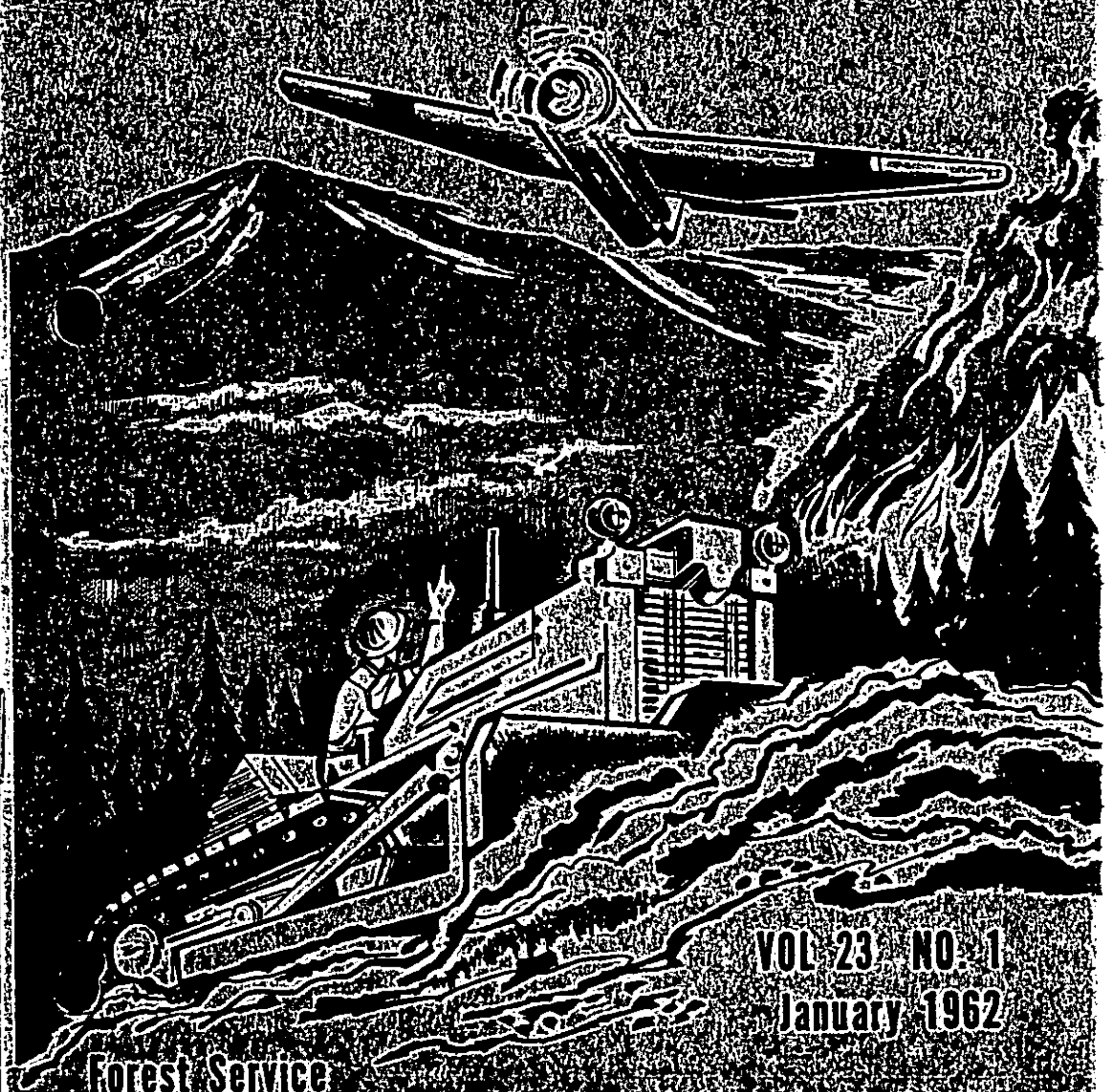
25th ANNIVERSARY

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL



VOL 23 NO. 1
January 1962

Forest Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

Volume 23 Number 1

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

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

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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1962

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TWENTY-FIFTH ANNIVERSARY

Fire Control Notes came into being in December 1936 because of the premise that the widely scattered, creative efforts of individuals and separate groups in fire control work could not be fully effective unless they were shared with others. The lead article in that issue, *Fire Control Offers Its Services*, is reprinted here because the purpose and aims expressed in it are as true today as they were 25 years ago.

And in this anniversary issue we have also reprinted *Fire Cooperation in Region 2—the Beginning*, which appeared in January 1937. It is of interest from many standpoints; it is also thought-provoking. After looking back to the early part of the century at the rocky but interesting road of progress in forest fire control, the author observed ". . . no doubt much was accomplished in other regions, but there was a lack of general knowledge among the field men of the various forests as to how results were obtained. . . ." Had it been possible for these pioneers in forest fire control to share their knowledge and experiences other than by infrequent personal contact, progress in the total effort would perhaps be even farther ahead today. Once again Fire Control Notes offers its services.

FIRE CONTROL NOTES OFFERS ITS SERVICES

ROY HEADLEY
Forest Service, Washington, D. C.

The Fire Control Meeting at Spokane, Washington, in February, 1936, gave the Forest Service Division of Fire Control in Washington, D. C., a mandate to issue from time to time a publication which would serve as a medium for exchange of information and ideas between all the groups and individuals who are doing creative work in forest fire control. On the assumption that readers will respond with ideas and information to publish, the mandate is accepted.

Over a period of 30 years since the inception of organized effort to stop the fire waste of American natural resources, impressive advances have been made. Considerable body of knowledge of the arts and sciences involved has accumulated. Systems of organizing and managing human forces and mechanical aids have in some instances attained dramatic efficiency. Fire Research has won the respect of owners and managers of wild land. The advancement to date in technique entitles fire control to a place among the amazing technologies which have grown up in recent decades.

The advance of the technology of forest fire control is not, however, a completed thing. Its forward march has not even begun to slow down. On the contrary, there is good reason to anticipate a period of broader and more rapid growth. Fire control has won a large measure of public interest. Its relation to conservation of wild land resources is better understood. Financial support is increasing. A growing number of men are making technical contributions from a wider range of ability and training. More men know more about how to climb to new plateaus of efficiency in stopping this fire waste.

Future advances will come not from the work of small groups, but from the experience, thinking, and experiments of the large number of men now engaged in pushing back the frontiers of fire control. The integrated experience and study of such a body of interested men may easily yield results overshadowing all that has been gained so far.

The surprising thing is that the need for a vehicle for interchange of ideas among such men has not been recognized before. Widely scattered as they necessarily are, the creative efforts of individuals and separate groups cannot be fully effective without the aid of something which will serve as a common meeting ground, a clearing-house of developments. Fire Control Notes

aspires to render that service. It hopes to be a carrier of whatever men need to know to keep abreast of developments and trends in fire control.

Fire Control Notes will seek to act as a channel through which useful or suggestive information may flow to each man in this field, whether he be a fire research worker attacking some fundamental of combustion, or a fire fighter, facing the flame and smoke, who discovers some new device for organizing a crew of laborers. These pages will also hope to be used as a mouthpiece for every man, whatever his job, who discovers something which would be useful to others, or who has a criticism to make, a question to raise, or an unusual fire experience to relate.

As implied by the name, "Fire Control Notes," it matters not how long or how short a contribution may be nor what angle of fire control is presented. The man who discovers some new device which can be presented in four lines owes it to himself and others to report it. Likewise, the fire research man who needs ten pages for a worthwhile presentation of his subject should share what he has learned with others who need his help or who may be needed to supply the intelligent interest required to sustain the inquiry.

The only requirement imposed upon contributions to Fire Control Notes is that they be interesting or helpful to some group of people concerned with some phase of fire control.

FIRE COOPERATION IN REGION 2—THE BEGINNING

JOHN McLAREN
Liaison Officer, Sixth Corps Area

For many years prior to the creation of the National Forests in Colorado, I lived in Pitkin County in wooded areas which later became part of the Holy Cross National Forest. In the fall during those years one could see smoke from unattended fires at almost any point of the compass, and naturally Colorado suffered enormous timber losses, for conditions in my locality were not materially different than in other sections of the State, as I afterward learned.

The Holy Cross and other Colorado Forests were placed under administration in 1905 and 1906, and an extremely limited field force was kept busy long hours each day trying to keep up with marking and scaling timber, and fire control was about the only interruption tolerated. From the beginning, however, all forest officers were impressed with the fact that they must be on the alert to prevent fire damage, and necessarily must act promptly if fires were to be suppressed.

Foresters coming into the service today can have no conception of the situation faced in those early years, for there was an almost universal antagonism from every quarter toward forest administration, and some of it was very bitter. Timber operators and grazing men were sure their individual rights were being jeopardized, and others were "agin" it because it was something new and they were not sure it would be of benefit, so preferred to let the old order ride.

This drab outlook faced a ranger when he found it necessary to tackle a fire. Perforce he must get as many men as possible as fire fighters from any and all walks of life, and "please each man bring his own ax or shovel," for those days preceded the era of fire tool caches, telephone lines, automobiles, truck trails, and lookout systems.

Most of the old timers in field service in those days have been replaced by men with more education and nimbler typewriter fingers, but my hat is off to that advance guard that had the hardihood to stick with and worry at the job in the face of the discouraging outlook; and boys, did that bunch do an excellent public relations job, though the term did not come into usage until some years later. Strangely enough, doggedness and perseverance in fire work seemed to be the opening wedge in getting public confidence, and after a while there was a sort of grudging

admission that it did really seem possible to check and whip a fire with man-power, and the efforts of the field men began to bring some praise.

Thus it became apparent that fire publicity was the best means at hand to arouse public interest in the Service and its aims and policies. Fire suppression jobs were publicized in the newspapers, and particular effort was made to give credit to civilians who took part in the work either of detection or suppression. Stress was laid on the need for eliminating fire from the ranges in the interest of stockmen; on the fact that timber must be free of fire in the interest of loggers and lumbermen, and that success in the mining industry depended a great deal upon the elimination of fire. Furthermore, if returns to the counties from the 25 per cent fund were to be worth while and maintained, the resources must be kept free of fire damage. Naturally, individual selfish interests were played upon: Farmers might be bankrupt through the loss of their improvements and the reduced fertility of the soil; a mining operation might be stopped by fire through loss of surface buildings and the necessary timber; and, too, many towns and settlements might be wiped out, with loss of life.

I have been asked how our system of fire cooperation got started. The foregoing indicates something of the way in which the start was made. As to when and where it started, I cannot say. In all probability field men were doing the same thing simultaneously on all forests. Apparently the first universal step was to interest people in detection work. "Keep a sharp lookout for fires and make prompt report to the nearest forest office." As I recall, my first personal attempt along this line was to line up teamsters hauling lumber and logs into Norrie to report railroad fires.

Logging operations were confined largely to the mountainous slopes south of the Frying Pan River, while the Colorado Midland Railroad wound a tortuous route along the mountain slopes north of the river. Only a few miles of right-of-way could be sighted from the ranger station, but the teamsters had a panoramic view of the entire railroad, so they could and did watch for fires and report them. Among those lined up to scan large areas under their immediate control were a resort owner, a mine superintendent, and a German farmer. The latter was a valuable find, for he was German born, had a very intimate knowledge of German forests and forestry practices, and was inordinately proud of having a connection, even without pay, with the U. S. Forest Service in the capacity of a fire guard. He was so enthusiastic and so willing that in a very short time fire tools were placed in his barn, and he was given authority to take direct charge of any fire in his territory and to employ fire fighters as needed.

Even after a few lookouts were manned, the public was requested to see how many times they could beat the lookout observer in reporting fires, and they gleefully responded. This voluntary service was extended year after year until there was a very large number of individuals who could be depended upon

for detection and a smaller number who were entrusted to take initial action and incur expense in fire suppression. Let me repeat that this was not the only territory where progress was being made. No doubt much was accomplished in other regions, but there was a lack of general knowledge among the field men of the various forests as to how results were obtained, and such information as was obtained came largely from inspectors of the Regional Office at infrequent intervals and at rangers and supervisors' meetings.

When the Regional Office established the position of Fire Chief, a survey disclosed that while excellent progress had been made in rousing the public to be fire-minded and co-operative, it was very spotted even as to individual forests: There was a lack of standardization in fire tools both as to kind and number, and the majority of the fire plans were of the old narrative type—too voluminous and bulky to be of much value even to the men who made them. Fire tools were standardized rapidly, and Region One's Fire Organization Chart was adopted in modified form.

