TECHNICAL MEMORANDUM (NASA) 21

FLIGHT TEST OF 4-HZ AND 30-HZ OMEGA RECEIVER FRONT-END

A test flight in a DC-3 aircraft was conducted to evaluate the performance of a 4-Hz ultra-narrow-band, Omega receiver front-end compared to a more conventional 30-Hz bandwidth receiver. Results indicate that the 4-Hz front-end has superior signal-to-noise performance. Other interesting results obtained during the test flight were recordings of the sunset noise effects on amplitude, and the attenuation of signal levels when flying through clouds.

by

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(NASA-CR-146383) FLIGHT TEST OF 4-Hz AND 30-Hz OMEGA RECEIVER FRONT-END (Ohio Univ.) 18 p HC $3.50 CSCL 17G

N76-17085

Unclas
G3/04 14236

February 1976

Supported by

National Aeronautics and Space Administration
Langley Research Center
Langley Field, Virginia
Grant NGR 36-009-107

I. INTRODUCTION

The primary purpose of this test was to gather in-flight information on two Omega receiver analog modules ("front-ends"), one having a 4-Hz bandwidth and the other a 30-Hz bandwidth. This data is to be used in the determination of a front-end design to be incorporated in the Ohio University receivers for the Omega prototype contract. A secondary purpose of the test was to gather in-flight data on the Mini-O receiver, recently designed and built at the Ohio University Avionics Engineering Center.

II. RESULTS

As would be expected, the narrower bandwidth (4-Hz) front-end displayed better signal-to-noise characteristics than did the 30-Hz front-end. This property can be seen upon inspection of Figures 3, 5 and 12. (Note that figures are arranged in time sequence as recorded during the flight.)

As predicted by the calibration curves[1,2] of the two front-ends, the 30-Hz circuit has a larger dynamic range than the 4-Hz and the saturation of the 4-Hz limiter occurs at a lower signal level (see Figure 8). Although this dynamic range can and may be improved, it really is of little consequence in Omega receiver operation.[1] The gain was increased for this flight evaluation to observe the amplitudes on the weaker Omega signals. The gain has very little effect on the phase measurement. (At the extremes of gain it may introduce a 1% error or 1/100th of a lane, but with a 6-bit receiver the resolution is not quite 1/100th of a lane, making the error negligible.)

Also, the slower rise and fall times, which are characteristic of the narrower bandwidth front-end, can easily be viewed in Figure 10. Other interesting flight data such as the sunset noise effect is included within and noted on the figures.

III. CONCLUSIONS

An improved signal-to-noise characteristic of the narrower bandwidth front-end with negligible loss in dynamic range indicates that the 4-Hz front-end is the more desirable for the prototype Omega receivers.

The Mini-O receiver was found to function quite satisfactorily on its second test flight, and has a very real potential for a low-cost, low-power, compact and light-weight Omega receiver.

IV. DATA

Included in this technical memorandum are some of the data records gathered on a flight evaluation conducted on the three pieces of equipment: A 4-Hz bandwidth front-end, a 30-Hz bandwidth front-end and the Mini-O Omega receiver which uses the 4-Hz front-end. The test flight was conducted on December 12, 1975. The morning flight (approximately 0500-0630 hours EST) was from the Ohio University Airport, Albany, Ohio to Langley Air Force Base, Hampton, Virginia. The evening flight (approximately 1630-1900 hours EST) was from Langley back to Albany.

V. RECOMMENDATIONS

(1) Preamplifier bandpass filtering should be used to minimize occurrences of broadcast band and VLF communication interference. (It should be noted that the Avionics Engineering Center is presently bench-testing a Omega preamplifier with response which is 10 dB down at 6.6-KHz and 19-KHz. This preamplifier also has an output for driving an ADF receiver in the event that the user is receiving Omega signals via an existing ADF antenna.)

(2) As can be seen in Figure 6, strong interference was encountered shortly after takeoff from Langley on the return flight. It is believed that the airplane was near a power plant at this time, which may have been the cause (10.2-KHz is the 170th harmonic of 60-Hz). Also, on previous test flights some type of interference has been experienced while near the Henderson, West Virginia VOR. Such observations indicate that the problem of local interference with Omega reception should be given further study.

(3) A study should be undertaken to determine the exact effects of the type of antenna used, physical location of the antenna on the plane, environment of the antenna and aircraft orientation in space. Coinciding with the antenna tests, experimentation with different preamplifiers is needed to determine optimum combinations. Shown on Figures 4, 9 and 11 are changes in Omega signal strength reception. Although these changes can be correlated to certain conditions (i.e. changing altitude, noise envionment and humidity) their specific cause is an area needing further research. (The antenna used in this test was a top-mounted wire, stretched from the tail to the forward cabin of the DC-3, a length of about 10 meters, at a distance of approximately 2 meters above the aircraft body.)

(4) Although the Mini-O receiver performed very well, it did display some interference anomalies which need further examination. Testing of this receiver should be continued.

VI. REFERENCES

[1] Burhans, R. W., "Low-Cost, High-Performance, VLF Receiver Front-End", Technical Memorandum (NASA) 18, Avionics Engineering Center, Department of Electrical Engineering, Ohio University, Athens, Ohio, September, 1975.

[2] Burhans, R. W., "The Mini-O, A Digital Superhet, Or, A Truly Low-Cost Omega Navigation Receiver", Technical Memorandum (NASA) 20, Avionics Engineering Center, Department of Electrical Engineering, Ohio University, Athens, Ohio, November, 1975.

VII. DISCUSSION OF FIGURES

The figures included in this report are arranged chronologically with Figures 1 through 4 being the morning flight. All data was taken at 10.2-KHz and the following arrangement was followed on the chart recordings:

Channel 8 - phase measurement by Mini-O (as indicated where appropriate).
Channel 7 - phase measurement by Mini-O (as indicated where appropriate).
Channel 6 - signal amplitude from 4-Hz bandwidth front-end.
Channel 5 - signal amplitude from 30-Hz bandwidth front-end.
Channel 4 - unused.
Channel 3 - event mark.

VIII. ACKNOWLEDGEMENTS

Ralph W. Burhans of the Avionics Engineering Center designed and constructed the equipment for evaluation and directed the flight test, while student assistants Gerald Bryant, Dan Moyer and the author assisted in testing and evaluation. Dr. Richard H. McFarland is Director of the Avionics Engineering Center.

