# PRINCIPLES *of* FOREST FIRE MANAGEMENT

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# PRINCIPLES OF FOREST FIRE MANAGEMENT

*by*

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# FOREWORD

THE FIRST EDITION of this book in 1954 received immediate acceptance among the Division of Forestry fire control people for whom it was primarily written. Then requests for the book began to come from throughout the Nation.

Several new techniques, organizational needs and fire control concepts have developed in the dozen years since the first printing. These have resulted primarily from field experience and the cooperative studies conducted among the several research and administrative agencies actively interested in the complex problems of fire control. Admittedly, the application of these techniques is described here as they impinge upon and have developed within this particular fire control organization. This is essentially a training document for a corps of thousands of dedicated individuals charged with the responsibility of preventing and controlling wildfire over some 28 million highly flammable acres of California, at a cost to the citizens of thirty or more millions of dollars annually.

To those readers who find the writing too elementary in style or content, the authors will quickly reply that they labored hard to accomplish just that quality of simplicity. Our thesis is that the origin and subsequent behavior of a wildfire and the actions taken to suppress it are a matter of cause and effect in a developing pattern of influences and events. The hope is that the serious reader will come to develop habit patterns and a reserve of practical knowledge which, when he finds himself with Fire Boss responsibility, will sustain and guide him.

F. H. Raymond
*State Forester*

Sacramento, California, 1966

# PART I

## Fire Behavior

# CHAPTER ONE

## Principles of Combustion

THE MANNER in which a spark flames into life, flares up, spreads, fades and eventually dies is all in accordance with natural laws. These laws are well enough understood so that Man can predict with reasonable accuracy what will occur when certain conditions of fuel, topography and weather are host to the process of combustion in the forest. If the day ever arrives when the firefighter is in a position to make complete use of such information he may well claim to be master of the situation. Presently we are taking only the first full step in that direction.

The old timer among firefighters is often inclined to forget that knowledge of fire behavior is not the knowledge of instinct. He gathered this knowledge for himself bit by bit from personal experiences as the years progressed. Sometimes he has difficulty in passing along to others that knowledge for the very good reason that he fails to realize how much can remain unknown to the man who has never had the opportunity to personally observe similar events.

To demonstrate this lack of knowledge due to lack of experience a middle-aged man tells a little story about himself of an event that happened more than 20 years ago. That day the young fellow easily reached an observation point near the fire before the old ranger arrived. There before him was a rolling inferno of flames such as he had never before seen. Fascinated and frightened he told himself that all the power of Man could never stop this fire. The old ranger wheezed up, rolled himself a cigarette and mumbled to himself, "The head will run into that old burn in half an hour and by sundown the wind will die and we'll cold trail her." Then he turned slowly to a messenger and said, "Joe go phone headquarters and tell them the fire is under control."

The young man's misjudgment was built upon fear and ignorance. Ignorance is simply a lack of knowledge. The older man certainly had jumped too far to a conclusion but he had made an estimate of the situation and formulated a plan of action with quiet confidence based upon the knowledge of long experience. Such experience requires the passage of years and observation of many errors. Errors of judgment are generally very costly in the field of fire control.

The purpose of this writing is to guide the firefighter away from errors by pointing out basic facts and to speed the process of learning by putting on paper the combined knowledge of many men of experience.

It is not within the province of this writing to dwell upon the improvements that certainly shall be developed in the future for the control of forest fires. Yet it would seem that any machines or chemical agents which may respond to the push buttons of the future will rise from the solid foundation built from the small bits of knowledge gathered in the meantime.

Good generalship in any battle demands that all possible information on the enemy be gathered and studied. The enemy in this case is fire. Properly managed fire has been perhaps the most valuable natural phenomenon enslaved by man. But a glance at fire damage statistics would cause some people to believe that fire is seeking revenge for its enslavement whenever it gets loose.

We have no such illusions. Fire behaves according to very precise scientific laws, and in nearly every case when it runs loose Man is paying the price of his own carelessness or ignorance. In seeking knowledge about fire, the enemy, our first natural questions are: what is it and why does it occur?

Fire, like life and death, must be accepted for what it is, a basic natural phenomenon. We can, however, scrutinize this action which we term combustion.

## COMBUSTION AND THE TRIANGLE

Fire is a chemical reaction sometimes called rapid oxidation. The process is basically similar to the formation of rust on a piece of iron. However, in fire the process is tremendously speeded up.

When many substances are affected by enough heat a flammable gas is released. Then, in the presence of enough oxygen and continued heat, a flame bursts forth. This is fire. With a

continuous supply of heat, furnished by the combustion itself, the process will continue as long as enough oxygen is added to the fuel-gas. Thus it is obvious that three elements or essentials must be present and satisfactorily combined before combustion can occur and continue. For the sake of simplicity we term this the "fire triangle."

There must be **fuel** to burn, there must be **air** to supply oxygen for the flame, there must be **heat** to start and continue the wonderful, useful, sometimes devastating phenomenon we call fire. *Remove any single one and there can be no fire.* In fact, there is no other way to cause a fire to cease burning.

## BREAKING THE TRIANGLE

Of course, the best way to keep the undesirable fire triangle from forming is to keep the three elements apart. It is rather difficult to do much about the oxygen in the **air,** especially if it is provided by great quantities of wind. But we are very conscious of that extra hazard. "Be careful with fire today," we say. What we mean is—the rising wind will furnish so much moving oxygen that your fire will run out of control.

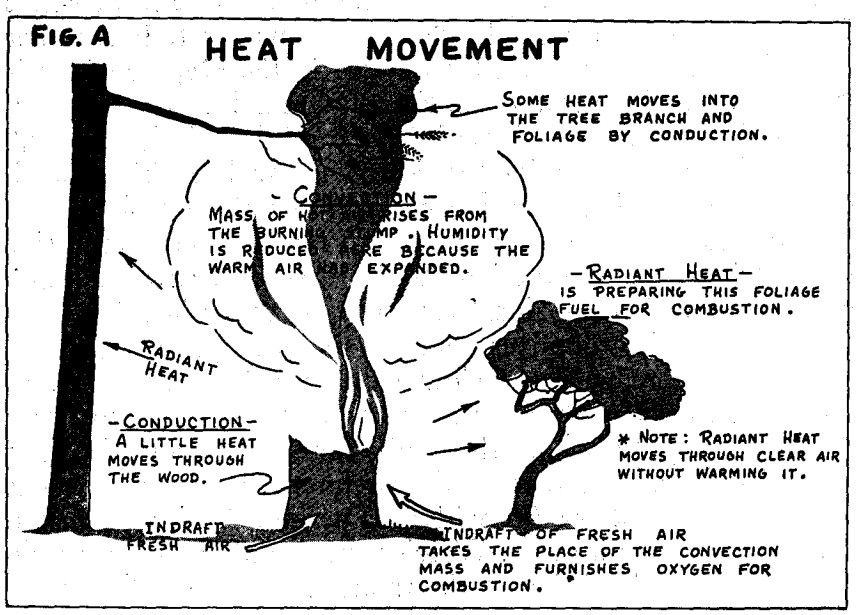
After the fire has started we try to remove the oxygen side of the triangle by smothering the fire with dirt, or some heavy gas such as carbon dioxide, or a spray of water in a fog. It is said that the air around us contains about 21 percent oxygen. If this can be reduced to below 15 percent by the mixture of smoke or non-flammable gases most fuels will cease to burn.

In fire prevention work the public hears most about the **heat** side of the triangle, that is, the preliminary heat that causes ignition. "Don't start a fire without a permit. Break your match before you throw it away. Watch your campfire." Man can do most about the heat side of the triangle, before the fire starts, if he only will. But once the fire has started he has a problem on his hands trying to break the triangle by the process of removing heat, especially if he arrives late and the chemical reaction called fire has built up great quantities of heat.

If he has water available he can apply it to the fuel and the water will absorb heat until it gets so hot it blows away as steam. Water is a very effective heat absorbing substance. Or he can separate pieces of burning material so that the heat is dissipated into cool air. This is effective with burning logs during the nights of late summer. Or while he is throwing cool dirt

on the burning fuel to keep away the oxygen he is also causing the triangle to give up heat because the dirt will absorb heat without turning into steam or into more combustible gas.

Before the fire starts Man talks and does quite a bit about removing the fuel side of the triangle. He builds firebreaks and burns slash in the woods, he proclaims "clean-up" days in the springtime, and he fireproofs some fuels like clothing and Christmas tree ornaments, he passes laws on building construction and for the storage and use of highly flammable materials. After the fire starts in the woods he breaks the triangle by removing fuel with hand tools, bulldozers, and fire used under control. In fact, the removal of fuel is the most important approach to the task of wild fire suppression.




## HEAT TRANSFER

We have learned that a high enough **heat** is a necessary condition before combustion can occur and continue. We know of many methods whereby heat can be applied to a fuel to start the fire process—from the small boy and matches to dry lightning. But how is the process continued, and why is it so important in fire control? We know that heat must move from one morsel of fuel to another or the fire triangle will be broken.

Heat is transferred by three processes of movement: **radiation, convection** and **conduction.** The importance of each to the forest fire problem is in that order.

**Radiation** refers to rays or waves. When you hold your cold hands before a stove they are warmed by radiated heat moving in waves away from the source of supply. The sun radiates rays of heat down to the earth surface and causes it to grow warmer. Then during the cool of night part of that earthly heat again radiates away from the surface into the cooler atmosphere. This radiation of heat is in accordance with a law of nature that is of vital importance to any firefighter, and the most significant phase of that law is the effect of distance upon the quantity of heat transferred. The formula says: the transfer of heat by radiation varies inversely as the square of the distance from the source. For example, let us think of three cold fishermen standing around a camp fire: The nearest is comfortable at a distance of two feet from the fire. The second is four feet away but he cannot receive the same amount of radiated heat unless the fire is made *four times* as hot. The third is standing six feet away from the fire—only three times as far as the first man, but he will suffer from the cold until the fire is made *nine times* as hot. Nine times the heat is required before the third man is comfortable at the mere distance of six feet. Such an increase of heat would probably ignite the clothing of the nearest man. That is the law of radiant heat. The importance of the movement of heat by this process will be observed in later comments on slope, air temperature, and fuels.

**Convection** heat moves in heated air masses. For example, in a room heated by a stove the air in contact with the stove absorbs some heat by conduction. The heated air expands and becomes drier and lighter than the surrounding cooler air. Then it rises to the ceiling, where it drifts about like an invisible cloud. The transfer of heat by convection is quite important in the problem of forest fire control. Masses of warm air arising from the burning forest floor move about raising the temperature of surrounding forest fuels, thus bringing them nearer to the point of ignition. The hot air masses rising through the green foliage of high timber from the burning litter and brush below will raise the temperature and cause drying of leaves and needles to the point where a roaring crown fire could readily "blow up." Sparks and hot embers are carried into new fuel by the convec-

tion air stream. A secondary effect of convection heat movement is the natural in-draft of new cooler air toward the fire. This is an element of importance to be considered in suppression strategy.

Heat movement by **conduction** is not very important between the fuel particles because forest fuels are poor conductors of heat. However, the heating of air in this manner is of importance. In this process the temperature change (heat movement) occurs as heat passes through the material itself just as electricity is conducted through a wire. The poor conduction of heat through wood is the reason why a burning log must be turned over to allow heat from the underside to radiate into the air, or why smoldering fire must be chopped out of a log or tree. Wood "holds fire" inside itself for the same reason that it insulates your house in winter or summer.

*In summary, think of radiant heat as a ray or wave; think of convection heat as an air mass "cloud"; think of conduction heat as being conducted like electricity through solid objects, or from the hot solid to the air which touches it.*

# CHAPTER TWO

## Weather

ANYONE who is even remotely acquainted with the behavior of a forest fire cannot escape recognizing the vital influence of the weather upon the manner in which the fire burns. Likewise, anyone who has undertaken the study of how weather is made and modified in nature and how it is forecast by man should be impressed with the complexity of that science.

The relationship of weather to fire behavior is much too important to be passed over lightly in this writing. Yet we would be wise to detour around the principles of forecasting, which are largely involved with the peculiar habits of the vast cyclonic movements around the earth. While doing this we must not belittle the effect of general weather conditions upon the fuel and fire situation. The storm being born off Alaska or the low pressure area in Arizona followed by strong north wind in California are of tremendous importance. Warning of anticipated weather could very well rank as unsurpassed in value among all of the tools available to the fire manager. However, the point of the moment is that in forecasting we have a project so complex, and requiring facilities so widespread, that this aspect of weather had best be left in the hands of experts with our fervent best wishes.

General external weather influences are actually important to the firefighter only as they bear upon the fuel being consumed by fire at this instant or fuel which may be consumed in the near future. In other words, all of our interest in weather influence is really pinpointed upon the burning condition of fuel material.

In order to understand this **microclimate,** even as an admitted amateur, we must start back near the beginning to obtain an understanding of the great fundamental laws which are constantly at work making and remaking our weather at every level. With this basic knowledge our field observations on weather behavior should be much more profitable.

When the experienced firefighter is given a general prediction of the weather he automatically, and probably subconsciously, converts the prediction into anticipated fuel condition and thence to fire behavior. The long habit of associating brisk, dry winds with severe burning conditions is inclined to make anyone forget that the first is cause and the other effect.

Quite often the effect is not what the fire specialist had expected, including some situations when he considered himself completely master of the fire. It is doubtful if Nature changed any of her rules when this happened; most probably a number of very small things were added together to build up a rather large and overlooked cause. Possibly, while the ranger was whirling a sling psychrometer at an average level of four feet above the ground his old dog was wandering around looking for just the right climate down where the fuel existed. Temperature, humidity, and fuel moisture could have been quite different down there, as any old dog would have known.

But before we become involved in searching out the basic reasons for these small reactions in the local weather a couple of points should be emphasized. The first is that continuous, yet constantly changing inter-related influences are working within, around, and among the several elements of weather which we must segregate for the sake of discussion. Expressed another way this means that while we are considering only wind or humidity or temperature we should remember that any change in one very probably causes a change in all of the others. Secondly, we should keep in mind three great natural laws or factors governing the making of weather upon this earth. These master forces are: heat from the sun, called solar energy; the force of gravity; the desire of all elements to seek a state of balance or equilibrium.*

Just keeping in mind these very elementary natural forces will not qualify anyone as a meteorologist. It will, however,

* For instance, a body (including air) will move with gravity until it finds some substance firm enough to hold it against that pull. Gas will move or expand or contract under one pressure only until an equal pressure conteracts the first pressure. Temperature tries to spread out and equalize itself. A temporary state of equilibrium reached by one element does not necessarily mean a lessening of its influence upon some other element. In fact, the stronger element of the moment may have reached such a state only by upsetting the natural balance of another, or while it maintains a state of equilibrium it may be holding other elements in a very unstable condition.

form a solid foundation from which to observe the making and remaking of our weather, both on a grand scale and within the space occupied by a dry leaf.

## TEMPERATURE

Temperature is a natural phenomenon of utmost importance to the firefighter. We have considered temperature during combustion as an element absolutely necessary to initiate and continue the fire process. Now we approach temperature as an element of the weather. As **solar heat** the temperature has been a controlling factor in the creation of the plant fuel during growth and thereafter in altering the acceptance or resistance of that fuel to combustion.

The range of ignition temperature of wood is between 400 and 700 degrees Fahrenheit. Normally the woody fuels of the forest will burst into flame at approximately 540 degrees (assuming sufficient oxygen to be present). Of course, the time required to produce fire at this temperature will vary with the amount of moisture in the fuel which must be driven out by the heat. Now, the highest temperature which the sun could be expected to develop on a wind-sheltered surface would be 150 or 160 degrees. This is far below any possibility of spontaneous combustion. However, this solar heat is significant—entirely aside from the drying effect of such a high temperature—in that the fuel which gains a boost of a hundred degrees or more as a donation from the sun is well along toward combustion temperature before the igniting spark is applied.

Of course, the firefighter may take advantage of the same rule operating in reverse, especially at sight or during periods of relatively cool air. Heavy fuel may be separated and turned over to cause it to give up accumulated heat into the air.

Elsewhere in this writing there is considered the effect of topography upon weather and subsequent fire behavior. This pertains to the manner in which slope, exposure, latitude and seasons affect the amount of solar heat reaching different plots of earth. So, without worrying about these locally important details for the present we may consider some generalities in respect to heat coming from the sun.

Someone has calculated in broad figures that from the total sun's heat beamed toward the earth about 43 percent is reflected

back into outer space by clouds and haze and the earth's surface. Of the remaining 57 percent, 40 percent is absorbed by the earth and 17 percent by the atmosphere. But things are just beginning to happen at this point. The earth radiates pretty much all of its heat away again into the atmosphere and the atmosphere again radiates some of this heat (plus other solar heat it has collected directly) back to the earth and also some out into space. In other words, great quantities of heat are radiated down upon the earth during the day and less so at night, and the earth radiates it away day and night. And above the earth surface a protective blanket of clouds, haze and air does a vital job of filtering and reducing the solar heat descending to earth and then preventing it all from radiating away the moment the sun has set each day.

It should follow then that a cloud cover will "flatten out" daily temperature trends as compared to those of a clear day. This is exactly what happens during either winter or summer. The firefighter who feels uncomfortable during a cloudy day in summer should obtain some psychological comfort by remembering that the increased humidity, which is the real cause of his discomfort, is joining with the lowered temperature to discourage fire from burning.*

A forest cover exerts considerable influence upon the earth temperature and upon the air between the ground and the tree tops. It is a common saying that forests are cooler in summer and warmer in winter than the outside air. This is no doubt a dependable general rule; however, it has been observed that within the high crown of a forest the temperature may be several degrees higher throughout the warmest part of the day than the air above the trees and the air near the ground. It has also been determined that at the edge of forests and in small clearings there may be greater fluctuations of temperature (including more frost) than in open land for the same reason. Wind movement is discouraged yet radiation of heat downward and upward has little interference.

The movement of air is important to the behavior of a fire because different masses of air affecting the fuel contain differing amounts (or intensities) of oxygen, heat, and moisture to react

* The physical and psychological behavior of the human element at the disposal of the fire manager could well be the subject of a chapter in this writing. Of course, only a specialist in that field could compile it.

with the fuel. We shall discuss part of this under the subject of wind. In respect to the element of temperature in the air we should determine at this point how temperature causes air movement, especially the reversed flow of night winds, and how it hinders air movement by the creation of inversion boundaries.

(a) Atmosphere is a much denser fluid than the average person realizes. That, of course, is because it is difficult to grasp a visual impression of air and because our bodies are adjusted to its pressure. But air has weight. The deeper the column of air, the greater the pressure at the bottom. In other words, the air pressure will be greater as distance descends from outer space to the lowest levels upon the earth. Sea level is, of course, the practical bottom level.

(b) Outer space has very little substantial material to retain heat from the sun so it is cold there. As distance increases away from the earth the air becomes cooler and less dense. That is why high mountains are generally always cooler than lowlands and why they become colder more quickly at light. Heat gathered by the earth at high elevations has a cooler blanket above to quickly absorb the radiated heat.

(c) Disregarding other factors that may affect its behavior, a mass of air moved up and down in free atmosphere would expand and become cooler as it rose, compress and grow warmer as it descended. That is to say, it would equalize or stabilize itself within the surrounding atmosphere.

(d) If a block of air is warmed it is forced to expand. But the internal pressure of the block remains. However, now the pressure is spread throughout the expanded block and must, therefore, be reduced at all places. The greater outside pressure now acts to push this block of warm air up like a cork under water. So the warm air will move up to its own density level, giving up heat to the surrounding air if that air is cooler. Sometimes the rising air mass may "bump its head" on a layer of air of lower density having the effect of a ceiling of pressure and be held there. Or perhaps the rising air has enough strength or pressure to break through this inversion boundary. The inversion layer itself is generally quite stable.

Probably the world's best known inversion layer is that which often hangs against the mountain walls above the Los Angeles lowlands and causes smog to be trapped below.

But smaller and more treacherous inversion traps are well known to experienced firefighters, especially along the north coast. Such situations develop and behave in the following manner. Decreasing temperature and increasing humidity of evening will cause a fire burning in a wooded canyon to "lay down" in the evening and through the night. Warmth from the ground and the fire will rise until it strikes the inversion ceiling. Throughout the night some cold air may slide down the canyon sides and cover the fire area. In the morning probably a low blanket of smoky haze is the only indication that yesterday this area was ablaze. Then the sun's heat begins to be absorbed by the canyon bottom. Temperature near the ground builds up rapidly and new convection masses struggle upward against the inversion boundary. Suddenly the pressure blanket is pierced and the hot air rushes up. Fresh air is sucked toward the fire from a lower elevation or down along the canyon sides and the sleeping fire bursts into new life with explosive speed and energy. One common cause of the blow-up has been demonstrated again.

(e) When air is cooled it contracts into a smaller volume and any given quantity of it becomes denser and heavier. In order to settle into equilibrium or balance with the surrounding pressures it tends to descend under the force of gravity. This mass of air is not like the warm block which ascended into a lesser pressure area and cooled down to a temperature equal to the high air. This lower air mass was made colder where the pressure was already heavy. It might be said to have taken its share of the atmospheric density and rolled it into a smaller package which was then more concentrated. So cooler air becomes heavier and tends to seek lower levels when its density is greater than the air surrounding it. This fact can be tested by blowing tobacco smoke toward an open refrigerator or by placing a thermometer on the floor in front of it. The cold air "pours" downward almost like a liquid.

*Temperature is an important cause of fire; a necessary part of the combustion process; an element of the weather important in itself and important to the behavior of two other fire weather elements—humidity and air movement.*

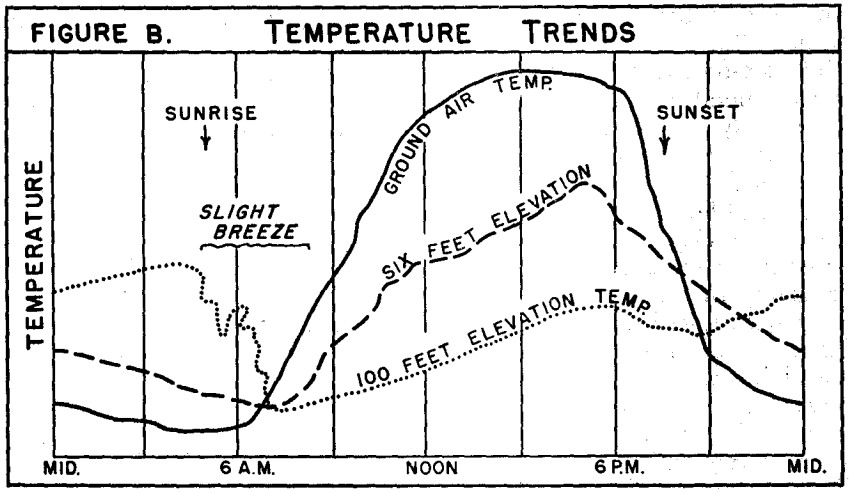



Figure B indicates a typical condition of temperature trends which no doubt is duplicated often in nature. The purpose of the chart is to point out the difference in the trends of temperature at different elevations above the ground throughout an average day and night. Of course, this situation would vary greatly from day to day and place to place, especially as wind and local air movements either minimized or augmented the temperature spread throughout the atmosphere.

We must assume that thermometers are constantly recording air temperature at the ground level, at six feet above the surface, at one hundred feet in the air. A rule says: *Most extremes of climate occur nearest the ground.* This rule is modified when the ground is protected by a blanket of high vegetation. But Figure B is quite typical in showing the greatest change in range of temperature near the ground.

Ground air temperature is lowest at about sunrise although the greatest loss of heat occurred near sunset. Heat absorbed by the ground during the day is radiated upward at night and decreases the cooling of the air at a height of six feet. Note that this level was warmer than the ground from about 8 p.m. until 8 a.m.

By 9 p.m. the air at 100 feet was warmer than the ground and in this location was getting warmer. In fact, it stayed warmer than the lower levels until a slight breeze disturbed the quiet air at sunrise. But a rule of nature says that temperature should decrease as elevation above the earth increases. In Figure B, the situation is upside down throughout the night. We have an inverted or inversion blanket of warm air no doubt extending even beyond the 100-foot level. Probably this was caused by stronger pressures above preventing redistribution of lower air that had been warmed by heat from the ground, but which was not hot enough to rise and dissipate the heat into the upper atmosphere. Apparently the breeze at sunrise caused enough air movement to allow the lower air to break up through the inversion. As the warm air ascended or was driven away, cooler air arrived at the 100-foot level and temperature dropped rapidly between sunrise and 7 a.m. Then the

ground heat began radiating upward with solar energy received on the new day.

The six-foot level was naturally more responsive to the heat changes of the ground. Shortly after the ground began to absorb solar heat (approximately 6 a.m.) the six-foot level felt the radiated heat and began to increase in temperature. Heat began disappearing upward about 5 p.m., but from 8 p.m. until 7 a.m. the air at six feet was warmer than the ground level. This fact also reflected the inversion condition which prevailed during the night.

Generally these inversions take the shape of a horizontal blanket of air having the same approximate temperature and density. One of the following causes is usually responsible for the inverted temperature condition: (a) air near the ground is cooled at night more rapidly than air at a higher level, as typified by Figure B; (b) turbulent forces roll air upward where it is cooled by expansion and downward where it is warmed. The upper portion of this agitated layer may be colder than the relatively quiet air above it: (c) a moving mass of cold air may slide under warm air; (d) a moving mass of warm air may slide up and over cold air.

## RELATIVE HUMIDITY

When water is boiled steam drifts away into the surrounding atmosphere as water vapor. When air passing over a water surface picks up water vapor the process is called evaporation. The process of evaporation (water molecules moving from the liquid water state to a gaseous state) *increases* as the air above the water is (a) dryer, (b) moving faster. Warm air can hold more water vapor than cold air before the saturation or precipitation point is reached.

When air is made colder its volume is "squeezed" into a smaller space. The same amount of moisture or water vapor remains so it naturally makes up a greater portion of that atmosphere. The "humidity" of a body of air increases as it is made colder—decreases as it becomes warmer.*

When any body of atmosphere is made colder the point in temperature will eventually be reached when free water (or ice) will be released in some form, such as fog, dew, rain or snow. That temperature is called the *dew point* for that particular body of air. The farther the air is from being saturated with water vapor the lower will be the dew point temperature necessary to cause precipitation.

* For estimating increase and decrease in humidity a good "rule of thumb" is: every 20 degree decrease in temperature doubles humidity; every 20 degree increase in temperature reduces humidity by one half.

The total actual amount of water vapor in any body of air is called absolute humidity. This holds much less interest for the firefighter than the nearness of the saturation, or dew point. He wishes to know what is the relationship between the moisture vapor in the air now and the total it could hold at its present temperature. He is interested in **relative humidity.**

When the air is saturated and ready to precipitate moisture it has reached 100 percent relative humidity. When the relative humidity descends below about 30 percent the situation is becoming favorable for wild fire. That is because the dryer air is more able to pick up water vapor from the fuel. The less moisture in the fuel the less time is required for heat to bring about combustion. As humidity increases or decreases in the air the moisture content of fuel is likewise affected. (This relationship is discussed under Fire Danger Rating.)

It was stated above that warm air could hold more water vapor than cold air. However, if the amount of water vapor remains constant the *relative* humidity of the air will have to decrease as the air is warmed and increase as the air is cooled, all because of the contraction and expansion of the air volume. Therefore, it would appear that if there is no considerable movement of new and different air to a location we should find humidity decreasing as temperature increases and vice versa throughout the day. That is exactly what instruments will record.

There can be exceptions to this opposite trend between temperature and humidity. That is to say, warm air can be close to the saturation point. This is a familiar condition in some tropical areas where the abundance of water vapor could provide saturated air at practically any temperature. The opposite condition can prevail during a cold wind from desert areas. Temperatures can be very low and the air humidity yet remain much lower than saturation point. Either of these unusual relations between temperature and humidity does not change the basic natural law. Their development was simply responsive to the scarcity or abundance of water to provide water vapor and the condition of the air mass to absorb it.

The air over lush green vegetation is generally quite humid because it can pick up water vapor that has been transpired through the leaves. Humidity is generally higher within a forest

cover for the same reason and also because there is less temperature increase in the shade. Also there is less air movement within the forest to carry away water vapor. Relatively speaking this should cause fire to burn less intensely in low forest fuels than in such open fuels as chaparral.

## WIND VELOCITY AND DIRECTION

What is wind? It is simply a movement of air. If you try to enlarge upon this very broad definition you will just confuse yourself. The average person thinks of wind as generally horizontal air movement fast enough to be felt by him. That is only because he is much less aware of the causes than of the horizontal air movement he can feel and observe as a mover of light objects.

Over the face of the earth several major forces are at work unceasingly to stimulate air movement. First, there are the vast areas of heated earth surface producing rising air currents which return to earth in the cooler regions; then there is the gravitational effect of the turning earth upon these tremendous churning currents. The changing seasons change the pattern of wind movement because the hot and cold regions of the earth are shifted. From this point on the wind (and with it all weather behavior) is modified by the effect of bodies of water and land masses, and then by the lesser local things in each local area.

Wind (moving air) is a fluid that can be compressed under pressure, expanded and contracted with heat and cold, made moist or dry. It may pause unmoving and then spring in any direction with violent gusts.

Wind movement is of vital importance to the firefighter. It would appear that the best approach to becoming master of such a flexible and untamed natural element would be for the fire specialist to acquaint himself as far as possible with the air movement habits of his own region.

Wind is important to the firefighter because of three inherent powers or influences it can exert upon fire behavior. These are (a) supplying oxygen, (b) exerting pressure to move heat or fire, (c) reducing fuel moisture by increasing evaporation.

The effect of an increased supply of oxygen for the fire has been discussed in another section. Air pressure in one primary direction has two effects upon a forest fire. It pushes flame and

sparks into new fuel and it can preheat fuel on the leeward side of the fire by forcing heated air in and around the fuel. It is important to recognize that wind pressure increases much faster than wind speed. For instance, upon one square foot of surface facing a wind the following pressures will prevail: 15-mile per hour wind, one and one-eighth pounds; 30-mile wind, four and one-half pounds; 60-mile wind, 18 pounds.

If fuel and topographic conditions do not alter the result, it can be said that a strong wind in one prevailing direction will cause a long, wedge-shaped burn. This comes about not only from the driving force of the wind but also because an augmented combustion will demand an in-draft *toward* the fire from the flanks. It is estimated that one pound of fuel requires 200 cubic feet of air during combustion. The more available that oxygen becomes the more rapidly will the fuel be consumed by flame.

Winds may cause fires to jump prepared or natural barriers. It may drive a crown fire through tree tops when normally a lack of understory heat would cause a crown fire to subside.

Large fires can be said to make their own local weather, especially in respect to air movements. Large convection updrafts cause air currents along the ground toward the fire, and sometimes cause downdrafts of importance out beyond the fire perimeter. Smoke clouds may shade the sun and alter the temporary radiation of solar heat toward and away from the earth.

Over broad areas, such as plains or long, wide valleys the prevailing direction of the wind can be quite easily predicted throughout the year. But in rough topography the local wind courses may be quite different from the major prevailing conditions and also more changeable from time to time. Rough topographic objects and vegetation act as a drag upon ground wind movements. Wind currents are thrown into confusion while passing over disturbing objects as is indicated by the sketch of windflow over a windbreak.

The common habit of winds changing direction or intensity throughout the day and night is well known. The peculiar condition in each locality will depend upon the temperature changes in and around local topography. Large bodies of water, such as the ocean and lakes, usually cause winds to blow inland as the

sun warms the land area about midday. Then the wind blows outward when the lands cools more rapidly than the water area at night. Isolated mountains draw air upward as in a chimney when the mountain slopes warm under the sunshine. The local effects of topography on wind are as varied as are the shapes of the topographic features. The directions and velocities of the wind, the time of day, the aspect (exposure) in respect to the moving sun and many other influencing factors control the way surface winds blow. The gradient (general) winds blowing above the surface are the predominant element much of the time. But whenever these winds weaken in the presence of strong daytime heating and nighttime cooling, convective winds of local origin become important features of weather in areas of broken topography.

The one general statement that can be made regarding expected normal wind movement in the mountains is that upslope winds will occur as the result of surface heating in the daytime and downslope winds will occur as the result of surface cooling at night.

Orientation of topography is an important factor governing strength and timing of wind flow. Upflow begins first on the east facing slopes as the sun rises. Other areas are affected gradually, soon after the sun strikes their slopes. The intensity of upslope wind increases as daytime heating continues. South and southeast slopes heat the most and therefore have the strongest upslope winds, often with velocities considerably greater than those on opposite north slopes. Morning upslope winds flow straight up slopes and minor draws. The increased velocity of canyon winds later in the day turns the direction of upslope winds diagonally up canyon. (See Figures C-2 and C-3).

Strong up-canyon winds can be quite turbulent and will form large eddies at bends and tributary junctions. Fires burning in these locations will behave very erratically and may spread alternately one way and then another but generally will move diagonally upslope.

The change from upslope to downslope wind will usually begin on those areas first shaded from the sun. First, the upslope wind will gradually diminish, there will be a period of calm and then a gentle downslope movement will begin. A large drainage

can easily have varying degrees of this transition in process at the same time, depending upon exposure to the heating rays of the sun. When all areas are in the shadows, the downward movement of air strengthens until winds are moving in 180 degree change of direction from daytime flows.

It has been noted that strong daytime heating usually produces convective winds which hold gradient winds aloft above the ridges. This condition can create strange fire behavior and pose a perplexing problem to firefighters. If the gradient wind is relatively cool, some portion of it near the surface may join the local downslope wind to considerably increase its force. If the gradient wind is warm and dry, an even more frustrating condition (for the firefighter) can develop. The cool downslope winds flow like water down drainages and settle in the bottoms of canyons and other low spots while the warm dry gradient winds blow along the surface of the exposed ridges and slopes above a temperature inversion. A fire which has spread into these two areas during the daytime will behave quite differently at night. Those portions below the inversion will be influenced in the early evening by downslope winds but will usually become quite inactive by midnight in the stable cool air. Those portions above the inversion will probably burn extremely hot—in many cases explosively.

Along the coastal range of mountains in California, another factor—that of marine air intrusion—enters the picture to further complicate the firefighter's ability to forecast wind movement. All of the above discussion of convective winds would lead one to believe that downslope winds in the heat of a summer day are either non-existent or rare. Such is not the case. They do occur regularly and frequently. Marine air moving inland over the coastal mountains can often spill into *east* facing canyons or draws and flow beneath the locally created warmer upslope winds. Being heavier, the marine air will flow first through saddles and other low points and follow drainages and slopes closely, thus reversing ground wind direction from upslope to downslope. The change in direction can occur rather quickly. Cases have been recorded where the reversal took place within a few minutes with the downslope velocity considerably

greater than the upslope had been shortly before. Needless to say, this sudden shift in wind direction can adversely affect fire behavior in the areas involved.

The formation of cumulus clouds directly over peaks or ridges can have a marked influence on wind velocities and direction. As the cloud cell grows, strong indrafts are created which can increase upslope winds on the higher land surfaces nearby. After the thunderstorm cell has passed its most active stage, large volumes of cold air may be cascaded to the ground as a strong downdraft. Although usually only lasting a few minutes, these gusty winds can strike suddenly and violently with speeds up to 30 miles per hour.

The passage of a cold front * will invariably affect wind velocity and more often than not cause a shift in wind direction. Cold fronts will often give visible evidence of their presence in the form of high cloud cover. As these fronts pass over there will usually be a marked increase in wind velocity followed by an abrupt clockwise shift in direction from 45 to 180 degrees. A dry cold front will usually give no visible evidence of its presence. The wind will increase in velocity somewhat but will not always change direction as the dry cold front passes by.

Wind of any kind has a marked influence on fire intensity and behavior. But the foehn † winds which normally occur in the fall of the year have the most devastating and adverse effect on fires. They are known as north winds in northern California and as Santa Ana (also called santana) winds in southern California. They are capable of reaching extremely high velocities—80 to 90 miles per hour across ridge tops and peaks. They are characterized by the properties of blowing downhill while hugging the land profile, being warm (at least warmer than they were at the same elevation on the windward side of the mountain), and becoming progressively more dessicating (drying) as they descend. They can blow unabated around the clock for several days.

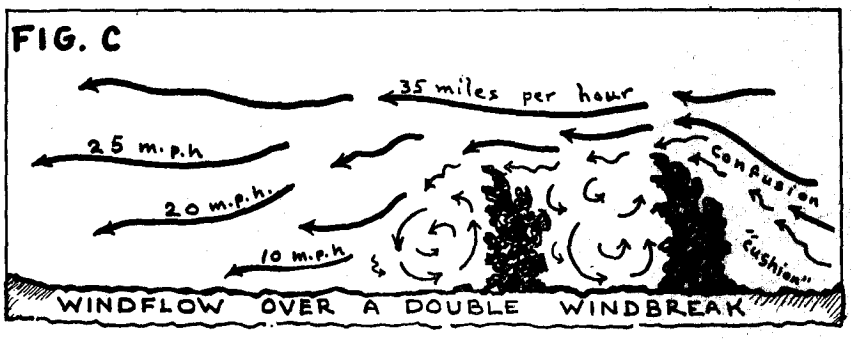
* A cold front is the leading edge of an advancing mass of air that is colder and denser than the air that it displaces.

† The term *foehn* is used worldwide to describe winds that flow from high elevations toward the low, generally becoming warmer and dryer. In western America this occurs most often in the months from September to April.

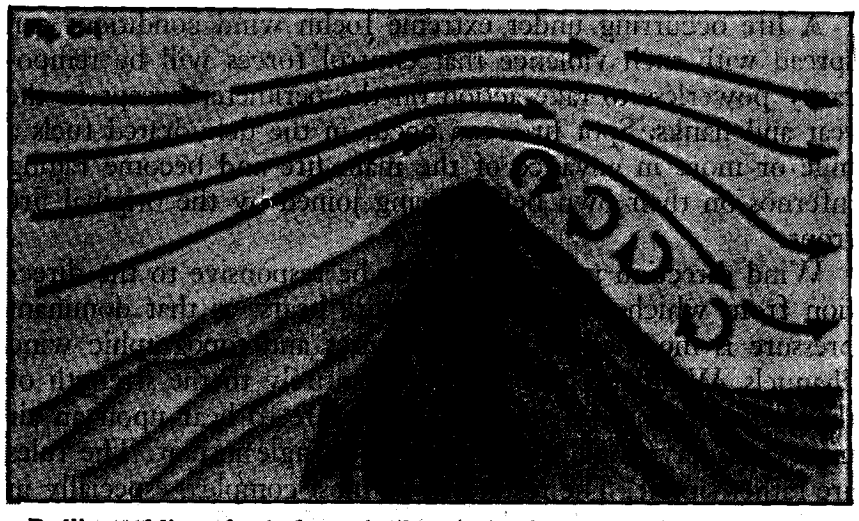
A fire occurring under extreme foehn wind conditions can spread with such violence that control forces will be temporarily powerless to take action on the perimeter except in the rear and flanks. Spot fires can occur in the dehydrated fuels a mile or more in advance of the main fire and become raging infernos on their own before being joined by the original fire front.

Wind direction might be said to be responsive to the direction from which the greater pressure bears, as that dominant pressure is modified by local pressures and topographic wind channels. Wind speed is responsive entirely to the strength of the dominant force that causes a pressure to bear upon an air mass from any single direction at any single instant. The rules are rather simple. The result can be most complex, especially in the broken topography where so many forest fires occur.

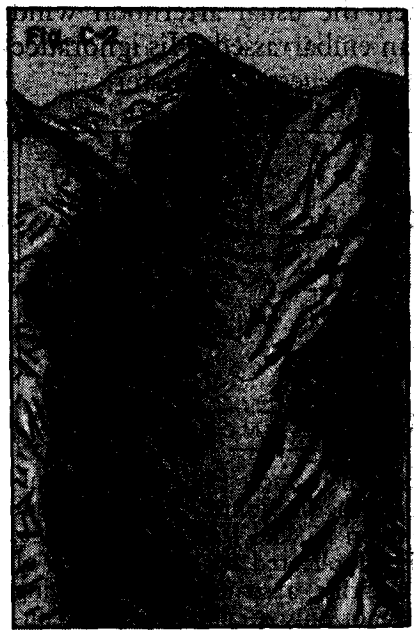
A knowledge of the change of local climate during the day and night is of vital importance to the fire manager. If he is not aware that the long and quiet flank of his fire at dawn may suddenly become the fire's head when the usual afternoon wind shifts direction he may be more than embarrassed. His ignorance may have been responsible for an unnecessary disaster.




The effect of a windbreak is well known to most California agriculturists but is inclined to be overlooked by the firefighter. Air movement deflectors of this nature are not uncommon in wild lands. For instance, the strip shown in Figure C could be duplicated by many miles of power line clearings. Tests have shown that a strong wind blowing straight across such a strip will produce not only a confused eddy condition within the strip but very likely gusts blowing *each way* at right angles to the main wind. When the high wind crosses the strip at an angle, the wind in the strip will take the same angle of direction, increasing its intensity on the far (leeward) side of the strip.



Rolling eddies of wind on the leeward side of a ridge are shown in Figure C-1. Fires burning within the influence of such eddies can behave quite erratically. Their effect becomes increasingly important as the wind speed increases.



Figures C-2 and C-3 indicate the typical manner in which upslope winds can be expected to follow draws and gulches of relatively small dimensions during periods of low velocity winds. This situation will normally occur as main canyon or mountain faces warm during the early hours of sunshine. As the intensity of upslope air movement in-

creases with the increasing heat of day, the major upsweep will naturally cause the lesser side gulches to have less effect. Winds will then move diagonally and possibly erratically across the side drainages.

## FUEL MOISTURE

*Water does not burn.* We have considered water vapor in the air (measured as humidity) and we have considered the effect of temperature upon fire behavior. Actually, neither air humidity nor air temperature have any effect upon the flame, or if they do it is too technical a matter to be discussed here. What really concerns the firefighter is the condition of the fuel that will feed his fire.

That fuel will be flammable to a large extent in proportion to its moisture content. Moisture in the fuel will not burn; it must be converted to steam by heat and driven away before combustion will take place. Air moisture is absorbed into dry fuel or taken away from the fuel by dryer air during Nature's eternal striving to set a balance.

Rain is almost a forgotten element in a discussion of fire behavior in California. If it is the firefighter's friend that goes elsewhere during the long, fair summer, it nevertheless has provided quantities of moisture to soak into the forest fuels during winter. Of equal importance, winter rain, by delivering water to the soil reservoir has set the length of the growing season for wild vegetation, thus controlling the moisture content of living fuels to a very great extent.

As the storage of rain moisture is dissipated into the open air by transpiration through growing leaves, or by evaporation from logs and litter, we can measure a cumulative water loss from our forest fuels. This moisture loss can easily be measured as a loss in weight of the fuel particles. Eventually, the lighter dry fuels will lose their stored winter moisture and then reflect only a change in moisture content as air humidity causes water vapor to move into and away from the body of the fuels.

Heavy fuels such as logs will give up their moisture slowly and they will absorb it slowly. Dry leaves and grass will respond quickly to the relative humidity of the air and will vary from hour to hour and day to day. Green, living leaves naturally respond in accordance with the complex transpiration habits developed by each species.

The fuel that will not burn in a midnight backfire will probably be ready to roar when the decreasing air humidity of midmorning has sopped up moisture from the fuel and transformed it into invisible water vapor.

A great deal of the chaparral vegetation of California may be actually dry and dormant during the hot summer. These plants have passed the wilting point but nature has provided them with rigid green structure. Unfortunately, too many strangers to our outdoors mistakenly believe that green leaves simply will not burn.

# CHAPTER THREE

## Topography

### SHAPE OF THE COUNTRY

THE TERM topography refers to practically all of the earth's surface, especially in respect to the shape of hills, plains, and waterways. Except for the basic geologic material from which the soil is formed it would appear true that, first, the weather, and secondly, the vegetation of the earth are the result of topography. Fire behavior is governed by the effect of local weather upon the available fuel. Therefore, the importance of topography upon fire behavior is self-evident.

In this writing there is no intention of searching for the basic reasons for broad weather movements nor why certain types and zones of vegetation grow where they do. These interesting subjects may be fundamental, but the fire manager must work with the weather, fuel and topography that he finds in a relatively small area during the period of the fire. However, before giving consideration to the more localized effects of topography in respect to fire behavior it is well to recognize that natural laws developed for one locality often have a reason for being varied in another.

Probably the reason is to be found in the effect of very large features of the earth's surface. For instance, a broad plain near sea level has quite a different climate from a similar broad expanse at 4,000 feet elevation. The height of a mountain range is not necessarily the dominant factor in the effect of the range upon weather and vegetation. It is probable that the prevailing direction of the courses of valleys and ridges is a more important matter, especially as those features meet and react to (and upon) the wind, rain, and sunshine.

Latitude (distance from the equator) also has a considerable influence upon the development of weather and vegetation in California. Also the proximity of the ocean is of great importance to California weather and consequently to fire behavior.

At the other extreme from the broad geographic or topographic influences are the human modifications made upon the local landscape and local weather. The creation of reservoirs and irrigation projects, and the removal of fuel in favor of structures or agriculture sometimes produce effects of considerable importance to local fire behavior.

## EXPOSURE (OR ASPECT)

Exposure, sometimes called aspect or direction of slope, has a direct bearing upon the possibility of fire starting and its behavior during the burning process.

North of the equator the sun's rays shine most directly upon a full southern exposure and therefore deliver considerably more heat to that face than to any other. Southwest faces indicate about an equal treatment, essentially because of the cumulative heating of atmosphere and the land surface throughout the day as the sun progresses westerly. Southeast and western exposures are each subjected to approximately an equal degree of effective solar heat.

Such a difference in the quantity of heat delivered to these southern exposures, as compared to north slopes, starts a chain of reactions that could only end with differences in soil and vegetation regardless of the geologic parentage of the soil.*

* The story of actual temperature conditions at the surface of the soil on the various exposures throughout the hours of the day and the days of the changing season is much too complicated to discuss in detail here. Nevertheless, the conditions prevailing in this very local microclimate are what produces the vegetation which furnishes the fuel for the fire which does concern us. Only the solar heat reaching the land exposure was mentioned above in the hope of simplifying the situation with a reasonable generalization.

In following the subject farther for some precise bit of land surface, we would wish to know, among other things, what is the actual quantity of solar heat reaching our particular plot of land at the various hours on various days; how much heat could be available to the soil because of the surface angle presented to the sun at different hours of the different days; how much heat is absorbed or radiated away because of the color of the soil or vegetation, or the height (umbrella) of vegetation; how much solar heat must go into converting surface moisture into vapor before the soil can begin to receive the heat, and at what hours of the day and days of the year is this factor most important; how deeply does the solar heat penetrate this particular soil; what is the usual pattern of radiation of heat away from the soil—throughout the day and night and throughout the seasons, when the various winds blow, on cloudy days, under a snow blanket; what effect upon soil temperature is caused by vegetation in shading, drawing upon moisture, increasing humidity by transpiration, modifying the movement of air currents over the soil? We obviously have here an interesting but somewhat complex problem in plant ecology.

Some species of vegetation enjoy the heat to be found on southern faces of California mountains and some do not. However, the need for moisture is probably a more important natural factor than heat in segregating plant species. Higher temperature and generally prevailing southern winds remove the moisture more rapidly from southern slopes, both as free evaporation from soil and litter and also as transpiration from the plants. The result is that only a "dry land" plant can survive on the south slopes, while the more luxuriant species, finding more moisture, will grow on the northern slopes. No preponderance of rain may have been delivered to the northern slopes, but the essential fact remains that deeper soil and less solar heat produce a remarkably different local climate on north slopes.

Since southern exposures are subjected to higher temperature, lower humidity, and the rapid loss of available soil moisture, a dry, light, flash-type fuel is produced. The essentials are at hand for easy ignition and large fires and that is just what has occurred. On south slopes both the long period of flammability during the year as well as the ease of ignition have caused a preponderance of fires to start. The flash fuels are especially vulnerable to spot ignition blown in from other areas.

The laws of mathematical chance coupled with vulnerable fuel would naturally account for more fires starting and becoming large on the south slopes. But there has been a strong human factor at work, probably since the days of Spanish occupation, which has tipped the balance even farther. The desire to improve or convert wild vegetation into more valuable browse has automatically caused the more flammable south slopes to be subjected to more intentional fires for this purpose. This is not the place to discuss the very broad subject of Range Improvement accomplished through the use of controlled fire and the application of artificial seeding, nor for that matter, the possible economic improvement in range values following fire without any scientific treatment to the land. The point under consideration is this: past fires have had a strong influence upon the creation of presently existing vegetation, and most of all upon south slopes. More fires have started and grown larger upon south slopes, especially in the hotter, drier parts of California, than upon northern exposures.

An important link in the chain of reactions mentioned above is soil erosion. A lighter, drier vegetation on south slopes burns more easily, has more and larger fires and leaves the soil exposed. Heavier rains on south exposures cause slow and sure (or rapid and dramatic) erosion of soil. Less moisture can be held in the

remaining soil and only a poorer form of vegetation can live under the circumstances. Thus the trend of deterioration is on its way to half-barren desert as the possible result.

This sad story of the south slope should not cause any fire-fighter to under-estimate the savage combustion potentialities of vegetation on northern exposures. There is no doubt but that ideal burning conditions for north exposures are delayed in the spring and depart early in the fall when shadows lengthen and the earliest rains dampen the fuel. Nevertheless, there yet remains a lengthy summer period when the more luxuriant growth on northern slopes offers considerably more ready fuel than the moisture-starved flash types on southern exposures. When the north wind blows during the late summer it probably achieves its greatest drying effect where it strikes north slopes with all of its devastating force. Then the fire hazard is compounded on these slopes. The heavy fuel becomes highly flammable while the supply of oxygen is increased. Under these uncommon circumstances the south exposures may offer the most logical ground for meeting and holding a fire.

In this discussion about the effect of exposure the experienced observer will recognize that extreme (but not exaggerated) situations were mentioned in order to emphasize the great climatic differences which actually do exist between northern and southern slopes. That observer would also be aware of local modifications in the "natural laws of slope." For instance, vegetation on the broad slopes of a high mountain will probably show more response to exposure than will be found on the sides of smaller hills. Probably the steeper slopes will show much more difference than more gradual slopes.

Areas subjected to some strongly dominating factor in local weather may be so responsive to that condition that exposures will produce relatively little difference in vegetation or burning conditions. An example of such areas would be found in dry desert or very moist coastal timber land. At the other extreme are a few spots above the ocean on the Monterey Coast. Small gulches, cut into steep mountain faces, are influenced alternately by damp fog and hot sun. The tiny exposure changes have produced moisture-loving redwood and desert cactus growing literally within a few feet of each other.

The object lesson here for the firefighter is to observe the effect of exposure upon fuel and fire behavior wherever he may be. It is very real and very important.

Mention was made of heavier rains on south exposures. This fact is subject to local differences and may have relatively little effect upon either vegetation or fire behavior. Nevertheless, it is an interesting condition that is almost completely disregarded in any general study of the effect of weather.

Rain-bearing storms are preponderantly out of the south and this causes more rain to fall on south exposures for two reasons. Large mountain ranges cause clouds to rise, to cool, and then to precipitate the rain on the southern face of the mountains. Commonly it is said that such ranges cast a "rain-shadow" on their leeward, or inward, side. Secondly, the slant of wind driven rain bears more directly upon a south exposure, just as the sun rays do. In other words, a square mile of sky may be delivering rain to a square mile of south slope exposure. On the other hand, a square mile of north exposure hillside, slanting in the same direction as the rain, may be affected by only a fourth of a square mile of sky during the same storm.

Instead of improving the quality of vegetation on southern slopes the probability is that this preponderance of rainfall, coming when it does, serves more to erode the exposed south slope soil than to guarantee against the dryness of summer.

This points up the danger of expecting too much relief from casual summer rains. Behind them is generally a cumulative drying period that has prepared the heavier fuels to quickly absorb and minimize a few raindrops. The lighter fuels will resist ignition readily enough after a light rain, but they can also lose moisture quickly through evaporation.

Then too, the rule of slopes should be remembered after a summer rain. Very probably the north slopes did not receive as much rain as the Weather Bureau gauge reported from a station on the roof of a city building. And if the south slopes received more than the reported rainfall they are most ready to give it up quickly to vegetation, to the air, and to run-off.

## ELEVATION

Higher elevations on the earth's surface have thinner air and lower temperatures in accordance with natural laws. We have

observed that lower temperature generally tends to act against the loss of moisture from fuel and also retards the heating action necessary to bring fuels to the point of ignition. Also, of course, greater rainfall (or snowfall) at higher elevation tends to produce heavier plant growth instead of the flash type.

From these facts the fairly reliable rule is developed that *fewer fires occur as the elevation increases*, and furthermore, the percentage of large fires decreases accordingly. This condition of decreasing fires does in fact prevail upward from the flash fuel types of the rolling grassland, through the chaparral, woodland, pine, the mixed conifer types and into the "asbestos area" of subalpine trees and sage in the high Sierra.

The above rule must be recognized as a generality related to forest fires and elevation above sea level. It is easy to point out that difference in resident population could account for the same decreasing fire incidence upward from the lowlands. Records might even prove that in some parts of the high country a greater portion of the fire starts have developed into large fires. In opposition to this argument it must be admitted that the low fire incidence over very large areas (at high elevation) has required such a relatively lean fire protection system that during rare adverse periods a few fires were given the opportunity to develop before they could be reached by even a minimum attack force.*

This points up the one contrary statistic in the general rule of high elevation fire behavior, namely, the rather consistent pattern of lightning caused fires. The number and location of fires starting from lightning is just about in reverse of the rule developed above. More lightning fires start as the elevation increases (in spite of the occasional course that dry lightning storms take inland from the sea).

While considering the effect of elevation upon the type of fuel developed in the natural vegetation it should be remembered that the rain-shadow falling upon much of the high plateau land of eastern California probably has more to do with the species that will grow there than does the elevation alone. Sage and similar species grow there because it is dry, not because it is high.

* Of course, in the development of a fire protection plan much more is to be considered than the fire risk (chance of a fire start). Items of importance: values at stake, hazard (difficulty of control), strategic transportation routes, composition of the ideal striking force, lines of communication, fire detection.

The local weather over a high plateau will generally be much less variable than weather at the same height of land throughout a broken mountain chain. The broken land is subject to day and night air movements which are known to actually raise the mountain top temperatures at night while the temperature in the lowlands is lowered. This is due to an exchange of air through the canyon passes. Lowland air is heated excessively during the day. At night the law of balance in nature begins to function. Warm air rises and cold air descends.

Every student of vegetation and fire behavior in California should bear in mind the role that latitude plays in this lengthy state whenever some effect of elevation is under consideration. The north-south distance between Mt. Palomar and Mt. Shasta causes a climatic effect upon vegetation comparable to about 4,000 feet difference in elevation. Consider, for instance, that in the north, ponderosa pine is ready to yield to the firs and high-elevation pines after it reaches 5,000 feet, more or less. On the other hand, in the mountains of Southern California it would be a hardy ponderosa that would venture as far down the mountain-side as the 5,000 foot level.

Therefore, any broad rule of fire incidence, or rate of spread, based upon elevation without regard to regional geography would be most questionable. However, since fire behavior is obviously responsive to the fuels provided by the natural vegetation, and since various species grow in climatic zones favoring the most thrifty vegetation for that particular soil region, and since local climate depends very largely upon elevation and slope conditions, then it would appear most advisable for the student of fire behavior to learn what type of fuel he can anticipate finding growing naturally at the various aspects and elevations of his particular area. He will find the natural laws controlling vegetative growth surprisingly dependable.

## SLOPE

The degree * of slope is quite another thing from exposure, both in relation to vegetation produced and in fire behavior. Probably the most basic rule in fire behavior involves the ten-

* Slope is usually expressed in percent, wherein 1 percent of slope means a rise or fall of one foot of elevation at a distance of 100 feet; thus, 45 degrees would equal 100 percent of slope.

dency of fire to burn fast uphill and slowly downhill. But why? There are two simple reasons and they are as important as they are simple. Two sides of the fire triangle are favored in the upslope burning of fire through (a) heat movement and (b) the supply of oxygen.

We have learned that fuel must be heated to a point of ignition before combustion will occur. Heat moves by radiation away from its source. The closer the unburned fuel to the fire source the greater is the amount of heat transferred. Flames licking upward will be closer to an object above the fire than to an object straight out from, or below, the fire. In brief then, upslope fuel is actually closer to a fire than downslope fuel.

Secondly, we know that heat moved by convection (hot air masses) rises and in so doing raises the temperature of the vegetation and other fuel it mingles with upslope from the fire. Another habit of convection currents that pushes a fire upward is the spotting ahead by the delivery of sparks. By these two natural laws heat and fire are inclined to move upward more easily than otherwise.

As air and combustion gases are heated their inclination is to rise rapidly. Fresh air is drawn in to replace the hot air and the new supply of oxygen helps in the process of combustion. During the normal day this air is probably furnished from the flanks of a fire if the canyon or slope is steep and the lower air is considerably cooler. But at night if the pressure of descending cold air from the mountain top is strong enough it is entirely conceivable that the head of the fire will be reversed and the fire will start a drive downhill if fuel is available in that direction.

