RADIO COMMUNICATION

in

THE NATIONAL FORESTS

by

D. L. BEATTY

JUNE 1931

RADIO COMMUNICATION IN THE NATIONAL FORESTS.

by

Dwight L. Beatty

I.

Late one afternoon, in a park like grove of timber near Missoula, Montana, during the spring of 1927, a small group of men studied with interest a crude little contraption of coils and condensers built around a single 199 radio receiving tube. Attached were a couple of small copper wires, one stretched some 20 feet high by cords thrown over convenient limbs and the other stretched between trees close to the ground. These wires served as an antenna system for the apparatus which in spite of its small size was a fairly efficient radio receiver and code transmitter. The author had constructed it to check-up the possibilities of extremely low-power radio communication in the woods with the idea of using it to supplement the regular Forest Service telephone communication system.

Successful tests using a wavelength of 200 meters had been made over distances up to nine miles with this equipment which weighed complete with batteries, antenna and headphones less than seven pounds. It was planned to continue the tests, experimenting with wavelengths under 100 meters.

The demonstration in the grove was merely to indicate the effectiveness and feasibility of using a light weight portable code transmitter working into a central station equipped with a radio telephone of suitable power output. For the test I had rigged up an old 5 watt army phone in my residence, to represent a central station, pressing my wife into service as operator.

About 15 minutes were required to set up the little code outfit and it was then time to make the scheduled contact with the "central" station. I tuned up the transmitter and began pounding out the call with the key mounted on the baseboard of the set. After sending the call two or three times I switched over to "receive" and was rewarded with an "Okey - you are coming infine." I replied with one word; "Talk" and each man in the group then took turns listening with the extra set of headphones. They then visited the "central station" while I remained with the code equipment and exchanged brief messages with them. The code signals were put on a loud speaker at the residence and one of the group operated the phone.

This demonstration presented a fairly good picture of this scheme of communication and it seemed reasonable to expect that a good operator at the central station could handle message traffic with several portable stations.

The question will occur to many; "Why not use phone both ways?" The answer is that an extremely light weight power supply providing a

(Over)

reliable code range of 20 miles would, at best, give us a voice range of only a mile or two.

The little demonstration described, was arranged during a Fire Conference in Missoula and was witnessed by the Forester; Colonel Greeley; Assistant Forester Headley; Regional Forester Morrell; Earl W. Loveridge of the Washington Office; Theodore Shoemaker, Public Relations; Regional Forester Rutledge and Assistant Regional Forester Woods.

The group was very favorably impressed, it developed the following morning, when the subject was thoroly discussed before beginning the scheduled business of the meeting. It was the conclusion that the matter should be followed up during the coming Fall or Winter and the author, regardless of his protests and much to his dismay, was assigned the job of "follow up."

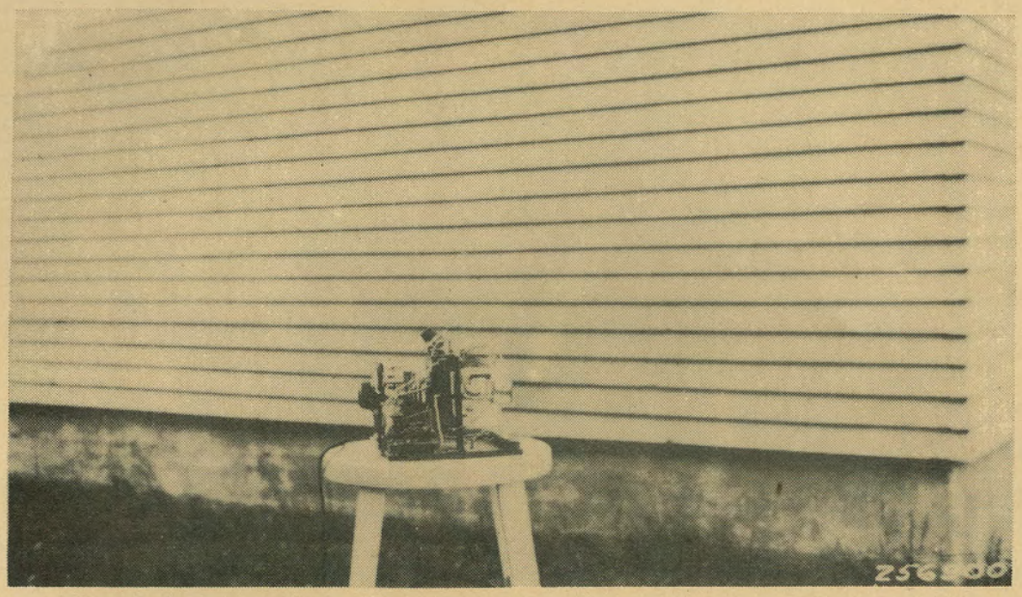
This seems to be a good place to pause in the story and fill in some essential details.

While this was the first serious consideration given to the use of low-power short wave radio communication in the Forest Service a previous attempt to use radio was made during the field seasons of 1919 and 1920. Telephone Engineer R. B. Adams was in charge of the work and the equipment used consisted of 50 watt and 5 watt radio phone sets operated by dynamotors and storage batteries. Usually a gasoline charging plant was required and the entire outfit had to be transported on pack animals. This was long wave equipment and rather elaborate and costly antenna systems were required. The sets were operated as fixed stations principally to provide communication with fire lookouts which were not connected with the regular telephone system.

The present need for radio in the Forest Service is chiefly to provide emergency communication with firemen and improvement crews. Equipment requirements for the two uses, may be briefly described as follows:

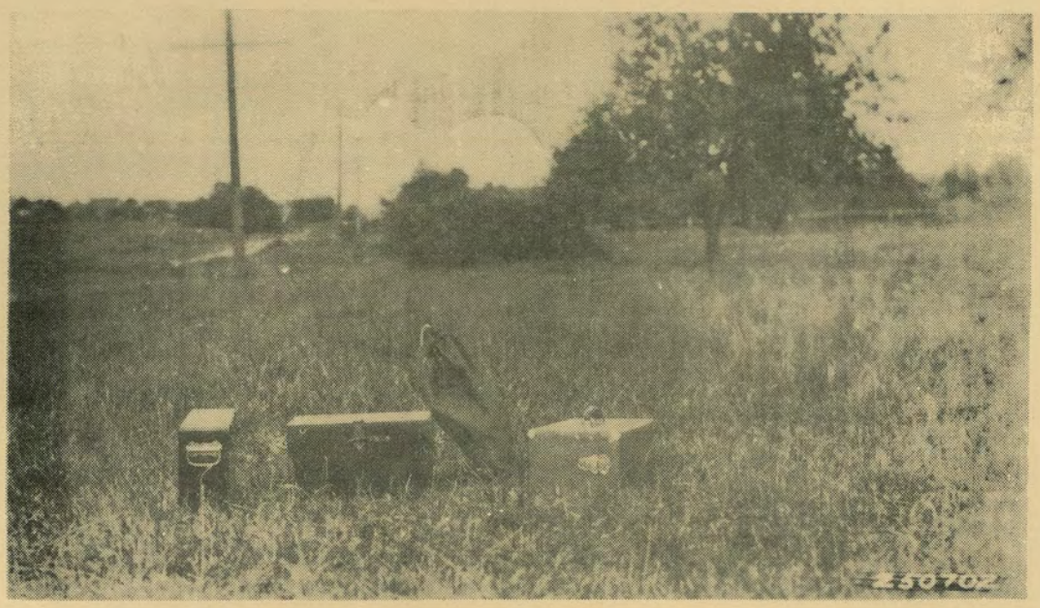
1. A low-power code transmitting and receiving set light and sturdy enough to include in a fireman's pack which would enable him to communicate with headquarters when in need of help or food supplies and for instructions when he was not within reasonable distance of a telephone.

2. A sturdy receiver and low-power code, or combined phone and code set which may be readily transported on a pack animal and quickly set up for use by small improvement crews, etc., when due to the short period of occupancy of each camp, or extreme distance from a telephone line, the crews are unable to use the latter means of communication. It would be necessary for a member of the crew to listen in at stated intervals for fire calls unless some sort of an audible radio signaling device could be developed.

