Aerial Fire Control

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INTRODUCTION

From the time that private and public agencies came to the realization that forest fires were destroying thousands of acres of valuable timber, speed in detecting, getting to the fires, and bringing the fires under control in the shortest time possible, have been their main objectives. Lookouts have been established on the highest peaks to afford the maximum amount of coverage. Roads and trails have been built into the more remote and inaccessible areas so as to shorten the time necessary for traveling. Radios have been installed in patrol cars, at lookouts, and at guard stations to facilitate communications. Expense has been a small item in cutting down the time from the start of a fire until men are at the fire.

To enable the private and public agencies to accomplish the above objectives in the shortest time possible, they have been turning more and more to aviation. The airplane has been helping in detection, patrol, aerial delivery, transportation of manpower, and other phases of fire control. With new developments in aviation brought about by the recent war and through experiments conducted by the Forest Service, the near future should show some remarkable advances in the further use of aviation in combatting fires.

The information in the following pages has been compiled to present the important part aviation is now playing in fire control and the future developments that can be expected.

HISTORY OF AVIATION IN FIRE CONTROL

EARLY PATROLS

The use of airplanes in fire control dates back to 1919, when the Army Air Force furnished planes and the necessary personnel to fly patrol over the hills of California during the fire season. In these early patrols the Forest Service cooperated with the Army and furnished most of the necessary topographic maps and set up the routes to be traveled. Many square miles of timber land were covered during the first season of operation and considerable fires were reported by the planes. People were very enthused about the prospect of using planes in patrol work and congress appropriated funds to further the experiment.

This early fire patrol in California was later extended to include Oregon, Washington, Idaho, and Montana, and in 1925 a fire patrol was organized at Spokane.

The early use of airplanes in fire control did not take the place of lookouts as many of the fire control officers had hoped. The airplane was not dependable and radio communication which had been set up between the plane and the ground was often inadequate. Many times a plane would sight a fire but would be unable to contact the ground stations until it had landed. Being unable to compete with the lookouts, the airplane was confined mainly to flights after lightning storms, during periods of low visibility, and in other emergencies.

FIRST EXPERIMENTS IN DROPPING CARGO

The dropping of cargo from planes had been tried in 1928 but it was not until 1930, in Region One (12), that any cargo was dropped on an actual fire. The first cargo was dropped without the use of parachutes in what was called the "free dropping" method. This method required special packaging and tying and was later abandoned for the parachute. Many types of homemade parachutes were tried and in 1935 some condemned army parachutes were secured and found to work satisfactorily. Army parachutes were not always to be had so small burlap parachutes were designed for this specific purpose and found to give excellent results.

EARLY SMOKEJUMPERS

The use of parachutes for lowering firefighters from planes had been suggested in 1935 but the idea was thought to be impractical and nothing was done about it until the fall of 1939. In 1939 the Forest Service (15) authorized experiments to be carried out in parachute jumping on the Chelan National Forest. This experiment proved successful and led the way for the growing use of smokejumpers.

EXPERIMENTS IN BOMBING FIRES

The bombing of fires with water and chemicals was tried in 1935 by Flint (15) but this method of controlling fires did not prove to be practical and was later abandoned.

PRESENT PICTURE OF AVIATION IN FIRE CONTROL

DETECTION

Detection of fires by airplane has proven successful and more regions are beginning to depend on the airplane to supplement their ground forces during the fire season. The early use of the airplane for this purpose failed because of unreliable airplanes and inadequate communication between the observer and ground stations. These faults have been alleviated and now men can be notified a few minutes after the fires have been discovered.

From tests conducted by the Forest Service (6) aerial detection has been found to be faster and cheaper in some regions than ground patrol and lookout detection. In regions which contain thousands of acres of remote and inaccessible forest land, and which require the use of many lookouts to give the proper detection, the airplane is becoming more popular. In these regions many of the lookouts can be eliminated and the cost of maintaining them can be applied on the cost of operating airplanes.

Large portions of our national forests are found in the higher altitudes and are subjected to fires mainly during lightning storms. In these areas a regular patrol can be maintained during normal weather and special patrols sent out after lightning storms. Region One, in 1945, did away with 32 detectors and depended almost entirely on airplanes for detection. The results were very encouraging.

