RECORD OF THE PANEL DISCUSSION ON SPECIFICATIONS FOR AERIAL PHOTOGRAPHY AND MAPPING BY PHOTOGRAMMETRIC METHODS FOR HIGHWAY ENGINEERING PURPOSES

16TH ANNUAL MEETING OF THE AMERICAN SOCIETY OF PHOTOGRAMMETRY, HOTEL SHOREHAM, WASHINGTON, D. C., JANUARY 13, 1950

THE Panel met in the terrace banquet room of the Shoreham Hotel at 2:30 P.M. on January 13, 1950, and continued in session until 5:00 P.M. There were over seventy people present in the audience. The participating members of the Panel were:

Mr. H. J. Spelman, Moderator
Division Engineer, Bureau of Public Roads
National Forests and Parks east of the Mississippi River

Mr. M. W. Landon, Route Planning Engineer
Michigan State Highway Department
Lansing, Michigan

Mr. Elmer C. Houdlette, Location and Survey Engineer
Massachusetts Department of Public Works
Boston, Massachusetts

Mr. K. H. Siddall, Location Engineer
Department of Highways
Toronto, Ontario, Canada

Mr. Charles H. Davey, Chief of Topographic Survey Section
Research and Technical Control Branch
Topographic Division, U. S. Geological Survey
Washington, D. C.

Mr. Talbert Abrams, President
Abrams Aerial Survey Corporation
Lansing, Michigan

Mr. Robert Smith, Vice-President
Aero Service Corporation
Philadelphia, Pennsylvania

Mr. William H. Meyer, Jr., Eastern Manager
Jack Ammann Photogrammetric Engineers
Manhasset, New York

Mr. Ford Bartlett, President
Lockwood, Kessler & Bartlett, Inc.
Brooklyn, New York

Mr. William T. Pryor, Chairman
Highway Engineer, Division of Design
Bureau of Public Roads
Washington, D. C.

NOTE: Comments on this paper are invited. To ensure consideration for publication in the December Issue, receipt before October 15 is necessary.

Mr. Spelman called the discussants to the stand, and introduced them to the audience.

Before the members of the Panel began discussing the paper, "Specifications for Aerial Photography and Mapping by Photogrammetric Methods for Highway Engineering Purposes," as read by Mr. Pryor at the forenoon meeting of the Society, Mr. Spelman made the following short keynote statement:

"The highway engineer user of aerial photographs and topographic maps obtained by photogrammetric methods has a unique problem. He must first make a reconnaissance survey of a large area to determine possible routes for the highway. Then he must determine which of those routes is the best for survey and for location of the highway.

"Once the highway engineer has determined the route possibilities for the highway that are worthy of further study, he can use the aerial photographs which were used to determine them in conjunction with an examination of those routes on the ground to compare them and choose the best one. Similarly, when the highway engineer has narrowed the route selection to one or two routes, the aerial photographs and the large scale topographic maps that can be made from the photographs can both be used as the working base for the preliminary location of the highway. Furthermore, the aerial photographs are often used for other purposes, such as illustrating the proposed solution to highway location problems, and the selling of a highway project to the officials of state and government agencies and to local organizations that are concerned. Photographs are also a basic source of information on land use in each of the highway location stages.

"In highly developed areas, particularly those that are urban in character, land use usually affects the location of a highway more than topography, which, in a way, makes the aerial photograph a more useful tool in many respects than a map wherever highways have to be located in urban areas.

"It is hoped that the discussion of Mr. Pryor's paper by this Panel and you people from the floor will provide a wealth of information that will be useful in the preparation of specifications for aerial photography and for mapping by photogrammetric methods for highway engineering purposes.

"Many highway engineers in this country are not as familiar with aerial photography and mapping by photogrammetric methods as the men on this Panel and you people in the audience. They will be grateful to you for your contribution of material to aid in the objective of obtaining better specifications. I will now ask each member of the Panel to express his thoughts on this subject."

Mr. Landon: I think Mr. Pryor's paper contained an outline that was very much to the point and we would do well to consider the subject matter in the paper as fully as possible in order to meet the objectives explained by Mr. Spelman.

The use of aerial photographs in our highway department in Michigan during the past few years has been limited largely to stereoscopic examination of the photographs and an assembly of the photographs to form mosaics. Our highway locations have been accomplished effectively by such a procedure. Our uses of aerial photographs have resulted in our consideration of the type of specifications which should be used.

One of the questions that it would be well to place before the group at this time is: Should the specifications for aerial photography and topographic mapping be supplementary to the general specifications now used for highways and bridges, or should they be complete in and of themselves and in no way related to the general specifications used for highway and bridge construction by the

highway department? Perhaps the various state highway departments may have a preference for one method or the other, yet the choice of the method appears optional.

Another point that I have been thinking about is the ability of the aircraft pilot to control the altitude while taking photographs. A slight variation in aircraft flight altitude, combined with variations in the elevation of the topography and the tilt that may occur in vertical photographs, alters the scale of the photographs so much that it is difficult to use them. We in Michigan would like to have our photographic scale remain constant as much as possible, and not vary more than five per cent between photographs.

I am somewhat uncertain, Mr. Moderator, in regard to all that is wanted in the initial statements to be given by the Panel members. I have some specific points I should like to bring out later to provoke discussion. That is all I have to say at this time.

Mr. Abrams: I should like to give a new idea for discussion. It is to determine if we are thinking correctly about aerial surveys. I do not think an aerial survey is quite like the construction of a highway. Instead, it is more like the design in preparation of plans, such as an architect might prepare for a building. I think of aerial surveyors as professional men with a responsibility similar to that of an architect. When we—the aerial surveyors—are classified as professional people with a good organization behind us, we can do a great deal to help the highway engineer in his planning for aerial photography and mapping by photogrammetric methods.

One set of specifications cannot be suitable for all types of photography and topographic mapping required for highways. The aerial surveyor must be told where the highway location problem is, and the points between which the survey must be made. We can then draw upon our experience to aid the highway engineer in the preparation of specifications for the specific aerial photography and photogrammetric mapping. Then a contract can be entered into for performance of the work. In that way, you would get aerial surveys a lot cheaper, better and quicker.

I know that my remarks have introduced additional points on a controversial subject. An aerial surveyor, to perform the best service, should be thought of and dealt with as a professional consultant.

Mr. Spelman: As Mr. Abrams said, that is a subject—quite a subject at that. It can have many ramifications. Highway engineers requiring aerial photographs and topographic maps made by photogrammetric methods are often regulated by laws in their preparation for contracting services, as well as in the establishment of practices for the administration of their various projects. Aside from that, highway engineers need to have specifications developed that will result in the aerial photographs and the topographic maps to the degree of accuracy needed, whether the work be undertaken after competitive bidding for a contract or after negotiation with a consultant.

It is true also that the highway engineer must know what he wants. But that is the purpose of our endeavor today, to develop specifications so that what the highway engineer wants can be obtained. Highway engineers know in most instances the scale of map or aerial photograph required to aid them in solving their particular engineering problems. They also have a good idea about the supplementary information that will be needed for the design of the highway.

Let me emphasize that, regardless of the method of contracting for the work, whether it be advertising and competitive bidding or by negotiating with a consultant, specifications must be prepared so that the highway engineer will obtain exactly what is needed.

Mr. Houdlette: As far as Massachusetts is concerned, we are primarily interested in the type of aerial photograph that will best fulfill our needs. In cooperation with Harvard University, we made a careful study to determine the type of photograph, the scale to which it should be taken, the season of the year in which it should be taken, and the focal length of aerial camera that should be used in order to obtain a photograph that will best serve our highway engineers. For this study, aerial photographs were taken with cameras of various focal lengths, using both black and white, and color film.

The results of the project proved that for urban work the scale of photography should be 400 ft. to 1 inch and for rural areas the scale should be 600 ft. to 1 inch, all taken with a 12-inch focal length aerial camera. In addition, we have used aerial photographs for a lot of purposes on which I shall speak later on.

Mr. Smith: In general, the specifications for topographic mapping by photogrammetric methods, that are in use at the present time were originally written and designed by commercial firms. These like any specification in use for some time, need revision. This revision in my opinion must not be made entirely by either the highway departments or by the commercial firms alone. Rather it should be made by a group, such as Mr. Pryor has called together today. We must also bear in mind that no one specification will suffice for all jobs; the highway departments should be particularly cognizant of this fact.

Mr. Spelman: A large number of highway engineers are not acquainted with the methods and the procedures of aerial surveying used by aerial survey contractors. Many of them are unable to prepare specifications to obtain the end product which they need. We had hoped to evolve from this Panel discussion a series of specifications which would be applicable to the various needs of highway engineers, according to the character of the topography and the use of land.

Specifications most useful in Massachusetts, for example, might not be adequate for highway location throughout the Appalachian Mountains. It is necessary that general specifications be considered for the entire country with a modification of provisions permitted which would make them useful in any particular region, depending upon the character of the topography, the climate and the use of land.

Since it is essential that some sort of specifications be prepared, whether for general or for specific use, the American Society of Photogrammetry is logically the organization best qualified to write them. Representative specifications prepared by the Society would adequately aid the inexperienced highway engineer in getting the aerial photograph or map which he needs.

Mr. Siddall: The Ontario Department of Highways spends $75,000,000 a year, of which about $1,000,000 is allocated to Highway Surveys. Ontario is only one of the Provinces in Canada, the same as an individual State in the United States. Our highway location problems are somewhat typical for the country as a whole, and compare with some of your Northern States. We do not contract for topographic mapping. We do however, contract for aerial photography and require a contractor to supply us with contact prints. We insist that the following specifications be adhered to by the company or contractor that takes the aerial photographs and supplies us with the prints.

1. The camera is to have a six inch metrogon lens, when photos are to be used in conjunction with multiplex equipment.
2. Fiducial marks are to be edge markings.
3. Negatives are to be 9×9 inches.
4. Overlap to be a minimum of 55% and a maximum of 65% in direction of line of flight.
5. Side overlap on strips to be 10 to 30%, or about 1 to 2½ inches of the aerial negative.

