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INSTRUCTION MANUAL FOR MOBILE NONDESTRUCTIVE VIBRATORY TEST EQUIPMENT

Glenn T. Baird, et al

New Mexico University

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INSTRUCTION MANUAL FOR MOBILE NONDESTRUCTIVE VIBRATORY TEST EQUIPMENT

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August 1975

Final Report for Period 15 November 1973 - 30 November 1974

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Air Force Systems Command
Kirtland Air Force Base, NM 87117

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This technical report has been reviewed and is approved for publication.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

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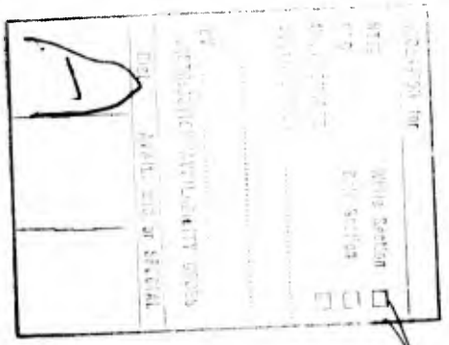

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Detailed operating instructions for use of the nondestructive pavement testing van developed at the Civil Engineering Research Facility, University of New Mexico, are outlined. Full descriptions of the equipment components are included as well as appropriate operator checklists.

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WARNING

Improper operation of the vibrator and its high-energy power supply can be hazardous. Only well-trained personnel who are familiar with this operating manual and the manufacturer's manuals should operate this equipment. Copies of all manuals should be kept in the van at all times and they should be referred to frequently.

EMERGENCY SHUTDOWN

Emergency shutdown may be necessitated for several reasons. Some of these are as follows:

- Personal danger to crew or visitors
- Electrical arcing in the system
- Fire (electrical, oil, or fuel)
- Cooling-oil pump or system failure
- Ruptured oil lines (high and low pressure)
- Abnormal noises and/or vibrations
- Loss of generator power regulation
- Loss of or damaged oil seals in vibrator

CAUTION

Care must be exercised since three-phase power is present in the power amplifier.

If during the operation of the power amplifier it becomes necessary to shut down the system immediately, one or more of the following actions should be taken. The extent of the emergency will determine which action is to be taken; they are listed in order from full to partial shutdown.

- Shut off the generator completely.
- Switch off the Main Power Relay Switch on the engine control panel of the generator. (This electrically isolates the generator.)
- Switch off the three-phase power to the vibrator system at the Main 220-V Breaker Box.
- Immediately sequence the power amplifier to the OFF position. (At this point, only 220-V three-phase input power will be present.)
- Open the left front or any rear door on the power amplifier. (This activates interlocks which drop the power amplifier to a low-voltage mode only.)
- Switch off the Field Coil Switch and the Oil Pump Switch. (This powers down and isolates the vibrator and drops the power amplifier, through interlocks, to the FILAMENTS position.)

If the vibrator has been running for any length of time before an emergency shutdown, a large amount of heat has been generated and excessive heat can damage the output tubes in the power amplifier, the coils in the vibrator baseplate, and various other components. Also a relatively large amount of cooling oil trapped within the vibrator baseplate by emergency shutdown can damage or break various baseplate seals if the vibrator is transported this way. Therefore, the trouble should be isolated or remedied as soon as possible and the rest of the system put into the cooling mode, if possible, and shut down normally.

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ILLUSTRATIONS

SECTION 1
INTRODUCTION

As new aircraft with heavy multiwheeled gear loads were introduced into the Air Force inventory, determination of the ability of the pavement to support these aircraft became necessary. However, the techniques presently employed to evaluate the load-carrying capacity of pavements are slow. Also the pavement facility under investigation must be closed to airfield traffic while test pits and trenches are dug and identifiable layers of the pavement structure are tested.

The Air Force Weapons Laboratory (AFWL) has, therefore, undertaken a study to develop a method for nondestructively evaluating airfield pavements. This can be accomplished by measuring the wave velocity in the various pavement layers and relating it to the elastic properties of that layer. Interpreting vibratory wave propagation data in conjunction with the theoretical dispersion curve relationships is an ideal way to determine the elastic properties of layered pavement systems. From the stiffness data (i.e., dynamic force versus surface deflection), the uniformity of the pavement may be determined by establishing the location of weak as well as strong areas within the pavement system. Resonant frequency and amplitude attenuation data could be used to develop distress criteria for the evaluation of existing airfield pavement systems.

During the past three years, the Eric H. Wang Civil Engineering Research Facility (CERF) has been developing unique nondestructive vibratory test equipment. A mobile van was built to house an electromagnetic vibrator and all the necessary conditioning, recording, and playback instrumentation for determination of the elastic properties of layered pavement systems.

This manual provides the necessary information to enable qualified technicians to safely operate the test equipment in the Nondestructive Pavement Test (NDPT) Van. Because of the high-voltage equipment, at least two technicians are required to operate the van; in this way each technician can operate and monitor certain equipment. Thus, setup, testing, and shutdown can be accomplished more efficiently.

This manual, supported by the following individual equipment manuals (filed in the van), comprises the entire operational documentation on this test equipment.

Instrumentation Manuals

Rack 1

Model 8420 Digital Multimeter/Counter (California Instruments)
DSI-210-K Digital Comparator & Display Unit (Gulton Industries, Inc.)
Model DST-840 Time Code Reader-Generator (Gulton Industries, Inc.)
Model 5323A Automatic Counter (Hewlett-Packard)
Type 556 Oscilloscope (Tektronix, Inc.)
Model 4204A Oscillator (Hewlett-Packard)
Model SD104A-1 Sweep Oscillator (Spectral Dynamics)
Lambda Power Supply (No manual available)

Rack 2

Type 2001 Digital Phase Indicator (AD-YU Electronics)
Model SD1012B Tracking Filter (Spectral Dynamics)
Model SD1010B Carrier Generator (Spectral Dynamics)
Type 524A3 Phase Computer (AD-YU Electronics)
Model 3400A RMS Voltmeter (Hewlett-Packard)

Rack 3

CPR-4010 Magnetic Tape Recorder/Reproducer (Bell & Howell)
Model 7035B X-Y Recorder (Hewlett-Packard)

Vibrator and Power Amplifier Manuals

Model 4120MB Power Amplifier (Gilmore Industries)
Oil-Cooling System for Vibrator and C90 Vibration Exciter (Gilmore Industries)
Associated Electronic Meters for Power Amplifier (Gilmore Industries)

SECTION 2
DESCRIPTION OF VAN

The Nondestructive Pavement Test (NDPT) Van (fig. 1) is 8 ft wide and 35 ft long; the van, which is divided into three compartments (fig. 2), houses all the test equipment necessary for nondestructive vibratory testing of pavements.

GENERATOR COMPARTMENT

The forward compartment contains a 100-kW diesel generator which supplies 110/220-V, three-phase electrical power for the test equipment.

VIBRATOR COMPARTMENT

The center compartment contains the electromagnetic vibrator, the vibrator oil-cooling system, the power supply for the vibrator field coil, a step-up transformer to convert the 220-V to 440-V power, and the hydraulic system for raising and lowering the vibrator.

Figure 1. Nondestructive Pavement Test Van

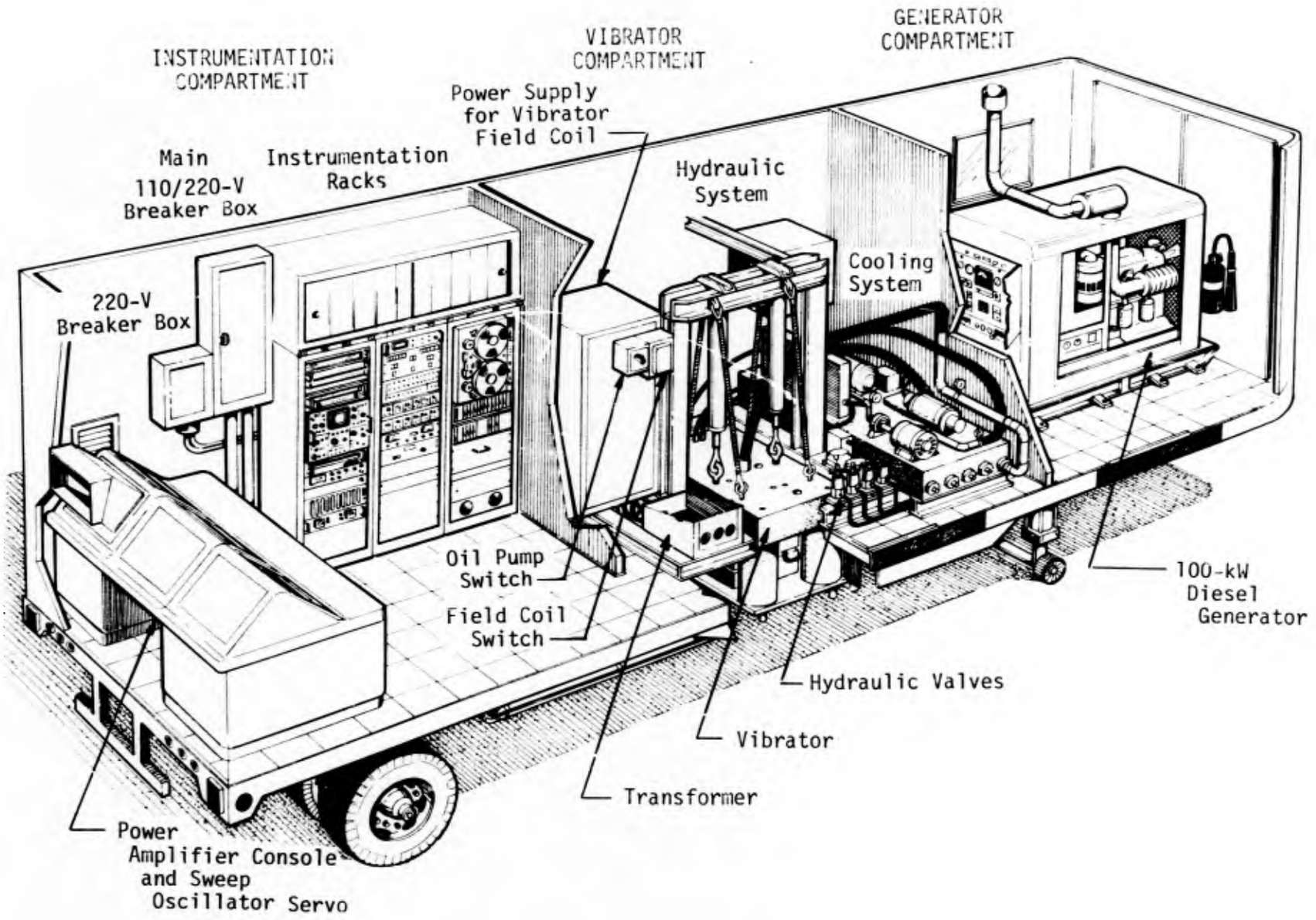


Figure 2. Equipment Layout in NDPT Van

A large mass is used to keep the vibrator baseplate in contact with the pavement being tested. This mass/vibrator combination weighs approximately 6750 lb. The vibrator consists of armature coils and field coils. The electrical field moves the armature which is connected through three load cells to a 2-in-thick, 12-in-diameter baseplate. The dynamic load generated is measured by the load cells. A velocity pickup and an accelerometer are located on the baseplate. The output from the velocity pickup is integrated to obtain the displacement amplitude of the baseplate. Once the electronically operated hatch door is opened, the vibrator can be lowered into position with two hydraulic jacks. Four stabilizer feet are provided on the vibrator to prevent damaging the armature suspension system. With this arrangement, dynamic loads (i.e., sinusoidally varying loads about a static load of 6750 lb) can be varied from a few hundred pounds to approximately 5000 lb (peak-to-peak load); the frequency of the dynamic load can be continuously varied from 10 to 5000 Hz by a sweep oscillator servo. Cooling of the vibrator is achieved by pumping oil from a reservoir into the coils of the vibrator. The hot oil returned from the vibrator is cooled by an air/oil heat exchanger.

INSTRUMENTATION COMPARTMENT

The aft compartment contains the instrumentation, recording and monitoring equipment, and the power amplifier console and sweep oscillator servo which controls the vibrator.

Instrumentation is provided for measuring the force, frequency, acceleration, velocity, and displacement of the vibrator baseplate during a test. Vertical pavement acceleration at selected distances from the baseplate can be measured, the phase angle between any two accelerometers on the pavement can be determined, and load basin data can be obtained with geophones.

The recording and monitoring equipment consists of a 14-channel FM magnetic tape recorder/reproducer, an X-Y recorder, an oscilloscope, a digital voltmeter, and a digital frequency counter.

A servomechanism on the sweep oscillator is used to hold the load or acceleration at a desired level. The power amplifier console contains readout units

for load, displacement, and acceleration and six panel meters to observe any malfunctions in the power amplifier unit.

This compartment is equipped with a heating/cooling system for temperature control. The temperature should be kept at approximately 68°-70°F.

SECTION 3
EQUIPMENT SETUP PROCEDURES

Before any equipment in the NDPT van can be operated, electrical power must be supplied from the 100-kW diesel generator located in the forward section of the van or from an external power source (220 V, 3 phase). However, equipment inspection steps can be performed before the generator is started. Three technicians, one working in each compartment, can best accomplish these checks.

100-kW DIESEL GENERATOR (fig. 3)

(1) Open front doors and side door in generator compartment to allow air circulation for engine cooling. Also open vibrator compartment doors.

(2) Unlatch door at rear of van and open side window in generator compartment to provide emergency exit for personnel.