When lookouts can be replaced with air detection there is not only a saving in the salaries of the lookouts that can be applied on the cost of operating planes, but also a saving in the cost of maintaining the station, building and maintaining telephone lines, supervising the lookouts, packing in supplies, upkeep of equipment, and servicing. To be effective, a lookout must be at his post at all times regardless of weather conditions, which means spending a great deal of his time uselessly. On the other hand an airplane can be grounded during periods of extreme fire hazard. By using the airplane in conjunction with fixed lookouts the detection system becomes a great deal more flexible.

The costs of air detection in comparison to fixed detection varies directly with the degree of coverage that is desired. For a low degree of coverage the airplane is more expensive but as the degree of coverage increases the costs per unit decrease. By using coverage curves as established by Hand and Harris (6) which have been set up for both air detection and fixed detection the cost comparisons can readily be made. For one million acres of timber land it takes approximately 88 lookouts at a cost of $16 per man day to give 79 percent coverage. This

I. Coverage Curves

costs $1400 per day. For air detection the present rates are $40 per hour for a plane capable of carrying two smoke-jumpers and approximately $20 per hour for a plane that will serve adequately for patrol work only. Using the $40 per hour figure it is found , on the basis of a 16 hour day and giving 79 per cent coverage, that the costs will be $1300. For 73 per cent coverage, air detection and fixed detection are about the same, and below 73 per cent air detection is higher. Using the $20 per hour figure it is found that air detection is cheaper above 39 per cent.

The most economical method would be a combination of both aerial detection and fixed detection. With the use of coverage curves the point where the curve of fixed detection and aerial detection cross can easily be found. Above this point it would be cheaper to use airplanes.

Factors affecting the visibility of smoke

Large smokes can be readily seen from an airplane and present no difficulties in detection. The small smokes are very difficult to see and the observer must keep a sharp lookout for them. As found by Morris (8), the most important factors affecting the visibility of small smokes from an airplane are:

1. The brightness of the color of the background.
2. The angle of the line of sight from the plane to the smoke, and from the plane to the sun.
3. The size of the smoke.
4. The amount of haze in the air.

Visibility of smoke against a light background is poor. Against a dark background or a mottled background the visibility is much better. Even against a dark or mottled background the visibility depends to a large extent upon the angle of the line of sight from the observer to the smoke, and from the observer to the sun. The less the angle the better the visibility until an optimum angle of 40° is reached. Above 70° the visibility decreases rapidly.

In full sunlight the visibility is much better when looking toward the sun than when looking away from the sun, unless the smoke is in a shadow. If the smoke is in a shadow the visibility is better when looking away from the sun, but still less than if it were in full sunlight.

On a cloudy day the visibility distance is the same whether looking toward the sun or away from the sun.

On a clear day better visibility will be had by the observer if the plane is flying toward the sun and flying fairly low. The best part of the day is around midday when there are not many shadows cast by the hills. On a cloudy day there are no shadows, consequently it makes very little difference which way the plane flies. Clouds in the sky, however, make detection more difficult.

According to pilots who have searched for smokes the best results will be had if the plane flies at about 1,000 feet in elevation. More territory can be covered by flying across canyons, but small smokes in canyons will appear and disappear or might be missed entirely. In steep mountains where the canyons run in different directions, it is more difficult for aerial detection than in country where the drainage is more regular and the topography is more rounded. In mountains containing large granite outcroppings, which form a light colored background, the detection of small smokes is very difficult.

Tests were made on the Chelan National Forest to determine the visibility of small smokes from an airplane and according to Morris (8) the following results were found.

Horizontal distance of smoke	Elevation of airplane above smoke	Notes on visibility of smoke columns compared to approximate horizontal angle between line of sight to smoke and to sun
Miles	Feet	
1	700	Clearly visible at all angles
1	1,100	Difficult to see with sun at observer's back
2	1,300	Clearly visible toward the sun and satisfactorily visible at right angles to sun
3	1,700	Visible toward the sun and at right angles but not distinguishable with sun at back
5	4,000	Not distinguishable with sun at back
5	5,000-6,000	Not distinguishable with sun in the 90° sector at observer's back
5	6,600	Not distinguishable when sun in the 120° sector at observer's back and on the borderline of visibility the shadow of the smoke becomes visible before the smoke itself
5	7,000	Identification of smoke not certain when sun slightly behind observer
5	9,000	Neither smoke nor shadow discernable when sun at observer's back
5	10,000-14,000	Barely seen when sun slightly behind observer but satisfactorily visible when horizontal angle between sun and line of sight about 45°. Most visible when horizontal angle 0°.

