<u>Research on the Radar Properties of Birds in the United Kingdom.</u>

Echoes produced by birds are important to radar users. [illegible] revealed the presence of potentially hazardous situations, for example, where birds cross operational runways daily at dawn and dusk [illegible] flights. They also [illegible] unwanted echoes that affect the efficient operation of the radar.

Current radar research in the UK is being directed at both these aspects, and since both problems require a knowledge of the properties of birds and radar, current work is being concentrated in this area.

Specifically, we have a contract at the Marconi Research Laboratories reviewing the frequency and the nature of natural echoes detectable on air traffic control radars in the UK. As one of the most important sources of natural echoes in the UK are birds, the radar properties of birds will be studied on this or on a subsequent contract.

We have another contract at Loughborough University considering the radar properties of birds in connection with the birdstrike problem. From this work we hope to say whether or not we might obtain data on the amount of bird material (flesh and bone) hazarding the aircraft under radar surveillance. We want to know bird mass rather than bird density, because one Blackbird per square kilometre would produce a very dense PPI display of bird echoes on a powerful surveillance radar, while a flock of 10 Mute Swans would show up as one echo. The Swans would present a very serious hazard, but the Blackbirds would not.

We have a further contract at EMI Ltd looking at the echoing areas of birds. The echoing area varies as the position of the bird changes with respect to the radar. The echo signal is directly proportional to echoing area and is small at the head and tail aspect and large when the bird is broadside-on. EMI with aid from MAFF, are placing specially prepared dead birds on a rotating mount and measuring their echoing areas at different aspect angles. This is being done for a number of birds of the flocking varieties. From these results and fluctuation data we shall studied the possibility of assessing the bird mass detected by radar. Echoing area diagrams are also [illegible] in our fluctuation studies.

RRE with the aid of RAE, is looking at the fluctuation characteristics of echoes received from birds, because max. detection range depends upon the fluctuation characteristics. Bird echoes fluctuate because the bird's aspect changes in flight and its body changes as it flaps its wings. We are specially interested in the wingbeat modulation patterns, first discovered by Capt. A.F.Davenport, RFMS,TA, on his war-surplus radar, because in many cases they can be used for quickly sorting out single birds from other targets and large birds from small birds. This interest will be heightened if it should prove as limited trials have shown that a very large number of birds fly alone at night (ie., sufficiently separated to be resolved by a suitable radar).

The first four slides show wingbeat modulation patterns obtain from birds on Spring migration by a C-band tracking radar. Slide 1 is the radar signal from a bird continuously flapping its wings. The Y and X axis scales are one large square for 10dB change in signal level and for 1 second duration of time, respectively. The periodicity of the sawtooth wingbeat modulation pattern is about 9 cycles per second, and this is probably the physical wing beat frequency of the bird. A spectrum analysis of this radar signal is shown in fig.1, and for this short piece of record the spectrum curve shows a peak at 9.14 Hz. The radar signal on slide 2 is for a bird flying with bursts of wing activity and then pauses. The sort of flight that finches and titmice make. The spectrum of this signal is shown in fig.3, the curve in the thick line, gives a peak about 1.4 Hz and this corresponds to the recurrence frequency of the cycle of activity and pause. The second peak at 9.8 Hz is the fundamental wingbeat frequency and the third peak at 19.7 Hz is the second harmonic frequency of the wingbeat. Slide 4 is of another bird with this finchlike cycle of wingbeat activity. The spectrum curve of fig.4 again shows the recurrent frequency about 1.4 Hz but the wingbeat frequency is 7.7. Hz for this bird. The effect of changes in the bird's trajectory can be seen in slide 5, this is from the same record as slide 4 but some seconds later. The effect on the spectrum can be seen in the dotted curve of fig. 5. The first peak is still at 1.4 Hz and the fundamental wingbeat frequency is still at 9.14 Hz, but this peak is broader and the second harmonic is absent.

