CHAPTER 1

Introduction and Some Basic Concepts of Mechanics

INTRODUCTION

Why We Need "Theories"

To design, evaluate, or understand any kind of mechanism it is helpful to be able to measure or predict the forces, accelerations, velocities, and displacements which occur in various parts of the mechanism. From this information the designer can then determine stress levels and performance characteristics. Will the mechanism do the job expected of it? Will it do it in the time available? Will it have the desired operating life, etc.?

But Theories Do Not Always Work

The engineer or designer acquires his understanding of force, acceleration, velocity, and displacement through his study of mechanics. Too often, however, his early struggles to apply his knowledge of mechanics to actual design problems defeat him. The abstract language of mathematics has not given him sufficient "feel" for the subject to allow him to apply it to a specific design situation, or the machine just does not seem to obey the rules which he was taught because the machine is not a collection of rigid bodies connected by ideal joints. It is, instead, a series of elastic bodies interconnected by links that introduce friction, backlash, and clearance, all subject to impact, vibration, and chatter; and it seems often to have a mind of its own and be determined never to complete the performance or life intended for it.

At this point, most beginners give up, usually decide that the theoretical approach is wrong, and that only a trial and error experimental approach gives the "correct" answer. Too frequently the result is a machine that works, but whose performance is so dependent on a delicate balance of forces and dimensions that the designer's employer has a long string of production problems ahead to contend with. Small variations in part dimensions, hardness, or material composition can lead to large and mysterious changes in machine performance and life.

Experimental Versus Theoretical Models

It would be far better if the designer had enough feel for, and patience with, theoretical design so that he could build a crude theoretical model of his machine in parallel with the construction of his experimental model. He should realize that both models are imperfect at the start—that both will require debugging and development. Thus, the theoretical model must be refined, when experiments with an actual prototype machine show that the theoretical model is inadequate, to describe the actual performance.

The physical model must be refined and debugged when its performance turns out to be inadequate, and particularly when the theoretical model shows that the performance of the actual machine will change drastically if there are slight variations made in the dimensions and in the composition of certain critical machine elements.