A firing sabot for bird-impact tests

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FIELD NOTE - NO. 46

In the belief that rapid exchange of information is of the utmost importance to a solution of the bird problem, the Associate Committee on Bird Hazards to Aircraft has decided to release rough field notes as soon as they are produced, rather than to wait until these data would normally appear in formal reports
.
These field notes are produced for information and will not usually receive the editorial care given to formal reports.

It is hoped that other groups will contribute similar notes on an exchange basis.

May 1967

Field Note No. 46

A Firing Sabot For Bird-Impact Tests

1. Introduction

The testing of Aircraft engines or structures against bird impact is often carried out by placing a real or synthetic bird carcass in a gun, and firing it at the target structure by means of a charge of compressed air.

Since the "bird" is essentially a bag of very viscous fluid (e.g. gelatine or grease), when it is exposed to an acceleration of 100 g, or more, it has a strong tendency to "mushroom" in the barrel.

If the "bird" is large enough to fit the barrel of the gun in use, the design of the "sabot" or case in which the "bird " is contained for firing is very simple (Ref. 1). However, if a smaller bird is being fired from the same gun, as is often the case, the sabot design is more difficult. Such a sabot has to preserve the "bird" from mushrooming, to stabilize it in the barrel, and has to be discarded from the bird at the gun muzzle so that it does not remain with the 'bird' and cause spurious damage to the target which may be as close as six feet to the gun muzzle.

2. Simple Sabot (full-calibre)

If the "bird" is of full barrel diameter, the problem is simple, and a sabot of the type described in Field Note 44 (Ref. 1) is adequate, at any rate for firing at up to 450 ft/sec.

The styrofoam base plug acts as a base pressure distributor, and also absorbs some of the peak acceleration by slight axial compression. Since its density is very low, it does not contribute appreciably to the destructive effect of the shot, although the whole packet arrives at the target.

For higher speed firing, it would be worthwhile trying a greater thickness of styrofoam baseplug if trouble is experienced with the bird breaking up and smearing in the barrel. If the bird breaks up after leaving the gun, a tougher polythene bag is suggested. (See Fig. 1).

3. Sabot for Sub-calibre "birds"

It is often required to fire a bird smaller than the bore of the gun.

From the point of view of reasonable simulation of the impact, and also of getting acceptable ballistic performance, the "bird" should be roughly cylindrical, with a length/diameter ratio of between 1 and 2.

As a specific example, we will consider the firing of 5 oz. "birds" from the 3-3/4" gun, which was also used to fire the 1 lb. and 2 lb. birds described in Ref. 1. The 'birds" (representing starlings) were made very simply by filling a wax-paper drinking-cup with grease-sawdust mixture of the correct density, and firing the cup open-end first. High-speed motion pictures showed that it arrived at the target intact.

However, these bullets measured only 2-1/2" d. and 3" long, so firing them from a 3-3/4" bore gun presented a problem.

Five conditions have to be met.
1. The bird must be in a good tensile bag, where rigidity must be small, since it accompanies the bird to the target.
2. This bag must be held in a sabot of high tensile hoop strength, to prevent the bird mushrooming under 'g' in the gun
3. The sabot must be stable in the gun barrel, keeping the bird on the centreline. and not permitting it to tumble in the gun.
4. The sabot must be removed by a device at the gun muzzle, without ripping the bird's tensile bag.
5. The sabot must be backed by a stiff plug. which will stand the propellant force end transmit it evenly over the load.

These requirements have been fulfilled by the device shown in Fig. 2. In the case of the small (5 oz.) birds, fired over a short range (6 ft) at up to 450 ft/sec, the open-ended wax paper cup has been found an adequate "bag". For larger birds, longer range, or higher speed, a polythene bag would be recommended. It would be held in a light paper or thin cardboard cylinder to maintain its shape while loading the sabot.

To prevent this very flexible bird from mushrooming into a large flattened glob in the back of the sabot under the g-loading in the barrel, it must be encased in a strong cylinder, which will be almost in pure hoop tension. for the size tested, a length of tough cardboard tube, about 1/8" thick, was suitable. This has sufficient strength to resist the radial mushrooming load, but is easily split by the muzzle knife.

This tube is glued firmly to the baseplug, which is made of 1/8" cardboard, cut to full bore diameter lass about .020" diametrical clearance. This is stiff enough to resist the 100 psig or so of the propellant air charge, but again is easily destroyed by the muzzle knife.

