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SECOND INTERIM REPORT ON PROJECT RICHY
(The Destruction of Aircraft by Atomic Airbursts)

A. Y. Pope

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ABSTRACT

This memo covers the new knowledge and general progress gained from July 15, 1953, to September 15, 1953, on the problem of determining the destruction of aircraft by atomic airbursts.

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SECOND INTERIM REPORT ON PROJECT RICHY
(The Destruction of Aircraft by Atomic Airbursts)

SUMMARY

This memo covers the new knowledge and general progress gained from July 15, 1953, to September 15, 1953, on the problem of determining the destruction of aircraft by atomic airbursts.

GENERAL PROGRESS

A number of new developments seem to warrant a second interim report at this time to bring interested parties up to date. As regards general progress, the most important contribution has been due to an extended trip made by E. S. Rose, Jr., to a number of interested agencies. His findings are partially reported in Reference 2, and will be contained in other Tech Memos to be published shortly. Basically, his most important conclusion is that the problem has not been solved; the preponderance of work still emphasizes escape of a delivery aircraft.

Additional and significant help has been contributed by John Wemser, 1271, and M. V. Barton, summer consultant. This work will be discussed in relevant paragraphs. It has led to the Tech Memo (1925-3-(29)) Project Richy: Trend Studies.

NEW INFORMATION ON PROBABLE TARGETS

Associated Press releases have described a TUG-75, a six turbo-prop, tractor, swept-wing long-range airplane "now in production" by the Russians. Information available indicates the TUG-75 is almost exactly the size of our B-36, but of a more modern, cleaner design. Eighteen are reported in service.

The Air Force currently has no turbo-prop airplanes flying and almost none in the design stage so that performance estimates of good accuracy are not possible.

Some semi-educated guesses follow:

Turbo-propeller airplanes are not as fast as jets, and probably the TUG-75 has a top speed between 410 and 450 knots. Structural limitations probably prevent the top speed from occurring at sea level. One could guess the sea

level maximum speed at 340-380 knots; with 410-450 knots at 10,000 ft. decreasing to 400-440 at 45,000 ft.

The range of the TUG-75 is very probably less than that of the B-36 (6700 nautical miles) due to fundamental inefficiencies in the turbine engines. Such an airplane would have a kill hardness greater than the B-29, but less than an F-86; say 6-9 psi.

The decision to employ a turbo-prop drive is interesting (if true). It implies a solution to propeller difficulties encountered with the Convair-Allison flying test bed; and it also implies a failure to improve the poor fuel consumption of the German jet engines. That is, we can get good range with our jet powered B-52. Apparently, the Russians could not.

Construction of a large number of TUG-75's would prove very difficult for Russia if magazine estimates of their aluminum production (300,000 metric tons in 1952) and jet engines (63,000 in 1951) are accurate (2.0 spares per installation is reasonable).

TERMINOLOGY

Having a lot of people working on the problem naturally results in confused terminology, and accordingly, some definitions are advanced below:

Escape Problem: The problem of computing that both crew and aircraft will be safe after delivery of an atomic bomb.

Destruction Problem: The problem of determining by analysis the proper orientation and slant range of an atomic airburst to assure destruction of crew or structure of a manned aircraft. "Destruction" is believed to be more definitive than "lethality", "mortality", "Fatality" or "vulnerability".

Project Richy, accordingly has been re-defined as "The Destruction of Aircraft by Atomic Airbursts."

NEW INFORMATION ON OVERPRESSURE KILL

It has been suggested that analytical considerations of overpressure kill include the shock reflection increment. Fortunately, the whole field of analytical overpressure studies may be by-passed through the availability of excellent empirical data from various Nevada shots. The best of this

information is contained in Paper 1. In using this data, the effect of precursors should be considered.

One overpressure "circle" has been corrected (i.e., distorted) for the effect of non-uniform atmosphere and time of shock wave travel. Further work along this line is being indefinitely postponed while more important gust effects are being examined.

NEW INFORMATION ON GAMMA KILL

The latest information is that instantaneous incapacitation of the crew by gamma radiation results from a dose of 5000R. Minimum dosage rates do not in a practical sense pertain to this problem.

