

Chapter XI

Good Fences:

Regional Networks, Portable Radios, and Interference

And the more clearly the laws are understood whereby "interference" can be prevented, the more clearly the laws will be understood whereby "prevention" [sic] can be prevented; that is, the better the laws of the game are understood, the better both sides will play it.

- Comdr. Bradley A. Fiske, U.S.N.¹

Earl Loveridge asked Roy Headley in January 1934 to appoint an independent radio review board that Horton and Simson could not disregard. Headley passed the memo on to the Regions. Jack Horton was a bit miffed, although he agreed on the need for stronger direction. He suggested to Headley that the Washington Office may not have been correctly informed or was a little too far behind the times. "We have had," he emphasized on behalf of the Radio Laboratory in his lengthy reply, "more business than we could attend to under this plan." The design, purchase, inspection, and shipment of units was no small task for the limited staff, and was already placing demands on the Laboratory personnel that could not be met, Horton contended. He voiced numerous objections.

Apprehensive that Loveridge's requested review board might cause many more Rangers to demand radios, Horton asked for more manpower before matters got "out of hand." Horton warned: "We can't run a \$100,000 business with a few temporary men and get desirable results. Of course we can toss out equipment if, and when, the Regions make requests and furnish the jack." But, he added, "It may wreck the project." Recommending that each Region hire a communication engineer, and that "someone or a

committee" be appointed to decide the kind of equipment and frequencies to be used, Horton called Headley's attention to the trend in the field away from the original concept of the role of radio. He wrote:

When we started this radio work I insisted that low power was essential. Also we contemplated only an extension of communication from our present system, mainly for fire control. Now we seem to be leaning to high power and to [the] replacement of telephone lines. This is wrong and is the result of not enough technical planning. We should stick to our plans.²

Headley and Loveridge ignored his alarm and continued to waver between feeling "overjoyed" and oversold. They issued occasional reminders of the IRAC regulations and the A. T. & T. lease agreements, but evaluated specific purchases or Regional applications only in terms of the annual budget. By adhering to the Forest Service philosophy of decentralized control, the Washington Office created an administrative vacuum with the potential for significant conflict even over relative trifles. It did not take long for the related issues of interference and output power to move into the breach.

High Power Caused Interference

At the various communication conferences held in Portland during the 1930's, the transmitter output power was often a major topic of debate. The 1935 conference spent considerable time discussing interference among the 700 forest radios and the effects of output power on the problem. These two inseparable issues were handled by a conference recommendation (though the conference was "practically divided on

this point") that low power should govern. "With the limited frequency assignments at our disposal," the recommendation concluded, "and the increasing use of the air [line] channels, the interference problem will become acute unless we limit power to that which is the minimum necessary to make satisfactory contact."³

It is not apparent that the resolution had any effect. Shortly after the meeting, the Angeles National Forest, which had originally installed a 500-watt base station and a number of 100-watt outlying transmitters, objected to "too much outside interference." In a letter he thought important enough to send to the Chief Forester, Alfred K. Crebbin, Assistant Supervisor, complained that fire control efforts were hampered by "unauthorized information arriving in fire camps through the medium of every Tom, Dick, and Harry..."⁴

In Region 5, which possibly exercised a significant amount of control and planning through Fred Funke's efforts, Belleville and Lawson learned that "one of the principal difficulties experienced on the Shasta in the use of 3000 kc [3 MHz] exists with the Wenatchee and Siuslaw Forests in Region 6 and the Salmon Forest in Region 4."⁵ Due to this interregional interference, Mt. Shasta had to limit radio use by arranging a schedule of operating periods for alternative air time with these two Regions--an action that could result in effective fire control communication.

An ironic turn of events also occurred in 1939 when the Ogden office complained to Portland of interference caused by the Radio Laboratory's high-powered station, KBAA, with its station, KBAS. Engaged in a fire fight, Ogden (R-4) was hampered and perturbed by interference

from KBAA and smaller transmitters at Grant's Pass and Gold Beach, Ore., and Helena, Mont. "Unless some means of eliminating such interference is soon devised," complained Arnold R. Standing, R-4 assistant in Operations, "the effectiveness of radio communication is seriously handicapped since we are rapidly approaching the critical period in our fire hazard and [we] need our radio communication."⁶ Regional Forester Watts apologized, attributing the problem to an inexperienced technician from Region 6. He then informed Ogden that "steps are being taken to make it impossible for Station KBAA to turn on more power."⁷

Many solutions were offered. They ranged from reemphasis on telephone use to proper transmission procedures, support of vhf, cooperative operating schedules, increased frequency allotments, better communication planning, and, as expected, increased power.

To encourage brief transmissions and thereby limit some frequency congestion, Gael Simson suggested that messages on fire-weather reports, grub orders, scout reports, and tactical discussions be written down before being transmitted.⁸ Francis Woods attempted to achieve this same effect by devising a code and using tape recordings to play back to the "long-winded" violators of proper transmission protocol.⁹

In Region 1, Bill Apgar designed a confidential code for the most frequent messages used on the fireline. He originally conceived it as a procedure to cut down the number of inaccurate reports by the news media. Following a conflict on his first fire (the Pete King in 1934), he had banned newsmen from the scene because they intercepted messages and, he believed, irresponsibly revealed several deaths; this had overloaded the fireline switch-

board with calls from the worried parents, wives, relatives, and friends of some 3,000 firefighters. Although Apgar later admitted this banishment "cured the newsmen of sucking eggs" (that is, it was ineffective), he revised the code in an attempt to resolve the issue with the press and make brevity a necessity, while still retaining relatively confidential transmissions.¹⁰ Through the facilities of the KBCX Operations Center in Missoula, he was then able to monitor the results, enforce compliance, and offer another reason in favor of hand-picked amateur radio operators.

Telephone Vs. Radio

In a statement reminiscent of his earlier doubts about radio acceptance, Loveridge said that telephone lines were as "cheap as radio in the long, long run." Horton questioned Loveridge's source of information, and Loveridge cited an earlier study on the Olympic National Forest showing "...no very great difference in cost ... when one considers the greater dependability of the former [telephone]."¹¹ Because vhf required a corresponding development period, Loveridge thought it would make economic sense to utilize the CCC and "other cheap labor." He concluded, "It seems to me we should encourage the use of regular telephone communications, rather than establishing a radio network which will have to depend on the limited number of frequencies we have available."¹²

Jack Horton disagreed with Loveridge's premise and pointed out the error of his logic. With regard to the "greater dependability" of telephone over radio, he reminded his superior that using the Olympic case was arguing from the specific to the general; the implication was that a single incidence in favor of radio could generate the opposite conclusion.

But Horton's most telling criticism--one that would be borne out in the future--effectively resulted in the issue being ignored for several more years.

As for the value of the "cheap labor," Horton was worried that the CCC would eventually be disbanded, leaving the Forest Service with countless thousands of miles of new telephone line in need of continued maintenance and repair, but without the necessary manpower. "Very probably in the future," Horton perceptively noted, "we will roll up some of our telephone lines and install radio, because we will be able to demonstrate that from a maintenance and reconstruction standpoint radio should have been installed in the first place."¹³

The cash value of the A. T. & T. discounts notwithstanding, there was an inherent disadvantage to the agreement restricting the equitable division of telephone and radio applications. If there were no leases, a more realistic appraisal of the matter may have led to guidelines allowing the use of each communication tool in the most appropriate manner. Cost-benefits may have been calculated, particularly for point-to-point communication, and substituting one for the other economically justified.

