NATIONAL TECHNICAL UNIVERSITY
LABORATORY OF PHOTOGRAMMETRY
ATHENS - GREECE

"LOW ALTITUDE AERIAL PHOTOGRAPHY"

by

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I. INTRODUCTION

For many technical, architectural, archeological, environmental and other applications, low altitude vertical aerial photography is needed.

When we speak about low altitude photography we mean aerial photography which is not possible to be obtained by airplanes. In these cases other means must be used.

In Greece with the variety of archeological and architectural surveys low altitude photography becomes extremely important. For this reason the Laboratory of Photogrammetry has attempted for several years to develop the capability of acquiring vertical photography from a few meters to several hundred meters.

To fulfill this objective we have tried to develop the following three separate systems:

a. Bipod photography.

b. Balloon photography.

c. Helicopter photography.

The bipod system is suitable for vertical photography from 2-9 m height. The balloon system is good from 5 m to 3-5 hundred meters, and the helicopter system is suitable from 20 to several hundred meters height. Although the balloon system and helicopter system seem to have a very big overlap the characteristics of the two systems are so different that both systems are finally desirable.

To achieve this aim as quickly as possible and to save money and effort we have started from existing systems focusing the effort mainly on the cameras and films to be used, photographic techniques allowing only minor modifications to the available equipment.

In this paper we will present briefly the three completed systems as well as their initial applications.

For the bipod considerable help we have received by J. Whittlesey. For the balloon systems and the balloon photographythe cooperation with Prof. J. Mayer who has permitted the construction of a similar system with his own and the cooperation on the execution of several balloon projects in Greece was very helpful.

2. THE BIPOD SYSTEM

2.1 System`s Description.

The bipod camera support is a very useful tool for near vertical photography of objects lying on a horizontal surface. The bipod is used to elevate the camera at the prescribed height.

The bipod is composed from aluminium tubes and is assembled in two legs forming a Λ shape with maximum length 9.15 m. The assemblage of the bipod is very easy and can be performed within a few minutes. The bipod weight is approximately 40 kg., therefore its transport and use require two persons.

At the junction of the two legs of the bipod, a pulley is fitted to make possible the lift of the camera up to the desired altitude. The camera is fitted to a rectangular plexiglass support, which is suspended by four light weight ropes ending in a common rope which is used from the ground to lift the camera (Fig. 1).

The Laboratory of Photogrammetry, of the National Technical University, disposes two camera supports especially made for the Hasselblad 500 CM and for the Ashahi-Pentax (36 mm).

There are no special arrangements for the orientation of the camera axis except the suspension pattern and the weight of the camera which have been proved sufficient to secure an approximate and within small deviations vertical

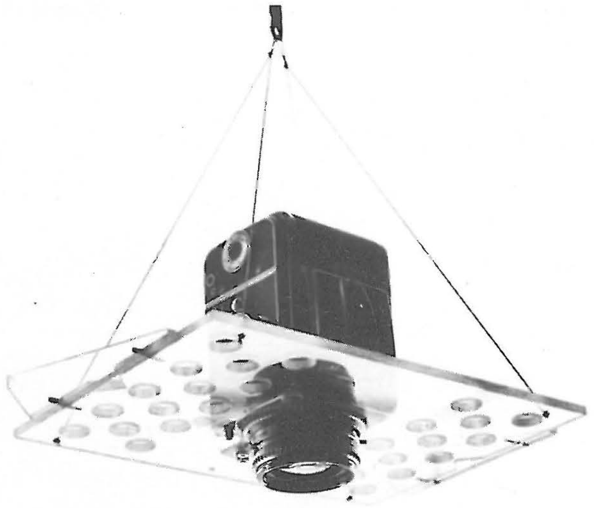


Fig. 1

position of the axis.

Two strong ropes connected with the top of the bipod are used to put and maintain the system at the desired vertical position.

The photo exposure can be realized by a radio-telecontrol unit or a manual system since the maximum distance (9.00 m) between the camera and the operator is relatively small. A motor-drive, radio-controlled camera however could give the maximum flexibility to the system.

2.2 The Use of the System.

After the assembly of the bipod on the field and the preparation of the camera, the system is moved to the desired position. Then the bipod is lifted to the vertical position and is stabilized by the two ropes; then the camera is lifted until the top of the bipod in order to keep the camera motion as minimum as possible and when the camera is fully stabilized the photo is realized.

The camera-object distance and the camera focal length are basic parameters and they are fixed during the planning stage of every project.

The bipod system is used for the realization of photo coverage with small or large overlap. A 60% overlap can give the possibility for stereoscopic viewing while a 10-20 % overlap permits the production of photomosaícs.

The percentage of the overlap for the consecutive photos is fixed in accordance with the planned project. The overlapping is realized either by a parallel translation of the system, or by tilting the bipod from one to the other side of its central vertical position.

The second solution is suitable for a photo pair with the same tilt of the bipod from the vertical, because a different tilting angle will give a different photo scale.

2.3 System Performance.

When using the bipod the following main parameters of the project must be considered:

a. The subject to be photographed.
b. The camera to be used.
c. The later use of the photography.

The above parameters must be always viewed as a whole. A slight predominance could be given however to the later use of the photographs. Since the question of the type of photography which could be chosen will be decisive for the planning process. Usually we are to choose between photography to be used for simple documentation and photography to be used for photogrammetric restitution.