Texas Forest Patrol

The Texas Forest Service (4) has found that in using airplanes for fire patrol many hours can be saved, more territory can be covered, and less men are needed for ground patrol. Their patrol was set up during the war in cooperation with the Civil Air Patrol. It was during this period that the manpower situation was critical and a method was needed to cover large areas of timber lands as quickly as possible. During periods of extreme fire hazard their planes now cover nine million acres of timber lands.

Texas Fire Patrol uses a slow flying plane of about sixty-five to seventy-five horsepower with a cruising range of two to three hours. With these slow flying planes better observation can be had and landings can be made in small areas. During the patrols these planes keep in contact with the lookout towers and patrol cars by the use of a two way radio. If the pilot spots a fire he either radios headquarters or searches for a patrol car and gives his message. Sometimes a plane and patrol car will work together checking fires in a district. If the observer sees a smoke he notifies the patrol car and then scouts the fire to see if an investigation is needed.

If a fire is burning in a remote district, the plane may fly over a small settlement or ranchhouse and drop a message asking for volunteer firefighters. Later it will come back to see how the firefighters are progressing and to give any directions that may be needed. Dropping of of messages has proven successful and little trouble in getting volunteers has been noted.

The towermen may even call on the air patrol to investigate fires to determine those which demand immediate attention and those which are burning in areas containing no valuable timber stands and can wait. In this way the fires in flammable cover or valuable timber get first priority.

Texas has found, along with many other regions, that in using airplanes to supplement the ground forces, the detection system becomes more flexible.

SCOUTING

The fire boss has long been wanting a method whereby he could cut down the time required to get information on the progress of the fire. With the old standby method of ground scouting many hours are needed to gather the required information, and by the time it is all assembled the direction of burning may have changed, making the information of little use. With an airplane to supplement the ground scouts the fireboss can have up to the minute data on the fire at all times.

The Forest Service (11), along with State and private agencies, is now using airplanes to scout many of the larger fires and some of the smaller ones in inaccessible areas. With the airplane an overall picture of the fire can be had in a much shorter time than is possible by ground scouting, and the ground forces can be notified as to which portion of the fire to attack first. By making a few runs over the fire an observer can determine the direction of burning, type of cover, topography, speed of burning, and much other information necessary to bring the fire under control in the shortest time possible. In case of more than one fire, such as may happen during a lightning storm, one plane can scout several fires and notify the fire boss as to which one deserves first attention.

The observer has no difficulty contacting the fire boss with the two-way radio that has been developed. The fire boss has a small portable radio that he can carry with him and no matter where he happens to be, the observer can contact him and give the necessary information.

Should the fire boss need more detailed information than the observer can give, aerial photographs can be taken, developed in the plane, and dropped to him in a matter of minutes. These aerial photographs of a fire prove very beneficial, especially if previous photographs have been taken, showing topography, cover types, and fuel hazards. Having good photographs, the fire boss does not have to depend on the observer to give an accurate and detailed description of the area.

By having an airplane above, the danger of the ground forces being cut off by fire can be eliminated. If a blow-up should occur unexpectedly, the ground forces can be directed to safety by the two-way radio.

Many times in steep topography it is difficult for the ground forces to locate a small fire. Here again the airplane is of great value. The airplane can locate and direct the searchers to the fire by the easiest routes, saving them hours in search and travel.

DIRECTING THE FIRE

Now it is not necessary for the fire boss to appear in person on the fire. By using the airplane to the best advantage he can do his directing from the air, doing away with the necessity of spending several days to a week away from headquarters. Once or twice a day he can fly over the burning area, size up the fire, and with his radio, contact the ground forces and give them the necessary directions for fighting the fire. If reinforcements are needed, headquarters can be contacted by radio, and in a matter of minutes smokejumpers can be on the job to combat a spot fire or take over some critical sector that is getting out of control.

