*Close Range Photogrammetry— A Useful Tool in Traffic Accident Investigation**

JAMES R. SALLEY,
University of Illinois

WHEN Aimé Laussedat introduced photogrammetry some 100 years ago, topographic mapping was its main field of application. Now nontopographic mapping is an almost boundless field. One of the potential areas of application of photogrammetry is the investigation of traffic accidents.

Our police departments have generally made rapid progress in adapting scientific methods to their work. But investigation of traffic accidents has been lacking in any of these adaptations. The police officers still pace distances and measure with tapes in recording evidence at the accident scene, much as they did forty years ago. These measurements are often critical in determining the liability of an accident, and it is difficult to adequately measure the site with a tape. The time element is critical as the victims must be cared for and damaged vehicles must be quickly removed to clear the road for traffic. The officer is normally under great pressures in these situations and his report may be affected by these pressures. He must accurately record the pertinent data the first time, for after the site has been cleared there is generally no chance for remeasurements.

The officer's report could be somewhat improved by photographing the scene with a press camera to supplement his observations. However, only two-dimensional measurements can be taken from such photographs and the benefit of the photographs is severely limited.

A possible remedy for this situation is the use of a stereometric camera to record the evidence. This means so far as known to the author hasn't been generally accepted by police authorities in the United States as approved standard practice. With such an apparatus the officer could record all the evidence with a few pairs of pictures which could be taken at the rate of 5–10 minutes per pair. The stereo-pairs of pictures obtained from such a camera could then be viewed in a stereoplotting machine where they produce a relief model of the area photographed. This stereo-model could be measured very accurately in three dimensions and from it a plan view of the site could easily be drawn. The negatives could be stored in a safe place, and made available for additional measurements at any time. This method would quickly, precisely, objectively, and permanently record the situation of a traffic accident with ease as compared to conventional methods.

This method will be discussed in the following manner: photogrammetric principles involved, further advantages over present methods, testimonies of police departments who have used this method, examples of pictures and maps made by this method, and results of the author's contacts with American traffic authorities.

At least two big companies currently manufacture stereometric cameras and special plotters for police use (Wild and Zeiss). The cameras of both companies, Figures 1 and 2, consist of a 120 cm. horizontal base tube* with a camera mounted on each end with its axis normal to the base tube. The base tube is mounted on a column held by a tripod. The photogrammetric principles involved in such a setup are those of the "normal case" of terrestrial photogrammetry.

The Zeiss Terragraph plotter, Figure 3, is based on the principle of the von Orel-Zeiss Stereoautograph, the classical instrument of terrestrial photogrammetry, To geometrically reproduce an object point from the image values x', px', y', the base b, and the focal-length f, the projections of the rays determining the planimetry are presented by two guide arms (for x and px). A Zeiss parallelogram was introduced in order to avoid the direction intersection of guide arms at the

* Both companies also make a camera with a 40 cm. base for close-range work.

* This paper pertains to a project sponsored by the National Science Foundation (Undergraduate Research Participation Program). Original compilation: 1960.

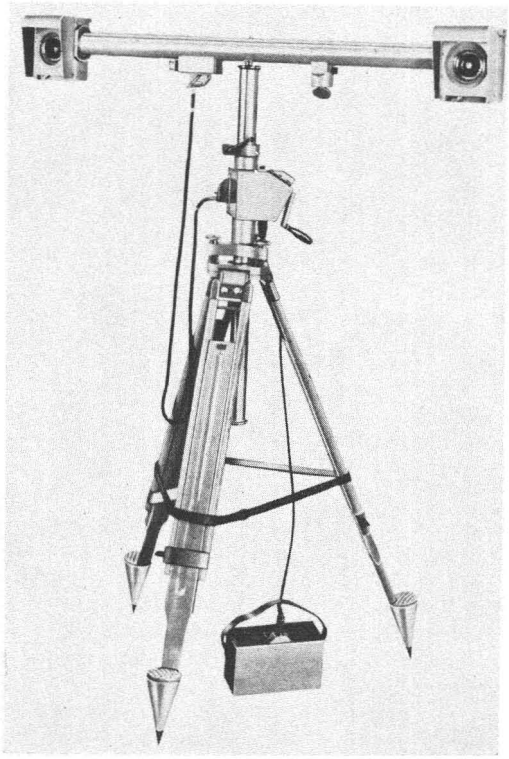

FIG. 1. Zeiss SMK stereometric camera.

object point. The height of the object point focussed—as referred to the right-hand station—is obtained in an analog manner by the intersection of the third guide arm (for y) with the distance bridge. The three guide arms are driven from the object side through spindles which are turned by a pedal disk and two handwheels (Figure 4). From their fixed pivots they control the displacements of the photos with respect to the measuring marks. Further information on the Terragraph is available in Zeiss's brochure ZA 387.

