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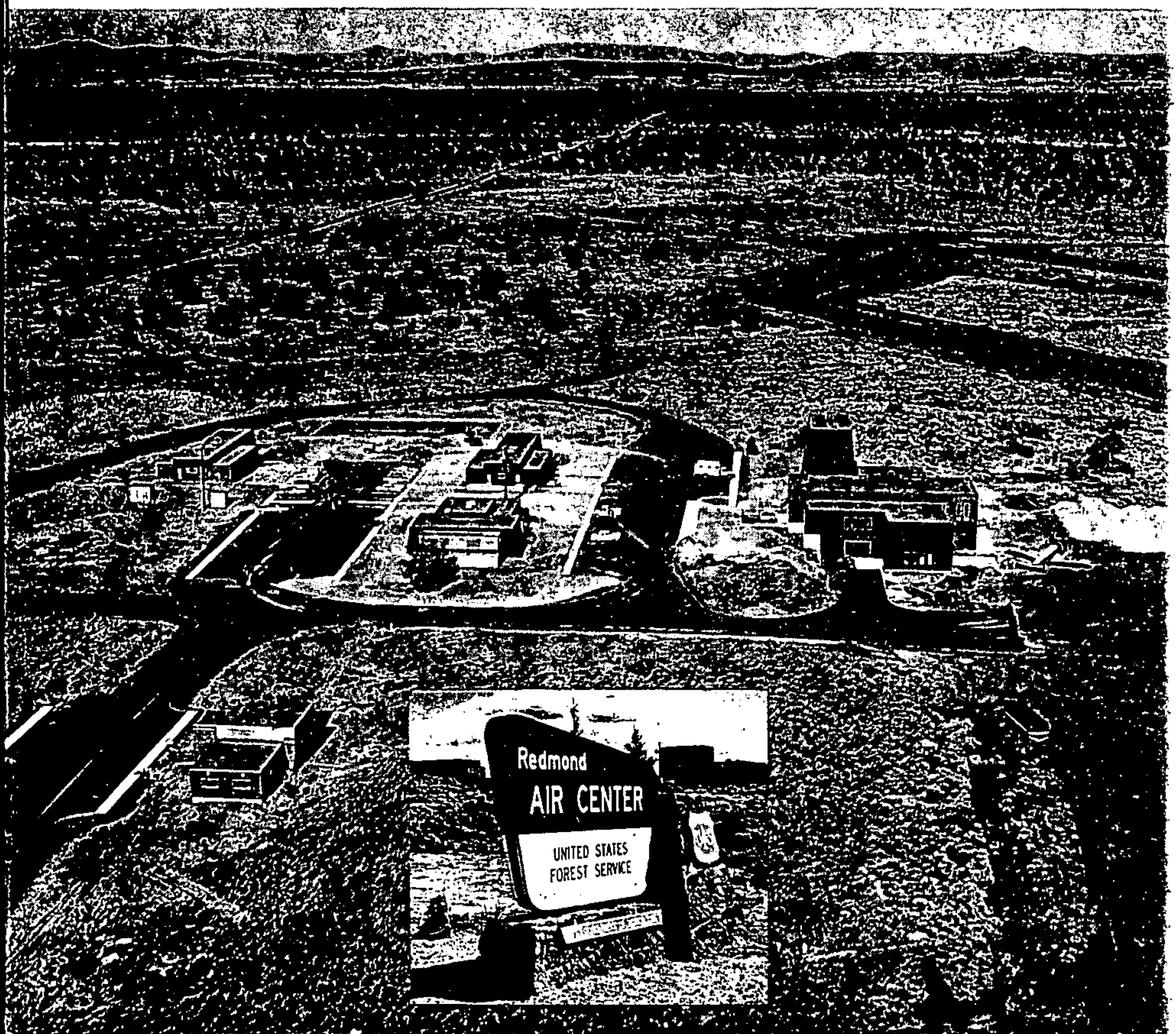
FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service



FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate, double space, and with no paragraphs breaking over to the next page. Elite and pica copy should be 54 and 45 spaces wide, respectively.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and organization.

Authors are encouraged to include illustrations with their copy. Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints or India ink line drawings are acceptable. Captions for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the caption being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. ***Paper clips should never be used.***

When Forest Service photographs are submitted, the negative number should be indicated with the caption to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

COVER—The Redmond, Oreg., Air Center was dedicated on August 29, 1964, by the U.S. Forest Service. It is the hub of aerial firefighting operations for the Pacific Northwest. The Air Center is home base for smokejumpers, air tankers, air cargo planes, and an interregional fire suppression crew that may be flown anywhere in the West.

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SIMULATING FOREST FIRES FOR RESEARCH

ROBERT C. HARE, *Plant Physiologist,*
Institute of Forest Genetics,
Southern Forest Experiment Station[1]

The effects of a forest fire on a single tree can be simulated by burning an oil wick encircling the tree near groundline. Some of the advantages of this method over the setting of fires in natural fuel include ease of replication, standardization of amount of heat, a saving of labor, and low risk of fire escape. Trees are also conserved, for only those needed are burned, whereas natural-fuel burns usually damage many trees not used in a study.

Figure 1.—Wick braided from wire-reinforced asbestos and saturated with SAE-30 motor oil in kerosene is wrapped around the trunk and ignited.

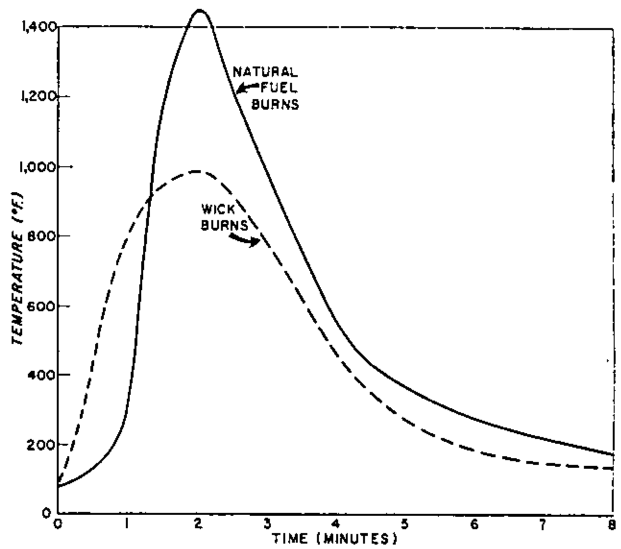

Figure 2.—Typical lee-side, bark-surface temperature curves 1 foot above the wick and in natural-fuel burns.

The wick, braided from wire-reinforced asbestos and saturated with SAE-30 motor oil in kerosene (1:3), is wrapped around the trunk about 1 foot off the ground, and ignited after litter is removed (fig. 1). Temperature regimes on and under the bark are recorded by thermocouples connected to a multiple recorder.

