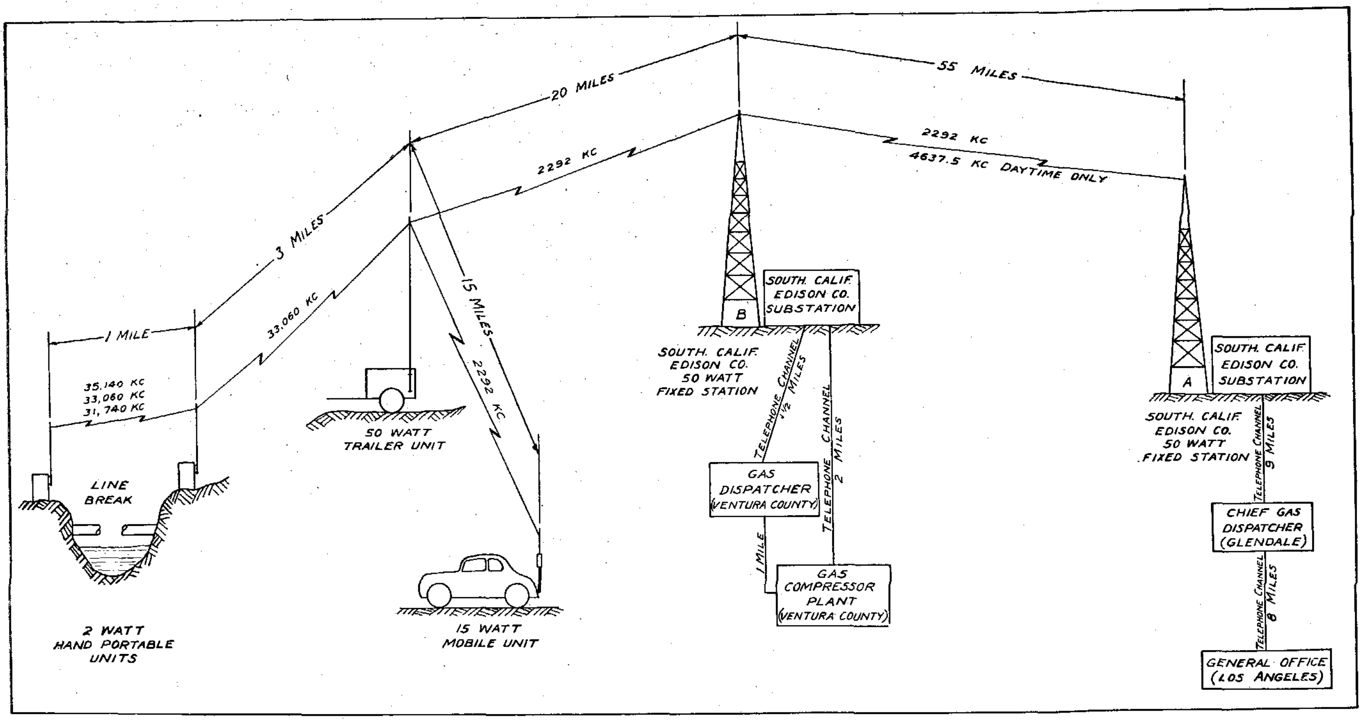


FIG. 1—Diagram showing the typical operation of the Southern Counties Gas Company radio communication system, showing how the different units are used to relay information from a line break in the mountains at a remote point directly to the general office in Los Angeles.

Radio Communication in a Public Utility

By HARRY J. KEELING

FOR many years public utility operating men have dreamed of the day when, through the magic of the radiotelephone, their dispatchers would have instant communication with all field crews and service men. This idea is a natural outgrowth of the rapid increase in the number of two-way radiotelephone sets used by the police and sheriff's departments in communicating with their patrol cars. Unfortunately, the dream may never progress to reality. Although it is always dangerous to forecast what the future will bring in this rapidly changing world, it is safe to say that for a number of years at least, it is not likely that radio communication for ordinary routine business will be possible. The wishful thinkers do not realize that there are only a limited number of usable channels in the radio spectrum, and this number is rather small when compared with the number of services desiring to use them. The army, navy, and government agencies require the use of a large proportion of the radio spectrum, while ships, aircraft, and commercial point-to-point stations require most of the remaining channels.

