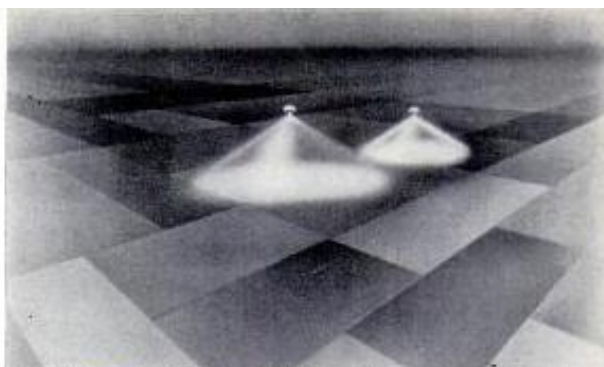


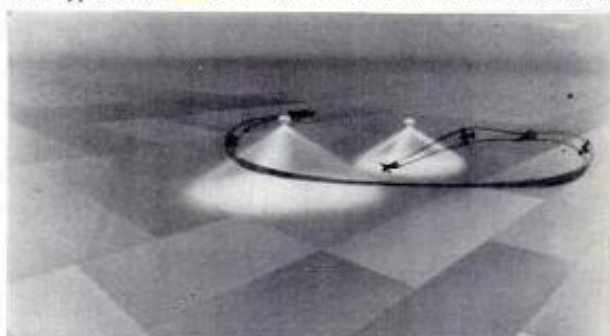
Phase II flare fired at 2,000 ft. indicates its drift. Note decreasing area and increasing intensity of cone of illumination as flare descends.

Below: Flight pattern overlay on Phase II flare. Field selection is done best below flare level but plane must stay within cone of illumination.



Phase III flare fired at 1,200 ft. Note drift and extremely small area of cone of illumination, especially at lower altitude in final stage.

Below: Phase III, approach and landing. Plane is making 360° overhead approach as flare drifts downwind. A 180° could also be used.



WHEN YOUR ENGINE QUILTS

The findings of the parachute flare project at the University of Illinois.

IT'S DARK OUTSIDE. You're on a night flight en route from a business meeting to your home field. Your light airplane is adequately equipped with instruments and radio gear. A glance at the panel shows all needles in position. This is strictly a routine night flight. You've got it made.

Everything is so rosy that you don't notice the slight offbeat of the engine . . . not for a while at least. There! Now you hear it! Your pulse quickens slightly. You turn up the red cockpit lights. There it is again! The tach indicates a definite fluctuation in rpm. Check the carburetor heat; a slight drop in rpm with no following build indicates no ice. The fuel gauges show plenty of gas, and the tank selector valve's okay. The tach still dances slightly and the engine is beginning to sound strangely unfamiliar—no longer a friend. Your insides are beginning to churn now. How about a lighted field? A glance at the map shows the closest one back at Terre Haute, over 20 miles away. This may be serious! Better park

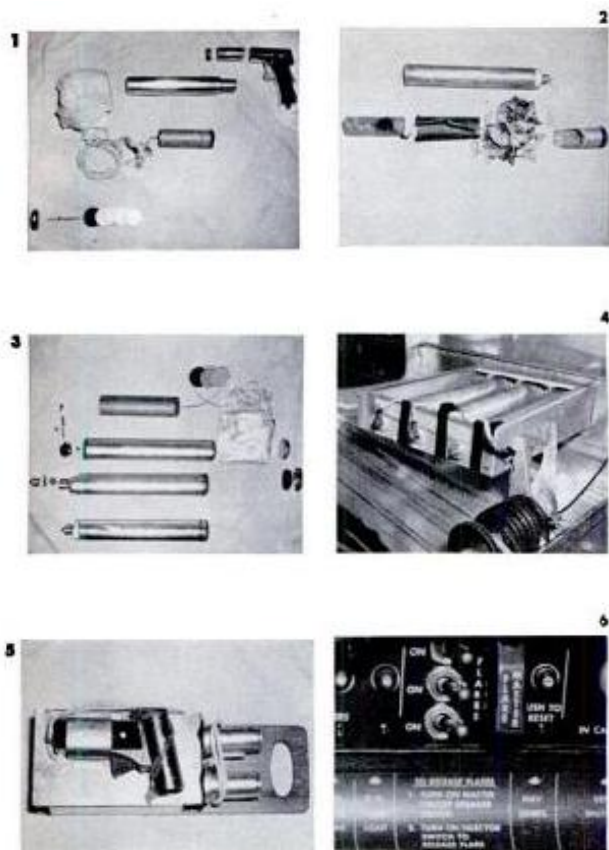
This is it! Let's get on the ground before it quits altogether. . . . Too late, she's gone!