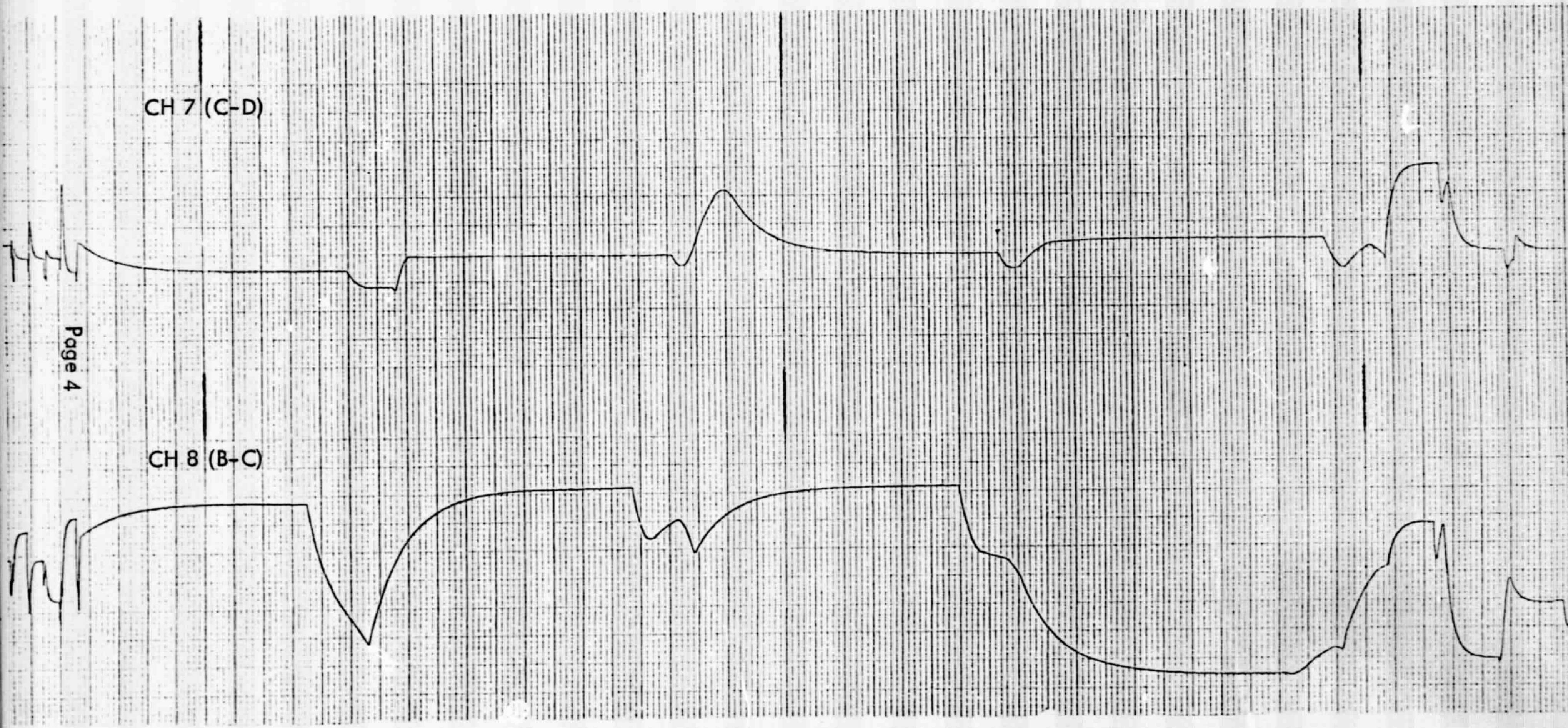

Figure 1. Display of Phase Measurement at Increased Chart Speed $(2.5 \frac{mm}{s})$.

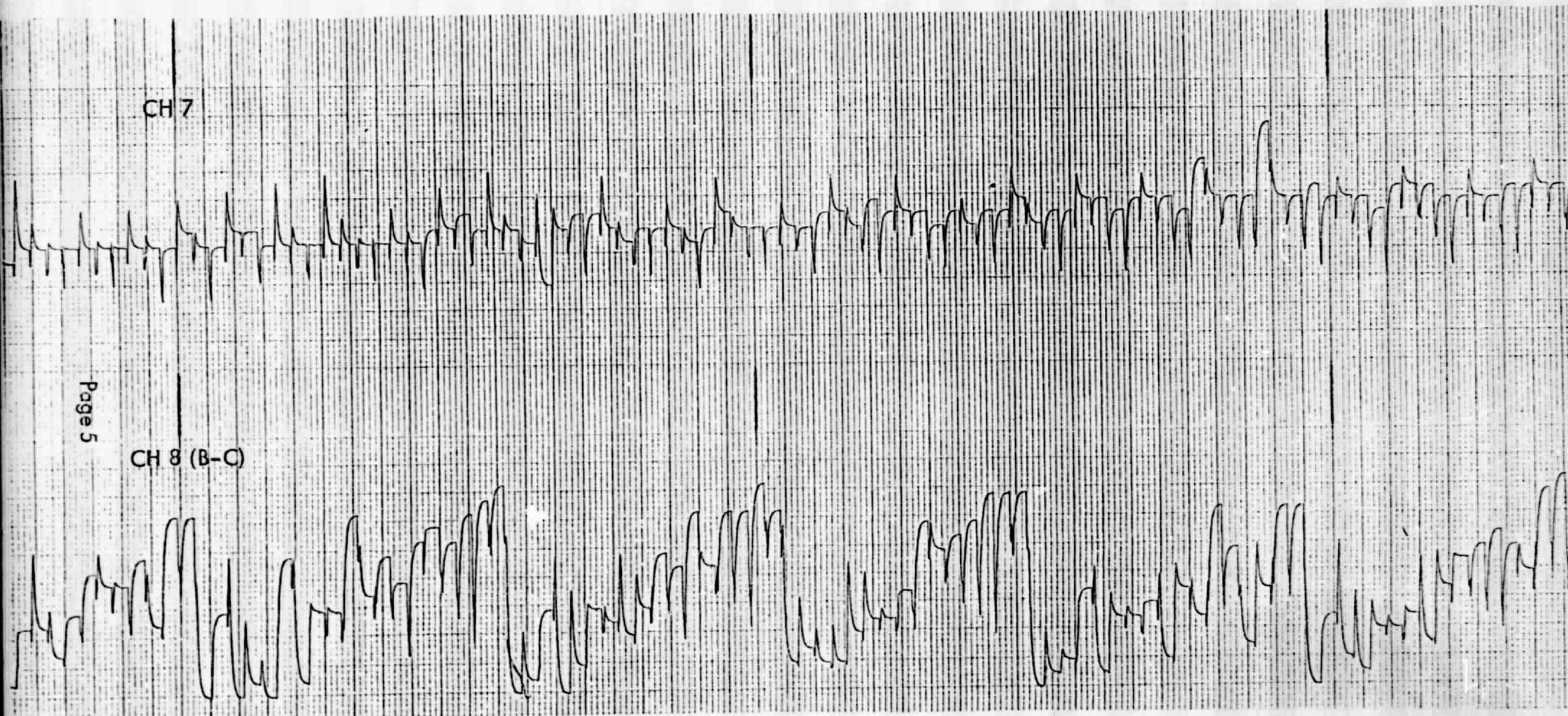

Figure 2. Phase Measurement. Note obvious l.o.p. tracking on Channel 8.