6. Maximum tilt to be 5 degrees, or we allow an average of 3 degrees or less.
7. Negatives to have a fairly full density.
8. Negatives should be of such quality as to print well on #3 paper or softer.
9. Prints are made on a multilight printer.
10. The negatives become the property of the Department of Highways.
11. Contact prints are to be at a scale of:
    (a) 1,000 feet equals 1 inch for general photography and mapping at 400 feet equals 1 inch.
    (b) 200 feet to 1 inch for detail mapping at 100 feet to 1 inch.

We have a photogrammetric section staffed by 10 men who do nothing but work with aerial photographs. The results of their work provide the basis of route location, and guide all field survey location parties. Three photogrammetrists are Highway Location Engineers who have spent a number of years in the field, either in charge of or working on a survey location party, and have had considerable field experience in the use of aerial photographs.

When the contact prints are received by our Branch they are studied carefully by using stereo pairs and under a stereoscope, in order to select the most feasible and economical route possible between terminal points. The proposed center line for the new highway is marked directly on to the contact prints, and these are given to our field engineers for running in the field as the recommended location. In Northern Ontario a line map or plan is practically useless, but using an aerial photograph the engineer can keep in the proper position at all times. We rely entirely upon the use of the photographs in stereo pairs, both in the field and office. Plans are used only as a guide to orient the aerial photographs.

By the use of the multiplex equipment and the aerial photographs we prepare several types of study plans. In our Northern work the scale is 1,000 feet to 1 inch. In the Southern section, the scale of a plan is 400 feet to 1 inch, and on these plans we show the topography and principal drainage. On them we outline in detail the route location for the highway. The detail location plan is prepared to a scale of 100 feet to 1 inch, showing topography 300 feet each side of the center line of the new highway. The contours for this plan are located by field surveys in the field and not from aerial photographs.

The mapping by multiplex equipment for the 400 foot to 1 inch plans including the cost of photography, costs about 20¢ an acre. This figure is for an area of about 30,000 to 40,000 acres for which 10 foot contours are obtained. We assess the value of vertical aerial photographs in the following manner: 25% for mapping, 50% for selecting highway routes or locations, and 25% for field use in running the projected line or location as marked on the contact prints.

Mr. Wm. H. Meyer, Jr.: I do not have a prepared discussion, but I desire to mention a few points for discussion.

We must differentiate in our discussion of specifications between aerial photography and the products that can be obtained from the aerial photographs by use of photogrammetric procedures and equipment. We should never attempt in the specifications to combine aerial photography to be used only for examination and the making of mosaics with no intention of using them for mapping, with aerial photography taken for both engineering purposes and topographic mapping by photogrammetric methods. In my sales work, I find highway engineers are confused on those points. They cannot distinguish between aerial photographs that will not be used for mapping and the aerial photographs that will be used for photogrammetric mapping. We must be sure that everyone understands the distinction. True, we do use aerial photographs to make topographic maps by use of photogrammetric equipment, but the aerial surveyor and mapper knows that photographs must be taken with that purpose in mind,

or they would be useless to the mapper. Once that is understood, many misunderstandings now existing between the aerial surveying contractor and the highway engineer will be eliminated.

I presume that we have now become accustomed to the fact that specifications for aerial photography (just pictures) can be quite complete and adequate for competitive bidding. Aerial photographs taken for delivery as pictures become a product in themselves and must be distinguished from an end product that can be obtained from the aerial photographs, such as a controlled mosaic or an accurate topographic map.

Aerial photographic contracting agencies, and the directors of budgets, comptrollers, etc., have a strong argument in awarding contracts for aerial photography, on the basis of competitive bidding. That is because an aerial photograph is an immediate end product of itself and is not taken for use in precise work. I should like to promote the thought that when the aerial photograph is to be used for topographic mapping by precise photogrammetric methods, that type of work should be considered an engineering service. Mapping by photogrammetric methods demands a true horizontal scale and contours to an accuracy that will make possible computing earth work quantities for the highways to be located on the maps.

When topographic mapping by photogrammetric methods is open to competitive bidding, on a price-tag basis, confusion results in a highway department. Many times the highway department has no knowledge of who will bid or who is qualified to bid for the mapping. They do know that if an organization makes a low bid, whether qualified to do the work or not, the highway department will have a hard time rejecting its bid even though it is known in advance that maps prepared by that organization will not suffice.

Every highway engineer is reluctant to depend upon a topographic map for his engineering work, when he doesn't know whether the map is good or bad. That forces him to make ground surveys to determine the reliability of the map. Topographic mapping by the photogrammetric engineer should be considered an engineering service; such mapping should not be procured on a bid basis, because a topographic map as distinguished from aerial photography is a professionally produced product.

Specifications for aerial photography and for topographic mapping will have to be prepared in two categories: (1) for the aerial photograph as an end product for which samples can be submitted with the bid; (2) for topographic mapping by photogrammetric methods, with emphasis on the end product—the topographic map—leaving the type and scale of the aerial photography that will be used to the discretion of the mapper. This is necessary betause the mapper must take the aerial photograph which will enable him to produce the map required at the least cost, according to the type of photogrammetric equipment he will use. The highway engineer in this case should specify the scale of the map, the amount of detail required on the map, the contour interval, and the degree of accuracy required in the scale of the map and the contour interval. Those are the points that should be definitely set forth in the specifications, but the method of photogrammetric procedure and type of photogrammetric equipment to use, the scale of the aerial photograph and many other details should not be mentioned. Actually, the most important specification details for topographic mapping by photogrammetric methods are the scale of the map, the contour interval and the accuracy required.

Mr. Spelman: Mr. Meyer has brought out some important points. But the specification and contract problem isn't necessarily solved from the administrator's point of view, by considering the mapping project as a professional job

for which he must obtain an engineer on a retainer basis. This is so because he might have more difficulty in finding a competent aerial photographer and mapper to negotiate with, than he would have in choosing a reliable and competent bidder. In either case, however, whether the mapping from aerial photographs be done on a retainer basis negotiated with an aerial surveyor, or whether it be done on a bid basis by accepting the bid of a qualified firm, the highway engineer must have specifications which clearly set forth his needs and contain the details which will assure him that in the end he will obtain the aerial photograph and the topographic map required for his engineering work.

Mr. Bartlett: Mr. Pryor's excellent paper, prepared as a basis for discussion here, contains much valuable factual data for the information of the highway engineering and photogrammetric engineering professions, especially for those who have occasion to write or to interpret mapping specifications.

He has drawn upon his long experience as a highway engineer who early recognized the uses of photogrammetry, and who pioneered in the letting of contracts to aerial mapping organizations. It was not Mr. Pryor's purpose to write an all-inclusive paper on specifications, but rather to outline subject matter to be included in specifications for highway engineering jobs.

To me, the most significant points brought out in his paper are those included in the paragraph saying, "First of all, the writer of the specifications should know exactly what type of aerial photograph and map will fulfill his particular needs. He also must have a knowledge of the techniques of aerial photography and mapping by photogrammetric methods that will be employed in taking the aerial photographs and in producing the maps. And above all, he must keep in mind the purpose of all good specifications: (1) to obtain what is needed and (2) to do it at the least cost in conformity with the quality and the accuracy of the aerial photographs and maps required."

I believe there will be no contradiction of these points. However, it is not unusual in our experience for municipal or government agencies to call upon us for assistance in preparing the specifications for photogrammetric mapping and for other aerial surveys. Obviously, those asking for help are not familiar with this work. In my opinion, our work and the advice we give to a highway department in the preparation of specifications, is distinctly a professional service. The sad part is that, after all our efforts to assist with the preparation of specifications that conform with the requirements of the particular job, the client will usually ask a number of other organizations to submit bids, and then award the work to the lowest bidder.

I think you will agree that aerial surveying at the present time includes a broader field than mere picture-taking. It has been my experience, in advising clients as to their needs, such as working out alternate plans and specifications, that the technical and engineering phases entailed a large part of the work. It is my contention that such work on our part should be considered a professional service.

Let us consider a typical example. We received a letter from the city planning board of a small but progressive city asking for quotations on mapping. They sent preliminary specifications, in which one paragraph reads:

"A cloth tracing of the entire area at a scale of approximately 800 ft. to 1 inch, showing details as roads, streams, township boundaries, etc."; and further on: "Secure necessary ground control, both vertical and horizontal, to prepare a topographic map to a scale of 200 ft. to 1 inch, showing contours at 5-foot intervals and all planimetric details, such as roads, houses, railroads, etc. Horizontal and vertical control of third order accuracy or better is required."

The vagueness in those specifications is distressing. In the first case, we can-

not tell whether they want a planimetric map or some sort of a sketch map traced from contact prints. No mention is made of what, if any, grid system is to be used. By mentioning only roads, streams, and township boundaries, they show their ignorance of the wealth of other detail customarily brought out photogrammetrically, such as houses, power lines, railroads, bridges and pipe lines. Again, I cannot be actually sure whether they want us to prepare topographic maps or not. The paragraph could easily be interpreted to mean that they want us to put in the ground control for another mapping firm. We do not believe that is what they mean, but the doubt exists.

Our follow-up on this matter would be either a lengthy correspondence or the sending of our representative to consult with them. Either alternative is both costly and time-consuming.

I am convinced that the requirements for photogrammetric services have not been sufficiently explained in terms of engineering services. Most people think that photogrammetry is merely aerial photography and therefore should be contracted on a bid basis. This is not true. Such services often require a knowledge of highly specialized practices, expecially where photographic interpretation techniques are applied to such problems as soil classification, highway and airport site selection, analysis of forestry resources, and the investigation of the earth's geological structure. Experienced engineers and scientists are necessarily employed on such work and, as a rule, they are members of a professional group.

Most of us who hold membership in professional societies subscribe to a code of practice or a canon of ethics. These canons usually include a clause to the effect, and I quote from the code of the American Society of Civil Engineers, ". . . that it is unprofessional and inconsistent with honorable and dignified bearing for any member to participate in competitive bidding on a price basis to secure a professional engagement." Among the many statements included under the heading of "Business and Objectives of the Society" (and I refer, of course, to the American Society of Photogrammetry), there is the following: ". . . to exert influence toward the betterment of standards and ethics."

