DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

BOREHOLE DILATOMETER INSTALLATION, OPERATION AND MAINTENANCE AT SITES ALONG THE SAN ANDREAS FAULT, CALIFORNIA.

by

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CONTENTS

1. INTRODUCTION

A network of Sacks-Evertson dilational strainmeters has been established by the U. S. Geological Survey in the state of California (Johnston et al., 1987). The network consists of clusters of instruments in 1) the Palmdale area in southern California, 2) Mammoth Lakes, 3) San Juan Bautista in central California, and 4) Parkfield, California. The general locations of these instruments are shown in Figure 1. The latitudes and longitudes of each instrument are listed in Table 1.

The purpose of this network is to monitor crustal deformation associated with earthquakes in California. This report describes:

1. the principles of operation of dilational strainmeters,
2. the methods used to locate instrument sites,
3. the procedures used in the installation of dilatometers,
4. the electronics used for signal amplification and telemetry,
5. the maintenance procedure for these instruments and the on-site recorders.

1.1 DILATOMETER INSTRUMENTATION

The Sacks-Evertson dilational strainmeter used in this experiment (Sacks *et al.*, 1971) are installed at depths between 138 m and 335 m below the ground surface at the sites listed in Table 1, and are shown in Figure 1. The sensors, installed as part of a cooperative program between the U.S. Geological Survey and the Carnegie Institution of Washington, are cemented in the borehole with expansive grout having density characteristics approximating those of the host material (ideally granite). The borehole is then filled to the surface with cement to avoid long-term strains from hole relaxation effects and re-equilibration of the aquifer system.

Table 1. Volumetric Strainmeter Locations in California

Site	Instrument	Lat.	Lon.	Depth(m)	Install. Date	Rock Type
AMSS	Adobe	34.7240	-117.6760	174.4	11/5/1980	granite
BBSS	Black Butte	34.5690	-117.7300	170.4	11/13/1980	granite
EVSS	Echo Valley	36.8320	-121.6330	117.6	10/5/1981	granite
GH1S	Gold Hill 1	35.8314	-120.3461	117.6	6/27/1983	granite
GH2S	Gold Hill 2	35.8372	-120.3445	177.7	7/01/1983	granite
SRLS	Searle	36.8650	-121.5770	137.7	7/10/1983	granite
PUBS	Punchbowl	34.4340	-117.8740	176.2	11/8/1983	sandstone
POPS	Postpile	37.6380	-119.0840	162.1	10/18/1983	granite
PCIA	Pinon Flat	33.6092	-116.4553	151.0	09/16/1983	granite
EADS	Eades	35.8946	-120.4220	267.2	10/24/1984	sandstone
VCDS	Vinyard Cyn.	35.9223	-120.5332	204.1	11/24/86	granite
FRDS	Froelich	35.9108	-120.4858	323.36	12/6/86	rhyolite
DLDS	Donna Lee	35.9401	-120.4234	176.48	11/19/86	sandstone
RHDS	Red Hills	35.6244	-120.2550	229.16	1/19/87	sandstone
JCDS	Jack Cyn.	35.7158	-120.2045	169.13	1/18/87	sandstone

The sensor consists of a 2 m long strainless steel oil reservoir filled with 100 cs silicon oil. Small compressions on the side of this reservoir force oil into a small bellows.

Displacement of the ends of the bellows is monitored by a LVDT displacement transducer which produces an output that is proportional to the imposed dilational strain. The mechanical gain of the system is about 200,000. The frequency response is flat from about 20 Hz to less than 0.000000001 Hz. The 20 Hz high frequency cut-off is caused by the hydraulic filter effect as the oil flows from the large reservoir into the bellows chamber through a small orifice.

Data from the instrument are routinely recorded on-site with low-speed analog recorders (72 dB dynamic range from zero Hz to 10 mHz) and are transmitted with a satellite-based 16 bit digital telemetry system (96 dB dynamic range from zero Hz to 1 mHz) at 1 sample every 10 minutes to Menlo Park, California (Silverman*et al.*, 1989). The sensor and the telemetry system are calibrated using ocean-load corrected earth tides. The calibration is repeatable to within 5%.

To extend the bandwidth and resolution of recorded strain data, wide dynamic range (16 bit; 96 dB), broad bandwidth (0 to 600 Hz), portable recorders (General Earthquake Observational Systems: GEOS) were used to record simultaneous data from the strainmeters and colocated seismometers (1 Hz; Mark Products, L-4). The GEOS recorders, described by Borcherdt *et al.*, (1985), permit parameters such as gain (0 - 60 dB in 6 dB steps), anti-aliasing filters (7 pole Butterworth), sample rate (up to 1200 sps), and a variety of other parameters, to be selected on site. In this application pre-set time, trigger and continuous record modes have all been used to record the strain and simultaneous seismic signals in the bandwidth 0.0067 to 10^5 seconds. Continuous recording mode with DC coupling and no low-cut filters were used to obtain continuous records of Earth tidal strains with superimposed high frequency seismic strain variations associated with seismic events and nuclear explosions over periods of 24 to 30 hours. The event triggering mode was used to record simultaneous seismic and strain data during several thousand local and distant earthquakes.

These borehole strain sensors can detect strains at levels at least 20 dB below those obtained on near-surface strainmeters (Johnston *et al.*,, 1982; Johnston and Borcherdt, 1984) with a dynamic range exceeding 100 dB (Sacks *et al.*, 1971; Sacks, 1979; Gladwin, 1984) over a period band of 0.1 seconds to several months. The wide dynamic range and broad bandwidth of the sensors, when utilized in conjunction with that of modern recording capabilities, offers the possibility to detect strain signals from a wide range of sources up to frequencies overlapping the pass-band of standard short period seismic networks. At this point, only borehole strain instruments appear capable of recording static strain field changes reliably under conditions of high acceleration.

2. SITE SELECTION AND PREPARATION

Instrument sites have been selected in regions where the probability of an earthquake of magnitude 4 or greater is large. For the most part dilatometers have been installed near existing arrays of surface tiltmeters, strainmeters, creepmeters and laser geodimeter arrays. At these locations an attempt has been made to identify tectonic signals and the various sources of crustal noise that are also recorded in the various data from each instrument type.

The basic selection criteria used to identify a good dilatometer site are: 1) competent unfractured rock at a depth of 100 m to 300 m typically in granitic or similarly competent sedimentary or metamorphic rock 2) absence of fracture zones through which water may be flowing 3) low probability of nearby pumping which may disturb the local strain field 4) a well drained surface site to avoid flooding 5) secure from possible vandalism.

Following preliminary site selection based on geologic maps, topographic maps, and a geologists recommendations, a permit is obtained from the landowner and a contract is drawn up to begin exploratory drilling to verify the site geology and fracture state and to obtain core from the exact location of the final installation . To achieve this, an uncased hole is drilled to 400 ft (120 m). Where appropriate, a 4 inch (10.16cm) core is taken. Sections of competent rock, where a strainmeter might be installed, are identified in the recovered core from depths below about 400 ft. Based on the core and logs from the hole, a target installation site is identified and this exploratory hole is cased and cemented for use as a heat flow hole or as a water well if no suitable site is identified. Assuming a potential site is identified, a second hole (8 inch/20.32 cm) is then drilled nearby to 30 feet (9.14 m) above that target depth. The final 30 to 40 feet is core drilled using drilling mud containing no polymers or compounds which might compromise the cementing of the instrument to the surrounding rock. In order to have the instrument in as close contact with the rock as possible, a 6 in (15.24 cm) core bit is used. When the recovered core appears competent, with no major fractures within a 20-30 foot section, the core drill is removed. The hole drilling fluids are then displaced with clear water. The drilling table is then pulled back from the hole and electric logs are taken. Televiewer (sonic pictures), self potential, natural gamma, resistivity, and caliper logs are collected and used along with the core to select an instrument location. An example of logs observed with these tools from a hole in competent rock is shown in Figure 4 in the Appendix.

3. DILATOMETER INSTALLATION

3.1 Introduction

Installation is generally accomplished with a truck mounted hydraulic derrick and winch. A 30 foot (9.144 meter) long grout dump is lowered to the bottom of the hole. If this is successfully completed, the instrument is prepared for installation and tested to ensure that all functions and cable resistances are correct. Enough non-shrink expansive grout to completely cover the instrument when it is in the bottom of the hole is mixed and lowered with a grout dump. The instrument is lowered and sinks through the grout until completely covered. Before the grout sets, the instrument and cable are checked. If no problems are apparent, the open hole above the instrument is then filled with cement to the surface.

In some cases 4 inch (10.16 cm) pvc pipe is lowered into the hole next to the instrument cable to allow additional instrumentation to be installed in the future. Electronics for signal conditioning, amplification, data collection and transmission are temperature tested in the lab and installed in closed bottom fiberglass enclosures at 5 feet (1.5 meters) depth. Nylon bags filled with with styrofoam pellets cover the electronics to reduce temperature effects in the field. The electronics are powered by solar charged batteries. They are located in a closed bottom fiberglass enclosure within 15 feet (4.57 meters) of the electronics.

At most sites additional effort has been made to record the higher frequency signals detected by the dilatometer. At these sites a digital tape recorder has been installed in a surface fiberglass enclosure with solar charged batteries in a separate enclosure.

3.2 Step-by-Step Installation Details

3.2.1 Prior to installation, the instrument is checked electronically to determine 1) whether the resistance between the various pins is correct, 2) whether the differential transducer appears to operate correctly when powered, and 3) whether the valve closes and opens correctly. (see Installation Notes in Appendix)

3.2.2 The dilatometer is inverted with the valve open (see photo 1), and the open center section is filled with the same grout that will be used to cement the instrument in the hole. (This additional weight acts as a ballast to help sink the instrument in the grout which mates it with the surrounding rock.) The grout has a slump of 12, or zero cone, not watery but like a thick malt.(see photo 2). When the center section is full of grout, a steel plug is attached to the bottom of the instrument.

3.2.3 The instrument is laid horizontally and the instrument cable is attached.

3.2.4 The cable connection is pressure tested and the instrument is again checked for proper operation. (see photos 3,4,5)

3.2.5 All details (i.e, the cement volumes, cable resistance values, and instrument output values) are recorded with the date and time. (see Installation Field Notes, attached in the Appendix, under Resistance Check).

3.2.6 An 8 inch instrument hole is drilled to about 20 feet (6.1 m) above the planned installation depth with a rotary bit using a drilling mud that has no polymers or chemical compounds which might react with the instrument grout.

3.2.7 The hole is cored to verify the location of competent rock and to ensure that no aquifers or fractures are encountered. When a 20 foot (6.1 m) unfractured section of hole is identified in the extracted core (see photo 6), the fluids in the hole are displaced with clear water.

3.2.8 The hole is logged with standard logging techniques which include S.P., Natural Gamma, Resistivity, Caliper, and Televiewer logs. Figure 5 shows an example of typical output from these logging techniques. An instrument site is then selected based on the electric logs and the cored section.

3.2.9 A truck-mounted hydraulic derrick and winch is set up (see photo 7), its wire cable reeled out, measured and color coded every 50 feet (15m) for 1200 feet (365 m), (see HOIST operation).

3.2.10 The grout dump, which is transported in three sections, is assembled. Its bottom opening trip mechanism is assembled, greased, threaded to the bottom of the grout dump, and checked for operation (see photos 8-12).

3.2.11 The truck-mounted derrick and winch are moved over the hole and the 27 foot (8.23 m) grout dump is lowered to the bottom to check the depth of the hole and to ensure that the bottom trip opens correctly. If the hole depth agrees with that determined by the drilling, the drill rig is allowed to leave the site (see photos 13-15).

3.2.12 A pulley assembly for guiding the instrument cable into the hole is clamped to the casing,(see photo 16).

3.2.13 The instrument cable (mounted on a cable reel stand in the back of a pick-up, see photo 17) is unreeled, measured and marked with colored tape every 50 feet (15 m). A warning mark is attached twenty feet from the determined instrument depth. For the bottom depth mark for the instrument, a bright colored tape is attached over a 2 foot (0.6 m) section of the cable. The edge of the tape nearest the instrument marks the beginning of the two foot section. The cable is reeled back in and positioned near the hole and pulley assembly.

3.2.14 A 4.5 in (11.43 cm) internal diameter clamp is bolted onto the top of the instrument and the instrument is secured in a vertical position next to the hydraulic derrick (see photo 16).

3.2.15 All functions of the instrument are again checked (see Installation Notes in Appendix).

3.2.16 The grout dump is raised over the hole with bottom trip attached, and run in the hole twice to recheck the depth. If the instrument site is found to be above the hole bottom, the bottom is raised with grout mixed in a mortar mixer and lowered to the bottom of the hole with the grout dump. Approximately 6 hours is allowed between each dump for proper hardening of the grout.

3.2.17 When complete, the empty grout dump is run down the hole to check the grout hardness and the depth, (see attached copy on "SET-GROUT" in Appendix).
The cement dump has a capacity of 2.36 cu ft (0.068 cu m), which fills approximately 12.02 linear feet (3.66 m) of 6 inch (15.24 cm) hole. Each bag of non-shrink grout (Corps of Engineer Spec for non-shrink grout CRD-C 621, 50-lb (22.68 kg)), is mixed with 9.8 lb (4.45 kg) or 1.225 gal (5.4 l) of water to yield approximately 0.46 cu ft (0.13 cu m). It takes 5.13 bags to fill the cement dump for one trip in the hole to cover the instrument. Six bags are usually mixed in the mortar mixer for each instrument emplacement. This leaves approximately 6 feet of grout above the instrument if the instrument settles to the bottom (see table for instrument cover by grout in Appendix).

3.2.18 The expansive non-shrink grout is mixed (see photo 2). To ensure that the grout does not stick and seal the trip mechanism, a cup of water is first poured into the grout dump. The grout is poured into the dump using 5 gal plastic pails and a funnel (see photo 18) Since the grout begins to harden in 1 hour, the mixing start time is noted. The grout dump is then lowered to within 15 ft (5 m) of the bottom, the tension of the cable is checked, and the dump is allowed to free fall. This trips the bottom device, the dump is slowly raised and the tension is again checked to determine whether the grout has been successfully dumped. A slow withdrawal allows time for the grout to flow out without turbulence and possible uneven mixing. When the dump is about 30 ft (9 m) off the bottom it is raised quickly to the surface and removed from the hole.

3.2.19 The instrument is positioned over the hole using the derrick and winch (see photo 19). Its cable is laid over the pulley assembly and the instrument is lowered using a brake that controls the speed of the reel carrying the cable. As the instrument is lowered, the depth marks are called out. When the target depth as marked on the cable approaches the pulley the instruments' descent is slowed by its contact with the grout. The instrument then sinks slowly though the grout and stops within 1-2 feet of the bottom (see photos 20-24; see table for instrument cover by grout in a 6 in (15.3 cm) hole, in appendix).

3.2.20 The instrument and cable resistances are again read and noted. Power is connected to check the down-hole displacement transducers' operation. These values are recorded along with the date and time (see installation notes in appendix). If, before one hour has elapsed, any resistances are bad or the instrument appears not to be working properly, it is slowly retrieved from the grout.

3.2.21 The instrument cable is secured to the pulley assembly using 1/2 inch rope with 3 or 4 half hitches. One to two days are allowed before the tension is relieved from the cable (see photo 25).

4. HOLE COMPLETION

In order to prevent any aquifers from mixing, creating temperature instability near the instrument, the hole is filled to the surface with cement approximately 2-3 days after instrument installation. The depth from the top of the instrument to the surface is calculated and belled pvc, schedule 40 3/4 in or 1 in (1.9 or 2.54 cm), pipe is assembled on the surface. It is then lowered down the hole by hand to avoid damage to the cable.

Using the hydraulic derrick, a short piece of 4" (10.2 cm) pvc is suspended 20 ft (6 m) in the air approximately 10 ft (3 m) from the hole. The smaller pvc is guided through the larger pvc, and then both are raised to provide enough of an arc to prevent the pvc from breaking as it is lowered into the hole. Three people, one at the hole to provide guidance, and two to carry the pvc to the hole, are needed to lower the pipe within 10 ft (3 m) of the top of the instrument. The pipe is buoyant enough for two people to hold while another bolts a riser clamp to it to prevent the pipe from falling into the hole.

A steel pipe the same diameter as the pvc pipe (3/4 in or 1 in, 1.9 or 2.54 cm) is threaded to the pvc. A 2 in (5.1 cm) belled coupling to 2 in steel pipe is attached. This allows mating to cement pump hoses (see photos 26-28). A clean up pit, 10 ft x10 ft x4 ft (3 m x 3 m x 1 m), is dug with a backhoe for cement disposal and site clean-up.

The volume of cement needed to fill the hole to the surface is calculated and pumped into the hole. A pure cement mixture is used for pumping through a 3/4 in (1.9cm) pipe and a cement and perlite mixture is used for pumping through a 1 in (2.54cm) pipe. Adding perlite to the cement reduces the total amount of cement needed and therefore reduces the cost of cementing the hole. If perlite is used for cementing through pipes with diameters less than 1 in (2.54cm) it adheres to the walls, clogging the pipe.

If the cementing of the hole is done commercially, the most practical and versatile system available involves on-site mixing and pumping with accurate determination of the volume of cement or mix that is pumped down the hole. Since such a system can be stopped at any time, the problem of disposal of unused wet cement does not occur. These systems are commonly available for oil field cementing operations.

5. ELECTRONICS ENCLOSURES

Following cementing and site clean-up, electronic subsurface and surface enclosures are installed. These enclosures consist of a 3 ft,(0.92 m) diameter 5 ft,(1.53 m) deep closed bottom fiberglass cylinder with a steel lid for the electronics, and a closed bottom fiberglass box for batteries, (4 ft,(1.22 m) l, by 2 ft, (0.61 m) w, by 2 ft,(0.61m) d; see photo 30).

The modules within the enclosures include strainmeter electronics, signal amplifiers, signal buffers, an on-site 16-bit recorder (GEOS - Borcherdt et al., 1985) for the dilatometer, a barometric pressure transducer, and a Data Collection Platform housed in the cylindrical enclosure. The 16-bit digital data recorder is installed to record the short period strain (long period seismic response) of the dilatometer. The electronics modules are insulated from short-term thermal effects with styrofoam filled nylon bags. A battery enclosure is installed a short distance from the electronics pit to avoid corrosion of the electronics. The batteries are charged with solar panels mounted on a supporting rack above the battery enclosure. All enclosures are connected by pvc conduit for power and signal routing (see Figure 3 and photo 29).

6. DILATOMETER ELECTRONICS

The strainmeter electronics are installed in a water-resistant box placed in the surface enclosure. They consist of a DC/DC converter, amplifiers with different DC (strain) gains, a thermister amplifier circuit, an automatic valve opener, a "bias stepper" for an on-site chart recorder, and a notch filter (to reduce microseisms). The strain signal, after filtering, is amplified and provides a long period seismic output from the strainmeter. A fifth amplifier with a 400 sec time constant provides intermediate period (0.03 sec to 200 sec) strain data to the GEOS data recorder (see electronics schematics).

As the strainmeter in the borehole is squeezed by the surrounding rock, silicon oil in the instrument is forced through a small orifice and displaces the end of a small bellows. The displacement is monitored by an LVDT transducer. The movement of the core of the LVDT generates a voltage of approximately .318V for 0.01in (.318V/.254mm) of movement as powered by a 6.8V regulated battery source. At the surface this signal is attenuated by 20 percent. This signal can be biased to cancel the DC offset inherent in the transducer and then amplified by three parallel amplifiers. The gains can be preset to either 1, 5, 10, 20, 50, 100, 200, or, 500.

The long period seismic signal from the dilatometer is obtained by capacitively coupling the filtered strainmeter output to amplifiers that also have presetable gains of 1, 5, 10, 50, 100, 200, and 500. This signal is called SP (short period) strain output on the face plate of the electronics box.

The electronics is powered by a 12-V, deep-cycle, maintenance-free, gelled electrolyte battery. This battery is kept trickled charged by a 35-42 watt solar panel using a automatic sequencing charger. This charger keeps the panel charging the battery in the range 13.2 to 14.3 +/-0.2 V. During the night a blocking diode acts to prevent discharge of the battery through the panel. The electronics package draws approximately 200 milliamps.

A barometric pressure transducer with an 800-1100 millibar range operates at each site. Its' purpose is to allow corrections for variations in barometric pressure to be applied to the strain data. These pressure generated strains are then removed from the strain data. (see barometric pressure transducer in Section 11.)

The DCP is also powered by a 12 volt deep-cycle battery of the same type as above. It also uses a auto sequencing charger and a 9 or 16 watt solar panel to keep the battery charged. (see Section 9)

7. DILATOMETER MAINTENANCE PROCEDURE

In general the maintenance of a dilatometer installation is fairly straightforward. While unexpected problems may arise, most maintenance is routine.

As a routine procedure, the data from each strainmeter are monitored daily to identify operational problems and tectonic strain changes. They are inspected for tidal response (data quality), data dropouts (satellite problems, computer problems, missing transmissions), time of transmission, transmission power levels, and battery voltages. Information obtained from this inspection helps in planning field maintenance. Routine maintenance involves a visit every two months to change the recording paper and to set the time on the satellite DCP.

RUSTRAK PAPER CHANGE: Upon arrival note the date and time and the reason for the visit. Carefully remove the insulation bag and then the amplifier box. Open the box and read the power supply voltages, the telemetry voltages, and the DT signal in/out voltages and record them. Unscrew the left face-plate and open the lid to reveal the circuitry; shut off the valve opener circuit card; shut off and then unplug the Rustrak recorder. Note the date and time on the chart paper being removed and on the paper being installed. Plug in the chart recorder
and turn on the automatic valve opener. Read the telemetry voltages again and record them. Note how they compare to the values read on arrival. The chart paper or tide tables will aid in determining which direction of the tidal cycle the dilatometer signal will be moving. Watch the dt amp 3 for 2 to 5 minutes to see if it is changing with the expected tidal movement. When this is done close the electronics package, lower the box into the pit, replace the insulation bag, and close the lid (see accompanying copy of field note; for resetting GMT, see section 9, Data Telemetry System).

8. CABLE TESTS

There may be a time after the instrument has been operating for a number of years when the down-hole instrumentation will begin to fail. This failure is thought to be caused by water leakage into the cable head. There is a water-blocking medium in the cable and the cable head, however it can fail. When this happens the down-hole resistances are read and recorded and a new electronics package is assembled which current amplifies the signal and telemeters that signal back to Menlo Park. The values expected between the various wires are given in Table 2.

Table 2. Cable Wiring.

Instrument and Cable Resistances*			
Pin	Color Code	Resistance	Identification
M	to all conductors	infinity	shield to all conductors
B-L	Red-Black	450 Kohms	+ to - power to transducer
E-F	Blue-Green	20 Kohms	+ to - signal out of transducer
J-K	White-Grey	60 ohms	Calibration
C-N	Orange-White	60 ohms	Valve open
D-N	Yellow-White	60 ohms	Valve close
R-A	White-Brown	27 Kohms	Thermister com to power
R-H	White-Purple	5 Kohms	Thermister signal
R-P	White-Grey	5 Kohms	Thermister shunt

*Resistance values are approximate.

By checking the field notes from each visit and monitoring the information made available through the telemetry, it is possible to properly maintain the dilatometer installation.

9. DATA TELEMETRY SYSTEM

The satellite DCP requires attention at unspecified times. This unit is a 16-bit, analog-to-digital, programmable data collection platform. It is setup to collect information from three or four components of the dilatometer, down-hole temperature, barometric pressure and the satellite and dilatometer battery voltages. It samples at 9 minutes past the ten minute mark, and transmits at an assigned time every ten minutes. The sample and transmit times are controlled by an internal crystal clock. The maintenance required for this unit is the resetting of the clock to Universal Time at infrequent intervals that vary with the temperature environment and aging of the crystal. Resetting involves opening the enclosure, carefully removing the insulation and the grey steel box housing the DCP, and hooking up a hand-held terminal or TRS-80 Model 100 computer. Any ASCII terminal may act as a programmer of the DCP for universal time, the transmit interval, time of transmission, and other programming constants. The Model DCP currently being used is the Sutron Corporation Model 8004 (16 bit; see accompanying table for the assigned times of transmission, I.D. (identification number), parameter inputs, and instrument name and code).

9.1 Data Collection Platform (DCP) Programming (16-bit Sutron 8004)

After attaching an RS-232 connector to the DCP at the location marked terminal, and putting a jumper between tr and gnd (hand-held terminal), the DCP can be programmed. The TRS-80, Model 100 computer, can also be used by attaching a RS-232 connector to the terminal location. To communicate with the DCP, the Model 100 must be put in TELCOM mode using the arrow keys (STAT, 37I1E,10 pps), then F4.

The DCP's first response will be "16 bit-V1.1" (with the hand-held terminal only), and then "CMD:". For the TRS-80/100 to get responses from the DCP, the 80/100 must be in caps-lock mode (lower left hand corner key). When carriage return/enter is pushed the DCP will respond with the universal time. When S is pushed, the setup/programming mode for the DCP is entered. The DCP will respond with "GMT:". A correction of the time can be made by entering the hours, minutes, and seconds in this format: 24:24:24, (24 hour) then carriage return [(CR)/enter] exactly at the mark for the time (a WWV time code signal, or watch set to WWV). A response by the operator of just (CR)/enter to each of the DCP commands will eventually loop out of the program mode and back to "CMD:". Push "E", the DCP will respond with, "0,DISABLE 1,ENABLE", push "1", and the DCP is now enabled with the correct GMT.

In order to change any of the other constants the operator must follow Table 3.

Table 3.
Access order for DCP programming commands.

16 Bit 8004 DCP Programming		
prompt	response	meaning
GMT	00:00:00	universal time
TNC	00:00:00	time of next collection
UI	10	update interval
WT	5	warm-up time
NS	18	number of stored values
TNT	00:00:00	time of next transmission
TI	10	transmit interval
ID	12345678	platform identification
CHAN	134	transmit channel(frequency)
FMT	0	format in engineering units
INC	17	increment 17 samples with each transmission
CAR	150	baud rate of data transmission
PAR 1	Y/N	parameter(data) input location #1, Y(es)
PT	2	parameter type 2 = raw analog
CO	0	conversion option 0 = none
C1	0	
C2	0	
PAR 2	Y/N	The same as PAR 1, except this is location #2. Each site may have a different number of parameter(data) inputs, up to 8. Each will have PT,CO,C1,C2 responded to in the same fashion as PAR 1.
WND SPD	N	

All responses to DCP prompts are followed by a Carriage Return/enter.

A response of "E" after one of the "PAR 1 Y/N" commands will loop you to "CAL N". A CR/Enter will put you to "WND SPD N". A CR/Enter will loop you out of the program.

At the end of this loop, push "E", and then Carriage Return.

The DCP will respond with: "0, DISABLE ; 1, ENABLE".

Pushing a "1" will enable the DCP to operate on the commands entered and it will start to collect and transmit at the times just programmed.

To disconnect from the DCP, when using the hand-held terminal, simply unplug the RS-232 connector and remove the jumper; when using the

TRS-80/100, push F8, the TRS-80/100 will say; "Disconnect?", you say "Y", and ENTER key, then push F8, (the TRS-80/100 will go into Menu). Shut off power and disconnect the RS-232 connector.

Following these commands and using Table 4 for instrument names, ID's, transmit times, etc., the DCP can be programmed.

Table 4. Dilatometer DCP Coding Table.

Satellite Telemetry Coding			
Instrument	ID	Transmit Time*	Sensor Parameters
Gold Hill 1	26300266	00:00:03	gh1a,1b,1c,1t,1p,1v
Gold Hill 2	26314396	00:07:49	gh2a,2b,2c,2t,2v
Black Butte	26301110	00:00:16	bbsa,sb,sc,pp,st,bp,bv,dv
Adobe Mtn	263037FC	00:00:41	amsa,bp,bv
Punchbowl	2630521A	00:01:01	puba,bb,bc,bt,bp,bv
Postpile	263074F6	00:01:21	popa,pb,pc,pt,bp,b2,bv
Searle	1614E31E	00:05:14	srla,lp,lv
Eade	1614F068	00:05:25	eada,dp,dv
Froelich	16150216	00:05:36	fr01,- fr06
Donna Lee	263257EE	00:06:26	dl01,- dl06
Vineyard	26326274	00:06:39	vc01,- vc06
Echo Valley	26327102	00:06:52	evsa,sp,bp,bv
Jack Canyon	26328186	00:07:05	jc01,- jc06
Red Hills	263292F0	00:07:18	rh01,- rh06

*The transmit time is set to be the time of reception in Menlo Park. Set Transmit Time 3 seconds early for 16-bit DCP's.

10. GEOS DIGITAL RECORDER

Because the dilatometer functions as a very good long period seismometer, broad-band recording is possible.

At some of the dilatometer sites an on-site, 16 bit digital data tape (GEOS) recorder is used (Borcherdt et al., 1985). The GEOS recorder is set up to record two channels from the dilatometer, one (Channel 2) at 0 db gain (unity), and the second (Channel 3)
at 36 db gain. Both are configured to have a 36 hz anti-aliasing filter.

A seismic velocity transducer is connected to Channel 1 and parameters are set so that the GEOS recorder will be triggered from this channel when small earthquakes (<1 to 2.5 M) occur. Force-balanced accelerometers are connected to Channels 4, 5, and 6 with sufficient gain that accelerations of 6×10^{-6} g are resolved. These gains are usually 36 db with a 50hz anti-aliasing filter. At two sites, the unfiltered output from the strainmeter displacement transducer is recorded on Channel 1. At these sites, three seismic velocity transducers are recorded on Channels 4, 5, and 6. The GEOS is set to trigger from the seismometer recorded on Channel 4.

The GEOS recorders are located at the following Dilatometer sites;

1. Devils Postpile
2. Vineyard Canyon
3. Donna Lee
4. Froelich
5. Gold Hill 1
6. Red Hills
7. Jack Canyon
8. Devils Punchbowl

10.1 TO CHANGE THE GEOS TAPE

10.1.1 REWINDING THE TAPE

Open the GEOS box.
Remove the brown folder and record on the Master Sheet and the field sheet, the following.

Push "STATUS"; record time, 122:22:44:02
Push "STATUS"; record events, tape usage.
Push "STATUS"; record voltage.
Push "MENU"; GEOS says REWIND DATA TAPE?
you push "YES" and than push "ENTER"

THE TAPE WILL REWIND
GEOS goes to Change I.D. Parameters.
you push the "eject" button of the tape,
you remove the tape.
you fill out the tape label with:
julian time,
voltage,
tape #,
name,
channel inputs.

10.1.2 NEW TAPE

Before putting in a new tape, fill out a label, as you found on the old tape when you ejected it.

Start time,
voltage,
tape #,
name,
location, project.

Put the new tape in, and after each of the GEOS queries answer them with a "NO" and "ENTER".
When you get to TIME (WWVB SYNC) 000:00:00:00 push "ENTER"

Until you get to REVIEW PARAMETERS? NO? You push "YES", and "ENTER".

Now you are starting at the beginning of the MENU.

GEOS will say REWIND DATA TAPE? NO? You push "YES", and "ENTER".

THE TAPE WILL REWIND

It is important that the tape rewind, to insure that the tape is at its beginning and that the recording of information starts on track 1 and not on track 3. Rewinding the tape positions a recording pointer on the correct track.

10.1.3 SETTING EXPERIMENT

GEOS asks CHANGE I.D. PARAMETERS? NO, push "YES" and "ENTER"

GEOS asks EXPERIMENT NO.: push "CLEAR", than a new tape number (in sequence) with the previous.

GEOS asks LOCATION NO.: 0 (stays the same) push "ENTER"

GEOS asks EVENT NO.: 0 (will have changed to 0) push "ENTER"

GEOS will now come up with the following:

CHANGE SENSORS PARAMETERS? NO push "ENTER"*

CHANGE RECORDING MODE? NO push "ENTER"**

10.1.4 SETTING WWVB TIME AND YEAR

GEOS will now come up with the following:

TIME (WWVB SYNC) : 000:00:00:00

CHANGE CLOCK PARAMETERS? NO push "YES" and "ENTER"

CURRENT YEAR: 86 push "CLEAR" then the correct year and "ENTER"

NO SYNC-RESTART CLOCK? YES push "ENTER"

CLOCK START: WWVB-1;MST-2;MAN;-3: 1 push "ENTER"
it is set for wwvb.

SET CLOCK SWITCH TO "WWVB"

STARTING WWVB SYNC...

GEOS will now tell you to put switch in upper right corner to WWVB. and it will then take about 5-10 minutes to sync to WWVB depending on the radio signal quality.

When it syncs it will ask if time is satisfactory? push "YES & ENTER"

If it doesn't sync within 10 minutes, push "ENTER". The machine will say *WWVB SYNC-UP CANCELLED*, and then it will go back to NO SYNC-RESTART CLOCK? YES, push "NO and ENTER"

GEOS will now say:

AUTO-SYNC TO WWVB LATER? NO push "YES and ENTER"

AUTO-SYNC RETRY PERIOD: 3 HRS push "ENTER"

RECORD WWVB CORRECTIONS? NO push "YES and ENTER"

WWVB CORRECTION PERIOD: 12 HRS push "ENTER"

GEOS will say *SET CLOCK SWITCH TO "WWVB"*

If the GEOS doesn't sync to WWVB time in that first 10 minutes, it is okay. As long as the GEOS has been on for an extended period of time it's existing CLOCK TIME is probably more accurate than what you could do as a manual sync. The 3 hrs retry period will make up for any lack of sync at the time of the paper change.

