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Vol. 28, No. 1

FIRE CONTROL NOTES

copy to each man in fire
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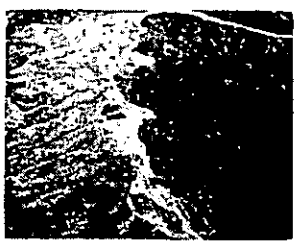
U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS



COVER—The fuel-break shown stopped the Horse Fire on the Mendocino National Forest (Calif.). See related story on page 4.

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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THE CAROLINA BLOWUP[1]

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April 1, 1966, was not a day for April Fool jokes in the coastal pinelands of North and South Carolina. It was an explosive fire day unrivaled in recent times. In those hot 24 hours, 72,000 acres in the two States were burned, 3,000 acres per hour. It was a Black Friday for more than 50 families whose homes were destroyed.

A news release from the South Carolina State Forester's office in Columbia summed up the situation: "The driest March in ten years created the forest fire danger that exploded on Friday, April 1st. into an almost uncontrollable situation. In three days, Friday, Saturday, and Sunday, 480 wildfires burned 70,000 acres bringing the total fire loss since July 1965 to 4,800 wildfires burning 120.000 acres of woodland."

This was the greatest loss in 11 years. Before the rains came on April 4, the forest area burned in the two Carolinas during this explosive period reached 144,000 acres. The largest fires were in the coastal pinelands, but damage was not limited to that area as numerous fires sprang up across the Piedmont.

The conflagration came as no real surprise to forest protection personnel. A very dry March had followed a dry winter.

On March 30, a meteorologist from the U. S. Forest Service's Southeastern Forest Fire Laboratory in Macon, Ga., telephoned the State forestry headquarters in Raleigh, N.C., and Columbia, outlining the full danger of the unstable weather conditions. Wind and pressure patterns such as these had come to the South before. They usually meant trouble on going fires.

The North Carolina State Forester immediately cancelled all burning permits and prohibited use of fire near woods. Yet even with this preventive measure, fire crews in the Tarheel State fought 273 wildfires covering 18,000 acres on the last 2 days of March.

In South Carolina on the same day, the Forestry Commission closed all State parks to public use. On the evening of March 31, the governor issued a proclamation prohibiting the use of fire adjacent to woodlands—the first time this had ever been done. (The authority was provided in a law passed after the disastrous 1954-55 fire season, when 7,000 fires burned 159,000 acres.)

APRIL 1

April 1 dawned clear and windy. The 10 a.m. report from Jones Lake tower on North Carolina's Bladen Lakes State Forest showed a high spread index, fuel moisture of 6 percent, and a steady wind of 18 miles per hour from the southwest.

By early afternoon rural residents and travelers in the Carolinas knew there was a serious fire situation. They didn't have to be told over the radio or see it in the news. They could smell the smoke and feel it burn their eyes.

The steady southwest winds were flowing between two areas of high pressure. One of the systems had recently passed out into the Atlantic. The second, a fast-moving cold front, was coming in from the Mississippi Valley. At 7 a.m. the leading edge was over the Great Smoky Mountains. By 1 p.m. it was in the Piedmont crossing over Charlotte and Winston-Salem. That evening it reached the Atlantic coast, bringing thunderstorms to Wilmington, N.C.

As the front hit, prevailing winds were pushed eastward by the strong winds within the system. This meant a 90-degree wind change as it passed. Fires that had made a narrow run to the northeast quickly turned southeast, their long flanks becoming new wide heads.

THE AMMON FIRE

One of the blazes that got the most publicity threatened the little town of Ammon, N.C., for 2 days and blackened 17,000 acres around it. The smoke was first reported at 1:30 p.m. on April 1. Rumor was that someone had been burning off an area to improve duck hunting, but no one was quite sure who it was.

Forty minutes later a forestry truck on patrol radioed that a second fire was coming out to the highway from nearby Black Lake. Crews just completing control lines on the White Oak fire only 15 miles away rushed to both new blazes.

Reconnaissance aircraft swung over from the large Newton Crossroads fire a scant 20 miles eastward and advised ground crews on the course of the flames and the best control action.

The fire towers, now nearly all socked in by smoke, relayed urgent radio messages between headquarters and the men on the firelines. "Fire

(Continued on page 15)

[1] Adapted from American Forests. July 1966.

FUEL-BREAKS—EFFECTIVE AIDS, NOT CURE-ALLS

JAMES L. MURPHY, LISLE R. GREEN, and JAY R. BENTLEY,[1]
Pacific Southwest Forest and Range Experiment Station

"This fire hit the ridge and kept right on going—it didn't even know the fuel-break was there." Or: "That fuel-break sure didn't do what it was built for—we wasted a lot of money and time building it." Or: "Fire will spread faster in tall grass on a fuel-break than in the brush." Or: "We don't need to worry about that side of the fire—there's a fuel-break up there." Such remarks have long been made and will continue to be made. Obviously, all firefighters do not understand the purposes and limitations of fuel-breaks, but strategically placed fuel-breaks help reduce the conflagration or fire disaster problem.

Figure 1.—Fuel-break in southern California brush.

Figure 2.—Fuel-break in Sierra-Nevada mixed conifer type, in central California.

DEFINITION OF A FUEL-BREAK

A fuel-break is a strip of land on which the primary fuel, usually brush (fig. 1) or timber (fig. 2), has been permanently converted to a lighter, less dense fuel type to facilitate fire control. As prescribed by an interagency committee (Anonymous 1963)[2], fuel-breaks on ridgetops, in valleys, and along roads and wide benches are at least 200 feet wide. A firebreak—a road or other strip with exposed mineral soil—is often within the fuel-break.

A fuel-break may be built to help protect a single campground or community, or a connected network may be constructed to safeguard large wildland areas.

PURPOSE OF FUEL-BREAKS

1. Fuel-breaks break up the continuity of heavy fuels, and if the fuel-break system is dense enough, they help firefighters prevent fires from reaching and maintaining high-energy output levels. Resistance to control is less on fuel-breaks, and retardants dropped from aerial tankers may be more effective.

2. Fuel-breaks are permanent preattack installations, and when they are well located and constructed, they are effective in firefighting. They provide access for crews, ground tankers, and other vehicles. Thus, a fireman can backfire while *he* is the "boss"—not when the fire is.

