PETROLEUM INDUSTRY USE OF THE RADIO SPECTRUM

National Petroleum Council

Washington, D. C.

1960

NATIONAL PETROLEUM COUNCIL

REPORT OF

THE COMMITTEE ON USE OF RADIO AND RADAR (1959)

JANUARY 5, 1960

MORGAN J. DAVIS — *Chairman*

ROBERT E. ROEHL — *Government Co-chairman*

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HUMBLE OIL & REFINING COMPANY

HOUSTON 1, TEXAS

MORGAN J. DAVIS
PRESIDENT

January 5, 1960

Mr. Walter S. Hallanan
Chairman
National Petroleum Council
1625 K Street, N. W.
Washington 6, D. C.

Dear Mr. Hallanan:

This report is submitted on behalf of the Committee on the Use of Radio and Radar (1959) in response to the request of the Honorable Elmer F. Bennett, Acting Secretary of the Interior, on January 21, 1959, that the National Petroleum Council create a committee to review its previous reports and recommendations in this specialized field, to make a current study concerning the use of radio and radar in the petroleum and natural gas industries, and to submit a report thereon, together with such recommendations as the National Petroleum Council deems appropriate.

The Committee met on July 23, 1959, September 8, 1959, and November 8, 1959. At the first meeting, previous reports were reviewed and plans made for preparation of this current report. Assignments of specific topics were made to individuals and groups. At the second meeting, drafts of the various sections were reviewed and the nature of the desired revisions agreed upon. An editorial group prepared the final rough draft. This final rough draft was submitted to all Committee members in advance of the November 8, 1959 meeting, at which all editorial changes were approved and the final report was unanimously adopted.

Part I of this report is a summary of the main body of the report.

Part II contains the recommendations of the Committee.

Part III gives the details of the organization of the Committee.

Part IV is the main body of the report and is titled "Petroleum Industry Use of the Radio Spectrum."

Respectfully submitted,

Committee on the Use of Radio and Radar (1959)

Morgan J. Davis

Morgan J. Davis, Chairman

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PART I

SUMMARY OF REPORT

SUMMARY

The National Petroleum Council Committee on Use of Radio and Radar (1959) has carefully reviewed past and present uses of radio and radar in the oil and natural gas industry, examined the probable future needs and studied the problems which pose threats to the industry's continued effective use of radio and radar.

On the basis of this study, eight recommendations are offered for most serious consideration. These recommendations concern vital and, sometimes, urgent problems. They are given on page vii of this report.

Supporting these recommendations, *Section 1* describes the ever-increasing dependence of our national well being on the petroleum and natural gas industry. This is an industry which provides 70% of our national energy consumption. Likewise statistics are quoted on the growth of use of radio by the oil and natural gas industry that may be surprising even to members of that industry.

The privilege of using radio and radar effectively is not automatically granted to an industry. This privilege is acquired only by great effort, proof of need and demonstration of real benefit to the public. The price of maintaining this privilege is eternal vigilance. The effort is demonstrated by the history given in *Section 2*. A description of industry organizations which provide the necessary vigilance is given in *Section 3*.

The most serious challenge to the petroleum industry's continued effective use of radio is the growing intensity of competition for radio channels — for spectrum space. There is a definite, immutable upper limit to possible utilization. Technological improvements will increase the efficiency of radio spectrum utilization. But demand will increase at a far more rapid rate than efficiency.

This problem is not peculiar to petroleum radio or even industrial radio. It affects broadcasters, government users, communications common carriers alike. The problem is clearly recognized in high governmental circles and will receive intensive study. It is essential that petroleum radio needs be adequately presented in such studies. This question is considered in *Section 4*.

The petroleum industry has complex relationships with communications common carriers. *Section 5* outlines some resultant problems. The oil and natural gas industry constitutes a major user group of communications common carriers and relies on them to a very important extent. But other communications needs of the petroleum industry are best served by communications systems within the sole and direct control of the user. Such private systems, however, lead to competition for frequencies with the communications common carriers.

Section 6 relates to the increasing importance of petroleum industry communications facilities in the event of a national emergency and outlines recent developments of national defense planning with which these facilities are concerned. At the request of government agencies, the industry has cooperated in studies to insure top priority transmission during a national emergency; however, to develop a plan under which petroleum industry facilities would provide a ready alternate communications link for oil and gas administration and other governmental emergency communications needs, without disrupting industry operations, would require the expenditure of considerable time and money.

The agency responsible for regulating all radio use, except by the federal government, is the Federal Communications Commission. *Section 7* briefs some of the recent dockets of the FCC and discusses their impact on the oil and natural gas industry.

Two relatively new developments are certain to result in an increase in rate of growth of petroleum radio and radar uses. These are automation and offshore operations, described in *Sections 8 and 9*.

The statistics on petroleum radio use, in *Section 1*, give an idea of the magnitude of the industry's needs, but to understand the true role of radio, it is necessary to consider in some detail actual applications. The final nine sections, *Sections 10-18*, cover each phase of the oil and natural gas industry's operations — exploration, drilling, producing, transportation, refining and marketing — on land, sea and in the air. Each phase is keyed in an important manner to the use of radio. Safety and efficiency are greatly enhanced by this usage. Without radio, some petroleum operations would be impractical and numerous others would be seriously handicapped.

PETROLEUM INDUSTRY USE OF THE RADIO SPECTRUM

Section 1. Petroleum's growth and use of radio. Productivity, industrialization, and living standards of any nation are reflected in its consumption of energy in fuels and water power. Since 1927, the United States' consumption of such energy has almost doubled. In 1927, petroleum and natural gas supplied 27.5 per cent of such energy. By 1957, this had increased to 69.2 per cent. Growth of petroleum consumption in the United States has more than paralleled the growth of the economy. In turn, industrialization of this nation is the sinew of its military strength. Petroleum has a double significance in national defense. It not only powers the industrial plants but also military vehicles and equipment. Our military establishment runs on oil.

To provide an abundant, uninterrupted supply of oil and natural gas requires increasing activity of vast magnitude on the part of the industry. These operations, often scattered and in remote areas, require constant communications. Radio and radar are often the best, or only, possible means. Other sections describe such applications of radio and radar in detail. The scale of these uses is indicated by the fact that in the *Petroleum Radio Service* over 700 users operate over 44,000 radio transmitters other an microwave. In addition, 176 gas distribution companies operate nearly 18,000 such transmitters. Moreover these petroleum and natural gas users have in operation or planning stage nearly 27,000 miles of microwave system incorporating 1200 stations.

Section 2. History. The history of radio in the petroleum industry is essentially the story of the growth of usable radio spectrum space, in turn governed by technological developments in the radio art. The petroleum industry's first usage of radio was on board tankers and primarily concerned the safety of life at sea. In 1925, radio was first used by geophysical crews prospecting for oil. In 1928, the industry sought the privilege of wider usage. This led to a cooperative communications company formed in 1929. Additional usage was permitted in 1932 in the Louisiana swamps in the *Special Emergency Radio Service.* In 1938, somewhat broader use became available in the *Provisional Radio Service.*

The major technical advances of the radio art during World War II, particularly the development of frequency modulation and of equipment usable in the Very High Frequency bands, led to an explosive growth of radio. The Federal Communications Commission recognized this possibility and held a series of allocation proceedings that resulted in a number of new radio services. The efforts of the petroleum industry, directed first through the Petroleum Industry Electrical Association and later the American Petroleum Institute Central Committee on Radio Facilities, resulted in the formation in 1949 of the *Petroleum Radio Service* for users engaged in prospecting for, producing, refining and transporting by pipeline, oil or natural gas. Natural gas distributors became eligible in the *Power Radio Service.* The petroleum service companies are eligible in the *Special Industrial Radio Service.*

Section 3. Industry associations and committees. The Central Committee on Radio Facilities of the Division of Transportation of the American Petroleum Institute acts as a forum for formulation of petroleum radio users' position concerning Federal Communications Commission proposals. It presents such positions to the Federal Communications Commission.

The National Petroleum Radio Frequency Coordinating Association is an advisory organization open to all licensees and applicants in the *Petroleum Radio Service.* It assists them in the selection of a specific frequency which will result in a minimum of interference.

The Petroleum Industry Electrical Association is an association open to companies engaged in any phase of petroleum operations having communications systems or electrical departments. It provides for study and interchange of knowledge with respect to the construction, maintenance and operation of electrical power and communications systems of interest to its members.

The National Committee for Utilities Radio combines on behalf of gas distribution, electric, water and steam utilities, functions corresponding to both the API Central Committee on Radio Facilities and the National Petroleum Radio Frequency Coordinating Association.

The American Gas Association Committee on Communications and Tele-control considers all problems of communications of interest to the gas industry. It arranges for discussions of technical topics. It presents statements to the Federal Communications Commission. It does not engage in frequency coordination work.

The Operational Fixed Microwave Council serves all microwave users in the safety, industrial, land transportation, marine and aviation radio services. It aids in selection of frequencies and provides a means of exchanging information.

Section 4. Spectrum problems. Unfortunately there are physical limits to the number of radio transmitters that can be used. With a steadily and rapidly growing demand for the advantages afforded by radio usage, there results an increasing intensity of competition for radio frequencies.

There are two international aspects. First, certain frequency bands provide long range transmission and therefore international interference. Second, maritime and aeronautical uses require international agreements so that ships and aircraft can communicate with one another and with ports and airports in any country. A complicating factor is the propaganda utilization of international radio broadcasts.

In the United States, the federal government has present rights to over a third of the vital bands from 25 mc to 890 mc. A serious difficulty is that no suitable agency exercises control over federal usage comparable to that exercised by the Federal Communications Commission over non-federal usage. This problem is being studied seriously by both executive and legislative branches of the federal government.

The largest assignment of frequencies in the United States is to the broadcasters, with TV and FM having the major share. Unfortunately, these allocations necessarily were made when both technical and economic knowledge were inadequate. Major changes are needed but will meet strong opposition from those who have investments in the status quo.

The communications common carriers are vigorous contenders for additional frequencies. At the moment they are stressing a broad band general exchange type mobile service in metropolitan areas and are asking for 75 mc of spectrum to provide this service. These common carriers at present are permitted and, indeed, required to serve anyone without regard to their relative contributions to the public welfare. Their spectrum requirements, therefore, should have low priority in this type of service.

Section 5. Communications common carrier problem. Broadly stated, communications common carriers believe they should have the sole right to fulfill all communication needs. From time to time, they acknowledge some exceptions to this position. The petroleum industry's position has been that there is a proper field for communications common carriers and also a proper field for private communications systems. Neither should preempt the entire field. The user should have freedom of choice in most instances, for only he has both the knowledge and incentive to make the proper choice.

Continued vigilance and continued effort to maintain good relations with communications common carriers are essential.

Section 6. Petroleum radio and the national defense. Three aspects currently are being actively considered. 1. CONELRAD is a program to control the use of radio in time of enemy attack so that radio homing devices will be ineffective. 2. More far reaching in its possibilities is the study of emergency utilization of a part of petroleum radio facilities by various government agencies, including the Oil and Gas Division of the Interior Department and the Defense Department. Such usage can be invaluable when normal communication channels are inoperative. However, careful, detailed planning is required to insure that essential operations of the petroleum industry also can be carried on. This planning will require expenditure of considerable time and money. 3. A third aspect is the priority of restoration of leased circuits that might be requisitioned for emergency use. Present regulations provide petroleum users with little assurance of prompt restoration of service following such requisitioning.

Section 7. Recent FCC Dockets. The use of radio by the petroleum industry, in common with all use except by the federal government, is controlled by rules and regulations of the Federal Communications Commission. Therefore the outcome of any action by the FCC is of vital importance to the industry. Two recent major actions were Docket 11866, covering use of all frequencies above 890 mc — the microwave bands — and Docket 11997, covering use of frequencies from 25 mc to 890 mc, the most important general purpose segment of the radio spectrum.

A Report and Order in Docket 11866 was released on July 29, 1959. It establishes basic FCC policy concerning microwave usage. It substantially confirmed the position taken by the petroleum industry, by permitting broad private microwave usage without regard to availability of communications common carrier service. However, since the decision was handed down, the communications common carriers have petitioned for a rehearing which, if granted, would postpone placing the decision into effect.

The hearing in Docket 11997 was concluded in late June, 1959, and no decision is expected before late 1960, after results of the Geneva Conference have been assessed.

Other important recent Dockets provided for "split channel" usage, increasing efficiency of spectrum utilization, and established new services with liberal eligibility requirements, vastly increasing the number of potential users.

Section 8. Impact of automation on communications. With inevitable increases in costs of many petroleum industry activities, is is obvious that to remain competitive, more efficient, precise and economical methods of operation in all phases of the industry must be found. More rapid data collection and processing, more accurate forecasts, more rapid decisions and greater flexibility of utilization of equipment are essential. The results are already apparent in pipelines, refineries and even oil and gas field operations. An integral part of an automated system is the communications facility. Growth in scope and importance of automation in the petroleum industry will demand more and better communication facilities. Many situations will require private systems.

Section 9. Radio in offshore operations. For more than a decade, the petroleum industry has been searching for, finding and producing oil and gas offshore, sometimes more than 30 miles from the nearest land and in water over 150 feet deep.

It is obvious that the exploratory phase is totally dependent on radio for coordination of effort and for location. The location of a site for a well is likewise dependent on radio.

Similarly erection of a drilling platform could not be performed efficiently without radio. While drilling a well, the need for radio is even more acute than on land.

Even after the well is completed, producing operations are best carried out with the aid of radio. Indeed in many cases, offshore operations can be carried out only if radio is available. Automatic remote control is a case in point. Throughout the operations, boats and helicopters must transport men and supplies. Their coordination and safety require radio.

Section 10. Radio in exploration. Some 11,000 to 12,000 wildcat wells per year are drilled to maintain United States petroleum reserves at a satisfactory level. Geologists and geophysicists must select locations for each of these wells. Radio and radar make major contributions to this effort.

Often these activities are in remote areas where there are no established communications systems. Coordination of the activities and safety of the men are dependent on private radio. Also, radio is an integral part of some of the data gathering systems. A third use of radio and radar in exploration is for radiolocation. Exploration measurements are useless unless it is known with precision where they are made. In many cases, such as offshore, radio and radar provide the only practical surveying method. Most of the 500 to 600 seismic crews in the United States are equipped with radio.

Section 11. Radio in drilling and production. Approximately 50,000 wells must be drilled each year in the United States. This is a hazardous and complicated operation. There are frequent needs for instructions, reports and requests for supplies and special services. Good communication is essential for efficiency and safety. Often the drilling site is remote from any established communications system. This is true even when the site is in a relatively well-populated area. The site may be occupied only a few weeks. In such cases, private radio provides the most feasible and economical method of communication. Supervisory and engineering advice is required at unpredictable times. Such services as delivery of "drilling mud" or "logging the hole" must be available on short notice. Such hazards as blow-outs, which may result in fire, or failure of equipment, call for immediate aid to minimize loss of life and property. All of these demand reliable communications. The operation may be 100 or more miles from the nearest commercial telephone. Or it may be offshore. Radio is the obvious answer.

After the well is completed and oil or gas is being produced, it becomes one of some 658,000 producing wells in the United States. A producing well is a facility requiring operation and maintenance. Valves must be opened and closed. Pressures and flow rates must be determined. Routine and emergency repairs must be made. Some of these varied activities are now automated, others must be done manually. In any case, each of them requires good communications. If the producing areas are near centers of population, wirelines may be used. More often the locations are such that only private radio is practical. Even where wirelines are used, mobile radio is essential to coordinate activities of men and vehicles.

Rarely are producing oil wells located closer than one well to each 10 acres. One well to 20 or 40 acres is very common today, and one well to 80 acres is not unusual. In the case of gas wells, only one well for each 160 acres is usual.

Thus, oil and gas drilling and producing operations are not concentrated in a building or group of buildings like a manufacturing or industrial plant.

Section 12. Radio in pipeline operation. The growth of pipelines has been very rapid. By the end of 1957, there were over 145,000 miles of crude oil (trunk and gathering) and refined product pipelines delivering nearly four and a half billion barrels per year. Likewise in 1958, there were 217,000 miles of gas transmission and field gathering lines and 354,000 miles of gas distribution lines delivering over eight trillion cubic feet of natural gas per year.

Obviously these vast and widely dispersed operations require full time use of many types of communications facilities. Often they traverse areas where even today public communications are difficult to obtain. Moreover the need for a reliable and flexible communications network is another reason why many pipeline companies have constructed, operated and maintained a major portion of their communications systems. However, where feasible they also employ full period leased circuits. In the past 10 years pipeline companies have pioneered use of microwave radio relay systems to supplement or supplant wirelines because of their economy and greater reliability.

Communications always has been an essential part of pipeline operation, but the advent of automation and other techniques to permit economies in operation have increased the demand for communications and raised requirements for reliability. The basic use is for the dispatching of the crude oil, product or gas the line is carrying. This is primarily a point to point fixed service. Equally essential, however, is the coordination of maintenance and repair. This involves mobile radio.

The pipeline industry is essential to our economy. Radio, in turn, is essential to the pipeline industry.

Section 13. Radio in refinery operations. Unlike most other petroleum operations, refining operations take place in a well-defined concentrated area. This resulted in a somewhat slower acceptance of radio, but today all major refineries and many smaller ones find radio an extremely valuable tool. High pressures and temperatures in modern refineries present new hazards.

Radio makes a contribution to safety that is beyond dispute. Moreover radio is a most attractive method of reducing costs. It increases efficiency of materials handling, dispatching of specialized heavy equipment, technical personnel, coordination of operations and plant security. In times of emergency it is irreplaceable.

Section 14. Radio in marketing operations. The most extensive use of radio in marketing is in natural gas distribution. The economic and safety contributions in this field are obvious. Over 17,700 transmitters are used in the work. Bulk marketing of petroleum products has made little use of radio, largely because of Federal Communications Commission regulations. Recent changes probably will result in wider usage. An exception is the distribution of liquefied petroleum gas (LPG) and fuel oil. Mobile radio is widely used in this field and results in substantial reduction of distribution costs.

Section 15. Radio in petroleum marine transportation. The petroleum industry's first use of radio was on tankers. Now its vast fleet is fully equipped with radio and radar. Ocean-going vessels of 1600 gross tons and upward have medium frequency radiotelegraph, usually high frequency telegraph and 2 mc ship-to-shore radiotelephone. Many foreign ports have 156 mc radiotelephone. Recently the FCC has permitted 156.65 mc bridge-to-bridge telephone. Radar is almost universal. The Great Lakes vessels have 2 mc and 156 mc.

The vast inland waterways system is an important segment of petroleum transportation. Vessels involved in this service fully utilize radar and radio for navigation, safety and communications, both intership and ship-to-shore. While Very High Frequency radiotelephone has certain valuable applications, the 2 mc to 9 mc Amplitude Modulation band is the backbone of the system. A current problem is the failure of previous international communications conferences to provide for continued use of frequencies in the 6 mc band. The U. S. delegation to the current Geneva Conference will endeavor to remedy this lack.

Section 16. Radar and radiolocation. The petroleum industry makes extensive use of three radiolocation methods—radar, Shoran and phase comparison. Radar is widely known. It is principally used as a navigation aid, at night or in fog. With some modification of equipment, it has been used by petroleum prospectors as a surveying method. It has limited range and other difficulties which minimize its usefulness as a surveying tool. Shoran, which is similar to radar but employs "beacons" at known fixed points, instead of echoes from natural objects, is fairly widely used. It also has limited range. Its use is complicated by the fact that its operating frequencies are primarily allocated to military operations.

Phase comparison methods provide much greater range and higher precision. Two systems were developed especially for use in petroleum operations in the Gulf of Mexico. Efforts are now being made to secure permission to use these systems in Alaska and off the Pacific Coast. A third system, developed abroad for aircraft and ship navigation, is not yet available for petroleum use in the United States.

Section 17. Radio in petroleum aircraft. The petroleum industry is a large user of business aircraft, both fixed wing and helicopter. In addition to conventional aircraft use of radio and radar for route control, traffic control and navigation, petroleum aircraft have a number of specialized radio applications. These are involved in flying inspection of pipelines to detect leaks, offshore operations and airborne geophysics.

Section 18. Petroleum relay and control stations. Normally radio communication in the petroleum industry is direct from transmitter to the desired receiver. Sometimes, however, the distance to the receiver is too great and the message must be relayed by one or more intermediate relay stations. Microwave systems are examples of the use of relay stations. Another example is a control station, where it is desirable for a base station to be located some distance from the operating station, frequently to take advantage of a hill or other desirable location.

PART II

RECOMMENDATIONS

RECOMMENDATIONS

Radio is daily becoming a more essential aid to safety, a more important economic tool, a greater convenience, a greater source of enlightenment and entertainment and a more important component of military planning and operations. This evergrowing demand coupled with physical limitation of the radio spectrum results in more and more vigorous competition for use of available frequencies. Technological advances will permit more efficient utilization of the spectrum, but growing demand will surely outstrip increases in efficiency.

The oil and natural gas industry has adopted radio as a tool to a far greater extent than most persons realize. Usage of radio is an essential element of all of the industry's operations, largely because of their extremely scattered sites and need for constant access to instructions and assistance. In light of the vigorous competition for use of the radio spectrum, the industry must maintain its legitimate position in radio. The industry must see that its radio needs are well understood by the industry itself, by the public and by all governmental agencies concerned with radio matters.

Based on the detailed study reported herein, the Committee recommends:

1. That the Secretary of the Interior have additional studies of the petroleum industry's use of radio and radar prepared at intervals of two to three years. This recommendation is based on the fact that there has been a substantial increase in the use of radio and radar generally by industry and a great increase in usage by the petroleum industry specifically since the last National Petroleum Council report on January 1, 1955. Furthermore, there have been outstanding technological advances which have affected use of radio and radar since that date. Additional growth in usage and further improvement in applied technology are certain.

2. That all appropriate governmental agencies concerned either with petroleum industry problems or general utilization of radio be informed fully of the importance of the petroleum industry's use of radio and radar to the public welfare and national defense.

3. That any Congressional or Executive Committees or Commissions studying problems of radio utilization or radio spectrum allocation be informed fully of the petroleum industry's usage of radio and radar and of its national importance.

4. That governmentally instigated plans for cooperative use of the petroleum industry private communication systems by government agencies, in times of emergency when normal communication channels are unavailable, should be based on adequate and timely planning. Such planning will require a considerable expenditure of time and money. This planning should insure both effective governmental usage and continuity of usage by the petroleum industry for its vital needs. Safeguards should be provided to avoid excessive or unplanned governmental usage. This might well be done by appointment of National and Regional Petroleum Emergency Communications Directors, acting within the Office of Oil and Gas of the Department of the Interior.

5. That a vigorous effort be made to make the public aware of the need for an allocation of frequencies which gives proper weight to the importance of each radio usage and its relationship to public welfare and national defense. The assistance of the American Petroleum Institute Committee on Public Affairs and other petroleum trade organizations with Washington contacts should be enlisted.

