Revolving lights are acquitted on charge of creating 'flicker vertigo' after seven years of research, but author of 1963 PILOT article on subject believes strobe system provides superior anticollision protection

The Rotating Beacon Revisited

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EDITOR'S NOTE: Dr. Wick, author of this article on rotating beacons, is associate professor of aerospace medicine at Ohio State University and assistant director of the Aerospace Medicine Research Laboratory there. At the time he wrote 'Rotating Beacon: Friend Or Foe" for The PILOT *in 1963, he was a member of the staff of the Department of Aerospace Medicine and Bioastronautics, Lovelace Foundation, Albuquerque, N.M. Later he joined the Federal Aviation Administration as chief of the Aeromedical Standards Branch at the Civil Aeromedical Research Institute, Oklahoma City. After a stay at FAA Headquarters in Washington, as research flight surgeon, he joined the space effort as a project engineer with Garrett-AiReseach in the Life Sciences Division. He remained there until 1967, when he went to Ohio State, at Columbus, O.*

■■ The night skies over the United States almost any evening are no longer the private domain of the scheduled airliner and the military pilot. Comet watchers find their view occasionally interrupted by winking red beacons as scores of private pilots, and even an occasional student, discover the delights of night flight.

Modern aircraft reliability has removed any significant hazard of an engine failure. Navigation is more simple for VFR pilotage, since the lights of cities and airports can frequently be seen at far greater distances than the objects themselves can be seen during the day. It is generally more smooth than daytime flight, and the view over a large city can be spectacular.

Thanks to the rotating beacon, other airplanes are a great deal easier to spot. Aviation progress marches on, however, and our friend the red rotating beacon may at last be ready to join the biplane and the tailwheel as relics of another age.

What was the point of the rotating beacon, and what purpose did it serve? In the days before the rotating beacon, airplanes generally had only three lights. These position lights, as they were called, were borrowed from ships and served basically the same purposes. A red light on the left wingtip shows forward and to the left side. A green light on the right wingtip does the same thing for that side. The white light on the tail can be seen from the rear and from either rear quadrant. Just as is the case with ships, if red and green are seen simultaneously, the other airplane is approaching head on. A red-and-white or green-and-white combination indicates the other airplane to be about broadside. White only means that the other aircraft is headed away from the observer.

The sailor on lookout generally has an easier job than the pilot flying at night. After all, ships on the surface of the water are all at the same elevation. The nautical lookout doesn't have to scan both above and below his altitude. Speeds are slow, too, and spotting another vessel several miles away means that a good deal of time is available to figure out which way the other ship is traveling. Collision avoidance is a simple matter, compared with the aircraft problem. Several miles of separation between two airplanes may only provide seconds in which to make decisions.

A major part of the problem is to see and recognize another aircraft as soon as possible. A single white taillight may appear stationary if a fast airplane is closing on a slower craft ahead. Over a brightly lit city, any of the position lights may look like white or colored lights on the ground. Against a background of bright stars, the white taillight may appear to be another star or planet. More than one Navy pilot has been trapped far at sea and short of fuel when chasing Venus rather than his leader's taillight.

The first major improvements were position-light flashers. Any rhythmically blinking light is much more likely to attract attention than a steady light. Aircraft of the 1930s began to flash wingtip lights, and some added a yellow light to the tail alternating with the white.

The next big change was the present rotating beacon, more properly called an anticollision light. This red light, attention-getting because it appears to flash, is considerably more powerful than any of the position lights. For example, the red and green lights must project 40 candlepower directly ahead of the aircraft. From 20° to 110° off the centerline of the aircraft on either side, these lights only need five candlepower (Figure 1). The rotating beacon must project 100 candlepower all around the airplane in a horizontal direction.