NEW INFORMATION ON THERMAL KILL

The reader is referred to "Project Richy: Trend Study", Tech Memo 1925-3-(29) for new data on thermal kills. Briefly, 50 calories/centimeter^2 will produce a probable kill; 150 a certain kill.

NEW INFORMATION ON GUST KILL

The gust kill facet has been discussed extensively by E. S. Rose in Reference 2. Some additional items are offered herewith. All comments apply to the plane of symmetry which is currently receiving the preponderance of our attention.

The steady state lift increment due to a change in angle of attack of an aircraft may be easily calculated if the lift and drag curves are known. In the work of Bond and Pope, the curves for the B-29 were approximated from an earlier paper by Pope (Reference 5). However, the nature of the sudden angle change produced by a shock wave is such that five transient effects arise:

1. The vertical translation of the airplane acts in a direction to relieve the gust velocity. This effect is called <u>gust alleviation</u>, and it tends to reduce the steady state lift increment by a factor of 0.7 to 1.0.

2. The application of a sudden load produces a momentum in the structure which makes the structure overshoot its slow load

application stress value. This effect is called dynamic overstress, and in a simple linear case it increases the steady state stress by a factor of 2.0.

In a carefully computed study, the combined gust alleviation and dynamic overstress combined to give a factor of 1.3 on a Grumman S2F airplane. This was in the Hookian stress-strain range. However, we are interested in the non-linear case wherein the structure is carried through the non-linear yield range to rupture, and a dynamic overstress value of 2.0 is not admissible. M. V. Barton verbally reported a study of the action produced by applying a 2500-pound load to the yielding system shown in Figure 1. When the load, which would produce a 4-inch deflection under steady conditions, was applied for 0.2T, the overstress factor was 0.75; when applied for 1.0T the factor was 2.25. It would appear that the non-linear dynamic overstress for a B-29 wing is probably between 0.5 and 3.0

3. The sharp edged gust with which we are concerned dies out quite rapidly, and hence we are affected by a step function diminution effect. M. V. Barton, assuming that the lift grew instantaneously, (see next section) computed the diminution effect for a structure whose period = 0.4 seconds (B-29 wing) and loading curves the same as a 1 and a 10 KT burst. The dynamic overstress factors were respectively 1.35 and 1.60 instead of 2.0. (Factors are 0.85 and 0.80) a larger burst would yield a still lower factor, say 0.70.

4. The steady state maximum lift of some wings is increased when the angle of attack is changed rapidly; in some cases it is decreased. The factor known as dynamic lift overshoot is probably between 0.8 and 1.5.

5. It is well known that lift does not arise instantaneously when new conditions occur. In our case, this essentially means that the diminishing step function has a maximum value of less than the true peak. Previously, estimates had been that the lift build up would take a ten chord travel or 0.25 seconds at 400 fps. Shorter travels are now being considered — say 0.1 second. On a 10 KT burst, the gust velocity 0.1 second after arrival has decreased by a factor of 0.87.

The spread of unknown factors is currently

(1)	Gust alleviation	0.7 to 1.0
(2)	Dynamic non-linear overstress	0.5 to 3.0
(3)	Step function diminution	0.7 to 0.85
(4)	Dynamic lift overshoot	0.8 to 1.5
(5)	Lift build-up	0.87 to 1.0

The total product of the factors (0.171 to 3.92) makes little sense except illustrate our zone of ignorance; and that said zone is large.

FUTURE PLANS

The following steps are planned to reduce the spread of our ignorance:

1. Gust alleviation: Further study by Sandia Corporation and a research group.

2. Dynamic Non-Linear Overstress: Obtain a stress strain curve from Boeing and have a consultant complete the analysis.

3. Step function diminution: Get help from a consultant.

4. Dynamic Lift Overshoot: Consult with NACA. This may take some Sandia research in a blast tube or wind tunnel.

5. Lift build-up: Continue study of NACA work and possibly ask for new studies by NACA.

It should be noted that all work so far reported has been for bursts in the aircraft plane of symmetry. Tunnel tests expected soon (Oct. 26-30) at North American Aviation may shed some light on bursts out of the symmetry plane.

