

June 25, 1946.

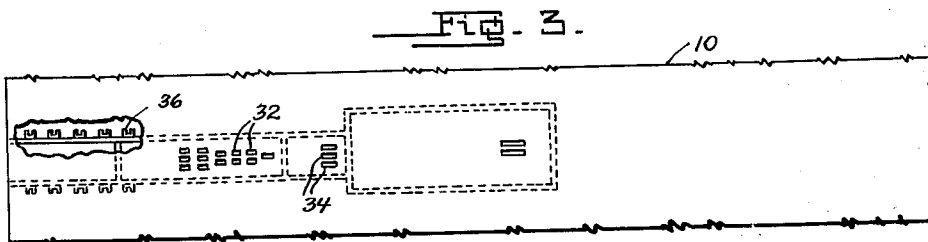
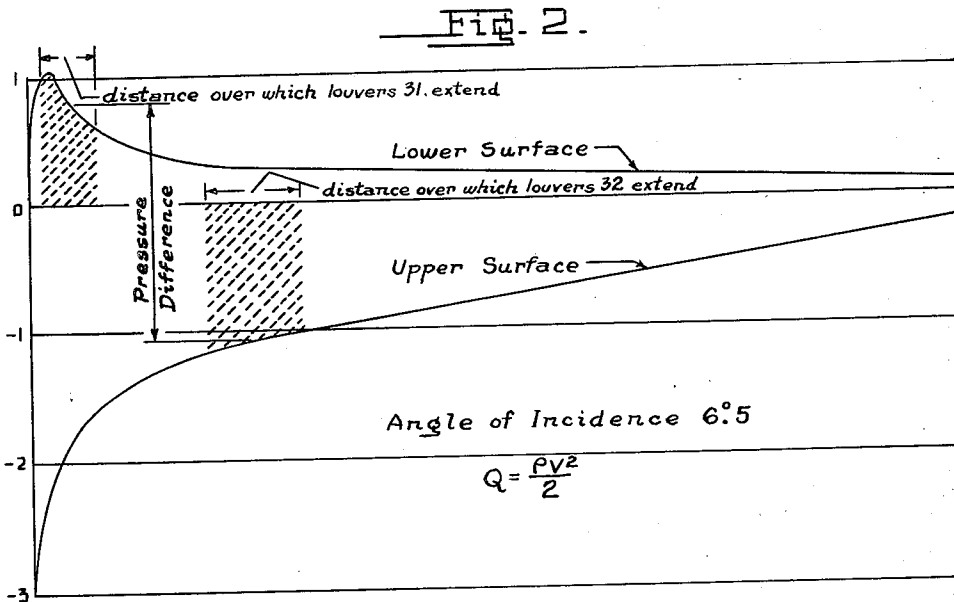
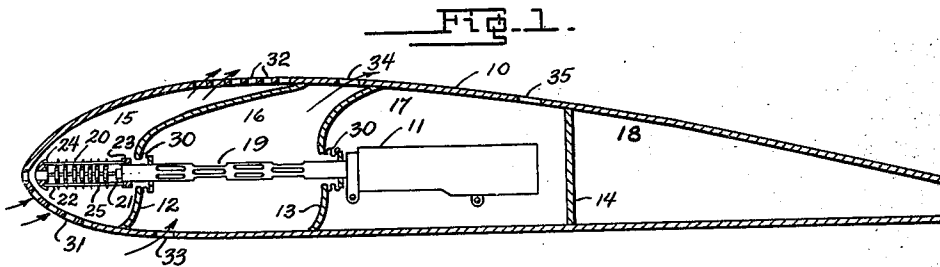
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2,402,632

BLAST DEFLECTOR AND GUN INSTALLATION

Filed Feb. 7, 1942

2 Sheets-Sheet 1



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Fig. 4.

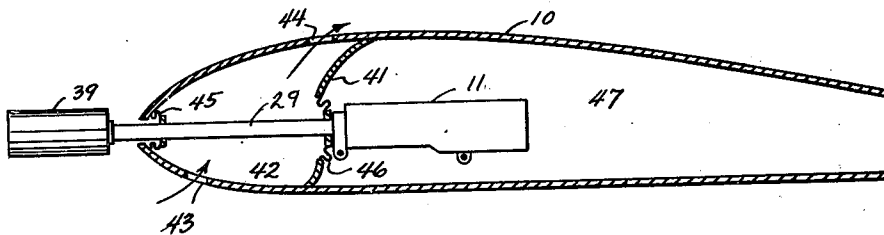


Fig. 5.