Wick flames, lasting about 7 minutes, give temperature histories on both windward and lee sides that are quite similar to those obtained in natural-fuel burns (fig. 2). Maximum cambium temperatures in a number of tests varied from 85° to 520° F. in wick burns, and from 85° to 500° in pine-litter burns.

Although the wick fire cannot reproduce a moving front, it responds to wind much as natural fires do. Because of a cooling effect on the windward side and a convection column buildup on the lee side, maximum lee temperatures in both types of fires are at least twice as high as windward maxima, and the difference increases with height.

[1] This research was conducted when the author was with the fuels and fire control project at the Southern Forest Experiment Station.

VORTEX TURBULENCE—ITS EFFECT ON FIRE BEHAVIOR

JAMES B. DAVIS, *Forester,*
Pacific Southwest Forest & Range Experiment Station
and CRAIG C. CHANDLER, *Fire Behavior Specialist,*
Forest Fire Research, Washington Office[1]

"The fire wasn't doing much until the air tanker went over, and then it spotted all over the place," complained the fire crew foreman.

Such reports have caused fire control officers to ask, "Can air tankers really cause erratic fire behavior?" The answer is yes—under some conditions. The gremlin is "vortex turbulence," a pair of whirlwinds streaming out behind the wingtips.

What is Vortex Turbulence?

Vortex turbulence is a sheet of turbulent air that is left in the wake of all aircraft. It rolls up into two strong vortices, compact fast-spinning funnels of air, and to an observer on the ground appears to trail behind each wingtip (fig. 1). Because it moves out at right angles to the flight path, vortex turbulence can be distinguished from propeller wash, which is largely localized to a narrow stream lying approximately along the flight path. Unfortunately, however, vortex turbulence is usually invisible.

Under certain conditions the two vortices may stay close together, sometimes undulating slightly as they stretch rearward. The interaction between them tends to make them move first downward, then outward along the surface of the ground.

How Important are Vortex Wakes?

The Flight Safety Foundation, Inc., reports: "In recent years, there have been increasingly frequent reports by pilots encountering severe disturbances of another airplane even when separated from it by distances of several miles. There also are an increasing number of fatal accidents to lighter airplanes, resulting from upsets near the ground or structural failures which are being ascribed to encounters with wakes of large airplanes. It is now generally accepted that the only disturbance which an airplane can produce that is powerful and persistent enough to account for these incidents arises from the vortices which trail from the wingtips of any airplane in flight."

Ordinarily, vortex turbulence does not pose any difficulties to fire control forces. But under special circumstances vortex wakes may cause a fire to act most unexpectedly. Line personnel should become familiar with the vortex problem and the situations where it is likely to affect fire behavior.

What Causes Vortex Turbulence?

Vortex turbulence is a byproduct of the phenomenon that gives lift to an airplane. Air flowing the longer route over the top of the wing has to travel

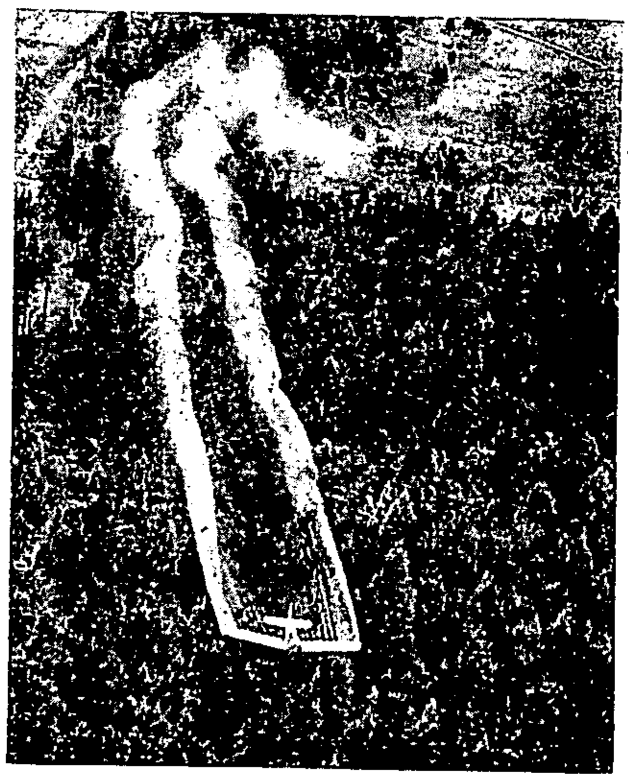

Figure 1.—Low-flying spray plane. Note funneling effect of spray trailing behind each wingtip. This is vortex turbulence.

[1] The authors have received technical guidance from many sources but are especially grateful to Richard C. Rothermel, Aeronautical Engineer, Northern Forest Fire Laboratory; Herbert J. Shields, Supervisory Engineer, Arcadia Equipment Development Center; and Alan W. McMasters, Operations Analyst, Pacific Southwest Forest & Range Experiment Station.

faster than the air flowing across the bottom in order to reach the trailing edge simultaneously. The difference in speed causes a difference in pressure between the top and bottom of the wing with a resultant upward force, or lift. If you want to demonstrate this effect, hold the back of a spoon in a stream of water from a faucet. The spoon will be pulled into the stream as soon as the water touches it. However, here is where the trouble starts. Since the air pressure is greater on the under surface of the wing than on top, some air tries to flow around the end of the wing to the lower pressure area. Because of the flow around the tip, the main stream—instead of flowing straight back across the top and bottom of the wing—tends to fly inward toward the fuselage on the top of the wing and outward on the bottom. As a result, the air doesn't "fit together" at the trailing edge but forms a vortex sheet that rolls up into two large whirlwinds that trail from each wingtip (fig. 2).

Is Turbulence the Same for All Air Tankers?

Vortex severity and persistency vary with several factors. Most important are the type and size of the aircraft and the condition of the air. Vortex turbulence is greatest when produced by a large aircraft with a heavy wingspan loading. Thus, the heavier the aircraft or payload per unit of wing surface, the more severe the turbulence will be. The B-17 is a heavier airplane than the PBY. Thus, when the vortex wake immediately behind a B-17 is 29 m.p.h., the lighter PBY's vortex will be only 16 m.p.h. under the same flying conditions since both planes have the same wingspan.

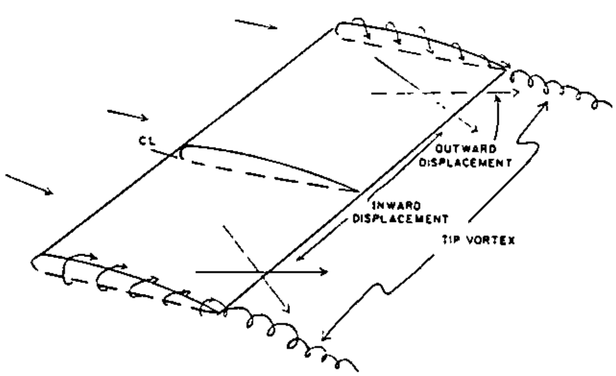

Figure 2.—Airflow over wing with distortion of flow and vortex formation.