This evaluation did not take place largely because of the knee-jerk reaction each time someone suggested radio for a unique application. When, for example, Oregon newspapers reported that Forest Service radios would be used in conjunction with the elk hunting and winter sports seasons, the Forest Supervisor on the Umatilla was forced to cancel the experiment. "...Whereby the charges for our use of their facilities [Pacific Telephone and Telegraph] are discounted by 50 percent," Carl Ewing wrote his forest

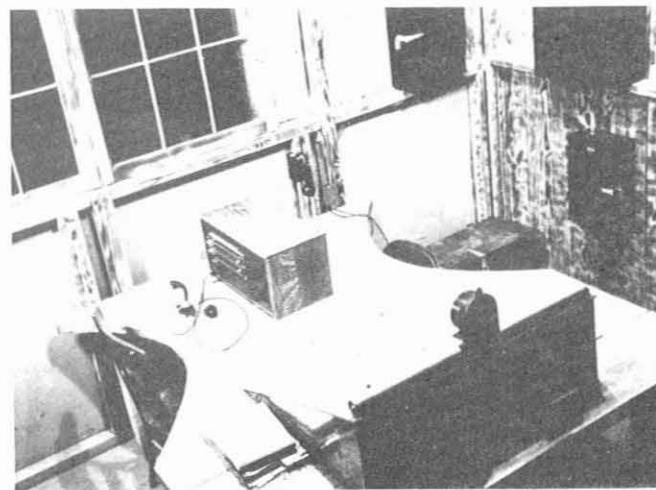


Figure 106. Forest Service desk-type telephone switchboard in a field location. (Forest Service photo, History Section)

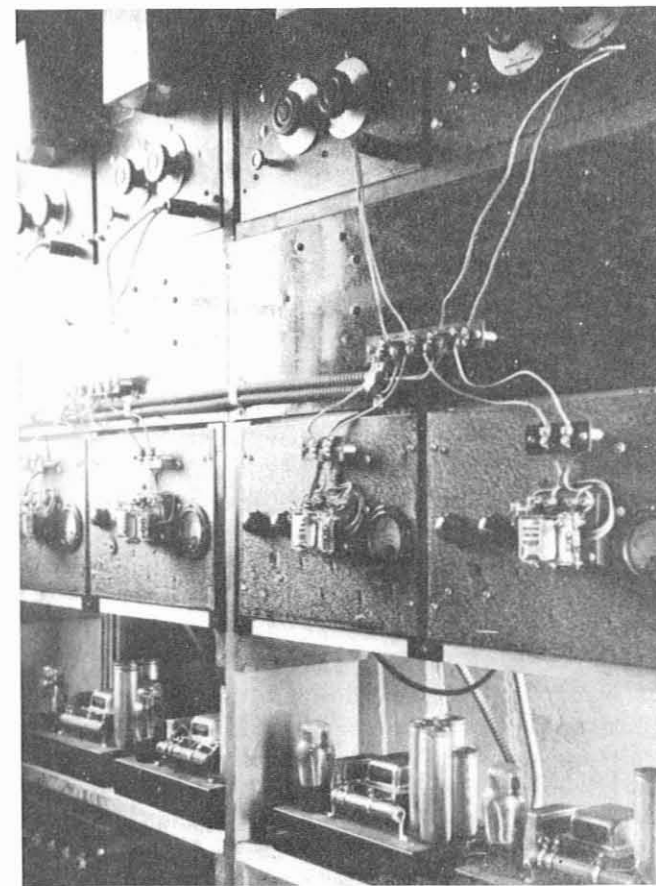


Figure 107. Forest Service electronic telephone switching circuits. (Forest Service photo, History Section)

officers, "[regulation] prohibits our using, except in emergencies, Government-owned facilities which parallel or duplicate the commercial facilities already available."¹⁴

Considering that more effective radio plans were being hampered by A. T. & T. lease agreements, insufficient attention was given to telephone as one way to reduce radio interference, and vhf began to acquire a reputation for adequate intraforest communication. If networks were placed on the line-of-sight vhf, the administrative functions of a forest could be

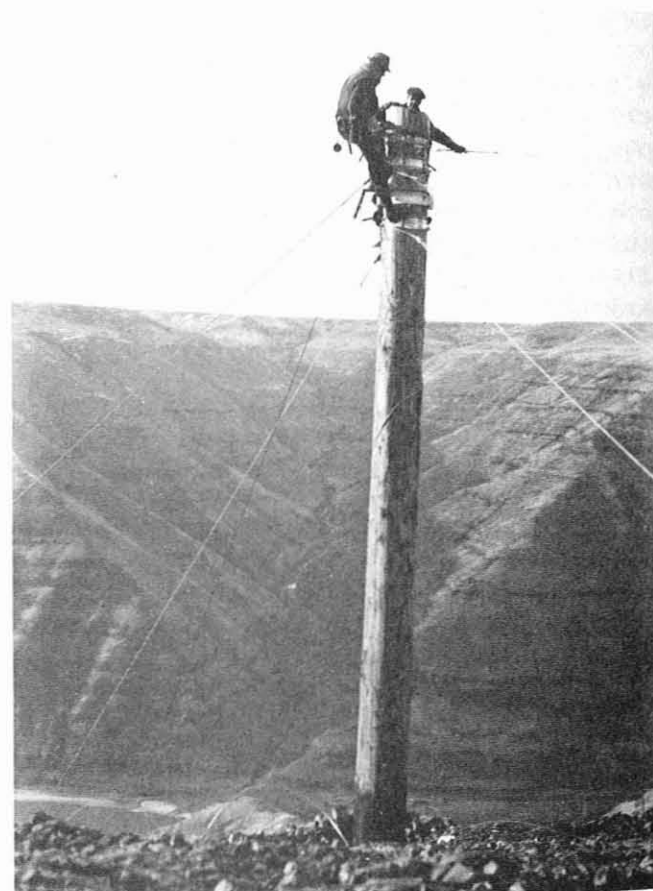


Figure 108. Men installing a Forest Service telephone line to a lookout point in the Southwest have a spectacular view. River at base of bluffs is possibly the Colorado or a tributary. (Forest Service photo, History Section)

accomplished without interference to the 3-MHz "fire channels."¹⁵

Previous experience with vhf, particularly with the semiportable set, had not been successful. Gael Simson was the first to recognize that "none of them have been satisfactory," and he admitted that the early vhf semiportables were intended only as "stop-gap makeshifts" until the radio industry provided better vhf components.¹⁶

Yet by the late 1930's, when technology had improved, advanced vhf design had been achieved at the Radio Laboratory. Vhf was used on the Klamath National Forest to the exclusion of hf, with such gratifying results that Region 5 proposed drawing up vhf plans to use some 30 type T sets, 60 type S sets, 6 type SV sets, and 30 vhf mobile receivers for each of its forests.¹⁷ This proposal led Harold Lawson to conclude, no doubt for the benefit of Region 1, that "in view of the fact that the Klamath Forest embraces an extremely rugged area, the satisfactory use of ultra-high [vhf] only provides rather definite evidence that proper planning, personnel training, technical aid in maintenance, and an impartial attitude can produce a very workable communication system without the use of frequencies in the range of 3,000 kc [kHz]."¹⁸