MAPPING BURNED AREAS

Mapping the areas burned is another job in which the airplane can be employed. The usual practice is to send a ground crew out to map the burned areas at the end of the fire season, in order that the total area burned during the year may be determined. This takes several days by the time the crew hikes to the fire, maps the area, and hikes out. With the airplane and an aerial camera, the area can be mapped in less than an hour. All that is needed to do the required work is a few runs over the area so as to get a complete picture. After getting back to the office all of the necessary computations can be made to get the exact area.

A new method of measuring the fire area has been devised by Region 5 (13).

> Region 5 reports a very ingenious method of measuring the size of fire developed by one of their pilots. While flying across the fire at 120 miles per hour the observer presses his face against the window watching the trailing edge of the wing strut. As the strut crosses into the burn the observer calls "now" and another passenger begins timing with the second hand of his watch. When the other side of the fire is reached the observer again calls "now" and the timing is stopped. Two flights are made in each direction to compensate for wind. In a case which was cited the data obtained was an average of 12 seconds one way and 6 seconds on the cross trip. With the speed of the plane at 120 miles per hour, 2 miles per minute, or 2.67 chains per second, it was determined that the fire was 32 chains long and 16 chains in average width. This indicated that the fire had spread over an area of 51 acres.

SMOKEJUMPERS

The parachuting of men and equipment to fires has developed from an experiment on the Chelan National Forest in 1939 to a full fledged operation, whereby men and equipment are being transported over many miles of rough and relatively inaccessible terrain in a minimum amount of time to attack fires shortly after the fires are detected. Prior to 1930 a few progressive foresters had considered dropping men from planes but the idea was given up as being a little too dangerous. In 1935 a few dummy tests were performed by an inventor claiming a quick opening parachute, but the Forest Service would not authorize any practical demonstrations, so smokejumping was delayed for several years.

By the fall of 1939 there were many more advocates of smokejumping so the Forest Service decided to experiment with the idea and see if it was at all feasible to drop men into the rough areas comprising much of our national forests. A large number of dummy tests were run and then a professional parachute jumper made approximately 60 jumps for the purpose of determining the best type of chute and to develop the necessary equipment to protect the jumper when landing in trees or on sharp rock outcroppings.

The experiment on the Chelan National Forest proved successful and the Forest Service came to the conclusion that parachutists could safely land in most types of timber and at altitudes from 2,000 to 7,000 feet. Landings in green timber, which had been feared previous to jumping, proved to be the softest and are now called "feather bed" landings. Landings in snag infested areas, abrupt rock slopes, canyons, and on cliffs are dangerous and the jumpers attempt to stay clear of them.

Before being allowed to jump the prospective smoke-jumper is put through a rigorous training course to accustom his body to the sudden strain of the parachute opening and checking his rate of fall. Also, he must be prepared for rough landings on the ground. The training consists of an obstacle course, diving and rolling exercises to teach him to relax his body, and one exercise which simulates a parachute opening. In this last exercise the student jumps from a platform about 18 feet off the ground. Attached to his suit is a rope which snubs him up a few feet from a safety net. This exercise toughens his leg muscles near the crotch where the most strain is placed when the parachute opens. To take his mind off the jump and leave it free for other duties the trainee passes a stone from one hand to the other.

On his first jump from the plane the trainee is given the necessary instructions from the ground through a loudspeaker. After about seven jumps on open fields and in different types of timber he is ready for a fire.

According to Andreeva (1) the smokejumper looks much like a football player when he is ready for a jump.

> The jumping suit worn by the forest paratrooper consists of a heavy pullover with a high collar to protect the neck against scratches from limbs of trees, should the jumper be unable to guide his chute to an opening. A leather helmet, virtually the same as worn by football players, covers the head and ears, while a heavy wire mask, not unlike that worn by baseball catchers, protect the eyes and face. A wide leather belt protects the kidneys, and other organs of that region, while anklets and wristlets are worn to give support to those parts. Heavy gloves complete the outfit.

Besides the equipment mentioned above the smokejumper carries a backpack parachute which is operated by a static line. It has a 28 foot canopy equipped with special guideline controlled steering slots. In addition to the main parachute each man carries a manually operated 22-24 foot emergency chute. He also carries a stout coil of rope in case he gets hung up in a tree, and a knife in a sleeve pocket where it will be handy.