6. That all companies in the petroleum industry be informed as to the importance of radio regulatory matters if they are to have continued and efficient usage of radio and radar. They should be urged to cooperate fully with the American Petroleum Institute Central Committee on Radio Facilities and the National Committee on Utilities Radio.

7. That all licensees in the Petroleum Radio Service fully support the work of the National Petroleum Radio Frequency Coordinating Association and that all licensees make available qualified engineering personnel to aid in the coordinating work of the Association.

8. That contact be maintained at an appropriately high level with representatives of the communications common carriers to assure mutually helpful understanding between the two groups.

PART III

ORGANIZATION OF THE COMMITTEE ON USE OF RADIO AND RADAR (1959)

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
Washington 25, D. C.
January 21, 1959

Dear Mr. Hallanan:

Several years have passed since the National Petroleum Council studied and reported on the use of radio and radar. Since then I understand there have been developments which have a vital effect upon the petroleum and gas industries' use of these communications facilities.

I am, therefore, requesting that the Council create a committee to review its previous reports and recommendations in this specialized field, to make a current study concerning the use of radio and radar in the petroleum and gas industries, and to submit a report thereon, together with such recommendations as the National Petroleum Council deems appropriate.

Sincerely yours,
(sg.) Elmer F. Bennett
Acting Secretary of the Interior

Mr. Walter S. Hallanan
Chairman
National Petroleum Council
1625 K Street, N.W.
Washington 6, D. C.

NATIONAL PETROLEUM COUNCIL
(Created by the Secretary of the Interior)
Suite 601, 1625 K Street, N.W.
Washington 6, D. C.
March 13, 1959

Mr. Morgan J. Davis
President
Humble Oil & Refining Company
P. O. Box 2180
Houston 1, Texas

Dear Mr. Davis:

I am pleased to appoint you Chairman of the National Petroleum Council's Committee on the Use of Radio and Radar (1959).

The Agenda Committee, in its report of January 26, 1959, which was unanimously adopted by the Council at its meeting on January 27, 1959 stated:

"Under date of January 21, 1959, Honorable Elmer F. Bennett, Acting Secretary of the Interior, addressed a letter (copy of which is attached hereto) to Mr. Walter S. Hallanan, Chairman of the National Petroleum Council, requesting the National Petroleum Council to undertake a current study concerning the use of radio and radar in the petroleum and gas industries.

As provided in the Articles of Organization of the Council this letter was considered at a meeting of the Agenda Committee on January 26, 1959 in Washington, D. C., at which meeting it was unanimously agreed to recommend to the Council the appointment of a Committee to make the study as requested by Mr. Bennett in his letter of January 21, 1959, and to report to the Council. The Committee should not suggest plans or programs but should confine its report to findings of fact."

Each member of the Committee, as shown on the enclosed membership list, has been informed of his appointment as per the attached sample letter.

As you know, the Council is now operating under new procedures, which it adopted at its last meeting (copy attached). On March 6, Secretary of Interior Seaton, pursuant to the Articles of Organization of the Council, as amended, designated Captain Matthew V. Carson, Jr., as the Co-Chairman of the National Petroleum Council.

Pursuant to Article 6 of our amended Articles of Organization the proposed membership of this Committee was submitted to officials of the Department of Interior for approval. On March 11, Co-Chairman Carson approved the establishment and membership of the Committee on Radio and Radar, and designated Mr. Hans C. Jensen of the Office of Oil and Gas, Department of the Interior, as Co-Chairman of this Committee.*

As Chairman of this Committee you will set the agenda, time, and place for all meetings, and preside at each committee meeting. The function of the Co-Chairman of the Committee is to approve the agenda and call of meetings, and to call any meeting of the Committee to a close if he feels it is being improperly used. With respect to obtaining these required approvals of the Government Co-Chairman, and to facilitate the handling of other steps involved under the new rules of procedure, you may wish to utilize the services of the Staff Advisor on your Committee.

In addition to such other duties as you may assign to them, the Secretary and Staff Advisor of your Committee will have the responsibility for maintaining comprehensive minutes of all proceedings.

Should you wish to appoint any assistant, or arrange to set up necessary subcommittees, please advise me so than any procedural requirements, such as approval of the Government Co-Chairman of the Council, may be worked out for you in Washington.

I trust I may have your acceptance of this important assignment, and will appreciate your advising me.

Sincerely,
/s/ Walter S. Hallanan
Walter S. Hallanan

Enc.

**On July 2, 1959, Mr. Robert E. Roehl of the Office of Oil and Gas, Department of the Interior, was designated Government Co-Chairman of this Committee.*

PART IV

PETROLEUM INDUSTRY USE OF THE RADIO SPECTRUM

NATIONAL PETROLEUM COUNCIL
COMMITTEE ON USE OF
RADIO AND RADAR (1959)

PETROLEUM INDUSTRY USE OF THE RADIO SPECTRUM

1. Petroleum Growth and Use of Radio

I. Introduction

The national economy of the United States, its productivity, industrialization, living standards, and its national security require a high consumption of energy. Petroleum, including natural gas, provide almost 70 per cent of this energy. Adequate supplies of these fuels are vital to the nation.

As for the future, a steady and rising demand for petroleum is forecast for at least the next ten years. One recent study, by the National Planning Association, predicts petroleum will contribute an increasing portion of the nation's overall energy consumption as far ahead as 1980. The same study estimates that nuclear energy will capture something less than 10 per cent of the total U. S. energy requirements by 1980. In any event, the importance of petroleum to the national economy and defense is expected to increase in the years to come.

II. Energy Consumption

The productivity, industrialization, and living standards of any nation are reflected in its consumption of energy in fuels and water power. Since 1920, the United States' consumption of energy from coal, oil, natural gas, and water power has more than doubled. Measured in terms of British thermal units, for a common denominator, the total U. S. energy consumption between 1920 and 1927 rose from 19,782 to 21,828 trillion BTU's, then in 1957 to 41,920 trillion BTU's, according to the Bureau of Mines as shown in Chart One. During the 1958 recession year, the total was somewhat less, approximately 41,165 trillion BTU's.

The increase in United States energy consumption is even greater if one goes back to the turn of the century for comparison. One study, by the National Industrial Conference Board, indicates that America's production of energy from all sources is now five times greater than it was six decades ago.

On a per capita basis, energy consumption in the United States amounted to 245 million BTU'S in 1957. This is the equivalent of about 8.48 metric tons of coal, or 1,773 gallons of oil, during the year for every man, woman and child. It is an increase of 32 per cent over per capita consumption in 1920.

III. Living Standards

The correlation between energy consumption and living standards can be seen in national income. The United States has the highest per capita energy consumption in the world. And it has the highest living standards. In 1920 national income per capita in the United States was $654. In 1957 it was $2,104.

By comparison with the United States, per capita consumption of energy in West Europe amounted to 78.4 million BTU's in 1957. This is the equivalent of 2.8 metric tons of coal or 567 gallons of oil per person. During this same year, the average gross national product of all countries in the European Common Market amounted to $831 per capita, as contrasted to the United States per capita GNP of $2,585.

In other parts of the world, energy consumption is lower than that of West Europe, and national income is correspondingly smaller. A study prepared by the Joint Congressional Committee on Atomic Energy has shown, for example, in 1952 an energy consumption in Brazil of 163 gallons of oil equivalent, and national income of $183 per capita; in Peru, 118 gallons of oil and $119 national income per capita; in India, 73 gallons of oil and $57 income per capita.

If a nation's energy consumption is related to national income and living standards, it is also related to industrial production. In the United States, industrial production increased 428 per cent in the years from 1910 through 1957, according to one analysis. Total energy consumption over these years increased only 184 per cent because of the great increase — estimated at 146 per cent — in efficiency of energy utilization. Modern engines and improved fuels have increased the efficiency of energy utilization an average of 1⅞ per cent each year from 1910 through 1957.

IV. Petroleum Growth

Use of fuels and sources of commercial energy in the United States have changed over the years as the economy has changed. At the turn of the century, oil supplied approximately 5 per cent of the nation's energy; natural gas supplied 3 per cent; coal 89 per cent; and water power 3 per cent.

By 1957, according to the Bureau of Mines, oil accounted for 41.4 per cent of United States energy consumption; natural gas 27.8 per cent; coal 27.1 per cent; and water power 3.7 per cent. Thus almost 70 per cent of the nation's commercial energy consumption in 1957 was provided by the oil and natural industry. (See Chart One.)

There are many reasons for the phenomenal growth in consumption of oil and natural gas in the United States. One is convenience. Liquid or gaseous fuels are easily transportable. Unlike solid fuel, they flow through pipes and fill containers of any shape or size. This helps make possible a ready availability of fuel supply at any location desired. Another reason is cost. Oil and natural gas have been relatively inexpensive for most purposes. The existence of large supplies in the United States has made possible rapid growth of oil and gas production in this country. Other reasons include cleanliness and efficiency of fuel. Moreover, petroleum is unique for purposes of motive propulsion — especially as fuel for automobiles, farm machinery and aircraft. No other practicable type of fuel has yet been developed for such vehicles.

V. National Defense

Growth of petroleum consumption in the United States has paralleled the growth of the economy. The very availability of large quantities of energy in this country has made possible its industrialization. In turn, the industrialization of this nation is the sinew of its military strength, since in modern war the industrial machine is the equivalent of a military machine.

Petroleum has a double significance and a dual role in national defense. First, it powers industrial plants of America. Secondly, it powers military vehicles and equipment turned out by the industrial plants. Our military establishment runs on oil. In 1945, U. S. military procurement of petroleum products reached a peak of 588 million barrels.

But even in peacetime, the military forces require vast quantities of oil. In 1957 and 1958 United States military procurement of petroleum products totalled 244 million and 230 million barrels respectively. Interestingly, the total in each of these years is greater than the total in each of the early war years, 1942 and 1943, when military requirements ran to 99 million and 219 million barrels.

VI. Petroleum Radio

To provide this abundant, uninterrupted supply of oil and natural gas requires increasing activity of vast magnitude on the part of the industry. To carry out these extensive operations, scattered through numerous states and often in remote areas, requires constant communications. Lack or unsuitability of other facilities often makes radio and radar the best possible means. Consequently the oil and gas industry depends on radar and radio communications to an extent which probably exceeds that of any other industry.

The essentiality of radio and radar to the petroleum industry is detailed in following sections of this report. The extent to which the industry currently relies on radio and radar is best demonstrated by the statistics on the number of users and authorized radio transmitters and microwave systems as shown in the following tabulations, and by the growth shown in Chart Two.

VHF RADIO TRANSMITTERS

	Users	*Base Stations*	*Mobile Units*	*Fixed (Below 890 mc)*	*Total*
Petroleum Radio Service	736	7,569	36,343	205	44,117
Power Radio Service (Gas Distribution)	176	1,174	16,583	—	17,757
Industry Total	912	8,743	52,926	205	61,874

NOTES:

(1) Petroleum Radio Service station totals are from the NPRFCA 1958-59 Annual Report. The number of users is from a list of Petroleum Radio Service licensees compiled from FCC records as of September 15, 1959. This list is open for inspection at the National Petroleum Council headquarters.

(2) Power Radio Service figures are from the recent AGA Communication Tele-Control Survey.

(3) OFMC records of industry microwave stations were subtracted from NPRFCA Operational Fixed or Relay total, to obtain number of fixed VHF transmitters.

MICROWAVE SYSTEMS

From OFMC Records as of August 1, 1959

	Freq. Band	*No. of Users*	*Number of Stations Const.*	*Proposed*	*Total*	*Path Miles*
Petroleum Radio Service	960	16	64	12	76	1,101
	2000	24	445	130	575	13,702
	6000	33	377	88	465	10,036
Total		73	886	230	1,116	24,839
Power Radio Service (Gas Distribution)	960	2	5	0	5	29
	2000	3	15	0	15	292
	6000	6	57	14	71	1,593
Total		11	77	14	91	1,914
Industry Total		84	963	244	1,207	26,753

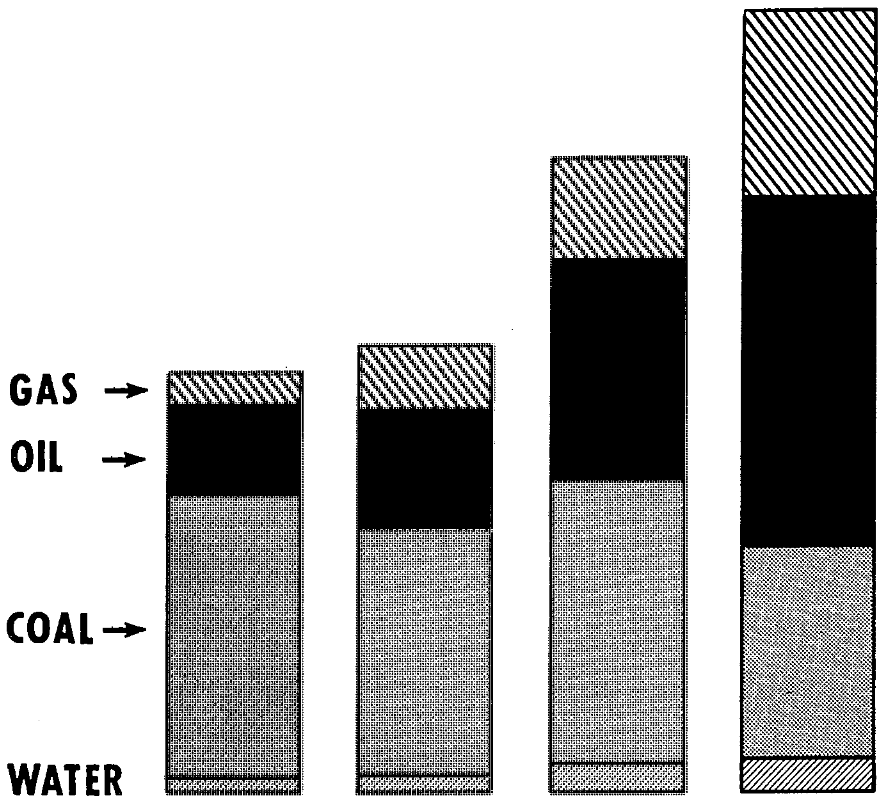
NOTE: Path miles scaled from OFMC maps.

OIL AND GAS SUPPLY INCREASING PORTION OF U. S. EXPANDING CONSUMPTION OF ENERGY FUELS

SOURCE: U. S. BUREAU OF MINES

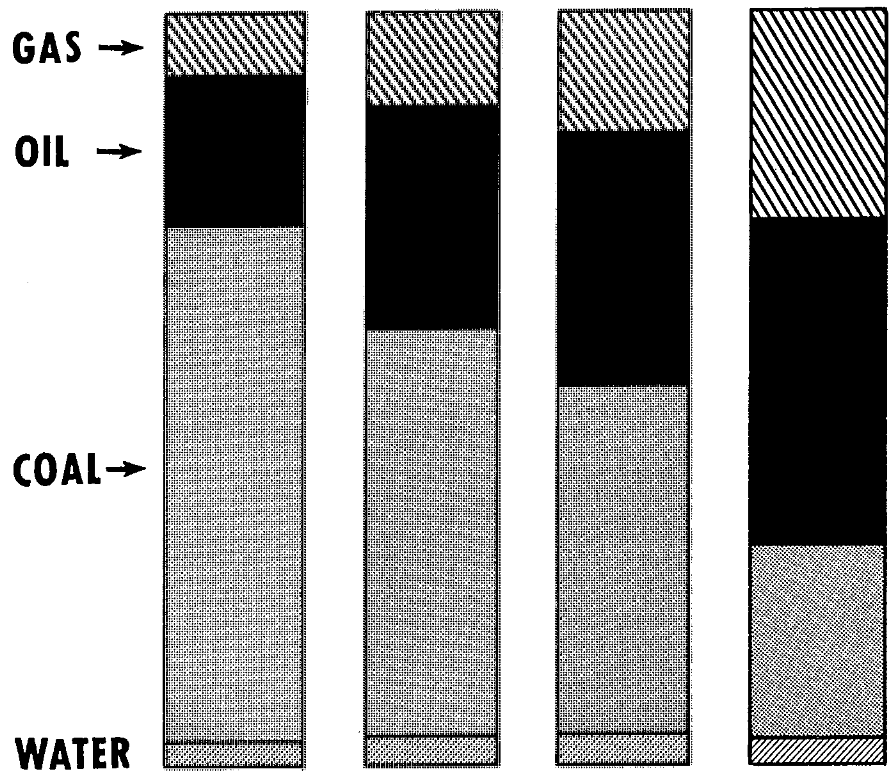
U.S. ENERGY FUEL CONSUMPTION

(In Trillion British Thermal Units Annually)



	1927	1937	1947	1957
GAS	1,644	2,676	5,082	11,658
OIL	4,377	6,604	10,803	17,328
COAL	14,992	12,566	15,526	11,366
WATER	815	905	1,459	1,568
TOTAL	21,828	22,751	32,870	41,920

PERCENT OF ENERGY SUPPLIED BY VARIOUS FUELS



	1927	1937	1947	1957
GAS	7.5	11.7	15.5	27.8
OIL	20.0	29.1	32.9	41.4
COAL	68.7	55.2	47.2	27.1
WATER	3.8	4.0	4.4	3.7
TOTAL	100.0%	100.0%	100.0%	100.0%

CHART ONE

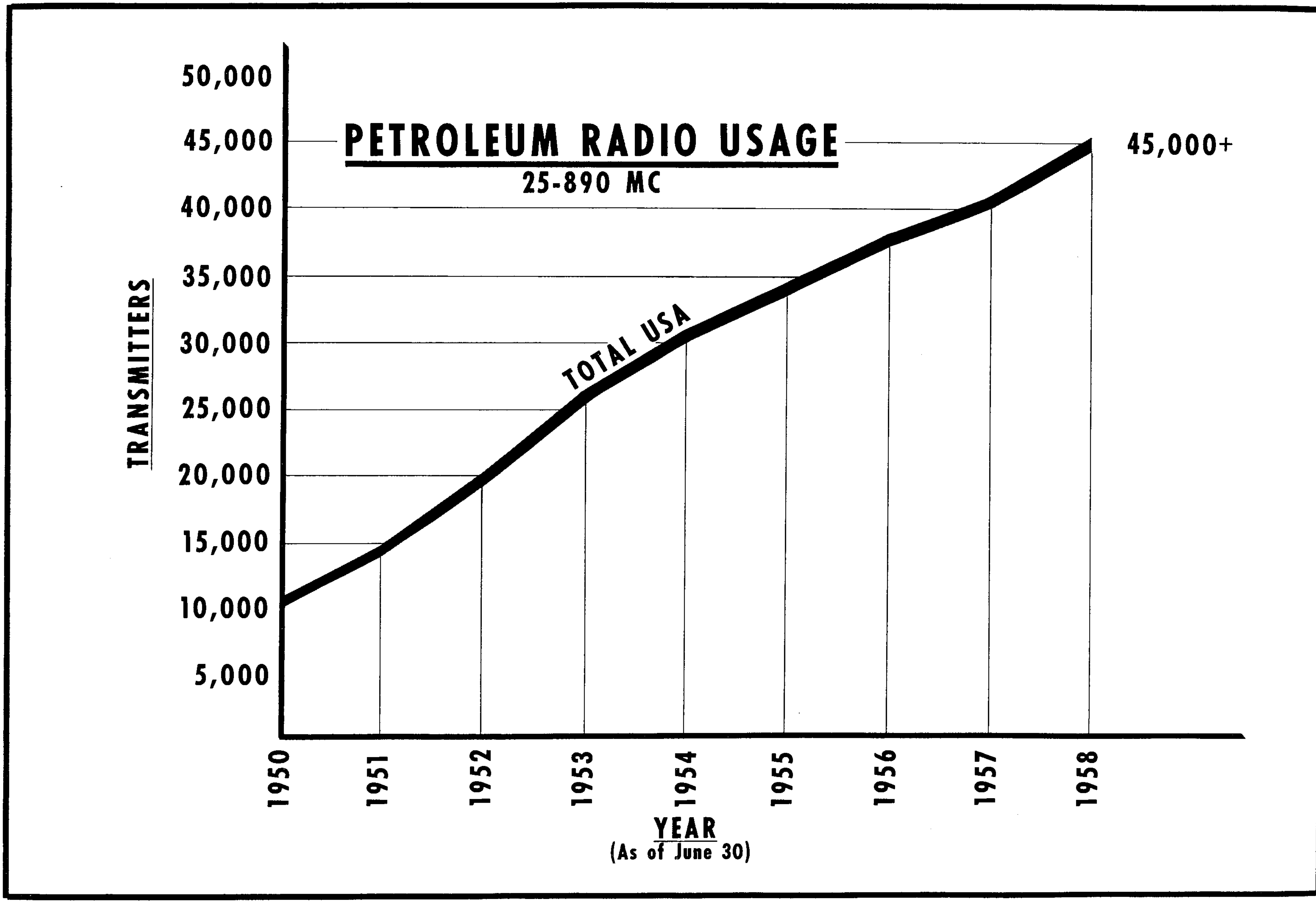

PETROLEUM RADIO USAGE
25-890 MC
TRANSMITTERS
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
TOTAL USA
45,000+
1950
1951
1952
1953
1954
1955
1956
1957
1958
YEAR
(As of June 30)

CHART TWO

2. History of Radio in the Petroleum Industry

I. Introduction

The history of radio in the petroleum industry is essentially the story of the growth of utilizable radio spectrum space, in turn governed by technological developments in the radio art. Industrial, together with other uses of radio, will continue to be so governed. But there exists a definite limit to the usable spectrum though no apparent limit to future needs. Hence, for the forseeable future use of radio must be governed by judicious allocation of this space to those users having the most urgent needs and which are of such nature that the benefits of radio facilities ultimately revert to the national welfare.

An exception may occur in the microwave portion of the spectrum particularly applicable to fixed point-to-point systems. Within this sphere of application, there is hope that technology may clear the path for almost unlimited expansion.

II. Marine Radio

In common with a large segment of early radio history, radio's first use in the petroleum industry was on board tank ships where, as in all early maritime applications, its prime purpose was promotion of safety of life and property at sea. Greatly expanded tanker fleets and more sophisticated communications needs have added enormously to the industry's radio facilities involved in marine transportation. Such growth necessarily continues to keep pace with the ever-increasing importance of petroleum in world commerce. Moreover, rapid advances in technology have further accentuated the volume of radio communications equipment. In addition, radar and related navigational equipment which emerged from the war effort are now considered essential and almost universal in tanker operation. Thus, the history of radio and radar equipment in the marine phase of the petroleum industry's activities has been one of accelerated expansion.

In 1921 the United States ocean-going tanker fleet under all flags comprised 314 ships of approximately three million deadweight tons. By 1956 these figures had increased to 823 tankers of fourteen million deadweight tons of which 60 per cent were owned directly by petroleum companies themselves. The total United States tanker fleet provided 33 per cent of the world's ocean-going capacity in 1956. The recent high rate of new tanker deliveries is reflected by the statistics at the beginning of the year 1959. Tankers under U. S. control numbered 947, totaling almost 19 million deadweight tons or 35.2 per cent of the world's carrying capacity.