The only time to do a MANUAL SYNC. would be if the machine were shut off, it had to be re-programmed, and it would not do a WWVB SYNC.

10.1.5 CALIBRATION AND SENSOR TEST

PERFORM AMP/SENSOR TEST? NO push "YES & ENTER"

GEOS says CONNECT SCOPE TO FRONT PANEL and jumps to
AMP TEST: HIT ANY KEY TO STOP push the "7" key

SENSOR TEST: HIT ANY KEY TO STOP push the "7" key

GEOS again says PERFORM AMP/SENSOR TEST? NO push "ENTER"

GEOS says RECORD CALIBRATION? NO push "YES & ENTER"

The GEOS will now count down from 108 sec. You should be perfectly still until it finishes.

GEOS says REVIEW PARAMETERS? NO push "ENTER"

GEOS says ENTERING RECORD MODE....

10.1.6 SENSOR STOMP TEST

GO OUT NEAR THE SENSORS AND DO A GOOD STOMP.
Come back to the GEOS and the tape will be turning if you triggered the GEOS
Push "STATUS" and you will see 3 EVENTS
One will be the amp calibration recording
One will be the sensor test recording

The last will be the stomp test. (you jumping up and down at the sensor)
You are now done changing the GEOS tape.
Write the Julian Day and time on the Master sheet in the brown folder and you are done.
If there are any problems call Doug Myren, Joe Sena, Tom Noce,
At 1-800-223-8081. ext 4858,5603,5601 respectively.

****

*CHANGING SENSOR PARAMETERS

Push "YES" at CHANGE SENSOR PARAMETERS and GEOS comes back with:
ACTIVE CHANNELS : 1 THROUGH 6
you can enter the active channels by moving the cursor with the arrow key and entering the correct channels and then "ENTER".

The GEOS then comes back with:
CH 1:FBA 1,VEL 2: 1; 0 DB; 50 HZ
You can enter the correct DB and HZ by moving the cursor with the arrow keys and entering the values you want for that line and then "ENTER".
The GEOS will go through each CHANNEL you have ACTIVATED and allow you to change the DB and HZ.
When you are done with this it will say:
REVIEW AMP SETTINGS? NO push "YES & ENTER"
Go back and double check that what you want has been entered.
You will again return to REVIEW AMP SETTINGS? NO push "ENTER"
GEOS says:
SAMPLE RATE: 1200 S/SEC push "ENTER"

**CHANGING RECORD MODE

GEOS says:
CHANGE RECORDING MODE? NO push "YES & ENTER"

SELECT RECORDING MODE......

MODE : TRIGGER-1; PRESET-2; BOTH-3; 1 push "ENTER"

TRIGGER PARAMETERS FOLLOW.....

TRIGGER CHANNEL : 4 push "ENTER"
unless you want some other trigger channel push "ENTER", otherwise push "CLEAR", than the channel you want and "ENTER".
STA INTERVAL : 0.5 SEC
unless you want some other value push "ENTER", otherwise push "CLEAR", than the number you want and "ENTER".
LTA INTERVAL : 10 SEC

unless you want some other value push "ENTER", otherwise push "CLEAR", than the number you want and "ENTER".

TRIGGER LEVEL RATIO: 2**2 push "ENTER"

unless you want some other value push "ENTER", otherwise push "CLEAR", than the number you want and "ENTER".

POST-TRIGGER RECORD TIME: 10 SEC push "ENTER"

unless you want some other value "ENTER", otherwise push "CLEAR", than the number you want and "ENTER".

At this time you will go back to TIME (NO SYNC) 000:00:00:00

If you are going to set up a GEOS or you are changing parameters, you will need a scope when you do the AMP/SENSOR TEST. This is necessary to see that the 4,5,6 sensors are level and that the AMPLIFIERS in the GEOS are operating properly.

11. BAROMETRIC PRESSURE TRANSDUCER

A barometric pressure transducer (Setra Systems Model #270) with an 800-1100 millibar range housed in a water resistant container operates at each site. Its purpose is to allow determination of the strain generated by the variations in barometric pressure.

The pressure transducer is powered by two 12 volt, deep-cycle, maintenance-free, gelled electrolyte batteries connected in series to provide 24 volts. The transducer draws 35 milliamps. These batteries are trickle charged just as the batteries for the dilatometer. The data are transmitted with the same satellite telemetry system as the strain data (see specification sheet Barometric Pressure section 13.15).

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14. APPENDIX

14.1 INSTALLATION FIELD NOTES

Table 5

Instrument Resistance Checks Prior To, During, and After Installation									
Instmt#	Site	Date	Time						
Resistance Read Between Pins									
OHM Test	Expected Value+	Pins*	1#	2	3	4	5	6	7
shield to pins	infinite	M/shell-all							
red-black	420K	B(12)-L(2)							
blue-green	20K	F(5)-E(11)							
grey-white	13ohm	J(9)-K(3)							
org/brn-org	18ohm	N/K(10)-C(7)							
org/brn-yel	18ohm	N/K(10)-D(6)							
wht-violet	3.75K	R(3)-H(4)							
wht-brown	4.26K	R(3)-P(8)							
wht-wht/brn	27.6K	R(3)-A(1)							
Cable length at time of resistance measurement.									

+ Add .016 ohms per foot of cable to expected value.

* Pins: Letters refer to electronics box plug, numbers refer to instrument head and instrument cable plug (LP-08 bulkhead connector and LP-08 cable plug; see 13.12 Dilatometer Instrument Cable Connector).

1 Test cap prior to field assembly (male receptacle).
2 Cable attached first time (female cable plug or open wires).
3 Cable attached, cable head pressure tested.
4 Instrument at site, grout inside, prior to installation.
5 Instrument ready to go down.
6 Instrument in grout in borehole, final check, if bad remove.
7 Cable cut to length for electronic hook-up.

Table 6

Instrument Power-Up Voltages Prior To, During and After Installation									
Instmt#	Site	Date	Time						
Voltages Read Between Pins									
DT Pwr-Up:	Pins	Values	1	2	3	4	5	6	7
DT pwr-HI DT pwr-LO	red/B/12 blk/L/2	Apply 6.8V							
DT-HI out DT-LO out	blu/F/5 grn/E/11	Read in mV							
Valve Open/Close									
Valve cmn Valve open Valve close	org-brn/K/10 org/C/7 ylw/D/6	Apply 24V							
DT Volts valve open DT Volts valve closed DT Volts valve open	blu/F/5 & grn/E/11 " "	Read in mV							
It is important to insure that the valve is open at the end of testing. Read between these pins and record.	blu/F/5 & grn/E/11	Read in mV							
			24hr Time and DATE						

Apply 6.8 volts between DT pwr-HI and pwr-Lo, and read DT-HI and LO out on BLU and GRN.

To open and close valve, apply 24-54 volts between ORG-BRN and ORG or YLW respectively. Voltage applied depends on cable length.

Read and record these voltages in the appropriate columns.

14.2 STRAIN FIELD NOTES

Strain Field Notes

Name____________________

Station Name____________________Station Code________Date_______Day______
Arrival Time: Local___________GMT__________
Departure Time:Local___________GMT__________

Strainmeter DC Voltages (read at Telemetry Test Points)

	ID#	Gain	Arrival	valve open	valve closed/depart
Common (white)					
DT amp 1 (blue)	_____	_____	_________	________	________
DT amp 2 (green)	_____	_____	_________	________	________
DT amp 3 (brown)	_____	_____	_________	________	________
SP amp (orange)	_____	_____	_________	________	________
Temp (purple)	_____	_____	_________	________	________
DAC 2 (yellow)	_____	_____	_________	________	________
DT OUT-HI (blue,lower right)			_________	________	________

Power Voltages
(read across red & black of Supply Test Points)

BAT ___________ 12 volt battery
6.8V___________ 6.8 volt regulated
-15V __________ 15V ___________ 15 volt unregulated
-12V __________ 12V ___________ 12 volt regulated

D.T.
IN 6.8V __________
(across High&Low)
(red & black)
OUT __________
(across High&Low)
(blue & green)

Pressure Transducer DC Voltages

	Pore	Baro
Battery	_________	_________
DC/DC	+____-____	+____-____
Signal out	_________	_________
Signal to telem	_________	_________
ID#	_________	_________

Telemetry

DC Voltages Battery Voltages: Telem.Unit________
Antenna RF Output Level:Fwd________Ref________
DCP S/N (existing)________________(replacement)_______________
Site ID#_______________ Time of Transmission ________________
Parameters used_______________ Parameter Type__________________

Reason for Visit____

Remarks____

14.3 INSTRUMENT GROUTING

The depth to which an instrument can sink in grout can easily be determined from knowledge of the volume of grout, the volume of the instrument, and the diameter of the hole. The volume of the instrument can be determined from

$$V_i = L\pi r^2$$

where L is the length of the instrument and r is the radius of the instrument. Similarly, the volume of hole to be filled eventually with instrument and grout is given by:

$$V_h = H\pi R^2$$

where H is the length of hole to be cemented, and R is the Radius of the hole. If the section of hole chosen for the instrument installation site is about 20 ft (6.1 m) long and the hole has a 6 in (15.2 cm) diameter, the volume required is 3.9269 cu ft (0.111 cu m). Since a dilatometer with a 12 ft (3.66 m) length and 4.5 in (11.4 cm) O.D. has a volume of 1.325 cu ft (0.375 cu m), and since a 6 in (15.2 cm) O.D. hole with a 12 ft (3.66 m) length has a volume of 2.356 cu ft (0.067 cu m), the grout volume required to fill the space between the dilatometer and the wall of the hole is 2.356 - 1.325 = 1.0306 cu ft (0.029 cu m). The 1.325 cu ft (0.375 cu m) of grout that the dilatometer displaced can fill 6.74 linear feet (2.05 m) of 6 in (15.2 cm) O.D. hole. Provided bottom of the hole is hard, the dilatometer should sink into the grout a minimum of 6 ft (that would than be a minimum of 6 ft above the target depth) (As long as the log and core above and below the site are satisfactory this will be the minimum requirements for instrument installation.)

Table 7

Cement Cover		
Above Instrument	Instrument Location	Below Instrument
6.74 ft	on bottom	0 ft
5.74 ft	1 ft off	1 ft
4.74 ft	2 ft off	2 ft
3.74 ft	3 ft off	3 ft
2.74 ft	4 ft off	4 ft
1.74 ft	5 ft off	5 ft
0.74 ft	6 ft off	6 ft

If the target depth for the bottom of the instrument is marked on the cable at 500 ft (152 m) (including the length of the instrument at end of the cable), there should be another mark 12 ft (3.65 m) before that 500 ft (152 m) mark; then when the instrument enters the grout it will began to slow at the 12-ft (3.65 m) mark and come to a stop at the 500 ft (152 m). The above table shows how much grout will cover the instrument. If the instrument settles more than 6 ft (1.83 m) short of the mark, the instrument must be removed; it does not have enough grout covering it.

These values should be calculated for each installation and double checked to ensure the instrument is being installed where you want it.

14.4 DILATOMETER ELECTRONICS

14.4.1 ELECTRONICS BOX TELEMETRY CONNECTOR WIRING CODE

Table 8

Telemetry Connector		
ID	PIN	COLOR
DT amp 1	A	blue
DT amp 2	B	green
DT amp 3	C	brown
SP amp	D	orange
Temp(therm)	E	purple
DAC 2	F	yellow
Common	H	white
Stepped DT amp 1B	J	red*
-12 volts	K	black

*This pin is used as the 6.8V monitor at all sites except Searle Rd. , Black Butte, and Eades.

14.4.2 GEOS RECORDER AND POWER CONNECTORS

Table 9

Recorder/GEOS Connector		
ID	PIN	COLOR
Stepped DT amp 1	A	blue
DT amp 2	B	green#
DT amp 3	C	brown
SP amp	D	orange*
Temperature	E	purple
DAC 2	F	yellow
Common	H	white**
-12 volts	J	black
Recorder common	K	white

DT X1 op/amp to GEOS Chan. 1. At Devils Postpile & Devils Punchbowl.

* Buffer op/amp AC signal to GEOS Chan. 2 & 3. At all sites except Eades, Black Butte, Searle Rd, and Echo Valley.

** GEOS signal ground at all GEOS sites.

Table 10

Power Connector		
ID	PIN	COLOR
Battery Power	B & C	red
Battery Common	D & E	white

14.4.3 DILATOMETER CABLE CONNECTOR

Table 11

Dilatometer Cable Connector		
Color	ID	Pin
brown	therm power	A
red	DT power +6.8V	B
org/org	Valve open	C
ylw/ylw	Valve close	D
green	DT signal com	E
blue	DT signal	F
purple	Thermister signal	H
grey	Calibrator	J
white	Calibrator	K
black	DT power common	L
shield	cable shield	M
white	valve common	N
grey	Therm shunt	P
white	Therm common	R

14.4.4 HARDWARE, DILATOMETER

Table 12

HARDWARE FOR DILATOMETER ELECTRONICS

QUAN	PART DESCRIPTION	PART#
1	Dilatometer Plug for jacketed cable	Amphenol 165-29, 14 pin
1	Dilatometer Receptacle, Square Flange	Amphenol 165-32, 14 socket
2	Rustrak Plug for jacketed cable	Amphenol 165-13, 9 pin
2	Rustrak Receptacle, Square Flange	Amphenol 165-16, 9 socket
1	Power Plug for jacketed cable	Amphenol 165-34, 5 socket
1	Power Receptacle, Square Flange	Amphenol 165-35, 5 pin
1	Telemetry Plug for jacketed cable	Amphenol 165-9, 12 pin
1	Telemetry Receptacle, Square Flange	Amphenol 165-12, 12 socket
1	Earth Ground Receptacle	Burndy KAC14-4
7	Card Edge Connector (22 pin)	Amphenol #143-022-01-110
1	Battery, 6 volt, 4.0 amp/hr, sealed rechargeable	any manufacturer
1	Electronics Box	Skydyne, code #74284, part #99390
1	Strip Chart Recorder	Rustrak/Gulton, model #288/F137, 12VDC, 1RPM motor, 1/2" per hour chart drive, chart style WA, Galvanometer #A B 101 462 2 A.

14.5 BAROMETRIC PRESSURE TRANSDUCER

14.5.1 BAROMETRIC PRESSURE TRANSDUCER CABLES

Table 13

Barometric Pressure Power Connector		
ID	Pin	Color
Gnd power	A	black
nc	B	nc
nc	C	nc
+24V power	D	red
nc	E	nc

Table 14

Pressure Transducer Cable to 2 PIN to DCP Cable			
Cable	Color	2 PIN	DCP Color
Signal out +	yellow	red or wht	red or wht
Signal out -	brown	black	black
+24V power	white	nc	nc
Gnd power	black	nc	nc
Calibration	red	nc	nc
Shield to Gnd	shield	nc	nc

14.4.2 PRESSURE TRANSDUCER HARDWARE

Table 15

BAROMETRIC PRESSURE TRANSDUCER HARDWARE

QUANTITY	PART DESCRIPTION	PART #
1	Box	Skydyne #74284
1	Transducer,Barometric (800-1100 mbar)	Setra #270
1	Socket	Amphenol #3102A 14S-5S
1	Socket	Amphenol #3102A 14S-9S
1	Plug	Amphenol #3102A 14S-5P
1	Plug	Amphenol #3102A 14S-9P
2	Strain Relief	Amphenol #97-67-14-76
1	Airstone, Aquarium	Kordon #62502
1	Pressure Fitting	1/8"-27 NPT to 1/4" O.D. Compression
1	Flexible Tubing, Plastic	1/4" O.D.

14.6 ADDITIONAL ELECTRONICS

14.6.1 DCP VOLTAGE MONITOR EXPANDER BOARD

Attached to the DCP is an additional board to expand the data collection capacity of the DCP. This board is currently being used to monitor the DCP battery voltage and the 6.8 v battery which runs the down-hole transducer of the strainmeter.

The expander was designed to accomodate eight additional analog inputs sharing on DCP parameter input. It is powered by the protected 12 v of the DCP, and its' sampling is controlled by the switched-12 v of the DCP. There are 4 CMOS chips and 1 analog switch that control this sampling. The DCP samples data and transmits every 10 minutes. At these times the switched 12 v comes on to power or control other equipment.

In this circuit the switched 12 v goes through a NAND Schmidtt Trigger and then to a dual j-k flip-flop. Here the flip-flop inverts and lengthens the 5 s pulse every 10 m. Thus when the switched 12 comes on at the time the DCP transmits, the next chip, an Up/Down Counter, won't count this pulse, but will count only the pulse which occurs at the time of sampling. The Up/Down Counter counts these pulses and resets to seven when it reaches a pre-programmed number determined by the setting of the analog switches. The Counter can be set to control sampling of from one to eight analog inputs through an 8-channel, analog multiplexer.

The analog multiplexer will pass through to the one analog parameter location on the DCP from 1 to 8 different analog values. These values are sampled and transmitted in a cascade manner.

14.6.2 DCP/VOLTAGE MONITOR PARTS LIST

Table 16

DCP/VOLTAGE MONITOR EXPANDER BOARD PARTS LIST

QUAN	KEY	PART DESCRIPTION	SOURCE
1	U01	MC14093B	Motorola
1	U02	CD4027BCN	National
1	U03	76STC04-SPDT DIP SWTCH	Grayhill
1	U04	MC14051B	Motorola
1	U05	4510PC	Fairchild
1	SW01	MTM-206N-RA DPDT SWTCH	ALCO
1	R1,R01,R02	RES. 750K 5%	Dale
1	CR01-02	Diode, 1N4001	Any
1	CON	12 pin connector	Any

14.6.3 GEOS SIGNAL BUFFER

An operational amplifier circuit is used to impedance match the inputs of the GEOS. This circuit (see Section 13.12 for schematic of SIGNAL BUFFER) acts as a buffer with a filter constant of 400 s. The AC portion of the dilatometer signal is derived from the 5 second notch filter card, after the 40 mf capacitor, and is buffered by the op/amp before the signal is sent to the GEOS.

14.6.4 GEOS SIGNAL BUFFER PARTS LIST

Table 17

GEOS SIGNAL BUFFER PARTS LIST

QUAN	KEY	PART DESCRIPTION	SOURCE
1	R1	RES.,51.1k 1/4w 1% 50ppm,RN55C	DALE
1	R2	RES.,976 1/4w 1% 50ppm,RN55C	DALE
1	R3	RES.,976 1/4w 1% 50ppm,RN55C	DALE
1	R4	RES ,variable,20k,NO43w203	SPECTROL
1	C1	CAP.,0.1ufd,100vdc,WMF1S82	CDE
1	C2	CAP.,0.47ufd,50vdc,	ANY
1	C3	CAP.,0.47ufd,50vdc,	ANY
1	P1	Card edge connector, 22pin,143-022-01-110	Amphenol
1	UO1	OP-07, operational amplifier	PMI

14.6.5 CURRENT AMPLIFIER FOR DAMAGED CABLES

At those sites where water has leaked into the cable or cable head at the instrument, it is possible to recover a signal from the instrument with a different amplifier.

After measuring the down-hole cable resistances and determining that the instrument signal output may be recoverable, a current amplifier can be installed in-place of the conventional op-amp.

This circuit is seen in the accompanying schematic. Its operation is controlled by the switched 12 v from the DCP. Power is turned on and off by this switch every 10 m for 15 s and then sampled by the DCP.

14.6.6 CURRENT AMPLIFIER PARTS LIST

Table 18

CURRENT AMPLIFIER PARTS LIST

QUAN	KEY	PART DESCRIPTION	SOURCE
1	U1	IC ultra-low offset v op-amp LF355	National
1	U2	IC ultra-low offset v op-amp LF355	National
1	R1/R2	500 ohm 1% RN60D	DALE
1	R3	4K " " "	"
1	R4	5K " " "	"
1	R5	10K " " "	"
1	R6	30K " " "	"
1	R7	50K " " "	"
1	R8	100K " " "	"
1	R9	300K " " "	"
1	R10	10K " " "	"
1	R11	30K " " "	"
1	C1	.1uF, 100VDC, ceramic	CDE
1	C2	2.5uF " "	"
1	RY1	RELAY, WD57-172DIP-23	MAGNECRAFT
1	L1	INDUCTOR, ML-8, MINIDUCTOR, 10hy	TRW/UTC

14.7 HOIST OPERATION

Before setting up make sure there are no overhead obstructions.

1. Position the truck approximately 4-5 ft from the drill hole.
2. Set Parking Brake. Note engine hours.
3. Chock wheels, open all lock boxes.
4. Start truck: Put transmission in Park, push the accelerator to the floor and release, then start the truck.
5. Put transfer case in neutral.
6. Move shift lever to "D". Keeping your foot on the brake, give the truck a little gas to insure it will not move and that the transfer case is in neutral.
7. Put transmission in "N" (neutral).
8. Pull "PTO" out quickly. It will protest, but it will engage.

   Put transmission back in "D" (drive).
9. Put on your hard hat and gloves.
10. Go to back of truck and lower "outriggers".

    right lever = right side

    left lever = left side.

    To lower, push levers forward.
11. When you have insured that there are no overhead projections, the outriggers are down, the wheels are chocked and you are wearing a hard hat and gloves, raise the mast BY PULLING THE MAST LEVER TOWARDS YOU WHILE PULLING THE SANDLINE FREE-FALL LEVER TOWARDS YOU.

    The mast should only be extended out from the back of the truck 4-6 feet. Going back further could damage the hydraulic rams.
12. There are two winches: the main winch with approximately 200 ft of cable, and the sandline winch with 1200 ft of cable. Both winches are capable of lifting 2000 lbs. single line.

    The MAIN WINCH has a smoother operation than the sandline. A small movement gets a small movement of the cable.

    The SANDLINE WINCH was designed for high-speed operation, 400 ft/m, as a consequence its operation is more abrupt. BE CAREFUL with this winch.

    Test the sandline winch before full use to familiarize yourself with its operation.

    With both winches the movement of the levers is the same;

    Pull lever OUT to LET CABLE OUT.

    Push lever IN to BRING CABLE IN.
13. To extend the mast: Let the cable on the SANDLINE WINCH out, let the cable on the MAIN WINCH out and attach the yellow weight in the driver's-side, rear lockbox to the MAIN WINCH cable hook. Raise this weight to the top of the mast. This weight acts to help lower the cable. The winch cable will raise the mast, 6 ft than 10 ft, for a total height above the ground of 32 ft.

When it reaches these height increments, a dog will drop into a notch and lock the mast in place. There is a cable with a handle above you for dog release.

Once the mast is raised and the dogs are set, lower the MAIN WINCH cable, store the weight and secure the main winch line if it is not going to be used.

Now you are setup for operation.

14. For High Speed operation of cables, flip switch next to the dog release cable. This kicks the engine speed to 1200 rpms.

15. To retract the mast: Raise the weight to the top until the dog can be released easily by the cable handle above you. Pull that handle until the mast is fully retracted; now lower the weight and store it.

    To lower the mast: Secure the main winch in its original position.

    Secure the sandline hook and pull the sandline

    freefall towards you while pushing the mast lever away from you.

    Once the mast is lowered, raise the out-riggers

13. SHUTTING DOWN

    To disengage the PTO: Push the PTO knob in, Shut the engine off, put the transmission in "P" (park), Put the transfer case in "H" (high).

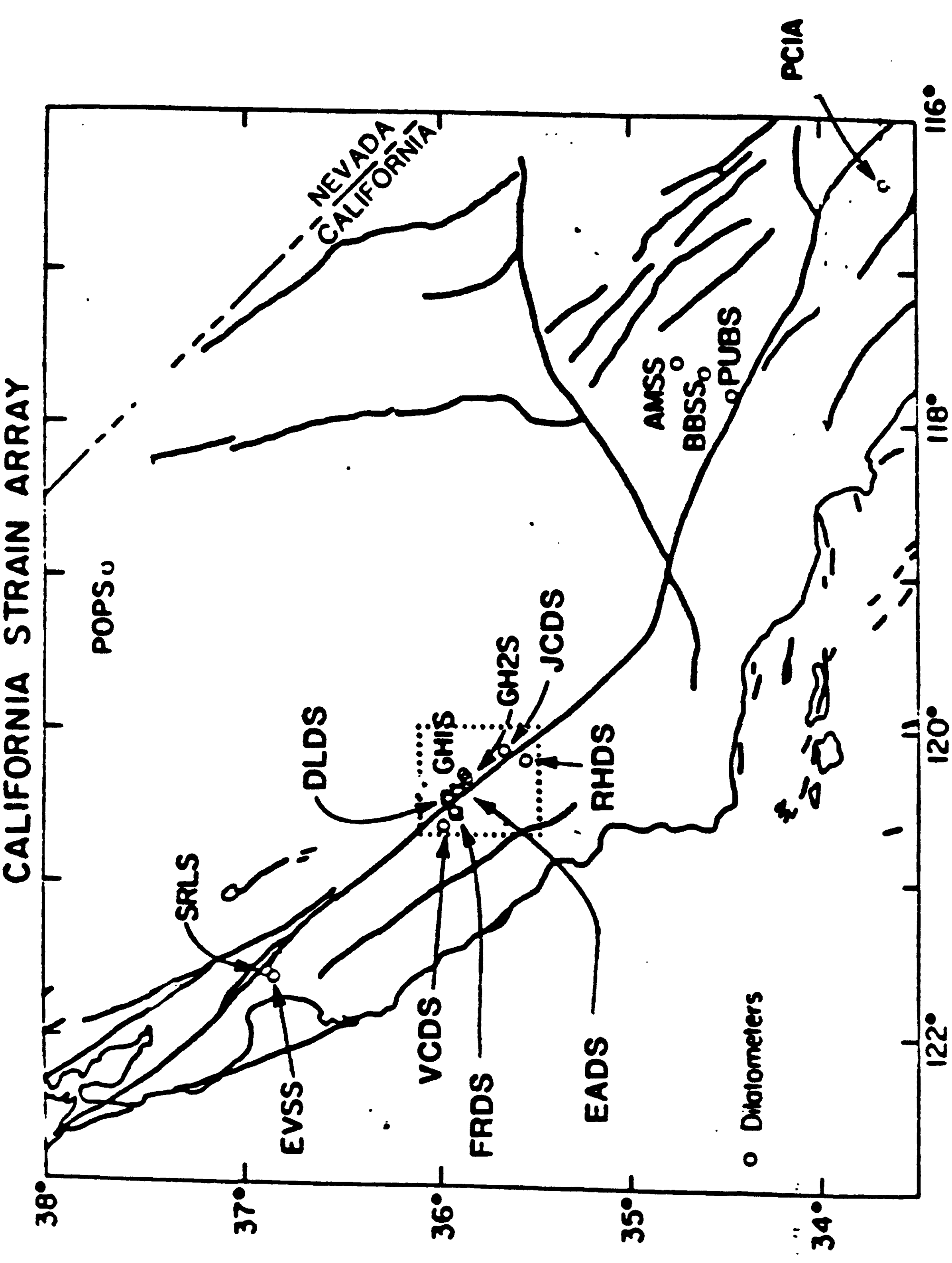
    NOTE THE ENGINE HOURS. Every 100 hours change the engine oil, oil filter and air filter.

    Ensure that the high speed switch is off, and the fuse (for the high speed switch) at the battery, is removed. This ensures that if the switch is left on inadvertently, the battery wont be discharged.

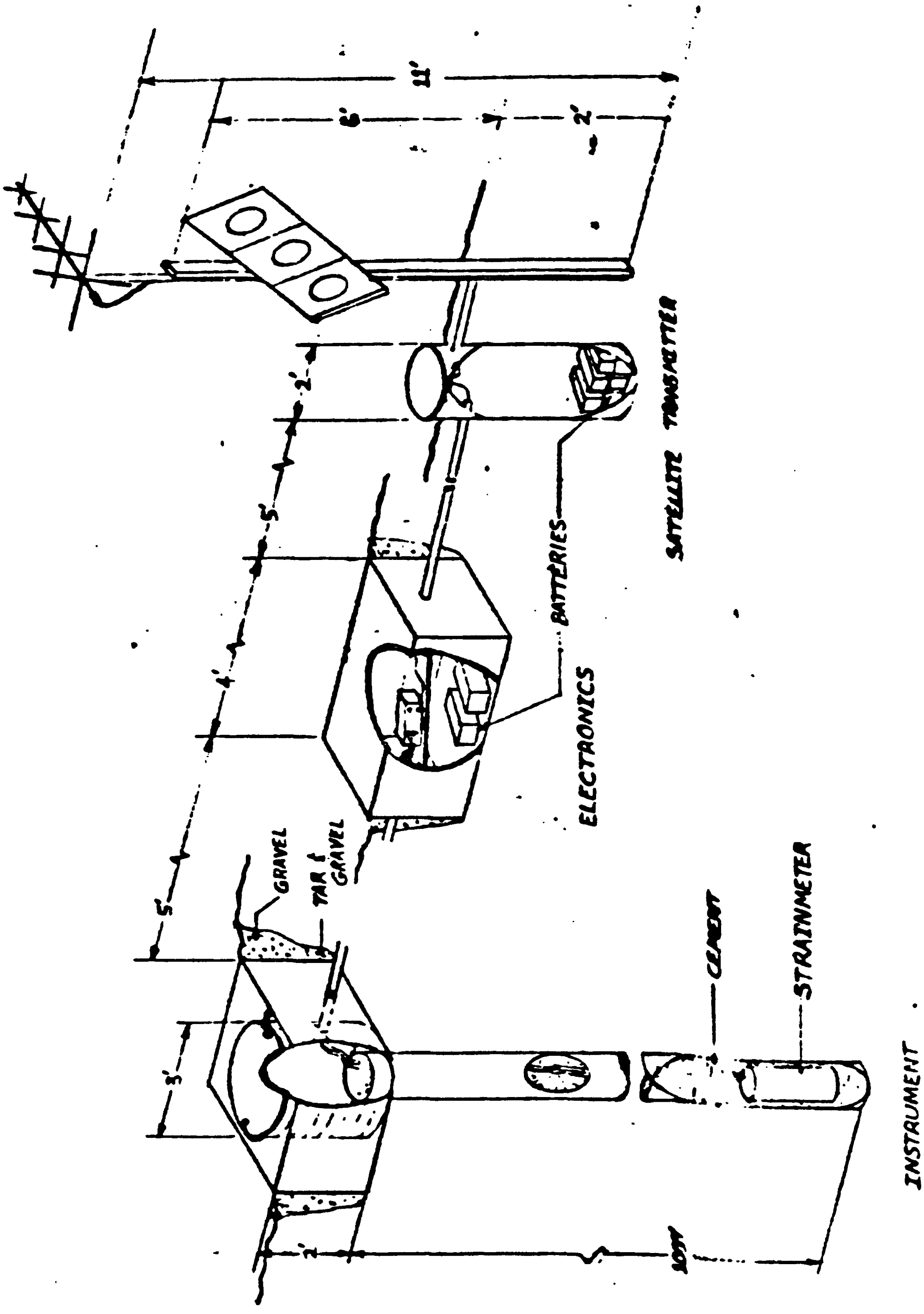
    Now you can remove the chocks and drive off.

    ALWAYS WATCH THE CABLE AND WINCH. ENSURE THAT ANYONE NEAR THE RIG IS WEARING A HARDHAT.

14.8 MAP OF INSTRUMENT LOCATIONS



14.9 SURFACE ENCLOSURES



14.10 WELL LOGS

page 47 follows

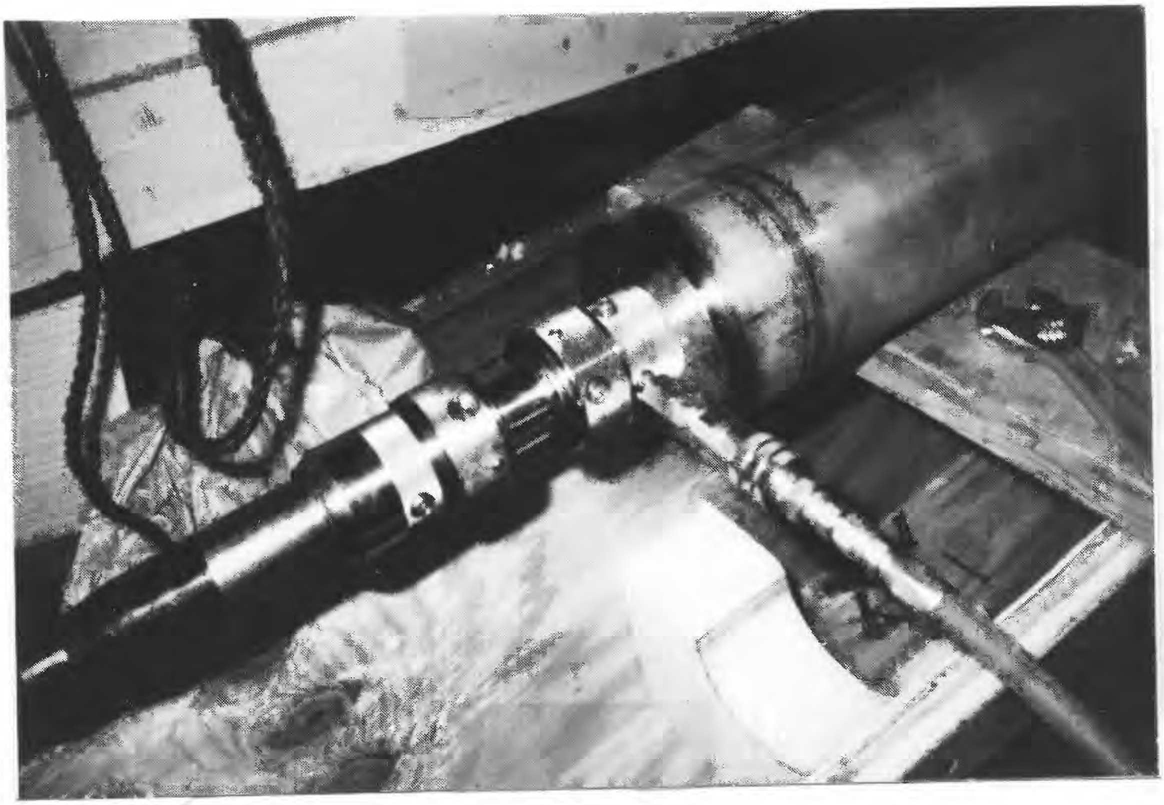
14.11 PHOTOS

Photo # 1
Expansive grout being poured into the center section of an inverted Dilatometer.
The grout acts as ballast.

