

Aug. 28, 1962

D. B. FINKELSTEIN

3,051,085

PYROTECHNIC FLARE

Filed Nov. 24, 1958

3 Sheets-Sheet 1

Fig. 1

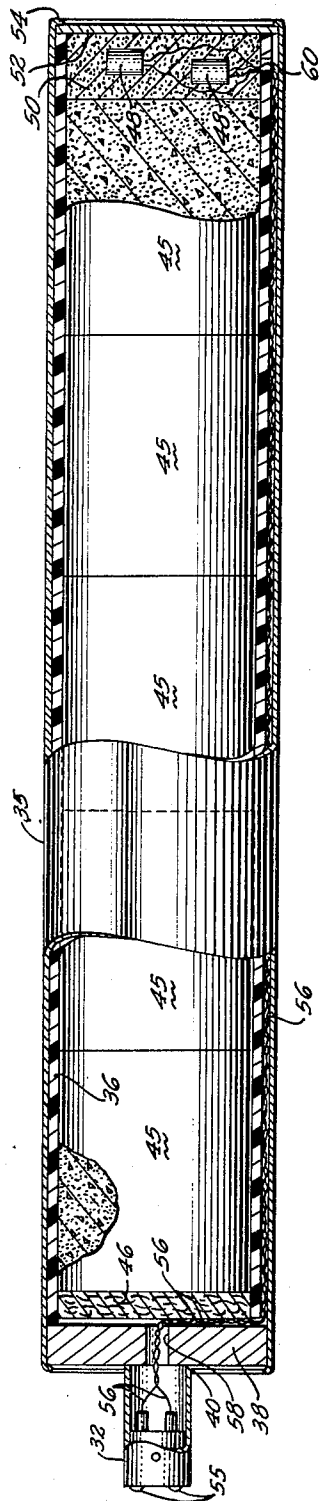
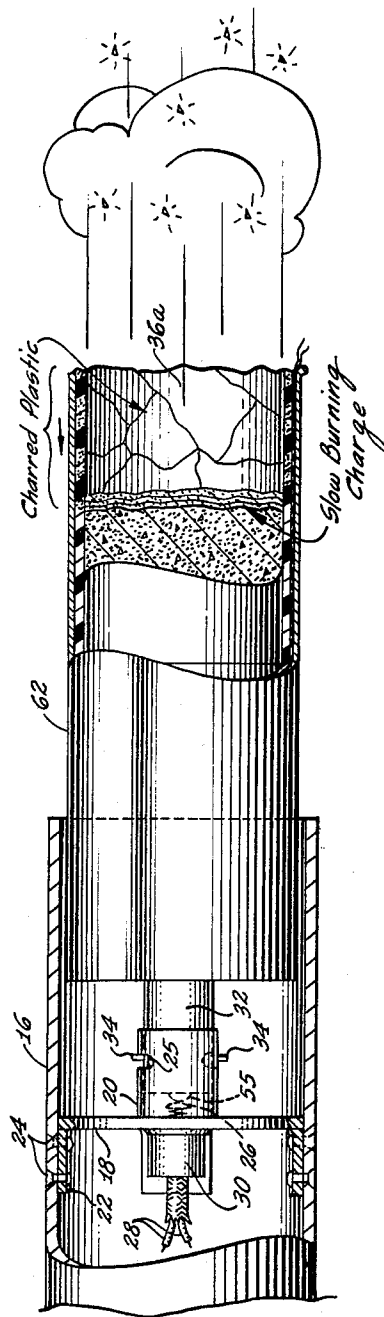


