VOL. 4 JULY 1940 NO. 3

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

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

Volume 4 Number 3

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FIRE CONTROL

*

FIRE CONTROL NOTES is issued quarterly by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., 15 cents a copy, or by subscription at the rate of 50 cents per year. Postage stamps will not be accepted in payment.

The value of this publication will be determined by what Forest Service officers, State forestry workers, and private operators contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, personnel management, training, fire-fighting methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

Address DIVISION OF FIRE CONTROL
Forest Service, Washington, D. C.

Fire Control Notes is printed with the approval of the Bureau of the Budget as required by Rule 42 of the Joint Committee on Printing

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1940

CONTENTS

ORGANIZING NATIVES TO FUNCTION AS FIRE-FIGHTING UNITS USING THE 10- TO 15-FOOT METHOD

HENRY C. HULETT

Fire Control Assistant, White Mountain National Forest, Region 7, U. S. Forest Service

The extensive areas of tangled heavy fuels left in the wake of the New England hurricane of September 1938 presented a fire-control problem of great proportions. Realizing that previously used methods of line construction would be of no avail, the forest officers of the White Mountain National Forest set about the development of a new method suited to the unusual situation. The method and its development through the period of training local crews is a fine example of creative effort.

Within a month after the 1938 hurricane, reconnaissance was started and every available man in the region took part. After several weeks of this work it was estimated that more than 50 percent of the timber on 150,000 acres was piled up on the ground in jack-straw fashion from 5 to 25 feet deep.

During the 10 years preceding the hurricane, the fire record on the White Mountain National Forest showed an average of only five fires per year, with a total annual loss of less than 2 acres. In this time and with this record the local people and the forest officers naturally became extremely optimistic. There was a feeling that the horrifying fire days of the 90's (when 5,000- to 20,000-acre fires commonly burned in several parts of New Hampshire simultaneously) had vanished forever.

All this was changed overnight. Stories of the past became street corner gossip wherever two or more lovers of the forests got together. In the face of the crisis the local population was ready and willing to go to almost any length to avert a parallel or repetition of those former disastrous conflagrations. Since the days when the smoke of logging fires darkened the New Hampshire sun, her people have learned what the scenic beauty of their forested mountains and the value of the few remaining timber operations actually mean to them, and the possibility of this precious beauty and wood supply being wiped out overnight in another holocaust of flame and smoke was appalling.

Organization and training of fire crews was begun to meet the new situation. Crew organizations averaged about 135 men, but varied from 90 to 175 men. Varying the size of the crews did not materially cut down production per man hour. Fire training required approximately 6,850 man days. Included in the training program were 850 local people; 120 forest officers, guards, and CCC camp overhead; and 725 CCC enrollees. In total, in the course of the 1939 fire season, 15

local and 18 CCC special fire schools were held. The schools included the entire personnel normally needed in the suppression of a moderate-sized fire. The largest unit included approximately the following organization:

Fire boss and assistant	2
Head scout and 3 assistants	4
Clearing foreman and assistant (4 sections)	2
Crew leaders	4
Crew laborers	40
Digging foreman and assistant (5 sections)	2
Crew leaders	5
Crew laborers	50
Patrol and mop-up foreman and assistant (3 sections)	2
Crew leaders	3
Crew laborers	30
Communication boss and crew (telephone and radio)	5
Water boys (1 per section)	12
Camp organization (timekeepers, property clerks, packers, etc.)	14
	175

Overhead includes all those not directly connected with either the clearing, digging, or patrol and mop-up crews. The smaller units were very much like this 175-man unit except that they had a proportionately smaller number of sections in the various crews and in the number of overhead.

To those accustomed to working in light fuel only occasionally intermingled with short streches of heavy fuel the overhead listed may seem top heavy. But schools conducted on the White Mountain National Forest were almost exclusively confined to fuel types uniformly heavy throughout. The safety of the men must be constantly watched while they are in these heavy fuels. The men once on the fire line were spread over a distance varying from 1,200 to 1,800 feet. A spread such as this in any type of fuel is dangerous and needs extra overhead to reduce the danger of trapping those out in front. Fuel types encountered are illustrated in A on page 103 and A, E, and F on page 105.

The three crews (clearing, digging, and patrol and mop-up) of the unit worked as individual groups; that is, the clearing crew advanced as fast as it could, not waiting for the digging crew to keep pace. Often this caused an opening of as much as 5 chains between the last man on the clearing crew and the first man in the digging crew. These openings in the line usually occurred when the heavy fuel thinned out momentarily. The gaps never lasted long because, generally, the diggers were pressing or occasionally working into the rear of the clearing crew.

The patrol and mop-up crew served as a digging crew until each member was assigned to his 3-chain patrol beat. Additional patrolmen (besides those available from the three 10-man sections) when needed, were available from three sources: (1) the digging crew; (2) the clearing crew (with tools brought in by camp packers); or (3) by doubling the distance each man of the first patrol section patrolled, and thus relieving one patrol section for moving forward. The latter source was used only when the patrol work slackened. Foreman and crew leaders on the patrol and mop-up crew were utilized to watch for and direct action on spot fires within easy discovery distance of the fire line.

Clearing and digging crews working in medium to heavy hardwood-conifer fuel types: Clearing crew—*A*, Line locator advancing into medium fuel type; *B*, first section of choppers in clearing crew have cut line through; *C*, last section of choppers. Line ready for digging crew. Digging crew—*D*, Line clearing completed. Lead-off man in digging crew marking dug line location; *E*, condition of dug line after two raker sections had passed by; *F*, end of digging crew. Line ready for backfiring or line firing and patrol.

The number of scouts listed in the 175-man unit holds for all units. They were necessary in order to obtain the best location for the line. Scouts were seldom able to see, because of heavy brush, more than 20 to 30 feet ahead at any one time, and for this reason at least three men were required to locate the line of least resistance fast enough to keep ahead of the clearing crew. Advance scouting in extremely heavy fuel type materially helps to reduce the amount of clearing necessary. Fire-line locations used in the schools did not always occur on the *best* line location for two reasons: (1) the desire to give the training crews as tough going as possible, and (2) the inexperience of the scouts in avoiding tough going in the extremely heavy fuels.

As line-location work eased off, because of less fuel, the excess scouts were used in checking for possible spot fires at greater distances back of the line than normally would be covered by the members of the patrol and mop-up crew.

The training of natives to function as organized fire-fighting units is accepted as a desirable Service-wide practice. The one-lick method is an excellent way to increase line production and to keep the spirit and morale of the fire fighters at a high pitch at all times. The 10- to 15-foot method used in the schools described in this articles differs only slightly from the one-lick method. It was developed to cope with the extremely heavy fuels encountered in a blowdown area.

The heavy fuels encountered, including both slash and duff, necessitated a man working in place and taking several licks rather than just one or two licks and then stepping ahead as practiced in the one-lick method. To regulate the forward speed of the men in the 10- to 15-foot method, the men were instructed to work continuously as they proceeded, taking as many licks as possible, but never getting closer than 10 feet to or more than 15 feet back of the man ahead. A 5-foot space was thus provided for each man to work intensively whenever a hold-up prevented forward progress.

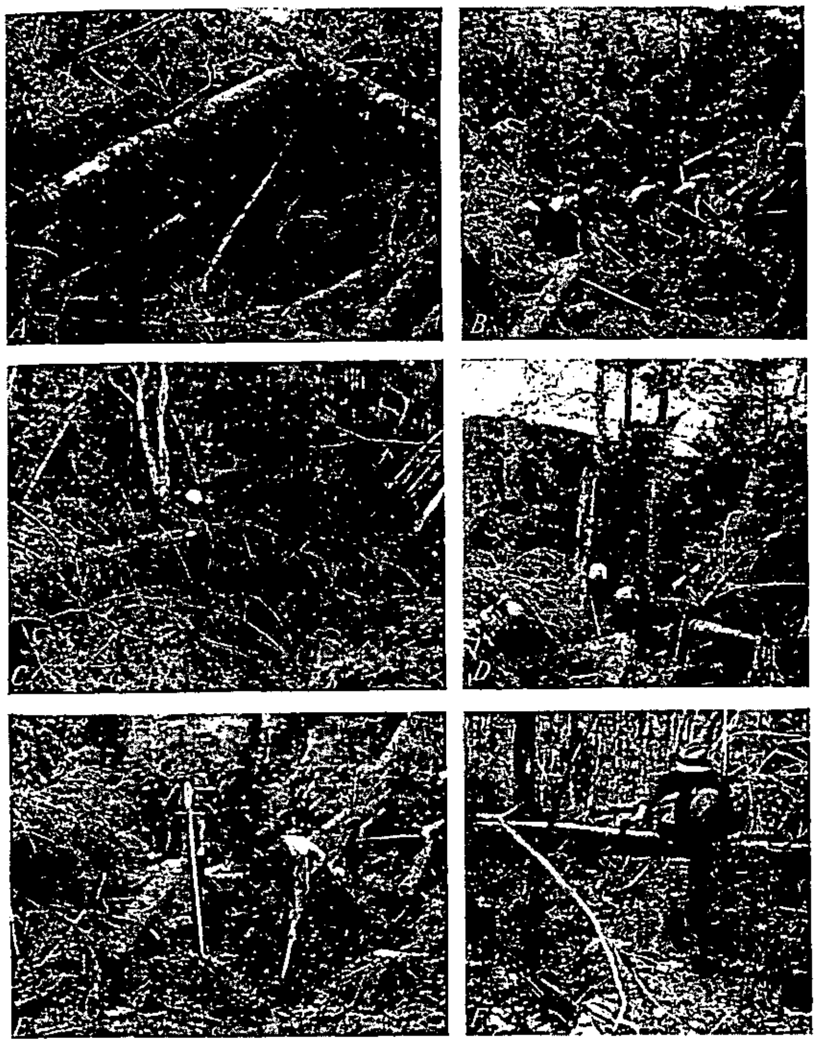
Following is a further breakdown of each crew in the unit and some of the difficulties and problems encountered with the crews at the various schools. It is hoped that this will clarify some of the problems and show the advantages and need of training natives into organized fire-fighting units.

Clearing.—The secret of speed in line construction rests almost entirely on spacing the men at the stipulated 10- to 15-foot distances and knowing when and how fast to push forward the lead man in the line. During the first schools the first men in the clearing crew had a tendency to go too fast and leave too much work for the last men in the crew. As a result a part of the clearing crew had to hold back to complete the work and this in turn held up the entire digging crew.

Elimination of this difficulty was accomplished by assigning assistant foremen to the clearing and digging crews. One foreman would stay at the head of the line to judge the situation and set the pace for the clearing and digging crews so as not to leave more work than the men toward the end of the line could handle.

Often, when the clearing was extremely heavy, the chopping could best be handled by advancing all choppers at a rapid rate of speed until the last chopper entered the thicket and then let each man work in place until the line was chopped through. The men would then move ahead again at a rapid pace and continue the same operation until the fuel type thinned out to permit more steady advancement. In other words, the choppers would work at a fast and slow rhythm. The advantage of a lead of five chains or more over the diggers became apparent when the clearing crew was confronted with extremely heavy slash. This lead often allowed the clearing crew to work their way through the tough going before the digging crew could catch up and close the gap.

As in most clearing crews, the saw teams worked independently of each other and did not attempt to keep in the rhythmic swing of the rest of the clearing crew. Two methods of distribution were tried and both seemed to be effective; one was to include one or two saw teams



Fuel types and fire-line construction on the White Mountain National Forest: *A*, Heavy conifer fuel type. Scouts have nicked logs; *B*, first five men of digging crew raking heavy top-duff with council tools. Rakers will work into clearing team left to clean up leaving conifers; *C*, advance scouting in medium heavy conifer-hardwood fuel type; *D*, clearing crew has cut line through and is now working on snags and Pulaski-tool crew coming up will remove rotten stumps and roots; *E*, line completed with patrolmen digging out rotten spruce root, stake set to end of patrol beat; *F*, line locator in light conifer-hardwood fuel type.

as a part of each 10-man chopping section; the other was to follow the chopping section with a 10- or 14-man saw section.

The last section of the clearing crew was made up of 10 men with pulaski tools. The principal job for this section was to finish off the clearing job and place the line in shape for the diggers. When no clearing was needed above ground, they devoted their time to chopping

out dead roots and obstacles which would hold up the rakers at the head of the digging crew.

The two following clearing-crew organizations seemed to function equally well. Set-up No. 1, however, was used on most of the trials.

Set-up No. 1:
- 1 Foreman.
- 1 Assistant foreman.

1. Crew leader and 10 men.
   - 10 Axes.
   - 1 Brush hook.
2. Crew leader and 10 men.
   - 10 Axes.
   - 1 Brush hook.
3. Crew leader and 12 men.
   - 4 C C saws and axes.
   - 2 Pulp saws and axes.
   - 2 Peaveys.
   - 1 Pole ax.
4. Crew leader and 10 men.
   - 1 Pole ax.
   - 10 Pulaski tools.

Total, 48 men.

Set-up No. 2:
- 1 Foreman.
- 1 Assistant foreman.

1. Crew leader and 10 men.
   - 1 Brush hook.
   - 7 Axes.
   - 1 C C Saw, peavey and ax.
   - 1 Pulp saw and ax.
2. Crew leader and 10 men.
   - 1 Brush hook.
   - 7 Axes.
   - 1 C C saw, peavy and ax.
   - 1 Pulp saw and ax.
3. Crew leader and 10 men.
   - 5 Axes.
   - 2 C C Saws and axes.
   - 2 Peaveys.
4. Crew leader and 10 men.
   - 1 Pole ax.
   - 10 Pulaski tools.

Total, 46 men.

Pictures A, B, and C on page 103 and B on page 105 show the clearing crew in action.

Digging.—The digging crew is much easier to control as to spacing and forward progress than the clearing crew. This is true because a defined area has been laid out in which the men in the digging crew will work. Many of the obstacles that impaired the rhythm of the clearing crew have been removed. The men in line have less difficulty keeping the regulated 10- to 15-foot spacing. Consequently, less lost time or unnecessary work resulting in decreased production, is experienced.

The ganging up of the men or too great a spread reduces the efficiency of the operation. But, on the other hand, when the men spread out more than 15 feet apart, they have a tendency to walk ahead spasmodically, instead of gradually working ahead, thus passing over and leaving weak sections in the line. The gaps in the line usually are caused by a slow worker who is unable to maintain the pace of the others in the line. When this slow worker is told to catch up and close the gap, his tendency is to walk forward and carry his tool. When he does this, each man behind him immediately follows suit and walks forward without working. Such irregularities, while susceptible to all crews, are more common with the digging crew. Usually they occur during the first hour on the job. After that, the crews develop a steady speed and rhythmically move forward.

The organizational set-up of the digging crew consists of two 10-man sections, equipped with light digging tools used chiefly to remove the upper layers of duff. These are followed by three 10-man sections equipped with heavy digging tools capable of completing the line to a point where it could be backfired, condition permitting, and mopped up or patrolled by the patrol and mop-up crew which follows on the heels of the digging crew.

The light digging tools used in New England are chiefly council tools. The heavy digging tools are pulaski tools, hazel hoes, and ax

mattocks. The distribution of the men and tools in the average-size digging crew follows:

1 Foreman.

1 Assistant foreman.

1. Crew leader and 10 men.
   1 Pulaski tool.
   10 Council tools.

2. Crew leader and 10 men.
   1 Pulaski tool.
   10 Council tools.

3. Crew leader and 10 men.
   1 Pole ax.
   2 Pulaski tools.
   4 Hazel hoes.
   3 Ax mattocks.
   1 Council tool.

4. Crew leader and 10 men.
   (Same as under No. 3.)

5. Crew leader and 10 men.
   (Same as under No. 3.)

Total 57 men.

The assistant foreman was added to the digging crew to (1) provide the necessary close supervision to work effectively so many men along a line varying from 500 to 750 feet in length and normally traversing rugged topography; (2) have a man at the head of the line capable of judging the intensity of work to be performed by the head of the crew in order to have the line completed when the last man in the crew passes over it; (3) provide a capable leader to assist in the backfiring; and (4) have someone available to direct a small crew in controlling spot fires without disturbing the forward progress of the main digging crew.

The tools for each of the last three sections of the digging crew consists of the necessary equipment for controlling a small spot fire. On several fires within the State during the 1939 season, it was noted that spot fires left uncontrolled were directly responsible for failure to catch the fire during the first period, and that lack of adequate overhead resulted in failure of the fire fighters to attack and prevent these spot fires from getting out of control.

Pictures D, E, F on page 103 and C on page 105 show the digging crew in action.

Patrol and mop-up.—The patrol and mop-up crew serves in various ways, depending upon the conditions prevailing at the time the line is constructed:

1. Conditions permitting, they will function as a backfire or line-firing crew improving dug line as they advance, dropping the patrol men every three chains from the end of the crew. If employed at backfiring, they might not keep up with the digging crew. But, in line firing, since the original line location would normally be dangerously exposed to the edge of the fire and would need constant patrolling they would normally keep up with the rear end of the digging crew.

2. Where weather conditions are not favorable for backfiring or line firing, the crew will work along as if a part of the digging crew. The last man in the line is dropped off at three-chains intervals unless the fuel type, necessity of line betterment, topography, degree to which fuel has been exhausted, or a cold line dictates that a patrolman can effectively handle more than three chains of fire line.

Many of the conditions encountered on a real fire were difficult to get across to the men in the patrol and mop-up crew during the experimental schools. We did find, however, that three chains was about the maximum length of line a patrolman could cover and improve the line so as to provide a satisfactory break in the duff to mineral soil.