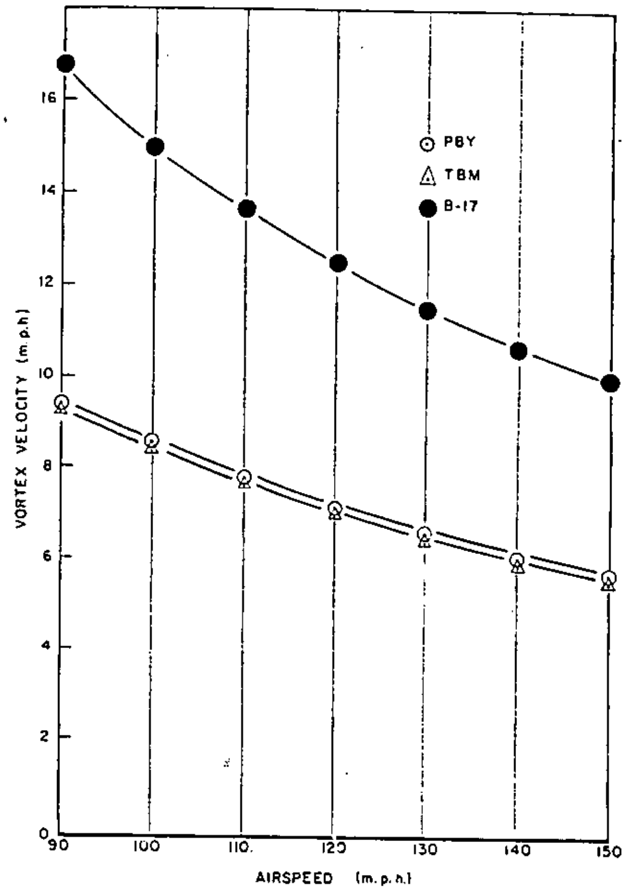

Figure 3.—Relation of vortex velocity to air tanker speed. The tanker's altitude was 75 feet; vortices took about 15 seconds to reach the ground, where their velocities were obtained.

How Does Air Tanker Speed Affect Turbulence?

It may seem surprising, but turbulence is inversely related to airspeed (fig. 3).

Other factors being equal, an aircraft with a high wingspan loading at slow airspeed is the source of the strongest vortices. In terms of air safety, one of the greatest hazards is a heavily loaded aircraft flying at slow speeds before landing or after takeoff. Essentially, this is the condition when an air tanker slows down for an accurate airdrop.

How Does Aircraft Height Affect Turbulence?

At high altitude, the two vortices remain separated by a distance slightly less than the aircraft's wingspan. However, the interaction of the two causes them to drop. As they approach within approximately a wingspan of the ground, they begin

to move laterally outboard from each wingtip. The lateral motion may be better termed "skidding" than "rolling," for at the ground contact point the direction of rotation is opposite the core's lateral movement (see fig. 2). The downward movement may require only 10 seconds from a TBM flying at 50 feet, but a minute or more from the same aircraft flying at 150 feet. The time required for downward movement is important for two reasons:

1. Wind can blow the vortices away from the drop area. For example, a 10-m.p.h. wind can blow the vortices more than 800 feet in the short time required to drop from 150 feet.

2. Vortices weaken rapidly with time. Under average air conditions, the turbulence may lose its danger potential in less than a minute. In rough air, the funnels break up and weaken even more rapidly. Calm air is the worst situation because it permits the turbulence to persist for a longer period.

How Does Vegetation Affect the Vortex?

Natural surfaces are more or less rough and, therefore, cause frictional resistance to air movement above them. The rougher the surface, the greater the friction. Timber, for example, has a much greater slowing effect on wind than does open grassland. Whereas a vortex turbulence is more like a horizontal whirlwind than what we normally think of as a wind, the same frictional considerations apply. A heavy stand of timber would dissipate most of the force of a vortex; the same vortex would be only slightly weakened in grass or scattered timber.

How Do Vortex Wakes Affect Fire Behavior?

Although there are many observations on the effect of vortex wakes on other aircraft, we have

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Figure 4.—Wake from a DC-3 and pronounced vertical motion of the vortex.

LOOKOUT VISIBLE AREA—ILLUMINATED AND PHOTOGRAPHED

CLAUDE PHILLIPS, *Forester,*
Oregon Forestry Department

Because of changing fire detection systems there is recurrent need for lookout visible area charts. Office or field methods of charting seen area require tedious sketching.

The darkroom photographic method developed in the Oregon Forestry Department eliminates much of this effort and produces new features on the charts. Reference to flashing light on relief models is found in Davis (1959)[1] (photography is not mentioned). Modest exploration of the method's potential became possible only with the advent of plastic relief maps. This process was tested during a project requiring extended coverage for several lookouts on a district being considered for combination lookout and air patrol.

Concept

To illustrate the method, visualize taking a picture at night from a high altitude directly over the lookout while using a powerful flash at the lookout point for exposure lighting. The area illuminated and recorded in the picture would correspond to the area seen by the lookout. The area hidden from the lookout by ridges and canyons would be in shadow.

Utilization of Relief Maps

In practice, the same method is used on a miniature scale. Miniature terrain is provided by Army Map Service plastic relief maps with a horizontal scale of 1:250,000 and a vertical exaggeration of 2:1.

The tiny point source of light needed to match this miniature terrain might be difficult to obtain from light bulbs, lenses, or reflectors. Therefore, the flash from a small arc created at the lookout point on the map surface was used.

The map used in this project (fig. 1), which covered the Northwest Protection District of Oregon, was made by gluing together two of the "Wrinkle Quads." The main concern was over the accuracy to be expected of terrain impression and the effects of using the small scale of one-fourth inch per mile. On these relief maps with a vertical scale of 1:125,000, one-hundredth inch is equivalent to a tower height of 104 feet. The requirements of this project permitted the indication of slightly greater coverage than the ground surface really seen.

Figure 1.—Front of map used in darkroom method.

Measurement of the height of model terrain on the relief map with a surface gage revealed the map to be surprisingly accurate. Corrections of 0.01 to 0.03 inches were made by gluing balsa blocks to the back and trimming to support at the correct height before gluing the map to a ½-inch-thick fiberboard base. These blocks gave rigidity to the map when it was glued to the base for wiring.

