For flights 7–8, the maximum elevation is 4,300′, or 2,500′ above assumed ground. The Width Chart indicates an allowable value for W_h of 17,000′ when $H=18{,}700$ and $h=2{,}500'$. Allowing 1,000′ for tilt displacement, allowable $W=16{,}000'$. This is less than the calculated value of 16,630 for W. However, in this case, it is advisable to risk a gap rather than fly higher, for the following reasons:

1. The peak elevation is at only one point; gapping will not occur unless the peak is at the extreme corner of the model, and the photo centers are exactly opposite each other.
2. Over the peak, there is as much chance of the tilt displacement increasing the overlap as there is of reducing it.

From the foregoing tabulation, the range of H is calculated as follows:

Maximum $H=20{,}000-300=19{,}700$

Minimum $H=20{,}500-4{,}300=16{,}200$

Since W is constant at 16,630, the range of W/H is as follows, assuming accurate flying.

Minimum $W/H=16{,}630/19{,}700=.84$

Maximum $W/H=16{,}630/16{,}200=1.03$

Allowing ten per cent of the flight height for deviation from flight line, the allowable value of W/H ranges from .74 to 1.13. This range is automatically maintained when the photographic flight follows the flight line as drawn on the flight map, within allowable limits.

Figure 8 illustrates the resulting flight plan for Case II.

CONCLUSION

If the methods used in this approach seem unduly complicated, it should be remembered that the end product, the Flight Design Work Sheet, is comparatively simple. It is, after all, necessary to understand the complications before they can be reduced to acceptable simplicity.

LUNCHEON ADDRESS*

Arthur C. Lundahl, Naval Photo Interpretation Center, Washington, D. C.

LADIES and Gentlemen, Distinguished Guests and Friends of the American Society of Photogrammetry:

In the few minutes that I have to speak with you today, I should like to dwell on two subjects, very briefly. I should like to talk in general, first, about some of the things that are happening to the American Society of Photogrammetry—some of the trends which are developing and that I have observed in my year's service as the Chairman of the Publications Committee, and then I should like to relate in a remote fashion these events to some of the things which we have been doing at the U. S. Naval Photographic Interpretation Center where I am employed.

The American Society of Photogrammetry is becoming big business. You do not realize this until you attend some of the long sessions of the Publications Committee with the Editor. Each of the issues is growing larger and larger. This year marks the biggest year that we have ever had in pages published. Over 682 pages. I have no doubt that we will publish much more next year; the trend is definitely upward.

* Delivered extemporaneously at the Luncheon Session, Sixteenth Annual Meeting of the Society. Washington, D. C., January 14, 1950.

There is no problem and no real effort is needed, it appears, to get the interest and support of those engaged in mapping, either directly or indirectly. The membership of our organization is now well over two thousand, and the number is growing. The rate of growth is what concerns me, and I should like to say that I believe that the rate will be materially accelerated if we continue to do some of the things which we have started to do. There are many groups of scientists perched around the fringes of our organization, like campfires around the horizon; we can pull them into our camp if we make apparent to them what we have to offer in aiding them to solve their own problems.

Back in '47, we published a symposium on photogeology in our Journal. It has been the single most popular issue we have had. It is almost out of print. We are receiving requests every day for repetitions of symposia on photogeology. At the same time, the first rumblings are occurring to "give us some information on the applications of photogrammetry to medicine and to economic problems of all sorts," whether it be to assess the volume of coal which the Pennsylvania Railroad has at the end of a fiscal year or to make a better measurement for a tailor-made suit. The problems are coming to us, which cause us, then, to re-examine the title "photogrammetry" which, by the definition accepted by the Society, is the science of extracting reliable measurements from photographs.

We have concentrated heavily on mapping, and this will always be justified because the greatest commercial interest lies in the mapping field. But to make our membership grow, we must make apparent to these outlying groups that we have something to offer to them, as we have apparently already done for the photogeologists. For instance the medical groups, the economic groups, the highway groups, agriculture, the dairy industry—some of these may seem remote to you, but photogrammetry has definitely been applied to their sciences. Dr. Zeller's books, and some others which you perhaps will have a chance to read when they are translated, will bear out some of these applications, uses and values of photogrammetry.

One thing which has held us back to a certain extent is the lack of adequate textbooks. Photogrammetry is a new science; it is growing, but the rate of growth in numbers or quality of our texts has not kept pace with it. People are constantly besieging the Society with requests for information about this or that subject, and it is almost always a "hot" story which we whip together at the eleventh hour, to tell them what our Society does.

