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THE DREP 'QMIS' GEOMAGNETIC MICROPULSATION DATA RECORDS, 1969 T--ETC(U)
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Victoria, B.C.

Technical Memorandum 78-2

THE DREP 'QMIS' GEOMAGNETIC MICROPULSATION DATA RECORDS, 1969 TO 1974 — THEIR CONTENT AND INTERPRETATION

J. A. Shand

April 1978

Research and Development Branch

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Approved for distribution Kd Kendall
C/DREP

RESEARCH AND DEVELOPMENT BRANCH
DEPARTMENT OF NATIONAL DEFENCE
CANADA

ABSTRACT

A set of 25 digital magnetic tapes contain the better part of five years' single-component quantitative geogmagnetic micropulsation information recorded at a quiet site in Southern Alberta. These tapes, derived from the original records, now exist in a standard, readable format.

THE DREP 'QMIS' GEOMAGNETIC MICROPULSATION DATA RECORDS, 1969 TO 1974 - THEIR CONTENT AND INTERPRETATION

Foreword

Between June 1969 and October 1974 DREP recorded some salient features of the natural micropulsation background at position 50° 24' North, 111°02' West, a quiet site in Southern Alberta. The sensor was a metal-cored solenoid oriented in the X-direction (true north). Great care was taken to exclude unwanted noise, first through double shielding and burying the sensor, its calibrating circuit and connecting cable, next by treating the signal with a low-noise chopper-amplifier of DREP design and, further, by attending the site no more than once per week — to ensure that local activity effects be minimized.

Reference 1 describes the overall plan and function of the Quantitative Micropulsation Information System (QMIS). It also treats some examples of data development conducted by this Establishment. The following description, for the most part excerpted from that paper, serves to introduce the present one.

After suitable amplification and integration the micropulsation signal was originally fed to eight parallel measuring circuits, each covering successively narrower frequency bands, as the family of computed response curves in Figure 1 shows. Within each of these eight channels there were ten discrete amplitude-sensing levels set to increments of 4 dB plus an eleventh level to indicate channel overload. Although the lowest comparator levels differed between some of the adjacent channels, they did so in multiples of 4 dB. Figure 2 illustrates how a typically varying signal was treated by one of the comparators, in this case level 2. First, the signal represented by the heavy line was full-wave rectified, then, whenever the resulting signal