Since approximately 95 percent of all forest fires below the higher National Forest lands in California start for some man-caused reason, it follows that there will be a higher fire occurrence where more people come in contact with the fuel. In general, it can be said that fewer people traverse the slopes, with the number decreasing as the slope increases. Thus, most fires start on level areas, or at the base, or at the top of slopes. Those fires starting at the base of a slope have a far greater opportunity to reach large proportions because of poor acccessibility to the fire and because of the speed with which fire travels uphill. Slope also adds a handicap in fire control if such burning fuel as cones and logs are inclined to roll downhill into unburned vegetation.

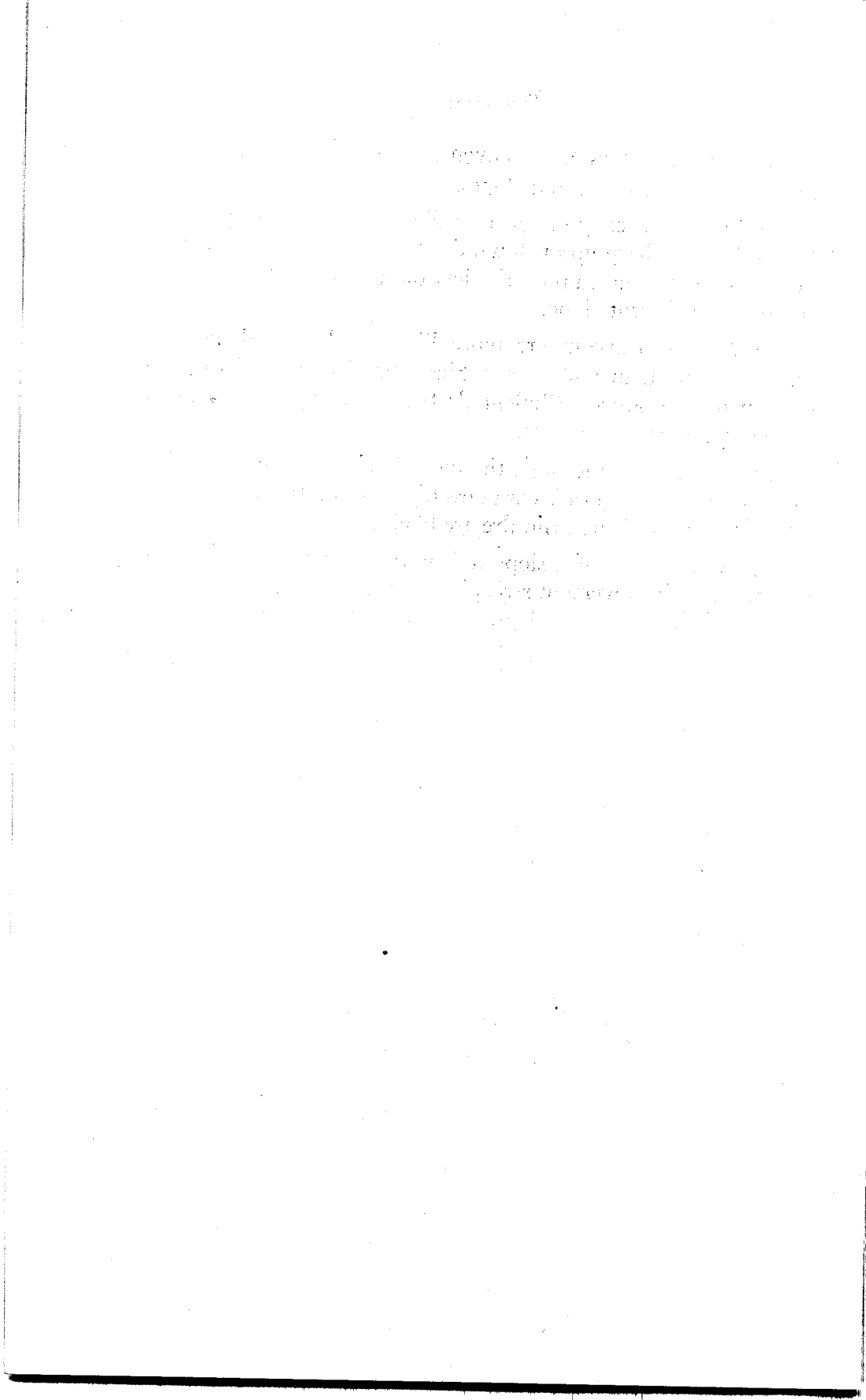
A few general rules of air movements probably will prevail in respect to fire behavior and slopes, for instance:

(a) In a wide canyon the prevailing wind will not be deflected by any sharp up or down draft in the course of the canyon. The wider the canyon the less the danger of fire spotting across to a different slope.

(b) Narrow canyons are more likely to have independent wind currents than wider ones. Sharp breaks and forks in the canyon may produce turbulent drafts. Fires are more inclined to spot across such canyons.

(c) The steeper the slope the more likely is the fire to drive upward in a narrow head, with possibly an in-draft on the flanks. Spot fires ahead of the main fire are likely.

(d) At the crest of a slope it is normal for the fire to meet an opposing air movement sweeping upward from the other side of the hill. It is the most logical place to stop and hold an upslope fire.



# CHAPTER FOUR

## Fuels

SINCE FUEL provides an all-important side to the fire triangle it deserves very serious study by the student of fire behavior. This is especially true since fuel is the one component of fire that Man can do most about.

Whether he is conscious of it or not every Fire Boss makes some calculations in his mind about the potential burning qualities of the fuel that is situated in every possible path that his fire may take. The old ranger did it quickly and easily from experience. But the small things he knew nothing about that were having an effect on the fire pattern were numerous, complicated, and interrelated. This appears to be a contradictory statement. It is not. A specialist in any field can have far more knowledge of his work than the inexperienced person and yet be lacking

in much information on the subject. This is because such information has never come to his attention, or possibly has not yet been discovered or developed. Consider the average physician of fifty years ago, now, and in the year 2000. Each respectively in his time is to be recognized as a learned professional man, but the relative scientific knowledge available to each is tremendously different. The professional fighter of forest fires is in exactly the same situation.

Forty years ago the importance of relative humidity was just within grasp of the student of fire behavior. Today we are manipulating the humidity itself by seeding clouds. Have we explored only the surface of the valuable information which should be pursued on the fuel side of the fire triangle? This seems quite probably true.

Very often fires that are under special scrutiny, or are assumed to be "managed" for range improvement or other purposes, behave in an unexpected manner. No doubt one reason could be that the fuel upon which the fire feeds is not actually as it appeared to be at the first casual observation. This could be a matter of "climate" right in and around the fuel particles, or it might be because of the position of one particle of fuel to another while that particular local climate prevailed.

The object of this writing is not to engage in a discussion of precise research but rather to approach both large and small things which make up the total field of circumstances surrounding the fire manager. Relatively little has been said about classes of fuel. In order to catalogue the fuels and discuss their combustion potentialities it is necessary to develop some common word-tools. This has been done throughout the following discussion of forest fuels.

Presently we group the forest fuels in reference to their position on the ground or in the air, as to their size, compactness, continuity, volume, and moisture content. Strangely, we find little discussion among firefighters about the fuel characteristic that would be of most interest to a heating engineer, namely, the respective output of heat units and the ignition points of the various fuels due to their chemical and physical composition. Probably the reason is that the availability of oxygen and heat has overwhelming effect upon the combustion process in a forest fire.

## GROUND FUELS

The distinction between ground fuels and aerial fuels is probably more difficult to define in California than elsewhere because one of the most prolific fuel types here is midway between. That type is brush or chaparral.* Mature plant species of the brush type can be found with their heads only a few inches from the earth up to more than 20 feet above, depending upon species and growing site. The major value in any segregation of fuels is the creation of a reference term for groups having similar burning tendencies. Compactness of fuel particles and their size regulate the two elements of fire that are most essential in the burning process, namely, the transfer of heat, and the application of oxygen to the fuel. This allows for a very great difference in the burning habits of the brush species, especially between chamise † and the others, as we shall discuss later.

It therefore seems reasonable to group among the ground fuels those for which the scraping tools are most effective in suppression work.

When either the low aerial fuels or the ground fuels are in such condition that they offer easy ignition and are consumed rapidly and completely by combustion they are often called **flash fuels.** Among the growing things listed as ground fuels are grass, sage and other perennials. Any low brush growth that did not allow for the easy movement of air through the foliage would be considered a ground fuel, including small conifer reproduction.

The nonliving material includes down logs, heavy limbs and smaller twigs, leaves, needles, bark and cones. Punky logs or any pulverized wood material most often makes the quickest ignition when exposed to sparks or heat. This was determined to be true in studies made of tobacco-caused fires along highways, where drifted dust of wood, weeds, and manure was found to be more subject to ignition than dry grass. Large logs, particularly if their surface is not punky or splintered, may resist ignition, and once burning may not aid the spread of fire

* It has been convenient to foresters to use the name brush for those bushy, perennial "succession" species growing on land capable of producing a timber crop. The dry "climax" type, dominated by chamise, manzanita and scrub oak is called chaparral. That distinction is disregarded here.

† *Adenostoma fasciculatum;* sometimes called greasewood and, rarely, mesquite.

unless the close proximity of numerous logs builds up terrific heat, which in turn throws out burning brands in the convection currents created.

Large limbs will burn more easily when dead needles are attached. Pine slash will offer this hazard for several years while fir and Douglas fir limbs will usually drop needles after the first summer. Sometimes these dry needles and leaves constitute very treacherous firebrands when picked up by hot air rising from a fire.

Smaller twigs, branches and needles compose what is generally called litter, and this is the material that can be expected to carry a relatively slow ground fire through timber because of the fineness of the fuel particles and the continuity of the fuel carpet.

As this litter breaks down and begins to decompose (but before it reaches the earthy stage called leaf mulch by gardeners) it is referred to as duff. Duff fires can be very aggravating and should be taken seriously because they have the treacherous habit of coming to life after being presumably suppressed. Also in the duff may be found occasional roots, and roots have the same habit of allowing fire to "sleep," with the additional unhappy reputation of allowing fire to creep underground across a control line into the unburned areas. Crew leaders should take care that flammable black humus on the line is not assumed to be mineral soil.

One strange and distressing arrangement of ground litter observed by firefighters are the many huge nests built by woodrats in the north coastal area of California. These energetic animals construct homes, often well hidden under thick vegetation, which may be seven or eight feet tall and fifteen feet across. The thousands of twigs and branches in such nests will ultimately become tinder dry and punky. Sparks from an advancing fire front which will not ignite other ground litter will often smolder for hours in these nests before suddenly erupting to life.

Sawdust makes a very perplexing ground fuel because fire is so difficult to control in this material. Some sawdust piles have been known to burn for a decade and they have been not only a decided smoke nuisance but have also constituted a menace for people walking over the invisible fire. In some parts of California peat soil ignites and gives about the same suppression problem as

a sawdust pile, but this is hardly to be expected anywhere in the forested area.

Some species of sage, or probably it would be more accurate to say, some well-covered areas of sage, constitute a flash type of fuel. In the less luxuriant, high elevation sage types the fire hazard may be either low or high, very much dependent upon how much dry grass is available as an understory.

Grass is a fast burning type in a "cured" state. This rapid and easy combustion allows for one advantage to the firefighter. After the grass fuel is ignited a non-flammable area is produced quickly for safety purposes, or for backfiring, or for getting a suppression job quickly over and done with. On the other hand, heavy grass fuels burning ahead of a high wind can develop a dangerous menace that should never be underestimated, as to either its heat, speed of travel, or power to roll over barriers.

Very little grass or other curing species of ground vegetation are found on the forest floor unless it is open enough to allow considerable sunlight to enter.

The low jungle of berries, ferns and succulent plants on the floor of the dense coastal forests will require most unusual drought conditions before they will continue a combustion process on their own. However, they are consumed in any holocaust.

Mature ponderosa pine naturally develops into open stands as it grows older. Here grass grows, cures and lends great support to any fire consuming scattered litter and small branches throughout the forest.

## AERIAL FUELS

The suspended and upright fuels grouped under the term aerial should have the single characteristic of being physically separated from the earth and from each other to the extent that air can circulate around the fuel particles.

Snags will be listed among aerial fuels and all standing trees of every size (except the reproduction that has not grown above the ground litter). Living or dead leaves and needles are aerial fuels while suspended, and also moss, lichens, bark, mistletoe, and such creepers as poison oak and honeysuckle. Then there are most of the brush species and sometimes high sage.

Grass can sometimes be found as high as a man's head, but it still has the burning behavior of a flashy ground fuel. Most grass fuel is best

handled by a scraping tool in fire prevention or suppression work. Besides, it has a relatively short fire-season life under normal conditions. This period extends from the time it reaches a cured state dry enough for combustion until its consumption as animal feed. It should be arbitrarily listed as a ground fuel.

## FUEL VOLUME, CONTINUITY, COMPACTNESS, ARRANGEMENT

The total **volume** of fuel available for combustion is going to determine the total heat units developed during a fire. If compactness is such that quantities of oxygen allow for rapid combustion then the total generated heat will be thrown off correspondingly fast. One way or another the job of fire suppression must take into account the heat volume and the part it can play in spreading the fire.

Large logs may put out a tremendous heat volume, especially if there is such close continuity of the fuel objects that the source of heat is centralized and is so great that it cannot be easily approached. A pile of burning logs will require a vast quantity of water to eliminate the fire. A cover of earth will serve to subdue the peak of the heat output and thus serve admirably to reduce spot fires and the outward movement of fire. This is because radiation and convection heat are both subdued. But the hazard of this treatment lies in the great potentiality of buried heat that will break into open combustion if ever enough oxygen becomes available. Actually a form of combustion called smoldering can be taking place where there is just enough oxygen, but not enough for open flame.* Breaking the continuity of the log pile would spread the heat by reducing concentration, allow individual logs to be attacked and the fire suppressed at close range. Or the heat of separate logs could be more safely allowed to disperse into the atmosphere and thus eliminate itself harmlessly.

**Continuity** relates to the position of fuel particles to each other, that is, the distance which allows, or refuses to allow, heat to move from one particle to another. The speed of fire spread and the total heat that can be generated over any area is dependent upon the continuity of fuel. Rocks, plowed land, wet ditches, succulent herbs and other non-flammable objects cause what is best termed **patchy fuel.** It can have very considerable

* This smoldering process is used to produce commercial charcoal.

effect upon the behavior of a fire in favor of the firefighter. On the other hand, patchy fuel may reduce the possibility of a good backfire. Rocks in particular may interfere with the construction of fire lines and they are a special nuisance in the lava outcroppings of the northeastern Sacramento Valley.

Continuity of fuel may vary in effectiveness depending upon the combination of types of fuel. A jack-straw jumble of firm logs would hold no particular terror for the firefighter if no small fuel such as litter and dry grass were present to kindle the fire and cause a rapid increase in the broad base of the burning area.

**Compactness** refers to the proximity of fuel particles to one another in respect to the free movement of oxygen around the particles. It is an opposite characteristic from continuity in that close continuity produces faster and greater heat spread while great compactness could mean less heat and possibly discouragement of combustion because of lack of enough oxygen.

Both of these characteristics vary from high to low combustion response as local weather conditions take effect. For instance, an area may be so thinly covered with scattered fuel that normally it would be said that poor continuity of fuel has reduced the fire risk to a very tolerable low point. High elevation sage growth would be a good example of such fuel. Yet an unusual supply of dry air in the shape of a strong north wind could bridge the gaps in fuel continuity by increasing the speed of combustion. Expanding fire would produce more intense heat radiation, while at the same time the wind would be pushing convection heat through the sage fuel in a leeward direction.

Suspended pine needles on timber slash may be so uncompacted that fire would not move among the clumps of needles on a high-humidity day. But the same kindling fuel would be adequately compacted to carry fire with a slight breeze on a very dry day. Fir, juniper or chamise needles on the ground will nearly always be less flammable than pine needles or oak leaves at the same place and time. This is because the finer needles rest together so compactly that not enough oxygen is available for rapid combustion.

The vertical **arrangement** of fuel in relation to the length of the crown will often influence fire spread. Thick pure stands of some brush species will have very little growth near the

ground surface. Hence, except under severe burning conditions, fire will not sustain itself in the crowns.

Using the foregoing terms as word tools to express our ideas we can now say that the most serious possible fire risk and hazard exists where we find moderately compacted aerial and ground fuels of unbroken (uniform) continuity in a mixture of many size particles.

## FUEL MOISTURE, OR SAP CONTENT

During the discussion of weather factors the variation of moisture within fuels was discussed, especially as it was caused by air humidity and rain. In living plant * fuel, especially among the species that "cure" into a dry straw-like material and among the chaparral species that pass the wilting point yet remain turgid (rigid), there comes a time each spring when "the fire season begins."

There are two conditions which cause the curing plant species to hold such a place of importance in the firefighter's calendar. This particular type of plant fuel makes up a great bulk of the total available wild land fuel throughout California, and secondly, during a very short time it evolves from a green and succulent "wet blanket" of vegetation into an explosive flash fuel.

In the timber-watershed area protected by the Division of Forestry, grass fuel is recorded as being a major type in from 40 to 50 percent of the fires. Outside of this zone there occur several thousand fires each year which burn grass or grain fuel predominantly.

Where sufficient ground moisture is available (such as may be found in stream channels, including dry gulches in the brush fields) species of trees, shrubs, and vines can exist and remain quite resistant to combustion. Also, under the protection of dense forests very fire resistant plants including ferns, vines and similar species will thrive when their local climate is not unduly

* "Living plant" fuel is by no means an accurate term for the type of fuel considered here. Some of the plant material will actually revive; some plants will produce new stems and leaves from the dormant root system; the annuals are entirely past any living state before they are ready to burn. Nor should such fuels be lumped under the common reference "flash type"—for reasons made obvious in this discussion. About the only common distinction between these and the "dead" forest fuels is their attachment to a root system that has (or very recently had) life enough to produce new growth under satisfactory external conditions.

disturbed. Such green plant material is worthy of consideration by the firefighter. Each morsel serves not only as a minute fire barrier when green, but lacking enough moisture it can be added to the enemy's side as additional fuel when dry.

To express the moisture content of plant fuels in respect to their inflammability we have now developed another set of word-tools or descriptive adjectives. The words are: *green, curing, dry,* and *flash.*

In grass and other light fuels, conditions affecting combustion can develop which are not to be described by any of the above terms. Although they are caused by rainfall, the conditions to which we refer below are not reflected as moisture content of the fuel. (After isolated rains, a fuel moisture increase may be real but it is subject to easy and rapid dissipation when the sun shines for a few hours.)

Late spring rains falling upon browse species in the curing stage can be detrimental to the stockman and the firefighter alike. Such rains can cause a certain leaching action within curing vegetation which renders it less palatable and nutritious as well as so lifeless that fire is easy to start and difficult to put out.

Rains in late summer will probably wash away more of a protective dust cover from all exposed fuels than is easily imagined. Also, these early rains will compact leaves on the ground. This should make it more difficult to start a fire among them. On the other hand, a sharp rise in temperature after this wetting treatment will increase the normal "curling" of leaves and other light fuel so that an actual lessening of normal compactness is the result.

## FUEL TEMPERATURE

Temperatures of fuels influence the rate of fire spread. Ambient (air) temperature and direct sunlight are responsible for fuel temperatures. Naturally, the higher the fuel temperature the more easily fuels ignite, and hence the rate of fire spread will increase. However, the rate of spread factor increases at a greater rate than a proportioned increase in fuel temperature. For instance, if fuel temperature of 61 degrees causes a rate of spread factor of 1, a rise of 100 degree fuel temperature will result in a spread factor of 2, or twice as fast—all other factors

remaining static. Thus, the rate of spread factor will be doubled long before the fuel temperature is doubled.

Since it is impractical to measure fuel temperatures while fighting fire, some general guides should be remembered.

(a) Fine fuels are more quickly and easily heated by ambient (air) temperature and direct sunlight.

(b) During the hottest part of the day, all fuels on the south and west facing slopes will have higher fuel temperatures than those on the north and east facing slopes.

(c) Heavy fuels react more slowly than fine fuels to ambient temperature and direct sunlight.

(d) Heavy fuels will usually have a lower fuel temperature than the surrounding fine fuels in the daytime, and the reverse at night.

(e) Of fuels exposed to direct sunlight, ground fuels will usually have a higher temperature than those above the ground (aerial).

*The behavior of a forest fire will vary as it feeds upon different qualities and quantities of fuel under varying weather conditions. The strategy of controlling a forest fire must be guided largely by an understanding of how a fire will react to all the fuels and weather affecting it until the moment it ceases to exist.*

# CHAPTER FIVE

## Behavior of Small and Large Fires

IF ALL OF the factors which influence fires were known and understood, the behavior of any given fire could be precisely predicted. It is doubtful, however, if Man will ever attain complete knowledge or understanding of this extremely complex but natural phenomenon. Although large fires appear to behave differently, with many more aggravated problems than small fires, they are each reacting in the same way to environmental influences that are present at that particular time and place. But for the purpose of discussion, they will be separated here so that certain generalizations can be made.

### SMALL FIRES

As discussed in previous chapters, fuels, topography and weather are found to have varying influences on fire behavior. Any one of these may be dominant in influencing what any individual fire will do, but usually the combined strength of all three dictates the fire's behavior. The particular topography does not change, of course, but we have seen how wind movements are influenced by orientation of topography and hence the direction that fires will burn. The actual shape of topography will similarly have its effect. For instance, a saddle or low point in a ridge will act as a funnel, tending to draw a fire in its direction. Fires will burn very rapidly upslope, but (in the absence of other strong influences) will usually burn slowly downslope. Fires burning in the upper portions of steep slopes or backing downhill often spread themselves rather quickly by means of rolling pieces of flaming fuel. Pine cones are the most common culprit because of their rounded shape. Those lying on the ground are loosened as they burn and will then roll downslope into unburned fuel.

Except for relatively small areas which are devoid of fuel, California wildlands are well covered with unbroken stands of

vegetation. Hence, we must consider what fire will do in relation to fuels as they exist. Theoretically, a fire burning in any type of flammable vegetation on flat ground, with no wind, would create a perimeter in the form of a circle with flames and smoke leaning toward the center. But we know that fuel varies in size, shape, arrangement, amount of dead material, and relative flammability. Hence certain portions will burn more rapidly than others, and soon an unsymmetrical shape in the fire perimeter will develop. Eventually a prominent bulge will influence an adjacent portion of the fire, and the intervening fuel will burn out rapidly.

Fires spreading upslope or with the wind assume a wedge-like shape. The point of the wedge is the head where the most rapid spread is occurring. The flanks of the fire will gradually widen with the passage of time. That portion of both flanks immediately behind the head will unquestionably be influenced by an indraft caused by the convection column at the head. A shift in wind will, of course, cause a greater movement of the leeward flank and probably change the direction of the head.

Should the head of this theoretical fire be suddenly stopped, the rate of spread of the flanks will increase. If the wind is strong, or the slope is steep, the original forward impetus of the fire remains unchanged. It is probable that the fire will now progress with two new heads (on either side of the old) until they join, or until one becomes dominant.

Depending on fuel type and condition, spot fires can occur ahead of small fires as well as large. Burning embers are carried with the wind in the convective updrafts with the smoke and are dropped in unburned fuel in advance of the main fire. Embers will nearly always come from the under side of the heaviest smoke concentration. Flying embers can also originate from burning snags or trees with punky pockets on fire; and again, the spots will occur downwind. The rapid spread of a fire up a steep slope to a ridge crest will often result in spot fires on the opposite downslope or even on the upslope of the next ridge in advance. Spotting can also be expected downwind when individual trees "crown out" or when large piles of dead material—such as slash—are burning at peak intensity.

## LARGE FIRES

The tendency is for a large fire to beget a larger fire. In California at the present time the efficiency and economy of maintaining crews ready for prompt attack upon a fire is well understood by all fire officials, and fortunately, by many elected officials responsible for appropriating necessary funds. Statistics show that 95 percent of the reported fires have been kept from growing large. The other 5 percent could be reduced by more presuppression expenditure, or more effort at the proper place, or by less human carelessness at the improper time. However that may be, many of the large fires are the result of adverse conditions of weather or topography.

*Adverse* may mean too tough for the strength of the initial suppression forces at that particular time and place, or it may mean a condition worse than the average bad condition for which preparations can be made with the funds provided. Both amount to the same thing. The point is that if natural conditions were essentially the cause of the fire getting large it is reasonable to assume that the same conditions would allow the fire to get even larger. That is why it has been mentioned elsewhere in this writing that the initial attack crew should have as its primary objective the prevention of the expensive large fire.

If weather is to blame for the small fire becoming large, then we know that the odds against the firefighter increase as the weather becomes more adverse. It has been stated that a doubled wind speed may quadruple the fire spread. Reducing fuel moisture by half (when it is already low) may cause fire spread—not twice—but five or six times as fast.

Added to whatever adversity may exist in the shape of topography or weather there are characteristic habits of large fires within themselves which mean trouble for the firefighter. There are the tendencies to crown and spot ahead because of the build-up of convection currents over large fires. Also the effect of heat radiation upslope is increased as the intensity of heat of the fire increases.

On the other hand, unless unusually heavy and dry winds from one general direction overwhelm the effect of local broken topography, a large fire can be expected to subside considerably when it reaches ridge tops. This will result from the heavy in-draft demanded by the large fire running uphill.

Large fires are generally less predictable in behavior at night, especially if variable fuels and varying topography are involved. This is because of the local changes in wind movement and temperature that nightfall brings. Sometimes individual trees seem to crown more readily at night than during the day. This is often observed in the grassy woodland types of the Sierra foothills.

The development of strong convection columns over large fires, with smoke rising thousands of feet into the air, is one of the most striking differences between small and large fires. The essential cause of this difference is, of course, found in the difference in the concentrated heat mass.

Convection column formation depends upon the effect of the fire as a heat source and the atmospheric conditions existing at that time and location. For example, atmospheric instability causes vertical motion to be accelerated and will allow towering convection columns to develop, with resulting high fire intensity on the ground. On the other hand, an inversion layer can stop the upward growth of the convection column and cause the smoke to spread out beneath it. Fire intensity, in the latter case, will not usually be as great as during the unstable situation.

Consider the several steps of cause and effect in respect to the single matter of spot fires caused by firebrands originating in the main fire. If the air mass over the fire is stable, that air will resist the development of a strong convection updraft in the form of a heavy smoke column. Consequently, the fire will burn less intensely than it would under a strong updraft. Unstable air is more conducive to the development of a strong convection column and a more intense fire. The stronger updraft naturally has more carrying capacity for burning embers. But it should be noted that the longer time period in the stronger updraft will allow many of the potential firebrands to lose most of their heat. Also, when they reach their height and fall out of the smoke column they probably are entering cooler atmosphere than that at the ground level.

Should a force of wind aloft be brought to bear upon each of these fire conditions, tilted convection columns will result. It has been stated that the column occurring in unstable air will be stronger and will carry firebrands higher and farther. On the other hand, the less intense updraft will drop firebrands sooner,

closer, and hotter, and in a more concentrated pattern in front of the advancing fire.

Long distance spotting will more than likely occur on the right flank of an advancing fire because of the tendency of the smoke column under the influence of wind to rotate in a clockwise direction with increased height.

A convection column is not a "chimney" in the sense that all the air must flow into the bottom of the convection coil. Most combustion takes place near the ground and naturally the oxygen requirements is most intense there. Nevertheless, some combustion of gases occurs in the rising heat columns. To supply needed oxygen, and undoubtedly because it is entrapped in the roiling updraft, outside air is gathered into and along the vertical exterior wall of the rising convection column.

Normally, a general in-draft into the convection column can be expected from all sides. If there is a prevailing wind, wind speeds on the lee (advancing) side of the column will usually be less than on the windward side of the flanks. But occasionally, pronounced out-drafts (winds moving away from the column at a greater velocity than the free air movement) have been observed on the lee side. At the time of this writing, no guides can be given as to their occurrence since there appears to be no correlation with fire size or intensity, or with weather conditions. Several instances have been observed when winds in advance of the fire were double or even quadruple the velocity of winds along the flanks or rear. In any event, fire control personnel should be aware of and alert for the occurrence of this phenomenon. The possibility that the wind velocity may increase two to four fold in advance of the fire front could drastically change fire suppression strategy.

Another important difference between small and large fires is the relative unimportance of size, distribution and arrangement of fuel particles in favor of total fuel volume in the high intensity fires. Larger size fuels will burn faster and hotter, producing temperatures up to 2,650 degrees F., under extreme conditions. This intense heat results in large areas being rapidly consumed with extreme violence and nearly total reduction of all combustible material.

As pointed out earlier, topography is important in the rate of spread of all fires. Generally speaking, the steeper the slope

the greater the increase in fire spread uphill. Considering the vast area usually encompassed by high intensity mass fires this generality could be misleading. It has been noted that rate of spread in mountainous topography is greater for two or three hours at a time. Mountainous country has as many downslopes (where fires burn more slowly) as upslopes, and breaks or barriers will retard spread for periods of time. On the other hand, rate of spread on flat or rolling topography can be greatest for periods of 12 to 24 hours due to lack of natural breaks or retarding steep downslopes.

## AREA IGNITION

The logs in the cold fireplace were giving out a desultory smudge when a merry blaze was in demand. A crumpled newspaper was then ignited and pushed toward the throat of the fireplace. Suddenly the gaseous smudge around the logs burst into flame and the logs began to crackle with combustion.

What caused the outburst of flame in the fireplace? Two vital sides of the fire triangle had been strengthened where the fuel was situated although *the action which caused it occurred elsewhere*. No doubt the most important action was the creation of a convection updraft in the chimney, thus pulling in more oxygen for the fuel. More specifically, a sharp in-draft against the flank of the fuel facing the open room was created. Secondly, heat radiation from the burning newspaper raised the temperature of the flammable gas around the smoldering fuel to the extent that it was ready to ignite in the richer air brought in by the convecion updraft.

This principle of augmented ignition and combustion from an adjacent source of heat has long been appreciated by experienced firefighters. However, its full significance from the standpoint of potential destruction seems to have been rarely considered until the occurrence of "fire storms" created in large cities by wartime bombing.

The phenomenon of increased intensity of conflagration due to multiple adjacent points of combustion is termed Area Ignition. The same incentive produced by the burning newspaper in the fireplace can be compounded outward in geometric proportion as the individual sources of fire act upon one another in an open area.

It was stated above that the tendency of a large fire is to beget a larger fire. It was intimated that this is true because adverse conditions around a fire act to make bad things even worse. Part of the resultant trouble may be due to the effect of Area Ingition as it occurs in a natural manner during the progress of the wild fire. However, this phenomenon is much more likely to occur outside than within the perimeter of a large fire. This would happen when a number of spots outside the fire area flare up together in fuel that is highly inflammable. This, of course, constitutes an added hazard for the firefighter.

Aside from spot fires and concentrated lightning strikes, it is true that a great quantity of the vegetation burned as a result of the Area Ignition process is by human design. The clever incendiary has made use of it as well as the backfiring specialist and the stockman using fire under control to eliminate unwanted vegetation.

When a number of fires are ignited in such relation to one another that the heat of each one affects its neighbor there develops a situation about as follows. Radiant heat prepares unburned vegetation in the intervening spaces for easy ignition at approximately the same time. If we could look down upon such a condition of multiple fires at an early stage we might observe perhaps one-tenth of the area in flames. This would leave some nine times the flaming area in a state rapidly approaching a readiness for ignition. While this is going on the individual fingers of convection currents are thrusting hot air upwards. Each is tending to pull in-drafts toward its base.

Soon the convection updrafts begin to mingle and multiply the dimensions of the invisible "chimney." A constantly increasing supply of new air on the floor where the numerous fires are burning is demanded to supplant the increasing updraft. Then in an explosive moment the entire area around the numerous fires flames into combustion. A blow-up has been created. Whether it has been created intentionally or otherwise the blow-up can be a fire monster difficult to hold within prescribed limits.

It is obvious that this condition should not normally be expected from a fire moving outward from a central source, actually flaming for the most part at the perimeter and leaving behind only the ashes of the fuel it has consumed. It should be

remembered, however, that if quantities of fuel are by-passed, either unburned or smoldering, the powerful forces of multiple ignition may be suddenly unleashed at one critical moment when heat, air and the crucial spark of ignition are ready.

## AREA INFLUENCE

The effects of mass fire burning large areas in a relatively short period of time can be felt for a considerable distance from the source. This may influence fire behavior in other areas—sometimes adversely. It is, therefore, quite important for fire-fighters to be aware of mass fire occurrence on any part of the fire and be alert for possible changes in their own areas because of it.

Mass fire occurrence can adversely effect "firing out" operations. (Backfiring and burning-out are discussed in Chapter Eight.) Particular care should be taken when firing is conducted down long ridges where major bends in the line are unavoidable.

Ideal firing operations are conducted from the top of the ridge downhill into the intended burn with no wind or only a light and favorable wind. With such favorable conditions, firing along the line should proceed rapidly in order to take advantage of the situation before more critical burning conditions develop. However, it should be remembered that a major run of the main fire or the backfire near the top of the ridge can change the wind flow and adversely affect the backfire elsewhere. For example, if there is an obtuse bend in the line near the newly developed mass fire the combination of topography and wind change at this point could become quite serious. Under no wind or light wind conditions, in-drafts into a mass fire can affect wind flow for a considerable distance downslope from the fire area.

Two major convection columns burning in close proximity to each other will usually result in a very rapid and violent burn-out of the intervening vegetation.

## FIRE WHIRLWINDS

A fire whirlwind can be described as a violent, noisy tornado of fire, shaped like an elongated inverted funnel. The phenomenon spins at an extremely high velocity and emits a loud roar which is best compared to the sound of an aircraft jet engine.

Size can vary from a few feet to several hundred feet in diameter and from a few feet to 4,000 feet in height.

Fire whirlwinds are usually associated with large or mass-fuel fires, although they have also occurred on small fires. This is probably due to the fact that some of the conditions (unstable air is one) condusive to whirlwind formation are also factors in the creation of large fires.

The cyclonic action (rapidly whirling fire around the outer perimeter of a center cone of air or gas) can pick up debris, sometimes including small logs, and raise it to great heights. A central "tube" is present whether or not it is always visible.

Topography plays an important part in fire whirlwind occurrence. Although fire whirls have been known to happen in flat terrain, by far the majority occur in mountainous areas. Some generalities can be stated regarding possible locations and conditions under which these whirls are likely to occur. But there have also been notable exceptions observed which have little or nothing in common with these general rules of behavior.

The majority of whirlwinds observed by firefighters have occurred on the leeward sides of ridges, near the top. The shearing action upon wind flowing over the abrupt edge of a ridge has proved to be an important factor in whirl formation. This has been found to be true in the case of dust devils also.

All of the theories on whirlwind formation include air stability as an important factor. Some, however, advance the belief that it is a local thermal instability caused by the fire and not the degree of upper air instability that has the greatest effect. But others point to the extremely unstable upper air conditions known to exist when large destructive fire whirls have occurred. Unfortunately, in the past, too little attention on the part of firefighters has been paid to upper air instability as an indicator of potentially violent fire behavior. This matter is discussed in the next Chapter.

Heat supplied by the fire provides the "trigger" to set the whirl in motion when all of the other factors are present. Sometimes a mass of fire is required and this usually results in a rather large whirl. At other times, relatively small whirls have formed along a moderately burning fire edge with no noticeable increase in fire intensity prior to their formation.

The intensity of the heat source seems to control the position and length of life of many whirls. Numerous examples have been noted wherein the whirlwind, once generated by an intense fire, remained stationary and active at one location until the largest volume of the fuel was consumed. One observer of a small whirl reported that he was able to move it downslope by rolling debris against the hottest portion of the fuel.

On the other hand, another instance was observed in which a small fire whirlwind (10 feet wide and 150 feet high) formed itself at a fire edge in brush cover, then moved away from the main fire finding fuel sustenance in its path as it moved. It traveled about 300 yards into fine grass fuel before dissipating itself.

Other notable exceptions to the above generalizations have occurred. On one fire in southern California giant whirlwinds occurred repeatedly in or near the bottom of a deep canyon. One of these whirls began when one head of fire traveling upslope met another head moving downslope in the adjoining drainage. (Undoubtedly the fire moving downslope was under the influence of a marine air intrusion. See Wind Velocity and Direction).

The resulting large fire whirlwind formed itself around a prominent point on a ridge which contained not only ranch structures but a number of men and firetrucks placed there to protect them. These firefighters could well be the first human beings to view a fire whirl from the *inside*. If this honor is somewhat dubious there can be little question of their particular good fortune in emerging unscathed from such an unusual situation.*

In yet another case (Pole Line Fire, San Bernardino, 1957) a very large whirlwind developed and became the head of the fast moving brush fire in moderately rolling topography. The whirl continued as the head of the fire, moving with the prevailing wind for a considerable distance. It is known to have advanced one and a quarter miles in six minutes.

As if to prove the old saying among southern California firefighters that a 13-month fire season exists in that portion of the State, a very destructive fire whirlwind occurred near the end

* Co-author Chatten witnessed this frightening phenomenon from outside the fire whirl on the De Luz Fire, San Diego County, August, 1949.

of the winter of 1960–61 in Santa Barbara County. Moderately strong foehn winds were driving this fire downslope when many small whirlwinds suddenly formed into one large one. As it moved from the main fire its flaming path of destruction led through homes, barns and avocado orchards. Then the whirl lifted to travel overland toward the Pacific Ocean.

# CHAPTER SIX

## Nature's Danger Signals

LIGHTNING does hit twice in the same place. In fact, where it is common it strikes in a pretty well established pattern. But in California it is not the rapid build-up of a potential lightning storm that offers the greatest unpredictable nuisance to the firefighter. It is sudden gusts of wind or violent changes in force and direction that can quickly upset the firefighters' best plans. As a matter of fact, lightning most often is born of the same natural phenomenon that can cause most local air turbulence—the convection upsweep of the cumulonimbus cloud.

### CLOUD FORMS

Clouds are simply moisture particles in the air (which may be ice crystals when high enough), They form when a mass of relatively warm air containing water vapor has its temperature lowered by one means or another to the point where the water vapor condenses into fog, rain, hail or snow. When the fog or mist rises above the ground it is called a cloud. Clouds may form on a grand scale in a tropical monsoon, or in the solitary miniature cloud cap where warm ascending air is chilled when it reaches the tip of a snow peak.

Clouds are generally segregated into families occupying a relative height above the earth. The drizzly mist that drifts over the hills in winter is cousin to the pale sheet clouds of warmer weather; they are of the stratus family and they generally indicate stable air conditions. Certainly the high stratus sheet clouds of summer are friendly to the firefighter. They indicate a lack of turbulence at their elevation and they reduce the penetration of heat rays from the sun. Also they counteract the violent upheaval of cumulus updrafts that may be forming below them.

When a mass of warm air containing a relatively large amount of water vapor moves upward in a convection current the cumu-

lus cloud is born. This happens when the warm air reaches an elevation at which the temperature is capable of condensing the air moisture. This condensation point most often occurs at a rather precise elevation and thus the flat undersurface of the cumulus cloud is formed.

If the strength of the updraft is powerful enough, the rising air (now visible as beautiful, rounded cloud billows) in seeking a state of equilibrium reaches the height and temperature where the vapor turns to ice particles. The cloud is now a potential rainmaker and it is a fully formed cumulonimbus. Thereafter it may degenerate into the high cirrus or lower altocumulus formations, or even disappear if the temperature aloft changes enough to absorb the moisture particles. But most likely the familiar thunderhead (sometimes called anvil or cauliflower) will develop and rain or hail and lightning will strike the earth.

Lightning is caused by the equalizing of positive and negative electricity at the upper and lower limits of the cloud. Sometimes this violent readjustment uses the earth to help dissipate the electrical tensions and sometimes it occurs in lightning flashes from cloud to cloud. Hail forms as the turbulent currents within the storm cloud drop and lift and drop the water particles, changing each into an increasingly larger ice pellet. Sometimes, in lesser storms, the falling hail, snow or rain may pass through air so warm that the moisture particles are absorbed into the air before they reach the earth.

Strong winds will be experienced as a thunderstorm of this variety passes overhead. The tremendous convection updraft is generally confined to small areas and movement upward is known to have reached one hundred miles per hour in some storms. This, of course, will mean that the wind will blow toward the bottom of an approaching storm and then change directions to the observer as the storm passes by. The downdraft that flows away from these cumulus clouds is another disturbing element surrounding the clouds. Extremely strong and erratic winds can occur where these downdrafts pancake against the ground surface.

No doubt most of the cloud masses that are commonly observed over the Sierra during summer are the result of the lifting effect of warm ground air sliding up the mountain slopes from the valley lands.

Large forest fires send up a warm column of air that often cause a true cumulus cloud to form over them. Here, too, a downdraft will be a natural phenomenon, but fortunately it can be expected to reach the earth well beyond the fire perimeter.

Small, separate cumulus cloud tufts or "cottonballs" are called fair weather cumulus. Nevertheless, they are the result of convection updrafts and the firefighter should expect to find turbulence around him as they pass overhead. The glider pilot searches them out because the rising air is there to support his craft. When any of these clouds become shredded or elongated like cigars, it is because strong winds aloft are acting upon them. That is a sign that soon the air near the ground will be affected by the same turbulence. It is a danger signal for the firefighter. Verga or moisture streamers beneath cumulus clouds is another visual warning that adverse winds may soon be expected on the ground.

## DUST DEVILS AND MIRAGES

**Dust devils** are small whirlwinds that always indicate an unstable condition of the atmosphere with a readjustment soon to come. They are most prevalent during the middle of the day when the sun has heated air near the ground to the point where expansion caused by heat is out of balance with the density of atmosphere above the ground. At this point, a small triggering action can create a turbulence. This becomes a reality as warm surface air movements are interrupted by a rock or haystack or a small updraft in a gully. Friction and confusion upset the even flow of air which begins to whirl around and upward until it expends its energy in a crazy gyration.

The uneven burning effect of scattered patches of fuel on a large fire can develop the same type of whirlwind. Here it is potentially more serious than the flamethrower which it is. It may also generate enough of a convection current to cause a blow-up over the smoldering fire area. Utmost caution should be observed when the surface air is capable of producing dust devils.

It is true that during any hot day there is danger of turbulent air movements that could create treacherous fire behavior. The safety valve is, of course, a reasonable adjustment of pressures and tensions in nature which do not react so rapidly as to cause

a situation which man cannot control or, at least, which he cannot predict. Inversion layers of atmosphere are said to be stable enough. It is the violent rupture of the inversion boundary under pressure which can cause the trouble for man. Normally on a hot day warm currents of air will move upward. A low flying aeroplane over broken topography and different vegetation often gets a rough ride through these convection chimneys. Often, too, a very great change in temperature is felt at definite elevation levels in the air. These are the inversion blankets interfering with the upward dispersal of the convection currents. Such indications are prime danger signals for the firefighter on the ground.

The same potentially unstable air condition over warm earth that produces dust devils may also produce mirages. These are familiar as "lakes of water" that disappear when one approaches near them or changes his observation point. The illusion is caused by refraction or bending of light rays through layers of air of different density. The "lake" is probably the reflected sky. This thin and very warm layer of ground air should be rising and losing its heat, but air of somewhat higher density presses down upon it from above. With enough turbulence in the vicinity this low blanket of warm air would have an opportunity to seek an area of equilibrium at a higher elevation. Mirages are a danger signal which indicate that the proper triggering action could cause air turbulence near the earth, very probably in the form of sharp convection updrafts.

*Turbulent air movements near the ground create difficulty in fire control as well as a serious hazard to life and property.* The hazard is found not only in the existing disturbed weather conditions but largely in the treachery of sudden and unexpected shifts from gentle to violent local weather behavior. This occurs when natural forces under tension move abruptly toward a state of equilibrium.

The visible behavior of some natural elements will warn those capable of reading the signs that the apparent calmness or normalcy of surface weather is not trustworthy. The firefighter should be aware that the unusual behavior of fires burning on some days of apparently normal weather could very well be the logical but unhappy result of the abnormal or highly unstable local weather conditions he fails to observe around him.

# CHAPTER SEVEN

## Fire Danger Rating

IN ITS BROADEST and most complete sense, fire danger can be considered as the potential for damage from fire. This damage potential is created for a given place or thing by such factors as weather, fuels, topography and the different types of values inherent in the particular flammable resource or property.

The more intensely a fire burns the more damage it usually does and the more difficult it is to control. It is, therefore, of utmost importance that the fire manager be aware of the total influences bearing upon incipient fires *before* they start. In short, he wants to know his potential *fire load* on a day-to-day basis.

The reaction of fire to its environment is infinitely complex. As we know, the environment varies with the time of day, the season of the year, and it can even change from minute to minute. To attempt to precisely measure every factor which influences fire is not only impractical, but impossible. On the other hand, any prediction system that does not account for the important major variables within a localized area does not answer the fire manager's need.

The California Fire Danger Rating System was developed through the cooperative efforts of the California Division of Forestry, the U. S. Weather Bureau, Region 5 of the U. S. Forest Service, and the Pacific Southwest Forest And Range Experiment Station of the U. S. Forest Service.

The system is designed to estimate the relative effects of weather on the several aspects of fire behavior—fire spread, fire intensity and fire ignition.

The State has been divided into more than 150 climatic zones. Not only does each zone have a similar climate throughout its area but it usually has one predominant fuel type. The various agencies protecting wildland in California participate in this uniform fire danger rating system. Each maintains a network of fire weather stations to daily sample and record the weather and

fuel condition within each of the numbered zones in its area of responsibility.

The California Fire Danger Rating System is made up of a blending of several individual factors: Ignition Index, Spread Index, Intensity Index, Burning Index, all of which are used to determine Fire Load Index.

The **Ignition Index** is an estimate of the probability of fires occurring. It is determined by temperature, moisture content of fine dead fuel (standard fuel moisture stick readings).

The **Spread Index** includes fine dead fuel moisture, the curing stage for grass and wind speed. It is an estimate of rate of fire spread and hence potential length of fire line.

The **Intensity Index** estimates the intensity with which a fire will burn once started, and indicates relative width of fire line required to contain it. It is determined by moisture content of dead fuel of medium size (using fuel moisture stick readings); moisture content of green brush fuels (using as a guide the days since green growth started but not exceeding 120); and moisture content of heavy fuels (a formula derived by accumulating rainless days with a correction factor for any actual rainfall).

The **Burning Index** is determined by combining the *Spread Index* and the *Intensity Index*. It represents the job load per fire. As the index increases the length and width of line needed for perimeter control increases.

Finally, the **Fire Load Index** is derived by combining the *Ignition Index* and the *Burning Index*. This indicates the potential daily job load in any management area.

*Each* of the above indexes can be meaningful to a Ranger Unit administrator. Each has a scale of zero to 100 set up in an arithmetical progression. In other words, an Ignition Index of 40 is twice as adverse as 20, etc. Thus, with a knowledge of his area he could, for example, forecast the possibility of fires starting in recreation areas where grass is the predominant fuel, or the relative intensity and rate of spread of a fire occurring in a remote area during hunting season. This would allow him to bolster the local forces, intensify patrols, or "spike out" crews or take other appropriate action.

The Fire Load Index is an overall management tool which can be used as the basis for cancelling (or giving) days off, assigning Conservation Camp crews to projects close to primary

travel routes, ordering standby (or release) of aircraft, spiking out crews to predetermined points to reduce travel time to any fire start, using aerial detection to supplement fixed lookouts, activating patrols in certain areas, increasing (or decreasing) strength and composition of first attack forces, and so forth.

Each afternoon during the declared fire season, weather observations are made at each fire weather station. These recordings are used to determine the actual fire danger rating for that particular day for the zone in which the station is located. The afternoon weather forecast from the U. S. Weather Bureau is then used in combination with the current and previous day's fire load indexes to predict the next day's Fire Load Index. It is the predicted index that will be used by Unit administrators and fire managers in their respective planning. This procedure also brings to light *trends* in weather and fuel conditions which are just as important as an individual predicted index.

This particular fire danger rating system is unique in that it can be improved and refined by having the factors or indexes added without necessarily changing the ones already included. For example, we have seen that atmospheric stability (or instability) can have a marked effect on fire behavior. It is, therefore, anticipated that the rating system will ultimately include a stability index weighted according to the estimated effect that a given index reading will have on fire behavior. Other indexes may also be added as experience is gained in using the system and as research indicates the need.

It should be borne in mind, however, that a fire danger rating system is only a relative measure of potential damage for a particular time and place. It can be meaningful only if it is compared with experiences of the day before, the week before or even the year before. Nevertheless, it is an important tool that a conscious administrator will use to advantage.

# PART II

## Techniques of Fire Control

# CHAPTER EIGHT

## Fire Fighting Methods

IT HAS been said that Knowledge is Power, and Ignorance is Costly. That would seem to be a pretty sound axiom for the guidance of any human endeavor, including forest fire suppression. Hard and dangerous work over long hours will accomplish little unless the work is efficiently directed toward the proper goal. The science of fire control is based upon numerous dependable natural laws. The problem facing every firefighter is to learn of those laws and then try to read the measuring devices that either Nature or man has provided as indicators or guides. Unfortunately, the elements that influence fire behavior are so complex, and our knowledge of them so inadequate at the present day, that our accomplishments are still much governed by the laws of chance.

It was commonly said among the old "fire stompers" that no one could ever write a text book about the job of putting out forest fires. They felt that Nature was too capricious, and anyway, the only way to learn what could be learned was to go out on the fire line and absorb it along with the smoke and ashes.

It is truly difficult to find a substitute for experience in such an earthy task as combatting a wild fire. But during the intervening years a tremendous amount of scientific work has been accumulated, tested and recorded. Statisticians have analyzed tens of thousands of fire reports. Chemists, physicists, meteorologists and other scientists have been making tests and measurements in the laboratory and on the fire line. As a result we can make use of a steadily growing supply of text books, pamphlets and articles on the subject of forest fire suppression. Steadily also the tools of measurement, observation, and attack are being put into the hands of the men who go out and get the job done.

Efficiency in fire suppression can rarely be measured by comparing cost of effort against value of fire damaged property. The real value to consider is the property that escaped damage when

the effort succeeded in stopping a wild fire. These are abstract qualities to calculate but they have much to do with the matter of fire behavior. They point to an objective that is often overlooked. The primary aim of the responsible firefighter should be to prevent the blow-up, the campaign fire—what might be called catastrophe. The secondary objective should be to suppress the fire with the least acceptable loss at a cost we are willing to pay. In meeting the first objective the second will usually be accomplished.

## SIZE UP

A fire is reported burning in forest fuels and a crew is dispatched. The mission before the leader of the first attack suppression crew is simple enough. He is to put out the fire. He shall suppress the fire before it gets large and do it with whatever facilities are within practical availability. That is to say, he shall not hesitate in the hope that in due time perhaps overwhelming forces of men will come to share the problem.

Proper attack and control actions can only be taken if the fire problem is fully evaluated—or sized up—with consideration to the current and potential burning conditions. This size up begins with the first report—sketchy though the information may be—and continues until the fire is controlled.

The Fire Boss *enroute* with his first attack force begins to evaluate his problem from the facts at hand. The sooner suppression action can be started and the proper forces placed on the fireline, the better the chance of early control.

The Fire Boss must ask himself a number of questions at this time: In what area and general fuel type has the fire been reported? What has been the history of fires in this area—particularly large fires? What are the expected weather conditions for this time of year? What has been said about the fire's behavior by people who have seen it (lookout, aerial observer, public)?

The **general location** of the fire may have a bearing upon the logistics of moving men, vehicles, and material to the fire area. The grades and quality of roads may have an effect upon the speed of transport, and might possibly preclude the movement of heavy line building equipment. Or it might be that access to the immediate fire area is not possible over any existing roadways. The distance that must be covered by men and equip-

ment dispatched to the fire could certainly affect the elapsed time required in travel and might also introduce a fatigue factor in long journeys. The general location of a fire will indicate to the knowledgeable Fire Boss whether he is working in a land of very little surface water, or which has perhaps a reasonably adequate supply of water for firetrucks that is not fit for human consumption.

The *first sight* of a fire will give the Fire Boss an opportunity to gain additional information concerning the magnitude of the job he faces. Again he should ask himself certain questions. From the appearance of the smoke, what is the intensity of the fire? What fuel types are burning? Will the hottest portions of the fire perimeter be accessible for attack? Is the fire still within the control capabilities of the forces that are responding?

When he arrives *at the scene* of a fire the Fire Boss must quickly conclude his size up so that his forces may be promptly and effectively deployed. *Does the situation require the immediate dispatch of additional forces?*

The competent Fire Boss will undertake this project the way every intelligent workman approaches any task. He will determine just what the conditions of the job are and then he will calculate how to go to work in the best manner with the best tools he can obtain.

He will *size up* the fire suppression project before him and then he will *attack*. Most likely he will make a preliminary size up at a glance, order the most logical attack, and then devote more time to determining the finer points of his problem. If he is a man of long experience he will move through those three steps so naturally that it would be practically impossible to separate them as such in his thoughts and actions.

To take an inventory of the fire control project facing him the Fire Boss will need to know many details about the three major influences affecting fire behavior—fuel, topography, weather.

In order to gather necessary information he had better *see* the fire with his own eyes. The best way to do that is to walk around the fire, or at least, approach *all* of the burning perimeter closely enough to see it for himself in the most expeditious manner. A helicopter, if available, should not be overlooked

as providing one of the best and quickest methods for making a reconnaissance flight.

These are the approximate questions that the Fire Boss will ask himself: What **fuel** is burning now and how hot and dangerous would it be for men working close to the fire? What type of tools or treatment will be required to suppress fire in that kind of fuel? What fuels will be burning very soon if the fire is not stopped? What fuels in the path of the fire are of most economic value, including homes, timber, industrial plants and watersheds? What fuels in the path of the fire when ignited will cause greater difficulty in control or perhaps cause a blow-up of the fire? Will the fire run faster or slower in the various fuels in its path? Will it flash, or crown, or throw spot fires? Will some of the fuel reburn or hold fire for a later break-out? Are there any snags burning or any that should be dropped immediately?

While considering the **topography** affecting the fire the Fire Boss will be looking at the fire perimeter, but probably more at the country surrounding the fire. He will ask himself a number of questions and call upon his experience and knowledge for satisfactory answers. What is the slope doing to the speed and heat of the fire? Will certain areas be hazardous to the safety of men or equipment? Will stones roll and endanger men or will burning material roll and spread fire? Which slopes will allow the fire to burn faster or slower and at what period of the day will it happen? Will some canyons cause turbulent air currents? Will fire spot across the narrow canyons? Is the ground surface composed of rocky material, or is clean mineral soil available, or is there a deep layer of duff and humus?

Are there any sweeping upslopes, especially southerly exposures, in the path of the fire that will cause greater difficulty in control and more acreage burned if they are ignited? By what path can men and equipment reach the work area? If a camp must be established, where is the location safest and most accessible to the job and to outside contact? Where is the nearest source of water for drinking and for tank trucks or hose lines?

**Weather** has to be sized up for the past, present and future by the Fire Boss gathering information for the battle before him. He will be forewarned of the probable moisture content of the fuel around him if he has been watching weather read-

ings and observing the behavior of fires in recent days. If he is a man of experience the way the fire before him is moving through different fuels will tell him a great deal about how it may behave in another hour or in another day. He will be aided in this by the predicted Burning Index as described in Chapter 7.

The Fire Boss will be as sensitive to the wind as an old sailor. Probably the direction and force of the wind will be the dominating factor in the numerous decisions he must make now and throughout the life of this fire. If the fire will not be under control before nightfall, he must make the best possible determination as to probable changes in the wind speed and directions at different hours of the night. How will the night humidity affect the burning capacity of the fuels with which he must work? An unfortunate misjudgment of conditions for the first working night of the suppression crew will be unfortunate indeed.

In all of his deliberations and evaluations of the fire problem and in deciding his strategy and tactics, the Fire Boss will bear uppermost in his mind the *safety* of his men and equipment. His decisions will be predicated upon the reasonable assurance that the planned method of attack can be carried out safely.

## DETERMINING THE ATTACK METHOD

The essential job before the Fire Boss is to "break the triangle" in his forest fire. He could approach the flames and eliminate oxygen by smothering the fire with dirt or a fog of water or chemical, or he could beat out the flames with a pine branch if the fuel is not too heavy and hot. He could spray enough water or have airtankers drop fire retarding chemicals on the fuel at the place of combustion to discourage the burning process. All of these procedures would require that his crew work practically at the edge of the flames. If he is going to depend upon water he will have to have a sufficient supply as well as pumping equipment to properly apply it to the fire. If he is going to depend upon airtankers he must know that the frequency of retardant drops will adequately support the efforts of the ground forces.

A second method or technique of fire suppression does not require a close approach to the burning edge of the forest fire. The Fire Boss may use his men to remove fuel from the path of the fire so that the combustion process must cease when all

available fuel is consumed by the fire. Regardless of the method used, the basic technique of suppressing forest fires is one of perimeter control. The perimeter may be established at the burning edge of the fire, near to it, or a considerable distance away. The objective is to establish cleared breaks that completely encircle the fire with all of the fuel inside of the breaks burned out or otherwise rendered harmless.

In California under present day conditions the great majority of fires are suppressed by the use of all of these methods used to some degree. This becomes more the case as the fire becomes larger and more complex.

Nevertheless, the Fire Boss is obliged to decide promptly if his men and equipment can and should adopt the *direct* method of attack and work at the burning edge of the fire, or if they should or must work at a distance from the fire perimeter in an *indirect* attack. Or just as important, a decision in strategy may demand that he consider striking part of the fire perimeter directly while he takes indirect action elsewhere.

The various techniques may all eventually be used to a greater or lesser degree along the fire line before the job is done, but the early decisions of the Fire Boss can and should be precise and to the point. Ten minutes of a man's effort at this time may be more valuable than an hour of work a few hours later.