Photo # 2
Expansive grout (non-shrink, Corps of Engineers Spec. CRD-C 621), 6 - 50# bags, with 9.8 # of water per bag. This mix has a slump of 12 or 0 cone.

Photo # 3
Kintec cable-head attachment to strainmeter.

Photo # 4
Pressure test at one of two port locations on Kintec LP-08 bulkhead receptacle. Pressure brought to 800 psi.



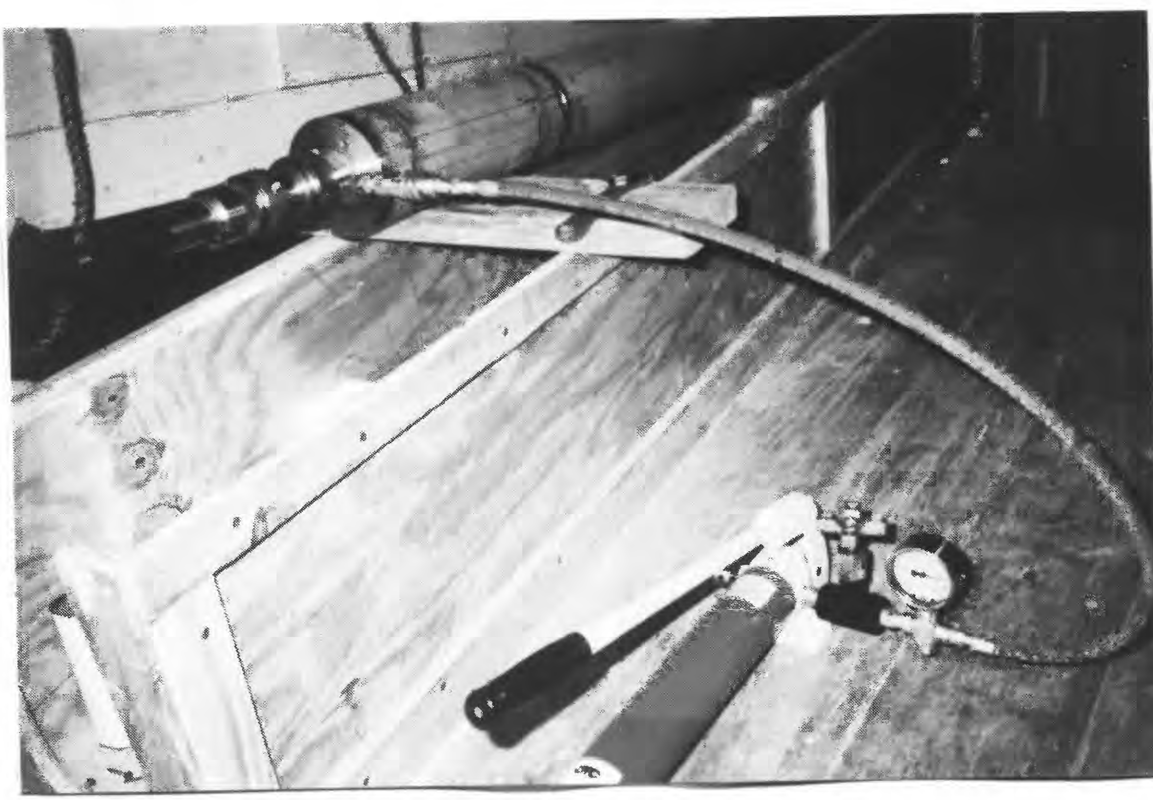


Photo # 5
Pressure test at one of two test locations on cable-head plug assembly.

Photo # 6
Core recovered from Jack Canyon Dilatometer Site, 2.9 miles (4.5 km) from the San Andreas Fault near Parkfield, Calif.. Depth of instrument at this location is 552 ft (169.84 m), same as core.

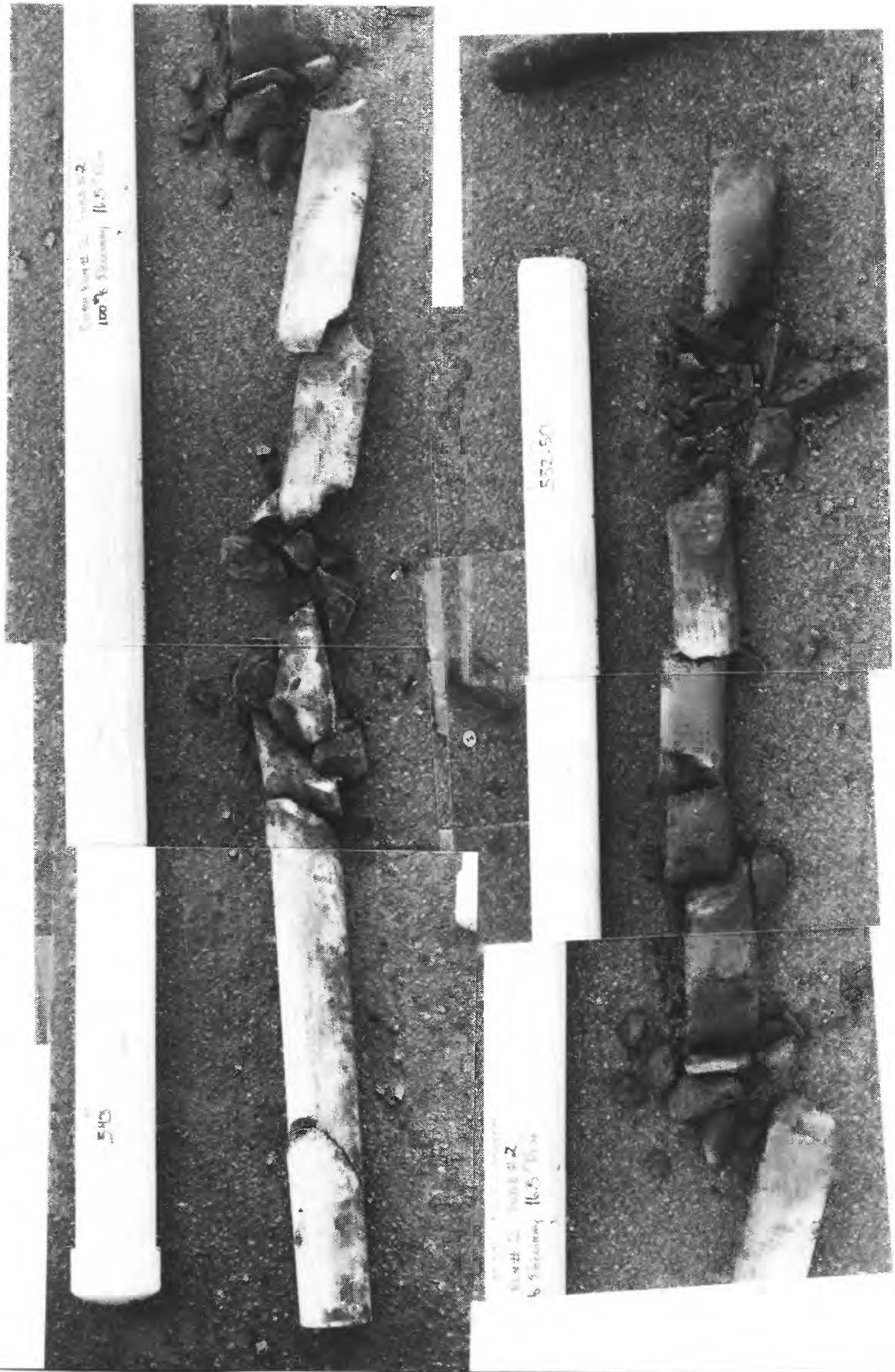


Photo # 7
Hydraulic derrick, water tank, and Dilatometer over borehole.

Photo # 8
These are the parts for the Cement Dump Trip Mechanism. Clockwise from top; bottom plate, bolts, coil spring (insert), allen wrench, latching spring, trip rod, and keeper plate, 2-1" steel balls (not in photo).

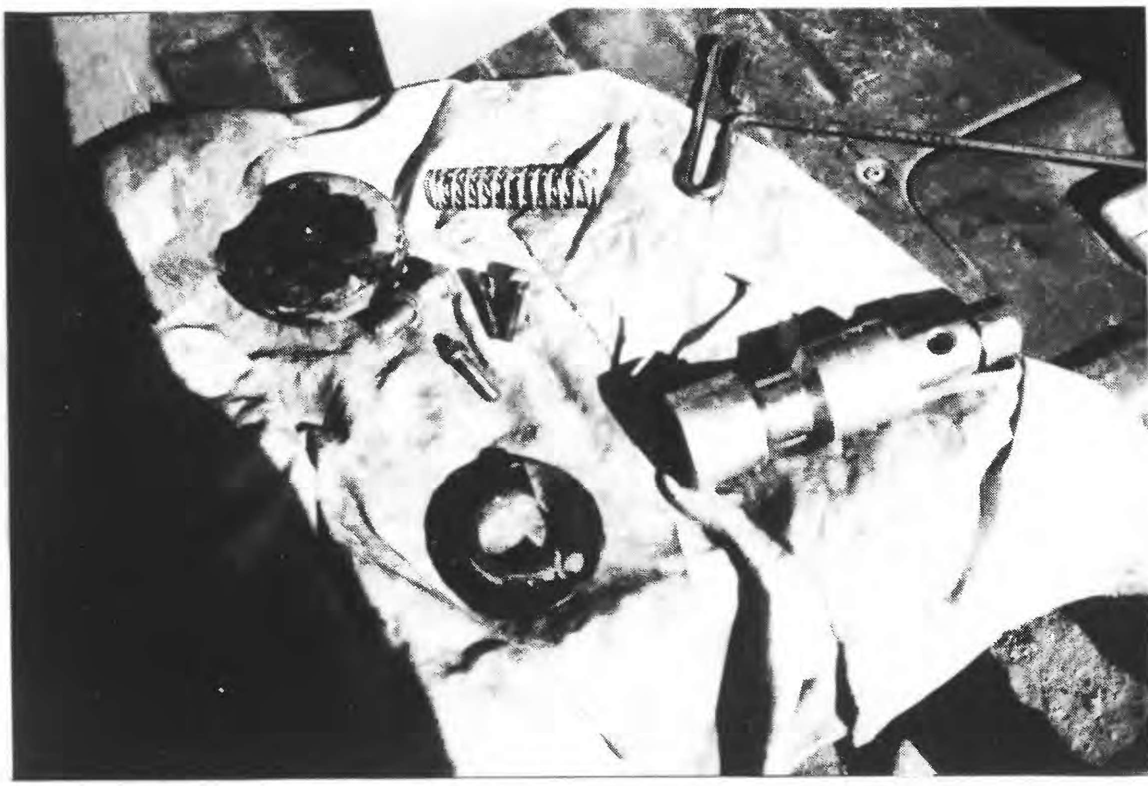


Photo # 9
Assembly of Trip Mechanism.

Photo # 10

Trip Mechanism assembled with chain wrenches and rags required for assembly.

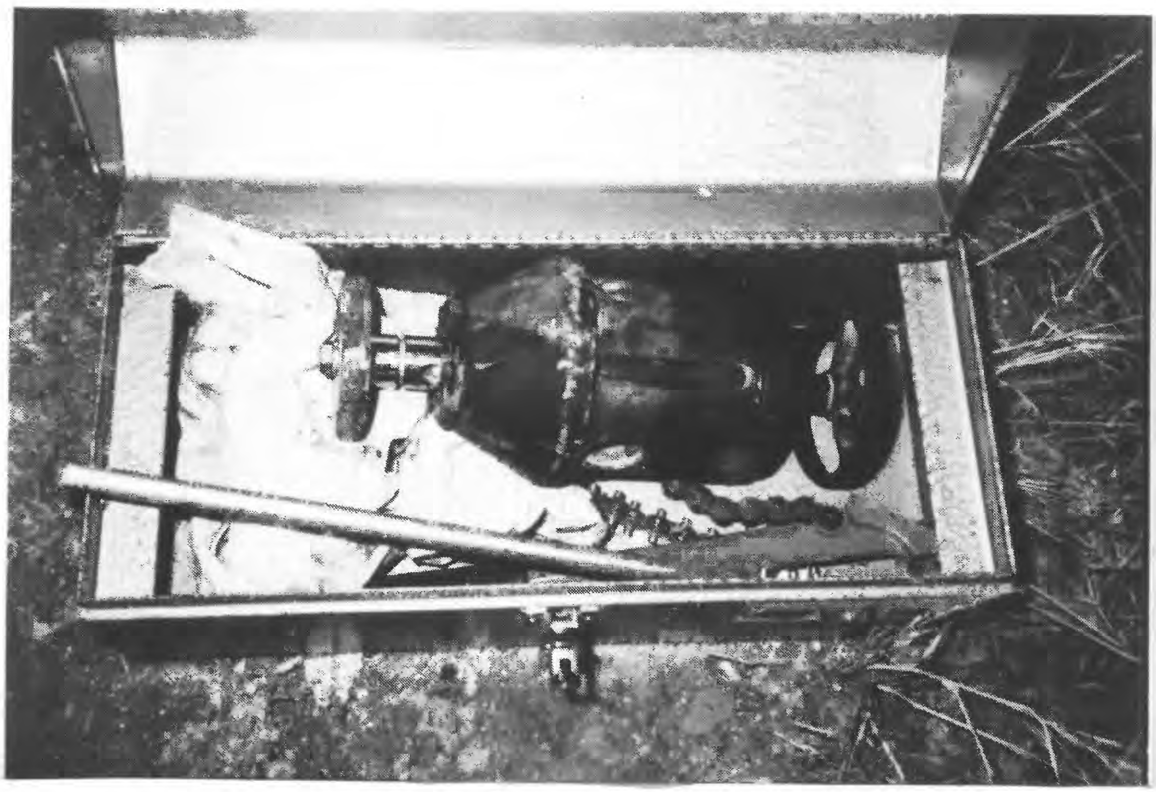


Photo # 11
Bottom of Cement Dump with Trip Mechanism latched to prevent cement flow through openings.

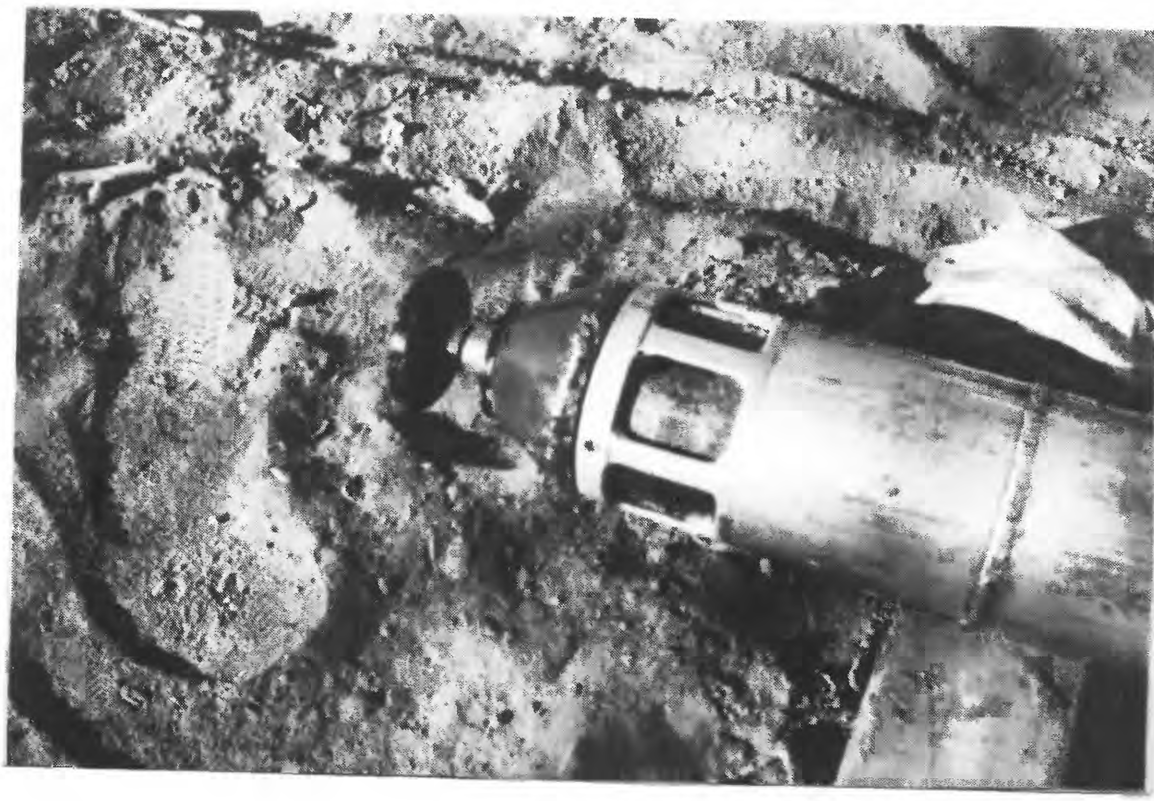


Photo # 12
Bottom of Cement Dump with Trip Mechanism open.

Photo # 13
Cement Dump; 27 feet (8.23 m) L, by 4.5 in (11.43 cm) O.D., with a capacity of 2.36 cu ft (.067 cu m).

Photo # 14
Sheave support stand on left tied to casing with pipe chain vise. The latched Trip Mechanism attached to Cement Dump going into borehole.

Photo # 15
Top of Cement Dump going into borehole. The Sheave Support Stand on left.

Photo # 16
From bottom right going clockwise: Top of Cement Dump attached to wire rope, borehole, Sheave Support Stand, Dilatometer (Volumetric Strainmeter), Truck mounted hydraulically operated crane and winch.

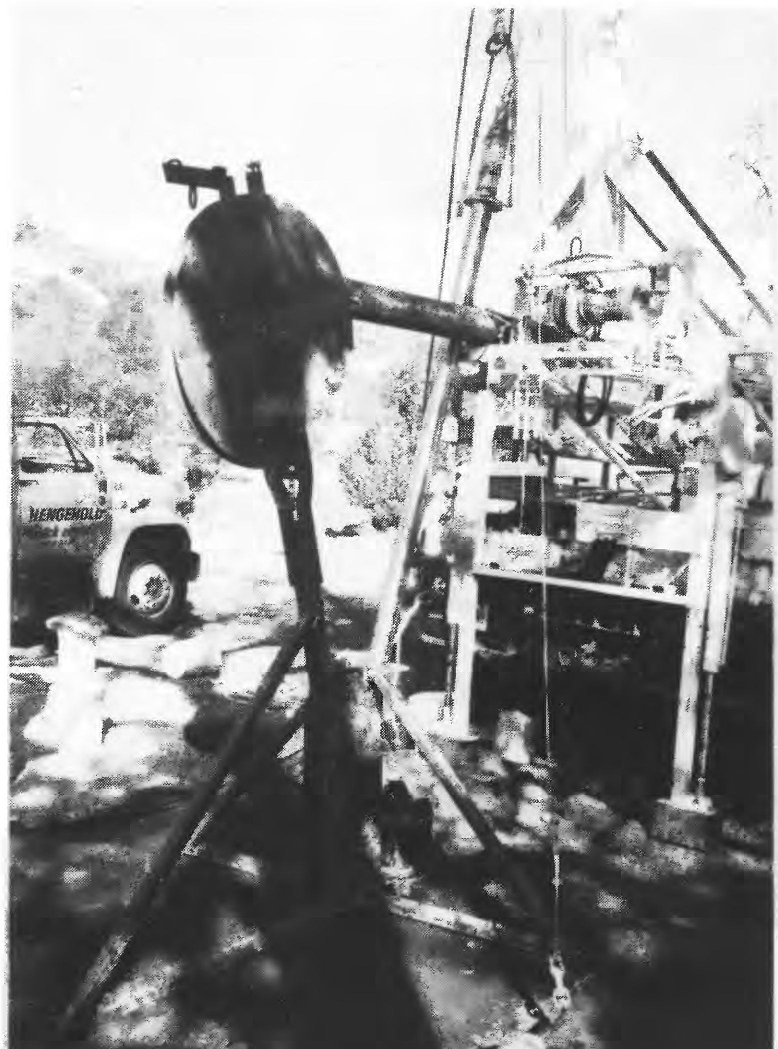


Photo # 17
Instrument Cable Reel with man on Reel Brake, and Reel Stand on back of pickup.

Photo # 18
Expansive grout being poured into Cement Dump before being lowered to the bottom of the borehole.

Photo # 19
Raising a Dilatometer over the borehole.

Photo # 20
Lowering the Dilatometer into the borehole, and positioning the sheave support stand (Delivery System) over the borehole.

Photo # 21
The removal of the lifting clamp from the Dilatometer after lowering into the borehole. Before this is done the weight of the Dilatometer is taken up by its' cable.

Photo # 22
The instrument cable under tension, with the instrument ready to be lowered into the grout.

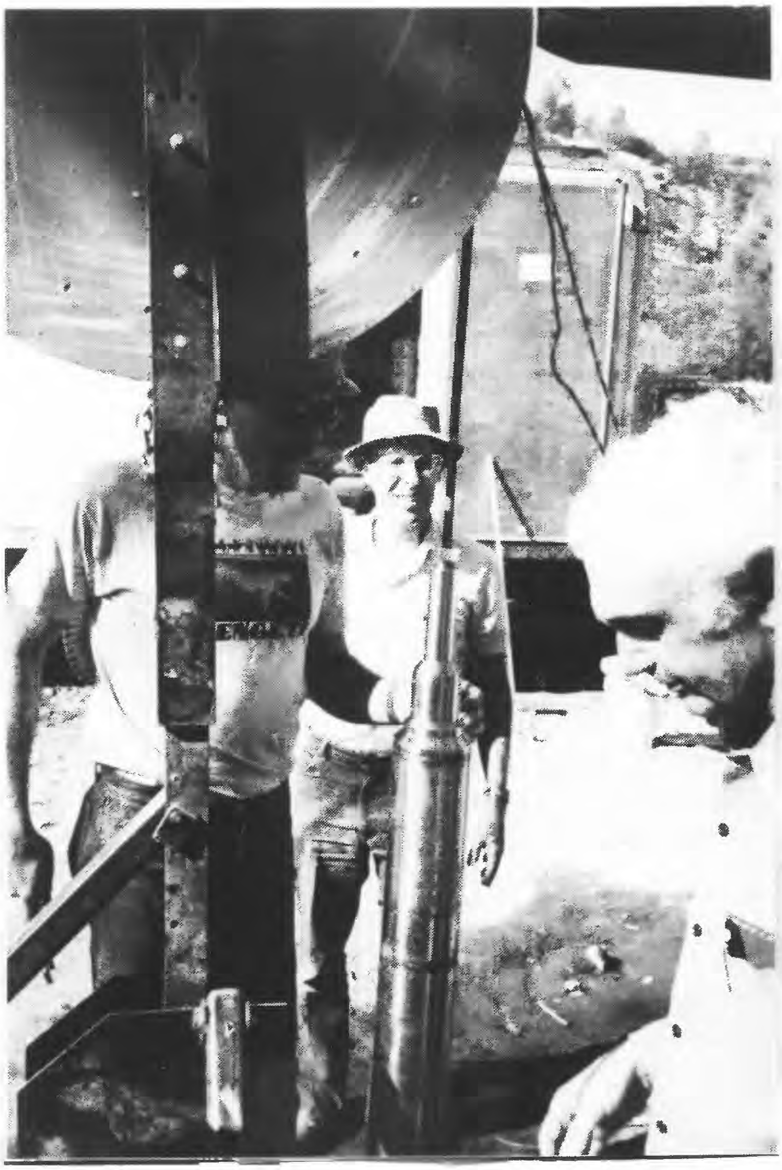


Photo # 23
A full view of the final instrument installation; hydraulic crane, delivery system, and cable reel and brake.

Photo # 24
Scientist checking instrument cable tension as instrument sinks into grout.

Photo # 25
The cable tension has been taken up by rope and tied off to the Delivery System. This helps keep the instrument verticle in the borehole.

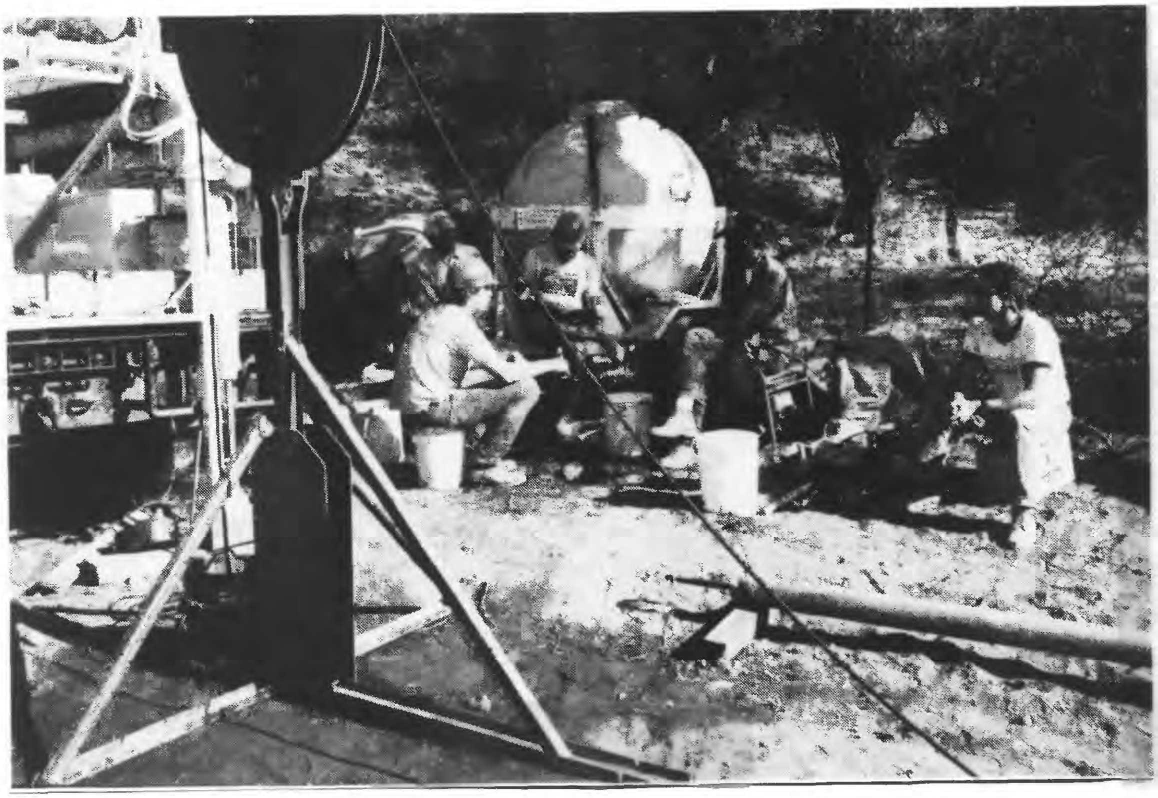


Photo # 26
2 inch to 1 inch reducer for cement hose to PVC mating. This is for cementing of the borehole above the instrument.

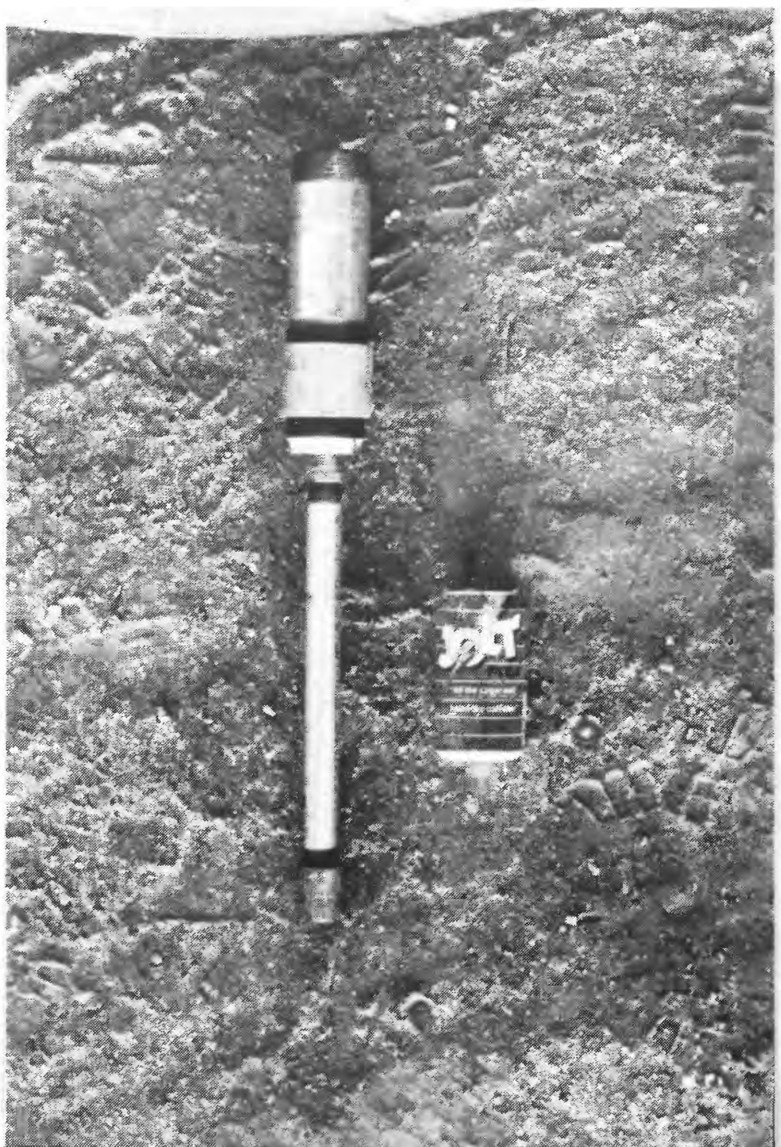
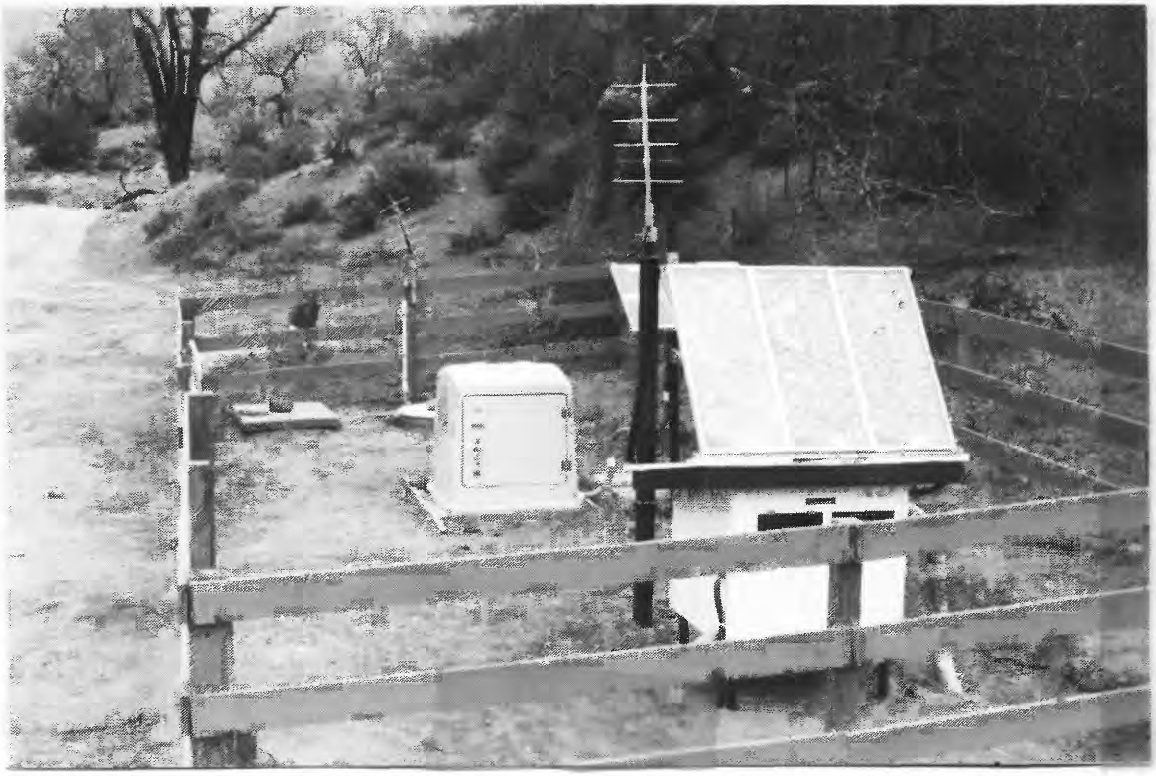


Photo # 27

Cement being pumped into borehole after instrument installation. Seen in this photo are: 4 inch PVC for additional instrumentation, 1 inch PVC electrical 90 for cable protection at the surface, top of 1 inch PVC mated to 2 inch cement pump hose. They are all tied down to prevent them from raising as the cement is pumped down.

