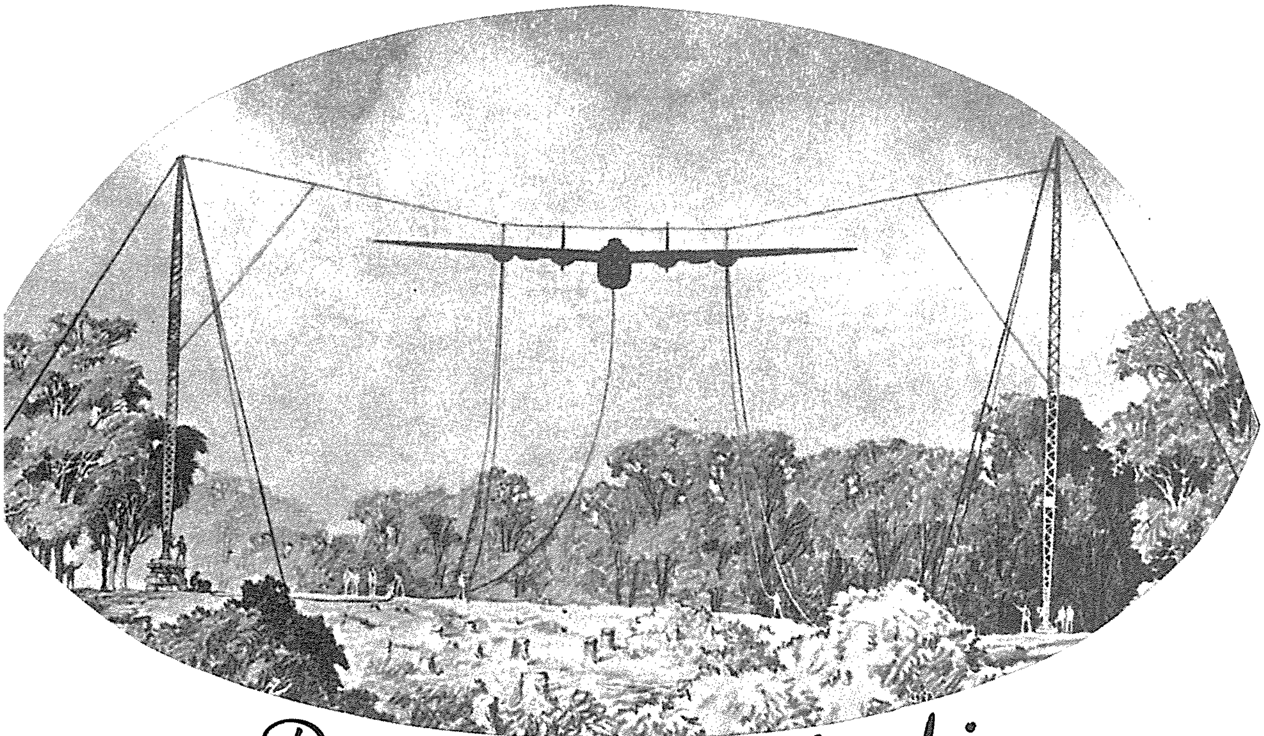
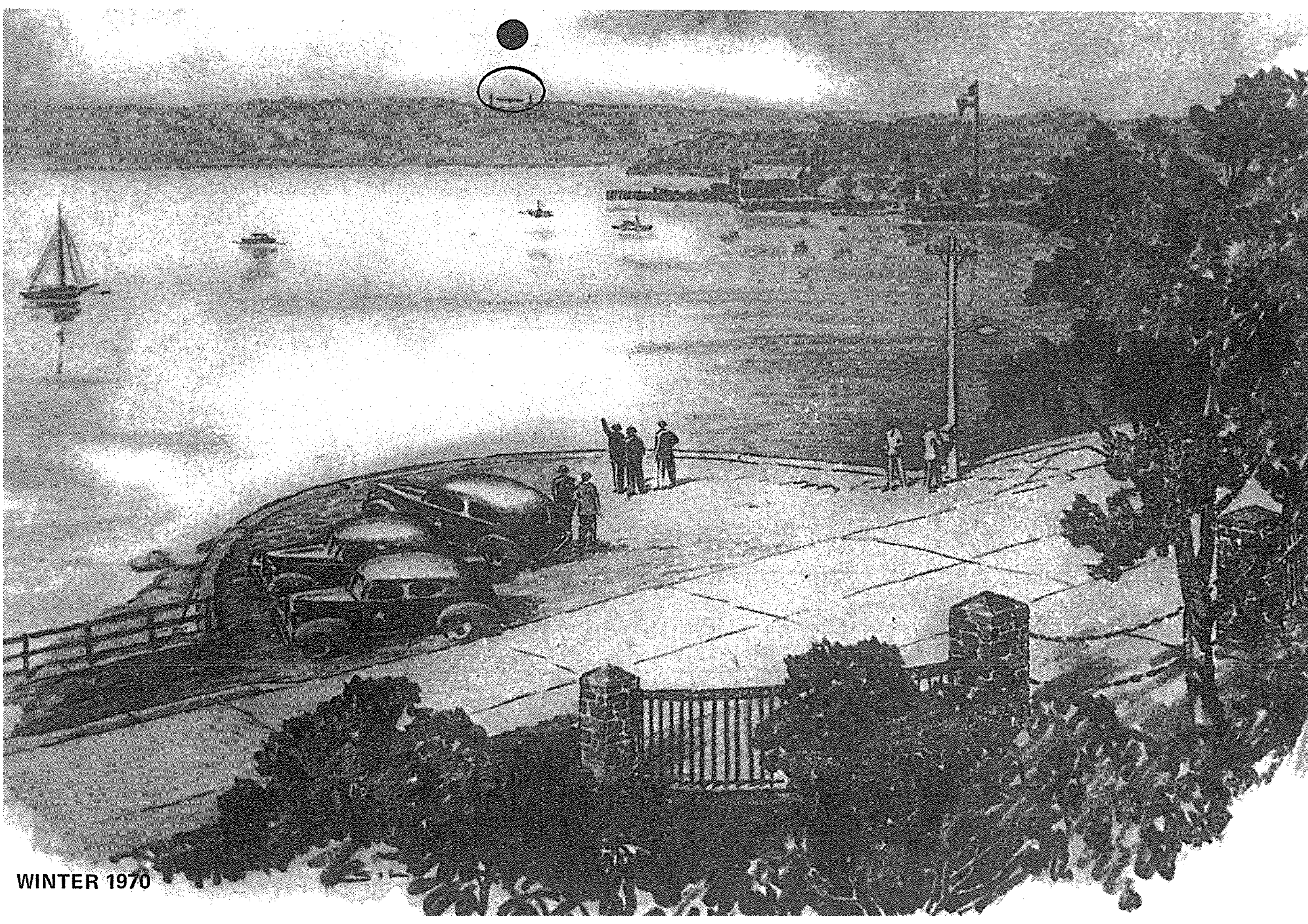


Project Yehudi

A STUDY OF CAMOUFLAGE BY ILLUMINATION, 1935-1945

By JOHN C. REILLY, Jr.