According to King and Davies (7) a few of the techniques that the jumper should take into consideration when approaching the ground are:

1. Don't attempt to break the fall by grabbing branches or the tops of trees when descending through the timber.

2. The maneuvering of the parachute should not be attempted within 100 feet of the ground.

3. By landing in smaller trees it is much easier to let down and to retrieve the parachute.

4. If possible, land facing the slopes.

Upon landing the smokejumper gets rid of his parachute and suit, sets out a yellow cloth to notify the airplane of a safe landing and waits for his tools to be parachuted to him. According to Andreeva (1) his equipment consists of the following:

1. pulaski
2. sleeping bag
3. concentrated rations
4. compass
5. canteen
6. first aid kit

7. matches

8. headlight

If the fire is large and a radio is needed it may be dropped to him. Any other equipment such as axes, shovels, hammers, mess equipment, and power pumps will be parachuted to the smokejumper if he signals for it.

To bring back the valuable equipment and to give the smokejumpers any assistance that may be needed men and pack animals are dispatched to the fire at the same time that the smokejumpers are sent in.

It takes approximately one hour for a crew of smoke-jumpers to get to a fire within a radius of 50 miles. One hour allows for dressing, warming up the plane, climbing to altitude, traveling 50 miles, and letting out the jumpers. This is quite a saving in time compared to hiking to the fire or traveling by horse. By arriving in one hour the fire may be kept out of flashy fuel or the fire boss may be able to save a portion of the line that was getting out of control.

From 1940 to 1945 smokejumpers played a more important part each year in keeping the area burned down to a minimum. During the war years there was a critical shortage of man-power as most of the physically qualified men were in the armed forces. To help ease this shortage the Civilian Public Service Program was initiated in 1943. The majority of men entering into this program consisted of conscientious objectors who wanted noncombatant work. Without these conscientious objectors the Forest Service would have been unable to maintain its prewar record of area burned.

In 1944 many of the national forests reduced their ground forces below what at one time was considered an absolute minimum and depended on smokejumpers to give the necessary protection over large areas. In 1945, Region One, in an experiment with over two million acres of inaccessible timber land on the Continental Divide, reduced its ground forces to a mere skeleton crew and most of the detection and suppression was carried on by airplane. The experiment was considered successful and is a trend toward greater economy and more efficiencey.

Smokejumpers are not used only on small fires where 8 or 10 men may be sufficient to handle the blaze, but also on larger fires where many more men are needed. Even though the fire is past the smokechaser stage it is often less expensive to fly the necessary men to the fire than let them walk in. Not only is considerable time saved but the men arrive fresh and ready for work instead of worn out and in need of rest.

The fire season of 1945 was the first time since initiating the smokejumping program that adequate personnel was available. With returning service men and the remaining members of the Civilian Public Service parachute program a very good distribution of manpower could be had. According to the Forest Service (15) an excellent record was made in 1945.

The record for 1945 shows that in the three regions smokejumpers were used on 269 fires, with a total of 1,236 individual jumps. From the four operating bases, the jumpers covered fires in 23 national forests located in the States of Montana, Idaho, Washington, Oregon and California. They also jumped to fires in Yellowstone and Glacier National Parks, U. S. Indian lands, private timber association lands, and in one instance, just over the International Boundary in Canada.

The following is an estimate of the savings by smokejumpers from 1940 to 1945 in Regions One, Two, and Three. The estimates are based on actual costs of similiar fires where smokejumpers were not used.

Yr.	Estimated savings	No of fires used on
1940	$30,000	9
1941	30,000	9
1942	66,000	35
1943	75,000	47
1944	No data	over 100
1945	346,000	269

Since initiating the smokejumpers in 1939 some of the later developments include:

1. The static line that was developed by the army was put into use by the Forest Service. By using the static line to open the chutes more confidence was installed in the smokejumpers during the first few jumps and much of their nervousness was reduced.

2. The training of paradoctors for rescue missions is

a big step in reducing deaths to smokejumpers and other personnel injured in the back country. Before training doctors for these jumps an injured person might have to wait hours and sometimes days before help arrived. Region One has completed arrangements for a former Army paradoctor to jump on emergency cases in the inaccessible portions of the Rockies. In 1945 55 rescue jumps were made in Region One.

3. A single point release harness was adopted which results in a faster let down for jumpers who land in trees.

4. The Derry Slotted Chute was developed which is more maneuverable, opens easier, and descends slower.

5. Larger planes are now being used for transporting smokejumpers.

Now that the war is over there is every indication that the use of smokejumpers in controlling fires over large areas of inaccessible areas of timber land will continue to increase.