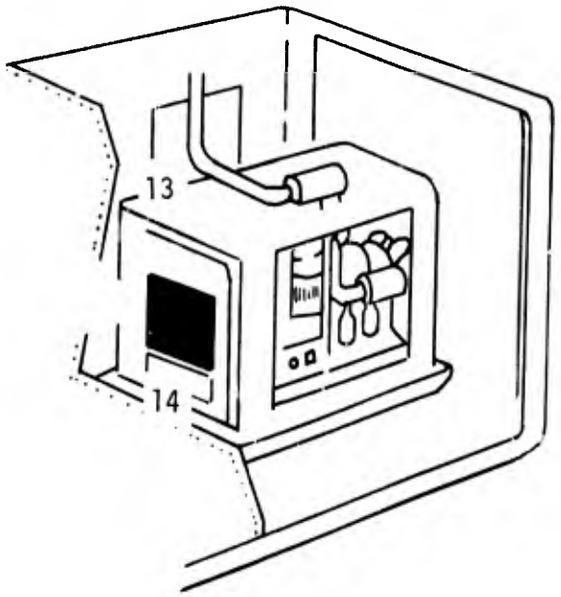
(3) Check engine lubricating oil level (dipstick located at right center of generator), battery water levels (batteries located under radiator at front of generator), and antifreeze/water level and refill if necessary.

CAUTION

Be sure that the breaker on the side of the generator is in the GENERATOR POWER position and that all electrical loads (i.e., lights, instrumentation, etc.) are off.

(4) Open the Generator Wiring Access Door at the rear of the generator and using an ohmmeter check the wiring for shorts as follows: Using the terminal labeled N as common, check each of the terminals (L1, L2, and L3) to be sure none are shorted to N; in the same manner, check to see that none of the terminals are shorted to each other. The N terminal should be chassis grounded (zero resistance to ground).

1. Engine Control Switch
2. Start Clutch Lever
3. Lubricating Oil Pressure Indicator
4. Volt/Amp Meter Switch
5. Speed Control Knob
6. Frequency Meter
7. Generator Control Switch
8. DC Exciter Switch
9. Main Switch
10. Pilot Light
11. Water Temperature Gage
12. Ammeter
13. Fuel Level Gage
14. Generator Wiring Access Door



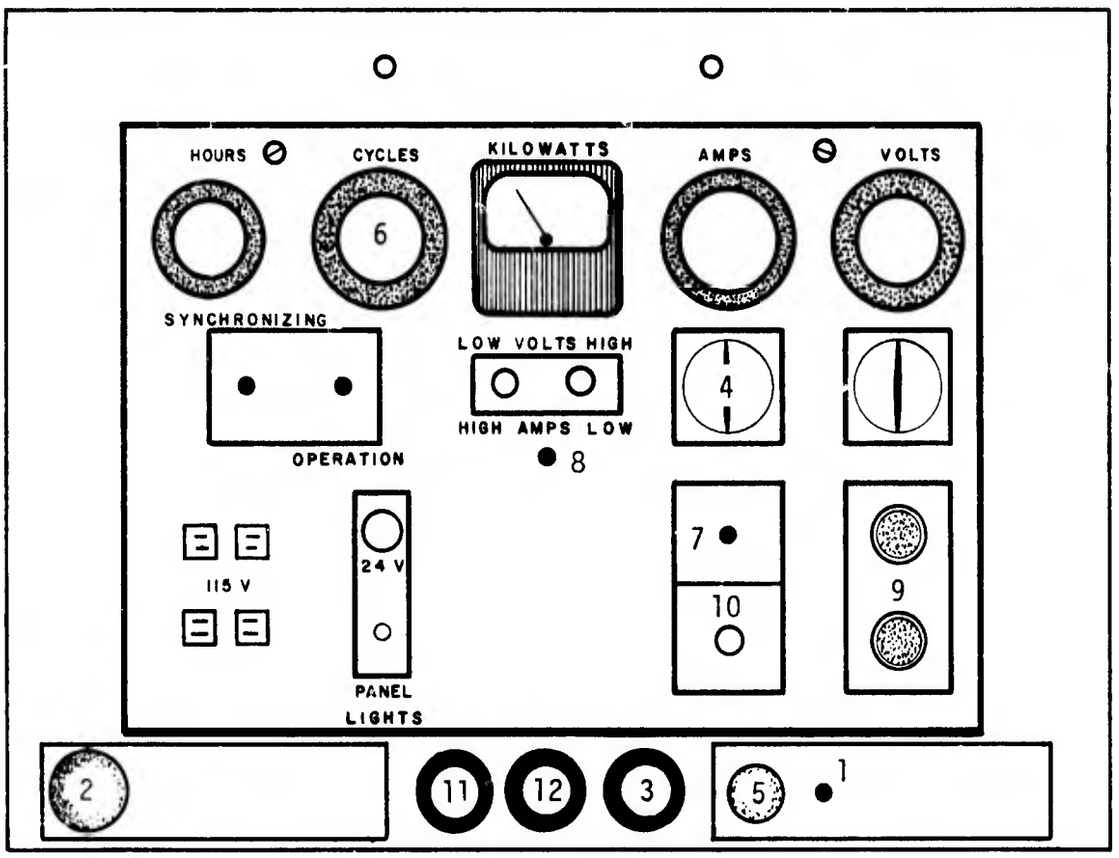


Figure 3. 100-kW Diesel Generator Engine Control Panel

(5) Set the Engine Control Switch to START.

(6) Push the Start Clutch Lever until the engine fires; then release it.

NOTE

In cold weather a small amount of ether sprayed into the air breather may be needed for easier starting.

(7) Let the engine idle until the Lubricating Oil Pressure Indicator reads 50 psi.

(8) Check to see that the Volt/Amp Meter Switch is set at the position indicated by the Amps 2, Volts 2-3 setting.

(9) Slowly pull the Speed Control Knob to increase the engine speed until the Frequency Meter indicates 60 Hz.

(10) Flip the Generator Control Switch from IDLE to RUN. (Normally the voltage is 220 volts at this stage. If it is not, momentarily flip the DC Exciter Switch to ON.)

NOTE

This spring-activated toggle switch is connected to a 6-vdc battery and is used to activate the residual electrical field around the main electrical generator.

(11) Push the On Button on the Main Switch.

NOTE

The amber Pilot Light should now be lit, indicating that the generator is producing 110/220 vac.

(12) Flip the Engine Control Switch from START to RUN.

(13) Adjust the Speed Control Knob as necessary to maintain an output frequency of 60 Hz.

(14) Check the following gages every 2 to 3 hours during operation:

(a) Water Temperature Gage (Normal water temperature is 150 to 160°F.)

(b) Lubricating Oil Pressure Gage (Normal oil pressure is 75 psi.)

(c) Ammeter (Ammeter should indicate slight charge.)

(d) Fuel Level Gage (Fuel should be maintained above the 1/4 mark to avoid clogging fuel filters. The tank capacity is 80 gallons The engine uses about 2 gallons per hour at idle and about 3 gallons per hour at full load.)

NOTE

The fuel tank can be easily and safely filled by taking the fuel hose through the window rather than through the door and across the engine.

(15) Turn on the breaker switches for the heating/cooling system. One is located at the left rear corner of the generator; the other is located under the van near the heating/cooling system.

All 110-vac equipment can now be operated by switching the 110-vac breaker switches, located in the main breaker box in the instrumentation compartment, to the ON positions.

VIBRATOR AND RELATED SYSTEMS

(1) Open the vibrator compartment doors.

(2) Remove the two wooden blocks from the sides of the vibrator by

releasing the four chain binders from the corners.

(3) Fully open the six valves of the hydraulic system.

NOTE

Valves 5 and 6 are located on each side of the hydraulic system fluid storage tank. The other four are located on the floor just to the right of the doorway (fig. 2); valves 1 and 4 control the rear horizontal jack and valves 2 and 3 control the front horizontal jack.

CAUTION

Hydraulic valves must be completely opened before the hydraulic system pump is turned on. Failure to open these valves will result in severe damage to the hydraulic filter system located under the van.

(4) Turn on the hydraulic system pump using the pushbutton switch located on the lower right hand side of the doorway and allow the pump to warm up for at least 30 sec.

NOTE

Slight noises may be heard on startup. However these can be ignored provided they cease after the motor has warmed up for a few seconds.

(5) Inspect the hydraulic system hoses, cylinders, and fittings for leaks.

(6) Open the door beneath the vibrator by activating the toggle switch located to the right of the hydraulic control levers.

NOTE

This door is equipped with automatic cutoff switches for fully-opened and fully-closed positions.

(7) Return the toggle switch to its neutral position after the door is fully opened.

(8) Release the horizontal hydraulic jacks by pulling out on the Horizontal Hydraulic Control Lever. Be sure the jacks clear the vibrator by approximately 4 in.

NOTE

White plastic indicators mounted on the jacks provide visible means of estimating the position of the jacks.

(9) Raise the vibrator to its maximum height to slacken the four safety cables by pulling out on the Vertical Hydraulic Control Lever.

(10) Detach the four safety cables from the vibrator by removing the clevis pins and secure the cables by attaching each clevis to the upper safety cable attachment hook.

(11) Check that the 19 clamps on the oil-cooling system hoses are tight.

(12) Check that the area under the vibrator baseplate is clear of all loose material.

(13) Slowly and gently lower the vibrator onto the pavement by pushing carefully on the Vertical Hydraulic Control Lever.

CAUTION

Do not jam or push the jacks into the vibrator system.

(14) Once the vibrator is resting on the pavement, continue to extend the hydraulic jacks until they hang free and no longer support the vibrator.

(15) Depress the Stop Pushbutton to turn off the hydraulic system pump.

(16) Check that the small feet at the corners of the vibrator clear the pavement by at least 1/8 in.

(17) Inspect the oil-cooling system hoses leading to the vibrator to be sure that they are not crimped.

(18) Loosen the two Allenhead bolts on each side of the vibrator approximately 1/2 in.

NOTE

These bolts prevent overextension of the air columns when the vibrator is raised and thus prevent damage to the vibrator. They, therefore, should be checked periodically when testing to ensure that they have not vibrated loose and become lodged under the vibrator.

(19) Using the compressed-air system located under the van and an air hose, inflate the vibrator air-suspension system using the valve on the side of the vibrator to give a 1/8-to-1 4-in gap. The air valve is located in front of the vibrator on the overhead trailer brace.

NOTE

Compressed air is supplied to the van through a 1/4-in air line by the compressor on the diesel or gasoline tractor, whichever is being used.

(20) With the air-suspension system inflated, remove the air hose from the compressed-air system.

(21) Remove the two red shipping blocks (one on each side of the vibrator) before operating the vibrator.

POWER AMPLIFIER CONSOLE (fig. 4)

The first six steps of the following procedure may be performed before the generator is started.

CAUTION

The left-side rear door in the instrumentation compartment must be opened carefully to prevent damage to the cooling ducts.

(1) Completely open the doors at the rear of the van.

(2) Open front and rear doors of the power amplifier console and inspect for damage (i.e., broken wires, loose components, power cord condition, etc.)

(3) Remove the top rear panels and bench top and continue inspection. Be sure to inspect the main power supply rectifier tubes located at the lower rear area of the left section of the console.

(4) After inspection is complete install the main power output tubes, which are stored in cartons in the instrumentation compartment during shipment, in their respective sockets; make sure they are well seated and that the caps have been placed on them.

(5) Close all console doors, replace bench top and top rear panels, and close the left-side rear door of the van. Use care in closing the van door for proper alignment of cooling ducts.

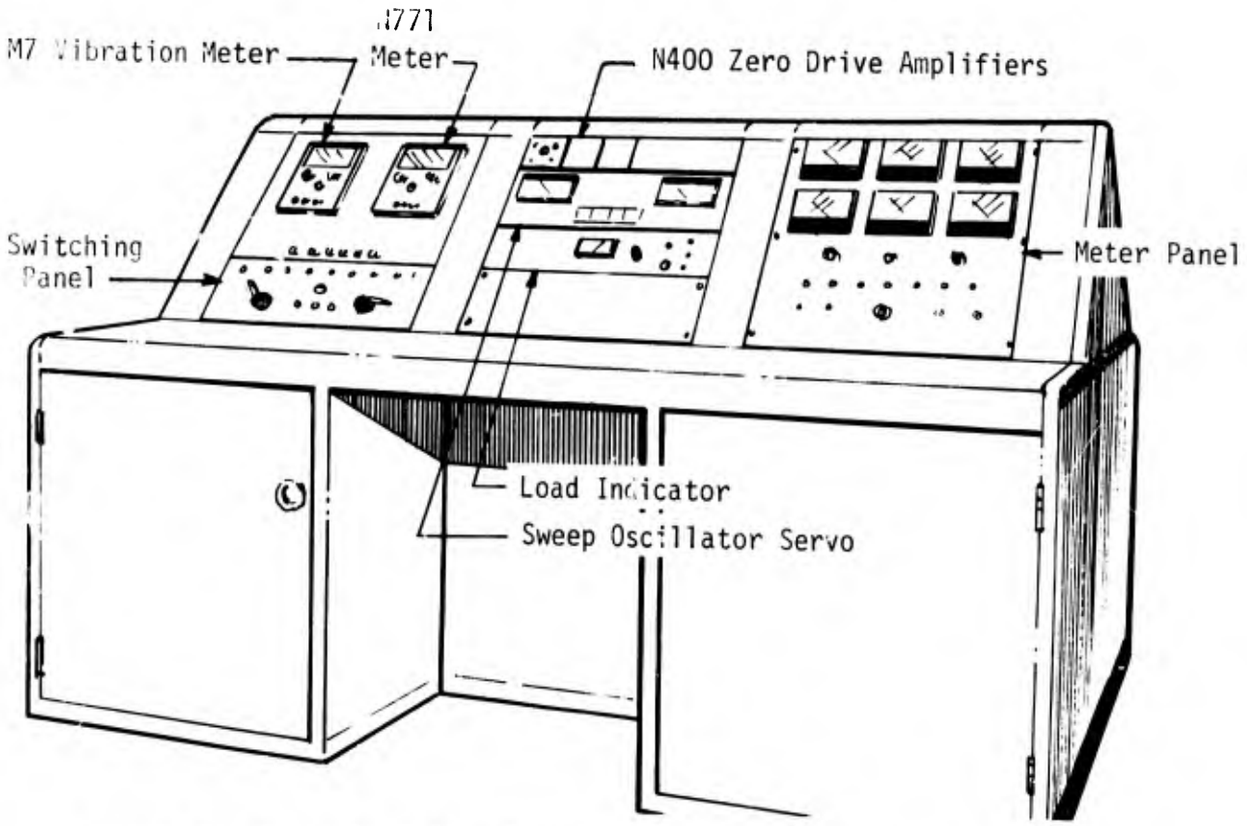


Figure 4. Power Amplifier Console and Sweep Oscillator Servo

NOTE

The console doors must be completely closed before the power amplifier will operate.