Although many municipalities and other clients have used maps prepared by photogrammetric methods, the number still in need of such maps, who have not used them, is tremendous. If we create the impression that by asking for competitive bids, the prospective client is going to get a product completely satisfactory to his particular needs, we are perhaps barring the way to a more mutually satisfying and closer relationship to the client. The photogrammetric engineer's first job should be to consult with and to advise the client on the best adaptation of photogrammetry to provide photographs and maps to fulfill his needs. In this manner, instead of the client arbitrarily picking a set of specifications from a book or other publication, which may or may not be adapted to his needs, the way would be left open to develop the job procedure designed to supply the client with aerial photographs and with topographic maps to the scale and the contour interval most nearly suited to his purposes. This would result in a better satisfied client with a consequent improvement in good will.

In the past, much effort by the firms, who are sustaining members of the American Society of Photogrammetry, has been directed toward convincing the clients of their ability to quickly and cheaply take aerial photographs and to produce topographic maps. It may be time now to devote some of our energies toward convincing clients that it is not to their advantage to submit proposals asking for competitive bids on such service. Under the circumstances, I believe it would be worthwhile to have the membership of the Society express their opinion as to whether the preparation of not only specifications but also the prep-

aration of maps constitutes a professional service. If it is the feeling of the membership of the Society that this work is of a professional nature, would it not be worthwhile for the Society to formally recommend that this practice of competitive bidding be discouraged?

Mr. Spelman: In the future, more and more highway engineers of our country are going to make more extensive use of aerial photographs and maps produced by photogrammetric methods, and whether the end product of the aerial photograph or map is to be obtained through the process of competitive bidding by qualified firms, or whether they are to be obtained by engaging one of those firms by negotiation for their professional services, it will be necessary that the highway engineers prepare a complete statement of what is needed before their services can be solicited.

You will all agree, I am sure, that regardless of the method used to engage the services of qualified firms, good specifications setting forth what is needed, whether it be an aerial photograph or any type of map, are essential. It is our objective here, today, to bring about an understanding of the importance of having the right type of specifications for each specific need of the highway engineer in this country.

Mr. Davey: I should like to make some comments that I believe are worthy of consideration by the Panel group. First, it seems that one of the items that will have to be taken care of is education of engineers in the use of aerial photographs, what can be expected from them and what can be produced from them. I believe that much difficulty in the writing of specifications is because engineers do not know what to expect from aerial photographs or what they are able to get from them by engaging the services of photogrammetrists.

It is a common experience in the Geological Survey to receive requests from cooperating agencies to enter into some sort of agreement that we will obtain aerial photographs adequate for every problem that arises where aerial photographs may be used alone, while at the same time expecting those photographs to be suitable for the preparation of topographic maps. Such requirements cannot be met with one set of photographs. We have finally convinced our cooperating agencies that there is no such photograph obtainable. We cannot obtain a photograph to one scale and expect it to serve every purpose in the mapping and engineering fields. That is another fact that must be publicized more.

Before specifications can be written to fulfill the requirements of those engaged in the various kinds of highway engineering work, I think it is going to be equally necessary to educate highway engineers in regard to the limitations of aerial photographs, and the need of procuring photographs to serve specific purposes. As an example of the misunderstanding that seems to exist, one highway engineer will say, "I must have aerial photographs at a scale of 800 ft. to 1 inch." Another will say, "I must have aerial photographs to a scale of 1,200 ft. to 1 inch." Each of the two engineers may intend to use the photographs for the same purpose, yet their opinion as to the scale of the required photograph varies greatly. The scale of aerial photographs should be standardized according to the purpose for which the photographs will be used. When the details have been standardized, then it will be easy to standardize specifications.

Mr. Spelman: Mr. Pryor should be given an opportunity to reply to some of the comments that have been made. The well-meant comments about his paper and those added on other topics are all worthy of summary.

Mr. Pryor: Your suggestion, Mr. Moderator, that I make a summary statement to all that has been said by the Panel discussants, is appreciated. Of course, it will be difficult for me to consider every point that has been raised.

First of all, I want to thank each man on the Panel for his cooperation and the assurance of his interest in the subject which he gave by being a member of this Panel. The response of each Panel member gave assurance that helped me a lot in the preparation of the paper which I read this morning at the general session, and which we now have before us for discussion. They prove that such an endeavor would be worthwhile.

The purpose of the paper was to provide a brief outline for your consideration of Specifications for Aerial Photography and Mapping by Photogrammetric Methods for Highway Engineering Purposes and to indicate certain items that should be discussed for inclusion in them. In addition, it was thought that the material of the paper would serve as a means of focusing our attention on many of the things that specifications for such purposes should contain, when we want to obtain aerial photographs for examination and for the preparation of photographic mosaics, and to prepare topographic maps from aerial photographs.

Mr. Landon has effectively mentioned the fact that Michigan is aware of the need for adequate specifications. He also acknowledges that there is much to be gained by having the specifications prepared so that the highway engineer will be assured that he can obtain the aerial photograph and topographic map that he needs.

Mr. Abrams has effectively stated that no one set of specifications would be suitable to procure the photograph and the topographic map required to solve every type of highway engineering problem. Furthermore, he has let us know that the aerial surveyor must be given a complete statement by the highway engineer setting forth what he needs in the way of an aerial photograph or a topographic map, to solve a specific highway engineering problem.

Mr. Spelman has emphasized that, regardless of the way in which the aerial surveyor is employed to furnish aerial photographs and topographic maps, adequate specifications are a must, and that specifications applicable to the procurement of aerial photographs and maps for the solution of a highway engineering problem in one region of the United States might not be adequate for another region, because of differences in the character of topography and the use of land.

Mr. Houdlette has brought to our attention the fact that Massachusetts has learned much by cooperating with Harvard University in a project to find out what type of aerial photograph serves the highway engineers' needs best in Massachusetts. That in itself is a pioneering endeavor worthy of commendation and careful study by all of us.

Mr. Smith has made it known that the contractors of aerial photography and topographic mapping by use of aerial photographs have had a profound influence on the early specifications prepared to obtain aerial photographs and topographic maps for use in the solution of highway engineering problems. Since the initial beginning of specification writing for such purposes, it has been evident that there were weaknesses in those specifications and that many topics should be omitted and new ones introduced. I feel that we should point out in our discussions here: (1) exactly which sections of the specifications used in the past should be omitted; (2) what new sections should be introduced to improve the specifications; (3) how the highway engineer can be assured that he will obtain what he needs; and (4) that the contractors of aerial photography and topographic mapping can get a better understanding of what the highway engineer's requirements are when the specifications contain the proper topics.

Mr. Siddall has given us some factual information about the use of aerial photographs by the Department of Highways, Ontario, Canada. He has let us know that aerial photographs can be used effectively by the highway engineer

for highway location purposes without maps and without the preparation of mosaics. He has shown that they can also be used effectively for mapping, and to determine where the preliminary survey shall be made on the ground for the location of a highway.

Mr. Meyer has effectively brought to our attention that we must make a distinction between aerial photographs that are taken for use as aerial photographs for interpretation purposes and the preparation of mosaics, in contrast to aerial photographs that are taken for an additional purpose, that of topographic mapping by photogrammetric methods. He has shown that an aerial photograph can be obtained by use of proper equipment and the services of technicians, but that on the other hand, a topographic map to a specified scale containing specific detail to a specified degree of accuracy in the position of all points on the map and of the contours, requires the services of professional men in addition to the use of the proper type of photogrammetric equipment. We must keep those points in mind in order to prepare specifications that will obtain for the highway engineer what is needed, and to do it at the least cost.

Mr. Bartlett has added emphasis to the need for more clarity in specifications and, of course, clarity cannot be written into them unless the writer of the specifications knows exactly what is required and how it may be obtained. He has also pointed out the services that are being given by the photogrammetrists to highway engineers engaged on other work throughout the country. In effect, they have taken on the task of educating the uninformed engineer concerning the services they are equipped and staffed to perform.

Mr. Davey has added to the general pattern of our discussion, saying that many of the people with whom the Geological Survey cooperates do not understand fully the uses and the limitations of photographs taken to any one scale. Consequently, we may conclude that there are many engineers in nearly every field of endeavor who are not cognizant of the uses and limitations of aerial photographs.

I may say that highway engineers in general are in need of much assistance and that our work in the preparation of specifications for their use will be a step forward in providing them with the material they need. If they could obtain specifications from this group of well-informed men that will result in giving them the type of aerial photographs and topographic map needed, according to the type of engineering problem they have to solve, they then will gain faith in the use of aerial photographs and of the topographic maps that can be prepared from them. Such faith in turn will increase the scope and the use of aerial photographs as time passes. I do not believe that we can emphasize too strongly the benefits that would accrue to highway engineering with the development of good specifications.

I agree that there is a need for education among the users of aerial photographs. As pointed out by Mr. Davey, the better we furnish the users of aerial photographs with fundamental information and working data in the form of tested specifications or of sample specifications to fill each of their particular needs in the separate engineering stages of locating highways, the better we serve those people and at the same time have the benefits to be obtained by furthering the use of aerial photographs in the solution of highway engineering problems.

In highway location, the first problem is one of making a reconnaissance of a large area. Photographic coverage must be obtained of that area and the photographs examined carefully and thoroughly. By that examination, the highway engineer must learn all that he can about the topography and the use of land in the area that includes all the feasible routes for a highway between the

designated terminal points. This applies whether the area problem is to determine highway routes in rural areas, or in urban areas.

Photographs taken for the reconnaissance of an area should be taken to a scale that will best serve the highway engineer, according to the character of the topography and the intensity of land use. The scale of photography is also affected by the width of the area of reconnaissance. The width is ordinarily 40 to 60 per cent of the air-line distance between the terminal points. As an example, if the distance between terminal points is 80 miles, the width of coverage required would be between 30 and 50 miles. Of course, specific widths would be determined by the location engineer; often the shore line of oceans, large lakes and large rivers, and the barrier of a rugged mountain range mark one side of the area for reconnaissance. A good rule to suggest, however, is not to attempt to economize by being conservative in the widths of area photographed for reconnaissance work.