3. Fuel-break systems provide defense in depth. The first objective of an attack is to stop the fire in place. Subsequent strategy is directed by current fuel and fire behavior, but the fuel-break becomes important in fire-suppression strategy. If the fire jumps, fire control forces can be regrouped and redeployed until the fire can be held. Meanwhile, under most burning conditions, the flanks and rear of fires can be held at fuel-breaks. Because fuel-break systems improve the chances of fire control forces controlling fires during the first burning period, "control by 10 a.m." becomes a realistic objective, even for conflagration fires.

4. Fuel-breaks used as line locations tend to reduce mopup and patrol costs after a fire is controlled. They provide safer access for firefighters. And the lighter fuels on the breaks do not hold fire tenaciously or as long. Consequently, the problem of high costs due to slow, tedious mopup and long, intensive patrols can be alleviated.

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[1] Research Forester and Range Conservationists, respectively.

[2] Anonymous. Guidelines for fuel-breaks in southern California. U.S. Forest Serv. Pacific SW. Forest and Range Exp. Sta. Fuel-Break Rep. 9. 1963.

USE OF FUEL-BREAKS

Fuel-breaks alone are not expected to stop a hot, fast-moving fire. They are designed for offensive tactics, such as backfiring, and must be manned—usually the sooner the better. They must be further cleared to serve as control lines, but with their reduced resistance to line construction, a wide defense line can be established fairly quickly.

Fuel-breaks provide some security to the fireman. He can better estimate his safety and his opportunity for attacking successfully when he has an opened ridge or canyon bottom from which to reconnoiter and work. However, fuel-breaks, while furnishing *relatively safe* access and attack points, can lure a crew into false security. The ground cover may be flashy fuel with a rate of spread greater than that of adjacent fuels in which the fire is burning. Men should not be placed far out on a fuel-break unless larger, standard safety zones are at about quarter-mile intervals, as recommended in guidelines.

Experienced crews must quickly fire out the flashy ground fuel at the right time. Enough time is needed to plan and safely execute the firing. It is preferable not to fire when a high-intensity fire is "making a run" at the break. Wind and heat generated by a big fire close to a grass-covered break can cause many spot fires in annual grass and dry perennial grass that spread rapidly and imperil men on the line. Also, firing-out can be risky in dry grass during adverse winds because of the rapid spread of the fire and the high proportion of spots that "take". The situation may not be so critical on timbered fuel-breaks, where low-growing perennials, such as bearclover, which are not as flashy as grass, provide fuel-break ground cover.

BENEFITS OF VEGETATION ON FUEL-BREAKS

Vegetation on fuel-breaks limits their effectiveness as barriers to fire spread. Firefighters know that dry, herbaceous ground cover—specifically tall grass—is a flashy fuel which burns with much heat. However, to reduce soil erosion, such vegetation must be left on fuel-breaks or new ground cover must be established.

A dense cover of grass or forest litter is fairly stable and can be maintained free of brush quite inexpensively. However, it is first necessary to kill all brush sprouts and seedlings, preferably by chemical spraying. Killing may require 3 to 5 years, and fuel-breaks should not be started unless funds will be available to complete the job. Eventually grass or litter will usually choke out new brush seedlings and make maintenance fairly easy.

Although a grass cover may be needed on a fuel-break, all grass need not be left as hazardous dry fuel. The excess can be removed by grazing, mowing, or burning. Grass species that remain green for long periods are desirable. Techniques for management of the current vegetation growth can be developed after the heavy fuels have been modified during fuel-break construction.

A mixture of grass or litter and brush is unstable, and attempts to maintain it usually fail, or only a small acreage can be maintained because of high costs. Also, a mixture of grass or litter and low-growing brush may burn hotter than grass alone. Brush clumps, when left on fuel-breaks, may flare up from sparks and burning embers during firing operations.

Vegetation on fuel-breaks may do more than reduce erosion and stabilize ground cover. Forage grass or timber can be grown on areas formerly covered by dense brush. However, a thinned timber stand left after fuel-break construction may produce less than a natural stand, and thus add to the costs rather than benefits of fuel-break construction.

MULTIPLE-USE AND FUEL-BREAKS

Fuel-breaks must be planned and constructed as part of the total management program. Specific guidelines for fuel-break planning, engineering, and construction are usually formulated and approved by fire control specialists and timber or other resource management specialists working together under the concept of multiple-use management. The guidelines help assure that fuel-breaks are compatible with good land management. Thus, the very factors that make fuel-breaks valuable in fire control also make them valuable from a total management standpoint. Brush areas may be converted to forage grass or to timber production. Slash and other debris are cleaned off the forest floor in timber areas. Trees are thinned and pruned. The wildlife habitat is improved. Live ground cover maintained on fuel-breaks reduces erosion. The net effect of fuel modification should be higher production in both timberlands and brushlands.

CONCLUSIONS

Fuel-breaks are not cure-alls—they are prebuilt firelines that provide safer access to otherwise dangerous areas; they give the firemen a better chance of controlling fires. And, like other fire tools, they must be used for a specific purpose, in a specific place, and at a specific time.

A NEW APPROACH TO FIRELINE CONSTRUCTION[1]

R. W. JOHANSEN, *Research Forester,*
Southeastern Forest Experiment Station[1]

Backfiring from single- or multiple-plowed lines often does not control fast-spreading fires where spotting occurs. Because backfires spread slowly into the wind, they frequently do not burn out an adequate isolation strip quickly enough to stop fire spread. A new approach is needed to quickly increase the effective fireline width.

In a study in which a ground tanker with a high-output pump was used, it was shown that a chemical solution fireline can stop a head fire in the highly flammable palmetto-gallberry fuel type of southern Georgia. Fifteen percent diammonium phosphate solution was used to make chemical lines 30 feet wide and 300 feet long. A head fire was then started and allowed to run 170 feet to the treated line. Fire spread averaged 1 chain per minute. Fire did not penetrate more than 10 feet into the chemical line before the flames were extinguished, even though application rates were as low as 1 gallon per 100 square feet. The burning experiments were conducted with a Spread Index of 16-18 (High) and a Buildup Index of 30-55. Plowed lines would easily have been crossed by the spreading fire.

This test suggested a method for the quick construction of a wide control line in front of an approaching wildfire. Instead of depending on the slow spread of a backfire to reinforce a plowed line or road, firefighters could quickly make a line by strip head firing into the prepared chemical line. Width would depend upon burning conditions. Subsequent strip head fires would quickly extend the line width to 500 feet or more if desired (fig. 1). A chemical line could also be established on the downwind side of a road; this line would be used primarily to catch spot fires. The road would serve as the fire break into which the fire would run.