ALAN POPE

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Bibliography of Papers Relevant to Project Richy

1. Vulnerability of Parked Aircraft to Atomic Bombs, Operation Snapper, Nevada Proving Grounds, April-June 1952, Project 3.1, WADC Report dated February, 1953. (Excellent photographs of a large number of damaged aircraft.)

2. E. S. Rose, Jr., State of Knowledge in the Gust Destruction Problem, with Recommendations for Sandia Corporation Efforts, 5141 (432) Tech Memo 144-53-51, September 1953.

3. Alan Pope, First Interim Report on Project Richy, Tech Memo 117-53-51, July 1953.

4. Alan Pope, Project Richy, Trend Study, Tech Memo 1925-3 -(29).

5. Alan Pope, Wind Tunnel Tests of an NACA 0015 Airfoil through 180° Angle of Attack Range, Aero Digest, April 1949.

6. Burnett P. Gadeburg, The Effect of Rate of Change of Angle of Attack on the Maximum Lift Coefficient of a Pursuit Airplane, NACA TN 2525, 1951.

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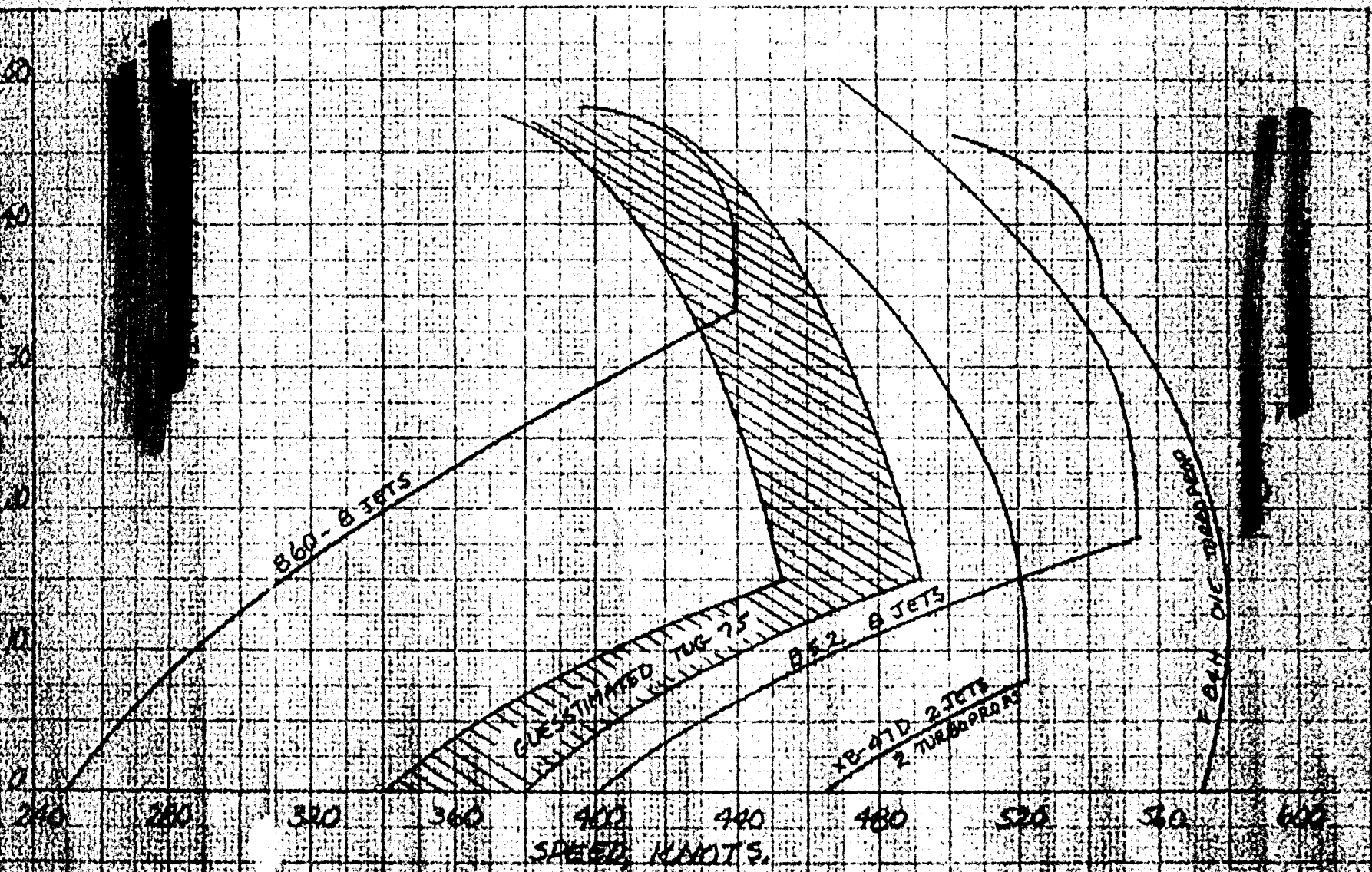