Since the airplane first went to war, military colors and markings have alternated between drabness and flamboyance. At one time muted earth-and-sky tones have prevailed as combat planes tried to fade into their background. This would then give way to an almost medieval brightness. Vivid colors have replaced camouflage, blossoming out in gaudy distinguishing insignia and color patterns. Then, back to dull tones again. Between World War I and Vietnam we have seen this cycle go through its paces several times. Though land-based aircraft in Southeast Asia have long since gone to camouflage and muted markings, Navy carrier planes still go into battle looking like flying billboards. Though camouflage finishes have been tested for Navy use, they have never gotten beyond the experimental stage as far as contemporary carrier aviation is concerned. And only recently USAF has again ordered removal of personal markings from all its aircraft.

In the years following WWI color was king; the principal visual purpose of most aircraft finishes and markings was visibility rather than concealment. The upper wing surfaces of U.S. Army and Navy airplanes were bright yellow, so disabled planes could be spotted at long distances. A smorgasbord of organizational emblems, colorings, and markings were conspicuously applies to facilitate formation flying and simplify unit assembly in the air. The system was geared to peacetime operations, and some, in fact, argued that if bright colors and prominent insignia made formation flight easier and more precise then this would be an advantage in combat as well.

In the U.S. Army and Navy alike there were those who realized that, in spite of postwar revulsion, there was nonetheless the chance that the nations might once again find themselves at war, and both services carried out tests of camouflage materials and patterns. In the early 1930's the Naval Research Laboratory (NRL) laid the groundwork for the Navy's camouflage systems of World War II, experimenting with colors and paint patterns designed to reduce the sky visibility of airplanes. Fleet patrol planes conducted early field tests at Coco Solo, Canal Zone, in 1934 and early 1935.[1]

Paint proved of limited use in concealing flying aircraft from observation from below. This was before radar, when the only way to positively locate an airplane was to see it. An airplane, seen against a daylight sky, cast a dark silhouette; no matter what the painters might do, it still looked like an airplane.

This was of importance to the Navy in its use of the airplane as the "eyes of the fleet." The concept of the carrier striking force was years off, and battle at sea was still thought of in terms of the traditional surface actions in the style of Trafalgar and Jutland. To fight such actions, the greatest possible amount of accurate, up-to-date information was needed on the enemy's strength, location, and intentions, hence the importance of aerial reconnaissance.[2] Fast surface scouts were now supplemented – as weather permitted – by far-ranging reconnaissance planes, and the aircraft carrier's function was that of a "glorified cruiser."

To find the enemy was the first problem. If this could be done "unbeknownst" to him, so much the better. To do an adequate job of identifying and reporting on an enemy fleet, at the then prevailing speeds a scouting plane would have to approach to a distance where its changes of being seen and shot down made aerial observation a chancy business.

At this point, someone in the Bureau of Aeronautics remembered some proposals made during World War I to reduce the visibility of an airplane in flight by fitting it with lights to illuminate those parts of its surface which were in shadow and, hence, darker than the surrounding sky background. The Chief of Naval Operations had been following the progress of BUAER's camouflage work. On 9 November 1935 Admiral Joseph K. Taussig, acting GNO, asked BUAER to determine the value of illuminating the undersurfaces of airplanes as a means of concealment.[3] "It appears probable," he wrote, "that the work already done has carried the subject about as far as is possible by the use of ordinary paints alone." Reducing or eliminating the shadows cast on the undersurfaces of a flying plane, he went on, by "normal visible light" seemed the "most promising field of research for further improvement."

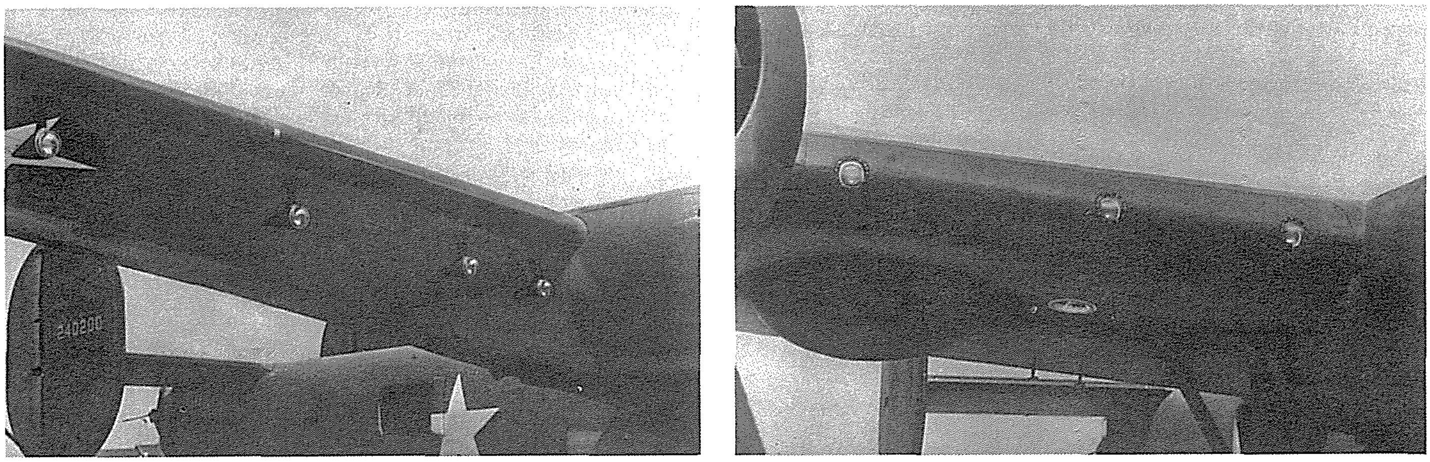
Before beginning a full-fleged test project, BUAER posed some preliminary questions to NRL. Lights, it was assumed, were to be installed on the undersurface of an airplane painted in a light color. Light intensity was to be controllable to allow for natural variations in shadow contrasts. "What intensity of light source," BUAER asked, "is necessary to compensate for shadow effect under normal conditions? How many watts would be required for a typical observation airplane? What is the effectiveness of an adequate illumination as a camouflage agent?" The Bureau also suggested that colored as well as white light be tried.[4]