Because of the extreme congestion, the Federal Communications Commission is forced to restrict the use of radio to services which cannot be handled by wire telephone systems. Police and public utility companies are permitted to operate radio communication systems; however, they may be used only in case of emergencies when there is no other means of communication available.

Electric utilities were quicker in adopting radio communication for emergency service than were gas or other utilities. This is natural when it is remembered that a gas or water utility handles its product in pipes below the ground, where they are fairly well protected from the elements. An electric utility, on the other hand, is more likely to have frequent interruptions to service, since overhead wires are vulnerable to wind, storms and traffic accidents. Although an electric utility may have several hundred minor service interruptions during a year, a gas utility will have only one or two interruptions; but these interruptions are usually more serious.

The Southern Counties Gas Company of California was among the first of the natural gas public utilities to install two-way radiotelephone equipment for emergency communication. The earthquake of 1933, and the severe rains of 1938, brought to the attention of the management the desirability of supplementing the regular telephone system with another means of communication, so that field units would not be isolated from headquarters if the usual channels were not available because of a breakdown or congestion.

The company, with headquarters at Los Angeles, supplies gas to many small communities covering an area of about 700 square miles and operates pipelines extending as far north as Paso Robles and as far south as San Diego. These pipelines in many cases pass through rough mountainous country where they are subject to land slides or floods. In past emergencies, the lack of communication between the repair parties on the opposite banks of a stream greatly increased the difficulty in repairing breaks to the lines where they were washed out by rivers. The same floods that damage the pipelines usually disrupt public telephone facilities, cutting communication lines between the repair

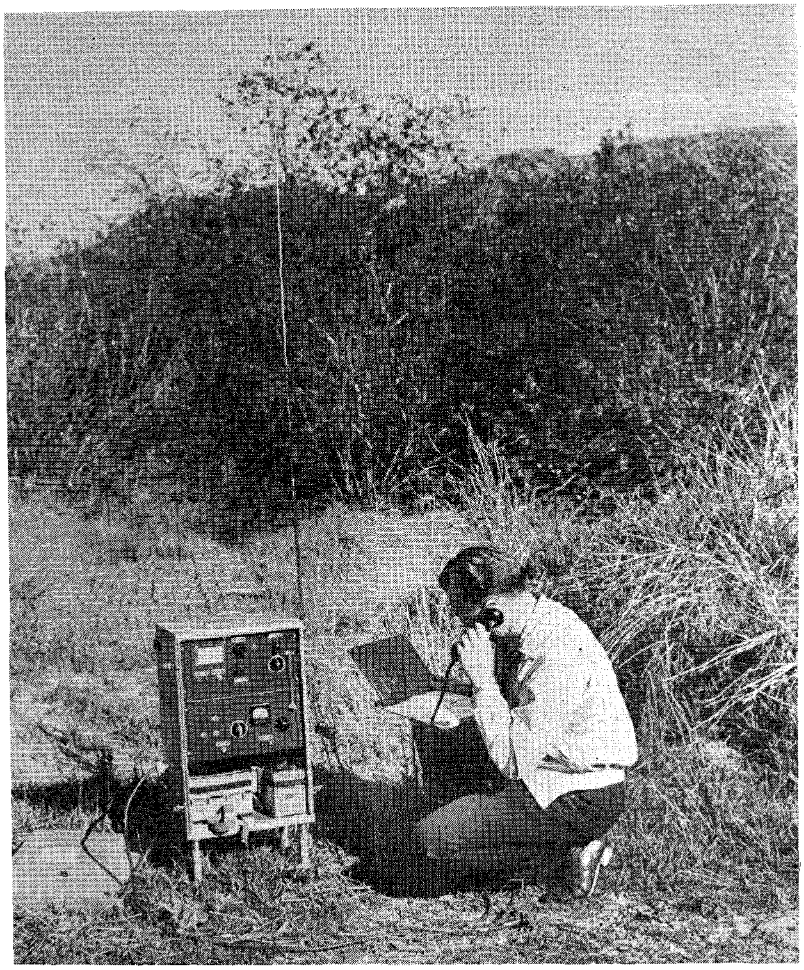


FIG. 2—The two-watt portable radiotelephone unit in use in the field. The removable legs have been installed on the box to raise the set out of the damp grass. The batteries may be seen in the lower compartment. The operator is reporting information to headquarters.

crews and their headquarters at a time when communication is most important.