AERIAL DELIVERY

In the past the delivering of supplies and equipment to men on the fire line has been one of the major roles of the airplane in fire control. It has continued to increase with better methods of packaging,dropping, and the building of more air fields within the national forests, until at the present time many thousands of pounds of cargo are delivered annually. Even this important role of the airplane is limited by certain factors. When smoke from the fire obscures the fire camps or fog settles down over the area, cargo cannot be dropped with any degree of certainty and regular methods of delivery must be depended on.

The airplane has proved to be most valuable in delivering cargo where the fires occur in remote areas. If crews hike to the fire they can travel light, saving their energy for the job of fighting fire, and knowing ahead of time that the necessary supplies will be at the fire shortly after they arrive. If smokejumpers are dropped into remote areas they have to be supplied immediately and the airplane is the only means by which this can be done. When using pack animals it takes anywheres from one to three days to get the supplies to a fire. With the airplane the time can be cut down to several hours. On large fires the airplane can not only be used for the initial delivery of cargo, but may be used to supply an entire fire camp for the duration of the fire.

On small fires where only a few men are needed it is often less expensive to deliver hot meals in special containers than go to the expense of setting up a kitchen. If a kitchen is set up a cook and flunky are necessary, the mess outfit will have to be cleaned and repacked, pack animals will have to be sent in to pack out the equipment, and the firefighters will use valuable time and energy hiking from the fire line to the kitchen for meals. If containers are used any type of meal desired can be flown in, dropped to the men, and if need be, the containers can be abandoned. The containers are made out of five gallon cans packed in kapok and will keep a meal hot for about four hours. Any restaurant can supply the required food upon short notice.

The costs of aerial delivery compare favorably with the costs of using pack animals. If the cargo is to be delivered around 20 miles from the base and there are trails into the area the costs are about the same for either method. According to the Forest Service (12), on a fire that requires 75 men it will take a pack string approximately three days to deliver the supplies and the costs will be around .09½ cents per pound. By using an airplane of the cargo type, the costs will run about .09 cents per pound and the supplies can be delivered by noon of the first day. When speed is desired the costs of flying cargo to a fire cannot be compared to that of using pack animals. If supplies can be delivered to a camp shortly after the crews arrive, and this results in the fire being brought under control sooner than otherwise, then the overall cost of the fire will be much less, even though the delivery costs are higher.

In the beginning of cargo dropping, the cargo was dropped without the use of parachutes. Many tons of supplies were dropped by this method but a great deal of special padding and tying was necessary to keep the breakage down to a minimum. All of this extra padding took up valuable space and reduced the payload that could be carried by the plane. To cut down the unnecessary padding and to reduce the time required to package the supplies, parachutes were tried and found to be satisfactory. Various homemade chutes were used with considerable success until 1935 when condemned army chutes were secured and found to be superior. A few alterations had to be made on these chutes to fit the cargo, but this was easily done. Condemned chutes were not always to be had so burlap chutes were designed and now most regions use chutes of this type. Burlap chutes are very sturdy, require little skill in packing, and give satisfactory service.

There are many different techniques used in dropping the supplies from an airplane. On large fires where thousands of pounds of supplies are used, a large plane is required and the supplies are dropped with the use of a static line. On a small fire the pilot or an assistant will drop the supplies overboard without the use of a static line.

The following is a record of air delivery by parachute in Region One (1):

Year	Pounds of freight dropped
1936	109,000
1937	25,000
1938	1,400
1939	120,000
1940	297,000
1944	130,000
1945	455,000
1946	220,000

Packaging of supplies

The degree of packaging needed for the supplies depends on the type of supplies to be dropped. Cartons of canned goods need no special packaging but are bound together in 120-180 pound bundles. Long handled tools are placed in a canvas bag and tied with rope. Small tools and equipment that can stand rough treatment are dropped in wooden containers bound with iron strips. Tools, such as axes and saws, are crated to protect their edges. Delicate instruments are securely fastened in wooden boxes with shock absorbers of rubber strips, and then placed on a partially inflated inner tubes and wrapped with canvas.

