LIGO-T880006

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List of 3/1/89

MEMO

From: Alex
To: Robbie
Subject: Comments on P. Saulsons's note on vibration isolation qualities of bellows
Date: July 22nd 1988

1 Summary

I think Peter's note provides us with a simple and quick way to produce a rough estimate of the mechanical transfer function of a system of coupled elastic elements.

In Section 2 I present some data which support Peter's choice of input parameters.

Since the example which is analyzed in Peter's note is potentially of practical interest, I think it deserves further thought. In Section 3 I describe a slightly modified version of Peter's model, which I think relates to the actual case in a more realistic way. If it will be perceived that the matter is interesting enough, than Peter and I should probably discuss it and a rerun of the numerical analysis should be carried out along lines we agree upon.

Conclusions are listed in Section 4.

2 The Input Data

The 40 m prototype contains a large mass of pipe attached to several bellows. The total mass of one 40 m section of 8" pipe plus 40 m of 4" pipe which rides on top of it is estimated to be $\sim 900\ kg$.

The mechanically coupled pair of pipes is attached to 8 bellows - 4 8" ones for the big pipe and 4 4" ones for the small pipe. The pipes are suspended at 5 intermediate points from ropes $\sim 1.5\ m$ long. From all this and from the measured longitudinal eigenfrequency of the pipe ($1\ Hz$), one calculates the elastic constant of the bellows system to be $3 \times 10^4\ N/m$. Since the larger bellows are likely to have slightly different mechanical characteristics than the ones in the 40 m system and since the resonant frequency is proportional to the square root of the elastic constant, the value of 3.77×10^5 N/m assumed by Peter is adequate for an order of magnitude estimate.

3 The Distributed Parameter Model

Consider the sequence *4 km pipe-bellows-short pipe-bellows-tank*, where the short pipe section is connected to the ground by a massive, rigid anchor (this is the case analyzed by Peter). Since anchors can be made extremely massive and rigid (e. g. a big, solid concrete block), the short pipe is likely to be the springier element in the pipe-anchor combination. The anchor acts only as an extension of the ground and bears on the transfer function only insofar as it influences the spring constant of the short pipe through the short pipe-anchor boundary conditions. It seems to me that the mass of the anchor thus becomes irrelevant.

The above argument then would suggest the impedance model shown in Fig. 1. I think this model is likely to display a substantially higher degree of vibration attenuation (at all frequencies) than the one used by Peter.

4 Conclusions

1) I think that a distributed parameter model is a useful tool for estimating the long pipe-to-instrumentation tank mechanical transfer function.
2) The spring constants used by Peter for his estimate are adequate for order of magnitude estimates.
3) I present an impedance model which I think is closer to the real case. If the whole matter is perceived as important, more discussions are desirable, since they are likely to lead to a deeper understanding and therefore to a better design of the bellows assembly.
4) It is desirable that the issue of damping be addressed in more detail.

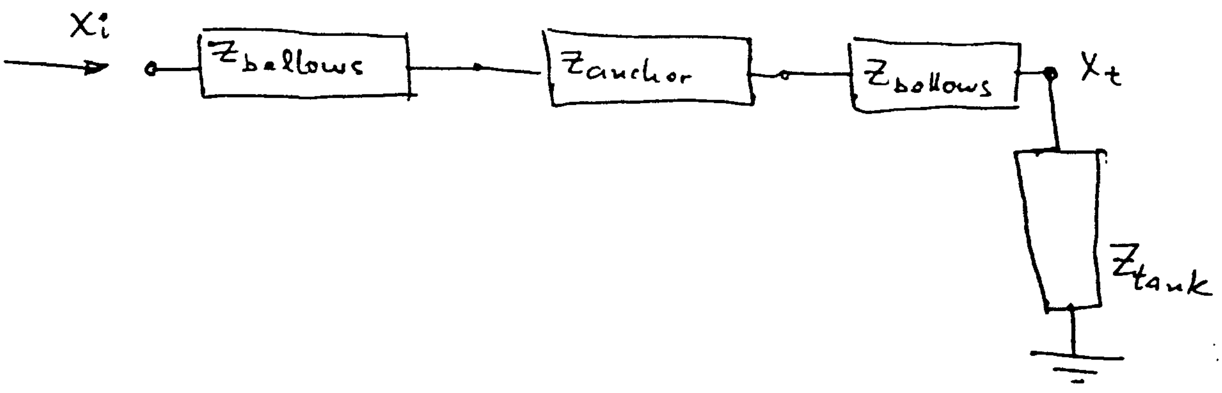

Fig. 1. Suggested impedance model