The sabot is stabilized in the barrel by wrapping the cardboard cylinder with a spiral of corrugated cardboard, well glued. This is light, stiff, and very easily destroyed at the muzzle.

The muzzle knife is a simple annular knife, turned from a mild steel plate. Its cutting edge is inserted inside the strong cylinder of the sabot as it passes through the muzzle, and the conical surface of the knife then wedges the sabot into small fragments which fly out radially between the knife-plate and the muzzle proper. Some sort of cylindrical guard placed around this region will reduce the amount of flying debris when the gun is fired.

It is important to mount the muzzle knife on springs, as shown, to reduce the shock to the barrel when the knife suddenly stops the sabot. In early tests this was not done, and on two occasions the whole barrel was pulled out of the breech fixing by the shock of the arrested sabot.

Since the mushrooming load presses the "bird", in its flexible skin, outwards into very tight contact with the cardboard cylinder, the crux of the whole problem is how to insert the knife between bird skin and cylinder, to destroy and discard the sabot without ripping the bird, or allowing pieces of sabot to continue with it to the target.

This problem was solved by leaving a 3/16" annulus all around the "bird", and filling the space between bird and cardboard cylinder with tightly packed powder. Dry plaster-of-paris powder is used. This is incompressible, and does not flow to allow the bird to mushroom. It gives the knife blade a large tolerance to enter inside the cardboard cylinder without cutting the skin of the bird. Finally, it disappears completely as a cloud of powder round the gun-muzzle, leaving the bird itself free to continue toward the target. The only piece of sabot which flies with the bird is the small bird-diameter disc of hardboard which is cut out by the knife. the weight and bulk of this is small relative to the bird.

4. Testing Jig

If it is desired to check any particular sabot, to see that it can withstand the acceleration load during firing, this can very easily be done in the jig shown in Fig. 3. In the absence of better information, constant acceleration in the barrel is assumed. From the curve of Fig. 4, the mean acceleration to attain any given muzzle velocity in a barrel of fixed length is found.

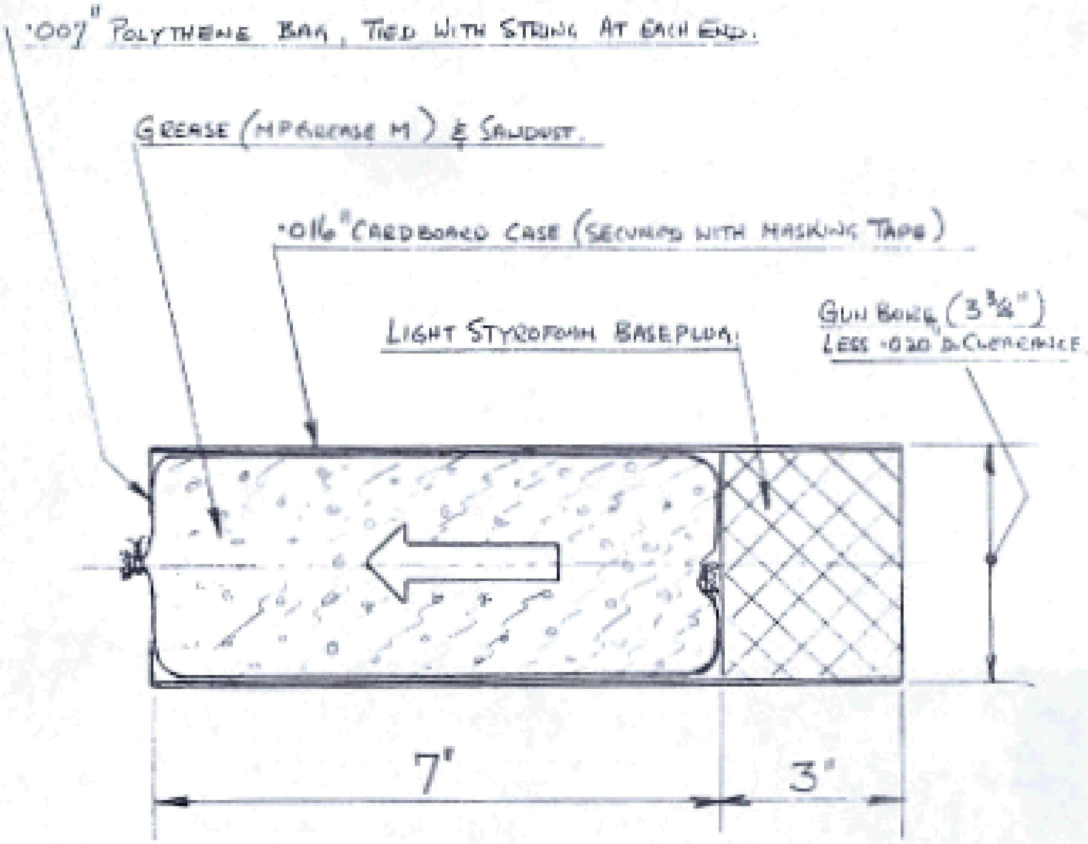
For example, to reach 400 ft/sec in a 10 ft barrel, an acceleration of 250 g is required. This will be the load acting on the base end of the bird in the sabot. The, for example, a 5 oz bird would exert a force of 5/16 x 250 = 78 lbs on the base. The bird in its sabot is therefore placed in the jig, as if in the gun barrel, and a load of 78 lbs is placed on the piston, which transmits the load onto the bird alone. If the sabot will withstand this without crushing radially, then it should not fail in firing.