Panic seizes you. . . . Think! Think, man! If you don't do something fast, you've had it! A flare! Where's the kit? It must be in the back somewhere. . . . There it is under your coat. Grab it and get a flare over the side.

Then what? . . . They didn't tell you that. . . .!

That was a sad tale, wasn't it? And, whether you like it or not, it could happen to you. The answer for the chap in the story might well be the salvation for all of us who wish to realize maximum utility from our light airplanes. It points to the need for a definite technique in the use of flares under night forced-landing conditions. Whatever the pilot's experience level, he usually expects, and attempts, to realize maximum utility from his airplane proportionate to his own abilities. The high price tag on today's lightplane make this an absolute necessity.

If you expect a reasonable amount of transportation from your plane, you've probably made an occasional



1
Components of the Class 3, one-minute, pistol flare.

2
Deterioration of black powder expellant charge due to age (5 years) caused this flare to plummet directly to earth.

3
Components of the Class 3, one-and-one-half-minute flare.

4
Interior view of three rack-mounted one-and-one-half-minute electrical flares located aft the baggage compartment in a Bonanza.

5
Portable flare and pistol used in Cessna 140 and 170, Tri-Pacer and Stinson 150.

6
Flare switching arrangement in circuit breaker panel of a Bonanza.

a study of flare performance; and has practiced coordinating its performance with that of his airplane.

There are two types of available flares which lend themselves to the peculiar problems of the lightplane pilot. One of these is the one-minute, pistol-fired flare, and the other is the one-and-one-half-minute, electrically-fired flare. Local prices vary somewhat but the 37 mm pistol costs approximately \$42 and one-minute flares \$21 each. A complete rack of 3 one-and-one-half-minute, electrical flares, including switches, runs to \$130. These prices are not high in terms of their value to the pilot in a night forced landing situation.

The rack type flare should be mounted only by an aircraft mechanic faithfully following instructions provided by the manufacturer. Correct installation is important, and the flare tubes must not be dented or damaged in any way. The surrounding airplane structure must be capable of withstanding a momentary thrust of 150 lbs., and sometimes a "beefing" up of the supporting portion is necessary.

The pistol kit offers the advantage of lower cost as well as portability. Although it requires little stowage space, it is sometimes difficult to place it in a position where it will be readily available in time of need. If your airplane is suitable, the rack type electrical flare is definitely recommended; there is no stowage problem and firing with toggle switches is a simple operation compared to loading, aiming, firing and reloading the pistol.

Firing the pistol flare is quite an experience. Our pilots described it variously as anything from the equivalent of a 12-gauge shotgun to an elephant gun. Actually the shoulder will adequately absorb all recoil if the arm is kept straight at both the wrist and the elbow when firing. Accompanying photographs illustrate the line and method of fire used. Potential "hangfires" can be easily dropped clear using the quick release on the side of the pistol. However, we found removing a spent cartridge sometimes required two hands.

Both flares must meet certain minimum specifications laid down by the CAA in TSO-C24. We've attempted to simplify flare information, both specifications and recommendations, by tabulating this data in Table 1. Check it carefully, it contains the minimum technical information you should have regarding flares.