NRL began its preliminary study by setting up its hypothesis.

> An airplane is at a distance of a few miles from an observer at sea level and at an altitude of several thousand feet. It is assumed to appear to the observer as a small dark object against the sky. Suppose that there were lights properly disposed on the plane to illuminate the dark portions of the plane. The pilot turns on the lights and slowly increases their intensity . . . . To the observer viewing the airplane from below the plane becomes less dark and its contrast with the sky background becomes less. When the plane becomes as bright as the sky background it vanishes from the view of the observer. Conceivably, the pilot could be provided with a little optical gadget which would enable him to tell when he had adjusted the intensity of the illumination to the correct value.
>
> These ideas are theoretically sound, the picture is enticing, and although obvious practical difficulties immediately come to mind, it seemed of value to examine the ideas with care to estimate how much artificial illumination might be required to produce appreciable effects.[5]

The first step was to measure the brightness of clear and cloudy skies. This was measured with an illuminometer and determined for various azimuths and angles of observation. The brightness of flat white and "Navy gray" surfaces, held vertically and horizontally aloft in cloudy and in clear weather, was similarly measured. This gave the researchers a general idea of the intensity of illumination that would have to be provided to match the sky's brightness under different conditions. They concluded that the shadow areas of a Navy-gray airplane would have to be brightened by 700 to 1,000 foot-candles; a white-painted airplane would need 500 to 800. Allowing for the degree of reflectivity of the airplane's surfaces, illumination sources providing 750 to 1,200 foot-candles would be needed to conceal a white airplane. A gray one would need 2,100 to 3,000 foot-candles. More illumination would be needed in bright tropical weather.

To test its calculations, NRL illuminated white and gray surfaces, and "a white wall, none too clean," with a 24-inch searchlight at 30- and 90-degree angles. This showed that over 75 per cent of the light produced by the 24-inch Navy carbon arc searchlight was immediately lost, due both to limitations in the carbon arc light itself and to the size and shape of the searchlight reflector. A gas-filled tungsten



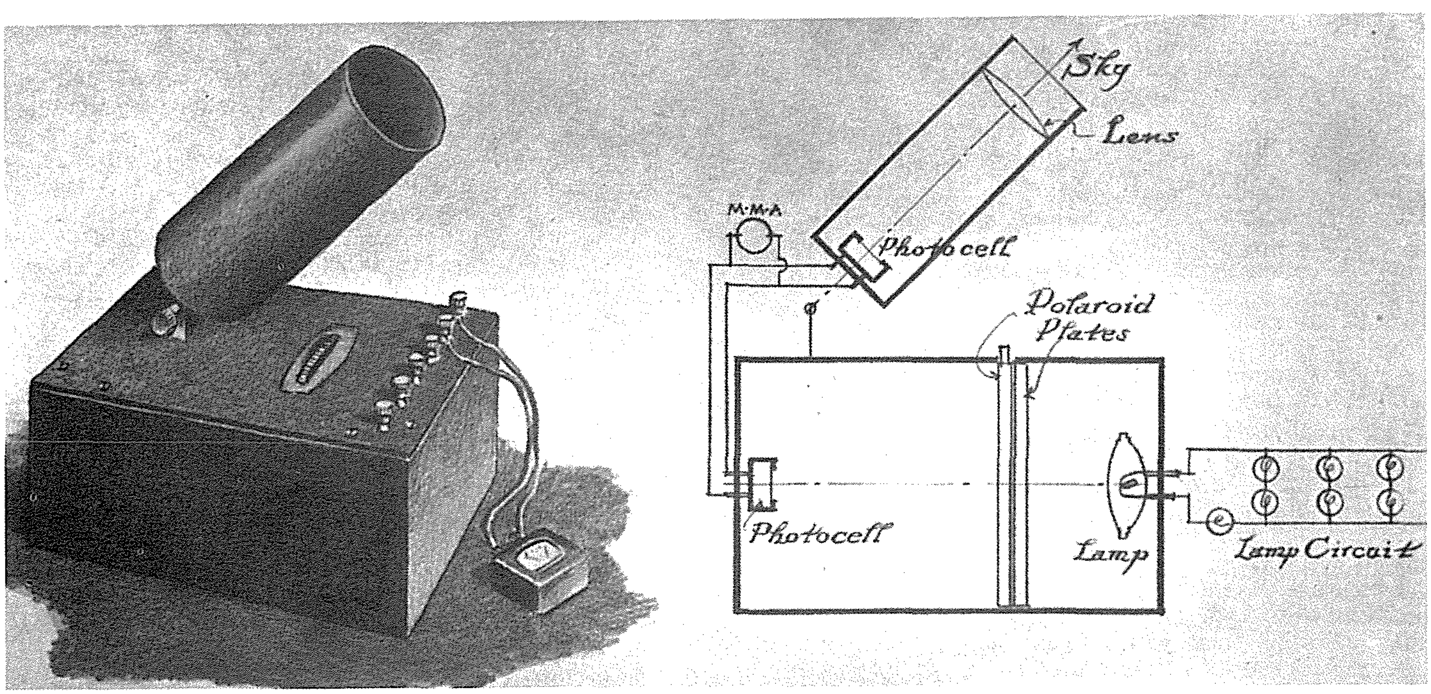
The full-scale Project Yehudi installation on B-24D, 42-40200, at Wright Field, c. 1943. The lamps were mounted on pylons under the outer wings but could be mounted within the leading edge profile of the inner wings. Intensity of the illumination was adjustable in flight. (Photo – USAAF)

lamp, they decided, would be "slightly more efficient" than the carbon-arc type, and an improved reflector could be designed for camouflage use. Even this hypothetical rig would be far from perfect; it would still be difficult to obtain a projection efficiency over 50 per cent. Tests and calculations had already shown that a considerable amount of "delivered" illumination would be required, even on a relatively dull winter day, to blot an airplane's silhouette from the sky. Now, due to limitations inherent in the light source itself, about twice the amount of lighting power actually required for concealment would have to be provided even with custom-designed lighting. A camouflage light system would have to deliver 15 to 75 kilowatts per 100 square feet of shadow area, depending on the sky's brightness and the color of the plane.

