VOL. 19 APRIL 1958 No. 2



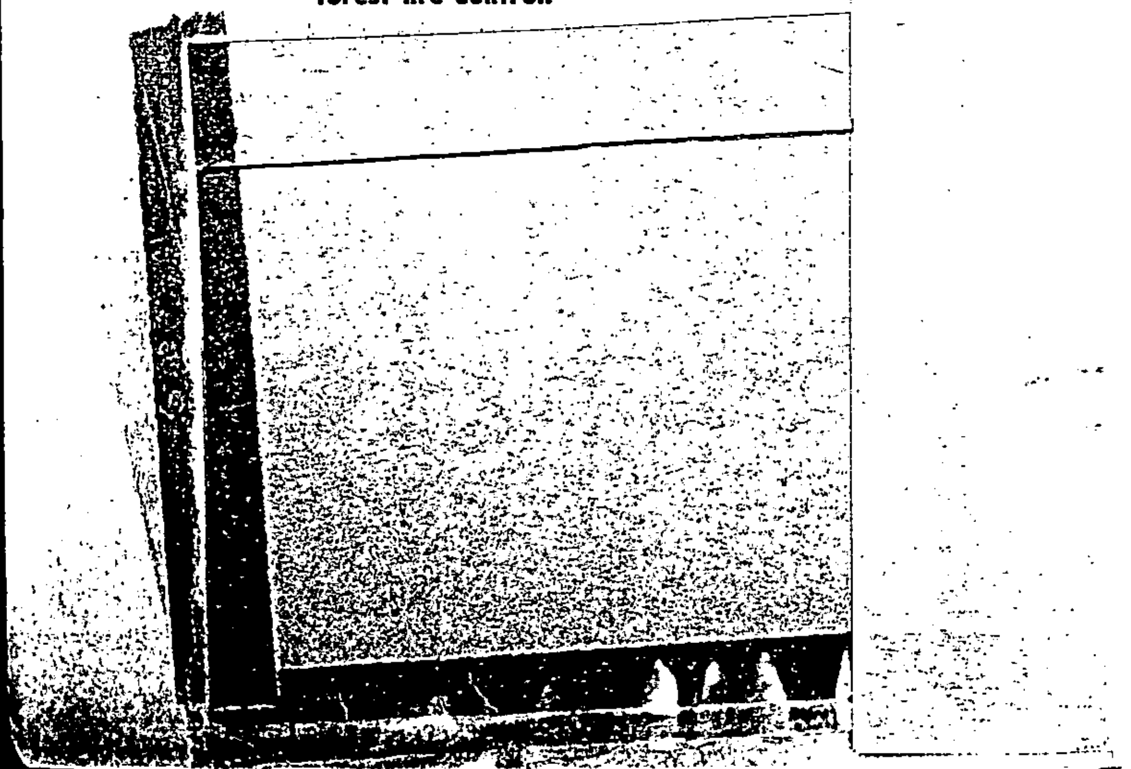
# FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL



FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

**FORESTRY** cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.



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Volume 19 Number 2

# FIRE CONTROL NOTES

## A Quarterly Periodical Devoted to the

## TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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# CONTENTS

# CONTROL OF AIRCRAFT ON FOREST FIRES

Carl C. Wilson
*Forester, California Forest and Range Experiment Station*[1]

[The many new uses of aircraft in fire fighting have posed numerous problems in organizing air operations. This article describes the functions that are necessary for a safe operation and suggests one way of fitting them into the conventional fire fighting organization. This plan has not been adopted as the standard organization by the Forest Service.—Ed.]

If you have flown by commercial airline recently, you must be aware of the elaborate precautions taken to assure that each plane arrives safely and on schedule at its destination. Few controls were needed when Lindbergh made his historic flight, but today major airports are beehives of traffic and rigid air traffic control is essential.

When the first air patrol was organized in California, few rangers could foresee that air traffic over forest fires would ever be a critical problem; today air attack[2] has come of age and airplanes are commonplace over our forests. In 1957 air tankers dropped water and fire retardant chemicals on 101 forest and brush fires, and helicopters delivered specially trained fire fighters to 42 small fires.

## DEVELOPMENT OF AIR ATTACK

The breakthrough in fire fighting techniques involving aircraft probably began in 1919 when Regional Forester Coert duBoise and Major "Hap" Arnold organized a regular patrol for the west side of the Sierra Nevada. It may have started in the early 1920's when serious thought was first given to fighting fire by dropping water from aircraft. It was given a big boost in 1936 when extensive aerial bombing experiments were conducted in California by the Forest Service.

We like to think that modern air attack began during Operation Firestop in 1954 when all sorts of new tools, methods, and techniques were studied in southern California. During this 1-year crash program, helicopters were used to lay fire hose, carry helitanks, and fan backfires. A torpedo bomber dropped 600 gallons of water from its bomb bay on a test fire.

Then in 1955 the Mendocino National Forest demonstrated that a low-flying crop-duster plane could carry and drop as much as 120 gallons of water at a time. Trials on wildfires showed the air tanker could be helpful to the ground forces.

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

This report is made in collaboration with the California Air Attack Executive Committee. The committee coordinates air attack research and development in California. Representatives are from the California Division of Forestry, and from Region 5, Arcadia Equipment Development Center, and California Forest and Range Experiment Station of the U. S. Forest Service.

[2]Tactical air support for ground forest fire fighters.

These trials were so promising that in 1956 a fleet of 7 agricultural-type airplanes became part of the California fire fighting force. These planes fought 25 fires from the Oregon border to the Mexican border by cascading sodium calcium borate and plain water through the dump valve in the bottom of their tanks. Air support was a deciding factor in assuring control of 15 of the 25 fires and was a definite help to ground forces on 5 others.

## OPERATIONAL DIFFICULTIES GROW

But operational problems showed up. Air traffic was hard to control, and it was difficult to coordinate the air arm with the ground forces. These problems were magnified on large fires. For example, air traffic control was extremely difficult on the 10,250-acre McKinley Fire on the San Bernardino National Forest in 1956. In addition to the 7-plane air tanker squad, 1 experimental TBM air tanker, a reconnaissance plane, several cargo ships, 2 helicopters, and many sightseeing craft were over the fire area.

Near misses occurred in the smoke. Scouts in helicopters often were forced to stay on the ground while the air tankers were making drops. Condensation trails from jets blended with the smoke from the fire. An overtaxed fire organization was burdened by the problems of air traffic control, and local forest communication channels were jammed. Fortunately, no air crashes occurred.

As the 1956 season progressed it became more and more apparent that aircraft, like any other specialized fire tool, have to be closely coordinated with other fireline action. When an air tanker attacks a fire, for example, its effectiveness depends on timing and accuracy, and this can be assured only if there are good air-to-ground and ground-to-air communications. The speed of these aircraft further emphasizes the need for careful control.

## CONTROL NEEDS ANALYZED

In February 1957 specialists in ground fire fighting, aircraft, and organization met at the California Forest and Range Experiment Station to plan an organizational pattern for use on fires where there is tactical air support. First, all of the useful air functions that can be performed by long-range transport, short-range transport, attack, and reconnaissance types of aircraft were summarized and classified. Next, present aircraft capabilities were listed for all commercial models, both fixed-wing and rotary-wing craft, that are used or might logically be used by fire agencies in California. These categories were separated by the four types of aircraft already classified.

Fire situations were then classified in terms of changing aircraft requirements. These situations included pre-fire and fire-detection reconnaissance, and Class A and B, Class C and D, Class E, and multiple fires.

The most important part of the analysis job came next, i. e., determining the method of control for particular air operations. Each fire situation was built up from the simple detection needs after a lightning fire to the Class E fire conceivably involving fixed-wing ships to deliver smokejumpers, make cargo drops, and serve as air tankers; and helicopters for reconnaissance, laying hose, dropping water, and delivering helipumpers and manpower.

## NEW ORGANIZATION SUGGESTED

After the aircraft requirements and control problems for each fire situation were reviewed, it was evident that special control jobs had to be performed in each situation. For example, a man was needed to direct aircraft operations on each air mission and on each fire. On a large fire this man might serve under the direct supervision of the fire boss with close liaison with the plans, service, and line units. On small fires the fire boss logically could handle this job.

The primary assignment of this man would be to maintain direct control of all aircraft movements and supervise the officers who direct the airports or heliports within the immediate fire area. He would inform the fire dispatcher of the aircraft needed for missions ordered by the fire boss and maintain records and reports as required. The man chosen for this job should be familiar with the capabilities and limitations of all aircraft used and by all means should be well trained in fire fighting. This proposed assistant to the fire boss would be called an "Air Control Chief."

It was also evident that a man was needed to direct air operations at a specific airport or heliport—a job usually handled in the Forest Service by an Air Operations Officer. This man would orient and brief ground and flight crews and maintain all necessary records. At a commercial airport he maintains liaison with the airport manager. Officers in this job outside of a fire area ordinarily report directly to the central dispatcher. Inside the fire area they report to the Air Control Chief. This man would be called an "Air Traffic Manager."

It was agreed that an "Air Unit Leader" should be selected when two or more aircraft of the same type are assigned to a specific mission. (In California we have used a reconnaissance ship to direct each air tanker to its target. This plane is called the "Bird Dog," and the pilot and his passenger function as the Air Unit Leader.) In or near an airport or heliport this man would report to the Air Traffic Manager. In the fire area he would report to the Air Control Chief.

The interrelationship of these proposed positions and the established fire organization is shown in figure 1.[3]

## PROPOSALS APPRAISED

The proposed organizational pattern was reviewed by representatives of the major California fire agencies, the California Forest and Range Experiment Station, and the Washington Office of the Forest Service, and was approved for field testing during

[3]To assure that these proposed air control jobs function smoothly, the need for good radio communications is emphasized. Often a separate air net will be required.

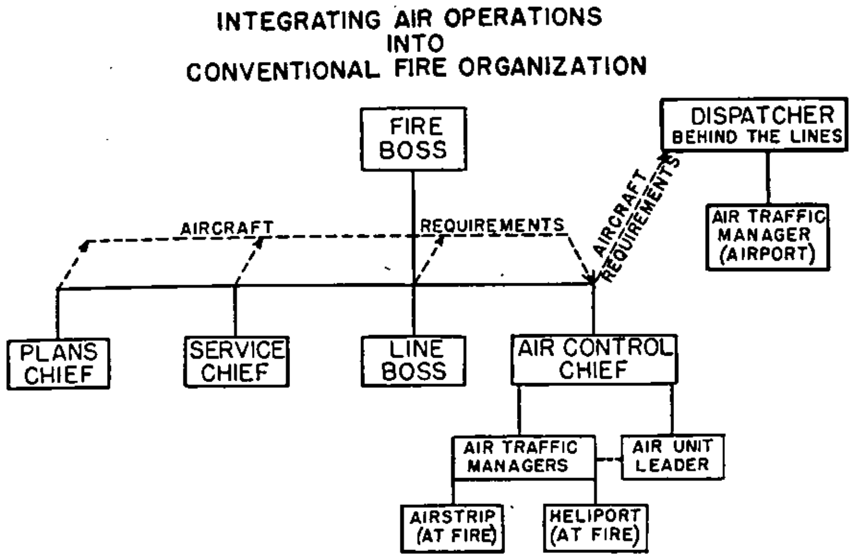


FIGURE 1.—How the suggested air operations positions fit into conventional large-fire organization. The solid lines indicate the direct command relationship in a fire operation. The dash lines show coordinating or advisory relationships. This proposed organization for air operation in fire fighting was field tested in California in 1957.

the 1957 fire season. Reports from the field indicate that there were numerous breakdowns in carrying the plan out. Lack of trained forest officers to fill the new air control positions and inadequate radio communications were the main reasons.

On the other hand, there were reports to show that a well-planned air control organization produces excellent results. One such report by experiment station employee James Murphy demonstrates how such an organization was used effectively on the Angeles National Forest.

"The air arm consisted of 7 air tankers, a 'Bird Dog' plane, and 3 helicopters. The air tankers and 'Bird Dog' were operating out of the Palmdale Airport about 10 miles from the fire. The helicopters used a base heliport near the main fire camp. The situation was critical because there was another major fire on the forest, and some of the aircraft were shuttling back and forth to it. The fire boss assigned an assistant ranger to the Air Traffic Manager job at Palmdale; the Helitack foreman to the Air Traffic Manager job at the nearby heliport; and I became the Air Control Chief. The 'Bird Dog' pilot functioned as Air Unit Leader for the air tankers.

"Here's how we operated: When an air tanker drop was needed on a particular section of line, the fire boss requested the drop through me and gave the location by sector number. I relayed the request to the Air Traffic Manager at the airport, and he assigned the air tankers to the mission. The Air Unit Leader led the ships to the fire. As soon as the tankers were airborne, I asked the heliport Air Traffic Manager to ground the helicopters operating in the drop sector. When the Air Unit Leader and the tankers arrived in the drop area, I notified the Division or Line Boss in that area and he worked closely with the Air Unit Leader in getting the drops where he wanted them.

"When the last tanker made his drop, the Air Unit Leader reported to me (Air Control Chief), and the tankers were cleared to return to the airport. I then notified the base heliport that they could resume operations. It sounds complicated, but it isn't if the communications system operates well. If it doesn't, the safety record can go sour in a hurry."

We know, of course, that the safe way is the most efficient way to fight forest fires. As ground fire equipment became more specialized, we recognized the need for specially trained men to supervise new tools. Cat bosses and pumper bosses are common on most big fires now. On the other hand, we have been slow to see the need for special personnel to direct our new system of air attack. Strict air traffic control is mandatory if we expect to have safe and effective air operations on forest fires. Safety and efficiency are functions of coordination, and coordination is possible only with adequate communications.

# AIRCRAFT SUPPORT OF FIRE CONTROL IN NORTH CAROLINA

R. C. WINKWORTH
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The North Carolina Division of Forestry now owns and operates a small but highly efficient fleet of three liaison type aircraft for fire control purposes. This vital support unit has evolved during the past 9 years from a beginning when field fire control men attempted to satisfy the obvious need for air scouting by authorized use of local aircraft and pilots. Present operations are under established policy which includes planned expansion for the future. This article summarizes lessons learned during this period of development and outlines current thinking on the future use of aircraft in this southeastern State.

At present, air support is used in the presuppression jobs of detection and smokechasing and in several prevention jobs, including fire investigation and law enforcement. In suppression, planes are used for long- and short-range transportation of material and personnel, logistic support of remote ground crews, and scouting. Direct attack is in the experimental stage. Because of the number of large fires, the suppression values of the existing fleet far outweigh those of prevention and presuppression. In the inaccessible areas, particularly of the Atlantic Coastal Plain, scouting service alone more than justifies all costs.

## PRESUPPRESSION AND PREVENTION

Detection from airplanes has proved to be a supplement but not a substitute for detection from towers. The critical factor in successful use of aircraft for various types of patrol service is the fact that the degree of intensity required sharply limits the size of the patrol area that can be covered. This ratio of intensity to area depends upon local conditions and must be established by local experience. For example, use of a patrol plane in high occurrence areas, or where brush and field burning is prevalent, must be restricted to a relatively small area because of time lost in locating and investigating the numerous smokes. Regular use of aircraft in lieu of a group of towers during periods of marginal danger, such as at the beginning or end of fire season, appears to have doubtful economic value in the big woods areas of the coastal plain region. Cost studies showed other parts of the State to be more promising. In contrast, aircraft patrol in specific high-hazard areas following dry thunderstorms and during periods of limited visibility has been highly successful.

Use of a plane to supplement smokechasers in "hot" areas during critical periods has also been of extreme value. By taking station between two or more primary towers, the pilot is able to monitor tower radio traffic. He can pinpoint smokes, identify wildfires, and determine best means of access almost before the smokechaser has time to leave his station. Smokechasers are thus saved unneccessary trips.

Excellent prevention work can be done by use of a plane-to-ground loudspeaker for warning brush and field burners. Doubtful cases are referred by radio to smokechasers for personal warning or assistance. As in smokechasing, the plane takes station in a "hot" area and utilizes the tower radio traffic. The planes are well marked and easily identified from the ground.

Chronic prevention problems require more vigorous measures. Handbills, copies of the fire law, and other prevention messages have been dropped to people in the woods in special prevention campaigns. A very serious deer hunter problem has been eliminated by repeated annual projects of this nature.

The possibilities of radio coordinated air-to-ground law enforcement have not been fully explored. The value of the aircraft as a deterrent to incendiarists is quickly apparent, and results in several areas can be amply verified. North Carolina has not actually sent an incendiarist to court as a direct result of aerial observation but sufficient observations of fires of a questionable origin have been made to develop field procedures which are accepted with confidence. Cameras are carried on all flights and photographic evidence has been used successfully in one critical felony case.

Brush burner law enforcement offers an easier field. Patrolling aircraft happen upon a considerable number of farm fires at the instant of origin, and coordination with the ground smokechaser offers no problem to a well-trained pilot. A polaroid camera has been used successfully to photograph escaping fires as they enter the woods. This type of evidence has been unquestioned in court cases to date.

The key to effective use of aircraft in prevention and presuppression seems to be in restricting the area covered. This concentration must be to such a degree that the local people recognize the aircraft. The Division of Forestry has now adopted a distinctive color scheme for its aircraft with this purpose in mind.

## SUPPRESSION

Scouting of large fires and fires in large inaccessible areas has been the primary aircraft mission since the beginning. Dispatch of a plane to such fires is now automatic. All tractors in the big woods areas are radio equipped and marked for easy identification from the air. They are kept in sight and in communication practically throughout the daylight hours.

At times the fire boss actually directs critical operations from the air. This practice can be overworked, however, and could result in neglect of other important duties. This emphasizes the need for trained pilots and, equally important, trained observers. It also calls for the delegation of responsibility by the fire boss to these key men.

All of the normal scouting functions can be accomplished from the air. In the rough inaccessible swamps of eastern North Carolina the plane is actually the only efficient means of scouting. The time saved is too great to attempt to measure and supplementary ground scouting is seldom needed. By use of two-way radio, amplifier, message drop, polaroid camera, and visual signals, communications are very satisfactory. The success of aerial scouting depends entirely upon the use of the right aircraft and intensive training for pilots, observers, and ground crews.

One of the most vital services performed in scouting work is guiding tractor crews in areas of soft ground and heavy underbrush. In addition to keeping the tractor "afloat," this service makes tractor operation safer by insuring escape routes. Crew morale shows a marked improvement when fire fighters know that the plane will get them to safety in case of emergency and keep them from getting lost or traveling unnecessary distances. The plane observer is literally the eyes of the fire crew. Painting top surfaces of equipment yellow and painting radio calls on the tops of all tractors and other woods vehicles is a must.