Instrumentation

Holes were drilled through the map and the base at the lookout point, and wire electrodes were inserted until flush with the map surface. Under

[1] Davis, Kenneth P. Forest fire: control and use. 584 pp., illus. New York: McGraw-Hill. 1959.

the base the wires were bent flat (fig. 2), anchored with screws, and soldered to a common conductor. Map electrodes are made from number 18 copper magnet wire (0.040 inch diameter) with enamel removed. The arcing circuit was completed by a carbon electrode (penlight battery core) mounted on a slender adjustable support arm above the map (fig. 3). Current was supplied to the electrodes from 45- and 67½-volt B-type used radio batteries connected in a series to give 450 to 500 volts. The carbon electrode was connected positive through a momentary switch. Actual arcing was controlled by a fine adjustment screw in a leg of the stand supporting the overhead arm. The arm was lowered and raised to strike and break the arc as in welding. The switch protects against accidental flashes. Capacitors were tried successfully as a power source, but the arc created more sparks than the battery system and the recharging time was too long.

Application of The Method

Direct photography of the lighted area was the real expedient in this venture. It permitted a simultaneous record of geographic map, seen area, and composite coverage as desired. Pictures were made on Kodak Royal Pan film[2] by a 4 by 5 Speed-Graphic camera mounted on a tripod directly over

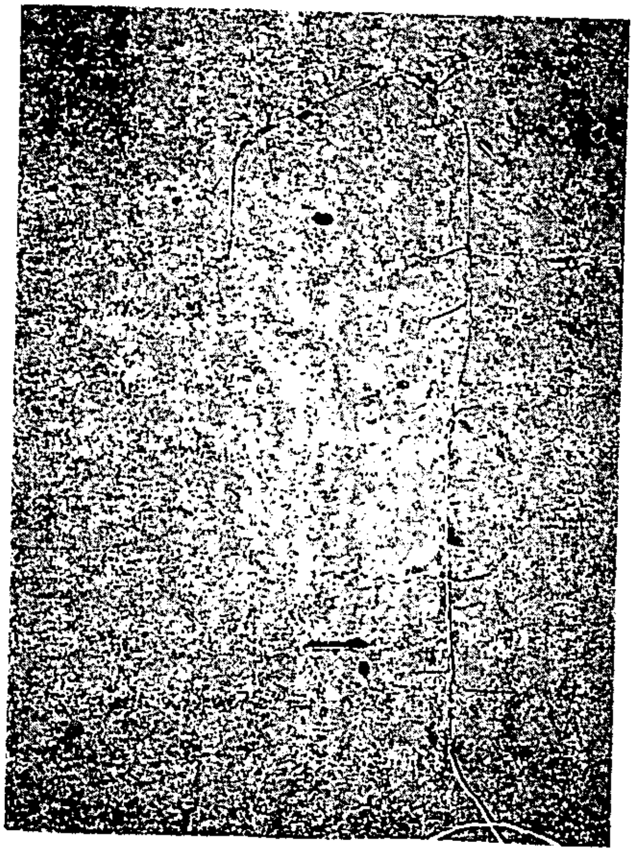

Figure 2.—Back of map used in darkroom method. Firtex backing and wiring detail is shown.

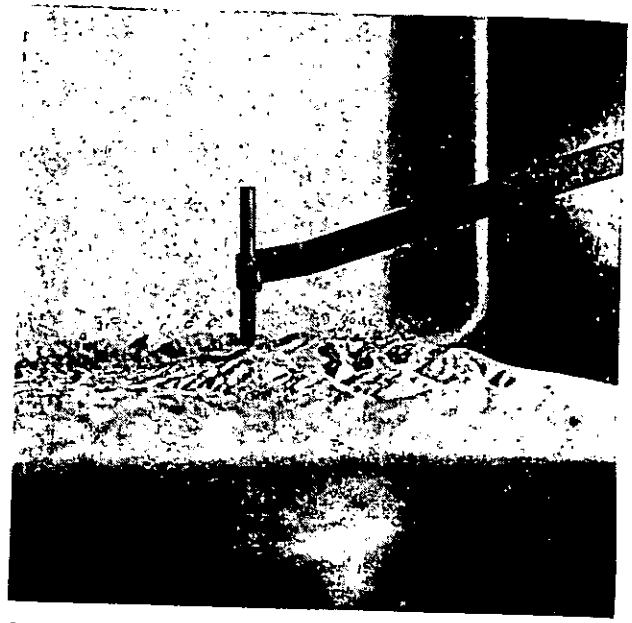

Figure 3.—Meeting of contacts showing map electrode slightly extended.

[2] Use of trade names is for information purposes and does not imply endorsement of products by the U.S. Department of Agriculture over other products not mentioned.

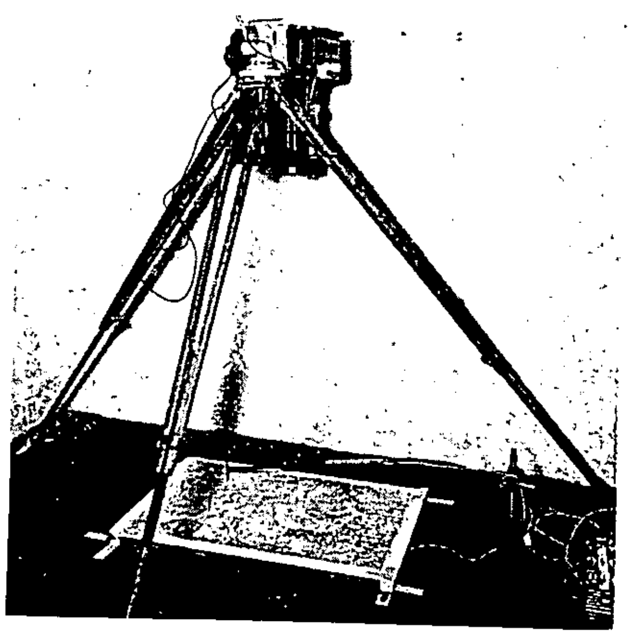

Figure 4.—Camera setup with map on darkroom floor; exposed portion of arcing circuit is shown.

the map in the darkroom (fig. 4). The aperture was f-8, and the exposures were made with an open shutter. Two to four flashes were used, depending on the quality and duration of the flash. Sustained arc with this power source can set the map on fire or overheat the wires. The shutter was closed for moving the contact on composite pictures, and a separate floodlight exposure was made at 1/150 second for map background lighting.

Light diminishes with distance at a rate somewhat comparable to visual perception, providing a gradual limit instead of the arbitrary 8-mile circle.

The seen area appears gradually darker farther from the lookout. This feature apparently helps in making a visual estimate of lookout potential. Also the recorded light is attenuated in the shadow of obstructions so that we have some representation of nearly seen surface. Areas slightly below the line of sight are only lightly shaded, indicating the area where it is possible to detect rising smoke.