There have been some very definite trends in the last year. Some new books are being prepared. The American Geographical Society has a new text coming out on photogrammetry; it is over 50 per cent completed; Dr. O. M. Miller is putting it together. Mr. Duane Lyon, of the Aeronautical Chart Service in St. Louis, has been editing a large work which will have chapters which are mutually related and will be interesting to all of the membership. As you well know, our own MANUAL OF PHOTOGRAMMETRY is more than 80 per cent complete. We expect to give it to the publisher sometime this spring. Another new book is just off the press, the *ABC's of Photogrammetry*, by Mr. McNeil and Mr. Anderson. This is a fine book, dealing with the elements; too many books have been written on elementary photogrammetry, without actually getting down to the elements of the science, and, as a consequence, we have too many people, engaged in government or large production-line operations, who know not much more about photogrammetry than that which embraces their working day. Our objective should be to interest these people, not only in the task which lies before them, such as tightening bolt 36 all day long, but in the total implications of where their work goes, and the effects of variations in accuracy or precision, on their part as related to the end product.

Accordingly we are going to encourage the publication of helpful material and, once published, we are going to try to get active discussion amongst our membership.

The MANUAL itself is undergoing some considerations for change. We are considering a double column instead of a single line across the page of text. We are considering using smaller type under certain conditions. Utilizing the long experience of the American Society of Civil Engineers, certain papers in our Journal will be opened up for discussion. We find that it is most stimulating to present to the membership two sides of a problem, to give them the pros and cons of an issue, and the views and experiences of others than the author of a published paper.

It is true that this takes a tremendous amount of work, and the Publications Committee, in seasons past, has not had the time to devote to it. So we are invoking another practice. We will have dual leadership on this committee; by dividing the workload, we hope to extend the scope of things that we can cover.

Also, we are actively getting into collaboration phases with the International Society for Photogrammetry. It has something to offer us, and we know we have something to offer it. Photogrammetrists in Latin America are continually showing interest in our Journal and are asking for permission to reprint not only single articles, but whole editions. We will try to meet these interests in so far as we possibly can.

These are all trends but we should extrapolate and look into the future. Such gatherings as this meeting are most stimulating. I am sure that each person here does not get too much, individually, out of the technical sessions; he sees the speaker and he gets the idea of what he is talking about. But he really relies on a later study of the material which comes out in the Journal. Therefore, we have invoked another practice. The contents of the March issue will be restricted to technical papers. Henceforth other material for the Annual Meeting will be published in a new issue, a non-technical Yearly Number. This will allow you to examine in detail many of the things which you did not have a chance to look at, in the process of meeting old friends, and so forth.

Now a brief word about the organization with which I work.

At the U. S. Naval Photographic Interpretation Center, our problems in photogrammetry are radically different from those in most of the mapping and government activities. It is largely a research organization, in some cases to improve the techniques of mapping and in other cases to solve a problem which no one else has been able to solve. The organization is very small and the results of its work are not too widely distributed. However, I should like to put this forth as an optimistic note in a sea of rather pessimistic feeling in Washington in the last few months. That note is that, in our functioning in this relatively new organization (we only started as a civilian group in '46), in our functioning as a center, we have had admirable luck, shall I say, in our dealing with the fellow services and government activities. You read in the paper continually about disagreements between the leaders of our armed forces, and it strikes me as being very peculiar that we never see these disagreements at the working level.

Wright Field gives us the things we want, the most whole-hearted cooperation; we could ask for nothing more. The Engineer Board has been wholehearted in its support of us, loaning us equipment, ideas, personnel. The Army Map Service, the Hydrographic Office, Coast and Geodetic Survey, Geological Survey—I could go down the list of agencies in Washington. There is no disa-

greement between us at the working level; we try to cooperate to the best of our ability, and we certainly appreciate the efforts in our behalf and the consideration these groups have given to us.

At the P.I. Center, our problems in peacetime are very interesting, as you can well imagine. Certain things upon which we have worked may be described to you. Operation Crossroads was the single largest project that we had, at which time we were supplied with many thousands of photographs from which the Military Command endeavored to find out exactly where the A bomb went off. They tried to find the position and orientation of each of the target vessels at the instant of detonation; they endeavored to determine the path of the bomb-carrying aircraft as it came into and out of the area; they wanted to know the orbit plots of each of the camera-carrying aircraft around the lagoon. These answers were derived, from photographs, after many months' work.

We have heard of the work done at Wright Field headed by Mr. Katz. In all of these dealings, our arrangements in time and equipment and personnel have been optimum, so far as we have been concerned.