Parachute dropping of equipment and supplies from Cub aircraft had to be developed from study of larger plane techniques and knowledge of local needs. A cheap homemade cotton parachute has been designed in 3¾-foot and 7½-foot diameters and has proved highly efficient operationally. Some materials are dropped free fall. Most commonly dropped are hot meals, drinking water, coffee, tools, and spare parts. Practically everything from aspirin tablets to items of clothing have been dropped and a fleet of four tractors was supplied with fuel for several hours on one occasion.

Air transportation has been limited by the normal use of two-place scouting planes, but enough has been accomplished, with help from contract planes, to clearly demonstrate the need for a fast four-place plane. In addition to transportation of key personnel such as project fire overhead and tractor drivers, freight transportation could be expanded to include machinery parts and other heavy or bulky items. The type of plane to be selected would have enough reserve power, weight, and stability to operate from roads and restricted strips in weather that limits normal operation.

A National Guard C-47 has been used on one project fire for long-range transportation of personnel. Tremendous savings of critical time and personal effort were realized. This item of military cooperation has been included in fire plans as a standard practice.

Progress in direct attack by aerial delivery of water, retardants, and other chemicals is being watched with considerable interest. Some preliminary experimenting has been done with packaged and free fall water. Intensive tests are planned by the Southeastern Forest Experiment Station of the U. S. Forest Service in cooperation with States and other agencies in the immediate future. Use of the PBY tanker, operated from water, looks like the best possibility for eastern North Carolina at this time. Aerial attack in some form could be the answer to many of the serious problems.

## TYPE OF EQUIPMENT

The ideal scouting plane should have these characteristics for—

*Observation.*—High wing, two-place, tandem seats, slow speed operation (flaps), fast rate of climb, and good cockpit windows.

*Safe operation.*—Plenty of reserve power, inherent stability, low stalling speed, rugged landing gear, safe cockpit design, and short field takeoff specifications; auxiliary equipment including crash helmets and shoulder straps for the front seat; a bright color scheme on top surfaces for rescue purposes.

*Cross-country flying and sustained operation.*—Adequate speed, good fuel supply, primary instrument panel, landing lights, CAA (preferably omninavigational type) and forest service radio, comfortable and quiet cabin (to lessen fatigue and help communications), and low operating cost.

While no single aircraft will possess all of these features, the Super Cub type has many. Surplus military artillery spotting aircraft would be excellent.

The four-place plane should have as many of these features as possible with emphasis on the safe operating and cross-country ones. Reserve power is a must in fire work and justifies much higher costs in choice of makes and models. Good built-in radio equipment is also a necessity. All planes of the fleet should meet all critical standards, regardless of variations in local needs, so that all equipment can be used without restriction in an emergency.

## TRAINING

Training of pilots, observers, and ground personnel is a never-ending job. Pilots must become rangers to the extent of being able to anticipate and understand what the observer wants to see and the fire boss wants to know. They must understand the fire control organization thoroughly. Low flying in the immediate vicinity of smoke, convection columns, and artificial drafts, and road and strip landing are routine. Even competent crop dusters have much to learn.

The observer is the key man in critical situations and he requires more training than any other man in the entire fire control organization. North Carolina gives formal training to beginners to assist them in mapping, recognizing fuel types, handling communications and drops, and becoming familiar with the aircraft. Only by trial and error over a long period of time can he develop ability to judge rate of spread, flotation of heavy equipment, degree of underground burning in peat bogs, and fire behavior. Personnel must be experienced as fire control overhead and have a love for flying to become qualified.

All regular observers in the North Carolina Division of Forestry are being given pilot training. In addition to the obvious advantages of safety and aircraft familiarization, this program is aimed at alleviating the serious problem of pilot fatigue on project fires. Routine flights, such as trips for fuel and supplies, will be flown by substitute pilots.

Ground crews must be trained to understand the limitations of the aircraft, to handle communications, including emergency signals in case of radio failure, to receive drops safely, and to make full use of the plane and observer. This is accomplished as part of the curriculum at regular annual ranger training schools.

## HELICOPTERS

The practical use of the helicopter as an operating aircraft in North Carolina is still in question because of the tremendous cost difference and pilot skill required. A highly trained and experienced crew in a Super Cub can accomplish almost as much in aerial scouting as can a helicopter and with several advantages, including an operating cost about 5 percent of that of the helicopter.

Military helicopters have been used on fire work in the State for about 7 years. Such services as crew delivery and relief in inaccessible areas, rescue operations, hose laying, and direct pumping cannot be approached by fixed wing aircraft. But purchase of a conventional helicopter by the State is not anticipated in the near future.

A new design one-man rotor type aircraft that works on the old autogyro principle (no power to the rotor) is now available at a low cost. Very little is known about its performance as it is still in the developmental stages. But it is a fact that it can be transported in a station wagon, flown safely by any pilot after a brief checkout, and operated at the cost of a Cub. It is designed for tree-top use and can be slowed to about 15 miles per hour (cannot hover). Present flight range is about 2½ hours. Development of this craft is being watched closely.

## ADMINISTRATION

Past experience and lessons learned from others have established a few principles of aviation administration that North Carolina personnel have accepted:

1. State-owned aircraft and regularly employed pilots allow a standard of quality and safety unobtainable from contract flying. When justified, maintenance men should also be employed.
2. Because the plane is a fire control tool, all flying operations should be supervised by fire control officers, not set apart in a separate branch of the organization. Operational supervision should be under appropriate field overhead. Maintenance, CAA regulation, certain aspects of training, and other administrative procedures and policies should be delegated by the fire chief to one central office administrator.
3. The central office administrator should be responsible for keeping written policy current and for future planning. All policy must recognize that the pilot is captain of his ship.
4. As a matter of good practice, all administrative personnel dealing with aviation should become pilots.

## SUMMARY

An effective program of aircraft support for fire control operations has been developed in North Carolina. Its success has been due to good equipment, highly trained personnel, careful operational use, and written policy. The morale factor which results from a flow of information from the air to fire fighting crews is in itself an important development. With keen administration, careful research, and vision, the probable future growth of aviation as a fire control tool in the Southeast is almost unlimited.

# AIRPLANES FOR DIRECT ATTACK ON FOREST FIRES IN THE NORTHEAST

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Airplanes have been used in forest fire control activities in the Northeastern States for many years. In Maine, for example, a hired plane was used as early as 1927 for detection and observation. Since 1933, State-owned and rented planes have been extremely useful in detection work, in scouting going fires, and in transporting men and equipment to fires in areas not easily accessible by road or trail. However, so far as I have been able to learn, airplanes have not been used in direct attack on forest fires in any of the Northeastern States.

A lively interest in the use of planes for dropping water and chemical retardants is being shown by several State forestry departments and fire control personnel in Region 7 of the U. S. Forest Service. There is also interest in helicopters for specialized use. New York State has tentative plans to acquire a plane for use in dropping water or chemical retardant on fires. Maine is reportedly considering the purchase of a helicopter. Forest Service officials in Region 7 are making preliminary plans with the States to obtain equipment and stage demonstrations of direct air attack.

Devastating forest fires will occur in the Northeast when conditions are right for such fires. One area in particular has a history of fires that have crowned and spread rapidly over large acreages. This area embraces about 4 million acres of rather flat land along the Atlantic coast, extending from the vicinity of Machias, Maine, through southern New Hampshire, eastern Massachusetts, Rhode Island, Long Island, and the pine region of New Jersey, to the Eastern Shore of Maryland. The soils in this area are mostly sandy and droughty. Humus types are mostly mors, which means the forest litter accumulates on the soil surface rather than being incorporated as humus. Hard pines, white pines, and various oaks, mostly of scrubby form, make up the bulk of the stands.

Over considerable portions of the coastal area mentioned above, real-estate development in rural wooded sections is advanced. This development consists of yearlong residences, summer homes, and an increasing amount of industry, which in recent years has tended to locate away from urban centers. Much of this real estate is subject to destruction by fast-moving crown fires, and human casualties are a definite possibility.

In view of the relatively level terrain and the generally low tree heights, airplanes could operate very effectively in the coastal areas. Recent reports indicate that under certain conditions, chemical fire retardants dropped in advance of a crown fire in second growth have succeeded in bringing the fire down out of the crowns so that ground crews could attack directly. In the Northeast it may be possible to knock down some fires in this manner. If prompt air attack were made on incipient fires in hazardous areas, when warranted by burning conditions, many of these fires which might otherwise escape from initial attack should be controlled without difficulty. In dealing with surface fires the plane would drop water or chemical retardant directly on the advancing edges of the fire. Ground crews would of course complete control and mop-up.

Airplanes for direct attack should be tried in this Coastal Plain area. Tests should include drops of both plain water and chemical fire retardants; and insofar as possible they should cover the major fuel types under a variety of weather or burning conditions.

Due to similarity of terrain and cover, a test in any one locality should be fairly indicative of what can be accomplished throughout the northeastern Coastal Plain. McGuire Air Force Base and Lakehurst Naval Air Station are both located within the high-hazard pine region of New Jersey. It seems quite probable that arrangements could be worked out to use their facilities in conducting tests in this area.

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## Airplane Helps Catch Incendiarist

March 5, 1956, on the Poplar Bluff Ranger District in Missouri started as an uneventful day of an average fire season. No fires had occurred in the morning and none of any consequence were expected.

At noon that day two 22-year-old country boys, with criminal records, were eating lunch at a highway cafe and planning their afternoon activities. And Missouri Conservation Commission Pilot Bob Larkins was in the air patrolling the State-protected land west of the Shawnee National Forest.

An hour later the 2 boys parked their car, went north of the main highway, and set 2 fires. They crossed the highway and walked about a mile east through the woods where they made the third set. Then for approximately 2 miles in a southeasterly direction they set fires every 25 to 50 yards.

Within minutes after the first set, which was discovered by a Forest Service lookout, crews were dispatched to the fire and others were being organized. As Ranger Paul R. Larsson and the headquarters fire crew reached the fire, they received word by radio that Pilot Larkins was scouting the fire and had seen the two men making a set. The pilot added that he believed he could keep one of the fire setters in sight and that if someone would come to the vicinity he was circling there would be a good chance of catching him.

By a circuitous route of about 7 miles by car and then on foot, Ranger Larsson arrived below the plane which was circling just above the tree tops. On the ground, with his shirt off and his face buried in the leaves and needles, lay the fire setter. Pilot Larkins shouted down to the ranger, "That's him!"

The fire setter was taken to the ranger station and turned over to the FBI. His trial will be held in Federal court after he has been released from the State penitentiary where he is serving a 2-year sentence for a crime committed before his fire-setting spree.

This is an excellent example of airplane and ground coordination as well as cooperation between the State and Federal organizations.—*Shawnee National Forest.*

# WATER DROPPING FROM FLOAT-EQUIPPED PLANES

*Ontario Department of Lands and Forests*

Development of equipment for dropping water from float-equipped aircraft in Ontario dates back to 1944-45. At that time a system of valves was built into the floats of a Norseman aircraft to enable the pilot to take water into the floats while on a lake and release it as required while in flight. This system was abandoned for several reasons, the main one being the inability to make a drop in sufficient bulk.

By 1950 we had developed a water bombing technique. This involved the use of latex-lined paper bags each filled with 3 imperial gallons of water, dropped in salvos of up to eight bombs from a roller conveyor mounted in the floor of the Beaver aircraft fuselage, the drop being made through the camera hatch.

Our most recent development, the installation of a 90-gallon rotating tank on each float of the DeHavilland Otter, is briefly summarized in this article. The tanks and control system were developed by the Air Service Division of the Ontario Department of Lands and Forests at Sault Ste. Marie, Ontario. The primary aim was "To drop the greatest possible amount of water in the shortest possible time with a minimum delay in pickup and assembly, the whole operation to be handled by one man—the pilot."

The "greatest amount of water" was governed by the weight load capacity of the aircraft. The time it took to release the water depended on the size of the discharge opening which, since the aircraft would be moving at approximately 120 feet per second, would have to be quite large if the water was to be concentrated at the target.

Investigations proved that the maximum discharge area allowable with an internal tank emptying through the camera hatch in the rear of the fuselage was 150 square inches. This was obviously insufficient. The port cargo door was then considered as an alternative and we built an internal mockup tank which allowed an opening of 400 square inches. This was still not considered satisfactory. We also had the problems of release mechanism and floor anchorage.

Because of these problems and limitations, the internal tank was abandoned in favor of two rotating tanks carried externally. This system offered the following advantages: (1) Total discharge area of 1,400 square inches; (2) carrying the tanks would not interfere with normal operation and load capacity of the aircraft; (3) no appreciable change in the center of gravity of the aircraft; (4) it could be applied to both Beaver and Otter aircraft which make up our air fleet.

Each tank, made of 0.081 half hard aluminum, is 6 feet long and 22 inches in diameter. The opening is 10 inches wide and runs the entire length of the tank (fig. 1). Total capacity of each

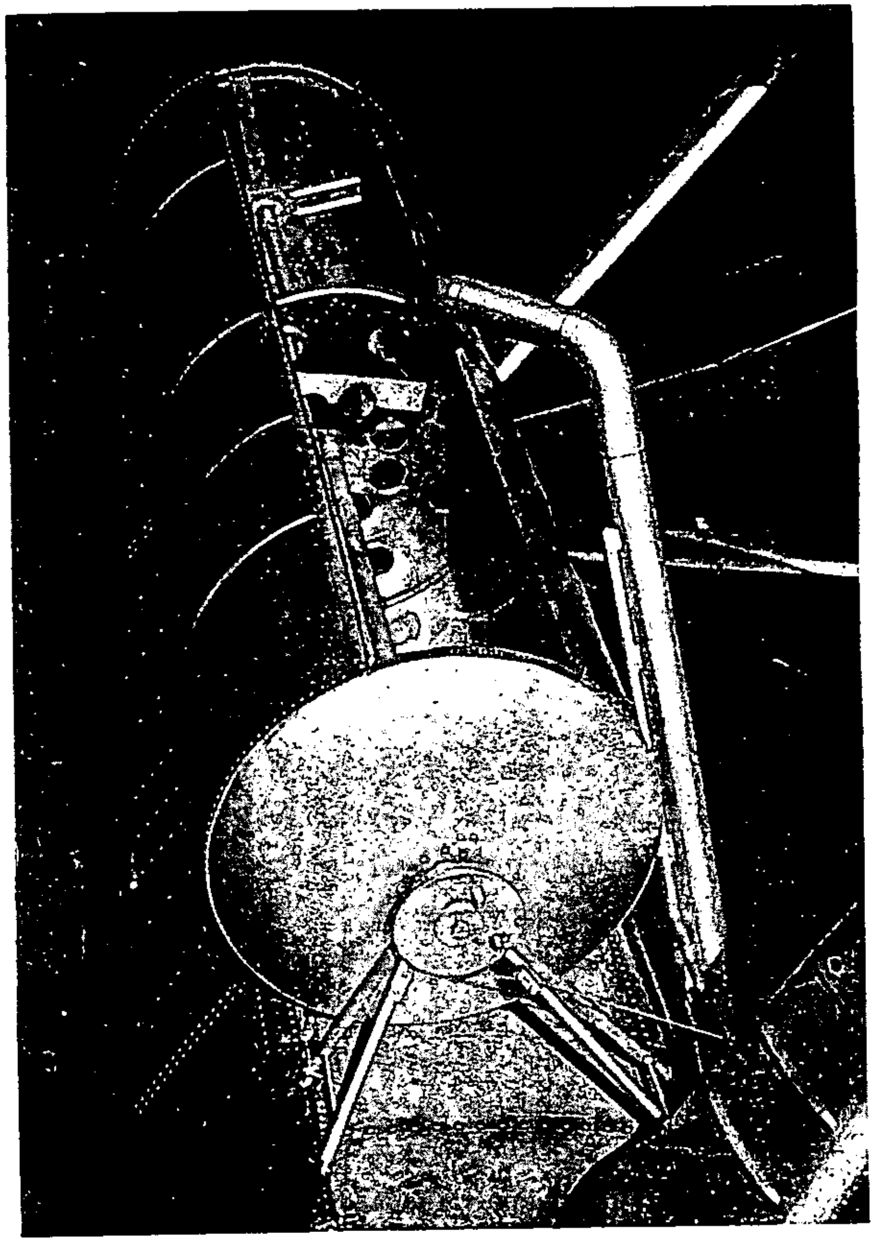

FIGURE 1.—Front view of starboard tank.

tank is 97.5 imperial gallons, operational load is 80 imperial gallons. Tubular frames support the bearings and provide attachment points to eye bolts mounted permanently on the floats.

The two filling scoops are made of 2½-inch-diameter steel tubing welded to a tubular frame attached to the float at the beaching gear lug and supported by two additional eye bolts at the top of the float. Each scoop is removed by the withdrawal of the clevis pins from the eye bolts.

The tanks are filled in 10 seconds at an airspeed of 40 m. p. h. under calm conditions. Total time from "touch-down" empty to "take-off" full (wind 5 m. p. h.) is 18 seconds.

The tanks are rotated by means of a lever on the floor of the cockpit at the pilot's right hand. This lever actuates control cables connected to 5½-inch aluminum pulleys fixed to the front end of each tank axle. The tanks return to the upright position when the control lever is released.

Although the tanks do not interfere greatly with the normal operation and load carrying capacity of the aircraft, they can easily be removed. Two men can install the tanks in 10 minutes. Total weight of tanks and scoops is 175 pounds. The tanks can easily be carried inside the aircraft.

## FIELD TESTS

Field tests were needed to determine pattern and density of water distribution. Several 160-gallon drops were made from an estimated height of 100 feet to a dry concrete surface (fig. 2). In addition, two drops were made with part loads equal to the carrying capacity of the Beaver aircraft (50 gallons per tank). For various flight directions in relation to wind, the water pattern had the following dimensions, with the longer along the flight line:

| | | *Pattern* | |
|---|---|---|---|
| | *Wind velocity (m. p. h.)* | *Length (feet)* | *Width (feet)* |
| 160-gallon drop: | | | |
| Into wind | 10 | 285 | 85 |
| Down wind | 10 | 315 | 85 |
| Cross wind | 2 | 375 | 75 |
| Cross wind | 8 | 260 | 100 |
| Cross wind | 16 | 285 | 135 |
| 100-gallon drop: | | | |
| Into wind | 10 | 320 | 90 |
| Cross wind | 8 | 260 | 100 |

Observations indicate that although the area of greatest saturation for a given height varies little under the above wind speed range, the wind does blow the lighter spray a considerable distance when no trees are present to intercept it.

An arrangement of rain gages set out in an open field, under a coniferous cover, and in a hardwood stand provided specific measurements of water density. Each area was subjected to ten drops into the wind aimed at a target in its center. The 25 rain gages in the open field, where wind velocity was 5-7 m. p. h., showed traces of water as far as 75 feet out on both sides and almost 300 feet along the line of flight.

The coniferous stand, typical black spruce-balsam fir, had 460 trees per acre with an average diameter breast high of 7.6 inches and an average height of 78 feet. The 24 rain gages were placed at 10-foot intervals in four rows 10 feet apart. Ten drops were made at 3-minute intervals from an estimated height of 100 feet.