Effort was immediately centered on convincing each and every field man of the importance of enlisting dependable public co-operation. This, by the way, was not accomplished in a season. Eventually it did exist well toward 100 per cent as a mass consciousness from the newest member of the force, through the Supervisor's office to the Regional office, to the Regional Forester himself. There was an essential objective, for mass effort produces mass results. The chart referred to became the fire plan for each ranger district, and responsible citizens at strategic points were listed as keymen. These were men who were, and are, called on to drop their private work and devote time and energy to public interests. These plans were frequently inspected and checked in the field to insure that they were not paper plans only.

The methods employed were many and varied, and depended upon the initiative of individual forest officers and the individuals to be worked on. In general terms: "We are a skeleton force willing and anxious to do everything possible to protect the resources, but you are the owners of these forests—the stockholders in this concern—and without your whole-hearted interest and action we must fall short of the success otherwise possible."

Each forest officer must believe whole-heartedly in the worth of converting apathetic or indifferent individuals and communities to an active sense of duty in fire control—it can be done. The forest ranger has better chance for success than others, for he personally knows the people in his territory, has a knowledge of their personal interests and their idiosyncrasies, and therefore has the best approach.

TRAINING FIRE PROFESSIONALS[1]

MERLE S. LOWDEN
Director, Division of Fire Control, U.S. Forest Service

Training of professional firemen for forest fire control work has received increased attention in recent years. There is general recognition that this training is not of the quality nor in sufficient amount in most cases to do a fully satisfactory job of providing qualified personnel needed for this important job. Such training has lacked stature, financing, and the necessary interest of some administrators in the past. There are encouraging signs, however, that forest fire control training is to get increased attention and a more prominent place in the entire fire control job. My remarks on this important subject will relate most specifically to the work of the U.S. Forest Service, but the job to be done is quite similar on areas protected by the States, other Federal agencies, and private organizations.

Forest fire control involves the protection of valuable resources, is often costly, and is highly technical and important work. It requires skilled personnel who know their jobs. Decisions of supervisory personnel must be made quickly and must be right. A wrong decision may be costly in fire fighting costs, expensive in lost resources, and tragic as it concerns the lives of participants and others in the area.

All training work should start with an analysis of training needs. This in reality is the difference between total needs of capable personnel to do the needed job and those currently on hand and capable to do the work. In fire control this means determining the number of men we need for lookouts, patrolmen, smokechasers, fire bosses, plans chiefs, supply chiefs, and the many other specific positions we have to do our fire job. In the suppression organization we have specific positions. From analysis and with our qualification system, which I will describe later, we then determine the number of employees we have qualified for each position. The difference is the number to be trained. However, this is an oversimplification as some only need refresher work and others need all the fundamentals. Of course before we figure our training needs we have a plan for the desired fire control jobs which is modified to fit the money available. As you all know whether in government or in private industry, we must match the organization to the budget.

Fire control training can be divided into the three main categories of the job itself; i.e., prevention, presuppression or preparation and suppression or the actual fighting of a fire. From my experience I have noticed most attention in training is given to preparing men for fire fighting with usually decreasing attention to training for preparedness and prevention. The latter is begin-

[1]Presented to the National Academy of Sciences, National Research Council, Woods Hole, Mass., July 21, 1961.

ning to get more attention and the outlook is that prevention training will receive more deserved recognition in the future.

The Federal Forest Service requires training for four groups of personnel and their various needs must be recognized in the training program. The first group includes the full-time fire control professional who devotes all or practically all of his working time to fire activities. Next is the professional forester or other full-time employee who devotes only part of his time to fire work either regularly or as called upon in an emergency to help on a suppression job. Men with fire work as part of their normal duties may work on one or several multiple-use land management functions the balance of their time. These folks cannot be expected to know as much or be as skilled in the fire job as the full-time fireman. In addition to yearlong employees the Forest Service and most other forestry agencies employ many for seasonal work. Some seasonal employees are primarily fire employees working on such jobs as lookouts, crewmen, smoke-jumpers, dispatchers, and patrolmen. Other seasonal employees such as laborers, truck drivers, packers, and machine operators may work on construction or maintenance jobs or other work most of the time but are available for fire work when needed.

Our full-time fire employees are either foresters or professionals in related fields or employees who have come up through the ranks from seasonal fire employees. One might think that graduates from an accredited forestry school would have received fire control training as part of their undergraduate work, but usually they get very little such work in college. Most often they have had only one course in protection which may have included pest control as part of the course. One full fire course, or two fire courses at the most, is all a forester now gets in college. The work is usually more of an orientation to fire control and not of immediate application. However, often forestry graduates have worked on seasonal fire control jobs during their vacations while in college and have received much valuable training and experience in this manner. Most of our present fire leaders worked on vacation fire jobs during their college days, and in the process, received many fire fundamentals.

Apprenticeship or understudying is a common method for fire control and other personnel to advance in the Forest Service. Many nonprofessional fire employees are classed as technicians and through experience and training can advance to responsible positions in fire control. At the lower grades there is less distinction between professionals and technicians in training given. In the Forest Service we are establishing training standards which, as they are refined and fully adopted, will require that men receive and pass certain specific fire control courses of increasing complexity in order to advance from one grade to another. We have a big job to get these standards fully defined and operating but I'm sure they will mean better qualified men and improve the performance in our fire work in the future.

In addition to these standards for Civil Service grades we have a qualification program that applies to men in fire suppression

supervisory positions. Each of our regular men qualified for a fire overhead position has a "red" card which designates the position or positions which he can handle and those in which he needs training. A qualified sector boss may be listed as needing training as a division boss or as a camp manager. Minimum standards have been established for the top positions on a national basis and for the lower positions on a regional basis. A Class I fire boss or fire general, for example, must have passed qualified fire behavior and fire generalship courses, must be a thoroughly qualified Class I line boss, must have had current experience (within 3 years) on Class C or larger fires and experience on a total of at least 30 fires, including 10 Class E fires (over 300 acres).

Our fire training is given at national, regional, or local schools depending on the level of instruction, the number to be trained, and other considerations (fig. 1). Local fire schools on ranger districts or forests have been held for many years and many of our regions have given training in more advanced courses.

The annual fireman school is a tradition on most national forests and is a practice followed by many States. These sessions often run for 3 to 5 days and train men in such jobs as detection, smokechasing, suppressing small fires, operating machinery, fire prevention, law enforcement, and safety. Such specific skills are taught as map reading, "running" a compass, operating a fire finder, building a fireline, and similar doing jobs. These schools serve to orient many new employees and are good morale builders. Regular full-time employees mingle and work with seasonal trainees and prepare for the teamwork needed in the fire season ahead. Fireman schools haven't changed greatly through the years except more training aids are used and subjects such as air operations and fire behavior have been added. The emphasis is on real work and the men are given a chance to demonstrate what they have learned by doing the jobs in most cases. Often seasonal employees working in other activities are included to train needed replacements or to give these employees selected training in such subjects as fire fighting.

Increased attention is being given to training through special assignment; that is, training in place by working at some location other than the usual assigned station. Men are detailed to other offices or locations to do preparedness or prevention jobs or to going fires in other forests or regions. Training on fires may be as apprentice or understudy to a regular position, or part of the time may be spent in a regular organized group receiving planned training on the fire. At the national level we have been featuring interregional details for training and last year nearly 150 men received training in this manner. We have encouraged our regional officers to detail men between forests for suppression training on fires. We have trained a great many men in our Washington office by detailing them in to do specific jobs. This method has great possibilities but must be well planned, aimed at specific objectives, and carefully supervised.

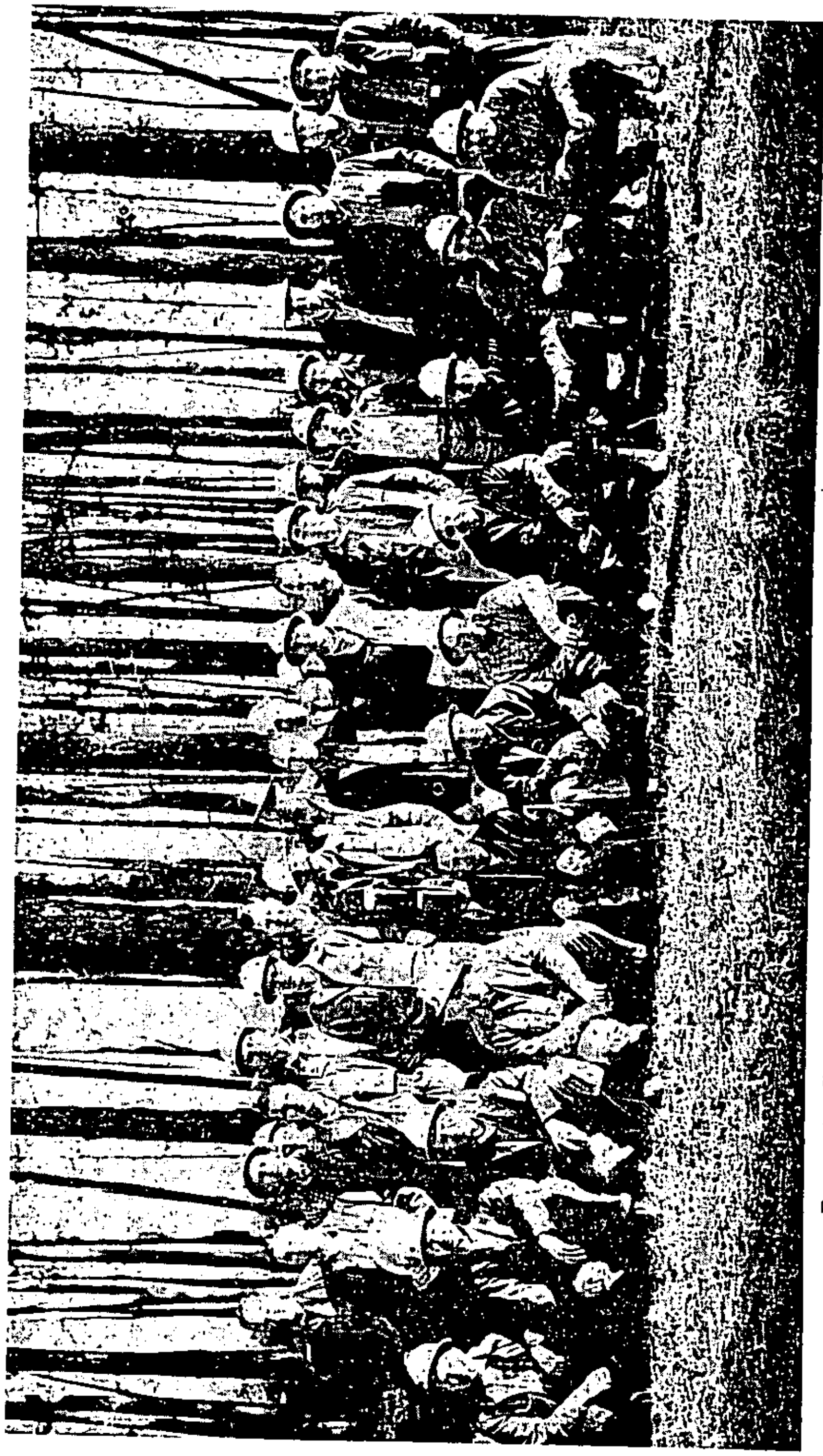

FIGURE 1.—Trainees and instructors, Fire Behavior Training Meeting, Alexandria, La.

Within the past 4 years we have conducted several national courses in advanced fire work and we intend to have more. Because we had recognized an urgent need to increase knowledge in fire behavior we have had three national schools in this work of 3 or 4 weeks' duration. These schools were aimed at training men to be fire behavior officers on fires, providing training materials for additional training, and training men who could serve as trainers for others in the field. This last objective has been especially fruitful and thousands of our men as well as State and Department of the Interior employees have had fire behavior training of varied intensity and amount. We have also had courses in fire generalship and air operations in national schools. Fire personnel from State forestry organizations and the Department of the Interior have been trainees at the national courses and we plan to continue this practice.

Our regional schools are usually aimed at training for fire suppression overhead positions. Their length varies depending on number of subjects covered and experience of the men. In recent years these courses have featured tactical support in service of supply, plans, and finance subjects. Generally a more well-rounded program is emerging although we recognize deficiencies in both quality and quantity of training in various subjects and locations.

Although not in practice but on the immediate horizon is advanced university training of selected individuals for careers in fire control. We have selected several individuals this year for this training under the national training act which permits the Government to finance this training. They will be given some choice in their advanced work under general guides. We hope their specialties will vary but we want them to have general objectives. Arrangements for such advanced work have been made at Yale and the University of California.

At the national level we have underway several projects to improve our training program. Training is high priority work since it involves so many people and is so vital to success of our entire fire control efforts.

Simulation is the watchword in training these days and we have endeavored to utilize its advantages as far as we could. A special project on simulation has been underway about a year and we are near a contract with a leading development company for a completed training problem and related equipment. We have had some men attend national seminars and work conferences in simulation such as that in management conducted by the American Management Association. The principles of simulation have long been applied in our fireman schools, in national courses, and at other fire training, but we know there are many opportunities to do more of it.