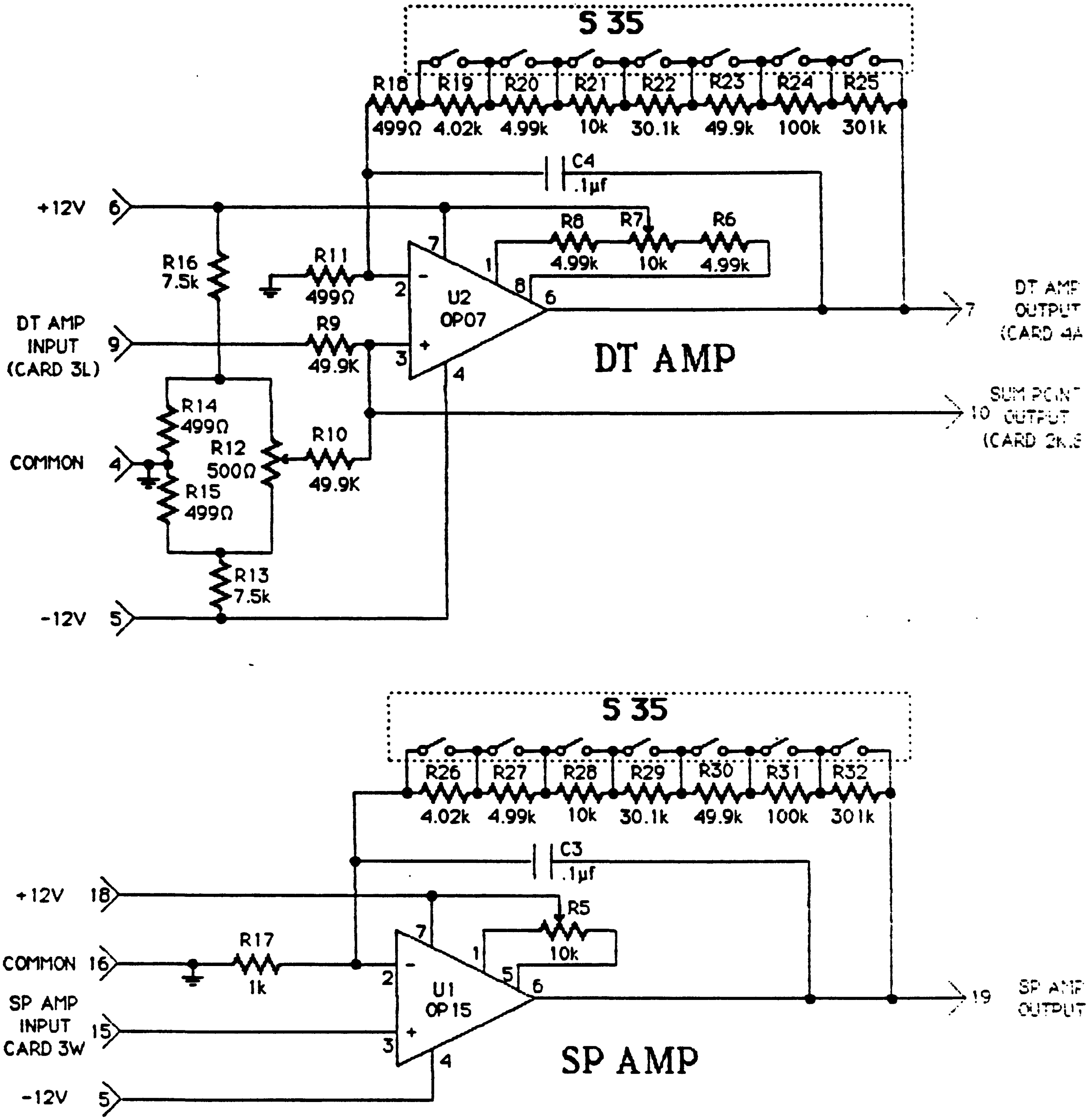
Photo # 28
Oil field cementing operation used for cementing borehole. Left to right are: Water truck, pump truck, and dry cement truck.

Photo # 29
A completed Strainmeter Installation: Tensor Strainmeter surface electronics with solar panels and satellite antenna in the foreground, GEOS housing in the middle ground, and Volumetric Strainmeter surface electronics enclosures in the background.

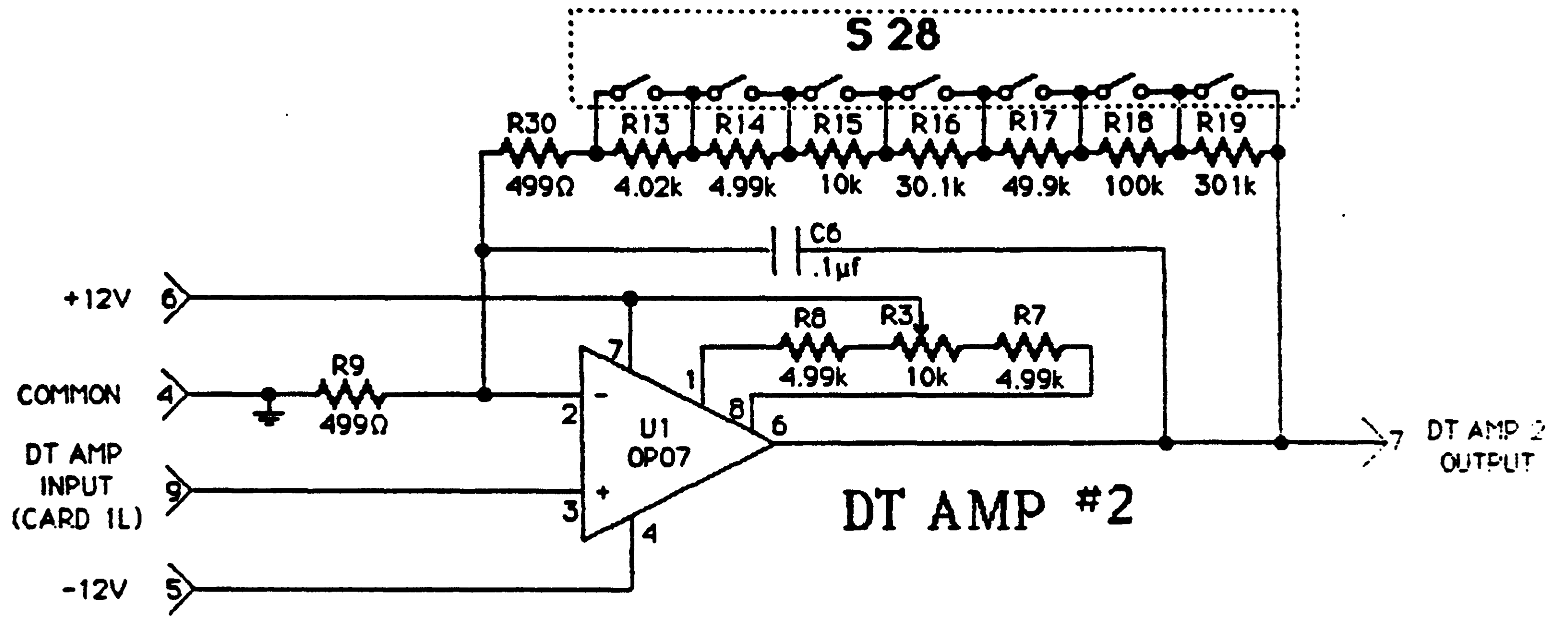


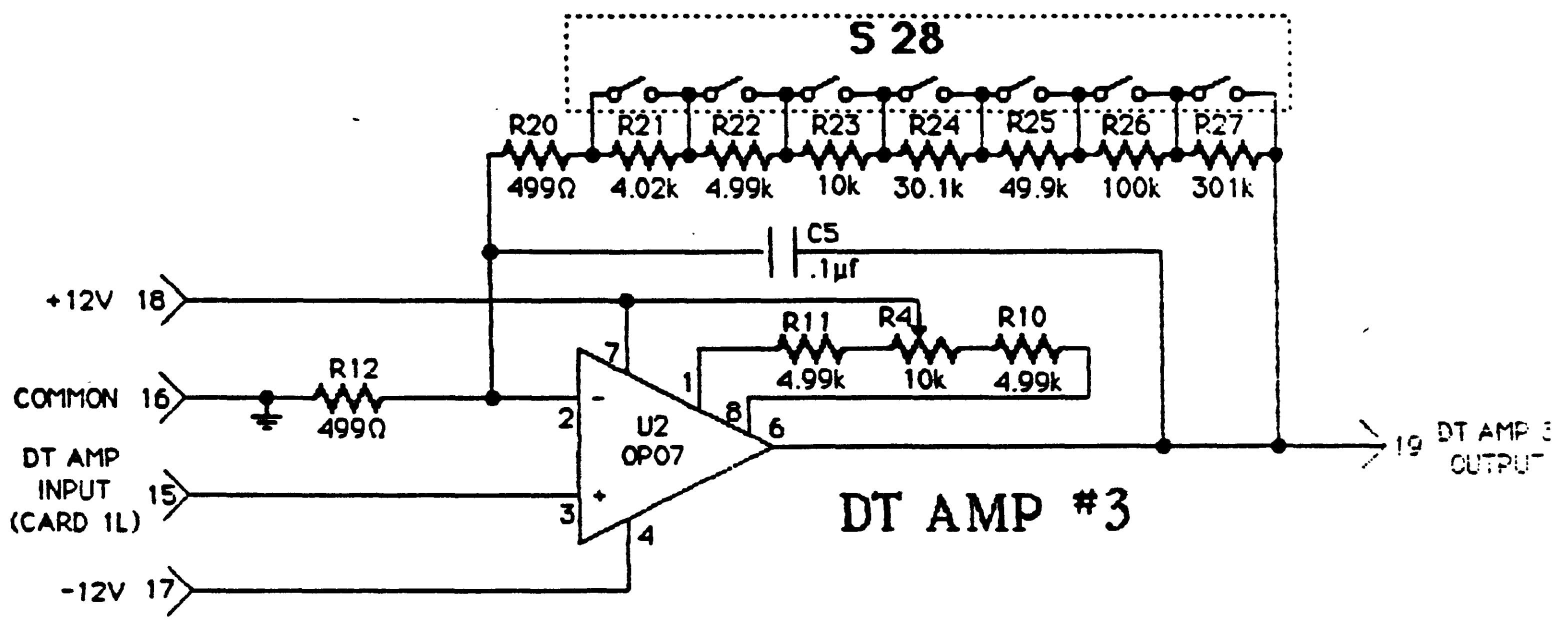
14.12 DILATOMETER ELECTRONICS SCHEMATICS

CARD #1 SEISMIC AMPLIFIER

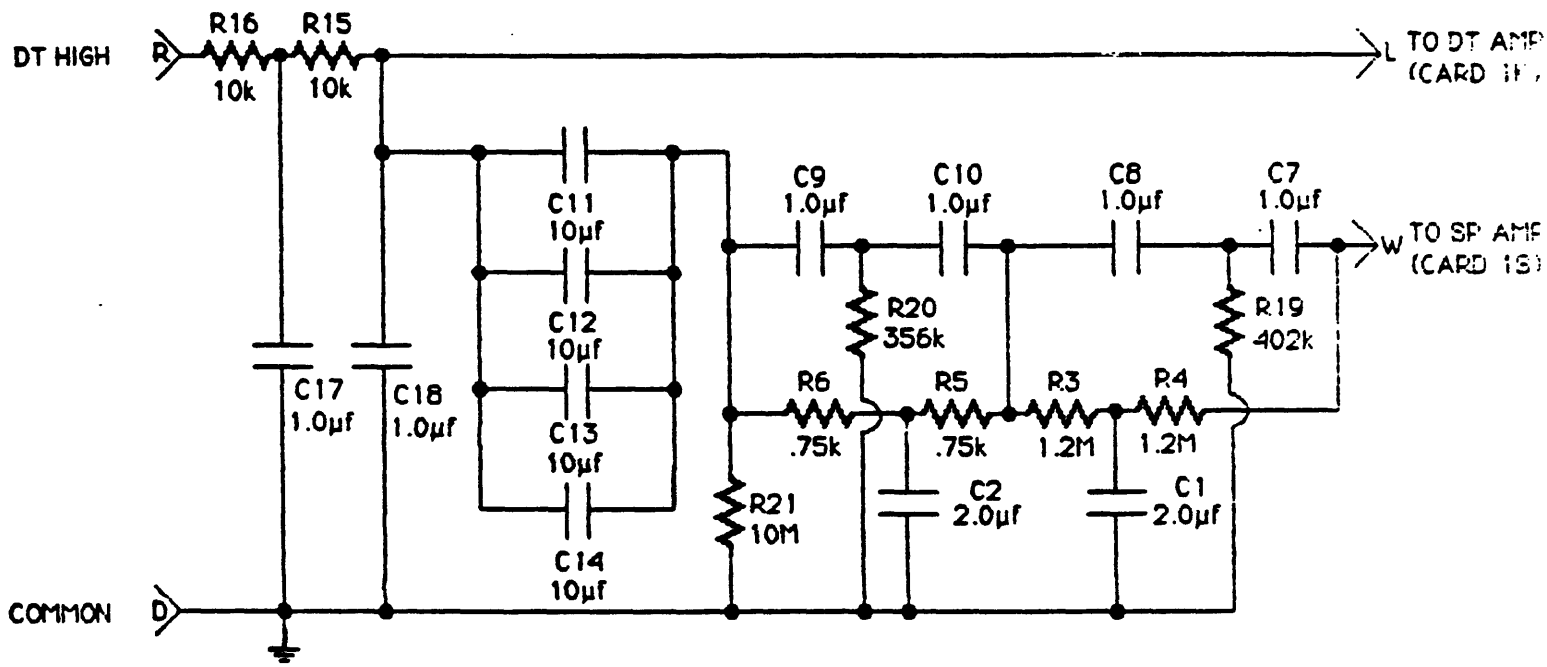


CARD #2 IL/CA AMPLIFIERR





CARD #3 INPUT PAD



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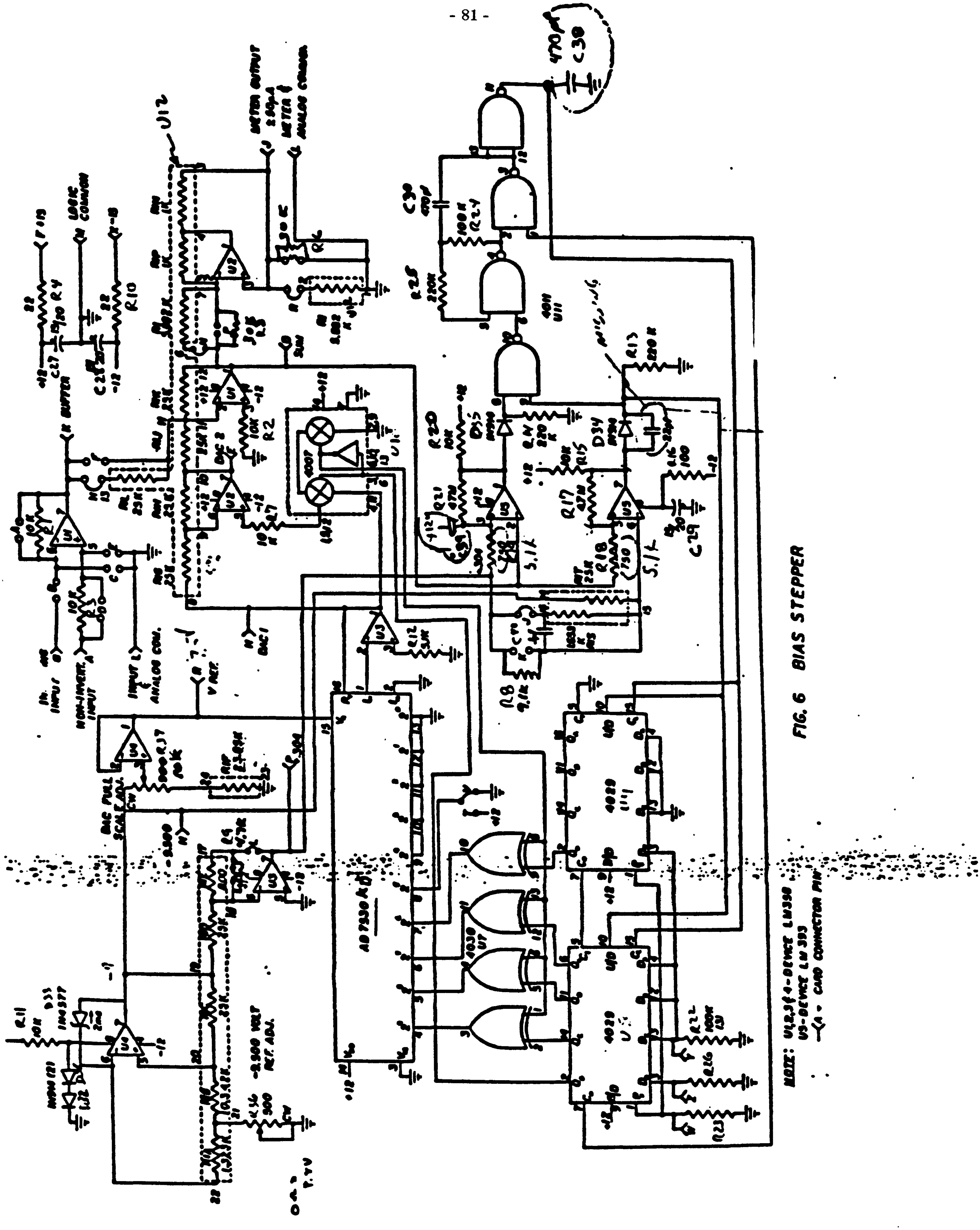

FIG. 6 BIAS STEPPER

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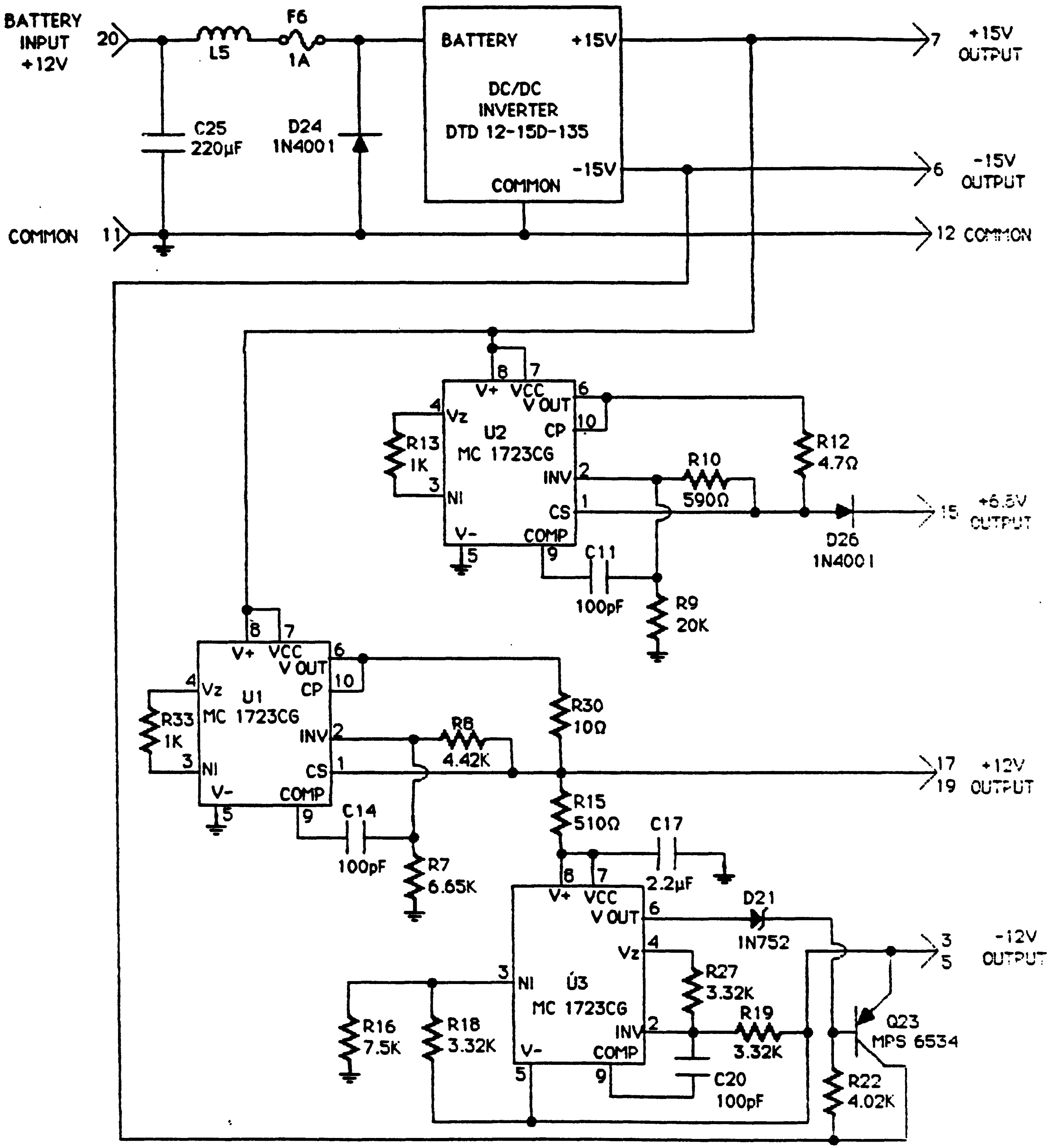
CARD #5 REGULATED POWER BOARD



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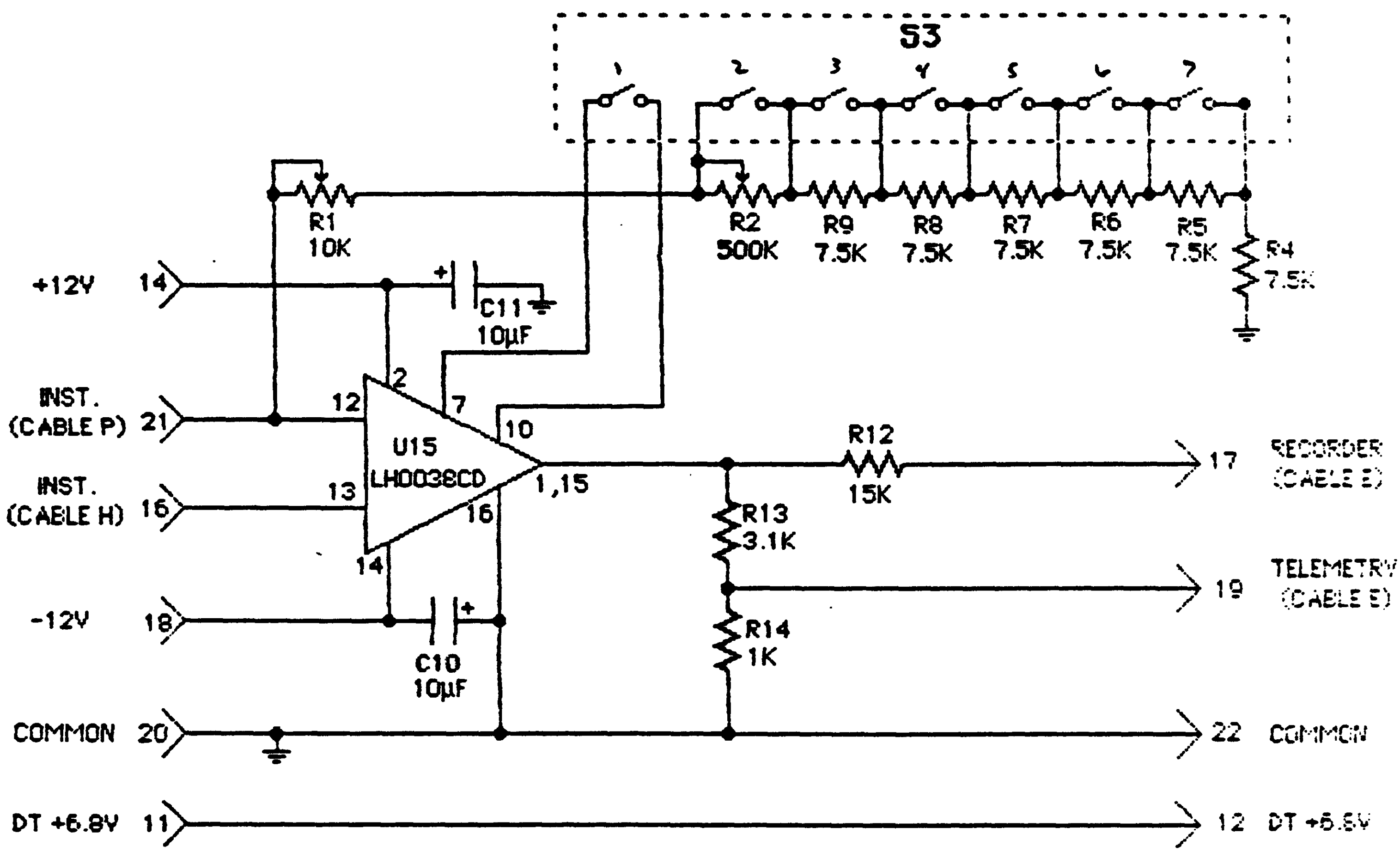
CARD #6 TEMPERATURE CHECK



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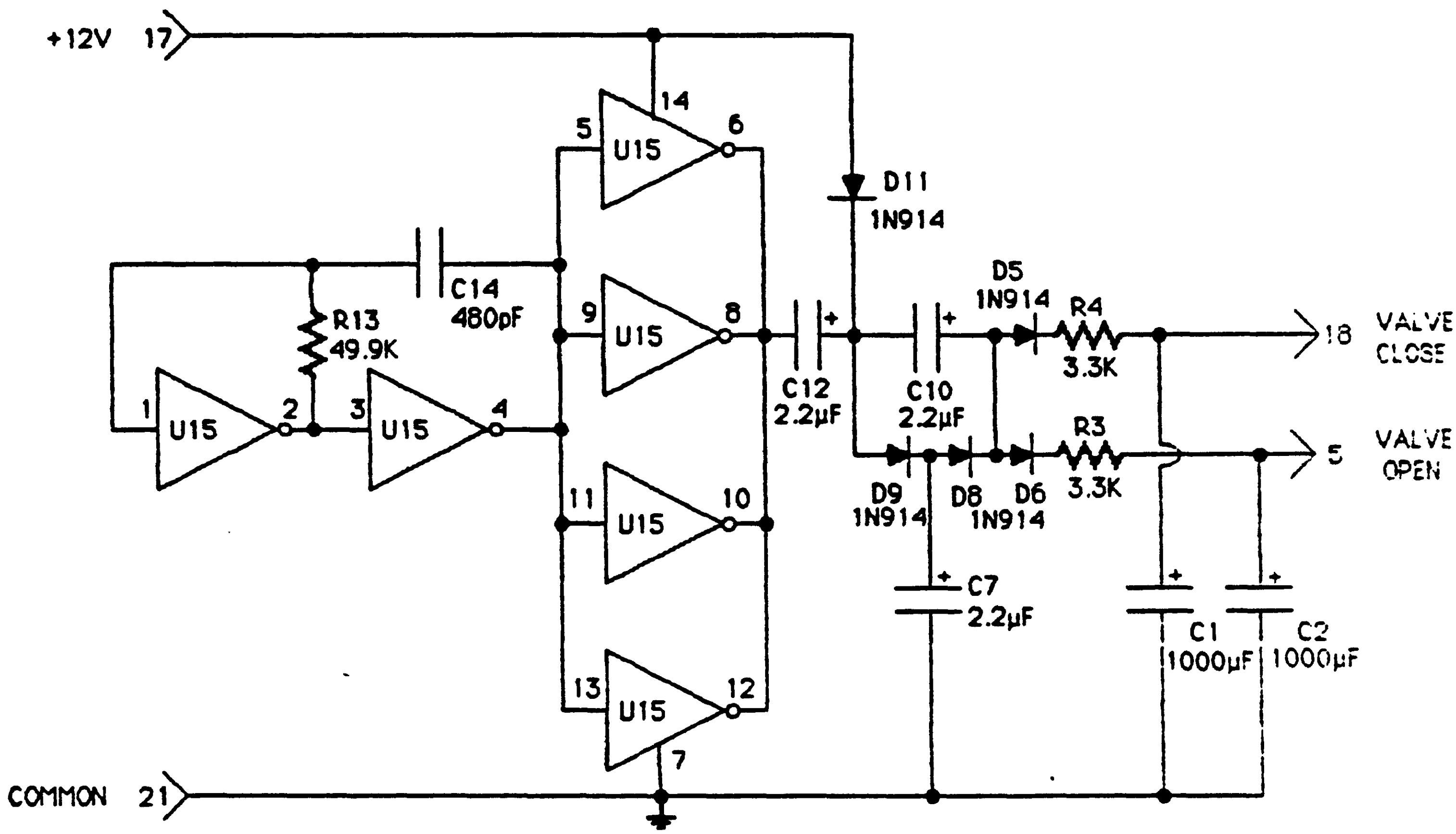
CARD #7 VALVE OPENER



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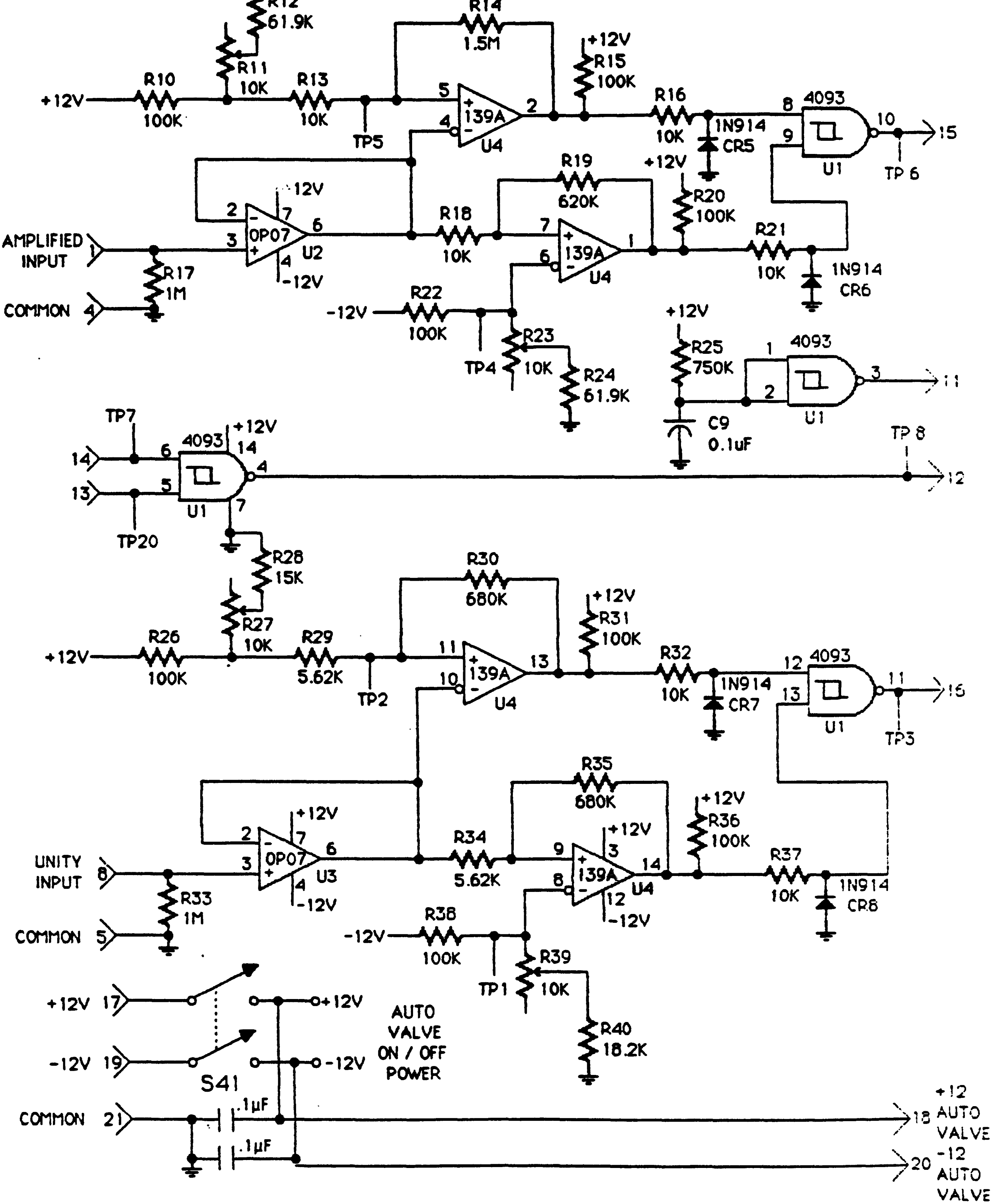
CARD 8: AUTO VALVE OPENER – ANALOG PART