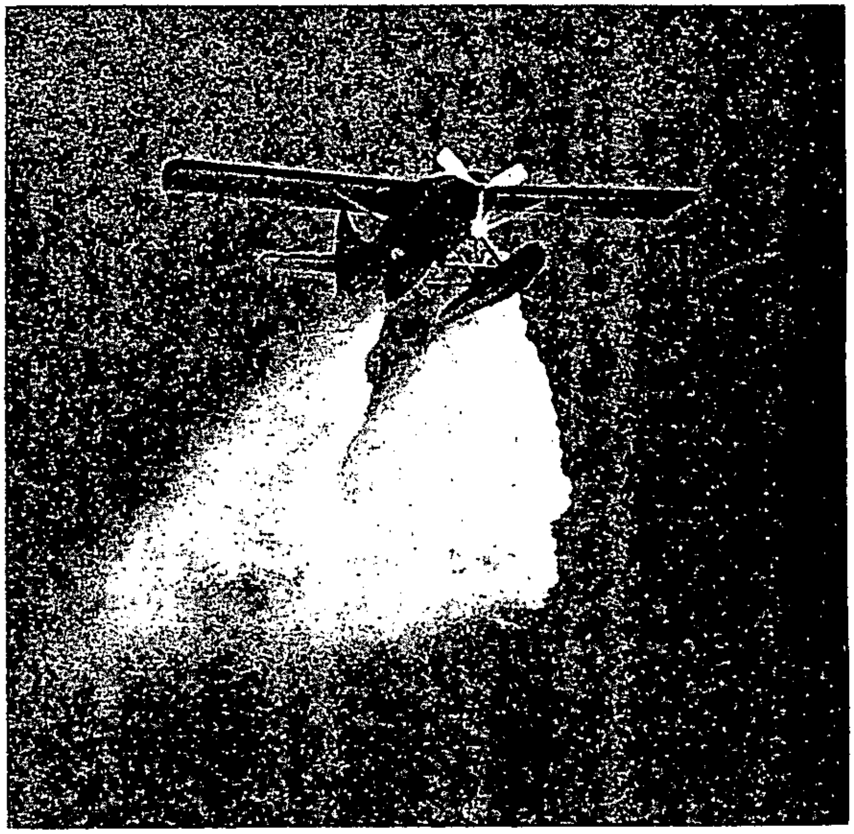

FIGURE 2.—Water drop from tanks on the floats of an Otter aircraft.

Relative humidity, taken at intervals in the center of the target area beneath a large tree, rose from 65 to a maximum of 87 percent. After the fourth drop, a steady dripping of water from the trees similar to that experienced during a brisk rain shower continued throughout the test period and for 30 minutes after the last drop, at which time the relative humidity had decreased to 69 percent. Water density varied from 0.025 in some gages at the outer edge of the 30-by-50-foot target area to 0.25 toward the center. Distribution in general was fairly uniform, with an average density of 0.085.

The hardwood stand had 1,980 trees per acre with an average diameter breast high of 2.9 inches and an average height of 27 feet. This was an immature stand of aspen with scattered white spruce and birch having an understory of balsam fir and scattered willow, alder, and mountain maple. Here also the 24 rain gages were set out at 10-foot intervals in four rows 10 feet apart.

Ten drops were made at approximately 3-minute intervals from an estimated height of 75 feet. Trees in the center of the target were swayed violently by the impact of the water. After the tenth drop, the target area was completely saturated. Relative humidity in the target area rose from 73 to 93 percent after the third drop. Water density recorded by the gages ranged from 0.03 to 0.40 and averaged 0.225, about 2½ times that for the coniferous stand. Except for a few gages, water was very well distributed.

## CONCLUSIONS

The factor that most influences water pattern and density is altitude. The lower the aircraft is flying at the point of release, the greater the knockdown effect of the water, the greater the density, and the smaller the area covered.

The trajectory of the water mass changes progressively as the water meets the resistance of the air, breaking up into smaller and smaller particles which do not maintain the initial forward speed but are increasingly affected by wind and gravity.

In practice, the direction of the dropping run will depend on topography, forest type, and smoke conditions. A rough formula for drift when dropping from a height of 100 feet above the ground is 8 feet of drift per mile per hour of wind regardless of the direction of flight, for example, when dropping from 100 feet in a 10-m. p. h. wind, the pattern will be offset 80 feet in a downwind direction.

The immediate tendency is to judge the potential of this equipment on the effect of a single drop. This, is like assessing a machine gun on the effect of a single round fired from it or judging the potential of a backpack pump on a single filling.

The total effect of the equipment must be measured by the number of gallons of water delivered to the fire in reasonable operating time. This obviously varies with the distance the aircraft must fly to the water source. The accompanying tabulation shows the number of loads per hour and the total gallons per hour that may be delivered under average conditions. Under adverse conditions or hilly terrain the delivery rate will vary slightly.

| Distance of fire from nearest landable lake (miles): | *Water delivery per hour* | |
|---|---|---|
| | *Imperial gallons* | *Loads* |
| 1 | 2,900 | 18.1 |
| 2 | 2,100 | 13.1 |
| 3 | 1,640 | 10.2 |
| 4 | 1,325 | 8.2 |
| 5 | 1,125 | 7.0 |
| 6 | 975 | 6.0 |
| 7 | 850 | 5.3 |
| 8 | 775 | 4.8 |
| 9 | 690 | 4.3 |
| 10 | 625 | 3.9 |

The tabulation may also be used to determine the number of aircraft that should be engaged on a fire or sector of a fire. For example, if the nearest water source is 2 miles away, one aircraft can drop 2,100 imperial gallons per hour, whereas it would take two aircraft to deliver at approximately this rate if the water supply were 6 miles away.

The most valuable features of this equipment are—

1. The speed at which the tanks can be refilled.
2. The whole operation is conducted by the pilot alone.
3. The equipment can be used simultaneously and in conjunction with other control measures without danger to the fire fighters.
4. The equipment may be carried at all times either in the operating position or within the fuselage of the aircraft (two men can complete the assembly in 10 minutes) without undue interference with the ability of the aircraft to perform other work.

A blender unit is presently being considered to introduce a wetting agent into the water as it passes through the intake pipe. Due to the abundance and convenient location of water, the addition of chemical fire retardants is not being considered for the present at least.

Construction of water dropping tanks and fittings for all six Otter aircraft has now been completed. Experimental work on Beaver adaptation has also been completed and plans are now under way for manufacture of the units.

Although it is realized that this may be only another step forward toward a better means of aerial fire attack, the future for this new development is extremely bright. Inquiries regarding further detail are welcome and should be addressed to the Division of Forest Protection, Department of Lands and Forests, Parliament Buildings, Toronto 5, Ontario, Canada.

# AIR TANKER REPORT—CALIFORNIA, 1957

HARRY R. MILLER, *Forester, California Forest and Range Experiment Station,*[1] and H. P. REINECKER, *State Forest Ranger, California Division of Forestry*

In 1956 air tankers became a reality as tactical support for ground fire fighters in California.[2] They demonstrated their value as a new fire tool with great success. They also showed they had many limitations.

In 1957 the number of fires on which air tankers were used quadrupled, as did the number of air tankers available for use:

| Plane type (capacity): | | *1956* | *1957* |
|---|---|---|---|
| Stearman and N3N (100-180 gallons) | number | 7 | 20 |
| TBM (400-600 gallons) | do | 1 | 4 |
| PBY (1,500 gallons) | do | 0 | 1 |
| C-82 (2,000 gallons) | do | 0 | 1 |
| Fires attacked | do | 25 | 101 |
| Water dropped | gallons | 83,000 | 125,000 |
| Retardant dropped | do | 66,000 | 500,000 |

This expanded use provided an opportunity to study the limitations of air tankers and to determine what must be done to make the most effective use of this new tool. Since the aircraft were used on fires throughout the State, a large variety in fuels, topography, and burning conditions was encountered.

## AIR TANKER EFFECTIVENESS

Analysis of reports indicated that air tankers were completely effective on about 25 percent of the fires; that is, all drops either extinguished the fire or retarded it so that ground forces were able to complete control. On 65 percent of the fires effectiveness varied widely. On the remaining 10 percent all drops were termed non-effective.

Fire bosses said that the air tankers were generally most effective on initial attack. The small fire offered less opportunity for misplacement of drops. If the fire was not extinguished, the air drops held the fire down until ground crews arrived.

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. This report was prepared in collaboration with the California Air Attack Executive Committee, which coordinates air attack research and development in California. Representatives are selected from the California Division of Forestry and from Region 5, Arcadia Equipment Development Center, and California Forest and Range Experiment Station of the U. S. Forest Service.

[2]Ely, Joseph B., Jensen, Arthur W., Chatten, Leonard R., and Jori, Henry W. *Air Tankers—A New Tool for Forest Fire Fighting.* Fire Control Notes 18 (3): 103-109, illus. 1957.

On larger fires the air tankers helped secure control and held burned acreage to a minimum by dropping on key points such as running fingers, spot fires, and slopovers. In some places, where inaccessibility or lack of time had prevented mechanical construction of firebreaks, borate lines were laid down by the air tankers ahead of the fire and successfully retarded the spread of the fire. These lines were generally most successful in the lighter fuels.

## AIR TANKER LIMITATIONS

*Ground action.*—Practically all air drops had to be backed up by ground action. Delays in ground action frequently resulted in loss of temporary control gained by the air tankers.

*Interception by fuel canopies.*—Interception by dense brush or timber canopies reduced the effectiveness of air drops on ground fires. Two or more drops on the same spot were often necessary to penetrate the crowns and hold the fire. Crown fires in these canopies, however, were often knocked down by accurate drops, thus permitting ground forces to move in.

*Topography.*—Rugged topography adversely affected the height and direction of flight, airspeed, and accuracy of drop placement.

*Winds.*—Strong or gusty winds prevented low approaches at minimum speeds and caused drift or complete dispersal of the dropped material.

*Radio communication.*—Many field reports stated that the air tankers would have been more successful if radio communications had been available. "Bird-dog" planes flying experienced fire personnel were of great help in visually directing the placement of air tanker drops but did not completely fill the need for direct air-to-ground and air-to-air contact with each pilot. The need for direct communication to each air tanker pilot was especially noticeable on larger fires where close support of ground action was required. Uninstructed pilots often made their drops on the hottest burning spots. These spots were frequently inside the fire front and presented no real threat. Lack of communication also affected air safety, which was of critical importance on large fires where close control of the various types of air activity was necessary.

*Pilots.*—Many reports again emphasized that all air tanker pilots should receive basic instruction in fire control strategy and tactics and fire behavior.

*Air tanker facilities.*—The round-trip time for the air tankers also affected their efficiency. Distance of refill ports from the fireline and limited facilities at these refill ports added to round-trip costs. Planning of such facilities is urgently needed to eliminate confusion and loss of time when staging a large air attack operation (fig. 1).

*Air tanker design and mechanisms.*—Continuing investigation and improvement in air tanker design is another need. Some of the existing gate sizes and opening mechanisms proved to be inadequate. The ability of tankers to make multiple drops was found to be desirable at times (figs. 2 and 3). Pilots with such

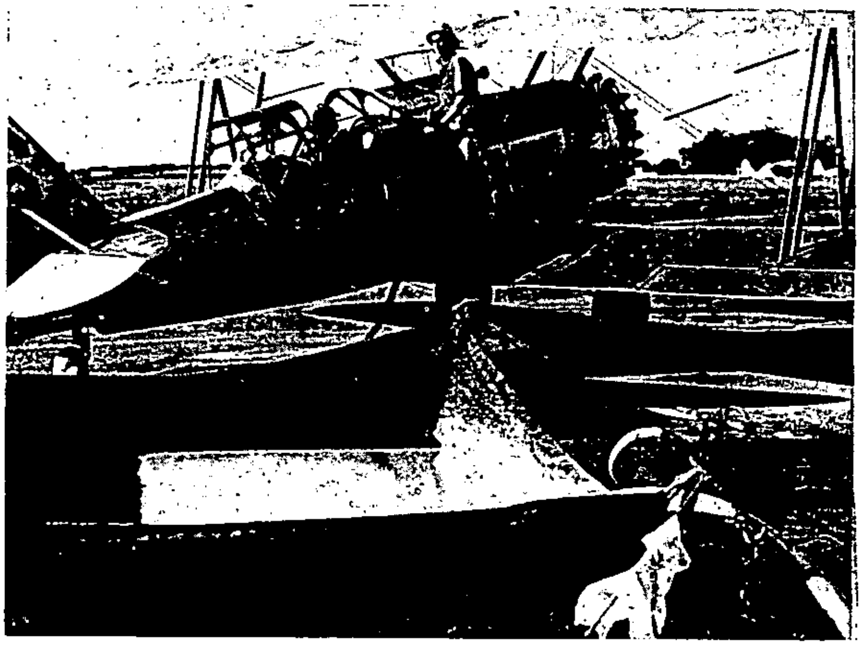

FIGURE 1.—N3N taking on load of borate from a portable refilling station.

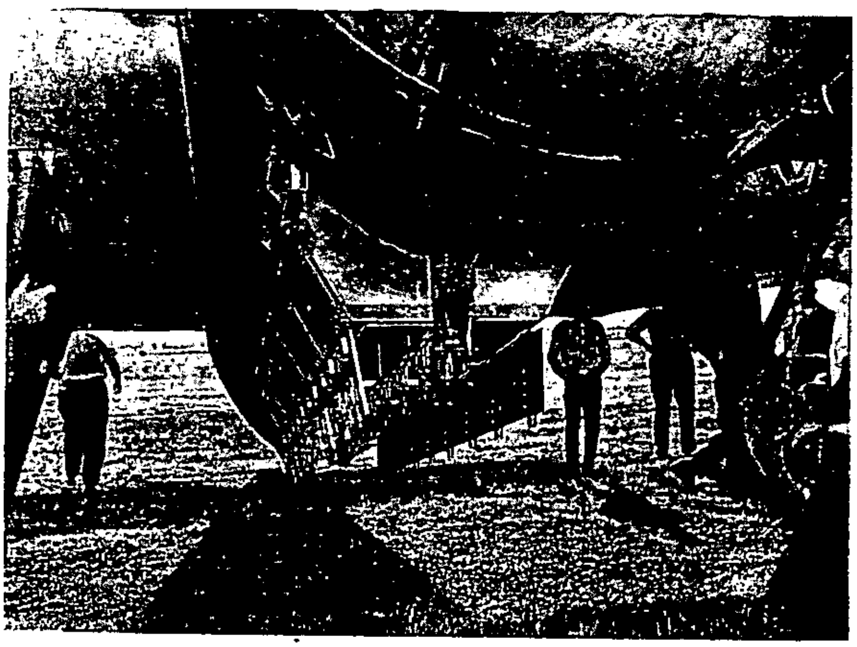

FIGURE 2.—TBM tank designed and built by the California Division of Forestry.

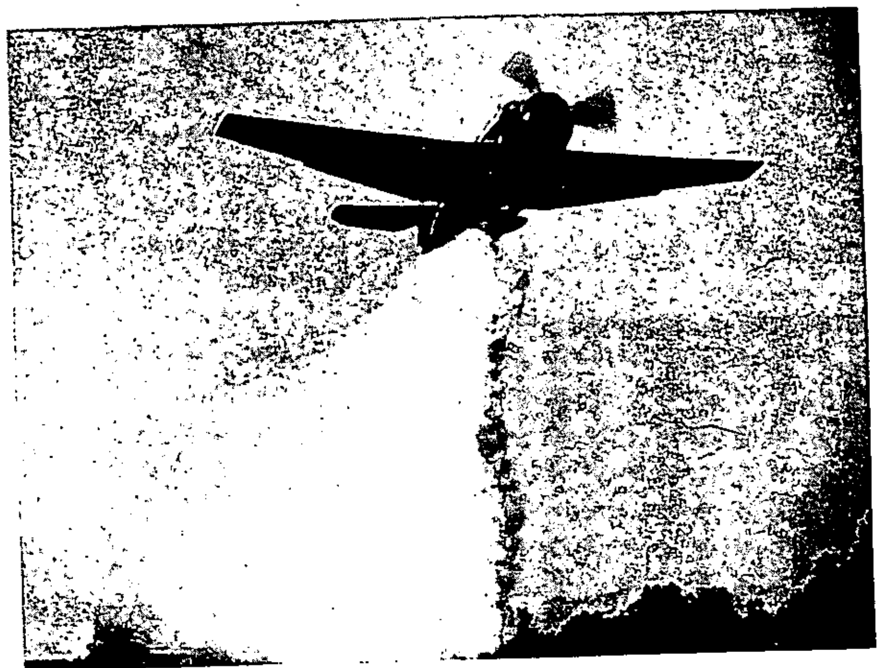

FIGURE 3.—TBM with California Division of Forestry tank making drop.

planes were able to release the amount of material needed for a given situation, either to test wind effect or to drop on a fire of certain size and heat volume. To be effective, however, it was necessary that the amount of material released in each drop be matched with the airspeed so that the material reached the ground in sufficient quantity.

*Dispatching.*—Air tankers often were dispatched to fires after control had been achieved by ground action. In many situations fire bosses believed that if the air tankers had been dispatched earlier, the fire could have been controlled at much less cost in suppression effort and values destroyed.

## AIR TANKER COSTS

Rental for air tankers is not low. Considering the additional costs of fire retardants and of personnel necessary to handle ground and air operations, tankers can be an expensive tool. The decision to use them must be made with great caution by budget-minded administrators. This decision is of utmost importance when we stop to consider that in California approximately 95 percent of all fires are controlled in the "A" and "B" size classes with current equipment and methods of operation. Reviewing the past two seasons of air tanker use, it is apparent that much more study will have to be made of costs and returns before we can specify the proper time and place for their use.

# 1957 AERIAL-TANKER PROJECT FOR REGION 6

ROBERT M. BEEMAN
*Fire Control Officer, Wenatchee National Forest*

The Wenatchee has 2 million acres lying east of the summit of the Cascade Mountains to protect from fire. From east to west, fuel conditions change from steep cheatgrass slopes along the Columbia River to typical open ponderosa pine forest, through dense lodgepole pine stands, and into the typical heavy fuels of the Douglas-fir-hemlock type. Three hundred thousand acres at higher elevations have no fixed detection. Fuel types there vary from dense fir timber in the valley bottoms to scattered subalpine clumps at higher elevations, and the terrain is often rugged and precipitous.

Lightning and man-caused fires are generally evenly divided in number. In 1956, however, we had 200 fires of which 160 lightning fires occurred within a 10-day period. Forty of these were handled by smokejumpers. The man-caused fire season lasts from early April into November, with debris-burning fires the early problem and hunter fires the late problem.