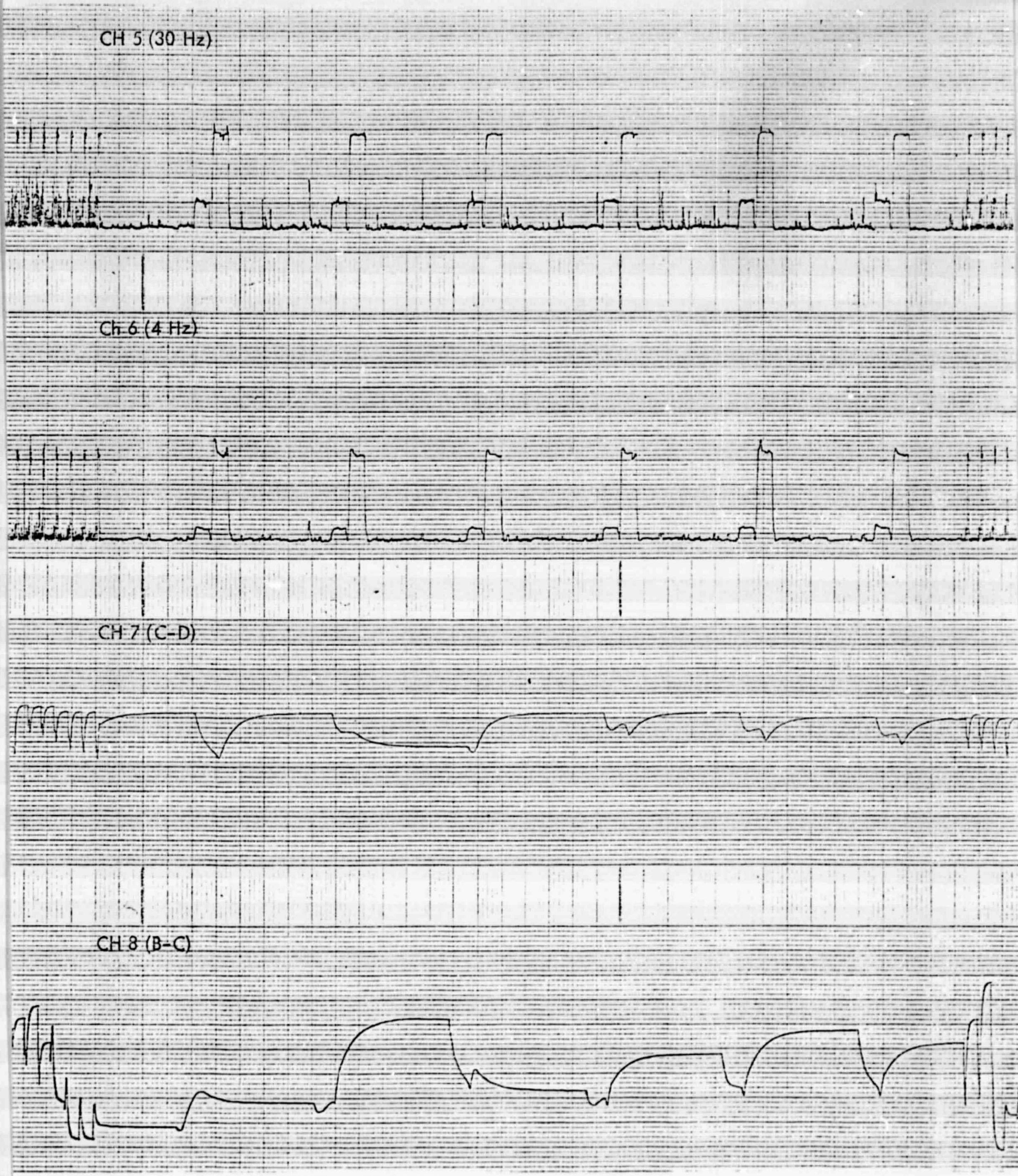

Figure 3. Channels 5 and 6 are Amplitude Measurements. Note difference in noise levels. Channels 6 and 7 are phase measurements at increased chart speed (2.5 $\frac{mm}{s}$).

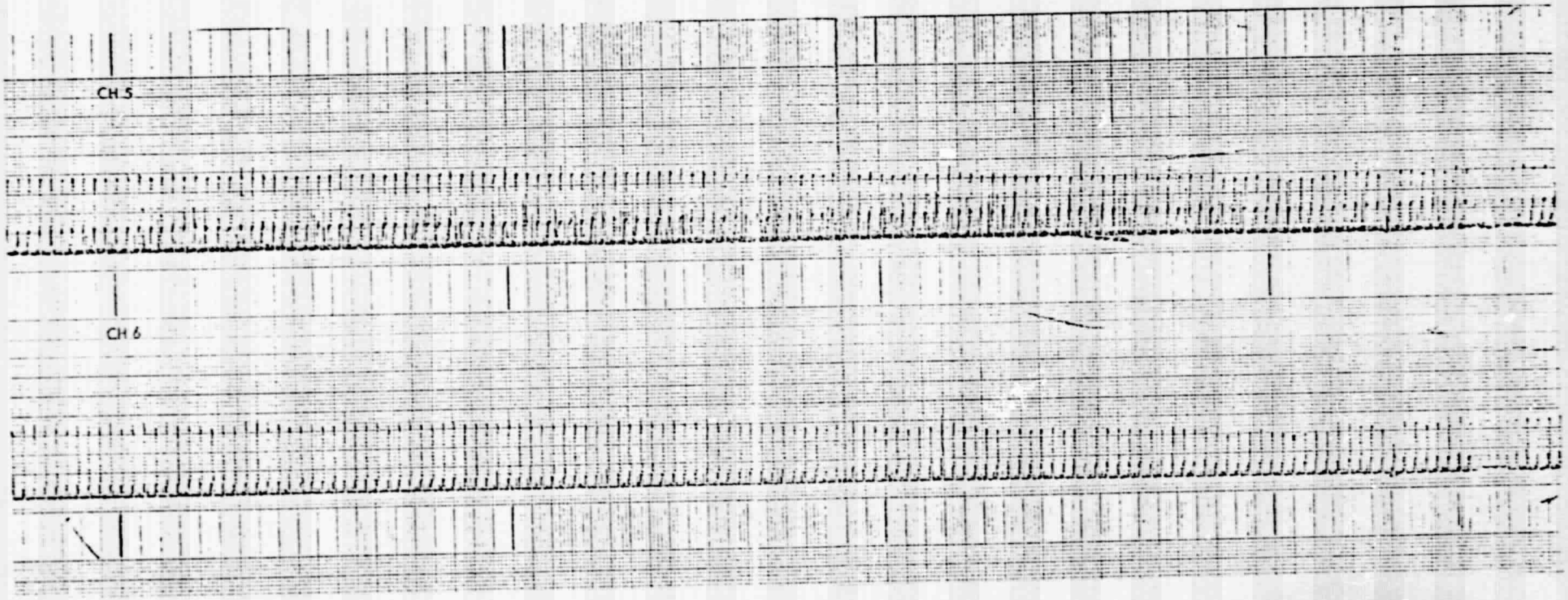

Figure 4. Signal Amplitude. Not decreasing signal levels during landing (at Langley AFB, Virginia).

