The Ultra-High Frequency Relay System As Proposed by the U. S. Forest Service

by

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INTRODUCTION

The purpose of this paper is to explain the ultra-high frequency relay system as proposed by the U. S. Forest Service. It is a relatively new idea and as yet has not been fully developed due to the war.

The objective of this system is to set up a sure and fast way of communicating with the headquarters of the forest or regional office with emergency messages, reports of fire, or weather from any part of the forest or region. The present methods are by telephone, telegraph, or some other system which involves continuous expense or delay of important messages. Some radios are used for this purpose, but they are of the lower frequencies and are subject to various noise-producing devices, such as; heating pads, motors, clinical diathermy machines, and neon signs; especially if the radio is in use near a population center.

Shortly after World War I, the first attempt was made to use radios in the forest. The experiment was made with long-wave equipment and was a complete failure. However, previous to this experiment, the airplane in co-operation with radio was used successfully on the west coast for the detection and reporting of forest fires. In 1919, the U. S. Forest Service installed permanent radios in the lookouts of Lolo Hot Springs, Montana, and Beaver Ridge, Idaho, to demonstrate the possibilities of radio. They were a success.

The first portable radio used in the forest weighed about twenty-six pounds, had a long antenna, and was very clumsy to handle. However, its experimental use 'started the ball rolling.' Gradually radios were perfected with less weight and improved efficiency until we now have small, compact, four pound ultra-high frequency radio sets.

Ultra-high frequency radios are now common in the present day methods of message sending over short distances. Of the modern ultra-high frequency radios, several seem to be in general use. The semi-portable Type T-Model D Radiophone is generally used in the lookouts. It weighs about thirty pounds (depending upon the type of batteries used), has about twenty feet of antenna, and is used over an intra-visible path of about one hundred miles maximum rated working range for sending all types of messages. Its transmitter is crystal controlled but has a variable receiver. The portable S-set weighs eight pounds, has fifteen feet of antenna, and is used over an intra-visible path of about fifty miles maximum rated working range. It is also used for sending messages; especially those from the fire lines. The other modern ultra-high frequency radio used by the U. S. Forest Service is the Type SX-Model A Radiophone. This set is coming more and more into general use. It was designed to work into the ultra-high relay system, so it will be explained later.

The typical radios used in lower frequencies are the SPF-set and the M-set. The SPF-set can be used for many purposes but is only semi-portable due to its weight.

Hence, it is generally used in offices, lookouts, or base-fire camps. The M-set is dependable and has a long range, but it wastes power and needs a trained man to operate it efficiently. The cost of both radios is high as is all equipment of high frequency. When compared to the relatively low cost of the ultra-high radios, the cost does not justify using high frequency radios. The ultra-high relay system will eliminate the need for the higher cost radios.

Last summer, while acting as communication officer on a fire, I had the opportunity to observe some of the problems of communication. The present ultra-high radios with their limited range and intra-visible paths create a problem of transmission, especially in rugged country where the heavier, lower frequency radios cannot be taken. The lower frequencies used ~~were~~ are satisfactory as far as communication ~~was~~ are concerned, but their weight ~~prevented~~ prevents them from being used on the fire line where they ~~were~~ are most needed. The frequency was contested by the armed forces, and since it was crystal controlled, it would be prohibitive from the standpoint of expense to change, even if a priority could be obtained for the crystals. I was informed that the ultra-high relay system would go into effect soon after the fire season ended in 1942, but due to lack of equipment and personnel, even the final experiments have had to be postponed as well as the installation of the system.

In this paper there will be no technical information since it is being used every day by the Army in their systems.

DEVELOPMENT OF THE RELAY SYSTEM

Anyone who uses ultra-high frequency radios knows that transmission is limited by the terrain features. If one climbs to the top of a mountain and is the least radio-minded, he can easily visualize the communication possibilities with even the lowest powered communication to be had with any distant station.

Over eight years ago, the Forest Service Radio Laboratory in Portland decided that something should be done to utilize these vantage points. Communication relay systems using power have been in use for some time. The traffic control system on the Pennsylvania Turnpike is an example. Because of complications and the heavy battery drain of radios in use eight years ago, the idea was not thoroughly investigated until 1939. At this time, developments in vacuum tubes enabled active investigation since the tubes permit large savings in the amount of battery drain.