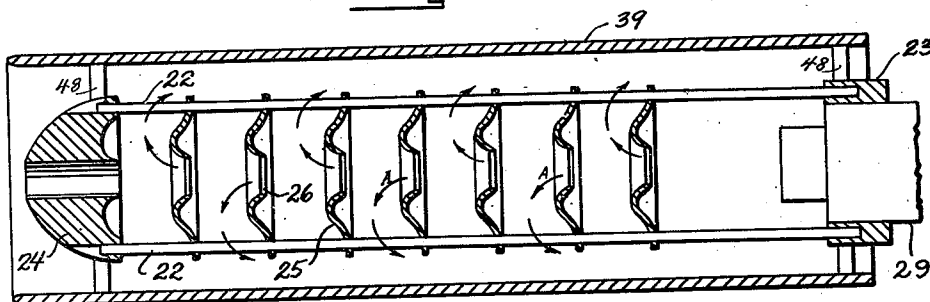
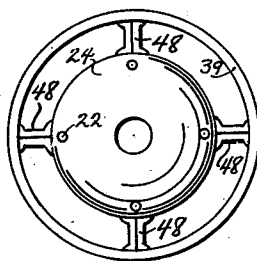


Fig. 6.



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## UNITED STATES PATENT OFFICE

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BLAST DEFLECTOR AND GUN  
INSTALLATION

Nicholas Ivanovic, Philadelphia, Pa.

Application February 7, 1942, Serial No. 429,868

3 Claims. (Cl. 89-14.1)

(Granted under the act of March 3, 1883, as  
amended April 30, 1928; 370 O. G. 757)

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This invention relates to aircraft provided with automatic firearms, and more particularly to the installation of the automatic firearms in an airfoil of said aircraft.

In a majority of interior gun installations found in the prior art a blast tube in some form or other is utilized, since it is essential in these prior art installations that the interior surface be screened from the effects of the firing of the gun. The several disadvantages accompanying the use of the blast tubes have long been recognized but no installation has been proposed which would permit their elimination. Furthermore, the prior art gun mounts and aircraft structures are required to absorb all of the recoil energy of the gun blasts and as a consequence thereof they must be of sufficient strength to withstand the impact produced as a result of the said recoil.

The British patent, 500,836, is illustrative of the characteristics of the prior art gun installation to which reference has been made. In this British patent the blast tube is secured to the muzzle and surrounds the barrel substantially all the way to the breech. One of the foremost disadvantages encountered in the use of such a blast tube is that it acts as a gas accumulating chamber which, after a few machine gun bursts gives rise to secondary gas explosions. These secondary explosions cause long flame streaks to be emitted, thus making the aircraft visible to anti-aircraft gun crews, and the reaction produced by these secondary explosions causes a reduction in the forward speed of the aircraft.

Furthermore, the use of the blast tube requires that a relatively large opening be cut in the leading edge of the wing to permit the required sight adjustment. Such an opening is obviously a source of large drag and causes turbulence in the flow of air over the leading edge of the airfoil. In multi-gun installations this drag and turbulence is a source of serious consequence. Many attempts have been made by those working in this art to eliminate the drag effects produced by this large opening but such attempts generally created additional design or mechanical difficulties. Another disadvantage attributed to the use of the prior art blast tubes is the reduced cooling of the gun barrel. Since the gun barrel is confined within the relatively small space surrounding the blast tube, heat cannot be easily removed from this area.

It is an object of the applicant's invention to overcome many of the inherent disadvantages in the prior art interior gun installations by providing a novel combination of airfoil, machine gun

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and blast deflector which eliminates the necessity of the blast tube.

It is a further object of this invention to provide a blast deflector which not only eliminates recoil but which may also be designed to produce a positive forward thrust to the aircraft.

It is also a further object of this invention to provide means for sealing the explosive gases from the working parts of the gun, whereby the deleterious effects which these gases ordinarily have on metallic surfaces will be eliminated.

It is a still further object of this invention to utilize the differences in pressure existing over the airfoil to quickly and continuously scavenge the blast gases from the wing interior, thereby preventing their accumulation and erratic secondary explosion.

It is a further object of this invention to provide an improved gun cooling means which utilizes the pressure differences on the airfoil for obtaining a blast to cool expanded air over the barrel of the gun. This blast of cool expanded air reduces the operating temperature of the gun barrel thereby minimizing key holing and dispersion of bullets found in the prior art installations, increasing the life of the gun barrel and permitting, as well, an increase in the rate and burst of fire.