The documentational photos have no special requirements except the good quality of the imagery, while the second requires in addition the special conditions and process which are indispensable for every photogrammetric survey.

Attention must be paid however to the documentation photography which will allow in some later time to complete a photogrammetric survey.

The precision requirements for every application determine the combination of:

a. The camera.
b. The mono or stereo coverage.
c. The plotting method.

So far usually amateur cameras have been used for bipod photography which means that unknown systematic errors interfere to the photogrammetric process. These errors may come from:

a. The lens distortion with maximum linear deviation 200-400 µm at the focal plan.
b. The lens axis position (deviation from the image center and the vertical to the image plan.
c. The non flattening of the film at the exposure time.
d. The shrinkage of the film during the photographic process.

In addition to the above errors the distance of the photographic plane from the lens is unknown. Due to these limitations an analog photogrammetric restitution using amateurs camera with:
a camera focal distance f=100 mm
an object to camera distances s=5,00 m
a base to distance ration b/s=1/5
a maximum distortion dr=400 µm

would give errors to the horizontal position about 5 cm and to the heights about 10-15 cm.

An analytical photogrammetric restitution with sufficient number of control points can many times give an accuracy within a few milimeters.

Well defined points natural or artificial are required for control points in both analog and analytical restitution.

The bipod camera system is a powerful tool for photographic acquisition of horizontal objects with application in architecture and archeological excavations.

Figure 2 shows the bipod system at work during a photogrammetric survey of the floor of the Temple of Apollo at Vassae executed by the Photogrammetric Laboratory of the N.T.U. of Athens. From that floor the photography is shown in figure 3.

3. BALLOON PHOTOGRAPHY

To examine the balloon photographic system many subsystems of it and their performance could be studied. In this report the balloon system is subdivided into:

a. The balloons.
b. Camera and suspension-system.
c. Guidance and control.
d. Performance and applications.

In the following these subsystems will be examined briefly. Details of the manipulation of the entire system although very important for the success of relative projects will be avoided since we believe that such details is impossible to be presented in a short article.

3.1 The Balloons.

Information about tethered balloons could be found in recent bibliography like Whittlesey (1970) and Manual of Remote Sensing Vol. I page 545 etc., from the American Institute of Aeronautics and Astronautics and from special