III. Exploration Operations

Petroleum's first use of radio for land operation was, rather curiously perhaps, in the mobile field. Geophysical crews engaged in prospecting for possible petroleum-bearing structures had need for coordinating communications between vehicles carrying their instruments and related equipment. Even more important was the need for transmitting and recording time information with high precision. Following a short period of makeshift methods, about 1925 radio came into use for both telegraphic communications and transmission of essential time data. This resulted in a very great improvement in reliability of the recorded geophysical data and a more expeditious and efficient handling of operations.

These early operations were in the 1.6-1.7 mc band, using privately constructed equipment because of the complete lack of commercially available units. This practice continued until relatively recent years when channels in the 25 and 30 mc bands became available for geophysical use. By then, mobile radio had become well established and field-worthy units in the higher frequency channels were available commercially. However, the five channels in the 1.6-1.7 mc band still assigned to geophysical operations remain essential in many areas and equipment is still largely designed and built by the users.

Increasing scarcity and ever-growing difficulty in finding domestic petroleum has moved exploration into more remote areas or those involving terrain of increasingly difficult accessibility. Thus, time has added new demands for radio facilities and frequently the very modern radiolocation and doppler radar navigation equipment are essential operational requirements. These needs have been further enhanced through development of new geophysical methods and techniques requiring improved coordination in operations and higher resolution in the recorded data.

Thus, since about 1925, which also marks approximately the advent of geophysics in petroleum exploration, radio has been an essential adjunct to these operations. Accordingly, wherever economical and practical, the industry has adopted the newest radio techniques to meet exploration needs. In recognition of its importance, and in keeping with growth and advancing technology, the Federal Communications Commission has made continuous effort to provide adequate frequency allocations for geophysical use, including some of the first applications of radiolocation techniques by industry.

IV. Drilling and Production

A. Pre-1940 Period

The embryonic stage of radio in the drilling and production phases of the industry appears to coincide with the development of production in N. W. Texas and S. W. Oklahoma, the so-called Panhandle area, about 1926 - 1928. Drilling and production operations in portions of that area were virtually without means of communication with company headquarters and point-to-point radio facilities were sorely needed.

In an especially urgent case covering general needs, both drilling and production, a low power point-to-point telegraph system on about 7.5 mc was in operation between Ponca City, Oklahoma, and S. W. Oklahoma in 1928. The efficacy with which this simple installation relieved a serious situation led to additional applications for point-to-point licenses. These the Federal Radio Commission was obliged to deny on statutory grounds but with the suggestion that if interests were pooled to form a public service corporation the desired results could be achieved. Accordingly, consolidated applications of the interested petroleum companies were filed with the Commission January 26, 1929, and frequencies were assigned to Western Radio Telegraph Company in June of that year. However, other applicants for point-to-point systems complicated the situation and Western Radio Telegraph Company's final authorization to proceed was delayed until January 1931.

Subsequent development of the system resulted in establishment of radio-telegraph stations at Bartlesville and Oklahoma City in Oklahoma, at Breckenridge, Judkins and League City in Texas, Smackover, Arkansas, and Cahokia, Illinois. The system operated on 182, 2252, 3045, 4530, 4805, 6745, and 7775 kc, until June, 1942, when it was closed by wartime restrictions.

In 1932 the Federal Radio Commission's *Special Emergency Service* provided the category for licensing radio facilities in isolated areas and a few petroleum companies began such use on a very limited scale between drilling rigs in the swamps of Louisiana and base offices. As drilling operations inevitably moved to more remote fringes of the swamps and into offshore areas, communication by radio became increasingly important. Some of this service was handled through common carrier facilities but where these services were unavailable a few individual oil companies with extensive holdings in the area provided their own radio systems in order to be able to take care of the most urgent needs.

Similarly, under this *Special Emergency Service* gas pipelines were among the first licensees in industrial radio during this early period. Eligibility requirements were met because of the potential hazard involved if pipeline maintenance was handicapped by inadequate communications or inordinately delayed in the case of emergency. Likewise, certain land drilling and production operations were eligible and radio was used in more remote areas to meet essential requirements.

In 1938 the Federal Communications Commission designated a new class of station under their rules governing *Miscellaneous Radio Service*. This new class termed *Provisional* was instituted to provide for safety of life and property. Under authorizations in this category a number of petroleum operators were able to qualify. However, technical problems, basic limitations involved in qualifying, and perhaps some general lethargy toward use of radio in other than the most urgent circumstances worked against its immediate acceptance by the industry as an everyday operating tool. But this lethargy was short-lived and interest was growing rapidly when in 1941 World War II curtailed expansion of such private facilities.

B. Post-1940 Period

Even prior to 1940 the primary deterrent to expansion of radio in the industrial field was lack of channel space, not the failure of industry to recognize its utility. The available spectrum space useful to industry covered the range from about 1 to 25 megacycles with practically all other commercial radio communications also confined within this space. Within these limits very few channels were available for even the most urgently needed high-priority industrial requirements and then only those primarily involving safety of life. Thus, the history of petroleum radio inherently reflects the availability of channel space though as we shall see it was scheduled for rapid expansion.

This period just prior to World War II marked the beginning of extraordinary technical advance in the radio field, particularly in the High Frequency and Very High Frequency bands. Frequency modulation methods in these portions of the spectrum were developed to the point that compact and reliable voice communication equipment could be designed. Moreover, as discussed in *Section 4,* signals at very high frequencies are substantially limited to line - of - sight transmission. Thus, identical frequencies can be used simultaneously by stations fairly closely spaced geographically without serious mutual interference. Furthermore, improved freedom from extraneous "noise" interference permitted reliable communication at relatively low power levels. Thus, the way was opened for establishment of short range systems on a scale never before possible. With entirely new higher frequency portions of the spectrum available for communications, the basic concept of radio usage was changed.

In recognition of these technical developments and in keeping with its statutory obligations to study new uses of radio, the Federal Communications Commission considered broadening the field of eligible users to include several categories previously denied the use of radio because of the paucity of usable spectrum space.

As part of its comprehensive study of frequency allocations in the light of the now feasible expansion into higher frequencies, the FCC in 1942 suggested that the radio industry set up an organization which might be effective in resolving the problems of frequency allocations and possibly develop standards for new equipment.

Early in 1943 a committee composed of representatives of the Radio Manufacturers Association and the Institute of Radio Engineers undertook the development of a plan to carry out this proposal. This resulted in formation of the Radio Technical Planning Board with headquarters in Chicago. Any individual or organization having either direct or indirect interest in any of the services or problems to be considered was invited to participate in the Board's activities.

This activity received the serious attention of a few members of the Petroleum Industry Electrical Association, an organization then composed principally of communications superintendents of most of the major oil and pipeline companies in the Midwest and Southwest. As a result of their vigorous interest in all methods of communication vital to the petroleum industry, the PIEA became a contributing sponsor in the Radio Technical Planning Board and appointed a committee to formulate the petroleum industry's radio requirements.

This committee became known as Committee No. 9, Provisional and Special Emergency Oil Industry Services, Panel 13, RTPB. It prepared a very comprehensive statement outlining in minute detail the petroleum industry's radio requirements.

The Petroleum Industry Electrical Association appeared in Docket No. 6651, the initial hearing before the FCC in the matter of new frequency allocations. This hearing held in Washington, October, 1944, was the first at which the petroleum industry had any semblance of united action in support of the requirements for a share of the frequency spectrum.

The Commission's report in this Docket was released in May, 1945. It permitted new uses of radio under *Experimental* grants. From a commercial operating viewpoint, the implied temporary nature of the authorizations was not particularly attractive and certainly not conducive to extensive developments. But it was a step toward meeting an urgent need.

In August, 1946, the Commission established the *Utility Radio Service* which included among others the petroleum pipeline class of station which permitted radio to be used on a regular basis in connection with operation and maintenance of crude, products, and natural gas long-distance pipelines. However, other petroleum industry radio operations, with the exception of geophysics, were still classified as *Experimental.*

Realizing the importance of radio as an operating tool for all branches of the industry, the PIEA group attacked the problem realistically and, on behalf of the industry, petitioned the FCC for establishment of a "New Radio Service Governing Radio Stations Used in Petroleum Industry Production and Pipe Line Operations and Promulgation of Rules and Regulations Therefor." This petition was filed January 20, 1947,

> "not only on behalf of the PIEA, but in the interest of all companies desiring to use radio in order to improve the safety and efficiency of petroleum production and pipeline activities and to aid in increasing and conserving this nation's oil supply and reserves."

The petition also requested that pipeline usage be transferred from the *Utility Radio Service* to the proposed new *Petroleum Radio Service.*

Under date of March 27, 1947, notification was received from the FCC that the petition has been denied without prejudice to resubmission subsequent to a pending release of the Commission's proposed *Rules Governing the Industrial Radio Service.* It was further stated that the Commission was then engaged in a study of the communications needs of all industries, including petroleum, with view to revising its *Rules Governing the Miscellaneous Services* so as to provide for the establishment of a new *Industrial Radio Service.*

When the Radio Technical Planning Board went out of existence the petroleum industry's only representative group concerned with protecting its over-all stake in radio was the original PIEA Committee. Since the PIEA was considered insufficiently representative of the entire petroleum industry, steps were taken to interest the American Petroleum Institute in taking an active part in these radio matters. Recommendations were made and on April 23, 1947, the Board of Directors, API, authorized the formation of the Central Committee on Radio Facilities in its Division of Transportation. A temporary committee was immediately formed and the first permanent committee was appointed November 4, 1947, in Chicago. The Society of Exploration Geophysicists Radio Facilities Committee, representing the industry's exploration phase with frequency assignments over the previous twenty years, joined forces and was given representation on this API committee.

The newly created Central Committee on Radio Facilities of the API concerned itself immediately with the problem of finalizing the establishment of the *Petroleum Radio Service.*

On May 3, 1949, the Commission announced the adoption of its *Industrial Radio Service Rules* in final form to become effective July 1, 1949. Subpart "G" of Part 11, *Rules Governing Industrial Radio Services* established a *Petroleum Radio Service* and included all of the major goals contained in the original petition for this service.

The Rules governing the new *Petroleum Radio Service* (Rule 11.57a) provided that

> "all applicants for, and licensees of, stations in these services shall cooperate in the selection and use of the frequencies assigned in order to minimize interference and thereby obtain the most effective use of the authorized facilities."

The structure of the API seemed inappropriate for the required cooperation; therefore, following a temporary organization meeting on May 16, 1949, a new association was formed on June 13-15, 1949, for the specific purpose of providing an efficient mechanism for the necessary coordination. This is the National Petroleum Radio Frequency Coordinating Association.

V. Microwave Facilities

The region of the radio spectrum usually referred to today as microwave includes those frequencies above about 890 megacycles. These frequencies were laboratory playthings prior to World War II and the early wartime radar, of necessity, started in the much lower frequency region. However, under the impetus of war, progress was rapid. The necessary theoretical knowledge was available or developed concurrently and the equipment to instrument radar techniques even to frequencies of 25,000 megacycles became available during that period.

It has been mentioned that the history of the use of radio in industry is essentially a history of channel availability and in turn of technological developments. As previously indicated, developments in the High and Very High Frequency and subsequently the Ultra High Frequency bands opened spectrum space for extensive mobile radio utilization. So also has microwave technique opened space for a vastly greater number of channels for very attractive and practical point-to-point communications.

This area was opened to industrial use by certain priority industries including petroleum by Federal Communications Commission action in 1948. Authorizations were on a *Developmental* basis. Fully appreciating the advantages of microwave systems and disregarding the implied temporary nature of the authorizations, oil and gas pipelines immediately adopted microwave as the communication facility along new lines and replacement of wirelines where expansion was indicated or maintenance was difficult or inordinately expensive. This growth was so rapid that for a time the petroleum industry was the largest single user of microwave. To date these pipeline facilities constructed or proposed comprise some 1,200 stations serving approximately 27,000 path miles.

While currently, pipeline communications comprise the greatest single application of microwave, other phases of the petroleum industry use microwave facilities and, with the pending expanded eligibility, still other phases of the industry will enter this field. Currently, production operations in the Gulf of Mexico are using microwave as the most practical means of maintaining communications with offshore installations. Indeed, the paucity of spectrum space for other fixed radio systems ultimately will leave no choice but microwave for routine production operations offshore.

VI. Conclusion

Discussion of the continuing role of the radio organizations of the petroleum industry is given in *Section 3*. But the above account of their early activities is an essential part of the history of radio in the industry for, as already stressed, this history is basically that of channel availability. Marine use, licensed under the *Maritime Service,* was free to develop from the very beginning; indeed, forced to do so by maritime rules. Geophysical exploration needs, though representing relatively few channels, have been recognized officially and adequately instrumented since the late 1920's. But following the opening of new higher-frequency portions of the spectrum to practical use, the action of the Commission May 3, 1949, establishing the *Petroleum Radio Service* and recognizing this service among the several high-priority groups in industry, provided the essential atmosphere of permanence required for the enthusiastic development of radio communications in the land operational phases of the industry.

The availability of frequencies for more general petroleum use, and reasonable assurance of permanency, came none too soon to meet rapidly growing needs as witnessed by the very rapid expansion outlined in *Section 1* of this report. The essential nature of radio in present day petroleum developments and technology is discussed adequately elsewhere in this report. But it is the object of this brief historical review to emphasize, and it should be apparent, that the industry did not acquire the necessary channels by watchful waiting. Such channels are far too scarce in the limited radio spectrum to be acquired without effort and proof of need. Rather it is the duty of industry to keep those officials responsible for the supervision and allocation of radio frequencies adequately informed so that they may view the needs of the petroleum industry in proper perspective as to their importance relative to the needs or desires of numerous others. Diligence in this respect must continue since presently eligibility for radio facilities in industry, business, and other related fields is being broadened considerably and competition for channel space will become more intense.

The petroleum industry may well be proud of its history to date in the radio field. It has maintained a reasonable attitude in competition for channel space, has been alert to technological advances and quick to adopt every practical device to enhance available spectrum usage. It voluntarily led the way in proving channel-splitting to be a practical means for doubling the number of useful channels in its assigned spectrum space, a device since adopted by the Commission, where applicable, to other portions of the spectrum. Petroleum was one of the first among industry to develop microwave systems on a large scale. In short, the recognized alacrity with which this industry moves to improve efficiency is well reflected in the growth of its radio facilities once the frequencies were made available.

3. Industry Radio Associations and Committees

I. Introduction

Since there are a number of industry associations and committees at work in the radio and radar activities of the petroleum industry, it will be helpful at this point to have a brief statement of the purpose of each such group and their relations to the other groups.

II. Central Committee on Radio Facilities of the American Petroleum Institute

The Central Committee on Radio Facilities is one of the committees in the Division of Transportation of the American Petroleum Institute. The Committee is made up of representatives of the oil and natural gas industry, which has a very sizeable investment in radio facilities and, therefore, has many licensees in the *Petroleum Radio Service*. The Central Committee on Radio Facilities acts as a forum for formulation of positions with regard to Federal Communications Commission proposals whether in the form of rule makings or otherwise. All Federal Communications Commission proposals are carefully reviewed. The Central Committee's Coordinating Committee, which is made up of a chairman, vice chairmen and several other representatives from the petroleum industry, determines, on the basis of the consensus of the Central Committee's members, whether or not the Central Committee should file statements in Commission proceedings and whether such statements should support or oppose the Commission proposals.

For example, the Central Committee on Radio Facilities prepared lengthy and exhaustive testimony in two recent Commission hearings relating to the allocation of the frequency spectrum. In Docket 11997, committee witnesses testified in June, 1959, with regard to the use of frequencies between 25 and 890 megacycles. In 1957, in Docket No. 11866, the Central Committee testified on the needs of the *Petroleum Radio Service* with regard to the microwave portion of the spectrum, above 890 mc.

In addition to the Coordinating Committee, there are several standing committees: Radio Engineering, Radio Coordination, Geophysical Use of Radio, Use of Radio in Oil Production, Pipeline Use of Radio, Maritime Use of Radio, Refinery Use of Radio, and Natural Gas Use of Radio. These committees all deal with problems particularly within their province as regards the use of radio in the *Petroleum Radio Service*. These standing committees represent every major function and phase of exploration, drilling, production, transportation and refining.

Through its reports and in semi-annual meetings, the Central Committee brings together experts in the field of petroleum radio and promotes exchange of ideas and developments.

III. National Petroleum Radio Frequency Coordinating Association

When the Federal Communications Commission established the *Petroleum Radio Service* in 1949, it became apparent that an organization was needed to coordinate the use of the newly won frequencies by the petroleum industry. Thus, the formation of the National Petroleum Radio Frequency Coordinating Association was initiated. The petroleum industry radio users were expected to provide their own system of coordination and to perform the necessary work in connection with making the most effective use of the frequencies assigned. All licensees or applicants in the *Petroleum Radio Service* are eligible for membership in the NPRFCA. The general plan of frequency coordination divides the United States into seven administrative divisions, called "Regions." Each region selects its own chairman and a sufficient number of personnel to represent the different phases of the industry: drilling and production, geophysics, oil and products pipelines, gas pipelines and refining.

The NPRFCA does not formulate positions with regard to Federal Communications Commission rule makings or other regulatory proposals. The function of the NPRFCA is not to advocate, but to coordinate.

Simply stated, the objective of the NPRFCA is to assist all applicants for licenses in the *Petroleum Radio Service* in the selection of frequencies, in order to minimize interference and thereby obtain the most efficient use of the authorized facilities. The frequency recommendations issued by the NPRFCA are purely advisory and have no binding force whatsoever.

Not only does the NPRFCA coordinate frequencies within the *Petroleum Radio Service,* but it also cooperates in coordination of frequencies shared with other services. For example, interservice coordination is now in effect between the *Petroleum Radio Service,* the *Forest Products Radio Service* and the *Manufacturers Radio Service*.

IV. Petroleum Industry Electrical Association

The Petroleum Industry Electrical Association, organized in 1928, is an association open to companies engaged in any phase of petroleum operations having communication systems or electrical departments. The object of the Association is the study and interchange of knowledge and ideas relative to the oil and gas industry with respect to construction, maintenance and operation of electrical power and communications systems and other related operations. The Association is authorized to participate in any administrative or judicial proceeding in which the Board of Directors deems the welfare of the member companies may be concerned. For example, the Petroleum Industry Electrical Association was active in opposing the Pacific Telephone and Telegraph Company's Tariff 108T which provided for the leasing and maintaining of private mobile radio equipment to Federal Communications Commission licensees in California.

The standing committees of the Petroleum Industry Electrical Association are Membership, Public Relations, New Equipment, Radio, Safety, Resolutions, Magazine and Scholarship.

The PIEA holds an annual meeting of representatives of its member companies, in conjunction with the Petroleum Electrical Suppliers Association, at which the Association's business is conducted, technical papers presented and exhibits of new equipment displayed.

V. American Gas Association Committee on Communications and Tele-Control

The American Gas Association deals with all problems of communications in the gas industry through its Committee on Communications and Tele-Control. This committee does not duplicate, but does effectively supplement, the services performed for gas radio users through other associations and committees. Thus, this committee does not engage in any frequency work, since this vital function is performed by the National Petroleum Radio Frequency Coordinating Association for gas transmission radio users and by the National Committee for Utilities Radio for gas distribution radio users. The Committee holds an annual meeting at which prominent speakers are invited to discuss technical topics of wide interest to the industry. Current surveillance of all Federal Communications Commission matters of interest to the gas industry is exercised and formal actions are taken in appropriate circumstances. The Committee also maintains a current registry of all gas radio users and cooperates fully with the Operational Fixed Microwave Council. It makes formal reports to the Board of Directors of the American Gas Association on all current radio matters of interest to them.

VI. National Committee for Utilities Radio

The National Committee for Utilities Radio (NCUR) was organized shortly after the creation of the *Utility Radio Service* to cope with the numerous problems arising from the rapidly expanding use of mobile radio by utilities and others. It is sponsored by seven national associations, including the American Gas Association, and by ten regional associations. The working base of NCUR is the ten regional groups, each of which draws its membership from the licensees in the *Power Radio Service* within its geographical borders.

NCUR collects opinions and formulates policies in matters concerning the use of radio and files comments agreed upon by licensees concerning proposals for changes in rules made by the Federal Communications Commission. It also organizes appearance of industry witnesses at hearings and makes certain that the interests of licensees are represented before the Commission.

NCUR has participated in every important rule making proceeding before the Federal Communications Commission which has affected the *Power Radio Service*. NCUR has worked diligently to insure continuous and better use of radio for the nation's electric, gas distribution, water and steam utilities.

NCUR has a Frequency Coordination Subcommittee organized with a chairman and with members who are the frequency coordinators of all the regional organizations of NCUR. The Frequency Coordination Subcommittee operates to unify the practice of the regional coordinators in the selection of frequencies and in the preparation of recommendations to the Federal Communications Commission for assignments to applicants for land mobile radio stations. The representative from NCUR on the Operational Fixed Microwave Council supplies the regional coordinators with information on assignments in the microwave part of the spectrum and is in turn supplied with data on each microwave installation by a *Power Radio Service* licensee.

Thus NCUR combines in one group, for *Power Radio Service* users, the functions of both the Central Committee on Radio Facilities of API and the National Petroleum Radio Frequency Coordinating Association in the *Petroleum Radio Service.*

VII. Operational Fixed Microwave Council

Since World War II, and particularly since 1949, many private industrial radio users have become increasingly aware of the vast potential usefulness available through use of microwave—often times called the "last frontier" of unused spectrum space. Because microwave frequencies are allocated on a shared basis to all *Safety and Special Radio Service* users, it became inevitable that, as more and more users took advantage of microwave, vexatious and economically detrimental interference would necessarily follow. Therefore, the chairman of the 1952 National Petroleum Radio Frequency Coordinating Association appointed a committee to study the problem of microwave frequency coordination. This committee, at the following NPRFCA meeting in 1953, reported that effective coordination required cooperation of all radio services authorized to use microwave, other than communications common carriers, since the allocated frequencies are identical. Following this suggestion, the Operational Fixed Microwave Council became a reality in 1954, when delegates from many various fields of Safety and Special Radio use met to give their unanimous approval to the Council. The petroleum representative was elected as the first chairman.

The Operational Fixed Microwave Council provides the convenient forum which is so greatly needed by the various organizations whose members are eligible to use microwave frequencies for operational fixed communications needs, in order that technical information, mutual ideas, and common problems may be discussed. The objectives and purposes of the Operational Fixed Microwave Council are:

1. To foster the mutual interests of organizations concerned with the use of operational fixed radio systems in the Public Safety, Industrial, Land Transportation, Marine and Aviation Radio Services.
2. To support and promote the allocation of microwave frequencies suitable and adequate for the use of such operational fixed radio systems.
3. To assist in member organizations formulating and coordinating views on uniform standards, fair and efficient regulations and technical developments beneficial to utilization of operational fixed radio systems.
4. To assemble data on microwave systems within the operational fixed radio service, maintain such information on a current basis, and furnish prospective users of such facilities with such information on existing or proposed installations in a specified area.