Since that time, we have worked on another problem. You have read of the Navy's two Antarctic expeditions, the thousands of photographs, and the very very tough problem they have had in putting these things together into a map. More recently, we were saddled with the responsibility of doing something with V-2 missile tests, these things which are shot off the sands at White Sands, New Mexico. The problem of orientation of these missiles had eluded the physicists for many years, and it was only after a camera was installed in the waist of these missiles, automatically tripping the exposures that we had the data from which, through photogrammetric means, we could come out with the bearing of the long axis of the missile, the elevation along that bearing, and the rotation on that axis.

These were three very important points because the physicist, in installing instruments in these missiles, such as cosmic ray counters, and so forth, had to know the orientation of the missile; otherwise the results of the test would be fruitless. Very simply, my fountain pen might be a V-2 missile. I have a cosmic ray counter where the clip of the pen is, and at one instant of flight the clip is up, that is the counter is up; then there is full cosmic intensity falling into the missile at a peak; whereas, an instant later, when the missile rolls around, the counter itself is shielded by the whole body of the missile and, as a result, the graph falls off.

We were trying, in these orientation studies, to separate the ambient conditions, from those which were resulting from the orientation of the missile; and I may say that photogrammetry was more than a match for the job.

We have had other problems which I will not discuss today. Instead I should like to make a few remarks about what I see in the future for photogrammetry.

I think photogrammetry is going to grow continually. And that we have much to offer many organizations. I encourage you to broaden your horizons, not to think entirely of photogrammetry as the business of making maps. That will always be a most important function—I have no delusions about that—but think of its other applications in terms of what we can do to attract other people. Continually we have requests from people in industry.

I enjoyed very much reading Mr. Katz' paper in the *Journal of the Optical Society*, wherein he proposed two new categories of photography-photographic instrumentation and instrumentation photography. Into these two large bins a great number of problems can fall. I think it necessary that we think in these terms and to supply answers in all these fields. There is no other court of appeal.

We are the American Society of Photogrammetry; we should broaden our horizons to accommodate the needs of the industry. I believe we can do it. I know that the Society, in its Annual Meetings, will encourage free discusion, and free thinking. As Chairman of the Publications Committee, I encourage you to send me your ideas, your suggestions, your thoughts for symposia. We will then do our best to broaden these horizons.

PHOTOGRAMMETRY IN ASTRONOMY*

Francis J. Heyden, S. J., Director, Georgetown College Observatory, Washington, D. C.

WITH the development of new lenses and cameras for aerial photography, it is quite evident that scientific personnel who create our modern precision maps from photographs are finding themselves face to face at certain crossroads with astronomers who have been matching their wits with photographic problems in astrometry for more than three quarters of a century. Mapping from high altitudes brings into play long focus cameras, equipped with lenses of astronomical quality and guided during exposures to compensate for the motion of the planes in which the cameras are mounted. Photographs taken under such conditions present problems in measurement and reduction to true scale that are almost comparable with those of the most exacting positional astronomy.

Just one hundred years ago, in July, 1850, William Cranch Bond, the director of Harvard College Observatory, placed a daguerreotype plate at the focus of the 15 inch equatorial telescope and obtained a successful photographic image of the brightest star in the northern sky, Alpha Lyrae. The extremely low sensitivity of his plates and the unsteadiness of the driving clock for the telescope prevented him from obtaining photographs of any fainter stars. After seven years, the new collodion process plates had appeared and a new driving mechanism for the telescope had been obtained. With these two advantages, Professor Bond was able to photograph stars as faint as sixth magnitude.

These early photographs of stars were not very satisfactory because of the color curve of the lenses which had been ground and polished for visual work. In the region of the spectrum where the photographic plate was sensitive, the slope of the color curve of the lens was very steep, so that it was impossible to obtain sharp images.

L. M. Rutherford was the first to repeat Professor Bond's experiments in 1858 specifically for the purpose of measuring the relative positions of stars. He used a telescope of $14\frac{1}{4}$ inches in aperture and of 14 foot focal length, and obtained a photograph of Gamma Virginis which readily showed a separation of 3″ on collodion plates. Even though he had no problem from city lights in New York City at that time, he could not get any impression of stars of the sixth magnitude. It was the same problem of working with a lens that had been ground for the visual region of the spectrum. In 1861 he substituted a 13 inch mirror of 8 foot focal length which he strapped to his equatorial. His experiment with a reflector failed because of the vibrations from the city and from the atmosphere which spoiled the surface of his mirror. It was then that he decided that he must build a photographic lens. This was the first large astronomical objective to be corrected for violet or photographic light, and while it

* Paper read at the Sixteenth Annual Meeting of the Society, Washington, D. C., January 12, 1950.