Some radio men tried to sidestep the interference issue by suggesting that the problem could be eliminated by an increase in frequency allocations. This remedy had the least chance of success. The proponents of this solution saw the problem not as one of interference but of an insufficient number of frequency assignments. But the Forest Service was fortunate to have what were considered "generous allocations" in comparison to its occasional secondary-user classifica-

tion by IRAC, subject to appropriation by primary users.¹⁹ The military services were given highest priority in frequency assignments, but they had allowed the Forest Service to use some of their 3-MHz frequencies with the understanding that power output would be limited and that use would be surrendered when necessary. This surrender would occur if national priorities required their return to the primary assignee, or if a previous noninterfering joint frequency assignment over vastly separated points abruptly changed due to a relocation or reconsideration by the primary assignee (the military). For this reason, National Forest officers were reminded that the use of radio "...is dependent upon the willingness of the U.S. Navy to permit us to use the [3-MHz] channels allocated to them..."²⁰

The closely spaced assignments between users of frequencies in the 3-MHz band

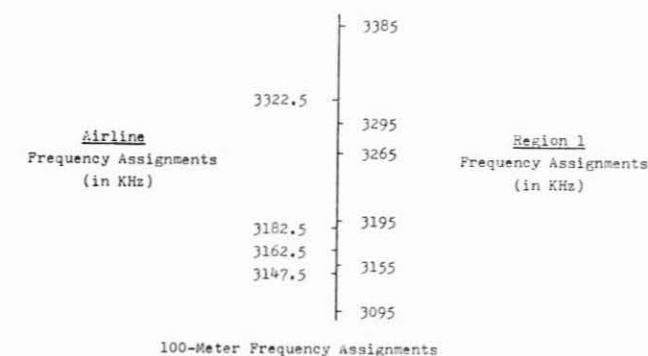


Figure 109. This diagram of frequency assignments in the 100-meter band in the early 1930's shows why radio transmissions to and from overhead commercial airplanes were interfering with the sending and receiving of messages during firefighting missions in the Northern Region of the Forest Service. The diagram is from William Apgar's 1934 "Radio Report to the District [Regional] Forester," (Gaylord A. Knight Collection)

also resulted in numerous cases of interference. A common complaint of Region 1 during fire fights was the reception of airline broadcasts from overhead commercial flights. Lacking receiving equipment that could bring about adequate separation, the Region requested the reassignment of airline channels to those either above or below theirs. The request ignored the cost of converting transmitters and receivers for the airlines, and also failed to recognize that IRAC had assigned these adjacent frequencies through necessity.

Two Regions Favor High Power

Support for "brute-force propagation" as another way to reduce the overcrowded conditions on the 100-meter band, came from Region 1. Francis Woods in Ogden also found merit in this approach, to a lesser extent. "I always thought that a good thing to shoot for was Region 1 radio communications," remembered Woods. He even borrowed a technique from Apgar and purchased a 100-watt Hallicrafter transmitter for the Wyoming (now Bridger) National Forest supervisor at Kemmerer, Wyo. It had 80 watts over the type M set but was within the recommended Forest Service power limit. This singular act gained little attention although Woods later admitted that he expected a reprimand from the Washington Office. He never received it.²¹

The justification for using higher levels of power was that overpowering the adjacent transmissions could eliminate interference. Depending on the conditions--including transmission distance, return from the ionosphere, the quality of both the transmitter and receiver, and the time of day--this might represent an output of no more than 20 watts. On other days, however, it might take 250 watts to force the message over

the same path. This could work if the one being overpowered did not retaliate in kind, or the offended party did not have primary-user classification for that frequency and take offense at the lack of protocol displayed by the secondary user. The latter situation was more probable in the case of the Forest Service. With the Navy granted primary-user classification for most Forest Service 3-MHz frequencies, there was little danger that the low-powered, Laboratory-designed sets would interfere with ships at sea. It was more likely at 250 watts.

Region 1 records indicate that Missoula had experienced problems with interference as early as 1932. During the first Savenac experiments, Apgar was reporting significant conflicts between the Chelan National Forest in Washington and the St. Joe National Forest in Idaho while using the low-power SP sets. The ability of the SP's one watt to traverse great distances was noted by Apgar. "A case was reported where a fire call on the West Coast was seriously hindered by interference from an Idaho set."²²

Authorized to use three 100-meter frequencies for the 1933 fire season, Apgar apportioned the 102 Regional radios among 7 National Forests. By the time of heaviest use, he found that even trained operators could not eliminate interference. "Interference from our own stations," he emphasized, "was one of the greatest difficulties encountered..."²³ It hampered effective communications significantly. As reported on the Flathead, "...the air seemed to be fully occupied by other stations and it was almost impossible for us to find any vacant period."²⁴ Apgar also learned that under ideal conditions "the SP sets will consistently lay down a signal at 400 miles...and it can readily be seen what interference will occur within this radius."²⁵

The knowledge gained about interference effects, even at low power, was not lost on Bill Apgar. The proliferation of sets throughout the Forest Service increased network overcrowding, and severely threatened his plan. The fixed transmission schedules of a daily network depended upon each radio being on the air at a given time for roll call and exchange of information and orders; it could not be a hit-or-miss operation. If 900 messages, as Major Kelley reported to Chief Silcox, were to be distributed in 30 minutes,²⁶ each station had to be ready to take its turn and have sufficient output power to reach Missoula, whether transmitting from the Canadian border or the Custer National Forest in South Dakota. By definition, then, the output power required on any given day was the minimum wattage required on the Region 1 network.

Bill Apgar found technical justification for his philosophy on high-power in two examples. In Spokane, Wash., where Region 1 then kept a radio fire cache, the city police force had 60-watt mobile radios; Apgar had borrowed a few of these units several times for use on active fires. In addition to citing the state-of-the-art of mobile communications and the problems associated with hf transmissions even in a relatively small city, he would use this example as testimony of the untenability of the Laboratory's stand for low power. With a small group--the Spokane police--using 60 watts, he wondered how the Forest Service could expect him to communicate over thousands of square miles with 20 watts. This situation suggested to him that Portland was "playing around" with radio.

The second example was provided in the IRAC regulations allowing some Government agencies to use a maximum

output power of 500 watts. Apgar viewed this as an indication of the actual value placed on high power by other knowledgeable sources, and took it as implied approval for his use of the higher values.²⁷

In retrospect, it is obvious that Region 1 was aware of the interference problems that would occur if two or more Regions followed Apgar's lead. To overcome the accompanying interference, Apgar suggested communication schedules between National Forests and Regions on the order of one half-hour transmission followed by one half-hour of silence, when fire conditions required simultaneous frequency use. He supported this recommendation by citing the relatively good relations between Francis Woods and himself when KBCX in Missoula interfered with a fire fight in Region 4.²⁸

Other officials did not agree. "Attempts to follow regular schedules are of no avail as emergencies arise that disrupt not only our schedules but others," complained one Forester.²⁹ More significantly, operating schedules could work only between National Forests or Regions with enough power to break their periods of silence when an unscheduled emergency arose. The fire boss on a California fire operating perhaps with only a 2 1/4-watt SPF had no way to overpower the stronger signals from the 100- or 250-watt Region 1 transmissions if he needed to request frequency clearance for emergency use.

Radio Laboratory Opposes Regional Networks

The staff at the Radio Laboratory found the various solutions to the interference problem inadequate. They couldn't get more frequencies, they had to uphold the A. T. & T. leases, they had a mission to produce portable

radios for the fireline, and they opposed dividing the hour between conflicting users. The staff, however, had an even more compelling reason for resisting solutions that supported network communication. The Radio Laboratory had been established only because the private sector was not producing products required by the Forest Service. Dwight Beatty had continually emphasized this point, and the Washington Office later upheld it; the sacrosanct ground of the free-enterprise system was not to be abridged by a Government agency. Indeed, the Forest Service intended to withdraw from competition when the portable radios it needed became commercially available.