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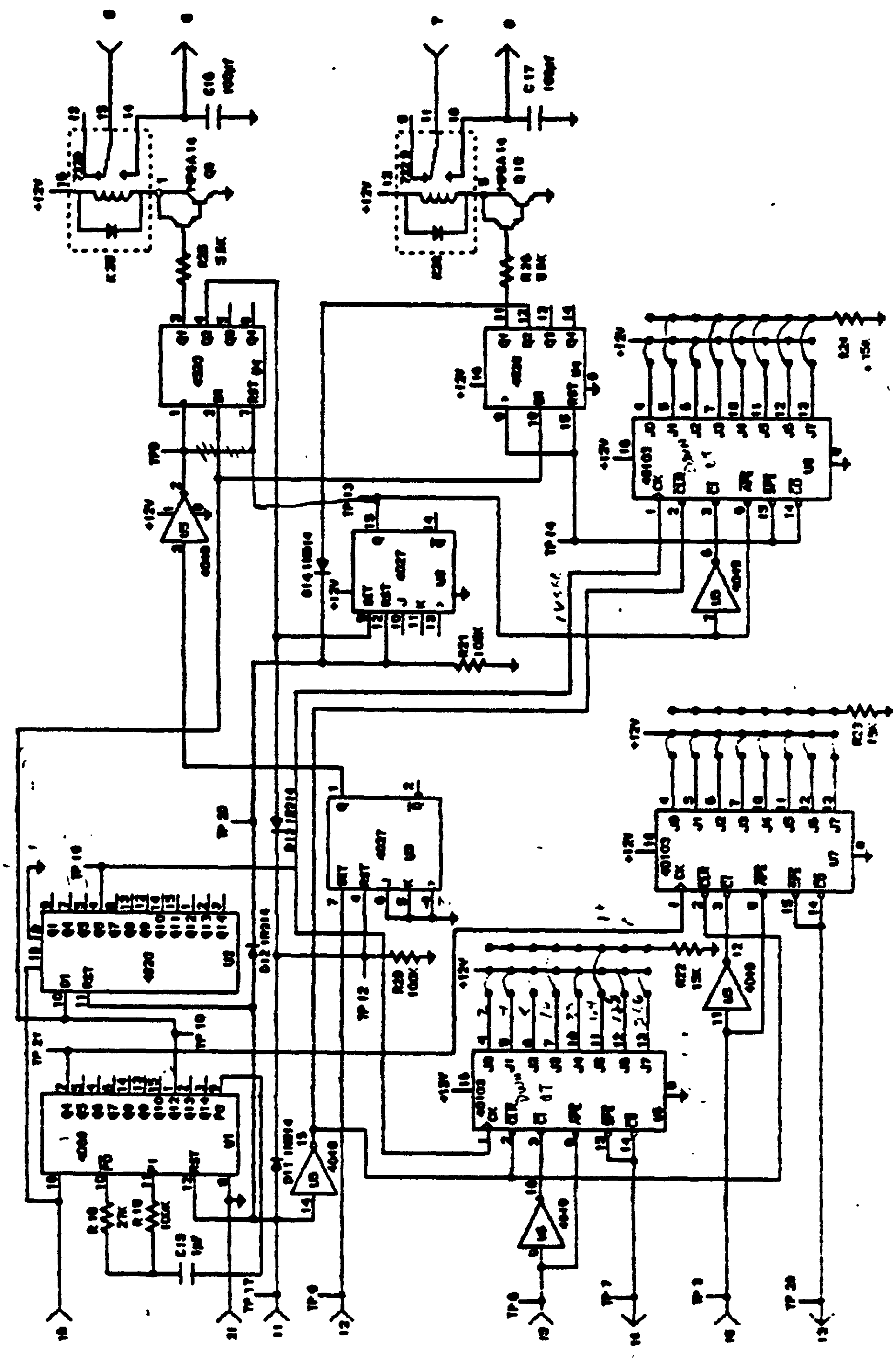
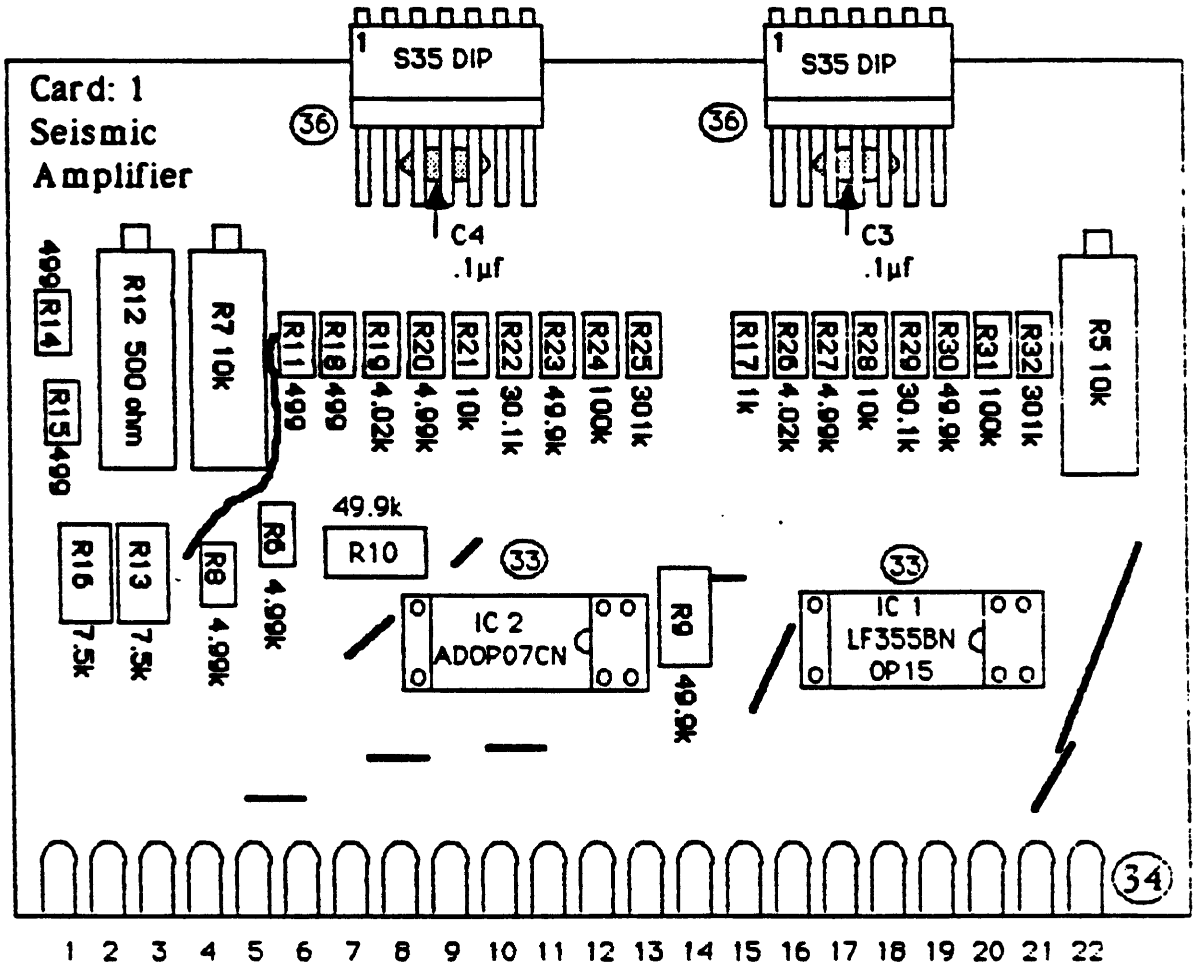
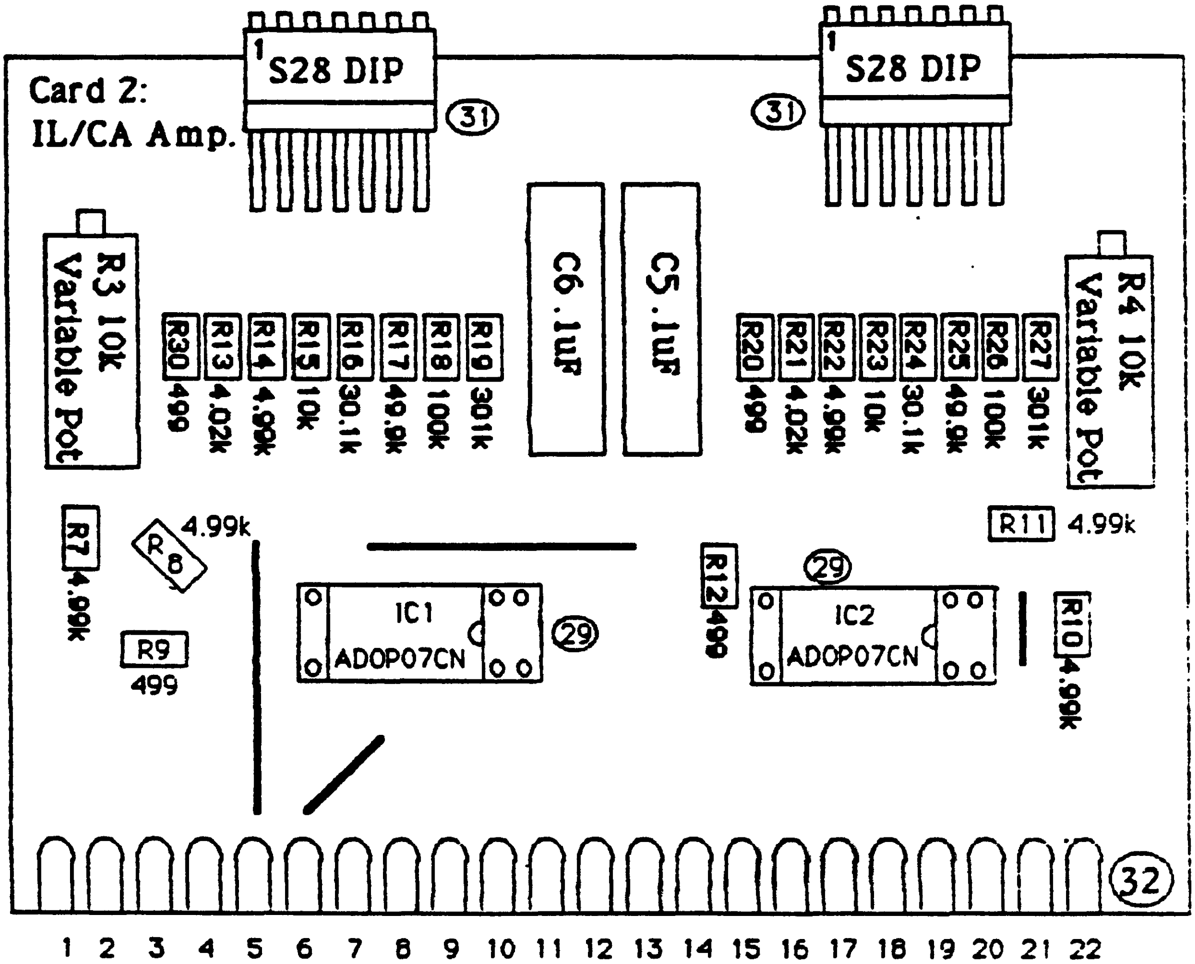


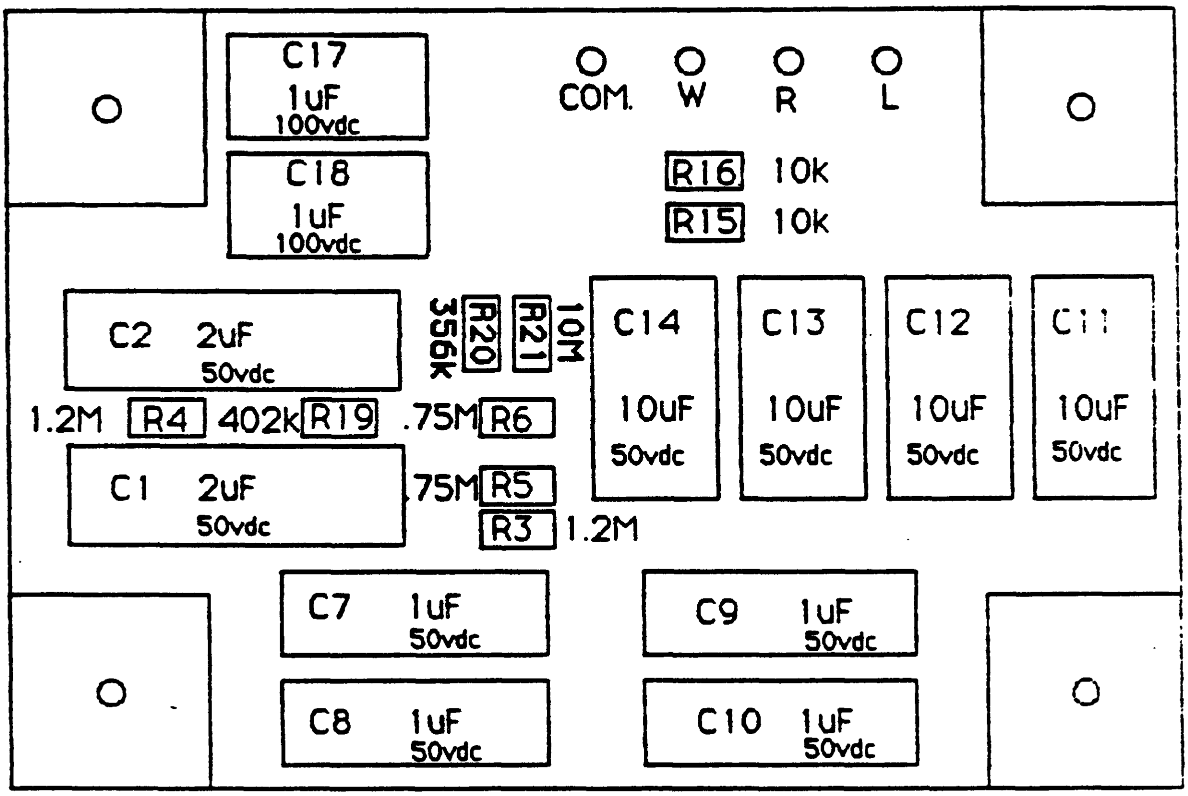
CARD 9 AUTO VALVE OPENER - DIGITAL PART


Card: 1
Seismic
Amplifier
S35 DIP
S35 DIP
36
36
C4
.1µf
C3
.1µf
R14
499
R15
499
R12 500 ohm
R7 10k
R11 499
R18 499
R19 4.02k
R20 4.99k
R21 10k
R22 30.1k
R23 49.9k
R24 100k
R25 301k
R17 1k
R26 4.02k
R27 4.99k
R28 10k
R29 30.1k
R30 49.9k
R31 100k
R32 301k
R5 10k
R16 7.5k
R13 7.5k
R8 4.99k
R6 4.99k
49.9k
R10
33
IC 2
ADOP07CN
R9 49.9k
33
IC 1
LF355BN
OP15
34
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

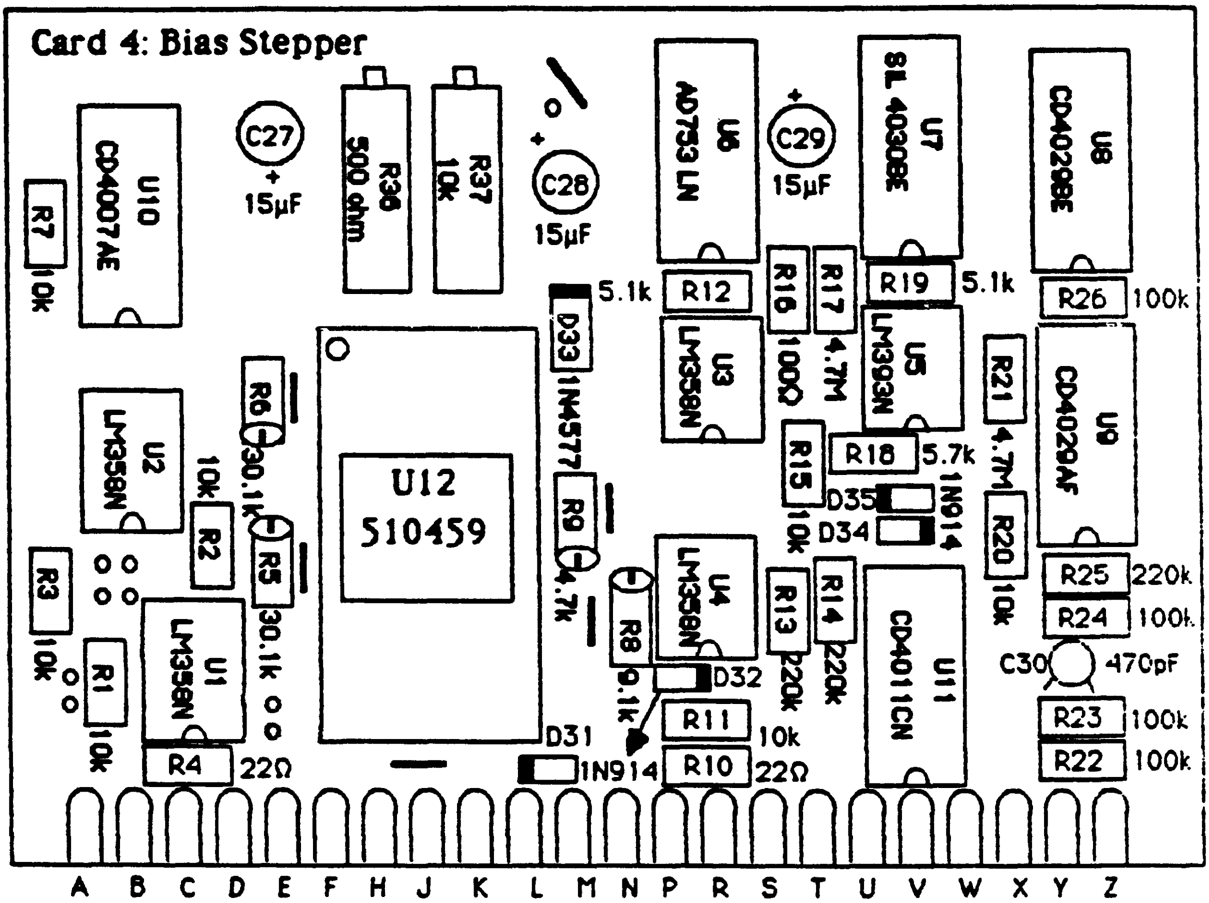


Card 2:
IL/CA Amp.
S28 DIP
S28 DIP
31
31
R3 10k Variable Pot
R4 10k Variable Pot
C6 .1uF
C5 .1uF
R30 499
R13 4.02k
R14 4.99k
R15 10k
R16 30.1k
R17 49.9k
R18 100k
R19 301k
R20 499
R21 4.02k
R22 4.99k
R23 10k
R24 30.1k
R25 49.9k
R26 100k
R27 301k
R7 4.99k
R8 4.99k
R9 499
R11 4.99k
R12 499
R10 4.99k
IC1 ADOP07CN
IC2 ADOP07CN
29
29
32
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

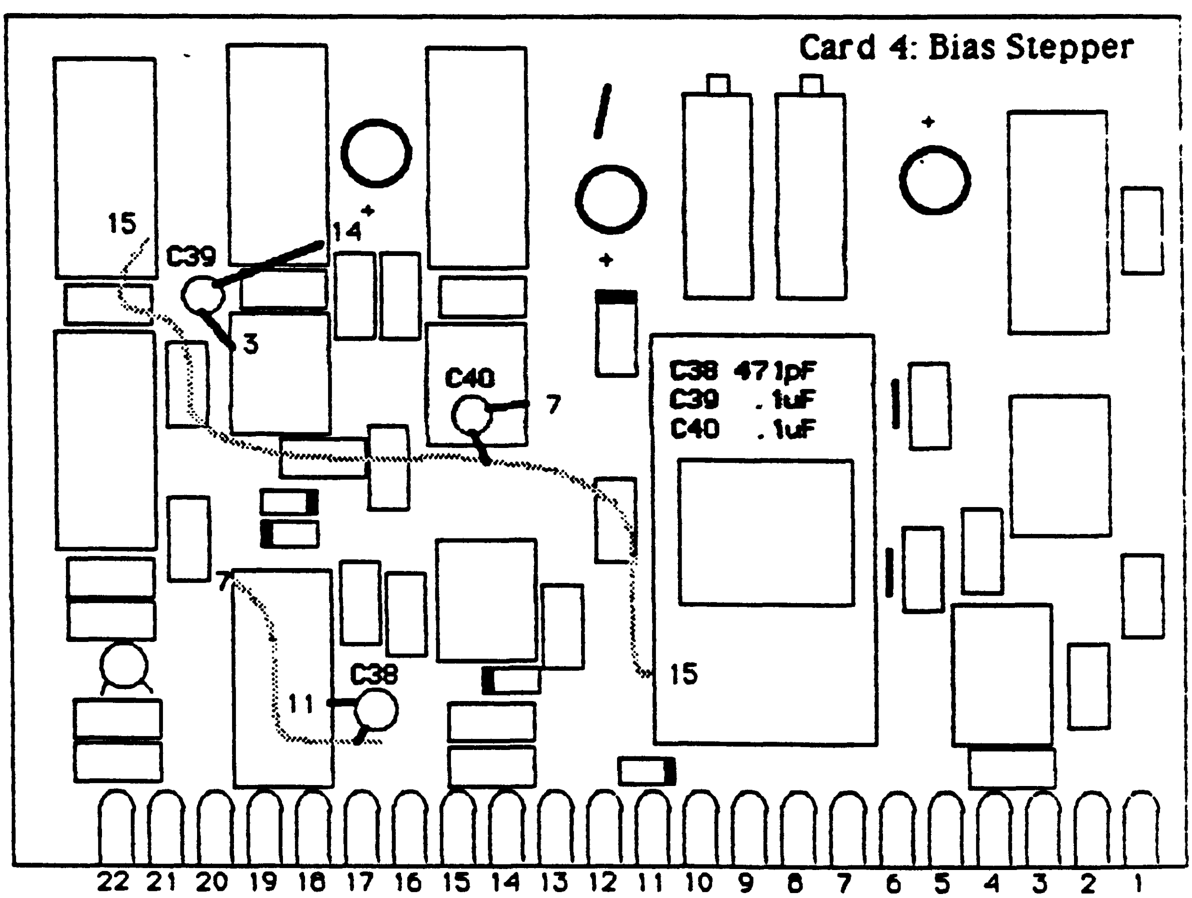
CARD #3 INPUT PAD

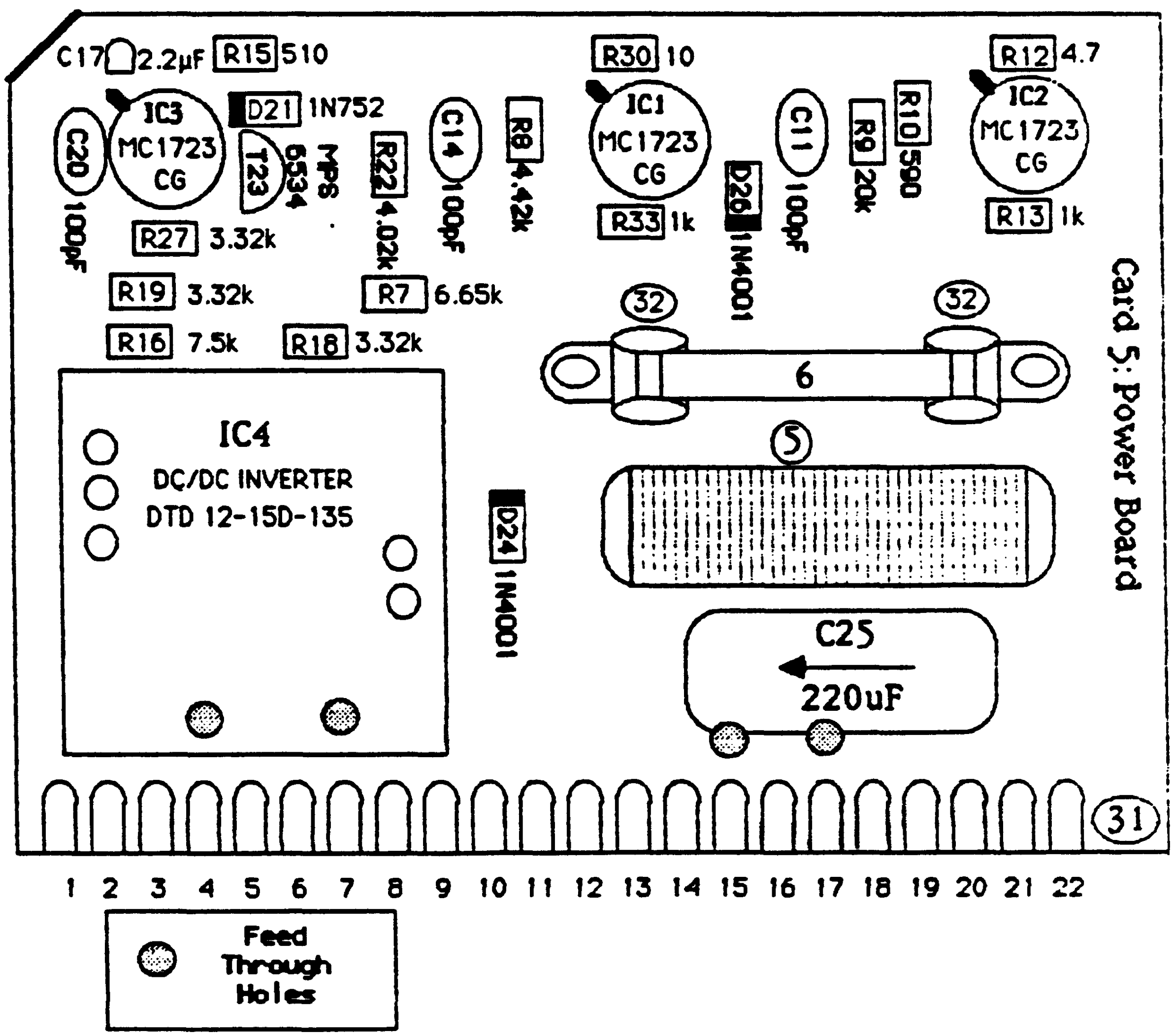


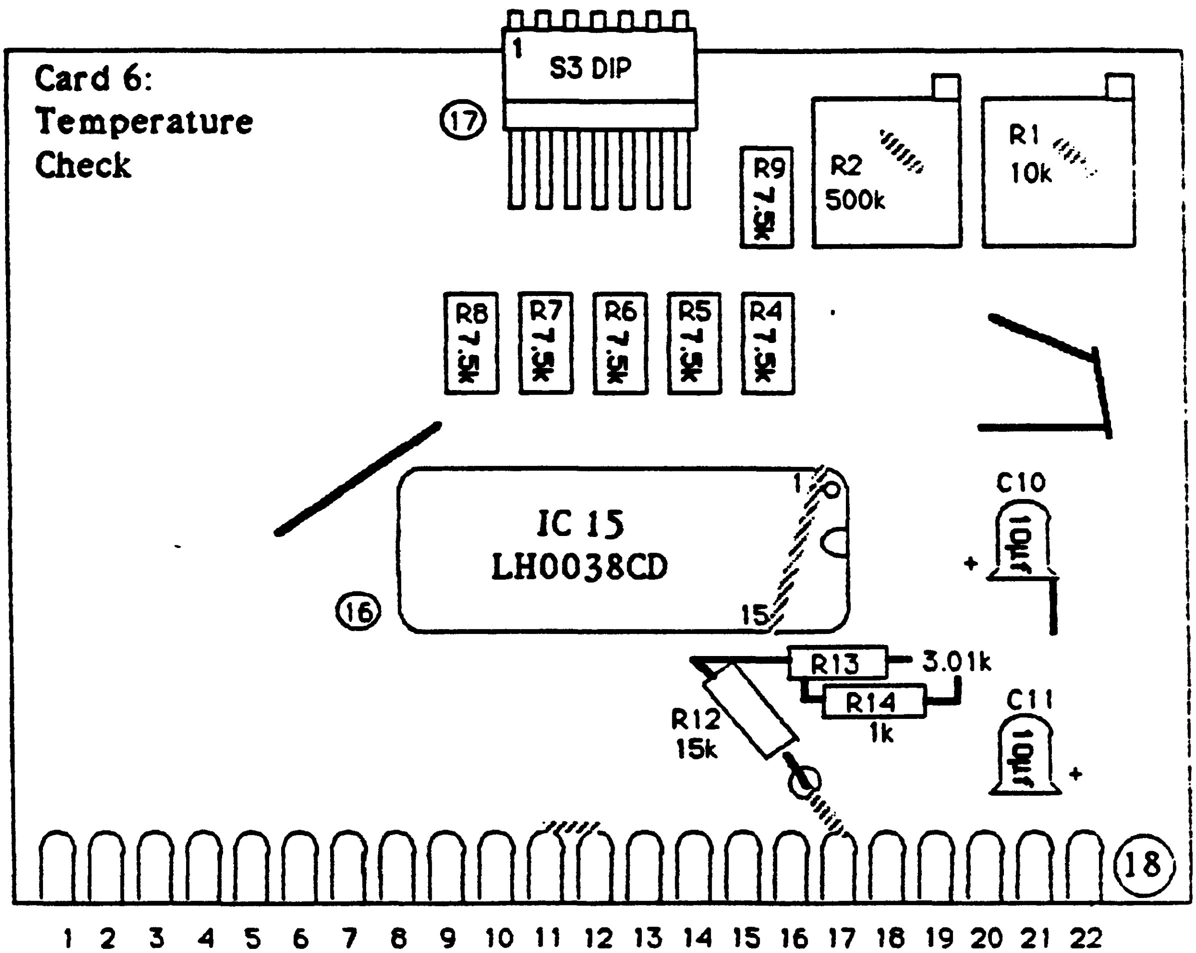
Front View

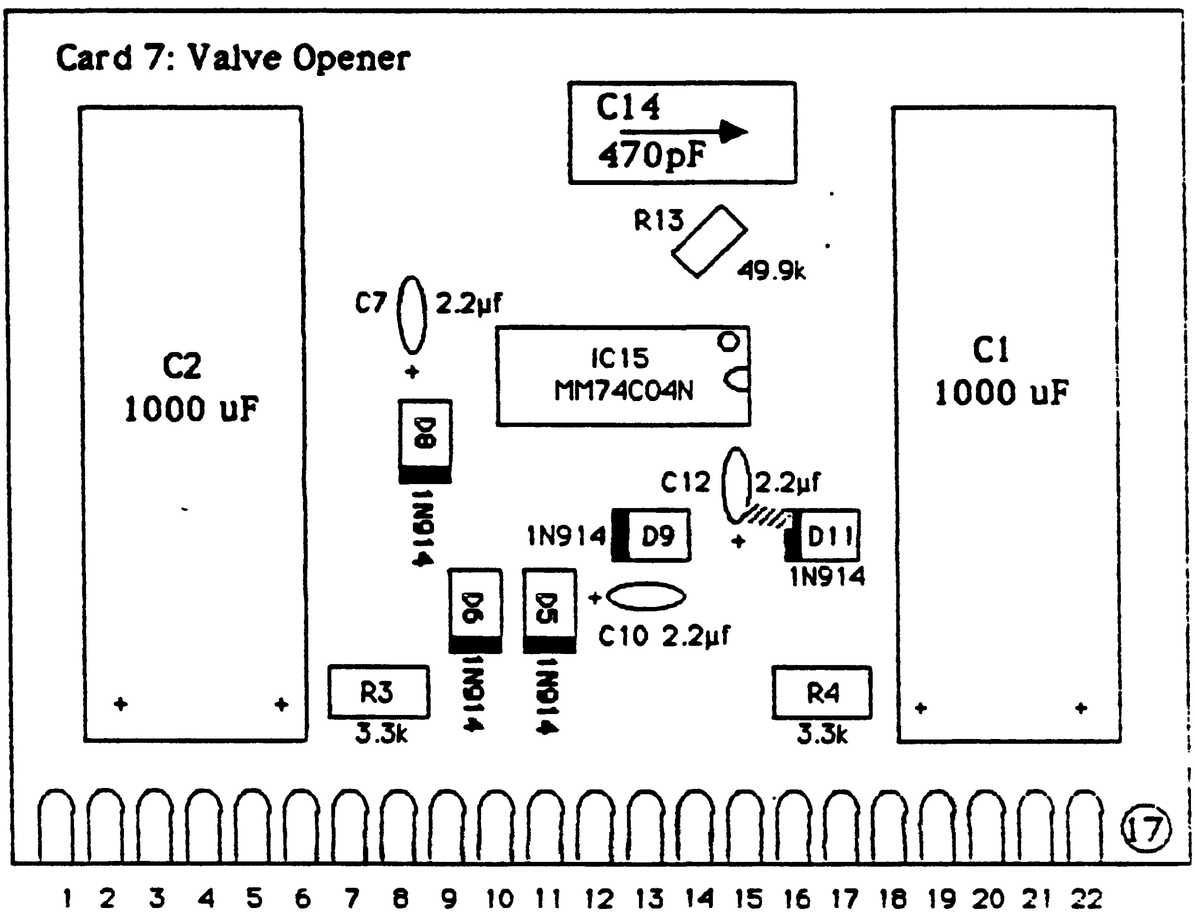


Back View




C17 2.2μF
R15 510
D21 1N752
IC3
MC1723
CG
C20 100pF
T23 MPS 6534
R22 4.02k
C14 100pF
R8 4.42k
R27 3.32k
R19 3.32k
R7 6.65k
R16 7.5k
R18 3.32k
R30 10
IC1
MC1723
CG
R33 1k
D26 1N4001
C11 100pF
R9 20k
R10 590
R12 4.7
IC2
MC1723
CG
R13 1k
Card 5: Power Board
32
32
6
5
IC4
DC/DC INVERTER
DTD 12-15D-135
D24 1N4001
C25
220uF
31
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Feed
Through
Holes


