THE FIRST TRANSCONTINENTAL TELEPHONE CABLE

By W. C. THOMAS and H. H. HONSAKER

AS PART of the Bell System's program for establishing a nation-wide coaxial cable network, the Southern California Telephone Company, along with the long lines department of the American Telephone and Telegraph Company, has received approval from the Federal Communications Commission for the placing of an eight-coaxial cable from Phoenix to Los Angeles. Each pair of coaxials in the cable can be arranged to provide up to 480 new telephone circuits into Los Angeles for use to the West Coast.

About a year ago the American Telephone and Telegraph Company announced a five year coaxial cable program involving 6,000 to 7,000 route miles of construction. The rapid pace at which the job is going forward has been dictated by the steadily increasing need for more telephone circuits between the nation's business centers.

Southern California Telephone Company engineers are actively proceeding with the engineering of their section between the Colorado River near Blythe, California, and Los Angeles, which will cost approximately $5,000,000. The cable crews already have worked westward on the new all-cable West Coast route to the vicinity of Fort Worth and Dallas. The aim is to reach Los Angeles in the spring of 1947.

In addition to its use for long distance telephone service, coaxial cable is capable of transmitting the very broad bands of frequencies required for television. The coaxial cables now being placed are therefore suitable to form the backbone of future nation-wide television program networks.

The five-year coaxial cable program as now visualized is shown in *Fig. 1.*

THE COAXIAL SYSTEM

When a telephone circuit is mentioned, the average person thinks of a pair of wires, either on one of the open wire leads or in a telephone cable. For a coaxial system, however, a copper tube about the size of a large lead pencil *(Fig. 2)*, with a copper wire suspended in its center by means of insulating disks spaced about ¾ inch apart, is used instead of the conventional pair of wires. The tube and the central wire are called a "coaxial" because they have the same axis.

Transmission over this novel type of conductor employs frequencies also used for radio. The impulses are wire-directed and travel through a space which has been segregated electrically from all the rest of the space in the world by the tube. The tube not only guides these impulses but protects them from fading, static, and other similar troubles of ordinary radio transmission.

The nature of coaxial transmission is such that it is necessary to use one tube for transmission in one direction and a separate tube for transmission in the other direction. Other pairs of coaxials in any particular cable may be similarly used for other circuits as spares, or may be energized as stand-bys to be used as substitutes for working coaxials which are in trouble or require routine maintenance.

Simple as they are, these coaxials in pairs are capable of carrying 480 separate telephone circuits with equipment now available. If not needed for telephone use, a single coaxial, suitably equipped, can carry a one-way television channel. For 480 telephone circuits, a band