The decisions that the Fire Boss will make will be based upon his knowledge of fire behavior, upon what he believes can be accomplished with the men and tools available for the attack, and to some extent upon the potential economic effect of the fire.

The arguments for and against the use of **direct attack** upon the fire line and questions requiring answers will either consciously or subconsciously pass through the mind of the Fire Boss about as follows:

(a) Will there be too much heat and smoke to permit men to work at the edge of the fire?

(b) Will men be safer there where they may step into the burned area, or are the heavy fuels holding heat too long to provide a genuine safety zone? Or is the particular fuel likely to flare up and trap the firefighters under existing burning conditions?

(c) Would trucks, hose lines, or bulldozers be exposed to too much risk of wreckage or burning while they are worked in that kind of topography and vegetative cover?

(d) Are there areas of vegetation or structures that should be kept from burning because of their economic value or because the fire will probably be much more difficult to control unless fast action is taken to keep the fire away from them? For instance, should a probable crown fire be avoided by taking direct action to stop the fire before it reaches a thick stand of timber, even though the concentrated effort may give the fire perimeter a chance to spread elsewhere unimpeded in the meantime? Or should the fire be allowed to temporarily run into open timber while the great effort is made to keep it out of heavy brush?

(e) Will it be worth the effort to work a meandering line along the edge of the burning fire, covering possibly more actual distance in trail construction than if an indirect attack were used? Certainly the fire line constructed will have to be pretty much where the fire dictates. The probability is that the direct attack line will be built in heat, smoke and under pressure of time, to say little of the necessity of taking soil, roots, rocks, and logs as they come in the course of the trail building.

(f) Are the men in such physical shape and are they skillful enough to work best in direct attack? For instance, will they realize that careless work may actually throw sparks across the line, and that every inch of the burning fire perimeter must be extinguished or all the effort may be wasted? Can the supervision required to accomplish the necessary quality of work be devoted to the line constructon job now?

(g) Are there parts of the fire perimeter which are practically out, so that advantage can be taken of this reduction of total distance around the fire?

While weighing the reasons for and against the use of an **indirect attack** on the fire the following questions would present themselves to the Fire Boss:

(a) Are there natural barriers to the fire which can be used to advantage? For instance, are there roads, streams, cultivated or burned land which can be used as backfire lines or which will in themselves halt the forward movement of the fire?

(b) Is the topography around the fire such that it will be safer or more effective to choose the most advantageous topographic features away from the fire and prepare them as a defense line? For instance, will it be necessary to take advantage of a ridge, a canyon bottom or a land bench for one or more of the following reasons: because of the heat of the fire while it is approaching such natural features; because of the difficulty of directly suppressing fire in the fuel that is burning; because the area now burning favors fire spotting ahead or burning fuel rolling behind the fire line; because of an anticipated change in the weather favorable to holding prepared lines.

(c) Is the economic value of the fuel that will be destroyed between the present fire line and the proposed holding (or backfire) line so relatively small that it is best to take advantage of a cooler, safer, cheaper line back from the present fire edge, especially with the added advantage of less patrol effort required afterward?

(d) Is there the disadvantage of possibly leaving an area unburned between the present fire and the holding or backfire line? This could be a nuisance requiring close observation throughout the remainder of the fire season or it could require added effort to be sure the fire is out along what could remain as a very spotty and difficult dead fire perimeter.

(e) Would it be difficult to force a backfire to burn during the safe backfiring period? Or would there be too much danger of a backfire escaping once it is started?

## DIRECT ATTACK METHODS

*Provided heat and hazard to life do not preclude it,* the direct method of attacking a forest fire will usually be used if (1) the fire is small, or (2) the rate of spread is slow, or (3) some fuel of great economic or nuisance value could readily be ignited if any delay is tolerated in bringing the fire under control.

Separate phases, or distinct actions, are segregated and described below in order to explain the salient features of the direct attack plan. The fact that these actions may be used in every manner of combination to effect the most success in the control of a fire is not important. The important thing is to present to the firefighter a group of work processes or "tricks of the trade" that will be consciously fixed in his mind for use

in time of need, and secondly, to describe and name certain phases or actions so that there can be a prompt and accurate exchange of ideas among firefighters through the use of accepted word names.

### *a. Working the Fire Edge*

By far the most effective place to expend effort to subdue and eliminate a forest fire is where combustion is occurring at the exterior advancing edge of the fire.

The statement above does not proclaim that the best strategy is to begin an attack on the flaming edge of every fire. That particular matter is discussed rather fully a little farther along. Suppose you figuratively stand back and take a look at the basic problem of stopping a forest fire. You ask yourself: what is going on here? A satisfactory answer might be: a continuous combustion action is spreading out all around where there is fuel. There is nothing to be gained by beating out the remaining fire on the inside. The object is to stop the fire where the flame is meeting new fuel. I can go to work where the flame exists now or I can arrange things so that I meet up with the edge of the flames when and where I will have more of an advantage. The rule still stands; the most effective place to stop a fire is at the advancing flaming edge.

This rule is not airtight. Certainly there are times when the effective place to strike is outside the perimeter if spot fires are starting there. Occasionally, a potential blow-up inside the line or some burning snags may deserve primary attention. Then, of course, there can be plenty of opportunity for much wasted effort along a fire perimeter. This could result from poor strategy or from ignorance. As an example of the first we might consider how futile might be an attack into the face of a chamise fire at midday. The second is typified by the vast effort that has often gone into fighting it out on a line that had already been enveloped by a pincers advance of the fire around the flanks of the operation. This latter is not the same thing as losing a scratch line or even a primary line because of the unpredictable fortunes of war. This is a matter of lack of information or proper direction causing heroic effort to be wasted in the wrong place. Or a fire might have slopped over a ridge and be burning on an extremely steep slope with large volumes of potential

rolling material. In this case, it would be better to establish a line at the bottom of the draw below and allow the slope to burn out.

Assuming that the most profitable and reasonable place of attack is right where the fire is presently burning the fuel, we should now consider how to go about this Direct Attack at the fire's edge.

Along the fire's edge suppression work can be accomplished with bulldozers, air tankers, water, or hand tools, or a combination of them all. In an emergency the fire may even be attacked with a flail consisting of a tree branch. The intent is to cause the combustion to cease and be done with.

Fuel that is burning or about to burn should be pushed into the burned area. New fuel should be separated from the burning area by the construction of a trail dug to clean mineral soil. Logs and roots that extend across the line should be cut or pulled into the burned area if there is the slightest chance that fire will use them to cross the trail.

Snags * are a special nuisance to the firefighter. They are very susceptible to spot fires because they present a dry and punky fuel up in the air where flying sparks can come to rest. Then when the snags are on fire they become torches in the higher wind movement above the forest floor. Thus they are the one fuel in the old forest most likely to catch fire from flying embers and then become a spreader of more spot fires. Along a fire line it is therefore necessary to fell † all dangerous snags. Their potential danger will, of course, vary with topography, weather and surrounding fuel. A general rule would include as dangerous all snags two hundred feet within the burned area and fifty feet on the unburned side. Snags should in all cases be dropped away from the constructed fire line.

If lack of time or manpower does not allow for the felling of snags they are still important enough along the fire line to receive other treatment. Fires burning in snags should be suppressed if possible by the use of water or dirt. Snags with fires so high they cannot be reached should have the surrounding area fireproofed until the snag is dropped and the fire extinguished.

* A snag is described as a dead tree, or broken trunk more than 20 feet high from which leaves and most branches have fallen.

† At the present time the verb fell is still holding firm in the dictionary. However, common use in the woods has definitely displaced "feller" in favor of faller or chopper.

Special care should be taken to grub out any fire that may have descended into the roots of snags. Pitchy roots make excellent fuel for a smoldering fire.

Snags not burning but situated in a dangerous area should have all fuel scraped away in a ring around their bases so that fire may pass them by if the ground fuel burns.

Snags should always be approached with caution. The old trunk of the dead tree, limbs or deceitfully dangerous chunks of bark may fall at practically any time. The violent shock of logging operations and fires of the past or the casual deterioration caused by insects, rot, and weather have all been working toward the final destruction of the standing snag. The first blows of the firefighter's axe could well be the shock that brings down death or injury. Every snag-falling crew should have one alert lookout with his eyes aloft and ready to yell a warning to the workers near the trunk.

Where should the work at the edge of the fire begin? That is an important question. The obvious answer would appear to be: where most can be gained for the effort expended. Since the final object is to stop the forward progress of the fire and thereafter eliminate all cumbustion along the edge it seems logical to first subdue the fastest moving parts of the fire perimeter.*

It is quite impossible to set down a positive rule as to just where the initial action along the edge of a forest fire should be attempted. This is because there are so many variable conditions which naturally give each fire a character unto itself. This reduces each fire to an individual problem awaiting the solution of the Fire Boss. Perhaps an acceptable rule would be this: Move to secure the fire's flanks so that the most important goal can be accomplished. The object is to halt the head of the fire. Availability of adequate manpower or the fortunate circumstances of topography and fuel along the flanks and rear might make it

* When a fire is definitely moving in one direction faster than any other because of a driving wind or pronounced upslope the forward edge is practically always called the head. Sometimes it is referred to as the lead, front or hot spot. However, the term hot spot is more precisely confined to each relatively small area of intense combustion which may flare up anywhere along the fire perimeter. An isolated fire completely separated from the main fire is a spot. This word becomes a verb when such fires *spot* into the surrounding vegetation. On the other hand, when a fire moves across a line that was believed to have been secure the result is termed a slop-over. The burning fire edges from head to rear are most commonly called the flanks of the fire.

entirely possible to start vigorous direct action at the head of a fire. But this certainly cannot be proposed as rule of attack. However, the use of airtankers to make concentrated attacks with fire retardants on the head should always be given serious consideration if such action can be productive in the overall plan.

The historical record of battle plans developed and pursued in the smoke of literally thousands of forest fires of the past would be of great value here. No doubt we should find that on the majority of occasions when work was attempted at the edge of the fire it started at some well-secured rear position. From there, crews moved around and along each flank with the object of meeting at the head of the fire. An attack method such as this is called *Pincer* action.

A crew too small to split for effective double flanking would of necessity have to choose one side only for their work. It must be remembered that a certain amount of patrol work or mop-up begins almost when the first foot of fire line is constructed. That is to say, even with the smallest of crews someone should keep an eye to the rear. A little fire sneaking across the line could undo all the preliminary work.

Assuming that the Fire Boss believes the crew should work along only one flank he should choose the side that will offer most profit for the effort. That side could be burning faster than the other, or it could be of most concern because the fire was approaching timber that might crown, or a long steep slope, or for some other reason that caused spread of the fire to be less desirable on one side than the other. Perhaps, also, one flank could give less concern because of some existing barrier such as a road or stream that would eventually stop the fire.

But if values and barriers, and so forth, are relatively equal along the flanks of a fire and the Fire Boss must make a decision upon the direction of attack he should keep one thought paramount in his mind. The fire flank of this moment may be the fire's head within the hour. He should work to insure himself against the most probable shift in the wind.

The reasons given above for choosing one flank above another as the line to be worked could be reason enough for originally striking at a flank rather than the head of a fire. Even though the head may not offer any serious difficulty in suppression it could very well be that most is to be gained by keeping fire

away from some hazardous fuel on either flank. Perhaps such action would prevent fire from spreading into another drainage, or across to another side of a canyon and eventually result in a much lesser total area burned. In any event, this method is called *flanking* action.

If the head of the fire is burning in fuel that causes too much heat for direct suppression work, or if it is too dangerous to work there, or if there is just so wide a frontal movement that the fire would simply squeeze around a small crew, then most may be accomplished by attacking at the rear and at least accomplishing positive elimination of part of the perimeter of the fire pending the arrival of more forces. Or, for instance, it could be most imprudent to exhaust crews in trying to subdue the running side of a chamise fire during the heat of the day when the evening hours will almost certainly favor closer action.

In this respect it must be remembered that before a fire can be considered out and dead *all* of the fire perimeter must be out. There can be no loose ends slipping away. Every backfire line or main fire line must tie into itself or into some anchor point that will prevent the fire from infiltrating from the rear. That, of course, immediately points up the great advantage in striking a fire with enough manpower to at least prevent a loss at one end of a fire line while work progresses at the other. Two trained crews working along both flanks from the rear can often accomplish amazing results, especially if they are favored by an indraft retarding the outward spread of the fire.

A direct attack by a number of firetrucks or bulldozers working in *tandem* with crews is a tactic often applied effectively in a flanking action. This type of deployment permits rapid forward movement along the fire edge by the equipment with follow up and holding action being accomplished by work crews.

There may be cases on small fires when burning conditions are right and the fire is accessible from all sides so that key or critical areas around the entire perimeter can be attacked at approximately the same time. This method is termed an *envelopment* action.

From time to time various specialists in the profession of firefighting have endorsed the One Lick, and the Two-foot, and the Parallel Line methods of attack. The ideas are all very fine but they essentially refer to good and sensible actions that

should be used, or not used, as the occasion requires almost from yard to yard or bush to bush along the fire line. No single positive theory can be substituted for the variable exercise of good judgment.

The Parallel Line method proposes building a line from five to fifty feet in front of an advancing fire line and then waiting for the fire to reach it and burn itself out, or backfiring the little distance if necessary. This is obviously a modified indirect system of attack upon the fire. The Two-foot method is a modified Parallel method with the line constructed much closer to the fire. Both ideas have the advantage of working away from the heat and smoke, and most important, of taking advantage of the ground cover to construct the safest and fastest line. In uniform fuel many twists would be avoided by taking the line from point to point rather than along the burning edge. But the fact remains that the theories will lose their distinctiveness at the hands of a trained crew taking advantage of every natural feature on the ground. The work performed is essentially a direct attack on the fire perimeter and hardly worthy of special nomenclature.

The One Lick method is rather different in that it purports to be only a teamwork system of using several types of tools most effectively. In practice an axeman may walk along the proposed line lopping off limbs or bushes as he proceeds at the speed of a slow walk. Perhaps another axeman or man with a brush hook will follow and then a shovelman, then a pair of sawyers to break up logs, then men with scraping tools and swampers as they are needed. The advantage in this system is the freedom gained for workmen to work in safety to themselves and others, and also in providing more profitable and open working space for the latter men in the procession. The requirement is, of course, intelligent teamwork by the workmen.

Closely allied with the One Lick idea is the Scratch Line construction of an emergency fire trail. This would be recommended if there were danger of losing the fire because of the speed of its advance. The scratch line should be depended upon only to slow the advance until a more dependable line can be constructed. Nevertheless, the scratch line can create a delaying action of high strategic value which should not be disregarded by the Fire Boss.

### *b. Hot Spotting*

Hot Spotting is verb in the firefighter's language that refers to the rather specialized job of suppressing the "hot spots" which are the most rapidly advancing heads along a forest fire's perimeter. Obviously, the hazard to safety, the tremendous physical effort often required and the necessary knowledge of fire behavior indicate that only the most experienced and able men should be selected for hot-spotting work.

Hot spotting may be accomplished by firetrucks, airtankers, or ground crews, attacking one critical point after another instead of working a continuous line along the fire edge. It is essentially a delaying tactic to allow ground crews to get on with the solid job of constructing the main fire line around the fire without having some head (or hot spot, or finger as it may be called) streak away and upset the plan of control by spreading the disaster. Hot spotting may be necessary here and there on a fire perimeter that is otherwise dead and being treated to cold trailing procedure.

### *c. Cold Trailing*

Where the edges of a fire perimeter are relatively "cold" the construction of a minimum trail to assure against further advance of the fire is referred to as Cold Trailing. A fire may cease to burn actively for three general reasons. There may be an insufficiency of fuel that will continue the combustion process, or the weather may completely discourage combustion (as it could in rain or wet fog), or there may be a combination of weather and fuel that will cause the fire to go out. The latter condition is well known to occur often during the night in chamise brush.

Cold trailing may be practiced when the fire edge appears to be out beyond question or when fuel is smoldering with occasional flareups.

Before any portion of what was formerly the hot fire perimeter can be left without any attention there must be absolute certainty that the fire is dead out. The price for carelessness in this respect is so great that the time honored custom of "feeling out the fire line" is most positively recommended. And furthermore, it should be the responsibility of a man of experience. Many a deceitful fire looks to be out. But human fingers ex-

ploring ashes and leaves and under logs at the fire's edge are a pretty sensitive detecting device.

To preclude the slightest possibility that the fuel may again ignite it will be necessary to build a trail into the clean soil to a width that would prevent either flames, sparks or falling material from reaching across the line. It is well to bear in mind that when an active fire perimeter degenerates to the cold trailing stage the strong probability is that there does exist a fuel supply on the burn side. Moreover, that residue of fuel could well have become an increased menace because of the smoldering heat it may be hiding and because its fuel moisture content has been reduced during the fire. This "toasting" effect upon green fuel should not be taken lightly. Some rangers will vouch for having seen fire make three successive sweeps through the same manzanita patch.

The line constructed during cold trailing meanders along the edge of the fire. All fuel matter scraped away from the soil must be thrown into the burned area. Potential fuel near the line on the burn side should be lopped and generally broken up and scattered farther from the fire line. Logs, limbs, cones and animal manure should be pushed well away from the line. Smoldering fuel should be given every opportunity to burn itself away. This important business will be discussed further under Mop-up and Patrol.

### *d. Burning-Out*

Fingers of fire led away by fast moving heads, or the natural topographic features over which a fire burns, will often cause a very irregular fire perimeter to develop. Very often complete islands of unburned fuel will be evident even after the fiercest forest fires.

The term Burning-out has come to refer to a clean-up by the use of fire of any residue of fuel between a constructed line and the edge of the dead fire. This process is in no sense a backfire. (To avoid confusion in terminology a backfire should be considered as any fire set to consume fuel in the path of a free burning wild fire.)

In the discussion of line building the fact was noted that most is to be gained by building the straightest line, while taking advantage of topography and vegetation. In other words, the

direct attack on the fire might occur in the very flames at the fire's edge or five or twenty feet away. Where irregular fingers have spread out the residue fuel may amount to several acres. If combustion stopped short of the line in any place there would obviously be left a residue of dangerous fuel. Burning-out this fuel is an important insurance against a future flare-up. Of course, only the good judgment of the Fire Boss can establish the circumstances under which cold trailing inside a constructed line may eliminate the need to burn out remaining fuel. Any fire, including one set under control, still harbors the hazards of an escape.

## INDIRECT ATTACK METHODS

When the firefighter stands back and chooses the ground upon which he will meet his opponent and chooses the moment of his own greatest strength to strike hardest at the fire, then he can be said to employ an indirect method of attack. On the other hand, direct attack requires that the firefighter go down into the arena and meet the fire where it exists. Three factors will influence the decision of the Fire Boss in his choice of methods. They are: safety of men and equipment; difficulty of suppressing combustion in the type of fuel that is burning; economic and time factors involved.

Values threatened by the advancing fire must receive their rightful consideration also. Whenever a concentrated value such as structures, a sawmill, or an isolated block of merchantable timber can be saved within a larger area that will inevitably burn, then specific *area protection* can certainly be justified—but not at the total expense of ignoring perimeter control.

### *a. Line Location in Indirect Attack*

In planning the location of his fire line the Fire Boss will ask himself this important question, "In the construction of my line how can I best take advantage of existing fire barriers and favorable topography?"

The best answer to that question will also provide the best rule for procedure in practically every line-building project. There could be a few rare exceptions to this rule. For instance, it is possible that such a broad expanse of uniform fuel and topography exists that time will really be the governing feature.

That is to say, the Fire Boss "buys" the time he thinks his construction project will require in terms of distance that the fire will travel in that time.

Another rare exception to the good rule for making use of the best topography and barriers might occur when the Fire Boss gambles on a poorer line location for the sake of saving a valuable area of fuel, such as a stand of timber below the crest of a ridge. In such cases a secondary line of defense to the rear is the essence of wisdom.

Occasionally one may encounter a situation in which the fire is burning with such intensity or in such rough topography that it becomes necessary to establish control lines which encompass a natural area well in advance of any portion of the fire edge. This effort is called *area control* action.

A plan for indirect attack, including a constructed fire line, may be prepared with either one, or a combination of two ideas in mind. Either the firefighter waits for the main fire to move up to his barrier under conditions of speed and heat that can be controlled at that line, or he destroys the fuel in the intervening space through the use of backfire.

Before considering the backfire it is pointed out that the holding (or waiting) line system may result in the need for additional work beyond that required for either direct attack or backfiring. This would come about if the main fire ceased its forward movement short of the constructed line. Such a situation would very likely require cold trailing of the fire's edge or burning out the intervening fuel. No doubt more hours of patrol of such a line would also be required.

### *b. The Backfire*

*A person shall not set a backfire, or cause a backfire to be set, except under the direct supervision or permission of a state or federal forest officer, unless it can be established that the setting of such backfire was necessary for the purpose of saving life or valuable property.* (Sec. 4426, Public Resources Code of California.)

The above quotation of law testifies to the serious consequences that may follow the ignorant or careless practice of backfiring. Without doubt over the years in California millions of acres have been needlessly burned and millions of dollars in property destroyed because, without direction or in a panic of desperation, some unauthorized person ignited a backfire. Every

old firefighter in past years could recount tales of being nearly caught in an unexpected backfire. Fortunately, at the present time such incidents are very rare because of the confidence the public and fellow professionals place in the fire managers charged with the responsibility of bringing wild fire under control.

Nevertheless, backfiring on a broad scale requires skill, courage, and much knowledge of fire behavior. It is best left in the hands of experienced men. Backfiring should not be employed unless it is quite necessary. Justification for backfires is found in conditions at the edge of the main fire, such as speed of spread, great heat, hazard to life or resistance to suppression by direct action.

A proper backfire should be made only when control lines or barriers are in existence all around the area of fuel to be consumed in the backfire. This will mean that both ends of a backfire line should have anchor points. In the grass fires of the rolling and precipitous foothills of the Sierra (where backfiring is a common practice because of the speed of the main fire and the relative ease of controlling a clean, fast backfire), the man who "leads" the backfire will tell you he must have an end goal where he can "drop" the backfire.

The key to the hazard involved in fighting fire with fire is found in the desire to accomplish diametrically opposed objectives on each side of the backfire line. On one side it is desired to consume all of the fuel by fire (often in great haste) and on the other side the day will be lost if fire breaks away. Obviously then, the weather that favors one side will hold a risk for the other.

A certain chance must be taken in practically every backfire. Providing the men on the line are not placed unduly in jeopardy it is better to risk losing a backfire than lose the main fire and all the effort put into line construction.

The greatest threat to personal safety will be found in ridgetop saddles and on a descending line when the main fire has an inclination to finger out horizontally below and close to the constructed line. Such fingers may have to be counteracted by the ignition of a preliminary spot backfire sometimes called a buffer. This is a hazardous and unfortunate situation unless firing along the adjoining backfire line above can follow promptly and successfully.

Saddles are generally always at the head of a canyon or natural chimney. When burning conditions are entirely satisfactory this is where the backfire will be more inclined to funnel upward rather than spread downhill as desired.

Since a successful backfire should dispose of all of the fuels between the line and the main fire it is necessary to backfire the entire line during that period when it will burn best and still be subject to control. Therefore, every effort should be made to avoid heavy fuels in favor of light, fast burning fuels within the backfire area. A slowly moving backfire is not desirable in most cases. However, it must be acknowledged at the same time that a wild and turbulent backfire is a very treacherous tool.

Generally, the best time to start a backfire is one or two hours after the peak burning period. Morning backfires nearly always fail. Yet, whenever it may be, when the best time arrives there should be no hesitation to take advantage of it. The right moment to backfire may well be more important than getting the whole job done properly. That is to say, with disaster imminent it may be wiser to gain in a holding action along part of the main front than to lose everything because the line is not fully constructed.

Backfiring is a specialized maneuver that deserves the best skill, tools and men that can be assigned to the task of getting lines built and the firing done.

Properly located lines simplify the task. Where some existing barrier cannot be utilized it is generally always proper to look to a ridge top as the proper place to construct a backfire line. On broad ridges it is often wise to back away from the very crest. Then when the main fire on the other side of the ridge exerts some tendency to cause an in-draft the backfire has the additional advantage of burning slightly uphill to the summit. This is vastly different from trying to force the backfire to burn downhill against the convection updrafts of the main fire. However, the line should not depart from the crest if it must be located on a sidehill steep enough to allow burning fuel from the backfire to roll down the backslope and possibly start a new fire in another drainage.

Some backfires may very well be started along a canyon bottom. In Southern California there have been some strong advocates of such a practice for the reason that so much heat is

developed in a brushfire rushing up a steep slope that they believe the danger to firefighters on the widest breaks and the chance for failure do not justify ridgetop firebreak construction. Of course, the primary argument against backfires started from the canyon bottom is that when vegetation will burn there it will burn too well elsewhere. The difficulty will be found in keeping fire from spreading throughout the entire canyon. Advocates of canyon bottom backfiring point out that once the firing begins the vegetation upslope is brought to a higher state of combustion.

On rare occasions it may be best to meet the above problem by actually splitting the difference and backfiring (without any more line construction than is needed for safety) from halfway up the slope. That is to say, a fast and effective backfire can be made to sweep upslope and meet the main fire near the crest, while a slower fire creeps downhill to the actual line of defense at the canyon bottom. Or more precisely, just across the canyon bottom if it is extremely narrow, so that rolling fire will not start flames up the opposite slope. This practice of sidehill backfiring will be largely governed by the fuel and the topography.

This brings up the **undercut line** as something to be avoided in either direct or indirect attack or even mop-up work whenever it can be prudently avoided. Sometimes, however, its use will save much time as well as loss of burned area. An undercut line is simply a horizontal fire line constructed across a slope and below the fire. The obvious possibility of fire rolling across the line detracts tremendously from its value.

On the other hand, a considerable area may have to be sacrificed below any proposed undercut line before a more secure topographic position is reached for the fire line. Also the area below a potential undercut line may be so lacking in promise because of hazardous vegetation and tangled topography that better judgment dictates construction of a well prepared and well patrolled undercut line across the sidehill at higher elevation.

Since the great majority of backfire lines will be constructed along ridgetops it is generally possible to start firing the line from a high point first and then descend along the line. This practice insures the safety of men along the line because a descending fire is easier to control. Often it will be necessary to

start firing peaks at either end of a saddle at the same time and bring the fire down into the saddle to prevent a possible run up one peak and consequent loss of the line.

Fire should be advanced down along the backfire line no faster than it can be kept under control. As a matter of fact, good judgment may require considerable hesitation at times to allow fuel at higher elevations to be burned out before it may be ignited from a lower fire fingering in at dangerous speed from the backfire line. At such times, or any time burning is too slow in a backfire it may be helpful to use such stimulants to the blaze as oil, flamethrowers or fusees.

When wind conditions are adverse, that it to say, blowing into the face of the backfire, it may be possible and highly desirable to ignite and hold an auxiliary backfire. This consists of starting fires downwind (toward the main fire) as far from the backfire line as is dared. Perhaps this distance may be only a dozen feet in heavy fuel or it may be a hundred feet in low flashy fuel. The limiting factor will be the difficulty of keeping these "sorties" or strip-burns from running out of control. Successful accomplishment produces a widened firebreak and probably a well launched backfire as the heat and in-draft encourage the fuel to burn toward the main fire.*

Always during backfiring care must be taken that fires do not spot or jump across the line. Every proper backfiring crew should consist of enough of a rear guard to strike immediately at every spark that crosses the line and to eliminate or mitigate danger spots.

Water or dirt should be used to cool the intensity of burning fuel when necessary, and if possible, water should be available to apply to fuel on the unburned side during the period it is exposed to great heat from the backfire. The latter practice is most effective on low flash-type vegetation.

Timing has been emphasized as the all important element in backfiring strategy. Lines should be constructed in time to take

* Strip-burning is a relatively new term that refers to the deliberate burning of strips or blocks of unwanted vegetation to accomplish any of several purposes. It may be practiced by the firefighter as described above or to induce Area Ignition which is described in another section. The landowner may strip-burn to make browse areas accessible to stock or game and to improve hunting. The essential meaning of the term is found not so much in the reference to strips as to the fact that only a portion of some area of unwanted vegetation is eliminated at one time through the use of fire under control.

advantage of the proper burning time, or failing that, any emergency backfiring must be timed to gain most from the main fire and lose the least. Timing the movement of the actual ignition along the backfire line requires the direction of a specialist. Perhaps the most precise requirement in timing is seen when use is made of the very real benefit that in-drafts to the main fire may offer. (Refer to Behavior of Large Fires). To detect the presence of air movement favorable to the backfire a shovel or handful of dry dirt tossed high into the air at intervals should indicate from the drifting dust when a significant in-draft begins. Or a small fire or smoke bomb may be used as an indicator of the same nature. However, proper timing of the backfire is again emphasized. Care should be taken that the smoke making device does not ignite a premature backfire.

### *c. Combined Use of Direct and Indirect Attack Methods*

In the discussion entitled Determining the Attack Method the various facets to the problem of choosing a method of controlling the fire were brought out by listing questions that the Fire Boss would probably ask himself as he sized up the fire situation. It was mentioned that *both* Direct and Indirect Attack Methods might be used.

Such a strategy would be more common than otherwise, especially as the fire grows in size. It would be more common as the time of control lengthened and also with greater variations in the types of fuel and topography. The reason is, of course, that more variations in the behavior of the fire would result, thus requiring entirely different methods of control. For instance, it has been pointed out that a high wind will probably cause the development of a fast traveling head which only a courageous and skilled backfiring could halt. In the meantime, the in-draft along the flanks which usually prevails in such fires will favor direct attack on the fire's edge there.

When a fire is running fast in one or more identifiable heads, it is sometimes possible to take delaying action by attacking the heads until the arrival of reinforcements. This could be most profitable if stable ends of a portion of the fire perimeter exist because of the presence of a body of water, road, bare rocks, or some other non-flammable area. Such a condition will make is feasible to treat a running salient of fire as a single sup-

pression problem. The total fire will not be contained by such a *confining* action, but the total problem may be greatly reduced.

A forest fire never retreats but it often changes direction of advance and it sometimes falters. The skilled fire manager will not hesitate to change his plan and take advantage of any unanticipated behavior of the fire. There is no dishonor and only good judgment in departing from an elaborately constructed backfire line in order to cold trail a quiescent fire edge below the constructed line.

Good strategy may require both direct and indirect attack measures along the same fire edge at the same time. If measures to suppress flames or to cold trail part of the fire perimeter have a strong possibility of failure the construction of a secondary line of defense should proceed without delay. In topography and fuel that makes for difficult control and possibly high values (or high suppression costs) the experienced Fire Boss will keep in mind at all times the next line upon which he will make a stand if he is forced to retreat. Such thinking indicates proper planning rather than a defeatist attitude. A Fire Boss may be an optimist by nature but in dealing with natural forces of destruction he must be a thorough realist and plan for the ultimate worst.

## MOP-UP AND PATROL

In California before the development of organized crews of professional firefighters there was more enthusiasm and honest toil contributed on the fire line by farmers, lumbermen and townspeople than a present day observer might believe. Many volunteers joined in the enthusiasm that the cry of "Fire" will generate at all times of day or night. But most were simply demonstrating the qualities of good citizenship in answering the call when danger threatened. Such a contribution should be remembered with gratitude.

Farmer firefighters would seem to be about as far from the subject of Mop-up and Patrol as a backpump is from a backfire. Yet there is a vital relationship that should be impressed upon the present day student of forest fire management. The farmer had cows to milk and the merchant had his store to attend. Consequently, there was little enthusiasm for the cinderella job along the fireline and many fires broke out and away after they had

been very adequately brought under control. Probably no single argument was used more sincerely by the advocates of the professional fire crew than this need for adequate mop-up and patrol.

The establishment of full time suppression crews was an historic milestone along the sometimes rough road to adequate wild land fire protection. However, its importance can be easily forgotten because *the fire that was never allowed to get started does not cause any excitement at all.* A proper job of mop-up and patrol won't cause any excitement. But its vital importance should never be forgotten.

Mop-up starts immediately the first bit of fire trail is constructed, or at any rate, immediately after the first hopeful emergency scratch line has been put down. Probably no individual on the crew will be assigned specifically to mop-up work until the pressure of initial attack subsides to the point where patrol of the line has to be someone's primary responsibility. But in the meantime the well trained crew will be automatically accomplishing mop-up work for the simple reason that this is essentially only the strengthening of the main fire barrier.

The first mop-up work may consist only of widening the line of mineral soil exposed. But most often the work will involve the disposal of burning or smoldering material on either side of the fire line and also the elimination of any unusual fuel hazards.

Snags are such a prime threat to the safety of a fire line that they were considered under the discussion of Direct Attack methods. The U.S. Forest Service and the State Forest Practice Committees recognize their potential hazard as indicated by the requirement that operators fell snags as a fire prevention measure.

After the snag is on the ground it becomes a log—generally a "dead log"—to distinguish it from bucked lumber stock still in the woods. Either type of log is potential fuel and deserving of prompt attention by the mop-up crew if it is near the line.

Heavy logs and stumps that cannot be moved from the vicinity of intense heat, or are especially vulnerable to falling embers, should be fireproofed by having fuel scraped away from them and by a covering of dirt. They are worth a considerable investment in fire prevention effort because of the nuisance they can become if fire once gets well established in them.

Smaller material should be carried back into the burned area to the greatest practical extent. Partly burned brush, pine cones,

animal manure and such fuel on the burn side of the fire line should be thrown back and encouraged to burn itself away. Or if it appears to be dead out it should be so scattered that no accumulated piles could build up a later fire that may carry across the line. Aerial fuel that has been scorched should be lopped and carried well into the burn.

Under no circumstances should smoldering fuel be covered with dirt and left that way under the assumption that the fire will die. This is especially true of stumps that have shown any trace of fire. Before leaving any such stumps in the vicinity of the fire line a diligent search should be made with axes and shovels to be certain without question that no fire has crept into the roots.

The use of viscosity agents (thickened water) for mop-up work has an advantage over ordinary water in many situations because: it can cling to the fuel surface in greater quantities; it provides a continuous wet film effect which excludes oxygen when applied to burning logs, chunks of fuel, fence posts and the like; it provides a dry film effect after water evaporates, and this continues to exclude oxygen; hot coals can be more effectively treated if they can be mixed with viscous water; a quantity of treated water can "go farther" since less is required; it can reduce total mop-up time. Some of the disadvantages of viscous water are: lack of penetration if soaking into the fuel is desired; accident hazard is increased because the viscous agent is slippery.

Smoldering fuel near the line should be encouraged to burn itself away or the fire should be put out. Naturally, the most satisfactory method of eliminating such fire is by *drowning* it in water. Even if a generous quantity of water is available for that purpose the judicious use of an axe around the burned area gives the only dependable assurance that the fire has been eliminated. To often a surface sprinkling gives the appearance of a thorough soaking. Lacking water, any hot embers should be mixed with clean soil which will soon absorb the heat and hold them safe in the meantime.

Burning logs on a side hill and chunks that will fall as the log burns should be prevented from rolling by the construction of a trench on the underside. This, of course, is assuming that rolling fire could possibly jeopardize unburned fuel at a lower elevation. Wherever a fire line runs more or less along a side-

hill contour above unburned fuel it is wise procedure to construct enough of a trench along the line to stop and hold any material that may roll out of the burned area.

If it is physically possible all logs on the upper side of a side-hill line should be pointed up and down hill to guard against their rolling across the line.

During the mop-up stage of a fire a sharp lookout should be kept for spot fires across the line. This does not mean they could be less devastating during the later patrol period. Probably the opposite is true since less help will be available to suppress a new fire when the suppression force has departed. But the probability of spot fires over the line should drop rapidly as time progresses.

In smaller fires the mop-up and patrol crews should attempt to suppress or burn up smoldering fuel over the entire fire area and be done with it. On larger fires this may be quite impractical. It is, however, not only practical but necessary to keep a patrol on all fires where there remains the slightest possibility of its escape.

Patrol duty should be very precisely delineated by the Fire Boss so that careless instructions cannot be used as an excuse for careless patrol. Patrolmen left on a fire line should know just where their respective areas of responsibility lie, when, where and how they should make contact with other patrolmen or some designated source of assistance, and when they shall be relieved.

The Fire Boss or a responsible line officer should travel (preferably walk) over all of the line with the patrolmen to be certain that all hazards are pointed out and all pertinent questions and information transmitted between them. It would be well if no misunderstanding is allowed to exist over what particular tool the patrolman shall carry with him at all times and where most of his time shall be spent.

The Fire Boss, or someone with adequate authority, must make as many inspections of the fire line as are needed to guarantee its safety and eventually the withdrawal of patrol.

When that time comes and the fire area is abandoned the inspector should satisfy himself that fuel inside and near the line is burned away or completely out, that the line itself is still capable of stopping a ground fire, that unburned islands are

not likely to flare up, that no spot fire across the line is possibly smoldering.

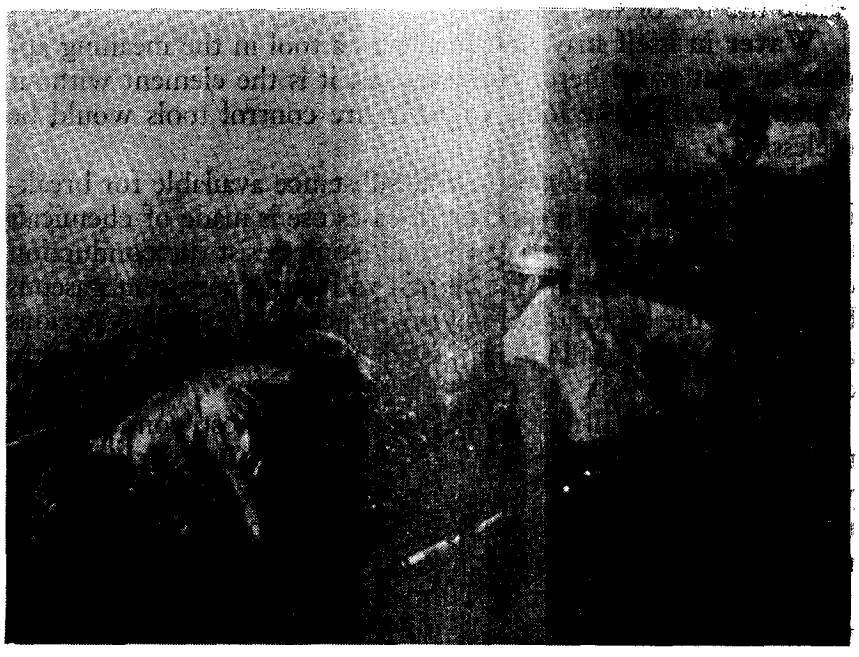
A frequent or periodic recheck of the fire should be carried on until there is every assurance that the fire is *dead out*. Often this inspection can be made from the air as the time increases since mop-up crews were removed. But this should not replace on the ground inspections for as long as they may be required. A new technique to aid mop-up crews in locating hot spots (both inside and outside the line) is on the horizon. An airborne infra-red device sensitive to heat sources can promptly detect hot materials which might prove to be a threat to the line. Such inspection can be carried out with greater confidence that something is not being overlooked. The equipment and its use for mop-up and fire mapping is described in a following chapter.

# CHAPTER NINE

## Tools for the Fire Manager

THE METHODS used to accomplish any job may be said to depend upon three things, the requirements of the job, the tools available to get the job done, and the ability and knowledge required to bring the first two together in the job performance. At the present day, the Fire Boss will more than likely have available for first attack action a considerable striking force of trained man and specialized tools in considerable depth. On the other hand, he may have to accomplish some very difficult tasks with men and tools of a number and quality well below his desires.

The word *tool* has often been used in this writing in a very broad sense. Perhaps facility or function would have been better words to describe units of power or action available to the



fire manager to accomplish his fire control task from beginning to end. The object has been, of course, to segregate and discuss these separate "function-tools" so that every potential Fire Boss would think about them as separate striking forces.

But few of these tools, or units of power, are complete and self-sufficient in themselves. This becomes more certain as the size or complexity of a fire increases. Therefore, any full discussion of tool units must consider how such a unit must be used in conjunction with other tools on the fire control project. The most important function-tools available to the fire manager at the present day are briefly discussed in the following pages.

Perhaps a word of caution here will prevent some misunderstanding as the reader considers each tool or facility described. No single tool is considered so important that all fire control work must cease until the fire manager has it in his possession. Probably many executives will not be convinced that funds must be immediately provided to acquire all of these implements just because they are described here. Nor is one tool to be considered more important than another just because more words were used in discussing it. Possibly there was more to be said about that particular item. The intention is to enumerate and generally describe the use of the various tools.

**Water** in itself may not qualify as a tool in the meaning applied to that word here. Nevertheless, it is the element without which several of the most valuable fire control tools would be useless.

Water is by far the most usable substance available for breaking the fire triangle. In specialized cases use is made of chemicals that have qualities superior to water. Some resist the conduction of electricity. Others might be said to form a persistent gaseous blanket for the exclusion of oxygen. There is nothing mysterious about fire extinguishing gases and all of them are relatively expensive.

Water is generally available, but under most conditions in the mountains of California it will have to be carried many yards or miles to the fire. Therefore, economy and efficiency in the use of water is a matter of prime importance to the fire manager.

The reason for the effectiveness of water in fire suppression was discussed under Fuel Moisture. It will absorb tremendous

quantities of heat and it will displace oxygen in the air when it is sprayed out as a fog.

Before mechanical pump-tank devices were developed for the triple purpose of storing, transporting and projecting water its use on fires was crudely handled. Structural firemen had their bucket brigade which simply made use of human hands to transport water instead of human legs.

From the great plains came stories of how prairie fires were quenched by two horsemen dragging a fresh steer's hide between them along the fire's edge. In California the wet sack was without doubt the first water tool used to suppress fires. In low fuel which was neither heavy nor compact a couple of sturdy sack flailers could discourage the flaming fire edge quite effectively. The sack was swung downward toward the burning area at about a 45 degree angle, striking the flames a sweeping blow. Any material driven by the force of the blow would be thrown into the burned area. Some care was required to prevent sparks from being carried back over the line when the sack was retrieved and lifted for another blow. The action essentially blanketed out oxygen from the flame. It did not succeed through depositing water for the absorption of heat or increasing the fuel moisture. A dry sack of proper weight, pliability and heat resistance could have been as effective. The point is that a wet gunny sack seemed to have those qualities to the proper degree.

Moving swiftly into the second half of the twentieth century we find a modern quality in one possible use or treatment of water that has not yet been developed to a satisfactory economic stage. That is the entirely practical possibility of making water 30 or 40 percent more effective in its fire suppression potentialities by the addition of certain chemicals. This results in the breaking down of molecular cohesion. Loosely speaking, the water falls apart and just spreads out until there is no more. This is "wet water." Wet water aids the firefighter because of its habit of dispersing freely over and through other materials. Sawdust, forest duff, cotton and thatch-like fuels such as bent grass and grain can be quite easily moistened.

Certain additives called **viscosity agents** thicken water and cause it to cling to the fuel surfaces in much thicker layers than plain water. (See Mop-up). Much less quantity is required

for handling many situations because of this property since it will more nearly stay where it is applied.

The use of chemicals which change the combustion process of fire may one day be practical (logistically) for use in firetrucks. As a matter of fact, so-called "light water", which was developed principally to attack flammable liquid fires, may have some application to wild fire control. In the end, use of such special agents must be made upon a judgment of cost versus efficiency.

## HAND TOOLS

The fire manager will ask himself after he decides where and when a fire line or trail must be constructed: "By what process will the vegetable matter be removed from the soil in the creation of the fire line?" *

Regardless of the availability of power driven tools there is always considerable use for hand tools along a fire line. They may be used as an auxiliary to the power tool or they may be used exclusively along parts of the line where the power machine cannot operate. Perhaps hand tools may be necessary to prepare the way for the use of a power tool, as for instance axes, wedges and saws in the felling, limbing or bucking of trees ahead of a bulldozer.

A hand tool is simply the extension of the human arm, giving it more length through the handle, more power as a fulcrum

* In all professions a number of technical terms and special meanings for old words naturally develop for the reason that they are necessary tools in themselves.

Fire line and fire trail seem to mean the same thing when they pertain to the barrier cut around a "going" fire. But "on the line" refers to any spot in the close vicinity of the burn (up to the end of the patrol period) as distinguished from the fire camp, office, air, or elsewhere. If a pathway is built prior to the occurrence of a fire for use as a transportation route for men and horses, it is called a fire trail and never a line. But a substantial transportation route for fire type motor vehicles, built prior to a fire is a truck-trail. However, a roadway of lesser quality along ridges would probably be called a "motorized firebreak." If the roadway is used for general automotive transportation it will most likely be termed a fire road or fire access road.

However, a genuine fire barrier, built over strategic topography without regard to its value as a transportation route is always a firebreak when it is built prior to the occurrence of a fire. If it is used during a fire it temporarily becomes "the line" at that time.

A fuel-break is a continuous broad strip of modified natural vegetation created with the intent that the residual fuel will be more resistant to ignition or will present less of a heat hazard to firefighters when it burns. A proper fuel-break includes a motorized firebreak.

and lever, and more ruggedness by the addition of metal claws, teeth, blade or hammer head. But all human hands are not adept at the manipulation of tools that were created to add power to human hands. Therefore, the fire manager must consider the quality of men available to him to construct a "hand line" or perform other hand tool work. Conversely, the fire manager would be wise to be aware of the exact opposite situation among his firefighters. He may have available some experts in the use of certain tools who would be dissatisfied if they were assigned to use other tools, especially if they did not feel that there was a justifiable reason. Practically all craftsmen are proud of their individual skill, as they should be. An expert faller might feel that he was doing degrading work if he was asked to shovel while there were snags to be felled.

Aside from developed skill there is also the matter of physical or what might be called cultural adeptness to use certain tools. Anyone who has watched Mexican railroad workers use short-handled, square-pointed shovels to build fire lines has seen artists at work.

Disregarding the skill and morale of the men available to wield hand tools in the construction of a fire line the fire manager will have the responsibility for assembling the proper type of tools. If there is scraping to be done he must consider the kind of fuel that is to be removed. Is it light leaves or flash-type fuel without strong roots? Is it dense, sometimes heavy, or well-rooted? Will there be deep duff, or rocks? Will it be necessary to dig trenches—or saw through logs?

For raking light duff and for working in flames the asphalt rake will be valuable. In a light cover of grass, leaves or litter the Barron tool (California Fire Tool) is useful because it is light in weight and sturdy enough to rake, scrape, chop and spread fire. For similar work of a heavier nature the McLeod Tool and Kortick are recommended.

In low grass, or following a line scratched by a Barron Tool, a wire push broom can be used to literally sweep out the flames along the fire line. If there is trenching to be done and deep duff to be dragged aside the sturdy U-bolt hoe is valuable.

When roots are to be chopped and general prying and grubbing around brush and small trees is necessary the Pulaski and hazel hoe are desirable hand tools. But if the soil is rocky a regular mattock will serve better.

For an all-purpose tool familiar to nearly all men the round pointed shovel is supreme. It can be used to turn over or carry soil, carry burning chunks of fuel, throw dirt, scrape, and to a considerable extent be used to chop, pry, and beat.

For chopping by experienced men sharp double-bit axes are necessary. The single-bit axe has more utility since it can be used to drive or pound stakes and other nonmetallic objects. Being more wedge-like the single-bit axe is a better splitting tool than the double-bit; however, wedges and sledges should be available when heavy splitting work is to be done.

For chopping and slashing brush and small limbs the brush hook and machete are favorite tools.

Cross-cut saws long enough to accomplish their purpose may be needed for snag felling or bucking logs. Then there may be need for such firing instruments as may be popular in that particular vicinity, including fusees, power flame throwers, fire bombs and the Hauck or Orchard torch.

Sufficient drinking water is so important to workers along the fire line that canteens should be considered a primary tool in the calculations of the fire manager.

After a determination is made in regard to what type of hand tool and how many should be available for use in fire line construction, the fire manager must be satisfied that his Support organization will deliver the tools, keep them sharp and otherwise effective, recover as many as possible and return them to proper storage.

## POWER TOOLS

The extent of power tool use in fire line construction will be governed by the availability of the machine and the practicability of its use over the terrain. Certainly, there is no reason why the fire manager should not take advantage of every type of power driven machine that can be put into operation.

The foremost by far in his thoughts will be the machine created to accomplish precisely the type of work required—the bulldozer. But there are others that may have been developed, or are in process of development, essentially for fire line construction. These would be heavy plows or drags or brush mowers with hoggers attached to chew up the woody material. As a matter of fact, if a tractor is available without a bulldozer blade

it could serve to mash down fuel or better still, pull out a great deal of brushy vegetation by hauling a heavy drag.

Road scrapers or graders could be used very effectively for line construction where they can be manipulated.

In an area of many snags and logs the fire manager may have use for portable power saws. There, too, when bulldozers are busy elsewhere he may press his heavy automotive equipment into use if it is adaptable to supplying the power for block and tackle moving jobs.

## CREWS

The value of a crew over an individual in any type of human endeavor is that a single integrated unit is created which will have more force or effect than the total of its individual parts, provided the crew unit is properly organized and operated. This added force is developed by teamwork which derives the best from the weak as well as the strong through a complementary division of both labor and resting time. In addition to this, team morale is generally considerably higher than that of a lone individual engaged in such hazardous and exhaustive work as fire control sometimes is.

It was not an easy matter to assemble the first "sit-tight" forest firefighting crews (as they were then called) about the year 1930 for the reason that money going out for wages between fires was just too much for the harried fiscal experts in government to tolerate. And they were indeed harried as the Great Depression began to bear upon them. But, paradoxically, the incendiarism born of hunger and desperation among the drifting people seeking any type of work (or even a fire camp where food could be begged) gave the first impetus to the creation of permanent fire crews in California. At least it caused money to be provided for firefighting and conservation work crews. The good reasons for the creation of regular crews which go unquestioned now had long been expressed by the foresters. Crews rather than pick-up or impressed labor for firefighting can be justified for the following reasons:

(a) Regular crews have no incentive to start a fire or prolong its life.

(b) Pride in their achievement as a crew is equal to the enthusiasm of local citizens protecting local property.

(c) Regular crews are assembled and ready for immediate action. Potential property loss in the fires that could have become large no doubt equals the cost of crews.

(d) Training and experience keeps fires small and reduces chance of injury to firefighters.

(e) Crews respect authority and work within an organization scheme.

(f) The crew unit is more easily worked, supervised, and cared for.

(g) Trained and able men in the crew unit can be used as a nucleus for necessary build-up in emergency, or for specialist's jobs. (Many have advanced into administrative positions after valuable crew experience.)

It might be said that five types of crews may be available to the fire manager. Each will have certain characteristics which should be respected, not only during their work shifts but throughout their stay on the fire. The groups are:

(a) Regular Division of Forestry crews.

(b) Wards and inmates from forestry honor camps jointly operated with the Youth Authority or Department of Corrections.

(c) Military personnel from all branches of the service.

(d) Hired groups by prearrangement; from industry, such as lumbering, agriculture, public utilities, or selected crews direct from prisons.

(e) Hired pick-up labor.

Perhaps there should be included in the above listing those crews from the several fire protection agencies operated by the federal government, counties, cities or districts. Such crews generally appear as a mutual aid gesture in time of emergency or at borderline fires. They are hardly to be listed as a source of crew labor. But the understandings between the fire manager and these crews is an extremely important matter.

The Fire Boss should follow certain rules whenever he may be working closely with crews on the line, and he should see that other line and camp bosses adhere to them if the fire organization grows larger. For instance:

(a) Try to keep crews intact as working and resting units.

(b) Know which crews should not be commingled for legal or good management reasons (example: adult prisoners and Youth Authority wards).

(c) Keep special supervisors with their special crews and do not expect them to be fire line experts (examples: officers with military crews; guards with prison inmates).

(d) When extra leaders must be provided for special crews, look for men experienced with that group.

(e) Pass on instructions and criticism to any group or person of the group through their leaders as privately as it can be done with effect.

(f) Emulate a very successful group leader, the late Napoleon Bonaparte; see that the stomachs and feet of men on the line are properly cared for.

(g) Insist upon regular rest schedules because exhaustion is a cumulative thing. Rotate work loads to aid in providing recuperation of strength for hardest working crews.

(h) Avoid breaking up trained crew groups unless important jobs are to be filled by them. Able Division of Forestry crews should be used for hot spotting or as lead crews instead of manning standby trucks or working as kitchen flunkies, unless such jobs are actually the most important at the moment.

## BACKPUMPS

The backpump (referred to in the statutes as back-pack or pump-type water extinguisher) could, with considerable justification, be proclaimed the greatest single invention among fire control tools. Thousands of them are located throughout the State in the possession of every type of fire department and on farms and industrial plants. The success of the device is found in its effective and economical delivery of water in fog or stream without the requirement of any power or intelligence beyond that which a healthy man can provide.

All tools do require some instruction or training in use. Every American is acquainted with the manner in which most girls throw a baseball (not including the tomboys by any means). Foreigners from lands where baseball is not played throw in the same awkward manner although they may be trained athletes. The fire manager and line officers should keep this in mind if they sometime find it necessary to strap a backpump onto vol-

unteers or pick-up workers who have never been taught how and where to direct a stream or spray to best advantage.

Backpumps are most effective in two respects. A stream of water can be directed upon a spot of flaming or smoldering fuel 20 feet away or somewhat more. They are very effective in dampening fuel at the edge of a fire line when the stream is deflected into a spray. Spray nozzles are commonly used as deflectors, but the experienced firefighter finds his thumb or finger to be best.

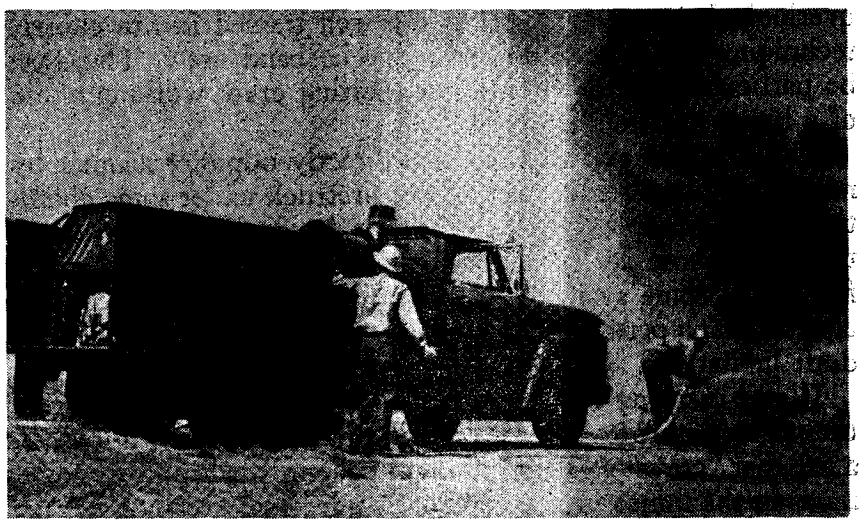
If there is not too much flame at the fire's edge a backpump man and one or two follow-up men with tools can do rather amazing suppression work. The pump man must understand that his primary aim is to reduce the heat and speed of the advancing fire so that the handtool men have less to cope with. In this manner the available water will serve to cover at least three times the distance as would the same amount of water used to drench the fire adequately without any follow-up.

Backpumps are valuable as a tool that can strike a heavy blow against a spot fire and do it quickly when there is less concern about conserving the water supply. For this reason the Fire Boss should have backpumps ready for action whenever there is danger of spot fires, during mop-up and during patrol. Sometimes a patrolman should walk the line with the equipment, and at some stages of patrol it may be more reasonable to place backpumps filled and ready at strategic points along the line.

## PUMPER TRUCKS

The terms firetruck and pumper truck are commonly used interchangeably. A firetruck used for wildland protection is an automotive vehicle which carries a supply of water and pumping equipment sufficient to deliver the water effectively in fire suppression work under a wide variety of conditions. The firetruck is essentially an early attack facility designed to be worked in conjunction with the crew of firefighters responding at the same time. "Mother tankers" or pickup trucks with small pumping units would not be properly called pumpers or firetrucks.

No record exists as to when the first wheeled vehicle carrying a water pumping device was used in forest fire control work. Probably it was on a horse drawn wagon or a trailer attached to a conventional automobile of the early 1900's. The



Division of Forestry used a few locally fabricated devices in the 1920's. But year 1929 is historic in this respect. During that summer the first four pumper trucks, designed specifically by forest fire experts, were constructed at the State Highway Shop and sent into the field. They were a magnificent contribution for the use of fire managers throughout the State that summer and during their long life.

The modern pumper truck has capabilities far beyond those vehicles developed prior to World War II. This is due to numerous mechanical developments and devices such as four-wheel drive, the automatic transmission, limited slip differential, fire hose specially designed to withstand high working pressures, specially engineered pumps and similar devices. This, of course, means that water as a weapon of fire suppression can be delivered in places and under conditions which would have been impossible in years past. It also means that the relative importance of the firetruck as a tool on the fireline has been greatly enhanced.

Paradoxically, this points up potential weaknesses in the use of the firetrucks which should be kept in mind by the fire manager. It is possible that the men normally working with a truck will not be used to best advantage if a situation should arise when the truck cannot be used through lack of access to the fireline, or some other reason. In such cases, the fact should not be

overlooked that pumper crews are well trained in fire control techniques and can be used as a special hand crew. They can be particularly effective as a hot spotting crew working ahead of a larger line building crew.