Liquids, such as water, gasoline, and oil, are dropped to crews without any special padding to take the shock. Water is usually dropped in regular 10 gallon milk cans with the lid wired on to prevent spilling. Oil is packaged in cartons the same way as canned food, and gasoline is dropped in cases of two five gallon containers.

FUTURE POSSIBILITIES OF AERIAL FIRE CONTROL

From all indications the use of aviation in fire control will continue to grow. At the present time the United States Forest Service in cooperation with various agencies is carrying out experiments in aerial detection, smokejumping, aerial delivery, and many other aspects of fire control with both the airplane and the helicopter. When these new methods are perfected they may take the place of many of the methods now used in fire control.

THE AIRPLANE

The Forest Service is contemplating spacing small airfields throughout the national forests so that no spot in the forests will be more than one hours hike from any airfield. A little farther apart but placed in strategic spots will be larger airfields capable of handling large transport planes. The transport planes will bring the men, supplies, and equipment to the large fields and then have the smaller planes shuttle them to the actual fires. If this program is carried out a fire starting in what is now an inaccessible area will have little chance to develop into a major conflagration.

THE HELICOPTER

The future possibilities of the helicopter in fire control are more than the old time fire warden ever hoped to dream about. If developments and experiments which are being carried on at the present time prove successful, the near future may see helicopters over every forest during the fire season. As the helicopter is the most versatile of flying machines, being able to rise and descend vertically, fly forward, backward, or sideways, stay practically motionless over a given spot, and land in an area hardly larger than the machine itself, it would be invaluable in fire control.

At the present time the helicopter is not very dependable. The load limitations does not allow enough payload to be carried in the form of firefighters and equipment. With a heavy load the helicopter is unable to gain enough altitude to clear many of our higher ranges, even though many of them have been stripped of all the unnecessary parts. As these difficulties are overcome the helicopter should take its place along with other standard firefighting equipment.

The helicopter does not need a landing field but just a small opening in the forest. Any flat hill top, opening in a canyon, or small clearing is sufficient for the helicopter to land. Many more landing strips could be built in the national forests for small planes but the cost of clearing and leveling these fields in the rough topography would be enormous. Some clearings would be necessary for the helicopter but these would not have to be nearly as large as for an airplane. The building of roads, trails, and telephone lines into inaccessible areas for fire control purposes could be done away with and still complete coverage could be had.

The helicopter could transport well trained men with their equipment to small fires shortly after the discovery of the fire. Any small opening in the forest near the fire would be suitable for landing the firefighters. Radios could be left with the crews and if reinforcements were needed they could be sent for without any delay. As soon as the fire was out the helicopter could pick them up and transport them back to the base where they would be available for another call. With the helicopter to bring the men back from a fire there would be no need to send in pack animals to pack out the equipment used on the fire. Very little time or manpower would be wasted.

On large fires the helicopter could perform a variety of chores. Men, supplies, and equipment could be shuttled from one part of the fire to another if the occasion arose, saving many hours and the energy required to hike over the rough terrain. Hot food could be sent out to the men on the fire line, saving them a hike into the fire camp for meals. Scouting could be done from the air and the fire boss would have all the information necessary in the shortest time possible.

The helicopter could serve adequately for patrol work and fire detection. If a fire was discovered the helicopter could get to it in a short time. The observer could get a good view of the cover type and topography and would know how many men and what kind of equipment would be needed. If the fire was small enough the helicopter could land and a trained firefighter could start to work immediately.

The helicopter would come in handy for transporting supplies to a fire camp. If there were no suitable places to land the helicopter would hover just above the tree tops while the pilot dropped the supplies free fall. In experiments conducted by the Forest Service (3) the helicopter has dropped supplies close to the ground and at speeds under 15 miles per hour. There is no danger of missing the fire camp when using the helicopter as sometimes when dropping supplies from an airplane. Also, when dropping supplies from an airplane there are always some chutes that don't open and the supplies are scattered all over the forest. When the fire is over the equipment could be loaded into the helicopter and transported back to headquarters, saving the use of pack animals.

The first use of the helicopter in fire control was initiated on an 800 acre fire on the Angeles National Forest in the fall of 1946 (3).