231304—40——2

Fire-line-construction tests held on White Mountain National Forest

Test 1939	Kind of crew	Number of men	Average time on the line	Man-hours without overhead	On job with overhead	Chains of line	Chains of line built per man-hour: Without overhead	Chains of line built per man-hour: With overhead	Remarks
A Aug. 12	Clearing	38	4 hours 26 minutes	168	211	111	0.660	0.526	Overhead consisted of 28 men as follows: Fire boss, assistant fire boss, 2 scouts, 14 water and equipment, 6 communication, and 3 camp overhead. Average travel 1 hour 14 minutes per man. Total manpower 146 (Androscoggin).
	Digging	45	4 hours 26 minutes	200	252	104	.520	.413	
	Mop-up and patrol	36	4 hours 26 minutes	160	201	104	.650	.517	
	Overhead	27	Entire organization		664	[1] 108		.163	
B Aug. 15	Clearing	60	4 hours 35 minutes	275	346	99	.360	.286	Overhead consisted of 31 men as follows: Fire boss, assistant fire boss, special messenger, 4 scouts, 12 water and equipment, 9 communication, 3 camp overhead. Average travel 1 hour 20 minutes per man. Total manpower 151 (Pemig).
	Digging	41	4 hours 35 minutes	188	236	79	.420	.334	
	Mop-up and patrol	19	4 hours 35 minutes	87	110	79	.909	.718	
	Overhead	31	Entire organization		692	[1] 87		.126	
C Aug. 21	Clearing	56	5 hours 15 minutes	294	380	129	.438	.340	Overhead consisted of 39 men as follows: Fire boss, assistant fire boss, 3 scouts, messenger, 22 water and equipment, 5 communication, and 6 camp overhead. Average travel 35 min. per man. Total manpower 174 (Ammonoosuc).
	Digging	45	5 hours 15 minutes	235	303	115	.489	.380	
	Mop-up and patrol	34	5 hours 15 minutes	178	229	109	.612	.476	
	Overhead	39	Entire organization		912	[1] 117		.128	
D Sept. 9	Clearing	39	5 hours 30 minutes	214	247	90	.420	.364	Overhead consisted of 20 men as follows: Fire boss, assistant fire boss, 4 scouts, 11 water and equipment, and 3 camp overhead. Average travel 1 hour per man. Total manpower 148 (Androscoggin).
	Digging	57	5 hours 30 minutes	313	383	113	.360	.295	
	Mop-up and patrol	32	5 hours 30 minutes	176	203	113	.641	.556	
	Overhead	20	Entire organization		833	[1] 100		.120	
E Sept. 16	Clearing	46	5 hours 32 minutes	254	312	141	.555	.452	Overhead consisted of 29 men as follows: Fire boss, assistant fire boss, 1 special messenger, 5 scouts, 9 water and equipment 8 communication, and 4 camp overhead. No travel time. Total manpower 156 (Pemig).
	Digging	46	5 hours 32 minutes	254	312	133	.524	.426	
	Mop-up and patrol	35	5 hours 32 minutes	193	237	133	.690	.561	
	Overhead	29	Entire organization		861	[1] 135		.157	
F Sept. 18	Clearing	45	5 hours 30 minutes	247	340	108	.437	.318	Overhead consisted of 34 men as follows: Fire boss, assistant fire boss, manager, 4 scouts, 17 water and equipment, 4 communication, and 6 camp overhead. Average travel 30 minutes per man. Total manpower 125 (Ammonoosuc).
	Digging	23	5 hours 30 minutes	126	173	77	.601	.445	
	Mop-up and patrol	23	5 hours 30 minutes	126	173	77	.601	.445	
	Overhead	34	Entire organization		686	[1] 90		.131	

G Oct. 7	Clearing	47	5 hours 40 minutes	256	329	118	.444	.358	Overhead consisted of 26 men as follows: Fire boss, 5 scouts, 16 water and equipment, 1 first aid, and 3 camp overhead. Average travel 37 minutes per man. Total manpower 135 (Androscoggin).
	Digging	40	5 hours 40 minutes	227	281	95	.418	.338	
	Mop-up and patrol	22	5 hours 40 minutes	125	155	95	.760	.613	
	Overhead	26	Entire organization		765	[1] 105		.137	
H Oct. 18	Clearing	35	4 hours 30 minutes	157	194	85	.541	.438	Overhead consisted of 21 men as follows: Fire boss, assistant fire boss, special messenger, 4 scouts, 9 water and equipment, 3 communication, 2 camp overhead. Average travel 1 hour 20 minutes per man. Total manpower 116 (Pemig).
	Digging	35	4 hours 30 minutes	157	194	82	.522	.423	
	Mop-up and patrol	25	4 hours 30 minutes	112	138	82	.732	.594	
	Overhead	21	Entire organization		526	[1] 82		.156	
I Oct. 20	Clearing	45	5 hours	225	276	120	.533	.435	Overhead consisted of 23 men as follows: Fire boss, assistant fire boss, 3 scouts, 4 communication, 11 water and equipment, and 3 camp overhead. Average travel 1 hour per man. Total manpower 125 (Ammonoosuc).
	Digging	34	5 hours	170	208	94	.553	.452	
	Mop-up and patrol	23	5 hours	115	141	94	.817	.666	
	Overhead	23	Entire organization		625	[1] 105		.168	
J Nov. 9 DCC	Clearing	57	5 hours 30 minutes	313	336	74	.236	.220	Overhead consisted of 9 men as follows: Fire boss, 2 scouts, 3 communication, 3 camp overhead. Average travel 1 hour 30 minutes per man. Total manpower 135 (Camp Gale River).
	Digging	35	5 hours 30 minutes	193	207	74	.384	.363	
	Mop-up and patrol	34	5 hours 30 minutes	187	200	74	.386	.370	
	Overhead	9	Entire organization		743	[1] 74		.099	

[1] Average.

The tool distribution is the same for each 10-man section of the patrol and mop-up crew. These sections are so equipped that they may be readily shifted onto spot fires or sent back along the line to handle a dangerous area temporarily until reenforcements can arrive. Each man assigned to a section of line for patrol and mop-up duty is equipped with a light digging tool (council tool or shovel), a heavy digging tool (pulaski tool, hazel hoe, or ax mattock), a 5-gallon back-pack pump, and lantern.

One man of each section packs the extra tools and equipment, except the 5-gallon back-pack pumps, for his section. This man does not work in the line while packing this equipment. Once in the vicinity of the area to be patrolled by his section, he caches his load and devotes his time to distributing the tools to the other members of the section and scouting for spot fires. All tools, except the heavy digging tools, are packed by regular packers and not left with the man until he is assigned a patrol beat.

The lanterns are placed one each at the termini of the patrol boats. The lanterns readily mark the limits of a patrol area at night and are easily moved for increasing or decreasing the length of a patrol area. The back-pack pumps are brought in by a special pack crew working out of the fire camp. This same special crew may be assigned to packing water to refill these back-pack pumps whenever water is not readily available to the various sections of the line. The distribution of the men and tools in the average-size patrol and mop-up crew was as follows:

1 Foreman.
1 Assistant foreman.
1. Crew leader and 10 men.
   - 1 Pole ax.
   - 5 Pulaski tools.
   - 5 Ax mattocks (or hazel hoes).
   - 5 Shovels.
   - 5 Council tools.
   - 10 Back-pack pumps.
   - 10 Lanterns.

2. Crew leader and 10 men.
   (Same as under No. 1.)
3. Crew leader and 10 men.
   (Same as under No. 1.)
   Total 35 men.

A patrolman near one termini of his beat and the condition of the line and type of fuel which requires not less than one man every three chains are shown in D on page 105.

From the tests carried on during the latter part of the 1939 fire season, data have been computed and is shown in the table. The data present an excellent picture of what actually happened on the ground and many interesting angles may be found in studying and comparing the data on the different tests. Space does not permit the full explanation of all the possible questions that arise in studying the table, but the following highlights may clear up some of the most obvious ones:

The line location for the various tests were all at widely different places on the forest. Test A was comparable in conditions to test I, yet the number of sections per crew were different. The averages for chains of line built per man-hour on test E and test H were very nearly the same, 0.157 and 0.156 chains per man-hour respectively, yet there were 40 more men on test E than on test H. The topography on test H was considered the toughest of all tests undertaken. The ratio of

manpower distribution by crews for these two tests is practically the same.

Test G also was located on a rough area with an exceptionally heavy fuel-type in which to build a fire line. Pictures A, B, C, and D on page 105 were taken on this line. The average for chains of line built per man hour was nearly as good on this test as on test H, yet there were approximately 20 more men, besides every man worked, in all crews, an hour and 10 minutes longer than the men on test H. The entire complement of men on test G were completely exhausted at the end of 5 hours and 40 minutes of steady work. They were given only a 30-minute lunch period at noon, which made the only appreciable break in the day's work.

A point of interest disclosed is that the average time worked on the line in the tests varied from 4 hours and 26 minutes, to 5 hours and 40 minutes. The majority of the crews worked between 5 and 5½ hours on the line. All men were on the job 8 hours. This period covered the time the men were hired and names placed on the payroll at the fire camp until they signed their time slips and were discharged. Time not charged against line construction was utilized in hiring the men, organizing crews, instructing the crew members in the 10- to 15-foot system of fire-line construction, instructing the men in the use of various types of tools, safety measures, travel to and from the fire-line location, checking in all equipment, and signing time slips and travel vouchers. Everything was carried on just as if an actual fire existed.

The tests indicate that under normal conditions from ⅓ to ½ a chain of line per man-hour, in extremely heavy fuel-type and duff-cover, can be cleared and dug for each hour the crews are actually on the job. This includes all overhead normally needed to safeguard the organization and carry on the job of fire suppression effectively. It is true that the tests were all undertaken during daylight hours and that results obtained in 24-hour tests might show widely different results. Night tests are planned during the 1940 season.

The training of natives as provided by the tests undertaken on the White Mountain National Forest during 1939 will not provide fire crews or units that can compete with or replace the need for highly organized 40-, 50-, or 60-man fire-suppression crews that are regularly employed primarily as fire-fighting units. However, highly organized crews are not as yet a Service-wide reality, and it is doubtful if they alone will ever be able to handle all types of fires that the Service must contend with during the ensuing years. Organized natives are needed in our fire organization as well as highly developed and trained regular fire-supression crews. It is certain that the 800 to 1,000 natives who were subjected, either directly or indirectly, to this systematic method of fire-line construction, have profited considerably and will materially strengthen the fire organization on the White Mountain National Forest for a number of years to come.

COOPERATIVE FIRE PREVENTION

PAUL K. TAYLOR

District Ranger, Wenatchee National Forest, Region 6, U. S. Forest Service

Fire prevention has been a plodding and not very imaginative member of the fire-control family. In this publication as in the whole field of fire control, far too little is contributed to this important subject—so the presentation of this new slant is most welcome.

An analysis of the man-caused fires on the Leavenworth Ranger District, Wenatchee National Forest, for the 1939 season up to July 10, showed that of 24 fires 70 percent were caused by smokers; of the total, 60 percent were charged to local residents. No particular class or group of people could be charged with the responsibility for setting the fires.

To meet this problem a meeting was called, comprised of four chamber of commerce presidents, one county commissoner, one major, one irrigation-district president, two prominent sportsmen, two editors, and a sergeant of the Washington State Highway Patrol. The matter was presented to the group by Fire Assistant Blair, who emphasized the fact that local people were causing most of the fires and that the community was dependent on the resources of the national forest for irrigation and domestic water, timber, and recreation. It was pointed out that under certain weather conditions a fire might easily wipe out a watershed upon which the surrounding communities depended for their water and timber supply and that the people residing within the community would be the greatest losers should this occur. Those present put the following program into action, based on the idea that in a fire-prevention program the force of public opinion should be brought to bear on the unthinking person who carelessly starts a fire:

1. A group of Citizen Fire Wardens was organized who served in a cooperative capacity, without reimbursement. These men were selected for their honesty and dependability. Any fire-law violation observed by the wardens was corrected on the ground if possible; if not, the violation was reported to the supervisor on a card designed for that purpose. A sticker as illustrated was printed in red lettering and paid for by the various chambers of commerce to be placed on the car driven by a Citizen Fire Warden.

Each warden was furnished with franked postcards on the reverse side of which was printed a "Report of Forest Fire Violations." Should he discover a fire-law violation, he would check which law was violated, where and when it occurred, and the license number of the car. Each warden was assigned a number to be used instead of his signature on the bottom of the card. On receipt of the card the supervisor wrote a letter to the offender calling attention to the viola-

tion and asking his cooperation in the future in preventing fires. Result: Forest-using public, contacting a large number of Citizen

Car sticker used by the citizen fire wardens.

Fire Wardens, found they must be careful with fire, not only because there was a law, but because responsible people just wouldn't put up with carelessness.

2. The editors responded with a series of news articles telling what was being done to curb man-caused fires; they also printed editorials. These articles and editorials stressed the point that the general public, civic organizations, etc., were becoming alarmed about the great number of man-caused fires, and passed out a warning to fire-law violators. The Forest Service was seldom mentioned. Results: Editorial comment stirred irrigationists, sportsmen, and recreationists to action. This was shown particularly by their efforts in cooperating with the Forest Service in suppression of lightning fires occurring later in the season.

3. The chambers of commerce sponsored a number of timely announcements from radio station KPQ at Wenatchee.

4. The State police cooperated fully. Each patrolman, acting in his capacity as a State officer, was empowered to make arrests for violations of any State fire laws. In addition, they operated car-checking stations on the major highways. All cars passing through the forest on a certain day were stopped, ash trays checked, and occupants

cautioned about throwing away lighted material, leaving campfires, etc. Results: Not a single complaint from occupants of stopped cars; in fact, several letters were received by the supervisor commending this action.

5. The sheriff's office cooperated in the same manner as the State patrol, except that they did not check cars.

6. Ash-tray stickers were printed and paid for by the chambers of commerce in this locality. Competent service station attendants were furnished these stickers.

Service-station operators added ash-tray service to their regular duties, which gave them an opening to place the sticker on or above the ash tray. Many times they were asked why they did this, which gave them an opportunity to talk fire prevention. Result: Tourists were impressed by this service and it gave a contact with people who otherwise could not have been reached.

REPORT OF FOREST FIRE VIOLATIONS

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

___ Smoking while traveling off a paved or surfaced highway thru brush, grass, or forest land, effective July 1 to September 30.

___ Throwing lighted and burning materials away, such as cigars, cigarettes, pipe heels, matches, and fire crackers, or other burning substance.

___ Leaving a fire to burn unattended.

___ Failing to totally extinguish a fire before leaving it.

___ Building a campfire in grass, leaves, rotten wood or other dangerous places, or in windy weather, without clearing around the fire pit and confining the fire to a hole.

___ Setting on fire any timber, brush, or grass land, except as authorized by a Forest Officer.

___ The willful tearing down or defacing of a Forest Service sign.

Offender's license number __________

Location of Violation __________

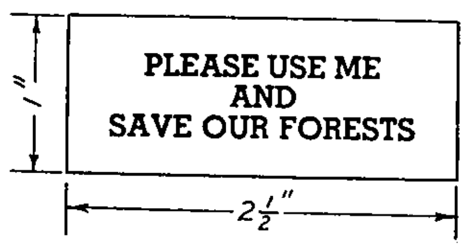
Form 642

__________ Date __________

Name __________ No. __________

Post-card form for reporting forest-fire violations.

The plan was inaugurated about the middle of July and continued through the driest fire season known to the Wenatchee Forest which did not end until late in October. Material results were that only eight more fires were caused by man. Those who carried on the program have a much better idea of our problem. And, best of all, they have signified their willingness to put the same machinery into action again.



Ash-tray sticker distributed by service-station attendants.

NEW AIR-COOLED ENGINE

H. M. White

Fire Control, Region 6, U. S. Forest Service

Mechanization is increasingly a factor in greater work production from suppression tools but with our peculiar problems portability is often a prerequisite to design of motorized equipment. This is particularly true of the power plant required for chain saws and trenchers and other small-scale mobile devices which may be evolved in the future. This article is a cheering progress report of the development of the air-cooled light engine.

In 1938 Ted Flynn, who is in charge of the Region 6 Forest Service equipment laboratory, suggested the possibility of air-cooling one of the small two-cycle Marine engines used on portable pumpers so that it could be used on light machines where water cooling is impracticable. The laboratory engineers had greatly improved the Stihl chain saw purchased for experimentation, but nothing could be done about the Stihl engine, which is much too heavy and has insufficient power. Region 1 engineers had developed the Bosworth trencher, and the engine selected for it, while reasonably satisfactory, showed certain weaknesses.

Air-cooling a standard engine the efficiency of which had been proved seemed to be worth trying, and at the Washington meeting last year the fire-control equipment committee agreed that an allotment for the purpose should be made from the all-Service equipment-development fund.

After a thorough study of the principles of air-cooling, plans were drawn and an attempt was made to contract the construction of an experimental engine. No bids were received. The engineers had however, become so interested in the development that they were eager to do the construction work at the laboratory. Various makes of engines were investigated, and the Champion Senior Twin was selected. This engine has two cylinders, opposed, with piston displacement of 12.46 cubic inches. Its rated horsepower is 6.6 at 4,000 r. p. m. as compared to 4.5 for the Bendix engine used on the Bosworth trencher. The crankshaft and bearings are considerably larger than those on the Bendix, the main bearing surface being 50 percent larger.

To air cool the Champion engine new cylinders with cooling fins were machined from solid steel blocks (S. A. E. 4140). The cylinder heads were cast from aluminum alloy and screwed to the steel cylinders while the latter were packed in dry ice for maximum shrinkage. A new fly wheel of the proper weight and with Bosch magneto assembly was purchased. The air fan and shroud were fabricated from aluminum.

The engine has been completely assembled at much less cost than was anticipated. So far it has been run for short periods only, without

load. It is now (April 10) being mounted on a base with a Pacific-Marine pump, and in a few days a long test run will be started. This test under load at the laboratory will be continued until it is reasonably certain that all weaknesses in design or construction have been discovered and corrected, after which the engine will be adapted to the Bosworth trencher and the chain saw and thoroughly tested in the field. Results of the tests and further engineering data will be made available later.

It is not expected that this engine, which weighs only 34 pounds, will develop sufficient power for the longer 6- to 7-foot saw blades, but the power should be ample for the Bosworth trencher and chain saws with blades up to 5 feet in length. To keep weight to the minimum and still have plenty of power for the work to be performed, it appears desirable to have two sizes of light engines. It is estimated that an engine similar to the Senior Twin with ample power for the longer saws and portable pumpers meeting the requirements of MSF-273 would weigh not to exceed 42 pounds.

