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AIR PUBLICATION 956.

**A SELECTION OF LECTURES AND  
ESSAYS FROM THE WORK OF  
OFFICERS ATTENDING THE FIRST  
COURSE AT THE ROYAL AIR  
FORCE STAFF COLLEGE,  
1922-1923.**

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The following lectures and essays, which have been selected from papers prepared by officers attending the first course at the Royal Air Force Staff College, 1922-1923, are promulgated for the general information of all concerned. The personal opinions of the several authors as expressed in the papers must not necessarily be taken as representing the views of the Air Staff.

*By Command of the Air Council,*

*W F Nicholson*

AIR MINISTRY.  
December, 1923.

## EXPERIENCES OF BOMBING WITH THE INDEPENDENT FORCE IN 1918.

*A Lecture by*

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Bombing now has advanced from the stage when explosive objects of almost any size and shape were thrown overboard in a haphazard manner.

It has now become a science which calls for skilful execution, both in the choice of suitable objectives, and the actual method of bombing those objectives.

It is proposed to deal with some of the most successful methods that were adopted in the last war.

Particular attention will be paid to the bombing of targets situated well behind the enemy's frontier, such as those attacked by the independent force.

The remarks will chiefly apply to day bombing from a high altitude.

Night bombing and low-flying bomb raids rely for their success more on the individual initiative of the personnel taking part and the principles cannot be so concisely defined.

To commence I think it would be as well just quickly to run through what actually happened when a raid was sent out, and the routine method of carrying out the usual raid.

The squadron would be detailed to carry out a raid on a certain target, with perhaps two alternative targets, certainly one.

The squadron commander would detail twelve machines for the raid, as nearly as possible keeping to flights, and would detail one of the formation leaders as raid leader, each raid of 12 machines being split up into two formations of six machines.

Combined raids by several squadrons were seldom undertaken for reasons to be given later.

The formation leaders and the squadron commander decided the route to be taken according to wind, ground operations, &c., and chose the alternative target. It was important that H.Q. should be notified if anything prevented the departure of the raid at the scheduled time, as this probably affected the time of departure of other squadrons. I will deal with this spacing of raids later. Once a raid had left it was the raid leader's responsibility whether it was pushed home or the alternative target attacked. Weather conditions change so completely during a raid of any length that it is impossible

to say definitely whether a raid can be carried out or not until it actually arrives at its destination. Many times raids passed over the Vosges and found that the whole of the Rhine valley was hidden by fog, although it was bright sunshine on the west side. In order to avoid haphazard bombing, which is to be avoided at all costs, it was therefore necessary to detail definite alternative targets.

The formation adopted was the usual wedge shape and was standard throughout the wing, the only difference being in the heights at which the various machines flew.

Formation was adopted on the ground and each formation took off together, height was gained in formation and 45 minutes was the average time taken in getting height.

The leader then headed for the lines and the machines packed up to correct distances.

The lines were usually crossed in under 60 minutes, at approximately 16,000-17,000 feet.

The leader would calculate the time the raid would take to reach the objective by choosing suitable land marks soon after crossing the lines and check his ground speed by them. On the results of this calculation he would decide whether the raid could be successfully carried out or whether the alternative target was to be attacked.

On approaching the target the leader would fire his warning signal, a red light, to attract the attention of the formation.

The leader was responsible for the sighting of the bombs, and No. 2 and No. 3 dropped by him. No. 5, the deputy leader, also took a sight, and No. 4 and No. 6 dropped by him.

This was the usual procedure; in good formations when pilots were flying at correct distances, it was possible for all six machines to release their bombs simultaneously with excellent results.

Cameras were carried by at least one machine in each formation; the majority of exposures were made over the target itself, but photographs were also taken throughout the flight, provided enemy aircraft did not attack in such numbers as to prevent this. Valuable information of future targets was thus obtained.

It was over the target and during the return that most of the fighting took place. Anti-aircraft fire was not a serious consideration at this height.

Formations were generally fairly heavily engaged both at the target and especially on the way back. "Jackal" tactics were almost invariably adopted and only on three occasions can I find records of attempts being made to break up the formation. In none of these cases was the attempt successful.