In 1957 the Wenatchee conducted a pilot aerial-tanker project financed by Region 6. The operator of a local agricultural aerial spraying service gave us space for installation of borate mixing apparatus (fig. 1), and devised and installed a gate release valve on two of his planes at his own expense (fig. 2). The

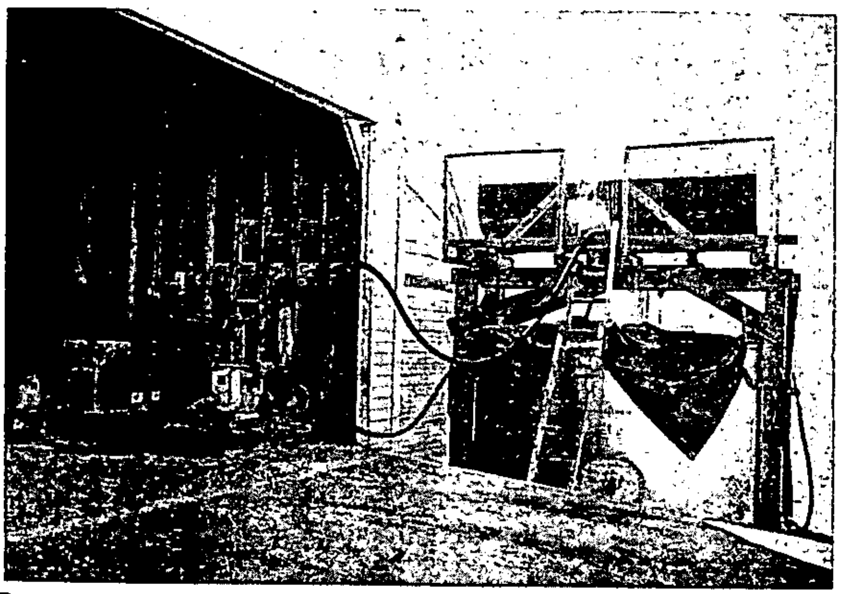

FIGURE 1.—Slurry mixing setup. Borate storage on left. Water storage in large bottom tank. Slurry storage in 1,200-gallon tank on top.

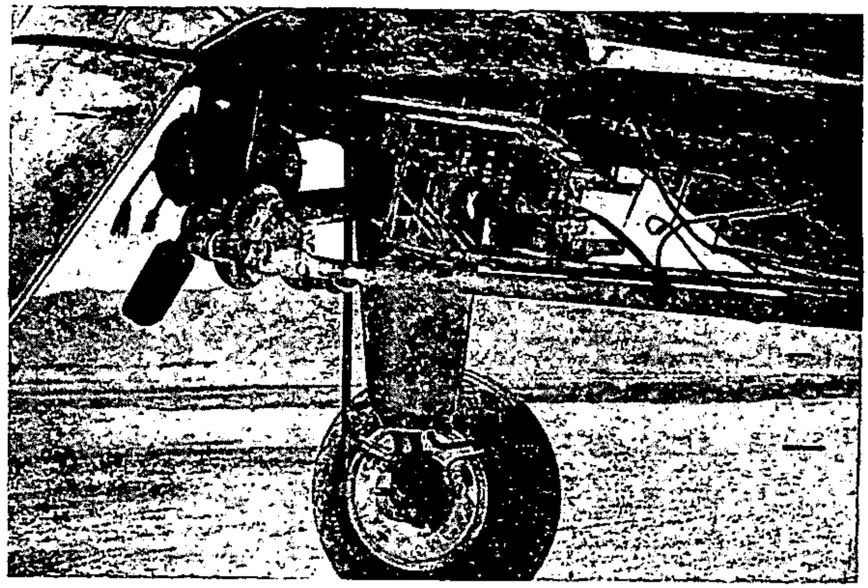

FIGURE 2.—Gate release valves. Pilot can use any of three opening sizes. When the large-sized opening is opened and closed quickly, 2-second dumps of 30 gallons can be made. This is advantageous on small fires.

Piper Super Cub could operate safely with only 60 gallons of borate slurry, but it carried enough fuel for a 4½-hour flight; this permitted rapid dispatching to distant back-country smokes. The Stearman could operate safely with 100 gallons of slurry, but carried enough fuel for only a 1¼-hour flight. We made no commitment on minimum hours of use for the planes, and no standby time was paid. Actual flying time cost $120 an hour for the Stearman tanker, $90 for the Super Cub tanker, and $21 for the Super Cub reconnaissance plane.

Our instructions were to use the tankers on a variety of fires over the full spread of our fuel types and terrain conditions. A light fire season resulted in tanker attack on only seven fires. However, these seven gave a good spread. Two were fast-moving cheatgrass fires on steep slopes. One was an operator fire in selective logging slash. One was a fast-moving dry lightning fire, another a high-country hunter fire in the subalpine type.

The largest of the 7 fires was a 60-acre railroad fire burning on a steep slope in dense second-growth Douglas-fir. Aerial attack by the 2 tanker planes, dumping 400 gallons of borate slurry and 520 gallons of wet water on this hot crown fire, did not knock it out of the crown completely. Fire overhead generally agreed, however, that the aerial tankers were the decisive element of the attack in that they prevented the fire from blowing up and spreading over 2 to 10 times the 60 acres. The dumps were made first across the top of the fire about 50 yards ahead of the flames, and then down the hottest flank. Consistently, as the moving crown fire hit the treated strip, it slowed down for a few minutes. This checking of the rate of spread was just enough to permit the 75-man control crew to complete their lines and burn out, with control accomplished at 11:45 p. m. of the day the fire started.

The 2-acre dry lightning fire occurred in ponderosa pine second growth on a moderate slope and with a 20 m. p. h. wind. One Super Cub tanker plane, 4 smokejumpers, and an 8-man ground crew all arrived on the fire at about the same time. The first dump of 70 gallons 30 to 50 feet ahead of the fire, applied in 2 passes, prevented further crowning.

The 6-acre grass fire occurred on a 60-percent southeast slope with a 12-mile west wind. The Super Cub dumped two 90-gallon loads of wet water, the first load across the top and the second down the hottest flank. The dump was made directly on the fire edge and dampened it down quite thoroughly. There is no question that aerial-tanker attack on a fast-moving grass fire is highly effective.

The 2-acre, high-country hunter fire picked up by aerial patrol was just starting to crown in subalpine timber on a 40-percent slope. One dump of 100 gallons of borate slurry by the Stearman knocked the fire down so that it had not spread farther when the smokejumpers arrived 30 minutes later.

A unique use of the aerial tankers was made on an October cheatgrass and sagebrush fire of 50 acres. The fire moved rapidly up a steep slope and threatened the hangars of the Wenatchee Air Service at which our tanker project is based. The Air Service manager promptly loaded up the Super Cub with wet water and the Stearman with borate and dumped five loads of each on the approaching fire. By the time the rural fire department arrived, the fire had been completely stopped with no property damage done.

Our borate slurry mixing technique is the same as that developed in California (fig. 1). By placing the slurry storage tank about 12 feet above the ground, we have enabled the pilot to pull in his plane alongside and load by gravity (fig. 3). The gate release mechanism gave us flexibility in application, permitting more effective use of the borate or wet water on light fuel grass fires and also on small lightning smokes. Despite the high cost of plane rental and of the mixed borate slurry, the use of aerial tankers on fires of this type is economical. Although our experience with aerial tankers is limited, we have listed tactics to be employed and key points to be considered in meeting our conditions.

## TACTICS

*Lightning smokes and other small fires.*—Either wet water or borate is effective. Use the large gate opening and make several passes, with the pilot opening and closing the gate at the minimum 2-second interval. This permits several 30-gallon drops directly on the smoke. If the fire is in a snag or green timber, change direction on each pass (providing topography permits more than one safe approach and getaway).

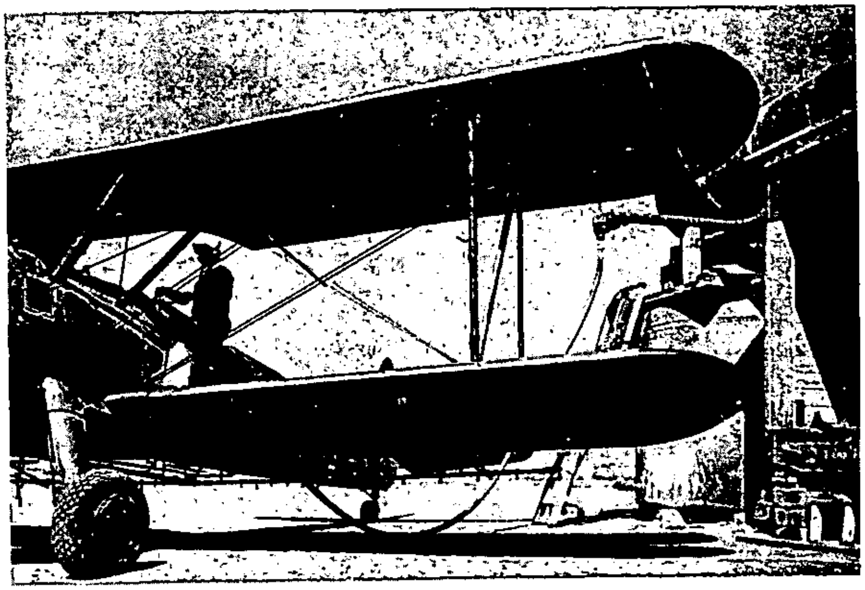

FIGURE 3.—Pilot loading Stearman by gravity.

*Running fire in light fuels.*—Wet water is just as effective as borate, and it is cheaper and requires no mixing apparatus. One pint of the liquid wetting agent (Solvoid Fire Wet or equal) poured into the 100-gallon load of water just before the plane takes off will mix itself in flight. Tanker should attack hot spots directly, working independently of ground crews. A cheatgrass fire on a steep slope should be hit with the first plane load at the uphill point; this involves several passes across the face of the slope, on the flames or immediately ahead. Use small or medium gate opening and short interval passes. Following planes should then make a run down the hottest flank directly over the fire edge, using the small opening. A downhill run with a loaded plane is much safer than an uphill run. If the fire edge is fairly straight, the tank can be emptied with one long pass. If not, 2 or 3 shorter passes will utilize the load more effectively.

*A running fire in medium to heavy fuels.*—Use borate only, unless the fire can be hit directly. Hot spot the fire, working independently of ground crews. This gives the ground crew time to build lines and burn out. Use same plane tactics as with light fuels, except use large gate opening. Ground-air coordination is required on one point; aerial tankers should not dump on a back fire unless requested to do so to reduce heat and spotting.

*Fire too hot to check by direct tanker attack.*—Use borate only. Use the middle opening of the gate valve for light fuels, the large opening for heavy fuels. Stay away from the main fire; strengthen the lines being prepared by the ground crew. Dump slurry along the outer edge of lines on ridgetops, roads, and other firebreaks;

also over the entire area of a saddle. Attack spot fires across the line directly, using the 2-second, open-and-close technique and the large opening.

*Project fire or lightning bust.*—During night move mixing setup to the nearest airstrip. Mobilize all available tanker planes. Attack at daylight (winds normally light, smoke normally drifted downslope, humidity normally up). Dump wet water on fire edge where the main ground crew is using a direct method of attack. Then dump borate slurry to supplement the fire boss' plan of indirect attack. Hit it hard while wind and smoke are down.

## KEY POINTS

1. An aerial-tanker project requires an aerial-tanker boss. He must be an experienced fire man. He must be physically capable of riding a small plane in turbulent air and during steep dives and abrupt pull-outs. He must be capable of making independent fire decisions. His job involves not only riding the "bird dog" plane and keeping in touch with the fire boss by radio, but also setting up the slurry mixing apparatus, planning mobilization of plane and overnight moves to a new airstrip, and developing new techniques to fit this new method of fire control.

2. The pilot of the "bird dog" plane should be a man with much experience in mountain flying and in agricultural spraying or other flying that requires close-to-the-ground maneuvering. He should develop wing signals so that he can convey to the incoming tanker-plane pilot how and where the tanker boss wishes the load deposited. Plane to plane radio would perhaps be more effective than wing signals; in our limited operations, we found that the latter were adequate.

3. The pilot of a tanker plane must be fully capable of handling the plane in fire conditions and over rough terrain. Except when safety factors do not permit, he must be willing to accept the plan of attack established by the tanker boss.

4. Initial attack with the aerial tankers is highly important on a fire that starts during severe burning conditions. The monitor of our forest radio net (a centrally located district headquarters assistant) is authorized to dispatch the unit immediately to any fire when available information indicates it would be useful. This insures that the effectiveness of aerial-tanker attack is taken advantage of during the crucial first few minutes. The district ranger can decide later whether to continue the tanker attack or terminate it. If several fires develop, the forest dispatcher must determine priorities.

5. Good visibility is essential to safe and effective operation of the aerial tanker. Obviously, a pilot must have daylight and a cloud ceiling high enough to permit approach and attack. Nor can we expect a pilot to operate close to rugged terrain when his visibility is obscured by smoke. The smoke limitation is a very real one and sharply limits the use of aerial tankers once a fire has become large.

6. Air turbulence during lightning storms limits use. It is not safe to bring a loaded plane within 50 feet of rugged terrain if the air is turbulent. Moreover, the material dumped will be blown away from the target. If a lightning storm is wet, effective use can still be made of the tanker after the air has quieted down. In the event of a dry lightning storm, however, fires often spread rapidly and we should not expect too much help from small aerial tankers.

7. Strong prevailing winds also limit the effectiveness of this technique, particularly if topography is rugged and the fire has begun to crown. Both safety of the pilot and dispersion of the dropped material are affected. Our 60-acre, second-growth fire brought out an interesting sidelight on this point. The fire started on a day of light wind. If the aerial tankers had not assisted in controlling at a modest 60 acres and a much larger fire had resulted, we would have been in serious trouble the next day when the prevailing wind was quite strong.

8. The fuel type has a direct bearing on aerial-tanker use. Our 60-acre fire in dense second growth on a steep slope demonstrates that the slurry is of some value in this fuel type, and that aerial-tanker attack certainly should be used. However, the wind was very light that day. Also, the second growth was only 30 to 40 feet high. We do not feel that the small aerial tanker would be of much value on a crown fire in old-growth Douglas-fir, particularly with a strong prevailing wind.

9. Distance from the air field to the fire or fires. Stearmans carry only 1¼ hours' gasoline supply. Be prepared to move to the nearest airstrip.

10. A forest that depends upon agricultural spray planes should not take availability for granted. One problem is that an agriculture air service is apt to be reluctant to tie up most of their planes on fire suppression during the height of an agricultural season. This problem can be met by signing up one or two planes from each of several companies within an hour's flying time of the forest. Prior arrangements for standby, ferrying, plane service at other airstrips, and mobilization of daylight attack are important.

## CONCLUSION

The indications are that aerial-tanker attack can be effective on perhaps half of our fires. The cost-benefit ratio of aerial tankers goes up in proportion to roughness of terrain and to inaccessibility of the fire to ground crews. Even smokejumpers cannot land directly at a fire in cliffy terrain or in a snag patch. Aerial tankers can operate effectively under such conditions, providing the air is reasonably quiet, the terrain permits approach and getaway, and visibility is good. When operating conditions are right, the aerial tanker is a wonderful tool for initial attack.

# TESTING THREE NEW AIR TANKERS

*Arcadia Equipment Development Center, U. S. Forest Service*

In the spring of 1957 three new air tankers of a new class were in the last stages of being fitted with tanks of differing designs and capable of carrying from 400 to 1,500 gallons of water (fig. 1). Since we had no data regarding drops from these aircraft, the Development Center was requested to conduct tests.

Some of the objectives desired were (1) to establish distribution patterns for water drops from these aircraft at different elevations and various gate opening combinations; (2) to evaluate gate release and control mechanisms; and (3) to determine impact forces on the ground from the water drop.

The three air tankers submitted for testing were a PBY-6a owned by a private operator in Long Beach, Calif., a TBM owned by an operator in Santa Ana, and a TBM owned by the Forest Service.

The owner of the PBY utilized the unique feature of his amphibious craft, the watertight hull, to hold fire suppressants. The fore-and-aft compartments on either side of the wheels were equipped with internal tank walls fastened to the hull. A pair of hydraulically operated doors were located on the bottom of each tank, thus providing all, one-half, or train dump combinations. Furthermore, the doors could be quickly closed and sealed by the pilot. Total capacity of both tanks was 1,500 gallons, although

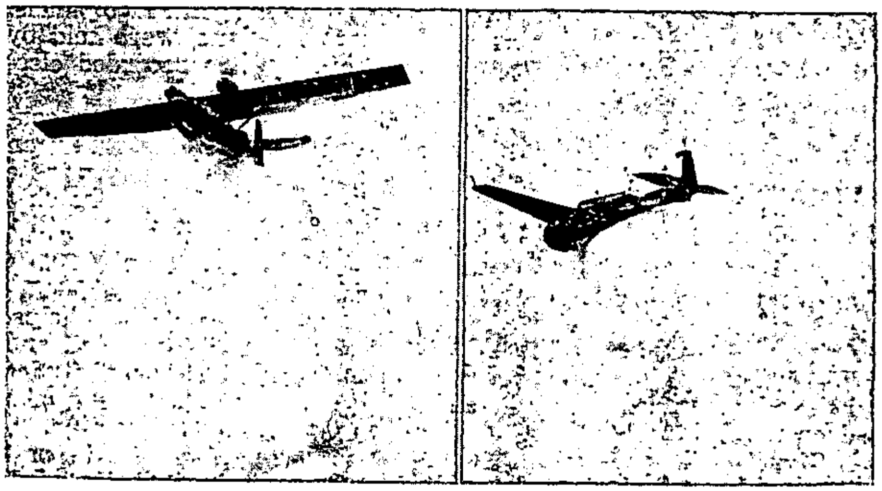

FIGURE 1.—Water drops: *Left*, PBY, 1,500 gallons; *right*, TBM, 400 gallons.

normal fire flying since these tests has been about 1,000 gallons of borate. Each door has approximately 1,000 square inches area.

The privately owned TBM had a 515-gallon tank fitted into the torpedo bomb bay. The tank was divided longitudinally into three compartments, each having a single door with an opening approximately 575 square inches in area. Electric bomb shackles were used for locking and tripping the doors, which necessitated manual closure on the ground. Individual, combination, or sequence drops could be made with this arrangement.

A 400-gallon tank installed in the Forest Service TBM had two doors which completely covered the bottom of the tank. Since the tank was separated longitudinally, each side dumped 200 gallons. These doors also could be operated independently. After the latches were tripped and the doors dropped open, hydraulically operated levers automatically returned the doors to the closed position. By reversing the release levers the pilot could then relock them. Each door had approximately 900 square inches of area, and in essence "dropped the bottom" of the tank.