REQUIREMENTS OF THE RADIOTELEPHONE SYSTEM

After studying the radio communication systems used by the forest service, police department and electric utilities, the specific requirements were formulated from a study of work done by the company during previous disasters. It was found that there was a definite need for emergency communication of three types:

1. Short-range communication (one or two miles) for use between repair parties working on opposite sides of the stream or canyon where pipelines have been washed away.
2. Medium-range communication (five to 20 miles) for exchanging information between the site of the pipeline break and the district headquarters.
3. Long-range communication (20 to 60 miles) for communicating between district headquarters and the Los Angeles general office or between the district headquarters and district emergency crews working a long way from headquarters.

EARLY DEVELOPMENTS

Early in 1937, the Southern Counties Gas Company acquired a pair of two-watt hand portable ultra-high-frequency radiotelephone units. These were custom built since at that time standard commercial equipment was not available. These sets were used to train operators and to gain experience before investing in more elaborate and expensive long-range equipment. Because of the uncertainty of the degree to which it would be used, the management decided to establish a radio communication system gradually by obtaining additional units from time to time. In this way, it was felt that the operating experience would lead to development of additional useful features when newer sets were added. The development of radio communication apparatus is so rapid that in a few years a complete system may become obsolete.

By 1940, six two-watt portable units were in operation, and in September, 1941, two 50-watt trailers and five 15-watt mobile units were added, making a total of $9,000 invested in radio equipment. Plans to install additional units were interrupted by the bombing of Pearl Harbor and the outbreak of the war.

RADIO OPERATORS

The Federal Communications Commission has jurisdiction over all radio equipment. Public utilities operate as a part of the "Special Emergency" section of the "Emergency" service. The equipment must meet the rigid requirements which the Commission has set up to minimize interference with other radio services. All persons operating or adjusting radio transmitting equipment are required to hold a license issued by the Commission. If the transmitting equipment is equipped with foolproof controls so that it is not easily put out of adjustment, it may be operated by a person holding a "Restricted Radiotelephone Permit." No technical knowledge is required for this permit beyond the ability to handle the equipment properly. The person holding it, however, is required to pass an examination on the rules, regulations and laws governing the operation of radio equipment. The Southern Counties Gas Company has trained about 40 of its regular personnel to operate the radio equipment. These radio operators are recruited from its office force as well as its field operating crews, so that during an emergency there will always be plenty of trained people available.

In order to get the greatest use out of the few sets available, the equipment is stationed at strategic points throughout the system so that no matter which area of the territory experiences the emergency, there will always be radio equipment stationed nearby which quickly can be dispatched to the scene of the trouble. For short-range communication, the equipment operates on three ultra-high frequencies. Medium and long-range communication is carried on a special frequency of 2292 kilocycles assigned for the exclusive use of public utilities operating in the emergency service.

TWO-WATT PORTABLE MOBILE UNIT

This short-range communication equipment transmits and receives on three frequencies in the ultra-high frequency band, namely, 35,140 kilocycles, 33,060 kilocycles and 31,740 kilocycles. There were two reasons for justifying more than one operating frequency: first, this feature permits several pairs of units to work in the same vicinity without interfering with each other. Second, when receiving conditions are bad on one frequency, it will usually be found that reception is satisfactory on one of the other frequencies.

The units, which cost about $250 each, comprise transmitting and receiving sets in a weatherproof wood cabinet with an eight-foot collapsible "whip" antenna mounted on the side. Clips are provided on the cabinets, permitting them to be attached to standard "back-pack" frames of the type which ordinarily are used to carry camping equipment on a hike. This feature is a great convenience when the sets are to be carried a long distance by one man on foot. Removable legs on the bottom of the box raise the equipment above the ground and prevent entry of mud or water in swampy or muddy locations. The unit is powered by self-contained dry cell batteries which are capable of operating the receiver for 27 hours continuously and the transmitter for nine hours when used intermittently. The entire set weighs 56 pounds. This is rather heavy for hand portable equipment, but it is felt that the long battery operating life more than justifies the additional weight.