Card 6:
Temperature
Check
S3 DIP
1
17
R9
7.5k
R2
500k
R1
10k
R8
7.5k
R7
7.5k
R6
7.5k
R5
7.5k
R4
7.5k
IC 15
LH0038CD
1
15
16
C10
10µf
+
R13
3.01k
R14
1k
R12
15k
C11
10µf
+
18
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22



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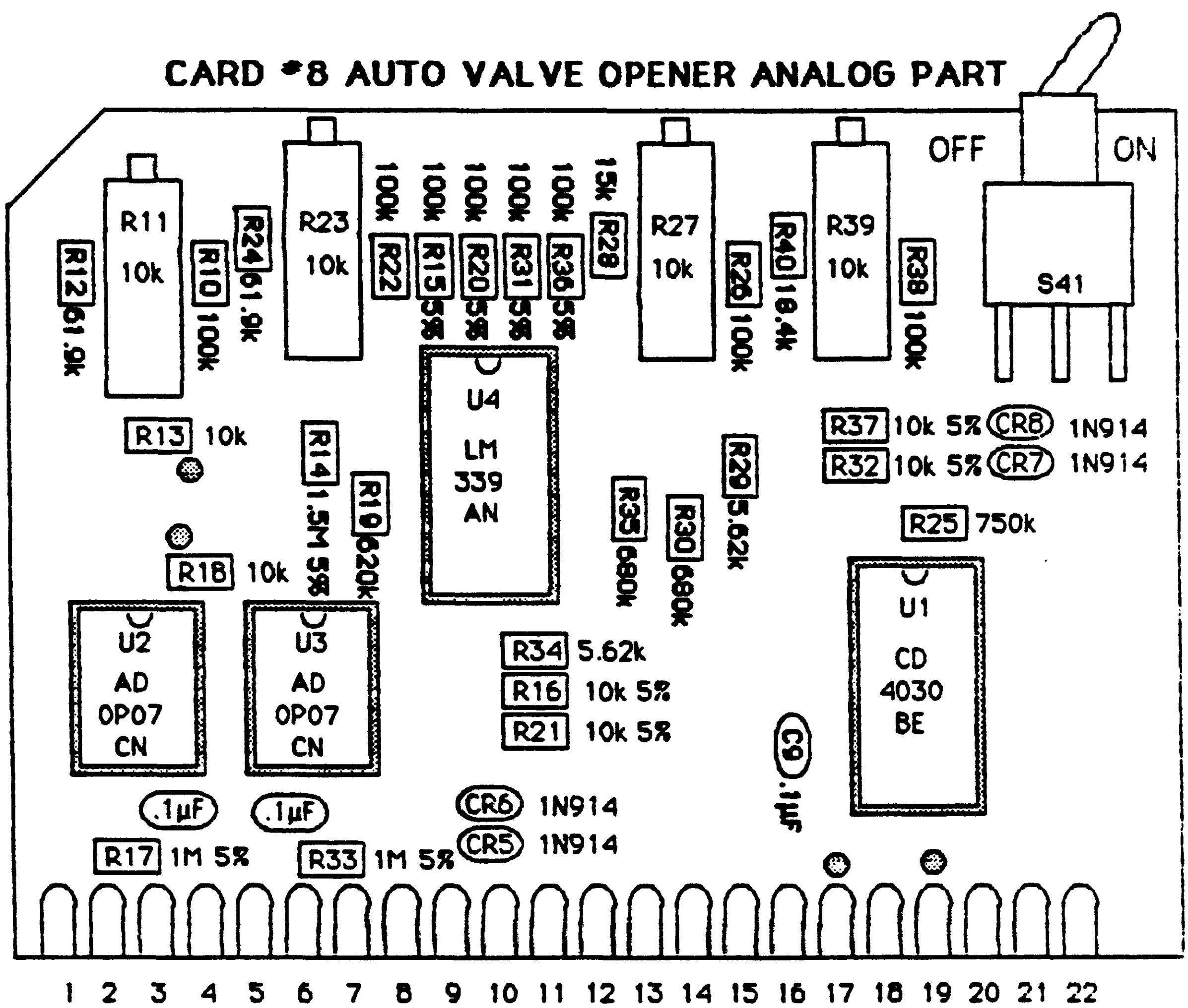
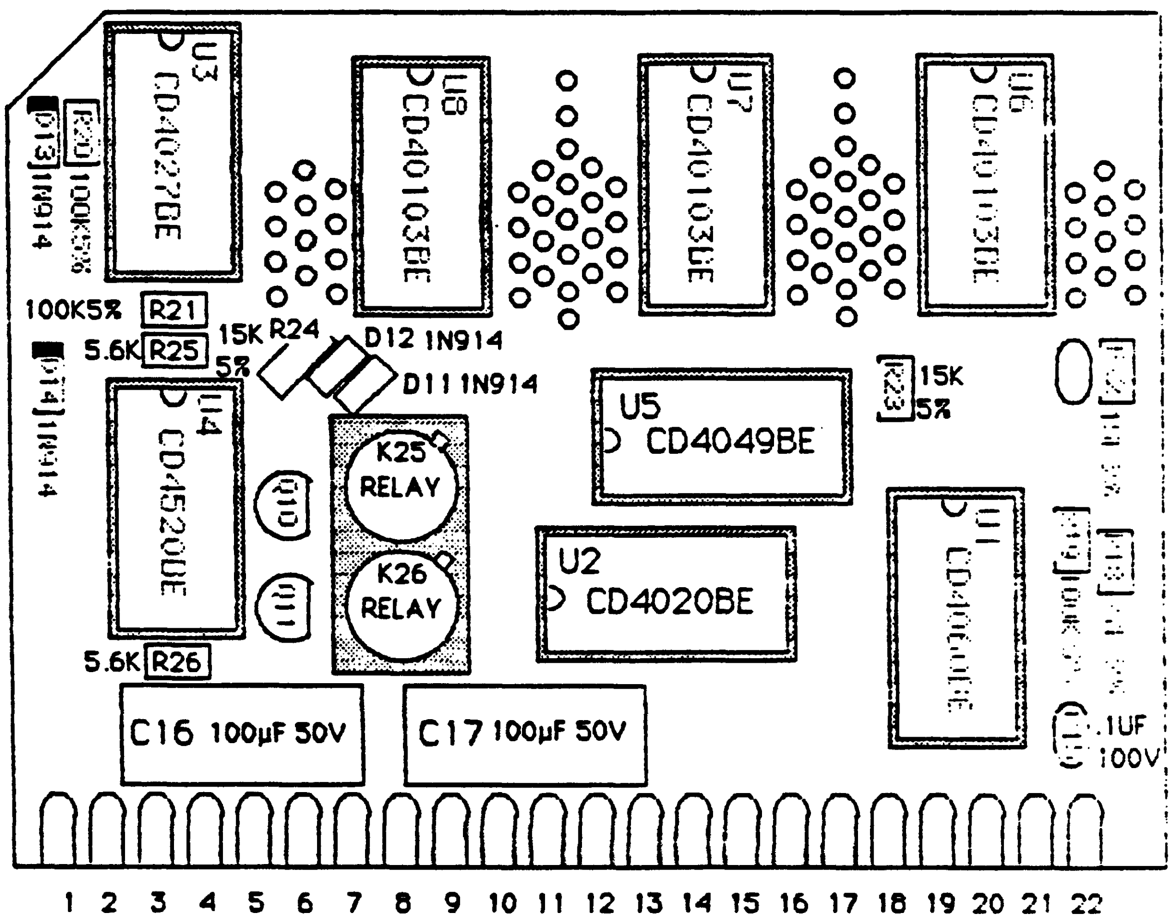

CARD *8 AUTO VALVE OPENER ANALOG PART
OFF
ON
S41
R11
10k
R12
61.9k
R10
100k
R24
61.9k
R23
10k
R22
100k
R15
100k
5%
R20
100k
5%
R31
100k
5%
R36
100k
5%
R28
15k
R27
10k
R26
100k
R40
18.4k
R39
10k
R38
100k
U4
LM
339
AN
R13
10k
R14
1.5M 5%
R19
620k
R18
10k
R35
680k
R30
680k
R29
5.62k
R37
10k 5%
CR8
1N914
R32
10k 5%
CR7
1N914
R25
750k
U1
CD
4030
BE
U2
AD
OP07
CN
U3
AD
OP07
CN
R34
5.62k
R16
10k 5%
R21
10k 5%
C9
.1µF
.1µF
.1µF
CR6
1N914
CR5
1N914
R17
1M 5%
R33
1M 5%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

CARD #9 AUTO-VALVE OPENER DIGITAL PART



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CARD 1: SEISMIC AMPLIFIER

QUAN	KEY	PART DESCRIPTION	MAT'L / SOURCE
1	U1	IC, JFET input op-amp	OP15 PMI
1	U2	IC, ultra low offset voltage op-amp	ADOP07CN PMI
1	C3	cap, .1µF 100vdc ceramic	Z5U RMC
1	C4	do do	do
1	R5	res, variable, 10k No (960-20)	8149 VRN
1	R6	res 4.99k 1/4w 1% 50ppm fix film	RN60C Dale
1	R7	res, variable, 10k No. (960-20)	8149 VRN
1	R8	res 4.9k 1/4w 1% 50ppm fix film	RN60C Dale
1	R9	res 49.9k 1/4w 1% 50ppm fix film	RN60C Dale
1	R10	do	do
1	R11	res 499 Ω 1/4w 1% 50ppm fix film	RN60C Dale
1	R12	res, variable, 500. Ω No. 960-20	8149 VRN
1	R13	res 7.5k 1/4w 1% 2ppm fix film	Mar 40 T18
1	R14	res 499 Ω 1/4w 1% 50ppm fix film	RN60C Dale
1	R15	do	do
1	R16	res 7.5k 1/10w 1% 2ppm fix film	MAR 40 T18
1	R17	res 1k 1/4w 1% 50ppm fix film	RN60C Dale
1	R18	res 499 Ω 1/4w 1% 50ppm fix film	do
1ea	R19/26	res 4.02k 1/4w 1% 50ppm fix film	do
1ea	R20/27	res 4.99k 1/4w 1% 50ppm fix film	do
1ea	R21/28	res 10k 1/4w 1% 50ppm fix film	do
1ea	R22/29	res 30.1k 1/4w 1% 50ppm fix film	do
1ea	R23/30	res 49.9k 1/4w 1% 50ppm fix film	do
1ea	R24/31	res 100k 1/4w 1% 50ppm fix film	do
1ea	R25/32	res 301k 1/4w 1% 50ppm fix film	do
2	33 a/b	socket, IC, DIP, 14 pin gold-plated with solder tabs. No. 814-AG10D	Augat
1	34	card, PC, 22conn, .15 spacing, single side, 3.56w x 2.93h x .06t	epoxy glass
2	S35	switch, DIP, 7 pos., 7000 series	AMP Type 435802-60
2	36 a/b	socket, DIP switch, 14 pin gold-plated No. 814AG10D.	Augat

CARD 2; DTM IL/CA AMPLIFIER

QUAN	KEY	PART DESCRIPTION				MAT'L / SOURCE
1	U1	IC, ultra-low offset voltage op-amp				AD0P07CN PMI
1	U2	do				do
1	R3	res, variable pot, 10k No. (960-20)				8149 VRN
1	R4	do				do
1	C5	cap .1 µF 100wvdc				WMF1P1 CDE
1	C6	do				do
1	R7	res 4.99k	1/4w	1%	50ppm	RN60C Dale
1	R8	do				do
1	R9	res 499. Ω	1/4w	1%	50ppm	RN60C Dale
1	R10	res 4.99k	1/4w	1%	50ppm	do
1	R11	do				do
1	R13/21	res 4.02k	1/4w	1%	50ppm	do
1ea	R14/22	res 4.99k	1/4w	1%	50ppm	do
1ea	R15/23	res 10k	1/4w	1%	50ppm	do
1ea	R16/24	res 30.1k	1/4w	1%	50ppm	do
1ea	R17/25	res 49.9k	1/4w	1%	50ppm	do
1ea	R18/26	res 100k	1/4w	1%	50ppm	do
1ea	R19/27	res 301k	1/4w	.1%	50ppm	do
1ea	R20/30	res 499. Ω	1/4w	1%	50ppm	do
2	S28a/b	switch, DIP, 7 pos, 7000 series				AMP type 435802-60
2	29a/b	socket, IC, DIP, 14 pin gold-plated with solder tabs, No. 814-AG10D				Augat
2	31a/b	socket, DIP switch, 14 pin gold-plated, No. 814AG10D				do
1	32	card, PC, 22 conn .15 spacing, single-side, 3.56w x 2.93h x .06t				epoxy glass

CARD 3: INPUT PAD

QUAN	KEY	PART DESCRIPTION	MAT'L / SOURCE
1	C1	cap 2µF 50wvdc 10%	WMF05W2 CDE
1	C2	do	do
1	R3	res 1.20M 1/4w 1% 50ppm	RN60C Dale
1	R4	do	do
1	R5	res .75M 1/4w 1% 50ppm	do
1	R6	do	do
1	C7	cap 1 µF 50wvdc 10%	WMF05W1 CDE
1	C8	do	do
1	C9	do	do
1	C10	do	do
1	C11	cap 10µF 50wvdc 5% No.74-106A5	Texcap
1	C12	do	do
1	C13	do	do
1	C14	do	do
1	R15	res 10k 1/4w 1% 50ppm	RN60C Dale
1	R16	do	do
1	C17	cap 1.0µF 100wvdc No. 225PV	Sprague
1	C18	do	do
1	R19	res 402k 1/4w 1% 50ppm	RN60C Dale
1	R20	res 365k 1/4w 1% 50ppm	RN60C Dale
1	R21	res 10M 1/4w 1% 50ppm	RN60C Dale
1	*22	card, PC, 22conn, .15 spacing, single side, 3.56w x 2.93h x .06t	epoxy glass

* USGS card size: 4-in x 6-in x .06t

CARD 4: BIAS STEPPER

QUAN	KEY	PART DESCRIPTION			MAT'L / SOURCE
1	U1	IC, dual op amp, LM358N			National
1	U2	do			do
1	U3	do			do
1	U4	do			do
1	U5	IC, dual comparator, LM393N			National
1	U6	IC, D/A Converter, AD7530LN			National
1	U7	IC, CMOS Quad Exclusive OR gate CD4030BE			RCA
1	U8	IC, presettable UP/DN BCD binary counter No. CD4029BE			RCA
1	U9	IC, presettable UP/DN BCD binary counter No. CD4029AF			RCA
1	U10	IC, dual comparator pair, plus inverter No. CD4007AE			RCA
1	U11	IC, quad 2-input NAND gate, No. CD4011CN			National
1	U12	Resistor Pack (510459)			EFI 7948
1	R1	res 10k	1/4w	5%	gen'l purpose
1	R2	do			do
1	R3	do			do
1	R4	res 22 Ω	1/4w	5%	do
1	R5	res 30.1k	1/4w	5%	do
1	R6	do			do
1	R7	res 10 k	1/4w	5%	do
1	R8	res 9.1k	1/4w	5%	do
1	R9	res 4.7K	1/4w	5%	do
1	R10	res 220 Ω	1/4w	5%	do
1	R11	res 10k	1/4w	5%	do
1	R12	res 5.1k	1/4w	5%	do
1	R13	res 220k	1/4w	5%	do
1	R14	res do			do
1	R15	res 10k	1/4w	10%	do
1	R16	res 100 Ω	1/4w	5%	do
1	R17	res 4.7 Meg	1/4w	5%	do
1	R18	res 5.1k	1/4w	5%	do
1	R19	res 5.1k	1/4w	5%	do
1	R20	res 10k	1/4w	5%	do

CARD 4: BIAS STEPPER (cont'd)

QUAN	KEY	PART DESCRIPTION	MAT'L / SOURCE
1	R21	res 4.7M 1/4w 10%	do
1	R22	res 100k 1/4w 5%	do
1	R23	res do	do
1	R24	res do	do
1	R25	res 220k 1/4w 5%	do
1	R26	res 100k 1/4w 5%	do
1	C27	cap 15µF 20wvdc	
1	C28	do	
1	C29	do	
1	C30	cap 470pF 50wvdc 10% ceramic	
1	D31	diode 100V 100µA 1N914	
1	D32	do	
1	D33	diode, zener, low level sub-miniature 6.4 V, 1N4577	Motorola
1	D34	diode 100V 100µA 1N914	
1	D35	do	
1	R36	res, variable pot, 500 Ω, No. 43W501	Spectrol
1	R37	res, variable pot, 10k No. 89PR10K	Beckman
1	C38	cap 470pF 100wvdc 2% Mica	
1	C39	cap .1µF CW20C	
1	C40	cap do	
1	41	card, PC, 22 con, .15 spacing, double sided, 3.56w x 2.93h x .06t	epoxy glass

CARD 5: DTM REGULATED POWER BOARD

QUAN	KEY	PART DESCRIPTION	MAT'L / SOURCE
1	U1	IC, vari output voltage reg, MC1723CG	Motorola
1	U2	do	do
1	U3	do	do
1	U4	IC, dc/dc inverter, DTD12-150-135	Semi-Conductor Circuits, Inc.
1	L5	RFC choke, 15 uH, .17 ohm, 1000ma	J.W. Miller type 4624
1	F6	fuse 1A, 250V FB ,1/4 dia x 1.25L (3AG), No 312001	Littelfuse
1	R7	res 6.65k 1/4w 1% 50ppm	RN60C Dale
1	R8	res 4.42k 1/4w 1% 50ppm	do
1	R9	res 20k 1/4w 1% 50ppm	do
1	R10	res 590 Ω 1/4w 1% 50ppm	do
1	C11	cap 100pF 5% sil mica	
1	R12	res 4.7 Ω 1/4w 5%	RCR07
1	R13	res 1k 1/4w 1% 50ppm	RN60C Dale
1	C14	cap 100pF 5% sil mica	any
1	R15	res 510 Ω 1/4w 5%	any
1	R16	res 7.5k 1/4w 1% 50ppm	RN60C Dale
1	C17	cap 2.2µF 25v tantalum	
1	R18	res 3.32k 1/4w 1% 50ppm	RN60C Dale
1	R19	do	do
1	C20	cap 100pF 100wvdc 5% sil mica	
1	D21	zener diode 5.6Vz @ 20Izt	1N752 Motorola
1	R22	res 4.02k 1/4w 1% 50ppm	RN60C Dale
1	T23	transistor, silicon (TO-92)	MPS 6534 Motorola
1	D24	diode, silicon 1A 50V	1N4001 (case 59)
1	C25	cap 220µF 16wvdc 227H016DC7	Sprague 'lytic
1	D26	diode, silicon 1A 50V rect., glass	1N4001 Motorola
1	R27	res 3.32k 1/4w 1% 50ppm	RN60C Dale
3	S28a/b/c	sockets, 10-pin circ., .230 pitch circle, solder tab., No. 8059-269	Augat
2	29a/b	clips, fuse, lug type, No. 121004	Littelfuse
1	R30	res 10 Ω 1/4w 5%	
1	31	card, PC, 22conn, .15 spacing single side, 3.56w x 2.93h x .06t	glass epoxy
2	32	rivet, fuse clip to PC board	1/8/ dia x 3/32 L
1	33	res 1K 1/4 W 1% 50ppm	RN60C Dale

CARD 6; TEMPERATURE CHECK

QUAN	KEY	PART DESCRIPTION		MAT'L / SOURCE
1	R1	res, variable pot 10k,	No. 752-10	8149 VRN
1	R2	res, variable pot, 500k,	No. 752-10	do
1	Sw3	switch, dip, 7 position,	type 8229	CTS 206-7
1	R4	res 7.5k 1/4w 1%	2ppm	Mar 40 (8309) TRW
1	R5	do		do
1	R6	do		do
1	R7	do		do
1	R8	do		do
1	R9	do		do
1	C10	cap 10µF 25vdc 10%	tantalum	
1	C11	do		
1	R12	res 15k 1/4w 1%	50ppm	RN60C Dale
1	R13	res 3.01k 1/4w 1%	50ppm	do
1	R14	res 1k 1/4w 1%	50ppm	do
1	U15	IC instrument op-amp		LH0038CD Nat'l
1	16	socket, IC, DIP, 16-pin gold-plated with solder tabs,	No. 816-AG10D	Augat
1	17	socket, dip switch, 14-pin gold-plated with solder tabs.	No. 816-AG10D	Augat
1	18	card, PC, 22 conn, .15 spacing, single side, 3.56w x 2.93h x .06t		epoxy glass
1*	R19	res 49.9k 1/10w 1%	2ppm	MAR 40 T18 8309 TRW
1*	R20	do		do
1*	R21	res 4.42k 1/10w 1%	2ppm	do
1*	T22	thermister, YSI-44202		Yellow Springs Instrument

* In strain meter

CARD 7; VALVE OPENER

QUAN	KEY	PART DESCRIPTION	MAT'L/SOURCE
1	C1	cap 1000 µF 50wvdc 10% 'lytic	Mallory TC50100C
1	C2	do	do
1	R3	res 3.3k 1/4w 5%	any
1	R4	do	do
1	D5	diode, silicon, 1N914b	any
1	D6	do	do
1	C7	cap 2.2 µF 35wvdc 10% tantalum	
1	D8	diode, silicon, 1N914B	any
1	D9	do	do
1	C10	cap 2.2 µF 35wvdc 10% tantalum	
1	D11	diode, silicon, 1N914B	any
1	C12	cap 2.2 µF 35wvdc 10% tantalum	
1	R13	res 49.9k 1/4w 1% 50ppm	RN60C Dale
1	C14	cap 470 pF 2% sil mica	any
1	U15	IC, hex converter	MM74C04N (CD4069CN)
1	16	socket, IC, dip, 14-pin, gold-plated with solder tabs, No. 814-AG10D	Augat
1	17	card, PC, 22conn, .15 spacing, single side, 3.56w x 2.93h x .06t	epoxy glass

CARD 8: AUTO VALVE OPENER - ANALOG BOARD

QUAN	KEY	PART DESCRIPTION	MAT'L / SOURCE
1	U1	IC Quad 2-input NAND Schmitt Trigger	CD4030BE
1	U2	IC Ultra-Low Offset Voltage OP-AMP	ADOP07CN PMI
1	U3	do	do
1	U4	IC Voltage Comparator	LM339AN
1	CR5	diode 100V 100μa	1N914
1	CR6	do	do
1	CR7	do	do
1	CR8	do	do
1	C9	cap .1μF 100v ceramic	Z 5U RMC
1	R10	res. 100K 1/8w 1%	RN60D Dale
1	R11	res. variable 10K No. 960-20	8149 VRN
1	R12	res 61.9K 1/8w 1%	RN60D Dale
1	R13	res 10K 1/8w 1%	RN60D Dale
1	R14	res 1.5M 1/4w 5%	RCR07
1	R15	res. 100K 1/4w 5%	RCR07
1	R16	res 10K 1/4w 5%	RCR07
1	R17	res 1M 1/4w 5%	RCR07
1	R18	res 10k 1/8w 1%	RN60D Dale
1	R19	res 620k 1/4w 5%	RN60D Dale
1	R20	res 100K 1/4w 5%	RCR07
1	R21	res 10K 1/4w 5%	RCR07
1	R22	res. 100K 1/8w 1%	RN60D Dale
1	R23	res variable 10k No.960-20	8149 VRN
1	R24	res. 61.9K 1/8w 1%	RN60D Dale
1	R25	res. 750K 1/8w 1%	RN60D Dale
1	R26	res. 100K 1/8w 1%	RN60D Dale
1	R27	res variable 10K No. 960-20	8149 VRN
1	R28	res. 15K 1/8w 1%	RN60D Dale
1	R29	res. 5.62K 1/8w 1%	RN60D Dale
1	R30	res 680K 1/4w 1%	RN60D Dale
1	R31	res. 100K 1/4w 5%	RCR07
1	R32	res. 10K 1/4w 5%	RCR07
1	R33	res. 1M 1/4w 5%	RCR07

CARD 8: AUTO VALVE OPENER - ANALOG BOARD (cont'd)

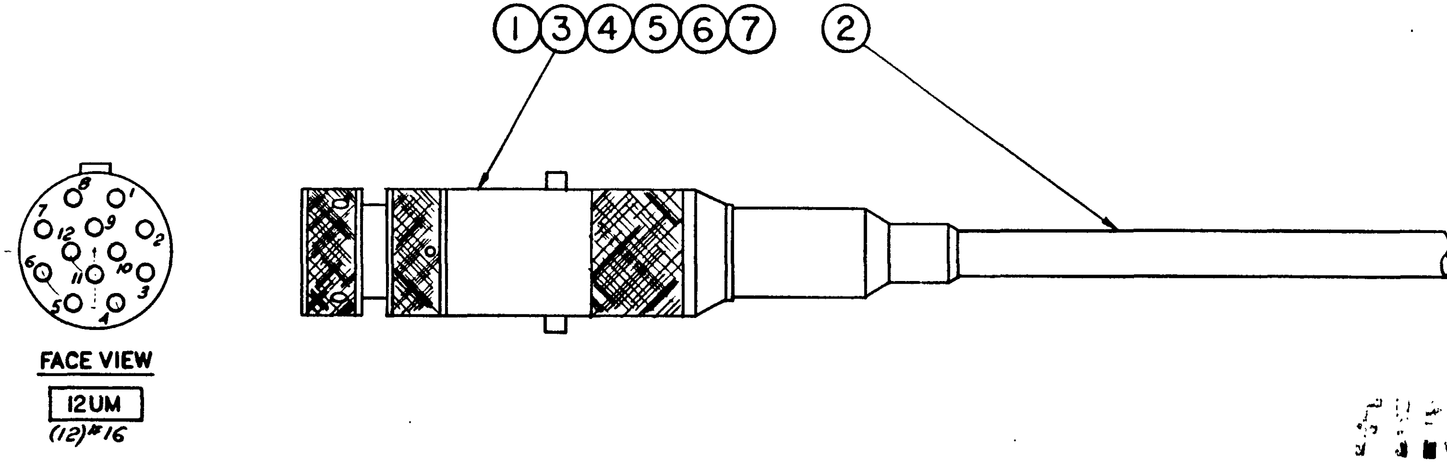
QUAN	KEY	PART DESCRIPTION				MAT'L / SOURCE
1	R34	res	5.62k	1/8w	1%	RN60D Dale
1	R35	res	680k	1/8w	1%	RN60D Dale
1	R36	res	100k	1/4w	5%	RCR07
1	R37	res	10k	1/4w	5%	RCR07
1	R38	res	100k	1/8w	1%	RN60D Dale
1	R39	res	variable	10k	No.960-20	8149 VRN
1	R40	res	18.4k	1/8w	1%	RN60D Dale
1	S41	switch, Type 573-2413-0301-100				Dialight
3	42	socket, IC, DIP, 14-pin gold-plated with solder tabs, No. 814-AG10D				Augat
2	43	socket, IC, DIP, 16-pin gold-plated with solder tabs, No. 816-AG10D				Augat

CARD 9; AUTOMATIC VALVE OPENER-DIGITAL BOARD

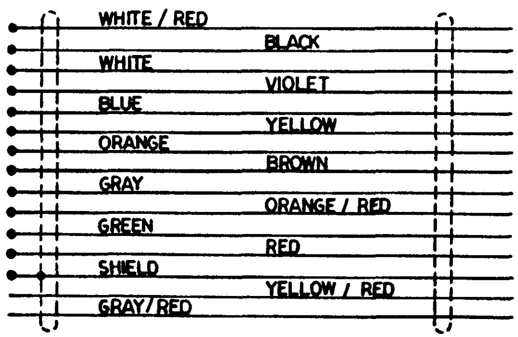
QUAN	KEY	PART DESCRIPTION	MAT'L/SOURCE
1	U1	IC 12-stage binary counter	CD4060BE
1	U2	IC 14-stage binary counter	CD4020BE
1	U3	IC dual j-k master/slave flip-flop	CD4027BE
1	U4	IC dual synchronous UP counter	CD4520BE
1	U5	IC hex inverting buffer	CD4049BE
1	U6	IC presettable 8-bit binary counter	CD40103BE
1	U7	do	do
1	U8	do	do
1	Q9	Darlington transistors	MPSA 14 Motorola
1	Q10	do	do
1	D11	Diode 100V 100μA	1N914
1	D12	do	do
1	D13	do	do
1	D14	do	do
1	C15	cap .1μF 100wvdc ceramic	Z5U RMC
1	C16	cap 100μF 50wvdc, min 'lytic	TT50X100 Mallory
1	C17	do	do
1	R18	res 27K 1/4w 5%	RCR07
1	R19	res 100K 1/4w 5%	do
1	R20	do	do
1	R21	do	do
1	R22	res 15K 1/4 5%	RCR07
1	R23	do	do
1	R24	do	do
1	K25	relay	Teledyne 732D
1	K26	do	do

14.13 DILATOMETER INSTRUMENT CABLE CONNECTOR

REVISIONS				
EO. NO.	LTR	DESCRIPTION	DATE	APPROVED
7578	A	ADDED COLOR CODE	8/22/85	VM.