To allow for non-uniform acceleration, it is considered likely that a peak/mean acceleration factor of 2 would be ample to cover the worst case likely to be experienced in the air-operated gun. The test weight should therefore be increased by this factor. A more accurate estimation of this factor would need consideration of the dynamics of the air reservoir, breech, and firing diaphragm or valve of the particular gun.

H.S. Fowler

References

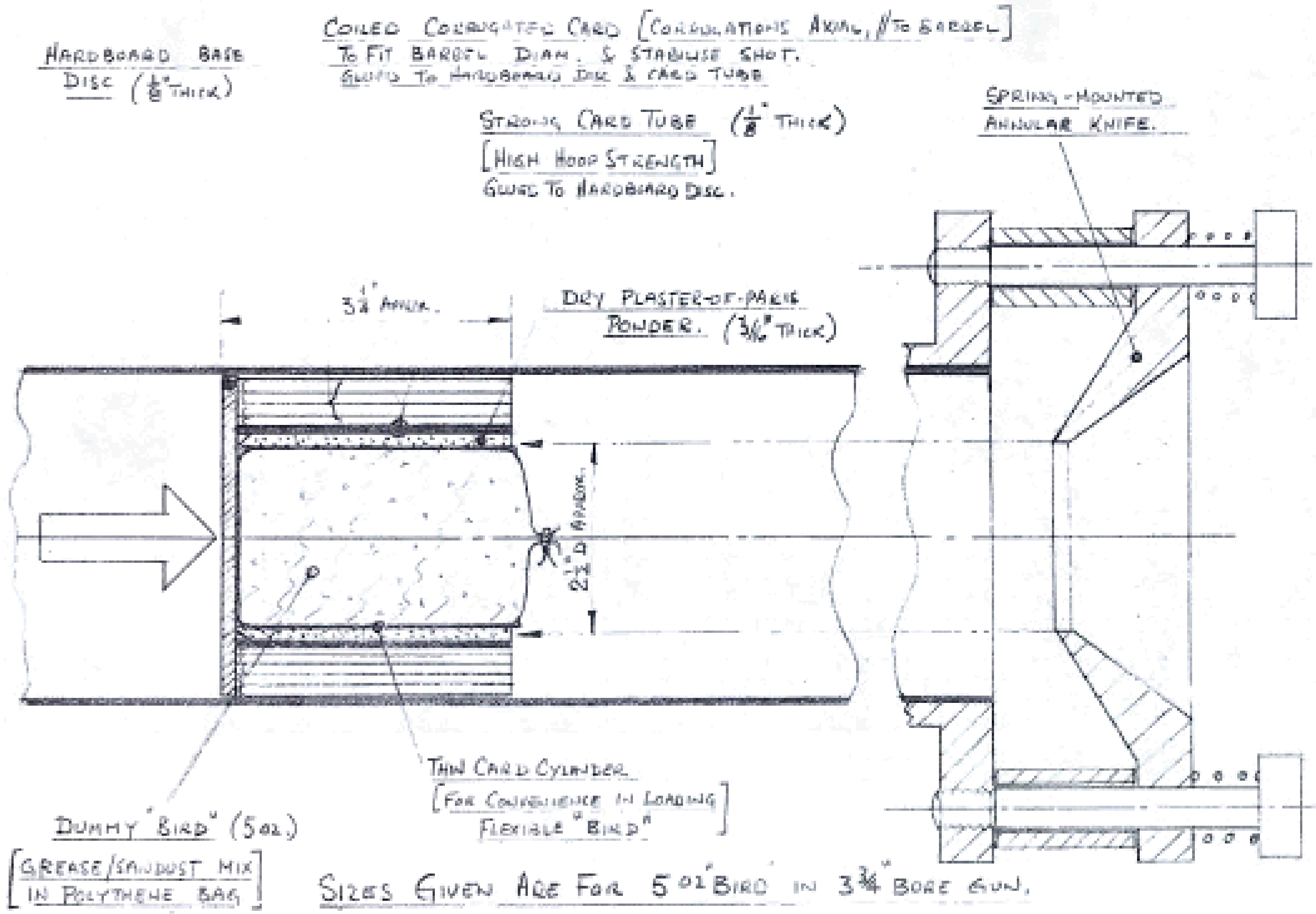
1. Fowler, H.S. "Tests on the Bird-Impact Resistance of Polyethylene Foam" Field Note 44.
2. Sommers, J. "Test of Materials and Packaging Methods for use in Aircraft Windshield Bird-Impact Simulation". FAA Tech Report ADS-23