On returning pilots and observers at once gave in a verbal report to the squadron commander and then went to the

B.I.O.'s office; this office should always be in close proximity to the photographic hut, and, if possible, part of it.

Photographic personnel were in attendance on the aerodrome and collected the plates from machines as soon as they landed, and negatives were ready before the B.I.O. had finished examining the observers. This is roughly the usual procedure that was carried out.

Points to bear in mind when carrying out raids are:— In long raids allowance must be made for change of weather conditions, alteration in the strength of wind, fog, &c. Fog was frequently found in the Rhine valley.

The leader of the raid must, therefore, have an alternative target to switch to, such as Pirmasens for Mannheim, &c.

Time is the most important of all factors when dealing with long distance raids, no time can be wasted on this side of the lines.

Many minutes can be saved by getting off the ground in formation with machines in their correct positions and getting height in formation, although not packed to correct intervals. The correct intervals are only assumed in the last ten minutes before machines cross the lines; there is ample time for this as no formation gains height near the lines in sight of the enemy or it would receive a very warm reception on crossing.

Also No. 2—Formation of a raid has ample time to conform to the raid leader's movements.

Co-operating formations should not endeavour to fly in actual station with the leading formation and should be within visual distance only.

No additional security is obtained by a huge cloud of machines, in fact the reverse, and the speed of the raid is much reduced.

If formations of a raid are some distance apart, hostile machines will divide their attention between the formations and will not concentrate on any one machine.

Raids must be sustained to be any good at all.

The material results, up to date, obtained from high altitude bomb raids are not on the whole great; their greatest effect was against the enemy's morale.

An isolated raid on a factory will not seriously upset the morale of the workers for any length of time and will probably do little material damage. If, however, raids are maintained for 24 hours the work of the factory may not be completely stopped, but it will certainly be very completely disorganised. To maintain a 24 hours' raid does not necessitate the large number of machines that would at first appear necessary.

During the hours of darkness machines go out singly at intervals and the alarm will be given on the approach of each

machine. During the day formations must be employed as a protection against opposition from hostile aircraft, and this of course increases the number of machines. I do not think pack formation will ever be employed at night for this purpose.

But by day two raids of six machines judiciously spaced will cause fairly complete disorganisation.

In the case of the German towns attacked, their arrangements for receiving warning of the approach of hostile machines were most thorough; the alarm was given immediately the approach of hostile machines was signalled.

This alarm was usually given 20 to 30 minutes before the arrival of the raiders; all work ceased from the time the alarm was given until the "All clear" went.

The "All clear" did not go until it was ascertained that the last machine had left the neighbourhood. In the case of night raids this might be several hours, and was generally well over an hour in the case of day raids which merely passed over the town without attacking.

Adding on to this the time taken for personnel to get out of dug-outs and back to work, one sees that a considerable portion of an eight-hour working day has gone.

In the case of one town there were 291 alarms given, on each of which the inhabitants took cover for an average period of two hours; yet only seven actual raids were carried out against this town.

When the raid was actually carried out the period of interruption was much greater. Thionville was raided on July 16th by 12 machines; this raid did a large amount of damage, which I will touch on later.

The inhabitants took cover at 2 p.m. and did not come out till after dark, doubtless largely due to the exploding ammunition. But this bears out my point, that two raids would have been all that would have been necessary to keep up the effect of a continuous raid during the day. Another example is the output of machine guns at Vickers works in England, which fell to zero on the day when two raids took place.

This gives one an idea as to the effect that raids have on the morale of the civilian population.

Now to touch on the material damage caused by bombs.

Railway centres were the chief objectives attacked and in some cases damage held up traffic for over the 48 hours. Usually, due to large and well organised working parties, the damage was repaired in a few hours.

This at once brings up the question should railway junctions be attacked, or, is it better to attack the railway in some isolated spot.

Unless a viaduct or tunnel is available it is improbable that sufficient damage could be done to the permanent way to make repairs impossible within 48 hours, even in some isolated spot.