In contrast to the von Orel-Zeiss Stereoautograph, the Wild A4 Police Autograph Plotter, Figure 5, is designed as a "spatial autograph" according to Wild's photogrammetric method after the Porro-Koppe principle. In it two main systems are differentiated. One system consists of the baseplate with the carriages and slides running on three rails arranged at right angles to each other. The suitable movements are obtained by rotating two handcranks (x = side, y = depth of distance), and a foot disc (z = height). The other main system is the so-called tilting part, suspended on two supports, together with the two autograph cameras for the photographic plates and with the optical equipment (double telescope for viewing the pictures), which contains the measuring marks. By the means of two sliding sleeves, a pair of links connects the autograph cameras with the first main system and transmits the movements of the operating wheels to the cameras.

The horizontal plan of the Wild A4 is schematically shown in Figure 6. A and B correspond to the fixed rotation centers of the guides and are placed on the X-axis. The separation (s) of the rotation centers A and B is 200 mm. and was chosen for mechanical reasons. The guide sleeves L_o and R_o must be in the same position relative to each other as were the left and right stations on the stereometric camera, so that the guides can automatically take up the direction of the object rays LP and RP.

The base can be set only in the x-direction (no b_z) because the camera base is always normal to the camera axes in the stereometric camera. The swing rotation (κ) is also eliminated from this plotter since the stereometric cameras are rigidly attached to the base tube and photographs with swing are not possible.

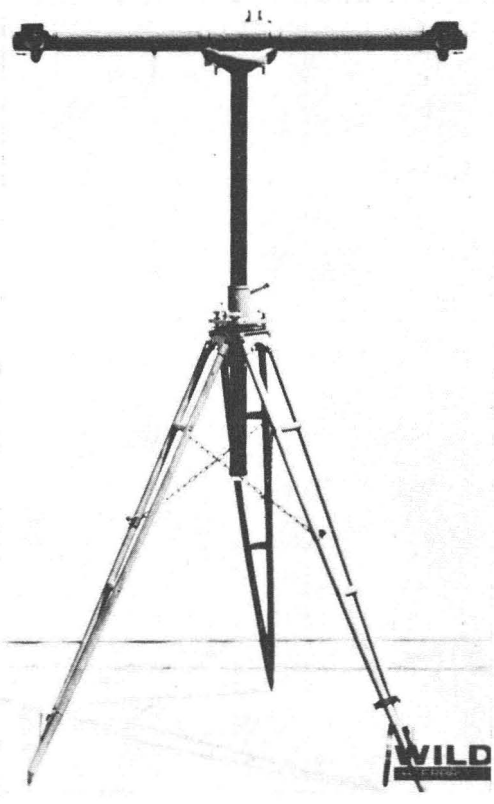

FIG. 2. Wild C-12 stereometric camera.

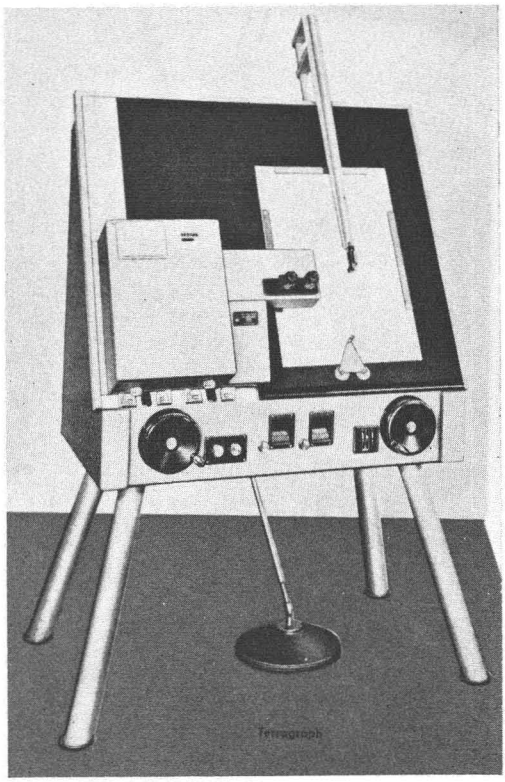

FIG. 3. The Zeiss Terragraph.