(6) Leave the right-side rear door ajar for an emergency exit.

(7) Replace all N400 Zero Drive Amplifiers in the console rack above the sweep oscillator servo. (The amplifiers are stored in a packing carton in the instrumentation compartment during shipment.)

(8) Check the generator output for proper frequency and voltage.

NOTE

Frequency and voltage are displayed by the gages above the main breaker box. The frequency should be 60 Hz and the voltage should be 110 V.

(9) Check that the Field Coil Switch and Oil Pump Switch located in the vibrator compartment (fig. 2) are in the OFF position.

(10) The following switches on the power amplifier console should be in the positions indicated:

Switch	Setting
Sequence (on switching panel)	OFF
Load Indicator Power (on load indicator)	OFF
M7 Vibration Meter Power (on M7 vibration meter)	OFF
Sweep Oscillator Output (on sweep oscillator servo)	PRESET (detent position)
Amplitude (on meter panel)	0 (fully counterclockwise until in detent position)
Line Voltage (on switching panel)	3

(11) Turn the Power Amp/Vib. System Circuit Breaker (located in the 220-volt breaker box) to ON. The three amber Phase Lights (A, B, and C) on the switching panel should now be lit.

(12) Check for the following readings on the AC Monitor Meter for the various AC Monitor Switch settings:

Switch Position	Approximate Reading
X10 CONT. (control circuit)	110 V
X1 FIL. (filaments)	6.3 V
X40 3Ø	440 vac
X20 3Ø	220 vac

NOTE

The Cooling Power, Bias, Door, and Air Lights on the switching panel should now be lit.

(13) Turn the Sequence Switch on the switching panel to the FILAMENTS position.

NOTE

The green Power Light and Time Delay Light should come on.

(14) Warm up the equipment for 2 to 3 min.

NOTE

When the equipment is warmed up, the Time Delay Light on the Meter Panel will go out and the Plate Sequence and Driver Lights on the switching panel will come on within 1 min. Sequencing up to the FIELD position is now possible.

(15) Turn on the M7 Vibration Meter.

(16) Turn on load indicator.

(17) Verify that the Plate Sequence Light on the switching panel is on.

(18) Turn on the Oil Pump Switch in the vibrator compartment (fig. 2).

(19) Check that there are no cooling-oil leaks, cooling-oil pressure is 100 psi, all pump motors and cooling-system fan are operating, and sump-pump pressure does not exceed 10 psi.

(20) Turn on the Field Coil Switch (fig. 2) and allow the field coil to operate for approximately 15 min.

(21) Turn the Sequence Switch on the switching panel to the FIELD position, pausing 2 to 3 sec at each intermediate position and observing the indicator lights and monitor meters which should read as follows:

Sequence Position	Lights and Readings
High Voltage START	Plate Light (switching panel): on Overtravel Light (meter panel): on Plate Sequence Light (meter panel): off Operate Monitor Light (meter panel): on Plate Voltage Meter (meter panel): 6 kV
High Voltage FULL	Plate Voltage Meter (meter panel): 7.5 kV
SCREEN	Screen Light (switching panel): on Cathode Current Meter (meter panel): 1.0
FIELD	Field Light (switching panel): on Operate Light (switching panel): on Cathode Current Meter (meter panel): 1.0

NOTE

The total time from the High Voltage START position to the FIELD position must be less than 20 sec. If more time is taken, an override system interrupts and the Sequence Switch must be returned to the FILAMENTS position. Sequencing to the FIELD position must then be started again.

(22) Check for the following readings on the DC Monitor Meter for the various DC Monitor Switch settings:

Switch Position	Reading
FIELD	60 V
+200	200 V
+500	500 V
+1300	1300 V
BIAS 1	-300 vdc
BIAS 2	-300 vdc

(23) Using the Cathode Current Meter and Switch on the meter panel, check TUBE 1 and TUBE 2 by switching to the respective switch positions and observing the meter readings. With the switch in the NEUTRAL position, the meter should read approximately 1.0. This is the sum of the two tubes. When TUBE 1 and TUBE 2 are checked individually, a meter reading of 0.5 should occur.

(24) Warm up the equipment for approximately 30 min before performing any calibration. Calibrations are required before any tests can be run.

SWEEP OSCILLATOR SERVO (fig. 4)

(1) List the following information in the log book and on the data sheets:

(a) Mode -- Acceleration (A), Velocity (V), or Displacement (D)

(b) Accelerometer Levels

(c) Computed Crossover Frequency

(d) Sweep Frequency Range

(e) Sweep Rate

(f) Compressor Speed and Speed Limits

(2) Set the Output Control on the sweep oscillator servo to PRESET (detent) position.

(3) Place the Amplitude Switch on the meter panel in the OFF (detent) position.

(4) Set Sweep Rate Vernier and A Multiplier Switch on the sweep oscillator servo for desired sweep rate.

(5) Set the following sweep oscillator switches to the positions indicated:

Switch	Setting
Oscillator Function	MAN
Compressor	AUTO
Operate	A-V-D PRESET

(6) Set the desired A-V-D and accelerometer range.

(7) Adjust the A-V-D Level Control for desired parameter level (dB Meter).

NOTE

If the program requires a crossover, A-A, V-A, D-A (2 levels), perform steps 8, 9, and 10 and skip step 11; if not (i.e., no crossover), skip to step 11.

(8) Set Operate Switch to the ACCEL PRESET position.

(9) Adjust accelerometer level (dB Meter).

(10) Set Oscillator Function to crossover frequency and adjust to crossover frequency (Frequency Meter).

(11) If single level program (A, V, or D), set ACCL Range Switch to OFF.

(12) Set Oscillator Function Switch to SINGLE (log or lin).

(13) Press RESET DOWN Button.

(14) Adjust lower limit.

(15) Press RESET UP Button.

(16) Adjust upper limit.

(17) Press RESET DOWN Button.

CAUTION

Compressor speed should always be less than system.

(18) Adjust Speed Control (Compressor Speed Meter).

(19) Set Operate Switch to the OPERATE-FLAT position.

(20) Set Compressor Switch to the STBY position and wait for compressor level to reach at least 80 dB.

(21) Adjust Amplitude Switch on the meter panel to a setting of approximately 5.5.

NOTE

This setting is a compromise between the maximum power needed to maintain the test load and overloading (red-lining) the power amplifier. Therefore, this setting will vary with pavement type and condition.

(22) Adjust Output Level Control to a setting of approximately 5.

(23) Set Compressor Mode Switch to the AUTO position.

(24) Adjust A-V-D Level Switch for desired indication on loadmeter.

SECTION 4
FIELD CALIBRATION PROCEDURES

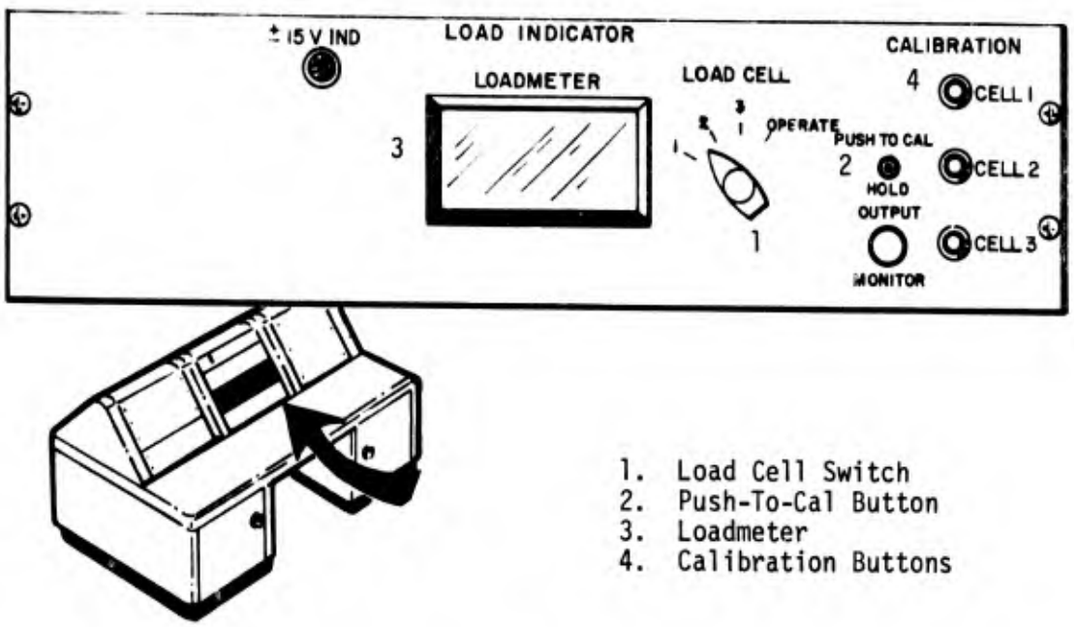
CERF LOAD INDICATOR (fig. 5)

The load indicator individually makes zero and gain adjustments for each load cell on the vibrator baseplate. The signals are amplified before any signal conditioning is performed; thus, the high-level signals are less subject to noise. A digital loadmeter reads in total load pounds and an RMS circuit is built into the load indicator so that an additional RMS-to-DC conversion unit is not necessary. The ac signal used for input to the sweep oscillator servo is filtered to remove the dc voltage.

The dynamic load of the system is equivalent to the static load. The load system is designed so that, through the RMS-to-DC converters (load and deflection), 1-V RMS or 1-vdc input is equivalent to 1-vdc output. Outputs from the load converter are gained through an operational amplifier for system servo and to drive the digital loadmeter. A 10-to-1 divider through an operational amplifier provides the proper voltage. The deflection converter is similar to the load converter except that it lacks the 10-to-1 divider. The voltage level to both units is limited to 10 V (RMS or dc). Amplifier gain to the deflection converter is adjusted for the correct output level.

NOTE

Equipment should be warmed up for at least 30 min before calibration is attempted. For this, the Field Coil Switch and the Oil Pump Switch should be on, and the Sequence Switch should be in the FIELD position. In low-temperature field conditions the operating temperature can be obtained more quickly by applying a load of approximately 1000 lb to the vibrator. When the temperature has stabilized, remove the load.



1. Load Cell Switch
2. Push-To-Cal Button
3. Loadmeter
4. Calibration Buttons

Figure 5. CERF Load Indicator

(1) Turn on the hydraulic system pump; pull out on the Vertical Hydraulic Control Lever and lift the vibrator approximately 6 in above the pavement.

(2) Remove the load indicator from the power amplifier console and place it on top of the console bench.

(3) Place the Load Cell Switch in position 1 to calibrate load cell 1.

(4) Depress the Push-To-Cal Button and adjust the zero potentiometer to read zero on the loadmeter.

(5) Repeat steps (3) and (4) for load cells 2 and 3.

(6) Verify zero by placing the Load Cell Switch in the OPERATE position.

NOTE

Depending on the precision of the individual load-cell calibrations, the loadmeter should read approximately zero.

(7) Return the Load Cell Switch to position 1, once the zero calibration is satisfactory.

(8) Depress, simultaneously, the Push-To-Cal Button and the CELL 1 Calibration Button for adjustment of the upper load limit.

(9) Repeat step (8) for load cells 2 and 3.

NOTE

The loadmeter should read as follows when the load cells are so tested:

CELL 1 - 7446 mV
CELL 2 - 7534 mV
CELL 3 - 7525 mV

(10) If the readings do not coincide with these values, adjust the high-end potentiometer until they do.

NOTE

The high-end values were obtained through individual load-cell sensitivity calibration and readings taken under laboratory-imposed loads.

(11) Reinstall the load indicator in the power amplifier console.

NOTE

If the load cells are ever removed from the vibrator baseplate, a laboratory calibration must be made before they are replaced.

(12) Slowly and gently lower the vibrator onto the pavement by pushing carefully on the Vertical Hydraulic Control Lever.

CAUTION

Do not jam or push the jacks into the vibrator system.

(13) Once the vibrator is resting on the pavement, continue to extend the hydraulic jacks until they hang free and no longer support the vibrator.

(14) Depress the Stop Pushbutton to turn off the hydraulic system pump.

(15) Check that the small feet at the corners of the vibrator clear the pavement by at least 1/8 in.