Aerial Delivery of Hot Food on the Line.—Due to lack of trails, pack stock had difficulty in supplying food. If it were not for the airplane service (two planes used on this fire) many men would have gone without food and beds. Cooked food was dropped from the plane. The forest reports the following results:

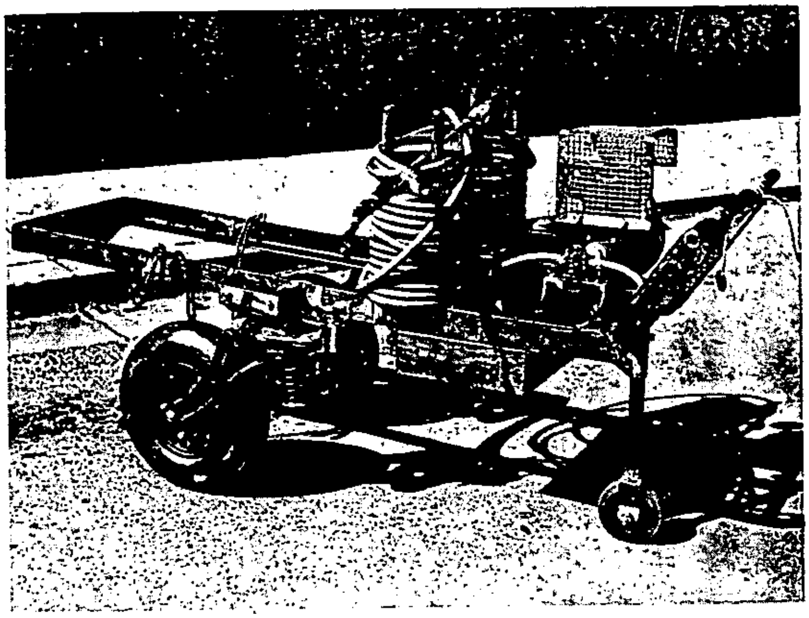
"Dropping hot cooked food by airplane was tried on this fire. Vegetable and meat stew, macaroni and cheese, bread, butter, and hot coffee were dropped on this fire the first day, and with great success. Fifty men were fed hot cooked food as listed, dropped by one six-place airplane which came in under the smoke and dropped this food at a target which was placed where the base camp was later located. Hot coffee and other liquids were packed in 5-gallon tin cans, 2-inch screw tops, in pasteboard cartons, and wrapped in canvas. Paper plates and cups, and wood spoons and forks were used with the cooked food, and 10 gallons of coffee remained hot enough for use after being packaged 13 hours. Each 5-gallon can was packaged and dropped with a wool sack 7 x 7-foot parachute, but little damage was done to the cans, and no loss of food occurred. It is believed a breakage of cans can be entirely eliminated by the use of the ⅝ steel-strap packaging method as used commercially for cartons. Especially should this strap be applied around the 5-gallon can about one-third way up from the bottom. With a few other minor improvements this method of feeding fire fighters, especially in the first attack, is far superior to any other method we have used."—*Region 4 report on the North Fork Stoddard Fire, Idaho National Forest, 1939.*

MOBILE FLAME THROWER

F. W. FUNKE

Specialist in Fire Control Equipment, Region 5, U. S. Forest Service

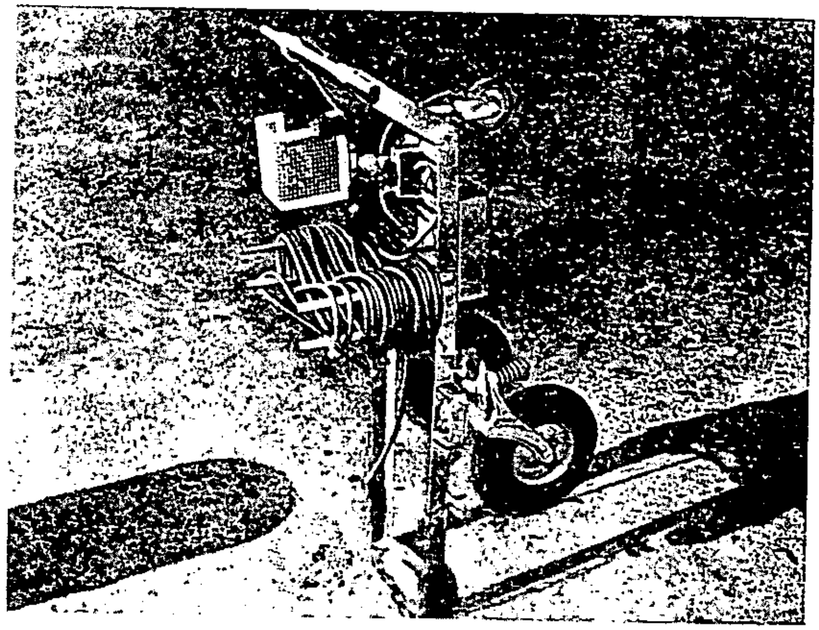
There has long been a need for a flame thrower device larger than the regular back-pack outfit. The standard portable back-pack outfit when used as a flame thrower serves a definite purpose, but because of the intermittent blast produced by the trombone pump it is im-



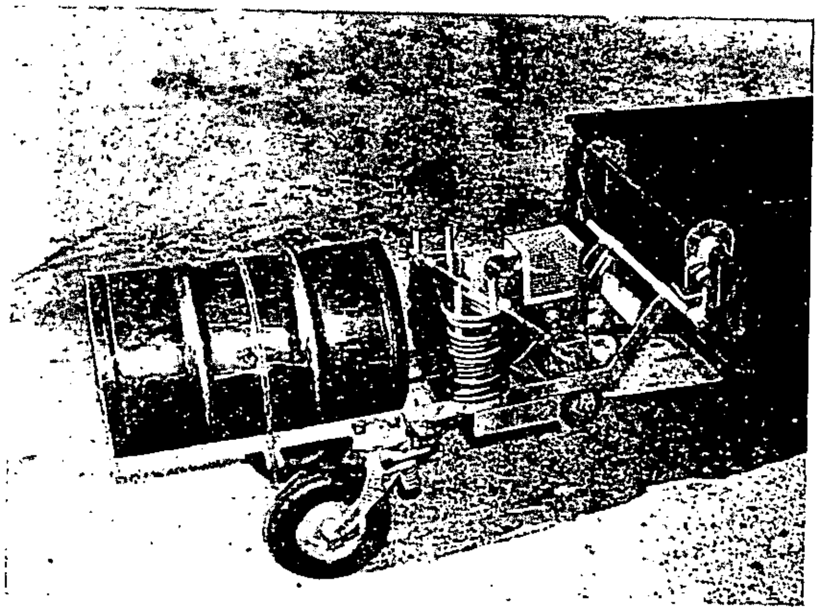
Flame thrower in position to load barrel.

possible to develop the flame intensity desirable for defoliating jobs along roads or fire lines. There are many cases where it is necessary to produce an intense backfire along motorways, in order to generate heat to assist in controlling spread of the main fire or to remove foliage from unburned "islands" along the fire-control line. A continuous and intense blast of flame is needed to do a satisfactory job, and while the back-pack type outfit is a great aid, it lacks the volume and concentration which can be developed with a power outfit.

The mobile flame thrower was designed to provide a larger and more powerful unit for use in difficult backfiring jobs along roads and trails. It consists of a light angle frame mounted on standard swivel-type trailer wheels. The wheels are sprung and so attached to the frame that they are free to turn, lock pins being provided to hold the



General detail of flame thrower.

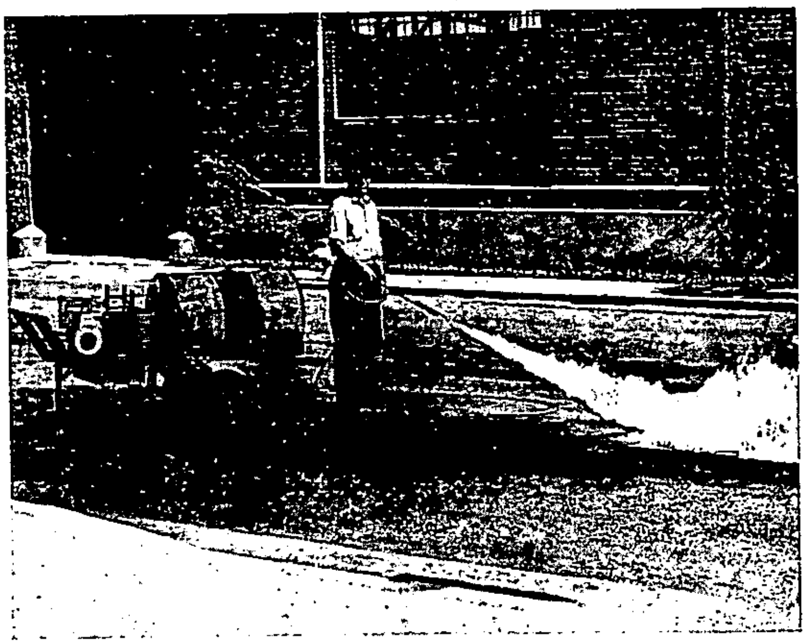


Flame thrower ready to trail.

wheels in alignment when the outfit is being moved by hand. A small adjustable castor wheel carries the weight in front. A drop-type tow-bar attachment is provided to slip over the tail gate of a pick-up truck, providing a means of making a rigid tie between tow bar and truck.

The frame is designed to hold a standard barrel, which is fastened to it with a loop chain and wing nut. The forward end of the frame holds a small tool box, a pony-type 1 h. p. air-cooled gasoline engine of the 4-cycle type, and a small gear pump. Standard plugs with fittings are provided for attaching the hose to the barrel opening. A regulation by-pass is provided so that fuel will return when the nozzle-control valve is closed. The barrel is loaded on the rig by standing the unit on end and picking up the barrel in the same manner as would be done with a hand truck. One hundred feet of gasoline hose is provided to permit use at some distance from the road. The flame thrower head is a standard device to which has been fitted a pneumatic-type plunger control valve.

When attached to the pick-up the wheels are free and the outfit becomes, in effect, an extension of the pick-up body, since the connection between tail gate and tow bar is rigid. It can be backed or otherwise moved, and tracks quite well except on rough and uneven roads. The narrow tread has not proved a handicap on rough ground. The outfit was designed with the idea that it might be desirable to haul it by hand over fire lines. For this purpose a drag rope is provided and lock pins for the wheels hold the swivels in line. The total weight of the unit loaded is approximately 500 pounds.



Flame thrower in action.

One barrel of fuel oil will give a continuous blast of flame for 55 minutes with the standard flame-thrower head; however, it probably will never be so used. There will always be periods when it will be desirable to shut off the flame. The flame thrower operates cold—no pre-heating is necessary—and there is no heat generated in the device during operation. The bypass, which is set at 100 pounds pressure, permits shut off of the control valve at will, without injury to pump or engine.

While the unit was originally intended as a flame thrower outfit, it appears to have a field as a water-using rig. It can be used alternately for flame-thrower work or as a water outfit by merely substituting a barrel of water for the barrel of fuel oil and using a standard back-pack nozzle tip.

The outfit has been assigned to Los Padres for a thorough field test both as a water rig and flame thrower. Blueprints are now being prepared and will be available to interested agencies through the regional forester at San Francisco, Calif.

"SPINNING FIREMEN" METHOD FOR GRASS FIRES

AXEL LINDH

Fire Control, Region 1, U. S. Forest Service

At the Ogden meeting, methods of increasing the output of held line per man-hour on grass fires came under discussion. The presentation of prodigious line work in Region 8 by use of belting flaps aroused the competitive spirit of Region 1 representatives who, though confident of equally good records, had no statistics at hand. The following article not only shows remarkable production but presents a new and interesting method of suppression:

A major part of the grass-type area in which Region 1 must fight fires is located outside of national-forest boundaries in the association areas where fire protection is under a cooperative agreement. The table herewith was prepared from the 929 records of the fires fought in the principal grass areas of Region 1 during 1939. Cheat grass average production of held line worked per man-hour on the Lolo Forest is 32.3 chains. In the bunch grass on the Helena and Deerlodge, production figures show an average of 9.5 chains per man-hour.

CHEAT GRASS

Name of fire	Number men working	Fire edge worked (chains)	Production chains per man-hour
Lolo:			
Reid	21	539	10. 3
Waterworks	4	120	37
De Smet	2	30	30
Mount Sentinel	5	32	40
Airport	2	20	20
Ball park	6	7	14
Airplane	1	18	72
Reservoir	4	30	20
Fairgrounds	4	12	48
Average	5. 4	90	32. 3

BUNCH GRASS

Name of fire	Number men working	Fire edge worked (chains)	Production chains per man-hour
Helena:			
Mount Lenox	5	83	23. 7
Cabin Gulch	20	40	1. 6
Hauser Lake	1	6	4. 3
White Horse	18	150	7. 5
Average	11	69. 7	9. 2

BUNCH GRASS—Continued

Name of fire	Number men working	Fire edge worked (chains)	Production chains per man-hour
Deerlodge:			
Thampom Park	7	5	5
School House	4	25	2.5
Haggart Ranch	2	3	4.5
Fitz Creek	2	35	30
Red Hill	29	275	5.5
Average	8.8	68.6	9.5

The method used in suppressing these fires was developed by Ranger Al Austin of the Lolo National Forest. The Fox-Newsreel men called the organization method the "spinning firemen." Others have called it the "Austin rotary crew" method.

Instructions to the firemen handling these fires are to take a shovel only, start at the back or lower end of the fire from a dead point in the line and dirt out the edge of the fire, looking back every three or four shovelfulls to be sure that no fire is being left on the edge behind. When two or more men attack a grass fire they start from a common point and proceed in opposite directions along the edge.

If one man alone begins, he must start his line from a road, trail, railroad track, ditch, or break in the grass which will not be outflanked, or depend upon immediate follow-up. Here, if we can't send two men together, the follow-up is immediate, and the first man's instructions are to start at the back at the point of slowest spread and attack immediately. From 6 to 12 feet of line are made with each shovelfull of dirt, properly placed. Efficiency in placing dirt to best advantage is gained after about two fires with coaching. Here this experience is usually gained in burning firebreaks at the beginning of the grass-fire season each year. There is a crucial point in the edge of the blaze which may be found only through practice and experience, and placement of dirt anywhere else is wasted effort.

Four or five men are about the maximum that can perform efficiently on one part of the line at a time; with more than three, one is assigned to carrying water and to watching the rear so the others can devote their entire attention ahead. Where two or more men are working together it is important that they not get in each other's way at any time, and this is avoided by having the last man throwing dirt, step out several feet from the line. Thus he gets away from the heat of the fire and has the greatest possible choice of places to get a fresh shovelfull of dirt. The next man passes along the line behind him, throws his dirt straight along the out edge of the blaze, quickly spats out with the back of his shovel any small missed parts of the blaze and steps out of the way for the next man, so rotating clockwise for right side of the fire line and anticlockwise for the left.

AN EYE TEST FOR LOOKOUT MEN

George M. Byram

Appalachian Forest Experiment Station

The importance of keen eyesight to efficient detection has always been recognized, but none of the standard optical test methods have been suited to the conditions under which forest-fire lookout men operate. The device and test method here described were presented at the recent Ogden meeting and their general acceptance is indicated by requisitions for a supply of the cards by each region.

The efficiency of a forest-fire lookout man depends mainly on four qualifications: (1) experience, (2) knowledge of his territory, (3) alertness, and (4) quality of his eyesight. A man's rating on the first three factors can be judged with reasonable accuracy, but some sort of measurement is necessary to determine his rating on the fourth.

The importance of eyesight can be shown by considering possible advantages to be obtained by manning a lookout network with individuals having keen eyesight. These advantages are: (1) an increase in the visual range of small smokes, which might be regarded as equivalent to a haze-cutting filter (no such device is known at present) used by a man with ordinary eyesight and (2) shorter discovery times for smokes within the visual range. A lookout network with men of keen eyesight, compared with a net work with men of normal eyesight, other qualifications being equal, might be regarded as giving more protection for the same amount of money or, by using fewer men, the same protection for less money.

In 1932, the writer assisted in developing a preliminary eye test at the Pacific Northwest Forest Experiment Station for measuring the ability of lookout men to see small smokes.[1] This test was developed for another purpose but since then has been widely used by the Forest Service for testing the vision of lookout men. If carefully given under uniform lighting conditions, it yields good results, but since it is often difficult to obtain the proper lighting, the test at times has proved unsatisfactory for general use.

An eyesight test for forest lookout men has been developed at the Appalachian Forest Experiment Station which meets the following essential requirements: (1) gives ratings proportional to the distance at which lookout men can see small smokes, (2) gives ratings the values of which are independent of light intensities, and (3) is sufficiently simple for field use.

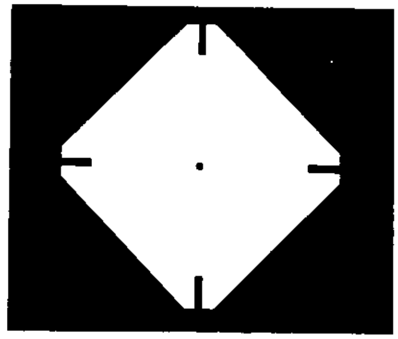
The test consists of measuring the distance at which an individual can see a black circular spot 1/16 of an inch in diameter on a white background about 7 inches square. The eye-test pattern (see p. 124) is printed on glossy white photographic paper by means of a master negative, and is cemented to stiff, inflexible backing. The 1/16-inch black dot is located on a diagonal of the eye-test board or target halfway between a 1/4-inch central black circle and the end of a black strip

[1] McArdle, Richard E., and Byram, George M. An eye test for fire lookouts. Jour. Forestry 34: 794–796, August 1936.

at the corner of the diagonal. The last two figures on the pattern serve only as markers which enable the observer to know where to look for the small black circle.

The test can be given most satisfactorily on a day when the sky is overcast, but equally good results can be obtained on a sunny day if the target is shaded from the direct rays of the sun. In any event, the target should not be in deep shade such as occurs directly under the canopy of a tree, but should be exposed to the full light of the open sky.

In taking the test, the observer walks away from the eye-test board until the 1/16-inch black spot becomes rather faint, and this usually happens at about 35 or 40 feet. The eye-test board is then whirled so that the small black spot is in a new position, which may be up, down, right, or left. The observer then indicates the position of the spot,



Lookout eye-test pattern.

and if correct, he steps back a few feet and the procedure is repeated until he indicates a false position of the spot. His rating is then recorded as the distance in feet to the last point at which he indicated correctly the position of the black spot.