Closely related to this simulation work is the use of training machines in our training. The opportunities in this field look particularly promising. Self training has always been a strong part of our program but with training machines we can apply the best techniques, teachers, and methods to individual learning.

We have leaders in this field assisting us in getting this program started and the outlook is particularly good, especially in certain fields of study.

As a strong base for training we recognize the need for basic instructional material. Our national Fire Control Handbook and specific guides such as the Fireman's Guide, Air Tanker Guide, and Air Operation Handbook are examples of fundamental material on how, when, and where to do fire jobs. We also have a national project to develop training films to aid local training efforts. Several films have been completed recently and are in widespread use. Others are in the planning or making stage. We recognize a film is merely an aid and part of a total program for any subject. Some films are aimed at general orientation and others are more specific on "how to do" jobs.

Looking ahead there are many things we plan or hope to do on training. Training machines, simulation, films, and other aids may be made better and more specifically devoted to accomplish defined objectives. We need better facilities in training centers. These are being developed now at regional and interregional locations. For many years the proposal for a national fire institute has been discussed. Finances have been one strong deterrent. The idea of a national training center for forest fire control is very intriguing and likely we'll have a facility arrangement for special advanced training for fire leaders. I'm sure, too, we'll tie more closely to universities in this work. They have facilities and discipline capabilities of many types that could not reasonably be assembled any place else. They should be able to arrange specific courses for the particular needs of fire organizations. The forthcoming staff and command school to be held by the Office of Civil and Defense Mobilization for both rural and urban firemen is a great opportunity to get underway advanced fire instructions for all fire leaders.

Not strictly training but closely allied to it is the problem of selecting the right people for fire control careers. Little has been done on this in our field and we recognize the deficiency. We are making a start in it in selecting smokejumpers, but this is not on the major problem. Those not capable of becoming good fire men or with the wrong mental attitudes must be taken out before we apply expensive training. From what my urban fire friends tell me I understand they have done much more on this than we have. We also need to analyze jobs more thoroughly to know just what men in certain positions do and how well they do it. Because of the importance of the position we are making a study of our crewboss who is the key leader of men in our suppression organization. We know these men are not always as strong as they should be, but we need to know more about how they perform. what they know, how best to select and train them, and similar requisites.

The fire training outlook is encouraging. New techniques, new aids, different ideas, more funds, greater recognition of training, and the general demand for better fire control, all point to better forest fire control training in the future.

FIRE WHIRLWINDS IN THE LABORATORY

GEORGE M. BYRAM, *Physicist,* and ROBERT E. MARTIN, *Research Forester, Southeastern Forest Experiment Station*

Most experienced firefighters have encountered fire whirlwinds. These whirls, or "fire devils" as they are sometimes called, range in size from small twisters a foot or two in diameter up to violent whirls equal to small tornadoes in size and intensity. Graham[1] gives examples where tornado-like fire whirls have twisted off large trees and lifted large logs. Whirlwinds have also occurred on urban fires. In his account of the great Chicago fire of 1871, Musham[2] states that burning planks were lifted by fire whirlwinds and dropped as far as three-eighths of a mile ahead of the main fire. He attributes a large part of the destruction of the city to burning material carried by the fire whirlwinds.

Because of their importance as a hazard to firefighters and as a cause of rapid and erratic fire spread, fire whirlwinds are one of the fire behavior phenomena being studied at the Southern Forest Fire Laboratory at Macon, Ga. These whirlwinds can be produced readily on a small scale and studied by modeling techniques.

In the past miniature whirlwinds have been produced in several different ways. In some of these there was no heat source. In others steam or heated water vapor has been used as a heat source. Usually the initial cylinder or cell of gently rotating air was produced by a blower or fan. However, a thermally driven whirlwind appears to work equally well and has the advantage of being partially self-regulating.

Chambers for producing thermally driven fire whirlwinds on a model scale are shown in figure 1. The large chamber on the right consists of a cylindrical shell 26 inches in diameter and 72 inches high over which is mounted a truncated conical shell 60 inches in height. The cone tapers from a base 26 inches in diameter to a top 13 inches in diameter. The front half of the cylinder is transparent plastic; the rear half of the cylinder and the cone are fabricated from poster board. Air enters the chamber through two ¼-inch tangential slits located on opposite sides

[1]Graham, Howard E. A fire whirlwind of tornadic violence. Fire Control Notes 13(2): 22-24, illus. 1952. *Also,* Fire whirlwind formation as favored by topography and upper winds. Fire Control Notes 18(1): 20-24, illus. 1957.

[2]Musham, H. A. The great Chicago fire. Papers in Illinois State History and Transaction for the year 1940; The Illinois Historical Society, Springfield, Ill., 69-189, illus. 1941.

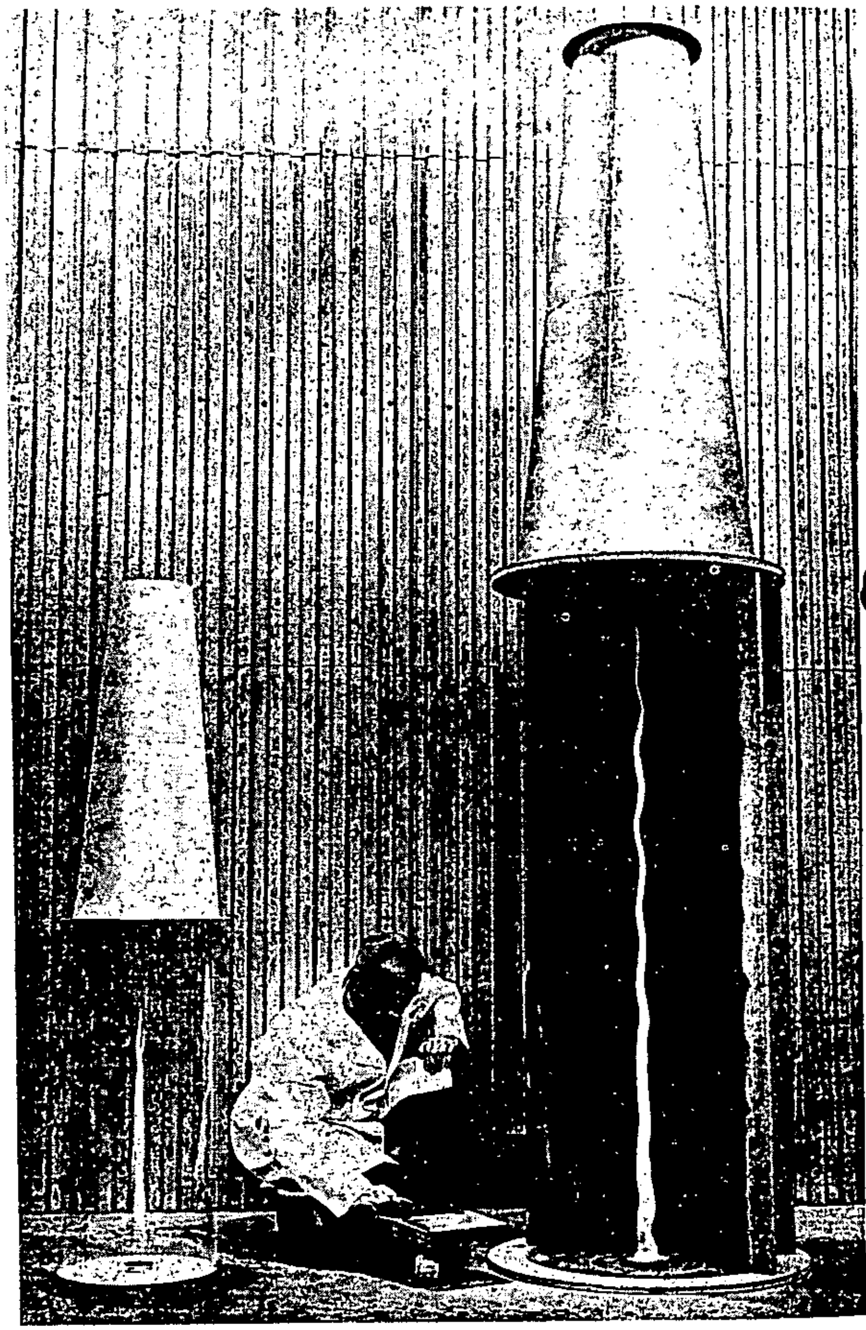

FIGURE 1.—Two sizes of fire whirlwind chambers of slightly different design. The large chamber on the right can produce whirls up to 11 feet in height. The small chamber on the left forms whirls from 15 inches to 36 inches in height.

of the cylindrical section, producing a gentle rotation of the air inside. The heat source is a pool of burning alcohol 4.8 inches in diameter and ½ inch deep located on the vertical axis of the cylinder. Its rate of heat output is about 11 B.t.u. per second, or slightly less than half the output of an average oil house furnace.

The small chamber in figure 1 was built as a portable demonstration chamber. It has an all-plastic transparent cylinder 15 inches in diameter with one tangential air entrance slit. The conical section is thin cardboard and tapers from a base 15 inches in diameter to a top 8 inches in diameter. Both the cylinder and the cone are 3 feet in length. For portability the cone can be inverted and placed inside the cylinder. Depending on the size of the burning alcohol pool, it can produce whirlwinds from about 15 to 36 inches in height. Those more than 25 inches in height show most of the features that can be seen in the whirlwinds in the larger chamber.

After the alcohol is ignited in the large chamber, the whirl forms in 20 or 30 seconds. At first the alcohol pool burns with a lazy flame. As the heated air rises and cool air flows tangentially into the chamber, the flame becomes tilted in the form of a curved arm which slowly rotates around the pan. The tip of this flame then curls back on itself and begins to spiral upward, forming the base of a crude, off-center vortex which finally stabilizes over the center of the alcohol pool. The whirl is then visible to a height of 3 or 4 feet (fig. 2), with a smooth inner column surrounded by strands of flame spiraling upward. The whirl gradually lengthens and becomes thinner. In the fully developed whirlwind, the average diameter of the inner tubelike column is about three-fourths of an inch and is visible to a height of 9 or 10 feet. At this stage the smooth inner column, which corresponds to the funnel of a tornado, constitutes most of the fire whirlwind (fig. 3). The outer spiraling flames form a column about 1.6 inches in diameter and are visible to a height of about 18 inches above the burning pool, as shown in figure 4.

For its size, the model whirlwind appears to generate a very high velocity in the hot gases spiraling upwards. This velocity has a horizontal component which creates the spin or rotation, and a vertical component, or updraft, which carries the heat from the burning fuel upwards. Although they will have to be verified by direct measurement, approximate values of these velocity components can be calculated from the energy equations using the temperature and dimensions of the whirl. The horizontal component comes out to be about 20 or 25 miles per hour at the surface of the inner column, which would give it a rotation of about 6,000 or 7,000 revolutions per minute. More surprising, and possibly more significant from the fire behavior standpoint of full-scale whirls, is the probable high updraft velocity, which has a computed value of about 40 or 50 miles per hour. If an updraft on a full-scale whirl had a velocity of five times this

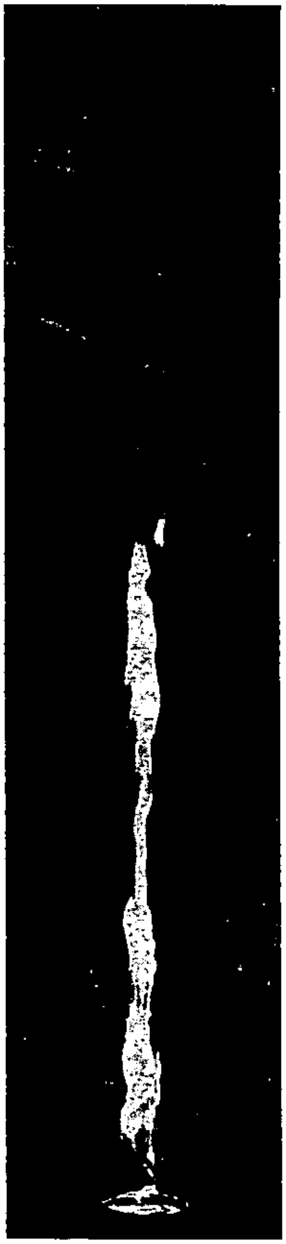

FIGURE 2.—A fire whirlwind in the large chamber in its early stages of formation. A tube or tornado funnel has started to form inside the whirl near its base.

