Academic Research Institutes in the Microwave Field

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SINCE World War II, large research institutes have burgeoned forth on the campuses of many colleges and universities throughout the United States. Fulfilling at their inception a national need in time of crisis, they have continued in these less critical times to contribute importantly to the national research program. Their impact on academic curricula has been varied but no less important. The effective increase in faculty provided by academic research institutes is permitting the expansion of graduate course programs into ever widening areas of science and engineering in a manner responsive to contemporary scientific and technical developments. Expanded curricula and research facilities make it possible for students in increasing numbers to enter into research programs that attempt to prepare them realistically for the demands our technological society imposes upon them. Despite these evident advantages, research institutes have yet to find a truly permanent place in the academic structure. Financial difficulties, together with related problems of securing balance between research and academic obligations, characterize this paradoxical situation. Since these points bear strongly on the question of the proper utilization of our national scientific and engineering potential, let us examine the role academic research institutes can play on the educational scene with particular stress, by example, on those in the microwave field.

Recent public emphasis on the need for expansion and intensification of our general educational program from the secondary to the graduate school level does not place in proper perspective the influence of such expansion on basic research in this country. For however great is the need for more graduate scientists and engineers, equally great is the need for that specialized and quite small echelon of graduates upon whom falls the disproportionate burden of the exploratory research on which future engineering applications depend. The problem of insuring a properly qualified national supply of scientists and engineers does not necessarily reflect the problems peculiar to the needs of the research minded group with which we are concerned herein. A balanced national educational program demands the separate consideration and solution of the distinct problems involved in the two categories.

Academic research institutes influence mostly the development of the "upper segment" of graduate scientists and engineers, although they are not without influence on the entire body of students and faculty. The staff at such institutes is primarily composed of an admixture of research scientists and engineers who allocate their time in varying degrees to teaching and research. Such institutes should tend to supplement (but not replace) the classic type of departmental research involving a key professor plus a small group of graduate students. Because of the greater facilities and staff concentrated at research institutes, a broad spectrum of interdepartmental research programs is made available to a large number of graduate students and faculty. The unusual opportunities thereby provided for training and contributing to significant research programs, can and should be incorporated as an integral part of a graduate curriculum. If this potential for creative effort resident in academic research institutes is to be properly exploited, their flexibility of operation should not be hamstrung by an inadequate budget and by their involvement in programs indistinguishable from those in industrial research laboratories.

Since the cost for the training of graduate students is many times higher than for undergraduates, the additional maintenance of research institutes, which appear to be a necessary adjunct of every major graduate school, imposes financial burdens on tuition supported private colleges that are almost impossible to carry without outside cooperation. Up to the present, government sponsorship has been, for the most part, the financial mainstay of this type of academic research activity, but the vagaries of annual congressional budgets impart an aura of uncertainty to this source of research funds. This uncertainty has, in turn, not proven beneficial to the morale and program of academic research staffs. It is to be hoped that the recent re-evaluation of government sponsorship of basic research will result in a policy more conducive to the development of the academic potential in this area.

Consideration of the question of government sponsored research must, of course, include both academic and industrial research. Since the term research has begun to cover an ever widening spectrum of activities, it is of interest to contrast differences in the nature of university and industrial research programs that stem from different motivations. The primary goal of academic research is the pursuit of programs of broad exploratory research that conforms with the basic academic obligation of training scientists. Research in industrial organizations, on the other hand, usually has specific, economically motivated, technological goals. This does not imply an absence of exploratory research; in fact, some industrial organizations engage in fundamental research programs of which any university could well be proud. However, differences in motivation do exist and these should be properly exploited in the

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national interest by means of academic and industrial programs that complement rather than duplicate one another. This demands a government policy that with proper balance effectively utilizes the potentialities of those programs of academic and industrial research whose development appears indispensable for the healthy growth of our national economy vis-à-vis that of other nations. This, in turn, demands distinct fiscal policies for application to university as against industrial research. The nature of an academic research operation is such that long-term repercussions are created by budgetary changes that would have little influence on an industrial operation.

Not unrelated to the fiscal problem is the nature of the research programs at some existing academic research institutes. For, in order to maintain an effective staff under the present fiscal support structure, contractual obligations are assumed which often run counter to what is considered as proper academic research. Resulting pressures to "produce" and to obtain contracts involve the research faculty in time consuming efforts that inhibit the full utilization of its abilities and talents. This involvement is tolerated only because of the conviction that a research effort is a vital part of a graduate academic program and by the pious hope that some of the defects of the present academic research structure will ultimately be remedied. Hoped for remedies would provide long-term funding on a broad exploratory basis for at least 50 per cent of the total budget of a research institute. This would assure, certainly in the applied science field, the desired flexibility and stability for the development of research programs in keeping with the basic academic obligation of training graduate scientists and engineers. If such programs were carried out on a national scale, it should be possible to insure at key academic institutions throughout the country the existence of centers engaged in specialized and high-level research programs as an integral part of academic activity.

Academic research centers should have a varied nature dependent on the scientific manpower capabilities of specific institutions. Some should be devoted to basic research in the fundamental and classic meaning of the term; others, such as research institutes at engineering colleges. should be devoted to broad spectrum research characteristic of the applied sciences. In the latter category belong the academic research institutes in the microwave field. From these we shall attempt to choose, by way of illustration, a few typical research programs that provide possibilities for graduate training and significant scientific contributions and are, as well, a desirable supplement to related industrial efforts.

About 15 years ago, technical advances in the rapidly growing microwave field created a need for development of a network theory utilizing distributed and lumped circuit elements more general than the then familiar inductance, capacitance, and resistance elements so effectively employed at the lower frequencies. Under wartime pressure, academic research contributed to a microwave network and mode theoretic viewpoint that conditioned the thinking of microwave engineers and provided valuable assistance to the development of microwave components for numerous radar systems.

At the present time, the advent of novel anisotropic microwave devices incorporating ferrites, plasmas, and other electron beam loaded waveguides is lending impetus to the creation of more general network and fundamental physical viewpoints to provide a corresponding service for present-day microwave engineers. High speed rockets and missiles have given great technical importance to flush mounted "open waveguide" structures of the surface and leaky wave type. Here too, there is room for the development of network techniques for the quantitative description of interacting radiative discontinuity elements, in order to provide stimulation for future applications. Continuing technological penetration into the millimeter part of the electromagnetic spectrum is bringing forth fundamental problems that demand facile multimode network or quasi-optic theories for the quantitative understanding of wave phenomena in this range. Recently developed semiconductor and other solid state structures have placed new classes of active and nonreciprocal microwave network elements at the disposal of microwave engineers. This added versatility creates new horizons for theories in analysis and synthesis of distributed electromagnetic structures.

Of a somewhat different character is the need for broad interdepartmental programs to exploit magnetic resonance and other microwave spectroscopic techniques that promise to yield not only important technological applications, but also useful information at molecular and cellular levels in the fields of biophysics, physics, and physical chemistry. One can continue along these lines but the above are exemplary of a few of the programs that can and are being pursued at academic research institutes in the microwave field.

In summary, it is evident that we have tried to state the case for the establishment and financing of academic research institutes as an integral feature of a graduate school activity. At present, the research viewpoint is an unintegrated supplementary activity frequently hampered by inadequate and academically unbalanced contractual arrangements. If basic research at academic institutions is to be regarded as vital to our national economy, it ought to be effectively utilized by government and industry to permit the realization of its full potential.