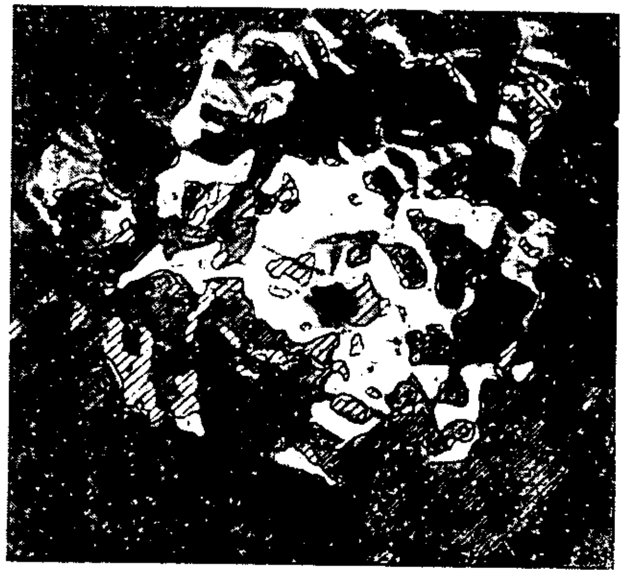

Figure 5.—King Mountain, Northwest District, showing overlay by profile method superimposed over photo. Unseen area of profile overlay is hachured. Discrepancies are partly due to slight scale differences and photo distortion.

Figure 6.—Point tried near the bend of Wilson River in Northwest District.

Comparison with Profile Method

Seen-area charts made by the profile method use 1-inch-per-mile topographic maps, and then the charts are reduced to a ½-inch-per-mile scale. The reduction method is subject to error and may account for much of the discrepancy between the photos and previously drawn charts done by the profile method (fig. 5).

It is not difficult to orient an overlay chart when

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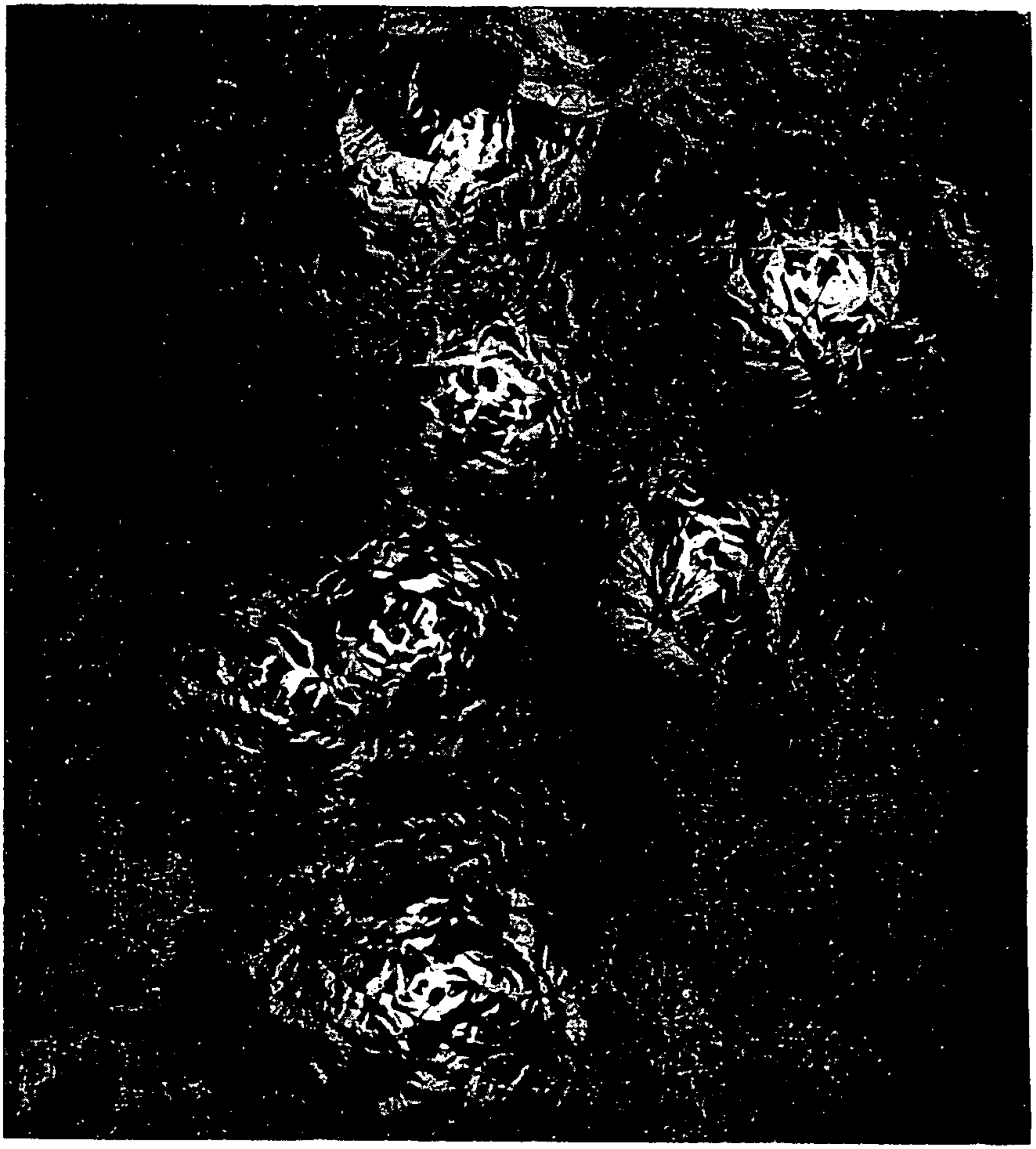

Figure 7.—This composite photo shows seven selected points. There is attenuated but recorded light up to 15 miles. Background lighting brings out the printing detail of the map.

THE UNIMOG, A VERSATILE VEHICLE

SAMUEL S. COBB, *Chief, Division of Forest Protection, Pennsylvania Department of Forests and Waters*

The Pennsylvania Department of Forests and Waters has consistently sought better means by which its personnel could reach and control all forest fires as quickly as possible.

Although Pennsylvania is populous and highly industrial, most of its people and extensive road networks are concentrated in small areas. Except for the coastal piedmont region in the State south of the Appalachians, the western fringe along the Ohio border, and a few wide agricultural valleys, the State is heavily forested. There are many large, unbroken blocks of forest. Fifty-two percent of the land area is in woodlands, and more than half of the 67 counties have forested areas of 60 to 90 percent.

In these heavily forested counties the road networks are sparse, especially in the mountains. Even in areas with large population centers, there are sizable forested blocks without roads or with only very poor roads.

Over the years, particularly since the end of World War II, many types of vehicles have been tested for use in off-the-road travel into such inaccessible areas. Many conventional four-wheel-drive trucks and military surplus four-wheel-drive vehicles have been tried. However, when any of these vehicles were used to traverse rough terrain, expensive breakdowns or crippling "hang-ups" sometimes occurred.