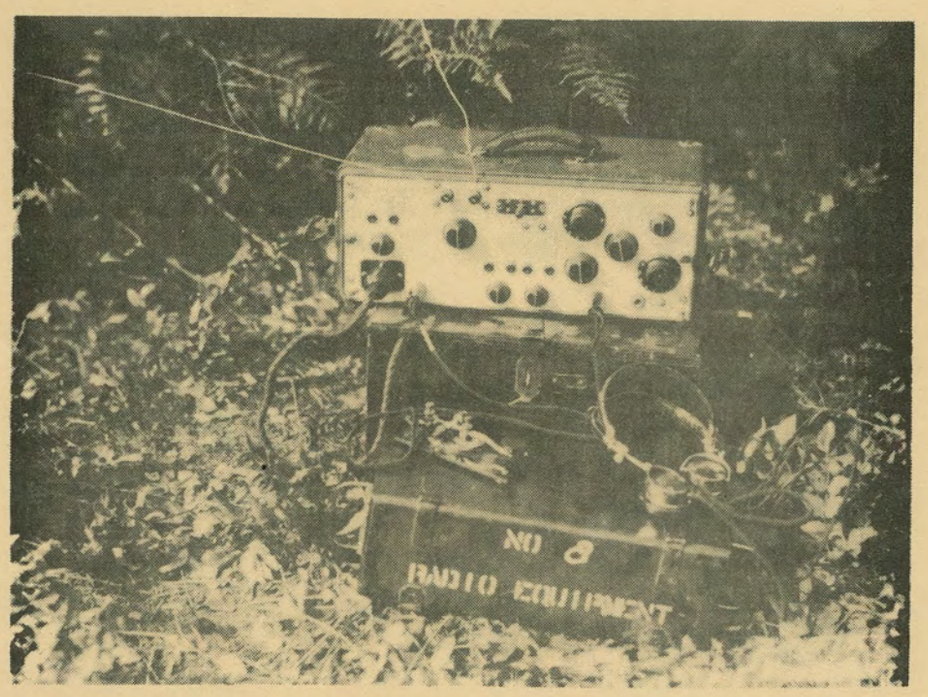


"A crude little contraption of coils and condensers."
(see page one)

Radio test set-up in open, 18 miles south of Tacoma, Washington.



1930 Field set. From left; equipment case, batteries, sack antenna equipment and combined transmitter-receiver.



1930 Field set ready to operate.

Transmitting and receiving equipment designed and built by the author for check-up work. "Set-up" in heavy timber, 18 miles south of Tacoma.

The author operating 1930 field set

The fireman's or crew set could also be used to provide communication on large fires when it did not prove feasible to secure connection with the regular telephone system.

The equipment for fireman's use, usually referred to as the "Feather-weight," while first in importance, presented an almost impossible problem with the present stage of development of radio and power supply such as dry batteries, etc. Such a set including phones, key, antenna and power supply should not weight more than 10 or 12 pounds and have a night or day reliable transmitting range of at least 15 miles.

The transmitter and receiver desired for crew use, however, seemed entirely feasible as the weight limitations were not severe. A complete weight of less than 100 pounds, with a maximum weight of 50 pounds for any single package would be okey. Specifications included the following more important features:

Since the sets would be severely jolted on pack-animals and be subject to considerable vibration in motor trucks and cars the wiring job must be exceptionally rugged. A good grade flexible wire rather than stiff bus wire must be used.

Delicate meters, usually considered essential in the operation of a transmitter, could not be expected to stand up under the rough usage anticipated. A plug-in voltmeter, to measure filament and power supply, would probably "ride" safely if packed in a sponge rubber lined compartment. The biggest problem was to find a more rugged substitute for an antenna meter. A flash-light lamp was not considered good enough to indicate resonance since a small variation in the tuning of the antenna would result in considerable difference in the output of the transmitter. The usual meter for measuring plate current could be dispensed with since the frequency adjustment of the transmitter would be set and locked before the apparatus was placed in the field.

The output power of the transmitter seemed definately limited by the radio tubes available which could be operated from dry batteries. To make possible the use of tubes of greater power output, a manually driven generator, providing both filament and plate supply, might be developed which could be manipulated by the operator at the same time he was using the transmitting key. Since the development of a generator of this type would undoubtedly prove a rather formidable job it apparently was best to start, at least, with dry battery power supply.

This limits the transmitting tube to the '01-A, '12-A or '71-A type receiving tube since the filament of these tubes draws only 1/4 ampere. The next larger tube, used so much in low-power transmitters, is the '10 type rated 7 1/2 watts. The filament of this tube draws 1 1/4 ampere which eliminated it from serious consideration since dry batteries

for filament supply would be heavy and have a very short life. The plate current drain from the "B" battery (used for power supply) would also more than double that of the less powerful tubes referred to.

In the interest of simplicity, weight limitation and battery economy, choice of receiver hook-ups is limited to the regenerative type without radio-frequency amplification. Receiver should work with equal efficiency in the reception of voice or C. W.; therefore smooth regeneration control must be provided so that the detector tube can be maintained in a condition of weak oscillation for the reception of telegraph signals or held at the point just below oscillation for phone reception. The transmitter should be simple, highly efficient, limited to a single tube if possible, and designed to deliver steady clean-cut signals. Since the sets would usually be operated by inexperienced men, tuning controls and adjustments should be reduced to the minimum and simplicity should rule in the design of the entire apparatus from power supply to antenna system.

The central station radio phone set should have an output of probably 50 watts or more. A sensitive battery operated receiver suitable for both voice and C. W. would also be required. In many locations the usual electric power would not be available so a reliable power supply for a 50 watt transmitter (or larger) may be listed as a problem presenting many difficulties.

II.

Nothing further was accomplished during the spring of 1927 but when the time arrived to continue the investigation the following check list of questions was set up:

1. What work has been done in checking up the use of radio transmission in the mountains or heavy timber, especially with frequencies around 3,000 kilocycles (100 meters) or higher?

2. What difficulties may be expected from "shadow effects"[o] in the mountains and absorption of radio energy by green timber?

3. What is the best frequency (or wavelength) under these conditions considering power limitations of field sets?

4. Is there radio transmitting and receiving apparatus on the market which would satisfy the job requirements?

5. If not can someone be found to design and build such apparatus at reasonable cost?

The search for information and advice proved very discouraging. The inquiry covered both the extreme western and eastern parts of the country and radio amateurs, heads of laboratories, army and navy experts, and Dr. Dellinger, Dr. Jolliffe and other members of the Bureau of Standards were consulted.

Opinions varied widely. The three following, copied from notes made at the time are typical:

No. 1. " it would be impossible to operate the simplest transmitting equipment with inexperienced men as they would not be able to handle code even if reduced to the simplest terms and it would be out of the question for them to keep a transmitter functioning properly. He thought that the problem of power alone made the undertaking almost impossible and he was doubtful of the success of radio communication in mountains and green timber.

[o] Radio waves and light waves differ in length but otherwise are similar; they have the same speed, may be reflected and refracted, and to some extent show the same shadows. Therefore hills close to the transmitter may cast radio "shadows" which are more pronounced for the shorter waves."

No. 2. " *** operating the sets and sending and receiving code by comparatively inexperienced men would give no trouble. He stated he was familiar with the Forests in Regions 5 and 6 and that the average man we had in our summer force would be able to send and receive messages at the rate of 5 words a minute after a week's practice. He thought the men would not have the slightest trouble in operating the sets, that dry batteries could be used for power, and that while rough topography was a handicap, it, in itself, would not make the proposition impossible. The timber situation, however, he felt was something that could not be overcome. He said he simply could not see putting up an antenna between green trees and getting out at all in a timbered region. He did not think it would be possible to reach a mile under these conditions with a power supply that could be transported by a single pack animal.