The following is a brief technical discussion of the functioning of the proposed relay as first developed:

> "The transmitter and receiver proper of the test unit are fundamentally duplicates of those portions of the new type T model D radiophone. Each part, however, has been built as a separate unit to facilitate experimental alterations. The local oscillator of the super-heterodyne receiver has been crystal controlled on the standby frequency. The automatic control device is mounted on a third unit and consists of an open chassis about 6 by 8 by 2 inches, which carries three tubes and relays.
>
> In order to conserve batteries to the utmost, the receiver does not operate continuously,

but is turned on for 5 seconds out of each half minute by means of a weight driven clock. If a carrier of 6 microvolts or greater is present on the receiver standby frequency during the 5 second 'on' period, the receiver automatically locks into continuous operation and the relay transmitter comes on the air retransmitting any signal which may be coming into the receiver.

In order that the entire circuit shall not be interrupted during the switchover time between terminal stations, when operating simplex, a time delay of 10 seconds has been provided. This allows adequate time for each terminal station to come on the air and hold the relay system in operation without waiting for the receiver to recycle each half minute.

The total battery drain during each 5 second period is 200 ma. at 3 volts, 50 ma. at 1.5 volts, and 18 ma. at 180 volts. Without an incoming signal the relay station consumes the above battery power for a total time of only 4 hours out of every 24." (2)

Very little change has been made in the recent relays except for minor details. Battery development enables the receiver to operate continuously without breaking circuit. As first used, the relay had just one antenna which was used for both receiving and transmitting; now it has a separate antenna for each. A very recent development has added another unit to enable the use of telephone direct from the relay without manual operation or repeating. This cannot be discussed in this paper.

Several tests with the relay proved to be highly satisfactory. For example, one experimental relay had been undergoing tests in the laboratory and was proved satisfactory. It was then taken into the field for testing on a going fire. It enabled the head ground scout to communicate directly from the base camp with scouts who were working from two to eight miles away in extremely broken

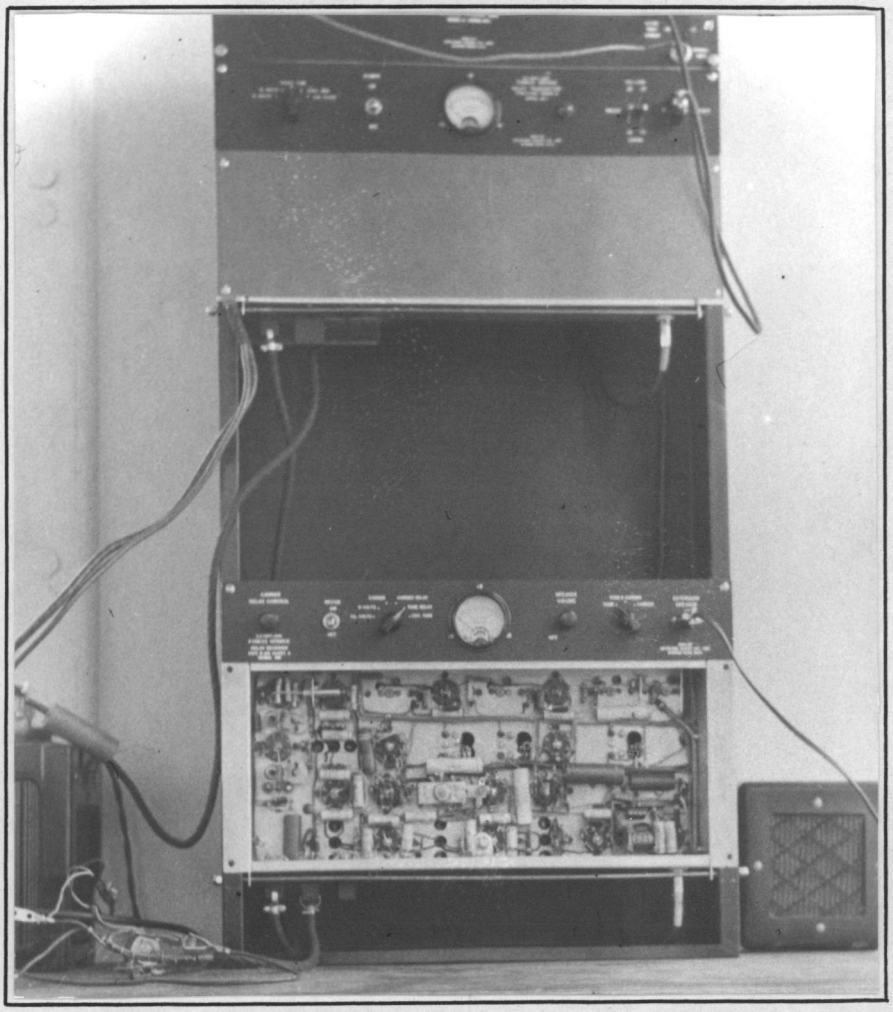
and mountainous country.