The concept of network communication did not fit into the framework of justifiable Forest Service radio development. High-powered sets were available through well-established manufacturers and could be acquired through regular Government procurement channels. There was no reason to continue the Radio Laboratory if the network concept, to the exclusion of fireline radio, was to be the goal. Design efforts at the Laboratory concentrated on development and perfection of lightweight, low-power, portable radios not available in the marketplace. Excursions into the areas of semiportability, mobiles, and fixed-base units took place only as necessary adjuncts, even if one eye was kept on economy.

Once the concept of portability was abandoned, there would be no justification for the Radio Laboratory. The issue of interference concerned the Radio Laboratory not because it affected network communications, but because it might affect the concept of portability and the ability to provide radio communications for the men in the field fighting fire.

Thus, the staff at the Radio Laboratory viewed the problem of interference from a technological standpoint. It was not a matter of increasing frequency allocations, devising operating schedules, moving other users off the band, or accomplishing communication through brute force. Rather, it was a matter of refining the system to overcome restrictions imposed by the other systems that came out of the revolution in communications. The Laboratory attempted to find the answers by improving the Forest Service sets and system to a point nearer technological perfection.

The extent to which differences of opinion could compound the problems of radio design came up during a review of the SPF set at the 1940 Portland Communications Conference. Francis Woods complained that the canvas bags for the SPF had a tendency to shrink. Bill Claypool then questioned the need for the bag, Apgar and Woods argued for its retention, Lawson pointed out that the Park Service no longer used the bag, the Park Service people said they did not use them because they were losing them, and Fred Funke said they were sometimes necessary. Interrupted briefly by a discussion over SPF antenna wire, Gael Simson returned to the problem, suggesting that the shrinking problem could be cured if a "surplus of one inch or so" was sewn into the bags. Somehow this led to a discussion of a shoulder strap and whether this modification should be included on the bag for \$1.00 or left as a carrying handle on the SPF case. The responses were decidedly varied, as follows:

Funke (R-5)	No straps are necessary.
Apgar (R-1)	Leave as is.
Woods (R-4)	Add on shoulder straps.

Claypool (R-6)	Leave off, R-6 will attach.
Huckeby (R-2)	Leave as is.
Indian Service	Add on shoulder straps.
Oregon	Leave as is.
Washington	We don't use them.
Knight (R-8)	No response. ³⁰

If a minor modification could cause some dissension, it is easy to understand how major issues evolved into disagreements far removed from the immediate issues. Logan Belleville suggested reducing the output power of the SPF to reduce interference and achieve significant reductions in battery drain, and, thereby, reduce operating cost and weight. Responses reflected total support for the existing SPF without regard to the proposed technological changes. In his presentation, Belleville noted that improvements in the SPF receiver had been achieved with "newly developed low-drain tubes." To effect further gains, he proposed a reduction in transmitter output power from 2 1/4 watts to 1 3/5 watts. This change could either provide a worthwhile 50 percent reduction in battery weight, or a 100 percent increase in present battery life. The conference was not impressed when Belleville pointed out that the SPF was already operating at or below the suggested new output level when its batteries were not at full charge, and that this modification would result in only a minimal decrease of 1.5 decibels (dB).³¹

The SPF was understandably the most popular Forest Service set, and modifications would be resisted if only because no one could argue with success. But the many responses

sidestepped the technological issues and, like discussion of the canvas bag straps, reflected distrust of change, questionable logic, and doubtful motives. In order of response, the arguments were as follows:

Apgar (R-1)	You are suggesting a reduction in power. We can't stand for that. If you are going to do anything, increase the power to give us more effective communications.
Woods (R-4)	In other words we would get poorer signals over a longer period of time.
Funke (R-5)	The SPF is a fine set and everyone likes it. Making changes would be a mistake.
Claypool (R-6)	We should maintain our present power for several reasons.
Knight (R-8)	The SPF should be left in its present form.
Huckeby (R-2)	We shouldn't reduce the power.
Indian Service	The SPF is highly satisfactory.
Oregon	The SPF should remain in its present form.
Washington	We don't use it. ³²

Conspicuously absent from these responses was a proposal for constructing several prototypes for Regional field tests. If these trial units did not measure up to previous performance, then the logic of the new design could have been properly criticized on its merits.

Overcoming Noise in Receiver

Many years later, Belleville would recall one irony of the power issue --the traditional overemphasis placed upon transmitter output power in the Forest Service. He was to point out that a better approach, especially in the 1930's, would have been to concentrate on alternatives such as "front-end," or receiver sensitivity. "You can improve the sensitivity of a receiver by a factor of two," he mused, "and everyone wonders what in the hell you've been wasting your time on. But improve the transmitter output by a factor of two and everyone applauds." Both achieve the same result, Belleville added, except that the receiver improvement has the great extra advantage of not causing a corresponding increase in the serious problems of transmitter interference with adjacent stations.³³

The important issue, and the one which the staff at the Radio Laboratory pursued, was the need to improve the signal-to-noise ratio of the receiver. Improved reception could be achieved by adopting circuits that (1) increased the audibility of the transmitted signal over the ever-present background noise, (2) decreased the inherent noise of the receiver, and/or (3) provided adequate separation from adjacent signals. This is why the design philosophy of the Radio Laboratory was first to improve receiver sensitivity and selectivity, and then to reduce output power to a commensurate level and thereby reduce the potential interference on the already crowded frequencies.

It is interesting to note that this approach tied in with the Radio Laboratory emphasis on portability; Laboratory designs yielded sets weighing 25 pounds or less with a rated transmission capability of

15 to 25 miles for hf and 50 miles for the vhf portables over inter-visible ranges. An increased range would have resulted in heavier sets. As Gael Simson pointed out, "...reducing inter-Forest interference is a powerful reason for holding our equipment to low power."

"Moreover, our most portable sets must be low-powered in order to be portable," he reiterated.³⁴ To advocates of higher power, the Laboratory would argue that this consideration improved communications planning. In practical terms, it meant buying more low-power sets that could communicate over shorter distances, instead of fewer high-power sets. The latter, unit for unit, would cost more, create more interference, and still not be portable on the fireline.

An example of how this concept might be applied was presented by Fred Funke at the 1940 conference. Communication planning in Region 5 reflected a move to lightweight radio use following the earlier trials with high-power sets on the Angeles National Forest. By 1939, the San Francisco office had decided to eventually use some 5,800 radios consisting of 623 hf sets, 3,998 vhf units, and 1,288 separate radio receivers. Of this number, 3,430--the vast majority--were S, SV, and SPF lightweight sets, and only 100 were in the M and U class of fixed-base stations. Funke pointed out at the conference that the projected cost of \$213,956 meant the total Regional radio investment would be less than the telephone investment for a single California National Forest. He expected to have this plan implemented in four or five National Forests by 1941, with a few more added each year.³⁵

Region 1, of course, adopted the opposite approach. Although no exact

figures are available, a fair estimate of the comparative costs of a network based on 20-watt M sets can be made and projected against the known, approximate costs of the portable S or SV used in Region 5. An example follows:

Type	Purchases	Unit Cost	Total
S, SV	4,000	\$ 61	\$216,000
M	720	300	216,000

Thus, for the same investment, Region 5 inventories could have included 3,280 more radios than Region 1 and even eliminated many telephone expenses. Continued maintenance of the telephone lines between lookouts and Ranger Stations would increase expenses considerably. To preserve its network concept, however, Missoula gave up the greater fire control capability of portable radios and created an inherently much more expensive system. It was apparent at the 1940 radio conference that the levels of communication planning in other Regions were in varied stages of refinement. Region 2 at Denver, which until now had had a limited use for radio because "the fire hazard is not extreme," sent a representative to Portland from its Division of Engineering. H. M. Hucceby arrived with a collection of communication maps for review by the Radio Laboratory that reflected a decided emphasis upon telephone use. The maps showed completed telephone plans for each National Forest in the Region, including wire hookups into Supervisors' offices and the Regional office. Radio was to be used "...only to get into the telephone line, rather than plan large hookups." When Simson asked about plans for future radio use in Region 2, Hucceby said that portable units capable of transmitting "20 miles would cover 90 percent of the cases."

