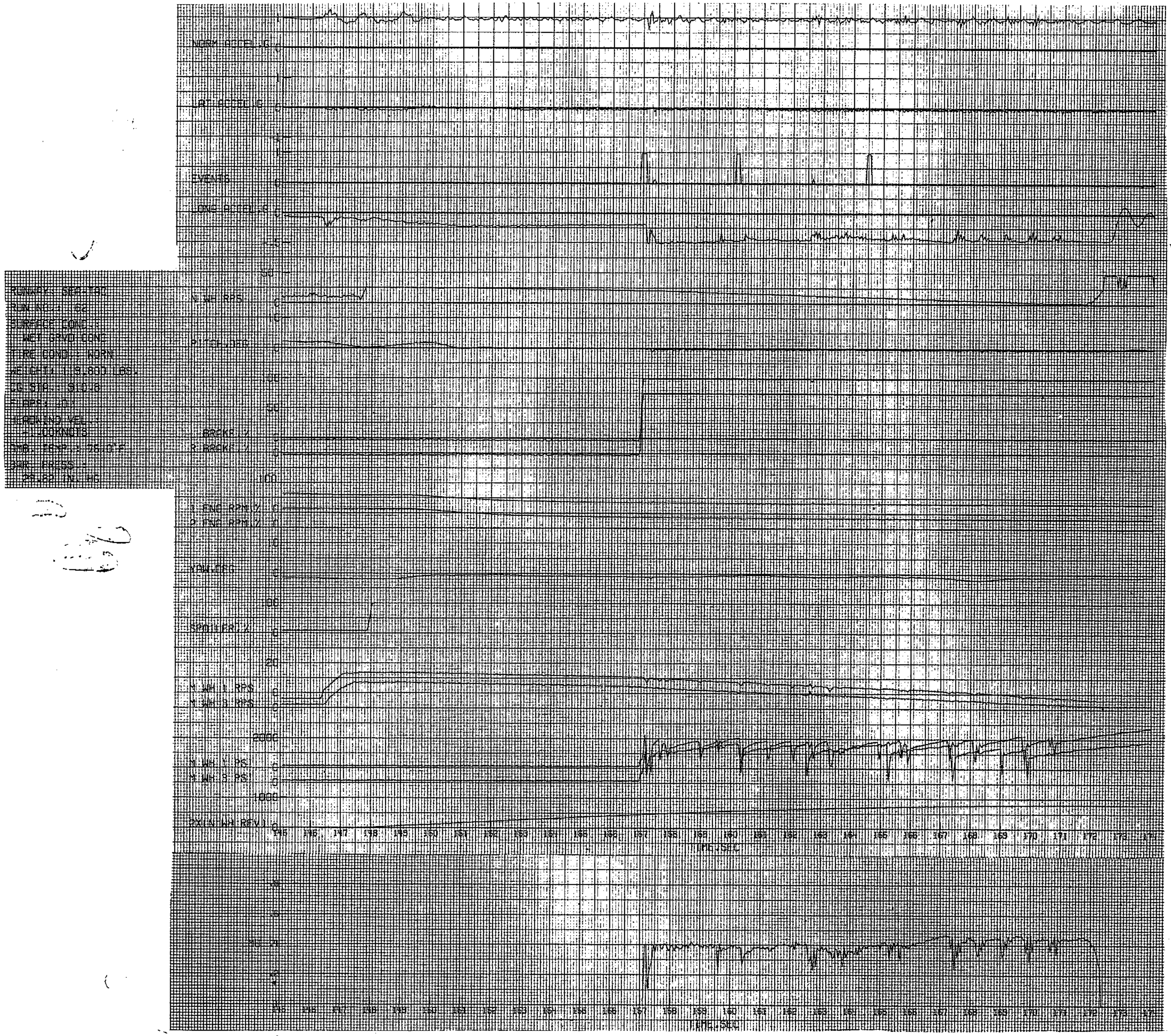
(d) Wet runway; all main wheels turning; reverse thrust, and brake application speed at 94 knots

Figure 33.- Concluded.