The fire manager may fail in a directly opposite manner by not taking utmost advantage of the firetruck under some conditions. For example, it is possible that he could make a longer than usual hose lay to a location of urgent need or he might fail to tap some available water supply through the use of an ejector which permits the lifting of water beyond the theoretical draft limitations.

Water carrying pumpers have come to be so basic a part of the protection force built up in preparation for the outbreak of a fire that "crew" and "truck" have become practically synonymous in the minds of fire control people. The firetruck has become a somewhat makeshift home and transporter of necessary property. Hand tools, drinking water and food, medical supplies, sleeping gear, lighting and communication equipment are brought to the scene of the fire. No wonder the crew and the truck have become an integrated unit.

Since its earliest development there has been continuous and healthy controversy over a desirable balance of water load, number of crewman passengers, amount of hand tools and hose to be transported upon the firetruck. No doubt variable conditions of fuel and topography coupled with the progressive development of mechanical equipment will prevent the absolute standardization of any firetruck. Valuable improvements remain standard only as long as they produce superior results.

The Fire Boss should never forget that there is a different limit or quality of performance to be obtained from each of the different types of pumper truck available for his use. More important, he should remember that there is a distinction between the men on the truck and the vehicle itself. The men have an earlier physical and mental limit of endurance which tends to reduce the working efficiency of both men and machine, and at the same time creates a considerable accident hazard for both.

The firetruck has limitations which the fire manager must keep in mind. It eventually reaches its capacity to perform and it rarely delivers the knockout punch entirely on its own. In the

first place, there must be a limited gallon-per-minute delivery of water at any certain place even if the truck is drawing water from a boundless source. When the truck has to stop delivering water at the fire and travel for a new supply then the valuable contribution is suddenly reduced to nothing. Also there is the handicap of maneuverability. Tank trucks will not fly in spite of the enthusiasm of some of their more inexperienced pilots. There is a limit of travel accessibility which must be acknowledged by the fire manager in his plans.

There may be a tendency to rely too heavily upon what might be termed the armored attack of firetrucks (or bulldozers) when the foot soldier must still be regarded as the vital factor in securing and holding the ground line. Crews must recognize that some fires will be lost unless they leave the vehicle to attack the fire in order to gain the advantage of a favorable time or location.

A great deal has been said about the value of water in fire control. The pumper truck handles it in exactly the same manner as the little backpump. The difference is, of course, in the quantity of water stored, transported and delivered. That difference in quantity and force of water put on the fire line is a mighty considerable thing. The pumper can deliver water in volume or in pressure, as a stream or as spray. It can take the water to the fire on wheels and then when wheels become impractical the point of delivery may be extended by the use of hose. When a limitless source of water and the truck are brought together the quantity of continuous water delivery is limitless for all practical purposes.

However, the possibility of drafting water from a plentiful source in the vicinity of most going fires is so remote that a paradoxical saying has become a common warning to the firefighter in California. It goes about like this, "If enough water is used to completely extinguish the blaze then too much has been used."

This warning is twofold. It refers to the danger of assuming that the apparently drowned combustion is really out beyond all question and it cautions against an inefficient use of the precious fluid. To counteract the first hazard it is usually wise to follow up the wet fire edge with the construction of a trail into the soil. To conserve water it should be used to knock down the hot blaze so that hand tool men can work at the fire edge, or

to hold and delay the rapid advance of the fire in order that other equipment may be used to construct line.

During mop-up an opposite situation prevails. An adequate or even excessive use of water can be justified to assure the positive extinguishment of the fire in addition to reducing the patrol time and effort. During backfiring and mop-up work the pumper can quickly drench a flare-up or raise the local air humidity and increase fuel moisture in either smoldering or hazardous fuel.

The pumper truck should not be regarded as a self-sufficient tool. The fire manager should understand how it can be most efficiently used in combination with other striking forces and also with additional pumper units.

The combination of pumper and manpower is used more often than any other whenever areas of the fire are accessible to automotive equipment. Four-wheel drive apparatus extends this use considerably in rough, steep terrain. On initial attack particularly, this combination will usually be the most effective. The pumper is used to knock down, cool and hold the fire edge while the crew constructs a line to mineral soil. Here time is one of the most important factors. Careful coordination between the pumper and crew is needed to prevent a waste of time and effort. The aim of the suppression force is to stop the spread of the fire as soon as possible. Hence, the movement along the fire perimeter will be as rapid as conditions permit.

The pumper will often be able to knock the fire down faster than the men are capable of "pulling in" the smoldering edge. Care should be exercised not to allow the pumper to get so far in advance of the crew that spots rekindle between the two and thus slow the progress of the men still more. Generally the movement of the pumper in this type of operation will be in accordance with the speed at which the crew can secure the line; the length of time before rekindle takes place; and the amount of water available measured against the amount of fire line to be knocked down and held. It must be recognized that the greater the length of fire line, the slower the crew will progress. This is due to both the fatigue factor and the necessity of mopping-up and patrolling trouble spots reducing the number of men closely following the pumper. A fairly large crew can soon be so

thinly distributed along the fire line that the action of the pumper will be affected. It must then either slow down, backtrack constantly to knock down the rekindles, or begin using more water to lengthen the rekindle time. Any one of these may spell failure. When adequate manpower is available, fast pumper progress can be maintained by using one or more men with backpumps to hold the smoldering line until the arrival of advance crew members with hand tools.

When more than one pumper truck is available they both may be worked with a crew to guarantee a safer and somewhat faster line construction. The following pumper will be quickly available to spray any flare-up that may occur either to the front or behind the advance crewmen. But the greatest assurance given by two trucks is the opportunity to alternate in breaking off action to replenish the water supply. This factor seems to be too logical to overlook but it is well worth the effort of the Fire Boss to satisfy himself that the water supply of all pumpers will not be exhausted at the same time.

In areas of the Nation where soil and fuel types lend themselves to the use of plows a profitable combination can be developed with these two tools. The pumper in the lead uses a minimum of water to knock down the hottest part of the fire so that the plow may be worked very close to the fire edge. This technique is certain to leave buried and smoldering material if the furrow berm is on the fire side. Such material should be spread out by the mop-up crew to eliminate a possible delayed flare-up. The pumper and plow used in this manner will prepare a rough line very rapidly.

If the fire area is too rough for direct action at the fire edge, or if the intent is to prepare a line for indirect action, the position of plow and pumper is reversed. The plow constructs the line from which the pumper and crew will be used for any backfire or holding action.

It must be reported, however, that this technique has not been accepted in California. Two conditions prevent its profitable use. This is the generally prevailing hard and dry soil surface and the wide variability in the vegetation and surface features, including trees, heavy brush, rocks, gulches, arroyos, and steep slopes. Other types of equipment appear to accomplish as

much as the plow and also have greater adaptability to the variable conditions of use.

Pumper and bulldozer form a good combination for making and securing a fire line through heavy fuels. The dozer in the process of constructing control lines can often provide an access roadway for the pumper. Later mop-up and patrol will probably be greatly improved by having water and transportation available over the roadway. The pumper may be used to knock down hot areas of the line where it is necessary for the dozer to work close to the fire's edge, or it can be used while holding or backfiring the dozer line. Four-wheel drive equipment should be used for this activity when available, since the increased performance is a safety factor for both men and equipment. No guide can be provided to assure a margin of safety to pumpers taken into remote areas along a dozer line. Even four-wheel drive equipment is relatively limited in its capacity to travel over rough terrain compared to the bulldozer. Only experience and good judgment can provide this guide.

Unfortunately, the physical limitation of a firetruck is a subject closely related to the high wreckage statistics for these valuable instruments. In order to gain time and geographic position in the placement of his truck where it will deliver the greatest striking force some drivers will exceed the bounds of prudent judgment. Some fail to understand fire behavior and consequently lose or damage vehicles by exposing them beyond the danger point.

Of course, it is very difficult to place blame upon this or that active leader when damage or disaster takes its toll in such a hazardous occupation as the fighting of forest fires. There does come a point, however, when some action can be considered an unreasonable risk to life or property and therefore not to be tolerated. The Fire Boss must assume the responsibility for keeping Truck Drivers, and all other personnel, within these limits whenever he is actively in command of the particular situation or when he lays out a hazardous plan of action. Aside from the possible pain and personal tragedy involved in that last step beyond the bounds of caution it may be too utterly expensive to be tolerated by the Fire Boss. It may cost the permanent loss of a pumper truck from his striking force. Courage is a praise-

worthy virtue for the driver along the fire line but it cannot fully substitute for good judgment.

In topography where pumpers cannot travel directly to the fire, the hose lay has its place in providing water under pressure to the firefighter. As part of the control plan, it may seem desirable to lay a long hose line to assist in controlling a section of the fire that is particularly difficult to handle. The Fire Boss must first determine whether such a hose lay is possible. Among other things he will consider capabilities of pumps, length of lay, size of hose, amount of lift or drop, requirement in men, equipment and time. Secondly, he must decide if this action is practical, that is, will the effort and time expended be worth while for the results expected. A third consideration should be whether this action would make the best possible use of the equipment—or would there be a more important use for it somewhere else in the general plan.

Once the hose lay is begun, men and equipment will be tied up and not readily available to be moved to other areas. In many cases, however, it may prove to be the only action which will handle the situation. Plans should include arrangements for an adequate water supply—by using other pumpers or mother tankers if no natural water source exists. The hose line that starts as a fire control tool immediately becomes a "life line" for the men who use it. Continuous water flow, without shutdowns, is a necessity if the hose lay is to be effective.

The use of several pumpers in a cooperative action to knock down or hold a fast moving fire head at an established line or road is not always the last desperate effort it sometimes appears to be. Although it may rarely be used in the primary plan of action, it should not be overlooked as an alternate or secondary plan. The first consideration must be that there is every assurance that the action may be carried out without men and equipment being trapped. Rapid, unrestricted movement to and from the area is therefore necessary. This type of operation can involve every conceivable combination of pumpers, manpower, and dozers. Timing becomes all-important. Some preparatory work can usually be done such as widening or "checker-boarding" with bulldozers or wetting down areas where the stand is expected to be made. But the all-out effort is required at the proper time when the greatest good can be accomplished. The decision of whether to "front" the fire head directly with large

volumes of water or to strike at the slop overs, should they occur when the head hits the control line (which may or may not have been backfired), must be made according to the existing conditions. Numerous examples exist where both methods have been successfully used.

During direct action at the fire edge the pumper truck can reduce the heat of burning fuel so that line construction will become more comfortable, efficient and safe for the crewmen. While a fire is crowning it is not likely that pumpers will be used in direct action. Nevertheless, the presence of a pumper truck at this time can certainly reduce the hazard to human life by offering escape transportation and also a protective spray of water.

## BULLDOZERS

Heavy line building equipment has tremendously increased firefighting strength, but has not eliminated the use of manpower. Each has its own use and place in the fire organization. A bulldozer should be recognized as just another tool—it has certain potentialities and limitations. The basic principles of fire control must be followed, regardless of whether a two-foot line is being constructed with McLeod tools, or a 20-foot break with bulldozers. Under most conditions a 20-foot break is better and more desirable, but unless properly used, it will not be as effective as the two-foot line. Too often a wide bulldozer break around the fire perimeter has given a sense of false security. Hazards inside and adjacent to the line such as islands or other unburned fuels, burning snags or stumps, and potential rolling material which would normally be cared for, are many times ignored because of the feeling of safety where a wide line exists.

Following are some of the basic rules to observe in the use of dozers:

(a) Locate line in accordance with the fire control strategy, vegetation, and topography. Avoid "taking the fire where the dozer can go" unless it is the best method to use.

(b) Shove all unburned debris to the side, away from the fire, unless the dozer is actually working in the fire. Clumps of material which are cast off on the fire side can be potential trouble spots.

By virtue of being designed to "pioneer" a pathway through heavy fuels, the bulldozer is more frequently exposed to fire hazards than other fire fighting apparatus. As may be noted in the above picture, agency-owned bulldozers are equipped with specially designed canopy tops to protect the operator from falling objects such as heavy limbs or snags. Sudden wind shifts or flare-ups of the fire along the perimeter can sometimes also endanger the dozer operator or his swamper.

Agency policy requires that non-flammable protective blankets be carried on all bulldozers which are subject to use on fires. Several instances have occurred where these blankets have saved men from serious or fatal burns when they were overrun by the fire. Similar protective devices are being considered for possible future use with firetrucks.

(c) Scatter and spread (into the fire side) windrows of dirt-covered debris which have resulted from direct attack on the fire edge. Material may smolder in these "cat piles" for long periods of time, awaiting only daytime heat and a little wind to be fanned into live fire.

(d) Burn out as soon as practical any intervening strip of vegetation between the dozer lines and the fire edge.

(e) Trench undercut lines and treat all hazards to the line in the same manner as with hand line construction and mop-up. Don't depend on the extra width of a dozer line to halt the fire.

The assigning of dozers, even on initial attack, to areas of the fire where it is not known whether they can successfully and safely construct line should be avoided. Effort should be made to determine the sections of the planned line where dozers can be used effectively and those where they cannot. This does not

mean that there should be any hesitation in using bulldozers on initial attack where time does not always permit a detailed reconnaissance of the area. Successful initial attack depends upon stopping the spread of the fire as quickly as possible. However, improper assignment of dozers to areas more suitable to hand crew action can result in loss of the fire due to such things as:

(a) Line construction being slowed or halted because of steep, rocky terrain, leaving an uncompleted area through which the fire can escape.

(b) The dozers being forced to allow hazards such as snags and log piles to remain within the fire line, or the necessity of constructing line in heavy fuels (while fire is burning in light fuel) due to the nature of the terrain and limitations of motorized equipment.

During an initial attack, dozer operators are often required to use their knowledge of fire behavior in locating or constructing lines according to their best judgment. Urgent business elsewhere may not allow the responsible fire officer to be with them at all times. However, proper supervision is essential to insure maximum results. On fires going beyond the initial action stage, planning should include sufficient overhead to provide at least one man in addition to the operator for each dozer, and a supervisor to direct their efforts. The supervisor should have knowledge of dozers and the work they can perform as well as the knowledge of fire behavior. Proper direction *must* be provided for *hired equipment*.

Radio contact should be maintained with each unit whenever possible. Arrangements should be made before dark to have dozers which are not equipped with lights supplied with portable lights, or removed from operation.

The proper balance of manpower to supplement the work of the dozers can greatly speed up line progress. However, crews should not be worked in the immediate area of the equipment since they will be constantly in the way when the dozer must back up for manipulating.

Care must be exercised that dozers do not duplicate or nullify the efforts of hand labor. There are times when it is necessary to strengthen a line or relocate it in a safer location after the spread of the fire has been halted. Where both machinery and manpower are available, each should be assigned so that the greatest production may be realized. Constructing a cleared line

solves only part of the problem. It must be fired, held, and mopped-up. This requires manpower, or a combination of manpower and equipment working together.

Burning-out crews should not follow the dozer so closely that firing will handicap the dozer operation or jeopardize line construction. Where difficulty is experienced in starting backfires in heavy fuel types, the dozer can often assist this operation by mashing and compacting fuel on the inside (fire) edge of the line.

When adequate manpower is available, the dozers may not need to spend the time to completely clean up the line. If the burning-out crew is to follow immediately, they should clean up such light debris as falls back. If the line is not to be fired immediately, a small crew can be detailed to follow the dozers to do this clean-up job. It may be faster and cheaper than having the dozer constantly backing to clear away loose fuels. On steep slopes, especially, a considerable increase in line production may be realized.

Those sections of line which are not suited to dozer operation or which would result in an excessive time loss should be bypassed and assigned to hand crews. Later line strengthening can be done when the fire is in the mop-up stage.

There are certain advantages in working at least two dozers together when practical to do so. Dozers can assist each other in difficult line building situations where one dozer operating alone might become stalled. Safety to operators and equipment will thus be increased when working close to the fire edge.

Rate of line construction for each machine will be increased. Many nonproductive backs and other maneuvers will be eliminated by the following machine which will clean up or widen the line. The width of line desired and the nature of the terrain will determine the feasibility of using two or more dozers for this purpose. Under most circumstances diminishing returns may be expected if more than two or three dozers are worked together.

The line may be strengthened at critical points, or action may be taken on fire slop-overs without halting the forward progress of line construction when more than one bulldozer is available.

There are also some disadvantages to working dozers together. These will vary with the nature of the terrain, vegetation and operating conditions. Boulders loosened by one machine have been known to roll down upon another working lower on the slope, resulting in injury to its operator. In rocky country it is seldom good practice to work one dozer below another on other than moderate slopes. In such use the rear unit must wait until the forward dozer works clear of any potential danger. For the same reason, men must not be allowed to work immediately below a dozer.

The presence of additional machines to lend assistance in difficult situations may cause some operators to take undue chances. Closer supervision is required as the operating conditions become more difficult.

Where line construction is slow or difficult, following dozers may be forced to slow or halt their operations. The lead dozer will usually break trail and construct a rough line. It should not, however, get either too far in advance of the following machine, or spend so much time in improving its line that the second dozer will be held up.

Bulldozers are rarely operating within reach of roads. This makes a problem of supplying their needs. Careful planning is necessary to arrange a service schedule when several dozers are involved, in order that equipment does not remain idle for lack of fuel or proper servicing. The servicing schedule must be set up to fit the line action, rather than the reverse. Many times equipment has been taken from the line for servicing at inopportune times, thus jeopardizing control efforts.

Providing proper relief operators is of utmost importance in getting the greatest production from men and machines. Fatigue plays a large part in the safety factor for this type of work. Whenever possible, the change in operators should coincide with the servicing of the unit. This will reduce the transportation problem and provide the definite contact point for the operators. When a relief operator must locate a unit working on the line, many valuable hours may be lost for both him and the other operator who should be getting a rest.

Each operator is responsible for seeing that the unit he operates is properly serviced at the end of his shift. The need for any mechanical repairs should be immediately passed on to his line supervisor. This does not absolve the relief operator of the re-

sponsibility for assuring himself that the required servicing has been done or that the equipment is in proper mechanical shape to perform the job.

A few simple **signals** are desirable to aid the spotter or line supervisor in directing the activity of a dozer. Since voice communication is impossible except when the unit is stopped or throttled down, a great deal of time may be saved, or misunderstandings prevented by employing signals with either the hand or flag in the daytime, and a flashlight at night. The following are examples of commonly used directions:

(a) STOP or SHUT DOWN: Swing arm (palm down), flag or light, back and forth in a level motion across in front of the body, chest high.

(b) REVERSE or BACK UP: With arm fully extended, swing in full circle in front of the body.

(c) TURN: Hold arm, flag or light, directly overhead and swing downward on the side of the turn.

(d) CAUTION: Wave arm, flag, or light, back and forth in a half circle, at arm's length, overhead.

Dozers may be effectively used, particularly where heavy fuels are present, to remove or minimize hazards to the line which cannot be handled by hand crews, and to reduce the actual time needed for complete mop-up.

Consideration should also be given to making sections of the line accessible to four-wheel drive pumping equipment. Often a small amount of work on the part of a dozer will improve the break so that motorized equipment may be employed as a tool for mop-up or patrol. Long hard hikes for crews going to or coming from the line may be eliminated by transporting them to their destinations. Each situation must be carefully analyzed by the Fire Boss and line officers to determine where such improvements are justified. Indiscriminate road building just for the sake of building roads should not be tolerated.

It is easy to think of the bulldozer as being the mechanical hero of the front line, performing the wearisome toil of fifty men where the fire is hottest. There is, in addition to this, a very important role for the bulldozer in the immediate vicinity of the fire perimeter. This work consists of backing up the front line troops with the construction of strategically located second-

ary lines, opening alternate access routes, or clearing out old firebreaks or roads. Such work could very well be of primary importance in the total fire control strategy.

As the fire problem diminishes, it will undoubtedly be advantageous to have one or more dozers on the scene of large fires as a safety measure, doing such mop-up and line strengthening as may be feasible. This should be closely watched, however, and the amount of equipment reduced as soon as conditions permit. Hired equipment should be released first, after a general check-up to determine if it may have received any damage while being operated on the fire.

## FIRE HOSE

Even those persons well acquainted with modern forest fire-fighting methods will be inclined to think of fire hose as merely an integral part of the complete firetruck. This it is. However, its use is not limited only to extending the firetruck's striking power. Hose in itself is important enough as a physical element in the total fire control program to deserve independent attention.*

Fire hose, as such, is not by any means a new tool in forest fire control work. However, its extensive use was handicapped for many years because of three primary conditions, namely, its weight, bulk, and difficulty of handling. Two other secondary adverse conditions also existed. Low working pressure of most available hose became apparent in recent years as better fire pumps were put into use. Numerous examples exist during the late 1940's and the early 1950's when long hose-lays were made on fires. But their practical utilization often became a major project, requiring the diversion of substantial manpower. Numerous relay points require the stationary assignment of many firetrucks.

Another factor which often discouraged long hose-lays was a lack of sufficient water to make the effort pay off. In recent years more stored water in various types of reservoirs and the availability of more water transporting vehicles (especially including firetrucks) has often made long hose-lays practical.

* In the recent fiscal year the California Division of Forestry purchased new hose to the extent of $230,000. It is estimated that all sizes and types of fire hose owned and currently available for use throughout this organization would reach from Sacramento to San Diego, a lineal distance of some 600 miles.

In 1953 this agency began exploring with a fire hose manufacturer the problem of developing suitable lightweight hose. As a result, today's product is vastly superior to that produced earlier. Not only does the hose have added strength but its light weight immediately opened the way for new methods of storage, handling and use.

Increased use of extended hose-lays led to the demand for improved pumps. This in turn required hose capable of withstanding higher pressures. Thus began a project of matching the capabilities of fire pumps and fire hose. At the date of this writing, 450 pounds working pressure is the requirement of both hose and pumps. Although continuous hose-lays of 10,000 feet or more in length are not common, they have been found to be practical on a few fires.

### *a. Ground Equipment Hose-lays*

Prior to the development of lightweight hose, fire hose was usually stored and handled in individual rolls. On firetrucks some of it was usually carried in an intercoupled folded form. The bulk and weight of regular heavy hose restricted or prevented it from being handled or used in other ways. Since twice as much lightweight hose can be handled by one person, or stored in the same area as that occupied by old hose, different handling methods are now practical.

One such method called the "pin hose-lay" permits the carrying or laying of hose with many different types of equipment—including bulldozers. Coils of specially rolled hose are stacked on rigidly mounted vertical pins. The individual coils of hose are coupled to each other and each stack is intercoupled to another stack. Thus a continuous hose-lay may be made by pulling off the exposed coupling and driving the vehicle along the route of the intended lay.

In addition to firetrucks, pins can be affixed to other equipment such as jeeps, pickups or bulldozers. The hose that is carried to a fire on a firetruck can be quickly transferred to another type of unit, if it is desired to do so. In the event a vehicle cannot be used and manpower is to make the hose-lay, the coils are easily uncoupled and individually removed from the pins.

One of the big advantages of this method is that the hose is made ready in one form that is retained from warehouse storage

until ultimate use on a fire. It should be noted that a special hose roller is required in order to differentiate between the loop and the fold of the hose when it is rolled doubled. Improper rolling of the hose can cause it to hang up on a pin.

The same roller permits rapid retrieval of hose from a lay and rolled back into its original form. Thus it is possible to pick up hose after it has been used in one area and move to another area with it prepared for action.

### *b. Helicopter Hose-lays*

Operation Firestop, where the concept of bulk delivery of liquids on fires by airtankers was shown to be feasible, also included the first successful demonstrations of extended hose-lays by helicopters. The development of the standard hose tray accessory attachment for helicopters stemmed from those tests in which military craft were used. A load of 1,000 feet of lightweight hose may be expelled from the tray with the helicopter in flight in a matter of seconds. It is obvious, however, that there must be people on the ground at the beginning and ending of the lay in order to hook it to a pump and use it, or to connect it with the next module of hose. Therefore, when planning an extended hose lay by helicopter the accessibility to beginning and ending points by men must be considered.

It has been found that helicopter hose-lays are even practical in timber where individual lengths may sometimes be draped through the crowns of 60 foot trees. Naturally, more hose will be required to reach the objective point.

The most time consuming operation of an extended hose-lay by helicopter is the repacking of trays. Each tray must be packed with extreme care in order to maintain load distribution as the hose is expended. All couplings must face the rear, which is the direction of withdrawal, so that there is no danger of them being whipped into the aircraft structure. Finally, the leading folds of hose must be methodically tied with light nylon cord in order to restrict the flow of hose to the extent that it will be spread out over its extended length.

It has been found that the job of refilling trays can be measurably hastened by prepacking hose on plyboard pallets which are cut to fit the bottom of the tray. Hence, only the job of tieing the leading folds of hose remains to be done.

## AIRCRAFT

Fixed wing and rotary wing aircraft have been developed into important facilitating tools in forest fire control operations. Their use is admittedly costly when calculated on a flying time basis. The potentially wide area of coverage, speed of attack, and work accomplishment all indicate clearly that the considered use of aircraft is financially justified. This is especially true wherever the land area under protection is large and relatively inaccessible.

Measured against the cost of aircraft, their use provides an unquestioned reduction of burned area per fire. The hypothetical extension of fire costs and losses into "what might have happened" is an unfortunate fact of fire control economics. However, one aspect of the situation, as it has become more increasingly evident in California, should not be overlooked. More citizens have more reasons for wishing to see forest fires extinguished when they are small rather than large. Aircraft as a firefighting tool can often be used with spectacular success in this respect.

Only during periods of extremely high winds, at night, or under heavy smoke conditions, will the fire manager be deprived of the services of specialized fire fighting aircraft. However, as will be discussed later, some aerial services can be made available on a 24 hour basis.

The development of aircraft to perform highly specialized firefighting jobs offers an unusual opportunity. But it also imposes an additional responsibility upon fire control personnel. The opportunity is presented in the form of a specialized fire attack system with capabilities which cannot be matched by any other "tool." This relatively new dimension in fire control permits the attack forces to use strategies previously not possible. It also makes possible a more rapid adjustment to changing fire situations. The responsibility then follows that all fire control personnel must learn the individual uses and limitations of each type of aircraft and the ways to effectively coordinate action which involves both air and ground forces.

Ranger Unit plans include the automatic dispatch of various types of aircraft as part of the first attack action, depending on location of the fire, fire danger rating, and first report information. From this point on, as conditions dictate, it is the responsi-

bility of the Fire Boss to request additional air units or to release those assigned to his fire.

In the use of aircraft on going fires it is necessary that an adequate system of communication be employed. This will include radio communication both air to ground and between aircraft in the air ("air to air"). Without such communication it is realistic to say that the use of aircraft will be without value, and further, a considerable safety hazard will be created.

The aerial activity over most of the forest fires in California, with the resulting need to coordinate the movement of aircraft over and near the fire, makes it mandatory that unless proper communication equipment is available and working, the flight shall not be sanctioned.

### *a. Reconnaissance and Mapping*

Aerial reconnaissance, and mapping from the air, provide the fire manager a very valuable source of intelligence. Most of this is accomplished with light utility fixed-wing (high wing) aircraft. It can, however, be done by helicopter. In fact, sometimes the latter craft has an advantage in respect to slow flight and access into very rough topography. But the heliocopter is generally less often available and is certainly more expensive to maintain in the air.

An aerial observer can provide information to the ground from an ideal point of observation and he can easily change that point to improve his observation. One very valuable contribution from the first aerial observer over a new fire is his portrayal of the fire location and condition to the responsible Dispatcher. Such information will frequently develop the principal action program to be followed during the life of the fire.

An experienced man must be selected as the "eyes" of the fire manager. It is probable that the Fire Boss will be anxious to see his total problem from the air. This is commendable and desirable. On the other hand, the primary job of fire management must be handled on the ground and that is where the Fire Boss should spend most of his time.

The qualified aerial observer must be able to interpret what he sees from the air in terms of the fire management problem as it exists on the ground. That is, he must be able to relate visible

topography, flame and smoke to a paper map location, and secondly, he must make a fire behavior and control judgment to *recommend* to the Fire Boss.*

It is quite important that the most current and accurate maps be available for aerial observation. And it is essential that the ground managers have copies of the same map. This will permit the use of printed marks (such as names) to be used as common reference points.

Topographic maps are considerably more usable than flat (planimetric) maps. However, plane maps of scale one-half inch to the mile have a value for general orientation, especially if a number of smoke plumes arising over the countryside could confuse an incoming aerial scout. Over the fire, topographic maps of scale from one-half inch to two and one-fourth (1:24,000) inches to the mile are most commonly available and most usable.†

After first orienting himself on his map, the observer should familiarize himself thoroughly with the fire perimeter, rate of spread and general behavior by circling the area a few times—keeping well out of the smoke column and well above the general ground level. While so doing, he can also search the region for indications (car, truck, or horse), of anyone in the area who might be responsible for the fire. The psychological effect alone of the plane circling overhead may discourage an incendiary from starting another fire. The circling should be done in the direction that will give the observer an unrestricted view of the terrain. He should then widen his survey to examine the adjacent area, noting on his map such things as will be important in the control of the fire, for example, fuel types, natural barriers, ridges, water sources, access roads and trails, places of habitation or other buildings in the path of the fire. He can then give a detailed description of these conditions to the ground units on, or en route to, the fire and also to the Unit Dispatcher. This

* The inclination for many high observers to feel that they are in command of the broad landscape within their view is a management hazard to keep in mind. This attitude is known to develop among some lookout observers after long service at the same station. The highly technical process of infrared scanning is less subject to personal judgment because the prime interpretation is done on the ground.

† Maps of these scales are usually referred to as "30 minute," "15 minute" and "7½ minute" quadrangles, in relation to the longitudinal angle they cover.

rapid size-up and report on conditions will materially assist the initial attack crews in planning their actions and will aid the Dispatcher in preparing for the fire's needs.

The observer can often assist the incoming crews by directing them along the proper roads or to the side of the fire where initial action will be most effective. Similarly, as control actions proceed, he can advise of danger areas or spot fires or he can perform other services as requested by the Fire Boss. As soon as possible after crews arrive, the observer should drop a map to them showing all pertinent information regarding fire conditions. This will minimize the chance for confusion which often exists where verbal descriptions alone are relied upon.

The value of aircraft on large fires is sometimes diminished because of restricted visibility due to smoke concentrations and rough air conditions resulting from heated air currents. However, where conditions permit, periodic flights along the fire perimeter can assist the Fire Boss in keeping abreast of current developments, line progress, and potential trouble spots. Such flights should generally help tie his entire operational plan together.

The plane can also assist the forces actually on the line by giving on-the-spot information. The observer's vantage point generally enables him to clearly see the fire line, the burned area, and the adjacent unburned area outside of the fire line. Even though the only information which the observer has to pass on to the local fire line manager is to assure him that his area is remaining quiet, a valuable service has been performed. So many blind areas exist for the man on the ground that he can rarely be completely satisfied that an undetected spot fire or flare-up may not be occurring in one of them. Instances have been noted where spots in the tops of snags went unnoticed until detected from a plane.

In some cases, unburned material inside the line will burn out during the following burning period. The heavy smoke rising as a result may cause the useless movement of men and equipment before it is found to be a false alarm. Occasionally lookouts will report drift smoke as a spot fire or an entirely new fire. The aircraft scout can readily check on these reports, thus preventing the movement of control forces out of position.

The observations of the air scout must be reflected in detailed maps and notes to be of maximum value in fire administration and planning. Verbal descriptions are important as a supplement to, but should not take the place of, the written material which was prepared as the observations were made.

When crews are actually working on the fire perimeter, there is an opportunity for a very close tie between air and ground observations. This is not usually the case, however, where the fire is making a fast run and the ground forces may be unable to accurately determine the location of the fire edge. A plane, in such cases, can usually fly the fire just before dark and establish the location of the head, areas where the fire has "laid down," and the general location of the perimeter. This "last minute look" will probably provide the information which will determine the night's activities for such areas.

When communications are difficult between the ground forces because of topography, the plane can be of material aid during the daylight hours in relaying messages from one area of the fire to another.

Periodic checks by a reconnaissance plane of areas of the fire which have been mopped-up and reduced to a minimum ground patrol are often practical as the most economical means of utilizing manpower and equipment and still provide reasonable precaution. Similarly, fires which have been abandoned as out often show smokes well inside the lines or dust devils which alarm the lookouts into reporting a possible line break. These can be quickly checked by plane without the time lag required by land means. This will usually be coordinated with work on another fire or a series of fires which justify the full time use of the plane.

Following extensive electrical storms, a plane is often found to be of tremendous value in detecting and reporting the fires resulting from lightning strikes. Numerous fires have been discovered in this manner when lookouts were unable to see the smoke.

Since most lightning fires occur along the ridges and often in country remote from roads, long elapsed time periods may be expected before crews arrive and can report on conditions or request additional needs. Where aircraft is used, this information can usually be given long before the men arrive. It is sometimes

possible to direct crews from one fire to another in the same general area without the necessity of sending additional men and equipment. The plane can be used to check on the fires which are controlled while the crews proceed to attack new fires.

Unless the observer carefully plots each known fire on his map, confusion can easily result later. Because of the rainfall which usually accompanies the strikes, lightning fires will often lie dormant for many hours or several days before developing. One fire may be put out and the smoke be completely gone before another, only a short distance away, will show up. Without an accurate record, the second fire may be confused with the first and thought to be controlled. The situation may be worsened should a second storm follow closely upon the first, bringing additional lightning strikes to the same area.

### *b. Supplies and Messages*

It is often advantageous to deliver a message, map or small object by gravity from a plane to the fire line.* Some suitable means of dropping should be prepared ahead of the flights. A number of different methods have been used to drop messages. Dropping sacks with sand or shot or other weighted objects have had wider use than any other means. This method takes considerable practice to develop accuracy since the article must be dropped before the plane is over the target. Weighted objects have most tendency to curve in the direction of flight. The use of small 'chutes causes very inaccurate drops since they are subject to wind drift and may land far from the intended location.

One of the most accurate means is an ordinary 2-inch cardboard mailing tube, one foot in length. The message or map is inserted inside the tube and secured by means of a strip of tape over each open end. The light tube has enough wind resistance to overcome the curving drop in the direction of flight, yet not enough to be overly affected by wind drift. It may be dropped

* Prior to the advent of airtankers the dropping of a physical object from a plane was commonly referred to as an "air drop." In most of these drops an adequate (though sometimes crude) parachute was used. When the dropping of fire retardant liquids developed as an important and common procedure in fire control, it was natural that the word *drop* came to include the retardants and then to be dominated by that practice alone. In fact, the term became so limited that the officer supervising retardant drops came to be known as the drop coordinator, or "Dropco." The next step in the metamorphosis of this word tool was shaped by the realization that the duties of that official went beyond the direction of drops to include the supervision of air traffic in the vicinity of the fire. The officer is therefore currently known as **Airco.**

when almost over the target and will descend relatively straight downward. A small light object other than a message (such as a fan belt) may also be inserted in the tube and dropped with approximately the same degree of accuracy. The safety factor of using this method is an item for consideration. There is no danger of damage to the plane or injury to individuals on the ground should the tube strike them.

Regardless of what dropping method is used, it is good practice to make the container conspicuous with several bright colors contrasting with the landscape. An attachment of several feet of red or orange colored streamers to facilitate observing the drop and locating the object on the ground is often used. However, these streamers may catch in tree tops.

The amount of supplies which can be delivered by air drops from a light plane is obviously limited by the carrying capacity of the aircraft if nothing else. Furthermore, the technique of delivering aerial cargo is highly specialized. No attempt is made in this writing to treat with that complex subject. It can be noted, however, that instances may arise on particular isolated fires where the dropping of some vital supplies in relatively small quantities may be of utmost importance.

There are instances in the developing stages of fires, starting early in the day, when initial attack crews get into remote areas not reachable by ordinary means of supply. Their usual demand is for lunches and additional water. Inability to meet these needs may result in progressively diminishing work production. Dropping sufficient food and water to these men and keeping them working steadily on the line may be a deciding factor in the control of the fire.

Eight-foot converted bomb parachutes will handle approximately 25 pounds of supplies. One or two of these 'chutes will usually meet the situation described above. However, should the conditions demand, several drops could be made to crews working on a fire in a remote area pending the establishment of a fire camp and permanent supply lines.

### *c. Airtankers*

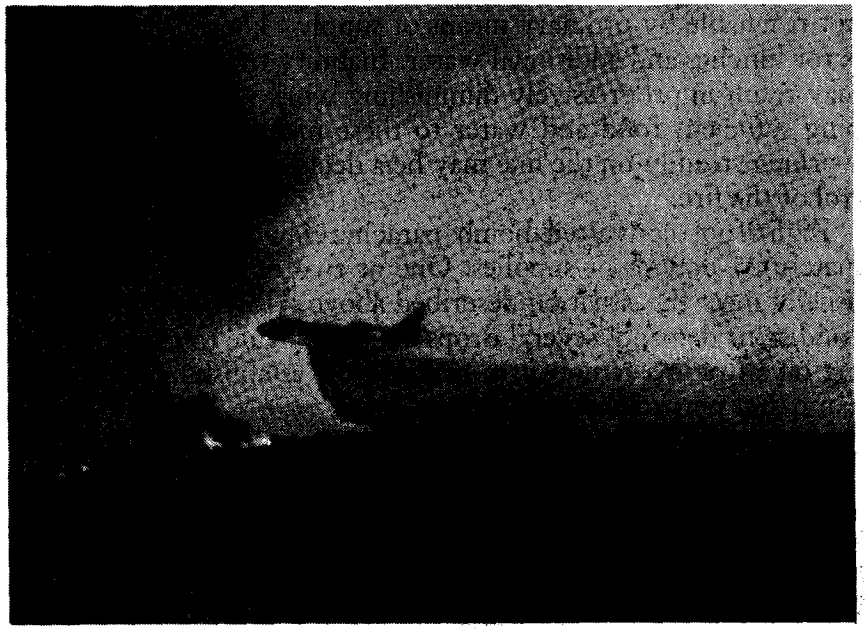
The fact that airtankers can "cascade" relatively large volumes of liquid chemical onto fires from the air has added a tremendous punch to wildland fire protection organizations in California. Where fires spread rapidly, it is particularly impor-

tant that some type of control action be taken within minutes after detection. Airtankers are well suited to fast response and will often be able to attack a fire before ground forces arrive. It is therefore quite important that airtanker pilots be trained in fire control techniques and fire behavior.

At the close of World War II, the various forest protection agencies received numerous unsolicited suggestions to use military bombers to bomb forest fires. The responsible fire specialists had not been unaware of this potential new tool. In fact, the use of military planes for fire control observation and transportation in 1919 probably saved the embryo air unit of the Army from complete disintegration.

Between the two wars numerous experiments had been made by Canadian as well as American military and forestry specialists and a few private pilots in the dropping of liquid in volume from aircraft, both in containers and as free liquid. The results were not at all promising as measured in effect upon ground fuel. And the personnel safety hazard was most formidable. Yet the experiments were continued.

Then the fortuitous circumstance of testing the bulk release of water from a torpedo bomber on the Jamieson Fire in Orange County in 1954 gave renewed hope of technical success. This



occurred during a joint agency experiment known as Operation Firestop. There had been no original intention of making the drop on an actual wild fire. Concentrated testing of techniques and equipment thereafter soon assured the practical use of liquid drops from airtankers. It yet remains a hazardous undertaking, requiring great personal skill on the part of the pilots and thoroughly adequate equipment.

Two conditions inherent in the use of airtankers make it fiscally wise and practically desirable to develop a cooperative system among wildland forest protection agencies. One is the high cost of maintaining the specially equipped and manned aircraft. The other is the widespread service which can be rendered by the aircraft because of the relatively short flying time between base and the fire scene. In California the majority of anticipated forest fires can be reached from the nearest planned base within a period of 20 minutes after detection.

Experience has shown that airtankers are most effective in forest fire control work while fires are still small. Likewise the fires on which airtankers have been predominantly successful were those which were attacked within 20 minutes after discovery. Hence, there should be no delay in requesting or dispatching airtankers if it appears likely that they can be used to advantage. Most areas where serious fires may be expected to occur have been delineated on dispatch maps so that airtankers will automatically be considered for dispatch as part of the first attack force.

Except for certain holding or delaying actions, airtankers will usually support the ground forces in carrying out a plan for controlling a fire rather than ground forces supporting an air operation. Coordination of airtanker action is normally provided through an Air Coordinator (Airco) who responds with the airtankers to fires in a light, high-wing aircraft. Normally, ground to air radio contact should be made to Airco who in turn will instruct the airtanker pilots. Orbiting 1500 feet above the terrain, it is the responsibility of Airco to control all aircraft movement over and near the fire area. Direct contact from ground to airtankers in the absence of an Airco will, of course, be necessary.

The greatest success with airtankers is experienced when they are used tactically and strategically in the same manner as other equipment or tools. Natural barriers, lighter fuels, openings in fuel canopies, tops of ridges or benches, etc., should be consid-

ered as conditions of advantage. The ability of ground forces to move in and secure the treated area must be considered before drops are ordered. Except in cases where action is taken on a developing head or hot spot, for the purpose of "buying" time or minimizing fire spread, the closer the application of retardant can be to the line construction forces, the more effective the aerial support will be.

Airtankers should attempt to entirely contain a small fire, if they can. If they cannot entirely surround the fire on the first series of drops, and no ground forces are readily available, they may be most successful in flanking or indirect (pretreatment) action.*

The amount of retardant and the number and character of drops needed for effective fire control from airtankers depends on types of fuel and fire intensity. Light fuels such as grass and woodland or fires burning with low intensity can be treated with fewer repeated drops than heavier fuels and high intensity fires.

Most airtankers can drop bulk fire retardants in three patterns. These are called *salvo* (total load at one time and place—all tanks opened); *entrained* (overlapping series from two to four tanks); *split* (single drop from one tank at a time at widely spaced intervals or twice to four times on the same place).

On large fires, airtankers are most effectively used in hot spotting, on spot fires, in flanking action, and in pretreatment in those instances where ground forces need such action to support their effort.

On fast moving fires with a broad front the most profitable use of airtankers will probably be through attacking active flanks. This is to say that without successful ground holding

* Two words in this paragraph require a little discussion. In the mid 1950's it was felt that a term was needed to indicate that a fire might be neither controlled nor "raging" (in newspaper terminology). The word *contained* means that the forward progress or perimeter spread has been halted by natural or man-made barriers.

*Treatment* has become the accepted term in reference to an application of a fire retardant material to a fuel surface. A *pretreatment* indicates an application of retardant well in advance of the fire front. The technicalities of selecting particular retardant chemicals and their preparation is not considered a subject within the province of this publication. It might be noted, however, that at the date of this writing the policy of the Division requires the use of so-called long term retardants, exclusively. These are satisfactory for application in direct attack on the fire perimeter or as a pretreatment. The fire manager does not become involved in the selection of the type of "slurry" loaded, but he is, of course, very much concerned with its application to the fuel.

action any contribution on a hot front may be wasted, while the same retarding effort on the flank can result in a secured piece of line. If a fast moving head is narrow enough, several drops may be adequate to stop the forward drive of the fire.

Prior to the availability of airtankers it was a generally accepted axiom that rarely anything except a hazardous position could result from taking action against the face of a fire moving up a steep slope, even in relatively light fuel. Usual action was to attempt to hold the fire at the ridge with the further sacrifice of the broadening flanks.

In many cases the most logical strategy with air drops might be to pretreat a ridge or bench where both retardant material and a natural decrease in fire intensity will have the most beneficial result. On the other hand, the possibility of greatly reducing fire intensity, or even eliminating the active fire spread, with airtankers used on the upslope, offers a new dimension to the strategy of fire control. Success in this action should be expected, however, only if the frequency of drops can dominate a rate of fire spread that could cause the fire to outflank the retardant line.

The effectiveness of airtankers increases as the following conditions are approached: As grass or light brush fuel predominates, as wind movement decreases, as topography becomes less steep, as the time of fire incidence passes mid-afternoon, as the distance to the fire from the airport decreases within the 20 minute maximum ideal first attack striking limit.

A frequency of 10 to 12 drops (300–500 gallons per drop) per hour will be sufficient to accomplish all that can be expected from airtankers in most fire situations. This is also the maximum number of drops that an Airco can safely direct.

During critical periods of a backfiring operation, an orbiting airtanker may be desirable to furnish immediate action on spot fires.

If there are a series of separate fire starts occurring almost simultaneously in the same general area, airtankers can normally be most profitably used on the small and isolated fires.

It should be recognized that certain conditions may seriously limit the use of airtankers. Fire managers should recognize that:

(a) Steep topography seriously reduces airtanker effectiveness. Deep canyons may rule out their use entirely for certain fire targets.

(b) Winds over 20 mph sharply reduce airtanker effectiveness. Shifting and high velocity winds and turbulent air may restrict or exclude airtanker use.

(c) Early morning and late afternoons are periods when airtankers may be less effective. Deep shadows are produced by the sun on certain aspects of topography that make it difficult for pilots to see fire targets or ground obstructions.

(d) Dense smoke may make airtanker operations both hazardous and ineffective on part or all of the fire area.

(e) Airtankers cannot be used at night—a period when a fire is normally expected to become less active.

(f) Tall dense timber and snags may require airtankers to make drops higher than desirable and may intercept most of the retardant before it reaches the fire.

Under certain conditions vortex turbulence from low flying airtankers can cause serious disturbance to air and thus effect fire behavior. Vortex turbulence consists of a pair of miniature whirlwinds trailing from the wingtips of any aircraft in flight. The more heavily loaded the aircraft, and the lower and slower it flies, the stronger the vortex turbulence will be and the more likely to reach the ground. The vortex will be in the form of a horizontal whirlwind with velocities up to 25 mph—sufficient to cause sudden and violent changes in fire behavior on calm days in patchy fuels.

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

The fire crew should be alert for trouble during airtanker drops when:

(a) The air is still and calm.
(b) The fire is burning in open brush or scattered timber.
(c) The airtanker is large or heavily loaded.
(d) The airtanker is flying low and slowly.

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

(a) Don't fly parallel with the fireline more than necessary.

(b) Keep high, except when making the actual drop.

(c) Be assured that ground crews are alert to the presence of the airtanker and of the pilot's intentions.

Low drops of fire retardant from an airtanker can knock a man down and carry him with such force he can be thrown against rocks or trees and injured seriously.

Line crew men must watch for low flying airtankers. Often the pilot cannot see them unless they attract his attention by waving their hats. If possible, the responsible line supervisor should radio Airco (or the airtanker pilot) to tell him where men are working on the line.

Airtanker pilots have instructions not to drop retardants from low altitudes. The result is poor and the hazard to workers is greatly increased. They also have instructions to refrain from making drops that will obviously fall on workmen. Unfortunately, these things may occur under the difficult conditions of a running fire.

All line crew men near a target area should take the following precautions when an airtanker approaches:

(a) Move out, but only if there is time to do so.

(b) Never stand up in the path of a drop. It is better to be lying face down than hit while trying to run.

(c) If there is not time to get out of the way, lie face down, head toward the drop, hard hats on, and hold tools away from the body.

(d) If there is a tree or secure object near, lie face down and hold on to it to keep from being carried by the force of the retardant.

(e) Get behind a large rock or shrub to help break the force of the drop and lie face down.

(f) Stay away from large, old trees. Limbs can break off and cause injury.

(g) If possible, take cover away from any loose dirt. A low retardant drop can throw loose rocks—a prime cause of injuries. Even hand tools can be thrown about.

The most dangerous area for ground crew men in a low retardant drop is the center 15 to 20 feet.

After a retardant drop has been made, crews must work quickly to follow up its advantage on the fire—but most re-

tardants are slippery and men should be warned to watch their footing.

### *d. Helicopters*

One of the principal advantages of a helicopter is its ability to operate from locations near and on the fireline. Its vertical take-off and landing characteristics make it a valuable piece of equipment for close support action for ground based and for other aerial operations. Various accessory attachments are available which permit a helicopter to perform certain jobs that cannot be duplicated by any other method.

**Heliports** are main bases of operation serving a fire. They should be located near a good access road. **Helispots** are temporary sites located on or near the fire perimeter for the purpose of delivery or return of men or equipment.

Helicopters may be effectively used for the delivery of firefighters and supplies to remote fire areas and also for their return. They may also be used for the application of liquids over key fireline targets, for the laying of fire hose, for reconnaissance and also for rescue. A doctor may be transported to a severely injured person or injured people may be transported out to proper medical attention. Helicopters have often served dramatically to evacuate persons stranded and threatened by fire.

All fire control personnel are subject to assignment to work with or around helicopters. Personnel should have at least a general familiarity with the type of work that can be accomplished; and those employees who will be engaged directly in some activity involving helicopters must, of course, have a thorough understanding of the part they are to play. All employees who may possibly be working near or transported by helicopters should be familiar with safety practices and they shall observe such precautions at all times in the vicinity of a helicopter.

The fact that a helicopter can fly at slow speeds at low level makes it difficult to imagine a better way to do fireline inspection, reconnaissance, or mapping. Its capability of operating from a base on the fire (often immediately adjacent to the fire camp) adds to its value.

The fire manager will probably find his helicopter in demand to perform several tasks simultaneously. He will need to set

priorities and adjust them in accordance with fire conditions. In fact, he should be able to justify to himself the observation flight that he thinks that he himself should make. The point is that the services of a helicopter are so valuable that it can easily be tied up completely in one activity to the detriment of others.

If there are several helicopters working on one fire and if there are various demands for helicopter service, as there probably will be, there will soon come a time when one supervisor of helicopter activities is appointed. This man is known as the *Helicopter Coordinator*. Along with the general supervision of helicopter activity, which includes the setting of priority projects, he is also responsible for seeing that safety measures are respected. For example, because a pilot is allowed to fly only a maximum number of hours each day because of the fatigue element, the Coordinator will be obliged to see that the most important projects are undertaken and that the pilot does not extend his flight-time beyond recognized safe limits.

The Coordinator should also see that the pilot, prior to each mission, understands fully what he is expected to accomplish and he should also be furnished with an adequate map if a map is necessary for the particular mission. Any known hazards which will affect the mission must be explained clearly to the pilot before the flight. As a matter of fact, maps containing information which pertains to the use of helicopters should be made available to all key personnel on the fire. These maps should show known hazards to helicopters flights, where helispots are located, and the flying time from one important point to another. It is also necessary that a system which will provide good radio communication between the helicopter, the fire camp, the various landing areas, and the key line personnel, should be established.

In respect to reconnaissance and general orientation of important line personnel, or on mapping flights, it is best if the helicopter is operated at a relatively slow speed and, of course, the observers should be trained to accomplish their particular mission. A valuable service may be rendered by helicopters during daylight hours by transporting important overhead personnel over the line to observe their particular areas of responsibility or to scrutinize problem areas that may require special attention. If it is possible, such flights should be arranged during the change in shift assignment, or prior to it, so that the par-

ticular observer is not withdrawn from his regular task. It also gives line supervisors the latest possible chance to study the situation as it exists on the ground before they take up their assigned duties.

Should the helicopter be used for dropping water or retardant material on hot spots or other designated local areas of a fire, the general supervision of such work must, of course, come under the control of the Airco (if one has been assigned to the fire). The supervisory work of the Helicopter Coordinator takes place principally on the ground.

Because the helicopter offers so much diversity in its use there has been considerable study of the fabrication of equipment which can be carried by, or attached to the helicopter for particular uses. These attachments will include a water-carrying tank, trays for laying hose, and a "helipumper" which is a self-contained gasoline pump unit. Other specialty devices, such as litters for transport of injured persons, may be attached as required.

At the present time of development and availability of helicopters, the dropping of water (plain or chemically treated) is generally not a primary use. Nevertheless, this particular aircraft has one, and sometimes two advantages over fixed wing planes in the matter of retardant drops in spite of its lesser cargo capacity. It can make a closer approach for a precise drop into rough topography. Also, if there is a short shuttle to a loading point, the quantity of liquid dropped in a given time can certainly exceed that of a much larger airtanker which must return to a relatively distant base.

What might be termed the intimate, localized use of the helicopter constitutes its primary value on a fire. This derives from its slow speed and omni-directional capabilities in flight. It also is found in the relative ease of landing and taking off.

Generally speaking, the more landing bases available in the immediate vicinity of the fire, the more valuable is the aircraft to the fire manager. This leads to the construction of helispots as a studied program of large fire management whenever helicopters are available in support of other forces and facilities. It is of utmost importance that those field officials charged with the responsibility of planning or constructing these temporary landing bases know of the hazards to be avoided and the desir-

able conditions to be provided when possible. There follows a listing of such items.

(a) Landing areas should be located on exposed knobs whenever possible so that the pilot has a wide choice of approach and departure options with take-off and landing made into the wind.

(b) Planned helispot locations should never include a required vertical take-off or landing.

(c) Landing areas should not be on the lee side of ridges.

(d) Canyon bottoms should be avoided because downdrafts from neighboring ridges may be experienced if the canyon is deep and narrow.

(e) Meadows with high grass should be avoided since the rotor ground cushion may be dissipated, obstacles may be hidden, or a serious fire hazard may exist.

(f) The clearance of trees and brush within a 50 foot diameter circle, and below the level of the landing area, is necessary (100 feet for large helicopters).

(g) Landing areas should be marked so that they are visible from the air.

(h) Landing areas must be level and firm, without rocks or debris.

(i) Some type of wind indicator—rag, ribbon or streamer—is necessary at all regular landing spots.

The pilot is basically responsible for anything that is done to or with the helicopter, and his word is final. Nevertheless, there are many recognized safety hazards involved in the operation of the helicopters under any conditions, and especially in fire control work. To eliminate or greatly reduce these hazards some positive safety precautions must be observed.

The Helicopter Coordinator and the Air Attack Boss should see that the pilot does not fly under conditions they judge to be unsafe, or longer than the maximum allowable hours. He should never be permitted or encouraged to extend himself or his ship beyond reasonably safe limits. Missions should be reviewed with the pilot to allow him to express an opinion.

All gear stowed in or on the helicopter shall be done so only with the pilot's approval, and a check shall be made to assure its proper and secure stowage or attachment.

When wind velocity over exposed mountain ridges exceeds 30 mph, or when there is severe air turbulence helicopter flights should not be attempted over rough country.

Night flights shall be permitted only when performed under approved techniques. Otherwise no flights should occur except in the period one-half hour before sunrise to one-half hour before sunset.

Pilots should be cautioned to avoid flight too slow and low near the fire's burning perimeter because the rotor blast can easily increase the fire spread.

All persons working closely with helicopters must know arm signals for ground-to-air communication.

Whenever the helicopter is equipped with some accessory attachment, federal regulations require that a "Restricted" sign be placed on it. This means that no passengers may be carried. The sign must be placed and its conditions rigidly respected.

Suitable fire extinguishers should be available at all heliports, and personnel should be alert for fire when the engine is started or during refueling operations.

Cargo and personnel waiting areas should be 100 feet from touch down spots.

Supervisory personnel in the near vicinity of helicopters on the ground or while in flight should assume responsibility for their own and the safety of others. They should see that persons without authority are requested, and if necessary, ordered to keep out of the danger zone. In flight the supervisors should keep oriented with the terrain under them. If they have any reason to believe the pilot is not aware of some ground hazard such as power or telephone lines, they shall not hesitate to call his attention to the condition.

Some general rules which apply at all times for personnel flying in or working around helicopters follow:

(a) Stay at least 50 feet from the ship at all times unless a specific job requires otherwise.

(b) Do not smoke during flight or within 50 feet of the ship or refueling equipment, and see that regulations to this effect are posted.

(c) Ground personnel should wear goggles to protect eyes against dirt and other light objects thrown up by the rotor blast.

(d) Approach and leave the ship from the front so that the pilot can see you.

(e) Do not approach the ship over higher ground than that on which the ship is standing or hovering.

(f) Carry all long handled tools in such a manner that they will not be inadvertently raised into the rotor path.

(g) Stay from beneath the flight path of a helicopter equipped with any accessory such as hose tray or helitank.

(h) Wear hard hat with chin strap in place both in flight and when working around the ship on the ground.

(i) Fasten, properly adjust, and keep seat belt secured until pilot signals release.

(j) Stay clear of ship controls.

(k) Never make a hover jump from a helicopter unless you are trained in this technique.

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A **helijump** is an exit from an airborne helicopter to low elevation without any device to restrain free fall. The jump should be executed from the hover position or with the helicopter in very slow forward flight. Only persons experienced in fire control and hover jump techniques, and clothed in protective gear, should be used for this purpose. Some of the guides for helijumping are:

(a) Whenever possible two or more men should jump in the same location (one following the other) so that they may assist each other if necessary.

(b) The pilot and jumper should jointly choose the jump spot and be certain that there is no mistake on the part of either as to the exact location.

(c) The helicopter must be able to reduce flying speed to 10 mph or less during the jump and be no more than 10 feet above the ground.

(d) Flat, open or bare areas should be selected if possible (watching for partially concealed rocks or logs). Very uneven ground, rocky areas or burns with sharp stubs should be avoided.

(e) The four pass method should be used: a high reconnaissance pass to look over the entire area and select a general jump site, a low reconnaissance pass to pick the specific jump site, a low pass to drop tools adjacent to jump site, a final low pass to make the jump.

(f) If jumps into vegetation are made, the vegetation should be not higher than 8 feet (helicopter skids should be at least two feet above the canopy). A green patch should be chosen,

avoiding manzanita which is rigid and tough. Also avoid vegetation with excessive visible dead material which may be brittle and sharp. Vegetation best suited for jumping includes pliable ceanothus species, scrub oak, chamise and coniferous reproduction, with the jumps being made near the edge of the crown to avoid entanglement and possible injury in the heavy stems and limbs.

(g) Remember that dense vegetation may hide rocks, logs or similar hazards. Seek out small openings if they exist.