He declined further analysis. "We haven't used radio extensively, so I haven't much to report."³⁶

Francis Woods said that the Ogden office in Region 4 was finding applications for vhf that suggested movement away from a heavy emphasis on telephone. "We have lookouts," he reported, "on the Challis, Salmon and Idaho Forests, that see from 20 to 70 other lookouts. Uhf (vhf) could fill that need and also give us about 85 percent coverage of the entire Forest." Woods thought that Region 4, unlike Region 8, would not "have much need for mobile units for fire control."³⁷

Region 6 Emphasizes Telephone

Region 6, which administered both Bill Claypool's Regional communications office and the Radio Laboratory, continued to place heavy emphasis on the telephone. "Our principal use," Claypool said of radio, "is in the extension of our present telephone system and to supply certain lookouts that are manned for short periods, to which it would be unreasonable to build telephone lines." Claypool also reported that in applying this approach to radio, the Portland office expected that putting all communications on vhf would eventually be "technically possible." In response to the Region 1 criticism that obsolescence had previously made vhf investment economically impractical, Claypool responded in a manner indicating that the Portland office, while well aware of this factor, had not limited development because of it. "Limited funds for procurement, high costs of operation, and rather early obsolescence," Claypool countered, "had made necessary a very conservative Regional policy for radio utilization which normally prohibits extensive application for purposes other than fire control." In other words, because Region 6 was interested in vhf for purposes other

than "large networks," it had found a significant niche for its use in fire control. In fact, Claypool stressed, "Most of our [radio] communication is uhf [vhf]."38

Gaylord Knight represented Region 8 at the conference. He had continued to function as the quasi-Regional communication engineer in Cleveland, Tenn. His attendance at the conference indicated that the Atlanta office was awakening to the possibilities of radio, even to the point of picking up the expense of his 2-week trip to Portland. The limited extent of Region 8 financial resources in the past was reflected in Knight's statement that "if we shifted to uhf [vhf], I believe we would almost have to stop radio at present because we haven't funds to purchase equipment." The few radios in the Region were hf, but the 30 to 40-MHz units probably could be useful because there were

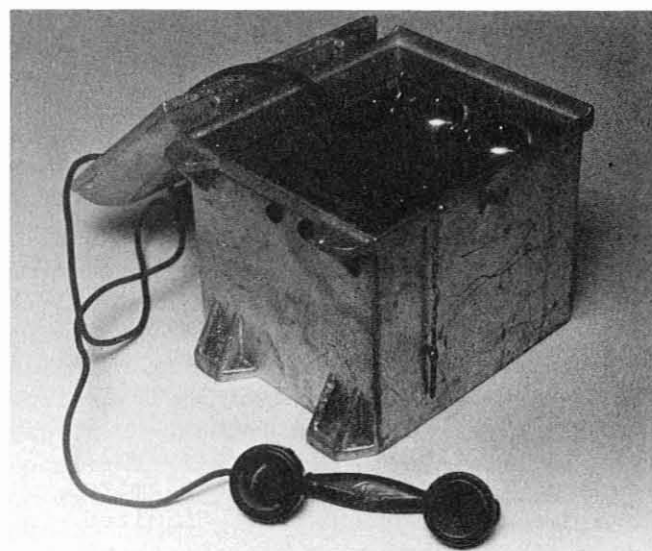


Figure 110. Lightweight aluminum field telephone case for a fixed location, a successor to the cast-iron model shown in figure 7. This was the A-1 model, dated 1932, made by the Kellogg Switchboard and Supply Company and used by the Forest Service. (Forest Service photo, History Section)

"intervisible lookouts where telephone was so expensive to maintain." Knight also believed that "our biggest need is for some better mobile equipment with a consistent 30-mile range..." The prevalent fire conditions in the Southern Region determined this need. He pointed out the importance of "twenty minute" speed in dispatching fire trucks to the scene. "If we didn't get to it in a hurry the fire could be out in the Atlantic ocean and half way back again," he later recalled with tongue in cheek.³⁹



Figure 111. A strong emphasis on portability in communications began early on the National Forests. These Forest Service portable telephone handsets, made by Kellogg, were carried by Rangers and clamped to field telephone lines for use. Wooden box model (C-608) has a folding crank on the right side. The front is hinged to open down. This model, which dates from the late 1920's, was used through the 1930's. A more truly portable set in the modern sense, the aluminum model B-209 dates from the late 1930's and was used through the 1940's. It has an external contact for the telephone wire and two buttons to press--one to send a sound to alert the other party on the line, and one to press while talking. (Forest Service photo, History Section)



Figure 112. Portable S set being used by fire scout George Clisby on the Willard fire, Columbia (now Gifford Pinchot) National Forest, Wash., August 1939. (NA:95G-391295)

Both before the conference and again for several weeks after, the Laboratory staff worked through administrative channels to resolve the interference issue. The opportunity came when Region 1 brought out its plans for network improvement at the Ogden Fire Conference in mid-1940. During the discussion of communication systems, Region 1 outlined four substantial steps needed for complete implementation of the network concept:

1. Additional 3-MHz frequencies should be obtained.
2. New 6- to 8-MHz frequencies should also be obtained for daytime use, and the type M should be correspondingly redesigned for two-channel operation.
3. A 250-watt station should be approved for Missoula.
4. Region 1 should be authorized the use of permanent 50- and 100-watt stations in

Supervisor's offices and Ranger stations.⁴⁰

Gael Simson composed a lengthy memorandum for Earl Loveridge, and reviewed the Region 1 requests. On the first three points, there was little to discuss: additional 100-meter frequencies were "certainly needed, but there is little prospect of getting more frequencies." Action toward obtaining two 5.9-MHz telegraph frequencies was already awaiting IRAC approval. An unfavorable attitude by other Regions towards a 250-watt station on shared frequencies was well known.

On the fourth point, however, which represented the requirements for a Regional network, Simson said that this "engendered other implications" not directly related to technology. He questioned the economic benefits of radio over telephone by pointing out the large investment in equipment, salaries, and maintenance needed for a Regional radio network. Still another consideration was the IRAC-enforced Government policy that forbid use of radio where other satisfactory facilities were available. "Although I have no doubt there have been successful local departures from this policy by other agencies, the Forest Service has tried to maintain strict adherence," he wrote.