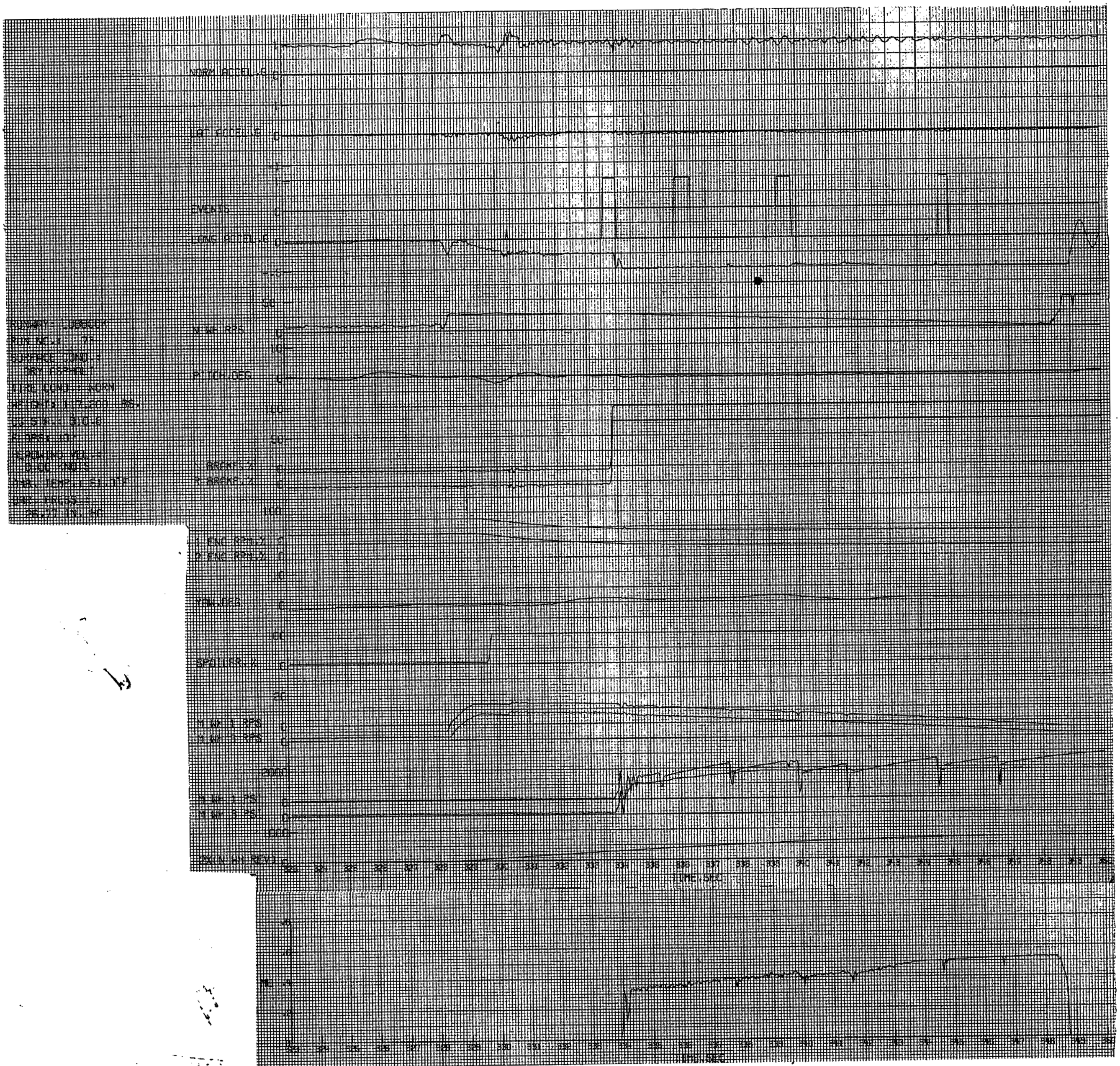
(a) Dry runway

Figure 34.- Typical time histories of aircraft test runs at Sea-Tac.



