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INTEGRATION, SPECIFICATION TESTING, ADJUSTMENT, AND REPAIR OF THE PT-700 SEISMIC SYSTEM AND ASSOCIATED EQUIPMENT BY DRESSER AUSTRALIA PTY LIMITED, BRISBANE, MAY/JUNE 1967

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SUMMARY

A new set of PT-700 amplifiers, manufactured by Dresser-SIE, Inc., was purchased for use by Bureau of Mineral Resources (BMR) seismic parties at the beginning of the 1967 field season. The integration of these high quality amplifiers with existing associated equipment and the specification testing, adjustment and repair of the whole seismic recording system was carried out by Dresser-SIE (now Dresser Australia Pty Ltd) in Brisbane during May and June, 1967. BMR personnel participated in this work.

A number of faults, some of which occurred during the integration, were discovered. The equipment was brought up to specification in all but a few points, which were not thought to be sufficiently serious to delay the use of the equipment in the field.

INTRODUCTION

A new set of PT-700 amplifiers, manufactured by Dresser-SIE, Inc., was purchased for use by Bureau of Mineral Resources (BMR) seismic parties at the beginning of the 1967 field season. The amplifiers were integrated with other equipment, not all manufactured by Dresser-SIE, to make up a complete seismic recording system. A list of this equipment is given in Appendix 1.

A contract was awarded to Dresser-SIE in Brisbane (now Dresser Australia Pty Ltd) to complete the integration, and to carry out specification testing, adjustment and repair of the whole system. The integrated equipment installed in a new cab mounted on a Bedford chassis was made available to Dresser on May 22. It was originally estimated that the work by Dresser would be completed in 3 weeks followed by a week's field testing in the Lockyer Valley near Brisbane with a minimal seismic party. However the overhaul of the equipment by Dresser was not completed until June 28 when the equipment was sent direct to the field for the Roma Shelf Seismic Survey.

Several BMR geophysical and technical personnel took part in the work. A. Turpie, Geophysicist Class 3, supervised the equipment testing from June 6; J.K.C. Grace, Technical Officer Grade 1, assisted Dresser personnel during the entire contract; G.L. Abbs, Technical Officer Grade 2, took part in the tests from June 6 to June 16 and G.S. Jennings, Technical Officer Grade 1, assisted in testing and repairing the equipment from June 16 to June 28. These personnel all gained a thorough familiarity with the seismic recording system.

During the contract there was a serious lack of information on specification testing procedures, for both overall performance and remedial checks. Circuit diagrams were available indicating numbered check points but no information was available on what should be measured at these points. Although the service provided by Dresser Brisbane was not completely satisfactory the Dresser personnel did their best and the overall results were worthwhile.

The then Dresser personnel in Brisbane, R. Ward, General Manager and G. Lange, Instrument Engineer, visited the seismic field party in Roma on July 16 and 17 for discussions and advice on the performance of the equipment in the field.

This report includes information on the performance of the equipment in the field during the early part of the Roma Shelf Seismic Survey.

INTEGRATION

BMR, Canberra

All available units in the seismic recording system were installed in the recording cab prior to sending it to Dresser in Brisbane. Interconnecting cables from the previous seismic system were used where suitable however about a half of the number of cables required were new or had to be remade. Of these the cables to connect filters, amplifiers and the Output Connector Unit were made by Dresser.

Because the Monitor link MU70 AB normally supplied with the PT-700 system was not purchased, the following units were included in the system in its place:

SZC-1	Junction and Monitor Panel
AIB71B	Output Connector Unit
TRO6	Oscillograph Camera

Dresser, Brisbane

The main integration work carried out by Dresser was as follows:

1. Installation of ganged AGC.
2. Alteration of output circuits to the DS7-700 and galvanometers.
3. Alteration of a programmed gain unit to give a 4 kHz control voltage required by the PT-700 system.
4. Installation of a gain indicator trace.

The programmed gain unit had been modified to work with the Texas Instruments 7 000B amplifiers, which were previously in the system. The frequency of the suppression voltage which had been changed to 7.5 kHz was changed back to give the 4 kHz control voltage required by the PT-700 system.

The gain indicator trace was installed to enable true amplitude recovery. A trace deflection was obtained proportional to the 4 kHz control voltage on the final gain bus. It was intended to record the trace on magnetic tape to allow digitization as required. Since the trace as installed was limited in that it was linear and had a range of only 40 dB, it was decided to replace it by the log level indicator, (LLI) which gives a logarithmic output over a range of 80 dB. A switch was provided to allow the LLI to monitor either the input signal level on channel 3 or the external 4 kHz gain control voltage. However the gain indicator trace was not recorded on magnetic tape.