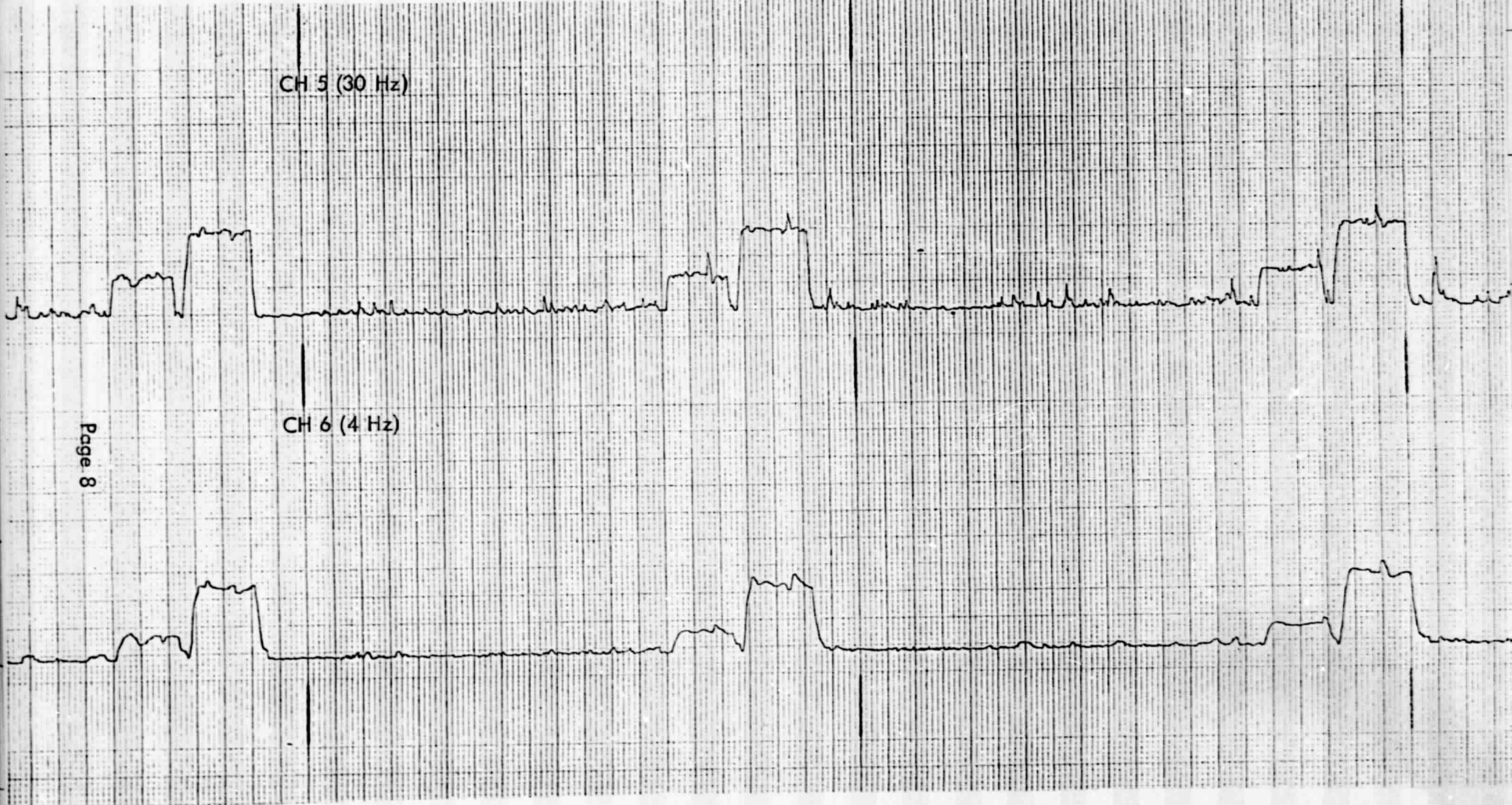

Figure 5. Signal Amplitude. Note the difference in noise levels of the two front ends.