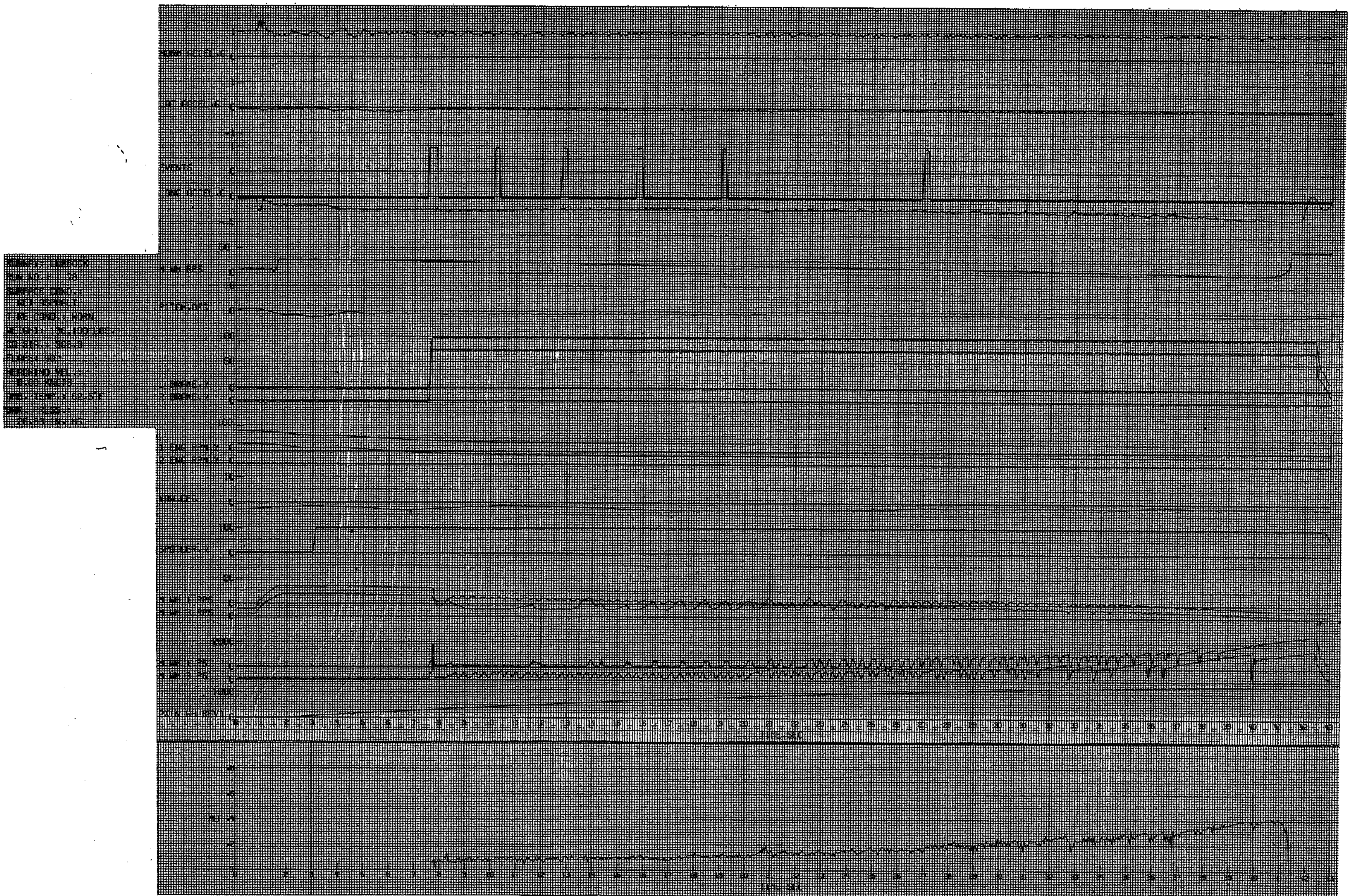
(b) Wet runway; all wheels turning

Figure 34.- Concluded.