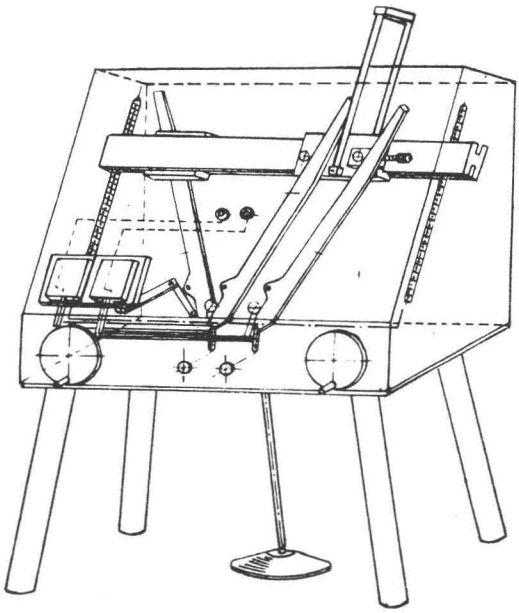

FIG. 4. The principle of Zeiss Terragraph.

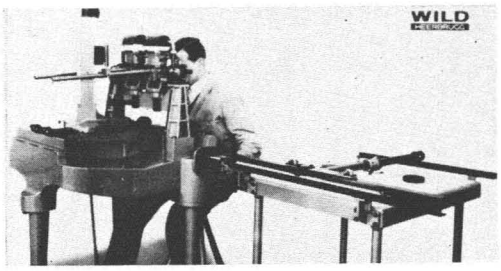

FIG. 5. Wild A4 Police Autograph.

The elimination of b_z and κ from the stereoplotter makes the Wild A4 simple in construction and easy to manipulate. Further details on the Wild A4 can be found in brochure Ph 159 prepared by Wild Heerbrugg Ltd.

Many traffic accident investigators wish that they could go back and investigate some accidents a second time. They may have neglected to look into an important area or forgot about some essential details. Using stereometric methods, it is possible to check on and even supplement the accident report as the original negatives are always kept on file. Since a small error in ground measurement can reverse the liability of an accident, the accuracy requirements must be quite high.

Experience has shown that accuracies obtained from the plan are better than by taping in the usual way. With a distance of 150 ft., a 30 ft. object can be measured to within $\frac{1}{2}$–1 inch. One main advantage of the photogrammetric process, as compared to taping, is that use of the photogrammetric process considerably shortens the time required at the accident scene. As a result, the road can be cleared for traffic much sooner.

No special knowledge is required to operate the plotter, a week's training is sufficient to become familiar with the procedure and the instrumentation. In many cases the plan map

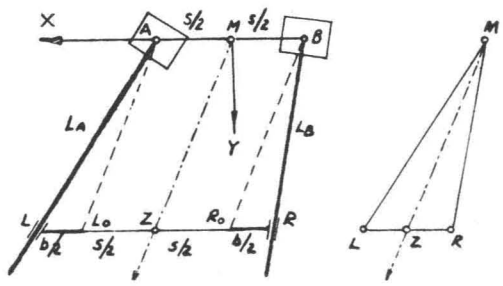

FIG. 6. Plan of the Wild A4.

of the accident can be available within 1–2 hours after the photographs are taken.

Some European police departments have plans ready for dangerous intersections with control points (hydrants, fence corners, etc.) accurately plotted. Where such plans are available the time required to plot the details of the accident (vehicles involved, dead and wounded persons, position of debris, and length and location of skid marks) will be substantially reduced. The cost of the necessary instrumentation is very low. The number of officers required at the accident scene is reduced because traffic control will not be as demanding.

Flash attachments are available, so the camera can be used at night or under adverse weather conditions. The camera and its stand are highly portable and are easily carried by auto to the scene of the accident.

There are many other advantages, but in summary, this photogrammetric method of measuring is far superior to taping with respect to accuracy and reliability.

The Wild Heerbrugg Company includes a track marker, Figure 7, with their equipment to clearly show the skid marks. The question of validity of photos as evidence when the skids have been marked in this manner has been raised by some American traffic authorities in letters to the author. However, the marker is designed to indicate the actual tire marks on the ground thus making easier their detection on the photographs, and not to cover them.