Fig. 2



INVENTOR:
Don B. Finkelstein

By *Amth & Loston*
Attorneys

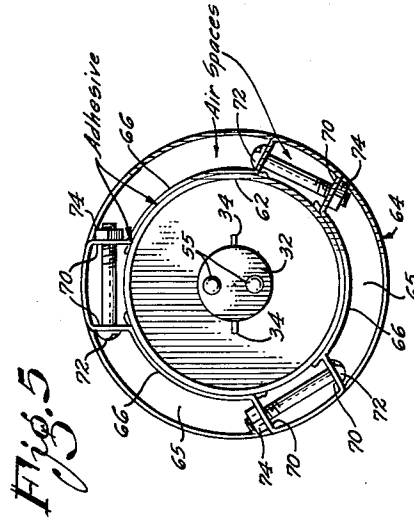
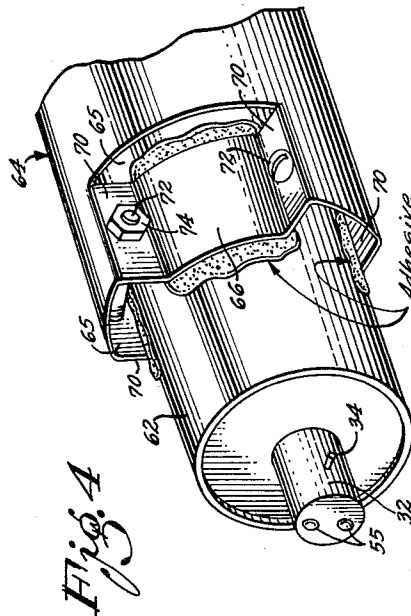
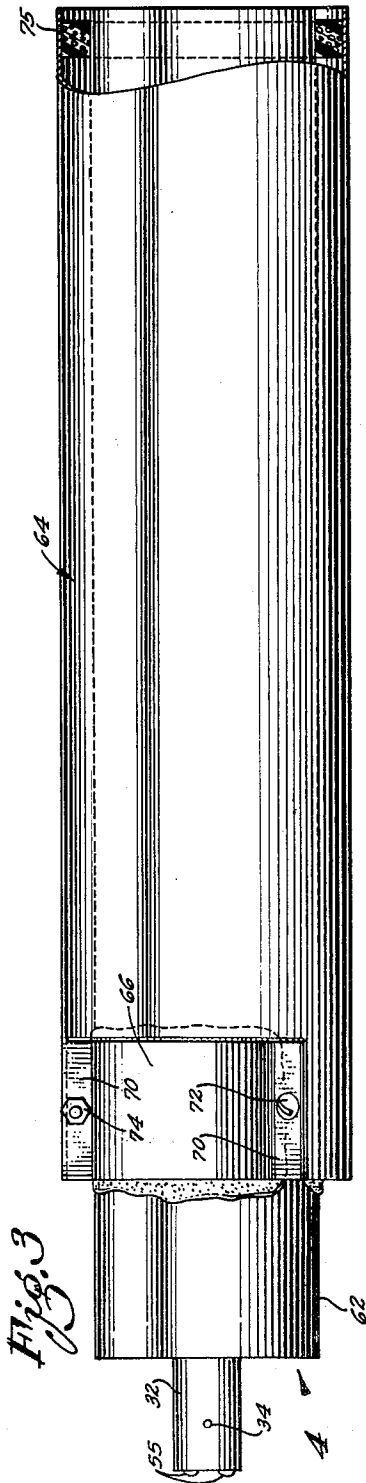
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INVENTOR:
Don B. Finkelstein

By *Amth & Roston*
Attorneys

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Fig. 6

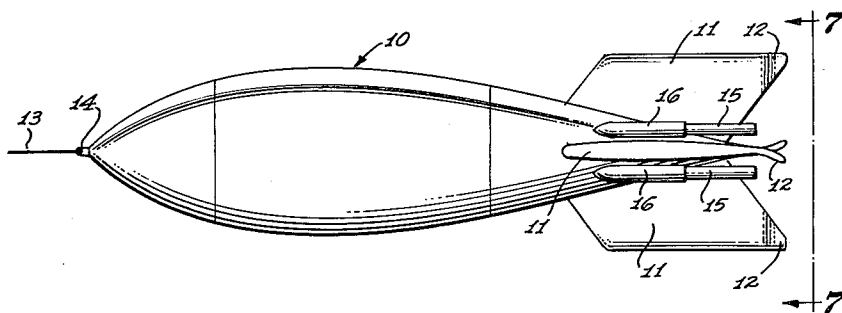


Fig. 7

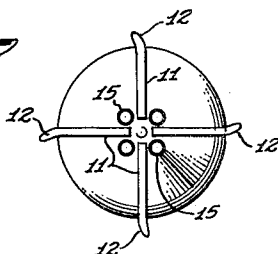
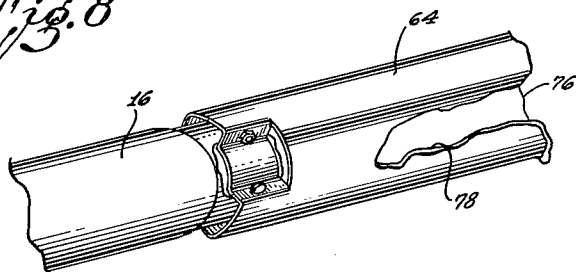