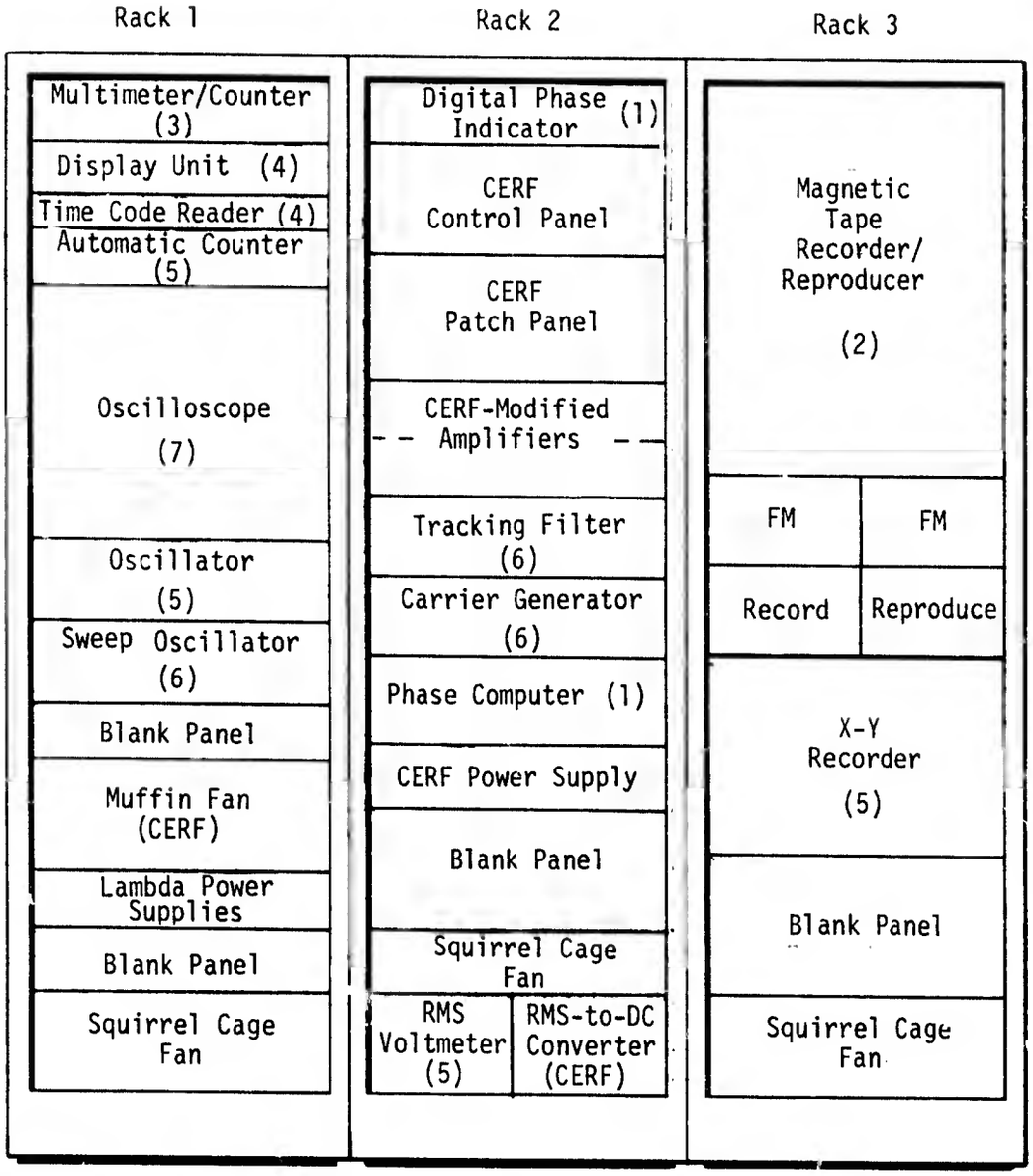
(16) Inspect the oil-cooling system hoses leading to the vibrator to be sure that they are not crimped.

PHASE COMPUTER AND DIGITAL PHASE INDICATOR (fig. 6)

If any of the following calibrations cannot be accomplished, refer to the manufacturer's manuals for troubleshooting procedures.

(1) Depress the 0° ADJ Calibrate Button on the digital phase indicator and adjust until the indicator reads 0°.

(2) Depress the 360° ADJ Calibrate Button on the digital phase indicator



Manufacturers

(1) AD-YU Electronics
(2) Bell & Howell
(3) California Instruments
(4) Gulton Industries
(5) Hewlett-Packard
(6) Spectral Dynamics
(7) Tektronix

Figure 6. Instrumentation Racks

and adjust until the indicator reads 360°.

(3) Turn the Function Switch on the phase computer to the 0° ADJUST position.

(4) Adjust the 0° SET on the phase computer until the indicator reads 0°.

(5) Turn the Function Switch on the phase computer to the 360° ADJUST position.

(6) Adjust the 360° SET on the phase computer until the indicator reads 360°.

(7) Return the Function Switch to the OPERATE NORMAL position before testing.

CARRIER GENERATOR (fig. 6)

NOTE

Refer to the manufacturer's manual for laboratory calibration.

(1) Turn the OPER CAL Switch to the CAL position.

CAUTION

The Frequency Adjust Potentiometer should not be adjusted once the manufacturer's laboratory calibration is accomplished.

(2) Verify that the needle is in the green area on the Tuning Amplitude Meter. If not refer to the manufacturer's manual for the proper calibration procedure.

(3) Switch to the OPER position.

(4) Periodically during the test, check that the Tuning Amplicude Meter needle is reading in the green area; adjust if necessary using the Tuning Amplitude Potentiometer with the OPER CAL Switch in the OPER position.

TRACKING FILTER (fig. 6)

CAUTION

Accelerometers should not be connected to the instrumentation during this calibration.

(1) The following switches on the CERF control panel (fig. 7) should be activated:

(a) Fet. Pwr
(b) Direct
(c) Phase vs Freq.
(d) Acceleration E Input (1)
(e) Acceleration E Input (2)

(2) Using cables and connectors, place the six accelerometer inputs on the CERF patch panel (fig. 7) in a parallel circuit with the sweep oscillator servo (i.e., Channel 14).

NOTE

The wiring diagram for the CERF-built panels is shown in figure 8.

(3) Apply a frequency of 3500 Hz with the sweep oscillator servo.

(4) Turn the Channel 1 and Channel 2 Range (Vrms) Selector Switches on the

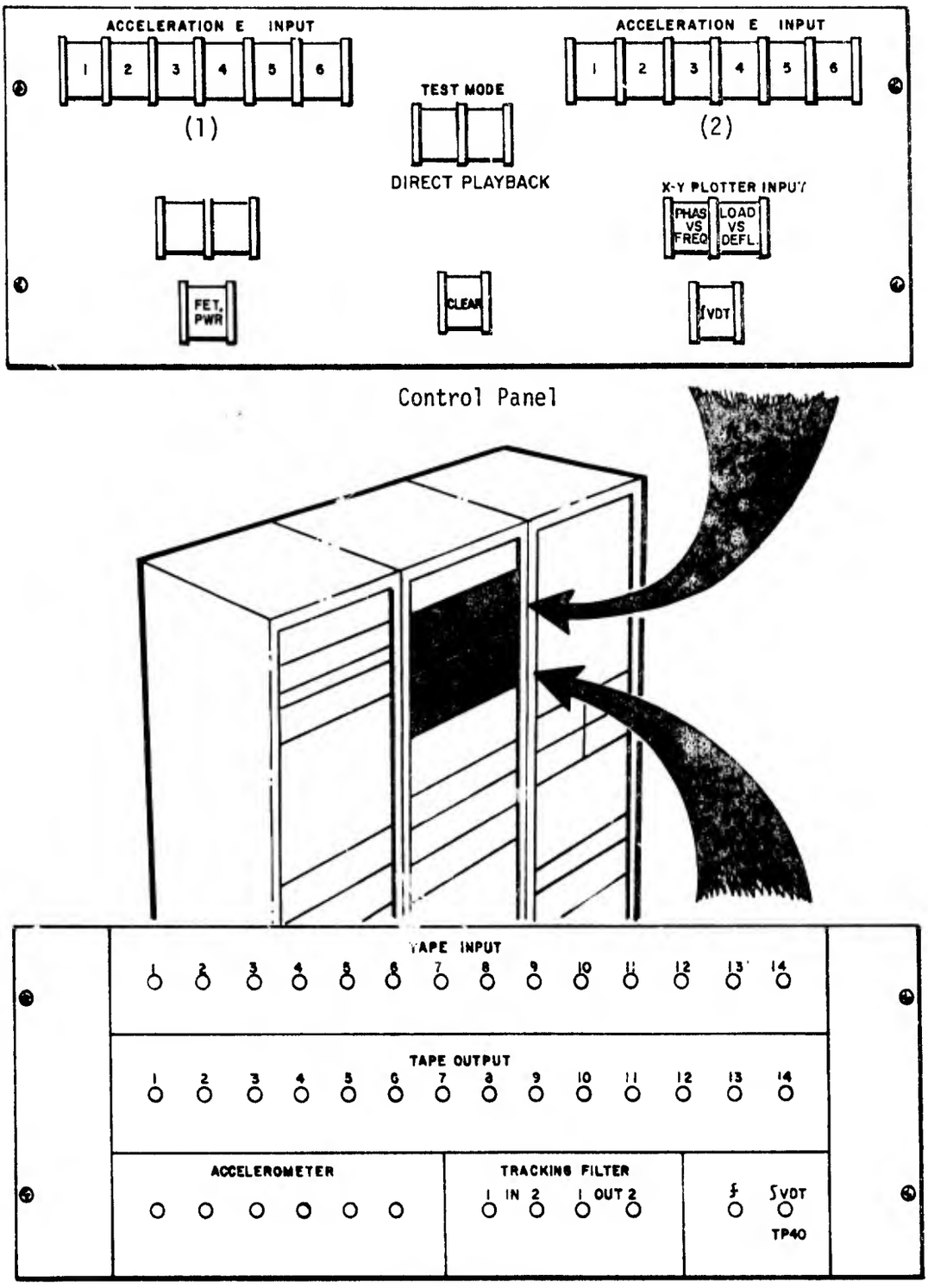


Figure 7. CERF Control and Patch Panels

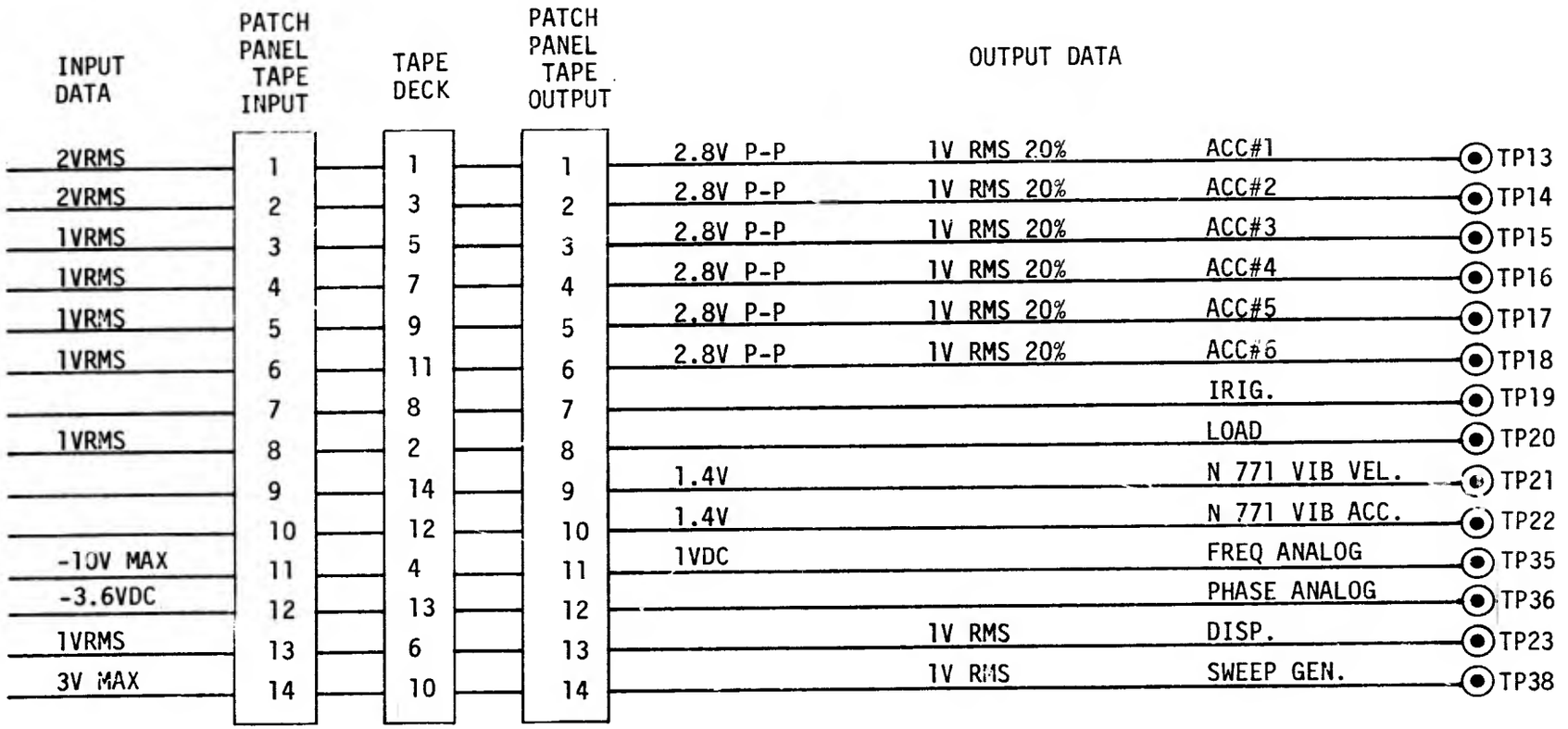


Figure 8. Wiring Diagram for CERF-Built Panels

tracking filter to position 3.

(5) Turn the Meter Multiplier Switches to position 1.

(6) Turn the Filter Switch to position 1.

(7) Turn the Mode Selector Switch to position 1 SINE AVG.

(8) Adjust the CERF-modified accelerometer amplifiers to give an approximate mid-scale reading on the Tracking Filter Meters.

(9) Adjust the Ø Adjust Potentiometer for Channel 1-Filter 1 of the tracking filter until the digital phase indicator reads 180°.

NOTE

A reading of 180° is used for calibration because a switch internal to the tracking filter allows one signal to be placed 180° out of phase from the original signal for easier data reduction on the X-Y recorder.

CERF-MODIFIED AMPLIFIERS (fig. 6)

The Bell & Howell amplifiers have been extensively modified by CERF. The Output Switch nomenclature (upper right-hand corner of each amplifier) indicates the following functions:

NOR - normal amplifier output
OFF - the output shorted
REV - a straight-through function (input signal switched directly to output)

The REV function is useful in determining amplifier failure and in setting zero output. The OFF and REV settings are used for calibration and troubleshooting

the tape recorder/reproducer and the X-Y recorder. The amplifiers must be set for DC on the Input Switch for proper conditioning of dc signals; ac signals may be either ac-or dc-coupled to the inputs.

