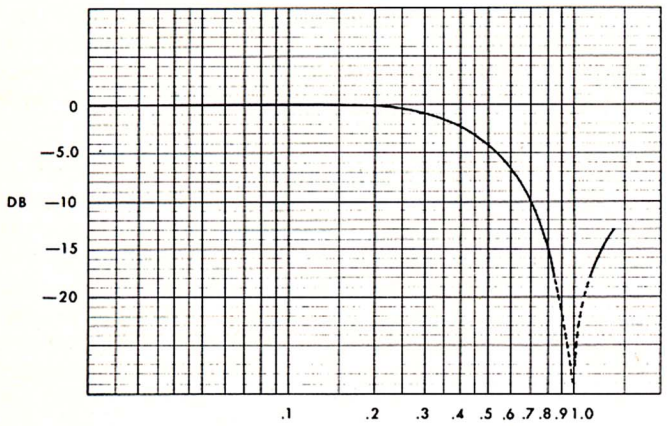
The gap effect may be negligible when we are dealing with audio frequencies at 7½ or 15 ips tape speeds. For instance, the AMPEX reproduce heads have a gap of 0.2 mil, and the gap loss is unimportant at the wavelengths involved. However, at lower tape speeds, or for instrumentation or video applications where the high frequency requirements are greatly extended, it becomes a serious limitation.



The loss that occurs when the wavelength of the recorded signal approaches the length of the reproduce head gap is indicated on this graph.

Head Resonance

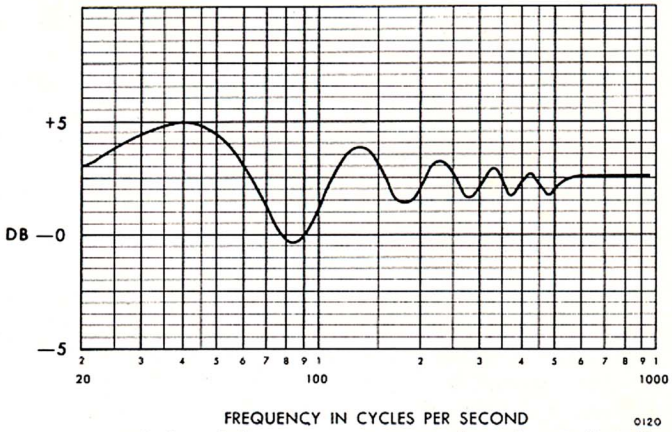
The coils of the heads are inductances which will resonate with lumped or distributed capacity in the circuit. At the resonant frequency of the reproduce head there is an increased output, but a sharp drop of approximately 12 db per octave occurs directly after this point. Thus the resonant frequency must normally be outside the pass band of the system, or placed (in video and data recorders) at the extreme upper limit so that it actually provides a shelf at the point of resonance to extend the response.

As circuit capacitance is reduced to an absolute minimum, only one way remains to place the point of resonance at a higher frequency, and that is to reduce the inductance of the head coil by employing a lesser number of turns of wire. A reduction in the number of turns, however, will reduce head output over the entire frequency range, so a compromise design must be provided.

Low Frequency Response

Low frequency response is almost completely a function of the effects generally known as "head bumps". This effect will occur in the reproduce mode at the low frequencies, as the recorded wavelength of the signal on the tape begins to approach the overall dimension of the two pole pieces on either side of the head gap. In effect, the two pole pieces now begin to act as a second gap, because they *can* pick up magnetic flux on the tape quite efficiently.

As our frequency decreases we may start to notice bumps and dips in the output of the head. The largest *bump* will occur when one-half wavelength of the recorded signal equals the combined distance across the two pole pieces, but there will be progressively smaller bumps at 1½ wavelengths, 2½ wavelengths, etc. Similarly the largest *dip* will occur when one complete wavelength of the recorded signal equals the distance across the pole pieces, and again there will be progressively smaller dips at 2 wavelengths,



Uncorrected head bump curve produced artificially by excessive tape wrap around an experimental reproduce head.

3 wavelengths, etc. So as our frequency goes lower and lower the bumps and dips will get bigger and bigger. Below the largest bump, at ½ wavelength, the output rapidly falls to zero.

It is interesting to note the similarity between the head bumps at the low frequencies and the gap effect at the high frequencies. When the head gap intercepts a complete wavelength we have no output; when the pole pieces intercept a complete wavelength we have a decline in output. The largest theoretical output occurs when the head gap intercepts one-half wavelength, there is an increase in output when the pole pieces intercept one-half wavelength. There is of course one great difference — *increasing* the tape speed diminishes the gap affected by spreading the signal over a greater length of tape, but *decreasing* the tape speed dimishes the head bumps by shortening the wavelength on the tape. At 15 ips tape speed the head bump is a rather serious problem, at 7½ ips the problem is reduced, and at 3¾ ips it has practically disappeared.

Good engineering design is the only way to alleviate the head bump situation. The physical configuration of the pole pieces and shields, and the angle of wrap of the tape around the head, can be designed so that the extremities of the pole pieces are farther from the tape and cannot pickup the signal so readily. An ideal solution, but rather impractical in today's compact equipments, would be to make the pole pieces so large that no problem would exist down to 10 or 15 cps.

In any event, the head assembly must be designed so that the head bumps occur at the lowest possible frequency, so that if possible no more than one