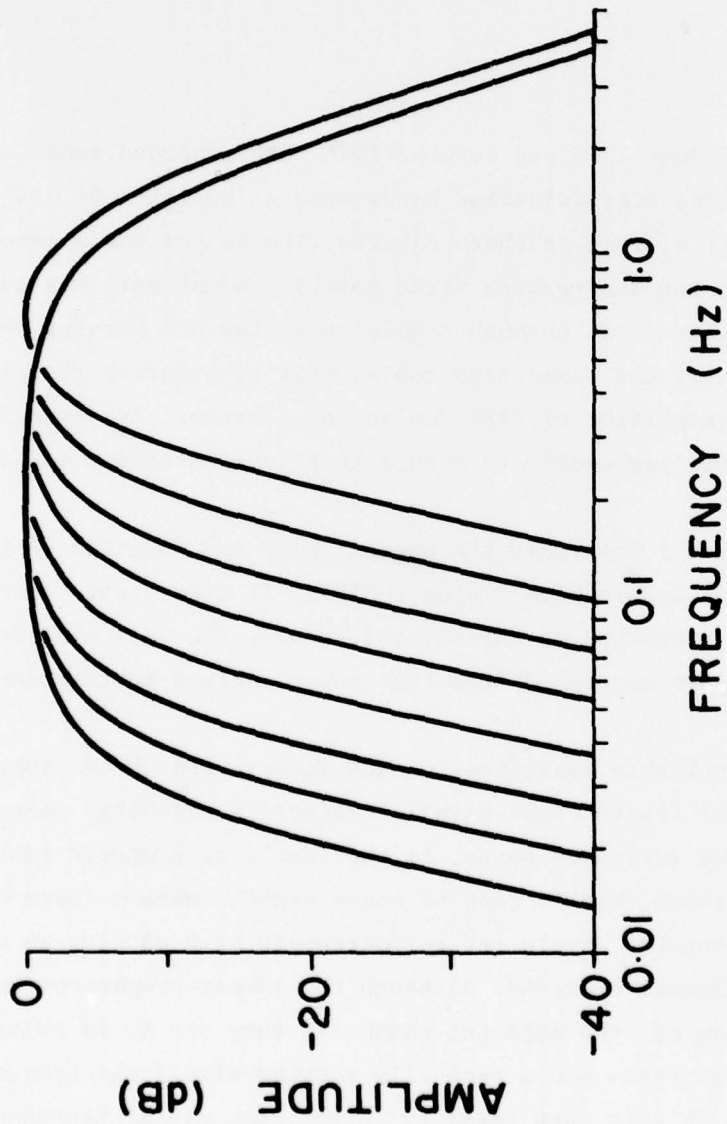

Figure 1. The computed frequency responses of channels 1 to 8, left to right respectively. To avoid confusion, the low-pass limits have been included for the first and last channels only; those for intermediate channels fall in order.