*Conducting the tests.*—An unpaved area on the airport at Santa Ana, Calif., was obtained for setting up a grid collection system 150 feet wide and 600 feet long. This grid system consisted of 121 specially built steel paper-cup holders for a standard 10-ounce cup. The cups were maintained at a uniform height above the ground, and the cups were completely enclosed except for the open top. Each holder bore a number defining its position in the grid, so that the cups could be numbered and identified after each drop. Each cup and a lid was weighed to the nearest tenth of a gram prior to the drops. After each drop, the cups were covered, numbered, and reweighed. By plotting values of the grid, contour lines of concentrations could be drawn.

To determine the impact force of drops, a box having hinged panels one square foot in area was located in the grid. Two panels, one in the vertical and one in the horizontal plane, were held by force rings employing strain gages. Forces were recorded electrically through cables to a recording oscillograph.

Other instruments were on hand for measuring weather conditions. Height of aircraft above the ground was checked by an abney mounted on a tripod. Ground to air communications were maintained at all times. Forty-four drops were made at heights varying from 15 to 200 feet.

*Results of tests.*—From the study of all patterns (fig. 2), it appears that gate openings of 1,000 square inches for each 200-250 gallons yield good clean drops. Proper venting of tanks also helps. Optimum altitude for the TBM's appears to be 50-150 feet, and 75-150 feet for the PBY. Small patterns will result from altitudes below 50 feet. A 10-m. p. h. side wind will shift the pattern of a drop made at 100 feet about half its width from the drop line.

The PBY had the highest consistent concentrations in the patterns, with values up to 19 gallons per 100 square feet recorded.

Gates that can be relocked in flight appear to have an added safety advantage in the event they fail to open.

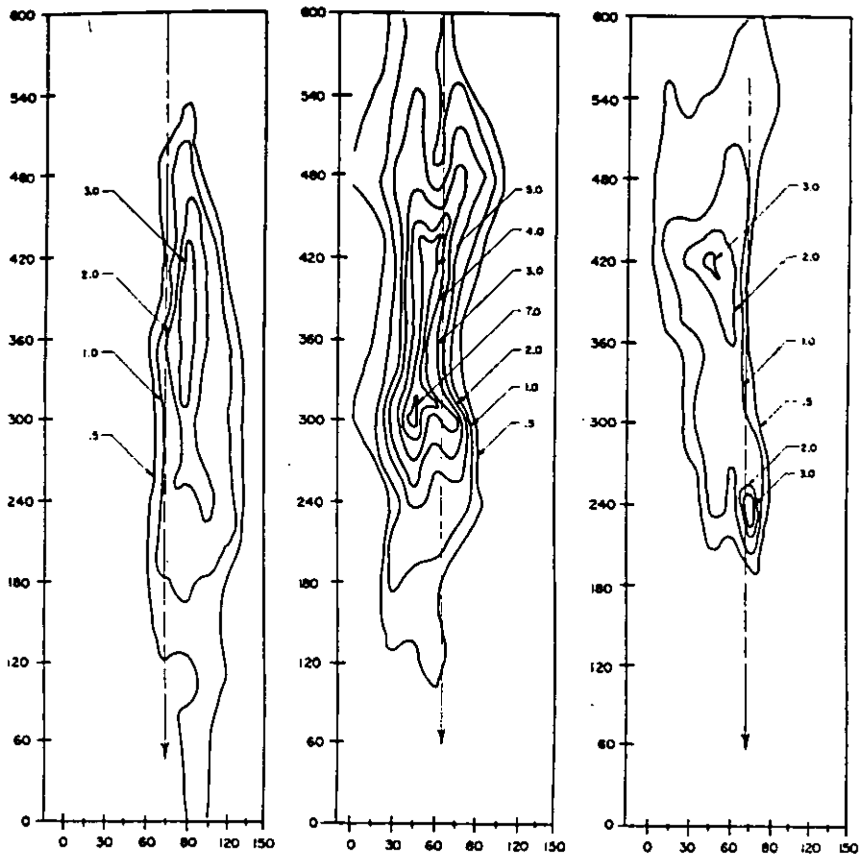


FIGURE 2.—Three typical drop patterns: *Left*, Santa Ana TBM, 515 gallons at 50 feet; *center*, PBY, 1,500 gallons at 70 feet; *right*, F.S. TBM, 400 gallons at 100 feet. Contour lines show concentrations in gallons per 100 square feet. Airspeeds averaged 110 m. p. h.

Impact forces from drops below 25 feet can be very great, particularly in the horizontal direction. An instantaneous acceleration of about 4 G's was recorded. The safest procedure for ground crews who might be subjected to very low drops would be to lie prone with heads, protected by hard hats, toward the oncoming aircraft.

# FIGHTING FIRES WITH AIRPLANES AND SODIUM CALCIUM BORATE IN WESTERN MONTANA AND NORTHERN IDAHO—1957

H. K. HARRIS

*Forester in charge, Missoula Equipment Development Center, U. S. Forest Service*

On August 8, 1957, the Northern Rocky Mountain Region of the U. S. Forest Service initiated experimental operations to determine regional possibilities for retarding the spread of wildfires by aerial applications of sodium calcium borate and water, based upon earlier developments in California. A local contractor of flight service equipped a Ford Tri-motor with three 100-gallon tanks, each with a separate dump valve and control. The 300 gallons was believed to be the maximum safe load if the borate and water mixtures were to be dropped from low elevations in the excessively rough topography common to the Region's remote areas. Three tanks were selected for control of the loading and to permit adjustment in the event the pilot erred in "spotting" the first tank on the selected area. Three charges or loads are also believed necessary if the pilot needs to place retardant entirely around a small spot-sized fire on a single trip.

On August 9, two loads of water were dropped on the ramp at the Aerial Fire Depot. Spread and concentration of the water were observed and operation of the dump valves was checked. We followed these tests by field application in open grass and timbered areas to observe effects, conduct flammability studies, and check our information on concentration. These preliminary runs were good training for pilots as well as selected smokejumpers who were to report the results on fire application (fig. 1).

Following the training period the Ford tanker was dispatched to 8 selected fires. Smokejumpers were available in most cases for

FIGURE 1.—Ford Tri-motor cascading borate over timber.

fast control action and to observe retarding effects. A spotter accompanied the plane on each load to assist in selecting the dump spot and record the effects as observed from the air. Participating personnel later met to discuss the action and the possibilities. The following details were reported:

| Fire number | Loads[1] (number) | Flight time (minutes) | Fire character | Report |
|---|---|---|---|---|
| 1 | 2 | 75 | 6 acres. Running. | Fire flanked borate—insufficient number of drops. |
| 2 | 1 | 120 | 13 acres. Spreading in scattered timber. | Load ineffective in timber. |
| | 1 | 120 | Smouldering spots in snags, windfall, and brush. | Good coverage; held fire down. |
| 3 | 1 | 175 | Class A. Creeping in scrub timber and duff. Several small fires. | Held some smouldering duff; coverage good on snags and windfalls. |
| 4 | 1 | 70 | Heavy duff with thicket of fir and pine; some open, rocky area. | Ineffective in duff and under trees; some benefit in open. |
| 5 | 1 | 120 | Creeping. Dense brush cover; several snags and a few windfalls; no green timber. | Retarded advance temporarily. Control obtained before plane arrived. Did good job on brush. |
| 6 | 1 | 85 | Spot size. Alpine-type heavy duff; some windfalls. | Drop made in very strong winds. Light application resulted but effective on duff. |
| 7 | 1 | 30 | Alpine fir with several windfalls and considerable heavy duff. | Held fire; simplified control and mopup. |
| 8 | 1 | 50 | 1.5 acres mill debris, grass, brush. Spreading. | Hit hot spots—good judgment in dropping—highly effective. |

[1]300 gallons per load; 4 pounds borate per gallon.

General results were definitely encouraging. The fire observers brought out that effectiveness was greatly reduced by a heavy tree canopy. Where such a condition existed, retarding effects were limited, and general opinion held that much heavier concentrations will be required.

Cost of borate, applied on the fireline, averaged $280 per fire. All the fires were considered to be of smokechaser size and were selected with possible benefits from borate drops in mind.

A single load (300 gallons) averaged 86 minutes flying time, which indicates the considerably restricted area used in the test. Borate is estimated to cost approximately $1.50 per gallon on the minimum size operating area (average cost per gallon during these operational tests was $0.747) for application to fires of smokechaser size.

Although our 1957 testing was definitely limited, we believe the possibilities of retarding the spread of small fires by cascading borate, or the use of some other aerial technique, are worthy of further investigation. We are confident that costs will be reduced with greater use, faster flying and larger capacity aircraft, and careful selection of operational bases. The special performance possibilities of the Ford Tri-motor and the helicopter also must not be overlooked in future planning.

# PLANNING FOR SMOKEJUMPING

L. M. STEWART
*Air Operations Officer, Region 1, U. S. Forest Service*

Smokejumping is no longer experimental and is paying fire control dividends in the mountain areas of U. S. Forest Service Regions 1, 3, 4, 5, and 6 (Montana, Idaho, Arizona, New Mexico, California, Oregon and Washington), as well as Yellowstone and Glacier National Parks (fig. 1). In addition, the Province of Saskatchewan operates a 16-man unit and the U. S. Bureau of Land Management plans to activate a small Alaskan unit in 1959.

There is steadily growing recognition of the value of smokejumpers as trained and highly mobile reinforcements for the control of threatening fires in relatively accessible areas. However, it is believed that such use must be considered as incidental from a planning standpoint. Evaluation of proposed jumper units should be limited to probable value in areas otherwise deficient in manpower where, because of poor access by other means, smokejumping promises improvement in first-attack action. Smokejumping is far from a cure-all for all back-country fire suppression problems. Before seriously considering initiation of a unit, land managers should obtain competent advice on the effect of the following factors, singly or in combination, in the specific areas under study:

*Elevation.*—Ground elevations above 8,000 feet may limit jumping.

F-470029
FIGURE 1.—Smokejumper descending to jump spot in mountain terrain. Jumper is facing camera. Note two slots in parachute canopy. These are used by the jumper to change his direction. Also air escaping through the slots propels the airborne jumper forward in the direction he is facing.

*Terrain and soil,* insofar as these affect availability of suitable jump spots within acceptable distance from fires.

*Cover.*—Unbroken areas of heavy windfall and snags or of certain timber species and age classes may make jumping unduly hazardous.

*Weather.*—Consistent high winds or turbulence may cause undependability of jumper attack when such air conditions make parachuting highly dangerous.

Given acceptable conditions in these four factors, further planning will include studies to determine size, organization, and location of crews by calendar periods, equipment complement, type of aircraft, etc. Analysis of fire occurrence and behavior is the best basis for calculating probabilities in fire fighting work load, both gross volume and distribution by areas. Given similar conditions, this phase may be greatly simplified by drawing on the experience of an existing unit in such factors as average manning, time away from base per fire jump, etc., and applying these to expected occurrence.

Lacking similar conditions, planners are advised to study carefully individual fire records over an extended period and tabulate, for each fire, their best judgment of hypothetical smokejumper action in terms of (1) distance of fire from road or airport; (2) number of jumpers required; (3) time and date they would leave base; (4) time, date, and method of return to base; (5) ground reinforcement action, if any; (6) extra flying required for supply of jumpers or ground crew, if any; (7) date and method of return of jumper gear.

When assembled and charted, this information is used to determine probable seasonal loads and the requirements in (1) number of jumpers to meet peak fire loads; (2) jumper equipment: amount, frequency of use, rate of return from field; (3) number of aircraft by type by periods for outgoing traffic; (4) trucks, packstock, helicopters, and fixed-wing aircraft for return of men and equipment; (5) base facilities and airfields.

For most proposed operations, planners will find that economics do not permit smokejumper organization on a scale to care for worst probable situations because such situations occur too infrequently. They then compromise upon units of sufficient size to handle loads at some practicable level below the worst probable peak, planning to supplement smokejumper action by other methods of attack as needed. Smokejumping units are relatively limited in ability to expand on short notice as critical seasons develop, and this characteristic forces preseason commitment as to size of unit. This handicap is, of course, due to the degree of advance preparation involved—specialized, expensive, and time-consuming training and equipment procurement.

However, on the credit side, mobility and wide range of quick striking power greatly increase the potential coverage per man in terms of area protected or fires manned. These characteristics also permit unprecedented pooling of first-attack manpower, in effect, and widespread use of jumpers as needed without regard to regional or other unit boundaries. As an example, it is not un-

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FIGURE 2.—Army and Forest Service records show that feet, ankles, and lower legs are critical points in prevention of landing injury, especially for the smokejumper who often lands on rough ground. Careful selection and conditioning of candidates are major factors in maintaining a low rate of injury.

common for a given Forest Service smokejumper to make fire jumps in four separate Forest Service regions during a season. In addition he may also jump to fire in a national park, an Indian reservation or on area protected by a private timber association. Such use tends to reduce the impact of localized highs and lows in fire incidence upon the jumpers, as compared with less mobile ground facilities.

Smokejumping is for young men. Forest Service policy precludes continuation of jumping beyond age 40 and new candidates must be 18 to 28. Weight limits for new men are 130 to 180 pounds in most units, height 65 to 75 inches. Sound physique, good general health, mental stability, and good hearing and eyesight are prerequisites (fig. 2), as are work experience in fire protection and a better-than-average work record. This is important; the pay-off is at the fire and you cannot justify the high investment in a man who does not produce accordingly when he gets to the fire.

The initial basic training of a new smokejumper will cost about $650, not including any prorated share of such items as base facilities or project overhead. Equipment to outfit him will cost $475 to $750, depending on degree to which double equipping is necessary (fig. 3). Some units double equip all jumpers. Equip-


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FIGURE 3.—Smokejumper trainee receiving an equipment check prior to loading into the airplane for a practice parachute jump.

ment first cost may of course be amortized over a period of years, depending on established service life of individual items.

Aircraft of proper type and number for the particular operation is a key factor. Smokejumping aircraft are also readily fitted to paracargo work. In most areas of heavy smokejumper activity the extreme peaks in jumping and paracargo demands do not ordinarily coincide and heavy dual use of airplanes may be depended upon if they are suitable to both types of missions. Careful study and planning to obtain maximum correlation is well worthwhile.

For large smokejumping areas planners often have a difficult time deciding between centralization and multibasing. Both have certain apparent advantages, some of which may be misleading if not analyzed.

*Multibasing*: (1) Shorter travel distance to fires; (2) quicker get-away to first call fires, at least; (3) more localized control of dispatching and communication; (4) better opportunities to use men on productive work when not on fire.

*Centralization*: (1) Greater flexibility in manning; (2) more efficient use of aircraft and other equipment, with proportionate economies; (3) better average elapsed time through ability to take manning action on more fires concurrently.

# SIGNAL SYSTEM FOR SMOKEJUMPER AND PARACARGO AIRCRAFT

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*Missoula Equipment Development Center, U. S. Forest Service*

In the early days of smokejumping and cargo dropping all signals between spotter and pilot were either verbal or manual. Permanently installed bells, horns, buzzers, and lights were used for cargo discharge signals, but until recently, smokejumper spotter signals were made primarily by hand. Voice intercom systems have been used since 1944, but the high voice level and vibrations around the open doors of airplanes in flight made these systems unworkable in most airplanes. Headphones and microphones with connecting wires are cumbersome and restrict movements of spotters and cargo droppers.

In recent years the increasing interregional exchange of airplanes, pilots, and jumpers has shown the need for standardizing the cargo discharge and smokejumper signal system.

The Intermountain Region of the U. S. Forest Service made the first practical use of an electric signal system for smokejumper signals. The unit consisted of red and green lights located in the pilot's compartment and a two-way toggle switch mounted near the jump door. Flashes of appropriate colored light indicated amount and direction of turn needed. Alternate flashing of both lights told the pilot when to cut engine power for jumps. A cargo discharge signal was not an integral part of this system.

The Missoula Equipment Development Center was assigned the project of developing a standard signal system for jumper and cargo aircraft. All Forest Service units engaged in smokejumping and paracargo operations cooperated.

Pilot models of an electric signal device were made up for preliminary field testing. Briefly, these units were small electrical makeup boxes containing red, green, and amber lights energized by flashlight batteries and controlled by toggle switches. A pilot-to-dropper buzzer served as a paracargo discharge signal.

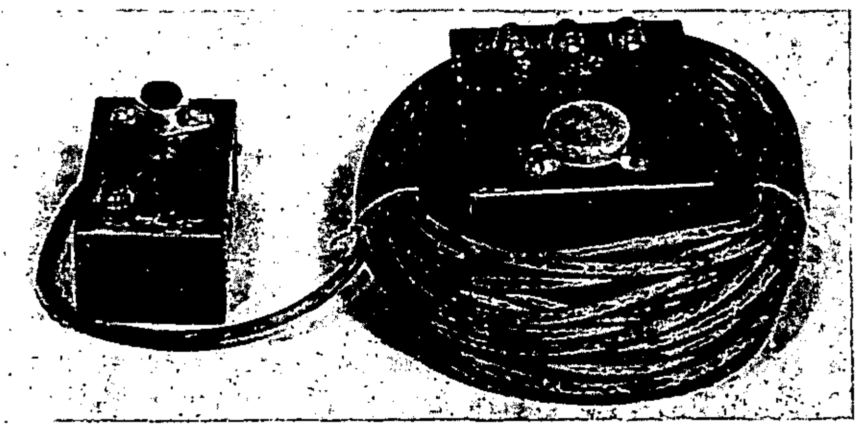

FIGURE 1.—Temporary installation model of the signal system for jumper and paracargo aircraft.

Generally, preliminary test results were favorable. Insofar as possible, suggestions for improvement were incorporated into the final model. The most noteworthy change was in the cargo drop signal where a simultaneously combined light and bell with greater audibility were substituted for the buzzer. Larger makeup boxes were required to accommodate the bell and light assembly. A 6-volt battery was substituted for the flashlight batteries. The overall size of the unit was kept to a minimum.

Field trials of the improved models during the 1957 fire season were satisfactory. Some units favored the use of the light system in conjunction with radio intercom. Others felt the light signal system to be unnecessary where workable intercoms were available. All regions recommended that the signal device be adopted as a servicewide standard for use in contract aircraft where the installation is of a temporary nature (fig. 1).

One suggestion was to replace the cargo discharge bell with a landing gear warning horn. This was not done as it was felt that use of a gear warning horn would be confusing. Many of the jumper aircraft are equipped with gear and stall warning horns as integral safety equipment. Gear warning horns cannot be operated with 6 volts.

At the completion of the field tests, signal light systems were permanently installed in several Government and contract aircraft. These were advantages of the electrical light system:

1. It allows the pilot to do a better and safer job of flying by eliminating the necessity of looking over the shoulder while attempting to fly on course.
2. Better response to signals is possible. With hand signals the pilot cannot keep his eyes on the spotter's hand at all times; consequently, the spotter whose head is out the open door or window frequently signals while the pilot is not looking.
3. More freedom in loading and positioning cargo and jumpers within the ship is possible since an unobstructed line of vision between pilot and spotter need not be maintained. The jumpers can observe the drift streamer without interfering with the signal procedure.
4. The spotter has freer use of his hands during signaling.
5. The pilot can keep both hands at the controls of the ship during the final and critical stages of the cargo approach and can easily signal for the drop by depressing a button. An audible signal gives the cargo dropper greater freedom to make a last minute check of cargo bundle and static line.
6. Temporary installation models can be quickly installed by the pilot or mechanic since no cutting of air frame and no connection to plane's electrical system is involved.