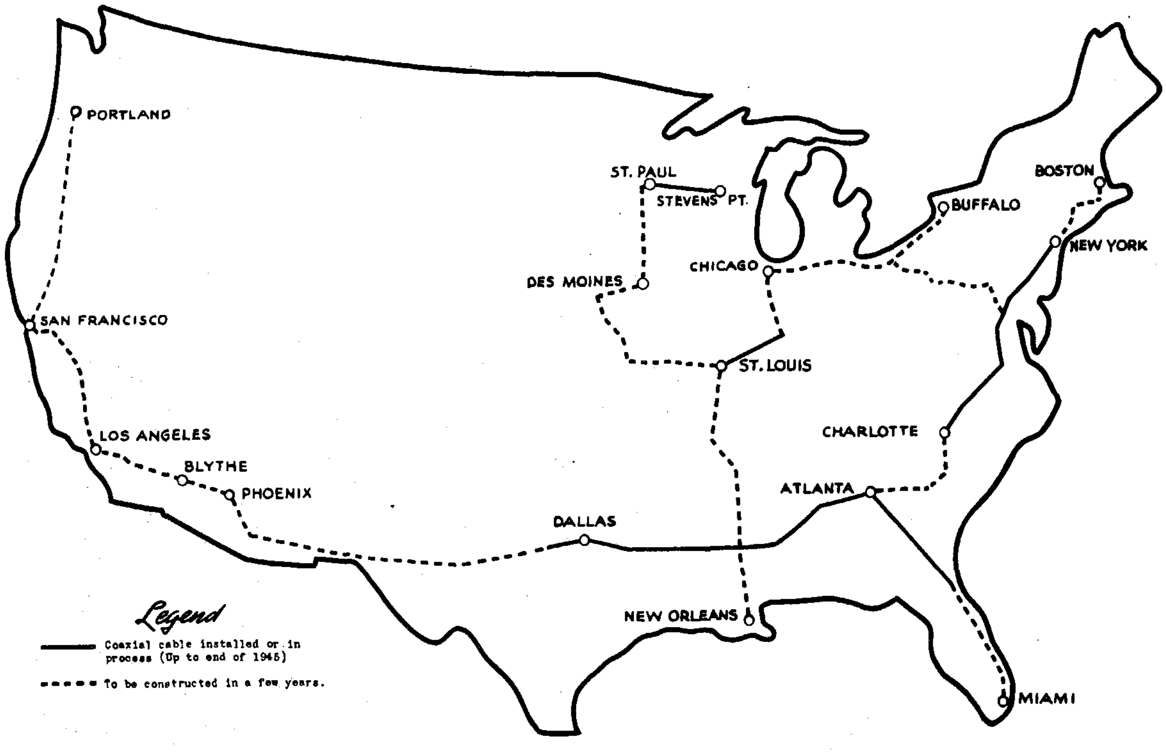

FIG. 1.

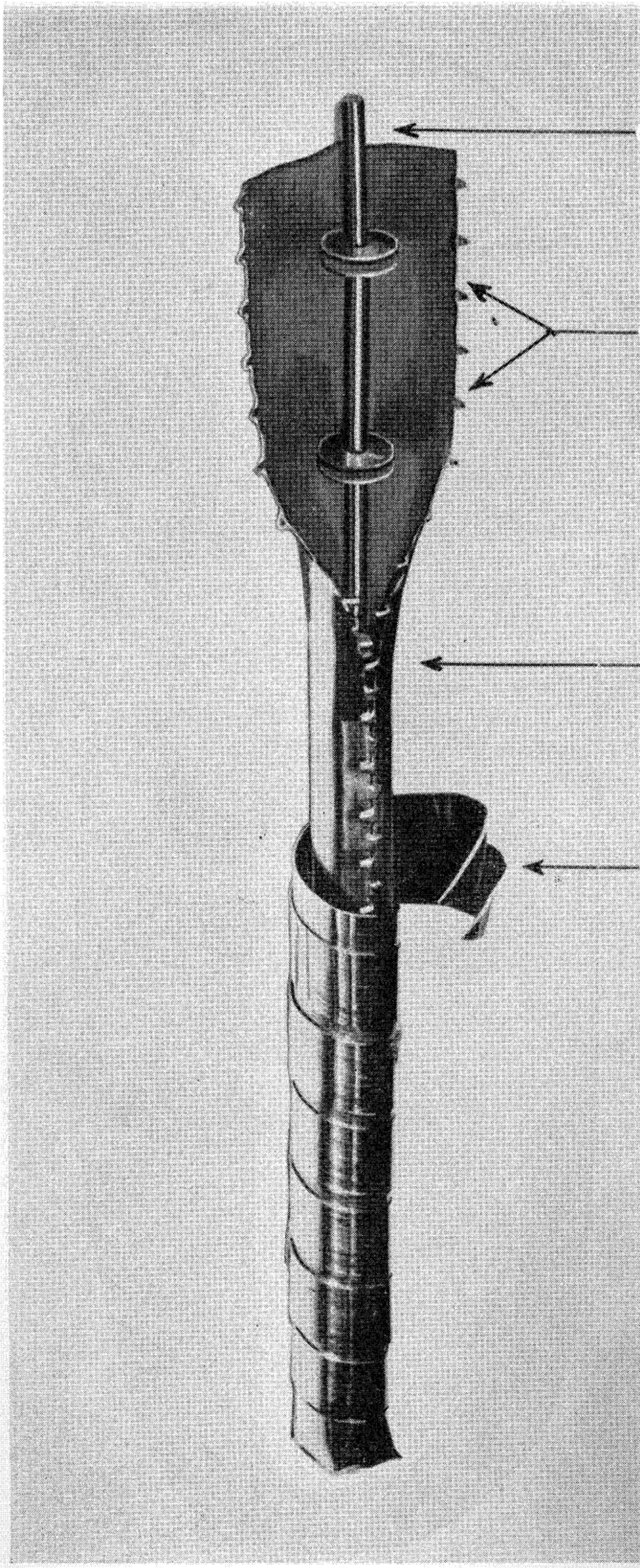

FIG. 2—Exploded view of a coaxial.