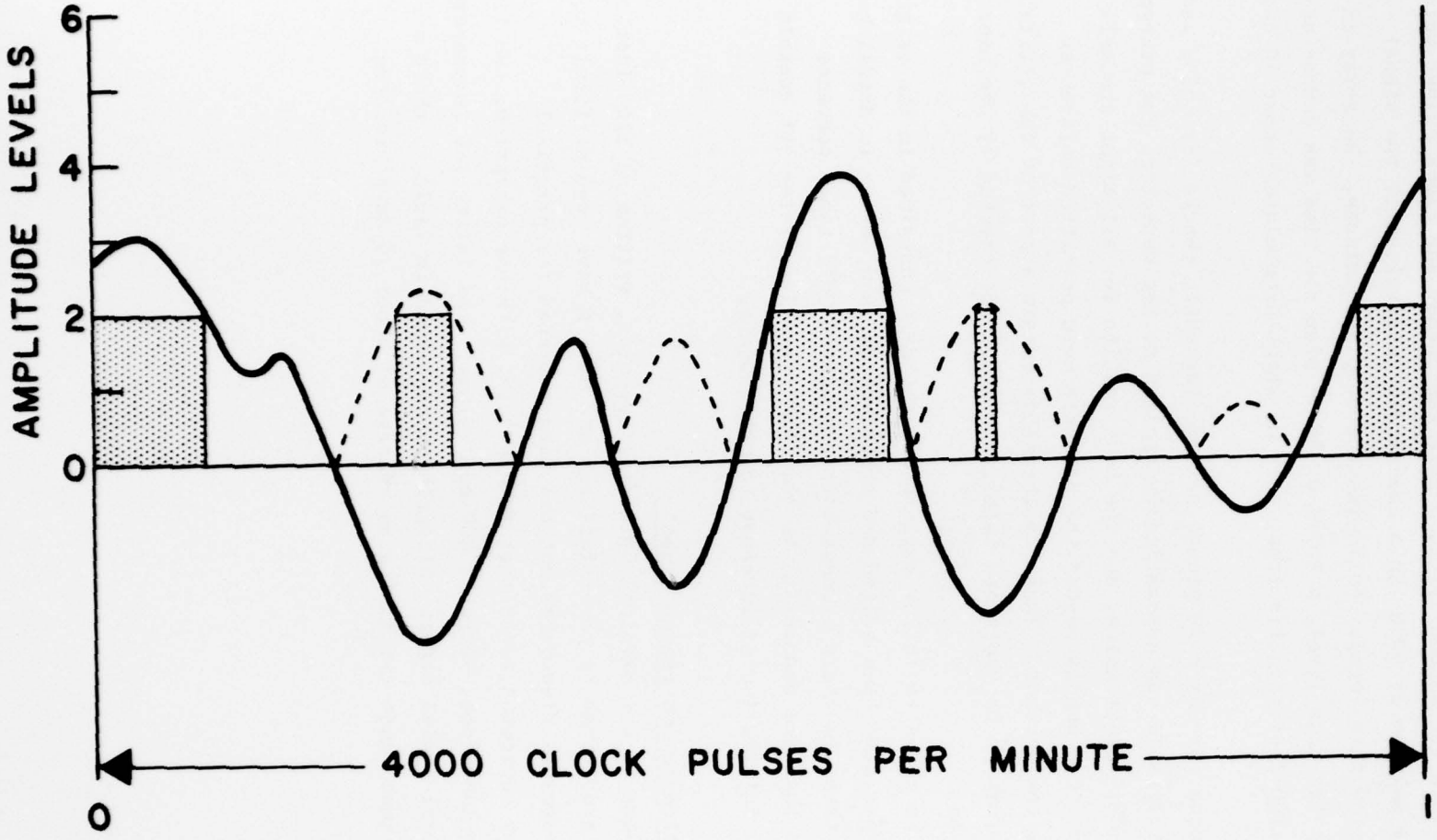

Figure 2. Background activity treatement by QMIS. The heavy trace represents the amplified incoming signal, while the dotted sections show the effect of inverting its negative excursions. When the full-wave rectified signal reaches or exceeds level 2, clock pulses are counted and the total, corresponding to the sum of the shaded portions, is recorded for each minute.

amplitude reached the second level, a gate was opened and clock pulses were counted, to a maximum of 4000 in a one-minute interval, until the signal again fell below this level. Following the completed minute, the array of counts — one for each level, a total of 88 — plus the time was dumped as a record on a 1200-foot magnetic tape, each of which accumulated about 40 days of records.

Once per day a 20-minute set of diagnostic checks for noise and calibration tolerance was automatically applied to the detector, the preamplifier and the QMIS electronics, and the test results for all eight channels were recorded. Components beyond the detector were permitted tolerances not exceeding one percent. These calibrations remain a part of the available record, in a form to be explained later, and should be checked by the user as the need arises.

The notes to follow explain how the data contained in the original QMIS field tapes have been edited and consolidated, and define in detail how to interpret them. In their present form the edited QMIS tapes commence with headings that are meaningful to the DREP operating system but contain little if any information of interest to other users.

The Organization of 'Corrected Tapes'

Some of the original QMIS field records, written on 1200-foot tapes, were interrupted by power failures and others have been difficult to read. This somewhat disordered set has been replaced for practical examination by corrected tapes that incorporate, with one exception, two field tapes on each 2400-foot, 9-track, 800-bpi volume. The latter set is numbered in chronological serial order. Altogether, as listed in Table 1, there are 26 corrected tapes each containing an average of about 76 days' records.

TABLE I

A Record of Original QMIS Field Tapes
and the volume to which they were copied

Field Tape Numbers	Start Time *	Stop Time	Final Tape Number	Start Time	Stop Time	
0308	176,23,1	177,19,1	3600	176,23,1	259,23,1	
0309	177,20,44	210,20,1				
0345	210,23,7	213,3,1				
0410	232,13,41	247,0,1				
0428	247,1,2	260,0,1				1969
0429	260,2,44	296,21,1	3601	260,4,0	332,1,0	
0431	296,21,49	332,1,1				
0432	332,4,48	372,16,1	3602	332,6,0	35,16,0	
0433	7,22,56	35,16,1				
0434	35,21,42	77,16,1	3603	35,23,0	107,20,0	
0436	92,21,51	107,20,1				
0620	107,21,12	120,21,1	3604	107,23,0	159,0,0	
0621	120,21,30	159,0,1				1970
0622	159,1,9	195,21,1	3605	159,3,0	232,20,0	
0624	196,21,35	232,20,1				
0625	232,20,50	269,17,1	3606	232,22,0	308,0,0	
0626	269,18,8	308,0,1				
0627	308,1,7	343,23,1	3607	308,3,0	384,16,0	
0628	344,0,26	384,16,1				
0629	19,19,1	63,21,1	3608	19,22,0	97,23,1	
0806	67,23,48	98,0,1				1971
0807	98,1,27	138,17,1	3609	99,3,0	174,17,0	
0664	139,5,19	174,17,1				
0920	174,19,1	195,10,1	3610	174,20,0	244,16,0	
0921	203,17,59	244,16,1				
0922	244,18,27	286,17,1	3611	244,20,0	327,16,0	
0923	286,19,13	327,16,1				

*The three sections, separated by commas, that specify time are days of the year (which did exceed 365 as will be explained), hours of the day, 0 to 23, and minutes. A zero minute indicates a completed hour and a one signifies the end of the first minute following the noted hour.