No. 3 " *** that practically no work had been done with light-weight low-power transmitting and receiving equipment which would be suitable for our needs. He stated that there had been no demand for this type of equipment and that it would be necessary for us to do our own experimental work as well as design more sturdy parts than the market afforded. He felt that, due to rough topography and dense forests in which we desired to use this form of communication, unusual difficulties were presented in addition to the weight and power problems. He believed, however, there was a fair chance for success in the undertaking.

Dr. Dellinger and Dr. Jolliffe thought the idea fundamentally sound but believed that much research work would be necessary before considering the design of equipment since the field was new and presented unusual problems due to operating conditions, power limitations, rough topography and heavy green timber. They believed the rough topography would cause shadow effects resulting in "dead spots" and that a heavy loss of radio energy could be expected in green timber, especially when an antenna system is closely surrounded by green trees. Both men considered the necessary research work a gamble but thought the chances of success were so good and the values at stake so high compared to the cost of the job that they believed the investigation was warranted.

Dr. Dellinger said they had no data which would help us and he did not know of any one who had done any work under conditions comparable to ours.

Apparently the situation could be summarized about as follows:

The proposed use of radio was not considered feasible by a large number of well informed men.

The opinion was general that "shadow effects" due to rough topography and absorption of radio energy by green timber would prove formidable obstacles. Just how serious these factors might be was little better than a guess as no data was available.

Generally accepted theory indicated that it would be impossible to use frequencies higher than 4,000 kilocycles (75 meters), due to absorption, when a transmitter was set up in heavy green timber. On the other hand it seemed probable that approximately 90 meters was the limit in the other direction due to antenna length limitations if advantage was to be taken of natural openings in the woods. Of course a loading coil might be used but it seemed obvious that sacrifice in output would result which considering other handicaps could not be afforded.

There was no portable radio transmitting and receiving equipment on the market which would meet the job specifications.

Special designs offered by various laboratories were impracticable, due in every case, to some radical departure from specifications. In these cases, of course, the designer felt that it was not feasible to meet the requirements as outlined.

"Where do we go from here" was the next question to be settled and the following "pro and con" lineup is copied from a memorandum prepared at the time;

We have now reached the point where we must size up the job from a little different angle and decide whether or not it is good business to continue the work.

1. It was planned to put some sets into service this summer providing the Bureau of Standards could give us the information we lacked concerning the effect of shadows and absorption and providing such data indicated that radio communication under our conditions would probably be successful. We are unable to get this information from any source and cannot find any agency contemplating research work of this character.

2. It does not seem wise, with so many problems to contend with, to place sets with crews. Any checking done must be under much closer control than would be possible when sets were operated by more or less inexperienced men and often in locations which would not give us the information desired.

3. The checking necessary to gain the desired information is a big job and will require a great deal of time.

4. Possible results of research work:

a. Within three or four months may find we are on a "blind trail".

b. If results are not sufficiently discouraging to warrant discontinuing the work sooner, may not finish before the close of the year 1929.

c. If data obtained is favorable we would then be ready to have sets designed and built for crew use (which was our objective in the beginning).

After a full discussion of the entire proposition with Mr. Headley, it was decided that it would not be good business to abandon the project since there was no real proof that it was not feasible.

The next job was to secure the proper equipment to do the work. This seemed somewhat of a problem since there was no portable radio transmitting equipment on the market which would be suitable for the work planned.

Before leaving Washington proper authority was secured for the use of high frequency radio channels necessary to the project and call signals 7XAP and 7XAQ were assigned.

III.

Securing radio equipment suitable for the check-up work planned, proved as difficult as anticipated, but finally, and with some misgivings, two combined transmitters and receivers were contracted for delivery August 4.

The sets were actually received September 11. They were not built to specifications, were bulky and heavy but looked fairly good - from the outside. The arrangement of parts was poor, the wiring a mess and the first audio stage of both receivers refused to work. The latter was not difficult to correct (the same error in wiring in both sets) but it proved impossible to make the receivers perform efficiently.

The location that had been picked for the work was near Newport in Eastern Washington and in this region the snow falls early. Work must be started at once if anything was to be accomplished that season and I was very anxious to make some tests which I thought would supply information that would be very helpful in planning the field work for the next season. It was therefore decided to use the new equipment as the transmitters were okey and I had some "bread-board" receiving equipment which was quite efficient and would not be too awkward to use.

The weather soon "got rough" but enough work was accomplished to give the desired index for future plans and to indicate also that a low powered radio signal would "get out" of the tall timber and have considerable pep left even after it had traveled several miles.

It was obvious that lighter, more compact and certainly more efficient apparatus would be required. Many "set-ups" could not be reached with a car therefore the outfit must often be back packed. Power and efficiency should not exceed the limitations imposed in the design of final field equipment. Apparently the best way to obtain this apparatus was to design and build it. This would also present an opportunity of working out and incorporating in the test equipment the more important principles of design which might later be used in the construction of "crew sets" if found satisfactory.

The winter was accordingly spent on this job and satisfactory transmitter-receiver sets were constructed. Aluminum cases housed the sets, which provided all the shielding necessary, and the sets were fitted in a carrying case with removable front and hinged cover which permitted coils or tubes to be changed with ease.

An 0-250 thermo-milliammeter, used for an antenna meter, and a plate milliammeter with a range of 0-50 were built into the transmitter. The tube filament voltages could be measured with a plug-in type pin-jack voltmeter.

A great deal of time was spent on receiver design. Various circuits and arrangements were built up and compared. Considerable attention was also devoted to a monitor scheme whereby the detector tube could be used to monitor the transmitter output and also serve to tune the transmitting antenna to resonance. This was worked out successfully and included in the receiving apparatus referred to above to enable checks to be made in the field of the accuracy of the proposed tuning method and also to determine whether or not it would be reliable in the hands of comparatively inexperienced men.

IV.

The most suitable area for the field check-up work that could be found is located a few miles south of Tacoma, Washington. A large, flat, heavily timbered country fairly free of wire lines and streams is available here and it is not far to rugged, heavily timbered mountains. Both areas are well supplied with good roads.

The first job was to attempt to learn what happened to the strength of a radio signal put "on the air" from an antenna system closely surrounded by heavy timber as compared to a signal of equal strength started on its way from an antenna located in a space entirely free of timber.

To accomplish this, identical antenna systems were erected in the timber and in a clearing, the distance between them being one fourth mile. In every test, length of wire, height, etc. were carefully measured and the systems laid out with the aid of a compass to prevent any possibility of error due to directional effects of antenna.

The timber in the area referred to is principally large fir having a diameter of from 2 to 6 feet, a height of 200 feet or more, with an understory of young fir and cedar. Some reproduction and a great deal of vine maple and other brush covered the ground.

The bent form of the Hertz (antenna and counterpoise) was used for this and other test work since it gave as good results as several other schemes tried and was much easier to set up in timber. In the timber set-up the antenna and counterpoise was stretched between large trees, other trees and brush crowding closely but without limbs or leaves actually touching the wires. Directly above the antenna the sky was only visible thru a few small openings in the heavily branching crowns of the larger trees. The height of the antenna was 15 1/2 feet and the counterpoise 3 1/2 feet. The length of both varied with the wavelength used of course.

A "recording" station was established 6 1/2 miles, airline, north of the test set-ups described, with a shielded receiver, vacuum tube voltmeter and low-power combined phone and code transmitter, for apparatus.

During the tests, signals were transmitted at regular intervals from a station in the outskirts of Tacoma, which was twelve miles north of the recording station and eighteen and one-half miles from the timber "set-up". These signals were used to check possibility of error at the "recording station" which might occur thru faulty handling of the receiver and vacuum tube voltmeter or variation in signal strength due to interference, fading, etc. The operator at the Tacoma station also recorded the signal strength of the test transmitter.

This arrangement of stations and the equipment proved satisfactory. The most serious obstacle to rapid progress of the work was static and electrical interference. If either was at all severe the vacuum tube voltmeter could not be used, therefore, the loss of several hours and even the entire day was of frequent occurrence. It was also found difficult to measure the strength of 90 meter signals during the late afternoon due to swinging or fading, so work on this wavelength had to be completed before 3 p.m.