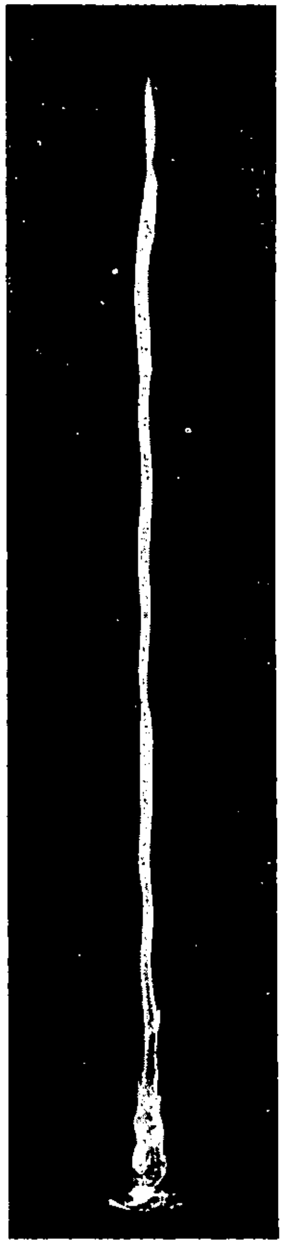

FIGURE 3.—The visible part of the fully developed whirlwind consists mostly of the smooth central column or tube, which has a very high rate of rotation.

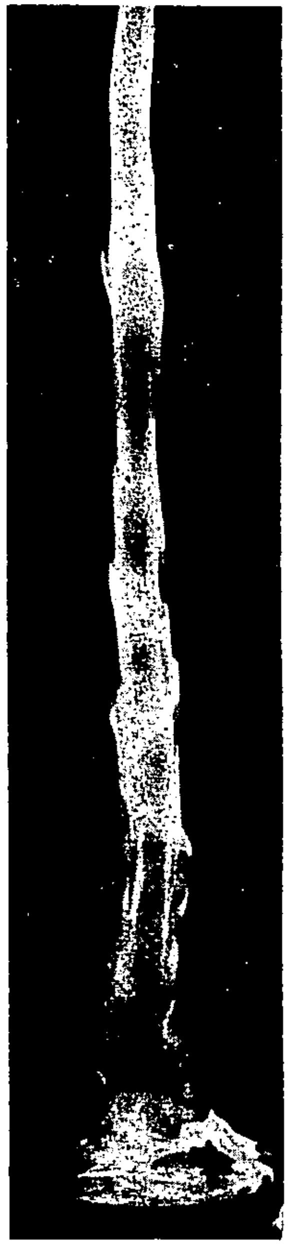

FIGURE 4.—A closeup of the lower part of the fully developed fire whirlwind showing the strands of flame spiraling upward around the central tube.

value, it would explain the lifting capacity of the fire whirlwinds described by Graham and Musham.

Another significant feature of the model whirlwind from the fire behavior standpoint is a sudden three-fold increase in the alcoho. burning rate when the whirl forms. It is possible that a marked increase in burning rate also occurs in forest fuels when whirlwinds develop.

The principal value of model whirlwinds, and other types of convection models, is in the detailed study of their physical structures and dynamic characteristics (such as vertical and horizontal velocities). Through the application of scaling laws a better understanding of the cause and behavior of the full-scale phenomenon should be possible.

TESTING AND EVALUATING CHEMICAL FIRE RETARDANTS IN THE LABORATORY[1]

D. L. DIBBLE, S. S. RICHARDS, and L. V. STECK
Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service

Western fire control agencies dropped 7 million gallons of fire retardant mixtures from aircraft in 1960. They are continuing aircraft drops in 1961 and are testing both retardants and suppressants in fire trucks. It is not surprising that firefighters have expressed considerable interest in learning how new materials are selected for trial on actual fires. This paper describes the first steps in the process of seeking new or improved materials and the laboratory methods used in this preliminary screening. Subsequent steps include small-scale field trials on forest and range fuels and then operational tests on wildfires.

Before any new material can be tested by field or operational trials, a great amount of factual information is required. For example, the men in charge of forest firefighting will need to know if ample supplies will be readily available; what the material will cost; whether special techniques will be needed in mixing, handling, and storage; and if the mixture could damage equipment or endanger personnel. Firefighters will also want specific answers to the following questions:

1. Are high temperatures or other chemicals required to obtain applicable mixtures?
2. How will the retardant mixture be affected by the acidity or alkalinity and hardness of the water to be used?
3. Does the material adhere well to fuels when first applied?
4. Does the coating tend to crack or crumble under extreme drying conditions?
5. Is the material sufficiently slippery to constitute a hazard to men working around fire trucks or aircraft?

Much of this information can be obtained from brochures of suppliers or through correspondence with the manufacturer. For some of the questions, however, specific answers must be obtained by laboratory evaluation.

PHYSICAL AND CHEMICAL PROPERTIES

Mixing

Simple tests will show whether the product is readily soluble in hot or cold water and whether it requires mixing by rapid agitation or by injector-type mixers. The effect of the acidity or alkalinity and the hardness of the water on the test mixture can be observed at the same time. When available, the manufac-

[1]Issued Aug. 1961 as Pacific Southwest Forest and Range Expt. Sta. Misc. Paper 59; original paper included illustrations and list of references.

turer's recommendations are very helpful in determining the best method of making a solution of the proper viscosity. A sample of the mixture is placed in a beaker and its viscosity recorded at room temperature with a Brookfield viscometer.

Stability

Fire retardants to be used by initial-attack aircraft or ground tankers often have to be mixed and stored in advance of anticipated use. To determine stability of stored mixtures, a beaker sample is placed in an oven maintained at 80°F., and viscosity is measured after 24, 48, 168, and 720 hours. The mixture is checked to see if the retardant has tended to separate or has remained in solution, if evaporation has been excessive, or if bacteria have caused spoilage. To prevent spoilage, a preservative may have to be added to the mixture.

Corrosiveness

The corrosive action of a fire retardant on metal parts of fire equipment, such as hose connections, pumps, and storage facilities, may definitely restrict its use. The increased use of air tankers makes it doubly important that corrosive effects of retardants on aircraft parts be known and eliminated, because of the danger to operating personnel and the high upkeep costs of the aircraft. Therefore, suggested retardants are subjected to two types of corrosion tests.

One type is a "static" test conducted according to the method outlined in J. H. Perry's *Chemical Engineering Handbook*. The metals used in these tests are copper, brass, bronze, mild steel, aluminum, and magnesium. Test samples 0.025 inch to 0.075 inch thick are cut into 1- by 2-inch rectangles before submersion; they are lightly polished on a buffing wheel to remove scratches and toolmarks, washed in a solvent to remove any oil film, and dried. The retardant to be tested is placed in 250 cc. beakers and allowed to stabilize for 1 hour at room temperature. A sample of each test metal is then placed in a beaker with the retardant for 5 days. Each test piece is weighed to the nearest 0.1 milligram on a precision balance before and after the test. The weight loss is calculated in milligrams per square decimeter per day.

The second type of test simulates field conditions in which the metals are not only exposed to the chemicals, but to the air as well, or they are alternately exposed to chemical and air. Materials for this "dynamic" test are prepared as for the static test, but the test pieces are suspended from a shaft rotating at 1 r.p.m. so that they are alternately submerged and then exposed to the air for about 30 seconds. This cycle is continued for 72 hours. In both the dynamic and static procedures each test is repeated from two to five times.

Fire Retardant Effectiveness

Three test procedures are used to evaluate fire retardant effectiveness. Two of these tests are relatively simple procedures used to measure resistance to ignition and reduction in combustion

rate. The third, called the "steady-state fire model technique," is somewhat more time consuming, but more nearly simulates fire spread through vegetation. It is usually reserved for those materials showing the most promise in ignition and combustion tests. It should be emphasized that these tests are part of a screening process. They make it possible to determine which materials should be evaluated in the field, but they are not a substitute for field evaluation.

Ignition Test

Resistance to ignition is determined by measuring the time required for treated and untreated maple dowels to burst into flame when placed in a muffle furnace. Sixty-four maple dowels, 1/4 inch in diameter by 5 1/2 inches in length, are prepared for a single test. Eight of them are sawed into quarter-inch lengths for fuel moisture determination by the xylene distillation method. One set of six dowels is reserved as control samples. Five sets of 10 each are used for the ignition test.

All six sets are clamped upright into aluminum holders, placed in a drying oven, and held in circulating air at 115° F. for 24 hours. After drying, the control set is weighed, all sets are dipped 5 inches deep in the retardant to be tested, and the control set is again weighed. All six sets are then placed in the drying oven. The time is recorded. At the end of 1 hour, the control set is again weighed and returned to the oven, and a set of 10 dowels is removed for the ignition test. This procedure is repeated at hourly intervals through 5 hours.

For the ignition test, the dowels are placed one at a time in a holder and inserted in the muffle furnace. The time elapsing before a burst of flame is measured by a stopwatch, and this ignition time for the 10 dowels is averaged.

The control set is kept in the drying oven 24 hours and then weighed. This set provides a record of the amount of retardant and water adhering to the fuel, the water loss each hour for 5 hours, and the amount of retardant adhering to each dowel after 24 hours of drying.

This same test may be made with plain, untreated dowels and with dowels dipped in water, as a basis for future comparisons if required. The test may also be made for different furnace temperatures, usually from 1,000° to 1,700° F. at 100° intervals.

Combustion Test

The ability of a retardant to slow or inhibit combustion is determined by burning treated dowels and recording the resulting radiation intensity and weight loss.

Weight loss is measured with a 5-kilogram laboratory scale. The scale is equipped with an aluminum frame clamped to the side of its main platform. This frame supports a horizontal, slotted metal strip from which the test dowels are hung with a half-inch intervening air space between each. A pan beneath the dowels collects falling ash or charcoal. A Gier and Dunkle

radiometer is placed 9 feet horizontal distance from the fire, and the radiation intensity is registered by a recording potentiometer.

Each test requires four untreated and three retardant-treated ponderosa pine dowels ½ inch in diameter and 7.5 inches long. The untreated dowels produce the heat required to burn the three treated ones with which they alternate on the slotted strip. Each dowel is hung by a small wire brad driven into one end.

Forty-one dowels are needed to test each retardant mixture. They are conditioned 24 hours in the drying oven to approach equilibrium moisture content. Six dowels in a special holder are used as a weight control. The tare weight of the holder is determined, as is the weight of the six dowels. These dowels, together with five other sets of three each, are then dipped in the retardant to be tested, and the weight of the control set is again recorded. All are then replaced in the oven for drying. At the end of each hour of drying time, the special holder of six is weighed to determine the water loss, and three treated dowels are removed from the oven and suspended from the scale in positions 2, 4, and 6 on the slotted strip of metal. Four untreated dowels are hung in the 1, 3, 5, and 7 positions.

A horizontal asbestos wick containing 6.7 cc. of ethyl alcohol directly below the dowels is ignited; at the same time the weight is recorded from the scale and a stopwatch is activated. Every 30 seconds the scale reading is recorded. These readings show the loss of fuel weight due to combustion, while the chart connected to the radiometer registers the radiant heat produced by the combustion.

These records show the comparative effectiveness of various retardants. Some retardants may slow down the combustion process in the treated dowels; others may prevent combustion. The test is repeated at hourly intervals to show the ability of a retardant to remain effective after different drying periods.

Steady-State Technique

In the steady-state test, the rate of spread, the radiant energy, and the convective heat of a fire burning in an untreated portion of a crib of ½-inch dowels are compared with measurements obtained when the fire burns into the retardant-treated part of the same crib.

The fuel for this test is a crib built of 6 tiers of 21 dowels 7.5 inches long and 6 tiers of 5 dowels 35.5 inches long. These dowels are half-inch-round ponderosa pine. They are placed in a jig, glued with small drops of resin, kept under pressure overnight, and subsequently conditioned in the drying oven for 24 hours at 115° F.

The crib is removed from the oven and weighed. One end is dipped 12 inches into the test retardant and then allowed to drain for 5 minutes. It is again weighed to determine the amount of retardant and water adhering, and replaced in the oven for a specified time (1 to 24 hours). It is then weighed again and placed on the movable center strip of the fire table.

The untreated end (in line with the eyes of the operator) is ignited with an asbestos wick containing 6.7 cc. of ethyl alcohol. As the crib is consumed, the operator cranks the fire "front" forward to keep it in a steady position before him, recording the number of revolutions he has turned the crank each minute. A Gier and Dunkle radiometer, which is aimed at the fire and mounted at a horizontal distance of 14 feet, records the radiant energy on a recording potentiometer. The 2 feet of untreated fuel bed gives the fire a chance to reach a "steady state" before reaching the retardant. After this, the drop in intensity and rate of spread, as graphically represented on the recorder charts, forms a basis for comparison between retardants.

In all tests using wood dowels or cribs, the moisture content of forest fuels is determined by xylene distillation and considered in the analysis of the results.