Fig. 8



INVENTOR:
Don B. Finkelstein

By *Amth & Roston*
Attorneys

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PYROTECHNIC FLARE

Don B. Finkelstein, Redondo Beach, Calif., assignor to
Del Mar Engineering Laboratories, Los Angeles, Calif.,
a corporation of California

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4 Claims. (Cl. 102—37.8)

This invention relates to pyrotechnic flares for airborne installations to produce visual energy or infra red energy for observation, tracking and for high energy heat source simulation purposes. While the invention may be adapted for use on various types of airborne vehicles for various specific purposes, it has been initially embodied in a flare construction to meet the special requirements for use on a tow target. Such an embodiment of the invention is selected for the purpose of the present disclosure and will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles for other specific purposes.

A flare of the type to which the invention is directed consists of an elongated charge of suitable highly combustible material in an elongated metal casing. When the flare is in operation, the charge burns progressively from one end to the other with a traveling combustion zone, and the resulting flame is discharged from the end of the metal casing.

One problem is to cause the charge to burn in the desired progressive manner of a cigarette without ignition occurring in advance of the desired traveling combustion zone. To meet this problem, the charge must be packed snugly in the surrounding metal casing to prevent combustion from creeping along the periphery of the charge, and steps must be taken to prevent such excessive heat transfer to and along the metal casing as would cause ignition of peripheral portions of the charge in advance of the desired traveling combustion zone.

The invention meets this problem by employing a plastic liner for the metal casing and by employing a compact charge, preferably in molded form, which fits snugly into the plastic liner. The snug fit keeps combustion from creeping along the periphery of the charge and the material of the surrounding plastic liner is of sufficiently low thermal conductivity to retard heat flow to the metal casing and thus keep the temperature of the metal casing far below the adiabatic temperature of the burning charge. In the burning of a flare exemplifying the invention, the adiabatic temperature of the burning charge is on the order of 3200°–3400° K. and the plastic liner is effective to keep the temperature of the metal casing down to a maximum of approximately 1000°–1300° F. during the combustion cycle.

A further requirement for a flare to be used for airborne installations is that the flare be of a rugged construction to withstand handling and be of a construction adapted for quick installation. The flare of the present invention is completely enclosed in metal to withstand handling and may be installed quickly on an airborne vehicle simply by being seated by one end in a mounting socket or receptacle on the airborne vehicle.

One feature of the invention is the concept of closing the outer end of the metal casing by suitable closure means and the utilization of an explosive at the outer end of the flare for the dual purpose of blowing out the closure and of igniting the combustion charge. A further feature is the enclosure in the metal casing of the wiring required for electrical ignition of the flare. The wiring is interposed between the plastic liner and the surrounding casing and is connected to exposed contacts at the inner or base end of the casing which complete the firing circuit by cooperation with complementary contacts in the socket or receptacle in which the flare is

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mounted. Heretofore it has been common to extend a metal tube axially through the combustion charge to carry the ignition wiring. The new arrangement makes such an axial tube unnecessary and thereby not only simplifies the procedure of filling the casing with the charge but also increases the area of the combustion zone.

When a flare of the present type is to be used on a fragile tow target, the problem arises of protecting the tow target against heat damage by the flare. One answer to this problem is the use of a rugged steel casing for the flare to withstand the temperature of the flare flame and to confine the flame sufficiently to keep the flame from spreading laterally to damage the tow target in which the flare is mounted. One disadvantage of using a steel casing sufficiently rugged for this purpose is the weight imposed on the tow target. It is contemplated that four flares will be employed, and four flares of steel construction have a combined weight of ten pounds, five pounds being dead weight. Weight is an exceedingly important consideration in the use of tow targets, and while a flare load of ten pounds may be carried, there are many instances in which it would be highly desirable to reduce the weight, if only by one pound.

If a thin aluminum metal casing is substituted for the steel casing, the thin aluminum burns away as fast as the combustion charge and causes damage to the tow target by failure to confine the flare flame and by the splatter of hot metal against the tow target body. The present invention has two provisions which make it possible to employ an aluminum casing for the flare.