Toward the close of the summer transmitting and receiving stations were located in the mountain country adjoining Rainier Park to determine, at least in some rough measure, what difficulties might be expected from "shadow effects" in rough topography.

In nearly all cases the transmitter was set up in timber and close to the base of the mountain range across which transmission tests were made.

The results obtained may be summarized briefly:

It was found that the loss in signal strength due to placing the antenna in heavy timber as compared to a location free of timber was approximately 25 to 35 per cent when operating on wavelengths of 55, 72 and 91 meters. However, using dry battery plate supply of 180 volts and a 112-A tube in the transmitter, the signal was received - in flat country - with ample volume during daylight, at a distance of 40 miles when operating on a wavelength of 91 meters, and with greatly increased volume (during daylight only) when working on 55 meters.

The receivers, in all cases, were without radio frequency amplification and only one stage of audio was used. The total "B" supply for the receivers was 45 volts and the tubes were type '99.

It has occurred to me that the losses referred to above may be due to both absorption and shielding or shadow-like effect of the heavy timber surrounding the antenna.

It was found that dry but green vine maple brush making slight contact with both antenna and counterpoise wire of the transmitter caused a loss in signal strength of about 38 per cent.

A few limbs of brush touching only antenna or counterpoise resulted in a loss of 20 to 25 per cent.

Raising the antenna 10 feet increased the signal strength approximately 20 per cent. In most timber this additional height would not be feasible, however, since considerable trimming of over-hanging branches, that could only be reached with great difficulty, would be necessary.

When the test transmitters were set up in the mountains, the loss in signal strength due to "shadow effect", was serious during daylight hours when a wavelength of 91 meters was used. At night the "shadow" seemed to disappear, the signal apparently being as loud as it would have been in level country.

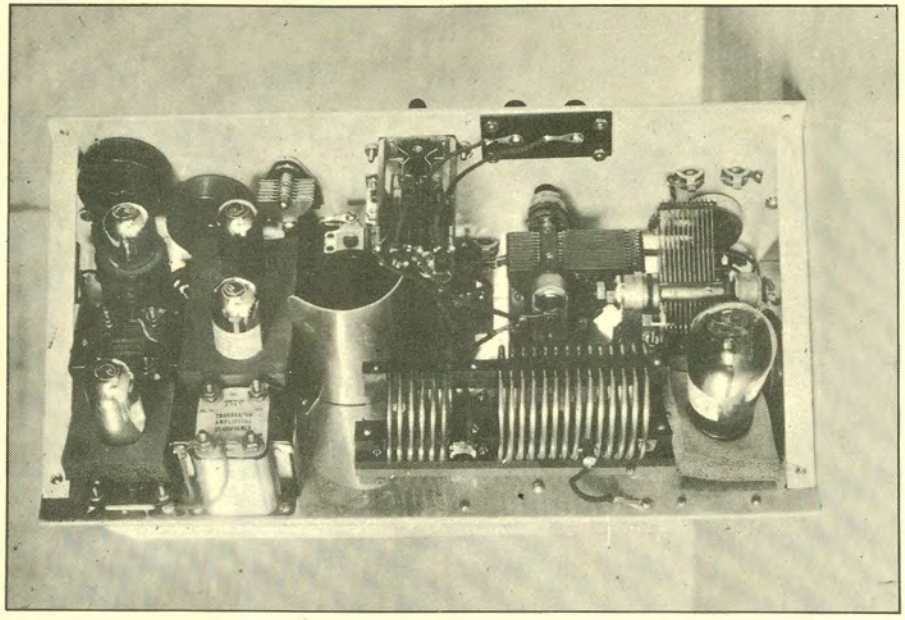
A fifty-five meter signal, however, was apparently free from "shadow effect" during daylight and came thru with excellent volume. At night the fifty-five meter signal entirely disappeared due to skip effect.

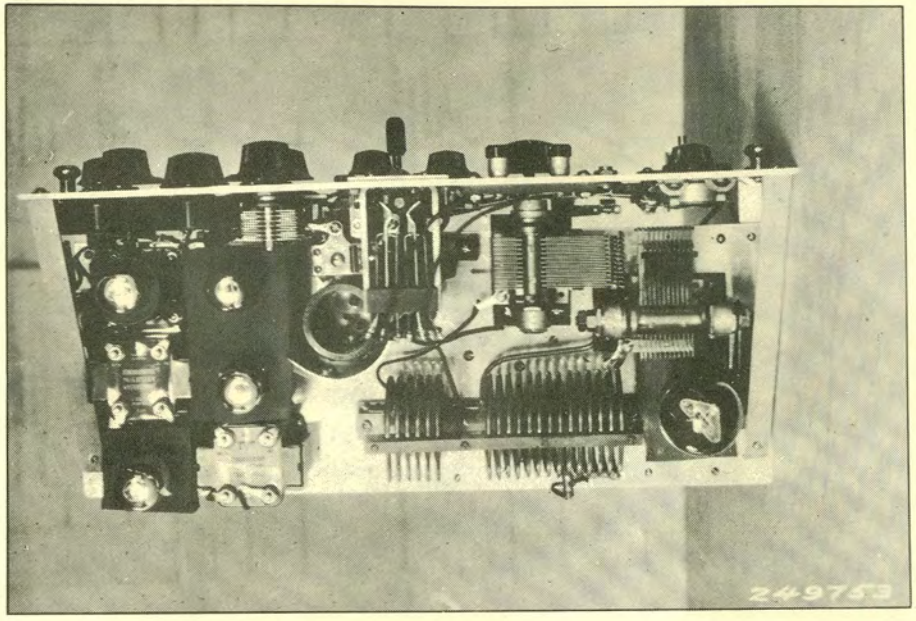
The great difference in signal volume between the two wavelengths about mid-day is interesting. The 91 meter signal at that time could just be copied solid with the headphones clamped over the ears while the 55 meter signal could be easily read when the phones were lying ten feet away. This difference and the signal strength described varied little whether the receiver was five or twenty miles from the transmitter or the intervening ridges 1800 or 3000 feet high. The 55 meter signal did not seem to vary during daylight but 91 meters picked up in volume about 4 p.m., increasing steadily until dark but swinging considerably toward sunset.

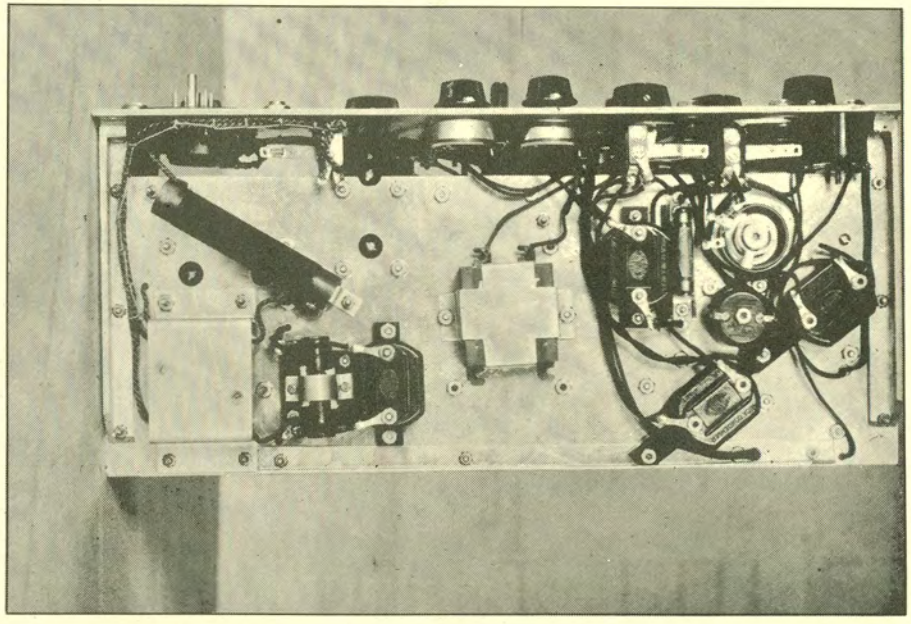
A few 72 meter tests were made and this wavelength proved much better during daylight than 91 meters in both rough topography and timber.