(h) If jumping on slopes is necessary, an open slope under 60 percent should be chosen. Avoid slopes with gullies and bluffs. The flight course should contour the slope with the jumper on the uphill side.

(i) Tools should be flagged so that they can be easily located. On slopes they should be dropped in brush clumps where they will not roll.

## SMOKEJUMPERS

Undoubtedly the most daringly romantic, seemingly preposterous, and yet practically successful technique for attacking forest fires is the smokejumper. A few visionary Forest Service men talked about the idea in the 1920's and 30's. By 1939 planes and equipment for personnel had been developed to the extent that the method was considered entirely sound.

Then on July 12, 1940, two men made a successful parachute jump to the near vicinity of a forest fire in Montana.

Thousands of such jumps have been made into wild country since then, and up to the date of this writing not a single loss of life has occurred because of the jump.

This technique was developed almost solely to overcome the time lag of land travel into remote country. There is a vast wilderness of such terrain in the Western States. Much of the land protected by the California Division of Forestry is rugged enough, but it is generally accessible by some type of roadway, at least to within a practical walking distance of most potential fire sites. For this reason this organization has not made use of smokejumpers. The U.S. Forest Service has long maintained a training camp and base at Redding. That agency is rightly proud of its smokejumper program. There is, however, a growing question as to the effect the rapidly developing techniques in the use of helicopters will have upon the smokejumper sys-

tem of attack. At this date, helicopters are generally used to good advantage in assisting the jumpers by transporting first their gear and then the men away from some accessible point near the fire area.

## INFRA-RED MAPPING

Smoke and darkness have often made it impossible to locate the perimeter of a large fire. Visual mapping and reconnaissance from the air are many times not possible. Fire managers have had to depend upon ground scouts who move slowly and sometimes cannot traverse the rugged terrain. At best, reconnaissance and mapping on the ground is a slow, tedious process that too often has been inaccurate as to location and not current in respect to the fire when the Fire Boss finally did receive the information.

An airborne infra-red scanning device can "see" through darkness and smoke. Being sensitive to temperature differences, the scanner can accurately record a fire perimeter in relation to topography. As the aircraft flies over the fire area the scanning equipment continually transmits images of the heat sources it senses. These can be reproduced on rapid finish film in the aircraft.

The photograph of the image can then be used to plot the fire perimeter on aerial photos. This latter process is not as simple as it sounds because a trained interpreter is required to bridge the gap between the two photos. Nevertheless, experience with this technique has demonstrated that fire perimeters and hot spots can be quite accurately located and mapped regardless of smoke conditions or time of day.

Infra-red scanners do not produce a true picture (although it closely resembles one). Differences in temperature of the area covered by the scanner cause images to be recorded in black, gray and white. The higher the temperature the lighter the image and vice versa. Thus, fire will show as intense white. Because of the varying temperatures of land slopes, depending on aspect to the sun, shade by vegetation, etc., topography will usually be well defined in the daytime. Of lesser definition but still capable of identification is night time imagery of topography.

In many cases, black literally becomes white and white black. For example, in the daytime a body of water may show on an

image as black and the surrounding land as light gray because the water is considerably cooler than the sun heated land surface. At night it is possible for these colors to be reversed if the land areas grow cooler than the water temperature.

It is therefore possible (when infra-red scanning equipment is available) for the Fire Boss to know exactly where his fire perimeter is at any given time. Flights can be made as frequently as deemed necessary. The existence and location of spot fires outside of the main fire perimeter can also be determined. By comparing two or more images of the same area taken at different times, rate of spread measurements may be plotted. The relative intensity of various portions of the fire can be determined. This will allow more effective deployment of control forces.

Even after the fire is controlled, airborne infra-red equipment can be of value to the men engaged in mop-up. Again, imagery will reveal the hot spots—some of which might still be undetected. Patrol crews can also be aided in the same manner.

## AERIAL PHOTOS

Aerial photos offer a very valuable tool to the fire manager in those areas where they are available for use. Taken prior to the existence of the fire, aerial photos portray a "bird's-eye view" unaffected by smoke, darkness, or other confusing elements which are present after the fire occurs. To fail to use them may be ignoring a source of information for which there is no substitute. Even men thoroughly familiar with the country cannot always offer within the required time limits the type of information which can be obtained from aerial photos—when properly interpreted. Conversely, aerial photos should not be used as the major source of information without appropriate ground checks. As with any other tool, they are not in themselves self-sufficient, but have certain uses and limitations. Although their potentialities are generally recognized, there have been many instances where they have not been exploited to the fullest extent.

Air photos are taken with precise cameras in a vertical direction from planes flying generally from 14,000 to 20,000 feet above the average land surface. The height of the plane of course governs the size of ground details appearing in the photos.

Different scales are used in air photos for exactly the same reason that different scale maps are made on the ground. It's a matter of cost balanced against adequate map or photo scale. However, most aerial photos made for, or available to, the Division of Forestry are on a scale of approximately 1:20,000* (1 inch on the photo equals 1,667 feet or 25 chains; 3 and 3/16 inches equals one mile or 80 chains). This means that each photo, being generally 9 x 9 inches square, will show an area of approximately 5,300 acres or 8¼ square miles. It is almost impossible for these measurements to be precise for reasons explained below. (Note: older photos may be 7½ x 9 inches in size).

Some aerial photos are taken at an oblique angle from the plane and then the viewed objects are "pushed" into their relative horizontal position by the use of lens distortion. Such a complex procedure need not concern the fire manager since he will probably never come into contact with this particular system developed and used by military specialists principally.

The scale from point to point cannot be precise on aerial photos because of several constantly changing factors including the tilt of the plane, the angle away from true vertical to the point, and most of all because the rising and falling surface of the earth changes the distance from the various points to the camera. When maps are made from aerial photos these differences can be rectified.

The strips of photos are taken so that there is approximately 60 percent "end" or "forward lap" and about 30 percent "side lap" among all consecutive and adjoining photos. This overlap allows any person with vision in both eyes and a stereoscope to view any overlapping pair of photos and see the shape of the earth tremendously exaggerated. (In effect the observer is taken some three miles up in the air and given eyes a mile apart.) In other words, the earth's surface appears with the third dimension of height so pronounced that the slightest changes in elevation are emphasized.

Without a stereoscope a single photo has almost as much value, especially to a person who has studied photographs of familiar areas and thus has become acquainted with the appear-

* The scale 1:20,000 means that any distance on the paper is equal to 20,000 times that distance on the ground. This is a universal system that cannot be misunderstood. Remember, the smaller the number the larger the scale. A handy scale to remember always is 1 to 63,360. At that scale, one inch on paper equals how many miles on the ground?

ance of vegetation. That is to say, the various tones and textures of the photograph can be recognized as different plant communities, bodies of water or cultivated farms, while over all the different intensities of light and shade indicate the shape of the land surface. With practice, roads of different quality, railroads, rock outcroppings and such features that affect fire control operations will be identified by the observer. Practice on the ground with the actual aerial photo in hand is a type of training that should be made available to every fire manager. In this manner he will also learn to make allowances for the exaggerated effect of slopes that appears in the stereoscope.

In selecting a photograph of any particular area from the overlapping series it is always best to work with the photo where the area of interest is near the center of the picture. Distances and areas are less distorted in this portion of any photograph for several reasons but especially because the camera lens did not "see" them at an angle.

During the initial attack on fires the office Dispatcher can act only in accordance with whatever information he has available concerning the current status of the fire and anticipated behavior. Many times this information comes to him in a sketchy, incomplete, or general nature so that he must often guess and hope for the best until more complete information is forthcoming. In such instances a Dispatcher who has immediate access to aerial photos of the area in which the fire is reported, has certain advantages during this interim period. By studying the topography, cover types, etc., he may:

(a) Determine the easiest and fastest means of access to the fire area and pass this information on to the forces en route.

(b) Determine the proportions of pumping equipment, hand crews, and bulldozers to dispatch initially.

(c) Anticipate requests for additional control forces or specialized equipment, thereby minimizing the elapsed time needed to place the required items on the scene.

The Fire Boss and his assistants will use aerial photos to inform them in several respects. For example:

(a) Control lines may be located. Strategic ridges, natural barriers and openings, thin or sparse cover, light fuel types, accessible terrain, may be identified and used to determine line location. These factors will remain relatively constant and usable

even though the photos may be several years old (except where extensive logging or fires have taken place after photos were made).

(b) Rates of spread may be determined. Fuel types and density, slope, and general topography may be combined with the known burning conditions and anticipated weather to provide an estimate of the rate at which the fire will spread.

(c) Types and quantities of manpower and equipment may be estimated. The use of manpower or equipment, or a combination of both, is dependent upon the steepness or roughness of the terrain, fuel types involved, accessibility to roads, length of line perimeter, availability of water in quantity (where pumping equipment is to be considered), and general resistance to control. Careful study of the area where lines are to be constructed can provide information for estimating the quantities of manpower and equipment needed. This same information may also be employed to make full use of the control forces that are on the scene by assigning them according to their specialized abilities (pumpers to areas requiring the use of water, bulldozers to sections where machinery can be operated, hand crews to locations where motorized equipment cannot be worked, or where holding or firing action is needed in combination with motorized equipment).

(d) Problem areas can be identified and planned for in advance. Such hazards as snag patches, or concentration of oak and pine on steep slopes which may indicate large amounts of potential rolling material, can be recognized and made a part of the plan of action when control lines are being laid out, and men and equipment are being assigned.

(e) Travel routes to the line may be determined. While the fire is spreading, the best routes for getting men to and from specific portions of the fire line may change at frequent intervals. Special problems of supply are often created when bulldozers and crews are not working in areas accessible to conventional drive equipment. Aerial photos can be used to pick out the best routes so that crews can arrive on the line with a minimum of hiking, motorized equipment may be serviced at the proper times, arrangements may be made for picking up crews according to their location at the end of the shift.

**Briefing** of line overhead can be greatly assisted through the use of aerial photos. Words alone are generally inadequate for describing the operating conditions and the topography in which crews and machines must operate. A drawing or sketch usually tells more than words, but an actual picture gives individuals the best means of acquainting themselves with the area in which they will be working. It is particularly helpful to men who are unfamiliar with the country or who must find, and work in, a specific area at night. Both an understanding of the general terrain and the specific relationship of one topographic feature to another may be gained from aerial photos. Experienced men with years of fire duty have become lost on fires at night within their own areas because of extremely broken topography, a closed canopy of timber and brush, or the confusing nature in which the fire burned. Aerial photos with which to orient themselves could have been practically as valuable as daytime reconnaissance to such experienced men.

Aerial photos provide one of the most exact references obtainable for fire **mapping and reconnaissance** work. Accurately establishing a reference point on an aerial photo is like driving a stake into the ground itself. The objectives of fire reconnaissance and mapping are twofold. They are, first, to gather information (as complete as possible within specific time limits) on the current fire situation and those things which may influence its future behavior. The second objective is to portray that information in a form which will also be understandable to individuals other than the mapper. Aerial photos provide a common reference medium much less subject to distortion than each individual's personal interpretation of a map or verbal description.

By using the aerial photo as a base map and listing all information concerning the fire or its control with colored grease pencils on an acetate overlay sheet, the photo will be protected from damage and the information may be easily changed or kept current. When duplicate sets of photos are available, overlays made by air reconnaissance may be dropped to ground forces for immediate use. In all cases when using overlays, it is advisable to mark an orientation point on the overlay so that it may be accurately replaced on the photo in the proper position by anyone wishing to use it.

Usually the information which will be placed on the overlay will consist of:

(a) Location of the fire perimeter.

(b) Sections of line which have been controlled.

(c) Uncontrolled heads or heavy fire concentration areas.

(d) Alternate control lines (indicating those on which equipment may be used).

(e) Changes since photo was taken that will affect fire control operations. (Roads or breaks, logged areas, recent burns, etc.)

(f) Current locations of crews or equipment on the line (if desired by the Fire Boss).

Some of the limitations and *disadvantages* of aerial photos are:

(a) Photos become obsolete. No standard can be set for the length of time photos will be usable for fire control purposes. Changes may take place over a period of many years, or may occur within a year or two of the time photos were taken. Changes which may render them useless, or at least ineffective, are usually due to such things as extensive logging, large burns, new roads or changes in road location, growth of the vegetation, new cultivation, new structural developments.

(b) Supply is limited. Very rarely are duplicate sets of the same area available which means that the only set may be in use elsewhere when needed for fire duty.

(c) Although aerial photos of some age and relative value are available for virtually all of the forested area of the United States, they may not be owned by the fire manager's office because of the cost of building up a full coverage. Most photos covering a large area would probably never see fire duty.

(d) Too few individuals are properly qualified to use aerial photos. It is true that amateurs may abstract much valuable information from the scrutiny of aerial photos, yet it is also true that serious errors may be made in their interpretation by the inexperienced person.

There can be little question about the widespread use of such a valuable tool as aerial photos on large fire management. Training in general aerial photo interpretation for all Fire Bosses should be undertaken.

## RAPID-FINISH PHOTOS

The so-called polaroid camera, which produces finished photographs in less than a minute can be of considerable value for fire reconnaissance. The finished photo may appear either in color or black and white. Generally, the latter will serve adequately.

Any Fire Boss would prefer to gain fire intelligence directly, that is, by personally viewing the fire, either from the air or from the ground. For many reasons, such direct observation by the Fire Boss is rarely practicable on large fires involving more than one minor drainage. Perhaps the best alternative is for him to receive photographs showing the fire's perimeter and behavior. To be useful in showing the current status of the fire, these photographs must be made available to the Fire Boss soon after they have been taken.

Polaroid photographs are the best method of supplying the Fire Boss with current pictures of his fire, with the present state of the photographic arts. To reach the Fire Boss quickly, the photographs most often should be taken from the air. If the photographer is in a fixed-wing airplane and cannot land adjacent to the Fire Camp, he should have drop tubes (see Supplies and Messages) for dropping the photos from the air to a designated spot near the Fire Camp. If the photographer is in a helicopter, he should be able to land near the Fire Camp and explain the photos to the Fire Boss personally.

Ground scouts can also make good use of polaroid cameras. Although the element of speed is lost in getting the photographs to the Fire Boss, the photographs are still highly useful in helping to explain fire behavior and fire control problems to the Fire Boss.

Rapid-finish photographs generally will be supplemental aids to topographic maps which depict the fire's perimeter, behavior, and control problems. The map may be thought of as the primary intelligence tool only because it presents a total broad picture and because so many written notes and symbols can be easily placed upon it. The photographs help to illustrate the more important points of interest to the Fire Boss. Therefore, the photographs must be well identified and explained, especially if they are dropped in tubes from airplanes. Notes can

be written on the back of the photographs in ink or pencil explaining the location of the photographed terrain, the direction of the view, and important points that should be noted by the Fire Boss. Other notes and symbols can be placed on the face of the photograph with a "marker" pen so long as they do not obscure important details. A set of sharp pointed water-soluble ink pens are good for writing on the glossy surface of the photographs.

If photographs are to be considered supplemental to the topographic map in providing fire intelligence, only a few are generally needed for each reconnaissance sortie. There should be at least one photograph showing as much of the fire area as possible in relation to the surrounding terrain; this shot is most easily taken as the aircraft approaches the fire from a distance. Other photographs should be taken at closer range to illustrate in better detail fire behavior, problem areas, and progress of line construction.

About the only precaution to be taken in using a polaroid camera while flying in a fixed-wing airplane is to keep the lens close to the window of the airplane. This precaution helps to eliminate reflections. A clean window also helps provide a clear picture. When riding in a helicopter, remove the side door and photograph as much as possible through the unobstructed opening, thereby eliminating both reflection and obscurations due to the glass.

Noting fire intelligence on a map and taking rapid-finish photographs often becomes quite a chore for one man in an airplane. Certainly it is best to send two men: one man to map and guide the pilot, another to act only as a photographer. The ground scout is not quite so pressed in time and usually can perform both the job of mapping and the job of photographing without much difficulty. But again, two or more men are better than one if maximum fire intelligence is to be gathered in minimum time.

A polaroid camera is the best tool for obtaining photographs that are most certain to show the Fire Boss what he wants to know. The results of the photography are known almost at once. If a poor picture is obtained, the camera can be adjusted and another photograph taken immediately.

## THE FIRE STATUS AND TOPOGRAPHIC MAPS

It is of vital importance that adequate maps be available and be used by fire managers. And there are times when line overhead should be furnished a map of the area under their supervision.

**Topographic quadrangles,** such as those published by the U. S. Geological Survey, contain information of utmost value to the Fire Boss and other responsible supervisors. As a matter of fact, it would be desirable to have such maps in the possession of every Fire Boss when he makes his first size up of a fire. This is certainly true for fires burning in densely vegetated or broken topography.

On all major and campaign fires two working maps should be kept current. This proposition assumes two things, namely, the availability of topographic quadrangles for the area, and the drafting of a larger base upon which numerous fire details can be recorded.

The latter is called the **fire status map.** It will undoubtedly be sketched at the scene of the fire, and show enough details of topography and landmarks to be easily related to the working areas on the ground. The scale of the map should be large enough to accommodate the needs; certainly larger than four inches on paper equal to one mile horizontal land distance. The scale need not be absolutely precise, but care must be taken that inaccuracies on the map do not lead to confusion in fire management. In addition to prominent topographic features the status map should show the map scale and a north arrow.

The details of topography shown on the fire status map should be adequate for its satisfactory use, as mentioned above. In general it might be said that the scale and quality of any topographic map used in conjunction with the status map will indicate how much detail is needed. In short, the maps should complement each other. Certainly the changing fire perimeter, sketched at given time periods should be placed upon both maps. And it is likely that these lines will be first set down on an identical topographic map out on the ground, or from the air, or transposed from a photograph. Care should be taken by the recorder that he does not fail to note the precise time and day each segment of fire perimeter was sketched.

The fire status map is a valuable working tool which should portray the prevailing situation at all times in respect to the important elements of fire management. For example, the indication of an intermittent stream on the topographic map is very good as general information. But the fire status map should indicate at what locations water is available, in what volume and whether safe to drink, and how accessible to vehicles.

Other than these basic features, there are numerous work references which can best be recorded on an acetate overlay sheet with colored grease pencils.

Information on matters which may be controlled, modified, or which are subject to change because of fire behavior should be superimposed on the acetate overlay. Locations on this overlay will, of course, be directly related to the base map beneath it. Those things which should be indicated on the overlay are:

(a) Fire perimeter—controlled and uncontrolled, with changes made as information is received.

(b) Planned control lines. (Status is changed when line is built.)

(c) Potential and actual secondary line locations for use in event of a major breakover, including indication of quality of the line.

(d) Camp locations—existing and potential.

(e) Problem areas—snags, rolling logs, heavy slash, young growth thickets, etc.

(f) Segregation of fire line authority—Divisions, Sectors.

(g) Deployment of line forces—shown in appropriate Division or Sector and including:

Division and Sector Boss' names—with indication that he has or has not radio;

Crew names and number of men in each—Crew Boss, with or without radio;

Equipment—kind, with or without radio.

(h) Location of reserve or standby crews and equipment. Indicate size and type, agency, names of leader or operator.

(i) Location of semifixed communication facilities—base camp and relay points.

In addition to the working map with its overlay (described above) there could be a very valuable addition to the records if a sheet of tracing paper were kept handy as an additional overlay sheet. On this paper should be sketched the fire perimeter at those periods in the life of the fire that will indicate how and when it spread. Or more specifically, a permanent map record at the end of each burning period is desirable. Such a record would not only be valuable for any Board of Review on the particular fire but it will help build up the knowledge of fire behavior for the next writing of this kind.

The comprehensive picture of the fire situation at any given time can be only as accurate as the information from which it is compiled, and the care shown by the compiler. Much of the information reflected on this map will have to be obtained from the line forces. When certain information is not readily available from the fire line within the required time limit it is often necessary to assign specific individuals to gather it. This may be accomplished by air or ground observation, depending upon the nature of the fire and the equipment available for use. Certainly no amount of reconnaissance and mapping will in itself put out the fire, but they provide a guide for the Fire Boss upon which to base his decisions or make his assignment. The press of time in many instances will not allow for delayed action until all facts are known. However, this does not mean that every effort should not be made to collect and record all information from every available source when opportunities are presented. Insignificant facts of the moment may have great importance by virtue of a mere shift of the wind at a later time.

## RECORDS

It is no exaggeration to say that the most important instrument involved in the entire fire control project is the mental machinery centered in the fire manager himself. That would seem very good reason for removing as many of the small burdens as possible during the period when most is demanded of the fire manager's mental capacity and energy. Written memoranda can adequately substitute for a great deal of detailed information which otherwise should be committed to memory.

Beyond the personal relief to the fire manager there is much to be gained by transferring some known facts to a paper record.

In this way the condition or article described is positively removed from any unknown or indefinite verbal status. The record is then made available for any persons, not just those who commit it to their personal memory. Thereafter the written record continues unchanged throughout any desired period of time, and it can be used as a reference over and over again.

The Fire Status Map has been discussed as a valuable record tool. Perhaps weather records would be next on the list in point of interest to the Fire Boss. But as a fire becomes larger and more complex the fire manager who studies his file of UNIT RECORDS OF FIRE ACTIVITY cards will come to appreciate them as a valuable source of information.

He will quickly determine what forces in men and equipment are, or have been, at work and at what locations. He will see where they came from so that he can plan for their future use or release. He may observe that some men on the line are working either too far above or too far below the fire classification recorded for them on their card. While making this perusal the Fire Boss is gathering information for the potential build-up of his organization in the event that becomes necessary. Or of equal importance, he is able to spot potential strength that can be released to meet fire problems elsewhere if the call comes. The cards indicate how work loads can be properly rotated between individuals and crews both for training purposes and for recuperation.

Equipment listed on the cards is also represented in respect to its general performance capabilities. There is no good reason for privately owned equipment to be held beyond its useful period with this written memorandum constantly before the fire manager or his record keeper.

Lastly, of course, the FIRE ACTIVITY cards are probably the most appreciated collective tool in the hands of the Fire Boss when the time comes to close the books on this one fire episode and make the necessary reports and pay the bills. The file of cards represent a thoroughly business-like approach to a task that has assumed some of the proportions of big business.

## COMMUNICATION

The encompassing tie that binds the fire organization together into a properly functioning unit is an adequate communication

system. Such a system makes it possible for the fire manager to keep abreast of fire conditions and to rapidly adjust his organization to meet new situations as they occur.

The objective of this communication system is twofold. First there is the need for communication between the fire and the Unit Dispatcher. This very valuable link is important on small fires because the Dispatcher is actively engaged in the Support function, and on large fires because he must acquire the myriads of items that keep the organization in action. Second, there is a basic need to have good communication for every Supervisor on the fire in order that information can be rapidly exchanged with fire headquarters.

Because of its mobility, portability, and coverage, **radio** provides the means to accomplish the majority of communication requirements on fires. A system of mountain top repeaters which is planned to provide maximum coverage in terms of distance and penetration into remote areas would seem to be ideal. Ironically, a radio network capable of meeting the objective set forth above can defeat itself unless it includes specific safeguards that permit local adjustment. Unfortunately, fires do not always occur with sufficient distance between them to keep radio transmissions from interfering with one another. Hence, a single channel system which provides maximum flexibility must be foregone for the more realistic multi-channel network which is localized at the Ranger Unit level. There are other methods which can be used to "isolate" radio communication and minimize interference for the benefit of a large fire organization. Repeaters may be turned on or off by remote controls. Direct car-to-car communication for all mobile units may be established.

Radio adds a very great advantage in the form of the message. That is to say, the personal delivery of a message by the spoken word should give the listener the advantage of demanding a message completely understandable to him and also allows him to answer or pursue the subject farther if he desires. It is also a fact that the speaker's voice can place quite a variation in meaning upon words by different inflections and tones. This introduction of the human personality into the transmitting of messages can, however, result in a lack of clarity unless care is exercised by both parties.

The fire control organization can be made highly flexible and at the same time a cohesive unit largely through the proper use of radio communication. On the other hand, its improper use can cause great confusion. This means that radio communication must be under control at all times.

Even on a relatively small fire if many radios are in operation the air soon becomes saturated and a "party line" atmosphere develops. Every listener hears everything and many will believe they have a contribution to make to the confusion. This emphasizes the need for the establishment of a Message Center at an early hour. It also indicates the value of code numbers in reducing the amount of time of a message that otherwise might be composed of fumbling words.

The Message Center must become the focal point of all messages relating to management on a large fire. Here all messages are reduced to writing and logged. The Message Center has three major values. It provides a constant and known receiving point for messages. It can pursue urgent business when time is the all-important factor. It will follow through on business of a complicated or delayed nature without letting it become "lost in a shuffle."

Radio communication firmly under control and properly operating gives these advantages to the Fire Boss.

(a) The fire situation on the line and in camp can be quickly surveyed.

(b) Ground scouts, air reconnaissance, lookouts, superior officers and office dispatchers can be consulted by means of direct conversation.

(c) Instructions and plans can be quickly changed to meeting changing circumstances.

Handie-Talkie instruments are of tremendous value in fire control work, in scouting, on the line, with hot-spotters, crews after spot fires, on mop-up and patrol, and with aerial observers. The failure of these instruments to transmit around physical obstacles (and also not through stationary repeaters, as currently arranged by the State) makes it necessary for the fire manager to give early consideration to some type of repeater service if he wishes to take full advantage of the valuable service that Handie-Talkies can give. The most practical solution is found

in sending another Handie-Talkie operator to occupy a site where he can view both sender and receiver and thereafter pass along the messages between them. This is called a manually operated relay, or manual relay.

The less the average firefighter, or average citizen anywhere, does of his own radio repair work the better will the instrument operate. However, the general care and operation of Handie-Talkie instruments should be a subject of training for crew leaders, firetruck drivers and others who may use them in the field. The subject of training should cover the instrument's potentialities and limitations but especially what small disorders may put it out of order. The advantage will be in preventing some breakdowns and possibly in effecting some simple field repairs.

Since the battery life of Handie-Talkies is important, the wise procedure is to equip instruments with new batteries for fire duty. The displaced batteries are always subject to testing and continued use.

Radio communication is a wonderful tool in the hands of the firefighter. The fire manager may almost come to feel that it was invented just for his sole purpose, especially during the stress of a fire battle. But the "air" should be shared by many who may need it just as urgently. One of the fire manager's duties is to see that the rigidly controlled privilege of radio use is not abused.

Although the **telephone** has long been accepted as a basic means of one individual communicating with another, it is often overlooked as a supplement to radio. It does not have the qualities that lend themselves to practical use on the fire line. However, most fire camp headquarters which are established on large fires should arrange for one or more commercial telephone outlets, depending on the need. Less urgent messages between the fire camp and Unit Dispatcher—such as orders for additional supplies, manpower, and equipment—will be satisfactorily accomplished, and the load on radio channels will be relieved.

# PART III

## Organization and Management for Forest Fire Control

# CHAPTER TEN

## The Fire Suppression Counterforce

IT HAS often been said by students of military affairs that the basic principles of warfare have not actually changed since the early cavemen chose up sides and began throwing stones at one another. The essentials of battle are fire-power and movement, attack and counter-attack. Forest fire battles are made up of the same elements. As in the case of military affairs, the tools and techniques used in fire control are changing with the march of material progress. As a matter of fact, foresters and military men have contributed ideas each to the other to a greater extent than is commonly realized.

Primarily this writing intends to emphasize the "management" principles necessary to insure the most efficient accomplishment of the mission facing every Fire Boss, regardless of the size of the fire. That mission calls for prompt suppression with the smallest acceptable fire damage and the most reasonable cost in suppression effort.

The anticipated behavior of fire (as it is affected by local weather, fuel, and terrain) is a major influencing factor along with available tools in determining the manner in which the Fire Boss will build up his organization of men. Parts I and II are therefore devoted to those subjects.

Foresters, by the very nature of their work, are inclined to be about as unregimented as any profession, and possibly their well recognized esprit de corps is because of, rather than in spite of that fact. Nevertheless, the serious business of fire control demands at least a semimilitary approach in attacking the fire problem on the fire line and in developing the organization responsible for directing the fire. There must exist positive and known lines of authority at all times and a dependable response to instructions.

Beyond this there are the fundamental principles of fire management that are basically the same on all fires regardless of size

As a fire increases in size from a spot to 10,000 acres, the only change is in the complexity of the organization built upon those same principles.

That fire fighting agency which cannot expand its management organization to meet the demands of fire emergency, and do it in accordance with a predetermined, fundamental and yet simple plan is in danger of promoting an embarrassing mob scene at a time when quiet competence is so necessary to the public welfare.

Consider the elemental aspects of the fire control job. An unwanted fire is reported to a responsible fire control agency. Men and facilities deemed adequate to halt the expanding condition of the fire are dispatched to the scene. If that force is not effective enough to accomplish the task within an acceptable elapsed time period, it is strengthened to the extent estimated to be required.

Much is said later about the details of a fire management organization—the counterforce gathered to overwhelm the dynamic fire force. However, something of a general nature should first be recognized. The actions discussed here are based upon the existence and availability of forces of men and equipment as they are currently provided for the California Division of Forestry. Essentially this means that trained and equipped crews are ready in strategically located stations throughout the wildland area, so that under normally anticipated conditions of fire occurrence and fire behavior, reasonable success in the prompt extinguishment of wildfires is to be expected. Local fire plans include the extension of forces through mutual aid and by hire. This agency is put to the test several thousand times each fire season in respect to the adequacy of its plans and accomplishment. The Division has a record of about 95 percent success in preventing the development of large fires.

The elapsed time from discovery until fire containment was mentioned above as one elemental aspect to be considered. This is important because:

(a) An expanding forest fire continues to destroy flammable property, both private and public.

(b) The subsequent cost of extinguishing a growing fire will increase at a rate out of proportion to the size of the fire.

(c) Wildfire is a fickle creature, presenting an unknown potential for calamity as long as it lives. Those forces committed to an active fire line must be reckoned as a reduction in the total standby striking force available for fire duty elsewhere.*

Compared with a decade or two in the past, it is obvious that two situations have changed in respect to the job of forest fire control. The need to promptly suppress fires has been intensified, and both the cost and complexity of the organization to accomplish the task have increased.

There is a higher fire incidence, roughly proportional to the increasing population of human "users" in the wildland area. This increased use is reflected in higher values placed upon flammable materials, both natural and man-made. It also causes increased operational problems in the job of fire control for the reason that people and their structural values are intermingled with the natural flammable vegetation. The citizenry in general, demands, expects, and pays for better fire protection.

Secondly, the cost and complexity of the fire suppression organization has part of its cause in new and sophisticated machines which are expensive to acquire and to operate and repair. Also it is necessary to pay wages for labor reasonably comparable with similar wages in industrial employment. More than this, forest fire control has become a recognized profession and is no longer accomplished as a part time contribution by the local citizen at a time of civil emergency.

In order to abate the *dynamic force* represented by the wild fire, within a desired elapsed time period, *there must be brought against the fire a superior counterforce.*

The judgment upon which to take action, made by any responsible fire manager at *any time* in the life of a fire, must flow in interrelated steps or concepts. First, he must see the problem in two dimensions, namely, the fire which is currently burning, and also the estimated course and behavior of the fire (even as

* The policy of this agency requires prompt attack on all wildfires on lands under its responsibility with sufficient force to confine the fire to a relatively small area. In planning any necessary supplementation of forces the time goal for containment is to be within the first burning period (the first active period of a fire's life, and under any circumstances ending at 10 a.m. the morning following the day the fire was discovered). As nearly as may be feasible under the conditions that exist, plans for control of the fire thereafter are shaped to gain containment before the end of the next burning period.

it is modified by the suppression forces brought to bear against it).

Secondly, he must translate the fire problem into terms of necessary men, tools and equipment to accomplish the fire extinguishment within the anticipated time period.

Under the heading Size Up in Chapter Eight, the elements of fuel, topography and weather were discussed at some length. Now, the primary subject is the adequacy and the composition of the counterforce of men and equipment to accomplish the intended job.

Here is a dual condition, the broad fire *situation* and the necessary counterforce *strategy*. To emphasize the vitally important dual aspect of the problem, a word tool of double origin has been adopted.

*The fire suppression problem is to be interpreted in respect to the necessary counterforce as a* ***Strategy-Situation.***

The strategy-situation may change at any time during the life of any wild fire. Strictly speaking, there is no "situation" and no need for strategy unless an unwanted forest fire is in fact burning out of control.

Somewhat arbitrarily, four positive strategy-situation steps have been adopted and named.

It is reasonable to state in very broad terms that the organization developed to suppress a growing fire problem (or at least, any fire problem beyond the capacity of the forces on the ground at any given time) is of a strength generally commensurate with the dimensions of the problem. In more simple words: the greater the need the greater the force needed. Why not drop the issue at this point instead of seemingly complicating the matter with four designated strategy-situation steps?

The answer lies in the need to think and to be able to communicate in lucid patterns known to all of the responsible participants. The difficult business of fire control is fraught with the possibility of confusion. Every reasonable effort must be made prior to the fire emergency to establish the most simple and dependable plans and methods to meet unpredictable as well as anticipated requirements.

The four "size up" judgment steps of a fire condition, which are to be known as strategy-situations, ascend in the following order of fire problem (or organization need, since that is the

intended practical form of interpretation of the problem): *Initial Attack*, *Extended Attack*, *Major* and *Campaign*. Their essential differences will be discussed later. For the moment, it will be well to point out again that these word tools and thinking patterns will simplify and not complicate a vitally important emergency program which is by nature highly vulnerable to mistakes, confusion, human suffering and economic disaster.

Blocks or levels of organization development are something that can be mentally grasped and talked about in a common language. In opposition to this the comparative terms small, large, larger, are difficult to pin down and associate with very positive and important items such as men, bulldozers, and airplanes. Regarded in terms of graphic statistics this approach represents the use of four bar graphs instead of an indefinite rising trend line. And further, experience indicates that required changes in the structure of the organization do actually occur in the step patterns under discussion. This will be evident in the description of each strategy-situation. The use of bars or blocks is a common statistical method of reducing mass information to simple group units.*

The two lower level strategy-situations, that is, Initial Attack and Extended Attack are closely related in that the organizational machinery is essentially informal as compared with the higher steps of development. The Support arm, so necessary to keep a complex camp and fire line functioning smoothly, is represented almost entirely by an office dispatcher during the operation of Initial and Extended Attack fire suppression actions.

The forces put into action are readily available for movement around the fire. That is to say, the broad work problem has not been segregated into areas requiring special attention, and crews have not been assigned different work shifts. The Fire Boss, individually, is the master and director of planning and fire line projects. He would rarely have an established base of operations on the fire.

The plan of attack should be sound and logical, but it will rarely need to be complicated. Being basic and relatively simple,

* A good example is showing areas of relatively consistent fire incidence per acre per year by using swatches of different colors on maps to indicate arbitrary occurrence intensity zones. By this method the small details are eliminated in favor of easily appreciated broad blocks. A statistician would say the trend line is smoothed out.

trained workers will be able to function effectively without close direction.

The average Initial Attack fire striking force will vary with the availability of crews and facilities within the particular Ranger Unit, the location of the fire, the time of year and the current weather conditions. Under such variable conditions an adequate striking force may consist of a single patrolman, or a single firetruck with its crew. Elsewhere, or at another time, the striking force might consist of several firetrucks, perhaps one bulldozer, airtankers as deemed necessary, and one or more hand crews. Under any circumstances, the forces dispatched will be considered adequate to bring the fire under control promptly.

An Extended Attack action is to be definitely recognized whenever the Fire Boss has deemed it necessary to divide the fire line into two division segments with a designated Division Boss in charge of each. Probably, also, the complexity of the suppression problem has made it necessary to modify the original plan of attack. Under any circumstances, the extended striking force is expected to contain the perimeter spread of the fire within the first burning period.

In this stage of organization development an adequate, typical force may consist of one Associate Ranger in charge, one or more Assistant Rangers, several firetrucks and crews, two or more bulldozers, two or more airtankers with Airco, and two or more hand crews.

Major and Campaign organizations are naturally larger and more complex. This requires more formality and discipline to insure against confusion or failure in the interrelated details of work and organization maintenance. A substantial number of individuals are required to service (support) the many men, crews and facilities engaged directly on the fire line. Bases of operation in the immediate vicinity of the fire are established for this purpose. At one of these, the headquarters command post will very probably be established.

Job responsibilities will be specifically assigned, and work areas designated. Lines of authority will be precise. The active fire line will be segregated into numerous divisions and possibly larger zones. Supervisory personnel will undoubtedly have been drawn from a considerable distance beyond the local Ranger

Unit. Probably private equipment will have to be hired. Other agencies will be represented, both under mutual aid agreement and by hire.

Planning in advance of work shifts will be required, and the plans will of necessity be more detailed than would be necessary on smaller fire suppression projects. Alternate action plans should be available to meet every conceivable future behavior of the fire. A reserve of manpower should be held available if possible.

In most cases during a Major fire action, a General Headquarters group will be formed if one or more other protection agencies are directly involved in the protection of land under their jurisdiction. Such a group is generally necessary to coordinate intended action and to formulate basic strategy.

In the case of a Campaign Fire the establishment of such a General Headquarters is mandatory. This is true because of the serious potential for great damage inherent in a Campaign type of fire. It is also generally true because of the complexity and the high flammable values of the land areas which are invariably threatened during the life of a Campaign fire.

The essential difference between a Campaign fire and a Major fire action is the magnitude of the organization. However, in the Campaign action, Zones of decentralized authority for suppression effort are always established. Whenever a combination of weather and fuel present the imminent hazard of a conflagration—"a raging, destructive fire," as the dictionary says—it can be assumed that a Campaign fire can come into being.

When either a Major or Campaign Strategy-Situation exists it is possible that the fire will not be contained within the first burning period. This is a valid assumption because of the prevailing highly adverse burning conditions. By definition such conditions indicate that type of situation. Nevertheless, the organization (i.e. strategy) planned to effect control of the fire should be aimed at prompt and effective containment.

Under adverse burning conditions, a Major or Campaign Strategy-Situation may in fact exist from the very moment of ignition of a wildfire. The Strategy-Situation may change in any direction at any time during the life of any uncontrolled forest fire.

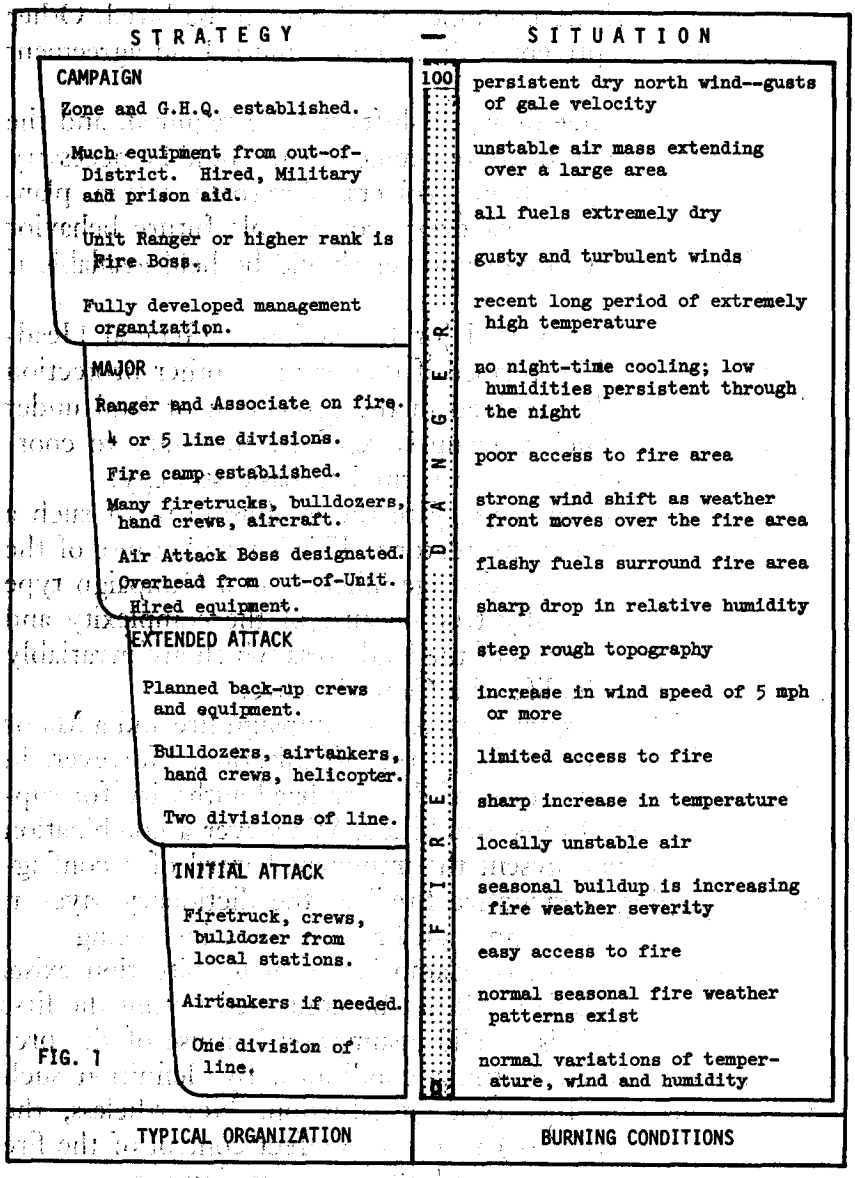
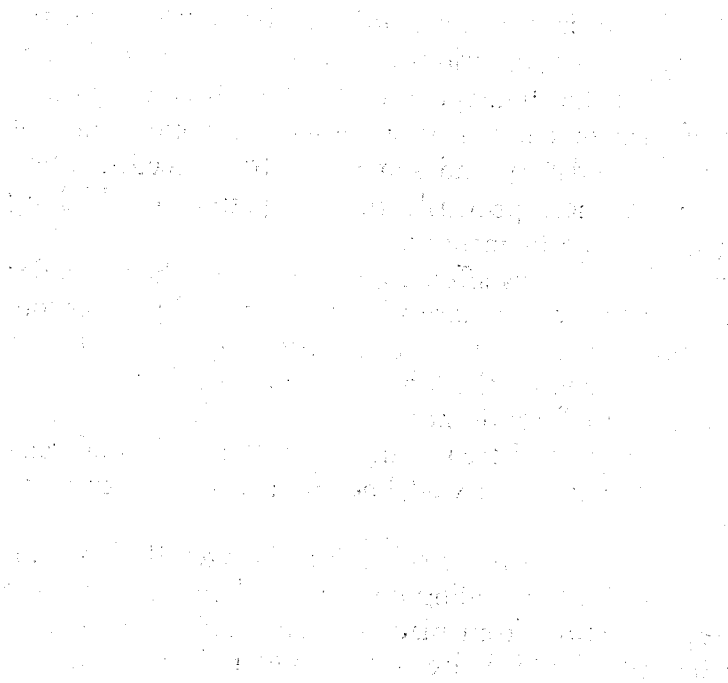

STRATEGY
SITUATION
CAMPAIGN
Zone and G.H.Q. established.
Much equipment from out-of-District. Hired, Military and prison aid.
Unit Ranger or higher rank is Fire Boss.
Fully developed management organization.
MAJOR
Ranger and Associate on fire.
4 or 5 line divisions.
Fire camp established.
Many firetrucks, bulldozers, hand crews, aircraft.
Air Attack Boss designated.
Overhead from out-of-Unit.
Hired equipment.
EXTENDED ATTACK
Planned back-up crews and equipment.
Bulldozers, airtankers, hand crews, helicopter.
Two divisions of line.
INITIAL ATTACK
Firetruck, crews, bulldozer from local stations.
Airtankers if needed.
One division of line.
100
DANGER
0
persistent dry north wind--gusts of gale velocity
unstable air mass extending over a large area
all fuels extremely dry
gusty and turbulent winds
recent long period of extremely high temperature
no night-time cooling; low humidities persistent through the night
poor access to fire area
strong wind shift as weather front moves over the fire area
flashy fuels surround fire area
sharp drop in relative humidity
steep rough topography
increase in wind speed of 5 mph or more
limited access to fire
sharp increase in temperature
locally unstable air
seasonal buildup is increasing fire weather severity
easy access to fire
normal seasonal fire weather patterns exist
normal variations of temperature, wind and humidity
TYPICAL ORGANIZATION
BURNING CONDITIONS

FIG. 1

Figure 1 indicates in ascending order under *Strategy*, on the left side, the typical organizations developed to manage the fire control project as the dimensions of the task become greater. The items of men or equipment as shown are typical and not intended to be mandatory and some may be unneeded. Steps or blocks are used here primarily to set a pattern of thinking and acting in an orderly manner.

The series of conditions affecting fire behavior shown under *Situation* obviously become more adverse in upward progression. These conditions are typically and not precisely related to the organization developed on the left. The actual field relationship of these causes and effects do not occur in any precise relationship. Observed as general trends, however, the horizontal relationship across the graph is well known to every experienced firefighter.

The center bar represents a rising Fire Danger Rating indicator. Theoretically, the reading on the bar should indicate the exact strategy-situation from place to place and time to time. With the benefit of added fire history and refinement of the rating areas this theory may some day become an operational fact.



# CHAPTER ELEVEN

## Fire Management Organization

GENERALLY speaking, the problems involved in controlling a forest fire become larger and more complex as the fire increases in size or as the rate of spread increases. It then follows that individuals assigned to assume responsibility for supervising some aspect of fire suppression work will increase in number as the fire control problem becomes more complex. And at the same time there will be an increasing need to designate "specialists" who will concern themselves with portions of the broadening job.

This Chapter deals with the functional segregation of the fire management organization in its varying stages of development. Structure charts are included to indicate graphically the typical offices and lines of authority and responsibility at four steps in organization development. It is to be noted that the charts reflect what might be termed ideal schemes for a management structure under assumed typical conditions. Both the terms, typical and ideal, can rarely be applied to the actual conditions on the fire line. Nevertheless, or rather, because this is true—it is necessary to use a consistent and disciplined pattern of development of a fire management organization. The actual position filled will naturally depend upon the need for that service. The basic pattern has been tested by experience. Adjustments may be freely made—but only within the established structural framework of organization.

The organization charts are found at the end of this Chapter. Job descriptions for the individual positions have been gathered in the Appendix by function groups, Command, Suppression and Support.

## FUNCTIONAL DIVISIONS OF MANAGEMENT

Experience indicates several human weaknesses in this respect which are not a matter of personal incompetence. Often a

Fire Boss has found that the little details have rather suddenly compounded themselves into a muddle that is ready to overwhelm him. Equipment is not operable because no one recognized a maintenance responsibility. A crew on the other end of the line has not been fed. With the press of details upon the Fire Boss, and undoubtedly a growing mental fatigue that he does not recognize, he may seriously believe that he has everything well in hand.

Another handicap for some men may be an actual lack of experience in large fire management. And these are the fires of most concern. Many times the Fire Boss will not recognize the dimensions of the problem that has been growing around him, or the imminent hazard which is threatening. He is plugging away in the wholly dedicated manner that brought him successfully through hundreds of fires which seemed to act about like this one when he arrived at the scene. Undoubtedly, if the Fire Boss had recognized the signs that must have been present, or had he properly sized up the entire situation when he arrived, the fire would not have progressed beyond his actual comprehension of it.

The experience of suppressing many large fires has also shown clearly that the total job of mobilizing forces and equipment, directing their labors, and keeping them operating effectively can be most efficiently handled by recognizing those three broad objectives as stated. The terms, adopted for these management phases of functional components are: **Command, Suppression** and **Support.**

On a small fire, where the Fire Boss is adequately directing all operations, he does in fact personally supervise all necessary aspects of these three functions. However, in respect to Support, he is practically certain to be served by the office Dispatcher, at least until such time as the fire problem requires local assistance on the ground.

### *a. Command*

Briefly stated, Command embraces the executive direction of the fire control operation. The Command function is responsible for developing fire strategy and putting it into effect in the most satisfactory manner. The Fire Boss is the Fire Manager.

He may be aided by such immediate assistants as he deems necessary, but generally by no more than one or two designated Assistant Fire Bosses.

The fire manager must analyze the fire problem by evaluating the known circumstances and estimating future developments. His ability to adequately accomplish this will often mean the difference between early control of the fire and a long campaign.

*On every fire one, and only one, individual must be recognized as Fire Boss at all times.* The individual person may change. As a matter of fact, in a well-manned organization it is hardly reasonable to presume that the man who started as the Fire Boss of a small fire will continue in that capacity if the fire grows to large proportions. In no sense is this an adverse reflection on any man's individual ability. Rather it should be understood that it is the duty of higher ranking officers (certainly including Rangers) to assume the increasing administrative responsibility incumbent upon the Fire Boss of a large fire.

*The arrival of a higher ranking officer on the fire does not mean that he is assuming the responsibility as Fire Boss.* Any such transfer of responsibility and command must be clearly indicated and made known. At the same time the new assignment for the former Fire Boss should be made.

The well-qualified Fire Boss, regardless of the size of the fire, should naturally respond to the following good principles of management. He should:

1. "Expand his thinking" as the fire situation develops.
2. Plan ahead.
3. Gear his strategy to expected as well as current developments.
4. Create an alternate plan of action.
5. Be prepared to make adjustments or sacrifices.
6. Have complete knowledge of the disposition of his on-shift, off-shift, and standby forces at all times.

The Fire Boss, in a complex organization, will probably share his strategy problems with a planning group, such as may be represented by a *General Headquarters*. This will be especially true if other agencies are heavily involved in, or are threatened

by the fire. Higher executive authority within his own agency may participate in such strategy formulation.*

Secondly, among those related to the Command function are the *Facilitating Agents*. These are the working persons and groups, away from the fire area, who help with the job by providing some special service within their own authority. Included would be civil officials, police, lookout observers, Dispatchers, and so forth.

A person unfamiliar with the difficult business of fire control will be inclined to assume that the qualifications of the attack leader can safely be in direct proportion to the size of the fire at the time action is first begun to control it. This is a dangerous assumption. All large fires were once small. Many were originally no larger than the head of a match. Some unhappy circumstance allowed the large fire to reach great proportions. It could well have been that the leader of the initial suppression party was not properly equipped in training, initiative, or experience.

In this leader (who is, of course, the Fire Boss even though he may be working alone) reposes all of the dormant powers and responsibilities that may grow into functions requiring the undivided effort of many men when the fire grows large. As long as a man is assuming the fire manager's authority he should be able to properly develop and complete a plan of attack, organize and direct effectively any incoming forces, foresee the need for additional men or equipment and ask for them.

### *b. Suppression*

The Suppression function embraces all aspects of applying any attack and extinguishment action against the fire, either upon the ground or from the air. All activities and men involved in the direct suppression effort on the fire perimeter are parts of the Suppression function. This includes men and machines actively engaged in constructing or holding the fire line. The

* On very large fires, especially where there is a serious threat to the property and lives of many people, the external pressures from civic officials and disturbed citizens can become a burden which diverts too much effort of the Fire Boss away from his primary task. For this reason it has sometimes been found expedient for the Unit Ranger to act as a general coordinator and expeditor in continuous touch with all fire actions as well as external parties and agencies. In this capacity he must relinquish direct supervision of fire work but not his strong advisory position.

development of plans is not the responsibility of this function. However, the bulk of the information concerning current and anticipated developments which may influence the planning will come from the line forces. Strategy must realistically consider "on the ground" conditions and no one can better outline them than the men who have been there.

The primary responsibility of the Suppression function is to construct and hold a safe line around the fire, following the plan of action outlined by the Fire Boss. Since a fire presents a constantly changing situation, the line forces are given wide latitude to make such modifications and changes in the plan as are necessary to meet the actual conditions. However, these modifications must be closely coordinated with all other fire line activity and any major change should be approved by the Fire Boss. When immediate and obviously appropriate action must be taken by the forces on the fire line before receiving the approval of the Fire Boss he should be promptly informed of such action.

The importance of constant interchange of information regarding fire status is often overlooked. Planning, arrangements for relief, transportation, supply, and similar "behind the line" activities are so closely geared to the fire line situation that any changes in strategy or progress must result in appropriate changes in the other functions. In short, the needs of the fire line dictate the action of all other forces on the fire and if the needs are not made known a breakdown will occur.

### *c. Support*

The Support function represents the housekeeping, maintenance and servicing duties, from gathering weather reports to greasing firetrucks. It also embraces duties of liaison with identifiable groups and agencies assisting with the fire line work. The use of the word support is applied in its most obvious sense in this case. Personnel assigned to this area of the total fire suppression responsibility have the primary duty of furnishing every reasonable need of the Command and Suppression arms of the organization. The Support function is segregated into three important sub-functions: Plans, Service and Liaison.

Support must be established and developed to any necessary extent required to make a prompt and adequate response to

demands. This requires the assigned personnel to be fully aware of current and potential fire conditions.*

The work responsibilty assigned to **Plans** embraces what might be termed intelligence and record keeping. As a fire organization becomes more complex several specialist positions will be established as required. On small fires the gathering of sufficient information for proper direction of suppression action is a relatively simple matter. The Fire Boss can probably keep in mind the locations and movements of men and equipment, the fire situation, available resources, and so forth. But it is not very long before it is necessary to have this job assigned to someone else so that the Fire Boss will not find himself bogged down in details. Records, maps, and communications are the tools of the Plans sub-function.

While the fire is going, records are very important as a management tool. Their use is often overlooked by the Fire Boss who may think of them only as a history of activity for compiling the fire report. When records are properly organized and kept up to date a great deal of information needed currently for good fire management will be readily available in a usable form.

Proper communication of information and orders becomes of increasing importance as a fire progresses in time or size. The Fire Boss who is ignorant of vital facts reposing in the minds of his assistants is less effective than if he were literally blinded by smoke. Personal messengers, telephone, point to point signals, smoke signals, radio; these are only methods of carrying one man's thoughts to another. The best, or at least the most readily available, system must be promptly and effectively put into use if the other tools of forest fire control are to be used to advantage.

The importance of record keeping and adequate communications were emphasized in Chapter Nine. In the description of positions and responsibilities for large fire management, the duties of Message Center Operator, Intelligence Officer, and similar assignments in the Plans sub-function will be discussed.

* The quantity and type of forces deemed a requirement as well as those being available from a practical or financial standpoint is a variable throughout the course of time and from place to place. Ten years ago the required airtanker of today was but a wishful dream.

Obtaining and distributing the supplies required by men and machines is important from the very beginning. Need for supplies or equipment that are not carried by the units operating on the fire line necessitates the creation of a **Service** sub-function. On initial attack fires, the job is handled by the Ranger Unit Dispatcher acting on requests from the Fire Boss. When a base of operations is established, supplies and equipment are usually provided from that base. The size of the organization needed to handle the problems of service and supply will vary in direct proportion to the number and type of men and equipment involved. Small fires with relatively few men and little equipment may need only one man and a camp crew (including cooks) to provide the necessary service for the units on the fire. In this case the Fire Boss usually sees to the arrangements and in general performs the duties of Service Boss. On larger fires, a qualified individual is designated to head this responsibility, and according to the work load involved is given sufficient personnel to perform the following:

1. Operate the fire camp (or camps);
2. Feed and rest all personnel;
3. Issue, repair, and account for tools;
4. Service all motorized equipment in camp or on the line;
5. Transport crews (needing transportation) to and from the line;
6. Install a communication system and keep it in operation.
7. Establish and manage base heliports.

The term liaison, from the French "to bind," is commonly used to indicate a coordination of activity or linking of two or more parties. The **Liaison** sub-function of Support performs just that important service on the fire. Experience has amply proved that whenever men or equipment come from several sources, either government or private, the proper recognition and direction of the several entities is very necessary to prevent confusion, and sometimes needless quarrels. Whenever groups of men in custody of some penal institution are involved, it is obviously necessary for the responsible fire managers to clearly recognize the authorized spokesman for the particular group.

It is difficult to establish any reasonable fixed guides in respect to the assignment of liaison personnel. A judgment of need on the part of the Fire Boss is required. However, as a fire management organization becomes enlarged with the addition of forces outside of his own agency, a Fire Boss would be well advised to appoint a **Liaison Boss.** Without such a representative, the necessity of personally dealing with an increasing number of group leaders can tax the energies of the Fire Boss beyond his capacities before he is fully aware of this particular burden.

With the assignment of a Liaison Boss, the Fire Boss is not only relieved of numerous problems of feeding, sleeping, work assignment, and sometimes special supervision, he should also be in a position to depend fully upon his aide to recommend the assignment of added liaison specialists whenever the latter deems them necessary.

Under some conditions the responsible fire control agency (in this case the Division of Forestry) may assign one of its regular employees to work with a group in total, or with their particular leader (such as a custodial officer). With other groups, or under different conditions, it is quite possible that the Liaison Boss can handle all of the pertinent problems of coordination and operation by making his own personal contacts with the other party's representative spokesman.

In summarizing the functional divisions of fire suppression management, the three major segregations of labor and responsibility stand out. These are Command, Suppression and Support. Command may be extended away from the actual fire line job to include an advisory group and also the facilitating entities. Support is to be considered in terms of its three components. If this arrangement were translated into a simple graphic organization chart it would appear about like this.