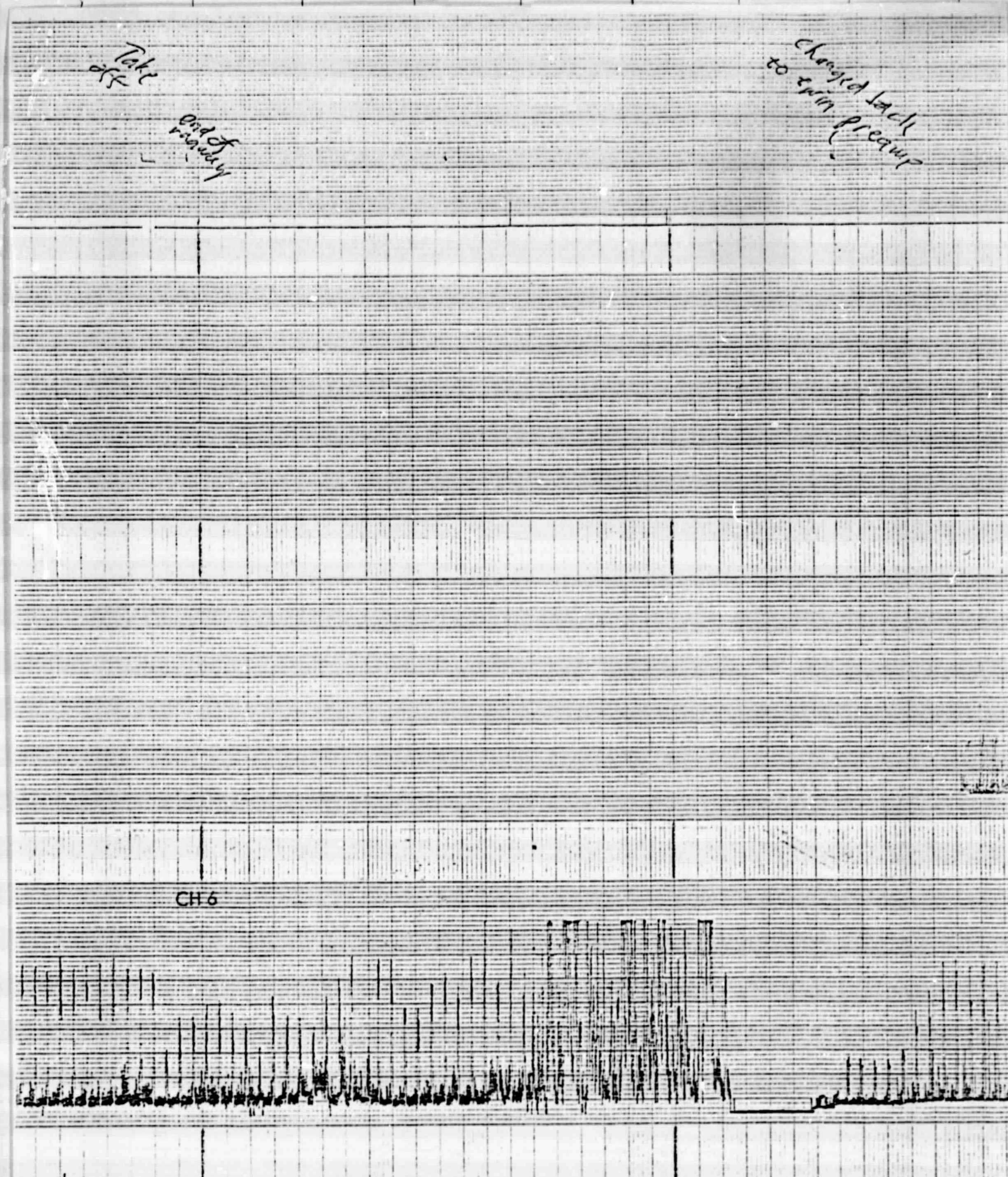

Figure 6. Signal Amplitude--note unknown interference. Possible strong 60 Hz - possible preamp problem.

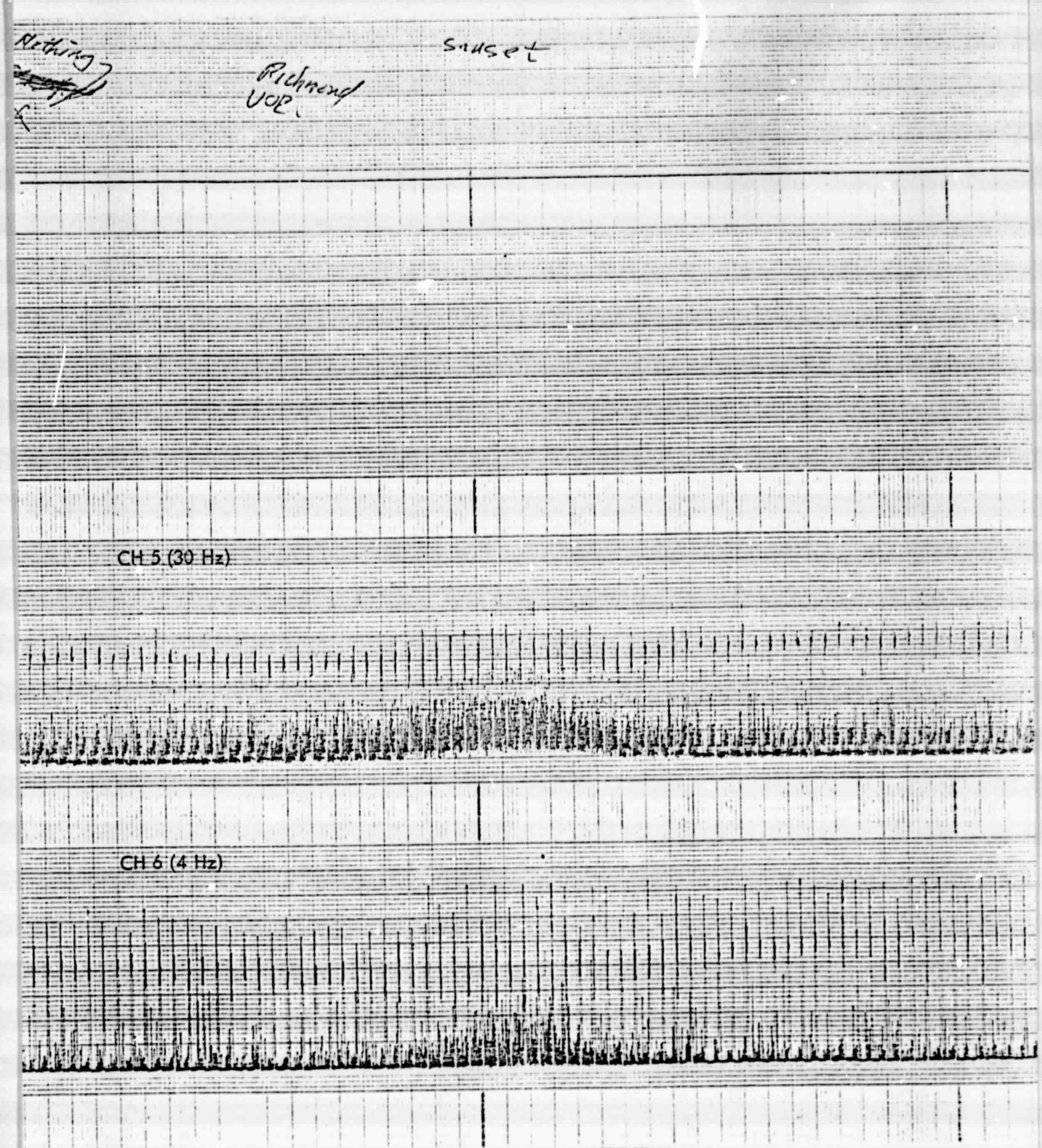

Figure 7. Signal Amplitude. Note sunset effect on signal levels.