BOY SCOUTS USE HERBICIDES IN FOREST FIRE CONTROL PROGRAM

NORMAN H. DILL[1]
Director of Conservation, Rodney Scout Reservation, North East, Maryland

Since World War II there has been considerable use of herbicides in controlling vegetation, notably along rights-of-way and roadsides. These herbicides have also been used in controlling unpalatable and poisonous plants on the western ranges and deciduous woody vegetation in coniferous forests.

In certain forest regions, breaks of low, stable, relatively nonflammable vegetation are important in a fire control program. In times of emergency such breaks serve for access by foot or jeep and as a base from which to start backfires. Since 1957 breaks of this type have been part of a research and demonstration project in the Conservation Program at the Rodney Scout Reservation, North East, Cecil County, Maryland.

Soil erosion can become a serious problem on these breaks if all vegetation is killed. This is especially true in the southeastern Coastal Plain, and is particularly true at the Rodney Scout Reservation. On such areas a cover of low nonflammable vegetation is needed to stabilize the soil and prevent erosion.

Early Practices not Satisfactory

In recognition of the fire hazard, several firebreaks had been constructed on the 1,050-acre Scout reservation prior to the start of this program. These breaks included not only strips along roadsides and electric powerlines, but also several breaks constructed solely for fire safety purposes. The procedure had been one of cutting and felling the trees, piling branches in large brush piles at a safe distance from the fire break, and rolling the logs to the side. Vigorous resprouting of the forest trees made maintenance of these vegetation breaks a continuing and costly job. For these reasons it was decided to use herbicides to control the vegetation.

Basal Sprays Kill Unwanted Trees

The herbicides used were 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) mixed with kerosene in the ratio of one part commercial herbicide to 25-50 parts kerosene (or fuel oil). They were sprayed on the bases

[1]The program reported here was suggested by Mr. Ted S. Pettit, National Director of Conservation, Boy Scouts of America. Valuable guidance and assistance was received from Dr. Frank E. Egler, Consultant for the Vegetation Management Program at the Rodney Scout Reservation.

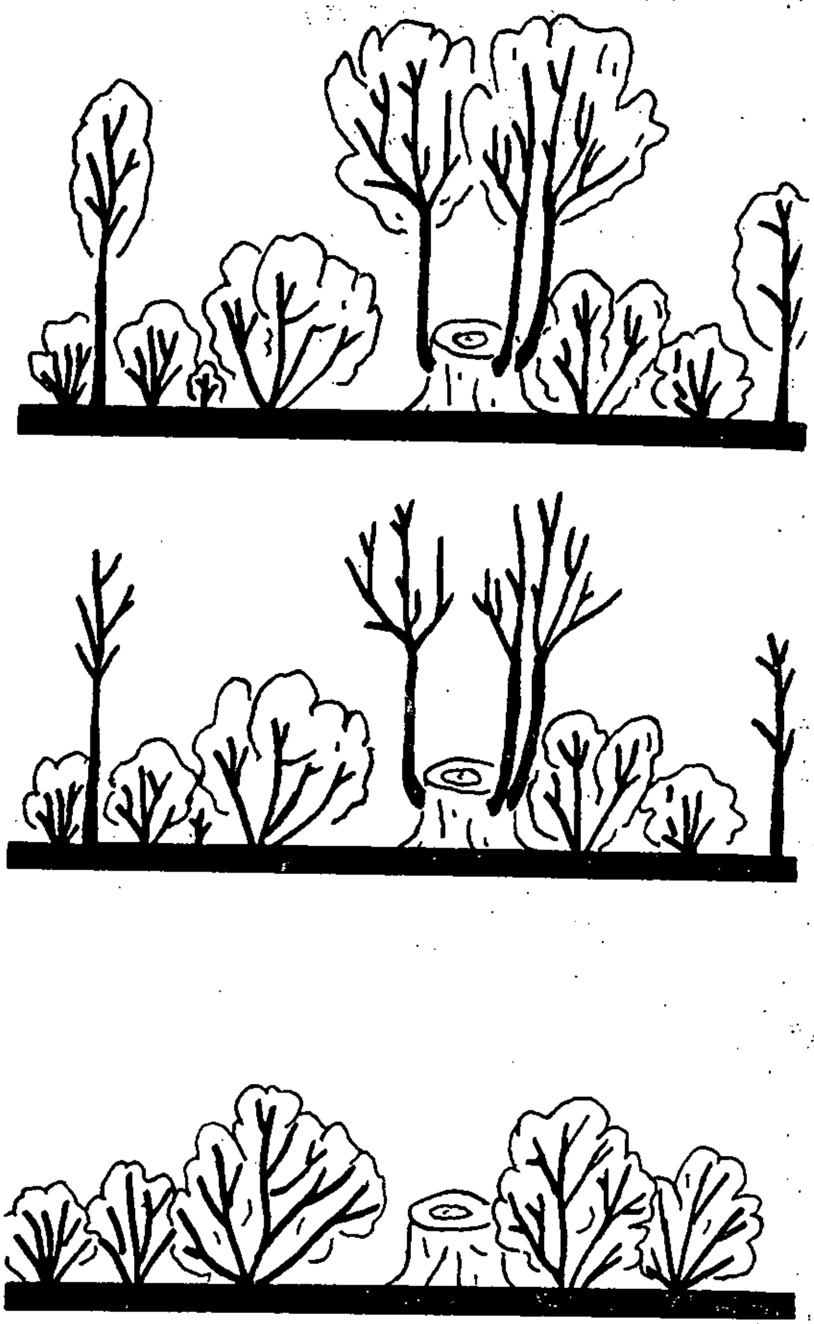

FIGURE 1.—*Top*, Diagrammatic representation of cross section of unsprayed trail showing tree saplings and stump sprouts among shrubs. *Middle*, Same cross section one year after spraying showing death of unwanted trees. *Bottom*, Three years after spraying showing closing of shrub canopy.

of the trees with specially adapted backpack sprayers. Great care was taken to spray only the unwanted tree sprouts and saplings. In new breaks, the stumps of the larger trees are being sprayed soon after cutting, thus eliminating the more costly work of spraying the sprouts a year or two later.

All desirable shrubs such as blueberry, huckleberry, azalea, and male-berry were left unsprayed so that they would grow and form a closed canopy to retard the establishment and growth of tree seedlings (fig. 1).

The powerline vegetation break at Rodney (fig. 2) was constructed in 1955. Part of its vegetation has been under yearly herbicide treatment since 1957 by Scouts working on conservation merit badges. Inadequate spraying and misses were high at the beginning because of untrained Scout assistance. Vigorous sprouting from large oak stumps and excessive rootsuckering from sassafras caused conditions which would not have occurred had adequate spraying followed the original clearing of the break in 1955. Each successive spraying, however, reduced the number of surviving unwanted woody plants and allowed the shrub canopy to close. And most important, *no reinvasion of unwanted*

FIGURE 2.—Powerline vegetation break during August 1959. Note the almost complete closing of the shrub canopy, which retards growth of tree seedlings. The shrubs in the foreground are sweet pepperbush (*Clethra alnifolia*). In the background are blueberries, huckleberries, male-berries, and azaleas. (Photo by J. Bazzoli.)

woody plants is occurring! No spraying will be required for at least 5 or 10 years.

Reinvasion of Woody Species is Low

The soundness of the selective herbicide treatment lies in the relative stability of pure shrub cover. The inability of trees to invade pure stands of shrubs is well known to foresters dealing with the hazel thickets of the Lake States and the rhododendron thickets of the southern Appalachians. The rhododendron balds in the latter areas have been surviving since Indian times.

The application of these principles for firebreaks is reported in another Scout project[2] at the Ten Mile River Scout Camps, Sullivan County, New York. In this area, a stable low vegetation was accidentally developed in one small part of a 40-mile boundary firebreak following the cessation of CCC activities in 1936. This stable vegetation, of a type that can now be purposely constructed by selective spraying, *has already lasted for 25 years* without one dollar being spent upon it, nor have any unwanted trees yet invaded it!

[2]Pound, C. E., and Egler, F. E. Brush Control in Southeastern New York: Fifteen Years of Stable Tree-less Communities. Ecology 34: 63-73. 1953.

A DYNAMIC TRAINING EXERCISE FOR SUPPRESSION CREWS

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Assistant Fire Control Officer, Angeles National Forest

There is need for new training approaches to meet the increasingly specialized and difficult fire training job. A dynamic "battle"-type exercise for all categories of fire suppression crews offers many challenges to trainees. To be fully effective, such an exercise must fit the needs of the large-fire suppression crew and many types of initial attack crews.

A particularly perplexing training problem facing many national forests is the followup or maintenance training of initial attack crews. For example, the Angeles National Forest in southern California has a sizable training program for its 22 five-man ground tanker crews. It needed an inexpensive exercise that would require participation by all crew members, stimulate their interest and thinking, force leadership by the crew boss, and be simple and easy to operate.

A fireline game designed to meet these criteria was used by tanker crews on the Angeles during July and August 1961 (fig. 1). Without exception, crew foreman and crew members remarked that this exercise added much to their training and helped to maintain a high degree of interest. The original exercise was expanded and further refined by the foremen during the summer.

The game requires:

1. A magnetic board (about 2 by 3 feet) with a drawing of a small fire whose perimeter is marked off into 20 equal parts, or 20 chains.
2. A colored magnetic marker for each player (or team).
3. A set of practical problems of varying levels of difficulty from 1 chain (easy problem) to 4 chains (difficult problem). These problems are the key to the success of the exercise.
4. A game manager, i.e., crew foreman.
5. Individual players (or teams), i.e., crew members.

Rules for playing the game (to be explained by game manager before starting):

1. Each player (or team) is assigned a colored magnetic marker.
2. The players (or teams) draw for starting positions.
3. The game manager records the order of players.
4. All markers are placed at the initial attack position, marked X.

FIGURE 1.—Tanker foreman exercising two tanker crews with fireline game, and a single crew indoors.

5. The game manager asks the first player whether he wants a 1-, 2-, 3-, or 4-chain problem.
6. The first player (or team) then chooses a problem.
7. The problem is read by the game manager.
8. The player is given a specified amount of time to think of an answer; the time varies from 5 to 30 seconds, depending on difficulty of the problem.
9. The player answers the problem.
10. The game manager then asks if other players agree.
    - (a) If they do, and if the answer is correct, the game manager moves the answering player's (or team) magnetic marker ahead the number of chains assigned to the problem.
    - (b) If the other players do not agree, and if the answer is correct, the answering player must explain why it is correct before his marker is moved.
    - (c) If the other players do not agree, and if the answer or any part is wrong, the answering player loses the same number of chains of fireline assigned to the problem, and his marker is moved back.
11. The next player, and the others in turn, then proceed as above. This procedure forces participation and alertness of all players.
12. The first player (or team) to move completely around the fire wins the game.

The game manager acts as a referee and leader to bring out discussion by all players and to further specific training objectives. He also uses the game to present problems that will bring out key training points he wishes to stress.

Some examples of typical problems for the ground tanker exercise are as follows:

1-Chain problem (low level of difficulty).—Don hands you a wrench to tighten a valve on your tanker. Do you use it? If not, why not? (5 sec.)

2-Chain problem (medium level of difficulty).—Wind is a key weather factor affecting fire behavior. Name two other weather factors of concern to the firefighter. (10 sec.)

3-Chain problem (high level of difficulty).—Your fire is burning in highly flammable fuels on a steep slope. You think of standard order No. 10. What is it? (15 sec.)

4-Chain problem (very high level of difficulty).—What are four important factors in determining your point of attack? (30 sec.)

The fireline game, when properly managed, involves the whole crew, develops interest and keen competition. This game can be used for testing and evaluating trainees during fire training sessions.

TILT BED UNIT MOUNTED ON TRACTOR-PLOW TRANSPORT

Santee Ranger District, Francis Marion National Forest[1]

A tilt bed body, modified as mentioned, was used on the Santee Ranger District, Francis Marion National Forest, during the prescribed burning and fire season 1960-61 (fig. 1). The tractor-plow unit was loaded and unloaded approximately 100 times under all operating conditions during the period. No defects or difficulties in design were encountered. The only disadvantage of the tilt bed in contrast to other beds is that it costs more and requires more time for loading and unloading.

Experienced personnel formerly operating the standard droop tail bed all were enthusiastic in their preference for this new tilt bed unit.

Specifications of body:

- Schwartz hydraulic-operated ramp hoist subframe assembly complete with hydraulic-operated winches and approach plate assembly.
- Lift frame: Double 6-inch heavy (13) channel for 21-foot platform.
- Hoist cylinders: Two 5-inch cylinders with 35-inch stroke, 14-ton capacity, Model 120 T.

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[1]Taken from a report on the use of the tilt bed unit submitted by M. J. Dixon, District Ranger. The use of brand names is necessary to report factually on available data. Their use implies no approval of the products to the exclusion of others which may also be suitable.