width slightly over 2,000,000 cycles is used; for television, this band is raised to nearly 3,000,000 cycles. Bell Laboratories' developments are under way, looking toward a future system capable of transmitting a band of 7,000,000 cycles. With this system it will be possible to transmit a 4,000,000 cycle band for television, plus 480 telephone channels, simultaneously over the same coaxials, or to transmit a broader television band if the standards of television should be so raised as to require it.

TEMPERATURE PROBLEMS

Coaxial systems are particularly susceptible to temperature changes, and wide variations of transmission may result from this cause. To avoid temperature difficulties as much as possible, cables are usually placed in the ground, instead of in aerial construction. To compensate for any variations which still remain, special narrow band pilot frequencies are included in the frequency band regularly transmitted. These pilot frequencies are sent out initially at a fixed volume, and their levels are automatically measured at control stations spaced along the route. If, for any reason (including temperature changes) deviations are found to exceed a predetermined amount, all circuits are automatically adjusted.

CABLE MAKE-UP PROPOSED

In the Phoenix-Los Angeles section, the cable proposed will contain eight coaxials, each 0.375 inches in diameter, together with sixteen paper insulated pairs of wires which will be used for alarm and maintenance purposes.

Fig. 3 illustrates a coaxial cable somewhat similar to that to be used in sections of the route where the cable is to be buried.

In the initial job it is planned to equip one pair of coaxials for 252 circuits. A second pair of coaxials will be used for stand-by purposes, leaving four additional