In 1958, Horace B. Rowland, then Chief of the Department's Division of Forest Protection, became interested in a vehicle called the Unimog[1] (figs. 1-3). Manufactured in West Germany by the Mercedes-Benz Company, it had been designed as a combination small truck and farm tractor for the European farmer. It was also quickly accepted as a valuable military vehicle by several European armies. Rowland had become interested in the vehicle's application as a fireplow unit. When two of these vehicles were delivered late in 1961, they were further equipped by the installation of an hydraulically operated Anderson fireline plow.

The vehicles delivered to the Division were the

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[1] Use of trade names is for information purposes and does not imply endorsement of products by the U.S. Department of Agriculture over other products not mentioned.

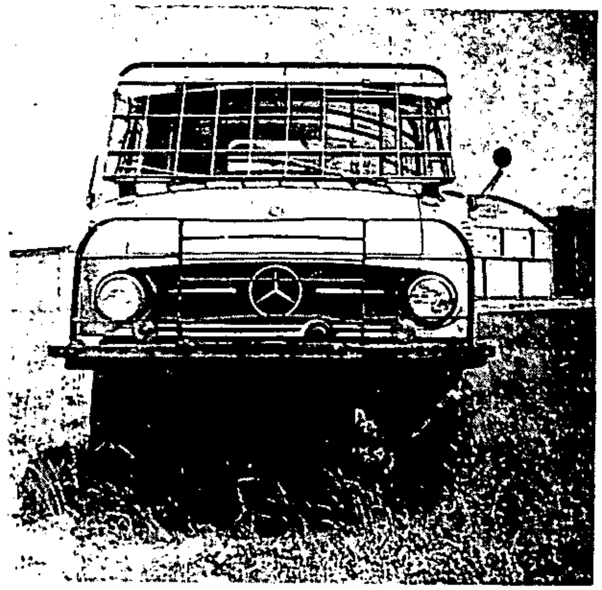

Figure 1.—Front view showing the guard shields that protect the grill, headlights, and windshield.

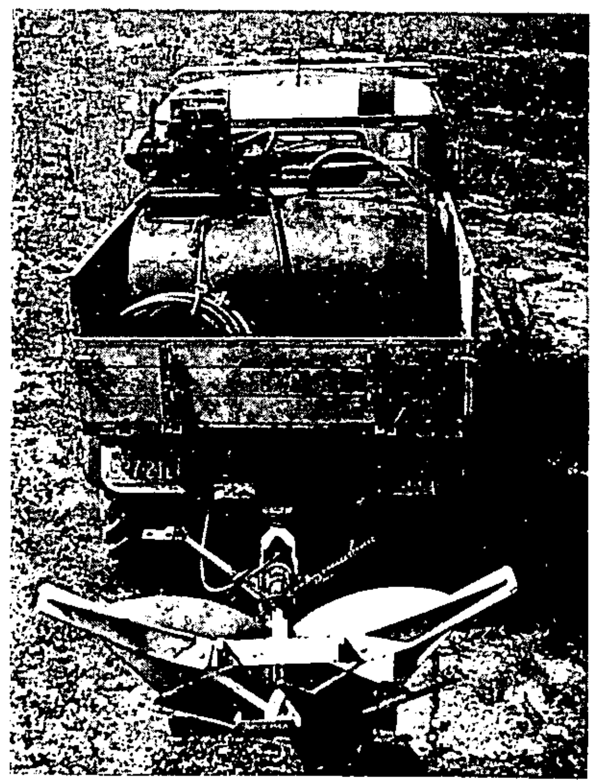

Figure 2.—Rear view showing the plow attached and the slip-on pump tank unit in place.

WOODS ARSONISTS AT WORK

JOHN E. BOREN III, *Criminal Investigator, Kisatchie National Forest*

It was 10:30 a.m. on March 22, 1964, on the Evangeline Ranger District, Kisatchie National Forest. A Forest Service lookout spotted a column of smoke. Before he could reach for his phone to alert a suppression crew he saw another, then another, then more. By 4:15 p.m. 89 individual incendiary sets had been recorded (fig. 1). The arsonist(s) had planned their work well.

Eleven tractor-plow units and 70 firefighters from the U.S. Forest Service and the Louisiana Forestry Commission limited several potential large fires to a loss of only 795 acres of burned-over National Forest land.

An investigation was immediately initiated by the National Forest Criminal Investigator in cooperation with law enforcement agents of the Louisiana Forestry Commission. It was learned that a horseman had been observed deep in the "Piney Woods," and that numerous fire sets had been reported in the same area. A detailed search of these areas disclosed a fresh set of horse tracks,

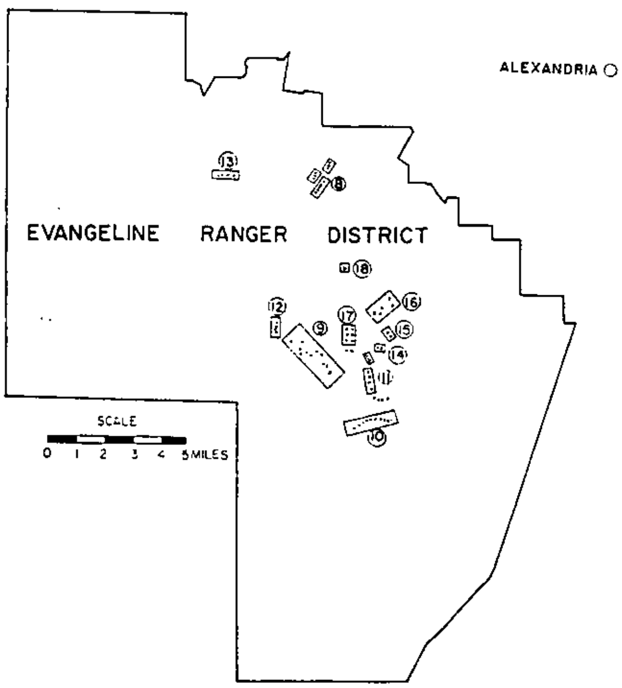

Figure 1.—Map of the Evangeline Ranger District. Each "X" denotes an incendiary set. The numbers indicate the District fire number.

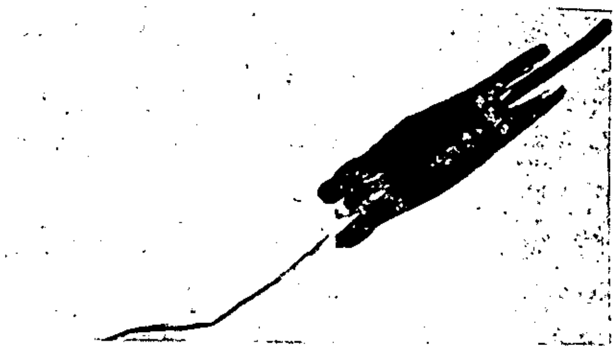

Figure 2.—Remains of the slow-match found at one fire set. Note the fiber glass core, kitchen matches, and electrician tape.