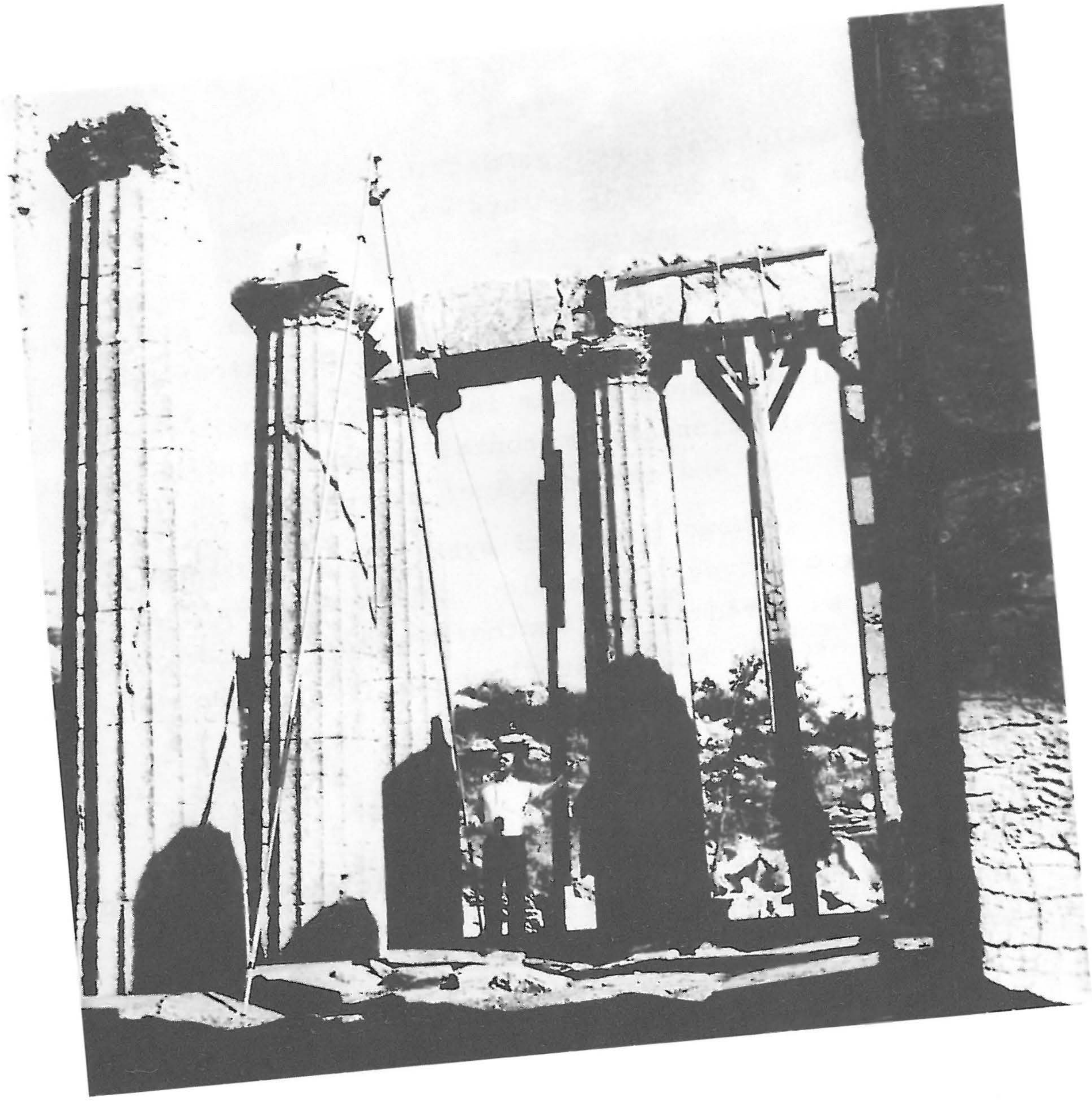


Fig. 2

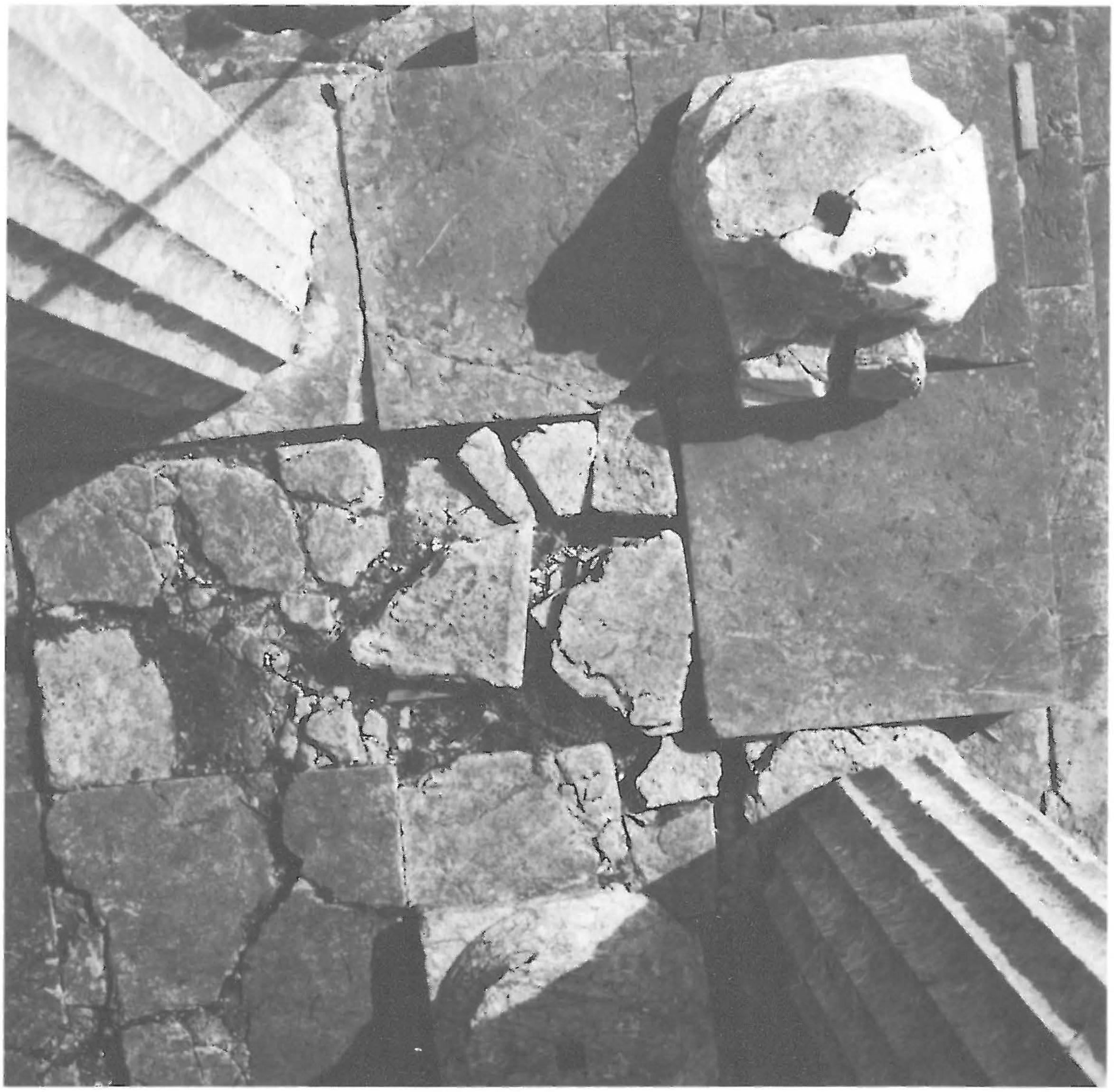


Fig. 3

publications of balloon manufacturers like Goodyear Aerospace, RAVEN INDUSTRIES Inc., Winzen Research Inc., Airborne Industries limited, Robert Fulton Company and many others. It could be useful to point out the promptiness with which we have received information about balloons from the various sources but the difficulties to focus or to relate this information to the low altitude photography and the even greater difficulty to pursue a limited number of such balloons.

