

how devious the route, takes an unselfishness that stems from placing scientific truth above any personal gain or ambition.

## PART III—COMMENTS ON INSTRUMENT RESEARCH

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### INTRODUCTION

THE chairman of the research committee of this society, Mr. McNeil, requested that this article be written for publication, commenting on instrument research in photogrammetry. This opportunity to record a few thoughts related to instrument research as applied to this field is welcome and worthwhile if it proves of interest to those who support instrument research, particularly in photogrammetry.

### BASIC RESEARCH

Instrument research is fundamentally dependent on basic research for establishment of basic facts needed for sound results. To evolve new basic facts needed for stimulating useful ideas is essentially the difficult function of basic research groups. But new facts are not produced exclusively by such groups, but by all persons who think carefully and logically. Those who are engaged in basic research continually discover new facts which stimulate ideas of their own and lead them into applied research activities. These ideas can often be directly applied to building an instrument to serve a specific need. This need may be for an instrument to be used by these groups to establish new facts; but often their ideas lead toward an instrument meeting the economic needs of others. This is the point where instrument research begins.

### BASIC PROBLEM OF INSTRUMENT RESEARCH

Instrument research in photogrammetry, as well as in other fields of instrumentation, is primarily the searching for and stimulating of dormant or original ideas from many sources, and their development to the point of economic usefulness in the form of an instrument. A dormant idea usually is an idea that has been previously expressed but never advanced to practical economic use. An original idea is one usually conceived when other ideas and facts meet. An original idea may be called a pregnant one being capable of producing a new result, but needing considerable nursing before arriving at mature usefulness.

### INSTRUMENT RESEARCH AND INVENTION

One of the chief elements of instrument research is the subject of invention. An original idea alone is not the entire basis of invention, although it is often loosely called an invention. Invention, in part, is an original idea proven capable of being reduced to useful practice. For a person to claim an invention solely because of his earlier expression of an idea is a dubious assertion. This statement is particularly important because in all fields or research there are those who speak and write prolifically to express ideas vaguely on all phases of a particular subject. Often these expressed ideas are in a form so complex or obscure that the idea is barely recognizable. To simplify such ideas, and to combine them with other practical ones, leads toward their reduction to practice. In this reduction to practice of an idea in the form of an instrument lies the essence of invention. Although "invention" is often used as a synonym for "patent," it is

not the same thing; a patent is a complex legal document of which an invention is but a part. Patents are needed, however, to protect inventions and to stimulate investments or appropriations for research activities. Sometimes ideas lead to the ways of stating particular problems so clearly that the practical ways and means of solving them are obvious and not considered new. Yet extensive applied research is at times required to discover the specific problems which are in economic need of solution. So invention also includes a third factor of a clear statement of the problem requiring a solution; the other two factors being a clear expression of the ideas used for its solution, and illustration of the method of reducing them to practice, usually in a working model.

#### ESTABLISHMENT OF ECONOMIC NEEDS

How, then, in the field of instrument research and development are these economic needs established? Such needs, together with viewpoints as to what the exact problems are, can be learned from the individuals who actually operate instruments, as well as from their observant associates. To be of value, such expressed needs must come from organizations using instruments similar to those under development. Each organization must be as independent of the others as possible for their comments to be useful. Too often such expressed needs are based on misinterpreted occurrences arising from the use of instruments; and unfortunately such a situation leads to a fixed opinion within the organization as a whole. This opinion may take years to correct. It is only when the same need has been expressed independently by several individuals in organizations in close contact with instrument operations, that real needs become soundly established. A user of instruments often states a particular need with the added remark, "As for cost, we will pay anything to solve this problem." Such statements are like an intoxicant to people responsible for performing instrument research, for it eliminates cost as a factor. This usually makes instrument research relatively simple. The development of the atom bomb, for example, is a classic exception because of its magnitude. But such needs are rare, and sound instrument specifications cannot be established without expression of associated cost limitations. To the users of an instrument, cost of obsolescence through change of operations caused by an entirely new instrument is also a factor. Consequently, the price that will be paid for each instrument can be established only by contacting equipment users. Their reliability as to cost estimates is a factor to be considered. Then, with a composite expression of several unbiased users, a sound basis for establishing the economic soundness of an established instrument need, results.

#### SOURCES OF PRACTICAL IDEAS

Once these economic needs and the related basic problems are stated in detailed specifications through applied research, their solution is evolved by subsequent stimulation of practical ideas from others in organizations using and manufacturing the equipment. Statement of the basic problems to management, design, manufacturing, and sales divisions of the manufacturer results in a wealth of practical applications. The ideas from all these sources are numerous, but each idea requires testing for practical and economic value in view of all the current problems needing solution. Consequently, this integrating of all these ideas is a complex one. At times, the choice of one idea prevents the use of another good one. The process of reducing these collective ideas to practice, in an instrument manufacturing organization, requires several stages of development. In passing through these stages, other ideas result which make possible, yet sometimes preclude, reduction to practice of the basic idea. These stages

are usually:—

Engineering Survey	Operational Test
Applied Research	Engineering Design
Design of Instrument Models	Manufacturing
Development of Instrument Models	Marketing

The final and most important stage of a new idea incorporated in an instrument is its sustained economic usefulness by map producing organizations.