In undeveloped regions where topography is rugged, the scale of photography will range between 1:24,000 and 1:60,000, depending upon the project size. In the more developed rural areas, where the topography is not so rugged, the scale of photography for reconnaissance purposes might range between 1:6,000 and 1:24,000, the smaller scale being used where the topography is the most rugged and the land use light, and those in the large scale range being used wherever the topography is not rugged and the use of land has reached a high degree of development.

After the route possibilities have been determined, it is necessary to obtain large scale photographs of those routes, in order to compare one with another and to select the best route for preliminary survey. This means that all routes must be photographed to a large scale. Reconnaissance of alternate routes by use of large scale photographs leads to determination of the best route that can be found, considering all types of controls that can occur in the topography and in the use of the land.

Mr. Houdlette has indicated that Massachusetts has found that route photography should be taken to a scale of 600 ft. to 1 inch when the highway location must be made through rural areas and to a scale of 400 ft. to 1 inch in urban, areas. This agrees with the experience of other highway location organizations who have used aerial photographs. In fact, route photography for reconnaissance of alternate routes will range in scale from 1:2,400 (200 ft. to 1 inch) to 1:12,000 (1,000 ft. to 1 inch), depending upon the character of topography and intensity of land use.

As I recall a statement by Mr. Siddall, 1,000 ft. to 1 inch scale photography is used effectively in the northern part of Ontario. Mr. Siddall also indicated that photographs to a scale of 400 ft. to 1 inch were used in the southern, more highly populated, areas of Ontario. Again there is an agreement in the principle that wherever there is a little use of the land and the topography is rough, the scale of the photographs can be small as compared to the scale required for highway route reconnaissance where topography is not rough and the use of land is intensive.

After the route reconnaissance work has been completed, topographic mapping by use of the route photographs, as mentioned by Mr. Meyer, is a natural sequence wherever the ground is not heavily covered by tall timber or other types of vegetation.

Wherever the ground is covered by tall vegetation for a large portion of the best route, the aerial photographs of that route can be used as a guide for a preliminary survey of the route by ground survey methods.

Wherever the preliminary survey can be accomplished by use of topographic maps, made by use of the route aerial photographs and the precise types of stereophotogrammetric equipment, the route photography must be taken with that in mind. However, if the routes cannot be mapped by photogrammetric methods because of ground cover, the aerial photographs can be taken with a longer focal length camera to make them more easily used for preparation of mosaics and for stereoscopic studies, and as a guide to the survey crews when the preliminary survey is made upon the ground by ground survey methods.

Such a sequence of stages in the location of a highway makes it obvious that the highway engineer must define the purpose for which the aerial photographs will be used before specifications can be written to obtain what he needs. Likewise, it will be impossible to standardize specifications to such an extent as to require aerial photography at one particular scale taken with an aerial camera with one particular focal length, to serve all purposes of the highway engineer, such as: (1) the reconnaissance of area; (2) the reconnaissance of alternate routes and (3) the preliminary survey of the best route to determine the place for the highway on that route.

Whether a highway department should obtain the services of an aerial surveying firm by engaging it on a consultant basis, or by selecting the firm on the basis of competitive bidding would depend upon many factors, among which are: (1) the administrative policy in the state highway organization; (2) the laws of the state; (3) the funds available; and (4) the highway department's knowledge of the competency of firms.

We in the Panel group here, and you engineers in the audience, can perform a needed service by providing a set of specifications containing our composite opinion based on what we know today. We must adhere to specific points in the discussion, and bring out as many facts as possible. Otherwise, we will not have sufficient information written into the record to fulfill the objectives for which this Panel was organized.

Mr. Houdlette: Our state of Massachusetts, has been recently mapped by the Geological Survey, in quadrangles showing all of our horizontal control within each quadrangle. We have aerial photographs taken of possible highway routes; we then assemble them to the control on the topographic map, after the map has been enlarged to the scale on which we are working. This method works effectively to provide us with semi-controlled mosaics, which are studied in conjunction with the aerial photographs and topographic maps. We are then prepared to outline the route to be surveyed on the maps and on the mosaic.

All of our state highway surveys are based on the Massachusetts system of rectangular coordinates. We find that the rectangular coordinate system must be established on the ground and maintained by the use of permanent monuments that are inter-visible from each other.

Whenever topographic mapping is accomplished by photogrammetric methods to large scale, for the preliminary survey of a highway, it is essential that the ground control survey monuments be set when the control surveys are made for the mapping work. These monuments must be set so that they will be useful in establishing the position on the ground when our engineers begin to stake the highway location from the preliminary survey. These monuments also assure that wherever test profiles are run to determine the accuracy of the maps, they are correctly established on the same coordinate grid as the map. I cannot see how any highway engineer can place a line for highway alignment on a topographic map and be sure that he will have the same line run on the ground unless he has the control monuments from which to begin his surveys.

ENGINEERS IN THE AUDIENCE OFFER COMMENTS

Mr. Kenneth Sime, Aeronautical Chart Service, Washington, D. C.: I agree wholeheartedly with almost everything that has been said thus far, and especially about the need for education of highway engineers in the use of aerial photographs and in the need for preparation of the right kind of specifications. Our job is two-fold.

It is the responsibility of the informed photogrammetric engineer and the informed highway engineer to get things started. They are the men who know what can be obtained and what is needed to serve the highway engineer best.

I understand that the American Society of Photogrammetry will soon publish a new manual on photography. It should contain material that will popularize the use of aerial photography among the professional engineers who are not familiar with the benefits that they can obtain by greater application of the use of such photography as an aid to them in their work.

It has been my experience, with regard to the professional services of taking aerial photographs and producing topographic maps from them by the use of photogrammetric equipment, that the main service being provided highway people is topography.

There are license laws in the various states governing the activities of professional engineers and land surveyors. I have travelled in the east during recent years and have seen no evidence of any law in these states requiring topographic engineer to have a license. If this be the case topographers cannot be classified as people providing a professional service. Perhaps there should be laws licensing them in the same way that professional engineers and land surveyors are licensed and governed in their work. Unless the topographer is licensed by law, there will be no standard of protection for the highway engineers buying topography unless they obtain such services through competitive bidding and negotiated contracts controlled by adequate specifications.

Mr. Abrams: Mr. Sime, I think you have hit the nail on the head. Topography and mapping should be a licensed profession. You have given us good ground to work on. I intend to check further into such an important objective.

Mr. Davey: I should like to ask Mr. Houdlette a question. He mentioned the desirability of having all maps for highway purposes established on a coordinate grid. It was also said that monuments should be set for later use by the ground survey crews who establish horizontal control for mapping, so that the monuments would be referred to the same coordinate grid system. My question is whether it would be possible to write specifications to set forth such requirements?

Mr. Houdlette: Yes. And that is what I intend to have done in specifications in Massachusetts. In addition, I will remark that if the control survey monuments are not inter-visible, there should be an azimuth mark determined that is visible from a transit set-up over each monument; otherwise a control monument is of no use.

Most of the control survey work done by the contractor for mapping from the photographs is of third order accuracy. We have checked the topographic maps by running lines between control points and found an accuracy of 1 foot over a distance of 2 miles.

By having the control survey monuments set to the same coordinate grid as the system to which the topographic map was prepared, we are absolutely sure that the line run on the ground to test the map is the same as the line drawn on the map. Without control points established in that manner, no adequate check

can be made to determine the accuracy of the map made by use of the aerial photographs.

Mr. Bartlett: In Massachusetts, it has been a specified requirement that property surveys be tied to the state's established rectangular system of coordinates. If the topographic maps prepared by aerial surveys are tied to the same coordinate system, the route of the highway laid out on such a map would also be tied to the same system. The next natural step is to relate the property surveys to the highway location, as they have both been surveyed on the same coordinate grid system. For the highway right of way, the land acquisition could be determined in the offices in one step since both surveys have the same orientation.

While such a method may be useful in Massachusetts, it may not be in Long Island, where a state rectangular system of coordinates is not in use. To introduce a system of rectangular coordinates separate from the system of the property surveys might cause confusion.

I think that specifications must be tailored for a particular job in a specific area, according to the system of coordinates used. No one system, it seems to me, will be useful in all cases.

Mr. Wm. H. Meyer, Jr.: I recommend that specifications for all mapping by photogrammetric methods include a requirement that the maps be prepared to conform with the state plane coordinate system which has been established for each state by the Coast and Geodetic Survey. This requirement should be in the specifications whether the state highway department or the state itself has formally adopted the state plane coordinate system established for that state by the Coast and Geodetic Survey.

To comply with that requirement, on our part, would be easy because the Coast and Geodetic Survey has computed the plane coordinate position for each of the primary horizontal control survey monuments that have been set in each of the states, by the Coast and Geodetic Survey. The advantage of such a requirement in the specifications is two-fold: (1) it would further a good cause by making engineers conscious of the advantage of the state plane coordinate system, and (2) it would provide an accurate and easily used means of checking the scale of the topographic map and its accuracy.

Let us all work toward the objective of getting the state plane coordinate system written into all specifications for large scale mapping by photogrammetric methods, and particularly for the highway engineer.

Mr. Spelman: In the Washington area coordinate systems have been established. There is a system in use in Prince Georges County, Maryland, and a system for the District of Columbia. Sometimes the various coordinate systems are not tied together, but it would be easy to tie them together whenever mapping for highway engineering purposes is contiguous through two zones where the system of coordinates is not the same. That can be done by the use of appropriate equations, which has been standard practice in highway engineering for years. In fact, highway engineers have been using a coordinate system for all highway location surveys, although they are not always based upon the state plane coordinate system. More often they may be based on an assumed point of origin. It would be desirable to begin basing all highway location surveys on the state plane coordinate system, established for the respective state in which the surveys are made.

Mr. Robert Smith: In order to obtain our opinion on what should be written in specifications for aerial photography and for mapping by photogrammetric methods, Mr. Pryor has listed a number of special topics for Panel discussion.