The A. T. & T. lease agreements posed another barrier. Abrogation of these leases would have been contrary to the wishes of "several of the Regions [which] have placed a rather high cash value on this agreement..." Simson indicated that he would not be opposed to the Regional radio network concept if these policy issues could be resolved by the Washington Office. Meanwhile, he concluded, "There seems little point in going into the technical aspects until the policy phases have been evaluated."⁴¹

In spite of Simson's effort to force a policy decision from the Washington Office, Earl Loveridge sent a letter to Major Kelley, with a copy to Simson. The letter showed no evidence that Washington had more than a casual concern over the issue or intended to back off from its decentralized approach to Regional administration. "If a network is contemplated, it constitutes somewhat of a departure from our ordinary use of radio," Loveridge pointed out to Region 1.

Loveridge also included a copy of Simson's earlier memorandum for Kelley's review; it gave no evidence that Washington was remotely aware of the issues raised by Simson or Lawson. "The proposals for more powerful radio transmitters," Loveridge casually remarked to Region 1, "evidently raises questions of an administrative and policy nature." Then, in a gesture that threatened to set the issue back another year or more, Loveridge as Acting Chief, asked Region 1 to provide a host of network figures on transmitter locations, availability of telephone facilities, types of message traffic to be handled, importance of the network, and relative costs.⁴²

Laboratory Personnel Study Region 1

Simson's response is not known. It would have been understandable had he thrown up his hands in despair over the words "somewhat of a departure" and "evidently raises questions." Instead, he sought to get his point across another way. He wrote to Headley and Loveridge on August 14, 1940 and volunteered, though the thought was not attractive, to go to Region 1 with Roy Headley. Loveridge declined the offer for both men, but expressed an elementary grasp of

Simson's problem. "We appreciate at least some of the circumstances which made it distasteful for you to spend any more time in that Region looking into this matter, but also feel that regardless of how distasteful it might be to you a further exploratory trip would be made if you felt it would be worthwhile." Then, indicating for the first time that the Washington Office had misgivings over the Region 1 network concept, Loveridge noted, "We both feel that the Region should be required to get in line with established Service policy and the practice followed in other Regions..." This attitude was tempered with concern that Region 1 be offended by its loss of autonomy. "Denial of the radio network will make Region 1 feel we are not appreciative of their needs and are being obstructive," he cautioned Simson.⁴³

Simson had already concluded that a definitive policy from the Washington Office would be some time in developing. In one last attempt to demonstrate the value and application of vhf to Apgar, he sent Lawson and Carl Davis to Region 1 to review Missoula's plans and needs. Lawson and Davis spent 2 days reviewing the topography on several Region 1 National Forests during the second week in July and the other 5 days observing KBCX operations, holding discussions with Apgar, and conducting vhf experiments.

Lawson presented his trip report in a lengthy, six-page memorandum. This report showed Lawson as decidedly impartial in his approach. He did not go to Missoula with preconceived notions. Neither did he attempt to defeat the proposal by defending either A. T. & T. agreements or IRAC policies. Instead, he considered Region 1 needs and plans entirely on

merit. Simson would later point out, "It will be noted that Lawson's memorandum is purely technical and his conclusions and comments are purposely based entirely on technical considerations and without reference to policy."⁴⁴

Lawson agreed with Apgar's observations on a number of points. If, for example, the network concept was approved, the power of KBCX should be increased to 500 watts on an exclusive 3-MHz channel, or provided a 50-meter (6-MHz) frequency with a 50-watt transmitter. Lawson noted that Region 1 had obtained "reasonably exceptional performance" with Radio Laboratory sets even though they were not designed for network distances. Lawson attributed this to "...a very excellent system of maintenance, personnel training, and an exceptionally fine operating procedure." Pointing out the ineffectiveness of mobile transmitters spread over distances of 250 miles between the widely scattered units in the Custer National Forest, Lawson also noted the technological problems associated with developing 3-MHz mobile equipment for those distances and instead recommended 45 50-meter mobile sets at 20 watts.

Lawson also reviewed his analysis of vhf use in the Region. He knew from information obtained during topographic inspections of the Lolo, Helena, Deerlodge, and Bitterroot National Forests, as well as experience in the Coeur d'Alene, Clearwater, and Flathead National Forests, that there were few, if any, "outstanding topographic prominences, and that most peaks are about the same elevation." He pointed out this was not an obstacle to vhf use and that there were "...no unusual conditions or physical obstacles to prevent the intensive use of ultra-high frequency [vhf] in the Region.

To support this conclusion and to illustrate "the possibilities of ultra-high frequency [vhf] along the fire line and for scouting work," Lawson arranged a test along O'Brien Creek west of Missoula. The results indicated "...that non-intervisable [sic] points can intercommunicate and that a small amount of technique, to be gained through experience with such equipment, can be applied to gain a very high degree of reliability." He also noted for the record that this experiment, "together with a topographic profile, was recorded by "Mr. Apgar," and said in summary:

There are numerous places on all Forests in the Region where ultra-high frequency [vhf] can be used to advantage in place of long-haul telephone circuits which serve only two or three isolated lookout points. The development of automatic relay equipment for ultra-high frequencies [vhf] will open and enlarge such possibilities to a point where much of the present 300 kc (3 MHz) radio equipment may be retired from point-to-point service.⁴⁶

Lawson offered one further suggestion to upgrade 3-MHz installations in places with power lines and other forms of local interference. He recommended remote receivers, a contribution made by Bill Claypool in Region 6 for these kinds of locales.⁴⁷

If Lawson's approach to the issues dividing the Radio Laboratory and Region 1 may be characterized as fair, it is considerably more difficult to conclude that the Regional office in Missoula responded the same way. In fact, the Missoula arguments toyed with truth. Arguing that "the Regional policy has called for the discontinuance of radio on all lookout points as

rapidly as satisfactory telephone service can be provided," and then contradicting this with the statement that the "network is desired to relieve an over-burdened telephone system," the Region told Lawson that vhf had no application because "the Region did not wish to consider a duplication of communication where telephones already exist."⁴⁸

Given the past history of radio use in Region 1, it is difficult to give these claims much credence. Indeed the lengths to which Region 1 would resist the Laboratory philosophy of low-power portability for the fireline in the interest of its network concept are reflected in one cogent example. After insisting that portables have sufficient power to transmit consistently up to 100 miles, Apgar and the chief of fire control in Region 1, Otto Lindh, expressed a "...desire for an extremely compact smokechaser radio unit to weigh about 5 pounds..."⁴⁹ Since in 1940 halving the batteries also halved the weight, this design goal would have produced a unit with less than one-watt output. This was in stark contrast to Apgar's objections to reducing the output power of the 2 1/4-watt SPF to 1 3/5 watts, and the fact that this popular 3-MHz semiportable weighed about 20 pounds.

At the 1940 radio conference, Bill Apgar, attacking what he persisted in calling the "worthlessness" of current Laboratory-designed Forest Service radio equipment, argued against vhf use. By this time, Region 1 had a considerable investment in high-powered 3-MHz radio for its "17 Forest radio networks" and could not alter its course without significant economic loss, if not embarrassment.⁵⁰ The degree of difference between the advocates of radio for the fireline and the Region 1 network plan was also succinctly underscored in an

exchange of dialogue at the conference. A question from Bill Claypool led Apgar and Funke to respond in diametrically opposite fashion, as follows:

Claypool: Do you take portable sets out on the fireline?

Apgar: Ordinarily a fire chief will not want to be hampered with it. If communication is necessary, we might send a set together with a high-powered generator. We have not tried uhf [vhf].