5. To concern itself with such other matters as may be incidental or implied in any of the foregoing specified objectives.

Prospective microwave users are invited to consult with the Council on their frequency problem so that interference may be avoided and so that the most efficient use may be made of available spectrum space. The Council organization represents the first successful broad scale effort to deal with mutual frequency problems at interservice levels.

4. Spectrum Problems

I. Introduction

As forcefully demonstrated by following sections, the many uses of radio make contributions to the efficiency and safety of petroleum industry operations of extraordinary value. The same is true of other industries and of such public activities as military, fire and police forces. The public impact of radio and television broadcast is universally recognized.

These factors mean that there is very strong competition for the privilege of operating radio systems. This competition for radio spectrum space is inevitable and will increase in vigor. Only a finite, although rather large, number of radio transmitters can operate on the earth. There are three factors which permit multiple usage. First, most transmitters are in use less than 100 per cent of the time, so that two or more transmitters that otherwise would interfere may share time. Second, the signal from a transmitter falls off with distance, hence transmitters far enough apart may transmit simultaneously on the same frequency. Third, a given transmitter emits energy only within a given frequency bandwidth and a given receiver is affected only by energy within a given frequency bandwidth. Thus if a second transmitter's emission lies in a frequency band that does not partially overlap the frequency band of the receiver associated with the first transmitter, the two transmitters can operate simultaneously without interfering with each other.

The minimum practical difference in frequency required between two transmitters to prevent interference, with a moderate distance between them, is the "channel width." It varies with type of information transmitted (more precisely with the *rate* of information transmission), type of modulation and design standards of transmitter and receiver.

While the distance required between two transmitters, on the same frequency, depends on type of modulation, power and antenna design, another most important factor is the propagation characteristic of the particular frequency. Propagation characteristics vary uniformly with frequency, but it is convenient to think of the spectrum in five somewhat arbitrary segments. These are 10 kc to 200 kc, 200 kc - 2 mc, 2 mc - 25 mc, 25 mc - 890 mc, 890 mc - up. Aspects of international concern, which are discussed in the next portion of this section, are important to varying degrees over these frequency segments.

The frequencies below 200 kc are transmitted largely by ground wave. Long range, stable operation is possible, but natural radio noise is high, so high power and large transmitting antennas are necessary. International aspects are paramount. The next segment, to 2 mc, is a transitional band with daylight operation similar to the lower frequencies, but with night operations largely "sky-wave," i.e. by ionospheric reflection. Very long night distances are possible but conditions are erratic. These frequencies also involve international considerations. The next segment, to 25 mc, is largely one of ionospheric reflection. Thousands of miles can be covered with fairly low power. In general, the lower frequencies in this segment are useful at night and the higher in the daytime. To assure good communication, three or four frequencies are necessary. The international aspects are obvious.

From 25 mc to 890 mc, the usable distances are limited. These frequencies are particularly useful for mobile operations or relatively short range fixed station service. At the upper frequency end, the normal useful range is strictly limited to line of sight. At progressively lower frequencies, the range extends progressively farther beyond the line of sight. In the lower part of this band, sporadic ionospheric reflection is experienced. It is too irregular and unpredictable to be utilized for normal communications but can be a serious cause of "skip" interference between stations hundreds of miles beyond the normal working range. The seriousness of this problem decreases with an increase in frequency and is essentially negligible above 70 mc and usually is not serious above 40 mc. At higher frequencies, atmospheric conditions may sometimes extend the range to several times its normal value and give rise to sporadic interference. International aspects are of secondary importance. They arise in part from sporadic long range transmission and in part from certain applications of international character, such as maritime and aeronautical.

The segment above 890 mc is the microwave band. Normally, operation is limited strictly to line of sight propagation. It is practical to use highly directive antenna systems, so that such frequencies provide a service quite similar to wireline service. International considerations are of little or no importance, except for aeronautical applications.

II. International Aspects

From this discussion of propagation characteristics of various frequency bands, it can be seen that the possibility of a transmitter in one country causing interference in another country is quite serious below 25 mc and of some importance up to 70 mc. Of course, problems occur at all frequencies near common boundaries. Furthermore, international cooperation is necessary in order that ships and aircraft of all nations can communicate with one another and with port or airport facilities.

International conferences on radio communication date back to 1903 when the first international radio telegraph conference was held in Berlin. The seventh conference was held in Atlantic City in 1947. The most recent conference, in Geneva, began on August 17, 1959. The petroleum industry was represented on various State Department committees charged with formulation of the United States position on matters to be discussed.

The petroleum industry was concerned principally with three points:

1. Avoid restriction on United States allocations that serve no useful international purpose. In a field where developments are as rapid as they are today in radio, it is difficult to foresee the effects of current agreements. The process of changing international radio agreements is inevitably very time consuming, so that unduly restrictive agreements may seriously hamper the practical application of worthwhile new developments. Restrictions that serve a real international need are, of course, essential.

2. Provide for use of several frequencies near 2 mc, 4 mc, 6 mc and 8 mc on the inland waterways. At present the 6 mc usage is in derogation of international treaties. The essentiality of this provision is discussed more fully in *Section 15*.

3. Provide for bridge-to-bridge radio on shipboard. This also is discussed in *Section 15*. Briefly, it provides for direct communication by voice between the two men actually navigating two ships, or between the navigator and the operator of some such device as a canal lock. International agreement on frequencies for this purpose and other details are necessary, in order that ships of different nationality can communicate.

III. U. S. Government Spectrum Needs

Under existing laws, the President of the United States has the authority and responsibility for assigning frequencies to radio transmitters operated by agencies of the federal government, including the military, while the Federal Communications Commission has the authority and responsibility of assigning frequencies to all other radio transmitters. No single agency has overall authority or responsibility. No systematic procedure of evaluating governmental needs and usage exists.

The seriousness of this problem is seen easily by examining current allocations in the vital band from 25 mc to 890 mc, which provides for nearly all mobile operations, in which there can be no effective substitute for radio. The federal government, with over 300 mc out of the total 865 mc, is second only to the broadcast industry which has over 500 mc. The aeronautical and meteorological services (which include some federal usage not counted in the 300 mc mentioned above) have slightly under 50 mc. A total of less than 50 mc is available for all industrial users, all police, fire, highway maintenance and other local or state government, all land transportation including railroads, trucks, and taxicabs, all communications common carriers, and all the citizens radio.

The urgency of this problem has been recognized by both Executive and Legislative branches of the federal government. In 1950, President Truman appointed a high level committee under the chairmanship of Dr. Irving Stewart to study the problem. As a partial enactment of their recommendations, President Truman appointed Haraden Pratt as Tele-communications Adviser to the President on July 31, 1951. Mr. Pratt's assignment was

1. Assign frequencies to governmental users.
2. Exercise the President's emergency and war powers.
3. Cooperate with the FCC in resolving conflicts between needs of government and non-government users.
4. Formulate policies for international negotiations.

Inherent difficulties limited the effectiveness of this approach and at the completion of Mr. Pratt's term, no successor was named. In 1955, the Senate Interstate and Foreign Commerce Committee appointed a special advisory committee under Edward L. Bowles, with particular emphasis on the problem of television allocation. This advisory committee reported in September 1958 that the basic problem of allocation of frequencies could not be handled by the FCC because of the limits of their power. The committee proposed the formation of a commission of five members within the Executive branch with full power to conduct a classified review of radio usage at the highest executive level. An appropriation of $600,000 was recommended for the study.

On July 21, 1958, the Senate passed the Potter resolution which called for a five-man commission to study government radio usage and recommend changes in allocation procedures. This resolution was strongly opposed by the Department of Defense and other executive departments. As a compromise, agreeable to the Administration, the House Interstate and Foreign Commerce Committee offered a resolution which extended the study to non-government usage as well as government usage. This was subjected to strong pressure from spokesmen for the broadcast industry and the House took no action on the resolution.

President Eisenhower appointed a Special Advisory Committee on Tele-communications, under the Chairmanship of Victor Cooley, retired Board Chairman of Southwestern Bell Telephone Company. This committee held its first meeting on November 18, 1958, and submitted its report two days before its deadline of December 31, 1958. Following the receipt of this report, the Office of Civil and Defense Mobilization submitted to the House an Administration-sponsored resolution supposedly based on the Cooley report. This is House Joint Resolution 331. It calls for a five-man, part-time commission to study for one year and make recomendations concerning the

1. Role of the federal government in managing the United States telecommunications resources.
2. Administrative organization for the discharge of the government's responsibility.
3. Existing methods of allocating frequencies between government and non-government users.
4. Existing table of such allocations.

Finally on June 8-9, 1959, the Office of Civil and Defense Mobilization made the Cooley report available to the House Interstate and Foreign Commerce Committee. The recommendations embodied in HJR 331 turned out to be a minor part of the Cooley committee's recommendations. As subsequently incorporated in House Resolution 7057, they called for a three-man National Telecommunications Board with powers greater than those OCDM now has. The Board would be established by Congress. Its members would serve six-year terms with the same salary as Federal Communications Commissioners. It would have direct access to the President and all major department heads. It would have its own staff. It would have complete security clearance with authority to require any government agency to produce information on its current and future needs for radio. It would not be an operating department and would not take over any functions of the FCC. It would have authority to allocate frequencies between government and non-government users in broad categories, with detailed allocation by the FCC and government respectively. HR 7057 is opposed by the Administration as premature.

On April 30, 1959, OCDM and FCC announced that they were engaged in a long-range study of spectrum utilization. They made a progress report to the House Interstate and Foreign Commerce Committee on July 30, 1959, pointing out that FCC Dockets 11866 and 11997 provided detailed information on present and future non-government radio usage. Government users had been asked to make corresponding reports by August 1, 1959. It is not contemplated by OCDM and FCC that these studies will bring major changes in the near future. They are designed to provide improved allocations 10 to 15 years in the future. However, early attention will be given to the bands of frequencies from 50-1000 mc where the problems are most urgent for broadcast, land mobile, aeronautical mobile, maritime mobile, radio positioning, radio navigation and earth-space uses.

The Cooley committee characterized the present set-up by saying that there is no adequate provision for high-level consideration on the government side of a variety of matters of national importance in the area of telecommunications. Conflicts are now settled at staff level by persons highly competent in their particular area but without opportunity of seeing broad aspects of the problem. It is clear that congressional action will be necessary before any workable solution is devised. It is essential that the importance of petroleum radio and the magnitude of its spectrum requirements not be overlooked or inadequately presented in such congressional and administrative studies.

IV. Broadcast Spectrum Problem

Somewhat more than 500 mc between 25 mc and 890 mc are allocated to broadcasting in addition to the standard broadcast band from 535 kc to 1605 kc. It is primarily the broadcast frequencies above 25 mc that are important in the current spectrum problem. This allocation consists principally of TV channels 2-4 (54-72 mc), 5-6 (76-88 mc), 7-13 (174-216 mc), 14-83 (470-890 mc) and the FM band 88-108 mc. The importance of television and FM broadcasting is not questioned by anyone. Likewise no one seriously contends that the present allocations are technically defensible. Very few of the UHF channels, 470-890 mc, are in actual use and the number is decreasing. On the other hand, the 12 VHF channels (2-13) are insufficient to provide a truly competitive nation-wide TV service. One proposal, originating with a Federal Communications Commissioner, and now being seriously considered, is to abandon channels 2-6 and the UHF channels and to add some 18 to 23 channels immediately above channel 13. Such an allocation is attractive technically. The propagation characteristics of all these channels are sufficiently similar so the lowest channel would have little advantage over the highest. The design of a receiver for all channels would be relatively simple.

There are three problems. First, the government stations (and some civil aviation stations) just above 216 mc would have to change frequency. Second, the TV receivers now in the hands of the public would need substantial modifications. Third, the owners of stations on channels 2-6 would be involved in a costly conversion of equipment and would suffer some loss of coverage area. It is certain that strong pressure will be brought on Congress to prevent this move.

V. Communications Common Carrier Spectrum Problem

Section 5 discusses the broader aspects of the communications common carriers problem. Attention here is confined to the spectrum aspects. Above 890 mc, the microwave region, the petroleum and other private user stations are referred to as *Operational Fixed Stations.* The FCC Docket 11866 (see *Section 7* of this report) established three policies. First, there is a definite need for both private microwave systems and common carrier microwave systems. Second, the availability of common carrier service is irrelevant to eligibility for a private system. Third, in general, private systems and common carrier systems should not share frequencies. For the foreseeable future, with the possible exception of intracity systems, there seem to be adequate frequencies for both private and common carrier systems.

Below 25 mc, there are certain well established common carrier services, principally international or marine. It appears that spectrum space for these is reasonably adequate and little future difficulty is anticipated. Careful planning for transfer of some services to higher frequencies better adapted to their needs should provide room for future growth.

The main concern, therefore, lies in the band 25 mc to 890 mc. The situation here needs careful study and continued vigilance. At the moment, the communications common carriers are proposing that they be allocated a very substantial band of frequencies, say from 815 mc to 890 mc, in order to provide a general-exchange-type mobile service in metropolitan areas. This is intended to serve a vast number of users in cars and trucks. They intimate they will abandon essentially all other radio service between 25 mc and 890 mc if they are permitted to furnish such a service. It may be expected that some major exceptions will be proposed if this plan shows any sign of realization. There are very serious questions as to whether the proposed broad band service is either technically or economically feasible. Petroleum users fear that the proposed system, whether it fails or succeeds, might be used as a method of encroaching on frequencies so desperately needed by private users, petroleum included.

In determining the relative amount of spectrum space to be allocated to various types of service, the FCC should weigh heavily the eligibility requirements of users and the importance to the national economy and defense of the particular use of radio by these users. So long as communications common carriers are permitted or, indeed, required to serve any and all users without any eligibility requirements and without regard to the contribution the resulting radio service makes to the public welfare, their spectrum requirements for such service cannot have a high priority.

VI. Other "Private" Users

The term "private" is used here to distinguish from federal government, broadcast and communications common carrier users. It includes municipal and state governments. As pointed out in *Section 7,* it seems unlikely that there will be any shortage of frequencies above 890 mc for a considerable time, with the possible exception of intracity systems. It might well be that developments in the next several years, particularly in the semiconductor and related fields, will very substantially reduce the cost of the radio portion of a microwave system. If so, systems connecting units of a business occupying several buildings in a city might become economically attractive for transmission of data to a central processing point and for similar uses. This might lead to intracity congestion at an earlier date than would have been predicted two years ago. The prediction of adequate frequencies for cross-country service is contingent on sound engineering and continued inter-industry cooperation such as is now provided by the Operational Fixed Microwave Council.

The problems below 25 mc will be handled on a case by case basis and in general should not be serious so long as the petroleum industry is prepared to present its case to the FCC in a timely and effective manner.

Consequently, the problems of the petroleum radio users arising from other "private" users will lie primarily between 25 mc and 890 mc. The requirements of other "private" users are a lesser hazard to petroleum, than those previously discussed, simply because their total spectrum requirements will remain small compared to requirements of government and broadcast services.

A serious potential source of trouble from other "private" users is the greatly relaxed eligibility requirements adopted by the FCC in recent years. For example, essentially any legitimate business is eligible in the *Business Radio Service* and any citizen in the *Citizens Radio Service*. It is true today that these Services are allocated relatively small segments of the spectrum and must accept a relatively poor quality of service. But as the number of such users multiplies, the amount of pressure they can bring to bear will also multiply. It is essential that the growth of these Services be watched closely and that continued emphasis be given to the principle that the amount of spectrum space allocated to a given Service, and consequently the quality of radio service afforded, should be based on the value to the public of the use of radio by that Service.

VII. Future Prospects

On the encouraging side, one can confidently expect technological improvements to continue, permitting more efficient utilization of the radio spectrum. This will permit far more transmitters to be utilized than at present. It must be remembered, however, that the implementation of these improvements frequently will involve substantial costs and temporary inconvenience to the radio users and the public. Both users and the public should be warned that this is the inescapable price of progress.

From strictly a spectrum point of view, most other prospective developments are discouraging, in the sense that they will certainly vastly increase the requirements for radio communications. One important development of this sort is mentioned in *Section 8* of this report — automation. Automation is totally dependent on communications and if the automated system, whatever it may be, has parts separated more than a few miles, the communications probably can best be furnished by use of radio.

One very intriguing development, that is not free from problems and pitfalls, is long distance relay of television or other broad band signals by satellites. Both active and passive relays have been discussed. At the moment, the costs involved seem high, but it is a reasonable prediction that such relays will be routine in the not too remote future. The problems posed by passive reflectors are particularly disturbing. Such relays are attractive because of their simplicity and lack of maintenance requirements. Unfortunately they are likely to be very broad band devices and consequently will reflect not only the signals they are intended to reflect but also many other signals. This will result in "skip" interference even at microwave frequencies such as is now a serious problem from 200 kc to about 40 mc.

Over the next several decades, there will develop requirements for channels as a result of the partial conquest of space. The magnitude of these requirements is unpredictable at the moment.

5. Communications Common Carrier Problem

I. Statement of Problem and Background

The petroleum industry currently has an investment of perhaps a quarter-billion dollars in privately owned electronic communications facilities of all kinds. Many of these facilities serve the specialized needs of the industry, some of which are detailed in this report. Many facilities are located in remote areas in which there are few, if any, public communications circuits. Still others are located overseas. However, many of the industry's own wireline, microwave and Very High Frequency radio facilities within the continental United States often operate in direct competition with the facilities now offered for lease by the communications common carriers.

Since the petroleum industry and the communications industry have had a parallel history of development during the past century, the early petroleum pipelines had a need for communications long before there was any network of common carrier circuits within the United States. In fact, even during the first half of this century, the petroleum industry was forced to supply the majority of its own communications circuits because of the lack of facilities or interest on the part of the common carriers. Yet, the common carriers traditionally have opposed the development of private communications wherever and however possible. After the development of private Very High Frequency radio and microwave, this opposition, which had been relatively passive in nature up to then, became open and active.

Since private communications are dependent to a large extent on Very High Frequency and microwave frequencies, common carrier control of radio frequencies would completely eliminate the petroleum industry's freedom of choice of whether to lease or supply for themselves this universally vital part of their operation. This is the "communications common carrier problem." It is impossible to describe its many details and ramifications in this short report, but the record should, at least, spell out in some detail the basic positions of both the common carriers and of the private users on the matter.

II. Position of Common Carriers Toward Private Communications

The communications common carriers' attitudes appear to be:

First, private communications are needed only in certain public safety and so-called right-of-way operations, such as pipelines and railroads, where direct operational control is necessary, but, even in these cases, should be used to carry "operational" traffic only.

Second, private communications constitute an encroachment on franchised general public telephone exchange and toll services and therefore ought not be permitted except in the specialized categories and under the restricted circumstances indicated above.

Third, where permitted to develop competitively with franchised common carrier services, private communications "skim the cream" from the profitability of such services to the disadvantage of common carriers and users of common carrier services alike.

Fourth, except in the so-called right-of-way operations, common carrier facilities should not be used to terminate or extend private telephone communications for private use.

Fifth, more efficient utilization of the radio spectrum would generally result from assignment of available frequencies to common carriers for their use in providing a general public radio service than would result from assignment of some frequencies to the users directly.

III. Position of the Petroleum Industry

The position of the petroleum industry with respect to the communications common carriers has been often misunderstood and occasionally misrepresented. The position is simple.

First, communications common carriers are indispensible for random access to the general public. The monthly bills of the petroleum users for such service provide a substantial part of the common carrier income.

Second, communications common carriers provide a valuable saving of investment, manpower and, in the case of radio, frequency space, where the needs of a number of independent users can be met adequately by the shared use of a common system.

Third, where the needs of the user are such that a privately owned system will be better adapted to his particular requirements or less expensive, the interests of the public are best served by permitting him freedom of choice to provide his own communication service in the absence of overwhelming reasons to the contrary.

Fourth, the nature of petroleum operations is such that it is impossible to make the distinction between "operational" and "administrative" communications often urged by the communications common carriers. This position was upheld by the FCC in its findings in Docket 11866.

Fifth, in the case of radio services rendered by a communications common carrier, the frequencies employed should be only those frequencies allocated to the common carriers in order to avoid difficulties of coordination and the possibility of undesirable incidents.

Sixth, in times of labor difficulties, sudden catastrophies and enemy attack, communications common carrier services are more vulnerable to disruptive outages, and therefore are less acceptable in critical operations.

Seventh, the communications common carriers' contention, that by unified control they can achieve greater efficiency of spectrum utilization, fails to distinguish between a general exchange type service and a private line type of service. In the general exchange case, the contention rests on the joint use of facilities and frequencies by a number of subscribers. It assumes that the proper measure of efficiency is the number of words per day per megacycle and ignores the factor of the value to the national economy and defense of the messages transmitted.

In the private line case, the contention is that unified engineering can somehow provide the same quality of service with fewer frequencies than can an equivalent group of private systems. In fact, the private user can, and does, engineer his system to meet his specific needs with only a moderate margin, whereas the common carrier, of necessity, must design a system with the capabilities of meeting the unknown needs of a large number of users.

IV. Recent Developments

To a large extent, the petroleum industry's position has been supported by the Federal Communications Commission in the recent policy determination made in Docket 11866, wherein it was concluded that:

A. "There is a demonstrated need for private point-to-point communication systems."

B. "There is no basis for generally concluding that the licensing of private communications systems would adversely affect, to any substantial degree, the ability of common carriers to provide service to the general public or adversely affect the users of common carrier service."

C. "There are now available adequate frequencies above 890 mc to take care of present and reasonably foreseeable future needs of both the common carriers and private users for point-to-point communications . . ."

D. "Availability of common carrier facilities will not be considered as a condition of eligibility for such private users."

E. "Sharing of frequency bands by common carriers and private users, except in very limited circumstances, is neither feasible nor desirable."

The American Telephone and Telegraph Company and other communications common carriers have petitioned the FCC for a rehearing, contending that the evidence in the hearing failed to support these findings and that new evidence is now available. The outcome of this petition is not yet known. The API Central Committee on Radio Facilities, of course, vigorously opposed this petition.

V. Conclusion

The above action on the part of the Commission, unless reversed, tends to lessen the common carrier problem, but in no sense does it eliminate it. The petroleum industry would be short-sighted indeed were it to assume that common carriers will not continue their endeavors to curtail private communications. The petroleum industry's uses and needs for private communications are set forth fully in other sections of this report. They are vital and will remain so. Thus the industry must remain alert to the common carrier problem and be ready to defend and promote the proper use of private communications at all times. The price of freedom of choice in communications, as in government, is eternal vigilance.