One provision is the use of a material for the plastic liner which chars instead of completely disintegrating under the action of the heat of the burning charge. A charred portion of the plastic liner survives long enough to enclose the traveling combustion zone and is of sufficiently low thermal conductivity to delay the melting of the aluminum casing. The traveling melting zone of the aluminum casing lags sufficiently behind the traveling combustion zone to cause the aluminum casing to confine the flare flame with substantial effectiveness.

The second provision is a thin sheet metal shield surrounding the aluminum casing in radially spaced relation thereto. This outer shield acts as a boundary layer splitter and changes the turbulent boundary layer upstream from the flare assembly into a laminar airstream between the shield and the flare.

It has been found that such a shield may be made of aluminum and may be quite thin if it is to serve merely to create the air cooling action and to shield the tow target body from excessive heat radiation. The aluminum shield must be substantially thicker, however, if it is to perform the additional function of withstanding the hot particles, including hot metal splatter, that are thrown off when the enclosed flare casing is made of thin aluminum. In this regard, a feature of the invention is the concept of rotating the tow target on its longitudinal axis with the consequent creation of sufficient centrifugal force to cause the hot particles, including hot metal splatter, to be thrown outward away from the tow target body. With the tow target body rotating in this manner, the shield need be only as thick as necessary to carry out the air-cooling function and to protect the tow target body from heat radiation. The shield may be made of aluminum so thin that it disintegrates under the action of the metal splatter, but because of the centrifugal action, the only portion of the shield that disintegrates prematurely is the portion that is positioned radially outward from the tow target body. Such a thin air-cooled shield may reach a temperature of only 250° F. on the side of the shield towards the adjacent tow target body.

The various features and advantages of the invention

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may be understood by reference to the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a view partly in longitudinal section and partly in side elevation showing an embodiment of the invention that employs a steel casing capable of withstanding the heat generated by the flare.

FIG. 2 is a similar view of a second embodiment of the invention which employs a thin aluminum casing that melts under the heat generated by the burning charge. This figure further illustrates the manner in which a flare may be mounted in a socket or receptacle on a tow target;

FIG. 3 is a side elevation with portions broken away showing the construction of a flare which incorporates a light sheet metal shield surrounding the flare casing;

FIG. 4 is a perspective view of the base end of the flare shown in FIG. 3;

FIG. 5 is an elevation of the same end of the flare;

FIG. 6 is a side elevation of a typical tow target carrying four of the flares of the invention;

FIG. 7 is an elevation of the trailing end of the tow target as viewed along the line 7—7 of FIG. 6; and

FIG. 8 is a fragmentary perspective view of the shielded flare of FIGS. 3, 4 and 5 after the combustion charge is completely consumed, this view showing how the laterally outward portion of the thin shield disintegrates under the action of the hot particles that are thrown centrifugally outward by rotation of the tow target body.

The embodiment of the flare shown in FIGS. 1 to 5 is intended to be mounted on a tow target of a well-known construction shown in FIGS. 6 and 7. The tow target in FIG. 6 has a light-weight bulbous streamlined aerodynamic body of revolution, generally designated 10, and is provided with four stabilizing tail fins 11 which are angled or bent as indicated at 12 to serve as aerodynamic means to cause the tow target body to rotate on its longitudinal axis in reaction to the air stream. The tow target is connected to a suitable tow line 13 by means of a swivel fitting 14 which permits the tow target to rotate without twisting the tow line. The tow target shown in FIGS. 6 and 7 has four pyrotechnic flares 15 which are mounted in corresponding receptacles 16, the receptacles being faired into the streamlined tow target body.

It is to be understood, of course, that a flare of the present invention may be mounted on an airborne vehicle in any suitable manner. In this instance, however, it is contemplated that the flares will be mounted on the tow target by bayonet-type connections. For this purpose, each of the receptacles 16 is of cylindrical configuration and, as shown in FIG. 2, has an inner transverse partition 18 on one side of which is mounted a bayonet socket fitting 20. The partition 18 may comprise a metal disk formed with a circumferential flange 22, which flange is secured to the surrounding wall of the receptacle by suitable rivets 24. The socket fitting 20 has the usual pair of diametrically opposite bayonet slots 25 and at its inner end is provided with a pair of spring-equipped contacts 26. The contacts 26 are connected to a pair of corresponding wires 28 which extend rearward from an electrical fitting 30 on the opposite side of the partition 18. The wires 28 are part of a firing circuit on the tow target which may be controlled by suitable means, such as means for remote control by radio signals.