A 112 lbs. bomb dropped more than seven feet from the centre of the track will not damage the permanent way; similarly, 230 lbs. bomb will do no damage if dropped more than 12 feet from the centre of the track. In these days of steam navvies, even on a single line, it would not take long to clear away the debris resulting from a bomb raid carried out against a railway running through a cutting. If, however, the entrance to a tunnel or a viaduct was damaged, several days' delay might be caused.

Railway junctions attacked in co-operation with a ground operation may seriously inconvenience the enemy in bringing up his reinforcements.

The junction of Metz Sablon was attacked during the days the Americans were making their attack on the St. Mihiel sector. In addition to damaging the tracks at the junction and stopping traffic for 24 hours, the turntable at the entrance to the locomotive depôt was damaged and put out of action, and 94 locomotives were unable to leave the depôt.

Again, at Thionville a raid was carried out while an ammunition train was in the sidings and this caught fire, and besides the fifteen trucks of the train that were burnt out the following damage was caused by bombs and the exploding shells. The goods station and trucks in the goods sidings were completely burnt out, and shells and hand grenades stacked here exploded. Another 50 trucks were burnt out and a further 50 partially destroyed; these set fire to a troop train and killed 60 horses. Rails and points were badly damaged and water mains and towers were destroyed. All traffic was suspended for 48 hours in spite of the fact that 400 soldiers were called in to assist in repairing the damage. Ten engines were also damaged. The casualties were 83 military killed or wounded and 10 civilians killed. The inhabitants took cover at 2 p.m., and the "All clear" was not given till 7 p.m. The raid was carried out by 10 machines.

The Germans at this time were very short of rolling stock and could not find the material or labour for ordinary running repairs, and so our efforts were directed at increasing the shortage of rolling stock. In such circumstances it was policy to attack junctions and other places where concentration of rolling stock was to be expected.

From the above it is evident that these raids certainly were of good value.

At first through fear of reprisals on the French aerodromes, attacks were not carried out against enemy aerodromes. However, when the Germans started to raid French

aerodromes, permission was obtained to attack them. This was a popular move from the pilots' point of view, as enemy air activity had become much more intense of late. Very numerous raids were carried out against the aerodromes. Owing to the fact that many of them were situated within 40 miles of the lines, they formed useful instructional raids for young pilots, in spite of this fact, very few casualties were incurred on the raids. In one D.H. 9 Squadron 21 raids were carried out and only one observer was killed, and two machines were damaged, but returned safely to our side of the lines. The other squadrons were equally fortunate. Up to June, 1918, only three raids had been carried out on aerodromes. In July, out of 118 raids, 33 were on aerodromes. In August out of 120 raids, 65 were on aerodromes. From this date the initiative had been wrested from the Germans, and raids on aerodromes became less urgent. In October, out of 104 raids, only 23 were against aerodromes.

The Germans estimated that they lost an average of two machines for each raid we undertook against their aerodromes. Roughly it took five machines to destroy one. This does not include the damage resulting from the frequent changes of aerodromes, which also, of course, reacts on the morale of the personnel. We lost, on an average, one machine in three raids.

Factories came next in order of importance, as far as the number of raids carried out against them is concerned.

In only one case was a factory completely destroyed through the result of a raid. This was the factory at Kaiserlauten. A S.A.A. factory of three stories, 100 ft. by 100 ft., which was completely destroyed on the night of 21-22 October, by a 1,650 lbs. bomb. Also the chemical works at Oppau were put out of action for two days as a result of the raids mentioned on Ludwigshafen by the destruction of the gas mains. It was estimated by the directors that the total material damage to the works was 4,093,000 marks exclusive of any loss from decrease in production and increase in wages.

As a result of these raids the Germans themselves state that they were compelled to (1) denude important centres of guns, machines and men, in order to reassure the public; (2) To expend vast sums of money in the construction of shelters, warning controls, &c., and to divert a large amount of labour to carry out these works; (3) That the output of essential factories such as the Oppau works, blast furnaces, and gas factories fell off, and the morale of the workmen deteriorated and forced them to pay high wages for greatly inferior work, and that (4) general depression was increasing as it became more and more obvious that the communications were liable to be attacked and that the factories and works

were exposed to increasing danger, and probably complete stoppage.