NRL felt that "the conclusions just given are, if anything, underestimates." In summer or in tropical weather the scale of outdoor brightness might be as much as five times that of the Washington winter days on which the tests were carried out. Great exactness in distributing the illumination, NRL concluded, was not necessary since this would not be noticeable at any distance. "The exact tint of the surfaces and of the lights would appear to be unimportant as long as the surfaces were somewhere near neutral and the lights somewhere near white."

BUAER's experts realized the negative import of NRL's study; "the report . . . indicates that, at the present state of the art of airplane design and construction, the added electrical output required for artificial illumination renders this method of camouflage on the verge of being impracticable."[7] They still believed, though, that, even considering the technical problems involved, the "possibilities of a highly flexible, instantaneously changeable and controllable camouflage are so attractive . . . that it is deemed desirable to continue the investigation further, from the standpoint of camouflage effect alone, and to reserve the question of means of illumination for later study if it be justified." After reviewing NRL's findings, BUAER's Specifications Section recommended that the Bureau arrange full-scale aerial tests. Work was also suggested on a practical means of controlling illumination to suit the natural background. $500, it was felt, would be enough to cover the cost.

The Yehudi-developed instrument matched the intensity of the lamps to the sky background by exposing photoelectric cells, one to the background light and another to a lamp hooked to the main camouflage circuit. Difference in illumination would show on the attached milliammeter, and light intensity could then be adjusted to the new background brightness. Drawing by National Defense Research Committee, courtesy of author.



Experts from BUAER and NRL met on 11 May 1936 to determine how the tests were to be carried out. A BUAER project order had been set up to finance the work, but NRL thought the money allocated would be inadequate.[8] Since a large amount of illumination would be required to achieve any effect, this would involve fitting a test airplane with numerous lights and a heavy power source, as well as a considerable amount of wiring. This, in turn, would require the help of an aeronautical engineer to insure that the airplane could be suitably equipped without structural or aerodynamic harm.

NRL asked that BUAER furnish two airplanes for the test. One would be fitted with camouflage lights; the other painted and marked in the normal manner, would serve as the "control" plane for comparison.

Convinced by now that worthwhile results were possible, BUAER wanted to continue the project so long as it could be done on the allotted funds. The Bureau suggested that NRL scientists consult the Commanding Officer of Naval Air Station Anacostia to see what type of airplane could be made available. Once this was done, then the kind and cost of equipment needed could be determined. If it then seemed that the project money would be enough, work could proceed. Though BUAER would not be able to provide full-time technical assistance, Bureau engineers would be available for consultation whenever needed.[9]

BUAER now explained the proposed project to NAS Anacostia, asking them to recommend a suitable aircraft type for experimental use.[10] Air Station technical officers met with NRL representatives shortly afterward, and plans were made for the actual flying of the test.[11]

The Grumman XFF-1 (BuNo 8878) was selected. Twelve 600-candlepower tungsten landing lights were to be mounted on the lower surface of the fuselage, spaced to provide uniform illumination. Instead of aiming these lights at the fuselage, they were directed away from it, toward the observer. If, NRL reasoned, the lights themselves were turned in the observer's direction and properly spaced, they would blend into a pattern of brightness that would blot out the airplane's silhouette as effectively as reflected light, but with a power consumption low enough to make the scheme usable. Power would come from four aircraft storage batteries, weighing 280 pounds in all, to be placed in the plane's rear cockpit. Battery power would suffice for 20 minutes of full illumination before recharging. Only fuselage undersurfaces were to be illuminated; wings and horizontal stabilizers would be left unlighted. The estimated total cost of batteries, lamps, and associated wiring and parts would be $430.00.

On 24 July 1936 BUAER approved the proposed arangements, directing that "...the plan proposed...be followed in so far as practicable."[12] The Bureau recognized the technical problems involved, particularly the limitations of the lights and batteries then available. What was now at issue, though, was a matter of principle rather than of details. BUAER was solely interested in determining whether artificial light could conceal a flying airplane. If the principle was valid, further research would eventually produce serviceable lights and power sources.

In the typically closehanded way made so necessary by years of meager budgets, the Bureau then went on to direct NAS Anacostia to issue the needed equipment from station stores. Payment was to be made only for material damaged or destroyed.

The test plane was not fitted out, and 1 October 1936 was chosen for the experimental flight. The day was clear, with "thinnish" white clouds partly covering the sky. In each of three flights between 10:00 A.M. and 3:00 P.M. the SFF-1's pilot climbed to 5,000 feet and flew "into the sun" for about six miles. Reversing course, he then flew back toward the observers. Keeping the sun behind him insured a light sky background for maximum contrast. At 30-second intervals he switched the plane's camouflage lights on and off, the test aircraft thus providing its own unilluminated "control" silhouette.[13]

Results were meager. Up to about two miles, it seemed to be the unaided eye that about one-quarter of the visible fuselage undersurface was illuminated "to somewhere near the brightness of the sky background." At greater distances not even the lights themselves, much less any illumination effect, were visible. In every instance, whether lights were on or off, the plane appeared "always as a dark speck against the sky background." On top of this, observers noted that each time the fighter landed two lights on its port side were shattered by stones thrown back by the propeller airstream.

These results were discouraging to those who had hoped that the theory, at least, would be proven workable. To produce a perceptible lighting effect, test observers remarked, a degree of illumination perhaps ten times greater than that actually used would be needed. This light could not merely be confined to the lower fuselage, either; it would have to be well-spread over all the airplane's visible surfaces.