He begins with the weather and the seasons. What importance do they have and what should be said about them in specifications for such purposes? We need to give our opinion on such an important topic.

The aerial camera is also listed, together with thirteen separate items that might be discussed concerning the camera. It is my experience that the aerial surveying and mapping contractors have aerial cameras that generally comply to the letter on each of those thirteen items, which are fully covered in specifications for aerial photography that has been accomplished in the past for various government agencies.

I do not believe that the various state highway departments are qualified or equipped to inspect or pass on the precision of an aerial camera or to determine which particular type of camera would be required to obtain the type of aerial photograph needed to prepare the particular topographic map which he needs.

I suggest that some standard method for acceptance of the aerial camera be agreed upon. I propose that highway departments accept the aerial cameras to be used in connection with their work that have passed inspection for use in mapping projects by the U. S. Geological Survey. The U. S. Geological Survey has long engaged in topographic mapping from aerial photographs, and has adequately developed specifications and methods of testing to assure that the aerial camera used will provide aerial photographs that can be relied upon to produce the type of topographic map required by the highway engineer.

It will not be possible for me to consider all of the items listed by Mr. Pryor but I desire to discuss briefly the methods of designating flight-lines. It is our opinion at Aero Service that it is better for the highway department to specify the area that he must have photographed and mapped and that the determination of flight-lines be left to the judgement of the contractor. The contractor is more familiar with his particular methods and equipment and can more effectively designate flight-lines for his photographic crew. In this way, he can save the state highway department money. A good rule to follow is to outline the general requirements for coverage by photography and mapping, specifying what type of photograph or map is required and let the contractor work out the details. This also applies to the amount of overlap in line of flight and the side overlap on adjacent strips of photographs.

Generally, the work of taking aerial photographs and producing a topographic map from them is a step by step process with which the highway engineer can not be expected to be entirely familiar. Therefore, it is only natural for him to set up certain restrictions that will not be practical, even though he did not intend them to be so. Such restrictions may not produce any better results. On the contrary, they may interfere with the attainment of good results. After all, the contractor is responsible for the end product of the printed photograph or topographic map. He should not be tied down too closely in his procedures of getting that product.

The highway engineer must know what he needs and so state in the specifications, but the contractor for aerial photography and topographic mapping from those photographs is the one best qualified to determine the intermediate steps.

The requirement that sample aerial photographs shall be submitted, or that sample photographic negatives shall be submitted, to be used as a guide in determining the quality of photographs taken for the project, is only a theoretical means of guessing what is supposed to be obtained under actual conditions. When flying and taking aerial photographs under ideal conditions, anybody with a certain amount of experience for doing the work should produce a photographic negative and photographic print that are ideal.

Ideal conditions however, are not always available. Then, too, there are other restrictions such as time limit of the contract and the change of seasons. It should therefore be left to the good judgement of the contractor whether or not the photograph is adequate to produce a map within the specifications.

One example of the above is a specification for a topographic map which states that the photography shall be taken without snow on the ground. Snow coverage in some cases is objectionable and makes it difficult to produce a good map. This is particularly true in open or suburban areas; however, in wooded areas, it very often is desirable to have a few inches of snow and this will assist the mapper in his work. Therefore, it should be stated again that each particular project must be judged on its merits, depending upon its location, the amount and type of ground cover.

Mr. Wm. H. Meyer, Jr.: Serious thought should be given to the preparation of a paragraph setting forth the manner in which the topographic map will be checked to determine whether it meets the specification requirements for accuracy and completeness of detail. Tolerances must be agreed upon when the contours are checked for elevation and for position, as well as for checking the position of all other topographic features and the cultural detail. In the past some efforts have been made to write specifications that will provide for equitable checking of the elevation of the contours. We must continue to work on the problem of providing a logical way of checking the maps.

The specifications should also limit the period that the state highway department or other contracting organization will have in which to check and accept all maps, when completed by the contractor. Some specifications have avoided mentioning how long it will take to complete the checking of the map, and when notification will be given the contractor as to acceptance or rejection of the maps. The contractor should not be left wondering whether his maps have been accepted or rejected. It should be decided how many days will be permitted for acceptance or rejection of a map after the contractor has submitted it for testing.

In order to protect themselves against excessive checking costs, one state highway department has written a clause into its specifications that excessive map checking costs will be charged to the mapping contractor. The highway department, of course, is entitled to some protection against spending large sums for checking topographic maps that have been found inaccurate. On the other hand, however, the mapping contractor must have some idea of how much checking costs may be, should he have to pay for them. We should find another way of protecting the highway department from excessive expenses in the checking of inaccurate maps.

The perfect map has not yet been made. While I do not have the answer to the problem of excessive costs in checking maps, it is a vital problem and I have presented it here, feeling that it is worthy of careful consideration.

I agree with Mr. Smith in his suggestion about specifications for the aerial camera. Aerial cameras that will comply with the specifications of the U. S. Geological Survey for its photography and mapping requirements should also meet the requirements of the highway departments.

Mr. Pryor: In our Panel discussion we need to speak in terms of definite quantitative and qualitative ideas. Talking in generalities will not provide answers to specification questions, nor provide factual data for specification writing. I should like to ask, that in the remainder of our Panel discussion, each discussant be specific.

Undoubtedly each man here has a definite opinion in regard to the question

by Mr. Meyer in regard to the testing and the inspection of maps and of aerial photographs. Likewise, he must have definite opinions about the specifications that should be prepared, to assure the highway department that the aerial camera is precise, and that its use will provide aerial photographs suitable for use in the type of photogrammetric equipment that will be used in making the topographic maps.

Furthermore, I believe that there are definite opinions about the length of time that should be specified for the preparation of the maps, after the aerial photographs have been taken, and for the testing of the maps by the contracting officer, after they have been submitted for testing by the contractor. Undoubtedly each one also has a definite idea about the number of test profiles that should be run and used in the checking of high quality maps, and in the rejection of those maps that do not meet specification requirements. In addition, undoubtedly each one of you has a definite opinion about the variation that should be allowed on one map sheet as compared to the average required throughout the entire area of the mapping project, regardless of whether the specifications set forth the fact that each map sheet shall be fully adequate within itself.

To the highway engineer the over-all accuracy of a survey and the maps produced from the record of that survey are important. Likewise, the accuracy at any one point on any map sheet is of great importance and must be reliable. You cannot overlook the fact that units (that is, the separate map sheets) combined together make up the complete map, and together the maps will be used by the highway engineer in solving his highway engineering problems. Together, as well as individually, those map sheets must be reliable within the accuracy set forth in the specifications. What accuracy can be attained at reasonable cost?

So far we have not discussed the tolerances that should be allowed in the mapping by photogrammetric methods, of areas where dense vegetation and tall timber obscure the ground. It seems to me that we cannot expect the same degree of accuracy of topographic mapping by photogrammetric methods in vegetation-covered areas as in open areas. In open areas, most specifications used thus far have specified that ninety (90) per cent of the elevations interpolated from the contours must be accurate to within one-half a contour interval. Wherever the ground is covered by dense vegetation and trees perhaps another accuracy should be specified, such as one contour interval or two contour intervals, depending upon the character and height of the vegetation which hides the ground.

In conclusion, may I again plead for specific statements in order that we may arrive at specific answers to the many points that need to be discussed.

Mr. Abrams: I have an example in the use of specifications that I feel will be of interest to this group. Once specifications are written and the contract based on those specifications entered into, they literally must be "lived with." The following case history will emphasize that point. A government agency in the northwest advertised a project for which 400 to 500 miles of mapping were required. This agency apparently did not know whether the mapping could be done by ground survey methods, by aerial survey methods, or by a combination of both. They wanted to be fair. Consequently, they merely specified the end product which they needed. Briefly, it was a center line profile with a planimetric map extending on each side of the profile line a distance of 300 ft. The scale of the map was to be 200 ft. to 1 inch. The accuracy of the center line profile was to be plus or minus 2 ft. for each change in ground slope.

The agency placed the project open to competitive bidding. While doing so, it hoped that the one obtaining the contract would photograph the strip-area to

a scale of 400 ft. to 1 inch so that the agency could use those photographs in determining the 600 ft. wide strip to be mapped. When the bids were opened and prices compared, the job went to a ground surveyor. The federal agency did not get its photographs.

In order to tell the ground surveyor where he should run survey lines, the government agency had a difficult task and much more work than it had estimated because it had been expecting to get aerial photographs which would make that work easy. That agency learned in the hard way how unsatisfactory it is to designate a strip for a ground surveyor to map by ground methods.

Finally, the mapping project became an expensive one, as the agency had to select the place for the location of the center line survey without the aid of aerial photographs; it did not have the time it needed to do a good job.

The agency's needs should have been fulfilled in a hurry. The ground survey was delayed by the slowness of the agency in designating the strip-area to be surveyed.

This agency would have been much better off if it had asked for aerial photography in the specifications. Undoubtedly it has learned that it cannot obtain aerial photographs by wishing for them. It is regrettable, however, that if did not get what it wanted. Undoubtedly its sad experience has taught the agency that it would be better and cheaper to engage the services of a consultant to help it in the preparation of the right kind of specifications.

Mr. Pryor is to be congratulated on his paper and the many topics he has placed before us for discussion, each one of which should be considered while writing a set of specifications. Really, he is to be complimented further. He did not omit any topics that require discussion.

Mr. Kenneth Sime: It is my opinion that there has been some confusion here. We have not differentiated between the education of engineers in regard to aerial photography and topographic mapping by use of the aerial photographs and the writing of specifications to obtain what the engineer needs. While education is an important subject and justifiably could be considered by this group, we have a problem of considering topics pertinent to the writing of good specifications.

I disagree with Mr. Houdlette. Instead of four types of mosaics, there can be only two—the uncontrolled and the controlled. Whenever we try to distinguish mosaics by the use of some other term, we do not change the class, whether they are controlled or uncontrolled. We simply infer that the control used or the method employed in the preparation of the mosaic was inferior or superior. In my opinion the term semi-controlled or precise mosaic is misleading and confusing.