It is also a further object of this invention to locate the inlet and outlet louvers providing air cooling and gas scavenging on the lower and upper wing surfaces of the airfoil near its 25% cord length. Locating the louvers in this position improves the stalling characteristics of the aircraft by the addition of kinetic energy at a point where the boundary layer of the air flowing backward along the upper surface begins to separate from the said upper airfoil surface. The addition of the said kinetic energy maintains the flow of air over the upper surface of the main airfoil at greater angles of attack than the normal critical angle for installed airfoils.

While it is understood that blast deflectors similar to those utilized by the applicant are old per se, it has not been proposed heretofore, so far as the inventor is aware, to utilize a blast deflector in an interior machine gun installation.

In order that the invention may be fully understood and readily reduced to practice, there is illustrated in the drawings accompanying this specification modifications of preferred constructions. It is understood, however, that these illustrated modifications are not to be construed as restricting the invention to that as shown.

With the foregoing and other objects in view,

the invention consists in the construction, combination and arrangement of parts hereinafter rescribed and illustrated in the drawings, in which:

Fig. 1 is a schematic view showing a wing section having a machine gun and blast deflector mounted entirely within said wing.

Fig. 2 is a curve of the pressure distribution on the upper and lower surfaces of the wing shown in Fig. 1.

Fig. 3 is a plan view of Fig. 1, showing the size and location of the louvers on the upper surface of the airfoil.

Fig. 4 is a schematic view of a modification of the arrangement shown in Fig. 1, wherein the blast deflector is not contained within the wing structure.

Fig. 5 is an elevational view showing in cross-section the structural details of the blast detector illustrated in Fig. 4; and

Fig. 6 is an end view of Fig. 5.

Referring now to the drawings, and particularly to Fig. 1, which shows an installation wherein a machine gun 11 is mounted wholly within the wing 10 of an airplane. The wing 10 is divided by means of gas-tight partition members 12, 13 and 14 into four compartments, each of which are indicated by reference numerals 15, 16, 17 and 18. The forward compartment 15 is hereinafter referred to as the blast compartment. The gun 11 is mounted in such a manner that the muzzle 21 and the blast deflector 20 connected to the muzzle are contained wholly within the blast compartment 15. The blast deflector 20 is similar in construction to the blast deflector shown in an enlarged view in Fig. 5, except for the omission of the tube 39 which surrounds the deflector and serves the function of a flame shield and nozzle for confining and directing the outwardly and rearwardly expansion of the blast gases. The tube 39 is dispensed with in the installation shown in Fig. 1, since the blast compartment 15 serves a function similar to that of the tube 39.

The blast deflector per se consists of a nose-piece 24 which is streamlined in order to reduce the air resistance of the deflector by presenting a low equivalent flat plate frontal area. A plurality of rods 22 is secured to the nose-piece 24 and to the gun attachments 23. These rods 22 serve to position a plurality of deflector plates 25 and to tie the parts of the blast deflector into an integral assembly. The major function performed by the blast deflector 20 is to control the direction and expansion of the high speed blast gases which are emitted from the muzzle of the gun. The blast deflector 20 also acts as a flame extinguisher since by expanding the gases adiabatically from the region of high pressure adjacent the muzzle to a region of low pressure within the airfoil, a drop in the temperature of the blast gases is obtained. The deflector 20 reduces the recoil of the gun since the ring attachment 23 is secured to the cooling tube 19 of the gun and the reaction of the rearwardly deflected gases produces a forward thrust which counterbalances the thrust of the reaction of these blast gases acting upon the bullet. Furthermore, by proper design the deflector may be capable of changing the rearward thrust or recoil into a positive forward thrust which may be advantageously utilized to increase the speed of the aircraft during firing of the gun.

In the case of the prior art machine gun wing

installations the blast gases emitted by the gun act similarly to a rocket jet, and since the reaction is in the direction opposite to that of the aircraft the speed is appreciably reduced. This is especially noticeable in those instances wherein a multi-machine gun installation is used. The utilization of the blast deflector 20 causes the blast gases emitted from the muzzle to change their direction when they are expanded outwardly against the deflector plates 25. This change in direction indicated by the arrows of Fig. 5 produces a positive forward thrust on the deflector plates 25 which is utilized to increase the forward speed of the aircraft. In this manner the objectionable features of losing air speed when the machine guns are being fired in the same direction as the aircraft's flight, is to a large extent eliminated. The blast deflector 20 also serves the function of reducing the noise because the gases are expanded gradually after leaving the muzzle.