TABLE 1, CONTINUED

0924	327,19,14	369,21,1	3612	327,20,1	46,15,1	
0925	5,19,38	46,16,1				
0926	46,17,15	84,16,1	3613	46,18,0	124,15,0	
0927	84,16,25	124,15,1				
0928	124,16,6	159,16,1	3614	124,18,0	200,15,0	
0929	159,17,29	200,15,1				
1076	201,15,22	238,15,1	3615	200,17,0	276,16,0	1972
1077	238,16,27	277,15,1				
1078	276,19,0	314,16,1	3616	276,21,0	350,16,0	
1079	315,17,15	351,16,1				
1080	350,17,14	391,16,1	3617	350,19,0	6,16,0	
1081	25,17,28	66,16,1				
1082	66,17,351	07,16,1	3618	66,19,0	149,15,0	
1083	107,17,46	149,15,1				
1084	149,16,16	191,15,1	3619	149,18,0	204,14,0	1973
1085	191,16,57	204,14,1				
1086	207,8,1	241,14,1	3620	205,10,0	277,15,0	
1087	241,15,13	277,15,1				
1088	277,17,9	318,16,1	3621	277,19,0	353,16,0	
1089	318,18,27	353,16,1				
1110	353,18,31	394,16,1	3622	353,20,0	65,15,0	
1111	29,17,25	65,15,1				
1112	65,16,6	107,16,1	3623	65,18,0	142,15,0	1974
1113	107,20,1	142,15,1				
1114	142,15,40	184,15,1	3624	142,17,0	225,15,0	
1115	184,15,26	225,15,1				
1116	225,15,16	262,14,1	3625	225,17,0	296,13,0	
1117	262,15,12	296,13,1				

Tape Format

The principal unit of tape organization is the block, each of which with the exceptions for calibrations consists of one full hour of data, 10920 bytes in length. Only those hours during which no interruptions occurred have been included. Within the block, the shortest time resolution is the minute, known as a record, containing 91 elements of two bytes each. The first three elements, written in packed decimal format, identify Universal Time by day, hour and minute, a note on which seems appropriate.

However conventional their expression may seem, the designation of dates and times deserves explanation. Days of the year are numbered consecutively commencing with 1 January, but the first hour in the day is noted as zero. So also is the first minute in the hour. Because in this particular data set the readout distinguishes only integral minutes at the conclusion of the record interval, the first minute in the hour is denoted by a one rather than a zero. Some examples follow: 0001 0000 0001 denotes the first minute in a given year, 0001 0001 0000 denotes the last minute in the first hour and 0002 0000 0000 denotes the last minute of the first day. Until the counter had been reset manually, days of the year were recorded beyond 365.

Following its date and time notation a record's 88 serial elements, written in binary integer format, are best visualized if arrayed in 8 columns of 11 rows each as shown in Table II. Then, appearing from left to right are channels 1 to 8 and, from top to bottom, levels 1 to 11. Commencing 20 January 1971 Channels 6 and 8 were replaced by positions reserved for extending the dynamic range of channels 1 and 3, hence the anomalous appearance of these columns. Their content will be explained in the section 'Quantitative Interpretations.'

TABLE II

Programmed Arrays that Display the First Two Records in Adjacent Blocks *

Channel

LEVEL	1	2	3	4	5	1-X	7	3-X
	DATE 0020 0009 0001							
1	3160	2636	2461	2114	1178	0	604	0
2	2488	1894	1624	1393	390	0	25	0
3	1271	628	638	605	58	0	0	0
4	255	12	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
	DATE 0020 0009 0002							
1	3182	3161	2575	2237	994	0	490	0
2	2869	2382	1818	1394	211	0	42	0
3	2095	1492	954	425	0	0	0	0
4	1309	944	0	0	0	0	0	0
5	610	87	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0

*These examples have been chosen to illustrate the usual degree of continuity between successive minutes together with a rather extreme activity increase within an hour. As the simulated line printer outputs imply, the rows, not the columns, are reproduced in serial order.