FINAL
RELEASE MAY 21 1986



COLOR CODE

1	7	14407-A-2(304)	WEDGE, POTTING LP08
1	6	14403-A-2(304)	HOUSING, EXTENSION LP08
1	5	12137-12DF	BOOT, FEED THRU LP08
1	4	12137-12DC	BOOT, CONTACT LP08
1	3	12133-J-2(304)	INSERT, FEED THRU LP08
A/R	2	CUST. SUPP.	CABLE
1	1	14402-12UM-8-304	CONN. LP08-CP-FITA HDW ONLY
-12UM	ITEM	P/N	DESCRIPTION

QTY W/O 5754

KINTEC INC.
9540 COZYCROFT AVENUE
CHATSWORTH, CALIFORNIA 91311

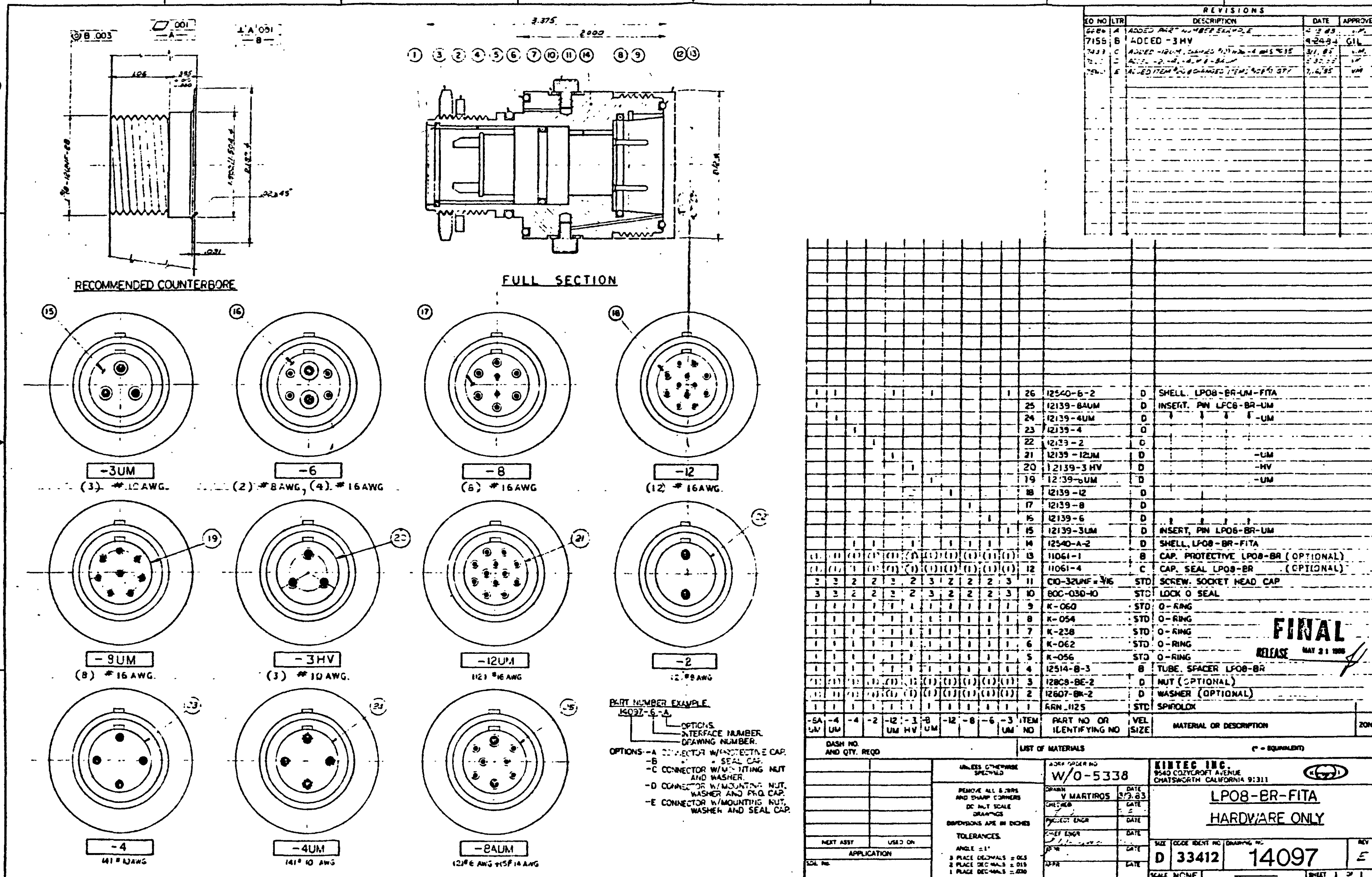
UNLESS OTHERWISE SPECIFIED
Remove all burrs and sharp corners
Do not scale drawings
Dimensions are in inches
TOLERANCES:
Angle ± 1°
3 place decimals ± .005
2 place decimals ± .015
1 place decimals ± .030

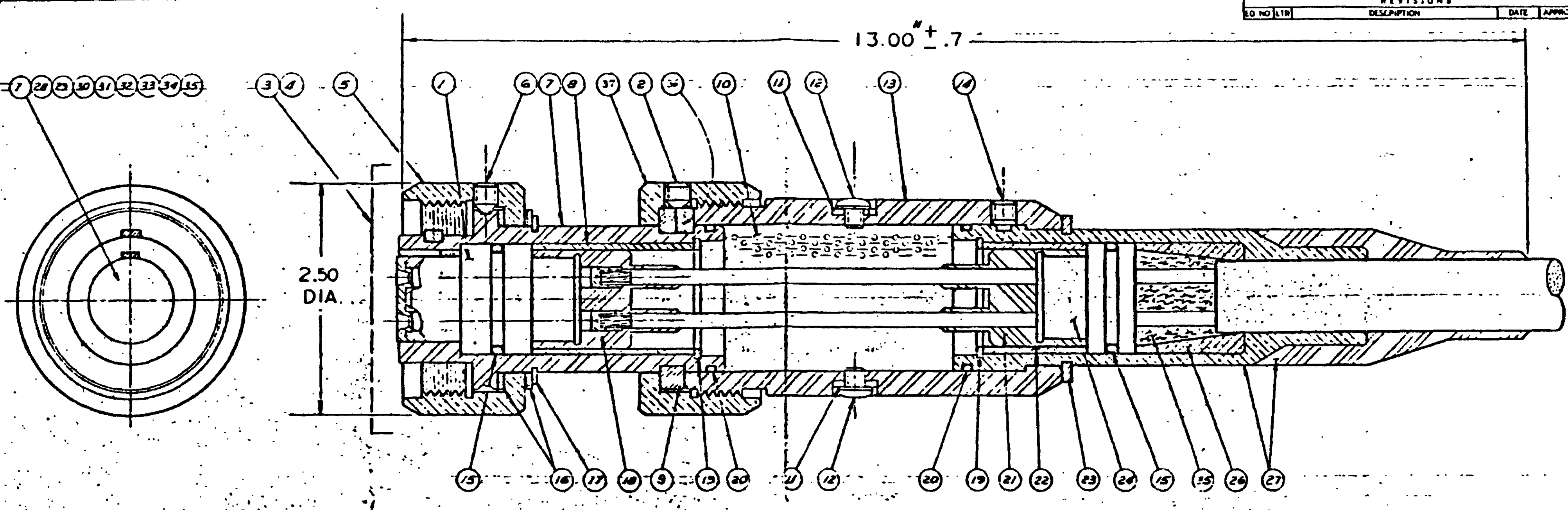
NO. REQD.	NEXT ASSEMBLY		DATE
		DRAFTSMAN V. MARTIROS	5/29/85
		CHECKER	6-17
		PROJECT ENGR.	
		CHIEF ENGR.	6-17
		APPR.	
		APPR.	

CABLE ASSEMBLY
LP08-CP-FITA

SIZE	CODE IDENT NO.	DWG. NO.	REV.
B	33412	14558	A
SCALE NONE	WEIGHT —	SHEET 1 OF 1	

BISHOP GRAPHICS/ACCUPRESS REORDER NO. A-1423


RECOMMENDED COUNTERBORE
FULL SECTION
-3UM
(3) #10 AWG.
-6
(2) #8 AWG, (4) #16 AWG
-8
(6) #16 AWG
-12
(12) #16 AWG.
-9UM
(8) #16 AWG.
-3HV
(3) #10 AWG.
-12UM
-2
-4
-4UM
-8AUM
PART NUMBER EXAMPLE
14097-6-A
OPTIONS
INTERFACE NUMBER
DRAWING NUMBER
OPTIONS -A CONNECTOR W/PROTECTIVE CAP.
-B " " SEAL CAP.
-E CONNECTOR W/MOUNTING NUT, WASHER AND SEAL CAP.
REVISIONS
EO NO | LTR | DESCRIPTION | DATE | APPROVED
A ADDED PART NUMBER EXAMPLE
7155 B ADDED -3HV 9-24-84 GIL
26 12540-6-2 D SHELL, LP08-BR-UM-FITA
25 12139-8AUM D INSERT, PIN LP08-BR-UM
24 12139-4UM D -UM
23 12139-4 D
22 12139-2 D
21 12139-12UM D -UM
20 12139-3HV D -HV
19 12139-9UM D -UM
18 12139-12 D
17 12139-8 D
16 12139-6 D
15 12139-3UM D INSERT, PIN LP06-BR-UM
14 12540-A-2 D SHELL, LP08-BR-FITA
13 11061-1 B CAP, PROTECTIVE LP08-BR (OPTIONAL)
12 11061-4 C CAP, SEAL LP08-BR (OPTIONAL)
11 C10-32UNF x 3/16 STD SCREW, SOCKET HEAD CAP
10 80C-030-10 STD LOCK O SEAL
9 K-060 STD O-RING
8 K-054 STD O-RING
7 K-238 STD O-RING
6 K-062 STD O-RING
5 K-056 STD O-RING
4 12514-8-3 B TUBE, SPACER LP08-BR
3 12809-BE-2 D NUT (OPTIONAL)
2 12607-BK-2 D WASHER (OPTIONAL)
1 RRN 1125 STD SPIROLOX
ITEM NO | PART NO OR IDENTIFYING NO | VEL SIZE | MATERIAL OR DESCRIPTION | ZONE
DASH NO. AND QTY. REQD
LIST OF MATERIALS
FINAL
RELEASE
UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND SHARP CORNERS
DO NOT SCALE DRAWINGS
DIMENSIONS ARE IN INCHES
TOLERANCES
NEXT ASSY
USED ON
APPLICATION
W/O-5338
DRAWN V MARTIROS 3/3/83
CHECKED
PROJECT ENGR
CHIEF ENGR
KINTEC INC.
9540 COZYCROFT AVENUE
CHATSWORTH CALIFORNIA 91311
LP08-BR-FITA
HARDWARE ONLY
SIZE D
CODE IDENT NO 33412
DRAWING NO 14097
REV E
SCALE NONE
SHEET 1 OF 1



NOTES:

1) PART NUMBER EXAMPLE

14402 - 4UM - A - B
- OPTIONS
- REAR SHELL WITH BOOT SEE TABLE "A"
- INTERFACE NUMBERS
- DRAWING NUMBER

OPTIONS
- -A = CONNECTOR / PROTECTIVE CAP
- -B = CONNECTOR / SEAL CAP

2) MAXIMUM PRESSURE RATING EXTERNAL ____ PSIG

3) MAXIMUM TENSIL LOARD ____ LBS

4) MAXIMUM INTERNAL PRESSURE 1500 PSIG.

TABLE "A"

DASH NO	SHELL W/BOOT PART NO	BOOT DIA.
-A	14405-A	.489
-B	14405-B	.430
-C	14591-A	MAT
-D	14591-B	MAT
-E	14591-C	MAT
-F		
-G		
-H		
-J		
-K		
-L		
-M		
-N		
-P		

FOR L.O.M., E.S. & FACE VIEWS SEE SHT 2

FINAL RELEASE

KINTEC INC.
CHATSWORTH, CALIFORNIA 91311

LP06-CP-XSC-UM-FLTA CONN. ASSY HDW ONLY

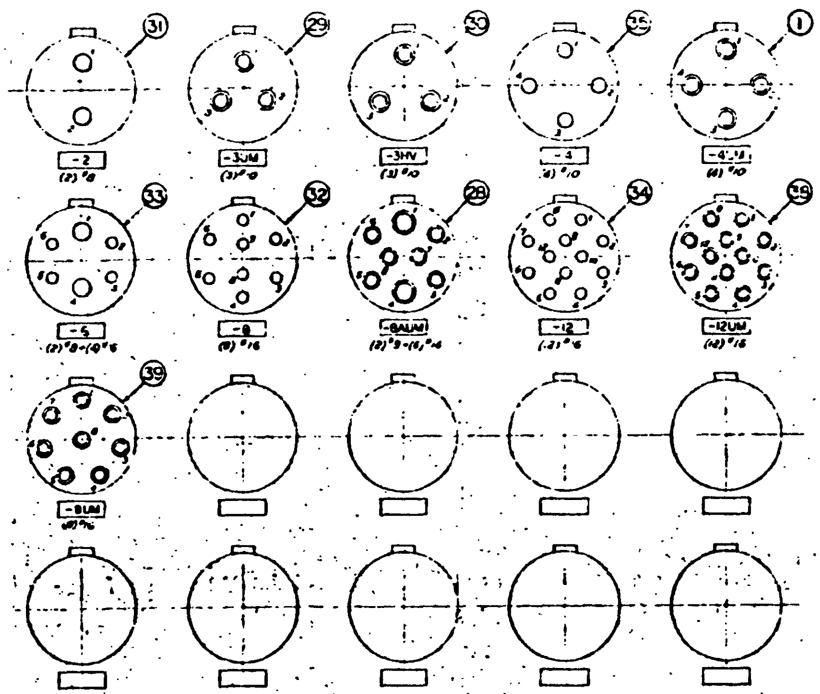
D 33412 14402 E

SCALE 2/1 SHEET 1 OF 2

NEXT ASSY 14382 C SIZE

5437

REVISIONS				
EO NO	LTR	DESCRIPTION	DATE	APPROVED
[illegible]	A	[illegible]	[illegible]	[illegible]
[illegible]	B	[illegible]	[illegible]	[illegible]
[illegible]	C	[illegible]	[illegible]	[illegible]
[illegible]	D	[illegible]	[illegible]	[illegible]
[illegible]	E	[illegible]	[illegible]	[illegible]



-8UM	-12UM	-4	-12	-3HV	-6	-8	-2	-3UM	-8AUM	-4UM	ITEM NO.	CODE IDENT	PART NO. OR IDENTIFYING NO.	VEL SIZE	MATERIAL OR DESCRIPTION
1											39		12613-8UM	D	INSERT, SOCKET LP08
	1										38		12613-12UM	D	INSERT, SOCKET LP08
1	1	1	1	1	1	1	1	1	1	1	37		5549-E-5	D	NUT, ENGAGING LP08
1		1	1	1	1	1	1	1	1	1	36		D 3/16 X 3/4		DOWEL PIN
		1									35		12136-4	D	INSERT, SOCKET LP08-CP
			1								34		12136-12	D	INSERT, SOCKET LP08-CP
					1						33		12136-6	D	INSERT, SOCKET LP08-CP
						1					32		12136-8	D	INSERT, SOCKET LP08-CP
							1				31		12136-2	D	INSERT, SOCKET LP08-CP
				1							30		12136-3HV	D	INSERT, SOCKET LP08-CP
								1			29		12613-3UM	D	INSERT, SOCKET LP08-CP
									1		28		12613-8AUM	D	INSERT, SOCKET LP08-CP
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	1	27		SEE TABLE "A"	D	SHELL, WITH BOOT LP08
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	26	(REF)	14607-(1,-3)	C	POTTING, WEDGE LP08
3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	3 oz	25		SOCKETPASTE		POLYESTER RESIN
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	24	(REF)	12133-(X)-2	D	INSERT, FEED THRU LP08
1	1	1	1	1	1	1	1	1	1	1	23		5160-137H		TRUARC
1	1	1	1	1	1	1	1	1	1	1	22		12131-K-2	C	TUBE, SPACER LP08
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	21	(REF)	12137-(X)	D	FEED THRU BOOT LP08
2	2	2	2	2	2	2	2	2	2	2	20		K-250		O-RING
2	2	2	2	2	2	2	2	2	2	2	19		N5000-112H		TRUARC
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	18	(REF)	12137-(X)	D	BOOT, CONTACT LP08
1	1	1	1	1	1	1	1	1	1	1	17		5100-150H	D	TRUARC
2	2	2	2	2	2	2	2	2	2	2	16		12807-8L-2	D	WASHER
2	2	2	2	2	2	2	2	2	2	2	15		K-238		O-RING
1	1	1	1	1	1	1	1	1	1	1	14		SDP 1/4-28UNF x 5/16		SCREW, SOC HD DOG POINT
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	13	(REF)	14403-(X)-2	D	EXTENSION HOUSING LP08
2	2	2	2	2	2	2	2	2	2	2	12		510-32UNF x 3/16		SCREW, BUTTON HEAD
2	2	2	2	2	2	2	2	2	2	2	11		800-030-10		LOCK-O-SEAL
12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	12 oz	10		AEROSHELL #4		DIELECTRIC
1	1	1	1	1	1	1	1	1	1	1	9		14305-A-5	C	RING, SPLIT LP08
1	1	1	1	1	1	1	1	1	1	1	8		12131-J-2	C	TUBE, SPACER LP08
1	1	1	1	1	1	1	1	1	1	1	7		14404-2	D	SHELL, LP08-CP-FITA
1	1	1	1	1	1	1	1	1	1	1	6		S 1/4-28UNF x 9/16		SCREW, SOCKET HEAD SET
1		1	1	1	1	1	1	1	1	1	5		8548-C-5	D	NUT, ENGAGING LP08-CP
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	4		11193-4	D	CAP, SEAL LP08-CP (OPTIONAL)
(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	3		11193-1	D	CAP, PROTECTIVE LP08-CP (OPTIONAL)
1	1	1	1	1	1	1	1	1	1	1	2		1/4-28UNF x 1/4	STD	SCREW, SOCKET HEAD SET
										1	1		12613-4UM	D	INSERT, SOCKET LP08-CP

DASH NO. AND QTY. REQD — LIST OF MATERIALS

FINAL

RELEASE

14382	C SIZE
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND SHARP CORNERS
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLE ±1°
2 PLACE DECIMALS ± .030
3 PLACE DECIMALS ± .010
1 PLACE DECIMALS ± .100

WORK ORDER NO. W/O-5437
DRAWN GILBERT / T. HAGAMAN
CHECKED
PROJECT ENGR.
DESIGN ENGR.