Because of the "light-like" characteristics of ultra-high-frequencies, these sets do not operate satisfactorily where there are physical obstructions such as hills, buildings, etc., between the two units. However, they give dependable communication over a distance of one-half mile when used on the ground in ordinary city streets, and two miles in open country where there are no obstructions. When operating from the tops of high buildings or hills, the range is increased to five or six miles. Vertical antennas supported by hydrogen-filled balloons have been used successfully to communicate over distances of from six to nine miles in rugged mountainous country. The balloons make tempting targets for amateur sharpshooters, however. On one occasion most of the radio operator's time was spent in replacing the balloons after they had been shot down by some unknown rifleman.

It may not be apparent that the short range of the sets is definitely an advantage under certain circumstances. Operators working with these high-frequency units on opposite sides of a canyon are not bothered by interference from signals transmitted by distant but more powerful stations, because of the shielding effect of the surrounding hills. When lower frequencies are used, operators in remote points in the mountains sometimes find that their work is interfered with by strong signals from stations many miles away.

15-WATT MOBILE UNIT

The 15-watt mobile installations consist of standard Motorola ultra-high-frequency transmitting and receiving units rebuilt to operate on medium frequency (2292 kilocycles). They are designed to be permanently installed in the luggage compartment in the rear of a conventional coupe or sedan passenger car. The installed cost of these sets is about $500. The equipment is energized from the six-volt auto battery and contains no other auxiliary power supply.

Four of these units are installed in coupes, and one is installed in a pick-up truck. The truck is equipped with a 35-foot collapsible self-supporting antenna. Although the set can be operated with the truck in motion and the antenna fully extended, this is seldom done because of limited highway clearance. Ordinarily, the truck is operated with only the upper "whip" part of the antenna extended, making the overall height about 15 feet.

The coupes originally were equipped with a 10-foot "whip" antenna mounted on the rear bumper. After experimenting with several different types of antenna systems, an improved antenna was developed recently which uses a loading coil in the center of a "whip" to increase its electrical length. Not only is there a greater radiation from this type of antenna, but unlike the simple "whip" antenna, its efficiency is not lowered during extremely wet weather when the supporting insulators are subjected to a continuous stream of water. This is explained by the fact that the voltage across the insulator at the base of the center-loaded antenna is much lower than the voltage across the base of the simple "whip" antenna.

OPERATING RANGE OF MOBILE UNITS

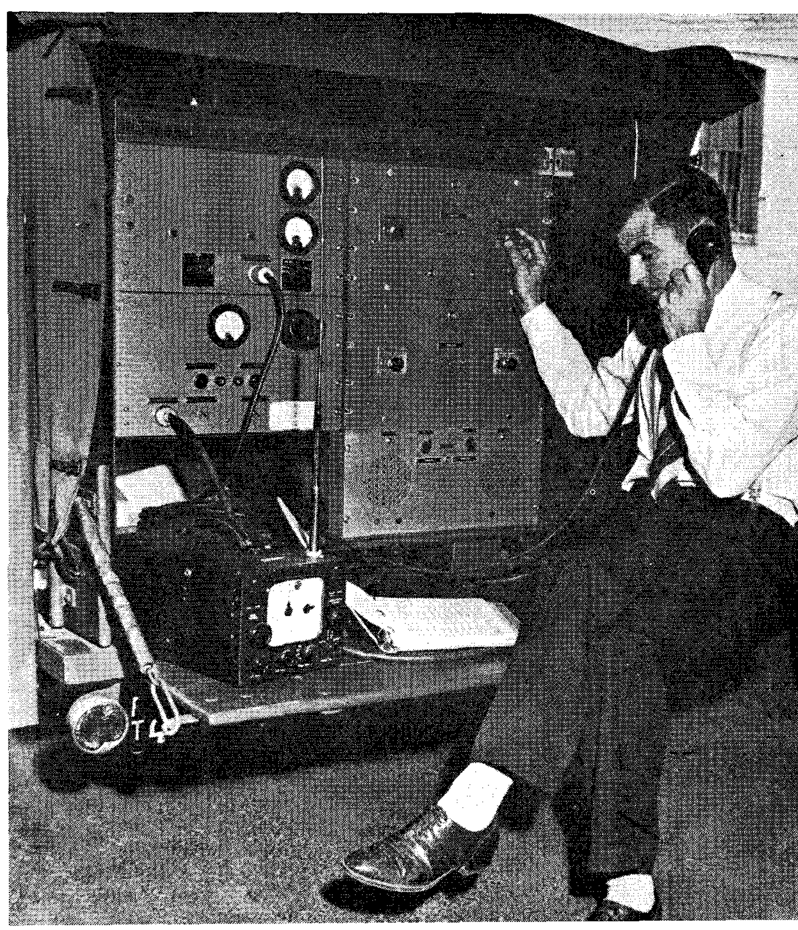
The average dependable operating range of the 15-watt mobile units when talking from one car to another is from five to 20 miles, depending upon conditions. The range depends upon: first, the amount of local interference from noise and static from power lines, street cars, etc., and second, the type of soil. Along the coast where the transmission path may be across salt water, it is possible to achieve satisfactory and dependable communication between cars separated by a distance of 65 miles or more. On the other hand, in other locations conditions may not permit communication at distances greater than eight or 10 miles.