These results indicated clearly that the project was feasible and the next step was the design and construction of a field set for use with improvement crews.

A test station located near Rainier National Park. Antenna pole and counterpoise support in foreground.

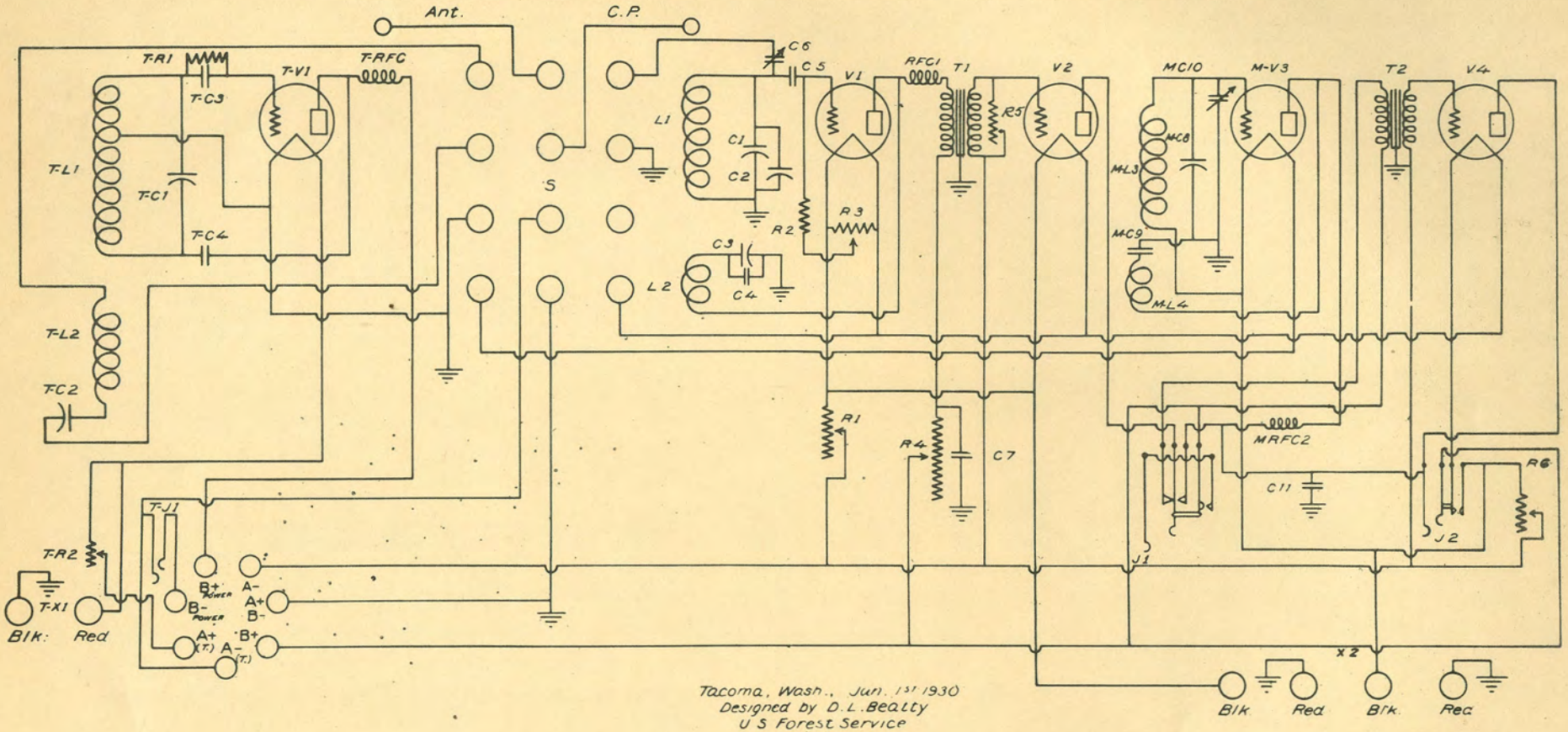






Three views of the interior of the 1930 field set. The lower left shows parts mounted under subpanel.

COMBINED PORTABLE TRANSMITTER-RECEIVER



Tacoma, Wash., Jun. 1st 1930
Designed by D.L. Beatty
U S Forest Service

The portable field sets were operated on 3265, 3445 and 4135 kilocycles during 1930 and the central phone station on 3385 kilocycles. Most of the portables, however, were set for the frequency channel 3445 kilocycles (87 meters).

The Columbia Forest, east of Vancouver, Washington, and north of the Columbia River, was selected for the final test of the proposed radio communication system. A radio phone transmitter, kindly furnished by the Northern Electric Company, Seattle, was established at the Hemlock Ranger Station, which is located about 11 miles north of the town of Carson, Washington. This station, headquarters of the fire despatcher for the Columbia Forest, Mr. Mann, served as the "Central" of the radio system.

July 3 the phone set was on the air and on July 4 hourly contact was maintained with a portable radio set located on the Dog Mountain Lookout which is about 12 miles air line southeast of Hemlock. On this date a report of a fire was transmitted by the lookout and several messages concerning the lookout's work were exchanged. During the entire summer radio furnished the only means of communication with this lookout. Communication with the other portable radio sets was established during the next few days.

Seven portable sets were located at various points on the Forest, one with the lookout referred to above and the other with improvement crews.

In nearly all cases the portable sets were placed with crews that had no other means of communication. The air line distance between portable stations and the central station varied from a few miles to 40 miles.

Due to power failure on account of low water, the phone transmitter could only be used intermittently after the first of September. Cummunication was maintained however, with a low power code set at Hemlock. It was found that the phone transmitter gave good coverage using 50 watts output if nearly 100% modulated.

One serious handicap was poor receiving conditions at Hemlock due to electrical interference from the power plant at that point. Signals which were easily readable with the power plant shut down were entirely inaudible with it in operation. It was necessary of course to operate the plant to supply power to the transmitting equipment. This meant that the signals from the portable sets had to be powerful enough to be heard above the interfering noise, to be received at the central station. Signals which could be copied with ease outside the range of the power noise were not readable at Hemlock. This condition prevented much of the test work planned.

The performance of the portable equipment, considering the receiving condition described plus a great deal of trouble from static, is remarkable. The records show a 94% or better message transmission reliability from the portable transmitters working over distances up to 40 miles and across the roughest topography. The 6% or less failures of the portable transmitters were due almost entirely to weather conditions. These sets gave little mechanical trouble and there was little tube loss tho the sets were back packed, transported on pack animals, hauled in automobiles and in trucks. One defective battery cable and a shorted equalizing condenser sums up the total trouble shooting.

With the exception of Mr. Squibb, who operated a portable on the Dog Mountain fire and handled the phone transmitter during the last half of the season, the men using the portables were not familiar with radio equipment and only one had learned the code before beginning work. Each was given two or three days rather sketchy training before going out "on his own". They had practically no trouble operating the equipment. They were able to send in orders for supplies and reports of various kinds from the start and in a couple of weeks were sending clearly 6 to 8 words per minute. I believe the monitor, which enabled them to hear their own signal, had a lot to do with the success in transmitting. The men practiced receiving code also for emergency use but it was several weeks before they were able to receive at a worth while speed.

During the season the operator at Dog Mountain sent 90 messages with a total of 3,173 words, traffic from the other stations varying from 200 to 700 words. Less important messages not recorded would undoubtedly much more than triple these figures. In recorded messages the central phone station transmitted from 200 to 800 words to the various portable stations. The heaviest traffic was with fire camps. On the Dog Mountain fire 52 messages totalling 1,503 words were "put on the air" with a portable set and 54 radio phone messages totalling 1,231 words were received from the central station (the fire dispatchers headquarters) at Hemlock. Unrecorded messages about double these figures.