TABLE II
(continued)

Channel

LEVEL	1	2	3	4	5	1-X	7	3-X
	DATE 0020	0010	0001					
1	3919	3974	3960	3965	3969	3308	3938	3393
2	3884	3953	3932	3946	3956	2885	3901	3089
3	3856	3929	3900	3919	3927	2294	3848	2615
4	3786	3889	3840	3879	3869	1512	3755	2015
5	3698	3788	3743	3818	3799	598	3615	1393
6	3527	3651	3620	3724	3692	66	3377	611
7	3307	3410	3396	3595	3531	0	2950	50
8	2891	3016	3079	3323	3214	0	2323	0
9	2297	2426	2606	2965	2747	0	1298	0
10	1518	1657	2013	2467	2019	0	329	0
11	0	0	0	0	0	0	0	0
	DATE 0020	0010	0002					
1	3989	3965	3983	3968	3957	3821	3878	3672
2	3982	3946	3973	3948	3926	3601	3821	3372
3	3971	3912	3958	3914	3979	3244	3702	2968
4	3953	3862	3934	3865	3823	2792	3492	2459
5	3929	3767	3893	3779	3735	1618	3178	1675
6	3885	3549	3832	3649	3564	622	2749	684
7	3821	3392	3671	3503	3348	0	2150	151
8	3602	3176	3360	3191	3027	0	1543	0
9	3248	2826	2961	2841	2365	0	775	0
10	2798	2251	2457	2421	1488	0	236	0
11	0	0	0	0	0	0	0	0

Overall Tape Organization.

1. The tape label consists of 88 bytes which, from a user's point of view can be ignored since its essential contents, the applicable volume numbers, are listed in Table I. Should the subject be of interest, the tape label does include its volume number and the corresponding numbers of the two field tapes that have been corrected and incorporated. These last appear as two consecutive 4-digit groups following QMIS, e.g., on volume serial numbered 3608 there is written QMIS 06290806. Volume 3600 is an exception; it contains parts of five field tapes.

2. Next is an end-of-file mark, two bytes in length.

3. A file label of 84 bytes follows. Although of possible interest to the DREP computer centre, this label should be ignored.

4. A block of data follows immediately. Excepting the one hour per day that includes calibrations, all of these are integral hours of 60 records each. There are no inter-record gaps since every record is headed by its own time marks, but a completed block is followed by a physical gap.

5. The calibration routines commence each day in the minute following 0400 hours UT. Their six modes treat the system in sequence.

(i) During the first minute a constant positive potential generated by a D/A converter was applied to all channels at the rectifier stage. Its function was to check the rectifiers and comparators for possible change in their dc response levels.

(ii) Similarly during the second minute a numerically equal negative potential was applied.

(iii) In the fourth minute the inputs to postamplifiers were grounded. An array of zeros can be expected.

(iv) Occupying the sixth minute a standard ac signal was applied to the first amplifier following the chopper-amplifier. Its function was to check the analog circuitry from that stage on.

(v) Throughout the eighth minute a standard ac signal was applied to the calibration winding of the detector coil and so provided a check on the entire system. However, the resulting outputs were influenced by the presence of natural background signals.

(vi) During the 14th minute a system noise test was performed by grounding the input to the preamplifier through a 39-ohm copper resistor. Under normal system operation only zeros should result.

6. The end-of-tape should be indicated by one or more end-of-file marks. Some volumes contain irrelevant writing beyond the end-of-tape. Since it has not been economically practical to erase this, it must be ignored.

As indicated above, the calibrations were expected to deviate by no more than $\pm$ 1 percent. A quick scan of the numerical arrays should usually confirm the system's state of serviceability. Table III samples a calibration set.

Complementing the hour per day that contains the calibrations are 40 data records commencing with the 21st minute. The complete block then consists of 8372 bytes.

TABLE III

THE FIRST THREE OF SIX SYSTEM

DIAGNOSTIC CHECKS

LEVEL	CHANNEL 1	2	3	4	5	6	7	8
	DATE	0022	0004	0001				
1	3941	3940	3941	3942	3942	3942	3941	3942
2	3907	3907	3908	3909	3909	3908	3908	3909
3	3854	3854	3855	3855	3855	3855	3854	3855
4	3769	3770	3770	3771	3771	3770	3770	3771
5	3634	3635	3636	3637	3637	3637	3636	3637
6	3421	3424	3425	3422	3425	3424	3424	3425
7	3083	3089	3087	3088	3089	3088	3087	3089
8	2550	2555	2549	2554	2554	2554	2554	2550
9	1700	1708	1716	1710	1713	1711	1709	1714
10	373	360	380	364	374	373	373	378
11	0	0	0	0	0	0	0	0
	DATE	0022	0004	0002				
	3942	3942	3942	3942	3942	3942	3942	3942
	3908	3908	3909	3909	3908	3908	3908	3909
	3855	3855	3856	3855	3854	3855	3855	3855
	3771	3771	3772	3771	3769	3771	3771	3771
	3635	3636	3638	3636	3634	3637	3637	3637
	3424	3424	3427	3422	3421	3424	3425	3424
	3086	3089	3091	3087	3083	3088	3089	3088
	2555	2554	2554	2552	2545	2553	2556	2549
	1707	1705	1723	1707	1699	1710	1712	1712
	383	356	390	358	352	370	376	375
	0	0	0	0	0	0	0	0
	DATE	0022	0004	0004				
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