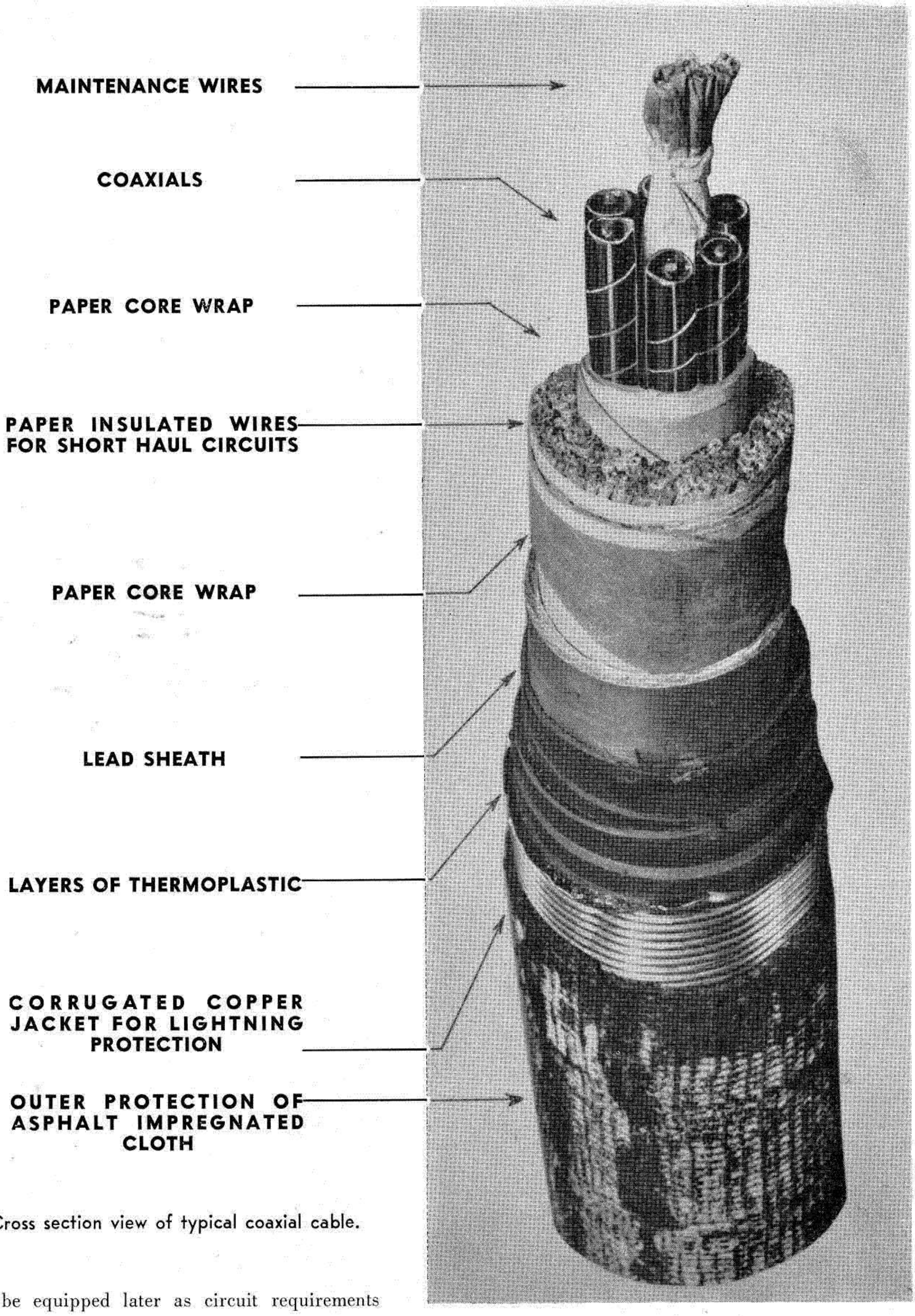

FIG. 3—Cross section view of typical coaxial cable.

coaxials to be equipped later as circuit requirements materialize.

GENERAL DATA

The section of the route between the Colorado River and Los Angeles will be approximately 240 miles in length. From the river to Whitewater, some fifteen miles east of Banning, the cable will be buried. Much of the buried cable will be placed directly in the ground* by plow (see *Fig. 4*), but considerable trenching by hand or machine digging will be necessary because of the nature of the geological formation.

*See article, "Buried Voice Channels", by Max B. Alcorn, *ENGINEERING AND SCIENCE*, January, 1945.

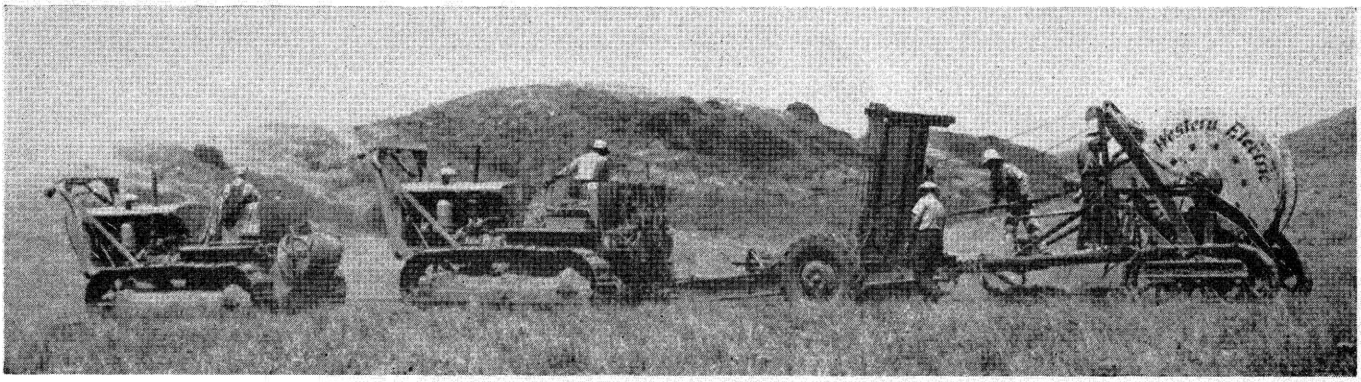

FIG. 4.—Tractors and cable-burying plow which deposits the cable 30 to 36 inches deep.

In general, the cable will be buried by the plow at a minimum depth of 30 inches. Through washes, or where erosion problems exist, or in rocky terrain, the cable may have to be buried to a depth of 10 feet or more.

From Whitewater to Los Angeles the cable will be placed in an available duct in the existing underground vitrified clay conduit system via Banning, San Bernardino, and El Monte.