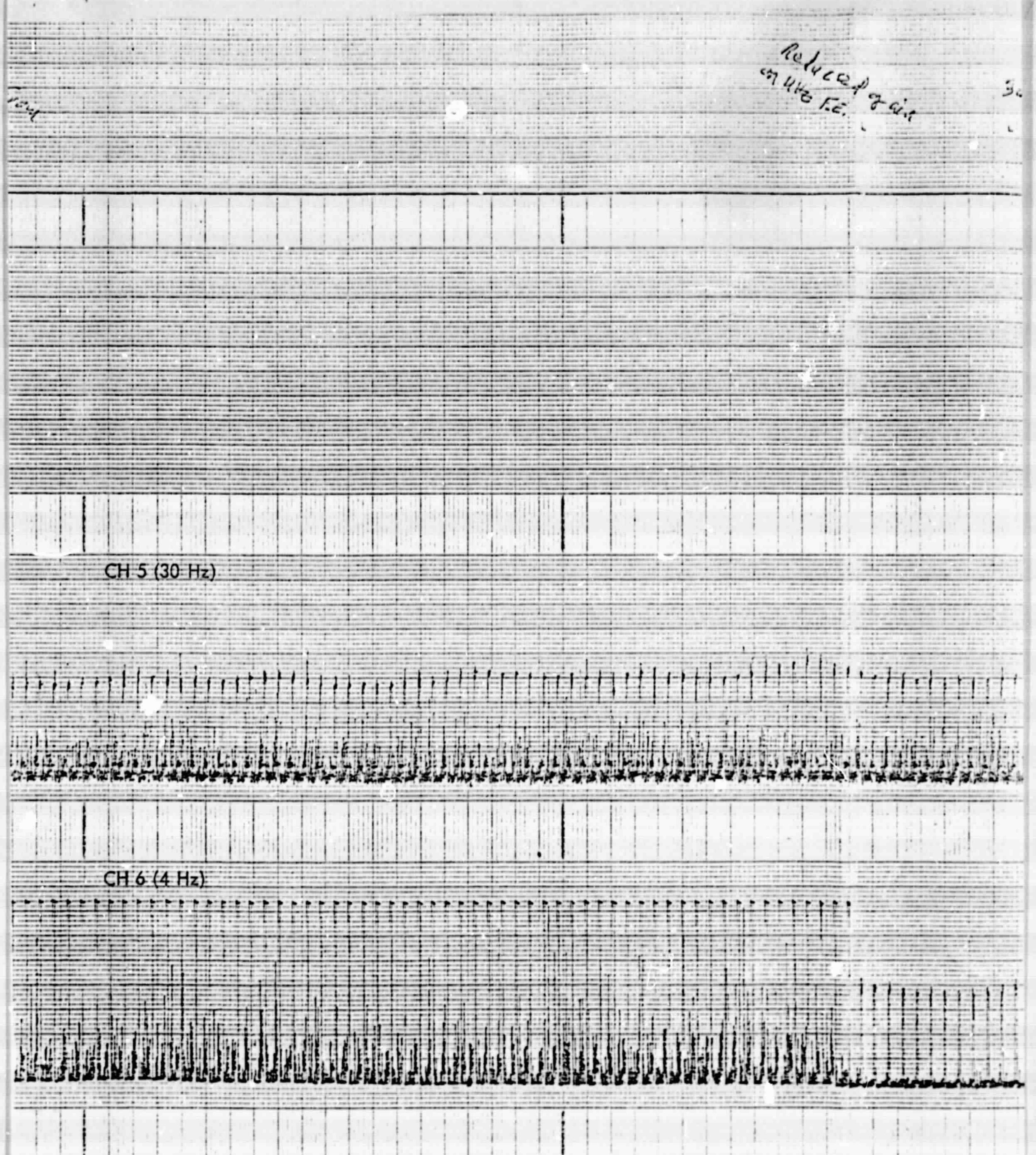

Figure 8. Signal Amplitude. Note saturation of 4 Hz Front-End at High Gain Setting.

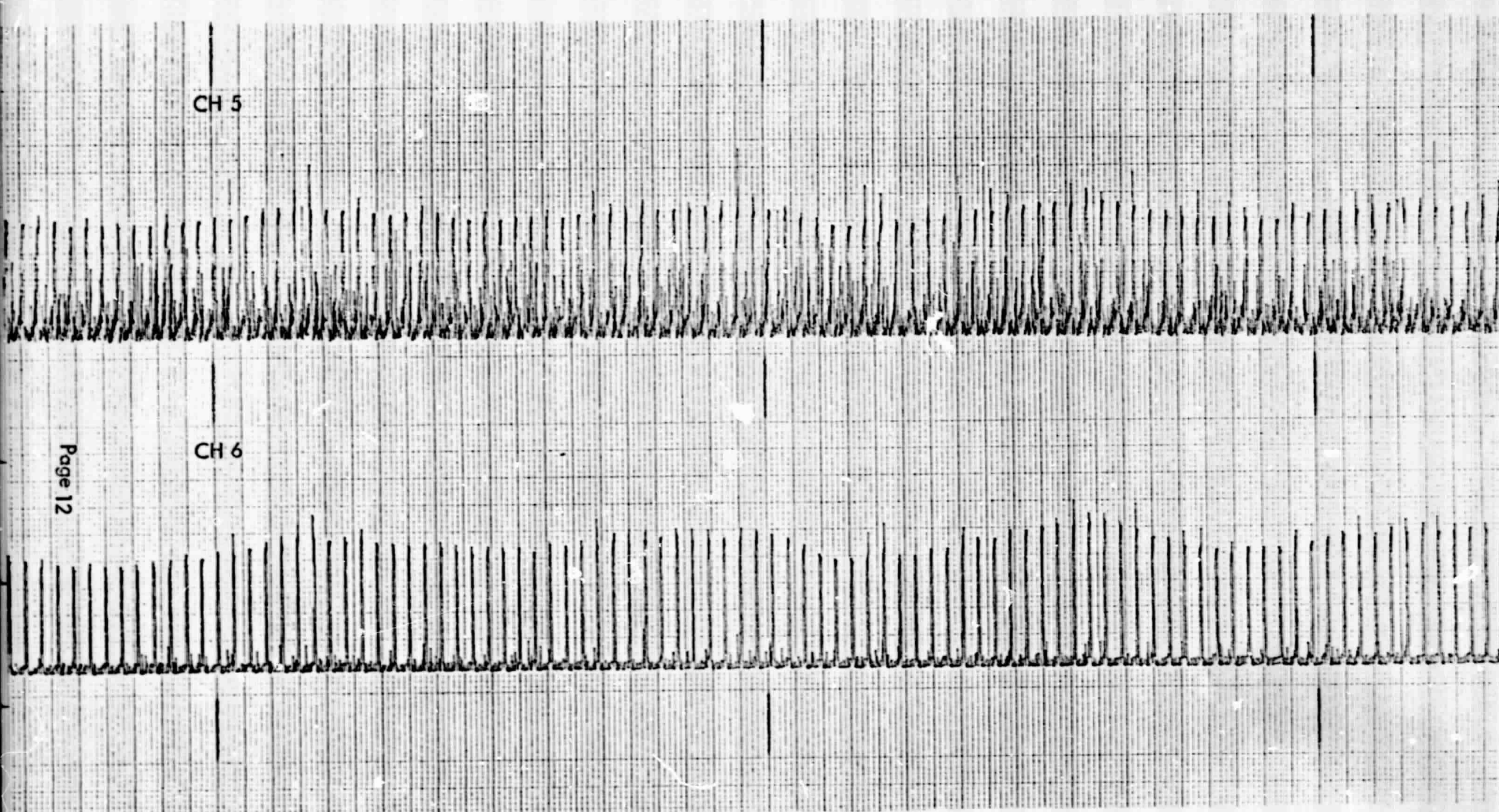

Figure 9. Signal Amplitude. Note wet cloud effect on signal level.