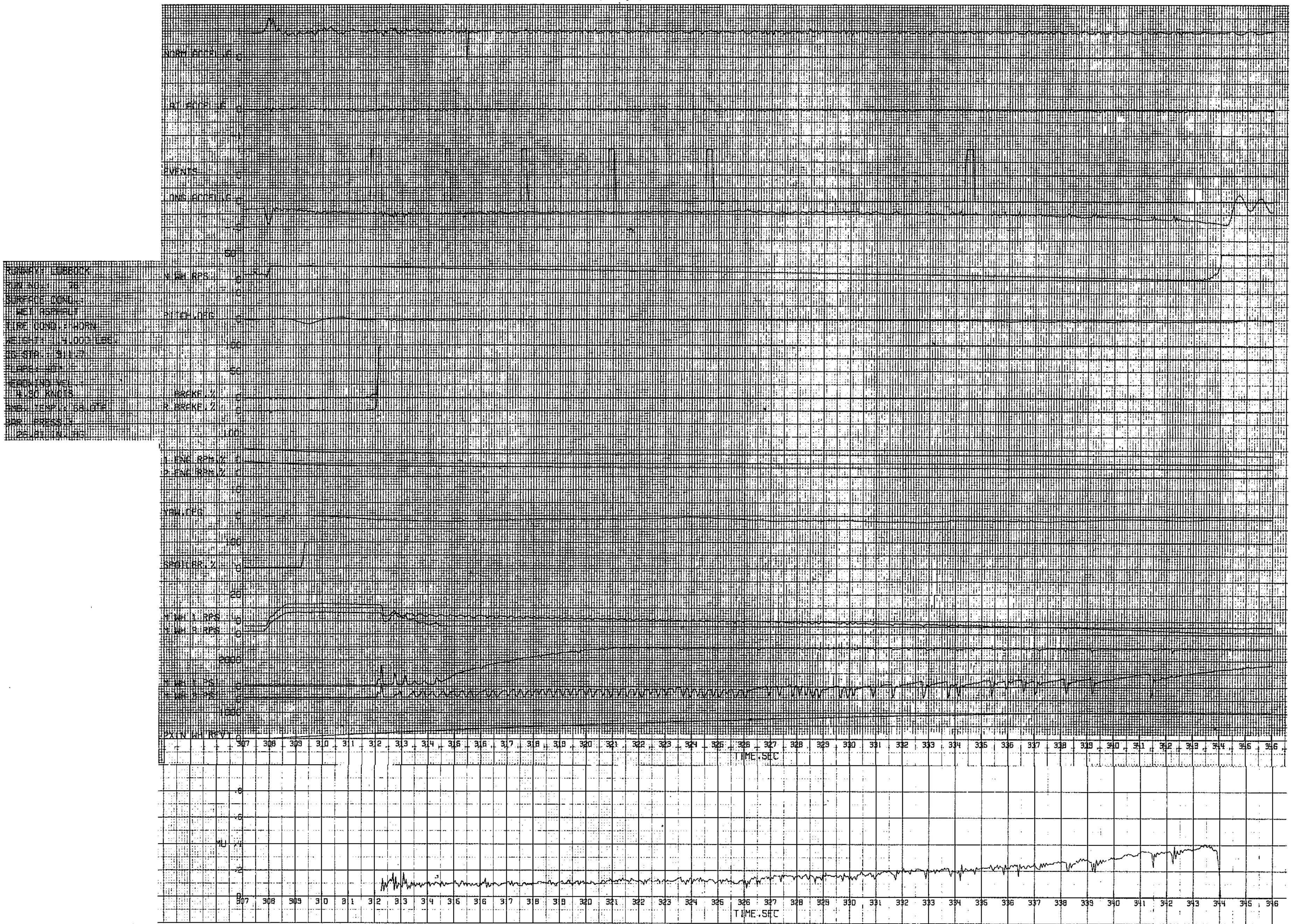
(a) Dry runway

Figure 35.- Typical time histories of aircraft test runs at Lubbock.