All the curves shown are for single birds at night, flying relatively straight trajectories and at fairly constant velocities. Some birds, flying alone, fly twisting courses or yaw and pitch in flight. The sixth slide is of a Rock Pidgeon. This bird flew a jinking flight and the radar signal fluctuates in a very random manner. The spectrum of fig.6 shows the wingbeat frequency to be quite lost in the heavy fluctuation produced by aspect changes. The final slide is of a herring gull making a foraging flight for food. Because the bird's flight, is erratic, there are large random fluctuations that cover up the wing beat frequency. Fortunately in a record lasting a few minutes it is usually possible to find a part of the record where it is possible to extract the wingbeat rate.

Fig. 1

WINGBEAT MODULATION SPECTRUM

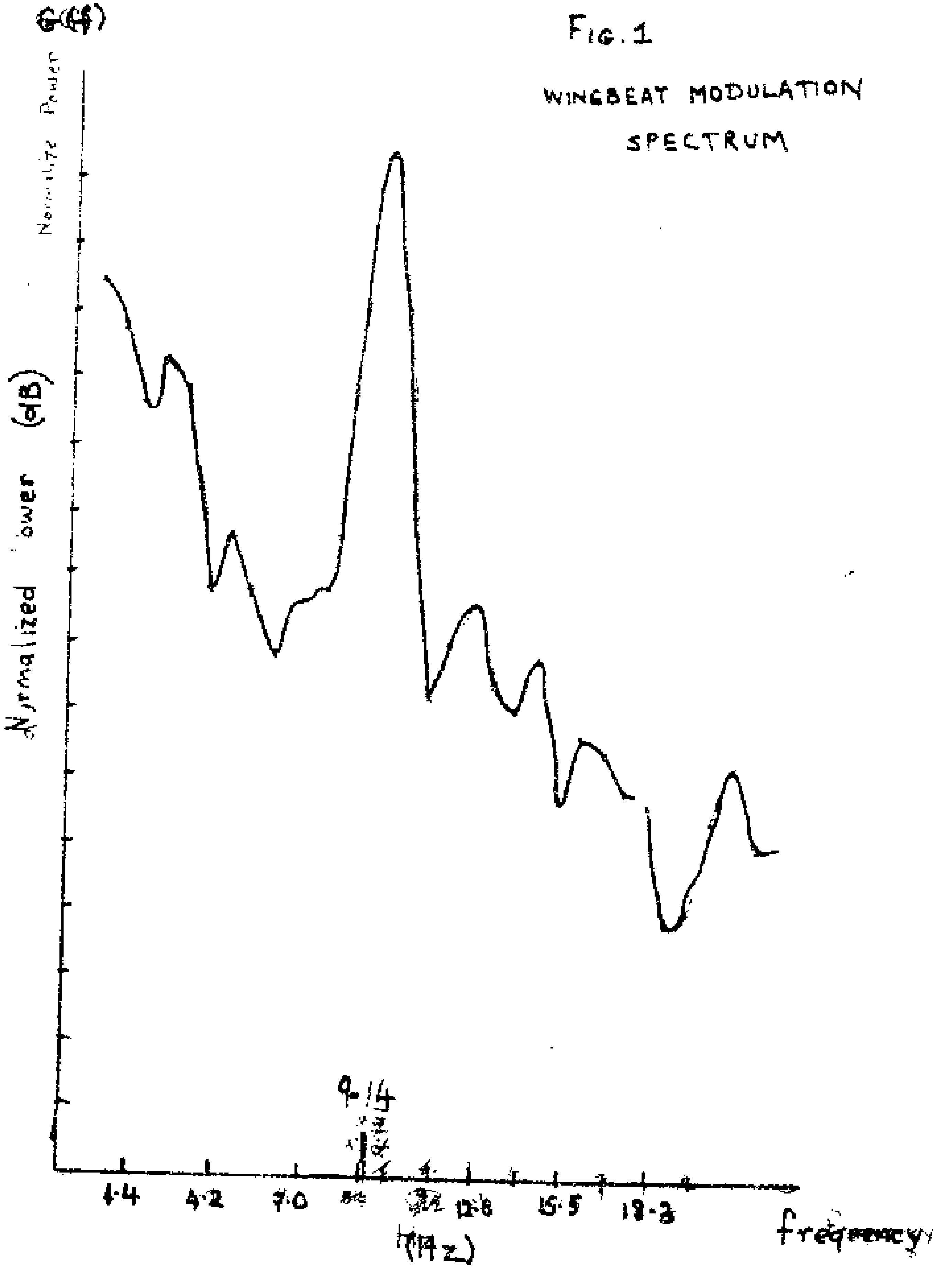
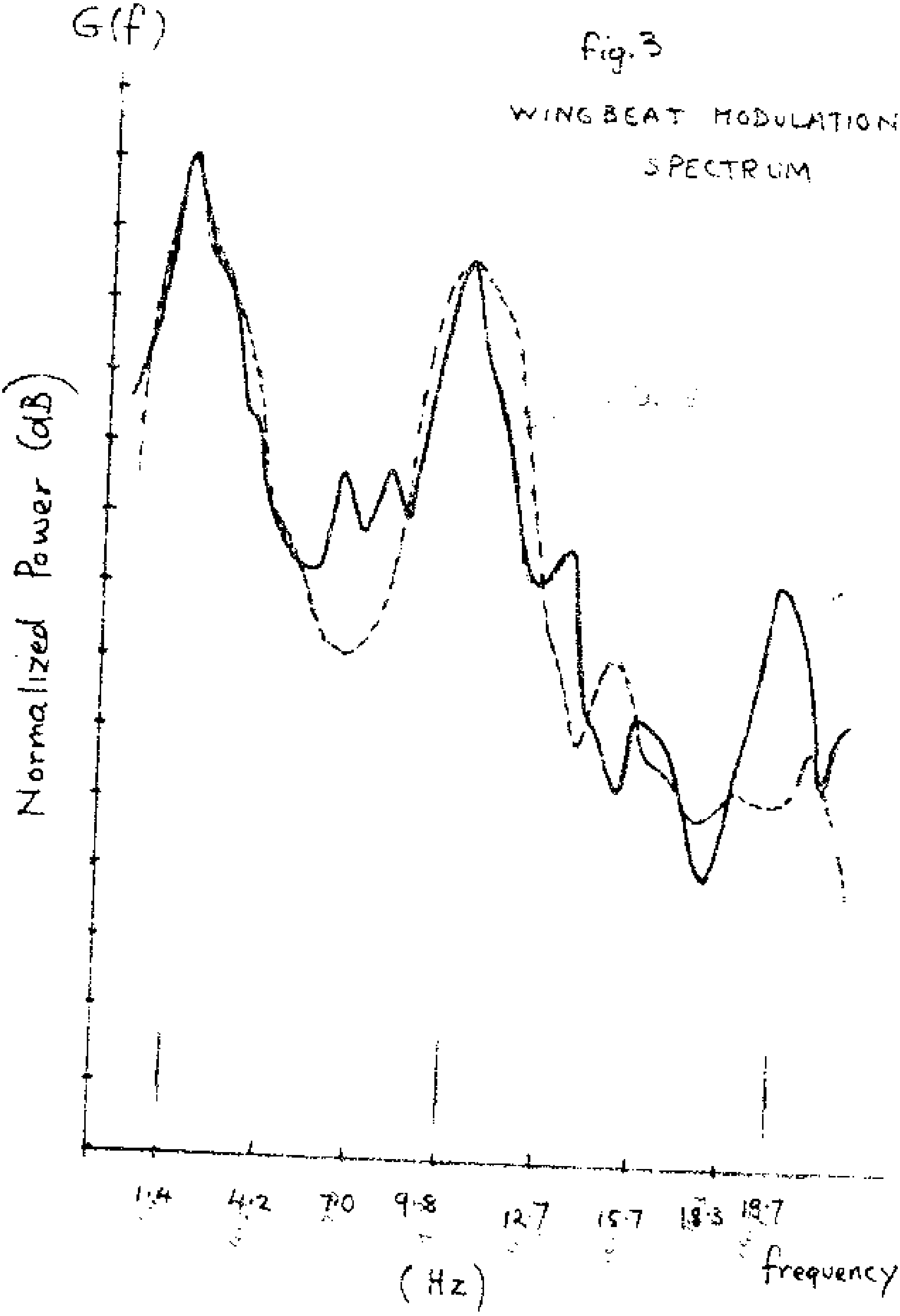