The base ends of the different embodiments of the flares of the present invention telescope into the receptacle 16 in the manner shown in FIG. 2 and these base ends are provided with cylindrical bayonet connectors 32 for cooperation with the bayonet socket fittings 20. The bayonet connectors 32 are provided with the usual diametrically opposite lugs 34 for engagement with the bayonet slots 25.

The first form of the flare shown in FIG. 1 has a steel cylindrical casing 35 protected by a liner in the form of an inner plastic shell 36. The plastic liner 36 may be made of any suitable material, such as a polytetrafluoro-

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ethylene or a phenolic resin either of which chars instead of completely disintegrating under the action of a high temperature flame. A polytetrafluoroethylene resin for this purpose is available under the trademark "Teflon."

The base end of the steel casing 35 may be closed by a heavy metal disk or base member 38 to which the casing is rigidly united and to which the bayonet connector 32 is in turn firmly united as by welding 40.

It is contemplated that a charge of suitable combustion material will be compacted in snug fit with the plastic liner 36. For this purpose, the combustion charge may comprise a series of molded cylindrical pellets 45 which are dimensioned for close fit with the surrounding plastic shell 36 and which back against a heavy cardboard spacer 46 at the base end of the casing. At the outer end of the flare, a pair of electrical ignition devices in the form of squibs 48 of a well-known type are imbedded in a small body of explosive 50. This body of explosive is confined between a metal closure disk 52 and the combustion charge comprising the series of pellets 45. The closure disk 52 may be secured in place by crimping of the rim of the steel casing 35, as indicated at 54. Two electrical squibs 48 are provided for increased reliability and when the body of explosive 50 is detonated by one or both of the squibs, it blows the closure disk 52 free from the steel casing 35 and, at the same time, ignites the end face of the adjacent combustion pellet 45.

As heretofore stated, a feature of the invention is the manner in which the flare is internally wired. In the construction shown, a pair of contacts 55 carried by the bayonet connector 32 for cooperation with the previously mentioned receptacle contacts 26 are connected to the two squibs 48 in parallel by a pair of wires 56. The wires 56 pass through a central aperture 58 in the metal base disk 38 and extend radially outward between the base disk and the cardboard spacer 46. The two wires 56 extend longitudinally of the flare between the plastic liner 36 and the surrounding steel casing 35 and pass through an aperture 60 in the plastic liner for connection to the two squibs 48.

The manner in which this first form of the invention serves its purpose may be readily understood from the foregoing description. It is apparent that with the combustion charge of the flare completely encased in steel, the flare will stand rough handling and may be relied upon to be in good working order when installed on a tow target. The installation of a flare requires the simple manipulation of inserting the flare into the corresponding tow target receptacle 16 and then rotating the flare to complete the bayonet engagement between the bayonet connector 32 and the bayonet socket fitting 20. Rotation of the flare to complete the bayonet connection places the two electrical contacts 55 of the flare against corresponding spring-equipped contacts 26 of the receptacle, thereby completing the firing circuit for the squibs 48.

When the squibs 48 are energized to detonate the explosive body 50 at the outer end of the flare for removal of the closure disk 52, the outer end of the elongated explosive charge comprising the series of pellets 45 is ignited and the charge burns progressively with a combustion zone traveling towards the base end of the flare. The snug fit of the explosive charge in the surrounding plastic liner 36 prevents migration of combustion in advance of the desired traveling combustion zone and the plastic liner retards the rate of heat transfer from the combustion zone to the steel casing 35 to keep the casing from reaching a temperature that would cause ignition of the combustion charge ahead of the advancing combustion zone. As the elongated combustion charge is consumed, the resulting flare is confined by the steel casing 35, the steel casing keeping the flare from damaging the tow target body.

Any suitable pyrotechnic material may be employed for the combustion charge. For example, if the purpose of the flare is to produce light in the visible spectrum, the

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combustion material may comprise a mixture of magnesium and sodium nitrate. Some other material is required to produce radiation that is primarily in the infra red spectrum. For example, the combustion material may comprise magnesium mixed with a grease of the type sold under the trademark "Kel-F."

