INTRODUCTION

It is natural to hope that the large literature on the theory of large scale systems is relevant to the common control problem of synthesising regulators for complex linear or nonlinear multivariable systems. However there appear to be significant differences in the literature on these two topics. This paper attempts to explore these differences, briefly surveying the relevant literature, in the hope of drawing lessons for future advances.

Rosenbrock [1] has emphasized elsewhere the untidy nature of many engineering problems. Firstly, they have many objectives such as (in our case) stability, speed of response, insensitivity to disturbance and parameter variation, resulting in the existence of more than one satisfactory solution, and requiring knowledge of trade-offs between objectives. Secondly, they have numerous constraints, often too many to list formally, although non-satisfaction is easily recognised. Thirdly, knowledge of the system is usually inexact, often because of simplification (for example, replacement of distributed parameter components by lumped approximations). Certainly the design problem is complex, and the theory of large scale systems should help.

LARGE SCALE SYSTEMS

An important part of the literature on large scale systems is concerned with solving large sets of equations or large mathematical programming problems. The purpose of this literature is quite clear - reduction of computation - and this purpose provides the criterion by which the work can be judged. Despite its success for certain
linear problems (e.g. decomposition of linear programs), this work is not directly applicable to the control of large noisy systems for many reasons, including (i) optimal feedback control (necessary because of random noise) is prohibitively difficult to calculate and to implement, and (ii) engineering problems typically have many objectives.

Certainly there do exist techniques for finding (an approximation to) the locus of non-inferior points in multicriteria optimization. In principle, since engineering problems typically have more than one objective such work should have some relevance. However, I am unaware of any application to multivariable control/decision problems.

Of more direct relevance is the large literature on decentralized control of stochastic systems. The set up is the usual one of a set of controllers, each with the same performance criterion, but having its own set of permissible decisions, its own information and its own model of the system. As Varaiya [4] points out, there are three categories of relevant literature: (a) team theory; (b) competitive organizational forms; (c) hierarchical organizational forms.

The interesting feature of the competitive economy is its achievement of optimality through the decentralized action of numerous agents, each supplied merely with information of prices of various commodities. However this result is somewhat specialized relying heavily on special features (determinism, convexity) of the problem, and should not be too readily adopted as a desirable model in other fields; its overenthusiastic adoption in the area of nonlinear programming (decomposition algorithms) has not achieved a substantial reward.

The team theory literature, on the other hand, gives due attention to the stochastic nature of many decision problems. In the static case under reasonable conditions (Gaussian disturbances, convexity of cost function) the optimal decision rule is linear. In the dynamic case, the classical information structure results, under the usual LQG conditions, in a linear optimal decision rule, but Witsenhausen's [2] well known result showed that for non-classical information structures the optimal decision rules need not be linear. Ho and Chu [6], performed a valuable service by showing that linear optimal decision rules also result if the information structure is nested; the problem is reduced to an equivalent static problem. The resultant optimization problem, though feasible, is still severe. In fact, Varaiya [4] conjectures that the computational effort necessary for calculating optimal decision rules for a team is considerably greater than that for centralized decision making, so the former would only be chosen because of constraints, or communication costs. Unless some result is obtained extending the class of problems admitting linear solutions, further progress is unlikely. In general the optimal decision rules are