fig. 3

WINGBEAT MODULATION SPECTRUM



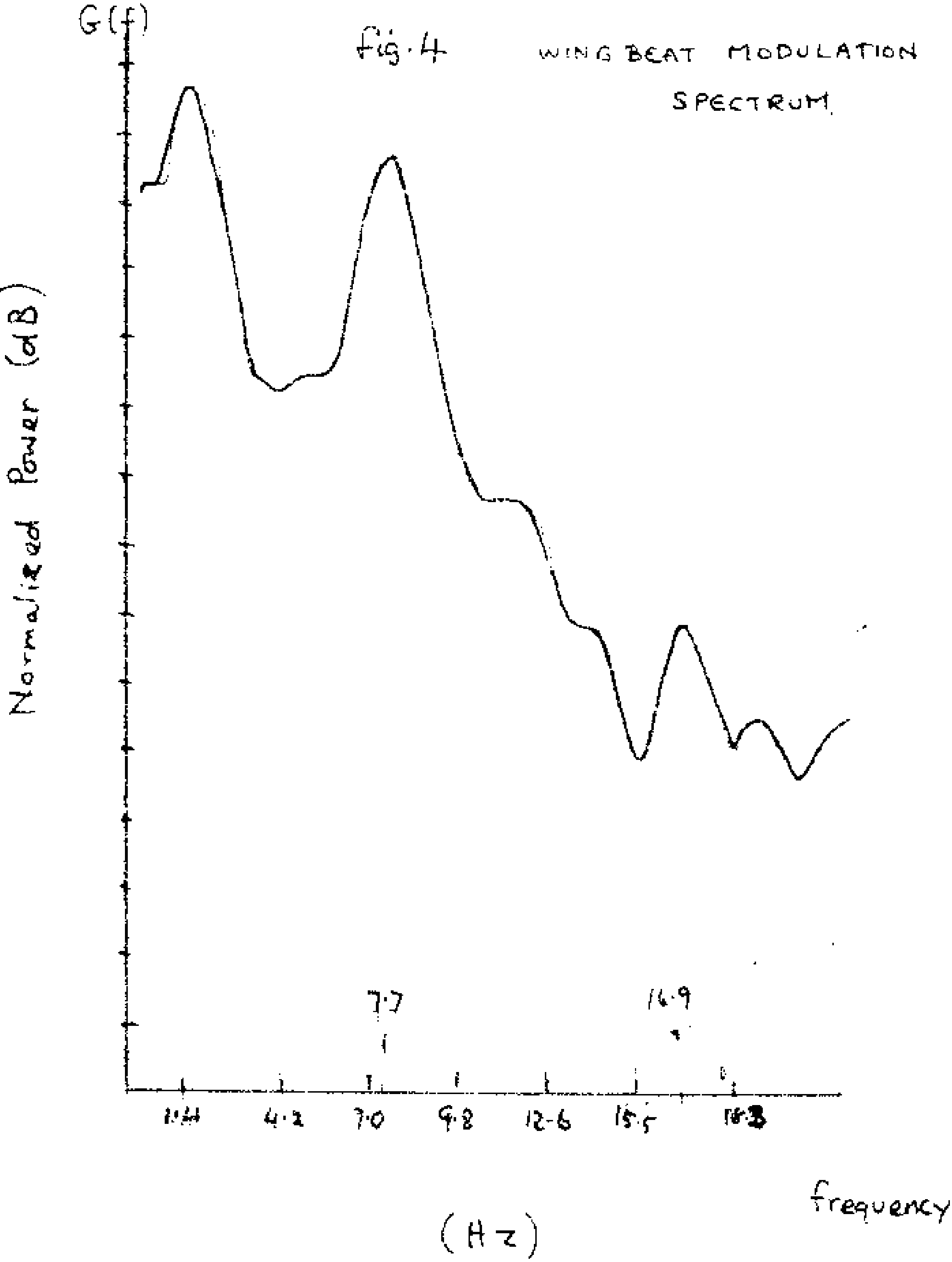
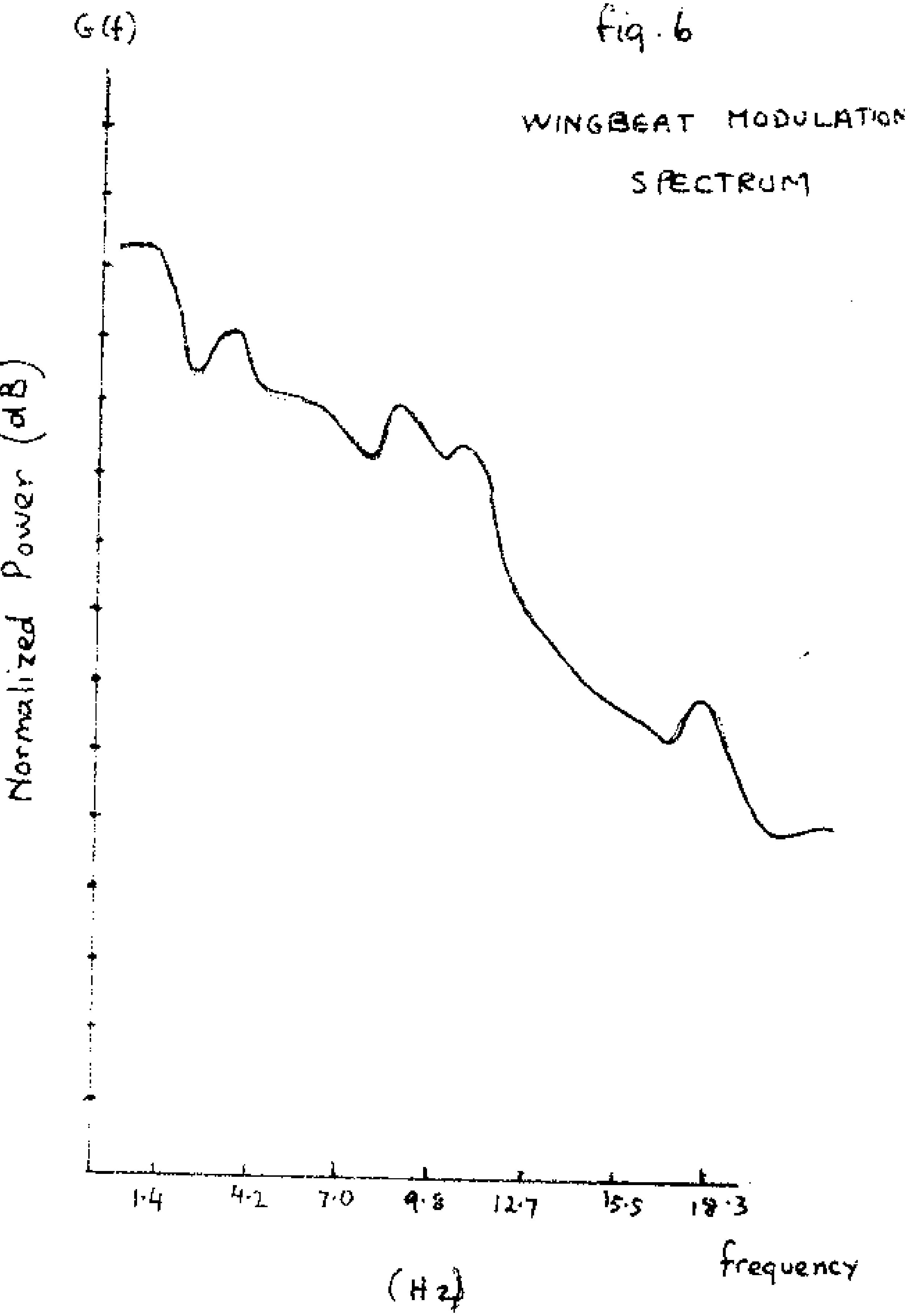


fig. 4 WING BEAT MODULATION SPECTRUM

fig. 6


WINGBEAT MODULATION
SPECTRUM
G(f)
Normalized Power (dB)
1·4
4·2
7·0
9·8
12·7
15·5
18·3
frequency
(Hz)