The second form of the invention shown in FIG. 2 is largely identical to the first form as indicated by the use of corresponding numerals to designate corresponding parts. This construction differs from the first described construction solely in the substitution of an aluminum casing 62 for the previously described steel casing 35. The aluminum casing 62 may be of the same wall thickness as the steel casing 35, for example approximately one-sixteenth of an inch thick. The melting point of aluminum is so much lower than the melting point of steel that the casing 62 melts in response to the heat generated by the burning charge. The aluminum melts readily under the intense heat and in the absence of some retarding expedient, a traveling melting zone of the casing would coincide with the traveling combustion zone of the burning charge.

An important feature of this embodiment of this invention, however, is that the plastic liner 36 chars and maintains its cylindrical configuration in the presence of the heat of the traveling combustion zone. The charred portion of the liner survives long enough to surround the combustion zone and thus protect the surrounding aluminum casing 62 sufficiently to cause the traveling melting zone of the casing to lag substantially behind the traveling combustion zone. By virtue of this action, a substantial portion of the aluminum casing 62 lined by the charred portion of the liner 36 survives to confine the flare flame and direct the flare flame axially out of direct contact with the adjacent body of the tow target. FIG. 2 shows the charred portion 36a of the plastic liner that surrounds the combustion zone and delays the melting of the aluminum casing.

For some purposes, a flare constructed as shown in FIG. 2 may be used without a surrounding shield. For use on a tow target, however, in relatively close proximity to the tow target body, the shielded construction shown in FIGS. 3, 4 and 5 is desirable.

The flare shown in FIGS. 3, 4 and 5 is identical with the flares shown in FIG. 2 except for the addition of a thin aluminum shield 64. The aluminum shield 64 is of cylindrical configuration and surrounds the aluminum casing 62 of the flare in spaced relation thereto to form an annular passage 65 for the flow of cooling air around the flare casing.

The thin aluminum shield 64 may be mounted on a flare casing in any suitable manner. In the construction shown, the base end of the flare is lanced to form a circumferential series of three straps 66, which straps are offset for supporting engagement with the aluminum casing 62. Thus, as shown in FIGS. 4 and 5, each of the straps 66 has a central offset portion that is curved for intimate contact with the periphery of the aluminum casing 62 and is further formed with two radial portions 70 that connect the offset portion with the peripheral portion of the shield. As further shown in FIGS. 4 and 5, the aluminum shield 64 may be provided with a series of three screws 72 and corresponding nuts 74 to connect the radial portions 70 at the adjacent ends of the straps 66. It is apparent that the screws 72 may be tightened to constrict the three offset portions 68 for clamping the shield 64 onto the aluminum casing 62 in radially spaced relation thereto. Preferably the offset portions 68 are additionally bonded to the aluminum casing 62 by suitable adhesive material.

In the preferred practice of the invention, the second end of the aluminum shield 64 is supported and stabilized by a plastic spacer ring 75 interposed between the inner circumferential surface of the shield and the outer circumferential surface of the aluminum casing 62. The

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addition of the spacer ring 75 makes the cylindrical aluminum shield 64 rigid relative to the flare casing 62 and makes the aluminum shield capable of withstanding relatively rough handling. The detonation of the explosive body at the outer end of the flare by the previously described electrical squibs and the initial melting of the material of the aluminum casing 62 insures the disintegration or removal of the spacer ring 75 to clear the annular passage 65 for air flow therethrough.

The wall of the aluminum shield 64 is relatively thin but is adequate in the presence of the cooling air flow to protect the material of the tow target body from excessive radiation of heat from the flare. The wall of the aluminum shield 64 is not thick enough to withstand the heated particles and splatter metal caused by the burning of the combustion charge and the melting of the aluminum casing 62. As heretofore stated, however, the rotation of the tow target creates sufficient centrifugal force to cause the hot particles and molten metal to be thrown laterally outwardly away from the tow target body. Consequently, only the radially outward side of the shield 64 is subjected to the deteriorating effects of the burning charge and the molten metal.

It is apparent that the deterioration of this radially outward portion of the aluminum shield 64 is of no consequence since the outwardly directed hot particles and splatter metal do not reach the surface of the tow target body. It is also to be noted that a portion of the shield 64 may melt all the way around the circumference of the shield without the tow target being damaged so long as the melting zone of the shield lags substantially behind the melting zone of the aluminum casing 62 to shield the tow target body from direct radiation from the combustion zone. Any splatter metal produced in this way by the melting of the shield 64 will be thrown outward away from the tow target body by the centrifugal force that results from the spinning of the tow target on its longitudinal axis.