This is what the Germans themselves felt about these raids into Germany, and I feel that it is a very strong argument for the adoption of intensive bombing programmes in the future, and a proof, that in the last war, the detachments of a force to attack the enemy at home was justified.

Now to consider the lessons that were brought home to us:—

**1. Choice of suitable targets is the first consideration.—**

—Targets should be so chosen that the enemy never knows which target is to receive attention, and therefore the alarm is certain to be given and work disorganised at every target you approach. The area allotted to each wing or squadron should be large enough to allow of considerable alteration in the direction of attack. For instance, the 8th Brigade acted on the arc of a circle from Cologne to south of Stuttgart. The enemy is then forced to disperse his defending aircraft over a wide area.

At least two targets can be threatened by each raid undertaken. The false alarms are almost as damaging to the morale of the populace as actual raids. In the case of blast furnaces, that are shut down as the result of an alarm, it is certain that the quality of the metal will be affected even if it is not completely ruined.

**2. Formation Flying.**—A strong defensive formation is an essential to a successful bomb raid. A defensive formation must be such that no machine is left in the rear, unsupported by the covering fire from observers' guns in the neighbouring machines. Any form of diamond formation illustrates this fault.

The actual spacing of a formation depends entirely on the field of view obtained in the particular type of machine flown.

Numerous small formations are more successful than a large "Mass Formation." In the first place each additional machine cuts down the speed of the formation as a whole. Secondly, six machines are as much as any one leader can handle. Thirdly, the additional security afforded by a mass formation is very doubtful. It will attract all the hostile machines, and they will concentrate their attack on any one machine which happens to be in an exposed position.

Lastly, formations composed of several units call for careful interunit training and preparation, the time for which was not available during the last war.

The importance of good leadership need not be elaborated upon, as it is sufficiently obvious from the above remarks.

**3. Raids must be continuous.**—Night raids should always be followed up by day raids, and *vice versa*. This insures both

material and moral damage. Also the raids must be sustained throughout the day and night in order to obtain the maximum result. This is, perhaps, the chief factor in limiting the size of the formations employed.

**4. Timing of Raids.**—The raids, therefore, must be so timed that there is no danger of one raid stirring up trouble for the next one. The officer dispatching the raids must space them so that the E.A. that went up to attack the first raid are returning to refuel as the second raid arrives.

5. The possibility of "*Dud Weather*" raids must not be overlooked. Given a fairly experienced pilot and a turn indicator in addition to the usual instruments, the results possible from these raids are proportionally much greater than from formation raids. Surprise is almost certain to be obtained and due to the low height at which they are carried out the material damage is usually much greater. Aerodromes are very suitable targets for this form of attack.

**6. Photography.**—Besides giving indications of the results of bomb dropping, and the existence of other suitable targets, photographs can be a very useful guide in determining the errors committed by a formation in the actual dropping of its bombs. Such errors as dropping with the formation on a turn or straggling are very clearly shown by a photograph of the bomb bursts.

Long distance reconnaissance should also be the duty of a long distance bombing squadron.

It is usually possible to combine a certain proportion of the reconnaissance needed with a raid. The bomb sight is usually suitable as a photographic sight, and at present the machines are of the same type.

The chief advantage is that single machine reconnaissances give the squadron leader a chance of discovering the pilots that are most likely to make successful formation leaders.

Also these reconnaissances give a pilot a chance to do individual work and vary the monotony of continual formation flying, which has a tendency to destroy the individual initiative except in the case of the leader.

**7. Instruments.**—It is desirable that all instruments should be as fool proof as possible. The brain moves slowly when the pilot has to remain for hours at high altitudes, and is incapable of rapid calculations. Bomb sights should therefore be as simple as possible in operation. If automatic course and speed deflection sights are fitted, it must be remembered that all movable parts require oil and that even non-freezing oil congeals at high altitudes unless the instrument is electrically heated. The same remarks apply to cameras and bomb release gear.