At top center is the Command unit. At one side of this is the GHQ or consultation group; at the other side, the Facilitating Agents. Two separate functions descend directly in the chain of command from the Command function. These are Suppression and Support. Support is made up of sub-units Plans, Service and Liaison. *Unless the Fire Boss of a Major or Campaign fire keeps this simple concept of organization constantly in mind he is in danger of being overwhelmed by the hazards of multiplex details.*

## DEVELOPING THE ORGANIZATION

The primary purpose of this writing is to describe the guiding principles for the development of a fire suppression organization to meet the actual and varying needs on the ground. In most instances a fire organization will be increased in size and complexity through a period of time. This development is inevitable as a practical matter of mobilization even when a Campaign Strategy-Situation is recognized at the outbreak of a wildfire. In other cases, the forces of circumstance—vicissitudes of fortune—will make it necessary to expand the organization to meet changed conditions. In fewer instances, an organization may be reduced or demobilized sooner than had been originally contemplated. Regardless of such factual conditions, this writing can best follow and discuss the most common steps of organizational development for fire control. The transition from a small to a very large fire problem will be considered in the four steps or patterns selected as organization and problem levels in the adopted four steps described in Chapter Ten.

### *a. Example of Organization on Initial Attack Fire*
*(Refer to Chart 1)*

Much of the procedure during the initial attack on a small fire will follow some basic predetermined rules based upon experience and the cumulative judgment of many men. This, however, does not lessen the responsibility of the Fire Boss to make practical adjustments in the basic rules if weather, geographic or fuel conditions demand them. Nor does it eliminate his responsibility for "thinking ahead" in the manner that has been prescribed above for the well-qualified Fire Boss.

During this initial attack operation, the Fire Boss actively participates in a number of fire line jobs. Since the organization is comprised of only a few men or a few crews and a relatively small amount of equipment, he personally directs and coordinates their actions and:

1. He immediately engages his force in suppression action.
2. He scouts the fire to determine line locations, considering cover types, natural barriers, topography, and general resistance to control.

3. He decides on a plan of action according to his own observations of the fire situation and assigns crews and equipment after briefing them on the actions they are to take.
4. He coordinates dropping of fire retardants from airtankers in accordance with fire behavior and ground force requirements.
5. He shifts forces from one area to another as the fire situation changes, modifying the plan of action or line location according to "on the spot" conditions.
6. He keeps himself informed on special hazards or problem areas and assures himself that the proper margin of safety is being maintained by all personnel.
7. He is a working example of how to do the job and "pitches in" to help with the control action whenever necessary.
8. He maintains communication (in the most practical manner and often) with the Ranger Unit Dispatcher, keeping him advised of fire conditions and requesting such additional forces or supplies as needed.
9. He arranges for the delivery of sufficient food and other supplies to the forces on the line at the proper times so that control actions will not be restricted.
10. If the fire appears to require more than a one-shift operation, he determines his needs sufficiently ahead of time to allow relief forces to be obtained, or for the alternation of the men and equipment on the scene.
11. He closely observes fire behavior for unusual occurrences which may indicate that changing weather conditions may be affecting the fire situation. This is correlated with the general weather forecast available through the Dispatcher.
12. He requires that activity records be prepared by each unit on the fire so that he in turn may compile the fire report.

During this time the Support function is handled by the Ranger Unit Dispatcher who sends the number and types of men and equipment for initial attack, in accordance with a general predetermined plan. This is tempered by his good judgment, based on the location of the fire, rate of spread, values involved, weather conditions and forecasts, fuel types, and travel time to the fire. He then acts as expediter of requests from the Fire Boss

for additional men, or services and supplies. The Unit Fire Plan provides the guide for the Dispatcher's use in filling these requests. He must then coordinate the delivery of supplies with the movements of men and equipment so that the greatest utilization is made of transportation facilities.

Through messages received from the suppression forces on the fire line or aerial observation the Dispatcher gathers information on conditions so that the Ranger may be kept informed of the fire situation. He also uses this information for anticipating requests from the fire and making preparations for them. The Dispatcher:

1. Alerts men and equipment in order to reduce the time required for get-away;
2. Moves crews into locations where there will be less travel time to the fire if and when they are needed;
3. Contacts local sources of supply to be assured that items most likely to be requested are readily available;
4. Anticipates the need, and initiates requests, for special weather forecasts whenever it appears that the fire will extend into the second burning period and such forecast may be of benefit. Similarly, if it appears that a mobile weather forecasting unit may be requested, he determines whether or not it will be available.

### *b. Extended Attack Organization*
*(Refer to Chart 2)*

When a fire strategy-situation has made necessary the development of a suppression organization of typical Extended Attack dimensions the components and management may be described generally as follows.

The first attack forces have been augmented by a substantial number of men and equipment. Normally no base of operations will have been established in the vicinity because containment is expected during the first night of the fire. If, however, men have been transported a long distance, and a considerable number of meals are required, the establishment of a field kitchen is quite practical, even for a short period.

*Definition:* A division is a designated area or distance of fire perimeter, usually determined by a combination of topographic features and fire

control problems, whereon the area of work can be generally supervised on the ground by the Division Boss within a period of two hours.

A **sector** is the designated unit of a division of fire area or perimeter whereon the work is supervised by one **Sector Boss.**

A fire of this nature will have enough distance of perimeter or difficulty of line construction along all or portions of the work area so that more than one supervisor is required to direct the work around the entire fire line. As a good practical rule it can be said: the more intensely the fire is burning, the smaller will be the area requiring the immediate supervision of a local boss. The first established and recognized divided areas of perimeter work are termed divisions. The assigned supervisor of each is called a **Division Boss.**

Whenever the task of supervision of work within any division becomes so great that the Division Boss cannot contribute sufficient personal time to the details of operation, there may be an assignment of assistant line supervision over designated sectors of area. Generally a division is divided into two sectors. However, more may be created if the work problem requires it.

At this stage of organization development, the Fire Boss as an individual represents the three primary functional aspects of management. Most of his time will be spent on the fire line. For this reason he should consider the designation of a **Line Boss** to relieve him of some detail in the total job of fire line management. Such an assistant could prove to be especially valuable if the fire situation worsens and cumulative fatigue becomes a factor.

The Fire Boss and his Line Boss will share the following responsibilities in any manner clearly understood between them.

(1) Continuous information on fire conditions is gathered and evaluated, including reports from the line, aerial observation and personal scouting trips.

(2) Division and Sector Bosses are adequately briefed on general and specific plans and on work assignments.

(3) Shifts in crews or equipment are made to meet changing needs.

(4) Crews are properly fed and rested.

(5) Adequate fire activity records are kept and reliable communication maintained.

(6) Fuel for powered equipment is acquired in sufficient quantity.

It is probable that airtankers and possibly a helicopter will be used in some stage of this fire. And an Airco will be in the vicinity directing traffic and drops. (Airco service is a firmly intended aspect of air attack and only unusual circumstances will cause its absence, such as the demands of numerous different fires, mechanical trouble or time out for refueling).

When the air-ground coordination is relatively simple, the Fire Boss or Line Boss will communicate with Airco and designate drop areas. It is not likely that the intensity of aerial activity over a fire of this dimension will require the assignment of a special ground assistant to devote his exclusive time to this aspect of the suppression job.

If the establishment of a camp at the fire is necessary, the Fire Boss will promptly designate a **Camp Boss** to manage its installation and operation. This man will set up the camp at a location selected by the Fire Boss (see The Fire Camp in Chapter Twelve). He will assume responsibility for obtaining adequate supplies and arranging feeding schedules. If the kitchen duties become heavy, a **Kitchen Foreman** will be appointed as an assistant to the Camp Boss.

As soon as the Fire Boss is aware that he is involved in an Extended Attack Strategy-Situation he should be certain that some person is keeping records of incoming crews and other personnel, and also equipment. He will appoint a **Timekeeper.** As the fire extends in time and complexity a number of maps, photos, and general messages will begin to accumulate. Eventually a center of information, communication and planning will be required. This will be known as the Information Center.

As the complexity of the fire increases and a base of operations is established the Timekeeper will quite logically set up his "office" at the most common point of entry to the camp. Eventually this place will become an intelligence and reception center. At some point of congestion it will probably be necessary to move the Timekeeper's desk a sufficient distance to permit the other elements of the Information Center to conduct their work somewhat aside from the comings and goings of crews, overhead, and other reporting personnel. Civic officials,

interested citizens, and news people will undoubtedly first approach this traffic center.

The need for an official representative of the Fire Boss in this area of planning, record keeping, communication and reception will be evident early in the development of a fire management organization. To handle the job, the Fire Boss will appoint a **Plans Boss.**

The Plans Boss must keep available or, if necessary, take action to accumulate such information as he believes will be of value to the Fire Boss. For example, the availability for assignment of new forces or equipment, or the withdrawal of forces should be matters of intelligence which the Fire Boss can expect to receive promptly and accurately from his Plans Boss. A flow of necessary information between fire line and office Dispatchers must be maintained by this center of plans and information.

### *c. Major Fire Organization*
*(Refer to Chart 3)*

A single large fire problem is now under consideration. This is a typical Major Fire Strategy-Situation. Undoubtedly the weather conditions over a broad area are unfavorable, and possibly several other large fires are burning. This discussion of one fire suppression organization will ignore the problems of the central dispatchers, without any intention of devaluing the vital importance of their continuous support.

On this Major fire a considerable number of hand crews have been assembled and assigned to 12-hour work shifts. At least four or five divisions of fire line have been delineated. A fully developed fire camp is installed as a base of operations and management headquarters. Many pieces of motorized equipment are on the fire, and a definite system for their maintenance is established.

The management of a Major fire must be recognized as "big business." Aside from the technical problems involved with extinguishing a fire of this dimension, and the positive losses and threat of losses, the administrative aspects of developing and managing the collection of men and machines demands high executive competence of the Fire Boss. The expenditure of many thousands of public dollars rests almost solely upon his judgment.

The three functional entities—Command, Suppression and Support are staffed and operating as separate but integrated elements of organization.

An **Assistant Fire Boss** has been appointed. He not only assumes particular aspects of management as his independent responsibility; he is also the recognized relief and acting chief in the absence of the Fire Boss.

If the current history of the fire is of high public interest, the Command officials could be sorely burdened with requests for information from the general public, public officials and news media. The public has a right to know. The fire abatement agency has a primary responsibility of efficiently extinguishing the fire.

When personal visits and phone calls from the public and others to the fire camp is building up to the point of interfering with fire management and fire communication, an **Information Officer** should be appointed. If it is at all feasible he should have separate commercial telephone service brought to his post and that post should be located close enough to the fire so that he can obtain direct personal knowledge of the course of events.

The Suppression function will undoubtedly be staffed to work by land and by air. This will be true except possibly during periods when strong wind, or turbulent air at lower levels, or a dense smoke blanket make air operations too hazardous or difficult.

Two Line Bosses relieving each other on 12-hour shifts will coordinate and generally supervise all ground work around the fire perimeter. Each will be in close contact with the Assistant Fire Boss to whom they report as the immediate superior. Information relative to all aspects of the fire's behavior, work progress, and future plans, must be fully exchanged among these officials.

The control of movement of aircraft in flight over a fire area rests upon Airco who is aloft.* On the ground an **Air Attack Boss** will be appointed for the purpose of coordinating all use of aircraft. If a number of helicopters are in use, he may be assisted by a **Helicopter Coordinator.**

* By notification to the Federal Aviation Agency from the fire service that a serious fire "disaster area" exists, instructions from the Agency will be repeatedly broadcast by radio for all unauthorized aircraft to keep a prescribed distance from the officially designated area.

The priority of air actions comes down from Command as an integrated element of the total fire suppression effort. The details of performance are worked out between the Line Boss and the Air Attack Boss. The projects may involve retardant drops upon designated parts of the fire perimeter, the transportation of crews by helicopter, helijumps, an aerial hose lay, an infra-red mapping flight, or any other use of aircraft.

Specific action control from the ground will probably be placed in the hands of a local work supervisor to execute the actual job. For example, consider the dropping of retardants from airtankers upon an active salient of fire perimeter. Probably the Sector Boss in charge of the particular area will be told to communicate directly with Airco to accomplish the drops. (See Airtankers in Chapter Nine.)

In the Support function the Plans Boss will require "office" space easily available to the Fire Boss (and preferably offering him some means of retiring to a relatively quiet desk, table, trailer or otherwise segregated area where he may consider individual problems without interference from the noise and confusion of this busy intelligence center).

On a Major fire the Timekeeper will need relief to handle personnel and property records. And further, the job of receiving, sending and transcribing messages will have to be turned over to **Message Center Operators** who will maintain continuous day and night service.

The task of maintaining maps to show the current fire perimeter and control status, aerial photos and similar intelligence records will be assigned to an **Intelligence Officer.** It will be this man's responsibility to secure adequate information, sometimes personally but more commonly by order of the Plans Boss, so that accurate current knowledge of the fire and the deployed forces is on paper for immediate use. Sketch maps showing fire line work assignment for divisions and sectors will be prepared for outgoing line overhead by the Intelligence Officer.

On this Major fire it is most probable that the bulk of hand crew personnel are dispatched from Conservation Camps. Each crew of 15 to 20 men is directed by one or two Division of Forestry Foremen. With several such crews, both camp custodial officers and forestry superintendent class personnel will

be present. From the ranking forestry men the Fire Boss will probably select a couple to deal with him in liaison matters, each as **Liaison Boss** on a shift basis.

With the numbers of powered vehicles and other types of machinery and the bulk of food and other imported supplies, the Support function requires a general property and maintenance overseer who is termed the **Service Boss.**

One aspect of this Service sub-function deals with maintaining all items of transport and communication. This would involve the repair of radio equipment, the greasing, fueling, and repair of motorized automotive vehicles or stationary engines. As deemed necessary, he will have assigned to assist him: a **Transportation and Communication Officer,** several **Mechanics** working under a **Repair and Service Manager** and **Radio Technicians.**

If the Service Boss feels that more time is required to make safety inspections around the camp than he is able to contribute, he may ask for the appointment of a **Safety Inspector.**

The job of planning needs, ordering, arranging for transportation, and receiving all of the general supplies used on a large fire requires the full attention of a **Supply Manager** working directly under the Service Boss. These supplies will be stored, issued and accounted for by a **Property Foreman** working under the immediate direction of the Camp Boss.

### *(d) Campaign Fire Organization*
*(Refer to Chart 4)*

In Chapter Ten the large and destructive wildfire burning under seriously adverse conditions was described and classed as a Campaign fire. The prevailing problem confronting the fire suppression organization is more difficult than will be encountered during the large fire of Major proportions. Again the statement is made—such a situation and the strategy required to overwhelm the fire problem may exist from the moment of the fire's ignition if the united conditions of fuel, weather, and location harbor the forces of impending catastrophe.

It was said that the delineation of area zones and the magnitude of the suppression organization, in company with the highly adverse fire suppression situation, distinguishes the Campaign Strategy-Situation from the Major.

The organization developed to suppress the Campaign type fire will include all of the elements described for the management of a Major fire. Some positions described under that category will require strengthening in numbers to provide relief and assistance.

In the area of Command the Fire Boss will be confronted with a considerably larger executive job than will bear upon most Major fire managers. The pressure of making continuous judgments and decisions under conditions of civil emergency or probably very real human catastrophe, can be known only to the man who has found himself in such a lonely position.

It is doubtful if any amount of training in the techniques of fire management will fully prepare an individual for the burden of assuming Fire Boss responsibility during catastrophe. Certain it is, however, that without such a background of knowledge, a tough nervous and physical constitution is not sufficient to adequately handle the job.

The ideal Fire Boss of a Campaign fire will possess the following qualifications. He will have had considerable command experience on large fires. He will have a nervous system which permits him to relax when he is off duty, and enough personal discipline to rest at least several hours during each 24 hour period. He must be able to delegate responsibility and insist that projects be adequately accomplished without his personal attention. He must realize that his job is bound up in the present moment and the time ahead, and not look back at his battle losses except to profit from mistakes that could have been avoided.

Two aspects of the Command function have been mentioned earlier. These were the General Headquarters group and the various Facilitating Agents. It was indicated that because of the number of parties having a political, economic, and what might be termed social interest in the going Campaign fire, a representative, consultative and advisory group will be quite necessary.

If two or more fire control agencies are directly and jointly involved in this large fire there must be a correlation of activities. Generally, segregated portions of the fire perimeter will be assigned among the agencies. Methods of close communication must be maintained. The GHQ session will be the place to establish this type of cooperative plan.

In respect to higher administrative authority within the Division of Forestry, it should be pointed out that the authority of exclusive action command on the fire line which reposes in the Fire Boss does not reduce the wide operational responsibility of high administrative officials of the Division. The State Forester and his District Deputy State Foresters must ultimately answer for the conduct of the public agency they represent. In this respect the GHQ presents an opportunity for high administration to become an active party in the discussions of problems and propositions of general strategy. Both the representatives of administration and fire management can contribute to the public welfare if each respects the responsibilities of the other at such a time of emergency.

The times or place of meetings of a GHQ advisory group cannot be recommended in any meaningful manner. In respect to conferences among representatives of active firefighting agencies on the line it can be assumed that meetings will occur at any time of day or night as deemed necessary by the parties. Where other agencies or groups are involved, the Division's ranking field administrator of the particular area should assume the primary interest in arranging for GHQ sessions whenever he foresees that necessity.

Another possible officer to be appointed in the Command function could relieve the Fire Boss, and to a certain extent the Intelligence Officer, of some very prickly problems. This would be a **Fiscal Advisor.** Such an appointee would very definitely have to be well acquainted with the complications of State fiscal procedures, current available funds, and the numerous expenditure controls pertaining to the several fund allotments. It is not intended that this fiscal expert be a paymaster or record keeper. His primary responsibility would be in advising and assuring the Fire Boss how considerable sums of public money are to be legitimately expended to accomplish a necessary task under unusual conditions.

The Facilitating Agents that contribute to the area of Command were briefly mentioned. Some of these parties or agencies away from the fire scene could impinge heavily upon the course of events during a Campaign fire. For example, the control of traffic, the closing of hazardous areas or the evacuation of residents may be a vital service contributed by a law enforcement agency.

Within the Division itself the matter of dispatching through higher echelons deserves a little comment. This writing has been rather rigidly directed toward its declared purpose—the influences and actions bearing upon the suppression of a going fire out in the wildland. The actions taken during a Campaign fire can very well be influenced by other large fires, and certainly by the imminent threat of more large fires during a period of high fire danger. The Fire Boss on a large fire is known to have his particular problems. All of the agency personnel beyond the scene of the fire know this, and as a matter of course contribute whatever assistance they can. When the problem of available forces becomes acute over a widespread area, the Fire Boss on the large fire could well be the last to know of it. To the ultimate degree he is furnished every item he requests. The dispatchers of higher administrative units bear the principal burden.*

The Fire Boss will certainly require the help of two Assistant Fire Bosses on a Campaign fire. One will devote his interest to the general supervision of the Support function. If a Fiscal Advisor is called in to assist the fire managers he will be attached to this Assistant Fire Boss.

The other Assistant Fire Boss will concern himself exclusively with the Suppression project. He will deal primarily with **Zone Bosses** and the Air Attack Boss. General supervision and coordination of the entire line work program will be his responsibility.

It was stated that the designation of zones is a recognized necessity in Campaign fire management. This is an assumed fact because of the fire's size and complexity. The essential reason for establishing at least two zones (and more if required) is found in the advantage of a certain degree of dispersal of management control. Experience has shown that when a fire has grown to great proportions, and especially when there are several active portions of the line, the whole problem begins to assume the dimensions of several independent fires. The relative operational independence of a zone force will most efficiently

* The Division Headquarters Dispatcher states that probably every Ranger Unit from Oregon to Mexico feels the impact in some way when even one Campaign fire is going in the State. Dispatch of crews, firetrucks and overhead to the fire requires a move up to offset weakness in strength from vacated stations and posts.

deal with these isolated line projects. An isolated zone command will have its own base of operations which is an extension of the main fire camp. The zone unit will be better prepared to meet some possible sudden and unexpected thrust of the fire because it contains a certain elasticity in the movement of reserves which a smaller force might lack.

The Support function will be called upon to extend its effort in meeting greater problems of acquisition, housekeeping and maintenance. For example, the Property Foreman and the Supply Officer will have crews of helpers.

A **Maps Man** and a **Recon Man** will have been appointed to assist the Intelligence Officer. It is likely that the Weather Bureau will have been called upon to send a mobile unit to the scene of the fire. In this case, the **Weather Man** will work in the intelligence office under the Plans Boss.

The job of caring for vehicles and the communication systems will have grown tremendously along with property and housekeeping duties. The Service Boss will place supervisors over these two branches of his sub-function. He will have established **Assistant Service Bosses,** one in the field of Supply; the other handling Transportation and Communication. The latter will have his own immediate assistants under the titles **Communications Service Officer,** and **Repair and Service Manager.**

If heliports have been constructed in the general fire area, the **Heliport Boss** with his **Heliport Foreman** and crew will be working under the Assistant Service Boss—Supply.

The need for entirely adequate liaison between the responsible fire managers and every representative group on the fire is positively mandatory on a Campaign fire. A failure in this respect will result in almost certain confusion. And confusion is a primary degenerating factor in any attempt at maintaining an efficient fire suppression organization. On a Campaign fire in California at the present day, it is hardly conceivable that several different agencies will not be represented.

A competent Liaison Boss should be aware of any weakness or failure to adequately keep up a flow of necessary communication among all parties. To a great extent he and one Assistant should be able to accomplish this on a 24-hour basis. As the forces of any one particular agency grow, it may be necessary

to assign Division personnel solely to maintain a constant liaison with the forces of that particular agency. This will be especially true if the other party is not clearly represented by some one responsible leader.

It is important, of course, that liaison people keep the communications center continuously informed of their whereabouts. Messages traveling in either direction, from or to the particular group should be handled through the recognized liaison officer to the greatest possible extent. In this manner he will become acquainted with some aspects of the work which actually involves him, and in addition it can be assumed that messages or instructions will more surely reach the intended recipient.

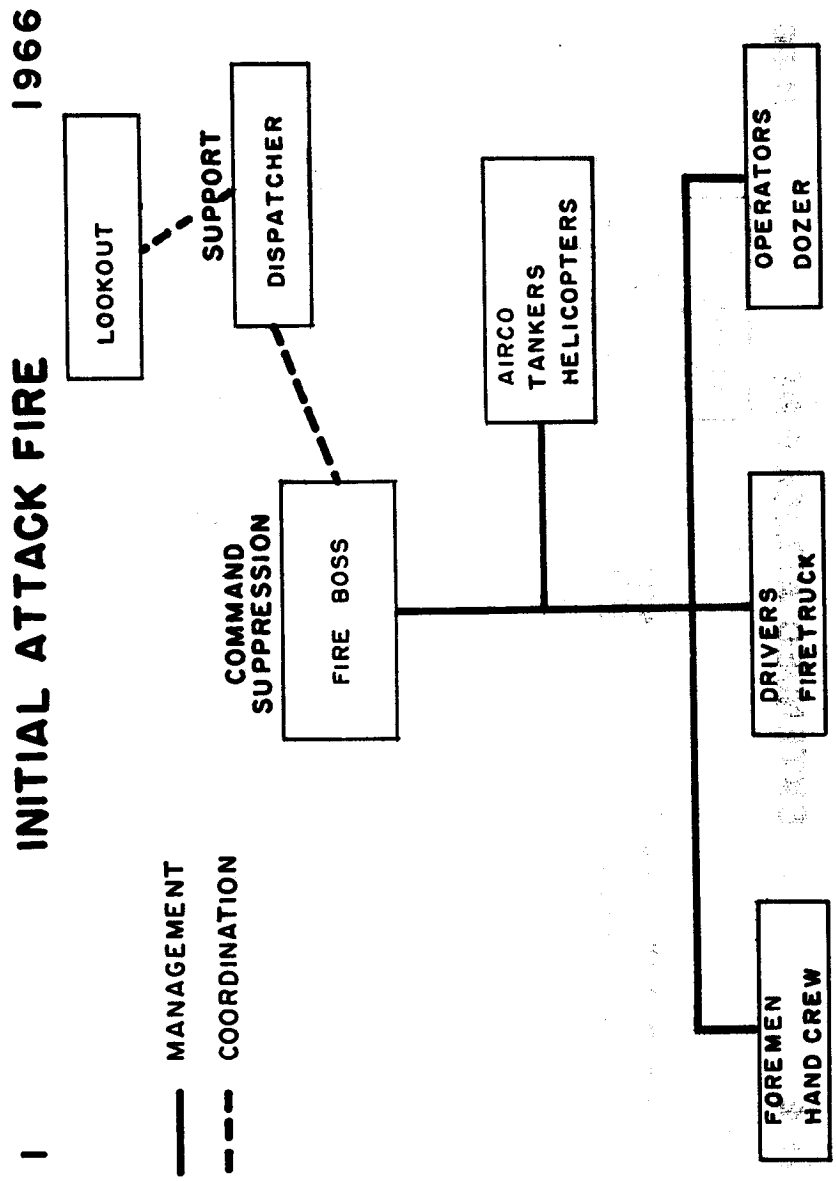
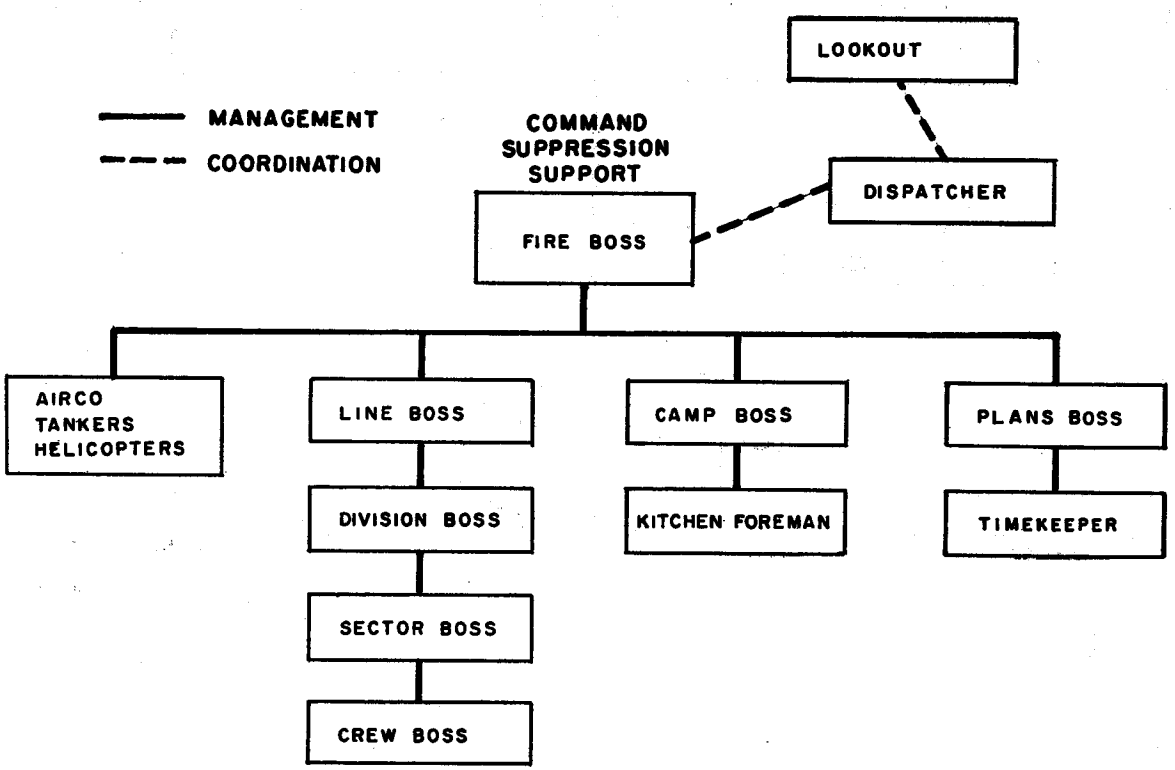


Chart I
INITIAL ATTACK FIRE
1966
MANAGEMENT
COORDINATION
LOOKOUT
SUPPORT
DISPATCHER
COMMAND
SUPPRESSION
FIRE BOSS
AIRCO
TANKERS
HELICOPTERS
OPERATORS
DOZER
DRIVERS
FIRETRUCK
FOREMEN
HAND CREW

Chart 2

## EXTENDED ATTACK FIRE 1966



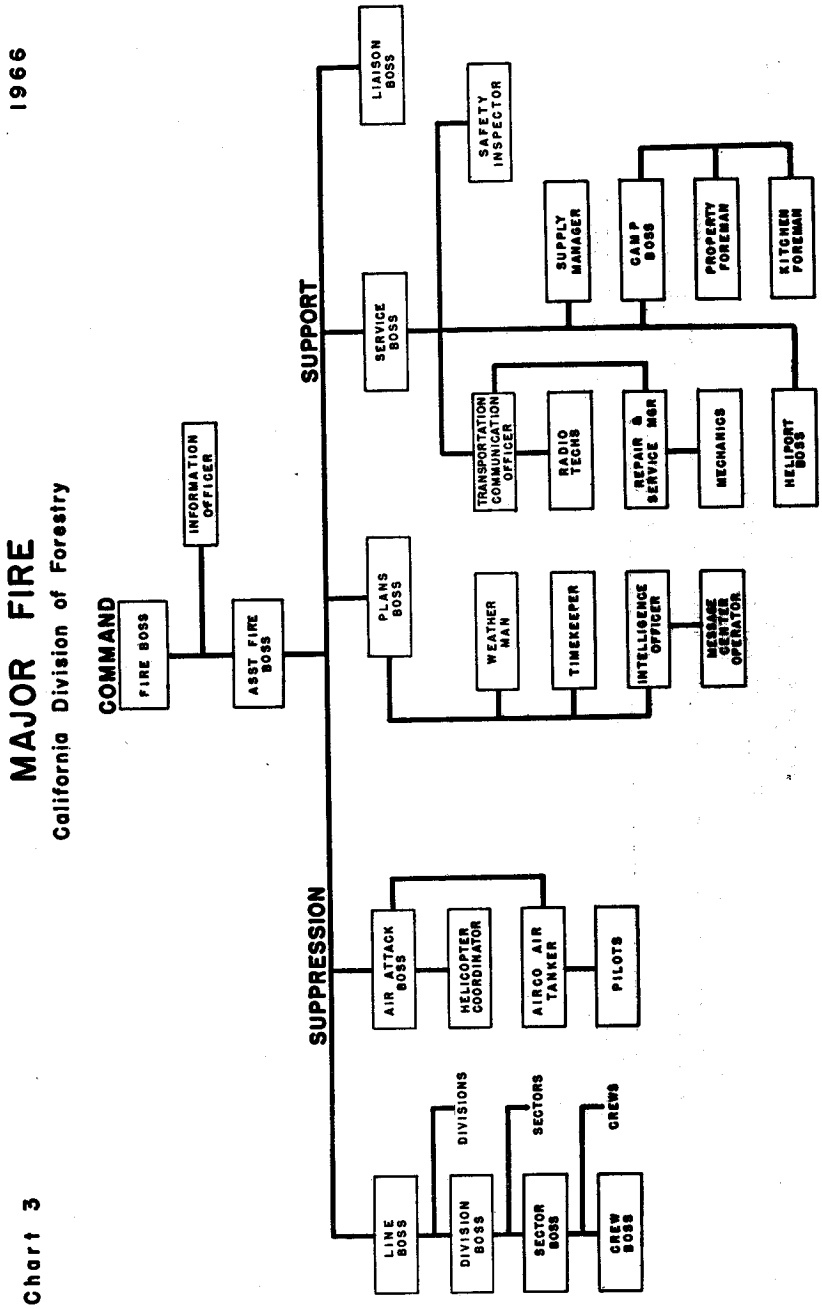

MAJOR FIRE
California Division of Forestry
1966
COMMAND
FIRE BOSS
INFORMATION OFFICER
ASST FIRE BOSS
SUPPORT
LIAISON BOSS
SAFETY INSPECTOR
SERVICE BOSS
SUPPLY MANAGER
CAMP BOSS
PROPERTY FOREMAN
KITCHEN FOREMAN
TRANSPORTATION COMMUNICATION OFFICER
RADIO TECHS
REPAIR & SERVICE MGR
MECHANICS
HELIPORT BOSS
PLANS BOSS
WEATHER MAN
TIMEKEEPER
INTELLIGENCE OFFICER
MESSAGE CENTER OPERATOR
SUPPRESSION
AIR ATTACK BOSS
HELICOPTER COORDINATOR
AIRCO AIR TANKER
PILOTS
LINE BOSS
DIVISIONS
DIVISION BOSS
SECTORS
SECTOR BOSS
CREWS
CREW BOSS

Chart 3

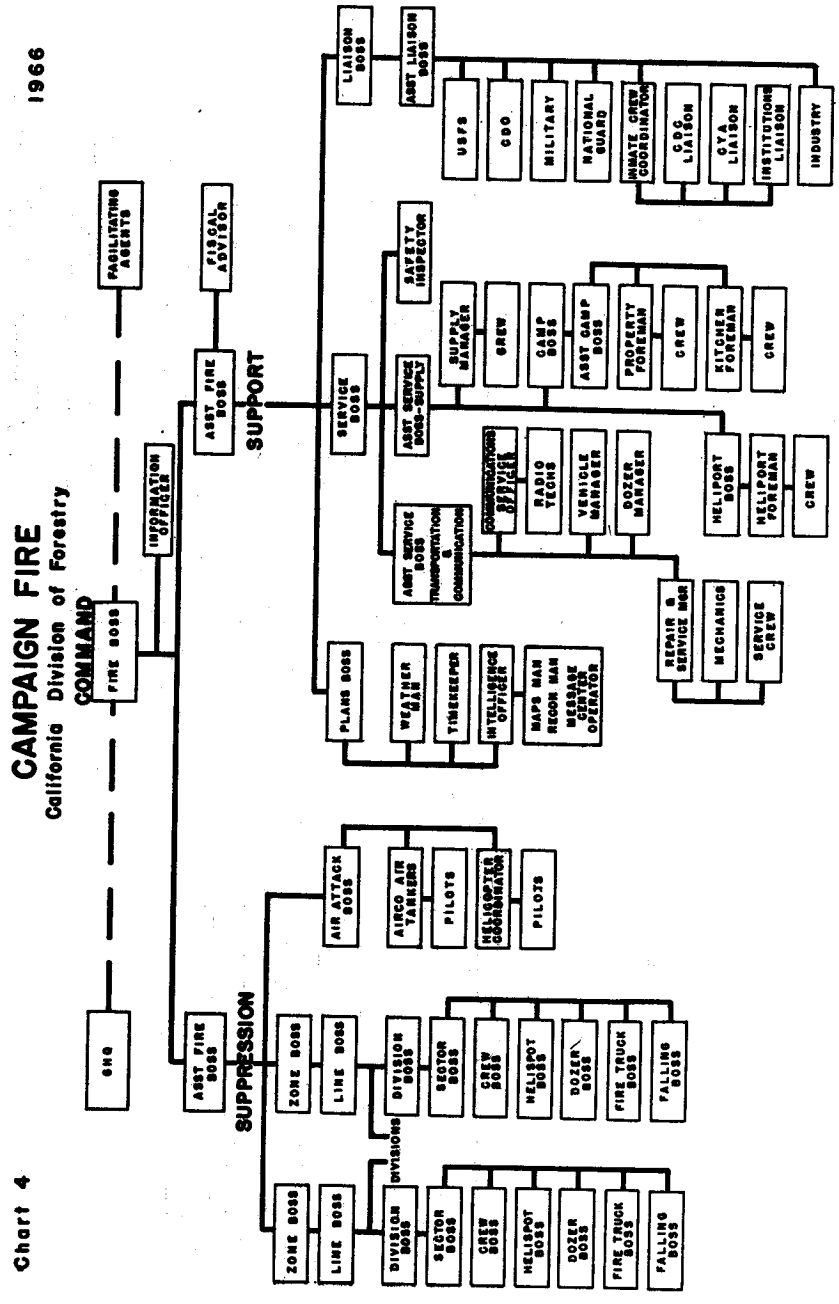

CAMPAIGN FIRE
California Division of Forestry
1966
COMMAND
FIRE BOSS
FACILITATING AGENTS
FISCAL ADVISOR
INFORMATION OFFICER
ASST FIRE BOSS
SUPPORT
SERVICE BOSS
LIAISON BOSS
ASST LIAISON BOSS
USFS
CDC
MILITARY
NATIONAL GUARD
INMATE CREW COORDINATOR
CDC LIAISON
CYA LIAISON
INSTITUTIONS LIAISON
INDUSTRY
SAFETY INSPECTOR
ASST SERVICE BOSS-SUPPLY
SUPPLY MANAGER
CREW
CAMP BOSS
ASST CAMP BOSS
PROPERTY FOREMAN
CREW
KITCHEN FOREMAN
CREW
COMMUNICATIONS SERVICE OFFICER
RADIO TECHS
VEHICLE MANAGER
DOZER MANAGER
HELIPORT BOSS
HELIPORT FOREMAN
CREW
ASST SERVICE BOSS TRANSPORTATION & COMMUNICATION
REPAIR & SERVICE MGR
MECHANICS
SERVICE CREW
PLANS BOSS
WEATHER MAN
TIMEKEEPER
INTELLIGENCE OFFICER
MAPS MAN
RECON MAN
MESSAGE CENTER OPERATOR
SUPPRESSION
AIR ATTACK BOSS
AIRCO AIR TANKERS
PILOTS
HELICOPTER COORDINATOR
PILOTS
ASST FIRE BOSS
ZONE BOSS
LINE BOSS
DIVISION BOSS
SECTOR BOSS
CREW BOSS
HELISPOT BOSS
DOZER BOSS
FIRE TRUCK BOSS
FALLING BOSS
DIVISIONS
ZONE BOSS
LINE BOSS
DIVISION BOSS
SECTOR BOSS
CREW BOSS
HELISPOT BOSS
DOZER BOSS
FIRE TRUCK BOSS
FALLING BOSS
SHO

Chart 4

# CHAPTER TWELVE

## The Art of Fire Management

THE PROPER management of a fire control organization made up of many men and machines must be recognized as a comparatively difficult task. The work can be both hazardous and wearisome as well as demanding of special skills along with physical endurance. But the one attribute most valuable to the fire manager will be confidence in his own judgment and the ability to demonstrate or express that confidence to the workers around him.

Great emphasis has repeatedly been placed on the leadership responsibility that must be assumed by the Fire Boss. The experience of human calamities down through the centuries has proved beyond question that responsible and recognized leadership is required to avoid confusion to say the least, and at worst, defeat and disaster. There must be no doubt as to which individual assumes final authority and responsibility in forest fire management, regardless of the advice or assistance he chooses to ask for or use.

The science of efficiently guiding the effort that must be expended to bring a wild fire under control demands even more of a man than strength, skill and courage. He must try to labor cheerfully under the handicap of never knowing for certain just where are the eventual limits of the task before him. His own job is subject to rapid and violent growth. More than that, even when his own theater of operation is reasonably stabilized he is subject to calls for aid from other quarters.

It has been pointed out that the demands upon the Fire Boss can outgrow the capacity and ability of the first, and possibly the second man to assume the job on a single growing fire. This is not an indication of failure on the part of the first managers by any means. It is, however, a strong commentary upon the basically difficult type of managerial chore confronting the man who bears the proud title "Fire Boss" at any time.

## COGS OF THE MANAGEMENT MACHINE

The structure of the interrelated management organization assembled to carry out attack on wildfire has been discussed and charted in considerable detail, through every stage of its development. Possibly too little emphasis has been placed upon the need for designated "office holders" within the organization structure to understand the importance of their work performance as part of the *team.*

Much thought and much learned writing has been devoted to the problems of developing organizations in which individuals will accomplish all that is expected of them and do it within the chain of command. Instructions, training and experience are all valuable teaching tools to develop individuals to fill the various jobs in any management structure. Unfortunately, however, the single most important ingredient of success reposes in individual human character and ability.

Only in the ultimate performance on the job can the effect of training, experience or native ability be measured. For the Fire Boss and his immediate problem all this may be a little late in coming. He must have dependable cogs for the wheels of the management machine he often has to erect under difficult circumstances in a minimum of time.

Each of these human cogs has an important place in the machine regardless of its placement in the paper management chart. The failure of some one person to see that drinking water is available for a crew down in a hot canyon may mean the loss of a line as surely as the misjudgment of the Division Boss. After all, there are Sector and Crew Bosses as well as the Line Boss available to bolster some partial failure on the part of the Division Boss, unfortunate as that may be.

Except for those individuals known personally to the Fire Boss, he must depend to a large extent on the stated qualifications which should be carried by the personnel of all large and efficient forest fire control agencies. Such specified qualifications are prepared by the supervisors of each particular employee. How important then it is for a thoroughly *realistic* appraisal to be recorded on each man's fire classification card, both for the good of the man and the entire organization.

It would seem most wise to create a managerial structure under conditions which are not dependent upon personalities but rather upon the accomplishment of certain direct and simple staff jobs. This will require that the personnel assigned to all jobs know the scope of their duties and responsibilities and also be well enough disciplined to appreciate the importance of meeting all of their respective tasks without transgressing into the field of another.

Further, the managerial structure to be created must be subject to orderly and rapid expansion in response to the needs of any rapidly expanding fire problem. This will be a task for the fire manager requiring the most orderly thinking processes, often in the midst of deep surface confusion. For this reason the fire manager would do well to keep before himself always the simple major goals he is trying to reach while he selects a staff that will not fail to accomplish the necessary details along the way.

## ASSIGNING PERSONNEL

The assignment of individuals and crews to fire line or camp duties will naturally be governed by two major factors: what the unit (man or crew) can do, and what the fire manager knows of that potentiality. This immediately points up the importance of proper fire job specifications entered on the identification card of regular employees. This record also provides a source of information regarding alternate and local qualifications for the individual which may be of great value to the Fire Boss if he is pressed to fill some new position requiring such a class.

There are different degrees of good health that should be recognized by the Fire Boss when assignments are made. Permanent cripples will usually seek their own work level because they are used to it if they have spent their life in some field of labor. A one-armed lumber worker may be able to accomplish far more with any tool or vehicle on the fire line than most able-bodied men who follow a quiet life. Regular work crews should certainly be assigned as units under their regular leaders to the greatest extent possible. Those crews with the most training and physical endurance should be expected to pick up the heaviest burdens, such as hot spotting or constructing difficult line.

In military warfare the commander in even the smallest battles will strive to keep some strength in reserve to bolster his line

against some unexpected thrust from the enemy. Rarely does the fire manager have enough forces to hold back a reserve. But once the line is stabilized he may be able to take a substantial step in that direction by placing his off-duty crews in a position of strategy. If necessary, he can establish rest areas in a safe location immediately adjacent to questionable sections of the line. If the resting crews are never disturbed for an emergency nothing is lost.

When one man works on a fire by himself, he handles (or represents to any necessary extent) all functions and positions in the fire organization. When more than one man is involved, the work load is split according to assignment by the Fire Boss. When the fire is small or the problems relatively simple, functions and jobs can be combined and performed by individuals in lower classifications. Just as it is the responsibility of each higher administrative officer within the Ranger Unit to assume the position of Fire Boss when the need arises, so it is the responsibility of the Fire Boss to expand the organization as problems become more complex. This he will accomplish by assigning more men to perform the individual jobs or by making changes in the caliber of individuals heading up the functions.

In assigning personnel, under any circumstances their qualifications and limitations must be considered in relation to the job. The position of Service Boss might be assigned to one individual when the work load or complexity of the problems were not extreme but another and better qualified individual should be selected when the situation is difficult. That same personnel assignment rule applies in fire management just as in the world of business, except that it is quite possible for the fire situation to expand and subside with tremendous rapidity. For this reason the Fire Boss must bear in mind that as his other troubles increase along the fire line he runs the risk of a breakdown in his management organization if the problem suddenly outgrows a manager of some function.

## ROTATING WORK LOADS

The practice of rotating work loads among different individuals or crews may gain the double advantage of resting the unit that has most need of it while at the same time the strongest

force of the moment is brought against the greatest potential threat or difficult job.

When a number of both day and night crews have been engaged along a fire line for several days it is possible that some of the crews will have had very strenuous periods of labor. With the first lull in operations a resting break should be arranged so that the most exhausted crews may skip an entire work shift. Bodily fatigue is a cumulative thing that begins to demand more recuperative time as a man passes the point of reasonable exertion. It is a sensible investment in time to allow a man to make himself physically and mentally ready for the next call for an emergency output of energy. At the same time it should not be forgotten that during any extended rest period the man (or crew) still constitutes a valuable unit of the fire manager's striking force in reserve.

Regular personnel, and sometimes experienced men from the outside, may be very valuable workers in some of the phases of camp management after they have exhausted themselves on the fire line or suffered some minor injury. By making reasonable reassignments in that direction the Fire Boss is not only taking a humane approach to the difficult business of personnel management, but he probably is adding genuine strength to his entire force by replacing weakness with physical strength where strength is needed.

In the matter of rotating positions among available personnel, the qualification record of regular employees again becomes a valuable guide for the Fire Boss. In his assignments he may be able to arrange for men to obtain good training in positions higher than their statewide or District rating. Of course, in doing so, the Fire Boss must feel confident that the individual can cope with the particular assignment.

## SAFETY

The safety of everyone engaged in firefighting is the personal business of everyone—both for himself and his fellows. Under the best of circumstances firefighting is a hazardous type of work. The fire manager's responsibility in this respect is to use his best judgment in making decisions for action that will not place his men in unreasonable jeopardy. Thereafter, he must presume that line leaders are experienced enough in safety meas-

ures to look to the protection of their men. No leader is properly qualified unless he has received training in fire line safety.

The ability to use or operate tools and machines properly includes the ability to use them with safety to the operator and others about him. It is rather late in the day to commence that instruction after a fire is reported.

This writing does not intend to discuss the vitally important details of accident prevention, except to point out that it is a subject that must not be omitted in any phase of fire control—including organization management. Accidents are not ended with the personal pain or tragedy involved. They are a needless expense in money and loss of manpower.

Of late years the fire manager, and all line officers for that matter, are faced with an added responsibility as the attitude of government and the courts changes. This is in respect to liability for injury to persons working as unsolicited volunteers on the fire line. Many of them are boys attracted to the local excitement. Minors who are not on the pay roll should be told to stay away from fire activity. The same applies to all persons appearing physically unable to do rugged work. All fire officers should realize that when they direct any person to perform some work on the fire line they are very probably placing a legal obligation upon the State to assume liability for a possible injury to that person. Such direction would no doubt be quite justifiable in the case of obviously healthy volunteers. On the other hand, it emphasizes the need for deliberately making a point of keeping the poor risk individuals away from possible accidents. The fire officers have a responsibility in this respect even among unknown persons around the fire.

It would be impossible to write laws or rules to describe the proper action of an official leader for all the cases in which some unauthorized or unfit person becomes too active on a fire line. But certainly the recognized leader during this time of emergency should be expected to exercise reasonably good judgment in the cause of public safety. Very often the untrained person is acting in a state of extreme emotion or ignorance, or both.

## PLANNING MEN AND EQUIPMENT NEEDS

There are many tools of varying types available to the fire manager to assist him with the control of a fire. Some are direct

producers of a cleared line along the fire's edge; others are indirect producers which serve as guides for effective action. Both are of equal importance. Each tool has a use and limitation. The Fire Boss must have the ability to analyze the job to be done, consider the control forces available to him and assign each tool according to its capabilities and location of maximum accomplishment. Following the best made plans and assignments must come a constant adjustment to meet developments on the ground.

The type of action to be taken must first be determined. Whether to construct a hand line or use bulldozers will often be decided by the fire location, slope, terrain, fuel type, time required for line construction and availability of the men or machines.

After the decision is made regarding the type of action and line, the actual requirements to accomplish the job must be considered. Some of the questions that the Fire Boss must ask himself at this time are:

(a) How many men or pieces of equipment will be required to construct the line?

(b) If bulldozers are used, will men also be needed in the construction process? What balance is essential?

(c) Will burning-out crew be needed?

(d) How many men and pieces of equipment will actually be needed to hold and mop-up the line? Will some of the construction forces or burning crews be available for this?

(e) Have reliable arrangements been made to feed and deliver sufficient drinking water to men on the line?

(f) What is the reallocation potential of these men and equipment as work progresses and conditions change? For instance, in the event the fire situation suddenly worsens, can the present personnel assume the added leadership responsibilities that may be demanded of them? Will the equipment meet the test?

(g) How many men and what equipment are going to be needed for standby or back-up purposes?

(h) What are the relative costs of using equipment instead of manpower, and are they justified?

(i) On which areas of the fire perimeter can airtankers and helicopters be effectively used?

## ASSIGNING THE PROPER CONTROL FORCES

Assigning the men and machines is merely to put into action the conclusions reached in the determination of the requirements. However, the Fire Boss should again ask himself certain questions:

(a) Is there any duplication of effort? Are the crews which are assigned to the same area as equipment only there "in case," or is there work for them to do?

(b) Are specialized tools in the right locations?

(c) What is the time limit for completing the job? Are there enough men and machines to accomplish the job within that limit?

(d) Are the abilities of men and machines being considered realistically?

(e) Are the reserve or standby crews in the proper locations?

(f) Is full utilization going to be realized from radio equipment?

(g) Have the men and equipment that are on the scene now been used to the utmost?

(h) Have the most capable men available been assigned to the important jobs?

(i) Are ground forces available in sufficient strength at locations where aircraft will be supporting their fire line actions?

## ADJUSTING THE ORGANIZATION

In order that full utilization be realized of all of the control forces on the fire, *a flexible organization, adaptable to modification and change according to the fire situation must be maintained*. The Fire Boss must utilize every available tool at his disposal to direct the organization toward the most satisfactory control of the fire. As the fire manager, it is his responsibility to check on the various actions that have been initiated and to satisfy himself that they are being properly carried out.

Radio, aircraft, the fire status map, weather forecasts, aerial photos and records are all tools to be used by the Fire Boss to keep abreast of line progress and fire potentialities and to guide him in making adjustments. Some of the modifications he may need to make and his means of making them are:

(a) Committing reserve or standby forces to critical areas. If committed too early, greater need of them might develop in another area; if committed too late, their purpose is lost. Fire Boss may use radio reports from the fire line, aircraft, fire status map, or weather forecasts to make his decision.

(b) Making surplus men and equipment available to other areas. Fire Boss may use radio, aircraft, fire status map to determine the need and availability.

(c) Shifting the work load in order to minimize the fatigue factor and not overwork the best men. Records showing activity history of individuals or crews are used.

(d) Assigning jobs in higher classifications than present ones to individuals under emergency circumstances. Records showing fire classification in home districts are used to select the most qualified men.

(e) Adopting an alternate plan when progress in line construction indicates that the job will not be completed, burned out and cooled sufficiently to be safe within the required time limits. Radio, aircraft, fire status map, weather forecasts and aerial photos together or in combination may be used to complete this move.

## MOBILIZATION AND DEMOBILIZATION

Forest fire control requires a rapid massing of forces unparalleled in any other civilian activity. Only military operations exceed the complexity of the organization required to combat a Campaign fire. Rarely is even military mobilization for battle accomplished within the time limits that are required to cope with a large, fast moving fire.

In many ways, combatting a forest fire can be compared to a military battle. The organization and logistic requirements contain similar basic elements in both cases. For every man and machine actively engaged on the "firing line," support facilities of many kinds must be provided to assure their continued operation.

The mere arrival of forces at the scene of any fire larger than the Initial Attack stage does not mean necessarily that they are ready to begin effective work. It is often required that combinations of two or more work components be made before they can be effectively used. For example, overhead may be needed

to supervise crews; bulldozers may have to open roadways before other equipment may be used. Thus, the mobilization process becomes a sort of assembly line operation because one unit will often be dependent on another. At times, unless a particular component is present at the right time and place, the operation can halt or be seriously impaired.

Well planned and executed dispatching procedures can do much to improve the speed and adequacy of mobilization. It can also aid in eliminating what could otherwise develop into problems during demobilization. For instance, if four overhead supervisors of different fire classifications are sent to fire duty in one vehicle, a serious transportation problem could exist for some of these men in performing their intended jobs. With enough vehicles the men could be split into different shifts or assigned to different functions. During demobilization it will probably be necessary to release all of them at the same time so that they can return to their home base together. Briefly stated, the added cost of transportation may be more than offset if qualified fire overhead are adequately equipped with the means to move quickly and independently to, around and away from the scene of a fire. Therefore, it is usually considered wise to dispatch not more than two men of such qualifications in one vehicle.

From the moment the first piece of equipment responds to a fire it can be assumed that some type of supporting service will be required, and the responsible Dispatcher should keep himself on the alert for requests of such a nature. When a fire supression situation reaches such dimensions that a local base of operations is established, then the fire camp with its servicing facilities for men and equipment becomes a standard installation. The size, arrangement of the camp and quantities of supplies must naturally be consistent with the force that is to be serviced. Any special services will, of course, depend upon the nature of the activity. The important point is that arrangements for *all* services must be made early enough to assure their availability at the time needed.

When very large numbers of men and equipment are involved, serious thought should be given to decentralizing points of assembly to prevent the mass confusion that can result when all forces descend upon one location. This is particularly true with

hired men and equipment since the necessarily regimented procedures of check-in are usually unknown to them.

During the entire mobilizing process the fire managers are constantly haunted by the specter of elapsed time. When orders are placed it is not always possible to know the time factors involved in obtaining many of the components. However, as these time conditions become known, plans should be made to correlate the arrival of the various units which are needed to make effective combinations. Whenever possible, specific times should be indicated in the request. Too often the fire problem grows faster than an organization is mobilized to cope with it. Orders placed only for forces that are actually needed on the fire at that moment will very often result in the organization having "too little too late". Requests should always be made on an estimate of the fire problem to be faced when the requested forces shall have arrived. Should some excess of forces be available over the actual need at that planned time, there is no valid ground for criticism. It is entirely justifiable to have a reasonable reserve on standby in the event of sudden unanticipated difficulties.

Many problems are inherent in the use of hired motorized equipment which are not encountered with the use of equipment owned by the fire control agency. Before being assigned to a fire job, rented units should be inspected by a qualified agency employee to determine if the equipment is mechanically sound and is designed to do the job. Privately owned units are usually not equipped or designed to do fire work as effectively as those owned by the agency. Dozers will often lack canopies or logging winches, and portable lights will nearly always have to be furnished for night operation. Additional specialized agency personnel will be required to perform this inspection job. Additional manpower is also usually required to supervise the work of hired equipment on the fire line.

The use of military or penal institution crews will require special arrangements. Probably neither source of manpower will have their own tools, so these must be provided. Their transportation vehicles have no provisions for carrying tools to and from the fire line. Therefore, additional manpower and vehicles of the fire control agency must be on hand to put these valuable crews effectively on the fire line.

Reversing the procedure of mobilization by disbanding the forces and facilities on a fire is not a simple matter. It might be somewhat less complex if fires were suddenly and completely out when they were controlled so that no forces would still be required on the scene. In all cases it happens that there is a tapering off condition during which portions of the work forces may be released. The size of these portions and the length of the tapering off period will naturally be different on each fire.

Demobilization can and should be a very orderly and studied process. Mobilization, on the other hand, can rarely, if ever, be completely orderly because of the speed required to assemble at a time when a concentrated effort is being made to control the fire. The same basic guide applies to demobilization as to mobilization: sufficient forces and facilities should be on hand to cope with the fire problem. The remaining fire organization must never be jeopardized by lacking either sufficient strength or availability of needed specialized units. This rule applies regardless of the fact that the forces in question may be hired. And, quite naturally, everyone would like to be released as soon as the fire is controlled.

The process of demobilization consists of reuniting segments of original mobilization components and releasing them. This process can be very complex. The case of several men in one vehicle from a far base was mentioned. Other men may have to be assigned to take their places so that they may depart together. In some cases it may be necessary to bring in men who were not previously on the fire. Firetrucks that have had their hose removed to make an extended hose lay, or crew members assigned to a special detail, must likewise be reassembled into original work units.

The myriads of detail can be in many respects greater and more complicated than during mobilization. When the forces were mobilized there were undoubtedly dispatchers and others making the necessary arrangements to move components to the fire. During demobilization the great burden of making arrangements to return them to their points of origin has been transferred to the fire line. In some cases, additional personnel may actually be required to assist with demobilization.

Before release, hired equipment must be reinspected by a competent employee. If damage has occurred as a result of operation on the fire, a documentation of this fact should be made for

later reconciliation. It is also quite necessary that all records for operation and use of hired forces be complete and in agreement before releases are made. Additional men may be needed to handle the volume of this activity.

"Anticipate" and "estimate" are key words for demobilization. The objective is to have supplies dwindle at the same rate that forces are depleted. Very close coordination between Command and the functions of Suppression and Support is most important so that orders for additional supplies will be in line with actual needs. The most critical item will be food—particularly perishables. The use of bag lunches or rations is recommended for the last day that the fire camp is in operation.

Cooperators should be kept informed of plans for the release of their forces. All records, maps and reports must be placed in final and complete form by the people responsible for them before those individuals leave the fire. The basic information is never fresher or more available than at that time. Too often the pressure to disband results in poor and incomplete records when key personnel are released too soon.

## THE FIRE CAMP

The reasons for establishing a fire camp can be summed up as follows. The facilities at fixed based stations are too far distant (in miles or time) to adequately serve the immediate needs of the leaders and men on the fire line. This involves the need for collecting first hand information at the scene of the fire and making it available to the Fire Boss and other leaders. It means the collection of a supply of tools for attacking the fire, and it means providing all personnel on the fire with sufficient food, rest, direction, and physical care when necessary. In effect, home, office and workshop are moved into temporary quarters at the scene of action, while lines of communication are kept open and busy back to the fixed bases.