6. Petroleum Radio and the National Defense

I. Introduction

The oil and natural gas industry's use of radio and radar are indispensible in times of peace. In times of war, the accelerated demand for petroleum will greatly enhance the importance of such use. Likewise, an outbreak of hostilities would create a host of other problems for petroleum and other radio users. These problems merit most serious consideration.

II. Conelrad

The subject of control of electromagnetic radiation for defense purposes has received mounting interest and attention since early in 1951. On October 24, of that year, the President signed a bill, S.357, which amended Section 606 of the Communications Act, concerning emergency powers of the Chief Executive, to provide for control of electromagnetic radiations which might serve as navigational aids to an enemy, and to provide penalties for violations.

Under the authority thus given the President, an Executive Order was issued on December 10, 1951, empowering the Federal Communications Commission to enforce regulations designed to minimize use of electromagnetic radiations by radio stations in event of an attack or the immediate threat thereof. CONELRAD (an abbreviation of the phrase "Control of electromagnetic radiation") is the short name given to the present Commission project to carry out the mandate of this Executive Order. The Commission has stated that the primary object of the CONELRAD program "is to minimize the use of radio signals which might guide enemy aircraft and, at the same time, assure the maximum possible availability of radio stations and equipment for defense purposes and for use in connection with other essential emergency activities, such as the production and distribution of essential goods and services and the maintenance of communication services in the interest of public safety and morale."

The Commission has adopted CONELRAD plans for many radio services including the *Industrial Radio Services* of which the *Petroleum Radio Service* is a part. On October 11, 1956, the Commission announced finalization of Docket 11618 and a resultant amendment of Part 11 of their rules placing the *Industrial Radio Services* under the CONELRAD plan effective January 2, 1957. A manual of instructions was issued November 28, 1956, outlining procedures to be followed by all licensees in this service with respect to receiving the alert signal and operating during the periods of the alerts.

Fundamentally, the plan now adopted provides that no transmissions shall be made during a period of "RADIO ALERT" (the term applied to the military warning that an air attack is probable or imminent which automatically orders the immediate implementation of the controlled operations of all radio stations) unless they are of an emergency nature affecting the national safety, or the safety of people and property; and transmissions during these periods of emergency shall be as short as possible.

"RADIO ALERTS" shall be broadcast by all standard broadcast, FM and TV stations and it would be the responsibility of stations in other services to monitor and receive the alert and relay it to mobile units in the air and on the ground. Thereafter all operations except those by designated "key" broadcast stations operating on 640 or 1240 kc would cease until notification of the "RADIO ALL CLEAR" was received.

A provision in the CONELRAD manual for the *Industrial Radio Services* provides that "No radio transmissions shall be made during an alert unless they are of an emergency nature affecting the national safety or the safety of people and property." Among others, a footnote expanding on this restriction states that permissible transmissions during an alert may be:

"Radio transmissions necessary for the protection of pipelines, transmission systems or other property and for the expeditious handling of oil, gas, or other materials necessary to the national defense may be made during the CONELRAD alert."

"Microwave relay systems may continue to operate for the transmission of messages or intelligence when necessary for the national defense and/or the protection of people or property."

III. Oil and Gas Communications Facilities

Under date of October 18, 1955, Mr. H. A. Stewart, Director, Office of Oil & Gas, Department of the Interior, addressed a letter to Mr. Walter S. Hallanan, Chairman of the National Petroleum Council, requesting that the Council make a study of the communications facilities of the petroleum and gas industries to determine the feasibility and desirability of organizing existing oil and gas industry communications facilities into a nationwide wartime communications network for wartime mobilization and operation of the oil and gas industries to handle communications between these industries and the oil and gas war agency and other Government agencies as appropriate.

The Council authorized the study and under date of May 26, 1956, Dr. Robert E. Wilson, Chairman of the Committee on Oil & Gas Emergency Defense Organization, appointed a Subcommittee on Oil & Gas Communications Facilities of the National Petroleum Council's Committee on Oil & Gas Emergency Defense Organization.

This committee surveyed the existing communications networks in use by the various oil and gas companies to determine whether they could be used to coordinate the efforts of the petroleum industry in national defense emergencies when other means of communications might be unavailable or inadequate. To illustrate the nature of their conclusions a portion of their report is quoted as follows:

> "It is the considered view of your Subcommittee, composed of communications experts trained in providing the essential wire and radio facilities to the petroleum and natural gas industries, that there would be ways and means of utilizing the industries' private communications facilities to fulfill some of the emergency communications requirements of the Department of the Interior as requested.
>
> "While your Subcommittee deems such arrangement feasible, and even desirable in some instances in facilitating the common defense effort, it should be noted that such a program would require much advance planning and could only be done at a considerable expenditure of time and money. Although the basic facilities required for such an adaptation already exist in many parts of the country, much planning and some construction would be necessary in other sections. In general, however, the basic facilities exist in areas where the potential need would be greatest.
>
> "The implementation of such a program must be done in such a manner that it would not interfere with the essential day to day operations of these facilities by the petroleum and natural gas industries, since the needs for such communications facilities would increase materially in any national emergency. The proposed plan should also include the leased wire circuits now used by these industries but which are not now included in any effective priority schedule for use under emergency conditions.
>
> "It is not feasible, or desirable, at this time to outline a detailed plan of operation. Your Subcommittee does recommend, however, the appointment of a National Petroleum Emergency Communications Director in the new petroleum war agency, if one is created, who will have full responsibility in making certain that there will be no interference to

essential petroleum radio or wire facilities, that they are not closed down or taken over by any other government agency and who would also have the responsibility of then integrating the government's needs in this area with the industry's use of its own private facilities. There should also be appointed, in whatever regional organizations be created, a similar Regional Petroleum Emergency Communications Director with responsibility for carrying out the same functions at the regional and state levels, since he will be more intimately acquainted with the local needs. The national and regional Directors would then have close liaison with an Emergency Petroleum Communications Committee to be selected from existing groups in the petroleum and natural gas industries such as the Central Committee on Radio Facilities of the American Petroleum Institute, the Communications Committee of the American Gas Association, the National Petroleum Radio Frequency Coordination Association and the Petroleum Industry Electrical Association.

"If this phase were put into effect, it would be of maximum usefulness to the Office of Oil and Gas and would minimize possible after-effects of attack damage to commercial common carrier communications, since those remaining would be overloaded with high priority messages with the result that many important petroleum and gas messages would be delayed or not sent. Thus, such an emergency communications plan would be desirable to both the government and the industries in coordinating their common efforts in this important area of national defense."

Since the Committee submitted its report to the National Petroleum Council September 28, 1956, there have been no further developments with respect to Oil and Gas communications facilities being used for National Defense purposes, by the government agencies to coordinate petroleum activities. However, the growing awareness of the important role petroleum industry communications play in our national defense posture is illustrated by the October 20, 1959, report of the National Petroleum Council Committee on National Emergency Oil and Gas Mobilization. One of the principal recommendations of that report is that any effective plan of nation-wide mobilization of oil and gas operations "provide for a Director of Communications, both on the regional and national level, who would be responsible for, and coordinate, the serious communications problems which would arise."

IV. National Industry Advisory Committee

The National Industry Advisory Committee has been formed by the Federal Communications Commission to assist the Commission, and specifically, the Commissioner charged with FCC activities relating to national defense, in discharge of its responsibilities under the provisions of certain Executive Orders relating to national emergency conditions. This committee is assisting the Commission in development of alternate means of insuring continuity of service for certain top priority communications in event normal leased common carrier circuits are disrupted or destroyed during periods of national emergency.

The work of this committee is classified in nature and it is not possible to disclose fully the nature and extent of its activities. However, it can be said that radio facilities owned by petroleum companies eventually may become involved in certain defense preparations.

For example, it is of the utmost importance that communications continuity be available at all times to NORAD, SAC, and other vital defense activities under any eventuality. In addition, continuity of network and radio broadcasting operations must be maintained for use by the President and other designated officials. Certain industrial communications facilities could serve these functions, without unduly restricting the emergency communications requirements of the industrial user in re-establishing and maintaining continuity of certain vital public services performed by the industry. Private microwave, such as that authorized by the Federal Communications Commission would be ideally suited for such defense purposes, in those cases where excess capacity is available.

The first meeting of the NIAC was October 7, 1958, and was attended by four representatives from the petroleum industry who had been appointed to the committee by Commissioner Robert E. Lee.

Commissioner Lee later advised the presidents of most petroleum pipelines by letter dated March 9, 1959, of the general nature of the activities being carried on by this committee. The letters in reply indicated a willingness on the part of the petroleum industry to cooperate in any way which will assist in our country's defense.

Some of the subsequent work of this group has involved testing emergency fall-back circuits between certain vital defense installations routed over petroleum microwave systems. In cooperation with the FCC and a military committee, these tests were made from April 15 to June 15, 1959. These tests proved that petroleum microwave routes could be used for this desired purpose. The entire matter is being studied further by the FCC and the military committee.

V. Leased (Common Carrier) Circuit Priorities

The Office of Civil and Defense Mobilization Order IX-4 of November 6, 1958, provides for a priority system governing restoration to private service of a leased inter-city circuit that has been requisitioned for emergency use. This refers to inter-city common carrier circuits, wire or radio, together with local lines and facilities which are an integral part of the leased system.

The order states "When such a circuit is interrupted for emergency use, private service shall be resumed by the common carriers in the following order of priority insofar as practicable." Briefly, the priority classifications are:

Priority 1 — Comprise those circuits involving communications vital to the nation and essentially, defense warnings or top armed forces emergency communications.

Priority 2 — Circuits involving urgent civil activities, armed forces, diplomatic communications, or natural disasters of extreme seriousness.

Priority 3 — Circuits involving, (a) civil defense or public health, (b) important governmental functions, (c) maintenance of essential public services, (d) communications concerning production, procurement and distribution of food, essential materials and supplies which require rapid completion of transmission, (e) Armed Forces communications, and (f) official government and diplomatic communications requiring rapid transmission.

It is evident that petroleum will qualify under Priority 3 as a supplier of essential material. So also will a host of other industries. Consequently, the real status of a vital leased circuit is not ascertainable except through experience after emergency conditions prevail. While it is perhaps true that the chance of a leased circuit being even temporarily requisitioned is quite remote, it is nevertheless possible and the loss of a vital communications link could be extremely serious in the petroleum industry. It would appear that more definite assurance of continuity of service under wartime conditions is needed and particularly so since petroleum products comprise one of the prime implements of war.

7. Recent FCC Dockets

I. Introduction

There have been several Federal Communications Commission actions recently that have had far reaching effect on use of radio by the petroleum industry. A few of the more important Dockets, the implications and results that affect the petroleum industry are discussed here.

II. Docket No. 11866

Oral Hearings in this proceeding were held during May, June and July of 1957. There were 30 days of oral hearings. Over 200 persons and organizations filed comments with over 160 persons appearing at the hearing and presenting oral testimony. Some 5000 pages of hearing record were accumulated in addition to 166 exhibits. Thirteen individual statements were presented by members of the Central Committee on Radio Facilities. Twelve additional statements were incorporated into the record by order of the Federal Communications Commission.

On July 29, 1959, the Federal Communications Commission released its decision in the form of a Report and Order in this proceeding. This decision constitutes the basic policy of the Federal Communications Commission governing the allocation of frequencies above 890 megacycles, constituting the microwave portion of the spectrum. The microwave policy decision represents a reassuring determination for the API Central Committee on Radio Facilities, which advocated the position of the private petroleum users of microwave. The decision stated that the record supports the following conclusions:

There are now available adequate frequencies above 890 megacycles to take care of present and reasonably foreseeable future needs of both common carriers and private users for point-to-point communications systems, provided orderly and systematic procedures and proper technical criteria are applied in the issuance of authorizations, and that implementation is consistently achieved with respect to all available and future improvements in the art. There is a demonstrated need for private point - to - point communications systems. Accordingly, the decision looks toward liberalization of the basis for issuance of such authorizations. The availability of common carrier facilities will not be considered as a condition of eligibility for such private users.

There is no basis for generally concluding that licensing private communications systems would have any substantial effect on the ability of communications common cariers to provide service to the general public or adversely affect the users of such common carrier service. Therefore, it is unnecessary to consider whether such licensing is contrary to the public interest.

Sharing of frequency bands by common carriers and private users, except in very limited circumstances, is neither feasible nor desirable.

Authorizations for cooperative use of private microwave systems will not be issued except for (1) persons eligible in the *Police Radio Service,* (2) so-called right-of-way companies, like pipelines and railroads and (3) other organizations whose rates and charges are regulated by a governmental entity. The FCC cited the following justifications for these exceptions (1) in order to afford the Commission a good basis upon which to make meaningful observations as to the desirability and impact of such arrangements and (2) because it is evident that any economic benefits flowing out of such arrangements will assuredly flow directly back to the public, either as taxpayers or rate payers.

The restrictive reference to pipelines is a matter of some concern and the terms of the specific rulemaking proceedings which will implement the policy decisions of Docket 11866 must be watched closely. At the present time, a number of oil companies, having pipeline companies as subsidiaries, have microwave sharing arrangements with the pipeline company. No justification can be seen for reversing the FCC's past policy.

With release of this Commission decision on the policy which it will follow in regard to allocation of microwave frequencies, the way is now clear for regular licensing of private industrial microwave systems. It is expected that the Commission will in the very near future actually issue authorizations in response to applications which have been on file for several years. The policy decision in this Report and Order will be implemented by release of many notices of proposed rule-making.

The American Telephone and Telegraph Company and other communications common carriers have petitioned the FCC for a rehearing, contending that the evidence in the hearing failed to support these findings and that new evidence is now available. The outcome of this petition is not yet known. The API Central Committee on Radio Facilities, of course, vigorously opposed this petition.

III. Docket No. 11997

The proceedings in Docket No. 11997 relate to the use of the frequencies between 25 and 890 megacycles. Written comments in response to the Commission's Notice of Inquiry were filed by many groups, including the API Central Committee on Radio Facilities in November of 1957. On March 30, 1959, the Central Committee filed its written testimony in this proceeding.

The oral hearings in this proceeding began on May 25, 1959, with five Central Committee witnesses testifying in the oral proceedings on June 25. During presentation of the Central Committee's oral testimony, the Commission heard an actual tape recording of the use of one of the *Petroleum Radio Service* mobile channels. The recording illustrated the extreme overloading of the channel.

The American Telephone and Telegraph Company proposed a broad-band public exchange type mobile service, primarily for major metropolitan areas. The Central Committee stated that such a system would have little applicability to petroleum problems. The Central Committee also questioned the technical validity of the claims that such a broad-band system would represent an improvement in efficiency of spectrum utilization, particularly on a long-term basis. The proposed solution would take much of the mobility out of mobile radio. While the Central Committee would not oppose such a system if there were adequate spectrum space available, the long-term prospects are disturbing.

With oral hearings in this proceeding so recently concluded, a release of a Report and Order delineating the Commission's basic policy with regard to the allocation of frequencies in this portion of the spectrum is not expected for some time. With the International Radio Conference underway in Geneva, it is expected that the conclusions there will help the Commission in formulating its final decision in this Docket. The petroleum industry's main interest in this portion of the spectrum is in the preservation and expansion of its use of mobile radio.

IV. Docket No. 11991

The Commission released a Report and Order in Docket No. 11991 in June of 1958, which is of wide significance to *Industrial Radio Service* licensees, including Petroleum. In terms of actions affecting the *Petroleum Radio Service,* the following should be noted:

The Commission finalized its original proposal allocating the so-called secondary split channels between the present *Power Radio Service* 152-162 megacycle allocations and the three secondary splits between the present 173.225 - 173.375 megacycle motion picture relay press frequencies to the *Power Radio Service* everywhere except in the states of Texas, Oklahoma, Louisiana, Arkansas, Washington and Oregon. In these states, these frequencies will be assigned to the *Petroleum Radio Service* and the *Forest Products Radio Service* on a shared basis.

The Commission abandoned its earlier proposal to assign the so-called "taxicab splits" in the 152 and 157 megacycle ranges to the *Petroleum* and *Forest Products Radio Services.* Instead, these channels will be assigned to the *Business Radio Service.*

The Commission assigned a total of five frequency pairs in the 450-460 megacycle band for the *Forest Products* and *Petroleum Radio Services.* While the petroleum industry has made relatively little use of 450 mc systems in the past, current developments, in particular the need for offshore telemeter and control links, make this allocation seem quite inadequate. The contrast with the allocation to common carrier use is marked.

Among other changes brought about by the release of this Report and Order in Docket No. 11991 are establishment of a *Manufacturers Radio Service,* retention of the *Special Industrial Radio Service* in substantially modified form, the combination of the *Low Power Industrial Service* with elements of the *Special Industrial Radio Service* and elements of the *Citizens Radio Service* into a new *Business Radio Service,* and establishment of a *Telephone Maintenance Radio Service* with eligibility for communications common carriers engaged in construction, maintenance or repair activities.

The Commission adopted its original proposal to allocate 15 frequencies in the 158 megacycle band to the new *Manufacturers Radio Service* on a shared basis with the *Petroleum* and *Forest Products Radio Services.*

V. Split-Channel Proceedings

With the adoption of several key Dockets, No. 11253, 12169 and 12295, by the Federal Communications Commission, "split-channel" operation on a regular basis is now a reality. These proceedings included a number of Dockets but will be discussed here as a group rather than on a Docket by Docket basis, in order to present an over-all picture.

Briefly, based on the new Rules and Regulations, allocations will now be made on a 20 kc instead of 40 kc channel spacing in the 25-50 mc band, on a 30 kc instead of a 60 kc basis in the 150-174 mc band and with a 50 kc instead of 100 kc separation in the 450-470 mc band. This adds substantially to the number of channels regularly available in the *Petroleum*

Radio Service, probably enough to meet the needs for two or three years in the future.

At the same time, these Dockets reclassified and reallocated some categories of services, established new technical standards for channel operation, and finalized cut-over dates when users in various services must comply with these standards.

Most recently, the Commission requested comments in a Further Notice of Proposed Rule Making in Docket No. 12295 whereby it proposes to reduce frequency coordination requirements in the 25-50 mc and 152-162 mc bands to those stations within 35 miles and 15 kc of the proposed channel. This is in lieu of the former 30 kc requirement. Implementation of this Rule Making by the Commission will align the frequency coordination criteria with the narrow band standards. As a counter proposal to this 15 kc proposal by the Commission, the Central Committee on Radio Facilities on August 28, 1959, requested that the Commission substitute 15 and 30 kc standards depending on mileage separation. This would be a compromise between the proposed and existing requirements and provide for coordination with nearby adjacent channel stations.

8. Impact of Automation and Computers on Communications

I. Introduction

The following sections discuss the need for and specific use of radio, microwave and radar in almost every phase of oil and natural gas operations. Present and predicted future needs for oil, natural gas and their products have been outlined. The increased difficulties coupled with increased costs in finding our raw material, especially in the Western hemisphere, will be touched upon. Operations are becoming more far flung; sources of raw material are steadily growing more distant from the areas of demand for them and their products. To be competitive, indeed to remain in business, the industry managements must be, and are, continually seeking and implementing more efficient, precise and economical methods of operation in all phases of the petroleum business. The pace of conducting business is continuing to accelerate and business itself is continuing to grow more complex. There are increasing requirements for more accurate data to be made more rapidly available, for industry equipment to be more flexible and readily adaptable to meet changing requirements. The whole business complex must be continually surveyed and modified in the light of new facts and situations as they develop. Decisions throughout the industry organizations must be made and implemented more rapidly.

II. Automation and Computers

The requirements for more speed, flexibility and accuracy in the face of a more intricate business complex have led to increased reliance upon new mechanical, electric and electronic aids as they became available.

The age of automation and computers of necessity came quickly. Unattended pipeline pump and compressor stations are no longer a rarity but are fast becoming commonplace. Computer control of refinery units is at hand. Automatic production of oil and gas fields, with attendant testing and other ramifications, is a reality. Automatic data processing is usual, not unusual. In many instances operating data are being produced in the field in such form that they can be used directly, without change or translation, in data processing machines and computers. The nerve system of this network is communications. The muscles are the machines; the slave brains are the computers and data processing machines; neither are any better than the communications that link them together.

III. Communications Requirements

The petroleum industry has often in the past found it necessary to furnish its own internal private communications facilities either because of disinterest or reluctance of the communications common carriers to do so. These private communications facilities are now an integral part of the companies' operating plants. A rapid rise in requirements for private communications can be foreseen as the use of automatic plant and field facilities, computers and data processing machines increase.

There also will be an increased demand for use of common carrier facilities, especially in data transmission and processing. Specialized transmission equipment will be extremely useful to industry if and when it is generally made available for use. Some modification of common carrier policy regarding lease line facilities will have to be sought. Multipurpose use of leased voice circuits should be expanded for both economical and operational reasons. Termination privileges should be made firm and positive. The common carrier companies must, of necessity, be more flexible. Doubtless, as in the case of other phases of petroleum communications, both common carrier and privately owned communications will be employed in automation systems.

The choice will depend on a number of factors and the freedom to make the most appropriate choice is important to the petroleum industry. Where a company already has an existing private system with spare capacity and of adequate quality, the choice is obvious. Where a company has a leased circuit of adequate quality and has assurance that the necessary continuity of service can be relied upon, the only reason for installing a new private system would lie in tariffs that either result in undue costs or involve unacceptable conditions.

However, when a major operation becomes fully automated, with the operation totally dependent on the adequacy and continuity of the communications link, a high premium is placed on direct and sole control of the communications link. This factor of control in critical instances might well outweigh the direct cost factor and a company may decide the proper choice would be a private system even if the direct cost were somewhat higher than a comparable leased circuit.

The industry's private communications needs will surely be increased by the advent of automation. The communication system, as the vital link between the controlling computer and its sources of information and the means for carrying out its commands, must carry the highest priority.

9. Radio in Offshore Operations

I. Introduction

For more than a decade the oil and natural gas industry has been engaged in exploration, drilling and production activities in what is generally termed "offshore" locations. The following discussion also will apply to all operations on waters of inland bays and lakes, as well as the offshore Gulf of Mexico and the coastal waters of the Atlantic and Pacific Oceans. It, thus, will include locations varying from a short distance to more than 30 miles from land, in waters ranging to depths exceeding 150 feet.

In its constant effort to discover and develop new reserves of oil and natural gas, the industry has turned to these offshore locations. This has been done at tremendous expense and investment, but, as the records will indicate, successfully. These areas are believed by many to be the last frontier on the North American Continent to find sizeable reserves of this vital fuel so necessary to the economy and security of this nation.

Section 11 of this report describes the use of radio in petroleum drilling and production, but some of the communications problems encountered in offshore work are of such importance and so specialized it is believed necessary to discuss them here even though to do so may be, in part, repetitious.

II. Exploration

The first phase of offshore operations is that of exploration. Petroleum companies, by use of the various exploration methods described in *Section 10* of this report, move into an area and attempt to locate structures on which oil or natural gas may be found. The use of radio in this operation is fully described in that section. At this point it is sufficient to say that without the use of radio and radar these exploration operations offshore would not be possible.