FIXED ANTENNA FOR MOBILE UNIT

An important district headquarters is located in an area where conditions are very poor for radio transmission or reception. Recently a 100-foot vertical antenna was installed at the top of a nearby hill to insure dependable communication with another district, about 30 miles away, using a 15-watt mobile unit. A 275-

(*Continued on Page* 15)

FIG. 3—Close-up of operating panel on 50-watt trailer, with author at the controls. The transmitter on the left-hand side of the panel operates on 2292 kilocycles or 33,060 kilocycles. The two separate receivers and loud-speakers which may be seen on the right-hand side of the panel permit reception on both frequencies simultaneously. The portable all-wave receiver resting on the end gate is used when it is ncessary to receive messages from other radio stations which are not transmitting on the standard frequencies.



13. What kind of appeal would be most successful in getting acceptance from the workers? Who should introduce and sell the plan to them?

14. What is the proper timing for introducing the proposed plan? Are the workers or supervisors temporarily upset about something? When should the plan be installed?

15. What are the long-time human relations effects of the proposal? Can management honestly fulfill the commitments made? Are there other changes which will follow?

We can all remember cases in our own experience where failure to consider such factors has led to the downfall of plans for improvement. The following examples, although in part hypothetical, were suggested by actual experience and serve to illustrate the point:

(a.) An industrial engineering plan called for the transfer of certain grinding machines from the machine shop to the foundry cleaning room. The change was expected to streamline the flow of material and eliminate a bottleneck in the material's handling system. Shortly after the change, the number of castings per day began to fall off despite the fact that the grinders were working on piece rate and no change in equipment or method had been made. The anticipated benefits were completely offset by the lowered production of the grinders.

Investigation showed that the grinders were upset because they had been moved into the cleaning room along with the foundry laborers. Since it was a generally accepted fact that the foundry laborers were lower than machine shop workers in the social scale, the grinder's standing in the factory social organization had been lowered. No amount of persuasion could convince them that it made no difference where they worked as long as their pay remained the same. To them, they had lost prestige. Finally the entire plan was abandoned and the machines moved back to their former place before production could be brought back to normal.

(b.) Another plan called for the rearrangement of the equipment in a plating room to eliminate one of the dipping processes. From the start it was opposed by the foreman of the plating department. Trouble developed with the improved process and things grew from bad to worse. Finally it was discovered that the foreman had made the same suggestion for improvement a number of years before, but had been turned down by a former plant manager. It was only after the present plant manager had been apprised of this fact and the foreman given public recognition for his idea that the new plan began to work properly.

(c.) On the other side of the picture there was the case of the industrial engineering department which was responsible for making all the job evaluations in a steel mill. From the start the system of job evaluation was opposed by the department superintendents and foremen. The job evaluation technique was complicated and difficult to understand. The job evaluations developed by the industrial engineering department seemed arbitrary, and industrial engineering recommendations on rates were generally questioned by department supervisors.