Remember that the rotating beacon has essentially just one function. That is to call attention to the airplane out in the night sky. An airplane with a beacon can normally be seen before the

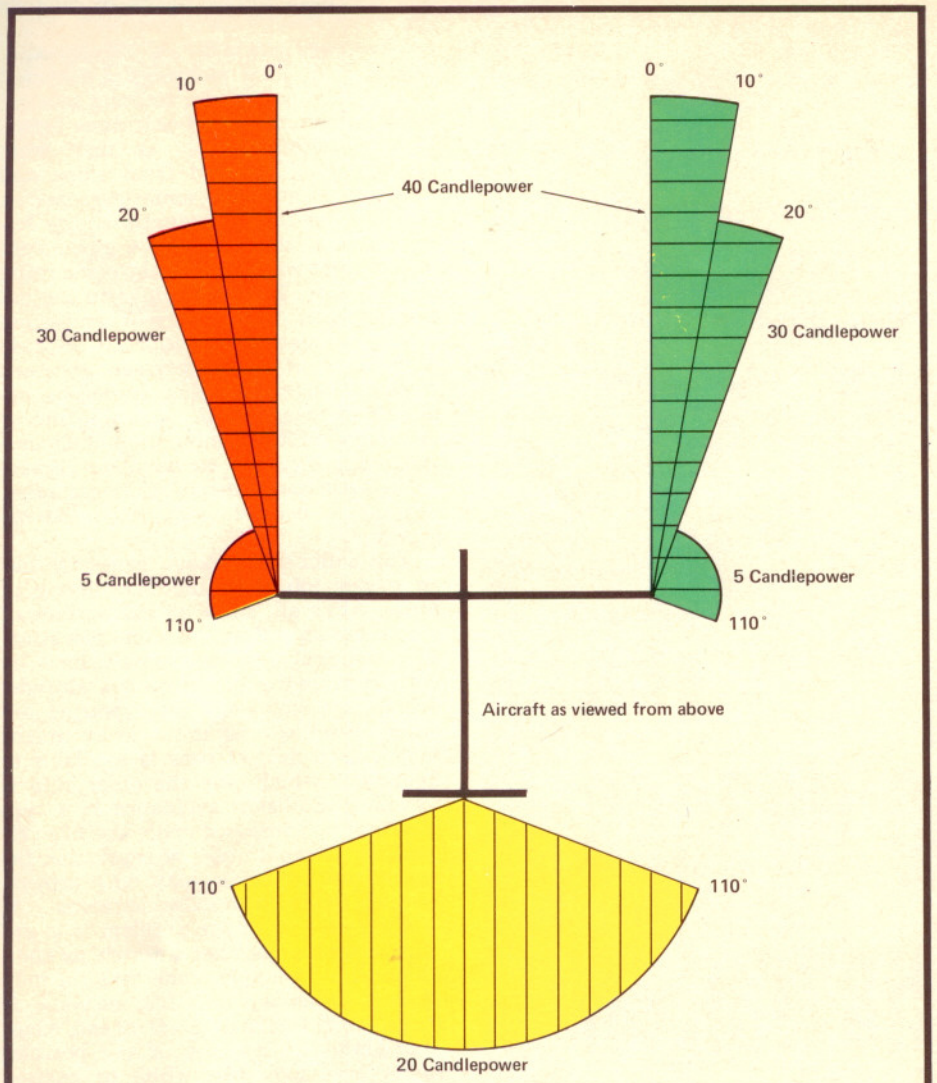

Figure 1.

Minimum Standards For Position Lights

(Horizontal Plane)

(Note: Some overlap is permitted between lights)

position lights become visible. This is to be expected, since the beacon is at least two and a half times more powerful than the navigation lights. In practice, a number of factors must be considered, so that recognition distance is not two and a half times that with position lights alone; nevertheless, there is no question that the beacon is a very substantial improvement.