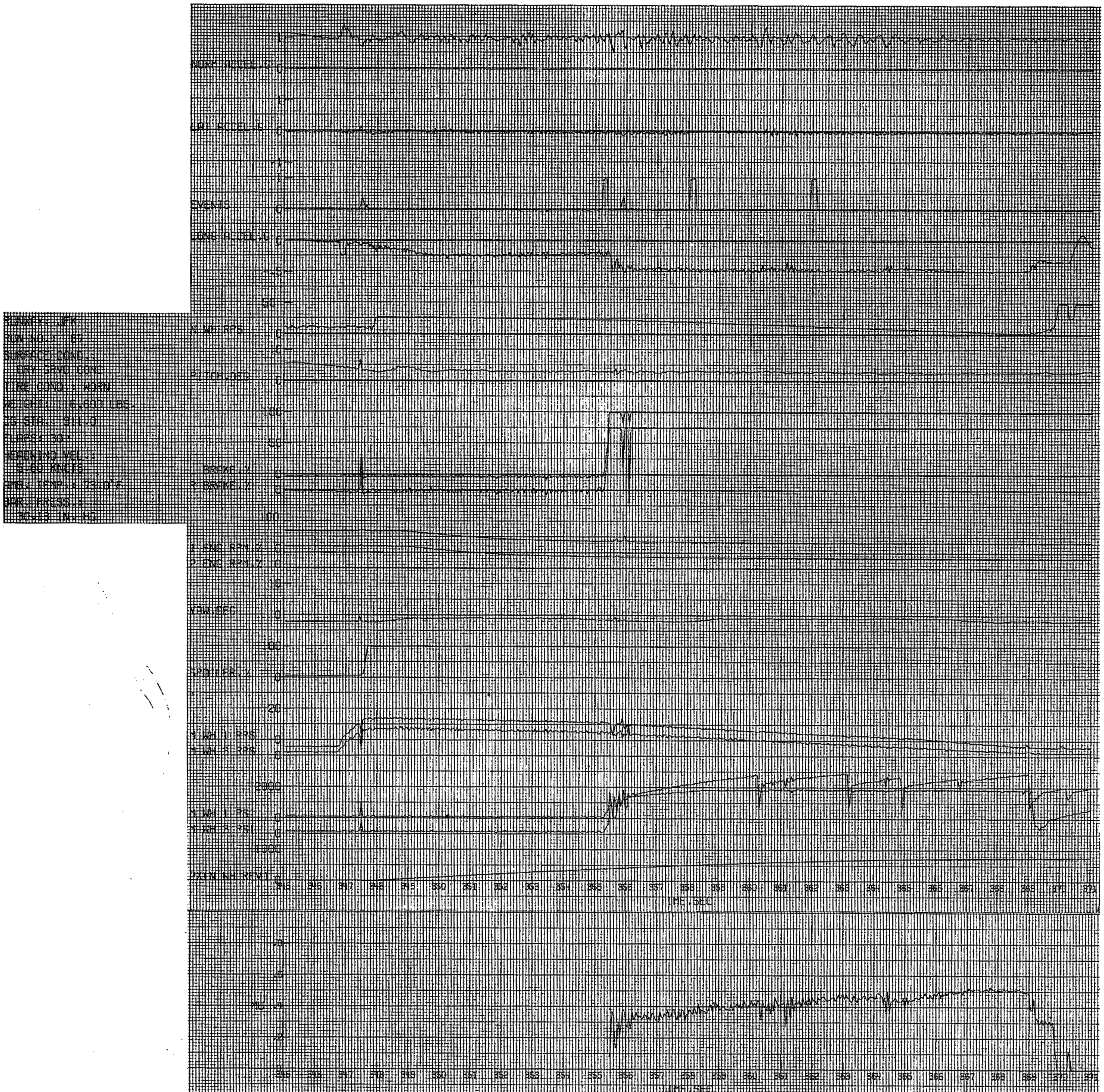
(b) Wet runway; all wheels turning

Figure 35.- Continued.



(c) Wet runway; two outboard wheels locked

Figure 35.- Concluded.



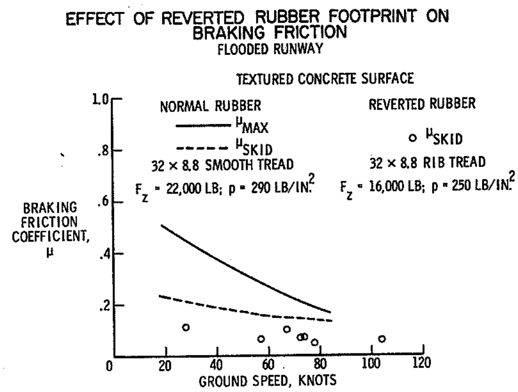
(a) Dry runway

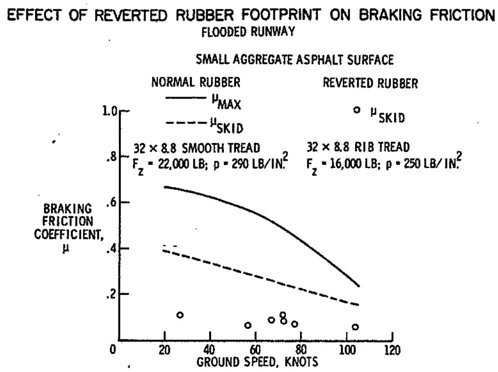
Figure 36.- Typical time histories of aircraft test runs at JFK.

(b) Damp runway with isolated puddles; all wheels turning

Figure 36.- Concluded.

NASA Landing Loads Track Tests - 1965 **(reference 3)**





	Run No.	Airport	Surface Condition	Water Depth, in.	Gross Weight, lb
○	48	Edwards	Dry		119,000
□	39	Houston	Dry		117,700
◇	50	Edwards	Wet	0.049	112,000
△	40	Houston	Wet	0.022	113,500