While the records show a 95% message transmission reliability for the portables in spite of power plant noise at the receiving station, at times messages were copied with considerable difficulty and repeats were often required which slowed up communication. Therefore if it is planned to use such low power equipment one of the requirements is a central station location free from power, noise, etc. Even then static during the summer months will make receiving of low power signals difficult at times.

Forest Supervisor Bruckart's description of the use of radio on a project fire is of interest:

"One of the best tests we have had an opportunity of making with radio communication was in connection with the Dog Mountain Fire that burned over 1800 acres of National Forest and private land in the State protective unit, along the Columbia River, about 7 miles east of Carson. Within a half hour after the first Forest Officer arrived on the fire, which was located about 6 miles from the nearest Forest Service or commercial telephone line, communication was established with the central station at Hemlock. A large number of messages were exchanged during the course of this fire and greatly facilitated the efforts of the Forest Officers in handling the work on the fire. A second set was placed in operation at a Forest Service camp established the morning of the third day after the fire started. Both sets operated very satisfactorily and the first set to be installed was kept on the fire at the State fire camp for a period of about 2 weeks. Forest Service crews worked on this fire about 6 days after which time the State crews took over the entire fire. State Fire Wardens, after they used the radio a few times were very enthusiastic regarding this form of communication and were very reluctant to have the set at their camp moved, even after the fire had been reduced to a patrol basis and but 6 or 8 men remained.

To have established telephone communication with fire camps on the Dog Mountain fire, we would have had to put out about 13 miles of emergency wire a large part of the distance thru rough country away from any road or trail. It would have taken 3 men and a pack string at least 3 days to get this line in to the fire and later we would have had the expense of reeling up the wire after the fire was out."

Mr. Mann's mid-season comments are of particular value:

"Being right under the gun, so to speak, I thought perhaps you would like to get my slant on radio communication as I have seen it. Frankly, I have been rather skeptical as to whether dependable communication was possible with sets sufficiently portable to lend itself to our use, that is, one that could be back-packed for several miles. I have also been skeptical as to whether inexperienced operators could, with only a very little training, get their stuff across. I thought it would require experienced operators, not only because they could handle the code, but to keep the equipment in adjustment. I find after one month's observation that this is not true.

"On account of the amount of travel along the Columbia Highway on the Mt. Hood Forest, it was decided this year to use Dog Mt. on the north side of the Columbia River as a lookout point to cover this stretch of the Columbia River Highway. Incidentally, this point is on and covers a considerable part of the Columbia Forest. To have connected this lookout by telephone would have required at least 12 miles of line of very difficult construction and it would have been out of the question to construct it this year. When we found that the portable radio sets would be available this year, it was decided that one would be placed on

Dog Mt. I scouted around considerable for an operator as I did not want to slip up and have too much delay on getting fire reports. I did not seem to have much luck in finding a good lookout man, one who was willing to live up on this high windy point and who was also an operator. Finally, I approached Bob Walker, a young chap who had worked for us before and whom I knew to be somewhat interested in radio. Bob said he didn't know much about it but he would like to give it a trial, so I loaned him a buzzer telephone and wrote out the code. He learned the code and practiced it on the buzzer a few evenings. On July 3 he was sent to Dog Mt., made contact that night, and on July 4 we got his first message. Since that time we have had a practically unbroken 15 minute to one hour schedule with two exceptions; one time a loose battery connection caused trouble and he could not get thru. When this happened he loaded the set in a pack sack, packed it down to the highway, caught a ride, came to Hemlock, got the set repaired and wanted to return to Dog Mt. that night, but I insisted that he wait until next morning. On July 13 a fire on Dog Mt. threatened to wipe out the lookout's camp. Bob frantically called in and asked me what to do. I told him to bury what equipment he could and beat it, but to wrap his radio in a blanket, dig a hole and cover it up. This he did and came off the Mt. in record time and, by the way, a goat which he has for company and also for milk was right at his heels bleating every jump. After the fire danger had passed he went back to his camp which fortunately had not burned, dug up his radio and has been making regular contacts since. Walker's time in getting in a complete fire report is about 3 minutes, a very little longer time than by telephone. He has reported many fires as the log book will show.***

In a trail camp on Lewis River where Fred Good has one of the portables it is the only means of communication. Good had never had any experience with sending apparatus. Within one week he was putting out an order for groceries, canvas gloves and "snoose" for the Swedes.

I am not skeptical any more. The sets are working, schedule after schedule, the inexperienced men are getting their messages thru. I sometimes believe the inexperienced, where they are interested, will work out the best. They will try to do as they are told. It is yet too early in the game to make a comparison between radio communication and emergency telephone lines, but I do know now that we will establish communication with isolated trail crews and fire camps much quicker by radio, and we well know that quick action is what counts on fires in the old burns such as we have on the Columbia."***

The addition of voice (radio phone) to the portable sets which could be used for short distances under fairly favorable conditions would be of great value if the addition did not make the operation of the transmitter too complicated.

A microphone with microphone transformer connected in the plate supply lead meets this requirement as only a single additional switch would be needed. This scheme was tried out during 1929 and was found reliable for distances of from 5 to 8 miles.

A featherweight transmitter and receiver looks somewhat simpler since the '30 tube became available, as this tube has proven to be a good little transmitting tube, is rugged and may be operated with a very light filament battery. This piece of equipment, however, presents at best a stiff problem due to the extreme weight limitations.

From the results obtained it seems reasonable to conclude that low-power radio communication may be successfully used in mountain and timbered regions and that it may be expected to be of material aid in the protection and administration of large forest areas.

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A P P E N D I X

List of Parts, Portable Transmitter-Receiver
Designed by D. L. Beatty,
Forest Service, 1930.

C1	Condenser, variable, midget, capacity .000050
2	" " " 2 plate, space between plates 1/4"
3	" " , equalizer, capacity 20 to 100 mmfds.
4	" , Fixt, .00015
5	" " .00015
6	" Variable, midget, 3 plate.
7	" By-pass Fixt, 1 mfd.
MC8	" Variable, midget, 3 plate
9	" Fixt, .001
10	" Variable, equalizer, capacity 20 to 100
C11	" Fixt, .002
L1&2	Plug-in coils
ML3&4	Coils wound on bakelite tubing 1 1/2" outside diam. length 2 1/2".
R1	Rheostat, 20 ohms.
2	Grid-leak, 5 megohms.
3	Variable resistor, 400 ohms.
4	" " 50,000 ohms, 3 taps, bakelite case
5	" " 500,000 " " " " " (with off position)
6	Rheostat, 30 ohms.
R.F.C1	Radio Frequency choke
2	" " "
J1	Two circuit filament lighting jack
2	Single " " control "
T1	Transformer, ratio 4-1
2	" " 2-1
V1-4	Four spring type sockets & tubes.
X2	Two pair insulated phone tip jacks (red & black)
TC1	Condenser, variable, .0005
2	" " .0005
3	" Fixt, .0005
4	" " .002
TL1&2	Plate & Antenna coils, made of 1/8" copper tubing
TR1	Transmitting grid-leak, 10,000 ohm, 20 watt
2	Rheostat, 10 ohm
TRFC	Transmitting choke
TJ1	Open circuit jack
S	Anti-capacity switch, 4 pole double throw
P	Battery cable & pluge
TV1	Tube socket (spring) & '12-A tube
TX1	One pair, insulated phone tip jacks (red & black)

Head-phone, key, voltmeter, binding posts, hook-wire, etc.
Copper antenna strand wire, Roebling's
Sons 7 x 22, B & S, H.D.

OPERATING RULES

A Portable Station calling will make the call by transmitting not more than 3 times the letter Q and word DE, followed by the calling stations own call number not more than 3 times thus: Q Q Q DE 3 3 3. This should be repeated once, then the portable station operator should listen for an answer from the operator of the central phone station, who will give call of station (W 7 X A Q) and tell him that the central phone station is ready to take message.

The portable station will then send the message or messages (each message, if more than one, should be ended with the word AR) concluding with the word SK (end of work) followed by station's call number repeated three times.