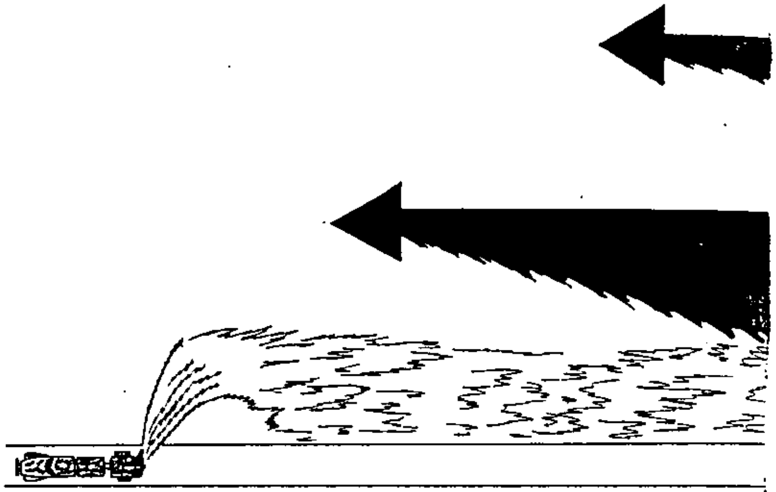

Figure 1.—Construction of a fireline with chemicals and strip head fires is shown.

The cost of diammonium phosphate would be about 2½ cents per foot of line for a 30-foot-wide line at an application rate of 1 gallon per 100 square feet. Thus, 1,000 feet of line would cost $25 and $50 for 1- and 2-gallon chemical applications.

Table 1 shows the rate at which chemical firebreaks can be completed along woods roads with mobile-pumping equipment. The rate of line construction depends on the speed of the vehicle, the pump output, and the desired application rate. For example, the table shows that a 300-gallon-per-minute pumper can supply 2 gallons of retardant per 100 square feet of land to a 30-foot-wide line while traveling at 5.7 miles per hour.

TABLE 1.—*Rate of chemical fireline construction by application rate*[1]

Rate of vehicle movement (m.p.h.)	Application	Rate
	Gal./100 sq. ft	Gal./1,000 ft. line
11.33	1	300
5.67	2	600
2.84	4	1,200
1.42	8	2,400

[1] A 300-gallon-per-minute pumper was used; the line width was 30 feet.

[1] The author is stationed at the Southern Forest Fire Laboratory, Macon, Ga.

Because of costs, chemicals should not be used when plowed lines and backfiring will stop fire spread. However, on high fire-danger days, when spotting may be a problem, and lines 30 feet and wider are needed quickly, the chemical lines plus variable-width strip head fires could be advantageous.

SUMMARY

Results of this study indicate that a 30-foot-wide fireline of diammonium phosphate can stop a strip head fire moving into the prepared chemical line. To provide more safety against spotting during high danger days, successive strip head fires can be used to widen the burned-out strip in the path of a wildfire.

HELICOPTERS AND FIREMEN—THE RUBY FIRE TEAM

FRED W. TYLER, *Fire Control Officer*
Saugus District, Angeles National Forest

"The helicopter will prove to be the most versatile firefighting tool ever developed." Frank C. Jefferson, Fire Chief of the Forest Service's California Region, said that about 20 years ago. . . . How true his prediction proved to be! Helicopters, when used in support of ground crews on fires, have repeatedly shown their effectiveness.

For example, helicopters and firemen united to control the potentially dangerous Ruby Fire on the Angeles National Forest. On July 23, 1965, at about 3:40 p.m., the Warm Spring lookout on the Saugus District of the Angeles National Forest detected smoke in nearby Ruby Canyon. When the initial-attack pumper unit hit the fire, it was burning on about a half acre of medium to heavy brush in the bottom of a deep canyon. The fire spotted to both sides of the canyon. The initial-attack crews, aided by air tanker support, were able to hold the fire on the south slope of the canyon. However, due to the steep slopes and dry brush, it burned over the top of the ridge on the north side of the canyon. Quick followup by hand crews and tractors held the main fire to about 500 acres.

But . . . a potentially dangerous situation had developed. As the main fire burned up the slope and approached the ridge, many firebrands carried over the fireline on the flanks and at the ridge. Many spot fires developed. However, since it was late in the day, these fires didn't flare up; they only smoldered. Crews could not have found them during the night. But many were sure to flare up the next morning when burning conditions intensified.

TEAMWORK—HELICOPTERS AND MEN

Fire control plans were needed to keep the spots from developing into a major fire in Ruby Canyon and the adjacent canyon. Three helicopters were ordered to the fire that evening; all crew and sector bosses assigned to the next day's shift were alerted to the spot fire danger. The helispot was established. Helicopter and ground crew radios were checked. Fire retardant (Gelgard) was ordered, and equipment was checked and readied for use.

By dawn of July 24th, fire crews were lined out along the fireline and the helicopters were loaded with retardant. The helicopter-firemen team was ready for action.

When it was light enough to fly safely, one helicopter flew almost constant reconnaissance. Ground crews kept alert for spot fires. At about 10 a.m. the first spot fire occurred. The reconnaissance helicopter radioed a location and condition report to the heliport and to the nearest ground crew. A helicopter dropped retardant on the fire. The retardant held the fire until the nearest crew could break through the brush and control it. This combined helicopter-ground attack continued throughout the day. Twenty-five spot fires were controlled by this team, and more than 7,000 gallons of retardant was dropped by the helicopters. It took 32 to 38 seconds, an average of 34 seconds, to fill the helicopter tank with retardant. Average flight time to the spot fires was 8 minutes. The total effort was efficient because of trained and experienced heliport crews, good air to ground communications, and the versatility of the helicopter.

SUMMARY

A team of helicopters and ground crews prevented a major fire on the Saugus District of the Angeles National Forest. The helicopters dropped retardant which kept spot fires small until ground crews could control them. The versatility of the helicopter was again proved. The helicopter can fly reconnaissance, ferry men and equipment to and from the fireline, and give ground crews the confidence they need to control the fire.

Experienced firemen believe that the combined helicopter and ground crew control of the spots prevented a major fire which could very possibly have exceeded 5,000 acres. A conservative estimate of savings in suppression costs and watershed damage is $400,000.

DEVELOPING FOAM WITH AN AERIAL TANKER

J. W. COLQUITT[1] and R. W. JOHANSEN, *Research Forester, Southeastern Forest Experiment Station*

All forms of foam have been used to control fires. Several types of foam dispersal equipment are used with different foam systems; however, aerial tankers had not been used for dispersing foam.