Figure 3.—Fiber glass core of the "fuse" of another slow-match. The pen is 5½ inches long.

and later the remains of the incendiary device—a slow-match—was found (fig. 2). Additional searching revealed what was subsequently identified as the core of the "fuse" of another slow-match (fig. 3).

By careful handling, these two fragile items of evidence were preserved and sent to the FBI laboratory in Washington for examination. The FBI reported that the slow-match was constructed of one-quarter-inch braided cotton cord, was cotton filled, and had strands of fiber glass as a center. Common kitchen matches were bound to the cord with one-half-inch electrician-type plastic tape. The other core that was found was identified as fiber glass of the same type used in the slow-match.

Field experiments with slow-matches (fig. 4) made from materials similar to that shown in figure 2 revealed that the cord burns at the rate of 1 inch per 12 minutes. It was determined that the incendiary device had a "fuse" cord of approximately 5 inches. Thus, the arsonist(s) had 1 hour to make their getaway from the area after dropping the slow-match in the forest litter.

Due to the unusual fiber glass core, it was believed that if the store selling this type of cord could be located, it might lead to the identity of the arsonist(s). Numerous inquiries were made at local outlets, but no rope or cord with this particular characteristic was found. These inquiries did, however, develop a list of wholesalers and cord manufacturers. Correspondence with 21 of these companies resulted in the receipt of many

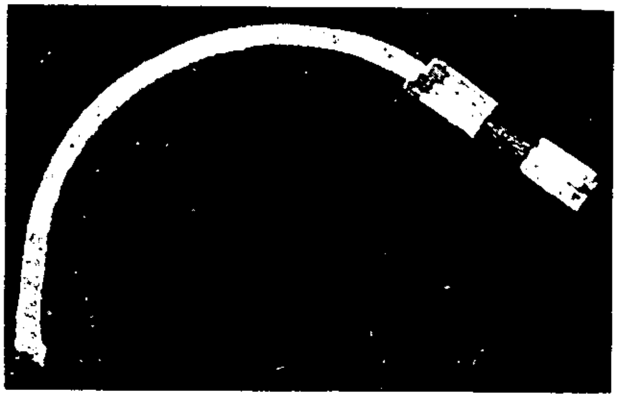

Figure 4.—Sample of a slow-match before burning. The cord measures 5 inches from the end to the head of the matches.

samples of cord. One sample, furnished by a Boston, Mass., manufacturer, appeared identical to the cord used to make the incendiary device. This cooperative company also furnished the identity of their wholesale outlet in the South.

More than 150 forest residents, local businessmen, law enforcement officers, and Forest Service employees have been interviewed. Stories and alibis have been checked, and more leads have developed. The store from which the arsonist(s) obtained their cord has not been located. The investigation is continuing, and it is hoped that the arsonist(s) will be identified and brought to justice through the medium of a piece of 6-inch cotton cord (with fiber glass core).

REWARD PROGRAM MADE STATEWIDE

From The Voice of Forestry
Mississippi Forestry Association,
Jackson, Miss.

As a positive step toward combating destructive forest fires, the Mississippi Forestry Association (MFA) has launched a statewide forest fire reward program, announced James M. Vardaman, Jackson, chairman of the MFA reward committee.

Vardaman said that tree farmers from all parts of the State have pledged a total of $10,000 to be used in offering a $500 reward in each county for information leading to the arrest and conviction of persons setting woods fires. The reward program was started last year, and by the end of the fire season 14 counties were participating. The effectiveness of the program led the MFA board of directors to make the project statewide.

Vardaman said that the MFA is working in close cooperation with the Mississippi Forestry Commission. In each county, personnel of the Commission are posting notices of the reward in public places and at the scene of burned forested areas.

Last year, according to the State Forestry Commission, Mississippi suffered nearly 9,000 forest fires which destroyed more than 90,000 acres at a loss of $3¼ million. Besides timber destroyed, this loss included a number of crops, fences, barns, and other buildings.

Unimog—Continued from page 11

Model 411.117. They have a four-wheel drive system. The front drive can be engaged while in motion without use of the clutch. The unit will operate at from 1 m.p.h. (for pulling a plow) to 40 m.p.h. (for use on the highway). A few details of the vehicle follow:

Cost, $5,200 (delivered on State bid).

Total dimensions, 70.5 inches wide, 151 inches long.

Wheelbase, 83.5 inches.

Tire size, 10 by 18.

Clearance under differential, 14.5 inches.

Engine, four-cylinder Mercedes-Benz diesel.

Workload capacity, 2,205 pounds.

Drawbar pull, 4,840 pounds.

As used by the Pennsylvania Forest Service, the units have proven quite versatile. They have, in addition to the fireline plow, been equipped with slip-on units consisting of a 120-gallon steel tank, a portable pump, and a live reel with 300 feet of three-fourth-inch hose. They have been used on fires as follows:

1. As a fireplow that can travel roads at 40 m.p.h., cross rough terrain, and plow firelines.

2. As a direct attack unit, applying water on the fire edge.

3. For scouting fires over terrain unsuitable for use of conventional vehicles.

4. For moving men, equipment, and food from road to fire over difficult terrain.

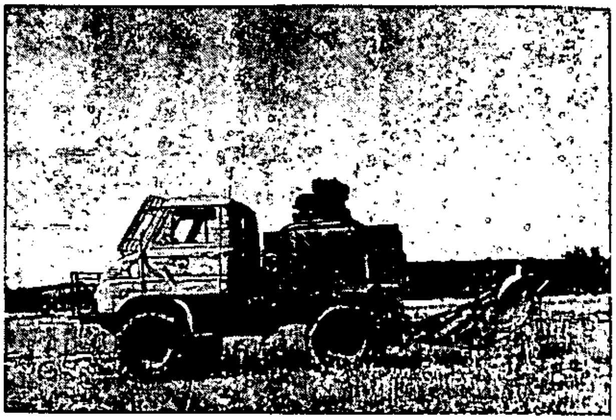

Figure 3.—Side view showing the plow in position ready for final lowering. In transit the plow is carried in the lift position, secured to the tailgate.

5. To support retardant warterdrops on incipient forest fires, made by water bombers, thus insuring early control and the loss of only small acreage.

In addition to on-fire jobs, the plow units have been used extensively to construct and maintain back lines for hazard-reduction burning in connection with railroad rights-of-way, dumps, hazardous residential and play areas, and similar areas that are prone to fire. Operating costs have been quite low.

No difficulty has resulted from damage to the pump unit from branches or other overhead hazards. However, the units have been used mostly in scrub oak and hardwood brush areas where this hazard is minimal.