The small black spot becomes more indistinct as the observer moves farther away, but he should continue to guess its position even though he lacks confidence in his ability to do so correctly. Some individuals wish to rest their eyes between observations, although prolonged looking does not seem to change a man's rating.

The chart on page 125 shows the effect of light intensity on the visual range of three different types of eye-test targets. Light intensity is expressed as brightness of the white component of the target in candles per square foot. Curve A is plotted from observations made with the new eye-test board under various light intensities. Only a very low brightness levels are the ratings seriously affected. For this reason the test should always be given out of doors, where even on rather dark, cloudy days the light intensity is high enough (about 75 candles per square foot for a white surface) to give reliable ratings. On the other hand, the target should not be in direct sunlight (about 1,000 candles per square foot for a white surface) or ratings will be slightly lowered. Curve B shows the relation between light intensity and the visual range of a 1/16-inch white spot on a black background. The visual range of the white spot is considerably affected by light intensity. Curve C is a similar curve for a white spot on a grey black-

ground. This type of target would also be suitable for a lookout eye test but it is difficult to construct so that the white and grey components will always have the same brightness ratio.

The visual range chart also shows that the target combination of black on white satisfies the second requirement for a lookout eye test. That this combination also satisfies the first requirement was determined in three different ways:

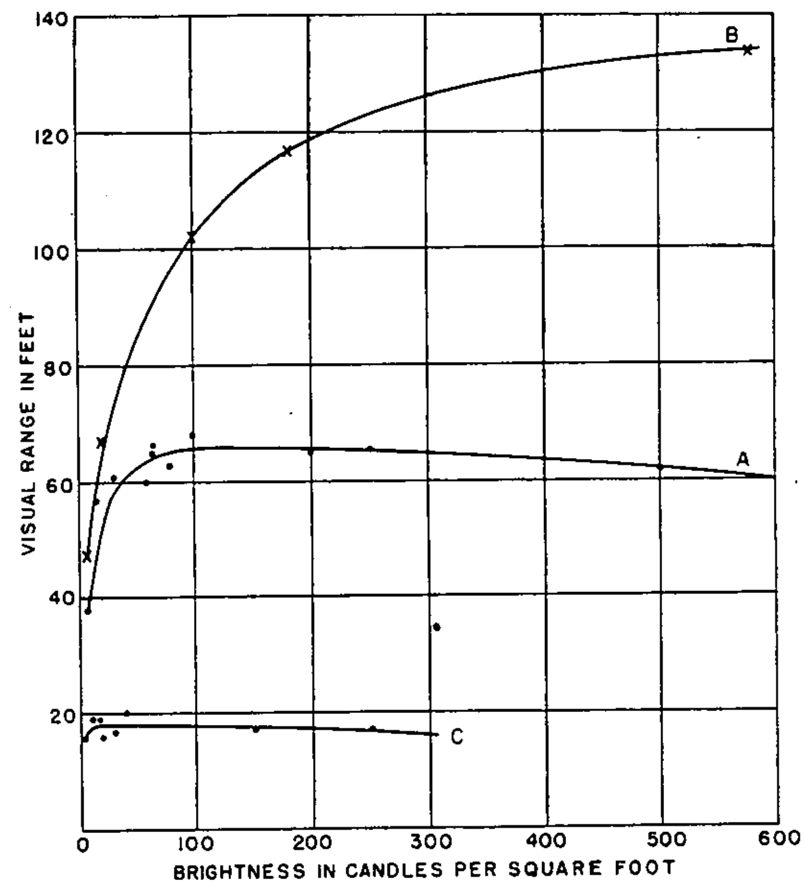


CHART 1.—The visual range of three different target-background combinations plotted against the brightness of their white components. Curve A, black on white; curve B, white on black; curve C, white on grey.

(1) Tests were made on actual smokes with men of known but different eye test ratings. This was the most direct but least satisfactory method of determining whether the eye test met the first requirement. The results of five tests on seven men showed that men who rated poor on the test could not see smokes as far as men who rated average, and men who rated average could not see smokes as far as men who rated good or exceptional. To obtain actual quantitative relations between eyesight and smoke-seeing ability by this

method would require hundreds of tests and the results probably would not be as reliable as the more indirect laboratory methods.

(2) An observer with normal eyesight simultaneously viewed a smokelike target and the lookout eye-test target with his vision normal and then with his vision impaired in some way, such as by using glasses with strong convex lenses, or by viewing the targets through small diaphragms. In this way it was possible to duplicate various visual defects and yet have all observations made by one man.

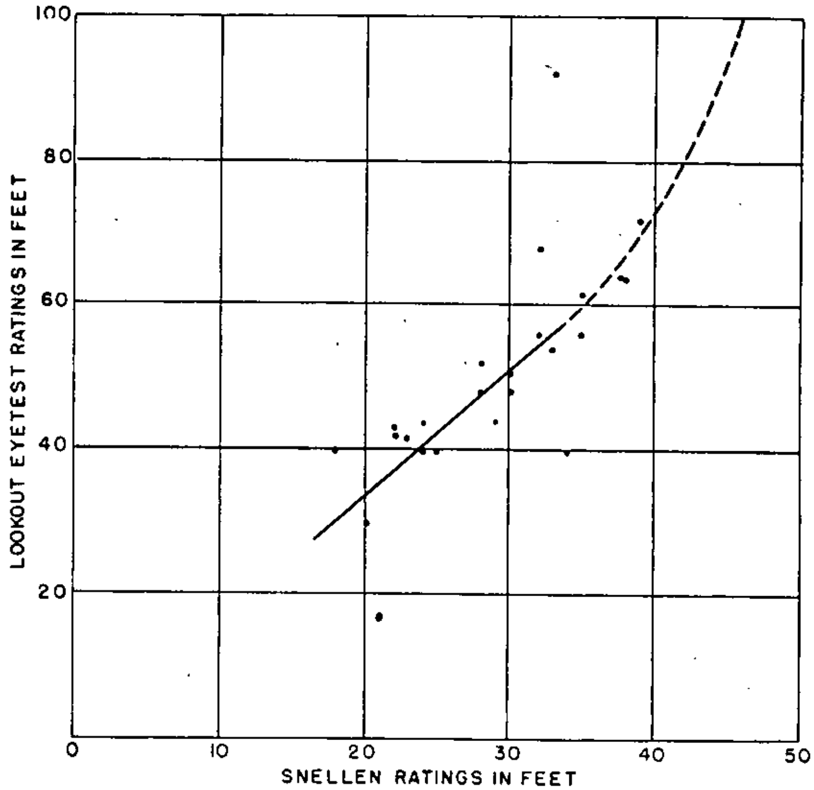


CHART 2.—Ratings obtained with the lookout eye-test plotted against ratings obtained with 0.3-inch letters on the Snellen chart.

The results showed that the visual range of both types of target was reduced in almost the same ratio by any given visual defect.

(3) Mathematical calculations of the true form of retinal images showed that the form of the image of a small smoke on a distant landscape is the same as the image of a small target (either black or grey on white or white on grey).

The chart on this page shows the relation between ratings of different men, obtained with the new lookout eye test and with the usual letter-type charts used by oculists. Ratings were plotted against the maximum distance that each man could read 0.30-inch letters on the Snellen chart. This curve indicates that the letter-type chart could be used for determining poor or even average eyesight, but would not show which men have exceptionally good eyesight ("eagle eyes"). The reason for this is that the visual range of small letters

which can just be read is affected by any factor which obscures detail, and for men with poor eyesight the most important factors are structural defects in the eye and lack of retinal sensitivity. The visual range of the eye-test target is affected by these factors in a corresponding manner, so a linear relation is obtained for the lower part of the curve when the visual range of small letters is plotted against the visual range of the eye-test target. However, individuals with exceptional eyesight probably have highly sensitive retinas and few defects in the structure of their eyes. The visual range of small letters for these men will be limited chiefly by the wave length of light, and there is a definite limit to the distance the letters can be read, no matter how good the observer's eyesight. There is no definite physical limit to the visual range of the black spot on the eye-test target or the visual range of a small smoke. Retinal images of these objects are affected differently by diffraction that are the retinal images of letters.

The data plotted in chart 2, page 126, are not sufficient to determine whether that portion of the line shown as dotted should curve upward. That this must be true can be found from calculating the angular limit at which the details of the letters can be recognized. For the 0.30-inch letters used in this test, this limit comes at about 60 or 65 feet. No matter how keen a man's eyesight, he will not be able to recognize the letters at distances greater than this, hence the curve should turn upward and approach the 60- or 65-foot limit as an asymptote.

The letter type of test should give fairly accurate results for about 70 percent of the men tested. It probably would not be accurate for the upper 30 percent, and since there is a definite limit to the distance at which a letter of a given size can be recognized, the letter test would be inaccurate for the upper 5 percent or "eagle eyed" individuals. The letter type of test has other drawbacks:

1. Men familiar with letters can recognize them at slightly greater distances than men who are not familiar with them. The visual range is affected by the "degree of literacy."
2. Different letters of the same size are not equally visible.
3. The letters on any one chart can be memorized.

Table 1 shows the visual range of a small standard smoke for various eye-test ratings and haze-meter readings. It can be seen that large variations in eyesight cause much smaller variations in the visual range of smokes. This might indicate that a man who rated high on experience, alertness, and knowledge of his territory would perhaps make a good lookout even though his eyesight were no better than average. A new man, or a man who rated only average on the qualifications just listed, should perhaps have better than average eyesight. With the figures of table 1 available to him, the judgment of an experienced fireman on this point might be more effective than any set rule as to how good a prospective lookout man's rating should be to qualify for detection work.

Table 1 appears to contradict the statement that the distances at which lookout men can see small smokes are proportional to eye-test ratings. However, this is not so, because the figures in table 1 have been corrected for the difference in atmospheric haze between the distances corresponding to the high ratings and the distances corresponding to the low ratings. If one man has an eye-test rating of 60 feet and another man a rating of 50 feet, then the first could see a

smoke column 6 miles when the second could see it only 5 miles, provided both men were looking through the same amount of haze. However, in actual practice the man who has a high rating will have to look through more haze and this will reduce his superior range of vision, which tends to bear out the statement that of all factors affecting the visibility of small smoke columns, haze is the most important.

TABLE 1.—*Visibility distance of small smoke (miles)*

Eye-test rating	Hazemeter readings							
	2	4	6	8	10	12	14	16
72	3.4	5.5	7.3	8.9	10.5	11.9	13.2	14.5
64	3.3	5.3	7.0	8.6	10.1	11.4	12.7	13.8
56	3.1	5.1	6.8	8.3	9.7	10.9	12.1	13.2
48	3.0	4.9	6.5	7.9	9.2	10.4	11.4	12.4
40	2.8	4.6	6.1	7.5	8.7	9.7	10.7	11.6
32	2.6	4.3	5.7	6.9	8.0	8.9	9.8	10.7

Table 2 gives the average ratings (separated into groups) of 54 men. It is possible that as additional tests are made the weighted average will be changed slightly. As a class, the relief workers rated considerably lower than other classes, and it was assumed that diet was largely responsible for this low rating.[2]

Standards or classes of performance are shown in table 3 for various distance ratings in feet. The approximate relative smoke-seeing ability corresponding to each class is also given. For purposes of comparison, atmospheric conditions are assumed to be such that a man with average eyesight could see a small smoke 10 miles away.

TABLE 2.—*Average eye-test ratings for four different groups of men*

Class	Number of men	Average rating in feet
CCC enrollees	15	55.5
Regular Forest Service personnel	19	57.0
College students	11	54.3
WPA relief workers	9	43.4
Weighted average		53.8

TABLE 3.—*Tentative standards of performance and relative smoke-seeing ability for different class intervals of eye-test distance ratings*

Eye-test rating in feet	Performance rating	Relative smoke visibility rating in miles
64 or more	Exceptional	11.0 or more.
58–64	Good	10.5.
50–58	Average	10.0.
44–50	Fair	9.5.
44 or less	Poor	9.0 or less.

[2] Byram, George M., Vision and diet, Service Bulletin, February 5, 1940.

A SLIP-ON TANKER UNIT

F. W. Funke

Specialist in Fire Control Equipment, Region 5, U. S. Forest Service

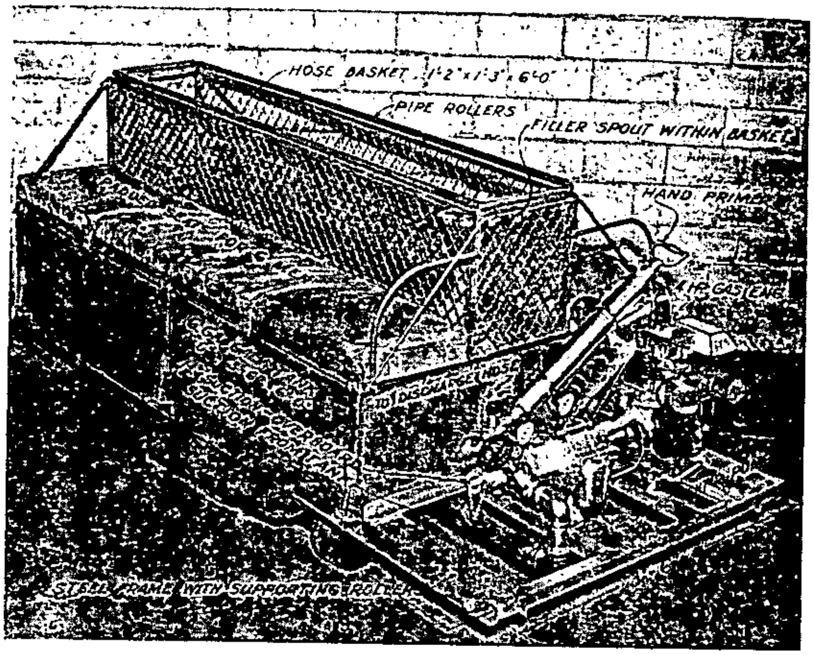
Experience in 1939 strongly emphasized the need for some cheap and flexible way of converting ordinary stake-body or pick-up trucks into efficient tanker units. At times of extreme fire danger there is an urgent need for more tankers than can possibly be provided when a tank, a pump, and a truck are all built into one permanent unit in the conventional way. Such build-on units tie up a truck permanently for tanker purposes and so increase the investment per tanker unit that the total number available would always be less than if tanks and pumps were readily detachable from the truck when the truck is needed for other purposes—or when the truck chassis is worn out. The Region 5 slip-on tanker unit is therefore a direct answer to a fire-fighter's prayer. While the slip-on tanker equipped with a hand-power pump, now used on the Texas National Forests, supplies the same flexibility at a cost of perhaps $120 less for the pump, this Texas outfit requires at least two men to operate the pump. Sometimes this need for two pump men would be a serious drawback.

We have long toyed with the idea of a compact slip-on type of pumper unit which could be quickly mounted and carried by a standard stake-side truck. Region 5 forests have urged such a development for some time. However, it is only recently that a suitable pump and engine have been made available.

There is a definite appeal to development of this kind. Cost is, of course, an important factor in determining the type of equipment which will buy the most effectiveness for the money invested. From an investment standpoint the present unit probably offers more in the way of utility than any thus far suggested by the field. It is generally accepted that a small quantity of water in the hands of an experienced suppression man is equal in effectiveness to the efforts of three men with hand tools. We do not yet know how much more effective the combination of a trained crew and a power pumper is over a similar crew without water. However, there are many instances on record where fires could not have been held without the liberal application of water from pumpers. Probably of greatest importance is that low cost units can be made more generally available to the field and the effectiveness of initial attack crews increased to a point far beyond that possible by a similar expenditure for manpower.

The Slip-On Unit

The unit (see p. 130) consists of a light 4-inch channel frame, to which is attached a 16-gage galvanized iron water tank built to specifications contained in the Fire Control Equipment Handbook. Present capacity is 196 gallons, this capacity being determined by



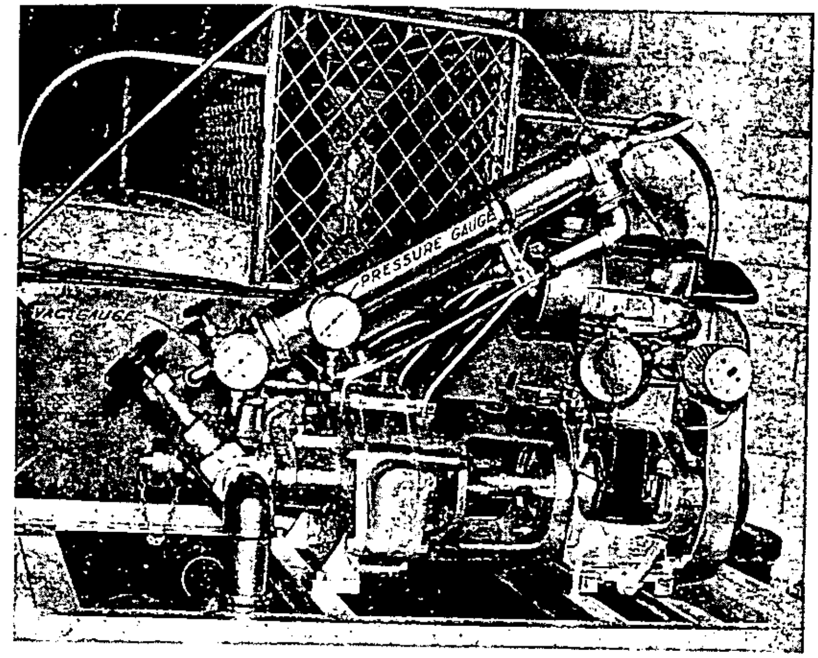
the sheet metal sizes used in framing the tank. A hose basket mounted on the top of the tank also serves as a back rest for the crew. Latex-treated hair cushions provide a comfortable seat. Connection between pump and tank is through a short section of suction hose. The complete unit as shown, empty, weighs less than 500 pounds; loaded with water and hose weighs approximately 2,600 pounds. As provided the field in Region 5, the unit is equipped with 200 feet of ¾-inch high-pressure hose, a shut-off nozzle with three tips and four lengths of 1½-inch suction hose with foot valve and strainer. Total cost of the unit is approximately $500 in lots of 10.