To camouflage expert and NRL consultant Charles Bittinger, this did not mean that the whole concept should be discarded. The idea, he felt, was good, and in December 1936 he proposed that BUAER carry the work further.[14] The Anacostia test had demonstrated the practical difficulty of providing enough power for adequate illumination. Enough batteries of the type used in the test to give a tenfold power increase would weigh some 2,800 pounds, not counting the weight of more powerful lights. Bittinger nonetheless considered the effort worthwhile, and urged that work be carried on. The technical obstacles, he insisted, could be surmounted.

In April 1937 a meeting at BUAER between Bittinger and service representatives considered the whole question of airplane camouflage.[15] After discussing the results of experiments with paint finishes carried out in 1936 illumination camouflage was then brought up. Theoretically, BUAER conceded, the idea was sound. A plane which could be made to reflect the same amount and type of light as the sky would be invisible to the eye. But how could this be carried into practice? Though Bittinger vigorously defended the usefullness of illumination camouflage, he did not specify how it could be put to service use with the airplanes and lighting equipment then available. Indirect lighting, he suggested, might be the proper approach. Dr. E.O. Hulburt of NRL disagreed, pointing out that indirect light would be about a third less efficient than direct. Nor would it, he went on, be adjustable to compensate for changes in available natural light. This inflexibility would cancel out one of the principal advantages foreseen for the light-camouflage system; the ability to "custom-tailor" a plane's camouflage to changing visibility conditions.

Other problems, Dr. Hulburt went on, were involved. A formidable amount of electrical power would be needed to produce the desired silhouette-canceling effect; about 210 watts per square foot of undersurface for Navy Gray, even if 100 percent efficiency could be assumed, and somewhat less for flat aluminum or white paint.

Even if this amount of power could be fitted into a suitable airborne installation, it would still be difficult to arrange the illumination pattern in such a way that the various undersurface shadow areas would be properly canceled out.

To compound the problem, every change of a flying airplane's orientation (bank, turn, climb, or descent) would change the shadow pattern and require readjustment of the lighting pattern to maintain concealment. "To arrange suitable control and adjustment of illumination distribution," Dr. Hulburt felt, "seems to be practically out of the question."[16] Beyond this, he continued, a satisfactory electric camouflage would have to allow ready adjustment of light color as well as of distribution and intensity. This, he concluded, presented "almost insurmountable difficulties." Shortly afterward, BUAER's Specifications Section recommended that no further research be carried out in illumination camouflage.

In spite of the unfavorable conclusions reached at the April conference, NRL continued to study the problem for another several months. No new approaches were discovered. "Unfortunately," NRL advised BUAER in September, "no further practical solutions have come to light. Inasmuch as the Bureau has made no provisions for an extension of this problem . . . and in view of the lack of promise in this field of research at the present time, it is suggested that the problem be closed until such time as definitely promising suggestions are presented."[17] BUAER agreed, telling NRL that it had no intention of carrying the study any further. Here the matter was to rest for the next six years.[18]

Interest in camouflage was far from dead, though. Rumors of war preparations were drifting across Atlantic and Pacific alike and a new note of urgency was added to the preparations for national defense urged by the Army and Navy. Gaudy aircraft color schemes gave way to the more somber hues of 1940 and 1941. Questions of collision avoidance and *esprit* were supplanted by the need for concealment.

The Army Air Corps, profiting from the experience of European combatants, produced several camouflage schemes suited to different zones of operations. The Navy, whose camouflage conditions at sea were not so much affected by area and climate, adopted an overall light gray color scheme in 1940, then replaced this in 1941 with a dull blue-gray for upper surfaces of warplanes, continuing to coat their undersides with light gray.[19] Large national insignia and bright rudder stripes served, during the first months of war, to identify American naval planes to their fellows, whose recognition training left something to be desired. Even this burst of color was keyed to survival in aerial combat rather than to any "Red Baron" attitude. At this time shipboard radar began to limit the usefulness of visual camouflage; aircraft could now be located and tracked electronically long before they came within sighting range.

By 1941, the German submarine offensive had assumed ominous proportions. Allied shipping losses were soaring, and every imaginable scheme for countering the U-boat was being examined. One effective weapon, the radar-equipped land-based patrol bomber, now entered the lists, achieving a worthwhile degree of success. A patrol bomber's airborne radar could sweep a wide expanse of ocean, picking up a surfaced submarine even in foul weather and bringing the plane in to attack. U-boats losses mounted, and surviving boats were forced to adopt cautious tactics when operating anywhere within range of the long-legged British and American patrol bombers.[20]

A submarine detected on the surface had two choices; crash-dive, hoping to conceal itself before the attacker could reach bomb-release position, or stay on the surface and shoot it out.

Since submarines at this time did not carry their own search radar, they depended on passive radar-detection gear and meticulous visual observation by trained lookouts. If an attacking airplane could get within 30 seconds' flying time of a surfaced U-boat before being spotted, it was virtually sure of being able to deliver its bombs before the submarine could dive and – hopefully – before it could inflict a serious amount of flak damage.

The attacker's principal worry was the U-boat's lookouts. These were professionals; to stay alive, they had to be. So the question resolved itself. How, then, was an approaching bomber to conceal itself from their sharp eyes and excellent optics? "Sea-search" camouflage paint schemes, using gray and white paints, had been devised for sub-hunters. These new finishes, though, proved no more effective at concealing aircraft from surface observation than had the earlier paint schemes of the 1930's. No matter what kind of paint was used, the airplane still presented an unmistakable black silhouette against the sky.