FIG. 8 shows how at the termination of the burning period, the outer end of the shield 64 may be melted away along the jagged line 76 and further shows how the metal of the shield on the side that is radially outward from the spinning tow target may be melted away to form a jagged slot 68. Thus the invention utilizes the centrifugal force generated by the rotation of the tow target on its longitudinal axis to make possible a relatively light weight flare installation. A set of four flares constructed in accord with FIGS. 3, 4 and 5 reduces the total weight to seven pounds as compared to ten pounds for four steel-encased flares, and reduces the dead weight from five pounds to one pound. The burning of the flares further reduces the tow target load by the disintegration of the aluminum casings 62 and the disintegration to a lesser extent of the shields 64. This reduction in weight is especially important because it lessens the difficulty of recovering the tow target at the end of the target run.

My description of the selected embodiments of the invention in specific detail will suggest various changes, substitutions and departures from my disclosure within the scope and spirit of the appended claims.

I claim:

1. A flare for use in a tow target to facilitate tracking thereof, comprising: an elongate hollow metal casing; an inner plastic shell lining said casing; a compacted charge of highly combustible material enclosed by said inner shell; means within said casing at one end thereof for igniting the contiguous end of said charge to create a traveling combustion zone for progressively igniting said charge longitudinally of the casing with consequent projection of a flame longitudinally from said casing, said charge fitting said inner plastic shell snugly and the plastic material of the inner shell having a low thermal conductivity to retard ignition of the peripheral portions of the charge in advance of the traveling combustion zone, said casing being a thin-walled shell of metal having

a relatively low melting point to be melted by said flame with the melting zone traveling progressively longitudinally of the casing, the plastic material of said inner shell charring as the shell is subjected to the flame whereby a charred portion of the inner shell survives the heat of the combustion zone to cause the melting zone to lag behind said combustion zone for continuous confinement of the combustion zone by the casing.

2. A flare as set forth in claim 1 which includes a thin-walled shield to protect the tow target from said flame, said shield being supported with an annular clearance space between the casing and the shield, said shield being open at both ends and defining with the casing a flow path for air as the target is towed to thereby cool the casing during the towed flight of the target.

3. A flare to be mounted on a tow target to facilitate tracking thereof, which target includes a socket having contact means therein electrically connected into an energizing circuit of the target, comprising: an elongate casing; a charge of highly combustible material carried by said casing; electro-responsive means within said casing at one end thereof for igniting the contiguous end of said charge to create an initial combustion zone for progressively igniting said charge longitudinally of the casing with consequent projecting of a flame longitudinally from the said one end of the casing; means carried by the opposite end of the casing for cooperative receptive engagement with the socket for mounting the flare to the target; contact means externally carried by said last-named end of the casing for engagement with the contact means of said socket when said last-named end of the casing is mounted in the socket; and conductor means electrically connected to the contact means carried by said casing and extending internally of said casing and electrically connected to said electro-responsive means, whereby energization of the firing circuit of the target electrically ignites the combustible material contiguous of said electro-responsive means, thereby to create the traveling combustion zone and the consequent projection of the flame longitudinally from the casing.

4. A flare for use in an airborne vehicle to facilitate tracking thereof, comprising: an elongated metal casing; an inner plastic shell lining said casing; a compacted charge of highly combustible material enclosed by said

inner shell; means to ignite one end of said charge at one end of said casing for burning of the charge to create a combustion zone with the combustion zone traveling progressively longitudinally of the charge with consequent projection of a flame longitudinally from said casing, said charge fitting said inner plastic shell snugly and the plastic material of the inner shell being of low thermal conductivity to prevent ignition of the peripheral portions of the charge in advance of the traveling combustion zone, said casing being a thin-walled shell of metal having a relatively low melting point to be melted by said flame with the melting zone traveling progressively longitudinally of the casing, said inner shell being made of a plastic material that chars in contact with a high temperature flame whereby a charred portion of the inner shell survives the heat of the combustion zone to cause said melting zone to lag behind said combustion zone for continuous confinement of the combustion zone by the casing; a thin-walled shield to protect the airborne vehicle from said flame; said shield being supported with an annular clearance space between the casing and the shield, said shield being open at both ends to flow therethrough of the slipstream of the aerial vehicle to be cooled thereby, said shield being a sheet metal cylinder, portions of said cylinder being lanced and offset radially inward for supporting engagement with the periphery of said casing, paired opposed portions of said offset portions being interconnected by screw means to tighten the grip of the shield on the casing.

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