Four rollers to the side are provided, as shown on the channel frame, so that the loaded unit can be rolled from a skid frame to a stake-side truck and bolted in position by one man. Suitable bolsters and U-bolts, not shown, are provided to hold the outfit in place on a truck bed.

Power Plant and Pump

The power unit, which weighs 160 pounds, is a 4 h. p. air-cooled, 4-cycle Wisconsin engine driving a 2-stage centrifugal pump through a built-on cage, the entire assembly being manufactured by a local pump company. Present cost of the pump and engine assembly is $154 each. A standard marine type bilge pump is attached for priming purposes and suitable vacuum and pressure gages are installed. Attachments and piping have been reduced to a minimum (see p. 131).

The performance of the unit is somewhat lower than standard portable power pumps, and it is not intended in any sense to displace



the regular portable pumper with units of this type. The performance range is 140 pounds per square inch at 22 g. p. m., and at the other end 80 g. p. m. at no head. However, the pump characteristic is such that from the no-head side pressure is quickly built up and approximately 60 g. p. m. is available at 100 pounds pressure.

In some applications the unit might be cut down in size to 80 gallons and used on a pick-up truck where such a vehicle is provided the initial attacking force.

Interested agencies may secure additional technical data by addressing the Regional Forester, United States Forest Service, San Francisco, Calif., Office of Fire Control.

Gelatin for Greater Work Output.—The part played by protein in the diet has been brought to the fore this year by the report of Ray and his associates that gelatin increases the capacity for work. Six men, after a period of training on the bicycle ergometer, washed down with orange juice 60 grams of dry gelatin daily for 6 weeks. Their capacity for work rose steadily for a month or more, finally attaining an output 50 percent or more higher than at the beginning. When gelatin was discontinued, their work capacity diminished nearly to the control level. A large fraction of the work was done anerobically, that is, by accumulating an oxygen debt, and the authors suggest that gelatin increases the store of phosphocreatine and so the capacity for accumulating a debt. If these conclusions prove to be sound, gelatin pills may take their place beside salt and glucose tablets in modern mills and factories.—The Management Review.

DEVICES FOR COMPUTING SUPPRESSION COVERAGE

MARION N. NANCE [1]

Junior Forester, Region 6, U. S. Forest Service

Guard-placement planning, in order to be sound, should be based on data which are fundamentally accurate to an acceptable degree.

In an attempt to assist field men in the construction of suppression coverage maps of a more nearly consistent degree of accuracy and to reduce the time necessary for this work, the two devices illustrated (see pp. 133 and 134) and explained here were developed.

CHART 1

A. Use of the device.

1. Determine the rate of travel in miles per hour for the trail in question. Consider an average fire guard, the weight of his pack, condition of the trail, gradient, etc.

2. Set the straightedge of the transparent arm D on the rate of travel along the A axis (miles per hour). The arm is set on 3 miles per hour on chart 1.

3. Determine the number of minutes available for travel along the trail.

4. Follow vertically from the horizontal axis B the minutes-traveled line until it intersects arm D. For example, the 40-minute line intersects arm D at X on chart 1, page 133.

5. By following to the left the horizontal line which forms the intersection at X, the number of ¼-inch divider units to be stepped off along the trail may be read directly from the chart along the C axis; i. e., four divider units in the example stated. No computation is necessary to convert distance to divider units.

B. Adverse grades (vertical curvature) are given consideration in the rate of travel used.

C. Poor alinement and angles and bends in the trail (horizontal curvature) are considered in the size of divider unit used along the C axis and in setting the dividers before stepping off the distance along a trail.

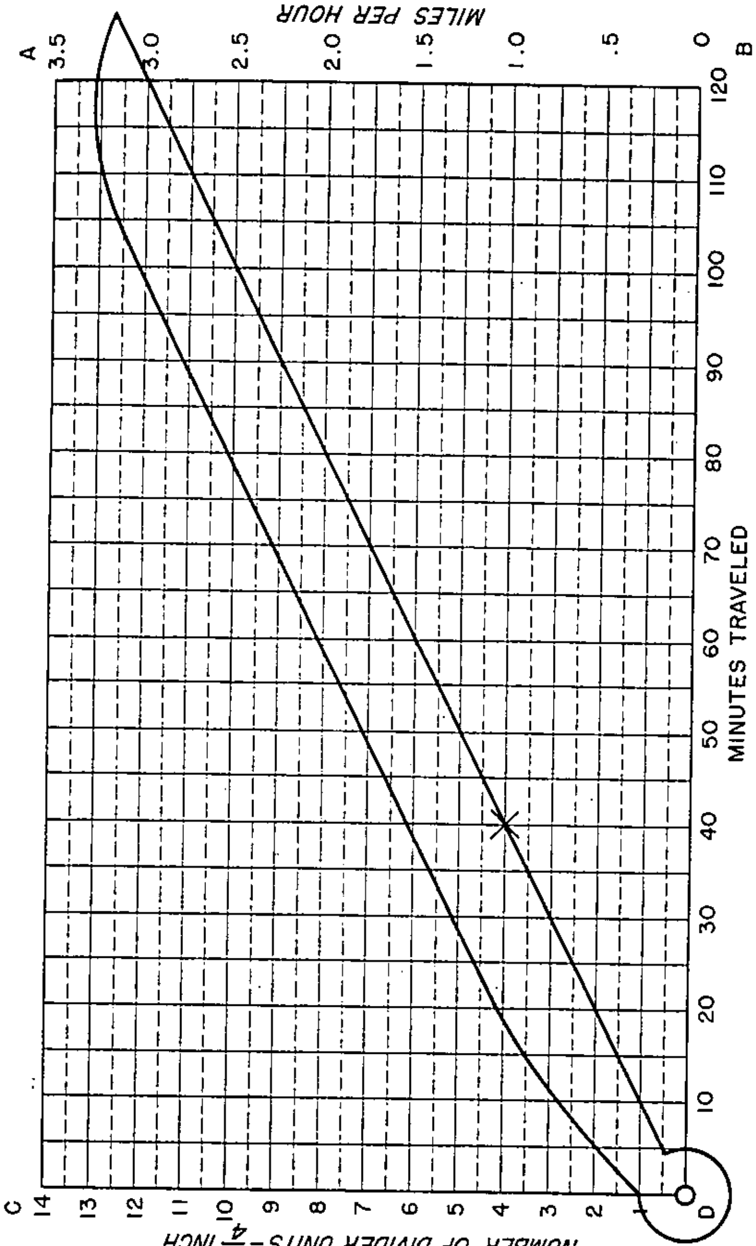
D. Variations in chart arrangement.

1. The chart can be made for 60 or 120 minutes.

2. If 120-minute chart is used, an A axis (miles per hour) can be added at the 60-minute line.

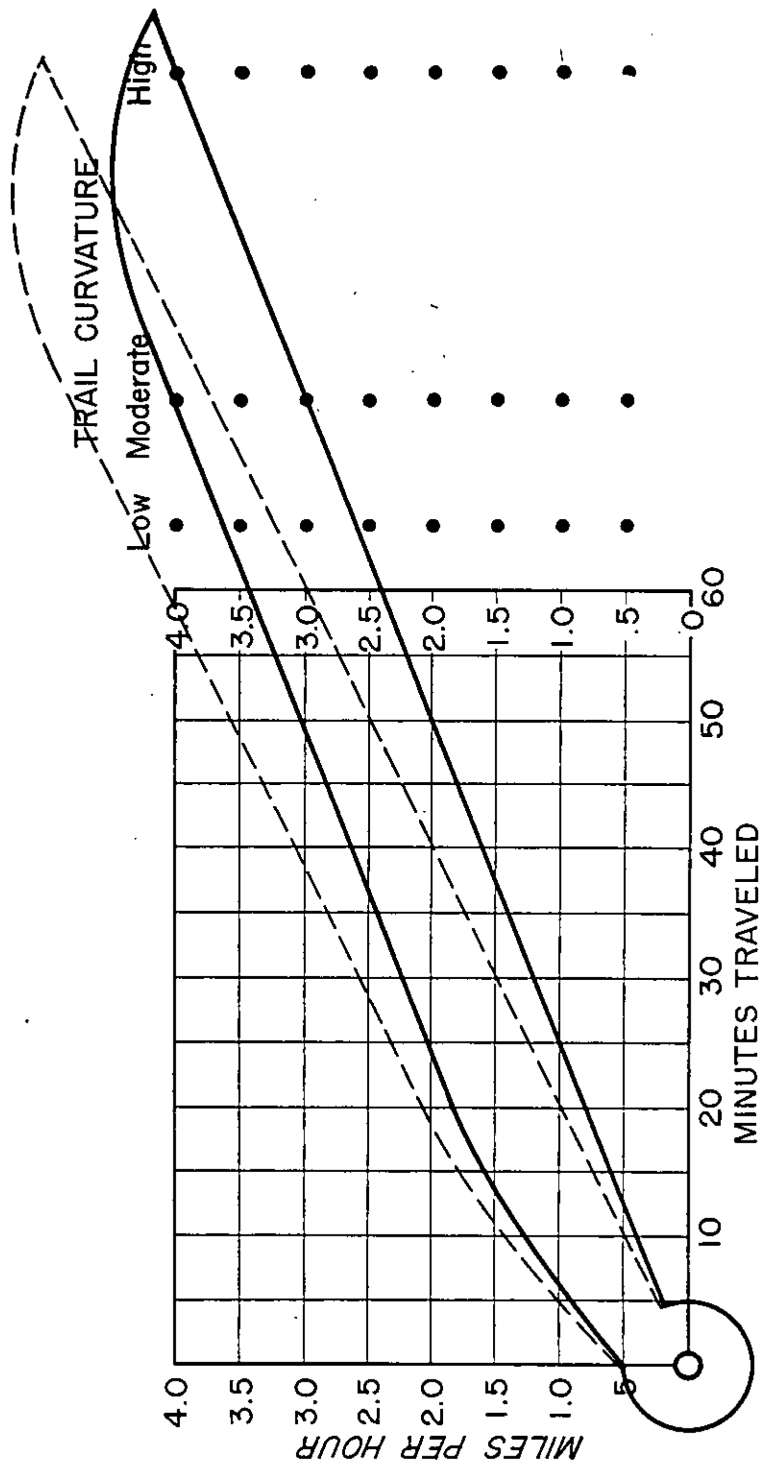
3. The C axis (number of divider units) can be graduated in any convenient unit. Chart 1 is for a ½-inch-scale map. The units on this chart would be ⅛ inch for a ¼-inch-scale map, ½ inch for a 1-inch-scale map, etc.

[1] The author expresses his appreciation for the advice and friendly criticism of this article by John C. Wilkinson and Robert E. Reinhardt. Special recognition is given Robert E. Reinhardt for his original ideas in the development of the travel coverage computer.



(For 1/2" scale map)

CHART NO. I



(For $\frac{1}{2}$" scale map)

CHART NO. 2

4. Horizontal and vertical scales can be lengthened or shortened to suit individual preference by changing the graduations along these axes.

5. For travel along roads a similar chart can be made.

6. For comparable accuracy rough topography requires the use of a small divider unit.

Chart 2

This chart illustrates a very practical variation of chart 1. The device, called a Travel Coverage Computer, is made of plastacele and is 3 x 6 inches in size. Compensation for trail curvature is provided by the addition of three rows of dots which are prolongations of each horizontal "miles per hour" line. As shown on chart 2 the rows of dots are used to allow consistent adjustments for low, moderate, or high trail curvature.

A. Directions for use of the Travel Coverage Computer:

1. The procedure for determining the miles per hour that the average fire guard can travel is the same as stated for chart 1. On chart 2 the selected rate of travel is shown as 3 miles per hour by the dashed lines of the transparent arm.

2. To compensate for differences between actual field conditions and those indicated on the map a further adjustment of the device is necessary for trail curvature. It is assumed that the person using the computer is familiar with the trail in question and can therefore decide whether the trail has a low, moderate, or high amount of curvature. On chart 2 the transparent arm has been moved from its first setting of 3 miles per hour to the dot under "moderate" trail curvature, indicating that we are considering a 3-mile-per-hour trail with moderate curvature.

3. The distance traveled in any number of minutes up to 60 is automatically shown directly below the transparent arm as the length of the vertical line corresponding to the number of minutes traveled. Thus on chart 2 the distance traveled in 50 minutes is 2 miles.

4. Since dividers are not always available, small holes are bored at the intersection of each horizontal and vertical line; i. e., at 5-minute and ½-mile intervals. To use the device place the point of a sharp pencil in the bottom hole of the column representing the number of minutes available for travel. Using this and the remaining number of holes between it and the lower edge of the transparent arm as pivots (to follow bends in the trail) "walk" the distance off directly on the map.

B. Cross-country travel can be calculated in the same manner as for trails. Travel along roads can be computed by multiplying the miles-per-hour figures on the computer by 10 (2.5 m. p. h. equals 25 m. p. h.) and scaling 10 times the distance along the road.

C. An eyelet or a small bolt can be used to attach the arm to the plastacele.

EFFECT OF SIZE OF CREW ON FIRE-FIGHTING EFFICIENCY

DONALD N. MATTHEWS

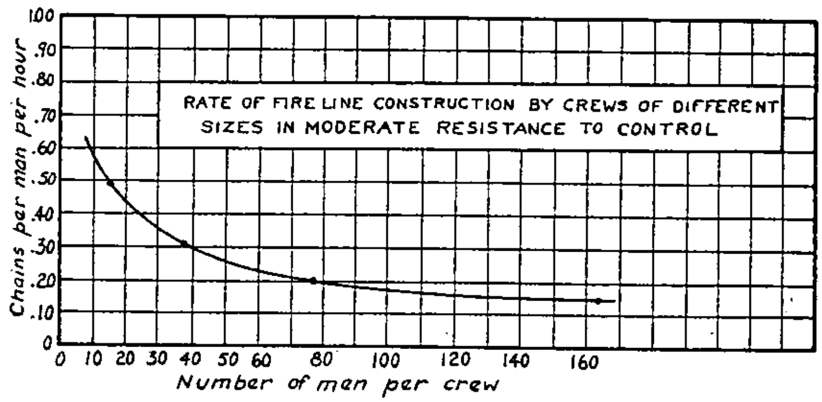
Pacific Northwest Forest and Range Experiment Station

Hand-work methods of fire control are still required in the heavy fuel types and the rugged topography of the Douglas fir region in spite of the advances that have been made in the use of machinery. Thus, on many fires topography, accessibility, and to some extent fuel types make machinery impractical and make it necessary to fight fires with crews of men equipped with hand tools. Immense amounts of work are required per mile of fire perimeter. Therefore the per-man efficiency of the men in the crews is a vital concern and has been the subject of the study reported upon here.

Because of its importance and the large amount of time it consumes, the control-line construction job was singled out for study. Specifically, this includes such operations as clearing the line of brush, small trees, snags, vines, windfalls, rotten wood, and roots, and digging a trench to mineral soil. It does not include such subsequent operations as burning out the strip between the control line and the fire, backfiring, snag falling inside the line, patrol, or mop-up. In practice it was not practical to draw this distinction very fine because some time is spent on these other jobs while line construction is in progress.

The accompanying chart indicates the per-man output of completed control line obtained from data gathered on 40 crews since 1935. As used here, a crew is the total aggregation of men working from one end to the other of a unit of control line regardless of the number of the internal subdivisions into straw-boss or foreman groups.

The chart reveals the most important fact uncovered by the study: The chains of control line produced per man per hour decreases as the



size of the crew increases. Thus the data gathered indicated that 8 crews of from 10 to 20 men (average 15 men) produced an average of 0.49 chain (1 chain=66 feet); 19 crews of 21 to 55 men (average 38 men) produced an average of 0.31 chain; 7 crews of from 56 to 105 men (average 76 men) produced an average of 0.20 chain; and 6 crews of from 106 to 212 men (average 163 men) produced an average of 0.15 chain per man per hour.

Admittedly, these results are not very precise because of the difficulties encountered in getting comparable measurements in a study of this kind. The production figures were obtained from many different kinds of crews—CCC's, loggers, and pick-ups—working under a wide range of conditions on the national forests and private lands of the region. Some of the data were collected by the administrative personnel of the national forests, but most of them were obtained by the research personnel of the experiment station. Most of the crews were organized according to patterns in vogue before the one-lick method was developed. Each unit of line varied in length from 10 chains for the shortest to 196 chains for the longest with an average length of 69 chains. In almost all cases each unit of line was worked in one shift or working period and most of these working periods were from 3 to 10 hours in length. The data reveal only a very slight effect of length of working period; i. e., there is only a slight tendency for the lowest rates per man per hour to be associated with the longest shifts. Possibly this is due to the fact that most of the working periods were short.

Early in the study it was found that the best way to get worth-while records was for one trained man to devote all of his time to observing a crew. The usual procedure was for this man to follow along behind the crew and rate each chain of completed line as being either *low*, *moderate*, *high*, or *extreme* resistance to line construction, according to the standard fuel-type classification used in the region, and to make note of the number of men and the hours worked. The foremen, straw bosses, water boys, etc., with the crew were included in counting the workers; truck drivers, packers, cooks, etc., not on the control line were not included as workers. Travel time to and from the control line and rest periods of more than 30 minutes were not included in the working time. Since by definition the four resistance-to-line-construction classes have approximately the numerical relationship 1–2–4–8, it was possible to compute an average resistance-to-line-construction rating for each unit of line studied as well as the rate per man per hour and to recompute these to obtain an approximate rate per man per hour under a uniform *moderate* resistance-to-line-construction condition. Thus the rates obtained from the measurements made on the individual crews were all made roughly comparable by determining what the rate would be under *moderate* resistance to line construction before they were included in the figure for purposes of comparison.

Analysis of the records of 1,564 fires controlled in the first work period by crews of from 1 to 30 men also revealed a strong tendency for output per man per hour to decrease as the number of men working on a fire increased, although the fire records do not sharply separate time spent on control-line production from other control work. This

analysis indicated that the longer the period worked the lower the rate of output per man per hour. More recently time and production records obtained in the field by the record keeper of the Forest Service's experimental 40-man crew assigned to Region 6 (Washington and Oregon) on 19 units of fire perimeter on which they worked were analyzed, and these indicate that after making the resistance to line construction roughly comparable (*moderate*) for all cases, in the 11 cases where the crews working on line construction contained less than 18 men (10 to 17 men) they produced 1.31 chains per man per hour, but that in the 8 cases where the crews contained 18 or more men (18 to 29 men) they produced 0.93 chain per man per hour. These records, which were based upon the performance of one crew and measured under one standard procedure, are probably as comparable as any that have been collected in this region. They show a strong tendency for the output per man per hour to decrease as the number of men in a crew increases, although they cover a comparatively narrow range in size of crew.