A unit was established on Mount Diablo, California, using alternating current. It was to provide direct communication between reporting stations on seven different forests and the fire weather office at Mills Field, San Francisco. The distances between the relay and reporting stations ranged from seventy-five to two hundred ten miles. Except for an hourly shifting in signal strength on the two hundred ten mile path and a hundred sixty-five mile path, the results of this installation were 'extremely gratifying.'

At the same time, a relay operated by dry-batteries was installed on Grey Butte (Shasta National Forest) and further proved the possibilities of the ultra-high frequency relay system.

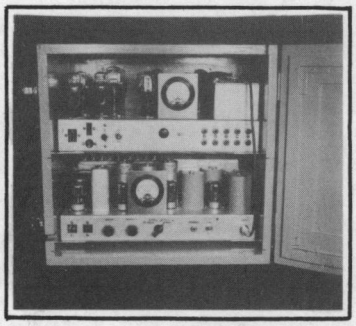
The relay is known technically as an automatic relay station in that it picks up radio waves from one point and transmits them to another. It is the first known development of an automatic relay of portable size operated by dry-batteries. It will greatly enlarge the application of the ultra-high frequency equipment now in use.

THE AUTOMATIC RELAY STATION



A Relay, using wet-batteries, undergoing tests. The center unit is for automatic telephone takeoff. (Air to line)

Automatic Relay Antenna, Mt. Hood, Oregon.



Dry battery operated ultrahigh frequency automatic relay station. Upper deck - transmitter; lower deck - receiver.

TYPE SX RADIOPHONE

MODEL A

Because of certain limitations of the Type S radiophone when working the automatic relay, the type SX radiophone was developed.

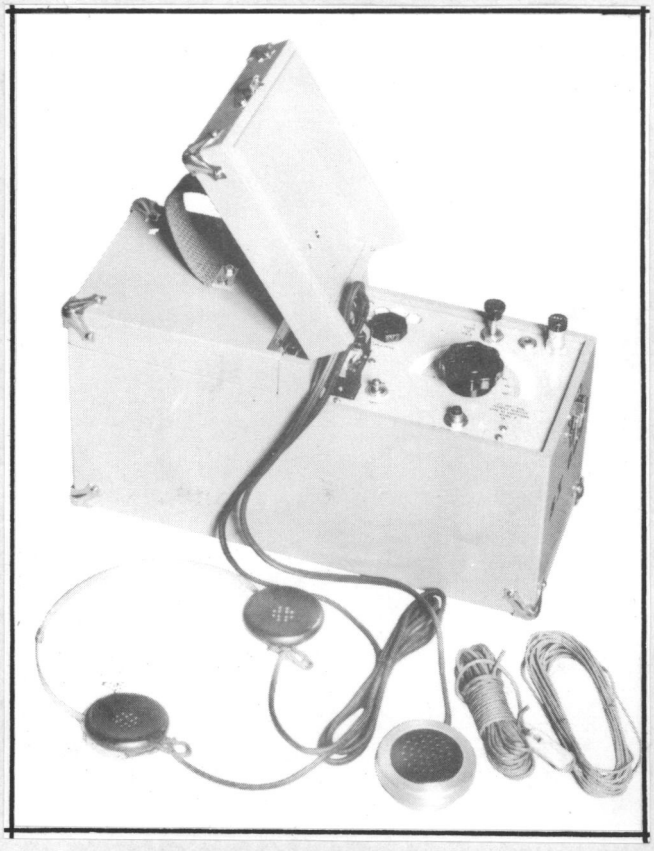
The SX transmitter may or may not be crystal controlled.