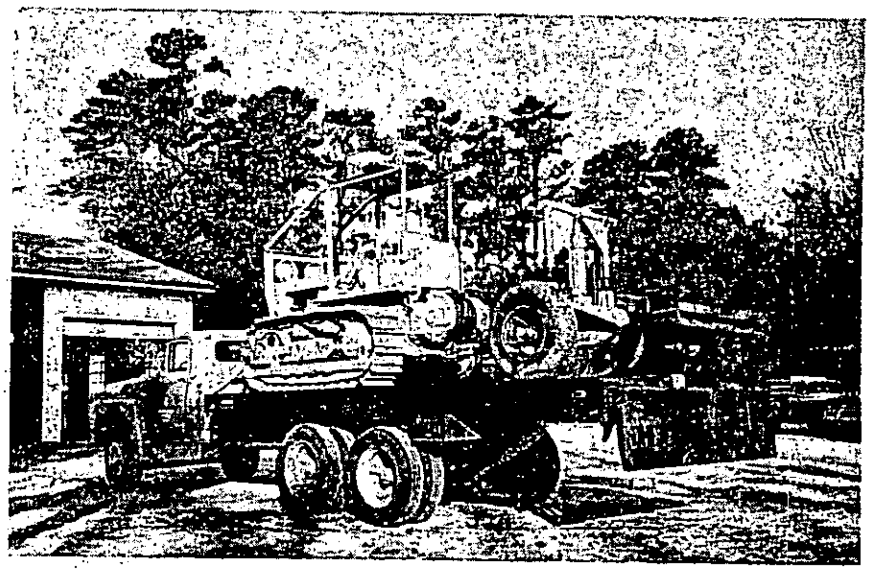


FIGURE 1.—Tilt bed with tractor and plow loaded and ready to go. Approach plate in rear of bed is down.

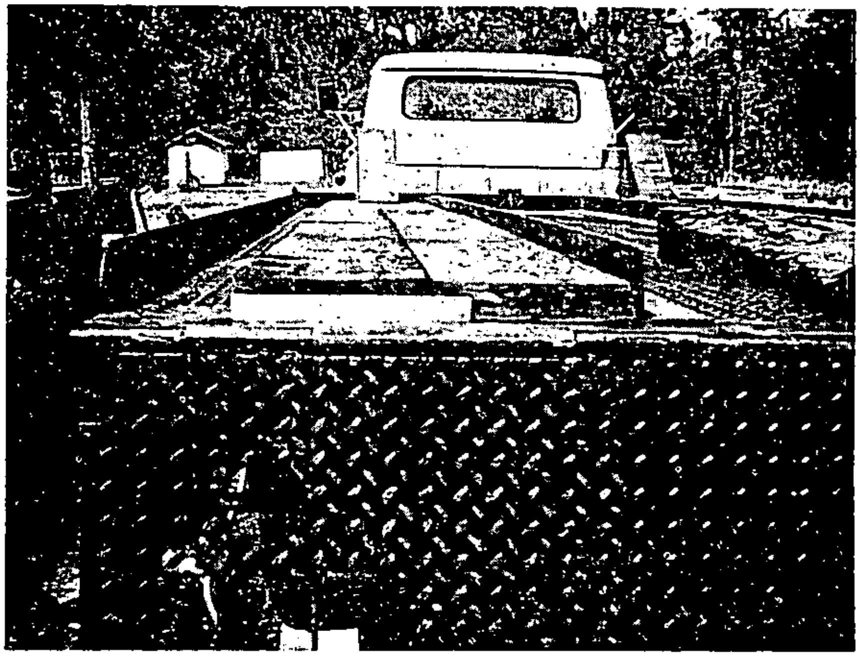


FIGURE 2.—Rear view of bed mounted on truck. Oak planks are 2 by 10 inches for tractor treads. L-irons as track guides are important to prevent side movement while TD-9 is loading.

Winch cylinder: 5-inch, 15,000-pound capacity.
Hold down clamp: Hydra-Spring unit for positive lock and automatic release when bed is raised.
Winch cable: ⅝-inch.
Winch chain: 6-foot ⅜-inch.

The tilt bed transport 165-024 was received on the Santee District October 17, 1960, and put into use in November. The complete unit consisted of a Ford T-700 truck, the tilt bed body, and an International TD-9 with a hydraulic Mathis plow attached.

The unit was driven 2,200 miles, for use on 30 wildfires and several prescribed burn areas. This required loading and unloading over 100 times. The unit proved to be a very satisfactory and dependable piece of equipment.

The tilt bed was used as received with the following modifications:

1. The chocks were moved to a position 2 feet back from the front of the bed to distribute the weight evenly over the rear wheels. The balanced weight made the truck easier to drive.

2. A 4-inch by 8-inch by 4-foot timber was bolted to the bed for the coulter and plow point to rest on. This prevented the plow from moving from side to side and injuring the coulter.

3. The tilt bed winch cable was shortened so that it held the TD-9 tracks tight against the chock blocks.

4. A large safety snap hook was attached to the end of the cable for ease in hooking and unhooking the TD-9, which has a steel pin with nut and safety pin.

5. L-shaped grease fittings facing down were installed under the bed of the truck so it can be greased from below. This eliminates raising the bed to get to the fittings.

6. Four oak 2 by 10's were bolted to the bed (two on each side) for the tracks of the TD-9 to run on. On the inside of these planks, two 4-inch L-irons were bolted as track guides to prevent side movement of the TD-9 while loading and in transit (fig. 2).

7. Two chains were attached to the bed with cold links for securing the front of the TD-9 and the plow. Binders were fastened to these chains with cold links to prevent their being lost.

8. A safety step was welded to the front of the bed.

Standard procedure for unloading the TD-9 (fig. 3): (1) With truck engine running, set hand brake; (2) engage bed gear; (3) set throttle to fast idle (the faster the engine runs the faster the bed operates); (4) start tractor, release brakes, and place in neutral gear; (5) raise plow to clear bed; (6) lower bed

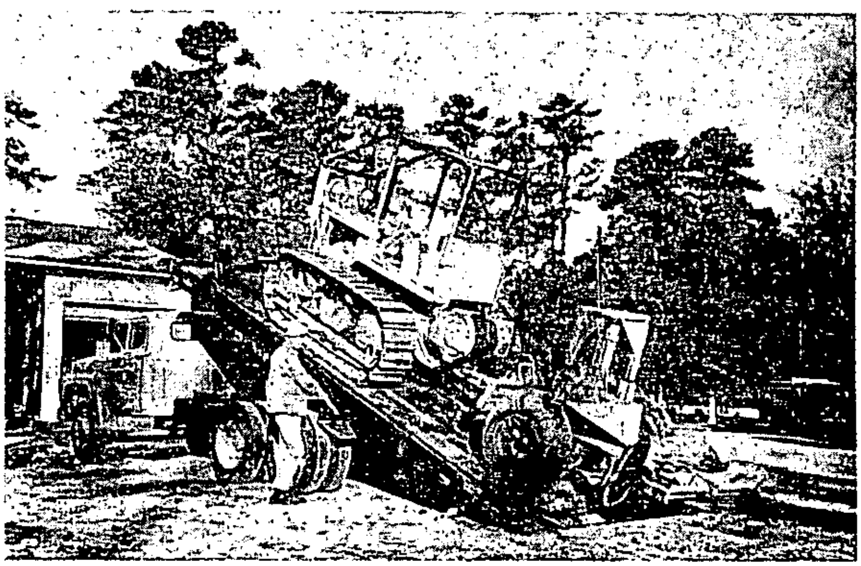


FIGURE 3.—Tractor and plow being unloaded from tilt bed. Operator is manipulating controls. This is the maximum elevation of bed. Tractor and plow are descending slowly; held back by cable. Operator can ease the tractor unit down. Weight and momentum of tractor-plow unit permit sufficient descent until all except the last cleat of tractor is on ground. Momentum is not sufficient to have all of the treads flat on ground. Note approach plate is parallel.

to ground; (7) let winch out until tractor stops; (8) unhook winch cable; (9) drive TD-9 away; (10) turn off truck engine.

To load, the procedure is reversed.

The tilt bed body cost $2,852 complete. A droop tail body mounted on an identical transport cost $1,200. In our opinion, however, the tilt bed body is superior to the droop tail and worth the extra cost. There are no heavy runners to handle; this eliminates a danger of ruptures. Danger of tractor falling from bed and injuring driver is reduced. Loading and unloading are easier and safer; tractor is under control from ground at all times. An expert tractor operator is not needed to handle loading and unloading; personnel trained in elementary operation can handle this procedure. Truck can be used to haul other equipment and is more versatile. The entire unit is shorter than the droop tail when the approach assembly is down. The truck handles better than conventional droop tails.

FOREST DISPLAY RACK

Arcadia Equipment Development Center, U.S. Forest Service

Time and again fire protection personnel and resource officers are called upon to exhibit a wide variety of items. Foresters often display posters, photographs, timber products, collections, or new tools at ranger stations, at fairs, and in public buildings. At this Center we have found that these requests involve quite an investment, especially in man-days. It appeared that a little more care in initial layout could make such displays usable for many occasions. Much of our show material was being seriously damaged, primarily in transit and in storage.

For our use we needed a large mounting surface. Often several display boards were required and this created a transportation problem with vehicle space at a premium. Excessive "wear and tear" was another consideration. To help overcome these limitations we designed and built several racks including the features described in the following paragraphs.

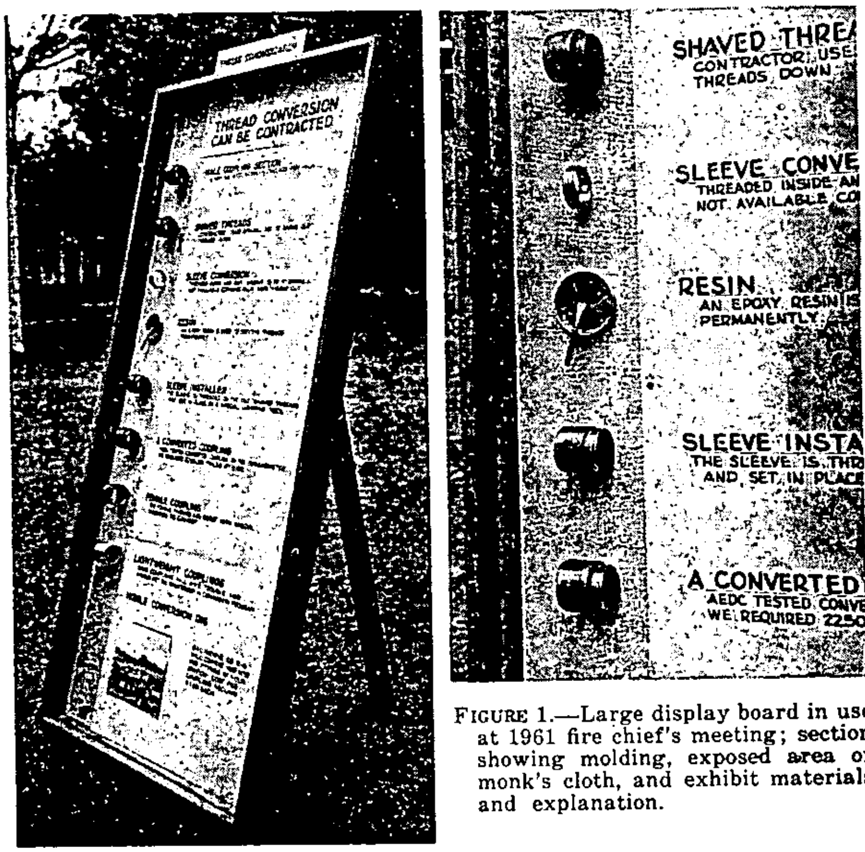


FIGURE 1.—Large display board in use at 1961 fire chief's meeting; section showing molding, exposed area of monk's cloth, and exhibit materials and explanation.