*Recommendations.*—This light-signal system should be adopted as a servicewide standard for use in contract planes or other aircraft where temporary use is desired. The signal light box should be installed where it can be continuously observed by the pilot as well as where the danger of injury from bodily contact during rough landings or turbulence is eliminated. In the cabin the wiring and switch box should be located where it will not be damaged during cargo loading and dropping, jumping, and other normal activities.

# GROUND OPERATIONS FOR HELICOPTERS

JAMES L. MURPHY
*California Forest and Range Experiment Station*[1]

So you're going to use a helicopter? Good idea! Outfits all over the country are finding the helicopter valuable in fire control work. The Angeles National Forest has used a permanent standby ship for the past eight fire seasons. We found that there is a lot of work to be done before the helicopter can take to the air. The following suggestions are a result of our experiences.

## ESTABLISHING PERMANENT BASE HELIPORTS

*Location.*—The most important consideration in planning a helicopter operation is the selection of the base heliport. The base heliport for the Angeles is located at Chilao Fire Camp near the center of the forest. The heliport is at a 5,200-foot elevation—high enough that it isn't an uphill pull to every fire in the forest, yet low enough for safe, dependable helicopter operation. The landing area was constructed on a high point so that a helicopter can always take off or land into the prevailing wind and can drop off into the canyon when taking off.

The Chilao base heliport is large enough to accommodate several ships safely. The landing surface, or "pad," is 75 yards wide and 100 yards long and has an asphalt surface to prevent dust from being picked up by the rotor blasts. The field name, "Chilao," a "North" arrow, and the elevation are painted across the pad to insure positive identification from the air (fig. 1).

*Ground operations crew.*—All heliports require ground crews. The crew usually consists of an air traffic manager and two or three men. The traffic manager directs air operations and orients and briefs the ground and flight personnel. He is responsible for enforcing safety relations. He also maintains necessary records. The crew helps him load and unload personnel and prepare, weigh, and load cargo. On unpaved heliports, the crew also dustproofs the heliport. Otherwise dust might injure the men's eyes or enter gasoline and oil containers and dispensers in the refueling area. Personnel working at the heliport should wear goggles when the rotor is turning.

*Air traffic manager.*—The air traffic manager has a big job. He must plan and coordinate all cargo dropping, reconnaissance, and transportation of personnel. He must establish priorities and

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Work covered by this report was conducted while author was employed as Air Officer on the Angeles National Forest.

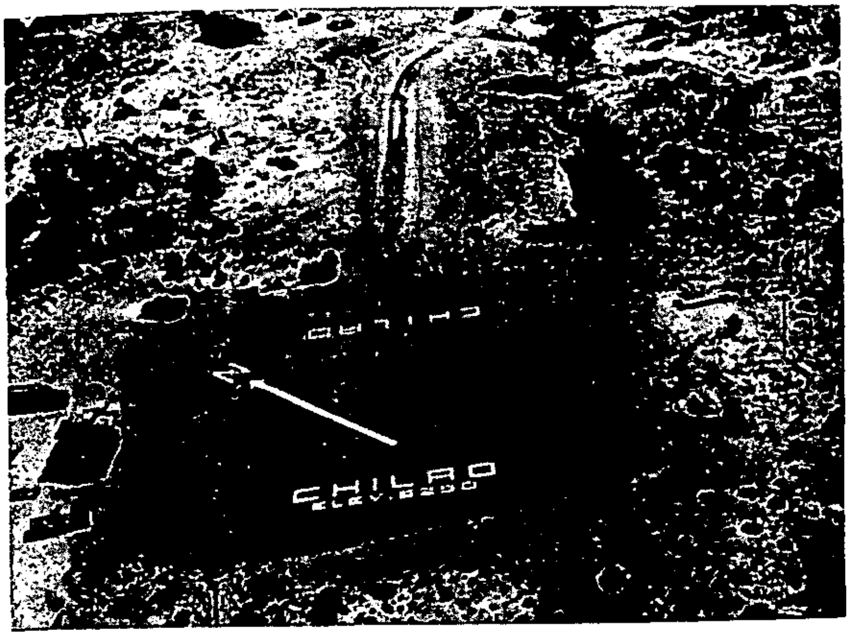


FIGURE 1.—The Chilao base heliport can accommodate several ships.

schedule all flights, and therefore should be supplied with daily fireline crew assignments and fire maps. He is also responsible for all ground operations at the base heliport, including instruction of all personnel in the safe methods of approaching, loading, and departing from the ship.

The air traffic manager should have full control over scheduling trips from his heliport. Even if the fire boss wants to use the ship away from the base heliport, the air traffic manager should be notified. Any time the helicopter has completed its assigned mission it should be returned to the heliport. If all pilots understand this procedure, it will prevent commandeering of the ship by unauthorized personnel.

*Base heliport facilities.*—At Chilao we installed an 8-foot wind sock on a swivel and mounted it on a 25-foot section of 1-inch pipe. This wind indicator was placed in a visible spot on the edge of the heliport safely away from the normal takeoff and landing lanes.

All preventive maintenance must be done at the base heliport by the assigned helicopter mechanic, usually at night when the helicopter is not operating. To help the mechanic, we built a work bench and installed an electrical outlet.

High octane aviation gasoline is delivered to the base heliport from a central distributor in large quantities at infrequent intervals. We built a latticework house in which to store the 50-gallon drums of gas. The floor of the house is raised for quick loading of the drums into a pickup truck. Many forests place a gas supply at several accessible landing spots throughout the forest.

Good communications are vital at the base heliport. We installed a telephone with a loud Klaxon that can be heard above the motor noise of the helicopters.

Safety is important in all phases of the ground operations. The Chilao heliport was posted with "No Smoking" signs. Fire extinguishers were placed at the work bench and at a convenient spot near the refueling areas. To warn curious sightseers, we posted "Danger—Heliport" and "No Smoking" signs across the entrance to the pad.

*Helicopter accessory equipment.*—The helicopter may be dispatched at any moment during daylight hours. Accessory equipment for any type of mission must be readily available at the base heliport. Inventory lists of kits prepared for the Chilao operation will be provided by the California Forest and Range Experiment Station upon request.

*Operational maps and records.*—Daily flight-time records are needed whenever a rental helicopter is used. The most efficient system is for both the air traffic manager and pilot to keep a record in pocket-sized field notebooks. At the end of each day the two flight records are compared, and the final entries are made in the permanent flight record.

Most helicopter operators are guaranteed a minimum number of flight hours as a condition of the contract. It is important to the contracting agencies to know whether full use is being made of this time. At Chilao we placed a large bulletin board in the heliport operations shack and displayed two charts. The first chart gave a day-to-day total of all flight time and the remaining time available during the rest of the contract period. The second was a line graph with each date of the contract period as the vertical axis and the total flight time as the horizontal axis. Two lines were plotted on the graph. The first was a uniform slope line of expected flight time, and the second was the fluctuating line of actual flight time. By comparing the actual with the expected, we could see how quickly the time was being used.

*Helicopter operation map.*—A master helicopter operation map of the Angeles National Forest was started in 1956. It was made from small-scale topographic maps of the 15-minute series and was displayed on the bulletin board. To be useful the following information must be current and accurate on the map: Aircraft hazards, such as utility lines; areas of extreme air turbulence; helispots and field heliports approved by the pilot; flight time from the permanent base heliport plotted by circles in 5-minute intervals.

## ESTABLISHING SEMIPERMANENT FIELD HELIPORTS

*Location.*—Here are some important points to consider before selecting a field heliport:

1. Accessibility to men and supplies or to the fire camp.
2. Presence of hazards such as power lines.

3. Location so that a drop-off can be made *into* the prevailing wind.

4. Area level and free from all obstructions.

5. Higher than surrounding ground so that men approaching and leaving the ship will be well below rotor-blade level.

6. Accommodations for several ships (each small helicopter requires about 2,500 square feet).

7. Should be fireproof.

*Field heliport operation.*—Once the field heliport has been selected, ground operations must be established. When the helicopter was dispatched to a fire from the Chilao base heliport, the mobile base heliport kit was sent at the same time on the helicopter maintenance truck.

The ground crew should stockpile a good supply of fire tools, water, and other items at the heliport. The storage area should be at least 100 feet from the landing spot for maximum safety.

Communications also are an important part of field heliport ground operations. Radios are a must. Telephones may be installed but they are not always adequate. Helicopter-to-fireline communications are necessary to coordinate cargo drops. It is also imperative that the air traffic manager be in contact with the pilot while the ship is in flight. It may be necessary to ground the ship while other low-flying aircraft are in the area. This can be done only by radio.

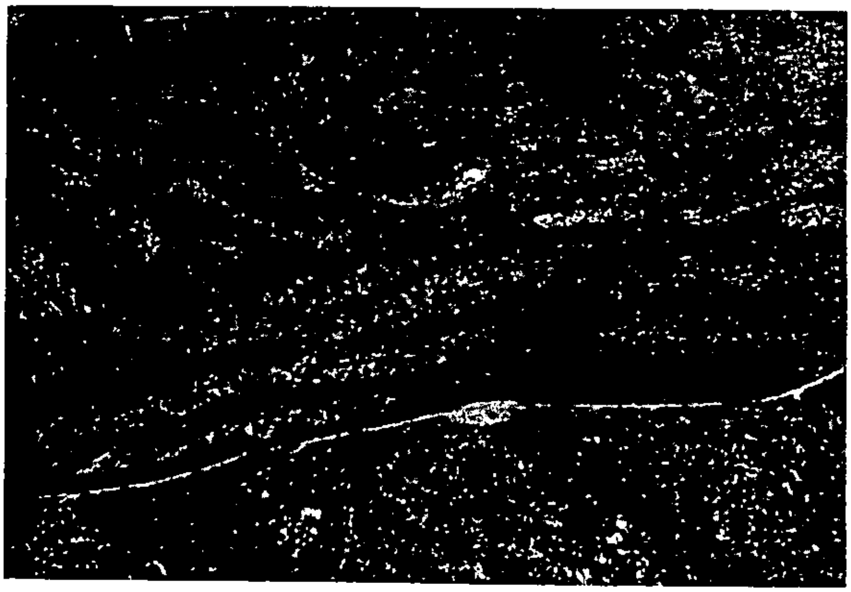

FIGURE 2.—An ideal field helispot offers a 360° choice of takeoff and landing direction. The vegetation is cleared well below the level of the landing area, and the touchdown pad is level and free of obstructions.

## TEMPORARY HELISPOTS

Specially needed helispots can be built at key locations requiring very little improvement. The pilot should select these spots and then give instructions and the location to the crews on the ground by radio or a dropped message.

Helispots must furnish takeoff and landing choices into the prevailing wind (fig. 2). For small helicopters, they should be about 50 feet in diameter and fairly level with no obstructions. A 15-foot square touchdown spot may be elevated to raise the rotors to a safe height above personnel. A wind indicator must always be placed as close to the actual landing spot as is safe.

## SUMMARY

Helicopter ground operations demand considerable planning and work. Permanent base heliports must be located, constructed and equipped for efficient, fast, and safe action. Semipermanent field heliports call for expert location and close supervision of ground operations by a trained ground crew. Temporary field helispots located at strategic spots on the fireline in response to a momentary need present special hazards because of less supervision and control.

Experience during the past few fire seasons on the Angeles National Forest has shown that well-planned and well-executed ground operations are essential for the efficient and successful use of helicopters.

# THE HELICOPTER FLIES HIGH

JOY BALDWIN
*Fire Staff Officer, Gila National Forest*

The Gila National Forest of Region 3 sprawls across the Arizona-New Mexico State line, the Mogollon Mountains and the Black Range, which is also the Continental Divide in this part of New Mexico. The forest is just short of being 3 million acres in size. The Gila Wilderness Area—the first wilderness area created in the United States, the Black Range Primitive Area, and a part of the Blue Range Primitive Area are within its boundaries.

In this area fire occurrence is thought to be the highest of any such roadless area in the United States. Lightning is responsible for 95 percent of the fires which concentrate in number during the critical period between May 15 and July 15 and occur in lesser numbers in the pre- and post-season.

As an example of concentration density at one time in 1956, men were actually working on 109 going fires. These fires, all lightning-caused, were in the highest and most inaccessible country in the Mogollon and Black Range Mountains in New Mexico and that part of the Mogollon Rim extending into Arizona. Elevations range from 6,500 feet to more than 10,000, with very high fire occurrence in the range of 6,500 to 8,500 feet.

## THE PROJECT

The Gila uses a combination of aerial and ground fire organization with each being assigned a given hour-control zone for initial attack purposes. The zones are not rigid in that each group assists the other as needed, or when one group is occupied—whether ground or aerial—the other covers or reinforces it. Some 2 dozen initial attack ground stations are used, and a crew of 18 smokejumpers is based at Silver City.

But there was deficiency in this initial attack organization. It was a common occurrence to have all jumpers out on fires with no way of moving them back in less than 12 to 24 hours; they had to come back on foot. This also involved using one of our ground control men and mules to pack out equipment (average 105 pounds per jumper). The men could have been used for initial attack purposes. Three possibilities of overcoming some of this deficiency were considered: (1) Increasing the number of men and ground stations; (2) enlarging the smokejumper crew; and (3) finding a rapid means of retrieving jumpers and equipment from the back country.

The increase in men in the back country was eliminated as a possibility because we are unable to obtain men properly qualified in the use of livestock who are willing to go in and stay there. Economics also entered into this decision. It would be hard to keep such men gainfully employed even if they were available; horses and mules are scarce, and feed for the animals is extremely expensive to either pack or airdrop. Thus we chose the third possibility and elected to try the helicopter.

All of the people in our organization with helicopter experience, as well as people in the helicopter business, helped in the preliminary planning, and specifications by helicopter manufacturers were examined. After analysis of performance requirements to meet difficult high-altitude and high temperature conditions, a late model 3-place helicopter was chosen. This helicopter was provided by a commercial operator under a bid contract.

## RESULTS TO DATE

The following summary of helicopter use in 1957 speaks for itself:

1. 128 jumpers were retrieved from 64 fires. As mentioned earlier, walkout and return to base of smokejumpers is anywhere from 12 to 24 hours, and other personnel is tied up retrieving them. Conservatively, use of the helicopter saved 12 hours per smokejumper or a total smokejumper time of 1,440 hours. The big advantage, of course, is in having the jumpers available to meet another possible fire emergency.

On one fire, when all jumpers were out, the helicopter made it possible to retrieve 4 jumpers to jump on another fire in the wilderness area. The 4 men plus 3 others, 2 of whom were jumpers walking in, were able to control a fire at 20 acres. It took approximately 17 hours to get assistance to this force by ground. Possibly several thousand dollars was saved in this particular case.

2. 16 jumpers built 18 helispots and, with the exception of 4, all were built by smokejumpers without assistance from other personnel. Without the "chopper" to retrieve the men, we could not have advanced so rapidly in our program.

3. On one fire 11 firemen were returned to their cars by "chopper" at a savings of 3 hours per man. The important thing was that the men were immediately available for other fires had they occurred.

4. Four men put on 2 fires by helicopter for initial attack saved about 2 hours each and, in addition, both fires were held to small B size. Otherwise, additional men would have been required 2 hours later and damage would have been much greater.

5. One rescue mission—injured lookout. This mission would have required the jumper plane for 2 hours, 8 men for 10 hours, and 1 ambulance for 80 miles. The "chopper" did the job in 1 hour, thus alleviating a great deal of suffering for the injured man. We were not exposed to a major disaster by tying up our smokejumpers and plane.

6. 13,126 pounds of freight, the equivalent of 88 mule loads, were hauled for fire suppression; 480 man-hours and 704 mule-hours were saved.

7. One emergency repair to remote radio equipment with radio technician.

8. Three reconnaissance flights selecting helispots.

9. 330 flights were made in the helicopter from altitudes of 6,000 feet (home base) to 9,300 feet over a wide temperature range. Landings were as follows:

| *Altitude (feet)* | *Number* | *Altitude (feet)* | *Number* |
|---|---|---|---|
| 5,501-6,000 | 78 | 7,501-8,000 | 56 |
| 6,001-6,500 | 2 | 8,001-8,500 | 41 |
| 6,501-7,000 | 30 | 8,501-9,000 | 0 |
| 7,001-7,500 | 107 | 9,001-9,500 | 1 |

Payload had a wide range depending on altitude and temperature; however, a general average of 200 to 220 pounds was handled at 7,500 feet and up to 350 pounds at 6,000 feet.

## MISCELLANEOUS

One standby crew was placed in an isolated, very high occurrence area. All supplies were by plane, and the parachutes plus remnants were returned by helicopter.

During the 1957 season, the Packsaddle, McKenna, Turkey, Rocky, White Creek, and Flare Fires were all potentially dangerous and gave much trouble to initial attack forces. The helicopter, through all uses, played a major role in preventing one or more of the fires from becoming project size.

## THE LOOK AHEAD

During 1957 a study was started to determine what upper limits of altitude are imposed by temperature and turbulence at any given time. The test is continuing and we hope to establish a few spots in 1958 that will permit more testing at altitudes from 8,500 to 10,000 feet. When completed, we will be able to determine density altitude for a particular location and from a conversion table, we should be able to safely state what performance in load may be expected. The testing in marginal altitudes is to be done in a safe and prudent manner, and under no circumstances do we intend to experiment where life or property is placed in jeopardy.

New developments in rotary wing aircraft are coming rapidly, and helicopter limitations as they exist today are being so rapidly overcome that it is hard to visualize all we may be doing with these machines in the future.

# FIRE ACCESSORIES FOR THE LIGHT HELICOPTER

*Arcadia Equipment Development Center, U. S. Forest Service*

Many who have flown over and around fires in a helicopter have thought, "If only I could drop a couple of gallons of water on that spot," or "these 'copters are terrific, but there must be other things we can do besides haul men and sightsee." Well, we now have an equipment system which will do four basic fire jobs with the speed and mobility that is inherent with a helicopter. They are (1) bulk drop 35 gallons of water or chemicals, (2) lay up to 1,000 feet of 1½-inch fire hose, (3) transport a lightweight pumper outfit complete with hose and water, and (4) deliver other cargo with a simple dual sling, electric-release device.

This equipment has been developed at Arcadia as part of the joint Air Attack (helitack) Program being conducted in cooperation with the U. S. Engineers, California Division of Forestry, and Los Angeles County. The aim of this program is to exploit the potential fire fighting abilities of the helicopter.