The beacon, however, says little about how far away the airplane is, which way it is going, whether it is higher or lower than the observer's airplane and, most important, whether or not the two are on a collision course. It is generally necessary to see the position lights to answer these questions. The beacon only alerts other pilots to the airplane's presence and allows them to watch it. When in range, one must study position-light patterns and movement. A set of lights with a constant bearing—that is, fixed in the same relative spot on the windshield—is either another airplane on a parallel course at identical speed or, far more likely, an aircraft on a collision course. Any movement across the windshield means that a collision is unlikely unless the movement is slow and the airplanes are close together.

The rotating beacon, therefore, buys time for the pilot seeing it. The brighter the light, the greater the distance at which it can be seen, and the more time it buys. The more time it buys, the more maneuvering room one has.

To buy maximum time, however, a red lens covering the standard beacon is a bad deal. Any colored glass works by absorbing light of other colors and allowing only a certain portion of light energy through. Red glass appears red because it absorbs all the greens, blues, yellows, and so on. Only red is allowed to pass. Consequently, any conventional rotating beacon will appear much brighter, and therefore can be seen at a far greater range, if the red glass is removed and clear glass substituted. One commonly used rotating beacon has had its light output tested with both a red and a clear lens. With the red lens in place, only about 17% of the light energy escaped when compared with the clear lens. In other words, substituting a clear glass will increase the light output more than five times with no other changes to the system.

There really is no good reason for the use of a red glass other than the fact that red has been used as a danger signal in the past. Actually, if any color is to be used, green or a yellow-green would be far more visible. The human eye is much more sensitive to colors in the green area than to red, and the day may come when even automobiles use green stoplights. However, this information seems to take a long time to seep into the red-tape jungles of various governmental organizations.

Fortunately, aircraft manufacturers have not been slow to adapt to the situation, and rotating beacons with clear lenses are available. Unfortunately, another quirk in the regulations prevents their use in new or late-model aircraft, but older airplanes are allowed to take advantage of modern technology, and do.

Rightly or wrongly, the rotating beacon has been incriminated in some aircraft accidents. The term "flicker vertigo" can be found in many places, including the Airman's Information Manual. This is supposedly a condition in which the flashing light produces vertigo, and this, in turn, induces a typical loss-of-control accident. There is an old saying in medicine to the effect that new discoveries or findings can be written into textbooks in about two years. If this information ultimately turns out to be wrong, it takes 20 years to get it back out. So it is with flicker vertigo.

A previous article ["Rotating Beacon: Friend or Foe?" by Robert L. Wick—Ed.] in the June 1963 AOPA PILOT, based on the information then available, discussed the pros and cons of rotating beacons. It was then thought that in addition to vertigo, these flashing lights could lead to nausea. However, research in this area was scanty at that time, and the whole concept was based on some chance observations in Germany during World War II. At one time it was proposed to flash lights at bomber pilots raiding Berlin to disorient them. It is probable that this concept was not used as a war weapon because, in practice, it doesn't seem to hold water.

Since the previous article appeared, two different researchers have tackled this problem. The first, Dr. Jacek Szafran, a former *Spitfire* pilot in the Polish Free Forces, looked into the problem while he was a staff member of the famed Lovelace Foundation in Albuquerque, N.M. He is a well-known experimental psychologist whose interests lie in the area of brain function, and I was privileged to assist him. We set up an experimental testing situation to measure speed and correctness of de-

cision-making and reaction time. To this setup was added a bright strobe light, flashing at any frequency we desired, but generally set at the flash frequency considered to be most dangerous, which could be obtained from two rotating beacons directly out of phase with each other.

A large number of pilots come to Albuquerque for their examinations, so the population available included student, airline, military, and experimental test pilots. When placed in this test situation, there was absolutely no difference in the performance of any of these pilot groups, regardless of whether the strobe was on or not. No nausea or vertigo appeared. In fact, there was a very slight suggestion that their performance might improve. However, this was so slight as to be insignificant. All did complain about the beacon annoying them, but there were just no other findings beyond this subjective annoyance.