(1) Zero the amplifiers by setting the Attenuator Switches to ZERO and adjusting the Offset Switch.

NOTE

Amplifiers are marked for approximate zero offset positions.

(2) Check the amplifier gain by either using a known input signal and switching through the attenuator positions, or using the internal CAL on the Input Switch and checking for the proper output level.

MAGNETIC TAPE RECORDER/REPRODUCER (fig. 6)

CAUTION

Do not remove or replace the record or reproduce modules while the tape recorder/reproducer is on.

NOTE

Scratch tape should be used for testing amplifier levels and tape skew.

(1) Check the center frequency (i.e., 27 kHz $\pm$ 2 Hz) using the automatic frequency counter for all FM record channels.

NOTE

If calibration of center frequency is needed, refer to the manufacturer's manual.

(2) Check that the CERF-modified amplifiers are off.

(3) Set record amplifiers to desired voltage (40% bandedge) level.

(4) Check reproduce amplifiers for output voltage using the 1-V calibration signal from the amplifiers. This can be done using the dB Meter on the tape recorder/reproducer; it should read 0 $\pm$ 1 dB for optimum output.

CAUTION

Do not turn Rec Test Switch to the ON position during voice test. The tape recorder/reproducer will stop immediately if this is done.

(5) Check voice channels (A and B) for proper operation by recording and reproducing voice test.

(6) Check IRIG recording levels by recording and reproducing IRIG signal using IRIG equipment.

CAUTION

Tape skew adjustment should be performed only by qualified technicians and personnel familiar with this type of equipment.

(7) Using the sweep frequency signal, adjust the tape skew to minimize the input/output phase shift.

NOTE

The resulting final phase shifts for various combinations of accelerometers should be noted for possible future reference.

X-Y RECORDER (fig. 6)

Refer to the manufacturer's manual for periodic laboratory calibration.

SECTION 5
TEST PROCEDURES

LOAD/DEFLECTION TEST

Load/deflection tests are usually performed at 15 or 25 Hz. The output from the velocity pickup located in the baseplate of the vibrator is integrated to obtain the vertical displacement of the baseplate. The magnitude of the displacement can be read directly through the M7 Vibration Meter located on the power amplifier console or the output of the M7 Vibration Meter can be processed through an amplifier and an RMS converter and fed to one of the axes of the X-Y recorder. The output from the load cells can be read directly from the loadmeter or from the digital multimeter/counter. The output from the loadmeter can also be processed through an RMS converter and fed to the X-Y recorder. The test setup is shown in figure 9.

(1) Ensure that all necessary calibrations and checks have been performed on the above equipment before proceeding with this test.

(2) Sequence up to the FIELD position.

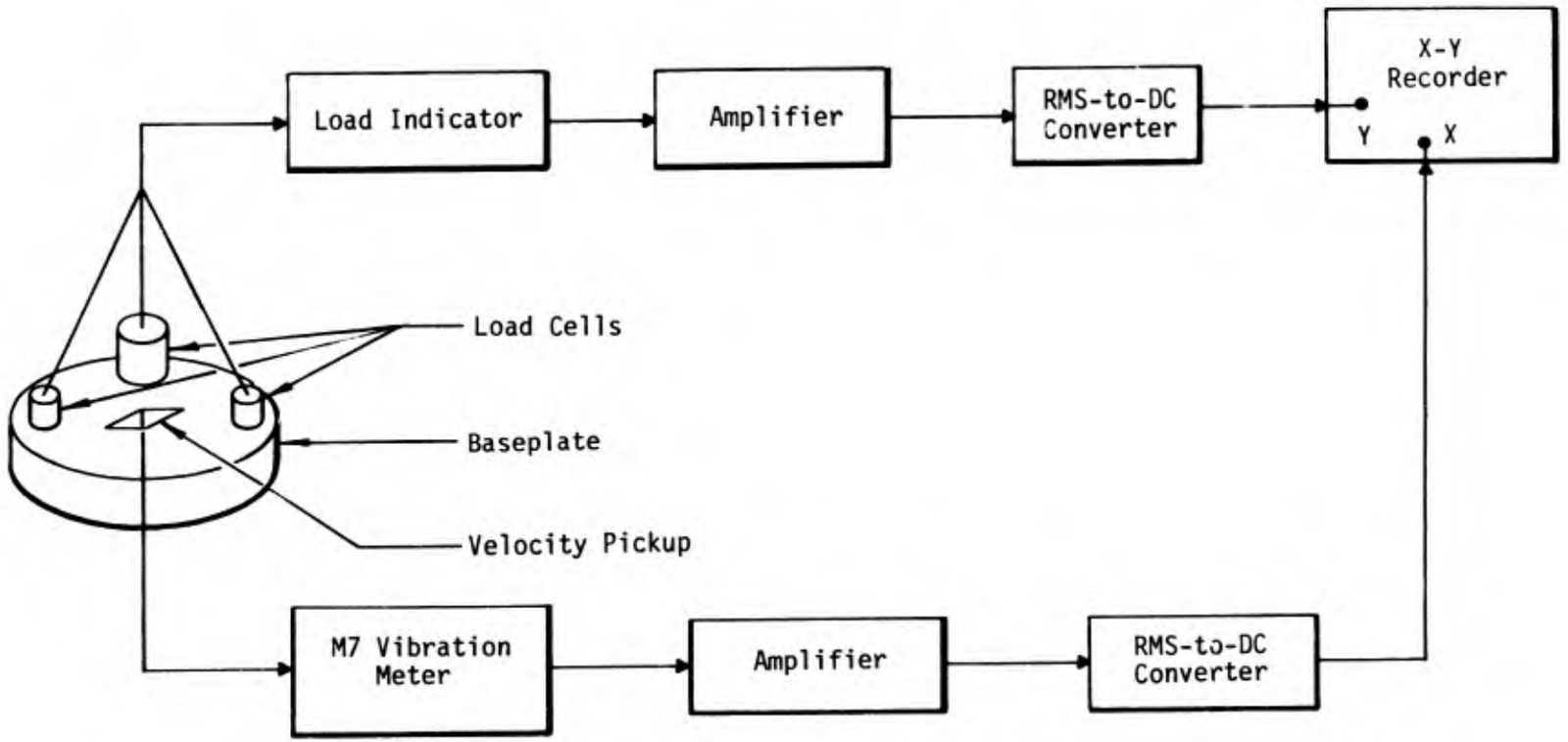
(3) Set frequency to desired level (i.e., 15 or 25 Hz) using the Freq Adjust Control on the sweep oscillator servo and the digital multimeter/counter for precise setting.

(4) Turn the following switches to the positions indicated:

Switch	Setting
Compressor	OFF
Output	PRESET (detent)
Amplitude	ZERO (detent)

(5) Depress the Direct and Load vs Defl. Switches on the control panel.

(6) Coordinate the axes of the X-Y recorder to coincide with zero load and zero deflection.



Note: When data are played back on playback mode from the tape recorder/reproducer, the load/frequency analog plots can be directly plotted on the X-Y recorder.

Figure 9. Load/Deflection, Frequency/Deflection, and Frequency/Load Test Setup

(7) Increase Amplitude Switch to a setting of approximately 5.5.

NOTE

This setting is a compromise between the maximum power needed to maintain the test load and overloading (red-lining) the power amplifier. Therefore, this setting will vary with pavement type and condition.

(8) Using the Output Switch on the sweep oscillator servo, apply a 5500-lb load by monitoring the loadmeter.

(9) Adjust the ranges of the following equipment for optimum ranges:

(a) M7 Vibration Meter
(b) Solid State RMS Meter (Deflection)
(c) HP RMS Meter (Load)
(d) CERF-Modified Amplifiers (Load and Deflection)
(e) X-Y Recorder

(10) Verify zero load and zero deflection adjustments of X-Y recorder.

(11) Manually increase the load to the desired level using the Output Switch.

(12) Gradually decrease the load (i.e., slowly turn the Output Switch to the ZERO (detent) position and simultaneously record on the X-Y recorder.

(13) Turn the Amplitude Switch to the ZERO (detent) position.

FREQUENCY/DEFLECTION TEST

Frequency/deflection tests can be performed by holding the load constant at a preselected value (i.e., 1000 lb) using a servo monitor and varying the frequency between preselected values (i.e., 10 to 50 Hz) to obtain a frequency/

deflection relationship. This type of test provides the response curve and the resonance characteristics of the pavement system. The test setup is the same as that for the load/deflection test (fig. 9).

The following instructions are for running a frequency/deflection test using the servo load control and the automatic frequency sweep capabilities of the sweep oscillator servo. However, it is also possible to perform this test by manually adjusting load and frequency.

(1) Place the Sequence Switch in the FIELD position.

(2) Turn the Function Selector Switch to the LINEAR SWEEP-SINGLE SWEEP position.

(3) Depress the Reset Down Button.

(4) Adjust the lower sweep limit for the desired low-frequency limit (i.e., 10 Hz).

(5) Depress the Load vs Defl. and the Direct Buttons on the control panel.

(6) Connect the deflection signal to the Y-axis and the frequency analog signal to the X-axis of the recorder.

(7) Using the frequency analog signal, adjust the X-axis of the X-Y recorder.

NOTE

This adjustment can be accomplished by selecting a scale for the X-axis and adjusting for the desired scale on the plotting paper.

(8) Sweep up to the high-frequency limit by pressing the Sweep Up Button on the sweep oscillator servo and pressing the Hold Button when the

desired frequency is reached.

(9) Adjust the frequency analog signal amplitude on the CERF-modified amplifiers to give a 1-V output signal.

(10) Adjust the X-Y recorder to give the desired scale.

NOTE

Steps (3), (7), (8), and (10) may have to be repeated several times to accomplish this adjustment.

(11) Reset the frequency to the low-frequency limit by pressing the Reset Down Button.

(12) Adjust the Y-axis of the X-Y recorder for zero deflection.

(13) Apply load. (Refer to procedure for sweep oscillator servo operation.)

(14) Adjust the Y-axis upper limit utilizing the deflection reading from the M7 Vibration Meter.

(15) Adjust the sweep rate to the desired rate (e.g., 0.3 Hz/s).

NOTE

The slower the sweep, the more accurate the data plot.

(16) Press the Sweep Up Button.

NOTE

This test can be done in either sweep direction. Experience will dictate which is more appropriate for the particular test setup.

FREQUENCY/LOAD TEST

Frequency/load tests can be performed by holding the load constant at a preselected value (i.e., 1000 lb) using a servo monitor and varying the frequency between preselected values (i.e., 10 to 3500 Hz) to obtain a frequency/load relationship. This provides the exact load being maintained by the servo system at any given frequency during the test. The test setup is the same as that for the load/deflection test (fig. 9).

The following instructions are for running a frequency/load test using the servo load control and the automatic frequency sweep capabilities of the sweep oscillator servo. However, it is also possible to perform this test by manually sweeping the frequency range.

(1) Ensure that all calibrations on the above equipment have been made.

(2) Place the Sequence Switch in the FIELD position.

(3) Turn the Function Selector Switch to the LINEAR SWEEP-SINGLE SWEEP position.

(4) Depress the Reset Down Button.

(5) Adjust the lower sweep limit for the desired low-frequency limit (i.e., 10 Hz).

(6) Depress the Load vs Defl. and the Direct Buttons on the control panel.

(7) Connect the load signal to the Y-axis and the frequency analog signal to the X-axis of the X-Y recorder.

(8) Using the frequency analog signal, adjust the X-axis of the X-Y recorder for the low-frequency limit.

NOTE

This adjustment can be accomplished by selecting a scale for the X-axis and adjusting for the desired scale on the plotting paper.

(9) Press the Reset Up Button.

(10) Adjust the upper sweep limit for the desired high-frequency limit (i.e., 3500 Hz).

(11) Adjust the CERF-modified amplifiers to give a minimum of 1-V amplitude output signal for this frequency analog signal.

(12) Using the frequency analog signal, adjust the X-axis of the X-Y recorder for the high-frequency limit.

NOTE

Steps (4), (8), (9), (10), and (12) may have to be repeated several times to accomplish this adjustment.

(13) Reset frequency to low-frequency limit by pressing the Reset Down Button.

(14) Adjust the Y-axis of the X-Y recorder for zero load limit.

(15) Apply load following procedures in sweep oscillator servo section.

(16) Adjust the CERF-modified amplifiers to give a minimum of 1-V amplitude output signal for this load signal.

(17) Adjust the Y-axis upper limit (load) to the desired scale.

(18) Adjust sweep rate as desired (usually the same as that used for

the wave propagation test; i.e., 25 Hz/sec).

(19) Activate and lower X-Y recorder pen.

(20) Press Sweep Up Button.

NOTE

This test can be performed in either sweep direction. Experience will dictate which is more appropriate for a particular test.

WAVE PROPAGATION (PHASE/FREQUENCY) TEST

To perform wave propagation tests, six accelerometers are glued onto the pavement surface with rapid-setting epoxy. The vibrator is operated in one of two modes: (1) manual mode--the force output is not controlled but is limited to a maximum value of 1000 lb; (2) servomode--the force output is controlled. The test consists of measuring the phase difference between two accelerometers at different distances from the vibrator baseplate as the frequency is varied with the load held constant. The test setup is shown in figure 10.

(1) After the vibrator has been positioned for the test, locate the positions of the six accelerometers by measuring from the center of the vibrator baseplate and marking the spacing (i.e., 2, 4, and 6 ft).

NOTE

These distances should be measured in a straight line along the centerline of the van.

(2) Cement the accelerometer mounting pegs to the pavement with a one-to-one mixture (Part A-to-Part B) of a quick-setting epoxy (Type 608, Clear Epoxi-Patch) and allow to set for approximately 5 min.