Three factors will bear upon the decision to establish a fire camp. Each will no doubt hold a different degree of importance for each particular case. All are related to the end result which is described in the paragraph above, namely, getting the service to the place where it is put to use. The factors are (a) the probable duration of the fire, (b) the size of the operation, especially in respect to manpower on the line, (c) the relative difficulty

of getting a service or action transported as needed from its home base to the fire if the camp is not established.

After the decision has been made to establish a camp its composition (facilities gathered there) may be expected to vary in accordance with the same influences. Stated a little more directly it might be said: If the fire control job is big enough or important enough, then the men, supplies and facilities should be brought to a location where they will be close enough to do the necessary job without the added burden of fatigue and delay which could be the result of repeated travel to and from the job. As the duration and size of the fire are changed upward or downward during its life the size and complexity of the camp may likewise continue to vary. Perhaps, instead of referring to the size of the fire it would be more correct to emphasize difficulty of control. A stubborn small fire in difficult fuel and topography could be more demanding than many large fires.

After the main fire camp is in operation it may be necessary to establish secondary camps. This will occur when there is too much difficulty or time involved in transporting or walking crews to the far ends of the fire line. The requirements for an appropriate camp site apply as much to these secondary camps as to the main camp. Of course, the main camp must remain as the single primary information and control headquarters for the entire fire. The secondary camp must be sufficiently equipped and staffed to offer adequate food, water and rest to firefighters. It is also possible that some facilities will be established to service and repair tools and equipment used locally. A reliable communication tie with the main camp must be maintained since secondary camps are essentially "housekeeping" extensions of the primary fire camp.

The importance of selecting a proper site for a fire camp and arranging its facilities in a functional manner cannot be overstated. A poorly located or inefficiently operated camp can seriously affect fire fighting actions. In addition to being the headquarters (in most cases) it is the hub of all activities on the fire.

### *a. Establishing the Fire Camp*

Even a well planned fire camp will present a disjointed appearance to an uninformed observer. This is due to the premeditated segregation of certain working units and the arrangement of others to achieve maximum efficiency.

Naturally a fire camp should be close to the fire it is to serve, but a number of things must be considered. In some cases a location close to the fire must be forgone in favor of another which has more favorable facilities. There should, however, be easy accessibility to the most serious problem areas of the fire. In addition, a good road to sources of supply should be available. One-way roads which can cause delay for vehicles coming or going should be avoided.

The camp site must have sufficient room to allow smooth functioning of each work unit without causing interference with another. There should also be sufficient room to expand all operations in the event the fire grows in size and scope.

If one single item were to be selected as being most important it would have to be the element of shade. Daytime sleeping for night shift crews is difficult under the best conditions when insects, high temperatures, and noise must be tolerated. Lack of shade in addition to these annoyances would create an unbearable condition. Thus an area suitable for sleeping in the daytime becomes a mandatory requirement. It is desirable, of course, to have as much of the balance of the camp as possible in the shade during the hottest part of the day. In any event, priority should be given to the kitchen and camp management areas. Canvas flies may need to be erected in the absence of natural shade.

Another mandatory element is an adequate supply of water for drinking, cooking and washing purposes. Local or natural water sources with the proper quality and quantity are rarely found near most fire camp sites in California. Arrangements must usually be made to transport water to the camp.

Terrain which is relatively flat is more desirable than sloping ground or broken topography. This element can usually be considered in lower priority, however, if other elements are favorable.

As noted in the subchapter headed Communication, dependable radio communication between fire line personnel and the camp must be possible. In the absence of forestry or commercial telephone service, radio communication between the camp and Unit Dispatcher must also be possible. On all large fires, it is always desirable to have telephone service to handle the load of less urgent messages.

Another desirable item for fire camps is commercial power. Power requirements exist at all times of the day and night for the operation of radios, refrigerated vans, lights, power tools, etc. From one to several noisy generator plants are usually required, in the absence of commercial power.

Needless to say, any proposed camp site location should be safe from the potential encroachment of the fire. Unfortunately, a few instances have occurred where all elements of a good fire camp were favorable except this one. The embarrassment of abandoning camp to the advancing fire can only be compared to the burning of the fire house itself.

### *b. The Camp Layout*

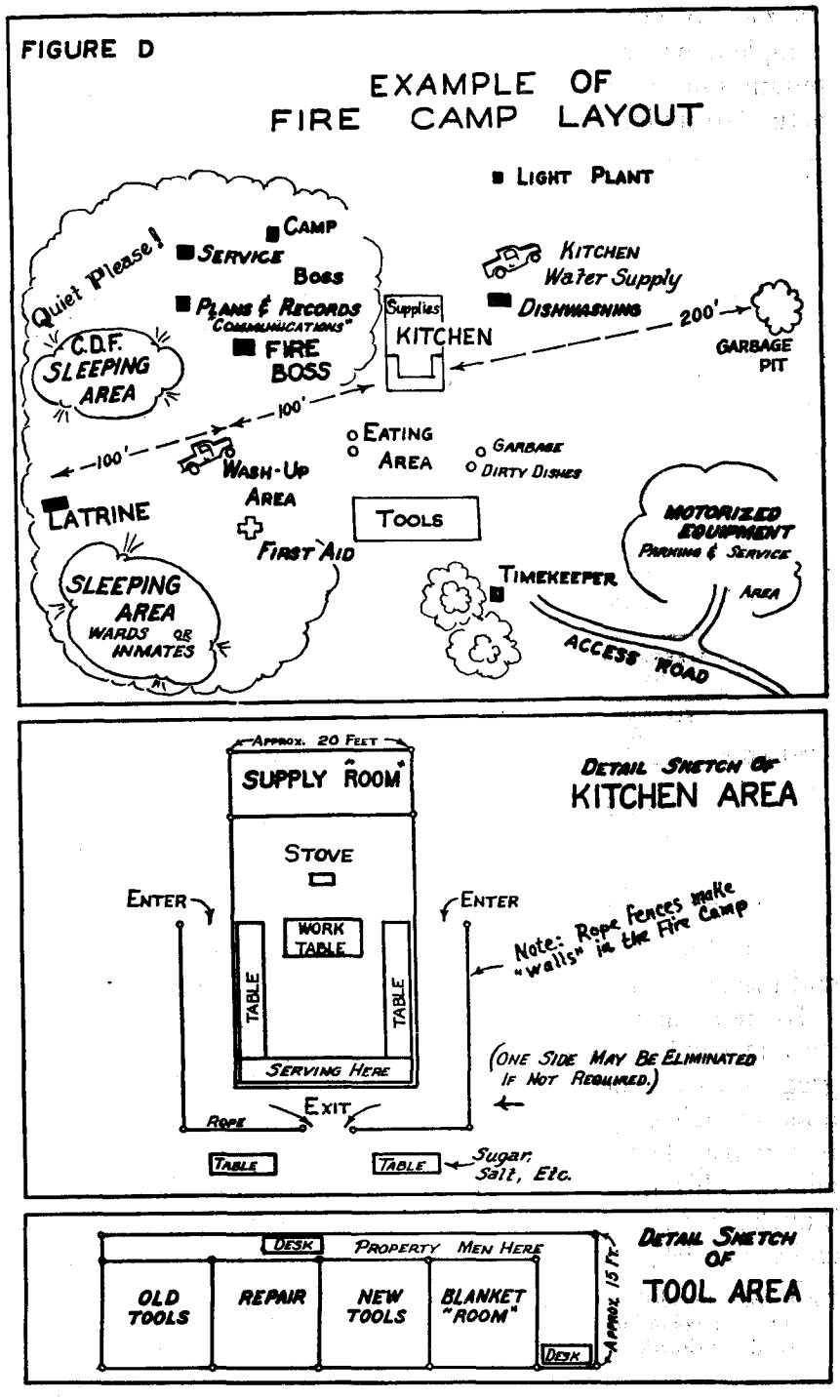
At some future time a completely mobile and self-contained fire camp may cause the words printed here to become obsolete. Until that time it must be assumed that the necessary materials for a fire camp will be brought to some selected field location and erected for temporary use. That being the case, the particular fire situations, the precise locations selected, and the prevailing topography will have a great bearing upon the quality of the camp and its general operational efficiency. Because the local controlling factors are variable, there is no single ideal fire camp layout presented here.

The camp layout must be flexible enough to allow for adjustments due to two major circumstances. These are (a) a *varying need* for the several camp facilities throughout the life of the fire, and (b) an internal arrangement to best fit the *topography* available for the camp site.

Once the constitution of a camp is determined by need the most variable of all conditions will still confront the Fire Boss who has the problem of putting the camp into operation. That is topography. Topography in this case is inclusive enough to embrace the shape of the land surface, availability of water and adequate drainage, vegetation and other surface features such as rocks, roads and other man-made features, access to the fire and safety for the camp.

With so many conditions which may affect the camp layout it is obviously futile to describe any single ideal. For this reason a sketch of typical arrangements is presented here rather more for purposes of study than as a classic example of perfection (see Figure D). Possibly of more importance is an appreciation of

FIGURE D


EXAMPLE OF
FIRE CAMP LAYOUT
LIGHT PLANT
CAMP
SERVICE
BOSS
PLANS & RECORDS
"COMMUNICATIONS"
FIRE
BOSS
QUIET PLEASE!
C.D.F.
SLEEPING
AREA
SUPPLIES
KITCHEN
KITCHEN
WATER SUPPLY
DISHWASHING
200'
GARBAGE
PIT
100'
100'
EATING
AREA
GARBAGE
DIRTY DISHES
WASH-UP
AREA
LATRINE
TOOLS
FIRST AID
SLEEPING
AREA
WARDS OR
INMATES
MOTORIZED
EQUIPMENT
PARKING & SERVICE
AREA
TIMEKEEPER
ACCESS ROAD
APPROX. 20 FEET
SUPPLY ROOM
DETAIL SKETCH OF
KITCHEN AREA
STOVE
ENTER
ENTER
WORK
TABLE
TABLE
TABLE
SERVING HERE
NOTE: ROPE FENCES MAKE
"WALLS" IN THE FIRE CAMP
(ONE SIDE MAY BE ELIMINATED
IF NOT REQUIRED.)
EXIT
ROPE
TABLE
TABLE
SUGAR,
SALT, ETC.
DESK
PROPERTY MEN HERE
OLD
TOOLS
REPAIR
NEW
TOOLS
BLANKET
"ROOM"
DESK
APPROX. 15 FT.
DETAIL SKETCH
OF
TOOL AREA

the *units* of area or service which go into the composition of a complete fire camp. This is shown on the "building block" pyramid in this section labeled Figure E and also in the meshed natural grouping of services of Figure F.*

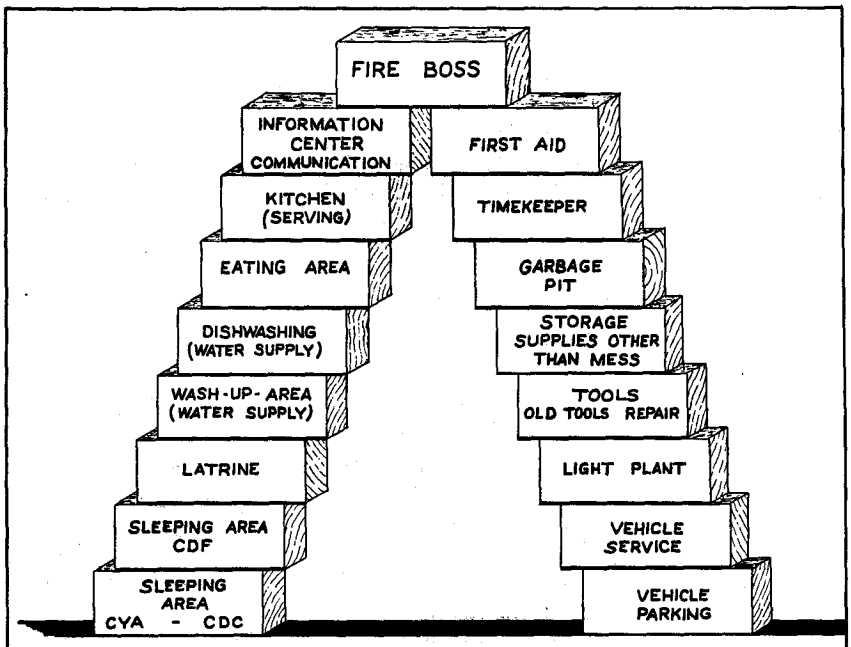



FIG. E

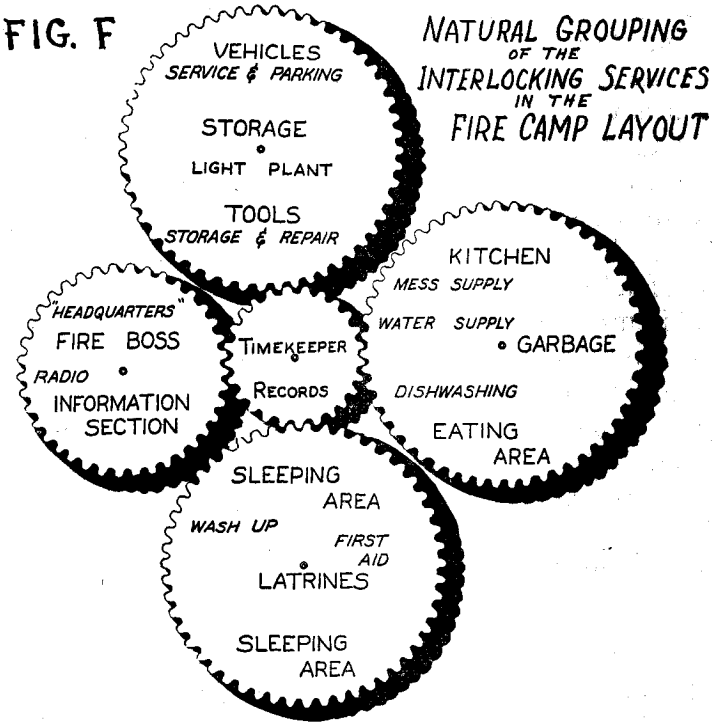
"BUILDING BLOCKS" OF THE FIRE CAMP STRUCTURE

There follows a few comments pertinent to good supervision and management in respect to several of the unit areas.

**Information Center** should be located away from any disturbing camp activity and especially away from natural congregation areas such as mess and sleeping. This area is dependent upon electric power in a well-constituted fire camp and therefore it may have to be located where such service can be obtained. This need of electricity means that the kitchen and Timekeeper may have to be closer to the Information Center and each other than is desirable. On large fires it is recommended

* It is recommended to classes in fire control training that fire camp layouts under different conditions be studied by arranging these "unit blocks" under simulated fire situations out in the field.

FIG. F




that telephone service be arranged between the Information Center and both the Fire Boss and Timekeeper.

**Sleeping Areas** should be located away from noise and other disturbance to the greatest extent possible. Dust and heat nuisance should be kept to a minimum. Power plant, radio noises, vehicle and personnel movements are disturbing elements. Generally the sleeping areas and the vehicle entrance (or parking area) should be the most widely separated parts of the camp. Shade for daytime sleeping is quite essential. In some camps it may be necessary to segregate crews. This will be true with men or youths under custodial supervision. Military leaders generally prefer separate areas for their units.

**Wash Area** should be convenient to the kitchen but not where muddy ground (from wash water) will be tracked into the kitchen and eating areas. This area should be trenched and drained away from kitchen or other working areas. In nearly all cases the wash area will be serviced by a tank truck. This means that a roadway may be necessary.

**Eating area** should be close to the kitchen but away from mess lines and wash area. Shade is desirable.

**Kitchen.** This is the area of greatest activity. No other unit should interfere with free access within and around the kitchen area. Shade is very important here and should be provided by canvas flies when trees are not sufficient. Food supplies must be brought to this area and stored. This means that a roadway is necessary. Garbage cans and cans for dirty dishes should be convenient to the dishwashers and each plainly marked. These cans should also be convenient to the eating area so that crews can dispose of leftovers and their dishes.

Food items which restrict the rapid flow of a mess line should be placed on separate tables (not to be used for eating). These tables should provide water, salt and condiments. In large crews it may be well to place coffee pots and cups away from the main mess lines.

The interior arrangement of the kitchen tables and work areas may be placed at the convenience of the cook. Supplies should be stored immediately to the rear of the actual kitchen work area.

### *c. Operating the Camp*

To facilitate the smooth functioning of the fire organization and to prevent confusion or general lack of coordination, certain routines at the base of operations must be followed and observed by *everyone*. There must be fire camp discipline. Some overhead and administrative personnel may feel themselves "above the rules" and tend to ignore the established procedures, thus contributing to disorganization in both management and record keeping. Failure to observe the few simple procedures merely indicates that the responsible individuals lack understanding of good management principles. Following are some of the more important routines to be observed:

The simplest of routines—*checking in and out* with the Timekeeper—is the one most often overlooked. Only through complete compliance with this rule can any degree of accuracy be realized in keeping time and records. In the past, cases have been noted where overhead and crews have been active for days on a fire without there being any record of their arrival. Any system of record keeping will break down without the cooperation of all concerned in this first requirement. Nearly all fire camps will have job units or areas plainly marked by identification

signs. The Timekeeper will probably be the most prominently identified.

To cut down the time and workload connected with this process, the following policy shall apply:

1. Overhead shall individually check in and out.

2. Crew leaders *only* shall check in and out for themselves and crew members. The crew leaders of pickup (hired) labor shall keep a list of the names and time slip numbers of their crew members to give to the Timekeeper.

3. Individuals responsible for operating specialized equipment (bulldozers, pumpers, etc.) shall check in and out for themselves and equipment.

Each crew leader should be assured that the Camp Boss knows where he and his crew is sleeping. Probably the situation will be reversed and the Camp Boss will designate the sleeping area. At any rate, the Camp people should know where to find anyone during rest periods. This applies especially to the leaders. It may be necessary to arouse them when others should not be disturbed. At night it would be sensible to have some identifiable marker near them. The Camp Boss or his assistant on duty will undoubtedly have responsibility for awakening crews in time to be ready for shift duty. On large fires the general planning for such routine occurs in the presence of the Plans Boss during strategy conferences or briefing sessions. The Plans Boss must then be assured that line and service managers are aware of their specific responsibilities.

The Fire Boss and all responsible camp personnel should be informed of any special supervision or custodial requirements that may apply to crews from military agencies or from prisons, honor camps or the Youth Authority. Responsible supervisors will generally be present to look after their own crews. But confusion can easily occur during the rapid build-up of crew personnel.*

* The necessity of a special relationship between the average citizen and those individuals living under a different status must be recognized by all agency personnel and it should be pointed out to others as quietly and firmly as is necessary to have them understand. Sometimes very innocent gestures can have serious consequences. For example, a grateful landowner would never guess that he is committing a felony when he hands a bottle of beer to a sweating firefighter who just happens to be a state convict dressed and acting like everyone else around the fire.

Establishing some semblance of routine in the serving of meals will do much to eliminate confusion and improve general morale in the developing fire camp. In addition to his other duties, the Timekeeper can be of great assistance by keeping the Plans Boss advised of new arrivals and by informing them of when they will be fed. The well managed fire camp will be serving five scheduled meals daily, although a casual visitor could well believe the process was continuous.

Line crews should have priority in any plans for feeding. In shift arrangements most generally in use, this will call for a breakfast at 4:30 a.m. for out-going crews and again at 8 or 9 for the in-coming night shift. There will be a noon lunch for camp people, resting crews, and the inevitable stragglers. From 4:30 p.m. until around six o'clock the night crews will be fed. The last full meal of the day will be for the day crews coming off shift. This will be served between 7 and 9 o'clock in the evening.

Crews having the longest travel time to their work area should be fed first. And it is obviously necessary that bag lunches be prepared and ready by the time crews move out. In respect to lunches, however, it is much better to serve hot lunches on the line whenever this can be accomplished.

Out-going overhead personnel should be fed before their crews in order to have them available for the latest briefing while the crewmen are eating. It is not good management from a psychological as well as work production standpoint to have crews waiting around when the men know they should be getting into the action.

It should be possible to obtain a hot meal around the clock or receive a few ready bag lunches. There are certain to be late arrivals or special departures who deserve this accommodation.

Because of the quantity of food subject to spoilage, it is profitable as well as an improvement in general kitchen efficiency to have a refrigerator van in the fire camp. When large numbers of people are to be fed throughout several days the rental of such equipment should be seriously considered. In any case, the Service Boss and his staff should make a determined effort to reduce the quantity of perishable food and have it consumed as the population diminishes.

Open latrines must not be allowed to become a nuisance. Some individual assistant to the Camp Boss should be assigned the duty of seeing to this so that the chore will not be neglected. If the camp is located near a considerable population or within recreation lands of high use value, it may be entirely practical to hire a number of chemical toilets.

Dust can become a nuisance by the time any land surface is tramped over by many feet and rolled by heavy equipment. Utilizing a firetruck to wet down the area once or twice a day will greatly improve the situation.

It is quite important that the noise level around the camp during the day be kept at the lowest reasonable level. There will naturally be more activity in such jobs as vehicle repair and freighting to create noise. This nuisance should not be added to the common difficulty of sleeping in the middle of a summer's day for men who are expected to labor strenuously throughout the coming night.

Safety on the fire line is an important program not precisely within the province of this writing. Firefighting can be a hazardous occupation and at least a minimum of safety precautions were touched upon in the discussion of tools. This acknowledged need for thinking of human safety on the line may tend to cause safety measures in the camp to be overlooked. This is a very serious matter.

Mention was made of considering the chance of the camp site becoming a victim of the spreading fire. Thought and remedial action should be applied to the hazards of fires originating internally. For example, dry grass and other flash fuels should not be permitted to jeopardize sleeping men or the entire camp. Liquid petroleum gas and gasoline should be handled with utmost respect and in accordance with safety regulations.

Sometimes a lack of equipment to properly handle dangerous materials causes men to improvise in an obviously unsafe manner. Perhaps the greatest hazards around a camp occur during the refueling of automotive equipment directly from barrels of gasoline. Electric power brought into camp deserves as much respect there as it does in a town. Wiring and outlets should be examined by a competent person at the time of installation.

Sharp edged tools should be delivered to the tool tender when they are brought into the camp. Under any circumstances, tools

without a specific purpose for their placement, should not be scattered around the camp area.

Sharp tools are a hazard in the sleeping area, as are pieces of automotive equipment. There should be a positive prohibition against men sleeping around parked equipment unless they are safely inside the vehicle.

The camp area should be periodically cleaned up to dispose of bits of garbage and litter. Some camp personnel should have a definite responsibility in this respect. When the camp is deactivated a thorough cleanup should take place. The property should be restored as nearly as is reasonable to its state when first occupied. This does not mean necessarily that a considerable investment is to be made in the restoration of bridges, fences, and so forth. Such repair may require a preliminary legal judgment as to responsibility. It does include the closing of gates, removal of signs, minor repair of fences which were damaged by the fire control project and not the fire. The agency is in truth a servant of the people at large and its employees must respect that public trust.

# CHAPTER THIRTEEN

## What of the Future?

BACK WHEN the practice of scientific forestry was no more than a hopeful dream in California and most wildland fire protection was handled by a few volunteers, a small story was born. It was declared to have been blurted out by some old timer being examined for a ranger position. The examiner asked, "and what will you do when the fire starts crowning through the trees before a heavy wind."

The old timer knew about fires and he obviously knew the value of a straightforward answer. He replied, "Mister, I'd run like hell and pray for rain."

Those people closely associated with research or administration in forest fire protection at the present day have no less respect for the unbridled power of running fire during highly critical periods. They may not be so inclined to run straightaway as to put up a dogged fight along the flanks or rear. They can do so in numbers and with tools and equipment beyond the wildest conception of the old timer. And they do sometimes perform near miracles in fire suppression during times of imminent catastrophe. Yet, with all of his creative intellect and desperate energy, there come days and places when fire remains Man's master. This writing will make no prediction of a time when this will not be true.

Every experienced administrative official in the field of wildland fire management knows that the preservation of natural resources is a great public cause which can bestir many citizens to favor him with gratuitous advice in fair weather and condemn him for his inefficiency when the smoke pall is heavy.

Rarely will a helpful citizen contribute an idea which can stand the test of the physical or economic hurdles which must be surmounted. Yet the administrator is warned that he must be alert to every possible scientific advance that holds some pos-

sibility for improving the efficiency of his meeting a difficult task.

Almost all of the tools and techniques used in the art of fire management have had their origin in the recognition of a need by some clear-headed professional in the business, and then an investigation of available materials and methods of utilization which will together fulfill the need. In the future there will be no relaxation in the inventive genius of the field man. Field testing of fabricated equipment or proposed methods will still go on. However, it does seem practically inevitable that most future tools and techniques will have their origin in the laboratory.

The scientific progress of recent years has opened a world of physical complexities which require very special thought processes and testing to determine how promising new things and conceptions can be applied profitably to wildfire control. Yet, of course, it can be presumed that not all the advances of the future will be in the realm of science fiction; the fantastic flying "man-hole covers" (which have actually been tested by this agency), or fire suppression bombs shot from a cannon (which have been seriously recommended).

The accumulation of small conveniences should not be overlooked in the total impact they have made in recent years. Warm meals of substantial food, a place and a time to lie down in reasonable comfort to rest, a serious consideration for human safety, protective type clothing and the application of first aid treatment. Such small advances gain both human efficiency and human comfort. They will no doubt keep pace with the development of some weird devices which would surely have been classed among supernatural things a few decades in the past.

There is little doubt but that some variety of helicopter will take its place as probably the most valuable motorized equipment on the fire line. Elapsed time and topography are basic factors in wildland fire control which can be dominated by this type of air vehicle.

Television has been tested for its practical use in scanning the landscape for smoke columns. With sufficient attention to improving its efficiency, and with an indication that its cost can be justified, this technique of ground or air fire detection

may come into use. Detection of heat by infra-red scanning will unquestionably find a prominent place in ground stations and in mobile aircraft. It is one of the amazing new devices in a world that has seen men ride skyrockets into the near nothingness of space.

During the conflagration type fire there is certainly the most need and often the most difficulty in determining just where the fire is burning. Active fire may be hidden in dense smoke or vegetation along what could be termed the recognizable perimeter, or in spot fires ahead of the main fire, or in so-called islands within the main fire where separate local problems could become serious, especially if the area contains numerous structures. Infra-red scanning is a tool of the future holding great promise.

Considerable investment of money and mind is being devoted to what might be termed the abstract approaches to fire prevention and control. For example, investigation is being conducted into the vagaries of human behavior which causes fires to be ignited, and into general citizen attitudes toward fire in the wildland. These psychological studies could very well have an impact upon the methods adopted to suppress fires as well as to prevent them. It would seem that those difficult investigations of the cost of fire control and the various savings estimated to be accomplished through fire protection will sooner or later be of vital importance in establishing an ultimate acceptable expenditure limit.

Not far removed from the very practical studies and testing of retardant chemicals for applying to flammable material at the edge of the going fire is the idea of modifying cellulose in fuels at an earlier stage. Some vegetable matter is not so flammable as others. This is a well known fact of nature. The questions considered by a few serious scientists are these. How can certain native plant species be made to grow and produce less flammable bodies? What plant species of lower flammability but equally desirable in other characteristics can be induced to grow in the place of some native plants of high flammability? A satisfactory answer to such questions could mean a great deal in the establishment of useful fuel-break systems in California.

Automatic Data Processing (ADP) at the present time is regarded too much as a miracle tool instead of what it really is, a rapid mechanical calculator which can work with combinations of figures stored on tapes whenever someone pushes the right button. Nevertheless, the speed, accuracy, and volumes of material which can be handled by these machines does indeed permit mere human beings to engage in highly complex activities, such as space flights, which undoubtedly would prove so cumbersome as to be impractical without such electronic calculators.

With enough data, based primarily upon experience, stored in computers, and with the aid of remote sensing equipment (weather recording instruments, television, infra-red detectors, etc.) it is entirely possible and practical to use ADP in Dispatch-Command Centers to plan and execute the control of wildfires. At the time of this writing this agency is making the first small step in that direction by installing its first prototype of a very localized fire weather recording station.

Planning of ideal, imaginative and even obviously impractical methods of meeting such challenging problems as wildfire control is not wasted effort. History is replete with examples of such originally ludicrous inventions as steamboats and telephones. The well equipped ADP Fire Command Center has therefore been given some preliminary but entirely serious thought. Perhaps time will see the master planning and sequence of commands for the management of large fires furnished by processing devices located at any number of centers, including the fire camp.

Knowledge is the great power assisting the fire manager, now or in the future. Of the three great influences bearing upon fire: fuel, topography and weather, the one least within the comprehension of the fire manager is weather. In that field we should anticipate the greatest advance on behalf of the firefighter of the future.

It is true that a few learned scientists are scrutinizing the secrets and unexplored bypaths of microclimatology and the capricious fire blow-ups. Following more certain knowledge should come practical tools of measurement and prediction in the hands of the fighter of forest fires.

Cloud seeding to produce rainfall and dissipate lightning storms was once an actual working project of this agency. However, modern society is very complex and one who tampers with the laws of nature may soon find himself heavily involved with the laws of the commonwealth. Numerous private and public agencies have an interest in cloud seeding at the present time, including researchers. It is yet possible that such a promising tool may be made available to the fire manager.

Along the same line, the idea has been advanced that someday the tremendous electrical power of lightning storms may be captured and stored, thus eliminating a fire causal agent as a byproduct highly profitable to the fire control specialist.

Among the less spectacular tools for fire control in the future we can expect to see creations and adaptations in power driven equipment which will improve pumper trucks and enhance the removal of fuel. Possibly new chemicals and chemical treatments will offer advantages to the firefighter at several steps of his problem, from food preparation to fire suppression.

But with all the promise held forth by the scientific advantages of the latter half of the twentieth century it is difficult to believe that the single most important element in the principles of forest fire management will be greatly altered. That element is the indomitable human courage to persevere and succeed in the timeless struggle against the destructive forces of Nature.

Men, in the final analysis, with their ability to apply experience and knowledge to fire problems will determine the effectiveness of what we presently must refer to as "miracle tools" of the future.

# APPENDIX

## *Job Descriptions for Major and Campaign Fire Organizations*

It has been repeatedly stated in this writing that particular positions within the fire management organization should be filled only when there is an actual need. On the other hand, it is of utmost importance that the Fire Boss should promptly recognize the need to designate a sufficient number of supervisory and technical assistants to properly accomplish the fire control project. In fact, he should anticipate such needs as far in advance as possible.

Of equal importance is the necessity of having each appointee understand the scope of his particular responsibility. The following job descriptions and duty analyses represent the general duties and some specific typical tasks for practically all of the leaders or specialists who may be assigned to fill the individual positions on the fire management team.

### COMMAND FUNCTION

### *Fire Boss*

The Fire Boss is responsible for developing an organization and then giving it direction in the task of controlling a forest fire. He is the executive officer in charge of all operations. Every fire upon which organized suppression action is taken has one, and only one, Fire Boss.

As the fire grows, he must never allow himself to become so involved in any specific task that his primary responsibility for overall supervision is neglected. As the fire grows he will delegate authority and responsibility to other men. This build-up of a working organization beneath him will be geared to the needs of the fire job, the availability of men and equipment, and to all factors which influence the behavior of the fire.

In a fully developed organization to control a fire the Fire Boss is the administrator who is responsible for formulating strategy. He coordinates the three general functions of the organization which are Command, Support and Suppression.

The operational phases of the job of Fire Boss embrace three separate, yet inter-related, steps. They might be called problem analysis, planning, execution.

Only when the Fire Boss knows the full extent of the problem confronting him can he take proper action. It is true that very often, in fact most often, there should be no hesitation in striking a fire immedi-

## *Fire Boss (Continued)*

ately because of the importance of the time element. But the fact remains that the general strategy for control of a forest fire can be basically strong only when there has been gathered an accurate evaluation of current circumstances and an estimate of future developments. The Fire Boss must have an "inventory" of facts and sound predictions in order to make his problem analysis.

Once the problem has been analyzed the Fire Boss is in a position to plan his strategy for current and future action. He can begin to request the type and quantity of men and supplies needed, with the time of delivery stipulated.

In executing the plan of action the Fire Boss will be careful to maintain as much flexibility as possible in its actual operation. He will be prepared to shift forces, make sacrifices and adopt alternate plans as circumstances on the ground demand.

### SPECIFIC TASKS

1. Assumes full responsibility for organizing and directing all activities to completely control the fire in the most satisfactory manner.
2. Analyzes the fire problem.
   a. Determines the scope of the fire problem by considering:
      (1) History of the behavior of the fire to date and progress toward control;
      (2) Burning conditions, specifically involving fuel, topography and weather;
      (3) Resources available to control the fire, including the source, number and condition of men; the number and type of tools and equipment;
      (4) All other factors affecting the fire which bear upon the ease or difficulty of control, including the values at stake and the importance of time in effecting control.
3. Plans strategy based on current fire development and anticipated behavior.
   a. Determines type and quantity of manpower and equipment needed.
   b. Determines priority of attack and areas of major operations.
   c. Establishes plans for each shift to the extent that operations can be properly executed when the time arrives.
   d. Considers realistically the work that can be accomplished within the allowed time limits with the men and machines at his disposal. Sets time schedules which will allow for the contemplated work to be accomplished, with due consideration for sharing the task among the crews and operating units on the job.
   e. Calls strategy meetings of such personnel as he wishes to assist him with the planning. (Generally this advisory group will include the Assistant Fire Bosses, Plans Boss, Service Boss, Line or

***Fire Boss (Continued)***

Zone Boss and possibly other line officers, counselors from higher administrative levels who may be at the scene of the fire).

f. Develops alternate plans to be used if necessary. Such plans will include prearranged instructions to each operating unit for their advice in the event the plan is adopted.

4. Anticipates needs in respect to men, equipment and supplies.
   a. Places orders and requests so that men, equipment and supplies will arrive at the time they are anticipated and needed, with proper allowance made for travel schedule.
   b. Requests specialized equipment deemed necessary, such as aircraft, nurse tankers, bulldozers.
   c. Plans for reserve strength of men and facilities in addition to the absolute requirements of the fire.
5. Assigns overhead, crews and equipment.
   a. Determines fire line assignments of local personnel in accordance with their known abilities. Men from outside units or agencies are assigned in accordance with best determination of their abilities, making most use of Fire Classification Cards.
   b. Deploys available forces to best advantage in initial assignments and redeploys them if it is considered expedient after conference with Line Boss and Assistant Fire Boss.
   c. Considers the fatigue influence upon work accomplishment and provides for rotation of crews at points of heavy work load.
   d. Provides for relief of line forces on 12-hour basis.
6. Briefs personnel on duties and responsibilities.
   a. Sees that fire line overhead are briefed before they begin work.
   b. Provides for maps and instructions which outline the objectives and general strategy for each major operating area. (Plans Boss gathers material and information).
7. Assigns Bosses to direct Suppression effort.
   a. Appoints a Line Boss for each 12-hour shift to direct and coordinate the efforts of ground based forces in carrying out the plan of action.
   b. Appoints an Air Attack Boss to coordinate and set priorities for aircraft use in accordance with requirements of the ground forces.
   c. Appoints Zone Bosses to provide adequate fire line supervisor on Campaign fires.
8. Develops the Support Function.
   a. Appoints a Service Boss when the work load in that function is heavy enough to require a supervisor. Determines need and appoints assistants as required in the following positions:
      (1) Property;
      (2) Transportation and Communication;

## *Fire Boss (Continued)*

(3) Camp Boss;
(4) Supply.

b. Approves or disapproves requests for additional assistance channeled through Service Boss and Assistant Fire Boss.
c. Makes decisions upon all Fire Camp problems of importance.
d. Appoints a Plans Boss when the Plans function needs an independent supervisor because of the work load. Appoints assistants when they are considered necessary in the following positions:
(1) Timekeeper;
(2) Message Center Operator;
(3) Reconnaissance and Maps;
(4) Weather;
e. Approves or disapproves requests for other assistants channeled through Plans Boss and Assistant Fire Boss.

9. Establishes a GHQ (General Headquarters) on Campaign Fires and as may be necessary on Major Fires.
a. Arranges for GHQ to be established away from existing fire camps.
b. Sees that all personnel are located in close proximity to each other.
c. Sees that desks, work space, telephone and radio communications are provided for each agency representative.
d. Arranges for 12 hour shifts for staff personnel.

10. Makes himself available and his itinerary known at all times during the entire fire.
a. Makes the main Fire Camp or GHQ his base of operations during the entire fire.
b. Maintains communications with the Fire Camp when fire activities require his presence elsewhere.

11. Arranges for the Dispatcher of the Ranger Unit to be kept informed at regular intervals upon the development of the fire.
a. Assures himself that the Plans sub-function is making prescribed reports and using prescribed forms, especially 8 a.m. Dispatcher's Memorandum.

12. Supervises the entire organization in the execution of the broad fire control plan.
a. Constantly analyzes progress being made in relation to time schedules established for work on the line. Constantly analyzes fire behavior and weather reports.
b. Recognizes failure of men or crews to perform adequately on the job and takes action to correct deficiencies.
c. Places alternate plans into operation promptly when it is evident that current plans are not appropriate.

### *Fire Boss (Continued)*

d. Makes contacts through proper supervisor and does not bypass channels of authority except when emergency circumstances require it.
e. Does not build the fire control organization beyond a reasonable size or complexity consistent with the fire problem.
f. Reduces forces as conditions permit, releasing hired men and equipment as early as possible. Of the regular organization personnel those from other units are never held for mop-up except under unusual circumstances and as agreed upon by the higher level dispatcher responsible for their original assignment.

13. Makes (or arranges for the compilation of) all necessary reports on the fire.
    a. Preserves all records incident to the fire for future reference or review.
    b. Completes the Individual Fire Report and all others without delay at the termination of the operation, without hesitating until all secondary data, such as damage figures or ownership records, are gathered.
    c. Reports examples of outstanding or poor performance to the responsible supervisor.

### *Information Officer*

Under the authority of the Fire Boss, the Information Officer is responsible for preparing and disseminating information about the fire to the public through various news media. He may also be responsible for preparing similar information for fire line forces. More than one individual will sometimes be required to perform the responsibilities of this position—especially in the case of a large fire threatening structures, communities or important resources. The degree of public interest or concern with any particular fire should be considered in determining the number of individuals needed to perform the duties of this position. The Information Officer is the liaison link between fire management and the public.

SPECIFIC TASKS

1. Keeps constantly informed regarding fire developments and control progress.
    a. Consults frequently with Fire Boss, Assistant Fire Boss and Plans Boss so that up-to-date information is always available.
    b. Visits fire area or takes reconnaissance flight over fire at all practical times.
2. Anticipates public information needs and prepares to meet them.
    a. Consolidates latest fire information for ready reference.
    b. Prepares "fact sheet" containing pertinent information in condensed form for handout to reporters.

### *Information Officer (Continued)*

c. Sees that adequate telephone service is established and available to news media.

3. Arranges for interviews and pictures.
   a. Schedules interviews with fire management personnel for reporters and cameramen at times when least interference with fire actions will be caused.
   b. Arranges for clearance of news media representatives to fire areas at times when it is practical and favorable to do so. Arranges for requested flights over fire area to first be cleared with Air Attack Boss and Airco.
4. Photographs and documents fire actions.
   a. Takes pictures of fire activities throughout the life of the fire.
   b. Obtains pictures whenever possible from news media and records the source of useable photos.
   c. Collects news releases about fire for official file.
5. Acts for the Fire Boss in public relations matters.
   a. Consults with Fire Boss on all public relations aspects of the fire.
   b. Keeps the Fire Boss informed of any potential adverse reactions from the general public.
   c. Whenever other agency employees have responsibility for disseminating information concerning the fire, keeps such individuals currently informed.
   d. Briefs visiting officials regarding status of the fire and arranges tour of fire areas if necessary.
6. Provides current fire news to personnel assigned to the fire.
   a. Establishes and services fire information bulletin board.
   b. Prepares and disseminates fire news to all personnel through processed handouts.

### *Assistant Fire Boss (Suppression)*

On a Major fire, only one Assistant Fire Boss is needed to aid the Fire Boss in the supervision of the combined duties of Suppression and Support. A Campaign fire organization, due to the complexity of operations, will require two position assignments—Assistant Fire Boss (Suppression) and Assistant Fire Boss (Support). The combined job analysis of both positions will encompass the responsibilities for the Assistant Fire Boss in a Major fire organization.

The Assistant Fire Boss (Suppression) is in a Command position. He forms the link between the Command and Suppression functions. He assists the Fire Boss with strategy planning and is responsible for tactical action on the fire line based on these plans.

## *Assistant Fire Boss (Suppression) (Continued)*

SPECIFIC TASKS

1. Familiarizes himself with the fire problem and the plan for control.
   a. Consults with the Fire Boss concerning the basic strategy and its application in accordance with current and predicted fire behavior.
   b. Makes aerial reconnaissance if possible, to gain an overall perspective of the fire situation.
2. Coordinates all suppression activities with the Line and Air Attack Bosses.
   a. Establishes priorities of aircraft use with coordination to the fire attack plan.
   b. Determines that ground and air suppression forces are operating within the prescribed time limits and basic strategy.
3. Evaluates the fire problem continuously.
   a. Obtains information on fire behavior from the Line Boss or from aerial reconnaissance and scouting activities.
   b. Makes personal observation flights or visits critical problem areas on the fire as necessary.
   c. Keeps up to date on current and predicted fire behavior.
   d. Considers progress being made by control forces in relation to the time factor, current and anticipated fire behavior and the total work to be accomplished.
   e. Considers current fire developments to determine if a change in strategy is required.
   f. Estimates the air and ground force requirement.
   g. Keeps the Fire Boss consistently advised of the fire conditions or the need for additional forces.
4. Adjusts the plan of action for air and ground forces to meet worsening fire conditions.
   a. Consults with Fire Boss when possible concerning strategy changes, but uses best judgment in the absence of such contact or when time will not permit delay.
   b. Redeploys air and ground forces for most effective action.
   c. Commits reserve forces if available and needed.
   d. Requests additional manpower, equipment or aircraft to cope with unforeseen circumstances.
5. Consults with Assistant Fire Boss (Support) to coordinate the actions of the Support function in servicing the Suppression forces.
   a. Arranges for a priority schedule for servicing motorized equipment on the line.
   b. Advises of the anticipated need of additional men and equipment.
6. Assumes other Command responsibilities.
   a. Serves on strategy boards.
   b. Assumes full authority of the Fire Boss in the absence of that individual when so assigned.

## *Assistant Fire Boss (Support)*

On a Major fire only one Assistant Fire Boss is needed to supervise the combined duties of Suppression and Support. Campaign fire organization, due to the complexity of operations will require two position assignments—Assistant Fire Boss (Suppression) and Assistant Fire Boss (Support).

The Assistant Fire Boss (Support) is in a Command position. He is the link between the Command and Support functions. He assists the Fire Boss with strategy planning. He is responsible for the logistics based on these plans.

### SPECIFIC TASKS

1. Determines that Support facilities are adequate to provide the required services.
   a. Consults with the Fire Boss to become familiar with the plan of action and the numbers and types of equipment and manpower for for which service must be planned.
   b. Consults with Plans, Service and Liaison Bosses to determine that staffing and servicing facilities are adequate.
   c. Determines the adequacy of facilities in sub-camps (if any are established).
   d. Estimates the Plans and Service requirements for the Fire Boss.
2. Coordinates the Support function with the Suppression effort.
   a. Consults with Assistant Fire Boss (Suppression) to work out servicing schedules which are compatible with fire line activities.
   b. Sees that maps and written instructions are prepared for designated line supervisors.
   c. Assists Fire Boss in briefing line personnel.
   d. Sees that Support function is geared to meet the requirements of the plan of action.
3. Performs other assignments.
   a. Serves on strategy boards.
   b. Acts as Fire Boss when so designated by the Fire Boss.
   c. Carries out the responsibilities of any special assignment from the Fire Boss.

## SUPPRESSION FUNCTION

### *Zone Boss*

This position is used only on Campaign fires.

Under the general supervision of the Assistant Fire Boss (Suppression) the Zone Boss assumes responsibility for a geographical section of the fire perimeter. When zones are established, fire management will be decentralized to permit localized strategy and tactics to be employed on each zone. However, the Fire Boss remains as the overall strategist who also sets priority of effort.

The Zone Boss is not a "little Fire Boss" in the sense that he is responsible for the actions of the Support function. A fire camp which may service his zone will be considered an extension of the main camp. He will, however, assume some Command function responsibilities which relate directly to fire line action. While overall strategy and priority rests with the Fire Boss, the Zone Boss has wide latitude to take such action and set priorities for the forces assigned to him as he deems necessary as long as the operations fall within the Fire Boss' overall plan.

A Line Boss will carry out the details of the zone plan of action in a similar manner as on a Major fire.

### SPECIFIC TASKS

1. Develops plan of action for his zone after conferring with the Assistant Fire Boss (Suppression) on overall strategy.
   a. Determines priority of attack and areas of major operations.
   b. Establishes plans for each shift.
   c. Considers realistically the work that can be accomplished with the men, machines and aircraft at his disposal. Sets time schedules which will allow for the completed work to be accomplished.
   d. Consults with Line Boss frequently and adjusts plans as fire conditions change.
   e. Develops alternate plans to be used if necessary. Such plans will include prearranged instructions to each operating unit.
2. Assigns overhead, crews and equipment.
   a. Deploys available forces to best advantage and adjusts or redeploys them as necessary after consultation with Line Boss.
   b. Considers the fatigue influence upon work accomplishment and provides for rotation of crews at points of heavy workload.
   c. Provides for relief of line forces on 12-hour basis.
3. Briefs personnel on duties and responsibilities.
   a. Sees that fire line overhead are briefed before they begin work.
   b. Provides for maps and instructions which outline the objectives and general plan of action for each major operating area.

## *Zone Boss (Continued)*

4. Anticipates needs.
   a. Places orders and requests so that men and equipment will arrive at the time they are needed, with proper allowance made for travel schedule.
   b. Requests specialized equipment deemed necessary, such as aircraft, nurse tankers, bulldozers.
   c. Plans for a reserve strength of men and equipment in addition to the absolute requirements of the zone.
5. Works with Line Boss in directing fire control effort on the line.
6. Participates as a member of strategy conferences.

## *Line Boss*

The Line Boss directs and coordinates the suppression effort of forces actively combatting the fire on the actual perimeter. He is responsible to the Assistant Fire Boss or Zone Boss.

The Line Boss is primarily responsible for carrying out the basic fire strategy and is generally freed of responsibility for support service and long range planning (except as specified in this job description).

SPECIFIC TASKS

1. Familiarizes himself with the fire problem and the plan for control.
   a. Consults with Assistant Fire Boss concerning the basic strategy and its application in accordance with predicted fire behavior.
   b. In the absence of complete and authentic fire progress maps, makes checks of the situation at the earliest possible moment to determine that control plan fits current situation.
   c. Obtains briefing from Line Boss he is relieving.
2. Acts as field coordinator of all fire fighting units on the line.
   a. Coordinates activities of divisions and sectors.
   b. Sees that surplus resources of manpower and equipment are available for re-distribution or release; and conveys this information to Fire Boss or Plans Boss.
   c. Sees that inter-division, inter-sector, or inter-crew resources are properly utilized, particularly bulldozers, firetrucks, jeeps, nurse tankers and other special equipment.
   d. Sees that aircraft are used in accordance with planned priorities.
3. Coordinates fire line activities with Service sub-function.
   a. Arranges a priority schedule with the Division or Sector Bosses and Service Boss for servicing of motorized equipment on the line.
   b. Modifies when necessary, plans for transportation of crews coming off the line in accordance with the location of such crews at the end of the shift.

### *Line Boss (Continued)*

4. Keeps fire headquarters advised of fire developments and control progress.
   a. Sets up a schedule and the manner for reporting information.
   b. Advises of changes in strategy, line locations, or deployment of forces, because of unanticipated conditions.
   c. Relays all pertinent information which may affect planning.
   d. Calls to attention of fire headquarters any inadequacies of equipment or manpower.
5. Keeps himself constantly aware of the fire problem.
   a. Receives information on fire behavior from fire headquarters following aerial reconnaissance or scouting activities.
   b. Obtains information through communication or direct contact with Division or Sector Bosses.
   c. Keeps up to date on current and predicted weather conditions.
   d. Considers progress being made by control forces.
   e. Considers the quantity and type of equipment and manpower, and decides if proper techniques are being used.
   f. Considers current fire developments to determine if basic strategy still applies and if:
      (1) a proper balance is maintained between motorized equipment and manpower;
      (2) divisions and sectors are properly correlated.
6. Adapts the line forces to current fire developments and anticipated behavior.
   a. Consults with Assistant Fire Boss when possible concerning strategy changes, but uses best judgment in absence of such contact or when time will not permit delay.
   b. Reassigns manpower and equipment for the most effective control of the fire.
   c. Requests additional manpower and equipment or reserve forces to cope with unforeseen circumstances.
7. Sits on strategy board meeting when conditions permit, and gives recommendations for further action on the fire.
   a. Sends recommendations when unable to be present.
   b. Considers special problems which will carry over to next shift.
   c. Counsels with Division and Sector Bosses and receives advice regarding additional needs to effect control.
   d. Bases recommendations on current fire status and predicted behavior.

### *Division Boss*

The Division Boss is responsible for directing and coordinating the suppression efforts of all forces within a unit of the fire known as a division. He is responsible to the Line Boss.

## *Division Boss (Continued)*

SPECIFIC TASKS

1. Familiarizes himself with the general plan for controlling the fire and particularly the fire problem for his area.
   a. Gets briefing, map and written instructions from Line Boss on the general plan of action for his division and its relationship to the overall plan.
   b. Makes a check of his division as soon as possible to assure himself that the control plan meets the current situation.
   c. Obtains information from Division Boss whom he is relieving.
2. Briefs Sector Bosses in their duties.
   a. Outlines the general plan of sectors and the techniques to be employed.
   b. Describes special problems of the unit and how they shall be handled.
   c. Outlines the standards for doing the job; width or type of line construction, time factors involved, intensity of mop-up and patrol.
   d. Specific arrangements for servicing motorized equipment (as outlined by Line Boss).
   e. Specifies arrangements for relief and location where transportation will be available (as outlined by Line Boss).
   f. Assigns Sector Bosses to sectors, may recommend areas of operation for Crew Bosses.
3. Keeps Line Boss advised of division's fire conditions.
   a. Arranges for means of communication and sets up schedule.
   b. Advises locations of lines, line progress, and change of strategy developed because of unanticipated conditions.
   c. Advises of surplus, shortage or inadequacy of forces as soon as they become evident.
4. Keeps constantly aware of fire problem in his division.
   a. Maintains constant communication and obtains information and advice from his Sector Bosses or Line Boss.
   b. Keeps up to date on current and predicted weather conditions.
   c. Considers progress being made by control forces in relation to the time factor, fire behavior and total work to be accomplished.
   d. Considers type of cover and topography, natural barriers and general resistance to control.
5. Deploys and uses his forces in the most effective manner.
   a. Determines the most effective place for the construction of the fire line in his division.
   b. Consults with Line Boss and other Division Bosses for unity of action.

### *Division Boss (Continued)*

c. Takes immediate action to cope with unanticipated conditions, using his best judgment when unable to contact Line Boss (or Assistant Fire Boss). He assures himself first, however, that such action will not jeopardize the safety of personnel or nullify the action of adjacent divisions.
d. Communicates with Line Boss as soon as possible if changes in general planned action are necessary.
e. Where realignment of control lines will involve an adjacent division makes contact with Line Boss or other Division Boss to correlate the activities.
f. Sees that inter-sector resources are properly distributed on the fire line and shifts forces from one sector to another when necessary.
g. Requests additional resources when his own forces are unable to handle the problem.
h. Does not allow men to work in an area where margin of safety becomes questionable.
i. Coordinates use of aircraft to meet fire line needs.

6. Provides information for next shift.
   a. Advises Line Boss of all special problems which will carry over into the next shift.
   b. Briefs officer who relieves him.
   c. Sits on strategy board when requested to do so.
7. Remains on division fire line until relieved by replacement or unless specifically instructed to the contrary by the Line Boss or Assistant Fire Boss.

### *Sector Boss*

The Sector Boss supervises and directs the fire line action of two or more Crew Bosses and their crews. He will work directly for the Division Boss.

He supervises the forces assigned to his unit in carrying out the general strategy outlined by the Division Boss with latitude for making on-the-spot changes when necessary for effective action. He must be constantly aware of the current fire conditions within his unit and be prepared to reassign his forces to fit changing situations.

#### SPECIFIC TASKS

1. Familiarizes himself with the general plan for controlling the fire and particularly the fire problem for his area.
   a. Gets briefing and written instructions from Division Boss on general plan of action for his sector and its relationship to adjoining sectors.

## *Sector Boss (Continued)*

b. Makes a check of his sector as soon as possible to assure himself that the control plan meets the current situation.
c. Obtains information from Sector Boss he is relieving.

2. Briefs Crew Bosses in their duties.
   a. Describes the anticipated course of action for each crew and methods of operation.
   b. Specifies the type and width of line construction, intensity of mop-up and patrol and time limits to complete the job.
   c. Indicates location of problem area and outlines proposed methods of handling.
   d. Outlines alternate plans and action required to place into effect.
   e. Gives instructions on procedure of checking out tools and checking crews in and out of camp.
   f. Specifies arrangements for relief and location where transportation will be available.
3. Keeps up on current fire conditions for entire sector.
   a. Observes fire progress or behavior and considers fuel types in the immediate fire path.
   b. Notes progress being made by line constructing crews in relation to the total job they must accomplish.
   c. Notes all items which may affect control measures.
4. Keeps the Division Boss advised of fire situation for his sector.
   a. Sees that line is located as outlined by Division Boss or in accordance with fire situation.
   b. Checks for proper deployment and use of forces.
   c. Checks line condition.
   d. Checks for special hazards: snags near the line, spot fires, unburned areas inside the line, rolling material.
   e. Reassigns forces to meet a change in conditions, using his best judgment when unable to contact Division Boss at once. He assures himself first, however, that such action will not jeopardize the safety of personnel or nullify the action of adjacent sectors.
   f. Where change of control lines or plans will involve another sector, makes contact with its Sector Boss to correlate the action. Advises his superior as soon as possible.
   g. Checks on general safety of men and does not permit crews to work in surroundings where margin of safety becomes questionable.
   h. Keeps Crew Bosses advised of his location.
6. Provides information for next shift.
   a. Advises his superior line officer of all special problems which will carry over into the next shift.
   b. Briefs officer who relieves him.

### *Sector Boss (Continued)*

c. If asked to attend strategy meetings, is prepared to give a concise, clear picture of conditions on the sector as he sees them.

7. Remains on sector until relieved by replacement or unless specifically instructed by his superior to leave.

### *Crew Boss*

The Crew Boss has charge of a crew of men actively engaged in constructing, mopping-up, or patrolling a unit of fire line. He works under the direction of the Sector Boss.

The crew unit is the basic working unit of the fire control organization. It is this group which actually constructs and holds the line around the fire perimeter. The best plan and organization will not prevail against the fire unless the Crew Boss and his crew do a good job.

A Crew Boss must understand fire behavior and firefighting methods to the extent that he can effectively direct the effort of five to twenty-five men. The work they perform must be in conformance with the specific plan of control and at the same time be governed by the conditions they find on the ground.

A Crew Boss will normally be assigned to the same crew unit during its entire operation on the fire line. He will be responsible for its safety, welfare and performance both on and off the line.

SPECIFIC TASKS

1. Outlines to his crew, at the beginning of each shift, the nature of their assignment.
   a. Describes the standards for doing the job including:
      (1) Width and type of line;
      (2) Extent of mop-up;
      (3) Time to complete the job.
   b. Describes the method of operation for the crew unit.
   c. Specifies the way in which special hazards or problems are to be handled.
2. Sees that a record is kept of crew activities.
   a. Checks crew out with Timekeeper.
   b. Keeps record of activities to be submitted to Timekeeper in the event that crew was on the fire before fire camp was set up.
3. Equip crew with proper tools and supplies.
   a. As directed by Sector Boss checks out proper tools and equipment from Property Man. Signs the Crew Boss Tool Record.
   b. Assigns tools to individuals and assures himself that each understands how to use his assigned tool.
   c. Provides for adequate water, lunches, and first-aid supplies.
   d. Considers flashlights if crew will (or may) be on fire line at night.

## *Crew Boss (Continued)*

e. Checks physical condition, clothing and equipment of crew members before going on fire line.

4. Supervises the crew during construction or holding action on the line.
   a. Remains with crew at all times unless otherwise directed by superior officer.
   b. Gives on-the-job instructions and demonstrations in techniques of operation, use of tools, and safety measures.
   c. Cautions crew about rolling materials, burning snags, sparks over the line, flare-ups and other special hazards.
   d. Keeps men spread out and working steadily with allowance for regular short rest periods.
      (1) Rotates men from one job to another to avoid excess tiring of any individual.
      (2) Uses encouragement, leadership and example to get work from crew.
      (3) Cautions men against overuse of water to prevent sickness and waste of water.
   e. Constantly checks line for proper width, location and adequacy.
   f. Watches for special hazards such as:
      (1) Spot fires outside of the fire line;
      (2) Smouldering snags or burning stumps or logs near the line;
      (3) Unburned fuels inside and near the fire line;
      (4) Rolling material on steep slopes.
   g. Burns out hazardous vegetation when conditions permit and keeps line clean, reducing to a minimum the possibility of flare-ups behind him.
   h. Does not allow crew to work in an area where the safety margin is questionable.

5. Adjusts plan of operation to meet unanticipated change.
   a. Uses own good judgment in changing line locations in the absence of the supervisor. Notifies supervisor of the necessity for change.
   b. Continues to work to control the fire even though line has been lost because of flare-ups or spot fires.
   c. Makes contact with adjoining Crew Bosses to correlate activities.