Shortly after this work was finished, Dr. Carl Melton, of the FAA's Civil Aeromedical Institute in Oklahoma City, became interested. Using their facilities, he was able to still more closely simulate the flight situation. He placed a *Bonanza* fuselage in their fog chamber, generated a real pea-souper, and subjected a number of pilots to both rotating beacons and strobe-light flashes. He also recorded electroencephalograms, or brain waves, while all this was going on. Again his subjects complained of annoyance and irritation, but his conclusion was, "These sources of light appear to be innocuous to normal people."

Although not prominent when these studies were originally performed, the strobe light now challenges the rotating beacon as the foremost anticollision light. These condenser discharge lights, as they are properly called, are outgrowths of modern photography and appear commonly on light aircraft as well as airliners. Since they were included in the studies, they present no additional hazard over rotating beacons with respect to vertigo. However, they do have other outstanding characteristics which make them useful for aviation applications.

Perhaps the most important is their tremendous light-energy output. One popular make of strobe light can generate up to 1,000 candles, or 10 times the FAA requirement for a rotating beacon. As an added bonus, most of this light energy can be seen at vertical angles around the strobe lights as well as in the horizontal plane. The rotating beacon, because of its reflectorized bulbs, limits much of its light output to a relatively narrow horizontal band. This is fine when two airplanes involved in a potential collision situation are both at the same altitude, but many midairs occur near airports when at least one aircraft is descending to pattern altitude or is on the final approach.

As is the case with the rotating beacon, several factors modify the visual range at which the strobe light can be seen. But it is certainly a major improvement over the red beacon and, in the case of an altitude difference, over a white beacon as well. Strobe-light flashes are very short, and the principal factor in visibility is the total amount of energy. A dim light shown for a longer period can be seen equally well. This accounts for the fact that the white rotating beacon may be seen even before some of the smaller strobes, assuming that both aircraft are at the same altitude.

You can easily demonstrate the merits of each for yourself. The next time you fly at night, notice how quickly you can see a strobe out of the "corner" of your eye. Often, the strobe can be seen flashing, and yet will be invisible if you look at it directly. Looking slightly off center will bring it back to your awareness. This use of "night," or photopic, vision alerts you at extreme ranges to the presence of another aircraft in the area. You are therefore provided the maximum period of time for collision-avoidance maneuvers. Notice also how much closer the other aircraft must be before the red beacon can be seen. This photopic vision is very sensitive to light, but totally insensitive to color, and provides still another reason for using the brightest white light possible.

The actual direction of the aircraft, and its orientation—that is, head-on, broadside, etc.—can only be ascertained when the lights are followed for a few moments or the various combinations of position lights can be seen. However, if the collision light appears to move with respect to a fixed position on your windshield, particularly while some distance away, no collision hazard exists. This also assumes that each aircraft maintains its course, speed, and altitude.

There is no radar set, transponder, or other black box on the horizon yet that will replace the old-fashioned, Mark One Model human eyeball. The white rotating beacon and the strobe, used in the Land of Winken, Blinken and Nod, however, are one large help. □

AOPA Comments On Strobe Lights

■■ FAA should *allow*, but definitely not force, general aviation aircraft owners to replace red rotating beacons with strobe lights, AOPA has informed Federal regulators. The agency has proposed a new rule that would make strobe lights mandatory equipment [May PILOT, page 62].

Stating the FAA was at fault for not heeding earlier requests to have strobes installed at the factory in place of red rotating beacons, AOPA said individual aircraft owners should not now be penalized for the agency's previous "procrastination."

Equipping aircraft with strobes in place of red rotating beacons would be helpful as an anticollision device, it has been said. Reduction of the potential for midair collisions is the objective of the rule.