After an appraisal of the different methods of producing foam—chemical, aerosal, and mechanical—the mechanical system was selected for economic reasons. A mechanical foam is generally produced by trapping air within a stabilizing liquid to form bubbles. The liquid is passed through a special nozzle, or it is introduced into a high-speed airstream such as that available in the air tanker slipstream.

OBJECTIVES

The study was initiated to establish whether air tankers could be used to dispense foams successfully. Answers to the following questions were also desired:

1. What types of foam solutions are compatable with diammonium phosphate salts?
2. What kind of volume expansion can be expected?
3. What effect do viscosity builders have on foam solutions and their foaming capabilities and stability?

PROCEDURE

Two types of foam materials were tested for air tanker use—protein-base and synthetic-base concentrates. Prior to the tests with an aerial tanker, these materials were tested in a laboratory to observe foam stability, compatibility with ammonium phosphate salts, effect of thickeners on foam formation and stability, and expansion rates.

Eight drops were made by a TBM air tanker. Except for one 400-gallon load, all solution volumes released from the aerial tanker were 200 gallons. The drop altitude was about 75 feet above the highest obstruction, unless otherwise noted.

RESULTS

Drops 1 and 2 were made with a protein-based foam concentrate in water. The first drop, a 200-gallon load, was made at 110 m.p.h. on a pulpwood-size pine stand. Complete aeration did occur, but the foam just floated into the trees with little if any force (fig. 1). The second drop, a 400-gallon load dropped at 100 feet and 140 m.p.h., was made on a flat, grassy area to assess foam expansion. The resulting pattern was 330 feet long and 220 feet wide, and the foam expansion ratio was 32:1. Foam stability was not good; the entire amount dissipated within 1 hour.

The ground pattern width resulting from a TBM retardant drop is normally 50 to 60 feet, and is not significantly affected by crosswinds of less than 10 m.p.h. However, the 220-foot width in the test resulted from an 8 m.p.h. crosswind. Therefore, the density of normal foam is low enough so that even light winds cause considerable drift.

To increase foam density, and thus overcome the drift problem, for several drops industrial gums were added to increase the viscosity of the solution. At 125 m.p.h., there was apparently not enough energy in the slipstream to aerate the solution, and no foaming occurred. At 170 m.p.h. some foam was formed, but not enough for a successful drop. The foam that did form was very stable.

The greatest foam production in the tests reported here was from a high-expansion synthetic-base concentrate in water dropped at 140 m.p.h. at 100 feet (fig. 2). Stability of this foam, however, was the

(Continued on page 11)

Figure 1.—Foam formed above tree crowns reached the ground mainly through canopy openings.

Figure 2.—A synthetic-based solution produced the most foam, but dissipation was most rapid.

[1] Colquitt was a Field Assistant at the Station when the work reported in this article was performed.

KEYS TO A SUCCESSFUL AIR-ATTACK PROGRAM

E. F. McNamara, *Assistant Chief, Division of Forest Protection, Pennsylvania Department of Forests and Waters*

Pennsylvania has had a very satisfactory water-bombing program since 1960. Costs and personnel requirements are probably the two main reasons why many State forest fire control agencies hesitate to initiate a water-bombing program. Water-bombing costs must be included in the total State budget for forest fire control. To obtain maximum utilization of the few available personnel, efficient organization and operation of water-bombing programs are necessary. In order to achieve this optimum use, the Division of Protection staff has given careful attention to three critical factors: Training, preseason preparations, and operational performance.

TRAINING

Training is probably the most important of the three factors. If training is conducted properly, operational performance should be good. Our slogan has been "Every man must be trained to do as much as possible beyond his regular job." Training is conducted annually: Policies change, experienced employees require refresher courses, and there are always new employees. The training of the three men who operate our airplanes and helicopters—the pilot, air operations officer, and pump operator—is basic. In addition, the fire control organization that may work where water bombing is conducted must also be trained.

Pilot training is done in two stages, prior to and during field operations. Key points covered are:

A. Department fire control organization

B. Radio communications

C. Forest fire terminology

D. Fire behavior and fire control tactics of ground control forces.

E. Drop techniques

Pilots with water-bombing experience in Pennsylvania are used as instructors to train new men with little or no retardant-dropping experience or to train pilots whose experience has been in other States.

Air operations officers are staff foresters in the Forest District offices or qualified forest foremen working on nearby State Forest areas. These men are trained before operations, and a review and critique session is held after operations are concluded. Training includes:

A. Aircraft performance and capabilities

B. Weather and its effects on operations

C. Air-attack program policies and procedures

D. Reports and forms

Pump operators who are new employees are trained at the airbase for several days before operations begin. Experienced men usually are also given a brief refresher course just prior to the start of operations. Areas covered are:

A. Pump operation and maintenance

B. Tank capacities, control system, and retardant mixing procedures

C. Use of radio, aircraft servicing, and similar routine operational tasks.

Training for the ground fire control organization varies. The district foresters are annually briefed on old and new procedures. Circular letters are used when needed to outline new policies and policy changes. Smokechaser units (two- or three-men hotshot crews who operate from a light firetruck in areas below aircraft operations) are given 1-day training sessions on aircraft drop techniques, safety factors, and followup ground attack. The volunteer fire wardens are similarly informed at annual fire warden meetings and in periodic District newsletters.

PRESEASON PREPARATIONS

The logistics of an effective air-attack program must be decided well before operations. This is one year-round duty of the Division of Forest Protection staff, especially the air operations advisor. Some of the more important items that must be arranged, at varying intervals, before operations are listed below. Most of these are handled by the Forest District staff in whose area the airbase is located.

A. Headquarters building or van (clean, neat, and with proper heating units)

B. Telephone (connected)

C. Radio (serviced and operational)

D. Maps (up-to-date and usable)

E. Aerial photos (properly filed and available)

F. Equipment including pump, standby pump, repair parts, and tools (available and functioning)

G. Storage tanks for water and retardant (repaired, in place)

H. Water and retardant (stocked to tank capacity)

I. Telephone lists of all Department personnel and cooperating individuals, fire companies, and other agencies (up-to-date and available)

J. Forms, reports, and Instruction Manual (available)

Through great effort and use of checklists based on experience, these details and many minor ones must be checked before the arrival of the aircraft and fire weather.