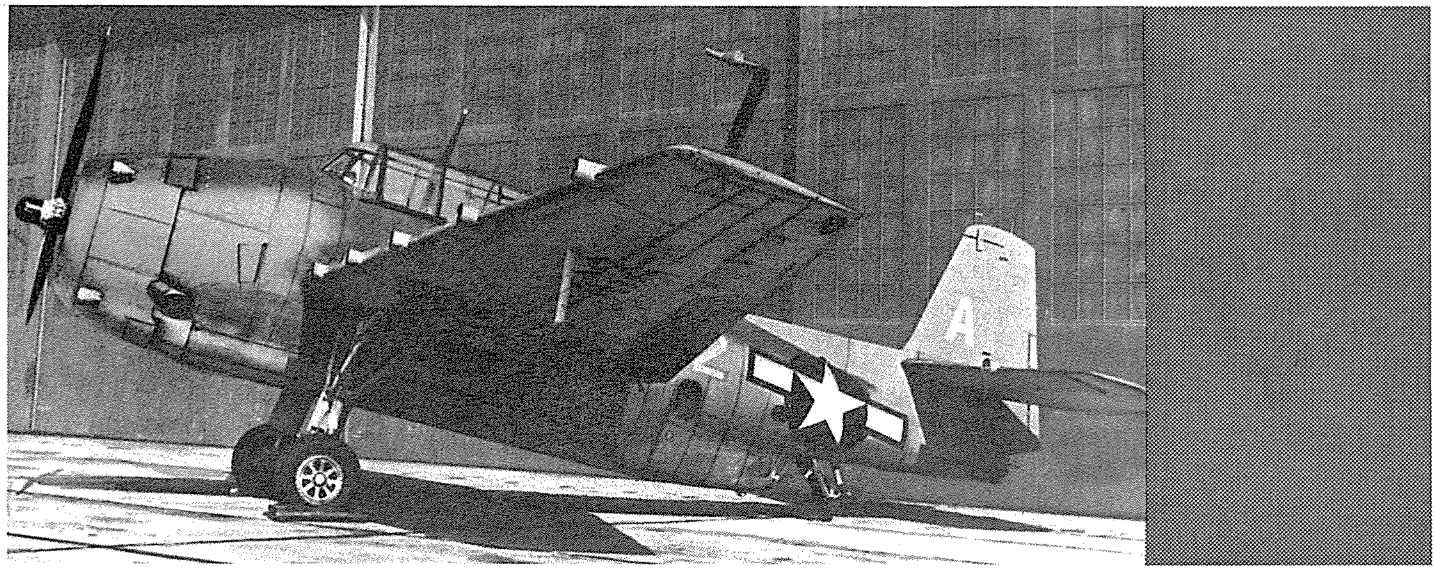
The Army now asked the Camouflage Section of the National Defense Research Committee (NDRC) to devise some sort of camouflage system that would enable a patrol bomber to come within 30 seconds of a surfaces submarine without visual detection. In honor of "the little man who wasn't there," the study was labeled Project Yehudi.[21]

NDRC first went back to have a look at the results of the 1936 Anacostia tests. From these, they could see that all-over camouflage protection of a silhouetted airplane by floodlighting was theoretically possible. The amount of power required, though, was still more than could be handled. But, NDRC reasoned on, a patrol bomber making its approach to a U-boat would always present pretty much the same head-on aspect to the submarine's lookouts. That particular aspect could, perhaps, be blocked out by bright lights mounted in the plane's nose and along the wing leading edges. This would not provide protection from any other angle, but under these circumstances it was not needed.

A series of experiments was carried out for NDRC during the winter of 1943 by the Louis Comfort Tiffany Foundation on its 80-acre Oyster Bay, N.Y., estate.[22] The first experiment involved mounting reflectors and bulbs from hand flashlights at 4-inch intervals along a 2-inch black-painted board 32 inches long. The lenses were opaqued, leaving a clear horizontal strip across the center. This was covered with a transparent blue film calculated to convert the bulbs' light energy to an approximation of daylight. A rheostat adjusted the light intensity to that of the sky background. This miniature model, seen at 900 feet against a clear sky with the lights off, was sharply silhouetted. When the lights were turned on, the model seemed to disappear. By adjusting the light intensity, the model's invisibility was maintained against changes in background lighting.

To the experimenters, this was convincing. Their next step was to construct a full-scale head-on silhouette of a Navy PB4Y-1 patrol bomber, a type widely used in longrange ASW work. This silhouette was suspended between two 100-foot steel towers atop a wooded ridge overlooking Oyster Bay. An observers' station was sited on the far side of the bay, about two and a half miles away. The location allowed the model to be displayed at something approximating actual attack altitude and to be observed over the bay's open water at a suitable distance. Woods surrounding the model display protected it to a considerable extent from outside observation.

The silhouette PB4Y was fitted with special sealed-beam lamps of 6.5 volts, their faces tinted to correct the light to a daylight type, and with a beamspread 3 degrees wide and 6 high. Lamp arrangements were theoretically calculated, then proven by observation. Observers took their places at the west end of Oyster Bay, the model was hoisted into



Grumman TBF-1 at Quonset Point with Yehudi lights installed. The experiments were highly successful, but by the time it was perfected, radar equipment was available and the need for Yehudi had passed. Five lights were mounted in each wing and four on the engine cowl. (Photo — U.S. Navy)