If, as all these studies seem to indicate, there is a strong tendency for output per man per hour to decrease as the size of the crew increases, this tendency reveals an important principal to use in planning fire suppression. The four elements of the fire-control equation are: (1) time, (2) work to be done, (3) manpower, (4) cost. Time must be short to make the work successful. Work to be done is fixed at any one time and place. Manpower can be increased or decreased. How does the effect of size of crew affect time and costs? Suppose there is 1 mile of line to build through cover with a resistance-to-line-construction rating of *moderate*. Based on the output per man per hour shown in the chart, 15 men working as a crew and producing 0.49 chain per man per hour can produce 1 mile of such line in 10.9 hours, and 75 men working as a crew and producing 0.20 chain per man per hour will do the same job in 5.3 hours. In this example it takes 5 times as many men and costs at least 5 times as much to cut the time in half. Knowing this fact, the men in charge of the fire can decide whether the gain in time is worth the cost or decide when the point of diminishing returns is reached as to the size of a single crew. In figuring the cost of using more men to save time full weight should be given to the cost of the supervision, transportation, camp, time keeping, tools, etc. required for the larger crews. This is but one of innumerable problems of this kind that might be cited, and is but one application of the principle that output per man per hour decreases as the size of crew increases.

It is worth while to speculate a little as to why the size of crew has such a drastic effect on output per man per hour in fire fighting. Although it is common knowledge that nonproductive time tends to increase and output per man per hour tends to decrease with an increase in the size of crew on almost any kind of manual labor, nevertheless this tendency seems to be especially strong with fire-fighting crews. What is different about the fire-fighting job that makes this true?

The one outstanding characteristic of fire fighting seems to be that the work is spread out over long distances. Thus the job is measured in terms of chains or miles of fire perimeter to be worked; and therein probably lies one special reason why size of crew affects fire-fighting

efficiency over and above what might be expected as the usual effect of size of crew. Fire fighting involves a great deal of walking on the job as well as the actual work of chopping, clearing, digging, etc. to be done; and therefore it seems reasonable to assume that the more men in the crew, the more men there are to walk over the same ground to do the same amount of work. If this walking time is thought of as being nonproductive time, an increase in the number of men going over the line increases the nonproductive time without any offsetting advantages except some saving in the total time required to do the job. The amount of work to be done per mile of fire perimeter is just about the same whether it is attacked by 10 men or 50 men, but 50 men spend 5 times as much time walking as 10 men working over the same ground.

Although the large amount of walking required in fire fighting seems to be an important factor in explaining why output per man drops rapidly as the size of crew increases, nevertheless nonproductive time of any kind—waiting, resting, or loafing—works in a similar way to reduce per-man output as the size of crew increases. Large crews do not have any offsetting advantages to increase their per-man efficiency; furthermore, it is common knowledge that walking is likely to be at a slower rate and that time spent in waiting, resting, or loafing is almost certain to increase with size of crew. Therefore these nonproductive time elements tend to pyramid; they increase in amount and they are at the same time multiplied by the number of men in the crew.

If, as the size of the fire-fighting crew increases, the decrease in useful work produced by each man is due principally to two elements, (1) time spent in walking, and (2) other nonproductive time such as waiting, resting, or loafing, the following conclusions and applications are pertinent:

1. Organizing a large crew into small units (e. g., straw-boss units of 8 or 10 men) or according to special patterns such as the one-lick method may have a very worth while effect in decreasing the nonproductive time due to waiting, resting, loafing, and other inefficiencies that tend to increase as the size of the crew increases and supervision is spread out thinner and thinner, but the internal organization of the crew cannot materially reduce the effect of walking as an important element of nonproductive time in fire fighting so long as all the men in the crew work from one end of the line to the other. Thus five 10-man crews working from the beginning to the end of a mile of control line have just as much walking on the job to do as 50 men covering the same ground in one crew. However, if there were a road along the mile of line to be worked and each of the five 10-man crews could be transported to and work upon ⅕ of the mile, then a very real saving in walking time on the job could be made by breaking the 50 men up into small crews, provided this was possible and desirable, because each man would have to walk only ⅕ mile while working.

2. The effect of size of crew will be most pronounced in fuel types having *low* or *moderate* resistance to line construction and less important in *high* or *extreme* resistance to line construction. Thus there is less loss in efficiency in working a large crew where there is a great deal of work to be done per unit of line than where there is very little work to be done per unit of line. This is true because the effect

of crew size is most pronounced when the nonproductive time is large in comparison to the productive time. An example of how this might work out is shown by the following theoretical values computed as indicated in the table herewith. (The table is not based on the data obtained in the study.)

Theoretical effect of size of crew on the time required to construct 1 mile of control by resistance-to-line-construction classes

Number of workers in crew	*Low* Walk 30 minutes per mile per man, work 15 minutes per chain or 1-200 minutes per mile.	*Moderate* Walk 35 minutes per mile per man, work 30 minutes per chain or 2,400 minutes per mile.	*High* Walk 40 minutes per mile per man, work 60 minutes per chain or 4,800 minutes per mile.
	Hours	*Hours*	*Hours*
10	2.5	4.6	8.7
20	1.5	2.3	4.7
30	1.2	1.9	3.3
40	1.0	1.6	2.7
50	.9	1.4	2.3
60	.8	1.2	2.0
80	.8	1.1	1.7
100	.7	1.0	1.5

The table indicates that in a *low* resistance-to-line-construction fuel type the point of diminishing returns in saving time is probably reached with smaller crews than in the more difficult fuel types. This table of theoretical estimated values should not be taken literally; i. e., the values in the tables may not be the true values under actual field conditions. Under actual conditions other nonproductive time in addition to walking time should be included in the calculations, and the total amount of nonproductive time per man should be increased as the size of the crew increases. This simple table is given to show how the fire-fighting job can be broken down and analyzed to determine the point of diminishing returns. It indicates how local conditions and local estimates of productive and nonproductive time might be used to obtain relative values that might have important implications for local use.

3. The effect of nonproductive time due to waiting, resting, and loafing tends to increase with size of crew the same as the effect of any other nonproductive time; therefore it follows that good management and good crew organization should strive to reduce all such time to a minimum.

4. How knowledge of the effect of size of crew can be applied to fire-fighting strategy is indicated by the following examples:

(*a*) It is more efficient to divide a crew into two (or more) crews and use each crew on a separate part of a fire than to use all the men in one crew. (This holds true unless the behavior of the fire itself indicates that all the men should be concentrated on one side.

Example: Fifty men are available to work a fire with 2 miles of perimeter rated *moderate* resistance to line construction. Using actual values found by the study and shown in the chart (p. 136) it will take 50 men in one crew 12.3 hours to work around the fire. By values in the same chart, two 25-man crews working simultaneously on two sides of the fire would do the same job in 8.2 hours, a saving of 4.1 hours. If it were practicable to place five 10-man crews around the

fire so that they could all work simultaneously on separate fifths of the perimeter, they should complete the same job in somewhat less than 6 hours.

(*b*) Because the time spent in walking crews to and from the control line is nonproductive time and has the same depressing effect on per-man output of productive work as walking on the job, it follows that any reduction of walking time to and from the fire by use of motor equipment or camping on or near the control line offers very real possibilities of increasing the effective per-man output of fire fighters.

Scouting as an Essential Part of Fire Suppression.—When a forest fire gets away and runs wild, scattering its unpredictable pattern over ridges and canyons, sweeping, spotting, and fingering through a maze of jumbled fuels, there's a big control job to be done. If there are to be orderliness and efficiency in this job, information must be gathered from all parts of the fire and gathered fast. Otherwise crews are likely to be found working in long, narrow bays practically surrounded by fire, spending precious time on a relatively slow-spreading main fire while a spot fire rages parallel and just beyond them, and making dozens of other costly errors because of inadequate information. The usual obstacles in scouting may be expected—smoke, rough country, darkness, heavy timber, brush, and logs, but the fire boss is going to attack and his action will be based on the best information available.

Control work the first morning is often ineffective for lack of information. Thorough scouting throughout the night should provide details as to location and condition of the fire for the fire boss before daylight, so that he can properly equip and place his men. After the first morning the ground and aerial scouts should currently report changes, spread, spot fires, cover conditions, and progress in establishing control lines. Ground scouts should be properly equipped and their work planned in such manner as to enable them to be away from camp for a 72-hour scouting trip if necessary, reporting their information by radio.

With an 8-pound, ultra-high-frequency radio it is possible for a scout, working through a relay station perhaps, to contact headquarters at any time. Map data should be transmitted by the coordinate method. Messages should be concise, following an outline which provides for complete information, readily interpreted and correlated with messages from other scouts. It is also possible for the fire boss to determine conditions on any part of the fire at any time if proper distribution of scouts and radios has been made.

The streamlined scout should carry a 4-pound, down sleeping bag and concentrated food. His packboard should be provided with a collapsible fish-pole antenna so that he can operate his radio while moving along. The pack, complete with radio, bed, food, first-aid kit, canteen, headlight, map, compass, and notebook should weigh less than 30 pounds. It is well for the scout to carry a pulaski or light ax for blazing or hot-spotting. There have been instances where scouts have handled hot spots at strategic control points until help could be sent from the nearest crew.

Care must be taken with scouting units to avoid building up overrefined organizations. Additional scouting personnel, such as radio operators, draftsmen, recorders, and telephone men, should be used in accordance with existing needs. The size of the scouting organization should be reduced as soon as the active need for scouting is past in order to provide additional overhead for control-line work.

Scouting has always been a vital function of fire suppression. As plans are made to do a better control job on future fires, appropriate consideration should be given scouting as a service absolutely essential to large fire management.—L. K. Mays, *Fire Control Planning, Region 6.*

A BRUSH-BREAKER FIRE TRUCK: THE TANK OF FOREST-FIRE WARFARE

Paul W. Stickel

Silviculturist, Northeastern Forest Experiment Station

The brush-breaker fire truck perfected by C. L. Cherry of the Division of Forestry, Massachusetts Department of Conservation, promises to revolutionize the method of controlling forest fires by means of mechanized suppression equipment. Developed upon the principle that the way to control fast-moving fires in oak brush and pitch pine stands is by direct attack, the brush-breaker fire truck can operate along the edges of a fire, regardless of the lack of roads or the presence of brush and small pole-sized trees. The brush-breaker is essentially an independently operating offensive unit, which, while it was evolved for the particular conditions on the pine-oak barrens of Cape Cod, should be useful in many other forest regions except in very dense large timber or on exceedingly steep terrain.

Mechanized equipment, especially of the automotive type, is rapidly altering modern warfare tactics. Next to aircraft, no modern weapon of war has played so important a role in this change as has the tank. This rapidly moving, independently operating, mobile fortress has become essentially an offensive unit that gives every indication of making the present-day battle one of open rather than trench warfare. Foresters may not realize it, but in the brush-breaker fire truck they have a "tank" that may materially alter the method of controlling forest fires. Under conditions wherein this newly developed suppression apparatus can operate successfully, it is no longer necessary to wait for a fire to burn up to a previously constructed control line; the fire can be attacked directly, and furthermore, it can be a running attack applied to any part of the edge of the fire.

As perfected by the Massachusetts Department of Conservation, this latest addition to present-day motorized forest-fire control apparatus is largely the result of the creative conception of Charles L. Cherry, supervisor of the Myles Standish State Forest. It has been the good fortune of the writer to witness the evolution of this fire truck; the initial model, chiefly locally constructed, is a far cry from the latest streamlined, massive piece of apparatus.

Specifications of the Brush-Breaker Fire Truck

The essential features of the brush-breaker fire truck are (*a*) the chassis and engine, (*b*) the front bumper and guard rails, and (*c*) water tank and pumping equipment.

Chassis and Engine.—The latest model of the brush-breaker truck is mounted on a regular V–8 Ford 95 horsepower truck chassis having

a 157-inch wheel base, which has been equipped with a Marmon-Herrington all-wheel-drive, so that when in motion all 10 wheels, 2 front and 8 rear, are driving. The motor has an auxiliary transmission that gives the unit the advantage of both a set of high gear ratios for main-road travel and an exceptionally low set of gear ratios for operation in the woods, i. e., where no roads exist. The tires used are 32 by 6, 10-ply, of the traction-type tread that has been found to give maximum tractive ability to the truck. The truck engine is of the standard V-8 Ford type. Both it and the pump motor are water-cooled by means of a small auxiliary circulating pump driven from

Side view of latest model of brush-breaker fire truck.

the rear motor. For this purpose water from the main tank is utilized. The headlights, siren, and flashing lights on the front of the truck are mounted on a hinged panel that can be raised and lowered by a vacuum cylinder controlled from the dashboard. This feature enables the truck operator to "duck" his lights out of the way of dead limbs or stubs, and in this manner prevent them from being torn away or broken.

When completely loaded with 1,000 gallons of water and the fire-fighting equipment mentioned later, the unit weighs 11½ tons. The weight has been carefully distributed, however, and more than meets the recommendations of the manufacturer of the chassis. As a matter of fact, the weight per axle of the truck is not as great as many conventional 250-gallon units.

Fully loaded, the unit has a maximum speed of 50 miles per hour on surfaced roads. However, in actual use 40 to 45 miles per hour is the usual top speed on main roads.

Front Bumper and Guard Rails.—The bumper or special crowding device mounted on the front of the truck has been so designed as to offer the minimum of resistance while knocking down or brushing aside trees and lesser woody vegetation; yet at the same time it offers the maximum protection to the chassis (see front-view illustrations). It consists of 3/16-inch sheet steel reinforced with 1 by 5 by 3/16-inch channel iron. Both the curvature of this plate and its attachment to the truck have been so designed that the initial impact and crowding action occurs as high from the ground as is practical. In this way, a minimum effort is needed to crowd down and ride over trees and brush. At the same time, there is a minimum of friction loss, both as

the forest vegetation is pushed down and as the unit rides over it on the ground.

Attached to the sides of the front bumper are two curved, tapered flanges. These are so placed that they catch and force inwardly, away from the front wheels, the trees and brush that are crowded down, forcing these to pass under the truck. In this manner, side-thrust of the front wheels is prevented, enabling the driver to steer the truck easily, regardless of the density of the down timber and brush through which and over which the vehicle may be passing.

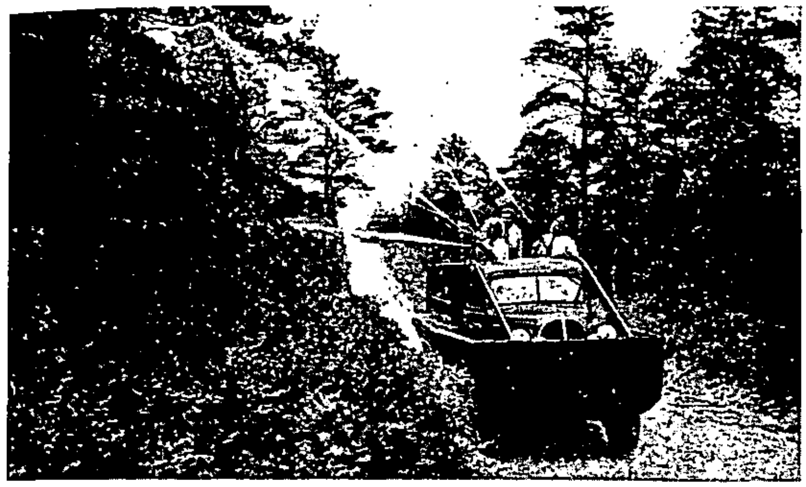
Two upper rub-rails consisting of half-round 3/16-inch steel welded to the back of 1- by 5- by 3/16-inch channel iron extend the entire length of the truck on either side from the upper side corners of the front bumper (see side-view illustration). These taper from a diameter of 3/16 inch at the front to 5 inches at the tank in the rear of the vehicle and are so placed as to give the truck a taper of about 2 feet in its entire length. This double taper provides for a gradual pushing aside of the trees that are not forced down by the front bumper, but which stand too closely together to permit clearance of the remainder of the chassis. Trees up to 10 inches d. b. h. have been spread apart easily to enable the truck to pass between them.

Lower rub-rails of the same construction as the upper ones extend from the front to the rear axles. These are placed at axle-center height and are set in from the outer edge of the upper rails, in order that contact with obstructions is made first with the upper rails. These lower rub-rails are indispensable in making it possible to execute short turns in heavy growth. The rails are constructed to withstand a calculated pressure of 4 tons per linear foot. The underframe of the truck is carefully reenforced, and the more vulnerable areas are further armored with steel plate.

The front view of the brush-breaker fire truck shows plainly the two 1-inch heavy duty chromium-plated pipes, or risers as they are called. These extend on each side from the upper edge of the front bumper over the engine hood to the top of the driver's cab. The function of these risers is to force upward the lateral branches of trees standing close to the sides of the truck which are not pushed over or forced aside, in order that the vision of the driver will not be obstructed.

Water tank and pumping equipment.—The body of the truck consists of a 1,000-gallon water tank. In order to keep the center of gravity as low as possible, provide correct distribution of the weight, and hold the surge of water to a minimum, this tank, constructed of 10-gage "Yoloy" steel, has the following specifications: Depth 3 feet, length 9 feet, and width 5 feet 6 inches. The over-all height of the tank from the chassis frame to its top is 2 feet 10 inches. The tank is divided into nine compartments, as follows: Two transverse partitions form three compartments, which in turn are further subdivided by two longitudinal baffle plates. Each compartment has individual discharge and refill openings, removable manhole covers, and vents.

The sides of the truck body extend 2 feet above the top of the tank to form a place for the hose line, and to provide space for the hose men to sit while using the nozzles. The combination steps, suction-hose sheaths, and rub-rails have been built as an integral part of the water tank and extend on the sides for the full length of the chassis.



Front view of latest model of brush-breaker fire truck.

Brush-breaker fire truck operating in oak brush and small-pole pitch pine stand.