Finally we have succeeded to acquire and to use three kind of balloons. A forth kind which we have ordered to Whittlesey Foundation we have been unable to acquire. Thus the available at present balloons at the Photogrammetric Laboratory are:

a. TOTEX CR-66 Chloropreme, 1.200 gr., meteorological balloons made in Japan (fig. 4). This balloon is spherical in shape, its volume is approximately 8 m^3 and its gross lift capacity about 7 kg. on the ground.
b. DELACOSTE meteorological balloon B.V.C. (Balloons Compensateurs de Vent) "BALLONS KYTOON" D 4 made in France (fig. 5). This balloon is aerodynamical in shape, it is placed in a tissue envelope, its volume is approximately 13.5 m^3 and its gross lift capacity on the ground about 8,5 kg.
c. RAVEN TRF-900 scientific balloon, made in U.S.A. This balloon is also aerodynamical in shape (fig. 6). Its volume is about 25 m^3 and its gross lift capacity on the ground is approximately 13 kg.

3.2 Cameras and Suspension System.

The camera suspension system has been constructed twice. Initially a simple gimbal for a Rollei Flex 6x6 cm camera with a home made remote control in conjuction with the TOTEX balloon was used. With this system photographs of a monastery

Fig. 4

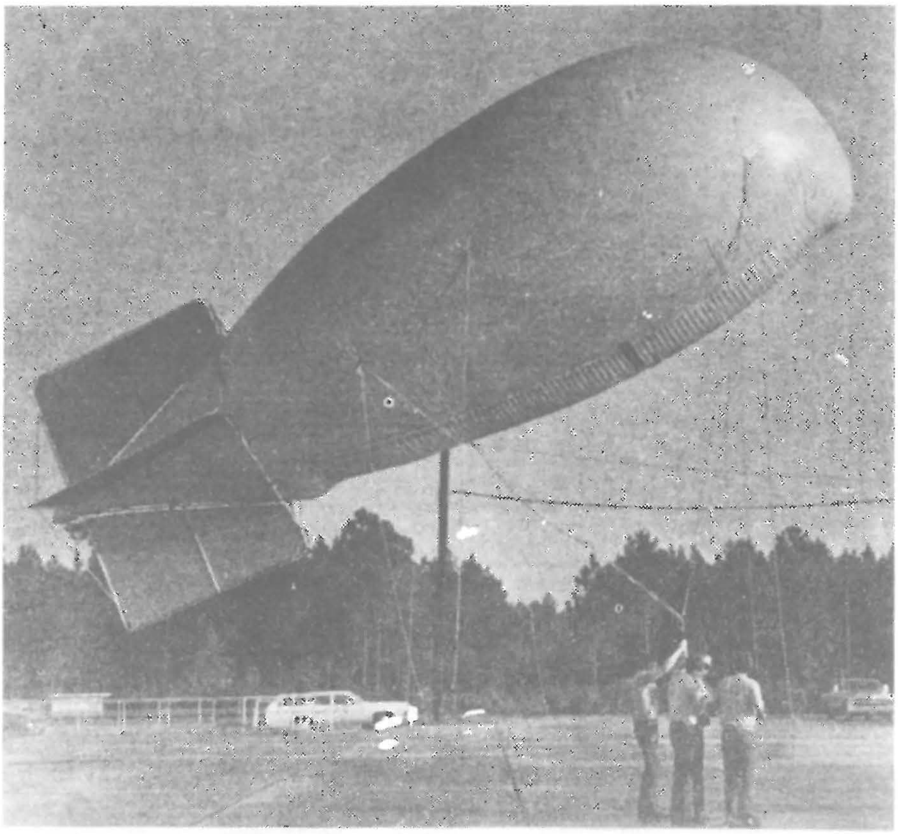
were taken and a photomosaic of the Acropolis was completed (fig. 7). Later we tried to purchase a complete system from Whittlesey Foundation but we have not been successful.

Then during the summer of 1978 a new gimbal and tow yokes were constructed under the guidance of Prof. J. Wilson Myers of Michigan State University. The yokes could accomodate either two EL Hasselblad cameras or one EL Hasselblad and one Nikon (fig. 8).

The new system has been experimentally used for the Temple of Vassai in Peloponnisos where B/W and color aerial photographs were taken (fig. 9).