Visible Area—Continued from page 10

the photo method is used with background lighting. The entire map may be floodlighted for a fast exposure (1/150 second) to faintly bring out the map detail where flashes have not illuminated it. The seen area is exactly where it belongs because the photo serves as the base map.

Results and Potential Uses

Comparison of the pictures (fig. 5) with seen-area charts made by the profile method indicated that the cost of the pictures was more than justified.

With this method indications are that the discrepancy in area might be held to a maximum of 10 percent. Some hidden area near the point source is lightened by reflection error when flashing for extended coverage (fig. 6).

This method is convenient for showing combined coverage of several lookouts (fig. 7). Composite pictures were made with up to 17 lookouts by bringing the whole district area into camera focus, and flashing succeeding lookout pivots without changing film.

This method has not been tried for charting the seen area of an air patrol path, but it is possible that wire tracks can be mounted on the map to represent the course and height of the patrol plane, and that light can be moved along the wire for progressive exposures. Such a method might aid in determining course and altitude in flight plans.

WINDSPEED AND THE PROBABILITY OF FIRE OCCURRENCE

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An Ignition Index is one of the indexes proposed in the National Fire Danger Rating System. It is questionable whether or not windspeed should be included as a variable. Supposedly, the number of man-caused fires should increase with an increase in windspeed. To check this supposition, analyses were made of several protection units in the East and South (table 1).

The r^2 column in the table refers to the percentages of variance in fires per day that can be attributed to windspeed. The maximum variance was 11.2 percent in New Jersey's Division B. Although the true effect of windspeed was partly masked by unknown changes in risk, the measured effect in terms of percent of variance was not great, considering the range of windspeed in all of the six areas.

TABLE 1.—*Relation of windspeed to number of man-caused fires*

Area	Period		Days	Fires	Range in windspeed	r^2*
			No.	*No.*	*M.p.h.*	
Georgia, District 4	Jan.–Apr.	1961–63	94	1,221	2–19	0.010
Georgia, District 6	Jan.–Apr.	1961–63	133	401	0–19	.060
New Jersey, Division B	Mar.–Apr.	1959–63	109	912	4–20	.112
New Jersey, Division C	Mar.–Apr.	1959–63	109	1,161	4–29	.083
Rhode Island	Spring cured	1951–60	90	337	1–32	.021
Virginia, District 2	Mar.–Apr.	1959–63	113	1,112	2–21	.048

*r^2 = Coefficients of Determination = the percentage of variance in fire occurrence attributed to windspeed.

In order to minimize error resulting from variability in fuel moisture, only days having estimated fine fuel moistures of 6.5 percent or less were considered. Fuels were highly flammable on all these days. Depending on the area, different methods were used to calculate fuel moistures. These included use of basswood slats, measurement of air temperature and dewpoint, and determination of air temperature and wet-bulb depression.

Also depending on the area, windspeeds were taken from well-operated standard fire danger stations or from airport exposures corrected to a 20-foot standard.

It was impossible to eliminate the effect of risk—the activity of fire starters. Thus, windspeed apparently had little effect on fire occurrence.

There was much scatter of points about regression lines for each area, but the slope was upward except for the two districts in Georgia. In District 6, the number of fires decreased as wind increased.

The reasons for the differences between protection units in New Jersey and Georgia are not clear. Perhaps the predominantly rural population in the Georgia areas, although careless at times with fires, is more aware of the danger in burning debris and in otherwise starting fires when windspeed is high.

Based on this analysis, windspeed would be a minor variable in an Ignition Index for the East and South and might well be omitted.

The article "The Forest Fires of April 1963 in New Jersey Point the Way to Better Protection and Management," *Fire Control Notes,* July 1964, contained an error. The first sentence of the final paragraph of page 4 should be: "More recent burns that left some surface fuel remaining only reduced the damage, but others that removed nearly all the fuel *did* stop the fire." The authors wish to make clear that relatively clean burns in the year before April 1963 stopped both strong head fires and flank fires, and enabled far better control by ground crews.

Vortex Turbulence—*Continued from page 6*

only two or three on forest fires. However, what is known about the vortex and about fire behavior can lead to some pretty good guesses.

Because wind tends to break up the vortex and is normally accompanied by much natural turbulence, the chances are that vortex turbulence will probably be noticeable only on a calm day. Not only will the vortex wake be stronger on quiet days, but because the fire will usually be spreading slowly, the sudden air turbulence will be even more unexpected and potentially serious.

On the ground, the effect of vortex turbulence will be felt as a sudden gust which may last only a few seconds or for up to half a minute. In litter, grass, or light brush the result will be a sudden but brief flareup or increase in local fire intensity and rate of spread. In heavy timber or brush fuels with a continuous overstory, vortex turbulence will usually not reach the ground and so will have no noticeable effect on fire behavior.

In patchy fuels, where timber or brush is interspersed with open grassy areas, the effects of vortex turbulence may be extremely serious. Although the vortex wake will not reach the ground beneath a timber canopy, it may in the openings. Because the core usually remains above ground, the true wind direction at the surface is not parallel to the ground but slightly upward (fig. 4). Thus both flames and burning embers tend to be swept upward as well as out. Thus vortex turbulence, compared with a natural gust of the same velocity, has a greater potential for triggering crowning and spot fires because flames and embers are driven up into the crowns.

The most serious situation is calm air on the ground but a light, steady wind aloft. Under these conditions the vortex may be carried far from the aircraft to strike the ground in an unexpected location, with ember showers being moved over long distances by the upper winds. Only rarely would one encounter a fire in patchy timber and brush under precisely these weather conditions; yet this was apparently the case on one well-documented fire in California in 1962.

Summary

Vortex turbulence consists of a pair of miniature whirlwinds trailing from the wingtips of any aircraft in flight. The more heavily loaded the aircraft, and the lower and slower it flies, the stronger the vortex turbulence will be and the more likely to reach the ground. The vortex will be in the form of a horizontal whirlwind with velocities up to 25 m.p.h.—sufficient to cause sudden and violent changes in fire behavior on calm days in patchy fuels.

Wind, gustiness, and surrounding high vegetation will tend to break up or diminish vortex intensity.

The fire crew should be alert for trouble when:

1. The air is still and calm.
2. The fire is burning in open brush or scattered timber.
3. The air tanker is large or heavily loaded.
4. The air tanker is flying low and slow.

The air tanker pilot should be aware of the problem his aircraft can cause. He may know the effect of vortex wakes on his or other aircraft, but may not know the effect on a fire. He can abide by the following rules during situations of possible danger from vortex wakes:

1. Don't fly parallel to the fireline more than necessary.
2. Keep high except when making the actual drop.
3. Ensure that ground crews are alert to the presence of the air tanker and the pilot's intentions.