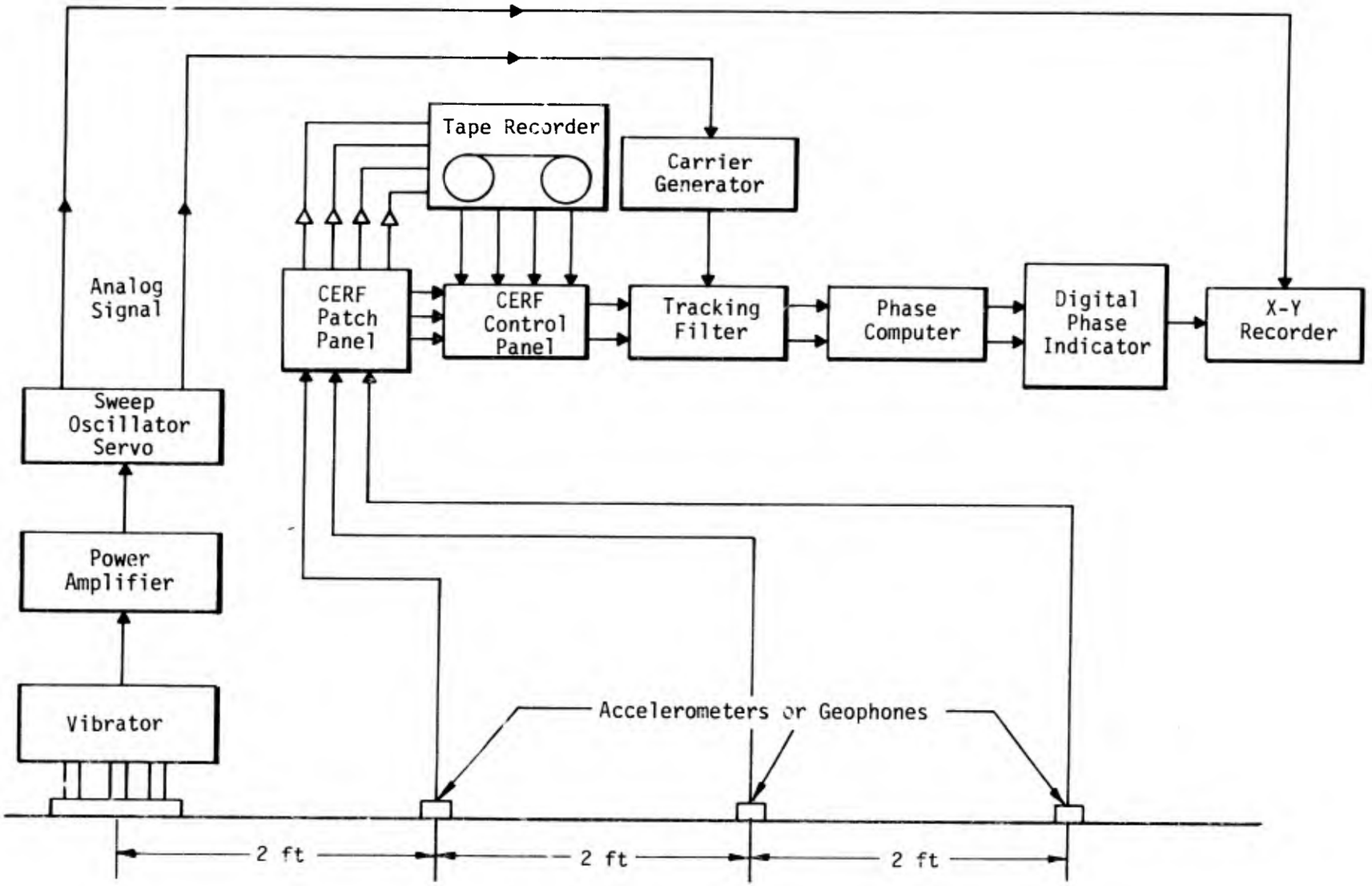


Figure 10. Wave Propagation (Phase/Frequency) and Deflection Basin Test Setup

(3) Screw the accelerometers into the pegs.

(4) Connect the accelerometer cables to the accelerometers and corresponding sockets on the patch panel located under the van.

(5) Turn on the Lambda power supplies.

NOTE

Be sure that the voltage is 18 V; if not, adjust the amplifiers.

(6) Warm up the vibrator and power amplifier systems for a minimum of 30 min.

(7) Ensure that all calibrations for the equipment shown in figure 10 have been performed.

(8) Press the following buttons on the control panel:

(a) Direct
(b) Phase vs Freq.
(c) Fet. Pwr
(d) Desired accelerometer inputs for field plot.

(9) Set the following switches to the indicated positions on the sweep oscillator servo:

Switch	Setting
Operate	OPERATE-FLAT
Accel Range	OFF
Function Selector	LINEAR SWEEP/SINGLE SWEEP

NOTE

The precise setup procedure is given in the sweep oscillator servo section.

(10) Set the lower sweep limit to the desired level (i.e., 10 Hz) on the sweep oscillator servo.

(11) Adjust the X-axis of the X-Y recorder to correspond to the low frequency.

(12) Press the Reset Up Button and adjust the upper sweep limit for 3500 Hz on the sweep oscillator servo.

NOTE

The lowest possible frequency adjustment is 500 Hz for the upper sweep limit. For the 10-to-350-Hz test, sweep up to 350 Hz and push the Hold Button when reached.

(13) Adjust the Y-axis of the X-Y recorder utilizing the 0° and 360° Function Switch calibrate signals from the phase computer.

(14) Place the Function Switch in the NORMAL OPERATE position before the test is run.

(15) Set the desired sweep rate (i.e., 2.5 Hz/sec for the 10-to-350-Hz test and 25 Hz/sec for the 10-to-3500-Hz test) with the Sweep Rate and A Multiplier Switches.

(16) Sweep down to verify that the limits and the rate are set properly.

(17) Turn the A-V-D Range Switch to the ACCEL 10 position.

(18) Turn the Compressor Switch to the STBY position.

(19) Turn the Amplitude Switch to a setting of approximately 5.5.

NOTE

This setting is a compromise between the maximum power needed to maintain the test load and overloading (red-lining) the power amplifier. Therefore, this setting will vary with pavement type and condition.

(20) Turn the Output Control Switch until it is just out of the detent position.

(21) Verify that the Compression Level Meter indicates at least 80 dB.

(22) Turn the Compressor Switch to the AUTO position.

(23) Turn the Output Control Switch slowly clockwise until a load of 1000 lb is reached or until the switch is in position 6. The Compression Level Meter should read 10 to 15 dB.

NOTE

With this load level the frequency may be swept through the resonant frequencies so that conditions will be just short of red-line situations.

(24) Sweep up to the upper-frequency limit and check the signal levels to the tape recorder/reproducer to be sure that no channel is overdriven. If it becomes necessary to adjust the amplifier gain, stop the sweep by pushing the Hold Button on the sweep oscillator servo.

(25) Set the IRIG code that is to be recorded for the test.

(26) Set the sweep oscillator servo for the upper limit of the test.

(27) Adjust the CERF-modified amplifiers for Tracking Filter Channel 1 and 2 for optimum signal level (approximately mid-scale).

(28) Start the tape recorder/reproducer and IRIG generator and provide any voice annotation desired on the voice channel (A or B).

(29) Activate the X-Y recorder with the pen in the down position.

NOTE

To aid in data reduction, the tape recorder/reproducer should be run in the record mode for about 30 sec before starting the frequency sweep.

(30) Sweep down from the upper frequency limit to the lower limit.

(31) Monitor and maintain the Tracking Filter Channel 1 and 2 Meters at optimum reading by adjusting the CERF-modified amplifiers for the tracking filter channels only. Do not adjust the accelerometer amplifiers. (This is only necessary if a field plot is desired.)

(32) After the sweep is completed, continue running the IRIG generator and the tape recorder/reproducer for 30 sec before turning off to allow easier calibration of the X-Y recorder for data playback and reduction.

(33) Turn the following switches to the indicated positions in the order given:

Switch	Setting
Output Control	PRESET (detent)
Amplitude Control	OFF (detent)
Compressor	OFF

(34) Run the tape recorder/reproducer in the RUN FWD position for 5 sec to provide a leader for the next test.

(35) Repeat the above procedures for each frequency range desired.

DEFLECTION BASIN TEST

The deflection basin test is used to determine how the deflection varies with the radial distance from the load point. Once the deflections are known at certain distances from the load, a radius of curvature of the surface can be computed. This is then used to determine the elastic modulus of the pavement. The displacements are determined by electronically integrating the velocity output of the geophones. The test is performed at low frequencies (i.e., less than 100 Hz) and the load is varied. The output of the geophones can be recorded on tape and played back.

(1) Ensure that the M7 vibration meter, sweep oscillator servo, tracking filter, X-Y recorder, RMS-to-DC converter, and tape recorder/reproducer have been calibrated and that the power amplifier is in the FIELD position.

(2) Ensure that all equipment is set as indicated in the sweep oscillator servo section.

(3) Place geophones on the pavement at the selected distances from the vibrator baseplate. (Refer to wave propagation test procedure for method of measurement.)

CAUTION

The Lambda power supplies must be off and remain off while geophones are connected to the system.

(4) Connect the cables to the geophones and patch panel located under the van.

(5) Press the following buttons on the control panel:
   (a) Direct
   (b) Load vs Defl.
   (c) $\int$Vdt

(6) Press Pickup Button 3 and turn the Pickup Type Switch to the DAMPED position on the M7 Vibration Meter.

(7) Connect the desired geophone channel on the patch panel to the input of Channel 2 on the tracking filter.

(8) Connect the output of Tracking Filter Channel 2 to the $\int$Vdt input on the patch panel and include in this connection a low-pass filter.

(9) Set up the X-Y recorder as per the load/deflection test procedure.

(10) Manually set the desired test frequency (i.e., 15 or 25 Hz).

(11) Coordinate the axes of the X-Y recorder to correspond to zero load and zero deflection with no load applied.

(12) Apply the desired load by turning the Output Switch on the sweep oscillator servo until this load is shown on the loadmeter.

(13) Verify that the RMS-To-DC Converters are set for optimum output.

(14) Adjust the axes of the X-Y recorder for maximum plot corresponding to maximum load and maximum deflection of the geophones.

(15) Verify calibration of zero load and zero deflection of the X-Y recorder by removing the load.

NOTE

Steps (12) through (15) may have to be repeated several times for accurate calibration.

(16) Reapply maximum test load and adjust appropriate CERF-modified amplifiers to give maximum recording signal for desired data channels using dB Meter on tape recorder/reproducer.

NOTE

Data can be recorded at any desired tape speed provided the appropriate filter in the reproduce module is available.

(17) Set IRIG to desired IRIG code.

(18) Start tape recorder/reproducer and record data by pressing RUN FWD and REC Buttons.

(19) Start IRIG.

(20) Activate X-Y recorder.

(21) Run the tape recorder/reproducer for 30 sec for a tape leader before decreasing the load.

(22) Manually decrease the load at a slow, constant rate to zero load using the Output Switch on the sweep oscillator servo.

(23) When the test is completed, deactivate the X-Y recorder.

(24) Run the tape recorder/reproducer and IRIG for 30 sec after zero load is reached.

SECTION 6
DATA PLAYBACK

FREQUENCY/LOAD DATA

(1) Depress the Load vs Defl. and the Playback Buttons on the control panel.

(2) Connect the load signal to the Y-axis and the frequency analog signal to the X-axis of the X-Y recorder.

(3) Locate the desired test record utilizing the IRIG Readout in the RD mode and the Tape-Footage Counter.

(4) Using the low-frequency limit (i.e., 10 Hz), as played back on the automatic (frequency) counter, set the low limit on the X-axis of the X-Y recorder.

(5) Rewind tape to beginning of test and set the high-frequency limit (i.e., 3500 Hz) on the X-axis to the proper scale.

NOTE

Steps (4) and (5) may have to be repeated to ensure accurate setting of the high- and low-frequency limits.

(6) Advance tape to the low end of the test (i.e., 10 Hz).

(7) With the load signal removed from the Y-axis of the X-Y recorder, set the low-load limit for the Y-axis (zero load).

(8) With the load signal applied (i.e., 1000 lb), set the high-load limit for the Y-axis (load) to the proper scale.

(9) Repeat steps (7) and (8) as required.

(10) Rewind tape to beginning of test and place in RUN FWD mode.

(11) Activate the X-Y recorder.

WAVE PROPAGATION DATA

(1) Warm up the instrumentation.

(2) Connect the phase computer, tracking filter, and patch panel as in the wave propagation test.

(3) Press the following buttons on the control panel:

(a) Playback
(b) Phase vs Freq.
(c) Desired accelerometer inputs that are to be compared.

(4) Check the X-Y recorder for correct inputs.

(5) Turn Function Switch on the phase computer to the 0° position.

(6) Calibrate the Y-axis of the X-Y recorder for -180° phase angle.

(7) Turn Function Switch to the 360° position.

(8) Calibrate the Y-axis of the X-Y recorder for +180° phase angle.

(9) Locate desired test on the tape utilizing the IRIG Readout and Tape-Footage Counter.

(10) Advance tape to end of test and set low-frequency limit (i.e., 10 Hz) on the X-axis of the X-Y recorder.

(11) Rewind tape to beginning of test and set high-frequency limit (i.e., 350 or 3500 Hz) on the X-axis of the X-Y recorder.

NOTE

Steps (10) and (11) may have to be repeated several times for an accurate calibration.

(12) Return Function Switch to NORMAL OPERATE position.

(13) Return tape to the beginning of the recorded test.

(14) Place the tape recorder/reproducer in the RUN FWD mode.

(15) Activate the X-Y recorder.

(16) During playback monitor the Tracking Filter Channel 1 and 2 Meters and adjust the Tracking Filter Channel 1 and 2 CERF-modified amplifiers to maintain approximate mid-scale meter readings.

DEFLECTION BASIN DATA

(1) Warm up the instrumentation.