> "It can be operated on any one of three crystal-controlled frequencies merely by turning a switch on the panel of the set. The inclusion of three transmitting frequencies permits setting up one channel for local district communication, one adjacent district or forest or regional fire communication, and one for automatic relay contract, or in any other combination desired." (3)

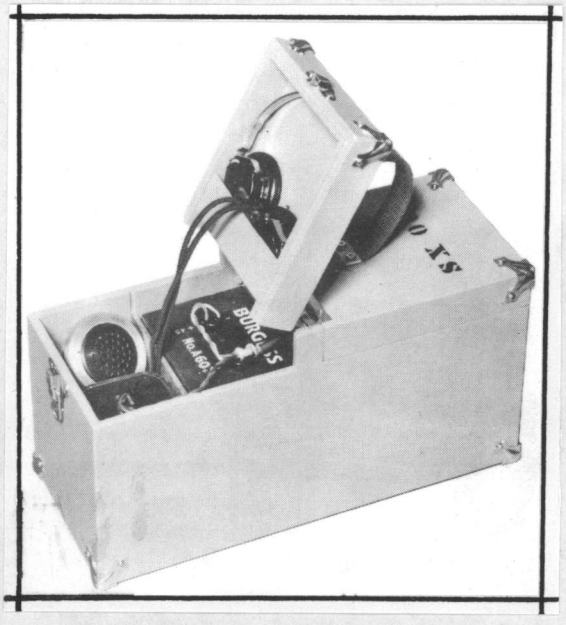
The set transmits and receives voice only. It has fifty miles maximum rated working range over optical paths. The weight of ten pounds is the portable weight with the batteries enclosed. It is a stabilized unit having extreme flexibility in application.

For use in lookouts, ranger stations, or other standby operations, it has an attachment called the SXA. This provides loudspeaker standby service and can be plugged into the SX when needed.

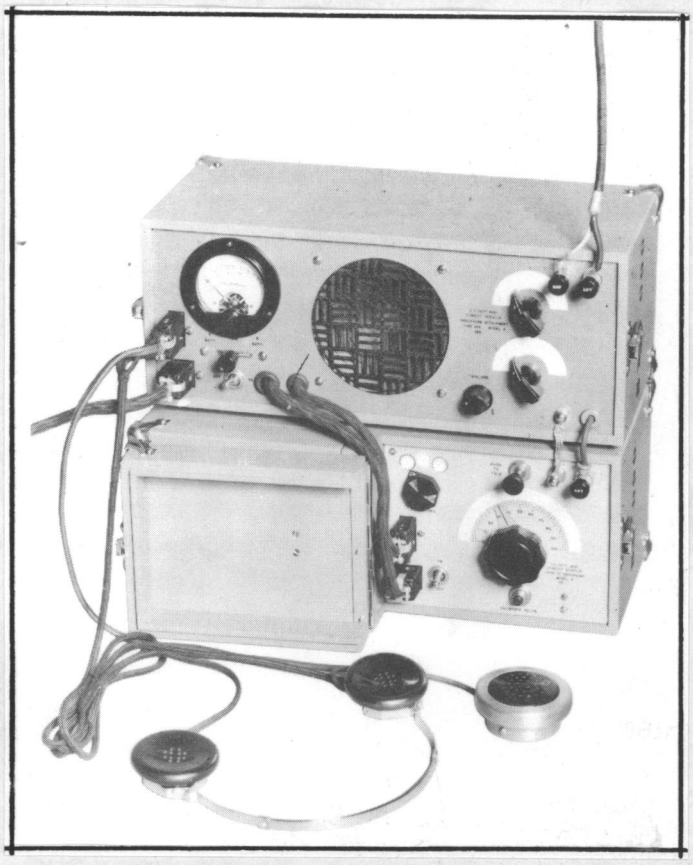
TYPE SX RADIOPHONE
MODEL A



Panel Compartment Open



Battery Compartment Open



Type SX with Type SXA Attachment
ready for standby operation.