The present system can operate with B/W, Infrared, color

Fig. 5



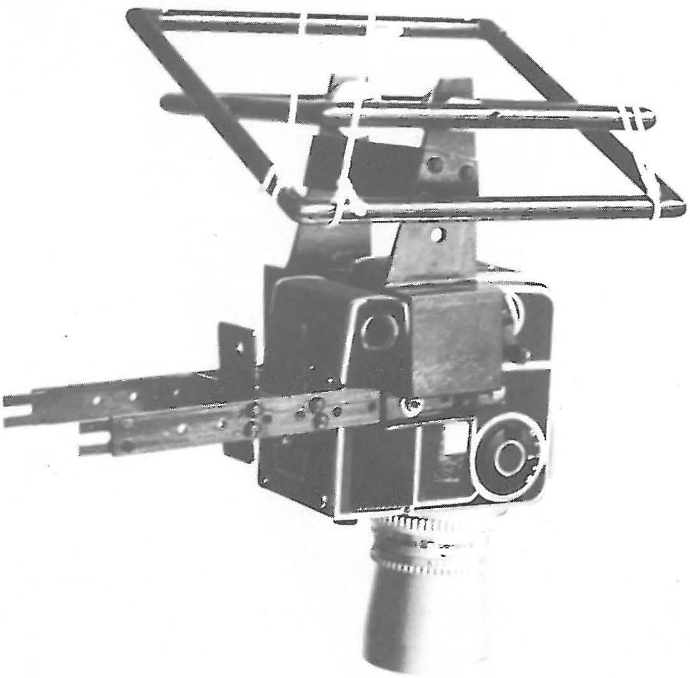


Fig. 6

Fig. 8

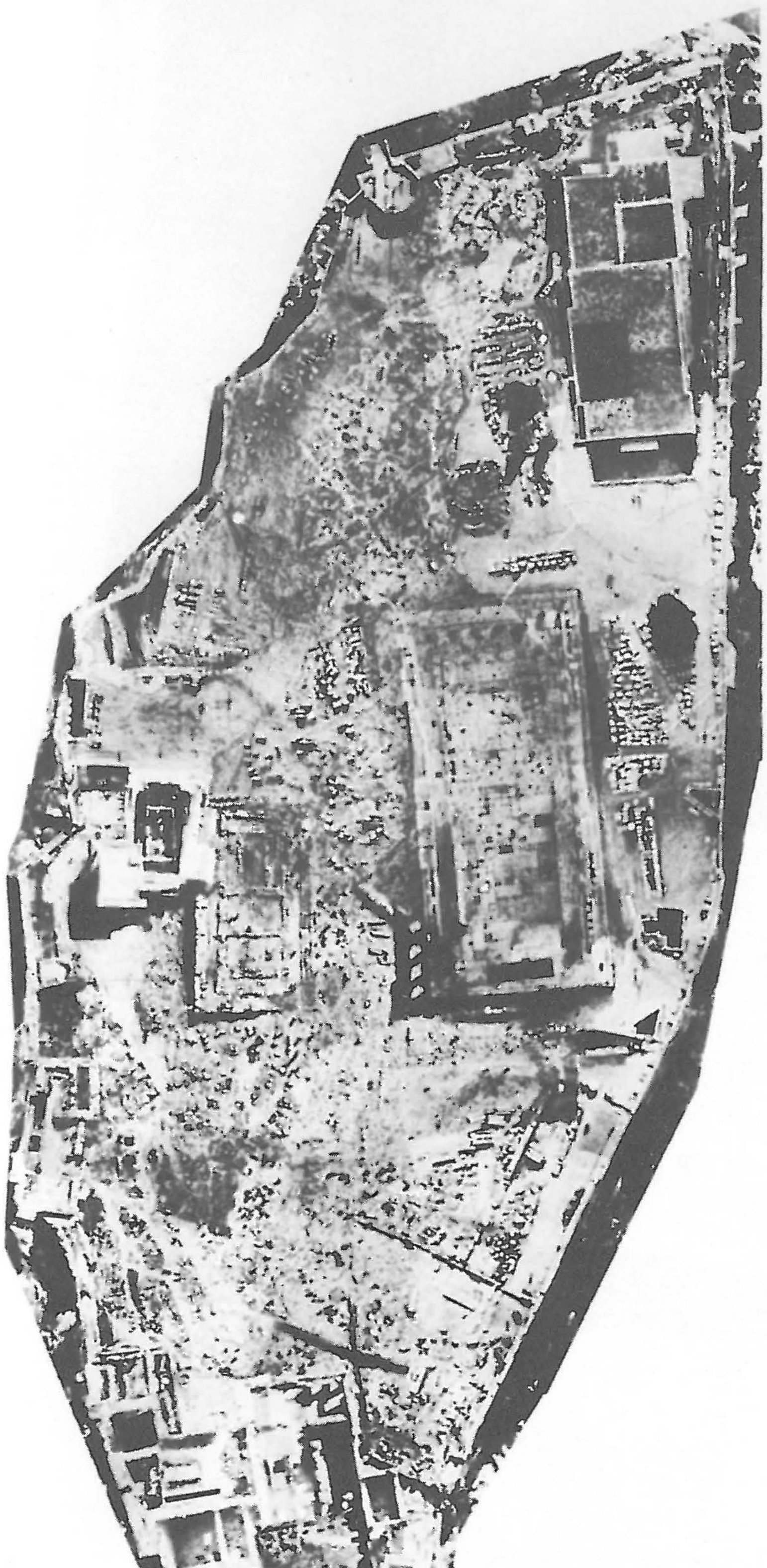


Fig. 7

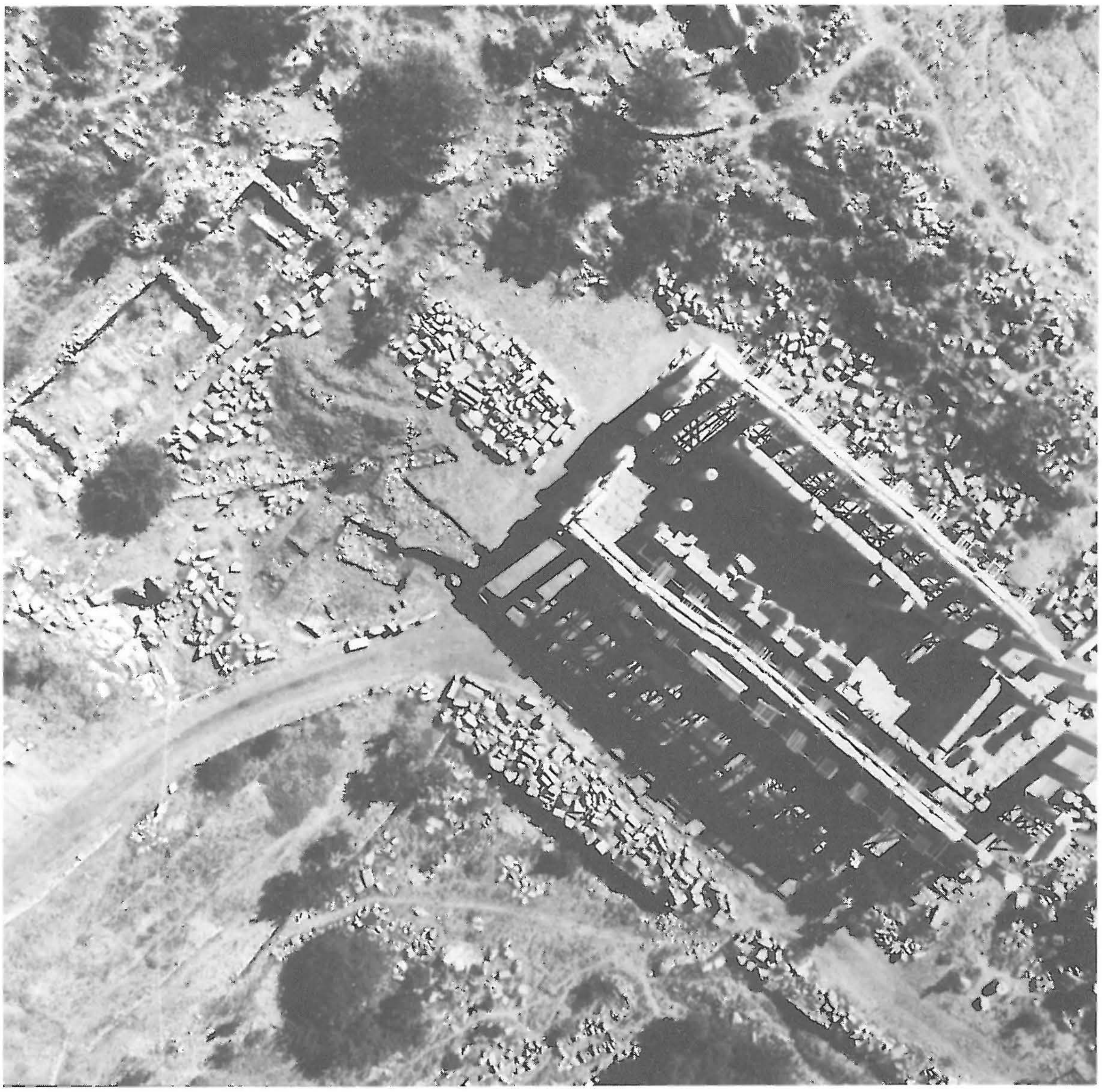


Fig. 9

and faulse color 70 mm film.

3.3 Guidance and Control.

To make the exposure special transmeter and receiver provided by Hasselblad is used.

To guide the balloon and keep it at positions where photographs must be taken one or two tethered lines of 4 solid braid polyester cord are used.

3.4 Performance and Applications.

Besides the applications already mentioned it is worth to mention the following three cases.

An experimental balloon aerial photography was taken over the Photogrammetric Laboratory with a TOTEX balloon where "panchromatic, color and infrared 70 mm film were used. The approximate scale of it was 1:500 and the results were extremely attractive.

An interesting application was the photography over the ancient theater of Dionyssos near the Acropolis in Athens (fig. 10). The original scale was 1:200 and only B/W photography was taken again with a TOTEX balloon.

Our latest project was the photography over the main building of the central campus of the National Technical University. In that case photographs from 20, 50, 100, 150, 200 and 250 m were taken (fig. 11) with a Delacoste balloon. Up to now we did not have any opportunity to use the RAVEN balloon.

For the performance the following general remarks could be made:

a. The success of balloon photography project depends largely from many technical details which only by proper experience could be overtaken.
b. The dominating factor for the balloon photography in weather and more precisely wind.
c. TOTEX balloons are sufficient for single camera, good weather conditions and heights up to 100 m. For greater heights or twin camera systems Delacoste or Raven balloons must be used.