After the results of exploration work are evaluated, leases are purchased, drilling sites selected and development begins.

III. Well Location

The next phase of offshore operations is locating the proposed drilling site accurately. The accepted standard for accuracy of location is one-half of one second latitude and longitude. This location work is accomplished by various methods such as conventional triangulation with optical instruments where distance will allow or by the various radiolocation methods described in *Section 16* of this report. In any case, use is made of some portion of the radio spectrum in this work. In the conventional optical methods, radio is used for voice communication between the men manning the instruments and the men in boats that are establishing the actual physical location.

IV. Drilling Platform

Drilling is accomplished by a number of methods from a variety of drilling platforms. In shallow waters the most common platform is a barge that can be sunk, resting on bottom with drilling equipment mounted atop the barge. In deeper waters platforms are built of either steel or wood piling, many of which are prefabricated at shore locations and transported to the offshore location on barges. Another type of drilling structure is the floating platform usually with legs that can be set on bottom to support the structure well above normal wave action. This type platform is generally used on wildcat locations and can be floated and moved from one location to another. In addition, in some areas man-made islands have been constructed that are served by boat or roadways to shore. Regardless of the type structure used, communications with shore and boats handling and servicing the structure must be maintained.

Permanent structures usually are transported and erected on location by a contractor, and close coordination between company and contractor must be maintained. Progress reports, information regarding transportation of men and materials, weather reports and warnings, emergencies involving sickness and accidents are only a few of the many requirements for radio during this construction phase.

Usually the contractor will have his own radio system, but the company must be capable of communicating with him regularly and during emergencies. In order to eliminate the duplication of radio equipment, frequencies licensed to both companies are sometimes used for this purpose, particularly in the 2 to 3 mc band. Commercial marine radio is another means of communication between the company and contractor during this phase of offshore operations.

V. Drilling Operations

On completion of the offshore drilling platform, equipment is set up and the actual drilling begins. In many cases barges for living quarters and auxiliary equipment are moored nearby. In other cases, only the actual working crew is on the platform with crews transported back and forth from a land base. Each location usually has some type of emergency transportation, such as a speed boat, for standby call. The use of helicopters for personnel transportation has become rather commonplace in offshore drilling operations.

It is essential that each barge or drilling platform be capable of continuous two-way radio communication with the operating base and with mobile units aboard vessels supplying men and material for the operation. These radio stations are usually classed as base stations at temporary locations because of the temporary nature of their operation. Nevertheless, they must be capable of communicating with the operating headquarters on shore which may be over 100 miles distant.

Radio stations offshore used in connection with offshore drilling operations must be in constant readiness because of the possibility of fires, blow outs and other accidents, and to receive and transmit weather information, a vitally important phase of operational safety. In rough weather, barges and other floating structures must be towed to sheltered areas and other precautions taken for the protection of life and property. Warnings of such weather conditions usually are relayed to the drilling site by the shore base in sufficient time for all these precautions to be taken prior to the actual storm.

In the case of accidents, threatened blow outs, fires, or other drilling emergencies, it is important that the drilling personnel be able to talk directly to key technical personnel on land. Instructions and directions between technical personnel engaged in such activities cannot be relayed satisfactorily through non-technical radio relay operators. The messages can be better understood between transmitting parties, and unnecessary repetition is eliminated when talking direct via two-way radio.

Drilling operations in offshore areas require the very best materials and services available. Much of this material and many of the services are provided by the so-called "service companies." The role these companies play in petroleum operations is covered in *Section 11* of this report. Here it is sufficient to say that in offshore operations, their role is vital and their use of radio to coordinate their activities and to dispatch their crews rapidly is of prime importance. When time and transportation problems to reach an offshore operation are considered, it is clear that these service companies could not serve the industry properly and quickly offshore without the use of radio.

VI. Production Operation

Upon the completion of any gas or oil well, some method of production must be decided upon. In offshore operations the drilling platform itself, if of a permanent type, usually become a support structure for separators, tank batteries and other production equipment. If the drilling platform is of a temporary nature, separate permanent platforms are built for production purposes. Most separators produce into tanks located on structures high enough above water to place the tanks above the surge and pounding of heavy seas.

As in drilling operations, production requires instantaneously available communications with the base headquarters on shore. Flow and pressure of oil wells must be measured for delivery records and production reports. These are transmitted promptly to the operating base. As oil is accumulated, it must be barged out or delivered into submarine gathering pipelines to intermediate delivery points. In many cases there is a central production platform which supports living quarters, warehouse and other supply facilities, all serving a number of oil or gas wells in the vicinity. In this case, two-way radio serves to communicate with the land base station as well as with all mobile units engaged in the production operation in the area.

In the delivery of gas into pipeline systems from offshore producing wells, the problem of coordination is as important as in oil deliveries. The operator of the gas system must be able to communicate with his base and delivery point at all times.

After production has been established in an offshore field, communications requirements multiply. The multiplicity of these requirements makes microwave the most logical means for providing these requirements. Several companies already have installed microwave between shore base locations and offshore production platforms. These provide for voice communications as well as remote control, telemetering and automation. Well head equipment is now available that makes remote control of an oil or gas well practical. Equipment is rapidly becoming available that will allow preplanned automatic control and scheduling of oil and gas well flows. These devices make the use of microwave more and more important in the operation of these facilities.

VII. Transportation and Supply

In all offshore operations the problem of transportation and supply is one of major importance. One large company has approximately sixty boats of various types and sizes supporting its offshore operation.

Crew boats which carry 15 to 20 men and small amounts of light equipment ply back and forth between platform and shore base making trips that require up to several hours one-way travel. Standby boats are used for local and emergency transportation. Other boats carry food supplies, laundry and other small items.

Providing for the needs of a drilling operation requires great quantities of fresh water, diesel fuel, drilling mud, cement, pipe and chemicals. These supplies must be transported by barge or cargo vessels in all types of weather. Seagoing tugs are used to handle large cargoes and barges. Many of the larger tugs and other boats are equipped with radar to assist in navigation through the waterways and harbors, especially during periods of fog or darkness. Some of these boats use the same channels and sea lanes as large ocean-going vessels. Radar is the only practical method developed thus far for continuous navigation during heavy fog with any reasonable degree of safety.

As mentioned earlier, the use of helicopters for the transportation of personnel has become commonplace. These ply back and forth between the offshore platform which is equipped with a landing area and the shore base, in addition to moving men from one platform to another.

All boats from small speedboats up to large cargo vessels must have two-way radio equipment to communicate into the company network. Many larger boats are equipped with *Marine Radio* sets to permit communications to any land station. Helicopters must also be equipped with *Petroleum Radio* to communicate into the company network. In addition, they must be equipped with the usual *Aeronautical Radio* for communications with other aircraft and airports.

VIII. Emergency Communications

Weather is probably the most important factor affecting offshore operations and, as a result, strictest attention is given to the slightest change in the weather and sea conditions. Weather reports are received at the operating base from the U. S. Weather Bureau or private weather service from two to six times daily and much more frequently when storms are brewing. All such weather information is relayed to the offshore operation via two-way radio networks.

A very minimum of 24 hours is needed to secure and abandon the drilling or producing area if such action is necessary. The movement of barges, portable marine equipment and personnel to safe and calm waters puts great demands on the transportation system and the radio communications network. High winds and waves preceding hurricanes make abandonment very hazardous, yet all men must be removed from the offshore structure where drilling or production is in progress. Drilling wells must be conditioned and flowing wells and pipelines must be shut in correctly and other operating material properly stored to weather the storm.

Safety of men and property is a prime factor in offshore operations when major disasters such as fire, collisions and blow-outs occur. Assistance from other operators is common during such emergencies and the use of common ship frequencies in rendering aid is an accepted practice.

IX. Summary

The importance of communications in offshore operations cannot be overemphasized. In late 1954, it was estimated that in excess of 525 million dollars was invested in offshore installations involving an estimated 10,000 to 12,000 people as operating personnel. It is reasonable to assume that since that date this investment has approached or, perhaps, passed a billion dollars. It has also been estimated that communications, as such, represent 2 to 3 per cent of this total investment, but this is the most important 2 or 3 per cent of the entire operation.

10. Radio in Petroleum Exploration

I. Introduction

Production of crude oil in the United States is in excess of 7 million barrels per day, while the volume of marketed natural gas exceeds 30 billion cubic feet per day. If the even greater demand, which the future is certain to bring, is to be met, new oil and gas fields must be found on a large-scale continuing basis.

The most recent available data show that only one exploratory well out of 2500 drilled finds an oil field with reserves as great as 100 million barrels — about two weeks supply. Only one wildcat out of 44 finds a field with reserves as great as one million barrels — about three hours supply. Only one in nine finds enough oil or gas to be classified as a commercial discovery.

It is therefore not surprising that some 11,000 to 12,000 wildcat wells must be drilled each year to maintain adequate oil and gas reserves in the United States. Every feasible method must be utilized to increase the chance of each well to be successful and to reduce the costs associated with the well.

Radio makes major contributions to both of these efforts. Its contributions to efficient drilling are described in *Section 11.* This section gives a brief account of petroleum exploration with particular emphasis on the essential role of radio in this operation.

II. Petroleum Prospecting

Oil and gas accumulations are usually found in sedimentary basins. These are areas where in the remote past the seas have repeatedly advanced and retreated, leaving behind deposits of materials carried into the sea from the neighboring land bodies. In the course of time, the layers of deposited rocks have been deformed so that they no longer are flat, but are tilted, folded and broken. In such traps lie the accumulations of oil and gas that can be produced by drilling, if they can be located. Often, geophysical measurements, made at or near the surface of the earth, may yield the necessary information. From 500 to 600 geophysical crews are usually at work in the United States.

Geophysical methods are dependent on the differences in the physical properties of different earth materials. The most commonly used is the seismic method. It is somewhat analogous to radar. A shock wave is produced in the earth, either by exploding dynamite in a shallow hole or by dropping a large weight. This shock wave travels down through the successive formations and is partially reflected at each boundary. These reflected waves return to the surface where sensitive electronic vibration detectors produce an electric signal when disturbed by returning reflections. These signals are accurately recorded. From these records it is then possible, in principle, to determine the round trip time and hence the depth to each reflecting interface. If the interface which seals the possible oil or gas trap is a seismic reflector, it can be mapped and a drilling site selected.

If the prospective structure is associated with a formation which is substantially different in density from the surrounding rocks, as, for example, a salt dome, gravity meter measurements may locate the structure.

Or if the magnetic properties are different, a magnetometer survey, perhaps airborne, may be helpful.

III. Radio and Radar Applications

Radio and radar are helpful and in some situations indispensable in the petroleum exploration effort in three ways. First, by its very nature, exploration is frequently conducted in remote and inaccessible regions. These include the offshore, swamps and marsh, barren or desert areas, foothills and so on. Moreover, various components of a single exploratory crew, such as core drills or seismic party, may be separated a number of miles. In such areas, established means of communication are non-existent or, at best, scattered. Use of temporary wirelines, if not physically impossible, is totally impractical. Thus the necessary coordination of the activities of these crews and their safety are absolutely dependent on private radio.

A second application of radio is transmission of control signals and data. Since reflection times must be determined with an accuracy of one thousandth of a second, data transmission must be very precise.

The third use of radio and radar in exploration is for radiolocation. Unless the location of observations is known with precision, the observations are of little value in exploration. In offshore operations, the only practical methods all involve radio or radar. In airborne work, radio or radar are extremely valuable. These uses are discussed more fully in *Section 16*.

IV. Radio Regulations and Usage

The absolute essentiality of radio in petroleum prospecting was recognized as early as 1925, and the FCC and its predecessor have always made adequate provision for this specific need. The specific frequencies, 1614, 1628, 1652, 1676 and 1700 kc, are available for such use and are necessary in certain special cases, for example in heavily wooded areas where high absorption makes portable Very High Frequency equipment impractical. By agreement with other segments of the petroleum industry and the approval of the FCC, geophysics has exclusive use of five frequencies from 25.02 to 25.18 mc and secondary sharing privileges on eight frequencies from 25.22 to 30.82 mc and nine frequencies from 153.05 to 158.43 mc. The transient nature of exploration activities is responsible for some problems in frequency coordination. These have been satisfactorily solved by the agreement just mentioned and by the special practice of the FCC in licensing geophysical stations on multiple frequencies. Normally, the FCC licenses a radio transmitter to use only one specific frequency. Exceptions are made in special cases. For example, the boats on the Mississippi River can communicate with their offices at certain distances and times on one frequency but not on another, whereas the reverse is true at certain other times and locations. They are authorized to use whichever licensed frequency is usable. Similarly, a geophysical radio station is licensed to use any one of a fairly large number of frequencies. When the crew moves into a new working area it is their responsibility to monitor the various frequencies available and to utilize the one which will cause the least interference. This is an entirely practical solution to what otherwise would be a most difficult problem.

The extent to which a given geophysical crew employs radio varies widely with specific circumstances. At one extreme, a gravity meter crew operating in an area which is not too isolated may have no radio equipment, and a seismic crew in a similar area shooting short spreads will have radio equipment available but will prefer to use a wireline. At the other extreme, an offshore seismic crew will have a shore-based radio transmitter for communication to the boats, three or four shore-based transmitters for a radiolocation network, radio transmitters on each of three to four boats for communication, radio transmitters in recording and shooting boats for transmitting control signals and shot explosion time signals. One or more boats will be equipped with radar for navigation at night or in bad weather and for auxiliary radiolocation. In addition, at least one boat will be equipped for radio-marine telephone service.

The variety of conditions under which a given crew must operate requires that it have radio equipment to meet the extreme case, although much of the equipment remains idle part of the time. This is necessary not only for efficient operation, but to protect the life and safety of the men when working in isolated or hazardous areas.

11. Radio in Drilling and Production

I. Introduction

The United States daily produces in excess of 7 million barrels of crude oil and 30 billion cubic feet of natural gas. To meet this demand the petroleum industry has about 575,000 oil and 83,000 gas wells capable of production. These production facilities must be kept in peak operating efficiency. In addition, the industry must complete nearly 30,000 new oil and gas producing wells yearly to offset the natural decline in older wells and to fulfill the rising needs of the nation for oil and gas. To provide these producing wells, a total of some 50,000 wells must be drilled annually. This is the approximate level attained in 1959.

Drilling activities and, to a somewhat lesser degree, producing activities are complicated and hazardous. Nevertheless, they have excellent safety records. To protect the lives of the men and to increase efficiency, good communications are mandatory. Some drilling locations are served by commercial or private wireline systems, but more frequently drilling sites are remote and require the use of private radio.

Production communications can be supplied either by telephone lines or by radio. In the early days, telephone lines were the only communication means available. When producing areas were smaller and closer to centers of population, this was no problem. Production is now spread out, and many of the producing areas are remote. Well spacing is greater. These conditions make the use of wireline communications both impractical and uneconomical.

Approximately two thirds of the radio transmitters licensed in the *Petroleum Radio Service* are used in connection with drilling and production operations.

II. Drilling Use of Radio

The first step in drilling a well is to choose the location on the basis of all available geological and geophysical information. Next, the actual location must be determined on the ground. This may require radio for coordination of the surveying activities and, in the case of offshore operations, the location is determined by means of radiolocation methods. Next, road building machinery is brought in to prepare the site. Areas are chosen for reservoir tanks and the installation of drilling equipment.

Modern drilling equipment is complex and powerful. For example, to rotate the drilling bit usually requires over 300 horsepower. The pumps, which circulate the drilling fluid, to lubricate the bit, to soften the formations and to flush out the cuttings sheared from the rock by the bit, require over 1000 horsepower. To raise and lower the string of drill pipe, which in extreme cases may be almost five miles long, requires a hoisting engine with some 2000 horsepower.

Radio is needed during this set-up period to coordinate these many complex activities. Where the site is remote, no other communication medium is suitable or available.

As soon as the drilling activity is started, frequent communication is needed between the drilling crew and various supervisory, advisory and service people involved in the project. Drilling activities proceed around the clock. Even in the case of wells being drilled in a partially developed field, the subsurface conditions that will be encountered cannot be predicted with any degree of certainty. The next foot drilled may encounter the totally unexpected. During normal drilling, the hoist must support part of the weight of the drill pipe, the drill bit and drill collars, and permit part of the weight to be supported by the rocks being drilled. If too much weight is placed on the rock, the drill pipe, whose length is several thousand times its diameter, will buckle with disastrous results. But if too little weight is placed on the rock, the drilling rate will be greatly reduced. In practice, for each combination of depth and type of formation, there is an optimum choice of bit type, mud type, speed of rotation, speed of mud circulation and weight on bottom. So long as the results of the drilling conform reasonably well to those expected, the driller and his crew can handle the situation. But if substantial differences occur, there is urgent need for prompt aid or advice. For example, the control of the properties of the drilling fluid, usually called mud, is an art and science requiring highly specialized training and experience. The mud engineers, with this ability, usually are responsible for a number of wells which are drilling simultaneously many miles apart. Their advice can be obtained almost instantly by radio and if necessary, they can start for the well quickly.

Likewise, it is necessary to determine what formation is being drilled from time to time, either by cutting an actual sample of the rock with special bits or by lowering electrical measuring devices into the well. Often the time when these special services will be needed cannot be predicted accurately. It depends on the drilling progress. The specialized equipment and personnel can be summoned by radio with a vast saving of time and reduction of danger of losing the hole.

The companies engaged in a multitude of highly specialized activities serving the petroleum industry in the drilling program are as essential to the process as are the individual oil companies themselves. Some of the services they render are:

Fire fighting	Water well drilling
Drilling mud	Tank building
Electric logging	Formation testing
Cementing	Core analysis
Acidizing	Mud logging
Formation fracturing	Rig building
Perforating	Road building

These service companies make very efficient utilization of radio. They are eligible in the *Special Industrial Radio Service.*

A typical land drilling operation may cost $1500 per day, and a minimum offshore operation $4000 per day exclusive of supplies and special services. The more remote the location, the higher the cost. Any time wasted in coordinating delivery of material, assistance from service groups, or supervision of the operation can be very costly. Also at times a delay of a few hours may mean the difference between a successful well and a failure. It is not unusual for an operator to have an investment of over a half million dollars in a well being drilled. The rig being used may have cost the drilling contractor a comparable amount. The protection of these investments is largely dependent on the availability of reliable communications. Radio generally provides the only satisfactory communications.

Safety of men and material is extremely important in the drilling operation. Unpredictable high pressures in water, oil or gas formations may result in the drilling fluid being blown out of the well. A likely, and most serious, consequence is fire. When this occurs, losses may run into millions of dollars. With good communications, many of these blowouts can be controlled quickly enough to prevent extreme damage. Mud engineers, companies with high - pressure truck - mounted pumps or, in the extreme, firefighters, can be called upon to aid the drilling crew. Quick and certain communications is necessary. In case of injury to drilling crews, the instant availability of communications may well save a life.

Drilling activity communications involve the two factors of time and distance. Drilling rigs may move to new locations every two weeks, or, in the case of deep tests, every two or three months. These short-time operations do not justify the building of wireline communications systems. Often the decision to drill a particular well must be made quickly and the decision promptly executed; in such cases, there is not sufficient advance notice to permit the construction of telephone lines. The nearest commercial telephone may be many miles away, perhaps a hundred miles or farther. Radio is the only practical and economical means for providing the necessary communications.

The reasons which lead to the choice of radio for drilling communications on land are magnified when the drilling operation is being carried out offshore.

III. Production Use of Radio

Drilling an oil or gas well requires from a little over a week to several months. The completed well will normally produce oil or gas for many years. When the drilling is complete and the oil or gas is flowing into the gathering lines or tanks, the life of the well has just begun. And so has the work that must be done. Pressures and flow rates must be determined and controlled. As the well ages, it must be reworked from time to time, to improve the efficiency of its operation or to reduce the production of water. Down-hole equipment wears or corrodes and must be replaced. One producing horizon may be depleted and the well recompleted in another. The surface equipment, such as valves, gauges, tanks, flow lines and the motive power for the pumps, must be maintained, repaired and replaced.

Radio provides an economical, modern and quick method of handling production communications. These communications are in several forms. Mobile radio is used to contact personnel in the producing areas. This can be between trucks and cars, and between motor vehicles and headquarters. Mobile radio promotes the maximum use of men, materials and vehicles. Many production facilities are being controlled automatically. Microwave and similar radio facilities provide the supervisory circuits and control circuits for automatic production. With the introduction of centralized computer installations to determine and control the optimum operation of a number of fields, greater demands will be placed on communications systems. Microwave systems are particularly suitable, technically and economically, for meeting such requirements. Many producing areas have field offices. Point-to-point radio such as microwave provides communications with headquarters and other offices.

For good production, the facilities must be properly maintained. An example of this is well workover. This activity of keeping a producing well in top operating efficiency requires communications with headquarters and with supervisory personnel. The prompt delivery of repair material and assistance in case of emergency is vitally important. Since many of the well workover activities last only one or two days, it is uneconomical to extend telephone lines for such a short period. In many cases, advance notice is only a few hours. Radio provides the best method for this important temporary type of communication.

The production of natural gas and natural gasoline requires close coordination between operating personnel opening and closing valves in the fields. The gathering systems of oil and gas throughout the producing areas can be coordinated more efficiently by the use of radio. Anything that can be done to improve the operating practices of production in order to increase the ultimate recovery is of vital importance to the nation and to the petroleum industry. Radio enters into all activities.

Oil field operations have good safety records, although there are many hazards connected with this work. Radio permits quick on-the-spot communications in cases of difficulty. Radio provides reliable and economical communications in remote and hard to reach locations. For example, much of Alaska is remote to commercial facilities; many offshore platforms can only be served economically by radio.

IV. Future

On the basis of the many needs, it is evident that the use of radio in petroleum drilling and production will increase rapidly. Since new productive areas are generally more remote, the use of radio will become more and more important. The problems to be solved can often find a practical solution only in the use of private radio. The conditions imposed on such usage should be liberalized.

12. Radio in Pipeline Operations

I. Introduction

Since the beginning of the petroleum pipelines about 90 years ago, the development of this form of transportation has been very rapid. By the year 1900 there were already 18,000 miles of oil pipelines. At the end of 1951 this interstate network had grown to 131,457 miles of crude oil (trunk and gathering) and refined products pipelines operated by 76 companies. By the end of 1957 the interstate network had expanded to 145,236 miles operated by 82 companies, and of this total more than 52,000 miles were in refined products service. Most of the major refining centers in the country today are connected to the network of crude oil or products pipelines. A major portion of these pipelines are in the Southwest, Gulf Coast, Midcontinent, and Great Lakes areas although there are now pipelines operating in almost every state including Alaska.

The gas industry, in terms of gross assets, is the sixth largest industry in the nation. Of its 31.2 million customers, approximately 28.8 million are residential, and 2.4 million are commercial and industrial. The principal areas of natural gas production are in the Southwestern and Gulf Coast states. Five of these states (Texas, Louisiana, New Mexico, Kansas and Oklahoma), plus California, accounted for 90 per cent of the total natural gas produced in 1958. The industry's markets, located in 48 states and the District of Columbia, require 217,000 miles of transmission and field gathering lines, and 354,000 miles of distribution lines.