Deflector plates 25 act upon the gases in a manner similar to the blades of a reaction turbine; that is, they cause an expansion of the gases within the plates and act to change the direction of these expanding gases. The amount of gas deflected by each plate is dependent upon the size of the opening 26 formed therein, the plate curvature and other design requirements. For example, the deflector may be designed as nozzles with convergent and divergent exits. The blast gases move at a higher speed than the bullet and are deflected outwardly along the deflector plates 25, since the bullet acts as a momentary plug as it passes through each succeeding deflector plate opening 26. Furthermore, the region surrounding the outer periphery of the deflecting plates is at a lower pressure than the region within the deflector; consequently, this difference in pressure causes the blast gases to move outwardly and to expand.

In order to prevent the explosive gases from collecting in the wing interior the partitioning member 12 is made gas-tight and a plurality of inlet and outlet openings 31 and 32 is provided in the lower and upper surfaces, respectively, of the airfoil. Fig. 2 shows a typical airfoil pressure distribution curve for the upper and lower wing surfaces, as well as the relative position of the blast compartment and the cooling compartment with respect to said curve. It is apparent from considering these pressure distribution curves that the air intake and exit openings can be so located that substantially any desirable pressure differential may be realized. This pressure differential which exists on upper and lower wing surfaces is utilized to force air into the lower opening 31 and discharge this air through the opening 32 into a region of the upper wing surfaces. This blast of air removes or scavenges all of the explosive gases out of the blast compartment 15.

In order to keep the drag to a minimum, the partitioning member 12 is faired to offer the least resistance to air flow passing through the blast chamber. Furthermore, drag is further reduced, as is apparent from a consideration of Fig. 3, by cutting the inlet and outlet openings so that they have their longest dimensions parallel to the air flow over the wing surface. The size, number and position of these openings is dependent upon the speed at which blast scavenging is to be accomplished. Stiffening channels 36 are provided, as is apparent from Fig. 3, to prevent distortion of the walls of the blast chamber as a

result of high pressures produced therein by the gun blasts.

The chamber included between the partitions 12 and 13, hereinafter referred to as the gun cooling chamber 16, accommodates a cooling tube 19 which surrounds the barrel of the gun throughout this portion of the wing structure. The function of this tube in addition to providing a large heat exchange surface, is to prevent "barrel whip" by providing additional support at the muzzle 21. To permit a blast of cooling air to be circulated throughout chamber 16, inlet and outlet openings 33 and 34 are provided in the lower and upper surfaces of the airfoil. Each of the partitions 12 and 13 is provided with flexible seals 30 which allow for vibration and initial gun alignment during installation.

It is the usual practice to heat the gun receiver either electrically or by means of a shroud exhaust heating system and in order to provide a low pressure point for maintenance of the hot air circulation in the event the shroud exhaust heating system is used, an outlet opening 35 is formed within a region of low pressure in the upper wing surface.

It is apparent from Fig. 2 that if the louvers 31 to 34 inclusive are located in the region between the zero per cent and twenty-five per cent cord length, it is possible to obtain pressure differential of approximately  $2Q$  to  $3Q$  wherein  $Q$  is the dynamic or impact pressure and is equal to

$$\frac{\rho V^2}{2}$$

$V$  being the true air speed and  $\rho$  the density of air in mass per unit volume. This pressure difference, with reasonable size intake and exit louvers, is more than sufficient to supply the requisite volume of air to accomplish gun barrel cooling and blast gas scavenging. The method of cooling herein illustrated affords a further advantage in that the air in passing through the wing expands because of the pressure difference at the inlet and outlet and imparts an additional velocity to the air. This drop in air pressure or expansion of air also aids in cooling the chamber 16, since it is accompanied by a corresponding drop in air temperature. In an actual test the air temperature within the blast compartment and the air cooling compartment was 5° centigrade lower than the temperature outside said wing.

The energy represented by the heat given off by the gun barrel and the blast gases is not entirely lost in the organization presented herein, since some of the energy is regained as kinetic energy imparted to the air flowing through the scavenging and cooling chambers. The effect of this addition of kinetic energy upon the aircraft is to propel the aircraft forward by means of jet propulsion of the discharged air and gases. The blast deflector, by directing the gases to the rear, also produces a resultant forward thrust which, in the case of a multi-gun installation, serves to materially increase the speed of the aircraft. Furthermore, elimination of recoil due to blast gases permits a reduction in the size of the supporting structure of the gun mounts as well as a reduction in weight.