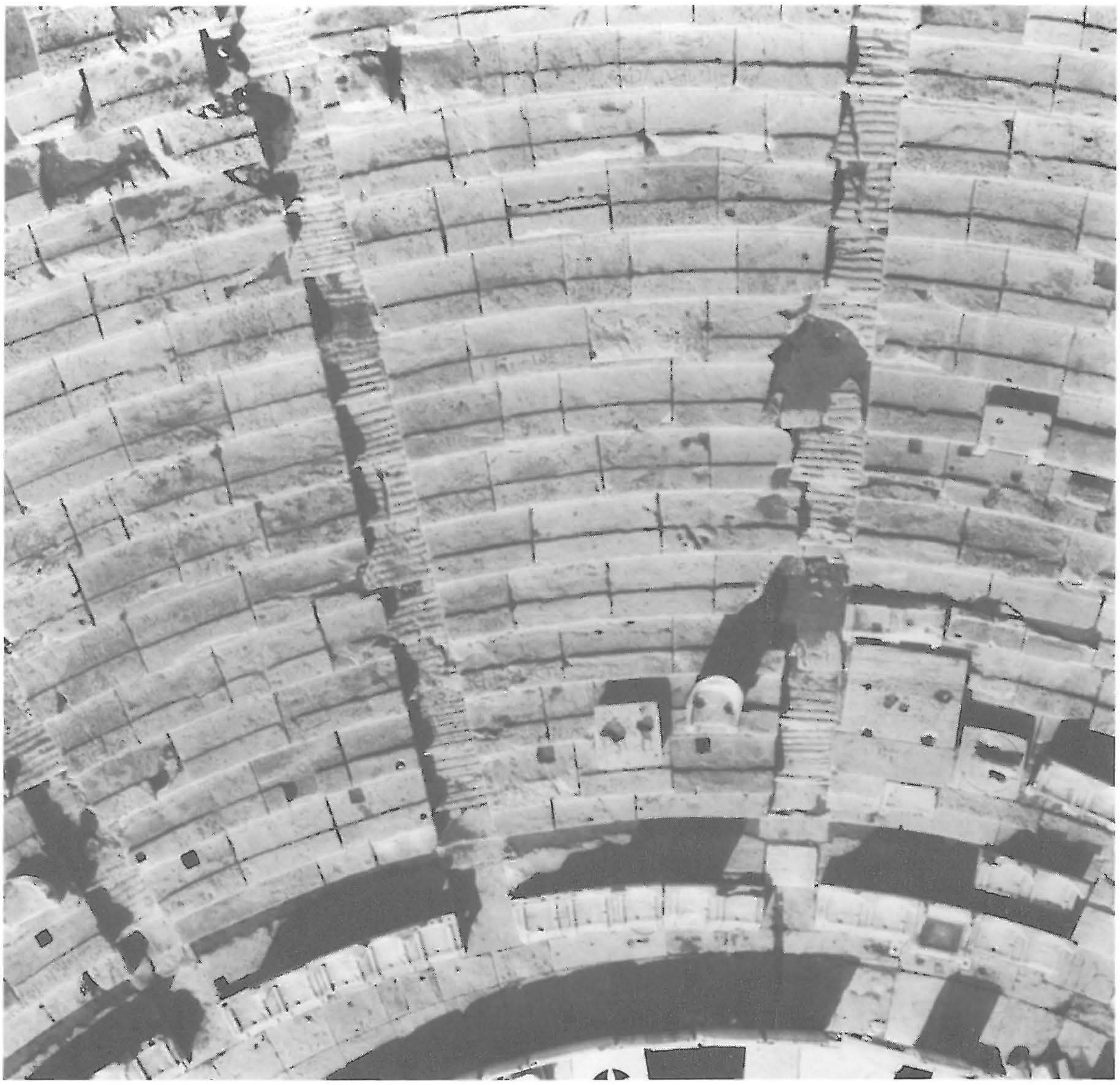


Fig. 10

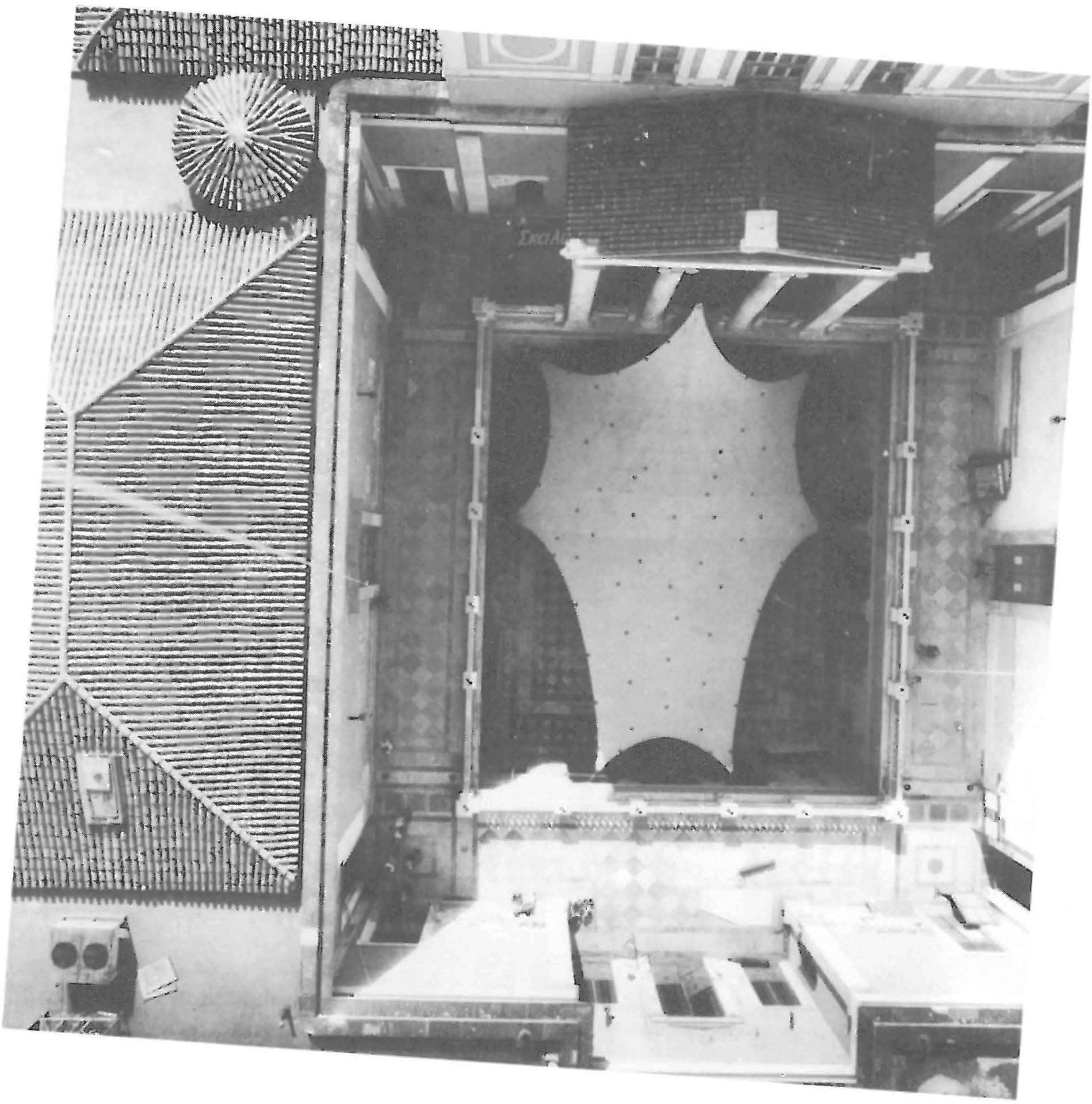


Fig. 11

4. HELICOPTER PHOTOGRAPHY

Since the balloon system is heavily weather dependent, helicopter photography has been also studied by the Photogrammetric Laboratory of the National Technical University of Athens.

Up to now we are forced to use commercial helicopters of the Olympic Airways. The helicopter for which our photographic system has been studied is an "ALLOUETTE II".

That helicopter has an orthogonal hole 20x20 cm on the floor, usually serving to distribute advertising material, from which the photography could be taken. For that hole a special camera mount which would absorb a part of the helicopter vibrations has been designed (fig. 12).

The camera used is again the EL Hasselblad with manual release since the operator will be sitting next to the pilot and no more than two meters from the camera.