6. Keeps supervisor advised of activity in his area.
   a. Maintains radio contact or arranges for messenger for important developments.
   b. Arranges with supervisor for scheduled fire line meals, supplementary water, or other supplies.
   c. Gets information on arrangements for relief or transportation.
   d. Advises of surplus, shortage or inadequacy of equipment.

7. Supervises crew when in camp.
   a. Keeps crew together as a unit and remains with his men at all times.

### *Crew Boss (Continued)*

b. Checks in himself and crew with Timekeeper.
c. Turns tools and equipment in to Property Foreman and sees that Crew Boss Tool Record is removed from files and checked against items returned.
d. Instructs crew members in camp routine, location of washing areas, latrine, sleeping area, etc.
e. Feeds crew as a unit.
f. Checks out sufficient blankets for his crew.
g. Sleeps crew as a unit. Reports to Camp Boss the exact location of himself and crew.
h. Is always responsible for conduct of his crew while in Fire Camp.
i. Sees that injuries are properly reported and medical attention given when needed, in spite of possible reluctance of some men.

### *Dozer Boss*

The Dozer Boss works under the supervision of a Division Boss or Sector Boss as assigned. Whenever bulldozers are being used on a Division or Sector in sufficient numbers to create a need for additional supervision, a Dozer Boss is assigned to direct their work. He must have knowledge and experience in fire line construction, in dozer capabilities and techniques of use. Special circumstances may require the Dozer Boss to assume the additional responsibilities of Division or Sector Boss.

SPECIFIC TASKS

1. Inspects equipment and supplies.
   a. Determines that all dozers are designed to perform fire line construction work and are mechanically sound.
   b. Determines that all machines have lights or notes those which will require them.
   c. Sees that all dozers are serviced and prepared for a full shift of of operation.
   d. Sees that arrangements have been made for sufficient drinking water and lunches.
   e. Determines that all machines are properly marked with an identifying number.
   f. Determines that some means of communication to hired equipment is available.
2. Briefs personnel in their assignments.
   a. Reviews plans of action with operators and swampers.
   b. Makes specific assignments and gives detailed instructions concerning the responsibilities of each individual.
3. Supervises dozer action.
   a. Provides for safety and welfare of personnel and equipment under his direction.

## *Dozer Boss (Continued)*

b. Sees that fire line is constructed according to plan within the intended time limits.

4. Cooperates with Dozer Manager in arranging for proper service for bulldozers.
5. Keeps time of hired equipment and personnel. Sees that these records are given to the Dozer Manager.
6. Consults frequently with Sector or Division Boss regarding line progress, additional requirements or special problems.

## *Firetruck Boss*

The Firetruck Boss is assigned to work under a Sector or Division Boss when a large number of firetrucks are used and supervision in addition to that given by the Sector or Division Boss is required. This may involve structure standby and protection, major hose lay operations, or large volumes of water or chemical use in direct attack or pretreating operations. He must be experienced in fire control work and fire behavior and must be familiar with the operation of the various types of pumpers. He must have experience and knowledge of extended hose lay operations and the techniques of use of water and chemicals. Special circumstances, as in the case of mop-up and patrol, may require the Firetruck Boss to assume the responsibilities of Sector or Division Boss.

SPECIFIC TASKS

1. Inspects equipment and supplies.
   a. Determines that all firetrucks are properly equipped to perform the intended assignment.
   b. Sees that arrangements have been made for sufficient drinking water and lunches.
2. Briefs personnel in their assignment.
   a. Reviews plan of action with all assigned personnel, including such special information as travel routes, water sources, coordinated efforts with other work units, methods of communication.
   b. Makes specific assignments and gives drivers detailed instructions concerning the individual responsibilities of each truck crew.
   c. When practical, assigns out-of-area personnel and equipment to work with local fire control personnel.
3. Supervises firetruck work action.
   a. Provides for safety and welfare of personnel and equipment working under his direction.
   b. Sees that the assigned job is carried out according to plan within the intended time limits.
4. Keeps time of hired equipment and personnel. Sees that these records are given to the Vehicle Manager.

## *Firetruck Boss (Continued)*

5. Consults frequently with the Division or Sector Boss regarding status of the assigned job, additional requirements, or the number of firetrucks available for other assignment.

## *Helispot Boss*

Under supervision of a Sector Boss, the Helispot Boss is in charge of all operations on the helispot to which he is assigned. He will assist helicopter pilots in landings and takeoffs. He must therefore know helicopter use signals, ground and air. In addition he must be familiar with helicopter flight characteristics and performance capabilities. Since helispots must sometimes be established in areas that are inaccessible on the ground, the Helispot Boss must be trained in and be able to perform helijumps. He must understand the desirable features of a helispot and be able to construct them. Quite often a helispot will serve as a base for direct attack on portions of the fire line nearby. It is, therefore, important that he be familiar with the installation and use of all of the helicopter accessories available for fire control action.

### SPECIFIC TASKS

1. Assists with the establishment of helispots.
   a. Helps helicopter pilot select appropriate site.
   b. Makes helijump if necessary and constructs heliport with or without assistance of a crew.
2. Maintains the helispot in proper condition for safe, effective use.
   a. Remains at the helispot at all times when helicopters are using it.
   b. Works alone or with a crew depending on workload.
   c. Assumes full responsibility for safety of persons using the helispot.
   d. Reduces dust by wetting down landing area, if water under pressure is available.
   e. Eliminates all smoking within 50 feet of helicopters or fuels.
   f. Keeps unauthorized personnel away from landing areas.
3. Assist pilots with landing, loading, and take off procedures.
   a. Uses official hand signals to guide pilots during landings and takeoffs.
   b. Assists passengers in and out of the aircraft in a safe manner in order that the pilot may remain in the ship.
   c. Briefs crews and individual passengers on proper and safe actions in or around helicopters.
   d. Fastens and checks seat belts on each passenger.
   e. Loads tools and cargo in accordance with pilots instructions.
4. Keeps records of helispot activity as required.

## *Falling Boss*

The Falling Boss is assigned to work under the Sector Boss when conditions dictate the need for timber falling crews in the fire control action. This is a specialized job and is assigned to an individual who has experience in fire control methods and fire behavior. He must know timber falling methods and proper use of power saws. Work may consist of falling and bucking trees and logs as necessary in line construction or in mop-up operations.

### SPECIFIC TASKS

1. Inspects equipment and supplies.
   a. Determines that all saws are in proper operating condition and that fuel and other supplies or equipment are on hand to perform the intended assignment.
   b. Sees that arrangements have been made for sufficient drinking water and lunches.
2. Briefs personnel in their assignments.
   a. Reviews plan of action with all personnel. Imparts special information such as coordinated efforts with other work units.
   b. Makes specific assignments and gives detailed instructions to each individual.
3. Supervises falling action.
   a. Sees that proper safety precautions are taken by all personnel.
   b. Sees that the assigned job is carried out according to plan within the intended time limits.
4. Keep time records for all hired personnel and equipment under his supervision. Sees that these reports are turned over to the Timekeeper.
5. Consults frequently with Sector Boss regarding the progress of the falling action.
6. Determines that appropriate arrangements have been made for a change of shifts.

## *Air Attack Boss*

Under the supervision of the Assistant Fire Boss (Suppression) the Air Attack Boss is responsible for the coordination of all suppression activities involving aircraft. He must be knowledgeable about the uses and limitations of air tankers, helicopters, and other aircraft in performing missions for fire control purposes. He must also understand basic fire behavior and fire control techniques. Normally, the duties of this position will be performed on the ground, rather than in flight.

## *Air Attack Boss (Continued)*

SPECIFIC TASKS

1. Briefs personnel regarding the plan of action and assigned responsibilities.
   a. Meets with Air Coordinator and air tanker pilots at air attack base, if possible, to outline operating plans and point out special problems.
   b. Meets with Helicopter Coordinator and pilots to outline plan of action.
2. Coordinates use of aircraft with fire line requirements.
   a. Deploys aircraft and sets priority of flights in accordance with fire control plan.
   b. Assigns times, elevations and patterns of flight traffic and advises Air Coordinator and the Helicopter Coordinator.
   c. Works with Line Boss and other fire line officials to adjust actions and priorities as may be necessary.
   d. Consults with Line Boss concerning the locations on or near the fire where helispots are needed.
   e. Makes frequent contacts with Air Coordinator and the Helicopter Coordinator or visits air tanker base and heliport to assure himself that operations are proceeding as planned.
3. Determines that all aircraft missions will be conducted safely.
   a. Reviews all intended missions in advance.
   b. Consults with Air Coordinator, the Helicopter Coordinator and pilots, for concurrence that all flights can be safely made.
   c. Determines that all Federal Aviation Administration (FAA) regulations and agency policies of operation are followed.
   d. Determines that adequate communication equipment is available and ready for use.
   e. Informs Air Coordinator or the Helicopter Coordinator of known flight hazards, such as power or telephone lines, TV tower installations, extreme turbulence, limited visibility, etc., in the areas of operation.
   f. Assumes responsibility for eliminating any interference with fire control operations by unauthorized aircraft.
   g. Determines that pilots do not exceed the maximum number of flying hours stipulated by agency policy.
4. Determines that proper records of the activities of the personnel and aircraft under his supervision are kept.

## *Air Coordinator ("Airco")*

Under the direction of the Air Attack Boss, the Air Coordinator controls the flights of all aircraft over and near the fire area. In effect, he is an aerial "traffic cop" with the responsibility to see that all aircraft are

## *Air Coordinator ("Airco") (Continued)*

able to carry out their assigned missions in a safe, orderly manner. He also directs air tanker pilots in making fire retardant drops on fireline targets as instructed by designated line supervisors. He must be experienced in air reconnaissance work and fire behavior and control methods, both air and ground. He must be familiar with the types of aircraft used in fire control action and understand their flight characteristics. He must also be adaptable both mentally and physically to the maneuvers required of this special type of flying.

### SPECIFIC TASKS

1. Briefs pilots regarding the plan of action and determines that equipment is in proper working order.
   a. Outlines, either by himself or in company with the Air Attack Boss, the plans for each day's operation.
   b. Identifies target locations and known flight hazards, such as high power or telephone lines, TV towers, etc.
2. Coordinates flights of all aircraft over or near the fire area and sees that they are made safely.
   a. Communicates with Air Attack Boss, Dispatcher, Heliport Boss, Helicopter Coordinator, designated line supervisors, and air bases, as necessary to insure that flights of all aircraft, both fixed and rotary wing, are coordinated and are conducted safely.
   b. Arranges clearance for special flights over the fire area as may be approved by the Fire Boss, Assistant Fire Boss, or Air Attack Boss.
   c. Keeps constantly aware of the location of all aircraft in flight and their scheduled arrival times over the fire area.
   d. Orbits at least 1500 feet above the terrain to provide sufficient space for safe operation of air tankers and helicopters.
   e. Allows only one aircraft over or near the target area at any given time.
   f. Stays constantly alert for the approach of unauthorized aircraft whose pilots may be attracted by the smoke.
   g. Surveys the target and approach areas continuously to detect hazards to flight previously unknown. Warns pilots of unusual air turbulence.
3. Directs placement of chemicals from air tankers as required by designated line supervisors.
   a. Communicates with line supervisor regarding target and number of drops required.
   b. Contacts pilot of each air tanker as it approaches and relays instructions on assigned target and information pertinent to the drop, such as estimated wind speed and direction.

## *Air Coordinator ("Airco") (Continued)*

c. Reports to designated line supervisors the effects of each drop and advises him of portions of the line which appear to need additional attention.
d. Determines that pilots are aware of intended missions and that such missions can be accomplished safely.

4. Assists Air Base Manager in checking flight time records for aircraft and pilots before giving them to Air Attack Boss.

## *Helicopter Coordinator*

The Helicopter Coordinator is appointed when large numbers of helicopters are used on any one fire. He works under supervision of the Air Attack Boss. He must have a thorough knowledge of the performance characteristics of the types of helicopters being used in forest fire control work. He must be trained in the use of all of the various helicopter accessories and be familiar with the helijump technique.

SPECIFIC TASKS

1. Determines that all arrangements have been properly made for planned helicopter operations, and briefs personnel accordingly.
   a. Consults with Air Attack Boss to become familiar with the fire control strategy, and specifically the plan of action for helicopters.
   b. Determines that helicopters, pilots and appropriate accessories or supplies are prepared for action at the appointed time.
   c. Determines that adequate communication equipment is available and ready for use.
   d. Briefs pilots and Heliport Boss on plan of action.
2. Coordinates the use of helicopters in performing missions on the fire.
   a. Makes reconnaissance flights as necessary over various parts of fire where helicopter missions are planned in order to determine that such flights can be conducted safely.
   b. Consults with Line Boss or other fire line supervisors to coordinate helicopter missions with fire line requirements.
   c. Checks helispots in company with line supervisors to determine that the minimum requirements for a safe operation have been achieved.
   d. Maintains contact with Airco when fixed wing aircraft are being used so that no conflict occurs in aircraft movement between helicopters and other aircraft.
   e. Sees that helicopters are used in compliance with Federal Aviation Agency regulations and agency policies.
3. Sees that complete records of helicopter use and pilot hours are kept and turned over to the Heliport Boss.
4. Determines that arrangements are made for necessary maintenance.
5. Determines that pilots do not exceed the maximum number of flying hours stipulated by agency policy.

## SUPPORT FUNCTION

### *Plans Boss*

The Plans Boss works under the supervision of the Assistant Fire Boss and is responsible for gathering and compiling all information necessary for planning control of the fire and for maintaining a record of all fire activities.

In order for the Fire Boss to make an accurate evaluation of current circumstances and an estimate of future developments, he must know as much as possible about the fire. He should be aware of the factors which influence fire behavior; progress being made to control it, deployment of forces, and available resources. To keep the Fire Boss informed of these things is the basic responsibility of the Plans Boss. In order that this information be in a useable form, the Plans Boss establishes systems for recording it. Fire status maps indicate line locations and progress, deployment of control forces, access roads, breaks or barriers. Records are maintained of all resources in such a manner that availability lists containing pertinent information about each operating unit (manpower or equipment) are readily obtainable. The Fire Boss will thus have access to information which will aid him in making decisions necessary to effect control of the fire.

The Plans Boss must see that all of the jobs that make up the subfunction of Plans are performed. The Assistant Fire Boss will assign individuals to assist the Plans Boss in performing the jobs of Timekeeper, Intelligence, Message Center Operator, Reconnaissance and Maps, and Weather.

#### SPECIFIC TASKS

1. Gathers information concerning the current status of the fire.
   a. Confers with Assistant Fire Boss and Service Boss for orientation on the fire history and present distribution of control forces.
   b. Utilizes aircraft for reconnaissance work, as necessary.
   c. Arranges for communication contact with Line Boss or Zone Boss and all fire areas.
   d. Arranges for scouts to be dispatched to areas of the fire where no information is available. Specifies type of information and method of recording it.
2. Compiles information into a useable form.
   a. Arranges for an up-to-date fire status map showing:
      (1) Fire perimeter with current divisions and sectors;
      (2) Vegetation type boundaries in relation to bearing on fire behavior;

***Plans Boss (Continued)***

(3) Control status of each operating area;
(4) Current fire developments which may affect strategy;
(5) General topography of the area and natural barriers, breaks, or features which reflect resistance or assistance to control;
(6) Access roads and rate of travel to various fire areas;
(7) Location of alternate control lines or bulldozer lines;
(8) Possible camp sites in relation to current and anticipated fire behavior;
(9) Deployment of resources.

b. Sets up a system for keeping current the status record of each operating unit (crew, overhead, mobile equipment) showing:
(1) Identification or type;
(2) Qualifications or specialized ability;
(3) Location (By division or sector if on-shift, off-shift, in camp, etc.)
(4) History of activity on the fire by shift.

c. Sees that fire organization chart is maintained.

3. Calculates probable fire behavior.
a. Obtains local weather data from around the fire area, using own personnel or the facilities of a U. S. Weather Bureau mobile unit.
b. Obtains weather forecasts from U. S. Weather Bureau.
c. Considers fuel types, topography and resistance to control and exposures of areas being threatened by fire.
d. Considers progress being made by control forces in relation to the time factor and total work to be accomplished.

4. Prepares maps and written instructions for designated overhead or units.
a. Confers with Assistant Fire Boss sufficiently before shift to allow for preparation.
b. Outlines in detail all of the pertinent information concerning each operating area including:
(1) A detailed map of the entire fire showing general areas of responsibility;
(2) Portion of line assigned each unit;
(3) Operating instructions for each area with particular reference to priorities of action, objectives, and time factor involved;
(4) Itemized list of control forces assigned to each area;
(5) Information concerning adjacent divisions or sectors so that activities may be correlated;
(6) Alternate plans of control or location of secondary lines;
(7) Arrangements for service facilities.

5. Assists in briefing line personnel.
a. Explains map in relation to current situation, interprets legends and identifies topographic features, indicates location of special problems and areas of greatest resistance to control.

## *Plans Boss (Continued)*

b. In the absence of the Fire Boss or Assistant Fire Boss or when directed to do so, does entire briefing of personnel on strategy and general operating procedures.

6. Arranges for the keeping and compiling of all activity records for the fire.
   a. Keeps fire log, listing chronological sequence of events.
   b. Records information on crew, overhead, motorized equipment activities.
   c. Records activity of hired resources (including compilation of aircraft use).
   d. Keeps radio log.
   e. Consolidates information for Daily Dispatcher's Memo.
   f. Keeps all other information needed for Fire Report or as required by the Fire Boss.
7. Coordinates activities with Service Boss.
   a. Keeps Service Boss advised of expected arrivals or departures of men and equipment.
   b. Arranges with Service Boss sufficiently ahead of each shift to have required manpower, equipment and supplies on hand at prescribed time.
8. Coordinates activities with Line Boss or Zone Boss.
   a. Keeps Line Boss or Zone Boss advised of fire developments, line progress, weather forecasts and other pertinent information gained through reconnaissance or other contacts.
9. Supervises the work of personnel assigned to his unit and arranges for relief.
   a. Checks and coordinates the work of individuals who are assigned to the following jobs:
      (1) Timekeeper;
      (2) Message Center Operator;
      (3) Intelligence Officer;
      (4) Weather Man.
   b. Arranges for relief on a shift basis where necessary in above jobs.
   c. Schedules his time and arranges the work load of his subordinates so that he will get a rest period.

## *Weather Man*

Under direction of Plans Boss, the Weather Man will take weather readings, obtain forecasts from U. S. Weather Bureau, and establish and operate a mobile weather station on the fire.

This position will rarely be filled on a full time basis except by a U. S. Weather Bureau Fire Weather Service Meteorologist. The responsibility for keeping abreast of the many and sometimes rapid local

## *Weather Man (Continued)*

changes in weather conditions is an important part of the sub-function of Plans. Without this knowledge of local weather conditions (which are a basic influence in fire behavior) the Fire Boss would be handicapped in his evaluation of fire developments. General and special weather forecasts are obtained from the U. S. Weather Bureau (their nearest office or a mobile unit on the fire). At times, an individual may be assigned to assist the Weather Bureau Meteorologist by taking local readings at various points on the fire.

SPECIFIC TASKS

1. Takes weather readings as instructed by Plans Boss.
   a. Operates weather instruments in taking local and fire area readings of wind, temperature and humidity and takes upper air soundings.
   b. Records observations at 0800, 1200 and 1630, and at such other times as required.
   c. Sees that 0800 readings are compiled in time to be included in Dispatcher's Memo.
2. Obtains general and special weather forecasts from U. S. Weather Bureau.
   a. Gets daily fire weather forecast.
   b. Requests special forecasts from Weather Bureau.
3. Takes microclimate readings as directed at various points around the fire, or in areas where fire may be expected to spread.

## *Timekeeper*

The Timekeeper works under the direction of the Plans Boss and is responsible for performing all clerical duties in connection with timekeeping, administrative recording and compiling data on all forces used on the fire.

If the volume of resources require it, or the type of manpower constitutes a special problem (e.g. large quantities of labor on time slips) more than one man per shift may be necessary. Then the duties may be split, with one individual doing timekeeping only. The Plans Boss and Assistant Fire Boss will determine when it is necessary and practical to use more than one individual to perform the duties of this job.

Record and timekeeping is essentially a part of all fire activity from the moment the fire is discovered but there will always be varying amounts of elapsed time before some one individual is designated to be responsible for the job. It must therefore be the personal responsibility of each individual or unit leader to maintain a record of his own activities to be turned over to the Timekeeper.

## *Timekeeper (Continued)*

SPECIFIC TASKS

1. Registers all incoming and outgoing personnel and specialized equipment.
   a. Maintains an activity log of chronological events.
   b. Maintains an activity record of each operating unit (overhead, crew, specialized equipment).
   c. Requests information from newly arrived or unknown overhead and crews as to identification and qualifications. Sees that Unit Record of Fire Activity is properly prepared.
2. Maintains time records of hired personnel and special equipment.
   a. Keeps emergency fire time record on proper forms and computes correct pay roll.
   b. Maintains a daily record of ordered pay time for hired equipment as basis for later issuance of sub-purchase orders.
3. Acquaints all personnel as they arrive with camp functions.
   a. Refers them to Fire Organization Chart for information on organizational set-up and individuals who are performing the various jobs.
   b. Conveys information on camp facilities and routines.
4. Prepares maps, written instructions and reports from rough drafts or as directed by Plans Boss.
   a. Assembles information for Dispatcher's Memorandum on proper form.
   b. Assists with the preparation of instructions and maps for line personnel.
   c. Compiles lists of available work resources prior to planning periods as requested by Plans Boss.
   d. Assists Plans Boss in keeping fire status map up-to-date.
   e. Prepares shift organization chart showing disposition of forces.
5. Does other work as required by Plans Boss.
   a. Supervises the work of others assigned to assist in the job of Timekeeping.
   b. Properly prepares and presents to Plans Boss at the close of the fire all records which he has kept throughout the duration of the fire. This may also include the Fire Report and accompanying forms.

## *Intelligence Officer*

The Intelligence Officer is responsible to the Plans Boss. He must be experienced in fire control work and fire behavior. This individual is responsible for field scouting and mapping, either aerial or ground, on designated portions of the fire, and for the preparation of fire status maps as requested.

### *Intelligence Officer (Continued)*

SPECIFIC TASKS

1. Provides information on the current fire status and factors which may influence its behavior.
   a. Makes personal reconnaissance if necessary to familiarize himself with the terrain and location of the fire.
   b. Requests the assignment of sufficient personnel to assist him.
   c. Supervises the subordinates working in the maps and reconnaissance section.
   d. Dispatches reconnaissance and maps men (as he deems necessary or as directed) to maintain up-to-date maps of fire perimeter, fire behavior and status of control.
   e. Interprets maps for Fire Boss and indicates problem areas, possible line locations and other pertinent information of value in planning strategy.
2. Prepares maps, written instructions, and reports as directed by the Plans Boss.
   a. Prepares work shift organization chart showing disposition of forces and keeps detailed records of personnel and equipment.
   b. Arranges to have the fire status board currently and properly maintained.
   c. Keeps current records and maps of the location of the fire perimeter and the fire's progress.
   d. Prepares sketch maps for Division and Sector Bosses showing fire line work assignments.
3. Establishes a message center and supervises Message Center Operators.
4. Assumes responsibilities of Plans Boss as requested.

### *Recon and Maps*

The duties of the job involving reconnaissance and maps may be handled by one man, or two or perhaps several. If one person only is assigned to this work on all or a portion of the fire he will commonly be called the **Recon and Maps Man.** If two are assigned most probably one will be called the **Recon Man**, the other the **Maps Man.** Further assignees will bear either title in accordance with their particular task. In any event, these men are specialists working directly under the Intelligence Officer.

The reconnaissance and mapping specialists are responsible for field scouting and mapping, either from the air or on the ground. When assigned they prepare and update the fire status map.

Normally, a generally satisfactory report of line conditions will be transmitted to headquarters by line officials, at least for the areas they are in a position to observe personally. When more detailed or more positive information is required, the reconnaissance and mapping specialist (or specialists) will be sent to observe, record and report. This

## *Recon and Maps (Continued)*

action will more certainly follow when more precise map information is needed. Such work is not a needless duplication of the valuable, but less intensive, reporting of fire line leaders. The several reports serve to complement one another. And, since it can be assumed that the basic information is gathered at different times, there is some added value in the number of repeated observations in point of continuity.

Basically the responsibility of the Reconnaissance and Maps job is to provide information on the current fire status and factors which may influence its future behavior. To be of value to the Fire Boss in his planning, there must be a certain amount of analysis and interpretation by the observer. It is essential that a Reconnaissance Man or Maps Man have a knowledge of fire control and behavior.

### SPECIFIC TASKS

1. Determines the nature of his assignment.
   a. Confers with Intelligence Officer to establish:
      (1) Location of assignment;
      (2) Method of scouting;
      (3) Type of information required and method of recording;
      (4) Type of equipment needed;
      (5) Time limits for completing the job;
      (6) Intensity of reconnaissance;
      (7) Method of reporting.
2. Carries out assignment as outlined.
   a. Obtains necessary equipment to do the job (topographic maps, aerial photos, protractor, etc.).
   b. Utilizes the available or necessary means of transportation; such as foot, auto, plane, helicopter, or horse.
   c. Observes assigned area and records the pertinent information including:
      (1) Fire perimeter and location of hot spots;
      (2) Special hazards;
      (3) Line construction progress and location;
      (4) Special topographic features which affect control;
      (5) Unburned "islands";
      (6) All other things which may tend to influence the fire or the manner in which it is controlled.
   d. Reports observations at the time and in the manner prescribed (such as fuel types currently burning or threatened).
   e. Prepares complete report upon return to base of operations.
   f. Prepares and maintains fire status map at plans headquarters when assigned.

### *Message Center Operator*

Under direction of the Intelligence Officer, the Message Center Operator is responsible for operating radio and telephone communication equipment in accordance with agency operating procedure and F.C.C. Rules and Regulations.

SPECIFIC TASKS

1. Receives and transmits messages.
   a. Operates radio and telephone at fire headquarters.
   b. Accepts only written and signed messages for transmittal.
   c. Refers to the Intelligence Officer all non-routine messages involving management or administrative matters, or those with conflicting priorities.
2. Records messages and maintains a permanent log.
   a. Enters accurate summary of each radio or telephone communication in respective log.
   b. Writes out all messages he receives which require action and routes them to the proper individuals.
   c. Files all written messages after action has been completed.
   d. Keeps current file of all messages which are pending or on which action has not been completed.
3. Does other work as required by Intelligence Officer.

### *Service Boss*

Under supervision of the Assistant Fire Boss, the Service Boss directs the establishment, maintenance and operation of the Fire Camp (or camps), and arranges for procuring and distributing services and supplies to all fire areas.

The Service Boss will be responsible for:

1. Field headquarters camp (or camps) established which can adequately handle all of the expected resources.
2. Personnel fed, rested and segregated by units for rapid dispatch.
3. Tools sharpened, segregated and properly accounted for.
4. Transportation facilities serviced and manned by drivers.
5. Specialized equipment serviced and manned by operators.
6. Communication facilities installed and serviced.

The Service Boss will ordinarily receive information from the Assistant Fire Boss regarding camp location, but in the absence of such instructions will locate camp sites, taking into consideration the general planning of the fire and will secure approval prior to actual establishment.

He must anticipate the general requirements by keeping himself informed of the strategy and plan of action through contacts with the

## *Service Boss (Continued)*

Fire Boss and Plans Boss. When he receives specific information on the expected quantities of manpower and equipment, he arranges to procure sufficient subsistence and supplies to maintain them. When advised of the shift assignments of manpower and equipment, he will arrange for their mobilization, dispatch (according to priorities established) and transportation to assigned locations.

### SPECIFIC TASKS

1. Assumes responsibility for organizing and directing all activities to perform the sub-function of Service.
   a. Supervises the activities of these positions:
      (1) Assistant Service Boss—Supply;
      (2) Assistant Service Boss—Transportation and Communications
      (3) Safety Inspector.
2. Supervises the establishment of camps.
   a. Consults with the Assistant Fire Boss concerning the location of sites.
   b. Locates the various functional units for their most efficient operation.
   c. Confers with Plans Boss on the location of plans section in relation to the other camp functions.
   d. Arranges for the establishment and service of communication systems between the Fire Camp, the Ranger Unit Dispatcher and fire areas.
   e. Sees that sanitary facilities are adequate and maintained.
3. Coordinates Service sub-function with control plan.
   a. Arranges for meals on time.
      (1) Considers elapsed time for feeding, gathering men and equipment together, and their travel time to assigned areas.
      (2) Keeps Camp Boss advised of feeding requirements.
   b. Arranges for overhead, crews and special equipment to be ready for dispatch at prescribed time.
   c. Arranges for sufficient transportation to be available and manned.
   d. Determines amounts and makes arrangements to obtain supplies and equipment necessary to maintain the total resources on the fire. Outlines procedure of obtaining supplies.
   e. Reviews combined list of supplies from entire Service sub-function determines the need for supplementary items or adjusts the amounts to meet expected demands. Checks for possible duplication of orders.
4. Coordinates Service activities with Suppression function.
   a. Arranges a priority schedule for servicing of motorized equipment on the line.

## *Service Boss (Continued)*

b. Arranges for transportation for crews coming off the line according to the estimated locations of such crews at the end of the shift.
c. Sits on strategy board when requested to do so.

5. Supervises the dismantling of camps.
   a. Sees that camp facilities are reconditioned and placed in shape for immediate use if needed.
   b. Arranges for inventory lists to accompany all loads of commodities leaving the camp.

## *Assistant Service Boss (Supply)*

The Assistant Service Boss (Supply) assists the Service Boss in all camp management activities including heliport operations.

### SPECIFIC TASKS

1. Assists with managing the fire camp.
   a. Supervises the activities of these jobs:
      (1) Supply Manager
      (2) Camp Boss
      (3) Heliport Boss
2. Assists with the supervision of camps.
   a. Consults with the Service Boss concerning the location of sites.
   b. Locates the various functional units for their most practical operation.
   c. Confers with Plans Boss on the location of plans section in relation to other camp functions.
   d. Arranges for the establishment and service of a communication system between the Fire Camp, the Ranger Unit Dispatcher and fire areas.
   e. Sees that sanitary facilities are adequate and maintained.
3. Assists with coordination of Service sub-function within the control plan.
   a. Arranges for meals on time.
      (1) Considers elapsed time for feeding, gathering men and equipment together and their travel time to assigned areas.
      (2) Keeps Camp Boss advised of feeding requirements.
   b. Arranges for overhead, crews and special equipment to be ready for dispatch at prescribed times.
   c. Arranges for sufficient transportation vehicles to be available and manned.
   d. Determines amounts and makes arrangements to obtain supplies and equipment necessary to maintain the total resources on the fire.
   e. Reviews combined list of supplies from entire Service sub-function. Checks for possible duplication of orders.

## *Assistant Service Boss (Supply) (Continued)*

4. Sits on strategy board when requested to do so.
5. Assists with the dismantling of camps.
   a. Sees that camp facilities are reconditioned and placed in shape for immediate use if needed.
   b. Arranges for inventory lists to accompany all loads of commodities leaving camp.

## *Supply Manager*

Under direction of the Service Boss or Assistant Service Boss, the Supply Manager is responsible for obtaining and distibuting all supplies required for the fire.

Where large volumes of supplies must be obtained and distributed one or more individuals may be required to do the job. The Supply Manager will obtain lists of supplies and equipment needed by each unit (Camp, Plans, Transportation and Communication, Heliport), and will procure and deliver the required items in accordance with established local procedures. He must establish the location of sources of supply for the types of commodities needed and times at which they are obtainable; or he may route orders through the Ranger Unit Dispatcher if so directed by the Assistant Service Boss. He coordinates the procurement and delivery of supplies with the movements of other resources to and from the fire.

SPECIFIC TASKS

1. Determines the quantities and type of supplies needed through contact with individuals responsible for originating orders.
   a. Obtains lists of supplies needed from each functional activity including:
      (1) Camp Boss (food and camp maintenance items; hand tools, repair parts, special tools, hose);
      (2) Transportation & Communication (gas, oil, repair parts; radio repair and service parts as needed by Communication Technician);
      (3) Heliport (fuel, accessories, retardants);
      (4) Plans (maps and mapping equipment, forms).
   b. Submits the combined list to Assistant Service Boss for review and adjustment to meet the fire control plan.
2. Places orders for supplies in manner determined by Service Boss.
   a. Gives combined list to Message Center Operator for relay to Ranger Unit Dispatcher or,
   b. Receives instructions from Service Boss on local supply sources and places orders according to type of commodity. Items obtainable from Forestry stocks ordered through Dispatcher.

## *Supply Manager (Continued)*

3. Determines when and if the various classes of items are obtainable.
   a. Contacts Unit Dispatcher or otherwise considers:
      (1) Type of commodity (food, fuel, repair parts);
      (2) Time required (special deadline or regular delivery);
      (3) Elapsed time for delivery (distance from source or time for preparation);
      (4) Availability of item (business hours of establishment, holidays, week-ends).
   b. Advises individuals responsible for originating orders of time limits in placing orders.
4. Obtains supplies in manner outlined by Service Boss.
   a. Arranges to pick up and deliver supplies at points designated or consults with Assistant Service Boss who coordinates the order with the anticipated movements of other resources.
   b. Checks to see if supplies picked up or delivered match the orders.
   c. See that drivers check with Unit Dispatcher or Fire Camp before returning, when picking up supplies.
5. Performs other duties as required by Assistant Service Boss.

## *Camp Boss*

The Camp Boss is responsible for the establishment and operation of a Fire Camp as directed by the Assistant Service Boss or Service Boss.

Given a general outline of the desired camp layout, the Camp Boss directs the activities of camp crews in setting up the various camp functions and supervises the operations of the kitchen and general camp maintenance. He organizes the operation of the kitchen to meet the demands of the fire control plan and assigns subordinate personnel accordingly. He keeps himself informed of the location of all men in camp and mobilizes them at the required time. When so instructed he may act for the Assistant Service Boss or Service Boss during their resting periods.

SPECIFIC TASKS

1. Sets up camp as outlined by Service Boss.
   a. Establishes the various camp areas and facilities including:
      (1) Kitchen (dishwashing, food preparation, storage and serving);
      (2) Eating area;
      (3) Latrine;
      (4) Motor pool area for motorized equipment, located so that dust and noise will not affect other camp installations;
      (5) Sleeping areas with consideration for both day and night sleeping;
      (6) Washing area and camp water supply;
      (7) First aid facilities for treatment of minor injuries.

## *Camp Boss (Continued)*

b. Arranges for the posting of identification signs on all camp facilities.

2. Supervises the kitchen and camp crews.
   a. Directs the activities of personnel assigned to:
      (1) Food preparation and service;
      (2) Dishwashing and kitchen maintenance;
      (3) Digging pits for garbage, latrine, etc.
      (4) Cleaning up camp and doing other camp details.
   b. Assigns shifts to camp personnel and cooks.
   c. Checks the camp power plant for proper operation and arranges for adequate fuel supply and a lighting system.
3. Plans and organizes feeding schedules as outlined by Service Boss.
   a. Oversees the planning of menus.
   b. Arranges for a priority of feeding when required.
   c. Keeps close inventory of food stocks.
   d. Orders food and kitchen supplies as situation warrants.
   e. Arranges for lunches to be ready at required time.
4. Acquaints new arrivals with camp routine.
   a. Meal schedules and eating area designated.
   b. Location of sleeping and parking areas, sanitary facilities.
5. Assembles personnel for dispatch as instructed by Service Boss.
   a. Keeps acquainted with location of all overhead and crews in camp.
   b. Sees that men are called prior to shift allowing sufficient time for feeding before required dispatch time.
   c. Maintains proper segregation of crews when inmate or ward labor is used.
6. Does other work as instructed.
   a. Acts for Service Boss or Assistant Service Boss in their absence.
7. Breaks up camp and reconditions equipment.
   a. Sees that kitchen equipment and mess gear are properly cleaned before being returned.
   b. Sees that garbage pit and latrine are covered and that all camp areas are clean.
   c. Inventories food and other commodities and sees that list accompanies each load leaving camp.
   d. Sees that gates are closed and generally eliminates causes for complaints from landowner.

## *Assistant Camp Boss*

Under the supervision of the Camp Boss, the Assistant Camp Boss aids in the general management of the day-to-day operations of the Fire Camp.

## *Assistant Camp Boss (Continued)*

SPECIFIC TASKS

1. Assists with organization of camp.
   a. Determines supply and personnel requirements for camp operations in consultation with Camp Boss.
   b. Organizes kitchen and property areas and supervises Kitchen Foreman and Property Foreman in their activities.
2. Assists with management of camp activities.
   a. Determines that personnel are fed and readied for assignment in accordance with plans for the shift.
   b. Establishes an assembly area and provides warming fires as needed.
   c. Organizes and schedules the feeding of personnel to meet the requirements of the fire control action plan.
   d. Provides for an adequate and potable water supply.
   e. Sees that men are provided with proper sanitary facilities within the limits of available resources.
   f. Specifically designates and makes assignment to sleeping area.
   g. Establishes the various camp areas and facilities including:
      (1) Kitchen (dishwashing, food preparation, storage and serving);
      (2) Eating area;
      (3) Latrine;
      (4) Motor pool area for motorized equipment (located so that dust and noise will not affect other camp installations);
      (5) Sleeping areas with consideration for both day and night sleeping;
      (6) Washing area and camp water supply;
      (7) First aid facilities for treatment of minor injuries.
   h. Assigns shifts to Fire Camp personnel.
   i. Checks the camp power plant for proper operation and arranges for adequate fuel supply and lighting system.
   j. Arranges for priority of feeding when required.
   k. Acquaints new arrivals with camp routine.
   l. Orders food and kitchen supplies as situation warrants in consultation with Camp Boss and Kitchen Foreman.
   m. Keeps himself acquainted with location of all overhead and crews in camp.
   n. Assists the Camp Boss in reducing camp subsistence and supplies commensurate with demobilization plan.
   o. Sees that the garbage pits and latrines are covered and all camp areas are clean prior to departure.
   p. Determines that gates are closed, and generally reduces causes for complaints by local persons.

## *Property Foreman*

Under the direction of the Camp Boss or Assistant Camp Boss, the Property Foreman assumes responsibility for the maintenance, issuance

## *Property Foreman (Continued)*

and receipt of tools and appliances, and for the establishment of a system of accountability.

The Property Foreman must be familiar with the use and care of all tools and other State property (non-motorized) used for, or associated with the fighting of fires. It is his basic responsibility to keep tools in first class shape through repairs and maintenance, and to keep records of the location of all such tools under his control. He places orders for required replacement or service parts and estimates additional tools and supplies needed according to the plan for control of the fire.

### SPECIFIC TASKS

1. Organizes property storage.
   a. Sets up property area as instructed by Camp Boss with roped-off boundaries enclosing the property.
   b. Stacks equipment in orderly piles easily accessible for distribution.
   c. Has dull, broken or otherwise nonserviceable tools or equipment segregated and piled out of the way.
2. Maintains and repairs tools and other property.
   a. Sees that used hand tools are inspected, repaired and sharpened.
   b. Sees that all equipment is checked and made ready for operation.
3. Utilizes property accountability system.
   a. Inventories all tools and appliances for which he is accountable.
   b. Checks tools out to crew leaders going on the fire line and records quantities on Crew Boss Tool Record Form.
   c. Requires Tool Record to be signed by person to whom tools are issued.
   d. Checks tools in from crews returning from the line and compares actual count with Tool Record previously made. Shortages or overages in tool count are noted. Excessive losses are reported to Assistant Camp Boss.
   e. Sees that blankets are issued to and returned by crew leaders and overhead. Sees that a daily inventory of blankets is made.
   f. Checks final with beginning inventory and prepares list of overages, damaged or missing property, and the individuals concerned.
   g. Prepares lists of property (for which he is accountable) to accompany each load leaving camp.
   h. Searches fire line and camp areas for missing tools and equipment.
4. Checks in tools from newly arrived crews and fire trucks.
   a. Obtains truck tool inventory from driver of each vehicle and checks list against truck.
   b. When trucks leave the fire camp for the last time, the Property Foreman must again check tool inventory to determine the losses. Deficiencies are noted and the record forwarded through channels to the proper Ranger Unit.

### *Property Foreman (Continued)*

5. Orders supplies and additional tools and equipment.
   a. Estimates needs of replacement or service parts.
   b. When so directed, prepares a list of additional tools and equipment needed to meet an anticipated situation.
6. Performs other assignments as directed.

### *Kitchen Foreman*

The Kitchen Foreman is assigned under the direction of the Camp Boss or Assistant Camp Boss. He is responsible for the entire operation of the kitchen facility.

SPECIFIC TASKS

1. Supervises the daily activity of the Fire Camp kitchen.
   a. Assists in organizing the kitchen facility.
   b. Supervises the cooks and crew.
   c. Directs food preparation and service.
   d. Supervises the dishwashing and kitchen maintenance.
   e. Assigns shifts to cooks and kitchen crews.
   f. Works with and oversees the planning of menus.
   g. Keeps inventory of food stocks and kitchen supplies.
   h. Orders food and kitchen supplies as necessary after consultation with the Assistant Camp Boss.
   i. Arranges for lunches to be ready at the required times.
   j. Sees that kitchen equipment and mess gear are properly cleaned and sanitary at all times.
   k. Inventories food and other commodities at closing of camp and sees that lists accompany each load leaving the site.
   *l.* Does other work as requested to aid the Assistant Camp Boss.

### *Heliport Boss*

A Heliport Boss is required when so many helicopters are being used on the fire that it has required the establishment of a heliport. The Heliport Boss works under the Service Boss or Assistant Service Boss (Supply) in close coordination with the Camp Boss. He must be experienced in Major and Campaign fire organization and knowledgeable in the use of helicopters. He manages the heliport operations in the same manner as the Camp Boss manages the Fire Camp. When the work load allows, the positions Heliport Boss and Heliport Foreman are combined.

SPECIFIC TASKS

1. Determine that heliport facilities and assigned personnel are adequate for the intended activity.
   a. Inspects heliport for conformance with established guidelines for heliports.

## *Heliport Boss (Continued)*

b. Consults with Assistant Service Boss (Supply) or Service Boss to determine the scope of planned activity.
c. Secures and provides all necessary facilities, supplies, and services required for heliport operation.
d. Determines that personnel under his supervision are properly trained in their duties.
e. Determines that heliport and helicopter communications equipment are adequate.
f. Determines that a sufficient number of people are assigned to his operations to meet the fire line requirements—this includes Helicopter Foreman, supply truck driver, work crews, etc.
g. Order helicopter firefighting accessories through the Service Boss and places them in condition for immediate use as requested.
h. Obtains and prepares fire retardant chemicals as may be necessary for use by helicopers.

2. Supervises all of the activities of the heliport.
   a. Assumes responsibility for safe practices on all heliport ground operations.
   b. Determines that the helicopters have been serviced and are prepared to make flights requested by the Air Attack Boss or other authorized individual.
   c. Obtains clearance from Air Coordinator prior to takeoff of any helicopters.
   d. Relays as received, coordinating information by the Air Attack Boss and Air Coordinator.
   e. Briefs the Heliport Foreman and other personnel under his supervision as to safe practices, work assignments, and expected activities.
   f. Meets and receives all personnel and equipment entering the heliport and arranges for their proper disposition.
   g. Arranges for the welfare of all personnel under his supervision.
3. Sees that proper records are maintained for helicopter use and other activity at the heliport.
   a. Keeps the following information on each aircraft operating from his port—type, owner and pilot, time of arrival, restrictions to use, and time records on helicopters and pilots as regards to standby, flight time, etc.
   b. Has information available at all times of the number and types of helicopters ready for use.
   c. Is responsible for the time records kept for individuals assigned to his supervision.

## *Heliport Foreman*

A Heliport Foreman is necessary at any time the workload at the heliport exceeds the ability of the Heliport Boss to handle. He should

## *Heliport Foreman (Continued)*

be experienced in the use of helicopters, be familiar with types of helicopters, their flight characteristics, and capabilities. The Heliport Foreman is responsible to the Heliport Boss and is the immediate supervisor of the Heliport work crews, cargo loaders, and other personnel assigned by the Heliport Boss.

SPECIFIC TASKS

1. Organizes and directs the work of personnel under his supervision.
   a. Supervises the loading and unloading of all cargo aboard helicopters.
   b. Briefs personnel under his supervision and those on heliport location as to safety practices to be followed at all times.
   c. Briefs personnel under his supervision on work assignments and expected production.
   d. Checks the helicopter accessories for proper condition and sees that necessary repairs or maintenance is accomplished.
2. Supervises the activities of the heliport.
   a. Supervises and assists in the attachment or removal of helicopter accessories to the helicopters.
   b. Instructs and assists personnel in entering and leaving aircraft.
   c. Checks safety belts for all passengers.
   d. Enforces all safety practices, rules and regulations.
   e. Keeps landing site and working area clear and clean.
   f. Keeps fire extinguishers ready and strategically located at heliport location.
   g. Signals the helicopter for takeoff and landing.
   h. Insures that the personnel under his supervision wear the proper safety clothing.
   i. Advises the Heliport Boss of needs and assists Heliport Boss in planning daily activities.
3. Keeps records.
   a. Maintains gas and oil records if necessary.
   b. Maintains flight records including type of aircraft, time in flight, etc.

## *Assistant Service Boss (Transportation and Communication)*

Under supervision of the Service Boss, the Assistant Service Boss (Transportation and Communication) is responsible for obtaining and maintaining proper amounts of motorized and communication equipment as required by the Command, Suppression and Support functions in order to accomplish the fire control job.

## *Assistant Service Boss (Transportation and Communication) (Continued)*

SPECIFIC TASKS

1. Assists the Service Boss in all matters concerning the acquisition and servicing of motorized equipment and the establishment and maintenance of an adequate communication system for the fire.
   a. Makes estimates of quantities of equipment and supplies needed.
   b. Supervises the activities of these jobs:
      (1) Communications Service Officer.
      (2) Vehicle Manager.
      (3) Dozer Manager.
      (4) Repair and Service Manager.
2. Sees that an adequate communication system is established and maintained for the entire fire.
   a. Determines the need for special radio and telephone equipment (mobile repeaters, etc.).
   b. Sees that facilities are established to service and repair mobile or portable radios.
   c. Sees that communication system is adjusted to meet changing condition.
3. Sees that adequate facilities are established for servicing and repairing motorized vehicles.
   a. Sees that an inspection system is placed in operation for vehicles coming off shift.
   b. Sees that an adequate supply of common replacement parts are on hand.
   c. Sees that repairs are readily made as necessary.
   d. Arranges a priority schedule through Assistant Fire Boss (Supression) for servicing motorized equipment on the line.
4. Sees that proper records are kept for hired vehicles.
   a. Arranges for inspection of all hired equipment before its being put to work and before release.
   b. Sees that operating time, travel time, standby time and appropriate rates are recorded. Sees that these records are turned over to Timekeeper.
5. Sees that a motor pool is maintained to furnish ground transportation of various sorts.

### *Communication Service Officer*

Under direction of an Assistant Service Boss, the Communication Service Officer will establish and supervise the maintenance of a communication system for the fire.

## *Communication Service Officer (Continued)*

SPECIFIC TASKS

1. Analyzes the communications problem.
   a. Receives information from the Assistant Fire Boss or Assistant Service Boss on the intensity and type of communication coverage needed.
   b. Considers the area of operation and topographic features which may influence communications.
   c. Considers the type and quantity of equipment available.
2. Establishes communication system.
   a. Arranges for such additional equipment as may be available to implement plan.
   b. Sets up mobile repeater unit or relay system when necessary.
   c. Sets up a Fire Camp unit (mobile or portable) for communication between the Fire Camp, Ranger Unit Headquarters and fire areas.
   d. Sets up field telephone system in or between fire camps as directed and arranges for contact to commercial lines where necessary and available.
3. Maintains communication system.
   a. Arranges for the service of portable power plants (operating radio units) through Assistant Service Boss.
   b. Keeps equipment repaired and in satisfactory working condition.
   c. Requests assistance from Assistant Service Boss when necessary in the installation and maintenance of communication system.
4. Determines repair or replacement needs.
   a. Places orders with Supply Manager or Assistant Service Boss for immediate supply needs not in his stock.
5. Supervises technicians in the servicing and repair of communication equipment.

## *Vehicle Manager*

The Vehicle Manager is needed when large numbers of firetrucks and nurse tankers are used—including agency owned, hired, and those belonging to other cooperators. He is responsible to the Assistant Service Boss (Transportation and Communication). He is responsible for seeing that all appropriate arrangements are made to have firetrucks, support vehicles and drivers constantly available for fire duty. He should be experienced in the use, service and repair of firetrucks and other motorized equipment and motor-pool operation.

SPECIFIC TASKS

1. Determines that all vehicles are ready for action and proper supplies available.
   a. Inspects hired equipment for adequacy to perform assignment.

## *Vehicle Manager (Continued)*

b. Sees that trucks are adequately equipped with required tools and accessories, and are otherwise ready to fulfill their line assignment.
c. Makes arrangements for adequate water either from local source or by some other means.

2. Sees that firetrucks and other support vehicles are properly serviced.
   a. Arranges with Repair and Service Manager for adequate fuel, lubricants and repair facilities.
   b. Arranges for prompt replacement of necessary equipment which is out of service.
   c. Maintains a number of additional pieces of equipment, manned and available for assignment.
   d. Sees that all firetrucks not on fire line assignment are manned and ready for action.
   e. Determines that relief drivers are available for shift change.
3. Determines that adequate records are kept on hired trucks, cooperating agency units, and the respective driver of each.
   a. Sees that records include the type of equipment, hours worked, ordered standby, traveltime or distance, and appropriate rates. Sees that these records are turned over to Timekeeper.
   b. Arranges for an inspection of the mechanical condition of each hired truck prior to use and prior to release.
   c. Determines that an Equipment Rental Agreement has been completed for each piece of hired equipment.

## *Dozer Manager*

Under the supervision of the Assistant Service Boss (Transportation and Communication), the Dozer Manager is used when a large number of agency owned or hired bulldozers and transports are working. He is responsible for seeing that all appropriate arrangements are made to have bulldozers, transports, and qualified operators constantly available for fire duty. He must have knowledge and experience in the use and limitations of bulldozers as well as their service and repair.

### SPECIFIC TASKS

1. Determines that all dozers and transports are ready for action.
   a. Checks condition of hired equipment for mechanical condition and determines if it is designed to do the assigned job.
   b. Sees that dozers have lights for night duty.
   c. Rejects poor equipment or inexperienced operators.
2. Arranges for adequate servicing for all bulldozers on the fire.
   a. Makes arrangements with Repair and Service Manager to obtain proper dozer servicing equipment.

## *Dozer Manager (Continued)*

b. Coordinates servicing of equipment on the line to fit fire control actions as requested by Dozer Boss or other appropriate fire line supervisor.

3. Sees that all operable bulldozers not on fire line assignment are manned and ready for action.
   a. Sees that dozers are serviced and ready for action and that relief operators are available for the next shift.
4. Determines that adequate records are kept on hired dozers, transports, and their drivers.
   a. Sees that records include the type of equipment, hours worked, ordered standby, travel time or distance, and appropriate rates. Sees that these records are turned over to Timekeeper.
   b. Sees that a number is assigned and affixed to each dozer for the duration of the fire for the purpose of adequate record keeping.
   c. Determines the mechanical condition of each hired dozer by close inspection prior to release.
   b. Determines that an Equipment Rental Agreement has been completed for each piece of hired equipment.

## *Repair and Service Manager*

Under supervision of the Assistant Service Boss (Transportation and Communication) the Repair and Service Manager is responsible for the repair of agency owned vehicles and the service of all motorized equipment on the fire with the exception of aircraft.

### SPECIFIC TASKS

1. Determines that service and repair facilities are adequate.
   a. Consults with Assistant Service Boss (Transportation and Communication) to determine service and repair requirements for all fire activities.
   b. Arranges for sufficient fuel and lubrication service units with operators to service all motorized vehicles on the fire.
   c. Orders and maintains adequate supplies of gasoline, oil and common replacement parts.
   d. Sees that vehicles in motor pool are conditioned, serviced and ready for assignment.
2. Inspects, services, and repairs vehicles or other specialized apparatus as necessary.
   a. Establishes a preventive maintenance inspection system at the base Fire Camp for vehicles coming off shift.
   b. Establishes service and repair facilities at the base Camp to perform normal service and make minor repairs.

## *Repair and Service Manager (Continued)*

c. Directs the work of agency personnel and mechanics.
d. Maintains fully equipped field service vehicles for emergency repair of motorized equipment on the fire line.
e. Provides for the maintenance and repair of special equipment such as generators, power saws, compressors.
f. Sees that safe practices are followed in all activities under his jurisdiction.

3. Arranges for the keeping of service and repair records.
   a. Sees that the delivery of fuels and lubricants are recorded.
   b. Sees that repairs and parts used are recorded.
4. Assists with the inspection of hired and other equipment prior to release from the fire.

## *Safety Inspector*

Under supervision of the Service Boss, the Safety Inspector is responsible for determining that hazards are reduced or eliminated and that safe practices are followed in the camp. The job may be performed by the Assistant Service Boss (Supply) or the Service Boss himself until the activities require an individual full time.

SPECIFIC TASKS

1. Inspects facilities at base Fire Camp and "spike" camps frequently.
   a. Notes vehicle fuel storage and delivery systems.
   b. Checks for dry grass in areas where portable engines or other ignition sources may cause fires.
   c. Checks LPG installations and container storage.
   d. Notes any item which can be a potential hazard.
2. Observes activities of personnel in camp.
   a. Sees that smoking is not permitted around flammable vehicle and cooking fuels.
   b. Sees that tools are not scattered around where they are subject to being walked on.
   c. Sees the men do not sleep on the ground where vehicles are parked or may be driven.
3. Makes recommendations to the Service Boss toward the elimination or reduction of existing hazards and unsafe practices.

## *Liaison Boss*

The Liaison Boss reports to the Assistant Fire Boss (Support). The Liaison Boss will be the primary contact for representatives from other participating agencies. These include Correctional Institutions, U.S. Forest Service, Military, California Disaster Office and industry. This

### *Liaison Boss (Continued)*

position is considered a requirement in Major and Campaign fire organizations.

The individual assigned to Liaison Boss should be familiar with and have administrative ability in large fire management. This includes familiarization with the personnel, operations and procedures of the cooperative agencies with which he will be working. He should work with the Plans Boss and be informed of the overall fire control plans at all times. He is responsible for the solution of fire activity problems of the groups with which he is working.

SPECIFIC TASKS

1. Keeps posted on the plans and control progress of the fire.
2. Keeps currently informed as to needs and requirements and problems which concern cooperating agencies.
3. Works with Assistant Liaison Boss and Inmate Crew Coordinator to keep cooperating agencies informed regarding the assignment and use of their crews and equipment.
4. Keeps representatives of these agencies informed as to overall needs of manpower and equipment to meet the fire control plan.
5. Is receptive to considering any problems which fire management or cooperating agencies have with each other. Endeavors to effect a satisfactory solution.

### *Assistant Liaison Boss*

The Assistant Liaison Boss aids the Liaison Boss in his primary contacts with representatives from other participating agencies. These include Correctional Institutions, U.S. Forest Service, Military, California Disaster Office and industry. This position will be filled on Major and Campaign fires whenever the overall liaison activity is such that the Liaison Boss needs an assistant.

The individual assigned to assist the Liaison Boss should be familiar with and have administrative ability in large fire management. This includes familiarization with the personnel, operations and procedures of the cooperative agencies with which he will be working. He should work with the Plans Boss and be informed of the overall fire control plans at all times.

SPECIFIC TASKS

1. Assists the Liaison Boss with all liaison activities.
   a. Keeps posted on the plans and control progress of the fire.
   b. Keeps currently informed as to needs and requirements and problems which concern cooperating agencies.
   c. Works with Assistant Liaison Boss and Inmate Crew Coordinator to keep cooperating agencies informed regarding the assignment and use of their crews and equipment.

## *Assistant Liaison Boss (Continued)*

d. Keeps representatives of these agencies informed as to overall needs of manpower and equipment to meet the fire control plan.
e. Is receptive to consideration of any problems which fire management or cooperating agencies have with each other. Endeavors to effect a satisfactory solution.

## *Inmate Crew Coordinator*

The Inmate Crew Coordinator is an assigned forestry employee who is the primary contact with senior Department of Corrections and Youth Authority liaison personnel and crew leaders of inmates and wards. He reports to the Assistant Liaison Boss or Liaison Boss. This assignment should be performed by an official who is thoroughly familiar with the use of inmates and wards.

### SPECIFIC TASKS

1. Keeps constantly informed of the plans and control progress of the fire.
2. Meets all new inmate crews coming into the Fire Camp; makes a contact with the correctional officer or the forest agency employee in charge.
3. Notifies the Liaison Boss about the arrival of new crews and current crew status at all times.
4. Keeps currently informed as to the requirements of the fire control organization and inmate or ward crews through fire management and crew leader contacts. Endeavors to effect satisfactory solution to any problems.
5. Keeps the Liaison Boss informed of all forces available on the fire for assignment from the institutions and conservation camps.
6. Determines that rules, regulations, and procedures governing the use of these participating agencies are followed.
7. Determines that the welfare of each agency's off-shift personnel are taken care of.
8. Determines that proper recording of all records relating to the use of each agency is taken care of and the information provided to the Timekeeper.

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