Type SX Kit Box

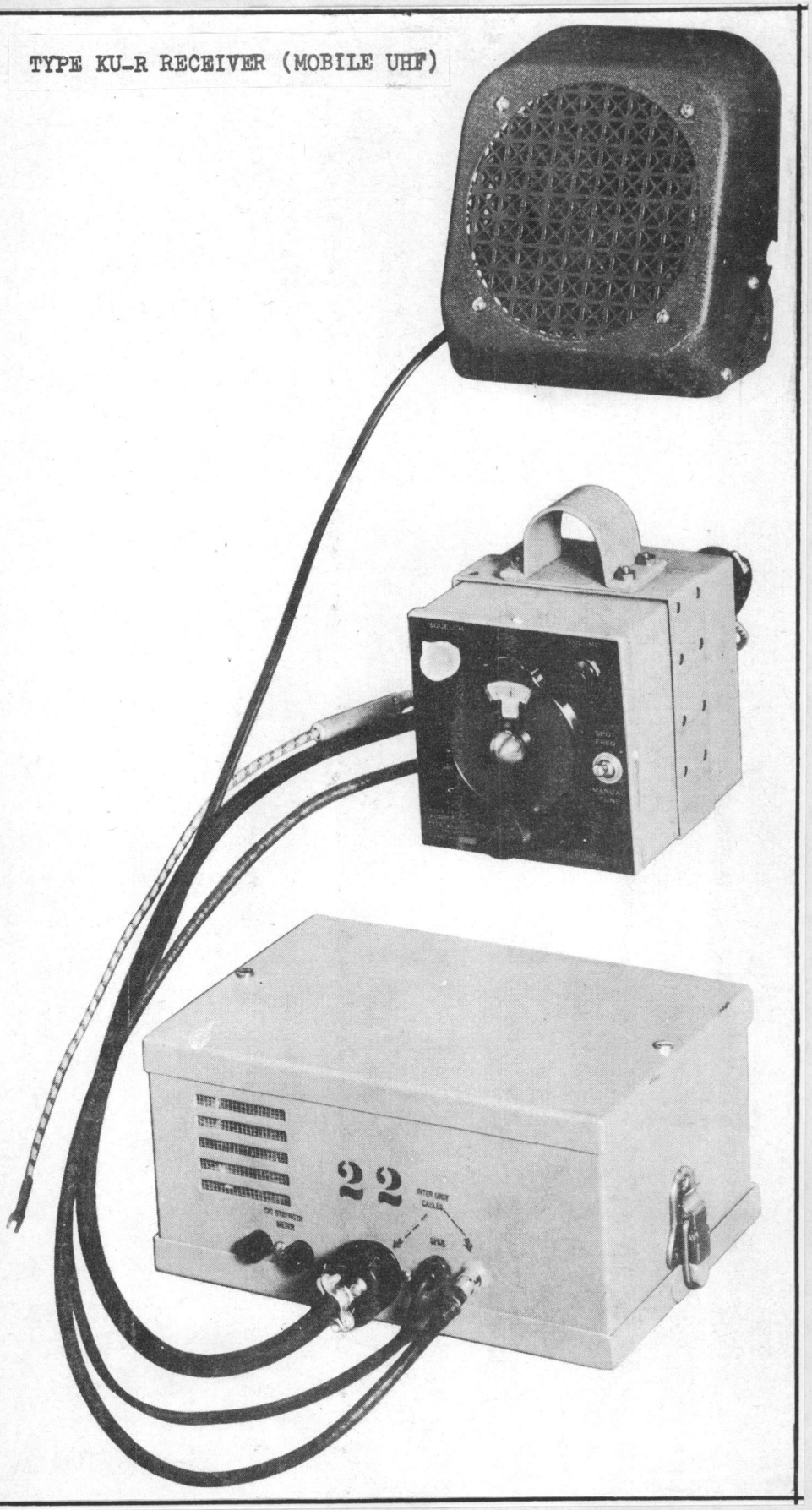
THE KU MOBILE RADIO

The KU radio has been developed especially for permanent installation in mobile equipment for use with the relay. The transmitter is known as the type KU-T2 and is a two-frequency unit having a power output of approximately four and a half watts. Either of the two frequencies are immediately available by manipulating a single panel control. This feature lends itself readily for using the relay communication system.