The uncontrolled mosaic may not be accurate when compared to a map for the position of the topography pictured on it, but there could be few mismatches of image points from one photograph to another. Consequently an uncontrolled mosaic can be a beautiful picture of even tone and reproduction qualities. The controlled mosaic, on the other hand, especially in areas of relief, must necessarily have some image mismatches at the edges of photographs, as no two adjacent photographs can have the same displacement of image wherever there is considerable relief in the topography. Controlled mosaics may approach map accuracy at the control points and present an overall accuracy of scale as compared to a map of the same area, but the mismatch of images may convey an impression to the user that it is less accurate than an uncontrolled mosaic.

Mr. Siddall: In Canada, we use the aerial photographs for stereoscopic study and mapping but we do not prepare mosaics. The highway route locations

are worked out on the photographs, and when taken into the field they are used to guide survey crews in their work. Mosaics are too large and cumbersome to be useful. We do not make mosaics.

Mr. Houdlette: We have let contracts to obtain aerial photographs for examination and for the preparation of mosaics from those photographs. I disagree with Mr. Sime. There are four classes of mosaics—the uncontrolled, the semi-controlled, the controlled and the precise.

We in Massachusetts have made use of three classes of mosaics—the uncontrolled, semi-controlled and controlled mosaic—and have prepared specifications to assure that we will get which one of the three we need for a particular project.

Mr. Sime: Again I disagree with Mr. Houdlette, there are only two classes of photographic mosaics. A semi-controlled mosaic has been controlled, therefore it is a controlled mosaic. It is only a matter of the accuracy and amount of control used.

Mr. Siddall: I should like to have the Panel tell me what should be written into the specifications to assure me that I will obtain the kind of aerial photograph needed for our work in Canada. This is important to us in the highway department at Toronto because we have used aerial photographs themselves in our location work instead of assembling them to make mosaics and for topographic mapping. We need aerial photographs for stereoscopic examination more than for any other purpose. Let me have an opinion on what should be written into the specifications to obtain photographs for such purposes.

Mr. Spelman: Mr. Siddall wants to know what the specifications should contain, to obtain aerial photographs. The Production and Marketing Administration of the U. S. Department of Agriculture has prepared a set of specifications which it has used for a long time to obtain photographs for use in the preparation of photographic mosaics and for stereoscopic examination. Perhaps Mr. Siddall could make good use of its specifications in his work. We have used and do use aerial photographs for highway reconnaissance, which we purchased from the Production and Marketing Administration. Photographs that are obtainable from that agency are adequate for many types of highway reconnaissance and provide an easy way to obtain photographic information in a short time, without the burden of taking aerial photographs every time they are needed. I feel sure that Mr. Siddall could readily obtain a set of the specifications.

Mr. Landon: In the United States we have a large number of mapping agencies. They think in terms of producing small-scale maps of large areas with a large contour interval. Most of the state highway departments do not require topographic maps of large areas. They can use the available aerial photographs to study an area and determine a highway route. After that, they need large-scale vertical photographs and a large-scale topographic map of the route in order to locate the highway. In Michigan, our highway location jobs are usually short. Many of them may be photographed to sufficient width by two or three strips of photographs. However, we occasionally have a highway location problem through an urban area where the width of coverage is considerably increased. Consequently, I may say that we use aerial photographs: First, as contact prints second, to make mosaics either of the uncontrolled or semi-controlled kinds; and third, in the preparation of topographic maps with contours at small intervals.

We are especially interested in having specifications developed for aerial photographs that will assure us that the contact prints will be uniform in scale and that uncontrolled mosaics can be made easily from those photographs and still have a fair degree of scale accuracy. Specifications should be written so that the highway engineer will obtain what he needs for solving his highway location problems effectively.

Specifications for aerial photography and mapping by photogrammetric methods *can* be standardized, and yet permit sufficient latitude for the highway engineer to specify the items needed and best suited for his particular job. State highway departments are accustomed to applying specifications to all phases of their work and operations where possible. Aerial photography and its products will be no exception to this rule, especially when the dollar value contracted for annually becomes sufficiently large. Arguments to the contrary are merely wishful thinking.

A tremendous job in education lies ahead. There are 48 state highway departments and hundreds of county and city engineers who should be increasing their efficiency and reducing engineering costs by using aerial photographs and allied products. The advantages of using an unconventional method must be proved to an engineer before he is willing to discard the old one. Once convinced, and if he has some imagination, he will find many new applications of photographic products to his work, and get excellent results.

The contractor who wishes to act as a consultant to the highway engineer would do well to acquaint himself with the details of the engineer's problem. They vary greatly in purpose and scope. Only then can he act in a true consulting capacity by speaking in understandable terms, giving competent advice on the most logical and economical plan of attack; and retain a good client by not over-selling him with a bill of goods which is not needed.

Our Department employes a photogrammetric engineer as a regular member of our organization. The unique education and experience requirements for this position (civil engineer with experience in both highway engineering and photogrammetry), enables us to work out economical solutions to many problems by using photogrammetric methods. Our field survey parties and design engineers have been given instructions in photo interpretation and use of the stereoscope. We anticipate that eventually all of our engineers will receive this training.

Proper education will create a greater demand for photogrammetric products and result in better highway engineering at less cost. The highway engineer will have specifications for this kind of work, even if *he* has to write them. Mutual cooperation between the photogrammetrist and the engineer in setting up proper specifications for the work will result in a contribution towards the educational problem and hasten the day when photogrammetry can take its predestined position in highway engineering.

With reference to the special topics set forth in Mr. Pryor's paper for discussion by the Panel, we wish to suggest the following which has been abstracted from our proposed specifications:

OWNERSHIP OF MATERIALS: All negatives exposed under this contract (regardless of whether or not they are acceptable), prints and photographic indexes shall become the property of the Michigan State Highway Department and must be available for reproduction and subsequent orders from that department. The negatives will be left in rolls, may be filed in metal containers in the film vaults of the contractor for additional reproductions, or shall be delivered to the Department upon requisition. Reproduction rights to these original negatives will be allowed the contractor only if all photographic products before release to the third party are stamped or lettered on the back thereof "Original Photography made under contract for Michigan State Highway Department, Charles M. Ziegler, Commissioner," and the Department be advised, by letter, the name and address of the buyer and the specific negative from which he desires reprints. All orders for reprints by a third party must have the approval of the Department for subject material and price.

WEATHER: Photographs shall be taken only between the hours when the

sun is 3 hours above the horizon in suburban areas, and 4 hours above the horizon in urban areas, on all days when weather conditions are such that clear well defined photographic negatives can be made. No photographs shall be taken on days when weather conditions are such that satisfactory results cannot be obtained. No photograph shall be taken when the streams are locally out of their normal banks or when the ground is covered with snow. The contractor will be responsible for making his own estimates of weather conditions, and no payment will be made for unsuitable photographs furnished due to inclement weather. However, due to requirements of the Commissioner, it may be necessary to make the aerial photographs despite the presence of some snow on the ground. In all such cases, the contractor must obtain a decision from the Commissioner, regarding the acceptability of these ground conditions before actual photography is made.

FLIGHT ALTITUDE: The negatives shall be exposed at the flight altitude above mean terrain specified on "Specified Data Sheet." Negatives should not show a departure from that altitude of more than plus or minus 5%.

FLIGHT LINES AND FLIGHT STRIPS: (a) When the area to be photographed is such that it can be covered by a single flight, the flight line shall be centered over the area as close as possible.

(b) When the area to be photographed is such that it cannot be covered by single flight, then additional parallel flight lines shall be drawn. The mean bearing of these additional flights with adjacent flights shall be within 5 degrees of parallel. In no case shall the lack of parallelism between adjacent flight lines or strips be such as to prevent the side lap between the strips from conforming with the requirements for sidelap between flights.

(c) Flight lines shall be planned by the contractor, and shall be in a direction to successfully cover the area with a minimum of flying operations.

(d) No photographs shall be taken on banks or turns between successive strips.

(e) Each flight shall be so photographed that the principal points of the first and last exposure in the flight shall fall on the outside of the area boundaries in order to insure complete stereoscopic coverage of all the area with boundaries.

(f) All photographs in a flight shall be continuous consecutive exposures, except when the area is irregular or curved. If a break in flight is necessary, due to length of flight line or changing of film magazine, there shall be at least a three (3) print overlap between the original flight line and continuation thereof.

(g) When any portion of a flight is rejected, that portion must be covered by a reflight which shall overlap each end of the acceptable portion of that flight by three (3) prints.

(h) Where the route over which the photographic flight is to be made is curved or in case of turns, the flights shall be broken and picked up again on new headings. In this case the flight line does not have to be parallel with the route as delineated on the flight map, but in no case shall the route as delineated fall outside the middle one-third of the resulting photographs.

OVERLAP: (a) Overlap in the line of flight shall not be less than 55%, nor more than 65%, and shall not average more than 60%. Any forward lap of less than 55% or greater than 65% throughout the entire width of the photograph or strip shall be sufficient ground for rejection.

(b) Sidelap between adjacent strips shall not be less than 15%, nor more than 35%, and shall not average more than 25% and shall be determined after all deductions for tilt, relief, and other factors have been considered.

(c) Boundary overlap or boundaries parallel to the flight line shall not be less than 10%.

(d) Boundary overlap at the ends of the flight line shall be as specified in Paragraph (e) under FLIGHT LINES AND FLIGHT STRIPS.

CRAB: Crab shall not exceed 10 degrees as measured from the line of flight. In any series of two photographs the relative crab shall be limited by the conditions of Paragraph (a) under OVERLAP.

TILT: Tilt shall not exceed 5 degrees for any exposure. The average tilt for a ten mile section shall not exceed 2°, and shall not exceed 1° for the entire project.

FILM: Only fresh, fine grained, high speed, ultra sensitive, panchromatic, topographic safety base aerial film shall be used.

NEGATIVES: All negatives shall be uniform in density and even throughout the image area. They shall be exposed and developed in such a manner that they shall contain all high-light and shadow detail. They must be sharp in detail, fine grained, free of snow, clouds, cloud shadow, light streaks, static marks or other defects which in any way make them unsuitable for the purpose intended.