TABLE III, CONTINUED

The final three system diagnostic checks. Again, as noted, the outputs in the sixth and eighth columns differ from the others.

DATE 0022 0004 0006

3974	3991	3996	3992	3968	3597	3936	3912
3960	3977	3992	3988	3948	3381	3900	3864
3938	3975	3988	3956	3924	3072	3824	3744
3897	3956	3980	3936	3876	2722	3724	3500
3838	3927	3964	3904	3808	2216	3560	3056
3743	3880	3948	3852	3696	1261	3088	2120
3597	3812	3916	3752	3492	0	2680	0
3384	3705	3860	3616	3212	0	2364	0
3074	3527	3740	3384	2776	0	1690	0
2727	3237	3492	3000	2028	0	1236	0
0	0	0	0	0	0	0	0

DATE 0022 0004 0008

3985	3994	3989	3991	3974	3759	3958	3785
3977	3988	3984	3981	3961	3615	3939	3669
3961	3983	3977	3973	3939	3389	3895	3486
3940	3972	3959	3960	3901	3011	3838	3191
3904	3957	3924	3937	3844	2326	3741	2797
3848	3932	3864	3908	3756	1563	3548	2247
3758	3892	3786	3843	3621	672	3114	1549
3617	3827	3668	3763	3405	0	2604	0
3390	3726	3487	3613	3061	0	2291	0
3022	3560	3191	3382	2541	0	1621	0
0	0	0	0	0	0	0	0

DATE 0022 0004 0014

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Quantitative Interpretations

The amplitude levels applicable to each recorded channel are specified in dB above 1.25×10^{-4} gamma or, very nearly, 10^{-7} amperes per metre peak. It is recalled that the incoming signals were full-wave rectified. Therefore, to obtain the approximate peak-to-peak amplitudes of the incoming signals, six dB should be added to the lowest threshold not exceeded.

Table IV lists the maximum sensitivities of each channel, i.e., those of level 1. Successive levels up to 10 register decreasing sensitivities in 4 dB steps. The eleventh level serves only to indicate that the tenth has been exceeded by 3 dB or more.

As a result of numerous overloads encountered during the first few months of operation, the system sensitivities were reduced in November 1969. Further overloads led to extending the dynamic range of channels 1 and 3 in January 1971. To accomplish this, channels 6 and 8 were abandoned and their comparators were employed to extend the levels of channels 1 and 3, hence to be designated as 1-X and 3-X. Note that the new threshold levels assigned to the positions once occupied by channels 6 and 8 result in the duplication of levels 7 to 10, inclusive, of channels 1 and 3 plus six higher levels. This feature becomes apparent in the calibration record of the eighth minute of Table III and in the natural background records of Table II.

TABLE IV

The threshold sensitivities of level 1

in dB above 125 microgammas peak.

	25 June to 28 Nov 1969	28 Nov 1969 to 20 Jan 1971		20 Jan 1971 to 23 Oct 1974
Channel	dB	dB	Channel	dB
1	28	36	1	36
2	24	32	2	32
3	16	28	3	28
4	16	24	4	24
5	16	24	5	24
6	12	20	1-X	60
7	12	20	7	20
8	12	20	3-X	52

Note that from 20 January 1971 the record units occupying positions assigned to channels 1 and 6 were combined to form channel 1 extended (1-X). Similarly, positions 3 and 8 were combined to form 3-X.

Reference

1. Shand, J.A., Progress with QMIS - Status 1974(U), DREP Technical Memorandum 74-1, December 1974.

Acknowledgements

The foregoing explanations and specifications result from the continued dedicated efforts of Susan Rountree, who programmed, edited and performed the tape conversions, and J.C. Farmer who reviewed carefully the arrangement, interpretation and validity of both the data and the calibrations.