A short technical discussion of the receiver follows:

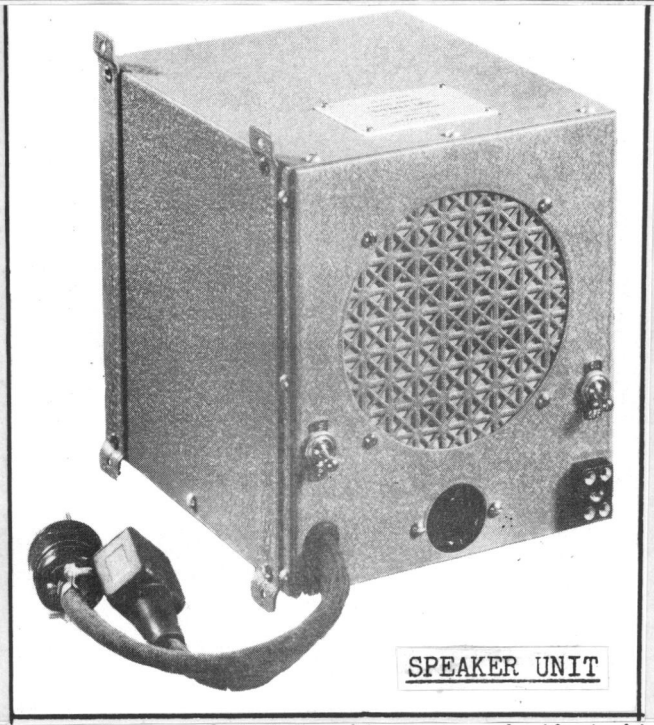
> "The new type KU-R receiver so effectively minimizes ignition interference that we can now say that reliable equipment is available for all normal forestry mobile communication problems where ultra-high frequency is desired. Provision is made in the receiver to permit tuning to any frequency in the range of 30.5 to 40 megacycles as well as for crystal-controlled spot-frequency stand-by operation. Crystal-controlled spot-frequency stand-by assures that the receiver will always be on the principle operating channel without the necessity of intermittent correction of the tuning dial." (3)

TYPE KU-R RECEIVER (MOBILE UHF)



MOBILE PATROL UNIT WITH ULTRA-HIGH
AND HIGH FREQUENCY EQUIPMENT

Type T Radiophone (UHF) Model D



SPEAKER UNIT

The size and shape of this unit are such that it can be set alongside the radiophone cabinet or attached to the end of the wood carrying case. No additional wiring or mechanical change is required to install the speaker. It is merely necessary to remove handset and battery cable plugs from the radiophone and insert them into receptacles on the speaker unit. Short stub cords on the speaker unit are then plugged into the radiophone receptacles.

SUMMARY

During the war the relay is being used intensively to protect our coast from enemy aircraft. Systems of these relays are being set up to connect the Aircraft Warning Stations with their headquarters. Wet-batteries, instead of dry, with wind chargers are used to supply the power where an attendant is near.

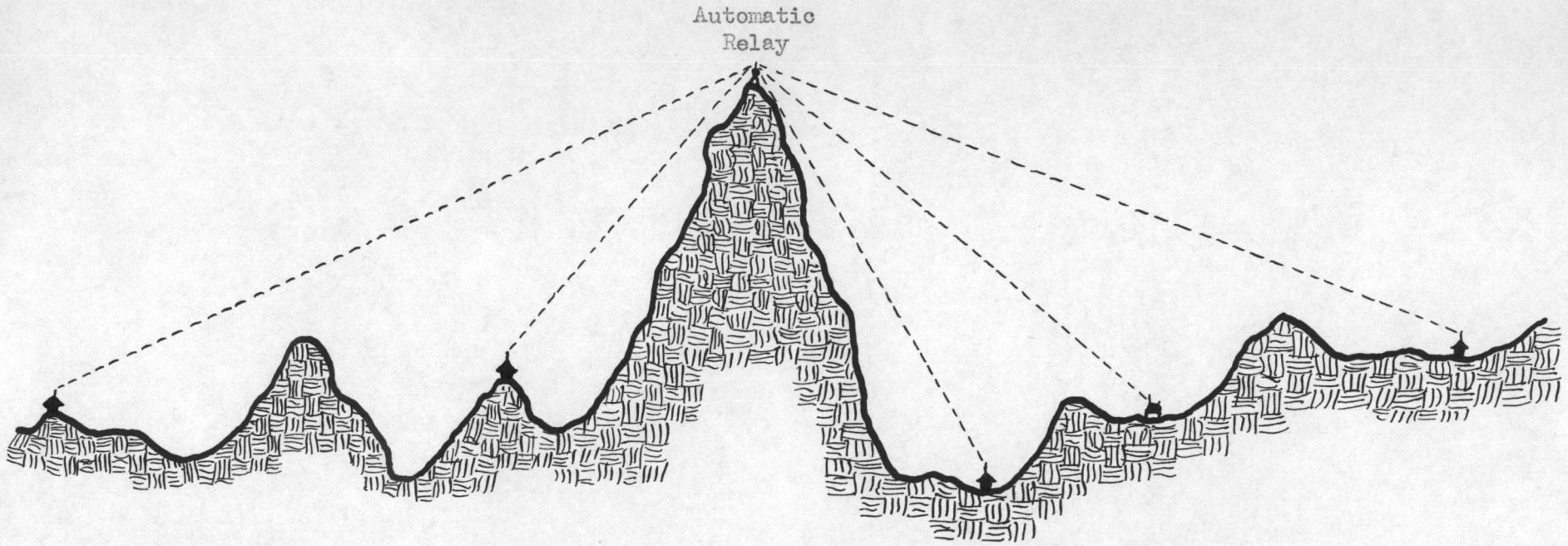
The ultra-high frequency relay system will be principally used in the communication net on large project fires. Nearly all fires will have an overlooking peak which could be utilized to reach any part of the fire line with ultra-high radios. The automatic relay, in semi-portable form, could be set up on a peak to contact the fire line from the base camp. Scouts and crew leaders would carry the small portable SX radiophone.