TESTING OF EQUIPMENT AND RESULTS

The tests to which the equipment were subjected are described and the results are summarized.

Comparison of Oscillator and Amplifier Attenuator Calibrations

Output levels on all 24 traces were adjusted equal with an oscillator signal of 100μV and a fixed gain of -40 dB. The signal level and gain controls were varied in 20 dB steps, over a range from 1μV at 0 dB to 10 mV at 180 dB, to give a constant output.

The output signal level was fairly constant except for an input signal of 1μV. The lower output signal for this level input was caused by the threshold of the AGC being higher than 1μV.

Amplifier Noise Level and Dynamic Range

The noise levels of the amplifiers were measured, with both fixed gain and AGC, in several different ways. However, the most usual method was to record an oscillator signal of 3μV on all 24 traces with a fixed gain of 0 dB, and then amplifier noise levels using a 390 Ohm termination across the amplifier input to each amplifier on panel CAB. The noise level varies markedly with input impedance, thus a 390 Ohm termination which gives a noise level of about 0.3μV was used as a standard input impedance. This impedance is greater than that of normal geophone arrays.

Individual channels showed excessive noise on several occasions.

1. Two particular amplifiers were intermittently noisy.
2. A bad connexion occurred in the signal patch panel.
3. A bad connexion occurred in the plug at the rear of the amplifier.

The amplifier specifications list an upper signal input level of 1 V. Measurements made indicated that clipping started at 0.5 V. An upper signal input level of 1 V may only be measured with a matched source impedance while the 0.5 V input was measured with a very low source impedance.

Check on AGC Circuits

Tests of AGC circuits were initially made by switching from a lower to a higher signal strength in steps of 10 dB, 20 dB and 30 dB. Clipping occurred with the 20 dB and 30 dB steps thus later tests were confined to using 10 dB steps. Most tests were run with a 35 Hz input signal however one test was run with a 150 Hz signal.

The tests covered the range of signal level from 1 μV to 1 V. The AGC was seen to start between 1 and 3 μV. A marked increase in AGC speed was apparent with increasing signal level. The AGC action was found to be uniform in the 26 amplifiers checked except in 4 amplifiers which had to be readjusted. Variations between amplifiers are most noticeable at low signal levels, at the AGC threshold and just above it, and on slow-slow (SS) speed.

Tests were also carried out switching from a higher to a lower signal strength. One amplifier showed a very low frequency instability (about 3 Hz) at signal levels less than 30 μV; this instability disappeared on later tests.

A normal amplifier test was carried out with amplifiers on different AGC speeds:-

Amplifiers	1 - 6	Slow-Slow	(SS)
Amplifiers	7 - 12	Slow	(S)
Amplifiers	13 - 18	Medium	(M)
Amplifiers	19 - 24	Fast	(F)

The purpose of this test was to examine whether any phase differences occurred because of different AGC speeds. No phase differences were discernible. It was however noticed that there was a considerable overswing with a 10 dB step on Fast AGC with a higher signal strength.

Measurement of the Dynamic Range of the PMR-20

The dynamic range of a magnetic recorder is the ratio of the inherent noise level to the maximum recording level; for the PMR-20 and other FM recorders, the maximum recording level is a 100% modulated signal.

The strongest noise component in the recorder, caused by variation in drum speed, appears as a 13 Hz Sine wave, which frequency is produced by a drive belt resonance. A new drive belt was fitted and adjusted and the noise cancelling was adjusted using a standard tape which has the same signal on all tracks.

The measurement of noise level was made by recording a tape with zero signal input and another with a known percentage modulation. Comparison of the noise and signal voltages obtained on playback gave the dynamic range. Without noise cancelling this was found to be 40 dB and with noise cancelling the dynamic range was 56 dB.

An improved method of measurement of dynamic range was devised later and used in the field. A signal was recorded on magnetic tape with filters out and a fixed gain of -80 dB first at 100 mV (100% modulation) and then in steps of 10 dB down to -80 dB. The tape was played back on AGC and the dynamic range read off by comparison of signal and noise levels. The dynamic range, measured by this method, was slightly in excess of 60 dB.

Check of the DS7-700 Transfer Tape System

Corrected playbacks cannot be produced on the PMR-20. In order to obtain corrected playbacks in the field, a facility was provided in the integrated system to make transfer tapes on the DS7-700 direct recorder. Corrected playbacks can be made on the DS7-700.

A 35 Hz oscillator signal was recorded on the 24 seismic signal channels of the PMR-20, transcribed to magnetic tape on the DS7-700 and played back. Satisfactory results were obtained although variations in level from trace to trace remained to be corrected. Pulses recorded on the up-hole and time-break traces of the PMR-20 were not transcribed successfully while the equipment was tested in Brisbane.