WEIGHT OF SABOT = ·10 LBS.
THIS IS INCLUDED IN THE 2·0 LBS. TOTAL WT. OF "BIRD",
AS THIS SABOT IS NOT DISCARDED IN FLIGHT.

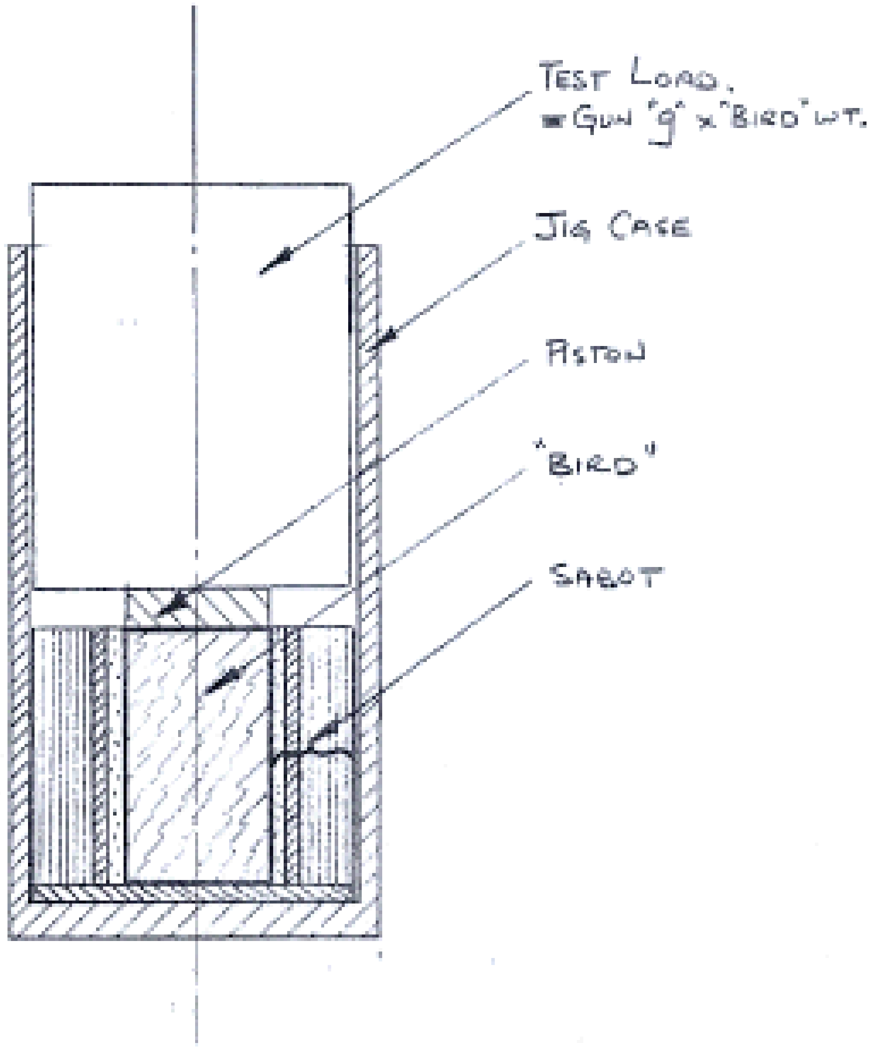
SIMPLE SABOT WITH FULL-CALIBRE "BIRD"

FIG. 1.