> On the third day of the fire, September 8, 1946, a Sikorsky R 5-A with standard blades, furnished by the 62d AAF Base Unit, March Field Detachment, and piloted by Lts. Chuddars and Frost, arrived at the fire just in time to carry George Reynolds, Angeles Forest Engineer, on a scouting and mapping

> expedition of an 800-acre breakover into the rugged and inaccessible Red Rock Mountain area. Within less than three quarters of an hour the helicopter was landed in a 200-foot clearing at the fire camp (abandoned Castaic CCC Camp) in the bottom of Castaic Canyon, and an unusually detailed and accurate map of the fire situation was delivered to the fire boss. With any other means, including conventional aircraft, much more time would have been required and considerable important detail could not have been obtained.

This first experiment with the helicopter turned out successfully and if future experiments turn out as well we may be sure the helicopter will soon be used on many fires.

BOMBING FIRES

The bombing of fires from the air, which was started in 1935 by Flint (15) and later abandoned, has been resumed by the Army in hopes that this method of controlling fires may prove feasible. Chemical and water bombs have been dropped on fires in Florida with some degree of success and plans have been made to continue the experiments in the mountains of Montana.

If these experiments prove successful it may not be long before a plane swoops down over a new blaze and releases a chemical bomb. When the bomb breaks it will release chemicals which are many times more effective than the same weight of water, and the vapor will deprive the fire of the much needed oxygen. The bombs may not extinguish the blaze but will hold the blaze under control until smokejumpers arrive on the scene to finish it.

CONCLUSION

It has been shown that Aerial Fire Control is being used more extensively by most fire fighting agencies to supplement their ground forces during the fire season. The airplane will never take the place of ground control, but, there are many phases of fire fighting that can be done more quickly from the air and in many cases at less expense. As aerial methods continue to improve, the need for lookouts, trails, and telephone lines into inaccessible areas will be diminished. There will be more small air-fields or small openings on which planes and helicopters may land. In place of large fire suppression crews scattered throughout the forests there will be small but efficient smokejumping and helicopter units. As the efficiency in detecting fires and the transporting of men to the fires increases, the number of men needed decreases. Use of aerial methods of fire control leads toward more efficiency and greater economy.

BIBLIOGRAPHY

1. ANDREEVA, T.
   1947. FLYING FIREMEN. Skyways 6:2:16.

2. CORNWALL, G. F.
   1943. FOREST FIRE PARATROOPERS. Timberman 14:1:10.

3. FUNK, I. C. AND KNUDSEN, C. S.
   1947. HIGHLIGHTS FROM THE RESULTS OF HELICOPTER TESTS. Fire Control Notes 8:1:10.

4. FROST, S. L.
   1945. AN AIR ARM FOR FORESTRY. American Forests 5:2:57.

5. GODWIN, D. P.
   1946. HELICOPTER HOPES FOR FIRE CONTROL. Fire Control Notes 7:1.

6. HAND, R. L. AND HARRIS, H. R.
   1947. PRELIMINARY REPORT ON AERIAL DETECTION STUDY. Fire Control Notes 8:1:28.

7. KING, H. AND DAVIES, A.
   1939. REPORT ON PARACHUTE JUMPING EXPERIMENT, CHELAN NATIONAL FOREST. U. S. Forest Service.

8. MORRIS, W. G.
   1946. A PRELIMINARY SURVEY OF FACTORS OF VISIBILITY OF SMALL SMOKES IN AERIAL DETECTION. U. S. Forest Service.

9. REDINGTON, P. G.
   1921. AIRPLANE AS A FACTOR IN FOREST FIRE DETECTION. Timberman 23:1.

10. SPACE, R.
    1946. AIRPLANE DELIVERY OF HOT MEALS. Fire Control Notes 7:2:8.

11. THOMPSON, P. A. AND THOMPSON, D. M.
    1946. FORESTERS ALOFT IN '46'. Fire Control Notes 7:3:39.

12. ————
1940. AERIAL DELIVERY OF FIREFIGHTING SUPPLIES AND EQUIPMENT. Region One, U. S. Forest Service.

13. ————
1947. NOVEL METHOD OF FIRE AREA MEASUREMENT. Fire Control Notes 8:1:16.

14. ————
1947. PARADOCTOR APPOINTED IN REGION 1. Fire Control Notes 8:1:44.

15. ————
1946. HISTORY OF SMOKEJUMPING. U. S. Forest Service.

16. ————
1921. AIRPLANE FOREST FIRE PATROL IN CALIFORNIA. Timberman 22:1.