Distortion Levels

No measuring equipment was available to check that the amplifiers came up to specification with regard to signal distortion.

Pre-Filter Check

An external oscillator was connected to all channels in parallel through Input Panel CAB with pre-filters inserted into the system. No phase difference between channels was caused by the pre-filters.

Programmed Gain Operation

The normal programmed gain facility was tested in Brisbane using an oscillator signal and the control voltage monitored with the gain indicator trace. It was found to work satisfactorily there and in the field later.

The automatic level adjusting facility in the programmed gain unit was initially defective. Although repairs were made it was concluded that unless the operation of this facility could be improved, it was too touchy and unreliable for operational use.

The auxiliary gain selector should be in position A for programmed gain operation. Should extra pre-suppression be required for the channels nearest the shot, the selector switch should be in position B.

Ganged AGC Operation

The ganged AGC facility was tested in Brisbane with a normal amplifier test and later in the field. Operation was satisfactory.

Channel Isolation

An external oscillator was connected to each channel in turn at the cable connector on Input Panel CAB, with all inputs terminated by a 390 Ohm resistor. The early gain was set to -40 dB on the signal channel and to 0 gain on all other channels. The pre-filters were out. A cross-talk of 55 dB would have been detectable at this level however no cross-talk was observed.

Further channel isolation tests were conducted using the amplifiers on Fast AGC and input signals, of frequencies 90 and 9 Hz, increased in 20 dB steps from 5μV to 500 mV. When the 90 Hz signal was applied to channel 14, it was found that the steady state cross-talk was considerably greater to channels in the same bank. The isolation from channels in amplifier bank 13-24 was in excess of 100 dB for all channels except 13 which was 86 dB. The isolation from all channels in bank 1-12 was well in excess of 120 dB. The cross-talk from the 9 Hz signal was lower by a few dB.

When the pre-filters were inserted the cross-talk was increased and became more uniform within the one bank. When the 90 Hz signal was applied to channel 14 the isolation from channels in bank 13-24 was about 85 dB and from channels in bank 1-12 it was about 105 dB.

In the field, another method of testing channel isolation was used. 1 320 feet cables were plugged into both amplifier banks and geophones were attached to each take-out except one to which the external oscillator was attached. The isolation tests were repeated as above. Little difference was observed between the isolations measured by the two methods.

The isolation for pulse cross-talk was found to be less than that for steady state but with the same degree of variation.

Considerable cross-talk from the up-hole geophone was experienced in the early part of the Roma Shelf Seismic Survey. This was considered to be due to particles blown from water-tamped holes striking the up-hole geophone. This cross-talk was reduced by rewiring the up-hole circuit and better earthing of the seismic cab.

FAULTS

A number of faults occurred and/or became apparent during the integration of the equipment and the subsequent testing.

Amplifiers (TGA-7)

Several faults (outlined in 1 to 4 below) show points of poor design or construction.

1. The amplifier is constructed of two boards back to back on a frame. Bus bars are mounted on the frame between the boards. In several amplifiers transistors were damaged by accidental contacts of points on amplifier boards to eccentrically mounted bus bars.

2. On at least three occasions transistors were ripped from their mounts when amplifiers were being removed from banks.

3. On several occasions bad contacts were experienced on the plugs at the rear of amplifiers. The faults were rectified generally by cleaning the plugs. Channel 8 was generally troublesome in this regard however after the female connectors were adjusted the fault was eliminated.

4. Several channels became intermittently noisy. In most cases the source of the noise was traced to an open circuit input by a bad connexion in a connector.

5. The -15 V supply for the amplifiers became defective repeatedly causing a transistor to fail. This fault was still recurring when the equipment was taken to the field. Later an associated power transistor became defective with a collector to emitter short. This transistor was replaced and the previous fault has not recurred.

Magnetic Recorder (PMR-20)

When the noise level of the PMR-20 magnetic recorder was measured with noise cancelling in, short pulses appeared across all 24 seismic traces. Most of these pulses were found to occur at the same time, relative to the time break, from test to test. It was found that one pulse was moved by moving the trip control. The pulses were associated with the microswitches on the drum. The output transistor on the noise cancelling modulator was defective and was not isolating the modulator on playback. After the output transistor was replaced these pulses disappeared, however other pulses which were random in time were still apparent. These appeared to be associated with irregularities in the noise cancelling signal, probably caused by fine particles under the magnetic head. These pulses were reduced by cleaning the heads thrice daily.