BUILDINGS

A total of thirty-two buildings will be involved in the Southern California Telephone Company's portion of the project. These will vary from the four-story building to be erected at 434 South Grand Avenue in Los Angeles, which will be used in part for the terminal equipment, to small booster stations required at a spacing of about eight miles. In addition to using several present buildings along the route, twenty-seven of these small booster stations and a larger building at Blythe will be constructed. The small booster stations will be about 7 feet by 9 feet, inside dimensions. To avoid temperature variations as much as possible, they will be constructed with hollow masonry walls and insulating material.

REPEATERS AND POWER

At each booster station a repeater (amplifier) will be provided for each of the four coaxials to be equipped initially. These are for the two eastbound and two westbound coaxials (regular and stand-by), as previously described. Each repeater amplifies the entire frequency band transmitted in its coaxial, and in this respect the practice differs from that followed in the usual type of voice frequency long distance cable, which requires a repeater for each circuit at about forty-mile intervals.

Each coaxial repeater is hermetically sealed in a copper box about 5 inches by 5 inches by 7 inches, so arranged that the whole amplifier may be readily plugged into, or removed from, the circuit. The repeater within the copper box provides three stages of amplification with two tubes in parallel for each stage, either tube being capable of carrying the entire load in event of the failure of its mate.

Commercial sixty-cycle power will be available, together with emergency power sources, at the larger attended stations at Los Angeles, Whitewater and Blythe. Power for the repeaters at the intermediate booster stations will be supplied from these offices, using the central conductors of two coaxials as the two sides of the supply circuit. Since each of the power supply points will provide power to the adjacent booster stations within a distance of approximately fifty to eighty miles on either side, and the power circuits of the amplifiers involved are all essentially in series, arrangements must be made to provide approximately constant current from supply offices. One of the effects to be compensated for is the resistance variation caused by temperature changes.

Los Angeles, Whitewater, Blythe, and Phoenix being attended offices and suitably located for control points, these will be used as "Switching Main Stations". The regular and stand-by coaxials, including their respective repeaters at the intervening booster stations, are lined up as complete units between these switching points, and in the event of trouble affecting transmission on a working coaxial, relays at the "Switching Main Stations" at the ends of the section in trouble will operate automatically to switch in the stand-by coaxial and switch out the coaxial in difficulty, so that the trouble may be located and corrected.

CABLE—PROTECTION FEATURES

Every effort must be made to exclude moisture from the cable, since a small amount of moisture may put circuits out of service. To protect the cable from the entrance of moisture, and to provide a means of detecting a break in the sheath before a service interruption occurs, the cable will be maintained under gas pressure. Nitrogen gas, being inert and relatively inexpensive, is used for this purpose. If the pressure should drop a predetermined amount, an alarm is sounded in the control office through an electrical circuit arrangement. By making accurate pressure measurements at a number of points along the cable and plotting a curve against distance, maintenance men can determine the location of a leak fairly closely. In the case of a very small leak the gas pressure, which is ordinarily about 9 pounds per square inch, will keep water out for some time, providing the water pressure does not exceed the gas pressure.

In the Whitewater-Los Angeles section, where the cable is placed in conduit, the copper jacket and thermoplastic layers, as shown in *Fig. 3,* will be omitted. However, in the buried section between the Colorado River and Whitewater a number of additional hazards must be provided for.

The corrugated copper jacket, together with the thermoplastic insulating layers between it and the lead sheath, serve to minimize the danger of damage due to lightning. The copper jacket provides protection against the effects of corrosive soils and also rodents. If ordinary lead-covered cable is buried in the ground, it has been found that rodents, particularly gophers, have the disconcerting habit of chewing on the lead sheath, thus making holes which admit moisture.

LOOKING FORWARD

During the last few years there has been a tremendous growth in toll circuit requirements, particularly between the West Coast and the large centers in the East, due principally to activities in connection with the war effort. Whereas there were only 167 toll circuits connecting the West Coast with the East in 1940 this figure grew to over 1,200 at the end of 1945, and it is expected to be over 1,500 by the end of 1946. Almost half of these circuits terminate in southern California. Although the war has ended, continued increasing demand for telephone circuits is expected, but at a slower rate than during the war period. Coaxial cable is a very useful tool for meeting such heavy demands. As previously described, it may also serve to provide for a nationwide network of interconnecting television stations.