OPERATIONAL PERFORMANCE

Small Airplanes

For the small airplanes (Stearmans), which have a 150-175-gallon capacity, and helicopters, the following procedures are used (fig. 1).

The aircraft are based where our studies have shown that many fires occur. They operate within a certain radius of the airbase. This radius is based on their speed and drop load.

Initial attack is the basic use for these units. Therefore, the initial fire report goes to Air Attack Headquarters, and the aircraft is dispatched immediately. To permit rapid initial attack on fires, a few false alarms can be tolerated.

If the area within the operational radius is free of fires, a plane may work on fires outside this area. Good communications permit a recall of the plane if a fire begins in the original operational area.

The small plane provides support action on fires that escape initial suppression only if it can be useful and no new fires have occurred.

In a multiple-fire situation, the air-attack officer considers the distance from the base, type of fuel, fire danger, and available manpower to determine priority of operation.

Helicopters

The procedure for use of helicopters is the same as that for small airplanes. Heliports are located on the basis of fire incidence, accessibility, and topography.

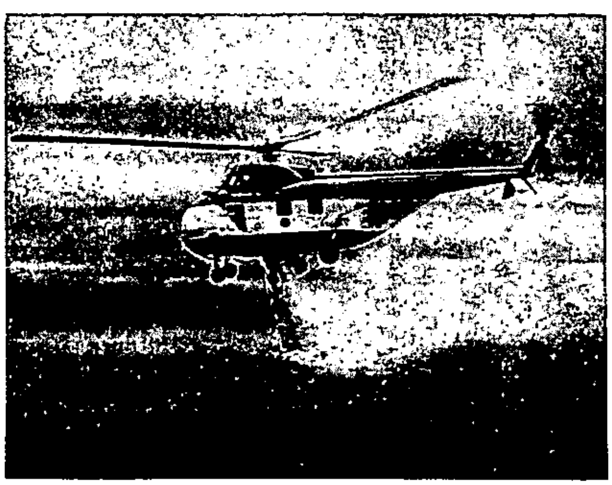

Figure 1.—This Sikorsky S-55 helicopter can carry 250 gallons of water and retardant, 125 gallons in each of two tanks. When not carrying a drop load, it can transport eight fully equipped firefighters. Its cruise speed is slightly over 100 m.p.h.

The helicopter's versatility is an important reason for its use in the air-attack program. While its use as a water bomber has priority over its other uses, helicopters have been used to transport men, equipment, and food and water to the fireline. They also permit a boss to see an entire fire.

Large Airplanes

Our experience with large air tankers has been limited to the 600-gallon TBM and the 1,600-gallon Chase (fig. 2).

Logistical problems governing the use of the TBM do not differ much from those for the Stearman. However, the operation must be from an adequately surfaced airstrip with facilities for faster loading.

The additional problems to be solved when the Chase air tanker is used are at least in proportion to the size of the Chase over the Stearman.

Only certain previously inspected airports are adequate to handle the weight of this plane when it is fully loaded. Fortunately, there are enough suitable airports in Pennsylvania to provide good statewide distribution. Two of our main operating bases, one each in the eastern and western parts of the State, handle this plane very well.

The storage facilities for this aircraft, which has a 1,600-gallon capacity, are much greater than for the 150-gallon Stearman. Also, a 50-gallon-per-minute-capacity pump is not adequate to refill the Chase. To solve many logistical problems, this aircraft carries a pump, hose, and fittings when it leaves the base to operate in another part of the State.

This large airplane is used for two types of operation. The basic guidelines for effective use of this expensive unit cover initial-attack and support action.

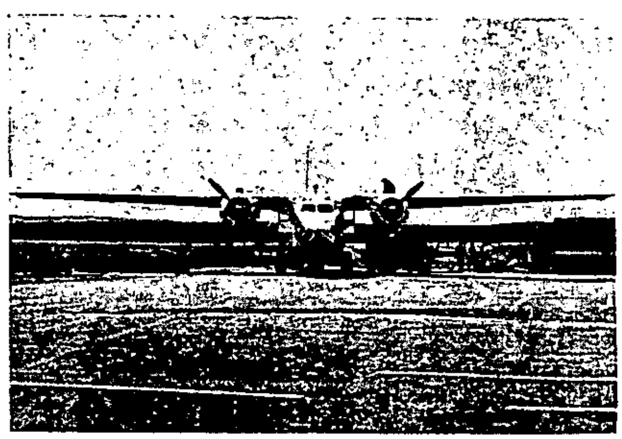

Figure 2.—The Chase, a twin-engine aircraft, can carry up to 1,600 gallons of water and retardant. It can make four drops of 400 gallons each, or two drops of 800 gallons each. Its cruising speed is 160 m.p.h.

Initial Attack

Within a 50-mile-radius attack circle of the Hazelton and Mid-state Airports, the Chase air tanker will operate on an initial-attack basis. District dispatchers needing the Chase air tanker within its initial attack circle can call the air control officer at the Air Control Center.

Within this circle, for fires reported within the operational circles of the Stearman, the latter will be dispatched on a first-call basis. However, if these aircraft are already attacking a fire, the Chase air tanker will be dispatched to new fires within the operational circles of the Stearman.

Support Action

If a large attack tanker is needed outside the 50-mile initial-attack zone, the District Office needing the aircraft must fill in a form containing basic data that will permit the Division Office to evaluate the necessity and desirability of sending the plane. These data include location and size of fire, potential area loss, and other technical data.

If the plane is not engaged in bombing operations within its basic circle and the fire potential is justifiably great, the aircraft is dipatched by the Division Office to the fire. Four auxiliary bases are cleared and processed for servicing the large bombers, and they must, after the initial drop, work from the one closest to the fire.

The tanker returns to its primary base as soon as it completes action on the fire and is released by the District, or it may be recalled by the Division Office if conditions within the primary operational circle dictate.

All the above operations are handled by the standard base crew of air operations officer, pump operator, and pilot. The Chase and one small bomber have headquarters at one base and are handled by a single crew. Two small bombers sometimes work together from a single base, and they are also handled by the standard base crew.

COST

The basic annual cost of the program, based on guarantees to contractors for the minimum operations period, is $56,000. The total cost depends on fire weather and fire frequency, particularly within the operational areas. During the severe 1963 fire year, the total cost for both water-bombing airplanes and helicopters was $71,761.19. This figure is for fire control; it did not include administrative costs for Department personnel and equipment.