Programmed Gain Unit

The automatic level adjusting facility in the Programmed Gain Unit was inoperative. It was found that the servo-loop amplifier had insufficient gain. Two transistors had been replaced by what were thought to be equivalents which in fact gave a much lower gain. The correct transistors were used and the fault was rectified.

Input Patch Panel (SZA-1)

Occasionally poor connexions occurred in the panel.

FULFILMENT OF SPECIFICATIONS

The recording equipment was brought up to or close to specifications for those aspects which were tested.

Amplifiers (TGA-7)

Noise Level:

- 0.15μV, peak-to-peak, for 10 to 100 Hz
- 0.30μV, peak-to-peak, for 5 to 200 Hz

It was not attempted to repeat this measurement exactly as the input impedance used was not known. However the noise level is of the correct order, although somewhat higher, and was measured as 0.30μV r.m.s., or 0.90μV peak-to-peak, with open filters and a 390 Ohm source impedance.

Maximum Input Signal Level:

- 1 V r.m.s., with source impedance of 2 500 Ohm shunted by 800 H.

As noted earlier in the "Testing of Equipment and Results", clipping started at about 0.5 V r.m.s. but with a very low input impedance, so that the measurement is compatible with that specified.

Frequency Response - High Level Output:

- AGC Off or Slow-Slow, within 3 dB, 3 to 250 Hz for a 1 ms sampling rate.
- AGC Slow, Medium or Fast, within 3 dB, 6 to 250 Hz for a 1 ms sampling rate.

This specification was not checked.

AGC - Control Range:

- 1μV to 1 V r.m.s.

The lower end of the range is variable and dependent on both lamp voltage setting and the criterion used to define the threshold. As already stated clipping starts at 0.5 V r.m.s. with the normal oscillator input.

Gain Control - Control Range:

- 80 dB above 1μV

The results of the test relevant to this specification are given earlier.

Ganged AGC - Control Range:

- 110 dB

This specification is correct.

Distortion - Total:

- Steady state, less than 0.2%, 1μV to 100 mV, 8 to 250 Hz with 1 ms sampling.
- 15 dB Burst-out, less than 1.7%, 1μV to 100 mV, 20 to 250 Hz with burst-out up to 15 dB.

These specifications were not tested. The steady state distortion could be measured by a distortion meter. However it was not clear what was meant by the burst-out specification or the conditions of measurement.

High Level Output:

- Nominal level 6 V peak-to-peak with 15 dB burst-out capability.
- Maximum level 20 V peak-to-peak.

The high level output feeds both the galvanometers and the DS7-700 magnetic heads through a resistance network. The Hi-Z output is taken directly to the PMR-20 recorder from in front of the high level amplifier. Higher burst-out may be allowable therefore on the magnetic tape than on the camera.

Magnetic Recorder (PMR-20)

Frequency Response:

- Within 1 dB, 1 to 300 Hz
- Within 3 dB, 1 to 500 Hz

This specification was not checked.

Dynamic Range:

- 60 dB, 1 to 500 Hz with noise cancelling.
- 54 dB, 20 to 200 Hz without noise cancelling.

The measured values agree with the specified values.

Harmonic Distortion:

- Less than 1%.

This specification was not checked.

Cross-feed

- Below noise level of recording system.

This specification was not checked.

Timing Accuracy:

- absolute, 0.2 ms/s + 1 ms
- relative, ± 0.25 ms
- transfer relative, within 1 ms
- time delay, 0.66 ms

Performance with regard to timing accuracy is good. The above specifications are given to one hundredth of a millisecond but measurements were not made at this accuracy.

CONCLUSIONS AND RECOMMENDATIONS

The overall exercise was most worthwhile in bringing the equipment as close to specification as possible and acquainting BMR personnel with the equipment. It is apparent from the work carried out using the contract and later in the field that the work-load on Seismic Observers is high with the increased sophistication of equipment and methods.

A fairly satisfactory repair service was supplied by Dresser in Brisbane. The firm attempted to improve the efficiency of the service both by training of their personnel and in providing information on test procedures and a standard amplifier. This serivce should be utilized whenever possible. However in future, when overhaul of seismic equipment is done under contract, full specification testing should be written into the contract.