Table No. 2 contains our recommendations for using the two types of flares in specific airplanes. Since the flare illumination is cone-shaped, all recommended altitudes are compromises between area and intensity of ground illumination. The higher the flare is fired, the greater the area illuminated but the lower the intensity at any given point. Conversely, the lower the altitude, the greater the intensity but the smaller the area of illumination. This feature, tempered with consideration for the airplane's rate of descent, was a prime factor in selecting recommended altitudes for firing. The high altitude flare may not give the detail you would like but

AT MIDNIGHT

By JESSE W. STONECIPHER

MILLER R. GREEN, RICHARD E. MANKUS

engine failure and the attendant forced landing in the dark. Admittedly this is a big decision to make and it will be tempered by the pilot's confidence in his machine as well as in his own navigational ability. There would be no problem if the pilot could select a field and land as safely at night as he can during daylight—not a very profound statement, but still quite true. Most pilots know that a solution to this problem is available. The parachute-supported illuminating flare will provide the source of light necessary for the short period involved in executing a forced landing. Only the technique for the proper use of such flares is lacking.

It was to develop this technique that a number of pilots who do extensive night cross-country flying at the University of Illinois undertook a formal study of the parachute flare. The study was made with the cooperation of the International Flare-Signal Division, Kilgore, Inc. of Westerville, Ohio. They provided 40 parachute flares and gave us carte blanche for development of a standard set of procedures tailor-made for light airplanes. The conclusions reached indicate flares can be used to a distinct advantage in this situation, provided the pilot has made

Below: Line of fire from Tri-Pacer with modified window open. Note the straight wrist, elbow, and left-handed fire of the pilot.



Above: Detail of window hinge pin modification in Tri-Pacer. The window can be operated normally when this pin is in place. Left: Hinge pin removed, allowing window to open completely. This modification could be used in other types of planes.

Right: Line of fire from Cessna 140 with no window modification. Note straight wrist and elbow. Left-hand fire lets shoulder absorb recoil.



Left: Pilot of Bonanza fired this flare at 1,200 ft. and was completely unaware that it had not expelled properly until he had landed. Chute was in this approximate position during flight.

it will allow you to select a suitable field for a safe landing.

In selecting an altitude for firing the second flare, we found the problem reversed, because, although we had ample intensity, the area of illumination was so small that exact positioning of the flare became difficult. The uncontrollable factor here is drift after the flare is fired. It was for this reason that we standardized our pattern on the 180 or the 360-degree overhead approach. We also timed flare firing altitude-wise to allow a margin for error in judging wind drift. You must constantly keep in mind the fact that the area of illumination will move downwind and thus favor this direction with your attention, both in selecting a field and in making your approach to it.

Now let's take the unhappy chap in the opening paragraphs and give him a second chance. Let's be specific and base our flight on a C-35 Bonanza, equipped with 1½-minute electrical flares. We're on a night cross-country over relatively unfamiliar terrain cruising at 4,000 feet above ground. We've already experienced those uneasy moments during which we became conscious of a sick engine. We've made our check of gas supply, mags, carburetor heat, tank selector valves, etc., all to no avail. The engine simply refuses to run. This is it! A forced landing at night. We'll break it down into three phases in order of occurrence:

Phase I—General Area Survey and Preparation.

First, let's make a mental note that we have 2,000 feet, or slightly less than three minutes, to complete Phase I. Three minutes is plenty of time, provided we go about the task in a methodical manner. Let's roll the trim tab, slowing the airplane to normal approach speed, 95 mph.

While we're adjusting trim and, incidentally, converting excess speed into altitude, we make a careful survey of the surrounding terrain. There's no point in firing a flare at this altitude; it would just be wasted. Let's see how much we can distinguish on the ground with night vision alone.

A large cluster of lights to our right indicates a town, and that narrow ribbon of lights below tells us that's a well-used highway. Off to our left there is nothing but a black void punctuated by single lights here and there. This is open country and the chances are good that's our best bet. Is it close enough? We must reach it during Phase I. At 95 mph in three minutes we can cover approximately four and one-half miles. Yes, we can make it, so let's wheel her over to the left and head for the selected general area.