CONCLUSIONS

The Division of Forest Protection believes that its air-attack program has greatly strengthened the initial attack on forest fires. More than 40 percent of all fires in the State have been suppressed when the aircraft are on contract. The cost of the program is justified because of the steady decline in average fire size. Also, by assisting small units of trained firefighters to hold fires to very small acreages, it has alleviated the problem caused by a shortage of firefighters. This acreage reduction has been achieved despite rising fire incidence and partly reflects the tremendous initial-attack capability of water-bombing aircraft.

Foam—Continued from page 8

poorest. Within 15 minutes all of the foam had disappeared. Dissipation was even quicker in diammonium phosphate salt solutions.

DISCUSSION

The rate of foam production from solutions containing liquid foam concentrates depends upon variables such as: (1) Nature of the concentrate, (2) amount of concentrate in solution, (3) solution viscosity, and (4) energy applied to the solution. The first three variables can be controlled easily, but it is difficult to regulate the energy supply in an aerial drop except within narrow ranges. The TBM tanker cannot safely carry a load at speeds under 115 m.p.h., and heavy loads should not be released at speeds exceeding 160 m.p.h. due to extreme negative G-force stresses that develop on the wings.

Water solutions of some foam concentrates tested did foam readily when released from the air tanker at normal drop speeds. However, the foams produced were light and very susceptible to drift, and were not very stable. The water quickly flowed down the film surfaces to the ground, leaving a "dry" foam residue.

In the laboratory foam stability and density are both improved by the addition of industrial gum thickeners, but more energy is required to make foam from thickened solutions. Enough energy to adequately aerate such a solution is not available in the airstream of a tanker travelling at 150 m.p.h. However, tankers capable of dropping at higher speeds may be able to lay a stable foam line.

The use of foaming agents in firefighting chemicals dropped from aerial tankers does not seem promising. But foaming can occur in a free-falling liquid drop from a tanker, and when further improvements in foam concentrates are made, new evaluations may be useful.

FIGHTING FIRE WITH HIGH-PRESSURE AIR JETS . . . SOME PRELIMINARY RESULTS

DEAN L. DIBBLE[1] and JAMES B. DAVIS, *Research Forester, Pacific Southwest Forest and Range Experiment Station*

Water is the traditional medium for fighting fire. But in some areas, water may be scarce, hard to obtain, or costly. The possibility of using a substitute for water, such as air, has interested many foresters. The idea is not new. Nearly 30 years ago, Lorenzen[2] reported on the use of compressed air in fire suppression. Other articles have since appeared. Also, another medium, high-expansion foam—produced by flowing air through a detergent system—has been tried.

Most investigators have considered air as a propulsion force for water, for blasting litter from the fireline, or for modifying wind patterns. However, the direction of an airblast at the fire has been tried only a few times, and most of these attempts have involved a large-volume, low-pressure airstream generated from some distance.[3] What would happen if a high-pressure jetstream was applied directly to the base of the flames?

LABORATORY STUDY

To determine the feasibility of this technique of fire suppression, a small-scale laboratory study was conducted at the University of California's Richmond field station in the spring of 1965. An attempt was made to extinguish fires burning in 7- by 12- by 36-inch chicken wire cages filled with excelsior in amounts equivalent to dry grass weighing 800 to 16,000 lbs./a. Similar tests were made with assemblies of 1/2-inch-diameter pine dowels. The fuel loading of these dowel assemblies was equivalent to 320,000 lbs/a. One end of the fuel was ignited, and after the fire became established, an attempt was made to put it out with a compressed airblast. Various airflow rates, pressures, and techniques were tried.

Success depended almost entirely on a combination of fuel arrangement and air pressure that permitted the airblast to penetrate through the unburned fuel to the base of the fire. If the air could penetrate, the extinguishment was quick—probably quicker than could have been accomplished with water. But if the fuel arrangement prevented penetration, the airblast formed eddies that actually spread the fire. Fires could be blown out consistently with air at 100 p.s.i. when fuel loading did not exceed the equivalent of 8,000 lbs./a.

PRELIMINARY FIELD TESTS

Next, preliminary field trials were conducted early in the summer of 1965. A trailer-mounted compressor was used as our "fire engine". This piston-type compressor had a capacity of 131 c.f.m., 100 p.s.i. It was equipped with 100 feet of standard airhose and a "forester"-type nozzle. Grass volume at the test site was relatively high (6,000 lbs./a.) (fig. 1). Burning conditions were moderate.

After blowing out eight fires, we concluded that the air-pressure technique was slower than water. Also, this technique was not always dependable. As in the laboratory, difficulty was experienced where the fuel was matted and air could not penetrate to the base of the fire. However, the technique did offer some promise; we never ran out of air or had to go for a new load. Consequently, we decided to combine techniques.

Figure 1.—This crew is fighting a grass fire with air from a trailer mounted compressor.

[1] Dibble was a Meteorology Technician at the Station when the work reported in this article was performed.

[2] Lorenzen, C. Tests on the use of compressed air in fire suppression. U.S. Forest Serv. Fire Control Notes, 22 pp., illus. 1939.

[3] Forest Service, USDA. A wind machine and fire control. U.S. Forest Serv. Firestop Progr. Rep. 8, 8 pp., illus. 1955.

We retained the airblast equipment and designed and built a small tank truck consisting of a pressurized 125-gallon water tank and 25-gallon tank for powdered fire retardant (flow-conditioned diammonium phosphate). The system was piped so that the crew could use either air, water, or retardant powder. The same hose and nozzle system was used for all three media. (fig. 2).

Since tanks pressurized with compressed air are potentially dangerous, they were designed with required safety tolerances and equipped with gages, regulators, and safety valves. Both the air and water systems worked very well. The unit could handle an airflow of 131 c.f.m., with a nozzle pressure of 90 p.s.i. The water system delivered about 20 g.p.m., with a nozzle pressure of about 80 p.s.i. The compressor did not have to be operated continuously when water alone was used. Once the tank was pressurized it could expel itself just like a rural-type pressure system. However, the powder system developed difficulties—the powder often became wet or caked.

FIELD TRIAL

The tank truck unit was used in 14 test fires in 1965. Each test plot was 100 feet square. Fuel was annual dry grasses that averaged about 3,000 lbs./a. The fire danger rating was usually "high". Other pertinent data were as follows:

Temperature	89-96° F.
Relative humidity	15-22 percent
Fuel moisture stick	2.2 percent
Wind velocity	3-8 m.p.h.
Burning index (grass)[1]	16-20

[1] California Fire Danger Rating System.