#### PURPOSE OF INSTRUMENT RESEARCH

It is this last stage of sustained economic use which often dooms excellent ideas. Instruments of impressive complexity—photogrammetric instruments are typical—can and are being marketed successfully, but unless they can meet this test of sustained economic usefulness, they soon join the long but distinguished list of museum instruments gathering dust. It is this last test on which many hopes of research are dashed; consequently, more emphasis on this last stage of instrument research is necessary, particularly for mapping purposes. In fact, the purpose in the development of photogrammetric instruments is to produce maps to detailed and precise engineering specifications, in time to meet the needs of map users, at costs reasonably lower than present methods. This is essentially an economic purpose. Fundamentally, the final user of the map is the real customer of all of us who work in the field of aerial photogrammetry.

#### RESPONSIBILITY OF MAPPING ORGANIZATIONS

To accomplish this economic purpose, each type of map-producing organization needs sound management, sustained distribution of maps to users, quality control of production of maps to engineering specifications, and a system of mapping instruments (not just individual instruments) manufactured to rigid specifications.<sup>1</sup>

#### RESPONSIBILITY OF INSTRUMENT MANUFACTURERS

The first three of the above four requirements are the responsibility of the map-producing organization. The latter is the responsibility of the instrument manufacturer, but he needs thorough cognizance of all four of these requirements as he continues research and development of instruments to meet the test of sustained economic usefulness. This responsibility is one of the many that an instrument manufacturer has. To meet this particular responsibility successfully requires a continued desire to advance sound ideas as part of the responsibility of every department. Then, organization can progress with a continually improved line of instruments, to fulfill in time, practical but changing economic needs and meet competition. However aggressively such research is sponsored by management, all departments of an organization need to be continually interested in sound progress. They must be so organized that needed changes can be made quickly and at low administrative cost. If individuals in a position of authority are not vitally interested in sound changes, they can resist and unwisely retard needed improvements. This is to be expected because improvements mean changes, and changes mean extra difficulties for those departments with many other important responsibilities. Such a situation is nevertheless detrimental to maintaining a progressive line of instruments, in both mapping and manufacturing organizations. It is interesting to note here that experienced

<sup>1</sup> Sharp, J. V., "Increased Accuracy of Multiplex System," *PHOTOGRAMMETRIC ENGINEERING*, vol. XV, no. 3, p. 430, September, 1949.

men usually resist sound change more than less experienced men. This resistance is encountered because change involves extra effort, and because it introduces definite elements of risk. Caution toward risks which results from long experience is the hardest obstacle a sound idea must overcome, if it is to be reduced to practice in time to be used by mapping organizations.

In other words, a sound idea for solving an existing need must be developed into the improved instrument before someone else develops or improves another instrument in less time. Calculated risks are an important factor in maintaining enterprising and profitable organizations. Those who are organized to risk sound changes rapidly, based on well developed ideas for manufacturing and using improved equipment, receive the economic rewards and the satisfaction of achievement. In photogrammetry, it is primarily the buyers and users of maps who bestow these economic rewards on the organizations who produce maps, and in turn on the manufacturer of the system of instruments with which those maps are made.

#### CONCLUSION

The logic, I trust, of these comments makes the purpose of instrument research in photogrammetry, more clearly understandable. This purpose, to repeat, is the development of a system of instruments for production of maps to sound engineering specifications in time to meet the needs of map users at reasonable costs.

What constitutes instrument research in photogrammetry, based on the above comments, may be stated as follows:

Development of the specific problems, which require instruments to solve them, arising from the collectively stated economic needs of all types of users of mapping equipment.

Stimulation of original and dormant ideas from several sources toward the solution of specified problems. These ideas come particularly from those who write concerning these instruments; from those who are responsible for their operation; and from those who develop, manufacture, and market these instruments.

Reduction to practice of those ideas through the stages of applied research, model testing, design, manufacture and marketing of instruments, in time to have sustained economic use. In photogrammetry, such use results in maps produced at reasonably lowered costs, to detailed specifications required by those who use these maps.

In closing, I should like to add that at Bausch & Lomb Optical Co., we welcome expression of needs and ideas for photogrammetric instrument research. It should be noted, however, that ideas to be considered by our company must be submitted in writing and with a statement that the submission is in accordance with the conditions of Bausch & Lomb pamphlet #1510, available on request. This pamphlet establishes certain safeguards, protecting the interests of the originator of an idea and of the Bausch & Lomb Optical Co.