While on the way let's complete a mental check-list of all tasks we can perform now to simplify the next two phases. Ignition switch to the "Battery" position reduces possibility of fire on gear-up landing, but we can't shut her completely "off" because we'll need the electrical system later. Turn gas selector to "off". If the prop stops windmilling, let's save that \$300 blade by bringing it to a horizontal position with the starter. How's the time? Twenty-eight hundred actual, another minute. Airspeed indicates trim okay at 95 mph. Let's open the circuit breaker panel door and check individual flare switches for "off" position—wouldn't want them all to go simultaneously when we throw the "Master". They're all "off" so we turn the "Master" switch "On" and double-check to see that it stays in the "On" position when released—a defective circuit breaker in the switch would throw it back to the "Off" position.

How's our speed and altitude? Ninety-five, okay, and coming up on 2,300 feet actual. A glance outside reveals we're over our selected general area and we have enough altitude remaining to head the plane directly into the wind. Let's see, that was Southwest at take-off, wasn't it? While we're completing the (Continued on page 60)

When Your Engine Quits at Midnight

(Continued from page 26)

turn, let's get our finger on the number one individual flare switch. Now we're headed into the wind, wings level, 2,000 above ground and we've completed Phase I. Whether we're in position or not, we must proceed to Phase II.

Phase II—Specific Field Selection and Positioning.

A flip of the flare switch and "Wham" off goes flare number one. We feel a slight tremor in the airplane structure as the flare was ejected from the projector tube, and a small stream of fire indicating the projectile path is visible to the left of the airplane. A subdued "pop!" is immediately followed by the brilliant white light of the burning flare candle. There is no time to stare at the burning flare, although this is a definite temptation.

We must start an immediate left turn to stay within the flare's cone of illumination. Our best position for viewing objects on the ground is below the flare's level, but we can allow our airplane's faster rate of descent to solve this problem for us. We have approximately one minute, or 800 feet, to select our specific field for the forced landing and to maneuver to the extreme upwind end of it. You should avoid looking directly into the flare for, although it won't completely blind you, it will reduce your night adap-

tation. Major ground details are visible for a distance of approximately one mile in every direction from the flare's position. The field selection search should favor the downwind area because of flare drift. You will note that lighter ground colors stand out more prominently than dark colors and a little knowledge of seasonal field colors will pay a big dividend.

Ah! There's a good field. It's easy to spot as a field in which a crop has been grown during the summer and we're thankful there's enough light-colored stubble remaining to make it stand out in the flare illumination. This field, selected during the first 180-degree of turn, is now to the rear of our left wing and it's apparent that the completion of a 360-degree turn will put us directly over it. We must reach the extreme upwind end before reaching 1,200 feet above ground. Where's that second flare switch? Ready or not, 1,200 actual is the end of Phase II and we must proceed to Phase III.

Phase III—Approach and Landing.

Wham! and away goes flare number two. One second later, our field is lighted up like Comiskey Park for the night portion of a double-header. Our upwind position headed directly into the wind points to an elongated 360-degree overhead approach to a landing, so we start a left turn immediately upon firing the flare. During the initial stages of our 135-degree left turn we allow the airplane to dive

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(Continued from page 60)

for approximately 200 feet. This not only serves to put us immediately below the flare for best ground visibility but increases our rate of descent to allow us to touchdown before the flare extinguishes in 1½ minutes.

At 900 actual we're headed straight-away on our outbound diagonal and must now make a final decision on gear position for the landing. This important decision was reserved for the final phase where ground illumination is at a maximum. The slightest element of doubt about field suitability calls for a gear-up landing because the comparative cost of repairing belly damage sustained gear-up is normally no more than that of replacing landing gear wiped off on a rough field. Personal safety is really the prime factor. Given a rough field, the chances of walking away from a landing are immeasurably better with gear up. When

in doubt, leave that gear up. Midwestern prairie, with an ample supply of quarter and half-mile fields, offers plenty of exceptions to this rule for the lightplane pilot.