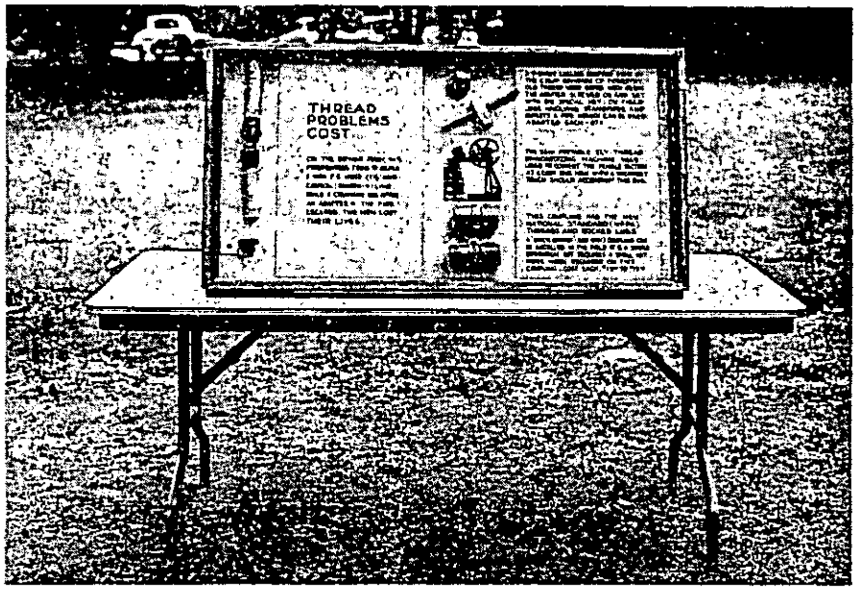


FIGURE 2.—The smaller display board demonstrating hose thread standardization.

A 36- by 68-inch section of ¼-inch pegboard was covered with good-quality monk's cloth. A sturdy frame of 1- by 4-inch material was fitted around the board (fig. 1). The board was held in the frame by quarter-round base shoe fastened with long wood screws. Assuming that there would often be display items on the board while in transit, the back was recessed as deeply as possible in the frame to protect them. Each display rack was carefully tailored to lie flat in the bed of a station wagon and, if necessary, several could be stacked.

A leg of 1- by 4-inch material has been hinged to the top of the frame. A chain keeps the leg from swinging out too far. When not in use the leg is pinned flat to the back of the rack.

We also built a smaller display rack which sits nicely on the top of a fire camp table. This 24- by 48-inch unit (fig. 2) is supported by two short legs.

The monk's cloth covers the holes in the pegboard and lends an attractive, professional appearance. The yardage is not costly and provides a good surface on which to mount or hang pictures and posters. If the peg holes are used the threads of the loosely woven cloth can be easily separated without damage.

This display board offers a large mounting area on a sturdy, easy-to-handle rack. The exhibit is protected in transport and in storage. After long hard miles on the road and a number of scheduled showings the basic material is still neat in appearance and ready for the next assignment. We believe the cost of the display rack will be saved many times over.

INCREASING THE HEIGHT OF STEEL FIRE LOOKOUT TOWERS

Owen T. Jamison
Fire Staff, Georgia National Forests

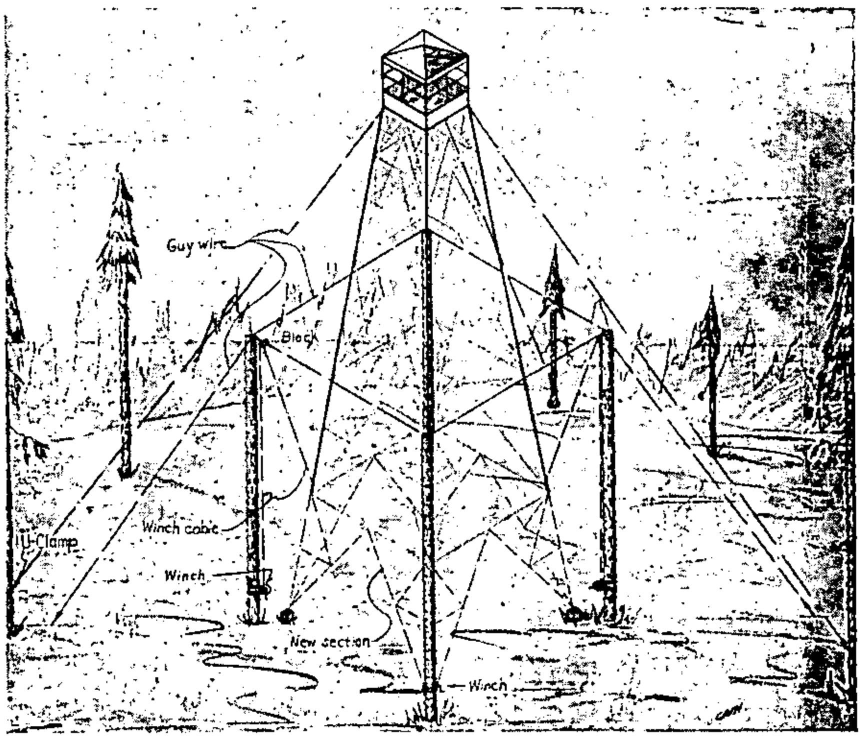
On high site index areas, especially in the South and Southeast Coastal Plains, timber growth is blocking visibility from many fire lookout towers. In such level areas, cutting trees near the tower will not restore adequate visibility.

The Croatan Tower, Croatan National Forest, New Bern, N. C., was blocked in by 60-year-old loblolly pines in 1960. The decision was made to increase the height of the tower from 100 to 120 feet.

Rather than dismantle the tower, the contractor lifted the entire tower 20 feet and bolted in the new 20-foot section.

The following steps illustrate how the job was done:

1. Larger and wider spaced foundations were constructed to the tower manufacturer's specifications.
2. Four 50-foot poles, one on the outside of each of the new foundations, were set. Cross braces were installed on



the poles at ground level to give more bearing surface in the soft soil. These poles were green, unpeeled loblolly pines.

3. The poles were guyed well to ground anchors and tied together at the top and midpoint. A powerline construction crew subcontracted this rigging job.

4. Heavy hand-cranked winches were attached to the poles.

5. One-half-inch wire rope was threaded from the winch spools, up through blocks at the top of the poles, then down and attached to the tower legs near the base.

6. Three-fourths-inch wire rope guys were attached to each top corner of the tower and to trees or other anchors 150-200 feet from the base of the tower. U-bolt clamps were used to secure these guy wires.

7. The base of the tower was unbolted from the old foundation.

8. The tower was centered between the new foundations by rolling on pipe rollers.

9. The new 20-foot section was then fabricated onto the new foundations.

10. Four men, each operating a hand winch, raised the tower evenly within the new steel base section.

11. When the top guy wires became taut, the U-bolt clamps were loosened on one guy wire at a time and the guy wire allowed to sag about 2 feet.

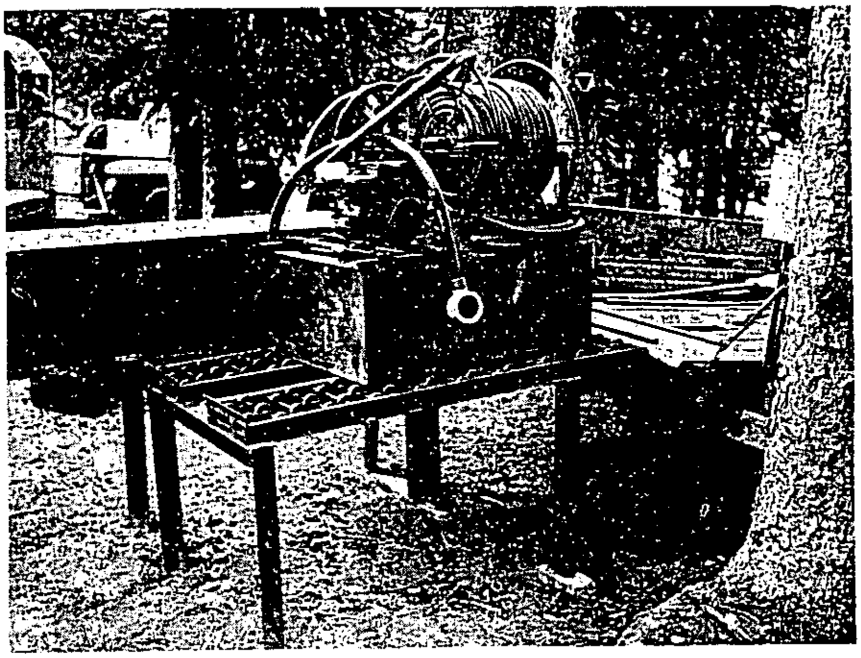
12. When the base of the tower was raised up to the top of the new section, the two parts were bolted together.

Steps #7-12 were finished in one working day to minimize the chance of an unfavorable weather change.

FIRE PUMP AND TOOL BOX LOADING PLATFORM

LYNN H. JONES, *General District Assistant,* and EDWARD D. DAY, *Assistant Ranger, Hahns Peak District, Routt National Forest*

This loading platform makes it possible for one man to load a 50- to 100-gallon pumper full of water or a 10-man fire tool box in a pickup. It consists of track rollers welded to ¼-inch angle-iron legs, 2 by 2 inches in size, with cross braces of the same size. The rollers extend 6 inches beyond the legs on the loading side. The bottom of the rollers can be slightly higher than the pickup



bed so that the truck can back under the rollers with the end gate down.

The pumper unit or tool box can be rolled into the truck on two or three pieces of 1-inch pipe. When the pumper is loaded, it should be blocked to prevent rolling around while traveling. Cost of the platform for a pump is $20 plus cost of the track rollers, which varies depending on the quality purchased.

POSSIBILITIES FOR USE OF A TEACHING MACHINE

BERT HOLTBY
Forester, Division of Fire Control, U.S. Forest Service

There is no argument about the need for highly trained fire personnel; we know that after we have set objectives and policies, organized, staffed, and established controls, the successful accomplishment of the fire management job depends on the performance of the assigned firemen and fire officers. The efficient performance of these men is largely built through successful training efforts, combined with experience.

Most wildland fire control leaders have long been concerned with the challenge of how to effectively train sizable numbers of personnel to accomplish a fire management job of increasing complexity. The sharp buildup in fire personnel during the fire season, the high rate of turnover of part-time employees from year to year, the increased use of specialized fireline equipment, the development of air attack, and the need to train more individuals in more subjects, are but a few of the factors complicating our training effort.

Military and industrial organizations have faced similar problems due to the growth and complexity of "space age" technology. Since the end of World War II, there has been a concerted effort by many military and private organizations to improve training programs to meet these changing requirements.

Likewise, much effort has resulted in some improvements in fire training approaches, methods, and tools. However, in the United States the general approach has remained about the same over the past 20 years.

Now, however, we have the opportunity to use a newly developed training approach, with its special tool the teaching machine. This could provide a major improvement in our overall training efforts.

During the past year a number of newspapers and periodicals have printed articles on this training tool—the teaching machine containing programed learning or self-instructional lessons. These articles have aroused interest among many individuals and organizations, who are also looking for an efficient method to help meet their increased training requirements. Most of these articles have indicated that through the proper use of teaching machines more effective training can be done in less time.

What is a teaching machine? For our purpose we can define it simply as a "device operated by the trainee which presents a lesson in such a way that it may be understood and retained". Some of the significance of such a device may be seen in these points.

1. Instruction is provided by a written "program," which is presented by means of a machine, independent of instructor assistance.
2. Learning occurs at the individual's rate of speed.
3. Two-way communication is provided between the machine and the learner, the trainee receives immediate knowledge of his progress.
4. The lesson sequence is presented in a series of instructional items which require immediate trainee reply.

The machine is only the vehicle that presents the lesson or instructional materials. To understand the principles of the teaching machine approach, let us describe a typical operation:

1. The trainee is seated before the teaching device.
2. It presents information, illustrations, and questions or problems by means of say a 35-mm. filmstrip.
3. The trainee studies the information and answers the questions and problems by selecting from several possible answers.
4. The trainee then pushes one of several response buttons.
5. The button action uncovers the answer and indicates whether or not it is correct.
    a. If not correct, the machine so indicates and shows some additional information to allow the trainee to understand the training point or idea.
    b. If correct, the trainee turns to the next item.
6. This process continues until all the lesson has been presented and answered correctly by the trainee.

Teaching machines are not new. A very early effort in this country was made by a scientist in 1866; but the present teaching machine work was started about 1926 at Ohio State University by Dr. Sidney Pressey. It was not, however, until the early 1950's that a number of educational leaders in the United States recognized the value of a device that permitted the learner to take an active role in the learning process and to provide him with immediate knowledge of his performance. By 1959 national interest had developed to a high point as evidenced by a growing number of research and development projects carried on in many universities and in a number of military and industrial organizations.

During 1960 and 1961 interest in the teaching machine grew at an extremely fast rate. The available machines vary greatly in size, complexity, and cost.

Psychologists have performed many experiments that show a person usually learns best when—

1. He learns easily.
2. He does something as he learns, that is, "learns by doing."
3. He receives a reward for learning.

Any successful teaching program is based on these three psychological learning principles.

Psychologists also point out that a trainee becomes discouraged when he has trouble with a subject, arithmetic, for example, and makes many mistakes in each day's lesson. Often the trainee says

he "hates" a subject, and may develop an unconscious block, or barrier, against learning it.

"If he can learn arithmetic without making mistakes as he goes along," the psychologists say, "he will not build up a mental block against it. And in that case he will work at it willingly and enthusiastically."