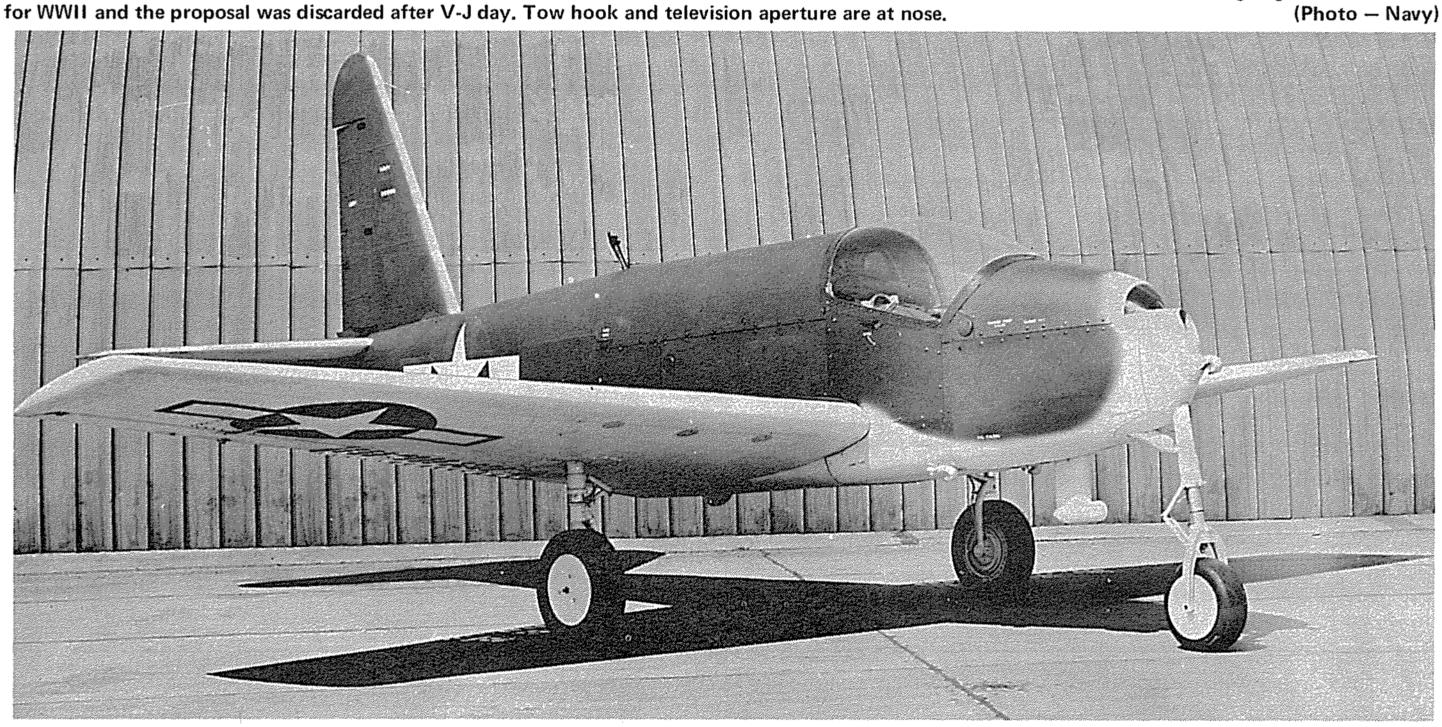
place 85 feet above the ridgetop and the lamps were switched on and off and brightened or dimmed as directed by telephone from the observers' station. Proper lamp arrangement and required intensity and color ranges were gradually determined as the tests went on. Some volunteer aircraft spotters in the area provided an unintentional tribute to the test silhouette's realism, reporting it as a four-engined bomber headed directly for their station the first time it was hoisted for testing.

While full-scale model tests were carried out, several meetings were held in Washington to discuss the "Yehudi principle." It was one thing to describe the tests, but how could results be demonstrated? A "skyscrape" was finally painted on a thin sheet of metal. On this was superimposed a 3.75-inch black head-on B-24 silhouette. At 30 feet, this scaled to the size of an actual plane seen at two miles. Tiny holes, drilled in the painted silhouette, corresponded to the locations of the lights on the full-scale model. Onionskin paper was attached to the back of the painting to cover the light holes and serve as a filter. When a desk lamp was lit behind the painting, the result closely reproduced the effect reached with the large model; the miniature silhouette could be made to disappear completely. This was not only an effective demonstration device, but turned out to be entirely adequate for test work. Fullscale model tests were thus no longer necessary.

The final step was to try out an actual set of lamps on a B-24. This was done at Wright Field on a B-24D-35-00, 42-40200. Miniature silhouette tests had shown that the lamps could be mounted on underwing brackets outboard of the engines, where the wings were relatively thin. Inboard, where the wings became thicker, lights were installed in the leading edge.

To allow a bomber crew to match their light intensity to the sky background — a problem unsolved in 1936 — an arrangement of two connected photoelectric cells was used.

The Pratt Read LBE-1 Glide Bomb, television-guided, for which Yehudi equipment was designed. Both the Glomb and its camouflage lights were too late for WWII and the proposal was discarded after V-J day. Tow hook and television aperture are at nose. (Photo — Navy)



One cell was illuminated by the sky, the other by an auxiliary lamp hooked into the camouflage circuit. Changes in sky brightness could be allowed for by adjusting a rheostat until a miliammeter, mounted between the two cells, registered dead center. Experimenters planned to make this fully automatic by use of a servomechanism.

It had originally been thought that painting an illuminated airplane a light color would be helpful. This did not work in practice. It made little difference what color was used on the undersurfaces, since these received little illumination either from the atmosphere or by reflection from the water. On the sides and upper surfaces, though, use of a high-reflectance paint would help produce the desired camouflage effect with a considerable saving in electrical power.

This, in turn presented another control problem. Natural illumination of the vertical surfaces would then vary "enormously" with the angle at which they were struck by sunlight. This would involve frequent, or even constant, adjustment of light intensity. If, on the other hand, visible areas were painted a "dark, saturated blue," researchers felt that power requirements could be reduced without the need for complicated adjustments, as the blue light reflected from a dark blue airplane would have little effect on its luminosity.

The success of these early experiments aroused the interest of the Navy's Aircraft Antisubmarine Warfare Development Detachment (ASDEVLANT), operating at Quonset Point, R.I. ASDEVLANT, in 1943, first asked NDRC to prepare an illumination design for a PBM flying boat, to be basically similar to NDRC's B-24 system but with a much larger horizontal beam-spread and the ability to match greater sky brightness for continuous patrol use in clear weather. A second ASDEVLANT request produced another design allowing for intermittent use with a narrower beam-spread, but with a still greater attainable brightness. Special lamps and mounts were prepared, but never actually used.[23]

Later in 1943 ASDEVLANT once more asked NDRC's aid in producing a suit of Yehudi camouflage; this time for a Grumman TBF torpedo bomber.[24] Four sealed-beam lights were installed on the cowling of a Quonset Point-based TBF-1, mounted externally in tapered housings similar to the auto headlights of the early 1930's. Ten more lights were installed in faired housings protruding from the leading edges of both wings. A series of test flights developed Yehudi's effectiveness to the point where, on a day when an uncamouflaged plane was visible at about 12 miles, the illuminated TBF could approach to within 3,000 yards without being spotted.