Simplicity in operation allied to reasonable accuracy is what is needed in a two-seater bomber. In the last war the mirror sight was by far the most useful and most popular. Even with this simple sight, pilots worked out still simpler methods of their own. For example, it was found that bombing down wind on a D.H. 4 at a target such as a munition factory, if one released the bombs as the centre of the target disappeared under the leading edge of the bottom plane in line with the port inside bay strut, this coincided with the moment when the target appeared on the intersection of the wires of your mirror sight.

8. **Oxygen** is essential for personnel engaged on long distance high altitude bomb raids, and its use must be made compulsory and not left to the discretion of the individual. It is recommended that some apparatus that gives a visible proof that oxygen is being delivered should be used in preference to one that does not. The Dryer apparatus had a turbine which revolved as the oxygen was given off and this was visible to the individual using the apparatus. The Sibe-Gorman had no such ocular proof; the result was that the repeated failures of the Sibe-Gorman were greatly in excess of those of the Dryer. Very often the apparatus was quite in order, but the amount of oxygen given off is comparatively small, and unless the individual has ocular proof he is liable to think that he is not getting oxygen, and will actually begin to feel sick.

9. **Light Codes should be cut down to a minimum.**—A red light for calling attention, a green light for engine failure, and a white light for "Wash out" were all that were found necessary for day bombing, and the last was very seldom used, as "formation" was always kept right up to the point of landing back on the aerodrome. The same number of coloured lights suffice for night flying, with the addition of the special lights required for recognition signals.

The interpretation of the coloured lights will be somewhat different when used at night.

10. Bombs left much to be desired in the last war, both in the actual bombs themselves and the types used.

A "killing bomb" for use against personnel, and of such a weight that single-scatter fighters can, in emergencies, carry at least two, is essential.

Also a bomb capable of penetrating the roof of a well-built factory and giving good "fragmentation" on bursting.

Open spaces predominate even in populous towns and the effect of a heavy bomb fitted with a delay fuse is very localised. It is therefore necessary to have a light cased bomb fitted with an instantaneous fuze of such dimensions that it is

capable of blowing down the walls of houses, &c., by blast effect.

Incendiary bombs should be capable of causing widespread damage when used against inflammable material, where an H.E. bomb would only have a local effect. During the war the various types of incendiary bombs were most unsuccessful.

Gas bombs could be most effectively used by aeroplanes, although at present the "Washington Treaty" forbids the use of gas as a weapon. The total weight of a container holding 660 6-in. gas bombs, is only 250 lbs., so even with the present type of machines a very good gas cloud is capable of being produced.

11. Fuzes are instantancous or delay, and fitted either in the nose or, for delay purposes, in the tail.

The longest delay fuse used in the war was 15 seconds delay.

But the possibilities arising from the use of prolonged delay fuses of anything up to days, must not be overlooked, and would render areas minhabitable for troops, &c.

12. The storage of bombs is of great importance. Internal storage is a great advantage in that the carrying of bombs does not offer increased wind resistance, nor is there the difficulty of so attaching your bombs as to insure sufficient ground clearance on muddy aerodromes, or in the event of a burst tyre.

Whatever carrier is used it should be capable of adjustment so as to carry any type of bomb that is likely to be needed. Many precious man hours were expended in changing over racks to carry the different types of bombs needed for attacks on the varying targets of the last war.

Standardisation of bombs and carriers should be one of the earliest aims of the R.A.F. in peace.

13. In conclusion, it is worthy of note that the casualties inflicted on bombing machines fitted with dropped radiators, such as the D.H. 9, were very much greater than in the case of machines with the ordinary radiator. It is concluded that the greater proportion of close shots from E.A. went under bombing machines by comparing the damage usually caused to under carriages, top planes, and centre sections. A percentage of these naturally hit the D.H. 9's radiator. The position of this radiator was responsible for quite as many extra casualties as the difference between the performance of this machine and the D.H. 4. This point is worth considering, as some modern machines, such as the A.D. Coys. D.H. 9a, have been fitted with "barrel radiators" on the undercarriage.