The portable station operator will listen while central station operator repeats message received and if entirely correct will send the letter R (meaning OK) three times signing call number as usual. The portable station will then listen for the central station operator to sign off.

All contacts will be concluded by the central station signing off.

When the portable station is calling on one of regular schedule periods and does not have a message to transmit, the call shall be made thus:

Q Q Q DE 3 3 3 SK and repeat once.

The portable station operator will then listen for an acknowledgement, the correct time, and any messages from the central station.

When the portable station operator is unable to understand a phone message, he will send rpt (repeat) and his call number.

INSTRUCTIONS

PORTABLE RADIO EQUIPMENT

ANTENNA SYSTEM

The total length of antenna is _____ feet.
The total length of counterpoise is _____ feet.
Height of antenna above ground should be 15 feet.
Height of counterpoise above ground should be 3 ft. 6 inches.
Tree limbs, leaves, brush, etc., should not touch antenna or counterpoise.
Reasonably level ground under the counterpoise is very desirable.
Before attempting to use transmitter, be sure antenna and counterpoise are tight and do now sway with the wind.
Slacken guy ropes in wet weather when transmitter not in use.

Place radio set on battery box or dry pieces of wood. Do not set on damp ground except in case of emergency.

Connect antenna and counterpoise wire to binding posts on panel, keeping wire free from case and arranging wire so it will not vibrate.

Plug in battery cable connector.

Plug volt meter in tip jacks (black and red) at point marked 5 volts. Turn rheostat (immediately under meter) until arrow points right. With switch on center ("Off" position) meter should read approximately 6 volts, which is the total voltage of the A battery on the transmitting tube.

Throw switch to "Transmit" position and adjust rheostat (immediately under meter) until meter reads 5 volts on lower scale. Keep filament at this voltage at all times. This should be checked frequently when transmitting.

Throw switch to "Off" position.

Now move meter to first unmarked tip jacks (black and red). Meter should read total voltage of "A" batteries for receiver (about 4 1/2 volts) with switch on "Off" position.

Throw switch to "Receive" position and adjust rheostat (immediately under meter) until meter reads 3 volts. Keep filament at this voltage at all times. (If these tubes are burned at a higher voltage than 3 volts, they will be ruined in a short time.)

Now move meter to last paid of pin jacks plugging phones in second stage jack and adjust last rheostat to 3 volts. Keep filament at this voltage.

Meter should now be removed. (It draws considerable battery current so should never be left plugged into pin jacks.)

To test "B" batteries, plug meter into meter base (which contains a resistance) and use cord tips, which are attached to meter stand, to make contact with "B" battery terminals (inside battery box). Then read upper scale. Caution: Always use meter stand when testing more than 6 volts. A higher voltage than this without using stand would probably burn out the meter.

When the four 45 volt batteries, which provide 180 volts for transmitting power, drop to 160 volts, new batteries should be obtained.

The next step is to tune the antenna for transmitting.

To do this turn "Ant. Cond." knob to your right as far as possible. (This opens the antenna condenser.) Now plug in key, throw switch to transmit, close key and turn "Monitor" dial until you hear note of transmitter. Adjust Monitor dial to zero beat. Now turn "Ant. Cond." knob to left (which closes condenser) very slowly. You should hear signal (still keeping the key closed of course) as tuning shifts out of zero beat which will almost or completely die away, then as condenser is turned still more to the left, the signal will again be heard. With the antenna condenser in this position, the antenna system is tuned exactly to the frequency of the transmitter. To obtain a steady signal, however, it is necessary to operate the antenna slightly "off tune".

The next move then is to turn the Ant. Cond. back (to your right) about 1/8 inch, adjust monitor to loudest note, and use key to determine whether or not signal is steady. If note breaks, turn Ant. Cond. about 1/8 inch more to right, adjust monitor and check again. Repeat until note steady.

Always keep the monitor tuned so you will hear your own signal when transmitting. This will help your keying and you will know immediately if your antenna starts to swing or if any other trouble develops in your transmitting equipment. Remember your signal sounds to the other follow the way it sounds in your monitor. If your signal is breaking or swinging he probably will not be able to read you.

To use receiver, throw switch to "Receive" and turn "Reg." (regeneration) knob to right until rushing sound is heard in phones. Turn "Tuning Cond." dial slowly to right, adjusting regeneration control as may be necessary. When the signal of a station is heard, it can be tuned in roughly with the tuning condenser then cleared up with the trimmer condenser (which should always be set with the arrow pointing straight up when starting to tune in a station) and adjustment of regeneration.

When receiving voice the adjustment of the regeneration control knob is very critical, unless the receiver is located rather close to the

transmitting station. Use as little regeneration as possible. The slightest movement of this control when near the "critical point" may make reception either good or very poor.

The second stage should only be used when the received signal is too weak to understand on the first stage.

The volume control may be used to cut down too loud a signal, especially when the second stage is used, or to soften static noise.

Be sure that the volume control is left in the off position (arrow pointing straight up) when not being used.

WARNING: When you have finished operating set disconnect battery cable plug.

CODE FOR USE WITH RADIO RECEIVING AND SENDING SETS

"N" to be key letter preceding all needs
Need (6) more men: N 6 M
Need (6) more men with tools: N 6 M T
Need (6) more men with tools and grub: N 6 M T G
Need (6) more men with tools, grub and blankets: N 6 M T G B
Need (6) more men with tools, grub for 5 days and blankets:
N 6 M T 5 G B
Need assistance of district ranger: N R
Need assistance of Chief Fire Guard: N C F G
Need 2 set Fallers: N 2 F
Need 2 " " with tools: N 2 F T
Need grub: N G
Need grub 5 days: N G 5
Need grub 5 days for 5 men: N G 5 M
Need pumper and hose: N P H
Need pumper and 1,000 ft. hose: N P 10 H

Amount of hose wanted, to be stated in
hundreds of feet.
If 500 ft. wanted, state 5 H;
1,000 ft. wanted, 10 H, etc.

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"S" to be key letter preceding messages to adjustment of set, etc.
Need assistance to adjust set: S A
Set does not receive code or voice: S C V
Voice fades: S F

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"F" to be key letter on all messages giving information on fires:
Fire in NE 1/4 S 16, T 6N., Range 6 E: F N E 16 . 6 . 6
Fire 5 acres: F 5 A
Fire in old burn, snags: F O B S
Fire in old burn, no snags: F O B N S
Fire in green timber: F G T
Fire on steep slope: F S S
Fire on steep south slope: F S S S
Fire quiet: F Q
Fire out: F O
Fire spreading rapidly; F S R (N.E.S. or W)
Fire crowning: F C
Fire work finished - Wish orders: F F W O

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"W" to be key letter preceding all messages relating to weather conditions:
Clear: W C
Temperature: W 60
Wind NE 12 miles: W W NE 12
Humidity 60%: W H 60
Cloudy: W Y
Part Cloudy: W P Y
Rain, trace: W R T
Heavy showers: W H S
Lightning storm: 6 miles NE: W L 6 NE
Lightning strikes 1 mile east: W 6 L 1 E
Lightning in vicinity of camp: W L C

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Regular Continental code for alphabet and numbers and the following symbols:
Period: ....
Question .. - - ..
O.K: . - . (R)
End of message: . - .-. (AR)
End of work: ... -.- (SK)
Repeat: . - . . - - . - (RPT)
Test signal: ... - (V) Send string of V's.
Wait: . - ...
Go ahead: - . - (K)
The following is a partial list of Q signal which can be used.
QRK? How do you receive me?
QRK I am receiving well.
QRQ? Shall I send faster?
QRQ Send faster.
QRS? Shall I send slower?
QRS Send slower.
QRL? Are you ready?
QRL I am ready.
QRX? Shall I stand by?
QRX Stand by: I will call you when required.
QRJ? Are my signals weak?
QRJ You signals are weak
QRK? Are my signals strong?
QRK Your signals are strong.
QTR? What is your exact time?
QTR My exact time is
QSZ? Do you wish me to send each word twice?
QSZ Send each word twice; I have difficulty in receiving you.