APPENDIX 1

List of Equipment

PT-700 System

- MU700 Master Unit consisting of 24 TGA-7 amplifiers, control units and GCU7 ganged AGC unit
- FU700 Filter Unit
- PS73 Power Supply
- SZC-1 Junction and Monitor Panel)
- AIB71B Output Connector Unit) Replacement for the MU70 AB Monitor Unit
- TRO-6 Oscillograph Camera)

Other equipment integrated with the PT-700 System

- PMR-20 Magnetic Recorder consisting of MU-20 Master Unit and MR-20 Magnetic Recorder
- Sercel Pre-Filter and Pre-Attenuator Unit
- FL-50CA Notch Filter
- GCU-3CE Programmed Gain Unit
- CAB Input Panel
- SZA-1 Input Patch Panel
- SZB-1 Signal Patch Panel
- DS7-700 Magnetic Recorder

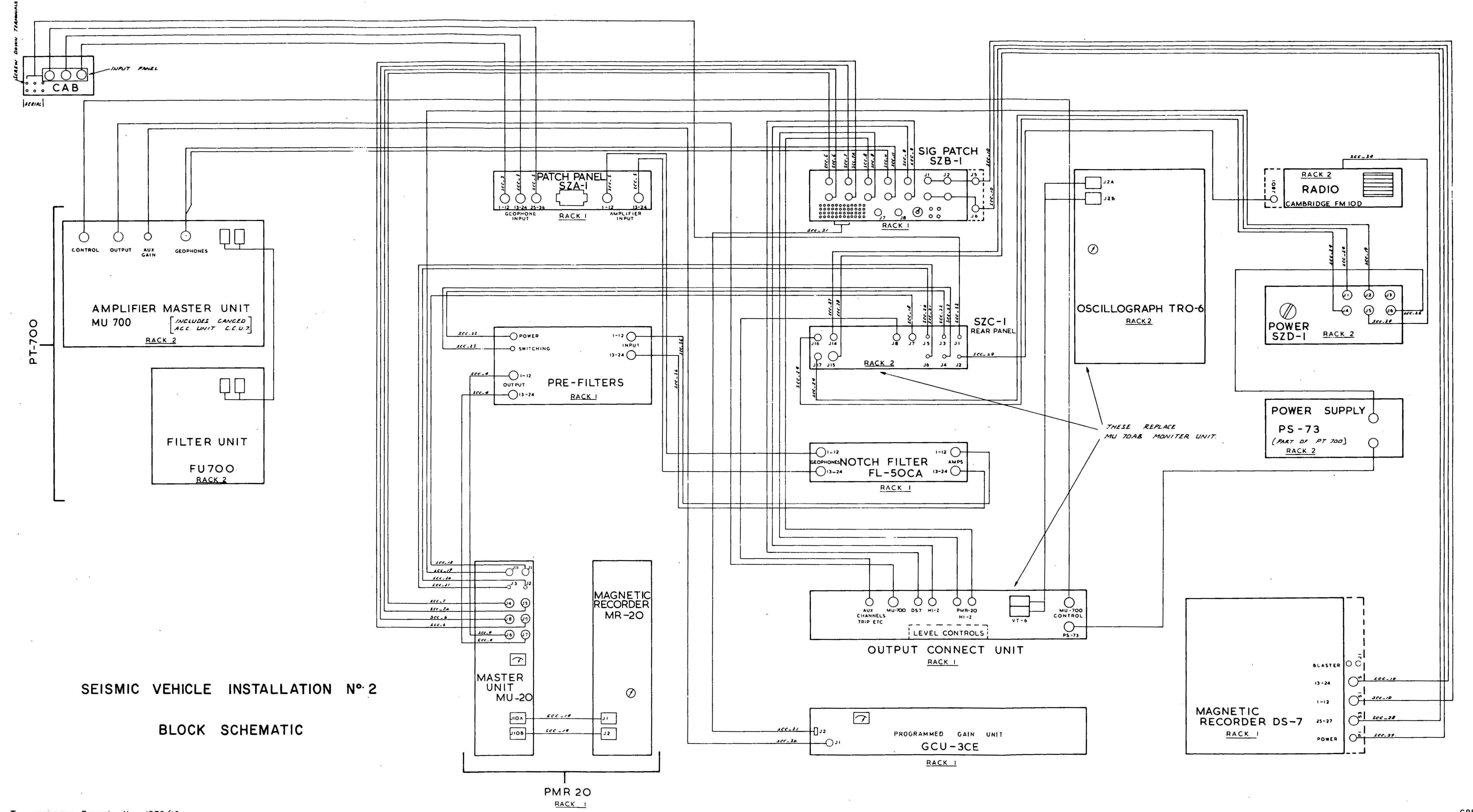
PLATE 1

- - - - - To be supplied by Bureau of Mineral Resources

SEISMIC RECORDING CAB

To Accompany Record No 1972/16

G85/1-2A



SEISMIC VEHICLE INSTALLATION No. 2

BLOCK SCHEMATIC

To accompany Record No. 1972/16

G85/1-24