INDEXING: Rolls of film used in the performance of this contract shall be numbered in unbroken series beginning with Number 1, and exposures on each roll shall be numbered in an unbroken series beginning each roll with Number 1. Each vertical negative shall be marked clearly with the following:

(1) Abbreviation for date of photography.
(2) County designation by number.
(3) Project designation within county.
(4) Film roll number.
(5) Negative number on roll.

Items 2-3-4-5 will be placed in the northeast corner of each negative for north and south flights, and in the northwest corner of each negative for east and west flights.

Item 1 will be placed in an adjacent corner in a counter clock-wise direction.

Items 2 and 3 will be furnished by the State Highway Department to the contractor.

All items will be placed just inside the image edge of each negative.

Items 2-3-4-5 will appear on one line, but Items 2 and 3 must be spaced as to make them appear separate from Items 4 and 5.

Item 2 will represent the county designation, and will be some number from 1 to 83.

Item 3 will be the project designation within that county. The combination of 2 and 3 will appear thus: (41–97). The combination of 2, 3, 4, 5 will thus appear about as follows: 41–97 ($\frac{1}{2}$″ space) 2–113.

The characters used in making negatives shall be approximately $\frac{3}{16}$″ high, and may be hand lettered or mechanically stamped with opaque ink in such manner as to print clearly in positive form on the image area of the photograph in the positions specified. The top of the characters shall not be less than $\frac{1}{8}$″ nor more than $\frac{3}{8}$″ from the image edge.

NEGATIVE SCALE: The average negative scale shall be that specified in "Specific Data Sheet" and exposures shall be made as per paragraph headed FLIGHT ALTITUDE.

CONTACT PRINTS: Contact prints shall be made on double weight matte or semi matte 9″×9″ photographic paper, using adequate variety of contrast grades to bring out all details of the negatives. All prints shall be trimmed to the image edge in such manner as to allow a positive identification of the collimation work.

On the back of each contact print shall be stamped the following:

Aerial Photographic Survey
for
Michigan State Highway Department
by
(Name of Contractor)

All prints shall be clean and free from chemical or other stains, blemishes, uneven spots, air bells, light fog, and finger marks, and shall be thoroughly washed to insure entire freedom from hypo or any other chemicals which would impair their permanency.

ENLARGEMENTS: The control furnished by the Department will be used by the contractor to prepare ratios for photographic enlargements to the size and scale as specified on Specific Data Sheet.

MOSAIC: (a) Uncontrolled mosaics shall be assembled from contact prints or enlargements using whatever method the contractor desires, to reduce all mismatches to a minimum.

(b) Semi-controlled mosaics shall be assembled from ratioed prints or enlargements. Ratios are to be computed by the contractor, using control furnished by the Department. Orientation of the individual prints within the mosaic shall be controlled by plotting a surveyed traverse line, using the straight line method, or by transferring important topographical features from a State Highway Department map to the mosaic board by means of a pantograph.

There shall be no apparent mismatching of detail in the mosaic, and patching to eliminate mismatches must not be more than 15% of the mosaic image area.

(c) Controlled mosaics shall be assembled on a radial line controlled network, and the accuracy of such network shall be such that 90% of all radial control points as mounted in the mosaic shall be within twenty-five one-thousandths (.025) of one (1) inch of the position as located by the radial control assembly of templets, and no radial control points as mounted in the mosaic shall be more than five one-hundredths (.05) of one (1) inch, from the position as located by the radial control assembly of templets.

(d) When the overall length of assembled mosaic requires it the mosaic shall be assembled in sections of 36 inch length, and sufficient tick marks shall be placed in the white borders of each section to allow for accurate orientation of the various sections when they are assembled together. Tick marks shall be in the form of short straight lines not over 1 inch in length. These marks shall be placed in the white border of the mosaic and shall be used in connection with a straight edge to determine a straight line and to carry the straight line across the various sections of the mosaic. In any 36 inch mosaic section there shall be 3 such tick marks in the white border, one at each end of the mosaic section and one approximately midway between these two.

QUALITY OF SAMPLES: Each bidder shall submit a sample contact print made without mask on double weight semi-matte paper, as specified in Paragraph headed CONTACT PRINTS hereof, from a vertical negative taken with the type of camera and lens at the maximum stop opening he proposes to use, and at the approximate scale specified in the schedule of the advertisement; and, unless otherwise specified in the schedule of the advertisement, a sample single weight semi-matte, unmasked, two-and-one-half-diameter enlargement from one-quarter of the same negative, including the center and one corner of the

negative. These samples shall show terrain having an average amount of clear-cut detail and shall represent the quality of work, including over-all definition, definition in the corners, and photographic quality, that bidder proposes to furnish; and will be used as criteria in judging the quality of the photographs the contractor delivers under the contract. Samples showing only heavily wooded areas or other types of terrain in which it is difficult to determine whether the photographic quality and definition meet the requirements herein specified, will not be accepted. If specimen contact prints and enlargements of the quality the Commissioner requires are attached to the schedule of the advertisement, the samples submitted by the bidder shall equal these specimens in all respects. The Commissioner reserves the right to reject the bid of any bidder who, in his opinion, fails to submit samples of the quality required by these specifications and the attached schedule.

CAMERA: The photography shall be made with a single lens aerial mapping camera of a type approved by the Department with an effective image area of not less than 80 square inches and a focal length as stated on the Specific Data Sheet.

Mr. Houdlette: We in Massachusetts have prepared specifications for that type of work.

Mr. Davey: The problem of the U. S. Geological Survey is considerably different from that of a state highway department. We must obtain aerial photographs on a large-area basis and require the use of aerial cameras of the highest precision. The aerial photographs must be taken to comply with strict specification. I do not believe that many of our rigid requirements should be put into your specifications for highway work.

As an example, the use of a precision camera is not necessary when aerial photographs will not be used for mapping purposes. Photographs taken with almost any type of usable camera would be suitable for stereoscopic studies and the preparation of uncontrolled mosaics. For some types of your work, I would recommend the Sonne strip camera. Continuous strip photographs can be taken with that camera to provide you with large scale information of good photographic quality.

There should be a distinction made between photographs that are taken for mapping purposes and photographs that are to be used for purposes other than mapping.

Mr. Siddall: There were no maps or mosaics used in location of the Alaska Highway. The location route was marked on the individual photographic prints, and they were then used by ground survey parties to guide them in their survey operations.

The Alaska Highway was located by the use of photographs taken by the Air Force during the war in a region where no maps were available, and when there was not time to use the photographs for mapping. Aerial photographs can be used effectively without producing maps.

Mr. Wm. H. Meyer, Jr.: I do not know how many states there are that have money to spend for aerial photography, like the Army and Air Force. It seems to me that highway departments in the various states must be more conservative in the taking of the photographs they will use. They should plan to use them effectively for a study of the topography and the nature of the development in a region as well as for mapping.

Mr. Lloyd O. Herd, Ohio Department of Highways: Specification writers are generally aided by basic standard specifications which they reference or incorporate. Clearly aerial photography and maps are two different and basic things. The highway engineer may want either or both. He should have made

available to him, in reference form, existing standard specifications for air photography and mapping so modified as to be applicable to large scale work. Copious instructions to contracting officers are necessary. Tentative specifications might be included in the manual that will shortly be published by the Society. They might also be made available to the Bureau of Public Roads for distribution to the engineers in the various highway departments.

Some specification details that should be considered are the effects of motion in low altitude work. Specification of minimum resolution or the use of motion compensation magazines may be worthwhile.

As highway departments have crews capable of running control surveys, attention should be given to the possibility of using this personnel and requiring only that mapping contractors furnish a member of their technical staff to assist in this important work.

Highway departments will normally want possession of the negatives if they have reproduction facilities.

It is my belief that maps and plans are of such importance that their preparation should be carried out under the direction of a professional engineer and that they should be sealed by him.

Mr. Spelman: I am a highway engineer and not a photogrammetrist. The photogrammetrist should cooperate with the highway engineer so that the specifications will be clear and understandable while at the same time provide for obtaining everything that is needed by the highway engineer. Otherwise, I wonder what the results will be.

Mr. John E. Meyer, Michigan Highway Department: We are interested in learning about specifications. We do not feel that engineering services should be a part of our discussion today. Let's confine our discussion to specifications. In Michigan, contact prints are used for 80 per cent of our work. Specifications for aerial photography, therefore are an important topic.

I should like to hear comments about the desirability of having snow appear on the photographs, cloud shadows on the photographs, or taking photographs when the sky is overcast, as compared to taking photographs under what may be considered "ideal" conditions.

Because of the use of contact prints for such a large portion of our work, the scale must be within plus or minus 5 per cent. In fact, a variance of 5 per cent in scale is too much. We use the photographs to make a mosaic of the topography in which the highway problem lies; and whenever the photographs do not have a high degree of accuracy in respect to scale, it is difficult to use them for such purposes. We procure topographic maps occasionally but I may repeat again that the majority of our work is accomplished by a study of contact prints.

Mr. Smith: The answer to more even scale of photography should not be sought by any requirement that the original photography be flown within 2% at a given scale. While I would not admit that this is impossible, it can be said with certainty that it would be more expensive. The proper way to obtain even scale photography is through ratio printing. This is far more economical. Then too, the engineers can have the exact scale of the portion of the photograph in which he is interested.

Mr. John E. Meyer: In view of what Mr. Smith has said, should the highway engineer specify that he must have rectified or ratioed prints?

Mr. Smith: Yes, if he requires photographs that have a scale accuracy of plus or minus 2 per cent.

Mr. Edward A. Schuch, Aero Service Corporation: There are some highway departments in this country that ask for an accuracy that is impracticable. The requirement for accuracy should be based upon that which can be obtained on a practical basis, at reasonable cost. Practical limitations and costs are two of the primary subjects that must be considered. Greater accuracy can be obtained by mapping from photographs in those areas where the ground is easily seen than in areas where the ground is covered by vegetation. It would not be practical to ask for the same accuracy in both types of areas. If a certain amount of tolerance cannot be permitted in vegetation-covered areas, money could be saved by mapping such areas on the ground by the plane table method. I am of the opinion that one standard set of specifications will not meet every engineer's needs under all conditions.

