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NOTE ON AERIAL PHOTOGRAPHS OF CANAL  
WORKS EXHIBITED AT THE 1924 CONGRESS.

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At the Engineering Congress will be exhibited a series of aerial photographs of works on the Sirhind Canal, taken by the photographing flight of the No. 5 Squadron, R. A. F., while stationed at Ambala.

These photographs are of two classes, oblique and vertical.

Oblique views are taken as views of the work; views taken from ground-level in the plains of the Punjab suffer from the fact that the view-point is almost invariably too low to be effective; the photograph shows details of elevation, without any indication of what the work is in plan; aerial photographs overcome this objection.

The difficulties in taking these photographs should be appreciated. The camera is a heavy one, which has to be held and pointed by hand; it must not be rested on the side of the aeroplane, as this is vibrating; the aeroplane is moving at a speed in the neighbourhood of eighty miles an hour, so that the moment for the best point of view has to be chosen very rapidly; this speed means that there is a wind of about equal speed on exposed parts of the body and on the camera; because of the wings and other parts, photographs can only be taken in certain directions.

The oblique views exhibited show the Rupar head-works, Budki and Siswan super-passages, and a series of furcations of decreasing size, Manpur Head, Koka Branch head, Kotla Branch head, Ghaggar Branch head, from different angles in each case.

Vertical photographs are more usually taken either to be made into plans, or as a substitute for plans; seldom is it possible to cover the area required by one photograph taken from low enough to show sufficient detail and be clear when enlarged to the required size; it is usual to fly backwards and forwards over the area on parallel lines taking a series of photographs which can afterwards be joined together into a mosaic. The camera is fixed under the body of the aeroplane; exposures are made at intervals depending on height and speed, and lines of flight are also spaced so as to avoid gaps in the mosaic.

The photographs are subject to distortion of several kinds. If the aeroplane is not quite level longitudinally and transversely, the view will be slightly in perspective, and there is always some perspective effect except at the point vertically under the camera;

with the most perfect lens, straight lines near the sides of the plate become slightly curved; the fast-moving aeroplane moves appreciably in the time that the focal-plane shutter passes over the plate. To avoid too serious distortion, it is usual to space exposures and lines so that adjacent views overlap by about a third.

It is impossible to fly absolutely level in spite of air disturbances; if the lines of flight are not directly up or down-wind, the photographs will be slightly en echelon; so it is rare for a first attempt to succeed in covering the area without gaps; when a first flight has covered 90 per cent. of the area, two or three more flights may be needed to cover the small remainder successfully.

By means of ample over-lapping, it is possible to obtain a fairly accurate survey of quite extensive areas without fixing the position of points independently by ground surveys. As the other extreme, a number of points may be fixed first by ground survey, and marked by laying out strips of white cloth which will show up in the photographs; the photographs can then be distorted in the enlarging camera so as to bring these points into their correct relative positions.

The photographs may be used to plot such details as are wanted, into a map of which the frame-work has been fixed either by ground survey or by selected points in such an aerial survey; or the photographs may be mounted together so as to form one comprehensive vertical view.

The first of the vertical views exhibited is such a mosaic of the river about Rugar: arrangements were made for the fixed survey pillars marking cross-section lines to be marked with ground-strips, but this was not carried out. But as it is rarely if ever necessary to measure distances on annual river surveys at head-works, such a mosaic seems to be quite sufficient; of course the usual cross-sections on fixed section lines will still have to be taken on the ground.

Comparing this mosaic with the annual survey shown, it is possible to judge their relative utility: at the island upstream of the weir it is possible to see the current flowing through the gap, towards the right bank, and gradually mingling with the current in the right-hand channel; the photograph shows how the sand-bank below the weir was formed by flow from the left, and how escape from the right flank of the weir had cut off the toe of the delta.

The photographs of this mosaic were taken from an elevation of 5,000 ft.; it is usual to take a photograph of such mosaics (if small) on one plate, and produce the prints required, by enlargement from this: a second copy of the mosaic was made in which the differences

of ground tone of the first were avoided : it will be seen that this and the resulting photograph of it have lost very much of the satisfactory detail of the first mosaic.

As the first photographs from 5,000 ft. showed so much detail, it was thought that a greater elevation would give sufficient result, and cover the area with less trouble ; several isolated photographs of the same area are shown, taken from 12,000 ft., 15,000 ft. and 19,500 ft. These naturally show less detail than the 5,000 ft. series, but that is partly due to the fact that when the latter series were taken, channels across sand-banks had not been dry for so long and water was higher, so that their beds were still moist. For the purpose for which these photographs are intended, it will be satisfactory to work at 12,000 or even 15,000 ft. The breadth that a plate covers on the ground across the line of flight is half the elevation, and along the line of flight 0.4 of the elevation ; thus flying at 15,000 ft. a single line of photographs would cover a strip  $1\frac{1}{2}$  miles wide, and in many cases a single line of flight would suffice, greatly diminishing the chance of gaps in the mosaic.