In fire control work in mountainous country of the western national forests, the automatic relay can be used to make communication with headquarters certain. When the small portable radios, carried by forest officers on fire patrol, cannot send the waves over the mountains, the contact can be made with an automatic relay which automatically turns on its transmitter and rebroadcasts with a powerful wave to the base station.

Searching parties hunting mountain climbers lost in the snow or snow sports enthusiasts who have gotten off the trail, have often been unable to keep track of each other by present radio devices. By means of the radio

relay, one party will be able to communicate with another directly under practically all conditions and thus may not only save time but human lives.

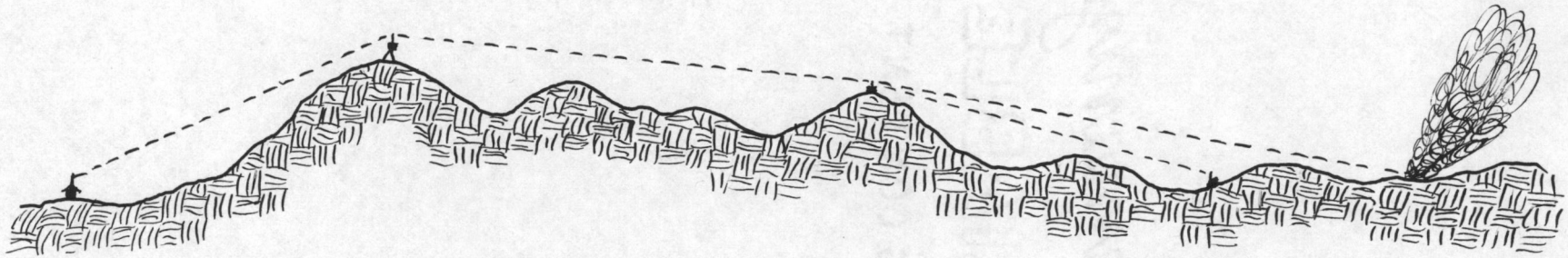
It will enable the Forest Service to make dependable use of ultra-high frequencies and thus reduce need for use of other frequencies valuable for national defense purposes. Even after the war, I believe that this system will come into full and prominent usage; if not from certain communication and low cost radios, then from the enlarged application the relay system gives to the ultra-high frequency radios.



This sketch illustrates the physical applications of ultra-high frequency relaying. The numerous possibilities of such a relay system are readily apparent from the sketch. (From "Fire Control Notes," Jan., 1940.)

Sketch A 17.

Application of the Semi-portable Relay
on a going fire.



Head-quarters
Type T
Model D

Auto-matic Relay using relay system

Semi-port-able Relay

Base Fire Camp.
SX & SXA

Fire Line
SX Radio

Sketch B 18.

BIBLIOGRAPHY

1. Laboratory Staff, "Random News Notes from the Forest Service Radio Laboratory," Fire Control Notes, January, 1940.

2. Laboratory Staff, "Random News Notes from the Forest Service Radio Laboratory, " Fire Control Notes, October, 1939.

3. Laboratory Staff, "Random News Notes from the Forest Service Radio Laboratory," Fire Control Notes, April, 1942.