The solution to this problem was to modify and simplify the job evaluation system so as to bring line supervisors' opinions into the decisions. Ranking scales for each factor in the evaluation were developed so that foremen could quickly make and check evaluations against their own background of experience. None of the accuracy of the evaluations was sacrificed, however, and the basic principles set up by the industrial engineers were in use. The result was that bickering stopped and the industrial engineering department was able to check its evaluations and profit from the broad experiences of the line supervisors.

It is obvious that a serious consideration of the human factors, at the time the above plans were developed, would have made it possible to eliminate some of the mistakes made in their application.

It is not inconceivable that at some future date a human relations analysis will be an integral part of every industrial engineering study made. The industrial engineer's report and recommendations may include a section on the human aspects of the plan and a recommended human relations procedure for its installation.

Just how the industrial engineering department will be organized to obtain this data will depend, of course, upon individual circumstances. It may be that someone in the industrial relations division would be qualified, or someone from line supervision, or someone from the industrial engineering department itself. The important thing, however, will be to obtain sound advice from persons who know the employees affected by the plan and their probable reaction to it.

All this will be worked out in the future as industrial engineers appreciate more fully their need for human relations planning. It is inevitable, however, that considerable progress will be made in this field—with surprising results. Industry is slowly learning something about human relations, and industrial engineering cannot afford to be left behind.

Radio Communications

(*Continued from Page* 13)

foot transmission line terminating in the headquarters garage building permits the mobile unit in the garage to be connected with the fixed antenna. Ordinarily, when the car is away from its headquarters, it operates as a mobile unit, using the short center-loaded antenna mounted on the car; however, when it is desired to increase its range or when the car is at headquarters, the short antenna is disconnected and the car set is plugged into the transmission line, connecting it with the fixed antenna. The equipment for doing this has been simplified so that the change-over can be made in 10 or 15 seconds by an operator with a "Restricted Radiotelephone Permit." The 100-foot fixed antenna has not been installed long enough to determine its maximum range; however, during recent tests satisfactory contacts were made with 50-watt units 140 miles away. It appears that dependable two-way communication is possible at all times with other 15-watt mobile units operating within a 30-mile radius.

50-WATT PORTABLE MOBILE UNIT

This equipment comprises two transmitting and receiving units (operating on 2292 and 33,060 kilocycles), housed in waterproof boxes, mounted on a trailer. It is designed to operate on 120-volt, 50- or 60-cycle alternating current power supply through a 50-foot extension cord. Where normal power is not available, the equipment is energized from an emergency source consisting of an 800-watt Kohler gasoline engine generator unit, which is also mounted in a waterproof box on the trailer. The antenna for this 50-watt unit consists of a 35-foot collapsible "whip" which is attached to the trailer. The unit was designed to be as versatile as possible. The two steel boxes housing the radio equipment and power supply may be demounted from the trailer and carried by hand in country where it is not possible to tow the trailer. With the gasketed steel covers closed, the equipment is completely waterproof and is instantly ready for operation even after complete submersion. The entire outfit, including the trailer and power supply, weighs 1500 pounds and costs about $2,000.

The specifications for these trailers provided for mobile operation of the equipment while the trailer was being towed by a truck. The microphone hand set is equipped with a 50-foot cable, allowing the operator in the cab of the truck to transmit while in motion. While traveling on public highways the 35-foot antenna is collapsed to the 15-foot height required to clear highway obstructions. This results in a decreased transmitting range. However, it is possible to receive satisfactorily with the shortened antenna; therefore, a truck towing one of these trailers can be called over the air while the truck is in motion. If the driver has difficulty in answering the call, it is only necessary for him to stop the truck and extend the antenna.

The dependable operating range of the trailer unit under average conditions is about 25 miles on a frequency of 2292 kilocycles and about 10 miles on 33,060 kilocycles. These figures are only approximate. As explained in the discussion of the 15-watt units, under certain conditions the range may be several times the figure given above. For example, regular schedules are maintained between two of these trailers over a distance of 240 miles between the towns of Avenal and Santa Ana, California.