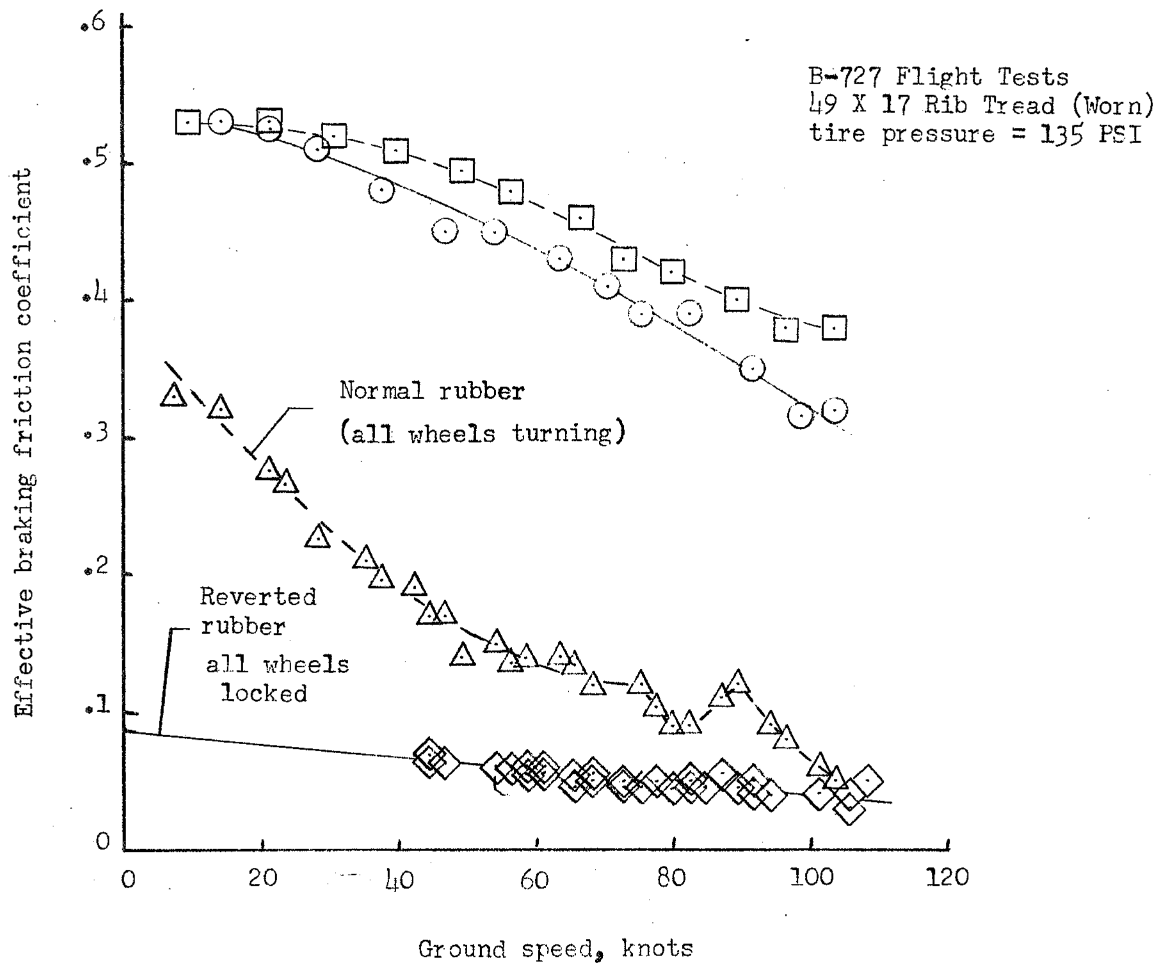


Figure 37.- Effect of reverted rubber skidding on aircraft tire braking coefficient.