Funke: In our Region no man wants to go out without an S set [vhf] along with him.⁵¹

Apgar was also instituting a revision of his Regional communication plan at this time. It would have assured another 5 years of conflict over the power issue. With the Radio Laboratory professing "...that inter-Regional radio interference will be almost completely eliminated with the use of ultra-high frequencies [vhf],"⁵² and Region 1 arguing that "the 3000 kc band [hf] is the mainstay of radio communication..."⁵³ the two sides had reached an impasse. Only a third party could resolve the issue.

Region 1 Ordered to Reduce Power

It is not known why Earl Loveridge dropped his earlier concern over "obstructing" Missoula and decided to take a stand. He may have been motivated by a number of factors, including mounting A. T. & T. complaints over violation of the telephone lease agreement, threats from IRAC and the Navy if the Forest Service continued to exceed the regulated power limits, the knowledge that Region 1 was forcing the Forest Service toward a conflict with

commercial manufacturers of fixed-base radios--or a combination of all three. More than likely, the major impetus for change accompanied the appointment in late December 1939 of Earle H. Clapp as Acting Chief Forester.

Clapp apparently had less fear of offending recalcitrant subordinates than did his predecessor, Silcox. He would "...chastise the field men for too often deciding for themselves whether or not they were going to follow orders..."⁵⁴ Loveridge subsequently complied with this new approach. He wrote to Major Kelley:

It is my understanding that the Missoula station was built locally and that it has a power greatly in excess of that authorized to the Forest Service except on one frequency.

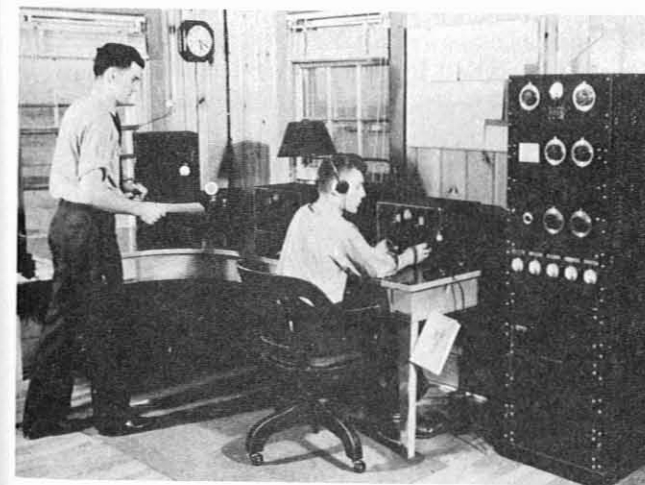


Figure 113. Allen Thompson and Jeffrey Geiser, right, operating KBCX, the Northern Region control station at Missoula, Mont., in 1937. William Apgar's powerful "home-brew" transmitter is the floor model unit at far right. The Region was ordered by the Washington Office to reduce its power in January 1941. (Forest Service photo, History Section)

Your violation of the power limit authorized to the Forest Service is a source of considerable embarrassment to this office. Had you procured the transmitter in the prescribed manner...this would not have occurred.

Henceforth, it will be appreciated if you will follow established policies in radio matters as I know you do in other activities.⁵⁵

It was probably not a happy day in Missoula when Loveridge's communiqué arrived. Overlooking the technical issue of radio use for administrative management, Apgar had focused on the question of who was in charge of Regional matters. He had allowed his opinions to degenerate into personal attacks. He then became handicapped by his view that Portland's opposition to his ideas was "just pure and plain stubbornness" brought about "because they hadn't thought of it themselves." Region 1 would continue to ignore such technical improvements of vhf because of the network emphasis on

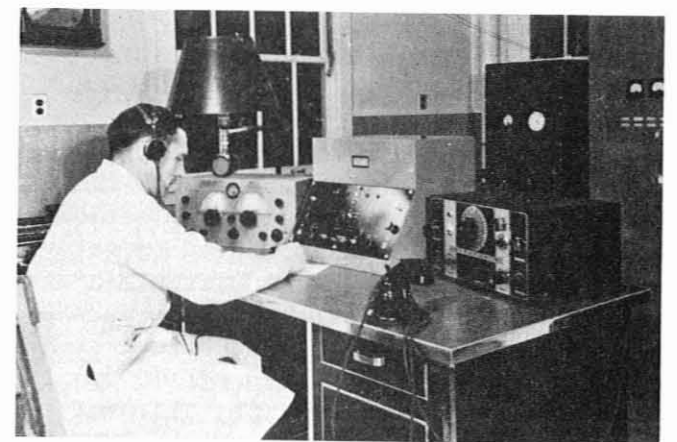


Figure 114. Carlton Brown at the console, designed by Logan Belleville, of Station KBAA, Radio Laboratory, Portland, Ore. This 250-watt transmitter was also ordered to a lower output. (Forest Service photo, History Section)

hf and Apgar's conviction that vhf was "kid's stuff" brought out by the Laboratory as "something new they hadn't fooled with." Frustrated by radio specialists who did not conform to his concept of Forest Service traditions, he lashed out at "Horton's Hobby Shop" because the men who worked at the Radio Laboratory "weren't Forest Service types."⁵⁶

Francis Woods had also supported higher power. "We went out on a limb to prove it, and I think Apgar and I succeeded, he later reflected. But Woods would not politicize his opinion or overemphasize the importance of the issue. Neither did he let a difference of opinion distort his attitude towards the Radio Laboratory and its work. Instead, he would agree that the limitations on power allowed them "to get along pretty well" on their own. "I was in awe of Lawson," he later recalled, and did not press the issue.⁵⁷

The tone of Loveridge's memorandum indicates that the Washington Office did not originate or encourage administrative radio in National Forest management. Until then, it was not clear whether the Washington staff members resisted giving direction to the development of network communication policy because of their attitude towards decentralization or because they actually wanted to encourage it. By ordering Missoula to cease and desist, they finally made it obvious that the network concept was entirely the brainchild of Region 1. Kelley, Stockdale, Thieme, Strong, Fickes, and Apgar represented the upper echelons of Regional management and first conceived of a use for radio that would extend their authority into the furthest reaches of the National Forests. The tasks normally delegated to Forest Supervisor,

District Ranger, Fire Boss, or Forest Ranger could now be influenced from Missoula at will. Advice and direction would be provided, whether it was requested or not.

Radio mocked distance and isolation even more than did the automobile. Before its introduction, the Ranger was expected to be proficient in a wide range of forestry skills. His measure was the ability to perform the many duties associated with timber scaling, fire control, road construction, and timber planting. Even if the demands occasionally taxed a Ranger's abilities, the Forest Service system compensated by allowing for the exercise of personal opinion and some individuality. In a single stroke, however, administrative radio swept aside the freedoms associated with these responsibilities, obliterated the gap between line and staff personnel, and rudely ushered in the age of specialization. The Ranger was no longer expected to become proficient in all phases of forest management. Specialists with expertise in silviculture, engineering, firefighting techniques, or even landscape architecture, could now go into the woods, figuratively if not literally. If Rangers came up against situations beyond their ability, the advice of other experts could be solicited by reaching for the nearest microphone. The possibilities for standardization were endless.

A certain irony is associated with the Missoula office's discovery of the portent of administrative radio for the Forest Service. Perhaps no other Region clung so tenaciously to the right of self-determination. Indeed, Region 1 was ready to defend the principle of decentralized control against the Washington Office down to the last breath. But it refused to

apply decentralization to its own Regional forest administration.