Many testimonials from practical experience are available, but all are from Europe. Tests have been made in London by the Traffic and Safety Division of the Road Research Laboratory and they report that stereophotogrammetric equipment produces maps that have greater precision than those normally accepted in court cases. According to Dr. Moreland of the above mentioned laboratory, this method is not used extensively in Great Britain because in every case it must be proved that it is a valid means of obtaining precise measurements. However, this modern method is used as routine in Germany, France, Italy and other European countries. Its most extensive use is in Switzerland. Since stereometric pictures are taken only for a major accident involving heavy damage or where someone was killed or critically injured, one might think that their photogrammetric apparatus is not used much. But in 1959 the Zurich police photographed 698 cases in this city of 500,000 people. Each set of pictures is

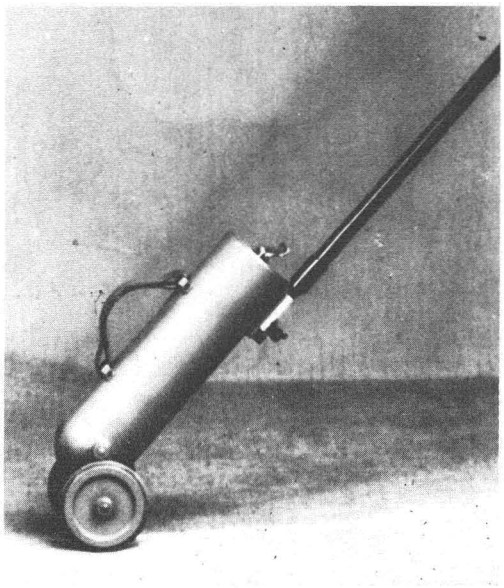

FIG. 7. Wild track marker.

plotted, only when essential to establishing the cause of the accident. Compared to the damage and liability claims resulting from an accident which may amount to over $100,000, the cost of making a map with the plotter is very small and is charged, in some cases, to the party responsible for the accident.

An example of the satisfaction gained from this method is this statement from the Police Department of the City of Basle in Switzerland, in a letter to the author:

> "The photogrammetric evaluation leaves absolutely nothing to be desired in respect to dependability and precision. The errors that can occur in measurements made with the tape are completely eliminated. Incorrect depositions of parties concerned in the accident or of witnesses of the occurrence can be refuted and the objective facts of the case proved. Our courts base their decision fully on the photogrammetric evaluation of the pictures taken. A further advantage of the photogrammetric method is to be found therein that much time is saved during the recording of the evidence. The troublesome measurements of the site of the accident, of the tracks, etc., are no longer necessary and the site can be cleared for traffic in a very short time. This advantage is particularly marked and important for accidents in which numerous tracks and marks require measurement. It is of course very important that these marks can be read correctly and interpreted properly."

An example of the end product, the plan map, can be seen in Figure 9. This was obtained through the courtesy of Wild and the

FIG. 8. Photograph of a collision between two trucks.

Police Headquarters of the Canton of Berne in Berne, Switzerland. The map shown in Figure 9 was plotted from three pairs of pictures. A single photograph from one of these is shown in Figure 8. This example shows the degree of details that can be expected from this method, and the value that they furnish as evidence in court.

Many American traffic authorities were contacted by the author concerning this project, and they knew of no American police department presently employing this method. In fact, most of them didn't know that such a method existed. Judges and traffic authorities in Switzerland were astounded upon hearing this because they couldn't imagine analyzing accidents without such precise instruments. The Americans agreed that this method has high potential, but they felt that the cost was too great for limited police budgets. This is admittedly a limiting factor as the price of the apparatus is fairly high (approximately $4,000 for the stereocamera, and $17,000 for the plotter).* However, the operating cost is low and technicians can be easily trained. If one considers that a precise recording of evidence might save an innocent person from receiving the blame for a serious accident, the importance of price declines.

Close range photogrammetric methods could be utilized to their fullest extent for accident investigation in many large American cities. But, its use has not been attempted even though European countries have been recording evidence successfully in this manner for 25 years.

It is hoped that the American police authorities will soon make full use of the potentialities of photogrammetry in investigating traffic accidents.

* These prices were computed from European prices with an allowance made for U. S. Customs.