JOINT OPERATION OF FIXED STATIONS

The experience with the 15-watt mobile units and the 50-watt trailer units demonstrated that this equipment filled our needs for medium-range communication. However, for long-range communication, a fixed station with a permanent antenna is required. Investigation of suitable sites for fixed stations revealed that many of the proposed locations were occupied by the Southern California Edison Company, Ltd., which operates radio equipment on the same frequency, 2292 kilocycles.

The three gas companies operating in this area, Pacific Lighting Corporation, Southern Counties Gas Company and Southern California Gas Company, cooperated closely in the establishment and operation of an emergency radio communication system. To minimize the capital investment required in fixed stations, an agreement was reached whereby the three gas companies could share the use of three of the Edison Company's fixed stations located in Los Angeles, Orange, and Ventura Counties. Apart from the saving in the costs, this arrangement is very desirable since there is only one radio network in this area instead of four separate networks. Consequently, there is a minimum of interference over the air.

The three gas companies also collaborated in the purchase of their radio equipment. The same designs and specifications were used by all three companies, and by combining their orders it was possible to obtain custom-built equipment from a Los Angeles manufacturer at reasonable costs. Although the individual gas company each owns and operates its own radiotelephone emergency units, the dispersal of the sets in the various districts takes into consideration the requirements of all three companies; thus duplication is avoided and maximum use is made of the available equipment.

During times of general emergency, the gas companies and the Edison Company combine their radio facilities to form a system of mutual benefit to all concerned. Messages for transmittal over the Edison Company's 50-watt fixed stations are relayed from the gas company offices either through public or private telephone channels or over the air from mobile units. The Southern California Edison Company operates a rather complete radio network comprising several fixed stations, each of which has a number of mobile units operating in conjunction with it. This system gives them 24-hour emergency radio service over the major part of the area served. The gas companies do not intend to provide such complete coverage of their territory because of:

1. The excessive cost due to the large area involved, and

2. The limited number of gas company emergencies where radio communication is necessary.

EMERGENCY OPERATIONS

Fig. 1 shows graphically how with relatively few pieces of radio equipment it is possible to set up an independent communication network through which information can be relayed quickly from a remote point in the mountains to the general office in Los Angeles. In this example, it is presumed that the broken pipeline is located in inaccessible hills in Ventura County. The emergency truck has towed the 50-watt trailer to a point as near as possible to the site of the break, and the portable units have been carried to opposite sides of the canyon where the break occurred. Since the 50-watt trailer can operate on both ultra-high frequency (33,060 kilocycles) and medium frequency (2292 kilocycles), it acts as a control station for the units operating in the vicinity of the line break. The control station is capable of relaying information from the two-watt sets on the opposite banks of the canyon or from nearby 15-watt units to either the Ventura County district headquarters or the general office in Los Angeles. This is done through the Southern California Edison Company's 50-watt fixed station and the telephone company's facilities. There is very little likelihood that all the telephone circuits between the Edison Company's fixed station and the gas company offices would be out of order at the same time. However, if this possibility did occur, the gap would be bridged by stationing a 15-watt mobile unit at the gas company office. The diagram, Fig. No. 1, serves to illustrate how it is possible to fulfill the requirements for short-range, medium-range, and long-range communications, using a limited number of pieces of equipment.

There has been no major catastrophe in the gas company territory since the emergency radio system was organized. The value of the plan has been amply demonstrated by several minor emergencies, however. In January of 1943, severe rains threatened to wash out an important pipeline river crossing in Ventura County. During this time the telephone lines between Ventura and Los Angeles were out of service because of the storm.

It was very important to the Los Angeles gas dispatcher to know the probability of the pipeline being broken at the river. A truck with a 15-watt two-way radio set was stationed at the river bank to observe the flood conditions. At regular intervals this information was relayed through the Edison Company's stations to Los Angeles through the system illustrated by Fig. No. 1. Fortunately, the river did not rise sufficiently to carry away the pipeline. In cases of this kind, the gas dispatchers and the operating crews can work with confidence, since they know at all times the conditions at the vulnerable points in their supply system.

In another district during this same storm, a repair crew was standing by, with men stationed at opposite sides of a river where rising waters threatened to break the pipeline. These repair crews were supplied with equipment for quickly installing a temporary bypass across the stream, should the main line be carried away. Two-watt portable radio sets were used to communicate between the parties on the opposite sides of the stream. Fortunately, the storm subsided before any damage was done.