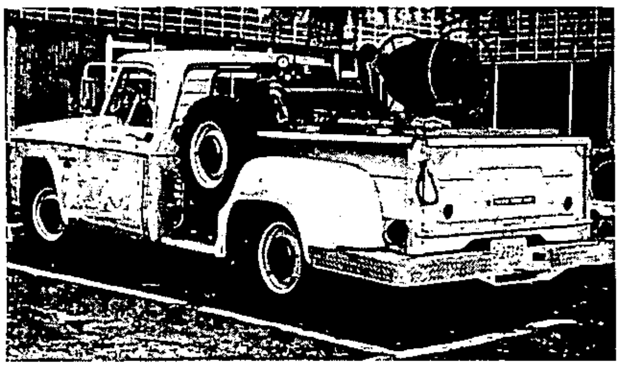

Figure 2.—This test truck is equipped with airblast, water, and retardant powder systems.

We started the fires at the upwind edge of the plots and began putting them out as soon as they had reached a uniform front. Although compressed air alone put the fires out in 10 of 12 trials, it took four times longer than water (table 1). In two trials the fire became so intense that it was necessary to rapidly switch to water to protect the nozzleman.

We also had 10 times more rekindles when the airblast was used. This number probably occurred because the nozzleman was too busy trying to stop the fire to be careful.

TABLE 1.—*Comparative fire suppression time using water and air*[1]

Fire number	Extinguisher	Time required for extinguishment	Rekindles
No.		*Seconds*[2]	*No.*
1	Air	68	4
2	....do....	69	4
3	....do....	64	3
4	....do....	77	8
5	....do....	65	5
6	....do....	68	4
7	....do....	64	3
8	Water	14	1
9	....do....	16	0
10	Air	[3] 60	---
11	....do....	67	2
12	....do....	68	5
13	....do....	[3] 58	---
14	....do....	66	2

[1] Wind—NW, at 3 to 8 m.p.h. with gusts of 12 m.p.h.
[2] Time needed to put out a line of fire 100 feet long.
[3] Water needed for final control for protection of equipment.

The most effective firefighting technique with the airblast was to start from an anchor point and progress along the fire edge, blowing the fire back into the burn. Much eddying and erratic fire spread resulted when the nozzleman started in the middle of a burning line. Airblasting is a special safety problem. Because air does not have a trajectory and will not carry like water, the nozzleman had to work closely ahead of the fire in the unburned fuel.

Two trials were conducted using air in an indirect attack; the results were disappointing. Al-

(Continued on page 15)

FIRE WEATHER TELEMETRY

FRANK E. LEWIS, *Forester,*
Forest Service Electronics Center, Beltsville, Md.

Telemetering is a system employing electronic instruments to measure quantities, transmitting the result to a distant station, and there indicating or recording the quantities measured. It sounds simple all right! Is it applicable to protection of forest and range lands from wildfire?

Fire control managers have long noted the lack of information on weather conditions in remote areas and on many midslope locations.[1] [2] In mountainous country, manned stations are few and are usually in the valleys or on ridgetops. Also, with the increasing use of aerial detection, in many areas lookouts are no longer available to make weather observations. Samples have been inadequate and dependable data has been expensive to obtain.

Telemetering weather conditions has been perfected using several systems. Various degrees of success have been obtained for many years, both by the military and others. Several systems are commercially available. However, generally the systems are too expensive or/and require too much attention by technicians for widespread use in fire protection.

Since the late 1950's, considerable work in developing a dependable, economical fire weather telemetering system specifically for fire danger data has been done at the Forest Service Electronics Center, Beltsville, Md. Extensive field tests continue, but contract costs, exclusive of weather sensors and communications equipment, remain high. Two operational systems based upon earlier basic designs were delivered to the Forest Service during 1966. They have been installed on National Forests in Montana and Wyoming and by the Bureau of Land Management in Nevada. These systems and their functions are described as follows:

The control station (fig. 1) consists of a control console with a modified electric typewriter and radio equipment. Data is transmitted by the various observation stations upon radio command and is automatically recorded on the typewriter. The central station can be programed to operate unattended and obtain reports at preset observation times.

The console is 20 by 18½ inches and weighs 80 lbs. It operates from a 60-cycle, 105-125-volt power source and draws 20 watts. The unit, exclusive of radio equipment, costs about $3,200.

A set of weather sensors is used to measure weather conditions at the observation station (fig. 2). The sensors convert the data into electrical quantities. The set costs approximately $700.

The circuit components and relays which process the information for radio transmission are mounted on panels in a standard 40- by 19-inch relay rack. The total weight is 85 lbs. The equipment operates from a 24-volt battery pack composed of 16 No. 6 industrial dry cells. One pack will operate the unit for a full fire season. The cost of this equipment is approximately $4,000. This does not include radio equipment, which is housed in a separate enclosure.

The station monitors the following five parameters of weather over the indicated ranges:

1. Wind direction, 8 cardinal points of the compass
2. Wind velocity, 2 to 60 miles per hour

(Continued on page 16)

Figure 1.—Control station console and radio equipment.

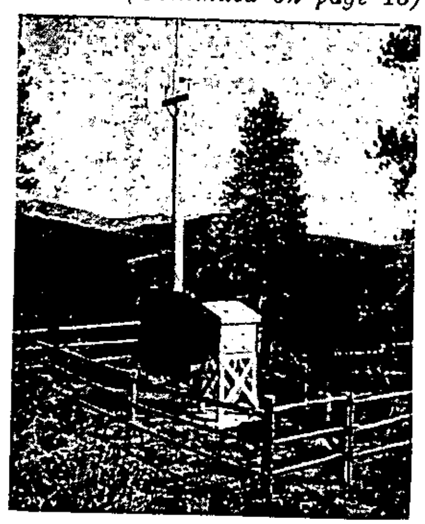

Figure 2.—Telemetry station No. 4 on Point Six near Missoula, Mont.

[1] Tucker, James B. Planning the locations of fire danger stations. Fire Control Notes 21 (2): 46–47. 1960.

[2] Keetch, John J. Developing a network of fire danger stations. Fire Control Notes 25 (4): 3, 4, 6. 1964.

Air Jets—Continued from page 13

though the technique has been successful elsewhere in leaf litter fires[4,5], enough dry grass could not be removed to stop the fire.

CONCLUSIONS

The airblast method alone is not as effective as water for controlling a running fire in medium to heavy grass. Furthermore, it is more hazardous to men and equipment. An adequate compressor is expensive and heavy. A compressed air system without proper engineering and required safety features can be dangerous.