Many people are amazed when they hear that students can go through an entire teaching machine program without making, at most, more than a few mistakes. Some people think this means that the students have not really learned anything new.

Tests based on controlled experimental studies, have proved that students do learn in a carefully designed teaching machine course. For example, one class of 8th-grade students finished a whole year's work in algebra in less than one term by the use of teaching machines. They took an algebra test, together with another class of students who had spent a full year studying the same course under conventional methods. The machine-using students received higher marks than those in the other group.

A year later, on a similar test, the machine-users again received high marks. This proved that they still knew the lessons learned many months before.

The program inside the machine.—The lesson, on filmstrip, inside a teaching machine is prepared by a method called programing.

This is how an "expert" goes about programing a subject:

1. First, he breaks the subject down into dozens, or even hundreds, of small steps, or frames. Each step leads to the next, and makes that next step easy to understand.
2. Second, he adds to each frame a question, or questions, that will test the trainee's understanding of what he has just read. The trainee may be asked to work out some problem. He may be shown several possible answers (multiple choice) and asked to choose the right one. Often a question will be asked in several different ways in different frames, to make sure that the trainee really understands what he has seen and read.
3. Third, at the end of each step, the correct answer is given to each question that has been asked in that frame.
4. Fourth, the important steps are repeated in different words and at different places in the program, so that the trainee can review what he has already learned and strengthen his understanding of it.

The most successful programs have been prepared by a team consisting of subject matter specialists, training specialists (or training psychologists), and visual aid specialists.

Developing teaching machine lesson plans is no easy or simple matter. Even with good existing "human" lesson plans, it is a tedious, detailed job requiring much analysis and work to present the material point by point in a logical sequence with reinforcing information. Also, expert technical assistance is needed in preparing graphics, photographs, and visual displays to strengthen the key points in the training material.

Each word in a successful program is designed to buy something in the way of learning, and all unnecessary verbiage is cut out, "chunk by chunk," then "piece by piece," and then "sliver by sliver."

A pilot plant development was started in 1961 by the U.S. Forest Service working with a corporation primarily engaged in the design and development of large, computerized information processing systems. The machine designed for pilot plant use is known as the ikor (immediate knowledge of results). Information, visual aids, and questions are projected onto a screen at the front of the machine.

The program selected for this 'pilot plant' effort is a one hour advanced fire behavior lesson on clouds and associated fire weather.

The lesson has been developed in four parts:

Part I—What are clouds? (A quick review.)
Part II—How are they formed? (A quick review.)
Part III—What type of clouds are there? (A quick review.)
Part IV—What effect do the various types of clouds indicate in terms of associated fire weather? (Main part of lesson.)

Here is an example of *one item* from Part II of the lesson:

(Advanced Fire Behavior) Item 11

WE HAVE JUST DISCUSSED TYPES OF CLOUDS, AND HOW THEY ARE FORMED. NOW, REMEMBER WE ARE ONLY REVIEWING CLOUD *FORMATION*.
NOW, WHAT DO YOU THINK WOULD HAPPEN IF A STRONG WIND ARISES IN THE AREA WE JUST DISCUSSED?

1. Adiabatic cooling takes place and the vapor content of the air becomes uniform.
2. The air mixes and the warmer air at the ground cools as it rises.
3. The cool air high above the ground mixes with the warm air and the warm air cools down.
4. The cool air mixes with the warm air and it warms up.

Feedback to the trainee depends on which button he pushes (figs. 1 and 2):

1. Correct—Good! Go to Item 16.
2. No—but almost right. Go to Item 13.
3. Wrong—not complete. Go to Item 14.
4. Wrong—incomplete. Go to Item 15.

In developing the feedback some items are often illustrated with pictures and might be written as follows:

Item 16. Yes! That's exactly what would happen. In the top part of the layer of air the process of MIXING has

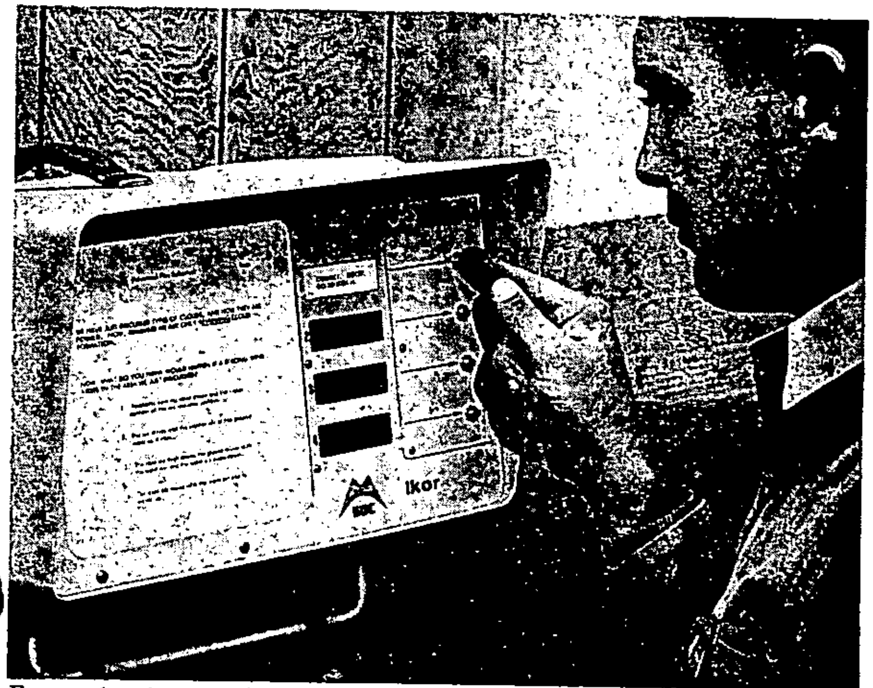


FIGURE 1.—A manually operated teaching machine designed and developed for research in programed learning techniques.

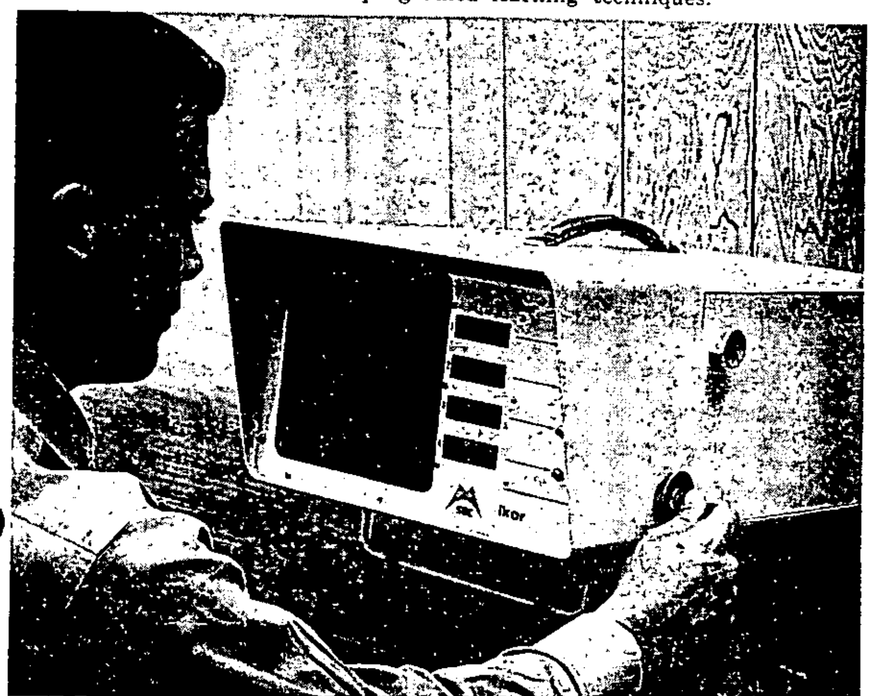


FIGURE 2.—Trainee turning handle to next training item.

created a cooling and an addition of water vapor effect. If enough MIXING takes place, a cloud will form at the top of this body of air.

Remember this though, MIXING usually occurs close to the ground.

Go to Item 17.

Item 13. That's true all right! But you forgot about the *water vapor* part of the MIXING.

Turn back to Item 11 and choose another answer.

Item 14. That's so. However, several other things happen at the same time.

Go back to Item 7 and review.

Item 15. Correct—as far as you went! Several other interesting and important phenomena occur in the process of MIXING.

Turn back to Item 7 and study it carefully. Answer all questions completely as you continue through the section on MIXING.

Part IV of the pilot plant program might begin like this:

Item 62

WE WILL NOW TALK ABOUT HOW CLOUDS ARE INDICATORS OF THE FOLLOWING *IMPORTANT* FIRE-WEATHER VARIABLES:

(a) Wind
(b) Fuel Moisture
(c) Fuel Temperature
(d) Atmospheric Stability
(e) Precipitation

BECAUSE CLOUDS ARE USUALLY ONLY THE RESULTS OF WHAT IS HAPPENING IN THE *ATMOSPHERE*, RATHER THAN THE *CAUSE* OF ATMOSPHERIC CHANGES, WE FIND THAT . . . etc.

The total pilot plant teaching machine program in advanced fire behavior will be demonstrated at the U.S. Forest Service National Training Workshop in January 1962.

A teaching machine with a carefully designed learning program is a "bridge" that permits expert instructors to reach students and to serve each as a private tutor. The idea of a private tutor is probably as old as mankind.

The teaching machine as a training tool is certainly not a magical device; without an efficient program inside it, the machine is simply an empty box. Some significant values in the use of teaching machines are—

1. They provide clear, concise, and complete training when needed, rather than when a "class" and instructor are available.

2. They present uniform information and require frequent responses by the trainee.

3. They provide immediate feedback to the trainee, in-

forming him whether his answer or analysis is correct or not.

4. They allow the trainee to work individually, and to adjust his own rate of progress to his needs and capabilities.

5. They easily provide refresher training.

This tool, if properly fitted into an overall training program, could help provide more effective training and bring about a saving in time.

INFORMATION FOR CONTRIBUTORS

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

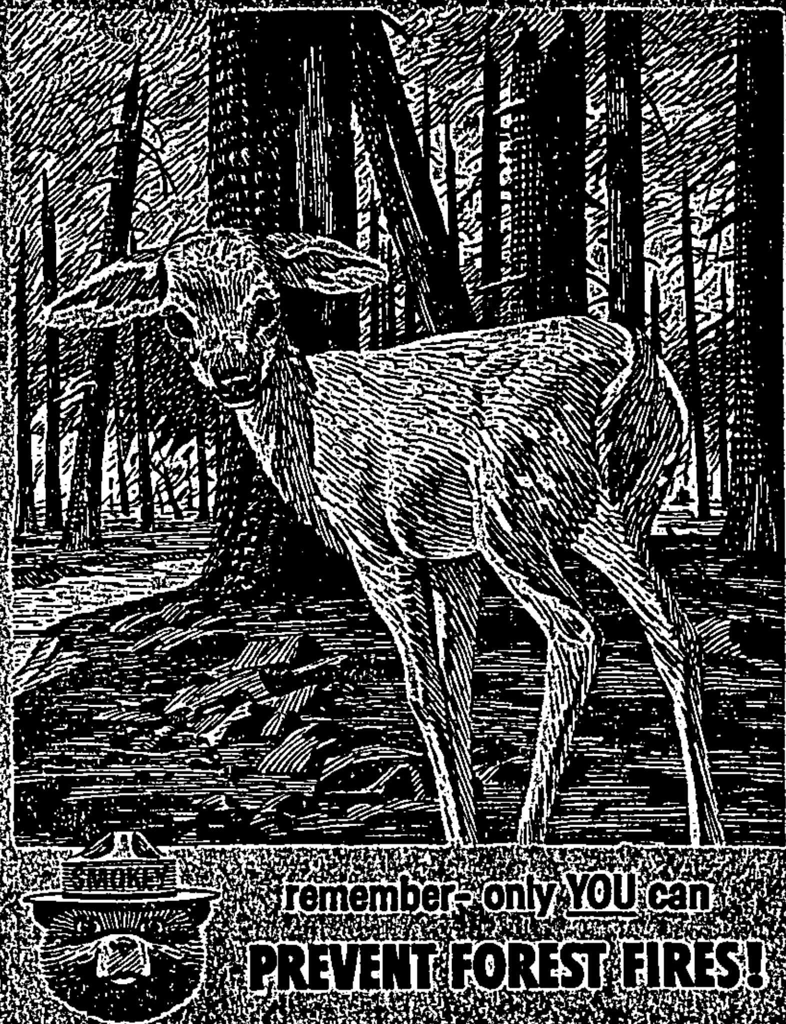
The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information 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. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

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

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


SMOKEY
remember- only YOU can
PREVENT FOREST FIRES!