Mr. Spelman: In highway location work, the cost of the aerial photographs and the topographic maps is small when compared to the cost of constructing a highway. The cost of a highway increases in most cases with the intensity of the land use and with the ruggedness of the topography. We cannot gauge our specifications according to what photogrammetrists can produce. The specifications must be prepared to obtain what is needed for the particular highway location problem that must be solved. Are you trying to say that photogrammetric methods are too expensive where much detail and accuracy is required in highly developed areas and in mountains where the ground is covered by tall vegetation?

Mr. Schuch: Specifications should be prepared for saving money. The aerial photographs and the maps made from them can be produced to fulfill any needs, but the cost must be considered.

Mr. Herd: The state highway departments need standard specifications. We in Ohio would appreciate having them. Many state highway departments do not have specifications of any kind for aerial photography and topographic mapping. The objective of furnishing them to the state highway departments is worthy of consideration.

Mr. Isaac W. Brown, Mississippi Highway Department: Much of the time today has been used in talking about mosaics. We in Mississippi have been using contact prints since 1932. We have never been concerned with mosaics. We use the contact prints which we buy from the Department of Agriculture. In addition, we have let some small contracts for photography of areas around municipalities. We have used some mosaics of the municipalities but not of the rural areas. We purchase the contact prints on double weight, semi-matte paper for stereoscopic study.

Snow: What is snow? We don't care about snow. It seems to me that snow is something you people in the north worry about. When we get snow it is your snow that has been melted into water. Water is our problem; when an area is covered with water photographing it is useless if the photographs are to be used for highway location purposes.

Mr. Paul S. Otis, New Hampshire Highway Department: I think that many highway departments may have men in the top positions who are not familiar with aerial surveying and I agree with Mr. Sime that there is a great need for education among engineers. One aerial surveying contractor attempted on his first visit to sell our Chief Engineer a large scale topographic map of an extensive area. The price quoted was considerable. It seems to me that it would have been advisable to suggest a small demonstration project first.

Our State is very heavily wooded and the expense of contours extending for a

mile on each side of the center is not justified. In some places it would be impossible to relocate a highway more than 500 feet to either side of the present location.

The small scale maps prepared by the Army of much of our State are not suitable for highway location work. We must have large scale photographs and maps in order to study the ground detail. This is particularly important in the built-up areas where wide deviations from established lines are not possible. Mosaics in the form of strips are currently being used for preliminary route study at a scale of 400 feet to the inch, with built up areas sometimes enlarged to 200 feet to the inch. These strips are being flown by our department personnel.

While contoured maps are extremely valuable, we believe that in our State the greatest use of aerial photography can be obtained with the actual photographic mosaics, at a controlled scale of complete routes. This is especially important where long relocations of the highway may be proposed and will be built in several sections. A master plan of the whole route may be projected with assurance that short sections will properly tie in with the complete plan. When several different groups are involved in a discussion of the merits of alternate routes, the photographic strips can be of great assistance.

I believe that wide latitude should be given the contractor when preparing specifications for aerial surveying. This necessitates confidence in his ability to do the work and brings up the important subject of prequalification. A proven record of satisfactory work should be demanded of all bidders.

The important points to be given in the specifications should include the area to be photographed, a finished mosaic to a prescribed scale with good photographic quality and not enlarged to such a degree as to seriously impair the detail. The work should be done when there are no leaves on the trees and a minimum of snow cover except when these conditions will not materially affect the purposes of the photography. The accuracy and quality of the planimetric map should fit the intended use of the maps with realization that the cost will be in proportion to the refinements.

I believe that details as to type of camera, lens, film, overlap, etc., should be the responsibility of the contractor and only the end result specified.

Mr. R. M. Towill, Honolulu, Hawaii: In Hawaii, I am engaged in engineering work and have taken aerial photographs and used them in making large-scale topographic maps. I have listened intently to the discussion today and I am interested particularly in what you speak of as "bidding for professional work." Such a practice has not yet developed in the Hawaiian Islands. It appears to me that the difficulty has been in placing a price tag on aerial photography and mapping rather than on engaging a contractor that is qualified and experienced for the services he can perform.

In so far as specifications are concerned one set of aerial photographs will not fulfill all requirements. Consequently, for economy as well as for obtaining the best highway location, specifications should be prepared for a specific job. Specifications in general terms attempting to meet all types of needs should not be written.

Mr. J. B. Harwood, Virginia Highway Department: I endorse Mr. Houdlette's recommendation that control survey points set on the ground should be shown on the maps. These control survey points should be monumented and referenced in some way, and their location shown on the maps. I feel this is important as they can be used effectively when the test profiles are run, and when the map-location for the highway is to be staked on the ground.

We have found that it is necessary to charge the mapping contractor with

the cost of running test profiles, when they exceed a certain number, to determine whether a map sheet will comply with specification requirements. Unless that is done, the cost of testing unsatisfactory maps can become greater than the amount paid for the actual mapping of the specific area. The subject of checking maps is one that should be studied and thoroughly discussed in order to eliminate unfairness of any kind to the state highway departments and to the mapping contractors.

Mr. Wm. J. Fulton, Highway Department of Ontario, Canada: I think that few difficulties would be met if highway officials knew as much about aerial photographs and photogrammetric methods of mapping as Mr. Pryor, and on the other hand if the aerial surveying contractors knew as much about highway engineering requirements as Mr. Pryor. All highway departments have specifications for the various types of work they do, such as grading, paving and structures, etc., but behind the specifications in each highway department are a corps of experts in each of these fields who know exactly what they want and who are constantly revising these specifications so they will better suit changing conditions and improvements in methods of carrying out work. Satisfactory specifications for various types of aerial surveying must have this same background to ensure equal satisfaction. That is in each highway department there should be a photogrammetry section varying in size depending on the amount of photogrammetric work they propose to do themselves, and on the amount they intend to have done by contractors. This, of course, does not mean that standard specifications for various kinds of aerial surveying would not be necessary. It means that these standard specifications would be supplemented or amended by the photogrammetric experts in the highway department, to fit the particular job that was being undertaken. This would engender a better understanding between the highway department and the surveying contractor and would ensure a product mutually satisfactory.

We in Canada started using aerial photographs for highway work in 1935. We trained our highway location men to use aerial photographs in the field and now they are fairly good photogrammetrists.

In our work we use contact prints all the time. However, in the southern part of Ontario, we have prepared maps by use of the photographs to a scale of 400 ft. to 1 inch. This mapping is done with our own staff, by the use of multiplex equipment.

I should like to emphasize the importance of the highway engineer becoming a photogrammetrist to make the most effective use of aerial survey methods in his engineering work.

Mr. J. C. Carpenter, Bureau of Public Roads: Specifications for highway construction have been developed and revised during the past 30 years so that a practically standard text is now used for the general requirements and covenants commonly known as items 1 to 9. The first section of these general requirements and covenants defines terms of special significance and abbreviations. When aerial surveying and photogrammetric processes are to be covered by contract in State or local highway work, the specifications used by the agency will need to be revised to incorporate new terms and their definitions in the adopted text. The outline prepared by Mr. Pryor may be developed in such a way that the additional material will fit into the recognized standards.

Specifications recommended by this Society for standard use will have little significance unless they are recognized by highway officials themselves. I therefore, suggest that we as technicians in photogrammetric work advise the American Association of State Highway Officials that the American Society of Photo-

grammetry will give them technical advice in the preparation of standard specifications for use in awarding contracts for aerial photography and development of maps and data for planning highways. I believe Mr. Pryor had such an objective in mind when he prepared the proposed outline discussed here. His summary is the result of an immense amount of work and time and it is fitting and proper that it be recognized by the American Society of Photogrammetry.

Mr Pryor: In closing this meeting, I want it known that the efforts and the words of all participants in the Panel and the discussion from the floor are sincerely appreciated. I hope that something of value for future use can be gleaned from the record of this Panel. I feel that many topics, for lack of time, have not been discussed and that many points have not been effectively discussed.

I should like to ask each man, who is interested in this type of work, to review his comments when they are made available to him. While reviewing them it is suggested that careful thought be given to the possibility of written discussion to supplement remarks made today. A written discussion would be most effective if it pertained to the special topics listed on pages 14, 15 and 16 of the paper which you have received today, and also the bid schedule items and units of measure listed on pages 17 and 18. I am convinced that it is a worthy task that we have undertaken—that of writing specifications which would enable the aerial photographer and the photogrammetric mapping firms to do their work effectively, efficiently, and at least cost while at the same time furnishing the highway engineer with a type and quality of aerial photograph and map required by the highway engineer to aid him in the solution of his highway location problems.

Perhaps the example given by Mr. Abrams is typical of the errors that can be made unless we focus our attention on aiding people who are less experienced. As a last plea, if you do have something more to contribute, please send it to me. It might be done either by revising or adding to your oral comments today. Such a record can be reviewed by everyone and consolidated to help in the development of better specifications in the future. If we can accomplish that, our efforts will have been expended in working toward a worthy objective.

Mr. Sime: Would it be appropriate to propose a resolution whereby the people in this group recommend to the American Society of Photogrammetry that a committee be appointed to prepare specifications which could be used by the various highway departments to obtain the aerial photographs and the topographic maps which they need, and that the specification so prepared be submitted to the American Association of State Highway Officials for adoption by that organization for use by the highway departments?

Mr. R. M. Towill: I wonder if we should recommend such an objective to state highway people?

Mr. Spelman: The American Association of State Highway Officials consists of the officials and engineers of the state highway departments and of the Bureau of Public Roads. The American Association of State Highway Officials is the group that develops specifications for highway work of all sorts. I believe that it would be appropriate for the American Society of Photogrammetry to offer its assistance in the preparation of specifications for such a worthy purpose.

(*The question asked by Mr. Sime was restated by him in the form of a motion. It was seconded and was passed by unanimous vote.* The meeting adjourned at 5:00 P.M., January 13, 1950.)