The radio equipment has been very useful in providing communication between different field crews who may be taking a portion of a major transmission line out of service for a short time in order to install a valve, clean the interior, repair leaks, etc. Since it is imperative that service to the consumers be uninterrupted at all times, valves at each end of the section to be taken out of service are closed to isolate it from the main line. Consumers served normally by the section which will be out of service are supplied with gas from small portable high-pressure storage tanks which are similar to welding gas tanks. Consumers downstream from the section of transmission out of service are supplied through the "line pack" or gas stored in the line. Naturally, when the main line valves are closed, the gas pressure in the section downstream from the closed valves gradually drops. If the repair party does not complete the repair operation in the scheduled time, there is danger that the downstream pressure will drop so low that service to the consumers is interrupted. Here again the emergency radiotelephone equipment fills an urgent need, since main transmission pipelines are frequently located in undeveloped territory far removed from good roads and public telephone service. Information concerning the pressure at the downstream side of the closed valve can be relayed rapidly to the crews working on the pipeline, and if the pressure becomes so low as to endanger the service to the consumer, repair operations can be halted and orders dispatched by radio to the valve crew at the upstream end of the section.

There are innumerable other ways in which a small emergency communication system can be helpful to a public service company. The emergency radio system described in this article was planned long before the present war started; therefore, it was not designed particularly for war emergency service. It is indeed fortunate that this system was built up prior to the war, since it will be invaluable in case of actual trouble in this area. When peace comes to this country, and civilians are permitted again to purchase items that are now reserved for the fighting forces, the gas companies plan to continue the growth of their emergency radio system by adding mobile units and a few fixed stations. Until the happy day of victory arrives, however, it will be necessary to continue to make the best use of the equipment on hand.

SYMPOSIUMS ON SYNTHETIC RUBBERS AND PLASTICS

THE increased production of synthetic rubbers has led to a demand for authoritative technical data and information on the applications and uses of these materials. In answer to this need the spring meeting of the American Society for Testing Materials will feature a symposium on this subject at Cincinnati, Ohio, on March 2. Many experts will present papers dealing with development, properties, testing, specifications, processing and uses of synthetic rubbers. Except in so far as necessary for background information the speakers do not plan to deal with the chemistry or manufacture of the crude synthetics.

On the evening following the A.S.T.M. meeting J. L. Collyer, president of The B. F. Goodrich Company, will speak before the Technical and Scientific Society Council of Cincinnati. He will discuss the development of synthetic rubbers and some of the economic and industrial aspects of this field.

The A.S.T.M. Philadelphia District Committees are to hold meetings on February 21 to 24 to discuss the subject of plastics. This is the first symposium on plastics since 1938 and there have been many notable developments in the field since that time. Many leading technical people in the industry will participate in the symposium, and a feature of the program will be the presentation of data on the leading plastic families by Dr. G. M. Kline, of the National Bureau of Standards. His paper will be based upon data obtained by seven technologists. Many important topics concerning the properties, testing, and uses of plastics will be presented by technologists of several industrial concerns and research laboratories.

The Society has announced that it is planning to issue the symposiums in the form of bound publications.

George Washington, Engineer

(*Continued from Page* 3)

degree and after having submitted a satisfactory thesis describing engineering work performed. Examination of the candidate by a board of examiners also is recommended.

The possession of a degree does not make a man something that he is not. If high standards are maintained by the degree-giving institution, the degree may be a symbol of true attainment. However, many who do not possess degrees are as competent—if not more so—than some who insist on placing letters after their names. A true measure of professional ability might lie in "solid information and sound judgment" as this phrase was exemplified in Washington.

ERRATUM

Attention of the editors of *Engineering and Science* has been called to an error in the item appearing on page 19 of the January issue. Aristotle D. Michal was elected associate secretary, not vice-president, of the American Mathematical Society.

The secretary, J. R. Kline, has also requested that a statement of the aims of the Society should read as follows:

"The American Mathematical Society is an organization to encourage and maintain an active interest in mathematical science. Its primary object is the promotion of mathematical research. To attain this, it conducts meetings for the presentation of research papers and maintains a publication program of mathematical journals and books on current research."