It's quite obvious, with flare illumination, that our selected field is a firm, relatively smooth, quarter-mile field and we decide to land gear-down. We'll wait for the turn from base to final for actually lowering the gear just in case we're a bit short. Turning base close-in, we note that we've almost 500 feet and now our attention is devoted to judging altitude and distance in terms of glide angle.

On base leg both landing lights are turned on just in case the flare extinguishes before touchdown, and we hit the gear switch at 250 feet turning onto final. We're conscious of the flare at 500-600 feet above and ahead, as we roll out on final approach. Let's use full flap now. A quick check indicates gear "down" as

we skim over the fence and begin our round-out for the landing. Easy here—there's a tendency to level off high under flare light. Let's be ready to hit the brake immediately upon contact with the ground. Whoa, airplane! We come to a halt, almost a third of our field remaining, just as our flare extinguishes directly

over the downwind end of the field.

If you're equipped with the one-minute pistol flare, the procedure is basically the same. The firing altitudes are lower due to reduced candle-power. The phase II flare should be fired at 1,500-1,800 feet and the phase III at 1,000. You'll find your total task is more complicated handling

the pistol, and the timing is more critical because the flare burns for only one minute. We elected to fire the pistol left-handed because this permitted a straight arm firing from the left window. The window itself may require a minor modification to permit this. In the Tri-Pacer, for example, we replaced the window hinge pin with a removable pin which allowed the window to open entirely. This modification requires about 30 minutes and costs 15 cents.

The entire procedure is based on the use of two flares for very good reasons. You simply don't have time to fire more than two, or three at best, pistol flares in the time available. With the electrical flares in racks of three the third flare is saved for possible misfire of one of the two planned. In firing 40 flares, we had only three misfires. Two of these were beyond the three-year recommended renovation period and the third was due to a dent in the projector tube which probably occurred during installation. Incidentally, in this particular case, the effectiveness of the safety device on the electrical flare was definitely proven. The pilot was completely unaware that the projectile had lodged half in and half out of the projector tube; the parachute opened and was dragged from 1,200 feet to the ground stringing out behind the airplane. These flares cannot ignite unless and until they have completely expelled from the projector tube in the airplane.

Personal confidence in this emergency procedure will only come through serious practice. Every one of the 13 pilots who participated in this project would unhesitatingly say, terrain provided, they feel confident they could walk away from a night forced landing. You can acquire this confidence by practicing the procedures. Preliminary practice can be done in daylight hours with a pilot friend who starts a stopwatch or photographic timer when you call "bang" at the flare firing point. He can tell you, or allow the timer bell to warn you, when the flare theoretically extinguishes. You will undoubtedly want to make two or three "dry runs" at night once you have the timing perfected. If you have any flares over three years old and thus due for renovation, you'll find it relatively inexpensive to use them for a simulated night forced landing over your home airport. In this case, you'll want to enlist the cooperation of your local airport manager and provide adequate fire protection on the ground for potential misfires. We had only one of 40 flares fired which failed to extinguish before striking the ground and the men in our fire truck smothered it almost immediately with two buckets of sand. This particular flare, over three years old, failed to expel properly from the projectile case

and fell to earth after igniting.

The complete results of our project are available free of charge in bulletin form. You can obtain a copy by writing to the International Flare-Signal Division, Kilgore, Inc., Westerville, Ohio. This information and some serious practice on your part can put potential night forced landings in the same mental category as similar daytime emergencies.

- END

FLYING—November 1955

Table No. 1—RECOMMENDATIONS BASED ON FOURTEEN SIMULATED NIGHT FORCED LANDINGS USING SPECIFIC AIRPLANES AND SPECIFIC FLARES