Ironically, too, Bill Apgar was one of the first casualties of the system he had so eagerly helped to create. The appearance of specialists, or men whom he believed "couldn't tell a cow from a goat," offended both his self-image and his perception of the Forest Service. Adhering to his belief in the value of rugged individualism, Apgar eventually chose early retirement rather than adjust to the change and compromise his principles.⁵⁸

Before this happened, however, the necessity for a showdown between the advocates of radio for administration and those of portable radio for fire control reached the point where the Washington Office was forced to act to protect its longterm responsibilities. By 1941 all of the Regions were ready to become involved in the issue. But World War II made the issue moot, at least for the duration. By the time the war drew to a close 4 years later, technological developments changed the issue. It would be resolved only when the Washington Office decided to change completely the administrative structure of the radio development program.

Reference Notes

1. L. S. Howeth, *History of Communications-Electronics in the United States Navy* (Washington, D.C.: Government Printing Office, 1963), p. 66.
2. F. V. Horton to Roy Headley, 26 January 1934, Gaylord A. Knight Collection.
3. U.S. Department of Agriculture, Forest Service, "Forest Service Communications Conference," Portland,

Ore., 20 February to 2 March 1935, Gaylord A. Knight Collection. The 1935 conference discussed such subjects as new equipment, needed improvements in equipment, maintenance and servicing, adjustment of apparatus, special installations, noise suppression, and the training of personnel in the use of radio. See Roy Headley to Regional Forester, 5 February 1935, Gaylord A. Knight Collection.

4. Alfred S. Crebbin to the Chief, 16 April 1936, Gaylord A. Knight Collection.
5. H. K. Lawson, "Memorandum for Files, 2 November 1939, Gaylord A. Knight Collection.
6. A. R. Standing to Regional Forester 26 July 1939, Gaylord A. Knight Collection.
7. Lyle F. Watts to Regional Forester, 16 August 1939, Gaylord A. Knight Collection.
8. Simson, "Role of Radio in National Forest Communication," 11 April 1935, typed, Gaylord A. Knight Collection.
9. Francis Woods, interview with the author in Ogden, Utah, January 1978.
10. W. B. Apgar, interview with the author in Sun City, Ariz., January 1978. A confidential version of this was published for joint Forest Service/Weather Bureau use in 1942. See *Interdepartment Fire Vocabulary Code, WB-11* (Washington, D.C.: Weather Bureau Office, 1942), mimeographed, Gaylord A. Knight Collection.
11. E. W. Loveridge, "Memorandum for Mr. Horton," 22 October 1935, Gaylord A. Knight Collection.
12. Loveridge, "Memorandum for Mr. Horton."

13. F. V. Horton, "Memorandum for Mr. E. W. Loveridge," 31 October 1935, Gaylord A. Knight Collection.

14. Carl Ewing to Forest Officers, 7 December 1938, Gaylord A. Knight Collection.

15. F. V. Horton ("dictated by HKL [Lawson] over phone") to Regional Forester (R-5), 20 December 1939, Gaylord A. Knight Collection.

16. A. G. Simson, "Memorandum," 27 January 1939, p. 4, Gaylord A. Knight Collection.

17. R. L. Deering to Regional Forester (R-6), 12 December 1939, Gaylord A. Knight Collection.

18. Lawson, "Memo," 12 December 1939, p. 1, Gaylord A. Knight Collection.

19. D. S. Nordwall, "Memorandum for the Record-Radio Laboratory Inspection," 24 March 1947, p. 2, Gaylord A. Knight Collection.

20. Ewing to Forest officers.

21. Woods, interview with author. Woods reported that Apgar purchased several of the Hallicrafters for Region 1. Woods also purchased an English-made Phillips frequency meter. This action was in direct violation of the ban on foreign purchases. This, too, was overlooked.

22. Apgar, "Radio Report-1933," 27 February 1934, typed, p. 12, Gaylord A. Knight Collection.

23. W. B. Apgar, "Radio Communication Report-1934," [n.d.] p. 5, Gaylord A. Knight Collection.

24. K. Wolfe to Regional Forester (R-1), 23 January 1934, Gaylord A. Knight Collection.

25. Apgar, "Radio Report-1933," pp. 10-12.

26. Evan W. Kelley, "Memorandum for Chief, Forest Service," 11 March 1936, pp. 2-5, Gaylord A. Knight Collection.

27. Apgar, interview with author. 500 watts was authorized for the military and Weather Bureau.

28. Apgar, interview with author.

29. A. R. Standing to Regional Forester (R-6), 26 July 1939, Gaylord A. Knight Collection.

30. Forest Service, Radio Laboratory, "Inter-Regional Radio Communication Conference-Minutes of Meeting," Portland, Ore., 2 December to 7 December 1940, p. 88, Gaylord A. Knight Collection.

31. Forest Service, Radio Laboratory, "Conference," p. 88.

32. Forest Service, Radio Laboratory, "Conference," pp. 81-91.

33. Logan Belleville, interview with the author in Saratoga, Calif., January 1978.

34. A. G. Simson, "The Role of Radio in National Forest Communication," 11 April 1936, typed copy, p. 2, Gaylord A. Knight Collection.

35. Fred Funke, "Communication Planning" (Paper presented at the Inter-Regional Radio Communication Conference, Portland, Ore., 2 December 1940. See Forest Service, Radio Laboratory, "Conference," p. 21.

36. Forest Service, Radio Laboratory, "Conference," pp. 3, 4.

37. Forest Service, Radio Laboratory, "Conference," pp. 2, 9.

38. Forest Service, Radio Laboratory, "Conference," pp. 6, 7, 11.

39. Forest Service, Radio Laboratory, "Conference," pp. 7, 8 and Gaylord A. Knight, interview with the author in Atlanta, Ga., November 1977, February 1978, April 1979.

40. Earl W. Loveridge to Regional Forester (R-1), 15 April 1940 and A. G. Simson, "Memorandum," 30 March 1940, both Gaylord A. Knight Collection. The Laboratory had constructed a prototype MX (Medium-power experimental) for experimental use on 5,902 kHz.

41. Simson, "Memorandum."

42. Loveridge to Regional Forester (R-1), 5 April 1940, Gaylord A. Knight Collection.

43. E. W. Loveridge, "Memorandum for Mr. Simson," 21 August 1940, Gaylord A. Knight Collection.

44. A. G. Simson, "Memorandum for Mr. Loveridge," 26 August 1940, Gaylord A. Knight Collection.

45. H. K. Lawson, "Memorandum for Files," 23 August 1940, p. 4, Gaylord A. Knight Collection.

46. Lawson, "Memorandum for Files," p. 5.

47. Lawson, "Memorandum for Files," p. 3.

48. Lawson, "Memorandum for Files," pp. 1, 2.

49. Lawson, "Memorandum for Files," p. 1.

50. Forest Service, Radio Laboratory, "Conference," pp. 1, 33.

51. W. B. Apgar, "Operating Procedure and Operator Training" (Paper presented at the Inter-Regional Radio Communication Conference, Portland, Ore., 2 December 1940.) See Forest Service, Radio Laboratory, "Conference," p. 40.

52. F. V. Horton to Regional Forester (R-5), 20 December 1939, Gaylord A. Knight Collection.

53. Evan W. Kelley to Mr. [Lyle] Watts (R-6), 5 November 1940, Gaylord A. Knight Collection.

54. Harold K. Steen, *The U.S. Forest Service: A History* (Seattle: University of Washington Press, 1976), p. 234.

55. E. W. Loveridge to Regional Forester (R-1), 2 January 1941, Gaylord A. Knight Collection.

56. Apgar, interview with author.

57. Woods, interview with author.

58. Apgar, interview with author.