What started out as one piece of equipment has developed into a family of accessories designed around a standard carrying device.

*Bomb shackle adapter assembly.*—The heart of all attachments is an assembly (fig. 1) using a standard Navy bomb shackle (1,600-lb. capacity), fitted with an external solenoid release. A manual cable release D-ring is also provided the pilot for emergency use in the event of electrical failure. The entire rack weighs 29 pounds, quickly clamps to the cross-tubes beneath the helicopter, and is fitted with slip joints to allow for dimensional differences. It is constructed entirely of 4130 steel rectangular aircraft tubing.

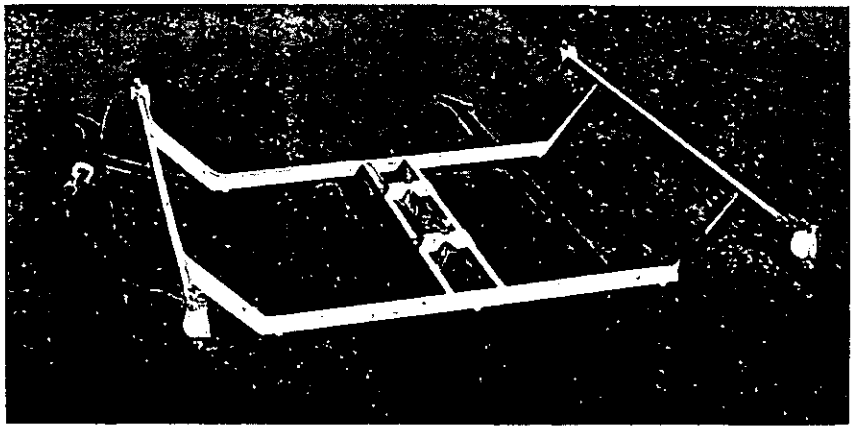

FIGURE 1.—Bomb shackle adapter assembly.

Some operators have wired the 24-volt solenoid directly to the dust hopper release button on the cyclic control stick, thus providing an instantaneous operation of the shackle.

The assembly has been CAA certified for use in an unrestricted category when not carrying accessories.

*Helitank.*—An accessory which has proved itself on fires during the past season is the helitank (fig. 2). The tank shape evolved from the standard pyramidal shape of the canvas relay tanks and is designed to be self-supporting while the tank is being filled on the ground. The 35-gallon capacity was selected to limit the load to a reasonable amount for operation under marginal flight conditions at high altitudes and temperatures. The tank is made of lightweight neoprene-coated nylon fabric and weighs 4¼ pounds. Certain dimensional limitations were maintained so that loading operations can be done underneath the helicopter and to keep sling length as short as possible.

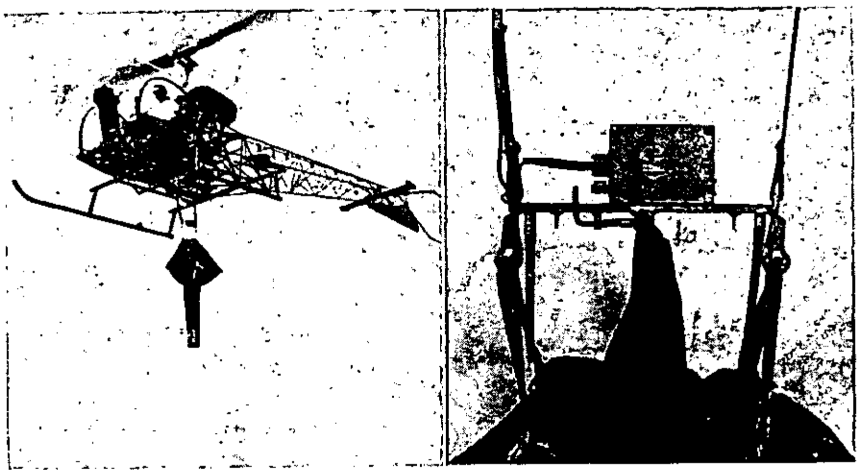

FIGURE 2.—*Left,* Helitank dropping 35 gallons of water. *Right,* Helitank sling release.

Several snout release methods were tried; the one selected consisted of turning the snout inside-out and suspending it up through the tank. As a result, the fastening is centrally located and better accuracy is provided by the discharge of water straight down when released.

The tank is suspended by nylon straps on a short spreader bar equipped with two parachute snaps on the ends. This bar in turn is attached to the bomb shackle by short web slings, and is equipped with a pin release in the center, operated electrically by a 24-volt solenoid (fig. 2).

This solenoid can be activated from the radio button on the cyclic stick, or it can be wired through a small switch taped to the stick and powered by a battery taped to the adapter. Grommets are located in the end of the drop snout of the tank through which the pin passes, thus holding the snout above the tank during flight prior to the drop.

In operation, the tank is placed inside the skid on the ground and hooked up to the sling release. Filling can be accomplished in this position, or the helicopter can land over the filled tank. It has been found practical to land over the filled tank when returning with an empty unit, and disengaging and taking off with a full unit in less than one minute. After setting up the operation, a marker or line alongside the skid on the ground will spot the ship exactly for hooking up. On one fire operation utilizing a pair of tanks, drops were made ¾ of a mile away by one helicopter every 4 minutes.

At 15-25 m. p. h. a good wetted area is obtained about 10-15 feet wide and 50-75 feet long. The pattern is of course shortened as speed decreases. Excellent coverage on single snags has been obtained. It is not normally safe to hover above fires because of rotor blast.

Since the sling is suspended from the bomb shackle, the pilot has the safety feature of being able to jettison the entire sling and tank in an emergency.

*Fire hose dispensing tray.*—A tray, approximately 4 by 8 feet, which can hold up to 1,000 feet of packed hose can be easily attached to an H-bracket which in turn is rigidly secured in the bomb shackle. The H-bracket weighs 15 pounds, and the tray 30 pounds. The same sling assembly used for the helitank can be fastened on the tray for electrically dropping a roll of hose which in turn starts the folds of hose in the tray flaking out while the helicopter is in flight. (figs. 3 and 4).

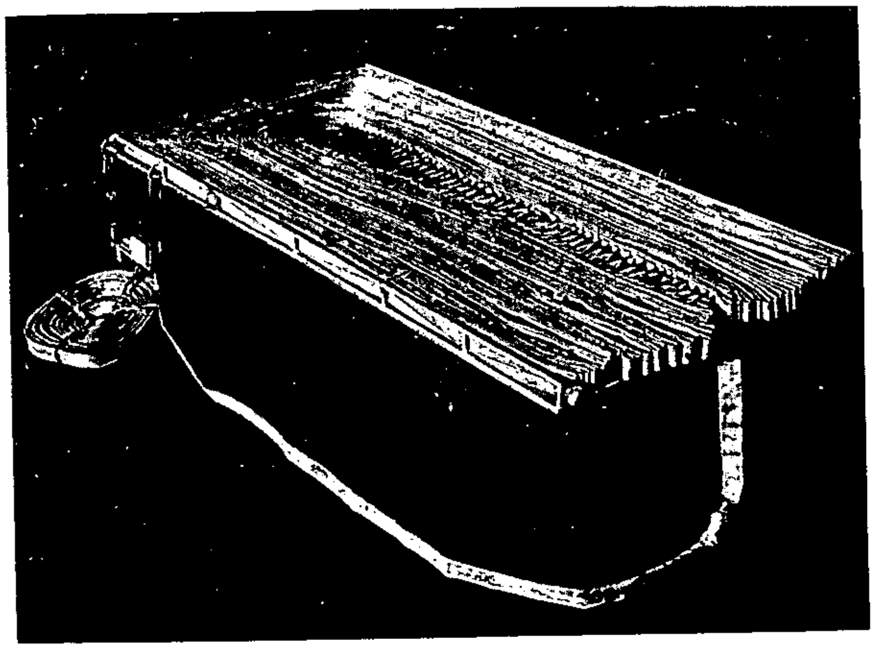

FIGURE 3.—Packed hose tray ready for flight.

The horseshoe pack minimizes center-of-gravity changes and permits smooth discharge. The hose is also tied in the tray at the forward end in sections with 21-pound break-away thread to prevent discharging in bunches.

Normally the tray is removed by lifting it out of the parachute snaps and sliding it from underneath the ship. In event of an emergency, tripping the bomb shackle lets the H-bracket and tray fall free.

Flight speeds of 10 to 20 m. p. h. were found to be the safest, although ground test studies have been safely conducted up to 50 m. p. h. An early model hose tray was flight tested by a helicopter manufacturer at maximum allowable center-of-gravity limits and it was found that helicopter controllability was well within the allowable range.

The first use of this hose lay method on a going fire occurred July 5, 1956, on the 400-acre Sterling Fire, San Bernardino National Forest, when 1,000 feet of hose was laid on the northwest edge of the fireline.

*Electric sling cargo release.*—Helicopter flight tests have shown that cargo slung beneath on a single point tends to oscillate and rotate causing unbalanced forces. The use of a double sling largely eliminates the fore-and-aft center-of-gravity changes in takeoff

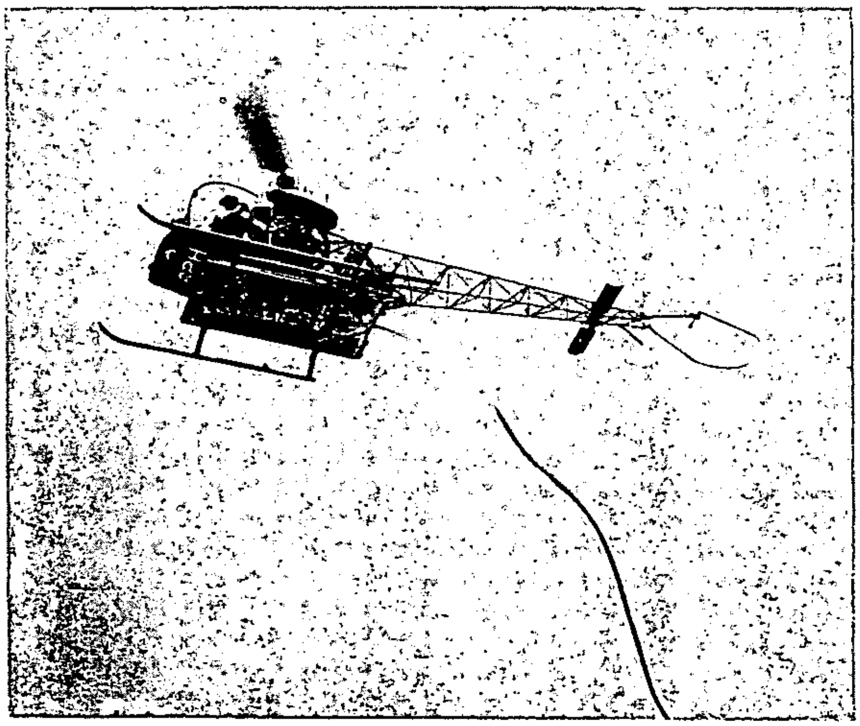

FIGURE 4.—Hose lay by helicopter.

and landing. The sling release, therefore, has been equipped with release arms that can electrically drop two cargo lines simultaneously (fig. 5). Although the bomb shackle can be used for handling cargo, it is somewhat inconveniently located for fast accessibility, while the sling release is handled off to the side beneath the helicopter.

The release arms do not impair operation of the release pin when used with the helitank. Thus the sling serves three purposes: Starts the hose lay, operates the helitank, and carries cargo. The prototype model has been load tested to operate at 1,050 pounds. Again, the pilot can jettison the entire cargo sling should the release arms fail.

*Helipumper.*—This useful piece of cargo was developed for helicopter transport. The unit consists of a lightweight portable pumper (7.5 gallons per minute at 150 pounds pressure per square inch), 200 feet of 1-inch lined hose, and a water hopper which can hold a pair of 5-gallon metal or disposable cardboard water cans for initial delivery (fig. 6).

In operation the hose is coupled to the pump, the pump started, and water poured into the hopper tank. A pressure relief valve is provided in the system to bypass the water when the nozzle is shut off. The helicopter can stockpile or supply water in cans or boxes by using the cargo sling release. Delivery of helipumper and water may thus be accomplished without landing.

Overall dimensions of the unit are low to permit placement on the ground inside the skid. This again keeps sling length as short as possible. Full weight of the unit is 187 pounds, empty 63 pounds.

*Other equipment.*—After using some of this equipment on fires, it became apparent that the speed of attack was sometimes lost as a result of slow delivery to the heliport. Calling the warehouse

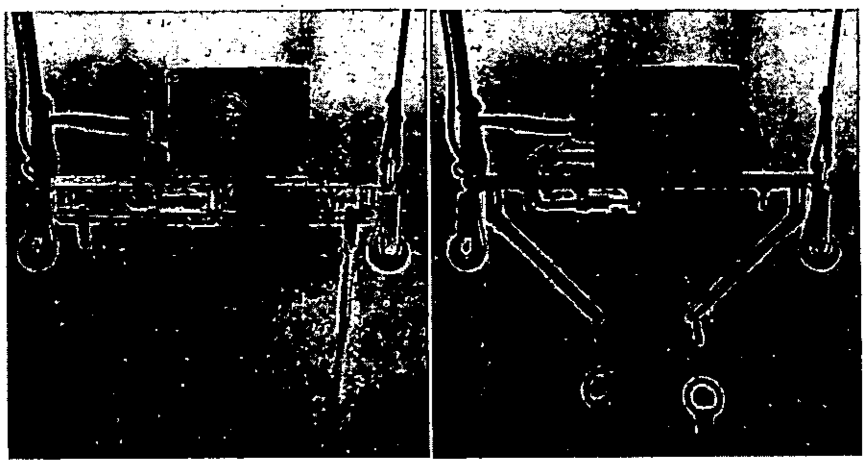

FIGURE 5.—A prototype design of a dual release attachment on the sling showing cargo lines in place and released.

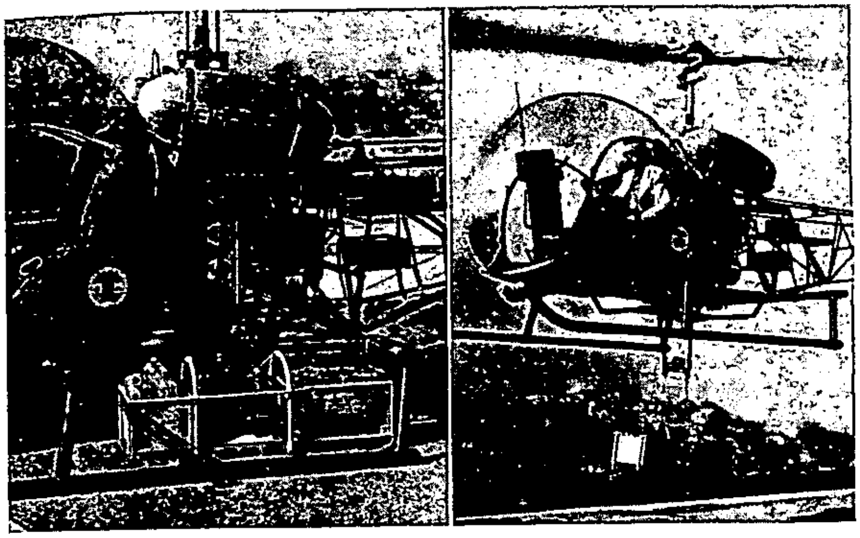

FIGURE 6.—Helipumper unit: *Left,* In position inside skid; *right,* being delivered.

and then waiting several hours for delivery cancels the entire potential speed advantage. To solve this problem the project has scheduled design of a truck-mounted slip-on, equipped with all the accessories and servicing tools so that it can be promptly dispatched to the flight scene. With the adapter assembly permanently mounted on the helicopter the accessories can be hooked up in minutes.

# THE HELICOPTER JOINS THE HOSE-LAY TEAM

FLOYD W. WAKLEE, *Forestry Equipment Engineer, California Division of Forestry;* HERB SHIELDS, *Mechanical Engineer, Arcadia Equipment Development Center;* CARL C. WILSON, *Chief, Division of Forest Fire Research, California Forest and Range Experiment Station.*

The helicopter proved it could lay fire hose over brush rapidly and safely in 1956.[1] Additional tests conducted in 1957 showed that it can do the job over timber and other cover types, and revealed some of the work still needed to make this versatile tool even more effective.

The 1957 tests,[2] carried out at Sorefinger Point near Weimar, California, covered three specific methods. First, we checked the time and performance of a ground crew making a 2-mile lay by hand; next, the ground crew did the job with a helicopter assist; finally, the pilot alone laid the hose from the helicopter.

*Hose lay by hand.*—A specially trained 6-man crew of the California Division of Forestry was used. Each man in the crew carried 200 to 300 feet of hose in conventional pack sacks, and the only assistance received was 5 hose deliveries by truck.

We found that a 2-mile hose lay by a small crew isn't the "impossible" job we had visualized. The 6-man crew took only 2 hours and 55 minutes to lay 10,900 feet of 1½-inch hose over the 10,819-foot course. This time included delays of 4½ minutes while the crew waited for hose deliveries by truck, 5 minutes while killing a rattlesnake encountered en route, and 23 minutes lost because part of the crew had to walk back uphill to get more hose. Thus, net time was only about 2 hours 22 minutes.

For the first 4,728 feet, the crew laid hose at an average of about 100 feet a minute. Fatigue began to show at about 47 minutes from starting time, and the men became increasingly tired as they fought through heavy brush. In spite of fatigue, with a brief rest this 6-man crew would still have been an effective suppression unit even after laying 2 miles of hose.

*Hose lay by hand with helicopter assist.*—During this phase of the tests 1,200 feet of hose was attached to a cartridge for dropping (fig. 1). In a preliminary test, the hose package was jettisoned from 60 feet by the pilot. The hose fell into a clump of brush and rolled across a rock-covered slope. The cartridge was so badly bent that it had to be repaired before further use. In addition, one length of hose was cut. The remainder of the hose was tested at 350 p. s. i. and found okay. Damage to the couplings was negligible.

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[1] *Improved Fire Hose Dispensing Tray for Helicopters.* Arcadia Equipment Development Center. U. S. Forest Service Equip. Devlpmt. Rpt. 44, 26 pp., illus. 1956. [Processed.]

[2] *The Helicopter—A New Member of the Hose-Lay Team.* Waklee, Floyd W., Shields, Herb, and Wilson, Carl C. U. S. Forest Service Calif. Forest and Range Expt. Sta. Res. Note 129, 11 pp., illus. 1957. [Processed.]