ASDEVLANT's test report was convincing. On 1 April 1944 Commander in Chief, U.S. Fleet (COMINCH) ordered a TBF squadron fitted with Yehudi gear for Atlantic operations.[25] At the same time, COMINCH asked the Navy's Coordinator of Research and Development, Rear Admiral Julius A. Furer, to arrange further research to shorten the detection range. The Naval Air Station at Patuxent River, Maryland, was directed to modify the engineering drawings for the TBF to allow factory installation of Yehudi equipment. Neither project, as far as is known, was ever carried out.[26] Admiral Furer did, however, forward a copy of ASDEFLANT's report to NDRC with a request that the research desired by COMINCH be carried out.[27]

By 1944 the first primitive missile weapons had made their appearance. Germany had produced the Hs.293 glider bomb as well as the V-1. The United States was also at work on its own "standoff" weapons, including the Navy-developed "Glomb" (Glider Bomb) – a small, remotely-controlled airplane with an explosive warhead.[28]

BUAER felt that Yehudi camouflage might increase the effectiveness of its early LBT and LBP Glombs and asked NDRC to devise illumination equipment for them. Since the Glomb had already gone into production, a suit of lighting equipment which could be installed in the field was required. It should allow the missile to come within six seconds' flying time of its target before being spotted. Dr. Seibert Q. Duntley of NDRC directed the project, and Dr. E.O. Hulburt, who had worked with the original illumination project in 1936, was named project liaison officer for NRL.[29]

Problems were encountered with the structure and aerodynamic configuration of the LBT-1 and LBP-1 Glombs, and at first the task seemed insoluble. However, production of the two models was discontinued in late 1944, and NDRC's attention turned to the new LBE-1, then under development.

Pratt, Read and Company of Deep River, Connecticut, designers of the LBE, worked out a set of lighting and control equipment for trial. An automatic photoelectric current control mechanism was developed from the device originally invented for the PB4Y. The earlier manually-operated rheostat was replaced by one driven by a servomotor which was, in turn, actuated by a vacuum-tube bridge between the two photoelectric cells. This bridge was set to constantly compare the inputs from both cells and to automatically adjust the rheostat to equalize them. Pratt, Read's work was interrupted several times by changes in system requirements as the Navy incorporated new technical developments and wartime experience into its specifications but by V-J Day, the engineering problems seemed to have been solved, and an experimental missile wing, fitted with Yehudi lights, was nearly finished.

The end of the Pacific war ended any further contract work on electrical camouflage. Pratt, Read's contract was terminated. Yehudi apparatus constructed by them and by the Interchemical Corporation was turned over to the Navy's Bureau of Ships. Project Yehudi was laid to rest.[30]

Had anything been accomplished? In an operational sense, no; Yehudi-equipped aircraft never saw combat. But as an example of successful problem-solving, the story is of interest. The original camouflage project undertaken by NRL had amounted to little, since its initiators had set themselves a task beyond the technical capabilities of 1936. Apparently futile, the seed sown at Anacostia eventually bore fruit when war came and such things as camouflage were no longer interesting theoretical projects but matters of urgent need. The Yehudi experimenters profited from the first failure and instead of taking a "whole-hog" approach, they confined their thinking to a single aspect of the aircraft camouflage problem where the illumination principle seemed to have the best chance. They produced a practical result, a suit of camouflage lights that concealed an airplane until it was within effective striking distance from its target.

Ironically enough, radar had canceled out much of its value by the time it became technically practicable.

Yehudi might have been of use to torpedo bombers, forced by the nature of their weapon to fly a straight-in, low-altitude attack run and thus particularly vulnerable to anti-aircraft fire. A warship could acquire attacking airplanes on her air-search radar at a considerable distance but when the aircraft began their attack most defensive gunfire had to be controlled by optics. As late as 1945 a large portion of the Navy's close-in automatic-weapon capability was still guided by the eye rather than by the electron.

However by mid-1944, when Yehudi development was complete, the aerial torpedo was no longer a major U.S.

naval weapon. Many were still in fleet use, employed for practically everything else except dropping torpedoes. Such torpedo-plane actions as those against Japanese battleships MUSASHI in 1944 and YAMATO in 1945 were rare exceptions.[31]

For all the thought and ingenuity and effort that had been put into grappling with a seemingly insurmountable problem and solving it, Project Yehudi never really emerged from the realm of trial and experiment.

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28. "The *Glomb* was a glider designed to be towed long distances by a powered aircraft, released in the vicinity of the target, and guided by radio control in its attack. It was equipped with a television camera to transmit a view of the target to the control plane." (Pearson & Van Wyen, *United States Naval Aviation 1910-1960,* Washington: G.P.O., 1968, p.88) *Glomb* development began in April 1941 at the Naval Aircraft Factory. Existing troop gliders proved unsatisfactory as bomb vehicles, and work then turned to original designs. The LBT was developed and built by Taylorcraft, while Piper built the LBP. Only three Pratt-Read LBE's were produced. War's end curtailed *Glomb* research, and CNO ordered it ended in March 1946.
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ABOUT THE AUTHOR

John C. Reilly, Jr. confesses to a strong liking for history of all kinds, majored in history in university and went back for a Master's in librarianship. He joined the Naval History Division in the Office of Naval Operations in 1967 as historian and is currently working, with a coauthor, on a book about battleships and battle cruisers for the U.S. Naval Institute. His hand in the Division's publications includes providing ship classifications for Vol. IV of the *Dictionary of American Naval Fighting Ships,* appendices for the forthcoming Volumes IV and V, and narrative histories of individual ships as well as a brochure on the development of destroyers. As time allows he is gathering data on floatplanes and the evolution of fire control.

A NAVY B-47?

Thomas Y'Blood, Boulder, Colorado

The Navy acquired two B-47's from the Air Force, 52-410 and 52-412, which I flew when I was in the 376th Bomb Wing. They are now assigned to the Fleet Electronics Warfare Support Group for testing, having been leased to the Navy in 1965 and then taken into the Navy inventory in late 1969. Now based at Tulsa.

QUOTATIONS

I feel that at some point we should make an effort to draw the line — not in censorship but in disgust. Freedom to create in all fields of American life has become broader and broader, and this freedom shoul be precious to all of us. But the freedom to reject is important too. Vulgarity and freedom are not synonymous. Obscenity and freedom are not synonymous. Freedom gives us the opportunity to do and be many things, and it can take many forms.

Ralph Graves
Managing Editor, *Life* Magazine
From *LIFE,* July 4, 1970