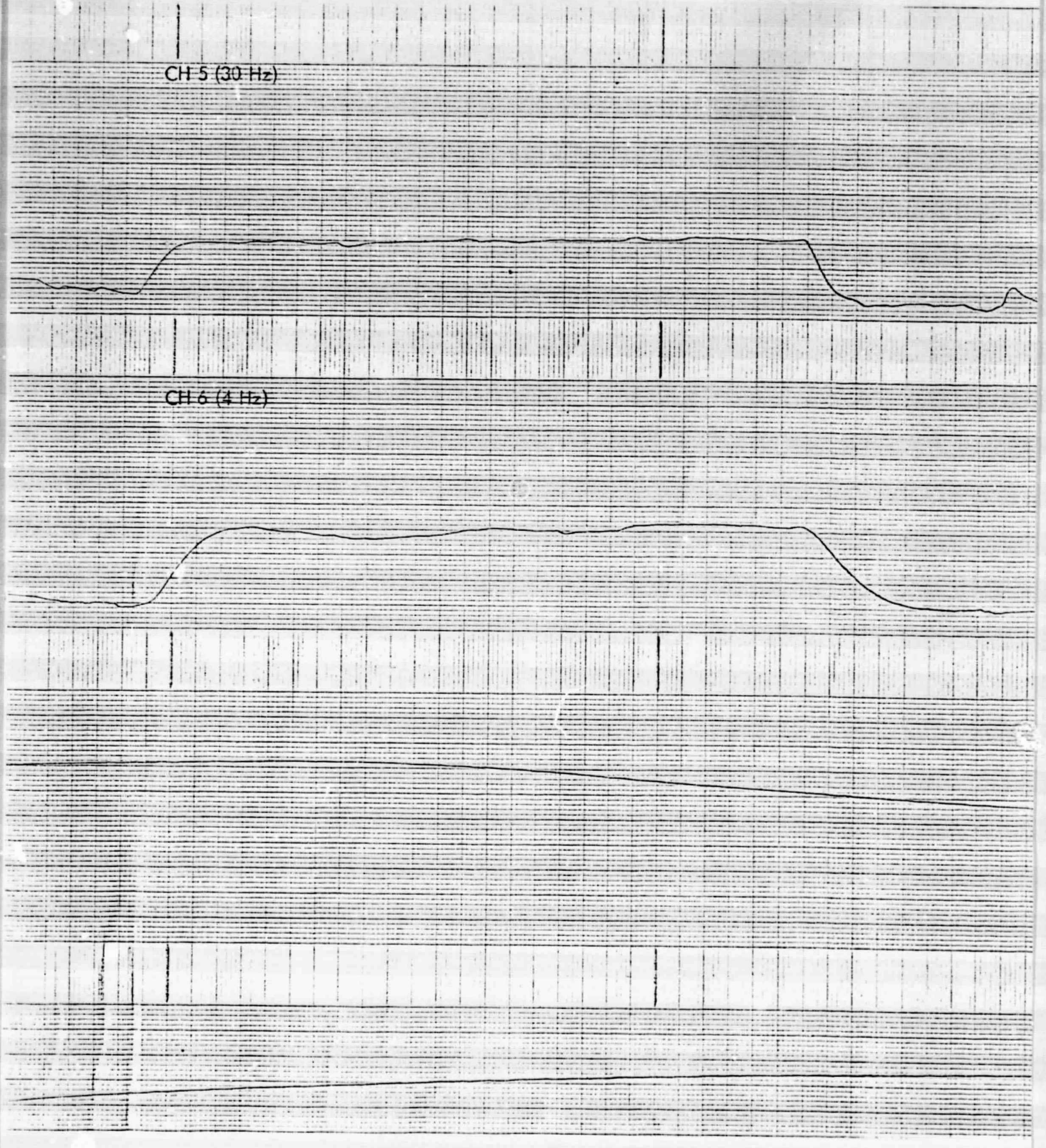

Figure 10. Signal Amplitude. Note rise and fall times.

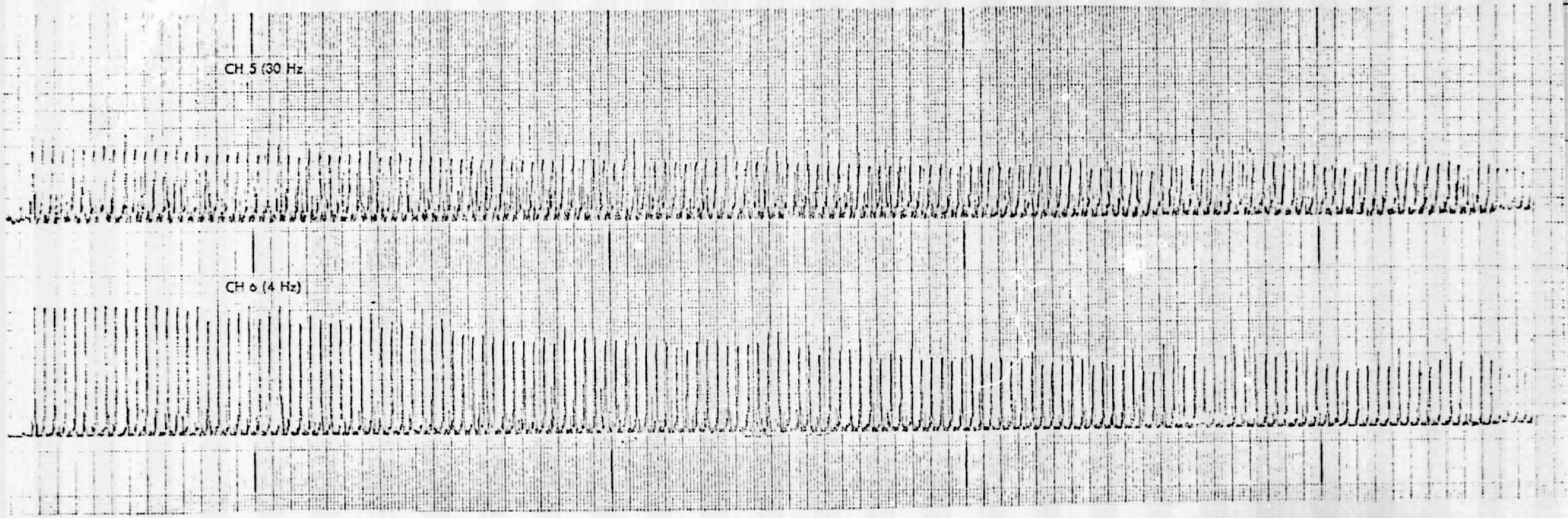

Figure 11. Signal Amplitude. This is during landing at Albany. Note decreasing amplitude.