Due to administrative and economical reasons so far we have not been able to perform any helicopter photography. We anticipate however that helicopter photography will be very common and very powerfull in the near future.

5. CONCLUSIONS

Low altitude aerial photography can be performed by bipods, balloons and helicopters. These systems are to a great extent complementary with some overlap between balloon and helicopter.

The comparison between these two systems is very difficult. Balloon systems are very weather dependent, time consuming and with the higher proportion of the expences coming from travel expences and personnel. The helicopter photography is not so weather dependent, is very quick and the biger part of the expences coming from the helicopter.

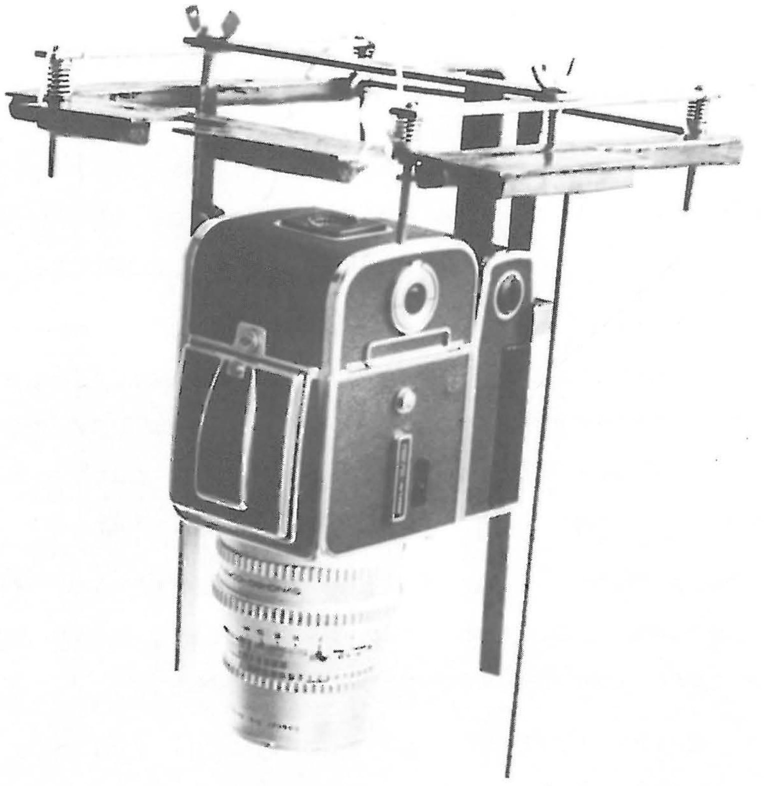


Fig. 12

It seems that in the future helicopter photography could be superior to balloon. Even from now when we could plan several projects in a row, helicopter photography could be proved more advantageous than balloon photography.