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FIG. 2 SPEED-ALTITUDE CURVES FOR SEVERAL BOMBERS

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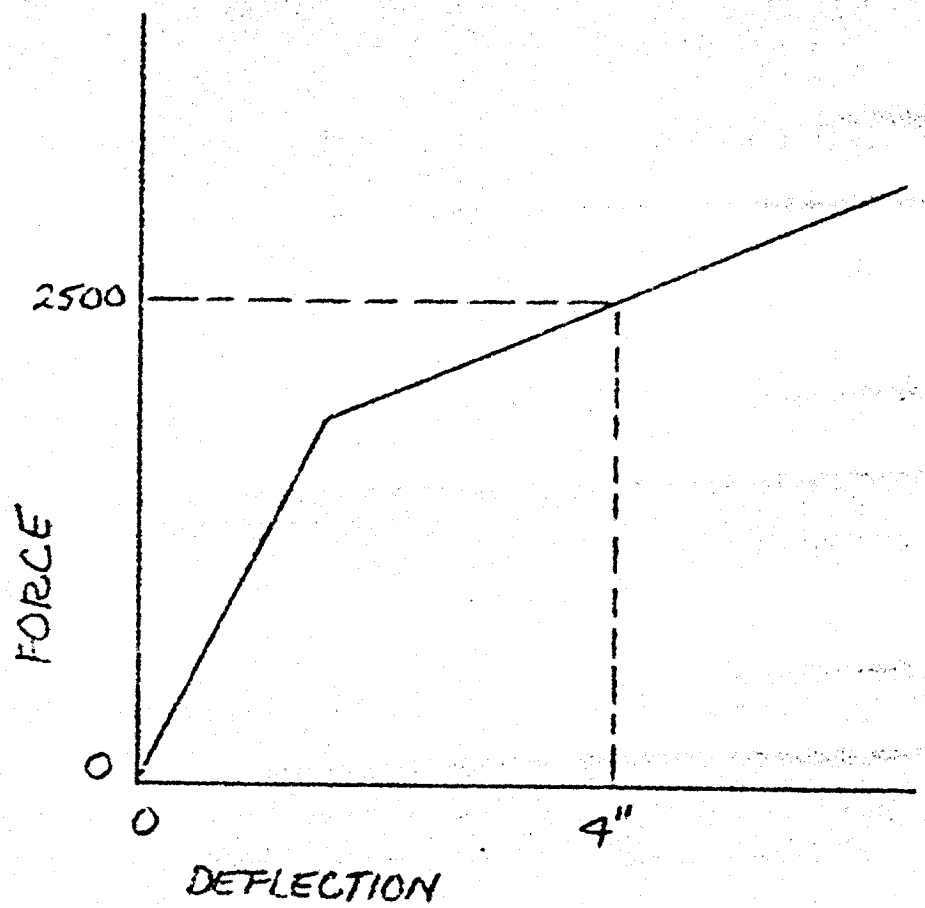

FIG 1

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