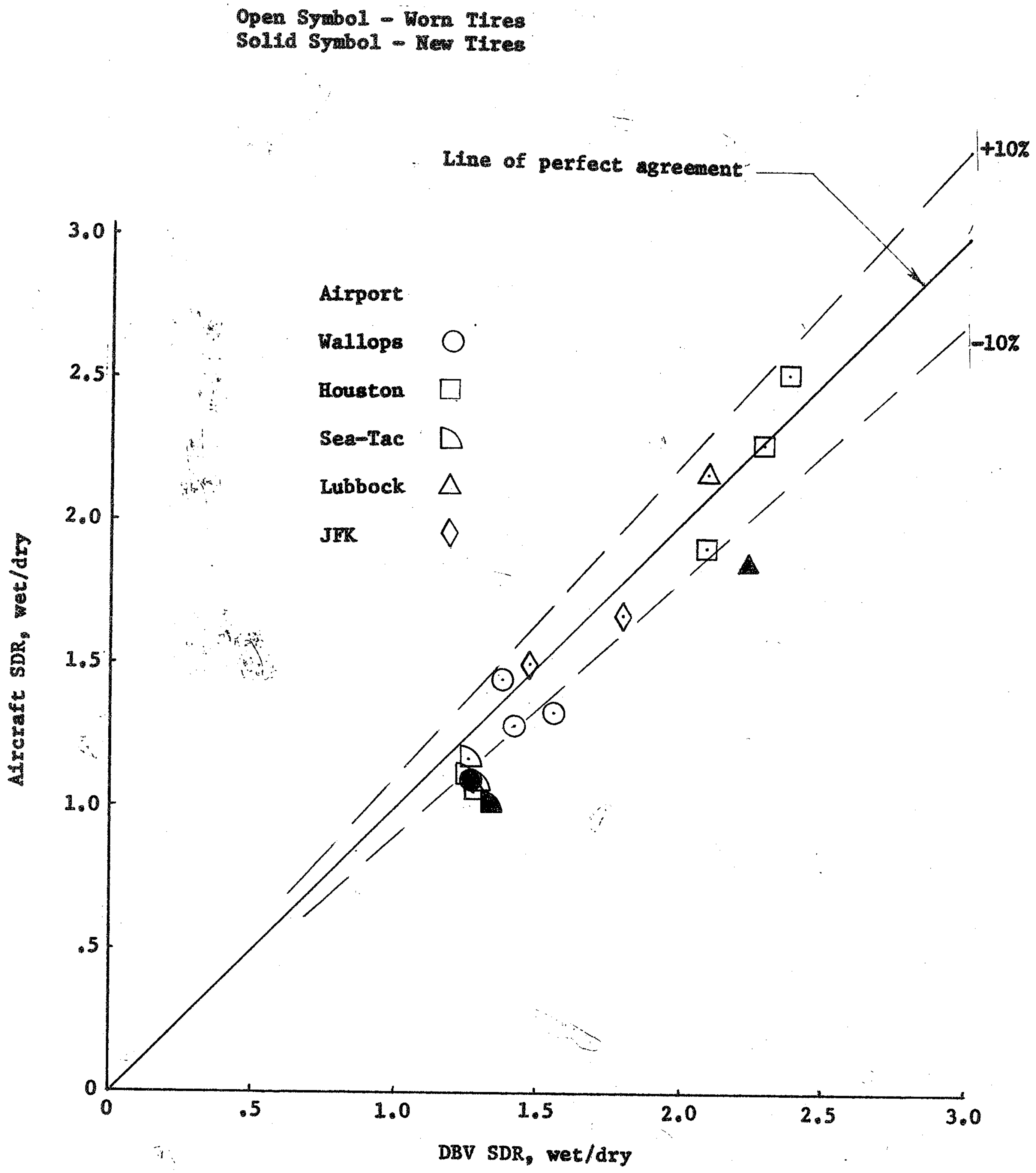


Figure 38.- DBV SDR correlation with aircraft SDR

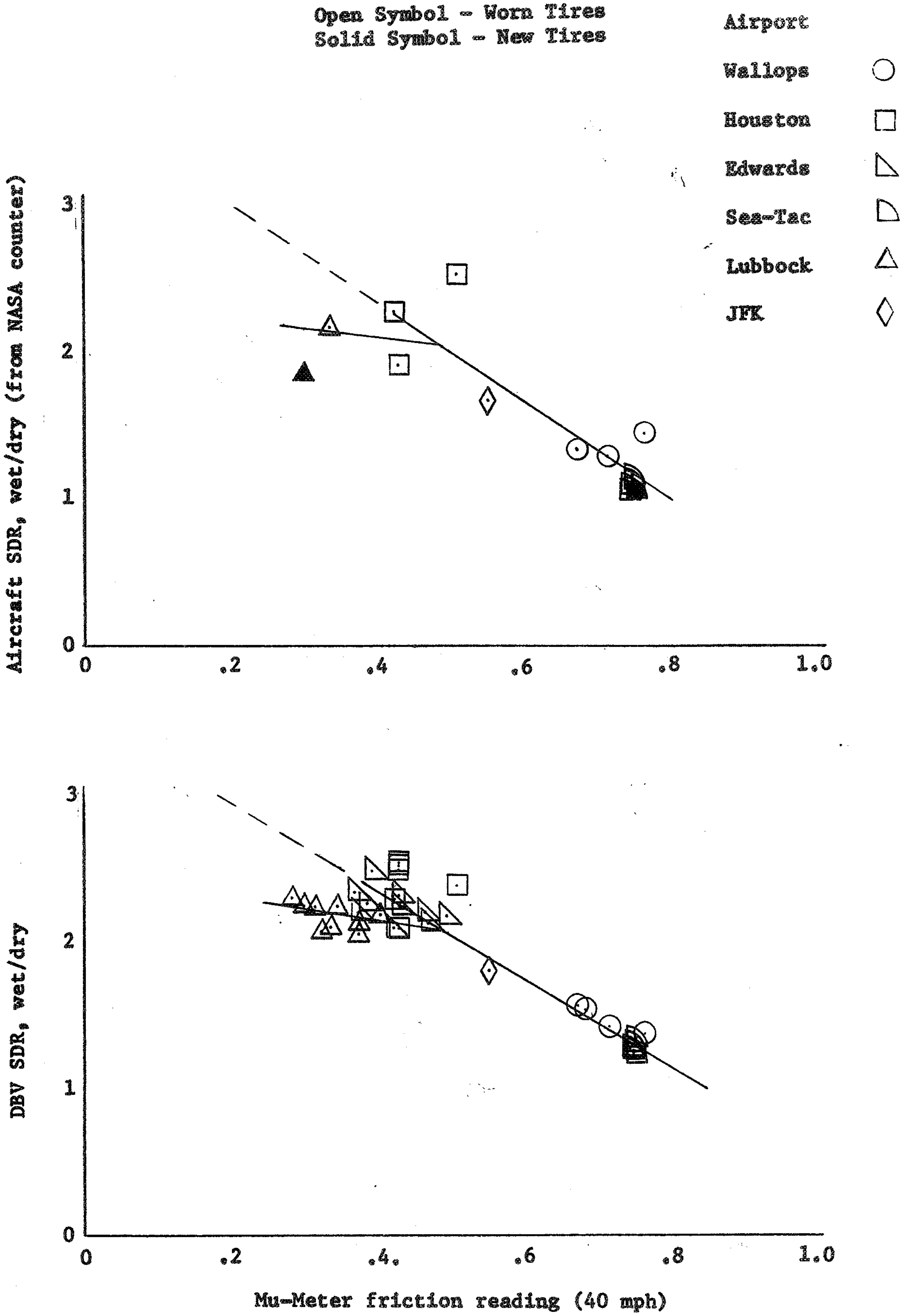


Figure 39.- Mu-Meter friction reading correlation with aircraft and DBV stopping distance ratio, wet/dry.