However, if fuel is light, water scarce, and the compressor can be used on other jobs, airblasting may be practical—particularly if it can be combined with a water system. The airblast looks promising for mopup in light fuels. Large compressors used for construction of forest roads could be sent to the fire for this purpose.

An airstream to propel water and fire retardant liquids and powders also has promise. Our water system worked well, and we expect our powder system to do a good job when it is reengineered. Related studies, here and elsewhere, have shown the effectiveness of portable backpack-type mistblowers for delivering both liquids and powders. The study of firefighting with air jets will be continued.

[4] Nicloles, J. Mand, and Paulsell, L. K. A new idea in firefighting: Airblast line building. Univ. Md. Agr. Exp. Sta. Bull. 725, 7 pp. illus. 1959.

[5] Welsh, J. L. Backpack mistblower as a fireline builder. U.S. Forest Serv. Fire Control Notes 26(7): 2 pp., illus. 1964.

Carolina Blowup—Continued from page 3

reported across from Melvin's store." "Fire has jumped the South River into Sampson County." "Fire burning two homes and a half-dozen farm buildings on Beaver Dam Church Road." Fire was everywhere!

By 3 p.m. the Ammon fire had jumped Cedar Creek Road and was headed toward the settlements. The district dispatcher reluctantly pulled a unit off the Black Lake fire, now only 10 miles away, and committed his last reserve tractor plow.

Still the flames continued their advance. Air tankers of the North Carolina Forest Service cooled hot spots and were credited with helping volunteer fire companies save several homes and outbuildings.

Evening came with a smoky orange light. Down in the swamp the fire rumbled. The cane went up with a crackle that sounded like a rifle platoon in action.

The cold front hit the Ammon fire at 7 p.m. As expected, the flames changed direction. Already the Whiteville District Forester was headed toward N.C. Highway 242 which now lay in front of the fire. Control was impossible now, but he wanted to be sure everyone was out of the way.

FLAME—150 FEET HIGH

Smoke was intense. The fire could be heard in the distance, and the glow of the flames appeared through the forest. Then the pines across the highway exploded into what he described as a sheet of flame 150 feet high.

Simultaneously, three lightning bolts from the thunderheads overhead accompanying the cold front struck the main fire. As rapidly as it came, the fire moved on, throwing burning limbs and brands 1,000 feet ahead of it. Finally, the skies opened up with a brief downpour that knocked the flames out of the trees until there was nothing but flickering snags in the night.

Tractor units spent the night plowing lines, but without the flames to guide them it was hard to locate the leading edge in the dark. The situation was made more difficult by the many small spot fires that were scattered out ahead as far as a quarter of a mile.

The thundershower was only temporary relief. Severe burning conditions were forecast for the next day. Again and again crews sought to strengthen their plowlines, but the backfires would not burn. Without fire, they were unable to construct a fire-break wide enough to hold a new onslaught.

As expected, a drying wind came up with the sun on April 2. By mid-morning the scattered embers were fanned to life. Crews worked in vain. Flames were rolling again and took little notice of the lines that had been plowed across their path. The Ammon fire had places to go and another 10,000 acres to burn before a general rain and a massive control effort would contain it 2 days later.

Yes, April 1, 1966, will be long remembered in the Carolina pinelands. But the severe test was well met by courageous firecrews and modern equipment.

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MARKING FIRE HANDTOOL HANDLES[1]

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Juneau, Alaska

A quick, efficient method of painting fire handtool handles for identification is described.

1. Select a piece of cloth 6 to 8 inches wide and 20 to 30 inches long.
2. Fold the cloth to the desired width of the identification band to be painted.
3. Fasten each end of the cloth to a solid, secure item. The ends should be approximately 25 inches apart (fig. 1).
4. Apply a coat of paint to the upper surface of the cloth. By folding the cloth several times, it will be able to hold plenty of paint.
5. Place one hand above the section to be painted and the other hand below the section. Thus, the handle will be at a 90° angle to the cloth.
6. Lower the handle to the cloth.

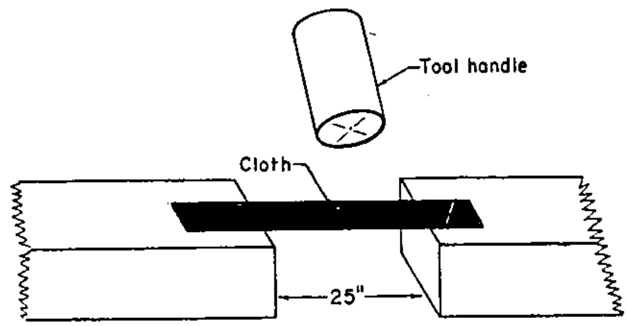

Figure 1.—Diagram of components used in painting fire handtool handles.

7. Rotate or roll the handle 360° to provide a smooth, even, continuous band of paint.

Approximately 10 handles can be painted before more paint must be added to the cloth.

[1] Adopted from R-10 Forest Service Handbook, FSH 5125.3, Fireman's Guide.

Telemetry—
Continued from page 14

3. Humidity, 0 to 99 percent relative humidity
4. Temperature, 0° to 129° F.
5. Precipitation, 0 to 99.99 inches

Equipment used for radio communication between a central station and its satellites are a standard VHF transmitter and receiver units. Central station equipment is typically a 25-watt tabletop console. Observation stations generally use an FM 3-watt battery-powered portable packset. Surplus older radios can often be used to perform the required function, thus saving an investment in equipment exclusively for telemetering.

Central stations, of course, must be at some suitable headquarters. Observation stations for a system should normally be at sites 2 to 25 miles from the central station, depending upon the needs of the rating area. Some of the more remote installations might require intervening repeater stations for reliable system performance. Up to 10 observation stations can be tied into one central station.

The fire weather telemetry system described above was designed to be compatible with the needs of the National Fire Danger Rating System. The equipment is capable of accommodating inputs from additional sensing equipment should it later prove necessary, but efforts are now directed mainly toward simplifying the system to reduce initial investment costs. Once reasonably dependable and economical equipment is available, use of telemetry to provide coverage for protection areas as large as an entire National Forest would be feasible. The data gathered by telemetry could be integrated with that gathered and transmitted by ordinary methods already in use.

Ultimately, improved sampling techniques and better knowledge of fire weather and fire behavior may permit use of totally automatic systems, tied into fire danger computers located at central points.