(2) Press the following buttons on the control panel:

(a) Playback
(b) Load vs Defl.
(c) $\int$Vdt

(3) Place IRIG generator in the RD position.

(4) Connect the tape output of the desired geophone to Tracking Filter Channel 2 input on the patch panel.

(5) Connect Tracking Filter Channel 2 output to $\int$Vdt input on the patch panel using the low-pass filter.

(6) Connect the sweep frequency output on the patch panel to the automatic (frequency) counter.

(7) Locate desired test on the tape utilizing the IRIG Readout and Tape-Footage Counter.

(8) Advance tape to end of test.

(9) Calibrate the X-Y recorder for zero load and zero deflection.

(10) Rewind tape to the beginning of the test and calibrate X-Y recorder for test load and deflection with appropriate scaling.

NOTE

Steps (8), (9), and (10) may have to be repeated several times for accurate calibration.

(11) When X-Y recorder calibration has been satisfactorily completed, start tape at beginning of test.

(12) Activate the X-Y recorder.

SECTION 7
EQUIPMENT SHUTDOWN PROCEDURES

INSTRUMENTATION

(1) Remove the vibrator load after the final test by turning the Amplitude Control Switch to the ZERO (detent) position, switching the Output Control Switch on the sweep oscillator servo to the PRESET position, and turning the M7 Vibration Meter off.

(2) Sequence down to the FILAMENTS position with a 2-to-3-sec delay between switch positions.

NOTE

Maintain the instrumentation in the FILAMENTS position until the vibrator cooling oil temperature drops below 110°F.

(3) When the oil temperature drops below 110°F, sequence to the OFF position.

NOTE

The cooling fans in the instrumentation compartment and the sump pump in the vibrator compartment will continue to run for a few minutes. When the main power tubes have cooled sufficiently, the cooling fans will automatically shut off; the sump pump will automatically shut off when the cooling oil is completely pumped out of the vibrator.

(4) When the sump pump and cooling fans shut off, turn the Power Amp./Vib. System Breaker Switch off.

(5) Turn off all 110-vac breakers in the main breaker box.

(6) Turn off Field Coil Switch and Oil Pump Switch in the vibrator compartment.

(7) Insert baffles in the main power tubes cooling duct and side windows.

NOTE

This should be done whenever the van is not in operation. For hauling information see section 8.

VIBRATOR AND RELATED SYSTEMS

(1) Ensure that the instrumentation is sequenced down to the FILAMENTS position.

(2) Replace the red shipping blocks on each side of the vibrator.

NOTE

Inflation of the air-suspension system may be necessary in order to replace the blocks.

(3) Once the shipping blocks are in place, bleed the air from the suspension system and tighten the four Allenhead bolts.

(4) Raise the vibrator to its maximum height by pulling out on the Vertical Hydraulic Control Lever.

NOTE

If, for any reason, the hydraulic system or generating system fails to operate, the vibrator can be raised manually in the following manner by using the winch mounted on the beam above the vibrator:

(a) Disconnect the vertical hydraulic cylinder rods from the vibrator and attach the lifting fixture to the two eyebolts on the vibrator.

(b) Connect the winch cable to the lifting fixture and crank the winch until the vibrator is high enough to connect the four safety cables.

This winch has a 10:1 lifting ratio and a gross load capacity of 10,000 lb. Therefore, one person could conceivably lift the vibrator.

(5) Attach the four safety cables to the vibrator eyebolts.

(6) Slowly lower the vibrator by carefully pushing in on the Vertical Hydraulic Control Lever until the cables carry the full weight of the vibrator and the hydraulic cylinders are free.

(7) Position the horizontal jacks flush against the vibrator by pushing in on the Horizontal Hydraulic Control Lever.

(8) Place the two wooden blocks in position on the sides of the vibrator.

(9) Attach the four chain binders at the corners of the vibrator. These should be attached in diagonal pairs.

(10) Turn off the hydraulic system pump (switch at lower right of door) and close all six hydraulic system valves.

(11) Close the sliding door below the vibrator (toggle switch to right of Hydraulic Control Levers).

100-kW DIESEL GENERATOR

(1) Turn the Main Switch off.

(2) Switch the Generator Control Switch to IDLE.

(3) Push the Speed Control Knob in to reduce engine speed to idle and let the engine idle for at least 30 sec.

(4) Turn off the engine by moving the Engine Control Switch to STOP.

(5) After the engine stops, turn the Engine Control Switch to RUN to avoid discharging the batteries.

(6) Close and fasten the side window and the compartment doors.

SECTION 8
HAULING PREPARATIONS

(1) Secure the aluminum cover plates over the two open screen air ducts in the refrigerated air-conditioning system (under the lower right side of the van) to prevent any foreign objects from entering the system during transit.

(2) Cover the ventilation windows in the instrumentation compartment with two slip-in panels from the inside and two aluminum cover plates from the outside.

WARNING

Failure to discharge the tubes and capacitors could be fatal since the tubes operate at 7.5 kV and 73 to 78 amps.

(3) Discharge the tubes and connected capacitors by touching the tube caps with the shorting bar.

(4) Remove the two high-voltage tubes (4CX10000 D) in the power amplifier.

NOTE

These tubes, located in the right rear section of the power amplifier, are marked V1A and V2A.

(5) Package the tubes in their shipping containers.

(6) Remove the N400 zero drive amplifiers.

(7) Package the amplifiers in their shipping containers.

SECTION 9

ROUTINE MAINTENANCE

100-kW DIESEL GENERATOR

(1) Change engine lubricating oil and oil filter after each 100 hours of operation. Use SAE 20 oil approved for use in diesel engines.

NOTE

The engine lubricating oil capacity is 7 gallons.

(2) Leave the antifreeze/water solution in the engine year-round to provide antirust protection; drain and replace every 2 years.

NOTE

A solution of half ethylene glycol antifreeze and half water will provide antirust protection and freezing protection to -34°F. Radiator capacity is 37 quarts.

(3) Inspect radiator and hoses at least twice yearly.

(4) Clean battery terminals twice yearly to remove corrosion. Check battery water level monthly or more often if used regularly.

(5) Drain, clean, and refill the air filter twice yearly under normal weather conditions with the same type of SAE 20 oil used in the engine.

(6) Apply SAE 10 oil to the engine generator twice yearly.

(7) Inspect fan belts twice yearly and replace if frayed or badly worn.

(8) Check oil level in governor reservoir twice yearly and refill with

SAE 20 diesel engine oil.

(9) Replace fuel filters once a year.

(10) Drain the fuel once a year using the drain valve, and flush the tank to remove sediment.

(11) Replace 6-V dry-cell exciter battery at least once a year.

NOTE

This battery is located behind the swing-out control panel on the generator.

VIBRATOR AND RELATED SYSTEMS

(1) Inspect all cooling-system hoses and hose clamps and check cooling-oil level before each use.

NOTE

The cooling-oil level should be approximately 1 in from the top of the tank with the system shut down.

(2) Lubricate the oil pump motors every 3 months with grease lube.

NOTE

The fan motor requires no routine maintenance.

(3) Inspect the power leads to the vibrator twice yearly for abrasion and frayed insulation.

(4) Inspect the hydraulic system, including hoses, for leaks and check the hydraulic fluid level once a year.

NOTE

The fluid level should be approximately 2 in from the top of the tank. The hydraulic system pump motor requires no routine maintenance.

(5) Remove, clean, and reinstall the cooling-oil filter strainer once a year.

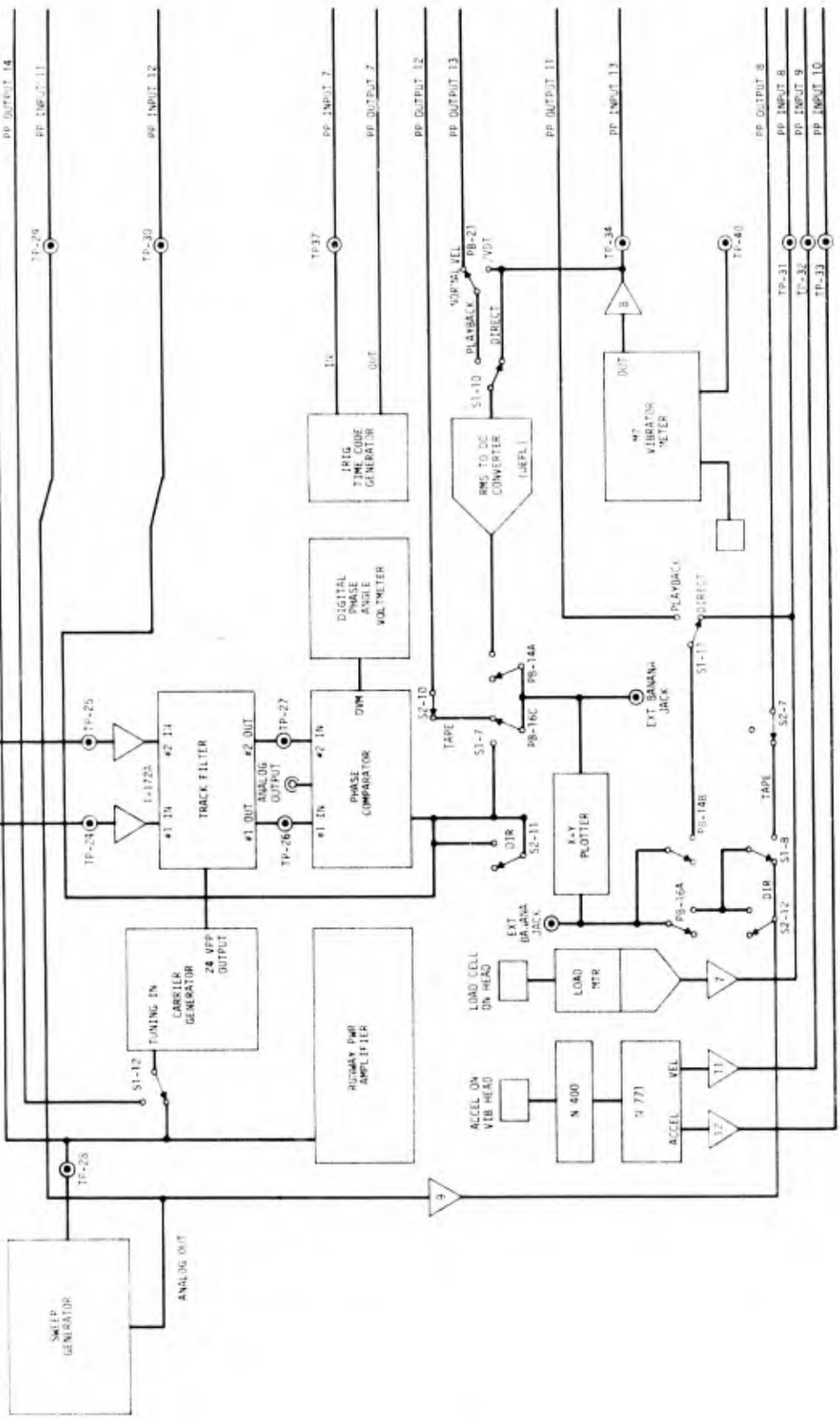
INSTRUMENTATION

Calibration of the electronic instrumentation in the NDPT Van, with the exception of the Bell & Howell CPR-4010 Magnetic Tape Recorder/Reproducer, should be accomplished by the Precision Measurement Electronic Laboratory (PMEL) under Air Force contract. The tape recorder/reproducer should be calibrated by an authorized Bell & Howell technical representative.

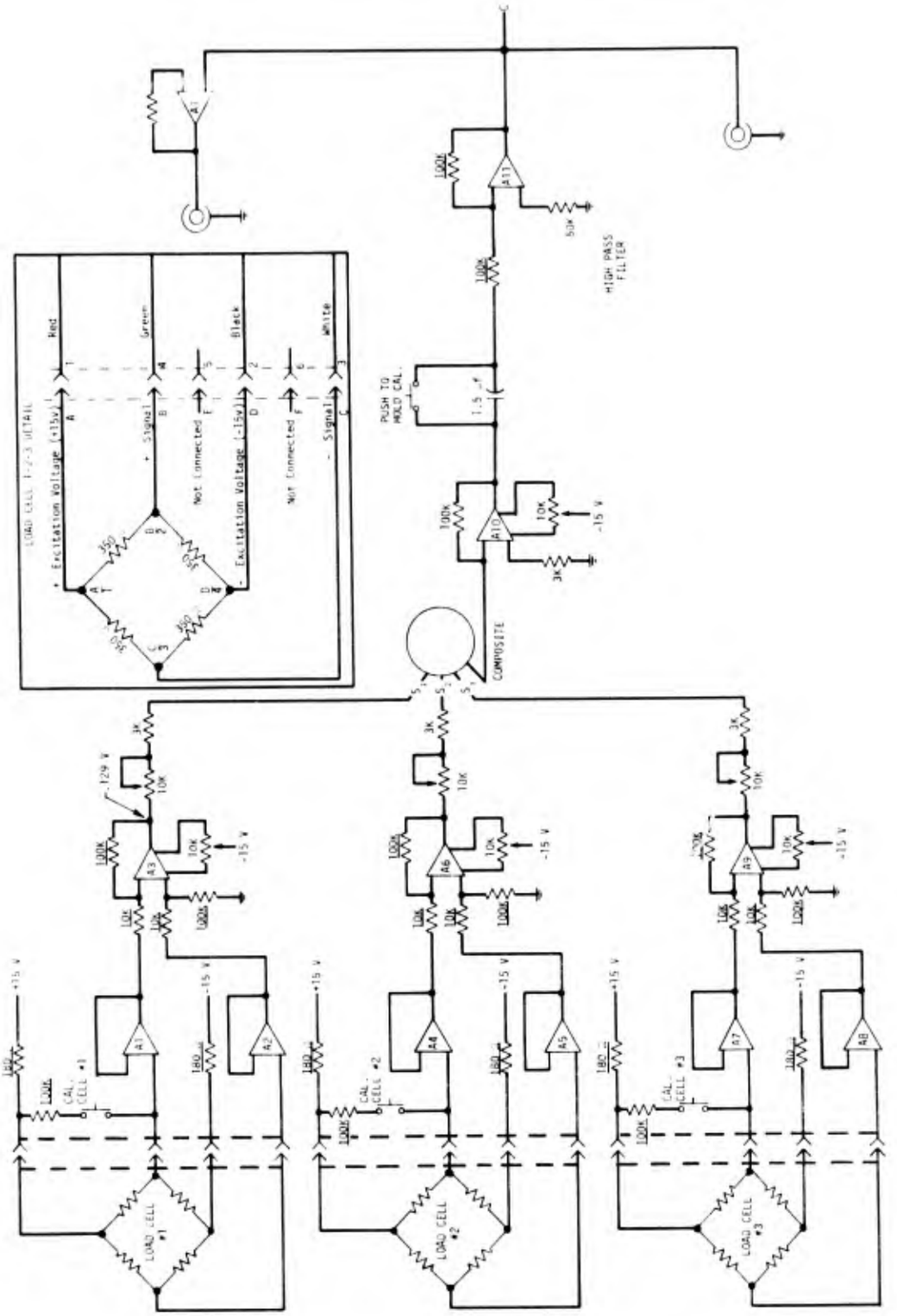
The Tracking Filter, Sweep Oscillator, Digital Phase Indicator, Oscillator, Oscilloscope, X-Y Recorder, and the Automatic Counter must be recalibrated every 6 months by PMEL. The Phase Computer must be recalibrated once a year at the factory because of the matched-tube components which are factory selected. This cannot be accomplished at CERF or PMEL since this procedure requires complex test equipment.