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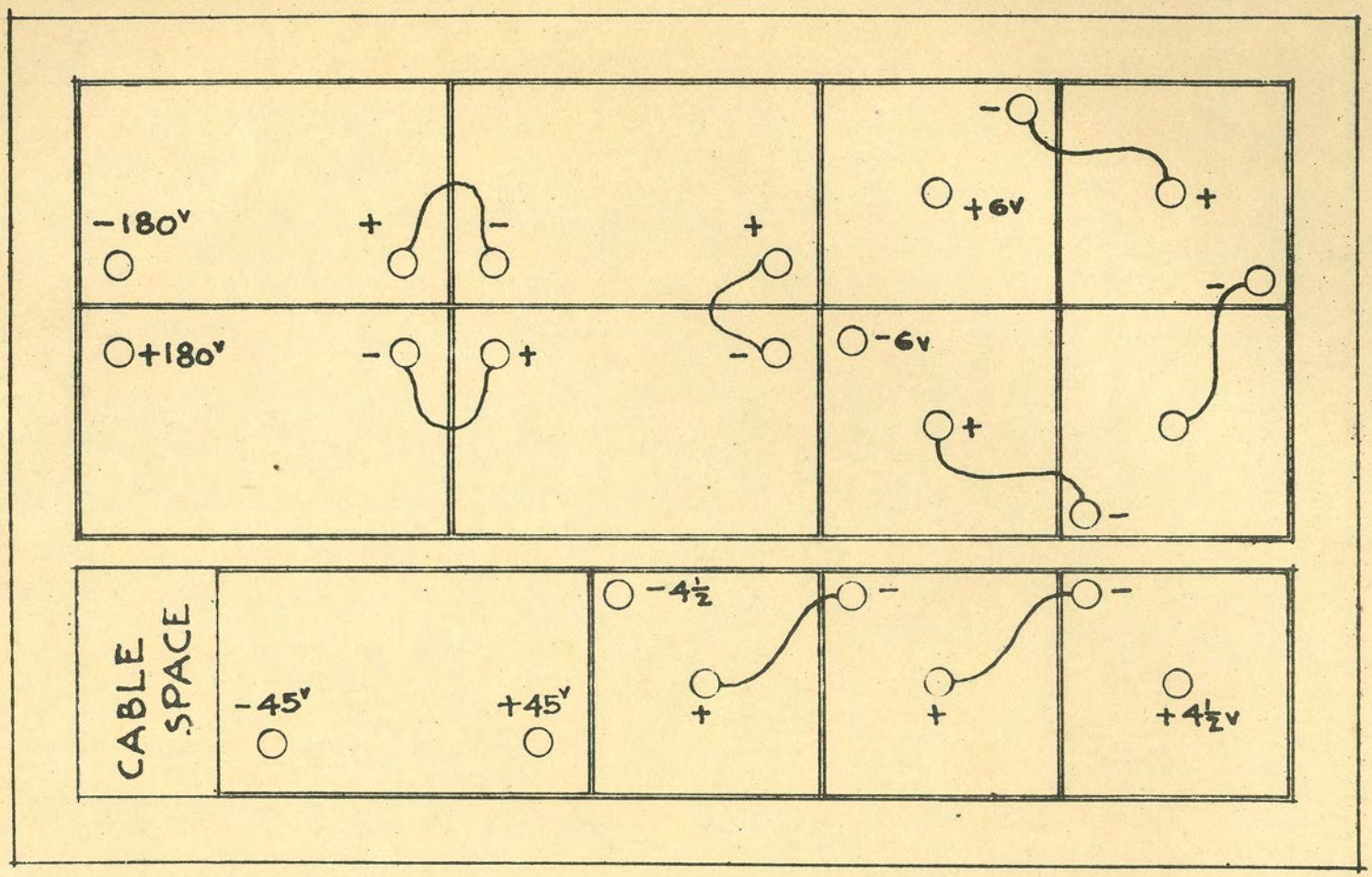
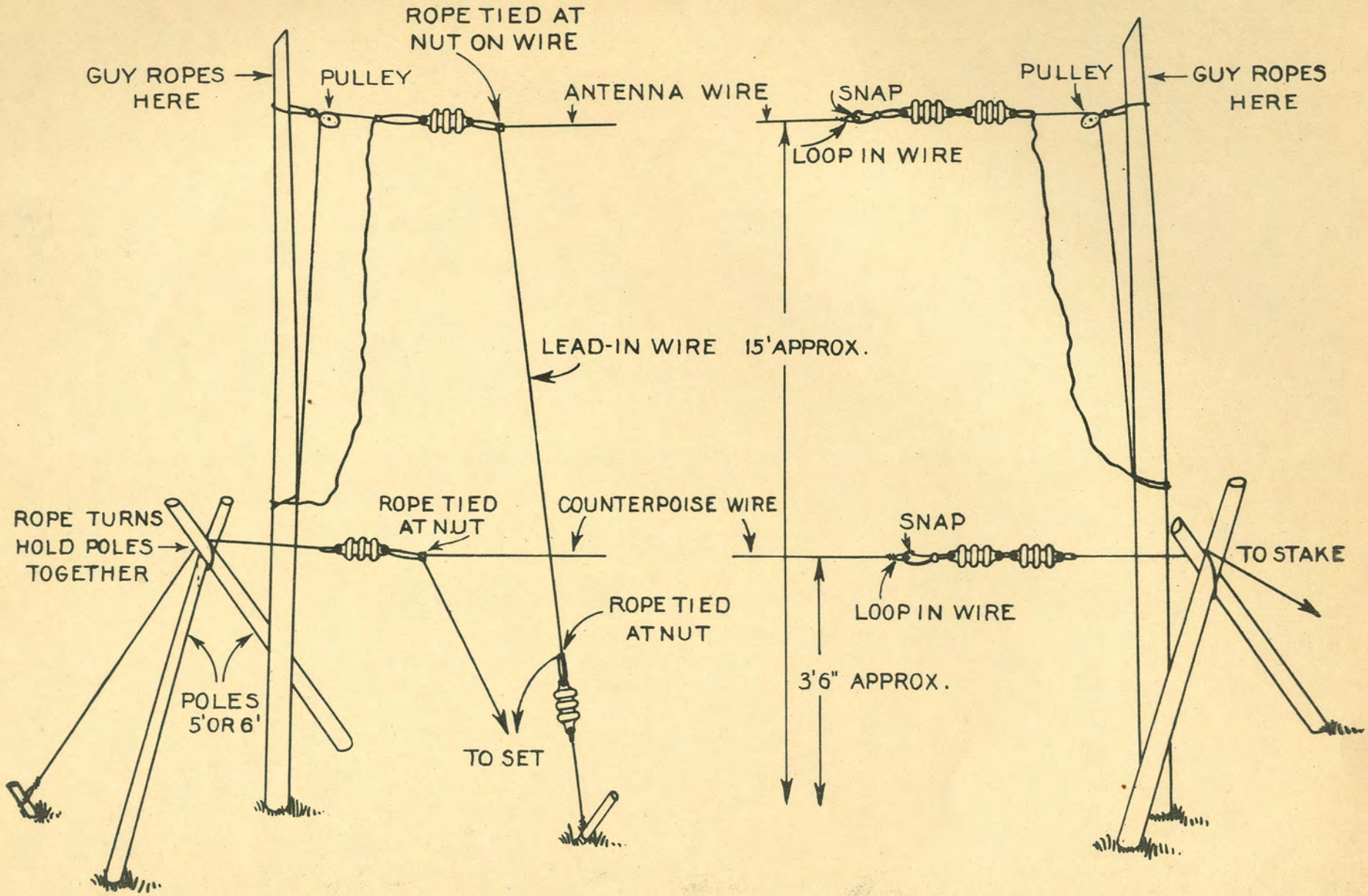


BATTERY CONNECTIONS - RADIO PORTABLE-1930



ANTENNA SYSTEM - U.S.F.S. PORTABLE RADIO

JUNE 1930