The importance of this country's pipelines lies not in the mileages or areas covered, but rather in their ability and capacity to move oil, products and gas from originating points to market areas better than any other means of transport. As an illustration of this importance the nation's network of oil pipelines delivered to terminals or to other pipelines in 1951 a total of 3.2 billion barrels of crude oil and products. In 1957 this total delivery volume had reached 4.47 billion barrels.

Most of the major population centers in the U. S. today are supplied with natural gas, transported by large diameter, high-pressure pipeline transmission systems. During 1958 these systems delivered 8.0 trillion cubic feet of natural gas, of which approximately 2.8 trillion cubic feet were used for domestic heating and cooking purposes, and 5.2 trillion cubic feet by commercial and industrial customers. Approximately 3 trillion additional cubic feet of natural gas were sold by non-utility producers and others for industrial use.

Coordination of these vast and widely dispersed operations requires the full-time use of many types of communications facilities. Pipelines originate in, and travel through, many sparsely settled areas where in the past, and even today, public communications are difficult to obtain. Because of these conditions and the need for reliable, private and flexible communications networks, pipeline companies have constructed, operated and maintained a major portion of their communications systems. A portion of their systems are composed of full period leased circuits obtained from telephone and telegraph companies where it is feasible to use their services.

In former years the pipeline companies depended upon communications composed almost entirely of open wire lines. In the past 15 years these wire lines were extensively supplemented by base and mobile radio systems and during the past 10 years these wire lines have been supplemented and, to a substantial degree, supplanted by microwave radio relay systems. Pipeline companies use almost all known means of electrical communications in their operations such as telegraph, teletype, telephone, facsimile, closed circuit television, telemetering, telecontrol and mobile radio.

II. Crude and Products Pipeline Operations

To understand the communications requirements of pipelines, it is necessary to realize the magnitude of the shipping problem handled by a large line. A 250,000 barrel-per-day line 1000 miles long moves approximately 37,500 tons per day through the line for a total movement of 37.5 million ton-miles per day. This is equivalent to a railroad keeping eighty 60-car trains in constant service.

Today's modern pipelines are vastly different from earlier systems and are operated in an entirely different way. Except for receiving and delivery stations most modern lines are operated as a "tight" or "closed" system with one station pumping directly into the input of the next station without an intervening tank, although some stations may "float" a tank on the line. Thus a change in the flow will affect all stations on that section of line being operated as a "closed" system.

Today's pipelines are equipped to a considerable degree with telemetering, telecontrol, and automatic controls. A survey made in 1958 by the Engineering and Technical Section of the API Committee on Pipe Line Transportation revealed that 20 per cent of crude oil trunk line pump stations and 26 per cent of the products pump stations are remotely controlled. Twelve per cent of the crude stations and 21 per cent of the products stations are completely unattended. Approximately 246,000 horsepower of pumping equipment were being remotely controlled over distances up to 1000 miles. Out of 754 trunk stations reported, 242 were remote controlled and 102 were automatically controlled by line conditions. In addition, it has become common practice to telemeter from pump stations and delivery points pipeline variables such as pressures, flow rates, flow quantities, tank levels, operating conditions of equipment, power consumption, and alarms for abnormal conditions.

There are several categories of communications requirements for operation of oil and products pipelines. One such requirement is for dispatching where the various operating locations along a pipeline must give to, and receive from, the dispatcher information about receipts into the line, deliveries from the line, and the current location of the various batches in the line. It is necessary that the dispatcher receive other types of information such as pressures, flow rates, temperatures, and power consumption so that the line can be operated in the most efficient manner. The record of line fill is kept together with receipts and deliveries so that "overage" or "shortage" of oil or products can be detected. A "shortage" or abnormal pressure or flow indication along the line may indicate a break in the line requiring emergency shutdown of a section of the system. It is common practice to use private party line voice circuits for dispatching circuits although there is some use of teletype or telegraph circuits for this purpose. These circuits usually are in full control of the dispatcher, that is, he may "seize" them at any moment and prevent other use of the circuits.

Another communications requirement is for the day to day operating, maintenance and repair of the pipeline system. This may involve district offices, maintenance headquarters, pump station personnel, and general operations control offices in the business of emergency repair of leaks, cathodic protection of lines, repair of pumping units, operating problems, such as starting up new stations or shutting down stations, and scheduling personnel for various operations. The regular dispatching circuits may be used for this purpose as well as special trunk telephone circuits.

Another relatively new type of communications requiring an exceptionally high degree of reliability is the telecontrol, telemetering, and alarm circuits. These usually terminate in the dispatching office although some companies terminate them in an adjacent manned pump station. The number of circuit miles in this type service has increased tremendously in recent years with individual pipeline companies reporting as high as 5,800 circuit miles for this purpose alone. These circuits may be either direct current or voice channels depending on the type of telecontrol and telemetering being used.

In addition, many companies maintain a teletype network so that written instructions can be transmitted to various offices and pump stations. These usually concern pumping schedules, receipts into line, delivery schedules, scheduling of personnel, etc. Some companies are now using facsimile which will reproduce written, printed, or pictoral material over a voice circuit.

While the illustrations of pipeline usage given above are drawn from long pipeline practice, radio is equally useful for gathering lines and short pipelines, such as those from tank farms to loading dock or from dock to ship.

In recent years, a large portion of the communications requirements listed above have been transferred from wire lines to microwave radio relay systems. Vulnerability of wire lines to extreme weather conditions has dictated much of this change as demands for communications with greater reliability has accompanied modernizing and automating of pipelines.

Another important communications need is for base radio station and mobile radio use in pipeline operations. The pipeline industry needs communication with field vehicles engaged in line maintenance and repair, particularly during emergencies such as a line break in a densely populated area or near a public highway or a river. Ability of the operating personnel to obtain answers to questions and decisions on immediate problems from supervisory personnel, who are not available to fixed communications facilities, is an operating necessity of considerable importance. Coordination of hazardous activities, through central direction of field personnel, results in such increased safety to personnel and the plant itself that there is no large line in operation today which is not equipped with good mobile radio facilities.

Many pipeline companies operate their own aerial patrol. Communication between the patrol planes and pump stations or repair crews is effected by means of radio, which greatly expedites the reporting and repair of leaks or other conditions requiring immediate attention. Such communications are conducted on mobile frequencies allocated to the *Petroleum Radio Service*. Patrol planes are also equipped with customary radio facilities operating on aeronautical frequencies.

III. Gas Pipeline Operations

The importance of gas to the American economy may be seen from the fact that gas now supplies approximately 28 per cent of the total energy needs of the nation. This compares with 11.4 per cent in 1940, indicating the rapid relative increase in public acceptance and use of gas as a fuel. It is further estimated that during the next seven years the number of customers will have increased to approximately 38 million, requiring an additional 165,000 miles of gathering, transmission and distribution lines to meet this need.

The primary objective of all gas pipeline systems is the delivery of adequate quantities of gas where and when required. The amount of gas required in a given area at a given time is dependent upon a number of factors, among the most important of which is weather. Were a pipeline system unable to adjust its deliveries to meet a sudden unexpected demand, an entire community might find itself without fuel for its homes, hospitals, schools, shops and factories. Speed in handling production and gas dispatching orders, in reporting and advising those concerned of emergency conditions, and in dispatching men and equipment in connection with pipeline repair work, is an important factor in assuring an uninterrupted supply of gas to these markets.

Natural gas is not readily adaptable to conventional storage methods and, although the industry has invested hundreds of millions of dollars to develop underground storage facilities near principal market areas, providing adequate quantities of gas is still a matter of anticipating and meeting hourly load requirements. Fast, reliable communications on a 24-hour basis to all operating locations is essential to efficient operation of a high-pressure gas transmission pipeline system. The need for this service was established with the construction of the first of these long haul pipeline systems, operating at pressures upwards of 700 pounds per square inch, and capable of delivering hundreds of millions of cubic feet of gas daily to markets over 1,000 miles distant from the gas supply area.

Gas pipelines were among the first large scale users of industrial radio facilities in their operations. Starting with relatively low frequency systems, licensed during the 1930's in the *Special Emergency Radio Service*, these installations have grown in size and importance. Today most gas pipelines have become dependent upon their field radio communications systems to such extent that these systems are considered an integrated plant facility, as vital to the various phases of the gas industry operations as are compressor stations and pipelines.

A recent survey indicated 50 of the principal gas transmission systems are operating 963 base radio stations and 6,779 mobile units in the *Petroleum Radio Service,* and 176 gas distribution companies are utilizing 1,174 base radio stations and 16,583 mobile units licensed in the *Power Radio Service.*

These radio facilities are used on a day-to-day basis to schedule and coordinate work of field maintenance crews, to maintain contact with field supervisors when away from their headquarters and to maintain contact with pipeline patrol aircraft. Radio permits immediate communication for reporting emergencies and for alerting and dispatching repair crews and equipment necessary for rapid repair of damaged facilities and the installation of service. Additionally, although most pipeline systems utilize fixed communication services, such as microwave relay or wire lines, to handle routine traffic to and between their principal offices and compressor stations, base radio stations at these locations provide an emergency means of relaying dispatching orders and other urgent traffic between these points at such time as their normal point-to-point facilities may be inoperative.

In some gas pipeline systems, the dispatcher receives telemetered information as to pressures, flow, and input quantities into the pipeline and delivered quantities from the pipeline to consumers. With this type of operation, the dispatcher continuously observes line conditions and, when system changes are required, uses remote control devices, which function over communications facilities to effect desired changes or utilizes voice channels to issue required orders.

On gas pipeline systems delivering appreciable quantities over long distances, flow must be maintained by installing and operating repressuring or booster stations. The average repressuring point is highly mechanized and kept in good operating condition so that flow can be maintained. All machinery and equipment failures are reported immediately to headquarters. These operations require adequate and reliable communications during normal operating conditions. When breakdowns and emergencies occur at these plants, the demands on communications facilities are greatly increased.

Radio is used in gas distribution to cover a wide range of services intended to increase safety of the public, safeguard operating personnel, give prompt and efficient service to the public and cover a vast range of problems. Radio in gas distribution is controlled from one central control point, at a district headquarters from which contact is maintained with mobile units throughout the operating territory. Service and repair work on all gas appliances, repairing gas leaks and inspection of premises for customers, sealing and unsealing meters for turning gas off and on when customers move from place to place, protecting the public during fires by cutting off gas mains and restoring services after the fire is out, construction work involving the installation, moving or repair of gas mains, inspecting premises for proper installation of gas service in connection with building permits and other similar services are examples of the use to which radio communications is put in gas distribution.

It is definitely in the public interest, either during times of peace or during national emergencies, that private radio communications facilities remain available to meet the specialized communications requirements in the widely scattered areas of operation of the gas industry, which is so vitally necessary to the safety, health and economy of the industry's 31.2 million customers in their homes, shops and factories.

IV. Microwave Radio Relay Systems

About the time oil pipelines adopted modernized operation and natural gas pipelines extended their systems over vast distances, thus creating a need for more reliable and continuous communications, microwave radio, fortunately, became available for industry use. The petroleum industry, always aggressive and striving to find the best facilities for every activity in which it is engaged, has adopted microwave, one of the fastest growing means of communication ever to be developed in this country.

Oil and gas pipelines were among the first to use microwave for their long haul communications needs and are perhaps the largest single private user group today. See Table page 2. It is estimated that about one-half of the private microwave radio relay system mileage in this country today is in petroleum service and the majority of petroleum use is by the oil and gas pipelines.

Microwave offers many advantages to pipeline companies over other means of communications. The multiplicity of circuits available in a microwave radio relay system is tailor-made for modern pipelines with their increasing demands for more and newer type circuits. Telemetering and telecontrol already is being used extensively over these systems and pipeline managements are considering data-logging of information (automatic or sequenced telemetering print out) and connecting closed pipeline systems into computers for control and analysis.

Microwave offers a degree of reliability not possible with wire lines. Maintenance and repair problems are simpler with fixed station locations. Ease of adding channels aids pipeline expansion plans. The inherent line-of-sight transmission of microwave energy in narrow beams permits an almost unlimited number of systems to be installed through an area so that there should be no shortage of microwave for pipelines in the future.

The pipeline transportation of crude oil, petroleum products and natural gas affects the welfare of every segment of our population. It is certainly in the public interest to have all necessary facilities at the disposal of the industry to insure daily deliveries.

The pipeline industry is essential to the continued expansion of our economy. It is also realized that the great network of pipelines now in operation is one of our first lines of defense, and will be as long as the engines of war are powered by petroleum products.

The petroleum industry has pioneered in the development of microwave facilities, and has proven their dependability, economy and efficiency. The petroleum industry today operates as many private microwave stations as all other private services combined. These established and well functioning systems are an integral and vital part of this important industry.

13. Radio in Refinery Operations

I. Introduction

The refining, or perhaps more properly the manufacturing, branch of the petroleum industry has grown rapidly since the 1860's when virtually the only product was kerosene distilled from crude oil produced in the newly discovered Pennsylvania fields. This growth has not been confined solely to volume but may be measured also in the quality and variety of its products and in the processing methods and equipment required to produce them.

Progressing from simple crude retorts and stills which were scarcely more than "teapots" of very limited capacity, modern refineries employ complex but highly efficient continuous run processes which allow close control over the conversion of the crude oil content into the most desirable and marketable products. These products include an ever-expanding and truly remarkable assortment of petrochemicals which make a significant contribution to our modern way of life. Such products, if they are to yield the results of which they are capable, must be closely controlled at all times. Even a momentary unscheduled shutdown may render vital facilities unusable for days or even weeks. High pressures and high temperatures, with large volumes of highly explosive gases and volatile liquids, make for hazardous operations in which safety has become a necessary byword.

This section will describe the manner in which radio has contributed significantly to the improvement of both economic and safety aspects of refinery operations.

II. Refinery Plant

As of the beginning of 1959, there were approximately 325 refineries in the United States. These ranged in size from around 200 barrels per day to well over 300,000 barrels with an aggregate total capacity approaching 10,000,000 barrels per day.

From a short distance away, an oil refinery appears to be composed mostly of large towers and tubes rising vertically from a maze of rambling pipes supported for the most part on overhead racks. These pipes serve to interconnect all process units with the adjacent tank farm and with each other where necessary. Even the larger installations appear from a distance to be quite inactive although actually they operate continuously hour after hour, month after month. The refinery is the perfect example of a continuous flow operation, one in which the materials under process are rarely seen except as samples in the laboratory. And even the sampling is being sharply reduced by the increased use of automatic analytical and control equipment.

A typical oil refinery of 100,000 barrels per day capacity may occupy an area of some 1000 to 1200 acres and employ approximately 1800 people. It probably will have an extensive network of both express and secondary streets as well as many miles of main line and company railroad trackage. It will have its own police and fire-fighting forces, private bus system, intra-plant mail, messenger and delivery services. To insure adequate control and coordination of all these services, it may employ several communications systems such as the common carrier, or public, telephone service, an intra-plant private telephone exchange, localized whistle call system and radio paging, and one or more two-way mobile radio systems.

The relative importance of the latter becomes strikingly apparent when it is realized that more than half of the total work force is devoted to some form of plant maintenance which, by the very nature of the plant and its size, requires a high degree of mobility in both men and specialized equipment.

III. Uses of Radio

Historically, the widespread acceptance of radio as a routine tool in refinery operation has lagged somewhat behind its application to the problems of the exploration, production and pipeline segments of the industry. In recent years, however, its use has spread rapidly. Today, virtually every refinery of 100,000 barrels or more capacity employs private radio as a matter of course, as do also the majority of the much smaller plants. Such systems range in size from the small ones with two or three mobile units to the giants with multiple base stations and 200 or more mobile units.

Although the inherently hazardous nature of the materials and processes employed places a premium on the emergency service which can be so readily and effectively supplied by a mobile radio system, safety is by no means the only justification for its use. Mobile radio has, in fact, proven to be one of the more attractive cost reduction methods introduced during the last two decades. As such, it has found its primary application as an everyday operating tool used to increase efficiency in materials handling, dispatching of highly specialized heavy machinery and equipment, coordination and dispatching of technical personnel, coordination of process operations and supervisory personnel, and in plant security.

Within these general categories, specific applications have been many and varied. In a typical 100,000 barrels-per-day refinery, a representative mobile radio system would have one main base station, with an antenna height of approximately 100 feet, probably located near the main office or shop of the transportation division. Control or dispatch points would be installed in the vehicle dispatcher's office, materials warehouse, maintenance shop, plant security office, main gatehouse and perhaps in other divisions having a need to communicate with personnel on the move. In addition to the main station, auxiliary base stations would be installed in the plant security office and dispatcher's office for use in an emergency which might disrupt the telephone lines used to connect the control points with the main base station.

Mobile units, perhaps 50 to 60 in total number, would be found installed in many of the following: trucks of all types from pickups to heavy equipment haulers, straddle carriers, fork lifts, busses, taxis, locomotives, cranes, fire chief's car, fire inspector's car, fire trucks, ambulances, first-aid vehicles, plant security vehicles, laboratory sample trucks, gaugers' cars, air pollution control vehicles, and the cars of the plant manager, superintendent and other supervisory personnel as needed.

In addition to the permanently installed vehicular mobile sets, various employees such as foot patrolmen, safety inspectors, and others would be equipped with hand portable or shoulder pack units of limited power and range. In at least one existing system, accounting department personnel have been supplied with radios for the purpose of expediting reports of tank measurements.

While these are the "bread and butter" uses of radio in a refinery, the jobs which provide the economic justification for its installation, its potential for service during an emergency cannot be overlooked. In event of a major disaster, in which the plant's internal telephone system may suffer damage, radio can be, and has been, moved rapidly into the breach to maintain essential intra-plant communications for the duration.

Perhaps the most spectacular and well-publicized example of just this application of a refinery radio system occurred during a disastrous explosion and fire in 1955. The explosion of a catalytic cracking unit destroyed 70 storage tanks and inflicted a total loss well in excess of ten million dollars. Yet, despite the intense heat which destroyed internal communications cables, the fire damage was confined to approximately 50 acres of the 1600-acre plant. While a well conceived standby emergency plan executed by a daring and well trained crew of fire fighters must be given the lion's share of the credit for this almost incredible feat, it was the mobile radio system, installed primarily for materials handling, maintenance control and plant protection, which made possible the high degree of flexibility and teamwork so necessary to permit the fire fighters to respond instantly, and adequately, to each new emergency as it occurred.

IV. Rules and Regulations

As in all non-government radio usage, refinery radio operations are licensed and regulated by the Federal Communications Commission. To facilitate administration, and allow for necessary difference in regulations, the FCC has divided the available frequencies between a number of radio services categorized according to certain basic activities or industries.

Refinery operations may qualify for radio licenses in at least two, and with few exceptions three, of these services. Refinery systems have been licensed in the *Petroleum Radio Service* since 1949 when the FCC established the *Industrial Radio Services*. The overwhelming majority still are authorized under the provisions of that Service as are those serving exploration, drilling, production and pipeline segments of the industry.

Refinery operations also have been eligible for radio authorizations in the *Low Power Industrial Service* since 1949. Very few general purpose mobile systems have been installed under the provisions of this Service, however, due primarily to the restriction of power to three watts input or less and severe limitations on antenna height. Although the *Low Power Industrial Service* lost its separate identity as a result of the Commission's action in 1958, which established the *Business Radio Service,* the same frequencies, augmented by several additional ones and subject to the same restrictions, were retained as a part of the latter and still are available for the same purposes as before.

In addition to being eligible for low power operation in the *Business Radio Service,* refineries also may qualify for higher power general mobile systems in that Service. Although there are a moderately large number of frequencies available in each of three mobile service bands, it is not probably that many refinery operators will choose this option, since all *Business Radio Service* frequencies are available on an equal basis to any lawful enterprise, and prior frequency coordination between a new applicant and existing users is not required before the Commission grants a license.

In the same action which brought the *Business Radio Service* into existence, the Federal Communications Commission also established the *Manufacturers Radio Service* and provided that 15 of the 152-174 mc frequencies available to the *Petroleum Radio Service,* already equally shared with the *Forest Products Radio Service,* be equally shared by all three services. In addition to these 15 frequencies, however, a number of additional channels in the 460-470 mc band were allocated for manufacturers use.

With only a few exceptions, refinery operations also qualify for radio use in the *Manufacturers Radio Service.* Some restrictions, primarily on maximum power and permissible base station locations, apply in this service which are not applicable in the *Petroleum Radio Service.* Hence it is also doubtful that many refinery managements will choose the *Manufacturers Radio Service.*

V. Predictions for Future Growth

Although as noted earlier, the vast majority of refineries already are using radio, future growth seems assured, albeit at a somewhat slower rate than now, by the continuing development of new applications in existing systems and by expansion of refining capacity through the construction of new and enlargement of existing plants.

In view of the extensive three-way sharing now in effect on most of the 152-174 mc frequencies available to the *Petroleum Radio Service,* coupled with the success of the 450 mc systems so far installed in refineries, it appears likely that the latter frequencies will become increasingly popular for essentially short range work such as that usually required of plant systems. Their inherent freedom from natural and man-made electrical noise also is a factor certain to make them more popular in plant areas where high levels of such interference invariably are generated. Their value also is enhanced considerably by the fact that signals are propagated quite well through relatively small openings, such as doors and windows, in metal structures, the interiors of which are completely shielded at lower frequencies.

Some refineries are utilizing computers for controlling large units. Where a company operates several refineries, there are advantages in utilizing a centrally located large computer, rather than a number of independent small computers. This places stringent demands on the communications system. A logical solution to this requirement may be a microwave system.

14. Radio in Petroleum Marketing

I. Introduction

Marketing is the final step in the complex operation which has evolved from the industry's efforts to provide the gargantuan volumes of petroleum and its products consumed daily by the general public, industry and military establishments. The marketing processes take many forms, but those in both the oil and gas branches of the industry may be classified generally in two categories, bulk sales and sales directly to the ultimate consumer.

This section will describe the manner and extent of use of radio in connection with both bulk and direct-to-consumer marketing activities.

II. Natural Gas Marketing

Natural gas distribution by pipeline direct to consumers has been eligible in the *Power Radio Service* since the Federal Communications Commission first adopted the rules which established the *Industrial Radio Services* in 1949. Economic and safety advantages of radio in natural gas distribution are readily apparent, and that segment of petroleum marketing lost no time in making excellent use of the new tool made available to it. Today, it is accepted as a virtual necessity and more than 17,750 mobile and base station transmitters, as well as some 15 microwave stations, are serving the natural gas marketing organizations. Growth seems certain to keep pace with the continued expansion of gas distribution facilities and will probably exceed it to some extent.