The pumping units and motor, consisting of a Ford model-B type driving a triplex plunger-type pump of 50-gallon capacity per minute at 400 pounds pressure, are housed in a compartment at the rear of the body of the truck. Through experience with different types of pumps, it has been found that a small volume of water under a high pressure of 400 pounds or more, is at least 50 percent more effective in controlling the fast-running fires on Cape Cod than double the volume of water under half the pressure cited. A second pump of the rotary type, having a capacity of 200 gallons per minute at 100 pounds pressure, is used to fill the tank rapidly from any type of water supply. By means of a suitable clutch the plunger and rotary pumps can be driven separately by the Model B Ford motor or both can be operated at the same time by the motor.

The discharge from each tank compartment is valved separately, so that one compartment at a time is emptied. The usual procedure

employed in emptying the tank is to pump off the compartments progressively from rear to front. This procedure holds the surge of the water to one compartment and at the same time keeps the distribution of weight where it should be. These are important features when driving such a heavily loaded piece of equipment over rough terrain.

An automatic pressure-regulator is used on the triplex pump that supplies water to the three high-pressure nozzles mounted on the forward deck, or fighting compartment, of the truck. These nozzles are of three sizes, namely, 3/16, 1/4, and 5/16 inches. They are of the new Bean Deluxe Spraymaster type, having a trigger control, and are capable of being regulated from a fog to a solid stream.

In addition to the high-pressure nozzles used on the forward deck, the truck is equipped with two 500-foot 1-inch live-hose lines and a 1,000-foot 1-inch dry-hose line. These can be used if the timber is too large and dense or the terrain is such that the truck cannot be driven along the edge of the fire. Furthermore, 1,000 feet of 1½-inch linen hose (dry) is coupled up ready for instant use on the deck rack. This hose line is intended for emergency use.

The brush-breaker principle is not necessarily confined to any special type or make of chassis, truck, or tractor. A heavier chassis may be used, and tanks of larger capacity can easily be constructed. However, the deterrent factor to increased size of the apparatus in the Cape Cod region is the inability of local bridges, bog dikes, flumes, etc., to stand up under the increased weight of heavier chassis and loads.

Operation and Performance of Brush-Breaker Trucks

Since no two fires present identical problems of control, no standard technique is possible in using the brush-breaker truck. As a general rule, however, the crew consists of around six men, a road or trail locator, a driver and helper who ride in the cab, and from two to three nozzle men on the forward compartment. The duty of the road locator is to scout out the way as close to the edge of the fire as it is possible to drive the truck, avoiding boulders, holes, and large trees. By a system of simple hand signals, he directs the driver along the best route selected. The nozzle men riding in the fighting compartment on the top of the tank just back of cab have at their disposal five nozzles ranging in discharge capacities of from 15 gallons per minute at 400 pounds pressure to 200 gallons per minute at 100 pounds pressure as follows:

1 nozzle 15 gallons per minute at 400 pounds pressure.
1 nozzle 25 gallons per minute at 400 pounds pressure.
1 nozzle 35 gallons per minute at 400 pounds pressure.
1 nozzle 50 gallons per minute at 300 pounds pressure.
1 nozzle 200 gallons per minute at 100 pounds pressure.

These are all charged and ready for immediate use. This feature allows the nozzle operators to use as little or as much water as the ever-changing conditions along the edge of the fire warrant. It also makes it feasible for the unit to follow the edge of the fire without stopping to apply more water to a given area than is absolutely necessary to extinguish or knock down the blaze at that particular point. When not in use, all the water in the lines is by-passed back to the tank by means of the pressure regulator. The action of the brush-breaker in

knocking down the flames along the edge of a fire is followed by a mop-up crew equipped with hand tools and back-pack pumps.

Brush-breaker fire trucks have now been in operation for several years on Cape Cod. Their performance on many fires has more than met the expectations of their designer. Several case histories will illustrate the value of these units.

During the 1939 fire season, two brush-breakers were called to a fire. Upon arrival, they met several conventional pieces of fire apparatus that were leaving the particular area because of inability to get close enough to the fire to do any effective work. These conventional fire trucks had intended to line up at the next road, where it was hoped to intercept the head of the fire. The two brush-breaker trucks, on the other hand, simply took off into the brush, one along each flank of the fire.

Fortunately, before their tanks were entirely empty the brush-breakers found a bog near the edge of the fire where they quickly refilled. With full tanks the two units set out once again; the fire was soon encircled, and the head pinched out by simply following the flanks. After checking the fire, the brush-breakers moved out to the road ahead, where at least $50,000 worth of motorized fire-control equipment was found lined up waiting for the head fire to come out to the road.

Even more impressive is the record that the brush-breaker trucks established on a 1,606-acre fire occurring in 1938. This fire had an average rate of spread of 251 acres per hour, with a maximum rate of spread at the height of burning of 10 acres per minute. The total air-line length of the fire was 27,500 feet, or 5¼ miles; the total perimeter was 84,300 feet, or almost 16 miles. The effectiveness of the various types of equipment and methods employed in controlling this fire expressed in linear feet of perimeter extinguished was as follows:

	Feet
Backfire	22, 900
Brush-breaker tank trucks (3 used)	26, 000
Conventional types of fire trucks (20 used)	17, 900
Shovel crews	17, 500
Total perimeter worked	84, 300

The conventional trucks, i. e., units equipped with booster tanks of 100– to 200–gallon tank capacities with various sizes and types of pumps, were not designed to enable them to leave the roads to work the edges of the fire. The 20 units of this type worked an average of 5 hours each; all told, their average hourly output was slightly less than 180 linear feet of perimeter extinguished. The three brush-breakers operated an average of 6 hours each. In contrast, their average output was approximately 1,450 feet of perimeter extinguished per hour or eight times as much.

The brush-breaker fire truck is also having a profound effect on another phase of forest-fire control practice on the Cape Cod region. For years much money and effort have been expended in establishing an adequate firebreak system. First the areas were divided into square-mile blocks with firebreaks 40 feet in width around each block. With the advent of the CCC, these blocks were split into half-square-mile

THE STATHEM FIRE-FINDER DISC

Paul Stathem

District Ranger, Sequoia National Forest, Region 5, U. S. Forest Service

To know definitely, to be certain beyond the shadow of a possible doubt, that you have the exact map location of the spotted fire, is a fine beginning for suppression action on any fire. Conversely, to be in doubt, to be several miles off, is not only disheartening but costly in dissipated manpower, time lost, and acreage burned. Yet this uncertainty sometimes prevails when a cross shot cannot be secured from another lookout.

With the progress which has been made in detection planning and expansion in the installation of lookouts, the total high-hazard area visible to but one lookout has been greatly reduced, thus minimizing the no-cross-shot problem. However, we still are faced with the difficulties inherent in securing accurate locations for fires at night. After nightfall, when topography and distances are so deceiving, a dependable, mechanical means of fire location is sorely needed.

Confronted by such problems, we evolved a simple tool which provides for mechanical location of a fire quickly and accurately, with but *one line of sight*. Following is an explanation of the principle involved in securing this location from the one line of sight, as illustrated in chart I.

Our common sense and a glance at chart I tells us that the line of sight from the lookout to any given point can intersect with the ground at only one elevation. From our knowledge of topographic map reading we know that the elevation of the point of intersection of this line of sight with the ground can be read on the contour on the map, and that such point is then the map location of the object being sighted upon. Thus, for example, if we sight out from the lookout on a level line (vertical angle 0°), the first place at which our line of sight (line a) intersects with the ground is the same elevation as the lookout from which we are sighting. On the contour map, the intersection of this line of sight (line a′) with the first contour equal in elevation to the lookout from which we are looking is then the map location of the point being sighted upon.

Now, if we look out on a line of sight whose vertical angle is minus 2°, as shown in chart II, line b, the first point of intersection on the ground of the line of sight will have to be lower in elevation than the point from which we are looking. How much lower is mathematically related in a direct ratio to the distance that point is from you. (For mathematical theorem explaining this ratio see p. 155 of this article.) For example, for a minus 2° vertical angle, the loss in elevation is 138 feet for 1 mile; an additional 138 feet for 2 miles, making a total of 276 feet loss for the 2 miles; 414 feet in 3 miles, etc. Thus, if the elevation from which you are looking is 8,500 feet, on a minus 2° vertical angle line of sight, the first point seen along that line of sight,

at 1 mile distant, would be 8,362 feet in elevation (referred to as *indicated* elevation); for a first point seen at 2 miles, 8,224 feet would be the point's elevation, etc.

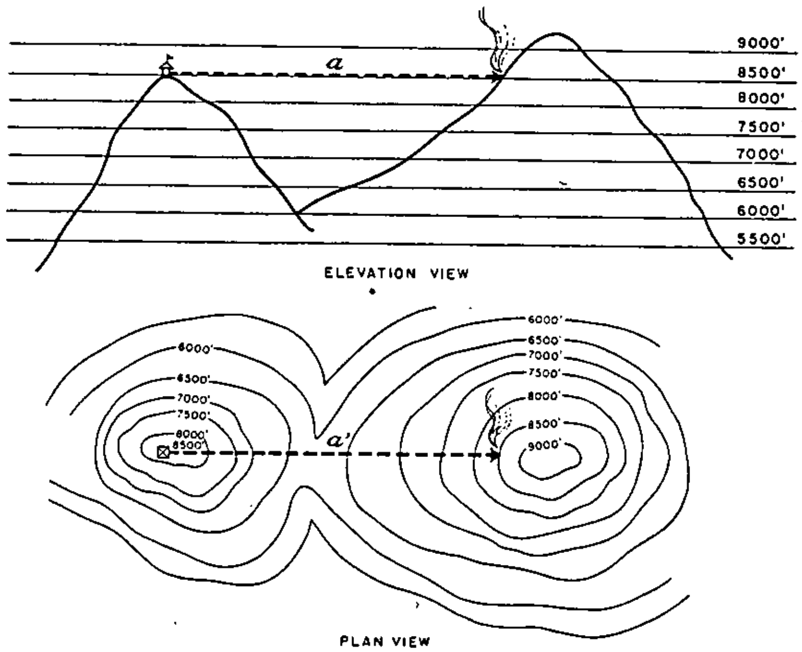


CHART I.

The practical application of this principle of constant loss in elevation per mile can best be illustrated by an example based on chart II. Suppose the lookout man, Jones, on Bull Peak (elevation 8,500 feet) sights (along line b) a fire on one of the ridges across from him. He isn't sure which ridge, or how far distant it may be. His vertical angle reading is minus 2°. He then knows that if the fire is 1 mile away, its elevation must be 8,362 feet and this elevation will be so indicated on the map where the line of sight and the topography intersect exactly 1 mile from the lookout. Jones looks on his topographic map along the line of sight (line b′), checks 1 mile in distance on the tape scale of the Osborne fire finder and at that point he reads the contour line crossing the line of sight. In the illustration this contour line would read 7,700 feet, which does not coincide with the *indicated* elevation which must pertain if the point is to be that sighted on the ground. He then checks the countour reading at 2 miles distant, and would again find no coincision of *indicated* (8,224 feet) with actual (6,700 feet) elevation. By this trial and error method he proceeds along the line of sight until the first point of coincision is determined, which in chart II would be at 11 miles distant where the contour line on the map would agree with the *indicated* elevation of 6,979 feet. This point is the exact map location of the fire, and all that remains to be done is to read the location on the map in terms of legal subdivision.

Knowing then that it was possible to secure an accurate map location for a fire with but one line of sight, the next problem was to develop a ready method of applying the principle of constant loss in elevation.

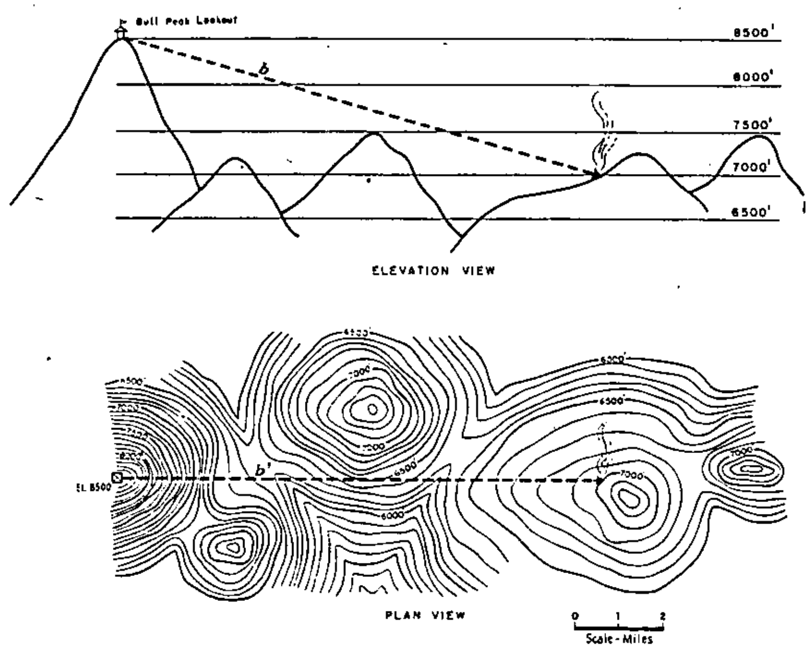


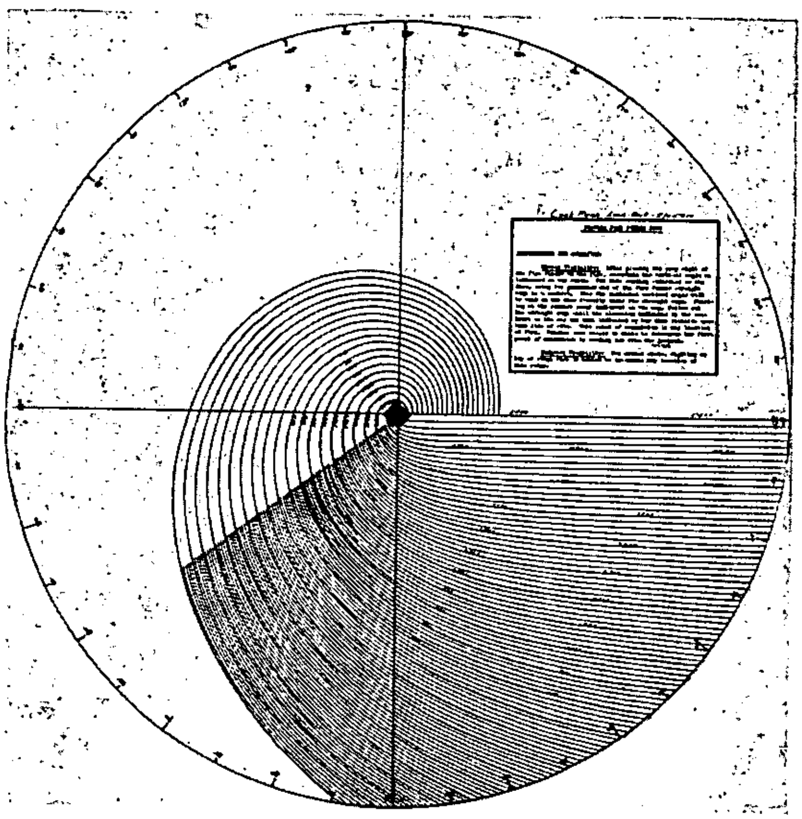
CHART II.

It is evident that it would be possible by the more or less prolonged method of profiling to determine the map location of the point being sighted upon. This took considerable time and was far from foolproof due to the lack of any such experience or training of the lookout along these lines, but, by the trial and error method, and, with a set of profile tables to show *indicated* elevations, it was possible to determine fairly accurately the map location of the point. This method did save the smoke chaser many weary miles and did put him on the fire in less time than had been the custom but it made a sorry story of report times. What we needed was a handy, precalculated means of applying the vertical angle. Furthermore, this tool must be easily manipulated by relatively untrained observers in order that the fire location be secured and reported in the shortest possible time, certainly within the regional standard of 2 minutes. This we accomplished in the celluloid discs pictured on p. 152. For a detailed story of its development see the last pages of this article.

Operating Instructions

Superimpose the celluloid disc upon the topographic map on the fire finder, as shown in picture on p. 153.

For direct visibility: After placing the peep sight of the fire finder on the fire, read the vertical angle. Revolve the disc until the desired



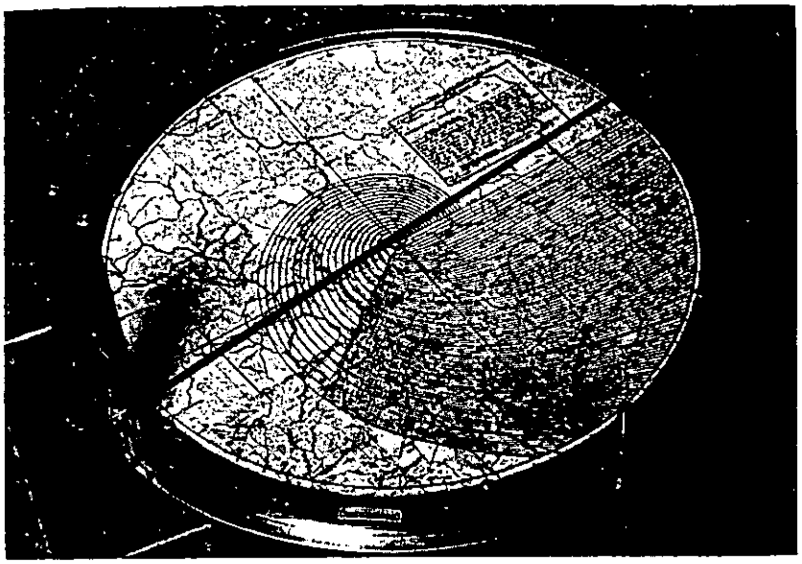
Celluloid disk alone.

vertical-angle reading is directly under the graduated end of the fire finder's straightedge (or scale tape). Starting at the lookout point on the map, follow out the straightedge until the elevation indicated by the contour on the map and that indicated by the disc coincide upon this line of sight. This point of coincision is the map location of the fire. Extreme care should be taken to determine the first point of coincision in reading out from the lookout.

Indirect visibility: Use method above, sighting on top of ridge fire is behind to determine map location of this ridge.