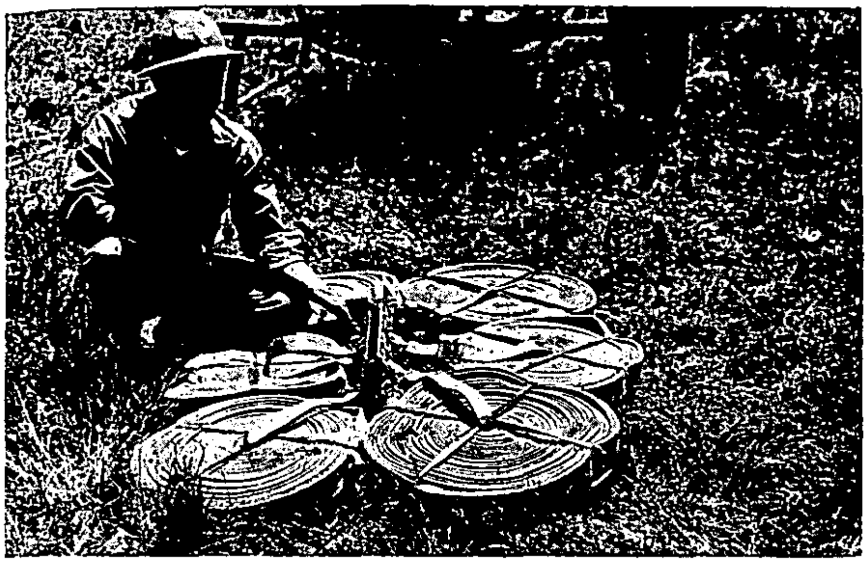

FIGURE 1.—A package of 1,200 feet of 1½-inch fire hose attached to cartridge and ready for installing on adapter assembly of helicopter.

After dropping 3 loads (3,600 feet of hose) at preselected spots, we called the operation off because of excessive hose damage. Several couplings were damaged, and 7 lengths of hose were ruptured or cut by the impact as the 300-pound load and the cartridge hit the ground. The two men who fitted the hose package to the helicopter found that there wasn't room to work under the helicopter and the cartridge straps were too short to allow any freedom. If this method is to become practical, we need to develop a way to package the 1,200-foot hose cargo so that it can be jettisoned from a helicopter 75 to 100 feet above the ground without damaging the hose or couplings.

*Helicopter hose lay.*—We then made the entire lay by a helicopter with the hose-lay tray. To speed up the operation, hose was prepackaged on plywood sheets and stockpiled at the heliport ready for immediate use. At first, the tray of hose was delivered by having a man on the ground start the lay by grabbing the dangling hose as the helicopter hovered overhead. But in timber stands, the cover was so thick the pilot could not hover close to the ground, and the other lays had to be started by the pilot (fig. 2). He released a 100-foot coil of hose tied to the skid gear, and the weight of the coil pulled the hose out of the tray.

Prepackaging the hose on plywood transfer pallets partially solved the problem of loading the helicopter hose tray. We still need better ways to strap the hose package to the plywood and tie the sections to the tray, but these problems can be solved by equipment development.

We found that the helicopter using the hose-lay tray can lay fire hose over gentle to steep topography and above brush and light timber. The key was in finding a way for the pilot to start

FIGURE 2.—Hose lay started by pilot. Hose pays out over tops of oaks and pine trees.

the lay at his convenience—using a length of hose for a weight.[3] Total time for the 2-mile lay by air was 2 hours and 29 minutes, including 42 minutes lost because of mechanical problems—26 minutes less than was required by the hand crew. Although 4 men were used to connect the hose when it reached the ground, they said that 2 could have done the job.

We also learned that the helicopter lay takes much more hose over timber and heavy brush. It required 12,570 feet, compared with 10,900 feet for the hand lay—about 16 percent more. Hose laid from the air catches in the tops of trees and drops down between them. We found that the extra 100 feet of hose used to start the lay is useful for splicing when the hose sections don't quite come together. This extra length could also be helpful for replacing ruptured lengths in a long lay.

Another point learned was that reduced airspeed during the hose-lay operation is important. The pilot should never fly faster than 20 and preferably between 10 and 15 miles per hour.

The pilot told us that the lay would have progressed faster and with a wider margin of safety if he had been able to contact the ground crew by radio. Not only can the ground crew be unaware of special hazards visible from the air, but also the pilot may be unable to see ground hazards. Ground-to-air and air-to-ground communications are as vital for helicopter hose lays as for other aircraft operations.

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[3]An electric device for releasing the 100-foot (25-pound) coil of hose to start the hose lay is reported in *Fire Accessories for the Light Helicopter* in this issue.

# TRAINING THE HELITACK CREW

JAMES L. MURPHY
*California Forest and Range Experiment Station*[1]

"Help!" the voice on the radio screamed, "I'm trapped, the fire's all around me!" The year, 1947; the fire, the Bryant Fire on the Angeles National Forest in southern California. The situation: a radio operator running an emergency radio relay station on a remote ridgetop was in the path of a blowup. Five minutes after his call, he was safely off the mountain. The helicopter had made its forest fire debut.

The helicopter is now a common forest fire-fighting tool in California. Its value and effectiveness are beyond question. But the helicopter is not an ordinary fire tool. It is expensive and is potentially as dangerous as it is valuable.

To obtain the safest and most efficient use of the helicopter the Helitack program[2] has included the organization and training of Helitack crews. In 1957 almost 300 fire fighters from 12 national forests, the California Division of Forestry, and the Los

FIGURE 1.—The San Bernardino National Forest base heliport is accessible by road, has a drop-off into the prevailing wind, and has an asphalt touch-down pad.

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Much of the work included in this report was conducted under terms of a cooperative student-aid agreement between Utah State University and the experiment station.

[2]A cooperative research and development program of the U. S. Army, the California Division of Forestry, and the U. S. Forest Service.

Angeles County Fire Department were trained in helitactics. An outline of the training plan follows.

I. Organization and qualifications of the Helitack Crew
  A. Helitack foreman: Qualified as sector boss (U. S. Forest Service fire rating) and experienced in air operations on forest fires.
  B. Assistant Helitack foreman: Qualified as crew boss and experienced in air operations on forest fires.
  C. Helitack crew member: Must have two seasons of fire experience.
  D. Helicopter pilot: Must be an experienced mountain pilot.

II. Ground operations
  A. Locating permanent base heliport (fig. 1).
  B. Installing base heliport facilities.
  C. Safety regulations.
  D. Equipment kits.
  E. Preparation of helicopter operations map.
  F. Flight and other records.

III. Training the Helitack Crew
  A. Pilot training.
    1. Helicopter-use policies not included in general CAA instructions. (One source is the Region 5 Supplement to the National Forest Manual for Forest Service Use Policies and Working Instructions.)
    2. Fundamentals of fire behavior.
  B. Crew training.
    1. Safety.
      a. Precautions while on ground
        (1) Keep at least 50 feet from helicopter at all times unless job designates otherwise.
        (2) Dustproof all landing areas by wetting down or oiling. Wear goggles at all times when helicopter is at heliport.
        (3) Approach and leave helicopter from the front so that pilot can see you at all times.
        (4) Do not approach or leave helicopter over ground higher than that on which the ship is standing.
        (5) Keep clear of main rotor and tail rotor. Watch long-handled tools.
        (6) Provide a wind indicator at all landing spots.
      b. Precautions before takeoff.
        (1) Obtain pilot's approval on all missions.
        (2) Check wind conditions. (Helicopters should never be dispatched for mountain flying when average wind velocity over a 5-minute interval at exposed peaks is more than 30 m. p. h.).
        (3) Fasten and adjust safety belt.
        (4) Keep clear of controls.
      c. Precautions while in the air.
        (1) Keep safety belt secured until pilot signals release.
        (2) Keep oriented at all times.
        (3) Watch for special hazards.
    2. Job familiarization.
      a. How the helicopter works.
      b. Maintenance and use of all Helitack equipment.
    3. Development of skills.
      a. Physical conditioning.
      b. Refresher course in fire behavior, use of tools, and line construction.
      c. Map reading and use of compass.
      d. Forest Service ground-to-air visual signal code.
      e. Use of radios.
      f. Hover-jump (dropping from ship hovering 6 to 8 feet above ground) training:
        (1) Protective suit.

(2) Jumping procedure.
  (a) Make a high-level pass to determine general area safest for jump.
  (b) Make a low-level pass and pick the jump spot.
  (c) On third pass, at pilot's signal, drop tools near jump spot.
  (d) On fourth pass, jump in compliance with established procedures (fig. 2).

g. Hover-landing procedure.
h. Helispot location and construction. (One of the big responsibilities of the Helitack Crew.)
i. Fire suppression procedure.
  (1) Initial attack on small fires.
    (a) First response. pilot, Helitack foreman, one crewman.
    (b) Reconnaissance of the fire.
    (c) Crew landing.
    (d) Initial attack.
    (e) Helispot construction.
  (2) Large fire procedure (where Helitack Crew will not make initial attack).
    (a) First response: pilot, Helitack foreman, one crewman.
    (b) Ground response: remainder of crew with Helitack Crew equipment.
    (c) Heliport location: foreman and pilot.
    (d) Traffic management: Helitack foreman.
    (e) Operation of base heliport: Helitack crew.

4. Standby duties: prevention, presuppression, insect and disease control, search and rescue, aerial seeding.

Experience during the past 10 years on California forest fires has proved that safe and efficient helicopter operation requires a specialized crew well trained in every use of helicopters on forest fires. This training can pay big dividends in cutting fire fighting costs and reducing overall damages.

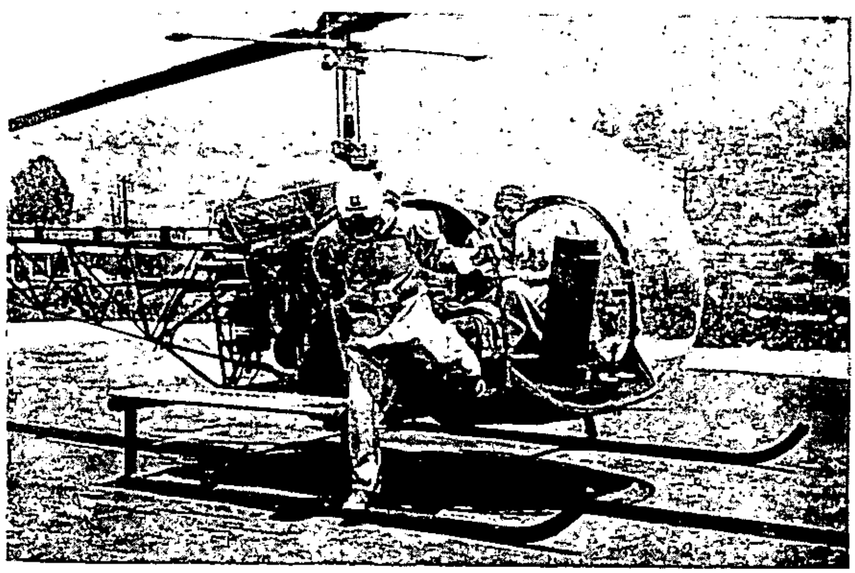

FIGURE 2.—At the pilot's signal, Helitack crewman grips both sides of the open door firmly. He swings his right foot out to the skid. His lower right leg and knee are placed snugly against the skid gear leg.

# HELITACK CREWS PAY OFF IN CALIFORNIA

JAMES L. MURPHY
*California Forest and Range Experiment Station*[1]

"Catch 'em while they're small" has been the goal of forest fire fighters since the beginning of organized forest fire suppression. Even the largest and most disastrous fires could have been stopped in their early stages had a few experienced men been able to reach them and take immediate action. Early detection and fast, efficient action are the only practical answers to successful initial attack.

The helicopter, introduced to California fire fighters in 1947, has shown promise in reducing the time interval between detection and initial attack. But helicopter use can be expensive, particularly if not closely supervised. We also know it can be dangerous to anyone not aware of its hazards.

## HELICOPTER SPECIALISTS

A team of specialists, highly trained in using helicopters on fires, may offer a solution to these problems. This was demonstrated in 1954 when the Angeles National Forest organized a 4-man crew of specialists trained in initial attack by helicopter, in location and construction of helispots, and in air operations on large fires.

Limited experience indicated that this type of crew could become an important part of the fire suppression organization. Consequently, when Helitack was organized in 1956,[2] one of the objectives was to study the use of crews in performing certain specialized fire jobs with helicopters. California was selected for the training area. During the 1957 fire season some 300 fire fighters from the national forests, the California Division of Forestry, and the Los Angeles County Fire Department were trained in "helitactics."

## USE OF HELITACK CREWS, 1957

In 1957 Helitack crews were used in a variety of ways in California. They made 42 initial attacks throughout the State, controlling 32 fires in the early stages with no other aid. On five

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Much of the work covered by this report was completed under terms of a cooperative student-aid agreement between Utah State University and the experiment station.

[2]A cooperative research and development program of the U. S. Army, the California Division of Forestry, and the U. S. Forest Service to integrate helicopters into fire suppression activities.

fires the Helitack crews were helped by another new fire tool: air tankers. On four other fires the Helitack crews were soon joined by ground or smokejumper crews who aided in suppressing the fires. Only once was a Helitack crew unable to stop the fire in initial attack.

Average travel time for the Helitack crews was 33 minutes, including flight time from the company base for those helicopters not on standby contract. Followup ground crews averaged 3 hours and 48 minutes travel time. The effectiveness of such fast initial attack is evidenced by the report of the fire boss of the Ditch Fire on the San Bernardino National Forest: "Helitack crew made initial attack, knocked down head and hot-spotted flanks."

Where the Helitack crews could not control a fire on initial attack, they paved the way for fast followup crews. This type of operation was reported on the Pate Fire on the Los Padres National Forest: "Fire in inaccessible area on ridgetop. Crew made hover-jumps near the fire and constructed helispot. Relief crews, supplies, and equipment were flown in and out by the helicopter. At least 30 acres and $900 in costs were saved."

## OPERATIONS ON LARGE FIRES

The Helitack team of specialists can also perform important jobs on large fires: Reconnaissance and scouting, management of air traffic, maintenance and service of heliports, location and construction of helispots, servicing helicopter accessories, and hot-spotting isolated sectors of the fireline. Helitack crews also proved effective in northern California as mopup and patrol crews on lightning fires following initial attack by smokejumpers.

The Devore Fire on the San Bernardino National Forest demonstrated another ability of the Helitack crew. Their efficiency in packing and installing helicopter hose trays and in helping lay 4,000 feet of 1½-inch hose was a vital factor in bringing the 96-acre fire under control in a brushy, rugged area.

## OTHER USES OF HELITACK CREWS

Because of their specialized knowledge, Helitack crews are especially valuable for training other fire fighters in helicopter use and safety. They also aid presuppression programs in other ways. They construct helispots. They increase detection coverage on days of low visibility and high fire danger by serving as observers. At least one national forest said that the helicopter and its crew were a valuable aid in fire prevention work: Once forest users were aware of the helicopter patrol, they remained out of areas closed to public use.

Helitack crews also have been used on nonfire projects, such as detecting and treating insect-infested trees in inaccessible timber areas on the Klamath National Forest.

## HOW HELITACK CREWS HAVE PAID OFF

In summary, field reports in California in 1957 showed that the following dividends can be obtained from well-trained Helitack crews:

*Safety.*—Helitack crews are trained, and can train other personnel, to recognize and avoid helicopter hazards. Helicopter-delivered crews get an aerial view of the entire fire and its hazards, are not fatigued by long hikes and, as a result, are better able to cope with emergency situations.

*Versatility.*—The Helitack crew can be trained in all forestry uses of the helicopter.

*Availability.*—Specialized crews with equipment specifically designed for helicopter use are kept available at all times. The assignment of untrained men could result in an inefficient and unsafe helicopter operation.

*Efficiency.*—Use of the helicopter reduces travel time to the fire. Aerial reconnaissance assures quick, decisive initial action that can result in prompt control.

*Economy.*—Fieldmen of the agencies participating in the Helitack crew training program estimate substantial savings in suppression costs and more than 15,000 acres saved on 26 fires as a result of Helitack crew activities during the 1957 fire season.

Even with these advantages, Helitack crews must still be viewed as an additional fire tool to be integrated into the overall fire organization. They can be efficient and economical only when used at the proper time and place. They are not intended to replace ground crews, smokejumpers, bulldozers, and fixed-wing aircraft where such units can perform better and cheaper. The next job is to determine the limitations of Helitack crews and to establish guidelines for their use.

## INFORMATION FOR CONTRIBUTORS

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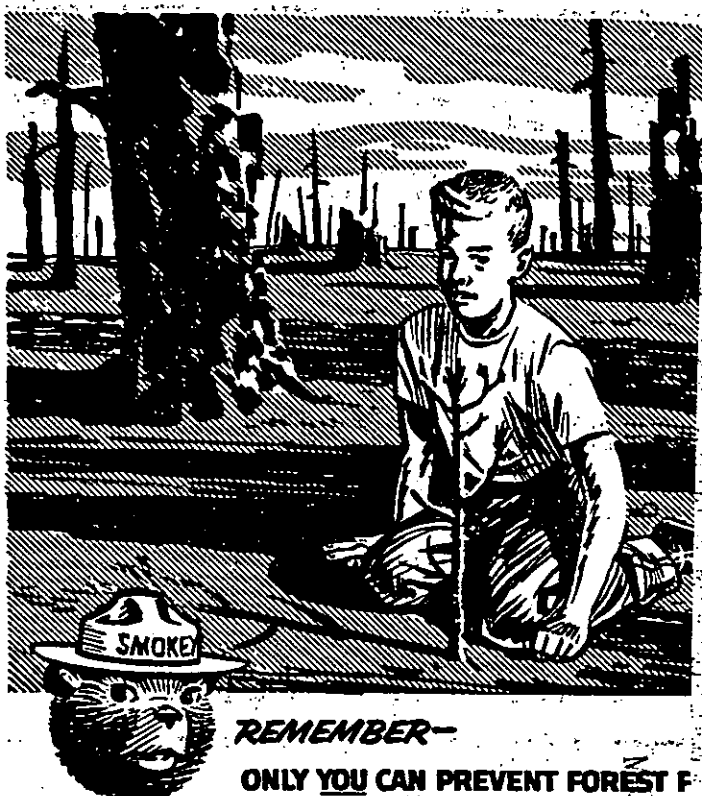
, whether drawings or photographs, should have clear a story. Only glossy prints are acceptable. Legends for ould be typed in the manuscript immediately following in which the illustration is first mentioned, the legend d from the text by lines both above and below. Illustra- labeled "figures" and numbered consecutively. All dia- be drawn with the type page proportions in mind, and to permit reduction. In mailing, illustrations should be n cardboards held together with rubber bands. *Paper ver be used.*

t Service photographs are submitted, the negative num- indicated with the legend to aid in later identification tions. When pictures do not carry Forest Service num- ce of the picture should be given, so that the negative l if it is desired.

ine drawings will reproduce properly, but no prints ints or blueprints) will give clear reproductions. Please nit well-drawn tracings instead of prints.

# Fire destroys his trees, t




*REMEMBER—*

**ONLY YOU CAN PREVENT FOREST F**