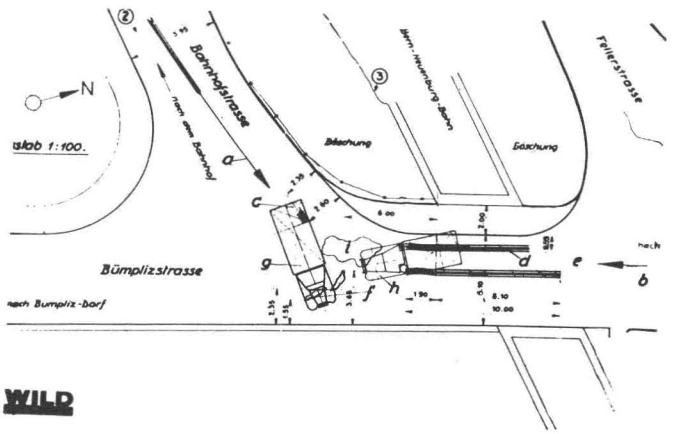

FIG. 9. A plan map of the collision in Figure 8.

ACKNOWLEDGMENT: The pictures in this paper are included through the courtesy of the Wild Heerbrugg and Zeiss Companies.

BIBLIOGRAPHY

1. Baker, J. Stannard, "Traffic Accident Investigators Manual for Police" (Traffic Institute of Northwestern University), Evanston, Illinois, 1957.
2. Donigan, Robert L., and Edward C. Fisher, "Know the Law" (Traffic Institute of Northwestern University), Evanston, Illinois, 1958.
3. Fruh, W., "Photogrammetry in the Service of the Police, especially in Connection with the Preparation of Factual Reports on Traffic Accidents," Courtesy of the Headquarters of the Police Department of City of Basle, Switzerland.
4. Moreland, J. D., "Stereophotogrammetric Analysis of Road Accident Scenes," Bulletin of the Road Research Laboratory, Department of Scientific and Industrial Research, London.
5. Scott, Charles C., Photographic Evidence, Kansas City, Missouri, 1942, Supplement in 1955 (Vernon Law Book Company).
6. Wild Heerbrugg Ltd., "Photogrammetric Instruments for Taking Photographs for Evidence." Brochure Ph. 159, Switzerland, 1956.
7. Zeiss-Aerotopograph, "Modern Procedures for Evidence Photography, Brochure ZA/XXIX/XXII/ES/8510, Munich, West Germany.
8. Zeiss-Aerotopograph, "Terragraph," Brochure ZA 387, Munich, West Germany.
9. Zeiss-Aerotopograph, "SMK—Wide-Angle Stereometric Camera," Brochure ZA 386, Munich, West Germany.
10. Zeller, M., *Text Book of Photogrammetry*, London, 1952 (H. K. Lewis and Co.).

*Aerial Photographic Coverage of Canada**

S. G. GAMBLE,
Director, Surveys and Mapping Branch,
Department of Mines and Technical Surveys,
Ottawa, Can.

ABSTRACT: *The Canadian air survey program covers a period of forty years and has its roots in the phototopographical work undertaken in the Western Cordillera. The oblique method for covering large areas of Central Canada in the early days of air photography was a logical development. The first stage of the program was completed by the RCAF in 1947 using the trimetrogon method. The second stage is now virtually completed with vertical air photographs available for the whole of Canada, and copies of some three million prints are contained in the National Air Photographic Library. Air photography is entering still another stage and in future programs the emphasis will be on smaller areas for a number of special purposes.*

THE early history of Canadian air photography not only parallels but is closely interwoven with that of the United States. However, in view of the great difference that existed in the state of mapping of our two countries, differences in the major effort and type of photography used are understandable. Our most pressing needs were for small-scale mapping of the areas immediately north of the fringes of the northern limit of settlement, whereas the U. S. needs were for better mapping of areas already mapped to good reconnaissance standards.

The foundation for mapping using air photographs was laid before the Wright brothers took to the air. In Canada photogrammetrical mapping had been used for mapping our mountainous regions since the 1880's and in fact mountain photography or photo-topography was extensively used well into the 1930's. Many square miles of Canada's more rugged topography were mapped to scales of 1/253,440 and 1/63,360 by this method, and more recently ground photography has been used to provide supplementary control for vertical air photographs in mountainous areas.

The earliest Canadian air photograph on

* Presented at Semi-Annual Meeting, American Society of Photogrammetry, Alexandria Bay, N. Y., September 12–14, 1963.