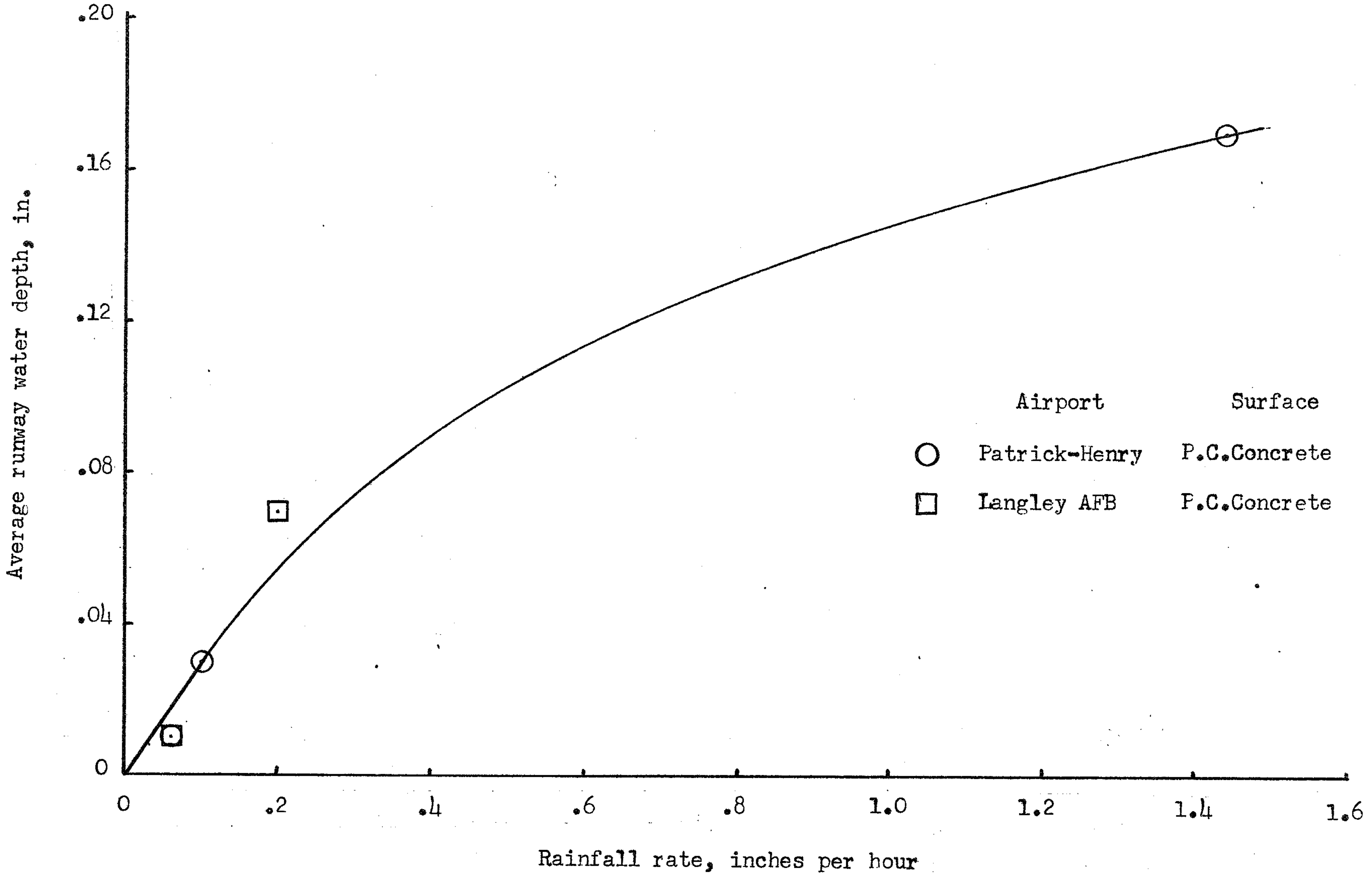


Figure 40.- Variation of runway water depth with rainfall rate for two Portland Cement concrete runways.

NASA-Langley, 1972