"On the one hand," AOPA told FAA, "the Administration is to be complimented on finally attempting to come forth with a constructive proposal for the use of strobe lights. On the other hand, we feel that it should be pointed out that the several years of procrastination by the Administration on this subject has not only hindered progress in this area of safety, but has brought about an unnecessary and erroneous sense of emergency regarding the installation of strobe lights, which has been evidenced in comments by some of our distinguished colleagues in ALPA [Air Line Pilots Association] and NBAA [National Business Aircraft Association].

"The procrastination to which we refer is that for several years the FAA has refused to allow the replacing of the red rotating beacon, which was installed as part of meeting the original certification of the aircraft when it was manufactured, by strobe lights, even though all of the technicians, manufacturers and users agreed that the strobe light was far more effective than the rotating beacon.

"To our knowledge," continued AOPA, "there was no reason for this lack of action on the part of the FAA. When attempts were made by those in the industry to influence the Administration to allow this change, we were informed that 'studies' were being made.

"While the 'studies' were being made, aircraft owners who wanted strobe lights were forced to spend two or three times as much money to install the

strobe lights in addition to the red rotating beacon, when they could have replaced existing red rotating beacons with a strobe light for a fraction of the cost. This obviously discouraged many aircraft owners from adding this valuable piece of safety equipment to their aircraft."

Those organizations now asking for mandatory equipping of all aircraft with strobe lights are "organizations who represent highly priced aircraft, generally owned by a company or air carrier, for which the additional cost of adding strobe lights would be insignificant," added AOPA. The largest group of owners to be affected, however, would be those having smaller and less expensive aircraft: "These are the people who would be forced to spend monies, frequently not tax-deductible monies, out of their own pockets to install this equipment."

Responding to a number of questions posed by FAA in the proposed rule, AOPA recommended:

1. Equipping aircraft with strobe lights should be voluntary and not mandatory and the FAA "should immediately *allow* aircraft owners to replace red rotating beacons with strobe lights."

2. Pilots should not be required by law to have strobe lights on during daylight hours. "Anyone who invests the money in this type of equipment is certainly going to use it. An educational program might be implemented, if necessary, but there is no need for regulations that would make the aircraft unairworthy, or the pilot in violation, if for some reason the strobe light was not turned on. For example, it would not be sensible to ground an aircraft if a beacon failed."

3. On increasing the minimum intensity level (100 effective candles in the horizontal plane) of strobe lights: "If this intensity level, or a higher level, is necessary for the use of PWI [proximity warning indicator], then the manufacturers should be alerted to meet this requirement, but this should not obsolete any existing strobe light." [Some companies are working on PWI systems that would be activated by light signals from strobe lights.—Ed.]

4. The FAA definitely should *not* require all aircraft to be equipped with "anticollision" lights. "Such a proposal does not take into consideration that some aircraft are not even equipped with electrical systems. In addition, many small aircraft are operated primarily at very low altitudes on pleasure flights. The cost of retrofitting with strobe lights could represent 10% of the value of these aircraft. This would be an unreasonable burden."

Summing up its formal comments, AOPA said, "As indicated, the FAA has not allowed—in fact, has essentially precluded—the natural evolution [for using strobes] that we have experienced in general aviation through omni, DME, transponders, etc., where, if the product is worthwhile, pilots will voluntarily put them on their aircraft in the interest of safety. An example of this is that so many general aviation pilots have installed so many transponders in their aircraft that the Approach Control and Center (ARTCC) controllers, more frequently than not, are forced to ask all aircraft in the area to put their equipment on standby.

"Had the FAA not, through its procrastination, discouraged this natural evolution for the past several years [replacing red rotating beacons with strobes], the great majority of aircraft operating in controlled airspace today would be equipped with this equipment.

"Consequently, the AOPA submits that the FAA should not make this a mandatory requirement, but should allow the users of the airspace to demonstrate again their voluntary concern for safety. If it is determined, in spite of our arguments, that strobe lights are necessary for safety, such a requirement should be restricted to new aircraft manufactured after a certain date. There is no precedent for establishing a retroactive regulation that would have such an economic impact." □