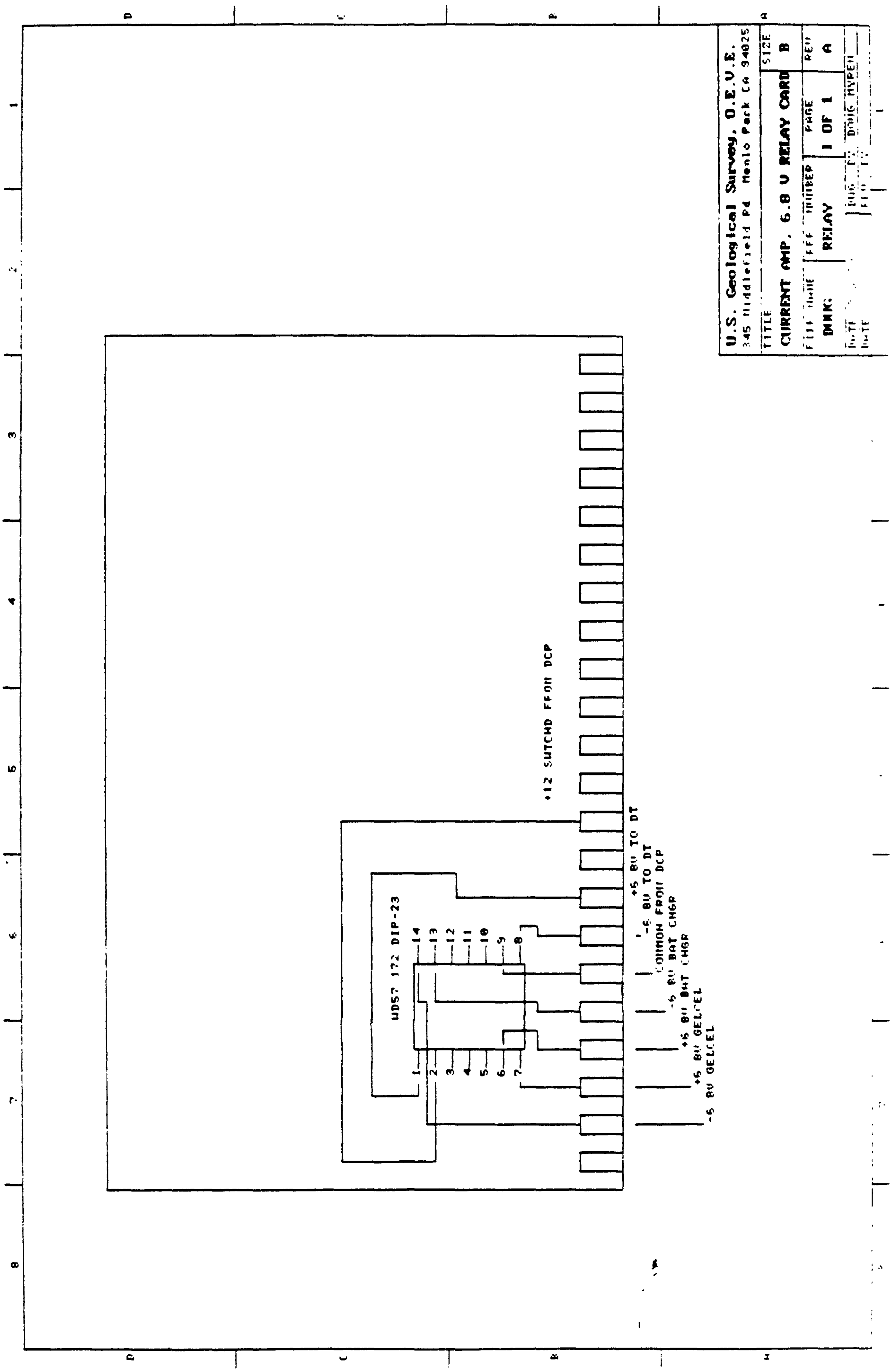
KINTEC INC.
9540 COZYCROFT AVENUE
CHATSWORTH, CALIFORNIA 91311

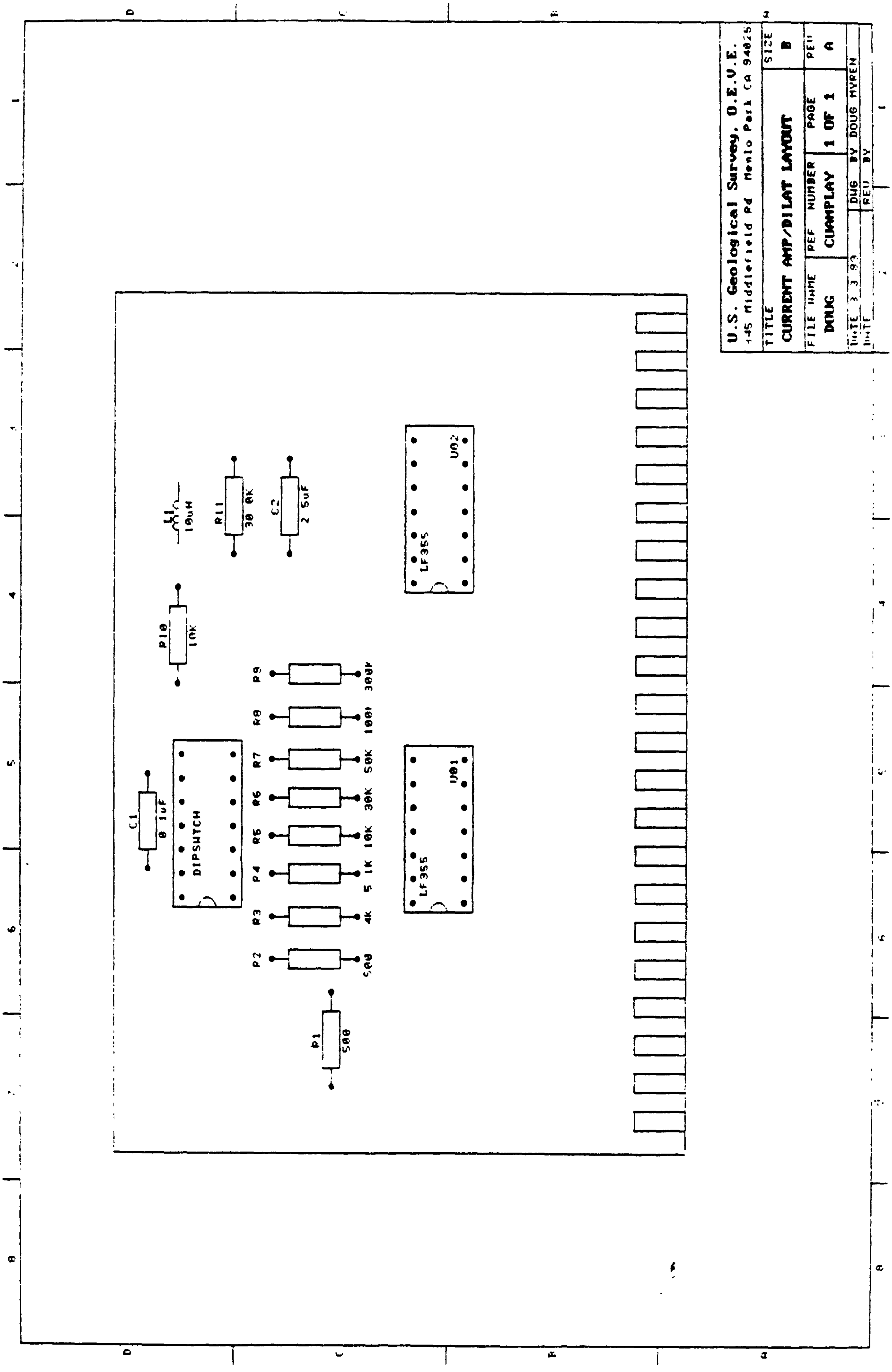
LPC8-CP-XSC-UM-FITA
CONN. ASSY

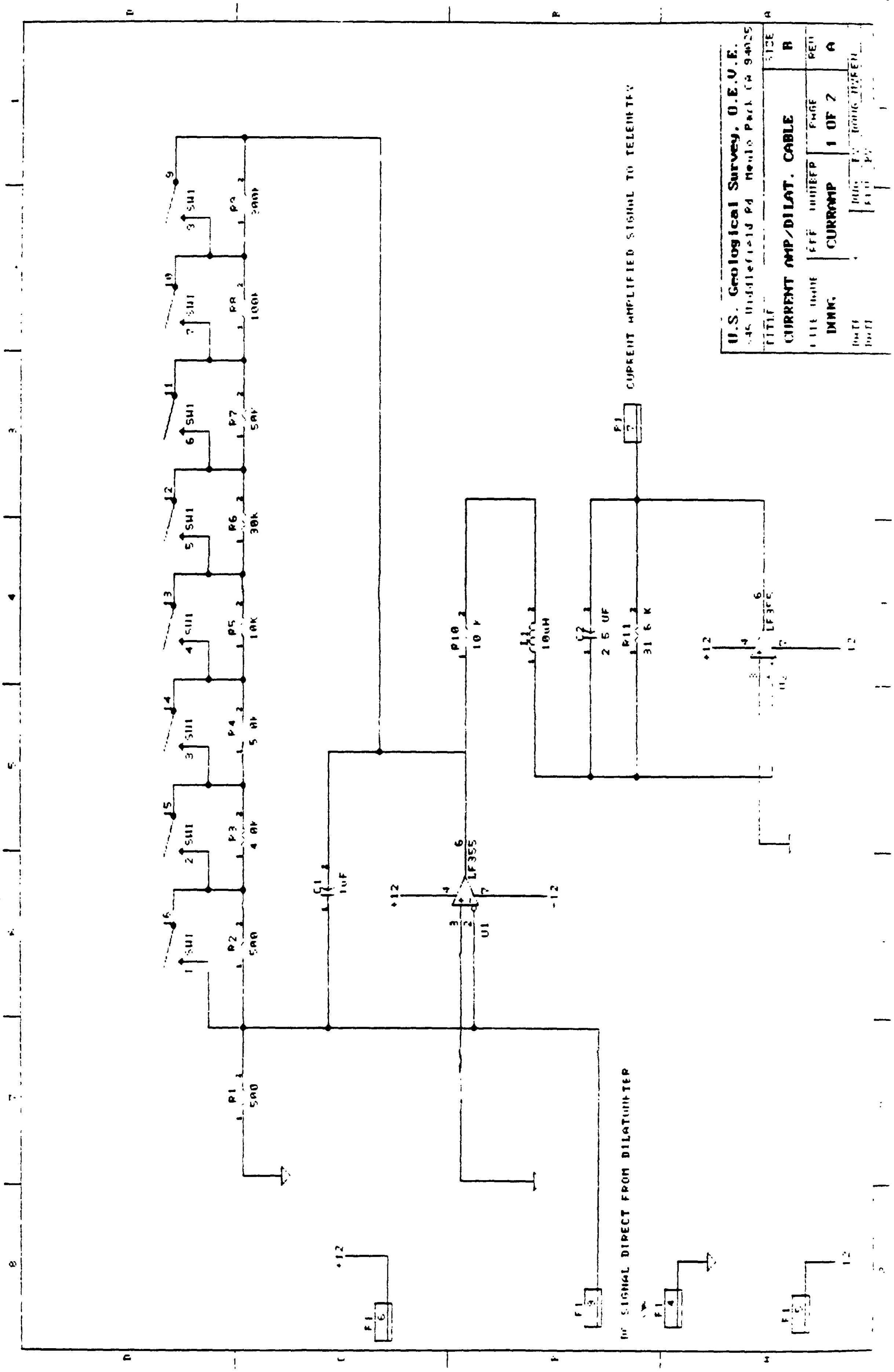
SIZE	CODE IDENT NO	DRAWING NO	REV
D	33412	14402	E

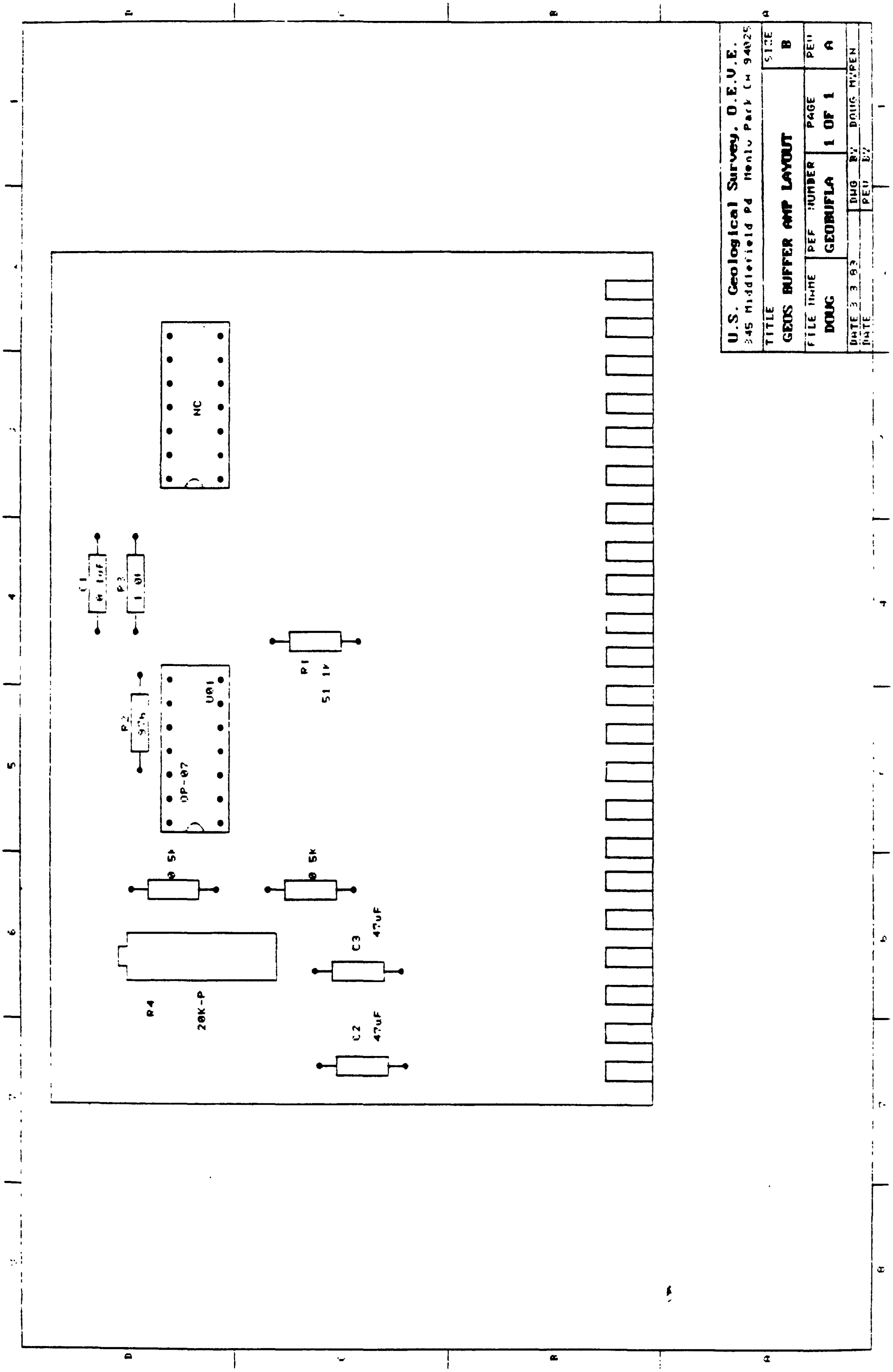
SCALE 2/1 — SHEET 2 OF 2

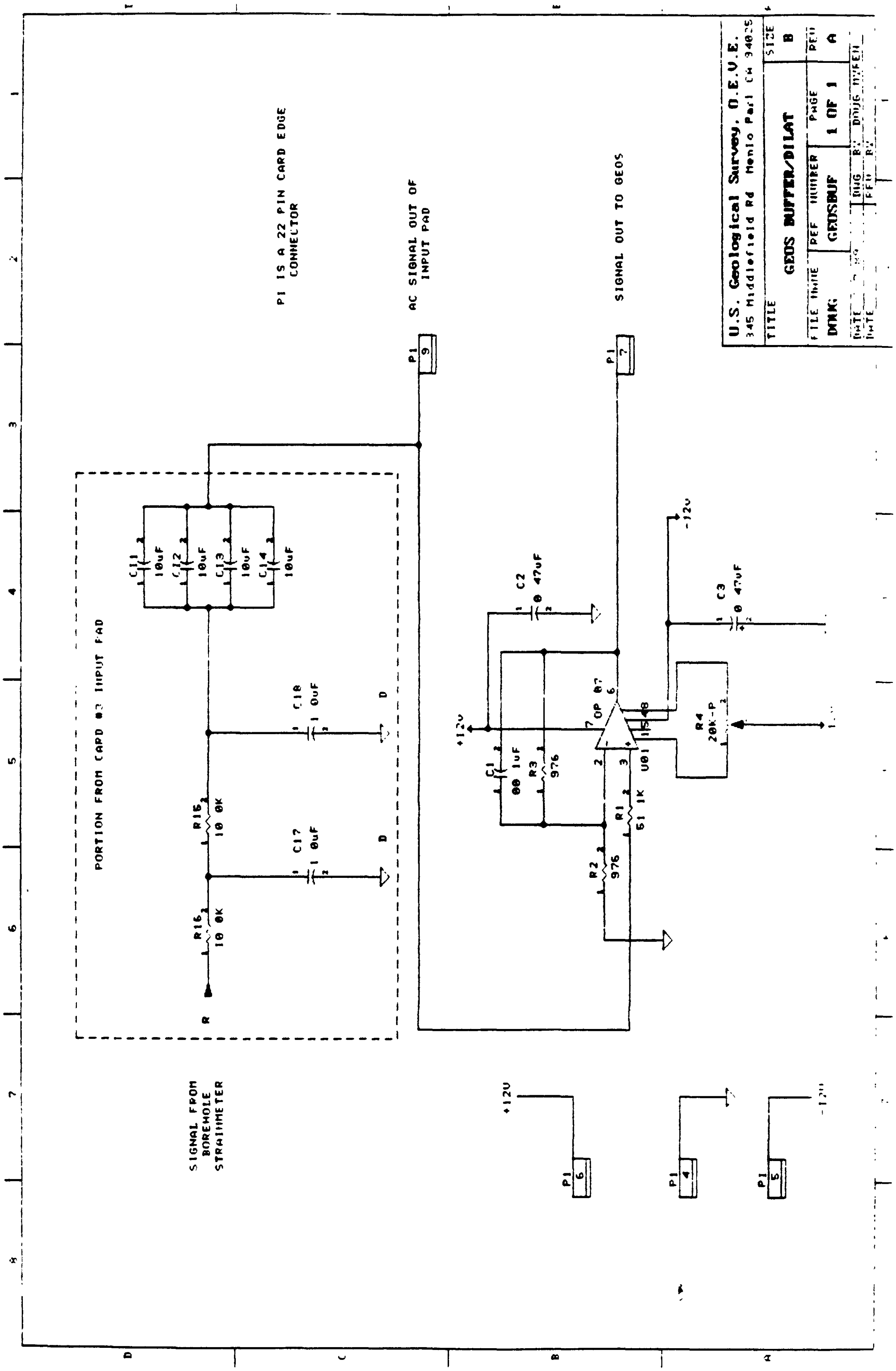
14.14 ADDITIONAL ELECTRONICS SCHEMATICS

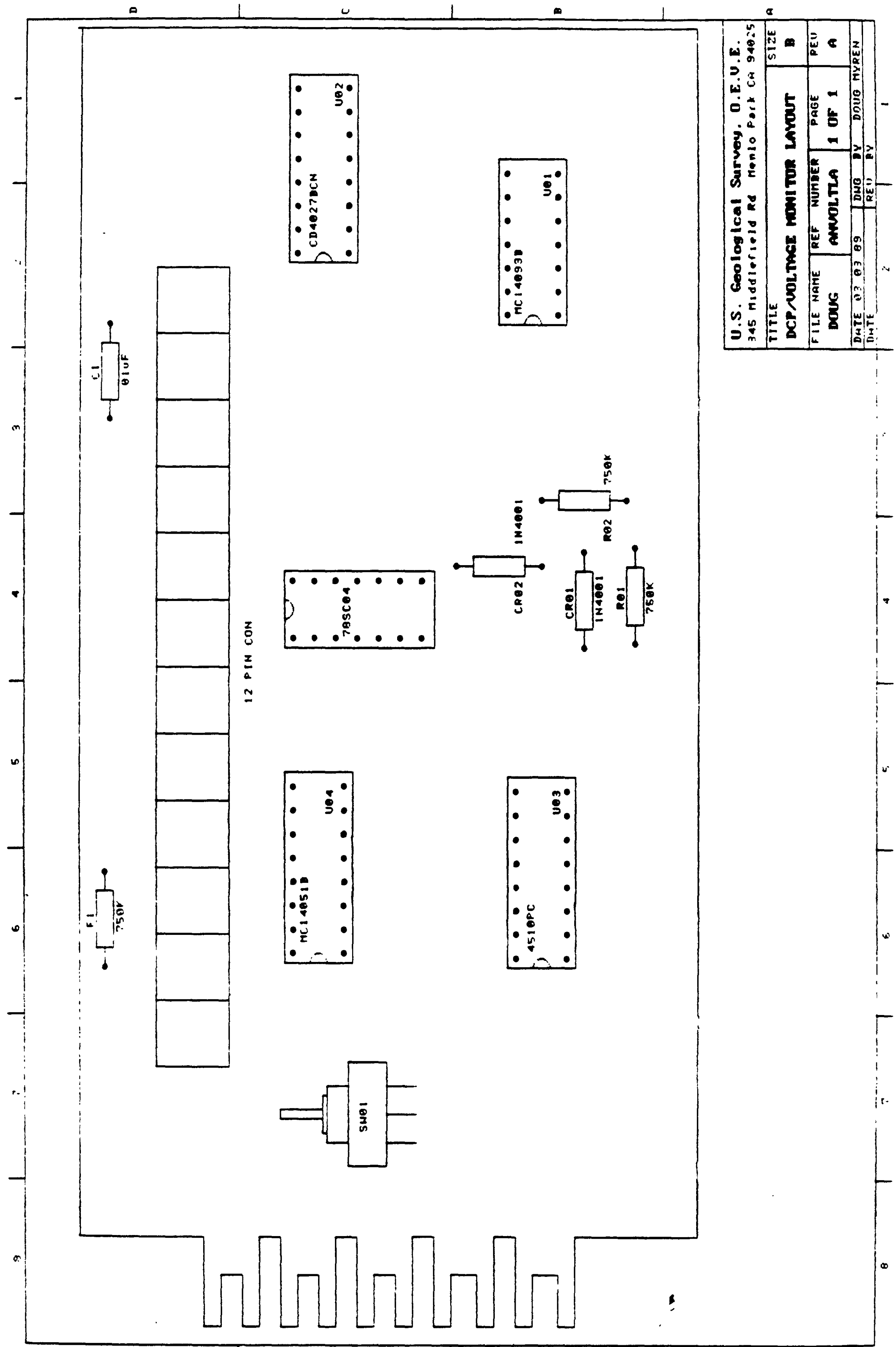

U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
CURRENT AMP, 6.8 V RELAY CARD
SIZE
B
REV
A
PAGE
1 OF 1
RELAY
+12 SWTCHD FROM DCP
+6 BU TO DT
-6 BU TO DT
COMMON FROM DCP
6 BU BAT CHGR
-6 BU BAT CHGR
+6 BU GELCEL
+6 BU GELCEL
-6 BU GELCEL
UDS7 172 DIP-23

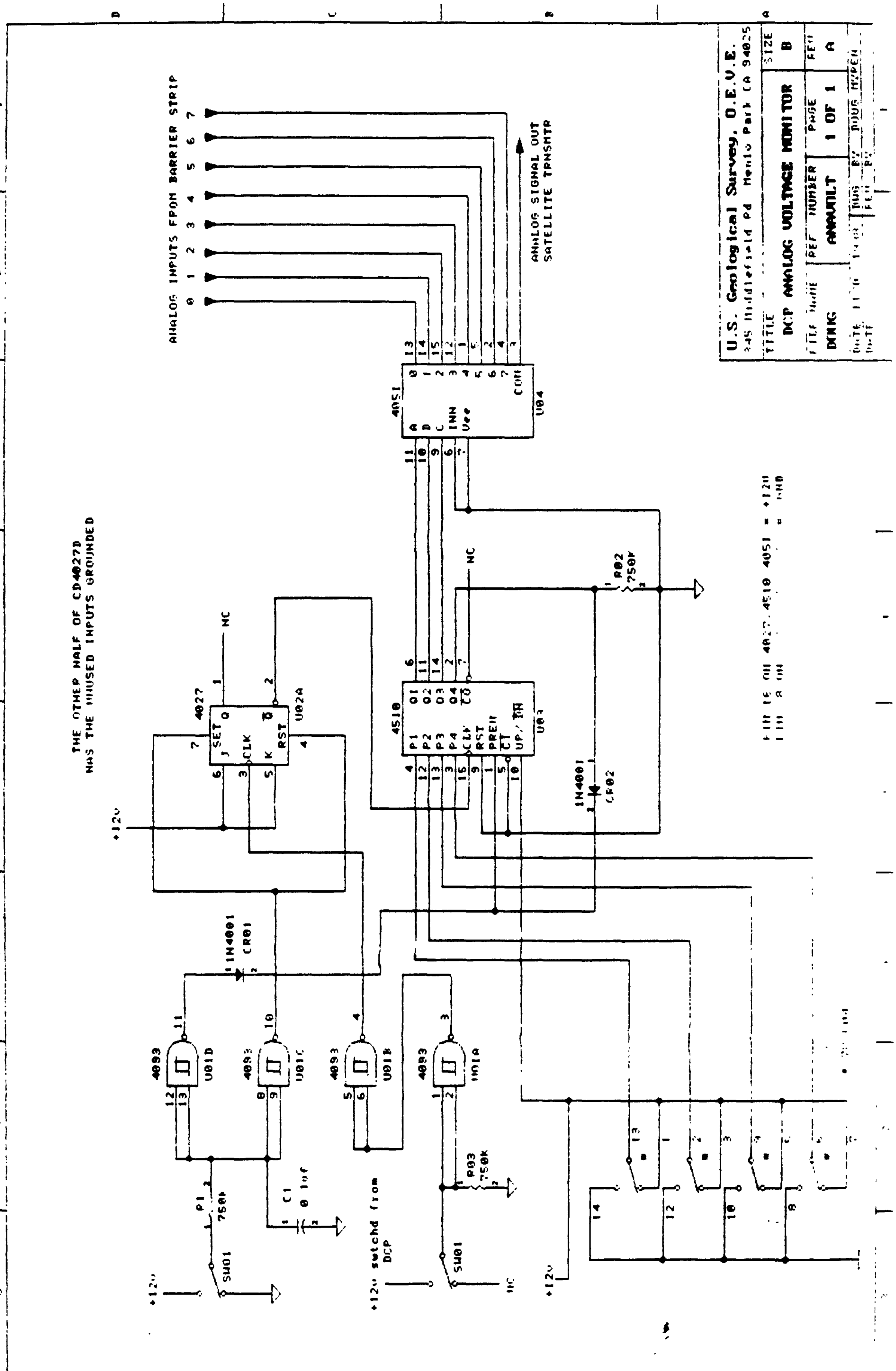

U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
CURRENT AMP/DILAT LAYOUT
SIZE
B
FILE NAME
DOUG
REF NUMBER
CUAMPLAY
PAGE
1 OF 1
REV
A
DATE 3 3 93
DWG BY DOUG MYREN
REV BY
DATE
L1
10uH
R11
30 0K
C2
2 5uF
U02
LF355
R10
10K
R9
300K
R8
100K
R7
50K
R6
30K
R5
10K
R4
5 1K
R3
4K
R2
500
R1
500
C1
0 1uF
DIPSWITCH
U01
LF355


U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
CURRENT AMP/DILAT. CABLE
CURRAMP
1 OF 2
SIZE
B
REV
A
CURRENT AMPLIFIED SIGNAL TO TELEMETRY
SIGNAL DIRECT FROM DILATOMETER
LF355
U1
LF356
U2
+12
-12
SW1
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
C1
C2
L1
F1


U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
GEOS BUFFER AMP LAYOUT
SIZE
B
FILE NAME
DOUG
REF NUMBER
GEOBUFLA
PAGE
1 OF 1
REV
A
DATE 3 3 83
DWG BY DOUG M/PEN
NC
U01
OP-07
R1
5K
5K
C3
47uF
C2
47uF
R4
20K-P


U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
GEOS BUFFER/DILAT
SIZE
B
FILE NAME
REF NUMBER
GEOSBUF
PAGE
1 OF 1
REV
A
P1 IS A 22 PIN CARD EDGE CONNECTOR
AC SIGNAL OUT OF INPUT PAD
SIGNAL OUT TO GEOS
PORTION FROM CARD #3 INPUT PAD
SIGNAL FROM BOREHOLE STRAINMETER
C11 10uF
C12 10uF
C13 10uF
C14 10uF
C18 1 0uF
C17 1 0uF
R15 10 0K
R16 10 0K
C2 0 47uF
C3 0 47uF
C1 00 1uF
R3 976
R2 976
R1 51 1K
OP 07
U01
R4 20K-P
+12V
-12V
P1 9
P1 7
P1 6
P1 4
P1 5

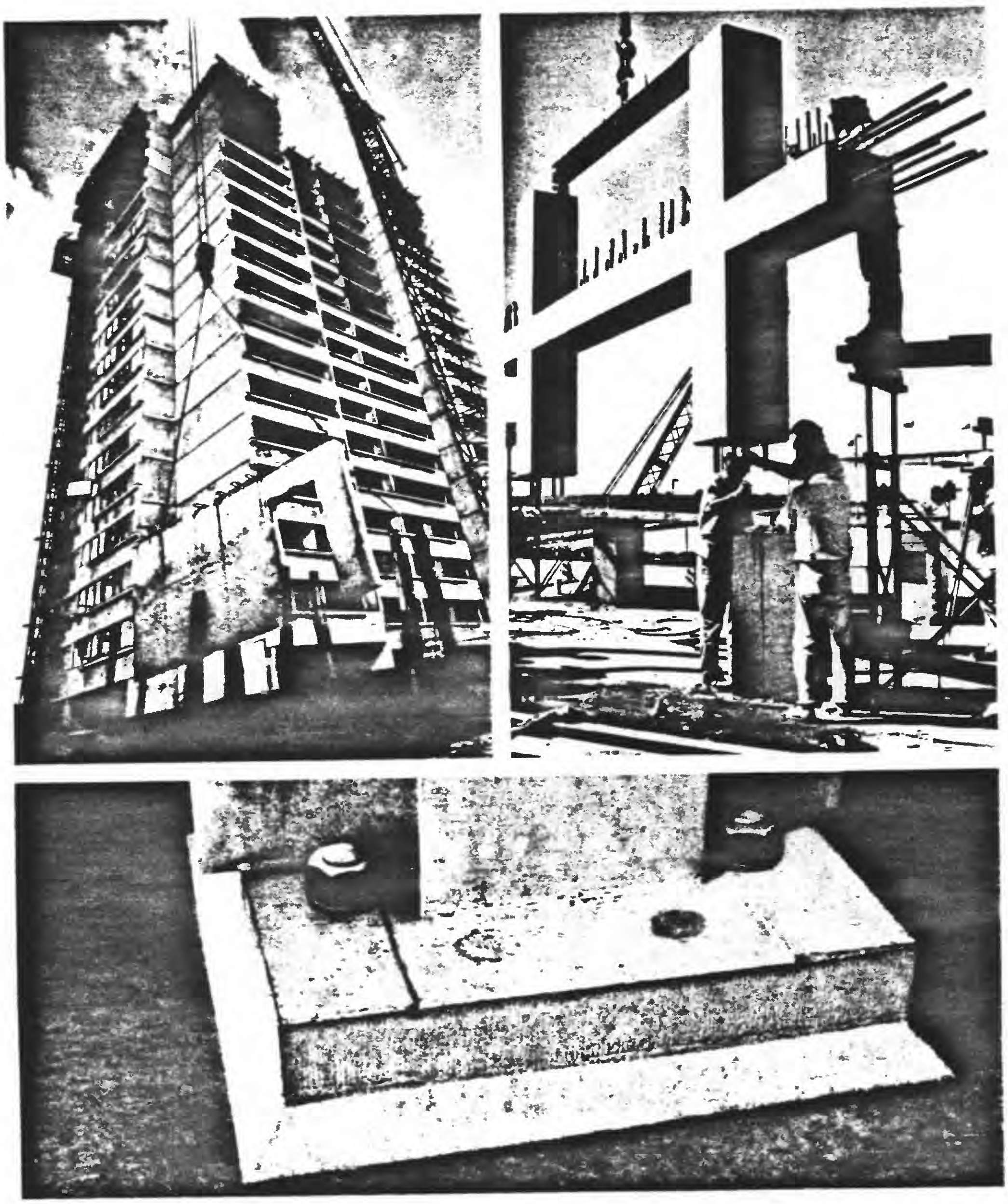

U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
DCP/VOLTAGE MONITOR LAYOUT
SIZE
B
FILE NAME
DOUG
REF NUMBER
AMVOLTLA
PAGE
1 OF 1
REV
A
DATE 03 03 89
DWG BY DOUG MYREN
REV BY
CD4027BCN
U02
MC14093B
U01
C1
01uF
750K
R02
1N4001
CR02
78SC04
CR01
1N4001
R01
750K
12 PIN CON
MC14051B
U04
4510PC
U03
F1
750K
SW01


ANALOG INPUTS FROM BARRIER STRIP
ANALOG SIGNAL OUT
SATELLITE TRNSMTR
THE OTHER HALF OF CD4027D
HAS THE UNUSED INPUTS GROUNDED
4051
U04
4510
U03
4027
U02A
4093
U01D
U01C
U01B
U01A
1N4001
CR01
CR02
R02
750K
R03
750K
C1
0.1uf
SW01
+12v switchd from DCP
U.S. Geological Survey, O.E.V.E.
345 Middlefield Rd Menlo Park CA 94025
TITLE
DCP ANALOG VOLTAGE MONITOR
ANAVOLT
1 OF 1
SIZE
B
REV
A

14.15 GROUT

MASTER BUILDERS

SET*
Nonshrink Grout



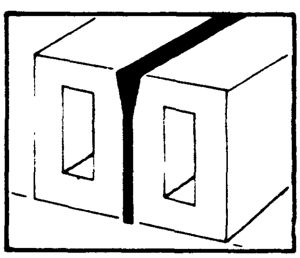
SET®
Nonshrink Grout

Nonshrink Performance

Set Nonshrink Grout is a portland cement-based, natural aggregate grout designed for use at a flowable consistency. Mixing requires only the addition of water to produce a nonshrink, nonbleeding grout which meets the performance requirements of the Corps of Engineers Specification for Nonshrink Grouts, CRD-C 621.

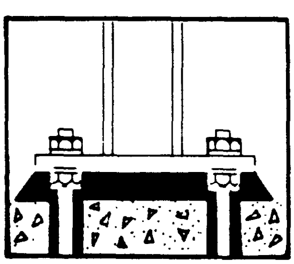
Multi-Use

Designed with field application in mind, Set Nonshrink Grout is the grout for structural grouting applications.



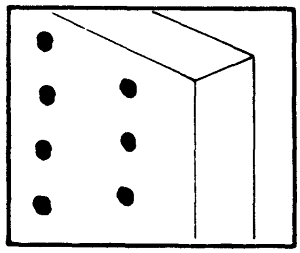
Precast, Prestressed Concrete Elements

Set Nonshrink Grout contains no chlorides or corrosive chemicals. It is non-staining and is approximately the color of concrete.



Structural Steel Baseplates and Members

Set Nonshrink Grout develops ample bearing strength and can be used above or below grade.

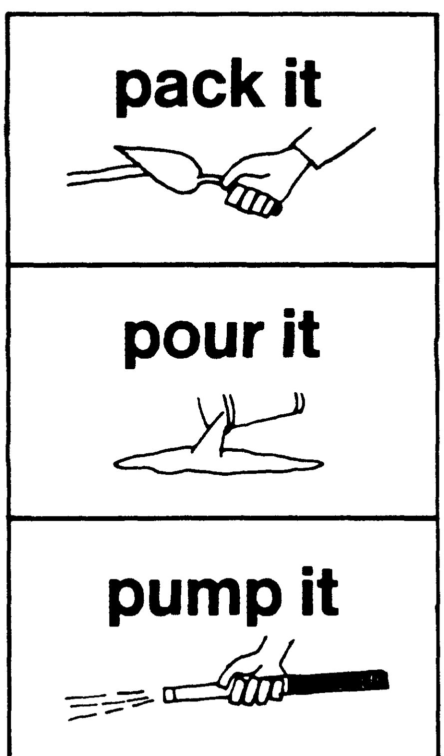


Nonshrink Repairs

Set Nonshrink Grout is perfect for plugging snap tie holes and filling pipe sleeves.

Versatility

Set Nonshrink Grout's water content can be controlled from a stiff mix for dry pack, to a nonbleeding flowable mix for gravity grouting or pumping.



Strength

Strict quality control, precise formulation and superior raw materials ensure the strength performance of Set Nonshrink Grout.

Compressive Strength-psi

Water Content per 50-Pound Bag

age	1.1 U.S. gal. flowable
1 Day	2500
3 Day	5000
7 Day	6000
28 Day	8000
*approx. flow @70°F	135%

*per ASTM C 109, 5 drops in 3 seconds

Approx. Setting Time at Flowable Consistency

initial	2 hrs., 15 min.
final	3 hrs., 45 min.

CRD-C 614

NOTE: Set Nonshrink Grout must be treated the same as any other high quality portland cement-based material. The water/grout ratio is important to obtain the required strength and nonshrink performance. The product is designed to simplify field applications and permit alternate methods of placement. Set Nonshrink Grout must be properly cured to achieve the desired performance.

Procedure for proper use of Set Nonshrink Grout

Description

Set Nonshrink Grout requires only the addition of water to provide nonshrink grouting and anchoring of structural steel and precast concrete members. It is a high quality grout and must be treated accordingly. Formulated to meet the current Corps of Engineers Specification for Nonshrink Grout, CRD-C 621, it can be packed, flowed or pumped for a variety of applications.

Preparation of Area

Roughen and clean the concrete foundation, pedestal or surface, including anchor bolt holes, of all grease, oil, dirt and particles. Remove all curing compounds or protective membranes. The concrete should be sound and the area in contact with the grout must be thoroughly saturated with water prior to placing the grout. Remove all free-standing water. Forms must be installed and caulked to contain the grout after placement.

Mixing

By using the minimum water content that will provide the desired workability, maximum strength is achieved. Mix grout with a mechanical mixer. Either a mortar mixer or an electric drill with a paddle device is acceptable. Put measured amount of water into mixer, add grout and mix until a uniform consistency is obtained.

Flowable mix: 1.1 U.S. gal. of water to one 50-lb. bag of grout.

Plastic mix: 0.95 U.S. gal. of water to one 50-lb. bag of grout.

Stiff mix: must be mechanically mixed with a minimum of 0.75 U.S. gal. of water to one 50-lb. bag of grout.

For pumping or special flow requirements: check with your field representative or dealer for further information.

Applications

Shim Plate Grouting: Use a plastic mix and tap shim plate to proper elevation.

Structural Steel Plates and Precast Concrete Members: Use a flowable mix and continuously flow the grout from one side, forcing out all air pockets to provide a void-free, bearing surface. Do not place grout at a flow or consistency which exhibits bleeding.

Anchoring: Use a flowable mix to completely fill the voids around the bolt, rebar or item to be anchored. Fill hole to top and cure with damp rags.

Nonshrink Repairs: Use a plastic mix and pack into holes or voids to be repaired such as snap tie holes.

Dry Packing: Use a stiff cohesive mix. Allow to set for approximately 10 minutes and ram into place. Do not mix more material than can be placed in 30 minutes.

NOTE: Have all grout in place before any of the grout becomes unworkable. *Do not retemper.* Do not vibrate grout.

Curing

Thoroughly curing Set Nonshrink Grout immediately after placement is critical. The grout should be protected from sun, wind, low humidity, high heat and fast drying conditions that will cause the grout to dry out. Wet cure all exposed grout for a period of 3 to 6 hours using wet rags, wet burlap, or by ponding. Apply a membrane curing compound meeting the moisture retention requirements of ASTM C 309 upon completion of the wet-cure period.

Cold Weather

Special precautions are required for grouting if ambient temperature is below 50°F. At low temperatures use warm water and allow extra time for strength buildup. Warm base to a minimum of 50°F. Protect grout from freezing with insulation blankets until 4000 psi compressive strength is achieved. Induce indirect heat for faster strength development. Reduce water content if bleeding occurs.

Hot Weather

At temperatures above 80°F, use ice water to prevent premature stiffening of grout. Place grout immediately after mixing. Dampen base prior to grouting and apply cure immediately to prevent rapid drying.

SET*

Nonshrink Grout

Color

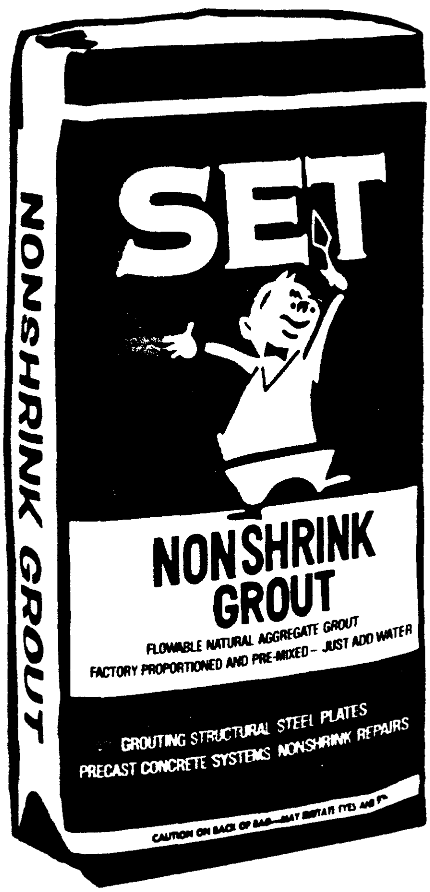
Set Nonshrink Grout cures and dries to the color of plain portland cement concrete.

Packaging

Set Nonshrink Grout is packaged in 50-pound, polyethylene-lined bags with suggestions for usage.

Yield

One 50-lb. bag mixed with 1.1 U.S. gal. of water yields approximately 0.44 cu. ft. of grout.



Caution

Cementitious material may cause irritation: avoid contact with eyes and prolonged contact with skin. In case of contact with eyes, immediately flush with water for at least 15 minutes. Call a physician. Wash skin thoroughly after handling. Keep product out of reach of children.

Warranty

Master Builders stands behind its products when used by competent persons in accordance with current published recommendations, but cannot be responsible for difficulty caused by other materials and conditions, or by inferior workmanship. Master Builders reserves the right to have the true cause of any difficulty determined by accepted test methods.

Special Notes

Contact your field representative or dealer for any special information or application assistance on Set Nonshrink Grout.

MASTER BUILDERS
IMPROVING CONCRETE WORLDWIDE
CLEVELAND, OHIO
TORONTO, ONTARIO

14.16 BAROMETRIC PRESSURE TRANSDUCER

SETRA SYSTEMS, INC. HIGH OUTPUT PRESSURE TRANSDUCERS

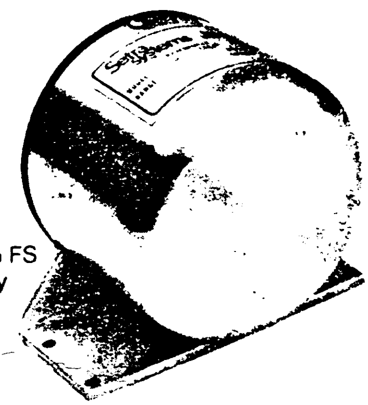
High Stability SETRACERAM™ Series

Model 270

HIGH ACCURACY

Barometric Pressure: 800 to 1100 millibars
Absolute Pressure. 0 to 10, 20, 50, 100 psia
Gage Pressure: 0 to 10, 20, 50, 100 psig
Gas or Liquid Media

Features

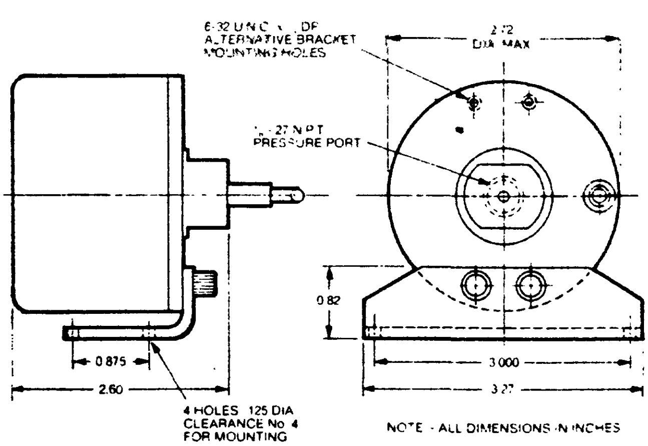


- SETRACERAM™ sensor
- High accuracy
  Barometric:
  within ±0.3 millibars
  Other ranges:
  within ±0.1% FS
- Repeatability within ±0.01% FS
- Excellent long-term stability
- Low power consumption
- Instant warm-up
- Fast response
- Small size, lightweight
- Virtually position insensitive
- Complete self-contained signal conditioning electronics with high level output

Description

The Model 270 pressure transducer is a complete pressure transducer system for accurate pressure measurement of gas or liquid media compatible with aluminum, alumina ceramics, gold, and elastomer sealant. The high level output signal, excellent stability and accuracy, combined with fast dynamic response make this unit ideally suitable for many environmental, industrial, laboratory and aerospace applications. The unique Setra electronic circuitry is combined with the rugged SETRACERAM™ sensor in this transducer. This high output transducer usually requires no further signal conditioning.

Outline Drawing



Applications

- High accuracy barometric pressure
- Weather and Environmental Data
- Databuoys and remote weather stations (rugged, low power consumption and instant warm-up)
- Air data (flight use)
- Engine test cells
- High accuracy transfer standard for laboratory, factory, and field calibration of pressure instrumentation.
- High accuracy pressure measurement into digital readout devices and computers
- Also available with Setra 300 series Digital Indicators and Readouts providing digital read-out and power supply

Construction

SETRACERAM™ Sensor

Setra's variable-capacitance ceramic sensor* approaches the ultimate in design simplicity. The symmetrical ceramic capsule deforms proportionally to the applied pressure. Gold electrodes on the inside surfaces of the ceramic capsule comprise the variable capacitance. As the pressure increases, the electrodes are moved closer to each other, increasing the capacitance.

The reference space inside the capsule is sealed shut under high vacuum. The excellent thermal expansion coefficient, low mechanical hysteresis, and long-term stability enable the spectacular performance of the SETRACERAM™ sensor.

Electronic Circuit

The capacitance is detected and converted to a highly accurate linear DC electric signal by Setra's unique new custom Integrated Circuit utilizing charge-balance principle.**

Unprecedented capacitance-measuring accuracy is achieved. Absolute accuracy may be further enhanced using the internal zero and sensitivity adjustments.

*U.S. Patent 4168518
**U.S. Patent 4054833

Setra systems
45 Nagog Park, Acton, Massachusetts 01720 / Telephone: (617) 263-1400

Model 270 Specifications

Pressure Ranges and Media	Pressure Range	Maximum pressure
Barometric	800 to 1100 millibars	30 psia
Absolute Pressure	0 to 10, 20, 50, 100 psia	1.5 x rated pressure
Gage Pressure	0 to 10, 20, 50, 100 psig	1.5 x rated pressure
Pressure Media	Typically, dry or wet air, water, petroleum products, or other media compatible with aluminum, alumina ceramics, gold, and elastomer sealant.	

Accuracy Data

Non-Linearity	<±0.05% FS (terminal method)
Hysteresis	<0.01% FS
Non-Repeatability	<±0.01% FS
Resolution	Infinite, limited only by output noise level (0.01% FS)
Thermal Effects	Operating temp. 0° to 175° F
Thermal zero shift	(30° to 150° F)
Barometric	<±0.002% FS/° F
Other ranges	<±0.001% FS/° F
Thermal coef. sensitivity	<±0.001% FS/° F
Accuracy*	
Barometric	Accurate to within ±0.3 millibars, over 3 months at room temp.
Other ranges	<±0.1% FS error, over 3 months at room temperature.
Static Acceleration Effect	<±0.01% FS/G
Instant Warm-up	<0.02% FS residual shift after turn-on (fully repeatable).
Time Constant	<50 milliseconds to reach 63% final output with step function pressure input.

Electrical Data

Full Scale Output**	0 to 5.00 VDC, internally adjustable, factory set within ±5 mv. As an option, barometric range (800 to 1100 millibar) units may be ordered with special 8.00 to 11.00 VDC output.
Zero Pressure Output	Internally adjustable to 0 mv. Factory set within ±5 mv.
Excitation Power	Nominal 24 VDC, 12 milliamperes (0.3 watts), 22 to 30 VDC. Reversed excitation protected, Internal regulation minimizes effect of excitation variation, with <±0.04% FS output change. Will operate on 28 VDC aircraft power per MIL-STD-704A and not be damaged by emergency power conditions.
Electrical Circuit	Four-terminal circuit for units with 0 to 5 VDC output. Three-terminal circuit for units with 8 to 11 VDC output.
Isolation	The insulation resistance between all signal leads tied together and case ground is 100 megohms minimum at 25 VDC.
Output Impedance	<60 ohms (effective).
Output Noise	<100 microvolts RMS (0 Hz to 100 Hz).

Environmental and Dimensional Data

Temperature	0 to 175°F operating -65°F to 250°F storage	Pressure fitting	1/8"-27 NPT internal
		Electrical conn.	2 foot multiconductor cable
Vibration	2 g's from 5Hz to 500Hz		
Acceleration	10 g's maximum	Weight (approx.)	9 ounces (0.25 Kgm)
Shock	50 g's operating		

**Higher accuracy units on special order.*

***Calibrated into 50 K ohm load; operable into loads of 5000 ohms or greater. You can attenuate output to match your data system.*

Electronic Circuit Information

Four-terminal equivalent circuit for 0 to 5 VDC units.
Three-terminal equivalent circuit for 8 to 11 VDC units.

For best performance, either negative excitation or negative output should be connected to case. Unit calibrated at the factory with negative excitation connected to case.

Ordering Information

Order as Model 270 pressure transducer containing SETRACERAM™ sensor.

Specify
- Pressure range:
- Electrical Output:

Specifications subject to change without notice.

Setra systems INC

45 Nagog Park, Acton, Massachusetts 01720 / Telephone: ~~(617)~~ 508 263-1400