Is International Control of Atomic Energy Feasible?

By RICHARD M. NOYES

A report of the Joint Conference of the Committee on Atomic Energy of the Carnegie Endowment for International Peace, the Federation of Atomic Scientists, and the Commission to Study the Organization of Peace, held in New York City, January 4 and 5, 1946.

This article was written before the issuing by the State Department of the Lilienthal report on international control of atomic energy. This excellent report discusses many of the problems raised below and through the use of "denatured" plutonium envisages the possibility of somewhat larger power developments than were contemplated at the New York conference.—Editor.

EVER since the news of the atomic bomb broke on August 6, 1945, we have all been reading and hearing an undiminished flood of comment and discussion regarding its ownership and control. Such discussion constitutes the vital essence of democracy and is not to be disparaged, although it soon becomes apparent that many people are trying to reach conclusions without sufficient factual background.

With the avowed purpose of studying the possibility of atomic control in terms of existing technical and political situations, a knowledgeable group of men met in joint conference in New York City on January 4 and 5. The conference was arranged by the Committee on Atomic Energy of the Carnegie Endowment for International Peace, the Federation of Atomic Scientists, and the Commission to Study the Organization of Peace. It was organized as a round table discussion in which men from various bomb sites (such as Los Alamos, Oak Ridge, and Chicago) met with professors of law and economics who had been special consultants on missions to foreign capitols and to the United Nations Conference at San Francisco. As a representative of the Association of Pasadena Scientists, the writer had the rare privilege of attending the conference. It is impossible in a short article to present an adequate summary of two days of highly intensive discussion, but a few of the more important points can be mentioned.

During the first session the scientists led the discussion of the question whether control of atomic energy installations would be technically feasible, provided it were politically possible. At subsequent sessions the current international political situation was reviewed, and the necessity for modifications in the Charter of the United Nations was discussed at some length.

The mining engineers presented the most optimistic report of any at the entire conference. Guided by mining experience with gold and diamonds, and the history of the international control of the narcotic trade, they reached the conclusion that it would be feasible for a staff of moderate size to check operations of known uranium mines and to account for virtually all of the ore removed. This work, they reported, to be completely effective should be supplemented by periodic aerial surveys for indications of mining activity at new sites, and spectrographic analyses of samples from all mines handling large tonnages of ore, in order to insure that uranium was not being extracted as a by-product.

Discussion of atomic power installations was limited to consideration of those handling separation of uranium isotopes by gaseous diffusion, and to the manufacture of plutonium in piles.

Although the leaders of the discussion were obviously hampered by their inability to reveal pertinent information, the general belief was expressed that a diffusion plant would be very difficult to construct in secret because of the necessity for large numbers of key items, but that a plant could probably be operated without detection once it was constructed. The scientists believed that it would be almost impossible to prevent a moderate diversion of fissionable material in a diffusion plant supposedly operating legally under international control. Because of these conclusions, the need for the initiation of international control at the earliest possible moment was emphasized.

The final decisions with regard to plutonium manufacture were very similar to those for diffusion separation, except that it was considered less likely that a hidden plutonium plant could operate without detection. It was recommended that at least for the next generation, no country be allowed piles capable of producing a total of more than 25,000 kilowatts of atomic power. Such installations were deemed adequate for research, and medical and small-scale developmental uses, and it was believed impossible to divert enough of this material to produce a decisive number of bombs.

It was the general consensus of opinion that although inspection and control of no one material or process could be completely effective, illegal manufacture of atomic bombs could very probably be detected by independent procedures. Provided that international inspection and control of several of these procedures were politically possible, it was believed that there would be no possibility of a nation's manufacturing a decisive number of bombs in secret.

The second session of the conference was devoted to reports on attitudes of various governments, especially of the members of the "Big Three", to the current situation. The last two sessions were concerned with what could be accomplished within the framework of the United Nations Organization and how the Charter should be modified in order to accomplish control.

It was pointed out that the United Nations Organization as such had no authority to institute inspection procedures in the territories of any of its members, but only in those areas assigned as dependencies under the