Bulk sales of natural gas are almost invariably made directly from the pipeline which transports it from its source, although in recent years there has been some development of underground storage facilities utilizing depleted oil and gas fields, natural caverns and caverns hollowed from relatively impermeable strata in the earth's subsurface. Transportation of gas by means of pipeline is an activity included in the eligibility rules of the *Petroleum Radio Service*. Application of radio to this phase of marketing is described with particularity in *Section 12*.

III. Marketing of Oil and Its Products

In bulk marketing of petroleum and its products other than natural gas, use of radio so far has been quite limited. This is due largely to the rules and regulations of the Federal Communications Commission. Until recently such activities were eligible for licensing only in the *Citizens Radio Service* which was restricted completely to the 460-470 mc band. The operating range of these frequencies under normal conditions is somewhat shorter than that obtainable in the lower bands, especially in areas of heavy foliage. Also, the price of such equipment has been appreciably higher. It is not surprising, therefore, that this lack of choice has served as an effective deterrent to widespread use.

The action of the Federal Communications Commission, in Docket 11991, has now effectively relieved the eligibility and frequency choice restrictions by establishing the new *Business Radio Service*. These new rules provide for the private use of radio by any lawful commercial enterprise and offer a choice of a wide range of frequencies between 25 mc and 470 mc. While undoubtedly many bulk plant operations are such as to make radio communications of limited value, it is certain that many installations will be able to utilize radio facilities to effect substantial economies through more efficient use and control of transportation equipment and thereby provide better service to their customers.

In direct-to-consumer sales of such products as liquefied petroleum gases and furnace oils, radio is a long standing and highly regarded tool. In contrast to both bulk and direct sales of gasolines and motor oils, the majority of sales of these products involve large fleets of tanker trucks delivering relatively small quantities to locations with limited storage capacity. Such operations call for full and constant control over the vehicle and its contents. Until the advent of mobile radio, such control could be exercised only to a limited extent and rather indirectly by instructing the driver to telephone in at prescribed intervals. This either called for time consuming special stops or for using the customer's telephone at successive scheduled stops.

Two-way mobile radio places full control of deliveries directly in the hands of the central office dispatcher. Thus emergency calls for fuel, last-minute cancellations or additions to earlier orders, and distribution of small lot orders from a large capacity tanker without the necessity of precise advance scheduling, all may be handled quickly and effectively. At the same time the driver's ability to call in for instructions when needed or to report emergencies which may develop during his rounds, is greatly enhanced by elimination of the necessity for seeking a telephone each time such an occasion arises.

IV. Prediction for Future Growth

It seems apparent that the application of radio to petroleum marketing operations, especially those involving other than natural gas, actually is in its infancy and that explosive growth may be expected in the next several years.

With its formerly questionable eligibility status now favorably clarified as a result of recent actions of the Federal Communications Commission, there appears to be no reason why the petroleum marketing branch of the industry will not expand its use of two-way radio, wherever it may prove economically or operationally advantageous or necessary for safety reasons, with the same enthusiasm evidenced by the other phases of the petroleum industry the last decade.

15. Radio and Radar in Petroleum Marine Transportation

I. Introduction

The first use of radio and radar in the petroleum industry developed in maritime operations. Initially installed to promote safety of life and property at sea, these facilities also have become completely essential to the efficient and economical operation of all maritime shipping. Expanded tanker and barge fleets together with more sophisticated communication requirements have brought enormous growth to the communication and navigational services used by the industry in all phases of maritime transportation. This section will cover some of the current uses in major areas of operation.

II. Ocean Shipping

Aboard vessels of 1600 gross tons and upward, radiotelegraph equipment operating in the medium frequency range, 405-515 kc, continues to carry the major burden of routine and safety communications. This equipment is mandatory and must be manned by at least one licensed radio operator standing specified watches. In addition to mandatory medium frequency telegraph, most ocean-going vessels voluntarily carry high frequency telegraph equipment for long distance communications and, in recent years, many have installed radiotelephone systems operating in the 2 mc band to provide ship-to-shore voice communications. Portable lifeboat transmitters are standard equipment.

A number of foreign ports have installed harbor control systems using shore-based radar in conjunction with very high frequency (VHF) radiotelephone operating in the 156 mc maritime band. So far, most American ocean shipping has displayed a lukewarm attitude toward such systems and for the VHF system in general. However, considerable interest has been generated in a short range VHF bridge-to-bridge radiotelephone to be used either alone or in conjunction with shipboard radar as a navigational aid. The Federal Communications Commission has made the frequency 156.65 mc available for this purpose on a developmental basis and has liberalized its Rules to encourage evaluation programs. Such a program, encompassing all shipping in the Delaware River and Bay, currently under development, has stirred international interest. Similar programs are being developed in other areas.

Radar continues to be accepted as a useful navigational aid and anticollision device, with most ships being fitted. Over the past few years various refinements and operational improvements have been introduced by most manufacturers. These included shorter minimum range, sharper definition, reflection plotters, and "true motion" presentation, all of which tend to increase the usefulness of radar.

III. Great Lakes

The "Great Lakes Agreement," a treaty between the United States and Canada which became effective in 1954, governs maritime communications on the Lakes. Under the terms of this agreement, 2 mc radiotelephone is the basic safety distress system rather than medium frequency telegraph as used in ocean areas. The agreement calls for mandatory fitting of Great Lakes vessels 500 tons and over, as well as certain other classifications. Originally planned to promote safety of lives and equipment, the system today also is of inestimable value in the handling of navigational and routine communications.

Because of "skip" interference and overloading on the 2 mc frequencies, multi-channel VHF radiotelephone equipment operating in the 156 mc band is being used by many vessels to supplement the earlier system not only for intership traffic handling but also to communicate with the VHF coastal harbor stations which serve the Lakes area.

Radar is universally used as an effective navigational aid and anticollision device. Direction finders and fathometers are considered standard equipment.

IV. Rivers and Intracoastal Canal

The Mississippi River, its principal tributaries and the Gulf intracoastal waterways comprise approximately 5300 miles of inland waterways. Because of the distances and rugged terrain traversed by the inland waterways system users of the system are confronted with communications problems unlike those encountered by ocean and Great Lakes shipping.

Voluntarily adopted in 1941, high frequency amplitude modulated radiotelephone is the backbone of communications on the inland waterways system. It is now universally fitted on all petroleum towing vessels. The system is served by six coastal harbor stations, utilizing frequencies in the 2, 4, 6 and 8 mc bands. Because each of these bands has different propagation characteristics, it is possible to communicate at anytime with vessels anywhere in the waterways with minimum dependence on land lines. This facility has been jeopardized in recent years by the fact that the 6 mc frequencies were available only in derogation to the primary international frequency allocation. Hearings inaugurated by the Federal Communications Commission in 1953 to delete the use of the 6 mc frequencies on the rivers were finally concluded in 1958, with the Commission agreeing to their continued use. The United States delegation to the Geneva International Telecommunications Conference now in session will endeavor to obtain international accord with this decision.

This high frequency radiotelephone service is supplemented on the intracoastal waterway and on portions of the rivers by common carrier VHF service in the 156 mc band. Because of the limited range of VHF frequencies and the inadequate placement of shore stations, this service has not been as widely accepted as it would be were adequate facilities available. VHF service could be used to advantage for handling ship-to-ship and ship-to-lock traffic. In the latter connection much interest is being generated in the possibility of utilizing the frequency 156.65 mc recently established by the FCC for developmental evaluation of single channel VHF as a navigational aid.

Radar has become universally accepted as a navigational aid for all vessels in petroleum transportation enabling these vessels to move many additional miles annually. Due to the size of the tows now operating on the inland waterways (1170′ x 105′ x 8′ 6″ draft in a nine-foot channel), radar is needed constantly during night time navigation, whether fair weather or foul.

Depth sounding equipment has been widely accepted for operation on the Mississippi River system. Its use is typical but the installation differs from that made for other shipping in that the soundings are taken at the forward end of the tows.

V. Summary

In general it can be said that use of radio and electronic navigational aids is expanding and continues to be vital to economical and safe operation of petroleum shipping in all waters. The industry must never relax in its efforts to assure continued availability of existing services and to promote new and improved facilities. Because of the international aspect of maritime frequencies, particular attention must be given to the work of committees preparing proposals for use by the United States delegations to international conferences.

16. Petroleum Use of Radar and Radiolocation

I. Introduction

One of the major electronic developments during World War II was radiolocation. There are many radiolocation methods that are technically feasible. The discussion here will deal only with those actually used by the petroleum industry — radar, Shoran and phase-comparison methods. Briefly, the petroleum industry makes very extensive usage of radar and radiolocation methods. This usage falls into two categories. First, navigation of vehicles, largely boats, in all types of weather both to save costs and to decrease the hazards of the sea and inland waterways. Second, location of positions in situations where conventional surveying methods are totally inapplicable, for example, offshore. These locations may be points at which geophysical measurements have been made or positions where wells are to be drilled. An accuracy of the order of fifty feet is needed.

II. Radar

Radar has so captured the public fancy and its principles are so well known that they need no discussion here. The fact that equipment can be self-contained on the boat or aircraft involved and requires no cooperation from shore or other vehicles makes it ideal for collision avoidance and short range navigation. Practically all of the petroleum industry's ocean-going tankers, lake and river boats are equipped with radar.

Most air travelers are familiar with GCA, Ground Controlled Approach, whereby an operator of a ground based group of radars directs the pilot by radio during his approach and landing. The petroleum industry, in its offshore operations on the often stormy and fog-covered Gulf of Mexico, has used a similar technique employing a shore-based radar to permit a dispatcher to radio directions to the navigator of a boat approaching or leaving a harbor.

Radar, as a radiolocation tool, has some application to offshore geophysical prospecting. The limitations are largely set by the difficulty of identifying known points on shore and by its line-of-sight operating range. The recent development of Doppler radar, to give precision ground speed control for aircraft, is directly applicable to aerial photography and airborne magnetics.

The importance of radar is so fully recognized by all concerned that no regulatory problems are likely to arise which might be of peculiar concern to the petroleum industry.

III. Shoran

Shoran is an offshoot of radar. Whereas radar depends on ordinary reflection from natural objects or special targets, Shoran uses beacons. A beacon in this sense is a combination of radio receiver and transmitter so arranged that whenever a radio pulse is received on a specified frequency, a radio pulse will be transmitted on a different specified frequency a precise length of time later. Two advantages are realized. There is no problem of identification, since the reflections from natural targets are not on the frequency of the beacon transmitter. That is, the only returning pulse received by the Shoran equipment is the beacon signal. Furthermore, the strength of the pulse transmitted by the beacon is far greater than any reflected pulse.

There are two difficulties, one natural and one man-made. The natural difficulty is that fixed beacons at known points are required. The system is usable only in a predetermined area within line-of-sight distance from the beacons. The man-made difficulty is that all of the approximately 30 sets of Shoran units available to the petroleum industry operate on frequencies assigned to the military and their use is limited to prevent interference with military operations. This is an outgrowth of the military development of Shoran. The military have been most cooperative in permitting the maximum utilization of Shoran by the petroleum industry because of their recognition of the importance to them of adequate petroleum supplies. For several years, the Joint Chiefs of Staff granted permission for Shoran usage on military frequencies on a six-month basis, requiring negotiation for renewal each six months. This was time consuming, both for the Joint Chiefs and for industry representatives, and eventually long-term permission was granted, subject, of course, to no interference to military operations.

The petroleum industry has used Shoran principally for two operations. One is offshore prospecting, either seismic or gravity, using boats; the other is airborne magnetics, either offshore or over land. The latter frequently includes photo-mapping the area. In general, the areas where airborne magnetic operations have been carried on are such that little loss of time has resulted from the joint use with the military. Likewise the operations in the Gulf of Mexico, off Louisiana and Texas, have been largely unhampered by military operations. Unfortunately, there are extensive military operations, either using Shoran or other equipment on Shoran frequencies, along the California coast. As a result, the petroleum industry usage of Shoran for prospecting and surveying of offshore well sites has been quite restricted in that area.

While the technical problems of modifying Shoran to operate on non-military frequencies are not insurmountable, the cost would be excessive in terms of currently attainable benefits. Continued close cooperation with the military will permit the maximum petroleum utilization, but the current restrictions are not likely to be removed, unless a broad scale reassignment of the spectrum incidentally provides relief.

IV. Phase-Comparison Methods

Both radar and Shoran employ short pulses of radio energy. In order to give a precise measure of travel time, these pulses must be very sharp. A radio wave travels approximately one billion feet in a second. If the distance involved is to be measured with an accuracy substantially better than a thousand feet, the travel time of the pulse must be measured with an accuracy correspondingly better than one-millionth of a second (one micro-second). In conventional radar and Shoran, it is not possible to match the individual cycles that make up the pulse, only the outlines, or envelopes, of the pulses are matched. The pulse length must be a fair number of cycles, therefore to permit a pulse match of substantially better than a millionth of a second, the individual cycles must be a small fraction of a millionth of a second; stated otherwise, the basic signal frequency must be many megacycles. To attain an accuracy of some 50 feet, the basic signal frequency must be above 100 mc. This restricts the range essentially to line-of-sight. For airborne operations this is not too serious, but for land or marine work it obviously is a most serious handicap.

If fairly low frequency signals, say 100 kc to 2 mc, with corresponding wavelengths of 10,000 feet to 500 feet, are used, long ranges are feasible with reasonable power. If two continuous radio waves of exactly the same frequency were transmitted from two transmitters exactly in phase when leaving the transmitters, the difference in phase between the two waves at a receiver would give the differences in travel times, and so the differences in the distances, between the receiver and two transmitters. All points with a certain difference in travel time, or phase, would lie on a known curve on the earth so that the measurement of phase difference would determine on which such curve the receiver was located. By using a second pair of transmitters, a second such curve would be determined and the position of the receiver would be the unique intersection of these two curves.

Aside from questions of engineering refinements, this method has two inherent problems. First, it is not possible to receive and then separate two radio signals of exactly the same frequency. Therefore, it is necessary to devise some method of simulating the transmission of two signals of the same frequency by actually transmitting two signals of different frequencies. One method of accomplishing this is exemplified by two competitive systems which were specifically created to meet the problems of petroleum prospecting in the Gulf of Mexico. A third system commercially available in many parts of the world, but not on the Gulf of Mexico, has a quite different solution.

The second inherent problem is that all cycles of a continuous wave are identical; therefore, while it may be possible by a phase measurement to measure a small fraction of a wavelength, it is not possible to measure the number of whole wavelengths. The present solution used in the Gulf of Mexico is to start at a known point and keep count of the wavelengths as the boat goes out or comes in. This can be done automatically. But if the equipment fails long enough for the boat to drift an unknown distance of more than half a wavelength, the count is lost. Position may easily be lost overnight since the systems do not work satisfactorily at night.

This problem of wavelength count, or "lane-identification" as it is usually called, is serious. The foreign system has a solution which apparently is satisfactory.

The domestic systems are studying the problem.

At present, the domestic systems operate near 2 mc and the foreign system near 100 kc. On theoretical grounds each frequency range has advantages and offsetting disadvantages. It would be helpful to the petroleum industry to have an opportunity to have comprehensive studies of both on an actual working basis. This involves some rule making by the FCC, as probably will any solution of lane identification. Any reasonable requests should be supported by the petroleum industry.

One further regulatory problem is current. Phase comparison operations are authorized by FCC to operate in the Gulf of Mexico but not off the Atlantic or Pacific coast nor in Alaska. This limitation was entirely There was an immediate need in the Gulf of Mexico, reasonable at the time the original rules were issued. but not in Alaska or off the Pacific coast. There were no operations in Alaska and the prospecting off the Pacific coast was confined to a narrow belt near the coast where Shoran or conventional surveying methods might be utilized. Moreover there was a fear that this new service might cause interference to the long-range aerial navigational aid Loran. No Loran net was operating in the Gulf of Mexico. The situation has now changed. Alaskan operations will become important. Pacific operations are extending further offshore and the greatly stepped-up Pacific missile program is making Shoran almost unusable.

A petition for rule making to extend the service area to the Pacific coast is now pending before the FCC and should be strongly supported.

17. Petroleum Aircraft Radio

I. INTRODUCTION

The petroleum industry is a large user of private aircraft. In addition to fulfilling the need for normal business and executive use, often a major portion of a company's aircraft fleet comprises operational units for routine and emergency transportation of men and materials. Helicopters find ideal application in offshore operations for transportation of men and high-priority supplies when use of boats would entail intolerable delays. Small planes have long been used for pipeline patrol in connection with routine maintenance. Geological and related exploration reconnaissance make frequent use of data unobtainable except from the air. Certain geophysical observations are made by suitable airborne instruments, together with radiolocation and advanced radar techniques. Additionally, the many separate organizations providing essential services in the drilling and production phase of the industry rely heavily on aircraft effectively to compress their otherwise far-flung operations. Indeed, aircraft comprise an essential facility in practically all phases of the petroleum industry.

II. RADIO EQUIPMENT

The wide variety of aircraft types used by the industry involves a corresponding diversity in the radio equipment installed. Clearly an executive plane will normally carry the full complement of radio equipment commonly required for transport aircraft in meeting normal safety requirements. However, such equipment does not involve the use of frequencies in the *Petroleum Radio Service*. On the other hand a light patrol plane will carry a minimum of such equipment but must carry additional radio equipment operating on frequencies that will permit direct communication with the company's mobile and fixed radio systems. A helicopter in offshore service, while necessarily equipped to permit access to the standard aeronautical communication channels must have additional equipment for communication with company systems operating on petroleum service frequencies.

Special purpose aircraft such as may be involved in geological, geophysical or related survey operations may require even more diversified installations. In particular, a geophysical survey plane while fully equipped with all modern aeronautical radio aids will have facilities on *Petroleum Radio Service* channels to permit communication with ground mobile and base stations in that service. If precise surveying is involved, complex radiolocation or recently developed doppler radar equipment may be used.

Clearly the radio facilities installed in petroleum industry aircraft are highly diverse. They range from the standard multi-channel aeronautical communications radio, to direction finders, and possibly surveillance radar necessary for normal operation and safety in transportation service. Additionally, a ship in operational service must have special equipment to communicate on the frequency channel or channels assigned to the company's ground systems and perhaps survey-type equipment involving investments up to $100,000 or more. Without such appropriate special radio equipment these aircraft would lose much or even all of their intended usefulness except as a transport facility.

18. Petroleum Radio Relay and Control Stations

I. INTRODUCTION

Radio communication from base stations to mobile units, between base stations, and mobile unit to mobile unit is used extensively in the development and operation of oil and gas fields. However, there are many applications of radio in the petroleum industry where communications are needed over distances greater than can be covered directly between base stations, or base station to mobile, or mobile to mobile. Very often mobile stations need to communicate with each other, but they cannot do so directly because of the terrain or distance involved. In these cases, radio relay stations must be used to extend the range and to accomplish the desired communication.

II. TYPES OF STATIONS

By definition in Part 11 of the Federal Communications Commission's Rules and Regulations, relay stations are:

A. Fixed Relay Station — "An Operational Fixed Station in the fixed service, established to receive radio signals directed to it from any source and to retransmit them automatically on a fixed service frequency for reception at one or more fixed points." All microwave stations fall in this category.

B. Control Station — "An Operational Fixed Station, the transmissions of which are used to control automatically the emissions or operation of another radio station at a specified location."

III. Station Usage

A. Fixed relay stations are used in the *Petroleum Radio Service* in many and varied ways. These relay stations may operate on frequencies in the 27 mc band, 72-76 mc band, 169-172 mc band, 406-413 mc band and in the 451-457 mc band, as well as many of the microwave bands above 890 mc. Certain limitations are placed on many of these uses by the FCC Rules and Regulations. For example, use of the 72-76 mc band is conditioned on no harmful interference being caused to reception of television channels 4 and 5, which very drastically limits its use in the *Petroleum Radio Service*. The bands below 890 mc are generally used where not more than one or two voice channels are required and over relatively short distances. The most common use, other than for voice communication, is for remote contorl of another radio station or some other device.

The frequencies above 890 mc are generally referred to as the microwave portion of the spectrum, and it is in this portion of the radio spectrum that fixed relay stations, over long distances and many hops, provide for multi-channel communications systems in the *Petroleum Radio Service*. Radio waves are electro-magnetic in character as are light waves, and their behavior is identical to those of light, with due consideration for the much shorter wavelength of light. However, even with wavelengths in the long microwave region, it is possible to devise antenna structures of moderate dimensions, or even lens-like devices, that will project the energy in a relatively narrow beam analogous to, though not as narrow as, a searchlight beam. Propagation of the energy is in essentially straight lines with transmission losses determined largely by the spreading of the beam.

This provides a nearly ideal means to transmit communications along a relatively narrow path over distances determined by the line-of-sight limitations of the intervening terrain, the amount of power put into the transmitting equipment, and the sharpness of the beam as determined by practical limitations on the size and perfection of the antenna structure. A fraction to a few watts of power is usually adequate to cover the distances limited basically to line-of-sight. For long-distance transmissions this distance limitation is circumvented by merely adding an appropriate number of intervening relay stations where the incoming signal is received, amplified and retransmitted to the next in line. The system is, of course, engineered for two-way transmissions.

A further important feature of microwave transmission is the extremely high frequency involved. This inherently provides the carrier upon which may be superposed a large number of subcarrier frequencies, each providing a separate communication channel. They may provide from 3 to 120 voice channels which in turn, by subchanneling equipment, can be used for telemetering, teletype, remote control, data processing and automation of all sorts.

A microwave system is far less costly than a comparable wireline system, both in installation and maintenance, and provides more reliable service.

The use of microwave radio relay systems by oil and gas pipelines has been thoroughly discussed in *Section 12* of this report and will not be repeated here. However, it is believed that maximum utilization of microwave relay stations in the petroleum industry may ultimately be in fields other than pipeline. This will include automation and remote control of producing fields, including remote opening and closing of wells.

Much study is being given to all forms of automation, programming, data processing and centralized accounting, in all segments of the petroleum industry. These studies are being made with the view of reducing operating costs and at the same time achieving better planning and control. These operations are not possible without reliable communications. Microwave provides the necessary communications media. The continued availability of adequate microwave facilities to the petroleum industry is necessary for the efficient and economical conduct of the industry. This, in turn, is certainly in the public interest.

B. Control stations are used extensively in the *Petroleum Radio Service*. Most of this usage is to allow a base radio station to be physically located at some remote point, usually to take advantage of favorable terrain that may be several miles from the operating headquarters. The control station is located at the operating headquarters and is used to control the operation of the radio station at the remote location. Frequencies used in this type of station are generally in the 72-76 mc or the 451-457 mc bands.

IV. Summary

There is a demonstrated need for relay and control stations in the petroleum industry. As discussed fully in *Section 7* of this report, the Federal Communications Commission has paved the way for regular licensing of private industrial microwave systems. This was done by establishing the basic policy on use of the microwave spectrum in its Report and Order in Docket No. 11866, released July 29, 1959. This alone will further stimulate the use of microwave in the petroleum industry. It will find many applications that are not now commonplace.

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