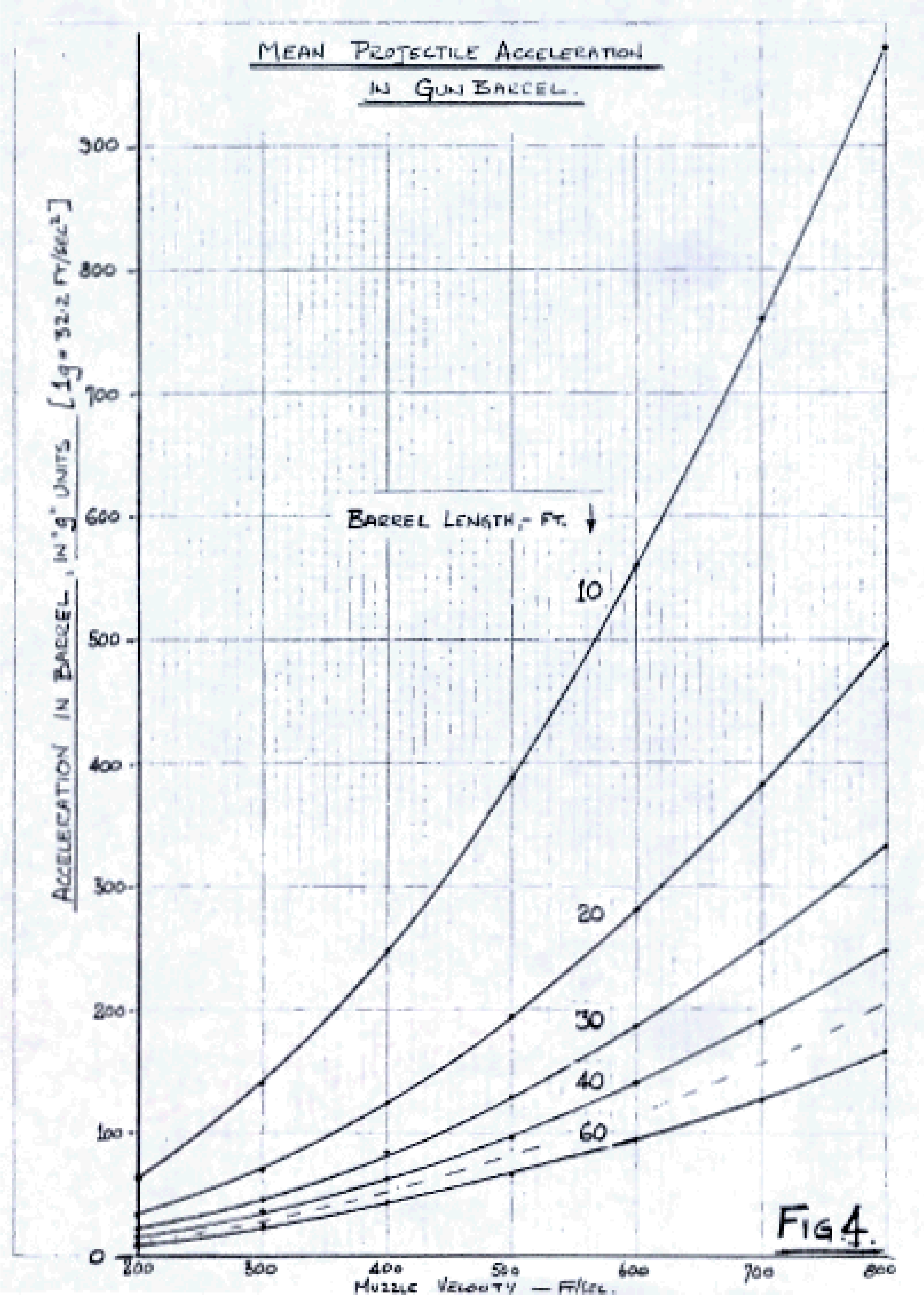
SABOT & KNIFE FOR BIRD IMPACT TESTS.

FIG. 2.



SABOT TEST JIG.

FIG. 3.



MEAN PROJECTILE ACCELERATION
IN GUN BARREL.
ACCELERATION IN BARREL, IN "g" UNITS [1g = 32.2 FT/SEC²]
BARREL LENGTH, - FT.
10
20
30
40
60
0
100
200
300
400
500
600
700
800
900
200
300
400
500
600
700
800
MUZZLE VELOCITY — FT/SEC.

FIG 4.