FLARE TYPE	CLASS 2 1½-MINUTE ELECTRICAL	CLASS 3, 1-MINUTE PISTOL FLARE			
	Bonanza C-35	Piper Tripacer	Cessna 170	Cessna 140	Stinson 150
Airplane Type	Bonanza C-35	Piper Tripacer	Cessna 170	Cessna 140	Stinson 150
Power setting used	Idling	Idling	Idling	Idling	Idling
Indicated Airspeed mph	95	80	80	70	85
Passenger load including pilot	4	4	4	2	4
Landing Gear	Lower on base or final as necessary	Down	Down	Down	Down
Flaps	Lower on base or final as necessary	Lower on base or final as necessary	Lower on base or final as necessary	Lower on base or final as necessary	Lower on base or final as necessary
Airplane's average rate of descent in feet per minute	740	870	670	640	860
Altitude above ground to release flare for field selection purposes	2000	1800	1600	1500	1800
Average time from release of first flare to altitude for second flare. In seconds.	67	55	57	59	55
Altitude above ground to release second flare for landing purposes	1200	1000	1000	1000	1000
Position of airplane relative to selected field for release of second flare	Extreme upwind	Extreme upwind	Extreme upwind	Extreme upwind	Extreme upwind
Recommended approach pattern from second flare to landing. Overhead approach.	180 or 360 degree	180 or 360 degree	180 or 360 degree	180 or 360 degree	180 or 360 degree
Desirable airplane position in relation to flare to obtain best visibility.	Below	Below	Below	Below	Below
Time from second flare to extinguishment. Minutes.	1½	1	1	1	1
Excess altitude necessary to dive off immediately following release of second flare to land before flare extinguished	200 ft.	100 ft.	400 ft.	400 ft.	150 ft.

Table No. 2—FLARE DATA AND PERFORMANCE CHARACTERISTICS

SOURCE	DATA OR CHARACTERISTIC	CLASS 3 1-MINUTE PISTOL	CLASS 2 1½-MINUTE ELECTRICAL
CAA	Minimum allowable burning time in minutes. CAA TSO-C24 dated 10/10/50.	1	1½
CAA	Minimum allowable Light Intensity in candle-power. CAA TSO-C24.	70,000	110,000
CAA	Maximum allowable rate of descent in feet per minute. CAA TSO-C24	550	550
CAA	Minimum number of flares required by C.A.R. Parts 42 and 43 for irregular or non-scheduled commercial night operation beyond 3-mile radius of airport.	5	3
CAA	Maximum number of years recommended prior to factory renovation of flare unit. Aviation Safety Release No. 321, dated 7/1/49.	3	3
Mfg.	Approximate retail cost per flare unit.	\$21	\$35
Mfg.	Weight in pounds and ounces per flare unit.	1 lb. 14 oz.	4 lb. 5 oz.
Mfg.	Momentary recoil in pounds.	100	150
Mfg.	Horizontal distance in feet flare is projected upon firing.	67-82	67-82
Mfg.	Parachute diameter in inches.	48	60
Mfg.	Safety device to prevent accidental firing of flare unit.	Safety catch on pistol	Double switch arrangement
Mfg.	Safety device to prevent accidental firing of flare unit.	Safety catch on pistol	Double switch arrangement
Mfg.	Safety device to prevent flare from igniting before leaving airplane	Same as center fire shotgun shell	Interrupter fuse
Mfg.	Minimum release altitude in feet to insure flare extinguishment before striking ground.	800	1,000
U of I	Recommended angle of fire	As nearly horizontal as possible	Horizontal
U of I	Recommended maximum release altitude for minimum usable illumination of ground objects. (Actual altitude in feet)	1,800	2,300
U of I	Recommended Maximum release altitude (in feet) for minimum usable AREA of illumination at time of flare extinguishment.	1,000	1,200
U of I	Desirable minimum altitude of flare to obtain minimum AREA of illumination for landing touchdown.	400-500	400-500
U of I	Radius in miles of usable ground illumination at maximum recommended release altitude.	½-¾	¾-1
U of I	Maximum drift distance in miles of flare from release to extinguishment in 30 mph wind.	½	¾
U of I	Functional reliability of flares over 3 years but less than 5 years of age.	92%	92%
U of I	Functional reliability of flares over 2 years of age but less than 3 years.	100%	92%
U of I	Functional reliability of flares less than 2 years of age.	100%	100%
U of I	Recommended airplane position in relation to flare for optimum vision of ground objects.	Below	Below