APPENDIX A

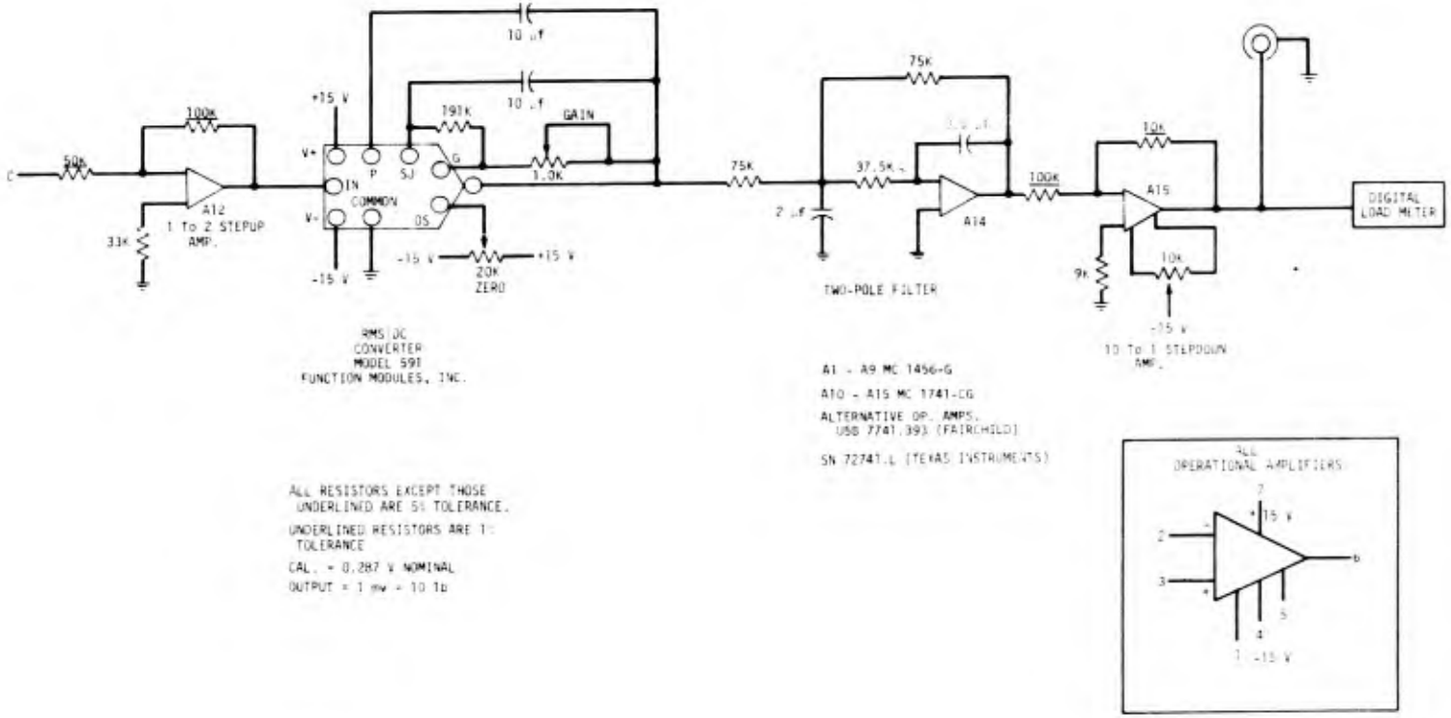
DIAGRAMS



Instrumentation System Block Diagram



CERF Load Indicator Schematic (1 of 2)



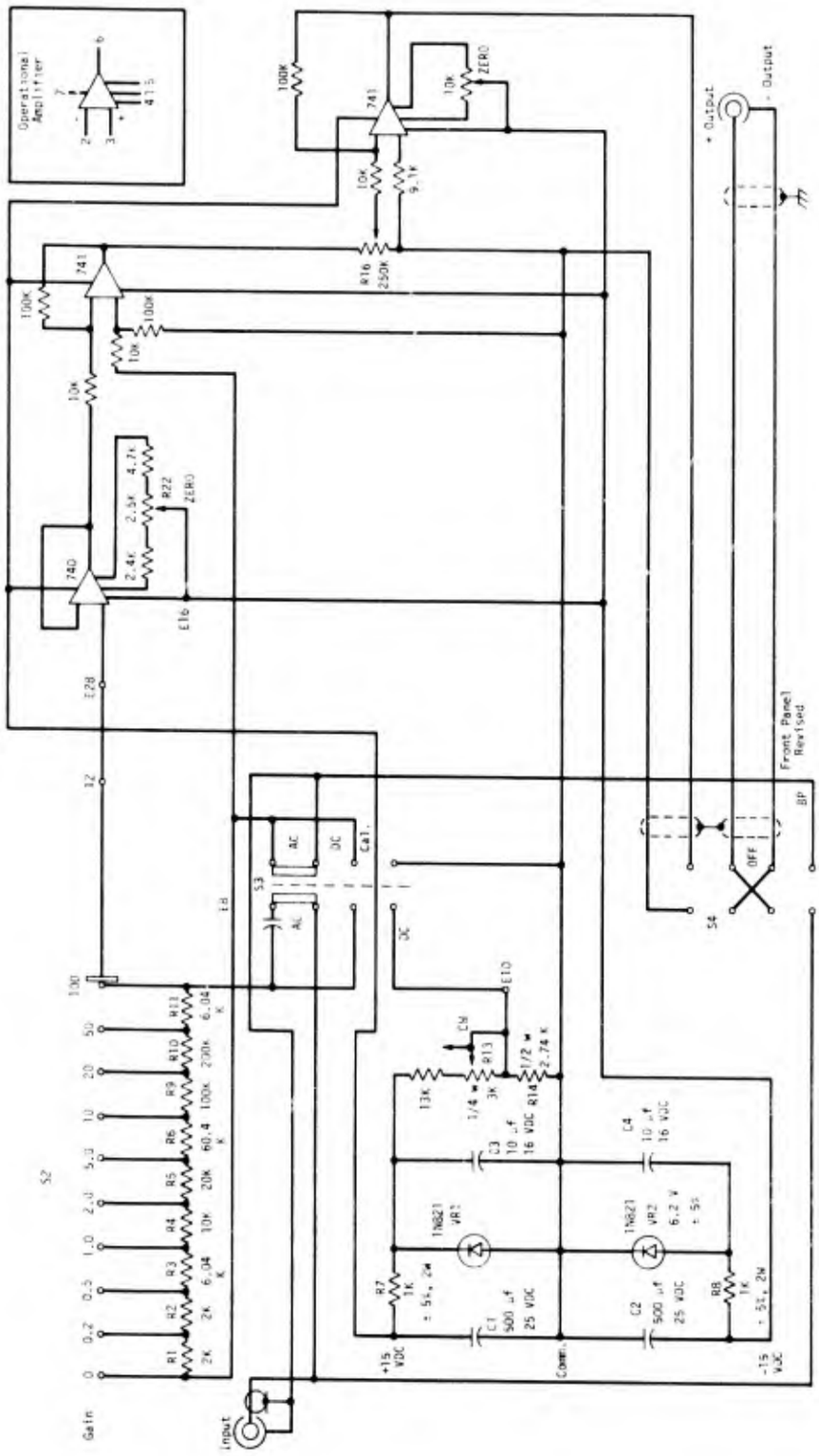
ALL RESISTORS EXCEPT THOSE UNDERLINED ARE 5% TOLERANCE.

UNDERLINED RESISTORS ARE 1% TOLERANCE

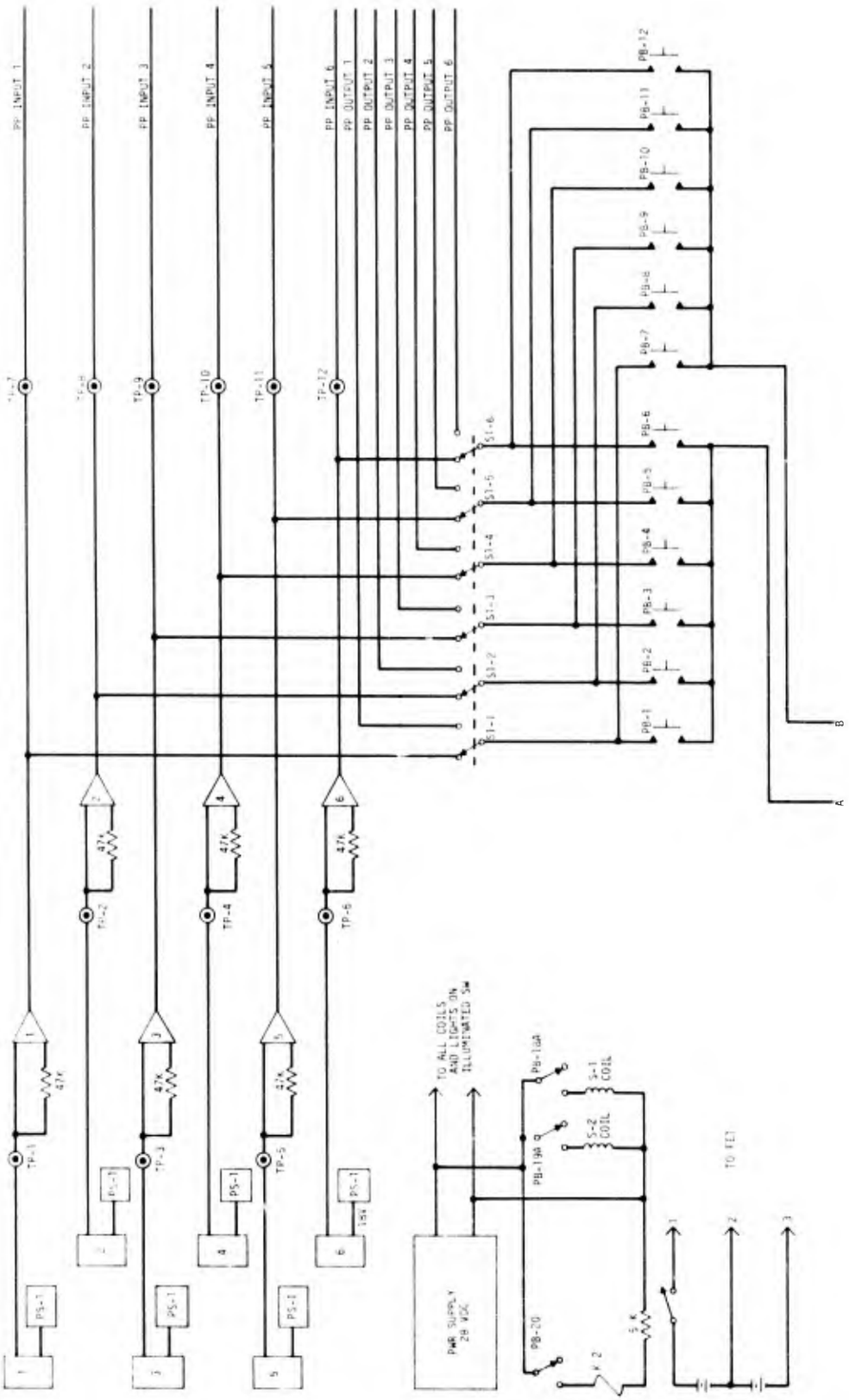
CAL. = 0.287 V NOMINAL

OUTPUT = 1 mv = 10 lb

CERF Load Indicator Schematic (2 of 2)



CERF-Modified Amplifier Schematic



Accelerometer/Geophone Pickup Schematic

APPENDIX B

EQUIPMENT MANUFACTURERS

AD-YU Electronics, Inc., 2517 East Norwich St., Milwaukee, Wisconsin 53207

Bell & Howell, Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109

California Instruments, Division of Aiken Industries, Inc., 5150 Convoy St., San Diego, California 92111

Gilmore Industries, Inc., MB Electronics Division, 3355 Richmond Road, Cleveland, Ohio 44122

Gulton Industries, Inc., Data Systems Division, 15000 Central East, Albuquerque, N. Mex. 87112

Hewlett-Packard Company (Main Office), 1501 Page Mill Rd., Palo Alto, California 94304

Spectral Dynamics Corporation of San Diego, 8911 Balboa Ave., San Diego, California 92112

Tektronix, Inc., S. W. Millikan Way, Beaverton, Oregon 97005