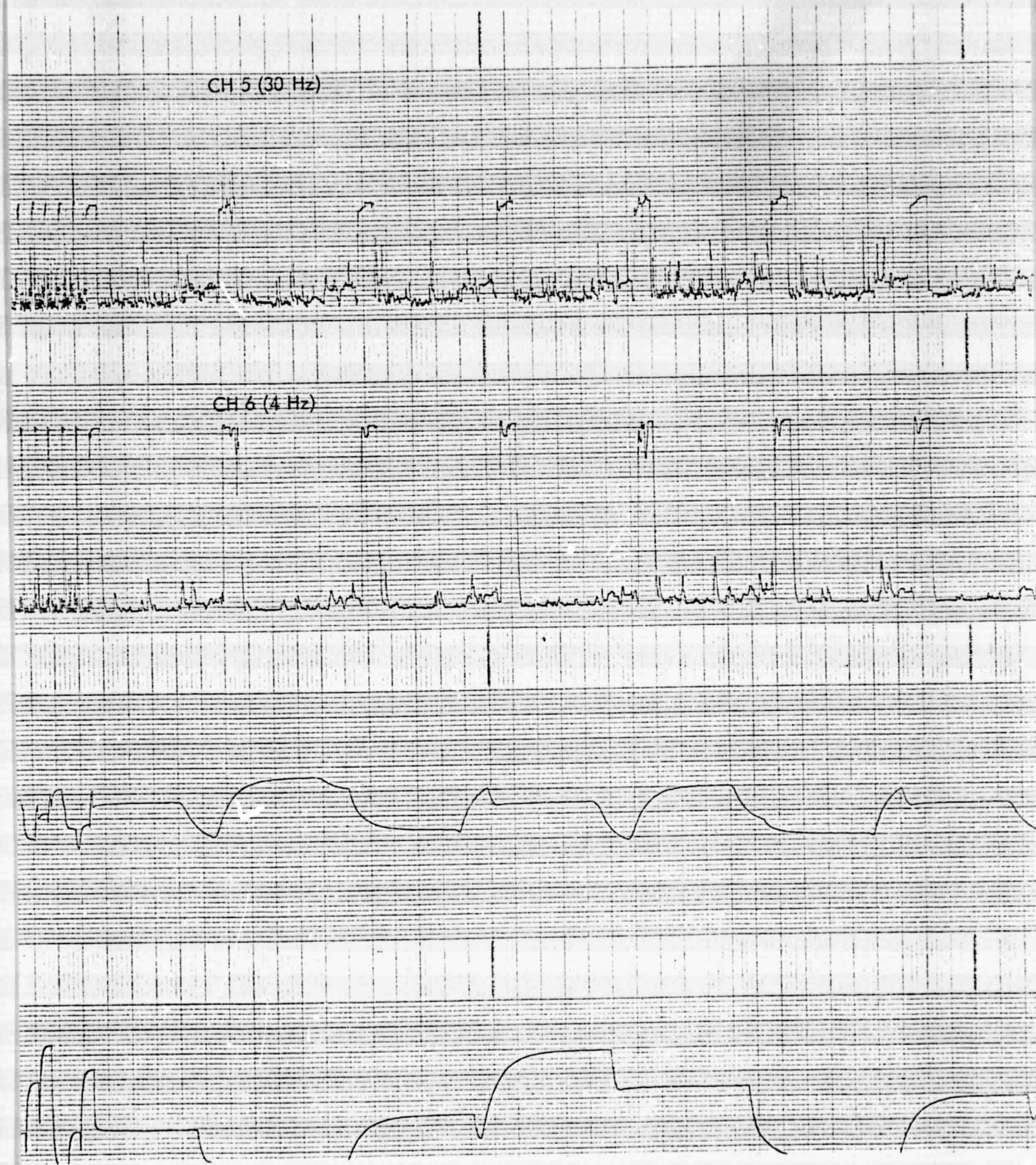

Figure 12. Signal Amplitude. Note difference in noise.

0458 hrs. EST - All Equipment On and Operating O.K.

Channel 8	Channel 7	Channel 6	Channel 5	Channel 3
B-C(.05V/D)	A-B(.5V/D)	AM-4-Hz (.05V/D)	AM-30-Hz (.05V/D)	EM

0502 hrs. EST	Take off.
0519 hrs. EST	114° @ 107NM/Hr.
0534 hrs. EST	Changed to small preamp - 30Hz. F.E. off recording Mini-O data only.
0537 hrs. EST	Changed to C-D on Channel 7
0530 hrs. EST	135° @ 130 NM/Hr.
~0600 hrs. EST	Bridgewater Airport
0611 hrs. EST	Gordonville VOR - approximately 1 mile to VOR we begin to turn more South.
--	155° @ 129 NM/Hr.
0623 hrs. EST	Changed back to original (dual) preamp
0628 hrs. EST	Richmond VOR
--	At Richmond we turned East to 130° on course directly towards Langley.
~0629 hrs. EST	Broadcast band interference.
--	After changing preamps it appears that the 2nd output preamp is worse as far as 2nd harmonic distortion is concerned.
0633 hrs. EST	Landed, Langley Air Force Base.

Figure 13. Log of Flight from Albany to Langley on December 12, 1975.

Return (Langley to Albany)

10dB Preamp in Operation to Mini-O

Channel 8	Channel 7	Channel 6	Channel 5	Channel 3
B-C	C-D	AM-4-Hz	AM-30-Hz	EM
A-B	C-A			
B-B(.05V/D)	B-D			
B-C(.05V/D)				

1637 hrs. EST	Take off from Langley.
--	EM #2 end of runway 25.
--	EM #3 Newport News Airport.
--	Changed back to original preamp.
1658 hrs. EST	Changed to A-B on Channel 8
1702 hrs. EST	325° @ 160 NM/Hr.
1711 hrs. EST	310° @ 140 NM/Hr.
1720 hrs. EST	8000 ft. - 315° @ 142 NM/Hr.
1722 hrs. EST	1000 ft. below strato-cummlus with moderate haze
1733 hrs. EST	Entered heavy clouds (Note: A.M. variations from wet cloud effect)
1806 hrs. EST	315° @ 140 NM/Hr.
1815 hrs. EST	315° @ 150 NM/Hr.
1821 hrs. EST	Level at 6000 ft. - Heading 290° @ 140 NM/Hr.
1840 hrs. EST	Began descent.
--	Unmarked event; just before turning chart speed up, turned off scope to try stabilizing clock (eliminate heat from scope).
~ 1905 hrs. EST	Downwind for runway 6.
1907 hrs. EST	Touchdown, Albany, Ohio.

Note: At about 1855 hrs. EST noticed that the Mini-O had been set to track B-B and C-A instead of A-B and C-D. At this point we switched to B-C on Channel 8 and B-D on Channel 7 for remaining minutes of flight.

Figure 14. Log of Flight From Langley to Albany on December 12, 1975.