If the louvers 31 to 34 inclusive are located near the twenty-five per cent cord length, the stalling characteristics of the aircraft will be improved by the addition of kinetic energy at the point where the boundary layers begin to separate on the wing surface. Although it is realized that a reduction in lift would result from the use

of such a system of louvers, it is believed that the improvement in the flight characteristics when the guns are being fired would more than offset this loss.

It is realized that there are installations where all of the conditions described above do not exist, and the modification illustrated in Fig. 4 eliminates the necessity of the blast or scavenging chamber, since in this modification the blast deflector illustrated in Fig. 5 is mounted on the barrel jacket 29 of the gun 11 which projects outwardly from the leading edge of the wing. This barrel jacket 29 prevents "barrel whip" by providing additional support at the muzzle 21. A faired partitioning member 41 seals the breech mechanism from the cooling air which is circulated through a cooling chamber 42 by means of the intake and outlet louvers 43 and 44, located respectively on the bottom and top of the wing surface. The flexible seals 45 and 46 permit alignment of the gun and prevent the blast gases from entering the interior of the wing structure, and also prevent the high pressure cooling air entering the cooling compartment from passing freely into the wing compartment 47 to build up an inflating pressure therein.

A cylinder or tube 39 surrounds the deflector and is secured to the nose-piece 24 and the muzzle attaching ring 23 by means of a plurality of radial ribs 48, as shown in Fig. 5. The cylinder or tube 39 is especially valuable in this type of installation shown in Fig. 4, because the blast gases are prevented from expanding outwardly and causing disturbances in the air at the leading edge of the wing.

It is thus apparent that a new and improved gun installation has been provided wherein the blast gases are quickly and continuously scavenged out of the wing, thereby preventing gases from accumulating and erratically exploding within the wing structure. Since the muzzle of the gun is confined inside of the wing, no flame bursts are visible externally nor is there a drop in the aircraft's speed because the functioning of the blast deflector prevents it. A blast deflector designed in accordance with the teachings set forth herein when mounted on a .50 calibre machine gun so efficiently deflected all the gases to the rear that no flame burst or blast gases were visible 8 inches from the muzzle of the gun. It should be understood that the foregoing description does not attempt to include methods employed in mounting the gun, nor does it attempt to cover such details as the design of the blast chamber and deflector. These must of necessity be designed to suit the particular installations. Likewise, the utilization of the louvers cut in the upper and lower wing surfaces is not to be construed as limited to the position shown, and it is evident that the principles covered by this patent application may be used for purposes other than those disclosed.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having now fully described my invention, what I claim is:

1. The combination in an aircraft of an airfoil, a gun mounted within said airfoil, means for rigidly securing said gun to said airfoil, blast deflecting means for minimizing the recoil of said gun and producing a forward thrust to said securing means, a cooling tube surrounding a portion of

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said gun, sealed partition means forming separate compartments for said cooling tube and blast deflecting means, and means defining a plurality of relatively narrow entrance and outlet openings in said sealed compartments, said inlet and outlet openings being located respectively on said airfoil surface in positions of positive and negative pressure and within an area included between the zero per cent and twenty-five per cent chord length of said airfoil.

2. The combination in an aircraft of an airfoil having sealed partition means forming gas-tight blast and cooling compartments therein, a gun having a barrel with air cooling means secured thereto, means for utilizing the energy of the gas issuing from the muzzle of said barrel to minimize the recoil of said gun, means rigidly mounting said gun wholly within said airfoil so that said air cooling means is confined within said cooling compartment and said recoil minimizing means is confined within said blast compartment, means utilizing the pressure differential existing

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on said airfoil for obtaining a blast of cooling air through said cooling compartment, and means utilizing the pressure differential acting on said airfoil for scavenging said explosive gases out of said blast compartment.

3. The combination in an aircraft of an airfoil, a gun disposed within said airfoil, means for rigidly securing said gun to said airfoil, blast deflecting means for minimizing the recoil of said gun and producing a forward thrust to said securing means, partition means between the top and bottom of said airfoil providing separate compartments for said blast deflecting means and the breech mechanism of said gun, an aperture in the leading edge of said airfoil just large enough to pass the missiles discharged by the gun, and inlet and outlet ports in the bottom and top respectively to said airfoil back of the leading edge for scavenging the gases from said blast compartment.

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