Considerable success has been realized with the use of this instrument, even in its present form. A disc was used for most of the 1939 summer field season and several fires were accurately located independently by the lookout. The first fire to be located was approximately 18 miles away and was a single tree. With the use of the disc, the guard was sent directly to the fire without loss of any time for searching. The guard had been instructed to check the location in detail as to its relationship to surrounding topography. His report was that the location as originally given was within 100 yards of the actual location of the fire.

Discs were prepared for each lookout on the Sequoia National Forest and used in the 1939 season. However, the discs were received too late for group instruction at the guard training camp, which resulted



Celluloid disc in use on map.

in varying levels of ability in their use. Even so, a number of lookouts became very proficient in the use of the disc and a number of independently secured locations were turned in during the summer season. A back-country guard who has had the same station for 14 years made the statement that never before had the locations been so definite and accurate in his entire experience. This statement was made after a season of lightning concentrations of unusual intensity.

Mathematically, the disc is just as accurate as the map upon which you are working, and that accuracy we have found is sufficient to give us dependable locations. However, at present the use of the disc is limited by the very nature of its physical construction. These difficulties are being remedied. The disc now in use is made up of two celluloid circles glued together, the bottom circle is a very light celluloid to provide visibility and on this circle are photographed the lines and figures of the scale. Both lines and figures are at the present time so large that they impair vision on the map. Attached to the light celluloid circle is a heavier one which serves a dual function of protecting lines on the lighter one from wear, and lending rigidity to the disc. This extra thickness of celluloid limits the vision still further. What is needed is a light rigid transparent material upon which the lines and figures can be finely photographed or etched. The discs used last summer cost $4 each and it is believed that a more satisfactory type can be developed within or below that cost.

The type of map used on the fire finder plays an important role in the use of the disc. It has been found that culture should be held to the barest minimum, as the superimposing of inked-in trails, roads, guard-district boundaries, etc., only adds a confusion of lines and is not necessary to the lookout since he needs only to secure an accurate location by legal subdivisions. The dispatcher is the only man concerned with the culture information and of course he has a map show-

ing such detail. (It will be noted that more culture than necessary appears on the map in pictures.)

If the main contour subdivisions (500 feet) are inked to make them stand out sharply, use of the disc is facilitated; also the number of numerical readings on the contour lines should be increased above that normally supplied on our standard maps.

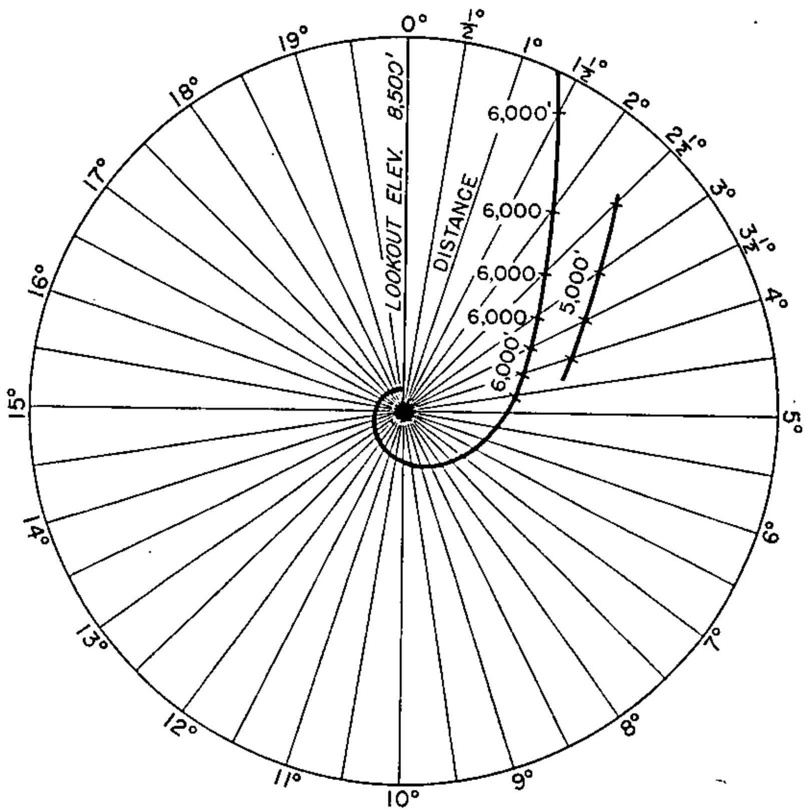


CHART 3.—Illustrating method of adapting scale sticks (see illustrations that follow) to the disk. Here the elevation of the lookout is used as a starting point in the common center for all scales, and each interval on the various lines indicates a loss of 100 feet in elevation.

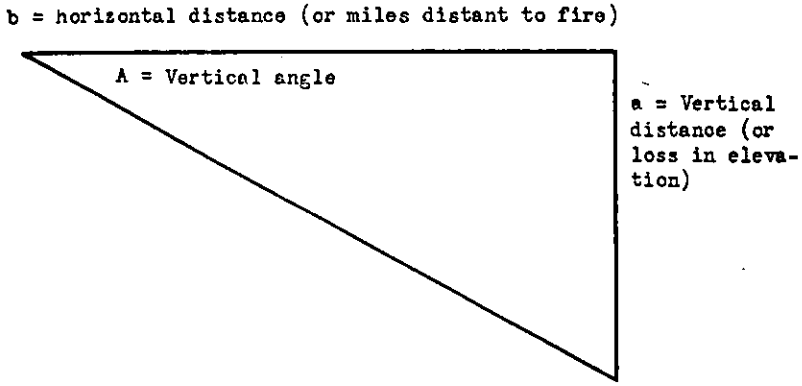
A suggestion which we are trying out next summer, is that of using a color matching scheme on the standard map and disc. For example 5,000-foot contours on the map and on the disc would be colored red, 5,500-foot contours colored blue, and so on. With this method, the point of coincision of the elevation indicated on the map and that on the disc is more easily identified.

As our experience in the use of the disc grows, other short cuts may appear, but one thing is certain—in all but flat or low rolling country the disc is a useful tool in fire detection, night or day.

Supplement

Statement of mathematical theory

The mathematical basis for the principle of constant loss in elevation per mile of distance, is found in the geometric theorem Tan A=a/b



In the solving of the right triangle, Tan A=a/b, any point being sighted upon will have only 1 angle A which establishes a definite relation between b and a, so if for a given reading b=20 and a=2, if b was increased to 40, a would necessarily increase to 4, or vice versa.

Development of the Stathem Disc

The explanation that follows, a description of the steps followed in arriving at the completed disc, is offered for what value it may have in making the disc more understandable.

The development of this disc went through four more or less distinct but closely related stages before the final disc was secured. They were as follows:

1. *Use of profile tables—*

Portion of a profile table: By interpolating and trial and error method, the map location of the point being sighted upon can be located

Vertical angle	Distance in miles														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Difference in elevation														
1°	46	92	138	184	230	276	322	369	415	461	507	553	599	645	691
1½°	92	184	277	369	461	553	645	738	830	922	1,014	1,106	1,198	1,291	1,383
2°	138	277	415	553	691	830	968	1,106	1,245	1,383	1,521	1,659	1,798	1,936	2,074
Etc.															

By the use of profile tables, it was possible to obtain a fairly definite map location of a spotted fire by going through the following steps:

a. Sight the fire finder (straightedge automatically falls on line of sight) and ascertain the vertical angle which, let us say, happened to be minus 2°.

b. Estimate the distance to the fire and read this distance out on the Osborne fire finder straightedge.

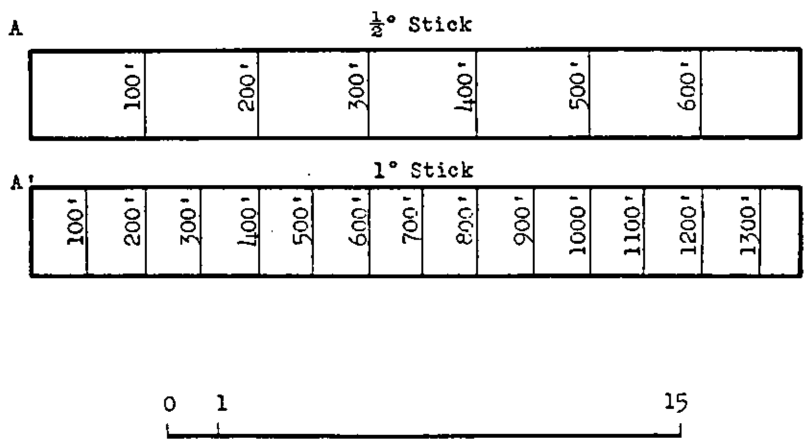
c. Check the indicated elevation on the map at this point where you estimate the fire to be and subtract this elevation from that of the lookout from which you are sighting. Let us say that the estimated fire location is 5 miles distant, its elevation is 7,000 feet and the elevation of the lookout is 8,500 feet. The loss is 1,500 feet.

d. Checking the profile table for the reading you find that the *indicated* loss for that angle is only 691 feet for 5 miles, and your estimate of the distance is incorrect.

e. The process is repeated on a trial and error basis until you find the correct distance, which is that distance where the loss indicated on the map agrees with that in the table.

Obviously, this method was much too cumbersome and time consuming.

2. *Use of a profile scale*.—Scale sticks were prepared from the profile tables, with even 100-foot losses being plotted on the same scale as the map, indicating losses in elevation for any given angles for any given distance. (See illustration.)

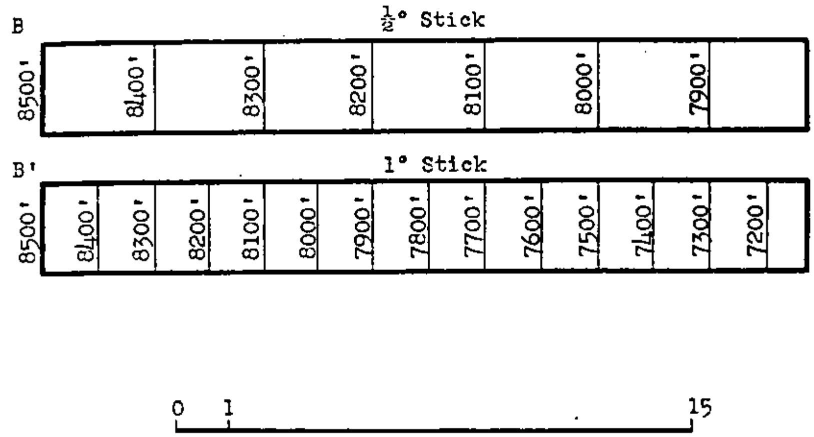


Scale sticks prepared from profile tables.

The scale sticks were then adapted to specific lookouts with true elevations in respect to the elevation of the lookout being substituted for loss-plotting. Thus the figure on any line is the elevation of the lookout minus the loss indicated on the scales.

In this method the lookout, after securing line of sight and vertical angle of, say 2°, selects the proper scale stick and places the scale along the line of sight. The first place that the elevation indicated on the scale coincides with the true elevation indicated by the contours on the map is the map location of the point being sighted upon.

3. *Modified disc system*.—It is evident, though, that the lookout would need a great many scale sticks to use this method, in fact, 120 would be needed if the vertical angles were read in 10-foot intervals



Scale sticks adapted to specific lookouts.

for 20°. Thus we still had a cumbersome device and it was desirable to combine on one instrument the 120 separate scales. A transparent object was necessary in order to permit the operator to read through on to the map and a disc seemed most appropriate for its form, inasmuch as all scales have a common origin at the center of the disc. The disc could be placed on the fire finder map and revolved quickly to enable the operator to select the correct degree scale. Furthermore, if the disc was of transparent material it could be left on the map at all times. The process of finding the map location is the same as with individual sticks.

4. *Stathem Fire Finder Disc.*—It was apparent upon completing the disc referred to that this could be still further simplified by the elimination of the lines for the scales, leaving only a fragment for indicating angles on the edge of the disc. Then too, the points of equal loss in elevation on the various scales could be connected together with a curve. Thus, it was possible to read the disc for any angle or fraction of any angle and interpolation was greatly simplified (see photograph of the completed disc).

Governors on Fire Trucks.—We observed that a governed fire truck motor will not pick up enough r. p. m. or power to pull its load through the sand and brush on this forest. A transmission governor might prove much more satisfactory because it would affect only the speed of the vehicle as compared to the type in use on carburetors at present which limits the flow of gas to such an extent that often the truck will not quite pull its load in low gear. The first time the Dodge fire truck stuck I am sure that 5 to 10 miles increase in motor speed would have pulled it out, as the truck was not digging in, but the motor was getting just enough gas to overcome the inertia, the truck pulling forward just a little and then stalling the motor before it could really get rolling. I recommend a study of this problem by appropriate officials.—*Report by District Ranger J. W. Cooper, on the Glenn Branch Fire, Ocala National Forest, 1939.*

THE SILK-SCREEN STENCIL FOR PRINTING AZIMUTH CIRCLES

VINCENT V. COLBY

Assistant Exhibits Designer, Region 3, U. S. Forest Service

Application of azimuth circles to fire-control maps may be completed in a few minutes with a silk-screen stencil instead of drawing them individually by hand or using other processes. Any shade of color may be used, even metallic, if desirable for better vision. The lines and numerals stand out in high relief, are nonfading and permanent.

The silk stencil was used by the writer as long ago as 1912 when it was desired to find a better way for applying letters on felt. A common netting material was stretched on a wooden frame. The letters were drawn with pencil on this stretched netting and the space around and between the letters was painted out with brush and shellac. This essentially was the stencil.

After many experiments a paint of the right consistency was found and with the help of a flat wooden scraper faced with rubber, the paint was scraped across the netting material. In this manner the paint was squeezed through the open spaces (the letters) and, upon lifting the stencil, all letters were found to stand out cleanly in high relief on the felt.

Following this early work improvements were made and there was then completed a better method whereby a fine-mesh silk was used and in combination with a photo gelatine solution.

The silk-stencil method became popular over the years and various patents were obtained, all of which, however, were based on the principle of squeezing paint through a cloth mesh.

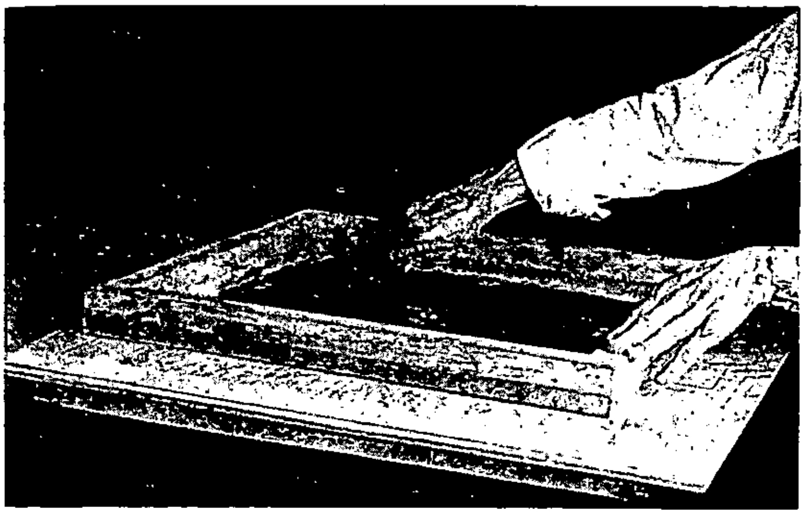
Today printing with silk screens is widely used but, curiously, even now the method has not been fully exploited. For instance, carbon tissue, whereby a sensitized gelatine sheet is exposed to light under photographic film and transferred onto the stretched silk, came out only a few years ago and, while used in industry, is still a sort of "hair-trigger" proposition for the reason that the very thin film of gelatine adhering to the silk does not stand up well under production.

Here in Region 3 the writer is producing stencils with a tissue of his own make from which over ten thousand copies may be printed. From such a stencil the finest of pen lines are reproduced cleanly and the requirement is merely that such lines be black (opaque) when originally drawn.

For reproducing pen drawings, maps, etc., in limited quantities the method is simple and economical since there are no plates to be made.

Place a clear sheet of celluloid over a preliminary pencil sketch and execute the drawing on this celluloid with pen and ink. This drawing is then brought into contact with a sensitized tissue which, after treatment, is transferred onto the stretched silk. This is the stencil and it is based on the same principle as the first commercial stencil made in 1912.

However, until recently there has been one fault which prevented the use of even this fine grade of stencil for printing items requiring extreme accuracy such as the azimuth circle on fire control maps.



Method of applying paste paint to stencil.

On such maps any distortion by reason of shrinkage and consequent distortion of the protractor would make the latter useless. There was always some distortion perhaps not very important when a pen-and-ink illustration had to be printed.

This has been overcome. There is no distortion of the asimuth circle and the stencil can be placed onto the printed map exactly where wanted. For this purpose the stencil is provided with a hole in the exact center for placing over the spot where the fire lookout is located on the map. Four more holes or windows rather are placed outside of the circle in such a way that each will cover a point of the compass. Each of these windows is provided with a fine hairline which coincides exactly with the small pencil lines previously drawn onto the map itself. Accuracy is assured by placing the stencil in position onto the printed map in this manner. Now a bit of heavy paste paint, any color, is dipped up with a small piece of stiff rubber and with a circular motion the paint is scraped over and around the circle (see illustration). The stencil is now lifted and it will be found that the circle is imprinted cleanly on the map. As an added safety factor the map may be previously coated with a spray of clear lacquer (duco) just in case the printing, through any accident, is faulty. With a small rag, moistened with turpentine, the print may be easily removed.

The finished print will dry in about 4 hours and by spraying on another coat or two of the same transparent lacquer the map is completely waterproofed.

With the silk stencil a print can be made on any flat surface not only on paper but cloth, leather, oilcloth, or other similar materials.

O

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and that no paragraphs be broken over to the next page.

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

If there is any introductory or explanatory information, it should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Text for illustrations should be typed on strip of paper and attached to illustrations. All diagrams should be drawn with the type page proportions in mind, and lettered so as to reduce well. In mailing illustrations, place between cardboards held together with rubber bands. Paper slips should never be used.

India ink line drawings will reproduce properly, but no prints (blackline prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.

The approximate position that illustrations bear to the printed text should be indicated in the manuscript. This position is usually directly following the first reference to the illustration.